Atmospheric Pollution & Climate Change (APCC)
Environmental Information System (ENVIS)
Resource Partner

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ABSTRACTS

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Contributed by

Dr. Gufran Beig

Mr. Samir Dhapare

Mr. Gaurav Shinde

Ms. Bhagyashri Katre

Ms. Darshana Jadhav

PREFACE

Environmental Information System (ENVIS) Resource Partner on Atmospheric Pollution & Climate Change (APCC) at Indian Institute of Tropical Meteorology (IITM), Pune is compiling the abstracts of new research done in the field air pollution and climate change categories, for the year 2020. This book has those abstracts from journals of Aerosol and Air Quality research, Atmosphere Chemistry and Physics Journal, Atmospheric Environment - 3.629, Atmospheric Research- 3.778, Environmental Science and pollution Research, Science of Total Environment- 4.9 which would help scientists, environmentalists and conservationists regarding monitoring, & controlling for atmospheric pollution and climate change.

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1. Aerosol and Air Quality research

Characterization and Spatial Source Apportionments of Ambient PM10 and PM2.5 during the Heating Period in Tian'jin, China

Baoshuang Liu1, Xiaoyun Sun1, Jiaying Zhang1, Xiaohui Bi 1, Yafei Li1, Liwei Li2, Haiyan Dong2, Zhimei Xiao2, Yufen Zhang1, Yinchang Feng1

Source: Aerosol and Atmospheric Chemistry,Volume: 20 | Issue: 1 | Pages: 1-13
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We collected ambient PM10 and PM2.5 samples from six sites in Tian'jin, China, from February to March 2016 and then analyzed their chemical compositions and identified the emission sources using the positive matrix factorization model. The mean concentrations of the PM10 and PM2.5 were 98 and 71 μg m−3, respectively, with a mean PM2.5/PM10 ratio of 0.67. The average concentrations of the combined SO42−, NO3−, and NH4+ were 19.9–23.4 μg m−3, accounting for 72.4–77.1% of the total measured ions. The concentrations and percentages were significantly higher for NO3− and OC than for other species. The SO42−/NO3− ratio showed a decreasing tendency as the PM10 and PM2.5 concentrations increased, implying a strong influence from mobile sources. The mean OC/EC ratios for PM10 and PM2.5 were 3.1 and 3.2, respectively, with small spatial differences. The most abundant elements were crustal, accounting for 73.2–84.2% of the total detected elemental mass, and mainly enriched in the PM10. The optimal number of factors for PM2.5 and PM10 was selected via PMF analysis: the decrease in the Q/Qexcept values of these two fractions lessened when choosing six instead of five factors, indicating that five factors may be optimal. All the factors were mapped in bootstrap (BS) for 100% of the runs, and no swaps occurred with the displacement of factor elements (DISP) for five factors. Secondary inorganic aerosol, coal combustion, crustal dust, vehicle exhaust, and biomass burning contributed 28–30%, 20–21%, 18–21%, 17–20%, and 4%, respectively. Secondary inorganic aerosol displayed less spatial heterogeneity than the other sources in its contributions. Backward trajectory and PSCF analysis showed that air masses affecting Tian'jin mainly originated in the northwest during the heating period, and northeastern He'nan, southwestern Shan'dong, Bei'jing, and Tian'jin itself were major potential source areas.

Keywords: Chemical species; Source apportionment; Heating period; Error estimation; PMF.

Influence of Meteorological Variables on Suburban Atmospheric PM2.5 in the Southern Region of Peninsular Malaysia

Nadhira Dahari1, Mohd Talib Latif2, Khalida Muda 1, Norelyza Hussein1

Source: Aerosol and Atmospheric Chemistry, Volume: 20 | Issue: 1 | Pages: 14-25
DOI: 10.4209/aaqr.2019.06.0313

Air pollution is a crucial contributor to premature mortality and health problems. The excessive inhalation of fine particulate matter (PM2.5) is strongly associated with adverse health effects due to its capability to penetrate deep into the human respiratory system. This study aimed to analyze the seasonal cycles of 24 h average PM2.5 mass concentrations in a suburban area in the southern region of Peninsular Malaysia. The meteorological variables and PM2.5 data were obtained via a Grimm Environmental Dust Monitor from August 2017 until January 2018. The maximum 24 h mass concentration was 44.6 μg m−3, with a mean value of 21.85 μg m−3, which was observed during the southwest monsoon . 43.33% and 8.33% of the daily concentrations exceeded the 24 h World Health Organization Guideline and Malaysian Ambient Air Quality Standard, respectively. The variation in the PM2.5 mass ranged between 0.53 and 0.90 times of the PM10 mass, indicating that the PM2.5 consistently contributed 52–92% of the PM10 mass concentration. During the monsoon seasons, the ambient temperature exhibited a significant positive correlation ($p < 0.05$) with the PM2.5 mass concentration ($r = 0.425–0.541$), whereas the wind speed ($r = –0.23$ to $–0.0127$) and the relative humidity ($r = –0.472$ to $–0.271$) displayed strong negative correlations with it. Additionally, the rainfall was weakly correlated with the mass concentration. The presence of northeasterly wind at the study site suggests that the PM2.5 originated from sources to the northeast, which are influenced by anthropogenic activities and high traffic.

Keywords: Atmospheric PM2.5; Meteorological influence; Particulate matter; Suburban area.

Assessment of Meteorological Impact and Emergency Plan for a Heavy Haze Pollution Episode in a Core City of the North China Plain

Simeng Ma1, Zhimei Xiao 2, Yufen Zhang1, Litao Wang3, Min Shao4

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DOI: 10.4209/aaqr.2019.08.0392

The Beijing-Tianjin-Hebei region, characterized by frequent episodes of severe haze pollution during winter, is recognized as one of the key regions requiring air pollution control. To reduce the effects of severe pollution, early warning and emission reduction measures should be executed prior to these haze episodes. In this study, the efficacy of emission reduction procedures during severe pollution episodes was evaluated using the Weather Research and Forecasting model coupled with chemistry (WRF-Chem). To provide feedback and optimize emergency emission reduction plans, a pollution episode that occurred during the period of December 20–26, 2015, which was characterized by a high

warning level, long warning period, and integrated pollution process, was selected as a case study to determine the influence of meteorological conditions and the effects of mitigation measures on heavy haze pollution episodes. Adverse meteorological conditions were found to increase PM2.5 concentrations by approximately 34% during the pollution episode. Moreover, the largest contributor to the episode was fossil fuel combustion, followed by dust emission and industrial processes; the first two factors play a significant role in most districts in Tianjin, whereas the third more strongly affects the adjoining districts and Binhai District. Emission reduction for industrial sources and domestic combustion more obviously decreases PM2.5 concentrations during the pollution dissipation stage than the pollution accumulation stage. Thus, different mitigation measures should be adopted in different districts and during different pollution stages. An approximate decrease of 18.9% in the PM2.5 concentration can be achieved when an emergency plan is implemented during the red alert period for heavy haze pollution episodes.

Keywords: WRF-Chem; Mitigation measures; PM2.5; Early warning.

Vertical Variation of Carbonaceous Aerosols with in the PM2.5 Fraction in Bangkok, Thailand

Parkpoom Choomanee1, Surat Bualert 1, Thunyapat Thongyen2, Supannika Salao3, Wladyslaw W. Szymanski1,4, Thitima Rungratanaubon1

Source: Urban Air Quality, Volume: 20 | Issue: 1 | Pages: 43-52
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Asian megacities are undergoing rapid population and infrastructure growth, which is resulting in significant air quality problems linked to atmospheric fine particles (PM2.5). This study focuses on characterizing carbonaceous aerosols in an urban area of Bangkok, Thailand. The Microclimate and Air Pollutants Monitoring tower is located on the edge of Kasetsart University campus and was used to perform vertical measurements. Mass concentration data were collected using area dust monitors (ADR1500) at different levels above the ground (30 m, 75 m, and 110 m) during two time periods, daytime (08:00–19:00) and nighttime (20:00–07:00), throughout the monsoon season in 2015. All relevant micrometeorological parameters were simultaneously monitored. Backward air mass trajectories were calculated using HYSPLIT to assess the possible external pollution contributions. The thermal optical transmittance (TOT) method following the NIOSH 870 protocol was used to determine amounts of elemental carbon (EC) and organic carbon (OC) in samples. A data analysis showed average PM2.5 values at observation heights of 30 m, 75 m, and 110 m of 6.21 ± 2.45, 8.12 ± 3.65, and 9.03 ± 3.93 μg m–3, respectively; corresponding OC concentrations of 4.13 ± 2.65, 4.01 ± 4.07, and 4.11 ± 3.58 μg m–3, respectively, and EC concentrations of 1.02 ± 0.84, 1.07 ± 0.95, and 0.50 ± 0.70 μg m–3,

respectively. The results show distinct gradients of increasing concentrations of PM2.5 with increasing elevation in contract with the OC and EC concentrations which decrease with height.

Keywords: Urban aerosols; Carbonaceous species; Fine particles; Vertical distribution.

Size Distributions of Suspended Fine Particles During Cleaning in an Office

Jun-Ho Ji

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DOI: 10.4209/aaqr.2019.10.0511

In this study, the concentration and size distribution of fine dust particles were analyzed by measuring the dust in air generated during the cleaning of an indoor office. We measured the PM10, PM2.5, and PM1.0 and analyzed the size distributions of particles larger than 0.3 μm in diameter during cleaning. The results showed that the concentration of PM10 increased rapidly during cleaning, whereas the PM1.0 did not increase. Prior to sweeping the floor with a broom, the fine dust concentration was ~50 μg m–3, but it increased to ~400 μg m–3 as the sweeping progressed. When a vacuum cleaner was used, the concentration of PM10 increased, but the increase in PM2.5 was relatively small. As in the case of sweeping, the PM1.0 did not increase while vacuuming.

Keywords: Indoor cleaning; broom; Vacuum cleaner; PM10; PM2.5; PM1.0.

PM2.5 Associated Phenols, Phthalates, and Water Soluble Ions from Five Stationary Combustion Sources

Zhiyong Li 1,2, Songtao Guo1, Zhenxin Li1, Yutong Wang1, Yao Hu1, Yiran Xing1, Guoqing Liu1, Rui Fang1, Hongtao Zhu1

Source: Air Toxics, Volume: 20 | Issue: 1 | Pages: 61-71
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Phenols and phthalates (PAEs) are always linked with the formation of secondary organic aerosols (SOA), while the water soluble ions (WSIs) are connected to the formation of secondary inorganic aerosols (SIA). A total of PM2.5 associated 20 phenols, 6 phthalates, and 9 WSIs were detected using GC-MS, ICS-1100, ICP-OES, and UV-VIS spectrophotometer for 5 stationary incineration sources including the domestic garbage (DG), garbage-fired power plant (GFPP), workshop of cable combustion for metal reclamation (WCC), peanut straw (PS), and wheat straw (WS). The anion equivalent (AE) and cation equivalent (CE)

concentrations indicated that the emitted PM2.5 was alkaline for all the 5 combustion sources. Cl– possessed high contents among all the 5 burning sources and the highest value occurred at WCC due to the high Cl content in PVC. The WSI profiles were different from each other for the 5 incineration sources on the basis of high coefficients of divergence (CDs). The mass contributions of 9 WSIs in PM2.5 from 5 sources were far lower than those of atmospheric PM2.5. DEHP and DBP dominated in PM2.5 from 4 sources, while WCC possessed high levels of DEHP, DNOP, and DBP. WCC possessed the highest daily intakes of PAEs due to its highest ∑6PAEs of 32000 ng g–1 resulted from the high usage of plasticizers in PVC. The PAE profile similarities were found for both GFPP vs. DG and PS vs. WS based on low CDs. Only 11 phenols were detected for the 5 sources and WCC possessed the highest level of phenols although only phenol was detected. WS had the high levels of phenols due to the using of phenolic pesticides during wheat growth process.

Keywords: Phenols; Phthalates; Water soluble ions; Combustion source; Daily intake.

Association between Particulate Matter Exposure and Short-term Prognosis in Patients with Pneumonia

Chien-Chih Chen1, Jyun-Bin Huang1, Shih-Yu Cheng2, Kuan-Han Wu1, Fu-Jen Cheng 1

Source: Air Pollution and Health Effects, Volume: 20 | Issue: 1 | Pages: 89-96
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Particulate matter (PM) and other air pollutants are reportedly associated with both lung and systemic inflammation; however, an association between air pollutants and pneumonia outcomes has not been well established. Therefore, we evaluated the effect of air pollutants on the short-term outcomes of emergency department patients with pneumonia. We collected data on PM2.5 (aerodynamic diameter < 2.5 μm), PM10 (aerodynamic diameter < 10 μm), sulfur dioxide (SO2), nitrogen dioxide (NO2), and ozone from 11 air-quality monitoring stations in Kaohsiung City between January 1, 2008, and December 31, 2013. Medical records were extracted for non-trauma patients aged > 17 years who had visited the emergency department with a principal diagnosis of pneumonia. In-hospital mortality and the association of air pollutant exposure with the need for invasive respiratory and/or vasopressor support (IRVS) within 72 h were evaluated. Interquartile range (IQR) increments of PM2.5 and PM10 were associated with an increased IRVS risk with odds ratios (ORs) of 1.211 (95% confidence interval [CI], 1.031–1.419) and 1.194 (95% CI, 1.020–1.394) on lag 1, respectively, and per-IQR increments of NO2 were associated with an increased IRVS risk with an OR of 1.146 (95% CI, 1.004–1.308) on lag 2. IQR increments of PM2.5 and NO2 were associated with an increased in-hospital mortality risk with ORs of 1.202 (95% CI, 1.100–1.429) and 1.175 (95% CI, 1.014–1.360), respectively. During the

warm season, IQR increments of PM2.5, PM10, and NO2 corresponded with an increased IRVS risk, with ORs of 1.333 (95% CI, 1.078–1.644), 1.348 (95% CI, 1.090–1.665), and 1.321 (95% CI, 1.101–1.585), respectively. For patients with pneumonia, PM2.5, PM10, and NO2 exposures were risk factors for a poor prognosis. Exposure effects appeared to be greater during the warm season. Regulations focused on PM2.5, PM10, and NO2 levels should be considered to improve patient outcomes.

Keywords: Particulate matter; Prognosis; Emergency department; Air pollution.

Characteristics of Volatile Organic Compounds during Different Pollution Periods in Winter in Yuncheng, a Typical City in North China

Qianzhuo Gao1, Yulong Yan 1, Rumei Li1,2, Yang Xu1,2, Yueyuan Niu1, Chenglong Liu1, Kai Xie1, Zeiwei Chang1, Dongmei Hu1, Zhiyong Li3, Lin Peng1

Source: Air Pollution and Health Effects, Volume: 20 | Issue: 1 | Pages: 97-107
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The composition characteristics and health risks of volatile organic compounds (VOCs) and their effects on secondary organic aerosol (SOA) during polluted and clean periods in winter 2018 for Yuncheng, a typical city in North China, were studied. The average concentration of VOCs was 2.3 times higher during the polluted period (105.29 μg m–3) than the clean period (45.78 μg m–3), whereas the average concentrations of the alkanes, alkenes, and aromatics were 3.4, 2.1, and 3.9 times higher, respectively, during the polluted period than the clean period. In addition, the VOC concentration was significantly influenced by meteorological conditions. Using positive matrix factorization (PMF), seven sources of atmospheric VOCs were identified, with the largest factors being vehicle emission (27.89%), coal combustion (23.37%), liquefied petroleum gas/natural gas evaporation (18.30%), and industrial emission (15.51%). Vehicle emission (30.04%) was the primary contributor during the polluted period, whereas coal combustion (33.53%) was the primary contributor during the clean period. The SOA formation potential (which almost exceeded 80%) was influenced by industrial emission (28.80%), solvent usage (26.30%), and vehicle emission (24.85%). Additionally, an assessment of the health risks of six aromatics based on the health risk exposure model of the United States Environmental Protection Agency revealed that the non-cancer risk was higher during the polluted period (6.61 × 10–2) than the clean period (2.20 × 10–2) but still below the Environmental Protection Agency (EPA) limit (1.00) and therefore negligible for the exposed population. However, the carcinogenic index of benzene (2.85 × 10–5 to 5 × 10–5) exceeded 10–6, suggesting a higher carcinogenic risk. Large-scale energy restructuring during recent years has sharply reduced coal combustion, but the VOC concentration has dramatically

increased due to vehicle emission. Hence, regulating vehicle emissions is an effective strategy for controlling VOCs in Yuncheng.

Keywords: Volatile organic compounds; Source apportionment; Secondary organic aerosol formation potential; Health risk assessment; Pollution period.

Application of the XGBoost Machine Learning Method in PM2.5 Prediction: A Case Study of Shanghai

Jinghui Ma1,2,3, Zhongqi Yu 2,3, Yuanhao Qu2,3, Jianming Xu2,3,4, Yu Cao2,3

Source: Air Pollution Modeling, Volume: 20 | Issue: 1 | Pages: 128-138
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Air quality forecasting is crucial to reducing air pollution in China, which has detrimental effects on human health. Atmospheric chemical-transport models can provide air pollutant forecasts with high temporal and spatial resolution and are widely used for routine air quality predictions (e.g., 1–3 days in advance). However, the model's performance is limited by uncertainties in the emission inventory and biases in the initial and boundary conditions, as well as deficiencies in the current chemical and physical schemes. As a result, experimentation with several new methods, such as machine learning, is occurring in the field of air quality forecasting. This study combined hourly PM2.5 mass concentration forecasts from an operational air quality numerical prediction system (WRF-Chem) at the Shanghai Meteorological Service (SMS) with comprehensive near-surface measurements of air pollutants and meteorological conditions to develop a machine learning model that estimates the daily PM2.5 mass concentration in Shanghai, China. With correlation coefficients that are higher by 50–100% and a standard deviation that is lower by 14–24 μg m–3, the machine learning model provides significantly better daily forecasting of PM2.5 than the WRF-Chem model. Thus, this research offers a new technique for enhancing air quality forecasting in China.

Keywords: XGBoost algorithm; PM2.5; WRF-Chem; Machine learning.

Performance of Four Consumer-grade Air Pollution Measurement Devices in Different Residences

Sydonia Manibusan, Gediminas Mainelis

Source: Aerosol Physics and Instrumentation, Volume: 20 | Issue: 2 | Pages: 217-230
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There has been a proliferation of inexpensive consumer-grade devices for monitoring air pollutants, including PM2.5 and certain gasses. This study compared the performance of four consumer-grade devices—the Air Quality Egg 2 (AQE2), BlueAir Aware, Foobot, and Speck—that utilize optical sensors to measure the PM2.5 concentration. The devices were collocated and operated for 7 days in each of three residences, and the PM2.5 mass concentrations were compared with those measured by established optical sensing devices, viz., the personal DataRAM and DustTrak DRX, as well as the filter-based Personal Modular Impactor (PMI).

Overall, the Foobot and BlueAir displayed the strongest correlations with the direct-reading reference instruments for both the hourly and daily PM2.5 mass concentrations. Comparing the 1-hour averages obtained with the DustTrak DRX for all of the residences with those obtained with the Foobot, BlueAir, AQE2, and Speck, the Pearson's correlation coefficients (R's) were 0.80, 0.88, –0.028, and 0.60, respectively. Overall, the strength of the correlation depended on the specific residence, likely due to the differences in aerosol composition. The correlations with the PMI measurements were moderate, with R values of 0.44 and 0.56 for the BlueAir and Foobot, respectively. The correlation coefficients for the daily values obtained with the AQE2 and Speck were –0.59 and 0.70 compared to the PMI. According to a paired t-test, the average 24-h PM2.5 concentration data obtained using the consumer-grade monitors were statistically different ($p > 0.05$) from the mass values measured by the gravimetric filters. Overall, this study demonstrates the ability of consumer-grade air pollution monitors to report PM2.5 trends accurately; however, for accurate mass concentration measurements, these monitors must be calibrated for a particular location and application. Further testing is needed to determine their suitability for long-term indoor field studies.

Keywords: Low-cost monitors; PM2.5; Indoor air.

Long-term Field Evaluation of Low-cost Particulate Matter Sensors in Nanjing

Lu Bai1, Lin Huang1, Zhenglu Wang2, Qi Ying 1,2, Jun Zheng1, Xiaowen Shi1, Jianlin Hu 1

Source: Aerosol Physics and Instrumentation, Volume: 20 | Issue: 2 | Pages: 242-253
DOI: 10.4209/aaqr.2018.11.0424

Low-cost particulate matter (PM) sensors can be widely deployed to measure aerosol concentrations at higher spatial and temporal resolutions than traditional instruments, but they need to be carefully calibrated under ambient conditions. In this study, a long-term field experiment was conducted from December 2015 to May 2017 at a site in Nanjing to evaluate the capabilities of in-house built low-cost PM monitors using the Shinyei PPD42NS

sensor for ambient PM2.5 monitoring. A BAM-1020 particulate monitor was co-located with the low-cost sensors to provide reference readings. Least-square regressions with linear and power-law functions, and an artificial neural network (ANN) technique were used to convert electrical instrument readings to ambient aerosol concentrations. Applying the ANN technique resulted in the best estimation of the hourly PM2.5 (R2 = 0.84; mean normalized bias = 12.7% and mean normalized error (MNE) = 29.7%). The low-cost sensors displayed relatively good performance with high aerosol concentrations but larger errors with concentrations below 35 μg m−3. High humidity (RH > 75%) can cause a larger MNE for these sensors, but the impact of temperature was negligible in this study. A clear sensor deterioration trend was observed during the 18-month field calibration. High correlations were found between the data from a single low-cost sensor and the data from the BAM-1020 when the low-cost sensor was individually calibrated, but the correlations between measurements taken by different low-cost sensor units were only moderate, possibly due to internal sensor variations. The results suggest that these low-cost sensors can measure ambient PM2.5 concentrations with an acceptable level of accuracy, which can and should be improved by calibrating each sensor individually. Special attention should be paid to the accuracy of these sensors after long-term application and in highly humid environments.

Keywords: PPD42NS; Field calibration; Long-term; Artificial neural network.

Evaluation of Nine Low-cost-sensor-based Particulate Matter Monitors

Jiayu Li1, Simar K. Mattewal1,2, Sameer Patel1,3, Pratim Biswas 1

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DOI: 10.4209/aaqr.2018.12.0485

Due to their affordability, compact size, and moderate accuracy, low-cost sensors have been studied extensively in recent years. Different manufacturers employ different calibration methodologies and provide users with calibration factors for their models. This study assessed the performance of nine low-cost PM monitors (AirVisual, Alphasense, APT, Awair, Dylos, Foobot, PurpleAir, Wynd, and Xiaomi) in a chamber containing a well-defined aerosol. A GRIMM and a SidePak were used as the reference instruments. The monitors were divided into two groups according to their working principle and data reporting format, and a linear correlation factor for the PM2.5 mass concentration measurement was calculated for each monitor. Additionally, the differences between the mass concentrations reported by the various monitors and those measured by the reference instruments were plotted against their average before and after user calibration to demonstrate the degree of improvement possible with calibration. Bin-specific calibration was also performed for monitors reporting size distributions to demonstrate coincidence errors that could bias the

results. Since monitors designed for residential use often display the air quality index, typically illustrating it with a simplified, color-coded index, the color schemes of various monitors were evaluated against the U.S. EPA regulation to determine whether they could convey the overall air quality accurately and promptly. Although these residential monitors indicated the air quality moderately well, their differing color schemes made the evaluation difficult and potentially inaccurate. Altogether, the tested monitors offer low-cost sensors in packages that are convenient for use and ready for deployment without additional assembly. However, to improve the accuracy of the measurements, user-defined calibration for the target PM source is still recommended.

Keywords: Low-cost PM monitors; Residential application; Calibration and characterization; Air quality index.

On the Inherent Variability of Particulate Matter Concentrations on Small Scales and the Consequences for Miniaturized Particle Sensors

Paul Maierhofer 1, Georg Röhrer2, Markus Bainschab1, Alexander Bergmann1

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DOI: 10.4209/aaqr.2019.01.0048

Despite all the evident benefits of miniaturized particulate matter (PM) sensors, an inherent drawback exists in the uncertainty and validity of the measurement, which is closely related to the discrete nature of particulates suspended in air. The miniaturization of these devices not only leads to a smaller footprint for the devices themselves but also to a smaller volume of air being sampled. Even if a perfect measurement system is assumed, an uncertainty lies in assigning a supposedly representative particle concentration value to an environment due to the inherent variability of PM concentrations on small scales. This stems from the fact that particles are stochastically distributed in the air, leading to a non-uniform concentration for arbitrarily small volumes. Consequently, an uncertainty exists according to counting statistics, as the number of investigated particles in a small air sample is also low. Depending on the metric, the uncertainty may be augmented, as a small number of particles cannot accurately capture the distribution of particle sizes, especially since the size distribution extends over several orders of magnitude. This distribution related uncertainty is relevant for surface and mass related metrics in addition to the uncertainty resulting from counting statistics. We detected a minor impact from the distribution of the particle mass density, which contributes to the uncertainty for mass-related metrics, such as PM1, PM2.5 and PM10. We investigated the expected measurement uncertainty by analytical means and concluded that the distribution of particle sizes, the sample size and the ambient particle concentration significantly affect the measurement

uncertainty for the range of conditions considered. To the best of our knowledge, this uncertainty has not been discussed in the current literature.

Keywords: Aerosol sampling; Measurement uncertainty; Miniaturized sensors.

Using Low-cost sensors to Quantify the Effects of Air Filtration on Indoor and Personal Exposure Relevant PM2.5 Concentrations in Beijing, China

Karoline K. Barkjohn1, Michael H. Bergin 1, Christina Norris1, James J. Schauer2, Yinping Zhang3, Marilyn Black4, Min Hu5,6, Junfeng Zhang7

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Residents of polluted cities frequently use indoor air purifiers in an attempt to improve their health by reducing their exposure to air pollutants, despite the fact that few studies have assessed these devices under relevant field conditions. Low-cost air monitors are increasingly popular for monitoring air pollution exposure; however, they must be calibrated and evaluated in their deployment location first to ensure measurement accuracy and precision. In this study, we developed a 2-step calibration method in which a low-cost monitor is calibrated against a reference analyzer and is then used to calibrate other monitors, shortening the required calibration time and reducing measurement error. The monitors in our experiment measured indoor, outdoor, and personal exposure PM2.5 concentrations during 1 week each of true and sham filtration in 7 homes in Beijing, China. On average, filtration reduced the indoor and personal exposure relevant concentrations by 72% (std. err. = 7%) and 28% (std. err. = 5%), respectively. This study indicates that minimizing personal exposure, however, also requires reducing the infiltration of outdoor air in homes or decreasing PM2.5 pollution at the city or country level.

Keywords: Air filtration; Low-cost sensors; PM2.5; Personal Exposure; Plantower.

Assessment of the Integrated Personal Exposure to Particulate Emissions in Urban Micro-environments: A Pilot Study

Phuong Thi Minh Tran, Jie Rui Ngoh, Rajasekhar Balasubramanian

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City dwellers' personal exposure to PM is influenced by numerous daily activities in multiple indoor and outdoor micro-environments (MEs). This study assessed the

integrated personal exposure to PM across urban MEs together with the recording individual time-activity patterns. We evaluated simultaneously the exposure to PM2.5, black carbon (BC), and ultrafine particles (UFPs) in the Central Business District (CBD) area of Singapore. In addition, we quantified the lung-deposited surface area (LDSA) concentration, which is an indicator of the potential health impacts of UFPs. The field study was conducted over a 7-km walking route to identify air pollution hotspots. Subsequently, the personal exposure to PM2.5, BC, and UFPs was measured at five selected hotspots for 1 hour each and across indoor and outdoor MEs during diverse daily human activities for 24 hours. The PM concentrations were found to vary considerably in both space and time in the CBD area. During the 1-hour personal exposure measurement, extremely high concentrations of PM2.5 (215 ± 129.5 μg m−3 and 36.4 ± 12.5 μg m−3) and BC (20.9 ± 10.4 μg m−3 and 18.1 ± 12.0 μg m−3) were observed at a temple and a bus stop, and elevated UFP number concentrations (320.8 ± 131.1 × 103 # cm−3) and high LDSA concentrations (564.6 ± 276.5 μg2 cm−3) were measured at a food court. The estimated potential health risk suggests that the continued inhalation of large amounts of PM2.5 emitted from combustion sources is likely to lead to adverse long-term health effects among the exposed individuals. Overall, we provide insight into an individual's total exposure to PM based on time-activity patterns. The results of this work form a scientific basis for developing air pollution control measures to mitigate personal exposure to PM on a city scale.

Keywords: Aerosol Sampling and transport; Air quality; Personal exposure.

Citizens' Surveillance Micro-network for the Mapping of PM2.5 in the City of Concón, Chile

Ernesto Gramsch 1, Luis Morales2, Marcelo Baeza3, Cristian Ayala1, Cristian Soto1, José Neira2, Patricio Pérez1, Francisco Moreno4,5

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A micro-network of low-cost sensors has been built and deployed in the city of Concón with the purpose of informing the community about the air quality in their neighborhood. Currently, 10 active stations, which are installed in resident-owned houses and public spaces, measure PM10 and PM2.5, rain, temperature, humidity, and wind speed and direction and display this information via a mobile application. The particulate matter is measured with a Dylos monitor, and the collected data has been calibrated using a Beta Attenuation Mass monitor for PM2.5 located in the same city as where the low-cost monitors are deployed. The PM2.5 concentration is obtained through a linear equation that uses small and large particle counts from the Dylos monitor. Additional calibration has been performed using neural networks, resulting in a noticeable improvement. The data

also show that calibrations performed in other cities cannot be applied to measurements taken in Concón. As noted in many other studies, the relative humidity strongly influences the particle count. For the months of June, July, and August, the hourly profiles reveal a prominent evening peak in downtown Concón but a less obvious increase at the other sites, indicating that wood burning (or a similar source) mainly occurs in downtown. The nearby oil refinery, Enap, does not seem to increase the concentration of particulate matter on average, but short-term PM2.5 events generated by the refinery have not yet been analyzed.

Keywords: PM2.5; Low cost sensor; Micro-network; Refinery.

Indoor Household Particulate Matter Measurements Using a Network of Low-cost Sensors

Shruti Hegde 1, Kyeong T. Min2, James Moore3, Philip Lundrigan3, Neal Patwari2, Scott Collingwood4, Alfred Balch4, Kerry E. Kelly1

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The World Health Organization estimates that 4.3 million deaths globally in 2012 were attributable to household air pollution, of which particulate matter (PM) with a diameter of 2.5 μm or less (PM2.5) is a significant contributor. When integrated with a wireless network, low-cost PM measurements potentially provide personalized information on indoor concentrations in real time so that individuals can take action. The objectives of this study were to (1) deploy a network of research-grade instruments and low-cost sensors in a home environment and evaluate the performance, (2) characterize activities and conditions that increase PM concentrations, and (3) identify how these activities affect the PM levels in different rooms of a home. The wireless sensor network included low-cost PM sensors, a gateway, and a database for storing data. Based on the commercially available Dylos DC1100 Pro (Utah Modified Dylos Sensor) and Plantower PMS sensor (AirU), the low-cost sensors were compared to three research-grade instruments—the GRIMM, DustTrak, and MiniVol—in two households in Salt Lake City during summer and winter, with the results suggesting that the low-cost sensors agreed well with the DustTrak. Of the activities, frying food and spraying aerosol products generated the largest increase in PM, both in the room of the activity (the kitchen and bedroom, respectively) and the adjacent rooms. High outdoor PM concentrations during a cold air pool episode also caused indoor levels to rise. In addition, different PM sources triggered different sensor responses. Consequently, obtaining accurate estimates of the mass concentration in an indoor environment, with its wide variety of PM sources, is challenging. However, low-cost PM

sensors can be incorporated into an indoor air-quality measurement network to help individuals manage their personal exposure.

Keywords: Indoor air; Particulate matter; Sensor network; Low-cost particulate matter sensor; Cold air pool.

Patterns and Sources of PM10 in the Ecologically Sensitive Himalayan Region in Himachal Pradesh, India

Raman Kumar1, Jui-Huan Lee2, Ruei-Hao Shie3, Chia-Pin Chio1, Chang-Chuan Chan 1

Source: Aerosols, Air Quality and Climate Change in the Himalayan Region, Volume: 20 | Issue: 3 | Pages: 410-418 DOI: 10.4209/aaqr.2019.03.0133

In this study, we aimed to comprehensively investigate particulate matter less than 10 μm in aerodynamic diameter (PM10) at industrial, residential, and ecologically sensitive sites in the western Himalayan region. To achieve this goal, PM10 data from 20 stations across the state of Himachal Pradesh were used to characterize the spatial and temporal patterns. To determine the potential sources of pollution, we created a bivariate polar plot based on wind speed and direction. Our findings showed that only the PM10 concentrations at the ecologically sensitive sites (59.02 ± 34.77 μg m−3) were below the National Ambient Air Quality Standard of 60 μg m−3. The concentrations at both the industrial (115.9 ± 47.82 μg m−3) and residential (87.16 ± 35.83 μg m−3) sites exceeded the standard, with the highest concentrations occurring during the winter and the lowest occurring during the monsoon season of the same year. The emission sources both within and outside of the Himachal Pradesh for each site were determined based on the bivariate polar plot, and industrial and vehicular emission, biomass and solid waste burning, dust from a nearby unpaved road, and long-range transported pollution were identified as contributors to the deterioration of air quality in this state. Moreover, the monsoon season significantly affected air quality. We conclude that local industrial and traffic pollution and long-range-transported emissions increased the PM10 concentration in Himachal Pradesh, resulting in its exceedance of the limit indicated in the World Health Organization (WHO) guidelines.

Keywords: Himachal Pradesh; Air pollution; Spatial and temporal variation; Ecologically sensitive; Bivariate polar plot.

Low-cost PM2.5 Sensors: An Assessment of their Suitability for Various Applications

Rohan Jayaratne1, Xiaoting Liu1, Kang-Ho Ahn2, Akwasi Asumadu-Sakyi1, Gavin Fisher3, Jian Gao4, Adrian Mabon1, Mandana Mazaheri1, Benjamin Mullins6, Mawutorli Nyaku1, Zoran Ristovski1, Yvonne Scorgie5, Phong Thai1, Matthew Dunbabin 7, Lidia Morawska 1

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Recently, there has been a substantial increase in the availability and use of low-cost particulate matter sensors in a wide range of air quality applications. They carry the promise of revolutionising air quality monitoring, yet considerable reservations exist regarding their performance and capabilities, thus hindering the broader-scale utilization of these devices. In order to address these concerns and assess their feasibility and accuracy for various applications, we evaluated six low-cost PM2.5 sensors (the Sharp GP2Y1010AU0F, Shinyei PPD42NS, Plantower PMS1003, Innociple PSM305, Nova SDS011 and Nova SDL607) in laboratory and field conditions using two combustion aerosols, concrete dust and ambient particles. In assessing the performance of these sensors, we focussed on indicators such as the linearity, accuracy and precision, critically differentiating between these qualities, and employed inter-comparison (the coefficient of determination, R2). In the laboratory, all sensors responded well, with an R2 > 0.91 when the PM2.5 concentration was > 50 μg m−3, as measured by the DustTrak. In particular, the PMS1003 demonstrated good accuracy and precision in both laboratory and ambient conditions. However, some limitations were noted for the tested sensors at lower concentrations. For example, the Sharp and Shinyei sensors showed poor correlations (R2 < 0.1) with the DustTrak when the ambient PM2.5 concentration was < 20 μg m−3. These results suggest that the sensors should be calibrated individually for each source in the environment of their intended use. We demonstrate that when tested appropriately and used with a full understanding of their capabilities and limitations, low-cost sensors can serve as an unprecedented aid in a broad spectrum of air quality applications, including the emerging field of citizen science.

Keywords: Low-cost sensors; PM sensors; Atmospheric aerosols; Air pollution.

Chemical Characteristics, Spatiotemporal Distribution, and Source Apportionment of PM2.5 Surrounding Industrial Complexes in Southern Kaohsiung

Huazhen She1,2, Po-Hung Cheng2, Chung-Shin Yuan 2, Zong-Mou Yang2, Chung-Min Hung2, Po-Hsuan Yen2, Iau-Ren Ie2

Source: Aerosol and Atmospheric Chemistry, Volume: 20 | Issue: 3 | Pages: 557-575
DOI: 10.4209/aaqr.2020.01.0007

This study investigated PM2.5, specifically, its chemical characteristics and spatiotemporal variation, and identified its potential sources in the Linhai industrial complex of southern Kaohsiung. Seasonal 12-h PM2.5 samples were collected simultaneously at three sampling sites. The results showed that high PM2.5 concentrations mainly occurred during winter and spring, with concentrations at the downwind sites always exceeding those at the upwind sites due to the transport of secondary aerosol by the prevailing winds. 31.4–56.8% of the PM2.5 consisted of water-soluble ions (WSIs), which were dominated by secondary inorganic aerosol (SIA) (SO_4^{2-} + NO_3^- + NH_4^+). High mass ratios between the SIA and the PM2.5 (SIA/PM2.5) were also observed during winter and spring, suggesting that SIA was the primary contributor to the high levels of PM2.5. A neutralization ratio (NR) < 1 indicated that the PM2.5 was acidic, and a nitrogen oxidation ratio (NOR) > 0.1 and a sulfur oxidation ratio (SOR) > 0.25 showed that SIA frequently formed during winter and spring. The metallic elements, which accounted for 12.0–20.2% of the PM2.5, tended to exhibit higher concentrations during daytime than nighttime, and the enrichment factors (EFs) revealed that the trace metals (Ni, Cr, Cu, and Zn) were mainly anthropogenic in origin. Carbonaceous content formed 9.3–24.3% of the PM2.5, and high mass ratios between the organic and the elemental carbon (OC/EC) were also observed during winter and spring. Moreover, the mass ratios between the malonic and the succinic acid (M/S) were always > 1.0 during winter and spring and < 1.0 during summer and fall, demonstrating that organic acids dominated the SOA during the first two seasons. The major sources of PM2.5 in the Linhai industrial complex were steel plants, followed by secondary sulfate and nitrate, vehicular exhaust, petrochemical plants, and incinerators.

Keywords: Industrial complex; Fine particles (PM2.5); Spatiotemporal variation; Chemical characteristics; Source apportionment.

Particle Mass Concentrations and Number Size Distributions in 40 Homes in Germany: Indoor-to-outdoor Relationships, Diurnal and Seasonal Variation

Jiangyue Zhao1, Wolfram Birmili2, Birgit Wehner1, Anja Daniels2, Kay Weinhold1, Lina Wang4, Maik Merkel1, Simonas Kecorius1, Thomas Tuch1, Ulrich Franck3, Tareq Hussein5,6, Alfred Wiedensohler 1

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Few studies investigated residential particle concentration levels with a full picture of aerosol particles from 10 nm to 10 μm size range with size-resolved information, and none was performed in central Europe in the long-term in multiple homes. To capture

representative diurnal and seasonal patterns of exposure to particles, and investigate the driving factors to their variations, measurements were performed in 40 homes for around two weeks each in Leipzig and Berlin, Germany. These over 500 days' measurements combined PM10 and PM2.5 mass concentrations, particle number concentration and size distribution (PNC and PNSD, 10–800 nm), CO2 concentration, and residential activities diary into a unique dataset. Natural ventilation was dominated, the mean ventilation rate calculated from CO2 measurements was 0.2 h–1 and 3.7 h–1 with closed and opened windows, respectively. The main findings of this study showed that, the residents in German homes were exposed to a significantly higher mass concentration of coarse particles than outdoors, thus indoor exposure to coarse particles cannot be described by outdoors. The median indoor PNC diurnal cycles were generally lower than outdoors (median I/O ratio 0.69). However, indoor exposure to particles was different in the cold and warm season. In the warm season, due to longer opening window periods, indoor sources' contribution was weakened, which also resulted in the indoor PNC and PNSD being very similar to the outdoors. In the cold season, indoor sources caused strong peaks of indoor PNC that exceeded outdoors, along with the relatively low penetration factor - 0.5 for all size ranges, and indoor particle losses, which was particularly effective in reducing the ultrafine PNC, resulting in a different particle exposure load than outdoors. This study provides a detailed understanding of residential particle exposure in multiple homes, facilitating future studies to assess health effects in residential environments.

Keywords: Indoor particle exposure; Indoor particle loss; Indoor source; I/O ratio; Penetration.

A Sampler for Collecting Fine Particles into Liquid Suspensions

Dongbin Wang 1,2, Jingkun Jiang1,2, Jianguo Deng1, Yuyang Li1, Jiming Hao1,2

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In this study, we developed a particle sampler for aerosol suspensions (PSAS) that collects ambient PM2.5 directly as liquid suspensions. The PSAS, which operates at a sampling rate of 50 L min–1, first pre-selects fine particles with a custom-designed PM2.5 inlet and then enlarges them into 2–5 μm droplets via condensational growth with a saturation-condensation unit. Subsequently, the enlarged droplets are sequentially collected in our novel collection impactor as liquid suspensions. Laboratory evaluations indicate good collection efficiencies for the PSAS with both polydisperse and monodisperse fine particles,

with 85% of the particles being effectively preserved in the collected suspensions. Field evaluations suggest good agreement between the PSAS suspensions and parallel filter samples for the analyzed chemical components (water-soluble Fe(II) and Cr(VI)) in the ambient PM2.5. Thus, the PSAS is suitable for long-term particle collection and can be used to facilitate the online chemical and toxicological analysis of ambient PM2.5.

Keywords: Aerosol sampler; PM2.5; Suspension samples; Condensational growth; Droplet impactor.

Compact Algorithms for Predicting the Atmospheric Visibility Using PM2.5, Relative Humidity and NO2

Hui Yi1,2,3, Jingjing Zhang1,2,3, Hang Xiao 1,3, Lei Tong1,3, Qiuliang Cai1,2,3, Jiamei Lin1,2,3, Weijia Yu4, Matthew S. Johnson4

Source: Aerosol and Atmospheric Chemistry, Volume 20, Issue 4, April 2020, https://doi.org/10.4209/aaqr.2019.06.0286

Visibility is a key parameter of the atmospheric environment that has attracted increasing public attention. Despite its importance, very few descriptions of methods for predicting visibility using widely available information in the literature exist. In this paper, we derive and evaluate two compact algorithms (Models I and II) for measuring and predicting visibility using records of PM2.5, relative humidity (RH) and NO2 from 16 cities around the world. Models I and II are simplified algorithms derived from Pitchford's algorithm. Our analysis shows that Model I is more consistent with the observations and can accurately predict changes in visibility. In a separate part of the study, the two algorithms are trained using data sets from individual cities. Better results are obtained when the models are trained with the data from London, Sydney and the Chinese mainland cities. Model II displays broader applicability when it is simulated using a single city's data set. This study indicates that atmospheric visibility can be well quantified based on measurements of PM2.5, RH and NO2 concentrations.

Keywords: Atmospheric visibility; Light extinction coefficient; Algorithm; PM2.5; Relative humidity; NO2.

Assessment and Comparison of Multi-annual Size Profiles of Particulate Matter Monitored at an Urban-industrial Site by an Optical Particle Counter with a Chemometric Approach

Sabina Licen 1, Sergio Cozzutto2, Pierluigi Barbieri1

Source: Air Pollution Modeling, Volume 20, Issue 4, April 2020,
https://doi.org/10.4209/aaqr.2019.08.0414

Air particulate matter dimensions are a key air quality parameter which can be related to composition, transport properties, exposure and effects on humans and the environment. Optical particle counters are increasingly used for dynamic ambient air particle matter size characterization. Monitoring campaigns lasting several months or years produces millions of single values to be elaborated, requiring effective data treatment procedures for extracting information and knowledge. Data mining algorithms as Self-Organizing Map (SOM) can support exploratory data analysis and pattern recognition in aerosol science. The use of SOM allows to elaborate a high number of data, with powerful visualization features using 2D maps, avoiding to lose information on data variability with data pre-treatments, such as compacting minute data to hourly or daily means. In the present study we describe the optical particle counter data elaboration for particulate matter profile assessment and comparison of a long monitoring time (nearly three years) carried out near residential buildings positioned very close to a steel plant. About twelve millions recorded single values have been handled on the whole. The approach allowed to identify four main particulate matter profiles and follow their variation during the years relating the differences with changes in the plant management and process. The possible applications of the present approach are broad in the field of air quality high frequency long monitoring campaigns with different types of instruments for size and compositional characterization of both particulate matter and gases.

Keywords: Ambient air; Pollution; Self-Organizing Map; Pattern recognition.

Emission Characteristics of Hazardous Atmospheric Pollutants from Ultra-low Emission Coal-fired Industrial Boilers in China

Tao Yue1,2, Kun Wang 1,3, Chenlong Wang1, Yali Tong1,3, Jiajia Gao 1, Xiaoxi Zhang1, Penglai Zuo1, Li Tong1, Quanming Liang1

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https://doi.org/10.4209/aaqr.2019.10.0531

This study comprehensively investigated the emission characteristics of primary air pollutants (PM, SO2 and NOx) and trace elements (As, Cd, Cr, Hg and Pb) from twelve coal-fired industrial boilers, nine of which were ultra-low emission (ULE) and three of which were non-ULE, based on field measurements. The concentrations, release ratios and relative enrichment factors (REFs) of the trace elements in both the coal and the bottom ash were obtained. Furthermore, the influence of atmospheric pollutant control devices

(APCDs) on the emission concentrations and emission factors (EFs) of these pollutants and elements, as well as on their removal efficiencies, was analyzed. The average release ratios for Hg, Cr, Pb and As from the coal were 96.28%, 59.95%, 65.34% and 84.85%, respectively, whereas the average overall removal efficiencies for PM, SO2, NOx, Hg, Cr, Pb and As with the APCD configurations of the ULE coal-fired industrial boilers were 99.5%, 95.9%, 81.0%, 95.6%, 95.6%, 99.3% and 96.0%, respectively. Using selective non-catalytic reduction (SNCR), and a hybrid of selective non-catalytic reduction and selective catalytic reduction (SNCR-SCR) in the ULE boilers, the EFs of the NOx were 5.5 × 10−1 kg t−1 and 4.9 × 10−1 kg t−1, respectively. Overall, the removal efficiencies for NOx and Hg were 2.1 and 2.8 times higher, respectively, with the ULE than the non-ULE coal-fired industrial boilers, which was mainly attributable to the higher denitrification efficiency, higher dedusting efficiency and higher liquid/gas (L/G) desulfurization ratio of the ULE boilers.

Keywords: Ultra-low emission; Coal-fired industrial boilers; Emission characteristics; Trace elements; Relative enrichment factors.

COVID-19: An Aerosol's Point of View from Expiration to Transmission to Viral-mechanism

Ta-Chih Hsiao1, Hsiao-Chi Chuang2,3,4, Stephen M. Griffith5, Shui-Jen Chen6, Li-Hao Young 7

Source: Aerosol and Atmospheric Chemistry, Volume 20, Issue 5, May 2020
https://doi.org/10.4209/aaqr.2020.04.0154

Coronavirus disease 2019 (COVID-19) emerged in Wuhan, China in late 2019, and soon unfolded as a global outbreak accompanied by declarations of a public health emergency of international concern (PHEIC) and later a pandemic from the World Health Organization (WHO). COVID-19 has resulted in 2,626,321 confirmed cases and 181,938 reported deaths worldwide (as of 14 April 2020). The underlying virus, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), is a highly contagious novel coronavirus that transmits as an aerosol and threatens people of all ages, from infant to geriatric, while those with cardiovascular disease are recognized as particularly susceptible to more severe symptoms from SARS-CoV-2 infection. WHO recommends using a mask to limit the COVID-19 outbreak; however, SARS-CoV-2 transmission models and its removal efficiency by wearing a mask remain unclear. Furthermore, differences in the field-specific definitions/terminologies related to transmission and mask usage tend to cause confusion and misunderstanding among both experts and the public.

Impact of the COVID-19 Event on Air Quality in Central China

Kaijie Xu1, Kangping Cui 1, Li-Hao Young 2, Yen-Kung Hsieh3, Ya-Fen Wang4, Jiajia Zhang1, Shun Wan1

Source: Urban Air Quality,Volume 20, Issue 5, May 2020,https://doi.org/10.4209/aaqr.2020.04.0150

In early 2020, the COVID-19 epidemic spread globally. This study investigated the air quality of three cities in Hubei Province, Wuhan, Jingmen, and Enshi, central China, from January to March 2017–2020 to analyze the impact of the epidemic prevention and control actions on air quality. The results indicated that in the three cities, during February 2020, when the epidemic prevention and control actions were taken, the average concentrations of atmospheric PM2.5, PM10, SO2, CO, and NO2 in the three cities were 46.1 μg m−3, 50.8 μg m−3, 2.56 ppb, 0.60 ppm, and 6.70 ppb, and were 30.1%, 40.5%, 33.4%, 27.9%, and 61.4% lower than the levels in February 2017–2019, respectively. However, the average O3 concentration (23.1, 32.4, and 40.2 ppb) in 2020 did not show a significant decrease, and even increased by 12.7%, 14.3%, and 11.6% in January, February, and March, respectively. This is because a lower concentration of NO2 resulted in constraints on the NO + O3 reaction, and the O3 could not be effectively further depleted. In addition, the average air quality index (AQI) for the three cities in January, February, and March 2020 were 32.2%, 27.7%, and 14.9% lower than the levels in 2017–2019, respectively. Based on the AQIs for the three cities, the combined proportions of Class I and Class Ⅱ in January, February, and March 2020 increased by 27.9%, 24.8%, and 4.3%, respectively, while the combined proportion of AQI Classes III, IV, V, and VI was reduced from 34.8% to 15.8%. In addition, in the first three months of 2020, the indicatory air pollutants in the three cities for the AQIs were predominant in the following order: PM2.5 (72.0%), O3 (16.4%), PM10 (8.3%), NO2 (2.9%), and CO (0.4%). This study provides useful information for establishing a scientific air pollution control strategy and is a valuable reference for future research on improving urban air quality.

Keywords: COVID-19; AQI; PM2.5; PM10; SO2; CO; NO2; O3.

Prediction of Potentially High PM2.5 Concentrations in Chengdu, China

Yingying Zeng1, Daniel A. Jaffe2,3, Xue Qiao4,5, Yucong Miao6, Ya Tang 1,5

Source: Air Pollution Modeling, Volume 20, Issue 5, May 2020, https://doi.org/10.4209/aaqr.2019.11.0586

Daily exposure to high ambient PM2.5 increases the mortality rate and contributes significantly to the burden of disease. In basin-situated cities with high local emissions of air pollutants, meteorological conditions play a crucial role in forming air pollution. One such city is Chengdu, which is located in the Sichuan Basin and serves as the economic, educational, and transportation hub of western China. Particulate matter with an aerodynamic diameter of < 2.5 μm (PM2.5) is the most critical pollutant in this city. Although the annually averaged PM2.5 concentrations declined from 92 to 57 μg m−3 between 2013 and 2017, the city still suffers from haze and smog, with 85 days during 2017 displaying 24-h PM2.5 concentrations > 75 μg m−3. To better understand the influence of meteorological factors on PM2.5 pollution with the goal of easily and reliably predicting the latter, we examined the relationships between the 24-h concentration and a variety of meteorological parameters in Chengdu. We found that the strongest predictors of the PM2.5 concentration were the temperature, precipitation, wind speed, and trajectory direction and distance. Furthermore, although the same-day sea-level pressure (SLP) was a weak predictor, the SLP 5 days in advance performed better. We developed generalized additive models (GAMs) that predicted the PM2.5 concentration as a function of multiple meteorological parameters. One of the GAMs developed in this study exhibited an adjusted correlation coefficient (R2) of 0.73 and captured up to 73.9% of the variance in the daily averaged PM2.5 concentrations. The model performance was improved by using the ΔSLP (i.e., mean pressure difference) for 5 days instead of the SLP, suggesting that ΔSLP5d is a good predictor of high concentration days in Chengdu. This study provides a useful tool for controlling emissions in advance to prevent heavy pollution days and issuing outdoor activity warnings to protect public health.

Keywords: PM2.5; Meteorology; Air pollution; Generalized additive models; Air pollution prediction.

Strengths and Weaknesses of the WHO Global Ambient Air Quality Database

Dietrich H. Schwela , Gary Haq

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The 2018 World Health Organization (WHO) global ambient air quality database is an impressive compilation of PM10 (particulate matter [PM] with an aerodynamic diameter ≤ 10 μm) monitoring data for 3,570 cities in 97 countries and PM2.5 (PM with an aerodynamic diameter ≤ 2.5 μm) data for 2,628 cities in 81 countries. The database collects PM measurements and estimates from established public air quality monitoring systems.

PM contain sulphates, nitrates, and black carbon that can penetrate deep into the lungs and the cardiovascular system, posing the greatest risk to human health. Unsurprisingly, the WHO database reports relatively low levels of urban PM pollution in high-income (HI) countries in Western Europe, the Americas, the Western Pacific, and Oceania. However, there are high PM levels in low- and middle-income (LMI) countries in Africa, Southeast Asia, and Latin America—where lack of funding and inadequate staffing are key barriers to effectively reducing the air pollution. Unfortunately, politicians, organizations, and the media have used the database to draw inaccurate and misleading conclusions based on comparisons between cities, such as occurred with the 2016 version. In this paper, we investigate the strengths and weaknesses of the 2018 database with respect to several criteria such as the selection of pollutants, completeness, spatial and temporal representativeness, and quality assurance and quality control, and offer recommendations for improvement.

Keywords: Air pollutants; Completeness; Comparability; Representativeness; Data coverage.

The Contribution of Large-scale Atmospheric Patterns to PM10 Pollution: The New Saharan Oscillation Index

Kenza Khomsi 1,2, Houda Najmi1, Youssef Chelhaoui1, Zineb Souhaili2

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https://doi.org/10.4209/aaqr.2019.08.0401

PM10, an urban air pollutant that originates from both natural and anthropogenic sources (desert dust and industrial and traffic emissions), reduces visibility and threatens human health, particularly in large cities. Casablanca, which exhibits the highest urbanization rate and population density in Morocco, possesses a concentration of industrial units as well as a large vehicle fleet. Marrakech, another of the most populated cities in the country, has also witnessed an increased rate of motorization during the recent years.

The primary objective of this study was to evaluate the relationship between the atmospheric circulation and the PM10 concentrations in Casablanca and Marrakech (based on daily measurements from 2013 to 2016). First, we assessed the correlations between the concentrations and the climate indexes (the North Atlantic Oscillation [NAO] and the Mediterranean Oscillation [MO]). Then, we characterized the contribution of large-scale atmospheric patterns related to extreme PM10 events. Finally, we created the Saharan Oscillation Index (SaOI), a climate index for characterizing the oscillation in the country's southern desert, between the Saharan depression and the Azores High, and calculated its time series.

Our results elucidate the relationship between the MO and the average PM10 concentrations, demonstrating that particulate pollution in the study area is partly induced by a northeasterly to southwesterly continental flow that is triggered by the Saharan trough and influenced by the high-pressure area in the north. The significant statistical correlations, mainly found in winter, confirm the relationships between the Saharan Oscillation Index, the average PM10 concentrations and the MO and NAO indexes—and thus the applicability of the SaOI—during this season.

Keywords: Particulate Matter (PM10); Correlation; Saharan Depression; Climate Index; Saharan Oscillation Index (SaOI); Air Quality.

Levels and Sources of PM2.5-associated PAHs during and after the Wheat Harvest in a Central Rural Area of the Beijing-Tianjin-Hebei (BTH) Region

Zhiyong Li 1,2, Yutong Wang2, Zhenxin Li2, Songtao Guo2, Yao Hu2

Source: Air Toxic, Volume 20, Issue 5, May 2020,
https://doi.org/10.4209/aaqr.2020.03.0083

Wheat harvesting and the subsequent straw burning for the planting of maize cause severe PM2.5 and polycyclic aromatic hydrocarbon (PAH) pollution. This study collected PM2.5 samples from the central area of the Beijing-Tianjin-Hebei (BTH) region on the North China Plain between 18 June and 7 July 2019, during and after the wheat harvest (DWH and AWH, respectively) and analyzed them for 18 PAHs. The average PM2.5 concentration DWH, 156 ± 42.5 μg m–3, was twice of that AWH (75.6 ± 31.9 μg m–3), which was attributed to fugitive dust generated by the wheat harvesters. However, the opposite trend, AWH > DWH, was observed for the total concentration of the 18 PM2.5-associated PAHs due to the open burning of wheat straw for maize planting. Four PAH sources, namely, biomass burning (BB), coal combustion (CC), vehicle emission (VE), and industry (IN), were identified by positive matrix factorization (PMF), and the elevated contribution from BB AWH demonstrated the effect of open wheat straw burning. CC accounted for the highest proportion DWH, indicating that residential coal combustion for cooking, due to its low economic cost, has remained a common practice despite the implementation of the Coal Removal Campaign in 2013. The 11.6% contribution of BB DWH also confirmed the use of biomass fuel for indoor cooking in rural areas of China. VE was the largest contributor of PAHs during the whole sampling period, reflecting the operation of wheat harvesters and rotary cultivators, but BB was the main source during three peaks in the PAH concentration, which occurred on 22 June, 28 June, and 2 July. Open BB, which also possessed a second source in air masses transported from northeastern China, was

responsible for the high levels of benzo[e]pyrene (BeP) and 5-ring PAHs. Backward trajectory clustering revealed that the adjacent cities of Shijiazhuang and Baoding were the primary IN source.

Keywords: PM2.5; PAHs; PMF; Backward trajectory clustering; Wheat harvest.

Two-phase Flow Dynamics and PM2.5 Deposition in Healthy and Obstructed Human Airways during Inhalation

Justus Kavita Mutuku1, Wen-Che Hou 1, Wei-Hsin Chen 2,3,4

Source: Air Pollution and Healthj Effects, Volume 20, Issue 5, May 2020, https://doi.org/10.4209/aaqr.2020.03.0107

Lately, there has been an unexpected increase in the global burden of diseases due to inhalation of ambient air contaminated with fine particulate matter (PM2.5). The adverse effects due to inhalation of PM2.5 are more exaggerated for patients with obstructive lung diseases such as Chronic obstructive pulmonary disease (COPD). In this study, numerical investigations were carried out on the effects of particle diameters and different Reynold numbers at the inlet on deposition patterns and fractions in COPD patients and healthy individuals. Three real and transient inhalation curves with average Reynolds numbers of 164.3, 362.4, and 606.4 were used to represent rest, light activity, and moderate exercise inhalation statuses. Four median diameters including 0.075 μm, 0.15 μm, 0.3 μm, and 0.6 μm were injected at the inlet of the control volume (G5–G8) of the Weibel's lung geometry to represent the particle size distribution for a PM2.5 concentration of 50 μg m−3. Deposition fractions and patterns were obtained from tracking a total of 350031, 692596, and 833553 PM2.5 particles corresponding to rest, light activity and, moderate exercise respectively. Deposition fractions (DFs) for the different sizes of PM2.5 ranged between 0.12% and 1.18% in the healthy airway geometry and between 0.05% and 0.49% in the COPD case. The deposition patterns were skewed for a COPD case due to jet flow phenomena, skewed mass flow rates, and the induced dean vortices. While depositions at the carina regions could be attributed to inertial impaction, those along the bifurcations could be attributed to centrifugal forces, complex secondary flows, and inertial impaction. The effects of the deposition mechanisms varied between the two geometries, among different particle diameters and inhalation statuses.

Keywords: Aerosol; Chronic obstructive pulmonary disease (COPD); Obstructed; Numerical methods; Two-phase flow; Deposition fractions (DFs).

Model-simulated Source Contributions to PM2.5 in Santiago and the Central Region of Chile

Joakim Langner 1, Lars Gidhagen1, Robert Bergström1,2, Ernesto Gramsch3, Pedro Oyola4, Felipe Reyes4, David Segersson1, Claudio Aguilera4

Source: Air Pollution Modelling,Volume 20, Issue 5, May 2020, https://doi.org/10.4209/aaqr.2019.08.0374

The contributions to PM2.5 from different emission sectors across central Chile and the Santiago metropolitan area during summer/fall and winter have been evaluated using a chemical transport model. The simulations generally underestimate the mean PM2.5 concentrations compared to measurements conducted at stations in Santiago that belong to the Chilean National Air Quality Information System (SINCA). The potential reasons for this discrepancy include underestimated direct PM2.5 emissions, missing emissions for semi- and intermediately volatile organic compounds (SVOCs and IVOCs) and overestimated wind speeds in the simulations. The simulated winter PM2.5 concentrations in Santiago are lower and higher than the values observed during nighttime, and daytime and late evening, respectively, which may be related to excessive simulated wind speeds, as well as to uncertainties in the diurnal variation in the emissions. During summer/fall, the simulated diurnal variation better agrees with the observations, but the peak concentrations during the morning are underestimated, whereas those during the evening are overestimated. The simulated contributions of different aerosol components to the PM2.5 at one station in Santiago are all lower than the observed values, except for elemental carbon equivalent black carbon (BCe) , which exhibit comparable or higher levels in the simulations. The absolute differences are the largest for the total organic matter, whereas the relative differences are the largest for BCe and ammonium. The simulated sector contributions indicate that emissions originating from transport and construction machinery dominate the PM2.5 in Santiago; however, residential wood combustion is the primary source in other urban areas of central Chile, except near major point sources. Away from urban areas, traffic routes and major industrial sources, secondary inorganic aerosol (SIA) is estimated to be the largest component of the aerosol, whereas the simulated secondary organic aerosol (SOA) only contributes a small fraction.

Keywords: Secondary aerosol formation modeling; Urban; Chemical composition.

Development of a PM2.5 Forecasting System Integrating Low-cost Sensors for Ho Chi Minh City, Vietnam

Nguyen Ky Phung 1, Nguyen Quang Long2, Nguyen Van Tin3, Dang Thi Thanh Le1

Source: Air Pollution Modeling, Volume 20, Issue 6, June 2020,
https://doi.org/10.4209/aaqr.2019.10.0490

Air pollution is a serious concern in urban areas, especially cities such as Ho Chi Minh City (HCMC). Because the air quality directly affects people's health, air quality monitoring is urgently needed. In this study, the models of Weather Research and Forecasting (WRF), Sparse Matrix Operator Kernel Emission (SMOKE), and Community Multiscale Air Quality (CMAQ) were integrated to develop an air quality forecasting system. Drawing input data from transportation and industrial emission inventories, the forecasting system was calibrated and configured using local parameters to deliver hourly forecasts for HCMC. To increase the accuracy of WRF and the meteorological forecasting, the global DEM and land use data were replaced by Lidar data, and land use data were also retrieved from MODIS. Output from the MOZART model served as the boundary conditions for CMAQ, and AOD values reported by the MODIS Aerosol Product were assimilated to enhance the accuracy of the results. A low-cost $PM_{2.5}$ sensor connected to a LinkIt ONE, a development board for Internet of things (IoT) devices, was employed for calibration and verification. The strong correlation (R^2 = 0.8) between the measured and predicted concentrations indicates that the estimates delivered by the proposed forecasting system are consistent with the values obtained via monitoring.

Keywords: WRF; CMAQ; Low-cost sensors; IoT; PM2.5.

Assessment of the Personal Dose Received by School Children due to PM10 Air Pollution in Lisbon

Eleftheria Chalvatzaki1, Sofia Eirini Chatoutsidou1, Vânia Martins2, Tiago Faria2, Evangelia Diapouli3, Manousos Manousakas3, Susana Marta Almeida2, Konstantinos Eleftheriadis3, Mihalis Lazaridis 1

Source: Air Pollution and Health Effects, Volume 20, Issue 6, June 2020,
https://doi.org/10.4209/aaqr.2020.01.0022

Investigation of the personal dose caused by air pollution in children is important due to their vulnerability. Exposure to PM10 and its components, particularly certain metals, may pose significant health risks therefore many studies have focused on measuring the ambient indoor/outdoor PM10 concentrations in school environments. However, little research has aimed at assessing the resultant personal dose. Hence, this study applied a dosimetry model (ExDoM2) to predict the personal dose received by students in five primary schools in Lisbon, Portugal. The calculations were performed for PM10 and PM10-bound metals, and the exposed subjects were assumed to be 10-year-old nose breathers. A

realistic exposure scenario involving three different settings (the indoor home, indoor school and outdoor school microenvironments) was implemented for an exposure period of one week (Monday–Sunday). Although the students spent only 24% of their total time inside a school (vs. 73% at home), this environment contributed 44% on average to the weekly deposited dose of PM10, providing further evidence that indoor exposure at schools is a major contributor to the total dose. The modeling results showed that the cumulative deposited doses in the respiratory tract (RT) reached as high as 2,004 μg, 0.16 μg, 0.65 μg, 0.58 μg and 0.06 μg for PM10, Cr, Mn, Pb and Ni, respectively, after one week.

Keywords: Particulate matter; Metals; Child; School; Dosimetry model.

Evaluation of PM2.5 Surface Concentrations Simulated by NASA's MERRA Version 2 Aerosol Reanalysis over India and its Relation to the Air Quality Index

Chimurkar D. Navinya, V. Vinoj , Satyendra K. Pandey

Source: Urban Air Quality, Volume 20, Issue 6, June 2020
https://doi.org/10.4209/aaqr.2019.12.0615

The PM2.5 (particulate matter with a diameter ≤ 2.5 μm), an essential component of air pollution, is closely linked to adverse effects on human health, including premature mortality following prolonged exposure. However, limited surface measurement and the lack of monitoring with adequate spatial resolution hamper studies related to air pollution and its impact on various societally relevant issues. More recently, the National Aeronautics and Space Administration (NASA)'s Modern-Era Retrospective Analysis for Research and Applications, Version 2 (MERRA-2) has begun estimating the global distribution of PM2.5 mass concentrations at high spatio-temporal resolutions, but the limitations of the applied estimation methodologies must be carefully evaluated in order to understand their strengths and weaknesses. This study assesses MERRA-2's PM2.5 results by comparing them with ground-based measurements conducted at 20 stations across the Indian region between 2015 and early 2018. Our analysis shows that MERRA-2 generally underestimates the PM2.5 in terms of both the mass concentration and the number of exceedance days. While the Central Pollution Control Board (CPCB) measured exceedances of the national ambient air quality standards (NAAQS) on 34% of the days, MERRA-2's prediction was only 11%, and its estimate of the annual average PM2.5 concentration across all of the sites was also negatively biased, by ~27 μg m−3. Correlations of 0.96 and 0.6 were found between the estimates and the measurements for the monthly and the daily averaged concentrations, respectively; these numbers can be dramatically improved by applying a simple bias correction. Overall, our evaluation reveals that MERRA-2's raw

estimates of PM2.5 on a monthly time scale or longer are helpful in long-term air quality studies.

Keywords: PM2.5; CPCB; MERRA-2; Air pollution; Aerosols; Evaluation.

Filterable PM2.5, Metallic Elements, and Organic Carbon Emissions from the Exhausts of Diesel Vehicles

Yuan-Chung Lin 1,2, Ya-Ching Li1, Kassian T.T. Amesho1, Feng-Chih Chou1, Pei-Cheng Cheng1

Source: Urban Air Quality, Volume 20, Issue 6, June 2020 ,https://doi.org/10.4209/aaqr.2020.02.0081

Urban air pollution in the form of fine particulate matter ($PM_{2.5}$) poses a substantial health threat to humans via inhalation. To assess the risks from this pollutant, we characterized and quantified the $PM_{2.5}$ exhausted by 15 diesel vehicles ranging from 28,306 to 883,374 km (an average of 525,854 km) in total mileage and varying in manufacturer and model year (1988–2005). We applied inductively coupled plasma optical emission spectroscopy (ICP-OES) to analyze the metallic element constituents, among which Ca composed the largest fraction, followed by Zn, Al, K, Fe, Mg, and Cr. Measuring the carbonaceous content, we found that the total carbon (TC), the organic carbon (OC), and the elemental carbon (EC) accounted for 3461 μg m^{-3}, 1410 μg m^{-3}, and 2051 μg m^{-3} of the $PM_{2.5}$ concentration, respectively. Of the metallic elements, Ca exhibited the highest emission factor (EF), between 45.3 and 259 μg L-$fuel^{-1}$ (with an average of 132 μg L-$fuel^{-1}$), whereas Zn and Cr displayed the lowest ones, averaging 13.1 μg L-$fuel^{-1}$ and 1.91 μg L-$fuel^{-1}$, respectively. We also investigated the relationship between the concentrations and the EFs of the metallic elements in the exhaust, and the ambient $PM_{2.5}$ composition. These results help illustrate the contribution of $PM_{2.5}$ emitted by diesel vehicles to metallic element concentrations in the natural environment and the consequent risks.

Keywords: PM2.5 emissions; Diesel vehicles; Metallic element concentrations; Organic carbon emissions.

Long-term Measurements of PM2.5 Concentrations in Lubbock, Texas

Mary C. Kelley1, Mallory M. Brown1, Clifford B. Fedler2, Karin Ardon-Dryer 1

Source: Urban Air Quality, Volume 20, Issue 6, June 2020, https://doi.org/10.4209/aaqr.2019.09.0469

Aerosol particles, such as $PM_{2.5}$ (particulate matter with an aerodynamic diameter ≤ 2.5 μm), are an important yet variable component of our atmosphere; their presence defines the air quality and profoundly affects human health. In this project, we examine changes in the $PM_{2.5}$ concentration, which is subject to temporal and spatial conditions and may vary by hour or day, in Lubbock, Texas, from 2001 to 2018. The hourly $PM_{2.5}$ concentrations were measured at the local Texas Commission on Environmental Quality (TCEQ) station, analyzed for diurnal, weekly, monthly, seasonal, and yearly changes, and compared with meteorological parameters (such as the temperature, wind direction or speed, and visibility) recorded by the local National Weather Service station at Lubbock Preston Smith International Airport. In addition, we examined the effects of El Niño and La Niña on the $PM_{2.5}$ concentration. The majority of the average daily $PM_{2.5}$ values fell below the Environmental Protection Agency (EPA) daily threshold of 35 μg m^{-3}, but many days exhibited high hourly concentrations, mainly due to dust storm events. No correlations were found between the concentrations and various meteorological parameters. Based on the hourly measurements, the diurnal distributions were bimodal, with morning and evening peaks, and the highest monthly averages were observed for April and June. A comparison of the $PM_{2.5}$ concentrations during El Niño and La Niña revealed higher values during the latter, with the maximum concentrations occurring during weak La Niñas.

Keywords: PM2.5; Lubbock Texas; Bimodal diurnal distribution; Dust storm

Estimation of Surface Particulate Matter (PM2.5 and PM10) Mass Concentrations from Ceilometer Backscattered Profiles

Avinash N. Parde1, Sachin D. Ghude 1,2, Prakash Pithani2, Narendra G. Dhangar2, Sandip Nivdange3, Gopal Krishna2, D.M. Lal2, R. Jenamani4, Pankaj Singh5, Chinmay Jena2, Ramakrishna Karumuri2, P.D. Safai2, D.M. Chate2

Source: Aerosol Physics and Instrumentation, Volume 20, Issue 7, July 2020, https://doi.org/10.4209/aaqr.2019.08.0371

In this study, we used remotely sensed backscattered profiles from a ceilometer to characterize the vertical and horizontal mixing of aerosols in the polluted planetary boundary layer (PBL). These profiles revealed the structure of the boundary layer, which included the mixed layer, the nocturnal residual layer and the elevated aerosol layer far above the mixed layer over Delhi. The accumulation of aerosols near the surface during feeble turbulence and the mixing of aerosols from the residual layer into the surface layer during convection was captured very well by a ceilometer. The backscattered signal from a height of 45 m above the ground was strongly correlated (82%) with the observed surface

PM2.5 and PM10 mass concentrations. We developed an empirical regression model based on this relationship, which was then tested and validated against independent measurements of the concentrations from November 2018. Although local meteorological conditions, particularly cloudiness and rain, influenced the strength of the correlation between the observed PM2.5 and PM10 mass concentrations and the backscattered signal, the magnitude of the mean bias between the observed and the values for PM2.5 (–21 μg m–3, RMSE = 75) and PM10 (31 μg m–3, RMSE = 118) indicated that the predicted values were fairly accurate. The model overestimated the PM2.5 by 7% and underestimated the PM10 by 6% on clear days.

Keywords: Pollution event; PM2.5 and PM10; Ceilometer backscatter.

Temporal Variations in the Air Quality Index and the Impact of the COVID-19 Event on Air Quality in Western China

Jiajia Zhang1, Kangping Cui 1, Ya-Fen Wang 2, Jhong-Lin Wu3,4, Wei-Syun Huang5, Shun Wan1, Kaijie Xu1

Source: Urban Air Quality, Volume 20, Issue 7, July 2020,
https://doi.org/10.4209/aaqr.2020.06.0297

This study investigated the AQI (air quality index) and atmospheric pollutants including PM2.5, PM10, CO, SO2, NO2 and O3 in Chongqing, Luzhou and Chengdu from 2017 to 2019. In addition, the impacts of the COVID-19 event on the air quality in the three cities in 2020 were compared and discussed. For the combined AQIs for the three cities, in spring, the daily AQIs ranged between 25 and 182 and averaged 72.1. In summer, the daily AQIs ranged between 24 and 206 and averaged 77.5. In autumn, the daily AQIs ranged between 22 and 170 and averaged 61.1, and in winter, the daily AQIs ranged between 28 and 375 and averaged 99.6. The distributions of the six AQI classes in spring were 3%, 94%, 3%, 0%, 0%, and 0%; in summer, they were 11%, 74%, 15%, 0%, 0% and 0%; in autumn, they were 29%, 70%, 1%, 0%, 0%, and 0%, and in winter, they were 1%, 52%, 44%, 3%, 0%, and 0%, respectively. The average AQIs, in order, were Chengdu (85.4) > Chongqing (73.8) > Luzhou (73.2). Both the highest AQIs and PM2.5 (as the major indicatory air pollutant) occurred mainly in the low temperature season (January, December, and February), while O3 was the main air pollutant in June and August when the weather was hot. In February 2020, during the epidemic prevention and control actions taken in response to COVID-19 for the three cities, the combined AQIs for the top five days with the highest AQIs in February 2020 was 79.4, which was 23.6% lower than that from 2017–2019 (AQI = 100.7), and the average concentrations of PM2.5, PM10, SO2, CO, and NO2 were 89.4 μg m–3, 106 μg m–3, 2.31 ppb, 0.72 ppm, and 12.3 ppb, respectively, and were 17.9%, 30.8%, 83.8%,

19.8%, and 62.1%, lower than those in February 2017–2019. However, the average O3 concentration (31.8 ppb) in February 2020 rather than decreasing, increased by 6.2%. This is because a lower NO2 concentration hindered the NO + O3 reaction and led to increase O3 concentration in the ambient air.

Keywords: COVID-19; AQI; PM2.5; PM10; SO2; NOx; CO; O3.

Impact of the COVID-19 Event on Trip Intensity and Air Quality in Southern China

Shun Wan1, Kangping Cui 1, Ya-Fen Wang2, Jhong-Lin Wu 3,4, Wei-Syun Huang5, Kaijie Xu1, Jiajia Zhang1

Source: Urban Air Quality, Volume 20, Issue 8, August 2020, https://doi.org/10.4209/aaqr.2020.07.0364

The COVID-19 epidemic discovered and reported at the end of December 2019 and began spreading rapidly around the world. The impact of the COVID-19 event on the trip intensity, AQI (air quality index), and air pollutants, including PM2.5, PM10, SO2, CO, NO2, and O3 in Shenzhen, Guangzhou, and Foshan (the so-called 'three cities') from January 12 to March 27, in 2019 and 2020, are compared and discussed. In 2020, the combined trip intensity in the three cities ranged between 0.73 and 5.54 and averaged 2.57, which was 28.4% lower than that in 2019. In terms of the combined AQIs for the three cities, from January 12 to March 26, 2020, the daily AQIs ranged between 21.0 and 121.3 and averaged 56.4, which was 16.0% lower than that in 2019. The average AQIs in order were Guangzhou (57.5) > Foshan (54.1) > Shenzhen (44.1). In 2019, the distribution proportions of the six AQI classes were 45.2%, 50.4%, 4.40%, 0%, 0%, and 0%, respectively, while those in 2020 were 62.7%, 37.3%, 0%, 0%, 0% and 0%, respectively. For the combined data for the three cities, on the top five days with the highest AQIs during the epidemic period, the average concentrations of PM2.5, PM10, SO2, CO, NO2, and O3 were 76.4 μg m–3, 113.4 μg m–3, 5.14 ppb, 0.88 ppm, 36.5 ppb and 55.5 ppb, which were 55.2%, 49.4%, 55.1%, 30.0%, 45.1% and 15.5% lower than those during the non-epidemic period (from January 12 to March 27, 2017–2019). The above results revealed that the comprehensive strict epidemic prevention and control actions reduced trip intensity and improved the air quality significantly.

Keywords: COVID-19; Trip intensity; AQI; PM2.5; PM10; SO2; CO; NO2; O3.

Changes in Air Quality during the COVID-19 Lockdown in Singapore and Associations with Human Mobility Trends

Jiayu Li , Federico Tartarini

Source: Urban Air Quality, Volume 20, Issue 8, August 2020,
https://doi.org/10.4209/aaqr.2020.06.0303

On the 7th of April, the Singaporean government enforced strict lockdown measures with the aim of reducing the transmission chain of the coronavirus disease 2019. This had a significant impact on the movement of people within the country. Our study aims to quantify the impact that these measures had on outdoor air pollution levels. We obtained air quality and weather data from April 2016 to May 2020, satellite data for 2019 and 2020 and mobility data for 2020 from Apple, Google, and the Singaporean Housing & Development Board. We determined that outdoor air pollution during the lockdown significantly decreased when compared with the same period in the previous four years even if we included corrections for long time trends in the analysis. The concentrations of the following pollutants PM10, PM2.5, NO2, CO, and SO2 decreased by 23, 29, 54, 6, and 52%, respectively, whilst that of O3 increased by 18%. The Pollutant Standard Index decreased by 19%. The trends of PM2.5 and NO2 were significantly correlated with mobility data. The NO2 and SO2 tropospheric concentrations and the total aerosol optical depth at 550 nm obtained from satellite data during the lockdown in 2020 were also lower than during the same period in 2019. Our results can be used to evaluate possible mitigation strategies for outdoor air quality in a longer term beyond this lockdown.

Keywords: Air pollutant; Anthropogenic pollution; Circuit breaker; SARS-CoV-2.

COVID-19 Lockdowns Improve Air Quality in the South-East Asian Regions, as Seen by the Remote Sensing Satellites

Abirlal Metya 1,2, Panini Dagupta1,3, Santanu Halder1,2, S. Chakraborty1,2, Yogesh K. Tiwari1,2

Source: Urban Air Quality, Volume 20, Issue 8, August 2020,
https://doi.org/10.4209/aaqr.2020.05.0240

The appearance of COVID-19 in December, 2019 in China and its rapid spread all over the globe, forced the governments to severely curb the social and economic activities of their respective countries. Barring the essential services, most of the business activities and transport sectors have been suspended and an unprecedented lockdown imposed over major economies in the world. South-East Asian regions, such as India and China, were no different. As a result, the pollutant level has gone down over these regions, and the air quality improved somewhat better than it was before the lockdown. This study uses

satellite retrievals and attempts to estimate the extent of the reduction of major pollutants, like carbon monoxide (CO), nitrogen dioxide (NO2) and sulfur dioxide (SO2) in India and China during January to April, 2020. We have calculated anomalies of pollutants during the lockdown period relative to their long-term records. NO2, which has significant emissions from the transport sector, is reduced on an average by 17% over India and 25% over China. SO2, which mainly emits from power plants, shows significant reductions (approx. 17%) especially over the Eastern sector of India. CO is found to be reduced by 6.5% over north-central China. The differential reduction was attributed to man made versus natural activities. This study is helpful to policy makers in mitigating the air-pollution on a long-term perspective.

Keywords: SARS-CoV-2; Coronavirus; COVID-19; Air quality; CO; NO2; SO2.

Impact of COVID-19 Event on the Air Quality in Iran

Parya Broomandi1,6, Ferhat Karaca1,2, Amirhossein Nikfal3, Ali Jahanbakhshi4, Mahsa Tamjidi5, Jong Ryeol Kim 1

Source: Urban Air Quality, Volume 20, Issue 8, August 2020, https://doi.org/10.4209/aaqr.2020.05.0205

The first novel coronavirus case was confirmed in Iran in mid-February 2020. This followed by the enforcement of lockdown to tackle this contagious disease. This study aims to examine the potential effects of the COVID-19 lockdown on air quality in Iran. From 21st March to 21st April in 2019 and 2020, The Data were gathered from 12 air quality stations to analyse six criteria pollutants, namely O3, NO2, SO2, CO, PM10, and PM2.5. Due to the lack of ground-level measurements, using satellite data equipped us to assess changes in air quality during the study on Iranian megacities, especially in Tehran, i.e., the capital of Iran. In this city, concentrations of primary pollutants (SO2 5–28%, NO2 1–33%, CO 5–41%, PM10 1.4–30%) decreased with spatial variations. Although, still SO2, NO2, and PM10 exceeded the WHO daily limit levels for 31 days, 31 days, and four days, respectively. Conversely, O3 and PM2.5 increased by 0.5–103% and 2–50%. In terms of the national air quality, SO2 and NO2 levels decreased while AOD increased during the lockdown. Unfavourable meteorological conditions hindered pollutant dispersion. Moreover, reductions in the height of planetary boundary layer and rainfall were observed during the lockdown period. Despite the adverse weather conditions, a decrease in primary pollutant levels, confirms the possible improvements on the air quality in Iran.

Keywords: SARS-CoV-2; Atmospheric pollution; Lockdown; Tehran; Nitrogen dioxide; Carbon monoxide.

Impact of SARS-CoV-2 on Ambient Air Particulate Matter in Tehran

Sasan Faridi1,2, Fatemeh Yousefian1,2, Sadegh Niazi3, Mohammad Rezvani Ghalhari2, Mohammad Sadegh Hassanvand 1,2, Kazem Naddafi 1,2

Source: Urban Air Quality, Volume 20, Issue 8, August 2020, https://doi.org/10.4209/aaqr.2020.05.0225

The pandemic caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has indirectly produced both positive and negative effects on the environment, particularly in terms of air quality. Our study aimed to determine these effects in the city of Tehran by comparing the ambient PM2.5 and PM10 levels recorded at 22 air quality monitoring stations during the outbreak (20 February–2 April 2020) with those from the corresponding period last year (20 February–3 April 2019). Contrary to expectation, the average concentrations of both the PM2.5 and the PM10 were markedly higher during the former, increasing by 20.5% and 15.7%, respectively, for the first month of the outbreak (20 February–19 March 2020) and by 23.5% and 20.0% for the subsequent Nowruz New Year holidays (from late March till early April), which resulted in overall increases of 20.5% and 16.5% for the entire period. The non-integrated responses to the pandemic, including the failure to close administrative centers and, in particular, the recommendation to maintain social distancing by reducing public transportation use (prompting citizens to travel by private vehicle), have worsened the ambient air quality in Tehran, providing an exceptional opportunity to evaluate the direct/indirect influence of air quality policies and emission control measures on PM2.5 and PM10. Because of the significant association between the lethality of coronavirus disease 2019 (COVID-19) and exposure to ambient air pollution, the rise in airborne PM2.5 during this outbreak may increase the mortality rate of SARS-CoV-2.

Keywords: SARS-CoV-2; COVID-19; Ambient air quality; PM2.5; PM10; Tehran.

Comparison of PM2.5 Chemical Compositions during Haze and Non-haze Days in a Heavy Industrial City in North China

Menghui Li1,2, Liping Wu2, Xiangyan Zhang3, Xinwu Wang3, Wenyu Bai1, Jing Ming4, Chunmei Geng 1, Wen Yang 1

Source: Aerosol and Atmospheric Chemistry, Volume 20, Issue 9, September 2020, https://doi.org/10.4209/aaqr.2019.11.0591

This study aimed to determine the chemical composition, sources and contributing factors of airborne PM2.5 (particulate matter with an aerodynamic diameter ≤ 2.5 μm) during a haze episode in Zibo, a heavy industrial city in China. Samples of PM2.5 were collected 8–27 January 2018 and analyzed for water-soluble inorganic ions (WSIs), trace elements (TEs), organic carbon (OC) and elemental carbon (EC). The PM2.5 concentration was 76.78% higher during the haze (mean ± standard deviation [SD] = 211 ± 39 μg m–3) than before it (49 ± 38 μg m–3), and the dominant ions were NO3–, SO42– and NH4+. Additionally, an elevated TE concentration was observed during the episode (exceeding the pre- and post-haze values by 54.70% and 31.98%, respectively), with crustal elements (K, Al, Ca, Si, Na, Fe and Mg), the most abundant elemental components, accounting for 88.64%. Carbonaceous species (OC and EC) contributed 15.45% of the PM2.5 on haze days and slightly more on non-haze days. The NO3–/SO42– and OC/EC ratios indicated that coal combustion and motor vehicle emission were the primary sources of pollution, and back-trajectory analysis revealed that the air masses over Zibo on haze days mainly originated in adjacent areas in Shandong Province and the Beijing-Tianjin-Hebei region (BTH). The haze episode was caused by a combination of unfavorable meteorological conditions, secondary formation, the accumulation of local pollutants, and peripheral transmission.

Keywords: Chemical composition; PM2.5; Haze episode; Heavy industrial city.

Health Risk Assessment of PM2.5-bound Components in Beijing, China during 2013–2015

Tianchu Zhang, Yangfan Chen, Xiaohong Xu

Source: Air Pollution and Health Effects, Volume 20, Issue 9, September 2020, https://doi.org/10.4209/aaqr.2020.03.0108

Risk assessment methods of the US Environment Protection Agency (U.S. EPA) were employed to estimate lifetime cancer risk in Beijing using the following fine particulate matter (PM2.5) components: six elements and 16 U.S. EPA priority polycyclic aromatic hydrocarbons (PAHs), and lifetime non-cancer hazard quotients (HQ) using 11 elements, based on data collected in Beijing during 2013–2015. The three-year average PM2.5 mass concentration was 82 μg m–3. Both lifetime cancer risk (1.9E-4) from exposure to ambient PM2.5-bound elements and PAHs and non-cancer HQ (18) from exposure to ambient PM2.5-bound elements in Beijing were much higher than the corresponding U.S. EPA acceptable levels. Cancer risks by source were, in descending order, road dust (7.3E-5), fossil fuel combustion (4.4E-5), vehicle exhaust (3.8E-5), soil dust (8.4E-6), metal processing (8.2E-6), secondary sulphur (8.0E-6), and biomass burning (6.4E-6). Cancer risks by PM2.5 component were, in descending order, As (1.1E-4), Cr(VI) (3.4E-5), total

PAHs (1.5E-5), Pb (1.1E-5), Co (8.4E-6), Ni (3.9E-6), and Cd (3.9E-6). HQ by PM2.5-bound elements were, in descending order, Cl (14), As (1.8), Pb (0.94), P (0.81), Cd (0.22), Mn (0.22), Ni (0.18), Ba (0.1), Cr(VI) (0.03), Co (0.01), and Se (0.002). Fossil fuel combustion and vehicle exhaust were the top two sources, accounting for 77% of total HQ. HQ by target organ were, in descending order, respiratory (15), reproductive (1.8), nervous (1.2), renal (0.22), fetus (0.1), and alimentary system (0.002). The seasonal variations in PM2.5 mass concentrations, risks, as well as source and element contributions were largely due to increased coal combustion in winter.

Keywords: Cancer risk; Non-cancer hazard quotient; PM2.5; Element; Polycyclic aromatic hydrocarbons; Seasonal variation.

Identification of Trace Element in Ambient Air Case Study: Industrial Estate in Waru, Sidoarjo, East Java

Gita Pati Humairoh1, Arie Dipareza Syafei 1, Muhayatun Santoso2, Rachmat Boedisantoso1, Abdu Fadli Assomadi1, Joni Hermana1

Source: Urban Air Quality, Volume 20, Issue 9, September 2020, https://doi.org/10.4209/aaqr.2019.11.0590

Metal is one of the air pollutants found in air particulates. The presence of heavy metals in air can be due to human activities or natural factors. Heavy metals can affect human health, causing respiratory disease and even death. The purpose of this study was to determine daily particulate matter (PM) concentrations in ambient air at the Waru Industrial Estate, analyze the results, and then characterize and estimate the locations of pollutant sources. PM was collected for 24-hour periods with gent stacked filter units. Filters were analyzed via X-ray fluorescence (XRF) to find concentrations of metal particles. The measurement data were analyzed via principal component analysis (PCA) and the conditional probability function (CPF) method in order to identify and estimate the industrial pollutant sources that contribute to these metal particles being in the ambient air. Results arrange PM2.5 concentrations from 2.65 to 32.68 μg m−3, with an average daily concentration of 17.67 ± 7.29 μg m−3, whereas PM10 concentrations ranged from 14.69 to 72.27 μg m−3, with an average daily concentration of 40.70 ± 13.78 μg m−3. The elements identified with XRF were Na, Mg, Al, Si, S, K, Ca, Ti, Cr, Mn, Fe, Cu, Zn, Pb, and Cl. The PCA results explain that there are four main components (factors) which then become a potential source of pollutants, namely the first is a marker of industrial activity. the second indicates the activity of the metal smelting industry. third shows the contribution of sea salt. Fourth shows the biomass combustion emissions. The results of the CPF method show that the first factor originates from north to northeast with a probability of 0.5. The second factor

comes from west to southwest with a probability of 0.4. The third factor comes from northeast to east with a probability of 0.4–0.45.

Keywords: Particulate matter; Metal; Industry; PCA; CPF.

Assessment of the Characteristics and Influencing Factors of Ozone in Fuzhou, China, Using Wavelet Analysis

Guiwen Luo 1, Lanyi Zhang1, Xisheng Hu1, Benjie Shi2, Rongzu Qiu 1

Source: Urban Air Quality, Volume 20, Issue 9, September 2020,
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In recent years, ozone (O3) air pollution has become a major problem—which is still increasing—in China. In this study, data on the O3 concentration as well as on two of its influencing factors, meteorological parameters and traffic conditions, were collected in Fuzhou and then analyzed via wavelet transforms to evaluate the variation in O3 concentration and its relationships with the factors. High concentrations appeared during spring and summer, and notable fluctuations occurred primarily from March till April, from June till July and during September. The level of O3 exhibited significant positive correlations with the temperature and sunshine duration but negative ones with the relative humidity, precipitation and air pressure; additionally, it increased when the wind speed was low and fluctuated when the wind speed was high. The concentration was also significantly negatively correlated with the concentrations of O3 precursors (NOx and CO) and hence closely related to the traffic conditions, as the reduced vehicle speed during rush hour due to increased vehicle flow and traffic density led to higher precursor emissions in the vehicular exhaust. A prominent "weekend effect" was observed with the precursor levels, which displayed greater fluctuations during the weekdays than the weekends; the vehicle flow and the O3 concentration.

Keywords: Ozone concentrations; Wavelet analysis; Meteorological parameters; Gas precursor; Traffic parameters.

The Effects of COVID-19 Measures on Air Pollutant Concentrations at Urban and Traffic Sites in Istanbul

Ülkü Alver Şahin

Source: Urban Air Quality, Volume 20, Issue 9, September 2020,
https://doi.org/10.4209/aaqr.2020.05.0239

Since December 2019, most countries have been working to stop the spread of SARS-CoV-2, the virus responsible for COVID-19. These measures, which include restricting movement, have environmental consequences. This study assessed the impact of COVID-19 measures on air pollutant concentrations measured in urban areas and traffic stations on both the European and Asian sides of Istanbul during March 2020. Significant reductions in pollutants: 32–43% (PM10), 19–47% (PM2.5), 29–44% (NO2), 40–58% (CO) and 34–69% (SO2) were calculated. The clearest reductions at the traffic stations were in NO2 which originates primarily from vehicle exhaust. The reduction of NO2 at the traffic station on the European side was found higher comparing the Asian side. The average concentrations of NO2, PM2.5, PM10 and CO during peak traffic hours were significantly ($p < 0.01$) decreased under COVID-19 measures. The results indicate that due to the measures taken in Istanbul and across Turkey and to control the spread of the virus, anthropogenic activities such as industry, vehicle traffic and sea transport have decreased, and consequently, air pollution has been significantly reduced. These pollutant levels demonstrate the anthropogenic contribution to air pollution and can inform clean air actions in Istanbul and in others cities throughout the world.

Keywords: COVID-19; Air pollution; Istanbul; NO2; Traffic.

Weather Conditions (with Focus on UV Radiation) Associated with COVID-19 Outbreak and Worldwide Climate-based Prediction for Future Prevention

Lucian Sfîcă1, Mihai Bulai 1 , Vlad-Alexandru Amihăesei1,2, Constantin Ion3, Marius Ştefan3

Source: Air Pollution and Health Effects, Volume 20, Issue 9, September 2020, https://doi.org/10.4209/aaqr.2020.05.0206

Respiratory infectious diseases are highly influenced by climate and feature seasonality, whose peak is December to February in the Northern Hemisphere. SARS-CoV-2 produced consistent debate regarding the relationship between its emergence and weather conditions. Our study explored these conditions, expressed by three main parameters—ultraviolet radiation, air temperature and relative humidity—that characterized Hubei (China), the source region of COVID-19 pandemic, in November 2019–March 2020. During COVID-19 outbreak, the low amounts of UV radiation (down to –273 kJ m–2 in January 2020) were associated with the early stage environmental survival of the novel coronavirus. As well, this period was characterized by a high relative humidity during peak

hours of the day, and a positive air temperature anomaly (+1.7°C in December 2019), which also favored the outdoor people mobility in winter. Based on Hubei analysis, a presumed optimal weather frame was set in order to identify other world regions with similar weather characteristics. In brief, the „Hubei weather profile" was recorded in those regions of COVID-19 outbreak in February 2020, such as northern Iran, Italy or Spain. Our results, which focused on the role of the UV solar radiation, could be used as a prediction tool for identifying the world regions with a higher risk of future faster increase in COVID-19 cases.

Keywords: COVID-19; UV radiation; Air temperature; Relative humidity; Climate change.

An Overview on the Role of Relative Humidity in Airborne Transmission of SARS-CoV-2 in Indoor Environments

Ajit Ahlawat 1, Alfred Wiedensohler1, Sumit Kumar Mishra2

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https://doi.org/10.4209/aaqr.2020.06.0302

COVID-19 disease is caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which originated in Wuhan, China and spread with an astonishing rate across the world. The transmission routes of SARS-CoV-2 are still debated, but recent evidence strongly suggests that COVID-19 could be transmitted via air in poorly ventilated places. Some studies also suggest the higher surface stability of SARS-CoV-2 as compared to SARS-CoV-1. It is also possible that small viral particles may enter into indoor environments from the various emission sources aided by environmental factors such as relative humidity, wind speed, temperature, thus representing a type of an aerosol transmission. Here, we explore the role of relative humidity in airborne transmission of SARS-CoV-2 virus in indoor environments based on recent studies around the world. Humidity affects both the evaporation kinematics and particle growth. In dry indoor places i.e., less humidity (< 40% RH), the chances of airborne transmission of SARS-CoV-2 are higher than that of humid places (i.e., > 90% RH). Based on earlier studies, a relative humidity of 40–60% was found to be optimal for human health in indoor places. Thus, it is extremely important to set a minimum relative humidity standard for indoor environments such as hospitals, offices and public transports for minimization of airborne spread of SARS-CoV-2.

Keywords: Aerosol; COVID-19; SARS-CoV-2; Indoor; Humidity.

Indoor Air Pollution was Nonnegligible during COVID-19 Lockdown

Wei Du, Gehui Wang

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COVID-19 spread globally in the past months and caused hundreds of thousands of people dead. Many countries took lockdown policy to restrict human activities and industry to slow down the virus spread. The implementation of stringent lockdown resulted in less traffic and industrial emissions, thus reduction of various ambient air pollutants were observed in urban areas. Considering people stayed longer time in indoor, the indoor air pollution (IAP) might play a more important role for human health during lockdown. People suffered from high possibility of IAP exposure risk increase during lockdown as they almost stayed at home the whole day. Unfortunately, available studies on IAP and its health impact during this period were rare compared with those on ambient air. By this, more investigations should be performed to estimate the impact of global COVID-19 lockdown on human health in the future.

Keywords: COVID-19; Lockdown; Indoor air pollution.

Recent Improvement in Particulate Matter (PM) Pollution in Ulaanbaatar, Mongolia

Gantuya Ganbat1, Tseren-Ochir Soyol-Erdene 2, Batbayar Jadamba3

Source: Urban Air Quality, Volume 20, Issue 10, October 2020,
https://doi.org/10.4209/aaqr.2020.04.0170

Ulaanbaatar, the capital city of Mongolia, has occasionally been considered the most polluted city in the world. Approximately 46% of the population resides in Ulaanbaatar, and over half of the population living in ger (traditional yurt dwelling) areas consumes raw coal, which leads to an increase in ambient air pollutants. The Government of Mongolia took a series of actions to reduce air pollution; one was the ban on the consumption of raw coal beginning on 15 May 2019. In this study, improvement in particulate matter (PM) air quality was shortly studied by assessing the hourly data for the last six years, from January 2014 to February 2020. The analysis exhibited a major improvement in PM concentrations during the 2019–2020 winter in Ulaanbaatar. The average PM concentrations clearly exhibited a decreasing trend in November 2019–February 2020 compared to the previous five years. The maximum PM2.5 and PM10 concentrations were reduced to 46% and 55%, respectively, compared to the mean maximum values of the previous five years. The most prominent occurrence frequency of PM concentrations shifted to a lower concentration

range. Although a PM pollution reduction was seen during the 2019–2020 winter, further air quality improvement can be obtained by taking a set of multiple actions with accurate planning management.

Keywords: particulate matter; Improvement in air quality; Reductions in PM concentrations; Ulaanbaatar; Mongolia.

Contribution of Meteorological Conditions to Inter-annual Variations in Air Quality during the Past Decade in Eastern China

Haibo Ji1, Min Shao 2, Qin'geng Wang 1

Source: Air Pollution Modeling, Volume 20, Issue 10, October 2020, https://doi.org/10.4209/aaqr.2019.12.0624

During the past decade, air quality in China has undergone considerable variation, which is mostly attributable to anthropogenic emissions and meteorological conditions. The relative effects of meteorological conditions in eastern China were quantified using the Comprehensive Air Quality Model with Extensions (CAMx) for the period 2007–2016, and the year 2012 was chosen as the reference. In combination with observations of the air quality, the relative contributions of the two factors were identified. Six regions were selected according to their geolocations and regional climatic features. The results showed that meteorological conditions alone may have caused up to 10% of the variation in the mean annual air quality index. These conditions were generally favorable in coastal regions but unfavorable in inland ones, and they usually exerted a greater influence during winter. On average, anthropogenic emissions contributed approximately 70% of the change in PM10 concentration (relative to 2012) during the studied decade, but the contribution ratio varied significantly by region and year. Most regions exhibited lower anthropogenic ratios before 2012, indicating the major effects of anthropogenic emissions on air quality after this year. Furthermore, the considerable improvement in the air quality of these regions was mainly ascribed to reduced anthropogenic emissions. This study provides clear evidence that the air pollution control efforts that have been initiated in China since 2013, such as the Air Pollution Prevention and Control Action Plan (APPCAP), have succeeded in improving the air quality. However, attention must also be directed to the effects of meteorological conditions, which may cause severe pollution episodes even during low levels of emissions; thus, air pollution forecasting and appropriate emergency measures should be implemented in the future.

Keywords: Air quality; Eastern China; Air pollution control; WRF-CAMx; Meteorological effect.

Analysis of a Severe Regional Haze-fog-dust Episode over North China in Autumn by Using Multiple Observation Data

Yingxiao Tang1,2, Suqin Han 1,2, Qing Yao1,2, Ziying Cai1,2, Yulu Qiu3, Jin Feng4

Source: Urban Air Quality, Volume 20, Issue 10, October 2020,
https://doi.org/10.4209/aaqr.2019.11.0567

The mixing of dust and haze is an important factor in the variation of fine particles. In this study, multiple observation data were used to analyze the characteristics and formation of a haze-fog-dust event that occurred in North China between November 23 and November 30 of 2018. This episode can be roughly divided into two stages, haze-fog and dust, with the transition occurring on November 27. Our analysis shows that stable weather conditions and temperature inversions in North China caused the haze-fog event (November 23–26), during which the PM2.5 concentration gradually increased. After November 27, the arrival of cold air accompanied by dust activity rendered meteorological conditions favorable to air quality in the northern part but not the central or southern part of North China. Instead, continuous adverse conditions and the dust backflow, which trapped dust aerosols in the southern part of North China for nearly two days, were responsible for high PM2.5 concentrations in Jinan and Zhengzhou after November 27 (146 and 156 μg m−3 vs. 114 and 144 μg m−3 before November 27, respectively). This study highlights the effect of dust transport on regional environmental pollution during the autumn and the winter.

Keywords: Air pollution; Haze; Dust; Atmospheric aerosols; Fine particles.

Characteristics and Source Apportionment of VOCs in a City with Complex Pollution in China

Yu Wang1,2, Guang Yang1,2, Litao Wang 1,2, Le Zhao1,2, Shangping Ji1,2, Mengyao Qi1,2, XiaoHan Lu1,2, Zhentong Liu1,2, Jingyao Tan1,2, Yingying Liu1,2, Qing Wang1,2, Ruiguang Xu1,2,3

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https://doi.org/10.4209/aaqr.2019.11.0608

Volatile organic compounds (VOCs) are important precursors in the formation of ozone (O3) and secondary organic aerosol (SOA). Hence, using an online monitor, we measured the concentrations of 56 VOC species in Handan, one of the most polluted cities in China, from Sep. 2017 till Aug. 2018. We also characterized the VOC pollution by measuring the O3 and NOx and determining the chemical reactivity of the VOCs at different levels of O3

pollution, analyzing the regional O3 formation mechanisms, and apportioning the VOC sources. The daily VOC concentrations displayed a wide range, from 37.7 to 288.9 μg m−3, with an average of 112.0 ± 45.5 μg m−3, during the observation period, and the contribution of alkenes and other aromatics to the O3 formation potential (OFP) of the VOCs was higher on medium pollution days than clean days. Furthermore, the majority of the O3 during spring and winter was formed in VOC-sensitive regimes, whereas the high diurnal concentrations during summer and autumn were produced in NOx-sensitive regimes. Based on the i-butane/n-butane and i-propane/n-propane ratios, the main sources of butane and propane were vehicular exhaust and liquid gasoline, respectively. Source apportionment by principal component analysis (PCA) revealed that the VOCs in Handan originated from vehicular emission, industrial production, solvent use, gasoline evaporation, and combustion.

Keywords: Volatile organic compounds; Chemical reactivity; Ozone formation; Source apportionment; Handan city.

Emission Characteristics and Control Device Effectiveness of Particulate Matters and Particulate-phase PAHs from Urban Charbroiling Restaurants: A Field Test

Sang-Cheol Kim1, Tae-Jung Lee1, Jun-Min Jeon2, Dong-Sool Kim1, Young-Min Jo 1

Source: Urban Air Quality, Volume 20, Issue 10, October 2020,
https://doi.org/10.4209/aaqr.2020.09.0457

Urban restaurants that charbroil meat are a major emission source of fine particulate matter (PM) and polyaromatic hydrocarbons (PAHs) and receive frequent public complaints in large Korean cities. This study evaluated the effectiveness of newly installed pollution control equipment, including electrostatic precipitators (ESPs) and filters, at five charbroiling restaurants in different metropolitan areas near Seoul. The PM in the exhaust gas, which was sampled from the inflow and the outflow of the control devices, was measured with a 3-stage cascade impactor. The particle-bound PAHs, following pre-treatment, extraction, and concentration, were then quantitatively analyzed using high-resolution gas chromatography-mass spectrometry (GC-MS). According to our field tests, the flue gas emitted by these five restaurants contained average PM10, PM2.5, and PAH concentrations of 22.6 mg m−3, 22.1 mg m−3, and 4,127.1 ng m−3, respectively. In addition, the ratio of the PM2.5 to the PM10 was 0.98, and the correlation coefficient between the PM10 and the particulate-phase PAHs was 0.95, suggesting a close relationship between the fine particle fraction and PAHs. The air pollution control equipment demonstrated an

overall removal efficiency above 90%, but specific cases exhibited an unexpectedly low efficiency (30%), indicating the necessity of periodic cleaning and consistent maintenance.

Keywords: Charbroiling restaurants; PM10; PM2.5; Particulate-phase PAHs; Control device.

Dual-height Distribution of Ozone and Nitrogen Oxides during Summer in Urban Tianjin: An Observational Study

Tiantian Zhang1, Weili Lin 1, Liang Ran2, Zhiqiang Ma3, Qing Yao4, Jingle Liu4, Jing Ming5

Source: Urban Air Quality, Volume 20, Issue 10, October 2020,
https://doi.org/10.4209/aaqr.2019.10.0505

Measurements of gaseous pollutants, including ozone (O3) and nitrogen oxides (NOx), were simultaneously conducted at 220 m (via the installation of an air flow drainage system on a 255-m meteorological tower) and 3 m above the ground in urban Tianjin during summer 2018. The observed O3 concentrations at the two altitudes exhibited similar diurnal variations but distinctly different values, with higher levels near the surface during the day and the opposite trend at night. Generally higher concentrations of NO and NO2 were found at 3 m than 220 m, and the difference in concentration between the two altitudes for the latter pollutant was smaller during daytime and highest at night. Ox (O3 + NO2) concentration near the surface during the day, but the difference was negligible at night. Based on the higher NOx level at 3 m, the photochemical production of O3 (Ox) at low altitudes intensified during the day, suggesting that the O3 surface concentration was mainly influenced by local photochemical production. Additionally, by measuring the reactive nitrogen (NOy) near the surface and calculating NOz (NOy – NOx), the ozone production efficiency (OPE; Ox/NOz) in urban Tianjin was assessed for the first time and determined to be 6.0 ± 0.4. Compared to the values measured during summer 2010, lower levels of NOx but significantly higher ones for O3 were observed during the same season in 2018.

Keywords: Nitrogen oxides; Ozone; Vertical observation; Ozone production efficiency.

Assessment of Urban Air Quality in Indonesia

Muhayatun Santoso 1 , Diah Dwiana Lestiani1, Syukria Kurniawati1, Endah Damastuti1, Indah Kusmartini1, Djoko Prakoso Dwi Atmodjo1, Dyah Kumala Sari1, Philip K. Hopke2, Rita Mukhtar3, Tamrin Muhtarom4, Agus Tjahyadi5, Sukadi Parian6, Nur Kholik7, Dimas Ageng Sutrisno8, Dwi Wahyudi9, Timora Diliyani Sitorus10, Jasmiyati Djamilus11, Ahmad

Riadi12, Jen Supriyanto13, Nurhayana Dahyar14, Stenly Sondakh15, Karelise Hogendorp16, Nurdian Wahyuni17, I. Gede Bejawan18, Lalu Syakhrizal Suprayadi19

Source: Urban Air Quality, Volume 20, Issue 10, October 2020, https://doi.org/10.4209/aaqr.2019.09.0451

This study assessed the urban air quality in 16 large Indonesian cities on the islands of Java, Sumatra, Kalimantan, Sulawesi, Maluku, and Papua from 2010 till 2017. 24-h samples of airborne particulate matter (PM) in two size fractions, PM2.5 (< 2.5 μm in aerodynamic diameter) and PM2.5-10 (2.5–10 μm in aerodynamic diameter), were collected weekly using a Gent stacked filter unit sampler and then analyzed for their mass concentrations, black carbon (BC) content, and elemental compositions. The majority of the average annual PM2.5 concentrations measured at the Java sites (Bandung, Jakarta, Semarang, and Surabaya) exceeded the Indonesian annual ambient air quality standard (15 μg m–3), although the other tested locations, excluding Pekanbaru and Palangka Raya, exhibited values below the standard. During the forest fire episodes of 2015, the average daily PM2.5 concentrations in Pekanbaru and Palangka Raya rose above the national daily ambient standard (65 μg m–3). The percentage of BC, which is associated with traffic emission and biomass burning, averaged between 15% and 26% (a significant fraction) in the PM2.5. The concentrations of the major elements in the PM2.5, viz., Si, S, K, Fe, Zn, and Pb, varied widely from site to site, although all of the locations displayed enhanced levels of the crustal elements Si and S, which originated from unpaved roads and volcanic eruptions, and vehicle fuel, forest fires, and volcanic emissions, respectively. Significantly higher concentrations of heavy metals (Fe, Zn, and Pb in Surabaya and Pb in Tangerang) were found at the heavily industrialized sites, demonstrating the effect of local industrial emissions on air quality. Our results, which are based on a crucial survey of PM concentrations and compositions in Indonesia, provide a scientific basis for developing and improving various air quality policies in the nation, including an early warning system for severe pollution events.

Keywords: PM2.5; PM10; BC; Chemical composition; Indonesia.

A Comparison Study of Indoor and Outdoor Air Quality in Nanjing, China

Ruochong Xu1,2, Ximeng Qi 1,2, Guoqing Dai1,2, Haoxian Lin1,2, Jiachun Shi1,2, Chengxu Tong1,2, Peng Zhai1,2, Caijun Zhu1,2, Lei Wang1,2, Aijun Ding1,2

Source: Urban Air Quality, Indoor Air Quality, China, Volume 20, Issue 10, October 2020, https://doi.org/10.4209/aaqr.2019.10.0496

Because humans spend much of their time in indoor microenvironments, the air quality indoors has attracted significant attention. This study simultaneously conducted real-time indoor observations and comprehensive outdoor measurements of O3, CO and PM2.5 in suburban Nanjing in eastern China from September to December 2018. The O3, CO and PM2.5 exhibited median indoor concentrations of 3.2 ppb, 395.8 ppb and 17.3 μg m−3, respectively, based on measurements in a room with closed windows and relatively regular daily indoor human activity, and median outdoor values of 30.5 ppb, 386.1 ppb and 37.2 μg m−3, resulting in median indoor-outdoor (I/O) ratios of 0.14, 1.01 and 0.46. Moreover, the indoor concentrations traced the outdoor variations with correlations of approximately 0.68, 0.82 and 0.82 for the O3, CO and PM2.5, respectively. During pollution episodes, the indoor O3 and PM2.5 concentrations reached about 30 ppb and 130 μg m−3, respectively. Both meteorological conditions (e.g., wind speed or relative humidity) and human activity indoors influenced the relationships between the indoor and outdoor concentrations, including the I/O ratios and time lag. A simplified indoor-outdoor mass-balance equation was developed to simulate the indoor concentrations, and the predictions fitted the observed data for most of the testing period, especially after considering the human activity indoors and limited penetration of particles. This study enhances our understanding of the indoor-outdoor relationships for gaseous and particulate matter concentrations in polluted areas such as the Yangtze River Delta and highlights the urgent need for improving indoor air quality in the megacities of China.

Keywords: Air quality; Indoor measurements; I/O ratio; Yangtze River Delta.

Relationship between UV Energy and Formation of Secondary Particles in Santiago de Chile

Ernesto V. Gramsch 1, Cristian R. Soto1, Pedro P. Oyola2, Felipe A. Reyes2, Yeanice Vasquez2, María A. Rubio3, Patricio A. Pérez1, Matías Tagle2

Source: Urban Air Quality, South America, Volume 20, Issue 10, October 2020, https://doi.org/10.4209/aaqr.2018.08.0318

Despite reduction efforts, the concentration of PM2.5 (particulate matter ≤ 2.5 μm in diameter) has remained steady or even grown slightly in Santiago, Chile, over the last few years. However, this potential increase may be due to the formation of secondary particles rather than a rise in primary emissions. Therefore, this study measured the size distribution of particulate matter with an Electrical Low Pressure Impactor (ELPI; Dekati) to investigate the generation of secondary ultrafine particles at several sites in this metropolitan area during 2013 and 2018. Little formation was detected during winter, but more activity was observed during fall, and the highest generation of these particles was

found during summer, when the number of new particles between 10 and 20 nm in diameter displayed an obvious peak in the afternoon during periods of high solar radiation. Overall, no clear relationship was discerned between the secondary particle number and the UV radiation until the latter exceeded ~4.5 kJ m−2, when an almost linear correlation (R2 = 0.739) appeared. Additionally, the particle number exhibited a much lower correlation with the total solar energy, indicating that UV solar radiation plays the major role in ultrafine particle formation. However, these trends may only apply to polluted cities, which already contain elevated particulate matter concentrations. Also, the fact that secondary formation primarily occurs in Santiago during summer, when the PM2.5 level is low, confirms that large numbers of pre-existing particles inhibit the creation of new ones.

Keywords: Ultrafine particles; New particle formation; UV radiation.

Emergency Response Measures to Alleviate a Severe Haze Pollution Event in Northern China during December 2015: Assessment of Effectiveness

Yaping Ma1, Tzung-May Fu 2,3, Heng Tian1, Jian Gao4, Min Hu5, Jianping Guo6, Yangmei Zhang7, Yele Sun8, Lijuan Zhang1, Xin Yang2,3, Xiaofei Wang9,10

Source: Urban Air Quality, China, Volume 20, Issue 10, October 2020, https://doi.org/10.4209/aaqr.2019.09.0442

Using the WRF-Chem model, we simulated the surface PM2.5 concentrations on the North China Plain (NCP) during a severe winter haze episode (December 6–10, 2015) with the goal of assessing the effectiveness of the implemented emergency response measures (ERMs) in alleviating the pollution. We estimated that the ERMs decreased the anthropogenic pollutant emissions, with the exception of NH3, by 8–48% during this event. Inputting these reduced emission estimates, our simulations reproduced the observed PM2.5 concentrations and compositions. Stagnant regional meteorological conditions increased the lifetime of the PM2.5 in the NCP boundary layer from 1 day during the clean period to 5 days during the haze episode. Additionally, local emissions accounted for approximately only 20% of the surface PM2.5 in Beijing but more than 62% over the rest of the NCP. We found that the ERMs achieved a modest reduction in the mean surface PM2.5 concentrations during the event, decreasing them by 7% and 4% in Beijing and across the rest of the NCP, respectively. The limited effect was due to the duration of the ERMs being much shorter than the lifetime of the PM2.5, which prevented the concentrations of the latter from fully reflecting the reduction in emissions. We conclude that anthropogenic

emissions on the NCP during severe winter haze episodes must be reduced by a much larger percentage to substantially abate the PM2.5 concentrations.

Keywords: PM2.5; Severe haze; Emission reduction; Northern China; WRF-Chem.

Assessment of Air Quality Changes in the Four Metropolitan Cities of India during COVID-19 Pandemic Lockdown

Jasbir Singh Bedi , Pankaj Dhaka, Deepthi Vijay, Rabinder Singh Aulakh, Jatinder Paul Singh Gill

Source: Urban Air Quality, India, COVID-19, Volume 20, Issue 10, October 2020, https://doi.org/10.4209/aaqr.2020.05.0209

In view of emerging threat of COVID-19 pandemic, stringent lockdown measures have been implemented in India since 25th March, 2020. The present study aims to assess the changes in air quality before and during lockdown in the four major metropolitan cities of India viz., Delhi, Mumbai, Kolkata and Chennai. The data on major air quality parameters and meteorological parameters was collected for 15 days before lockdown (i.e., March 10th–March 24th, 2020) and 15 days after implementation of lockdown (25th March–April 8th, 2020). The lockdown measures reflected a significant reduction in air pollutants, most significant fall was estimated for NO2 (29.3–74.4%) while the least reduction was noticed for SO2. On the contrary, levels of ground level ozone were found to be increased (except in Mumbai), could be related to the lower utilization of O3 owing to decrease of NOx in the environment. Since, the lockdown period has been extended, therefore further reduction of most pollutants is expected. Among the various metrological parameters, significant increase in diurnal temperature was observed at Delhi, Kolkata and Mumbai, however relative humidity has changed significantly only in Mumbai. In the absence of any major violent meteorological phenomena in India during recent months the significant difference in air quality parameters could be majorly attributed to the effect of lockdown measures. However, the regional differences may be because of the local emission of pollutants and the prevailing effects of secondary pollutants. These observations highlight the contribution of anthropogenic sources in air pollution, therefore, sustainable polices for mitigation of air pollution are essential in India.

Keywords: Air Pollution; Air Quality; COVID-19; India; Lockdown; Metropolitan cities.

Spatiotemporal Variations and Contributing Factors of Air Pollutant Concentrations in Malaysia during Movement Control Order due to Pandemic COVID-19

Zulfa Hanan Ash'aari1, Ahmad Zaharin Aris 1, Eliani Ezani2, Nurfatin Izzati Ahmad Kamal1, Norlin Jaafar3, Jasrul Nizam Jahaya3, Shamsuri Abdul Manan3, Muhamad Firdaus Umar Saifuddin1

Source: COVID-19, Volume 20, Issue 10, October 2020, https://doi.org/10.4209/aaqr.2020.06.0334

The restriction of daily and economic-related activities due to COVID-19 pandemic via lockdown order has been reported to improve air quality. This study evaluated temporal and spatial variations of four major air pollutant concentrations across Malaysia before (March 4, 2020–March 17, 2020) and during the implementation of different phases of Movement Control Order (MCO) (March 18, 2020–May 12, 2020) from 65 official regulatory air quality stations. Results showed that restriction in daily and economic activities has remarkably reduced the air quality in all sub-urban, urban, and industrial settings with relatively small contributions from meteorological conditions. Overall, compared to before MCO, average concentrations of PM2.5, CO, and NO2 reduced by 23.1%, 21.74%, and 54.0%, respectively, while that of SO2 was constant. The highest reduction of PM2.5, CO, and NO2 were observed in stations located in urban setting, where 63% stations showed significant reduction ($p < 0.05$) for PM2.5 and CO, while all stations showed significant reduction in NO2 concentrations. It was also revealed that 70.5% stations recorded lower concentrations of PM2.5 during MCO compared to before MCO, despite that high numbers of local hotspots were observed simultaneously from NASA's Moderate Resolution Imaging Spectroradiometer (MODIS). Spatial analysis showed that the northern part of Peninsular had the highest significant reduction of PM2.5, while the highest of NO2 and CO reduction were found in stations located in the central region. All pollutants exhibit similar diurnal trends when compared between pre- and during MCO although significant lower readings were observed during MCO. This study gives confidence to regulatory body; the enforcement of strict air pollution prevention and control policies could help in reducing pollution.

Keywords: Aerosols; Anthropogenic emissions; Area sources; Mobile sources; Stationary sources.

Impact of the COVID-19 Outbreak on the Long-range Transport of Particulate PAHs in East Asia

Lulu Zhang1, Lu Yang1, Quanyu Zhou1, Xuan Zhang1, Wanli Xing1, Hao Zhang1, Akira Toriba2, Kazuichi Hayakawa3, Ning Tang 2,3

Source: Urban Air Quality, China, Japan, COVID-19, Volume 20, Issue 10, October 2020, https://doi.org/10.4209/aaqr.2020.07.0388

Particulate polycyclic aromatic hydrocarbons (PAHs) were continuously observed at Kanazawa University Wajima Air Monitoring Station (KUWAMS), a background site located in western Japan and downwind of mainland China that is constantly under the influence of polluted air masses originating from China. The observations showed that the concentration of particulate PAHs at KUWAMS sharply dropped to the lowest level (62 pg m−3) of the cold season in the last 5 years after the implementation of COVID-19 control measures in China. Despite the occasional dilution with clean air, the decrease in PAHs at KUWAMS reflected the reduction in emission intensity in China. Moreover, the PAH concentrations at KUWAMS in February, March, and April of 2020 compared with the same period in the previous year decreased by 52.6%, 36.6%, and 36.7%, respectively. These changes were consistent with the decline in SO2 and NO2 in northern China, which intensified during the control of COVID-19 and was slightly moderated after the resumption of work. In addition, there was little change in the composition of PAHs at KUWAMS before and during the COVID-19 outbreak and compared with previous years, which suggests a stable source composition. These findings emphasize the importance of decreased emission intensity in China for reducing long-range transport of PAHs and pollution levels in downwind areas.

Keywords: Polycyclic aromatic hydrocarbons; Air pollution; Background site; KUWAMS.

Impact of COVID-19 Containment Measures on Air Pollution in California

Aaron R. Naeger , Kelley Murphy

Source: Urban Air Quality, USA, COVID-19, Volume 20, Issue 10, October 2020, https://doi.org/10.4209/aaqr.2020.05.0227

This study used space- and ground-based sensors in conjunction meteorological and traffic information to evaluate the impact of the COVID-19 containment measures on air pollution in California by comparing data from March–April 2020 to the similar period in 2019. Although significantly lower pollution levels were observed throughout the COVID-19 containment period in 2020 compared to 2019, our meteorological analysis found that periods of enhanced precipitation likely contributed to the cleaner environment over the Central Valley and southern California. Therefore, we focused our assessment on a 19-day period of drier conditions across the region. During this period, TROPOspheric Monitoring

Instrument (TROPOMI) data revealed strong reductions in tropospheric NO2 of 40% in Los Angeles, 38% in Fresno, and about 20% in Bakersfield and San Francisco when compared to 2019. The reductions were mostly within about 10% of the decrease in vehicle miles traveled (VMT), which indicates that the decrease in traffic-related NOx due to the COVID-19 lockdown was an important driver of the NO2 reduction. Ozone Monitoring Instrument (OMI) data showed similar NO2 reductions to TROPOMI over Los Angeles during the lockdown, but drastically different results over the other cities where little to no reductions were observed. The close agreement between ground-based and TROPOMI observations indicated that a more accurate assessment of the impacts from the COVID-19 lockdown can be accomplished using TROPOMI rather than OMI data, which is attributed to its improved resolution and sensitivity that can better characterize NO2 pollution associated with fine-scale emissions. Altogether, the space- and ground-based observations provide strong evidence that the containment measures led to NO2 reductions of around 35% in Los Angeles and Fresno and 25% in San Francisco and Bakersfield relative to 2019, along with decreases in PM2.5 and improved air quality at the surface.

Keywords: Air pollution; Emissions, Automotive; Regional air quality; Remote sensing; PM2.5.

Formation and Evolution Mechanisms of Severe Haze Pollution in the Sichuan Basin, Southwest China

Xianyu Yang1, Yaqiong Lu 2, Xinsheng Zhu 3, Jianjun He4, Qi Jiang5, Kai Wu1,6, Haolin Wang7, Xiaoling Zhang1, Shigong Wang1

Source: Air Pollution Modeling, China, Volume 20, Issue 11, November 2020, https://doi.org/10.4209/aaqr.2020.04.0173

Severe haze episodes are important environmental issues, and the rapid formation and evolution mechanisms of such episodes over complex terrain remain poorly understood. The Sichuan Basin (SCB) periodically experienced heavy haze pollution during the winter of 2016, with the maximum regional average PM2.5 concentration reaching almost 120 μg m–3. In this study, we characterize a severe haze episode in the SCB from 20 to 30 January 2017 using comprehensive measurements and model analyses. The evolution of this severe episode shows clear stages, with gradual PM2.5 increases under stagnant weather conditions in Stage I (aerosol accumulation stage) and with explosive PM2.5 increases mainly associated with cross-border transport from the southern SCB in Stage III (rapid formation stage). The process analysis results indicated that primary emissions and aerosol processes were the major sources of PM2.5 in these urban regions, whereas vertical transport and dry deposition generally acted as sinks of PM2.5. In the presence of

southwesterly synoptic winds, the aerosols emitted from the southern SCB were transported to Chengdu and the surrounding areas through horizontal transport and accounted for 66% of the PM2.5 concentration in Chengdu during Stage III. Our results reveal the detailed formation mechanism of a severe haze episode in the SCB under the effects of regional transport and synoptic forcing patterns to improve the understanding of haze formation in areas with complex terrain.

Keywords: Air quality; Haze pollution; Process analysis; Sichuan Basin.

Quantifying Emissions of PM10 Generated by the Implosion of Concrete Grain Silos

Mahmoud M. Abu-Allaban 1, Salahuddin M. Jaber1, Aiman Soleiman2, Hasan Almarayeh2

Source: Air Pollution Modeling, Volume 20, Issue 11, November 2020,
https://doi.org/10.4209/aaqr.2020.02.0053

This study quantified the effect of imploding old concrete grain silos in Aqaba, Jordan, on the eastern side of the Gulf of Aqaba, an arid region, on air quality by measuring the PM_{10} concentrations before and after the implosion at four monitoring locations. The implosion of the silos forms part of a comprehensive plan to relocate and upgrade the Port of Aqaba, which is situated on the coast of the Red Sea, with the goal of freeing space for development and improving the infrastructure in the heart of the city. The demolition, which occurred at 11:00 a.m. (local time) on 13 January 2019, generated a massive cloud of dust that was transported to nearby areas. To characterize these emissions, descriptive statistics, graphical methods, inverse distance weighting interpolation, decision trees constructed with recursive partitioning, the Gaussian dispersion model, the modified box model, and regression analysis were applied. The PM_{10} concentrations were in compliance with the Jordanian 24-h standard of 120 μg m^{-3} prior to the implosion but substantially increased (although still varied by distance from the demolition site) at all four stations afterward, with the maximum values (259–587 μg m^{-3}) exceeding the pre-implosion ones by as much as 26 times. However, these high concentrations were short-lived, and the majority of the stations returned to background levels within 30–33 hours. According to our calculations on the implosion, the PM_{10} emission rate was 17 ± 2 mg m^{-2} s^{-1}, which is equivalent to 215 ± 22 kg $silo^{-1}$, and the air mixing height was 613 ± 72 m, or approximately eight times the height of the silos.

Keywords: PM10; Demolition; Implosion; Emission rate; Air pollution; Aqaba.

Saharan Dust Events over the Valencian Community (Eastern Iberian Peninsula): Synoptic Circulation Patterns and Contribution to PM10 Levels

Ariadna Huerta-Viso, Javier Crespo, Nuria Galindo, Eduardo Yubero, Jose Francisco Nicolás

Source: Urban Air Quality, Europe, Volume 20, Issue 11, November 2020, https://doi.org/10.4209/aaqr.2020.01.0038

This study assessed Saharan dust events (SDE) passing over the Valencian Community (VC; eastern Spain) during the period of 2014–2017 by investigating the following topics: a) the occurrence of SDE and their impact on PM10 mass concentrations, b) the identification of the favorable synoptic patterns at 850 hPa associated with SDE via cluster analysis and c) the applicability of the gamma probability density function (PDF) in fitting the mass contributions of SDE. We determined that these events affect the VC on ~26% of the days of the year, thereby contributing 3.3 μg m–3 (~23%) to the average PM10 concentration. Five circulation scenarios were identified. In Scenario 1 (17.4%), the transport of Saharan dust was due to the combination of a trough situated over the southwest of the Iberian Peninsula and a high-pressure system centered on western Algeria, Tunisia and eastern Libya. According to the PDF analysis, SDE characterized by this type of pattern were the most likely to substantially increase PM10 mass concentrations. In Scenarios 3 (39.2%) and 5 (19.4%), which contributed to high concentrations of mineral dust in the VC, a high-pressure system was located over North Africa. Scenarios 1, 3 and 5 occurred more frequently during summer, especially Scenario 3 (69%). On the other hand, Scenarios 2 (16.2%) and 4 (7.2%), both characterized by a deep low over the west or northwest of the Iberian Peninsula, typically arose during spring and, to a lesser extent, winter. These two scenarios displayed a lower probability of elevating mineral dust levels in the study area.

Keywords: PM10; Meteorological scenario; Cluster analysis; Saharan dust; Gamma distribution.

Assessment of Metallic Content, Pollution, and Sources of Road Dust in the City of Białystok (Poland)

Mirosław Skorbiłowicz , Elżbieta Skorbiłowicz, Wojciech Łapiński

Source: Urban Air Quality, Europe, Volume 20, Issue 11, November 2020, https://doi.org/10.4209/aaqr.2019.10.0518

This study used flame atomic absorption spectrometry (FAAS) to determine the metallic content in 69 samples of street dust collected in various environments (viz., streets with heavy traffic, streets in residential neighborhoods, and streets near green areas and parks) of Białystok, Poland, during 2018. In descending order of average concentration, the measured metals were Fe (2,335 mg kg−1), Zn (68.99 mg kg−1), Mn (68.62 mg kg−1), Cu (16.37 mg kg−1), Pb (11.42 mg kg−1), Cr (9.12 mg kg−1), and Ni (5.20 mg kg−1). Only Zn and Cu exhibited concentrations exceeding the geochemical background levels for Polish soil. We mapped the metallic concentrations in the samples to evaluate the spatial distribution of these elements and identified proximity to main road junctions with high traffic as a major factor. Multivariate statistical analysis (Pearson correlation, cluster analysis, and analysis of major components) revealed an association between vehicle operation, and Zn, Ni, Cu, and Cr, as these elements were found in the most traffic-congested areas. By contrast, Fe and Mn, which were detected in potentially unpolluted areas, displayed concentrations that were similar to natural ones.

Keywords: Metals; Road dust; Identification of pollution sources.

Fossil and Non-fossil Fuel Sources of Organic and Elemental Carbonaceous Aerosol in Beijing, Shanghai, and Guangzhou: Seasonal Carbon Source Variation

Di Liu1, Matthias Vonwiller2, Jun Li 1, Junwen Liu3, Sönke Szidat2, Yanlin Zhang4, Chongguo Tian5, Yinjun Chen6, Zhineng Cheng1, Guangcai Zhong1, Pingqing Fu7, Gan Zhang1

Source: Aerosol and Atmospheric Chemistry, China, Volume 20, Issue 11, November 2020, https://doi.org/10.4209/aaqr.2019.12.0642

We measured the radiocarbon isotope signals in various fractions of carbonaceous aerosols sampled across four seasons (Oct 2013–Jul 2014) in three megacities of China, viz., Beijing, Shanghai, and Guangzhou. The contributions of fossil fuel (FF) and non-fossil fuel (NF) to the carbonaceous aerosol were estimated based on the radiocarbon content in the organic carbon (OC), water-soluble organic carbon (WSOC), water-insoluble organic carbon (WIOC), and elemental carbon (EC). Although NF generated the primary share (> 55%) during autumn in all of the cities, the seasonal contributions of the sources differed by location during the rest of the year. During winter, FF emissions constituted the majority of the carbonaceous pollution (64%) in Beijing, probably as a result of increased coal combustion for heating. On average, the EC, WSOC, and WIOC generated by FF composed ~10%, 35%, and 19% of the total carbon (TC). Overall, NF was identified as the largest

source of carbonaceous aerosol in Guangzhou (63%), whereas FF was the largest source, contributing slightly more than NF, in Shanghai (54%). During spring and summer, FF played a greater role than NF in Beijing (~55%) and Guangzhou (~63%); additionally, based on our limited number of samples, it contributed 71% in Shanghai during the latter season, with a significant portion due to fuel combustion (i.e., industrial, vehicular, fishing-boat, and large-vessel emissions).

Keywords: Carbonaceous aerosol; Fine aerosol; Source apportionment.

Chemical Characterization of Marine Aerosols in a South Mediterranean Coastal Area Located in Bou Ismaïl, Algeria

Sidali Khedidji1,2, Konrad Müller3, Lyes Rabhi2,4, Gerald Spindler3, Khanneh Wadinga Fomba3, Dominik van Pinxteren3, Noureddine Yassaa 2,5,6, Hartmut Herrmann 3

Source: Aerosol and Atmospheric Chemistry, Africa, Volume 20, Issue 11, November 2020, https://doi.org/10.4209/aaqr.2019.09.0458

Daily concentrations of inorganic and organic compounds associated with PM10, i.e., atmospheric particulate matter with aerodynamic diameter of less than 10 μm, was determined at the south Mediterranean coastal area located in Bou Ismaïl, 40 km west of the Algiers city area in Algeria. From September 2011 to January 2012, chemical characterization of aerosol particles comprising water-soluble ions (WSI), trace metals, carbonaceous aerosols, the anhydrosugars levoglucosan and arabitol, dicarboxylic acids, and semi-volatile organic compounds (SVOC), i.e., alkanes, PAHs, and hopanes, was carried out by using a variety of analytical techniques. Overall, the concentrations of selected ionic species were similar to those reported at other Mediterranean sites, ranging from 3.62 μg m–3 to 5.20 μg m–3 for the monthly total WSI. Sulfate was the most abundant ion. The total concentrations of semi-volatile organic compounds (SVOC) recorded in Bou Ismaïl ranged from 7.06 to 58.8 ng m–3 for n-alkanes, from 2.44 to 35.3 ng m–3 for polycyclic aromatic hydrocarbons (PAHs), from 0.14 to 1 ng m–3 for hopanes, and from 0.67 to 13.2 ng m–3 for n-alkan-2-one. In order to reconcile species concentrations and their emission sources, sampling days were grouped into two categories according to air mass origin. In the first group, the aerosol particles were mainly of a marine origin, while those of the second group originated in the dust sector. A source analysis of total contents organic compounds (PAHs, alkanes, hopanes, and alkanones) and individual inorganic compounds by spearman rank correlation illustrated that the principal sources consisted of sea salt, secondary aerosol, and biomass burning. Additionally, PM10 constituent diagnostic ratios and the carbon preference index (CPI) for n-alkanes indicated the importance of anthropogenic emissions.

Keywords: PM10; Ions; SVOC; PAHs; Anthropogenic sources.

The Role of PM2.5 Chemical Composition and Meteorology during High Pollution Periods at a Suburban Background Station in Southern Poland

Barbara Błaszczak , Natalia Zioła, Barbara Mathews, Krzysztof Klejnowski, Krzysztof Słaby

Source: Aerosol and Atmospheric Chemistry, Europe, Volume 20, Issue 11, November 2020, https://doi.org/10.4209/aaqr.2020.01.0013

This study conducted measurements of PM2.5 (particulate matter with a diameter ≤ 2.5 μm) in Racibórz, Poland, during 2018. Samples were collected daily and analyzed for their chemical composition, specifically, the carbonaceous (elemental and organic carbon) and water-soluble ionic (Cl–, NO3–, SO42–, Na+, NH4+, K+, Ca2+ and Mg2+) components. Additionally, the secondary inorganic aerosol (SIA) as well as the secondary and primary organic carbon (SOC and POC, respectively) content was estimated. To identify the causes of elevated PM2.5 concentrations, the contributions of these chemical species were further investigated, and the role of meteorological factors was also examined. During the measurement period, PM2.5 concentrations exceeding 50 μg m−3 were recorded on 38 days, and 7 pollution episodes were detected. Such events, however, were observed only in the heating season, when stable meteorological conditions (low air temperatures, weak winds, high relative humidity and lack of precipitation) and increased emissions of PM and its precursors from anthropogenic sources favored the accumulation of pollutants. The PM2.5 was dominated by carbonaceous aerosol, especially POC, although the SOC rose significantly during high pollution periods. Furthermore, the fraction of SIA clearly decreased as the concentration of PM2.5 increased, and its variability was greatly affected by regional and/or long-range transport events. Our results can help guide the development of effective strategies for reducing air pollution from fine particulate matter. Such control measures are particularly important in Poland, where PM2.5 concentrations remain high compared to many European countries.

Keywords: PM2.5; High pollution days; carbonaceous aerosol; Primary and secondary organic carbon; Secondary inorganic aerosol, meteorology.

Characterization of Residential Woodsmoke PM2.5 in the Adirondacks of New York

George Allen , Lisa Rector

Source: Aerosol and Atmospheric Chemistry, USA, Volume 20, Issue 11, November 2020, https://doi.org/10.4209/aaqr.2020.01.0005

Although woodsmoke from residential wood heating can be the dominant source of winter PM2.5 in rural areas, routine monitoring is done primarily in urban or suburban areas. To obtain data on elevated woodsmoke concentrations from nearby sources, the PM2.5, black carbon at 880 and 370 nm, particle-bound polycyclic aromatic hydrocarbons (PAHs), and wind speed and direction were measured during winter at three residential locations in Saranac Lake, New York. A paired-site design enabled the identification of local sources relative to larger spatial scales. With the exception of occasional regional PM events, the hourly measurements of this pollutant between the paired sites exhibited poor correlations, suggesting that local woodsmoke was responsible for the observed increases in PM values. One location that was adjacent to a residence with a wood stove, which was 40 meters from the monitoring site, experienced repeated episodes of elevated PM2.5 concentrations, with a maximum 3-hour average of 150 μg m−3, a maximum 24-hour rolling average of 64 μg m−3, and a maximum midnight-to-midnight average of 46 μg m−3. Despite these PM events, the data indicated that this location was likely in compliance with the current U.S. EPA National Ambient Air Quality Standards (NAAQS) for PM2.5. The daily PM2.5 concentration peaked and troughed during the nighttime and the daytime, respectively, at all of the sites, which is consistent with local ground-level pollution sources, such as woodsmoke; this diel pattern was also confirmed by Aaethalometer Delta-C (DC) data, a woodsmoke PM indicator. The particle-bound PAH data was less specific than the DC data to the PM in the woodsmoke, partly because the instrument for the former also responds to traffic pollution. One site repeatedly displayed the influence of 2-cycle engine snowmobile exhaust during the early evening hours, with very high PAH concentrations but only modestly elevated DC concentrations. Subsequent tests showed that fresh 2-cycle small engine exhaust produces a somewhat weaker response than woodsmoke in the DC in terms of the concentration per unit of PM.

Keywords: Biomass burning; Black carbon; Carbonaceous aerosols; Optical properties; Polycyclic aromatic hydrocarbon.

Real-time Monitoring of Suspended Particulate Matter in Indoor Air: Validation and Application of a Light-scattering Sensor

Anna Susz , Pascal Pratte, Catherine Goujon-Ginglinger

Source: Aerosol Physics and Instrumentation, Indoor Air Quality, Volume 20, Issue 11, November 2020, https://doi.org/10.4209/aaqr.2019.11.0604

Since the 1950s, awareness of the impact of air pollution on human health has been growing. Of the many recognized air pollutants, suspended particulate matter has received the most attention, as both PM2.5 and PM10 can affect humans upon inhalation. Consequently, PM monitoring is critical to linking indoor pollution and exposure, and a validated measuring instrument is essential. Portable monitors, which track temporal changes in the aerosol mass concentration in real time, are a faster alternative to offline gravimetric techniques, which provide only averaged values. Hence, this study evaluated the performance of the DustTrak DRX aerosol monitor in assessing indoor air quality and validated its ability to measure complex aerosols. Three DustTrak units were used to measure different aerosols, e.g., ambient air, polystyrene latex (PSL) spheres, and environmental tobacco smoke (ETS), and the results were compared to those obtained with the standard gravimetric method. Notably, the bias of the DustTrak relative to the gravimetric method for ETS measurements ranged from 2% to 15% when a photometric calibration factor (PCF) of 0.38 was applied. Additionally, the working range of the tested units was established, and the limits of detection and quantification were found to be 5 and 15 μg m−3, respectively. Finally, in order to serve as an alternative to the gravimetric method, these instruments must be accredited for PM measurement in accordance with standards such as ISO 17025.

Keywords: DustTrak DRX; PM2.5; PM10; Suspended particulate matter; Environmental tobacco smoke (ETS).

Effect of Fireworks, Chinese New Year and the COVID-19 Lockdown on Air Pollution and Public Attitudes

Peter Brimblecombe1,2, Yonghang Lai 3

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Concentrations of primary air pollutants are driven by emissions and weather patterns, which control their production and dispersion. The early months of the year see the celebratory use of fireworks, a week-long public holiday in China, but in 2020 overlapped in Hubei Province with lockdowns, some of > 70 days duration. The urban lockdowns enforced to mitigate the COVID-19 pandemic give a chance to explore the effect of rapid changes in societal activities on air pollution, with a public willing to leave views on social media and show a continuing concern about the return of pollution problems after COVID-19 restrictions are lifted. Fireworks typically give rise to sharp peaks in PM2.5 concentrations, though the magnitude of these peaks in both Wuhan and Beijing has decreased under tighter regulation in recent years, along with general reductions in

pollutant emissions. Firework smoke is now most evident in smaller outlying cities and towns. The holiday effect, a reduction in pollutant concentrations when normal work activities are curtailed, is only apparent for NO2 in the holiday week in Wuhan (2015–2020), but not Beijing. Lockdown in Wuhan was characterised by decreases in NO2, along with more subtle changes in particulate matter and other pollutants. Ozone noticeably increases as there is less NO available for titration, but such change may not be widespread geographically. Beijing, where restrictions were less stringent, showed some improvement in air quality, though this is more difficult to detect, even within the 5th Ring Road.

Keywords: Beijing; Holiday effect; Social media; Weekend effect; Wuhan.

Development of IoT Technologies for Air Pollution Prevention and Improvement

Yu-Lin Zhao1, Jiali Tang2, Han-Pang Huang1, Ze Wang3, Tse-Lun Chen4, Chih-Wei Chiang 5, Pen-Chi Chiang 4

Source: Air Pollution Modeling, Volume 20, Issue 12, December 2020, https://doi.org/10.4209/aaqr.2020.05.0255

In order to mitigate the challenges of air pollution, a large number of Internet of Things (IoT)-related technologies have been developed to evaluate and monitor various parameters of air quality. Hence, this paper reviews the fundamental characteristics of IoT; compares and analyzes radio frequency identification (RFID), M2M, and sensor networks; and accordingly proposes an intelligent and multifunctional monitoring platform for reducing air pollution. Our results indicate that establishing systems for comprehensive network communication, cloud-based decision making, information tracking, and online management based on these technologies will improve the ambient air quality more efficiently. Furthermore, we examine several cases verifying the availability and performance of IoT ambient air quality management platforms.

Keywords: Internet of Things (IoT); Ambient air pollution; RFID; M2M; Sensor networks; IoT platform.

A Long-lasting Winter Haze Episode in Xiangyang, Central China: Pollution Characteristics, Chemical Composition, and Health Risk Assessment

Huimeng Jiang1, Han Xiao1, He Song1, Jian Liu1, Tao Wang2, Hairong Cheng 1, Zuwu Wang 1

Source: Air Pollution and Health Effects, China, Volume 20, Issue 12, December 2020, https://doi.org/10.4209/aaqr.2020.02.0068

This study investigated the characteristics and chemical composition of PM2.5 during a long-lasting winter haze episode (Jan. 13–24, 2018) in Xiangyang of central China. The average daily concentration of the PM2.5 equaled 169.29 ± 56.98 μg m–3, with water-soluble inorganic ions (WSIIs), organic carbon (OC), elemental carbon (EC), and trace elements accounting for 111.45 ± 44.62, 20.74 ± 6.79, 6.48 ± 1.79, and 10.53 ± 3.84 μg m–3, respectively. The OC/EC ratios indicated mixed contributions from intensive traffic emission and secondary formation, and the estimated concentrations for the primary organic carbon (POC) and the secondary organic carbon (SOC) increased with the level of pollution. POC dominated the OC during mild and moderate pollution, whereas SOC dominated it during severe pollution. A strong positive correlation was found between the enrichment factor (EF) and geo-accumulation index (IGeo) values, which were used to assess the contamination level of PM2.5-bound metal(loid)s. A health risk assessment, which was conducted to examine the non-carcinogenic and carcinogenic risks of the PM2.5-bound metal(loid)s, found that As, Cr, Pb, and Sb posed potential non-carcinogenic risks to both children and adults and that two of these elements, As and Pb, also posed potential carcinogenic risks. The total non-carcinogenic and carcinogenic risks from the PM2.5-bound metal(loid)s were slightly higher for adults (3.07 × 103 and 3.78 × 10–3) than children (2.71 × 103 and 2.99 × 10–3) and depended on the concentrations of the metal(loid)s rather than the level of pollution. Thus, the public and the government should implement appropriate measures to mitigate the health risks posed by PM2.5-bound metal(loid)s during winter haze episodes in Xiangyang.

Keywords: PM2.5; Haze episode; Metal(loid)s; Winter; Health risk assessment.

Urban Air Pollutant from Motor Vehicle Emissions in Kuala Lumpur, Malaysia

Siti Haslina Mohd Shafie, Mastura Mahmud

Source: Urban Air Quality, South East Asia, Volume 20, Issue 12, December 2020, https://doi.org/10.4209/aaqr.2020.02.0074

The increasing amount of motor vehicles that emit pollutants are contributing significantly to urban air pollution, be it in industrial or developing countries. This study investigates the emission of particulate matter (PM10) from exhaust and non-exhaust sources and gaseous pollutants, such as carbon monoxide (CO) and nitrogen oxide (NOx) from several different classes of motor vehicles in the tropical city of Kuala Lumpur. Air pollutants from

fuel consumption were obtained from emission factors, while non-exhaust particulate matter was estimated from the United States Environmental Protection Agency (U.S. EPA) Compilation of Air Pollutant Emissions Factors (AP-42). The total PM10 emissions from all classes of motor vehicles estimated from the tail-pipe exhaust was 1,029,883 kg, while non-exhaust sources were 1,573,539 kg. Emissions of PM10 from newly registered private cars was the most dominant at 214,427 kg, followed by emissions from motorcycles at 118,582 kg in 2014. Private cars also contributed 14,605 kg of CO and 5,726 kg of NOx in 2014, compared with 9,830 kg of CO and 3,854 kg of NOx in 2010. Comparison with other Organisation for Economic Co-operation and Development (OECD) countries shows that the total emissions for PM10 and NOx were lower in Malaysia than in most countries, but the CO emissions here were higher than in Asian countries such as Japan and Korea, as well as in other European countries. Various strategies and policies should be implemented by the local authorities and government agencies to reduce emissions from the transportation sector in urban areas to improve the quality of the urban environment, human health, and the urban community.

Keywords: Urban traffic; Gaseous emissions; Private cars; Urban pollution; Asia Pacific.

Particulate Matter Concentrations in a Middle Eastern City – An Insight to Sand and Dust Storm Episodes

Tareq Hussein 1,2, Xinyang Li2, Qusay Al-Dulaimi2, Shatha Daour1, Nahid Atashi2,3, Mar Viana4, Andres Alastuey4, Larisa Sogacheva5, Sharif Arar6, Afnan Al-Hunaiti6, Tuukka Petäjä2

Source: Urban Air Quality, Middle East, Volume 20, Issue 12, December 2020, https://doi.org/10.4209/aaqr.2020.05.0195

In this study, the particulate matter mass (PM10 and PM2.5) concentrations we measured during May 2018–March 2019 in an urban atmosphere of Amman, Jordan. The results showed that the annual mean PM10 concentration was 64 ± 39 μg m–3 and the PM2.5/PM10 ratio was 0.8 ± 0.2. According to the Jordanian Air Quality standards (JS-1140/2006), the observed PM10 annual mean value was below the limit value but that of the PM2.5 was three times higher than the corresponding limit value. However, both exceeded the World Health Organization (WHO) air quality guideline values. In a larger perspective, the annual mean PM10 concentrations in Jordan were lower than what was reported in other cities in the Middle East but were higher when compared to other Mediterranean cities. During the measurement period, Jordan was affected by Sand and Dust Storm (SDS) episodes on 14 days. The source origins of these dust outbreaks were traced back to North Africa, the Arabian Peninsula, and the Levant. The 24-hour PM10

concentrations during these SDS episodes ranged between 108 and 188 μg m−3, which was about 3–6 times higher than the mean values during clean conditions (~33 μg m−3).

Keywords: Urban air quality; Particulate matter; Dust particles; Back-trajectory.

Using a Network of Low-cost Particle Sensors to Assess the Impact of Ship Emissions on a Residential Community

Rohan Jayaratne1, Tara Kuhn1, Bryce Christensen1, Xiaoting Liu1, Isak Zing1, Riki Lamont2, Matthew Dunbabin2, Jill Maddox3, Gavin Fisher4, Lidia Morawska 1

Source: Urban Air Quality, Others, Low-Cost Sensors, Volume 20, Issue 12, December 2020, https://doi.org/10.4209/aaqr.2020.06.0280

Shipping emissions are known to affect communities in coastal locations, especially near harbours. This study monitored the air quality near the premier cruise ship terminal in Melbourne over a continuous period of 98 days during the peak cruise ship season in Australia. As shipping emission plumes are intermittent and fluctuate spatially, they cannot be detected accurately by a single fixed monitor. To overcome this limitation, we deployed seven units of the low-cost KOALA air quality monitor, which measures PM2.5 and CO concentrations in real time and then transmits the data via 3G to an in-cloud database, in a spatially distributed configuration, four at ground level and three on the upper balconies of two high-rise apartment blocks. The time profile showed numerous spikes in the PM2.5 concentration, some of which exceeded 200 μg m−3 for periods of 5–10 min, coinciding with ship movements. On average, the spikes were ~4–5 times above the normal background value (~10 μg m−3). Because of their very short duration, these episodes did not significantly raise the 24-h averages at any of the locations; however, they increased the number of days on which these values exceeded the limit specified by the national air quality standard, resulting in more exceedance days for the monitored area than the nearest air quality station. Although the long-term health effects of elevated PM concentrations are known, few studies have been conducted on the risks of short-term exposures to extreme spikes.

Keywords: Low-cost sensor; Particle pollution; PM2.5; Ship emissions; Sensor network; Air quality.

Chemical Characteristics and Potential Sources of PM2.5 in Shahe City during Severe Haze Pollution Episodes in the Winter

Xiaoyong Liu1,2,4, Xiaole Pan 1, Zifa Wang1,2,5, Hong He1,3, Dawei Wang2, Hang Liu2,4, Yu Tian2,4, Weiling Xiang2, Jie Li2

Source: Aerosol and Atmospheric Chemistry, China, Volume 20, Issue 12, December 2020, https://doi.org/10.4209/aaqr.2020.03.0124

In recent years, North China has suffered from severe air pollution. Hence, this study performed a comprehensive field experiment during Dec. 2017 in Shahe (114.5°N, 36.85°E), a typical industrial city in this region that is characterized by intensive NOx emission from the local glassmaking industry. During the study period, the mass concentration of the PM2.5 (fine particulate matter) averaged 121.6 ± 91.8 μg m−3, whereas the mass concentrations of the nitrate and sulfate in the PM2.5 averaged 21.4 ± 16.3 and 15.9 ± 20.9 μg m−3, respectively. The high sulfate mass concentration primarily resulted from the oxidation of SO2, which was mainly due to gas-phase and heterogeneous reactions during low relative humidity (RH; < 40%) and enhanced aqueous reactions during high RH (> 40%). In addition, because the nitrogen oxidation ratio (NOR) increased as the RH decreased during the day, the nitrate was largely generated through photochemical reactions. The mass concentrations of the optical organic carbon (OC), elemental carbon (EC), and water-soluble organic compounds (WSOCs) equaled 50.4 ± 31.1, 5.8 ± 4.4, and 12.8 ± 10.1 μgC m−3, respectively, and applying the EC tracer method revealed that primary emissions contributed approximately 72% of the total OC. Furthermore, intense industrial activities were detected in a nearby area to the northeast, which potential source contribution function (PSCF) analysis identified as the main potential source area for PM2.5 during haze.

Keywords: Air pollution; Chemical composition; North China Plain; Potential source analysis.

Study on Mercury in PM10 at an Urban Site in the Central Indo-Gangetic Plain: Seasonal Variability and Influencing Factors

Junming Guo1, Kirpa Ram2,4, Lekhendra Tripathee 1,5, Shichang Kang1,3,6, Jie Huang3,4, Pengfei Chen1, Prakriti Sharma Ghimire1,5

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Mercury (Hg) is among the most toxic metals possessing a major threat to human health and aquatic ecosystems over the globe. However, measurement of Hg concentrations and seasonal variability remain poorly understood over the Indo-Gangetic Plain (IGP) in northern India. In this study, we present one-year data of particulate-bound mercury (HgP) in aerosol samples (PM10) collected from Kanpur to understand seasonal variability and factors influencing concentration, as well as dry deposition flux. The HgP concentration exhibit a large temporal variability and ranged between 100 (on 14 June 2007) to 4340 pg m−3 (on 4 March 2007) with an annual average concentration of HgP is 776 ± 846 pg m−3. The HgP concentrations and HgP/PM10 ratios showed a marked seasonality with the highest in winter (Dec-Feb) followed by post-monsoon (Oct–Nov) and summer (April–June) seasons. HgP and HgP/PM10 were positively correlated ($r2 = 0.77$, $p < 0.05$, $N = 58$) during the sampling period and the estimated dry deposition flux of HgP was 104.7 μg m−2 y−1. Although this study provides a comprehensive data set on HgP in an urban atmosphere of the IGP revealing high levels of HgP, measurement of gaseous Hg is needed for estimation of the total Hg budget. Therefore, future studies should focus on identification of different sources as well as emission characteristics of all forms of Hg (organic and inorganic forms) for better mitigation strategy to prevent health risks associated with toxic Hg in the region.

Keywords: Particulate mercury; Aerosol; Dry deposition flux; Indo-Gangetic Plain; South Asia.

Spatiotemporal Variation and Chemical Fingerprints of Marine Fine Particles (PM2.5) at the Matsu Islands in Northern Taiwan Strait

Chung-Shin Yuan 1,2, Yen-Lun Su1, Tsung-Chang Li1, Yu-Lun Tseng1, Hsueh-Lung Chuang1

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This study characterized the PM2.5 in terms of its spatial distribution, chemical composition, and seasonal/diurnal variation on the Matsu Islands in the northern Taiwan Strait. The PQ-200 samplers were employed to conduct simultaneous 24-h seasonal measurements of PM2.5 on four offshore islands, viz., Nankan Island (Site NK), Beigan Island (Site BG), Dongyin Island (Site DY), and Chiukung Island (Site CK) as well as 12-h diurnal measurements for both regular and intensive samplings, and 24-h episodic measurements at one of the locations (Site NK). Additionally, the chemical signatures of PM2.5 collected at six predominant local sources were established via chemical analysis, which coordinated as source profiles for chemical mass balance (CMB) receptor model to

resolve the source apportionment of PM2.5. Of the four seasons, summer exhibited the lowest average PM2.5 concentration. In winter and spring, the level of PM2.5 significantly rose under the influences of Asian Northeastern Monsoons (ANEMs). Furthermore, the spatial distribution of PM2.5 across the islands showed a tendency to gradually decrease from the west to the east, with the Site NK always displaying the highest value regardless of the season. In general, the chemical composition primarily consisted of water-soluble ions (WSIs) owing to the abundancy of secondary inorganic aerosol (SIA) which accounted for 69.8% of the WSIs and 45.5% of the PM2.5. Crustal elements dominated the metallic components, although the content of trace metals increased in both concentrations and proportion during the ANEMs. Organic carbon (OC) dominated the carbonaceous content of PM2.5 in all seasons, with OC/EC values ranging from 1.64 to 3.78. During the episodes of poor air quality, the majority of incoming air masses followed a northern transport route (N-route) or an anticyclonic outflow route (AO-route) transported from the continent to the islands. The CMB receptor modeling results showed that the major sources of PM2.5 on the Matsu Islands were road dust, industrial boilers, secondary aerosols, vehicular exhausts, and sea salts. Overall, the PM2.5 pollution was originated from both local and remote sources, with 28~68% of the PM2.5 concentrations arising from long-range transport.

Keywords: Matsu Islands; Marine fine particles; Spatiotemporal variation; Chemical fingerprints; Source apportionment.

COVID-19 and Air Pollution in Indian Cities: World's Most Polluted Cities

Sonal Kumari, Anita Lakhani, K. Maharaj Kumari

Source: Urban Air Quality, India, COVID-19, Volume 20, Issue 12, December 2020, https://doi.org/10.4209/aaqr.2020.05.0262

In the present study, pollutants levels from 24th March-31st May in 2020 were compared with the same time period in 2019 to estimate the impact of lockdown on air pollutants levels in 39 different cities of India (including 10 Indian cities considered among the world's 20 most polluted cities). Data for air pollutants was obtained from the Central Pollution Control Board (CPCB) which was statistically analyzed. Tropospheric NO2 column retrieved from Ozone Monitoring Instrument (OMI) were compared between 2019 and 2020 to compare the NO2 levels. Impact of lockdown measures on Ghaziabad which is the world's most polluted city and Patiala which showed maximum reduction during the lockdown period in the present study was studied in detail. After the implementation of lockdown measures, air pollution decreased but with substantial variation among pollutants. The most significant reduction was observed for nitrogen dioxide (NO2) (3–

79%) and carbon monoxide (CO) (2–61%), pollutants which are mainly related to traffic emissions. Ozone (O3) showed a mixed trend with increasing levels at some cities which may be attributed to lower titration of O3 by NO. Maximum reduction observed in PM10 and PM2.5 was 58 and 57%, respectively during the lockdown period in 2020 as compared to the previous year. Air quality of the cities also improved in 2020. During the lockdown period in 2020, AQI of only 15% of cities was in the 'Unhealthy' category (151–200) while in 2019, 56% of cities were in the 'Unhealthy' category. In Ghaziabad and Patiala all the pollutants showed significant reduction after lockdown implementation except O3. Diurnal patterns of PM10, PM2.5, CO and NO2 showed lower values during lockdown period in 2020 with less distinct bimodal patterns as compared to 2019. The present study provides evidence that widespread implementation of air pollution measures can result in immediate air quality benefits.

Keywords: Lockdown; World's most polluted cities; India; Air pollution reduction; AQI.

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2. Atmosphere Chemistry and Physics

Long-range and local air pollution: what can we learn from chemical speciation of particulate matter at paired sites?

Marco Pandolfi1, Dennis Mooibroek2, Philip Hopke3, Dominik van Pinxteren4, Xavier Querol1, Hartmut Herrmann4, Andrés Alastuey1, Olivier Favez5, Christoph Hüglin6, Esperanza Perdrix7, Véronique Riffault7, Stéphane Sauvage7, Eric van der Swaluw2, Oksana Tarasova8, and Augustin Colette5

Source: Atmos. Chem. Phys., 20, 409–429, 2020, https://doi.org/10.5194/acp-20-409-2020

Here we report results of a detailed analysis of the urban and non-urban contributions to particulate matter (PM) concentrations and source contributions in five European cities, namely Schiedam (the Netherlands, NL), Lens (France, FR), Leipzig (Germany, DE), Zurich (Switzerland, CH) and Barcelona (Spain, ES). PM chemically speciated data from 12 European paired monitoring sites (one traffic, five urban, five regional and one continental background) were analysed by positive matrix factorisation (PMF) and Lenschow's approach to assign measured PM and source contributions to the different spatial levels. Five common sources were obtained at the 12 sites: sulfate-rich (SSA) and nitrate-rich (NSA) aerosols, road traffic (RT), mineral matter (MM), and aged sea salt (SS). These sources explained from 55 % to 88 % of PM mass at urban low-traffic-impact sites (UB) depending on the country. Three additional common sources were identified at a subset of sites/countries, namely biomass burning (BB) (FR, CH and DE), explaining an additional 9 %–13 % of PM mass, and residual oil combustion (V–Ni) and primary industrial (IND) (NL and ES), together explaining an additional 11 %–15 % of PM mass. In all countries, the majority of PM measured at UB sites was of a regional+continental (R+C) nature (64 %–74 %). The R+C PM increments due to anthropogenic emissions in DE, NL, CH, ES and FR represented around 66 %, 62 %, 52 %, 32 % and 23 %, respectively, of UB PM mass. Overall, the R+C PM increments due to natural and anthropogenic sources showed opposite seasonal profiles with the former increasing in summer and the latter increasing in winter, even if exceptions were observed. In ES, the anthropogenic R+C PM increment was higher in summer due to high contributions from regional SSA and V–Ni sources, both being mostly related to maritime shipping emissions at the Spanish sites. Conversely, in the other countries, higher anthropogenic R+C PM increments in winter were mostly due to high contributions from NSA and BB regional sources during the cold season. On annual average, the sources showing higher R+C increments were SSA (77 %–91 % of SSA source contribution at the urban level), NSA (51 %–94 %), MM (58 %–80 %), BB (42 %–78 %) and IND (91 % in NL). Other sources showing high R+C increments were photochemistry and coal combustion (97 %–99 %; identified only in DE). The highest regional SSA increment was observed in ES, especially in summer, and was related to ship emissions, enhanced photochemistry and peculiar meteorological patterns of the Western Mediterranean. The highest R+C and urban NSA increments were observed in NL and associated with high availability of precursors such as NOx and NH3. Conversely, on average, the sources

showing higher local increments were RT (62 %–90 % at all sites) and V–Ni (65 %–80 % in ES and NL). The relationship between SSA and V–Ni indicated that the contribution of ship emissions to the local sulfate concentrations in NL has strongly decreased since 2007 thanks to the shift from high-sulfur- to low-sulfur-content fuel used by ships. An improvement of air quality in the five cities included here could be achieved by further reducing local (urban) emissions of PM, NOx and NH3 (from both traffic and non-traffic sources) but also SO2 and PM (from maritime ships and ports) and giving high relevance to non-urban contributions by further reducing emissions of SO2 (maritime shipping) and NH3 (agriculture) and those from industry, regional BB sources and coal combustion.

Mitigation of PM2.5 and ozone pollution in Delhi: a sensitivity study during the pre-monsoon period

Ying Chen1,2, Oliver Wild1,2, Edmund Ryan1,9, Saroj Kumar Sahu4, Douglas Lowe5, Scott Archer-Nicholls6, Yu Wang5, Gordon McFiggans5, Tabish Ansari1, Vikas Singh7, Ranjeet S. Sokhi8, Alex Archibald6, and Gufran Beig3

Source: Atmos. Chem. Phys., 20, 499–514, 2020, https://doi.org/10.5194/acp-20-499-2020

Fine particulate matter (PM2.5) and surface ozone (O3) are major air pollutants in megacities such as Delhi, but the design of suitable mitigation strategies is challenging. Some strategies for reducing PM2.5 may have the notable side effect of increasing O3. Here, we demonstrate a numerical framework for investigating the impacts of mitigation strategies on both PM2.5 and O3 in Delhi. We use Gaussian process emulation to generate a computationally efficient surrogate for a regional air quality model (WRF-Chem). This allows us to perform global sensitivity analysis to identify the major sources of air pollution and to generate emission-sector-based pollutant response surfaces to inform mitigation policy development. Based on more than 100 000 emulation runs during the pre-monsoon period (peak O3 season), our global sensitivity analysis shows that local traffic emissions from the Delhi city region and regional transport of pollution emitted from the National Capital Region (NCR) surrounding Delhi are dominant factors influencing PM2.5 and O3 in Delhi. They together govern the O3 peak and PM2.5 concentration during daytime. Regional transport contributes about 80% of the PM2.5 variation during the night. Reducing traffic emissions in Delhi alone (e.g. by 50 %) would reduce PM2.5 by 15 %–20 % but lead to a 20 %–25 % increase in O3. However, we show that reducing NCR regional emissions by 25 %–30 % at the same time would further reduce PM2.5 by 5 %–10 % in Delhi and avoid the O3 increase. This study provides scientific evidence to support the need for joint coordination of controls on local and regional scales to achieve effective reduction in PM2.5 whilst minimising the risk of O3 increase in Delhi.

Atmospheric ammonia variability and link with particulate matter formation: a case study over the Paris area

Camille Viatte1, Tianze Wang1, Martin Van Damme2, Enrico Dammers3, Frederik Meleux4, Lieven Clarisse2, Mark W. Shephard3, Simon Whitburn2, Pierre François Coheur2, Karen E. Cady-Pereira5, and Cathy Clerbaux1,2

Source: Atmos. Chem. Phys., 20, 577–596, 2020, https://doi.org/10.5194/acp-20-577-2020

The Paris megacity experiences frequent particulate matter (i.e.PM2.5, particulate matter with a diameter less than 2.5 μm) pollution episodes in spring (March–April). At this time of the year, large numbers of the particles consist of ammonium sulfate and nitrate which are formed from ammonia (NH3) released during fertilizer spreading practices and transported from the surrounding areas to Paris. There is still limited knowledge of the emission sources around Paris, their magnitude, and their seasonality.

Using space-borne NH3 observation records of 10 years (2008–2017) and 5 years (2013–2017) provided by the Infrared Atmospheric Sounding Interferometer (IASI) and the Cross-Track Infrared Sounder (CrIS) instrument, regional patterns of NH3 variabilities (seasonal and interannual) are derived. Observations reveal identical high seasonal variability with three major NH3 hotspots found from March to August. The high interannual variability is discussed with respect to atmospheric total precipitation and temperature.

A detailed analysis of the seasonal cycle is performed using both IASI and CrIS instrument data, together with outputs from the CHIMERE atmospheric model. For 2014 and 2015, the CHIMERE model shows coefficients of determination of 0.58 and 0.18 when compared to IASI and CrIS, respectively. With respect to spatial variability, the CHIMERE monthly NH3 concentrations in spring show a slight underrepresentation over Belgium and the United Kingdom and an overrepresentation in agricultural areas in the French Brittany–Pays de la Loire and Plateau du Jura region, as well as in northern Switzerland. In addition, PM2.5 concentrations derived from the CHIMERE model have been evaluated against surface measurements from the Airparif network over Paris, with which agreement was found ($r^2 = 0.56$) with however an underestimation during spring pollution events.

Using HYSPLIT cluster analysis of back trajectories, we show that NH3 total columns measured in spring over Paris are enhanced when air masses originate from the north-east (e.g. the Netherlands and Belgium), highlighting the importance of long-range transport in the NH3 budget over Paris. Variability in NH3 in the north-east region is likely to impact

NH3 concentrations in the Parisian region since the cross-correlation function is above 0.3 (at lag = 0 and 1 d).

Finally, we quantify the key meteorological parameters driving the specific conditions important for the formation of PM2.5 from NH3 in the Île-de-France region in spring. Data-driven results based on surface PM2.5 measurements from the Airparif network and IASI NH3 measurements show that a combination of the factors such as a low boundary layer of ∼500 m, a relatively low temperature of 5 ∘C, a high relative humidity of 70 %, and wind from the north-east contributes to a positive PM2.5 and NH3 correlation.

China's emission control strategies have suppressed unfavorable influences of climate on wintertime PM2.5 concentrations in Beijing since 2002

Meng Gao1,2,3, Zirui Liu4, Bo Zheng5,6, Dongsheng Ji4, Peter Sherman7, Shaojie Song3, Jinyuan Xin4, Cheng Liu8, Yuesi Wang4, Qiang Zhang5, Jia Xing9, Jingkun Jiang9, Zifa Wang4, Gregory R. Carmichael10, and Michael B. McElroy3,7

Source: Atmos. Chem. Phys., 20, 1497–1505, 2020, https://doi.org/10.5194/acp-20-1497-2020

Severe wintertime PM2.5 pollution in Beijing has been receiving increasing worldwide attention, yet the decadal variations remain relatively unexplored. Combining field measurements and model simulations, we quantified the relative influences of anthropogenic emissions and meteorological conditions on PM2.5 concentrations in Beijing over the winters of 2002–2016. Between the winters of 2011 and 2016, stringent emission control measures resulted in a 21 % decrease in mean mass concentrations of PM2.5 in Beijing, with 7 fewer haze days per winter on average. Given the overestimation of PM2.5 by the model, the effectiveness of stringent emission control measures might have been slightly overstated. With fixed emissions, meteorological conditions over the study period would have led to an increase in haze in Beijing, but the strict emission control measures have suppressed the unfavorable influences of the recent climate. The unfavorable meteorological conditions are attributed to the weakening of the East Asia winter monsoon associated particularly with an increase in pressure associated with the Aleutian Low.

Size-segregated characteristics of organic carbon (OC), elemental carbon (EC) and organic matter in particulate matter (PM) emitted from different types of ships in China

Fan Zhang1,2, Hai Guo1, Yingjun Chen2,3,4, Volker Matthias5, Yan Zhang2, Xin Yang2,4, and Jianmin Chen2

Source: Atmos. Chem. Phys., 20, 1549–1564, 2020, https://doi.org/10.5194/acp-20-1549-2020

Studies of detailed chemical compositions in particles with different size ranges emitted from ships are in serious shortage. In this study, size-segregated distributions and characteristics of particle mass, organic carbon (OC), elemental carbon (EC), 16 EPA polycyclic aromatic hydrocarbons (PAHs) and 25 n-alkanes measured aboard 12 different vessels in China are presented. The results showed the following. (1) More than half of the total particle mass, OC, EC, PAHs and n-alkanes were concentrated in fine particles with aerodynamic diameter (Dp) < 1.1 μm for most of the tested ships. The relative contributions of OC, EC, PAH and alkanes to the size-segregated particle mass are decreasing with the increase in particle size. However, different types of ships showed quite different particle-size-dependent chemical compositions. (2) In fine particles, the OC and EC were the dominant components, while in coarse particles, OC and EC only accounted for very small proportions. With the increase in particle size, the OC / EC ratios first decreased and then increased, having the lowest values for particle sizes between 0.43 and 1.1 μm. (3) Out of the four OC fragments and three EC fragments obtained in thermal–optical analysis, OC1, OC2 and OC3 were the dominant OC fragments for all the tested ships, while EC1 and EC2 were the main EC fragments for ships running on heavy fuel oil (HFO) and marine-diesel fuel, respectively; different OC and EC fragments presented different distributions in different particle sizes. (4) The four-stroke low-power diesel fishing boat (4-LDF) had much higher PAH emission ratios than the four-stroke high-power marine-diesel vessel (4-HMV) and two-stroke high-power heavy-fuel-oil vessel (2-HHV) in fine particles, and 2-HHV had the lowest values. (5) PAHs and n-alkanes showed different profile patterns for different types of ships and also between different particle-size bins, which meant that the particle size should be considered when source apportionment is conducted. It is also noteworthy from the results in this study that the smaller the particle size, the more toxic the particle was, especially for the fishing boats in China.

Urban canopy meteorological forcing and its impact on ozone and PM2.5: role of vertical turbulent transport

Peter Huszar1, Jan Karlický1,3, Jana Ďoubalová1,2, Kateřina Šindelářová1, Tereza Nováková1, Michal Belda1, Tomáš Halenka1, Michal Žák1, and Petr Pišoft1

Source: Atmos. Chem. Phys., 20, 1977–2016, 2020, https://doi.org/10.5194/acp-20-1977-2020

It is well known that the urban canopy (UC) layer, i.e., the layer of air corresponding to the assemblage of the buildings, roads, park, trees and other objects typical to cities, is characterized by specific meteorological conditions at city scales generally differing from those over rural surroundings. We refer to the forcing that acts on the meteorological variables over urbanized areas as the urban canopy meteorological forcing (UCMF). UCMF has multiple aspects, while one of the most studied is the generation of the urban heat island (UHI) as an excess of heat due to increased absorption and trapping of radiation in street canyons. However, enhanced drag plays important role too, reducing mean wind speeds and increasing vertical eddy mixing of pollutants. As air quality is strongly tied to meteorological conditions, the UCMF leads to modifications of air chemistry and transport of pollutants. Although it has been recognized in the last decade that the enhanced vertical mixing has a dominant role in the impact of the UCMF on air quality, very little is known about the uncertainty of vertical eddy diffusion arising from different representation in numerical models and how this uncertainty propagates to the final species concentrations as well as to the changes due to the UCMF.

To bridge this knowledge gap, we set up the Regional Climate Model version 4 (RegCM4) coupled to the Comprehensive Air Quality Model with Extensions (CAMx) chemistry transport model over central Europe and designed a series of simulations to study how UC affects the vertical turbulent transport of selected pollutants through modifications of the vertical eddy diffusion coefficient (Kv) using six different methods for Kv calculation. The mean concentrations of ozone and PM2.5 in selected city canopies are analyzed. These are secondary pollutants or having secondary components, upon which turbulence acts in a much more complicated way than in the case of primary pollutants by influencing their concentrations not only directly but indirectly via precursors too. Calculations are performed over cascading domains (of 27, 9, and 3 km horizontal resolutions), which further enables to analyze the sensitivity of the numerical model to grid resolution. A number of model simulations are carried out where either urban canopies are considered or replaced by rural ones in order to isolate the UC meteorological forcing. Apart from the well-pronounced and expected impact on temperature (increases up to 2 ∘C) and wind (decreases by up to 2 ms−1), there is a strong impact on vertical eddy diffusion in all of the six Kv methods. The Kv enhancement ranges from less than 1 up to 30 m2 s−1 at the surface and from 1 to 100 m2 s−1 at higher levels depending on the methods. The largest impact is obtained for the turbulent kinetic energy (TKE)-based methods.

The range of impact on the vertical eddy diffusion coefficient propagates to a range of ozone (O3) increase of 0.4 to 4 ppbv in both summer and winter (5 %–10 % relative change). In the case of PM2.5, we obtained decreases of up to 1 µg m−3 in summer and up to 2 µg m−3 in winter (up to 30 %–40 % relative change). Comparing these results to the "total-impact", i.e., to the impact of all meteorological modifications due to UCMF, we can conclude that much of UCMF is explained by the enhanced vertical eddy diffusion, which counterbalances the opposing effects of other components of this forcing (temperature, humidity and wind). The results further show that this conclusion holds regardless of the resolution chosen and in both the warm and cold parts of the year.

Modeling diurnal variation of surface PM2.5 concentrations over East China with WRF-Chem: impacts from boundary-layer mixing and anthropogenic emission

Qiuyan Du1, Chun Zhao1,2, Mingshuai Zhang1, Xue Dong1,3, Yu Chen1, Zhen Liu4, Zhiyuan Hu5,6, Qiang Zhang7, Yubin Li8, Renmin Yuan1, and Shiguang Miao9

Source: Atmos. Chem. Phys., 20, 2839–2863, 2020, https://doi.org/10.5194/acp-20-2839-2020

Diurnal variation of surface PM2.5 concentration (diurnal PM2.5) could dramatically affect aerosol radiative and health impacts and can also well reflect the physical and chemical mechanisms of air pollution formation and evolution. So far, diurnal PM2.5 and its modeling capability over East China have not been investigated and therefore are examined in this study. Based on the observations, the normalized diurnal amplitude of surface PM2.5 concentrations averaged over East China is weakest (∼1.2) in winter and reaches ∼1.5 in other seasons. The diurnal PM2.5 shows the peak concentration during the night in spring and fall and during the daytime in summer. The simulated diurnal PM2.5 with WRF-Chem and its contributions from multiple physical and chemical processes are examined in the four seasons. The simulated diurnal PM2.5 with WRF-Chem is primarily controlled by planetary boundary layer (PBL) mixing and emission variations and is significantly overestimated against the observation during the night. This modeling bias is likely primarily due to the inefficient PBL mixing of primary PM2.5 during the night. The simulated diurnal PM2.5 is sensitive to the PBL schemes and vertical-layer configurations with WRF-Chem. Besides the PBL height, the PBL mixing coefficient is also found to be the critical factor determining the PBL mixing of pollutants in WRF-Chem. With reasonable PBL height, the increase in the lower limit of the PBL mixing coefficient during the night can significantly reduce the modeling biases in diurnal PM2.5 and also the mean concentrations, particularly in the major cities of East China. It can also reduce the

modeling sensitivity to the PBL vertical-layer configurations. The diurnal variation and injection height of anthropogenic emissions also play roles in simulating diurnal PM2.5, but the impact is relatively smaller than that from the PBL mixing. This study underscores that more efforts are needed to improve the boundary mixing process of pollutants in models with observations of PBL structure and mixing fluxes in addition to PBL height, in order to simulate reasonably the diurnal PM2.5 over East China. The diurnal variation and injection height of anthropogenic emissions must also be included to simulate the diurnal PM2.5 over East China.

Fine particle characterization in a coastal city in China: composition, sources, and impacts of industrial emissions

Lu Lei1,2, Conghui Xie1,2, Dawei Wang1, Yao He1,2, Qingqing Wang1,2, Wei Zhou1,2, Wei Hu3, Pingqing Fu2,3, Yong Chen1, Xiaole Pan1,2, Zifa Wang1,2, Douglas R. Worsnop4, and Yele Sun1,2

Source: Atmos. Chem. Phys., 20, 2877–2890, 2020, https://doi.org/10.5194/acp-20-2877-2020

Aerosol composition and sources have been extensively studied in developed regions in China. However, aerosol chemistry in coastal regions of eastern China with high industrial emissions remains poorly characterized. Here we present a comprehensive characterization of aerosol composition and sources near two large steel plants in a coastal city in Shandong in fall and spring using a PM2.5 time-of-flight aerosol chemical speciation monitor. The average (±1σ) mass concentration of PM2.5 in spring 2019 (54±44 µg m−3) was approximately twice that (26±23 µg m−3) in fall 2018. Aerosol composition was substantially different between the two seasons. While organics accounted for ∼30 % of the total PM2.5 mass in both seasons, sulfate showed a considerable decrease from 28 % in September to 16 % in March, which was associated with a large increase in nitrate contribution from 17 % to 32 %. Positive matrix factorization analysis showed that secondary organic aerosol (SOA) dominated the total OA in both seasons, accounting on average for 92 % and 86 %, respectively, while the contribution of traffic-related hydrocarbon-like OA was comparable (8 %–9 %). During this study, we observed significant impacts of steel plant emissions on aerosol chemistry nearby. The results showed that aerosol particles emitted from the steel plants were overwhelmingly dominated by ammonium sulfate and/or ammonium bisulfate with the peak concentration reaching as high as 224 µg m−3. Further analysis showed similar mass ratios for NOx/CO (0.014) and NOx/SO2 (1.24) from the two different steel plants, which were largely different from those during periods in the absence of industrial plumes. Bivariate polar plot analysis also supported the dominant source region of ammonium sulfate, CO, and SO2 from the southwest steel plants. Our results might have significant implications for better

quantification of industrial emissions using ammonium sulfate and the ratios of gaseous species as tracers in industrial regions and nearby in the future.

The influence of residential wood combustion on the concentrations of PM2.5 in four Nordic cities

Jaakko Kukkonen1, Susana López-Aparicio2, David Segersson3, Camilla Geels4, Leena Kangas1, Mari Kauhaniemi1, Androniki Maragkidou1, Anne Jensen4, Timo Assmuth5, Ari Karppinen1, Mikhail Sofiev1, Heidi Hellén1, Kari Riikonen1, Juha Nikmo1, Anu Kousa6, Jarkko V. Niemi6, Niko Karvosenoja5, Gabriela Sousa Santos2, Ingrid Sundvor7, Ulas Im4, Jesper H. Christensen4, Ole-Kenneth Nielsen4, Marlene S. Plejdrup4, Jacob Klenø Nøjgaard4, Gunnar Omstedt3, Camilla Andersson3, Bertil Forsberg8, and Jørgen Brandt4

Source: Atmos. Chem. Phys., 20, 4333–4365, 2020, https://doi.org/10.5194/acp-20-4333-2020

Residential wood combustion (RWC) is an important contributor to air quality in numerous regions worldwide. This study is the first extensive evaluation of the influence of RWC on ambient air quality in several Nordic cities. We have analysed the emissions and concentrations of PM2.5 in cities within four Nordic countries: in the metropolitan areas of Copenhagen, Oslo, and Helsinki and in the city of Umeå. We have evaluated the emissions for the relevant urban source categories and modelled atmospheric dispersion on regional and urban scales. The emission inventories for RWC were based on local surveys, the amount of wood combusted, combustion technologies and other relevant factors. The accuracy of the predicted concentrations was evaluated based on urban concentration measurements. The predicted annual average concentrations ranged spatially from 4 to 7 μg m−3 (2011), from 6 to 10 μg m−3 (2013), from 4 to more than 13 μg m−3 (2013) and from 9 to more than 13 μg m−3 (2014), in Umeå, Helsinki, Oslo and Copenhagen, respectively. The higher concentrations in Copenhagen were mainly caused by the relatively high regionally and continentally transported background contributions. The annual average fractions of PM2.5 concentrations attributed to RWC within the considered urban regions ranged spatially from 0 % to 15 %, from 0 % to 20 %, from 8 % to 22 % and from 0 % to 60 % in Helsinki, Copenhagen, Umeå and Oslo, respectively. In particular, the contributions of RWC in central Oslo were larger than 40 % as annual averages. In Oslo, wood combustion was used mainly for the heating of larger blocks of flats. In contrast, in Helsinki, RWC was solely used in smaller detached houses. In Copenhagen and Helsinki, the highest fractions occurred outside the city centre in the suburban areas. In Umeå, the highest fractions occurred both in the city centre and its surroundings.

Satellite mapping of PM2.5 episodes in the wintertime San Joaquin Valley: a “static” model using column water vapour

Robert B. Chatfield1, Meytar Sorek-Hamer1,2, Robert F. Esswein1,3, and Alexei Lyapustin4

Source: Atmos. Chem. Phys., 20, 4379–4397, 2020, https://doi.org/10.5194/acp-20-4379-2020

The use of satellite aerosol optical thickness (AOT) from imaging spectrometers has been successful in quantifying and mapping high-PM2.5 (particulate matter with a mass <2.5 μm diameter) episodes for pollution abatement and health studies. However, some regions have high PM2.5 but poor estimation success. The challenges in using AOT from imaging spectrometers to characterize PM2.5 worldwide was especially evident in the wintertime San Joaquin Valley (SJV). The SJV's attendant difficulties of high-albedo surfaces and very shallow, variable vertical mixing also occur in other significantly polluted regions around the world. We report on more accurate PM2.5 maps (where cloudiness permits) for the whole winter period in the SJV (19 November 2012–18 February 2013). Intensive measurements by including NASA aircraft were made for several weeks in that winter, the DISCOVER-AQ (Deriving Information on Surface Conditions from COlumn and VERtically Resolved Observations Relevant to Air Quality) California mission.

We found success with a relatively simple method based on calibration and checking with surface monitors and a characterization of vertical mixing, and incorporating specific understanding of the region's climatology. We estimate PM2.5 to within ∼7 μg m−3 root mean square error (RMSE) and with R values of ∼0.9, based on remotely sensed multi-angle implementation of atmospheric correction (MAIAC) observations, and certain further work will improve that accuracy. Mapping is at 1 km resolution. This allows a time sequence of mapped aerosols at 1 km for cloud-free days. We describe our technique as a “static estimation.” Estimation procedures like this one, not dependent on well-mapped source strengths or on transport error, should help full source-driven simulations by deconstructing processes. They also provide a rapid method to create a long-term climatology.

Essential features of the technique are (a) daily calibration of the AOT to PM2.5 using available surface monitors, and (b) characterization of mixed layer dilution using column water vapor (CWV, otherwise “precipitable water”). We noted that on multi-day timescales both water vapor and particles share near-surface sources and both fall to very low values with altitude; indeed, both are largely removed by precipitation. The existence of layers of H2O or aerosol not within the mixed layer adds complexity, but mixed-effects statistical regression captures essential proportionality of PM2.5 and the ratio variable (AOT/CWV).

Accuracy is much higher than previous statistical models and can be extended to the whole Aqua satellite data record. The maps and time series we show suggest a repeated pattern for large valleys like the SJV – progressive stabilization of the mixing height after frontal passages: PM2.5 is somewhat more determined by day-by-day changes in mixing than it is by the progressive accumulation of pollutants (revealed as increasing AOT).

Soccer games and record-breaking PM2.5 pollution events in Santiago, Chile

Rémy Lapere1, Laurent Menut1, Sylvain Mailler1,2, and Nicolás Huneeus3,4

Source: Atmos. Chem. Phys., 20, 4681–4694, 2020, https://doi.org/10.5194/acp-20-4681-2020

In wintertime, high concentrations of atmospheric fine particulate matter (PM2.5) are commonly observed in the metropolitan area of Santiago, Chile. Hourly peaks can be very strong, up to 10 times above average levels, but have barely been studied so far. Based on atmospheric composition measurements and chemistry-transport modeling (WRF-CHIMERE), the chemical signature of sporadic skyrocketing wintertime PM2.5 peaks is analyzed. This signature and the timing of such extreme events trace their origin back to massive barbecue cooking by Santiago's inhabitants during international soccer games. The peaks end up evacuated outside Santiago after a few hours but trigger emergency plans for the next day. Decontamination plans in Santiago focus on decreasing emissions from traffic, industry, and residential heating. Thanks to the air quality network of Santiago, this study shows that cultural habits such as barbecue cooking also need to be taken into account. For short-term forecast and emergency management, cultural events such as soccer games seem a good proxy to prognose possible PM2.5 peak events. Not only can this result have an informative value for the Chilean authorities but also a similar methodology could be reproduced for other cases throughout the world in order to estimate the burden on air quality of cultural habits.

Nitrate-dominated PM2.5 and elevation of particle pH observed in urban Beijing during the winter of 2017

Yuning Xie1, Gehui Wang1,2, Xinpei Wang1, Jianmin Chen2,3, Yubao Chen1, Guiqian Tang4, Lili Wang4, Shuangshuang Ge1, Guoyan Xue1, Yuesi Wang4, and Jian Gao5

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The Chinese government has exerted strict emission controls to mitigate air pollution since 2013, which has resulted in significant decreases in the concentrations of air pollutants such as SO2. Strict pollution control actions also reduced the average PM2.5 concentration to the low level of 39.7 μg m−3 in urban Beijing during the winter of 2017. To investigate the impact of such changes on the physiochemical properties of atmospheric aerosols in China, we conducted a comprehensive observation focusing on PM2.5 in Beijing during the winter of 2017. Compared with the historical record (2014–2017), SO2 decreased to the low level of 3.2 ppbv in the winter of 2017, but the NO2 level was still high (21.4 ppbv in the winter of 2017). Accordingly, the contribution of nitrate (23.0 μg m−3) to PM2.5 far exceeded that of sulfate (13.1 μg m−3) during the pollution episodes, resulting in a significant increase in the nitrate-to-sulfate molar ratio. The thermodynamic model (ISORROPIA II) calculation results showed that during the PM2.5 pollution episodes particle pH increased from 4.4 (moderate acidic) to 5.4 (more neutralized) when the molar ratio of nitrate to sulfate increased from 1 to 5, indicating that aerosols were more neutralized as the nitrate content elevated. Controlled variable tests showed that the pH elevation should be attributed to nitrate fraction increase other than crustal ion and ammonia concentration increases. Based on the results of sensitivity tests, future prediction for the particle acidity change was discussed. We found that nitrate-rich particles in Beijing at low and moderate humid conditions (RH: 20 %–50 %) can absorb twice the amount of water that sulfate-rich particles can, and the nitrate and ammonia with higher levels have synergetic effects, rapidly elevating particle pH to merely neutral (above 5.6). As moderate haze events might occur more frequently under abundant ammonia and nitrate-dominated PM2.5 conditions, the major chemical processes during haze events and the control target should be re-evaluated to obtain the most effective control strategy.

Characterization and comparison of PM2.5 oxidative potential assessed by two acellular assays

Dong Gao1,a, Krystal J. Godri Pollitt2, James A. Mulholland1, Armistead G. Russell1, and Rodney J. Weber3

Source: Atmos. Chem. Phys., 20, 5197–5210, 2020, https://doi.org/10.5194/acp-20-5197-2020

The capability of ambient particles to generate in vivo reactive oxygen species (ROS), called oxidative potential (OP), is a potential metric for evaluating the health effects of particulate matter (PM) and is supported by several recent epidemiological investigations. Studies using various types of OP assays differ in their sensitivities to varying PM chemical components. In this study, we systematically compared two health-relevant acellular OP assays that track the depletion of antioxidants or reductant surrogates: (i) the synthetic

respiratory-tract lining fluid (RTLF) assay that tracks the depletion of ascorbic acid (AA) and glutathione (GSH) and (ii) the dithiothreitol (DTT) assay that tracks the depletion of DTT. Yearlong daily samples were collected at an urban site in Atlanta, GA (Jefferson Street), during 2017, and both DTT and RTLF assays were performed to measure the OP of water-soluble PM2.5 components. PM2.5 mass and major chemical components, including metals, ions, and organic and elemental carbon were also analyzed. Correlation analysis found that OP as measured by the DTT and AA depletion (OPDTT and OPAA, respectively) were correlated with both organics and some water-soluble metal species, whereas that from the GSH depletion (OPGSH) was exclusively sensitive to water-soluble Cu. These OP assays were moderately correlated with each other due to the common contribution from metal ions. OPDTT and OPAA were moderately correlated with PM2.5 mass with Pearson's r=0.55 and 0.56, respectively, whereas OPGSH exhibited a lower correlation (r=0.24). There was little seasonal variation in the OP levels for all assays due to the weak seasonality of OP-associated species. Multivariate linear regression models were developed to predict OP measures from the particle composition data. Variability in OPDTT and OPAA were not only attributed to the concentrations of metal ions (mainly Fe and Cu) and organic compounds but also to antagonistic metal–organic and metal–metal interactions. OPGSH was sensitive to the change in water-soluble Cu and brown carbon (BrC), a proxy for ambient humic-like substances.

Regional-scale modelling for the assessment of atmospheric particulate matter concentrations at rural background locations in Europe

Goran Gašparac1,2, Amela Jeričević1, Prashant Kumar3, and Branko Grisogono4

Source: Atmos. Chem. Phys., 20, 6395–6415, 2020, https://doi.org/10.5194/acp-20-6395-2020

The application of regional-scale air quality models is an important tool in air quality assessment and management. For this reason, the understanding of model abilities and performances is mandatory. The main objective of this research was to investigate the spatial and temporal variability of background particulate matter (PM) concentrations, to evaluate the regional air quality modelling performance in simulating PM concentrations during statically stable conditions and to investigate processes that contribute to regionally increased PM concentrations with a focus on eastern and central Europe. The temporal and spatial variability of observed PM was analysed at 310 rural background stations in Europe during 2011. Two different regional air quality modelling systems (offline coupled European Monitoring and Evaluation Programme, EMEP, and online coupled Weather Research and Forecasting with Chemistry) were applied to simulate the transport of pollutants and to further investigate the processes that contributed to increased concentrations during high-pollution episodes. Background PM measurements from rural

background stations, wind speed, surface pressure and ambient temperature data from 920 meteorological stations across Europe, classified according to the elevation, were used for the evaluation of individual model performance. Among the sea-level stations (up to 200 m), the best modelling performance, in terms of meteorology and chemistry, was found for both models. The underestimated modelled PM concentrations in some cases indicated the importance of the accurate assessment of regional air pollution transport under statically stable atmospheric conditions and the necessity of further model improvements.

Heavy air pollution with a unique "non-stagnant" atmospheric boundary layer in the Yangtze River middle basin aggravated by regional transport of PM2.5 over China

Chao Yu1,2, Tianliang Zhao1, Yongqing Bai3, Lei Zhang1,4, Shaofei Kong5, Xingna Yu1, Jinhai He1, Chunguang Cui3, Jie Yang1, Yinchang You1, Guoxu Ma1, Ming Wu1, and Jiacheng Chang1

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The regional transport of air pollutants, controlled by emission sources and meteorological factors, results in a complex source–receptor relationship of air pollution change. Wuhan, a metropolis in the Yangtze River middle basin (YRMB) of central China, experienced heavy air pollution characterized by hourly PM2.5 concentrations reaching 471.1 μg m−3 in January 2016. To investigate the regional transport of PM2.5 over central eastern China (CEC) and the meteorological impact on wintertime air pollution in the YRMB area, observed meteorological and other relevant environmental data from January 2016 were analysed. Our analysis presented noteworthy cases of heavy PM2.5 pollution in the YRMB area with unique "non-stagnant" meteorological conditions of strong northerly winds, no temperature inversion, and additional unstable structures in the atmospheric boundary layer. This unique set of conditions differed from the stagnant meteorological conditions characterized by near-surface weak winds, air temperature inversion, and stable structure in the boundary layer that are typically observed in heavy air pollution over most regions in China. The regional transport of PM2.5 over CEC aggravated PM2.5 levels, thus creating heavy air pollution in the YRMB area. This demonstrates a source–receptor relationship between the originating air pollution regions in CEC and the receiving YRMB region. Furthermore, a backward trajectory simulation using a Flexible Particle dispersion (FLEXPART) Weather Research and Forecasting (WRF) model to integrate the air pollutant emission inventory over China was used to explore the patterns of regional transport of PM2.5 governed by the strong northerly winds in the cold air activity of the East Asian winter monsoon season. It was estimated that the regional transport of PM2.5 from non-local air pollutant emissions contributes more than 65 % of the PM2.5 concentrations to

the heavy air pollution in the YRMB region during the study period, revealing the importance of the regional transport of air pollutants over China as a causative factor of heavy air pollution over the YRMB area.

Effects of atmospheric circulations on the interannual variation in PM2.5 concentrations over the Beijing–Tianjin–Hebei region in 2013–2018

Xiaoyan Wang1,2 and Renhe Zhang1,2

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The Chinese government has made many efforts to mitigate fine particulate matter pollution in recent years by taking strict measures on air pollutant reduction, which has generated the nationwide improvements in air quality since 2013. However, under the stringent air pollution controls, how the wintertime PM2.5 concentration (i.e., the mass concentration of atmospheric particles with diameters less than 2.5 μm) varies and how much the meteorological conditions contribute to the interannual variations in PM2.5 concentrations are still unclear, and these very important for the local government to assess the emission reduction of the previous year and adjust mitigation strategies for the next year. The effects of atmospheric circulation on the interannual variation in wintertime PM2.5 concentrations over the Beijing–Tianjin–Hebei (BTH) region in the period of 2013–2018 are evaluated in this study. Generally, the transport of clean and dry air masses and an unstable boundary layer in combination with the effective near-surface horizontal divergence or pumping action at the top of the boundary layer benefits the horizontal or vertical diffusion of surface air pollutants. Instead, the co-occurrence of a stable boundary layer, frequent air stagnation, positive water vapor advection and deep near-surface horizontal convergence exacerbate the wintertime air pollution. Favorable circulation conditions lasting for 2–4 d are beneficial for the diffusion of air pollutants, and 3–7 d of unfavorable circulation events exacerbates the accumulation of air pollutants. The occurrence frequency of favorable circulation events is consistent with the interannual variation in seasonal mean PM2.5 concentrations. There is better diffusion ability in the winters of 2014 and 2017 than in other years. A 59.9 % observed decrease in PM2.5 concentrations in 2017 over the BTH region could be attributed to the improvement in atmospheric diffusion conditions. It is essential to exclude the contribution of meteorological conditions to the variation in interannual air pollutants when making a quantitative evaluation of emission reduction measurements.

Decadal changes in anthropogenic source contribution of PM2.5 pollution and related health impacts in China, 1990–2015

Jun Liu1, Yixuan Zheng1, Guannan Geng1, Chaopeng Hong1, Meng Li1, Xin Li1, Fei Liu2, Dan Tong1, Ruili Wu1, Bo Zheng2, Kebin He1,2, and Qiang Zhang1

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Air quality in China has changed dramatically in response to rapid development of the economy and to policies. In this work, we investigate the changes in anthropogenic source contribution to ambient fine particulate matter (PM2.5) air pollution and related health impacts in China during 1990–2015 and elucidate the drivers behind the decadal transition. We estimate the contribution of five anthropogenic emitting sectors to ambient PM2.5 exposure and related premature mortality over China during 1990–2015 with 5-year intervals, by using an integrated model framework of a bottom-up emission inventory, a chemical transport model, and the Global Exposure Mortality Model (GEMM). The national anthropogenic PM2.5-related premature mortality estimated with the GEMM for nonaccidental deaths due to noncommunicable diseases and lower respiratory infections rose from 1.26 million (95 % confidence interval (CI) [1.05, 1.46]) in 1990 to 2.18 million (95 % CI [1.84, 2.50]) in 2005; then, it decreased to 2.10 million (95 % CI [1.76, 2.42]) in 2015. In 1990, the residential sector was the leading source of the PM2.5-related premature mortality (559 000, 95 % CI [467 000, 645 900], 44 % of total) in China, followed by industry (29 %), power (13 %), agriculture (9 %), and transportation (5 %). In 2015, the industrial sector became the largest contributor of PM2.5-related premature mortality (734 000, 95 % CI [615 500, 844 900], 35 % of total), followed by the residential sector (25 %), agriculture (23 %), transportation (10 %), and power (6 %). The decadal changes in source contribution to PM2.5-related premature mortality in China represent a combined impact of socioeconomic development and clean-air policy. For example, active control measures have successfully reduced pollution from the power sector, while contributions from the industrial and transportation sectors have continuously increased due to more prominent growth in activity rates. A transition in fuel consumption has dominated the decrease in the contribution from residential sector. Meanwhile, the contribution from the agriculture sector has continuously increased due to persistent NH_3 emissions and enhanced formation of secondary inorganic aerosols under an NH_3-rich environment.

Particle number concentrations and size distribution in a polluted megacity: the Delhi Aerosol Supersite study

Shahzad Gani1, Sahil Bhandari2, Kanan Patel2, Sarah Seraj1, Prashant Soni3, Zainab Arub3, Gazala Habib3, Lea Hildebrandt Ruiz2, and Joshua S. Apte1

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The Indian national capital, Delhi, routinely experiences some of the world's highest urban particulate matter concentrations. While fine particulate matter (PM2.5) mass concentrations in Delhi are at least an order of magnitude higher than in many western cities, the particle number (PN) concentrations are not similarly elevated. Here we report on 1.25 years of highly time-resolved particle size distribution (PSD) data in the size range of 12–560 nm. We observed that the large number of accumulation mode particles – that constitute most of the PM2.5 mass – also contributed substantially to the PN concentrations. The ultrafine particle (UFP; Dp<100 nm) fraction of PNs was higher during the traffic rush hours and for daytimes of warmer seasons, which is consistent with traffic and nucleation events being major sources of urban UFPs. UFP concentrations were found to be relatively lower during periods with some of the highest mass concentrations. Calculations based on measured PSDs and coagulation theory suggest UFP concentrations are suppressed by a rapid coagulation sink during polluted periods when large concentrations of particles in the accumulation mode result in high surface area concentrations. A smaller accumulation mode for warmer months results in an increased UFP fraction, likely owing to a comparatively smaller coagulation sink. We also see evidence suggestive of nucleation which may also contribute to the increased UFP proportions during the warmer seasons. Even though coagulation does not affect mass concentrations, it can significantly govern PN levels with important health and policy implications. Implications of a strong accumulation mode coagulation sink for future air quality control efforts in Delhi are that a reduction in mass concentration, especially in winter, may not produce a proportional reduction in PN concentrations. Strategies that only target accumulation mode particles (which constitute much of the fine PM2.5 mass) may even lead to an increase in the UFP concentrations as the coagulation sink decreases.

Aerosol radiative effects and feedbacks on boundary layer meteorology and PM2.5 chemical components during winter haze events over the Beijing-Tianjin-Hebei region

Jiawei Li1, Zhiwei Han1,2, Yunfei Wu1, Zhe Xiong1, Xiangao Xia3, Jie Li1,2, Lin Liang1,2, and Renjian Zhang1

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An online coupled regional climate–chemistry–aerosol model (RIEMS-Chem) was developed and utilized to investigate the mechanisms of haze formation and evolution and aerosol radiative feedback during winter haze episodes in February–March 2014 over the Beijing-Tianjin-Hebei (BTH) region in China. Model comparison against a variety of observations demonstrated a good ability of RIEMS-Chem in reproducing meteorological

variables, planetary boundary layer (PBL) heights, PM2.5, and its chemical components, as well as aerosol optical properties. The model performances were remarkably improved for both meteorology and chemistry by taking aerosol radiative feedback into account. The domain-average aerosol radiative effects (AREs) were estimated to be −57 W m−2 at the surface, 25 W m−2 in the atmosphere, and −32 W m−2 at the top of atmosphere (TOA) during a severe haze episode (20–26 February), with the maximum hourly surface ARE reaching −384 W m−2 in southern Hebei province. The average feedback-induced changes in 2 m air temperature (T2), 10 m wind speed (WS10), 2 m relative humidity (RH2), and PBL height over the BTH region during the haze episode were −1.8 ∘C, −0.5 m s−1, 10.0 %, and −184 m, respectively. The BTH average changes in PM2.5 concentration due to the feedback were estimated to be 20.0 µg m−3 (29 %) and 45.1 µg m−3 (39 %) for the entire period and the severe haze episode, respectively, which demonstrated a significant impact of aerosol radiative feedback on haze formation. The relative changes in secondary aerosols were larger than those in primary aerosols due to enhanced chemical reactions by aerosol feedback. The feedback-induced absolute change in PM2.5 concentrations was largest in the haze persistence stage, followed by those in the growth stage and dissipating stage. Process analyses on haze events in Beijing revealed that local emission, chemical reaction, and regional transport mainly contributed to haze formation in the growth stage, whereas vertical processes (diffusion, advection, and dry deposition) were major processes for PM2.5 removals. Chemical processes and local emissions dominated the increase in PM2.5 concentrations during the severe haze episode, whereas horizontal advection contributed to the PM2.5 increase with a similar magnitude to local emissions and chemical processes during a moderate haze episode on 1–4 March. The contributions from physical and chemical processes to the feedback-induced changes in PM2.5 and its major components were explored and quantified through process analyses. For the severe haze episode, the increase in the change rate of PM2.5 (9.5 µg m−3 h−1) induced by the feedback in the growth stage was attributed to the larger contribution from chemical processes (7.3 µg m−3 h−1) than that from physical processes (2.2 µg m−3 h−1), whereas, during the moderate haze episode, the increase in the PM2.5 change rate (2.4 µg m−3 h−1) in the growth stage was contributed more significantly by physical processes (1.4 µg m−3 h−1) than by chemical processes (1.0 µg m−3 h−1). In general, the aerosol–radiation feedback increased the accumulation rate of aerosols in the growth stage through weakening vertical diffusion, promoting chemical reactions, and/or enhancing horizontal advection. It enhanced the removal rate through increasing vertical diffusion and vertical advection in the dissipation stage, and had little effect on the change rate of PM2.5 in the persistence stage.

Simultaneous measurements of urban and rural particles in Beijing – Part 2: Case studies of haze events and regional transport

Yang Chen1, Guangming Shi1,3, Jing Cai2, Zongbo Shi4, Zhichao Wang1, Xiaojiang Yao1, Mi Tian1, Chao Peng1, Yiqun Han2, Tong Zhu2, Yue Liu2, Xi Yang2, Mei Zheng2, Fumo Yang1,3, Qiang Zhang5, and Kebin He6

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Two parallel field studies were conducted simultaneously at both urban and rural sites in Beijing from 1 to 29 November 2016. An online single-particle chemical composition analysis was used as a tracer system to investigate the impact of heating activities and the formation of haze events. Central heating elevated EC-Nit (elemental carbon-nitrate), EC-Nit-Sul (EC-nitrate-sulfate), and ECOC-Nit (ECOC: internal-mixed elemental carbon and organic carbon) levels by 1.5–2.0 times due to the increased use of coal in the urban areas. However, in the rural areas, residential heating, which mainly consumes low-quality coal, and biomass burning elevated ECOC-Nit-Sul, NaK-Nit, and OC-Sul levels by 1.2–1.5 times. Four severe haze events (hourly PM2.5 > 200 μg m−3) occurred at both sites during the studies. In each event, a pattern of transport and accumulation was found. In the first stage of the pattern, particles were regionally transported from the south and southwest and accumulated under air stagnation, creating significant secondary formation, then PM2.5 was elevated to 300 μg m−3. At both sites, the severe haze occurred due to different patterns of local emission, transport, and secondary processes. At Pinggu (PG), the sulfate-rich residential coal burning particles were dominant. The regional transport between PG and Peking University (PKU) was simulated using the Weather Research and Forecasting HYbrid Single-Particle Lagrangian Integrated Trajectory (WRF-HYSPLIT) model, confirming that the transport from PG to PKU was significant, but PKU to PG occurred occasionally. These cases can explain the serious air pollution in the urban areas of Beijing and the interaction between urban and rural areas. This study can provide references for enhancing our understanding of haze formation in Beijing.

Modelling of the public health costs of fine particulate matter and results for Finland in 2015

Jaakko Kukkonen1, Mikko Savolahti2, Yuliia Palamarchuk1, Timo Lanki3,4, Väinö Nurmi1, Ville-Veikko Paunu2, Leena Kangas1, Mikhail Sofiev1, Ari Karppinen1, Androniki Maragkidou1, Pekka Tiittanen3, and Niko Karvosenoja2

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We have developed an integrated assessment tool that can be used for evaluating the public health costs caused by the concentrations of fine particulate matter (PM2.5) in

ambient air. The model can be used to assess the impacts of various alternative air quality abatement measures, policies and strategies. The model has been applied to evaluate the costs of the domestic emissions that influence the concentrations of PM2.5 in Finland in 2015. The model includes the impacts on human health; however, it does not address the impacts on climate change or the state of the environment. First, the national Finnish emissions were evaluated using the Finnish Regional Emission Scenarios (FRESs) model on a resolution of 250×250 m2 for the whole of Finland. Second, the atmospheric dispersion was analysed by using the chemical transport model, namely the System for Integrated modeLling of Atmospheric coMposition (SILAM) model, and the source receptor matrices contained in the FRES model. Third, the health impacts were assessed by combining the spatially resolved concentration and population data sets and by analysing the impacts for various health outcomes. Fourth, the economic impacts of the health outcomes were evaluated. The model can be used to evaluate the costs of the health damages for various emission source categories and for a unit of emissions of PM2.5. It was found that the economic benefits, in terms of avoided public health costs, were largest for measures that will reduce the emissions of (i) road transport, (ii) non-road vehicles and machinery, and (iii) residential wood combustion. The reduction in the precursor emissions of PM2.5 resulted in clearly lower benefits when compared with directly reducing the emissions of PM2.5. We have also designed a user-friendly, web-based assessment tool that is open access.

The interaction between urbanization and aerosols during a typical winter haze event in Beijing

Miao Yu1, Guiqian Tang2, Yang Yang1, Qingchun Li1, Yonghong Wang3, Shiguang Miao1, Yizhou Zhang1, and Yuesi Wang2

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Aerosols cause cooling at the surface by reducing shortwave radiation, while urbanization causes warming by altering the surface albedo and releasing anthropogenic heat. The combined effect of the two phenomena needs to be studied in depth. The effects of urbanization and aerosols were investigated during a typical winter haze event. The event,

which occurred in Beijing from 15 to 22 December 2016, was studied via the Rapid-Refresh Multiscale Analysis and Prediction System – Short Term (RMAPS-ST) model. The mechanisms of the impacts of aerosols and urbanization were analyzed and quantified. Aerosols reduced urban-related warming during the daytime by 20 % (from 30 % to 50 %) as concentrations of fine particulate matter (PM2.5) increased from 200 to 400 μg m−3. Conversely, aerosols also enhanced urban-related warming at dawn, and the increment was approximately 28 %, which contributed to haze formation. Urbanization reduced the aerosol-related cooling effect by approximately 54 % during the haze event, and the strength of the impact changed little with increasing aerosol content. The impact of aerosols on urban-related warming was more significant than the impact of urbanization on aerosol-related cooling. Aerosols decreased the urban impact on the mixing-layer height by 148 % and on the sensible heat flux by 156 %. Furthermore, aerosols decreased the latent heat flux; however, this reduction decreased by 48.8 % due to urbanization. The impact of urbanization on the transport of pollutants was more important than that of aerosols. The interaction between urbanization and aerosols may enhance the accumulation of pollution and weigh against diffusion.

Tracking separate contributions of diesel and gasoline vehicles to roadside PM2.5 through online monitoring of volatile organic compounds and PM2.5 organic and elemental carbon: a 6-year study in Hong Kong

Yee Ka Wong1, X. H. Hilda Huang1, Peter K. K. Louie2, Alfred L. C. Yu2, Damgy H. L. Chan2, and Jian Zhen Yu1,3

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Vehicular emissions contribute a significant portion to fine particulate matter (PM2.5) air pollution in urban areas. Knowledge of the relative contribution of gasoline- versus diesel-powered vehicles is highly relevant for policymaking, and yet there is a lack of an effective observation-based method to determine this quantity, especially for its robust tracking over a period of years. In this work, we present an approach to track separate contributions of gasoline and diesel vehicles through the positive matrix factorization (PMF) analysis of online monitoring data measurable by relatively inexpensive analytical instruments. They are PM2.5 organic and elemental carbon (OC and EC), C2–C9 volatile organic compounds (VOCs) (e.g., pentanes, benzene, xylenes, etc.), and nitrogen oxide concentrations. The method was applied to monitoring data spanning more than 6 years between 2011 and 2017 in a roadside environment in Hong Kong. We found that diesel vehicles accounted for ~70 %–90 % of the vehicular PM2.5 (PMvehicle) over the years and

the remainder from gasoline vehicles. The diesel PMvehicle during truck- and bus-dominated periods showed declining trends simultaneous with control efforts targeted at diesel commercial vehicles and franchised buses in the intervening period. The combined PMvehicle from diesel and gasoline vehicles by PMF agrees well with an independent estimate by the EC-tracer method, both confirming PMvehicle contributed significantly to the PM2.5 in this urban environment (~4–8 μg m−3, representing 30 %–60 % in summer and 10 %–20 % in winter). Our work shows that the long-term monitoring of roadside VOCs and PM2.5 OC and EC is effective for tracking gaseous and PM pollutants from different vehicle categories. This work also demonstrates the value of an evidence-based approach in support of effective control policy formulation.

Numerical analysis of agricultural emissions impacts on PM2.5 in China using a high-resolution ammonia emission inventory

Xiao Han1,2, Lingyun Zhu3, Mingxu Liu4, Yu Song4, and Meigen Zhang1,2,5

Source: Atmos. Chem. Phys., 20, 9979–9996, 2020
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China is one of the largest agricultural countries in the world. Thus, NH3 emission from agricultural activities in China considerably affects the country's regional air quality and visibility. In this study, a high-resolution agricultural NH3 emission inventory compiled on 1 km × 1 km horizontal resolution was applied to calculate the NH3 mass burden in China and reliably estimate the influence of NH3 on agriculture. The key parameter emission factors of this inventory were enhanced by considering many experiment results, and the dynamic data of spatial and temporal information were updated using statistical data of 2015. In addition to fertilizers and husbandry, farmland ecosystems, livestock waste, crop residue burning, wood-based fuel combustion, and other NH3 emission sources were included in this inventory. Furthermore, a source apportionment tool, namely, the Integrated Source Apportionment Method (ISAM) coupled with the air quality modeling system Regional Atmospheric Modeling System and Community Multiscale Air Quality, was applied to capture the contribution of NH3 emitted from total agriculture (Tagr) in China. The aerosol mass concentration in 2015 was simulated, and results showed that the high mass concentration of NH3 exceeded 10 μg m−3 and mainly appeared in the North China Plain, Central China, the Yangtze River Delta, and the Sichuan Basin. Moreover, the annual average contribution of Tagr NH3 to PM2.5 mass burden was 14 %–22 % in China. Specific to the PM2.5 components, Tagr NH3 contributed dominantly to ammonium formation (87.6 %) but trivially to sulfate formation (2.2 %). In addition, several brute-force sensitivity tests were conducted to estimate the impact of Tagr NH3 emission reduction on PM2.5 mass burden. In contrast to the result of ISAM, even though the Tagr NH3 only provided 10.1 % contribution to nitrate under the current emission scenario, the reduction

of nitrate could reach 95.8 % upon removal of the Tagr NH3 emission. This deviation occurred because the contribution of NH3 to nitrate should be small under a "rich NH3"environment and large under a "poor NH3" environment. Thus, the influence of NH3 on nitrate formation would be enhanced with the decrease in ambient NH3 mass concentration.

Comprehensive analyses of source sensitivities and apportionments of PM2.5 and ozone over Japan via multiple numerical techniques

Satoru Chatani1, Hikari Shimadera2, Syuichi Itahashi3, and Kazuyo Yamaji4

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Source sensitivity and source apportionment are two major indicators representing source–receptor relationships, which serve as essential information when considering effective strategies to accomplish improved air quality. This study evaluated source sensitivities and apportionments of ambient ozone and PM2.5 concentrations over Japan with multiple numerical techniques embedded in regional chemical transport models, including a brute-force method (BFM), a high-order decoupled direct method (HDDM), and an integrated source apportionment method (ISAM), to update the source–receptor relationships considering stringent emission controls recently implemented in Japan and surrounding countries. We also attempted to understand the differences among source sensitivities and source apportionments calculated by multiple techniques. While a part of ozone concentrations was apportioned to domestic sources, their sensitivities were small or even negative; ozone concentrations were exclusively sensitive to transport from outside Japan. Although the simulated PM2.5 concentrations were significantly lower than those reported by previous studies, their sensitivity to transport from outside Japan was still relatively large, implying that there has been a reduction in Japanese emissions, similar to surrounding countries including China, due to implementation of stringent emission controls. HDDM allowed us to understand the importance of the non-linear responses of PM2.5 concentrations to precursor emissions. Apportionments derived by ISAM were useful in distinguishing various direct and indirect influences on ozone and PM2.5 concentrations by combining with sensitivities. The results indicate that ozone transported from outside Japan plays a key role in exerting various indirect influences on the formation of ozone and secondary PM2.5 components. While the sensitivities come closer to the apportionments when perturbations in emissions are larger in highly non-linear relationships – including those between NH3 emissions and NH+4 concentrations, NOx emissions and NO−3 concentrations, and NOx emissions and ozone concentrations – the sensitivities did not reach the apportionments because there were various indirect influences including other sectors, complex photochemical

reactions, and gas–aerosol partitioning. It is essential to consider non-linear influences to derive strategies for effectively suppressing concentrations of secondary pollutants.

The impact of traffic on air quality in Ireland: insights from the simultaneous kerbside and suburban monitoring of submicron aerosols

Chunshui Lin1,2,3, Darius Ceburnis1, Wei Xu1,2, Eimear Heffernan4, Stig Hellebust4, John Gallagher5, Ru-Jin Huang1,2,3, Colin O'Dowd1, and Jurgita Ovadnevaite1

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To evaluate the impact of traffic on urban air quality, the chemical composition of submicron aerosols (PM1) and sources of organic aerosol (OA) were simultaneously investigated at a kerbside site in the Dublin city center and a residential site in suburban Dublin (~ 5 km apart) from 4 September to 9 November in 2018. Through the detailed comparison of a 1-week nonheating period from 10 to 17 September and a 1-week heating period from 27 October to 4 November, black carbon (BC) was found to be the most dominant component (38 %–55 % or 5.6–7.1 µg m−3) of PM1 at the kerbside, while OA was the most important (46 %–64 % of PM1 or 1.0–8.1 µg m−3) at the residential site. The daily and weekly cycle of BC at the kerbside during the nonheating period pointed to the major source of vehicular emissions, consistent with that for nitrogen oxides (NOx). However, traffic emissions were found to have a minor impact on air quality at the residential site, due to its distance from traffic sources and the effects of wind speed and wind direction. As a result of vehicular emissions and the street canyon effect, the kerbside increment (from the urban background) ratio of up to 25 : 1 was found for BC during the nonheating period but reduced to 10 : 1 during the heating period due to the additional sources of solid fuel burning impacting the air quality at both sites simultaneously. OA source analysis shows only 16 %–28 % (0.9–1.0 µg m−3; upper limit for traffic due to the additional heating source of hydrocarbon-like OA – HOA) of OA at the kerbside associated with vehicular emissions, with higher contributions from cooking (18 %–36 % or 1.2 µg m−3), solid fuel burning (38 % or 2.4 µg m−3; resolved only during the heating period), and oxygenated OA (29 %–37 % or 1.2–1.9 µg m−3). At the residential site, solid fuel burning contributed to 60 % (4.9 µg m−3) of OA during the heating period, while oxygenated OA (OOA) accounted for almost 65 % (0.6 µg m−3) of OA during the nonheating period. Based on simultaneous investigations of PM1 at different urban settings (i.e., residential versus kerbside), this study highlights the temporal and spatial variability of sources within the Dublin city center and the need for additional aerosol characterization studies to improve targeted mitigation solutions for greater impact on urban air quality. Moreover, traffic and residential heating may hold different implications for health and climate, as indicated by

the significant increment of BC at the kerbside and the large geographic impact of OA from residential heating at both the kerbside and residential sites.

Aerosol pollution maps and trends over Germany with hourly data at four rural background stations from 2009 to 2018

Jost Heintzenberg1, Wolfram Birmili2, Bryan Hellack2, Gerald Spindler1, Thomas Tuch1, and Alfred Wiedensohler1

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A total of 10 years of hourly aerosol and gas data at four rural German stations have been combined with hourly back trajectories to the stations and inventories of the European Emissions Database for Global Atmospheric Research (EDGAR), yielding pollution maps over Germany of PM10, particle number concentrations, and equivalent black carbon (eBC). The maps reflect aerosol emissions modified with atmospheric processes during transport between sources and receptor sites. Compared to emission maps, strong western European emission centers do not dominate the downwind concentrations because their emissions are reduced by atmospheric processes on the way to the receptor area. PM10, eBC, and to some extent also particle number concentrations are rather controlled by emissions from southeastern Europe from which pollution transport often occurs under drier conditions. Newly formed particles are found in air masses from a broad sector reaching from southern Germany to western Europe, which we explain with gaseous particle precursors coming with little wet scavenging from this region.

Annual emissions for 2009 of PM10, BC, SO2, and NOx were accumulated along each trajectory and compared with the corresponding measured time series. The agreement of each pair of time series was optimized by varying monthly factors and annual factors on the 2009 emissions. This approach yielded broader summer emission minima than published values that were partly displaced from the midsummer positions. The validity of connecting the ambient concentration and emission of particulate pollution was tested by calculating temporal changes in eBC for subsets of back trajectories passing over two separate prominent emission regions, region A to the northwest and B to the southeast of the measuring stations. Consistent with reported emission data the calculated emission decreases over region A are significantly stronger than over region B.

Meteorology-normalized impact of the COVID-19 lockdown upon NO2 pollution in Spain

Hervé Petetin1, Dene Bowdalo1, Albert Soret1, Marc Guevara1, Oriol Jorba1, Kim Serradell1, and Carlos Pérez García-Pando1,2

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The spread of the new coronavirus SARS-CoV-2 that causes COVID-19 forced the Spanish Government to implement extensive lockdown measures to reduce the number of hospital admissions, starting on 14 March 2020. Over the following days and weeks, strong reductions in nitrogen dioxide (NO2) pollution were reported in many regions of Spain. A substantial part of these reductions was obviously due to decreased local and regional anthropogenic emissions. Yet, the confounding effect of meteorological variability hinders a reliable quantification of the lockdown's impact upon the observed pollution levels. Our study uses machine-learning (ML) models fed by meteorological data along with other time features to estimate the "business-as-usual" NO2 mixing ratios that would have been observed in the absence of the lockdown. We then quantify the so-called meteorology-normalized NO2 reductions induced by the lockdown measures by comparing the estimated business-as-usual values with the observed NO2 mixing ratios. We applied this analysis for a selection of urban background and traffic stations covering the more than 50 Spanish provinces and islands.

The ML predictive models were found to perform remarkably well in most locations, with an overall bias, root mean square error and correlation of +4 %, 29 % and 0.86, respectively. During the period of study, from the enforcement of the state of alarm in Spain on 14 March to 23 April, we found the lockdown measures to be responsible for a 50 % reduction in NO2 levels on average over all provinces and islands. The lockdown in Spain has gone through several phases with different levels of severity with respect to mobility restrictions. As expected, the meteorology-normalized change in NO2 was found to be stronger during phase II (the most stringent phase) and phase III of the lockdown than during phase I. In the largest agglomerations, where both urban background and traffic stations were available, a stronger meteorology-normalized NO2 change is highlighted at traffic stations compared with urban background sites. Our results are consistent with foreseen (although still uncertain) changes in anthropogenic emissions induced by the lockdown. We also show the importance of taking the meteorological variability into account for accurately assessing the impact of the lockdown on NO2 levels, in particular at fine spatial and temporal scales.

Meteorology-normalized estimates such as those presented here are crucial to reliably quantify the health implications of the lockdown due to reduced air pollution.

Elucidating the pollution characteristics of nitrate, sulfate and ammonium in PM2.5 in Chengdu, southwest China, based on 3-year measurements

Liuwei Kong1, Miao Feng2, Yafei Liu1, Yingying Zhang1, Chen Zhang1, Chenlu Li1, Yu Qu3, Junling An3, Xingang Liu1, Qinwen Tan2, Nianliang Cheng4, Yijun Deng5, Ruixiao Zhai5, and Zheng Wang5

Source: Atmos. Chem. Phys., 20, 11181–11199, 2020
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Nitrate, sulfate and ammonium (NSA) are the main secondary inorganic aerosols of PM2.5 and play an important role in air pollution. In this study, a 3-year observational experiment was conducted from 1 January 2015 to 31 December 2017, in Chengdu, southwest China. NSA pollution characteristics, chemical conversion generation, emission reduction control sensitivity and pollutant regional transport characteristics were analyzed. NSA are the most important chemical compositions of particles with aerodynamic equivalent diameter ≤2.5 µm in ambient air (PM2.5), and the contribution of nitrate to the accumulation of PM2.5 concentration is greater than that of sulfate and ammonium. NSA also have obvious characteristics of annual, monthly, seasonal, diurnal and weekly variations. Through observation data and model simulation, it was also found that the existence of an aerosol aqueous environment plays an important role in the formation and existence of NSA. Sensitivity analysis between NSA found that controlling NO−3 and SO2−4 plays an important role in reducing the contribution of NSA to PM2.5, which also implies that the current control of NOx and SO2 is important for improving air pollution. Combined with meteorological conditions and potential source contribution function (PSCF) analysis, local emissions and regional emissions of pollutants are found to have important impacts on Chengdu's atmospheric environment. This research result not only provides an assessment of the current atmospheric emission reduction effect but also provides an important reference for atmospheric pollution control.

Size-resolved particle number emissions in Beijing determined from measured particle size distributions

Jenni Kontkanen1,2, Chenjuan Deng3, Yueyun Fu3, Lubna Dada2, Ying Zhou1, Jing Cai2, Kaspar R. Daellenbach2, Simo Hakala2, Tom V. Kokkonen2,4, Zhuohui Lin1, Yongchun Liu1, Yonghong Wang2, Chao Yan1,2, Tuukka Petäjä2, Jingkun Jiang3, Markku Kulmala1,2, and Pauli Paasonen1,2

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The climate and air quality effects of aerosol particles depend on the number and size of the particles. In urban environments, a large fraction of aerosol particles originates from anthropogenic emissions. To evaluate the effects of different pollution sources on air quality, knowledge of size distributions of particle number emissions is needed. Here we introduce a novel method for determining size-resolved particle number emissions, based on measured particle size distributions. We apply our method to data measured in Beijing, China, to determine the number size distribution of emitted particles in a diameter range from 2 to 1000 nm. The observed particle number emissions are dominated by emissions of particles smaller than 30 nm. Our results suggest that traffic is the major source of particle number emissions with the highest emissions observed for particles around 10 nm during rush hours. At sizes below 6 nm, clustering of atmospheric vapors contributes to calculated emissions. The comparison between our calculated emissions and those estimated with an integrated assessment model GAINS (Greenhouse Gas and Air Pollution Interactions and Synergies) shows that our method yields clearly higher particle emissions at sizes below 60 nm, but at sizes above that the two methods agree well. Overall, our method is proven to be a useful tool for gaining new knowledge of the size distributions of particle number emissions in urban environments and for validating emission inventories and models. In the future, the method will be developed by modeling the transport of particles from different sources to obtain more accurate estimates of particle number emissions.

Effects of global ship emissions on European air pollution levels

Jan Eiof Jonson1, Michael Gauss1, Michael Schulz1, Jukka-Pekka Jalkanen2, and Hilde Fagerli1

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Ship emissions constitute a large, and so far poorly regulated, source of air pollution. Emissions are mainly clustered along major ship routes both in open seas and close to densely populated shorelines. Major air pollutants emitted include sulfur dioxide, NOx, and primary particles. Sulfur and NOx are both major contributors to the formation of secondary fine particles (PM2.5) and to acidification and eutrophication. In addition, NOx is a major precursor for ground-level ozone. In this paper, we quantify the contributions from international shipping to European air pollution levels and depositions.

This study is based on global and regional model calculations. The model runs are made with meteorology and emission data representative of the year 2017 after the tightening of

the SECA (sulfur emission control area) regulations in 2015 but before the global sulfur cap that came into force in 2020. The ship emissions have been derived using ship positioning data. We have also made model runs reducing sulfur emissions by 80 % corresponding to the 2020 requirements. This study is based on model sensitivity studies perturbing emissions from different sea areas: the northern European SECA in the North Sea and the Baltic Sea, the Mediterranean Sea and the Black Sea, the Atlantic Ocean close to Europe, shipping in the rest of the world, and finally all global ship emissions together. Sensitivity studies have also been made setting lower bounds on the effects of ship plumes on ozone formation.

Both global- and regional-scale calculations show that for PM2.5 and depositions of oxidised nitrogen and sulfur, the effects of ship emissions are much larger when emissions occur close to the shore than at open seas. In many coastal countries, calculations show that shipping is responsible for 10 % or more of the controllable PM2.5 concentrations and depositions of oxidised nitrogen and sulfur. With few exceptions, the results from the global and regional calculations are similar. Our calculations show that substantial reductions in the contributions from ship emissions to PM2.5 concentrations and to depositions of sulfur can be expected in European coastal regions as a result of the implementation of a 0.5 % worldwide limit of the sulfur content in marine fuels from 2020. For countries bordering the North Sea and Baltic Sea SECA, low sulfur emissions have already resulted in marked reductions in PM2.5 from shipping before 2020.

For ozone, the lifetime in the atmosphere is much longer than for PM2.5, and the potential for ozone formation is much larger in otherwise pristine environments. We calculate considerable contributions from open sea shipping. As a result, we find that the largest contributions to ozone in several regions and countries in Europe are from sea areas well outside European waters.

Differences in fine particle chemical composition on clear and cloudy days

Amy E. Christiansen1, Annmarie G. Carlton1, and Barron H. Henderson2

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Clouds are prevalent and alter fine particulate matter (PM2.5) mass and chemical composition. Cloud-affected satellite retrievals are subject to higher uncertainty and are often removed from data products, hindering quantitative estimates of tropospheric chemical composition during cloudy times. We examine surface PM2.5 chemical

constituent concentrations in the Interagency Monitoring of PROtected Visual Environments (IMPROVE) network in the United States during cloudy and clear-sky times defined using Moderate Resolution Imaging Spectroradiometer (MODIS) cloud flags from 2010 to 2014 with a focus on differences in particle species that affect hygroscopicity and aerosol liquid water (ALW). Cloudy and clear-sky periods exhibit significant differences in PM2.5 mass and chemical composition that vary regionally and seasonally. In the eastern US, relative humidity alone cannot explain differences in ALW, suggesting that emissions and in situ chemistry related to anthropogenic sources exert determining impacts. An implicit clear-sky bias may hinder efforts to quantitatively understand and improve representation of aerosol–cloud interactions, which remain dominant uncertainties in models.

The impact of urban land-surface on extreme air pollution over central Europe

Peter Huszar1, Jan Karlický1,3, Jana Ďoubalová1,2, Tereza Nováková1, Kateřina Šindelářová1, Filip Švábik1, Michal Belda1, Tomáš Halenka1, and Michal Žák1

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This paper deals with the urban land-surface impact (i.e., the urban canopy meteorological forcing; UCMF) on extreme air pollution for selected central European cities for present-day climate conditions (2015–2016) using three regional climate-chemistry models: the regional climate models RegCM and WRF-Chem (its meteorological part), the chemistry transport model CAMx coupled to either RegCM and WRF and the “chemical” component of WRF-Chem. Most of the studies dealing with the urban canopy meteorological forcing on air pollution focused on change in average conditions or only on a selected winter and/or summer air pollution episode. Here we extend these studies by focusing on long-term extreme air pollution levels by looking at not only the change in average values, but also their high (and low) percentile values, and we combine the analysis with investigating selected high-pollution episodes too. As extreme air pollution is often linked to extreme values of meteorological variables (e.g., low planetary boundary layer height, low winds, high temperatures), the urbanization-induced extreme meteorological modifications will be analyzed too. The validation of model results show reasonable model performance for regional-scale temperature and precipitation. Ozone is overestimated by about 10–20 µg m−3 (50 %–100 %); on the other hand, extreme summertime ozone values are underestimated by all models. Modeled nitrogen dioxide (NO2) concentrations are well correlated with observations, but results are marked by a systematic underestimation up to 20 µg m−3 (−50 %). PM2.5 (particles with diameter ≤2.5 µm) are systematically underestimated in most of the models by around 5 µg m−3 (50 %–70 %).

Our results show that the impact on extreme values of meteorological variables can be substantially different from that of the impact on average ones: low (5th percentile) temperature in winter responds to UCMF much more than average values, while in summer, 95th percentiles increase more than averages. The impact on boundary layer height (PBLH), i.e., its increase is stronger for thicker PBLs and wind speed, is reduced much more for strong winds compared to average ones. The modeled changes in ozone (O3), NO2 and PM2.5 show the expected pattern, i.e., increase in average 8 h O3 up to 2–3 ppbv, decrease in daily average NO2 by around 2–4 ppbv and decrease in daily average PM2.5 by around −2 μg m−3. Regarding the impact on extreme (95th percentile) values of these pollutants, the impact on ozone at the high end of the distribution is rather similar to the impact on average 8 h values. A different picture is obtained however for extreme values of NO2 and PM2.5. The impact on the 95th percentile values is almost 2 times larger than the impact on the daily averages for both pollutants. The simulated impact on extreme values further well corresponds to the UCMF impact simulated for the selected high-pollution episodes. Our results bring light to the principal question: whether extreme air quality is modified by urban land surface with a different magnitude compared to the impact on average air pollution. We showed that this is indeed true for NO2 and PM2.5, while in the case of ozone, our results did not show substantial differences between the impact on mean and extreme values.

Pollutant emission reductions deliver decreased PM2.5-caused mortality across China during 2015–2017

Ben Silver1, Luke Conibear1, Carly L. Reddington1, Christoph Knote2, Steve R. Arnold1, and Dominick V. Spracklen1

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Air pollution is a serious environmental issue and leading contributor to disease burden in China. Rapid reductions in fine particulate matter (PM2.5) concentrations and increased ozone concentrations occurred across China during 2015 to 2017. We used measurements of particulate matter with a diameter <2.5 μm (PM2.5) and ozone (O3) from more than 1000 stations across China along with Weather Research and Forecasting model coupled with Chemistry (WRF-Chem) regional air quality simulations, to explore the drivers and impacts of observed trends. The measured nationwide median PM2.5 trend of −3.4μgm−3yr−1 was well simulated by the model (−3.5μgm−3yr−1). With anthropogenic emissions fixed at 2015 levels, the simulated trend was much weaker (−0.6μgm−3yr−1), demonstrating that interannual variability in meteorology played a minor role in the

observed PM2.5 trend. The model simulated increased ozone concentrations in line with the measurements but underestimated the magnitude of the observed absolute trend by a factor of 2. We combined simulated trends in PM2.5 concentrations with an exposure–response function to estimate that reductions in PM2.5 concentrations over this period have reduced PM2.5-attributable premature mortality across China by 150 000 deaths yr−1.

Source apportionment of PM2.5 in Shanghai based on hourly organic molecular markers and other source tracers

Rui Li1,, Qiongqiong Wang2,, Xiao He3, Shuhui Zhu3,4, Kun Zhang1, Yusen Duan5, Qingyan Fu5, Liping Qiao4, Yangjun Wang1, Ling Huang1, Li Li1, and Jian Zhen Yu2,3

Source: Atmos. Chem. Phys., 20, 12047–12061, 2020
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Identification of various emission sources and quantification of their contributions comprise an essential step in formulating scientifically sound pollution control strategies. Most previous studies have been based on traditional offline filter analysis of aerosol major components (usually inorganic ions, elemental carbon – EC, organic carbon – OC, and elements). In this study, source apportionment of PM2.5 using a positive matrix factorization (PMF) model was conducted for urban Shanghai in the Yangtze River Delta region, China, utilizing a large suite of molecular and elemental tracers, together with water-soluble inorganic ions, OC, and EC from measurements conducted at two sites from 9 November to 3 December 2018. The PMF analysis with inclusion of molecular makers (i.e., MM-PMF) identified 11 pollution sources, including 3 secondary-source factors (i.e., secondary sulfate; secondary nitrate; and secondary organic aerosol, SOA, factors) and 8 primary sources (i.e., vehicle exhaust, industrial emission and tire wear, industrial emission II, residual oil combustion, dust, coal combustion, biomass burning, and cooking). The secondary sources contributed 62.5 % of the campaign-average PM2.5 mass, with the secondary nitrate factor being the leading contributor. Cooking was a minor contributor (2.8 %) to PM2.5 mass while a significant contributor (11.4 %) to the OC mass. Traditional PMF analysis relying on major components alone (PMFt) was unable to resolve three organics-dominated sources (i.e., biomass burning, cooking, and SOA source factors). Utilizing organic tracers, the MM-PMF analysis determined that these three sources combined accounted for 24.4 % of the total PM2.5 mass. In PMFt, this significant portion of PM mass was apportioned to other sources and thereby was notably biasing the source apportionment outcome. Backward trajectory and episodic analysis were performed on the MM-PMF-resolved source factors to examine the variations in source origins and composition. It was shown that under all episodes, secondary nitrate and the SOA factor

were two major source contributors to the PM2.5 pollution. Our work has demonstrated that comprehensive hourly data of molecular markers and other source tracers, coupled with MM-PMF, enables examination of detailed pollution source characteristics, especially organics-dominated sources, at a timescale suitable for monitoring episodic evolution and with finer source breakdown.

Model bias in simulating major chemical components of PM2.5 in China

Ruqian Miao1, Qi Chen1, Yan Zheng1, Xi Cheng1, Yele Sun2, Paul I. Palmer3, Manish Shrivastava4, Jianping Guo5, Qiang Zhang6, Yuhan Liu1, Zhaofeng Tan1,7, Xuefei Ma1, Shiyi Chen1, Limin Zeng1, Keding Lu1, and Yuanhang Zhang1

Source: Atmos. Chem. Phys., 20, 12265–12284, 2020
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High concentrations of PM2.5 (particulate matter with an aerodynamic diameter less than 2.5 μm) in China have caused severe visibility degradation. Accurate simulations of PM2.5 and its chemical components are essential for evaluating the effectiveness of pollution control strategies and the health and climate impacts of air pollution. In this study, we compared the GEOS-Chem model simulations with comprehensive datasets for organic aerosol (OA), sulfate, nitrate, and ammonium in China. Model results are evaluated spatially and temporally against observations. The new OA scheme with a simplified secondary organic aerosol (SOA) parameterization significantly improves the OA simulations in polluted urban areas, highlighting the important contributions of anthropogenic SOA from semivolatile and intermediate-volatility organic compounds. The model underestimates sulfate and overestimates nitrate for most of the sites throughout the year. More significant underestimation of sulfate occurs in winter, while the overestimation of nitrate is extremely large in summer. The model is unable to capture some of the main features in the diurnal pattern of the PM2.5 chemical components, suggesting inaccuracies in the presented processes. Potential model adjustments that may lead to a better representation of the boundary layer height, the precursor emissions, hydroxyl radical concentrations, the heterogeneous formation of sulfate and nitrate, and the wet deposition of nitric acid and nitrate have been tested in the sensitivity analysis. The results show that uncertainties in chemistry perhaps dominate the model biases. The proper implementation of heterogeneous sulfate formation and the good estimates of the concentrations of sulfur dioxide, hydroxyl radical, and aerosol liquid water are essential for the improvement of the sulfate simulation. The update of the heterogeneous uptake coefficient of nitrogen dioxide significantly reduces the modeled concentrations of nitrate. However, the large overestimation of nitrate concentrations remains in summer for all tested cases. The

possible bias in the chemical production and the wet deposition of nitrate cannot fully explain the model overestimation of nitrate, suggesting issues related to the atmospheric removal of nitric acid and nitrate. A better understanding of the atmospheric nitrogen budget, in particular, the role of the photolysis of particulate nitrate, is needed for future model developments. Moreover, the results suggest that the remaining underestimation of OA in the model is associated with the underrepresented production of SOA.

Size-segregated particle number and mass concentrations from different emission sources in urban Beijing

Jing Cai1,2, Biwu Chu1,2,3,4, Lei Yao2, Chao Yan1,2, Liine M. Heikkinen1,2, Feixue Zheng1, Chang Li1, Xiaolong Fan1, Shaojun Zhang5, Daoyuan Yang5, Yonghong Wang2, Tom V. Kokkonen1,2, Tommy Chan1,2, Ying Zhou1, Lubna Dada1,2, Yongchun Liu1, Hong He3,4, Pauli Paasonen1,2, Joni T. Kujansuu1,2, Tuukka Petäjä1,2, Claudia Mohr6, Juha Kangasluoma1,2, Federico Bianchi1,2, Yele Sun7, Philip L. Croteau8, Douglas R. Worsnop2,8, Veli-Matti Kerminen1,2, Wei Du1,2, Markku Kulmala1,2, and Kaspar R. Daellenbach1,2

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Although secondary particulate matter is reported to be the main contributor of PM2.5 during haze in Chinese megacities, primary particle emissions also affect particle concentrations. In order to improve estimates of the contribution of primary sources to the particle number and mass concentrations, we performed source apportionment analyses using both chemical fingerprints and particle size distributions measured at the same site in urban Beijing from April to July 2018. Both methods resolved factors related to primary emissions, including vehicular emissions and cooking emissions, which together make up 76 % and 24 % of total particle number and organic aerosol (OA) mass, respectively. Similar source types, including particles related to vehicular emissions (1.6±1.1 µg m−3; 2.4±1.8×103 cm−3 and 5.5±2.8×103 cm−3 for two traffic-related components), cooking emissions (2.6±1.9 µg m−3 and 5.5±3.3×103 cm−3) and secondary aerosols (51±41 µg m−3 and 4.2±3.0×103 cm−3), were resolved by both methods. Converted mass concentrations from particle size distributions components were comparable with those from chemical fingerprints. Size distribution source apportionment separated vehicular emissions into a component with a mode diameter of 20 nm (“traffic-ultrafine”) and a component with a mode diameter of 100 nm (“traffic-fine”). Consistent with similar day- and nighttime diesel vehicle PM2.5 emissions estimated for the Beijing area, traffic-fine particles, hydrocarbon-like OA (HOA, traffic-related factor resulting from source apportionment using chemical

fingerprints) and black carbon (BC) showed similar diurnal patterns, with higher concentrations during the night and morning than during the afternoon when the boundary layer is higher. Traffic-ultrafine particles showed the highest concentrations during the rush-hour period, suggesting a prominent role of local gasoline vehicle emissions. In the absence of new particle formation, our results show that vehicular-related emissions (14 % and 30 % for ultrafine and fine particles, respectively) and cooking-activity-related emissions (32 %) dominate the particle number concentration, while secondary particulate matter (over 80 %) governs PM2.5 mass during the non-heating season in Beijing.

The promotion effect of nitrous acid on aerosol formation in wintertime in Beijing: the possible contribution of traffic-related emissions

Yongchun Liu1, Yusheng Zhang1, Chaofan Lian2,6, Chao Yan3, Zeming Feng1, Feixue Zheng1, Xiaolong Fan1, Yan Chen2,6, Weigang Wang2,6, Biwu Chu3,4, Yonghong Wang3, Jing Cai3, Wei Du3, Kaspar R. Daellenbach3, Juha Kangasluoma1,3, Federico Bianchi1,3, Joni Kujansuu1,3, Tuukka Petäjä3, Xuefei Wang6, Bo Hu5, Yuesi Wang5, Maofa Ge2, Hong He4, and Markku Kulmala1,3

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Secondary aerosols are a major component of PM2.5, yet their formation mechanisms in the ambient atmosphere are still unclear. Based on field measurements in downtown Beijing, we show that the photolysis of nitrous acid (HONO) may promote the formation of organic and nitrate aerosols in winter in Beijing, which is supported by the fact that the mass concentrations of organic and nitrate aerosols linearly increase as a function of HONO consumed from early morning to noon. The increased nitrate content also leads to the formation of ammonium particulate matter through enhancing the neutralization of nitrate and sulfate by ammonia. We further illustrate that during pollution events in winter in Beijing, over 50 % of the ambient HONO may be related to traffic-related emissions, including direct emissions and formation via the reaction between OH and vehicle-emitted NO. Overall, our results indicate that traffic-related HONO may play an important role in the oxidative capacity and in turn contribute to haze formation in winter in Beijing. The mitigation of HONO and NOx emissions from vehicles may be an effective way to reduce the formation of secondary aerosols and severe haze events in winter in Beijing.

Differences in the composition of organic aerosols between winter and

summer in Beijing: a study by direct-infusion ultrahigh-resolution mass spectrometry

Sarah S. Steimer1,2,a, Daniel J. Patton1, Tuan V. Vu3, Marios Panagi4,5, Paul S. Monks6, Roy M. Harrison3,7, Zoë L. Fleming4,b, Zongbo Shi3, and Markus Kalberer1,2

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This study investigates the chemical composition of PM2.5 collected at a central location in Beijing, China, during winter 2016 and summer 2017. The samples were characterised using direct-infusion negative-nano-electrospray-ionisation ultrahigh-resolution mass spectrometry to elucidate the composition and the potential primary and secondary sources of the organic fraction. The samples from the two seasons were compared with those from a road-tunnel site and an urban background site in Birmingham, UK, analysed in the course of an earlier study using the same method. There were strong differences in aerosol particle composition between the seasons, particularly regarding (poly-)aromatic compounds, which were strongly enhanced in winter, likely due to increased fossil fuel and biomass burning for heating. In addition to the seasonal differences, compositional differences between high- and low-pollution conditions were observed, with the contribution of sulfur-containing organic compounds strongly enhanced under high-pollution conditions. There was a correlation of the number of sulfur-containing molecular formulae with the concentration of particulate sulfate, consistent with a particle-phase formation process.

Sensitivity analysis of the surface ozone and fine particulate matter to meteorological parameters in China

Zhihao Shi1, Lin Huang1, Jingyi Li1, Qi Ying2, Hongliang Zhang3,4, and Jianlin Hu1

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Meteorological conditions play important roles in the formation of ozone (O3) and fine particulate matter (PM2.5). China has been suffering from serious regional air pollution problems, characterized by high concentrations of surface O3 and PM2.5. In this study, the Community Multiscale Air Quality (CMAQ) model was used to quantify the sensitivity of surface O3 and PM2.5 to key meteorological parameters in different regions of China. Six meteorological parameters were perturbed to create different meteorological conditions, including temperature (T), wind speed (WS), absolute humidity (AH), planetary boundary

layer height (PBLH), cloud liquid water content (CLW) and precipitation (PCP). Air quality simulations under the perturbed meteorological conditions were conducted in China in January and July of 2013. The changes in O3 and PM2.5 concentrations due to individual meteorological parameters were then quantified. T has a great influence on the daily maximum 8 h average O3 (O3-8 h) concentrations, which leads to O3-8 h increases by 1.7 in January in Chongqing and 1.1 ppb K−1 in July in Beijing. WS, AH, and PBLH have a smaller but notable influence on O3-8 h with maximum change rates of 0.3 ppb %−1, −0.15 ppb %−1, and 0.14 ppb %−1, respectively. T, WS, AH, and PBLH have important effects on PM2.5 formation of both in January and July. In general, PM2.5 sensitivities are negative to T, WS, and PBLH and positive to AH in most regions of China. The sensitivities in January are much larger than in July. PM2.5 sensitivity to T, WS, PBLH, and AH in January can be up to −5 μg m−3 K−1, −3 μg m−3 %−1, −1 μg m−3 %−1, and +0.6 μg m−3 %−1, respectively, and in July it can be up to −2 μg m−3 K−1, −0.4 μg m−3 %−1, −0.14 μg m−3 %−1, and +0.3 μg m−3 %−1, respectively. Other meteorological factors (CLW and PCP) have negligible effects on O3-8 h (less than 0.01 ppb %−1) and PM2.5 (less than 0.01 μg m−3 %−1). The results suggest that surface O3 and PM2.5 concentrations can change significantly due to changes in meteorological parameters, and it is necessary to consider these effects when developing emission control strategies in different regions of China.

Evaluating trends and seasonality in modeled PM2.5 concentrations using empirical mode decomposition

Huiying Luo1, Marina Astitha1, Christian Hogrefe2, Rohit Mathur2, and S. Trivikrama Rao1,3

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Regional-scale air quality models are being used for studying the sources, composition, transport, transformation, and deposition of fine particulate matter (PM2.5). The availability of decadal air quality simulations provides a unique opportunity to explore sophisticated model evaluation techniques rather than relying solely on traditional operational evaluations. In this study, we propose a new approach for process-based model evaluation of speciated PM2.5 using improved complete ensemble empirical mode decomposition with adaptive noise (improved CEEMDAN) to assess how well version 5.0.2 of the coupled Weather Research and Forecasting model–Community Multiscale Air Quality model (WRF-CMAQ) simulates the time-dependent long-term trend and cyclical variations in daily average PM2.5 and its species, including sulfate (SO4), nitrate (NO3), ammonium (NH4), chloride (Cl), organic carbon (OC), and elemental carbon (EC). The utility of the

proposed approach for model evaluation is demonstrated using PM2.5 data at three monitoring locations. At these locations, the model is generally more capable of simulating the rate of change in the long-term trend component than its absolute magnitude. Amplitudes of the sub-seasonal and annual cycles of total PM2.5, SO4, and OC are well reproduced. However, the time-dependent phase difference in the annual cycles for total PM2.5, OC, and EC reveals a phase shift of up to half a year, indicating the need for proper temporal allocation of emissions and for updating the treatment of organic aerosols compared to the model version used for this set of simulations. Evaluation of sub-seasonal and interannual variations indicates that CMAQ is more capable of replicating the sub-seasonal cycles than interannual variations in magnitude and phase.

A comparison of PM2.5-bound polycyclic aromatic hydrocarbons in summer Beijing (China) and Delhi (India)

Atallah Elzein1, Gareth J. Stewart1, Stefan J. Swift1, Beth S. Nelson1, Leigh R. Crilley2,a, Mohammed S. Alam2, Ernesto Reyes-Villegas3, Ranu Gadi4, Roy M. Harrison2,6, Jacqueline F. Hamilton1, and Alastair C. Lewis5

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Polycyclic aromatic hydrocarbons (PAHs) are ubiquitous pollutants in air, soil, and water and are known to have harmful effects on human health and the environment. The diurnal and nocturnal variations of 17 PAHs in ambient particle-bound PAHs were measured in urban Beijing (China) and Delhi (India) during the summer season using gas-chromatography–quadrupole time-of-flight mass spectrometry (GC-Q-TOF-MS). The mean concentration of particles less than 2.5 µm (PM2.5) observed in Delhi was 3.6 times higher than in Beijing during the measurement period in both the daytime and night-time. In Beijing, the mean concentration of the sum of the 17 PAHs (∑17 PAHs) was 8.2 ± 5.1 ng m−3 in daytime, with the highest contribution from indeno[1,2,3-cd]pyrene (12 %), while at night-time the total PAHs was 7.2 ± 2.0 ng m−3, with the largest contribution from benzo[b]fluoranthene (14 %). In Delhi, the mean ∑17 PAHs was 13.6 ± 5.9 ng m−3 in daytime and 22.7 ± 9.4 ng m−3 at night-time, with the largest contribution from indeno[1,2,3-cd]pyrene in both the day (17 %) and night (20 %). Elevated mean concentrations of total PAHs in Delhi observed at night were attributed to emissions from vehicles and biomass burning and to meteorological conditions leading to their accumulation from a stable and low atmospheric boundary layer. Local emission sources were typically identified as the major contributors to total measured PAHs in both cities. Major emission sources were characterized based on the contribution from each class of PAHs, with the four-, five- and six-ring PAHs accounting ~ 95 % of the total PM2.5-

bound PAHs mass in both locations. The high contribution of five-ring PAHs to total PAH concentration in summer Beijing and Delhi suggests a high contribution from petroleum combustion. In Delhi, a high contribution from six-ring PAHs was observed at night, suggesting a potential emission source from the combustion of fuel and oil in power generators, widely used in Delhi. The lifetime excess lung cancer risk (LECR) was calculated for Beijing and Delhi, with the highest estimated risk attributed to Delhi (LECR = 155 per million people), which is 2.2 times higher than the Beijing risk assessment value (LECR = 70 per million people). Finally, we have assessed the emission control policies in each city and identified those major sectors that could be subject to mitigation measures.

Quantifying the emission changes and associated air quality impacts during the COVID-19 pandemic on the North China Plain: a response modeling study

Jia Xing1,2, Siwei Li3,4, Yueqi Jiang1,2, Shuxiao Wang1,2, Dian Ding1,2, Zhaoxin Dong1,2, Yun Zhu5, and Jiming Hao1,2

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Quantification of emission changes is a prerequisite for the assessment of control effectiveness in improving air quality. However, the traditional bottom-up method for characterizing emissions requires detailed investigation of emissions data (e.g., activity and other emission parameters) that usually takes months to perform and limits timely assessments. Here we propose a novel method to address this issue by using a response model that provides real-time estimation of emission changes based on air quality observations in combination with emission-concentration response functions derived from chemical transport modeling. We applied the new method to quantify the emission changes on the North China Plain (NCP) due to the COVID-19 pandemic shutdown, which overlapped the Spring Festival (also known as Chinese New Year) holiday. Results suggest that the anthropogenic emissions of NO2, SO2, volatile organic compound (VOC) and primary PM2.5 on the NCP were reduced by 51 %, 28 %, 67 % and 63 %, respectively, due to the COVID-19 shutdown, indicating longer and stronger shutdown effects in 2020 compared to the previous Spring Festival holiday. The reductions of VOC and primary PM2.5 emissions are generally effective in reducing O3 and PM2.5 concentrations. However, such air quality improvements are largely offset by reductions in NOx emissions. NOx emission reductions lead to increases in O3 and PM2.5 concentrations on the NCP due to the strongly VOC-limited conditions in winter. A strong NH3-rich condition is also

suggested from the air quality response to the substantial NOx emission reduction. Well-designed control strategies are recommended based on the air quality response associated with the unexpected emission changes during the COVID-19 period. In addition, our results demonstrate that the new response-based inversion model can well capture emission changes based on variations in ambient concentrations and thereby illustrate the great potential for improving the accuracy and efficiency of bottom-up emission inventory methods.

Amplification of South Asian haze by water vapour–aerosol interactions

Vijayakumar Sivadasan Nair1, Filippo Giorgi2, and Usha Keshav Hasyagar1,3

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Air pollution and wintertime fog over South Asia is a major concern due to its significant implications for air quality, visibility and health. Using a regional climate model coupled with chemistry, we assess the contribution of the hygroscopic growth of aerosols (ambient–dry) to the total aerosol optical depth and demonstrate that the increased surface cooling due to the hygroscopic effects of aerosols further increases the humidity in the boundary layer and thus enhances the confinement of pollutants through aerosol–boundary layer interactions. This positive feedback mechanism plays an important role in the prevalence of wintertime fog and poor air quality conditions over South Asia, where water vapour contributes more than half of the aerosol optical depth. The aerosol–boundary layer interactions lead to moistening of the boundary layer and drying of the free troposphere, which amplifies the long-term trend in relative humidity over the Indo-Gangetic Plain during winter. Hence, the aerosol–water vapour interaction plays a decisive role in the formation and maintenance of the wintertime fog conditions over South Asia, which needs to be considered for planning mitigation strategies.

Air quality impact of the Northern California Camp Fire of November 2018

Brigitte Rooney1, Yuan Wang1,2, Jonathan H. Jiang2, Bin Zhao3, Zhao-Cheng Zeng4, and John H. Seinfeld5

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The Northern California Camp Fire that took place in November 2018 was one of the most damaging environmental events in California history. Here, we analyze ground-based

station observations of airborne particulate matter that has a diameter <2.5 μm (PM2.5) across Northern California and conduct numerical simulations of the Camp Fire using the Weather Research and Forecasting model online coupled with chemistry (WRF-Chem). Simulations are evaluated against ground-based observations of PM2.5, black carbon, and meteorology, as well as satellite measurements, such as Tropospheric Monitoring Instrument (TROPOMI) aerosol layer height and aerosol index. The Camp Fire led to an increase in Bay Area PM2.5 to over 50 μg m−3 for nearly 2 weeks, with localized peaks exceeding 300 μg m−3. Using the Visible Infrared Imaging Radiometer Suite (VIIRS) high-resolution fire detection products, the simulations reproduce the magnitude and evolution of surface PM2.5 concentrations, especially downwind of the wildfire. The overall spatial patterns of simulated aerosol plumes and their heights are comparable with the latest satellite products from TROPOMI. WRF-Chem sensitivity simulations are carried out to analyze uncertainties that arise from fire emissions, meteorological conditions, feedback of aerosol radiative effects on meteorology, and various physical parameterizations, including the planetary boundary layer model and the plume rise model. Downwind PM2.5 concentrations are sensitive to both flaming and smoldering emissions over the fire, so the uncertainty in the satellite-derived fire emission products can directly affect the air pollution simulations downwind. Our analysis also shows the importance of land surface and boundary layer parameterization in the fire simulation, which can result in large variations in magnitude and trend of surface PM2.5. Inclusion of aerosol radiative feedback moderately improves PM2.5 simulations, especially over the most polluted days. Results of this study can assist in the development of data assimilation systems as well as air quality forecasting of health exposures and economic impact studies.

Significant wintertime PM2.5 mitigation in the Yangtze River Delta, China, from 2016 to 2019: observational constraints on anthropogenic emission controls

Liqiang Wang1, Shaocai Yu1,2, Pengfei Li3,1, Xue Chen1, Zhen Li1, Yibo Zhang1, Mengying Li1, Khalid Mehmood1, Weiping Liu1, Tianfeng Chai4, Yannian Zhu5, Daniel Rosenfeld6, and John H. Seinfeld2

Source: Atmos. Chem. Phys., 20, 14787–14800, 2020
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Ambient fine particulate matter (PM2.5) mitigation relies strongly on anthropogenic emission control measures, the actual effectiveness of which is challenging to pinpoint owing to the complex synergies between anthropogenic emissions and meteorology. Here, observational constraints on model simulations allow us to derive not only reliable PM2.5 evolution but also accurate meteorological fields. On this basis, we isolate meteorological

factors to achieve reliable estimates of surface PM2.5 responses to both long-term and emergency emission control measures from 2016 to 2019 over the Yangtze River Delta (YRD), China. The results show that long-term emission control strategies play a crucial role in curbing PM2.5 levels, especially in the megacities and other areas with abundant anthropogenic emissions. The G20 summit hosted in Hangzhou in 2016 provides a unique and ideal opportunity involving the most stringent, even unsustainable, emergency emission control measures. These emergency measures lead to the largest decrease (~ 35 μg m−3, ~ 59 %) in PM2.5 concentrations in Hangzhou. The hotspots also emerge in megacities, especially in Shanghai (32 μg m−3, 51 %), Nanjing (27 μg m−3, 55 %), and Hefei (24 μg m−3, 44 %) because of the emergency measures. Compared to the long-term policies from 2016 to 2019, the emergency emission control measures implemented during the G20 Summit achieve more significant decreases in PM2.5 concentrations (17 μg m−3 and 41 %) over most of the whole domain, especially in Hangzhou (24 μg m−3, 48 %) and Shanghai (21 μg m−3, 45 %). By extrapolation, we derive insight into the magnitude and spatial distribution of PM2.5 mitigation potential across the YRD, revealing significantly additional room for curbing PM2.5 levels.

The warming Tibetan Plateau improves winter air quality in the Sichuan Basin, China

Shuyu Zhao1, Tian Feng2, Xuexi Tie1,3, and Zebin Wang4

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Impacts of global climate change on the occurrence and development of air pollution have attracted more attention. This study investigates impacts of the warming Tibetan Plateau on air quality in the Sichuan Basin. Meteorological observations and ERA-Interim reanalysis data reveal that the plateau has been rapidly warming during the last 40 years (1979–2017), particularly in winter when the warming rate is approximately twice as much as the annual warming rate. Since 2013, the winter temperature over the plateau has even risen by 2 ∘C. Here we use the WRF-Chem model to lay emphasis on the impact of the 2 ∘C warming on air quality in the basin. The model results show that the 2 ∘C warming causes an enhanced easterly wind, an increase in the planetary boundary layer height (PBLH) and a decrease in the relative humidity (RH) in the basin. Enhanced easterly wind increases PM2.5 transport from the basin to the plateau. The elevated PBLH strengthens vertical diffusion of PM2.5, while the decreased RH significantly reduces secondary aerosol formation. Overall, PM2.5 concentration is reduced by 17.5 % (~25.1 μg m−3), of which the reduction in primary and secondary aerosols is 5.4 and 19.7 μg m−3, respectively. These results reveal that the recent warming plateau has improved air quality in the basin, to a

certain extent mitigating the air pollution therein. Nevertheless, the climate system is particularly complicated, and more studies are needed to demonstrate the impact of climate change on air quality in the downstream regions as the plateau is likely to continue warming.

Elevated dust layers inhibit dissipation of heavy anthropogenic surface air pollution

Zhuang Wang1,2, Cheng Liu2,3,1,6,7, Zhouqing Xie4,3,1,7, Qihou Hu1, Meinrat O. Andreae8,9, Yunsheng Dong1, Chun Zhao5, Ting Liu5, Yizhi Zhu1,2, Haoran Liu11, Chengzhi Xing1, Wei Tan1,2, Xiangguang Ji10, Jinan Lin1,2, and Jianguo Liu1,3

Source: Atmos. Chem. Phys., 20, 14917–14932, 2020
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Persistent wintertime heavy haze incidents caused by anthropogenic aerosols have repeatedly shrouded North China in recent years, while natural dust from the west and northwest of China also frequently affects air quality in this region. Through continuous observation by a multi-wavelength Raman lidar, here we found that wintertime aerosols in North China are typically characterized by a pronounced vertical stratification, where scattering nonspherical particles (dust or mixtures of dust and anthropogenic aerosols) dominated above the planetary boundary layer (PBL), and absorbing spherical particles (anthropogenic aerosols) prevailed within the PBL. This stratification is governed by meteorological conditions that strong northwesterly winds usually prevailed in the lower free troposphere, and southerly winds dominated in the PBL, producing persistent and intense haze pollution. With the increased contribution of elevated dust to the upper aerosols, the proportion of aerosol and trace gas at the surface in the whole column increased. Model results show that, besides directly deteriorating air quality, the key role of the elevated dust is to depress the development of PBL and weaken the turbulent exchange, mostly by lower level cooling and upper level heating, and it is more obvious during the dissipation stage, thus inhibiting the dissipation of heavy surface anthropogenic aerosols. The interactions of natural dust and anthropogenic aerosols under the unique topography of North China increase the surface anthropogenic aerosols and precursor gases, which may be one of the reasons why haze pollution in North China is heavier than that in other heavily polluted areas in China.

Measurement report: Seasonality, distribution and sources of organophosphate esters in PM2.5 from an inland urban city in Southwest China

Hongling Yin, Jinfeng Liang, Di Wu, Shiping Li, Yi Luo, and Xu Deng

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Organophosphate esters (OPEs) are contaminants of emerging concern, and studies have concluded that urban areas are a significant source of OPEs. Samples were collected from six ground-based sites located in Chengdu, a typical rapidly developing metropolitan area in Southwest China, and were analyzed for seven OPEs in atmospheric PM2.5 (Σ7 OPEs). The concentrations of Σ7 OPEs in PM2.5 ranged from 5.83 to 6.91 ng m−3, with a mean of 6.6 ± 3.3 ng m−3, and the primary pollutants were tris-(2-butoxyethyl) phosphate (TBEP), tri-n-butyl phosphate (TnBP), tris-(2-chloroethyl) phosphate (TCEP) and tris-(2-chloroisopropyl) phosphate (TCPP), which together made up more than 80 % of the Σ7 OPEs. The concentrations of Σ7 OPEs were higher in autumn and winter than in summer. Nonparametric tests showed that there was no significant difference in Σ7 OPE concentrations among the six sampling sites, but the occurrence of unexpectedly high levels of individual OPEs at different sites in autumn might indicate noteworthy emissions. A very strong correlation ($R2 = 0.98$, $p < 0.01$) between the OPEs in soil and in PM2.5 was observed. Backward trajectory analysis indicated that the OPEs in PM2.5 were mainly affected by local sources. Principal component analysis (PCA) revealed that the OPEs in PM2.5 were largely sourced from the plastics industry, interior decoration and traffic emission (34.5 %) and the chemical, mechanical and electrical industries (27.8 %), while the positive matrix factorization (PMF) model revealed that the main sources were the plastics industry and indoor source emissions, the food and cosmetics industry and industrial emissions. In contrast to coastal cities, sustained and stable high local emissions in the studied inland city were identified, which is particularly noteworthy. Chlorinated phosphates, especially TCPP and TCEP, had a high content, and their usage and source emissions should be controlled.

Study on the impact of three Asian industrial regions on PM2.5 in Taiwan and the process analysis during transport

Ming-Tung Chuang1, Maggie Chel Gee Ooi2, Neng-Huei Lin3, Joshua S. Fu4, Chung-Te Lee5, Sheng-Hsiang Wang3, Ming-Cheng Yen3, Steven Soon-Kai Kong3, and Wei-Syun Huang3

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The outflow of the East Asian haze (EAH) has attracted much attention in recent years. For downstream areas, it is meaningful to understand the impact of crucial upstream sources

and the process analysis during transport. This study evaluated the impact of PM2.5 from the three largest industrial regions on the Asian continent, namely the Bohai Rim industrial region (BRIR), Yangtze River Delta industrial region (YRDIR), and Pearl River Delta industrial region (PRDIR), in Taiwan and discussed the processes during transport with the help of air quality modeling. The simulation results revealed that the contributions of monthly average PM2.5 from BRIR and YRDIR were 0.7–1.1 and 1.2–1.9 μg m−3 (~ 5 % and 7.5 % of the total concentration) in Taiwan, respectively, in January 2017. When the Asian anticyclone moved from the Asian continent to the western Pacific, e.g., on 9 January 2017, the contributions from BRIR and YRDIR to northern Taiwan could reach daily averages of 8 and 11 μg m−3. The transport of EAH from BRIR and YRDIR to low-latitude regions was horizontal advection (HADV), vertical advection (ZADV), and vertical diffusion (VDIF) over the Bohai Sea and East China Sea. Over the Taiwan Strait and the northern South China Sea, cloud processes (CLDS) were the major contribution to PM2.5 due to a high relative humidity environment. Along the transport from high-latitude regions to low-latitude regions, aerosol chemistry (AERO) and dry deposition (DDEP) were the major removal processes. When the EAH intruded into northern Taiwan, the major processes for the gains of PM2.5 in northern Taiwan were HADV and AERO. The stronger the EAH, the more the EAH could influence central and southern Taiwan. Although PRDIR is located downstream of Taiwan under northeasterly wind, the PM2.5 from PRDIR could be lifted upward above the boundary layer, allowing it to move eastwards. When the PM2.5 plume moved over Taiwan and was blocked by mountains, PM2.5 could be transported downward, via boundary layer mixing (VDIF), as it was further enhanced by the passing cold surge. In contrast, for the simulation of July 2017, the influence from the three industrial regions was almost negligible unless there was a special weather system, such as thermal lows which may have carried pollutants from PRDIR to Taiwan, but this occurrence was rare.

Role of ammonia in European air quality with changing land and ship emissions between 1990 and 2030

Sebnem Aksoyoglu1, Jianhui Jiang1, Giancarlo Ciarelli2, Urs Baltensperger1, and André S. H. Prévôt1

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The focus of this modeling study is on the role of ammonia in European air quality in the past as well as in the future. Ammonia emissions have not decreased as much as the other

secondary inorganic aerosol (SIA) precursors – nitrogen oxides (NOx) and sulfur dioxide (SO2) – since the 1990s and are still posing problems for air quality and the environment. In this study, air quality simulations were performed with a regional chemical transport model at decadal intervals between 1990 and 2030 to understand the changes in the chemical species associated with SIA under varying land and ship emissions. We analyzed the changes in air concentrations of ammonia, nitric acid, ammonium, particulate nitrate and sulfate as well as changes in the dry and wet deposition of ammonia and ammonium. The results show that the approximately 40 % decrease in SIA concentrations between 1990 and 2010 was mainly due to reductions in NOx and SO2 emissions. The ammonia concentrations on the other hand decreased only near the high-emission areas such as the Netherlands and northern Italy by about 30 %, while there was a slight increase in other parts of Europe. Larger changes in concentrations occurred mostly during the first period (1990–2000). The model results indicate a transition period after 2000 for the composition of secondary inorganic aerosols due to a larger decrease in sulfate concentrations than nitrate. Changes between 2010 and 2030 – assuming the current legislation (CLE) scenario – are predicted to be smaller than those achieved earlier for all species analyzed in this study. The scenario simulations suggest that if ship emissions will be regulated more strictly in the future, SIA formation will decrease especially around the Benelux area, North Sea, Baltic Sea, English Channel and the Mediterranean region, leaving more ammonia in the gas phase, which would lead to an increase in dry deposition. In the north of the domain, the decrease in SIA would be mainly due to reduced formation of particulate nitrate, while the change around the Mediterranean would be caused mainly by decreased sulfate aerosol concentrations. One should also keep in mind that potentially higher temperatures in the future might increase the evaporation of ammonium nitrate to form its gaseous components NH3 and HNO3. Sensitivity tests with reduced NOx and NH3 emissions indicate a shift in the sensitivity of aerosol formation from NH3 towards NOx emissions between 1990 and 2030 in most of Europe except the eastern part of the model domain.

What can we learn about urban air quality with regard to the first outbreak of the COVID-19 pandemic? A case study from central Europe

Imre Salma1, Máté Vörösmarty1, András Zénó Gyöngyösi1, Wanda Thén2, and Tamás Weidinger3

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Motor vehicle road traffic in central Budapest was reduced by approximately 50 % of its ordinary level for several weeks as a consequence of various limitation measures

introduced to mitigate the first outbreak of the COVID-19 pandemic in 2020. The situation was utilised to assess the real potentials of urban traffic on air quality. Concentrations of NO, NO2, CO, O3, SO2 and particulate matter (PM) mass, which are ordinarily monitored in cities for air quality considerations, aerosol particle number size distributions, which are not rarely measured continuously on longer runs for research purposes, and meteorological properties usually available were collected and jointly evaluated in different pandemic phases. The largest changes occurred over the severest limitations (partial lockdown in the Restriction phase from 28 March to 17 May 2020). Concentrations of NO, NO2, CO, total particle number (N6–1000) and particles with a diameter < 100 nm declined by 68 %, 46 %, 27 %, 24 % and 28 %, respectively, in 2020 with respect to the average reference year comprising 2017–2019. Their quantification was based on both relative difference and standardised anomaly. The change rates expressed as relative concentration difference due to relative reduction in traffic intensity for NO, NO2, N6–1000 and CO were 0.63, 0.57, 0.40 and 0.22 (%/%), respectively. Of the pollutants which reacted in a sensitive manner to the change in vehicle circulation, it is the NO2 that shows the most frequent exceedance of the health limits. Intentional tranquillising of the vehicle flow has considerable potential for improving the air quality. At the same time, the concentration levels of PM10 mass, which is the most critical pollutant in many European cities including Budapest, did not seem to be largely affected by vehicles. Concentrations of O3 concurrently showed an increasing tendency with lower traffic, which was explained by its complex reaction mechanism. Modelling calculations indicated that spatial gradients of NO and NO2 within the city became further enhanced by reduced vehicle flow.

UK surface NO2 levels dropped by 42 % during the COVID-19 lockdown: impact on surface O3

James D. Lee1, Will S. Drysdale1, Doug P. Finch2, Shona E. Wilde1, and Paul I. Palmer2

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We report changes in surface nitrogen dioxide (NO2) across the UK during the COVID-19 pandemic when large and rapid emission reductions accompanied a nationwide lockdown (23 March–31 May 2020, inclusively), and compare them with values from an equivalent period over the previous 5 years. Data are from the Automatic Urban and Rural Network (AURN), which forms the basis of checking nationwide compliance with ambient air quality directives. We calculate that NO2 reduced by 42 %±9.8 % on average across all 126 urban AURN sites, with a slightly larger (48 %±9.5 %) reduction at sites close to the roadside (urban traffic). We also find that ozone (O3) increased by 11 % on average across the urban background network during the lockdown period. Total oxidant levels (Ox=NO2+O3)

increased only slightly on average (3.2 %±0.2 %), suggesting the majority of this change can be attributed to photochemical repartitioning due to the reduction in NOx. Generally, we find larger, positive Ox changes in southern UK cities, which we attribute to increased UV radiation and temperature in 2020 compared to previous years. The net effect of the NO2 and O3 changes is a sharp decrease in exceedances of the NO2 air quality objective limit for the UK, with only one exceedance in London in 2020 up until the end of May. Concurrent increases in O3 exceedances in London emphasize the potential for O3 to become an air pollutant of concern as NOx emissions are reduced in the next 10–20 years.

Effects of air pollution on cardiopulmonary disease in urban and peri-urban residents in beijing: protocol for the AIRLESS study

Yiqun Han1,2, Wu Chen1, Lia Chatzidiakou3, Anika Krause3, Li Yan2, Hanbin Zhang2, Queenie Chan2,4, Ben Barratt2, Rod Jones3, Jing Liu5, Yangfeng Wu6,7, Meiping Zhao8, Junfeng Zhang9, Frank J. Kelly2, Tong Zhu1, and the AIRLESS team

Source: Atmos. Chem. Phys., 20, 15775–15792, 2020
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Beijing, as a representative megacity in China, is experiencing some of the most severe air pollution episodes in the world, and its fast urbanization has led to substantial urban and peri-urban disparities in both health status and air quality. Uncertainties remain regarding the possible causal links between individual air pollutants and health outcomes, with spatial comparative investigations of these links lacking, particularly in developing megacities. In light of this challenge, Effects of AIR pollution on cardiopuLmonary disEaSe in urban and peri-urban reSidents in Beijing (AIRLESS) was initiated, with the aim of addressing the complex issue of relating multi-pollutant exposure to cardiopulmonary outcomes. This paper presents the novel methodological framework employed in the project, namely (1) the deployment of two panel studies from established cohorts in urban and peri-urban Beijing, with different exposure settings regarding pollution levels and diverse sources; (2) the collection of detailed measurements and biomarkers of participants from a nested case (hypertensive) and control (healthy) study setting; (3) the assessment of indoor and personal exposure to multiple gaseous pollutants and particulate matter at unprecedented spatial and temporal resolution with validated novel sensor technologies; (4) the assessment of ambient air pollution levels in a large-scale field campaign, particularly the chemical composition of particulate matter. Preliminary results showed that there is a large difference between ambient and personal air pollution levels, and the differences varied between seasons and locations. These large differences were reflected on the different health responses between the two panels.

A foehn-induced haze front in Beijing: observations and implications

Ju Li1, Zhaobin Sun1, Donald H. Lenschow2, Mingyu Zhou3, Youjun Dou1, Zhigang Cheng1, Yaoting Wang1, and Qingchun Li1

Source: Atmos. Chem. Phys., 20, 15793–15809, 2020
https://doi.org/10.5194/acp-20-15793-2020

Despite frequent foehns in the Beijing–Tianjin–Hebei (BTH) region, there are only a few studies of their effects on air pollution in this region, or elsewhere. Here, we discuss a foehn-induced haze front (HF) event using observational data to document its structure and evolution. Using a dense network of comprehensive measurements in the BTH region, our analyses indicate that the foehn played an important role in the formation of the HF with significant impacts on air pollution. Northerly warm–dry foehn winds, with low particulate concentration in the northern area, collided with a cold–wet polluted air mass to the south and formed an HF in the urban area. The HF, which is associated with a surface wind convergence line and distinct contrasts of temperature, humidity and pollutant concentrations, resulted in an explosive growth of particulate concentration. As the plain–mountain wind circulation was overpowered by the foehn, a weak pressure gradient due to the different air densities between air masses was the main factor forcing advances of the polluted air mass into the clean air mass, resulting in severe air pollution over the main urban areas. Our results show that the foehn can affect air pollution through two effects: direct wind transport of air pollutants, and altering the air mass properties to inhibit boundary layer growth and thus indirectly aggravating air pollution. This study highlights the need to further investigate the foehn and its impacts on air pollution in the BTH region.

Measurement report: dual-carbon isotopic characterization of carbonaceous aerosol reveals different primary and secondary sources in Beijing and Xi'an during severe haze events

Haiyan Ni1,2, Ru-Jin Huang1,3, Max M. Cosijn2, Lu Yang1, Jie Guo1, Junji Cao1, and Ulrike Dusek2

Source: Atmos. Chem. Phys., 20, 16041–16053, 2020
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To mitigate haze pollution in China, a better understanding of the sources of carbonaceous aerosols is required due to the complexity in multiple emissions and atmospheric processes. Here we combined the analysis of radiocarbon and the stable isotope 13C to investigate the sources and formation of carbonaceous aerosols collected in two Chinese megacities (Beijing and Xi'an) during severe haze events of a “red alarm” level from

December 2016 to January 2017. The haze periods with daily PM2.5 concentrations as high as ~ 400 µg m−3 were compared to subsequent clean periods (i.e., PM2.5 less than median concentrations during the winter 2016/2017) with PM2.5 concentrations below 100 µg m−3 in Xi'an and below 20 µg m−3 in Beijing. In Xi'an, liquid fossil fuel combustion was the dominant source of elemental carbon (EC; 44 %–57 %), followed by biomass burning (25 %–29 %) and coal combustion (17 %–29 %). In Beijing, coal combustion contributed 45 %–61 % of EC, and biomass burning (17 %–24 %) and liquid fossil fuel combustion (22 %–33 %) contributed less. Non-fossil sources contributed 51 %–56 % of organic carbon (OC) in Xi'an, and fossil sources contributed 63 %–69 % of OC in Beijing. Secondary OC (SOC) was largely contributed by non-fossil sources in Xi'an (56±6 %) and by fossil sources in Beijing (75±10 %), especially during haze periods. The fossil vs. non-fossil contributions to OC and EC did not change drastically during haze events in both Xi'an and Beijing. However, compared to clean periods, the contribution of coal combustion to EC during haze periods increased in Xi'an and decreased in Beijing. During clean periods, primary OC from biomass burning and fossil sources constituted ~ 70 % of OC in Xi'an and ~ 53 % of OC in Beijing. From clean to haze periods, the contribution of SOC to total OC increased in Xi'an but decreased in Beijing, suggesting that the contribution of secondary organic aerosol formation to increased OC during haze periods was more efficient in Xi'an than in Beijing. In Beijing, the high SOC fraction in total OC during clean periods was mainly due to an elevated contribution from non-fossil SOC. In Xi'an, a slight day–night difference was observed during the clean period with enhanced fossil contributions to OC and EC during the day. This day–night difference was negligible during severe haze periods, likely due to the enhanced accumulation of pollutants under stagnant weather conditions.

Emission factors for PM10 and polycyclic aromatic hydrocarbons (PAHs) from illegal burning of different types of municipal waste in households

András Hoffer1, Beatrix Jancsek-Turóczi2, Ádám Tóth2, Gyula Kiss1,2, Anca Naghiu3, Erika Andrea Levei3, Luminita Marmureanu4, Attila Machon5, and András Gelencsér1,2

Source: Atmos. Chem. Phys., 20, 16135–16144, 2020
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It is a common practice in developing countries and in some regions of Europe that solid wastes generated in households (e.g. plastic beverage packaging and other plastic wastes, textile wastes, fibreboards, furniture, tyres, and coloured-paper waste) are burned in wood- or coal-fired stoves during the winter months. In Europe, the types and volume of municipal waste burned in households is virtually unknown because these activities are illegal and not recorded, with the exception of a few media reports or court cases. Even though particulate emissions from illegal waste burning pose a significant hazard to human health due to the combination of excessive emission factors (EFs) and uncontrolled

chemical composition, there is scarce information on the specific EFs for PM10 and polycyclic aromatic hydrocarbons (PAHs) in the scientific literature. In this work, controlled combustion tests were performed with 12 different types of municipal solid waste, and particulate emissions were measured and collected for chemical analysis. Absolute EFs for PM10 and PAHs as well as the benzo(a)pyrene (BaP) toxicity equivalent of the latter are reported for the first time for the indoor combustion of 12 common types of municipal solid waste that are frequently burned in households worldwide. It was found that the PM10 emission factors from the combustion of wood-based waste samples were about twice that of firewood, whereas EFs in the range of 11–82 mg g−1 (a factor of 5–40 times higher than that of dry firewood under the same conditions) were obtained for different types of plastic waste. The latter were also found to emit exceptionally high quantities of PAHs, by a factor of 50–750 more than upon the combustion of dry firewood under the same conditions. Since the more toxic 4–6 ring PAHs were predominant in the particulate emission from plastic waste burning, BaP equivalent toxicity was up to 4100 times higher than that from wood combustion.

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3. Atmospheric Environment - 3.629

A comprehensive analysis of the spatio-temporal variation of urban air pollution in China during 2014–2018

Hao Fan Chuanfeng Zhao Yikun Yang

Source: Atmospheric Environment, Volume 220, 1 January 2020, 117066

Air pollution has been a serious environmental problem in China that damages human health and causes climate change. While air pollution has been extensively investigated, few studies have provided systematic research on the recent space-time changes in air pollution components, including the AQI, CO, O3, NO2, SO2, PM10 and PM2.5, over all of China. Based on the national air quality ground observation database, with data from more than 300 cities from May 2014 to December 2018, this study provides a comprehensive analysis of the characteristics and temporal trends of air pollution over the 7 classified regions in China. Compared to 2014, there are significant decreases of air pollutants in 2018, which are 16% AQI, 25% CO, 20% NO2, 52% SO2, 20% PM10, and 28% PM2.5. The constant improvement of air quality is mainly associated with rigorous emission control acts in China, along with the changes of meteorology. In contrast, O3 maximum daily 8 h average (O3MDA8) continuously increased at an average rate of 4.6% per year during the study period. The air pollution components demonstrate distinct differences in spatial distribution, with high values of CO in North China and Northwest China, NO2 in North China and East China, PM10 in Northwest China, PM2.5 in North China and Central China,

and SO2 in North China and Northeast China. Generally, air pollution is most serious in the North China Plain and in cities in central and western Xinjiang Province. Causes for these spatial distributions have been discussed from the perspective of emissions.

Keywords: Air pollution; Spatio-temporal analysis; Particulate matter; Emission control; China.

Tower observed vertical distribution of PM2.5, O3 and NOx in the Pearl River Delta

LeiLi a f ChaoLu a Pak-WaiChan b XuanZhang c Hong-LongYang a Zi-JuanLandWen-HaiZhang e Yue-WeiLiu c LauraPan c LiZhang a

Source: Atmospheric Environment, Volume 220, 1 January 2020, 117083

The vertical structure characteristics of the concentrations of PM2.5, O3 and NOx are analyzed in conjunction with the meteorological data collected in December 2017 from a new meteorology tower in the Pearl River Delta region. The results show that: (1) The concentration of PM2.5 generally decreased with height, while the magnitude of the decrease differed between the polluted and the clean situations. The concentration of O3 increased with height, and it increased more drastically during the polluted days than during the clean days. The vertical distribution of NOx concentration was quite similar to that of PM2.5, while the gradient of NOx concentration was much steeper below 220 m and was more gentle over 220 m. (2) The diurnal cycles of PM2.5 were different at different heights, while the diurnal cycles of O3 and NOx were similar at all heights. A diurnal pattern with a single peak appearing during 14:00 to 16:00 Local Standard Time was observed for PM2.5 at higher altitudes (220 m and 335 m), hinting that the secondary formation contributed significantly to PM2.5 at higher layers. (3) The correlation coefficients between PM2.5 and O3 were weak near the ground but increased with height and maintained their positive values. O3 and NOx were generally negatively correlated, and the correlation coefficients between the two pollutants decreased with height. The correlation between PM2.5 and NOx was always significant at all heights of the observation.

Keywords: PM2.5; O3; NOx; Vertical distribution; Shenzhen meteorology tower.

Characteristics and provenance implications of rare earth elements and

Sr–Nd isotopes in PM2.5 aerosols and PM2.5 fugitive dusts from an inland city of southeastern China

YuYan a, QuanZheng a, Rui-lianYu a, Gong-renHu a, b Hua-binHuang b, Cheng-qiLin b, Jian-yongCui c, YanYan c

Source: Atmospheric Environment, Volume 220, 1 January 2020, 117069

The chemical profiles of PM2.5 aerosols and PM2.5 fugitive dusts have been widely investigated in many cities; however, the characteristics and provenance implications of rare earth elements (REEs) and Sr–Nd isotopes have seldom been reported for PM2.5 aerosols and PM2.5 fugitive dusts. In this study, PM2.5 aerosol and PM2.5 fugitive (road, construction, and soil) dust samples were collected in Nanchang city, China, and analyzed for the characteristics and provenance implications via REEs and Sr–Nd isotopes. PM2.5 aerosol samples showed significantly higher ΣREE values (510.5 ± 347.4 mg kg−1) than PM2.5 fugitive dust samples (93.83 ± 35.23 mg kg−1 for road dust PM2.5, 185.0 ± 70.90 mg kg−1 for construction dust PM2.5, and 206.5 ± 34.28 mg kg−1 for soil dust PM2.5). Both the REE characteristic parameters and the chondrite-normalized REE distribution patterns indicated LREE enrichment and obvious negative Eu anomalies in both PM2.5 aerosol and fugitive dust samples. As shown in 87Sr/86Sr versus εNd(0) plot and ΣLREE/ΣHREE-Eu/Eu*-εNd(0) plot, the REEs in the PM2.5 fugitive dust samples were mainly affected by coal combustion, steelworks and construction cements and were also influenced by the background soil to some extent, while the REEs in the PM2.5 aerosol samples likely originated from both the investigated local sources and other nonlocal potential sources.

Keywords: PM2.5; Rare earth elements; Provenance composition; Sr–Nd isotope; Nanchang city.

Simulation of the responses of rainstorm in the Yangtze River Middle Reaches to changes in anthropogenic aerosol emissions

YongqingBai a, HaixiaQi a, TianliangZhao b, YueZhou a, LinLiuaJieXiong a, ZhiminZhou a, ChunguangCui a

Source: Atmospheric Environment, Volume 220, 1 January 2020, 117081

The model WRF-Chem sensitivity simulation experiments with changing intensity of anthropogenic emissions sources were applied to simulate a rainstorm process in the Yangtze River Middle Reaches (YRMR) during June 18–19, 2018 to study the responses of clouds and precipitation in the rainstorm to changes in aerosol concentrations in this

region. The simulation experiments revealed that the aerosol-cloud interaction during low and high emission phases tended to inhibit and to enhance the precipitation process with the precipitation peak lagging 1–2 h. In the later period of rainstorm, high concentrations of aerosols improved precipitation efficiency significantly, resulting in more centralized clusters of intense precipitation. The cloud droplet number concentrations and cloud water contents demonstrated an increasing logarithmic relationship with increasing PM2.5 concentrations. The PM2.5 concentration of about 25 μg/m3 was estimated as the response threshold of cloud droplet number concentrations from sharp to smooth changes. Before and after the peak precipitation, the relationship between the average precipitation rates and PM2.5 concentrations presented an inverse power function. Aerosol-induced precipitation changes were sensitive to ambient relative humidity (RH). When 80% ≤ RH < 85%, the response of precipitation to aerosol emissions was in equilibrium. When RH < 80% or RH > 85% increasing anthropogenic aerosol emissions tended to inhibit or enhance precipitation, especially in the case of low (high) aerosol emissions.

Keywords: Yangtze River Middle Reaches; Anthropogenic aerosol emissions; Rainstorm; Aerosol-cloud interaction; WRF-Chem.

Excitation emission matrix fluorescence spectroscopy for combustion generated particulate matter source identification

Jay W. Rutherford a, NealDawson-Elli a, Anne M.Manicone e, Gregory V.Korshin b, Igor V.Novosselov b, Edmund Seto d, Jonathan D.Posner a b c

Source: Atmospheric Environment, Volume 220, 1 January 2020, 117065

The inhalation of particulate matter (PM) is a significant health risk associated with reduced life expectancy due to increased cardio-pulmonary disease and exacerbation of respiratory diseases such as asthma and pneumonia. PM originates from natural and anthropogenic sources including combustion engines, cigarettes, agricultural burning, and forest fires. Identifying the source of PM can inform effective mitigation strategies and policies, but this is difficult to do using current techniques. Here we present a method for identifying PM source using excitation emission matrix (EEM) fluorescence spectroscopy and a machine learning algorithm. We collected combustion generated PM2.5 from wood burning, diesel exhaust, and cigarettes using filters. Filters were weighted to determine mass concentration followed by extraction into cyclohexane and analysis by EEM fluorescence spectroscopy. Spectra obtained from each source served as training data for a convolutional neural network (CNN) used for source identification in mixed samples. This method can predict the presence or absence of the three laboratory sources with an overall accuracy of 89% when the threshold for classifying a source as present is 1.1 μg/m3 in air

over a 24-h sampling time. The limit of detection for cigarette, diesel and wood are 0.7, 2.6, 0.9 μg/m3, respectively, in air assuming a 24-h sampling time at an air sampling rate of 1.8 L per minute. We applied the CNN algorithm developed using the laboratory training data to a small set of field samples and found the algorithm was effective in some cases but would require a training data set containing more samples to be more broadly applicable.

Keywords: Fluorescence; Source apportionment; Particulate matter; Diesel; Woodsmoke; Neural network.

Source apportionment of airborne particulate matters over the Athabasca oil sands region: Inter-comparison between PMF modeling and ground-based remote sensing

Zhenyu Xing Ying Xiong Ke Du

Source: Atmospheric Environment, Volume 221, 15 January 2020, 117103

The airborne particulate matters (PM) emissions associated with oil sands mining and processing operations in Athabasca oil sands regions (AOSR) could impact ambient air quality. But to what scales the effects could geographically reach remains unclear. The study was conducted to investigate the geographical influence of PM emissions within the AOSR at three sampling sites. The first site is sandwiched by oil sands mining and processing facilities. The second site is an urban site and close to the oil sands mining and processing areas. The third site is a remote rural site. Over the 2-year period (2015 and 2016), the observed geometric mean PM2.5 concentrations at Fort McKay (in AOSR), Fort McMurray (near AOSR), and Anzac (far away from AOSR) were 4.81, 5.89, and 3.30 μg/m3, respectively. The temporal variations of PM2.5 showed more elevated concentrations in spring and summer than winter and fall, which was consistent with the aerosol optical depth (AOD) observation. The Positive Matrix Factorization (PMF) modeling results at the above three sites suggest that anthropogenic sources were the dominant contributors of ambient aerosol concentrations within AOSR. According to the depleted vanadium (V) content in the surface dust factor from near AOSR site to remote site, the influence of petroleum coke dust as the primary source on aerosol emissions is geographically limited. The result also revealed the considerably long lasting influence of bitumen spill on the local aerosol source contributions. From the ground-based remote sensing observations of aerosol optical properties, petroleum coke could influence the atmospheric aerosol levels over AOSR with highly light-absorbing coarse-mode aerosols under warm and dry weather conditions.

Keywords: Oil sands; Fine particulate matter; Source apportionment; Petroleum coke dust; PMF.

Burden of ischemic heart disease and stroke attributable to exposure to atmospheric PM2.5 in Hubei province, China

WenyuanYu a b 1, SuyangLiu b c1, JunfengJiang b, GongboChen b c, HuijuanLuo b, YuanshanFu b, LinglingXie b, BaojingLi b, NaLi b c, ShuChen d, HaoXiang b c, ShenglanTang d e

Source: Atmospheric Environment, Volume 221, 15 January 2020, 117079

Studies on mortality and disability-adjusted life years (DALYs) of cardiovascular diseases (CVDs) attributable to exposure to ambient PM2.5 in China are very limited. This study aims to provide a city-level estimation of the PM2.5-related disease burden of two major CVDs, ischemic heart disease (IHD) and stroke, by age and sex in Hubei province, China in 2016. PM2.5 mass concentrations (μg/m3) at different cities were obtained from the Hubei Provincial Environmental Quality Supervision and Administration Bureau. The city-level demographic data in Hubei were obtained from the sixth demographic census of China in 2010. Sex- and age-specific mortality and DALY data were extracted from the Global Burden of Disease Study (GBD) 2016. The integrated exposure-response (IER) model, developed by the GBD, was used to estimate PM2.5-related CVD premature deaths and DALYs in Hubei province. We found that 55.76 thousand deaths and 1.11 million DALYs of IHD and stroke could be attributed to exposure to ambient PM2.5 in Hubei. Disease burden of IHD and stroke attributable to PM2.5 increased with age and were higher in males than in females. The PM2.5-related disease burden of IHD and stroke was mainly concentrated in the eastern part of Hubei. The highest population attributable fraction (PAF) of IHD and stroke was mainly concentrated in the western part of Hubei. Our findings suggest that China needs proper air quality management measures to effectively reduce ambient PM2.5, especially for cities with heavy disease burden.

Keywords: PM2.5; Cardiovascular disease; Premature deaths; Disease burden; DALYs; PAF.

Ecotoxicity, genotoxicity, and oxidative potential tests of atmospheric PM10 particles

S.Romano a, M.R.Perrone a, S.Becagli b, M.C.Pietrogrande c, M.Russo c, R.Caricato d, M.G.Lionetto d

Source: Atmospheric Environment, Volume 221, 15 January 2020, 117085

The aim of the present work was to investigate the likely toxicological impact of atmospheric PM10 particles by comparing different effect-based methodologies, namely the Vibrio fischeri bioluminescence inhibition bioassay to evaluate ecotoxicity, the SOS Chromotest assay to estimate genotoxicity, and the Dithiothreitol (DTT) and Ascorbic Acid (AA) acellular assays to assess oxidative potential. The chemical composition was characterized for about 30 species, to assess the potential health impact of specific chemical components. Atmospheric particles were collected from spring to summer at a coastal site of the Central Mediterranean, away from large sources of local pollution. The Toxicity Unit (TU) index, used to assess the ecotoxicity, showed that 33% of the samples were toxic. The Induction Factor (IF), generally used to assess particle's genotoxicity, varied from 0.3 to 1.5 that represents the threshold value for genotoxicity. The oxidative potential (OP) determined by the DTT and AA assay varied within the 4.9–34.5 and 4.8–140.6 nmol min−1 range, respectively. DTT-OP and TU values were significantly correlated with OC, EC, and nss-K+, likely because the DTT and Vibrio fischeri responses were mainly associated with species from combustion sources. The IF factor was significantly correlated with some metals (Al, Ba, La, P, Sr, and Ti) likely from traffic sources and did not show any significant correlation with TU and OP values. Overall, paper's results proved the episodic occurrence of ecotoxicity and genotoxicity levels in PM10 particles sampled directly from their natural environment and away from strong pollution sources, highlighting the role mainly of carbonaceous compounds and heavy metals. The impact of spurious correlations between DTT- and AA-OPV and chemical species concentration has also been addressed.

Keywords: PM10 Vibrio; fischeri; SOS chromotest; DTT assay; AA assay; Chemical composition.

Use of multivariate time series techniques to estimate the impact of particulate matter on the perceived annoyance

Milena Machado a, Valdério Anselmo Reisen b c e, Jane Meri Santos c, Neyval Costa Reis Junior c, Severine Frèred Pascal Bondon e, MártonIspány f, Higor Henrique Aranda Cotta b e

Source: Atmospheric Environment, Volume 222, 1 February 2020, 117080

As well known, Particulate matter (PM) is an air pollutant that causes damage to the health of humans, other animals, plants, affects the climate and is a potential cause of annoyance through deposition on various surfaces. The perceived annoyance caused by particulate matter is related mainly to the increase of settled dust in urban and residential environments. PM can originate from many sources, i.e., paved and unpaved roads,

buildings, agricultural operations and wind erosion represent the largest contributions beyond the relatively minor vehicular and industrial sources emissions. The aim of this paper is to quantify the relationship between perceived annoyance and particulate matter concentration and to estimate the relative risk (RR). The data was collected in the Metropolitan Region of Vitoria (MRV), Brazil. For this purpose, the variables of interest were modelled using vector time series model (VAR), principal component analysis (PCA), and logistic regression (LOG). The combination of these techniques resulted in a hybrid model denoted as LOG-PCA-VAR which allows to estimate RR by handling multipollutant effects. This study shows that there is a strong association between the perceived annoyance and different sizes of PM. The estimates of RR indicate that an increase in air pollutant concentrations significantly contributes in increasing the probability of being annoyed.

Keywords: Annoyance; Principal component analysis; Logistic regression; Relative risk.

Day-of-week patterns for ultrafine particulate matter components at four sites in California

WeiXue a, JianXue a, Farimah Shirmohammadi b, Constantinos Sioutas b, Annabelle Lolinco c, Alam Hasson , Michael J.Kleeman a

Source: Atmospheric Environment, Volume 222, 1 February 2020, 117088

Ultrafine particulate matter (PM0.1) samples were collected during three-day averaging periods over an annual cycle at four sites across California: Los Angeles, East Oakland, San Pablo, and Fresno. PM0.1 samples were analyzed for thermal carbon fractions using a thermal-optical carbon analyzer and trace elements using ICP-MS. A statistical analysis of the day-of-week trends for 15 PM0.1 components reveals location-specific patterns along with important general trends for UFP concentrations. PM0.1 elemental carbon (EC) concentrations are elevated in the middle of the week consistent with increased activity for diesel engines during this time period. Just as significantly, PM0.1 organic carbon (OC) concentrations do not exhibit a day-of-week pattern. Since OC accounts for the majority of the PM0.1 total mass, the lack of a day-of-week pattern for PM0.1 OC suggests that diesel engines do not dominate total PM0.1 mass in California. A paired t-test constructed using measurements on weekends compared to measurements immediately preceding or immediately following the weekend showed that PM0.1 potassium (K) and rubidium (Rb) concentrations were elevated on weekends. This pattern is consistent with increased biomass combustion on weekends (a previously unknown exposure pattern for UFPs). The two closest sampling locations (East Oakland and San Pablo) had the greatest number of UFP components with identical weekly trends, but even at these locations only 4 out of 15 components displayed the exact same day-of-week profiles. Less similarity was observed in measured day-of-week profiles for UFP components at other sites. The heterogeneity

between sites suggests that the details of UFP concentrations at each location reflect the mixture of sources immediately adjacent to that site. By extension, individual neighborhoods across California will each experience unique day-of-week concentration profiles for UFP components that reflect the surrounding sources. These factors must be considered when estimating population exposure to ultrafine particles during future health effects studies.

Estimating hourly PM2.5 concentrations using MODIS 3 km AOD and an improved spatiotemporal model over Beijing-Tianjin-Hebei, China

Xinpeng Wang Wenbin Sun Kangning Zheng Xiangyu Ren Peiwen Han

Source: Atmospheric Environment, Volume 222, 1 February 2020, 117089

The spatiotemporal distribution of PM2.5 during heavy pollution is a short-term dynamic change process, and quantifying the dynamic change process of PM2.5 is the premise and guarantee for short-term PM2.5 exposure research. However, given the low temporal resolution of polar-orbiting satellites and late launch time of geostationary satellites, the application of remote sensing aerosol optical depth (AOD) data in hourly PM2.5 spatial distribution prediction is greatly limited, which brings uncertainty to short-term PM2.5 exposure research. This study introduces the PM2.5 concentration predicted by Moderate Resolution Imaging Spectroradiometer (MODIS) 3 km AOD data and the PM2.5 concentration of monitoring stations into a spatiotemporal autoregressive (STAR) model to generate hourly PM2.5 spatial distribution and quantify the short-term dynamic change process of PM2.5. The monitoring data in the Beijing–Tianjin–Hebei (JingJinJi) region of 2014 were used to test the model performance. Time-based 10-fold cross-validation (CV) R2 was 0.82, and the root-mean-square prediction error (RMSE) was 37.37 μg/m3. The CV R2 and RMSE were higher by 0.04 and lower by 3.4 μg/m3 than the STAR model without monitoring station PM2.5 concentration as predictors, which indicated that the monitoring station PM2.5 concentration could improve the performance of the model. Hourly performance statistics results showed that the model's accuracy increased when the time was closer to the MODIS transit time compared with that at other hours. The farther away from the MODIS transit time, the greater the monitoring stations' PM2.5 concentration improved the performance of the model. The predicted results of the spatial distribution of PM2.5 showed that the spatial distribution of the average PM2.5 concentration in each hour varied greatly in JingJinJi, and the maximum difference reached 30 μg/m3. The model in this paper not only demonstrates high prediction accuracy but also provides high spatiotemporal resolution of PM2.5 for short-term PM2.5 exposure studies.

Keywords: PM2.5; MODIS AOD; Spatiotemporal autoregressive model; Hourly PM2.5; spatial distribution.

Retrieval of surface PM2.5 mass concentrations over North China using visibility measurements and GEOS-Chem simulations

Sixuan Li a b, Lulu Chen c, Gang Huanga b d, Jintai Lin c, Yingying Yan c, Ruijing Ni c, Yanfeng Huo e, Jingxu Wang c, MengyaoLiu c, Hongjian Weng c, Yonghong Wang f, Zifa Wang b g

Source: Atmospheric Environment, Volume 222, 1 February 2020, 117121

Despite much effort made in studying human health associated with fine particulate matter (PM2.5), our knowledge about PM2.5 and human health from a long-term perspective is still limited by inadequately long data. Here, we presented a novel method to retrieve surface PM2.5 mass concentrations using surface visibility measurements and GEOS-Chem model simulations. First, we used visibility measurements and the ratio of PM2.5 and aerosol extinction coefficient (AEC) in GEOS-Chem to calculate visibility-inferred PM2.5 at individual stations (SC-PM2.5). Then we merged SC-PM2.5 with the spatial pattern of GEOS-Chem modeled PM2.5 to obtain a gridded PM2.5 dataset (GC-PM2.5). We validated the GC-PM2.5 data over the North China Plain on a 0.3125° longitude x 0.25° latitude grid in January, April, July and October 2014, using ground-based PM2.5 measurements. The spatial patterns of temporally averaged PM2.5 mass concentrations are consistent between GC-PM2.5 and measured data with a correlation coefficient of 0.79 and a linear regression slope of 0.8. The spatial average GC-PM2.5 data reproduce the day-to-day variation of observed PM2.5 concentrations with a correlation coefficient of 0.96 and a slope of 1.0. The mean bias is less than 12 μg/m3 (<14%). Future research will validate the proposed method using multi-year data, for purpose of studying long-term PM2.5 variations and their health impacts since 1980.

Keywords: Visibility; Chemical transport model (CTM); PM2.5; Spatial pattern; Time series; North China plain (NCP).

A comparison of statistical and machine learning methods for creating national daily maps of ambient PM2.5 concentration

Veronica J. Berrocal a, Yawen Guan b, Amanda Muyskens c, Haoyu Wang d, Brian J.Reich d, James A.Mulholland e, Howard H.Chang f

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A typical challenge in air pollution epidemiology is to perform detailed exposure assessment for individuals for which health data are available. To address this problem, in the last few years, substantial research efforts have been placed in developing statistical methods or machine learning techniques to generate estimates of air pollution at fine spatial and temporal scales (daily, usually) with complete coverage. However, it is not clear how much the predicted exposures yielded by the various methods differ, and which method generates more reliable estimates. In this paper, we aim to address this gap by evaluating a variety of exposure modeling approaches, comparing their predictive performance. Using PM2.5 in year 2011 over the continental U.S. as a case study, we generate national maps of ambient PM2.5 concentration using: (i) ordinary least squares and inverse distance weighting; (ii) kriging; (iii) statistical downscaling models, that is, spatial statistical models that use the information contained in air quality model outputs; (iv) land use regression, that is, linear regression modeling approaches that leverage the information in Geographical Information System (GIS) covariates; and (v) machine learning methods, such as neural networks, random forests and support vector regression. We examine the various methods' predictive performance via cross-validation using Root Mean Squared Error, Mean Absolute Deviation, Pearson correlation, and Mean Spatial Pearson Correlation. Additionally, we evaluated whether factors such as, season, urbanicity, and levels of PM2.5 concentration (low, medium or high) affected the performance of the different methods. Overall, statistical methods that explicitly modeled the spatial correlation, e.g. universal kriging and the downscaler model, outperform all the other exposure assessment approaches regardless of season, urbanicity and PM2.5 concentration level. We posit that the better predictive performance of spatial statistical models over machine learning methods is due to the fact that they explicitly account for spatial dependence, thus borrowing information from neighboring observations. In light of our findings, we suggest that future exposure assessment methods for regional PM2.5 incorporate information from neighboring sites when deriving predictions at unsampled locations or attempt to account for spatial dependence.

A refined source apportionment study of atmospheric PM2.5 during winter heating period in Shijiazhuang, China, using a receptor model coupled with a source-oriented model

Wenhui Zhang a, Baoshuang Liu a, Yufen Zhang a, Yafei Li a, Xiaoyun Sun a, Yao Gu a, Chunling Dai b, NaLi c, Congbo Song a, Qili Dai a, Yan Han a, Yinchang Feng a

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With the intensification of Chinese source control of air pollution, there is an urgent need for refined and rapid source apportionment techniques. A refined source apportionment method was constructed based on an off-line sampling dataset using a receptor model coupled with a source-oriented model, and the method was implemented in Shijiazhuang during the heating period. The refined results for source apportionment mainly included temporal, spatial, and source-category refinement data. The results indicated that the mean concentration of PM2.5 during the heating period was 96 μg/m3. Organic carbon (OC) and NO3− were found to be the dominant species of PM2.5 during the study. A high correlation was detected between elemental carbon (EC) and NO3− on polluted days, which was suggestive of the stagnant condition that accumulates EC and nitrate simultaneously. Secondary particle formation greatly promoted the occurrence of haze events. Secondary sources (34.9%), vehicle exhaust (18.6%), coal combustion (20.0%), industrial emissions (9.2%), crustal dust (9.7%), and biomass burning (7.6%) were the major sources during the heating period. The contributions of secondary sources and vehicle exhaust increased on polluted days, while those of coal combustion, industrial emissions and crustal dust decreased significantly. The contribution percentage of secondary sources from the southeast direction was basically the highest, while those of vehicle exhaust from the northwest or southeast directions were relatively higher as well, likely due to the distribution of traffic arteries. Based on the refined results for the source-category assessment, we found that the heating boilers (17.0%), non-road mobile (13.8%), diesel vehicles (10.4%), residential combustion (6.7%), road dust (5.5%), and architectural material industry (4.9%) were the major contributors to PM2.5. There was some uncertainty in the distribution proportions of the refined results, which were derived based on the emission inventory and the results of CALPUFF model.

Keywords: PM2.5; Refined source apportionment; Source directional apportionment; PMF; CALPUFF model.

In situ continuous observation of hourly elements in PM2.5 in urban beijing, China: Occurrence levels, temporal variation, potential source regions and health risks

Yang Cui a b, Dongsheng Ji a b, Jun He c, Shaofei Kong d, Yuesi Wang a b e

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Elements in fine particles (PM2.5) have adverse impacts on ecosystems and human health. Using an online multi-heavy metal analyzer, one-year continuous hourly measurements were performed for thirteen elements, namely, K, Ca, Cr, Mn, Fe, Ni, Cu, Zn, As, Se, Ba, Hg and Pb, from June 1, 2016, to May 31, 2017, in urban Beijing. The total concentrations of 13 elements were in the range of 114–136,574 ng/m3, with a mean concentration of 2534 ±

5563 ng/m3. The four dominated elements were K (900 ± 3554 ng/m3), Fe (738 ± 1485 ng/m3), Ca (493 ± 1473 ng/m3) and Zn (174 ± 189 ng/m3). The annual mean concentrations of Cr and As exceeded the guideline values of the World Health Organization and the Chinese National Ambient Air Quality Standard. In the absence of firework-burning episodes and heavy dust storms, K, Cr, Mn, Cu, Zn, As, Se, Hg and Pb showed higher concentrations in autumn and winter, whereas lower concentrations were observed in spring and summer. The higher concentrations of Ca, Fe, and Ba observed in spring were associated with the frequent occurrence of dust. All elements showed higher concentrations on weekends than on weekdays. The diel patterns of Fe, Ba, Ca, Cu, Zn, Ni and Mn showed higher concentrations during peak traffic periods, whereas those of As, Cr, Hg, K, Pb and Se showed lower concentrations in the daytime but higher ones in the nighttime. The potential source function (PSCF) identified that neighboring provinces were the major source regions for most elements, whereas Ni mainly came from Shandong and the eastern ocean in spring and summer. Health risks of PM2.5 elements (Cr, Mn, Ni, As, Ba and Pb) via the inhalation pathway were estimated. Mn (As) and As posed the highest noncarcinogenic and carcinogenic risks to human health, respectively. Overall, this work can provide more detailed information on the characteristics of elements for the science community and be used in other receptor modelling and health risk assessment studies.

Keywords: Elements; PM2.5; Beijing; Temporal variation; Source analyses; Health risks.

Health effects of PM2.5 emissions from on-road vehicles during weekdays and weekends in Beijing, China

Ruipeng Tong Jiefeng Liu Wei Wang Yingqian Fang

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Mobile source emissions have significantly contributed to fine particulate matter (PM2.5) pollution in urban atmospheric environments. Few studies have explored on-road vehicular PM2.5 emissions and the health effects attributed to these emissions under different traffic conditions. Based on driving data obtained from 20000 taxi receipts, a motor vehicle emission simulator (MOVES) model was used to estimate the PM2.5 emission levels of motor vehicles in the urban area within the Sixth Ring Road of Beijing (SRRB) on weekdays and weekends, respectively. Two different PM2.5 exposure scenarios were further simulated using an atmospheric dispersion model. Subsequently, the health effects attributable to traffic-related PM2.5 exposure were quantified by using exposure-response function to calculate the population acute morbidity and premature mortality during different time periods. We found that PM2.5 emission levels of motor vehicles on normal weekdays were overall higher than those on weekends. The median vehicular

PM2.5 dispersion concentration in the study area was 2.68 μg/m3 on weekdays and 1.82 μg/m3 on weekends. Annually, there were 4435 premature deaths attributed to vehicle emissions (95% confidence interval (CI): 3655, 4904) under weekday exposure conditions, and this number sharply decreased to 3462 (95% CI: 3052, 4011) on weekends. Considering the hourly measurements, road traffic emissions have the greatest impact on public health during morning rush hour (8:00 a.m.). Total PM2.5 emissions were closely associated with road traffic conditions and largely determined the magnitude of the health impacts caused by traffic-related PM2.5 exposure. These findings provide information to aid in formulating reasonable public health policies to address vehicular PM2.5 emission-induced health implications.

Keywords: Health effects; Vehicular emission; Air pollution; PM2.5; Urban traffic.

Characteristics and meteorological mechanisms of transboundary air pollution in a persistent heavy PM2.5 pollution episode in Central-East China

Chune Shi a b, Ifeanyichukwu C.Nduka c,Yuanjian Yang c d e, Yong Huang a b, Risheng Yao f, Hao Zhang a b, Bingfang He a b, Chengbo Xie g, Zhenzhu Wang g, Steve Hung Lam Yim c d h

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Previous research has shown the significant transboundary air pollution (TAP) in China. Despite its adverse environmental and human health impacts, the characteristics and mechanisms of TAP have yet to be fully understood. This study comprehensively analyzed intensive ground and upper levels measurements along with the atmospheric modeling approach to determine the driving meteorological conditions responsible for the formation and evolution of a persistent severe PM2.5 pollution episode in Central-East China (CEC, 112°E −118°E, 30°N −34°N) starting from 18:00 on Dec. 3 to 18:00 on Dec. 5, 2017, which had obvious characteristics of TAP and explosive increases in PM2.5 concentration. We assessed and quantified contributions of local and nonlocal emissions to PM2.5 in the region and different cities during the episode and determined the altitude level at which TAP occurred. Results show that PM2.5 concentration in most cities in CEC region experienced two major increases: the first increase was due to the change in wind direction from south to north, transporting pollutants from north China to CEC; the second increase was driven by several important meteorological factors, including warm/cold advection at different altitudes, large-scale subsidence, and radiative cooling, jointly resulting in a deep (reaching around 800 m) and strong elevated temperature inversion with a significant reduction in mixing layer thickness and thus causing a rapid increase in PM2.5

concentration in CEC region. On average, TAP accounted for 42% of total PM2.5 concentration in the region during the event, in which the TAP impact varied by cities, ranging from ~26% to ~70%. Our findings demonstrate the synergetic effect of TAP and large-scale subsidence, providing a critical reference for air pollution forecast and assessment in the eastern China.

Keywords: Heavy PM2.5 pollution; Large-scale subsidence; Transboundary air pollution; Central-east China.

Characteristics of the atmospheric boundary layer and its relation with PM2.5 during haze episodes in winter in the North China Plain

Qianhui Li a, Bingui Wu b, Jingle Liu b, Hongsheng Zhang a, Xuhui Cai c, YuSong c

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Interactions between the spatiotemporal distribution of pollutants and the structure of the atmospheric boundary layer were studied using data obtained by GPS (Global Positioning System) sounding balloons in an intensive observation period from December 2018 to January 2019 at the Dezhou experimental station in the North China Plain. Under haze weather conditions, negligible variation or a slight increase in temperature, higher relative humidity (RH) and lower wind speed with uncertain wind direction are common characteristics. The concentration distribution of particulate matter ≤2.5 μm (PM2.5) has a close relationship with the inversion layer, which contributes to the accumulation of PM2.5 in the lower atmosphere. The reduction of pollutants suspended in the upper layer during haze periods is closely related to low-level jets and intermittent turbulence. Higher RH values are also favourable for the formation of heavy haze, and the value of PM 2.5 increases with an increase in humidity. During hazy days, the heat fluxes and turbulent kinetic energy (TKE) are much smaller than those during clear days. The values of the average maxima of net radiation, sensible heat flux, and latent heat flux are 154, 76, and 15 W/m^2 , respectively, and the value of TKE is approximately 0.67 m^2/s^2 . The decrease in atmospheric boundary layer height (ABLH) is caused by weaker turbulent transfer during haze episodes. The ABLH is approximately 400 m during the daytime and 240 m at night. The power function relationship is shown by a negative correlation between the ABLH and surface PM2.5 concentration in the convective boundary layer.

Keywords: Haze; PM2.5 concentration profile; Atmospheric boundary layer; North China Plain.

Spatiotemporal variation in the impact of meteorological conditions on PM2.5 pollution in China from 2000 to 2017

Yanling Xu a b, Wenbo Xue a, Yu Lei a, Qing Huang c, Yang Zhao d, Shuiyuan Cheng b, Zhenhai Ren b, Jinnan Wang a

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Fine particulate matter (PM2.5) concentration that exceeds standards is causing poor air quality in most Chinese cities. Meteorological conditions are an important factor affecting PM2.5 concentration, but few quantitative studies have been conducted on the effects of long-term and large-scale changes in meteorological factors on PM2.5 pollution. In this study, a Weather Research and Forecasting/Community Multiscale Air Quality (WRF/CMAQ) modeling system was applied to study the spatial and temporal distributions of the impact of meteorological conditions on PM2.5 pollution in China from 2000 to 2017. During the study period, Me-PM2.5 decreased in general ($P = 0.0018$) in nationwide, and showed significant spatiotemporal variations. There was an overall increasing trend for Beijing, Fujian, Shaanxi, Gansu, and Qinghai provinces ($P < 0.05$) as the meteorological conditions deteriorated, and there was an overall negative trend for nine provinces ($P < 0.05$) which indicated meteorological conditions were causing a decrease in concentrations. Substantial differences in the impact of meteorological changes on PM2.5 pollution were observed across the provinces, with FMe-PM2.5 (fluctuating range of Me-PM2.5) between 9.3% and 55.1%. In addition, the best, typical, and worst meteorological years were selected based on Me-PM2.5; these should be considered when setting air quality goals and pollution control plans.

Keywords: CMAQ model; PM2.5 pollution; Secondary inorganic aerosol; Meteorological impact.

Apportioning prescribed fire impacts on PM2.5 among individual fires through dispersion modelling

Ran Huang a b, Momei Qin a c, Yongtao Hu a, Armistead G.Russell a, M. Talat Odman a

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Prescribed burning is a prominent source of PM2.5 in the southeastern U.S. An air quality forecasting system called HiRes2 currently serves most areas in the southeastern U.S. to forecast PM2.5 concentrations one day in advance, including the impact of forecast prescribed burning activity. The output prescribed fire impact from the HiRes2 forecasting

system is the combined impact of all the fires in the domain. When there are many fires close to each other, it is difficult to distinguish the ones that are more likely to lead to air quality issues. A novel source apportionment method, Dispersive Apportionment of Source Impacts (DASI), has been developed and applied to split the combined prescribed fire impact obtained from a chemical transport model (CTM) by using simulated fields from a dispersion model. Comparisons of apportioned fire impacts with single burn impacts simulated directly by the CTM show that DASI works well with large and small fires that do not have too much interaction with other fires. Individual fire impacts obtained by splitting the combined fire impacts from CTMs could help local land and air quality managers to evaluate which burns should be allowed or restricted based on their individual impacts on air quality and public health in areas of concern.

Keywords: Air quality management; Fire activity; CMAQ-DDM; HYSPLIT; Source attribution; Emission contribution.

Impact of Chinese air pollutants on a record-breaking PMs episode in the Republic of Korea for 11–15 January 2019

Hye-Ryun Oh a, Chang-Hoi Ho a, Youn-SeoKoo b, Kwan-GuBaek a, Hui-Young Yun b, Sun-Kyong Hur a, Dae-Ryun Choi b, Jong-Ghap Jhun a, Jae-Seol Shim c

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A record-breaking episode of highly concentrated particulate matter (PM) with diameters ≤ 2.5 μm (PM2.5) and ≤10 μm (PM10) occurred in the Republic of Korea during the period January 11–15, 2019: the hourly PM2.5 (PM10) in Seoul was 188 μg m−3 (262 μg m−3) on January 14. At the Baengnyeong and Socheongcho stations, located in the Yellow Sea between China and Korea, the hourly PM2.5 concentration reached up to 155 μg m−3 and 119.8 μg m−3, respectively, 16–19-h prior to this episode. This and the fact that the maximum PM10 concentration at Baengnyeong was 199 μg m−3 indicated a westerly transport of air pollutants. Satellite observations and 72-h back trajectory analysis clearly indicate that air pollutants from China flowed into Korea via the westerlies. According to contribution analysis using particulate matter source apportionment technology in the Comprehensive Air-quality Model with extension, air pollutants originating from northeastern China including Hebei and Shandong provinces were largely linked to the present record-breaking high concentration event in Seoul. This study will elucidate the mechanism of transboundary transport of air pollutants and help East Asian countries cooperate on air quality management.

Keywords: Transboundary air pollutant; PMs; Source contribution; CAMx-PSAT.

Contrasts in chemical composition and oxidative potential in PM10 near flares in oil extraction and refining areas in Ecuador

F.Barraza a1, G.Uzu b c, J.-L.Jaffrezo b, E.Schreck a, H.Budzinski d, K.Le Menach d, M.-H.Dévier d, H.Guyard b, A.Calas b, M.-I.Perez e, L.-A.Villacreces e, L.Maurice a f

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For decades, oil extraction in rural sites in the North Amazon Region (NAR) in Ecuador, have generated mixtures of potentially toxic compounds, such as polycyclic aromatic hydrocarbons (PAHs) and metal(loid)s. The main national refinery and the thermal power plant located in Esmeraldas, on the North Pacific Coast (NPC), are also considered as important sources of air contamination. Particulate matter (PM10) emitted at both sites could induce the formation of reactive oxygen species (ROS) in the lungs upon inhalation and could be associated with respiratory diseases. In this study, PM10 mass composition was monitored over a two-year period in both regions: NAR (close to oil platforms and open flares) and NPC (in a public school close to the refinery). PM10 composition was assessed in terms of metal(loid)s, organic and elementary carbon (OC, EC), monosaccharides (levoglucosan, mannosan, galactosan), glucose, polyols (sorbitol, mannitol, arabitol), water soluble ions and polycyclic aromatic compounds (PAHs, oxy-PAHs and nitro-PAHs). Additionally, three complementary biochemical and acellular tests were performed to evaluate the oxidative potential (OP).

Results show that the PM10 mass and elemental concentrations were higher in NPC than in NAR. Barium and Mo concentrations, commonly used in oil operations, were up to 1000-fold higher than values recorded in other regions of Ecuador. OC/EC ratios and polyols concentrations were higher in NAR than in NPC, indicating a larger biogenic contribution to the PM mass in this region. In NAR, the main sources associated with ROS burden were biogenic emissions and oil production, as indicated by positive correlations between OP, sugars, Ba, some PAHs and oxy-PAHs. On the other hand, in NPC, associations between NH4+, Ba, As and Ni imply that oil refining and industrial activities are the main contributors to the OP of PM10.

Keywords: PM10; Ecuador; Oil extraction; Oil refining; Chemical composition; PAHs; Trace metal elements; Oxidative potential; Air quality.

Application of parallel factor analysis model to decompose excitation-emission matrix fluorescence spectra for characterizing sources of water-soluble brown carbon in PM2.5

Huanbo Wang a b, Leiming Zhang c, Tingting Huo a, Bin Wang a, Fumo Yang d, Yang Chen b, Mi Tian b, Baoqing Qiao b, ChaoPeng b

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The applicability of parallel factor analysis (PARAFAC) model for identifying potential sources of water-soluble brown carbon (BrC) in fine particulate matter (PM2.5) using seasonal and annual excitation-emission matrix (EEM) fluorescence spectra data was investigated. The uncertainties related to the application of PARAFAC model to water-soluble BrC analysis were evaluated and the physicochemical meanings of PARAFAC-derived components were clearly interpreted. EEM spectra were obtained from water-soluble extractions of PM2.5 samples, which were collected at an urban and a suburban site in Chongqing, southwest of China during four one-month periods, each representing a different season in 2015. The measured EEM spectra were decomposed into three individual fluorescence components using PARAFAC algorithm, and the potential sources of BrC were identified based on the fingerprinting characteristics of PARAFAC-derived components. Each of the individual component exhibited similar spectral profiles in different seasons except in summer at the urban site; however, the relative intensities between the components varied with season, suggesting seasonal dependent source intensity of BrC. The relative contributions of the individual fluorescence components to the total fluorescence intensity varied largely from 0 to 89.2% at different excitation and emission wavelengths. Therefore, the relative abundance of each individual component based on the maximum fluorescence intensity (Fmax) should be used carefully for source apportionment analysis of BrC.

Keywords: Water-soluble brown carbon; PM2.5; Excitation-emission matrix fluorescence spectroscopy; PARAFAC model.

Semi-volatile components of PM2.5 in an urban environment: Volatility profiles and associated oxidative potential

Milad Pirhadi a, Amirhosein Mousavi a, SinaTaghvaee a, Martin M.Shafer b, Constantinos Sioutas a

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The volatility profiles of PM2.5 semi-volatile compounds and relationships to the oxidative potential of urban airborne particles were investigated in central Los Angeles, CA. Ambient and thermodenuded fine (PM2.5) particles were collected during both warm and cold seasons by employing the Versatile Aerosol Concentration Enrichment System (VACES) combined with a thermodenuder. When operated at 50 °C and 100 °C, the VACES/thermodenuder system removed about 50% and 75% of the PM2.5 vol concentration, respectively. Most of the quantified PM2.5 semi-volatile species including organic carbon (OC), water soluble organic carbon (WSOC), polycyclic aromatic hydrocarbons (PAHs), organic acids, n-alkanes, and levoglucosan, as well as inorganic ions (i.e., nitrate, sulfate, and ammonium) exhibited concentration losses in the ranges of 40–66% and 67–92%, respectively, as the thermodenuder temperature increased to 50 °C and 100 °C. Species in the PM2.5 such as elemental carbon (EC) and inorganic elements (including trace metals) were minimally impacted by the heating process – thus can be considered refractory. On average, nearly half of the PM2.5 oxidative potential (as measured by the dichlorodihydrofluorescein (DCFH) alveolar macrophage in vitro assay) was associated with the semi-volatile species removed by heating the aerosols to only 50 °C, highlighting the importance of this quite volatile compartment to the ambient PM2.5 toxicity. The fraction of PM2.5 oxidative potential lost upon heating the aerosols to 100 °C further increased to around 75–85%. Furthermore, we document statistically significant correlations between the PM2.5 oxidative potential and different semi-volatile organic compounds originating from primary and secondary sources, including OC (Rwarm, and Rcold) (0.86, and 0.74), WSOC (0.60, and 0.98), PAHs (0.88, and 0.76), organic acids (0.76, and 0.88), and n-alkanes (0.67, and 0.83) in warm and cold seasons, respectively, while a strong correlation between oxidative potential and levoglucosan, a tracer of biomass burning, was observed only during the cold season (Rcold = 0.81).

Keywords: PM2.5 oxidative potential; Semi-volatile organic compounds (SVOCs); Gas-particle partitioning; Thermodenuder; Volatility; DCFH assay.

An enhanced interval PM2.5 concentration forecasting model based on BEMD and MLPI with influencing factors

Zicheng Wang a, Liren Chen b, Zhenni Ding a, Huayou Chen a

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In order to protect public health by providing an early warning of harmful air pollutants, various forecasting models are proposed to forecast the average values of daily pollutant concentrations. In fact, even on the same day, the concentration of pollutants will fluctuate greatly during different time periods, point-based models can not reflect the variability well. Thus, an enhanced interval PM2.5 concentration forecasting model is developed in this paper, which is based on interval decomposition ensemble and considering influencing factors. For the purpose of obtaining main influencing factors, interval grey incidence analysis (IGIA) is used to select input variables for model. The interval-valued time series (ITS) of PM2.5 concentration and its influencing factors are decomposed into a finite number of complex-valued intrinsic mode functions (IMFs) and one complex-valued residual by bivariate empirical mode decomposition (BEMD) algorithm. Considering the different amounts of various IMFs, the complex-valued IMFs and residual are clustered into fewer classes by reconstruction technique. Then, interval multilayer perceptron (MLPI) is employed to fit the lower and upper bound simultaneously of all classes to obtain the corresponding forecasting results, which are combined to generate the aggregated interval-valued output by a simple addition approach. The model is tested by the dataset collected from three environmental monitoring stations in Beijing, China. Experimental results show that the enhanced model outperforms other considered models by means of forecasting accuracy and stability.

Keywords: Bivariate empirical mode decomposition; Interval forecasting; PM2.5 concentration; Interval multilayer perceptron; Mode reconstruction.

Emission reduction effect on PM2.5, SO2 and NOx by using red mud as additive in clean coal briquetting

Yue Zhang a, Zhenxing Shen a, Bin Zhang a, Jian Sun c, Leiming Zhang d, Tian Zhang a, Hongmei Xu a, Naifang Bei a, Jie Tian b, Qiyuan Wang b, JunjiCao b

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Emissions of $PM_{2.5}$ and trace gases from residential coal consumption for winter heating have caused severe air pollution in northern China. Clean coal briquettes can meet both demands of clean environment and residential heating. As a byproduct from the Bayer process, red mud has the potential to be used as briquettes additive, although its recycling procedure is challenging. In this study, red mud was used to replace the currently used calcium oxide as additive in coal briquetting. Twelve sets of combustion experiments were conducted for bituminous coal, anthracite coal and their briquettes, and each set of the experiment was repeated at least three times. Emission profiles of $PM_{2.5}$, SO_2 and NO_x were

recorded during experiments. The highest emission reduction rates for $PM_{2.5}$, SO_2 and NO_x were achieved at red mud contents of 10%, 5% and 2.5%, respectively, for bituminous coal, and at 10%, 5% and 7.5%, respectively, for anthracite coal. The corresponding emission reduction rates were 37.5%, 25.8% and 61.9% for bituminous coal and 31.2%, 55.1% and 17.9% for anthracite coal. In addition, both SO_2 and NO_x emissions showed clear peaks during the initial-burning stage for the two kinds of coals, while SO_2 emission for anthracite coal burning showed another peak during the char-burning stage. Benefit analysis was also conducted assuming all the currently used raw coals were replaced with clean coal briquettes in Shaanxi province. The overall reductions are 2270.46 (t) $year^{-1}$ for $PM_{2.5}$, 1538.00 (t) $year^{-1}$ for SO_2 and 2177.81 (t) $year^{-1}$ for NO_x in the province. Results presented in this study highlight that development of clean energy policies, such as replacing bituminous coal and anthracite coal with clean coal briquettes, will be effective to improve the regional air quality.

Keywords: Clean coal briquettes; Red mud; Emission reduction.

An eigenvector spatial filtering based spatially varying coefficient model for PM2.5 concentration estimation: A case study in Yangtze River Delta region of China

Huangyuan Tan a, Yumin Chen a, John P.Wilson b, Jingyi Zhang c, Jiping Cao a, Tianyou Chu a

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Ordinary interpolation using PM2.5 ground monitoring observations can seldom reveal the PM2.5 concentration distribution characteristics due to the uneven distribution of monitoring stations and because ordinary linear regression often neglects the spatial autocorrelation among geographical locations. In this study, we developed an eigenvector spatial filtering based spatially varying coefficient (ESF-SVC) model to estimate ground PM2.5 concentration. To generate and analyze the spatiotemporal distribution of PM2.5 concentration in the China's Yangtze River Delta (YRD) region, ESF-SVC model which uses a set of satellite remote sensing data, factory locations, and road networks, was fitted at different time scales from December 2015 to November 2016. Comparisons among the ESF-SVC, eigenvector spatial filtering (ESF) and geographically weighted regression (GWR) models suggest that the ESF-SVC model with an average annual and seasonal adjusted R2 of 0.684, is 10.3 and 13.8% higher than the GWR and ESF models, respectively. The average annual and seasonal cross validation root mean square error (RMSE) of the ESF-SVC models lower than the GWR and ESF models. PM2.5 concentration distribution maps for

annual and seasonal were produced to illustrate YRD region's spatiotemporal characteristics. In summary, an ESF-SVC model offers a reliable approach for PM2.5 concentrations estimation in large area.

Keywords: PM2.5; Eigenvector spatial filtering; Spatially varying coefficient; GWR; Yangtze river delta region.

Source apportionment of PM2.5 and PM10 by Ionic and Mass Balance (IMB) in a traffic-influenced urban atmosphere, in Portugal

C.Pio a, C.Alves a, T.Nunes a, M.Cerqueira a, F.Lucarelli b, S.Nava b, G.Calzolai b, V.Gianelle c, C.Colombi c, F.Amato d, A.Karanasiou d, X.Querol d

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The recently developed Ion and Mass Balance (IMB) source apportionment methodology was applied to a traffic influenced urban aerosol, permitting the quantification of the contributions of 11 source components, or formation processes, which accounted for more than 96% of the measured aerosol mass loading. Main sources included exhaust and non-exhaust road vehicle emissions, biomass burning, secondary inorganic and organic pollutants, and primary soil and sea salt emissions. While in summer secondary carbonaceous matter is the predominant fraction, in winter biomass burning accounts, on average, for more than 40% of the PM2.5 aerosol. Comparison with Positive Matrix Factorization (PMF) showed the complementary characteristics of the two methodologies. PMF yielded 8 source profiles, including industry and oil combustion sources not discriminated by IMB. PMF is better at quantifying multiple component contributions to sources. IMB solves problems of collinearity between aerosol tracers and permits the discrimination of secondary formed pollutants.

Keywords: Urban aerosol; Carbonaceous aerosol; Source apportionment; Ionic and mass balance.

Chemistry and sources of PM2.5 and volatile organic compounds breathed inside urban commuting and tourist buses

AmaiaFernández-Iriarte a c, FulvioAmato a, Natalia Moreno a, Antonio Pacitto b, Cristina Reche a, Esther Marco a, Joan O.Grimalt a, Xavier Querol a, Teresa Moreno a

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Inhalable particulate matter (size <2.5 μm: PM2.5) inside commuting and tourist buses moving through the city of Barcelona, Spain, was chemically analysed. The analyses show PM dominated by organic carbon (mostly 10–20 μg/m3) and elemental carbon (mostly 3–6 μg/m3; OC/EC = 3.4), followed by SO42, Fe, Ca, K, Al2O3, Mg, and Na, with calculated mineral content being around one third that of total carbon. Elemental carbon levels are higher inside diesel buses than those powered by natural gas or electricity, and higher in the upper floor of open-top double decker tourist buses than in the lower floor. Overall, major element concentrations inside the buses are typically 2–8 times higher than 24 h-averaged urban background levels, although some metallic trace elements, notably Cu and Sb, are exceptionally enriched due to the presence of brake particles, especially on routes involving higher gradients and therefore more brake use. In contrast, Cu and Sb concentrations in electric buses are unexceptional, presumably because these buses rely more on regenerative braking and are hermetically sealed when moving. Seasonal differences reveal PM to be more mineral in winter (Al2O3 1.3 μg/m3 vs. summer average of 0.3 μg/m3), with summer enrichment in Na, Mg, P, V, Ni and SO42− being attributed to marine aerosols contaminated by port emissions. Source apportionment calculations identify 6 main factors: road dust resuspension, metalliferous (brake wear and metallurgy), local urban dust, secondary sulphate and shipping (6%), vehicle exhaust (19%), and an indoor source (46%) interpreted as likely related to the textile fibres and skin flakes of bus occupants. Volatile Organic Compounds measured inside all buses except one were dominated by 2-Methylpentane (14–36 μg/m3), Toluene (10–30 μg/m3), Xylene isomers (10–28 μg/m3, with m- » o- > p-Xylene) and n-Pentane (5–15 μg/m3). ΣBTEX concentrations were <70 μg/m3, with Toluene being commonest, followed by m-Xylene, with p-Xylene, o-Xylene and Ethylbenzene each below 7 μg/m3 and Benzene concentrations always less than the EU limit value of 5 μg/m3. The VOCs mixture is similar to that recently reported from inside Barcelona taxis (although inside the larger volume bus VOC concentrations are lower than in the taxis) and is interpreted as providing a chemical fingerprint characterising traffic-contaminated ambient air in the city road environment. The notable exception to the VOC content was a brand new hybrid diesel bus still offgassing volatiles to such an extent that Σ(alkane + alkene + aromatic) indoor concentrations exceeded 800 μg/m3, with ΣBTEX ten times higher than normal.

Keywords: Indoor air quality; Commuting; Public buses; Electric bus; Diesel bus; Tourist bus.

A high-time resolution study of PM2.5, organic carbon, and elemental carbon at an urban traffic site in Istanbul

Rosa M.Flores a, Elif Mertoğlu a, Hüseyin Özdemir b, Bülent O.Akkoyunlu c, Göksel Demir d, Alper Ünal e, MeteTayanç a

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Organic Carbon (OC) and Elemental Carbon (EC) were investigated on selected days between January 2017 and January 2018 in an urban area heavily impacted by traffic in Istanbul megacity. 300 PM2.5 samples were collected with a time resolution of 2 h during the daytime between 07:00–19:00. Nighttime samples were collected with a time resolution of 12 h between 19:00–07:00. Samples were collected for three weeks during the winter and one week during the spring, summer, and fall. The daily PM2.5 concentrations exceeded the standard of 35 μg m−3 29% of the time. Air quality was classified as fair (PM2.5>26.4 μg m−3) and unhealthy (PM2.5>39.9 μg m−3) 43% and 20% of the days, respectively. The annual average OC and EC were 11.3 ± 4.91 and 4.1 ± 1.16 μg m−3, respectively. Organic carbon showed strong seasonal variation with high concentrations during the heating season and low concentrations during the summer. Elemental carbon did not show strong seasonality due to the continuous influence of heavy traffic. Diurnal variations of OC and EC were characterized by high concentrations during the morning and evening rush hours, and low concentrations in the middle of the day due to the dilution effect of an increased mixing layer. Formation of secondary organic carbon was uncertain during the summer due to dilution and low primary organic carbon emissions. Concentrations heavily depended on surface wind speed. Average OC concentrations were 56–72% higher at wind speeds lower than 2 m s−1 compared to that at wind speeds higher than 3 m s−1 during fall and winter. Higher EC concentrations (15–56%) were observed at wind speeds higher than 3 m s−1, showing that in addition to traffic emissions, EC was transported from nearby areas. Continuous measurements of high time resolved OC and EC are necessary for the development and evaluation of air pollution mitigation strategies, particularly from combustion sources.

Keywords: Diurnal variation; Istanbul, Megacity; OC/EC; Organic aerosol; PM2.5.

Estimating hourly and continuous ground-level PM2.5 concentrations using an ensemble learning algorithm: The ST-stacking model

Luwei Feng a, Yiyan Li a, Yumiao Wang a, Qingyun Dua b c d

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Estimation of hourly and continuous ground-level fine particulate matter (PM2.5) concentrations is essential for PM2.5 pollution sources identifications, targeted policy

development and population exposure research. However, current PM2.5 estimation studies rely heavily on satellite-based aerosol optical depth (AOD) data, and the limited transit times of polar-orbiting satellites such as Terra and Aqua, nighttime gaps in data from geostationary satellites such as Himawari-8, and cloud contamination reported for both types of satellites challenge the estimation of spatiotemporally continuous PM2.5 concentrations. In this study, spatiotemporal PM2.5 characteristic was constructed by the spatiotemporal fusion method. Specifically, multi-source data, including spatiotemporal, periodic, meteorological, vegetation, anthropogenic and topological characteristics, were incorporated into an ensemble learning method that combined extreme gradient boosting (XGBoost), k-nearest neighbour (KNN) and back-propagation neural network (BPNN) algorithms in level 1 and used linear regression (LR) for integration in level 2. The optimized stacking strategy that considered PM2.5 spatiotemporal autocorrelation was called the ST-stacking model. The model was trained, validated and tested with data acquired for China in 2017. The ST-stacking model outperformed XGBoost, KNN and BPNN models by 9.27% on average, with an R2 = 0.9191. Using the model, the 24-h and continuous ground-level PM2.5 concentrations in mainland China on 11 May 2017 were mapped, and parts of Beijing and Chengdu were selected for more detailed analysis. The PM2.5 concentrations in Taklimakan Desert, North China Plain, Sichuan Basin and Yangtze Plain were much higher than those in other locations on this day, which was generally consistent with the long-term patterns reported in previous studies.

Keywords: Spatiotemporal fusion; Stacking strategy; Hourly PM2.5 concentration; China; PM2.5 mapping.

Integrating low-cost air quality sensor networks with fixed and satellite monitoring systems to study ground-level PM2.5

JiayuLi a 1, Huang Zhang a 1, Chun-Ying Chao a, Chih-Hsiang Chien b, Chang-YuWu b, Cyuan Heng Luo c, Ling-Jyh Chen c, Pratim Biswas a

Source: Atmospheric Environmen, Volume 223, 15 February 2020, 117293

Airborne particulate matter (PM) mass concentrations measured by conventional monitoring stations are reliable data sources for air quality communication, pollution mapping, and exposure estimation. A high spatiotemporal density of monitoring stations can provide a better understanding of PM transport on a regional and global scale and help to reduce exposure misclassification leading to a better assessment of the health impacts associated with PM exposure. However, due to the cost and operational complexities, only a limited number of such PM monitors can be deployed. Apart from conventional measurements, PM mass concentration can be estimated from aerosol optical depth (AOD)

data observations by using empirical, semi-empirical or modeling methods, but these datasets are usually compromised by weather conditions and lack of knowledge of aerosol properties. In addition to the above methods, a network of low-cost PM sensors is also a promising approach to increase the measurement density. In this study, we propose an integration of information from multiple measurement approaches. We demonstrate this approach by synergizing the data from 75 monitoring stations, 2,363 AirBox low-cost sensors (the amount of data entries is ~10 million), and the Terra remote sensing satellite to estimate surface concentrations of PM for Taiwan Main Island during July 14 2018 to Oct 31 in 2018. A machine learning method selects the useful data from the low-cost sensor datasets, and the ordinary Kriging method is used to create a visual daily PM distribution map. The integration of datasets can enhance the overall data quantity and quality, leading to more accurate pollution maps with greater detail. The maps created from these three data sources demonstrate an approximate 30-fold synergistic improvement in the spatial resolution of PM mapping. The Root Mean Square Error (RMSE) of the predicted maps was analyzed through leave-one-out cross-validation, ten-fold cross-validation, and standard data validation. It shows that including low-cost PM sensor data brings in greater detail and largely enhances the spatial distribution while maintaining the pollution mapping characteristics. The approach described here will greatly assist the validation of PM transport models and enhance the accuracy of exposure estimations in future studies.

Keywords: Low-cost sensor; Particulate matter; Remote sensing; Ground measurement; Pollution mapping.

Characteristics and determinants of personal exposure to PM2.5 mass and components in adult subjects in the megacity of Guangzhou, China

Xiao-Cui Chen a, hHeiko J.Jahn b, Tony J.Ward c, Hung Chak Ho d, Ming Luo e, Guenter Engling f g, Alexander Kraemer b

Source: Atmospheric Environment, Volume 224, 1 March 2020, 117295

Understanding the heterogeneity between ambient concentration and personal exposure is crucial in studies regarding the health risks of air pollution exposure. We performed a panel study with 4–19 (average = 10) repeated personal monitoring in 16 adult subjects (ages 18–30) for three consecutive weeks during the winter and summer of 2011–2012 in the Chinese megacity of Guangzhou. Also, we conducted simultaneous ambient measurements at eight districts (including five urban sites, two suburban locations, and one rural site) of Guangzhou. Significant seasonal variations were shown in personal PM2.5 exposure for most of the analyzed components ($p < 0.05$), with higher levels in winter than in summer. Average personal exposures exhibited a pattern of central urban > suburban >

rural areas for PM2.5 mass and most of the constituents (e.g., carbonaceous aerosols, ions). We applied mixed-effects models to estimate within- and between-subject variance components and determinants of personal PM2.5 exposure after adjusting for potential confounders. The within-subject variance component dominated the total variability (63.7–95.6%) for most of the investigated PM2.5 components. Ambient PM2.5 mass and its components were the dominant predictors and contributors of the corresponding personal exposures ($0.11 < < 0.97$; $p < 0.05$). The results indicate that season and district type affect personal PM2.5 exposure and its components, contributing to 4.9–51.6% and 8.0–77.8% of the variability. Time indoors and outdoors were also factors affecting personal exposure. The study findings revealed ambient concentrations at a fixed monitoring station underestimated residents' true exposure levels. In conclusion, the current study emphasizes the need for incorporating spatio-temporal activity patterns complementing evenly-distributed air quality monitoring networks to increase the estimation power in epidemiological analysis linking true personal exposure to health effects.

Keywords: Personal exposure; PM2.5 constituents; Within-subject variability; Mixed-effects model.

Control of both PM2.5 and O3 in Beijing-Tianjin-Hebei and the surrounding areas

Songlin Xiang a, Junfeng Liu a, Wei Tao b, Kan Yi c, Jiayu Xu a, Xiurong Hu a, Huazhen Liu a, Yuqing Wang a, Yizhou Zhang a, Haozhe Yang a, Jianying Hu a, Yi Wan a, Xuejun Wang a, Jianmin Ma a, Xilong Wang a, Shu Tao a

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Serious haze pollution (e.g., PM2.5, particulate matter with aerodynamic diameters less than 2.5 μm) and increased ground-level ozone are severe air quality issues in China. In Beijing-Tianjin-Hebei and the surrounding areas (denoted as BTH&SA), although recently the particulate matter pollution appeared to be under control due to stringent pollution mitigation measures, ozone pollution rebounded rapidly, especially during summers. Thus, the exploration of strategies for efficiently lowering both ground-level ozone and PM2.5 concentrations is urgently needed. In this study, we target on the precursors contributing to both ozone and PM2.5 formation (i.e., NOx and volatile organic compounds (VOCs)) and adopt a Combined Empirical Kinetics Modeling Approach (CEKMA) to synthetically evaluate the cost-effective mitigation strategies for air quality control. We find that over the BTH&SA region, the choice of mitigation strategy in the initial stage (e.g., within 20% reductions on NOx or VOCs emissions) is critical because NOx-focused strategies may exacerbate O3 pollution. In addition, equally reducing NOx and VOCs emissions may have

the least benefit for air pollution improvement. From a long-term perspective, we suggest reducing VOCs emissions by ~60% and NOx emissions by ~20% in the first stage, thereby avoiding the potential increase in ambient O3. Then in the second stage, the remaining VOCs and NOx emissions should be phased out to reach a deep mitigation of PM2.5 and O3. With those steps, both PM2.5 and ozone can be mitigated efficiently over the BTH&SA region.

Keywords: Particulate matter; Ozone; Co-mitigation; Empirical kinetics modelling; Mitigation pathway.

Analysis of the atmospheric dust in Africa: The breathable dust's fine particulate matter PM2.5 in correlation with carbon monoxide

Gerard Rushingabigwi a, b Philibert Nsengiyumva a, Louis Sibomana a,Celestin Twizere a, Wilson Kalisa b

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The dust has direct effects on people's health and climate change; so, this research studied the remotely sensed dust deposition in Africa from 1980 to 2018, and the dust's particulate matter of 2.5 μm size (or PM2.5), in particular, which pollutes the breathable air. PM2.5 is studied in comparison with multispectral carbon monoxide (CO), an abundant atmospheric air pollutant in central Africa. CO is an atmospheric gaseous pollutant for which the smoke, a gaseous aerosol from incomplete combustion processes, is the biggest source. The literature clarifies that both the particulate matter and the CO endanger human health while breathed in. The dust from the desert of Sahara is windblown all over the world. CO, in Africa, is from the anthropogenic fire and volcanic eruptions' smoke; these are two good reasons to have focused on Africa. Due to the big size of Africa, five sub-regions are set; these are the western, central, northern, eastern and southern sub-regions. The Goddard interactive online visualization and analysis infrastructure (GIOVANNI) has been a bridge to the collected remote sensing data, in this research. The data was collected online, from the measurement of pollution in the troposphere (MOPITT) as well as a second version of the modern era retrospective analysis for research and applications (MERRA-2); the analysis was done by a joint of the software tools, worth noting is the Arc GIS. As the amount of African dust dramatically increased by 2000; the heaviest in 2004, results are based on the selected dust deposition over 2000–2018: time-averaged maps, correlations, and quantitative estimations are reported in this research. The heaviest annual dust deposition reached 25.3 t/km2 over the year 2004, in Liberia, a focal point of study for the western sub-region. An important finding: the dust's PM2.5 positively correlated with multispectral CO from November to May; the positively high correlation coefficient was

0.86 in April 2018. The negative correlation between the two measurements started from June to October; the negatively high correlation was −0.68 in October 2015; this research discussed the possible reasons. This research recommends some onsite studies about the real figures and facts about the dust's effects on health, in all the seasons; thus, an alert to policymakers who would set some strategies to mitigate the dust hazards on the health of African inhabitants, neighbors, and visitors.

Keywords: Africa; Dust particulates; Wet and dry dust; Air pollutants.

The impact of biomass burning on the oxidative potential of PM2.5 in the metropolitan area of Milan

Maryam Hakimzadeh a, Ehsan Soleimanian a, Amirhosein Mousavi a, Alessandro Borgini b c, Cinzia De Marco b,Ario A.Ruprecht c,Constantinos Sioutas a

Source: Atmospheric Environment, Volume 224, 1 March 2020, 117328

In this study, we investigated the impact of biomass burning on the oxidative potential of PM2.5 in the metropolitan area of Milan, Italy. PM2.5 samples were collected on quartz filters during cold (December 2018–February 2019) and warm (May 2019–July 2019) seasons at the Municipality of Bareggio, a small town located approximately 14 km northwest of the Milan city center. The PM2.5 constituents were chemically analyzed, and its corresponding oxidative potential was measured by means of the dithiothreitol (DTT) assay. Total PM2.5 mass concentration was significantly higher in winter (71.82 ± 4.17 μg/m3) compared to summer (16.67 ± 0.27 μg/m3), mainly a result of enhanced biomass burning emissions combined with higher atmospheric stability and lower mixing during the cold season. The enhanced biomass burning activities during the winter period also resulted in very high polycyclic aromatic hydrocarbons (PAHs) concentrations (72.81 ± 16.59 ng/m3) which were more than 150-fold higher than the warm period values (0.40 ± 0.07 ng/m3). PAH concentrations were highly correlated with chemical markers of biomass burning (i.e., levoglucosan (R2 = 0.79), and K+/K (R2 = 0.87)) in the winter period. Spearman correlation analysis between DTT and PM2.5 chemical species showed a dominant role of secondary organic aerosols (SOA) and vehicular emissions in summer-time PM2.5 oxidative potential (i.e., the capacity of PM2.5 species to oxidize target molecules), while in the wintertime, the DTT values were highly correlated with chemical markers of biomass burning, vehicular activities, and re-suspended road dust. Multiple linear regression (MLR) analysis identified biomass burning (41%) as the dominant contributor to DTT, followed by SOA (20%), re-suspended road dust (18%), and vehicular emissions (16%). Our results underscore the importance of biomass burning to the overall

oxidative potential of PM2.5 in the metropolitan area of Milan, urging the need to promulgate effective mitigation policies targeting these emissions.

Keywords: Dithiothreitol (DTT); Biomass burning; Po valley; Milan; Oxidative potential; Polycyclic aromatic hydrocarbons (PAH).

Ensemble averaging based assessment of spatiotemporal variations in ambient PM2.5 concentrations over Delhi, India, during 2010–2016

Siddhartha Mandal a b, Kishore K. Madhipatla a, Sarath Guttikunda c d, Itai Kloog e, Dorairaj Prabhakaran a b f, Joel D.Schwartz g, GeoHealth Hub India Team

Source: Atmospheric Environment, Volume 224, 1 March 2020, 117309

Elevated levels of ambient air pollution has been implicated as a major risk factor for morbidities and premature mortality in India, with particularly high concentrations of particulate matter in the Indo-Gangetic plain. High resolution spatiotemporal estimates of such exposures are critical to assess health effects at an individual level. This article retrospectively assesses daily average PM2.5 exposure at 1 km × 1 km grids in Delhi, India from 2010 to 2016, using multiple data sources and ensemble averaging approaches. We used a multi-stage modeling exercise involving satellite data, land use variables, reanalysis based meteorological variables and population density. A calibration regression was used to model PM2.5: PM10 to counter the sparsity of ground monitoring data. The relationship between PM2.5 and its spatiotemporal predictors was modeled using six learners; generalized additive models, elastic net, support vector regressions, random forests, neural networks and extreme gradient boosting. Subsequently, these predictions were combined under a generalized additive model framework using a tensor product based spatial smoothing. Overall cross-validated prediction accuracy of the model was 80% over the study period with high spatial model accuracy and predicted annual average concentrations ranging from 87 to 138 μg/m3. Annual average root mean squared errors for the ensemble averaged predictions were in the range 39.7–62.7 μg/m3 with prediction bias ranging between 4.6 and 11.2 μg/m3. In addition, tree based learners such as random forests and extreme gradient boosting outperformed other algorithms. Our findings indicate important seasonal and geographical differences in particulate matter concentrations within Delhi over a significant period of time, with meteorological and land use features that discriminate most and least polluted regions. This exposure assessment can be used to estimate dose response relationships more accurately over a wide range of particulate matter concentrations.

Keywords: Particulate matter; Machine learning; Hybrid models; Pollution exposure; Satellite observations.

Aerosol vertical profile variations with seasons, air mass movements and local PM2.5 levels in three large China cities

Lingyu Wang a b, Baolei Lyu c, Yuqi Bai a b

Source: Atmospheric Environment, Volume 224, 1 March 2020, 117329

High atmospheric aerosol densities in China have significant influence on air quality and human health. It is critical to understand their variations with seasons, air qualities and regional meteorological conditions, not only in the horizontal dimension but also in the vertical dimension. In this study, we discussed aerosol vertical profiles from spaceborne lidar in different seasons, regional air mass movement patterns and ground-level PM2.5 concentrations in three large China cities of Beijing, Shanghai and Guangzhou. The extinction coefficient profiles exhibited apparent seasonal variations due to varied emission and meteorological conditions. Characterized by backward trajectories, the air mass movements, especially the moving speeds and their source regions, have strong impacts on both extinction coefficient values and its relative profile structures. The aerosol extinction coefficient values had positive correlation with ground-level PM2.5 concentrations within the altitude below 700 m, while the relationship in higher altitudes was inapparent. As the altitude increased, the mean extinction coefficient values of high PM2.5 clusters sharply decreased, while the extinction coefficient values of low PM2.5 clusters declined in a linear pattern with a gentle slope. This study provided insightful analysis to understand the vertical distributions of aerosol extinction coefficients under different scenarios, which is helpful for better understanding air pollution episodes.

Keywords: PM2.5 Aerosol profile; CALIOP; Backward trajectory.

Impact of control measures and typhoon weather on characteristics and formation of PM2.5 during the 2016 G20 summit in China

Yanru Zhang a b c, Zhenyu Hong a b c, Jinsheng Chen a b, Lingling Xu a b, Youwei Hong a b, Mengren Li a b, Hongfei Hao d, Yanting Chen a b, Yuqing Qiu a b c, Xin Wu a b c, Jian-Rong Li a b, Lei Tong a b, Hang Xiao a b

Source: Atmospheric Environment, Volume 224, 1 March 2020, 117312

The implementation of strict emission control during the G20 summit in China and the occurrence of Typhoon Malarkas in September 2016 provided a valuable opportunity to examine the role of control measures and special weather condition in the formation of PM2.5. Water-soluble inorganic ions (WSII) were measured hourly in addition to PM2.5 mass concentration and black carbon (BC) and gaseous pollutants in Ningbo located in the Yangtze River Delta (YRD) region of China. Three distinct cases, i.e., a control case, a normal case, and a typhoon case, were investigated during the study period. PM2.5 was higher in the control case (37.5 μg m−3) than in the normal case (29.8 μg m−3), whereas the lowest PM2.5 (14.2 μg m−3) was observed in the typhoon case. The analyses of meteorology and backward trajectory suggested that stable weather and regional transport from inland regions accounted for the high PM2.5 under strict control. Only the concentrations of Ca2+ and NO3− decreased in the control case, while those of all water-soluble inorganic components (except Na+ and Mg2+) decreased substantially in the typhoon case. SO42− dominated the WSII, with the highest contribution, 62%, in the control case. This result was attributed to a stagnant atmosphere with a high relative humidity (RH), which was beneficial for the transformation of SO2 to SO42−. The control and typhoon cases both resulted in extremely low NO2, but the contribution of NO3− to PM2.5 was reduced in the control case and increased in the typhoon case. The close correlation of the NOR (nitrate oxidation ratio) with Na+ and Mg2+ in the typhoon case was indicative of sea salt associated with the typhoon which provided a surface for the heterogeneous formation of NO3−. The presented results facilitate a better understanding of the characteristics and formation of PM2.5 under the influence of artificial control and natural intervention.

Keywords: Secondary inorganic aerosol; G20; Control measures; Typhoon; Regional transport; Formation mechanism.

Physical and chemical properties of non-exhaust particles generated from wear between pavements and tyres

C.A.Alves a, A.M.P.Vicente a, A.I.Calvo b, D.Baumgardner c, F.Amato d, X.Querol d, C.Pio a, M.Gustafsson e

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A road simulator was used to generate wear particles from the interaction between two tyre brands and a composite pavement. Particle size distributions were monitored using a scanning mobility particle sizer and an aerosol particle sizer. Continuous measurements of particle mass concentrations were also made. Collection of inhalable particles (PM10) was conducted using a high-volume sampler equipped with quartz filters, which were then analysed for organic and elemental carbon, organic constituents and elemental composition. Tyre fragments chopped into tiny chips were also subjected to detailed

organic and elemental speciation. The number concentration was dominated by particles <0.5 μm, whereas most of the mass was found in particles >0.5 μm. The emission factor from wear between pavements and tyres was of the order of 2 mg km−1 veh−1. Organic carbon represented about 10% of the PM10 mass, encompassing multiple aliphatic compounds (n-alkanes, alkenes, hopanes, and steranes), PAHs, thiazols, n-alkanols, polyols, some fragrant compounds, sugars, triterpenoids, sterols, phenolic constituents, phthalate plasticisers and several types of acids, among others. The relationship between airborne particulate organic constituents and organic matter in tyre debris is discussed. The detection of compounds that have been extensively used as biomass burning tracers (e.g. retene, dehydroabietic acid and levoglucosan) in both the shredded tiny tyre chips and the wear particles from the interaction between tyres and pavement puts into question their uniqueness as markers of wood combustion. Trace and major elements accounted for about 5% of the mass of the tyre fragments but represented 15–18% of the PM10 from wear, denoting the contribution of mineral elements from the pavement. Sulphur and zinc were abundant constituents in all samples.

Keywords: Non-exhaust emissions; Tyres; PM10; Size distributions; Organic compounds; Elements.

Prioritizing the control of emission sources to mitigate PM2.5 disparity in California

HyungJoo Lee Hye-Youn Park

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Previous research has investigated the spatial disparity of ambient PM2.5 concentrations in the context of environmental justice (EJ). However, source emissions associated with the PM2.5 disparity have not been well understood. In this study, we found 2.54 μg/m3 (40.9%, $p < 0.0001$) higher PM2.5 concentration, on average, in more vulnerable (MV) communities than in less vulnerable (LV) communities in California for the period 2012–2014. Multiple linear regression models were employed to quantify the contributions of on- and off-road vehicles and point source emissions to the PM2.5 disparity between MV and LV communities while adjusting for local meteorology and site-specific characteristics. Controlling for on-road vehicular emissions associated with PM2.5 reduced the spatial PM2.5 disparity the most between MV and LV communities down to 1.05 μg/m3 ($p = 0.0105$), followed by off-road vehicular emissions (1.75 μg/m3, $p < 0.0001$) and PM2.5 point source emissions (2.17 μg/m3, $p < 0.0001$). The comparison of the full (including 3 emission predictors together) and reduced (including 2 emission predictors) models also demonstrated the strongest association of on-road vehicular emissions with the observed

PM2.5 disparity. The largest contribution of on-road vehicular emissions to PM2.5 disparity seems to be attributable to disproportionately higher road density, especially for limited access roads such as Interstate highways (a factor of 1.76–2.39) and higher traffic volume (a factor of 1.62) in MV communities. These findings suggest that continuing efforts to reduce on-road traffic emissions and consider the spatial relation between MV communities and high-traffic roadways may be beneficial to alleviate potential PM2.5 health risks, particularly in MV communities.

Keywords: Disparity; Source; Environmental justice; Exposure; PM2.5.

Characterization of water-insoluble oxidative potential of PM2.5 using the dithiothreitol assay

Dong Gao a, James A. Mulholland a, Armistead G. Russell a, Rodney J.Weber b

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Both water-soluble and insoluble components of ambient particulate matter (PM) have been shown to contribute to the oxidative potential (OP) of PM. In this study, we used the dithiothreitol (DTT) assay to assess the water-soluble (OPWS−DTT) and total OP (OPtotal−DTT) of ambient fine particles (PM2.5), with water-insoluble OP (OPWI−DTT) determined by difference. Ambient PM2.5 filter samples were collected daily during 2017 in urban Atlanta and were analyzed for OP and major PM components. Results from measurements suggested a measurable contribution of water-insoluble components to OPDTT, which comprised on average 20% of total PM OP. Strong seasonal trends were observed in both volume- and mass-normalized OPtotal−DTT and OPWI−DTT, with higher values in the winter than in the summer, possibly driven by biomass burning emission seasonality. Correlation analysis indicated that all forms of OPDTT measurements were related to organic species and metals. OPtotal−DTT and OPWI−DTT were correlated with brown carbon (BrC) and total metals, especially total crustal elements. A multivariate regression model was developed for OPtotal−DTT based on particle composition data. The model suggested that the variability of OPtotal−DTT was primarily affected by BrC, followed by EC, total Cu and an antagonistic interaction between BrC and total Cu.

Keywords: Particulate matter; Oxidative potential; Water-soluble components; Water-insoluble components; Biomass burning; Transition metal ions.

Diagnostic analysis of wintertime PM2.5 pollution in the North China Plain: The impacts of regional transport and atmospheric boundary layer variation

Xipeng Jin a, Xuhui Cai a, Mingyuan Yu a, Yu Song a, Xuesong Wang a, Ling Kang a, Hongsheng Zhang b

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Air pollution has recently become a regional problem in the North China Plain, which is heavily populated with industrialized city clusters. The local air quality is frequently affected by air pollutant transport in this region, as well as other meteorological conditions. This study aims to reveal the roles of air pollutant transport and atmospheric boundary layer variation in the development of air pollution episodes. Two cities (Dezhou and Cangzhou in Shandong and Hebei Provinces, respectively) near the centre of the North China Plain are chosen, and PM2.5 (particulate matter with an aerodynamic diameter less than 2.5 μm) concentrations over two winters (January 2016 and December 2017 to January 2018) are evaluated. Both meteorological and air quality observational data are used to construct hourly wind and PM2.5 concentration fields. High-quality atmospheric boundary layer soundings provide detailed information on boundary layer height and its diurnal evolution. A simple box model is employed to simulate variation in PM2.5 levels in these two cities by using the spatial gradients and temporal variation rates in the diagnostic fields of wind and PM2.5 concentrations. Two prominent factors affecting PM2.5 concentration variation are identified by comparing the simulated and observed diurnal variation in PM2.5 concentration. The first one is the entrainment of upper-layer air pollutants into the boundary layer in the morning. And the second one is the temporary accumulation of PM2.5 during the day-to-evening period. After incorporating these two effects, the simulated PM2.5 is comparable with the observed data. The correlation coefficients between the simulation and observation are 0.84 and 0.77 ($P < 0.01$) for Cangzhou and Dezhou, respectively, and the normalized mean biases are −0.04 and −0.09, respectively. The relative contributions of different processes affecting PM2.5 concentrations during air pollution episodes are assessed with the model simulations. The percentage contributions for local emissions, deposition, horizontal advection, temporary accumulation, and boundary layer height variation are from 27% to 45%, −28% to −20%, 46% to 76%, 13% to 40%, and −6% to 22%, respectively. Local emission and regional air pollutant transport are the main causes of these episodes. Temporary accumulation of PM2.5 during the day-to-evening period is also an important contributor to the episodes. In addition, the entrainment shows varying contributions to PM2.5 increase with a maximum rate of 30% during the PM2.5 pollution episodes in the North China Plain.

Keywords: PM2.5 pollution; Regional transport; Atmospheric boundary layer.

Evaluating the impact of PM2.5 atmospheric pollution on population mortality in an urbanized valley in the American tropics

David Aguiar-Gil a b, Luisa M.Gómez-Peláez a b, Tatiana Álvarez-Jaramillo b, Mauricio A.Correa-Ochoa a b, Julio C.Saldarriaga-Molina a b

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There is enough scientific evidence indicating a relationship between particulate matter in ambient air and health. Since at a global scale there is an important number of people exposed to this pollutant, studies have focused on evaluating its possible effects on human population. Aburrá Valley Metropolitan Area (AMVA), in Antioquia-Colombia, is a region with about 3,909,729 inhabitants (2018), where 79% of PM2.5 present in the atmosphere is emitted by motor vehicles, with 1534 ton/year (AMVA, 2018). In the last decade, monitoring stations have reached daily mean concentrations of 113 μg/m3, which is 226% in excess of the maximum permissible daily level established at 50 μg/m3 by Colombian regulations (AMVA 2016; MinAmbiente, 2017). The object of the study was to evaluate the impact of PM2.5 concentrations in cases of premature mortality of urban population. To this end, the BenMap-CE v.1.1 model was used, together with Krewski et al. (2009) Health Impact functions to evaluate associations with adult mortality (>30 years of age) due to All Causes (AC)—including natural and non-natural—(ICD-10: A00-Y98), Ischemic Heart Disease (IHD) (ICD-10: I20–I25) and LungCancer (LC) (ICD-10: C34); and Woodruff et al. (2006) functions to explore associations with child mortality (population 0–1 year of age) due to All Causes (AC)—including natural and non-natural. Health impact was evaluated for year 2016 (baseline) and estimated for 2020 and 2030, from annual mean concentrations reported and projected by the environmental authority. The study was carried out based on annual mean mortality rates reported for the period 2007–2016. Among the most relevant results, it was found that for 2016 the areas with the highest annual concentrations of PM2.5 were Medellín (downtown area), Caldas, and Medellín (northern area) (39.4 μg/m3, 33.7 μg/m3, and 33.2 μg/m3, respectively). Consequently, health impact estimations (mortality due to all causes in adults) showed the highest associations: 15.70% (676 cases; CI: 470.29–873.06), 12.90% (32 cases; CI: 22.04–41.34) and 12.63% (736 cases; CI: 508.65–954.76), respectively.

For the Aburrá Valley Metropolitan Area in 2016, it was found that death cases attributable to PM2.5 levels were: 1971 cases (CI: 1362.96–2558.62) for adult mortality due to AC, 194 cases (CI: 92.04–284.17) due to LC and 932 cases (CI: 791.33–1063.56), figures

comparatively lower than the estimates for 2030, where death cases attributable to the same pollutant were: 5867 cases (CI: 4190.12–7410.53) for adult mortality due to AC, 497 cases (CI: 265.47–666.77) due to LC and 2415 cases (CI: 2157.06–2632.99). These values were calculated from the sum of the estimations given by the BenMap model for each municipality in the Metropolitan Area. Finally, avoidable death cases were calculated for a scenario with the implementation and execution of 100% of the measures for the prevention and control of emissions from motor vehicles, as defined by the Integral Plan for Air Quality Management (PIGECA, AMVA, 2017a) for year 2030: 55.93% of infant mortality cases due to AC; 50.32% in adults due to AC; 55.73% in adults due to LC and 60.87% in adults due to IHD associated with PM2.5.

Keywords: Atmospheric pollution; PM2.5; Ben MAP; Health impact functions; Aburrá Valley; Colombia.

Characteristics and potential inhalation exposure risks of PM2.5–bound environmental persistent free radicals in Nanjing, a mega–city in China

Xuewen Guo a, Nan Zhang b, Xin Hu a, Yue Huang b, Zhuhong Ding b, Yijun Chen a, Hong-zhen Lian a

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PM2.5–bound toxic elements and organic pollutants have been extensively investigated, while limited information is available for environmental persistent free radicals (EPFRs) associated with PM2.5, which may lead to oxidative stress in the human lung when exposed to PM2.5. In this study, the levels and types of PM2.5–bound EPFRs present in Nanjing, a mega–city in China, were analyzed. PM2.5–bound EPFRs were found to mainly be a mixture of carbon– and oxygen–centered radicals. The concentration of PM2.5–bound EPFRs ranged from 2.78 × 1012 to 1.72 × 1013 spins m−3, with an average value of 7.61 × 1012 spins m−3. The half–life of the PM2.5–bound EPFRs was calculated to be an average of 83.5 days when stored at room temperature, with only weak correlations observed between EPFRs and conventional air pollutants (NO2, O3, CO and PM2.5)/PM2.5–bound transition metals (Cu, Zn, Cr, Mn, V, Cd, and Ni) and significant correlations between EPFRs and SO2/PM2.5–bound Fe. PM2.5–bound EPFRs can induce the formation of reactive oxygen species (ROS) in both water and a H2O2 solution, which are used to simulate lung solution of a healthy person and patient, respectively. Therefore, PM2.5–bound EPFRs can lead to potential oxidative stress in humans. Overall, PM2.5–bound EPFRs show an obvious temporal variation and can pose potential health risks to humans via the induction of ROS in the lung solution.

Keywords: Temporal variation; Half–life; Inhalation exposure; Reactive oxygen species; Oxidative stress.

PM2.5 source apportionment during severe haze episodes in a Chinese megacity based on a 5-month period by using hourly species measurements: Explore how to better conduct PMF during haze episodes

Yingze Tian a, Yufen Zhang a, Yongli Liang a, Zhibin Niu b, Qianqian Xue a, Yinchang Feng a

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To understand rapid physicochemical changes and to explore how to better conduct PMF for source apportionment during haze episodes, EPA Positive Matrix Factorization (PMF) 5.0, including an assessment of uncertainties, was performed based on hourly measurements of PM2.5-bound species during a heating period in 2017–2018 in the Chinese megacity of Tianjin. Five haze episodes were the focus of this study. PMF was conducted using two modes (whole-based mode for the entire sampling period and episode-based mode for each episode), and some indicators, including bootstrap (BS), displacement of factor elements (DISP), E/M (ratios of estimated and measured concentrations), were then used to evaluate PMF performance. The contributions of secondary ions and secondary organic carbon (SOC) for episodes I and III were greater than 50% (which were defined as SPE: episodes strongly influenced by secondary particles). The coal combustion contribution in episode II (defined as coal combustion episode: CCE) was greater than in the other episodes, and fireworks burning were extracted in episode IV (defined as fireworks burning episode: FBE). The PMF solutions were poor for the regional transport episode (RTE), during which episode the species showed weak variations (low coefficients of variation) and similar patterns (high correlations). During SPE, E/M were 0.71–1.00 for episode-based mode and 0.65–1.28 for whole-based mode, indicating good performance for both modes; while during CCE and FBE, E/M were 0.53–0.99 for episode-based mode and 0.10–1.06 for whole-based mode, showing that estimation of some important markers were poor for the whole-based mode. Sensitivity tests were then conducted to systematically investigate the influence of heavy-pollution types on PMF and showed that PMF was insensitive to contribution variations but was strongly sensitive to variations in source profiles. Overall, episode-based mode of PMF is better for episodes with strong variations of primary sources (CCE and FBE), whereas whole-based mode can be used for SPE and RTE. This work will help us to accurately assess hourly source variations.

Keywords: Particulate matter; Source apportionment; Haze; PMF; Uncertainty.

Burden of mortality attributed to PM2.5 exposure in cities of Iran; contribution of short-term pollution peaks

Mostafa Hadei a b, Abbas Shahsavani c d, Michal Krzyzanowski e, Xavier Querol f, Massimo Stafoggia g, Seyed Saeed Hashemi Nazari h, Ahmad Jonidi Jafari I, Maryam Yarahmadi j, Majid Kermani I, Ardeshir Khosravi j

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The objective of this study was to determine the population exposure to PM2.5, and to quantify the effect of eliminating short-term pollution peaks on the number of cause-specific deaths, the number of years of life lost (YLL), and economic losses attributed to exposure to PM2.5 in 25 Iranian cities with available air quality data. Number of deaths and YLL were estimated with AirQ + software tool using available concentration-response functions and life table approach. Furthermore, the value of lost life in each city were calculated using the Value of Statistical Life (VSL) method. Two scenarios were defined; Scenario A, considering actual observed concentrations to estimate the real health effects of PM2.5, and Scenario B, controlling for the effect of air pollution episodes. The results showed that the annual average concentrations of PM2.5 in cities were 1.5–6.1 times higher than the guideline value of WHO (10 μg/m^3). The total number of all-cause deaths due to long-term exposure exceeding WHO air quality guideline level was 13321 (95% C.I.: 8837–17378) cases per year in all cities. The total numbers of chronic obstructive pulmonary disease (COPD), lung cancer, ischemic heart disease (IHD), and stroke deaths attributed to the exposure were 274, 315, 1536, and 963 cases, respectively. The total number of YLL over 10 years period in all 25 cities was 486,289 years and the loss of life expectancy ranged from 0.43 to 1.87 years. The sum of economic losses due to lost life exceeded 5.8 billion USD. Except for some cities, avoiding highly polluted days in Scenario B would result in only 5% reduction in overall health or economic effects. These results indicate an urgent need for new comprehensive plans to tackle air pollution in Iranian cities focused on reduction of long term average pollution levels since programs for avoiding highly polluted days lead to a limited health benefits only.

Keywords: Fine particles; Particulate matter; Dust, Life expectancy; AirQ+.

Traffic contribution to PM2.5 increment in the near-road environment

Mohammad Hashem Askariyeh a, JoeZietsman b, Robin Autenrieth c

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A growing number of studies have reported the adverse health effects of long-term exposure to air pollutants, especially fine particulate matter (PM2.5). Vehicular emission sources have been shown to contribute to elevated air pollution concentrations in the near-road environment, including PM2.5, based on monitoring data collected mainly during short-term campaigns. The United States Environmental Protection Agency (EPA) added near-road monitors to its national network to collect long-term National Ambient Air Quality Standard (NAAQS)–comparable data in the near-road environment. The EPA also mandated inclusion of near-road monitoring data in the Air Quality Index to reflect the elevated level of near-road PM2.5 concentrations to which millions of people in major urban areas are exposed to on a daily basis. For the first time, PM2.5 data collected at one of these near-road monitors were compared with those of other NAAQS monitors during 2016 in Houston, Texas. One of these NAAQS monitors was selected based on EPA guidance for quantitative hotspot analyses of particulate matter to represent background concentrations. The near-road PM2.5 increment was statistically significant. The traffic contribution to 24-h PM2.5 increment in the near-road environment was estimated to be about 23% of background concentration, which is close to estimates given by previous studies (22%) and is greater than a recent estimate based on a national-scale data analysis (17%), emphasizing the importance of background monitor selection criteria. Wind speed and direction were shown to have a considerable effect on PM2.5 increment in the near-road environment. A multiple linear regression model was developed to predict 24-h near-road PM2.5 concentrations using background PM2.5 concentration, wind speed, and wind direction. This model explained 83% of the variability of 24-h PM2.5 concentrations in the near-road environment and showed improvement in near-road concentration predictions when accounting for wind speed and wind direction.

Keywords: Near-road; Particulate matter; Traffic; Air pollution; Monitoring.

Use of low-cost PM monitors and a multi-wavelength aethalometer to characterize PM2.5 in the Yakama Nation reservation

Orly Stampfer a, Elena Austin a, Terry Ganuelas b, Tremain Fiander b, Edmund Seto a, Catherine J.Karr a c

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Rural lower Yakima Valley, Washington is home to the reservation of the Confederated Tribes and Bands of the Yakama Nation, and is a major agricultural region. Episodic poor air quality impacts this area, reflecting sources of particulate matter with a diameter of less than 2.5 μm (PM2.5) that include residential wood smoke, agricultural biomass burning

and other emissions, truck traffic, backyard burning, and wildfire smoke. University of Washington partnered with the Yakama Nation Environmental Management Program to investigate characteristics of PM2.5 using 9 months of data from a combination of low-cost optical particle counters and a 5-wavelength aethalometer (MA200 Aethlabs) over 4 seasons and an episode of summer wildfire smoke. The greatest percentage of hours sampled with PM2.5 >12 μg/m3 occurred during the wildfire smoke episode (59%), followed by fall (23%) and then winter (21%). Mean (SD) values of Delta-C (μg/m3), which has been posited as an indicator of wood smoke, and determined as the mass absorbance difference at 375–880 nm, were: summer – wildfire smoke 0.34 (0.52), winter 0.27 (0.32), fall 0.10 (0.22), spring 0.05 (0.11), and summer – no wildfire smoke 0.04 (0.14). Mean (95% confidence interval) values of the absorption Ångström exponent, an indicator of the wavelength dependence of the aerosol, were: winter 1.5 (1.2–1.8), summer – wildfire smoke 1.4 (1.0–1.8), fall 1.3 (1.1–1.4), spring 1.2 (1.1–1.4), and summer – no wildfire smoke 1.2 (1.0–1.3). The trends in Delta-C and absorption Ångström exponents are consistent with expectations that a higher value reflects more biomass burning. These results suggest that biomass burning is an important contributor to PM2.5 in the wintertime, and emissions associated with diesel and soot are important contributors in the fall; however, the variety of emissions sources and combustion conditions present in this region may limit the utility of traditional interpretations of aethalometer data. Further research on the interpretation of aethalometer data in regions with complex emissions would contribute to much-needed understanding in communities impacted by air pollution from agricultural as well as residential sources of combustion.

Keywords: Biomass burning; Aethalometer; Low-cost sensor; PM2.5; Rural; Agricultural.

Microenvironmental modelling of personal fine particulate matter exposure in Accra, Ghana

Christopher S.Malley a, Mike R.Ashmore a, Johan C.I.Kuylenstierna a, James A.McGrath b, Miriam A.Byrne b, Chrysanthi Dimitroulopoulou c, Daniel Benefoh d

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The health burden from exposure to fine particulate matter (PM2.5) is disproportionately concentrated in low- and middle-income countries. To evaluate strategies to reduce PM2.5 exposure, the contribution of different sources, both indoor and outdoor, to overall personal PM2.5 exposure needs to be identified. Despite this, exposure to PM2.5 from indoor and outdoor origin are most often considered separately. This work presents the first application of a microenvironmental modelling approach in a sub-Saharan African city (Accra, Ghana) to estimate personal PM2.5 exposures to population groups disaggregated

by gender and age and identify the key factors determining these exposures. Time-activity profiles for each population group were combined with PM2.5 concentrations estimated for three home microenvironments using a dynamic microenvironmental model, INDAIR, and for work, school and transport microenvironments using a steady-state model to estimate personal PM2.5 exposures. In Accra, cooking using charcoal, compared to liquified petroleum gas (LPG), was estimated to result in substantially higher home PM2.5 concentrations, and higher personal PM2.5 exposure for the female adult and child population groups, compared with the male population groups. In households cooking using charcoal, more than 60% of total personal PM2.5 exposure was estimated to be due to residential cooking for the child and female population groups, which reduces to less than 10% when LPG was used for cooking, with the remaining contribution from PM2.5 of outdoor origin. The key parameters to which personal PM2.5 exposure estimates are sensitive are the air exchange rate between indoor and outdoors, the kitchen volume, and charcoal emission rates. This study therefore informs on the additional data collection and measurements that could substantially enhance the parameterisation of micro-environmental models for application in low- and middle-income countries where a limited number of studies have been conducted, and improve their utility in assessing strategies to reduce personal air pollution exposure of different population groups.

Keywords: Microenvironmental modelling; Particulate matter; Personal exposure; Accra; Indoor air pollution; Outdoor air pollution.

Impacts of meteorology and emission control on the abnormally low particulate matter concentration observed during the winter of 2017

Xianjun Xu, Zhongjing Jiang, Jing Li, Yiqi Chu, Wangshu Tan Chengcai Li

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As the capital of China, Beijing is the subject of great concern regarding atmospheric pollution, especially that of fine particulate matter (PM2.5). In winter 2017 (i.e., November 2017 to February 2018), PM2.5 concentration in Beijing decreased to its lowest value in the past ten years. In this study, we sought to investigate the impacts of meteorology and emission control on this abnormally low pollution phenomenon. Weather Research and Forecasting coupled with Chemistry (WRF-Chem) simulations show that sensitivity to meteorological factors accounts for approximately 51% of the observed change between winters 2016 and 2017 in Beijing. We further compared the pollution dispersion condition of winters 2016 and 2017 in terms of large-scale circulation patterns and local mixing layer heights (MLHs). The meteorological condition in 2017 was characterized by stronger wind speed (WS) and higher MLH. We classified circulation patterns into two types using the

obliquely rotated Principal Component Analysis in T-mode (T-PCA) method. Active weather was found to be associated with high MLH, high near-surface WS, and high ventilation coefficient (VC), which favors the dispersion of pollutants. In contrast, the changes of meteorological variables and pollution conditions are almost opposite for stable weather. Active weather amounted to 73 and 85 days for winters 2016 and 2017, respectively. Stable weather conditions prevailed on 46 days in winter 2016, and 32 days in 2017. Less stable weather during winter 2017 compared with that of winter 2016 possibly favored efficient ventilation of boundary-layer pollution. A lack of persistent stable weather also contributed to low PM2.5 concentration in 2017. This research is important for air-pollution assessment and regional environmental management.

Keywords: PM2.5; Mixing layer height; Ventilation coefficient; Circulation pattern; Emission control; Beijing.

RS&GIS based PM emission inventories of dust sources over a provincial scale: A case study of Henan province, central China

Huan Yang a, Xuan Song b, Qi Zhang a

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Henan province, the most populous province in China, is facing serious particulate matter (PM) pollution problem. In this study, a provincial emission inventory of total suspended particles (TSP), particulate matter 10 (PM10) and particulate matter 2.5 (PM2.5) from dust source of the year 2016 was established on a grid of 3 km × 3 km resolution using the RS and GIS technology. The results show that the TSP, PM10 and PM2.5 emission from dust source in Henan province were 1261.11 kt·a−1, 461.24 kt·a−1 and 103.05 kt·a−1, respectively. Among various emission sources, construction dust was the main sources of PM emission, which contributes 56.72% of the TSP emission, 77.68% of the PM10 emission and 76.77% of the PM2.5 emission. Furthermore, the total emission of TSP, PM10 and PM2.5 in Henan province formed a Zhengzhou-centered high emission zone, which was surrounded by Luoyang, Kaifeng, Xinxiang, Jiaozuo and Xuchang cities. PM emission from different dust sources showed particular spatial characteristics, high PM emission of soil dust source was more likely to occur in cities with backward economic development and dry climate, PM emission of construction dust source mainly concentrated in developed and densely populated regions, city centers and the surrounding country centers were the area with high PM emission from road dust source.

Keywords: Emission inventory; RS and GIS technology; Spatial distribution; Henan province.

PM emissions from open field crop management: Emission factors, assessment methods and mitigation measures – A review

Jacopo Maffia a, ElioDinuccio a, Barbara Amon b c, Paolo Balsari a

Source: Atmospheric Environment, Volume 226, 1 April 2020, 117381

Globally, particulate matter (PM) emissions are a growing cause of concern due to the potential impact on human health and environment. The agricultural sector is responsible of the 17% of the total anthropogenic emission of PM10 and the agricultural operations (tilling, harvesting, residue burning etc.) have been recognized as one of the main drivers of this contribution. This topic has been addressed in many articles, focusing on the impacts coming from different steps of the agricultural production system and using different assessment methods. The aim of this review is to identify the main agricultural operations producing particulate emission, providing a collection of the Emission Factors (EF) available in literature. The most used EFs determination methods have also been described, by focusing on pros and cons of each method. Issues and lacks of information to be addressed by future research have been highlighted. It has been observed that very few PM emission assessment have been done by taking into consideration whole cropping systems and the information available is fragmented onto single cropping activities. In addition, very few mitigation measures have been developed so far.

Keywords: Particulate matter; Field operations; Emission factors; Mitigation measures.

Numerical assessment of PM2.5 and O3 air quality in Continental Southeast Asia: Impacts of future projected anthropogenic emission change and its impacts in combination with potential future climate change impacts

Giang Tran Huong Nguyen a b, Hikari Shimadera a, Katsushige Uranishi a, Tomohito Matsuo a, Akira Kondo a

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Air quality in future will change in response to anthropogenic emission change as well as climate change. In this study, an advanced online coupled Weather Research and Forecasting (WRF) and Community Multiscale Air Quality (CMAQ) model was applied to the Continental Southeast Asia. The targets were to investigate the impacts of projected

change in future anthropogenic emissions and its impacts in combination with climate change impacts on future particulate matter with an aerodynamic diameter of 2.5 μm or less (PM2.5) and ozone (O3) air quality. Future anthropogenic emissions were produced by scaling Hemispheric Transport of Air Pollution (HTAP) emissions in year 2010 using ratios taken from the Evaluating the Climate and Air Quality Impacts of Short-Lived Pollutants (ECLIPSE) emission database in year 2050 and 2010 under current legislation (CLE) scenario. Future climate projections were obtained by implementing a dynamical downscaling method based on pseudo global warming (PGW) technique using future (2046-2055) climate conditions and present (2006-2015) climate conditions provided by the Coupled Model Intercomparison Experiment (CMIP5) Community Earth System Model (CESM) data and the 2014 meteorological conditions. Two Representative Concentration Pathway (RCP) climate scenarios, RCP4.5 and RCP8.5, were considered. Overall, anthropogenic emission change alone appears to cause higher PM2.5 and O3 levels in future period. Across four target countries namely Cambodia, Laos, Thailand, and Vietnam, on average, PM2.5 and O3 concentrations increase by +4.56 μg/m3 (+13.76%) and +5.12 ppb (+13.20%) during the dry season, +3.03 μg/m3 (+27.72%) and +5.89 ppb (+23.97%) during the wet season, respectively. PM2.5 increase is attributed to the emission growth of primary PM2.5 and PM2.5 precursors. Among PM2.5 species, while raising trend was mainly predicted for anthropogenic secondary organic aerosol (PM2.5 ASOA), sulfate ion (PM2.5 SO42−), nitrate ion (PM2.5 NO3−), and ammonium ion (PM2.5 NH4+) concentrations, reducing trend was mainly predicted for element carbon (PM2.5 EC) and primary organic aerosol (PM2.5 POA) concentrations due to the projected primary PM2.5 emission decrease in China. O3 increase is driven by high nitrogen oxides (NOx) emission increase rather than non-methane volatile organic compounds (NMVOCs) emission increase since NOx-limited regime mostly dominates over the region. Both future PM2.5 and O3 increases in Continental Southeast Asia are also contributed by pollutant emission growth in India. Driven by climate change and emission change in combination, the rise in PM2.5 and O3 concentrations is larger in RCP8.5 scenario than that in RCP4.5 scenario. Averagely, under RCP4.5 scenario, PM2.5 and O3 concentrations, across four target countries, were projected to increase by +3.43 μg/m3 (+10.36%) and +4.37 ppb (+11.27%) during the dry season, +2.20 μg/m3 (+20.15%) and +5.20 ppb (+21.16%) during the wet season. Under RCP8.5 scenario, they increase by +7.10 μg/m3 (+21.43%) and +6.35 ppb (+16.38%) during the dry season, +3.08 μg/m3 (+28.15%) and +6.20 ppb (+25.20%) during the wet season, respectively. The simulation results indicated that emission trend is a major factor in the variation in PM2.5 and O3 concentrations, while the climate change also plays an important role. Current legislations and pollution controls as in ECLIPSE CLE scenario are inadequate for better PM2.5 and O3 air quality in the region. A stronger emission control strategy will be required to cope with this PM2.5 and O3 air quality degradation, particularly under RCP8.5 scenario.

Keywords: Online coupled WRF-CMAQ model; Future emissions; Climate change impacts; Fine particulate matter; Ozone; Continental Southeast Asia.

PM2.5-bound unresolved complex mixtures (UCM) in the Pearl River Delta region: Abundance, atmospheric processes and sources

HuaFang a c, Scott D.Lowther d, Ming Zhu a c, Chenglei Pei e, Sheng Li a c, Zheng Fang a c, Xu Yu a c, Qingqing Yu a c, Yujun Wang e, Yanli Zhang a b, Kevin C.Jones d, Xinming Wang a b c

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Unresolved complex mixture (UCM) accounts for a substantial fraction of particulate organic matters and plays an important role in forming secondary organic aerosol (SOA), yet their abundance, sources and atmospheric processes are not well understood. In this study, filter-based ambient PM2.5 samples were collected concourrently at an urban site and a rural site in the Pearl River Delta (PRD) region, south China, to characterize semi-volatile UCM. Dust, urban tunnel exhaust, ship exhaust and biomass burning samples were also collected to characterize UCM from typical primary emission sources. No obvious UCM humps were found in total ion chromatograms (TIC) of the PM2.5 samples collected during July–October, while the determined UCM reached 6.51 ± 4.92 μg/m3 at the urban site and 6.75 ± 4.78 μg/m3 at the rural site during November–May, accounting for ~9% of PM2.5 mass at both sites. The missing UCM humps in the hot months were due to much large fraction of these semi-volatiles partitioning to gas phase and their much faster atmospheric oxidation. In addition, the lower organic matter (OM) was also a non-negligible factor contributing to less particulate UCM in summer. Five major sources for PM2.5-bound UCM were identified by positive matrix factorization (PMF) involving organic and inorganic molecular source tracers. Vehicle exhaust accounted for 44.4% and 30.3% of UCM at the urban and the rural site, respectively. Biomass burning contributed more to UCM at the rural site (28.0%) than at the urban site (19.2%). Ship emission was found to contribute substantially to UCM (28.9% at the urban and 17.3% at the rural site) in the PRD harbor megacity. Coal combustion and dust altogether contributed much less at the urban site (7.5%) than at the rural site (24.4%).

Keywords: Unresolved complex mixtures (UCM); Gas/particle partitioning; Source apportionment; Vehicle exhaust; Biomass burning; Ship emission.

Workflow for comparison of chemical and biological metrics of filter collected PM2.5

Courtney Roper a 1, Allison Perez a, Damien Barrett b, Perry Hystad c, Staci L.Massey Simonich a d, Robyn L.Tanguay a

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There is limited understanding of adverse health effect associations with chemical constituents of fine particulate matter (PM2.5) as well as the underlying mechanisms. We outlined a workflow to assess metrics, beyond concentration, using household and personal PM2.5 filter samples collected in India as a proof of concept for future large-scale studies. Oxidative potential, chemical composition (polycyclic aromatic hydrocarbons and elements), and bioactivity (developmental exposures in zebrafish) were determined. Significant differences were observed in all metrics between personal and household PM2.5 samples. This work established methods to characterize multiple metrics of PM2.5 to ultimately support the identification of more health-relevant metrics than concentration.

Keywords: Indoor PM2.5; Household air pollution; Zebrafish; Oxidative potential; PM2.5 composition; PAH diagnostic ratios.

Observation of PM2.5 using a combination of satellite remote sensing and low-cost sensor network in Siberian urban areas with limited reference monitoring

Changqing Lin a, Lev D.Labzovskii b, Hugo Wai Leung Mak c, Jimmy C.H.Fung a d, Alexis K.H.Lau a e, Samuel TakeleKenea b, Muhhamad Bilal f, Joshua D.Vande Hey g, Xingcheng Lu a, Jun Ma e

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The lack of reference ground-based PM2.5 observation leads to large gaps in air quality information, particularly in many areas of the developing world. This study investigated a new solution for urban air-quality monitoring in regions with limited reference ground-based monitoring. We developed an observation-based method by combining satellite remote-sensing techniques and a newly established low-cost sensor network to estimate

long-term PM2.5 concentrations over Krasnoyarsk, a highly industrialized Siberian city. First, a physical model was developed to estimate PM2.5 concentrations using satellite remote-sensing with the aid of ground-based meteorological and radiosonde observations. Observations from the ground-based sensor network were then used to calibrate the deviations in the satellite-derived PM2.5 concentrations. The results show that the satellite-based PM2.5 concentrations obtained by our physical model were in good agreement with the sensor observations (R = 0.78 on the monthly scale). The deviation in satellite-derived annual PM2.5 concentrations resulted from data restrictions that occurred at noon and data loss in winter were identified as 20% and 30%, respectively. The regional transport of smoke from forest wildfires increased PM2.5 concentration to 150 μg/m3 in the summer 2018. The average PM2.5 concentrations in the urban districts could reach 35 μg/m3, which far exceeded the World Health Organization air quality guideline. These results underscore the good ability of our new method to determine PM2.5 concentrations in regions with limited reference ground-based monitoring. Use of sensor and meteorological observations greatly improved satellite detection of PM2.5 concentration. In addition, our method has the potential for global application to improve determination of PM2.5 concentrations, especially in sparsely monitored regions.

Keywords: Satellite; PM2.5; Low-cost sensor; Siberia; Air quality.

Chemical nature of PM2.5 and PM10 in the coastal urban Xiamen, China: Insights into the impacts of shipping emissions and health risk

Shui-Ping Wu a b, Mei-Jun Cai a, Chao Xu a, Ning Zhang a, Jia-Bin Zhou c, Jin-Pei Yan d, James J.Schwab e, Chung-Shin Yuan f

Source: Atmospheric Environment, Volume 227, 15 April 2020, 117383

With objective of estimating the impact of ship emissions on ambient PM2.5 and PM10 levels and human health at a coastal urban site in Xiamen Island, a one year long sampling campaign was carried out from January 2017 to January 2018. Samples were subject to chemical analysis for various chemical components including water-soluble inorganic ions, carbonaceous species, and elements. The annual average PM2.5 and PM10 mass concentrations were, respectively, 32.8 ± 18.9 μg m−3 and 54.5 ± 29.6 μg m−3. The highest seasonal average concentrations were found in winter-spring and the lowest in summer due to the seasonal monsoon and gas-particle conversion. The rapid accumulation of vehicle exhaust and the stable existence of NH4NO3 in the ground layer within the urban area contributed to the incremental PM. Sulfate, nitrate, ammonium and organic carbon in PM2.5 have decreased since 2011–2013, while elemental carbon increased significantly. This suggests that the motor vehicle and/or ship emissions contributions to PM2.5 have

increased relative to coal combustion over the past five years. The temporal variations of PM and its associated components during the BRICS summit control period further confirmed the important role of traffic related emissions in PM mass. Primary particulates resolved by PMF analysis plus secondary sulfate derived from secondary sulfate formation were estimated to account for 7.56% and 8.31% of PM2.5 and PM10, respectively. Selected heavy metals (As, Cd, Ni, V, Mn, hexavalent Cr, Ba and Pb) originating from ship emissions contributed 64.4% for PM2.5 and 53.2% for PM10 of the total non-cancer risk. Carcinogenic risk (lifetime cancer risk) for ship emissions associated with these hazard metals accounted for 50.6% for PM2.5 and 44.5% for PM10. Therefore, control measures applied to the ship emissions can benefit the local air quality improvement and reduce health burden to people around the port.

Keywords: Chemical species; Source apportionment; Trace elements, Ship emissions; Health risk.

Characteristics of the upstream flow patterns during PM2.5 pollution events over a complex island topography

Hsin-Chih Lai a b, Mei-Chi Lin b

Source: Atmospheric Environment, Volume 227, 15 April 2020, 117418

Meteorological and geographic conditions play important roles in the occurrence of air pollution. This is especially true in island countries like Taiwan, where the atmospheric flow plays a key role in determining air quality. The atmospheric flows of 334 air pollution events between 2013 and 2017 were analyzed via radiosonde data and WRF simulations to elucidate how the spatial distribution of PM2.5 concentrations in Taiwan is correlated to its terrain and environmental wind fields. The variables included in this analysis were the wind directions of the environmental wind field, Froude number (Fr), pitching angle (PA) of the surface-level and atmospheric boundary layer (ABL)-level airflows through the terrain, differences in wind speed between surface-level and ABL-level airflows, and the formation of lee-side vortices. Thus, we examined how the areas of air pollutant accumulation are related to the passage of environmental airflows through mountain ranges. Based on a composite analysis, we determined that the air pollution events can be divided into 10 categories, depending on the direction of the environmental airflows and the geographic location of the air pollution events. Fr was less than 0.25 in 87% air pollutant events, which indicates that the environmental airflows had a high stability and tended to split around the terrain. Each category corresponded to different environmental wind directions and PAs. It was found that air pollution events occurred the most frequently when PA was close to the north, and these events were accompanied by obvious

differences in wind speed between surface-level and ABL-level. During the analysis of airflow characteristics via the WRF simulation, it was found that lee-side vortices were formed on the orthographic lee-side of terrain in seven synoptic flow categories. The results of this study provide evidence and variables to demonstrate how atmospheric flow, terrain, and pollutant accumulation areas are linked to each other in island.

Keywords: Air pollution; WRF; Froude number; Pitching angle; Lee-side vortex.

The impacts of transported wildfire smoke aerosols on surface air quality in New York State: A case study in summer 2018

Wei-Ting Hung a, Cheng-Hsuan (Sarah)Lu a, Bhupal Shrestha a, Hsiao-Chun Lin a, Chin-An Lin a, Dustin Grogan a, Jia Hong b, Ravan Ahmadov c d, Eric James c d, Everette Joseph e

Source: Atmospheric Environment, Volume 227, 15 April 2020, 117415

Wildfire smoke aerosols, once emitted, can transport over long distances and affect surface air quality in downwind regions. In New York State (NYS), fine particulate matter (PM2.5) concentration continues to decrease due to anthropogenic emission reductions and regulatory initiatives in recent years. Smoke aerosols, however, are projected to increase, making them the dominant source of PM2.5. Thus, the influences of smoke aerosols could become more important in the future. In this study, the long-range transport of smoke aerosols, and their impacts on local air quality over NYS in mid-August 2018 were investigated using satellite measurements, ground-based networks, and model products. Satellite measurements showed extensive fire activities over the northwestern United States (US) during August 8th – 10th. Air quality monitoring sites in NYS reported a threefold increase in average PM2.5 concentration (from 8.4 ± 3.4 μg m−3 to 24.8 ± 4.0 μg m−3) on August 15th – 16th, while the ground-based profiler network detected aerosol layers at 2–5 km across the state. Analysis of backward trajectories revealed that the plumes originated from wildfires, transported through southern Canada and arrived at the east coast during a period of 5–7 days. The increased PM2.5 in NYS can be attributed to boundary layer entrainment and vertical mixing of the aloft transported smoke aerosols down to the surface. The NYS mesoscale weather network (NYSM), which is originally designed for severe weather monitoring, demonstrate the capability to probe the lower atmosphere and provide the vertical extent information of air pollutants.

Keywords: Wildfire; Long-range transport; Smoke; Air quality; Boundary; Layer entrainment.

Biomass burning sources and their contributions to PM10 concentrations over countries in mainland Southeast Asia during a smog episode

Patipat Vongruang a b ,Sittichai Pimonsree b

Source: Atmospheric Environment, Volume 228, 1 May 2020, 117414

Severe particulate matter problems are known to occur frequently in mainland Southeast Asia (MSEA) during times of intensified biomass burning (BB). Therefore, the objectives of this study are to investigate BB characteristics and their impacts on PM10 concentrations in MSEA during a smog episode that took place in March 2012. According to the analysis of our study, PM10 was emitted from BB and accounted for 72% of all sources. Using the WRF-CMAQ modeling system, the current study showed that severe PM10 levels in MSEA exceeded the World Health Organization (WHO) ambient air quality standard (AAQS) recommended safe level of air quality by 51%. Subsequently, based on aggregated monthly data, the area average PM10 concentration was found to be 80 μg/m3 over MSEA. In addition, the model showed that the major source of particulate matter was from BB and contributed to 49% of ambient PM10 concentrations in MSEA while it specifically contributed 73%, 69%, 59%, 45%, 33%, and 31% in Laos, Myanmar, Cambodia, Thailand, China, and Vietnam, respectively. Based on a sensitivity analysis, we found that every 1 Tg of PM10 increased in MSEA would result in a 27.8 μg/m3 increase in PM10 concentrations in MSEA. However, these research findings tend to vary from one country to another, where for every 1 Tg of PM10 increased, it would result in a 60.6, 50.8, 17.6, 14.1, 13.0, and 9.9 μg/m3 increase in PM10 concentrations in Laos, Myanmar, Thailand, China, Cambodia, and Vietnam, respectively. These findings assume great significance those who wish to establish PM10 control strategies at both regional and national levels, given that BB needs to be recognized as the primary genesis of PM10 problems.

Keywords: Biomass burning; PM10; Southeast Asia; Air quality control; WRF-CMAQ.

Meteorological characteristics within boundary layer and its influence on PM2.5 pollution in six cities of North China based on WRF-Chem

Zhe Lv Wei Wei, Shuiyuan Cheng, Xiaoyan Han, Xiaoqi Wang

Source: Atmospheric Environment, Volume 228, 1 May 2020, 117417

North China is recognized as one of the region with most severe air pollution in China, and the PM2.5 in six major cities (Beijing, Tianjin, Shijiazhuang, Taiyuan, Jinan and Zhengzhou) of this region was measured to be 108.7–186.0 μg m−3 in January 2017 and 39.2–56.3 μg m−3 in July 2017. This study conducts the meteorological and chemical simulations based on WRF-Chem, and explores the impacts of meteorology and emissions on PM2.5 (particulate matter with aerodynamic diameters ≤ 2.5 μm) pollutions. Simulations show a noticeable seasonal variation in planetary boundary layer height (PBLH) and relative humidity (RH), but a similar trend in wind speed (WS). Compared to PM2.5 good condition (≤75 μg m−3), daily PBLH decreased by 7.6–39.6% in January and 9.2–44.1% in July during PM2.5 polluted condition (75∼150 μg m−3), and by 22.3–51.2% in January during severely polluted condition (≥150 μg m−3). PBLH is thought of as the key factor for PM2.5. Then, the synergy between PBLH and other meteorological factors are studied. For a 100 m failing in PBLH, the decrease in surface WS reaches 0.2–0.8 m s−1 0.1–0.3 m s−1 in January and July. It means a synergic effect of unfavorable horizontal and vertical dispersions, more adversely in January than in July. While, RH presents an increasing trend with PBLH falling, about +2.1∼+3.2% in January and +2.7∼+4.6% in July per 100 m falling in PBLH. Considering the improvement of high RH in heterogeneous chemistry to form the secondary PM2.5, we believe that the disadvantaged dispersion condition is always accompanied by enhanced secondary PM2.5 formation chemistry. Then, we summarize the average simulated PM2.5 under various combinations of PBLH, WS and RH, and find that under the same meteorological combination, PM2.5 in January was about 1.7–3.6 times that of July, which could be explained by the more emissions of PM2.5 and its precursors in January. Finally, we determine the unfavorable meteorology condition based on current regional emissions and China's standard (hourly PM2.5<75 μg m−3), low PBLH (<600 m) or middle-high RH (>40%) for January, high RH (>60%) & low-middle WS (<4 m·s-1), or middle RH (40∼60%) & low PBLH (<400 m) for July. These unfavorable meteorological conditions accounted for 75.8% in January and 47.8% in July. Therefore, it is still necessary to continuously reduce anthropogenic emissions in this region for attainment of China's PM2.5 standards.

Keywords: North China; PM2.5 pollution; WRF-Che;, Meteorological factors
PBLH.

Vehicle-induced fugitive particulate matter emissions in a city of arid desert climate

Hala Hassan a b, Dikaia Saraga d, Prashant Kumar b c, Konstantinos E. Kakosimos a

Source: Atmospheric Environment, Volume 229, 15 May 2020, 117450

This study investigates and proposes emission factors (EFs) and models for vehicle-induced exhaust (VEX) and fugitive (VfPM) particulate matter emissions representative of areas with arid climates. Particle number (PNC) and mass (PMC) concentrations and their integrated samples were collected for a period of three months for both PM10 and PM2.5 next to a trafficked road in the city of Doha, Qatar. Using Positive Matrix Factorization (PMF) on the elemental data of the samples, six distinct PM sources were identified: traffic exhaust, dust resuspension, fresh and aged sea salt, secondary aerosols, and fuel oil/shipping. Dispersion modelling and regression analysis were combined to derive EFs (linear analysis) and models (non-linear analysis) for the total traffic fleet (heavy and light duty). The estimated EFs were between 620 and 730 mg VKT−1 (VKT; Vehicle Kilometer Travelled) (adj. R2 ~ 0.84) and between 1080 and 1410 mg VKT−1 (adj. R2 ~ 0.70) for VEX and VfPM, respectively. The integration of field measurements, chemical characterization, and dispersion modelling presented herein is one of the first similar studies conducted in the wider region, identifies the importance of fugitive PM (fPM), and marks the need for further studies to improve emissions modelling of VfPM in arid desert climates.

Keywords: Vehicle-induced particulate matter; Fugitive emissions; Source apportionment; Emission factors; Arid desert climates.

Acute and chronic health impacts of PM2.5 in China and the influence of interannual meteorological variability

Yuanlin Wang a b c, Oliver Wild b, Huansheng Chen a, Meng Gao d, Qizhong Wu e, Yi Qi f, Xueshun Chen a, Zifa Wang a

Source: Atmospheric Environment, Volume 229, 15 May 2020, 117397

High concentrations of PM2.5 in China have an adverse impact on human health and present a major problem for air quality control. Here we evaluate premature deaths attributable to chronic and acute exposure to ambient PM2.5 at different scales in China over 2013–2017 with an air quality model at 5 km resolution and integrated exposure-response methods. We estimate that 1,210,000 (95% Confidence Interval: 720,000–1,750,000) premature deaths annually are attributable to chronic exposure to PM2.5 pollution. Chongqing exhibits the largest chronic per capita mortality (1.4‰) among all provinces. A total of 116,000 (64,000–170,000) deaths annually are attributable to acute exposure during pollution episodes over the period, with Hubei province showing the highest acute per capita mortality (0.15‰). We also find that in urban areas premature

deaths are 520,000 (320,000–760,000) due to chronic and 55,000 (3,000–81,000) due to acute exposure, respectively. At a provincial level, the annual mean PM2.5 concentration varies by ±20% due to interannual variability in meteorology, and PM2.5–attributable chronic mortality varies by ±8%, and by >±5% and ±1% at a national level. Meteorological variability shows larger impacts on interannual variations in acute risks than that in chronic exposure at both provincial (>±20%) and national (±4%) levels. These findings emphasize that tighter controls of PM2.5 and precursor emissions are urgently needed, particularly under unfavorable meteorological conditions in China.

Keywords: High resolution; Air quality model, Exposure response functions; Health impacts; Acute and chronic exposure; Urban and rural; Meteorological variability.

Light absorption of brown carbon in PM2.5 in the Three Gorges Reservoir region, southwestern China: Implications of biomass burning and secondary formation

Chao Peng a b, Mi Tian a e, Xiaoliang Wang c, Fumo Yang d a, Guangming Shi a d, Ru-Jin Huang f, Xiaojiang Yao a, Qiyuan Wang f, Chongzhi Zhai g, Shumin Zhang h, Ruozhi Qian a, Junji Cao f, Yang Chen a

Source: Atmospheric Environment, Volume 229, 15 May 2020, 117409

Brown carbon (BrC) is known as a light-absorbing organic aerosol which affects the visibility and radiative forcing budget in the troposphere. The optical properties were studied for filter-based PM2.5 samples collected from the winter of 2015 to the summer of 2016 at one rural and three urban sites in the Three Gorges Reservoir (TGR) region, China. The average light absorption coefficient for BrC (βabs, 405,BrC) at 405 nm and its contributions to total aerosol light absorption during winter were 12.1 ± 7.0 Mm−1 and 23.8 ± 9.1% respectively, higher than those during summer (1.7 ± 0.8 Mm−1 and 11.2 ± 4.1%). Spatially, the average βabs,405,BrC was higher at the urban sites (13.4 ± 7.3 Mm−1) than that at the rural site (7.8 ± 3.2 Mm−1). The average mass absorption efficiency of BrC at 405 nm (MAE405,BrC) was 0.8 ± 0.4 m2 g−1 during winter which was 2.7 times higher than that during summer (0.3 ± 0.1 m2 g−1). Furthermore, the absorption Ångström exponents (AAE) at 405–980 nm (AAE405−980) were 1.1 ± 0.1 in summer and 1.3 ± 0.2 in winter respectively. Correlation analysis suggests that biomass burning (BB) played an important role in βabs,405,BrC during winter. Additionally, the relatively high AAE405−980 during winter was mainly due to the BrC from both BB and secondary organic aerosol. The fractional contribution of solar energy absorption by BrC relative to BC in the wavelengths of 405–445 nm was 23.9 ± 7.8% in summer and 63.7 ± 14.2% in winter, significantly higher than that in the range of 405–980 nm

(11.9 ± 3.4% and 29.9 ± 6.1% respectively). Overall, this study contributes to the understanding of sources of BrC in the climate-sensitive TGR region of southwestern China.

Keywords: Brown carbon; Light absorption; Biomass burning; Three gorges reservoir.

Modulation of synoptic circulation to dry season PM2.5 pollution over the Pearl River Delta region: An investigation based on self-organizing maps

Zhiheng Liao a b, Jielan Xie b c, Xingqin Fang b c, Yu Wang b d, Yu Zhang e, Xinqi Xu b c, Shaojia Fan b c

Source: Atmospheric Environment, Volume 230, 1 June 2020, 117482

Fine particle (PM2.5) pollution is of concern for the Pearl River Delta (PRD) region, particularly during the dry season (October to March), when the PM2.5 concentrations can exceed Chinese national standards. In part due to sparse observations, the dispersion/transport mechanisms that lead to PM2.5 pollution over the PRD region are not yet fully understood, and the potential synoptic controls have not been investigated. In this study, systematic analyses were conducted using the multisite surface meteorological observations, two-site radiosonde measurements, and regional PM2.5 observations, based on the application of self-organizing map neural network to large-scale mean sea-level pressure (MSLP) data. The results suggested that the relative position of the PRD to high-pressure systems exerted significant effects on the dispersion conditions and the PM2.5 distribution over the PRD region. When cold high pressure invaded, the PRD region was dominated by synoptic-scale northerly flow, which caused southward pollution transport and hence positive PM2.5 anomalies in the coastal area. When cold high pressure weakened and moved eastward, the PRD region was dominated by meso/local-scale flows, resulting in strong atmospheric recirculation and elevated PM2.5 concentrations in the inland area. However, the regional average of PM2.5 concentrations was not sensitive to the changes in synoptic circulation patterns, which implied that the synoptic circulation played roles most in redistributing the air pollutants within the PRD region and hence a regional PM2.5 pollution emission reduction is needed to improve regional air quality.

Keywords: Synoptic circulation classification; Scale of atmospheric motion; Atmospheric recirculation; PM2.5 pollution; Self-organizing map.

Real-time PM10 emission rates from paved roads by measurement of concentrations in the vehicle's wake using on-board sensors part 1. SCAMPER method characterization

Dennis R.Fitz a, Kurt Bumiller a, Charles Bufalino a, David E.James b

Source: Atmospheric Environment, Volume 230, 1 June 2020, 117483

Based on emission factors derived from the AP-42 algorithm, particulate matter from paved roads has been estimated to be a major source of PM10 of geologic origin. This is an empirical formula based on upwind-downwind measurement of PM10 concentrations and is dependent solely on the silt loading of the pavement and the weight of vehicles. A number of upwind-downwind studies conducted in urban areas to validate this algorithm have been generally inconclusive because the PM10 concentration difference between upwind and downwind often is within the measurement uncertainty. In the approach presented here PM10 concentrations were measured directly behind a moving vehicle in order to improve the measurement sensitivity for estimating the emission rates for vehicles on paved roads. Optical sensors were used to measure PM10 concentrations with a time resolution of approximately 10 s. Sensors were mounted in the front of the vehicle and behind it in the well-mixed wake. A special inlet probe was designed to allow isokinetic sampling under varying speed conditions. As a first approximation the emission rate was calculated by multiplying the PM10 concentration difference between the front and rear of a moving vehicle by the frontal area of the vehicle. This technique is also useful for quickly surveying large areas and for investigating hot spots on roadways caused by greater than normal deposition of PM10 forming debris. The method is designated as SCAMPER: System for the Continuous Aerosol Measurement of Particulate Emissions from Roads. Part I describes SCAMPER development and Part II describes a comprehensive field testing of mobile methods.

Keywords: Particulate; Paved road; Road dust; Emission factors; Fugitive dust;PM10.

Impacts of regional transport and boundary layer structure on the PM2.5 pollution in Wuhan, Central China

Zhisheng Xiao a b, Yucong Miao a, Xiaohui Du c d, Wei Tang c, Yang Yu c, Xin Zhang c, Huizheng Che a

Source: Atmospheric Environment, Volume 230, 1 June 2020, 117508

Wuhan, one of the most developed cities in Central China, has been experiencing frequent heavy haze pollution. To understand the impacts of large-scale synoptic patterns and the local-scale planetary boundary layer (PBL) structures on the PM2.5 pollution in Wuhan, this study applied an objective approach to the classifying of the daily synoptic patterns in 2017. It then combined observational analyses and meteorology-chemistry coupled simulations to investigate a typical pollution episode at the end of November 2017. The synoptic type associated with the heaviest PM2.5 pollution in Wuhan was characterized by high pressure to the northwest and low pressure to the northeast at the 850-hPa level, which can support northwesterly prevailing winds towards Wuhan. As a result, the aerosols from the highly polluted northern regions can be transported to Wuhan, leading to a high PM2.5 concentration. Also, when there was high pressure located to the east/southeast of Wuhan at the 850-hPa level, southerly warm advections could be induced. The warming of upper air can significantly suppress the development of PBL by enhancing thermal stability, favoring the accumulation of aerosols. This study elucidated the multi-scale physical mechanisms underlying the aerosol pollution in Wuhan, and has important implications for the forecasting and the mitigating of pollution.

Keywords: Aerosol pollution; Planetary boundary layer; Thermal inversion; Regional transport.

Evaluating the effectiveness of a stove exchange programme on PM2.5 emission reduction

Susana Lopez-Aparicio Henrik Grythe

Source: Atmospheric Environment, Volume 231, 15 June 2020, 117529

Residential wood combustion (RWC) is one of the most important sources of particulate matter (PM) in urban areas. As a consequence, different types of regulatory instruments are being implemented to reduce emissions. In this study, we evaluate both the potential and actual effect of a subsidy programme for stove exchange, which has been in place for over 20 years in Oslo (Norway). The subsidy programme provides economic support to the inhabitants for substituting old stoves for RWC with new and cleaner stoves as a measure to reduce PM emissions. Different approaches were selected to assess the potential effect of the Oslo subsidy programme. First, we evaluate the potential for reductions in emissions and pollution levels through the use of emission and dispersion modelling under different scenarios. We then assess the actual reductions associated with the stoves already replaced with the subsidy. We conclude the study by evaluating the time variation (2005 to 2018) in emissions, wood consumption and emission factors in Oslo in comparison with other municipalities with and without subsidy programmes in place. Results from emission and

dispersion modelling show that the replacement of old wood stoves for new ones could have a significant effect on the reduction of emissions (up to 46%) and PM2.5 levels (up to 21%). Despite that, with near 8% of the total existing stoves in Oslo being exchanged with subsidy, the potential for reduction based on improved emission factors was estimated to be smaller by an order of magnitude. We find no evidence that municipalities with subsidy reduce emissions faster than those without subsidy. We therefore conclude that there is no evidence from our modelling results, supported by available observation data, that indicate that the emissions or concentrations in Oslo have been reduced as a result of the subsidy programme.

Keywords: Air quality; MetVed emissions; Stove exchange subsidy; Residential wood combustion; PM2.5 emissions.

Air pollutant emissions from fossil fuel consumption in China: Current status and future predictions

Yan Lu a b, Min Shao c, Chenghang Zheng a, Haibo Ji b, Xiang Gao a, Qin'geng Wang b

Source: Atmospheric Environment, Volume 231, 15 June 2020, 117536

Energy consumption, especially the combustion of fossil fuels, is the main source of air pollutants emissions. Emissions of SO2, NOx, CO, PM10, PM2.5, BC, OC, and NH3 from fossil fuel consumption in different sectors were estimated for 2015, 2020, and 2030 based on updated and projected activity data and emission factors (EFs) in this study. The emissions in 2015 were: 22.8 Tg SO2, 19.8 Tg NOx, 140.7 Tg CO, 8.6 Tg PM10, 5.4 Tg PM2.5, 1.5 Tg BC, 2.1 Tg OC, and 0.3 Tg NH3. The industrial sector and coal consumption was the major source of pollutants except NH3, and the contribution of transportation to NOx, CO, and NH3 cannot be ignored. In the future, significant decline in industrial emissions may occur and the transportation sector may be the dominant source of emissions. It was predicted that the emissions of NOx will show an upward trend in 2030 due to increased vehicle emissions, while the range of areas with high emission fluxes will gradually narrow and the emissions will shift from point to nonpoint sources. The predicted results indicated that the emphasis of future mitigation policies should not only focus on the industrial sector and heavily polluted areas where emission fluxes will remain intensive, but also focus on the pollution control of the transportation sector to prevent NOx emissions from rising in some regions.

Keywords: Energy consumption; Air pollutant; Projection; Uncertainty analysis.

Analysis and accurate prediction of ambient PM2.5 in China using Multi-layer Perceptron

Rui Feng a b, Han Gao c, Kun Luo a, Jian-ren Fan a

Source: Atmospheric Environment, Volume 232, 1 July 2020, 117534

Whether PM2.5 can be long-range transported and what role secondary inorganic aerosols play in the episodes of haze have aroused numerous debates. In this work, Multi-layer Perceptron (MLP) is used to analyze and predict ambient PM2.5 in eight regional core cities in China to resolve the clashes, and the conclusions are listed as follows. Gaseous air pollutants (SO2, NO2, O3 and CO) are way more momentous than meteorological conditions in shaping PM2.5. PM2.5 level is dominated by the ups and downs of gaseous air pollutants, indicating the predominance of secondary inorganic aerosols and the existence of thermodynamic equilibrium between PM2.5 and gaseous air pollutants. The secondary PM2.5 tends to be generated within one hour. We quantitatively demonstrate that the primary emissions change and long-range transport are ubiquitously and conspicuously insignificant throughout the main cities of China and reductions of the gaseous air pollutants are most essential for regulating PM2.5. Furthermore, the phenology of local flora as the minor cause and lopsided thermodynamic equilibrium shift triggered by temperature change as the major cause elicit the severity of PM2.5 in wintertime--for every Celsius degree of temperature drop, PM2.5 increases by 5.9 μg/m3.

Keywords: Insignificance of long-range transport; Secondary inorganic aerosols; Thermodynamic equilibrium; Machine learning.

Evolution of source contributions during heavy fine particulate matter (PM2.5) pollution episodes in eastern China through online measurements

Juanyong Shen a, Qianbiao Zhao b c, Zhen Cheng a, Juntao Huo b, Wenfei Zhu a, Yihua Zhang b, Yusen Duan b, Xiaoliang Wang d, L.-W.Antony Chen e, Qingyan Fu b

Source: Atmospheric Environment, Volume 232, 1 July 2020, 117569

Ambient heavy fine particulate matter (PM2.5) pollution events occur frequently during winter seasons in eastern China. Investigating the evolution of source contributions during heavy pollution episodes is critical for strategies of pollution relief. In this study, a two-month field campaign was conducted in the winters of 2015 and 2016 at a regional

supersite in eastern China and over one thousand hourly online measurements for twenty PM2.5 species were obtained. Hourly source apportionment for the total mass of PM2.5, and its major species (primary organic carbon, elemental carbon, nitrate, sulfate and ammonium), were then performed by Positive Matrix Factorization (PMF) and Multilinear Engine-2 (ME2) models. Three PM2.5 heavy pollution episodes including ten high concentration peaks were identified for further analysis. Results showed that ME2 performed better than PMF by fixing source profiles of secondary nitrate, secondary sulfate and sea salt, although they have dominant consistencies. Two types of pollution sources were identified from high PM2.5 mass peaks: coal combustion-oriented responsible for four peaks and secondary inorganic aerosol-oriented responsible for the remaining six peaks. Low wind speed and planetary boundary layer favorited the coal combustion-oriented peaks, but also weakened the secondary inorganic formation due to low temperature and accumulated nitric oxide. Primary emissions from coal combustion can contribute 18% to ammonium in addition to 72% from secondary inorganic aerosol. Secondary organic aerosol would contribute 20% of PM2.5 mass during the heaviest episodes. Findings in this study provide insights into the causes of heavy pollution episodes and support implementing effective control strategies to mitigate heavy pollution events in eastern China.

Keywords: Source apportionment; Fine particulate matter (PM2.5); Receptor model; Chemical components; Heavy pollution events.

Influence of cloud, fog, and high relative humidity during pollution transport events in South Korea: Aerosol properties and PM2.5 variability

T.F.Eck a b, B.N.Holben a, J.Kim c, A.J.Beyersdorf d, M.Choi c e, S.Lee c, J.-H.Koo c, D.M.Giles a f, J.S.Schafer a f, A.Sinyuk a f, D.A.Peterson g, J.S.Reid g, A.Arola h, I.Slutsker a f, A.Smirnov a f, M.Sorokin a f, J.Kraft a i, J.H.Crawford j…SoojinPark k

Source: Atmospheric Environment, Volume 232, 1 July 2020, 117530

This investigation examines aerosol dynamics during major fine mode aerosol transboundary pollution events in South Korea primarily during the KORUS-AQ campaign from May 1 – June 10, 2016, particularly when cloud fraction was high and/or fog was present to quantify the change in aerosol characteristics due to near-cloud or fog interaction. We analyze the new AERONET Version 3 data that have significant changes to cloud screening algorithms, allowing many more fine-mode observations in the near

vicinity of clouds or fog. Case studies for detailed investigation include May 25–26, 2016 when cloud fraction was high over much of the peninsula, associated with a weak frontal passage and advection of pollution from China. These cloud-influenced Chinese transport dates also had the highest aerosol optical depth (AOD), surface PM2.5 concentrations and fine mode particle sizes of the entire campaign. Another likewise cloud/high relative humidity (RH) case is June 9 and 10, 2016 when fog was present over the Yellow Sea that appears to have affected aerosol properties well downwind over the Korean peninsula. In comparison we also investigated aerosol properties on air stagnation days with very low cloud cover and relatively low RH (May 17 & 18, 2016), when local Korean emissions dominated. Aerosol volume size distributions show marked differences between the transport days (with high RH and cloud influences) and the local pollution stagnation days, with total column-integrated particle fine mode volume being an order of magnitude greater on the pollution transport dates. The PM2.5 over central Seoul were significantly greater than for coastal sites on the transboundary transport days yet not on stagnation days, suggesting additional particle formation from gaseous urban emissions in cloud/fog droplets and/or in the high RH humidified aerosol environment. Many days had KORUS-AQ research aircraft flights that provided observations of aerosol absorption, particle chemistry and vertical profiles of extinction. AERONET retrievals and aircraft in situ measurements both showed high single scattering albedo (weak absorption) on the cloudy or cloud influenced days, plus aircraft profile in situ measurements showed large AOD enhancements (versus dried aerosol) at ambient relative humidity (RH) on the pollution transport days, consistent with the significantly larger fine mode particle radii and weak absorption.

Keywords: Aerosol; Air pollution, Remote sensing; Cloud processes; Aerosol-cloud interaction.

Forecasting PM10 and PM2.5 in the Aburrá Valley (Medellín, Colombia) via EnKF based data assimilation

SantiagoLopez-Restrepo a c, AndresYarce a c, NicolasPinel b, O.L.Quintero a, ArjoSegers d, A.W.Heemink c

Source: Atmospheric Environment, Volume 232, 1 July 2020, 117507

A data assimilation system for the LOTOS-EUROS chemical transport model has been implemented to improve the simulation and forecast of PM10 and PM2.5 in a densely populated urban valley of the tropical Andes. The Aburrá Valley in Colombia was used as a case study, given data availability and current environmental issues related to population expansion. The data assimilation system is an Ensemble Kalman filter with covariance

localization based on specification of uncertainties in the emissions. Observations assimilated were obtained from a surface network for the period March–April of 2016, a period of one of the worst air quality crisis in recent history of the region. In a first series of experiments, the spatial length scale of the covariance localization and the temporal length scale of the stochastic model for the emission uncertainty were calibrated to optimize the assimilation system. The calibrated system was then used in a series of assimilation experiments, where simulation of particulate matter concentrations was strongly improved during the assimilation period, which also improved the ability to accurately forecast PM10 and PM2.5 concentrations over a period of several days.

Keywords: Data assimilation; Air quality modelling; Chemical transport model; Ensemble kalman filter; Particulate matter.

A framework for setting up a country-wide network of regional surface PM2.5 sampling sites utilising a satellite-derived proxy – The COALESCE project, India

Nirav L.Lekinwala a, Ankur Bhardwaj c, Ramya Sunder Raman c d, Mani Bhushan a b, Kunal Bali e, Sagnik Dey e f

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Air quality management and assessment of aerosol climate effects over a large area require the strategic placement of regionally representative monitoring sites (RRMS) to capture the required information. Ground-based, fine particulate matter (PM2.5) concentrations measured for a long duration at high spatial resolution i.e. at several potential locations in a region help identify an optimal regionally representative site for the monitoring network. However, in the absence of long-term PM2.5 concentrations with high spatial resolution, identification of RRMS is a challenge. To identify for such situations, a novel methodology utilising satellite-derived PM2.5 is presented in this study. High spatial resolution (1 km × 1 km) daily aerosol optical depth (AOD) over several years (2004–2011) is used to derive surface PM2.5 using appropriate conversion factors. PM2.5 concentrations thus derived for a potential site and its nearby cells in the region are subjected to statistical analysis, to quantify linear/non-linear relationships between the respective PM2.5 time-series. Metrics such as coefficient of divergence (CoD), Pearson correlation coefficient (PCC) and Mutual information (MI) are calculated to assess the regional representativeness of a site. These criteria combined with physical criteria such as proximity of the site to local sources, local meteorology analysis and clustered air parcel back-trajectory analysis, are used in a weight-of-evidence approach to establish site adequacy. The selection and validation of eleven sites for the COALESCE project, is used as an illustrative example, to demonstrate the effectiveness of the site-selection methodology developed in this study.

Keywords: Regionally representative PM2.5 sampling sites; MODIS aerosol Optical depth; Coefficient of divergence (CoD); Pearson correlation coefficient (PCC); Mutual information (MI); COALESCE project.

Chemical characterization and sources of $PM_{2.5}$ at a high-alpine ecosystem in the Southeast Tibetan Plateau, China

Ya Meng a, Rui Li a, Yilong Zhao a, Hanyun Cheng a, Hongbo Fu a b c, Zhe Yan d, Haijian Bing e

Source: Atmospheric Environment, Volume 235, 15 August 2020, 117645

The study of atmospheric chemical compositions in remote areas is of great significance for understanding the biogeochemical impact of atmospheric dry deposition on ecosystems. In this study, a total of 50 p.m.2.5 samples were collected at a high alpine forest of Mt. Gongga, Eastern Tibetan Plateau from May 2015 to May 2016 to investigate the characteristics of PM2.5 mass concentration and its major compositions including elemental carbon (EC), organic carbon (OC), and 24 trace elements. The average PM2.5 mass concentration was 17.19 ± 8.81 μg/m3, which was at an intermediate level compared with other areas of Tibetan Plateau. The yearly average concentrations of OC and EC were 2.98 ± 1.95 and 0.43 ± 0.33 μg/m3, accounting for 19.49% and 2.51% of PM2.5 mass, respectively, and the sums of the total concentrations of the 24 analyzed trace elements were 3.70 ± 0.80 μg/m3, accounting 27% of PM2.5 mass concentration. PM2.5, EC and OC showed the higher concentrations and larger fluctuation in the dry season (October 2015 to May 2016) compared with those in the wet season (June 2015 to September 2015), which was attributed to the multiple factors including the increases of biomass burning and fossil fuel emissions, the relatively shallow boundary layer height and lower temperature, and the less precipitation. Two distinct seasonal patterns were observed for the 24 analyzed trace elements in PM2.5: the crustal-derived trace elements like Fe, Al, Mn and Sr showed the higher concentrations in the wet season, while anthropogenic-derived elements such as Cd, Pb, Ni and Zn exhibited the higher level during the dry season. Six sources were identified for PM2.5 at Mt. Gongga with the application of the positive matrix factorization (PMF). Biomass burning (27.06%) and crustal source (26.93%) were the two main sources, followed by secondary formation (16.41%), traffic-related source (12.89%), coal burning (10.57%) and industrial metallurgical process (6.15%). Finally, it was proposed that the atmospheric acidic processing could not only promote the dissolution of Fe, but also enhance the solubility of the other trace elements in the atmosphere during the transport. Accordingly, this would increase the bioavailability and/or toxicity to the biotic and plants.

Keywords: Chemical composition; PM2.5; Carbonaceous composition; Trace elements; Bioavailability; Alpine forest; Tibetan plateau.

Impact of volatile organic compounds and photochemical activities on particulate matters during a high ozone episode at urban, suburb and regional background stations in Beijing

Ping Shao a, Xiaobin Xu b, Xiaoling Zhang a, c,d, Jing Xu c, Ying Wang b, Zhiqiang Ma c, e

Source: Atmospheric Environment, Volume 236, 1 September 2020, 117629

Volatile organic compounds (VOCs) play key roles in the formation of particulate matter (PM) and oxidants and hence enhance the summertime air pollution. With data analysis from various field observations (urban station: Haidian, HD; suburb station: Changping, CP; regional background station: Shangdianzi, SDZ) in June 2011, we found that the mean O3 concentrations throughout the observation period can be arranged in order: SDZ＞CP＞HD. The mean PM concentrations can be arranged in order: HD＞CP＞SDZ. The mean concentration of total VOCs at HD was close to that at CP, but much higher than that at SDZ. Oxygenated volatile organic compounds (OVOCs) made the largest portion of VOCs (~40%) at the three stations, followed by alkanes and alkenes. Good positive correlations between the concentrations of PM and Ox (=O3＋NO2) at high air temperature (≥30 °C at HD and CP; ≥28 °C at SDZ) and low RH (≤60%) were found in the daytime (07:00–18:00 LT). However, the PM concentrations were partly negatively correlated with Ox at lower temperatures (≤26 °C at HD and CP; ≤22 °C at SDZ) and higher RH (≥80%). The PM concentrations were found either positively (HD and CP) or negatively (SDZ) correlated with aromatics at high temperature and low RH. The aging degree of air masses at the three stations can be arranged in order: SDZ＞CP＞HD. This can qualitatively explain the different PM–aromatics correlations. Our data suggested the other groups of VOCs may promote the increase of PM concentrations unless the PM levels become higher than 140 μg m−3 under humid conditions. This study confirms the importance of VOCs in the formation of summertime PM and oxidants over Beijing.

Keywords: Particulate matter (PM); Volatile organic compounds (VOCs); Ozone episode; Beijing.

Characterizing the ratio of nitrate to sulfate in ambient fine particles of urban Beijing during 2018–2019

Shangze Li a, Fang Zhang a, Xiaoai Jin a, Yele Sun b, c, Hao Wu a, Conghui Xie b, c, Lu Chen a, Jieyao Liu a, Tong Wu a, Sihui Jiang a, Maureen Cribb d, Zhanqing Li d

Source: Atmospheric Environment, Volume 237, 15 September 2020, 117662

A variety of legislative actions for air quality improvement have been conducted in China since 2013, and the emission control measures have achieved remarkable reduction in severe haze frequency. The composition of the fine particles may change along with the improved air quality, and thus may induce distinct environmental and climate effects in future. In this study, a very recent long-term dataset (2018–2019) of non-refractory chemical composition measured by a quadrupole aerosol chemical speciation monitor (Q-ACSM) observed in urban Beijing is applied to investigate the changes in ratio of nitrate (NO_3^-) to sulfate (SO_4^{2-}) in PM2.5 (particulate matter with diameters of less than 2.5 μm). We show that the ratio of NO_3^- to SO_4^{2-} varies seasonally, with a maximum in winter (1.6 ± 1.2) and a minimum in summer (0.7 ± 1.0). Compared with results from earlier studies showing a continuous increase in the ratio of NO_3^- to SO_4^{2-} since 1999, a decline in the ratio is found during the period of 2018–2019. This is partially associated with an attenuated nitrate formation likely due to reduced nitrogen oxides emissions since 2016 in China. Our results suggest that the strict reduction control measures in place serve only to improve SO_4^{2-} pollution in winter but not in summer when high SO_4^{2-} levels are still observed. SO_4^{2-} and NO_3^- concentrations during study periods together comprise 37–53% of PM2.5, presenting significant role in dominating the levels of PM2.5. In addition, we show that the ratio of NO_3^-/SO_4^{2-} in warm seasons generally increases with increasing relative humidity (RH) due to enhanced NO_3^- hydrolysis formation, but with a maximum value of only ~1.0 that is pulled down by the high levels of sulfate in summer, while the dependence of the ratios on RH is more pronounced in cold seasons when multiple factors (regional transportation, planetary boundary layer, PBL and sources of sulfate, etc.) can impact nitrate levels. We finally characterize two typical processes that lead to the rapid accumulation of nitrate in the atmosphere over urban Beijing: the regional transportation and PBL variations, which is found driving heavy haze in cold seasons, and the hydrolysis formation and partitioning of NO_3^- that tends to impact the diurnal patterns of nitrate in warm seasons.

Keywords: Fine particles; Nitrate; Sulfate; Seasonal variation; Trends.

Evaluation on the surface PM2.5 concentration over China mainland from NASA's MERRA-2

Jinghui Ma a, b, c, Jianming Xu b, c, d, Yuanhao Qu b, c

Source: Atmospheric Environment, Volume 237, 15 September 2020, 117666

One of the important products of MERRA-2 (Modern-Era Retrospective Analysis for Research and Applications) developed by NASA (National Aeronautics and Space Administration) is the long-term global records of surface PM2.5 mass concentration since 1980s, providing the ability of studying the interactions between air pollution, weather and climate changes. In this study, the PM2.5 mass concentrations of MERRA-2 are firstly validated across China mainland by independent surface measurements collected by Ministry of Ecology and Environment of People's Republic of China from 2014 to 2018. The results show that MERRA-2 well captures the spatial distribution and seasonal variation of PM2.5 mass concentration in China mainland. The spatial and temporal evolution of large scale persistent PM2.5 pollution event is also generally reflected by MERRA-2 by case study based on the target object match method. However significant underestimation of the PM2.5 mass concentration in MEERA-2 is revealed across China mainland, especially in BTH region by 34.6 μg m−3, followed by 19.8 μg m−3 in YRD and 9.1 μg m−3 in PRD region. Such underestimation is most substantial in winter and autumn seasons. In addition, the discrepancy between MERRA-2 and observations increases significantly with the enhanced PM2.5 level, for example, ranging from 29.9 μg m−3 in clean days, while 66.1 μg m−3 in polluted days in BTH region. We highlight the downward trends of PM2.5 from 2014 to 2018 in China mainland estimated by MERRA-2 which is basically consistent in the observations, but with ~50% underestimation, indicating the potential applications of MERRA-2 for the future aerosol climatological studies. We suggest that the underestimations of both magnitude and variability of PM2.5 in MERRA-2 probably result from the uncertainty of the magnitude of emission inventory used in GOES model (lower intensity and weaker variations), and the absence of nitrate in PM2.5 constitution. A parameterized method for nitrate is proposed and evaluated by the sensitive study to improve MERRA-2 PM2.5 underestimation by 19.2–23.6% in BTH region. However, the more comprehensive validations are still required in future studies, especially by the aerosol composition measurements.

Keywords: MERRA-2; PM2.5 mass concentration; Validation.

Iron and steel industry emissions and contribution to the air quality in China

Ling Tang a, b, Xiaoda Xue a, c, Min Jia b, c, Hong Jing d, Tong Wang e, Ruiqing Zhen f, Mantang Huang g, Jun Tian g, Jing Guo a c, Ling LI h,Xin Bo c, Shouyang Wang i

Source: Atmospheric Environment, Volume 237, 15 September 2020, 117668

To reduce the emissions from the iron and steel industry, China has imposed a series of strengthened emission standards since 2012. An accurate impact of emission reduction on the air quality is critical for evaluating policy efficiency. This study was the first attempt to explore the contribution of emissions from China's iron and steel industry to ambient air quality at national scale, after the implementation of current standards in 2012. First, all emission sources in production processes were estimated at unit level in China's iron and steel industry, covering sulfur dioxide (SO2), nitrogen oxides (NOx) and particulate matter (PM2.5), etc. Second, the corresponding air quality impacts were modeled with the Comprehensive Air Quality Model with extensions (CAMx) model. We find that emission hotspots from China's iron and steel industry, with following aspects. (1) From a spatial perspective, the largest emissions and ambient concentration contributors were mainly concentrated in eastern areas of China, with high crude steel production. (2) Among three main pollutants (i.e., SO2, NOx and PM2.5), SO2 made the largest contribution to ambient concentration in China's iron and steel industry. (3) As for temporal distribution, emission sources presented the greatest contribution to air quality concentration in summer. (4) For policy evaluation, under the current standards in 2012, the contribution of iron and steel industry emissions to air quality decreased by 92.07% and 72.91% for SO2 and PM2.5, respectively. Therefore, these results will be essential to reflecting current emission characteristics and underscoring further opportunities for emission reductions.

Keywords: Iron and steel industry; China, Air quality; CAMx.

Prediction of PM2.5 daily concentrations for grid points throughout a vast area using remote sensing data and an improved dynamic spatial panel model

Miao Fu a, J. Andrew Kelly b, J. Peter Clinch c

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The incorporation of spatial and temporal correlations can significantly improve the accuracy of PM2.5 concentration prediction models. However, the dynamic spatial panel model which explicitly deals with these two correlations remains absent from current approaches to out-of-sample concentration prediction. An issue is that the prediction of daily concentrations for grid points across a vast area may well overwhelm existing algorithms, as it requires an enormous amount of computational resources and an enlarged spatial weight matrix. This paper develops improved algorithms that address this issue. The dynamic spatial panel approaches used in this paper predict daily series PM2.5 concentrations for grid points covering Mainland China, using daily aerosol, vegetational and meteorological remote sensing data as the explanatory variables. The predicted

concentration maps offer more realistic detail in areas where monitoring stations are sparse. Indeed, the error map for the out-of-sample prediction shows that MAPE is less than 30% in most regions, and the average MAPE is 24.28%, which is relatively low compared with similar studies. In contrast to methods which cannot provide coefficients of variables, the developed method offers coefficients to assess the contributions of explanatory variables and temporal-spatial correlation terms, allows quantification of convergence effects, and can distinguish between spillover effects and local effects. A performance comparison of models with various spatial weight matrices shows that model achieves the optimal fitting levels by using the neighbouring unit number threshold of 18 or the distance threshold of 150 km. The case analysis in this paper finds that spillover effects are about three times larger than local effects, and the spatial correlation is greater than the cumulative effects of earlier concentrations. This finding adds further weight to the notion that management of PM2.5 pollution and associated impacts requires multi-regional and even multi-national coordination and effort.

Keywords: PM2.5 concentration; Out-of-sample prediction; Temporal-spatial correlation; Dynamic spatial panel model; Remote sensing.

The autumn haze-fog episode enhanced by the transport of dust aerosols in the Tianjin area

Liying Zhao a, Wencai Wang b,a, Tianyi Hao c, Wenjun Qu a, Lifang Sheng a, Chenghan Luo a, Xiadong An a, Yang Zhou a

Source: Atmospheric Environment, Volume 237, 15 September 2020, 117669

Dust aerosols from the desert areas of China can be lifted to the upper troposphere and transported eastward by the westerly, affecting regional and local air pollution process. In this paper, we analyzed the long-range transport of dust and its impact on the haze-fog process that occurred in Tianjin from 23 November to 5 December 2018. Satellite and ERA5 reanalysis data revealed that dust from northwestern China was transported to eastern China by the westerly flow behind the troughs, which subsequently enhanced the air pollution in Tianjin area. On 26 November and 2 December, the visibility was less than 2 km with a relative humidity (RH) over 90%, indicating there was fog weather in Tianjin. The dust influx from the northwest direction mixed with ground pollutants, increased the PM2.5 and PM10 mass concentrations and enhanced the air pollution with the cumulative peak value of the PM2.5 mass concentration reaching over 300 μg/m3 on 26 November. On 27 November and 3 December, the wind speed increased and large dust particles were transported to Tianjin, the PM10 mass concentration exceeded a much higher value of 550 μg/m3 whereas the PM2.5 mass concentration decreased to its lowest value, indicating

dust weather followed the typical haze-fog pollution period in Tianjin. The ground lidar observations indicated that a large amount of non-spherical dust aerosols transmitted to Tianjin at 1.5~2.5 km height and settled down near the ground, which substantially affected the aerosol optical characteristics and air quality over the area. The influx of dust successive after the haze-fog weather, aggravated the air pollution process in Tianjin area, make it lasting for 153 h.

Keywords: Dust; Haze-fog; Air quality; CALIPSO; Himawari-8; Lidar

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Air quality impacts of the 2018 Mt. Kilauea Volcano eruption in Hawaii: A regional chemical transport model study with satellite-constrained emissions

YouhuaTang a, b, Daniel Q.Tong b, c, Kai Yang d, Pius Lee a, Barry Baker a, b, Alice Crawford a, Winston Luke a, Ariel Stein a, Patrick C.Campbell a, b, Allison Ring a, d, James Flynn d, Yuxuan Wang e, JeffMcQueen f, Li Pan f, g, Jianping Huang f,g, Ivanka Stajner f

Source: Atmospheric Environment, Volume 237, 15 September 2020, 117648

Volcanic eruptions emit a vast amount of sulfur dioxide (SO2) and ash into the air, often imposing substantial impacts on air quality and the ecosystem. Quantifying its impacts, however, is difficult due to the uncertainties in estimating the strength and variations of volcanic emissions. Here we developed and evaluated a new approach to combine satellite SO2 detection and chemical transport modeling to assess the impact of the 2018 Mt. Kilauea eruption on air quality over Hawaii. During the sustained eruption of the Kilauea Volcano in Hawaii's Big Island from May to July 2018, considerable SO2 and PM2.5 enhancements were observed both from the ground and from space. We studied this case using an experimental version of the NOAA National Air Quality Forecast Capability (NAQFC) modeling system. Daily emissions of SO2 and ash were estimated using a combination of SO2 column density retrieved by Ozone Mapping and Profiling Suite (OMPS) Nadir-Mapper (NM) aboard the Suomi-NPP satellite and the NAQFC model with an inverse emission modeling approach. We found that the volcanic SO2 emission rates peaked at 15,000 mol/s from the Kilauea's East Rift zone and Summit. The formation and transport of volcanic smog, or Vog, was highly dependent upon the vertical distribution of the volcanic emission, controlled by the heat flux of emission sources. We conducted four model simulations with various emission settings, and compared them to satellite data (CALIOP, OMPS and VIIRS) and in-situ measurements. All the runs tended to underpredict the peak values of surface SO2 and PM2.5 (particulate matter smaller than 2.5 μm in

diameter). The “No Plume Rise” run underestimated the Vog plume rise and downstream transport. Using fixed emission rate or removing the temporal variations (”3-Day Mean”) led to miss peak Vog effects or inconsistent transport pattern compared to the observations. Therefore, the Base simulation with daily-varying emission and plume rise was used to quantify the air quality effects of the Kilauea eruption. We found that the volcanic eruption elevated surface PM2.5 concentration by 30–40 μg/m3 in the southeast part of the Big Island, with peak values up to 300 μg/m3. The Vog effect on trace gases, such as O3, NOx, and non-methane hydrocarbons, were much weaker (<1 ppbV), but extended to farther downstream.

Keywords: Volcanic eruption; Emission; Air quality; SO2; Hawaii.

Chemical composition and seasonal variations of PM2.5 in an urban environment in Kunming, SW China: Importance of prevailing westerlies in cold season

Yunhong Zhou a, b, Huayun Xiao a, Hui Guan a, Nengjian Zheng c, Zhongyi Zhang c, Jing Tian a, b, Linglu Qu d, Jingjing Zhao a, b, Hongwei Xiao c

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Kunming, a Chinese southwestern tourist city which has not large local pollution sources, has found to have an increasing tendency of haze pollution in recent years. But the pollution sources are unclear. In order to identify them, daily PM2.5 samples (n = 346) were collected from September 2017 to August 2018 in the urban area. And the major water-soluble inorganic ions (WSIIs) were determined to better understand the chemical characteristics, source categories and potential region of sources. Our study showed that the mass concentration of PM2.5 in Kunming ranged from 7.61 to 91.83 μg m−3, with an annual average value of 33.59 ± 15.71 μg m−3. Positive matrix factorization (PMF) model identified five factors including secondary aerosol (the contributions of 36.3%), coal combustion (26.0%), biomass burning (19.2%), dust (12.5%) and sea salt (6.0%). And coal combustion played a leading role in the source contribution of PM2.5 in winter while biomass combustion was dominant in spring. Being located between two severe haze zones in the world, northern-central China and north of South Asia, and affected by India monsoon and East Asia monsoon in summer and prevailing westerlies in winter, we found that air masses from South Asia (especially India) contained pollutants could be brought to Kunming by prevailing westerlies in winter. In spring, however, the sources of PM2.5 in Kunming were mainly affected by biomass burning from South Asia and Southeast Asia when prevailing westerlies gradually weakened.

Keywords: PM2.5; Water-soluble inorganic ions; Positive matrix factorization; Back trajectory; Prevailing westerlies.

Recent changes in winter PM2.5 contributions from wood smoke, motor vehicles, and other sources in the Northwest U.S.

Robert A. Kotchenruther

Source: Atmospheric Environment, Volume 237, 15 September 2020, 117724

In the Northwest U.S. elevated measurements of PM2.5 from anthropogenic sources occur most often in winter. Major contributors to winter PM2.5 are direct primary emissions of wood smoke from residential wood combustion, primary emissions from motor vehicles, gaseous NOx emissions leading to particulate nitrate, and primary and secondary sources of particulate sulfate. A number of communities in the Northwest U.S. now have long data records of chemically speciated PM2.5 from which receptor-based source apportionment can be performed. This work uses receptor-based source apportionment on data from these monitoring sites to evaluate changes in the major contributors to winter PM2.5 over the available monitoring time span. Data from 9 sites are analyzed in this work using the Positive Matrix Factorization (PMF) source apportionment model. Each site was modeled individually rather than grouping the data from multiple sites. All sites had data through the summer of 2018, with most sites having 11 years of data and one site having 9 years of data. The number of PMF factors identified was between 5 and 10, depending on the site. Associations were made between PMF factors and PM2.5 sources based on comparison of PMF factor chemical profiles with published source test data and source profiles identified in other published studies. The most common factors found were: fresh wood smoke, aged wood smoke, soil dust, gas engines, mixed – gas engines and nitrate, ammonium sulfate, and ammonium nitrate. In this work, total wood smoke was identified as the combined contribution of fresh and aged wood smoke, and winter season data was defined as encompassing the last two months of a year and the first two months of the next year. To evaluate changes over time, average winter season PM2.5 measurements, major PM2.5 chemical components, and PMF factor results for the winter seasons of 2007–2009 were compared with the winter seasons of 2015–2017. The result for total 3-year average winter season PM2.5 was a decrease between 2% and 29% at the 9 sites, and the decreases were statistically significant at 3 sites. However, total winter season wood smoke contributions to PM2.5 decreased at every site between the two 3-year periods and the decreases were statistically significant at 8 of 9 sites, with decreases from 48% to 74% at those 8 sites. All PMF factors associated with ammonium nitrate (identified at 5 of 9 sites) decreased a statistically significant 11%–54% between the two 3-year winter season periods. All PMF factors associated with ammonium sulfate (identified at 7 of 9 sites) decreased a

statistically significant 27%–81% between the two 3-year winter season periods. In contrast to the significant reductions in PM2.5 from PMF factors related to wood smoke, ammonium nitrate and ammonium sulfate, PMF factors associated with gas engines increased from 6% to 226% between the two 3-year winter season periods. Increases in PM2.5 contributions from gas engine related factors explain why overall average winter season PM2.5 had more modest percent reductions compared to the percent reductions for wood smoke, ammonium nitrate, and ammonium sulfate factors between the two 3-year winter season periods.

Keywords: Positive matrix factorization; Residential wood combustion; Mobile sources; Source apportionment; PM2.5.

Contributions of traffic and shipping emissions to city-scale NOx and PM2.5 exposure in Hamburg

Martin Otto Paul Ramacher Volker Matthias Armin Aulinger Markus Quante Johannes Bieser Matthias Karl

Source: Atmospheric Environment, Volume 237, 15 September 2020, 117674

We investigated the contribution of road traffic and shipping related emissions of NO2 and PM2.5 to total air quality and annual mean population exposure in Hamburg 2012. For this purpose, we compiled a detailed emission inventory following SNAP categories focusing on the detailed representations of road traffic and shipping emissions. The emission inventory was applied to a global-to-local Chemistry Transport Model (CTM) system to simulate hourly NO2 and PM2.5 concentrations with a horizontal grid resolution of 500 m. To simulate urban-scale pollutant concentrations we used the coupled prognostic meteorological and chemistry transport model TAPM. The comparison of modelled to measured hourly values gives high correlation and small bias at urban and background stations but large underestimations of NO2 and PM2.5 at measurements stations near roads. Simulated contributions of road traffic emissions to annual mean concentrations of NO2 and PM2.5 is highest close to highways with relative contributions of 50% for NO2 and 40% for PM2.5. Nevertheless, the urban domain is widely affected by road traffic, especially in the city centre. Shipping impact focuses on the port and nearby industrial areas with contributions of up to 60% for NO2 and 40% for PM2.5. In residential areas in the north of the port, shipping contributes with up to 20–30% for NO2 and PM2.5. Our simulation resulted in 14% of the population of Hamburg being exposed to hourly NO2 concentration

above the hourly limit of 200 μg/m^3, <1% to annual NO2 concentrations above the annual limit of 40 μg/m^3, and 39% to PM2.5 concentrations above the annual WHO limit of 10 μg/m^3. The calculation of the population-weighted mean exposure (PWE) to NO2 and PM2.5 reveals mean exposures of 20.51 μg/m^3 for NO2 and 9.42 μg/m^3 for PM2.5. In terms of PWE to NO2, traffic contributes 22.7% to the total and is 1.6 times higher than the contribution of shipping (13.9%). In total, traffic and shipping contribute with 36.6% to the NO2 PWE in Hamburg in 2012. When it comes to PM2.5, traffic contributes 18.1% and is 5.3 times higher than the contribution from shipping (3.4%). In total, traffic and shipping contribute 21.5% to the PM2.5 PWE in Hamburg in 2012. Two local scenarios for emissions reductions have been applied. A scenario simulating decrease in shipping emissions by instalment of on-shore electricity for ships at berth, revealed reduction potentials of up to 40% for total NO2 exposure and 35% for PM2.5 respectively. A road traffic scenario simulating a change in the fleet composition in an inner city zone, shows lower reduction potentials of up to 18% for total exposure to NO2 and 7% for PM2.5 respectively. The discussion of uncertainties revealed high potentials for improving the emission inventories, chemical transport simulation setup and exposure estimates. Due to the use of exposure calculations for policy support and in health-effect studies, it is indispensable to reduce and quantify uncertainties in future studies.

Keywords: Urban air pollution; Population exposure; NO2; PM2.5; Transport emissions; Road traffic; Shipping; Chemical transport modeling; TAPM.

Size-differentiated patterns of exposure to submicron particulate matter across regions and seasons in China

Ming Liu a, Rebecca K.Saari a, b, Gaoxiang Zhou a, c, Xiangnan Liu c, Jonathan Li a, d

Source: Atmospheric Environment, Volume 238, 1 October 2020, 117745

Air pollution in China has reached unprecedented levels due to rapid economic and industrial development. More than 90% of Chinese population experience higher health risks attributable to ambient fine particulate matter (PM2.5) exposure. Although evidence suggests that particle size may be an effect modifier on PM2.5-related health risks, few studies have explored this due to lack of size-resolved exposure data. In this study, we derive size-resolved particle effective radius of PM2.5 using theoretical relationships between aerosol microphysical characteristics and satellite optical measurements to explore the spatial variability and population exposure to ambient particle size. Applying this method to China in 2017, we observed annual mean effective radii between 0.3 and 1.3 μm with a mean average error of 0.1 μm. We find that 1% or less of the Chinese population

was exposed to annual PM2.5 concentrations less than 10 μg/m3 and a mean particle effective radius greater than 0.7 μm (i.e. aerodynamic diameter of PM1). Spatially, the Centre economic region had the highest annual-mean PM2.5 exposures, where 90% of the population was exposed to concentrations higher than 50 μg/m3 and 98% was exposed to particles with mean radius below 0.5 μm. Temporally, although the highest PM2.5 concentrations were more likely to occur in winter, summertime was the season during which the highest percentage of the national population (86%) lived in the regions in which the fine fraction had the smallest mean particle radii (<0.5 μm). This study demonstrates the potential of remote sensing techniques to enable large-scale PM2.5 estimation, including concentrations and sizes. The revealed prevalence of exposure to PM1, and lack of particle size validation data, motivate further research to better understand size-resolved exposures and impacts of PM2.5 at population scales.

Keywords: Air pollution; Exposure; Particle size; Satellite retrieval; Particulate matter; China.

Aeolian dust in Central Asia: Spatial distribution and temporal variability

Xiao-Xiao Zhang a, b, c, Candis Claiborn c, Jia-QiangLei a, JosephVaughan c, Shi-XinWu a, Sheng-Yu Li a, Lian-You Liu d, Zi-FaWang b, Yong-Dong Wang a, Shuang-Yan Huang a, Jie Zhou a

Source: Atmospheric Environment, Volume 238, 1 October 2020, 117734

Aeolian dust is a significant factor influencing the atmospheric environment in arid and semi-arid areas, and one which deeply involves biogeochemical cycling, energy exchange, and the global carbon balance. In this study, we investigated the synoptic features of atmospheric dust in the inland region of Central Asia and analyzed its spatiotemporal variation using meteorological observation records, satellite products from the Multi-angle Imagine SpectroRadiometer (MISR), and land use and land cover (LULC) data. Results showed that aeolian dust in Central Asia is particularly significant in the arid Aral Sea region where annual average dust event frequency reached 56 d during 1984–2018. Blowing dust and intense dust storms dominated the aeolian dust weather in Central Asia, which may severely affect the regional atmospheric environment and local inhabitants' health. Dust events occurred frequently in the Aralkum Desert, Kyzylkum Desert, Caspian Depression, Kara-Bogaz-Gol and, generally, along the southern and southeastern borders of

Central Asia in spring, summer and autumn seasons; such events resulted in both high particulate matter (PM) concentrations and high dust deposition rates. Meanwhile, aeolian dust event frequency around the Aralkum Desert area, Caspian Depression, and Kara-Bogaz-Gol region increased gradually from the 1980s–2010s. The Aral Sea region's Aralkum Desert is the chief dust source in the Central Asian region, emitting vast quantities of saliferous mineral dusts that are then transported into East Asia by strong westerly jets.

Keywords: Aeolian dust; Central Asia; Dust storm; Climatology; Atmospheric environment; Particulate matter.

Characteristics of air pollution episodes influenced by biomass burning pollution in Shanghai, China

Songying Tong a, Lingdong Kong a, b, Kejing Yang a, Jiandong Shen c, Lu Chen a, Shengyan Jin a, Chao Wang a, Fei Sha d, Lin Wang a

Source: Atmospheric Environment, Volume 238, 1 October 2020, 117756

In the atmosphere, biomass burning can interact with other pollution sources and thereby aggravate air pollution. However, its influences on the occurrence and development of air pollution remain poorly understood. In this study, the characteristics of air pollution episodes influenced by biomass burning was investigated based on the field observation in Shanghai from 2014 to 2016. Results indicated that the fine particle pollution was serious during the whole observation period, and the high particulate pollution episodes mostly occurred in winter and spring. Four studied cases indicated that the ways to initiate high air pollution episodes were diverse, including local pollution sources, external transport and combined interaction of multiple pollution sources. All four high air pollution episodes behaved high K+, CO and NH3 concentrations, showing the existence of biomass burning pollution. And most of biomass burning pollution were from northwest China and some provinces in east and southeast China, which had active biomass burning activities. In the high pollution episodes, secondary inorganic aerosols (SIA) accounted for a large proportion of PM2.5, but SIA did not always initiate high pollution episodes. The high concentrations of sulfate and nitrate aerosols brought by the transport of biomass burning could also induce the occurrence of high pollution episodes. Also, the mixing of biomass burning plumes with other pollution sources could enhance SIA formation and aggravate air pollution. This study highlights the significant roles of biomass burning in the occurrence and development of high air pollution.

Keywords: Air high pollution; Biomass burning; External transport; PM2.5; SIA.

Daily PM10, periodicity and harmonic regression model: The case of London

Yasin Okkaoğlu a, Yılmaz Akdi b, Kamil Demirberk Ünlü, c

Source: Atmospheric Environment, Volume 238, 1 October 2020, 117755

One of the most important and distinguishable features of the climate driven data can be shown as the seasonality. Due to its nature air pollution data may have hourly, daily, weekly, monthly or even seasonal cycles. Many techniques such as non-linear time series analysis, machine learning algorithms and deterministic models, have been used to deal with this non-linear structure. Although, these models can capture the seasonality they can't identify the periodicity. Periodicity is beyond the seasonality, it is the hidden pattern of the time series. In this study, it is aimed to investigate the periodicity of daily Particulate Matter (PM10) of London between the periods 2014 and 2018. PM10 is the particulate matter of which aerodynamic diameter is less than 10 μm. Firstly, periodogram based unit root test is used to check the stationarity of the investigated data. Afterwards, hidden periodic structure of the data is revealed. It is found that, it has five different cycle periods as 7 days, 25 days, 6 months, a year and 15 months. Lastly, it is shown that harmonic regression performs better in forecasting monthly and daily averages of the data.

Keywords: Harmonic regression**;** Periodograms**;** PM_{10}**;** London**;** Nonlinear; time series analysis**;** Air pollution.

The Effect of Corona Virus Lockdown on Air Pollution: Evidence from the City of Brescia in Lombardia Region (Italy)

MichelaCameletti

Source: Atmospheric Environment, Volume 239, 15 October 2020, 117794

After the outbreak of Corona virus pandemic in Italy, the government has taken extraordinary measures, including a national lockdown, to prevent the spread of the infection. This extraordinary situation has led to a reduction in air pollution levels measured in the whole Po Valley, usually known as one of the most polluted areas in Europe in terms of particulate matter (PM) and nitrogen dioxide (NO) concentrations. The main aim of this paper is to evaluate the effectiveness of the lockdown on the air quality improvement. In particular, an interrupted time series modelling approach is employed to test if a significant change in the level and the trend of the pollutant time series has occurred after the lockdown measure. The case study regards the city of Brescia (Northern Italy) and focuses on the comparison of the period before (January 1st–March 7th, 2020)

and after (March 8th–March 27th, 2020) the lockdown. By adjusting for meteorology and Sunday effect, the results show that a significant change in air quality occurring in the post intervention period was observed only for a single NO station located in a heavy traffic zone. In particular, the estimate of the time series slope, i.e. the expected change in the concentration associated with a time unit increase, decreases from -0.25 to -1.67 after the lockdown. For the remaining stations, no significant change was found in the concentration time series when comparing the two periods. This confirms the complexity of air pollutant concentration dynamics for the considered area, which is not merely related to emission sources but depends also on other factors as, for example, (micro and macro) meteorological conditions and the chemical and physical processes in the atmosphere, which are all independent of the lockdown measure.

Keywords: Po Valley; Interrupted time series regression; ARMAX model; PM10 and NO2 concentrations; Change in level and trend; Counterfactual.

Addressing the issue of exposure to primary pollution in urban areas: Application to Greater Paris

A.Elessa Etuman a, b, c, I.Coll c, I.Makni c, T.Benoussaid c

Source: Atmospheric Environment, Volume 239, 15 October 2020, 117661

This work aims to highlight the importance of refining the calculation of exposure to primary pollutants in dense urban areas, by taking into account both pollutant concentration heterogeneity at the street scale, and individual mobility during the day. To address this issue, we have set up an urban modeling chain based on the OLYMPUS and CHIMERE models, and offering innovative statistical work on simulation data. OLYMPUS is an emission modeling system that produces mobility matrices for individuals in a city through an activity-based approach of the travel demand. CHIMERE is a chemistry-transport model that uses anthropogenic and biogenic emissions, meteorological fields and large-scale chemical fields to produce hourly pollutant concentration fields in a given area. A statistical post-processing of CHIMERE output data has been developed to create sub-grid variability for NO2 and PM10 concentrations - mainly related to the proximity of busy roads, and its results have been crossed with daily mobility matrices for every citizen, in order to refine our estimate of the individual exposure budget. This urban modeling platform has been implemented over Greater Paris. The results show that such approach considerably expands the range of individual exposure values and raises the question of recurrent exposure of city dwellers to very high levels of pollution, even during reduced periods of time during the day. They also introduce the issue of environmental inequalities

linked to practices and constraints of dwelling place, mobility and work, which need to be apprehended by new modeling approaches.

Keywords: Urban area; Emissions; Air quality; Mobility; Exposure; OLYMPUS.

Canopy density effects on particulate matter attenuation coefficients in street canyons during summer in the Wuhan metropolitan area

Xiaoshuang Wang a, Mingjun Teng a, Chunbo Huang a, b, Zhixiang Zhou a, Xiaoping Chen c, Yang Xiang a

Source: Atmospheric Environment, Volume 240, 1 November 2020, 117739

Changes in vegetation traits influence the particulate pollution mitigating effects of trees in street canyons; however, it remains unclear whether tree canopy density (i.e. the proportion of the street floor covered by the vertical projection of the tree canopy) promotes or reduces this effect. A 12-day field experiment was conducted in four representative street canyons to examine the mitigating effects of street trees on particulate matter (PM) for PM1, PM2.5, PM4, PM7, PM10, and total suspended particles (TSP) among four canopy density treatments, including (1) open spaces and areas with (2) sparse (≤35%), (3) medium (35–70%) and (4) dense (≥70%) canopy densities.

The results showed that canopy density is the dominant vegetation trait that affects PM dispersion, with peak decreases occurring at a canopy density of ~30%. The particulate matter attenuation coefficient (PMAC) indicates the PM reduction capability of trees. The PMAC of each particle size class correlated negatively with canopy density and TSP (<100 μm) showed the greatest attenuation. In relation to open space treatment, a canopy density range 30–36% showed the largest reductions in the PM10 and TSP concentrations of 26.75% and 27.49%, respectively. And for the PM2.5 concentration, a canopy density range 24–36% exhibited the largest reduction (7.44%). It was also concluded that sparse canopy density is optimal for trees in areas with high PM concentration. Medium canopy density also promotes pollutant dispersion (especially PM2.5), while dense canopy density causes air quality deterioration. This study will provide new insights into the response of atmospheric PM spatial dispersion to the characteristics of tree cover in street canyons, as well as the regulation mechanism of this response. By investigating this issue under different scenarios, this study aims to contribute to the quantitative tree planting design in urban planning.

Keywords: Air pollution; Street canyons; Dispersion; Roadside tree; $PM_{2.5}$.

Prediction of PM2.5 concentrations at the locations of monitoring sites measuring PM10 and NOx, using generalized additive models and machine learning methods: A case study in London

Antonis Analitis a, Benjamin Barratt b c, David Green b, Andrew Beddows b, Evangelia Samoli a, Joel Schwartz d, Klea Katsouyanni a, b

Source: Atmospheric Environment, Volume 240, 1 November 2020, 117757

The adverse health effects of air pollutants, especially those of PM2.5, are well documented. However, a lack of adequate monitoring and weaknesses in modelling approaches do not allow a good assessment of health effects in many areas of the World. Advances in computational methods and the availability of new data sets, e.g. satellite remote observations, have enlarged the possibilities of modelling for application in large scale health effects studies. However, PM2.5 monitoring is very recent in most of the World and more limited compared to other pollutants, and understanding how to use PM10 monitors to estimate PM2.5 exposure is therefore important. Since interest in these methods is relatively recent, there is a need for testing their performance against ambient measurements, but long term PM2.5 datasets are less readily available than PM10 in many regions. In the present study we report the methodology and results of using regression modelling and a machine learning method (Random Forest-RF), as well as a combination of the two, to enhance a PM2.5 measurement data base in London using PM10 and NOx measurements as well as other predictors and compare the relative performance of each method. We found that the combination of predictions by the regression model and the RF performs best and we obtain a cross-validation R2 of 99.29% and 98.22% for the 5-year periods 2004–2008 and 2009–2013, respectively, and a Mean Square Error near 1. Our enhanced data base for PM2.5 is available for use by other researchers.

Keywords: PM2.5 prediction; Environmental exposure; Random forest; Ensemble methods; London case study.

Quantification of within-vehicle exposure to NOx and particles: Variation with outside air quality, route choice and ventilation options

Vasileios N.Matthaios, Louisa J.Kramer a, Leigh R.Crilley 1, Roberto Sommariva Francis D.Pope, William J.Bloss

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Vehicle use, as driver or passenger, is a key transport mode and important microenvironment for personal exposure to air pollutants. Here, the air pollution exposure of vehicle occupants, relative to external, ambient levels was explored under different vehicle ventilation settings and driving routes in an urban area. Four vehicles were driven on a consistent route encompassing three contrasting road types, measuring simultaneous within-vehicle and ambient levels of particulate matter (PM10, PM2.5, PM1), ultrafine particles number (UFP), lung surface deposited area (LSDA), nitric oxide (NO) and nitrogen dioxide (NO2). For the majority of ventilation settings available, the inside/outside (I/OVEH) ratio for PM10, PM2.5, PM1, UFP, LSDA and NO2 concentrations was below 1, with the exception of NO, for which the ratio was independent of ventilation settings, within uncertainty. The lowest within-vehicle exposure for particles and gases was observed under the conditions of windows closed, recirculation and air conditioning on. Vehicle occupants are exposed to and inhale more air pollution when traveling on urban roads, followed by ring-roads and sub-urban roads. However, through reduced within-vehicle concentrations and reduced physical activity and hence breathing rate, they inhale less air pollution than people cycling/walking on the same routes. Within-vehicle air pollution exposure displays significant dependence upon both the ventilation setting and route selected. Vehicle occupants can, therefore, modify their personal exposure through these choices. Finally, vehicle occupants inhale more mass of NO2 than PM2.5 with a trip-average inhalation dose ratio of 6.4 (NO2 dose/PM2.5 dose). These results may have significant health impacts upon highly exposed groups such as professional drivers.

Keywords: Air pollution exposure; Commuting; Driving; Inhalation dose; Particles; Nitrogen oxides; Nitrogen dioxide.

Stability of environmentally persistent free radicals (EPFR) in atmospheric particulate matter and combustion particles

Heather L.Runberg, Deborah G.Mitchell, Sandra S.Eaton, Gareth R.Eaton, Brian J.Majestic

Source: Atmospheric Environment, Volume 240, 1 November 2020, 117809

Environmentally persistent free radicals (EPFRs) are an emerging area of atmospheric interest due to their implications in adverse health effects. Previous EPFR studies have looked at 24-hour averages of EPFR concentration within ambient PM2.5. However, PM2.5 levels vary diurnally. This study demonstrates instrumental sensitivity that is adequate to assess EPFR concentrations at a much higher temporal resolution than previously reported. Ambient PM2.5 samples were collected for 90 min at 96 L min−1 and analyzed quantitatively via electron paramagnetic resonance (EPR) spectroscopy. For environmental samples that had no measurable PM2.5 mass, EPFR concentrations were found in the range

of 1012 spins m−3, which is similar to values that have been reported previously in other urban locations. Additionally, since combustion products are likely to contribute to the EPFR portion of PM2.5, hexane generated soot was assessed for radical stability when exposed to water and ambient atmospheric conditions. Radical concentrations decreased by about 5% over the course of 88 days, but there was no difference in degradation rates between wetted and non-wetted soot. This study highlights the potential for sub-hourly EPFR monitoring which would allow for better insight into human exposure.

Keywords: Environmentally persistent free radicals; EPFR; Quantitative EPR; Electron paramagnetic resonance spectroscopy; Particulate matter; Soot; PM2.5.

Long-term trends and variations in haze-related weather conditions in north China during 1980–2018 based on emission-weighted stagnation intensity

Jin Feng a, Hong Liao b, Yanjie Li c, Ziyin Zhang a, Yingxiao Tang d

Source: Atmospheric Environment, Volume 240, 1 November 2020, 117830

Recently, climatological and environmental researchers have paid significant attention to the long-term trends and variations in haze-related weather conditions in North China (NC). This study investigates this topic using a quantified air stagnation index (ASIE) that combines stagnation intensity with fixed emission information, given that haze occurrence depends strongly on the rate of emission. ASIE has a close spatial and temporal relationship with observed PM2.5 concentrations, and a strong sensitivity to haze occurrence in NC. The annual ASIE increased by 18.2% over the period 1980–2018 due to significant decreases in planetary boundary layer height and ventilation. However, there was an apparent drop during 2013–2018, which suggests that lower stagnation intensity may take effect on the improved air quality in NC reported in recent years. Such low-frequency oscillation occurred twice during 1980–2018. Hence, if the current trend of decreasing stagnation intensity reverses, haze events may become more common in the future. In addition, the interannual variations in stagnation intensity were very significant. The percentage change of ASIE was as high as 50%–70% in some years. Finally, using the year-to-year growth ratio of ASIE, we highlight the difficulty of the “clean air challenge” due to the variations in stagnation in NC. The results suggest that the enforcement of the emission reduction plan should be tailored according to the stagnation conditions in the region and period of interest.

Keywords: Haze; North China; Stagnation.

Modeled and measured near-road PM2.5 concentrations: Indianapolis and Providence cases

Kenneth J.Craig a, Lynn M.Baringer a, Shih-Ying Chang a, Michael C.McCarthy a, Song Bai a, Annie F.Seagram a, Vikram Ravi a, Karin Landsberg b, Douglas S.Eisinger a

Source: Atmospheric Environment, Volume 240, 1 November 2020, 117775

Modeling analyses were developed to evaluate near-road PM2.5 concentrations predicted by the AERMOD dispersion modeling chain under real-world conditions, and to assess the sensitivity of modeled near-road concentrations to the choice of dispersion model (AERMOD or CAL3QHCR), meteorological data, and travel data processing approach. We evaluate PM2.5 monitoring sites near major freeways in Indianapolis, Indiana (for 2016) and Providence, Rhode Island (for 2015–2016). The modeling analyses are built upon bottom-up estimates of temporally and spatially resolved roadway PM2.5 emissions based on traffic monitoring data and local vehicle fleet emission factors. The dispersion model simulations use local meteorological data collected at or close to the near-road monitoring sites. Predictions involved a modeling chain that included travel activity data processing, emissions modeling (MOVES and AP-42), and air quality dispersion modeling.

We estimated the difference between PM2.5 concentrations at the near-road monitor and at nearby urban air quality monitoring sites (the measured near-road "increment"), and compared modeled results to the measured increments. Based on monitoring data, estimates of multi-day-averaged near-road PM2.5 increments were 0.9 ± 0.6 μg/m3 at Indianapolis and 1.4 ± 0.2 μg/m3 at Providence (where the uncertainty represents the 95% confidence interval on the mean value), and were comparable to measured PM2.5 increments at these sites in the near-road literature.

Modeled roadway contributions to multi-day-averaged near-road concentrations substantially exceeded measured values based on the near-road monitoring data. The average near-road PM2.5 increment modeled with AERMOD was more than 300% (factor of four) larger than the measured increment at Indianapolis, and more than 500% (factor of six) larger than the measured increment at Providence. These biases reflect cumulative uncertainty throughout the near-road PM2.5 modeling chain.

The emissions modeling component may have contributed to the modeling chain biases in two ways. First, the relative contribution of modeled non-exhaust emissions (PM2.5 brake wear, tire wear, and re-suspended road dust) compared to tailpipe exhaust emissions was higher than what has been documented in several published studies. Second, other research findings indicate that the U.S. EPA MOVES2014 model may over-predict tailpipe

PM2.5 exhaust. The dispersion modeling component may have also contributed to the modeling chain biases. For example, when local meteorological data were used, AERMOD results were relatively insensitive to wind direction on a daily averaged basis; as a result, modeled concentrations exceeded measured values regardless of whether the near-road monitor was upwind or downwind of the roadway. In summary, this work provides a unique evaluation of PM2.5 concentrations predicted by the near-road modeling chain, and provides valuable information to understand potential sources of uncertainty in the near-road modeling process.

Keywords: Near-road; Particulate matter; Air pollution; Emissions modeling; Dispersion modeling; AERMOD.

Molecular characterization of biomass burning tracer compounds in fine particles in Nanjing, China

Wenjing Li a, Junfeng Wang b, Lu Qi c, Wentao Yu a, Dongyang Nie d, Shuangshuang Shi e, Chuanxin Gu f, Xinlei Ge a, Mindong Chen a

Source: Atmospheric Environment, Volume 240, 1 November 2020, 117837

In this work, a sensitive method based on the High Performance Liquid Chromatography-Electrospray Ionization-Mass spectrometry/Mass spectrometry (HPLC-ESI-MS/MS) technique was established and validated, and successfully applied to quantify biomass burning tracer species (in total 20 compounds) in fine aerosol particles (PM2.5) collected during the full year of 2016 in Nanjing, China. The annual levoglucosan concentration was determined to be 328.3 ng m−3, at a similar level as it in other Chinese cities; the concentration peaked in fall, indicating influences of crop/straw burning during harvest periods. Concentrations of other species were a few orders of magnitude lower than that of levoglucosan, with salicylic acid (1.53 ng m−3), cis-pinonic acid (0.60 ng m−3) and vanillic acid (0.51 ng m−3) as the three most abundant ones. Total concentrations of tracers indicative of softwood, hardwood and grass burning were about equal. Seasonal concentrations of these tracers were generally similar, and all peaked in winter, different from that of levolglucosan. Further positive matrix factorization (PMF) identified four types of biomass (cellulose, harwood lignin, softwood lignin and grass). Celluose was dominated in fall, while softwood and hardwood were both dominated in winter, and seasonal contributions (except summer) were relatively even to grass. On an annual basis, softwood, hardwood and grass contributions were almost on par to the selected tracers, in agreement with the results based only on concentrations, but seasonally, grass was the major one in spring, summer and fall, but much less important in winter.

Keywords: Biomass burning; Hardwood; Softwood; Grass; Source apportionment.

Significant influence of the intensive agricultural activities on atmospheric PM2.5 during autumn harvest seasons in a rural area of the North China Plain

Xuran Li a, d, Chenglong Zhang a, b, d, Pengfei Liu a, b, d, Junfeng Liu a, b, d, Yuanyuan Zhang a, b, d, Chengtang Liu a, b, d, Yujing Mu a, b, c, d

Source: Atmospheric Environment, Volume 241, 15 November 2020, 117844

The levels and composition of atmospheric PM2.5 were comprehensively investigated over an agricultural field in the North China Plain (NCP) during the autumn harvest season for the first time to reveal the influence of intensive agricultural activities on atmospheric PM2.5. In comparison with the pre-harvesting period, PM2.5 concentration increased by a factor of 1.20–1.73 during the harvesting and post-harvesting periods despite of relatively higher wind speeds. Organic carbon (OC) in PM2.5 increased most significantly, with its average concentration (and its proportion in PM2.5) increased from 9.0 μg/m3 (15.6%) during the pre-harvesting period to 18.8 μg/m3 (28.7%) during the harvesting period and to 28.8 μg/m3 (32.1%) during the post-harvesting period, implying that OC emission relating to the harvest event made conspicuous contribution to atmospheric PM2.5. The sources of OC varied significantly during the process of the harvest event, e.g., the ratio of OC to element carbon (EC) increased from 3.33 during the pre-harvesting period to 4.54 during the harvesting period and to 5.36 during the post-harvesting period. Straw crushing and agricultural machineries during the harvesting period were suspected to the major sources for the elevation of OC because of sparse fire spots around the sampling site, whereas biomass burning became the dominant contributor to atmospheric OC during the post-harvesting period. Besides OC and EC, the concentrations of Cl- and K+ were also evidently increased from the pre-harvesting period to the post-harvesting period. The remarkable elevation of both Cl- and K+ also linked with the harvest event besides biomass burning, e.g., the release from straw crushing during the harvesting period and fertilization of the compound fertilizer with NH4Cl during the post-harvesting period. The maximal concentrations of the crustal components (Na2+, Mg2+ and Ca+) appeared during the harvesting period, revealing that straw crushing for returning to the field was their important source. The atmospheric SO42− concentration exhibited a steady decreasing trend from 15.2 μg/m3 to 8.3 μg/m3, whereas NO3− concentration significantly increased from 11.2 μg/m3 during the harvesting period to 16.2 μg/m3 during the post-harvesting period. The significant increase of NO3− concentration during the post-harvesting period was mainly attributed to the fertilization event which resulted in emissions of NH3, NOx and HONO to accelerate NO3− formation. Given the considerable contribution (more than

20%) on PM2.5, the intensive agricultural activities during the harvest season in the NCP should be aroused greater attention, especially for the current disposal of crop straws and the surplus fertilization.

Keywords: Carbonaceous aerosols; Water-soluble ions; NCP; Source apportionment.

Transport of aerosols and trace gases during dust and crop-residue burning events in Indo-Gangetic Plain: Influence on surface ozone levels over downwind region

Sonal Kumari, Anita Lakhani, K. Maharaj Kumari

Source: Atmospheric Environment, Volume 241, 15 November 2020, 117829

The present study addresses the influence of long-range transport from dust storm (event 1) and crop-residue burning (event 2) sources over Indo-Gangetic Plain (IGP) using ground-based measurements and satellite observations. In the present study, the spatial distribution and temporal variation of ambient particulate matter (PM) were assessed at 15 air quality monitoring stations situated in Rajasthan, north-western-Indo-Gangetic Plain (NW-IGP) and downwind region. During the dust event, the daily average mass concentrations of PM2.5 and PM10 were 1.2–3.3 and 2.2–4.6 times higher than the National Ambient Air Quality Standards (NAAQS 60 μg/m3 for PM2.5 and 100 μg/m3 for PM10) across stations in the vicinity of the Thar Desert. Stations in NW-IGP showed enhancement in PM2.5 and PM10 during crop-residue burning period. Agra being a downwind site was influenced by both the events and enhancement in PM levels was observed, however ozone (O3) showed different variations during event 1 and 2. During the dust event, 6.1% reduction in the mean O3 level compared to the study period was found while a significant enhancement (15.1%) during event 2 was observed at Agra. To determine the possible reasons for different O3 trends, the variation of O3 precursors carbon monoxide (CO) and nitrogen oxides (NOx) along with the meteorological parameters was also assessed. CO and NOx levels during event 1 were reduced similar to O3 whereas during event 2 an enhancement in CO and NOx levels was observed. Satellite observations and backward air-mass trajectories suggested transport of aerosols from Thar Desert resulted in reduced O3 levels during dust event while transport of O3 precursors enhanced photochemical production of O3 during crop-residue burning period at Agra.

Keywords: Ozone; Particulate matter; Dust storm; Crop-residue burning; Spatiotemporal variation; Heterogeneous reactions.

Characteristics of aerosol within the nocturnal residual layer and its effects on surface PM2.5 over China

Yifan Shi a, Boming Liu b, Shihua Chen a, Wei Gong b, c, Yingying Ma b, c, Ming Zhang d, Shikuan Jin b, Yinbao Jin b

Source: Atmospheric Environment, Volume 241, 15 November 2020, 117841

Aerosol loading within the surface layer is an important aspect in studying air quality. However, a comprehensive understanding of the characteristics and effects of aerosol in the residual layer (RL) over China is yet to be achieved. In this study, the characteristics of aerosol in the RL and its effects on the surface PM2.5 over China are investigated using ten-year Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) data from January 2008 to December 2017. Our results show that the high aerosol optical depth in the RL (RAOD) is generally found in the north-central and southwestern parts, whereas low values are observed in the northeastern and northwestern areas. The RAOD accounts for >50% of the total columnar aerosols in most regions, and the main components of aerosols in RL are polluted continental aerosol and polluted dust. A decreasing trend of RAOD was observed in the Yellow River Delta (YRD), North China Plain (NCP), Central China (CC) and Sichuan Basin (SCB), which are related to the decreasing emission of aerosols. Moreover, the effects of meteorological parameters on the RAOD were investigated. The relative humidity and the latent heat flux has a positive correlation with the RAOD in most areas, while the wind speed and the sensible heat flux has a negative correlation with the RAOD. The relationship between the RAOD and the following daytime surface particulate matters (PM2.5) were assessed. The correlation coefficients between RAOD and following daytime surface PM2.5 in YRD, NCP, CC and SCB were 0.29, 0.34, 0.4 and 0.39, respectively. The results proved that a high RAOD can promote the concentration of surface PM2.5. These findings are significant to the improvement of our understanding of the effects of aerosols in the RL on air quality.

Keywords: Aerosol optical depth; CALIPSO; Residual layer; Aerosol types; Meteorological parameters.

The impact of Sahara dust on air quality and public health in European countries

Qiaoqiao Wang a, Jianwei Gu b, Xurong Wang a

Source: Atmospheric Environment, Volume 241, 15 November 2020, 117771

The frequent transport of Sahara dust toward Europe degrades the air quality and poses risk to human health. In this study we use GEOS-Chem (a global transport model) to examine the impact of Sahara dust on air quality and the consequent health effect in Europe (10°W – 20°E, 35°N – 60°N) for the year 2016–2017. The model performance is evaluated by comparisons with surface observations including aerosol optical depth (AOD) from AERONET, and PM2.5 and PM10 concentrations from numerous monitoring stations. The spatial distribution of dust concentrations, frequency of dust episodes, as well as the exposure and health effects are studied. The concentrations of Sahara dust decrease from 5–20 μg m−3 in south to 0.5–1.0 μg m−3 in north of Europe. Spain and Italy are most heavily influenced by Sahara dust in terms of both concentration levels and frequencies of occurrence. Strong dust episodes (>50 μg m−3) occur predominately in Southern Spain and Italy with frequency of 2–5%, while light dust episodes (>1 μg m−3) are often detected (5–30%) in Central and Western Europe. The population-weighted dust concentrations are higher in Southern European countries (3.3–7.9 μg m−3) and lower in Western European countries (0.5–0.6 μg m−3). We estimate a total of 41884 (95% CI: 2110–81658) deaths per year attributed to the exposure to dust in the 13 European countries studied. Due to high contribution to PM10 in Spain, Italy and Portugal, dust accounts for 44%, 27% and 22% of the total number of deaths linked to PM10 exposure, respectively.

Keywords: African dust; Particulate matter; Air quality; Health effect; Mortality; Europe; GEOS-Chem.

High PM10 concentrations in the city of Buenos Aires and their relationship with meteorological conditions

Andrea L.Pineda Rojas a, Rafael Borge b, Nicolás A.Mazzeo c, Ramiro I.Saurral a, d, Bruno N.Matarazzo d, Jose M.Cordero b, Emilio Kropff e

Source: Atmospheric Environment, Volume 241, 15 November 2020, 117773

In this work, the first long-term (eight years) record of hourly concentrations of carbon monoxide (CO), nitrogen dioxide (NO2) and particulate matter with diameter less than 10 μm (PM10) from three sites in the city of Buenos Aires is analysed. Considering the short-term guidelines suggested by the WHO, the daily mean PM10 concentrations present a relatively large number of exceedances at the three sites. Different statistical techniques are combined to study the relationship between these relatively high PM10 concentrations and relevant surface meteorological variables. For all pollutants and sites, wind speed shows the largest differences between the lowest and highest concentration quartiles. To further explore its role on daily mean PM10 concentration, a k-means algorithm is applied, grouping days with similar surface 1h-wind sequences. Five wind sequence clusters are found, presenting distinctive air quality data features. Two clusters (1 and 2) show that

PM10 exceedances occurring with winds entering the city from the river represent between 10 and 21% of total events at the three sites. The frequency of exceedance under these conditions decreases with the distance to the coast. For cluster 1, the hourly PM10 concentration profile and its associated daily wind sequence suggest an important contribution to exceedance events from the city's southernmost power plant. Two clusters (3 and 4), exhibiting continental winds, account for 49–59% of the exceedances and co-occur with relatively drier air conditions. The correlation between CO and PM10 for days belonging to cluster 3 supports the hypothesis of a potential remote or distributed source contribution with SW winds. For cluster 4, differences among sites in the number of events under NNW winds suggest an important contribution from the city's widest avenue to the PM10 levels at the most coastal site. A large contribution coming from urban sources is also indicated for these winds. Finally, cluster 5, exhibiting low wind speed sequences, accounts for 23–33% of the exceedances at the three sites. The average PM10 concentration increases with persistence of this cluster, which could be a driver for exceedances. These results contribute to show the importance of simple methods such as clustering analysis to obtain insights into air quality features such as exceedances and their potential drivers. They also suggest that further efforts in monitoring, modelling and emission estimates may help to better understand local, urban and regional source contributions to these events in the city of Buenos Aires.

Keywords: Air quality data; Buenos Aires; Exceedance conditions; Meteorological data.

PM emissions from heavy-duty trucks and their impacts on human health

Ana Carolina Rodrigues Teixeira a, Raquel Rocha Borges b, Pedro Gerber Machado c, Dominique Mouette b, Flavia Noronha Dutra Ribeiro b

Source: Atmospheric Environment, Volume 241, 15 November 2020, 117814

The Brazilian transport system is based on the use of highways and road heavy-duty trucks are the main type of vehicle to perform this activity. There are more than 1 million km of highways in the country and the search for alternative technologies to reduce emissions from the transport industry is increasing. The Blue Corridor research started to replace heavy-duty vehicles fueled by conventional diesel to liquefied natural gas (LNG) and its effect on pollutant emissions reductions. In this context, this paper aims at evaluating the atmospheric dispersion of particulate matter (PM) from road heavy-duty trucks in 12 cities in the São Paulo State, assessing the impacts of the replacement of full fleet powered by diesel to LNG and the effects on the health of the local population. The model AERMOD was used to simulate the dispersion of PM produced by heavy-duty vehicles fuel combustion

and the methodology suggested by the World Health Organization (WHO) was used to analyze the number of deaths attributed to the PM emitted. Results showed some municipalities with high PM concentrations, which exceeded the limits suggested by WHO. In terms of health issues, cardiovascular diseases in a population older than 30 years were the main cause of death from PM emissions. When it comes to fuel replacement, LNG helps to reduce PM emissions, but considering this reduction alone is not sufficient to avoid attributable deaths.

Keywords: Particulate matter; Heavy-duty trucks; Air pollution; LNG; Health impact; Air quality dispersion model.

Health impact assessment of air pollution in the metropolitan region of Fortaleza, Ceará, Brazil

Camille A.Rocha a, Joyce L.R.Lima a, b, Kamila V.Mendonça c, Elissandra V.Marques a, Maria E.Zanella d, Jefferson P.Ribeiro e, Bruno V.Bertoncini e, Verônica T.F.Castelo Branco e, Rivelino M.Cavalcante a

Source: Atmospheric Environment, Volume 241, 15 November 2020, 117751

The aim of the present study was to perform the first analysis of predictive scenarios for a reduction in air pollution and associated costs in one of the largest metropolises in Brazil (city of Fortaleza). The pollutants analyzed were particulate matter (PM) from 2.5 to 10 μm (PM2.5 and PM10) between the years 2015 and 2017. We evaluated the benefits to health that could be achieved if pollutant concentrations were reduced to certain values. Considering the predictive scenarios, a short-term reduction in PM10 by 5 μg m−3 would have avoided more than 130 hospitalizations due to cardiorespiratory diseases per year and a reduction by 20 μg m−3 would have avoided 410 hospitalizations. In monetary terms, this is equivalent to US$ 62,631.84 and US$ 191,329.24, respectively. For the long term, a reduction of 5 μg m−3 in PM2.5 levels have avoided more than 200 such hospitalizations and a reduction of 10 μg m−3 would have avoided more than 580 hospitalizations, corresponding to US$ 780,595,109.24 and US$ 2,239,924,053.64, respectively.

Keywords: Exposure; Particulate matter; Public policy.

Spatial decomposition analysis of NO2 and PM2.5 air pollution in the United States

Yuzhou Wang a, Matthew J.Bechle a, Sun-Young Kim b, c, Peter J.Adams d, e, Spyros N.Pandis f, C. Arden Pope III g, Allen L.Robinson e, h, Lianne Sheppard b, I, Adam A.Szpiro I, Julian D.Marshall a

Source: Atmospheric Environment, Volume 241, 15 November 2020, 117470

Length scales for spatial variability of air pollution concentrations depend on the pollutant and the location. In this paper, we develop a readily scalable algorithm based on "spatial-increment", to decompose the air pollution concentration into four spatial components: long-range, mid-range, neighborhood, and near-source. We apply the algorithm to annual-average concentrations of outdoor nitrogen dioxide (NO2) and fine particulate matter (PM2.5) for all census blocks in the contiguous US. For NO2, "neighborhood" and "mid-range" components dominate both within-city and between-city concentration differences (both components are ~5-fold larger in large urbanized areas than rural areas). For PM2.5, the "long-range" component dominates; this component varies by region (e.g., is three times greater in the Midwest [7 μg/m3] than in the West [2.3 μg/m3]), whereas variation by urban area size is relatively minor. Our study provides the first nation-level fine-scale decomposed pollution surfaces to date; this dataset is publicly available. Results can be used to estimate, at least to a zeroth order, the contribution of sources at different distances from the receptor to the annual average pollution in a location of interest.

Keywords: Spatial decomposition; Spatial increment; NO2; PM2.5.

Diesel, petrol or electric vehicles: What choices to improve urban air quality in the Ile-de-France region? A simulation platform and case study

M.Andre a, K.Sartelet b, S.Moukhtar c, J.M.Andre d, M.Redaelli e

Source: Atmospheric Environment, Volume 241, 15 November 2020, 117752

Air pollution from road traffic and its mitigation is a major concern in most cities. A platform for simulating pollutant emissions and concentrations was developed and applied to the Île-de-France Region (Greater Paris) of France, taking account of anthropogenic and natural sources and 'imported' pollution from elsewhere in France and Europe. Four technological scenarios for 2025 were studied and compared to the 2014 reference situation (1-REF). These scenarios included the current evolution of the park with widespread adoption of diesel particulate filters (DPFs) (2-BAU), decline in the sale of diesel vehicles and a corresponding increase in petrol vehicle sales (3-PET), promotion of electric vehicles in urban areas (4-ELEC), and a combinaison with a decrease in traffic of

about 15% in the densely populated area inside the A86 outer ring road (5-AIR). The corresponding vehicle fleets were determined using a fleet simulation model.
Traffic pollutant emissions were computed with the COPERT4 European methodology and hourly traffic data over the Île-de-France road network. Particulate matter (PM10, PM2,5 and PM1,0), particles number (PN), black carbon (BC), organic matter (OM), nitrogen oxides (NOx) and nitrogen dioxide (NO2), non-methane volatile organic compounds (VOC), ammonia (NH3), carbon monoxide (CO) and carbon dioxide (CO2) were considered. Emissions for other sectors were taken from a regional inventory. Emissions outside the Île-de-France region (Europe and France) were derived from the European and French emission inventories. Pollutant concentrations (PM2,5, PM10, organic and inorganic PM10, PN, BC, NO2 and O3) were simulated over nested domains (Europe, France and Île-de-France) using the Polyphemus platform for two scenarios (2-BAU and 3-PET). Methodological aspects and results for Île-de-France are discussed here.
All scenarios led to a sharp decrease in traffic emissions in Île-de-France (−30% to −60%) by 2025. The decline in diesel induced a stronger renewal of the fleet. PM and NOx emissions were more strongly reduced than VOC or NH3. Traffic reduction reduced all emissions in the densely populated area within the A86 outer ring road (−20% to −45% for exhaust particles and gaseous pollutants).
The 2-BAU and 3-PET scenarios lowered annual average concentrations, especially for NO2 and BC, and more strongly influenced daily-peak than daily-average concentrations. In Île-de-France, PM of diameter <10 μm (PM10), and NO2 concentrations, decreased in the most densely populated areas. The entire population would benefit from a PM10 annual mean concentration decrease of ≥0.4 μg/m3, and the annual mean NO2 concentration would decrease by ≥ 10 μg/m3 for 40–50% of the population. For other pollutants (PM2.5, secondary pollutants, etc.), reductions were more limited, due to the other activity sectors and atmospheric chemistry. Ozone concentrations might even increase in urban locations, suggesting an increase in oxidants and thus an increase in secondary aerosol formation if precursors were not reduced.
Differences between 2-BAU and 3-PET scenarios were slight. For PM and NO2 concentrations, the petrol scenario was slightly more favorable than the “business-as-usual” scenario with diesel vehicles and DPF; differences were strong for primary particles and NO2 and weak for secondary compounds. This slight advantage was due to lower emissions and accelerated fleet renewal (higher proportion of Euro 5 & 6).

Keywords: Road traffic, Pollutant emission, Concentration, Simulation, Vehicle technology, Vehicle fleet, Scenario, COPERT, Polyphemus.

Statistical field calibration of a low-cost PM2.5 monitoring network in Baltimore

Abhirup Datta a, Arkajyoti Saha a, Misti Levy Zamora b c, Colby Buehler c d, Lei Hao b, Fulizi Xiong c d, Drew R.Gentner c d, Kirsten Koehler b c

Source: Atmospheric Environment, Volume 242, 1 December 2020, 117761

Low-cost air pollution monitors are increasingly being deployed to enrich knowledge about ambient air-pollution at high spatial and temporal resolutions. However, unlike regulatory-grade (FEM or FRM) instruments, universal quality standards for low-cost sensors are yet to be established and their data quality varies widely. This mandates thorough evaluation and calibration before any responsible use of such data. This study presents evaluation and field-calibration of the PM2.5 data from a network of low-cost monitors currently operating in Baltimore, MD, which has only one regulatory PM2.5 monitoring site within city limits. Co-location analysis at this regulatory site in Oldtown, Baltimore revealed high variability and significant overestimation of PM2.5 levels by the raw data from these monitors. Universal laboratory corrections reduced the bias in the data, but only partially mitigated the high variability. Eight months of field co-location data at Oldtown were used to develop a gain-offset calibration model, recast as a multiple linear regression. The statistical model offered substantial improvement in prediction quality over the raw or lab-corrected data. The results were robust to the choice of the low-cost monitor used for field-calibration, as well as to different seasonal choices of training period. The raw, lab-corrected and statistically-calibrated data were evaluated for a period of two months following the training period. The statistical model had the highest agreement with the reference data, producing a 24-h average root-mean-square-error (RMSE) of around 2 . To assess transferability of the calibration equations to other monitors in the network, a cross-site evaluation was conducted at a second co-location site in suburban Essex, MD. The statistically calibrated data once again produced the lowest RMSE. The calibrated PM2.5 readings from the monitors in the low-cost network provided insights into the intra-urban spatiotemporal variations of PM2.5 in Baltimore.

Keywords: Baltimore; Field colocation; Gain-offset model; Linear regression; Low-cost monitors; PM2.5.

Observations of new particle formation, modal growth rates, and direct emissions of sub-10 nm particles in an urban environment

Alyssa Zimmerman a, Markus D.Petters a, Nicholas Meskhidze a

Source: Atmospheric Environment, Volume 242, 1 December 2020, 117835

Ultrafine particles with diameters less than 100 nm suspended in the air are a topic of interest in air quality and climate sciences. Sub-10 nm particles are of additional interest due to their health effects and contribution to particle growth processes. Ambient measurements were carried out at North Carolina State University in Raleigh, NC between April to June 2019 and November 2019 to May 2020 to investigate the temporal variability of size distribution and number concentration of ultrafine particles. A mobile lab was deployed between March and May 2020 to characterize the spatial distribution of sub-10 nm particle number concentration. New particle formation and growth events were observed regularly. Also observed were direct emissions of sub-10 nm particles. Analysis against meteorological variables, gas-phase species, and particle concentrations show that the sub-10nm particles dominated number concentration during periods of low planetary boundary layer height, low solar radiation, and northeast winds. The spatial patterns observed during mobile deployments suggest that multiple temporally stable and spatially confined point sources of sub-10 nm particles are present within the city. These sources likely include the campus utility plants and the Raleigh-Durham International Airport. Additionally, the timing of data collection allowed for investigation of variations in the urban aerosol number size distribution due to reduced economic activity during the COVID-19 pandemic.

Keywords: Urban aerosol; New particle formation; Sub-10 nm aerosol; Air pollution.

Stabilization for the secondary species contribution to PM2.5 in the Pearl River Delta (PRD) over the past decade, China: A meta-analysis

Fenghua Yan a 1, Weihua Chen a 1, Shiguo Jia b, Buqing Zhong a, Liming Yang c, Jingying Mao a, Ming Chang a, Min Shao a, Bin Yuan a, Shuping Situ d, Xinming Wang e, Duohong Chen f, Xuemei Wang a

Source: Atmospheric Environment, Volume 242, 1 December 2020, 117817

The fine particulate matter (PM2.5) pollution is one of the atmospheric environmental problems in densely populated areas of China. The secondary species contribution in PM2.5 is extensively studied but the comprehensive analysis on the long-term trend of the secondary species and the main drivers of this trend in the Pearl River Delta (PRD) have not been explored. Therefore, this study aimed to evaluate the long-term temporal variation of PM2.5 and its secondary species contribution in PRD for twenty years from 2000 to 2019. The results of the meta-analysis showed that the annual average concentration of PM2.5 in the PRD was 60.3 ± 16.8 μg/m3 and generally decreased by 3.9 μg/m3 per year from 2004 to 2019. Three significant transitions in secondary species percentage were observed during 2000–2019: first declined in 2000–2005 before rose in

2005–2008 and followed by a stable period in 2008–2019. The percentage of secondary species stabilized at around 80%, of which secondary organic aerosol (SOA) and secondary inorganic aerosol (SIA, including SO42−, NO3−, and NH4+) had identical contributions to PM2.5 over the past decade. SOA was affected by the concentration of total oxidant (OX) and volatile organic compounds (VOCs) emissions. SO42− and SO2 have declined with significant reductions in SO2 emissions. NO3− and NH4+ were positively and negatively correlated with the atmospheric concentration of NO2 and NH3, respectively. In addition to the current efforts on SO2 and NOx controls, further measures are needed to control NH3 and VOCs emissions over a larger area for PRD to effectively improve the air quality.

Keywords: Fine particulate matter; Secondary species; Pollutant emissions; Pearl River Delta (PRD).

Spatiotemporal variations in traffic activity and their influence on air pollution levels in communities near highways

Paola Filigrana a, Chad Milando b, Stuart Batterman b, Jonathan I. Levy c, Bhramar Mukherjee d, Sara D.Adar a

Source: Atmospheric Environment, Volume 242, 1 December 2020, 117758

Localized variations in traffic volume and speed can influence air pollutant emissions and corresponding concentrations in nearby communities, but most studies have utilized only aggregated traffic activity data. In this study, we compared the estimated influence of highway traffic activity on concentrations of primary oxides of nitrogen (NOx) and fine particulate matter (PM2.5) in communities near highways using a dispersion model informed by highly spatiotemporally-resolved variations of traffic volume and flow compared to the use of Annual Average Daily Traffic (AADT) data at a few locations.

We used two sources of traffic activity data on 500 half-mile roadway segments on the five major highways in the Washington State Puget Sound during 2013. The first consisted of vehicle counts available every half-mile and 5 min; the second was traffic information (e.g., AADT) aggregated across the year and roadway network. Using the Motor Vehicle Emissions Simulator (MOVES) and the Research Line source dispersion model (RLINE), we modeled hourly concentrations of primary NOx and PM2.5 generated by highway traffic at nearly 4000 residences within 1 km of major highways. These concentrations were aggregated to daily and annual average concentrations, which were compared by input data source.

At most locations, concentrations of primary NOx and PM2.5 modeled using the resolved traffic data had similar spatial and temporal distributions to concentrations predicted using the AADT data. However, several areas showed large differences. For example, 25% of residences within 150 m of a highway had concentrations that differed by more than 19% (8 ppb) for NOx and 32% (0.7 μg/m3) for PM2.5, and the AADT data consistently predicted lower concentrations than the resolved traffic data.

Our findings indicate that temporal and spatial variation in traffic patterns can result in complex spatiotemporal variations of air pollutant concentrations that can be captured with the use of dispersion modeling with the appropriate inputs. The use of spatiotemporally resolved traffic activity data can improve exposure estimates and help reduce exposure measurement error in epidemiological studies, especially in communities near highly congested highways.

Keywords: Traffic-generated air pollution; dispersion model; RLINE; Vehicle emissions; Exposure assessment.

Remote sensing of NO emission from light-duty diesel vehicle

Lijun Hao a, Hang Yin b, Junfang Wang b, Xiaohu Wang c, Yunshan Ge a

Source: Atmospheric Environment, Volume 242, 1 December 2020, 117799

Motor vehicle emission remote sensing technology has achieved good application results in the field of gasoline vehicle emissions monitoring, but it is still immature in testing NOx and other gaseous emissions from diesel vehicles due to the large deviation of the tested results. In this paper, a conversion calculation method for remote sensing test data of diesel vehicle emissions is established. Based on the relative concentration ratios of various gaseous components in the exhaust plume of diesel vehicle and the excessive air coefficient of diesel engine under the test condition, the concentrations of various gaseous components emitted from diesel vehicle are obtained. The remote sensing results of NO and other gaseous emissions from the diesel vehicle under the conditions of idling and constant speeds are close to the tested results by PEMS verifying the correctness and feasibility of the conversion calculation method for remote sensing data of diesel vehicle emissions.

Keywords: Diesel vehicle; NO emission; Remote sensing; Excessive air coefficient; Conversion calculation.

Chemical characteristics and source apportionment of ambient PM1.0 and PM2.5 in a polluted city in North China plain

Chunrong Chen a, Haixu Zhang b, Haiyan Li b, Nana Wu a, Qiang Zhang a

Source: Atmospheric Environment, Volume 242, 1 December 2020, 117867

Handan is a heavily polluted city in the northern China. From 6 to December 31, 2015, PM1.0 and PM2.5 samples were synchronously collected for 23.5 h of each day at an urban site in Handan, to study the chemical composition and sources of aerosols present during wintertime in North China Plain (NCP). The average mass concentrations of PM1.0 and PM2.5 in Handan were as high as 189.2 μg/m3 and 252.4 μg/m3, while the average PM1.0/PM2.5 ratio was relatively low (74.6%) compared with the results in megacities. Overall, the chemical characteristics of PM1.0 and PM2.5 were quite similar during the campaign. During pollution episodes, SNA (sulphate, nitrate, and ammonium) ions were found dramatically increased, while the fraction of organic carbon (OC) and elemental carbon (EC) decreased in both PM1.0 and PM2.5. As a result of reduced photochemical reactions, the weights of secondary organic carbon (SOC) in PM1.0 and PM2.5 decreased during the pollution episode. Besides, liquid water content (LWC) were found effective for SNA formation. The positive matrix factorization (PMF) model identified similar sources distributions for PM1.0 and PM2.5, and the top three contributors were coal combustion, secondary inorganic aerosols, and industrial emissions. Moreover, the potential source contribution function (PSCF) demonstrated that regional sources in southern Handan might be crucial contributors to haze pollution in Handan.

Keywords: PM1.0/PM2.5; Chemical characteristics; LWC; PMF; PSCF.

Modifying effects of temperature on human mortality related to black carbon particulates in Beijing, China

Ying Zhang a, Xiaoling Zhang a f, Xingang Fan b c, Changjian Ni a, Zhaobin Sun d, Shigong Wang a f, Jin Fan a, Canjun Zheng e

Source: Atmospheric Environment, Volume 243, 15 December 2020, 117845

Worldwide epidemiological studies have demonstrated that short-term associations of particulate matter (PM), might be further complicated by ambient temperatures, and increase human mortality. In China, among various PM indices, the health effects of black carbon (BC) are less understood due to the lack of data availability. Additionally, it is unclear how temperature modifies simultaneous and adverse effects of BC, and fine (PM

size <2.5 μm; PM2.5), and coarse particles (PM2.5-10), on mortality outcomes. We adopted time-series Poisson generalized additive models to investigate temperature modifying effects on the association between three different PMs (BC, PM2.5, and PM2.5-10) and mortality (non-accidental, respiratory and cardiovascular mortality) in Beijing, China, from 2010 to 2016. Average daily BC, PM2.5, and PM2.5-10 concentrations were 4.95, 72.3, and 52.1 μg/m3, respectively, which were all significantly associated with daily mortality. High temperature strongly amplified effects of BC, PM2.5, and PM2.5-10 on human mortality, especially BC effects that were most pronounced at >28 °C. Harmful effects were estimated for increases in non-accidental, respiratory, and cardiovascular mortality per interquartile increments in BC (4.11 μg/m3), PM2.5 (62.37 μg/m3), and PM2.5-10 (46.71 μg/m3) concentrations from the moving average of current and previous day (lag01) under high temperature (>28 °C). Mortality increases in non-accidental, respiratory, and cardiovascular categories were 5.12% (95% confidence interval [CI]: 4.79, 5.45), 7.41% (95%CI: 6.42, 8.40), and 6.36% (95%CI: 2.45, 10.3) for BC; 3.85% (95%CI: 3.27, 4.43), 6.64% (95%CI: 5.63, 7.65), and 4.54% (95%CI: 3.31, 5.78) for PM2.5; and 2.56% (95%CI: 1.45, 3.67), 3.41% (95%CI: 1.53, 5.29), and 3.19% (95%CI: 2.44, 3.94), for PM2.5-10, respectively. These findings suggest that controlling the emission of ambient particles, especially BC, and improving air quality during summer would substantially benefit population health. Furthermore, BC should be considered as a crucial air quality indicator to reflect PM health risk.

Keywords: Temperature; Black carbon; Particulate matter; Mortality; Modifying effect.

The spatio-temporal evolution of black carbon in the North-West European 'air pollution hotspot'

K.P.Wyche a, R.L.Cordell b, L.Smith M a, K.L.Smallbone a, P.Lyons a, S.M.L.Hama b c, P.S.Monks b, J.Staelens d, J.Hofman d e, C.Stroobants d, E.Roekens d, G.P.A.Kos f, E.P.Weijers g, P.Panteliadis h, M.B.A.Dijkema h, I, j

Source: Atmospheric Environment, Volume 243, 15 December 2020, 117874

Particulate black carbon has a range of negative impacts on health, the environment and climate, however despite this there are relatively few long-term studies on its ambient distribution as a tropospheric air pollutant. In order to address this lack of data, to help to provide greater insight into the spatio-temporal distribution of particulate black carbon and to assess potential influencing factors, a new, permanent suburban monitoring network was established with sites in four northwest European cities: London (UK), Leicester (UK), Amsterdam (the Netherlands) and Antwerp (Belgium). We report here an analysis of the first measurements made by the network over a twenty-seven-month

period (January 01, 2013–April 01, 2015), alongside data from pre-existing comparator urban roadside (AURN Marylebone Road, London, UK) and rural background (AURN Auchencorth Moss, Scotland) sites. The temporal evolution of black carbon was investigated at each site, as were associations with other commonly monitored pollutants (e.g. O3, NOx, PM2.5, PM10) and wind fields. Results showed clear anthropogenic signatures across the diurnal, weekly and annual timeframes, and positive correlations were obtained between black carbon measurements and other common traffic-related pollutants, highlighting the importance of vehicle emissions as a major contributor to ambient black carbon concentration in northwest Europe. Average black carbon concentrations varied from 6.6 μg m−3 at the urban roadside, to 0.2 μg m−3 in the rural background, with suburban and urban background sites having average concentrations in the range of 1.0–2.4 μg m−3. Wind field analysis further highlighted the importance of road traffic as a source of black carbon and demonstrated the importance of local emission sources at the various receptor locations. Statistical analysis of data between sites generally indicated a weak correlation (rs = −0.03 to 0.68, COD = 0.32–0.91), further highlighting the importance of local emissions in determining ambient black carbon concentration. It was also found that black carbon comprised a significant portion of total ambient particulate matter (PM), particularly at sites with the larger traffic volumes and during rush-hour (e.g. ~45% of PM2.5 at Marylebone Road), however, its contribution to total PM was found to decrease on days of high pollution, indicating the importance of other PM components when air quality is particularly poor.

Keywords: Black carbon**;** Particulate matter**;** Air quality**;** North-West; Europe**;** Health.

Estimating fugitive particle emission from coal storage yard of thermal power plant using the flux-gradient method

Sun Tae Kim a, Juin Kim a, IlHwan Choi a, Hui Li b, Jung Ho Kang a, Hyeon Jun Eo a

Source: Atmospheric Environment, Volume 243, 15 December 2020, 117860

In this paper, a 3D sonic anemometer and two optical particulate sensors were used to observe fugitive particulate matter 10 μm (PM10) emission from the coal storage yard of a thermal power plant for one month. The PM10 emission flux was calculated using the flux gradient method. The results show that the heat flux, convective velocity, and PM10 emission flux have obvious diurnal variation. The PM10 emission flux is positively correlated with heat flux, convective velocity, and frictional velocity, but negatively correlated with humidity. Based on the convective velocity, friction velocity and humidity as the independent variables, a multivariate regression model of PM10 emission flux was constructed. The prediction results of the model are in good agreement with the

experimental values. The emission flux of PM10 can also be estimated quasi-quantitatively according to the value of gradient Richardson number (Ri). There are two time windows for PM10 emissions, namely the discharge window period (9:00–20:00) and the static window period (20:00–9:00 of next day).In order to reduce PM10 emissions more effectively, artificial climate intervention such as watering, spraying, and other measures should be carried out during the discharge window period. Studies have shown that the flux gradient method can be successfully used to accurately measure the PM10 emission flux of a coal storage yard. This study also provides useful recommendations for real-time monitoring and controlling PM10 emissions from coal storage sites.

Keywords: Eddy covariance; Monin–obukhov similarity theory; Eddy diffusivity; Dust control; Atmospheric boundary layer; Turbulence.

Characterization of background particulate matter concentrations using the combination of two clustering techniques in zones with heterogeneous emission sources

Yumara Martín-Cruz a, Antonio Vera-Castellano a, Álvaro Gómez-Losada b

Source: Atmospheric Environment, Volume 243, 15 December 2020, 117832

The estimation of the background atmospheric concentration allows to assess local contributions and helping to the design of air quality improvement policies. Using clustering techniques and bivariate analysis, this study aims to characterize the background concentration of PM10 (particulate matter with an aerodynamic diameter less than or equal to 10 μm) and PM2.5 (particulate matter with an aerodynamic diameter less than or equal to 2.5 μm) in environments with heterogeneous emission sources. Background PM10 and PM2.5 pollution was characterized using Hidden Markov and Finite Mixture Models in four air quality monitoring stations, from 2011 to 2017. Average background concentrations in all stations were of 12.7 2.2 μg m-3 for PM10 and 4.6 0.4 μg m-3 for PM2.5. The contribution of background concentration to ambient pollution (both PM10 and PM2.5) was high (more than 40%) in all studied stations, being a 10% higher in background stations (Camping Temisas and Parque de San Juan) compared with stations influenced by an anthropogenic source (Castillo Romeral and San Agustín). Estimated background concentration showed significant differences among studied areas according to Kruskal-Wallis test (p 0.001) and coefficients of divergence, which were greater than 0.2. PM10 and PM2.5 monthly profiles (concentration level) showed that the traffic urban station presented seasonality, probably due to the summer tourism, and daily profiles exhibited a differentiated bimodal distribution. The estimation of background

concentrations in this study will allow to quantify local contributions from Saharan outbreaks and to study its possible effects on human health and marine biota.

Keywords: Particulate matter; Hidden markov models; Finite mixture models; Kruskal-wallis; Representative background concentrations.

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Estimation of background PM2.5 concentrations for an air-polluted environment

Sheng-Hsiang Wang a, Ruo-Ya Hung a, Neng-Huei Lin a, Álvaro Gómez-Losada b, José C.M.Pires c, Kojiro Shimada d 1, Shiro Hatakeyama e 2, AkinoriTakami f

Source: Atmospheric Research, Volume 231, 1 January 2020, 104636

The background PM2.5 concentration represents the combined emissions from natural domestic and foreign sources, which has implications for the maximum effect, in terms of air-quality control, that can be achieved by reducing emissions. However, estimating the background PM2.5 concentration via background monitoring sites for a densely populated region (e.g., Taiwan) has been a challenge. In this study, we compared two statistical methods of estimating the background concentration using an 11-year time series (2005–2016) of data from three air-quality stations in Taiwan. The results of two methods showed good agreement for the background PM2.5 concentration estimation, which was about 4.4 μg m−3 and comparable to literature reports. According to the trend analysis, the concentration has decreased at a rate of 1–2 μg m−3 decade−1 as a result of better emissions control in East Asia in recent years. Furthermore, the local concentration can exceed the regional background value by up to 5 times due to local emissions, topographic effects, and weather regimes. When considering the cross-county transport of PM2.5, a difference as high as 5 μg m−3 exists between two prevailing-wind scenarios. This study provides crucial information to policy-makers on setting an achievable and reasonable goal for PM2.5 reduction.

Keywords: Air-quality monitoring networks; Background level; Hidden Markov Model; PM2.5 concentration.

Characteristics and formation mechanisms of secondary inorganic ions in PM2.5 during winter in a central city of China: Based on a high time resolution data

Liuming Yang Shenbo Wang Shiguang Duan Qishe Yan Nan Jiang Ruiqin Zhang Shengli Li

Source: Atmospheric Research, Volume 233, 1 March 2020, 104696

This study aimed to investigate the characteristics of the water-soluble ions concentrations in atmospheric particulates. Highly time-resolved measurements of inorganic ions associated with PM2.5 were conducted from December 1, 2017 to February 28, 2018 in Zhengzhou. The hourly mean and standard deviation of PM2.5 concentration during the observation episodes were 108.2 ± 80.7 μg/m3. The hourly mass concentration of PM2.5 increased from 8 μg/m3 to 438 μg/m3 throughout the entire observation. The proportion of water-soluble inorganic ions in PM2.5 was 52.5% throughout the entire observation period. The ions existed mainly in the form of (NH4)2SO4 and NH4NO3. The average mass concentration ratio of NO3− to SO42− was 1.9 ± 0.8 throughout the entire observation period, which initially increased and then decreased with the increased pollution level. The average ratio of the molar equivalent concentration of [NH4+] to that of [NO3− + SO42−] was 1.14 ± 0.27, which decreased with the increased pollution level. Homogeneous reactions played an important role in the formation of nitrate, while, the heterogeneous reactions were important in the formation of sulfate. Both of the values of sulfur oxidation ratios (SOR) and nitrogen oxidation ratios increased with relative high humidity (RH) condition; especially, the SOR values sharply increased when the RH was above 50%. The results of potential source contribution function model demonstrated that the western and northeastern regions of Zhengzhou had a greater influence on PM2.5 pollution in Zhengzhou. All these results suggested that reducing the emission of precursors of secondary inorganic ions was highly important in controlling PM2.5 pollution in Zhengzhou.

Keywords: PM2.5, Sulfate; Nitrate; Secondary formation; Potential source contribution function.

Chemical and source characterization of PM2.5 in summertime in severely polluted Lahore, Pakistan

Mushtaq Ahmad a b, Siming Cheng a, Qing Yu a, Weihua Qin a, Yuepeng Zhang a, Jing Chen a

Source: Atmospheric Research, Volume 234, April 2020, 104715

Lahore is considered the most polluted city in Pakistan with high levels of atmospheric particulate matter. The PM2.5 chemical composition and sources in Lahore were investigated in this study in an effort to effectively mitigate the pollution of PM2.5 in Lahore. In the month of July 2018, the day and night samples of PM2.5 in Lahore were

collected and analyzed. Principal component analysis (PCA), concentration weighted trajectory (CWT) calculation and analysis of the spatial distribution of black carbon in Lahore obtained from MERRA-2 (Modern-Era Retrospective Analysis for Research and Applications, Version 2) reanalysis data were employed to identify the sources and contributing regions of PM2.5. The fuel consumption situation in Pakistan was also examined to further identify the major contributing sectors to air pollution. The most abundant species in the identified mass of PM2.5 were carbonaceous compounds, followed by ionic species such as SO42−, NO3−, Cl− and NH4+. Although secondary organic carbon showed a high percentage in OC (47%), primary organic carbon was still dominant in OC in Lahore. PM2.5 showed no correlation with meteorological parameters. Based on the CWT calculation and black carbon spatial distribution, local emission sources were the main sources of air pollution in Lahore, with an additional contribution from the western states of India. Overall, primary emissions from local sources showed a dominant contribution to PM2.5 pollution and controlling the emissions from industry, transportation, and power plants would show immediate effects for mitigating PM2.5 in Lahore.

Keywords: South Asia; Air pollution; Black carbon; CWT; Source apportionment.

Geochemistry of PM2.5 aerosols at an urban site, Varanasi, in the Eastern Indo-Gangetic Plain during pre-monsoon season

Manisha Mehra a, Felix Zirzow b, Kirpa Ram a, Stefan Norra b

Source: Atmospheric Research, Volume 234, April 2020, 104734

The knowledge of actual morphological features and composition of aerosols are very important to understand atmospheric chemistry, mixing state and radiative forcing on a global scale. Daily and weekly PM2.5 samples were collected during pre-monsoon season (March–May 2015) from an urban site, Varanasi, located in the eastern Indo-Gangetic Plain to study geochemical and morphological features of aerosols. PM2.5 samples were analyzed for their elemental concentration by means of an Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) whereas particle morphology and composition were ascertained by means of a Scanning Electron Microscope (SEM) coupled with an Energy Dispersive X-ray (EDX) spectroscopy. PM2.5 concentrations ranged between 22.2 and 70.5 μgm−3 in daily samples, whereas it varied between 52.0 and 106.2 μgm−3 in weekly samples. PM2.5 concentrations, except in one daily sample, were found to be higher than the 24-h threshold limit of World Health Organization (WHO) standards (25 μgm−3). Elemental concentration of Pb and Zn were as high as ~2000 ppm and 3700 ppm, respectively highlighting impact of heavy metal pollution in Varanasi. The mass concentration of Al was the highest amongst all the measured elements followed by K, Fe,

Zn, Ti, Pb, Mn, As, Cd. Enrichment Factors (EF) < 5 were observed for Fe, Ti and Mn pointing towards their crustal origin. However, an elevated Fe/Al ratio, with a mean value of 0.82, suggests an enrichment of Fe due to anthropogenic emissions. In contrast, EF values were > 5 for K, Zn, As, Pb and Cd suggesting anthropogenic sources as a major contributor to these elements at the study site. The cluster analysis suggests that biomass burning emissions and air mass traversing through northern and western parts of India majorly contributed to high PM2.5 concentration at Varanasi. In contrast, wind patterns did show lower velocities and different directions (from NW India to Eastern parts of India) during the days with relatively lower PM2.5 concentrations. Morphological features of individual particles reveal an irregular, aggregated and flaky morphology whereas the elemental composition revealed the dominance of aluminosilicates, soot and tarball with inclusion of anthropogenic elements (e.g. Pb) at Varanasi.

Keywords: PM2.5 aerosols; Urban air pollution; Indo-Gangetic Plain; Geochemistry; ICP-MS; SEM-EDX.

Chemical characterization and source analysis of water-soluble inorganic ions in PM2.5 from a plateau city of Kunming at different seasons

Wei Guo a b, Zhongyi Zhang a b, Nengjian Zheng a b, Li Luo a b, Huayun Xiao a c, Hongwei Xiao a b

Source: Atmospheric Research, Volume 234, April 2020, 104687

Water-soluble inorganic ions (WSIIs) in PM2.5 from different cities have been studied in previous studies. However, the studies of WSIIs in plateau cities are relative deficient. Due to differences in topography, climate and emission sources, the WSIIs characteristics of plateau cities are expected to be different. Here, we determined the concentrations of WSIIs (SO_4^{2-}, NO_3^-, NH_4^+, Ca^{2+}, Mg^{2+}, Na^+, K^+, F^-, Cl^-, NO_2^-) in PM2.5 from different seasons of Kunming, a typical plateau city in southwest China. The data will improve our understanding of the chemical characterization and source of PM2.5 in plateau environment. Our results showed that the secondary aerosols were the main pollutants (contributing >50% to PM2.5) in PM2.5 of Kunming, which mainly from coal combustion, agricultural activities and vehicle exhaust. Seasonally, high volatility of the NO_3^- and NH_4^+ and washout effects of rainfall in hot months (wet seasons) were favorable for the decreased of pollutants, while high emission, poor dispersion conditions and low removal rate could lead to the increased of pollutants in cold months (dry seasons). It suggested that adequate NH_3 and intense solar radiation promotes the photochemical reactions of

SO2, NOx and NH3 to form NH4HSO4, (NH4)2SO4 and NH4NO3. High temperature in hot months would promote the volatilization of NH4NO3 in Kunming.

Keywords: PM2.5; Water-soluble inorganic ions (WSIIs); Source identification; Seasonality; Kunming.

PM2.5 Humic-like substances over Xi'an, China: Optical properties, chemical functional group, and source identification

Tian Zhang a, Zhenxing Shen a, Leiming Zhang c, Zhuoyue Tang a, Qian Zhang a, Qingcai Chen d, Yali Lei a, Yaling Zeng a, Hongmei Xu a, Junji Cao b

Source: Atmospheric Research, Volume 234, April 2020, 104784

Humic-like substances (HULIS) in fine particulate matter (PM2.5) were investigated during May 2015 to January 2016 in an urban environment in Xi'an, China. UV-VIS spectrometer and Fourier transform infrared spectroscopy (FTIR) were used to investigate optical properties and chemical structures of HULIS. Annual mean concentrations of HULIS-C (the carbon content of HULIS) was 2.9 ± 2.1 μg m−3. On average, the contributions of HULIS-C to PM2.5, TC, and OC were 6.1%, 27.2%, and 34.5%, respectively. Seasonal average of HULIS-C concentration followed a decreasing order of winter, spring, summer, and autumn. The UV absorption intensity of PM2.5 HULIS showed the highest in winter and the lowest in summer. The chemical functional groups for PM2.5 HULIS were highlighted with the presence of aliphatic CH, hydroxy, carbonyl, carboxyl and aromatic rings structures. SUVA254 and SUVA280 values in autumn and winter exhibited more dispersive distribution than those in spring and summer, which indicated sources of HULIS in autumn and winter samples were relative complicated. The E2/E3 ratio showed a summer maximum and a winter minimum, indicating greater conjugation and aromaticity of HULIS in winter. In addition, strong correlations between HULIS-C with K+ and OC1 + OP2 in spring, autumn and especially winter implied the important source of biomass burning to PM2.5 HULIS. The CO stretching of COH, carbonyl groups (CO) and OH stretching of carboxylic acid were abundance both in winter and summer, implied that secondary organic aerosol (SOA) formation was found to be the dominant mechanism producing HULIS in Xi'an.

Keywords: Humic-like substances; Optical properties; Chemical groups; Sources.

Source directional apportionment of ambient PM2.5 in urban and industrial sites at a megacity in China

Baoshuang Liu a, Yafei Li a, Lu Wang a, Xiaohui Bi a, Haiyan Dong b, Xiaoyun Sun a, Zhimei Xiao b, Yufen Zhang a, Yinchang Feng a

Source: Atmospheric Research, Volume 235, 1 May 2020, 104764

Refined source apportionment plays an important role in precise control of atmospheric particulate matter sources. PM2.5 samples were collected and analysed in Tian'jin from February to October 2016, and directional contribution of individual source category was apportioned by applying a new approach. Results indicated that the mean concentration of PM2.5 was 64 μg/m3 during the studying period. NO3− and OC were dominated species in PM2.5 mass. The concentrations of OC and Cl−, and OC/EC were higher in winter than other seasons. Secondary sources (SS), coal and biomass burning (CBB), vehicle exhaust (VE), crustal dust (CD), and industrial emission (IE), were identified as major sources using the PMF model, their contributions to PM2.5 were 28.6–38.1%, 17.3–20.1%, 21.1–23.5%, 10.9–14.2%, and 4.0–10.3%, respectively. The contributions of dust source and coal combustion in Tian'jin are decreasing, while that of motor vehicles is gradually highlighted. The contribution of secondary sources is maintained at a high level in recent years. Source contributions from the directions 1–3 (SW, NW, NE) for SS (16.8%, 8.5%, 4.0%), CBB (10.1%, 8.5%, 2.0%), VE (8.7%, 7.9%, 3.2%), CD (7.3%, 7.0%, 0.9%), and IE (4.2%, 3.8%, 1.4%), were observed at TG site. Source contributions from the directions1–4 (SW, WNW, NNW, NE) for SS (16.5%, 9.7%, 5.9%, 6.3%), CBB (8.0%, 5.0%, 2.5%, 1.9%), VE (8.5%, 6.8%, 3.5%, 3.3%), CD (5.9%, 3.2%, 2.0%, 1.0%), IE (2.0%, 0.9%, 0.6%, 0.6%), were observed at FK site. The contributions of major sources from SW direction were higher than other directions.

Keywords: Source directional apportionment (SDA); PM2.5; Backward trajectory analysis; Positive matrix factorization (PMF).

Characteristics and source apportionment of PM2.5 on an island in Southeast China: Impact of sea-salt and monsoon

Taotao Liu a b c, Baoye Hu a b c, Yuxiang Yang e, Mengren Li a b, Youwei Hong a b, Xinbei Xu b c d, Lingling Xu a b, Naihua Chen e, Yanting Chen a b, Hang Xiao a b, Jinsheng Chen a b

Source: Atmospheric Research, Volume 235, 1 May 2020, 104786

To study the combined effects of the East Asian monsoon and ocean emissions on wintertime and summertime PM2.5 in island cities, filter samples were collected simultaneously at four different functional sites. Based on the chemical compositions of

PM2.5, and positive matrix factorization (PMF) model analysis, the pollution characteristics and sources were determined. Insignificant differences, and some correlation in PM2.5 reconstructed compositions were found among the sites (Pt-test > 0.05, P > .05), while significant differences, and no correlation, were found between winter and summer (PANOVA < 0.05, P > .05). There was more serious chloride depletion in summer (0.88 ± 0.05), caused by both significant Cl− depletion and Na+ enrichment, than in winter (0.18 ± 0.10). The concentrations of non-sea-salt-SO42− in winter were close to those in summer, but the sulfate oxidation ratio (SOR) in winter was much lower than that in summer. The results could be explained by the fact that sea-salt-SO42− has an important contribution to secondary inorganic aerosol on island cities. From both air trajectory clustering and PMF analysis, it was found that there was significant aerosol aging and regional transport in the island city during the East Asian monsoon, and that continental air masses control the variation of air pollution in winter, while sea breezes dominate the characteristics of PM2.5 in summer. This study helps to understand the characteristics and source mechanisms of PM2.5 pollution under complex meteorological conditions in island cities.

Keywords: PM2.5; Source apportionment; Island; East Asian monsoon; Sea salt.

A hybrid method for PM2.5 source apportionment through WRF-Chem simulations and an assessment of emission-reduction measures in western China

Junhua Yang a, Shichang Kang a c d, Zhenming Ji b, Xintong Chen a, Sixiao Yang b, Shao-Yi Lee b, Benjamin de Foy e, Deliang Chen f

Atmospheric Research, Volume 236, 15 May 2020, 104787

To alleviate air pollution in western China, experiencing rapid economic growth following national western development strategies, an accurate and compressive assessment of PM2.5 sources is critical. Here, we firstly investigated the spatiotemporal variation in PM2.5 and analyzed its association with weather conditions and emission changes. Then, WRF-Chem simulations were conducted for an entire year to obtain various emission sectors' contributions to the PM2.5 mass by a hybrid method, which considers both the proportions of various components as well as each sector contributing to these components. The results showed that residential emissions had the largest contribution to PM2.5 because of its dominating contribution for primary components of PM2.5 (BC and POA), which can explain >70% of PM2.5. Seasonally, the residential contributions to PM2.5 were higher in the non-monsoon period than in the monsoon period because of the

higher contribution ratios to primary components. Regionally, as an essential source of the gaseous precursors, the industrial and transportation sectors were the second-largest contributors to PM2.5 in the highly populated urban (HP) and remote background (RM) regions, respectively. Further assessment of emission reduction measures indicated that eliminating 50% of residential emissions induced a 29.4% and 33.1% decrease in the annual PM2.5 mass of the HP and RM regions, respectively, with higher decrease proportions in non-monsoon. By comparison, eliminating 50% of industrial emissions caused a significantly lower decrease in PM2.5 for both HP (10%) and RM (4.6%). Eliminating 50% of transportation emissions led to PM2.5 concentrations to decline by 9.3% in RM, which was greater than the 4.6% reduction caused by eliminating 50% of industrial emissions. Therefore, in addition to focusing on the residential sector, especially in non-monsoon in western China, the transportation sector should be a focus to alleviate PM2.5 pollution on the Tibetan Plateau. The outcome of this study provides valuable information for policy-makers to make strategies to mitigate air pollution in western China.

Keywords: PM2.5 source; Hybrid source apportionmen; Seasonal difference; Western China; Control strategies.

PM2.5 in Abuja, Nigeria: Chemical characterization, source apportionment, temporal variations, transport pathways and the health risks assessment

Ishaq Dimeji Sulaymon a b, Xiaodong Mei a b, Shujian Yang a b, Sumin Chen a b, Yang Zhang a b, Philip K.Hopke c d, James J.Schauer e f, Yuanxun Zhang a b g

Source: Atmospheric Research, Volume 237, June 2020, 104833

Due to rapid industrial development and urbanization, Abuja is characterized with poor and deteriorated air quality. The level of PM2.5 concentrations in Abuja is very high and above the statutory limits; however, the high levels of pollution in Lugbe do not seem to be consistent with local emission sources. This study analyzed the chemical composition of PM2.5 to perform source identification and contributions in Lugbe, Abuja, Nigeria. Sampling in 2016 provided 246 PM2.5 samples at 2 sites across all the four months of sampling. The highest ambient PM2.5 concentration (142 μg m−3) was recorded in winter while the lowest (84 μg m−3) was observed in summer. Chemical mass closure suggested that dust (40.5%) contributed most of the PM2.5 mass. Source apportionment of PM2.5 was performed using positive matrix factorization (PMF) model and six sources were identified. They include mineral dust, crustal dust, vehicle exhaust, secondary nitrate, secondary sulfate, and industrial sources. Crustal dust, vehicle exhaust, and secondary

sulfate were the major sources of ambient PM2.5 in Lugbe, contributing 33.3, 29.8, and 18.0%, respectively. The results of 120-h backward trajectories showed that external northeastern region was more dominant in January, while during the remaining three months, southwesterly winds prevailed. The results of bivariate polar plots for most of the factors showed the influence of the southern areas of Lugbe. The study found that there was long-range regional transport of PM2.5 into Lugbe area throughout the four months. Risk assessments revealed that ingestion route was the major exposure pathway for both children and adults. Non-carcinogenic and carcinogenic risk levels were below the acceptable threshold limits. Finally, the results of this study have shown that ambient air quality in Lugbe can be substantially improved by reducing the emissions from crustal dust, vehicle exhaust, and secondary sulfate sources in the external southern regions.

Keywords: Source apportionment; Regional long-range transport; PMF; Heavy metals; Health risks; Abuja.

Dominance of large-scale atmospheric circulations in long-term variations of winter PM10 concentrations over East Asia

Greem Lee a, Chang-Hoi Ho a, Lim-Seok Chang b, Jinwon Kim c, Maeng-Ki Kim d Seong-Joong Kim e

Source: Atmospheric Research, Volume 238, 1 July 2020, 104871

Concentrations of wintertime particulate matters of diameters below 10 μm (PM10) in South Korea and China have decreased since the 2000s largely owing to the emissions reduction policies of the two countries; however, this decreasing tendency has been notably weakened, or even been reversed, in recent years. This study examines the influence of large-scale atmospheric circulations on this PM10 change over East Asia for the winters (December–February) of the 2004/05–2015/16 period using an empirical orthogonal function (EOF) analysis. The first EOF mode, which accounts for 32.7% of the total variance, indicates decreases in PM10 concentrations until 2012 and thereafter increases in them particularly at most stations in eastern and northeastern China. Regression patterns of meteorological variables with respect to the first EOF time series indicate that the wintertime PM10 variations over East Asia are greatly influenced by the Ural blocking; the weakening of the Ural blocking after 2014 led to the weakening of cold air flows from the north and provided atmospheric conditions favorable for bad air quality events over East Asia. The second EOF mode, which accounts for 20.1% of the total variance, shows a similar spatial distribution as the linear trend of PM10 concentrations during the analysis period and would be related to the long-term changes in emissions. Our findings emphasize that the long-term variations in air quality over East Asia are affected

primarily by the variations in large-scale atmospheric circulations with secondary contributions from the changes in emissions.

Keywords: Particulate matter; PM10; Atmospheric circulation; Ural blocking; East Asia.

2009–2017 trends of PM10 in the legendary Riotinto mining district of SW Spain

Ana M.Sánchez de la Campa a b, Daniel Sánchez-Rodas a c, Gonzalo Márquez a b, Emilio Romero b, Jesús D.de la Rosa a d

Source: Atmospheric Research, Volume 238, 1 July 2020, 104878

This study is the first to perform a chemical characterization and source contribution of particulate matter (PM10) occurring through the abandonment and reopening of a historical sulphide mine. This long-range analysis covers the period 2009–2017 in the Riotinto mining district (Iberian Pyrite Belt, Southwestern Spain), which is a mining district of world-class importance. This mine represents a susceptible anthropogenic emission source of toxic sulphide-associated elements in atmospheric particulate matter, which affects the air quality of the nearby areas. A total of 567 samples of 24 h were collected from 2009 to 2017 in a rural station. The filters were analysed to determine Organic and elemental carbon, mayor and trace elements, and water soluble compounds of PM10.

The trends of PM10 and geochemical characterization were studied considering the following periods: mine abandonment (2009–2014) and the mine's state during (2015–2016) and after (2017) implementation of new emission abatement technology at this mine. The results revealed relatively high concentrations of Cu, Zn, Pb, As, Sb, and Bi during 2015–2016. A reduction of 42–59% was observed after 2017 for the same elements in PM10. Five sources were identified: regional, mining, aged sea salt, combustion + traffic and crustal, using positive matrix factorization model (PMF5). The contribution of the mining factor was higher in the reopening period (4.2 μg m−3, 16%). These results have been confirmed by As speciation analysis, in which the low extraction percentage obtained is related to the origin of the metalloids associated with sulphide ores.

The reduction of emissions of atmospheric particulate matter in the mining processes is the main objective in the implementation of measures considering the technological progress for cleaner and sustainable mining. In the case of reopening of historical mines, with low ore grade and greater extraction of ore and rock, a major effort must be made in order to avoid a negative influence on the environment and human health.

Keywords: Air quality; PM10; Arsenic; Metals; Mine.

Characterization and source analysis of water–soluble ions in PM2.5 at a background site in Central China

Yajun Xie a b, Haibo Lu a, Aijun Yi b, Zhongyi Zhang a, Nengjian Zheng a, Xiaozhen Fang a, Huayun Xiao a

Source: Atmospheric Research, Volume 239, 15 July 2020, 104881

Little updated observation of background aerosols in Central China is available since the clean air actions, despite increasing aerosols pollution in this region. PM2.5 was sampled at Dongting Lake during September 2017 to August 2018 to probe the chemical characteristics of background PM2.5 in Central China. We sampled aerosols at an urban site simultaneously. Annual mean PM2.5 level reached 43.4 μg m−3, and SO42−, NO3−, and NH4+ (sulfate–nitrate–ammonium, simplified as SNA) accounted for 22.8%, 26.8%, and 15.0%, respectively. PM2.5 and most ions levels were highest during winter and lowest during summer. PM2.5 mass was driven by NO3− during cold months (October–March) or SO42− during warm months (September, April–August), suggesting that different emission control measures should be applied in different seasons in future air quality policy of this region. Both SO42− and NO3− were almost completely neutralized by NH4+. Low temperature increased the SO42− concentration and sulfur oxidation ratio. Low temperature also facilitated the partition of NO3− from gas phase into particle phase. Severe particulate pollutions occurred in cold months when the diffusion and wet scavenging of aerosols and volatilization of NH4NO3 were weak, and the NO2 concentration was high. An interesting finding was the highest NO3− concentration and conversion ratios for SNA as well as lowest SO42− concentration in Dongting Lake among major background sites, despite low levels of local gaseous precursors. Industry, secondary SO42−, and NO3− were indentified as main sources of PM2.5 mass based on PMF analysis. Concurrent occurrences of PM2.5 and SNA pollution at Dongting Lake and Wuhan sites as well as back trajectories verified the regional effect. The results will be helpful for investigating water–soluble ions and the major sources as well as geographical origins for PM2.5 at Central China.

Keywords: PM2.5; SNA; Water–soluble ions characteristics; Formation mechanism; Source identification; Central China.

Changes in inorganic aerosol compositions over the Yellow Sea area from impact of Chinese emissions mitigation

Yu-Jin Jo a, Hyo-Jung Lee b, Hyun-Young Jo b, Jung-Hun Woo c, Younha Kim d, Taehyoung Lee e, Gookyoung Heo f, Seung-Myung Park g, Donghee Jung g, Jihoon Park g, Cheol-HeeKim a

Source: Atmospheric Research, Volume 240, August 2020, 104948

Substantial mitigation of air pollutants emissions has been performed since 2013 around Beijing, and changes in the atmospheric characteristics have been expected over the downstream area of Beijing. In this study, both WRF-Chem simulation and on-site measurements were utilized for the Baengnyeong (island) supersite, one of the representative regional background sites located in the Yellow Sea, the entrance area of the long-range transport process in Korea. The changes in the chemical compositions of inorganic aerosols were examined for spring-time during the Chinese emission mitigation period from 2014 to 2016.

The measured ratio of ionic species to PM2.5 at the Baengnyeong supersite showed changes in aerosol inorganic chemical compositions from sulfate in 2014 to nitrate in 2015–2016. The modeling results also showed that nitrate was low in 2014 and significantly increased in 2015 and 2016, and the acidic aerosol condition had also changed toward a more neutralized status in both the simulation and the observations. The WRF-Chem modeling study further indicated that the sulfur was not neutralized in 2014. However, in 2015 and 2016, SO2 was more sufficiently neutralized as sulfur emissions were substantially reduced in China, while at the same time nitrate had begun to increase in such a 'SO2–poor' condition in Beijing area in China, and thus approaching more enhanced neutralization over the Yellow Sea area. The causes of the higher nitrate based on the modeled characteristics of the ammonia-sulfate-nitrate aerosol formation in response to the SO2 emissions reduction in China are also discussed in this paper.

Keywords: Inorganic aerosol; Chinese emissions mitigation; Yellow Sea; Baengnyeong supersite.

Impact of assimilating multi-source observations on meteorological and PM2.5 forecast over Central China

Jian Liu a, Jia Hong b, Feiyue Mao a b c, Wei Gong b c, Longjiao Shen d, Shengwen Liang d, Jiangping Chen a

Source: Atmospheric Research, Volume 241, 1 September 2020, 104945

Data assimilation (DA) is a promising approach to improve meteorological and PM2.5 forecasts, but to what extent and by what process the DA of meteorological fields helps improve PM2.5 forecast still call for more discussion. By utilizing WRFDA and WRF-Chem models, we have assimilated AMSU-A, MHS radiances and conventional observations, and studied the influences of the meteorological DA on meteorological and PM2.5 forecasts over Central China through a series of experiments. The results show that multi-source meteorological DA helps improve temperature and relative humidity forecasts in the lower atmosphere, and the improved meteorological fields further improve PM2.5 forecast with a reduction of bias and RMSE by 7.4% and 4.1% over the study area, especially during PM2.5 episode. This study also helps understand how DA improve the PM2.5 forecasts over Central China.

Keywords: Data assimilation; WRFDA; WRF-Chem; AMSU-A, MHS; Proprietary in situ observations.

The statistical behavior of PM10 events over guadeloupean archipelago: Stationarity, modelling and extreme events

Thomas Plocoste a b, Rudy Calif b, Lovely Euphrasie-Clotilde a, France-NorBrute b

Source: Atmospheric Research, Volume 241, 1 September 2020, 104956

Environmental pollution management is one of the most important features in pollution risk assessment. Several studies have shown that exposure to particulate matter with an aerodynamic diameter of 10 μm or less, i.e. PM10, were associated to adverse health effects. To our knowledge, no study has yet investigated the modelling of PM10 frequency distribution and extreme events in the Caribbean basin. Here, the descriptive statistics and four theoretical distributions (lognormal, Weibull, Burr and stable) were used to fit the parent distribution of PM10 daily average concentrations in Guadeloupe archipelago with a database of 11 years. In order to determine the best distribution, the Kolmogorov–Smirnov statistic test (KS test) was computed as performance indicator value. With an annual average of 26.4 ± 16.1 μg/m3, the descriptive statistics highlighted that PM10 concentrations in Guadeloupe are lower than those measured in cities of Europe, Asia or Africa. Contrary to other megacities, we found that high PM10 levels in Guadeloupe are mainly due to natural large-scale sources, i.e. African dust. From May to September, i.e. high dust season, PM10 concentrations are 1.5 times larger since dust outbreaks are more frequent. A statistical stationarity threshold of 66 months is estimated using the distribution analysis. This underlines the cycle stability of African dust over this last decade. Concerning the statistical modelling, our results showed that Burr & Weibull

mixture model is the best distribution to represent PM10 daily average concentrations with a first statistical behavior corresponding to the low dust season and an another to the high dust season. By analysing the extreme events statistic with the classical power-law distribution, we observed that Burr & Weibull mixture model could also improve the modelling of these events. In summary, the Burr & Weibull mixture model is suitable to model both classical and extreme events.

Keywords: PM10 Statistical analysis; Stationarity; Mixture models; Extreme events; Caribbean area.

Satellite-based spatiotemporal trends of ambient PM2.5 concentrations and influential factors in Hubei, Central China

Yusi Huang a, Yuxi Ji a, Zhongmin Zhu a b, Tianhao Zhang a, Wei Gong a c, Xinghui Xia a, Hong Sun b, Xiang Zhong d, Xiangyang Zhou b,Daoqun Chen b

Source: Atmospheric Research, Volume 241, 1 September 2020, 104929

Accurate estimations of the concentration of ambient fine-particle matter with aerodynamic diameters of less than 2.5 μm (PM2.5) are necessary for human health studies. In this study, individual city-scale linear mixed effect models (LME) were employed to accurately estimate ground PM2.5 concentrations considering the spatiotemporal variability of the relationship between PM2.5 and atmospheric, meteorological, and land observations. The contributions of diverse influential factors including aerosol optical depth, planetary boundary layer height, relative humidity, vegetation index, and wind on local PM2.5 pollution were also determined. High correlation coefficient (R2 = 0.89) and low root mean square error (RMSE = 13.1 μg/m3) ensured satisfactory LME model performances in estimating ground-level PM2.5 concentrations. Spatiotemporal analyses of satellite-based PM2.5 showed high concentrations in eastern, southern, and northern Hubei, and low concentrations in the northwest and southeast because of unbalanced development. These analyses also displayed a mitigation trend of PM2.5 concentrations with a mean annual decline rate of 3–12% from 2016 to 2018. Moreover, from the statistical results of the model, the influential factor of aerosol optical depth was positively correlated with PM2.5 concentration, while planetary boundary layer height, relative humidity, and the normalized difference vegetation index were negatively correlated to local PM2.5 pollution. However, the winds had contradictory contributions on PM2.5 pollution; the northerly wind in western Hubei and the southerly and northeasterly winds in eastern Hubei alleviated local PM2.5 pollution, while the westerly wind in eastern Hubei facilitated PM2.5 diffusion between cities and aggravated PM2.5 pollution. The analysis of the spatiotemporal trend of local PM2.5 pollution at a city scale and the

identification of the influence of wind on PM2.5 pollution provide a theoretical reference for regional pollution warnings and controls.

Keywords: Haze pollution; Influential factors; Wind; Linear mixed effect model; Central China.

Interaction of PM10 concentrations with local and synoptic meteorological conditions at different temporal scales

Hanashriah Hassan a b, Mohd Talib Latif a, Liew Juneng a, Norhaniza Amil c, Md Firoz Khan d, Diong Jeong Yik b, Nur Aleesha Abdullah a b

Source: Atmospheric Research, Volume 241, 1 September 2020, 104975

Changing meteorological conditions over short and long time scales are anticipated to affect the concentrations of particulate matter with aerodynamic diameter below than 10 μm (PM10) in the atmosphere. This study aims to identify the temporal characteristics of PM10 including its relationship with local and synoptic meteorological conditions in Petaling Jaya (PJ), Malaysia from 1996 to 2016. A high volume sampler (HVS), mounted on the rooftop of MetMalaysia, was used to monitor daily PM10 concentrations. The meteorological parameter data were obtained from the MetMalaysia PJ station. The results showed the two highest PM10 concentrations recorded were 423.9 and 390.7 μgm−3 during the dry seasons in September 1997 and 2015, respectively. The temporal characteristics via wavelet analysis revealed clear annual (256–512 days), seasonal (64–256 days) and intra-seasonal (32–64 days) variations of PM10. Local temperature exhibited the highest positive correlation with PM10 ($r = 0.24$) at the daily scale compared to other meteorological parameters. At the seasonal scale, PM10 showed a negative correlation with local temperature during June, July and August (JJA) ($r = −0.33$, $p < 0.05$). Lead-lag analysis showed that the 3-month PM10 running averages in August September October (ASO) to October November December (OND) had a significant correlation ($r = 0.70$, $p < 0.05$) with the November December January (NDJ) Oceanic Niño Index (ONI). The PM10 monthly average in October exhibited the highest correlation ($r = 0.73$, $p < 0.05$) with NDJ ONI. This study concludes that PM10 is characterized by seasonal and intra-seasonal cycles. The ONI-PM10 analysis identifies that PM10 concentration varies with El-Niño Southern Oscillation (ENSO) phase modulation.

Keywords: PM_{10}; Urban environment; Meteorological parameters; Temporal variability; ENSO.

Nocturnal $PM_{2.5}$ explosive growth dominates severe haze in the rural North China Plain

Yaqi Wei a, Hui Chen a, Hao Sun a, Fei Zhang b, Xiaona Shang a, Lan Yao c, Hongguo Zheng d, Qing Li a, Jianmin Chen a

Source: Atmospheric Research, Volume 242, 15 September 2020, 105020

The North China Plain (NCP) is the most heavily polluted region in China and the explosive growth (EG) events of PM2.5 frequently occur in winter in this region. A campaign from 17 Nov. 2018 to 1 Mar. 2019 was conducted at a rural site in NCP. EG events of PM2.5 were defined as the dynamic increase in PM2.5 concentration by 100 μg/m3 within half day. The intensity of EG events were then graded by the time cost, i.e. 3, 6 and 9 h. EG events with a total number of 120 were identified during the study. Mean growth rates and corresponding standard deviations of PM2.5 of 3 h-, 6 h- and 9 h-EG events were 43.4 ± 6.9, 19.3 ± 1.8 and 12.5 ± 0.5 μg/m3/h, respectively. All of them except one 3 h-EG event occurred with windspeed lower than 2 m/s. Based on the evolution of hourly chemical composition of PM2.5, the EG events were investigated on their formation mechanism. The average mass fraction ratios of SNA (sulphate, SO42−; nitrate, NO3−; ammonium, NH4+) in PM2.5 were 26.3%/18.7%, 32.6%/18.0% and 33.6%/26.9% in 3 h-, 6 h- and 9 h-EG events in the daytime/nighttime, respectively. About two thirds of EG events occurred in the nighttime with a significant increase in the concentrations of organic matter (OM) and chloride (Cl−), which is attributable to nocturnal primary emissions such as coal combustion. In addition, CO-scaled growth rate was calculated as chemical growth rate, the results indicate that OM was the dominant components in EG events.

Keywords: $PM_{2.5}$; Chemical composition; Explosive growth; Organic matter.

Impact of atmospheric quasi-biweekly oscillation on the persistent heavy PM2.5 pollution over Beijing-Tianjin-Hebei region, China during winter

Libo Gao Tijian Wang Xuejuan Ren Bingliang Zhuang ShuLiRuanYaoXiu-QunYang

Source: Atmospheric Research, Volume 242, 15 September 2020, 105017

In recent years, persistent heavy PM2.5 pollution (PHP) events occurred frequently over the Beijing-Tianjin-Hebei (BTH) region in China, which posed a great threat to human life. This study investigates the evolution of PHP over the BTH region in China and its relation with atmospheric quasi-biweekly oscillation. A significant periodicity of 10–16 days of the PM2.5 concentration over the BTH region is observed in winters of 2013–2017, which notably contributes to the occurrence of PHP. A total of 12 PHP events are identified in the

five winters. The life cycle of PM2.5 pollution containing those PHP events is divided into eight phases according to the quasi-biweekly variation of PM2.5 pollution over the BTH region. The phase composites of circulation fields show that the atmospheric quasi-biweekly oscillation provides favorable conditions for the persistence of air pollution over the BTH region in winter. During the PHP events, the quasi-biweekly southerly anomalies prevail persistently over eastern China. The East Asian winter monsoon is weakened and more moisture is transported to the BTH region continuously. The anomalous warming in the lower troposphere indicates a stable stratification on a quasi-biweekly time scale. Moreover, in the mid-troposphere, the variation of East Asian trough's intensity is significantly correlated with PHP over the BTH region. It is suggested that the quasi-biweekly oscillation of East Asian trough can be traced back to a precursor signal over northwestern Eurasia about 11 days earlier, through a southeastward wave train propagation. Thus, the meteorological conditions conducive to PHP over the BTH region can be predicted on the quasi-biweekly time scale.

Keywords: Persistent heavy PM2.5 pollution; Atmospheric quasi-biweekly oscillation; The Beijing-Tianjin-Hebei region; East Asian trough.

Modelling hourly spatio-temporal $PM_{2.5}$ concentration in wildfire scenarios using dynamic linear models

Joseph Sánchez-Balseca Agustí Pérez-Foguet

Source: Atmospheric Research, Volume 242, 15 September 2020, 104999

Particulate matter with aerodynamic diameter < 2.5 μm (PM2.5) is one of the main pollutants generated in wildfire events with negative impacts on human health. In research involving wildfires and air quality, it is common to use emission models. However, the commonly used emission approach can generate errors and contradict the empirical data. This paper adopted a statistical approach based in evidence of ground level monitoring and satellite data. An hourly PM2.5 spatio-temporal model based on a dynamic linear modelling framework with Bayesian approach was proposed in a territorial context with a reduced number of monitoring stations for particulate matter. The model validation is complicated by the fact that all monitoring stations are used in the model calibration. The novel validation method proposed considered both the particulate matter with aerodynamic diameter < 10 μm (PM10) recorded as daily value from 24-h mean every six days as well as the PM2.5/PM10 ratio. Modelling was carried out to provide satisfactorily the exposure level of PM2.5 in a case study of wildfire event.

Keywords: Wildfire; Spatial modelling; Environmental statistics; Air quality; Particulate matter.

Black carbon and biomass burning associated high pollution episodes observed at Doon valley in the foothills of the Himalayas

Vignesh Prabhu a, b, Ashish Soni a, Sandeep Madhwal a, Amitesh Gupta c, Sangeeta Sundriyal a, Vijay Shridhar a, V.Sreekanth b, Parth Sarathi Mahapatra d

Source: Atmospheric Research, Volume 243, 1 October 2020, 105001

The Doon valley located in the foothills of the Indian Himalayan region, is recently undergoing rapid urbanisation. Hence, in this study, we investigate the variation of black carbon mass concentration (BC) and biomass burning generated black carbon mass concentration (BCbb) for one year (October 2017 to September 2018) using ground-based observations. We also present here the relationship of BC with meteorological parameters and effect of transport. Using three different case studies we explain the dominant role of local meteorological conditions and effect of long-range transported aerosols impacting the study site in different seasons. Satellite and reanalysis datasets were also used to strengthen the analysis. A seven channel Aethalometer (AE-33) was used to measure real-time BC at the study site. Seasonal analysis indicates a winter maximum (9.45 ± 2.65 μg m−3) followed by post-monsoon (6.94 ± 1.52 μg m−3), pre-monsoon (5.35 ± 1.46 μg m−3), and lowest in the monsoon season (3.36 ± 0.62 μg m−3). The daily mean ground-based BC had a moderately positive correlation with Modern-Era Retrospective analysis for Research and Applications, version-2 (MERRA2) BC (r = 0.52) and Copernicus Atmosphere Monitoring Service (CAMS) BC (r = 0.74), these correlations get better when compared with monthly datasets. Effect of local emissions and long-range transport was studied intricately using wind rose, Conditional Bivariate Probability Function (CBPF), and Concentration Weighted Trajectory (CWT) analysis. Case studies of high BCbb specifically in the months of November, January, and May precisely segregated the dominant effect of meteorology and transport phenomena in different seasons. Primarily during the months of November and May, the long-range transport of aerosols from regions dominated by crop residue burning and forest fires, respectively, increased the BCbb concentration over the study site. While during January, emissions generated from local burning activities for space heating and cooking, aided by lower temperatures, increased the BCbb, indicating the dominant role of meteorology. These results were further substantiated through the aerosol subtypes acquired from the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) satellite.

Keywords: Aethalometer; Reanalysis; CBPF; CALIPSO; MERRA2; CAMS.

Dust concentration over a semi-arid region: Parametric study and establishment of new empirical models

Nategheh Najafpour Hossein Afshin Bahar Firoozabadi

Source: Atmospheric Research, Volume 243, 1 October 2020, 104995

In recent years, the city of Tehran, Iran's capital, has encountered numerous dust events so that the dust concentration of PM10 has reached even more than 800 μg m−3. This emphasizes the importance of the statistical study of dust in Tehran and the development of correlations for estimating dust concentration of PM10. In the present study, by evaluating the data measured during dust observations over the years 2013–2016 in Tehran, new statistical models are established for estimating PM10 concentration in terms of horizontal visibility and MODIS AOD. Firstly, simple nonlinear regression models between dust concentration of PM10 and horizontal visibility as well as MODIS AOD are developed. Afterward, by combining the mentioned parameters with meteorological measurements, including wind speed, relative humidity, and temperature, multivariate nonlinear regression models are obtained. The descriptive statistical parameters and Taylor diagram concept are used in order to compare the performance of various models. Analyzing the developed models indicates that the simple model based on horizontal visibility has the best performance (R = 0.90) and considering meteorological parameters does not have a significant positive impact on the model performance. Furthermore, the estimated dust concentration of PM10 using simple models developed in this study has a better correlation with the measurements in Tehran in comparison with the results obtained by models of other researchers. This demonstrates the importance of developing such models according to the climatic and geological conditions of the investigated region.

Keywords: Dust storm; PM10; Visibility; MODIS AOD; Simple regression; Multivariate regression.

The abnormal change of air quality and air pollutants induced by the forest fire in Sumatra and Borneo in 2015

Shuai Yin a, Xiu feng Wang b, Meng Guo c, Heri Santoso d, Hongyou Guan e

Source: Atmospheric Research, Volume 243, 1 October 2020, 105027

We comprehensively integrated various remote sensing, modeling and meteorological datasets to assess and quantify the effects of Indonesia's forest fires in 2015 on the ambient

atmosphere. When the forest fires occurred, the fire spots in Sumatra and Borneo increased sharply to 78,055 and fire radiative power (FRP) rose to 4.05 × 106 MW in September–October 2015. The Aerosol Optical Depth (AOD) and the retrieved concentration of PM2.5 around these two islands also peaked during this period. With the remote sensing data from 2016 and 2017 as the background, we found that the carbon monoxide (CO) anomalies along the equatorial Indian and Pacific Oceans (25°S to 25°N and 40°E to 160°E) reached 10.32 ± 0.58 Mt. and 25.05 ± 1.35 Mt. in September and October 2015, respectively. Meanwhile, the nitrogen dioxide (NO2) changes were not so obvious; the NO2 anomalies within Sumatra and Borneo were only 0.46 ± 0.14 Kt and 0.49 ± 0.17 Kt, respectively. All the four indicators (AOD, PM2.5 concentration, CO and NO2 anomalies) revealed that the ambient air quality in October 2015 was even worse than that in September. The precipitation anomaly (PA) of these two islands decreased to −1.89 mm/day in September 2015, which is assumed to be the main meteorological factor to induce the forest fires. During the 1997/1998 El Niño event, the PA decreased to −3.04 mm/day on October 1997 and temperature anomaly (TA) increased to 1.52 °C on March 1998, the variation of which is more significant than other two El Niño events in 1982/1983 and 2015/2016.

Keywords: Aerosol; MODIS; MOPITT; OMI; Peatland; Total column.

Elucidating the sources and dynamics of PM10 aerosols in Cienfuegos (Cuba) using their multi-stable and radioactive isotope and ion compositions

Yasser Morera-Gómez a, c, Carlos ManuelAlonso-Hernández a, Héctor Alejandro Cartas-Águila a, Jesús Miguel Santamaría b, David Elustondo b, Esther Lasheras b, Marjorie Bagur c, David Widory c

Source: Atmospheric Research, Volume 243, 1 October 2020, 105038

In this study, PM10 aerosol samples were collected at 4 urban and 1 rural sites in the region of Cienfuegos (Cuba) and analyzed for their chemical compositions (total carbon (TC), total nitrogen (TN), NH4+, Cl−, NO3− and SO42−) and their stable carbon (δ13C) and nitrogen (δ15N), and radioactive (210Pb, 7Be, 137Cs and 40K) isotope systematics, in order to better constrain both their sources of pollution and their atmospheric dynamics. The average PM10 concentrations varied from 21.67 ± 8.54 μg m−3 at the rural site to 39.01 ± 8.23 μg m−3 at an urban site characterized by high road traffic. Chemical compositions showed low variability and similar abundances of the ionic species, but we observed strong correlations between i) NH4+ and SO42− that indicates the formation of secondary ammonium bisulfate (NH4HSO4), and ii) between PM10 and TC highlighting the

significant influence of carbonaceous aerosols. We are reporting here the first 210Pb aerosol concentrations in this region and demonstrate that, coupled with the corresponding 7Be concentrations, they allow characterizing the dynamics of the regional continental air masses. δ13C values in PM10 appear to be controlled by i) emissions from different types of combustion sources, including fossil fuel and biomass burning and ii) carbonate inputs from the industrial activities located around the limestone quarries, east of the city. δ15N values presented large isotope variations that can be explained by kinetic processes and the exchange between gas (NH3) and particle (NH4+) phases during the formation of secondary NH4HSO4, a reaction that was enhanced as Cl− concentrations decreased, revealing the preponderant role of local emissions in the budget of the aerosol nitrogen. This study confirms that isotope analysis is reliable for tracing the origin of aerosols and highlight the importance of a multi-isotope approach.

Keywords: PM10; Stable C and N isotopes; Radioactive isotopes; Chemical composition; Aerosol sources; Air masses dynamics.

The diurnal characteristics of PM-bound ROS and its influencing factors at urban ambient and roadside environments

Nirmal Kumar Gali a, Svetlana Stevanovic b, Peter Brimblecombe c, Reece Alexander Brown d, Zoran Ristovski d, Zhi Ning a

Source: Atmospheric Research, Volume 244, 1 November 2020, 105039

The airborne particulate matter (PM) is known to cause adverse pulmonary and cardiovascular health effects. This study investigated the diurnal characteristics of PM induced PM-bound ROS from real time measurements in typical roadside and urban background sites in Hong Kong, and identified potential influencing factors to its variation in atmosphere. A nitroxide probe (BPEAnit) was employed in the real-time measurement of separate PM and gas phase induced reactive oxygen species (ROS) with a Particle-into-Liquid-Sampler. Measurements were carried in 2 h intervals over a 24 h period, and repeated for 6 days at each site. The total ROS (particle + gas phase) measurements resulted in multiple peaks at 08:00, 16:00 and 20:00 h time periods at background site, compared to non-intermittent decrease/increase trends at roadside. The total ROS generation was noted significantly higher by 50–100% ($n = 6$ $p < .05$) at roadside compared to the background site. While the contribution of PM2.5- and gas phase-induced ROS to the total ROS was on average 48 ± 8% and 52 ± 8% across 24 h at background site, the ratio of gas phase-induced ROS increased to 79 ± 4% and that of particle phase decreased to 21 ± 4% at roadside site. The total ROS well correlated with black carbon (BC) and particle-bound PAHs (p-PAHs), which are 4–8 fold and 10–20 fold higher at roadside

than background. The ratio of p-PAHs/BC was high at roadside during peak hours compared to late nights suggesting fresh PM may have induced more total ROS generation compared to aged aerosols using this specific ROS probe.

Keywords: Particle-into-liquid-sampler; Particulate matter; Roadside; Diurnal analysis; Oxidative potential.

Intensive optical parameters of pollution sources identified by the positive matrix factorization technique

S.Romano a, R.Vecchi b, M.R.Perrone a

Source: Atmospheric Research, Volume 244, 1 November 2020, 105029

A new methodology based on optical parameters from integrating nephelometer measurements and chemically speciated PM10 mass concentrations, to associate intensive optical parameters with pollution sources identified by the Positive Matrix Factorization (PMF) technique, is presented. PM10 samplings and integrating nephelometer measurements at 450, 525, and 635 nm, co-located in space and time, were performed from November 2011 to November 2012. The PM10 samples were chemically characterized for 16 species, including ions (Na+, NH4+, K+, Mg2+, Ca2+, Cl−, NO3−, and SO42−), metals (Al, Cd, Cu, Fe, Mn, and Ti), OC, and EC. The scattering σs and backscattering βs coefficients at 450, 525, and 635 nm, and the PM10 chemically speciated data were used as input of the PMF model. Traffic (TRA, 28.3%), Biomass Burning and Nitrates (BBN, 27.4%), Soil Dust (SDU, 14.7%), ammonium Sulphate (SUL, 17.0%), and Aged Sea-salt (ASS, 12.6%) were the identified pollution sources, according to the PM10 mass apportionment, which did not show any significant difference in terms of source assignment and contribution, with respect to the solution without optical variables. The possibility of retrieving intensive optical parameters associated with the pollution sources from the related spectrally resolved σs and βs values is the main feature of the proposed approach. The mass scattering efficiency (ΣPM10), the scattering Ångstrom exponent (Å), the spectral curvature of the scattering Ångstrom exponent (ΔÅ), and the asymmetry parameter (g) were the main intensive parameters calculated at different wavelengths or wavelength pairs to characterize the identified pollution sources. ΣPM10 and g at 450 nm, Å(450, 635 nm) and ΔÅ were equal to 3.4 m2 g−1, 0.57, 0.96, and 0.54 for the TRA-source, to 5.0 m2 g−1, 0.58, 1.57, and − 0.06 for the BBN-source, to 5.0 m2 g−1, 0.67, 1.54, and 0.24 for the SUL-source, and to 0.6 m2 g−1, 0.33, −0.65, and 0.12 for the ASS-source, respectively. The analysis of monitoring days with a prevailing pollution source and the comparison of the paper's results with literature values have demonstrated the reliability of the used methodology.

Keywords: PM10 chemical composition; Nephelometer measurements; Intensive optical parameters; Positive matrix factorization; Source apportionment.

Seasonal and interannual variations of atmospheric dust aerosols in mid and low latitudes of Asia – A comparative study

Hui Sun a, Xiaodong Liu a, b, c, Anqi Wang a, c

Source: Atmospheric Research, Volume 244, 1 November 2020, 105036

Although variations of atmospheric dust aerosols emitted from different sources within Asia have been studied separately in previous research, the characteristics and causes of these changes have not been fully explored. This study used the Modern-Era Retrospective Analysis for Research and Applications Version 2 (MERRA-2) data set for 1980–2016 to compare seasonal and interannual variations of atmospheric dust aerosols between mid- and low-latitude sources of Asia and explore the reasons for these variations. The seasonal variation of atmospheric dust aerosols in mid-latitude sources was different from that of low-latitude sources. The column burden of dust aerosols in the mid-latitude sources (including East and Central Asia) reached their maximum in spring, and accounted for about 37% and 33% of their annual total load, respectively. The maximum dust aerosols in spring in the Central Asia sources resulted from multiple factors such as soil wetness, snow depth, and vertical wind shear, but they were negatively correlated with soil wetness on the interannual scale ($r = -0.65$). The maximum dust aerosol burden in spring in the East Asia sources resulted from vertical wind shear in the lower troposphere, and showed a positive correlation with the interannual change of dust aerosols in this source region ($r = 0.51$). However, the column burden of dust aerosols in the low-latitude sources (including South and West Asia) reached their maximum in summer, and accounted for about 41% and 37% of their annual total load, respectively. The maximum dust aerosols of summer in the low-latitude sources also resulted from vertical wind shear in the lower troposphere with correlation coefficients of 0.50 and 0.73 in the South and West Asia sources, respectively. The present results may help in further understanding the formation and change of Asian dust aerosols.

Keywords: Dust aerosols; Dust sources; Asian deserts.

Variation of industrial air pollution emissions based on VIIRS thermal anomaly data

Shuang Sun a, Lingjun Li b, Zhihong Wu a, Atul Gautam a, Jinxiang Li b, Wenji Zhao a

Source: Atmospheric Research, Volume 244, 1 November 2020, 105021

The Beijing-Tianjin-Hebei (BTH) region is the largest industrial cluster in northern China and its most prominent air pollution zone. Industrial emissions of PM2.5, SO2, NOx and other pollutants have a significant impact on regional air quality. Monitoring industrial pollution emissions is of great significance for the prevention and control of air pollution. The VIIRS Nightfire products can detect thermal anomalies in heavy industrial sectors, thus providing a new means for monitoring industrial activities. In this study, the VIIRS 375 product was selected to study the spatial and temporal changes of the heavy industrial thermal anomalies through spatial analysis and mathematical statistics methods. Furthermore, it is the first time to use thermal anomaly radiative power (CTRP) to evaluate the spatiotemporal pattern of industrial pollution emissions and its impact on air quality in the BTH region. We observed that the spatial distribution of CTRP was unbalanced and that Tangshan-Tianjin and Handan-Xingtai- Shijiazhuang were found to be high-density pollution areas. The CTRP in Tangshan and Handan were higher than in other cities, accounting for 72.41% of their area. From 2012 to 2018, CTRP in this region decreased by 17.2% per year while in Langfang decreased by 72.9% per year. The CTRP also showed a significantly positive correlation with industrial energy consumption. Emissions of SO2, NO2, and PM2.5 were high in the area of intense distribution of thermal anomalies. When compared to the density of tropospheric NO2 and SO2 columns and the monitored concentrations of SO2 and PM2.5, CTRP was consistent with the trend of interannual variations and spatial distributions. The energy-saving and emissions reduction measures taken by the industrial sector in the BTH contributed significantly to improving regional air quality. Remote sensing-based monitoring can provide regional industrial energy consumption in real-time and reflect pollution emissions, providing a basis for industrial pollution emissions regulation and reduction policy.

Keywords: Air pollution; Industrial emissions; CTRP; VIIRS Nightfire; Remote sensing.

High resolution spatial mapping of element concentrations in PM10: A powerful tool for localization of emission sources

Lorenzo Massimi a, Martina Ristorini b, Maria Luisa Astolfi a, Cinzia Perrino c, Silvia Canepari a

Source: Atmospheric Research, Volume 244, 1 November 2020, 105060

A very-low volume sampler of particulate matter (PM) on membrane filters, recently developed with the purpose of allowing spatially-resolved determination of PM and of its

chemical components, was employed from December 2016 to February 2018 in a wide and dense monitoring network across Terni, an urban and industrial hot-spot of Central Italy (23 sampling sites, about 1 km between each other). Terni basin can be considered as an open air laboratory for studying the spatial distribution of PM, as it includes several spatially disaggregated sources. PM10 samples were chemically characterized for the water-soluble and insoluble fraction of 33 elements (Al, As, Ba, Bi, Ca, Cd, Ce, Co, Cr, Cs, Cu, Fe, Ga, K, La, Li, Mg, Mn, Mo, Na, Nb, Ni, Pb, Rb, Sb, Sn, Sr, Ti, Tl, U, W, Zn, Zr). Spatial variability of the element concentrations across Terni was then mapped by using the ordinary kriging interpolation method. Spatial distribution of the analyzed elements successfully traced the various PM10 sources. In particular, the spatial mapping of Ba (water-soluble fraction), Bi, Cu, Sb, Sn and Zr (insoluble fraction) traced PM10 emission from the rail network and vehicular traffic, Ce, Cs, La, Li, Rb, Sr and U (insoluble fraction) traced soil resuspension, Cd, Cs, K, Rb and Tl (water-soluble fraction) biomass burning and Co, Cr, Mn, Nb, Ni, Pb (insoluble fraction), As, Cr, Ga, Li, Mo, Mn, W and Zn (water-soluble fraction) the steel industry pole. Principal component analysis was performed on the spatially-resolved chemical data to cluster the elements tracing the main PM10 sources. The winter and summer size distribution of the water-soluble and insoluble elements was analyzed to verify their link with the emission sources. The proposed experimental approach promises to be very effective for the assessment of population exposure to different PM10 sources.

Keywords: PM10 element; Chemical fractionation; Source tracer; Spatial variability; Seasonal variation; Size distribution

Enhanced atmospheric nitrogen deposition at a rural site in northwest China from 2011 to 2018

Yandan Fu a, Wen Xu a, Zhang Wen a, Mengjuan Han a, Jianhao Sun b, Aohan Tang a, Xuejun Liu a

Source: Atmospheric Research, Volume 245, 15 November 2020, 105071

Few related studies have been carried out for northwest China's the inland, although the increasing inorganic reactive nitrogen (Nr) deposition and severe air pollution in China have attracted considerable attention. Based on eight-year measurements of the concentrations of NH3, HNO3, particulate (p) NH4+, pNO3−, and NO2 in the air and inorganic nitrogen (NH4+, NO3−) in the precipitation at a rural site in Wuwei, Gansu Province, we quantified the dry and bulk/wet Nr deposition fluxes and analyzed their temporal trends in combination with air pollution data (2015–2018). The concentrations of the single Nr species in the air did not exhibit significant seasonal variations, except for that

of pNO3− which were the highest in summer and the lowest in winter. The average annual total Nr (dry + bulk) deposition was 27.2 ± 6.7 kg N ha−1 with a significant ($p < .05$) annual increase rate of 10%, which was dominated by the dry deposition flux (20.8 ± 7.1 kg N ha−1 yr−1) during the entire period. The NH4+-N and NO3−-N deposition fluxes in the precipitation were significantly ($p < .05$) higher in the summer than in the other three seasons owing to the heavy rainfall. The reduced N (NH3, pNH4+, and NH4+) deposition flux was 4.7 times that of the oxidized N (HNO3, pNO3−, NO2, and NO3−), which increased with a high annual rate (25%). The annual mean concentrations of the main air pollutants (PM2.5, PM10, SO2, NO2, and CO) significantly decreased by 15%–76%; in contrast, increasing trends of the O3 and NH3 concentrations were observed. Our results highlight the importance of the control of NH3 emissions and O3 pollution to comprehensively mitigate N deposition and improve air quality in the considered region.

Keywords: Reactive nitrogen; Nitrogen deposition; Ammonia; Air pollution; Agroecosystem.

A new approach of the normalization relationship between PM2.5 and visibility and the theoretical threshold, a case in north China

Xinrui Wu a, b, Jinyuan Xin a, c, Xiaoling Zhang b, Schafer Klaus b, Yuesi Wang a, Lili Wang a, Tianxue Wen a, Zirui Liu a, Ruirui Si a, Guangjing Liu a, Lei Zhao a, Shigong Wang b, Guangzhou Fan b, c, Wenkang Gao a

Source: Atmospheric Research, Volume 245, 15 November 2020, 105054

Both PM2.5 and visibility are important physical parameters to measure the air pollution condition. This paper first provided a new normalization approach for the relationship between PM2.5 and visibility in heavy pollutant region, which realized a mathematical calculation for two different physical parameters based on non-dimensional data process (also called Min-Max normalization). The normalization relationship showed a power function (y = axb) with high correlation coefficients. The inflection points of the maximum power function curvature composed the theoretical threshold range of PM2.5 for improving or deteriorating the visibility. In the case city of north China, the threshold range of PM2.5 was 112–121 μg·m−3 corresponding to the visibility range 4.5–5.9 km. Within the threshold range, the mean concentration of main pollutant components was 106 μg·m−3. The mean extinction coefficient, bext of 743.5 Mm−1, was mainly contributed by organic matter (34%), ammonium nitrate (19%), ammonium sulfate (18%) and elemental carbon (13%). When PM2.5 was below the range, the visibility increased significantly with the slow decrease of PM2.5. When PM2.5 exceeded the range, the visibility reduced seriously due to the saturated extinction contribution of the main pollutants. The new normalization

approach theoretically revealed the significance of threshold and how to improve visibility by controlling PM2.5 at different pollution stages.

Keywords: $PM_{2.5}$; Visibility; Normalization; Maximum curvature; Threshold.

The influence of meteorology and emissions on the spatio-temporal variability of PM10 in Malaysia

M.Alifa a, D.Bolster a, M.I.Mead b, M.T.Latif c, P.Crippa a

Source: Atmospheric Research, Volume 246, 1 December 2020, 105107

Equatorial Asia experiences frequent degraded air quality conditions, as a result of the complex interaction between the abundant air pollution sources and the local/regional meteorological patterns, which ultimately impact densely populated cities. Due to the scarcity of extensive observational datasets, both observational and modeling studies have been rather limited in their spatio-temporal extent and/or the certainty of their estimates. This study presents a country-wide, multi-decadal analysis of PM10 observations (i.e. particulate matter with aerodynamic diameter < 10 μm) from a network in Malaysia comprising 52 monitoring sites, which allows a novel and comprehensive assessment of the spatio-temporal variability of the country's air quality. Through statistical analyses and adoption of a parsimonious statistical model, we investigate the influence of urban and wildfire emissions, as well as of key meteorological variables on the observed PM10 patterns, at a variety of temporal scales. Our results suggest a strong influence of wildfire pollution from neighboring countries on the seasonal increase of both monthly average PM10 and number of days exceeding Malaysia's air quality standards. Regional differences in median PM10 during the non-fire season suggest the contribution of urban emissions in deteriorating air quality. The influence of meteorology varies by region and season, with an indication of wet deposition mechanisms reducing PM10 concentrations during the boreal winter and spring, while the summer and fall present temperatures and winds enhancing fire ignition conditions and long-range transport of transboundary pollution. The Klang Valley area remains the region with the most challenging pollution dynamics, showing both high persistent PM10 levels and yearly fire-season extreme pollution episodes. This study provides a baseline of model performance for future studies focusing on investigating regional scale transport and urban-level pollution, as well as on future projections of air quality conditions resulting from pollution mitigation strategies and climate change.

Keywords: Malaysia; Air quality; PM10; Local meteorology; Wildfires; Transnational pollution.

5. Environmental Science and pollution Research

Effects of long-term exposure to air pollution on the incidence of type 2 diabetes mellitus: a meta-analysis of cohort studies

Mei Yang, Han Cheng, Chaowei Shen, Jie Liu, Hongkai Zhang, Jiyu Cao & Rui Ding

Source: Environmental Science and Pollution Research, volume 27, pages798–811(2020)

This meta-analysis aimed to comprehensively assess the effects of long-term air pollution exposure on the risk of type 2 diabetes mellitus (T2DM). Studies were selected from three electronic databases. Random- or fixed-effect model was used to obtain the pooled hazard ratios (HRs) and corresponding 95% confidential intervals (CIs). Stratified analyses by regions of the studies and length of follow-up were conducted to assess the effects in different subgroups. Sensitivity analyses by omitted studies one by one, as well as adjusting certain confounding factors, were also conducted. The search resulted in 1878 studies, among which 16 studies with 18 cohorts were included. The incidence of T2DM was significantly associated with 10 μg/m3 increase of PM2.5 (overall HR = 1.11, 95% CI: 1.03, 1.19) and PM10 (overall HR = 1.12, 95% CI: 1.01, 1.23) exposure. Stratified analyses confirmed that PM2.5 was significantly associated with increased T2DM incidence in American countries but not European countries. The results in the long follow-up subgroup also confirmed that exposure of PM2.5 and PM10 was associated with increased T2DM incidence. Interestingly, educational level and gender could potentially affect the impacts of PM10 and PM2.5 on T2DM incidence. The findings show long-term exposure to PM2.5, and PM10 could significantly increase the incidence of T2DM, especially in cohorts with long follow-up time.

Particulate matter emissions of less harmful-looking super-slim size cigarettes appealing to women: a laser spectrometric analysis of second-hand smoke

Markus Braun, Amelie Langenstein, Doris Klingelhöfer, Nicole Zulauf, Ruth Müller & David A. Groneberg

Source: Environmental Science and Pollution Research, volume 27, pages1069–1077(2020)

Slim tobacco products shall appear by their look less harmful. In 2013, the European Union ministers discussed to ban them. However, only a ban on small package sizes was realized. To add more data for exposure risk assessment of slim tobacco products, the particulate matter (PM) amount in second-hand smoke (SHS) of super-slim size cigarettes compared

with a king size brand was investigated. PM amount of four super-slim size cigarette types of the brand Couture was analysed in comparison with the king-size reference cigarette. Therefore, SHS was produced in an enclosed space with a volume of 2.88 m3 by an automatic environmental tobacco smoke emitter. PM size fractions PM10, PM2.5 and PM1 were measured in real time using a laser aerosol spectrometer. SHS of Couture Gold contained about 36% and Couture Purple about 28% more PM than the reference cigarette. In contrast, Couture Green emitted about 37% and Couture Silver about 53% less PM than the reference cigarette. Depending on the brand, the PM2.5 mean concentrations increased up to 1538 μg/m3. This exceeds the 24-h mean concentration of at most 25 μg/m3 according to the WHO Air quality guidelines about 62-fold. Smoking in enclosed rooms leads to a massive increase of PM. The PM pollution by slim-size tobacco products are substantial and sometimes higher than by king size tobacco products. Therefore, SHS exposure from slim-size tobacco products is not less harmful to health. Decision makers should take this aspect in consideration.

Characteristics of indoor and outdoor fine particles in heating period at urban, suburban, and rural sites in Harbin, China

Wenxu Fang, Weiwei Song, Liyan Liu, Guangnian Chen, Linan Ma, Yuxuan Liang, Yujie Xu, Xueying Wang, Yehao Ji, Yu Zhuang, Amadou Hima Boubacar & Yifan Li

Source: Environmental Science and Pollution Research, volume 27, pages1825–1834(2020)

Concurrent indoor–outdoor fine particulate matter (PM2.5) measurements were conducted at urban, suburban, and rural sites in Harbin, a megacity in the northeast of China. Chemical constituents of indoor–outdoor PM2.5 were determined. Infiltration factors (FINF) of all sites were calculated according to the indoor to outdoor (I/O) ratios of PM2.5 based on the regression analysis. Linear discriminant analysis (LDA) is applied to determine the indoor–outdoor relationship. Secondary organic carbon (SOC) was calculated on the basis of organic carbon to elemental carbon (OC/EC) ratios. The mean concentrations of indoor and outdoor PM2.5 were 166.4 ± 32.5 μg/m3 and 228.4 ± 83.7 μg/m3, respectively, during the heating period. OC/EC and potassium ion to elemental carbon (K+/EC) ratios verified that biomass was an important source in Harbin especially for rural sites. The nitrate to sulfate (NO3−/SO42−) ratio indicates the higher contribution of traffic emissions in urban sites. Cr was the only species that exceeded the guidelines of WHO 2002, which was mainly emitted from coal and oil combustion. SOC/OC and NO3−/SO42− ratios, and ion-balanced acidity (the ratio of cation to anion, R+/−) showed a large urban–rural and indoor–outdoor difference. The highest SOC/OC ratio was found at urban sites, up to 38.3% for indoors. SOC/OC ratios and R+/− values of indoor

environments were higher, which is attributed to the conducive condition of forming the secondary pollutants during the heating period.

The results of LDA indicated that the distributions of the chemical components of PM2.5 at three sites were statistically dissimilar.

Health risk assessment of polycyclic aromatic hydrocarbons (PAHs) adsorbed in PM2.5 and PM10 in a region of Arequipa, Peru

Adriana E. Larrea Valdivia, Juan A. Reyes Larico, Jimena Salcedo Peña & Eduardo D. Wannaz

Source: Environmental Science and Pollution Research, volume 27, pages3065–3075(2020)

The concentrations of PM2.5 and PM10, as well as those of the PAHs bound to these particles, were quantified at four sites in the region of Arequipa, Peru, during the year 2018. These samples were collected with high volume samplers, and the concentrations of the PAHs were quantified by liquid chromatography (HPLC). The values found for PM2.5 and PM10 at all the sampling sites in Arequipa exceeded the norms established in Peru (50 μg m−3 annual average value for PM10 and 25 μg m−3 annual average value for PM2.5), with the industrial site presenting the highest values of particulate matter (PM10 max = 235.1 μg m−3; PM2.5 max = 218.4 μg m−3). With respect to seasonality, in the cold season (winter), the concentration of particles was higher compared to the other seasons. Concerning the PAHs, it was found that these had the highest concentrations at the industrial site, followed by the site with high vehicular traffic, with both these sites differing significantly from the rural sites. In addition, at the industrial and high traffic sites, there was a predominance of PAHs with 5 and 6 rings, whereas at the rural sites, PAHs with fewer rings predominated. Finally, the calculated values of lifetime lung cancer risk also revealed a difference between sites with marked emission sources, where irrigation was considered moderate, and the rural sites, where irrigation was considered low. This demonstrated that people living at sites with mobile sources and/or industries had a higher cancer risk compared to the inhabitants of rural sites.

Assessment of German population exposure levels to PM10 based on multiple spatial-temporal data

Xiansheng Liu, Haiying Huang, Yiming Jiang, Tao Wang, Yanling Xu, Gülcin Abbaszade, Jürgen Schnelle-Kreis & Ralf Zimmermann

Source: Environmental Science and Pollution Research, volume 27, pages6637–6648(2020)

Particulate matter is the key to increasing urban air pollution, and research into pollution exposure assessment is an important part of environmental health. In order to classify PM10 air pollution and to investigate the population exposure to the distribution of PM10, daily and monthly PM10 concentrations of 379 air pollution monitoring stations were obtained for a period from 01/01/2017 to 31/12/2017. Firstly, PM10 concentrations were classified using the head/tail break clustering algorithm to identify locations with elevated PM10 levels. Subsequently, population exposure levels were calculated using population-weighted PM10 concentrations. Finally, the power-law distribution was used to test the distribution of PM10 polluted areas. Our results indicate that the head/tail break algorithm, with an appropriate segmentation threshold, can effectively identify areas with high PM10 concentrations. The distribution of the population according to exposure level shows that the majority of people is living in polluted areas. The distribution of heavily PM10 polluted areas in Germany follows the power-law distribution well, but their boundaries differ from the boundaries of administrative cities; some even cross several administrative cities. These classification results can guide policymakers in dividing the country into several areas for pollution control.

Evaluation of particle penetration factors based on indoor PM2.5 removal by an air cleaner

Chaohua Peng, Peiyong Ni, Guannan Xi, Weiguang Tian, Lujian Fan, Dacheng Zhou, Qi Zhang & Yu Tang

Source: Environmental Science and Pollution Research, volume 27, pages8395–8405(2020)

The particle penetration factor is an important parameter to determine the concentration of indoor particles. In this paper, a mathematical model for calculating this parameter was established by combining with the decay of the indoor PM2.5 and CO2 concentrations measured in a bedroom with an air cleaner. The convergence of the penetration factors was analyzed under different working conditions. The results show that the particle penetration factors converge to stable values within the range of 0.69 to 0.84 close to the value from the empirical formula when the indoor PM2.5 concentration decays to stable values. When the role of particle deposition is ignored, the penetration factors at the low and middle airflow modes are 0.78 and 0.69, respectively. The particle penetration factors are mainly determined by the clean air delivery rate (CADR) of the air cleaner, clearance airflow, and I/O ratio during the balanced phase when the roles of indoor particle deposition and exfiltration can be ignored. This work can provide a convenient method for the calculation of the particle penetration factor.

Revisiting the environmental Kuznets curve of PM2.5 concentration: evidence from prefecture-level and above cities of China

Yongpei Wang & Supak Komonpipat

Source: Environmental Science and Pollution Research volume 27, pages9336–9348(2020)

In this paper, the panel data of China's four municipalities and 223 prefecture-level cities were used to investigate whether the EKC hypothesis for urban PM2.5 concentration was satisfied, considering such factors as urbanization population, electricity consumption, innovation capacity, and foreign direct investment in the cities. Assuming that the level of economic development directly affects the PM2.5 concentration, and the PM2.5 concentration will continue to increase at the early stage. Once the urban economy develops to a certain extent, the PM2.5 concentration will start to decline, and the environmental quality will be improved. Therefore, we attempt to construct the standard EKC by incorporating the quadratic and cubic terms of GDP per capita. The empirical results show that, except for the four municipalities of Beijing, Tianjin, Shanghai, and Chongqing, economic growth has a complex impact on PM2.5 concentration in most cities during the study period, rather than a simple inverted U-shaped pattern. Moreover, only in recent years has smog pollution shown an average decrease. But if the sources of smog are difficult to explore, it is worth considering the possibility of adjusting economic structure to meet environmental targets.

Characteristics of water-soluble organic acids in PM2.5 during haze and Chinese Spring Festival in winter of Jinan, China: concentrations, formations, and source apportionments

Shuting Tang, Xuehua Zhou, Jingzhu Zhang, Likun Xue, Yuanyuan Luo, Jie Song & Wenxing Wang

Source: Environmental Science and Pollution Research volume 27, pages12122–12137(2020)

PM2.5 aerosols from Jinan (36°256′N, 117°106′E) in the North China Plain region were investigated for water-soluble organic acids (WSOAs, i.e., oxalic acid, formic acid, acetic acid, methanesulfonic acid (MSA), and lactic acid) during 30 December 2016 to 21 February 2017. The average PM2.5 concentration was 168.77 μg/m3 with about 90.74% samples beyond the National Ambient Air Quality (NAAQ) standards (Grade II). The total

concentration of the measured WSOAs averaged at 1.34 μg/m3, contributing to 0.80% of PM2.5 mass. In the observation, acetic acid was the most abundant WSOA, followed by oxalic acid, lactic acid, formic acid, and MSA. During the period, serious haze events frequently happened. The average concentrations of PM2.5 and every WSOA species were higher in haze than those in non-haze. The correlations among species suggested that WSOAs in haze had complicated sources and secondary pathways, especially aqueous-phase reactions which played an important role on WSOAs. The concentrations of WSOAs declined in the Spring Festival compared with those in the non-Spring Festival due to holiday effect. Fireworks burning during the Spring Festival had different influences on WSOAs with slight increases for acetic acid and lactic acid. Five source factors were identified by positive matrix factorization (PMF) model for five WSOAs, respectively, and the results revealed that secondary reactions were the main sources of WSOAs in haze.

Source apportionment of metallic elements in urban atmospheric particulate matter and assessment of its water-soluble fraction toxicity

Darlan Daniel Alves, Roberta Plangg Riegel, Cláudia Regina Klauck, Alessa Maria Ceratti, Jéssica Hansen, Laura Meneguzzi Cansi, Simone Andrea Pozza, Daniela Müller de Quevedo & Daniela Montanari Migliavacca Osório

Source: Environmental Science and Pollution Research volume 27, pages12202–12214(2020)

Clean air is essential for the maintenance of human life and environmental balance. The atmospheric particulate matter (PM) is one of the main air pollutants and is characterized by the heterogeneity of its composition, being able to accumulate numerous components, such as metallic elements, which contribute to increasing its toxicity. The objectives of this study were to assess of the air quality in two urban environments, to carry out the source apportionment of the metallic elements Al, Ba, Cd, Pb, Cu, Cr, Fe, Mn, Ni, and Zn in the PM2.5 and PM2.5–10, and evaluate the toxicity of PM2.5 and PM2.5–10 water-soluble fractions using Lactuca sativa as bioindicator. The collection of PM2.5 and PM2.5–10 was performed using a dichotomous stacked filter unit (SFU) sampler. The source apportionment was carried out using the EPA PMF 5.0 receptor model and the toxicity tests followed the EPA Ecological Effects Test Guidelines OPPTS 850.4200: Seed Germination/Root Elongation Toxicity Test. The source apportionment demonstrated that vehicular and industrial emissions are the main anthropogenic sources contributing to the concentration of metallic elements to thePM2.5 and PM2.5–10. The studied sites did not show statistically significant differences in terms of phytotoxicity to the Lactuca sativa seeds. Cd and Cu were identified as the main metallic elements which able to cause negative effects on seed germination and root elongation, respectively. The presence of

cadmium and copper in the atmospheric particulate matter is one of the main causes of the phytotoxicity affecting the Lactuca sativa seed germination and root elongation.

Composition and source apportionment of saccharides in aerosol particles from an agro-industrial zone in the Indo-Gangetic Plain

Muhammad Usman Alvi, Magdalena Kistler, Imran Shahid, Khan Alam, Farrukh Chishtie, Tariq Mahmud & Anne Kasper-Giebl

Source: Environmental Science and Pollution Research volume 27, pages14124–14137(2020)

The characterization of saccharidic compounds in atmospheric aerosols is important in order to retrieve information about organic carbon sources and their transport pathways through the atmosphere. In this study, composition and sources of saccharides in PM10 were determined in a South Asian megacity (Faisalabad) during the year 2015 – 2016. PM10 sampled on quartz filters was analyzed by anion exchange chromatography for the selected saccharidic compounds. The average PM10 concentration was found to be 744 ± 392 μg m−3, exceeding the daily limits proposed by Pak-EPA (150 μg m−3), US-EPA (150 μg m−3), and WHO (50 μg m−3). The average total saccharidic concentration was found to be 2820 ± 2247 ng m−3. Among the different saccharidic categories, anhydrosugars were the most abundant in concentration followed by primary sugars and sugar alcohols. The correlation and principal component analysis indicated emissions from biomass combustion, soil suspensions from areas such as farmlands having high microorganism activity, and biogenic emissions such as airborne fungal spores and vegetation detritus as major sources of saccharides in the aerosol samples.

Size characteristics and health risks of inorganic species in PM1.1 and PM2.0 of Shanghai, China, in spring, 2017

Qingyue Wang & Weiqian Wang

Source: Environmental Science and Pollution Research volume 27, pages14690–14701(2020)

Ambient particulates of Shanghai with 5-stage particle sizes were firstly determined in spring, 2017. The particles' mass concentrations were mainly observed in fine particle matter (PM1.1) and coarse particles (diameter > 7.0 μm). Water-soluble ionic contents were also more distributed in PM1.1 with the great contents of secondary particles (NO3−, SO42−, and NH4+). Higher ratios of NO2/SO2 and NO3−/SO42− indicated that the vehicle

emissions might be made more greater contribution rather than coal combustions to the fine particles. Crustal enrichment factors (EFcs) of trace elements (V, Cr, Ni, Zn, As, Se, Rb, Cd, Pb, and Bi) in PM1.1 in that called slight air pollution events were always higher than those in that called severe air pollution events and EFcs of Se were up to 2.5 × 104, while EFcs of Pb, Bi, and Cd were over 100. Based on kinds of elemental ratios in PM1.1 and PM1.1–2.0, atmospheric pollutants in Shanghai might be mainly from coal and oil combustions, diesel, and gasoline vehicles. Air masses backward trajectories also showed that the air masses from the northern part of China were one important air pollutant origins, but other ones might be the local sources, such as traffic and industries. Based on carcinogenic risk analysis of PM2.0, it was considerable that 12–60 children and 37–87 adults among millions of people living in Shanghai might be attacked by cancer during their lifetime. Moreover, the great carcinogenic risk was also observed according to the high concentrations of elemental Cr and As in PM1.1.

Temporal trend of arsenic in outdoor air PM2.5 in Wuhan, China, in 2015–2017 and the personal inhalation of PM-bound arsenic: implications for human exposure

Xiang Mao, Xun Hu, Yao Wang, Wei Xia, Shasha Zhao & Yanjian Wan

Source: Environmental Science and Pollution Research volume 27, pages21654–21665(2020)

Arsenic in fine air particulate matter (PM2.5) has been identified as an important factor responsible for the morbidity of lung cancer, which has increased sharply in many regions of China. Some reports in China have shown that arsenic in the air exceeds the ambient air quality standard value, while long-term airborne arsenic concentrations in central China and human exposure via inhalation of PM–bound arsenic (inhalable airborne PM) have not been well characterized. In this study, 579 outdoor air PM2.5 samples from Wuhan, a typical city in central China, were collected from 2015 to 2017, and arsenic was measured by inductively coupled plasma-mass spectrometry. Personal exposure to PM-bound arsenic via inhalation and urinary arsenic concentration were also measured. The concentrations of arsenic in PM2.5 were in the range of 0.42–61.6 ng/m3 (mean 8.48 ng/m3). The average concentration of arsenic in 2015 (10.7 ng/m3) was higher than that in 2016 (6.81 ng/m3) and 2017 (8.18 ng/m3), exceeded the standard value. The arsenic concentrations in spring and winter were higher than those in summer and autumn. No significant differences ($p > 0.05$) were found among different sites. The daily intake of arsenic inhalation based on PM10 samples collected by personal samplers (median, 10.8 ng/m3) was estimated. Urban residents inhaled higher levels of PM-bound arsenic than rural residents. Daily intake of arsenic via inhalation accounted for a negligible part (< 1%) of the total daily intake of

arsenic (calculated based on excreted urinary arsenic); however, potential associations between the adverse effects (e.g., lung adenocarcinoma) and inhaled PM-bound arsenic require more attention, particularly for those who experience in long-term exposure. This study is the first report of a 3-year temporal trend of airborne PM2.5-bound arsenic in central China.

Characterization of particulate matter and its extinction ability during different seasons and weather conditions in Sinkiang, China: two case studies

Lina Wang, Shengqiang Zhu, Zilong Liu, Jianjiang Lu, Zhiyuan Xiang, Jian Lan, Jing Liu, Mingzhou Yu, Ying Chen & Jianmin Chen

Source: Environmental Science and Pollution Research volume 27, pages22414–22422(2020)

The Sinkiang Uygur Autonomous Region is located in western China and the centre of the Asian–European continent, which frequently suffers from sandstorm disasters and haze weathers. A 1-year measurement campaign in two selected points in Shihezi and Urumqi of Sinkiang was conducted to characterise the effects of particle matters and factors on particle extinction under different weather conditions. Results showed that the average concentration of PM1–2.5 was 19.83, 9.230, 28.93 and 122.4 μg/m3 in Shihezi and 67.25, 16.80, 59.19 and 324.0 μg/m3 in Urumqi for spring, summer, autumn and winter, respectively. PM5–10 concentrations can reach up to 500.0 and 160.0 μg/m3 during polluted weather conditions in Shihezi and Urumqi, respectively. PM5–10 also accounted for the largest fraction in Shihezi and Urumqi for all types of weather, reaching up to 40.0% under dusty weather conditions. PM1–2.5 significantly increased during winter possibly due to the increased demand for heating compared with non-heating periods. PM0.5–1 is possibly produced from motor vehicle exhaust. Particle size is concluded to be the dominant factor for particle extinction capability under fine weather based on calculations of aerosol optical properties. The refractive index for a particle with a diameter of 100 μm (3.10–3.11i) is substantially larger than that with a diameter of 0.5000 μm (1.600–0.07000i), but the extinction capability of the latter is 1.30 times that of the former. Comparatively, when the mass concentration of coarse particles is over 17.0 times that of the fine particles, and then mass concentration becomes the dominant factor. Therefore, visibility is negatively correlated to particle mass variations during dust storms and hazy days but not for fine days.

Seasonal and long-term trends of sulfate, nitrate, and ammonium in PM2.5 in Beijing: implication for air pollution control

Xiaokun Han, Qingjun Guo, Yunchao Lang, Siliang Li, Ying Li, Zhaobing Guo, Jian Hu, Rongfei Wei, Liyan Tian & Yingxin Wan

Source: Environmental Science and Pollution Research volume 27, pages23730–23741(2020)

Particulate matter pollution in Beijing is a serious environmental problem. In response to this, the Beijing government has implemented comprehensive emission reduction measures in recent years. To assess the effectiveness of these measures, the seasonal and long-term trends in chemical compositions of PM2.5 in Beijing have been studied based on daily samples collected from July 2015 to April 2016 and literature investigation (2000–2014). Results show that the concentrations of sulfate, nitrate, and ammonium in PM2.5 have significant seasonal variations, which are related to the changes in meteorological conditions and emission intensities. In addition, the long-term data display that the concentrations of sulfate, nitrate, and ammonium have significantly decreased between 2013 and 2016, which are consistent with the reduction in PM2.5 levels (~ 11.2 μg/m3 per year). The declines could not be interpreted by the meteorological factors. It suggests that the air pollution control measures in Beijing (2013–2016), especially the decreasing consumption of coal, can effectively decrease the mass concentration of fine particles. To further improve the air quality, similar measures should be adopted in the areas around Beijing. These air pollution control measures taken in Beijing can provide invaluable guidance for mega-cities in China and other developing countries to decrease their PM2.5 concentration and reduce health risk from particulate pollution.

Forecasting PM10 concentrations using time series models: a case of the most polluted cities in Turkey

Hatice Oncel Cekim

Source: Environmental Science and Pollution Research volume 27, pages25612–25624(2020)

Particulate matter (PM), which is one of the most important parameters in the area of air pollution, has widespread impacts on human health. Hence, the prediction of the probable concentration of PM is a highly significant subject with regard to primary warning for the protection of a population. Turkey is among the European countries with polluted air in terms of the concentration of PM with a diameter smaller than 10 μ m (PM10). The

PM10 data supplies significant knowledge about how much pollution is in the air and which city is the most polluted. In this study, the values of PM10 for the most polluted cities in Turkey are forecasted using time series models, including autoregressive integrated moving average (ARIMA), error, trend and seasonal (ETS), and singular spectrum analysis (SSA). Forecast values of PM10 averaging period of 24 h for the year 2019 are obtained using SSA as the optimum time series method. The results show that the annual means of PM10 concentrations in 2019 in Hatay and Yalova, the most polluted cities, will not exceed the 50 μgm− 3 value according to air quality standards determined by the European Commission. The air quality levels of eight other cities, which are Adana, Ankara, Icel, Istanbul, Kirklareli, Sakarya, Samsun, and Sivas, will reach acceptable standards between 50 and 70 μgm− 3 for annual mean in 2019. The remaining eight cities, Amasya, Bursa, Denizli, Kahramanmaras, Kutahya, Manisa, Nigde, and Tekirdag, continue to be the most polluted cities in 2019 according to the average annual PM10 values. This study also reveals that the average PM10 value of the most polluted cities in Turkey will be 68.97 μgm− 3 for the 24-h average in 2019.

Pollution characteristics of bioaerosols in PM2.5 during the winter heating season in a coastal city of northern China

Min Wei, Mingyan Li, Caihong Xu, Pengju Xu & Houfeng Liu

Source: Environmental Science and Pollution Research volume 27, pages27750–27761(2020)

Frequent heavy air pollution occurred during the winter heating season of northern China. In this study, PM2.5 (particles with an aerodynamic diameter less than 2.5 μm) was collected from a coastal city of China during the winter heating season from January 1 to March 31, 2018, and the soluble ions, organic carbon (OC), elemental carbon (EC), bacterial, endotoxin, and fungal concentration in PM2.5 were analyzed. During the winter heating season, PM2.5 and bioaerosols increased on polluted days, and the secondary inorganic ions, including NO3−, NH4+, and SO42−, increased significantly. Meteorological factors, such as wind direction and wind speed, had major impacts on the distributions of PM2.5 and bioaerosols. Pollutant concentration was high when there was a westerly wind with the speed of 3–6 m/s from inland area. Using the air mass backward trajectories and principal component analysis, we elucidate the potential origins of bioaerosol in PM2.5. The backward trajectory suggested that air mass for polluted samples (PM2.5 > 75 μg/m3) commonly originated from continent (9.62%), whereas air masses for clean samples (PM2.5 < 35 μg/m3) were mainly from marine (56.73%). The interregional transport of pollutants from continental area contributed most to PM2.5. Principal component analysis of the water-soluble ions and bioaerosol indicated that air pollution of the coastal city was

greatly affected by coal combustion, biomass burning, and regional transmission of high-intensity pollutants from continent. Among that, interregional transport, biomass burning, and dust from soil and plants were main sources of bioaerosol. Our findings provide important insights into the origins and characteristics of bioaerosol in PM2.5 during the winter heating season of the coastal city in northern China.

Indoor and outdoor PM2.5 exposure, and anxiety among schoolchildren in Korea: a panel study

Kyung-Hwa Choi, Sanghyuk Bae, Sungroul Kim & Ho-Jang Kwon

Source: Environmental Science and Pollution Research volume 27, pages27984–27994(2020)

This panel study aimed to evaluate the associations between short-term exposure to indoor and outdoor PM2.5 and anxiety in schoolchildren. During 3 waves in March, July, and November 2018 with 7 days per wave, 52 children aged 10 years were recruited from two schools in a city in Korea. To assess outdoor exposure, we used PM2.5 concentration measures for every hour at the national measurement station (NMS) closest to the two participating schools. To assess indoor exposure, we measured PM2.5 concentration at the children's homes and in classrooms, based on 30-min average. Based on time-activity logs, personal average daily exposure values were calculated for each participant, according to exposure values assessed at 30-min intervals by location. Children's anxiety was assessed via the Korean version of the State Anxiety Inventory for children every day during each wave. Linear mixed effects model was conducted to analyze the association between PM2.5 exposure and anxiety using repeated measurements. Personal exposure to PM2.5 by time-activity log was the highest in March and at home. A low correlation coefficient was observed between PM2.5 concentrations at home and at the NMS ($\rho = 0.36$, $p < 0.0001$) whereas a high correlation coefficient was observed between PM2.5 concentrations in classrooms and at the NMS ($\rho = 0.64$, $p < 0.0001$). There was no association between PM2.5 exposure and anxiety in children based on the analysis of repeated measurements during the study period. Since previous studies reported controversial results, long-term follow-up studies are needed in various regions to further investigate the associations between PM2.5 exposure and children's mental health.

Impact of VOCs emission from iron and steel industry on regional O3 and PM2.5 pollutions

Xufeng Zhang, Song Gao, Qingyan Fu, Deming Han, Xiaojia Chen, Shuang Fu, Xiqian Huang & Jinping Cheng

Source: Environmental Science and Pollution Research volume 27, pages28853–28866(2020)

Iron and steel industry emission is an important industrial source of air pollution. However, little is known about the relationship between volatile organic compounds (VOCs) emitted and regional air pollution. In this study, VOCs emissions from a typical iron and steel plant in Yangtze River Delta (YRD, China) were monitored from April 2018 to March 2019. The ozone formation potential (OFP) and secondary organic aerosol (SOA) formation of VOCs were calculated to reveal the influence of VOCs emissions on regional ozone and particulate pollution, and the sensitivity analysis approach was performed to explore the qualitative and quantitative relationships between VOCs and O3, as well as VOCs and PM2.5. The VOCs concentration was 93.76 ± 266.97 ppbv during the study. The OFP was 760.08 ± 2391.90 μg m−3, and aromatics were the predominant precursors, contributing 54.05% of the total OFP. Furthermore, the SOA estimated by fractional aerosol coefficient (FAC) and time-resolved (TR) methods were 6.032 ± 13.347 μg m−3 and 0.971 ± 4.650 μg m−3, accounting for 8.65–26.39% (13.78 ± 7.46%) and 1.55–4.20% (2.22 ± 1.23%) of the PM2.5 concentrations, respectively. The results indicated that VOCs were more sensitive to O3 pollution in high pollution domains, whereas VOCs were more sensitive to PM2.5 pollution in low pollution domains. We concluded that reducing VOCs emissions might be effective in alleviating photochemical pollution episodes in areas around iron and steel industry, and the haze pollution occurred in these regions may be caused by the primary emission of PM, and the contribution of SOA was relatively small.

The impact of prenatal exposure to PM2.5 on childhood asthma and wheezing: a meta-analysis of observational studies

Wu Yan, Xu Wang, Tianyu Dong, Mengqi Sun, Mingzhi Zhang, Kacey Fang, Yi Chen, Rui Chen, Zhiwei Sun & Yankai Xia

Source: Environmental Science and Pollution Research volume 27, pages29280–29290(2020)

With the accelerated pace of economic development and modernization, air pollution has become one of the most focused public health problems. However, the impact of particulate matter exposure during pregnancy on childhood asthma and wheezing remains controversial. We performed this meta-analysis to explore the relationship between prenatal exposure to PM2.5 and childhood asthma and wheezing. Candidate papers were searched on PubMed, Web of Science, Embase, and Cochrane Library before July 15, 2019. The main characteristics of the included studies were extracted, and the quality was evaluated by the Newcastle–Ottawa Scale (NOS). A sensitivity analysis was performed to

assess the impact of individual studies on the combined effects. The Egger and Begg tests were conducted to examine the publication bias. Nine studies were included in the final analysis. Prenatal exposure to PM2.5 significantly increased the risk of childhood asthma and wheezing (OR = 1.06, 95% CI 1.02–1.11; per 5 μg/m3). Maternal exposure was more strongly related to childhood asthma and wheezing before age 3 (OR = 1.15, 95% CI 1.00–1.31; per 5 μg/m3) than after (OR = 1.04, 95% CI 1.00–1.09; per 5 μg/m3). Children in developed countries showed more severe effects (OR = 1.14, 95% CI 1.02–1.27; per 5 μg/m3). Children who were born to mothers with higher levels of prenatal exposure were at higher risk of asthma and wheezing (OR = 1.07, 95% CI 1.02–1.13; per 5 μg/m3). This meta-analysis indicated that the impact of PM2.5 on childhood asthma and wheezing begins as early as utero, so regulating pollutant emission standards and strengthening prenatal protection are crucial to maternal and child health.

PM2.5 and ultrafine particles in passenger car cabins in Sweden and northern China—the influence of filter age and pre-ionization

Dixin Wei, Filip Nielsen, Lars Ekberg, Anders Löfvendahl, Maria Bernander & Jan-Olof Dalenbäck

Source: Environmental Science and Pollution Research volume 27, pages30815–30830(2020)

The main aim of the study was to evaluate the influence of filter status (new and aged), pre-ionization, on the particle filtration in modern passenger cars. Measurements of in-cabin and outside PM2.5 (dp < 2.5 μm) concentration and UFP (ultrafine particle, dp < 100 nm) counts, to calculate I/O (indoor to outdoor) ratios, were performed. They were done at two locations, to study the influence of different outside conditions on the HVAC (heating, ventilation, and air-conditioning) system. The measurements were performed in two new cars, with similar HVAC systems and settings, using a new filter and an aged synthetic filter. Furthermore, an ionization unit was installed upstream of the filter in both cars. This enabled the study of filter status, with and without ionization, under common driving conditions. The results show that the HVAC system performances were very similar at the two locations, with average I/O ratios of 0.35–0.40 without ionization and 0.15–0.20 with ionization applied, although the outside conditions were considerably different. Furthermore, the aged filter clearly worsened the filtration ability. Considering the corresponding average PM2.5 I/O ratios in one location as an example, the average for the new filter was 0.20 and 0.60 for the aged filter. The corresponding UFP I/O ratios were 0.24 and 0.57. Other findings are that the aged filter with ionization reached a performance close to the new filter (without ionization), and that increased ventilation airflow and

decreased recirculation degree, as expected, led to an increase in the I/O ratio for both particle sizes.

Spatiotemporal variation and determinants of population's PM2.5 exposure risk in China, 1998–2017: a case study of the Beijing-Tianjin-Hebei region

Ning Jin, Junming Li, Meijun Jin & Xiaoyan Zhang

Source: Environmental Science and Pollution Research volume 27, pages31767–31777(2020)

PM2.5 pollution has emerged as a global human health risk. The best measure of its impact is a population's PM2.5 exposure (PPM2.5E), an index that simultaneously considers PM2.5 concentrations and population spatial density. The spatiotemporal variation of PPM2.5E over the Beijing-Tianjin-Hebei (BTH) region, which is the national capital region of China, was investigated using a Bayesian space-time model, and the influence patterns of the anthropic and geographical factors were identified using the GeoDetector model and Pearson correlation analysis. The spatial pattern of PPM2.5E maintained a stable structure over the BTH region's distinct terrain, which has been described as "high in the northwest, low in the southeast". The spatial difference of PPM2.5E intensified annually. An overall increase of 6.192 (95% CI 6.186, 6.203) ×103 μg/m3 · persons/km2 per year occurred over the BTH region from 1998 to 2017. The evolution of PPM2.5E in the region can be described as "high value, high increase" and "low value, low increase", since human activities related to gross domestic product (GDP) and energy consumption (EC) were the main factors in its occurrence. GDP had the strongest explanatory power of 76% ($P < 0.01$), followed by EC and elevation (EL), which accounted for 61% ($P < 0.01$) and 40% ($P < 0.01$), respectively. There were four factors, proportion of secondary industry (PSI), normalized differential vegetation index (NDVI), relief amplitude (RA), and EL, associated negatively with PPM2.5E and four factors, GDP, EC, annual precipitation (AP), and annual average temperature (AAT), associated positively with PPM2.5E. Remarkably, the interaction of GDP and NDVI, which was 90%, had the greatest explanatory power for PPM2.5E′s diffusion and impact on the BTH region.

What factors influence PM2.5 emissions in China? An analysis of regional differences using a combined method of data envelopment analysis and logarithmic mean Divisia index

Shi-Chun Xu, Yi-Feng Zhou, Chao Feng, Yan Wang & Yun-Fan Li

Source: Environmental Science and Pollution Research volume 27, pages34234–34249(2020)

This study uses a combined data envelopment analysis and logarithmic mean Divisia index (DEA-LMDI) method to decompose affecting factors for PM2.5 emissions into effects related to the potential emission intensity (PEI), environmental efficiency and technology, production efficiency and technology, regional economic structure, and national economic growth, and investigates differences in the effects on PM2.5 emissions, considering the diversity among different areas and periods in China. This study provides a new insight in the decomposition method, which can decompose the emissions into new effects compared with the exiting studies. This study reveals that the regional environmental-based technology (EBT) effect is the key curbing factor for PM2.5 emissions, followed by the regional PEI effect. The curbing effect of regional EBT on PM2.5 emissions is strong in East China and weak in Northeast China. The environment-oriented scale efficiency (ESE), environment-oriented management efficiency (EME), production-oriented scale efficiency (PSE), production-oriented management efficiency (PME), and production-based technology (PBT) had relatively small effects on PM2.5 emissions on the whole. The effects differ among different areas and periods in China. The emission reduction potential of these efficiency effects has not been realized. The national economic growth greatly promotes PM2.5 emissions. The regional economic structure effect slightly increases PM2.5 emissions because of the unbalanced development of regional economy. The relative policy suggestions are put forward based on the findings of this study.

Associations of soluble metals and lung and liver toxicity in mice induced by fine particulate matter originating from a petrochemical complex

Hsiao-Chi Chuang, Ruei-Hao Shie, Chii-Hong Lee, Chia-Pin Chio, Tzu-Hsuen Yuan, Jui-Huan Lee & Chang-Chuan Chan

Source: Environmental Science and Pollution Research volume 27, pages34442–34452(2020)

Adverse health effects have been observed in nearby residents due to exposure to petrochemical-derived chemicals. The objective of this study was to examine associations of soluble metals with lung and liver toxicity in fine particulate matter (PM2.5) in the vicinity of a petrochemical complex. PM2.5 was collected in the vicinity of a petrochemical complex of Mailiao Township (Yunlin County, Taiwan) to investigate lung and liver toxicity in BALB/c mice. The PM2.5 concentration was 30.2 ± 11.2 μg/m3, and the PM2.5 was

clustered in major local emissions (19.1 μg/m3) and minor local emissions (14.1 μg/m3) using a k-means clustering model. The PM2.5 (50 and 150 μg/kg) and PM2.5-equivalent soluble nickel (Ni), vanadium (V), and lead (Pb) concentrations were intratracheally instilled into BALB/c mice. PM2.5 and V significantly decreased the tidal volume after exposure ($p < 0.05$). The peak expiratory flow (PEF) and peak inspiratory flow (PIF)/PEF ratio were significantly altered by 150 μg/kg V ($p < 0.05$). V and Pb significantly increased total protein and lactate dehydrogenase (LDH) levels in bronchoalveolar lavage fluid (BALF) ($p < 0.05$). Interleukin (IL)-6 in BALF significantly increased after exposure to Pb ($p < 0.05$) accompanied by lung inflammatory infiltration. PM2.5 and Pb significantly increased levels of 8-isoprostane ($p < 0.05$). The level of caspase-3 activity significantly increased after exposure to Pb ($p < 0.05$). LDH in the liver was significantly increased by PM2.5 ($p < 0.05$). 8-Isoprostane in the liver was significantly increased by PM2.5 and Pb ($p < 0.05$). IL-6 in the liver was significantly increased by PM2.5, Ni, V, and Pb after exposure ($p < 0.05$), accompanied by liver inflammatory infiltration. Our results demonstrated that V in PM2.5 was associated with an increase in 8-isoprostane for all emissions and major local petrochemical emissions. In conclusion, V contributes to in vivo liver toxicity induced by PM2.5 in the vicinity of a petrochemical complex.

Pollutant emission reduction of energy efficiency enhancement and energy cascade utilization in an energy-intensive industrial park in China

Jialin Ji, Shanshan Wang, Yilan Ma, Chunyang Lu, Tian Liang & Ruiqin Zhang

Source: Environmental Science and Pollution Research volume 27, pages35017–35030(2020)

Industrial parks play an extremely important role in the rapid development of China's economy. However, as the backbone of China's economic development, industrial parks also consume huge energy resources and cause serious pollution to the environment, making China face greater pressure on environmental issues. This article takes the Yongcheng Economic and Technological Development Area, a typical energy-intensive industrial park in Henan Province, as the research object to analyze its energy saving and emission reduction potential. Three scenarios (baseline scenario, energy cascade utilization scenario, and energy efficiency technology enhancement scenario) are set to quantify the energy-saving potential and air pollutant emission reduction of the park under different scenarios. The results show that in the energy cascade utilization scenario, by realizing the recycling of waste heat resources from heat source enterprises, it can bring energy saving of 6385 TJ, and reduce 0.35 kt SO2, 0.79 kt NOx, 0.067 kt PM10, and 0.035 kt PM2.5. And CO2 emission reductions have reached 604 kt. In the energy efficiency

technology enhancement scenario, by eliminating relatively backward technologies and adding advanced energy-saving technologies, 7306 TJ energy saving could be achieved. SO2, NOx, PM10, PM2.5, and CO2 emission reductions are 0.37, 0.82, 0.038, 0.071, and 719 kt, respectively. The results of the CALPUFF model indicate that the pollutant concentrations of SO2, NOx, PM10, and PM2.5 in the spring and autumn are relatively high, while those in the summer and winter seasons are relatively low. In four seasons, the highest 1-h average concentration and dispersion range of four pollutants have been reduced both in the energy cascade utilization scenario and in the efficiency technology enhancement scenario.

Characterization of particles emitted by pizzerias burning wood and briquettes: a case study at Sao Paulo, Brazil

Francisco Daniel Mota Lima, Pedro José Pérez-Martínez, Maria de Fatima Andrade, Prashant Kumar & Regina Maura de Miranda

Source: Environmental Science and Pollution Research volume 27, pages35875–35888(2020)

The burning of biomass in pizza ovens can be an important source of air pollution. Fine particulate matter represents one of the most aggressive pollutants to human health, besides the potential to interfere with global radiative balance. A study in real-world condition was performed in three pizzerias in São Paulo city. Two of the pizzerias used eucalyptus timber logs and one used wooden briquettes. The results from the three pizzerias revealed high average concentrations of PM2.5: 6171.2 μg/m3 at the exit of the chimney and 68.2 μg/m3 in indoor areas. The burning of briquette revealed lower concentrations of PM2.5. BC represented approximately 20% and 30% of the PM2.5 mass concentration in indoor and at chimney exhaust, respectively. Among the trace elements, potassium, chlorine and sulphur were the most prevalent in terms of concentration. Scanning electron microscopy (SEM) analysis revealed particles with an individual and spherical morphology, i.e. the conglomeration of spherical particles, flattened particles in the formation of fibres, the overlapping of layers and the clustering of particles with sponge-like qualities. The average emission factors for PM2.5 and BC due to the burning of logs were 0.38 g/kg and 0.23 g/kg, respectively. The total emissions of PM2.5 and BC were 116.73 t/year and 70.65 t/year, respectively, in the burning of timber logs.

The role of receptor models as tools for air quality management: a case study of an industrialized urban region

Elson Silva Galvão, Neyval Costa Reis Jr & Jane Meri Santos

Source: Environmental Science and Pollution Research volume 27, pages35918–35929(2020)

Evidence suggesting the association between the atmospheric particulate matter (PM) and health problems stress the need for the establishment of policies and actions aiming the improvement of air quality. As a start point, the knowledge of the main PM contributors is fundamental. Receptor models are frequently used for the identification and apportionment of local sources, nevertheless, some features of these models must be considered. For instance, whether the region has sources with similar chemical profiles and/or whether there is source temporal or spatial similarity, which can generate collinearity, affecting the sensibility of the models. In this work, it is presented some study of cases showing some strengths of the chemical mass balance model (CMB), such as to infer specific sources acting over specific locations in a same region, and its weaknesses for separating collinear sources. Besides, this work shows some study of cases reporting that the identification of specific PM markers (organic, inorganic, and crystallographic) and determined in the receptor samples can lead to better sources separation and improvements in the interpretation of the results using positive matrix factorization model. This work also highlights for the importance of the information provided by receptor models, in which should be carefully considered by the environmental agencies for decision-making concerning air quality management.

Validation of PM10 and PM2.5 early alert in Bogotá, Colombia, through the modeling software WRF-CHEM

Alejandro Casallas, Nathalia Celis, Camilo Ferro, Ellie López Barrera, Carlos Peña, John Corredor & Miguel Ballen Segura

Source: Environmental Science and Pollution Research volume 27, pages35930–35940(2020)

Air quality data from Bogotá, Colombia, show high levels of particulate matter (PM), which often generate respiratory problems to the population and a high economic cost to the government. Since 2016, air quality in the city of Bogotá has been measured through the Bogota Air Quality Index (IBOCA) which works as an indicator of environmental risk due to air pollution. However, available technological tools in Bogotá are not enough to generate early alerts due to PM10 and PM2.5. Currently, alerts are only announced once the measured PM values exceed a certain standard (e.g., 37 μ g/m3), but not with enough anticipation to efficiently protect the population. It is necessary to develop an early air

quality alert in Bogotá, in order to provide information that improves risk management protocols in the capital district. The purpose of this investigation is to validate the corrective alert presented on the 14th and 15th of February of 2019, through the WRF-Chem model under different weather conditions, using three different setups of the model to simulate PM10 and PM2.5 concentrations during two different climatic seasons and different resolutions. The results of this article generate a validation of two configurations of the model that can be used for the Environmental Secretary of the District (SDA) forecasts in Bogotá, Colombia, in order to contribute to the prediction of pollution events produced by PM10 and PM2.5 as a tool for an early alert system (EAS) at least 24 h in advance.

Top-down vehicle emission inventory for spatial distribution and dispersion modeling of particulate matter

Willian Lemker Andreão, Marcelo Felix Alonso, Prashant Kumar, Janaina Antonino Pinto, Rizzieri Pedruzzi & Taciana Toledo de Almeida Albuquerque

Source: Environmental Science and Pollution Research volume 27, pages35952–35970(2020)

Emission inventories are one of the most critical inputs for the successful modeling of air quality. The performance of the modeling results is directly affected by the quality of atmospheric emission inventories. Consequently, the development of representative inventories is always required. Due to the lack of regional inventories in Brazil, this study aimed to investigate the use of the particulate matter (PM) emission estimation from the Brazilian top-down vehicle emission inventory (VEI) of 2012 for air quality modeling. Here, we focus on road vehicles since they are usually responsible for significant emissions of PM in urban areas. The total Brazilian emission of PM (63,000 t year−1) from vehicular sources was distributed into the urban areas of 5557 municipalities, with 1-km2 grid spacing, considering two approaches: (i) population and (ii) fleet of each city. A comparison with some local inventories is discussed. The inventory was compiled in the PREP-CHEM-SRC processor tool. One-month modeling (August 2015) was performed with WRF-Chem for the four metropolitan areas of Brazilian Southeast: Belo Horizonte (MABH), Great Vitória (MAGV), Rio de Janeiro (MARJ), and São Paulo (MASP). In addition, modeling with the Emission Database for Global Atmospheric Research (EDGAR) inventory was carried out to compare the results. Overall, EDGAR inventory obtained higher PM emissions than the VEI segregated by population and fleet, which is expected owing to considerations of additional sources of emission (e.g., industrial and residential). This higher emission of EDGAR resulted in higher PM10 and PM2.5 concentrations, overestimating the observations in

MASP, while the proposed inventory well represented the ambient concentrations, obtaining better statistics indices. For the other three metropolitan areas, both EDGAR and the VEI inventories obtained consistent results. Therefore, the present work endorses the fact that vehicles are responsible for the more substantial contribution to PM emissions in the studied urban areas. Furthermore, the use of VEI can be representative for modeling air quality in the future.

Air pollution emission effects of changes in transport supply: the case of Bogotá, Colombia

Sonia C. Mangones, Paulina Jaramillo, Nestor Y. Rojas & Paul Fischbeck

Source: Environmental Science and Pollution Research volume 27, pages35971–35978(2020)

Transportation policy and planning decisions, including decisions on new infrastructure and public transport improvements, affect local and global environmental conditions. This work studies the effect of increased road capacity on traffic-related emissions in Bogotá using a tool that couples a transportation model with emission factors from COPERT IV. We followed a parametric approach varying transport supply and demand, comparing three scenarios: a baseline scenario that represents the transportation system in Bogota in 2015; scenario 1 incorporates five highway capacity-enhancement projects in Bogotá and assumes insensitive travel demand; scenario 2 incorporates the new highway projects but assumes a demand increase of 13% in vehicle trips with private cars. Results include daily and annual values of traffic-related emissions of five air pollutant criteria: CO, NOx, PM10, SO2, and VOC for the baseline scenario, scenario 1, and scenario 2. We found a reduction in emissions after adding highway capacity and assuming inelastic demand (scenario 1). Scenario 1 results in a 15% reduction in PM10 emissions and a 10% reduction in NOx emissions. In contrast, results for scenario 2 suggest increased emissions for all air pollutant criteria (e.g., VOC and CO emissions increase by 21% and 22% compared with the baseline scenario). Therefore, new traffic demand would eliminate the emission savings observed in scenario 1 and could potentially further degrade air quality in Bogotá. While an exact estimate of induced demand that may result from highway expansion in Bogotá is not available, this analysis highlights that such projects could lead to an increase in emissions unless there is a combined effort to managing demand of private vehicle trips.

Household air pollution from cooking and heating and its impacts on blood pressure in residents living in rural cave dwellings in Loess Plateau of China

Yuanchen Chen, Jie Fei, Zhe Sun, Guofeng Shen, Wei Du, Lu Zang, Liyang Yang, Yonghui Wang, Ruxin Wu, An Chen & Meirong Zhao

Source: Environmental Science and Pollution Research volume 27, pages36677–36687(2020)

Cave dwelling is an ancient and unique type of residence in the Loess Plateau of Northern China, where the economics are less-developed. The majority of the local dwellers rely on traditional solid fuels for cooking and heating, which can emit large amounts of particles into both indoor and outdoor environments. In this study, we measured the real-time household concentrations of PM2.5 and explored the association between personal daily PM2.5 exposure and blood pressure (BP). Cooking and heating activities with different energies made a great variation in the household PM2.5 air pollution, and residents using biomass had the highest personal PM2.5 exposure. Temperature and relative humidity are both significantly linear correlated with household PM2.5 air pollution. Besides, systolic blood pressure (SBP) was demonstrated to be positively associated with personal PM2.5 exposure: with each 10-μg/m3 incremental PM2.5 concentration when controlling all the other factors, SBP will increase by 0.36 mmHg (95% confident interval (CI) 0.05–0.0.77 mmHg). If solid fuels could be replaced with clean energies, personal PM2.5 exposure and SBP would reduce by more than 21% and 3.7%, respectively, calling for efficient intervention programs to mitigate household air pollution of cave dwellings and protect health of those residents.

Characteristics of exposure and health risk air pollutants in public buses in Korea

Ho-Hyun Kim

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The objective of this study was to estimate the concentrations of indoor air pollutants in unregulated public transport means in Korea and to determine the factors affecting the air quality as well as to assess the harmful effects of indoor air pollutants on the health of passengers. The correlation between particulate matter (PM10) and number of passengers on intra-city buses, express buses, town shuttle buses, or rural buses was insignificant whether it was during rush hours or non-rush hours. In regard to PM10 on express buses, there was no case where the standard limit was exceeded during the winter and summer seasons. In winter, however, the average concentration of PM10 increased by the travel distance. In regard to CO2, there was a statistically significant correlation ($p < 0.05$)

between CO2 concentrations and the number of passengers, owing to human respiration. Unlike the case of PM10, there was a difference between rush hours and non-rush hours. Regarding volatile organic compounds (VOCs) and aldehydes, the values were high among recently manufactured vehicles regardless of bus types. The standard limit was exceeded during the summer season, which seemed to be related to the temperature and humidity in both indoor and outdoor. The results of this study indicate that the excess mortality resulting from PM10 was as high as the safety margin during both non-rush hours and rush hours among all unregulated public transportation means. The excess cancer risk and non-cancer risk of VOCs and aldehydes were as high as the safety margin during both non-rush hours and rush hours.

Analysis of the PM2.5 emission inventory and source apportionment in Jilin City, Northeast of China

Chunsheng Fang, Liyuan Wang, Hanbo Gao & Ju Wang

Source: Environmental Science and Pollution Research volume 27, pages37324–37332(2020)

This study collected and compiled statistical data on atmospheric pollution in Jilin City, China during 2013–2014, using models and methods to calculate the source proportion of PM2.5 emitted by various sources. The statistical activity levels and emission factors of various pollution sources were found to be key parameters for obtaining the total amount of PM2.5 in the exhaust gas emitted from all types of pollution sources using an emissions model. In this study, relevant data were collected by the top-down method, and pollutant emission was calculated by the emission factor method to establish the PM2.5 pollution emission inventory of Jilin City. The source apportionment was calculated using the Chemical Mass Balance (CMB) model. Industrial process source and fixed combustion source are the largest sources of PM2.5 emission from all sources, respectively. Among the two calculation results, the results of pollution emission inventory are more accurate. The PM2.5 emission inventory in Jilin was established and countermeasures were proposed focused on the coordinated control of air pollution and the prevention and control of industrial dust pollution sources, as well as environmental management and impact assessment.

Inversion of PM2.5 atmospheric refractivity profile based on AlexNet model from the perspective of electromagnetic wave propagation

ChengJun Guo, YaLan Xu & Zhong Tian

Source: Environmental Science and Pollution Research volume 27, pages37333–37346(2020)

Human civilization has reached an unprecedented height, but the industrialization of economic development also brings global warming, ozone depletion, acid rain, fresh water resources crisis, energy shortage, and environmental problems. In autumn and winter, haze becomes the usual state in the modern society, and PM2.5 has been becoming an important form of air pollution. The research found that PM2.5 brings great influence to the human body or daily life. To some extent, the PM2.5 also affects the propagation of electromagnetic waves near the ground, reducing the transmission performance of electromagnetic wave. Based on Mie scattering theory, this paper qualitatively analyzed the scattering effects of PM2.5 particles on every frequency band of electromagnetic wave in daily use. Then the paper takes the satellite navigation signals as a research example, selecting university of Wyoming Davis stations in Antarctica sounding data by measuring the tropospheric atmospheric meteorological parameters (including the atmosphere pressure, geopotential height of different layers, dew point temperature, relative humidity and specific humidity, wind direction, wind speed, and temperature). The paper inversed the refractive index distribution of the troposphere based on AlexNet model and described the error quantitatively. The simulation results show that the estimated error is less than 5.1455%, proving the high accuracy of the AlexNet model. To test the influence of PM2.5, the paper takes Jiuquan, a city with serious pollution, as an example. Comparison between the inversion results and IGS products shows that high concentration of PM2.5 pollution has little influence on the inversion of refractive index profile.

The contribution of PM2.5 to cardiovascular disease in China

Shuqi Zhang & Michael N. Routledge

Source: Environmental Science and Pollution Research volume 27, pages37502–37513(2020)

China is experiencing rapid urbanization and industrialization with correspondingly high levels of air pollution. Although the harm of PM2.5 has been long reported, it is only quite recently that there is increasing concern in China for its possible adverse health effects on cardiovascular disease. We reviewed the epidemiologic evidence of potential health effects of PM2.5 on cardiovascular disease reported from recent studies in China (2013 onwards). There is clear evidence for the contribution of PM2.5 to cardiovascular outcomes, including mortality, ischemic heart disease, and stroke from studies based in various regions in China. This evidence adds to the global evidence that PM2.5 contributes to adverse cardiovascular health risk and highlights the need for improved air quality in China.

The impact of particulate matter 2.5 on the risk of preeclampsia: an updated systematic review and meta-analysis

Hongbiao Yu, Yangxue Yin, Jiashuo Zhang & Rong Zhou

Source: Environmental Science and Pollution Research volume 27, pages37527–37539(2020)

There is increasing and inconsistent evidence of a linkage between maternal exposure to particulate matter 2.5 (PM2.5) and preeclampsia. Therefore, this study was conducted to investigate this relationship. Electronic databases including PubMed, Embase, Web of Science, and Cochrane Library were searched to identify articles published from inception to March 23, 2020, which showed a correlation between PM2.5 and preeclampsia. Finally, 9 of 523 initial studies were deemed eligible for inclusion. A random effect model was adopted to calculate the standardized odds ratio (OR) and 95% confidence interval (CI). Based on potential effect modification, subgroup analyses were further performed. Meta-analysis showed that maternal exposure to PM2.5 (per 10 μg/m3 increment) elevated the risk of preeclampsia (OR = 1.32, 95% CI 1.10 to 1.58%). Compared with other pregnancy trimesters, the third trimester of pregnancy seems to be the period in which women are more susceptible to PM2.5. Significant effect modification of the correlation between PM2.5 exposure and preeclampsia according to multiple pregnancies, pregnancy stage, maternal-related disease history, and sample size was not observed. The results demonstrated that maternal exposure to PM2.5 may predispose pregnant women to develop preeclampsia, especially in the third trimester of pregnancy. Therefore, more efforts should be made to improve air quality to maintain the health of pregnant women.

Concentrations and mortality due to short- and long-term exposure to PM2.5 in a megacity of Iran (2014–2019)

Yaghoub Hajizadeh, Negar Jafari, Amir Mohammadi, Seyed Mojtaba Momtaz, Farzad Fanaei & Ali Abdolahnejad

Source: Environmental Science and Pollution Research volume 27, pages38004–38014(2020)

The present study aimed to survey the spatial and temporal trends of ambient concentration of PM2.5 and to estimate mortality attributed to short- and long-term exposure to PM2.5 in Isfahan from March 2014 to March 2019 using the AirQ+ software. The hourly concentrations of PM2.5 were obtained from the Isfahan Department of

Environment and Isfahan Air Quality Monitoring Center. Then, the 24-h mean concentration of PM2.5 for each station was calculated using the Excel software. According to the results, the annual mean concentration of PM2.5 in 2014–2019 was 29.9–50.9 μg/m3, approximately 3–5 times higher than the WHO guideline (10 μg/m3). The data showed that people of Isfahan in almost 58% to 96% of the days of a year were exposed to PM2.5 higher than the WHO daily guideline. The concentrations of PM2.5 in cold months such as October, November, December and January were higher than those in the other months. The zoning of the annual concentrations of PM2.5 in urban areas showed that the highest PM2.5 concentrations were related to the northern, northwestern, southern and central areas of the city. On average, from 2014 to 2019, the number of deaths due to natural mortality, lung cancer (LC), chronic obstructive pulmonary disease (COPD), ischemic heart disease (IHD) and stroke associated with ambient PM2.5 were 948, 16, 18, 281 and 60, respectively. The present study estimated that on average, 14.29% of the total mortality, 17.2% of lung cancer (LC), 15.54% of chronic obstructive pulmonary disease (COPD), 17.12% of ischemic heart disease (IHD) and 14.94% of stroke mortalities were related to long-term exposure to ambient PM2.5. So provincial managers and politicians must adopt appropriate strategies to control air pollution and reduce the attributable health effects and economic losses.

Major air pollutants seasonal variation analysis and long-range transport of PM10 in an urban environment with specific climate condition in Transylvania (Romania)

Zsolt Bodor, Katalin Bodor, Ágnes Keresztesi & Róbert Szép

Source: Environmental Science and Pollution Research volume 27, pages38181–38199(2020)

The air quality decrease, especially in urban areas, is related to local-scale conditions and to dispersion of air pollutants (regional and long-range) as well. The main objective of this study was to decipher the seasonal variation of PM10, NO, NO2, NOx, SO2, O3, and CO over a 1-year period (2017) and the possible relationships between air pollution and meteorological variables. Furthermore, trajectory cluster analysis and concentration-weighted trajectory (CWT) methods were used to assess the trajectories and the source-receptor relationship of PM10 in the Ciuc basin Transylvania, known as the “Cold Pole” of Romania. The pollutants show lower concentrations during warmer periods, especially during summer, and significantly higher concentrations were observed on heating season in winter due to seasonal variations in energy use (biomass burning) and atmospheric stability. Subsequently, in February, the highest concentration of PM10 was 132 μg/m3, which is 4 times higher than the highest recorded monthly mean. Our results indicate a

negative correlation between CO/temperature (− 0.89), NOx/temperature (− 0.84) and positive between NOx/PM10 (0.95), CO/PM10 (0.9), and NOx/CO (0.98), respectively. Dominant transport pathways were identified and the results revealed that slow-moving southerly (~ 45%) and northwesterly (~ 32%) air masses represent almost 80% and mainly regional flows were discerned. During 2017, increased PM10 levels were measured at the study site when air masses arrived mostly from northwest and southeast. The CWT and polarplot models show a strong seasonal variation and significant differences were observed between weekdays and weekends, namely highest PM10 concentrations during weekends at low wind speed (2–4 m/s).

Biomass energy, particulate matter (PM2.5), and the prevalence of chronic obstructive pulmonary disease (COPD) among Congolese women living near of a cement plant, in Kongo Central Province

Etongola P. Mbelambela, Sifa M. J. Muchanga, Antonio F. Villanueva, Masamitsu Eitoku, Kahoko Yasumitsu-Lovell, Ryoji Hirota, Yuki Shimotake, Gedikondele J. Sokolo, Atsuko Mori & Narufumi Suganuma

Source: Environmental Science and Pollution Research volume 27, pages40706–40714(2020)

This study investigated whether the individual and combined effects of using biomass energy and living in the neighborhood of a cement plant were associated with the risk of COPD and respiratory symptoms among Congolese women. A total of 235 women from two neighborhood communities of a cement plant participated in this cross-sectional study. Participants were classified into the more exposed group (MEG = 137) and a less exposed group (LEG = 98), as well as into biomass users (wood = 85, charcoal = 49) or electricity users (101 participants). Participants completed a questionnaire including respiratory symptoms, sociodemographic factors, medical history, lifestyle, and household characteristics. In addition to spirometry performance, outdoor PM2.5 (μg/m3) was measured. Afternoon outdoor PM2.5 concentration was significantly higher in MEG than LEG (48.8 (2.5) μg/m3 vs 42.5 (1.5) μg/m3). Compared to electricity users, wood users (aOR: 2.6, 95%CI 1.7; 5.9) and charcoal users (aOR: 2.9, 95%CI 1.4; 10.7) were at risk of developing airflow obstruction. Combined effects of biomass use and living in the neighborhood of a cement plant increased the risk of COPD in both wood users (aOR: 4, 95%CI 1.3; 12.2) and charcoal users (aOR: 3.1, 95%CI 1.7; 11.4). Exposure to biomass energy is associated with an increased risk of COPD. In addition, combined exposure to biomass and living near a cement plant had additive effects on COPD.

Impact of mixing layer height variations on air pollutant concentrations and health in a European urban area: Madrid (Spain), a case study

Pedro Salvador, Marco Pandolfi, Aurelio Tobías, Francisco Javier Gómez-Moreno, Francisco Molero, Marcos Barreiro, Noemí Pérez, María Aránzazu Revuelta, Isabel Martínez Marco, Xavier Querol & Begoña Artíñano

Source: Environmental Science and Pollution Research volume 27, pages41702–41716(2020)

The occurrence of local high-pollution episodes in densely populated urban areas, which have huge fleets of vehicles, is currently one of the most worrying problems associated with air pollution worldwide. Such episodes are produced under specific meteorological conditions, which favour the sudden increase of levels of air pollutants. This study has investigated the influence of the mixing layer height (MLH) on the concentration levels of atmospheric pollutants and daily mortality in Madrid, Spain, during the period 2011–2014. It may help to understand the causes and impact of local high-pollution episodes. MLH at midday over Madrid was daily estimated from meteorological radio soundings. Then, days with different MLH over this urban area were characterized by meteorological parameters registered at different levels of an instrumented tower and by composite sea level pressure maps, representing the associated synoptic meteorological scenarios. Next, statistically significant associations between MLH and levels of PM10, PM2.5, NO, NO2, CO and ultra-fine particles number concentrations registered at representative monitoring stations were evaluated. Finally, associations between all-natural cause daily mortality in Madrid, MLH, and air pollutants were estimated using conditional Poisson regression models. The reduction of MLH to values below 482 m above-ground level under strong atmospheric stagnation conditions was accompanied by a statistically significant increase in levels of NO, NO2, CO, PM2.5 and ultra-fine particle number concentrations at urban-traffic and suburban monitoring sites. The decrease of the MLH was also associated to a linear increase of the daily number of exceedances of the UE NO2 hourly limit value (200 μg/m3) and levels of air pollutants at hotspot urban-traffic monitoring stations. Also, a statistically significant association of the MLH with all-natural cause daily mortality was obtained. When the MLH increased by 830 m, the risk of mortality decreased by 2.5% the same day and by 3.3% the next day, when African dust episodic days were excluded. They were also higher in absolute terms than the increases in risk of mortality that were determined for the exposition to any other air pollutant. Our results suggest that when the prediction models foresee values of MLH below 482 m above-ground level in Madrid, the evolution of high-contamination episodes will be very favourable.

Therefore, short-term policy measures will have to be implemented to reduce NO, NO2, CO, PM2.5 and ultra-fine particle emissions from anthropogenic sources in this southern European urban location.

Characterization of PM2.5 sources in a Belgrade suburban area: a multi-scale receptor-oriented approach

Marija N. Todorović, Mirjana B. Radenković, Antonije E. Onjia & Ljubiša M. Ignjatović

Source: Environmental Science and Pollution Research volume 27, pages41717–41730(2020)

Designated as the most harmful for health, PM2.5 aerosol fraction was a subject of our study. It was collected for all four seasons during 2014/15 in the suburban area of Belgrade (Serbia) and analysed for Al, Si, P, S, Cl, K, Ca, Ti, V, Cr, Mn, Fe, Ni, Cu, Zn, Br, As, Ba and Pb elements and for NH4+, NO3− and SO42− ions by particle-induced X-ray emission and ion chromatography techniques, respectively. Obtained concentrations have been treated by a combination of several receptor-oriented models to reveal source contributions to the suburban PM2.5 at different spatial scales. Applied positive matrix factorization analysis indicated five main groups of emission sources: biomass burning (14.5%), traffic (3.9%), regional combustion/secondary sulphates (28.8%), local combustion/secondary nitrates (29.7%) and soil (5.4%). Local heating units had been pointed out as dominant contributors by long-range transport and ground-wind circulation analyses. Air masses circulating over the Balkan Peninsula denoted regional emissions as responsible for the high concentrations of secondary sulphates. Local and long-range transport analyses combined suggested that the BB and the LC/NO3 originated from the wider urban area. Several Saharan dust episodes were detected as well. Presented results might be a basis for the development of air pollution mitigation strategies in the continental Balkan area, considered one of the most polluted and under-investigated European regions.

Assessment of indoor air quality for a better preventive conservation of some French museums and monuments

Pauline Uring, Anne Chabas, Stéphane Alfaro & Mickaël Derbez

Source: Environmental Science and Pollution Research volume 27, pages42850–42867(2020)

Indoor air quality in museums and historical buildings is of great concern for curators, since it can be a source of various alterations on artworks. In spite of their importance, very

few studies study simultaneously the concentration of main gaseous pollutants, the composition of suspended (PM), and deposited (DPM) particulate matter. The aim of this article is to carry out a first environmental assessment in French museums or monuments. Three sites representative of contrasting environments (urban, marine, semi-rural) have been selected: the Cluny Museum (Paris), the Villa Kérylos (Beaulieu-sur-Mer), and the Château de Fontainebleau. The main results show that the input of terrigenous particles (calcite, clay) due to the surrounding restoration works dominates in Cluny; the external environment (O3, RH, and marine particles) influences the interior atmosphere of the Villa Kérylos and the deliquescence of the deposited salts; against all expectations, anthropogenic particles (mascagnite and soot) are largely dominant in Fontainebleau. They are emitted in winter, when the warm, pulsating air gets dirty as it passes through the old heating ducts. This research shows the importance of particle mixtures in the environmental signature of the sites. These mixtures must be taken into account in order to reproduce indoor atmospheres in simulation chambers to achieve realistic artificial aging. This study also makes it possible to target the sources of pollution on which to act.

Differential time-lag effects of ambient PM2.5 and PM2.5-bound PAHs on asthma emergency department visits

Shih-Chang Hsu, Jer-Hwa Chang, Chon-Lin Lee, Wen-Cheng Huang, Yuan-Pin Hsu, Chung-Te Liu, Shio-Shin Jean, Shau-Ku Huang & Chin-Wang Hsu

Source: Environmental Science and Pollution Research volume 27, pages43117–43124(2020)

Epidemiological studies have suggested the effects of ambient fine particles (PM2.5) on asthma, but the effects of specific components of PM2.5 on asthma remain to be explored. Here, we studied the effect of PM2.5-bound polycyclic aromatic hydrocarbons (PAHs) on asthma acute exacerbation. The data on daily counts of emergency room visits (ERVs) were obtained from Wan Fang Medical Center, Taipei, Taiwan, from 2012 to 2015. The daily concentrations of PM2.5 and pollutant gases were obtained from a local air quality monitoring station. The levels of PM2.5-bound PAH were estimated by an established grid-scale model. Relative risks for ERVs as the increase in the level of ambient pollutants were calculated by using a generalized additive model of Poisson regression. In the present study, we observed statistically significant positive associations between PM2.5 and asthma ERVs for all age groups. PM2.5-bound PAH was also associated with asthma ERVs for all age groups. In the adult subgroup analysis, there was a significant association between PM2.5-bound PAH and asthma ERVs at lags 1 and 2 (RR 1.289, 95% CI 1.050–1.582 and RR 1.242, 95% CI 1.039–1.485). The impacts of air pollution on the risk of

pediatric asthma ERV were found to be significant for PM2.5 at lag day 0 (RR 1.310, 95% CI 1.069–1.606). Moreover, pediatric asthma ERVs were significantly associated with the levels of PM2.5-bound PAH at lag 1 and 2 days (RR 1.576, 95% CI 1.371–1.810 and RR 1.426, 95% CI 1.265–1.607). The study provides evidence that PM2.5-bound PAHs were associated with an increased risk of asthma attacks.
Our data further suggested that traffic exhaust is a primary source of PM2.5-bound PAHs.

Associations between acute exposure to ambient air pollution and length of stay for inpatients with ischemic heart disease: a multi-city analysis in central China

Xuyan Wang, Yong Yu, Chuanhua Yu, Fang Shi & Yunquan Zhang

Source: Environmental Science and Pollution Research volume 27, pages43743–43754(2020)

Ambient air pollution (AAP) has been widely associated with increased morbidity of ischemic heart disease (IHD). However, no prior studies have investigated the effects of AAP exposure on the length of stay (LOS) due to IHD. Hospital data during 2015–2017 were obtained from hospital information system in five cities of Hubei province, China. We collected daily mean concentrations of air pollutants, including PM2.5, PM10, SO2, NO2, O3, and CO, and meteorological data during the same time period. Poisson regression was applied to estimate the acute impacts of AAP on the LOS of IHD inpatients. A total of 42,114 inpatients with primary diagnosis of IHD were included, 50.63% of which were chronic IHD inpatients. Annual average concentrations of PM2.5, PM10, SO2, NO2, O3, and CO were 61.93 μg/m3, 95.47 μg/m3, 18.59 μg/m3, 35.87 μg/m3, 100.30 μg/m3, and 1.117 mg/m3, respectively. After adjusting for temperature, relative humidity, gender, age group, payment method, number of hospital beds, location of hospital, and surgery or not, exposures to PM2.5, PM10, SO2, O3, and CO were associated with increased LOS for all IHD patients in both single- and multi-pollutant models, and stronger associations were observed among chronic IHD patients. In addition, subgroup analyses demonstrated that males and the group aged 65+ years were more vulnerable to air pollution, and the adverse effects were also promoted by low temperature in cold season. This study provides the first investigation of the adverse effects of AAP on the LOS for IHD patients. In order to shorten the LOS of IHD, measures should be taken to strengthen the AAP management and protect the high-risk population.

Air quality assessment among populous sites of major metropolitan cities in India during COVID-19 pandemic confinement

Gaurav Pant, Alka, Deviram Garlapati, Ashish Gaur, Kaizar Hossain, Shoor Vir Singh & Ashish Kumar Gupta

Source: Environmental Science and Pollution Research volume 27, pages44629–44636(2020)

The present study aims to determine the impact of COVID-19 pandemic confinement on air quality among populous sites of four major metropolitan cities in India (Delhi, Mumbai, Kolkata, and Chennai) from January 1, 2020 to May 31, 2020 by analyzing particulate matter (PM2.5 and PM10), nitrogen dioxide (NO2), ammonia (NH3), sulfur dioxide (SO2), carbon monoxide (CO), and ozone levels. The most prominent pollutant concerning air quality index (AQI) was determined by Pearson's correlation analysis and unpaired Welch's two-sample t test was carried out to measure the statistically significant reduction in average AQI for all the four sites. AQI significantly plummeted by 44%, 59%, 59%, and 6% in ITO-Delhi, Worli-Mumbai, Jadavpur-Kolkata, and Manali Village-Chennai respectively. The findings conclude a significant improvement in air quality with respect to reduction of 49–73%, 17–63%, 30–74%, and 15–58% in the mean concentration of PM2.5, PM10, NH3, and SO2 respectively during the confinement for the studied locations. The p values for all of the four studied locations were found significantly less than the 5% level of significance for Welch's t test analysis. In addition, reduced AQI values were highly correlated with prominent pollutants (PM2.5 and PM10) during Pearson's correlation analysis. These positive results due to pandemic imprisonment might aid to alter the current policies and strategies of pollution control for a safe and sustainable environment.

COVID-19 and air pollution: the worst is yet to come

Frédéric Dutheil, Julien S. Baker & Valentin Navel

Source: Environmental Science and Pollution Research volume 27, pages44647–44649(2020)

We read with interest the article by Wang et al. highlighting the burden of transport industry to carbon emissions in China (Wang et al. 2020). The authors described a massive increase of carbon emissions from fossil fuel in China, with an average annual growth rate of 9.72%. Interestingly, Northeastern China (epicenter of the beginning of COVID-19 pandemic) is particularly affected by this massive increase of carbon emissions related to transportation, with a northeast-southwest pattern. However, satellite images showed a massive decrease in nitrogen dioxide (NO2), carbon dioxide (CO2), and ozone (O3), which

was related to the reduction of human activities during the SARS-CoV-2 outbreak, i.e., traffic road, industrial productions, and individual traffic commuting (Dutheil et al. 2020). In the dramatical context of the SARS-CoV-2 pandemic, this global reduction in air pollution was a great sign for the preservation of our environment and some of the related cardiovascular and respiratory tract diseases (Guan et al. 2016; Cramer et al. 2020). More than half of humanity stayed at home for several months to avoid SARS-CoV-2 spreading. The isolation period has been referred to as a global economic crisis similar to the peak unemployment problems of the Great Depression (Arengo and Fuller 2020). However, to reduce the extent of the financial market collapse, some countries promptly reviewed the strict social distancing policy to boost industrial production and economic recovery (McCaffrey 2020). Some countries have already publicly stated that they will not meet the Paris agreement on climate change initiatives in order to boost their economic growth. China seems to increase the carbon-intensive development path, in accordance with the USA that wants to rescue struggling fossil fuel production firms (Harrabin 2020). Moreover, most of the worldwide trade routes were disrupted to fight against the COVID-19 pandemic, limiting economic exchanges and access to energy resources. This critical situation increases the exploitation of pollutant fossil fuels, particularly the redevelopment of previously closed carbon mines (Lelieveld et al. 2019). In addition to the probable increase in air pollution to fight against the 2-month lockdown in relation to the economy, individual behavior will also increase air pollution. Fearing the contagion in mass transit, people are more frequently using their individual cars for commuting (Smargiassi et al. 2020)—taking into account that traffic involves around 70% of air pollutants in urban areas (Ramacher and Karl 2020). There is also a noticeable upsurge in the use of disposable plastic, in line with mass media disseminating the survival of SARS-Cov-2 on inert surfaces (Otter et al. 2016). Considering the millions of tons of plastic waste entering the ocean each year, the global burden of plastic pollution will probably characterize the Anthropocene era as geological marker in the history of humanity (Jambeck et al. 2015). Thus, even if people fear a second wave of COVID-19, there may also be a tsunami of global pollution. Countries that are most affected by the SARS-CoV-2 pandemic may also be those with the highest economic consequences of the lockdown, and these countries may also have the highest increases in air pollution. Even if the global lockdown period benefitted air quality, we fear that countries worldwide will choose to protect the economy rather than the environment. This strategy might paradoxically cost more money than the massive containment due to SARS-CoV-2 restrictions—not meeting the Paris agreement may cost more than 600 trillion USD over the twenty-first century (Wei et al. 2020). The SARS-CoV-2 outbreak seems likely to be a brief respite in the fate of the world's increased air pollution.

Effects of the COVID-19 lockdown on criteria air pollutants in the city of Daegu, the epicenter of South Korea's outbreak

Quang Tran Vuong, Phan Quang Thang, Min-Kyu Park & Sung-Deuk Choi

Source: Environmental Science and Pollution Research volume 27, pages45983–45991(2020)

The outbreak of COVID-19 in Daegu, South Korea, early in 2020 has led this metropolitan city to become one of the major hotspots in the world. This study investigates the association of meteorology and the new daily COVID-19 confirmed cases and the effects of the city lockdown on the variation in criteria air pollutants (CAPs) in Daegu. Ambient temperature and relative humidity were negatively correlated to the new daily cases and played an important role in the spread of COVID-19. Wind speed could enhance the virus transmission through the inhalation of aerosols and/or droplets and contact with fomites. The lockdown has directly decreased the concentrations of CAPs. In particular, reductions of 3.75% (PM10), 30.9% (PM2.5), 36.7% (NO2), 43.7% (CO), and 21.3% (SO2) between the period before and during the outbreak were observed over the entire city. An increase in O3 (71.1%) was affected by natural processes and photochemical formation other than the lockdown effects. The three central districts were the areas most affected by the virus and showed the highest reductions in CAPs (except for O3) during the outbreak. Apart from the influence of the lockdown, the decreasing trend in CAPs may be a result of the actions taken by the government to mitigate air pollutants nationwide since 2019. The results of this study can be useful for government and medical organizations to understand the behavior of the virus in the atmosphere. Further studies are necessary to explore the detailed influences of the lockdown on the environment and public life.

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6. Science of Total Environment- 4.9

Impacts on human mortality due to reductions in PM10 concentrations through different traffic scenarios in Paris, France

C.N.Maesano a, G.Morel b, A.Matynia c, N.Ratsombath b, J.Bonnety c, G.Legros c, P.Da Costa c, J.Prud'homme a, I.Annesi-Maesano d

Source: Science of The Total Environment, Volume 698, 1 January 2020, 134257

Objectives

Air pollution is a well-known burden for population health and health systems worldwide. Reduction in air pollution is associated with improvements in mortality and rates of respiratory, cardiovascular and other diseases. Though air quality is a problem globally, efforts to lower air pollutant concentrations are usually regional or local. In industrialized countries, most urban air pollution is caused by vehicles, suggesting reductions in traffic

would result in reductions of pollution. However, detailed data on how such reductions can be achieved and impact public health is just beginning to emerge, and other influencing factors, including vehicle flow or urban landscape are largely unaccounted for.

Methods
We utilized a unique combination of vehicle emission measurements combined with simulations of traffic and vehicle variations, as well as urban topographies, to quantify health impacts of PM10 reduction in a single district of Paris, France, for various methods of traffic improvement. Here we rank and evaluate improvements in non-accidental mortality for thirteen possible scenarios to reduce traffic related PM10 emissions.

Results
The maximum impact scenario requires all passenger vehicles to meet Euro 5 standards and excludes diesel vehicles, resulting in long-term decreases in non-accidental mortality of 148.79 people per year, or 104.40 per 100,000 people. Similar reductions hold for the scenario requiring a completely electric passenger fleet, with long-term annual reductions of 137.14 premature mortalities. Removing all diesel vehicles is the third most impactful scenario, preventing 135.55 deaths yearly.

Discussion
PARTLESS provides comparisons between thirteen different traffic-related air quality reduction mechanisms in terms of improvements in mortality rates. Improving emissions standards, increasing electric vehicle use and removing diesel vehicles can prevent more than 148 deaths per year in this district alone. Further improvements in mortality reduction may require changes to the composition of vehicle components, asphalt or to the management of resuspended particulate matter.

Keywords: Urban air pollution; Particulate matter; Health impact analysis; Mortality.

Particulate matter inside and around elevated walkways

Huanhuan Wang Peter Brimblecombe Keith Ngan

Source: Science of The Total Environment, Volume 699, 10 January 2020, 134256

A number of cities have developed an elevated walkway network within street canyons in order to alleviate pedestrian congestion. Naively one may expect lower pollutant concentrations inside elevated walkways, on account of the increased distance from traffic-related emissions, but this hypothesis has received little critical attention. The primary objective of this study is to determine whether pedestrians on the elevated walkway

experience lower exposure than those utilizing the sidewalk below. Measurements of particulate matter (PM) inside and around elevated walkways in Hong Kong indicate that this is not always true. Nevertheless the variation in the ratio of sidewalk to walkway concentrations is relatively narrow (typically lying between 1 and 1.5). The robustness of the walkway-sidewalk ratio for PM2.5, i.e. PM with a diameter of less than 2.5 μm, is verified by examining the horizontal dependence, influence of traffic volume and diurnal cycle. This work highlights the importance of urban design, as well as the complex factors influencing PM concentrations.

Keywords: Pedestrian exposure; PM2.5, PM10; Street canyon; Urban design; Walkway microenvironment.

Temporal evolution characteristics of PM2.5 concentration based on continuous wavelet transform

Xiaobing Chen a, Lirong Yin b, Yulin Fan c, Lihong Song a, Tingting Ji a, Yan Liu a, Jiawei Tian a, Wenfeng Zheng a

Source: Science of The Total Environmen, Volume 699, 10 January 2020, 134244

Fine particulate matter (PM2.5) is an important haze index, and the researches on the evolutionary characteristics of the PM2.5 concentration will provide a fundamental and guiding prerequisite for the haze prediction. However, the past researchers were usually based on the overall time-domain evolution information of PM2.5. Since the temporal evolution of PM2.5 concentration is nonstationary, previous studies might neglect some important localization features that the evolution has various predominant periods at different scales. Therefore, we applied the wavelet transform to study the localized intermittent oscillations of PM2.5. First, we analyze the daily average PM2.5 concentration collected from the automatic monitoring stations. The result reveals that the predominant oscillation period does vary with time. There exist multiple oscillation periods on the scale of 14–32 d, 62–104 d, 105–178 d and 216–389 d and the 298d is the first dominant period in the entire evolutionary process. Moreover, we want to figure out whether the temporal characteristics of PM2.5 in the days with heavy haze also have localized intermittent periodicities. We select the hourly average PM2.5 concentration in 120 h when the haze pollution is serious. We find that the principal period has experienced two abrupt shifts and the energy at the 63-hour scale is the most powerful. The results in these two independent analyses come into the same conclusion that the multiscale features shown in

the temporal evolution of PM2.5 cannot be ignored and may play an important role in the further haze prediction.

Keywords: PM2.5; Continuous wavelet transform; Temporal evolution characteristic; Morlet wavelet.

High resolution vehicular PM10 emissions over megacity Delhi: Relative contributions of exhaust and non-exhaust sources

Vikas Singh a, Akash Biswal a, b Amit P.Kesarkar a, Suman Mor b, Khaiwal Ravindra c

Source: Science of The Total Environment, Volume 699, 10 January 2020, 134273

Exposure to particulate matter (PM) from traffic can cause adverse health risks. Recent studies project an increase in non-exhaust emissions in the future despite a reduction in exhaust emissions. While there is a lot of research on exhaust emissions, the challenges remain to quantify non-exhaust emissions, especially in developing countries. In this work, an approach has been developed, and on-road vehicular non-exhaust PM emissions are estimated due to brake wear, tyre wear, road wear and resuspension, at very high resolution (100 m2) over an Indian megacity Delhi. Further, the relative contribution of non-exhaust emissions to the total vehicular emission was also calculated. The total PM10 emissions in megacity Delhi were 31.5 Gg/year, which is mainly dominated by the non-exhaust sources. The non-exhaust emissions were found to be six times (86%) of the exhaust emission (14%). The highest contribution to the total vehicular PM emission comes from the cars (34%) followed by buses (23%) and heavy commercial vehicles (HCVs, 17%), which is dominated by resuspension of dust. Cars and buses contribute less to exhaust emissions and more to non-exhaust emissions. Majors roads are the largest contributors to the total emissions in Delhi. The emissions from HCVs, diesel cars along with the other diesel vehicles result in diesel vehicles contributing more than the petrol vehicles to both exhaust and non-exhaust emissions. As India target to reduce PM pollution under the national clean air program, the current study will be useful to plan a suitable intervention to mitigate air pollution and associated health impacts.

Keywords: Brake wear; Tire wear; Road wear; Dust resuspension; Silt load; Traffic pollution.

Deep learning-based PM2.5 prediction considering the spatiotemporal correlations: A case study of Beijing, China

Unjin Pak a, Jun Ma b, Unsok Ryu c, Kwangchol Ryom d, U.Juhyok e, Kyongsok Pak c, Chanil Pak f

Source: Science of The Total Environment, Volume 699, 10 January 2020, 133561

Air pollution is one of the serious environmental problems that humankind faces and also a hot topic in Northeastern Asia. Therefore, the accurate prediction of PM2.5 (particulate matter with an aerodynamic diameter of ≤2.5 μm) is very significant in the management of human health and the decision-making of government for the environmental management. In this study, a spatiotemporal convolutional neural network (CNN) and long short-term (LSTM) memory (CNN-LSTM) model (also called PM (particulate matter) predictor) was proposed and used to predict the next day's daily average PM2.5 concentration in Beijing City. The spatiotemporal correlation analysis using the mutual information (MI) was performed, considering not only the linear correlation but also nonlinear correlation between target and observation parameters; in addition, it was fully considered for the whole area of China with the target monitoring station as the center and also for the historic air quality and meteorological data. As a result, the spatiotemporal feature vector (STFV) which reflects both linear and nonlinear correlations between parameters was effectively constructed. The PM predictor secured a fast and accurate prediction performance by efficiently extracting the inherent features of the latent air quality and meteorological input data associated with PM2.5 through CNN and by fully reflecting the long-term historic process of input time series data through LSTM. The air quality and meteorological data from the 384 monitoring stations which represents the whole area of China with Beijing City as the center during the 3 years (Jan. 1st, 2015 to Dec. 31th, 2017) were used to verify the validity of the proposed method. In conclusion, the proposed method was proved to have a better stability and prediction performance compared to multi-layer perceptron (MLP) and LSTM models.

Keywords: PM2.5 prediction; PM predictor; Deep learning; CNN; LSTM; Spatiotemporal correlation.

Spatial hazard assessment of the PM10 using machine learning models in Barcelona, Spain

Bahram Choubin a, Mahsa Abdolshahnejad b, Ehsan Moradi b, Xavier Querol c, Amir Mosavi d e, Shahaboddin Shamshirband f, Pedram Ghamisi g

Source: Science of The Total Environment, Volume 701, 20 January 2020, 134474

Air pollution, and especially atmospheric particulate matter (PM), has a profound impact on human mortality and morbidity, environment, and ecological system. Accordingly, it is very relevant predicting air quality. Although the application of the machine learning (ML) models for predicting air quality parameters, such as PM concentrations, has been evaluated in previous studies, those on the spatial hazard modeling of them are very limited. Due to the high potential of the ML models, the spatial modeling of PM can help managers to identify the pollution hotspots. Accordingly, this study aims at developing new ML models, such as Random Forest (RF), Bagged Classification and Regression Trees (Bagged CART), and Mixture Discriminate Analysis (MDA) for the hazard prediction of PM10 (particles with a diameter less than 10 μm) in the Barcelona Province, Spain. According to the annual PM10 concentration in 75 stations, the healthy and unhealthy locations are determined, and a ratio 70/30 (53/22 stations) is applied for calibrating and validating the ML models to predict the most hazardous areas for PM10. In order to identify the influential variables of PM modeling, the simulated annealing (SA) feature selection method is used. Seven features, among the thirteen features, are selected as critical features. According to the results, all the three-machine learning (ML) models achieve an excellent performance (Accuracy > 87% and precision > 86%). However, the Bagged CART and RF models have the same performance and higher than the MDA model. Spatial hazard maps predicted by the three models indicate that the high hazardous areas are located in the middle of the Barcelona Province more than in the Barcelona's Metropolitan Area.

Keywords: Hazard assessment; Particulate matter; Air quality; Simulated annealing; Random forest; Bagged classification and regression trees; Mixture discriminate analysis.

Oxidative potential of ambient PM2.5 in Wuhan and its comparisons with eight areas of China

Qingyang Liu a b, Zhaojie Lu d, Ying Xiong c e, Fan Huang c, Jiabin Zhou b, James J.Schauer d

Source: Science of The Total Environment, Volume 701, 20 January 2020, 134844

Oxidative potential (OP) is a good indicator for assessing health risk associated with exposure to fine particulate matter (PM2.5, <2.5 μm in aerodynamic diameter). In this study, 24-h ambient PM2.5 samples were collected at three sampling sites throughout selected months of 2012 in Wuhan, Central China. Water soluble ions, metals, organic carbon (OC), elemental carbon (EC), levoglucosan, polycyclic aromatic hydrocarbons (PAHs), hopanes, and dicarboxylic acids were determined. The dithiothreitol (DTT) assay was used to characterize the oxidative potential of PM2.5. Linear regression analysis and principal component analysis (PCA) were used to link OP to the individual redox-active components originating from diverse emission sources. The OP results from the three sites

in Wuhan, combined with the findings from eight other field studies of OP conducted in China, were compiled in order to compare the OP data in developed countries. The average, normalized OP levels for volume and mass at the three sampling sites in Wuhan were in the range of 1.8–8.2 nmol min−1 m−3 and 18.2–52.8 nmol min−1 mg−1, respectively. The differences in OP levels across sampling sites depended on the temporal and spatial differences in redox-active components of PM2.5. Results from linear regression and PCA showed that the redox-active components emitted from secondary inorganic aerosols as well as secondary organic aerosols were associated with the volume normalized OP in Wuhan. Two notable findings are illustrated by synthesizing the OP results observed at multi-sites across China. Of the nine field studies conducted in China, the lowest measured mass-normalized OP levels are significantly higher than the highest OP levels from field studies conducted in developed continents. China shares the same sources responsible for OP (e.g., secondary sources, fuel combustion, biomass burning, and dust emissions) with several other countries in developed continents.

Keywords: Oxidative potential; China; PM2.5; Source apportionment.

Influence of marine vessel emissions on the atmospheric PM2.5 in Japan's around the congested sea areas

Ryohei Nakatsubo a b, Yoshie Oshita a, Masahide Aikawa c, Mitsuteru Takimoto a, Tomoko Kubo a, Chisato Matsumura a, Yutaka Takaishi a, Takatoshi Hiraki a b

Source: Science of The Total Environment, Volume 702, 1 February 2020, 134744

In recent years, PM2.5 concentrations in Japan have decreased as China's measures against the emission of air pollutants were strengthened and the subsequent transport of air pollutants to Japan decreased. On the other hand, along the coast of the Seto inland sea in Japan, the PM2.5 concentration remains high. In this study, in order to evaluate the impact of air pollutants from marine vessels on PM2.5 along the coast of the Seto inland sea, PM2.5 was seasonally collected in the vicinity of a congested sea lane (Akashi Strait) in 2016 and 2017, and a receptor-source analysis was performed to determine the main components of the collected PM2.5. In Japan's congested sea lane, the vanadium (V) concentration was very high and showed a strong correlation with the nickel (Ni) concentration. Also, the V/Ni ratio rose when the wind blew from the sea lane. Positive Matrix Factorization (PMF) analysis clarified that the contributions from marine vessel emissions to PM2.5 at the

current observation sites were 2.5–2.7 μg m−3 (17.3–21.4%), and the marine vessel emissions were the main source of PM2.5 along the coast of the Seto inland sea. Fuel oil regulations for marine vessels to be introduced in January 2020 are expected to improve the air quality of coastal areas.

Keywords: PM2.5; Marine vessel emissions; Vanadium; Nickel; PMF; Japan.

Seasonal exposure to PM2.5-bound polycyclic aromatic hydrocarbons and estimated lifetime risk of cancer: A pilot study

Guiyang Wang a b 1, Yao Wang c 1, Wenjun Yin a b 1 2, Tian Xu a b, Chen Hu a b, Juan Cheng a b, Jian Hou a b, Zhenyu He c 3, Jing Yuan a b 3

Source: Science of The Total Environment, Volume 702, 1 February 2020, 135056

Limited researches are available on seasonal variation of inhalation exposure of polycyclic aromatic hydrocarbons (PAHs) and its cancer risk assessment in China. We recruited 20 fresh postgraduates and measured outdoor and indoor (dormitories, offices and laboratories) daily PM2.5 concentrations in four seasons (seven consecutive days in every season) during 2014 –2015, calculated daily potential doses of personal exposure to total Benzo[a]pyrene equivalent concentration (BaPeq) in the microenvironments based on the total BaPeq and the time-activity patterns, and estimated incremental lifetime cancer risk (ILCR) using Monte Carlo method. Daily average concentrations of PM2.5-bound ∑PAHs on the campus ranked from high to low were winter, autumn, spring, summer in the dormitories and offices. Daily average concentration of PM2.5-bound ∑PAHs were higher in indoor environments than outdoor in the same season, except for that of PM2.5-bound ∑PAHs in laboratories in the winter. Median values of ILCR in both sexes from high to low were winter (men vs. women: 5.35e−9 vs. 4.96e−9), spring (3.71e−9 vs. 4.00e−9), autumn (2.92e−9 vs. 3.02e−9), summer (1.71e−9 vs. 1.87e−9). Indoor and outdoor PM2.5-bound PAHs concentrations showed seasonal and spatial variations. The ILCR value for PM2.5-bound PAHs was higher in women than in men.

Keywords: Polycyclic aromatic hydrocarbons; Time-activity pattern; Toxic equivalency factors; Incremental lifetime cancer risk; Monte Carlo simulation; Risk assessment.

Emission factors and composition of PM2.5 from laboratory combustion of five Western Australian vegetation types

Trang T.T.Dong a, William D.Stock a, Anna C.Callan c, Bo Strandberg d e, Andrea L.Hinwood a b

Source: Science of The Total Environment, Volume 703, 10 February 2020, 134796

This study investigated the emission of PM10 and PM2.5 (particulates with diameters of less than 10 μm and 2.5 μm, respectively) and the chemical composition of PM2.5 from laboratory combustion of five Australian vegetation types (three grasslands, a woodland and a forest). A mix of plants representative of Banksia (woodland) and Jarrah (forest) and three types of grasses (Spinifex – Triodia basedowii; Kimberley grass – Sehima nervosum and Heteropogon contortus; and an invasive grass (Veldt) – Ehrharta calycina) were burnt in 9 combustion conditions comprised of 3 fuel moisture levels (dry, moist, wet) and 3 air flow rates (no, low and high flow). PM (particulate matter) samples were collected onto filters and measured using gravimetric analysis. PM2.5 was then extracted and analyzed for water-soluble metals and polycyclic aromatic hydrocarbons (PAH) concentrations. The largest proportion of PM10 (98%) from vegetation fires was PM2.5. Banksia yielded the highest PM2.5 emission factor (EF), followed by Jarrah and Spinifex. Veldt grass combustion generated significantly higher emissions of PM2.5 compared with the other two grass types. High moisture contents and flow rates resulted in larger emissions of PM2.5. A strong correlation ($R2 = 0.84$) was observed between the EF for PM2.5 and combustion efficiency, suggesting higher PM emission with lower combustion efficiencies. Potassium and sodium were the most abundant PM2.5-bound water soluble metals, accounting for more than 97% of the total mass of metals analyzed. PAHs were found in significant concentrations, including the carcinogenic benzo(a)pyrene. Pyrene and fluoranthene were the most abundant PAHs detected, accounting for nearly 40% mass of the total PAHs. Indeno(1,2,3-cd)pyrene and benzo(g,h,i)perylene ratio (IND/IND + BghiP) appeared to be produced in a diagnostic ratio that indicated that the PAHs were derived from vegetation fires rather than other sources of emissions. The EF for PM2.5 and its chemical composition (water-soluble metals and PAHs) were strongly influenced by the type of vegetation burned. The results presented in this study could be useful in predicting the risks of human health effects on firefighters and the public who may be exposed to regular bushfires in Australia.

Keywords: Bushfires; Vegetation fires; PM2.5; Water-soluble metals; PAHs.

The correlation between PM2.5 exposure and hypertensive disorders in pregnancy: A Meta-analysis

Mengqi Sun a b 1, Wu Yan a b 1, Kacey Fang c, Danrong Chen a b, Jiani Liu a b, Yi Chen d, Junchao Duan e, Rui Chen e, Zhiwei Sun e, Xu Wang a b,Yankai Xia a b

Source: Science of The Total Environment, Volume 703, 10 February 2020, 134985

Objective
To find the correlation between exposure to PM2.5 (fine particulate matter) and hypertensive disorders in pregnancy (HDP), and provide medical evidence for decreasing the incidence of hypertensive disorders in pregnancy.

Method
A combination of computer and manual retrieval was used to search for keywords in PubMed (385 records), Cochrane Library (20 records), Web of Science (419 records) and Embase (325 records). Finally, ten epidemiological articles were considered in this meta-analysis. Stata 13.0 was used to examine the heterogeneity among the studies and to calculate the combined effect value (OR, odds ratio) by selecting the corresponding models. Sensitivity analysis and publication bias test were also performed.

Results
Meta-analysis indicated that there was an association between PM2.5 exposure (per 10 μg/m3 increase) and hypertensive disorders in pregnancy (OR = 1.52, 95% CI: 1.24–1.87). Exposure to PM2.5 (per 10 μg/m3 increase) enhanced the risk of pre-eclampsia (OR = 1.31, 95% CI: 1.07–1.61), but there was no evidence relating exposure to PM2.5 to gestational hypertension (OR = 1.35, 95% CI: 0.98–1.87).

Conclusion
There is a significant link between exposure to PM2.5 and hypertensive disorders in pregnancy. The first and the third trimester were more susceptible to PM2.5 exposure. It is recommended to further strengthen protective measures against PM2.5 during pregnancy.

Keywords: Prenatal exposure; Atmospheric fine particulate matter; PM2.5; Gestational hypertension; Pre-eclampsia.

The contributions of socioeconomic indicators to global PM2.5 based on the hybrid method of spatial econometric model and geographical and temporal weighted regression

Zhaoyang Fu b Rui Li a

Source: Science of The Total Environment, Volume 703, 10 February 2020, 135481

PM2.5 pollution poses a negative effect on human health and economic growth. However, the major socioeconomic driving forces of global PM2.5 pollution during a long-term period remained unclear. In this study, we explored the potential association between socioeconomic indicators and the PM2.5 level worldwide using a spatial econometric model coupled with a geographical and temporal weighted regression (GTWR). The results

suggested that renewable energy consumption ratio, per capita gross domestic production (GDP), per capita CO2 emission, urban population ratio, and fossil fuel consumption ratio were major factors responsible for the global PM2.5 pollution. The impacts of socioeconomic indicators on the PM2.5 level varied with the income-level and time. Fossil fuel consumption ratio, per capita CO2 emission, urban population ratio were major contributors for severe PM2.5 pollution in the developing countries (e.g., China and India). Further, these impacts have become more remarkable in recent years. Per capita GDP still played a crucial role on the PM2.5 pollution in India, indicating that energy-intensive industries were major contributors to its economic growth, thereby leading to the higher PM2.5 concentration in India. However, China has strode across the inflection of Environmental Kuznets Curve (EKC) as a whole and decreased the reliance on the secondary industries. Compared with the developing countries, the impacts of socioeconomic indicators on PM2.5 pollution in most of the developed countries remained relatively stable and weak, implicating that fossil fuel consumption and urbanization were not major contributors for local PM2.5 level. The findings of this study clarified major contributors for PM2.5 pollution, and provided scientific basis for mitigating the PM2.5 pollution.

Keywords: Socioeconomic factors; PM2.5; Spatial econometric model; GTWR.

Effects of land-use patterns on PM2.5 in China's developed coastal region: Exploration and solutions

Yifan Lin a, Xinyi Yuan b, Tianlin Zhai b, Jing Wang b

Source: Science of The Total Environment, Volume 703, 10 February 2020, 135602

While land-use models have often been used to determine the spatial distribution of air pollutant concentrations at urban spatial scales, the effects of land use on PM2.5 concentrations and removal are rarely investigated at regional spatial scales. We studied these effects in Jiangsu Province, which is part of the Yangtze River Delta Urban Agglomeration. Results showed that forest lands and industrial lands had greater effects on the PM2.5 concentration than did other land-use types. In addition, industrial lands and built-up lands had greater effects on the PM2.5 concentrations in winter than in summer. The spatiotemporal change in the PM2.5 concentration was mainly impacted by industrial distribution and development, while the spatiotemporal change in PM2.5 removal was mainly impacted by forest land distribution and change. Therefore, PM2.5 removal was generally higher in rural areas than in urban areas. The spatial PM2.5 concentration slowly increased with net primary productivity (NPP) first and then decreased with NPP, with an inflection point at 19 g C m−2 a−1 NPP. However, the spatial PM2.5 removal per unit area

exponentially increased with NPP. The average removal rate of PM2.5 by forests was about 0.03% in Jiangsu Province, while the absolute removed amount of PM2.5 was about 3013 tons in 2015. It was concluded that the impact of forests on air quality in terms of PM2.5 is significant at regional spatial scales. Therefore, scientific trade-offs and decision-making are necessary to maintain forest ecosystem services in order to improve air quality and human health.

Keywords: Land use, Forest land; PM2.5; PM2.5 removal; Spatial distribution.

PM2.5-bound polycyclic aromatic hydrocarbons and nitro-polycyclic aromatic hydrocarbons inside and outside a primary school classroom in Beijing: Concentration, composition, and inhalation cancer risk

Lulu Zhang a, Hiroshi Morisaki a, Yongjie Wei b, Zhigang Li b, Lu Yang a, Quanyu Zhou a, Xuan Zhang a, Wanli Xing a, Min Hu c, Masayuki Shima d, Akira Toriba e, Kazuichi Hayakawa f, Ning Tang e f

Source: Science of The Total Environment, Volume 705, 25 February 2020, 135840

PM2.5 samples were collected inside and outside a primary school classroom in Beijing in 2015 and analysed for 11 polycyclic aromatic hydrocarbons (PAHs) and 10 nitro-PAHs (NPAHs). In the sampling period in the heating season (namely, the heating period), the median concentrations of indoor and outdoor PAHs were 223 ng/m3 and 264 ng/m3, respectively, and those of indoor and outdoor NPAHs were 3.61 ng/m3 and 5.12 ng/m3, respectively. The concentrations of PAHs and NPAHs were consistently higher in the heating period than those (indoor PAHs: 8.75 ng/m3, outdoor PAHs: 8.95 ng/m3, indoor NPAHs: 0.25 ng/m3, outdoor NPAHs: 0.40 ng/m3) in the sampling period in the non-heating season (namely, the non-heating period). In both periods, total PAHs and total NPAHs in indoor PM2.5, as well as most individual PAHs and NPAHs, were positively correlated with the outdoor PAH and NPAH concentrations ($p < 0.05$). This finding suggests that indoor PAHs and NPAHs are largely dependent on outdoor inputs. It is inferred from the diagnostic ratios that PAHs and NPAHs in indoor and outdoor PM2.5 were affected jointly by coal combustion and vehicular emission in the heating period and mainly derived from vehicle exhaust in the non-heating period. Both indoor and outdoor PM2.5 showed considerable benzo[a]pyrene equivalent toxicity (BaPeq), especially in the heating period. Benzo[c]fluorene (BcFE) had relatively low concentrations but large contributions to BaPeq in both periods. This is the first report of PM2.5-bound BcFE inside and outside classrooms in Beijing. This result indicates that neglecting PAHs with low abundance but high toxicity leads to a significant underestimation of the overall PAH toxicity. The

inhalation cancer risk (CR) of PAHs and NPAHs in PM2.5 during the primary school year exceeded the acceptable level as defined by the U.S. EPA, emphasizing its impact on the lifetime CR in schoolchildren.

Keywords: Schoolchildren; Indoor pollution; Vehicle emission Coal combustion; Benzo[c]fluorine.

Particulate air pollution from different sources and mortality in 7.5 million adults — The Dutch Environmental Longitudinal Study (DUELS)

Paul H. Fischer a, Marten Marra a, Caroline B.Ameling a, Guus J.M.Velders a b, Ronald Hoogerbrugge a, Wilco de Vries a, Joost Wesseling a, Nicole A.H.Janssen a, Danny Houthuijs a

Source: Science of The Total Environment, Volume 705, 25 February 2020, 135778

Background

Long-term exposure to particulate air pollution has been associated with mortality in urban cohort studies. Few studies have investigated the association between emission contributions from different particle sources and mortality in large-scale population registries, including non-urban populations.

Objectives

The aim of the study was to evaluate the associations between long-term exposure to particulate air pollution from different source categories and non-accidental mortality in the Netherlands based on existing national databases.

Methods

We used existing Dutch national databases on mortality, individual characteristics, residence history, neighbourhood characteristics and modelled air pollution concentrations from different sources and air pollution components: particulate matter PM10, primary particulate matter PM10 (PPM10), particulate matter PM2.5, primary particulate matter PM2.5 (PPM2.5), elemental carbon (EC), nitrogen dioxide (NO2) and secondary inorganic aerosol (SIA) in PM10 (SIA10) or in PM2.5 (SIA2.5). We established a cohort of 7.5 million individuals 30 years or older. We followed the cohort for eight years (2008–2015). We applied Cox proportional hazard regression models adjusting for potential individual and area-specific confounders.

Results

We found statistically significant associations between total and primary particulate matter (PM10 and PM2.5), elemental carbon and mortality. Adjustment for nitrogen dioxide did not change the associations. Secondary inorganic aerosol showed less consistent associations. All primary PM sources were associated with mortality, except agricultural emissions and, depending on the statistical model, industrial PM emissions.

Conclusions

We could not identify one or more specific source categories of particulate air pollution as main determinants of the mortality effects found in this and in a previous study. This suggests that present policy measures should be focussed on the wider spectrum of air pollution sources instead of on specific sources.

Keywords: Particulate air pollution; Sources; Non-fatal total mortality; Registration cohort; Secondary inorganic aerosol.

Refined assessment of size-fractioned particulate matter (PM2.5/PM10/PMtotal) emissions from coal-fired power plants in China

Bobo Wu a b, Hezhong Tian a b, Yan Hao a, Shuhan Liu a b, Yujiao Sun c, Xiaoxuan Bai a b, Wei Liu a b, Shumin Lin a b, Chuanyong Zhu b d, Jiming Hao e, Lining Luo a b, Shuang Zhao a b, Zhihui Guo a b

Source: Science of The Total Environment, Volume 706, 1 March 2020, 135735

Chinese coal-fired power plants (CFPPs) are experiencing large-scale and rapid retrofitting of ultralow emission (ULE), causing significant changes in emission level of particulate matter (PM) from CFPPs. In this study, based on coal ash mass balance over the whole process, an integrated emission factors (EFs) database of three size-fractioned particulate matters (PM2.5, PM10, and PMtotal) for CFPPs is constructed, which covers almost all typical ULE technical routes installed in CFPPs. To verify the reliability of PM EFs established in this study, we compare those with related results based on field tests. Overall, the gaps in the EFs of PM2.5, PM10, and PMtotal obtained by the two methods are not outrageous within a reasonable range. By combined with the refined size-fractioned PM EFs and unit-based activity level database, a detailed high-resolution emission inventory of PM2.5, PM10, and PMtotal from Chinese CFPPs in 2017 is established, with the corresponding total emissions of 143, 207, and 267 kt, respectively. Our estimation of PMtotal emission is comparable to the official statistics announced by China Electricity Council (CEC), which further demonstrates the reliability of PM EFs constructed in this study. Moreover, potential reductions of PM from CFPPs at two stages before and after 2017 are assessed under three application scenarios of major ULE technical routes. We forecast the final annual emissions of PM2.5, PM10, and PMtotal until 2020 will be reduced

further, which fall within the range of 86–111 kt, 120–157 kt, and 142–184 kt, respectively, if all CFPPs achieve ULE requirements under the three scenarios. We believe our integrated database of PM EFs of CFPPs has good universality, and the forecast results will be helpful for policy guidance of ULE technologies, emissions inventory compilation, and regional air quality simulation and management.

Keywords: Size-fractioned PM emission factors; Chinese coal-fired power plants; Ultralow emission technical routes; Emission inventory; Scenario projection.

Quantification of primary and secondary sources to PM2.5 using an improved source regional apportionment method in an industrial city, China

Yufang Hao a, Xiangpeng Meng b, Xuepu Yu b, Mingli Lei b, Wenjun Li b, Wenwen Yang a, Fangtian Shi a,Shaodong Xie a

Source: Science of The Total Environment, Volume 706, 1 March 2020, 135715

Identifying and quantifying the major sources of atmospheric particulate matter (PM) is essential for the development of pollution mitigation strategies to protect public health. However, urban PM is affected by local primary emissions, transport, and secondary formation; therefore, advanced methods are needed to elucidate the complex sources and transport patterns. Here, an improved source apportionment method was developed by incorporating the receptor model, Lagrangian simulation, and emissions inventories to quantify PM2.5 sources for an industrial city in China. PM2.5 data including ions, metals, organic carbon, and elemental carbon were obtained by analyzing 1 year of sampling results at urban and rural sites. This method identified coal combustion (30.64%), fugitive dust (13.25%), and vehicles (12.51%) as major primary sources. Secondary sources, including sulfate, nitrate, and secondary organic aerosols also contributed strongly (25.28%–30.76% in total) over urban and rural areas. Hebei Province was the major regional source contributor (43.05%–57.51%) except for fugitive dust, on which Inner Mongolia had a greater impact (43.51%). The megacities of Beijing and Tianjin exerted strong regional impacts on the secondary nitrate and secondary organic aerosols factors, contributing 11.32% and 15.65%, respectively. Pollution events were driven largely by secondary inorganic aerosols, highlighting the importance of reducing precursor emissions at the regional scale, particularly in the Beijing–Tianjin–Hebei region. Overall, our results demonstrate that this novel method offers good flexibility and efficiency for quantifying PM2.5 sources and regional contributions, and that it can be extended to other cities.

Keywords: PM2.5; Source apportionment; Positive matrix factorization (PMF); Secondary sources; FLEXPART.

Integrative characterization of fine particulate matter-induced chronic obstructive pulmonary disease in mice

Qiuyue Li a b, Jingping Sun a b, Xiaowei Chen a b, Siling Li a b, Yan Wang a b, Chunjie Xu a b, Jing Zhao a b, Zhonghui Zhu a b, Lin Tian a b

Source: Science of The Total Environment, Volume 706, 1 March 2020, 135687

The impacts of ambient fine particulate matter (PM2.5) on public health are a worldwide concern. Epidemiological evidence has shown that PM2.5-triggered inflammatory cascades and lung tissue damage are important causes of chronic obstructive pulmonary disease (COPD). However, most laboratory studies of COPD have focused on animal models of cigarette smoke exposure or combined exposure to cigarette smoke and PM2.5. Furthermore, a single method is used to evaluate the development of COPD without integrality. In this study, we investigated pulmonary pathophysiological alterations using integrated functional, morphological, and biochemical techniques and a mouse model exposed to PM2.5 alone for 3 months. Emphysema in this model was confirmed by reconstructed three-dimensional micro-CT images. Typical histopathological signs were neutrophil/macrophage infiltration and accumulation at 2 months after exposure and emphysema/atelectasis at 3 months. Respiratory mechanical parameters confirmed that PM2.5 caused a decline in respiratory function. PM2.5 also triggered complex cytokine profile changes in the lungs with characteristic inflammation-related tissue destruction. This study showed that chronic PM2.5 exposure impaired lung function, triggered emphysematous lesions, and induced pulmonary inflammation and airway wall remodeling. Most importantly, prolonged exposure to PM2.5 alone caused COPD in mice. These results improve the understanding of the mechanisms and mediators underlying PM2.5-induced COPD.

Keywords: PM2.5; COPD; Emphysema.

Sources and vertical distribution of PM2.5 over Shanghai during the winter of 2017

Kun Zhang a b c d, Lei Zhou a c e, Qingyan Fu f Lei Yan a c, Lidia Morawska d, Rohan Jayaratne d, Guangli Xiu a c e

Source: Science of The Total Environment, Volume 706, 1 March 2020, 135683

Shanghai, a metropolitan city in China, has suffered from severe air pollution, especially PM2.5, in the last few years. Up to now the contribution of local emission and regional transport to the formation of haze in Shanghai remains unclear. With an aim to characterize the mechanism of haze formation in Shanghai, the present paper attempted to provide an overview of a tethered balloon-based field campaign. According to the backward trajectories, the air mass traveling slowly from Jiangsu province accounted for the highest PM2.5 concentration (66 ± 20 μg/m3). Seventy vertical profiles of PM2.5, NO, NO2, SO2 and O3 within 1000 m were obtained, through which a comparison study on the characteristics of the vertical distributions of air pollutants on clean days and haze days was conducted. When altitude increased, clearly decreasing pattern of PM2.5, NO, and NO2 was observed during the field campaign. Due to the low atmospheric boundary layer, the diffusion of air pollutants was suppressed, which favored the formation of haze. The results of the generalized additive model revealed NO2 could the most significant factor influencing the vertical distribution of PM2.5 in both clean and haze days. This study provides new insight into the sources and vertical distribution of PM2.5, which could offer references for air pollution modeling.

Keywords: Tethered balloon; GAMs; Vertical profiles; Shanghai.

The characteristics and mixing states of PM2.5 during a winter dust storm in Ningbo of the Yangtze River Delta, China

Qiu-Liang Cai a b c 1, Xiao-Rong Dai a c 1, Jian-Rong Li a c, Lei Tong a c, Yi Hui a b c, Ming-Yang Cao d, Mei Li e, Hang Xiao a c

Source: Science of The Total Environment, Volume 709, 20 March 2020, 136146

Dust particulates play an essential role for the nucleation, hygroscopicity and also contribute to aerosol mass. We investigated the chemical composition, size distribution and mixing states of PM2.5 using a single-particle aerosol mass spectrometer (SPAMS), Monitor for AeRosols and Gases (MARGA), and off-line membrane sampling from 2018.1.24 to 2018.2.20 at a coastal supersite in Ningbo, a port city in Yangtze River Delta, China. During the study campaign, the eastern part of China had experienced a wide range of cooling, sandstorm, and snowfall processes. The entire sampling campaign was categorized into five sub-periods based on the levels of PM2.5 and the ratios of PM2.5/PM10, namely clean (T1), heavy pollution (T2), light pollution (T3), dust (sandstorm) (T4) and cleaning pollution (T5) period. After comparing the average mass spectrum for each period, it shows that the primary ions, such as Ca2+and SiO3−, rarely coexist with each other within a single

particle, but secondary ions generally coexist with these primary ions. Furthermore, the coexistence of each two different ions within a particle does not show distinct variation for the whole study periods. All these suggest that the absorption and partitioning of gaseous contaminants into the surface of primary aerosol through heterogeneous reactions are the major pathways of aging and growth of aerosol; and the merging of particles through collisions usually is insignificant. Although the absolute concentrations of nitrate and sulfate all increased with the PM2.5 concentrations, the relative equivalent concentrations of NO3− and SO42− displayed opposite trends; the relative contribution of sulfate decreased and that of nitrate increased as the increase of pollution. During the dust period, the relative equivalent concentrations of calcium and/or potassium ions in PM2.5 are significantly higher. This study provided deep insights about the mixing states and characteristics of particulate after long-range transport and a visualization tool for aerosol study.

Keywords: Mixing state; SPAMS, MARGA; Coexistence; Dust; Modified Piper diagram.

The two-way feedback effect between aerosol pollution and planetary boundary layer structure on the explosive rise of PM2.5 after the "Ten Statements of Atmosphere" in Beijing

Tian Zhang a b, Huizheng Che a, Zhiqiang Gong c, Yaqiang Wang a, Jizhi Wang a, Yuanqin Yang a, Ke Gui a, Bin Guo a b

Source: Science of The Total Environment, Volume 709, 20 March 2020, 136259

Are there still persistent heavy aerosol pollution episodes (HPEs) in Beijing one year after the implementation of the "Action Plan for the Prevention and Control of Air Pollution ("Ten Statements of Atmosphere" in China: 2013–2017)"? Will the cumulative aerosol pollution still induce significant two-way feedback between PM2.5 and the planetary boundary layer structure? Answers to these matters are particular concerns of the government and the public. The analysis of the vertical structure of the aerosol and meteorological factors in planetary boundary layer shows that the two-way feedback between unfavorable meteorological conditions and PM2.5 pollution cumulating is still the primary mechanism for the maintenance of HPEs, accounting especially ~66% to 88% for explosive rise in PM2.5, in autumn and winter in Beijing area a year after the "Ten Statements of Atmosphere". This effect also shows that the concentration of PM2.5 in Beijing had not fallen low enough to decouple the influence of unfavorable meteorological factors. The increased level of PM2.5 mass during the explosive rise stage was similar to those of the precursor gases of NO2, SO2 and CO, as well as to the declining ratio of the

boundary layer height (BLH), which also suggest that the interaction between PM2.5 cumulating and the boundary layer structure is playing a leading role for the maintenance of HPEs and the PM2.5 explosive rise in Beijing. The depolarization ratio signal of the Lidar also shows that the transit of mineral aerosols from the northwest over Beijing often appears in the upper layer of the planetary boundary layer or higher atmosphere during the late or subside stage of HPEs.

Keywords: Two-way feedback effect; Planetary boundary layer structure; Vertical structure of aerosol optical properties; Explosive rise of PM2.5; Lidar.

Cause and Age-specific premature mortality attributable to PM2.5 Exposure: An analysis for Million-Plus Indian cities

Prateek Saini Mukesh Sharma

Source: Science of The Total Environment, Volume 710, 25 March 2020, 135230

In India, a majority population is exposed to high levels of ambient PM2.5 resulting in adverse health outcomes. Epidemiological studies have associated diseases such as Ischemic Heart Disease (IHD), Cerebrovascular Disease (Stroke), Chronic Obstructive Pulmonary Disease (COPD), Lower Respiratory Infection (LRI), and Lung Cancer (LNC) to long-term PM2.5 exposure resulting in premature mortality. In the present work, the Integrated Exposure Response (IER) model is used to estimate such premature deaths for the year 2016 in 29 million-plus Indian cities. The city-specific registered deaths data along with information of percent share of cause-specific deaths in the total deaths and measured ambient PM2.5 concentrations are used to estimate cause-specific baseline mortality in a city. The premature mortality attributable to PM2.5 exposure is estimated from this baseline mortality. The premature mortality burden attributable to PM2.5 exposure in these cities is 114,700 (104,100–125,500) deaths from the five causes (IHD, Stroke, COPD, LRI, and LNC). IHD is the leading cause of death accounting for 58% of PM2.5 related premature deaths, followed by Stroke (22%), COPD (14%), LRI (4%), and LNC (2%) in these 29 cities. The estimated number of PM2.5 related deaths in productive age group (25 – 50 years) is quite low compared to older people, but the percentage share of these deaths in the cumulative cause-specific baseline deaths is higher for productive age group. Thus, the productive population is considerably at a higher risk of mortality due to PM2.5 exposure. There is approximately 18% and 70% reduction in premature mortality if these cities can attain National Ambient Air Quality Standards (NAAQS) (40 μg/m3) and the World Health Organization (WHO) guidelines (10 μg/m3) of annual PM2.5, respectively. The estimates of air pollution related mortality at the city level could assist in city-specific policy formulation for better air pollution control.

Keywords: Registered Deaths; Baseline mortality; Measured PM2.5 levels; Indian cities; Integrated Exposure Response.

Explore a Multivariate Bayesian Uncertainty Processor driven by artificial neural networks for probabilistic PM2.5 forecasting

Yanlai Zhou a b, Li-Chiu Chang c, Fi-John Chang a

Source: Science of The Total Environment, Volume 711, 1 April 2020, 134792

Quantifying predictive uncertainty inherent in the nonlinear multivariate dependence structure of multi-step-ahead PM2.5 forecasts is challenging. This study integrates a Multivariate Bayesian Uncertainty Processor (MBUP) and an artificial neural network (ANN) to make accurate probabilistic PM2.5 forecasts. The contributions of the proposed approach are two-fold. First, the MBUP can capture the nonlinear multivariate dependence structure between observed and forecasted data. Second, the MBUP can alleviate predictive uncertainty encountered in PM2.5 forecast models that are configured by ANNs. The reliability of the proposed approach was assessed by a case study on air quality in Taipei City of Taiwan. We consider forecasts of PM2.5 concentrations as a function of meteorological and air quality factors based on long-term (2010–2018) hourly observational datasets. Firstly, the Back Propagation Neural Network (BPNN) and the Adaptive Neural Fuzzy Inference System (ANFIS) were investigated to produce deterministic forecasts. Results revealed that the ANFIS model could learn different air pollutant emission mechanisms (i.e. primary, secondary and natural processes) from the clustering-based fuzzy inference system and produce more accurate deterministic forecasts than the BPNN. The ANFIS model then provided inputs (i.e. point estimates) to probabilistic forecast models. Next, two post-processing techniques (MBUP and the Univariate Bayesian Uncertainty Processor (UBUP)) were separately employed to produce probabilistic forecasts. The Bayesian Uncertainty Processors (BUPs) can model the dependence structure (i.e. posterior density function) between observed and forecasted data using a prior density function and a likelihood density function. Here in BUPs, the Monte Carlo simulation was introduced to create a probabilistic predictive interval of PM2.5 concentrations. The results demonstrated that the MBUP not only outperformed the UBUP but also suitably characterized the complex nonlinear multivariate dependence structure between observations and forecasts. Consequently, the proposed approach could reduce predictive uncertainty while significantly improving model reliability and PM2.5 forecast accuracy for future horizons.

Keywords: Air quality; Probabilistic forecast; Bayesian Uncertainty Processor; Artificial intelligence; Taipei City.

Physical and chemical mechanisms of the daily-to-seasonal variation of PM10 in Korea

Seung-Uk Kim Kwang-Yul Kim

Source: Science of The Total Environment, Volume 712, 10 April 2020, 136429

In this study, the CSEOF technique is used to investigate the physical and chemical mechanisms associated with the weekly PM10 variation in South Korea. For this end, 9 years of hourly measurements of PM10 in South Korea is used together with other gaseous contaminants (NO2, SO2, CO and O3) and traffic counts at the toll gates. The diurnal variation of PM10 concentrations indicates a significant correlation with human activities; higher concentrations in densely populated areas with a large volume of traffics and vice versa. In particular, the diurnal cycles of PM10, NO2 and CO show bimodal structures with maxima corresponding to the morning and evening rush hours. While NO2 and CO maxima are observed at ~9 AM, with some delay from the traffic maximum, PM10 peak is observed ~11 AM, indicating roughly 2 h of conversion process from gaseous pollutants to particulate matter. After the sunset, gas-to-particle conversion efficiency is significantly reduced and PM10 concentration begins to increase slowly. SO2 exhibits a slightly different feature, showing diurnal variation with a single peak at 11 AM and relatively minor contribution to the diurnal variation of PM10. O3 participates in the photochemical reactions of the gaseous pollutants, providing OH radical as an oxidant. Physical factors (e.g. boundary layer height, 10 m wind gust, wind convergence) affecting horizontal and vertical mixing of polluted air are responsible for dispersion of accumulated PM10 in the afternoon. As a result, strong morning-evening asymmetry is seen in the diurnal variation of PM10 concentrations. Also, notable seasonal dependency is observed in the concentrations of PM10 and the gaseous contaminants due to the seasonal variation of emission and the physical factors.

Source apportionment and toxicity assessment of PM2.5-bound PAHs in a typical iron-steel industry city in northeast China by PMF-ILCR

Shibao Wang Yaqin Ji Jingbo Zhao Yu Lin Zi Lin

Source: Science of The Total Environment, Volume 713, 15 April 2020, 136428

This study was designed to evaluate the occurrence and variation in concentrations, sources and cancer risk of PM2.5-bound PAHs. Airborne PM2.5-bound PAHs were sampled during a one-year campaign (2014–2015) in Anshan city, a typical iron and steel city in northeast China. A total of 374 PM2.5 samples were collected. A source-oriented positive matrix factorization (PMF) model and PAH diagnostic ratios were used to investigate the potential sources of PAHs in the atmospheric environment of Anshan, and the lifetime cancer risk of the population associated with PAHs through inhalation exposure was assessed by a PMF-ILCR model. Concentrations of PM2.5 and 16 PAHs ranged from 13.55 μg/m3 to 315.96 μg/m3 and 5.08 ng/m3 to 520.02 ng/m3, respectively. These values were higher in winter. PAH content from stationary sources and biomass combustion was higher than from other sources. Through the coefficient of divergence and localized PAH diagnostic ratio methods, we concluded that PM2.5-bound PAHs in Anshan originated mainly from the following sources: biomass combustion, vehicle emissions, fugitive dust, coking dust and natural gas emissions. Based on the source-oriented PMF model, coal combustion, fugitive dust, vehicle emissions, coking dust, and biomass combustion were the main sources contributing to PM2.5, accounting for 26.3%, 24.6%, 21.9%, 18.0%, and 6.3% of PM2.5, respectively. According to the PMF-ILCR model results, ILCR risks estimated for adults and children were respectively 1.19 × 10−5 and 8.55 × 10−6 in winter, higher than in other seasons, and higher than the threshold value (10−6). Together, vehicle emissions (diesel exhaust and gasoline exhaust), coal combustion and coking dust, contributed to over 86% of the cancer risk associated with PM2.5-bound PAHs exposure in Anshan.

Keywords: PAHs; Coefficient of divergence; Diagnostic ratios; PMF-ILCR model; Anshan city.

Characterization of atmospheric PM2.5 sources at a Central European urban background site

Katarzyna Juda-Rezler a, Magdalena Reizer a, Katarzyna Maciejewska a, Barbara Błaszczak b, Krzysztof Klejnowski b

Source: Science of The Total Environment, Volume 713, 15 April 2020, 136729

For the purposes of this work, a first in Poland, full-year collection of daily PM2.5 (particulate matter with aerodynamic diameter smaller than 2.5 μm) samples was chemically analyzed to determine the contents of elemental and organic carbon, water-soluble inorganic ions and 21 minor and trace elements in PM in an urban background site in Warsaw. Annual mean PM2.5 concentration reached 18.8 μg/m3, with the lowest levels in summer (11.5 μg/m3 on average) and the highest in winter (27.5 μg/m3), with several

episodes reaching over 80 μg/m3. Strong seasonal differences were observed mainly for the contents of nitrate and secondary organic carbon (SOC), while sulphate showed the least variability. Secondary species constituted on average 45% of PM2.5 mass, suggesting large influence of regional and long-range transport of pollutants. Source apportionment with the use of positive matrix factorization (PMF) method, supported by the analysis of enrichment factors, led to identification of six main sources of PM2.5 origin: residential combustion (fresh & aged aerosol) (46% of PM2.5 mass), traffic exhaust (21%) and non-exhaust (10%) emissions, mineral dust/construction works (12%), high-temperature processes (8%) and steel processing (3%). Including primary organic carbon (POC) and SOC as two separate constituents helped to distinguish between the primary and secondary sources of the aerosol. The identification of sources was also supported by investigating their yearly and weekly profiles, as well as the correlation of PM constituents with meteorological conditions, which are one of the main drivers of heat generation activities. We found that the most distinctive markers of PM sources in Warsaw are SOC, Cl− and As for residential combustion, NH4+, Sb and POC for road transport, Ca and Mg for construction works and SO42− for long-range transport of PM.

Keywords: Particulate air pollution; Chemical composition; Source apportionment; Positive matrix factorization; Enrichment factors; Poland.

Joint pollution and source apportionment of PM2.5 among three different urban environments in Sichuan Basin, China

Jin Fan a, Yanan Shang b, Xiaojiao Zhang a, Xinni Wu a, Meng Zhang a, Jiayang Cao a, Bin Luo c, Xiaoling Zhang a, Shigong Wang a, Shuangzhi Li a, Hangqi Liu a, Pingli Wu d

Source: Science of The Total Environment, Volume 714, 20 April 2020, 136305

The PM2.5 were sampled in three different urban environments: (city of) Chengdu, Leshan, and Dazhou, which are located in Sichuan Basin. 8 types of water-soluble ion and 25 types of metal element were measured in each PM2.5 sample across the seasons of 2017. The study results suggest that the joint PM2.5 pollution among the three cities mainly occurred in autumn and winter, and the air quality of Chengdu and Leshan was largely affected by Dazhou. Overall, the mass concentrations of PM2.5 of these three cities exhibited no statistically significant differences. However, Leshan had the highest level of ionic pollution, and the dominant form of inorganic compound in ambient PM2.5 was NH4NO3, and a competitive relationship between form of NH4NO3 and (NH4)2SO4 (NH4HSO4) was found as well. High homology between SO42− and NO3− has been observed in all the three cities, and the ratio between [SO42−] and [NO3−] indicated that the stationary source contributed the most to ambient PM2.5 in Dazhou. The mass concentrations of the total metal elements

from the three cities exhibited similar levels, nevertheless, Dazhou had the highest mass fraction of total metal elements in PM2.5. The enrichment factor of each element indicated that the natural source was highly contributory to the crustal elements in PM2.5 of all the three cities, whereas Cr, Cu, Se, Mo, Cd, Tl and Bi were primarily originated from anthropogenic source. In addition, the source apportionment of PM2.5 suggest that Dazhou had the different factors and factor-contributions comparing with Chengdu and Leshan.

Keywords: HYSPLIT; PMF; Enrichment factor; Chengdu; Leshan; Dazhou

Significant ultrafine particle emissions from residential solid fuel combustion

Dongbin Wang a b, Qing Li c, Guofeng Shen d, Jianguo Deng a, Wei Zhou a 1, Jiming Hao a b, Jingkun Jiang a b

Source: Science of The Total Environment, Volume 715, 1 May 2020, 136992

When addressing particulate matter (PM) emissions from residential solid fuel combustion, ultrafine particles are usually merged into PM2.5, while whose mass concentration is applied as the index in evaluating PM pollution as well as assessing PM-induced health risk. This may not effectively represent the risk from ultrafine particles. In this study, we explored ultrafine particle emissions during residential combustion under both laboratory-controlled and real-world rural household conditions. Significant ultrafine particle emissions (i.e. with emission factors between 2 × 1015 to 2 × 1016 particles per kg of fuel) are found for both coal and biomass. High emissions of particle mass concentration often occur at the beginning of the combustion (i.e. the first 30 min after fire start) while high emissions of particle number concentration occur in a later combustion period (60–150 min). Ultrafine particles account for over 90% of the emitted total particle number concentration from 3 nm to 10 μm. These emissions elevate ultrafine particle number concentration by more than a decade in indoor environment under which household residents are directly exposed. In addition, we show that there is notable inconsistency between reducing PM2.5 mass based emissions and reducing ultrafine particle number based emissions among various control strategies that were proposed for reducing pollution from residential combustion. Both “cleaner” fuels and stoves that are designed to reduce PM2.5 emissions are found to be not necessarily effective in reducing ultrafine particle emissions, even increase their emissions in some cases. These findings indicate that the overlook of ultrafine particle emissions from residential solid fuel combustion can lead to potential health risk to household residents, especially to those vulnerable ones (e.g., the elderly and children) who are more sensitive to indoor air pollution. More

attentions are needed on ultrafine particle pollution and its potential health risk in comparison to using the PM mass concentration index alone.

Keywords: Residential solid fuel combustion; Ultrafine particles;PM2.5;Number concentration; Health risk.

Evaluating the contributions of changed meteorological conditions and emission to substantial reductions of PM2.5 concentration from winter 2016 to 2017 in Central and Eastern China

Wenjie Zhang a, Hong Wang a b, Xiaoye Zhang a c, Yue Peng a, Junting Zhong a, Yaqiang Wang a, Yifan Zhao a

Source: Science of The Total Environment, Volume 716, 10 May 2020, 136892

The monthly average PM2.5 concentration decreased from 127.15 μg m−3 in December 2016 to 85.54 μg m−3 in December 2017 (approximately 33%) in Central and Eastern China (33°N–41°N, 113°E–118°E). This decrease is attributed to the combined impacts of meteorology and emission sources changes, though the question of which is more important has raised great concerns. Four sensitivity experiments based on the Global-Regional Assimilation and Prediction System coupled with the Chinese Unified Atmospheric Chemistry Environment (GRAPES-CUACE) model, together with comparative analysis of the observed meteorological conditions and emission inventory between 2016 and 2017, are used to evaluate the relative contributions of meteorology and emission to the substantial reductions of PM2.5 concentration from December 2016 to December 2017. The results show that the meteorological conditions and emission in December 2017 were both beneficial to the PM2.5 decrease in Central and Eastern China. Regarding the entire region, 21.9% of the PM2.5 decrease was a result of the favorable meteorological conditions, and 78.1% of the decrease was a result of emission reductions, showing the distinct contributions of emission reductions on the air quality. The relative contributions of meteorology varied from 12.2% to 50.9% to the PM2.5 decrease from December 2016 to December 2017, while the emission contributed 49.1% to 87.8%, in different cities depending on geographical location and topography. Meteorology showed the largest contributions to the PM2.5 decrease from 2016 to 2017 in Beijing (BJ), which caused the greatest total decrease of PM2.5 compared to that of other cities. In addition, in Central and Eastern China, the dominant factors of the decrease of PM2.5 were favorable meteorological conditions (accounting for 98.2%) during clear periods and emission reductions (accounting for 72.5–81.2%) during pollution periods.

Keywords: Central and Eastern China; Meteorological conditions; Emission; GRAPES-CUACE model; PM2.5 concentration.

The distribution and drivers of PM2.5 in a rapidly urbanizing region: The Belt and Road Initiative in focus

Kai Fang a b, Tingting Wang a, Jianjian He a, Tijian Wang c, Xiaodong Xie c, Yiqi Tang a, Yang Shen d e, Anqi Xu a

Source: Science of The Total Environment, Volume 716, 10 May 2020, 137010

The accelerating urbanization has led to serious air pollution dominated by PM2.5, posing a critical challenge for the environmental sustainability of the Belt and Road Initiative (BRI). However, a focus on the distribution and drivers of PM2.5 concentrations in BRI is lacking. To fill in the gap, this study explores the spatio-temporal distribution of PM2.5 concentrations in 74 nations partnering the BRI and identifies the socioeconomic and natural drivers behind the variation through the joint use of spatial autocorrelation and regression analyses. We find that the PM2.5 concentrations of BRI show significant spatial autocorrelation and spatial heterogeneity on the national scale. The most heavily polluted regions are observed mainly in China, Southeast Asia, South Asia, West Asia and North Africa, particularly in the Arabian Gulf region. Energy intensity and per capita electricity consumption act as the major drivers of the PM2.5 concentrations, whereas the expanding forest area contributes to the decrease in PM2.5 concentrations notably. Our findings highlight the need for speeding up new-type urbanization as part of the green BRI practice, calling for international cooperation and coordinated action aimed at enhancing synergies of air-quality and climate policies that at present are mostly launched and implemented in isolation. From a broader point of view, in struggling towards BRI's cleaner air, more attention should be paid to creating policy synergies between the green BRI, the Paris Agreement, and the United Nations 2030 Agenda for Sustainable Development.
Keywords: Air pollution; PM2.5 concentrations; Urbanization; Spatial econometrics; Belt and Road Initiative.

Variability of air pollutants, and PM composition and sources at a regional background site in the Balearic Islands: Review of western Mediterranean phenomenology from a 3-year study

José C.Cerro a b, Víctor Cerdà a, Xavier Querol c, Andrés Alastuey c, Carles Bujosa d, Jorge Pey e

Source: Science of The Total Environment, Volume 717, 15 May 2020, 137177

The present study discloses the results of a comprehensive 3-years campaign (2010–2012) of air pollution measurements over an regional island background area (Can Llompart-Balearic Islands, Spain), contextualized with other measurements in the western Mediterranean region.
Gaseous pollutants and particulate matter fractions were measured in real time; and PM10 and PM1 daily samples were obtained regularly from which chemical analyses were performed. Furthermore, during three intensive observation periods, real-time concentrations of particle number, black carbon and ammonia were additionally measured.
Our results display particular diurnal and seasonal patterns for certain pollutants such as O3 and particle number concentration.
Our study reveals that concentrations of air pollutants and aerosol chemical composition are rather similar all over the central and western Mediterranean basin. The most abundant chemical components in PM10 were mineral dust, followed by organic matter, sea spray and SO42−; in PM1 organic matter and SO42− dominated, with significant contribution of mineral dust.
Furthermore, a source apportionment Positive Matrix Factorization analysis was conducted. Natural sources exert most of the impact on the coarse-mode fraction, while most of fine-mode aerosols are linked to anthropogenic sources coming from local, regional or long range transport emissions.
Prevalence of Atlantic air masses in 2010 had a positive effect in air quality, lowering mineral dust, SO42− and EC concentrations. On the contrary, the high incidence of African dust and regional recirculation situations during the 2012 warm season favoured an overall PM load increase governed by mineral dust, SO42− and trace elements associated to dust aerosols.
The continuous increase in tourists in the Balearic Islands, and in general all around the Mediterranean, is clearly changing air quality patterns: while urban air pollution has strongly decreased since 2010, such downward trend is less pronounced at the regional scale, thus related to crescent sources such as maritime and air transport.

Keywords: Aerosol; Particulate chemical composition; Source apportionment; Gas pollutants; Mediterranean; Air quality.

Quantifying public health benefits of PM2.5 reduction and spatial distribution analysis in China

Guiwen Luo 1, Lanyi Zhang 1, Xisheng Hu Rongzu Qiu

Source: Science of The Total Environment, Volume 719, 1 June 2020, 137445

In recent years, particulate matter (PM) air pollution has become a significant and growing public health problem in China. In this study, the daily PM2.5 exposure level at a spatial resolution of 100 km2 was simulated based on the data of 1328 monitoring sites and the Voronoi Neighborhood Averaging (VNA) interpolation method. The results reveal that the daily mean PM2.5 concentration reduced from 47.82 μg/m3 (2016) to 40.87 μg/m3 (2018), a reduction of 14.53%. We first calculated the heath impacts and economic benefits of this reduction (Scenario 1) by using Environmental Benefits Mapping and Analysis Program (BenMAP). The estimated avoided premature mortalities for all-cause, cardiovascular diseases, respiratory diseases, and lung cancer were in the range of 7214 to 81,681 cases (total of 154,176 cases). The estimated economic benefits based on willingness to pay (WTP) ranged from 3.96 to 44.85 billion RMB (total of 84.66 billion RMB). Moreover, the PM2.5 concentration in the control scenario was rolled back to the Grade I standards (35 μg/m3, Scenario 2). The avoided deaths are in the range of 58,820 to 590,464 cases (total of 1,217,671 cases). The estimated monetary value of the avoided cases of all health endpoints range from 36.63 to 367.66 billion RMB based on WTP (total of 758.21 billion RMB). In addition, the spatial autocorrelation analysis reveals that the distribution of both avoided premature mortality and economic benefits exhibit a certain spatial aggregation.

Keywords: PM2.5; Health benefits; Spatial distribution; BenMAP; China.

Assessing the usefulness of dense sensor network for PM2.5 monitoring on an academic campus area

Marek Badura a, Izabela Sówka a, Piotr Szymański b, Piotr Batog c

Source: Science of The Total Environment, Volume 722, 20 June 2020, 137867

Low-cost sensors provide an opportunity to improve the spatial and temporal resolution of air quality measurements. Networks of such devices may complement the traditional air quality monitoring and provide some useful information about pollutants and their impact on health. This paper describes the network of 20 nodes for ambient PM2.5 monitoring on a campus area of Wrocław University of Science and Technology (Wrocław, Poland). Sensor nodes were equipped with optical sensors PMS A003 (Plantower), which showed high reproducibility between units. The distribution of the sensor nodes was characterised by both high density (14 devices on the main campus area) and wide spread across the city (6 devices on peripheral campuses). During the measurement campaign, signals from sensor nodes were consistent with results from regulatory monitoring stations and sensor devices were capable of indicating elevated levels of PM2.5 concentrations. A great advantage of this system was the ability to provide up-to-date air quality information to the public.

Furthermore, air quality messaging was site-specific because of the observed differences in PM2.5 concentrations. Data analysis was aimed at assessing variability between locations using Kendall's τ metric and assessing the statistical significance of the differences in measurement results from neighbouring sensor nodes using the Kolmogorov-Smirnov test. The analysis showed high importance of the nodes in the middle of the main campus and variations of signals from nodes on the peripheries. Differences in signals from sensors located in close proximity to each other were in some cases significant, but only for short-term averaged data. Nevertheless, highly visible variation in PM2.5 signals was observed in the case of nodes arranged vertically on two buildings. PM2.5 concentrations were even 2–4 times greater near the top parts of the buildings than near the ground. The effect of stratification of PM2.5 levels was observed under conditions of temperature inversion.

Keywords: Ambient air quality; Particulate matter; Real-time exposure; Local variability; PM2.5 stratification; Temperature inversion.

Spatiotemporal and probability variations of surface PM2.5 over China between 2013 and 2019 and the associated changes in health risks: An integrative observation and model analysis

Zhongjing Jiang a, Matthew D.Jolleys b, Tzung-MayFu c d, Paul I.Palmer b, Yaping Ma a, Heng Tian a, Jing Li a, Xin Yang c d

Source: Science of The Total Environment, Volume 723, 25 June 2020, 137896

We used statistical methods and the GEOS-Chem model to interpret the observed spatiotemporal and probability variations of surface PM2.5 concentrations in China from December 2013 to November 2019, as well as to assess the drivers for the variations and the implications for health risks associated with long-term and short-term exposure to PM2.5. Annual and seasonal PM2.5 concentrations have decreased over most areas in China during the 6-year period. We decomposed the observed day-to-day variation of PM2.5 concentrations in eastern Chinese cities and found that it showed two distinct major spatial modes, which fluctuated in strength seasonally. The first mode, characterized by most of Eastern China being in the same phase, was mainly associated with the regional ventilation of pollutants. The second mode showed a dipolar pattern between the Beijing-Tianjin-Hebei area and the Yangtze River Delta area and was more prominent in summer. Using model simulations, we showed that this dipole mode was chemically driven by the secondary formation of sulfate in summer. We further used a gamma distribution to succinctly interpret the changes in the probability distributions of PM2.5. We found that

the nationwide decline in seasonal mean PM2.5 concentrations mainly reflected decreased occurrences of extremely high PM2.5 concentrations, which was strongly driven by the interannual variation of meteorology. These changes in the annual means and probability distributions of PM2.5 since December 2013 has led to significant decline of the estimated mortality risks associated with long-term and short-term PM2.5-exposures. Regions that were less polluted saw the largest relative benefit per unit decrease in PM2.5 concentration, due to the steepness of the exposure-response curve at the low-concentration end. Our integrated methodology effectively diagnosed the drivers of PM2.5 variability and the associated health risks and can be used as part of the decision tool for PM2.5 pollution management over China.

Keywords: PM2.5; Spatiotemporal variability; Probability distribution;Public health; GEOS-Chem model.

Spatiotemporal characteristics of PM2.5 concentration in the Yangtze River Delta urban agglomeration, China on the application of big data and wavelet analysis

Jiajia Wang a, Xiaoman Lu a, Yingting Yan a, Liguo Zhou a b, Weichun Ma a b

Source: Science of The Total Environment, Volume 724, 1 July 2020, 138134

PM2.5 pollution has been one of the main environmental issues of concern for the Yangtze River Delta Urban Agglomeration (YRDUA) during the recent decade. In this paper, allied with big data and wavelet analysis, spatiotemporal variations of PM2.5 and its influencing factors (air pollutants and meteorological factors) are studied based on hourly concentrations of PM2.5 from 2015 to 2018 in the YRDUA. Results showed that PM2.5 presented a step-shaped decline from northwest to southeast in space and significant multi-scale temporal variations in time. On the macroscopic level, PM2.5 concentrations decreased from 2015 to 2018, showing a U-shaped pattern within a year. On the microscopic level, it had a four-stage annual variation (January to March, April to June, July to September, October to December) and the mutation events mainly occurred in winter. There were two dominant periods of PM2.5, an annual cycle on the time scale of 250–480 d and a semi-annual cycle on the time scale of 130–220 d. In addition, PM2.5 showed time scale-dependent correlations with air pollutants and meteorological factors. Among air pollutants, the correlation between PM2.5 and CO was the most consistent, and the correlation between PM2.5 and SO2/NO2 improved with the increase of time scale, while the correlation between PM2.5 and O3 was positive at shorter time scales but negative at broader time scales. Among meteorological factors, the correlations between PM2.5 and wind speed, precipitation, temperature, air pressure and relative

humidity were mainly reflected at broader time scales. These findings would be helpful to improve the accuracy of prediction model and provide references for the ongoing joint prevention and control.

Keywords: PM2.5; YRDUA; Big data; Wavelet analysis; Air pollution.

Health impact analysis of PM2.5 from wildfire smoke in Canada (2013–2015, 2017–2018)

Carlyn J.Matz a, Marika Egyed a, Guoliang Xi b, Jacinthe Racine c, Radenko Pavlovic c, Robyn Rittmaster d, Sarah B. Henderson e, David M.Stieb f

Source: Science of The Total Environment, Volume 725, 10 July 2020, 138506

Smoke from wildfires contains many air pollutants of concern and epidemiological studies have identified associations between exposure to wildfire smoke PM2.5 and mortality and respiratory morbidity, and a possible association with cardiovascular morbidity. For this study, a retrospective analysis of air quality modelling was performed to quantify the exposure to wildfire-PM2.5 across the Canadian population. The model included wildfire emissions from across North America for a 5-month period from May to September (i.e. wildfire season), between 2013 and 2015 and 2017–2018. Large variations in wildfire-PM2.5 were noted year-to-year, geospatially, and within fire season. The model results were then used to estimate the national population health impacts attributable to wildfire-PM2.5 and the associated economic valuation. The analysis estimated annual premature mortalities ranging from 54–240 premature mortalities attributable to short-term exposure and 570–2500 premature mortalities attributable to long-term exposure, as well as many non-fatal cardiorespiratory health outcomes. The economic valuation of the population health impacts was estimated per year at $410M–$1.8B for acute health impacts and $4.3B–$19B for chronic health impacts for the study period. The health impacts were greatest in the provinces with populations in close proximity to wildfire activity, though health impacts were also noted across many provinces indicating the long-range transport of wildfire-PM2.5. Understanding the population health impacts of wildfire smoke is important as climate change is anticipated to increase wildfire activity in Canada and abroad.

Keywords: Wildland fires; Wildfires; Health impact analysis; Economic valuation; PM2.5; Canada.

Climate anomalies contributed to the rebound of PM2.5 in winter 2018 under intensified regional air pollution preventions

Zhicong Yin a b c, Yijia Zhang a

Source: Science of The Total Environment, Volume 726, 15 July 2020, 138514

Rigorous air pollution managements since 2013 resulted in decreasing trend in fine particulate matter (PM2.5) in China. Regional air pollution prevention measures were extra implemented in the "2 + 26" region since 2017. However, haze pollution dramatically rebounded in the winter of 2018. Both of the observed analyses and the numerical results (basing on a global 3-D chemical transport model) demonstrated that, although intensified prevention measures existed, atmospheric circulation and local meteorological conditions still significantly influenced the variation in haze pollution. The simulated PM2.5 concentrations (with fixed emissions) driven by meteorology in 2018 were 12–15% higher than those with atmospheric circulations in 2017 both under a low and a high emission level, close to the observed 10% PM2.5 rebound. In 2018, positive sea ice anomalies around Beaufort Sea and "triple pattern" anomalies of sea surface temperature in the North Pacific and North Atlantic enhanced the anomalous anticyclonic circulations over the air-polluted region, and thus resulted in minimum surface wind speed during 1979–2018 and 16.8% shallower boundary layer than those in 2017. In the stagnated air of winter 2018, the transported dispersion of pollutant particles was weakened, however more secondary aerosols were produced by enhanced chemical reactions, which jointly contributed to the PM2.5 rebound in 2018.

Keywords: Air pollution; Atmospheric teleconnection; PM2.5; Emission reduction.

The impact of diesel vehicles on NOx and PM10 emissions from road transport in urban morphological zones: A case study in North Rhine-Westphalia, Germany

Janos Lucian Breuer a, Remzi Can Samsun a, Ralf Peters a, Detlef Stolten a b c

Source: Science of The Total Environment, Volume 727, 20 July 2020, 138583

Harmful emissions like nitrogen oxide and particulate matter are one of the big challenges facing modern society. These emissions are especially apparent in agglomerations. Possible solutions to overcome this challenge within the framework of the transformation of the transport sector are the change of the transport vehicles of freight and passenger transport

or changing the fuel of the vehicles. Determining the viability of both approaches requires analyses to determine which vehicles are the main polluters in urban areas. This study outlines a bottom-up approach for the calculation of road transport emissions on street level in the representative model region of North Rhine-Westphalia in Germany, considering eight different vehicle classes as well as diesel and gasoline as fuel. Part of the approach is the development of a street-section traffic volume map considering all streets in the model region using a developed multivariate linear regression model for Germany and existing traffic counts. Using the approach developed here, the urban areas of Herne, Oberhausen and Bochum were identified as hotspots with the highest specific nitrogen oxide emissions, while the urban areas of Herne, Oberhausen and Gelsenkirchen were identified as hotspots with the highest specific particulate matter emissions. A detailed investigation of Oberhausen as a representative emission hotspot showed that 91% of road transport nitrogen oxide emissions are produced by vehicles that use diesel fuel and 9% from vehicles with gasoline fuel, while gasoline vehicles account for 43% of the total distance driven and diesel vehicles for 57%. With respect to particulate matter emissions in the urban area of Oberhausen, 29% are produced by gasoline vehicles and 71% by diesel vehicles. However, only 22% of particulate matter emissions are exhaust emissions, while 78% are produced due to the abrasion of tires, brakes and the road.

Keywords: Transport; Spatial; Mapping; Air pollution; Traffic emissions; HBEFA.

Monitoring road traffic participants' exposure to PM10 using a low-cost system

Krzysztof Brzozowski Andrzej Maczyński Artur Ryguła

Source: Science of The Total Environment, Volume 728, 1 August 2020, 138718

The paper presents the application of a low-cost system for monitoring the current level of road traffic participants' exposure to PM10 air pollution. The research was carried out from the end of August 2017 to the beginning of October 2017 on the central section of one of the main roads in Bielsko-Biała, Poland. In the analysed period, significant changes in the daily distribution of road traffic both into and out of the city centre were observed. The average travel time depended on the direction of traffic, and the difference between directions being almost 50%. The PM10 urban background concentration was also subject to daily changes, and in the fifth week of observation, it reached a value more than twice as high as in the first week of observation. The maximum level of road traffic participants' exposure was observed at a relatively low urban background PM10 concentration. It was observed that a significant slowdown in traffic in conditions of acceptable urban air quality led to a comparable level of exposure to that of standard traffic conditions and poor urban

air quality. It was also found that the slowdown in traffic increased the exposure time of traffic participants travelling towards the city centre by an average of 24% and, for those travelling in the opposite direction, by as much as 50%. In an extreme case of traffic delay, exposure to PM10 concentration in the vicinity of the road was two and a half times as long.

Keywords: Air quality; Exposure index; Travel time; Low-cost sensor; Bluetooth.

Indoor air partitioning of Synthetic Musk Compounds: Gas, particulate matter, house dust, and window film

Esin Balci a, Mesut Genisoglu a, Sait C.Sofuoglu a, Aysun Sofuoglu b

Source: Science of The Total Environment, Volume 729, 10 August 2020, 138798

Due to diversity of contaminants indoors and complexity in the physical structure of particulate matter, partition process of chemicals affects indoor concentration distribution. Synthetic Musk Compounds (SMCs) are ubiquitously found in household and personal care products, thus, in the environment. Exposure to SMCs is important for human health, therefore, their partitioning in indoor environmental media is a key issue. In this study, gas – particle, house dust, and window film partitioning of SMCs were investigated in an indoor micro-environment. In a sealed and unoccupied room, a polycyclic and nitro musk mixture was left for volatilization for an hour. Then, samples were collected using XAD-2 sandwiched between two PUF plugs, glass-fiber filter, and wipes for gas, PM10, window-film, house dust phases, respectively, for 145 h. Collected samples were analyzed using a GC–MS. Results demonstrated that SMC concentrations decreased over time, non-linearly. Six of the SMCs partitioned to PM10 with at least 10% at beginning of the experiment, whereas the number of compounds dropped to two at the end, showing that SMCs may partition well between the two phases but they tend to be in the gas phase. They were also detected in the film and dust phases but a decrease pattern similar to gas-particle was not observed. Spearman correlations indicate that the dust and film-associated concentrations were governed by similar processes but PM-associated concentrations were not. SMCs may be found in all phases, mainly in house dust in terms of mass among the studied media and unaccounted surface reservoirs. Therefore, their partitioning between indoor media has key implications for human exposure.

Keywords: Synthetic Musk Compounds; Polycyclic musks; Nitro musks; Partitioning; Indoor environment.

Assessing air quality changes in large cities during COVID-19 lockdowns: The impacts of traffic-free urban conditions in Almaty, Kazakhstan

Aiymgul Kerimray a, Nassiba Baimatova a, Olga P.Ibragimova a, Bauyrzhan Bukenov a, Bulat Kenessov a, Pavel Plotitsyn b, Ferhat Karaca c d

Source: Science of The Total Environment, Volume 730, 15 August 2020, 139179

Number of cities worlwide experienced air quality improvements during COVID-19 lockdowns; however, such changes may have been different in places with major contributions from nontraffic related sources. In Almaty, a city-scale quarantine came into force on March 19, 2020, which was a week after the first COVID-19 case was registered in Kazakhstan. This study aims to analyze the effect of the lockdown from March 19 to April 14, 2020 (27 days), on the concentrations of air pollutants in Almaty. Daily concentrations of PM2.5, NO2, SO2, CO, O3, and BTEX were compared between the periods before and during the lockdown. During the lockdown, the PM2.5 concentration was reduced by 21% with spatial variations of 6–34% compared to the average on the same days in 2018–2019, and still, it exceeded WHO daily limit values for 18 days. There were also substantial reductions in CO and NO2 concentrations by 49% and 35%, respectively, but an increase in O3 levels by 15% compared to the prior 17 days before the lockdown. The concentrations of benzene and toluene were 2–3 times higher than those during in the same seasons of 2015–2019. The temporal reductions may not be directly attributed to the lockdown due to favorable meteorological variations during the period, but the spatial effects of the quarantine on the pollution levels are evidenced. The results demonstrate the impact of traffic on the complex nature of air pollution in Almaty, which is substantially contributed by various nontraffic related sources, mainly coal-fired combined heat and power plants and household heating systems, as well as possible small irregular sources such as garbage burning and bathhouses.

Keywords: Air quality; Pollution; Almaty; SARS-CoV-2; Lockdown.

Public health effect and its economics loss of PM2.5 pollution from coal consumption in China

Hong Chen a b, Li Li a b d, Yalin Lei a b, Sanmang Wu a b, Dan Yan c, Ziyu Dong a b

Source: Science of The Total Environment, Volume 732, 25 August 2020, 138973

China's energy structure is based on coal resource and it accounts for main proportion in the primary energy consumption. Coal consumption produces PM2.5 pollution, which seriously affects public health. Considering that there are few studies on the effect PM2.5 pollution produced by coal consumption, this paper uses the Poisson Regression model to estimate the impacts on public health and the economic loss of PM2.5 pollution produced by coal consumption using the data in 2015. Based on these results, the paper also predicts the impacts on public health effect and its economic loss caused by PM2.5 pollution from coal consumption under the baseline scenario and total coal consumption control scenario in 2020 and 2030. Finally, based on the research conclusions, suggestions are proposed to reduce the public health economic loss from PM2.5 pollution caused by coal consumption.

Keywords: PM2.5 pollution; Health effects; Economic loss; Coal consumption; Poisson regression model.

Emissions vs. turbulence and atmospheric stability: A study of their relative importance in determining air pollutant concentrations

Yuval a, Torsten Tritscher b, Raanan Raz c, Yoav Levi d, Ilan Levy e, David M.Broday a

Source: Science of The Total Environment, Volume 733, 1 September 2020, 139300

Air pollution in the urban environment is a major concern. The ambient concentrations depend on the levels of transboundary imported pollution, the intensity of local sources and the prevailing atmospheric conditions. This work studies the relative impact of two atmospheric variables–atmospheric stability and regional scale turbulence–in determining the air pollution concentrations. We considered a setting (downtown Haifa, Israel) impacted by a large variety of sources, emitting pollutants with different chemical attributes and atmospheric life times. We found that traffic accounts for most of the locally produced pollution in the study location. However, the meteorological factors can overwhelm its impact and dictate the concentrations. The switch from stable to convective conditions and the more vigorous daytime wind are associated with a premature end of the morning peak concentrations that result from rush hour emissions of NOx, Black Carbon (BC) and ultra–fine particles. It results in daytime concentration which are lower than (winter) or equal to (summer) those at night, in spite of the much lower night–time traffic volumes. Similar, albeit weaker, impact was detected in the benzene and toluene concentrations. Sources outside the study area are responsible for most of the CO, PM1 and PM2.5 concentrations but during winter nights, characterised by strong atmospheric stability and low turbulence, their concentrations are elevated due to the local emissions. We developed a diagnostic statistical nonlinear model for the pollutant concentrations,

which points to a stronger association of the atmospheric stability with the concentrations during stable conditions but turbulence dominating during convective conditions. Our findings explain the relatively low overall concentrations of locally emitted pollutants in the study area but warn of the potential for high concentrations during night–time in locations with comparable meteorological conditions.

Keywords: Air pollution; Atmospheric stability; Regional scale turbulence; Temperature lapse rate.

The influence of increased population density in China on air pollution

Jiandong Chen a, Bo Wang a, Shuo Huang a, Malin Song b

Source: Science of The Total Environment, Volume 735, 15 September 2020, 139456

Even though the relationship between population density and air pollution in China has been studied in recent years, most previous studies have suggested that an increase in population density increases air pollution. Using a panel dataset of 284 cities over the years 2003–2016 and 30 provinces during 2004–2015, as well as PM2.5 and SO2 used as air pollution indicators, the results show that an increase in population density will reduce air pollution in china. Through the mediation effect test, we found that clean energy and public transportation are the two mediation channels for population agglomeration to affect air quality. The concentration of population in cities is conducive to reducing the average cost of natural monopoly industries such as electricity, coal gas, liquefied petroleum gas, natural gas, and public transportation, thereby increasing residents' consumption of clean energy and public transportation services, reducing gas emissions that cause pollution, and improving air quality.

Keywords: Population density; Air pollution; Mediation; China.

Explore spatio-temporal PM2.5 features in northern Taiwan using machine learning techniques

Fi-John Chang a, Li-Chiu Chang b, Che-Chia Kang a, Yi-Shin Wang a, Angela Huang a

Source: Science of The Total Environment, Volume 736, 20 September 2020, 139656

The complex mixtures of local emission sources and regional transportations of air pollutants make accurate PM2.5 prediction a very challenging yet crucial task, especially under high pollution conditions. A symbolic representation of spatio-temporal PM2.5 features is the key to effective air pollution regulatory plans that notify the public to take

necessary precautions against air pollution. The self-organizing map (SOM) can cluster high-dimensional datasets to form a meaningful topological map. This study implements the SOM to effectively extract and clearly distinguish the spatio-temporal features of long-term regional PM2.5 concentrations in a visible two-dimensional topological map. The spatial distribution of the configured topological map spans the long-term datasets of 25 monitoring stations in northern Taiwan using the Kriging method, and the temporal behavior of PM2.5 concentrations at various time scales (i.e., yearly, seasonal, and hourly) are explored in detail. Finally, we establish a machine learning model to predict PM2.5 concentrations for high pollution events. The analytical results indicate that: (1) high population density and heavy traffic load correspond to high PM2.5 concentrations; (2) the change of seasons brings obvious effects on PM2.5 concentration variation; and (3) the key input variables of the prediction model identified by the Gamma Test can improve model's reliability and accuracy for multi-step-ahead PM2.5 prediction. The results demonstrated that machine learning techniques can skillfully summarize and visibly present the clusted spatio-temporal PM2.5 features as well as improve air quality prediction accuracy.
Keywords: PM2.5; Spatio-temporal variation; Multi-step-ahead prediction; Self-organizing map (SOM); Back propagation neural network (BPNN) Gamma Test.

Source and sectoral contribution analysis of PM2.5 based on efficient response surface modeling technique over Pearl River Delta Region of China

Yuzhou Pan a, Yun Zhu a, Jicheng Jang a, Shuxiao Wang b, Jia Xing b, Pen-Chi Chiang c d, Xuetao Zhao e, Zhiqiang You a, Yingzhi Yuan a

Source: Science of The Total Environment, Volume 737, 1 October 2020, 139655

Identifying and quantifying source contributions of pollutant emissions are crucial for an effective control strategy to break through the bottleneck in reducing ambient PM2.5 levels over the Pearl River Delta (PRD) region of China. In this study, an innovative response surface modeling technique with differential method (RSM-DM) has been developed and applied to investigate the PM2.5 contributions from multiple regions, sectors, and pollutants over the PRD region in 2015. The new differential method, with the ability to reproduce the nonlinear response surface of PM2.5 to precursor emissions by dissecting the emission changes into a series of small intervals, has shown to overcome the issue of the traditional brute force method in overestimating the accumulative contribution of precursor emissions to PM2.5. The results of this case study showed that PM2.5 in the PRD region was generally dominated by local emission sources (39–64%). Among the contributions of PM2.5 from various sectors and pollutants, the primary PM2.5 emissions from fugitive dust source contributed most (25–42%) to PM2.5 levels. The contributions of

agriculture NH3 emissions (6–13%) could also play a significant role compared to other sectoral precursor emissions. Among the NOX sectors, the emissions control of stationary combustion source could be most effective in reducing PM2.5 levels over the PRD region.

Keywords: PM2.5; Response surface model; Differential method; Brute force method; Source contribution.

Increased ozone levels during the COVID-19 lockdown: Analysis for the city of Rio de Janeiro, Brazil

Bruno Siciliano a, Guilherme Dantas a, Cleyton M.da Silva a b, Graciela Arbilla a

Source: Science of The Total Environment, Volume 737, 1 October 2020, 139765

The first COVID-19 case in Brazil was confirmed on February 25, 2020. Partial lockdown measures came into force in the city of Rio de Janeiro, Brazil, on March 23. While CO and NO2 levels showed significant reductions, PM10 levels were only reduced in the first partial lockdown week. By contrast, ozone levels increased in all studied locations. In this study, the factors leading to this behavior were analyzed. Monitoring data obtained at two automatic monitoring stations showed higher ratios between non-methane hydrocarbons and nitrogen oxides (NMHC/NOx) during the partial lockdown (up to 37.3%). The increase in ozone concentrations during the social distancing measures could be attributed to the increase in NMHC/NOx ratios since atmospheric chemistry in Rio de Janeiro is under VOC-controlled conditions. However, the increase was higher when air masses arrived from the industrial areas, not only because of the higher NMHC/NOx ratios, but also because the reactivity of VOC was highly increased by these air masses, which are rich in aromatic compounds.

Keywords: COVID-19; Lockdown; Ozone; Nitrogen dioxide; Non-methane hydrocarbons.

Short-term PM2.5 exposure and circulating von Willebrand factor level: a meta-analysis

Qingqing Liang a, b, c, Mengqi Sun a, b, Fenghong Wang a, b, Yuexiao Ma a, b, Lisen Lin a, b, Tianyu Li a, b, Junchao Duan a, b, Zhiwei Sun a,b

Source: Science of The Total Environment, Volume 737, 1 October 2020, 140180

Background

Ambient fine particulate matter (PM2.5) is a major threat to cardiovascular health. Endothelial dysfunction is the initiating event associated with the PM2.5-induced cardiovascular disease (CVD). A sensitive marker of endothelial function-circulating von Willebrand factor (vWF), is an independent predictor of adverse clinical outcome in CVD patients. PM2.5 exposure may cause CVD, but the reports of relationship between short-term PM2.5 exposure and circulating vWF are inconsistent.

Objective

To explore the influence of short-term PM2.5 exposure on circulating vWF.

Methods

By using a combination of computer and manual retrieval, a systematic literature retrieval was conducted on PubMed, Cochrane Library, Web of Science, Embase and Scopus databases up to October 2019. The heterogeneity among studies was tested by Stata 12.0, and the pooled %-change (percentage change per 10 μg/m3 increase in PM2.5) and its 95% confidence interval (95%CI) were calculated by using random effect model. Sensitivity analysis and publication bias detection were also carried out.

Results

12 articles were included in this meta-analysis. Short-term PM2.5 exposure (per 10 μg/m3 increase) was associated with the increased vWF (%-change = 0.41, 95%CI: 0.11–0.71). The pooled effect estimates of subgroup with PM2.5 exposure level < 25 μg/m3 was higher (%-change = 8.26; 95%CI: 1.99–14.53) than that with PM2.5 exposure level ≥ 25 μg/m3 (%-change = 0.36; 95%CI: 0.09–0.63).

Conclusion

Short-term PM2.5 exposure is associated with the increased circulating vWF. It suggests that short-term PM2.5 exposure causes endothelial dysfunction.

Keywords: PM2.5; von Willebrand factor; endothelial dysfunction; cardiovascular disease; meta-analysis.

The relationship between personal exposure and ambient PM2.5 and black carbon in Beijing

Chun Lin a, b, Dayu Hu c, Xu Jia c, Jiahui Chen c, Furong Deng c, Xinbiao Guo c, Mathew R.Heal b, Hilary Cowie a, Paul Wilkinson d, Mark R.Miller e, Miranda Loh a

Source: Science of The Total Environment, Volume 737, 1 October 2020, 139801

This study is part of the “Air Polluion Impacts on Cardiopulmonary disease in Beijing: an integrated study of Exposure Science, Toxicologenomics & Environmental Epidemiology (APIC-ESTEE)” project under the UK-China joint research programme “Atmospheric Pollution and Human Health in a Chinese Megacity (APHH-China)”. The aim is to capture the spatio-temporal variability in people's exposure to fine particles (PM2.5) and black carbon (BC) air pollution in Beijing, China. A total of 120 students were recruited for a panel study from ten universities in Haidian District in northwestern Beijing from December 2017 to June 2018. Real-time personal concentrations of PM2.5 and BC were measured over a 24-h period with two research-grade portable personal exposure monitors. Personal microenvironments (MEs) were determined by applying an algorithm to the handheld GPS unit data. On average, the participants spent the most time indoors (79% in Residence and 16% in Workplace), and much less time travelling by Walking, Cycling, Bus and Metro. Similar patterns were observed across participant gender and body-mass index classifications. The participants were exposed to 33.8 ± 27.8 μg m−3 PM2.5 and to 1.9 ± 1.2 μg m−3 BC over the 24-h monitoring period, on average 24.3 μg m−3 (42%) and 0.8 μg m−3 (28%) lower, respectively, than the concurrent fixed-site ambient measurements. Relative differences between personal and ambient BC concentrations showed greater variability across the MEs, highlighting significant contributions from Dining and travelling by Bus, which involve potential combustion of fuels. This study demonstrates the potential value of personal exposure monitoring in investigating air pollution related health effects, and in evaluating the effectiveness of pollution control and intervention measures.

Keywords: Personal exposure; PM2.5; Black carbon; Personal monitoring; Portable monitor; Beijing.

Size-fractionated particulate air pollution and myocardial infarction emergency hospitalization in Shanghai, China

Jialu Hu a, 1, Minna Tang a, 1, Xiaochun Zhang a, 1, Yuanji Ma a, 1, Yinliang Li a, Renjie Chen b, Haidong Kan b, Zhaoqiang Cui a, Junbo Ge a

Source: Science of The Total Environment, Volume 737, 1 October 2020, 140100

Background

Fine particulate matter (PM2.5) air pollution has been associated with increased risks of acute myocardial infarction (AMI), but it remains unknown about the potentially differentiated effects of size-fractionated particulate matter on AMI risk.

Objective

To identify the specific size ranges that dominate the effects of particulate matter on AMI onset.

Methods
We conducted a time-series study in Shanghai, China from January 2014 to December 2018. We evaluated particle size distribution of 0.01 μm to 2.5 μm from an environmental supersite and AMI emergency hospitalizations from the largest cardiovascular hospital in Shanghai. We used over-dispersed generalized additive models to estimate the associations of size-fractionated particle number concentrations (PNC) with AMI and its types.

Results
We identified a total of 4720 AMI emergency hospitalizations. PM2.5 was significantly associated with increased AMI risk on the concurrent day. The associations were significant only for PNC < 0.3 μm. For an IQR increase of PNCs for size ranges 0.01–0.03 μm, 0.03–0.05 μm, 0.05–0.10 μm and 0.10–0.30 μm, AMI hospitalizations increased by 6.68% (95% CI: 2.77%, 10.74%), 6.53% (95% CI: 2.08%, 11.17%), 5.78% (95% CI: 0.92%, 10.88%) and 5.92% (95% CI: 1.31%, 10.74%), respectively. The associations of PNC < 0.05 μm remained significant when adjusting for other air pollutants. There were consistently much stronger associations of particles with ST-segment elevation AMI than those with non-ST-segment elevation AMI.

Conclusions
This epidemiological investigation suggested that ultrafine particles, especially those <0.05 μm, may be mainly responsible for the acute AMI risk induced by PM2.5.

Keywords: Acute myocardial infarction; Fine particulate matter; Particle size; Ultrafine particles; Time-series study

SARS-CoV-2 pandemic lockdown: Effects on air quality in the industrialized Gujarat state of India

S.Selvam a, P.Muthukumar a, b, S.Venkatramanan c, d, P.D.Roy e, K.Manikanda Bharath f, K.Jesuraja a

Source: Science of The Total Environment, Volume 737, 1 October 2020, 140391

Two weeks after the world health organization described the novel coronavirus (SARS-CoV-2) outbreak as pandemic, the Indian government implemented lockdown of industrial activities and traffic flows across the entire nation between March 24 and May 31, 2020. In this paper, we estimated the improvements achieved in air quality during the lockdown

period (March 24, 2020 and April 20, 2020) compared to the pre-lockdown (January 1, 2020 and March 23, 2020) by analyzing PM2.5, PM10, SO2, CO, NO2 and O3 data from nine different air quality monitoring stations distributed across four different zones of the industrialized Gujarat state of western Indian. The Central Pollution Control Board (CPCB)-Air Quality Index (AQI) illustrated better air qualities during the lockdown with higher improvements in the zones 2 (Ahmedabad and Gandhinagar) and 3 (Jamnagar and Rajkot), and moderate improvements in the zones 1 (Surat, Ankleshwar and Vadodra) and 4 (Bhuj and Palanpur). The concentrations of PM2.5, PM10, and NO2 were reduced by 38–78%, 32–80% and 30–84%, respectively. Functioning of the power plants possibly led to less reduction in CO (3–55%) and the declined emission of NO helped to improve O3 (16–48%) contents. We observed an overall improvement of 58% in AQI for the first four months of 2020 compared to the same interval of previous year. This positive outcome resulted from the lockdown restrictions might help to modify the existing environmental policies of the region.

Keywords: SARS-CoV-2; Air pollution; NO2; CPCB-AQI; Gujarat; India

How aerosol transport from the North China plain contributes to air quality in northeast China

Hujia Zhao a, b, Huizheng Che b, Lei Zhang b, Ke Gui b, Yanjun Ma a, Yaqiang Wang b, Hong Wang b, Yu Zheng b, Xiaoye Zhang b

Source: Science of The Total Environment, Volume 738, 10 October 2020, 139555

Northeast China (NEC) has unique climate characteristics and emission sources; continued urbanisation has aggravated regional pollution. The in situ observation data concerning PM2.5, visibility, surface meteorological elements and synchronous aerosol vertical extinction profiles obtained from ground-based Lidar were investigated to better understand local and regional particulate pollution in NEC. The WRF (3.7.1)/CAMx (6.40) model was employed to quantitative investigate the contribution of regional transport to PM2.5 in Shenyang. The results suggested that PM2.5 increased significantly from 9 to 14 January over NEC and the Northern China (NC), with monthly PM2.5 highest in Shijiazhuang and Baoding of NC about 145.2 ± 88.9 and 136.8 ± 83.1 μg m−3, respectively. The distribution of SO2 and NO2 for PM2.5 implied SO2 was more influence on PM2.5 in NEC, while NO2 has larger impact on PM2.5 in NC. The significant increasing of relative humidity (RH) and temperatures exhibited in the pollution indicate water vapor and warm air flow during the transport. The development of the southwest airflow was conducive to pollutant transport across the Beijing–Tianjin–Hebei (or Jing-Jin-Ji) megalopolis to NEC, and together with the local emissions in NEC to affect air quality. The modelling results

pointed out that contribution of regional transport to PM2.5 in Shenyang was about 80.12% at 00:00 LT in 10 January, of which the contribution of BTH was about 61.52%; the total regional contribution to PM2.5 in Shenyang reaching 60.70% at 02:00 LT on 13 January including 34.56% contributed by BTH region. Aerosol vertical extinction indicated the particle layer appeared in the near-surface and in the upper atmospheric layer from 0.5 to 1.0 km following the development of transport event. The findings of this study can facilitate a comprehensive understanding of the local and regional air pollution in NEC and helpful for national environment pollution controls and improvement.

Keywords: $PM_{2.5}$; Aerosol vertical distribution; Regional transport; Northeast China.

Assessing the relationship between surface levels of PM2.5 and PM10 particulate matter impact on COVID-19 in Milan, Italy

Maria A.Zoran, Roxana S.Savastru, Dan M.Savastru, Marina N.Tautan

Source: Science of The Total Environment, Volume 738, 10 October 2020, 139825

The novel coronavirus disease (COVID-19) is a highly pathogenic, transmittable and invasive pneumococcal disease caused by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), which emerged in December 2019 and January 2020 in Wuhan city, Hubei province, China and fast spread later on the middle of February 2020 in the Northern part of Italy and Europe.

This study investigates the correlation between the degree of accelerated diffusion and lethality of COVID-19 and the surface air pollution in Milan metropolitan area, Lombardy region, Italy. Daily average concentrations of inhalable particulate matter (PM) in two size fractions PM2.5, PM10 and maxima PM10 ground level atmospheric pollutants together air quality and climate variables (daily average temperature, relative humidity, wind speed, atmospheric pressure field and Planetary Boundary Layer-PBL height) collected during 1 January–30 April 2020 were analyzed. In spite of being considered primarily transmitted by indoor bioaerosols droplets and infected surfaces, or direct human-to-human personal contacts, it seems that high levels of urban air pollution, weather and specific climate conditions have a significant impact on the increased rates of confirmed COVID-19 Total number, Daily New and Total Deaths cases, possible attributed not only to indoor but also to outdoor airborne bioaerosols distribution. Our analysis demonstrates the strong influence of daily averaged ground levels of particulate matter concentrations, positively associated with average surface air temperature and inversely related to air relative humidity on COVID-19 cases outbreak in Milan. Being a novel pandemic coronavirus

(SARS-CoV-2) version, COVID-19 might be ongoing during summer conditions associated with higher temperatures and low humidity levels. Presently is not clear if this protein "spike" of the new coronavirus COVID-19 is involved through attachment mechanisms on indoor or outdoor airborne aerosols in the infectious agent transmission from a reservoir to a susceptible host in some agglomerated urban areas like Milan is.

Keywords: Coronavirus COVID-19; Particulate matter (PM2.5 and PM10); Air quality; Meteorological parameters; NOAA satellite data.

County-level variation in the long-term association between PM2.5 and lung cancer mortality in China

Ning Wang a, Kerrie Mengersen b, Shilu Tong a, c, d, Michael Kimlin e, f, Maigeng Zhou g, Yang Liu h, Wenbiao Hu a

Source: Science of The Total Environment, Volume 738, 10 October 2020, 140195

Introduction

The relative risk (RR) of long-term exposure to PM2.5 in lung cancer mortality (LCM) may vary spatially in China. However, previous studies applying global regression have been unable to capture such variation. We aimed to employ a geographically weighted Poisson regression (GWPR) to estimate the RRs of LCM among the elderly (≥65 years) related to long-term exposure to PM2.5 and the LCM attributable to PM2.5 at the county level in China.

Methods

We obtained annual LCM in the elderly between 2013 and 2015 from the National Death Surveillance. We linked annual mean concentrations of PM2.5 between 2000 and 2004 with LCM using GWPR model at 148 counties across mainland China, adjusting for smoking and socioeconomic covariates. We used county-specific GWPR models to estimate annual average LCM in the elderly between 2013 and 2015 attributable to PM2.5 exposure between 2000 and 2004.

Results

The magnitude of the association between long-term exposure to PM2.5 and LCM varied with county. The median of county-specific RRs of LCM among elderly men and women was 1.52 (range: 0.90, 2.40) and 1.49 (range: 0.88, 2.56) for each 10 μg/m3 increment in PM2.5, respectively. The RRs were positively significant ($P < 0.05$) at 95% (140/148) of counties

among both elderly men and women. Higher RRs of PM2.5 among elderly men were located at Southwest and South China, and higher RRs among elderly women were located at Northwest, Southwest, and South China. There were 99,967 and 54,457 lung cancer deaths among elderly men and women that could be attributed to PM2.5, with the attributable fractions of 31.4% and 33.8%, respectively.

Conclusions

The relative importance of long-term exposure to PM2.5 in LCM differed by county. The results could help the government design tailored and efficient interventions. More stringent PM2.5 control is urgently needed to reduce LCM in China.

Keywords: Geographically weighted Poisson regression; Lung cancer; $PM_{2.5}$; Relative risk; Spatial variation.

Changes in U.S. air pollution during the COVID-19 pandemic

Jesse D.Berman a, Keita Ebisu b

Source: Science of The Total Environment, Volume 739, 15 October 2020, 139864

The COVID-19 global pandemic has likely affected air quality due to extreme changes in human behavior. We assessed air quality during the COVID-19 pandemic for fine particulate matter (PM2.5) and nitrogen dioxide (NO2) in the continental United States from January 8th-April 21st in 2017–2020. We considered pollution during the COVID-19 period (March 13–April 21st) and the pre-COVID-19 period (January 8th-March 12th) with 2020 representing 'current' data and 2017–2019 representing 'historical' data. County-level pollution concentrations were compared between historical versus current periods, and counties were stratified by institution of early or late non-essential business closures. Statistically significant NO2 declines were observed during the current COVID-19 period compared to historical data: a 25.5% reduction with absolute decrease of 4.8 ppb. PM2.5 also showed decreases during the COVID-19 period, and the reduction is statistically significant in urban counties and counties from states instituting early non-essential business closures. Understanding how air pollution is affected during COVID-19 pandemic will provide important clues regarding health effects and control of emissions. Further investigation is warranted to link this finding with health implications.

Keywords: COVID-19; Pandemic; Air pollution; $PM_{2.5}$; NO_2.

Estimating the air quality and health impacts of biomass burning in northern South America using a chemical transport model

Karen Ballesteros-González a, Amy P.Sullivan b, Ricardo Morales-Betancourt a

Source: Science of The Total Environment, Volume 739, 15 October 2020, 139755

Biomass burning (BB) emissions significantly deteriorate air quality in many regions worldwide, impact human health and perturbing Earth's radiation budget and climate. South America is one of largest contributors to BB emissions globally. After Amazonia, BB emissions from open and agricultural fires of Northern South America (NSA) are the most significant. Recent evidence shows a strong correlation between fire counts in NSA and Brown Carbon in some Colombian cities, suggesting a substantial seasonal contribution of regional BB sources to air pollution levels in the densely populated areas of NSA. In this work we use the atmospheric regional chemical transport model WRF-Chem to assess the contribution of open BB events to pollutant concentration and to estimate potential health impacts associated with wildfire events in NSA. Three nested domains are used to simulate atmospheric composition in the Northern part of South America and the Caribbean. Simulations included biogenic and anthropogenic emissions from a global emission inventory merged with local emissions for the city of Bogotá. Two modelling scenarios were considered, a base case without BB emissions (NO_FIRE) and a sensitivity scenario with BB emissions. Simulations were carried out for periods of strong BB activity in NSA. In the NO_FIRE scenario, aerosol concentrations are unrealistically low. When BB emissions are is included background PM2.5 concentrations increase 80%. The increment in aerosol concentrations is mainly driven by Secondary Organic Aerosols. In the case of Bogotá, the most densely populated city in the domain, monthly mean increase in PM2.5 is 3.3 μg m−3 and 4.3 ppb for O3. Modeled meteorological and air pollution fields are in better agreement with observations when high spatial resolution (3 × 3 km) is used in the simulations. The total estimated short-term all-cause mortality associated to BB during February in the region is 171 cases, 88 PM2.5-related and 83 O3-related mortality.

Keywords: Biomass burning emissions;Regional atmospheric transport;Air pollution;Biomass burning aerosol;Health impacts;Secondary organic aerosols.

Significant changes in the chemical compositions and sources of PM2.5 in Wuhan since the city lockdown as COVID-19

Huang Zheng a, b, Shaofei Kong a, d, Nan Chen c, d, Yingying Yan a, d, Dantong Liu e, Bo Zhu c, d, Ke Xu c, d, Wenxiang Cao c, d, Qingqing Ding c, d, Bo Lan c, d, Zhouxiang Zhang c, d, Mingming Zheng b, c, Zewei Fan b, Yi Cheng a, Shurui Zheng a, b, Liquan Yao a, b, Yongqing Bai f, Tianliang Zhao g, Shihua Qi b, d

Source: Science of The Total Environment, Volume 739, 15 October 2020, 140000

Wuhan was the first city to adopt the lockdown measures to prevent COVID-19 spreading, which improved the air quality accordingly. This study investigated the variations in chemical compositions, source contributions, and regional transport of fine particles (PM2.5) during January 23–February 22 of 2020, compared with the same period in 2019. The average mass concentration of PM2.5 decreased from 72.9 μg m−3 (2019) to 45.9 μg m−3 (2020), by 27.0 μg m−3. It was predominantly contributed by the emission reduction (92.0%), retrieved from a random forest tree approach. The main chemical species of PM2.5 all decreased with the reductions ranging from 0.85 μg m−3 (chloride) to 9.86 μg m−3 (nitrate) ($p < 0.01$). Positive matrix factorization model indicated that the mass contributions of seven PM2.5 sources all decreased. However, their contribution percentages varied from −11.0% (industrial processes) to 8.70% (secondary inorganic aerosol). Source contributions of PM2.5 transported from potential geographical regions showed reductions with mean values ranging from 0.22 to 4.36 μg m−3. However, increased contributions of firework burning, secondary inorganic aerosol, road dust, and vehicle emissions from transboundary transport were observed. This study highlighted the complex and nonlinear response of chemical compositions and sources of PM2.5 to air pollution control measures, suggesting the importance of regional-joint control.

Keywords: COVID-2019; Fine particle; Chemical composition; Source apportionment; Random forest tree; Regional transportation.

Distribution, sources, risks, and vitro DNA oxidative damage of PM2.5-bound atmospheric polycyclic aromatic hydrocarbons in Urumqi, NW China

Wei Wang a, Xiang Ding b, c, Yusan Turap a, Yalkunjan Tursun a, Abulikemu Abulizi a, Xingming Wang b, c, Longyi Shao d, Dilinuer Talifu a, Juqin An a, Xiaoxiao Zhang a, Yuanyu Zhang a, Huibin Liu a

Source: Science of The Total Environment, Volume 739, 15 October 2020, 139518

Research has focused on the impacts of polycyclic aromatic hydrocarbons (PAHs) in the atmosphere due to their potential carcinogenicity. In this study, we investigated the seasonal variation, sources, incremental lifetime cancer risks (ILCRS), and vitro DNA oxidative damage of PAHs in Urumqi in NW China. A total of 72 atmospheric samples from Urumqi were collected over a year (September 2017–September 2018) and were analyzed for 16 PAHs that are specifically prioritized by the U.S Environmental Protection Agency (U·S EPA). The highest PAHs concentrations were in winter (1032.66 ng m−3) and lowest in spring (146.00 ng m−3). Middle molecular weight PAHs with four rings were the most

abundant species (45.28–61.19% of the total). The results of the diagnostic ratio and positive matrix factorization inferred that the major sources of atmospheric PAHs in Urumqi were biomass burning, coking, and petrogenic sources (52.9%), traffic (30.1%), coal combustion (8.9%), and the plastics recycling industry (8.1%). ILCRS assessment and Monte Carlo simulations suggested that for all age groups PAHs cancer risks were mainly associated with ingestion and dermal contact and inhalation was negligible. The plasmid scission assay results showed a positive dose-response relationship between PAHs concentrations and DNA damage rates, demonstrating that toxic PAHs was the primary cause for PM2.5-induced DNA damage in the air of Urumqi.

Keywords: PAH_S; Incremental lifetime cancer risks; DNA oxidative damage.

Indoor air pollution, physical and comfort parameters related to schoolchildren's health: Data from the European SINPHONIE study

Ramen MunirBaloch a, Cara Nichole Maesano a, Jens Christoffersen b, Soutrik Banerjee a, Marta Gabriel c, Éva Csobod d, Eduardode Oliveira Fernandes c, Isabella Annesi-Maesano a

Source: Science of The Total Environment, Volume 739, 15 October 2020, 139870

Substantial knowledge is available on the association of the indoor school environment and its effect among schoolchildren. In the same context, the SINPHONIE (School indoor pollution and health: Observatory network in Europe) conducted a study to collect data and determine the distribution of several indoor air pollutants (IAPs), physical and thermal parameters and their association with eye, skin, upper-, lower respiratory and systemic disorder symptoms during the previous three months. Finally, data from 115 schools in 54 European cities from 23 countries were collected and included 5175 schoolchildren using a harmonized and standardized protocol. The association between exposures and the health outcomes were examined using logistic regression models on the environmental stressors assessed in classroom while adjusting for several confounding factors; a VOC (volatile organic compound) score defined as the sum of the number of pollutants to which the children were highly exposed (concentration > median of the distribution) in classroom was also introduced to evaluate the multiexposure – outcome association. Schoolchildren while adjusting for several confounding factors. Schoolchildren exposed to above or equal median concentration of PM2.5, benzene, limonene, ozone and radon were at significantly higher odds of suffering from upper, lower airways, eye and systemic disorders. Increased odds were also observed for any symptom (sick school syndrome) among schoolchildren exposed to concentrations of limonene and ozone above median values. Furthermore, the risks for upper and lower airways and systemic disorders significantly increased with the VOCs score. Results also showed that increased ventilation rate was significantly associated

with decreased odds of suffering from eye and skin disorders whereas similar association was observed between temperature and upper airways symptoms. The present study provides evidence that exposure to IAPs in schools is associated with various health problems in children. Further investigations are needed to confirm our findings.

Keywords: Indoor air pollution; Allergy; VOC; Sick building syndrome; Multi-pollution; Thermal parameters.

An empirical study of the efficiency of haze pollution governance in Chinese cities based on streaming data

Yang Zhang a, Juanjuan Chen b

Source: Science of The Total Environment, Volume 739, 15 October 2020, 139571

The severe haze pollution brought about by China's extensive economic growth has attracted widespread attention from the academia and the international community. Based on the streaming data of the air quality index (AQI), PM2.5, and PM10 from 370 cities in China, this paper uses heatmaps to characterize the haze pollution governance of Chinese cities. Then, the meta-frontier efficiency, group frontier efficiency, and inefficiency under meta-frontier of the haze pollution governance of 101 key cities in China are measured using a directional distance function methodology. The sources of inefficiency of haze pollution governance are also analyzed. Although there have been improvements in AQI, PM2.5, and PM10 for most Chinese cities in recent years, the efficiency of haze pollution governance remains relatively low. In particular, the technology gap between the group frontiers and the meta-frontier of haze pollution governance of central China's cities is growing. Also, the inefficiencies of haze pollution governance mainly stem from the inefficient use and management of the resource inputs, rather than the technology gap.

Keywords: Haze pollution; Governance efficiency; Streaming data; Directional distance function.

Chemical characterization of PM2.5 emissions and atmospheric metallic element concentrations in PM2.5 emitted from mobile source gasoline-fueled vehicles

Yuan-Chung Lin a, b, Ya-Ching Li a, Kassian T.T. Amesho a, Sumarlin Shangdiar a, Feng-Chih Chou a, Pei-Cheng Cheng a

Source: Science of The Total Environment, Volume 739, 15 October 2020, 139942

Fine particulate matter with an aerodynamic diameter of <2.5 μm (PM2.5), particularly from the in-use gasoline-fueled vehicles, is a leading air quality pollutant and the chemical composition of PM2.5 is vital to the practical issues of climate change, health effects, and pollution control policies, inter alia. These atmospheric fine particulate matters (PM2.5) emitted from the exhausts of mobile source gasoline-fueled vehicles constitute substantial risks to human health through inhalation, and most importantly, affect urban air quality. Therefore, in order to explicitly determine the inhalation risks of PM2.5 which could potentially contain a significant amount of chemicals and metallic elements (MEs) concentration, we investigated the chemical composition (comprising of carbonaceous species and metallic elements) of PM2.5 emissions from mobile source gasoline-fueled vehicles. To further examine the chemical composition and metallic elements concentration in PM2.5 from the exhausts of mobile source gasoline-fueled vehicles, we systematically investigated PM2.5 emission samples collected from the exhausts of fifteen (15) mobile source gasoline-fueled vehicles. Our study has equally also determined the chemical compositions based on carbonaceous species (organic carbon - OC and elemental carbon - EC). Furthermore, the concentrations of PM2.5 and metallic elements (Ca, Al, Zn, K, Ca, Fe, Mg and Cr) in PM2.5 were analyzed with the help of Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES). The details of the tested gasoline-fueled vehicles cover the model years, consisting of the vehicles registered from 2000 to 2017 from several vehicle manufacturers (or brands) with various running mileages ranging from 123.4 to 575,844 km (average 123,105 km). Our results established that elemental carbon (EC) and organic carbon (OC) were the most significant concentrations of carbonaceous species. The concentration of metallic elements in PM2.5 and chemical characterization were studied by their relationship with atmospheric PM2.5 and the results showed that the metallic elements concentration in PM2.5 were in descending order as follows: Ca > Al > Zn > K > Fe > Mg > Cr. These results will help us to further understand how PM2.5 emissions from the exhausts of in-use gasoline-fueled vehicles contribute to both chemical and atmospheric metallic elements concentration in the ambient air.

Keywords: PM2.5 emissions; Metallic elements concentration; Gasoline-fueled vehicles; Carbonaceous species.

Effects of indoor activities and outdoor penetration on PM2.5 and associated organic/elemental carbon at residential homes in four Chinese cities during winter

Zhuozhi Zhang a, Yuan Gao a, Qi Yuan a, Yan Tan a, Haiwei Li b, Long Cui c, Yu Huang c, Yan Cheng d, Guangli Xiu e, Senchao Lai f, Judith C.Chow g, John G.Watson g, Shun-ChengLee a

Source: Science of The Total Environment, Volume 739, 15 October 2020, 139684

There is increasing public attention on exposure to PM2.5 and its related health impacts. It is essential to study the pollution levels, sources, and health implications of indoor PM2.5, especially for residential homes, as people tend to spend most of their time indoors. The indoor PM2.5 mass and organic/elemental carbon (OC/EC) during winter and early spring period of 2016–2017 at 68 residential households in four large Chinese cities (i.e. Hong Kong, Guangzhou, Shanghai, and Xi'an) were studied. Average indoor PM2.5 varied by two-fold, lowest in Hong Kong (34.0 ± 14.6 μg m−3) and highest in Xi'an (78.7 ± 49.3 μg m−3), with comparable levels for Guangzhou (47.2 ± 5.4 μg m−3) and Shanghai (50.3 ± 17.9 μg m−3). Lowest air exchange rate (AER, 0.8 ± 0.8 h−1) and PM2.5 indoor/outdoor (I/O) ratio (0.72 ± 0.23) were found for Xi'an households, indicating the limited influence from indoor sources, while importance of indoor PM2.5 sources is signified with the highest PM2.5 I/O ratio (1.32 ± 0.43) identified for Shanghai households. For households in four cities, OC and EC accounted for 29.5%–38.5% and 7.5%–8.9% of the indoor PM2.5 mass, indicating the significance of carbonaceous aerosols. Larger differences between indoor and outdoor OC (2.6–8.4%) than EC (−2.2–1.5%) indicate the presence of indoor OC sources. Decreasing trends of PM2.5 I/O ratio and indoor OC proportion were found as the worsening ambient air quality. On average, 11.8 μg m−3 (23.1%) and 3.02 μg m−3 (18.7%) higher indoor PM2.5 and OC concentrations were identified for households with other indoor combustions (e.g., tobacco smoking, incense burning) compared to those with only cooking activities. For Hong Kong and Shanghai households, increments of 13.2 μg m−3 (54.1%) of PM2.5 and 4.1 μg m−3 (45.4%) of OC were found at households with cooking activities as compared to households with no specific indoor combustion.

Keywords: Residence; $PM_{2.5}$ (fine suspended particulate); Carbonaceous aerosols; Indoor combustion; Ambient penetration.

Revisiting the impact of vehicle emissions and other contributors to air pollution in urban built-up areas: A dynamic spatial econometric analysis

Wei Qiang a, Harry F.Lee a, Ziwei Lin b, David W.H.Wong c

Source: Science of The Total Environment, Volume 740, 20 October 2020, 140098

Whether vehicle emissions are the primary source of PM2.5 in urban China remains controversial, which may be attributable to the insufficient consideration of the spatial autocorrelation and the spatial spillover effects of PM2.5. We employ data from built-up areas of 285 prefecture-level cities in China spanned 2001–2016 and dynamic spatial panel

data analysis to resolve this controversy. Our results show that the direct and indirect effects of vehicles on PM2.5 concentration (annual mean and spatial variation within the city) in urban China are not significant in the short- and long-term. Alternatively, SO2 emission directly increases the mean and spatial variation of PM2.5 within the city in the short- and long-term. Short-term direct and indirect positive association and long-term indirect positive association are found relative to economic growth and PM2.5. Population density increases PM2.5 directly and indirectly in the short-term and yet, directly decreases and indirectly increases PM2.5 in the long-term. In the short- and long-term, the spatial spillover effect of secondary industry increases PM2.5, and industry also directly increases the spatial variation of PM2.5 within the city. Although real estate investment directly increases PM2.5 in the long-term, the spatial spillover effect of investment reduces PM2.5 in the short- and long-term. Our results show that other factors, rather than vehicle emissions, are the major contributors to PM2.5 in urban China. Furthermore, the Environmental Kuznets Curve hypothesis does not apply to the relationship between economic growth and PM2.5 proliferation in urban China. When tackling air pollution, owing to the significant spatial spillover of PM2.5 that is driven by multiple contributing factors, short- and long-term inter-regional coordination is required to achieve an effective positive outcome.

Keywords: Vehicle emission; $PM_{2.5}$; Urban area; China.

Estimating daily ground-level PM2.5 in China with random-forest-based spatiotemporal kriging

Yanchuan Shao a, Zongwei Ma a, b, Jianghao Wang c, d, Jun Bi a

Source: Science of The Total Environment, Volume 740, 20 October 2020, 139761

Ambient fine particulate matter (PM2.5) plays an important role in cardiovascular- and respiratory-related death. Empirical statistical models have been widely applied to estimate ambient PM2.5 concentrations with correlated variables. However, empirical statistical models ignore the nonlinear relationship between PM2.5 and covariates and assume that residuals are independent and identically distributed random variables. Here, a hybrid approach, which integrates random forest (RF) model and spatiotemporal kriging, is proposed to estimate the daily PM2.5 concentration. The proposed RF-based spatiotemporal kriging (RFSTK) model effectively captures nonlinear interactions among different predictors and accounts for the detailed spatiotemporal dependence of the PM2.5 concentration. The RFSTK model performs well in predicting the daily PM2.5

concentration. The 10-fold overall cross-validation R2 value is 0.881, the mean absolute error (MAE) is 6.89 μg/m3 and the root-mean-square error (RMSE) is 11.48 μg/m3, indicating better performance than the original RF model (R2 = 0.848, MAE = 7.88 μg/m3 and RMSE = 13.26 μg/m3). The spatiotemporal prediction of the PM2.5 concentration shows that approximately 90.04% of China had a daily exposure to PM2.5 in 2018 that was below the nation's air quality standard of 75 μg/m3. The proposed hybrid method is entirely general and can be applied to map the ambient PM2.5 concentration over a large spatiotemporal domain.

Keywords: Aerosol optical depth; $PM_{2.5}$; Random forest; Spatiotemporal kriging.

Global review of recent source apportionments for airborne particulate matter

Philip K. Hopke a, b, Qili Dai c, Linxuan Li c, Yinchang Feng c

Source: Science of The Total Environment, Volume 740, 20 October 2020, 140091

Source apportionments have become increasingly performed to determine the origins of ambient particulate pollution. The results can be helpful in designing mitigation strategies to improve air quality. Source specific particulate matter (PM) concentrations are also being used in health effects studies to be able to focus attention on those sources most likely to be responsible for the observed adverse health effects. In 2015, the World Health Organization (WHO) released its initial compilation of source apportionment studies published through August 2014. This initial database was described by Karagulian et al. (Atmospheric Environment120 (2015) 475–483). In the present report, a new compilation has been prepared of those apportionments published since 2014 through December 2019. In addition, the database has been expanded to include apportionments of heavy metals, water-soluble components, and carbonaceous components in ambient PM. As a result of this work, we have developed and presented some perspectives on source apportionment going forward. We also have made a series of recommendations for source apportionment studies and reporting them. It is essential for papers to provide a minimum set of information so that the study can be adequately assessed, and the results utilized by others in making policy decisions or as part of other scientific studies.

Keywords: Source apportionment; Particulate matter; Global; $PM_{2.5}$; PM_{10}; Air quality.

Long-range air pollution transport in East Asia during the first week of the COVID-19 lockdown in China

Stephen Miles Griffith a, Wei-Syun Huang a, Chia-Ching Lin b, Ying-Chieh Chen b, Kuo-En Chang c, Tang-Huang Lin c, Sheng-Hsiang Wang a, Neng-Huei Lin a, b

Source: Science of The Total Environment, Volume 741, 1 November 2020, 140214

Long-range transport (LRT) of air pollutants from East Asia during the northeast monsoon season impacts several downwind locations. In 2020, the initial COVID-19 lockdowns in China overlapped with Week 3 of the Chinese New Year (CNY) holiday, and an Asian outflow event. Thus, movement of the Chinese populace from city to city was already greatly reduced by the time of the LRT episode, although the reductions in industrial output are less clear. We found NO2 column concentrations were reduced by 24% during the CNY Week 3 this year compared to previous years. The attenuated transport event arrived to northern Taiwan with a PM2.5 concentration <45 μg m−3 and most often <35 μg m−3, which is 2–3 times lower than LRT episodes of similar back-trajectory and synoptic patterns. The whole episode persisted for about 60 h, longer than most LRT episodes from China to Taiwan. CMAQ v5.2.1 modeling of the LRT event with 100% emission and reduced emission scenarios, revealed emissions in China were approximately 50% less than normal periods. Due to the length of the episode and the significant reduction in emissions, Taiwan avoided a PM2.5 surplus of 19.2 μg m−3 on average during the episode, equivalent to a 0.5 μg m−3 reduction for the whole 3-month winter season. Employing the 100% emission model scenario and scaling up to the average episode hours each winter, the PM2.5 surplus delivered via plumes on the northeast monsoon is equivalent to a 0.5 μg m−3 surplus for the whole year.

Keywords: Transboundary aerosol; Taiwan; Shutdown; Emissions reduction; CMAQ; PM2.5.

COVID-19 lockdown effects on air quality by NO2 in the cities of Barcelona and Madrid (Spain)

José M.Baldasano

Source: Science of The Total Environment, Volume 741, 1 November 2020, 140353

During the months of March and April 2020 we witnessed the largest-scale experiment in history in terms of air quality in cities. Any prediction of this experiment's results may be obvious to science, as it was totally expected, the air quality has improved substantially. Simply stated, it comes as no surprise. The lockdown has made it possible to quantify the limit of decrease in pollution in light of this drastic reduction in traffic, in Madrid and

Barcelona showed a significant decrease of the order of 75%. In the case of Spain's two largest cities, the reductions of NO2 concentrations were 62% and 50%, respectively. Hourly measurements were obtained from 24 and 9 air quality stations from the monitoring networks during the month of March 2020. These results allow us to see the limits that can be achieved by implementing low emission zones (LEZ), as well as the amount of contamination that must be eliminated, which in the cases of Madrid and Barcelona, represent 55%. This value defines the levels of effort and scope of actions to be taken in order to ensure that both cities achieve a clean and healthy atmosphere in terms of NO2.

Keywords: COVID-19; Nitrogen dioxide (NO_2); Lockdown measures; Traffic emission reduction; Air quality.

Air pollutant emissions from coal-fired power plants in China over the past two decades

Gang Wang a, b, JianguoDeng a, Ying Zhang a, Qiang Zhang a, Lei Duan a, c, Jiming Hao a, c, Jingkun Jiang a, c

Source: Science of The Total Environment, Volume 741, 1 November 2020, 140326

China is the largest coal producer and consumer in the world, and coal-fired power plants are among its major sources of air pollutants. The Chinese government has implemented various stringent measures to reduce air pollutant emissions over the past two decades. National statistical data, emission inventories, and satellite observations indicate that air pollutant emissions from coal-fired power plants have been effectively controlled. Field measurements at coal-fired power plants can provide valuable information about the long-term trend of air pollutant emissions and the driving factors. In this study, we evaluated air pollutant emissions from 401 units at 308 coal-fired power plants. An appreciable reduction in air pollutant concentrations and emission factors from coal-fired power plants in China is observed over the past two decades. The drivers for this trend from the perspective of policy making, application of removal technologies, tightening of emission standards, technological improvement, monitoring systems, and economic measures are discussed. Currently, concentrations of typical air pollutants from coal-fired power plants in China are lower than those in Japan, Germany, and the US. This can be attributed to the policies and lenient emission standards for power plants in these countries. The technological improvement of air pollution control devices is the key factor that has led to reductions in air pollutant emissions in China. China has built the largest system of clean coal-fired power plants in the world.

Keywords: Air pollutant; Coal-fired power plants; Emission trend; Technological improvement; Ultra-low emission.

Association of particulate matter pollution and case fatality rate of COVID-19 in 49 Chinese cities

Ye Yao a, 1, Jinhua Pan a, 1, Weidong Wang a, 1, Zhixi Liu a, 1, Haidong Kan a, c, Yang Qiu b, Xia Meng a, 2, Weibing Wang a, c, 2

Source: Science of The Total Environment, Volume 741, 1 November 2020, 140396

The COVID-19 epidemic, caused by the SARS-CoV-2 virus, has resulted in 3352 deaths in China as of April 12, 2020. This study aimed to investigate the associations between particulate matter (PM) concentrations and the case fatality rate (CFR) of COVID-19 in 49 Chinese cities, including the epicenter of Wuhan. We used the Global Moran's I to analyze spatial distribution and autocorrelation of CFRs, and then we used multivariate linear regression to analyze the associations between PM2.5 and PM10 concentrations and COVID-19 CFR. We found positive associations between PM pollution and COVID-19 CFR in cities both inside and outside Hubei Province. For every 10 μg/m3 increase in PM2.5 and PM10 concentrations, the COVID-19 CFR increased by 0.24% (0.01%–0.48%) and 0.26% (0.00%–0.51%), respectively. PM pollution distribution and its association with COVID-19 CFR suggests that exposure to such may affect COVID-19 prognosis.

Keywords: COVID-19; Particulate matter pollution; CFR; Cross-sectional study.

Effects of meteorological conditions and air pollution on COVID-19 transmission: Evidence from 219 Chinese cities

Zhenbo Zhang a, Ting Xue a, Xiaoyu Jin, b

Source: Science of The Total Environment, Volume 741, 1 November 2020, 140244

The spatial distribution of the COVID-19 infection in China cannot be explained solely by geographical distance and regulatory stringency. In this research we investigate how meteorological conditions and air pollution, as concurring factors, impact COVID-19 transmission, using data on new confirmed cases from 219 prefecture cities from January 24 to February 29, 2020. Results revealed a kind of nonlinear dose-response relationship between temperature and coronavirus transmission. We also found that air pollution indicators are positively correlated with new confirmed cases, and the coronavirus further spreads by 5–7% as the AQI increases by 10 units. Further analysis based on regional

divisions revealed that in northern China the negative effects of rising temperature on COVID-19 is counteracted by aggravated air pollution. In the southern cities, the ambient temperature and air pollution have a negative interactive effect on COVID-19 transmission, implying that rising temperature restrains the facilitating effects of air pollution and that they jointly lead to a decrease in new confirmed cases. These results provide implications for the control and prevention of this disease and for the anticipation of another possible pandemic.

Keywords: COVID-19; Ambient temperature; Relative humidity; Wind speed; Air pollution; China.

Impact of lockdown measures to combat Covid-19 on air quality over western Europe

Laurent Menut a, Bertrand Bessagnet a, b, Guillaume Siour c, Sylvain Mailler a, Romain Pennel a, Arineh Cholakian a

Source: Science of The Total Environment, Volume 741, 1 November 2020, 140426

Recent studies based on observations have shown the impact of lockdown measures taken in various European countries to contain the Covid-19 pandemic on air quality. However, these studies are often limited to compare situations without and with lockdown measures, which correspond to different time periods and then under different meteorological conditions. We propose a modelling study with the WRF-CHIMERE modelling suite for March 2020, an approach allowing to compare atmospheric composition with and without lockdown measures without the biases of meteorological conditions. This study shows that the lockdown effect on atmospheric composition, in particular through massive traffic reductions, has been important for several short-lived atmospheric trace species, with a large reduction in NO2 concentrations, a lower reduction in Particulate Matter (PM) concentrations and a mitigated effect on ozone concentrations due to non-linear chemical effects.

Keywords: COVID-19; Lockdown; Chemistry-transport modeling; Emissions scenario; CHIMERE.

Can exposure to PM2.5 particles increase the incidence of coronavirus disease 2019 (COVID-19)?

Khalid Mehmood a, Saifullah b, Muhammad Iqbal c, Muhammad Mohsin Abrar d

Source: Science of The Total Environment, Volume 741, 1 November 2020, 140441

Respiratory diseases caused by ambient air pollution are a contributing factor to prolonged bronchial inflammation leading eventually to hyper-activation of innate immune system, morbidity and mortality all over the world (Conticini et al., 2020; Liu et al., 2019). Severe Acute Respiratory Syndrome Corona Virus 2 (SARS-CoV-2) is the pathogenic agent of the coronavirus disease (COVID-19), previously known as 2019 Novel Coronavirus (2019-nCoV) (Lu et al., 2020). Recently it has gained a global importance after its emergence from the Chinese city Wuhan in December 2019. COVID-19 causes rapidly developing acute respiratory distress syndrome (ARDS), acute respiratory failure, and other life-threatening diseases (Liu et al., 2019; WHO, 2020). The source of COVID-19 is still not confirmed; however, the initial cases were reported from Huanan South China Seafood Market, in Wuhan, China.

Currently, research regarding the clinical features and epidemiology of pneumonia caused by COVID-19 is limited. However, it is noted that the pollution of particulate matter ≤2.5 μm in diameter (PM2.5) impairs the first line of defense of the upper airways called cilia (Yongjian et al., 2020). Studies by Cui et al. (2003) conducted during the SARS epidemic in China revealed that SARS, caused by a virus genetically identical to COVID-19, lead to a high mortality rate in areas with deteriorated air quality. A substantial relationship seems to exist between PM2.5 and COVID-19 infection spread over 120 cities. A 10 μg m−3 increase in pollution concentration caused a statistically significant increase in daily counts of the confirmed Corona-positive cases. Wu et al. (2020) have suggested that an increase of just 1 μ gm−3 of PM2.5 corresponded to a 15% increase in COVID-19 deaths. Thus, populations exposed to a high concentration of PM2.5 particles are more prone to developing chronic respiratory diseases favorable to infective agents. Long-term exposure to PM2.5 develops a chronic inflammatory stimulus, especially in children and unhealthy population (Conticini et al., 2020), while a short-term PM2.5 exposure may also increase susceptibility to infections (Chen et al., 2020), because the particulate pollution damages human airways, potentially facilitating viral infections. Also, human exposure to PM2.5 pollutants weakens the immune response, making human body less effective in fighting against the virus-caused diseases (Chen et al., 2020; Li et al., 2019; Liu et al., 2019; Sedlmaier et al., 2009). In an experiment conducted in a small cohort of mice exposed for three months to PM2.5, interleukin-4 (IL-4), tumor necrosis factor (TNF-α) and transforming growth factor (TGF)-β1 were found to occur substantially in the lung parenchyma, leucocytes, macrophages and serum (Yang et al., 2019). Noticeably, a large systemic inflammation damages heart function too, as confirmed by another cohort of mice exposed to PM2.5 (Radan et al., 2019). All these phenomena have been extensively reported to occur in humans also, as PM2.5 is known to contribute to a systemic inflammation in healthy, non-smoker, and young populations (Pope et al., 2016). Apparently, both the short- and long-term PM2.5 exposures contribute to a higher incidence of lethality of COVID-19. According to the WHO official

data on COVID-19, China is the first affected country by COVID-19, with more than 84,652 infected cases and 4645 deaths. Globally, COVID-19 cases are reported to be 8,750,480 with more than 461,813 deaths. According to the Chinese government's senior medical adviser, threat of a second wave of infections is looming large. We believe that epidemiological and experimental researches are urgently required to estimate the impact of PM2.5 incidence on the exposed population in almost every country. Further, the government and researchers of different countries should take into account the PM2.5 exposures in regions with higher levels of atmospheric pollution, while formulating policies to mitigate the incidence of COVID-19.

A vulnerability-based approach to human-mobility reduction for countering COVID-19 transmission in London while considering local air quality

Manu Sasidharan a, 1, Ajit Singh b, c, 1, Mehran Eskandari Torbaghan d, Ajith Kumar Parlikad a

Source: Science of The Total Environment, Volume 741, 1 November 2020, 140515

An ecologic analysis was conducted to explore the correlation between air pollution, and COVID-19 cases and fatality rates in London. The analysis demonstrated a strong correlation ($R2 > 0.7$) between increment in air pollution and an increase in the risk of COVID-19 transmission within London boroughs. Particularly, strong correlations ($R2 > 0.72$) between the risk of COVID-19 fatality and nitrogen dioxide and particulate matter pollution concentrations were found. Although this study assumed the same level of air pollution across a particular London borough, it demonstrates the possibility to employ air pollution as an indicator to rapidly identify the city's vulnerable regions. Such an approach can inform the decisions to suspend or reduce the operation of different public transport modes within a city. The methodology and learnings from the study can thus aid in public transport's response to COVID-19 outbreak by adopting different levels of human-mobility reduction strategies based on the vulnerability of a given region.

Keywords: COVID-19; Human mobility; Air pollution; Particulate matter ($PM_{2.5}$); Nitrogen dioxide (NO_2); Transport.

Changes in ozone and PM2.5 in Europe during the period of 1990–2030: Role of reductions in land and ship emissions

Jianhui Jiang a, Sebnem Aksoyoglu a, Giancarlo Ciarelli b, c, Urs Baltensperger a, André S.H.Prévôt a

Source: Science of The Total Environment, Volume 741, 1 November 2020, 140467

Air pollution is among the top threats to human health and ecosystems despite the substantial decrease in anthropogenic emissions. Meanwhile, the role of ship emissions on air quality is becoming increasingly important with the growing maritime transport and less strict regulations. In this study, we modeled the air quality in Europe between 1990 and 2030 with ten-year intervals, using the regional air quality model CAMx version 6.50, to investigate the changes in the past (1990–2010) as well as the effects of different land and ship emission scenarios in the future (2020,2030). The modeled mean ozone levels decreased slightly during the first decade but then started increasing again especially in polluted areas. Results from the future scenarios suggest that by 2030 the peak ozone would decrease, leading to a decrease in the days exceeding the maximum daily 8-h average ozone (MDA8) limit values (60 ppb) by 51% in southern Europe relative to 1990. The model results show a decrease of 56% (6.3 μg m−3) in PM2.5 concentrations from 1990 to 2030 under current legislation, mostly due to a large drop in sulfate (representing up to 44% of the total PM2.5 decrease during 1990–2000) while nitrate concentrations were predicted to go down with an increasing rate (10% of total PM2.5 decrease during 1990–2000 while 36% during 2020–2030). The ship emissions if reduced according to the maximum technically feasible reduction (MTFR) scenario were predicted to contribute up to 19% of the decrease in the PM2.5 concentrations over land between 2010 and 2030. Ship emission reductions according to the MTFR scenario would lead to a decrease in the days with MDA8 exceeding EU limits by 24–28% (10–14 days) around the coastal regions. The results obtained in our study show the increasing importance of ship emission reductions, after a relatively large decrease in land emissions was achieved in Europe.

Keywords: Ozone; PM2.5; Ship emissions; CAMx; Europe

Can PM2.5 pollution worsen the death rate due to COVID-19 in India and Pakistan?

Khalid Mehmood Sipra a, Saifullah b, Muhammad Mohsin Abrar c, Muhammad Iqbal d, Ehtesham Haider e, Hafiz Muhammad Hassan Shoukat f

Source: Science of The Total Environment, Volume 742, 10 November 2020, 140557

There is growing evidence of a positive correlation between PM2.5 pollution and COVID-19, suggesting that mitigation of PM2.5 will be a decisive step towards easing out the

lockdown over India and Pakistan. PM2.5 is a bothering factor for both countries experiencing the worst air pollution in the world. According to the World Air Quality Report (2018), 22 cities in India and two cities in Pakistan are among the world's top 30 most polluted cities (IQAir AirVisual, 2018). Recently, it has been estimated that 645,000 premature deaths in India, and 111,000 in Pakistan, are recorded every year (Lelieveld et al., 2015). The direct cost of environmental damages associated with the regional air pollution exceeds US$ 0.5 trillion in India and US$ 1.07 billion in Pakistan (Sanchez-Triana et al., 2014; OECD, 2014).

The World Health Organization (WHO) has notified that persons of any age group, who suffer from severe underlying medical conditions, are at a higher risk of getting critically sick from COVID-19. Certain preconditions, including lung cancer, and the respiratory or cardiovascular disorders are triggered by air pollution, and the residents of the region with high levels of PM2.5 before the Corona pandemic are more vulnerable to the infection in comparison to patients in cleaner parts of the world, reports WHO. Persons suffering from cardiovascular and chronic respiratory diseases like asthma and those immunocompromised due to conditions like smoking or cancer, etc., are more susceptible to Corona virus infection (WHO, 2020). A research conducted by Cui et al. (2003) during the SARS (Severe Acute Respiratory Syndrome) epidemic in China highlighted that SARS, caused by a virus genetically identical to COVID-19, caused high mortality in areas with deteriorated air quality. In a recent study in China, a substantial relationship has been found between PM2.5 and COVID-19 infection, which was reported across 120 cities (Zhu and Xie, 2020). It was noted that a 10 μgm−3 increase in pollution concentration led to a statistically significant increase in daily counts of the confirmed symptomatic Corona-positive cases. Wu et al. (2020) at the Harvard University T.H. Chan School of Public Health have suggested that an increase of just 1 μgm−3 of PM2.5 corresponds to a 15% increase in COVID-19 deaths. Another study that establishes the relationship of higher COVID-19 mortality and morbidity to PM2.5 in northern Italy provides a piece of sharp evidence that persons living in an area with high levels of PM2.5 are more susceptible to developing respiratory diseases, which facilitate the impact of any infectious agent, especially in children and unhealthy population (Mehmood et al., 2020; Conticini et al., 2020).

Recently, transboundary air pollution in this region has resulted in an exceptionally high PM2.5 concentration of 1000 μg m−3 in Lahore (Malik, 2017) and 700 μg m−3 in New Delhi (Anand, 2016). These levels are 40 and 28 times higher, respectively than the average daily PM2.5 level of 25 μg m−3, as established by the World Health Organization (WHO). After May 2020, the Pakistan and Indian governments have started to ease the lockdown restrictions, which were imposed to curtail the COVID-19 pandemic. They are trying to resume normal life in the larger more substantial interest of both the nations already perturbed with their crumbling economies. Industrial productions, public transport as well

as construction sites have already resumed their operation in most of the Pakistani provinces and Indian states with implementation of social distancing and personal hygiene practices. According to the WHO official COVID-19 data, India is now the 4th worst affected country by COVID-19 with more than 395,048 infected cases and 12,948 deaths till June 20. In comparison, Pakistan has so far recorded over 171,666 cases of infection with 3382 deaths.

There is a reason for the hope that the two governments can find common ground and resolve together to reduce PM2.5 pollution to improve the health condition of their citizens on both sides of the border. We suggest that multi-pronged efforts be urgently initiated in both the countries to avoid the worse disaster of the current pandemic in the days to follow.

Air quality changes in New York City during the COVID-19 pandemic

Shelby Zangari a, Dustin T.Hill b, c, Amanda T.Charette a, b, Jaime E.Mirowsky a, b

Source: Science of The Total Environment, Volume 742, 10 November 2020, 140496

In December 2019, a new, severe coronavirus (COVID-19) appeared in Wuhan, China. Shortly after, the first COVID-19 case was confirmed in the United States. The emergence of this virus led many United States governors to enact executive orders in an effort to limit the person-to-person spread of the virus. One state that utilized such measures was New York, which contains New York City (NYC), the most populous city in the United States. Many reports have shown that due to the government-backed shutdowns, the air quality in major global cities improved. However, there has been only limited work on whether this same trend is seen throughout the United States, specifically within the densely populated NYC area. Thus, the focus of this study was to examine whether changes in air quality were observed in NYC resulting from New York State's COVID-19-associated shutdown measures. To do this, daily concentrations of fine particulate matter (PM2.5) and nitrogen dioxide (NO2) were obtained from 15 central monitoring stations throughout the five NYC boroughs for the first 17 weeks (January through May) of 2015–2020. Decreases in PM2.5 (36%) and NO2 (51%) concentrations were observed shortly after the shutdown took place; however, using a linear time lag model, when changes in these pollutant concentrations were compared to those measured during the same span of time in 2015–2019, no significant difference between the years was found. Therefore, we highlight the importance of considering temporal variability and long-term trends of pollutant concentrations when analyzing for short-term differences in air pollutant concentrations related to the COVID-19 shutdowns.

Keywords: Particulate matter; Nitrogen dioxide; Air quality; United States; New York.

Air pollution in Ontario, Canada during the COVID-19 State of Emergency

Matthew D.Adams

Source: Science of The Total Environment, Volume 742, 10 November 2020, 140516

In March of 2020, the province of Ontario declared a State of Emergency (SOE) to reduce the spread of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which causes the coronavirus disease (COVID-19). This disruption to the economy provided an opportunity to measure change in air pollution when the population spends more time at home with fewer trips. Hourly air pollution observations were obtained for fine particulate matter, nitrogen dioxide, nitrogen oxides and ozone from the Ontario air monitoring network for 2020 and the previous five years. The analysis is focused on a five-week period during the SOE with a previous five-week period used as a control. Fine particulate matter did not show any significant reductions during the SOE. Ozone concentrations at 12 of the 32 monitors were lower than any of the previous five-years; however, four locations were above average. Average ozone concentrations were 1 ppb lower during the SOE, but this ranged at individual monitors from 1.5 ppb above to 4.2 ppb below long-term conditions. Nitrogen dioxide and nitrogen oxides demonstrated a reduction across Ontario, and both pollutants displayed their lowest concentrations for 22 of 29 monitors. Individual monitors ranged from 1 ppb (nitrogen dioxide) and 5 ppb (nitrogen oxides) above average to 4.5 (nitrogen dioxide) and 7.1 ppb (nitrogen oxides) below average. Overall, both nitrogen dioxide and nitrogen oxides demonstrated a reduction across Ontario in response to the COVID-19 SOE, ozone concentrations suggested a possible reduction, and fine particulate matter has not varied from historic concentrations.

Keywords: COVID-19; Nitrogen dioxide; Nitrogen oxides; Ozone; Fine particulate matter; Ambient air pollution.

Impact of city lockdown on the air quality of COVID-19-hit of Wuhan city

Xinbo Lian a, Jianping Huang a, b, Rujin Huang c, Chuwei Liu a, Lina Wang d, Tinghan Zhang a

Source: Science of The Total Environment, Volume 742, 10 November 2020, 140556

A series of strict lockdown measures were implemented in the areas of China worst affected by coronavirus disease 19, including Wuhan, to prevent the disease spreading. The

lockdown had a substantial environmental impact, because traffic pollution and industrial emissions are important factors affecting air quality and public health in the region. After the lockdown, the average monthly air quality index (AQI) in Wuhan was 59.7, which is 33.9% lower than that before the lockdown (January 23, 2020) and 47.5% lower than that during the corresponding period (113.6) from 2015 to 2019. Compared with the conditions before the lockdown, fine particulate matter (PM2.5) decreased by 36.9% and remained the main pollutant. Nitrogen dioxide (NO2) showed the largest decrease of approximately 53.3%, and ozone (O3) increased by 116.6%. The proportions of fixed-source emissions and transported external-source emissions in this area increased. After the lockdown, O3 pollution was highly negatively correlated with the NO2 concentration, and the radiation increase caused by the PM2.5 reduction was not the main reason for the increase in O3. This indicates that the generation of secondary pollutants is influenced by multiple factors and is not only governed by emission reduction.

Keywords: COVID-19; Lockdown; AQI; PM2.5; NO2; O3.

Temporal variations of short-term effects of particulate matter on hospital admissions in the most densely populated city in Thailand

Arthit Phosri Tanasri Sihabut Chate Jaikanlaya

Source: Science of The Total Environment, Volume 742, 10 November 2020, 140651

Short-term effects of ambient particulate matter (PM) on daily hospital admissions have been comprehensively elucidated, but very few studies evaluated the temporal variations of ambient PM associated with hospital admissions, especially in developing countries. This study aimed to explore the temporal changes of the short-term effects of PM10 on hospital admissions in Bangkok, Thailand from 2006 to 2014. The overdispersed Poisson regression model was applied to related daily PM10 concentrations to daily cardiovascular and respiratory hospital admissions by adjusting for temperature, humidity, long-term trend and seasonality, day of the week, public holiday, and population dynamics. The temporal variations of the effects of PM10 on hospital admissions were assessed by adding an interaction term between PM10 concentration and predefined time periods into the model. The relative risks per 10 μg/m3 increase in PM10 were 1.0092 (95% CI: 1.0046, 1.0138) for cardiovascular admissions at lag 0–3 day and 1.0209 (95% CI: 1.0145, 1.0273) for respiratory admissions at lag 0–7 day over the entire study period. Despite non-homogenous decreasing trends in annual PM10 concentrations during the study period, the effects of PM10 on cardiovascular and respiratory admissions remained significant and even showed an increasing trend for cardiovascular admissions. Specifically, the relative risks of cardiovascular admission per 10 μg/m3 increase in PM10 were 1.0050 (95% CI:

0.9965, 1.0135), 1.0086 (95% CI: 1.0000, 1.0174), and 1.0103 (95% CI: 1.0041, 1.0165) for the period of 2006–2008, 2009–2011, and 2012–2014, respectively (p-value for interaction <0.01). This finding indicated that estimated effects of PM10 on cardiovascular admissions significantly changed over time, speculating that the composition of PM10 might have changed and introduced the alterations of overall toxicity of PM10. Therefore, the efforts on air pollution control need to be continued to reduce health effects of PM10 in the future.

Keywords: Temporal variation; Particulate matter; Cardiovascular disease; Respiratory disease; Hospital admission.

Impact of quarantine measures on chemical compositions of PM2.5 during the COVID-19 epidemic in Shanghai, China

Hui Chen a, b, Juntao Huo c, Qingyan Fu c, Yusen Duan c, Hang Xiao d, Jianmin Chen a, d, b

Source: Science of The Total Environment, Volume 743, 15 November 2020, 140758

The COVID-19 epidemic broke out in Wuhan, Hubei in December 2019 and in January 2020 and was later transmitted to the entire country. Quarantine measures during Chinese New Year effectively alleviated the spread of the epidemic, but they simultaneously resulted in a decline in anthropogenic emissions from industry, transportation, and import and export of goods. Herein, we present the major chemical composition of non-refractory PM2.5 (NR-PM2.5) and the concentrations of gaseous pollutants in an urban site in Shanghai before and during the quarantine period of the COVID-19 epidemic, which was Jan. 8—23 and Jan. 24—Feb. 8, respectively. The observed results show that the reduction in PM2.5 can be mainly attributed to decreasing concentrations of nitrate and primary aerosols. Nitrate accounted for 37% of NR-PM2.5 before the quarantine period when there was no emission reduction. During the quarantine period, the nitrate concentration decreased by approximately 60%, which is attributed to a reduction in the NOx concentration. Ammonium, as the main balancing cation, showed an approximately 45% simultaneous decrease in concentration. The concentrations of chloride and hydrocarbon-like organic aerosols from primary emissions also declined due to limited human activities. By contrast, sulphate and oxygenated organic aerosols showed a slight decrease in concentration, with their contributions increasing to 27% and 18%, respectively, during the quarantine period, which resulted in two pollution episodes with PM2.5 exceeding 100 μg/m3. This study provides a better understanding of the impact of quarantine measures on variations of the PM2.5 concentration and chemical compositions. Atmospheric oxidation capacities based on the oxidant (Ox = O3 + NO2) and oxidation ratios have been discussed for elucidating the source and formation of haze in an environment with lower anthropogenic emissions.

With increasing contribution of secondary aerosols, lower NOx and nitrate concentrations did not completely avoid haze in Shanghai during the epidemic.

Keywords: COVID-19; PM2.5; Chemical composition; Quarantine.

Land use regression modelling of PM2.5 spatial variations in different seasons in urban areas

Tuo Shi a, b, Yuanman Hu a, Miao Liu a, Chunlin Li a, Chuyi Zhang a, b, Chong Liu a, b

Source: Science of The Total Environment, Volume 743, 15 November 2020, 140744

As one of the principal components of haze, fine particulate matter (PM2.5) has potential negative health effects, causing widespread concern. Identification of the pollutant spatial variation is a prerequisite of understanding ambient air pollution exposure and further improving air quality. Seven urban built-up areas in Liaoning central urban agglomeration (LCUA) were used for land use regression (LUR) modelling of PM2.5 concentrations using small amounts of spatially aggregated data and to assess the model's seasonal consistency. LUR models explained 52–61% of the variation in the PM2.5 concentrations at urban scales. The average building floor area was the key predictor in each model, and the percent water area was predictor with a negative coefficient. Good seasonal consistency was observed between the heating-seasonal model and annual average model, showing that the annual average PM2.5 pollution in the LCUA was mainly influenced by pollution during the heating season. Extending the linear LUR model with regression kriging improved the model's explanatory ability and predictive performance. The predicted PM2.5 concentrations in Shenyang and Anshan were the highest and that in Yingkou was the lowest. The building three-dimensional variables played important roles in the urban spatial modelling of air pollution.

Keywords: Land use regression model; Liaoning central urban agglomeration; Seasonal consistency; PM2.5; Air pollution.

Photochemical aging of Beijing urban PM2.5: Production of oxygenated volatile organic compounds

Hongling Xia Di Huang Fengxia Bao Meng Li Yue Zhang Chuncheng Chen Jincai Zhao

Source: Science of The Total Environment, Volume 743, 15 November 2020, 140751

PM2.5 has become the dominant atmospheric pollutant in many countries. Many components of PM2.5 are highly photoactive. However, the photochemical aging of PM2.5 remains poorly understood. In this study, the photoaging of real PM2.5 samples collected from 2017 to 2018 in Beijing under simulated solar radiation ($\lambda \sim 340–850$ nm) was investigated. Our study showed that large amounts of oxygenated volatile organic compounds (OVOCs), such as acetaldehyde, formic acid, acetone and acetic acid, were released during the photochemical aging of PM2.5. Furthermore, although a positive correlation between the OVOCs yield and the organic matter (OM) in PM2.5 was observed, the product distribution from the photoaging of PM2.5 was different from that in the direct photolysis of artificially synthesized SOA. Because of the release of OVOCs, the PM2.5 mass loss was evaluated to be ~1.80% per day under typical atmospheric conditions. The OVOCs released during the photoaging of PM2.5 may contribute substantially to the OVOCs sources omitted from troposphere chemistry models and may have a significant effect on the OVOCs distribution and oxidation capacity of the atmosphere.

Keywords: PM2.5; Photochemical aging; Oxygenated volatile organic compounds; Organic matter.

Levels and sources of hourly PM2.5-related elements during the control period of the COVID-19 pandemic at a rural site between Beijing and Tianjin

Yang Cui a, b, Dongsheng Ji a, b, c, Willy Maenhaut d, Wenkang Gao a, Renjian Zhang e, f, Yuesi Wang a, b, c

Source: Science of The Total Environment, Volume 744, 20 November 2020, 140840

To control the spread of the novel coronavirus disease 2019 (COVID-19) in China, many anthropogenic activities were reduced and even closed on the national scale. To study the impact of this reduction and closing down, hourly concentrations of PM2.5-related elements were measured at a rural site before (12–25 January 2020), during (26 January–9 February 2020) and after (22 March–2 April 2020) the control period when all people remained socially isolated in their homes and could not return to economic zones for work. Nine major sources were identified by the positive matrix factorization model, including fireworks burning, coal combustion, vehicle emissions, dust, Cr industry, oil combustion, Se industry, Zn smelter, and iron and steel industry. Before the control period, K, Fe, Ca, Zn, Ba and Cu were the main elements, and fireworks burning, Zn smelter and vehicle emissions provided the highest contributions to the total element mass with 55%, 12.1% and 10.3%, respectively. During the control period, K, Fe, Ba, Cu and Zn were the dominating elements, and fireworks burning and vehicle emissions contributed 55% and 27% of the total

element mass. After the control period, Fe, K, Ca, Zn and Ba were the main elements, and dust and iron and steel industry were responsible for 56% and 21% of the total element mass. The increased contribution from vehicle emissions during the control period could be attributed to our sampling site being near a town hospital and the fact that the vehicle activities were not restricted. The source apportionment results were also related to air mass backward trajectories. The largest reductions of dust, coal combustion, and the industrial sources (Cr industry, Zn smelter, Se industry, iron and steel industry) were distinctly seen for northwest transport (Ulanqab) and were least significant for northeast transport (Tangshan and Tianjin).

Keywords: COVID-19; Emission reduction; Elements; $PM_{2.5}$; Xianghe; China.

Meteorological influences on PM2.5 and O3 trends and associated health burden since China's clean air actions

Lei Chen a, b, Jia Zhu a, Hong Liao a, Yang Yang a, Xu Yue a

Source: Science of The Total Environment, Volume 744, 20 November 2020, 140837

Stringent clean air actions have been implemented to improve air quality in China since 2013. In addition to anthropogenic emission abatements, the changes in air quality may be modulated also by meteorology. In this study, we developed multiple linear regression models to quantify meteorological influences on the trends in fine particulate matter (PM2.5) and ozone (O3) concentrations and associated health burden over three polluted regions of China, i.e., North China Plain, Yangtze River Delta, and Fen-wei Plain during 2014–2018, with a novel focus on the contributions of the most influential meteorological factors to PM2.5 and O3 trends as well as the meteorological contributions to PM2.5- and O3-related mortality trends. The meteorology-driven PM2.5 (O3) trends for the three regions were −0.5∼−2.0 (+0.7∼+0.8) μg m−3 yr−1, contributing 10– 26% (12– 18%) of the observed five-year decreasing PM2.5 (increasing O3) trends. The decreased relative humidity (increased daytime planetary boundary layer height) was identified to be the most influential meteorological factor and explained 55% (42%) of the largest meteorology-driven PM2.5 (O3) trend among all regions and seasons. The meteorology-driven decreases in PM2.5 (increases in O3) concentrations led to overall decreases in PM2.5-related (increases in O3-related) mortalities with trends of −2.2∼−7.4 (+0.5∼+0.9) thousand yr−1 for the three regions, accounting for 10– 26% (15– 31%) of the total decreasing (increasing) trends in PM2.5-related (O3-related) mortalities. The results emphasize the important role of meteorology in PM2.5 and O3 air quality and associated health burden over China, and have important implications for China's air quality planning.

In particular, more efforts in emission control should be taken to offset the adverse effects on ozone caused by meteorology.

Keywords: PM2.5; Ozone; Meteorological influence; Health impact.

Spatiotemporal heterogeneity of PM2.5 and its relationship with urbanization in North China from 2000 to 2017

Xiangxue Zhang a, b, 1, Xinchen Gu c, 1, Changxiu Cheng a, b, d, Dongyang Yang e

Source: Science of The Total Environment, Volume 744, 20 November 2020, 140925

Fine particulate matter (PM2.5) pollution is becoming an increasing global concern due to rapid urbanization and socioeconomic development, especially in North China. Although North China experiences poor air quality and high PM2.5 concentrations, their spatial heterogeneity and relationship with the relative spatial risks of air pollution have not been explored. Therefore, in this study, the temporal variation trends (slope values) of the PM2.5 concentrations in North China from 2000 to 2017 were first quantified using the unitary linear regression model, and the Bayesian space-time hierarchy model was introduced to characterize their spatiotemporal heterogeneity. The spatial lag model was then used to examine the determinant power of urbanization and other socioeconomic factors. Additionally, the correlation between the spatial relative risks (probability of a region becoming more/less polluted relative to the average PM2.5 concentrations of the study area), and the temporal variation trends of the PM2.5 concentrations were quantified using the bivariate local indicators of spatial association model. The results showed that the PM2.5 concentrations increased during 2000–2017, and peaked in 2007 and 2013. Spatially, the cities at high risk of PM2.5 pollution were mainly clustered in southeastern Hebei, northern Henan, and western Shandong where the slope values were low, as demonstrated by the value of Moran's I (−0.56). Moreover, urbanization and road density were both positively correlated with PM2.5 pollution, while the proportion of tertiary industry was negatively correlated. Furthermore, a notable increasing trend was observed in some cities, such as Tianjin, Zaozhuang, Qingdao, and Xinyang. These findings can contribute to the development of effective policies from the perspective of rapid urbanization to relieve and reduce PM2.5 pollution.

Keywords: PM2.5 concentrations; Urbanization; Spatiotemporal heterogeneity; Temporal variation trends; Bayesian space-time hierarchy model.

Chemical characterization of PM2.5 and source apportionment of organic aerosol in New Delhi, India

Anna Tobler a, Deepika Bhattu a, 1, Francesco Canonaco a, 2, Vipul Lalchandani b, Ashutosh Shukla b, Navaneeth M.Thamban b, Suneeti Mishra b, Atul K.Srivastava c, Deewan S.Bisht c, Suresh Tiwari c, Surender Singh d, Griša Močnik e, f, Urs Baltensperger a, Sachchida N.Tripathi b, Jay G.Slowik a, André S.H.Prévôt a

Source: Science of The Total Environment, Volume 745, 25 November 2020, 140924

Delhi is one of the most polluted cities worldwide and a comprehensive understanding and deeper insight into the air pollution and its sources is of high importance. We report 5 months of highly time-resolved measurements of non-refractory PM2.5 and black carbon (BC). Additionally, source apportionment based on positive matrix factorization (PMF) of the organic aerosol (OA) fraction is presented. The highest pollution levels are observed during winter in December/January. During that time, also uniquely high chloride concentrations are measured, which are sometimes even the most dominant NR-species in the morning hours. With increasing temperature, the total PM2.5 concentration decreases steadily, whereas the chloride concentrations decrease sharply. The concentrations measured in May are roughly 6 times lower than in December/January. PMF analysis resolves two primary factors, namely hydrocarbon-like (traffic-related) OA (HOA) and solid fuel combustion OA (SFC-OA), and one or two secondary factors depending on the season. The uncertainties of the PMF analysis are assessed by combining the random a-value approach and the bootstrap resampling technique of the PMF input. The uncertainties for the resolved factors range from ±18% to ±19% for HOA, ±7% to ±19% for SFC-OA and ±6 % to ±11% for the OOAs. The average correlation of HOA with equivalent black carbon from traffic (eBCtr) is R2 = 0.40, while SFC-OA has a correlation of R2 = 0.78 with equivalent black carbon from solid fuel combustion (eBCsf). Anthracene (m/z 178) and pyrene (m/z 202) (PAHs) are mostly explained by SFC-OA and follow its diurnal trend (R2 = 0.98 and R2 = 0.97). The secondary oxygenated aerosols are dominant during daytime. The average contribution during the afternoon hours (1 pm–5 pm) is 59% to the total OA mass, with contributions up to 96% in May. In contrast, the primary sources are more important during nighttime: the mean nightly contribution (22 pm–3 am) to the total OA mass is 48%, with contributions up to 88% during some episodes in April.

Keywords: New Delhi; $PM_{2.5}$; Source apportionment; PMF.

Effect of meteorological parameters on spread of COVID-19 in India and air quality during lockdown

Sarvan Kumar

Source: Science of The Total Environment, Volume 745, 25 November 2020, 141021

The novel Coronavirus (COVID-19) was identified in Wuhan, Hubei Province, China, in December 2019 and has created a medical emergency worldwide. In India, it is already reported more than 855 thousand cases and more than 22 thousands deaths due to COVID-19 till July 12, 2020. The role of temperature, humidity, and absolute humidity in the transmission of COVID-19 has not yet been well established. In contrast, for the previous many viral infections like influenza, it is well established. Therefore the study to investigate the meteorological condition for incidence and spread of COVID-19 infection and to provide a scientific basis for prevention and control measures against the new disease is required for India. In this work, we analyze daily averaged meteorological data for the last three years (2017–2019) for March, April and May months and the same for the year 2020 for March 1 to May 31. We found a positive association between daily COVID-19 cases and temperature and a mixed association with relative and absolute humidity over India. We have investigated the association of aerosols (AOD) and other pollutions (NO2) with COVID-19 cases during the study period and also during the lockdown period (25 March-31 May) in India. During the lockdown period, aerosols (AOD) and NO2 reduced sharply with a maximum percentage drop of about 60 and 45, respectively. We have also found the reduction in surface PM2.5 PM10 and NO2 for the six mega cities of India during the lockdown period. Our results suggest that COVID-19 still may spread in warm, humid regions or during summer/monsoon, therefore an effective public health intervention should be implemented across India to slow down the transmission of COVID-19.

Keywords: Novel Coronavirus; India; Summer; COVID-19; Pandemic; Absolute humidity.

Implications for air quality management of changes in air quality during lockdown in Auckland (New Zealand) in response to the 2020 SARS-CoV-2 epidemic

Hamesh Patel a, Nick Talbot a, Jennifer Salmond a, Kim Dirks b, Shanju Xie c, Perry Davy d

Source: Science of The Total Environment, Volume 746, 1 December 2020, 141129

The current changes in vehicle movement due to ‘lockdown’ conditions (imposed in cities worldwide in response to the COVID-19 epidemic) provide opportunities to quantify the local impact of ‘controlled interventions’ on air quality and establish baseline pollution concentrations in cities. Here, we present a case study from Auckland, New Zealand, an isolated Southern Hemisphere city, which is largely unaffected by long-range pollution transport or industrial sources of air pollution. In this city, traffic flows reduced by 60–80% as a result of a government-led initiative to contain the virus by limiting all transport to only essential services. In this paper, ambient pollutant concentrations of NO2, O3, BC,

PM2.5, and PM10 are compared between the lockdown period and comparable periods in the historical air pollution record, while taking into account changes in the local meteorology. We show that this 'natural experiment' in source emission reductions had significant but non-linear impacts on air quality. While emission inventories and receptor modelling approaches confirm the dominance of traffic sources for NOx (86%), and BC (72%) across the city, observations suggest a consequent reduction in NO2 of only 34–57% and a reduction in BC of 55–75%. The observed reductions in PM2.5 (still likely to be dominated by traffic emissions), and PM10 (dominated by sea salt, traffic emissions to a lesser extent, and affected by seasonality) were found to be significantly less (8–17% for PM2.5 and 7–20% for PM10). The impact of this unplanned controlled intervention shows the importance of establishing accurate, local-scale emission inventories, and the potential of the local atmospheric chemistry and meteorology in limiting their accuracy.

Keywords: Covid-19; Transport; Black carbon; Particulate; Atmospheric pollution; Emissions inventories.

Air quality development during the COVID-19 pandemic over a medium-sized urban area in Thailand

Dimitris Stratoulias a, b, Narissara Nuthammachot c

Source: Science of The Total Environment, Volume 746, 1 December 2020, 141320

The COVID-19 pandemic has triggered an industrial and financial slowdown due to unprecedented regulations imposed with the purpose to contain the spread of the virus. Consequently, the positive effect on the environment has been witnessed. One of the most prominent evidences has been the drastic air quality improvement, as a direct consequence of lower emissions from reduced industrial activity. While several studies have demonstrated the validity of this hypothesis in mega-cities worldwide, it is still an unsubstantiated fact whether the same holds true for cities with a smaller urban extent and population. In the present study we investigate the temporal development of atmospheric constituent concentrations as retrieved concurrently from the Sentinel-5P satellite and a ground meteorological station. We focus on the period before and during the COVID-19 pandemic over the city of Hat Yai, Thailand and present the effect of the lockdown on the atmospheric quality over this average populated city (156,000 inhabitants). NO2, PM2.5 and PM10 concentrations decreased by 33.7%, 21.8% and 22.9% respectively in the first 3 weeks of the lockdown compared to the respective pre-lockdown period; O3 also decreased by 12.5% and contrary to similar studies. Monthly averages of NO2, CO and PM2.5 for the month April exhibit in 2020 the lowest values in the last decade. Sentinel-5P retrieved NO2 tropospheric concentrations, both locally over the ground station and the spatial average over the urban extent of the city, are in agreement with the reduction

observed from the ground station. Numerous studies have already presented evidence of the bettering of the air quality over large metropolitan areas during the COVID-19 pandemic. In the current study we demonstrate that this holds true for Hat Yai, Thailand; we propound that the environmental benefits documented in major urban agglomerations during the lockdown may extend to medium-sized urban areas as well.

Keywords: COVID-19; Sentinel-5P; Lockdown; Remote sensing; Air pollution; NO_2; Atmospheric particles.

Estimating PM2.5 with high-resolution 1-km AOD data and an improved machine learning model over Shenzhen, China

Wenqian Chen a, b, c, Haofan Ran d, Xiaoyi Cao d, Jingzhe Wang e, Dexiong Teng d, Jing Chen b, Xuan Zheng a

Source: Science of The Total Environment, Volume 746, 1 December 2020, 141093

Studies on fine particulate matter with an aerodynamic diameter of 2.5 μm or smaller (PM2.5) are closely related to the atmospheric environment and human activities but are often limited by ground-level in situ observations. Satellite remote sensing techniques have been widely used to estimate the PM2.5 concentration over large areas where ground-monitoring sites are unavailable. However, satellite-retrieved aerosol optical depth (AOD) products usually feature a coarse resolution, which is insufficient for the estimation of the urban-scale PM2.5 concentration. We developed a new improved random forest (IRF) model based on machine learning and a newly released AOD product with a high resolution of 1-km, which could more effectively and accurately estimate the PM2.5 concentration over Shenzhen in the Guangdong-Hong Kong-Macao Greater Bay Area (GBA), China. Daily PM2.5 concentrations from 2016 to 2018 were estimated from ground-level PM2.5 and meteorological variable data. The popular linear regression model, geographically and temporally weighted regression (GTWR) model and random forest (RF) model without spatiotemporal information were employed for comparison and validation purposes through the 10-fold cross-validation (CV) approach. The IRF model attained an overall R2 value of 0.915 and a root mean square error (RMSE) value of 3.66 μg m−3. This suggests that the IRF model can estimate the urban PM2.5 concentration with a high spatial resolution at the daily, seasonal and annual scales, and the improved machine learning method is better than the linear model proposed by previous studies in terms of the estimation accuracy of the PM2.5 concentration. Generally, the IRF model coupled with AOD data with a 1-km resolution can significantly improve the calculation accuracy of the atmospheric PM2.5 concentration over coastal urban areas in the future.

Keywords: PM2.5; Aerosol optical depth; Machine learning; Improved random forest; Urban area.

Impacts of the COVID-19 responses on traffic-related air pollution in a Northwestern US city

Jianbang Xiang a, Elena Austin a, Timothy Gould b, Timothy Larson a, b, Jeffry Shirai a, Yisi Liu a, Julian Marshall b, Edmund Seto a

Source: Science of The Total Environment, Volume 747, 10 December 2020, 141325

This study evaluates the COVID-19 impacts on traffic-related air pollution, including ultrafine particles (UFPs), PM2.5, black carbon (BC), NO, NO2, NOx, and CO in a Northwestern US city. Hourly traffic, air pollutants, and meteorological data on/near a major freeway in the downtown of Seattle, Washington, were collected for five weeks before and ten weeks after the Washington Stay Home Order (SHO) was enacted, respectively (February 17–May 31, 2020). The pollutants between pre- and post-SHO periods were compared, and their differences were statistically tested. Besides, first-order multivariate autoregressive (MAR(1)) models were developed to reveal the impacts specific to the change of traffic due to the COVID-19 responses while controlling for meteorological conditions. Results indicate that compared with those in the post-SHO period, the median traffic volume and road occupancy decreased by 37% and 52%, respectively. As for pollutants, the median BC and PM2.5 levels significantly decreased by 25% and 33%, relatively, while NO, NO2, NOx, and CO decreased by 33%, 29%, 30%, and 17%, respectively. In contrast, neither size-resolved UFPs nor total UFPs showed significant changes between the two periods, although larger particles (≥115.5 nm) decreased by 4–29%. Additionally, significant differences were found in meteorological conditions between the two periods. Based on the MAR(1) models, controlling for meteorological conditions, the COVID-19 responses were associated with significant decreases in median levels of traffic-related pollutants including 11.5–154.0 nm particles (ranging from −3% [95% confidence interval (CI): −1%, −4%] to −12% [95% CI: −10%, −14%]), total UFPs (−7% [95% CI: −5%, −8%]), BC (−6% [95% CI: −5%, −7%]), PM2.5 (−2% [95% CI: −1%, −3%]), NO, NO2, NOx (ranging from −3% [95% CI: −2%, −4%] to −10% [95% CI: −18%, −12%]), and CO (−4% [95% CI, −3%, −5%]). These findings illustrate that the conclusion of the COVID-19 impacts on urban traffic-related air pollutant levels could be completely different in scenarios whether meteorology was adjusted for or not. Fully adjusting for meteorology, this study shows that the COVID-19 responses were associated with much more reductions in traffic-related UFPs than PM2.5 in the Seattle region, in contrast to the reverse trend from the direct empirical data comparison.

Keywords: COVID-19; Traffic; Air pollution; $PM_{2.5}$; Ultrafine particle (UFP); Meteorology.

Estimating light-duty vehicles' contributions to ambient PM2.5 and PM10 at a near-highway urban elementary school via elemental characterization emphasizing rhodium, palladium, and platinum

Sourav Das a, Shankararaman Chellam a,b

Source: Science of The Total Environment, Volume 747, 10 December 2020, 141268

The primary objective of this research is to accurately estimate light-duty vehicles' (LDVs') emissions of PM2.5 and PM10 over the course of a year within the property line of an inner-city school located adjacent to a heavily-trafficked interstate highway by measuring platinum group elements (PGEs – Rh, Pd, and Pt) along with 49 other major and trace elements. Amongst PGEs, ambient Pd concentrations were the highest, averaging 11 pg/m3 in PM10 and 4.0 pg/m3 in PM2.5 followed by Pt (3.5 pg/m3 in PM10 and 1.4 pg/m3 in PM2.5), and Rh (1.6 pg/m3 in PM10 and 0.52 pg/m3 in PM2.5). Simultaneous three-component variations in Rh, Pd, and Pt in both PM size classes at this surface site closely matched the composition of (i) a mixed random lot of recycled autocatalysts obtained from numerous LDVs and (ii) PM inside a proximal underwater tunnel open only to light-duty vehicles. Additionally, quantitative estimates of LDV contributions to ambient PM calculated by chemical mass balance modeling (CMB) were strongly correlated with PGE abundances. Therefore, PGEs predominantly originated from gasoline-driven motor vehicles validating them as unique LDV tracers. Further, CMB estimated that vehicles contributed 37% on average (12–67%) to PM10 and 49% on average (25–73%) to PM2.5. Evidence is also presented for a subset of other trace metals; i.e. Cu, As, Mo, Cd, and Sb to also be relatively strong LDV tracers. Results highlight the importance of measuring PGEs in addition to numerous other elements in PM to accurately apportion aerosols emanating from LDVs, which will better isolate public health and environmental impacts associated with the transportation sector.

Keywords: Platinum group metals; Air pollution; Source apportionment; Elemental tracers; Aerosols.

Assessment of the PM2.5 oxidative potential in a coastal industrial city in Northern France: Relationships with chemical composition, local emissions and long range sources

Lamia Moufarrej Dominique Courcot Frédéric Ledoux

Source: Science of The Total Environment, Volume 748, 15 December 2020, 141448

The objective of this work was to relate PM2.5 Oxidative Potential (OP) data to PM composition and PM local and distant source contributions. PM2.5 collected in Dunkerque, a coastal industrial city in North of France, was extensively characterized for major and minor chemical species. PM2.5 filters were extracted using a synthetic pulmonary fluid to achieve OP estimation based on Ascorbic Acid (AA) and dithiothreitol (DTT) depletion assays. In order to evidence relationships between OP values, chemical composition and local and distant source contributions, correlation coefficient, Principal Component Analysis (PCA), concentration roses, polar plots and concentration weighted trajectories were used. Heterogeneous conclusions were drawn using the three first methods as the bivariate polar plots lead to dismiss some of the correlations evidenced using correlation coefficient and PCA. Both AA and DTT tests appeared complementary as they were not sensitive to the same species/source contribution. The bivariate polar plot representation of OP values versus wind direction and wind speed revealed that PM2.5 concentration and combustion sources were linked to OP-AA, whereas emissions from integrated steelworks, electric steelworks, heavy fuel oil combustion and traffic non-exhaust significantly contribute to OP-DTT. Sea-salts, aged sea-salts, crustal, secondary sulfates and secondary nitrates sources were not found to contribute to OP values. Constant weighted trajectories evidenced several source regions responsible for high OP values with Belgium, Germany, Netherlands and France at the leader position. Contribution of inland regions appeared possibly related to the biomass and traffic related combustion while heavy fuel oil combustion could also be involved in the contribution of marine and coastal areas.

Keywords: PM2.5; Source contribution; Oxidative potential; Dithiothreitol (DTT) assay; Acid ascorbic (AA) assay; Concentration weighted trajectories (CWT).

The influence of environmental efficiency on PM2.5 pollution: Evidence from 283 Chinese prefecture-level cities

Guangdong Li a, b, Chuanglin Fang a, b, Sanwei He c

Source: Science of The Total Environment, Volume 748, 15 December 2020, 141549

Environmental inefficiency caused by the extensive economic growth pattern is considered a critical driver of the unprecedented PM2.5 (fine particulate matter) pollution in China. However, the nexus between environmental efficiency and PM2.5 concentrations has rarely been examined. We used a recently developed data envelopment analysis method to measure environmental efficiency, environmental total factor productivity, and their

compositions in China at the prefecture level from 2003 to 2013 and examined the effects of environmental efficiency on PM2.5 pollution. The results indicated that improvements in environmental efficiency significantly ameliorated PM2.5 pollution. The effect of technological progress on PM2.5 reduction is limited, but the pure efficiency and scale efficiency promoted by enhanced management level and optimized production scale strongly contribute to PM2.5 mitigation. The significant spatial spillover of environmental efficiency and PM2.5 pollution introduces challenges and opportunities for lowering PM2.5 emissions. The impact of environmental efficiency on PM2.5 pollution exhibits significant spatiotemporal heterogeneity, and the strength of influence tends to increase with PM2.5 concentration and become more pronounced over time. Furthermore, several socioeconomic factors are related to PM2.5 pollution, which implies that PM2.5 control is a complex system and requires a comprehensive policy mix.

Keywords: Fine particulate matter; Environmental efficiency; Economic growth pattern; Spatial spillover; China.

Air quality variations in Northern South America during the COVID-19 lockdown

Juan F. Mendez-Espinosa a, Nestor Y.Rojas b, Jorge Vargas b, Jorge E.Pachón c, Luis C.Belalcazar b, Omar Ramírez d

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Lockdown measures led to air pollution decrease in several countries around the world such as China and India, whereas other regions experimented an increase in pollutant concentrations. Northern South America (NSA) was one of those areas where pollution changed during lockdown due to high fire activity. This study aims to analyze, for the first time in NSA, the behavior of selected criteria air pollutants during the implementation of the SARS-CoV-2 lockdown in two high populated cities of the region: Bogotá and Medellín in Colombia. A set of tools including surface measurements, as well as satellite and modeled data were used. 24-hour average concentrations of PM10, PM2.5, and NO2 were collected from air quality stations for the lockdown period ranging from February 21 to June 30, 2020. The Copernicus Atmosphere Monitoring Service (CAMS) was used to analyze the fire flux OC as a biomass burning (BB) indicator, and tropospheric NO2 concentrations were retrieved from TROPOMI. The HYSPLIT model was used to analyze back trajectories and fire data were obtained from MODIS sensor measurements. Our analysis shows short-term background NO2, PM10, and PM2.5 concentration reductions of 60%, 44%, and 40%, respectively, for the strict lockdown; and 62%, 58%, and 69% for the relaxed lockdown. Corresponding long-term reductions were of 50%, 32%, and 9% for the strict lockdown;

and 37%, 29%, and 19% for the relaxed lockdown. Regional BB increased PM2.5 concentrations by 20 μg/m3 during the strict lockdown, and the Saharan dust event increased PM10 concentrations up to 168 μg/m3 in Bogotá, and 104 μg/m3 in Medellín, bringing an additional risk of morbidity and mortality for population. Regional BB has several causes that need to be properly managed to benefit local air quality improvement plans. Future cleaner transport policies equivalent to reduced lockdown mobility could bring pollution close to WHO guidelines.

Keywords: SARS-CoV-2; Pandemic; Lockdown; Particulate matter; NO_2; Biomass burning.

Impact of the COVID-19 pandemic and control measures on air quality and aerosol light absorption in Southwestern China

Yang Chen a, Shumin Zhang b, Chao Peng a, Guangming Shi c, Mi Tian d, Ru-Jin Huang e, Dongmei Guo b, Huanbo Wang f, Xiaojiang Yao a, Fumo Yang c

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China has been performing nationwide social lockdown by releasing the Level 1 response to major public health emergencies (RMPHE) to struggle against the COVID-19 (SARS-CoV-2) outbreak since late January 2020. During the Level 1 RMPHE, social production and public transport were maintained at minimal levels, and residents stayed in and worked from home. The universal impact of anthropogenic activities on air pollution can be evaluated by comparing it with air quality under such extreme conditions. We investigated the concentration of both gaseous and particulate pollutants and aerosol light absorption at different levels of (RMPHE) in an urban area of southwestern China. During the lockdown, PM2.5, PM10, SO2, NOx, and BC decreased by 30–50%, compared to the pre-Level 1 RMPHE period. Meanwhile, the decrease of NOx caused the rise of O3 by up to 2.3 times due to the volatile organic compounds (VOCs) limitation. The aerosol light absorption coefficient at multiple wavelengths decreased by 50%, and AAE decreased by 20% during the Level 1 RMPHE. BrC played essential roles in light absorption after the RMPHE was announced, accounting for 54.0% of the aerosol absorption coefficient at 370 nm. Moreover, the lockdown down-weighted the fraction of fossil fuel in BC concentrations to 0.43 (minima). This study characterizes air pollution at the most basic level and can provide policymakers with references for the “baseline.”

Keywords: COVID-19; Lockdown; Air quality; Southern China; Black carbon.

Pollution control in urban China: A multi-level analysis on household and industrial pollution

Hongyan Zhang a, b, Yinqiu Song a, Lin Zhang b

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This paper studies the effectiveness of pollution control in urban China by constructing a two sub-system analysis: household pollution control subsystem and industrial pollution control subsystem. We integrate slack-based model with undesirable outputs to estimate the pollution control efficiency in two subsystems for Chinese provinces from 2011 to 2015. The results show strong evidence on provincial and regional heterogeneity in pollution control efficiency for both systems. At provincial level, Beijing, Shanghai, Jiangsu, Guangdong, Hainan, and Qinghai have achieved full efficiency in both household and industrial pollution control compared with other provinces. At regional level, the Eastern Coastal region is the most effective area in environmental protection among eight economic regions in China. We then measure the economic importance of controlling various pollutants by dual price approach. Policy suggestions for each region are given to improve the effectiveness of pollution control in urban China.

Keywords: Pollution control efficiency; Household pollution; Industrial pollution; Urban China.

Indian Institute of Tropical Meteorology
Dr. Homi Bhabha Road, Pashan, Pune - 411 008, India
Telephone: +91-20-2590-4200
E-mail: iitm-env@nic.in
Website: www.iitmenvis.nic.in