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ABSTRACTS

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Aerosol and Air Quality Research

Characterization of PM Using Multiple Site Data in a Heavily Industrialized Region of Turkey

Melik Kara, Philip K. Hopke , Yetkin Dumanoglu, Hasan Altiok, Tolga Elbir, Mustafa Odabasi, Abdurrahman Bayram

Source:*Volume 15, No. 1, February 2015, Pages 11-27, doi: 10.4209/aaqr.2014.02.0039*

Source apportionment has most often been applied to a time series of data collected at a single site. However, in a complex airshed where there are multiple sources, it may be helpful to collect samples from multiple sites to ensure that some of them have low contributions from specific sources such that edges can be properly defined. In this study, samples were collected at multiple sites in the Aliaga region (38°40′–38°54′N and 26°50′–27°03′E) located in western Turkey on the coast of the Aegean Sea. This area contains a number of significant air pollution sources including five scrap iron-steel processing plants with electric arc furnaces (EAFs), several steel rolling mills, a petroleum refinery, a petrochemical complex, a natural gas-fired power plant, a fertilizer plant, ship breaking yards, coal storage and packaging, scrap storage and classification sites, large slag and scrap piles, heavy road traffic, very intense transportation activities including ferrous scrap trucks and busy ports used for product and raw material transportation. A total of 456 samples of PM10 at six sampling sites and 88 samples of PM2.5 at one site were collected for four seasons and the elemental composition was determined for 43 elements. The newest version of EPA PMF (V5.0) that has the capability of handling multiple site data was used for source apportionment. Eight factors were identified as iron-steel production from scrap (23.4%), re-suspended and road dust (23.3%), crustal (20.5%), marine aerosol (14.4%), biomass and wood combustion (7.2%), salvage activities (4.7%), coal combustion (3.7%) and residual oil combustion (2.8%). The pattern of source contributions and conditional probability function analysis were consistent with the locations of the known sources. Thus, the multiple site data allowed for a comprehensive identification of the primary sources of PM in this region.

Keywords: *EPA PMF (V5.0); Trace elements; Source contribution; Iron-steel production; Aliaga.*

Bulk Level to Individual Particle Level Chemical Composition of Atmospheric Dust Aerosols (PM5) over a Semi-Arid Urban Zone of Western India (Rajasthan)

Rajesh Agnihotri, Sumit K. Mishra, Pawan Yadav, Sukhvir Singh, Rashmi, M.V.S.N. Prasad, C. Sharma1, Bhuwan Chandra Arya

Source: *Volume 15, No. 1, February 2015, Pages 58-71, doi: 10.4209/aaqr.2013.08.0270*

Mineral dust particles in the lower atmosphere may significantly influence radiative and optical budgets, along with the net chemical balance, through their interactions with ambient chemicals. Their ability to absorb/scatter incoming radiation strongly depends on their chemical composition (i.e., distribution of major crustal elements), but as yet there is no adequate regional database with regard to this for the Indian region. To create a regional database of background mineral dust from a semi-arid zone of western India, we measured the chemical composition of ambient particles (with aerodynamic diameter $\leq$ 5 μm; PM5), collected from seven locations of Jaipur city (in the vicinity of Thar Desert; Rajasthan) at varying altitudes, during late-winter of 2012. The chemical compositions of the sampled particles at both bulk and individual levels were measured using X-ray fluorescence (XRF) and Scanning Electron Microscope equipped with Energy Dispersive X-ray (SEM-EDX) techniques, respectively. Significant differences in chemical

compositions were observed among the seven sites, yet the bulk chemical compositions of the particles were broadly consistent with those of individual particles. Average elemental ratios of Mg/Al, Si/Al, K/Al, Ca/Al, Mn/Al, Fe/Al were found to be 0.44 ± 0.22, 1.96 ± 0.90, 0.65 ± 0.22, 1.52 ± 0.40, 0.84 and 1.54 ± 1.67 respectively. We also estimated the complex refractive index (RIs at 550 nm wavelength) for the studied sites, yielding an average n and k (the real and imaginary parts of RI, respectively) of (1.56 ± 0.03) + (6.5 ± 4.6) × 10–3i, with the aerosols collected from Kukas Hill area (27.02°N, 75.85°E) having the highest iron (Fe) mass fraction (~43%). Non-crustal elements e.g., Cu, S, C, Ag and Pb were found only in aerosols over the main city Birla Temple (Jaipur) at ground level (26.89°N, 75.81°E).

Keywords: *PM5; Mineral dust aerosols; Rajasthan; Chemical composition; Refractive index.*

Cultural and Ritual Burning Emission Factors and Activity Levels in India

Shamsh Pervez, Rajan Chakrabarty, Shippi Dewangan, John G. Watson, Judith C. Chow, Jeevan Lal Matawle, Yasmeen Pervez

Source: *Volume 15, No. 1, February 2015, Pages 72-80, doi: 10.4209/aaqr.2014.01.0022*

Real-world particulate matter, organic carbon, and elemental carbon (OC and EC) emission measurements were measured for different cultural and ritual burning practices. These were (g/kg): 11.36 (OC), 0.27 (EC) and 31.04 (RPM) for Marriage Events; 27.04 (OC), 0.18 (EC) and 123.82 (RPM) for Muslim Holy Shrines; 25.99 (OC), 0.85 (EC) and 47.93 (RPM) for Buddhist Temples; and 3.47 (OC), 7.96 (EC) and 20.13 (RPM) for Hindu Temples. When projected to reasonable levels of such activities throughout India, the total annual emissions would be 72.38 Gg/yr, comparable to those from transport (165 Gg/yr), power plants (19 Gg/yr), agricultural waste burning (428 Gg/yr) and forest and savannah burning (176 Gg/yr).

Keywords: *Emission factors; OC and EC fractions; Cultural and ritual performances; Combustion activities; Asian Brown Haze.*

In-Vehicle Exposure to Ultrafine Particles While Driving through a Tunnel System and Associated Lung Deposition Calculations

Pierre Madl, Hussain Majid, Felicitas Kwasny, Werner Hofmann

Source: *Volume 15, No. 1, February 2015, Pages 295-305, doi: 10.4209/aaqr.2014.01.0013*

Tunnels serve as enclosed particle loaded environments where mostly stagnant and stable abiotic conditions prevail throughout the year. In-vehicle exposure to ultra-fine particles (UFP) is therefore significant while driving through long tunnels. The objective of this study was to assess exposure to UFP while driving a car through a 3.4 km long highway tunnel system in Austria and to calculate the associated lung deposition. On board a mobile Scanning Mobility Particle Sizer (SMPS, Grimm model 5403) was used to monitor the particle number concentration in the size range of 5.5 nm to 350 nm. The influence of various air ventilation settings inside the passenger cabin of the car was investigated in terms of UFP concentrations. These ventilation settings and hence the associated particle concentrations inside the cabin were used in the lung deposition model IDEAL to determine their fate in the lung. To examine a real life situation, this heavily frequented highway tunnel system was chosen to serve as a particle laden environment. The data were obtained over several days throughout the year to analyze the effect of traffic mix on the resulting particle regime.

Our study revealed a decrease of in-cabin air pollution by up to 88% while using recirculating air (RA) settings in combination with the air-conditioning system. This mode of operation in comparison to plain tunnel air (TA) reduced the corresponding lung deposition by up to 95%. Our observations thus suggest making use of recirculating air setting while driving through poorly ventilated areas such as tunnels. Doing so considerably reduces the resultant particle deposition in the lung.

Keywords: *Ultrafine particles; Lung deposition; Particle distribution; Traffic; Tunnel.*

Short Term Health Effects of Particulate Matter: A Comparison between Wood Smoke and Multi-Source Polluted Urban Areas in Chile

Luis Díaz-Robles, Samuel Cortés, Alberto Vergara-Fernández, Juan Carlos Ortega

Source: *Volume 15, No. 1, February 2015, Pages 306-318, doi: 10.4209/aaqr.2013.10.0316*

Temuco and Pudahuel are two urban areas in Chile that are among the highest in particulate matter (PM10) air pollution in Chile. In fact, Temuco is also classified as one of the most polluted cities in Latin America by the World Health Organization. Both cities show important differences in the sources of this PM10 pollution. For Temuco, a southern city, the main source is the residential wood combustion (RWC), and for Pudahuel, located in the central zone, the main sources are mobile and point sources. The relationship between PM10 air pollution and health effects measured as the daily number of deaths and hospital admissions for cardiovascular and respiratory causes was determined. The Air Pollution Health Effects European Approach (APHEA-2) protocol was followed, and a multivariate Poisson regression model with gam.exact algorithm was fitted for these cities during 2001–2006. The results show that PM10 had a significant association with daily mortality, where the relative risks (RR) for cardio respiratory mortality of the elderly age group was 1.0126 [95% (CI: 1.0004–1.0250)] at Temuco and 1.0086 [95% (CI: 1.0007–1.0165)] for Pudahuel when PM10 increased by 10 μg/m3. For the hospital admissions due to chronic obstructive pulmonary disease (COPD), the RR were 1.0198 [95% (CI: 1.0030–1.0369)] at Temuco and 1.0097 [95% (CI: 1.0000–1.0204)] at Pudahuel. There is evidence in these cities of positive relationships between ambient particulate levels and the rates of mortality and morbidity for cardiovascular and respiratory causes; being the excess risk 47% and 104.1% higher in Temuco than Pudahuel for cardiorespiratory mortality of the elderly population and COPD hospital admissions, respectively. These results demonstrate that there is greater risk when people are exposed to air polluted with wood smoke.

Keywords: *Soot; Residential wood combustion; Mortality; Hospital admissions; Time series.*

Characterizing Particulate Pollutants in an Enclosed Museum in Shanghai, China

Lina Wang, Guangli Xiu, Yuanxiang Chen, Fangyuan Xu, Laiming Wu, Danian Zhang

Source: *Volume 15, No. 1, February 2015, Pages 319-328, doi: 10.4209/aaqr.2013.12.0360*

The present study reported simultaneous measurements of particle number concentration (PNC), particle mass concentration, water soluble organic carbon (WSOC), organic carbon (OC), elemental carbon (EC), particulate morphology and main elemental properties. The measurements were conducted in a museum located in the downtown area of Shanghai. The impacts of storey, particle size and decorative flooring on particle characteristics inside museum were investigated. Size fractionated PNC in display halls belonging to

the same storey exhibited similar daily variations. Particles within the range of 0.3–0.5 µm were identified as the most significant contributors to the overall size distribution measured, as ambient fine particles penetrated through the mechanical ventilation system. Multi-lognormal fitting OC concentrations can be assigned to the presence of tourists in the museum or originate from secondary OC formation. The latter can be estimated by comparing the relationship between OC and EC, as well as OC and WSOC.

Keywords: *Element carbon; Organic carbon; Particulate matter; WSOC.*

Impact of Elevated Ozone on Growth, Yield and Nutritional Quality of Two Wheat Species in Northern India

Ritu Tomer, Arti Bhatia, Vinod Kumar, Amit Kumar, Renu Singh, Bhupinder Singh, S.D. Singh

Source: *Volume 15, No. 1, February 2015, Pages 329-340, doi: 10.4209/aaqr.2013.12.0354*

Sensitivity to tropospheric ozone is highly variable in cultivars of different plant species. Wheat, an important cereal crop, has been found to be sensitive to elevated ozone levels leading to differences in grain yields. The objective of this study was to compare the effects of elevated tropospheric ozone on growth, yield and nutritional quality of two species of wheat, Triticum aestivum (PBW 343) and Triticum durum (HD 2936), which are tropical wheat cultivars commonly grown in northern India. Experiments were conducted growing winter wheat (rabi season) under elevated tropospheric ozone in northern India for two years in open-top chambers (OTCs) under charcoal-filtered air (CF), non-filtered air (NF), open air (OA) and elevated ozone (EO) concentration (NF + 25–35 ppb O3). There were different species responses to EO, with the modern aestivum wheat cultivar being more sensitive than durum wheat. The declines in all growth and yield parameters were greater in T. aestivum than T. durum in both the years. On average there was a 7% greater reduction in the photosynthetic rate and stomatal conductance in T. aestivum as compared to T. durum under EO at the flowering stage, and a 6% more reduction in leaf chlorophyll was observed on T. aestivum as compared to T. durum. Exposure to elevated O3 caused a decrease in the number of leaves and leaf area index, rubisco enzyme activity and chlorophyll in both the species. More reductions in grain yield were observed in T. aestivum (15 and 19%) as compared to T. durum (9 and 13%) under EO in the two years, respectively. Filtration of air significantly increased all growth and yield parameters in both species of wheat.

Keywords: *Tropospheric ozone; Triticum aestivum L.; Triticum durum L.; Grain yield.*

Inter and Intra-Annual Variability in Aerosol Characteristics over Northwestern Indo-Gangetic Plain

Atinderpal Singh, Neeraj Rastogi, Deepti Sharma, Darshan Singh

Source: *Volume 15, No. 2, April 2015, Pages 376-386, doi: 10.4209/aaqr.2014.04.0080*

This study reports the temporal characteristics of aerosols mass concentration (PM10, PM2.5, PM1), size distribution and optical depth from December 2011 to November 2013 over Patiala (30.33°N, 76.4°E, 249 a.s.l.), a site located in Indo-Gangetic Plain (IGP) in northwestern India, a region with the highest population density in the world. PM10, PM2.5, and PM1 varied from 71 to 221, 27 to 92, and 17 to 75 µg/m3, respectively, with the highest concentration of PM10 during summer of 2012, and PM2.5 and PM1 during autumn of 2013. These mass concentrations were significantly higher than National Ambient Air Quality

(NAAQ) standards (PM10 = 60 and PM2.5 = 40 µg/m3), suggesting poor quality of air over IGP. Both natural and anthropogenic sources were found to be responsible for poor air quality of IGP with more contribution from the latter source as inferred from Ångström exponent (α380–870) and fine mode fraction (FMF: PM2.5/PM10) of aerosols, which have shown large temporal variability. The particle size distribution is skewed towards particles with size less than 1.00 µm and very few particles are having the size greater than 6.25 µm. Aerosol optical depth at 500 nm (AOD500) ranged from 0.36 to 0.64 and shows the highest value during summer of 2012 (0.64 ± 0.09) and autumn of 2013 (0.64 ± 0.25) and minimum (0.36 ± 0.05) in spring of 2013, further reflecting the different effects of aerosols on climate during different seasons. The relation between AOD500 and PM mass has also been investigated, which has exhibited significant seasonality and AOD500 is more sensitive towards the concentration of PM1 rather than PM2.5 and PM10. These results give insight to the relative contribution of natural as well as anthropogenic aerosol sources to their total atmospheric abundances and their possible effect on ambient air quality and Earth's radiation balance.

Keywords: *Particulate matter (PM); Fine mode fraction (FMF); Aerosol optical depth (AOD); Ångström exponent.*

Chemical Composition of Fine and Coarse Aerosol Particles in the Central Mediterranean Area during Dust and Non-Dust Conditions

Antonella Malaguti, Mihaela Mircea, Teresa M.G. La Torretta, Chiara Telloli, Ettore Petralia, Milena Stracquadanio, Massimo Berico

Source: *Volume 15, No. 2, April 2015, Pages 410-425, doi: 10.4209/aaqr.2014.08.0172*

A two-month field campaign was carried out from May to June 2010 at a remote site (Trisaia ENEA Research Centre) in the Southern Italy aiming to identify and quantify the changes of aerosol chemical composition in the presence of Saharan dust. The 24-hr PM10 and PM2.5 filter samples were analyzed by mass, carbonaceous species, inorganic ions and elemental composition. Saharan dust transport events were identified with two approaches: one recommended by EC (2011) and one based on indicators derived from measurements. Three indicators were used: PM2.5/PM10 mass concentrations ratio, Ca/Al ratio and Al concentration. Based on these criteria, four Saharan dust transport events were identified, but only one had elevated dust concentration and leaded to an exceedance of the European short-term (24 hour) limit value of 50 µg/m3 for PM10 (June 16th). The comparison of chemical composition of fine and coarse aerosol fractions during dust and non-dust conditions shows that the presence of dust increases NH4 and nssSO4 concentrations in the fine fraction and NO3 and nssSO4 concentrations in the coarse fraction. OC and EC concentrations also increase in the fine fraction during dust transport. The uptake of primary and secondary species, inorganic and organic, by dust particles changes their composition and, thus, their properties and this may have implications for human health and climate change.

Keywords: *Saharan dust; Fine and coarse chemical composition; Central Mediterranean (Southern Italy).*

Measurement and Analysis of Fine Particulate Matter (PM2.5) in Urban Areas of Pakistan

Anjum Rasheed, Viney P. Aneja, Anantha Aiyyer, Uzaira Rafique

Source: *Volume 15, No. 2, April 2015, Pages 426-439, doi: 10.4209/aaqr.2014.10.0269*

In order to assess the extent of air quality within the major urban environments in Pakistan, PM2.5 pollutant has been analyzed during the period 2007–2011 in Islamabad; and 2007 to 2008 in Lahore, Peshawar and Quetta (high elevation, 1680 m MSL). Seasonal and diurnal variations of PM2.5 mass concentration formation and accumulation within these areas have been analyzed. Air quality monitoring data and meteorological data (both QA/QCed) were obtained from Federal and Provincial Pakistan Environmental Protection Agencies. In Islamabad, the annual average PM2.5 mass concentrations were 81.1 ± 48.4 μg/m3, 93.0 ± 49.9 μg/m3, 47.8 ± 33.2 μg/m3, 79.0 ± 49.2 μg/m3, and 66.1 ± 52.1 μg/m3 during 2007 to 2011 respectively. Comparison of the four cities during summer 2007 to spring 2008 shows that all the four cities had PM2.5 concentration exceeding the Pakistan National Environmental Quality Standards (annual average concentration of 25 μg/m3; and 24 hourly average concentration of 40 μg/m3) for ambient air. During the same time period, the highest seasonal PM2.5 mass concentrations for Islamabad were observed as 98.5 μg/m3 during spring 2008; 150.4 ± 87.9 μg/m3; 104.1 ± 51.1 μg/m3 and 72.7 ± 55.2 μg/m3 for Lahore, Peshawar, and Quetta during fall 2007, respectively. Wind speed and temperature have a negative correlation with the mass concentration of PM2.5. Diurnal profile for all the cities suggests an association of PM2.5 with vehicular traffic. Back trajectory analysis conducted using the NOAA HYSPLIT model indicates that air trajectories, during high pollution episodes, influencing the urban regions commonly originate from either western India, especially in summer as part of the prevailing monsoon circulation; or are located in eastern Afghanistan. The source areas in Western India i.e., states of Gujarat, Rajasthan and Punjab have high concentration of industrial activities and crop residue burning, and are likely sources of enhanced PM2.5 concentrations, in addition to the local sources.

Keywords: *Pakistan; Fine particulate matter; Pollution; Meteorology.*

Characterization and Elemental Composition of Atmospheric Aerosol Loads during Springtime Dust Storm in Western Saudi Arabia

Mansour A. Alghamdi, Mansour Almazroui, Magdy Shamy, Maria Ana Redal, Abdulrahman K. Alkhalaf, Mahmoud A. Hussein, Mamdouh I. Khoder

Source: *Volume 15, No. 2, April 2015, Pages 440-453, doi: 10.4209/aaqr.2014.06.0110*

Dust storm is a common phenomenonand, a severe environmental hazard in western Saudi Arabia. In this study, simultaneous measurement of PM10, PM2.5 and PM1.0 and elemental compositions analysis of PM2.5 in Jeddah city during springtime (March 2012) dust storm (DS) and non-dust storm (non-DS) periods were carried out to investigate the impact of DS on the levels, characterization and elemental compositions of atmospheric particles. Results indicate that PM fractions concentrations were higher in DS environment compared to non-DS. The diurnal variation of PM fractions concentrations was uni-modal in non-DS environment and bimodal in DS. PM1.0/PM10, PM2.5/PM10 and PM2.5/PM2.5–10 ratios were relatively lower in DS, indicating that sand-dust events in spring carry much more coarse than fine particles to Jeddah. PM10, PM2.5 and PM1.0 in DS and PM10 and PM2.5 in non-DS might originate from similar sources. PM10, PM2.5, PM1.0 in DS and PM10 in non-DS were correlated negatively with relative humidity and positively with wind speed. PM2.5 and PM1.0 in non-DS were correlated positively with relative humidity

and negatively with wind speed. The crustal elements accounted for 44.62 and 67.53% of the total concentrations of elements in non-DS and DS, respectively. The elements concentrations increased in DS, with highest DS/non-DS ratios for Ca, Si, Al and Fe. This indicates that the soil originating species contributed mainly in DS particles.The enrichment factors values and non-crustal fractions in both non-DS and DS indicate that the main sources of Na, Mg, Si, K, Ca, Ti, Cr, Mn, Fe, Rb and Sr are of a crustal type, whereas S, Cl, Co, Cu, Zn, Ga, As, Pb and Cd are anthropogenic. V and Ni in DS only are emitted from anthropogenic sources. The enrichment factors of these anthropogenic elements were lower in DS. They might originate mainly from local sources in Jeddah.

Keywords: *PM10/PM2.5/PM1.0; Diurnal variation; Elemental composition; Dust storm; Jeddah.*

Investigation of Desert Dust Contribution to Source Apportionment of PM10 and PM2.5 from a Southern Mediterranean Coast

Hassen Kchih, Cinzia Perrino, Semia Cherif

Source: *Volume 15, No. 2, April 2015, Pages 454-464, doi: 10.4209/aaqr.2014.10.0255*

In order to identify the source apportionment of particulate matter PM10 and PM2.5 in the southern Mediterranean coast of Tunis (Tunisia), three different sites characterized respectively by traffic, industries and being an urban background area are studied. The chemical characterization included a gravimetric determination of atmospheric particles mass concentration, measurements of the major anions (SO42–, NO3–, Cl–) and cations (Ca2+, Mg2+, K+, NH4+) concentrations in the aerosol samples by ion chromatography and analysis of 18 elements by energy dispersion X-ray fluorescence. Aerosol ion balance of various PM10 constituents are used to identify possible sources of the particulate matters. Thanks to these analysis, the particulate masses were reconstructed from the main possible constituents: crustal matter, primary and secondary pollutants, marine aerosols and organic matter. Wherever PM10 and PM2.5 were studied, PM10 crustal elements and sea salt aerosols were mainly associated with the coarse fraction whereas primary and secondary anthropogenic pollutants as well as organic matter rather compose PM2.5 fraction. In all the sites, PM10 mass was mainly composed of crustal matter (41–50%) and poorly of sea salt (3–4%). And so aerosols chemical composition is heavily affected by dust winds from Sahara desert, with some contribution of local traffic and industries and only a slight direct impact of the nearby Mediterranean sea.

Keywords: *Particulate matter (PM); Tunis; Source apportionment; Chemical characterization; ED-XRF analysis.*

Characterization of Black Carbon Aerosols over Darjeeling - A High Altitude Himalayan Station in Eastern India

Chirantan Sarkar, Abhijit Chatterjee, Ajay Kumar Singh, Sanjay Kumar Ghosh, Sibaji Raha

Source: *Volume 15, No. 2, April 2015, Pages 465-478, doi: 10.4209/aaqr.2014.02.0028*

A continuous monitoring of black carbon (BC) aerosols was carried over a high altitude station Darjeeling (27°01′N, 88°15′E; 2200 m a.s.l.) at eastern part of Himalaya in India during January 2010–December 2011. In this article, we have presented the results of our analysis of the data collected during this interval. This study is focused on the investigation of the temporal variations, potential sources, long-range transport of BC aerosols along with the meteorological impact on these aerosols. BC is found to exhibit strong seasonal

variation with the maximum concentration during premonsoon (5.0 ± 1.1 μg/m3) followed by winter (3.9 ± 2.2 μg/m3), postmonsoon (2.9 ± 1.0 μg/m3) and minimum during monsoon (1.7 ± 0.7 μg/m3). BC concentration varied between 0.2–12.8 μg/m3 with an average of 3.4 ± 1.9 μg/m3 over the entire period of study. The diurnal variation of BC aerosol shows sharp morning and evening peaks associated to the local anthropogenic activities as well as the impact of up-slope mountain wind. Amongst the long distant sources, BC concentration associated with the transport from Middle East countries and passing over South West countries like Pakistan, Afghanistan and Indo-Gangetic Plain is found to be comparatively higher. It is observed that the contributions of local emissions, long-range transport and mountain wind transport are approximately 56%, 27% and 17%, respectively, towards the total BC loading over Darjeeling during premonsoon. Fossil fuel emissions during premonsoon and biomass burning during winter are the major sources of BC with the overall dominance of fossil fuel burning throughout the entire study period. The BC concentration over Darjeeling is found to be much higher than any other high altitude stations in India and Nepal and even higher and comparable with some of the metro-cities in India.

Keywords: *Black carbon; Himalaya; Darjeeling; Fossil fuel; Biomass.*

Particulate Matter Distributions in China during a Winter Period with Frequent Pollution Episodes (January 2013)

Jingkun Jiang, Wei Zhou, Zhen Cheng, Shuxiao Wang, Kebin He, Jiming Hao

Source: *Volume 15, No. 2, April 2015, Pages 494-503, doi: 10.4209/aaqr.2014.04.0070*

Particulate matter distributions in China during January 2013 were analyzed using hourly PM2.5 and PM10 concentrations from 74 cities. Five haze episodes occurred in this month. Both PM2.5 and PM10 concentrations increased rapidly at the beginning of January 2013 and remained at high levels throughout the month with monthly average values of 128.7 and 184.4 μg/m3, respectively. On January 12th, the most polluted day in this month, 13 cites were severely polluted with daily average PM2.5 concentrations greater than 300 μg/m3, and 18 cities were heavily polluted with daily average PM2.5 concentrations between 200 and 300 μg/m3. These episodes often occurred in a large spatial domain with the North China Plain as the most polluted area, including Jing-Jin-Ji area (Beijing, Tianjin, and Heibei provinces). Both PM2.5 and PM10 had good correlations with ambient CO, NO2, and SO2 concentrations. High PM concentrations often occurred at low wind speeds and high relative humidity. In addition, PM levels in January 2013 were compared with those from other international cities.

Keywords: *Haze; Pollution Episode; PM2.5; PM10; China.*

Seasonal and Diurnal Variations of Fluorescent Bioaerosol Concentration and Size Distribution in the Urban Environment

Sampo Saari, JarkkoV. Niemi, Topi Rönkkö, Heino Kuuluvainen, Anssi Järvinen, Liisa Pirjola, Minna Aurela, Risto Hillamo, Jorma Keskinen

Source: *Volume 15, No. 2, April 2015, Pages 572-581, doi: 10.4209/aaqr.2014.10.0258*

A recently introduced fluorescence based real-time bioaerosol instrument, BioScout, and an ultraviolet aerodynamic particle sizer (UVAPS) were used to study fluorescent bioaerosol particles (FBAP) in the Helsinki metropolitan area, Finland, during winter and summer. Two FBAP modes at 0.5–1.5 μm (fine) and

1.5–5 μm (coarse) were detected during the summer, whereas the fine mode dominated in the winter. The concentration and proportion of the coarse FBAP was high in summer (0.028 #/cm3, 23%) and low in winter (0.010 #/cm3, 6%). Snow cover and low biological activity were assumed to be the main reasons for the low coarse FBAP concentration in the wintertime. Both the fine and the coarse FBAP fraction typically increased at nighttime during the summer. Correlations between the BioScout and the UVAPS were high with the coarse (R = 0.83) and fine (R = 0.92) FBAP. The BioScout showed 2.6 and 9.7 times higher detection efficiencies for the coarse and fine FBAP, respectively, compared to the UVAPS. A long-range transport episode of particles from Eastern Europe increased the fine FBAP concentration by over two orders of magnitude compared to the clean period in the winter, but these FBAP probably also included fluorescent non-biological particles. Correlation analysis indicates that local combustion sources did not generate fluorescent non-biological particles that can disturb fine FBAP counting. The results provide information that can be used to estimate health risks and climatic relevance of bioaerosols in the urban environment.

Keywords: *Fluorescence; Fungal spores; Bacteria; UVAPS; BioScout.*

Long-Term Trends in Visibility and Its Relationship with Mortality, Air-Quality Index, and Meteorological Factors in Selected Areas of Korea

Jeong-Young Lee1, Wan-Kuen Jo2, Ho-Hwan Chun

Source: *Volume 15, No. 2, April 2015, Pages 673-681, doi: 10.4209/aaqr.2014.02.0036*

We investigated temporal trends in atmospheric visibility as well as their relationship to non-accident-related daily mortality, the Comprehensive Air-quality Index (CAI) in Korea, and selected meteorological factors in four cities (Seoul, Busan, Daegu, and Ulsan) and one remote island (Ullungdo) for the period 2001–2009. According to the mean values, Seoul exhibited the lowest visibility (12.2 km), followed by Ullungdo (12.6 km), Ulsan (14.2 km), Daegu (14.7 km), and Busan (17.3 km). Conversely, Ullungdo had the lowest CAI value (82.4) and no respiratory mortality (RM) occurrences at all, and Seoul had both the highest mean CAI value (122) and the highest occurrence of daily RM (5.3). There were negative correlations between visibility and two meteorological parameters (relative humidity and ambient temperature) in all five areas, whereas there were generally positive correlations between visibility and the other two meteorological parameters (precipitation and wind speed). For some lag periods, the mortality in the cities was significantly correlated with visibility and the CAI, whereas mortality in Ullungdo was not. Busan had the highest excess risk for non-accident-related daily mortality, followed by Daegu, Seoul, and Ulsan.

Keywords: *Visibility; Comprehensive Air-quality Index (CAI); Respiratory mortality (RM); Meteorology; Excess risk.*

Mode and Place of Origin of Carbonaceous Aerosols Transported From East Asia to Cape Hedo, Okinawa, Japan

Kojiro Shimada, Masamichi Shimada, Akinori Takami, Shuichi Hasegawa, Akihiro Fushimi, Takemitsu Arakaki, Watanabe Izumi, Shiro Hatakeyama

Source: *Volume 15, No. 3, June 2015, Pages 799-813, doi: 10.4209/aaqr.2014.09.0190*

This study investigated the source categories and emission areas of carbonaceous aerosols transported from East Asia to the East China Sea. Mass concentrations of heavy metals, ionic components, organic carbon, and elemental carbon (EC) were measured at the Cape Hedo Atmosphere and Aerosol Monitoring Station in Okinawa, Japan, throughout 2010. The relative influences of different categories of aerosols were determined by positive matrix factorization, and the source regions of each emissions category were evaluated by using the total potential source contribution function. Five source categories were identified: dust, sea salt and nitrate, secondary species, coal combustion, and oil combustion. The results showed that the major source of aerosols in North China is coal combustion, whereas the major source in South China, Japan, and Korea is oil combustion. The relative contributions of the five sources to EC concentrations at Cape Hedo were dust 7.0%, sea salt and nitrate 19.1%, secondary species 28.5%, oil combustion 12.8%, and coal combustion 32.6%. In particular, wintertime coal combustion in residential areas of North China contributed significantly to EC in 2010. The results also indicate that the contribution of coal combustion in source areas was higher in winter (52%), whereas the contribution of oil combustion was higher in spring (33%).

Keywords: *Carbonaceous aerosols; Source area; Emission area; Contribution to EC.*

Characteristics of Particulate Matter during Haze and Fog (Pollution) Episodes over Northeast China, Autumn 2013

Yang Li, Hujia Zhao, Yunfei Wu

Source: *Volume 15, No. 3, June 2015, Pages 853-864, doi: 10.4209/aaqr.2014.08.0158*

Mass concentrations of particulate matter (PM), including PM1.0, PM2.5 and PM10, were measured from October 13th to November 30th 2013 at eight sites in Northeast China to evaluate their variations during pollution periods. Five major pollution periods were identified during the autumn of 2013. The maximum daily average PM2.5 concentrations were 437 ± 85 μg/m3 and 322 ± 50 μg/m3 in Harbin and Shenyang, respectively. The minimum was 75 ± 28 μg/m3 in Dandong. The presence of finer particles was significantly related to visibility degradation during pollution periods. Wind speeds had a negative correlation with PM concentrations, while high relative humidity (RH) favored the formation of haze in Northeast China.

Visibility on non-hazy days was approximately 2.5–3.0 times greater than that on hazy days. During hazy days, the PM1.0:PM2.5 ratios were 0.89 ± 0.04, 0.85 ± 0.04 and 0.91 ± 0.04 at Anshan, Shenyang and Dandong, respectively. These results show that PM1.0 was the dominant particle pollutant in Northeast China during periods of pollution. High RH and low wind speeds during hazy days may favor the accumulation of atmospheric pollutants. The results of this study provide useful information toward recognizing air pollution episode characteristics in Northeast China.

Keywords: *PM; Visibility; Haze; Northeast China.*

Characterization and Source Identification of Heavy Metals in Ambient PM10 and PM2.5 in an Integrated Iron and Steel Industry Zone Compared with a Background Site

Qi-Li Dai, Xiao-Hui Bi, Jian-Hui Wu, Yu-Fen Zhang, Jing Wang, Hong Xu, Lin Yao, Li Jiao, Yin-Chang Feng

Source: *Volume 15, No. 3, June 2015, Pages 875-887, doi: 10.4209/aaqr.2014.09.0226*

The purpose of this study is to characterize heavy metals in ambient PM10 (particles with aerodynamic diameter below 10 μm) and PM2.5 (particles with aerodynamic diameter below 2.5 μm) particles in a typical integrated iron and steel industry zone (HG) and a background site (ZWY) during February 2011 to January 2012 in the Yangtze River Delta (YRD) region, China. Twelve elements were measured to study their levels, size distribution and sources. At the two sampling sites, Fe was found as the dominated metal in the total detected metals in both particle sizes, followed by Zn and Pb. They were regarded as the marker elements of iron and steel production emission along with Cr and Mn. The concentrations of all measured heavy metals in HG were 1–3.53 times higher than those measured in ZWY. When compared with previous studies, the concentrations of steel related elements (Fe, Zn, Mn) in this work were significantly high. The highest correlation coefficient was observed in HG for Fe and Zn. Additionally, Cd was found as the most enriched heavy metal by the enrichment factor analysis, followed by Zn, Pb, and Cu. The main sources contributing to heavy metals at HG site were identified by principle component analysis: steel dust (including coal combustion of coal-fired power plant, coke making and steel making emission), vehicle emission and road re-suspension dust and soil dust. Besides, steel dust was also found as the possible source of heavy metals at ZWY site. The result suggested the steel dust has influence on the whole study area.

Keywords: *Heavy metals; Steel production; Particulate matter; Source identification.*

Stable Isotopic and Chemical Characteristics of Bulk Aerosols during Winter and Summer Seasons at a Station in Western Coast of India (Goa)

Rajesh Agnihotri, Supriya G. Karapurkar, Vedula V.S.S. Sarma, Kamana Yadav, Maripi Dileep Kumar, Chhemendra Sharma, M.V.S.N. Prasad

Source: *Volume 15, No. 3, June 2015, Pages 888-900, doi: 10.4209/aaqr.2014.07.0127*

We measured stable isotopic and chemical characteristics of bulk aerosols collected at a coastal station in western India (Goa) between December 2009 and January 2011, to characterize lower tropospheric atmospheric conditions and their influence on particle chemistry during winter and summer seasons. Marked differences were observed in terms of sources and chemical compositions of bulk aerosols. The δ15NTN values of winter aerosols (10.8 ± 2.2‰, n = 10) indicate biomass burning contributions in the carbonaceous fraction, while significantly depleted δ15NTN values of summer aerosols (6.2 ± 2.3‰, n = 12) hints incorporation of marine N species. The δ34STS showed depleted values during winter (5.0 ± 1.0‰, n = 10), which closely matched with those of typical urban polluted environments, while summer aerosols showed a systematic enrichment of δ34STS (up to ~14‰ with average value 9.0 ± 2.8‰, n = 13); possibly due to incorporation of volatile dimethyl sulfide (DMS) and its precursor dimethylsulfoniopropionate (DMSP) dimethyl sulfide (DMS) emitted from the adjacent Arabian Sea. Likewise, δ13CTOC values showed ~2‰ enrichment in winter aerosols (–24.8 ± 0.4‰, n = 10) with respect to those of summer values, indicating presence of bio-fuel and coal burning contributions in carbonaceous fraction of winter aerosols. We also measured major ions (Na+, K+, Mg++, Ca++, NH4+, Cl–, Br–, NO3–, SO4–2) in water soluble fraction of

aerosols to understand winter/summer changes in the atmospheric chemistry over this coastal area. This is the first ever dataset on triple isotopic characteristics of bulk aerosols at a coastal location of India showing signatures of continental bio-mass/bio-fuel burning influences during winter, whereas marine inventories (e.g., sea salt, DMS and mineral dust) appear to dominate chemical composition of summer aerosols.

Keywords: *Bulk aerosols; Stable isotopes; Coastal environment; Goa.*

Aerosol Column Size Distribution and Water Uptake Observed during a Major Haze Outbreak over Beijing on January 2013

Ying Zhang, Zhengqiang Li, Juan Cuesta, Donghui Li, Peng Wei, Yisong Xie, Lei Li

Source: *Volume 15, No. 3, June 2015, Pages 945-957, doi: 10.4209/aaqr.2014.05.0099*

Haze can cause serious atmospheric pollution affecting air quality, human health and even global climate. In order to investigate aerosol columnar size distribution and water uptake during haze evolution, we analyse ground-based observations during an extreme winter pollution case at Beijing on 12 January 2013 (haze day) as compared to those registered on 9 January (non-haze day). We study the evolution of the aerosol size distribution using retrievals from a ground-based CIMEL sun-sky radiometer of the Aerosol Robotic Network (AERONET). Our results show that while the hourly volume growth rate of a sub-micron fine mode presented in the size distribution remains below 0.010 μm3/μm2/hr during the non-haze day, it can rapidly increase during haze pollution event, reaching a maximum value of 0.075 μm3/μm2/hr. The mean size of fine mode particles becomes larger during the pollution event, while it is reduced for coarse mode particles. The mean volume of water uptake is 0.013 μm3/μm2 in haze day, being about 13 times larger than that in non-haze day. Meanwhile, the volume of water-soluble inorganic aerosols increases from 0.036 to 0.298 μm3/μm2, partly explained by the increase of water uptake during the haze event and also likely by accumulation of particle matters due to stagnating atmospheric conditions. The increase of water-soluble particle volume, which is enhanced by water uptake, significantly contributes to haze evolution.

Keywords: *Aerosol size distribution; Water uptake; Haze; Remote sensing; Beijing.*

A New Classification of Aerosol Sources and Types as Measured over Jaipur, India

Sunita Verma, Divya Prakash, Philippe Ricaud, Swagata Payra, Jean-Luc Attié, Manish Soni

Source: *Volume 15, No. 3, June 2015, Pages 985-993, doi: 10.4209/aaqr.2014.07.0143*

The aerosol properties retrieved from the AErosol RObotic NETwork (AERONET) measurements during the period 2009 to 2012 over Jaipur (26.9°N, 75.8°E, 450m asl) in Northwestern India are used for the first time to identify the types of aerosols. In order to consider the appropriate threshold of aerosol optical thickness (τ) at 500 nm (τ500) and Angstrom exponent (α) in the spectral band 440–870 nm, a novel approach has been conducted and applied for the identification process. Five prevailing aerosol classes are identified: desert dust, biomass, maritime, arid background and mixed aerosols. Arid background and desert dust type aerosols are the most common at Jaipur (34.7% and 13.6%, respectively), with a wide variability in both τ and α. In about 8.4% of the cases, aerosols can be classified as maritime, although mixing with other aerosols (33.6%) is substantial. The ground-based spectral optical thickness and the refractive index estimated at visible and near-infrared wavelengths are used to account for the type of atmospheric aerosols. They are compared with

four more AERONET sites located in India based upon their geographical distribution and extensive data availability. Simultaneously, single scattering albedo of dust is also inferred for all the available AERONET sites for the same period over India. The comparison results suggest that Jaipur arid background is more scattering in nature than Northern and Western regions in India. Finally, the absorption is less in summer than in winter over the Jaipur site.

Keywords: *Aerosols; Optical thickness; Desert dust; Arid; Biomass; Angstrom exponent.*

High Resolution Emission Inventory of NOx and CO for Mega City Delhi, India

Saroj Kumar Sahu, Gufran Beig, Neha Parkhi

Source: *Volume 15, No. 3, June 2015, Pages 1137-1144, doi: 10.4209/aaqr.2014.07.0132*

In order to support as critical input to air quality forecasting task during Commonwealth Games (CWG) – 2010 in mega city Delhi, we have developed a high resolution emission inventory of major atmospheric pollutants. For the same, inventories of ozone precursors like NOx and CO are developed over a domain of 70 km × 65 km with a grid of 1.67 km × 1.67 km resolution covering Delhi and surrounding region using Geographical Information System (GIS) technique for base year 2010. All possible source of emission like transport, thermal power plants, industries, residential, slum cooking and commercial cooking are taken into account for the first time. It has been found that total emissions of NOx and CO over the study area are found to be 255 and 703 Gg/yr for 2010 respectively. The spatial distributions of major hot spots are discussed with possible dominant sources at particular regions. The present inventory will help to improve the modeling study over mega city, Delhi and its surrounding regions.

Keywords: *NOx; CO; Emission inventory; Urban pollution; GIS; Mega city.*

Spectral Light Absorption of Ambient Aerosols in Urban Beijing during Summer: An Intercomparison of Measurements from a Range of Instruments

Yunfei Wu1, Peng Yan, Ping Tian, Jun Tao, Ling Li, Jianmin Chen, Yangmei Zhang, Nianwen Cao, Chong Chen, Renjian Zhang

Source: *Volume 15, No. 4, August 2015, Pages 1178-1187, doi: 10.4209/aaqr.2014.09.0224*

Aerosol light absorption is important to radiation balance, but it is difficult to accurately quantify using measurements. An intercomparison experiment for the measurement of the aerosol absorption coefficient (bap) was performed at an urban site in Beijing during the summer of 2012, including the filter-based particle soot absorption photometer (PSAP) and aethalometer (AE-31), and the reference photoacoustic extinctiometer (PAX), CRDS-Neph (cavity-ring down spectroscopy/nephelometer) system, and multi-angle absorption photometer (MAAP). The CRDS-Neph system and PAX performed poorly due to unexpected reasons. The corrected bap of the PSAP agreed well with the reference values determined by the MAAP, implying the applicability of this correction scheme as well as the credibility of the reference bap of the MAAP. A new conversion factor with a value of ~7.1 ± 0.05 m2/g at ~530 nm was established by regressing the reference bap against the AE-31 recorded black carbon (BC) concentrations, which is lower than the previously used value (8.28 m2/g).

Accordingly, the absorption Ångström exponent (αap) was estimated as 0.85 ± 0.21 on average. It was ~1 on clean days but significantly lower during pollution episodes, implying the main contributor to aerosol

light absorption is freshly-emitted BC on clean days but aged BC during pollution. BC core sizes and the coating are likely to have a great impact on the αap, which needs further investigation. The mass absorption efficiency of BC was estimated by regressing the bap against the filter-analyzed elemental carbon (EC) concentrations, resulting in a mean of 9.2 ± 0.5 m2/g at 670 nm. It was remarkably higher during pollution episodes than on clean days, implying a high variation of aerosol properties, such as the mixing state, with pollution levels.

Keywords: *Ambient aerosol; Black carbon; Spectral light absorption.*

A Method for Automated Estimation of Parameters Controlling Aerosol New Particle Formation

Aare Luts, Urmas Hõrrak, Jaan Salm, Marko Vana, Hannes Tammet

Source: *Volume 15, No. 4, August 2015, Pages 1166-1177, doi: 10.4209/aaqr.2014.10.0232*

We use a previously published simulator of aerosol new particle formation (NPF) events as the core component of the new method for automated estimation of its input parameters. The simulator has a large number of physical input parameters (e.g., nucleation and growth rates), and it yields results about the dynamics of particle concentrations and their size distributions as its output. Our new method automatically solves the inverse problem. It estimates the physical input parameters by recurrent simulations according to the criterion of best fit of the simulated output parameters with the known data. The method is implemented as a computer program that includes the previous simulator as a subroutine. The method enables the estimation of several physical parameters, e.g., the nucleation rate, particle growth rate, contribution from ion-induced and neutral nucleation, and particle charging state. The program was tested using the results of two NPF events measured at Hyytiälä, Finland. The measured time series of the concentration of atmospheric ions and nanoparticles in the diameter interval of 2.8–8.6 nm were well reproduced by our method. The estimated values of the analyzed input parameters are in agreement with the results known from many other studies carried out at Hyytiälä. The proposed method of inverse simulator may appear useful in the analysis and interpretation of air ion and atmospheric aerosol measurements during new particle formation events.

Keywords: *Atmospheric aerosols; Aerosol dynamics; Nanoparticle evolution model; Numerical simulation; Fitting to measurements.*

Fog-Induced Changes in Optical and Physical Properties of Transported Aerosols over Sundarban, India

Sanat Kumar Das, Abhijit Chatterjee, Sanjay K. Ghosh, Sibaji Raha

Source: *Volume 15, No. 4, August 2015, Pages 1201-1212, doi: 10.4209/aaqr.2014.11.0287*

A campaign was conducted at Kalas Island, Sundarban to address fog-induced changes in optical and physical properties of aerosols during the winter period (11–16 January 2014). Being an isolated remote island in the northern coastal region of Bay of Bengal, the measurement site provides a unique opportunity to investigate aerosol properties and foggy conditions during transported aerosol plumes from the Indo-Gangetic Basin (IGB). Two fog events were observed over Sundarban during the campaign increasing Aerosol Optical Depth (AOD) by almost a factor of three (1.6 ± 0.4) compared to “background” AOD of

0.52 ± 0.2 on a normal winter day. Back-trajectory analysis shows that aerosols mostly originate from the IGB contributing to higher fine-mode as well as coarse-mode aerosol concentrations during the foggy days. Black Carbon (BC), known as a tracer for anthropogenic sources, is found to be about 15.2 ± 1.3 μg/m3 at such a remote region and increased by 30% during foggy days indicating strong influence from transported anthropogenic aerosols from nearby urban regions. Similar enhancement is also observed in aerosol absorption coefficient, especially in the UV region. Low ventilation due to calm and cool atmosphere with a shallow boundary layer during foggy days could have 'trapped' BC over Sundarban and resulted in such an enhancement. On the other hand, the absorption angstrom exponent reduced indicating dominance of weakly spectral dependent aerosols during foggy period, mostly associated with fossil-fuel combustion. However, this could also be the result of BC coating with water-soluble species under high RH conditions. Enhancement of absorbing aerosols during foggy period reduces the incoming solar radiation, causing large perturbation in the radiation budget over the site.

Keywords: *Aerosol; Black carbon; Fog; Indo-Gangetic basin; Sundarban.*

Characterization of Ultrafine Particles and Other Traffic Related Pollutants near Roadways in Beijing

Nu Yu, Yifang Zhu, Xiaosen Xie, Caiqing Yan, Tong Zhu, Mei Zheng

Source: *Volume 15, No. 4, August 2015, Pages 1261-1269, doi: 10.4209/aaqr.2014.11.0295*

Developing countries, such as China, are facing serious air pollution issues due to fast economic development. In this study, traffic related air pollutants, including number concentration of ultrafine particles (UFPs, diameter < 100 nm), mass concentrations of PM2.5 and black carbon (BC) were measured near the Peking University (PKU) campus in Beijing in December 2011. Data were collected concurrently at a roadway site and on PKU campus. Meteorological data were collected at approximately 40 meters northeast from the roadway sampling site. The traffic density was determined from recorded video footage. Roadside UFP and PM2.5 concentrations were not significantly higher than on campus. A statistically significant Pearson's correlation of 0.75 was found between BC and PM2.5 mass concentrations. No apparent correlation was found between wind speed and UFP number concentrations, but strong log-decay correlations were found between wind speed and PM2.5 (R2 = 0.80). There were three days during the measurements when both PM2.5 mass concentrations and UFP number concentrations were higher at the campus site than at the roadway site. This suggests there were potential local emission sources on campus. Temporal profile of UFPs at the campus site peaked around lunch and dinner time, suggesting emissions from the surrounding restaurants and cafeteria that used Chinese-style cooking might have contributed to the observed PM2.5 and UFP levels on campus.

Keywords: *Ultrafine particles; PM2.5; Black carbon; Beijing; Roadway; Cooking emissions.*

Estimating Ground-Level PM2.5 Using Fine-Resolution Satellite Data in the Megacity of Beijing, China

Rong Li, Jianhua Gong, Liangfu Chen, Zifeng Wang

Source: *Volume 15, No. 4, August 2015, Pages 1347-1356, doi: 10.4209/aaqr.2015.01.0009*

Estimating ground-level PM2.5 in urban areas from satellite-retrieved AOD data is limited because of the coarse resolution of the data. The spatial resolution of recent MODIS Collection 6 aerosol data has increased from 10 km to 3 km. Taking advantage of this new AOD dataset, we used a mixed effects model to calibrate the day-to-day relationship between satellite AOD and ground-level PM2.5 concentrations. Regional daily PM2.5 concentrations were estimated by the AOD from March 1, 2013, to February 28, 2014, in the megacity of Beijing. Compared with the simple linear regression model, the accuracy of the PM2.5 prediction improved significantly, with an R2 of 0.796 and a root mean squared error of 16.04 μg/m3. The results showed high PM2.5 concentrations in the intra-urban region of Beijing because of local emissions. The PM2.5 concentrations were relatively low in the northern rural area but high in the southern rural area, which was close to the industrial sector in Hebei Province. We found that the 3 km AOD produces detailed spatial variability in the Beijing area but introduces somewhat large biases due to missing AOD pixels.

Keywords: *Particulate matter; Satellite remote sensing; Statistical models; Air quality.*

High Nighttime Ground-Level Ozone Concentrations in Kemaman: NO and NO2 Concentrations Attributions

Norrimi Rosaida Awang, Nor Azam Ramli, Ahmad Shukri Yahaya, Maher Elbayoumi

Source: *Volume 15, No. 4, August 2015, Pages 1357-1366, doi: 10.4209/aaqr.2015.01.0031*

High nighttime ozone (O3) concentration levels were observed in Kemaman, Terengganu, and results were compared with those in other places in Malaysia. In this study, the contribution of precursors [nitric oxide (NO) and nitrogen dioxide (NO2)] and meteorological factors wind speed, and wind direction) toward long-term high nighttime O3 over the period of 1999 to 2010 was evaluated. During this period, the recorded highest nighttime O3 ground level was 89 ppb with more than 25% surpassing 20 ppb. Analysis shows that minimal decreasing trends were measured in Kemaman. Lower nitrogen oxide (NOx) concentrations restricted the sinking agents; thus, reducing the depletion rates allowed O3 to remain in the atmosphere. Minimal associations were observed between the O3 concentration level and the speed and direction of wind. Accordingly, the largest contributor toward high nighttime O3 ground level concentration in Kemaman was most probably NOx concentration.

Keywords: *Long-term variations; NOx concentration; Nighttime ozone chemistry.*

Inter-Annual Variations of Cloud and Precipitation and their Possible Relationships with Surface Aerosols in Shanghai

Deqin Zhang, Chen Xu, Junyan Duan, Yifan Wang, Jianfei Du, Shuping Zha, Chunpeng Leng, Xiang Li, Tiantao Cheng, Jun Tao, Renjian Zhang

Source: *Volume 15, No. 4, August 2015, Pages 1367-1379, doi: 10.4209/aaqr.2014.08.0179*

Aerosol-cloud-precipitation interactions have attracted much more attention for decades, but there still remain many uncertainties in assessing global climate. Long-term ground-based measurements of aerosol, cloud and precipitation in Shanghai were used to examine their inter-annual variations and possible relationships. During 1990–2010, the yearly-averaged total cloud cover (TCC) and low cloud cover (LCC) decrease on average by 0.58% and 2.49% per year. LCC correlates to surface aerosols (e.g., PM10), with a correlation coefficient (R) of 0.67. Aerosol optical depth (AOD), as an indicator of columnar aerosol loading, shows a non-significant correlation with cloud cover. The yearly-aggregated heavy and extreme rain days and their rainfall amount increase gradually. The moderate rain day enhances but its annual rainfall amount declines year by year, while the light rain exhibits an opposite pattern to the moderate rain. These results imply that local aerosols maybe exert somewhat enforcing on low cloud and light rain through possible entrainment or updraft that can bring up surface particles into free troposphere, whereas its influence to total cloud and precipitation is negligible at a small scale. Future studies are needed to ensure whether local aerosols to directly affect low cloud, and to explore how surface aerosols to enter into higher atmospheric layers and impact cloud and precipitation at larger scales.

Keywords: *Rainfall; Aerosol; Cloud cover; Climate change.*

Primary Air Pollutant Emissions and Future Prediction of Iron and Steel Industry in China

Xuecheng Wu, Lingjie Zhao, Yongxin Zhang, Chenghang Zheng, Xiang Gao, Kefa Cen

Source: *Volume 15, No. 4, August 2015, Pages 1422-1432, doi: 10.4209/aaqr.2015.01.0029*

China is the largest iron and steel producing and consuming country in the world, which leads to enormous quantities of emitted air pollutants. Direct emissions of air pollutants from the iron and steel industry in China were estimated by developing a process and technology-based methodology using information of the proportion of pig iron, crude steel, and rolled steel produced from different processes and technology. Emissions of sulfur dioxide (SO2), nitrogen oxides (NOx), particulate matter (PM), volatile organic compound (VOCs), and dioxin (PCDD/Fs) were estimated for the year 2012, and future emissions of major pollutants (SO2, NOx, TSP) were projected up to 2030 based on technology developing trends and emission control policies. According to the estimation, 2222 kt of SO2, 937 kt of NOx, 1886 kt of TSP, 555 kt of PM2.5, 254 kt of VOCs, 618 g I-TEQ of PCDD/Fs was produced in China in 2012. Sintering produced 72.4% of SO2, 49.4% of NOx, 22.5% of TSP, 24.0% of PM2.5, 69.6% of VOCs and 98.0% of PCDD/Fs, which is the main emission source. Through faithful implementation of closing down outdated production and emission control policies, approximately 77%, 49%, 67% and 64% of SO2, NOx, TSP and PCDD/Fs emissions, respectively, could be further reduced in 2012. Emissions in 2020 and 2030 of iron and steel sectors were predicted applying scenario analysis. The removal potential for SO2 and TSP is larger than NOx by improvement of removal facilities, and southwest, northwest, and north China has the largest SO2, NOx, TSP and PCDD/Fs removal potential respectively.

Keywords: *Iron and steel industry; Emission inventory; China; Process and technology-based methodology.*

Characterization of Ambient PM10 Bioaerosols in a California Agricultural Town

Judith C. Chow, Xufei Yang, Xiaoliang Wang, Steven D. Kohl, Patrick R. Hurbain, L.W. Antony Chen, John G. Watson

Source: *Volume 15, No. 4, August 2015, Pages 1433-1447, doi: 10.4209/aaqr.2014.12.0313*

Ambient bioaerosols in PM10 samples were measured at three sites in Corcoran, an agricultural town in the southern San Joaquin Valley (SJV) of California, during fall of 2000 corresponding to the cotton harvest season. Elevated bioaerosol concentrations were measured near grain elevators (GRA site) and a cotton handling facility (BAI site) as compared to levels in a residential community (COP site), ~2 km northeast of these sources. Average endotoxin levels (13 ± 17 EU/m3) at the grain elevator site were three to eight times higher than averages at the nearby cotton-handling and residential sites. The highest level (47.6 EU/m3) at the grain elevator site was about half of the exposure limit of 90 EU/m3 set by the Dutch Expert Committee on Occupational Safety. Particle counts of fungal spore (66,333 particles/m3) and pollen grain (2,600 particles/m3) concentrations were more than double those reported in the literature. Average fungal biomarker concentrations of 170 and 131 ng/m3 for arabitol and mannitol, respectively, were 1–2 orders of magnitude higher than those from non-agricultural areas. The low correlation ($r < 0.11$) of three fungal markers (i.e., (1→3)-β-D-glucan, arabitol, and mannitol) with fungi counts is consistent with findings by others and indicates that these are insufficient as surrogates to represent fungal exposure. Agricultural activities contributed measureable amounts to PM10 mass and organic carbon (OC), dominated by fungal spores (i.e., 5.4–5.8% PM10 mass and 11.5–14.7% OC). The sum of fungal spores, pollen grains, and plant detritus accounted for an average of 11–15% PM10 and 24–33% OC mass. Bioaerosols can be important contributors to PM10 mass in farming communities similar to Corcoran, especially during intense agricultural activities.

Keywords: *Endotoxin; (1→3)-β-D-glucan; Fungal spores; Pollen grains; PM10 bioaerosol.*

Characteristics of Organic Carbon and Elemental Carbon in the Ambient Air of Coking Plant

Xiaofeng Liu, Lin Peng, Huiling Bai, Ling Mu

Source: *Volume 15, No. 4, August 2015, Pages 1485-1493, doi: 10.4209/aaqr.2014.12.0331*

To investigate the characteristics of organic carbon (OC) and elemental carbon (EC) in the ambient air of coking plant, particulate matter samples were collected and analyzed. The OC and EC mass concentrations were in the range of 104.2–223.2 μg/m3 and 93.7–237.8 μg/m3, respectively, which were much higher than those in the ambient air of industry, highway, and urban roadway tunnel. The OC concentrations did not significantly differ at the coke side and the machine side, whereas the EC concentration was significantly higher at the coke side. The OC/EC ratios ranged from 0.74 to 2.35, and coking was the primary source of OC and EC. Carbonaceous aerosol was a large component in the ambient air, and the total carbonaceous aerosol (TCA) accounted for 39.1%–73.0% of the total suspended particulates (TSP). TCA contributions to TSP were consistent at the coke side and the machine side, and both contributions were lower than those at other sampling sites. OC and EC emission control must be strengthened for improving coking plant air

quality and reducing health hazards to coke-plant workers. OC–EC correlation was evident, with a correlation coefficient of 0.976 ($p < 0.05$) at the coke-oven top, coke side, and machine side, whereas no significant correlations were observed at sites downwind of the coke oven ($p > 0.05$).

Keywords: *Coking; Organic carbon; Elemental carbon; Total carbonaceous aerosol; OC/EC.*

Surface and Column-Integrated Aerosol Properties of Heavy Haze Events in January 2013 over the North China Plain

Li Sun, Xiangao Xia, Pucai Wang, Renjian Zhang, Huizheng Che, Zhaoze Deng, Ye Fei, Liang Ran, Xiaoyan Meng

Source: *Volume 15, No. 4, August 2015, Pages 1514-1524, doi: 10.4209/aaqr.2014.10.0252*

Heavy haze events were recorded over the North China Plain (NCP) during January 2013. The meteorological condition, in-situ measurement, and ground remote sensing of aerosol size distributions and aerosol optical properties were analyzed to study the meteorological effects on surface and column-integrated aerosol loading. Besides special terrain, analysis of meteorological parameters showed that such a long-standing pollution event was attributable to stagnant weather with high humidity, frequent inversion and low wind speed. The monthly average mass concentration of particulate matter smaller than 1.0 μm (PM1), 2.5 μm (PM2.5), and 10 μm (PM10) was 169, 190, and 233 μg/m3, respectively. High mass fraction of PM1 (73%) and PM2.5 (82%) in PM10 indicated the domination of fine mode particles. Increase of the fraction of PM1–2.5 during haze events was attributed to the increase of secondary aerosol under high humidity. Two polluted aerosol types (A1, A3) and one background aerosol (A2) were classified based on aerosol optical depth at 440 nm (AOD440) and column-integrated size distributions. The AOD440 of cloud/fog processed aerosol (1.43) was about two and seven times larger than that of A1 and A2, respectively. The single scattering albedo at 675 nm (SSA675) of A3 was ~0.93, which was larger than that of A1 (0.85) and A2 (0.80) due to hygroscopic growth under humid environment.

Keywords: *Particle size distribution; Size growth; Aerosol optical properties; Heavy haze.*

Modelling the Effect of Aerosol Feedbacks on the Regional Meteorology Factors over China

Dongsheng Chen, Xin Ma, Xin Xie, Peng Wei, Wei Wen, Tingting Xu, Nan Yang, Qingxian Gao, Huading Shi, Xiurui Guo, Yue Li, Ying Zhou, Jianlei Lang

Source: *Volume 15, No. 4, August 2015, Pages 1559-1579, doi: 10.4209/aaqr.2014.11.0272*

The fully coupled online air quality model WRF/chem was used to investigate the aerosol-radiation interaction and aerosol-cloud interaction on the regional meteorological factors over China in 2006.The aerosol-radiation interaction and aerosol-cloud interaction of aerosols influence the various regional meteorological factors in the worst aerosol-polluted regions of China. Domain-wide monthly-mean over all day and night hours incoming solar radiation decreased by –11.03 W/m2, –9.84 W/m2, –5.84 W/m2 and –12.37 W/m2; temperature at 2 meters (T2) decreased by –0.22°C, –0.12°C, –0.06°C and –0.24°C; Planetary boundary layer (PBL) height decreased by –16.44 m, –15.90 m, –5.48 m and –31.59 m in January, April, July and October, respectively. The values of the monthly-mean incoming solar radiation, T2 and PBL height had greater decreases in east China. Due to aerosol feedbacks, a slight increase of the monthly-mean

precipitation occurred in southern and south-eastern China. The aerosol-radiation interaction and aerosol-cloud interaction of aerosols were compared for the United States (U.S.) continent, Europe, India and this study. Due to the higher aerosol load in China, the monthly-mean incoming solar radiation, T2 and PBL height exhibited greater decreases in China than in the U.S. continent and in Europe. Aerosol extinction was the dominant effect on the incoming solar radiation for either cloudless or cloudy weather conditions in China, but aerosol extinction was only apparent during cloudless weather in Europe. In India, the incoming solar radiation decreased by –20 W/m2 or more in the most aerosol polluted area, which is close to the value of decrease determined in China.

Keywords: *Aerosol-radiation interaction; Aerosol-cloud interaction; Meteorological factors; WRF/chem.*

Quantitative Assessment of the Emitted Criteria Pollutant in Delhi Urban Area

Dhirendra Mishra, Pramila Goyal

Source: *Volume 15, No. 4, August 2015, Pages 1601-1612, doi: 10.4209/aaqr.2014.05.0104*

The compositions of the emitted criteria pollutant from the anthropogenic sources are investigated in the present study for Delhi urban area. The quantitative study of various types of the criteria pollutants, i.e., Carbon Monoxide (CO), Nitrogen Oxide (NOx) and Particulate Matter (PM) emitting from various sources is carried out. The primary emitting sources of these criteria pollutants are the vehicles, industries, power plants, domestic and dust sources. The estimated emissions depends a number of factors such as fuel consumption, technological developments, industrial activity and other activities that cause air pollutions. The analysis shows that CO, NOx and PM emissions are mainly contributed by vehicular sources. The results of the present study are found to be well compared to those reported in literature. The estimated emissions are also shown by spatial variations isopleths over 26 km × 30 km gridded area of Delhi. The concentrations of these pollutants are predicted by using the emissions and meteorological variables as the input in AERMOD, an USEPA's dispersion model. Uncertainties in the emission estimates, measured as 95% confidence intervals, range from a low of ± 32% for NOx to a high of ± 235% for CO. Quantile-Quantile (Q-Q) plots and statistical performance have also been analyzed and it is observed that the predicted concentrations of CO, NOx and PM are in good agreement with respect to observed values. Further, in some locations the predicted concentrations are much higher than the permissible National Ambient Air Quality Standards (NAAQS) levels. These locations are ITO junction, DCE, ISBT Kashmere Gate, Dhaula Kuan, Indraprashta and Badarpur. Thus, this study shows high air pollution load in Delhi and degrading the ambient air quality creates many environmental problems.

Keywords: *AERMOD; Criteria pollutants; Emission inventory; Delhi.*

Comparison of Emissivity, Transmittance, and Reflectance Infrared Spectra of Polycyclic Aromatic Hydrocarbons with those of Atmospheric Particulates (PM1)

Dayana M. Agudelo-Castañeda, Elba Calesso Teixeira, Ismael Luís Schneider, Silvia Beatriz Alves Rolim, Naira Balzaretti, Gabriel Silva e Silva

Source: *Volume 15, No. 4, August 2015, Pages 1627-1639, doi: 10.4209/aaqr.2014.12.0329*

Polycyclic Aromatic Hydrocarbons (PAHs) are a group of various complex organic compounds composed of carbon and hydrogen, and two or more condensed benzene rings. They are released into the atmosphere by the incomplete combustion or pyrolysis of organic matter. Some of the major sources of PAHs are burning of coal, wood, oil or gas, vehicle engines exhaust, and open burning. PAHs are of great concern to human health mainly because of their known carcinogenic and mutagenic properties. Consequently, it is very important to study atmospheric PAHs, especially those associated with ultrafine particles. This study aims to identify the spectral features of PAHs in samples of particulate matter < 1 μm (PM1) using infrared spectrometry. Emissivity and transmittance spectra of PAHs were obtained by infrared spectroscopy. PAHs standards spectra contributed to effectively identify PAHs in PM1 samples. Emissivity and transmittance spectra in the range of 680–900 cm–1 exhibited the largest number of bands due to C–C out-of-plane angular deformations and C–H out-of-plane angular deformations. Bands of medium intensity in 2900–3050 cm–1 region were also observed due to C–H stretching typical of aromatic compounds, although with lower intensity. This study compared the emissivity and transmittance spectra acquired using two different infrared spectrometers in order to identify PAHs in samples of atmospheric particulate matter and analyzed the capability and advantages of each of the infrared spectrometers. In addition, it was confirmed that the PAHs under study can be distinguished by their infrared spectral fingerprints.

Keywords: *FTIR; Emissivity; Transmittance; Particulate matter; PAH.*

Organic Compound Concentrations of Size-Segregated PM10 during Sugarcane Burning and Growing Seasons at a Rural and an Urban Site in Florida, USA

Orhan Sevimoglu, Wolfgang F. Rogge

Source: *Volume 15, No. 5, October 2015, Pages 1720-1736, doi: 10.4209/aaqr.2015.02.0069*

Florida has the most land used to grow sugarcane crops in the United States. The preharvest sugarcane leaf burning elevates ambient particle matter (PM) concentrations in rural areas with dominant sugarcane agriculture (Belle Glade) and affects the air quality of coastal urban sites (Delray Beach). In this study, ambient particles segregated by size were analyzed to identify trace organic compounds from PM sources that may cause adverse health effects. The sampling campaign was conducted simultaneously at urban and rural sites, and revealed that the organic compound concentration of each particle size varies significantly between the sugarcane burning season (SBS) in January and sugarcane growing season (SGS) in May. The results indicated that PM3 contains at least 76% of the organic compound concentrations detected in the samples collected from both sites and during both seasons. The concentrations of trace organic compounds were higher in the SBS than in the SGS. Combustion-oriented hopanes, polycyclic aromatic hydrocarbons (PAHs), and oxygenated PAHs were mainly detected in PM0.49. The detection of elevated levoglucosan concentrations at the urban site indicates that fine particles generated from biomass burning traveled from the rural site to the urban site. Secondary organic compounds such as dicarboxylic acids, phytol, and 6,10,14-trimethyl-2-pentadecanone exhibited similar concentration patterns in the rural and urban sites during both

seasons. In the SGS, PM10 concentrations at both sites were extremely similar; however, the organic compound levels were lower at the rural site than at the urban site in the SBS. This result should be investigated further by researchers investigating the health aspects of organic compound concentrations.

Keywords: *Size segregated; Organic molecular markers; Airborne particles; Biomass burning; PM10.*

Pollution Properties of Water-Soluble Secondary Inorganic Ions in Atmospheric PM2.5 in the Pearl River Delta Region

Dingli Yue, Liuju Zhong, Tao Zhang, Jin Shen, Yan Zhou, Limin Zeng, Huabin Dong, Siqi Ye

Source: *Volume 15, No. 5, October 2015, Pages 1737-1747, doi: 10.4209/aaqr.2014.12.0333*

Based on the online observation of PM2.5 mass concentration, its water-soluble inorganic ions, and their gaseous precursors during August of 2013 to March of 2014 at the atmospheric supersite in the Pearl River Delta (PRD) region, the inter-action of the secondary compositions and their precursors was discussed, and the pollution properties of the secondary inorganic ions were revealed. During the whole measurement period, the average concentrations of SO42–, NO3– and NH4+ were 16.6 μg m–3, 9.0 μg m–3 and 10.2 μg m–3, respectively, with total contribution to PM2.5 of 55.8%, indicating the significant role of secondary transformation in PM2.5 pollution. The seasonal average total contributions of SO42–, NO3– and NH4+ to PM2.5 varied from 46.0% to 64.3%, lowest in summer and highest in winter. The contributions of SO42– and NH4+ to PM2.5 were relatively stable; while those of NO3– in different seasons were distinct, even dominating PM2.5 in some pollution cases in winter. NH3 was abundant with an annual average concentration of 15.2 μg m–3, facilitating the neutralization of H2SO4 and HNO3 with the average [NH4+]/(2[SO42–] + [NO3–]) equivalent charge ratio of 1.1. The maximum daily peak concentration of HNO3 was as high as 18.6 μg m–3, providing an evidence for the strong oxidizing property of the atmosphere in the PRD region. The theoretical equilibrium constant (Ke) of NH4NO3 is always lower than the observed concentration product (Km = [NH3] × [HNO3]) in spring and winter with higher HNO3 concentrations; while in over 60% of the time during summer and autumn, mainly during daytime, Ke was higher. In general, the strong oxidizing property and NH3 played important roles in the fine particle pollution in the PRD region.

Keywords: *PM2.5; Water-soluble inorganic ions; Secondary transformation; Gas-particle conversion.*

Chemical Composition of PM2.5 Based on Two-Year Measurements at an Urban Site in Beijing

Guoyuan Hu, Junying Sun, Yangmei Zhang, Xiaojing Shen, Yun Yang

Source: *Volume 15, No. 5, October 2015, Pages 1748-1759, doi: 10.4209/aaqr.2014.11.0284*

In this study, the daily PM2.5 atmospheric aerosols were collected on quartz and PTFE filters simultaneously from January 2008 to December 2009. Organic carbon (OC) and elemental carbon (EC), water-soluble ions including SO42–, NO3–, Cl–, NH4+, K+, Ca2+, and Mg2+ were analyzed for the samples. The annual average mass concentration of PM2.5 for PTFE was 79 μg m–3. The OC, SO42–, NO3–, NH4+ accounted for about 75 % of PM2.5, and secondary organic carbon (SOC) was estimated about 50% of OC. Monthly averages of SO42–, NO3–, NH4+, K+ were maximum in June and minimum in October, but EC, Cl– displayed the highest in December and the lowest in July, which is related to the coal-combustion emission

from heating. Three groups with high, medium and low PM2.5 concentrations were categorized. SO42–, NO3–, OC and NH4+ accounted for 24%, 20%, 21% and 11% of sum of defined components in the high concentration days. In the medium and low concentrations, OC occupied large fractions of defined components. Mass closure was obtained for PTFE, but not for quartz. The PM2.5 mass concentrations on quartz filters were about 50 μg m–3 higher than that on PTFE. The concentrations of water soluble ions on quartz filters were about 60–70% of that on PTFE filters. About 15–30% of PM2.5 was considered as the contribution of water vapor, the artifact of water vapor on quartz filter should be noted in later research works. PM2.5 displayed neutral during the year of 2008 and appeared acidic at the next year according to the calculation of cations/anion, concentration of hydrogen and acidic purity. Carbonaceous aerosols occupied same fractions in neutral and acidic aerosols. While sulfate and nitrate contributed 32% and 21% to PM2.5 for acidic aerosols, and 22%, 17% of PM2.5 from sulfate and nitrate for neutral aerosols.

Keywords: *PM2.5; OC; Water-soluble ions; Pollution; Acidity.*

Two-Years PM2.5 Observations at Four Urban Sites along the Coast of Southeastern China

Shui-Ping Wu, James Schwab, Bing-Yu Yang, An Zheng, Chung-Shin Yuan

Source: *Volume 15, No. 5, October 2015, Pages 1799-1812, doi: 10.4209/aaqr.2015.05.0363*

PM2.5 samples from four coastal urban sites (Fuzhou, Putian, Quanzhou, and Xiamen) in Southeastern China were collected to analyze their major chemical composition including inorganic ions, organic carbon (OC), elemental carbon (EC), and inorganic elements. Organic matter (OM = 1.6 × OC) was the largest contributor, accounting for 30.2% of PM2.5 mass concentration, and followed by sulfate (19.8%), ammonium (10.6%), and nitrate (9.7%), with minor contribution from trace species (5.1%), crustal species (4.7%) and EC (2.9%). Sea-salt and biomass burning potassium together contributed less than 2%. At the four sites, higher PM2.5 and its major components were observed in the northeast monsoon season while lower levels were found in the southwest monsoon season. The periodic PM2.5 cycle was observed and influenced mainly by rain wash out. However, regular diurnal variations of PM2.5 with high concentration during daytime were only observed in summer due to the greater production of sulfate and organic aerosols in spite of the fact that the vertical mixing coefficients were lower during nighttime. The relative contributions of secondary inorganic aerosols (sulfate, nitrate, and ammonium) to PM2.5 increased rapidly while the contribution of OM decreased during the haze episodes. The reconstructed visibility using revised IMPROVE method correlated well with the measured values. At Xiamen and Fuzhou sites, the major contributors of light extinction coefficient were ammonium sulfate, ammonium nitrate, OM and coarse mass, and accounted for more than 80% of the light extinction coefficient on average.

Keywords: *PM2.5; Chemical composition; Temporal variation; Visibility; Southeastern China.*

Characterizations of PM2.5 Pollution Pathways and Sources Analysis in Four Large Cities in China

Baolei Lv, Yu Liu, Peng Yu, Bin Zhang, Yuqi Bai

Source: *Volume 15, No. 5, October 2015, Pages 1836-1843, doi: 10.4209/aaqr.2015.04.0266*

Particulate matter with an aerodynamic diameter of 2.5 micrometers or less (PM2.5) is a primary pollutant in most cities in China. PM2.5 poses a significant human health risk, especially in the most densely populated urban areas. We used observations of PM2.5 and backward air mass trajectories modeled by HYSPLIT-4. We characterize how air movement patterns influence pollution levels in four large cities of China. Then we developed a method to evaluate regional and local sources and contributions of PM2.5. For Beijing and Shanghai, PM2.5 concentrations are sensitive to air moving direction, indicating significant influence of air movement on PM2.5 pollution. In Beijing, PM2.5 concentrations were higher when the air masses were from the south and the east. In Shanghai, pollution was greater with northerly air mass flows. Regional contributions of PM2.5 in Beijing during 2013 were 46, 62, 52, and 39% in spring, summer, autumn and winter, respectively. In Shanghai, regional contributions over four seasons were 36, 39, 45, and 35%. In Guangzhou and Chengdu, PM2.5 concentrations were more sensitive to speed rather than direction of air mass movements, indicating weaker pollution pathways. In Guangzhou, regional contributions were smaller over the four seasons: 15, 28, 16, and 22% while in Chengdu, they are 21, 52, 28, and 14%. These results are comparable to previous results obtained using complex atmospheric chemical transport models.

Keywords: *PM2.5; Large city; China; Pollution pathway; Source analysis.*

Impact of Meteorological Parameters and Gaseous Pollutants on PM2.5 and PM10 Mass Concentrations during 2010 in Xi'an, China

Ping Wang, Junji Cao, Xuexi Tie, Gehui Wang, Guohui Li, Tafeng Hu, Yaoting Wu, Yunsheng Xu, Gongdi Xu, Youzhi Zhao, Wenci Ding, Huikun Liu, Rujin Huang, Changlin Zhan

Source: *Volume 15, No. 5, October 2015, Pages 1844-1854, doi: 10.4209/aaqr.2015.05.0380*

Mass concentrations of PM2.5 and PM10 from the six urban/rural sampling sites of Xi'an were obtained during two weeks of every month corresponding to January, April, July and October during 2010, together with the six meteorological parameters and the data of two precursors. The result showed that the average annual mass concentrations of PM2.5 and PM10 were 140.9 ± 108.9 μg m–3 and 257.8 ± 194.7 μg m–3, respectively. Basin terrain constrains the diffusion of PM2.5 and PM10 concentration spatially. High concentrations in wintertime and low concentrations in summertime are due to seasonal variations of meteorological parameters and cyclic changes of precursors (SO2 and NO2). Stepwise Multiple Linear Regression (MLR) analysis indicates that relative humidity is the main factor influencing on meteorological parameter. Entry MLR analysis suggests that SO2 from local coal-burning power plants is still the primary pollutant. Trajectory cluster results of PM2.5 at BRR indicate that the entrained urban pollutants carried by the westerly or winter monsoon forms the dominant regional pollution sources in winter and spring. Ultraviolet (UV) aerosol index verified the source and pathway of dust storm in spring.

Keywords: *Xi'an; PM2.5 and PM10; Meteorological parameters; Gaseous pollutants.*

Temporal and Spatial Characteristics of Ambient Air Quality in Beijing, China

Ying Zhou, Shuiyuan Cheng, Dongsheng Chen, Jianlei Lang, Gang Wang, Tingting Xu, Xiaoqi Wang, Sen Yao

Source: *Volume 15, No. 5, October 2015, Pages 1868-1880, doi: 10.4209/aaqr.2014.11.0306*

The ambient air quality in Beijing was comprehensively assessed based on the real-time pollutant concentrations monitored at urban, suburban, roadside, and background sites in 2013. The results showed that the annual average concentration for CO, NO2, SO2, O3, PM2.5 and PM10 in 2013 was 2.0 mg/m3, 55.6 μg m–3, 28.5 μg m–3, 48.0 μg m–3, 92.2 μg m–3 and 118.6 μg m–3, respectively. The annual average concentration of CO, NO2, SO2, PM2.5 and PM10 was highest in roadside, while that of O3 was highest in background stations. The mean monthly statistics indicated the maximum concentration of CO, NO2, SO2, PM2.5 and PM10 occurred in January because of larger emissions in heating season, lower wind speed and higher relative humidity (RH), while the minimum was found in July or August due to larger precipitation or photochemical degradation. The peak concentrations of O3 occurred during May to August due to higher temperature and solar radiation which could promote the photochemistry activity. The monthly variation is also reflected in the corresponding season. Diurnally analysis showed the CO, NO2, SO2, PM2.5 and PM10 in urban and roadside area had two increase phases accompanying with the traffic peaks. Beside the temporal variation, we also found the spatial variation that higher concentrations of O3 and other pollutants occurred in northern and southern districts/counties, respectively. It could be attributed to the spatial distribution of various pollutant emissions in Beijing and the impact of pollutant transport from neighboring provinces. Moreover, we examined the visibility in Beijing and found its significant correlation with PM2.5 concentration and RH, respectively. Lastly, the air quality in Beijing was compared with that in other mega cities in the world. The higher pollutant concentrations and PM2.5/PM10 ratio indicated that the mitigation of the air pollution especially the PM2.5 pollution in Beijing still had a long way to go.

Keywords: *Ambient air quality; Temporal-spatial characteristics; Visibility; Meteorological conditions; Beij*

Chemical Composition and Light Extinction Contribution of PM2.5 in Urban Beijing for a 1-Year Period

Huanbo Wang, Mi Tian1, Xinghua Li, Qing Chang, Junji Cao, Fumo Yang, Yongliang Ma, Kebin He

Source: *Volume 15, No. 6, November 2015, Pages 2200-2211, Doi:10.4209/aaqr.2015.04.0257*

Daily PM2.5 samples were collected in Beijing across four consecutive seasons from June 2012 to April 2013. Major water-soluble inorganic ions, carbonaceous species and elements were analyzed to investigate their temporal variations and evaluate their contributions to visibility impairment over different seasons and under different pollution levels. The mass concentrations of PM2.5 ranged from 4.3 to 592.4 μg m–3, with an annual average of 112.4 ± 94.4 μg m–3. The predominant components of PM2.5 were secondary inorganic ions (NH4+, NO3– and SO42–) and carbonaceous compounds, which accounted for 45.9% and 24.1% of the total PM2.5 mass, respectively. Distinct seasonal variation was observed in the mass concentrations and chemical components of PM2.5. The average mass concentrations of PM2.5 were the highest in winter, followed by spring, and lowest in autumn. Light extinction coefficients (bext) were discussed over four seasons. (NH4)2SO4 was the largest contributor (28.8%) to bext, followed by NH4NO3 (24.4%), organic matter (19.5%), elemental carbon (7.4%), and coarse mass (7.2%), while fine soil, sea salt, NO2 and Rayleigh made minor contributions, together accounting for 12.7% of bext. During the polluted periods, the contributions of (NH4)2SO4 and NH4NO3 to bext increased dramatically. Therefore, in addition

to control primary particulate emissions, the reduction of their precursors like SO2, NOx and NH3 could effectively improve air quality and visibility in Beijing.

Keywords: *Chemical composition; Reconstructed light extinction coefficient; Visibility; PM2.5.*

Size Distribution and Optical Properties of Particulate Matter (PM10) and Black Carbon (BC) during Dust Storms and Local Air Pollution Events across a Loess Plateau Site

Wei Pu, Xin Wang, Xueying Zhang, Yong Ren, Jin-Sen Shi, Jian-Rong Bi, Bei-Dou Zhang

Source: *Volume 15, No. 6, November 2015, Pages 2212-2224, doi: 10.4209/aaqr.2015.02.0109*

We analyzed the suspended particle size distribution in the range of 0.5 to 10 μm and the optical properties of the particles from March 2007 to December 2010 at a site on the Loess Plateau (SACOL; 35.57°N, 104.08°E; 1965.8 m a.s.l.) about 48 km southeast of the center of Lanzhou. The results indicated that the variation in PM10 was much larger in spring than in winter because of frequent dust events or local blowing soil dust during spring. The highest number concentrations of coarse-mode particles were likely attributable to dust events that transported mineral dust or soil dust in the spring season, caused by cold fronts or strong local winds. In contrast, the fine-mode particles that dominated in the cold season at SACOL were probably indicative of anthropogenic sources related to fossil-fuel combustion and biomass burning. The comparison of dust events and anthropogenic air pollution shows a clear distinction of lower PM10 with higher Bap for pollution episodes and higher PM10 with lower Bap for dust events. These findings suggest that the results in the cold season were likely attributable to light absorption of black carbon, and the coarse mode particles were dominant during dust events in spring.

Keywords: *Dust storms; Local air pollutants; Aerosol scattering coefficient; Aerosol absorption coefficient; PM10; Black carbon.*

Diurnal Variability in Secondary Organic Aerosol Formation over the Indo-Gangetic Plain during Winter Using Online Measurement of Water-Soluble Organic Carbon

Neeraj Rastogi, Anil Patel, Atinderpal Singh, Darshan Singh

Source: *Volume 15, No. 6, November 2015, Pages 2225-2231, doi:10.4209/aaqr.2015.02.0097*

Understanding the secondary organic aerosol (SOA) formation is among most important topics in the field of aerosol research because its poor understanding leads to large uncertainty in the assessment of aerosol effects on air quality and climate. This study reports the diurnal and temporal variability in SOA formation over a site (Patiala: 30.2°N, 76.3°E, 249 m amsl) located in the Indo-Gangetic Plain (IGP) during winter using the first online measurements of water-soluble organic carbon (WSOC) over India. Online WSOC, measured with particle-into-liquid sampler (PILS) connected to total organic carbon (TOC) analyzer, ranged from 0.1 to 99 μg m–3 (avg: 15.6, sd: 9.4) with a considerable day-to-day and within the day variability, and attributed to meteorological conditions and regional sources. Diurnal trends of online WSOC suggest significant SOA formation during 7:00 to 22:00 hrs when sources of SOA precursors are active; and loss of SOA occurs during afternoon when ambient air temperature is at its peak. In parallel to online measurements, filter-based particulate matter smaller than 2.5 μm (PM2.5) samples were also collected and

analyzed for major cations, anions and carbonaceous aerosols. Filter-based PM2.5 composition suggests that the emissions from biomass burning contribute more to carbonaceous aerosols than those from fossil fuel burning. In spite of this, average primary WSOC was only ~20% whereas secondary WSOC (or SOA) dominated the total WSOC concentration with ~80% contribution. A strong linear relationship between PM1 and WSOC (R2 = 0.83, slope = 0.113, intercept = 4.7), suggests that a significant fraction of fine particles are SOA.

Keywords: *Biomass burning; SOA; Carbonaceous aerosols: WSOC; India.*

A Long Term Study on Characterization and Source Apportionment of Particulate Pollution in Klang Valley, Kuala Lumpur

Shamsiah Abdul Rahman, Mohd Suhaimi Hamzah, Md Suhaimi Elias, Nazaratul Ashifa Abdullah Salim, Azian Hashim, Shakirah Shukor, Wee Boon Siong, Abdul Khalik Wood

Source: *Volume 15, No. 6, November 2015, Pages 2291-2304, doi: 10.4209/aaqr.2015.03.0188*

Samples of airborne particulate matter, PM2.5 and PM10–2.5 were collected using a Gent stacked filter sampler at an urban site, Klang Valley, Kuala Lumpur between January 2002–December 2011. The samples were analyzed for their elemental composition and black carbon content by Particle Induced X-ray Emission (PIXE) and light absorption, respectively. The annual average for PM2.5, PM10–2.5 and PM10 ranged from 21 to 35, 18 to 26 and 44 to 56 μg m–3, respectively. Factor analysis method and the Positive Matrix Factorisation (EPA PMF3) technique were also applied to the fine fraction data set in order to identify the possible sources of particulate matter and their contributions to the ambient particulate matter concentrations in the Klang Valley. A five factor PMF solution was found for PM2.5 particulate matter. The sources identified were; motor vehicles, industry, smoke/biomass burning, secondary sulphate and soil. It was found that the primary source of haze air particulate matter was locally generated mostly from vehicular emissions which contribute about 35% of the PM2.5 mass. The Hybrid Single Particle Lagrangian Intergrated Trajectory (HYSPLT) model was also used to explore possible long range transport of pollution. Smoke trans-boundary events were identified based on fine potassium from the data base in 2004, 2006 and 2008.

Keywords: *Klang Valley; Elemental composition; Positive Matrix Factorization; Airborne particulate.*

Ultrafine Particles and PM2.5 at Three Urban Air Monitoring Stations in Northern Taiwan from 2011 to 2013

Guan-Yu Lin, Guo-Rui Lee, Sih-Fan Lin, Yi-Hung Hung, Shih-Wei Li, Guo-Jei Wu, Huajun Ye, Wei Huang, Chuen-Jinn Tsai

Source: *Volume 15, No. 6, November 2015, Pages 2305-2319,doi: 10.4209/aaqr.2015.04.0271*

In this study, long term measurements of PM2.5 and ultrafine particles (UFPs) for daily average mass concentration at Zhongshan (ZS), Sinjhuang (SJ), and Jhudong (JD) urban air monitoring stations were conducted from 2011 spring to 2013 autumn. The results showed that daily average UFPs mass concentrations in spring (average at 3 stations: 1.58 ± 0.74 μg m–3) and summer (average at 3 stations: 1.59 ± 0.53 μg m–3) were higher than those in autumn (average at 3 stations: 1.02 ± 0.28 μg m–3) and winter (average at 3 stations: 1.04 ± 0.48 μg m–3) due to the impacts by heavy traffic emission and new particle formation event. The effective density (ρeff) and dynamic shape factor (χ) for ultrafine particles (UFPs) were

found to be 0.68 ± 0.16 g cm–3 and 2.06 ± 0.19, respectively, suggesting that the particle morphology was irregular shape. Based on the calculated ρeff and χ, the average number and surface area concentration ratio of UFPs to those of PM2.5 at these monitoring stations was determined to be 89.0 ± 5.5% and 42.1 ± 12.8%, respectively, suggesting that UFPs contribute significantly to the health-relevant PM2.5 aerosol fraction in these stations.

Keywords: *PM2.5; Nanoparticle measurement; Ultrafine particles; Effective density.*

A Severe Air Pollution Event from Field Burning of Agricultural Residues in Beijing, China

Yanli Lyu, Carlo Jaeger, Zhangang Han, Lianyou Liu, Peijun Shi, Weiping Wang, Saini Yang, Lanlan Guo, Guoming Zhang, Xia Hu, Jing Guo, Yunliang Gao, Yanyan Yang, Yiying Xiong, Haiming Wen, Bo Liang, Mengdi Zhao

Source: *Volume 15, No. 7, December 2015, Pages 2525-2536, doi: 10.4209/aaqr.2015.05.0369*

Air pollutant emissions from agricultural burning are observed every year after harvest in China. While agriculture is not the main contributor to air pollution in China, agricultural activities can cause severe pollution events. Recognizing the key mechanisms involved in this process offers an opportunity to minimize pollution events caused by agricultural burning. In this paper, we review the meteorological conditions present during a selected air pollution episode and discuss those conditions using standard meteorological observations. The spatio-temporal variations of PM2.5 concentrations following agricultural burning in Beijing were measured from October 4 to October 7, 2013. This time period coincides with a Chinese public holiday and was selected because the influence of other anthropogenic emissions on air quality was strongly reduced during those days. As a result, we were able to identify the key sources and progress of a severe air pollution event. On October 4, average PM2.5 concentration in Beijing continuously increased from 49.7 μg m–3 at 1:00 to 302.5 μg m–3 at 23:00. Heavily polluted air (> 300 μg m–3) initially appeared in southeastern Beijing on the afternoon of October 4. On October 5 and in the early morning of October 6, heavily polluted air masses moved into central Beijing, the inner suburbs, and the suburbs. From 0:00 on October 6 to 15:00 on October 7, the average PM2.5 concentration in Beijing decreased from 291.6 μg m–3 to 19.2 μg m–3. Active fire information derived from the MODIS sensors and back trajectory analysis show that field burning of agricultural residues after a harvest triggered and massively contributed to this severe air pollution event. The results improve our understanding of PM2.5 air pollution development processes, and they provide scientific support for the Chinese government to accelerate emission reductions from the field burning of agricultural residues.

Keywords: *PM2.5 concentration; Field burning of agricultural residues; Post-harvest; Spatio-temporal variation; Beijing.*

Characterization of PM2.5 Source Profiles for Traffic and Dust Sources in Raipur, India

Jeevan Lal Matawle, Shamsh Pervez, Shippi Dewangan, Anjali Shrivastava, Suresh Tiwari, Pallavi Pant, Manas Kanti Deb, Yasmeen Pervez

Source: *Volume 15, No. 7, December 2015, Pages 2537-2548, doi: 10.4209/aaqr.2015.04.0222*

This paper describes results from a detailed source profile characterization study conducted in Raipur, India to prepare source profiles for traffic and dust-related sources. A companion paper has been published with results for a range of other combustion sources. PM2.5 samples were analyzed for mass, elements (Al, As, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, Mg, Mn, Mo, Na, Ni, Pb, S, Sb, Se, V, Zn), ions (Na+, K+, Mg2+, Ca2+, NH4+, Cl–, F–, NO3–, SO42–) and carbonaceous fractions (OC and EC). All dust profiles were dominated by crustal elements (Al, Ca, Fe and Mg), while carbonaceous species (OC and EC) were most abundant in vehicular emission profiles. Trace element fraction was found to be significantly higher in vehicular exhaust compared to the resuspended dust. Remarkably, sulphur abundance was observed to be several-fold higher in vehicular emission profiles than resuspended dust profiles. Al and Ca were identified as reliable markers for resuspended dust while V, Pb and EC were identified as markers for vehicular exhaust.

Keywords: *PM2.5; Source profiles; Source markers; Traffic; Dust.*

Chemical Composition and Size-Fractionated Origins of Aerosols over a Remote Coastal Site in Southern Taiwan

Ying I. Tsai, Khajornsak Sopajaree, Su-Ching Kuo, Ting-Yi Hsin

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In spring 2013 air samples were collected from a coastal site in the sparsely populated far south-west of Taiwan and analysed for ambient gases, inorganic salts, carboxylates, and saccharides. Concentration of ambient gases was in the order SO2 > HCl > HNO3 > NH3 > HNO2. Day-night variation in concentrations indicated that photochemical conversion of HNO2 to HNO3 occurs during the day. PM2.5 (16.16 ± 5.30 μg m–3) accounted for 61.1% of PM10 mass concentrations. The main inorganic salts were SO42–, NH4+, Na+, NO3–, and Cl–, collectively accounting for 48.8 ± 27.4% of the PM2.5. Cl-depletion during the day was higher than during the night due to the presence of reactive photochemical products. The average Cl-depletion of PM2.5 (53.1%) was markedly higher than that of PM2.5–10 (26.0%), indicating that in PM2.5, a high amount of Cl– reacts with acidic gases to form HCl, which then escapes into the atmosphere. The carboxylate concentration in PM2.5 was 0.50 ± 0.24 μg m–3. It was found that low-molecular-weight carboxylates formed more readily in the open coastal region than in urban regions of southern Taiwan. Additionally, the daily mean ratio of Oxalate/non-sea-salt SO42– (6.15 ± 2.28%) in the coastal region was higher than that in the urban regions in southern Taiwan. The most prevalent saccharide in PM2.5 was myo-inosital (333 ± 300 μg m–3), a type of soil fungus metabolite. Emissions of arabitol and mannitol, emitted through lichen and fungal activity, were markedly higher during the day. Only a trace amount (8.92 ± 16.92 μg m–3) of Levoglucosan (Levo), an indicator of biomass burning, was detected. The mean Levo/organic carbon ratio was 5.04 ± 8.72‰, suggesting that biomass burning contributed slightly to aerosols in the study area. An analysis of air mass backward trajectories showed that the products of biomass burning in Southeast Asia and southern China may be transported to the study area through long-range transport. This effect is more noticeable during the day when onshore breezes support the transport of particles sourced from the west of Taiwan.

Keywords: *Hengchun Peninsula; Carboxylates; Saccharides; Biomass burning; Cl-depletion.*

Characteristics of Concentrations and Metal Compositions for PM2.5 and PM2.5–10 in Yunlin County, Taiwan during Air Quality Deterioration

Yu-Cheng Chen, Chin-Yu Hsu, Sheng-Lun Lin, Guo-Ping Chang-Chien, Mu-Jean Chen, Guor-Cheng Fang, Hung-Che Chiang

Source: *Volume 15, No. 7, December 2015, Pages 2571-2583, doi: 10.4209/aaqr.2015.04.0261*

Concentrations of twenty trace metals in ambient fine and coarse particles were characterized during the period of air quality deterioration of elevated particulate matters (PM episode) in winter in the suburban area, Yunlin County, Taiwan. The potential emission sources of fine- and coarse-size metals were identified using the enrichment factor (EF) analysis, principal component analysis (PCA) and backward trajectory model. The high concentrations of fine and coarse particles and their associated metals were observed during the PM episode in Yunlin County. Al, Fe, and Ca were predominant in fine and coarse particles for sampling periods, accounting for 75–85% of all selected elements. When the PM episode occurred, mean concentrations of fine-size Pb and As were increased to 132% and 116%, respectively, while average concentrations of coarse-size Fe, Al, Mn, Ti, and Co were increased to 1.1–2.2 times, in comparison with non-episode period. The mean value of fine-size As (6.67 ng m–3) obtained from the episode period exceeds the proposed European Union standard (6 ng m–3). EF values were decreased with increasing particle size for Sb, Se, As, Mo, Cr, Cu, V, Pb, Zn, Ni and Cd in both episode periods. Fine-size metals is likely to refer to coal combustion (36.5%), iron and steel industry (30.5%), vehicular emission and oil burning (16.3%), and Cu smelting source (13.1%), while coarse-size metals are associated with soil dust and crustal elements (61.6%), traffic-related re-suspended road dust (19.4%), industrial process (10.6%) and coal/oil combustion (6.3%) for the PM episode.

Keywords: Trace metals; Episode; Enrichment factor; Source apportionment.

Characterization of Particulate Matter and Carbonaceous Aerosol over Two Urban Environments in Northern India

Abhilash S. Panicker, Kaushar Ali, Gufran Beig, Sarita Yadav

Source: *Volume 15, No. 7, December 2015, Pages 2584-2595, doi: 10.4209/aaqr.2015.04.0253*

Monitoring and simultaneous sampling of Particulate matter (PM10 and PM2.5) was carried out for the first time over two urban sites in Northern India (Jabalpur and Udaipur) during December 2010–November 2012 (up to August 2012 over Udaipur). The samples of PM2.5 were analyzed for elemental carbon (EC) and organic carbon (OC) using advanced DRI Thermal optical carbon Analyzer. The monthly mean PM10 values were as high as 149 ± 44 µg m–3 over Jabalpur (JBL) and 171 ± 42.2 µg m–3 over Udaipur (UDPR). PM2.5 mass over JBL varied between 25–79 µg m–3 and over UDPR between 24–82 µg m–3. The monthly mean OC concentration varied from 12.5 ± 7.3 µg m–3 to 28.4 ± 10.7 µg m–3 over JBL and from 7.8 ± 2.9 to 39.7 ± 11.6 µg m–3 over UDPR. The variation of monthly mean EC concentration was from 3.9–10.3 µg m–3 over JBL and from 3–10.9 µg m–3 over UDPR. The contribution of TC to PM2.5 was in the range of 31–75% over JBL and 30–83% over UDPR. The EC showed higher concentration in winter and minimal values in monsoon. The OC/EC ratio showed low variation over JBL compared to that over UDPR suggesting spectrum of sources responsible for EC and OC components over UDPR. Formation of secondary organic carbon (SOC) was also recognized as a potential component altering OC/EC ratio. Up on extracting the sub fractions, it is found that OC2 and OC3 are the major component over both the sites contributing up to 51%

to the total OC in different months. EC1 (EC component derived at 580°C) was found to be the major EC component contributing up to 79% over the sites.

Keywords: *Particulate Matter; PM10; PM2.5; EC; OC.*

Effects of Chalk Use on Dust Exposure and Classroom Air Quality

Chi-Chi Lin, Mei-Kuei Lee, Hsiao-Lin Huang

Source: *Volume 15, No. 7, December 2015, Pages 2596-2608, doi: 10.4209/aaqr.2015.04.0216*

This study explores human exposure to harmful dust when antidust chalk is used for teaching, as well as dust particle size distribution and how chalk dust affects indoor air quality. In this study, a classroom with 5 ventilation modes was selected. A dust size analyzer and a scanning mobility particle sizer were employed to measure the mass concentration and particle size distribution of chalk dust based on the frequency of chalk use during classes. The results indicate that antidust chalk can generate considerable quantities of dust particles and substantially increase the mass concentration of dust in the proximity of the chalkboard. Approximately 15% of observed chalk dust particles were respirable and high concentrations of chalk dust deteriorated the indoor air quality. Moreover, chalk dust was the primary source of indoor coarse particles. Mechanical ventilation resuspended the settled chalk dust particles, thereby increasing the mass concentration of airborne dust. Using antidust chalk generates coarse, fine, and ultrafine particles, particularly when cleaning the chalkboard. The best ventilation mode to reduce dust accumulated in the chalk teaching classroom was to open doors and turn on ceiling fans. Wearing face masks and increasing distance between seats and blackboard can also prevent teachers and students from chalk dust hazard. The results of this study should serve as a reference for improving indoor air quality and protecting teachers and students from harmful dust particles in classrooms.

Keywords: *Dust; Exposure; School; Indoor air quality; Ventilation.*

Source Apportionment of Submicron Particle Size Distribution and PM2.5 Composition during an Asian Dust Storm Period in Two Urban Atmospheres

Chi-Sung Liang, Tai-Yi Yu, Wen-Yinn Lin

Source: *Volume 15, No. 7, December 2015, Pages 2609-2624, doi: 10.4209/aaqr.2015.08.0505*

Asian dust storms (ADS), coming from deserts of China and Mongolia, have serious environmental impact on particulate matter (PM) and other pollutants in Taiwan. This study selected two urban sites, Taipei and Kaohsiung, to evaluate the influence of ADS on air quality. During the ADS periods, the hourly PM10 mass concentrations were 800 μg m–3 in Taipei and the 400 μg m–3 in Kaohsiung, which was three to five times higher than PM episodes during the non-ADS periods. By using the principal component analysis (PCA) manner, the potential sources, the dust storm contained, can be successfully identified during ADS periods. The other potential sources can be identified as vehicular emission and secondary organic aerosols from local area. There have been many studies conducted on the impact of ADS on airborne coarse particle concentration, but very few on fine particle concentration. This study focused on, using PCA for analysis and discussion, the impact of ADS on submicron particle size distribution. The results showed that there was no close relationship between the ADS and Aitken mode (30–100 nm or D30–100nm) or accumulation mode

(from 0.1–1 μm). However, it was found that strong correlation existed between the ADS and nucleation mode (10–30 nm or D10–30nm). In addition, it was found that nucleation mode appeared first, followed by an air plume of dust particles twelve (12) hours later. The nucleation component from the PCA could be used as predictors of arrival time for an ADS. Taking into account the effects of meteorological conditions and employing technique of backward trajectories, PCA can be utilized as a powerful tool to better identify the source of dust storms and provide accurate results.

Keywords: *Dust storm; Principal component analysis; Aerosol size distribution.*

SECTION-II
Atmospheric Chemistry and Physics Journal

The effect of dry and wet deposition of condensable vapors on secondary organic aerosols concentrations over the continental US

C. Knote, A. Hodzic, and J. L. Jimenez

Source: *Atmos. Chem. Phys., 15, 1-18, 2015*

The effect of dry and wet deposition of semi-volatile organic compounds (SVOCs) in the gas phase on the concentrations of secondary organic aerosol (SOA) is reassessed using recently derived water solubility information. The water solubility of SVOCs was implemented as a function of their volatility distribution within the WRF-Chem regional chemistry transport model, and simulations were carried out over the continental United States for the year 2010. Results show that including dry and wet removal of gas-phase SVOCs reduces annual average surface concentrations of anthropogenic and biogenic SOA by 48 and 63% respectively over the continental US. Dry deposition of gas-phase SVOCs is found to be more effective than wet deposition in reducing SOA concentrations (−40 vs. −8% for anthropogenics, and −52 vs. −11% for biogenics). Reductions for biogenic SOA are found to be higher due to the higher water solubility of biogenic SVOCs. The majority of the total mass of SVOC + SOA is actually deposited via the gas phase (61% for anthropogenics and 76% for biogenics). Results are sensitive to assumptions made in the dry deposition scheme, but gas-phase deposition of SVOCs remains crucial even under conservative estimates. Considering reactivity of gas-phase SVOCs in the dry deposition scheme was found to be negligible. Further sensitivity studies where we reduce the volatility of organic matter show that consideration of gas-phase SVOC removal still reduces average SOA concentrations by 31% on average. We consider this a lower bound for the effect of gas-phase SVOC removal on SOA concentrations. A saturation effect is observed for Henry's law constants above 108 M atm−1, suggesting an upper bound of reductions in surface level SOA concentrations by 60% through removal of gas-phase SVOCs. Other models that do not consider dry and wet removal of gas-phase SVOCs would hence overestimate SOA concentrations by roughly 50%. Assumptions about the water solubility of SVOCs made in some current modeling systems (H* = H* (CH3COOH); H* = 105 M atm−1; H* = H* (HNO3)) still lead to an overestimation of 35%/25%/10% compared to our best estimate.

Seasonal characteristics of fine particulate matter (PM) based on high-resolution time-of-flight aerosol mass spectrometric (HR-ToF-AMS) measurements at the HKUST Supersite in Hong Kong

Y. J. Li, B. P. Lee1, L. Su, J. C. H. Fung, and C.K. Chan

Source: *Atmos. Chem. Phys., 15, 37-53, 2015*

Atmospheric particulate matter (PM) remains poorly understood due to the lack of comprehensive measurements at high time resolution for tracking its dynamic features and the lack of long-term observation for tracking its seasonal variability. Here, we present highly time-resolved and seasonal compositions and characteristics of non-refractory components in PM with a diameter less than 1 μm (NR-PM1) at a suburban site in Hong Kong. The measurements were made with an Aerodyne high-resolution time-of-flight aerosol mass spectrometer (HR-ToF-AMS) at the Hong Kong University of Science and Technology (HKUST) Air Quality Research Supersite for 4 months, with one in each season of the year. The average NR-PM1 concentration of ~ 15 μg m−3 is higher than those AMS measurements made in South Korea and Japan, but lower than those in North China, the Yangtze River Delta and the nearby Pearl River Delta. The seasonal dependence of the total NR-PM1 monthly averaged concentrations was small, but that of the fractions of the species in NR-PM1 was significant. Site characteristic plays an important role in the relative fractions of

species in NR-PM1 and our results are generally consistent with measurements at other non-urban sites in this regard. Detailed analyses were conducted on the AMS data in the aspects of (1) species concentrations, (2) size distributions, (3) degree of oxygenation of organics, and (4) positive matrix factorization (PMF)-resolved organic factors in a seasonal context, as well as with air mass origin from back-trajectory analysis. Sulfate had the highest fraction in NR-PM1 (> 40%), and the surrogates of secondary organic species – semi-volatile oxygenated organic aerosol (SVOOA) and low-volatility oxygenated organic aerosol (LVOOA) – prevailed (~ 80%) in the organic portion of NR-PM1. Local contributions to the organic portion of NR-PM1 at this suburban site was strongly dependent on season. The hydrocarbon-like organic aerosol (HOA) factor related to local traffic emissions contributed > 10% to organic aerosols in spring and summer but only 6–7% in autumn and winter. The cooking organic aerosol (COA) factor contributed > 10% to organic aerosols in winter. With the aid of highly time-resolved data, diurnal patterns of the degree of oxygenation of organic aerosols were used to determine the sources and formation processes of the least understood organic portion of PM. The oxygen-to-carbon atomic ratio (O : C) and average carbon oxidation state OS C) showed little variation in autumn and winter, when the long-range transport of oxidized organics dominated, whereas they peaked in the afternoon in spring and summer, when locally produced secondary organic aerosol prevailed. Air mass origin, in contrast, had a strong influence on both NR-PM1 concentrations and the fractions of species in NR-PM1. The findings of the current study provide a better understanding of the role of air mass origin in the seasonal characteristics of the PM composition and the relative importance of local vs. transported organic aerosols in this region.

On the composition of ammonia–sulfuric-acid ion clusters during aerosol particle formation

S. Schobesberger, A. Franchin, F. Bianchi, L. Rondo, J. Duplissy, A. Kürten, I. K. Ortega, A. Metzger, R. Schnitzhofer, J. Almeida, A. Amorim, J. Dommen, E. M. Dunne, M. Ehn, S. Gagné,, L. Ickes, H. Junninen, A. Hansel, V.-M. Kerminen, J. Kirkby, A. Kupc, A. Laaksonen, K. Lehtipalo, S. Mathot, A. Onnela, T. Petäjä, F. Riccobono, F. D. Santos, M. Sipilä, A. Tomé, G. Tsagkogeorgas, Y. Viisanen, P. E. Wagner, D. Wimmer, J. Curtius, N. M. Donahue, U. Baltensperger, M. Kulmala, and D. R. Worsnop

Source: *Atmos. Chem. Phys., 15, 55-78, 2015*

The formation of particles from precursor vapors is an important source of atmospheric aerosol. Research at the Cosmics Leaving OUtdoor Droplets (CLOUD) facility at CERN tries to elucidate which vapors are responsible for this new-particle formation, and how in detail it proceeds. Initial measurement campaigns at the CLOUD stainless-steel aerosol chamber focused on investigating particle formation from ammonia (NH3) and sulfuric acid (H2SO4). Experiments were conducted in the presence of water, ozone and sulfur dioxide. Contaminant trace gases were suppressed at the technological limit. For this study, we mapped out the compositions of small NH3–H2SO4 clusters over a wide range of atmospherically relevant environmental conditions. We covered [NH3] in the range from < 2 to 1400 pptv, [H2SO4] from 3.3 × 106 to 1.4 × 109 cm−3 (0.1 to 56 pptv), and a temperature range from −25 to +20 °C. Negatively and positively charged clusters were directly measured by an atmospheric pressure interface time-of-flight (APi-TOF) mass spectrometer, as they initially formed from gas-phase NH3 and H2SO4, and then grew to larger clusters containing more than 50 molecules of NH3 and H2SO4, corresponding to mobility-equivalent diameters greater than 2 nm. Water molecules evaporate from these clusters during sampling and are not observed. We found that the composition of the NH3–H2SO4 clusters is primarily determined by the ratio of gas-phase concentrations [NH3] / [H2SO4], as well as by temperature. Pure binary H2O–H2SO4 clusters (observed as clusters of only H2SO4) only form at [NH3] / [H2SO4] < 0.1 to 1. For larger values of [NH3] / [H2SO4], the composition of NH3–H2SO4 clusters was characterized by the number of NH3 molecules m added for each added H2SO4 molecule n (Δm/Δ n), where n is in the range 4–18 (negatively charged clusters) or 1–17 (positively charged clusters). For negatively charged clusters, Δ m/Δn saturated between 1 and 1.4 for [NH3]

/ [H2SO4] > 10. Positively charged clusters grew on average by $\Delta m/\Delta n = 1.05$ and were only observed at sufficiently high [NH3] / [H2SO4]. The H2SO4 molecules of these clusters are partially neutralized by NH3, in close resemblance to the acid–base bindings of ammonium bisulfate. Supported by model simulations, we substantiate previous evidence for acid–base reactions being the essential mechanism behind the formation of these clusters under atmospheric conditions and up to sizes of at least 2 nm. Our results also suggest that electrically neutral NH3–H2SO4 clusters, unobservable in this study, have generally the same composition as ionic clusters for [NH3] / [H2SO4] > 10. We expect that NH3–H2SO4 clusters form and grow also mostly by $\Delta m/\Delta n > 1$ in the atmosphere's boundary layer, as [NH3] / [H2SO4] is mostly larger than 10. We compared our results from CLOUD with APi-TOF measurements of NH3–H2SO4 anion clusters during new-particle formation in the Finnish boreal forest. However, the exact role of NH3–H2SO4 clusters in boundary layer particle formation remains to be resolved.

Global and regional modeling of clouds and aerosols in the marine boundary layer during VOCALS: the VOCA intercomparison

M. C. Wyant, C. S. Bretherton, R. Wood, G. R. Carmichael, A. Clarke, J. Fast4, R. George, W. I. Gustafson Jr., C. Hannay, A. Lauer, Y. Lin, J.-J. Morcrette, J. Mulcahy, P. E. Saide, S. N. Spak, and Q. Yang

Source: *Atmos. Chem. Phys., 15, 153-172, 2015*

A diverse collection of models are used to simulate the marine boundary layer in the southeast Pacific region during the period of the October–November 2008 VOCALS REx (VAMOS Ocean Cloud Atmosphere Land Study Regional Experiment) field campaign. Regional models simulate the period continuously in boundary-forced free-running mode, while global forecast models and GCMs (general circulation models) are run in forecast mode. The models are compared to extensive observations along a line at 20° S extending westward from the South American coast. Most of the models simulate cloud and aerosol characteristics and gradients across the region that are recognizably similar to observations, despite the complex interaction of processes involved in the problem, many of which are parameterized or poorly resolved. Some models simulate the regional low cloud cover well, though many models underestimate MBL (marine boundary layer) depth near the coast. Most models qualitatively simulate the observed offshore gradients of SO2, sulfate aerosol, CCN (cloud condensation nuclei) concentration in the MBL as well as differences in concentration between the MBL and the free troposphere. Most models also qualitatively capture the decrease in cloud droplet number away from the coast. However, there are large quantitative intermodel differences in both means and gradients of these quantities. Many models are able to represent episodic offshore increases in cloud droplet number and aerosol concentrations associated with periods of offshore flow. Most models underestimate CCN (at 0.1% supersaturation) in the MBL and free troposphere. The GCMs also have difficulty simulating coastal gradients in CCN and cloud droplet number concentration near the coast. The overall performance of the models demonstrates their potential utility in simulating aerosol–cloud interactions in the MBL, though quantitative estimation of aerosol–cloud interactions and aerosol indirect effects of MBL clouds with these models remains uncertain.

Air quality and atmospheric deposition in the eastern US: 20 years of change

J. E. Sickles II and D. S. Shadwick

Source: *Atmos. Chem. Phys., 15, 173-197, 2015*

Data collected in the eastern US between 1990 and 2009 at 34 paired dry and wet monitoring sites are examined. A goal is to evaluate the air quality impacts occurring between 1990 and 2009 that are associated with concurrent legislatively mandated changes in emissions. Four 5-year periods, 1990–1994 (P1), 1995–1999 (P2), 2000–2004 (P3), and 2005–2009 (P4) are considered, with a primary focus on P1-to-P4 changes. Results suggest that legislatively mandated air pollution mitigation strategies have been successful in improving air quality and reducing atmospheric deposition in the eastern US.

Respective P1-to-P4 reductions of estimated sulfur dioxide (SO2) and nitrogen oxides (NOx) emissions in the eastern US are 50 and 42%. Corresponding behavior of the following metrics associated with these emissions reductions is examined: monitored atmospheric concentrations of SO2, aerosol sulfate (SO4), and oxidized sulfur (S); dry, wet, and total deposition of S; monitored atmospheric concentrations of nitric acid (HNO3), aerosol nitrate (NO3), and their sum, oxidized nitrogen (OxN); dry, wet, and total deposition of OxN; monitored atmospheric concentration of aerosol ammonium (NH4); dry, wet, and total deposition of NH4; summed monitored atmospheric concentration of oxidized and reduced nitrogen (N); dry, wet, and total deposition of N; wet deposition of hydrogen ion (H+); monitored atmospheric concentration of ozone (O3); dry deposition of O3; and the summed monitored atmospheric concentration of aerosol NO3, SO4, and NH4 (Clean Air Status and Trends Network particulate matter – CASTNET PM). Other metrics (e.g., ratios of dry to total deposition) are also considered.

Selected period-to-period changes of air quality and deposition metrics at site, regional, and seasonal scales are discussed. As an example, despite P1-to-P3 reductions in estimated emissions of both SO2 and NOx, aerosol NO3 concentration increased in the east, with widespread wintertime numerical increases in both aerosol NO3 concentration and CASTNET PM. However, a reversal of this behavior is associated with continuing P3-to-P4 reductions of SO2 and NOx emissions. Thus, additional P3-to-P4 reductions of these emissions, especially NOx, appear to have made progress in altering the chemical regime of the wintertime eastern US atmosphere so that future emissions reductions and their resulting reductions in aerosol concentrations may no longer be accompanied by sub-linear changes (or actual increases) in CASTNET PM.

Elemental ratio measurements of organic compounds using aerosol mass spectrometry: characterization, improved calibration, and implications

M. R. Canagaratna, J. L. Jimenez, J. H. Kroll, Q. Chen, S. H. Kessler, P. Massoli1, L. Hildebrandt Ruiz, E. Fortner, L. R. Williams, K. R. Wilson, J. D. Surratt, N. M. Donahue, J. T. Jayne, and D. R. Worsnop

Source: *Atmos. Chem. Phys., 15, 253-272, 2015*

Elemental compositions of organic aerosol (OA) particles provide useful constraints on OA sources, chemical evolution, and effects. The Aerodyne high-resolution time-of-flight aerosol mass spectrometer (HR-ToF-AMS) is widely used to measure OA elemental composition. This study evaluates AMS measurements of atomic oxygen-to-carbon (O : C), hydrogen-to-carbon (H : C), and organic mass-to-organic carbon (OM : OC) ratios, and of carbon oxidation state (OS C) for a vastly expanded laboratory data set of multifunctional oxidized OA standards. For the expanded standard data set, the method introduced by Aiken et al. (2008), which uses experimentally measured ion intensities at all ions to determine elemental ratios (referred to here as "Aiken-Explicit"), reproduces known O : C and H : C ratio values within 20% (average absolute value of relative errors) and 12%, respectively. The more commonly used method, which uses empirically estimated H2O+ and CO+ ion intensities to avoid gas phase air interferences at these ions

(referred to here as "Aiken-Ambient"), reproduces O : C and H : C of multifunctional oxidized species within 28 and 14% of known values. The values from the latter method are systematically biased low, however, with larger biases observed for alcohols and simple diacids. A detailed examination of the H2O+, CO+, and CO2+ fragments in the high-resolution mass spectra of the standard compounds indicates that the Aiken-Ambient method underestimates the CO+ and especially H2O+ produced from many oxidized species. Combined AMS–vacuum ultraviolet (VUV) ionization measurements indicate that these ions are produced by dehydration and decarboxylation on the AMS vaporizer (usually operated at 600 °C). Thermal decomposition is observed to be efficient at vaporizer temperatures down to 200 °C. These results are used together to develop an "Improved-Ambient" elemental analysis method for AMS spectra measured in air. The Improved-Ambient method uses specific ion fragments as markers to correct for molecular functionality-dependent systematic biases and reproduces known O : C (H : C) ratios of individual oxidized standards within 28% (13%) of the known molecular values. The error in Improved-Ambient O : C (H : C) values is smaller for theoretical standard mixtures of the oxidized organic standards, which are more representative of the complex mix of species present in ambient OA. For ambient OA, the Improved-Ambient method produces O : C (H : C) values that are 27% (11%) larger than previously published Aiken-Ambient values; a corresponding increase of 9% is observed for OM : OC values. These results imply that ambient OA has a higher relative oxygen content than previously estimated. The OS C values calculated for ambient OA by the two methods agree well, however (average relative difference of 0.06 OS C units). This indicates that OS C is a more robust metric of oxidation than O : C, likely since OS C is not affected by hydration or dehydration, either in the atmosphere or during analysis.

Estimation of PM10 concentrations over Seoul using multiple empirical models with AERONET and MODIS data collected during the DRAGON-Asia campaign

S. Seo, J. Kim1, H. Lee, U. Jeong, W. Kim, B. N. Holben, S.-W. Kim, C. H. Song, and J. H. Lim

Source: *Atmos. Chem. Phys., 15, 319-334, 2015*

The performance of various empirical linear models to estimate the concentrations of surface-level particulate matter with a diameter less than 10 μm (PM10) was evaluated using Aerosol Robotic Network (AERONET) sun photometer and Moderate-Resolution Imaging Spectroradiometer (MODIS) data collected in Seoul during the Distributed Regional Aerosol Gridded Observation Network (DRAGON)-Asia campaign from March to May 2012. An observed relationship between the PM10 concentration and the aerosol optical depth (AOD) was accounted for by several parameters in the empirical models, including boundary layer height (BLH), relative humidity (RH), and effective radius of the aerosol size distribution (Reff), which was used here for the first time in empirical modeling. Among various empirical models, the model which incorporates both BLH and Reff showed the highest correlation, which indicates the strong influence of BLH and Reff on the PM10 estimations. Meanwhile, the effect of RH on the relationship between AOD and PM10 appeared to be negligible during the campaign period (spring), when RH is generally low in northeast Asia. A large spatial dependency of the empirical model performance was found by categorizing the locations of the collected data into three different site types, which varied in terms of the distances between instruments and source locations. When both AERONET and MODIS data sets were used in the PM10 estimation, the highest correlations between measured and estimated values (R = 0.76 and 0.76 using AERONET and MODIS data, respectively) were found for the residential area (RA) site type, while the poorest correlations (R = 0.61 and 0.68 using AERONET and MODIS data, respectively) were found for the near-source (NS) site type. Significant seasonal variations of empirical model performances for PM10 estimation were found using the data collected at Yonsei University (one of the DRAGON campaign sites) over a period of 17 months including the DRAGON campaign period. The best correlation between measured and estimated

PM10 concentrations (R = 0.81) was found in winter, due to the presence of a stagnant air mass and low BLH conditions, which may have resulted in relatively homogeneous aerosol properties within the BLH. On the other hand, the poorest correlation between measured and estimated PM10 concentrations (R = 0.54) was found in spring, due to the influence of the long-range transport of dust to both within and above the BLH.

Development towards a global operational aerosol consensus: basic climatological characteristics of the International Cooperative for Aerosol Prediction Multi-Model Ensemble (ICAP-MME)

W. R. Sessions, J. S. Reid, A. Benedetti, P. R. Colarco, A. da Silva, S. Lu, T. Sekiyama, T. Y. Tanaka, J. M. Baldasano, S. Basart, M. E. Brooks, T. F. Eck, M. Iredell, J. A. Hansen, O. C. Jorba, H.-M. H. Juang, P. Lynch, J.-J. Morcrette, S. Moorthi, J. Mulcahy, Y. Pradhan, M. Razinger, C. B. Sampson, J. Wang, and D. L. Westphal

Source: *Atmos. Chem. Phys., 15, 335-362, 2015*

Here we present the first steps in developing a global multi-model aerosol forecasting ensemble intended for eventual operational and basic research use. Drawing from members of the International Cooperative for Aerosol Prediction (ICAP) latest generation of quasi-operational aerosol models, 5-day aerosol optical thickness (AOT) forecasts are analyzed for December 2011 through November 2012 from four institutions: European Centre for Medium-Range Weather Forecasts (ECMWF), Japan Meteorological Agency (JMA), NASA Goddard Space Flight Center (GSFC), and Naval Research Lab/Fleet Numerical Meteorology and Oceanography Center (NRL/FNMOC). For dust, we also include the National Oceanic and Atmospheric Administration-National Geospatial Advisory Committee (NOAA NGAC) product in our analysis. The Barcelona Supercomputing Centre and UK Met Office dust products have also recently become members of ICAP, but have insufficient data to be included in this analysis period. A simple consensus ensemble of member and mean AOT fields for modal species (e.g., fine and coarse mode, and a separate dust ensemble) is used to create the ICAP Multi-Model Ensemble (ICAP-MME). The ICAP-MME is run daily at 00:00 UTC for 6-hourly forecasts out to 120 h. Basing metrics on comparisons to 21 regionally representative Aerosol Robotic Network (AERONET) sites, all models generally captured the basic aerosol features of the globe. However, there is an overall AOT low bias among models, particularly for high AOT events. Biomass burning regions have the most diversity in seasonal average AOT. The Southern Ocean, though low in AOT, nevertheless also has high diversity. With regard to root mean square error (RMSE), as expected the ICAP-MME placed first over all models worldwide, and was typically first or second in ranking against all models at individual sites. These results are encouraging; furthermore, as more global operational aerosol models come online, we expect their inclusion in a robust operational multi-model ensemble will provide valuable aerosol forecasting guidance.

Multiday production of condensing organic aerosol mass in urban and forest outflow

J. Lee-Taylor, A. Hodzic, S. Madronich, B. Aumont, M. Camredon, and R. Valorso

Source: *Atmos. Chem. Phys., 15, 595-615, 2015*

Secondary organic aerosol (SOA) production in air masses containing either anthropogenic or biogenic (terpene-dominated) emissions is investigated using the explicit gas-phase chemical mechanism generator GECKO-A. Simulations show several-fold increases in SOA mass continuing for multiple days in the urban

outflow, even as the initial air parcel is diluted into the regional atmosphere. The SOA mass increase in the forest outflow is more modest (~50%) and of shorter duration (1–2 days). The multiday production in the urban outflow stems from continuing oxidation of gas-phase precursors which persist in equilibrium with the particle phase, and can be attributed to multigenerational reaction products of both aromatics and alkanes, especially those with relatively low carbon numbers (C4–15). In particular we find large contributions from substituted maleic anhydrides and multi-substituted peroxide-bicyclic alkenes. The results show that the predicted production is a robust feature of our model even under changing atmospheric conditions and different vapor pressure schemes, and contradict the notion that SOA undergoes little mass production beyond a short initial formation period. The results imply that anthropogenic aerosol precursors could influence the chemical and radiative characteristics of the atmosphere over an extremely wide region, and that SOA measurements near precursor sources may routinely underestimate this influence.

The global impact of the transport sectors on atmospheric aerosol in 2030 – Part 1: Land transport and shipping

M. Righi, J. Hendricks, and R. Sausen

Source: *Atmos. Chem. Phys., 15, 633-651, 2015*

Using the EMAC (ECHAM/MESSy Atmospheric Chemistry) global climate-chemistry model coupled to the aerosol module MADE (Modal Aerosol Dynamics model for Europe, adapted for global applications), we simulate the impact of land transport and shipping emissions on global atmospheric aerosol and climate in 2030. Future emissions of short-lived gas and aerosol species follow the four Representative Concentration Pathways (RCPs) designed in support of the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. We compare the resulting 2030 land-transport- and shipping-induced aerosol concentrations to the ones obtained for the year 2000 in a previous study with the same model configuration. The simulations suggest that black carbon and aerosol nitrate are the most relevant pollutants from land transport in 2000 and 2030 and their impacts are characterized by very strong regional variations during this time period. Europe and North America experience a decrease in the land-transport-induced particle pollution, although in these regions this sector remains a major source of surface-level pollution in 2030 under all RCPs. In Southeast Asia, however, a significant increase is simulated, but in this region the surface-level pollution is still controlled by other sources than land transport. Shipping-induced air pollution is mostly due to aerosol sulfate and nitrate, which show opposite trends towards 2030. Sulfate is strongly reduced as a consequence of sulfur reduction policies in ship fuels in force since 2010, while nitrate tends to increase due to the excess of ammonia following the reduction in ammonium sulfate. The aerosol-induced climate impact of both sectors is dominated by aerosol-cloud effects and is projected to decrease between 2000 and 2030, nevertheless still contributing a significant radiative forcing to Earth's radiation budget.

Top-down estimates of European CH4 and N2O emissions based on four different inverse models

P. Bergamaschi, M. Corazza, U. Karstens, M. Athanassiadou, R. L. Thompson, I. Pison, A. J. Manning, P. Bousquet, A. Segers, A. T. Vermeulen, G. Janssens-Maenhout, M. Schmidt, M. Ramonet, F. Meinhardt, T. Aalto, L. Haszpra, J. Moncrieff, M. E. Popa, D. Lowry, M. Steinbacher, A. Jordan, S. O'Doherty, S. Piacentino, and E. Dlugokencky

Source: *Atmos. Chem. Phys., 15, 715-736, 2015*

European CH4 and N2O emissions are estimated for 2006 and 2007 using four inverse modelling systems, based on different global and regional Eulerian and Lagrangian transport models. This ensemble approach is designed to provide more realistic estimates of the overall uncertainties in the derived emissions, which is particularly important for verifying bottom-up emission inventories.

We use continuous observations from 10 European stations (including 5 tall towers) for CH4 and 9 continuous stations for N2O, complemented by additional European and global discrete air sampling sites. The available observations mainly constrain CH4 and N2O emissions from north-western and eastern Europe. The inversions are strongly driven by the observations and the derived total emissions of larger countries show little dependence on the emission inventories used a priori.

Three inverse models yield 26–56% higher total CH4 emissions from north-western and eastern Europe compared to bottom-up emissions reported to the UNFCCC, while one model is close to the UNFCCC values. In contrast, the inverse modelling estimates of European N2O emissions are in general close to the UNFCCC values, with the overall range from all models being much smaller than the UNFCCC uncertainty range for most countries. Our analysis suggests that the reported uncertainties for CH4 emissions might be underestimated, while those for N2O emissions are likely overestimated.

Investigating types and sources of organic aerosol in Rocky Mountain National Park using aerosol mass spectrometry

M. I. Schurman, T. Lee, Y. Sun, B. A. Schichtel, S. M. Kreidenweis, and J. L. Collett Jr

Source: *Atmos. Chem. Phys., 15, 737-752, 2015*

The environmental impacts of atmospheric particles are highlighted in remote areas where visibility and ecosystem health can be degraded by even relatively low particle concentrations. Submicron particle size, composition, and source apportionment were explored at Rocky Mountain National Park using a High-Resolution Time-of-Flight Aerosol Mass Spectrometer. This summer campaign found low average, but variable, particulate mass (PM) concentrations (max = 93.1 μg m−3, avg. = 5.13 ± 2.72 μg m−3) of which 75.2 ± 11.1% is organic. Low-volatility oxidized organic aerosol (LV-OOA, 39.3% of PM1 on average) identified using Positive Matrix Factorization appears to be mixed with ammonium sulfate (3.9% and 16.6% of mass, respectively), while semi-volatile OOA (27.6%) is correlated with ammonium nitrate (nitrate: 4.3%); concentrations of these mixtures are enhanced with upslope (SE) surface winds from the densely populated Front Range area, indicating the importance of transport. A local biomass burning organic aerosol (BBOA, 8.4%) source is suggested by mass spectral cellulose combustion markers (m/z 60 and 73) limited to brief, high-concentration, polydisperse events (suggesting fresh combustion), a diurnal maximum at 22:00 local standard time when campfires were set at adjacent summer camps, and association with surface winds consistent with local campfire locations. The particle characteristics determined here represent typical summertime conditions at the Rocky Mountain site based on comparison to ~10 years of meteorological, particle composition, and fire data.

Ozone production and transport over the Amazon Basin during the dry-to-wet and wet-to-dry transition seasons

M. M. Bela, K. M. Longo, S. R. Freitas, D. S. Moreira, V. Beck, S. C. Wofsy, C. Gerbig, K. Wiedemann, M. O. Andreae, and P. Artaxo

Source: *Atmos. Chem. Phys., 15, 757-782, 2015*

The Regional Carbon Balance in Amazonia (BARCA) campaign provided the first Amazon Basin-wide aircraft measurements of ozone (O3) during both the dry-to-wet (November and December 2008) and wet-to-dry (May 2009) transition seasons. Extremely low background values (< 20 ppb) were observed to the west and north of Manaus in both seasons and in all regions during the wet-to-dry transition. On the other hand, elevated O3 levels (40–60 ppb) were seen during the dry-to-wet transition to the east and south of Manaus, where biomass burning emissions of O3 precursors were present. Chemistry simulations with the CCATT-BRAMS and WRF-Chem models are within the error bars of the observed O3 profiles in the boundary layer (0–3 km a.s.l.) in polluted conditions. However, the models overestimate O3 in the boundary layer in clean conditions, despite lacking the predominant NO source from soil. In addition, O3 simulated by the models was either within the error bars or lower than BARCA observations in mid-levels (3–5 km a.s.l.), and lower than total tropospheric O3 retrieved from the OMI/MLS instruments, which is primarily comprised of middle troposphere O3 and thus reflects long-range transport processes. Therefore, the models do a relatively poor job of representing the free troposphere-boundary layer gradient in O3 compared with aircraft and satellite observations, which could be due to missing long-range and convective transport of O3 at mid-levels. Additional simulations with WRF-Chem showed that the model O3 production is very sensitive to both the O3 deposition velocities and the NOx emissions, which were both about one-half of observed values. These results indicate the necessity of more realistic model representations of emissions, deposition, and convective processes for accurate monitoring and prediction of increases in O3 production in the Amazon Basin as the regional population grows.

Model calculations of the effects of present and future emissions of air pollutants from shipping in the Baltic Sea and the North Sea

J. E. Jonson, J. P. Jalkanen, L. Johansson, M. Gauss, and H. A. C. Denier van der Gon

Source: *Atmos. Chem. Phys., 15, 783-798, 2015*

Land-based emissions of air pollutants in Europe have steadily decreased over the past two decades, and this decrease is expected to continue. Within the same time span emissions from shipping have increased in EU ports and in the Baltic Sea and the North Sea, defined as SECAs (sulfur emission control areas), although recently sulfur emissions, and subsequently particle emissions, have decreased. The maximum allowed sulfur content in marine fuels in EU ports is now 0.1%, as required by the European Union sulfur directive. In the SECAs the maximum fuel content of sulfur is currently 1% (the global average is about 2.4%). This will be reduced to 0.1% from 2015, following the new International Maritime Organization (IMO) rules.

In order to assess the effects of ship emissions in and around the Baltic Sea and the North Sea, regional model calculations with the EMEP air pollution model have been made on a 1/4° longitude × 1/8° latitude resolution, using ship emissions in the Baltic Sea and the North Sea that are based on accurate ship positioning data. The effects on depositions and air pollution and the resulting number of years of life lost (YOLLs) have been calculated by comparing model calculations with and without ship emissions in the two sea areas. In 2010 stricter regulations for sulfur emissions were implemented in the two sea areas, reducing the maximum sulfur content allowed in marine fuels from 1.5 to 1%. In addition ships were required to use

fuels with 0.1 % sulfur in EU harbours. The calculations have been made with emissions representative of 2009 and 2011, i.e. before and after the implementation of the stricter controls on sulfur emissions from 2010. The calculations with present emissions show that per person, an additional 0.1–0.2 years of life lost is estimated in areas close to the major ship tracks with current emission levels. Comparisons of model calculations with emissions before and after the implementation of stricter emission control on sulfur show a general decrease in calculated particle concentration. At the same time, however, an increase in ship activity has resulted in higher emissions of other components, and subsequently air concentrations, in particular of NOx, especially in and around several major ports.
Additional model calculations have been made with land-based and ship emissions representative of year 2030. Following a decrease in emissions from all sectors, air quality is expected to improve, and depositions to be reduced. Particles from shipping are expected to decrease as a result of emission controls in the SECAs. Further controls of NOx emissions from shipping are not decided, and calculations are presented with and without such controls.

Characterization of biomass burning emissions from cooking fires, peat, crop residue, and other fuels with high-resolution proton-transfer-reaction time-of-flight mass spectrometry

C. E. Stockwell, P. R. Veres, J. Williams, and R. J. Yokelson

Source: *Atmos. Chem. Phys., 15, 845-865, 2015*

We deployed a high-resolution proton-transfer-reaction time-of-flight mass spectrometer (PTR-TOF-MS) to measure biomass-burning emissions from peat, crop residue, cooking fires, and many other fire types during the fourth Fire Lab at Missoula Experiment (FLAME-4) laboratory campaign. A combination of gas standard calibrations and composition sensitive, mass-dependent calibration curves was applied to quantify gas-phase non-methane organic compounds (NMOCs) observed in the complex mixture of fire emissions. We used several approaches to assign the best identities to most major "exact masses", including many high molecular mass species. Using these methods, approximately 80–96% of the total NMOC mass detected by the PTR-TOF-MS and Fourier transform infrared (FTIR) spectroscopy was positively or tentatively identified for major fuel types. We report data for many rarely measured or previously unmeasured emissions in several compound classes including aromatic hydrocarbons, phenolic compounds, and furans; many of these are suspected secondary organic aerosol precursors. A large set of new emission factors (EFs) for a range of globally significant biomass fuels is presented. Measurements show that oxygenated NMOCs accounted for the largest fraction of emissions of all compound classes. In a brief study of various traditional and advanced cooking methods, the EFs for these emissions groups were greatest for open three-stone cooking in comparison to their more advanced counterparts. Several little-studied nitrogen-containing organic compounds were detected from many fuel types, that together accounted for 0.1–8.7% of the fuel nitrogen, and some may play a role in new particle formation.

Influence of local air pollution on the deposition of peroxyacetyl nitrate to a nutrient-poor natural grassland ecosystem

A.Moravek, P. Stella1, T. Foken, and I. Trebs

Source: *Atmos. Chem. Phys., 15, 899-911, 2015*

Dry deposition of peroxyacetyl nitrate (PAN) is known to have a phytotoxic impact on plants under photochemical smog conditions, but it may also lead to higher productivity and threaten species richness of vulnerable ecosystems in remote regions. However, underlying mechanisms or controlling factors for PAN deposition are not well understood and studies on dry deposition of PAN are limited. In this study, we investigate the impact of PAN deposition on a nutrient-poor natural grassland ecosystem situated at the edge of an urban and industrialized region in Germany. PAN mixing ratios were measured within a 3.5 months summer to early autumn period. In addition, PAN fluxes were determined with the modified Bowen ratio technique for a selected period. The evaluation of both stomatal and non-stomatal deposition pathways was used to model PAN deposition over the entire summer–autumn period. We found that air masses at the site were influenced by two contrasting pollution regimes, which led to median diurnal PAN mixing ratios ranging between 50 and 300 ppt during unpolluted and between 200 and 600 ppt during polluted episodes. The measured PAN fluxes showed a clear diurnal cycle with maximal deposition fluxes of ~−0.1 nmol m−2 s−1 (corresponding to a deposition velocity of 0.3 cm s−1) during daytime and a significant non-stomatal contribution was found. The ratio of PAN to ozone deposition velocities was found to be ~0.1, which is much larger than assumed by current deposition models. The modelled PAN flux over the entire period revealed that PAN deposition over an entire day was 333 μg m−2 d−1 under unpolluted and 518 μg m−2 d−1 under polluted episodes. Additionally, thermochemical decomposition PAN deposition accounted for 32% under unpolluted episodes and 22% under polluted episodes of the total atmospheric PAN loss. However, the impact of PAN deposition as a nitrogen source to the nutrient-poor grassland was estimated to be only minor, under both unpolluted and polluted episodes.

Influence of aerosol chemical composition on N2O5 uptake: airborne regional measurements in northwestern Europe

W. T. Morgan, B. Ouyan, J. D. Allan, E. Aruffo, P. Di Carlo, O. J. Kennedy, D. Lowe, M. J. Flynn, P. D. Rosenberg, P. I. Williams, R. Jones, G. B. McFiggans, and H. Coe

Source: *Atmos. Chem. Phys., 15, 973-990, 2015*

Aerosol chemical composition was found to influence nighttime atmospheric chemistry during a series of airborne measurements in northwestern Europe in summer conditions, which has implications for regional air quality and climate. The uptake of dinitrogen pentoxide, γ (N2O5), to particle surfaces was found to be modulated by the amount of water content and ammonium nitrate present in the aerosol. The conditions prevalent in this study suggest that the net uptake rate of N2O5 to atmospheric aerosols was relatively efficient compared to previous studies, with γ (N2O5) values in the range 0.01–0.03. This is likely a consequence of the elevated relative humidity in the region, which promotes greater aerosol water content. Increased nitrate concentrations relative to particulate water were found to suppress N2O5 uptake. The results presented here contrast with previous ambient studies of N2O5 uptake, which have generally taken place in low-nitrate environments in the USA. Comparison of the N2O5 uptake derived from the measurements with a parameterised scheme that is based on the ratio of particulate water to nitrate yielded reasonably good agreement in terms of the magnitude and variation in uptake, provided the effect of chloride was neglected. An additional suppression of the parameterised uptake is likely required to fully capture the

variation in N2O5 uptake, which could be achieved via the known suppression by organic aerosol. However, existing parameterisations representing the suppression by organic aerosol were unable to fully represent the variation in N2O5 uptake. These results provide important ambient measurement constraint on our ability to predict N2O5 uptake in regional and global aerosol models. N2O5 uptake is a potentially important source of nitrate aerosol and a sink of the nitrate radical, which is the main nocturnal oxidant in the atmosphere. The results further highlight the importance of ammonium nitrate in northwestern Europe as a key component of atmospheric composition in the region.

Carbonaceous aerosols recorded in a southeastern Tibetan glacier: analysis of temporal variations and model estimates of sources and radiative forcing

M. Wang, B. Xu, J. Cao, X. Tie, H. Wang, R. Zhang, Y. Qian, P. J. Rasch, S. Zhao, G. Wu1, H. Zhao, D. R. Joswiak, J. Li, and Y. Xie

Source: *Atmos. Chem. Phys., 15, 1191-1204, 2015*

High temporal resolution measurements of black carbon (BC) and organic carbon (OC) covering the time period of 1956–2006 in an ice core over the southeastern Tibetan Plateau show a distinct seasonal dependence of BC and OC with higher respective concentrations but a lower OC / BC ratio in the non-monsoon season than during the summer monsoon. We use a global aerosol-climate model, in which BC emitted from different source regions can be explicitly tracked, to quantify BC source–receptor relationships between four Asian source regions and the southeastern Tibetan Plateau as a receptor. The model results show that South Asia has the largest contribution to the present-day (1996–2005) mean BC deposition at the ice-core drilling site during the non-monsoon season (October to May) (81%) and all year round (74%), followed by East Asia (14% to the non-monsoon mean and 21% to the annual mean). The ice-core record also indicates stable and relatively low BC and OC deposition fluxes from the late 1950s to 1980, followed by an overall increase to recent years. This trend is consistent with the BC and OC emission inventories and the fuel consumption of South Asia (as the primary contributor to annual mean BC deposition). Moreover, the increasing trend of the OC / BC ratio since the early 1990s indicates a growing contribution of coal combustion and/or biomass burning to the emissions. The estimated radiative forcing induced by BC and OC impurities in snow has increased since 1980, suggesting an increasing potential influence of carbonaceous aerosols on the Tibetan glacier melting and the availability of water resources in the surrounding regions. Our study indicates that more attention to OC is merited because of its non-negligible light absorption and the recent rapid increases evident in the ice-core record.

Fossil vs. non-fossil sources of fine carbonaceous aerosols in four Chinese cities during the extreme winter haze episode of 2013

Y.-L. Zhang, R.-J.Huang, I. El Haddad, K.-F. Ho, J.-J. Cao, Y. Han, P. Zotter, C. Bozzetti, K. R. Daellenbach, F. Canonaco, J. G. Slowik, G. Salazar, M. Schwikowski, J. Schnelle-Kreis, G. Abbaszade, R. Zimmermann, U. Baltensperger, A. S. H. Prévôt, and S. Szidat

Source: *Atmos. Chem. Phys., 15, 1299-1312, 2015*

During winter 2013, extremely high concentrations (i.e., 4–20 times higher than the World Health Organization guideline) of PM2.5 (particulate matter with an aerodynamic diameter < 2.5 μm) mass concentrations (24 h samples) were found in four major cities in China including Xi'an, Beijing, Shanghai and Guangzhou. Statistical analysis of a combined data set from elemental carbon (EC), organic carbon

(OC), 14C and biomass-burning marker measurements using Latin hypercube sampling allowed a quantitative source apportionment of carbonaceous aerosols. Based on 14C measurements of EC fractions (six samples each city), we found that fossil emissions from coal combustion and vehicle exhaust dominated EC with a mean contribution of 75 ± 8% across all sites. The remaining 25 ± 8% was exclusively attributed to biomass combustion, consistent with the measurements of biomass-burning markers such as anhydrosugars (levoglucosan and mannosan) and water-soluble potassium (K+). With a combination of the levoglucosan-to-mannosan and levoglucosan-to-K+ ratios, the major source of biomass burning in winter in China is suggested to be combustion of crop residues. The contribution of fossil sources to OC was highest in Beijing (58 ± 5%) and decreased from Shanghai (49 ± 2%) to Xi'an (38 ± 3%) and Guangzhou (35 ± 7%). Generally, a larger fraction of fossil OC was from secondary origins than primary sources for all sites. Non-fossil sources accounted on average for 55 ± 10 and 48 ± 9% of OC and total carbon (TC), respectively, which suggests that non-fossil emissions were very important contributors of urban carbonaceous aerosols in China. The primary biomass-burning emissions accounted for 40 ± 8, 48 ± 18, 53 ± 4 and 65 ± 26% of non-fossil OC for Xi'an, Beijing, Shanghai and Guangzhou, respectively. Other non-fossil sources excluding primary biomass burning were mainly attributed to formation of secondary organic carbon (SOC) from non-fossil precursors such as biomass-burning emissions. For each site, we also compared samples from moderately to heavily polluted days according to particulate matter mass. Despite a significant increase of the absolute mass concentrations of primary emissions from both fossil and non-fossil sources during the heavily polluted events, their relative contribution to TC was even decreased, whereas the portion of SOC was consistently increased at all sites. This observation indicates that SOC was an important fraction in the increment of carbonaceous aerosols during the haze episode in China.

Carbonaceous aerosols on the south edge of the Tibetan Plateau: concentrations, seasonality and sources

Z. Cong, S. Kang, K. Kawamura, B. Liu, X. Wan, Z. Wang, S. Gao, and P. Fu

Source:*Atmos. Chem. Phys., 15, 1573-1584, 2015*

To quantitatively evaluate the effect of carbonaceous aerosols on the south edge of the Tibetan Plateau, aerosol samples were collected weekly from August 2009 to July 2010 at Qomolangma (Mt. Everest) Station for Atmospheric and Environmental Observation and Research (QOMS, 28.36° N, 86.95° E, 4276 m a.s.l.). The average concentrations of organic carbon (OC), elemental carbon (EC) and water-soluble organic carbon were 1.43, 0.25 and 0.77 μg m−3, respectively. The concentration levels of OC and EC at QOMS are comparable to those at high-elevation sites on the southern slopes of the Himalayas (Langtang and Nepal Climate Observatory at Pyramid, or NCO-P), but 3 to 6 times lower than those at Manora Peak, India, and Godavari, Nepal. Sulfate was the most abundant anion species followed by nitrate, accounting for 25 and 12% of total ionic mass, respectively. Ca2+ was the most abundant cation species (annual average of 0.88 μg m−3). The dust loading, represented by Ca2+ concentration, was relatively constant throughout the year. OC, EC and other ionic species (NH4+, K+, NO3− and SO42−) exhibited a pronounced peak in the pre-monsoon period and a minimum in the monsoon season, being similar to the seasonal trends of aerosol composition reported previously from the southern slope of the Himalayas, such as Langtang and NCO-P. The strong correlation of OC and EC in QOMS aerosols with K+ and levoglucosan indicates that they mainly originated from biomass burning. The fire spots observed by MODIS and backward air-mass trajectories further demonstrate that in pre-monsoon season, agricultural and forest fires in northern India and Nepal were most likely sources of carbonaceous aerosol at QOMS. Moreover, the CALIOP observations confirmed that air-pollution plumes crossed the Himalayas during this period. The highly coherent variation of daily aerosol optical depth (500 nm) between QOMS and NCO-P indicates that both slopes of the Himalayas share a common atmospheric environment regime. In addition to large-scale atmospheric circulation, the unique mountain/valley breeze system can also have an important effect on air-pollutant transport.

Source sector and region contributions to BC and PM2.5 in Central Asia

S. Kulkarni, N. Sobhani, J. P. Miller-Schulze, M. M. Shafer, J. J. Schauer, P. A. Solomon, P. E. Saide, S. N. Spak, Y. F. Cheng, H. A. C. Denier van der Gon, Z. Lu, D. G. Streets, G. Janssens-Maenhout, C. Wiedinmyer, J. Lantz, M. Artamonova, B. Chen, S. Imashev, L. Sverdlik, J. T. Deminter, B. Adhikary, A. D'Allura, C. Wei1, and G. R. Carmichael

Source: *Atmos. Chem. Phys., 15, 1683-1705, 2015*

Particulate matter (PM) mass concentrations, seasonal cycles, source sector, and source region contributions in Central Asia (CA) are analyzed for the period April 2008–July 2009 using the Sulfur Transport and dEposition Model (STEM) chemical transport model and modeled meteorology from the Weather Research and Forecasting (WRF) model. Predicted aerosol optical depth (AOD) values (annual mean value ~0.2) in CA vary seasonally, with lowest values in the winter. Surface PM2.5 concentrations (annual mean value ~10 μg m−3) also exhibit a seasonal cycle, with peak values and largest variability in the spring/summer, and lowest values and variability in the winter (hourly values from 2 to 90 μg m−3). Surface concentrations of black carbon (BC) (mean value ~0.1 μg m−3) show peak values in the winter. The simulated values are compared to surface measurements of AOD as well as PM2.5, PM10, BC, and organic carbon (OC) mass concentrations at two regional sites in Kyrgyzstan (Lidar Station Teplokluchenka (LST) and Bishkek). The predicted values of AOD and PM mass concentrations and their seasonal cycles are fairly well captured. The carbonaceous aerosols are underpredicted in winter, and analysis suggests that the winter heating emissions are underestimated in the current inventory.

Dust, from sources within and outside CA, is a significant component of the PM mass and drives the seasonal cycles of PM and AOD. On an annual basis, the power and industrial sectors are found to be the most important contributors to the anthropogenic portion of PM2.5. Residential combustion and transportation are shown to be the most important sectors for BC. Biomass burning within and outside the region also contributes to elevated PM and BC concentrations. The analysis of the transport pathways and the variations in particulate matter mass and composition in CA demonstrates that this region is strategically located to characterize regional and intercontinental transport of pollutants. Aerosols at these sites are shown to reflect dust, biomass burning, and anthropogenic sources from Europe; South, East, and Central Asia; and Russia depending on the time period.

Simulations for a reference 2030 emission scenario based on pollution abatement measures already committed to in current legislation show that PM2.5 and BC concentrations in the region increase, with BC growing more than PM2.5 on a relative basis. This suggests that both the health impacts and the climate warming associated with these particles may increase over the next decades unless additional control measures are taken. The importance of observations in CA to help characterize the changes that are rapidly taking place in the region are discussed.

An attempt at estimating Paris area CO2 emissions from atmospheric concentration measurements

F. M. Bréon, G. Broquet, V. Puygrenier, F. Chevallier, I. Xueref-Remy, M. Ramonet, E. Dieudonné, M. Lopez, M. Schmidt, O. Perrussel, and P. Ciais

Source: *Atmos. Chem. Phys., 15, 1707-1724, 2015*

Atmospheric concentration measurements are used to adjust the daily to monthly budget of fossil fuel CO2 emissions of the Paris urban area from the prior estimates established by the Airparif local air quality agency. Five atmospheric monitoring sites are available, including one at the top of the Eiffel Tower. The

atmospheric inversion is based on a Bayesian approach, and relies on an atmospheric transport model with a spatial resolution of 2 km with boundary conditions from a global coarse grid transport model. The inversion adjusts prior knowledge about the anthropogenic and biogenic CO2 fluxes from the Airparif inventory and an ecosystem model, respectively, with corrections at a temporal resolution of 6 h, while keeping the spatial distribution from the emission inventory. These corrections are based on assumptions regarding the temporal autocorrelation of prior emissions uncertainties within the daily cycle, and from day to day.

The comparison of the measurements against the atmospheric transport simulation driven by the a priori CO2 surface fluxes shows significant differences upwind of the Paris urban area, which suggests a large and uncertain contribution from distant sources and sinks to the CO2 concentration variability. This contribution advocates that the inversion should aim at minimising model–data misfits in upwind–downwind gradients rather than misfits in mole fractions at individual sites. Another conclusion of the direct model–measurement comparison is that the CO2 variability at the top of the Eiffel Tower is large and poorly represented by the model for most wind speeds and directions. The model's inability to reproduce the CO2 variability at the heart of the city makes such measurements ill-suited for the inversion. This and the need to constrain the budgets for the whole city suggests the assimilation of upwind–downwind mole fraction gradients between sites at the edge of the urban area only.

The inversion significantly improves the agreement between measured and modelled concentration gradients. Realistic emissions are retrieved for two 30-day periods and suggest a significant overestimate by the AirParif inventory. Similar inversions over longer periods are necessary for a proper evaluation of the optimised CO2 emissions against independent data.

The role of aerosol in altering North Atlantic atmospheric circulation in winter and its impact on air quality

F. S. R. Pausata, M. Gaetani1, G. Messori, S. Kloster, and F. J. Dentener

Source: *Atmos. Chem. Phys., 15, 1725-1743, 2015*

Numerical model scenarios of future climate depict a global increase in temperatures and changing precipitation patterns, primarily driven by increasing greenhouse gas (GHG) concentrations. Aerosol particles also play an important role by altering the Earth's radiation budget and consequently surface temperature. Here, we use the general circulation aerosol model ECHAM5-HAM, coupled to a mixed layer ocean model, to investigate the impacts of future air pollution mitigation strategies in Europe on winter atmospheric circulation over the North Atlantic. We analyse the extreme case of a maximum feasible end-of-pipe reduction of aerosols in the near future (2030), in combination with increasing GHG concentrations. Our results show a more positive North Atlantic Oscillation (NAO) mean state by 2030, together with a significant eastward shift of the southern centre of action of sea-level pressure (SLP). Moreover, we show a significantly increased blocking frequency over the western Mediterranean.

By separating the impacts of aerosols and GHGs, our study suggests that future aerosol abatement may be the primary driver of both the eastward shift in the southern SLP centre of action and the increased blocking frequency over the western Mediterranean. These concomitant modifications of the atmospheric circulation over the Euro-Atlantic sector lead to more stagnant weather conditions that favour air pollutant accumulation, especially in the western Mediterranean sector. Changes in atmospheric circulation should therefore be included in future air pollution mitigation assessments. The indicator-based evaluation of atmospheric circulation changes presented in this work will allow an objective first-order assessment of the role of changes in wintertime circulation on future air quality in other climate model simulations.

Mixing state of carbonaceous aerosol in an urban environment: single particle characterization using the soot particle aerosol mass spectrometer (SP-AMS)

A. K. Y. Lee, M. D. Willis, R. M. Healy, T. B. Onasch, and J. P. D. Abbatt
B.

Source: *Atmos. Chem. Phys., 15, 1823-1841, 2015*

Understanding the impact of atmospheric black carbon (BC)-containing particles on human health and radiative forcing requires knowledge of the mixing state of BC, including the characteristics of the materials with which it is internally mixed. In this study, we examine the mixing state of refractory BC (rBC) and other aerosol components in an urban environment (downtown Toronto) utilizing the Aerodyne soot particle aerosol mass spectrometer equipped with a light scattering module (LS-SP-AMS). k-means cluster analysis was used to classify single particle mass spectra into chemically distinct groups. One resultant particle class is dominated by rBC mass spectral signals (C1+ to C5+) while the organic signals fall into a few major particle classes identified as hydrocarbon-like organic aerosol (HOA), oxygenated organic aerosol (OOA), and cooking emission organic aerosol (COA). A gradual mixing is observed with small rBC particles only thinly coated by HOA (~ 28% by mass on average), while over 90% of the HOA-rich particles did not contain detectable amounts of rBC. Most of the particles classified into other inorganic and organic particle classes were not significantly associated with rBC. The single particle results also suggest that HOA and COA emitted from anthropogenic sources were likely major contributors to organic-rich particles with vacuum aerodynamic diameter (dva) ranging from ~ 200 to 400 nm. The similar temporal profiles and mass spectral features of the organic classes identified by cluster analysis and the factors from a positive matrix factorization (PMF) analysis of the ensemble aerosol data set validate the interpretation of the PMF results.

Aerosol size distribution and radiative forcing response to anthropogenically driven historical changes in biogenic secondary organic aerosol formation

S. D. D'Andrea, J. C. Acosta Navarro, S. C. Farina, C. E. Scott, A. Rap, D. K. Farmer, D. V. Spracklen, I. Riipinen, and J. R. Pierce

Source: *Atmos. Chem. Phys., 15, 2247-2268, 2015*

Emissions of biogenic volatile organic compounds (BVOCs) have changed in the past millennium due to changes in land use, temperature, and CO2 concentrations. Recent reconstructions of BVOC emissions have predicted that global isoprene emissions have decreased, while monoterpene and sesquiterpene emissions have increased; however, all three show regional variability due to competition between the various influencing factors.

In this work, we use two modeled estimates of BVOC emissions from the years 1000 to 2000 to test the effect of anthropogenic changes to BVOC emissions on secondary organic aerosol (SOA) formation, global aerosol size distributions, and radiative effects using the GEOS-Chem-TOMAS (Goddard Earth Observing System; TwO-Moment Aerosol Sectional) global aerosol microphysics model. With anthropogenic emissions (e.g., SO2, NOx, primary aerosols) turned off and BVOC emissions changed from year 1000 to year 2000 values, decreases in the number concentration of particles of size Dp > 80 nm (N80) of > 25% in year 2000 relative to year 1000 were predicted in regions with extensive land-use changes since year 1000 which led to regional increases in the combined aerosol radiative effect (direct and indirect) of > 0.5 W m−2 in these regions. We test the sensitivity of our results to BVOC emissions inventory, SOA yields, and the presence of anthropogenic emissions; however, the qualitative response of the model to historic BVOC changes remains the same in all cases. Accounting for these uncertainties, we estimate millennial changes in BVOC emissions cause a global mean direct effect of between +0.022 and +0.163 W m−2 and the global

mean cloud-albedo aerosol indirect effect of between −0.008 and −0.056 W m−2. This change in aerosols, and the associated radiative forcing, could be a largely overlooked and important anthropogenic aerosol effect on regional climates.

Aerosol properties over the western Mediterranean basin: temporal and spatial variability

H. Lyamani1, A. Valenzuela, D. Perez-Ramirez, C. Toledano, M. J. Granados-Muñoz, F. J. Olmo, and L. Alados-Arboledas

Source: *Atmos. Chem. Phys., 15, 2473-2486, 2015*

This study focuses on the analysis of Aerosol Robotic Network (AERONET) aerosol data obtained over Alborán Island (35.90° N, 3.03° W, 15 m a.s.l.) in the western Mediterranean from July 2011 to January 2012. Additional aerosol data from the three nearest AERONET stations (Málaga, Oujda and Palma de Mallorca) and the Maritime Aerosol Network (MAN) were also analyzed in order to investigate the temporal and spatial variations of aerosol over this scarcely explored region. High aerosol loads over Alborán were mainly associated with desert dust transport from North Africa and occasional advection of anthropogenic fine particles from central European urban-industrial areas. The fine particle load observed over Alborán was surprisingly similar to that obtained over the other three nearest AERONET stations, suggesting homogeneous spatial distribution of fine particle loads over the four studied sites in spite of the large differences in local sources. The results from MAN acquired over the Mediterranean Sea, Black Sea and Atlantic Ocean from July to November 2011 revealed a pronounced predominance of fine particles during the cruise period.

Air quality monitoring in communities of the Canadian Arctic during the high shipping season with a focus on local and marine pollution

A. Aliabadi, R. M. Staebler, and S. Sharma

Source: *Atmos. Chem. Phys., 15, 2651-2673, 2015*

The Canadian Arctic has experienced decreasing sea ice extent and increasing shipping activity in recent decades. While there are economic incentives to develop resources in the north, there are environmental concerns that increasing marine traffic will contribute to declining air quality in northern communities. In an effort to characterize the relative impact of shipping on air quality in the north, two monitoring stations have been installed in Cape Dorset and Resolute, Nunavut, and have been operational since 1 June 2013. The impact of shipping and other sources of emissions on NOx, O3, SO2, BC, and PM2.5 pollution have been characterized for the 2013 shipping season from 1 June to 1 November. In addition, a high-resolution Air Quality Health Index (AQHI) for both sites was computed. Shipping consistently increased O3 mixing ratio and PM2.5 concentration. The 90% confidence interval for mean difference in O3 mixing ratio between ship- and no ship-influenced air masses were up to 4.6–4.7 ppb and 2.5–2.7 ppb for Cape Dorset and Resolute, respectively. The same intervals for PM2.5 concentrations were up to 1.8–1.9 μg m−3 and 0.5–0.6 μg m−3. Ship-influenced air masses consistently exhibited an increase of 0.1 to 0.3 in the high-resolution AQHI compared to no ship-influenced air masses. Trajectory cluster analysis in combination with ship traffic tracking provided an estimated range for percent ship contribution to NOx, O3, SO2, and PM2.5 that were 12.9–17.5 %, 16.2–18.1 %, 16.9–18.3 %, and 19.5–31.7 % for Cape Dorset and 1.0–7.2 %, 2.9–4.8 %, 5.5–10.0 %, and 6.5–7.2 % for Resolute during the 2013 shipping season. Additional measurements in Resolute

suggested that percent ship contribution to black carbon was 4.3–9.8 % and that black carbon constituted 1.3–9.7 % of total PM2.5 mass in ship plumes. Continued air quality monitoring in the above sites for future shipping seasons will improve the statistics in our analysis and characterize repeating seasonal patterns in air quality due to shipping, local pollution, and long-range transport.

How emissions, climate, and land use change will impact mid-century air quality over the United States: a focus on effects at national parks

M. Val Martin, C. L. Heald, J.-F. Lamarque, S. Tilmes, L. K. Emmons, and B. A. Schichtel

Source: *Atmos. Chem. Phys., 15, 2805-2823, 2015*

We use a global coupled chemistry–climate–land model (CESM) to assess the integrated effect of climate, emissions and land use changes on annual surface O3 and PM2.5 in the United States with a focus on national parks (NPs) and wilderness areas, using the RCP4.5 and RCP8.5 projections. We show that, when stringent domestic emission controls are applied, air quality is predicted to improve across the US, except surface O3 over the western and central US under RCP8.5 conditions, where rising background ozone counteracts domestic emission reductions. Under the RCP4.5 scenario, surface O3 is substantially reduced (about 5 ppb), with daily maximum 8 h averages below the primary US Environmental Protection Agency (EPA) National Ambient Air Quality Standards (NAAQS) of 75 ppb (and even 65 ppb) in all the NPs. PM2.5 is significantly reduced in both scenarios (4 μg m−3; ~50%), with levels below the annual US EPA NAAQS of 12 μg m−3 across all the NPs; visibility is also improved (10–15 dv; >75 km in visibility range), although some western US parks with Class I status (40–74 % of total sites in the US) are still above the 2050 planned target level to reach the goal of natural visibility conditions by 2064. We estimate that climate-driven increases in fire activity may dominate summertime PM2.5 over the western US, potentially offsetting the large PM2.5 reductions from domestic emission controls, and keeping visibility at present-day levels in many parks. Our study indicates that anthropogenic emission patterns will be important for air quality in 2050. However, climate and land use changes alone may lead to a substantial increase in surface O3 (2–3 ppb) with important consequences for O3 air quality and ecosystem degradation at the US NPs. Our study illustrates the need to consider the effects of changes in climate, vegetation, and fires in future air quality management and planning and emission policy making.

Impact of pollution controls in Beijing on atmospheric oxygenated volatile organic compounds (OVOCs) during the 2008 Olympic Games: observation and modeling implications

Y. Liu, B. Yuan, X. Li, M. Shao, S. Lu1, Y. Li, C.-C. Chang, Z. Wang, W. Hu, X. Huang, L. He, L. Zeng, M. Hu, and T. Zhu

Source: *Atmos. Chem. Phys., 15, 3045-3062, 2015*

Oxygenated volatile organic compounds (OVOCs) are important products of the photo-oxidation of hydrocarbons. They influence the oxidizing capacity and the ozone-forming potential of the atmosphere. In the summer of 2008, 2 months of emission restrictions were enforced in Beijing to improve air quality during the Olympic Games. Observational evidence reported in related studies that these control measures were efficient in reducing the concentrations of primary anthropogenic pollutants (CO, NOx and non-methane hydrocarbons, i.e., NMHCs) by 30–40%. In this study, the influence of the emission restrictions on ambient levels of OVOCs was explored using a neural network analysis with consideration of meteorological

conditions. Statistically significant reductions in formaldehyde (HCHO), acetaldehyde (CH3CHO), methyl ethyl ketone (MEK) and methanol were found to be 12.9, 15.8, 17.1 and 19.6%, respectively, when the restrictions were in place. The effect of emission controls on acetone was not detected in neural network simulations, probably due to pollution transport from surrounding areas outside Beijing. Although the ambient levels of most NMHCs were reduced by ~35% during the full control period, the emission ratios of reactive alkenes and aromatics closely related to automobile sources did not present much difference (< 30%). A zero-dimensional box model based on the Master Chemical Mechanism version 3.2 (MCM3.2) was applied to evaluate how OVOC production responds to the reduced precursors during the emissions control period. On average, secondary HCHO was produced from the oxidation of anthropogenic alkenes (54%), isoprene (30%) and aromatics (15%). The importance of biogenic sources for the total HCHO formation was almost on par with that of anthropogenic alkenes during the daytime. Anthropogenic alkenes and alkanes dominated the photochemical production of other OVOCs such as acetaldehyde, acetone and MEK. The relative changes of modeled HCHO, CH3CHO, methyl vinyl ketone and methacrolein (MVK + MACR) before and during the pollution controlled period were comparable to the estimated reductions in the neural network, reflecting that current mechanisms can largely explain secondary production of those species under urban conditions. However, it is worth noting that the box model overestimated the measured concentrations of aldehydes by a factor of 1.4–1.7 without consideration of loss of aldehydes on aerosols, and simulated MEK was in good agreement with the measurements when primary sources were taken into consideration. These results suggest that the understanding of the OVOCs budget in the box model remains incomplete, and that there is still considerable uncertainty in particular missing sinks (unknown chemical and physical processes) for aldehydes and absence of direct emissions for ketones.

Properties and evolution of biomass burning organic aerosol from Canadian boreal forest fires

M. D. Jolleys, H. Coe, G. McFiggans, J. W. Taylor, S. J. O'Shea, M. Le Breton, S. J.-B. Bauguitte, S. Moller, P. Di Carlo, E. Aruffo, P. I. Palmer, J. D. Lee, C. J. Percival1, and M. W. Gallagher

Source: *Atmos. Chem. Phys., 15, 3077-3095, 2015*

Airborne measurements of biomass burning organic aerosol (BBOA) from boreal forest fires reveal highly contrasting properties for plumes of different ages. These measurements, performed using an Aerodyne Research Inc. compact time-of-flight aerosol mass spectrometer (C-ToF-AMS) during the BORTAS (quantifying the impact of BOReal forest fires on Tropospheric oxidants over the Atlantic using Aircraft and Satellites) experiment in the summer of 2011, have been used to derive normalised excess organic aerosol (OA) mass concentrations (ΔOA / ΔCO), with higher average ratios observed closer to source (0.190±0.010) than in the far-field (0.097±0.002). The difference in ΔOA / ΔCO between fresh and aged plumes is influenced by a change in dominant combustion conditions throughout the campaign. Measurements at source comprised 3 plume interceptions during a single research flight and sampled largely smouldering fires. Twenty-three interceptions were made across four flights in the far-field, with plumes originating from fires occurring earlier in the campaign when fire activity had been more intense, creating an underlying contrast in emissions prior to any transformations associated with aging. Changing combustion conditions also affect the vertical distribution of biomass burning emissions, as aged plumes from more flaming-dominated fires are injected to higher altitudes of up to 6000 m. Proportional contributions of the mass-to-charge ratio (m/z) 60 and 44 peaks in the AMS mass spectra to the total OA mass (denoted f60 and f44) are used as tracers for primary and oxidised BBOA, respectively. f44 is lower on average in near-field plumes than those sampled in the far-field, in accordance with longer aging times as plumes are transported a greater distance from source. However, high levels of ΔO3 / ΔCO and −log(NOx / NOy) close to source indicate that emissions can be subject to very rapid oxidation over short timescales. Conversely, the lofting of plumes into the upper troposphere can lead to the retention of source profiles after transportation over extensive

temporal and spatial scales, with f60 also higher on average in aged plumes. Evolution of OA composition with aging is comparable to observations of BB tracers in previous studies, revealing a consistent progression from f60 to f44. The elevated levels of oxygenation in aged plumes, and their association with lower average ΔOA / ΔCO, are consistent with OA loss through evaporation during aging due to a combination of dilution and chemical processing, while differences in combustion conditions throughout the campaign also have a significant influence on BBOA production and composition.

Chemical and stable carbon isotopic composition of PM2.5 from on-road vehicle emissions in the PRD region and implications for vehicle emission control policy

S. Dai1, X. Bi, L. Y. Chan, J. He, B. Wang, X. Wang, P. Peng, G. Sheng, and J. Fu

Source: *Atmos. Chem. Phys., 15, 3097-3108, 2015*

Vehicle emissions are a major source of urban air pollution. In recent decade, the Chinese government has introduced a range of policies to reduce vehicle emissions. In order to understand the chemical characteristics of PM2.5 from on-road vehicle emissions in the Pearl River Delta (PRD) region and to evaluate the effectiveness of control policies on vehicle emissions, the emission factors of PM2.5 mass, elemental carbon (EC), organic carbon (OC), water-soluble organic carbon (WSOC), water-soluble inorganic ions (WSII), metal elements, organic compounds and stable carbon isotopic composition were measured in the Zhujiang tunnel of Guangzhou, in the PRD region of China in 2013. Emission factors of PM2.5 mass, OC, EC and WSOC were 92.4, 16.7, 16.4 and 1.31 mg vehicle−1 km−1 respectively. Emission factors of WSII were 0.016 (F-) ~ 4.17 (Cl−) mg vehicle−1 km−1, contributing about 9.8% to the PM2.5 emissions. The sum of 27 measured metal elements accounted for 15.2% of PM2.5 emissions. Fe was the most abundant metal element, with an emission factor of 3.91 mg vehicle−1 km−1. Emission factors of organic compounds including n-alkanes, polycyclic aromatic hydrocarbons, hopanes and steranes were 91.9, 5.02, 32.0 and 7.59 μg vehicle−1 km−1, respectively. Stable carbon isotopic composition δ13C value was −25.0‰ on average. An isotopic fractionation of 3.2‰ was found during fuel combustion. Compared to a previous study in Zhujiang tunnel in 2004, emission factors of PM2.5mass, EC, OC, WSII except Cl- and organic compounds decreased by 16.0 ~ 93.4%, which could be attributed to emission control policy from 2004 to 2013. However, emission factors of most of the metal elements increased significantly, which could be partially attributed to the changes in motor oil additives and vehicle conditions. There are no mandatory national standards to limit metal content from vehicle emissions, which should be a concern of the government. A snapshot of the 2013 characteristic emissions of PM2.5 and its constituents from the on-road vehicular fleet in the PRD region retrieved from our study would be helpful for the assessment of past and future implementations of vehicle emission control policy.

Aerosol physicochemical properties and implications for visibility during an intense haze episode during winter in Beijing

Y. H. Wang, Z. R. Liu, J. K. Zhang, B. Hu, D. S. Ji, Y. C. Yu, and Y. S. Wang

Source: *Atmos. Chem. Phys., 15, 3205-3215, 2015*

The evolution of physical, chemical and optical properties of urban aerosol particles was characterized during an extreme haze episode in Beijing, PRC, from 24 through 31 January 2013 based on in situ measurements. The average mass concentrations of PM1, PM2.5 and PM10 were 99 ± 67 μg m−3 (average ± SD), 188 ± 128 μg m−3 and 265 ± 157 μg m−3, respectively. A significant increase in PM1-2.5 fraction was

observed during the most heavily polluted period. The average scattering coefficient at 550 nm was 877 ± 624 Mm−1. An increasing relative amount of coarse particles can be deduced from the variations of backscattering ratios, asymmetry parameter and scattering Ångström exponent. Particle number-size distributions between 14 and 2500 nm diameter showed high number concentrations, particularly in the nucleation mode and accumulation mode. Size-resolved chemical composition of submicron aerosol from a high-resolution time-of-flight aerosol mass spectrometer showed that the mass concentrations of organic, sulfate, nitrate, ammonium and chlorine mainly resided on particles between 500 and 800 nm (vacuum diameter), and nitrate and ammonium contributed greatly to particle growth during the heavily polluted day (28 January). Increasing relative humidity and stable synoptic conditions on 28 January combined with heavy pollution on 28 January, leading to enhanced water uptake by the hygroscopic submicron particles and formation of secondary aerosol, which might be the main reasons for the severity of the haze episode. Light-scattering apportionment showed that organic, sulfate, ammonium nitrate and ammonium chloride compounds contributed to light-scattering fractions of 54, 24, 12 and 10%, respectively. This study indicated that the organic component in submicron aerosol played an important role in visibility degradation during the haze episode in Beijing.

Simultaneous reductions in emissions of black carbon and co-emitted species will weaken the aerosol net cooling effect

Z. L. Wang, H. Zhang, and X. Y. Zhang

Source:*Atmos. Chem. Phys., 15, 3671-3685, 2015*

Black carbon (BC), a distinct type of carbonaceous material formed from the incomplete combustion of fossil and biomass based fuels under certain conditions, can interact with solar radiation and clouds through its strong light-absorption ability, thereby warming the Earth's climate system. Some studies have even suggested that global warming could be slowed down in the short term by eliminating BC emission due to its short lifetime. In this study, we estimate the influence of removing some sources of BC and other co-emitted species on the aerosol radiative effect by using an aerosol–climate atmosphere-only model BCC_AGCM2.0.1_CUACE/Aero with prescribed sea surface temperature and sea ice cover, in combination with the aerosol emissions from the Representative Concentration Pathways (RCPs) scenarios. We find that the global annual mean aerosol net cooling effect at the top of the atmosphere (TOA) will be enhanced by 0.12 W m−2 compared with recent past year 2000 levels if the emissions of only BC are reduced to the level projected for 2100 based on the RCP2.6 scenario. This will be beneficial~for the mitigation of global warming. However, both aerosol negative direct and indirect radiative effects are weakened when BC and its co-emitted species (sulfur dioxide and organic carbon) are simultaneously reduced. Relative to year 2000 levels, the global annual mean aerosol net cooling effect at the TOA will be weakened by 1.7–2.0 W m−2 if the emissions of all these aerosols are decreased to the levels projected for 2100 in different ways based on the RCP2.6, RCP4.5, and RCP8.5 scenarios. Because there are no effective ways to remove the BC exclusively without influencing the other co-emitted components, our results therefore indicate that a reduction in BC emission can lead to an unexpected warming on the Earth's climate system in the future.

Chemical composition and size distribution of summertime PM2.5 at a high altitude remote location in the northeast of the Qinghai–Xizang (Tibet) Plateau: insights into aerosol sources and processing in free troposphere

J. Z. Xu, Q. Zhang, Z. B. Wang, G. M. Yu, X. L. Ge, and X. Qin

Source: *Atmos. Chem. Phys., 15, 5069-5081, 2015*

Aerosol filter samples were collected at a high-elevation mountain observatory (4180 m a.s.l.) in the northeastern part of the Qinghai–Xizang (Tibet) Plateau (QXP) during summer 2012 using a low-volume sampler and a micro-orifice uniform deposit impactor (MOUDI). These samples were analyzed for water-soluble inorganic ions (WSIs), organic carbon (OC), elemental carbon (EC), water-soluble organic carbon (WSOC), and total organic nitrogen (TON) to elucidate the size-resolved chemical composition of free tropospheric aerosols in the QXP region. The average mass concentration of the sum of the analyzed species in PM2.5 (particle matter) (WSIs + OC + EC + TON) was 3.74 μg sm−3, 36% of which was sulfate, 18% OC, 17 % nitrate, 10% ammonium, 6.6% calcium, 6.4% TON, 2.6% EC, 1.5 % sodium, 0.9% chloride, 0.5% magnesium, and 0.3% potassium. The size distributions of sulfate and ammonium peaked in the accumulation mode (0.32–0.56 μm), whereas the size distributions of both nitrate and calcium peaked in the range of 1.8–3.2 μm, suggesting the formation of nitrate on mineral dust. OC, EC and TON were also predominantly found in the accumulation mode. The bulk chemical composition and the average oxidation degree of water-soluble organic matter (WSOM) were assessed using a high-resolution time-of-flight aerosol mass spectrometer (HR-ToF-AMS). WSOM was found to be highly oxidized in all PM2.5 samples with an average oxygen-to-carbon atomic ratio (O / C) of 1.16 and an organic mass-to-organic carbon ratio (OM / OC) of 2.75. The highly oxidized WSOM was likely related to active cloud processing during upslope air mass transport coupled with strongly oxidizing environments caused by snow/ice photochemistry. High average ratios of OC / EC (7.6) and WSOC / OC (0.79) suggested that organic aerosols were primarily made of secondary species. Secondary organic aerosol (SOA) was estimated on average accounting for 80% (62–96%) of the PM2.5, indicating that SOA is an important component of free tropospheric aerosols over the northern QXP.

Greenhouse gas emissions from laboratory-scale fires in wildland fuels depend on fire spread mode and phase of combustion

N. C. Surawski, A. L. Sullivan, C. P. Meyer, S. H. Roxburgh, and P. J. Polglase

Source: *Atmos. Chem. Phys., 15, 5259-5273, 2015*

Free-burning experimental fires were conducted in a wind tunnel to explore the role of ignition type and thus fire spread mode on the resulting emissions profile from combustion of fine (< 6 mm in diameter) Eucalyptus litter fuels. Fires were burnt spreading with the wind (heading fire), perpendicular to the wind (flanking fire) and against the wind (backing fire). Greenhouse gas compounds (i.e. CO2, CH4 and N2O) and CO were quantified using off-axis integrated-cavity-output spectroscopy. Emissions factors calculated using a carbon mass balance technique (along with statistical testing) showed that most of the carbon was emitted as CO2, with heading fires emitting 17% more CO2 than flanking and 9.5% more CO2 than backing fires, and about twice as much CO as flanking and backing fires. Heading fires had less than half as much carbon remaining in combustion residues. Statistically significant differences in CH4 and N2O emissions factors were not found with respect to fire spread mode. Emissions factors calculated per unit of dry fuel consumed showed that combustion phase (i.e. flaming or smouldering) had a statistically significant impact, with CO and N2O emissions increasing during smouldering combustion and CO2 emissions decreasing. Findings on the

equivalence of different emissions factor reporting methods are discussed along with the impact of our results for emissions accounting and potential sampling biases associated with our work. The primary implication of this study is that prescribed fire practices could be modified to mitigate greenhouse gas emissions from forests by judicial use of ignition methods to induce flanking and backing fires over heading fires.

Sources of black carbon aerosols in South Asia and surrounding regions during the Integrated Campaign for Aerosols, Gases and Radiation Budget (ICARB)

R. Kumar, M. C. Barth, V. S. Nair, G. G. Pfister, S. Suresh Babu, S. K. Satheesh, K. Krishna Moorthy, G. R. Carmichael, Z. Lu, and D. G. Streets

Source: *Atmos. Chem. Phys., 15, 5415-5428, 2015*

This study examines differences in the surface black carbon (BC) aerosol loading between the Bay of Bengal (BoB) and the Arabian Sea (AS) and identifies dominant sources of BC in South Asia and surrounding regions during March–May 2006 (Integrated Campaign for Aerosols, Gases and Radiation Budget, ICARB) period. A total of 13 BC tracers are introduced in the Weather Research and Forecasting Model coupled with Chemistry to address these objectives. The model reproduced the temporal and spatial variability of BC distribution observed over the AS and the BoB during the ICARB ship cruise and captured spatial variability at the inland sites. In general, the model underestimates the observed BC mass concentrations. However, the model–observation discrepancy in this study is smaller compared to previous studies. Model results show that ICARB measurements were fairly well representative of the AS and the BoB during the pre-monsoon season. Elevated BC mass concentrations in the BoB are due to 5 times stronger influence of anthropogenic emissions on the BoB compared to the AS. Biomass burning in Burma also affects the BoB much more strongly than the AS. Results show that anthropogenic and biomass burning emissions, respectively, accounted for 60 and 37% of the average ± standard deviation (representing spatial and temporal variability) BC mass concentration (1341 ± 2353 ng m−3) in South Asia. BC emissions from residential (61%) and industrial (23%) sectors are the major anthropogenic sources, except in the Himalayas where vehicular emissions dominate. We find that regional-scale transport of anthropogenic emissions contributes up to 25% of BC mass concentrations in western and eastern India, suggesting that surface BC mass concentrations cannot be linked directly to the local emissions in different regions of South Asia.

Assessment of China's virtual air pollution transport embodied in trade by using a consumption-based emission inventory

H. Y. Zhao, Q. Zhang, D. B. Guan, S. J. Davis, Z. Liu, H. Huo, J. T. Lin, W. D. Liu, and K. B. He

Source: *Atmos. Chem. Phys., 15, 5443-5456, 2015*

Substantial anthropogenic emissions from China have resulted in serious air pollution, and this has generated considerable academic and public concern. The physical transport of air pollutants in the atmosphere has been extensively investigated; however, understanding the mechanisms how the pollutant was transferred through economic and trade activities remains a challenge. For the first time, we quantified and tracked China's air pollutant emission flows embodied in interprovincial trade, using a multiregional input–output model framework. Trade relative emissions for four key air pollutants (primary fine particle matter, sulfur dioxide, nitrogen oxides and non-methane volatile organic compounds) were assessed for 2007 in each Chinese province. We found that emissions were significantly redistributed among provinces owing to

interprovincial trade. Large amounts of emissions were embodied in the imports of eastern regions from northern and central regions, and these were determined by differences in regional economic status and environmental policy. It is suggested that measures should be introduced to reduce air pollution by integrating cross-regional consumers and producers within national agreements to encourage efficiency improvement in the supply chain and optimize consumption structure internationally. The consumption-based air pollutant emission inventory developed in this work can be further used to attribute pollution to various economic activities and final demand types with the aid of air quality models.

Aerosol composition and sources during the Chinese Spring Festival: fireworks, secondary aerosol, and holiday effects

Q. Jiang, Y. L. Sun, Z. Wang, and Y. Yin

Source: *Atmos. Chem. Phys., 15, 6023-6034, 2015*

Aerosol particles were characterized by an Aerodyne aerosol chemical speciation monitor along with various collocated instruments in Beijing, China, to investigate the role of fireworks (FW) and secondary aerosol in particulate pollution during the Chinese Spring Festival of 2013. Three FW events, exerting significant and short-term impacts on fine particles (PM2.5), were observed on the days of Lunar New Year, Lunar Fifth Day, and Lantern Festival. The FW were shown to have a large impact on non-refractory potassium, chloride, sulfate, and organics in submicron aerosol (PM1), of which FW organics appeared to be emitted mainly in secondary, with its mass spectrum resembling that of secondary organic aerosol (SOA). Pollution events (PEs) and clean periods (CPs) alternated routinely throughout the study. Secondary particulate matter (SPM = SOA + sulfate + nitrate + ammonium) dominated the total PM1 mass on average, accounting for 63–82% during nine PEs in this study. The elevated contributions of secondary species during PEs resulted in a higher mass extinction efficiency of PM1 (6.4 m2 g-1) than during CPs (4.4 m2 g-1). The Chinese Spring Festival also provides a unique opportunity to study the impact of reduced anthropogenic emissions on aerosol chemistry in the city. Primary species showed ubiquitous reductions during the holiday period with the largest reduction being in cooking organic aerosol (OA; 69%), in nitrogen monoxide (54%), and in coal combustion OA (28%). Secondary sulfate, however, remained only slightly changed, and the SOA and the total PM2.5 even slightly increased. Our results have significant implications for controlling local primary source emissions during PEs, e.g., cooking and traffic activities. Controlling these factors might have a limited effect on improving air quality in the megacity of Beijing, due to the dominance of SPM from regional transport in aerosol particle composition.

Particulate emissions from residential wood combustion in Europe – revised estimates and an evaluation

H. A. C. Denier van der Gon, R. Bergström, C. Fountoukis, C. Johansson, S. N. Pandis, D. Simpson, and A. J. H. Visschedijk

Source: *Atmos. Chem. Phys., 15, 6503-6519, 2015*

Currently residential wood combustion (RWC) is increasing in Europe because of rising fossil fuel prices but also due to climate change mitigation policies. However, especially in small-scale applications, RWC may cause high emissions of particulate matter (PM). Recently we have developed a new high-resolution (7 × 7 km) anthropogenic carbonaceous aerosol emission inventory for Europe. The inventory indicated that about half of the total PM2.5 emission in Europe is carbonaceous aerosol and identified RWC as the largest organic aerosol source in Europe. The inventory was partly based on national reported PM emissions. Use of

this organic aerosol inventory as input for two chemical transport models (CTMs), PMCAMx and EMEP MSC-W, revealed major underestimations of organic aerosol in winter time, especially for regions dominated by RWC. Interestingly, this was not universal but appeared to differ by country.
In the present study we constructed a revised bottom-up emission inventory for RWC accounting for the semivolatile components of the emissions. The revised RWC emissions are higher than those in the previous inventory by a factor of 2–3 but with substantial inter-country variation. The new emission inventory served as input for the CTMs and a substantially improved agreement between measured and predicted organic aerosol was found. The revised RWC inventory improves the model-calculated organic aerosol significantly. Comparisons to Scandinavian source apportionment studies also indicate substantial improvements in the modelled wood-burning component of organic aerosol. This suggests that primary organic aerosol emission inventories need to be revised to include the semivolatile organic aerosol that is formed almost instantaneously due to dilution and cooling of the flue gas or exhaust. Since RWC is a key source of fine PM in Europe, a major revision of the emission estimates as proposed here is likely to influence source–receptor matrices and modelled source apportionment. Since usage of biofuels in small combustion units is a globally significant source, the findings presented here are also relevant for regions outside of Europe.

Estimates of black carbon emissions in the western United States using the GEOS-Chem adjoint model

Y. H. Mao, Q. B. Li, D. K. Henze, Z. Jiang, D. B. A. Jones, M. Kopacz, C. He, L. Qi1, M. Gao, W.-M. Hao, and K.-N. Liou

Source: *Atmos. Chem. Phys., 15, 7685-7702, 2015*

We estimate black carbon (BC) emissions in the western United States for July–September 2006 by inverting surface BC concentrations from the Interagency Monitoring of Protected Visual Environments (IMPROVE) network using a global chemical transport model (GEOS-Chem) and its adjoint. Our best estimate of the BC emissions is 49.9 Gg at 2° × 2.5° (a factor of 2.1 increase) and 47.3 Gg at 0.5° × 0.667° (1.9 times increase). Model results now capture the observed major fire episodes with substantial bias reductions (~ 35 % at 2° × 2.5° and ~ 15 % at 0.5° × 0.667°). The emissions are ~ 20–50 % larger than those from our earlier analytical inversions (Mao et al., 2014). The discrepancy is especially drastic in the partitioning of anthropogenic versus biomass burning emissions. The August biomass burning BC emissions are 4.6–6.5 Gg and anthropogenic BC emissions 8.6–12.8 Gg, varying with the model resolution, error specifications, and subsets of observations used. On average both anthropogenic and biomass burning emissions in the adjoint inversions increase 2-fold relative to the respective {a priori} emissions, in distinct contrast to the halving of the anthropogenic and tripling of the biomass burning emissions in the analytical inversions. We attribute these discrepancies to the inability of the adjoint inversion system, with limited spatiotemporal coverage of the IMPROVE observations, to effectively distinguish collocated anthropogenic and biomass burning emissions on model grid scales. This calls for concurrent measurements of other tracers of biomass burning and fossil fuel combustion (e.g., carbon monoxide and carbon isotopes). We find that the adjoint inversion system as is has sufficient information content to constrain the total emissions of BC on the model grid scales.

Dust–air pollution dynamics over the eastern Mediterranean

M. Abdelkader, S. Metzger, R. E. Mamouri, M. Astitha, L. Barrie, Z. Levin, and J. Lelieveld

Source: *Atmos. Chem. Phys., 15, 9173-9189, 2015*

Interactions of desert dust and air pollution over the eastern Mediterranean (EM) have been studied, focusing on two distinct dust transport events on 22 and 28 September 2011. The atmospheric chemistry–climate model EMAC has been used at about 50 km grid spacing, applying an online dust emission scheme and calcium as a proxy for dust reactivity. EMAC includes a detailed tropospheric chemistry mechanism, aerosol microphysics and thermodynamics schemes to describe dust "aging". The model is evaluated using ground-based observations for aerosol concentrations and aerosol optical depth (AOD) as well as satellite observations. Simulation results and back trajectory analysis show that the development of synoptic disturbances over the EM can enhance dust transport from the Sahara and Arabian deserts in frontal systems that also carry air pollution to the EM. The frontal systems are associated with precipitation that controls the dust removal. Our results show the importance of chemical aging of dust, which increases particle size, dust deposition and scavenging efficiency during transport, overall reducing the lifetime relative to non-aged dust particles. The relatively long travel periods of Saharan dust result in more sustained aging compared to Arabian dust. Sensitivity simulations indicate 3 times more dust deposition of aged relative to pristine dust, which significantly decreases the dust lifetime and loading.

Evaluating BC and NOx emission inventories for the Paris region from MEGAPOLI aircraft measurements

H. Petetin, M. Beekmann, A. Colomb, H. A. C. Denier van der Gon, J.-C. Dupont, C. Honoré, V. Michoud, Y. Morille, O. Perrussel, A. Schwarzenboeck, J. Sciare, A. Wiedensohler, and Q. J. Zhang

Source: *Atmos. Chem. Phys., 15, 9799-9818, 2015*

High uncertainties affect black carbon (BC) emissions, and, despite its important impact on air pollution and climate, very few BC emissions evaluations are found in the literature. This paper presents a novel approach, based on airborne measurements across the Paris, France, plume, developed in order to evaluate BC and NOx emissions at the scale of a whole agglomeration. The methodology consists in integrating, for each transect, across the plume observed and simulated concentrations above background. This allows for several error sources (e.g., representativeness, chemistry, plume lateral dispersion) to be minimized in the model used. The procedure is applied with the CHIMERE chemistry-transport model to three inventories – the EMEP inventory and the so-called TNO and TNO-MP inventories – over the month of July 2009. Various systematic uncertainty sources both in the model (e.g., boundary layer height, vertical mixing, deposition) and in observations (e.g., BC nature) are discussed and quantified, notably through sensitivity tests. Large uncertainty values are determined in our results, which limits the usefulness of the method to rather strongly erroneous emission inventories. A statistically significant (but moderate) overestimation is obtained for the TNO BC emissions and the EMEP and TNO-MP NOx emissions, as well as for the BC / NOx emission ratio in TNO-MP. The benefit of the airborne approach is discussed through a comparison with the BC / NOx ratio at a ground site in Paris, which additionally suggests a spatially heterogeneous error in BC emissions over the agglomeration.

A global aerosol classification algorithm incorporating multiple satellite data sets of aerosol and trace gas abundances

M. J. M. Penning de Vries, S. Beirle, C. Hörmann, J. W. Kaiser, P. Stammes, L. G. Tilstra, O. N. E. Tuinder, and T. Wagner

Source: *Atmos. Chem. Phys., 15, 10597-10618, 2015*

Detecting the optical properties of aerosols using passive satellite-borne measurements alone is a difficult task due to the broadband effect of aerosols on the measured spectra and the influences of surface and cloud reflection. We present another approach to determine aerosol type, namely by studying the relationship of aerosol optical depth (AOD) with trace gas abundance, aerosol absorption, and mean aerosol size. Our new Global Aerosol Classification Algorithm, GACA, examines relationships between aerosol properties (AOD and extinction Ångström exponent from the Moderate Resolution Imaging Spectroradiometer (MODIS), UV Aerosol Index from the second Global Ozone Monitoring Experiment, GOME-2) and trace gas column densities (NO2, HCHO, SO2 from GOME-2, and CO from MOPITT, the Measurements of Pollution in the Troposphere instrument) on a monthly mean basis. First, aerosol types are separated based on size (Ångström exponent) and absorption (UV Aerosol Index), then the dominating sources are identified based on mean trace gas columns and their correlation with AOD. In this way, global maps of dominant aerosol type and main source type are constructed for each season and compared with maps of aerosol composition from the global MACC (Monitoring Atmospheric Composition and Climate) model. Although GACA cannot correctly characterize transported or mixed aerosols, GACA and MACC show good agreement regarding the global seasonal cycle, particularly for urban/industrial aerosols. The seasonal cycles of both aerosol type and source are also studied in more detail for selected 5° × 5° regions. Again, good agreement between GACA and MACC is found for all regions, but some systematic differences become apparent: the variability of aerosol composition (yearly and/or seasonal) is often not well captured by MACC, the amount of mineral dust outside of the dust belt appears to be overestimated, and the abundance of secondary organic aerosols is underestimated in comparison with GACA. Whereas the presented study is of exploratory nature, we show that the developed algorithm is well suited to evaluate climate and atmospheric composition models by including aerosol type and source obtained from measurements into the comparison, instead of focusing on a single parameter, e.g., AOD. The approach could be adapted to constrain the mix of aerosol types during the process of a combined data assimilation of aerosol and trace gas observations.

Black carbon, particle number concentration and nitrogen oxide emission factors of random in-use vehicles measured with the on-road chasing method

Ježek, T. Katrašnik, D. Westerdahl, and G. Močnik

Source: *Atmos. Chem. Phys., 15, 11011-11026, 2015*

The chasing method was used in an on-road measurement campaign, and emission factors (EF) of black carbon (BC), particle number (PN) and nitrogen oxides (NOx) were determined for 139 individual vehicles of different types encountered on the roads. The aggregated results provide EFs for BC, NOx and PN for three vehicle categories: goods vehicles, gasoline and diesel passenger cars. This is the first on-road measurement study where BC EFs of numerous individual diesel cars were determined in real-world driving conditions. We found good agreement between EFs of goods vehicles determined in this campaign and the results of previous studies that used either chasing or remote-sensing measurement techniques. The composition of the sampled car fleet determined from the national vehicle registry information is reflective of Eurostat statistical data on the Slovenian and European vehicle fleet. The median BC EF of diesel and

gasoline cars that were in use for less than 5 years decreased by 60 and 47 % from those in use for 5–10 years, respectively; the median NOx and PN EFs of goods vehicles that were in use for less than 5 years decreased from those in use for 5–10 years by 52 and 67 %, respectively. Surprisingly, we found an increase of BC EFs in the newer goods vehicle fleet compared to the 5–10-year old one. The influence of engine maximum power of the measured EFs showed an increase in NOx EF from least to more powerful vehicles with diesel engines. Finally, a disproportionate contribution of high emitters to the total emissions of the measured fleet was found; the top 25 % of emitting diesel cars contributed 63, 47 and 61 % of BC, NOx and PN emissions respectively. With the combination of relatively simple on-road measurements and sophisticated post processing, individual vehicle EF can be determined and useful information about the fleet emissions can be obtained by exactly representing vehicles which contribute disproportionally to vehicle fleet emissions; and monitor how the numerous emission reduction approaches are reflected in on-road driving conditions.

Impact of atmospheric circulations on aerosol distributions in autumn over eastern China: observational evidence

X. Y. Zheng, Y. F. Fu, Y. J. Yang, and G. S. Liu

Source: *Atmos. Chem. Phys., 15, 12115-12138, 2015*

Regional heavy pollution events in eastern China (110–122° E, 28–40° N) are causing serious environmental problems. In this study, the relationship between the degree of regional pollution and the patterns of large-scale atmospheric circulation over eastern China in October is investigated using 10-year (2001–2010) Terra/MODIS aerosol optical depth and NCEP reanalysis data by both case study and composite analysis. Eighteen polluted and 10 clean episodes are selected and categorised into six polluted types and three clean types respectively. Generally speaking, weather patterns such as a uniform surface pressure field in eastern China or a steady straight westerly in the middle troposphere, particularly when being at the rear of the anticyclone at 850 hPa, are typically responsible for heavy pollution events. Meanwhile, clean episodes occur when strong southeastward cold air advection prevails below the middle troposphere or air masses are transported from sea to land. Uniform descending motion prevails over the study region, trapping pollutants in the lower atmosphere. Therefore, the value of vertical velocity averaged from 1000 to 100 hPa and divergence of wind field in the lower troposphere are used in this study to quantify the diffusion conditions in each circulation type. The results reveal that it is often a clean episode when both the mean downward motion (larger than $2.56 \times 10{-}2$ Pa s−1) and the divergence of low-level winds (larger than $1.79 \times 10{-}2$ s−1) are strong. Otherwise, it is more likely to be a polluted episode.

The effects of global change upon United States air quality

R. Gonzalez-Abraham, S. H. Chung, J. Avise, B. Lamb, E. P. Salathé Jr., C. G. Nolte, D. Loughlin, A. Guenther, C. Wiedinmyer, T. Duhl, Y. Zhang, and D. G. Streets

Source: *Atmos. Chem. Phys., 15, 12645-12665, 2015*

To understand more fully the effects of global changes on ambient concentrations of ozone and particulate matter with aerodynamic diameter smaller than 2.5 μm (PM2.5) in the United States (US), we conducted a comprehensive modeling effort to evaluate explicitly the effects of changes in climate, biogenic emissions, land use and global/regional anthropogenic emissions on ozone and PM2.5 concentrations and composition. Results from the ECHAM5 global climate model driven with the A1B emission scenario from the

Intergovernmental Panel on Climate Change (IPCC) were downscaled using the Weather Research and Forecasting (WRF) model to provide regional meteorological fields. We developed air quality simulations using the Community Multiscale Air Quality Model (CMAQ) chemical transport model for two nested domains with 220 and 36 km horizontal grid cell resolution for a semi-hemispheric domain and a continental United States (US) domain, respectively. The semi-hemispheric domain was used to evaluate the impact of projected global emissions changes on US air quality. WRF meteorological fields were used to calculate current (2000s) and future (2050s) biogenic emissions using the Model of Emissions of Gases and Aerosols from Nature (MEGAN). For the semi-hemispheric domain CMAQ simulations, present-day global emissions inventories were used and projected to the 2050s based on the IPCC A1B scenario. Regional anthropogenic emissions were obtained from the US Environmental Protection Agency National Emission Inventory 2002 (EPA NEI2002) and projected to the future using the MARKet ALlocation (MARKAL) energy system model assuming a business as usual scenario that extends current decade emission regulations through 2050. Our results suggest that daily maximum 8 h average ozone (DM8O) concentrations will increase in a range between 2 to 12 parts per billion (ppb) across most of the continental US. The highest increase occurs in the South, Central and Midwest regions of the US due to increases in temperature, enhanced biogenic emissions and changes in land use. The model predicts an average increase of 1–6 ppb in DM8O due to projected increase in global emissions of ozone precursors. The effects of these factors are only partially offset by reductions in DM8O associated with decreasing US anthropogenic emissions. Increases in PM2.5 levels between 4 and 10 μg m−3 in the Northeast, Southeast, Midwest and South regions are mostly a result of increase in primary anthropogenic particulate matter (PM), enhanced biogenic emissions and land use changes. Changes in boundary conditions shift the composition but do not alter overall simulated PM2.5 mass concentrations.

Impact of emission controls on air quality in Beijing during APEC 2014: lidar ceilometer observations

G. Tang, X. Zhu, B. Hu, J. Xin, L. Wang, C. Münkel, G. Mao, and Y. Wang

Source: *Atmos. Chem. Phys., 15, 12667-12680, 2015*

The implementation of emission reductions during the 2014 Asia-Pacific Economic Cooperation (APEC) summit provides a valuable opportunity to study air pollution in Beijing. From 15 October to 30 November 2014, the height of the atmospheric mixing layer and the vertical attenuated backscattering coefficient profiles were observed online using a~lidar ceilometer. Compared with fine particulate matter (PM2.5) and aerosol optical depth (AOD) data, the attenuated backscattering coefficients measured by the lidar ceilometer were strongly correlated with the PM2.5 concentration and AOD (correlation coefficients of 0.89 and 0.86, respectively). This result demonstrated the reliability of the vertical distribution of particles measured by the lidar ceilometer. By classifying different degrees of air pollution based on visibility, we found that during the transition period of air pollution, which was affected by transport of southerly flows in the mixing layer, the attenuated backscattering coefficient from 0 to 1500 m was enhanced by approximately 1.4 Mm−1 sr−1 (140 %). During the polluted period, the attenuated backscattering coefficient from 0 to 300 m suddenly increased, and the coefficient near the surface peaked (approximately 14 Mm−1 sr−1); however, the attenuated backscattering coefficient from 300 to 900 m decreased gradually, and the average value from 0 to 1500 m decreased by 0.5 Mm−1sr−1 (20 %). The height of the mixing layer gradually decreased, and the ratio of CO / SO2 gradually increased, which indicate that the polluted period was dominated by local contribution. Due to the emission reductions during APEC (DAPEC), the concentration of PM2.5 decreased by 59.2 and 58.9 % and visibility improved by 70.2 and 56.0 % compared to before (BAPEC) and after APEC (AAPEC), respectively. The contribution of regional transport in DAPEC decreased by approximately 36 and 25 %, and the local contribution decreased by approximately 48 and 54 % compared to BAPEC and

AAPEC, respectively. The most effective method of controlling air pollution in the Beijing area is to reduce regional emissions during the transition period and reduce local emissions during the polluted period.

Characterization of PM10 sources in the central Mediterranean

G. Calzolai1, S. Nava, F. Lucarelli, M. Chiari, M. Giannoni, S. Becagli, R. Traversi, M. Marconi, D. Frosini, M. Severi, R. Udisti, A. di Sarra, G. Pace, D. Meloni, C. Bommarito, F. Monteleone, F. Anello, and D. M. Sferlazzo

Source: *Atmos. Chem. Phys., 15, 13939-13955, 2015*

The Mediterranean Basin atmosphere is influenced by both strong natural and anthropogenic aerosol emissions and is also subject to important climatic forcings. Several programs have addressed the study of the Mediterranean basin; nevertheless important pieces of information are still missing. In this framework, PM10 samples were collected on a daily basis on the island of Lampedusa (35.5° N, 12.6° E; 45 m a.s.l.), which is far from continental pollution sources (the nearest coast, in Tunisia, is more than 100 km away). After mass gravimetric measurements, different portions of the samples were analyzed to determine the ionic content by ion chromatography (IC), the soluble metals by inductively coupled plasma atomic emission spectrometry (ICP-AES), and the total (soluble + insoluble) elemental composition by particle-induced x-ray emission (PIXE). Data from 2007 and 2008 are used in this study.

The Positive Matrix Factorization (PMF) model was applied to the 2-year long data set of PM10 mass concentration and chemical composition to assess the aerosol sources affecting the central Mediterranean basin. Seven sources were resolved: sea salt, mineral dust, biogenic emissions, primary particulate ship emissions, secondary sulfate, secondary nitrate, and combustion emissions. Source contributions to the total PM10 mass were estimated to be about 40 % for sea salt, around 25 % for mineral dust, 10 % each for secondary nitrate and secondary sulfate, and 5 % each for primary particulate ship emissions, biogenic emissions, and combustion emissions. Large variations in absolute and relative contributions are found and appear to depend on the season and on transport episodes. In addition, the secondary sulfate due to ship emissions was estimated and found to contribute by about one-third to the total sulfate mass. Results for the sea-salt and mineral dust sources were compared with estimates of the same contributions obtained from independent approaches, leading to an estimate of the water content bound to the sea salt in the marine source.

SECTION-III
Atmospheric Environment

Spatial and indoor/outdoor gradients in urban concentrations of ultrafine particles and PM2.5 mass and chemical components

Stefano Zauli Sajani , Isabella Ricciardelli , Arianna Trentini , Dimitri Bacco , Claudio Maccone , Silvia Castellazzi , Paolo Lauriola , Vanes Poluzzi , Roy M. Harrison

Source: *Atmospheric Environment 103 (2015) 307e320*

In order to investigate relationships between outdoor air pollution and concentrations indoors, a novel design of experiment has been conducted at two sites, one heavily trafficked and the other residential. The novel design aspect involves the introduction of air directly to the centre of an unoccupied room by use of a fan and duct giving a controlled air exchange rate and allowing an evaluation of particle losses purely due to uptake on indoor surfaces without the losses during penetration of the building envelope which affect most measurement programmes. The rooms were unoccupied and free of indoor sources, and consequently reductions in particle concentration were due to deposition processes within the room alone. Measurements were made of indoor and outdoor concentrations of PM2.5, major chemical components and particle number size distributions. Despite the absence of penetration losses, indoor to outdoor ratios were very similar to those in other studies showing that deposition to indoor surfaces is likely to be the major loss process for indoor air. The results demonstrated a dramatic loss of nitrate in the indoor atmosphere as well as a selective loss of particles in the size range below 50 nm, in comparison to coarser particles. Depletion of indoor particles was greater during a period of cold weather with higher outdoor concentrations probably due to an enhancement of semi-volatile materials in the outdoor particulate matter. Indoor/outdoor ratios for PM2.5 were generally higher at the trafficked site than the residential site, but for particle number were generally lower, reflecting the different chemical composition and size distributions of particles at the two sites

Keywords: *Indoor; outdoor air; Deposition; PM2.5; Nanoparticles.*

Spatial and temporal variations in atmospheric VOCs, NO2, SO2, and O3 concentrations at a heavily industrialized region in Western Turkey, and assessment of the carcinogenic risk levels of benzene

Mihriban Yılmaz Civan , Tolga Elbir , Remzi Seyfioglu , Oznur O € guz Kuntasal , Abdurrahman Bayram , Güray Dogan , Sema Yurdakul , Ozgün Andiç € , Aysen Müezzinoglu , Sait C. Sofuoglu , Hakan Pekey , Beyhan Pekey , Ayse Bozlaker , Mustafa Odabasi , Gürdal Tuncel

Source: *Atmospheric Environment 103 (2015) 102e113*

Ambient concentrations of volatile organic compounds (VOCs), nitrogen dioxide (NO2), sulphur dioxide (SO2) and ground-level ozone (O3) were measured at 55 locations around a densely populated industrial zone, hosting a petrochemical complex (Petkim), a petroleum refinery (Tupras), ship-dismantling facilities, several iron and steel plants, and a gas-fired power plant. Five passive sampling campaigns were performed covering summer and winter seasons of 2005 and 2007. Elevated concentrations of VOCs, NO2 and SO2 around the refinery, petrochemical complex and roads indicated that industrial activities and vehicular emissions are the main sources of these pollutants in the region. Ozone concentrations were low at the industrial zone and settlement areas, but high in rural stations downwind from these sources due to NO distillation. The United States Environmental Protection Agency's positive matrix factorization receptor model (EPA PMF) was employed to apportion ambient concentrations of VOCs into six factors, which were associated with emissions sources. Traffic was found to be highest contributor to measured PVOCs concentrations, followed by the Petkim and Tupras. Median cancer risk due to benzene inhalation calculated

using a Monte Carlo simulation was approximately 4 per-one-million population, which exceeded the U.S. EPA benchmark of 1 per one million. Petkim, Tupras and traffic emissions were the major sources of cancer risk due to benzene inhalation in the Aliaga airshed. Relative contributions of these two source groups changes significantly from one location to another, demonstrating the limitation of determining source contributions and calculating health risk using data from one or two permanent stations in an industrial area

Keywords: *Volatile organic compounds; Inorganic pollutants; PMF; Passive sampling; Carcinogenic risk; Spatial and temporal distribution.*

On-road emission characteristics of VOCs from diesel trucks in Beijing, China

Zhiliang Yao , Xianbao Shen , Yu Ye , Xinyue Cao , Xi Jiang , Yingzhi Zhang , Kebin He

Source: *Atmospheric Environment 103 (2015) 87e93*

This paper is the first in our series of papers aimed at understanding the volatile organic compound (VOC) emissions of vehicles in Beijing by conducting on-board emission measurements. This paper focuses on diesel vehicles. In this work, 18 China III diesel vehicles, including seven light-duty diesel trucks (LDDTs), four medium-duty diesel trucks (MDDTs) and seven heavy-duty diesel trucks (HDDTs), were examined when the vehicles were driven on predesigned fixed test routes in Beijing in China using a portable emissions measurement system (PEMS). Tedlar bag sampling and 2,4-dinitrophenyhydrazine (DNPH) cartridge sampling were used to collect VOC species, and gas chromatography-mass spectrometry (GC/MS) and high-performance liquid chromatography (HPLC) were used to analyze these samples. We obtained the VOC emission factors and relative compositions for diesel trucks of different sizes under different driving patterns. In total, 64 VOC species were quantified in this study, including 25 alkanes, four alkenes, 13 aromatics, 13 carbonyls and nine other compounds. The emission factors of the total VOCs based on mileage traveled for HDDTs were higher than those of LDDTs and MDDTs. Carbonyls, aromatics and alkanes were the dominant VOC species. Carbonyls accounted for 42.7%e69.2% of the total VOCs in the three types of tested diesel trucks. The total VOC emission factors of the tested vehicles that were driven on non-highway routes were 1.5e2.0 times higher than those of the vehicles driven on the highway. As for the OFP calculation results, with increased vehicle size, the ozone formation potential presented an increasing trend. Among the VOC components, carbonyls were the primary contributor to OFP. In addition, the OFPs under non-highway driving cycles were 1.3e1.7 times those under highway driving cycles. The results of this study will be helpful in improving our understanding of VOCs emitted from on-road diesel trucks in China.

Keywords: *Diesel vehicles; VOCs; Emission factors; Emission characteristics; PEMS.*

Real time air quality forecasting using integrated parametric and nonparametric regression techniques

Aoife Donnelly, Bruce Misstear, Brian Broderick

Source: *Atmospheric Environment 103 (2015) 53e65*

This paper presents a model for producing real time air quality forecasts with both high accuracy and high computational efficiency. Temporal variations in nitrogen dioxide (NO2) levels and historical correlations between meteorology and NO2 levels are used to estimate air quality 48 h in advance. Nonparametric kernel regression is used to produce linearized factors describing variations in concentrations with wind speed and

direction and, furthermore, to produce seasonal and diurnal factors. The basis for the model is a multiple linear regression which uses these factors together with meteorological parameters and persistence as predictors. The model was calibrated at three urban sites and one rural site and the final fitted model achieved R values of between 0.62 and 0.79 for hourly forecasts and between 0.67 and 0.84 for daily maximum forecasts. Model validation using four model evaluation parameters, an index of agreement (IA), the correlation coefficient (R), the fraction of values within a factor of 2 (FAC2) and the fractional bias (FB), yielded good results. The IA for 24 hr forecasts of hourly NO2 was between 0.77 and 0.90 at urban sites and 0.74 at the rural site, while for daily maximum forecasts it was between 0.89 and 0.94 for urban sites and 0.78 for the rural site. R values of up to 0.79 and 0.81 and FAC2 values of 0.84 and 0.96 were observed for hourly and daily maximum predictions, respectively. The model requires only simple input data and very low computational resources. It found to be an accurate and efficient means of producing real time air quality forecasts

Keywords: *Nitrogen dioxide;Nonparametric kernel regression; Air quality forecasting; Statistical modelling.*

Critical pollutant emissions from the Indian telecom network

S.K. Sahu , M.G. Schultz , G. Beig

Source: *Atmospheric Environment 103 (2015) 34e42*

In recent years, India developed the world's 2nd largest telecom network based largely on mobile phone connections. The energy demand of the telecom sector especially in rural areas is mainly fueled by diesel combustion in mid-size generators due to either lack of grid power or unstable provision of electricity. This study quantifies the magnitude of emissions from the Indian telecom sector and presents a gridded inventory for the year 2011 with a spatial distribution derived on the provincial level including information on urban versus rural telecom installations. The estimated total NOx, PM, CO, BC, SO2, HC and CO2 emissions are found to be 295 ± 196 Gg/yr, 155 ± 108 Gg/yr, 61 ± 41 Gg/yr, 28 ± 18 Gg/yr, 114 ± 12 Gg/yr 19.50 ± 13 Gg/yr and 27.9 ± 12 million tons/yr, respectively. The future development of emissions from this sector will depend on the rate of electrification and possible market saturation. Air quality in rural areas of India could be improved by replacing diesel generators with renewable energy sources or electricity from the grid.

Keywords: *Anthropogenic emission; Telecommunication; Fossil fuel combustion; Air quality; Emission inventory.*

Greenhouse gas emissions from naturally ventilated freestall dairy barns

H.S. Joo , P.M. Ndegwa , A.J. Heber , J.-Q. Ni , B.W. Bogan , J.C. Ramirez-Dorronsoro , E. Cortus

Source: *Atmospheric Environment 102 (2015) 384e392*

Greenhouse gas (GHG) emissions from two naturally-ventilated dairy freestall barns measured for a total of 21 d, one week each in May, July, and September 2009, are presented in this article. The holding capacity of Barn 1 (B1) was 400 Holstein cows, while that for Barn 2 (B2) was 850 cows. Air samples were taken from inlets and outlets of the barns via a custom made multiplexer gas sampling system for measurement of gas concentrations using a photoacoustic infrared multigas analyzer. Barn ventilation rates were based on air velocity measured with arrays of 3-D ultrasonic anemometers at inlets and outlets. Gas concentrations (10 min means) in the barns ranged from: 443e789 ppm for CO2, 0.0 e39.4 ppm for CH4, and 0.25e0.39 ppm for

N2O; with mean concentrations ranging from 6 to 20%, 0 to 4%, and 26 to 180% above the average background concentrations for CO2, N2O, and CH4, respectively. The correlations between CO2 and CH4 enhanced concentrations were relatively stronger (R of 0.67e0.74) than between CO2 and N2O enhanced concentrations (R of 0.10e0.20). Environmental conditions did not significantly (p ¼ 0.46) impact the enhanced concentrations of N2O in the barns. All three parameters (T, RH, and v) had significant ($p < 0.01$) influences on CO2 enhanced concentrations; while only T ($p < 0.01$) and v ($p < 0.01$) had significant influences on CH4 enhanced concentrations. Enhanced concentrations of CO2 and CH4 correlated negatively with all three parameters. The influence of the temperature-humidity index (THI) on CO2 enhanced concentrations was higher than that of v; while the effect v had on CH4 enhanced concentrations was slightly higher than that of the temperature-humidity index. The average emissions, based on hourly means, ranged from 5.3 to 10.7 kg d1 AU1 for CO2; 0.3 to 2.5 g d1 AU1 for N2O; and between 67 and 252 g d1 AU1 for CH4. Nitrous oxide emissions from the smaller barn, B1 (0.4 e2.5 g d1 AU1), were significantly higher than from the larger barn, B2 (0.3e0.5 g d1 AU1) most probably because 50% of B1 was open (no stalls) loose dirt floor.

Keywords: *Greenhouse gases; Enhanced concentrations; Freestall barns; Environmental factors.*

Partitioning of Black Carbon between ultrafine and fine particle modes in an urban airport vs. urban background environment

F. Costabile , F. Angelini , F. Barnaba , G.P. Gobbi

Source: *Atmospheric Environment 102 (2015) 136e144*

In this work, we characterize the Black Carbon (BC) aerosol in an urban airport vs. urban background environment with the objective to evaluate when and how the ultrafine BC dominates the bulk aerosol. Aerosol optical and microphysical properties were measured in a Mediterranean urban area (Rome) at sites impacted by BC sources including fossil fuels (FF), and biomass burning (BB). Experimental BC data were interpreted through measurement-constrained simulations of BC microphysics and optical properties. A "scheme" to separate the ultrafine BC was experimented on the basis of the relation found between changes in the BC partitioning between Aitken and accumulation mode particles, and relevant changes in particle size distribution and optical properties of the bulk aerosol. This separation scheme, applied to experimental data, proved useful to reveal the impact of airport and road traffic emissions. Findings may have important atmospheric implications. The experimented scheme can help separating different BC sources (FF, BB, "aged" BC) when BC size distributions may be very difficult to obtain (satellite, columnar observations, routine monitoring). Indeed, separating the ultrafine BC from the fine BC may provide significant benefits in addressing BC impact on air quality and climate.

Keywords: *Black carbon; Single Scattering; Albedo; Ultrafine BC; Mediterranean Urban areas; Airport.*

Enhanced formation of fine particulate nitrate at a rural site on the North China Plain in summer: The important roles of ammonia and ozone

Liang Wen , Jianmin Chen , Lingxiao Yang , Xinfeng Wang , Caihong Xu , Xiao Sui , Lan Yao , Yanhong Zhu , Junmei Zhang , Tong Zhu , Wenxing Wang

Source: *Atmospheric Environment 101 (2015) 294e302*

Severe PM2.5 pollution was observed frequently on the North China Plain, and nitrate contributed a large fraction of the elevated PM2.5 concentrations. To obtain a comprehensive understanding of the formation pathways of these fine particulate nitrate and the key factors that affect these pathways, field measurements of fine particulate nitrate and related air pollutants were made at a rural site on the North China Plain in the summer of 2013. Extremely high concentrations of fine particulate nitrate were frequently observed at night and in the early morning. The maximum hourly concentration of fine particulate nitrate reached 87.2 mg m3 . This concentration accounted for 29.9% of the PM2.5. The very high NH3 concentration in the early morning significantly accelerated the formation of fine particulate nitrate, as indicated by the concurrent appearance of NH3 and NO3 concentration peaks and a rising neutralization ratio (the equivalent ratio of NH4 þ to the sum of SO4 2 and NO3). On a number of other episode days, strong photochemical activity during daytime led to high concentrations of O3 at night. The fast secondary formation of fine particulate nitrate was mainly attributed to the hydrolysis of N2O5, which was produced from O3 and NO2. Considering the important roles of NH3 and O3 in fine particulate nitrate formation, we suggest the control of NH3 emissions and photochemical pollution to address the high levels of fine particulate nitrate and the severe PM2.5 pollution on the North China Plain.

Keywords: *Fine particulate nitrates; Secondary formation; Ammonia; Ozone; North China Plain.*

Modelling Black Carbon concentrations in two busy street canyons in Brussels using CANSBC

O. Brasseur , P. Declerck , B. Heene , P. Vanderstraeten

Source: *Atmospheric Environment 101 (2015) 72e81*

This paper focused on modelling Black Carbon (BC) concentrations in two busy street canyons, the Crown and Belliard Street in Brussels. The used original Operational Street Pollution Model was adapted to BC by eliminating the chemical module and is noted here as CANSBC. Model validations were performed using temporal BC data from the fixed measurement network in Brussels. Subsequently, BC emissions were adjusted so that simulated BC concentrations equalled the observed ones, averaged over the whole period of simulation. Direct validations were performed for the Crown Street, while BC model calculations for the Belliard Street were validated indirectly using the linear relationship between BC and NOx. Concerning the Crown Street, simulated and observed half-hourly BC concentrations correlated well (r ¼ 0.74) for the period from July 1st, 2011 till June 30th, 2013. In particular, CANSBC performed very well to simulate the monthly and diurnal evolutions of averaged BC concentrations, as well as the difference between weekdays and weekends. This means that the model correctly handled the meteorological conditions as well as the variation in traffic emissions. Considering dispersion, it should however be noted that BC concentrations are better simulated under stable than under unstable conditions. Even if the correlation on half-hourly NOx concentrations was slightly lower (r ¼ 0.60) than the one of BC, indirect validations of CANSBC for the Belliard Street yielded comparable results and conclusions as described above for the Crown Street. Based on our results, it can be stated that CANSBC is suitable to accurately simulate BC concentrations in the street

canyons of Brussels, under the following conditions: (i) accurate vehicle counting data is available to correctly estimate traffic emissions, and (ii) vehicle speeds are measured in order to improve emission estimates and to take into account the impact of the turbulence generated by moving vehicles on the local dispersion of BC.

Keywords: *Black Carbon; Street canyon; Modelling Traffic.*

TSP, PM10, and PM2.5 emissions from a beef cattle feedlot using the flux-gradient technique

Henry F. Bonifacio , Ronaldo G. Maghirang , Steven L. Trabue , Laura L. McConnell , John H. Prueger , Edna R. Bonifacio

Source: *Atmospheric Environment 101 (2015) 49e57*

Emissions data on air pollutants from large open-lot beef cattle feedlots are limited. This research was conducted to determine emissions of total suspended particulates (TSP) and particulate matter (PM10 and PM2.5) from a commercial beef cattle feedlot in Kansas (USA). Vertical particulate concentration profiles at the feedlot were measured using gravimetric samplers, and micrometeorological parameters were monitored with eddy covariance instrumentation during the nine 4- to 5-day intensive sampling campaigns from May 2010 through September 2011. Emission fluxes were determined from the measured concentration gradients and meteorological parameters using the flux-gradient technique. PM ratios based on calculated emission fluxes were 0.28 for PM2.5/PM10, 0.12 for PM2.5/TSP, and 0.24 for PM10/TSP, indicating that a large fraction of the PM emitted at the studied feedlot was in the coarse range of aerodynamic diameter, >10 mm. Median daily emission factors were 57, 21, and 11 kg 1000-head (hd)1 d1 for TSP (n ¼ 20 days), PM10 (n ¼ 19 days), and PM2.5 (n ¼ 11 days), respectively. Cattle pen surface moisture contents of at least 20e30% significantly reduced both TSP and PM10 emissions, but moisture's effect on PM2.5 emissions was not established due to difficulty in measuring PM2.5 concentrations under low-PM conditions.

Keywords: *Particulate matter emission fluxes; Flux-gradient technique; Total suspended particulates; PM10; PM2.5; Cattle feedlots.*

Surface ozone concentration trends and its relationship with weather types in Spain (2001e2010)

Ana Santurtún , Jose Carlos Gonz alez-Hidalgo, Arturo Sanchez-Lorenzo , María Teresa Zarrabeitia

Source: *Atmospheric Environment 101 (2015) 10e22*

This paper assesses the temporal variations of surface ozone concentrations during the period 2001 e2010 in 3 regions of Spain with different geographical and socioeconomic features (northern coastland, central inland and northeast inland), as well as its link with atmospheric circulation. Specifically, daily surface atmospheric patterns over the aforementioned regions are characterized using NCEP/NCAR reanalysis data and an objective classification scheme in order to study the relationship between synoptic weather types and daily ozone levels. The results show that tropospheric ozone concentration has a tendency towards an increase during the study period, both during daytime and nighttime. Moreover, in general, this upward trend is seen throughout all of the seasons. The observed trends are in line with a reported decrease of NOX emissions and increase in surface solar radiation during the 2000s in Spain. On the other hand, interestingly, median

concentrations were statistically significantly lower in days with anticyclonic weather conditions than in the rest of meteorological situations, while days with a directional weather type showed higher median levels of ozone concentration, with maximum values in days with northern and eastern component. Due to the detrimental effect that ozone has on human health, the relationship between synoptic weather patterns and daily ozone levels shown in this work could potentially be used for implementing pollution level alert protocols depending on forecast weather types.

Keywords: *Tropospheric ozone; Weather types; Air pollution trends.*

Urban air quality simulation in a high-rise building area using a CFD model coupled with mesoscale meteorological and chemistry-transport models

Kyung-Hwan Kwak, Jong-Jin Baik , Young-Hee Ryu , Sang-Hyun Lee

Source: *Atmospheric Environment 100 (2015) 167e177*

An integrated urban air quality modeling system is established by coupling a computational fluid dynamics (CFD) model with mesoscale meteorological and chemistry-transport models. The mesoscale models used are the weather research and forecasting (WRF) model and the community multiscale air quality (CMAQ) model, which provide the initial and time-dependent boundary conditions for the CFD model. For the consistency of chemical processes in the CFD and CMAQ models, the same chemical mechanism used in the CMAQ model is implemented in the CFD model. Urban air quality simulations are performed from 0900 to 1800 LT on 3 June 2010 in a high-rise building area of Seoul, Republic of Korea, where mobile emission sources are concentrated. The NO2 and O3 concentrations in the CFD simulation are evaluated with data measured at a roadside air quality monitoring station, showing better agreements than those in the CMAQ simulation. The NO2 and O3 concentration fields exhibit high spatial variabilities in the high-rise building area. The spatial variabilities near the surfaces are strongly associated with the heterogeneity of mobile emission on roads, whereas the spatial variabilities near the top of high-rise buildings are strongly associated with the heterogeneity of building geometry. The average NO2 and O3 concentrations (46 and 30 ppb, respectively, at z ¼ 30 m) near the surfaces are considerably different from the NO2 and O3 concentrations in the CMAQ simulation (17 and 44 ppb, respectively, at z ¼ 30 m), implying the insufficient urban surface representation in the CMAQ simulation. The heterogeneity of building geometry is found to enhance the vertical pollutant transport, whereas the heterogeneity of mobile emission is found to confine emitted pollutants near the surfaces. When the vertical mixing is efficient, the O3 concentration decreases in substantial vertical ranges with the same amount of NOx emission. The integrated urban air quality modeling system realistically simulates the spatial variabilities associated with the local influences of building geometry and mobile emission. This is a promising modeling approach that accounts for multiscale influences on urban air quality.

Keywords: *Urban air quality; Integrated urban air quality modeling system; CFD model; WRF model; CMAQ model; High-rise building area.*

Non-sulfate sulfur in fine aerosols across the United States: Insight for organosulfate prevalence

Kabindra M. Shakya, Richard E. Peltier

Source: *Atmospheric Environment 100 (2015) 159e166*

We investigated the discrepancies in long-term sulfur measurements from 2000 to 2012 by two separate speciation methods, X-ray fluorescence (XRF) spectroscopy and ion chromatography (IC) across the United States (334 sites). Overall, there was a good correlation between sulfur measurements by XRF spectroscopy and IC (R 0.90 for most of the sites). However, the inorganic sulfate measured by ion chromatography was not sufficient to account for all the sulfur measured by XRF spectroscopy at many of the sites. Discrepancies were observed with the high ratios of sulfur measured by XRF spectroscopy to that by IC. Such high ratios also exhibited seasonal variation, and differed across land use types; significant differences occurred at locations classified as forest, agriculture, and mobile, but not in locations classified as commercial, desert, industrial, and residential. On average, the excess, or non-sulfate, sulfur (unmeasured organic sulfur or other inorganic species of sulfur) was variable and observed as high as ~13% of organic carbon and ~2% of PM2.5. The contribution of such assumed organosulfur was larger in the eastern region than other geographical locations in the United States. Besides the temporal and spatial trends, the additional sulfur was found to be related to other factors such as aerosol acidity and emission sources. The results suggest that these unmeasured sulfur species could have significant contribution to aerosol burden, and the understanding of these could help to control PM2.5 levels and to assess other effects of sulfur aerosols.

Size-resolved effective density of urban aerosols in Shanghai

Zi Yin, Xingnan , Shuqin Jiang, Ye Tao, Yang Shi, Xin Yang, Jianmin Chen

Source: *Atmospheric Environment 100 (2015) 133e140*

Size-resolved effective density of 50e400 nm urban particles was determined by a TDMAeAPM system in Shanghai during wintertime. The average effective density ranged from 1.36 to 1.55 g cm3 , increasing with the particle diameter. The size dependent increase of density was consistent with previous hygroscopic measurements. We attributed the increase in density to the condensation of hygroscopic secondary aerosols and large massive organics. The diurnal variation of effective density was pronounced for smaller particles. A similar diurnal pattern was observed between particle density and the contribution of secondary NH4NO3 and (NH4)2SO4 to PM1.0, suggesting that density change in response to particle compositions. The effective density of Aitken mode particles had a considerable increase during the NPF event, in agreement with the contribution of sulfate. Particle mass distribution was derived from particle number distribution in combination with effective density. PM0.6 was highly correlated with PM1.0, revealing that secondary aerosols tend to condense on smaller particles.

Keywords: *Effective density; Atmospheric aerosol; DMAeAPM system; Yangtze River Delta.*

Seasonal trends in the composition and ROS activity of fine particulate matter in Baghdad, Iraq

Samera Hussein Hamad , Martin Merrill Shafer , Ahmed K.H. Kadhim , Sabah M. Al-Omran , James Jay Schauer

Source: *Atmospheric Environment 100 (2015) 102e110*

Baghdad suffers from severe atmospheric particulate matter (PM) pollution and has limited infrastructure to monitor and control PM-pollution. To help better understand the nature of particulate matter in Baghdad, daily PM2.5 samples were collected every 6th day from September, 2012 to September, 2013. The samples were analyzed for chemical composition and cellular oxidative stress activity using a macrophage-based assay. The annual average PM2.5 concentration was 50 ± 19 mg m3 , and was comprised of approximately 28% crustal materials, 26% organic carbon (OC), 17% sulfate, 12% elemental carbon (EC), and 8.0% ammonium ion. No clear seasonal trend was observed for the total PM2.5 mass and PM2.5 OC, but EC exhibited higher concentrations in the warmer months, likely due to the extensive use of electric generators operated by diesel and gasoline for cooling. April showed the lowest levels of both EC and OC compared with other months due to both sand and rainstorm events which led to increased deposition and dispersion of local emissions. Concentrations of nitrate ion were low in all seasons due to the high temperatures and low humidity, but slightly higher levels were observed in the cooler months of winter. The oxidative stress (reactive oxygen species (ROS)) activity (59 ± 35 mg Zymosan equivalents m3) of the PM was relatively lower than in other studied areas. Association between the water soluble PM constituents and the oxidative activity was investigated using a multi-linear regression model which showed no strong relationships between ROS activity and the water soluble components of PM2.5, but a moderate correlation of water soluble organic carbon from biomass burning (WSOC-BB) was observed (R2 ¼ 0.52). Biomass burning PM has been shown to be an important contributor to ROS activity in other published studies, but additional work is needed to better understand the sources leading to the ROS activity in Baghdad.

Keywords: *Chemical composition; Fine particles; ROS-activity; Baghdad-Iraq.*

The effects of emission sources and meteorological factors on sulphur dioxide concentration of Great Isfahan, Iran

Fahimeh Hosseiniebalam , Omid Ghaffarpasand

Source: *Atmospheric Environment 100 (2015) 94e101*

The great Isfahan has experienced an almost fast industrialization during the last years. The different factories and industries near that, cause one of the important environmental problems, air pollution, which has not enough investigated before in this area. The hourly, diurnal and seasonal variations of SO2 concentration as one of the most dangerous air pollutants, are studied to clarify the rule of industry on the air pollution problem. The data had been measured continuously from April 2006 to March 2007 at two stations, Lale & Azadi. The air pollution concentrations in an urban area have a close relationship with meteorological factors. Hence, the variation of SO2 concentration is analysed respect to the meteorological factors such as temperature, relative humidity, wind speed, solar radiation, and pressure. Moreover, the studied air pollutant is also statistically investigated through correlation analysis and stepwise multiple linear regression equation. It was observed that electric power plant near the Isfahan, Montazeri, has significant effects on the SO2 concentration in the east and north of Isfahan. Long-term pattern of Isfahan winds which is westerly during the winter and spring, and easterly during the summer and autumn, was recognized as one of another

important factors influenced the SO2 concentration variations. It is also achieved that meteorological factors have considerable contribution, R2 ¼ 52%, on the SO2 concentration variation and temperature has largest effect among the others.

Keywords: *Air pollution; Sulphur dioxide; Isfahan; Meteorological factors; Statistical analysis.*

Influence of springtime biomass burning in South Asia on regional ozone (O3): A model based case study

Chinmay Jena , Sachin D. Ghude , G.G. Pfister , D.M. Chate , Rajesh Kumar , G. Beig , Divya E. Surendran , S. Fadnavis , D.M. Lal

Source: *Atmospheric Environment 100 (2015) 37e47*

In this study, for the first time, the influence of springtime (MAM) biomass burning in South Asia on regional ozone (O3) distribution has been evaluated using a regional chemical transport model (WRFChem) and the Fire Inventory from NCAR (FINNv1). Model results are compared with satellite retrievals of tropospheric column amounts of carbon monoxide (CO) from MOPITT and nitrogen dioxide (NO2) from OMI. With daily varying emissions, the model captures reasonably well the satellite-derived temporal variations in CO and NO2 (index of agreement (R) for CO is 0.83 and for NO2 is 0.76), indicating the effectiveness of the model in estimating the overall fire impact on a regional scale. Simulated tropospheric NO2 concentration shows better agreement with the magnitude of observed NO2 when FINNv1 NOx emissions are reduced by a factor of 2.2 over the model domain. A clear increase in CO and NO2 levels over Burma (35e60%), Central India (15e30%), the Indo-Gangetic (15e25%) region and the Bay of Bengal (15e40%) are simulated with fire emissions. The model results are also used to quantify the net O3 production from fires. Calculated O3 productions are up to 4 ppb h1 over inland and up to 0.1 ppb h1 over marine regions respectively. Our model-based analysis yields average enhancement ratios DO3/DCO of 0.12 ppbv/ppbv and a total O3 production of about 3.5 Tg from South Asia during the spring season. The findings demonstrate that the springtime fire emissions in South Asia have a noticeable impact on the O3 in this region.

Keywords: *Surface ozone; Fire emissions; FINNv1; WRF-Chem; OMI; MOPITT; South Asia.*

Combined effects of nitrogen fertilization and biochar on the net global warming potential, greenhouse gas intensity and net ecosystem economic budget in intensive vegetable agriculture in southeastern China

B. Li , C.H. Fan, H. Zhang, Z.Z. Chen, L.Y. Sun, Z.Q. Xiong

Source: *Atmospheric Environment 100 (2015) 10e19*

Field experiments were conducted to determine the effects of nitrogen (N) fertilization and biochar addition on the net global warming potential (net GWP), greenhouse gas intensity (GHGI) and net ecosystem economic budget (NEEB). These experiments were conducted in an intensive vegetable field with 4 consecutive vegetable crops in 2012 and 2013 in southeastern China. The experiment was conducted with a 32 factorial design in triplicate at N fertilizer rates of 0, 1475, 1967 kg N ha1 and biochar rates of 0, 20, and 40 t ha1. Although CH4 emissions were not obviously affected by N fertilization, N2O emissions increased by 27.2e116.2% and the net GWP increased by 30.6e307.2%. Consequently, the GHGI increased

significantly, but vegetable yield and the NEEB did not improve. Furthermore, biochar amendments did not significantly influence CH4 emissions, but significantly decreased the N2O emissions by 1.7e25.4%, the net GWP by 89.6e700.5%, and the GHGI by 89.5e644.8%. In addition, vegetable yields significantly increased by 2.1e74.1%, which improved the NEEB. Thus, N fertilization did not increase vegetable yields or the NEEB. However, N fertilization did increase the net GWP and GHGI. In contrast, biochar additions resulted in lower N2O emissions and net GWP and GHGI, but increased vegetable yield and the NEEB in the intensive vegetable production system. Therefore, appropriate biochar amendment should be studied.

Keywords: *Vegetable agriculture; Biochar; Net global warming potential (net GWP); Greenhouse gas intensity (GHGI); Net ecosystem economic budget (NEEB).*

Characterization of organic compounds in the PM2.5 aerosols in winter in an industrial urban area

P. Mikuska, K. Krumal, Z. Vecera

Source: *Atmospheric Environment 105 (2015) 97e108*

Urban aerosol particles in the fine fraction (PM2.5) were collected over the sampling interval of 24-hrs on quartz filters in Ostrava (Czech Republic) in winter 2012. The collected aerosols were analysed for selected organic compounds that serve as tracers of the main emission sources. The campaign was carried out under two different meteorological scenarios. During a smog episode due to high concentration of aerosols in the first part of the campaign, high concentrations of PM2.5 aerosols (mean concentration of 159 mg m3) and PAHs bound to particles were found, while in the second part of the campaign, after the smog episode, much lower concentrations of aerosols (mean concentration of 49.3 mg m3) were observed. Analysis of the source specific molecular markers and diagnostic ratios of PAHs, hopanes and alkanes imply that combustion of coniferous wood and coal in residential heating and traffic belong to the biggest emission sources of organic compounds associated with the PM2.5 aerosols collected during the winter campaign in Ostrava-Radvanice. The industrial production of coke and iron is another important contributor to the concentrations of BaP and other carcinogenic PAHs. The level of air pollution in Ostrava-Radvanice was considerably determined by the overall meteorological situation during the campaign. The highest concentrations of PM2.5 and bound organic compounds were found during a smog episode characterized by poor dispersion conditions due to temperature inversion and weak north-eastern wind, while during the subsequent period characterized by north-west or west wind, the concentrations of aerosols and bound organic compounds were much lower. Transboundary transport of polluted air from the Silesian Voivodeship could have contributed to the pollution in the Moravian-Silesian region during the smog episode.

Keywords: *PM2.5 aerosol; Organic compounds; Emission sources; Diagnostic ratios; Ostrava.*

On-road emission characteristics of VOCs from rural vehicles and their ozone formation potential in Beijing, China

Zhiliang Yao , Bobo Wu , Xianbao Shen , Xinyue Cao , Xi Jiang , Yu Ye , Kebin He

Source: *Atmospheric Environment 105 (2015) 91e96*

This paper is the second in a series of papers aimed at understanding volatile organic compound (VOC) emissions from motor vehicles in Beijing using on-board emission measurements, focusing specifically on

rural vehicles (RVs). In this work, 13 RVs, including 6 different 3-wheel (3-W) RVs and 7 different 4- wheel (4-W) RVs, were examined using a portable emissions measurement system (PEMS) as the vehicles were driven on predesigned fixed test routes in rural areas of Beijing. Overall, 50 VOC species were quantified in this study, including 18 alkanes, 5 alkenes, 11 aromatics, 13 carbonyls and 3 other compounds. The average emission factor (EF) of the total VOCs for the 4-W RVs based on the distance traveled was 326.2 ± 129.3 mg/km, which is 2.5 times greater than that of the 3-W RVs. However, the VOC emissions for the 3-W RVs had higher EFs based on their CO2 emissions due to the different fuel economies of the two types of RVs. Formaldehyde, toluene, acetaldehyde, m-xylene, p-xylene, isopentane, benzene, ethylbenzene, n-pentane, 2-methoxy-2-methylpropane and butenal were the dominant VOC species from the RVs, accounting for an average of 68.6% of the total VOC emissions. Overall, the RVs had high proportions of aromatics and carbonyls. The ozone formation potentials (OFPs) were 670.6 ± 227.2 and 1454.1 ± 643.0 mg O3/km for the 3-W and 4-W RVs, respectively, and approximately 60%e70% of the OFP resulted from carbonyls. We estimated that the 3-W and 4-W RVs accounted for approximately 50% and 10%, respectively, of the total OFP caused by diesel vehicles (including diesel trucks and RVs) in Beijing in 2012. Thus, more attention should be given to VOC emissions and their impact on ozone formation.

Keywords: *Rural vehicles; VOCs; Emission factors; Emission characteristics; PEMS.*

Evolution of on-road vehicle exhaust emissions in Delhi

Rahul Goel, Sarath K. Guttikunda

Source: *Atmospheric Environment 105 (2015) 78e90*

For a 40-year horizon (1990e2030), on-road vehicle exhaust emissions were evaluated, retrospectively and prospectively, for the largest urban agglomeration in India e the Greater Delhi region with a combined population of 22 million in 2011 (Delhi along with Ghaziabad, Noida, Greater Noida, Faridabad and Gurgaon). Emissions of particulate matter, sulfur dioxide, carbon monoxide and volatile organic compounds (VOCs) reached their peak during late 1990s through early 2000s after which they reduced significantly through year 2012. On the other hand, nitrogen oxides (NOx) and carbon dioxide show an increasing trend. The most reduction in emissions between 1998 and 2012 occurred as a result of implementation of four sets of vehicular emission standards, removal of lead, reduction of sulfur content, mandatory retirement of older commercial vehicles, and conversion of diesel and petrol run public transport vehicles to compressed natural gas. In addition, changes in the vehicular technology have also contributed to controlling emissions especially in case of auto-rickshaws and motorized two-wheelers, which changed from two-stroke to four-stroke. The rising trend of NOx along with the presence of VOCs indicates increasing tendency to form ground-level ozone and as a result, smog in the region. We predict that the current regime of vehicle technology, fuel standards, and high growth rate of private vehicles, is likely to nullify all the past emission reductions by the end of 2020s.

Keywords: *Emissions inventory; Transport emissions; India Fuel standards.*

Particulate matter deposited on leaf of five evergreen species in Beijing, China: Source identification and size distribution

Yingshi Song , Barbara A. Maher , Feng Li , Xiaoke Wang , Xiao Sun , Hongxing Zhang

Source: *Atmospheric Environment 105 (2015) 53e60*

Airborne particulate matter (PM) has become a serious problem, and urban plants can play important roles in reducing PM concentrations in the air. The morphology, size, and elemental composition of PM on tree leaves (five evergreen species) from Beijing, China, were obtained, together with number density of PM size fraction, by using scanning electron microscopy (SEM) and energy dispersive X-rays (EDX). The rinse and weigh method was used to characterize PM in three size categories (0.2e2.5 mm, 2.5 e10 mm, and 10e100 mm). The results showed that PM up to 2 mm can get into the stomatal cavity, and the most furrowed areas of the leaf surfaces were sites of maximum PM deposition. The leaf-deposited PM mainly comprised C, O, Si, and Fe. The number of particles per leaf per cm2 was 1.95 107 , and 96% of the particles were less than 2.5 mm. The mass concentration was 148.44 mg/cm2 , and PM2.5 comprised only 2.09% by weight while PM larger than 10 mm comprised 79%. Juniperus formosana was most effective at mitigating airborne PM on the leaf scale. Pinus bungeana accumulated the most PM on the tree scale. The results showed that urban plants can play important roles in mitigating urban airborne PM.

Keywords: *Particulate matter; Evergreen species; Particle number; Particle composition; Particle mass concentrations.*

Black carbon emissions reductions from combustion of alternative jet fuels

Raymond L. Speth, Carolina Rojo, Robert Malina, Steven R.H. Barrett

Source: *Atmospheric Environment 105 (2015) 37e42*

Recent measurement campaigns for alternative aviation fuels indicate that black carbon emissions from gas turbines are reduced significantly with the use of alternative jet fuels that are low in aromatic content. This could have significant climate and air quality-related benefits that are currently not accounted for in environmental assessments of alternative jet fuels. There is currently no predictive way of estimating aircraft black carbon emissions given an alternative jet fuel. We examine the results from available measurement campaigns and propose a first analytical approximation (termed 'ASAF') of the black carbon emissions reduction associated with the use of paraffinic alternative jet fuels. We establish a relationship between the reduction in black carbon emissions relative to conventional jet fuel for a given aircraft, thrust setting relative to maximum rated thrust, and the aromatic volume fraction of the (blended) alternative fuel. The proposed relationship is constrained to produce physically meaningful results, makes use of only one free parameter and is found to explain a majority of the variability in measurements across the engines and fuels that have been tested

Keywords: *Black carbon; Alternative fuels; Aircraft emissions.*

Methane uptake and emissions in a typical steppe grazing system during the grazing season

Xiaoya Wang, Yingjun Zhang, Ding Huang, Zhiqiang Li, Xiaoqing Zhang

Source: *Atmospheric Environment 105 (2015) 14e21*

This study investigated the effects of livestock grazing on CH4 emissions by testing six grazing conditions at Guyuan State Key Monitoring and Research Station of Grassland Ecosystem (China) in 2011 and 2012. Under all grazing systems, steppe soils were measured to be CH4 sinks. The uptake of CH4 by grassland was primarily determined by topsoil (7 cm) temperature and soil (0e7 cm) moisture in grassland at short-term grazing and non-grazing. The cumulative uptake of CH4 during the grazing period for all conditions was 0.88e3.23 kg hm2 CH4, and the highest level was observed in the continuously moderate grazing condition. Reducing grazing stocking in the short-term did not significantly change the uptake of CH4 when compared with continuously heavy grazing condition. Enteric CH4 emissions were not significantly affected by the grazing period or conditions. The uptake of CH4 by grassland soil offset 3.1e8.6% of the CH4 emissions from the grazing sheep and was most effective at the continuously moderate grazing condition. These findings imply that continuously moderate grazing is the best approach considered here for optimizing the soil as a sink for atmospheric CH4.

Keywords: *Typical steppes; Seasonal grazing; Sheep Methane; Uptake and emission.*

Elemental composition and radical formation potency of PM10 at an urban background station in Germany in relation to origin of air masses

Bryan Hellack , Ulrich Quass , Henning Beuck , Gabriele Wick , Wilhelm Kuttler , Roel P.F. Schins , Thomas A.J. Kuhlbusch

Source: *Atmospheric Environment 105 (2015) 1e6*

At an urban background station in Mülheim-Styrum, North Rhine Westphalia, Germany, a set of 75 PM10 samples was collected over a one year period, followed by analyses for mass, chemical composition and hydroxyl radical (OH) formation potency. Additionally, the origin of air masses for the sampling days was calculated by 48-h backward trajectories, subdivided into the four cardinal sectors. Significant lower PM10 mass concentrations were observed for summertime air masses from the west compared to the other seasons and cardinal sectors. For the OH formation potency higher values were detected if air masses originate from east and south, thus predominantly being of continental origin. From the elevated OH formation potencies in fall and winter a seasonal trend with low potencies in summers is assumed. Furthermore, source apportionment was performed by a positive matrix factor analysis, separating seven plausible factors which could be attributed to mineral dust, secondary nitrate, industry, non-exhaust traffic, fossil fuel combustion, marine aerosol and secondary aerosol factors. The intrinsic OH formation potency was found to be associated mainly with the fossil fuel combustion factor (45%) and industry factor (22%).

Keywords: *Particulate matter; EPR; DMPO; ROS; Hydroxyl radical; Source apportionment.*

Review on urban vegetation and particle air pollution e Deposition and dispersion

Sara Janhall

Source: *Atmospheric Environment 105 (2015) 130e137*

Urban vegetation affects air quality through influencing pollutant deposition and dispersion. Both processes are described by many existing models and experiments, on-site and in wind tunnels, focussing e.g. on urban street canyons and crossings or vegetation barriers adjacent to traffic sources. There is an urgent need for well-structured experimental data, including detailed empirical descriptions of parameters that are not the explicit focus of the study. This review revealed that design and choice of urban vegetation is crucial when using vegetation as an ecosystem service for air quality improvements. The reduced mixing in trafficked street canyons on adding large trees increases local air pollution levels, while low vegetation close to sources can improve air quality by increasing deposition. Filtration vegetation barriers have to be dense enough to offer large deposition surface area and porous enough to allow penetration, instead of deflection of the air stream above the barrier. The choice between tall or short and dense or sparse vegetation determines the effect on air pollution from different sources and different particle sizes.

Keywords: *Urban; Air quality; Vegetation; Deposition; Dispersion; Particle size.*

Associations between personal exposures to VOCs and alterations in cardiovascular physiology: Detroit Exposure and Aerosol Research Study (DEARS)

Hwashin Hyun Shin, Paul Jones, Robert Brook, Rob Bard, Karen Oliver, Ron Williams

Source: *Atmospheric Environment 104 (2015) 246e255*

An adult cohort consisting of 63 participants engaged in the US EPA's recent Detroit Exposure and Aerosol Research Study (DEARS) and a University of Michigan cardiovascular sub-study conducted during summer and winter periods over 3 years between 2004 and 2007 (5 seasons in total). Through all participants' wearing of a monitoring vest, personal exposures to various air pollutants were measured. Purpose: The study objective was to identify the association between personal exposure to volatile organic compounds (VOCs) and six cardiovascular health endpoints in an adult non-smoking cohort of the DEARS. Methods: Twenty five VOCs were collected using the DEARS exposure vest incorporating advanced passive diffusion tube. Six cardiovascular health endpoints including systolic and diastolic blood pressure (SBP, DBP), heart rate (HR), brachial artery diameter (BAD), brachial artery flow-mediated dilatation (FMD) and nitroglycerin-mediated arterial dilatation (NMD) were collected by novel, in-home clinical examinations. To reduce the number of personal VOCs highly correlated to each other, a principal component analysis was conducted. Accounting for more individual variations in association between personal VOCs and cardiovascular health endpoints, a linear mixed model was employed, where cohort subjects were not necessarily to have the same linear association. Results: Applying the principal component analysis, 3 out of 12 components were retained, which appeared to involve a petroleum source (1st component), a 1-3 butadiene source (2nd component), and an ambient (Freon) source (3rd component). Petroleum related VOCs were associated with increases in FMD and showed mixed relationships with NMD (lag 0e1 day increased NMD, lag 2 days decreased NMD). Butadiene related VOCs decreased DBP but increased HR and BAD. Freon (ambient background) related VOCs increased HR. Conclusions: We observed mixed and variable results in this first study to evaluate the relationships between personal exposures to VOCs of

different origin on cardiovascular physiology. In sum, the findings suggest that VOCs may have rapid impacts upon the human cardiovascular system; however, understanding the health implications and the mechanisms responsible is beyond the scope of this investigation.

Keywords: *Cardiovascular; Exposure assessment; Volatile organic compounds; Principal component analysis; DEARS; Linear Mixed model.*

Long term observations of PM2.5-associated PAHs: Comparisons between normal and episode days

Jia Wang, Xiao Li, Nan Jiang, Wenkai Zhang, Ruiqin Zhang , Xiaoyan Tang

Source: *Atmospheric Environment 104 (2015) 228e236*

The pollution characteristic of fine particular matter (PM2.5) and associated polycyclic aromatic hydrocarbons (PAHs) are currently drawing a great deal of interest because of their influence on environment and health. In this study, PM2.5 was collected from 2011 to 2013 (n ¼ 188) in a suburban area of Zhengzhou, China. 16-PAHs were analyzed to determine the concentration, seasonal variation and potential sources during normal days and episode events. The total mass of 16 PAHs and PM2.5 were in the range of 7e961 ng m3 and 55e697 mg m3 , with a 3-year average of 174 ng m3 and 194 mg m3 respectively. Winter is most polluted for both PM2.5 and PAHs. Average PAH and PM2.5 concentrations during three episode events are 454 ng m3 and 453 mg m3 , respectively, much higher than values during normal days (299 ng m3 and 180 mg m3 , respectively). Ratios of S16PAH/PM2.5 varied with seasons and concentrations of PM2.5, but showed a negative correlation with PM2.5 concentrations during episode events. The dominant components of PAHs are Benzo[b]fluoranthene, Chrysene, Fluoranthene, and Benzo[k]fluoranthene, Benz[a]anthracene, Pyrene, Indeno(1,2,3-cd)pyrene and their total concentrations vary from 27 to 342 ng m3 , accounting for 58e82% (average ¼ 73%) of 16 PAHs. The Benzo[a] pyrene (Bap) concentration obtained was 9.4 ng m3 (3-year average), exceeding nearly one order of magnitude of ambient air BaP standard (annual average: 1.0 ng m3) in China. Diagnose ratios and Positive Matrix Factorization results show that coal combustion, vehicles, coking plant, and biomass burning are main sources for PAHs in this area. The high concentrations of PM2.5 and PAHs, especially during episode events, reflected a potential health problem for nearby public and the necessity of air pollution control for both stationary and mobile sources.

Keywords: *PM2.5; PAHs; Episode events; PMF; Diagnose ratios; BaP.*

Wintertime characteristics of aerosols at middle Indo-Gangetic Plain: Impacts of regional meteorology and long range transport

M. Kumar, S. Tiwari, V. Murari, A.K. Singh, T. Banerjee

Source: *Atmospheric Environment 104 (2015) 162e175*

To develop a coherent picture of possible origin of Asian aerosol, transport and meteorological interaction; wintertime aerosol (January, 1 to March, 31, 2014 (n ¼ 90)) were measured in middle IGP in terms of aerosol mass loading, optical properties, altitudinal distributions and both high and low altitude transportation. Both space-borne passive (Aqua and Terra MODIS) and active sensor (CALIPSO-CALIOP) based measurements were concurrently used over the selected transect (25 100 e25 190 N and 82540 e8340

E). Exceptionally high aerosol mass loading was recorded for PM10 (233 ± 58.37 mg m3) and PM2.5 (138 ± 47.12 mg m3). Daily variations of PM2.5/PM10 persist in a range of 0.25e0.97 (mean ¼ 0.60 ± 0.14; n ¼ 90) and were in accordance to computed Angstrom exponent (0.078e1.407; mean: 1.002 ± 0.254) explaining concurrent contribution of both PM2.5 and PM10 for the region. Space borne (Aqua MODISAOD: 0.259e2.194) and ground based (MTP-AOD: 0.066e1.239) AODs revealed significant temporal variability and moderate association in terms of PM10 (MODIS-AOD: 0.46; MTP-AOD: 0.56) and PM2.5 (MODIS-AOD: 0.54; MTP-AOD: 0.39). Varying association of AOD and aerosol mass loading was also explained in terms of meteorological variables. CALIPSO altitude-orbit-cross-section profiles revealed presence of non-spherical coarse particulates (altitude: 1.2e5.4 km) and dominance of spherical fine particulates (altitude: 0.1e4.2 km). Contribution of trans-boundary aerosols transportation to mass loadings at middle IGP were recognized through lagrangian particle dispersion model, synoptic vector wind profiles at different geopotential heights and satellite images.

Keywords: *Aerosol; Aerosol optical depth; CALIPSO; Indo-Gangetic Plain; MODIS; Trans-boundary.*

Total and size-resolved particle number and black carbon concentrations in urban areas near Schiphol airport (the Netherlands)

M.P. Keuken, M. Moerman , P. Zandveld, J.S. Henzing , G. Hoek

Source: *Atmospheric Environment 104 (2015) 132e142*

The presence of black carbon, and size-resolved and total particle number concentrations (PNC) were investigated in the vicinity of Schiphol airport in the Netherlands, the fourth busiest airport in Europe. Continuous measurements were conducted between March and May 2014 at Adamse Bos, located 7 km from Schiphol, and in 2012 at Cabauw, a regional background site 40 km south of Schiphol. No signifi- cantly elevated black carbon levels were found near Schiphol. However, PNC increased during periods in which the wind direction was from Schiphol: at Cabauw by 20% and at Adamse Bos by a factor of three, from 14,100 (other wind directions) to 42,000 # cm3 between 06.00 and 23.00. The size distribution of Schiphol-related PNC was dominated by ultrafine particles, ranging from 10 to 20 nm. Four relevant particle number (PN) emission sources at Schiphol were identified as being responsible for the elevated PNC levels at Adamse Bos: take-off and climb-out on the Kaagbaan and Aalsmeerbaan runways, planes waiting at the gates, and landing on the Buitenveldertbaan runway. PN emissions from road traffic at and near the airport were less important than air traffic. The exposure to Schiphol-related PNC in urban areas northeast of Schiphol in Amsterdam and Amstelveen was estimated for 2012 using a Gaussian Plume model. The results showed that a considerable number of the 555,000 addresses in the modelling domain were exposed to elevated PNC. For example: 45,000 addresses suffered long-term exposure to an additional annual background PNC of 5e10,000 # cm3 originating from Schiphol and 60,000 addresses suffered short-term exposure (14% of the time) of additional 10e15,000 # cm3 originating from Schiphol. Further research on emission sources and the dispersion of PN is recommended and may support future studies on eventual health effects.

Keywords: *Airport emissions;Ultrafine particles; Black carbon; Dispersion modelling.*

Particulate concentrations during on-farm combustion of energy crops of different shapes and harvest seasons

S. Fournel , J.H. Palacios, R. Morissette, J. Villeneuve, S. Godbout , M. Heitz , P. Savoie

Source: *Atmospheric Environment 104 (2015) 50e58*

The increasing energy costs and environmental concerns of farms have motivated the growing interest of agricultural producers in using farm-grown biomass as a substitute to fossil fuels for heat production. However, the use of non-woody biomass is facing challenges due to variability regarding chemical composition and fuel properties that may induce problems during combustion such as particulate matter (PM). The aim of this work was to measure and compare total PM concentrations during on-farm combustion of wood and four agricultural crops: short-rotation willow, switchgrass, miscanthus and reed canary grass. In order to study the influence of physicochemical properties, different shapes (pellets, chips and chopped grasses) and harvest seasons (fall and spring) were also evaluated. In this context, a representative small-scale (29 kW), multi-fuel boiler for light commercial use was utilized. The boiler was also non-catalytic so that the burning took place in a single combustion chamber. Overall, twelve different biomass fuels were tested and each product was burned three times. Mean PM concentration of wood (416 mg Nm3 at 7 vol% O2) was lower than that of the four dedicated energy crops (505 e1417 mg Nm3 at 7 vol% O2). However, because of the high variability between the experiments, no statistical significance was observed at $P > 0.1$ level except in one case. The PM amounts were high compared to literature data and Quebec's environmental regulation mainly because of the boiler system used. Except for willow, pelletized products decreased PM levels by 22e52% compared to chopped materials. Bulky biomass of low density was unable to reach steady-state conditions and produced compounds associated with incomplete combustion including PM. Spring-harvested biomass fuels showed a PM reduction up to 48% compared to fall-harvested crops. This was likely due to a 20e60% decrease of several chemical elements in the biomass, namely S, Cl, K and P which are the main constituents of fly ash.

Keywords: *Agricultural biomass; Energy crops; Combustion; Particulate matter;Physicochemical properties.*

Lung burden and deposition distribution of inhaled atmospheric urban ultrafine particles as the first step in their health risk assessment

Imre Salma, Peter Füri, Zoltan N emeth, Imre Balash azy, Werner Hofmann , Arp ad Farkas

Source: *Atmospheric Environment 104 (2015) 39e49*

Realistic median particle number size distributions were derived by a differential mobility particle sizer in a diameter range of 6e1000 nm for near-city background, city centre, street canyon and road tunnel environments in Budapest. Deposition of inhaled particles within airway generations of an adult woman was determined by a stochastic lung deposition model for sleeping, sitting, light and heavy exercise breathing conditions. Deposition fractions in the respiratory tract were considerable and constant for all physical activities with a mean of 56%. Mean deposition fraction in the extra-thoracic region averaged for the urban environments was decreasing monotonically from 26% for sleeping to 9.4% for heavy exercise. The mean deposition fractions in the tracheobronchial region were constant for the physical activities and urban environments with an overall mean of 12.5%, while the mean deposition fraction in the acinar region averaged for the urban locations increased monotonically with physical activity from 14.7% for sleeping to 34% for heavy exercise. The largest contribution of the acinar deposition to the lung deposition was 75%.

The deposition rates in the lung were larger than in the extra-thoracic region, and the deposition rate in the lung was increasingly realised in the AC region by physical activity. It was the extra-thoracic region that received the largest surface density deposition rates; its loading was higher by 3 orders of magnitude than for the lung. Deposition fractions in the airway generations exhibited a distinct peak in the acinar region. The maximum of the curves was shifted to peripheral airway generations with physical activity. The shapes of the surface density deposition rate curves were completely different from those for the deposition rates, indicating that the first few airway generations received the highest surface loading in the lung.

Keywords: *Exposure assessment; Respiratory deposition; Surface density deposition; Nanoaerosol Stochastic; lung deposition model.*

On the severe haze in Beijing during January 2013: Unraveling the effects of meteorological anomalies with WRF-Chem

Li Zhang, Tao Wang, Mengyao Lv, Qiang Zhang

Source: *Atmospheric Environment 104 (2015) 11e21*

Despite the stringent emission reduction measures implemented in Beijing over the past decade, a series of unprecedentedly severe haze events hit this megacity in January 2013. It is of great interest to find out the cause so as to provide a scientific basis for refining emission control measures. In the present study, we examine long-term (2000e2014) surface meteorological observations and simulate four recent winter haze episodes in 2010e2014 using a coupled meteorology-chemistry model (WRF-Chem). In addition to confirming the large-scale meteorological anomalies in northern China, the analysis of local meteorological parameters revealed that January 2013 had more frequent sustained weak southerly winds and high relative humidity in Beijing. Comparison of WRF-Chem simulations of the four episodes unambiguously shows that the combination of anomalously strong contribution of local and regional sources resulted into the extreme event in 2013: meteorological anomalies caused thicker temperature inversion, lower boundary layer, and hence stronger local accumulation of PM2.5 in urban Beijing (212 mg m3 in 2013 case vs. 112e114 mg m3 in historical cases); longer duration of southerly winds transported more pollutants to urban area (107 mg m3 vs. 38e82 mg m3) from eastern China. Our study also suggests that, although the emissions in Beijing have been decreased, they were still the major contributor (61e77%) to surface-layer PM2.5 over the urban area in recent winter episodes. Since adverse weather conditions such as those in January 2013 are uncontrollable, to alleviate severe haze pollution, Beijing must further strengthen its emission reduction measures and similar control should be extended to the entire eastern China.

Keywords: *Haze; Beijing; Meteorological anomaly; WRF-Chem; PM2.5.*

A trans-Pacific Asian dust episode and its impacts to air quality in the east coast of U.S

Yonghua Wu, Zaw Han, Chowdhury Nazmi, Barry Gross, Fred Moshary

Source: *Atmospheric Environment 106 (2015) 358e368*

The transport of an intense trans-Pacific Asian dust episode to the Northeast United States (U.S.) is studied using a synergistic suite of observations and models including a ground-based lidar, AERONETsunphotometer, satellite measurements and global aerosol transport model for New York City

(40.821N, 73.949W). During the dust intrusion on March 17e19, 2010, the multi-wavelength lidar observations indicate dense dust plumes (~80% of total column AOD) located between 3 and 9 km altitudes with the lower layer mixing toward the planetary boundary layer (PBL). The column AOD shows a significant increase from 0.08 to 0.38 at 532-nm while the Angstrom exponent indicates a decrease from 1.3 to 0.7. The linear particle depolarization ratio is estimated to be 0.1e0.15 and the single-scattering-albedo shows the dust-like spectral dependence with the value of 0.9e0.95 at 440-nm. The NOAA-NCEP reanalysis and HYSPLIT model indicate that this long-range transport is driven by the strong western jets and travels for 6 days to arrive the U.S. east coast versus the western and northern U.S. Both the NAAPS aerosol transport model and satellite CALIPSO observations for multiple orbits clearly illustrate the dust-dominated aerosol along the transport path. In addition, coincident increase of both particulate matter (PM) and fine soil concentrations indicate the potential impact of transported dust on the air quality that is found to be associated with a large area of sinking air along the U.S. east coast.

Keywords: *Asian dust; Transport; Lidar; Particulate matter; Air quality.*

Long-term trend of NO2 in major urban areas of Korea and possible consequences for health

Hang Thi Nguyen, Ki-Hyun Kim, Chuljin Park

Source: *Atmospheric Environment 106 (2015) 347e357*

Long-term trend of the atmospheric NO2 was analyzed using ambient monitoring data collected from seven major cities in Korea over two decades (1989e2010). In light of the notable environmental policies initiated since June 2000, these NO2 data were also evaluated after dividing the entire study period into period I (1989e1999) and period II (2000e2010). Accordingly, the mean concentrations of NO2 in five out of seven cities in period II were higher by 1e26% than period I. This recognizable increase in period II is likely to reflect the effect of increasing consumption rates in primary energy (e.g., petroleum and LNG). An examination of the seasonal trend of NO2 consistently indicates the highest concentrations occurred during winter because of the combined effects of the anthropogenic emission and meteorological conditions. A health risk assessment of our data indicated that the NO2 exposure (to adults, children, and infants) increased from period I to period II. Also, the long-term trends of NO2 were analyzed based on the seasonal ManneKendall test and the Sen's slopes. It revealed that NO2 levels of most cities had the linearly increasing trends during period I. However, decreasing trends appeared during period II to reflect the direct effect of implementation of administrative efforts including the fuel switching control policy.

Keywords: Nitrogen oxides; Long-term; Urban; Health risk; Korea.

Assessment of air quality benefits from the national pollution control policy of thermal power plants in China: A numerical simulation

Zhanshan Wang, Libo Pan, Yunting Li, Dawei Zhang, Jin Ma, Feng Sun, Wenshuai Xu, Xingrun Wang

Source: *Atmospheric Environment 106 (2015) 288e304*

In 2010, an emission inventory of air pollutants in China was created using the Chinese Bulletin of the Environment, the INTEX-B program, the First National Pollution Source Census, the National Generator Set Manual, and domestic and international research studies. Two emission scenarios, the standard failed

emission scenario (S1) and the standard successful emission scenario (S2), were constructed based upon the Instructions for the Preparation of Emission Standards for Air Pollutants from Thermal Power Plants (second draft). The Fifth-Generation NCAR/Penn State Mesoscale Model (MM5) and the U.S. EPA Models-3 Community Multiscale Air Quality (CMAQ) model were applied to China to study the air quality benefits from Emission Standards for Air Pollutants from Thermal Power Plants GB13223-2011. The performance of MM5 and CMAQ was evaluated with meteorological data from Global Surface Data from the National Climatic Data Center (NCDC) and the daily Air Pollution Index (API) reported by Chinese local governments. The results showed that the implementation of the new standards could reduce the concentration of air pollutants and acid deposition in China by varying degrees. The new standards could reduce NO2 pollution in China. By 2020, for the scenario S2, the area with an NO2 concentration higher than the second-level emission standard, and the average NO2 concentration in 31 selected provinces would be reduced by 55.2% and 24.3%, respectively. The new standards could further reduce the concentration of declining SO2 in China. By 2020, for S2, the area with an SO2 concentration higher than the second-level emission standard and the average SO2 concentration in the 31 selected provinces would be reduced by 40.0% and 31.6%, respectively. The new standards could also reduce PM2.5 pollution in China. By 2020, for S2, the area with a PM2.5 concentration higher than the second-level emission standard and the average concentration of PM2.5 in the 31 selected provinces would be reduced by 17.2% and 14.7%, respectively. The new standard could reduce nitrogen deposition pollution in China. By 2020, for S2, the areawith a nitrogen deposition concentration>2.0 tons$km2 and the total nitrogen deposition in China would be reduced by 28.6% and 16.8%, respectively. The new standards could reduce sulfur deposition pollution in China. By 2020, for S2, the area with a sulfur deposition >1.5 tons$km2 and the total sulfur deposition in China would be reduced by 55.3% and 21.0%, respectively.

Keywords: *Thermal power plant; Emission standards; China; Models-3/CMAQ; PM2.5; Sulfur deposition; Nitrogen deposition.*

Satellite observations of tropospheric ammonia and carbon monoxide: Global distributions, regional correlations and comparisons to model simulations

Ming Luo, Mark W. Shephard, Karen E. Cady-Pereira, Daven K. Henze, Liye Zhu, Jesse O. Bash, Robert W. Pinder , Shannon L. Capps e , John T. Walker e , Matthew R. Jones

Source: *Atmospheric Environment 106 (2015) 262e277*

Ammonia (NH3) and carbon monoxide (CO) are primary pollutants emitted to the Earth's atmosphere from common as well as distinct sources associated with anthropogenic and natural activities. The seasonal and global distributions and correlations of NH3 and CO from the Tropospheric Emission Spectrometer (TES) satellite observations and GEOS-Chem model simulations for 2007 are investigated to evaluate how well the global and seasonal pollutant sources are prescribed in the model. Although the GEOS-Chem simulations of NH3 and CO atmospheric mixing ratio values are lower than the TES satellite observations, the global distribution patterns from the model reasonably agree with the observations, indicating that the model represents the general location of the source regions and the seasonal enhancements of NH3 and CO globally over large regional scales. In regions and seasons where biomass burning is the dominant source of both NH3 and CO emissions into the atmosphere, there are strong NH3:CO correlations, which is consistent with the relationship demonstrated by surface measurements over fires. In regions where the enhanced NH3 and CO are known to be produced by different sources, the NH3:CO correlations from TES observations and model simulations are weak or non-existent. For biomass burning regions the NH3:CO ratios are 0.015 (TES) and 0.013 (GEOS-Chem). In regions of high-population density, known heavy traffic, and limited biomass burning sources, such as the rapidly developing areas of South Asia and northern China, which include mixtures of megacities, industrial, and agricultural areas, the two species show weaker but still

positive correlations and NH3:CO ratios of 0.051 (TES) and 0.036 (GEOS-Chem). These enhancement ratios of NH3 relative to CO are useful in constraining NH3 emission inventories when CO emission inventories are better known for some events or regions (i.e. biomass burning).

Keywords: *Satellite observations of carbon monoxide and ammonia; GEOS-Chem model simulations.*

Seasonal behavior and long-term trends of tropospheric ozone, its precursors and chemical conditions over Iran: A view from space

Yunsoo Choi, Amir Hossein Souri

Source: *Atmospheric Environment 106 (2015) 232e240*

To identify spatial and temporal variations over the Iranian region, this study analyzed tropospheric formaldehyde (HCHO) and nitrogen dioxide (NO2) columns from Ozone Monitoring Instrument (OMI), carbon monoxide (CO) columns from the Measurement of Pollution in the Troposphere (MOPITT), and tropospheric column O3 (TCO) from OMI/MLS (Microwave Limb Sounder) satellites from 2005 to 2012. The study discovered high levels of HCHO (~12 1015 molec./cm2) from plant isoprene emissions in the air above parts of the northern forest of Iran during the summer and from the oxidation of HCHO precursors emitted from petrochemical industrial facilities and biomass burning in South West Iran. This study showed that maximum NO2 levels (~18 1015 molec./cm2) were concentrated in urban cities, indicating the predominance of anthropogenic sources. The results indicate that maximum concentrations were found in the winter, mainly because of weaker local winds and higher heating fuel consumption, in addition to lower hydroxyl radicals (OH). The high CO concentrations (~2 1018 molec./ cm2) in the early spring were inferred to mainly originate from a strong continental air mass from anthropogenic CO "hotspots" including regions around Caspian Sea, Europe, and North America, although the external sources of CO were partly suppressed by the Arabian anticyclone and topographic barriers. Variations in the TCO were seen to peak during the summer (~40 DU), due to intensive solar radiation and stratospheric sources. This study also examined long-term trends in TCO and its precursors over a period of eight years in five urban cities in Iran. To perform the analysis, we estimated seasonal changes and inter-seasonal variations using least-squares harmonic estimation (LS-HE), which reduced uncertainty in the trend by 5e15%. The results showed significant increases in the levels of HCHO (~0.08 ± 0.06 1015 molec./cm2 yr1), NO2 (~0.08 ± 0.02 1015 molec./cm2 yr1), and peak annual TCO (~0.59 ± 0.56 DU yr1) but decreases in minimum annual TCO (~0.42 ± 0.60 DU yr1) caused by an increase in NO2 species and annual CO (~0.95 ± 0.41 1016 molec./cm2 yr1) partly resulting from the transport of reduced CO. The time series of the HCHO/NO2 column ratio (a proxy for the chemical conditions) indicated that during the last decade, the cities of Tehran, Ahvaz, and Isfahan exhibited steady chemical conditions while Tabriz and Mashhad exhibited a change from NOx-saturated/mixed to more NOx-sensitive chemical conditions.

Keywords: *Tropospheric ozone; Ozone precursors; Chemical condition; Long-term trends;Remote sensing.*

Seasonal variation of urban carbonaceous aerosols in a typical city Nanjing in Yangtze River Delta, China

Bing Li , Jie Zhang , Yu Zhao , Siyu Yuan , Qiuyue Zhao , Guofeng Shen , Haisuo Wu

Source: *Atmospheric Environment 106 (2015) 223e231*

The Yangtze River Delta (YRD) is one of the regions with the most dynamic economy and severe atmospheric pollution in China. In order to characterize the particle features, especially the carbonaceous component in the YRD, particulate matter smaller than 2.5 mm (PM2.5) and 10 mm (PM10) samples in each season were collected in urban Nanjing, a typical city that locates in the west part of the YRD. The organic carbon (OC) and elemental carbon (EC) was differentiated using the thermal optical reflectance method. The average concentrations of PM2.5, OC and EC during the study periods were observed to be 117.6, 13.8, and 5.3 mg/m3 respectively, with all the highest levels in winter. The mass fraction of the Total carbonaceous aerosol (TCA) in PM2.5 was estimated at 23% on average, lower than those reported for other cities in the YRD. The OC and EC correlated well in all the seasons, especially in spring and winter, implying that OC and EC were attributed to common emission sources. Good correlation was observed between OC and estimated Kþ from biomass burning in the harvest season in autumn and summer, indicating biomass burning a significant source of carbonaceous aerosols. This could also be confirmed by the lower fraction of OC3 þ OC4 in OC during autumn and summer. The secondary organic carbon (SOC) estimated by EC-tracer method was the highest in winter (7.3 mg/m3) followed by autumn (6.7 mg/m3), summer (3.7 mg/m3) and spring (2.0 mg/m3). However, the SOC/OC in winter was not as high as that in summer and autumn, implying the high concentration of OC in winter was probably due to the stable weather but not mainly caused by SOC formation. The high SOC/OC ratio in summer was attributed to stronger oxidation, which could be suggested by higher sulfur oxidation ratio (SOR).

Keywords: *Particles; OC; EC; SOC; Carbon fractions; YRD.*

A comparative study of daytime-based methane emission from two wetlands of Nepal Himalaya

Dan Zhu , Ning Wu , Nabin Bhattarai , Krishna Prasad Oli , Kuenzang Tsering , Gopal Singh Rawat , Huai Chen , Gang Yang , Yinxin He , Srijana Joshi , Pradyumna Rana , Muhammad Ismail

Source: *Atmospheric Environment 106 (2015) 196e203*

Natural wetlands constitute one of the major sources of methane emission to the atmosphere. Data on methane emission from wetlands on southern slopes of the Himalaya (SSH) have not been reported so far. Such data are very valuable for filling the gap and generating the whole emission patterns at regional or even global scale. We selected two wetlands at different altitudinal locations in Nepal, i.e. Beeshazar Lake (286 m a.s.l.) and Dhaap Lake (2089 m a.s.l.), to monitor the daytime methane emissions in monsoon season and dry season separately. Daytime methane emission varied between monsoon and dry seasons and also across different plant communities. The daytime methane emission variations were stronger in dry season than in monsoon season. The source/sink strengths of the two selected plant communities in each wetland were significantly different, presenting the strong spatial variation of methane emission within wetland. The methane emissions recorded in monsoon seasonwere significantly higher (7.74± 6.49 mg CH4 m2 h1 and 1.00 ± 1.23 mg CH4 m2 h1 in low and high altitude wetlands, respectively) than those in dry season (1.84 ± 4.57 mg CH4 m2 h1 and 0.27 ± 0.71 mg CH4 m2 h1 in low and high altitude wetlands, respectively). Methane emissions from the low altitude wetland were significantly higher than those from the high altitude

wetland in both of the seasons. Plant community height, standing water depth and soil temperature correlated to the methane emission from wetlands in this region.

Keywords: *Daytime pattern; Himalayan wetlands; Methane emission; Plant growth; Soil temperature; Standing water depth.*

Development of land-use regression models for metals associated with airborne particulate matter in a North American city

Joyce J.Y. Zhang , Liu Sun , Olesya Barrett , Stefania Bertazzon , Fox E. Underwood , Markey Johnson

Source: *Atmospheric Environment 106 (2015) 165e177*

Airborne particulate matter has been associated with cardiovascular and respiratory morbidity and mortality, and there is evidence that metals may contribute to these adverse health effects. However, there are few tools for assessing exposure to airborne metals. Land-use regression modeling has been widely used to estimate exposure to gaseous pollutants. This study developed seasonal land-use regression (LUR) models to characterize the spatial distribution of trace metals and other elements associated with airborne particulate matter in Calgary, Alberta. Two-week integrated measurements of particulate matter with 0.70) or acceptable ($R2 > 0.50$) in both seasons. Industrial point-sources were the most influential predictor for the majority of PM1.0 components. Industrial and commercial zoning were also significant predictors, while traffic indicators and population density had a modest but significant contribution for most elements. Variables incorporating wind direction were also significant predictors. These findings contrast with LUR models for PM and gaseous pollutants in which traffic indicators are typically the most important predictors of ambient concentrations. These results suggest that airborne PM components vary spatially with the distribution of local industrial sources and that LUR modeling can be used to predict local concentrations of these airborne elements. These models will support future health studies examining the impact of PM components including metals.

Keywords: *Air pollution; Land-use regression modelling;Spatial air quality modelling; Airborne metals; Particulate matter; PM-Related metals.*

Nitrous acid (HONO) in a polluted subtropical atmosphere: Seasonal variability, direct vehicle emissions and heterogeneous production at ground surface

Zheng Xu , Tao Wang , Jueqi Wu , Likun Xue , James Chan , Qiaozhi Zha , Shengzhen Zhou , Peter K.K. Louie , Connie W.Y. Luk

Source: *Atmospheric Environment 106 (2015) 100e109*

Although nitrous acid (HONO) plays an important role in the chemistry of polluted atmospheres, its atmospheric abundances and sources are still not well understood. This paper reports ambient measurements of HONO taken over four select months in different seasons at a suburban site in Hong Kong. The data were analyzed to elucidate the seasonal characteristics, emission ratios and rates of heterogeneous production. The monthly averaged HONO concentrations ranged from 0.35 ± 0.30 ppbv in late spring (May) to 0.93 ± 0.67 ppbv in late autumn (November). The similar variation patterns of HONO, NOx, and traffic flow from midnight to rush hours suggest that the HONO concentration was strongly influenced by vehicle emissions. The emission ratios (HONO/NOx) were derived from an analysis of 21 fresh plumes ($NO/NOx > 0.80$), with

the range of 0.5e1.6%. The large variability in the emission ratios is attributed to the reaction of NO2 on black carbon (BC) emitted from vehicles, based on a strong correlation between the HONO/NOx and concurrently measured BC. The mean conversion rate of NO2 to HONO on ground surface during nighttime estimated on nine select days was 0.52 102 h1, which is relatively low compared with other reported values. This paper highlights a large variability in vehicle emission ratios and heterogeneous conversions of NO2 at ground surface. Photochemical models must consider this variability to better simulate the primary sources of HONO and subsequent photochemistry in the lower part of the troposphere.

Keywords: *Nitrous acid; Seasonal variation; Vehicle emission; Black carbon; Heterogeneous reaction.*

PM2.5 source apportionment in Lombardy (Italy): Comparison of receptor and chemistry-transport modelling results

G. Pirovano , C. Colombi , A. Balzarini , G.M. Riva , V. Gianelle , G. Lonati

Source: *Atmospheric Environment 106 (2015) 56e70*

This work discusses the source apportionment results produced by receptor and chemistry-transport modelling for PM2.5 in Northern Italy, selected as case study due to its very critical conditions. Receptor modelling was performed using the Chemical Mass Balance model, while source oriented analysis by means of the CAMx chemistry transport model. Models shared the same source profiles, mostly based on local data. CMB showed a better reconstruction of the mass closure, while CAMx systematically underestimated cold season concentrations. Nevertheless both models provided the same source ranking at several receptors. According to CMB results, the most relevant contributions during the cold season, ranging around 10 mg m3 , were yielded by road transport, domestic heating and ammonium nitrate. CAMx provided similar results for the secondary sources, while systematically underestimated road transport and domestic heating. A similar behaviour was observed during the summer season. The main discrepancies between the models were: the questionable results from CMB at some receptors, missing the road transport contribution, clearly pointed out by CAMx/PSAT; the ability of CAMx/PSAT to apportion the contribution of sources sharing similar profiles and strongly correlated such as CI and SI vehicles, altogether recognized as traffic source by CMB; the ability of CAMx/PSAT to identify the contribution of secondary PM deriving from complex chemical transformation, such as anthropogenic and biogenic SOA. Finally, the comparison of specific source contribution pointed out that CAMx missed the reconstruction of the road transport contribution to the OC, mostly as a consequence of deficiencies in the emission inventories concerning the primary OC in the cold season and the concurrent underestimation of emissions and secondary OC formation in the warm season.

Keywords: *Source apportionment; Chemistry transport models; Receptor models; Po valley; CMB8.2 CAMx/PSAT.*

Long-term measurements of submicrometer aerosol chemistry at the Southern Great Plains (SGP) using an Aerosol Chemical Speciation Monitor (ACSM)

Caroline Parworth , Jerome Fast , Fan Mei , Tim Shippert , Chitra Sivaraman , Alison Tilp, Thomas Watson, Qi Zhang

Source: *Atmospheric Environment 106 (2015) 43e55*

In this study the long-term trends of non-refractory submicrometer aerosol (NR-PM1) composition and mass concentration measured by an Aerosol Chemical Speciation Monitor (ACSM) at the Atmospheric Radiation Measurement (ARM) program's Southern Great Plains (SGP) site are discussed. NR-PM1 data was recorded at ~30 min intervals over a period of 19 months between November 2010 and June 2012. Positive Matrix Factorization (PMF) was performed on the measured organic mass spectral matrix using a rolling window technique to derive factors associated with distinct sources, evolution processes, and physiochemical properties. The rolling window approach also allows us to capture the dynamic variations of the chemical properties in the organic aerosol (OA) factors over time. Three OA factors were obtained including two oxygenated OA (OOA) factors, differing in degrees of oxidation, and a biomass burning OA (BBOA) factor. Back trajectory analyses were performed to investigate possible sources of major NR-PM1 species at the SGP site. Organics dominated NR-PM1 mass concentration for the majority of the study with the exception of winter, when ammonium nitrate increases due to transport of precursor species from surrounding urban and agricultural areas and also due to cooler temperatures. Sulfate mass concentrations have little seasonal variation with mixed regional and local sources. In the spring BBOA emissions increase and are mainly associated with local fires. Isoprene and carbon monoxide emission rates were obtained by the Model of Emissions of Gases and Aerosols from Nature (MEGAN) and the 2011 U.S. National Emissions Inventory to represent the spatial distribution of biogenic and anthropogenic sources, respectively. The combined spatial distribution of isoprene emissions and air mass trajectories suggest that biogenic emissions from the southeast contribute to SOA formation at the SGP site during the summer.

Keywords: *Aerodyne aerosol mass spectrometer (AMS); Rural; Organic aerosols; Back-trajectory analysis; Biomass burning.*

Global impacts of surface ozone changes on crop yields and land use

Clifford Chuwah , Twan van Noije , Detlef P. van Vuuren , Elke Stehfest , Wilco Hazeleger

Source: *Atmospheric Environment 106 (2015) 11e23*

Exposure to surface ozone has detrimental impacts on vegetation and crop yields. In this study, we estimate ozone impacts on crop production and subsequent impacts on land use in the 2005e2050 period using results of the TM5 atmospheric chemistry and IMAGE integrated assessment model. For the crops represented in IMAGE, we compute relative yield losses based on published exposure-response functions. We examine scenarios with either constant or declining emission factors in a weak climate policy future (radiative forcing target of 6.0 W/m2 at the end of the century), as well as co-benefits of stringent climate policy (targeted at 2.6 W/m2). Without a large decrease in air pollutant emissions, higher ozone concentrations could lead to an increase in crop damage of up to 20% locally in 2050 compared to the situation in which the changes in ozone are not accounted for. This may lead to a 2.5% global increase in crop area, and a regional increase of 8.9% in Asia. Implementation of air pollution policies could limit crop yield losses due to ozone to maximally 10% in 2050 in the most affected regions. Similar effects can be obtained as a result of co-benefits from climate policy (reducing ozone precursor emissions). We also evaluated the impact of the

corresponding land-use changes on the carbon cycle. Under the worst-case scenario analysed in this study, future ozone increases are estimated to increase the cumulative net CO2 emissions between 2005 and 2050 by about 3.7 Pg C, which corresponds to about 10% of baseline land use emissions over the same period.

Keywords: *Ozone crop damage; Land use change; Emission scenarios; Air pollution control; Climate change mitigation.*

Long-term variations in PM2.5 emission from open biomass burning in Northeast Asia derived from satellite-derived data for 2000e2013

Zang-Ho Shon

Source*: Atmospheric Environment 107 (2015) 342e350*

PM2.5 emissions from open biomass burning (BB) in Northeast Asia (NEA: China, Mongolia, Korea, and Japan) during 2000e2013 were estimated using satellite-derived data (GFASv1.0 and GFED3). The annual mean BB PM2.5 emission in NEA during the study period was 660 Gg yr1 , in which considerable interannual variability was observed. In general, PM2.5 emissions in NEA were the highest in spring (Mar. eMay), likely due to the burning of crop residues and forest fire. The contribution of PM2.5 from open BB in Northeast Asia was less than 10% of the anthropogenic PM2.5 emission, except in Mongolia, wherein BB emission was the predominant source of PM2.5. Although the emissions calculated by GFASv1.0 were significantly higher than GFED3 by a factor of 2.66 (Mongolia) to 10.9 (South Korea) due to difficulty in small fire detection by GFED3, they generally showed consistent temporal variation on average. In general, statistically significant long-term trends of open BB PM2.5 emissions were not observed in NEA, except in South Korea.

Keywords: *Biomass burning; PM2.5; GFASv1.0; GFED3 Satellite.*

Impact of biodiesel and renewable diesel on emissions of regulated pollutants and greenhouse gases on a 2000 heavy duty diesel truck

Kwangsam Na , Subhasis Biswas , William Robertson , Keshav Sahay , Robert Okamoto , Alexander Mitchell , Sharon Lemieux

Source: *Atmospheric Environment 107 (2015) 307e314*

As part of a broad evaluation of the environmental impacts of biodiesel and renewable diesel as alternative motor fuels and fuel blends in California, the California Air Resources Board's (CARB) Heavy-duty Diesel Emission Testing Laboratory conducted chassis dynamometer exhaust emission measurements on in-use heavy-heavy-duty diesel trucks (HHDDT). The results presented here detail the impact of biodiesel and renewable diesel fuels and fuel blends as compared to CARB ULSD on particulate matter (PM), regulated gases, and two greenhouse gases emissions from a HHDDT with a 2000 C15 Caterpillar engine with no exhaust after treatment devices. This vehicle was tested over the Urban Dynamometer Driving Schedule (UDDS) and the cruise portion of the California HHDDT driving schedule. Three neat blend stocks (soy-based and animal-based fatty acid methyl ester (FAME) biodiesels, and a renewable diesel) and CARB-certified ultra-low sulfur diesel (CARB ULSD) along with their 20% and 50% blends (blended with CARB ULSD) were tested. The effects of blend level on emission characteristics were discussed on g$km1 basis. The results showed that PM, total hydrocarbon (THC), and carbon monoxide (CO) emissions were

dependent on driving cycles, showing higher emissions for the UDDS cycles with medium load than the highway cruise cycle with high load on per km basis. When comparing CARB ULSD to biodiesels and renewable diesel blends, it was observed that the PM, THC, and CO emissions decreased with increasing blend levels regardless of the driving cycles. Note that biodiesel blends showed higher degree of emission reductions for PM, THC, and CO than renewable diesel blends. Both biodiesels and renewable diesel blends effectively reduced PM emissions, mainly due to reduction in elemental carbon emissions (EC), however no readily apparent reductions in organic carbon (OC) emissions were observed. When compared to CARB ULSD, soy- and animal-based biodiesel blends showed statistically significant increases in nitrogen oxides (NOx) emissions for 50% or higher biodiesel blends. The 20% blends of the biodiesels showed no statistically significant effect on NOx emissions on any cycle. In contrast, renewable diesel slightly decreased NOx emissions and the degree of reduction was statistically significant for 50% or higher blends over the UDDS cycle, but not at the 20% blends. The highway cruise cycles did not show a statistically strong NOx emission trend with increasing blend level of renewable diesel. Biodiesel and renewable fuel impacts on two greenhouse gases, CO2 and N2O emissions were of lower magnitude when compared to other regulated pollutants emissions, showing a change in their emissions within approximately ±3% from the CARB ULSD.

Keywords: *Biodiesel; Renewable diesel; Regulated pollutants; Elemental carbon; Chassis dynamometer.*

Ultrafine particle emissions by in-use diesel buses of various generations at low-load regimes

L. Tartakovsky , V. Baibikov , P. Comte , J. Czerwinski , A. Mayer , M. Veinblat , Y. Zimmerli

Source: *Atmospheric Environment 107 (2015) 273e280*

Ultrafine particles (UFP) are major contributors to air pollution due to their easy gas-like penetration into the human organism, causing adverse health effects. This study analyzes UFP emissions by buses of different technologies (from Euro II till Euro V EEV e Enhanced Environmentally-friendly Vehicle) at low-load regimes. Additionally, the emission-reduction potential of retrofitting with a diesel particle filter (DPF) is demonstrated. A comparison of the measured, engine-out, particle number concentrations (PNC) for buses of different technological generations shows that no substantial reduction of engine-out emissions at low-load operating modes is observed for newer bus generations. Retrofitting the in-use urban and interurban buses of Euro II till Euro IV technologies by the VERT-certified DPF confirmed its high efficiency in reduction of UFP emissions. Particle-count filtration efficiency values of the retrofit DPF were found to be extremely high e greater than 99.8%, similar to that of the OEM filter in the Euro V bus.

Keywords: *Ultrafine particles; Diesel engine; Diesel particle filter; Filter retrofitting.*

Quantifying the influences of atmospheric stability on air pollution in Lanzhou, China, using a radon-based stability monitor

Scott D. Chambers , Fenjuan Wang , Alastair G. Williams , Deng Xiaodong , Hua Zhang , Giovanni Lonati , Jagoda Crawford , Alan D. Griffiths , Antonietta Ianniello , Ivo Allegrini

Source: *Atmospheric Environment 107 (2015) 233e243*

Commercially-available "stability monitors" based on in situ atmospheric radon progeny measurements remain underutilised as a tool for urban pollution studies, due in part to difficulties experienced in relating their standard output directly to the atmospheric mixing state in a consistent manner. The main confounding factor has been a lack of attention to the fact that the observed near-surface atmospheric radon concentration includes large synoptic and fetch-related components in addition to the local stability influence. Here, a technique recently developed for stability classification using a research-quality dual-flow-loop two-filter radon detector is adapted for use with a commercially-available radon-based stability monitor. Performance of the classification scheme is then tested in Lanzhou, China, a topographically-complex region renowned for low mean annual wind speeds (0.8 m s1) and winter stagnation episodes. Based on an 11-month composite, a factor of seven difference is estimated between peak NOx concentrations in the city's industrial region and a rural background location under stable conditions. The radon-based scheme is evaluated against the Pasquil-Gifford "radiation" (PGR) scheme, and assigns pollutant concentrations more consistently between defined atmospheric stability states than the PGR scheme. Furthermore, the PGR scheme consistently underestimates all peak pollutant concentrations under stable conditions compared with the radon-based scheme, in some cases (e.g. CO in the industrial region) by 25%.

Keywords: *Atmospheric stability; Air pollution; Radon; Stability monitor; Pasquil-Gifford.*

Characterisation of particulate matter in different types of archives

Ludmila Ma skova , Ji rí Smolík, Petr Vodicka

Source: *Atmospheric Environment 107 (2015) 217e224*

To determine the composition of particulate matter (PM) in the indoor environments of four different types of archives (three naturally ventilated and one filtered), intensive size-resolved sampling was performed for four seasons of the year. For reconstituting indoor PM, nine aerosol components were considered. Organic matter was the dominant component of both fine and coarse fractions and represented approximately 50e80% of the PM. In the fine fraction, the next most abundant components were elemental carbon and sulphate, and in the coarse fraction the next most abundant were crustal matter, sulphate and nitrate. The resulting mass closure explained 95(±13)% and 115(±38)% of the gravimetric indoor PM in the fine and coarse size fractions, respectively. The results revealed that all the particles found indoors can be considered to be potentially threatening to the stored materials. The results also showed that the most important source of indoor PM in the naturally ventilated archives was penetration from the outdoor air, whereas in the filtered archive, the concentrations of particles were strongly reduced. In naturally ventilated archives the influence of domestic heating, road traffic and local sources (industrial pollution, camp fires) was observed. Furthermore, activities of the staff were identified as an indoor source of coarse particles in all archives.

Keywords: *Indoor particles; Chemical composition; Mass closure; Archive.*

The role of fossil fuel combustion on the stability of dissolved iron in rainwater

Joan D. Willey , Robert J. Kieber , Joshua J. Humphreys , Briana C. Rice , Mark J. Hopwood , G. Brooks Avery , Ralph N. Mead

Source: *Atmospheric Environment 107 (2015) 187e193*

The concentration of dissolved Fe(II) has decreased in coastal NC rainwater because of less complexation and stabilization of Fe(II) (aq) by automobile and coal combustion emissions. Better emission control has removed stabilizing organic ligands hence dissolved Fe(II) currently occurs more as inorganic iron, which is not protected against oxidation. Increasing rainwater pH allows oxidation by molecular O2 in addition to H2O2 and also increases the ratio of the ion pair Fe(OH)þ to Fe(II) free ion, which increases the oxidation rates by both H2O2 and molecular oxygen. The concentration of H2O2 in rain has increased; hydrogen peroxide is the primary oxidant of inorganic Fe(II) in precipitation. The East Coast of the USA is also receiving less rain of terrestrial origin, which tends to be higher in dissolved iron and organic compounds. All these factors operate in the same direction and contribute to the lower concentrations and lack of stability of Fe(II) in rainwater currently observed. Results of this study suggest that wet deposition of soluble Fe(II) is an episodic, temporally variable factor in the iron cycle in oceanic regions adjacent to developed or developing coastal regions.

Keywords: *Rainwater trends; Iron speciation; Fossil fuel exhaust; Marine iron cycle.*

Assessment of long-term measurements of particulate matter and gaseous pollutants in South-East Mediterranean

Petros Mouzourides , Prashant Kumar , Marina K.-A. Neophytou

Source: *Atmospheric Environment 107 (2015) 148e165*

This work examines long-term measurements of major criteria pollutants concentrations in an urban station in South-Eastern Mediterranean, in Nicosia e Cyprus, which is susceptible both to transboundary air pollution transport from Sahara-dust events as well as to evaporative transport of sea-sprays. The work investigates in particular the role of such multi-scale contributions in the urban air quality measurements, which are important considerations in the assessment of the effectiveness of any mitigation policies implemented by regulatory authorities. Attention is drawn in the regional-scale component of the particulate matter concentrations (PM10; 10 mm in diameter) and its contribution in the local measurements. Hourly averaged data of CO, NOx and PM10 concentrations as well as of meteorological parameters were collected from the Air Quality Monitoring Station (AQMS) of the University of Cyprus over a period of more than 5 years (2008e13) and were analysed. Scanning Electron Microscope (SEM) was used to identify chemical characteristics of PM10 and to attribute it to possible sources. A total of 321 days over the entire period were found to exceed the daily limit value of 50 mg/m3 for PM10 concentrations which corresponds to ~19% of the actual monitored time. Numerical simulations using the Dust REgional Atmospheric Model from Barcelona Supercomputing Center (BSC/DREAM) gave a strong indication that PM10 exceedances were associated with the high regional background dust concentrations during westerly winds. It was also found that despite the implementation of tighter regulations for vehicular and industrial emissions in Europe, the monthly average concentration values of criteria pollutants do not exhibit any falling trend.

Keywords: *Urban air quality monitoring; Background pollutant concentration; Transboundary pollution; Pollution concentration exceedances; Nicosia e Cyprus; Scanning Electron Microscope.*

Size-resolved global emission inventory of primary particulate matter from energy-related combustion sources

E. Winijkul , F. Yan , Z. Lu , D.G. Streets , T.C. Bond , Y. Zhao

Source: *Atmospheric Environment 107 (2015) 137e147*

Current emission inventories provide information about the mass emissions of different chemical species from different emitting sources without information concerning the size distribution of primary particulate matter (PM). The size distribution information, however, is an important input into chemical transport models that determine the fate of PM and its impacts on climate and public health. At present, models usually make rather rudimentary assumptions about the size distribution of primary PM emissions in their model inputs. In this study, we develop a global and regional, size-resolved, mass emission inventory of primary PM emissions from source-specific combustion components of the residential, industrial, power, and transportation sectors for the year 2010. Uncertainties in the emission profiles are also provided. The global size-resolved PM emissions show a distribution with a single peak and the majority of the mass of particles in size ranges smaller than 1 mm. The PM size distributions for different sectors and world regions vary considerably, due to the different combustion characteristics. Typically, the sizes of particles decrease in the order: power sector > industrial sector > residential sector > transportation sector. Three emission scenarios are applied to the baseline distributions to study the likely changes in size distribution of emissions as clean technologies are implemented.

Keywords: *Mass size distribution; PM emissions; Combustion sources; Global size-resolved emission inventory.*

Source apportionment of gaseous and particulate PAHs from traffic emission using tunnel measurements in Shanghai, China

Ying Liu , Siyao Wang , Rainer Lohmann , Na Yu , Chenkai Zhang , Yi Gao , Jianfu Zhao , Limin Ma

Source: *Atmospheric Environment 107 (2015) 129e136*

Understanding sources and contributions of gaseous and particulate PAHs from traffic-related pollution can provide valuable information for alleviating air contamination from traffic in urban areas. On-road sampling campaigns were comprehensively conducted during 2011e2012 in an urban tunnel of Shanghai, China. 2e3 rings PAHs were abundant in the tunnel's gas and particle phases. Diagnostic ratios of PAHs were statistically described; several were significantly different between the gas and particle phases. Principal component analysis (PCA), positive matrix factorization (PMF), bivariate correlation analysis and multiple linear regression analysis (MLRA) were applied to apportion sources of gaseous and particulate PAHs in the tunnel. Main sources of the gaseous PAHs included evaporative emission of fuel, high-temperature and low-temperature combustion of fuel, accounting for 50e51%, 30e36% and 13 e20%, respectively. Unburned fuel particles (56.4e78.3%), high-temperature combustion of fuel (9.5 e26.1%) and gas-to-particle condensation (12.2e17.5%) were major contributors to the particulate PAHs. The result reflected, to a large extent, PAH emissions from the urban traffic of Shanghai. Improving fuel efficiency of local vehicles will greatly reduce contribution of traffic emission to atmospheric PAHs in urban areas. Source apportionment of PM10 mass was also performed based on the organic component data. The results showed that high-temperature combustion of fuel and gas-to-particle condensation contributed to 15e18% and 7e8% of PM10 mass, respectively, but 55e57% of the particle mass was left unexplained. Although the results from the PCA and

PMF models were comparable, the PMF method is recommended for source apportionment of PAHs in real traffic conditions. In addition, the combination of multivariate statistical method and bivariate correlation analysis is a useful tool to comprehensively assess sources of PAHs.

Keywords: *Atmospheric pollution; Yan'an East Road Tunnel; PM10; PAHs; PMF; PCA.*

Greenhouse gas emissions from coastal freshwater wetlands in Veracruz Mexico: Effect of plant community and seasonal dynamics

Jose Luis Marín-Mu niz , María E. Hernandez , Patricia Moreno-Casasola

Source: *Atmospheric Environment 107 (2015) 107e117*

Wetlands play an important role in modulating atmospheric concentrations of Greenhouse Gases (GHGs), such as methane (CH4), nitrous oxide (N2O) and carbon dioxide (CO2). Despite the fact that ~30% of wetlands in the world occur in tropical latitudes, little is known about GHG emissions from these ecosystems and the variables that control such emissions. We investigated the CH4, N2O and CO2 emissions in tropical freshwater marshes (FM) and swamps (FS) on the coastal plain of Veracruz, Mexico. GHGs were measured every two months using the closed chamber technique from April 2010 to February 2012 (CH4 and N2O) and during the last year for CO2. The ranges of the emissions were 20e2000 mg CeCH4 m2 d1 , 2e16 mg NeN2O m2 d1 and 0.5e18 g CeCO2 m2 d1 . There were not significant differences in the emissions between FM and FS (P ¼ 0.314, 0.528 and 0.213 for CH4, N2O, and CO2, respectively). However, significant differences (P < 0.001) in CH4 and CO2 emissions were found in the different seasons. During the rainy and windy seasons, the water level was higher than during dry season, this enhanced reduced conditions in the soils and caused significantly higher (P < 0.05) CH4 emissions (>364 mg m2 d1) than during dry season (79.6%) and N2O contributed with less than 7% in the three seasons. Water level and redox potential were found to be main factors influencing GHG emissions in these wetlands.

Keywords: *Marshes; Swamps; Methane; Nitrous oxide; Carbon dioxide.*

Factors influencing spatio-temporal variation of methane and nitrous oxide emission from a tropical mangrove of eastern coast of India

Rita Chauhan , Arindam Datta , AL. Ramanathan , T.K. Adhya

Source: *Atmospheric Environment 107 (2015) 95e106*

We have studied the seasonal and tidal variation of methane (CH4) and nitrous oxide (N2O) emission from the intertidal sediment of Bhitarkanika mangrove in the east coast of India. Seasonal variability study was conducted at five sites (three replicate of each site) inside the core area of the national park during three different seasons (summer, monsoon and winter) whereas tidal variation was studied at three different sites outside the core area during monsoon and winter season. Both CH4 and N2O emission from the intertidal sediment were significantly higher under the low tide condition during the winter season. During the study period CH4 emission from five different sites was ranged between 0.08 and 2.30 mg m2 h1 and the N2O emission was ranged between 9.0 and 187.58 mg m2 h1 . Average seasonal N2O emission (mg m2 h1) from five different sites followed the order: winter (115.60 ± 21.90) > summer (45.29 ± 7.78) > monsoon (16.98 ± 2.54). CH4 and N2O emission was also recorded significantly higher during the winter season over the tidal cycle of three sampling locations. The CH4 emission was negatively correlated with sediment salinity (r ¼ 0.91, P < 0.05) and SO4 e2 (r ¼ 0.89, P < 0.05) concentration whereas; the N2O emission was positively

correlated with sediment salinity (r ¼ 0.48) and NO3 eN (r ¼ 0.88, P < 0.05) concentration during the monsoon season. Positive correlation of N2O emission with the sediment NO3 eN indicates possible influence of upstream anthropogenic activities on N2O emission from the mangrove sediment. In general, methylamine utilizing methanogen and denitrifying bacterial population was significantly higher during winter season in the mangrove sediment. The study concludes that the CH4 and N2O emission from the sediment at different sites during different seasons are influenced by allochthonous carbon and nitrogenous materials.

Keywords: *Methane emission; Nitrous oxide emission; Seasonal Tidal Mangrove.*

Application of herbicides is likely to reduce greenhouse gas (N2O and CH4) emissions from riceewheat cropping systems

Jingyan Jiang , Linmei Chen , Qing Sun , Mengmeng Sang , Yao Huang

Source: *Atmospheric Environment 107 (2015) 62e69*

Herbicides have been widely used to control weeds in croplands; however, their effects on greenhouse gas emissions remain unclear. The effects of three wheat herbicides (acetochlor, AC; tribenuron-methyl, TBM; fenoxaprop-p-ethyl, FE) and two rice herbicides (butachlor, BC; bensulfuron-methyl, BSM) on N2O and CH4 emissions were investigated in this study. In the wheat growing season, applications of AC and FE þ TBM significantly reduced N2O emissions by 31% compared with no herbicide use (p ¼ 0.001). In the rice growing season, the application of BC significantly reduced CH4 emissions by 58% (p ¼ 0.022), and BSM significantly reduced N2O emissions by 27% (p ¼ 0.040); however, no significant difference among treatments with regard to the aggregate emissions of N2O and CH4 in the CO2 equivalent for the 100-year horizon was observed (p > 0.05). Relative to control plots, which were not treated with herbicides, the combined application of the herbicides FE and TBM in the wheat season led to a significant decrease in greenhouse gas intensity (GHGI) by ~41% (p ¼ 0.002), and the application of BC together with BSM reduced GHGI by 22% in the rice season, although this reduction was not statistically significant (p ¼ 0.158). Further investigation suggested that the inhibitory effect of herbicides on N2O emissions in the wheat field could be ascribed to low soil ammonium nitrogen and less abundance of denitrifying bacteria. The inhibitory effects of separate applications of BC on CH4 emissions in rice fields, in contrast, were linked to high soil nitrate nitrogen and urease activity.

Keywords: *Methane; Nitrous oxide; Herbicides; Mitigation; Cropland.*

Top-down methane emissions estimates for the San Francisco Bay Area from 1990 to 2012

David Fairley , Marc L. Fischer

Source: *Atmospheric Environment 107 (2015) 9e15*

Methane is a potent greenhouse gas (GHG) that is now included in both California State and San Francisco Bay Area (SFBA) bottom-up emission inventories as part of California's effort to reduce anthropogenic GHG emissions. Here we provide a top-down estimate of methane (CH4) emissions from the SFBA by combining atmospheric measurements with the comparatively better estimated emission inventory for carbon monoxide (CO). Local enhancements of CH4 and CO are estimated using measurements from 14 air quality sites in the

SFBA combined together with global background measurements. Mean annual CH4 emissions are estimated from the product of Bay Area Air Quality Management District (BAAQMD) emission inventory CO and the slope of ambient local CH4 to CO. The resulting top-down estimates of CH4 emissions are found to decrease slightly from 1990 to 2012, with a mean value of 240 ± 60 GgCH4 yr1 (at 95% confidence) in the most recent (2009e2012) period, and correspond to reasonably a constant factor of 1.5e2.0 (at 95% confidence) times larger than the BAAQMD CH4 emission inventory. However, we note that uncertainty in these emission estimates is dominated by the variation in CH4:CO enhancement ratios across the observing sites and we expect the estimates could represent a lower-limit on CH4 emissions because BAAQMD monitoring sites focus on urban air quality and may be biased toward CO rather than CH4 sources.

Keywords: *Methane emissions; Emissions inventory; Greenhouse gas; Inventory verification; Top-down estimates.*

The variation of chemical characteristics of PM2.5 and PM10 and formation causes during two haze pollution events in urban Beijing, China

Jiajia Gao , Hezhong Tian , Ke Cheng , Long Lu , Mei Zheng , Shuxiao Wan , Jiming Hao , Kun Wang , Shenbing Hua , Chuanyong Zhu , Yong Wang

Source: *Atmospheric Environment 107 (2015) 1e8*

Airborne particles in urban Beijing during haze days and normal days were collected and analyzed in the autumn and winter seasons to reveal the chemical characteristics variations of air pollution. The air quality in haze days was substantially worse than that in normal days. Both the relatively low wind speed and high relative humidity were in favor of the accumulation of pollution species and new formation of secondary PM2.5 in the atmosphere. Elevated concentrations of elements and water-soluble inorganic ions were found on haze days for both PM10 and PM2.5. Particularly, the crustal element, such as Fe, in both PM10 and PM2.5 were substantially higher in autumn normal days and winter haze days than those in autumn haze days and winter normal days, indicating that the abundance of Fe in autumn haze days mainly be originated from crustal dust while in winter haze days it might be primarily emitted from anthropogenic sources (iron and steel smelting) instead of road dust. Secondary ion species (SO4 2, NO3 , NH4 þ) in particles were generated much more during haze episodes, and contributed a higher proportion in PM2.5 than in PM10 during the two sampling periods. Moreover, HYSPLIT model was used to explain the possible transport of airborne particles from distant sources. By comparing with south-type trajectory, west-type trajectory entrained larger amounts of primary crustal pollutants, while, south-type trajectory was comprised of a higher mass of anthropogenic pollution species. The results of back trajectory analysis indicated that the elevated concentration of aerosol and its chemical components during haze days might be caused by the integrated effects of accumulation under stagnant meteorological condition and the transport emissions of pollutants from anthropogenic sources surrounding Beijing city.

Keywords: *PM2.5; PM10; Haze; Elemental species; Water soluble inorganic ions (WSIIs); Beijing.*

The changes and long-range transport of PM2.5 in Beijing in the past decade

Lihui Han , Shuiyuan Cheng , Guoshun Zhuang , Hongbing Ning , Haiyan Wang , Wei Wei, Xiujuan Zhao

Source: *Atmospheric Environment 110 (2015) 186e195*

A sampling campaign of PM2.5 in Beijing from 2002 to 2004 and from 2011 to 2013 was performed to investigate the changes of typical characteristics of PM2.5 at the representative city over Northern China in the past decade. A spring PM2.5 monitoring network was operated to study the long-range transport of PM2.5 in five cities along the pathway of dust storm across Northern and Eastern China in spring 2004. PM2.5 concentrations gradually decreased, but PM2.5 pollution still retained a high level and has been changed from dust type to haze-fog pollution at Beijing in the past decade. The seasonal variation of PM2.5 was spring > winter > autumn > summer during 2002e2004, but winter > autumn > summer > spring in 2011e2013. The mass concentration of mineral aerosol was in the order of spring > winter > summer > autumn, and reached the highest level in dust storm episodes during the past decade. Secondary inorganic aerosol (SIA) followed the order of summer > autumn > winter > spring during 2002e2004, however winter > autumn > summer > spring during 2011e2013, and reached the highest level in haze events. The concentrations of SO4 2, NO3 and NH4 þ of SIA displayed the order of SO4 2 > NO3 > NH4 þ in haze days. SO4 2 concentrations in different seasons during 2011e2013 were almost lower than those in corresponding period in 2002e2004 respectively. But NO3 and NH4 þ concentrations in autumn and winter of 2011e2013 were higher than those in 2002e2004. The OA and SOA concentrations followed the order of winter > autumn > summer and spring, and SOA was one of the significant components in OA. The secondary chemical transformation was the most significant source for PM2.5 during 2011e2013, compared with that in 2002 e2004. Atmospheric pollution has exhibited severe complicated pollution. Dust storm carried not only large amounts of mineral dust, but also some secondary inorganic aerosol (SIA) and organic aerosol (OA), which would have significant impact on the wide downwind areas. The mass fraction of mineral aerosol decreased from the dust source to the downwind coastal sites, while those of secondary and carbonaceous components increased.

Keywords: *PM2.5; Mineral aerosol; Secondary inorganic aerosol; Organic aerosol; Seasonal variation;Spatial distribution.*

Characterization of carbonaceous aerosols over the East China Sea: The impact of the East Asian continental outflow

Fengwen Wang , Zhigang Guo , Tian Lin , Limin Hu , Yingjun Chen , Yifang Zhu

Source: *Atmospheric Environment 110 (2015) 163e173*

Seventy-five paired PM2.5 (aerodynamic diameter less than 2.5 mm) and TSP (total suspended particle) samples collected from a pristine island in the East China Sea (ECS) between October 2011 and August 2012 were analyzed for organic carbon (OC), elemental carbon (EC), and n-alkanes. The island lies in the pathway of continental outflow from Mainland China to the northwest Pacific Ocean driven by the East Asian Monsoon. The concentrations of OC, EC (in mg/m3), and n-alkanes (in ng/m3) were highest in winter (means: 4.7, 1.3, 140.1, respectively) and lowest in summer (means: 1.1, 0.3, 17.0, respectively). PM2.5 contained approximately 88% of the OC, 80% of the EC, and 61% of the n-alkanes in TSP. Petroleum residue was the dominant contributor to the n-alkanes. C12eC22 n-alkanes with strong even-to-odd predominance observed in winter were attributed to the microbial contribution from sea spray aerosol (SSA) driven by the higher wind speed. There was a higher secondary organic carbon (SOC)/OC ratio in warm

seasons (summer and fall) than that in cold seasons (spring and winter). The dominance of primary organic carbon (POC) and EC in cold seasons was possibly mainly due to the influence of the East Asian continental outflow. Three episodes of high concentrations of carbonaceous aerosols were observed, and we focused on the impact of these pollutants from East Asia on the air quality over the ECS. Carbonaceous pollutants were more concentrated in PM2.5 during the fall episode triggered by biomass burning in East China. The winter haze associated with intensive indoor heating in North China brought substantial carbonaceous pollutants, with a minor influence on their size distribution. The dust episode in spring was related to coarse particles (i.e., TSPePM2.5), yielding a distinctly different size distribution.

Keywords: *Carbonaceous aerosols; Concentration; Size distribution; Sources; East Asian continental outflow; East China Sea.*

Aerosol chemical composition and light scattering during a winter season in Beijing

Jun Tao , Leiming Zhang , Jian Gao , Han Wang , Faihe Chai , Shulan Wang

Source: *Atmospheric Environment 110 (2015) 36e44*

To evaluate PM2.5 contributions to light scattering under different air pollution levels, PM2.5 and its major chemical components, PM10, size-segregated water-soluble ions, and aerosol scattering coefficient (bsp) under dry conditions were measured at an urban site in Beijing in January 2013 when heavy pollution events frequently occurred. Measurements were categorized into three pollution levels including heavypolluted (Air Quality Index (AQI) 200), light-polluted (200 > AQI 100) and clean periods (AQI < 100). The average PM2.5 mass concentration was 248 mg m3 during the heavy-polluted period, which was 2.4 and 5.6 times of those during the light-polluted (104 mg m3) and clean (44 mg m3) periods, respectively. The concentrations of SO4 2, NO3 and NH4 þ increased much more than those of OC and EC during the heavy-polluted period compared with those during the light-polluted and clean periods. Good correlations between PM2.5 and bsp were found (R2 > 0.95) during the different pollution levels. The mass scattering efficiency (MSE) of PM2.5 was 4.9 m2g1 during the heavy-polluted period, which was higher than those during the light-polluted (4.3 m2 g1) and clean periods (3.6 m2 g1). To further evaluate the impact of individual chemical components of PM2.5 on light scattering, a multiple linear regression equation of measured bsp against the mass concentration of (NH4)2SO4, NH4NO3, Organic Matter (OM), EC, Fine Soil (FS), Coarse Matter (CM) and Other chemical compounds were performed. (NH4)2SO4, NH4NO3 and OM were the dominant species contributing to bsp under both dry and ambient conditions. OM contributed more to bsp than the sum of (NH4)2SO4 and NH4NO3 did under the dry condition during all the pollution periods and this was also the case under the ambient condition during the light-polluted and clean periods. However, the total contributions of (NH4)2SO4 and NH4NO3 to bsp under the ambient condition was 55%, much more than the 29% contribution from OM during the heavy-polluted period. High (NH4)2SO4 and NH4NO3 concentrations and their hygroscopicity were the main reasons causing visibility degradation during the heavy-polluted period, and the effect can be enhanced under high RH conditions.

Keywords: *PM2.5; Aerosol size distribution; Hygroscopic growth; Biomass burning; Visibility degradation.*

Characteristics of carbonaceous aerosols emitted from peatland fire in Riau, Sumatra, Indonesia (2): Identification of organic compounds

Yusuke Fujii , Haruo Kawamoto , Susumu Tohno , Masafumi Oda , Windy Iriana , Puji Lestari

Source: *Atmospheric Environment 110 (2015) 1e7*

Smoke emitted from Indonesian peatland fires has caused dense haze and serious air pollution in Southeast Asia such as visibility impairment and adverse health impacts. To mitigate the Indonesian peatland fire aerosol impacts, an effective strategy and international framework based on the latest scientific knowledge needs to be established. Although several attempts have been made, limited data exist regarding the chemical characteristics of peatland fire smoke for the source apportionment. In order to identify the key organic compounds of peatland fire aerosols, we conducted intensive field studies based on ground-based and source-dominated sampling of PM2.5 in Riau Province, Sumatra, Indonesia, during the peatland fire seasons in 2012. Levoglucosan was the most abundant compound among the quantified organic compounds at 8.98 ± 2.28% of the PM2.5 mass, followed by palmitic acid at 0.782 ± 0.163% and mannosan at 0.607 ± 0.0861%. Potassium ion was not appropriate for an indicator of Indonesian peatland fires due to extremely low concentrations associated with smoldering fire at low temperatures. The vanillic/syringic acids ratio was 1.06 ± 0.155 in this study and this may be a useful signature profile for peatland fire emissions. Particulate n-alkanes also have potential for markers to identify impact of Indonesian peatland fire source at a receptor site.

Keywords: *Peatland fire; PM2.5; Lignin n-alkane; Indonesia.*

Causes of increasing ozone and decreasing carbon monoxide in springtime at the Mt. Bachelor Observatory from 2004 to 2013

L.E. Gratz , D.A. Jaffe , J.R. Hee

Source: *Atmospheric Environment 109 (2015) 323e330*

We report trends in springtime ozone (O3) and carbon monoxide (CO) at the Mt. Bachelor Observatory (MBO) in central Oregon, U.S.A. from 2004 to 2013. Over the 10-year period the median and 95th percentile springtime O3 increased by 0.76 ± 0.61 ppbv yr1 (1.7 ± 1.4% yr1) and 0.87 ± 0.73 ppbv yr1 (1.5 ± 1.2% yr1), respectively. These trends are consistent with reported positive trends in springtime O3 in the western U.S. In contrast, median CO decreased by 3.1 ± 2.4 ppbv yr1 (1.9 ± 1.4% yr1), which is highly similar to springtime North Pacific surface flask measurements from 2004 to 2012. While a 10- year record is relatively short to evaluate long-term variability, we incorporate transport model analysis and contextualize our measurements with reported northern mid-latitude trends over similar time frames to investigate the causes of increasing O3 and decreasing CO at MBO. We performed cluster analysis of 10-day HYSPLIT back-trajectories from MBO and examined O3 and CO trends within each cluster. Significant positive O3 trends were associated with high-altitude, rapid transport from East Asia. Significant negative CO trends were most associated with transport from the North Pacific and Siberia, as well as from East Asia. The rise in springtime O3 is likely associated with increasing O3 precursor emissions in Asia and long-range transport to the western U.S. The decline in springtime CO appears linked to decreasing Northern Hemisphere background CO, largely due to anthropogenic emissions reductions in Europe and North America, and also to a recently reported decline in total CO output from China caused by more efficient combustion. These springtime O3 and CO trends suggest that hydroxyl radical (OH) mixing ratios in the North Pacific may have increased over the study period.

Keywords: *Ozone; Carbon monoxide; Western U.S. Long-term trends; Trajectory cluster analysis; Asian long-range transport.*

Measurements of emission factors of PM2.5, OC, EC, and BC for household stoves of coal combustion in China

Yingjun Chen , Chongguo Tian , Yanli Feng , Guorui Zhi , Jun Li , Gan Zhang

Source: *Atmospheric Environment 109 (2015) 190e196*

As follow-up efforts for measurements on emission factors (EFs) of fine particulate matter (PM2.5) and its carbonaceous fractions for China's household coal stoves, a large-sized dilution sampling system was designed to test a total of 20 coal/stove combinations, which involve five coals with wide-ranged geological maturities and three stoves. Coal smoke was simultaneously collected onto quartz filter for organic carbon (OC) and elemental carbon (EC) analyses by thermal-optical reflectance (TOR) protocol and monitored online for optical black carbon (BC) by Aethalometer. The mean EFs based on burned fuel weight of PM2.5, OC, EC, and BC are 4.25 ± 2.45, 1.11 ± 0.72, 1.43 ± 1.17, and 0.60 ± 0.42 g/kg for bituminous coal, and 1.44 ± 0.67, 0.05 ± 0.02, 0.04 ± 0.02, and 0.01 ± 0.01 g/kg for anthracite, respectively. Significant differences are observed among the EFs for various coal/stove combinations, which are attributable to the differences of coal maturity, burning style and stove efficiency. Although the EFs of BC and EC are closely correlated (r ¼ 0.97), the average BC/EC ratio is only 0.39, indicating a significant gap between the two methods; and the optical attenuation cross-section (s) for fresh coal smoke can be deduced as 6.47 m2 /g, much lower than the manufacturer's preset value of 16.6 m2 /g for Aethalometer.

Keywords: *Emission factor; Experimental measurement; Fine particle; Black carbon; Elemental carbon; Residential coal combustion.*

Characterization of ambient PM2.5 at a pollution hotspot in New Delhi, India and inference of sources

Pallavi Pant , Anuradha Shukla , Steven D. Kohl , Judith C. Chow , John G. Watson , Roy M. Harrison

Source: *Atmospheric Environment 109 (2015) 178e189*

Ambient PM2.5 samples were collected at a high-traffic location (summer and winter 2013) and characterized for a large suite of elemental and organic markers. Concentrations were found to exceed the Indian PM2.5 air quality standard on several occasions, especially in the winter. Winter concentrations of several individual tracer species were several fold higher compared to summer, particularly for some PAHs and trace metals. Enrichment factors relative to crustal material showed significant enrichment for elements such as Ti, Sb, Pb and As, although Ba, often used as a marker for non-exhaust emissions from traffic was not found to be enriched appreciably. Crustal material was found to be an important contributor in the summer (14.3%), while wood burning (23.3%), nitrates (12.4%) and chlorides (12.3%) were found to be major contributors in winter. The contribution of road traffic exhaust emissions was estimated to be 18.7% in summer and 16.2% in winter. Other combustion sources (wood and other biomass/waste/coal) were found to be a significant source in winter, and contribute to the higher concentrations. Secondary sulphates, nitrates and chloride (the latter two in winter) and organic matter also contribute substantially to PM2.5 mass.

Keywords: *Molecular markers; Traffic; India Mass closure; Particulate matter.*

Aldehydes in relation to air pollution sources: A case study around the Beijing Olympics

Brent Altemose , Jicheng Gong , Tong Zhu , Min Hu , Liwen Zhang , Hong Cheng , Lin Zhang , Jian Tong , Howard M. Kipen , Pamela Ohman-Strickland , Qingyu Meng , Mark G. Robson , Junfeng Zhang

Source: *Atmospheric Environment 109 (2015) 61e69*

This study was carried out to characterize three aldehydes of health concern (formaldehyde, acetaldehyde, and acrolein) at a central Beijing site in the summer and early fall of 2008 (from June to October). Aldehydes in polluted atmospheres come from both primary and secondary sources, which limits the control strategies for these reactive compounds. Measurements were made before, during, and after the Beijing Olympics to examine whether the dramatic air pollution control measures implemented during the Olympics had an impact on concentrations of the three aldehydes and their underlying primary and secondary sources. Average concentrations of formaldehyde, acetaldehyde and acrolein were 29.3 ± 15.1 mg/m3 , 27.1 ± 15.7 mg/m3 and 2.3 ± 1.0 mg/m3 , respectively, for the entire period of measurements, all being at the high end of concentration ranges measured in cities around the world in photochemical smog seasons. Formaldehyde and acrolein increased during the pollution control period compared to the pre-Olympic Games, followed the changing pattern of temperature, and were signifi- cantly correlated with ozone and with a secondary formation factor identified by principal component analysis (PCA). In contrast, acetaldehyde had a reduction in mean concentration during the Olympic air pollution control period compared to the pre-Olympic period and was significantly correlated with several pollutants emitted from local emission sources (e.g., NO2, CO, and PM2.5). Acetaldehyde was also more strongly associated with primary emission sources including vegetative burning and oil combustion factors identified through the PCA. All three aldehydes were lower during the post-Olympic sampling period compared to the before and during Olympic periods, likely due to seasonal and regional effects. Our findings point to the complexity of source control strategies for secondary pollutants.

Keywords: *Aldehydes; Air pollution; Acrolein; Pollutant sources; Principal component analysis; Olympics.*

Heterogeneity of passenger exposure to air pollutants in public transport microenvironments

Fenhuan Yang , Daya Kaul , Ka Chun Wong , Dane Westerdahl , Li Sun , Kin-fai Ho , Linwei Tian , Peter Brimblecombe , Zhi Ning

Source: *Atmospheric Environment 109 (2015) 42e51*

Epidemiologic studies have linked human exposure to pollutants with adverse health effects. Passenger exposure in public transport systems contributes an important fraction of daily burden of air pollutants. While there is extensive literature reporting the concentrations of pollutants in public transport systems in different cities, there are few studies systematically addressing the heterogeneity of passenger exposure in different transit microenvironments, in cabins of different transit vehicles and in areas with different characteristics. The present study investigated PM2.5 (particulate matter with aerodynamic diameters smaller than 2.5 mm), black carbon (BC), ultrafine particles (UFP) and carbon monoxide (CO) pollutant concentrations in various public road transport systems in highly urbanized city of Hong Kong. Using a trolley case housing numerous portable air monitors, we conducted a total of 119 trips during the campaign. Transit microenvironments, classified as 1). busy and secondary roadside bus stops; 2). open and enclosed termini; 3). above- and under-ground Motor Rail Transport (MTR) platforms, were investigated and

compared to identify the factors that may affect passenger exposures. The pollutants inside bus and MTR cabins were also investigated together with a comparison of time integrated exposure between the transit modes. Busy roadside and enclosed termini demonstrated the highest average particle concentrations while the lowest was found on the MTR platforms. Traffic-related pollutants BC, UFP and CO showed larger variations than PM2.5 across different microenvironments and areas con- firming their heterogeneity in urban environments. In-cabin pollutant concentrations showed distinct patterns with BC and UFP high in diesel bus cabins and CO high in LPG bus cabins, suggesting possible self-pollution issues and/or penetration of on-road pollutants inside cabins during bus transit. The total passenger exposure along selected routes, showed bus trips had the potential for higher integrated passenger exposure compared to MTR trips. The present study may provide useful information to better characterize the distribution of passenger exposure pattern in health assessment studies and the results also highlight the need to formulate exposure reduction based air policies in large cities.

Keywords: *Black carbon; CO; Bus cabins; Roadside bus stop; Bus terminal; PM2.5; Subway platform; Ultrafine particles.*

Long-range transport of air pollutants originating in China: A possible major cause of multi-day high-PM10 episodes during cold season in Seoul, Korea

Hye-Ryun Oh , Chang-Hoi Ho , Jinwon Kim , Deliang Chen , Seungmin Lee , Yong-Sang Choi , Lim-Seok Chang , Chang-Keun Song

Source: *Atmospheric Environment 109 (2015) 23e30*

Massive air pollutants originating in China and their trans-boundary transports are an international concern in East Asia. Despite its importance, details in the trans-boundary transport of air pollutants over East Asia and its impact on regional air quality remain to be clarified. This study presents an evidence which strong support that aerosols emitting in China play a major role in the occurrence of multi-day (4 days) severe air pollution episodes in cold seasons (October through March) for 2001e2013 in Seoul, Korea, where the concentration of PM10 (particulates with diameters 10 mm) exceeds 100 mg m3 . Observations show that these multi-day severe air pollution episodes occur when a strong high-pressure system resides over the eastern ChinaeKorea region. In such weather conditions, air pollutants emitted in eastern China/southwestern Manchuria are trapped within the atmospheric boundary layer, and gradually spread into neighboring countries by weak lower tropospheric westerlies. Understanding of trans-boundary transports of air pollutants will advance the predictability of local air quality, and will encourage the development of international measures to improve air quality.

Keywords: *PM10 episode; Long-lasting; Trans-boundary transport; Seoul China.*

Ten years of mercury measurement at urban and industrial air quality monitoring stations in the UK

Richard J.C. Brown, Sharon L. Goddard, David M. Butterfield, Andrew S. Brown, Chris Robins, Chantal L. Mustoe, Elizabeth A. McGhee

Source: *Atmospheric Environment 109 (2015) 1e8*

Concentrations and trends from a decade of measurements of total gaseous mercury and particulate phase mercury at a number of monitoring stations across the UK are presented. Both emissions and ambient concentrations of mercury in the UK have continued to fall slightly during the measurement period despite already being at historically low levels. The median UK concentration of total gaseous mercury recorded in recent years was around 2.0 ng/m3 . Small urban increments of about 0.4 ng/m3 above background concentrations were noted, with larger increments above the background only observed close to industrial point sources. The total gaseous mercury to particulate phase mercury ratio was large across the UK e indicating the dominance of the gaseous mercury in the atmosphere e and was observed to be larger at background and urban locations than at industrial sites, as a result of higher relative particulate phase mercury concentrations close to primary emissions point sources.

Keywords: *Air quality; Emissions; Particulate matter; Mercury vapour; Long term trends.*

Chemical characterization of biomass fuel smoke particles of rural kitchens of South Asia

Pratibha Deka, Raza Rafiqul Hoque

Source: *Atmospheric Environment 108 (2015) 125e132*

Biomass fuel smoke particles (BFSPs) of rural kitchens collected during dry and wet seasons were characterized for elements, anions and carbon. The BFSPs of kitchens using varied biomass fuel types viz. cow dung stick, mixed biomass, cow-dung stick-mixed biomass and sugarcane bagasse were chosen for the study. The BFSPs from cow dung fuel stick showed higher levels of elements, anions and particulate carbon than other BFSPs. Calcium, K, Fe and Mg were the major elements found in all BFSPs, which did not vary much between the seasons. Sulphate was found to be the dominant anion present in all BFSPs followed by Cl^- and PO4 3. Seasonal variation was pronounced in the case of abundance of anions and particulate carbon. The ratio OC/EC, often used as source signature of biomass burning, was found to be within 1.89e7.41 and 1.72e6.19 during dry and wet seasons respectively.

Keywords: *Biomass burning; Rural kitchen; Elements; Ions; Carbon.*

Life-cycle assessment of greenhouse gas and air emissions of electric vehicles: A comparison between China and the U.S.

Hong Huo , Hao Cai , Qiang Zhang , Fei Liu , Kebin He

Source: *Atmospheric Environment 108 (2015) 107e116*

We evaluated the fuel-cycle emissions of greenhouse gases (GHGs) and air pollutants (NOx, SO2, PM10, and PM2.5) of electric vehicles (EVs) in China and the United States (U.S.), two of the largest potential markets for EVs in the world. Six of the most economically developed and populated regions in China and the U.S. were selected. The results showed that EV fuel-cycle emissions depend substantially on the carbon intensity and cleanness of the electricity mix, and vary significantly across the regions studied. In those regions with a low share of coal-based electricity (e.g., California), EVs can reduce GHG and air pollutant emissions (except for PM) significantly compared with conventional vehicles. However, in the Chinese regions and selected U.S. Midwestern states where coal dominates in the generation mix, EVs can reduce GHG emissions but increase the total and urban emissions of air pollutants. In 2025, EVs will offer greater reductions in GHG and air pollutant emissions because emissions from power plants will be better controlled; EVs in the Chinese regions examined, however, may still increase SO2 and PM emissions. Reductions of 60e85% in GHGs and air pollutants could be achieved were EVs charged with 80% renewable electricity or the electricity generated from the best available technologies of coal-fired power plants, which are futuristic power generation scenarios.

Keywords: *Electric vehicles; Generation mix; Renewable electricity; Fuel economy; Life-cycle analysis.*

On-road emissions of carbonyls from vehicles powered by biofuel blends in traffic tunnels in the Metropolitan Area of Sao Paulo, Brazil

Thiago Nogueira , Kely Ferreira de Souza , Adalgiza Fornaro , Maria de Fatima Andrade , Lilian Rothschild Franco de Carvalho

Source: *Atmospheric Environment 108 (2015) 88e97*

On-road emissions of carbonyls from the current vehicle fleet of Brazil were determined in two experimental campaigns, conducted in traffic tunnels located in the Metropolitan Area of Sao Paulo (MASP), in ~ southeastern Brazil. Among carbonyl species, formaldehyde and acetaldehyde were the most abundant in all sampling periods. In Brazil, heavy-duty vehicles (HDVs) run on a blend of 95% regular diesel/5% biodiesel from soy, whereas light-duty vehicles (LDVs) run on gasohol (75e80% gasoline/20e25% ethanol) or hydrous ethanol. We found that HDVs showed the highest overall carbonyl emissions, although LDVs were responsible for high emissions of acetaldehyde. In comparison with LDVs in California, which are powered by 90% gasoline/10% ethanol, LDVs in Brazil were found to emit 352% and 263% more formaldehyde and acetaldehyde.

Keywords: *Air pollution; Aldehyde; Emission factor; Ethanol; biofuel; Megacity; Vehicle emissions.*

Evolution of surface O3 and PM2.5 concentrations and their relationships with meteorological conditions over the last decade in Beijing

Ziyin Zhang , Xiaoling Zhang , Daoyi Gong , Weijun Quan , Xiujuan Zhao , Zhiqiang Ma , Seong-Joong Kim

Source: *Atmospheric Environment 108 (2015) 67e75*

In this study, hourly and daily records since 2005 and correlation, regression and composite methods were used to analyze the long-term evolution of surface O3 and PM2.5 concentrations at the rural station of Shangdianzi (SDZ) and urban station of Baolian (BL) over Beijing and their relationships with meteorological conditions. The results show that the mean concentrations of PM2.5 (O3) decreased (increased) at the urban and rural stations over the last decade. The linear trends of the annual mean concentrations of PM2.5 at BL and SDZ were 31.8 ug/m3 /10yr (4.3%/yr) ($p < 0.01$) and 13.3 ug/m3 /10yr (2.9%/yr) ($p < 0.05$), respectively. In winter, the mean wind speed (Ws) and relative humidity (RH) were the most closely correlated with O3 at both stations, whereas RH and sunshine hours (S) were most closely correlated with PM2.5. The correlation coefficients and explained variances in spring and autumn were generally less than those in winter and greater than those in summer. Moreover, increase in precipitation can significantly reduce the PM2.5 concentration in both urban and rural areas in Beijing, whereas trace and light precipitation more effectively decreases the O3 concentration. Concentrations of PM2.5 (O3) on haze days increased by 114% (3%) and 162% (20%) compared with that on non-haze days at the urban and rural stations, respectively. This result suggests that haze is a major manifestation of air pollution in Beijing.

Keywords: *PM2.5; O3; Meteorological factors; Haze days; Beijing.*

Investigation of the tracers for plastic-enriched waste burning aerosols

Sudhanshu Kumar , Shankar G. Aggarwal , Prabhat K. Gupta , Kimitaka Kawamura

Source: *Atmospheric Environment 108 (2015) 49e58*

To better identify the tracers for open-waste burning (OWB) aerosols, we have conducted aerosol sampling at 2 landfill sites, i.e., Okhla and Bhalswa in New Delhi. The metals such as, As, Cd, Sb and Sn, which have been observed almost negligible in remote aerosols, are found abundantly in these OWB aerosol samples (n ¼ 26), i.e., 60 ± 65, 41 ± 53, 537 ± 847 and 1325 ± 1218 ng m3 , respectively. Samples (n ¼ 20) collected at urban locations in New Delhi, i.e., at Employees' State Insurance (ESI) hospital and National Physical Laboratory (NPL) also show high abundances of these metals in the particles. Filter samples are also analyzed for water-soluble dicarboxylic acids (C2eC12) and related compounds (oxocarboxylic acids and a-dicarbonyls). Terephthalic acid (tPh) was found to account for more than 77% of total diacids determined in OWB aerosols. However, such a high abundance of tPh is not observed in aerosols collected at urban sites. Instead, phthalic acid (Ph) was found as the third/fourth most abundant diacid (~3%) following C2 (>70%) and C4 (>12%) in these waste burning influenced urban aerosols. A possible secondary formation pathway of Ph by photo-degradation of phthalate ester (di-2-ethylhexyl phthalate) in plastic-waste burning aerosol is suggested. Ionic composition of OWB aerosols showed that Cl is the most abundant ion (40 ± 8% of total ions determined). The correlation studies of the potential metals with the organic tracers of garbage burning, i.e., phthalic, isophthalic and terephthalic acids show that especially Sn can be used as marker for tracing the plastic-enriched waste burning aerosols.

Keywords: *Plastic waste burning aerosol; Chemical composition; Tracer Metals; Diacids; Phthalic acid formation pathway.*

Characteristics of flow and reactive pollutant dispersion in urban street canyons

Soo-Jin Park , Jae-Jin Kim , Minjoong J. Kim , Rokjin J. Park , Hyeong-Bin Cheong

Source: *Atmospheric Environment 108 (2015) 20e31*

In this study, the effects of aspect ratio defined as the ratio of building height to street width on the dispersion of reactive pollutants in street canyons were investigated using a coupled CFD-chemistry model. Flow characteristics for different aspect ratios were analyzed first. For each aspect ratio, six emission scenarios with different VOCeNOX ratios were considered. One vortex was generated when the aspect ratio was less than 1.6 (shallow street canyon). When the aspect ratio was greater than 1.6 (deep street canyon), two vortices were formed in the street canyons. Comparing to previous studies on twodimensional street canyons, the vortex center is slanted toward the upwind building and reverse and downward flows are dominant in street canyons. Near the street bottom, there is a marked difference in flow pattern between in shallow and deep street canyons. Near the street bottom, reverse and downward flows are dominant in shallow street canyon and flow convergence exists near the center of the deep street canyons, which induces a large difference in the NOX and O3 dispersion patterns in the street canyons. NOX concentrations are high near the street bottom and decreases with height. The O3 concentrations are low at high NO concentrations near the street bottom because of NO titration. At a low VOCeNOX ratio, the NO concentrations are sufficiently high to destroy large amount of O3 by titration, resulting in an O3 concentration in the street canyon much lower than the background concentration. At high VOCeNOX ratios, a small amount of O3 is destroyed by NO titration in the lower layer of the street canyons. However, in the upper layer, O3 is formed through the photolysis of NO2 by VOC degradation reactions. As the aspect ratio increases, NOX (O3) concentrations averaged over the street canyons decrease (increase) in the shallow street canyons. This is because outward flow becomes strong and NOX flux toward the outsides of the street canyons increases, resulting in less NO titration. In the deep street canyons, outward flow becomes weak and outward NOX flux decreases, resulting in an increase (decrease) in NOX (O3) concentration.

Keywords: *CFD-chemistry-coupled model; Reactive pollutants; Street canyon; Aspect ratio; VOCeNOX ratio.*

Enhanced PM10 bounded PAHs from shipping emissions

S. Pongpiachan , M. Hattayanone , C. Choochuay , R. Mekmok , N. Wuttijak , A. Ketratanakul

Source: *Atmospheric Environment 108 (2015) 13e19*

Earlier studies have highlighted the importance of maritime transport as a main contributor of air pollutants in port area. The authors intended to investigate the effects of shipping emissions on the enhancement of PM10 bounded polycyclic aromatic hydrocarbons (PAHs) and mutagenic substances in an industrial area of Rayong province, Thailand. Daily PM10 speciation data across two air quality observatory sites in Thailand during 2010e2013 were collected. Diagnostic binary ratios of PAH congeners, analysis of variances (ANOVA), and principal component analysis (PCA) were employed to evaluate the enhanced genotoxicity of PM10 during the docking period. Significant increase of PAHs and mutagenic index (MI) of PM10 were observed during the docking period in both sampling sites. Although stationary sources like coal combustions from power plants and vehicular exhausts from motorway can play a great role in enhancing PAH concentrations, regulating shipping emissions from diesel engine in the port area like Rayong is predominantly crucial.

Keywords: *Industrial estate; Mutagenicity; Polycyclic aromatic compounds; Vehicle emissions; Thailand.*

Multi-wavelength optical determination of black and brown carbon in atmospheric aerosols

D. Massabo, L. Caponi , V. Bernardoni , M.C. Bove , P. Brotto , G. Calzolai , F. Cassola , M. Chiari , M.E. Fedi , P. Fermo , M. Giannoni , F. Lucarelli , S. Nava , A. Piazzalunga , G. Valli , R. Vecchi , P. Prati

Source: *Atmospheric Environment 108 (2015) 1e12*

In this paper, a new way to apportion the absorption coefficient (babs) of carbonaceous atmospheric aerosols starting from a multi-wavelength optical analysis is shown. This methodology can disentangle and quantify the contribution to total absorption of equivalent black carbon (EBC) emitted by wood burning (EBCWB) and fossil fuel (EBCFF) as well as brown carbon (BrC) due to incomplete combustion. The method uses the information gathered at five different wavelengths in a renewed and upgraded version of the approach usually referred to as Aethalometer model. Moreover, we present the results of an apportionment study of carbonaceous aerosol sources performed in a rural area and in a coastal city, both located in the North-West of Italy. Results obtained by the proposed approach are validated against independent measurements of levoglucosan and radiocarbon. At the rural site the EBCWB and EBCFF relative contributions are about 40% and 60% in winter and 15% and 85% in summer, respectively. At the coastal urban site, EBCWB and EBCFF are about 15% and 85% during fall. The OC contribution to the wood burning source at the rural site results approximately 50% in winter and 10% in summer and about 15% at the coastal urban site in fall. The new methodology also provides a direct measurement of the absorption Ångstrom exponent of BrC (€ aBrC) which resulted aBrC ¼ 3.95 ± 0.20.

Keywords: *Carbonaceous aerosol; Light absorption; Source apportionment.*

Impact of wildfires on size-resolved aerosol composition at a coastal California site

L.C. Maudlin , Z. Wang , H.H. Jonsson , A. Sorooshian

Source: *Atmospheric Environment 119 (2015) 59e68*

Size-resolved aerosol composition measurements were conducted at a coastal site in central California during the Nucleation in California Experiment (NiCE) between July and August of 2013. The site is just east of ship and marine emission sources and is also influenced by continental pollution and wildfires, such as those near the CaliforniaeOregon border which occurred near the end of NiCE. Two micro-orifice uniform deposit impactors (MOUDIs) were used, and water-soluble and elemental compositions were measured. The five most abundant water-soluble species (in decreasing order) were chloride, sodium, non-sea salt (nss) sulfate, ammonium, and nitrate. During wildfire periods, nss K mass concentrations were not enhanced as strongly as other species in the sub-micrometer stages and even decreased in the super-micrometer stages; species other than nss K are more reliable tracers for biomass burning in this region. Chloride levels were reduced in the fire sets likely due to chloride depletion by inorganic and organic acids that exhibited elevated levels in transported plumes. During wildfire periods, the mass size distribution of most dicarboxylic acids changed from unimodal to bimodal with peaks in the 0.32 mm and 1.0e1.8 mm stages. Furthermore, sulfate's peak concentration shifted from the 0.32 mm to 0.56 mm stage, and nitrate also shifted to larger sizes (1.0 mm to 1.8e3.2 mm stages). Mass concentrations of numerous soil tracer species (e.g., Si, Fe) were strongly enhanced in samples influenced by wildfires, especially in the sub-micrometer range. Airborne cloud water data confirm that soil species were associated with fire plumes transported south along the coast. In the absence of biomass burning, cloud condensation nuclei (CCN) composition is dominated by nss sulfate and

ammonium, and the water-soluble organic fraction is dominated by methanesulfonate, whereas for the samples influenced by wildfires, ammonium becomes the dominant overall species, and oxalate is the most abundant organic species.

Keywords: *MOUDI; Biomass burning; Marine; Aerosol Composition; Soil; Cloud water.*

Diurnal, weekly and monthly spatial variations of air pollutants and air quality of Beijing

Wei Chen , Hongzhao Tang , Haimeng Zhao

Source: *Atmospheric Environment 119 (2015) 21e34*

Under the National Ambient Air Quality Standard released in 2012 (NAAQS-2012), Beijing began to publicize hourly Air Quality Index as well as real time concentrations of 6 pollutants in its web platform to provide detailed information for air quality assessment from 2013. In this study, hourly air quality monitoring data from May 2014 to April 2015 were collected for all 35 monitoring stations in Beijing to analyze the temporal and spatial variations of air pollutants and air quality. It is found that in spatial pattern, the air qualities in southern and northern Beijing are totally different. The association between heavy pollution concentrations and wind situations suggested that neighboring area's air quality has an important role in the air quality of Beijing combining with air quality attainment rates in all 35 monitoring stations and northern China. For temporal variations, late night and early morning are the most polluted time while afternoon is the least polluted time for all pollutants except O3 with most polluted time in afternoon. Summer time in Beijing has the best air quality while winter time has the worst air quality coinciding with the heating season in the winter.

Keywords: *Air quality; Air pollution; PM2.5; PM10; O3; SO2; NO2; CO.*

Chemical speciation, human health risk assessment and pollution level of selected heavy metals in urban street dust of Shiraz, Iran

Behnam Keshavarzi , Zahra Tazarvi , Mohammad Ali Rajabzadeh , Ali Najmeddin

Source: *Atmospheric Environment 119 (2015) 1e10*

The distribution, pollution level, sources and health risk of Hg, As, Cd, Cu, Cr, Ni, Mn, Fe, Pb, Sb and Zn in urban street dust were investigated. X-ray diffraction analysis of dust samples shows that the mineralogy of airborne dusts is dominated by calcite, dolomite and quartz. The total concentration of trace elements across the sampling sites ranged from 36.8 to 234.3 mg kg1 for Pb, 0.004e4.504 mg kg1 for Hg, 160.9 e778.3 mg kg1 for Zn, 245e652 mg kg1 for Mn, 39.4e117.9 mg kg1 for Ni, 31.6e105.9 mg kg1 for Cr, 49.8e232.5 mg kg1 for Cu, 5.3e8.6 mg kg1 for As, 0.31e0.85 mg kg1 for Cd, 0.76e9.45 mg kg1 for Sb, and 16,300e24,900 mg kg1 for Fe. The enrichment factor results reveal the following order: Cu > Hg > Sb > Zn > Pb > Ni > Cr > As > Mn > Cd > Fe. Among the measured elements, the highest mobility factor belongs to Pb (79.2%), Hg (74.6%), Zn (64.1%) and Mn (56.4%). According to the calculated Hazard Quotient (HQ) and Hazard Index (HI), special attention should be paid to Hg, Pb, Zn, and Mn in the street dusts of Shiraz. Multivariate statistics indicate that traffic, natural soil particles and industrial activities are likely to be the main sources of heavy metals in Shiraz street dusts.

Keywords: *Street dust; Potentially toxic metals; Modified BCR; sequential extraction; Human health risk; Shiraz.*

Contributions of gas flaring to a global air pollution hotspot: Spatial and temporal variations, impacts and alleviation

Obinna C.D. Anejionu , J. Duncan Whyatt , G. Alan Blackburn , Catheryn S. Price

Source: *Atmospheric Environment 118 (2015) 184e193*

Studies of environmental impacts of gas flaring in the Niger Delta are hindered by limited access to official flaring emissions records and a paucity of reliable ambient monitoring data. This study uses a combination of geospatial technologies and dispersion modelling techniques to evaluate air pollution impacts of gas flaring on human health and natural ecosystems in the region. Results indicate that gas flaring is a major contributor to air pollution across the region, with concentrations exceeding WHO limits in some locations over certain time periods. Due to the predominant south-westerly wind, concentrations are higher in some states with little flaring activity than in others with significant flaring activity. Twenty million people inhabit areas of high flare-associated air pollution, which include all of the main ecological zones of the region, indicating that flaring poses a substantial threat to human health and the environment. Model scenarios demonstrated that substantial reductions in pollution could be achieved by stopping flaring at a small number of the most active sites and by improving overall flaring efficiency

Keywords: *Gas flares;Remote sensing; Dispersion modelling; Health impacts; Environmental impacts; Niger delta.*

Variability of aerosols and chemical composition of PM10, PM2.5 and PM1 on a platform of the Prague underground metro

M. Cusack , N. Talbot , J. Ondracek , M.C. Minguillon , V. Martins , K. Klouda , J. Schwarz , V. Zdímal

Source: *Atmospheric Environment 118 (2015) 176e183*

Measurements of PM10, PM2.5 and PM1 and particle number concentration and size distribution were measured for 24 h on a platform of the Prague underground metro in October 2013. The three PM fractions were analysed for major and minor elements, secondary inorganic aerosols (SIA) and total carbon (TC). Measurements were performed both when the metro was inoperative and closed to the public (referred to as background), and when the metro was in operation and open to passengers. PM concentrations were elevated during both periods, but were substantially increased in the coarse fraction during hours when the metro was in operation. Average PM concentrations were 214.8, 93.9 and 44.8 mg m3 for PM10, PM2.5 and PM1, respectively (determined gravimetrically). Average particle number concentrations were 8.5 103 cm3 for background hours and 11.5 103 cm3 during operational hours. Particle number concentrations were found to not vary as significantly as PM concentrations throughout the day. Variations in PM were strongly governed by passing trains, with highest concentrations recorded during rush hour. When trains were less frequent, PM concentrations were shown to fluctuate in unison with the entrance and exit of trains (as shown by wind velocity measured on the platform). PM was found to be highly enriched with iron, especially in the coarse fraction, comprising 46% of PM10 (98.9 mg m3). This reduces to 6.7 mg m3 during background hours, proving that the trains themselves were the main source of iron, most probably from wheel-rail mechanical abrasion. Other enriched elements relative to background hours included Ba, Cu, Mn, Cr, Mo, Ni and Co, among others. Many of these elements exhibited a similar size distribution, further indicating their sources were common and were attributed to train operations.

Keywords: *Underground train microenvironment; Sub-micron particles; Number concentration; Number size distribution; PM; chemical characterisation.*

Mobile assessment of on-road air pollution and its sources along the EasteWest Highway in Bhutan

Tenzin Wangchuk , Luke D. Knibbs , Congrong He , Lidia Morawska

Source: *Atmospheric Environment 118 (2015) 98e106*

Human exposures in transportation microenvironments are poorly represented by ambient stationary monitoring. A number of on-road studies using vehicle-based mobile monitoring have been conducted to address this. Most previous studies were conducted on urban roads in developed countries where the primary emission source was vehicles. Few studies have examined on-road pollution in developing countries in urban settings. Currently, no study has been conducted for roadways in rural environments where a substantial proportion of the population live. This study aimed to characterize on-road air quality on the EasteWest Highway (EWH) in Bhutan and identify its principal sources. We conducted six mobile measurements of PM10, particle number (PN) count and CO along the entire 570 km length of the EWH. We divided the EWH into five segments, R1eR5, taking the road length between two district towns as a single road segment. The pollutant concentrations varied widely along the different road segments, with the highest concentrations for R5 compared with other road segments (PM10 ¼ 149 mg/m3, PN ¼ 5.74 104 particles/cm3 , CO ¼ 0.19 ppm), which is the final segment of the road to the capital. Apart from vehicle emissions, the dominant sources were road works, unpaved roads and roadside combustion activities. Overall, the highest contributions above the background levels were made by unpaved roads for PM10 (6 times background), and vehicle emissions for PN and CO (5 and 15 times background, respectively). Notwithstanding the differences in instrumentation used and particle size range measured, the current study showed lower PN concentrations compared with similar on-road studies. However, concentrations were still high enough that commuters, road maintenance workers and residents living along the EWH, were potentially exposed to elevated pollutant concentrations from combustion and non-combustion sources. Future studies should focus on assessing the dispersion patterns of roadway pollutants and defining the short- and long-term health impacts of exposure in Bhutan, as well as in other developing countries with similar characteristics.

Keywords: *On-road; Bhutan; Particle number; PM10; CO.*

The forecasting research of early warning systems for atmospheric pollutants: A case in Yangtze River Delta region

Yiliao Song , Shanshan Qin , Jiansheng Qu , Feng Liu

Source: *Atmospheric Environment 118 (2015) 58e69*

The issue of air quality regarding PM pollution levels in China is a focus of public attention. To address that issue, to date, a series of studies is in progress, including PM monitoring programs, PM source apportionment, and the enactment of new ambient air quality index standards. However, related research concerning computer modeling for PM future trends estimation is rare, despite its significance to forecasting and early warning systems. Thereby, a study regarding deterministic and interval forecasts of PM is performed. In this study, data on hourly and 12 h-averaged air pollutants are applied to forecast PM concentrations within the Yangtze River Delta (YRD) region of China. The characteristics of PM emissions have been primarily examined and analyzed using different distribution functions. To improve the distribution fitting that is crucial for estimating PM levels, an artificial intelligence algorithm is incorporated to select the optimal parameters. Following that step, an ANF model is used to conduct deterministic

forecasts of PM. With the identified distributions and deterministic forecasts, different levels of PM intervals are estimated. The results indicate that the lognormal or gamma distributions are highly representative of the recorded PM data with a goodness-of-fit R2 of approximately 0.998. Furthermore, the results of the evaluation metrics (MSE, MAPE and CP, AW) also show high accuracy within the deterministic and interval forecasts of PM, indicating that this method enables the informative and effective quantification of future PM trends.

Keywords: *Particle matter (PM); Emissions distribution; Adaptive neuro-fuzzy (ANF) model; Dynamic interval forecasts; Forecasting and early warning systems.*

Mortality associated with particulate concentration and Asian dust storms in Metropolitan Taipei

Yu-Chun Wang , Yu-Kai Lin

Source: *Atmospheric Environment 117 (2015) 32e40*

This study evaluates mortality risks from all causes, circulatory diseases, and respiratory diseases associated with particulate matter (PM10 and PM2.5) concentrations and Asian dust storms (ADS) from 2000 to 2008 in Metropolitan Taipei. This study uses a distributed lag non-linear model with Poisson distribution to estimate the cumulative 5-day (lags 0e4) relative risks (RRs) and confidence intervals (CIs) of cause-specific mortality associated with daily PM10 and PM2.5 concentrations, as well as ADS, for total (all ages) and elderly (65 years) populations based on study periods (ADS frequently inflicted period: 2000 e2004; and less inflicted period: 2005e2008). Risks associated with ADS characteristics, including inflicted season (winter and spring), strength (the ratio of stations with Pollutant Standard Index >100 is <05 or ≥0.5), and duration (ADS persisted for 1e3 or 4 days), were also evaluated. Nonlinear models showed that an increase in PM10 from 10 mg/m3 to 50 mg/m3 was associated with increased all-cause mortality risk with cumulative 5-day RR of 1.10 (95% CI: 1.04, 1.17) for the total population and 1.10 (95% CI: 1.02, 1.18) for elders. Mortality from circulatory diseases for the elderly was related to increased PM2.5 from 5 mg/m3 to 30 mg/m3 , with cumulative 5-day RR of 1.21 (95% CI: 1.02, 1.44) from 2005 to 2008. Compared with normal days, the mortality from all causes and circulatory diseases for the elderly population was associated with winter ADS with RRs of 1.05 (95% CI: 1.01, 1.08) and 1.08 (95% CI: 1.01, 1.15), respectively. Moreover, all-cause mortality was associated with shorter and less area-affected ADS with an RR of 1.04 for total and elderly populations from 2000 to 2004. Population health risk differed not only with PM concentration but also with ADS characteristics.

Keywords: *Death; Particulate matter; Asian dust storm; Season Circulatory.*

Acute episodes of black carbon and aerosol contamination in a museum environment: Results of integrated real-time and off-line measurements

L. Cartechini , S. Castellini , B. Moroni , M. Palmieri , F. Scardazza , B. Sebastiani , R. Selvaggi , M. Vagnini , G.L. Delogu , B.G. Brunetti , D. Cappelletti

Source: *Atmospheric Environment 116 (2015) 130e137*

Aerosol size distributions together with black carbon and ozone concentrations have been recorded simultaneously at high temporal resolution (1 min) for three seasonal campaigns in a museum environment.

The aerosol measurements were essential to individuate acute episodes of black carbon intrusions, generated every day at meal times from a wood-burning oven located in an adjacent restaurant. This case study provided the opportunity to further investigate and characterize in details the properties of the airborne particles generated by the combustion episodes. Specifically, real-time data have been discussed and integrated with off-line chemical analyses of aerosol samples including chromatographic and SEM-EDX techniques. All the events of elevated particles concentration evidenced the presence of fresh carbonaceous particles (chain-like aggregates and tar balls) with relatively large size (200e400 nm) typical of biomass combustion processes. These have been associated also with high levels of PAH and low carbon number n-alkanes. Finally, this study found that the operation of the wood oven, even if located in an adjacent building, elevated the particle number concentration and BC mass from 4 to 20 times higher than the background values inside the museum.

Keywords: *Indoor air quality; Black carbon; Wood burning emission source; Particles size distribution; Museum environment.*

Net global warming potential and greenhouse gas intensity from the double rice system with integrated soilecrop system management: A three-year field study

Yinglie Liu, Ziqiang Zhou, Xiaoxu Zhang, Xin Xu, Hao Chen, Zhengqin Xiong

Source: *Atmospheric Environment 116 (2015) 92e101*

The impact of integrated soilecrop system management (ISSM) on net global warming potential (GWP) and greenhouse gas intensity (GHGI) is poorly documented though crucial for food security and nitrogen fertilizer use efficiency (NUE). Using local farming practices (FP) and no nitrogen (NN) as the controls, three ISSM practices at different N rates were established in 2009 in a double rice system in Hunan Province, China. Soil organic carbon sequestration rates (SOCSR) were estimated by changes in SOC between 2009 and 2014. Field measurements of methane (CH4) and nitrous oxide (N2O) fluxes, grain yield and NUE of early and late rice were measured from April 2011 through April 2014. The net GWP of the annual CH4 and N2O emissions and SOCSR and the GHGI over the three years in the FP was 15.35 t CO2 eq ha1 year1 and 1.00 kg CO2 eq kg1 grain. The ISSM (N2) treatment increased annual rice yield by 23%, NUE by 76% and SOCSR by 129%, with similar sizes of net GWP and GHGI under the same N input relative to the FP. A second ISSM (N1) treatment in which annual fertilizer N input was decreased by 20% also showed the potential to lower net GWP and GHGI and increase SOCSR and significantly increased annual rice grain yield by 8.6% and NUE by 59%. The third ISSM (N3) in which fertilizer N input was 20% greater than in FP, significantly increased annual rice yield by 26%, NUE by 57% and SOCSR by 98% but notably increased the CH4 and N2O emissions. Our findings show that the ISSM strategies are promising and feasible in sustainable rice agriculture for food security and GHGs mitigation.

Keywords: *Methane (CH4); Nitrous oxide (N2O); Soil carbon sequestration; Global warming potential (GWP); Greenhouse gas intensity (GHGI);Integrated soilecrop system management (ISSM).*

Characteristics of ground level CO2 concentrations over contrasting land uses in a tropical urban environment

M. Kishore Kumar, S.M. Shiva Nagendra

Source: *Atmospheric Environment 115 (2015) 286e294*

Indian cities feature high human population density, heterogeneous traffic, mixed land-use patterns and mostly tropical meteorological conditions. Characteristics of ambient CO2 concentrations under these distinctive features are very specific and the related studies are limited. This paper presents the characteristics of ground level CO2 concentrations at three contrasting land uses (residential, commercial and industrial) in a tropical urban area of India. The CO2 concentrations were monitored in Chennai city for 31 days at each land use during JuneeSeptember, 2013. Emissions of CO2 from all the major anthropogenic sources present at the three study sites were also quantified. Results indicated that the daily average CO2 concentrations were high at commercial (467 ± 35.15 ppm) and industrial (464 ± 31.68 ppm) sites than at residential site (448 ± 33.45 ppm). The quantified CO2 emissions were also showed high levels at commercial (1190 tons/day) and industrial sites (8886 tons/day) than at residential site (90 tons/day). On a diurnal scale, CO2 concentrations were low during afternoons and high during the late evenings and early morning hours at all the three types of land use sites. At the urban residential site, the domestic sector had a strong impact on the day time CO2 concentrations, while soil and plant respiration phenomena had a greater control over the night time CO2 concentrations. Further, the CO2 concentrations were high during the stagnation and stable meteorological conditions than the ventilation and unstable conditions.

Keywords: *CO2; Residential; Commercial; Industrial Meteorology; Traffic; Domestic; CO2 dome.*

Effects of Independence Day fireworks on atmospheric concentrations of fine particulate matter in the United States

Dian J. Seidel , Abigail N. Birnbaum

Source: *Atmospheric Environment 115 (2015) 192e198*

Previous case studies have documented increases in air pollutants, including particulate matter (PM), during and following fireworks displays associated with various holidays and celebrations around the world. But no study to date has explored fireworks effects on air quality over large regions using systematic observations over multiple years to estimate typical regional PM increases. This study uses observations of fine PM (with particle diameters < 2.5 mm, PM2.5) from 315 air quality monitoring sites across the United States to estimate the effects of Independence Day fireworks on hourly and 24-hr average concentrations. Hourly PM2.5 concentrations during the evening of July 4 and morning of July 5 are higher than on the two preceding and following days in July, considered as control days. On national average, the increases are largest (21 mg/m3) at 9e10 pm on July 4 and drop to zero by noon on July 5. Average concentrations for the 24-hr period beginning 8 pm on July 4 are 5 mg/m3 (42%) greater than on control days, on national average. The magnitude and timing of the Independence Day increases vary from site to site and from year to year, as would be expected given variations in factors such as PM2.5 emissions from fireworks, local meteorological conditions, and distances between fireworks displays and monitoring sites. At one site adjacent to fireworks, hourly PM2.5 levels climb to ~500 mg/m3, and 24-hr average concentrations increase by 48 mg/m3 (370%). These results have implications for potential improvements in air quality models and their predictions, which currently do not account for this emissions source.

Keywords: *Fireworks; Pyrotechnics; Particulate matter; PM2.5; Independence Day; 4th of July.*

Characteristics and reactivity of volatile organic compounds from non-coal emission sources in China

Qiusheng He , Yulong Yan , Hongyan Li , Yiqiang Zhang , Laiguo Chen , Yuhang Wang

Source: *Atmospheric Environment 115 (2015) 153e162*

Volatile organic compounds (VOCs) were sampled from non-coal emission sources including fuel refueling, solvent use, industrial and commercial activities in China, and 62 target species were determined by gas chromatography-mass selective detector (GC-MSD). Based on the results, source profiles were developed and discussed from the aspects of composition characteristics, potential tracers, BTEX (benzene, toluene, ethylbenzene and xylene) diagnostic ratios and chemical reactivity. Compared with vehicle exhausts and liquid fuels, the major components in refueling emissions of liquefied petroleum gas (LPG), gasoline and diesel were alkenes and alkanes. Oppositely, aromatics were the most abundant group in emissions from auto-painting, book binding and plastic producing. Three groups contributed nearly equally in printing and commercial cooking emissions. Acetone in medical producing, chloroform and tetrachloroethylene in wet- and dry-cleaning, as well as TEX in plastic producing etc. were good tracers for the respective sources. BTEX ratios showed that some but not all VOCs sources could be distinguished by B/T, B/E and B/X ratios, while T/E, T/X and E/X ratios were not suitable as diagnostic indicators of different sources. The following reactivity analysis indicated that emissions from gasoline refueling, commercial cooking, auto painting and plastic producing had high atmospheric reactivity, and should be controlled emphatically to prevent ozone pollution, especially when there were large amounts of emissions for them.

Keywords: *Volatile organic compounds (VOCs); Source profiles; BTEX ratios; Chemical reactivity.*

Evaluation of the impact of transportation changes on air quality

G. Titos , H. Lyamani , L. Drinovec , F.J. Olmo , G. Mocnik , L. Alados-Arboledas

Source: *Atmospheric Environment 114 (2015) 19e31*

Transport regulation at local level for the abatement of air pollution has gained significant traction in the EU. In this work, we analyze the effect of different transportation changes on air quality in two similarly sized cities: Granada (Spain) and Ljubljana (Slovenia). Several air pollutants were measured at both sites before and after the implementation of the changes. In Ljubljana, a 72% reduction of local black carbon (BC), from 5.6 to 1.6 mg/m3, was observed after the restriction was implemented. In Granada, statistically significant reductions of 1.3 mg/m3 (37%) in BC and of 15 mg/m3 (33%) in PM10 concentrations were observed after the public transportation re-organization. However, the improvement observed in air quality was very local since other areas of the cities did not improve significantly. We show that closing streets to private traffic, renewal of the bus fleet and re-organization of the public transportation significantly benefit air quality.

Keywords: *Black carbon; Air quality; Traffic pollution; Urban Aethalometer.*

Fine particulate matter events associated with synoptic weather patterns, long-range transport paths and mixing height in the Taipei Basin, Taiwan

Li-Wei Lai

Source: *Atmospheric Environment 113 (2015) 50e62*

Asian dust storms (ADS) and PM2.5 (particle pollution) events have an evident influence on air quality in Taiwan. However, the synoptic weather patterns and atmospheric conditions on ADS days are not entirely similar to those related to PM2.5 event days. The aim of this study is to clarify the weather characteristics such as synoptic weather patterns, long-range transport paths, and stagnant conditions that precipitate PM2.5 events. Air quality and meteorological data from 2006 to 2013 were obtained from government-owned observation stations, and the mixing height was estimated in relation to the Nozaki planetary boundary layer height. This study used back trajectories as simulated gridded analysis data, which were based on kinematic trajectory analysis using NASA's GMAO (Global Modeling Assimilation Office) and NCEP (National Centers for Environmental Prediction) analyses. For testing the differences between means of two large, independent samples, the confidence interval of a common statistical indicator was employed. The results show that in comparison to low PM2.5 level days, weather features such as stagnant conditions, including low mixing height and low wind speed, low rainfall amount, and high solar hours, are favorable for inducing PM2.5 events. Eighty percent of the synoptic weather patterns on PM2.5 days were associated with either polar continental high pressure, a high-pressure system in mainland China moving from the continent to the sea, or a stationary front stretching from southern China to the East Sea, and moving eastwards. More than 81% of the contributing factors of the causes of PM2.5 events were found to be related to stagnant conditions. The pattern of the contributing factors causing the maximum-recorded concentration of PM2.5, (73.90 mg/m3) was attributed to local emissions, and a long-range transport time that was extended for a longer period over the land than over the sea. The synoptic weather patterns were also found to affect the spatial distribution of PM2.5 concentrations in the basin.

Keywords: *PM2.5 events; Mixing height; Back trajectory tracks; Synoptic weather patterns; Long-range transport; Stagnant conditions.*

Variations in PM2.5, TSP, BC, and trace gases (NO2, SO2, and O3) between haze and non-haze episodes in winter over Xi'an, China

Qian Zhang , Zhenxing Shen , Junji Cao , Renjian Zhang , Leiming Zhang , R.-J. Huang , Chenjia Zheng , Linqing Wang, Suixin Liu , Hongmei Xu , Chunli Zheng , Pingping Liu

Source: *Atmospheric Environment 112 (2015) 64e71*

To investigate chemical profiles and formation mechanisms of aerosol particles in winter haze events, daily PM2.5 and TSP, 5-min BC, and 15-min trace gases (SO2, NO2, and O3) were measured continuously during Dec. 1e31, 2012 in Xi'an. Chemical analysis was also conducted for nine water-soluble inorganic ions (Naþ, NHþ 4 , Kþ, Mg2þ, Ca2þ, F, Cl, NO 3 , and SO2 4), organic carbon (OC), elemental carbon (EC), and eight carbon fractions (OC1, OC2, OC3, OC4, EC1, EC2, EC3, and OP) in both PM2.5 and TSP samples. Higher levels of TSP, PM2.5, BC, SO2, and NO2, and lower levels of O3 were observed during haze periods in comparison with non-haze days. The sum of the major secondary ionic species (NHþ 4 , NO 3 , and SO2 4) in PM2.5 or TSP during haze periods was about 3 times of that during non-haze days. Ion balance calculations showed that PM2.5 samples were acidic during haze periods and were close to neutral during non-haze days. The mean carbon levels were 52.9 mg m3 and 82.1 mg m3 in PM2.5 and TSP, respectively,

during haze events, which were ~1.5 times of those during non-haze days. The diurnal variations of BC during non-haze days showed a bimodal distribution with two peaks coincided with traffic rush hours. This was not the case during haze periods, which exhibited a relatively smooth pattern but with high concentration levels, providing evidence of particle accumulation. The ratios of SO2 4 /EC, NO 3 /EC, and NHþ 4 /EC sharply increased during haze periods, indicating the important pathway of secondary inorganic species formation through aqueous-phase transformation under high relative humidity condition. This study also highlights that wintertime secondary organic carbon (SOC) formation can be an important contributor to carbonaceous aerosol, especially during haze periods.

Keywords: *Aerosol formation; Inorganic aerosol; Organic aerosol; Secondary aerosol;Urban environment.*

Estimation of foreign versus domestic contributions to Taiwan's air pollution

Jen-Ping Chen , Cheng-En Yang , I-Chun Tsai

Source: *Atmospheric Environment 112 (2015) 9e19*

Based on the analysis of observational data obtained over a period of 17 years, this study developed a novel approach estimating long-term changes in the relative contributions of domestic and foreign sources to air pollution levels over the island of Taiwan. The contribution from foreign sources was calculated using data measured at selected coastal monitoring stations under specific meteorological conditions. The domestic contribution was derived by subtracting the foreign contribution from the overall concentration, which was calculated with island-wide monitoring station data averaged using Thiessen polygon area weighting. The trends of mean CO, NO, NO2 and SO2 concentrations in Taiwan were 2.1%, 3.3%, 1.4% and 0% yr1 ; while the background concentrations varied by 1.0%, 5.7%, 3.8% and 6.6% yr1 , respectively. These figures suggest that the efforts of Taiwan in reducing air pollution are largely being negated by foreign contributions. Ozone showed a steady increase of 3.3% yr1, and a portion of this was associated with a 1.0% yr1 increase in background values. Local and background PM10 concentrations did not show significant long-term trends, but rather strong inter-annual variations associated with dust storm activity in East Asia. The domestic fractions of NO and NO2 respectively decreased from 90% and 85% in 1994 to less than 60% and 70% in 2010. In contrast, the domestic fraction of SO2 decreased from 82% in 1994 to 27% in 2010. The domestic fraction of CO exhibited no obvious trend due to concurrent decreases in local and background contributions. Background O3 values tended to drop across Taiwan due to the titration effect from domestic NO emissions, and the fraction of domestic O3 titration decreased from 50% in the mid-90s to 25% in 2010.

Keywords: *Air pollution; Long-term trend;Foreign contribution; Domestic contribution; Taiwan.*

Climate effect of black carbon aerosol in a Tibetan Plateau glacier

Song Yang , Baiqing Xu , Junji Cao , Charles S. Zender , Mo Wang

Source: *Atmospheric Environment 111 (2015) 71e78*

In the Tibetan Plateau, the black carbon (BC) concentration in surface snow and snow pits has received much attention, whereas the seasonal behavior of aerosol-in-snow concentration, vertical profile, meltscavenging, and enrichment have received relatively little attention. Here we investigate these processes and their impacts on radiative forcing on the Muji glacier in the westernmost Tibetan Plateau during the 2012 snowmelt season. Increasing impurity concentrations were mostly due to post-deposition effects rather than

new deposition. On 5 July, BC concentrations in the surface snow were higher than those of fresh snow, implying enrichment via sublimation and/or melting of previous snow. Fresh snow contained 25 ng g1 BC on 27 July; afterward, BC gradually increased, reaching 730.6 ng g1 in September. BC, organic carbon (OC), and dust concentrations co-varied but differed in magnitude. Melt-scavenging ef- ficiencies were estimated at 0.19 ± 0.05 and 0.04 ± 0.01 for OC and BC, respectively, and the BC in surface snow increased by 20e25 times depending on melt intensity. BC-in-snow radiative forcing (RF) was approximately 2.2 W m2 for fresh snow and 18.1e20.4 W m2 for aged snow, and was sometimes reduced by the presence of dust.

Keywords: *Black carbon; Snow; Glacier melt; Tibetan Plateau.*

Spatial and temporal variability of ultrafine particles, NO2, PM2.5, PM2.5 absorbance, PM10 and PM coarse in Swiss study areas

Marloes Eeftens , Harish C. Phuleria , Reto Meier , Inmaculada Aguilera , Elisabetta Corradi , Mark Davey , Regina Ducret-Stich , Martin Fierz , Robert Gehrig , Alex Ineichen , Dirk Keidel , Nicole Probst-Hensch , Martina S. Ragettli , Christian Schindler , Nino Künzli, Ming-Yi Tsai

Source: *Atmospheric Environment 111 (2015) 60e70*

Exposure to outdoor air pollutants remains an important concern in Europe, as limit values for NO2 and PM10 continue to be exceeded. Few studies have addressed the long-term spatial contrasts in PM2.5, PM absorbance, PMcoarse and especially ultrafine particles. This scarcity of data hampers the possibility to conduct epidemiological studies, assessing the health relevance of these markers of potentially harmful pollutants. Air pollution measurements were performed in eight geographically distinct areas of the Swiss Study on Air Pollution and Lung and Heart Diseases in Adults (SAPALDIA) in Switzerland. NO2 was measured in all eight areas at 40 sites per area, and PM2.5, PM2.5 absorbance, PM10 and ultrafine particles (particle number concentration (PNC) and lung deposited surface area (LDSA)) were measured in 4 of these areas, at a subset of 20 out of 40 sites. Each site was sampled three times during different seasons of the year, using the same equipment, sampling protocols and the same central facilities for analysis of samples. We assessed the spatial variability between areas and between individual sites, as well as pollution contrasts between the seasons and correlations between different pollutants. Within-area spatial contrasts (defined as the ratio between the 90th and 10th percentile) were highest for NO2 (3.14), moderate for PMcoarse (2.19), PNC (2.00) and PM2.5 absorbance (1.94), and lowest for LDSA (1.63), PM2.5 (1.50) and PM10 (1.46). Concentrations in the larger cities were generally higher than in smaller towns and rural and alpine areas, and were higher in the winter than in the summer and intermediate seasons, for all pollutants. Between-area differences accounted for more variation than within-area differences for all pollutants except NO2 and PMcoarse. Despite substantial within-area contrasts for PNC and LDSA, 74.7% and 83.3% of the spatial variance was attributed to between-area variability, respectively. Coefficients of determination between long-term adjusted pollutants were high (R2 >0.70) between NO2, PM2.5 absorbance, PNC and LDSA and between PM2.5 and PM10. The measurement of spatial patterns for this large range of outdoor air pollutants will contribute to a highly standardized estimation of individual long-term exposure levels for SAPALDIA cohort participants.

Keywords: *SAPALDIA; NO2; Particulate matter; PM2.5; PM10; Absorbance; Coarse particles; PNC; LDSA; Air pollution; Traffic; Spatial contrast; Switzerland; Seasonal contrast; Exposure assessment.*

Real-time indoor and outdoor measurements of black carbon at primary schools

C. Reche , I. Rivas , M. Pandolfi , M. Viana , L. Bouso , M. Alvarez-Pedrerol , A. Alastuey , J. Sunyer, X. Querol

Source: *Atmospheric Environment 120 (2015) 417e426*

Epidemiological and toxicological studies have demonstrated the association between Black Carbon in indoor and outdoor air and the occurrence of health risks. Data on air quality in schools is of special interest, as children are more vulnerable to health hazards. In this context, indoor and outdoor measurements of real-time Equivalent Black Carbon (EBC) were collected at 39 primary schools located in Barcelona (Spain), with classrooms naturally ventilated under warm weather conditions. A main contribution of road traffic emissions to indoor and outdoor EBC levels was evidenced through different approaches. Simultaneous measurements of EBC levels at schools under different traffic conditions revealed concentrations by 30e35% higher at schools exposed to higher vehicles intensities. Moreover, a significant correlation was obtained between average outdoor EBC levels at different districts of the city and the percentage of surface area in each district used for the road network (R2 ¼ 0.61). Higher indoor than outdoor levels were recorded at some instances when the indoor sampling location was relatively closer to road traffic, even under low outdoor temperatures. Indeed, the average indoor/outdoor EBC ratios for each school correlate moderately between campaigns in spite of significant differences in temperature between sampling periods. These two facts highlight the strong dependency of the EBC levels on the distance to traffic. The peaks of exposure inside the classrooms seemed to be determined by outdoor concentrations, as shown by the parallelism between indoor and outdoor mean EBC daily cycles and the similar contribution of traffic rush hours to indoor and outdoor daily mean levels. The airtightness of the classroom was suggested as the responsible for the indoor/outdoor ratios of EBC higher than 1 recorded at nights.

Keywords: *Children's exposure; Traffic rush-hour; Infiltration; Airtightness.*

Real-world emissions and fuel consumption of diesel buses and trucks in Macao: From on-road measurement to policy implications

Xiaomeng Wu , Shaojun Zhang , Ye Wu , Zhenhua Li , Yu Zhou , Lixin Fu , Jiming Hao

Source: *Atmospheric Environment 120 (2015) 393e403*

A total of 13 diesel buses and 12 diesel trucks in Macao were tested using portable emission measurement systems (PEMS) including a SEMTECH-DS for gaseous emissions and a SEMTECH-PPMD for PM2.5. The average emission rates of gaseous pollutants and CO2 are developed with the operating mode defined by the instantaneous vehicle specific power (VSP) and vehicle speed. Both distance-based and fuel mass-based emission factors for gaseous pollutants (e.g., CO, THC and NOX) are further estimated under typical driving conditions. The average distance-based NOX emission of heavy-duty buses (HDBs) is higher than 13 g km1 . Considering the unfavorable conditions for selective reductions catalyst (SCR) systems, such as low-speed driving conditions, more effective technology options (e.g., dedicated natural gas buses and electric buses) should be considered by policy makers in Macao. We identified strong effects of the vehicle size, engine displacement and driving conditions on real-world CO2 emission factors and fuel consumption for diesel vehicles. Therefore, detailed profiles regarding vehicle specifi- cations can reduce the uncertainty in their fleet-average on-road fuel consumption. In addition, strong correlations between relative emission factors and driving conditions indicated by the average speed of generated micro-trips are identified based on a micro-trip method. For example, distance-based emission factors of HDBs will increase by 39% for CO,

29% for THC, 43% for NOX and 26% for CO2 when the average speed decreases from 30 km h1 to 20 km h1 . The mitigation of on-road emissions from diesel buses and trucks by improving traffic conditions through effective traffic and economic management measures is therefore required. This study demonstrates the important role of PEMS in understanding vehicle emissions and mitigation strategies from science to policy perspectives.

Keywords: *Vehicle; Diesel; Emissions; Fuel consumption; Macao; PEMS.*

Future trends of global atmospheric antimony emissions from anthropogenic activities until 2050

Junrui Zhou , Hezhong Tian , Chuanyong Zhu , Jiming Hao , Jiajia Gao , Yong Wang , Yifeng Xue , Shenbin Hua , Kun Wang

Source: *Atmospheric Environment 120 (2015) 385e392*

This paper presents the scenario forecast of global atmospheric antimony (Sb) emissions from anthropogenic activities till 2050. The projection scenarios are built based on the comprehensive global antimony emission inventory for the period 1995e2010 which is reported in our previous study. Three scenarios are set up to investigate the future changes of global antimony emissions as well as their source and region contribution characteristics. Trends of activity levels specified as 5 primary source categories are projected by combining the historical trend extrapolation with EIA International energy outlook 2013, while the source-specific dynamic emission factors are determined by applying transformed normal distribution functions. If no major changes in the efficiency of emission control are introduced and keep current air quality legislations (Current Legislation scenario), global antimony emissions will increase by a factor of 2 between 2010 and 2050. The largest increase in Sb emissions is projected from Asia due to large volume of nonferrous metals production and waste incineration. In case of enforcing the pollutant emission standards (Strengthened Control scenario), global antimony emissions in 2050 will stabilize with that of 2010. Moreover, we can anticipate further declines in Sb emissions for all continents with the best emission control performances (Maximum Feasible Technological Reduction scenario). Future antimony emissions from the top 10 largest emitting countries have also been calculated and source category contributions of increasing emissions of these countries present significant diversity. Furthermore, global emission projections in 2050 are distributed within a 11latitude/longitude grid. East Asia, Western Europe and North America present remarkable differences in emission intensity under the three scenarios, which implies that source-and-country specific control measures are necessary to be implemented for abating Sb emissions from varied continents and countries in the future.

Keywords: *Global emission inventory; Antimony; Scenario analysis; Geospatial distribution characteristics; Fuel combustion; Waste incineration.*

Association between air pollution and daily mortality and hospital admission due to ischaemic heart diseases in Hong Kong

Wilson Wai San Tam , Tze Wai Wong , Andromeda H.S. Wong

Source: *Atmospheric Environment 120 (2015) 360e368*

Ischaemic heart disease (IHD) is one of the leading causes of death worldwide. The effects of air pollution on IHD mortalities have been widely reported. Fewer studies focus on IHD morbidities and PM2.5, especially in Asia. To explore the associations between short-term exposure to air pollution and morbidities and mortalities from IHD, we conducted a time series study using a generalized additive model that regressed the daily numbers of IHD mortalities and hospital admissions on daily mean concentrations of the following air pollutants: nitrogen dioxide (NO2), particulate matter with an aerodynamic diameter less than 10 mm (PM10), particulate matter with an aerodynamic diameter less than 2.5 mm (PM2.5), ozone (O3), and sulfur dioxide (SO2). The relative risks (RR) of IHD deaths and hospital admissions per 10 mg/m3 increase in the concentration of each air pollutant were derived in single pollutant models. Multipollutant models were also constructed to estimate their RRs controlling for other pollutants. Significant RRs were observed for all five air pollutants, ranging from 1.008 to 1.032 per 10 mg/m3 increase in air pollutant concentrations for IHD mortality and from 1.006 to 1.021 per 10 mg/m3 for hospital admissions for IHD. In the multipollutant model, only NO2 remained significant for IHD mortality while SO2 and PM2.5 was significantly associated with hospital admissions. This study provides additional evidence that mortalities and hospital admissions for IHD are significantly associated with air pollution. However, we cannot attribute these health effects to a specific air pollutant, owing to high collinearity between some air pollutants.

Keywords: *Ischaemic heart disease; Air pollution; PM10; PM2.5; Hospital admissions; Mortality.*

Characterization of aerosol composition, concentrations, and sources at Baengnyeong Island, Korea using an aerosol mass spectrometer

Taehyoung Lee , Jinsoo Choi , Gangwoong Lee , Junyoung Ahn , Jin Soo Park , Samuel A. Atwood , Misha Schurman , Yongjoo Choi , Yoomi Chung , Jeffrey L. Collett Jr.

Source: *Atmospheric Environment 120 (2015) 297e306*

To improve understanding of the sources and chemical properties of particulate pollutants on the western side of the Korean Peninsula, an Aerodyne High Resolution Time of Flight Aerosol Mass Spectrometer (HR-ToF-AMS) measured non-refractory fine (PM1) particles from May to November, 2011 at Baengnyeong Island, South Korea. Organic matter and sulfate were generally the most abundant species and exhibited maximum concentrations of 36 mg/m3 and 39 mg/m3 , respectively. Nitrate concentrations peaked at 32 mg/m3 but were typically much lower than sulfate and organic matter concentrations. May, September, October, and November featured the highest monthly average concentrations, with lower concentrations typically observed from June through August. Potential source contribution function (PSCF) analysis and individual case studies revealed that transport from eastern China, an area with high SO2 emissions, was associated with high particulate sulfate concentrations at the measurement site. Observed sulfate aerosol sometimes was fully neutralized by ammonium but often was acidic; the average ammonium to sulfate molar ratio was 1.49. Measured species size distributions revealed a range of sulfate particle size distributions with modes between 100 and 600 nm. Organic aerosol source regions were widespread, including contributions from eastern China and South Korea. Positive matrix factorization (PMF) analysis indicated three “factors,” or types of organic aerosol, comprising one primary, hydrocarbon-like organic aerosol (HOA) and two

oxidized organic aerosol (OOA) components, including a more oxidized (MO-OOA) and a less oxidized (LO-OOA) oxidized organic aerosol. On average, HOA and OOA contributed 21% and 79% of the organic mass (OM), respectively, with the MO-OOA fraction nearly three times as abundant as the LO-OOA fraction. Biomass burning contributions to observed OM were low during the late spring/early summer agricultural burning season in eastern China, since airflow into eastern China during the Asian Monsoon generally prevents transport of emissions eastward to the Korean Peninsula. Concentrations of the m/z 60 AMS biomass burning marker were more abundant in autumn, when transport patterns appeared to bring some smoke from fires in northern Asia to the island.

Keywords: *HR-ToF-AMS; Baengnyeong island; Long-range transport; Biomass burning; Potential source contribution.*

Biomass burning in the Amazon region: Aerosol source apportionment and associated health risk assessment

Nilmara de Oliveira Alves , Joel Brito , Sofia Caumo , Andrea Arana , Sandra de Souza Hacon , Paulo Artaxo , Risto Hillamo , Kimmo Teinila€ , Silvia Regina Batistuzzo de Medeiros , Perola de Castro Vasconcellos

Source: *Atmospheric Environment 120 (2015) 277e285*

The Brazilian Amazon represents about 40% of the world's remaining tropical rainforest. However, human activities have become important drivers of disturbance in that region. The majority of forest fire hotspots in the Amazon arc due to deforestation are impacting the health of the local population of over 10 million inhabitants. In this study we characterize western Amazonia biomass burning emissions through the quantification of 14 Polycyclic Aromatic Hydrocarbons (PAHs), Organic Carbon, Elemental Carbon and unique tracers of biomass burning such as levoglucosan. From the PAHs dataset a toxic equivalence factor is calculated estimating the carcinogenic and mutagenic potential of biomass burning emissions during the studied period. Peak concentration of PM10 during the dry seasons was observed to reach 60 mg m3 on the 24 h average. Conversely, PM10 was relatively constant throughout the wet season indicating an overall stable balance between aerosol sources and sinks within the filter sampling resolution. Similar behavior is identified for OC and EC components. Levoglucosan was found in significant concentrations (up to 4 mg m3) during the dry season. Correspondingly, the estimated lung cancer risk calculated during the dry seasons largely exceeded the WHO health-based guideline. A source apportionment study was carried out through the use of Absolute Principal Factor Analysis (APFA), identifying a three-factor solution. The biomass burning factor is found to be the dominating aerosol source, having 75.4% of PM10 loading. The second factor depicts an important contribution of several PAHs without a single source class and therefore was considered as mixed sources factor, contributing to 6.3% of PM10. The third factor was mainly associated with fossil fuel combustion emissions, contributing to 18.4% of PM10. This work enhances the knowledge of aerosol sources and its impact on climate variability and local population, on a site representative of the deforestation which occupies a significant fraction of the Amazon basin.

Keywords: *Biomass burning; Amazon region; PM10; PAHs and lung cancer risk.*

Air quality and climate responses to anthropogenic black carbon emission changes from East Asia, North America and Europe

Makliyar Sadiq , Wei Tao , Junfeng Liu , Shu Tao

Source: *Atmospheric Environment 120 (2015) 262e276*

East Asia, North America and Europe are the world largest emitters of anthropogenic black carbon (BC). In this study, the role of each region's anthropogenic BC emissions on domestic air quality and climate is investigated. A ten-year six-member parallel simulation (i.e., with anthropogenic emissions in each region reduced by 0%, 50% or 100%, or increased by 200%, 500% or 1000%) is conducted based on the stateof-the-art Community Earth System Model (CESM). Linearity of the emission-response relationship is examined for a variety of air quality and climate indicators. Generally, a change in BC emissions tend to linearly influence BC concentrations over both source and nearby downwind regions even taking into account the effect of BC-induced climate perturbations. Aerosol optical depth (AOD) and the net radiative flux perturbation at top of atmosphere (TOA) tend to preserve a similar linear relationship to local BC emission changes, with a robust signal confined only to the source areas. However, the response of temperature in most places is inconsistent to BC emission changes. Though the presence of BC in the atmosphere absorbs solar and terrestrial radiation which has a tendency to warm the atmosphere, the perturbed atmospheric circulation induces substantial meridional exchanges of warm and cold air masses, which overpasses the warming tendency of BC exerted on the atmosphere. This indicates that reducing/increasing regional BC emissions immediately ameliorate/deteriorate local air quality proportionally, but the associated effects on climate perturbation may lack a clear trend within the initial 10-year time span.

Keywords: *Black carbon; East Asia; Europe; North America; Climate response; Radiation budget.*

Assessing the air quality impact of nitrogen oxides and benzene from road traffic and domestic heating and the associated cancer risk in an urban area of Verona (Italy)

Marco Schiavon , Martina Redivo , Gianluca Antonacci , Elena Cristina Rada , Marco Ragazzi , Dino Zardi , Lorenzo Giovannini

Source: *Atmospheric Environment 120 (2015) 234e243*

Simulations of emission and dispersion of nitrogen oxides (NOx) are performed in an urban area of Verona (Italy), characterized by street canyons and typical sources of urban pollutants. Two dominant source categories are considered: road traffic and, as an element of novelty, domestic heaters. Also, to assess the impact of urban air pollution on human health and, in particular, the cancer risk, simulations of emission and dispersion of benzene are carried out. Emissions from road traffic are estimated by the COPERT 4 algorithm, whilst NOx emission factors from domestic heaters are retrieved by means of criteria provided in the technical literature. Then maps of the annual mean concentrations of NOx and benzene are calculated using the AUSTAL2000 dispersion model, considering both scenarios representing the current situation, and scenarios simulating the introduction of environmental strategies for air pollution mitigation. The simulations highlight potentially critical situations of human exposure that may not be detected by the conventional network of air quality monitoring stations. The proposed methodology provides a support for air quality policies, such as planning targeted measurement campaigns, re-locating monitoring stations and adopting measures in favour of better air quality in urban planning. In particular, the estimation of the induced cancer

risk is an important starting point to conduct zoning analyses and to detect the areas where population is more directly exposed to potential risks for health.

Keywords: *AUSTAL2000; NOx; COPERT 4; Street canyon; Human exposure; Dispersion modelling.*

Main components and human health risks assessment of PM10, PM2.5, and PM1 in two areas influenced by cement plants

Francisco Sanchez-Soberon , Joaquim Rovira , Montse Mari , Jordi Sierra , Martí Nadal , Jose L. Domingo , Marta Schuhmacher

Source: *Atmospheric Environment 120 (2015) 109e116*

Particulate matter (PM) is widely recorded as a source of diseases, being more harmful those particles with smaller size. PM is released to the environment as a consequence of different activities, being one of them cement production. The objective of this pilot study was to characterize PM of different sizes around cement facilities to have a preliminary approach of their origin, and evaluate their potential health risks. For that purpose, three fractions of PM (10, 2.5, and 1) were collected in the nearby area of two cement plants with different backgrounds (urban and rural) in different seasons. Subsequently, main components, outdoor and indoor concentrations, exposure, and human health risks were assessed. Greatest levels of PM1, organic matter, and metals were found in urban location, especially in winter. Consequently, environmental exposure and human health risks registered their highest values in the urban plant during wintertime. Exposure was higher for indoor activities, expressing some metals their peak values in the PM1 fraction. Non-carcinogenic risks were below the safety threshold (HQ < 1). Carcinogenic risks for most of the metals were below the limit of 105 , except for Cr (VI), which exceeded it in both locations, but being in the range considered as assumable (106 e104).

Keywords: *Cement; Particulate matter fractions; Indoor/outdoor exposure; Human risk assessment.*

A tale of two cities: Comparison of impacts on CO2 emissions, the indoor environment and health of home energy efficiency strategies in London and Milton Keynes

D. Shrubsole , P. Das , J. Milner , I.G. Hamilton , J.V. Spadaro , E. Oikonomou , M. Davies , P. Wilkinson

Source: *Atmospheric Environment 120 (2015) 100e108*

Dwellings are a substantial source of global CO2 emissions. The energy used in homes for heating, cooking and running electrical appliances is responsible for a quarter of current total UK emissions and is a key target of government policies for greenhouse gas abatement. Policymakers need to understand the potential impact that such decarbonization policies have on the indoor environment and health for a full assessment of costs and benefits. We investigated these impacts in two contrasting settings of the UK: London, a predominantly older city and Milton Keynes, a growing new town. We employed SCRIBE, a building physics-based health impact model of the UK housing stock linked to the English Housing Survey, to examine changes, 2010e2050, in end-use energy demand, CO2 emissions, winter indoor temperatures, airborne pollutant concentrations and associated health impacts. For each location we modelled the existing (2010) housing

stock and three future scenarios with different levels of energy efficiency interventions combined with either a business-as-usual, or accelerated decarbonization of the electricity grid approach. The potential for CO2 savings was appreciably greater in London than Milton Keynes except when substantial decarbonization of the electricity grid was assumed, largely because of the lower level of current energy efficiency in London and differences in the type and form of the housing stock. The average net impact on health per thousand population was greater in magnitude under all scenarios in London compared to Milton Keynes and more beneficial when it was assumed that purposeprovided ventilation (PPV) would be part of energy efficiency interventions, but more detrimental when interventions were assumed not to include PPV. These findings illustrate the importance of considering ventilation measures for health protection and the potential variation in the impact of home energy efficiency strategies, suggesting the need for tailored policy approaches in different locations, rather than adopting a universally rolled out strategy.

Keywords: *Built environment; Housing; Energy efficiency; CO2 reduction; Indoor air quality; Health impacts.*

Sources of air pollution in a region of oil and gas exploration downwind of a large city

Andrew P. Rutter , Robert J. Griffin , Basak Karakurt Cevik , Kabindra M. Shakya , Longwen Gong , Saewung Kim , James H. Flynn , Barry L. Lefer

Source: *Atmospheric Environment 120 (2015) 89e99*

The air quality in the outflow from Fort Worth, TX was studied in June 2011 at a location surrounded by oil and gas development in the Barnett Shale. The objectives of this study were to understand the major sources of volatile organic compounds (VOCs) and organic aerosols and explore the potential influence each VOC source had on ozone and secondary organic aerosol formation. Measurements of VOCs were apportioned between six factors using Positive Matrix Factorization (PMF): Natural Gas (25 ± 2%; ±99% CL); Fugitive Emissions (15 ± 2%); Internal Combustion Engines (15 ± 2%); Biogenic Emissions (7 ± 1%); Industrial Emissions/Oxidation 1(8 ± 1%); and Oxidation 2 (18 ± 2%). Reactivity calculations suggest the Biogenic and Oxidation 2 factors were the most likely VOC sources to influence local ozone. However, enough OH reactivity was calculated for factors related to the oil and gas development that they could incrementally increase O3. Three organic aerosol (OA) types were identified with PMF applied to highresolution time-of-flight aerosol mass spectrometry measurements: hydrocarbon-like OA (HOA; 11% of mass) and two classes of oxidized OA (semi- and less-volatile OOA, SV and LV; 45% and 44%, respectively). The HOA correlated with the Internal Combustion Engine VOC factor indicating that a large fraction of the HOA was emitted by gasoline and diesel motors. The SV-OOA correlated with the oxidized VOC factors during most of the study, whereas a correlation between LV-OOA and the oxidized VOC factors was only observed during part of the study. It is hypothesized that SV-OOA and the oxidized VOC factors correlated reasonably well because these factors likely were separated by at most only a few oxidation generations on the oxidation pathway of organic compounds.

Keywords: *Barnett shale; Hydraulic fracturing; Organic aerosols; PMF; VOCs; Photochemical reactivity.*

Particulate and gaseous emissions from the combustion of different biofuels in a pellet stove

E.D. Vicente , M.A. Duarte , L.A.C. Tarelho , T.F. Nunes , F. Amato , X. Querol , C. Colombi , V. Gianelle , C.A. Alves

Source: *Atmospheric Environment 120 (2015) 15e27*

Seven fuels (four types of wood pellets and three agro-fuels) were tested in an automatic pellet stove (9.5 kWth) in order to determine emission factors (EFs) of gaseous compounds, such as carbon monoxide (CO), methane (CH4), formaldehyde (HCHO), and total organic carbon (TOC). Particulate matter (PM10) EFs and the corresponding chemical compositions for each fuel were also obtained. Samples were analysed for organic carbon (OC) and elemental carbon (EC), anhydrosugars and 57 chemical elements. The fuel type clearly affected the gaseous and particulate emissions. The CO EFs ranged from 90.9 ± 19.3 (pellets type IV) to 1480 ± 125 mg MJ1 (olive pit). Wood pellets presented the lowest TOC emission factor among all fuels. HCHO and CH4 EFs ranged from 1.01 ± 0.11 to 36.9 ± 6.3 mg MJ1 and from 0.23 ± 0.03 to 28.7 ± 5.7 mg MJ1 , respectively. Olive pit was the fuel with highest emissions of these volatile organic compounds. The PM10 EFs ranged from 26.6 ± 3.14 to 169 ± 23.6 mg MJ1 . The lowest PM10 emission factor was found for wood pellets type I (fuel with low ash content), whist the highest was observed during the combustion of an agricultural fuel (olive pit). The OC content of PM10 ranged from 8 wt.% (pellets type III) to 29 wt.% (olive pit). Variable EC particle mass fractions, ranging from 3 wt.% (olive pit) to 47 wt.% (shell of pine nuts), were also observed. The carbonaceous content of particulate matter was lower than that reported previously during the combustion of several wood fuels in traditional woodstoves and fireplaces. Levoglucosan was the most abundant anhydrosugar, comprising 0.02 e3.03 wt.% of the particle mass. Mannosan and galactosan were not detected in almost all samples. Elements represented 11e32 wt.% of the PM10 mass emitted, showing great variability depending on the type of biofuel used.

Keywords: *Pellet stove; PM10; OC/EC; Anhydrosugars; Inorganic species.*

Contributions to cities' ambient particulate matter (PM): A systematic review of local source contributions at global level

Federico Karagulian , Claudio A. Belis , Carlos Francisco C. Dora , Annette M. Prüss-Ustün , Sophie Bonjour , Heather Adair-Rohani , Markus Amann

Source: *Atmospheric Environment 120 (2015) 475e483*

For reducing health impacts from air pollution, it is important to know the sources contributing to human exposure. This study systematically reviewed and analysed available source apportionment studies on particulate matter (of diameter of 10 and 2.5 microns, PM10 and PM2.5) performed in cities to estimate typical shares of the sources of pollution by country and by region. A database with city source apportionment records, estimated with the use of receptor models, was also developed and available at the website of the World Health Organization. Systematic Scopus and Google searches were performed to retrieve city studies of source apportionment for particulate matter. Six source categories were defined. Country and regional averages of source apportionment were estimated based on city population weighting. A total of 419 source apportionment records from studies conducted in cities of 51 countries were used to calculate regional averages of sources of ambient particulate matter. Based on the available information, globally 25% of urban ambient air pollution from PM2.5 is contributed by traffic, 15% by industrial activities, 20% by domestic fuel burning, 22% from unspecified sources of human origin, and 18% from

natural dust and salt. The available source apportionment records exhibit, however, important heterogeneities in assessed source categories and incompleteness in certain countries/regions. Traffic is one important contributor to ambient PM in cities. To reduce air pollution in cities and the substantial disease burden it causes, solutions to sustainably reduce ambient PM from traffic, industrial activities and biomass burning should urgently be sought. However, further efforts are required to improve data availability and evaluation, and possibly to combine with other types of information in view of increasing usefulness for policy making.

Keywords: *Particulate matter; Urban ambient; PM; PM2.5; PM10; Source apportionment; Receptor models.*

Meteorological detrending of primary and secondary pollutant concentrations: Method application and evaluation using long-term (2000e2012) data in Atlanta

Lucas R.F. Henneman , Heather A. Holmes , James A. Mulholland , Armistead G. Russell

Source: *Atmospheric Environment 119 (2015) 201e210*

The effectiveness of air pollution regulations and controls are evaluated based on measured air pollutant concentrations. Air pollution levels, however, are highly sensitive to both emissions and meteorological fluctuations. Therefore, an assessment of the change in air pollutant levels due to emissions controls must account for these meteorological fluctuations. Two empirical methods to quantify the impact of meteorology on pollutant levels are discussed and applied to the 13-year time period between 2000 and 2012 in Atlanta, GA. The methods employ KolmogoroveZurbenko filters and linear regressions to detrended pollutant signals into long-term, seasonal, weekly, short-term, and white-noise components. The methods differ in how changes in weekly and holiday emissions are accounted for. Both can provide meteorological adjustments on a daily basis for future use in acute health analyses. The meteorological impact on daily signals of ozone, NOx, CO, SO2, PM2.5, and PM species are quantified. Analyses show that the substantial decreases in seasonal averages of NOx and SO2 correspond with controls implemented in the metropolitan Atlanta area. Detrending allows for the impacts of some controls to be observed with averaging times of as little as 3 months. Annual average concentrations of NOx, SO2, and CO have all fallen by at least 50% since 2000. Reductions in NOx levels, however, do not lead to uniform reductions in ozone. While average detrended summer average maximum daily average 8 h ozone (MDA8h O3) levels fell by 4% (2.2 ± 2 ppb) between 2000 and 2012, winter averages have increased by 12% (3.8 ± 1.4 ppb), providing further evidence that high ozone levels are NOx-limited and lower ozone concentrations are NOx-inhibited. High ozone days (with MDA8h O3 greater than 60 ppb) decreased both in number and in magnitude over the study period.

Keywords: *Meteorological detrending; Air pollution trends; KZ filtering; Accountability.*

Characterization of gaseous and semi-volatile organic compounds emitted from field burning of rice straw

Nguyen Thi Kim Oanh , Aungsiri Tipayarom , Thuy Ly Bich , Danutawat Tipayarom , Christopher D. Simpson , David Hardie , L.-J. Sally Liu

Source: *Atmospheric Environment 119 (2015) 182e191*

Rice straw (RS) field burning, commonly practiced in Asia, produces large amounts of toxic air pollutants but has not been comprehensively characterized. This study conducted field and laboratory measurements for

gaseous pollutants and semi-VOCs (16 PAHs, 16 chlorinated pesticides and 14 PCBs) in RS burning smoke to determine emission factors (EFs) and emission concentration profiles. Paddy burning experiments were done following common practices used by farmers in Southeast Asia and EFs were estimated using the carbon balance method. Laboratory hood experiments simulated burning of dry RS (moisture content ~ 5%) and normal RS (moisture ~ 23e30%). Semi-VOCs were analyzed separately in the particulate (PM) and gas phases, and the levels measured in smoke were compared with those in the paddy background and in general ambient air to identify enrichment of the compounds. Lower EFs of all pollutants were obtained for hood burning dry RS as compared to hood burning normal RS. EFs of all detected pollutants in the field burning were higher than hood burning. The EFs of field burning in mg kg1 RS were 760 for benzene, 230 for toluene, 510 for SO2, 490 for NO2, 260 for total PAHs (88% in gas phase), 0.11 for total PCBs (59% in gas phase) and 0.23 for OCPs (62% in gas phase). The EF of aldehydes determined in the hood experiment was 80e150 mg kg1 RS. As compared to ambient air, RS smoke had significant enrichment of light PAHs, fluoranthene in PM and acenaphthylene in gas phase. Smoke had a higher proportion of benzene in BTEX than roadside air. Levels of PCBs, OCPs and aldehydes were higher in the burning smoke compared to ambient air, but there was no significant enrichment of particular compounds. This study provides appropriate ranges of EFs for developing emission inventory of RS spread field burning.

Keywords: *Rice straw burning; Emission factor; Concentration profile; Gaseous pollutants; PAHs; Chlorinated compounds.*

Sulphuric acid and aerosol particle production in the vicinity of an oil refinery

Nina Sarnela , Tuija Jokinen , Tuomo Nieminen , Katrianne Lehtipalo , Heikki Junninen , Juha Kangasluoma, Jani Hakala , Risto Taipale , Siegfried Schobesberger , Mikko Sipila , Kai Larnimaa , Henrik Westerholm , Juha Heijari , Veli-Matti Kerminen , Tuukka Petaj , Markku Kulmala

Source: *Atmospheric Environment 119 (2015) 156e166*

In this paper we introduce in-situ observations of trace gases, aerosol particles and their precursors in the vicinity of an oil refinery and industrial area in Kilpilahti, Southern Finland. We conducted a onemonth measurement campaign near the oil refinery during summertime when the sulphur dioxide concentrations at the site are typically the highest. The source areas around the measurement location were divided into three sectors: oil refinery area, industrial area and non-industrial area. The atmospheric concentrations of aerosols and trace gases showed a large temporal variability, when exposed to the different source areas. The median sulphur dioxide concentrations for the oil refinery, industrial and non-industrial area were 1.88 ppbv, 0.75 ppbv and 0.38 ppbv, respectively, and the corresponding sulphuric acid concentrations were 11.5 106 molecules/cm3 , 4.4 106 molecules/cm3 and 1.3 106 molecules/cm3 . The observed concentrations were similar to what have been measured in urban or industrial sites. The ratio between sulphuric acid and sulphur dioxide was the highest when the air mass was coming from the oil refinery. The correlation between the sulphuric acid and 1e2 nm particle concentrations was significant, but the composition of the particles remained unknown as no neutral sulphuric acid clusters were detected with the mass spectrometer. Only a few new particle formation events were observed during the measurement period, and during these events a large fraction of the particle growth could be explained by sulphuric acid condensation.

Keywords: *Sulphuric acid; Atmospheric measurements;New particle formation; Oil refinery; Sulphur dioxide; Mass spectrometry.*

Characterization and source apportionment of health risks from ambient PM10 in Hong Kong over 2000e2011

Zhiyuan Li , Zibing Yuan , Ying Li , Alexis K.H. Lau , Peter K.K. Louie

Source: *Atmospheric Environment 122 (2015) 892e899*

Atmospheric particulate matter (PM) pollution is a major public health concern in Hong Kong. In this study, the spatiotemporal variations of health risks from ambient PM10 from seven air quality monitoring stations between 2000 and 2011 were analyzed. Positive matrix factorization (PMF) was adopted to identify major source categories of ambient PM10 and quantify their contributions. Afterwards, a pointestimated risk model was used to identify the inhalation cancer and non-cancer risks of PM10 sources. The long-term trends of the health risks from classified local and non-local sources were explored. Furthermore, the reason for the increase of health risks during high PM10 days was discussed. Results show that vehicle exhaust source was the dominant inhalation cancer risk (ICR) contributor (72%), whereas trace metals and vehicle exhaust sources contributed approximately 27% and 21% of PM10 inhalation non-cancer risk (INCR), respectively. The identified local sources accounted for approximately 80% of the ICR in Hong Kong, while contribution percentages of the non-local and local sources for INCR are comparable. The clear increase of ICR at high PM days was mainly attributed to the increase of contributions from coal combustion/biomass burning and secondary sulfate, while the increase of INCR at high PM days was attributed to the increase of contributions from the sources coal combustion/ biomass burning, secondary nitrate, and trace metals. This study highlights the importance of health riskbased source apportionment in air quality management with protecting human health as the ultimate target.

Keywords: *PM10; Health risk; Spatiotemporal variation; Source apportionment; Hong Kong.*

CO2 emission estimation in the urban environment: Measurement of the CO2 storage term

A.B. Bjorkegren , C.S.B. Grimmond , S. Kotthaus , B.D. Malamud

Source: *Atmospheric Environment 122 (2015) 775e790*

Eddy covariance has been used in urban areas to evaluate the net exchange of CO2 between the surface and the atmosphere. Typically, only the vertical flux is measured at a height 2e3 times that of the local roughness elements; however, under conditions of relatively low instability, CO2 may accumulate in the airspace below the measurement height. This can result in inaccurate emissions estimates if the accumulated CO2 drains away or is flushed upwards during thermal expansion of the boundary layer. Some studies apply a single height storage correction; however, this requires the assumption that the response of the CO2 concentration profile to forcing is constant with height. Here a full seasonal cycle (7th June 2012 to 3rd June 2013) of single height CO2 storage data calculated from concentrations measured at 10 Hz by open path gas analyser are compared to a data set calculated from a concurrent switched vertical profile measured (2 Hz, closed path gas analyser) at 10 heights within and above a street canyon in central London. The assumption required for the former storage determination is shown to be invalid. For approximately regular street canyons at least one other measurement is required. Continuous measurements at fewer locations are shown to be preferable to a spatially dense, switched profile, as temporal interpolation is ineffective. The majority of the spectral energy of the CO2 storage time series was found to be between 0.001 and 0.2 Hz (500 and 5 s respectively); however, sampling frequencies of 2 Hz and below still result in significantly lower CO2 storage values. An empirical method of correcting CO2 storage values from under-sampled time series is proposed.

Keywords: *Carbon dioxide; Wavelet analysis; CO2 storage;Urban environment; CO2 profile.*

Source apportionment of PM2.5 in top polluted cities in Hebei, China using the CMAQ model

Litao Wang , Zhe Wei , Wei Wei , Joshua S. Fu , Chenchen Meng , Simeng Ma

Source: *Atmospheric Environment 122 (2015) 723e736*

Hebei has been recognized as one of the most polluted provinces in China, characterized by extremely high concentrations of fine particulate matter (PM2.5) in many of its cities, especially those located in the southern area of the province and highly potentially northward transported to Beijing. Source apportionment of PM2.5 is the basis and prerequisite of an effective control strategy. In this study, the Mesoscale Modeling System Generation 5 (MM5) and the Models-3/Community Multiscale Air Quality (CMAQ) modeling system are applied to East Asia and North China at 36- and 12-km horizontal grid resolutions, and the source apportionment of PM2.5 in the three top polluted cities in Hebei, i.e., Shijiazhuang, Xingtai, and Handan, is performed using the Brute-Force method. It is concluded that the regional source contributions to PM2.5 are 27.9% in Shijiazhuang, 46.6% in Xingtai, and 40.4% in Handan. The major local contributors are industrial, domestic and agricultural sources in all the three cities with the contributions of 39.8%, 15.8%, and 10.6% in Shijiazhuang, 30.5%, 13.6%, and 6.9% in Xingtai, 35.9%, 13.5%, and 6.2% in Handan, respectively. As to the secondary aerosols of sulfate (SO4 2), nitrate (NO3), and ammonium (NH4 þ) in PM2.5, which are important chemical species in PM2.5 (about 30e40% in PM2.5) and cannot be further apportioned by receptor models, the regional source contributions to the total concentrations of SO4 2, NO3, and NH4 þ are 40.9%, 62.0%, and 59.1% in Shijiazhuang, Xingtai, and Handan, respectively. The local industrial, domestic and agricultural contributions to those are 23.7%, 6.6%, and 29.8% in total in Shijiazhuang, 17.5%, 5.0%, and 17.7% in Xingtai, and 20.6%, 4.8%, and 17.8% in Handan, respectively. The regional joint controls of air pollution are more important in Xingtai and Handan than in Shijiazhuang, and the emission controls of agricultural sources need to be further considered in the future policy.

Keywords: *PM2.5; Source apportionment; MM5eCMAQ; Hebei; Secondary aerosol.*

Spatial estimation of PM2.5 emissions from straw open burning in Tianjin from 2001 to 2012

Guanyi Chen , Yanan Guan , Ling Tong , Beibei Yan , Li'an Hou

Source: *Atmospheric Environment 122 (2015) 705e712*

Straw open burning in suburban areas contributes to an important proportion of air pollution threatening air quality of neighbouring highways and airports. This paper presents the characteristics of straw open burning-derived air pollution to understand its impact mechanism and take effective control measurements. In this study, PM2.5 emissions inventory from straw open burning was established at a high spatial resolution of 0.1 0.1 in Tianjin using geographic information systems (GIS) for the period of 2001e2012. PM2.5 emissions increased by 209.15% in the past nine years at an annual average rate of 23.24% from 2.95 Gg in 2002 to 6.17 Gg in 2010. WuQing District covering 13.17% of Tianjin land contributed to PM2.5 emission of 28.21% of total PM2.5 emissions from straw open burning.

Keywords: *PM2.5;Straw open burning; Emission inventory; GIS; Spatial estimation.*

Aerosol particle and trace gas emissions from earthworks, road construction, and asphalt paving in Germany: Emission factors and influence on local air quality

Peter Faber , Frank Drewnick , Stephan Borrmann

Source: *Atmospheric Environment 122 (2015) 662e671*

Aerosol emissions from construction sites have a strong impact on local air quality. The chemical and physical characteristics of particles and trace gases emitted by earthworks (excavation and loading of soil as well as traffic on unpaved roads) and road works (asphalt sawing, smashing, soil compacting, asphalt paving) have therefore been addressed in this study by using a mobile set-up of numerous modern online aerosol and trace gas instruments including a high-resolution aerosol mass spectrometer. Fuel-based emission factors for several variables have been determined, showing that earthwork activities and compacting by use of a plate compactor revealed the highest median emission factors for PM10 (up to 54 g l1). Construction activities were assigned to contribute about 17% (36 000 t a1) to total PM10 emissions and 3% (13 500 t a1) to total traffic-related NOx emissions in Germany. In particular, calculated PM10 emissions by earthworks are about 15 800 t a1 corresponding to 44% of total PM10 emissions by construction activities in Germany. Mechanical processes such as asphalt sawing (PM1/PM10 ¼ 18 ± 31%), soil compacting by a plate compactor (PM1/PM10 ¼ 5 ± 6%) and earthworks (PM1/PM10 ¼ 2 ± 5%) emit predominantly coarse mineral dust particles. Contrary to that, particle emissions by thermal construction processes (asphalt paving: PM1/PM10 ¼ 62 ± 14%) and by the internal combustion engines of heavy machinery (e.g. road roller PM1/PM10 ¼ 94 ± 9%) are mostly in the submicron range. These particles were mainly composed of organics containing non-polar saturated and unsaturated hydrocarbons (e.g. asphalting: O:C< 0.01, H:C ¼ 2.01). Besides construction activities, mineral dust is also emitted over cleared land by winddriven resuspension depending on wind speed. PM10 emissions by construction activities often result in local concentrations > 100 mg m3 and can easily breach the European limit level of PM10. This study also shows that particulate mineral dust emissions are strongly dependent on soil moisture and can thus successfully be reduced to a high percentage by wetting the ground (for PM10 up to 95 ± 34%) showing the importance of potential mitigation strategies.

Keywords: *Construction site; Aerosol mass spectrometry; Aerosol sources; Emission factor; Air quality.*

Association between exposure to ambient air pollution before conception date and likelihood of giving birth to girls in Guangzhou, China

Hualiang Lin , Zhijiang Liang , Tao Liu , Qian Di , Zhengmin Qian , Weilin Zeng , Jianpeng Xiao , Xing Li , Lingchuan Guo , Wenjun Ma , Qingguo Zhao

Source: *Atmospheric Environment 122 (2015) 622e627*

A few studies have linked ambient air pollution with sex ratio at birth. Most of these studies examined the long-term effects using spatial or temporal comparison approaches. This study aimed to investigate whether parental exposure to air pollution before conception date could affect the likelihood of the offspring being male or female. We used the information collected in a major maternal hospital in Guangzhou, China. The parental exposure to air pollution was assessed using the air pollution concentration before the conception date. Logistic regression models were used to assess the association between air pollution exposure and birth sex with adjustment for potential confounding factors, such as maternal age, parental education levels, long-term trend, season, and weather condition (mean temperature and relative humidity). The analysis revealed

that higher air pollution was associated with higher probability of female newborns, with the effective exposure around one week prior to conception date. In the one-pollutant models, PM10, SO2 and NO2 had significant effects. For example, the excess risk was 0.61% (95% confidence interval (95% CI): 0.36%, 0.86%) for a 10 ug/m3 increase in lag 2 day's PM10, 0.42% (95% CI: 0.21%, 0.64%) for lag 3 day's SO2 and 0.97% (95% CI: 0.44%, 1.50%) for lag 3 day's NO2; and in two-pollutant models, PM10 remained statistically significant. These results suggest that parental exposure to ambient air pollution a few days prior to conception might be a contributing factor to higher probability of giving birth to female offspring in Guangzhou.

Keywords: *Air pollution; Sex ratio; Birth; China.*

Global organic carbon emissions from primary sources from 1960 to 2009

Ye Huang, Huizhong Shen, Yilin Chen, Qirui Zhong, Han Chen, Rong Wang, Guofeng Shen, Junfeng Liu, Bengang Li, Shu Tao

Source: *Atmospheric Environment 122 (2015) 505e512*

In an attempt to reduce uncertainty, global organic carbon (OC) emissions from a total of 70 sources were compiled at 0.1 0.1 resolution for 2007 (PKU-OC-2007) and country scale from 1960 to 2009. The compilation took advantage of a new fuel-consumption data product (PKU-Fuel-2007) and a series of newly published emission factors (EFOC) in developing countries. The estimated OC emissions were 32.9 Tg (24.1e50.6 Tg as interquartile range), of which less than one third was anthropogenic in origin. Uncertainty resulted primarily from variations in EFOC. Asia, Africa, and South America had high emissions mainly because of residential biomass fuel burning or wildfires. Per-person OC emission in rural areas was three times that of urban areas because of the relatively high EFOC of residential solid fuels. Temporal trend of anthropogenic OC emissions depended on rural population, and was influenced primarily by residential crop residue and agricultural waste burning. Both the OC/PM2.5 ratio and emission intensity, defined as quantity of OC emissions per unit of fuel consumption for all sources, of anthropogenic OC followed a decreasing trend, indicating continuous improvement in combustion efficiency and control measures.

Keywords: *Organic carbon; Global emission; Temporal trend; Emission intensity; OC/PM2.5 ratio.*

Chemical composition and acidity of size-fractionated inorganic aerosols of 2013-14 winter haze in Shanghai and associated health risk of toxic elements

Sailesh N. Behera , Jinping Cheng , Xian Huang , Qiongyu Zhu , Ping Liu , Rajasekhar Balasubramanian

Source: *Atmospheric Environment 122 (2015) 259e271*

The severe winter haze episode that occurred in Shanghai from December 2013 to January 2014, characterized by elevated levels of particulate matter (PM), received considerable international attention because of its impacts on public health and disruption of day-to-day activities. To examine the characteristics of PM during this haze episode and to assess the chemistry behind formation of secondary inorganic aerosols (SIA) and associated health impacts due to exposure of toxic elements, we characterized eight water soluble inorganic (WSI) ions and twenty four trace elements in twelve sizefractionated PM (10 nme9.9 mm). The average mass concentrations of coarse (1.8 mm <Dp< 9.9 mm), fine (Dp < 2.5 mm), ultrafine (0.01 mm < Dp < 0.10 mm) and nano (0.01 mm < Dp < 0.056 mm) particles during hazy days were 2.8, 5.2, 5.3 and 5.1 times higher than those during non-hazy days, respectively. The in-situ pH (pHIS), as predicted by the

Aerosol Inorganic Model (AIM-IV) in all sizes of PM, was observed to be lower during hazy days (average of 0.64) than that during non-hazy days (average of 0.29); there was an increased acidity in haze aerosols. Based on the measured concentrations of particulate-bound toxic elements, health risk assessment was conducted, which revealed that the excess lifetime carcinogenic risk to individuals exposed to fine particles under haze events increased signifi- cantly ($P < 0.05$) to $69 \pm 18\ 10^{6}$ compared to non-hazy days ($34 \pm 10\ 10^{6}$). The qualitative source attribution analysis suggested that the occurrence of haze could be due to a combination of increased emissions of PM from multiple anthropogenic sources followed by its accumulation under unfavourable meteorological conditions with lower mixing heights and less wind speeds and the formation of secondary aerosols.

Keywords: *Size-fractionated aerosols; Aerosol acidity; pHIS; Human health risk assessment; SIA; Trace elements.*

Air quality in the GermaneCzech border region: A focus on harmful fractions of PM and ultrafine particles

Alexander Schladitz , Jan Lenícek , Ivan Bene, Martin Kova , Jirí Skorkovský , Ales Soukup , Jana Jandlova , Laurent Poulain , Helena Placha , Gunter Loschau , Alfred Wiedensohler

Source: *Atmospheric Environment 122 (2015) 236e249*

A comprehensive air quality study has been carried out at two urban background sites in AnnabergBuchholz (Germany) and Ústí nad Labem (Czech Republic) in the GermaneCzech border region between January 2012 and June 2014. Special attention was paid to quantify harmful fractions of particulate matter (PM) and ultrafine particle number concentration (UFP) from solid fuel combustion and vehicular traffic. Source type contributions of UFP were quantified by using the daily concentration courses of UFP and nitrogen oxide. Two different source apportionment techniques were used to quantify relative and absolute mass contributions: positivematrix factorization for total PM2.5 and elemental carbon in PM2.5 and chemical mass balance for total PM1 and organic carbon in PM1. Contributions from solid fuel combustion strongly differed between the non-heating period (AprileSeptember) and the heating period (OctobereMarch). Major sources of solid fuel combustion in this study were wood and domestic coal combustion, while the proportion of industrial coal combustion was low (<3%) . In Ústí nad Labem combustion of domestic brown coal was the most important source of organic carbon ranging from 34% to 43%. Wood combustion was an important source of organic carbon in Annaberg-Buchholz throughout the year. Heavy metals and less volatile polycyclic aromatic hydrocarbons (PAH) in the accumulation mode were related to solid fuel combustion with enhanced concentrations during the heating period. In contrast, vehicular PAH emissions were allocated to the Aitken mode. Only in Ústí nad Labem a significant contribution of photochemical new particle formation (e.g. from sulfur dioxide) to UFP of almost 50% was observed during noontime. UFPs from traffic emissions (nucleation particles) and primary emitted soot particles dominated at both sites during the rest of the day. The methodology of a combined source apportionment of UFP and PM can be adapted to other regions of the world with similar problems of atmospheric pollution to calculate the relative risk in epidemiological health studies for different sub-fractions of PM and UFP. This will enhance the meaningfulness of published relative risks in health studies based on total PM and UFP number concentrations.

Keywords: *Size-segregated particulate matter; Chemical composition; Ultrafine aerosol; Source apportionment; Ultrafine particle formation.*

Urban air pollution by odor sources: Short time prediction

Nicola Pettarin , Marina Campolo , Alfredo Soldati

Source: *Atmospheric Environment 122 (2015) 74e82*

A numerical approach is proposed to predict the short time dispersion of odors in the urban environment. The model is based on (i) a three dimensional computational domain describing the urban topography at fine spatial scale (1 m) and on (ii) highly time resolved (1 min frequency) meteorological data used as inflow conditions. The time dependent, three dimensional wind velocity field is reconstructed in the Eulerian framework using a fast response finite volume solver of NaviereStokes equations. Odor dispersion is calculated using a Lagrangian approach. An application of the model to the historic city of Verona (Italy) is presented. Results confirm that this type of odor dispersion simulations can be used (i) to assess the impact of odor emissions in urban areas and (ii) to evaluate the potential mitigation produced by odor abatement systems.

Keywords: *Dispersion modelling; Short averaging time; Odor pollution; QUIC.*

On-bicycle exposure to particulate air pollution: Particle number, black carbon, PM2.5, and particle size

Steve Hankey , Julian D. Marshall

Source: *Atmospheric Environment 122 (2015) 65e73*

Inhalation of air pollution during transport is an important exposure pathway, especially for certain modes of travel and types of particles. We measured concentrations of particulate air pollution (particle number [PN], black carbon [BC], fine particles [PM2.5], particle size) using a mobile, bicycle-based monitoring platform during morning and afternoon rush-hour to explore patterns of exposure while cycling (34 days between August 14 and October 16, 2012 in Minneapolis, MN). Measurements were geolocated at 1 s intervals along 3 prescribed monitoring routes totaling 85 h (1426 km) of monitoring. Mean morning [afternoon] on-road concentrations were 32,500 [16,600] pt cm3, 2.5 [0.7] mg m3 BC, 8.7 [8.3] mg m3 PM2.5, and 42 [39] nm particle diameter. Concentrations were correlated with street functional class and declined within small distances from a major road (e.g., for PN and BC, mean concentration decreased ~20% by moving 1 block away from major roads to adjacent local roads). We estimate the share of on-bicycle exposure attributable to near-traffic emissions (vs. regional pollution) is ~50% for PN and BC; ~25% for PM2.5. Regression models of instantaneous traffic volumes, derived from on-bicycle video recordings of nearby traffic, quantify the increase in particle-concentrations associated with each passing vehicle; for example, trucks were associated with acute, high concentration exposure events (average concentration-increase per truck: 31,000 pt cm3 , 1.0 mg m3 PM2.5, 1.6 mg m3 BC). Our findings could be used to inform design of low-exposure bicycle networks in urban areas.

Keywords: *Traffic-related air pollution; Active travel; Traffic mix; Non-motorized travel.*

Impact of pollutant emission reductions on summertime aerosol feedbacks: A case study over the PO valley

C. Carnevale , G. Finzi , A. Pederzoli , E. Turrini , M. Volta , F. Ferrari , R. Gianfreda , G. Maffeis

Source: *Atmospheric Environment 122 (2015) 41e57*

This study presents an evaluation of the impact by future pollutant anthropogenic emission reductions on summertime aerosol feedbacks over the Po valley. The fully coupled on line model Wrf/Chem has been used to examine the air quality and meteorology response over the region to 2020 emission reductions with respect to a simulation base case (2013). Future changes in net short wave radiation flux (SW) are also analyzed. The model domain is a 6 6 km2 resolution grid over Northern Italy; the simulation period covers two summer months (JulyeAugust). The work is divided into two parts. In the first, model results for the Base Case simulation (BC) are evaluated by comparing Wrf/Chem output to surface observations provided by two monitoring networks. Approximately 25 sites belonging to the regional ARPA Lombardia Network are used for both chemistry (NO2, O3 and PM10 concentrations) and meteorology (wind speed and 2-meters temperature) evaluation; 4 stations part of the global AEROsol Robotic Network (AERONET) are used for the evaluation of Aerosol Optical Depth (AOD). In the second part, a Maximum Feasible Reduction (MFR) scenario at 2020 have been simulated for the same months; monthly direct, indirect and overall aerosols feedbacks for both BC and MFR have been computed and analyzed. The emission reductions in the MFR 2020 lead to a sensible change in the aerosol overall feedbacks for all variables; a drop of SW over the valley (cooling effect) is visible in both BC and MFR, but it is less significant in the MFR (5Wm2) compared to the BC (45 W m2). This difference is mainly due to the abatement of SO2 primary emissions, which leads to lower sulfates concentrations scattering radiation, thus mitigates the cooling effect and favors the warming. As SW is higher in the MFR, T2 also increases over land with respect to the BC (the cooling of 0.5 C estimated in the Base Case almost disappears). The overall effects lead to an enhancement of PM10 concentration in the BC; they are less efficient in the MFR because of lower secondary aerosol concentrations (associated to the reduction of primary PM10 emissions by approximately 20%). Concerning NO2, some localized areas with high reductions in the BC are not visible in the MFR. This is consistent with the increase of T2, which leads to higher photolytic rates compared to the BC. Higher concentrations of NO2 in the MFR with respect to the BC lead to lower O3 concentrations (maximum O3 values drop from þ6 ppb to þ3 ppb).

Keywords: *On line models; Emission scenario; Aerosol feedbacks; Po valley.*

Source area identification with observation from limited monitor sites for air pollution episodes in industrial parks

Zihan Huang, Yuan Wang, Qi Yu , Weichun Ma, Yan Zhang, Limin Chen

Source: *Atmospheric Environment 122 (2015) 1e9*

Air pollution episodes of unknown origins are often detected by online equipment for air quality monitoring in industrial parks in China. The number of monitors available to provide observation data, as well as the source information, is often very limited. In such case, the identification of a potential source area is more practical than the precise back-calculation of the real source. The potential source area which can be deduced from the observation data from limited monitors was concerned in this paper. In order to do the source area identification, two inverse methods, a direct method and a statistical sampling method, were applied with a Gaussian puff model as the forward modeling method. The characteristic of the potential source area was

illustrated by case studies. Both synthetic and real cases were presented. The distribution of the source locations and its variation with the other unknown source parameters were mainly focused in the case study. As a screening method, source area identification can be applied not only when the number of effective monitors is limited but also when an ideal number of monitors are available as long as the source information is almost uncertain.

Keywords: *Source area analysis; Abnormal release; Industrial park; Limited monitor sites; Back-calculation.*

Ammonia emissions in tropical biomass burning regions: Comparison between satellite-derived emissions and bottom-up fire inventorie

S. Whitburn , M. Van Damme , J.W. Kaiser , G.R. van der Werf , S. Turquety , D. Hurtmans , L. Clarisse , C. Clerbaux , P.-F. Coheur

Source: *Atmospheric Environment 121 (2015) 42e54*

Vegetation fires emit large amounts of nitrogen compounds in the atmosphere, including ammonia (NH3). These emissions are still subject to large uncertainties. In this study, we analyze time series of monthly NH3 total columns (molec cm2) from the IASI sounder on board MetOp-A satellite and their relation with MODIS fire radiative power (MW) measurements. We derive monthly NH3 emissions estimates for four regions accounting for a major part of the total area affected by fires (two in Africa, one in central South America and one in Southeast Asia), using a simplified box model, and we compare them to the emissions from both the GFEDv3.1 and GFASv1.0 biomass burning emission inventories. In order to strengthen the analysis, we perform a similar comparison for carbon monoxide (CO), also measured by IASI and for which the emission factors used in the inventories to convert biomass burned to trace gas emissions are thought to be more reliable. In general, a good correspondence between NH3 and CO columns and the FRP is found, especially for regions in central South America with correlation coefficients of 0.82 and 0.66, respectively. The comparison with the two biomass burning emission inventories GFASv1.0 and GFEDv3.1 shows good agreements, particularly in the time of the maximum of emissions for the central South America region and in the magnitude for the region of Africa south of the equator. We find evidence of significant non-pyrogenic emissions for the regions of Africa north of the equator (for NH3) and Southeast Asia (for NH3 and CO). On a yearly basis, total emissions calculated from IASI measurements for the four regions reproduce fairly well the interannual variability from the GFEDv3.1 and GFASv1.0 emissions inventories for NH3 but show values about 1.5e2 times higher than emissions given by the two biomass burning emission inventories, even when assuming a fairly long lifetime of 36 h for that species.

Keywords: *Ammonia emissions; Vegetation fires; Fire radiative power; Biomass burning emission inventories; GFEDv3.1; GFASv1.0.*

Chemical composition of particles from traditional burning of Pakistani wood species

Imran Shahid , Magdalena Kistler, Azam Mukhtar , Carlos Ramirez-Santa Cruz , Heidi Bauer , Hans Puxbaum

Source: *Atmospheric Environment 121 (2015) 35e41*

Total particulate matter (TPM) emitted during burning of three types of Pakistani wood (eucalyptus camaldulensis, local name Safeeda; acacia nilotica, local name Kikar, Babul; dalbergia sissoo, Shisham, Tali) in a traditional brick stove were collected and analyzed for anhydrosugars, sugar alcohols, trace metals, soluble ions and carbonaceous species. This is a first study reporting anhydrosugars in wood smoke particles emitted during traditional burning of common wood types in Pakistan. Carbonaceous species showed the highest contribution to the particulate matter. Although the total carbon (TC) contribution was similar for all burnings (64.8e70.2%), the EC/OC ratio varied significantly, from 0.2 to 0.3 for Accacia and Dalbergia to 0.7e0.8 for Eucalyptus and Wood-mix. Among inorganic constituents potassium chloride and silicon were found at levels higher than 1%. The levoglucosan concentrations ranged from 3.0 to 6.6% (average 5.6%) with the highest value for Accacia and lowest value for the wood-mix. The high levoglucosan/mannosan ratios of 20e28 were typical for hardwood. The ratio between levoglucosan and galactosan varied stronger and was found to be around 13e20 for Accacia, Eucalyptus and Wood mix, and 43 for Dalbergia. The determined levoglucosan concentrations allowed assessing the conversion factor for calculation of biomass smoke contribution to ambient particulate matter levels in Pakistan.

Keywords: *Wood smoke; Levoglucosan; Elemental and organic carbon; Biomass combustion.*

New field-based agricultural biomass burning trace gas, PM2.5, and black carbon emission ratios and factors measured in situ at crop residue fires in Eastern China

Tianran Zhang , Martin J. Wooster , David C. Green , Bruce Main

Source: *Atmospheric Environment 121 (2015) 22e34*

Despite policy attempts to limit or prevent agricultural burning, its use to remove crop residues either immediately after harvest (e.g. field burning of wheat stubble) or after subsequent crop processing (e.g. "bonfires" of rice straw and rapeseed residues) appears to remain widespread across parts of China. Emission factors for these types of small but highly numerous fire are therefore required to fully assess their impact on atmospheric composition and air pollution. Here we describe the design and deployment of a new smoke measurement system for the close-range sampling of key gases and particles within smoke from crop residue fires, using it to assess instantaneous mixing ratios of CO and CO2 and mass concentrations of black carbon (BC) and PM2.5 from wheat stubble, rice straw, and rapeseed residue fires. Using data of our new smoke sampling system, we find a strong linear correlation between the PM2.5 mass and BC, with very high PM2.5 to BC emission ratios found in the smouldering phase (up to 80.7 mg m3 .(mg m3) 1) compared to the flaming phase (2.0 mg m3 .(mg m3) 1). We conclude that the contribution of BC to PM2.5 mass was as high as 50% in the flaming phase of some burns, whilst during smouldering it sometimes decreased to little over one percent. A linear mixing model is used to quantify the relative contribution of each combustion phase to the overall measured smoke composition, and we find that flaming combustion dominated the total emission of most species assessed. Using time series of trace gas concentrations from different fire cases, we calculated 'fire integrated' trace gas emission factors (EFs) for wheat, rice and rapeseed residue burns as

1739 ± 19 g kg1, 1761 ± 30 g kg1 and 1704 ± 27 g kg1 respectively for CO2, and 60 ± 12 g kg1, 47 ± 19 g kg1 and 82 ± 17 g kg1 respectively for CO. Where comparisons were possible, our EFs agreed well with those derived via a simultaneously-deployed open path Fourier transform infrared (OP-FTIR) spectrometer. These EFs, and the linear best fit relationships between both PM2.5 and BC mass and the CO2 and CO measurements, were used to generate particulate EFs, which varied over the 5.8 e20.3 g kg1 and 0.25e2.89 g kg1 range respectively. We note a particularly high 2.89 g kg1 BC emission factor for the rapeseed bonfires, reflective of intense flaming combustion that gave off visible clouds of soot. These field-measured EFs offer a different perspective than is obtained when burning in laboratory combustion chambers, and are suitable for combining with landscape-scale fuel consumption estimates to provide atmospheric modelling inputs of emissions from these types of crop residue fires.

Keywords: *Agricultural residue fires; Eastern China; Emission factor; Black carbon; FTIR; Biomass burning.*

When smoke comes to town: The impact of biomass burning smoke on air quality

Melita Keywood , Martin Cope , C.P. Mick Meyer , Yoshi Iinuma , Kathryn Emmerson

Source: *Atmospheric Environment 121 (2015) 13e21*

Biomass burning aerosols influence the radiative balance of the earth-atmosphere system. They also reduce visibility and impact human health. In addition, trace gases and aerosols emitted to the atmosphere during large biomass burning episodes may have a significant effect on atmospheric chemistry due to the presence of reactive species. Six hundred and ninety wildfires burned more than one million hectares in Victoria, Australia between December 2006 and February 2007. Thick smoke haze was transported to Melbourne (population 3.9 million) on several occasions, causing PM10 (particulate mass less than 10 mm in diameter) concentrations to exceed 200 mg m3. The presence of elevated total secondary organic aerosol (SOA) and speciated SOA compounds (including pinene and cineole oxidation products), O3, and the larger aerosol mode diameter during smoke impacted periods indicated the presence of photochemical oxidation within the plume. The presence of organosulfate compounds and nitro-oxy organosulfate compounds indicated oxidation may have occurred in the presence of acidic seed aerosol and that oxidation may also have occurred at night. Older smoke plumes (aged 30 h) displayed higher concentrations of a number of gaseous and aerosol species relative to the younger smoke plumes (aged 3 h). SOA compounds made up a greater fraction of speciated organic mass in the old plume than in the young plume where speciated biomass burning compounds dominated. Cineole oxidation products made up a greater fraction of the speciated SOA compounds in the old plume while pinene oxidation products made up a greater fraction of the total SOA speciated mass in the samples from the young plume. This may be a result of the slower reaction rate of cineole with OH. Organosulfate compounds and nitro-oxy organosulfate compounds made up greater fractions of the speciated SOA mass in the old plume consistent with the production of nitro-oxy organosulfate compounds under night time conditions in the presence of acidic seed. These results suggest that enhanced photochemical activity occurs in smoke plumes and can signifi- cantly change the composition and microphysical properties of aerosol, potentially leading to changes in the optical and thus radiative properties of the aerosol.

Keywords: *Secondary organic aerosol; Photochemical aging; Smoke; Air quality.*

Chemical characteristics and light-absorbing property of watersoluble organic carbon in Beijing: Biomass burning contributions

Caiqing Yan , Mei Zheng , Amy P. Sullivan , Carme Bosch , Yury Desyaterik , August Andersson , Xiaoying Li , Xiaoshuang Guo , Tian Zhou , Orjan Gustafsson , Jeffrey L. Collett Jr

Source: *Atmospheric Environment 121 (2015) 4e12*

Emissions from biomass burning contribute significantly to water-soluble organic carbon (WSOC) and light-absorbing organic carbon (brown carbon). Ambient atmospheric samples were collected at an urban site in Beijing during winter and summer, along with source samples from residential crop straw burning. Carbonaceous aerosol species, including organic carbon (OC), elemental carbon (EC), WSOC and multiple saccharides as well as water-soluble potassium (Kþ) in PM2.5 (fine particulate matter with size less than 2.5 mm) were measured. Chemical signatures of atmospheric aerosols in Beijing during winter and summer days with significant biomass burning influence were identified. Meanwhile, light absorption by WSOC was measured and quantitatively compared to EC at ground level. The results from this study indicated that levoglucosan exhibited consistently high concentrations (209 ± 145 ng m3) in winter. Ratios of levoglucosan/mannosan (L/M) and levoglucosan/galacosan (L/G) indicated that residential biofuel use is an important source of biomass burning aerosol in winter in Beijing. Light absorption coefficient per unit ambient WSOC mass calculated at 365 nm is approximately 1.54 ± 0.16 m2 g1 in winter and 0.73 ± 0.15 m2 g1 in summer. Biomass burning derived WSOC accounted for 23 ± 7% and 16 ± 7% of total WSOC mass, and contributed to 17 ± 4% and 19 ± 5% of total WSOC light absorption in winter and summer, respectively. It is noteworthy that, up to 30% of total WSOC light absorption was attributed to biomass burning in significant biomass-burning-impacted summer day. Near-surface light absorption (over the range 300e400 nm) by WSOC was about ~40% of that by EC in winter and ~25% in summer.

Keywords: *Biomass burning; WSOC; Saccharides; Levoglucosan; Light absorption.*

Characterization of aerosols in Beijing during severe aerosol loadings

Hao Chen, Tianhai Cheng , Xingfa Gu, Yu Wu

Source: *Atmospheric Environment 119 (2015) 273e281*

Severe aerosol pollutions in China significantly impact radiative forcing of climate at regional and global scales. Until now, the uncertainties in net climate forcing from severe aerosol pollutions in China are substantial, largely due to the lack of detailed knowledge of radiative properties of severe aerosol pollutions. Here the characteristics of aerosols under severe aerosol pollution days (APs) in Beijing are studied by analyzing the ground-based radiance measurements during the period from 2002 to 2014. We show that the mean single scattering albedo (SSA) values increase by 0.03e0.06 (7%) in APs, and the mean asymmetry (ASY) parameter values increase by 0.03e0.04 (6%) for the four wavelengths of 440 e1020 nm. The atmospheric forcing of the APs is 2 times higher than that in other days. Contrary to the RF values, the radiative forcing efficiencies in the APs are 38% lower than those in the other days. Larger values of SSA and ASY under APs represent larger presence of more scattering aerosols and irregularsized aerosols such as dust and non-absorbing fine mode particles. These particles are also verified by the much lower radiative forcing efficiency values. Analyses are applied on the dataset of the APs over Beijing, to group them into four discrete clusters. The two fine-size absorbing aerosols show larger mean atmospheric radiative forcing values (152.5 W/m2 and 184.5 W/m2 respectively) and forcing efficiency values (83.5 W/m2 and 108.5 W/m2 respectively). The non-absorbing aerosols and coarse aerosols exert large planetary cooling (86.7 W/m2 and 77.3 W/m2) and low atmospheric heating effect.

Keywords: *Severe aerosol loading; Optical properties; Radiative forcing; Climate change.*

Concentrations and emission factors for PM2.5 and PM10 from road traffic in Sweden

Martin Ferm , Karin Sjoberg

Source: *Atmospheric Environment 119 (2015) 211e219*

PM10 concentrations exceed the guidelines in some Swedish cities and the limit values will likely be further reduced in the future. In order to gain more knowledge of emission factors for road traffic and concentrations of PM10 and PM2.5, existing monitoring stations in two cities, Gothenburg and Umeå, with international E-road thoroughfares, were complemented with some PM2.5 measurements. Emission factors for PM10 and PM2.5 were estimated using NOX as a tracer. Monitoring data from kerbside and urban background sites in Gothenburg during 2006e2010 and in Umeå during 2006e2012 were used. NOX emissions were estimated from the traffic flow and emission factors calculated from the HBEFA3.1 model. PM2.5 constitutes the finer part of PM10. Emissions of the coarser part of PM10 (PM10ePM2.5) are suppressed when roads are wet and show a maximum during spring when the roads dry up and studded tyres are still used. Less than 1% of the road wear caused by studded tyres give rise to airborne PM2.5e10 particles. The NOX emission factors decrease with time in the used model, due to the renewal of the vehicle fleet. However, the NOX concentrations resulting from the roads show no clear trend. The air dispersion is an important factor controlling the PM concentration near the road. The dispersion has a minimum in winter and during midnight. The average street level concentrations of PM10 and PM2.5 in Gothenburg were 21 ± 20 and 8 ± 6 mg m3 respectively, which is 36% and 22% higher than the urban background concentrations. Despite the four times lower traffic flow in Umeå compared to Gothenburg, the average particle concentrations were very similar; 21 ± 31 and 7 ± 5 mg m3 for PM10 and PM2.5 respectively. These concentrations were, however, 108% and 55% higher than the urban background concentrations in Umeå. The emission factors for PM10 decreased with time, and the average factor was 0.06 g km1 vehichle1. The emission factors for PM2.5 are very uncertain due to the small increments in PM2.5 concentration at the thoroughfares, and were on average 0.02 g km1 vehichle.

Keywords: *PM10; PM2.5; Air dispersion; Gothenburg; Umeå; Traffic-related air pollution.*

PM2.5 pollution episode and its contributors from 2011 to 2013 in urban Shanghai, China

H.L. Wang , L.P. Qiao , S.R. Lou , M. Zhou , J.M. Chen , Q. Wang , S.K. Tao , C.H. Chen , H.Y. Huang , L. Li , C. Huang

Source: *Atmospheric Environment 123 (2015) 298e305*

Shanghai has suffered from severe fine particle (PM2.5) pollution in recent years. The characterization and formation mechanism of PM2.5 pollution episodes were investigated in the present study based on 3- year on-line measurements of PM2.5 chemical compositions with the temporal resolution of 1 h from 2011 to 2013 in Shanghai. Pollution episodes with PM2.5 mass higher than 75 mg/m3 occurred ~1400 h annually, which inserted the annual extra PM2.5 mass of 14 mg/m3 into the level of 33 mg/m3 without pollution episodes taken into account. Three kinds of typical episodes were identified as biomass burning events, suspended dust events, and fireworks events, which extra contributed ~1.5 mg/m3 relative to PM2.5 mass of clean periods. Most of pollution episodes were attributed to multiple and complex mechanisms, characterized by high contribution of the secondary inorganic components (e.g. nitrate, sulfate and ammonium) and carbonaceous matters, which dominated the monthly variations of PM2.5 mass. During the complex

episodes, the increasing contribution of nitrate mass concentration to PM2.5 burden was observed. The present study highlighted the necessity to pay more attention to the secondary pollution. The reduction of precursor gases emissions was essential to mediate the severe PM2.5 pollution in Shanghai megacity.

Keywords: *PM2.5 pollution episode; Chemical characterization; Formation mechanism; Contribution; Shanghai.*

Source apportionment of PM10 mass and particulate carbon in the Kathmandu Valley, Nepal

Bong Mann Kim , Jin-Soo Park , Sang-Woo Kim , Hyunjae Kim , Haeun Jeon , Chaeyoon Cho , Ji-Hyoung Kim , Seungkyu Hong , Maheswar Rupakheti , Arnico K. Panday , Rokjin J. Park , Jihyung Hong , Soon-Chang Yoon

Source: *Atmospheric Environment 123 (2015) 190e199*

The Kathmandu Valley in Nepal is a bowl-shaped urban basin in the Himalayan foothills with a serious problem of fine particulate air pollution that impacts local health and impairs visibility. Particulate carbon concentrations have reached severe levels that threaten the health of 3.5 million local residents. Moreover, snow and ice on the Himalayan mountains are melting as a result of additional warming due to particulate carbon, especially high black carbon concentrations. To date, the sources of the Valley's particulate carbon and the impacts of different sources on particulate carbon concentrations are not well understood. Thus, before an effective control strategy can be developed, these particulate carbon sources must be identified and quantified. Our study has found that the four primary sources of particulate carbon in the Kathmandu Valley during winter are brick kilns, motor vehicles, fugitive soil dust, and biomass/garbage burning. Their source contributions are quantified using a recently developed new multivariate receptor model SMP. In contrast to other highly polluted areas such as China, secondary contribution is almost negligible in Kathmandu Valley. Brick kilns (40%), motor vehicles (37%) and biomass/garbage burning (22%) have been identified as the major sources of elemental carbon (black carbon) in the Kathmandu Valley during winter, while motor vehicles (47%), biomass/garbage burning (32%), and soil dust (13%) have been identified as the most important sources of organic carbon. Our research indicates that controlling emissions from motor vehicles, brick kilns, biomass/garbage burning, and soil dust is essential for the mitigation of the particulate carbon that threatens public health, impairs visibility, and influences climate warming within and downwind from the Kathmandu Valley. In addition, this paper suggests several useful particulate carbon mitigation methods that can be applied to Kathmandu Valley and other areas in South Asia with similar sources and high particulate carbon concentrations.

Keywords: *PM10; Particulate carbon; Source apportionment; SMP model; Kathmandu.*

Health effects of ambient levels of respirable particulate matter (PM) on healthy, young-adult population

William J. Shaughnessy , Mohan M. Venigalla , David Trump

Source: *Atmospheric Environment 123 (2015) 102e111*

There is an absence of studies that define the relationship between ambient particulate matter (PM) levels and adverse health outcomes among the young and healthy adult sub-group. In this research, the relationship

between exposures to ambient levels of PM in the 10 micron (PM10) and 2.5 micron (PM2.5) size fractions and health outcomes in members of the healthy, young-adult subgroup who are 18e39 years of age was examined. Active duty military personnel populations at three strategically selected military bases in the United States were used as a surrogate to the control group. Health outcome data, which consists of the number of diagnoses for each of nine International Classification of Diseases, 9th Revision (ICD-9) categories related to respiratory illness, were derived from outpatient visits at each of the three military bases. Data on ambient concentrations of particulate matter, specifically PM10 and PM2.5, were obtained for these sites. The health outcome data were correlated and regressed with the PM10 and PM2.5 data, and other air quality and weather-related data on a daily and weekly basis for the period 1998 to 2004. Results indicate that at Fort Bliss, which is a US Environmental Protection Agency designated non-attainment area for PM10, a statistically significant association exists between the weekly-averaged number of adverse health effects in the young and healthy adult population and the corresponding weekly-average ambient PM10 concentration. A least squares regression analysis was performed on the Fort Bliss data sets indicated that the health outcome data is related to several environmental parameters in addition to PM10. Overall, the analysis estimates a .6% increase in the weekly rate of emergency room visits for upper respiratory infections for every 10 mg/m3 increase in the weekly-averaged PM10 concentration above the mean. The findings support the development of policy and guidance opportunities that can be developed to mitigate exposures to particulate matter.

Keywords: *Particulate matter; PM10; PM2.5; Health effects; Young healthy adults; Upper respiratory diseases.*

Comparison of NOx emissions from China III and China IV in-use diesel trucks based on on-road measurements

Zhiliang Yao, Bobo Wu, Yunong Wu, Xinyue Cao, Xi Jiang

Source: *Atmospheric Environment 123 (2015) 1e8*

To mitigate NOx and other emissions from diesel vehicles, China I, China II, China III and China IV emissions standards for new vehicles have been implemented nationwide. However, recent on-road measurements using a portable emission measurement system (PEMS) have revealed no significant reductions in the NOx emissions factors of diesel trucks due to the change from China II emissions standards to the more stringent China III standards. Thus, it is important to understand the effect of the China IV emissions standard on NOx emissions. In this study, nine China III and nine China IV diesel trucks of three sizes (light-duty diesel trucks (LDDTs), medium-duty diesel trucks (MDDTs) and heavyduty diesel trucks (HDDTs)) were tested on real roads in Beijing using a PEMS. Compared to the tested China III diesel trucks, the China IV diesel trucks showed significant reductions of the average NOx emissions factors in terms of both distance travelled and fuel consumption. However, the driving conditions had an important impact on the reduction. Under non-highway driving (NHD), several of the tested China IV diesel trucks experienced no reduction or an increase in NOx emissions compared to their China III counterparts. The NOx emissions factors of the 18 tested diesel trucks under NHD were on average 1.5-times greater than those under highway driving (HD), and the effects on NOx emissions removal from China III to China IV diesel trucks were greater under HD than under NHD. In addition, no significant reduction of NOx based on fuel consumption for China IV diesel trucks was observed for MDDTs and HDDTs compared to the test results for similar China II vehicles reported in a previous study. To reduce NOx emissions in China, additional control measures of vehicular NOx emissions should be formulated.

Keywords: *Emissions factor; Nitrogen oxides; Diesel vehicle; Vehicle emissions standard; PEMS; Beijing.*

Assessment of short-term PM2.5-related mortality due to different emission sources in the Yangtze River Delta, China

Jiandong Wang , Shuxiao Wang , A. Scott Voorhees , Bin Zhao , Carey Jang , Jingkun Jiang , Joshua S. Fu , Dian Ding , Yun Zhu , Jiming Hao

Source: *Atmospheric Environment 123 (2015) 440e448*

Air pollution is a major environmental risk to health. In this study, short-term premature mortality due to particulate matter equal to or less than 2.5 mm in aerodynamic diameter (PM2.5) in the Yangtze River Delta (YRD) is estimated by using a PC-based human health benefits software. The economic loss is assessed by using the willingness to pay (WTP) method. The contributions of each region, sector and gaseous precursor are also determined by employing brute-force method. The results show that, in the YRD in 2010, the short-term premature deaths caused by PM2.5 are estimated to be 13,162 (95% confi- dence interval (CI): 10,761-15,554), while the economic loss is 22.1 (95% CI: 18.1e26.1) billion Chinese Yuan. The industrial and residential sectors contributed the most, accounting for more than 50% of the total economic loss. Emissions of primary PM2.5 and NH3 are major contributors to the health-related loss in winter, while the contribution of gaseous precursors such as SO2 and NOx is higher than primary PM2.5 in summer.

Keywords: *PM2.5; Mortality; Economic loss; Source apportionment; Yangtze River Delta.*

Emission characteristics of carbonaceous particles and trace gases from open burning of crop residues in China

Haiyan Ni , Yongming Han , Junji Cao , L.-W. Antony Chen , Jie Tian , Xiaoliang Wang , Judith C. Chow , John G. Watson , Qiyuan Wang , Ping Wang , Hua Li , Ru-Jin Huang

Source: *Atmospheric Environment 123 (2015) 399e406*

Open burning of crop residue is an important source of carbonaceous pollutants, and has a large impact on the regional environment and global climate change. Laboratory burn tests were conducted using a custom-made combustion chamber to determine pollutants (i.e. CO2, CO, PM2.5, organic carbon (OC) and elemental carbon (EC)) emission factors (EFs) of wheat straw, rice straw and corn stalk; the three major agricultural crop residues in China. The average EFs were estimated to be 1351 ± 147 g kg1 for CO2, 52.0 ± 18.9 g kg1 for CO, 10.6 ± 5.6 g kg1 for PM2.5, 4.8 ± 3.1 g kg1 for OC and 0.24 ± 0.12 g kg1 for EC. In addition, the effect of fuel moisture was investigated through the controlled burning of wheat straw. Increasing the moisture content decreased the CO2 EF, and increased the EFs of CO, PM2.5 and OC. Based on measurements from this study and nationwide statistics in crop type and area, pollutants emission inventories for crop residue combustion with 11resolution were compiled for 2008. Total emissions were 120 Tg CO2, 4.6 Tg CO, 0.88 Tg PM2.5, 0.39 Tg OC and 0.02 Tg EC.

Keywords: *Crop residue;Open burning; Emission factor; Combustion chamber.*

SECTION-IV
Atmospheric Research

Physico-chemical characterization of PM2.5 in the microenvironment of Shanghai subway

Senlin Lu , Dingyu Liu , Wenchao Zhang , Pinwei Liu , Yi Fei , Yan Gu , Minghong Wu , Shang Yu , Shinich Yonemochi , Xiaoju Wang , Qingyue Wang

Source: *Atmospheric Research 153 (2015) 543–552*

The Shanghai subway metro system has brought great convenience to the city's travelling public, although passengers are exposed to airborne particles in this built micro-environment. However, investigations on the physicochemical characterization of PM2.5 air pollution in the Shanghai subway system are to date very limited. Three subway stations along the No. 7 line were selected as subway PM2.5 monitoring sites: Pan'guang, Shanghai University (SHU), and Jing'an, which are located in an outer suburban area, a suburban area and the urban area, respectively, airborne PM2.5 on the subway station platforms and in the ambient atmosphere above-ground was synchronously collected from 19th March to 4th, May, 2012. Cutting-edge techniques, including scanning electronic microscopy coupled with energy dispersive X-ray (SEM/EDX), inductively coupled plasma mass spectrometry (ICP-MS) and X-ray absorption near-edge structure (XANES) were employed to investigate microscopic characterization, chemical elements and speciation of the main heavy metals in subway PM2.5. Our results demonstrated that mass levels of PM2.5 in the subway stations were higher than that in ambient air. Mass levels of PM2.5 in the subway stations and in ambient air ranged from 49.17 ± 19.7 μg/m3 to 66.15 ± 25.20 μg/m3, and 24.52 ± 3.3 μg/m3 to 65.60 ± 5.6 μg/m3, respectively. The microscopic characterization of PM2.5 in ambient air and in subway stations showed marked differences. The PM2.5 in the subway stations was mainly composed of ironcontaining particles and mineral particles, while the PM2.5 in ambient air largely consisted of mineral particles and soot aggregates. Fe was the most abundant element in subway PM2.5, followed by: major elements (mass level N 100 ng/m3) including Na, Mg, Al, K, Ca, Zn, Mn, Ba; sub-major elements (10 ng/m3 b mass level b 100 ng/m3) including Li, Cr, Ni,Cu, Ga, Sr, Pb; and minor elements (mass level b 10 ng/m3), Be, V, As, Se, Rb, Ag, Cd, Tl, Bi. The mass levels of Ca, Al and Zn in ambient PM2.5 were higher than those in subway PM2.5, however those of the remaining 26 measured elements in subway PM2.5 were higher than in ambient PM2.5. The speciation of Fe in PM2.5 was in the form of Fe2+, while for Cu, that in the finer fractions (b0.25, 0.5 and 1.0 μm) was in the form Cu2+, but in the PM2.5 fraction itself, was as Cu1+.

Characteristics of black carbon concentration at a metropolitan city located near land–ocean boundary in Eastern India

Shamitaksha Talukdar , Soumyajyoti Jana , Animesh Maitra , Mukunda M. Gogoi

Source: *Atmospheric Research 153 (2015) 526–534*

Near surface aerosol black carbon (BC) concentration data were collected using a seven channel Aethalometer (AE31) during June 2012–May 2013 in Kolkata (22° 34′E, 88° 22′N), a metropolitan city located near the land–ocean boundary in Eastern India. BC concentration shows a prominent seasonal and diurnal variation associated with the meteorological parameters. The mean BC concentration varied from 5 μg/m3 to 27 μg/m3 seasonally. The variation of BC mass concentration and its significant association with atmospheric parameters such as temperature profile, relative humidity and wind speed have been studied. Moreover, the influence of the transported air masses on BC concentration at different seasons has also been discussed. An estimation of Angstrom exponent discloses that fossil fuel combustion is a major source of BC at this location.

Impact of long-range transport on aerosol properties at a regional background station in Northern China

Weiwei Pua , Xiujuan Zhao , Xuefeng Shi , Zhiqiang Ma , Xiaoling Zhang , Bo Yu

Source: *Atmospheric Research 153 (2015) 489–499*

The impact of long-range transport on aerosol properties at SDZ regional background station in Northern China during 2005–2010, was analyzed using trajectory clustering method with 3-day, 6-hourly backward trajectories determined by using HYSPLIT 4 model. Eleven clusters were determined by using the two-stage cluster method. PM2.5 levels, aerosol scattering coefficient (σsp) and scattering efficiency (αsp_2.5) of PM2.5 associated with each cluster were calculated. Based on the levels of PM2.5 and σsp, eleven clusters were classified into a relatively "clean" group (group A) and a "polluted" group (group B). The PM2.5 concentration and σsp of group A were lower than that of group B. Group A was mainly composed of the trajectories from northwest, north and northeast, which originated and passed through the emission areas such as Mongolia and Inner Mongolia. Group B mostly consisted of the air masses from the south and southeast, and the ones from the northwest. It was characterized with short and low trajectories over major anthropogenic emission regions in North China Plain (NCP), northwestern Hebei province and Inner Mongolia. The trajectory pathway of the northwest cluster in group B was lowest and slowest among all clusters from northerly direction, which caused the accumulation of pollutants along this pathway. High PM hours were identified in each cluster for each month, and were found mainly in group B, especially during March to October. Except of the contribution of high PM2.5 emissions in NCP, the production of secondary aerosols with the increasing solar radiation and humidity from March to October, and the straw burning that usually occurs in June in NCP are responsible for the high PM2.5 as well. The characteristics of αsp_2.5 of each cluster indicated that the northerly clusters were affected by anthropogenic pollutants mixed with dust, but southerly clusters were only influenced by the pollution aerosols. The αsp_2.5 of dust and anthropogenic pollution aerosols had a clear difference and ranged from 0.44 to 1.85, and 3.01 to 5.43, respectively. The higher αsp_2.5 of anthropogenic pollutant occurred mainly in the southerly trajectory pathways and partially in northwest pathways. The primary emissions and secondary formation of PM2.5 along these pathways were significant contributors to the aerosol properties of SDZ. However, emissions northwest of SDZ also make significant contributions to the PM2.5 mass loading and αsp_2.5, especially in spring and winter.

Keywords: *Transport pathway; PM2.5; Scattering coefficients; Scattering efficiency.*

Aerosol optical properties and their relationship with meteorological parameters during wintertime in Delhi, India

S. Tiwari , G. Pandithurai , S.D. Attri , A.K. Srivastava , V.K. Soni , D.S. Bisht , V. Anil Kumar , Manoj K. Srivastava

Source: *Atmospheric Research 153 (2015) 465–479*

In situ and columnar measurements of aerosol optical properties (AOPs) [Aerosol optical depth (AOD), Angstrom Exponent (AE), Aerosol scattering (σscat) and absorption (σabs) coefficients and single scattering albedo (SSA)] along with soot particles (Black carbon: BC) and fine particles (PM2.5: d ≤2.5) were continuously measured at an urban site in Delhi, India during winter period (December 2011 to March 2012). Average values of AOD, σscat, σabs, and SSA at 500 nm; and AE for the observation period were found to be 0.95 ± 0.32, 1027.36 ± 797.1 Mm−1 , 85.95 ± 73.2 Mm−1 and 0.93 ± 0.03; and 0.94 ± 0.19, respectively.

Higher values of σscat and σabs were occurred in the month of December (1857 and 148 Mm−1) while relatively lower values of σscat (585 Mm−1) and σabs (44 Mm−1) were occurred in March and February respectively. SSA, however, was higher during January (0.94) and lower in March (0.89). The mass concentration of PM2.5 and BC were 195.34 ± 157.99 and 10.11 ± 8.83 μg m−3 respectively during study period. Bimodal distributions were observed in σscat and σabs coefficients during 0800 and 0900 h LT (traffic rush hours) and at 2200 and 2300 h LT (low boundary layer conditions) with lower values during daytime between 1500 and 1700 h LT, respectively. The σscat peak in morning may be attributed to large emissions of aerosol in the traffic rush hours and production of secondary aerosols with increasing solar radiation and temperature. During study period, the σscat (mean) coefficient was 13% lower during daytime as compared to nighttime. An interesting feature was seen in monthly analysis of σscat in between day and nighttime which was 18% and 22% higher in December and January in nighttime however ~4% lower during February and March; it is due to effect of local meteorology. The impact of meteorological parameters such as wind speed (WS), wind direction (WD), visibility (VIS) and mixed layer depths (MLDs) on AOPs along with fine and soot particles were studied. A clear negative significant correlation between atmospheric visibility with σscat (−0.64); σabs (−0.57) and PM2.5 (−0.56) were observed. During foggy days (VIS ≤1000 m), the AOPs, fine and soot particles were substantially (~1.8 times) higher as compared to clean days, however, it was ~2.3 times higher during dense foggy days (VIS ≤500 m). Similarly higher (~2 times) AOPs and aerosol concentrations were also seen below 200 m MLDs. In addition to this, ~4 times higher AOPs and aerosol mass concentrations were observed when WS was below 1 m/s. In view of the above results and regression analysis, we can say that the meteorological parameters play a crucial role in enhancement of aerosols at ground level during winter period over Delhi.

Keywords: *Aerosol optical properties; PM2.5; Black carbon; Mixed layer depths; Foggy days.*

Temporal characteristics of atmospheric CO2 in urban Nanjing, China

Xiaoxian Huang , Tijian Wang , Robert Talbot , Min Xie , Huiting Mao , Shu Li , Bingliang Zhuang , Xiuqun Yang , Congbin Fu , Jialei Zhu , Xing Huang , Runying Xu

Source: *Atmospheric Research 153 (2015) 437–450*

Although China is a big carbon dioxide (CO2) emitter, in situ measurements of atmospheric CO2 are sparse in urban China. The mixing ratio of carbon dioxide (CO2) and its influencing factors in urban Nanjing were investigated in this study, from the 18th of January to the 31st of December 2011. The annual average mixing ratio of CO2 was 406.5 ± 20.0 ppmv over the study period. The signal analysis using the fast Fourier transform (FFT) algorithm showed that CO2 had different cycles as a result of multiple controlling factors. The seasonal and intra-seasonal fluctuations of CO2 were mainly caused by the terrestrial biospheric uptake and emission and atmospheric oscillation. The weekly variation of CO2 was largely influenced by traffic volume. The diurnal cycle of CO2 presented a bimodal pattern in winter (DJF) probably due to the rush hour emissions. The seasonal mean CO2/CO correlation slope varied from 0.024 ppmv/ppbv to 0.029 ppmv/ppbv, comparable to the fossil fuel combustion emission ratio. The diurnal pattern of CO2/CO was irregular, indicating random anthropogenic emissions in an urban area. Firework setting was a large source of CO2 during the Spring Festival holiday. The backward trajectories by the HYSPLIT model showed that the local anthropogenic emissions contributed the most to the high CO2 mixing ratio in the urban area.

Keywords: *Atmospheric carbon dioxide (CO2); Urban; Nanjing; Traffic emissions; Firework settings; The CO2/CO ratio.*

Effect of dramatic land use change on gaseous pollutant emissions from biomass burning in Northeastern China

Hongmei Zhao , Daniel Q. Tong , Chuanyu Gao , Guoping Wang

Source: *Atmospheric Research 153 (2015) 429–436*

Biomass burning contributes a substantial amount of gas and particle emissions to the atmosphere. As China's breadbasket, northeast China has experienced dramatic land use change in the past century, converting approximately 55 × 104 ha of wetland into farmland to feed a rapidly growing population. This study combines measured emission factors of dominant crops (rice and soybean) and wetland plants (Calamagrostis angu-stifolia, Carex lasiocarpa, Carex pseudo-curaica) and remote sensing land use data to estimate the effect of the unprecedented land use change on gaseous pollutants emissions from biomass burning. Our biomass burning emission estimates resulting from land use changes have increased because of increased post-harvest crop residue burning and decreased burning of wetland plants. From 1986 to 2005, the total emissions of CO2, CO, CXHY, SO2 and NO have increased by 18.6%, 35.7%, 26.8%, 66.2% and 33.2%, respectively. We have found two trends in agricultural burning: increased dryland crop residue burning and decreased wetland (rice paddy) burning. Our results revealed that the large scale land use change in northeastern China has induced more active biomass-burning emissions. The regional emission inventory of gaseous pollutants derived from this work may be used to support further examination of the subsequent effects on regional climate and air quality simulations with numerical atmospheric models.

Keywords: *Biomass burning; Land use change; Emission factor; Emission inventory; Sanjiang Plain.*

The effects of aerosol on development of thunderstorm electrification: A numerical study

Pengguo Zhao , Yan Yin , Hui Xiao

Source: *Atmospheric Research 153 (2015) 376–391*

The effects of aerosol on electrification of an idealized supercell storm are investigated using the Weather Research and Forecasting model coupled with electrification and discharge parameterizations and an explicit treatment of aerosol activation. It is found that the microphysical and electric processes of the thunderstorm are distinctly different under different aerosol background. Enhancing aerosol loading increases growth rate of snow and graupel particles, and leads to higher concentration of ice particles. Increasing aerosol concentration also results in enhancement in electrification process, due to more ice particles participating in the electrification process in the polluted case. In the clean case, the charge structure maintained dipolarity throughout the simulation, while in the polluted case the charge structure transformed from dipolarity at the initial stage of charging separation to the structure of a negative charge region above the main positive and the main negative charge centers at the later stage. A detailed analysis of the microphysical processes shows that increasing aerosol loading led to more liquid water content and higher rime accretion rate above the freezing level, which was in favor of graupel charge positively and ice crystal and snow charge negatively in this region. In a word, increasing aerosol loading leads to increased cloud water content, resulting in a new negative charge region developed above the main positive charge center.

Keywords: *Mesoscale model; Aerosol effects; Electrification; Charge structure.*

Secondary organic aerosol contributions to PM2.5 in Monterrey, Mexico: Temporal and seasonal variation

Yasmany Mancilla , Pierre Herckes , Matthew P. Fraser , Alberto Mendoza

Source: *Atmospheric Research 153 (2015) 348–359*

Air pollution caused by fine particles is a problem of great concern in the Monterrey Metropolitan Area (MMA) which is the third largest city and the second most important industrial center in Mexico. In this study, samples of fine particulate matter emissions with an aerodynamic diameter of less than 2.5 μm (PM2.5) were collected for 12-hour periods during the spring and fall of 2011 and 2012. Eighty-three samples were analyzed for organic carbon (OC) and elemental carbon (EC). The carbonaceous fraction (OC + EC) accounted for 28–55% of the PM2.5 mass. The average OC/EC ratios ranged from 7.4 to 12.6, and OC and EC concentrations were statistically significant correlated (R2 = 0.81, p b 0.01). The secondary organic aerosol (SOA) contributions were determined using two approaches: the EC tracer method based on a primary OC/EC ratio derived from a tunnel study and the minimum observed OC/EC ratio. SOAs were determined to constitute, on average, 59–87% and 32–45% of the total OC and PM2.5, respectively. The relationship between O3 and wind speed indicated that pollutant levels were influenced by transport events during the spring, while stagnation events predominated during the fall campaigns. Statistically significant correlations were observed between OC and EC and gaseous species (CO, NOx, and SO2), indicating a contribution by combustion of fossil fuels to the carbonaceous material.

Keywords: *Atmospheric aerosols; Secondary organic aerosols; PM2.5; EC tracer method; Monterrey.*

Improved aerosol retrieval algorithm using Landsat images and its application for PM10 monitoring over urban areas

Nana Luo , Man Sing Wong , Wenji Zhao , Xing Yan , Fei Xiao

Source: *Atmospheric Research 153 (2015) 264–275*

Aerosol retrieval using MODerate resolution Imaging Spectroradiometer (MODIS) has been well researched over the past decade. However, the application is limited to global- and regional-scale studies, which may not be applicable for urban areas due to its low spatial resolution. To overcome the limitation, this paper proposed an improved aerosol retrieval algorithm for Landsat images (ImAero-Landsat) at spatial resolution of 30 m. This ImAero-Landsat algorithm has been improved in the following two aspects: (i) it does not require a comprehensive look up table and thus it is more efficient in AOT retrieval; and (ii) it can be operated in both bright and dark surfaces. The derived aerosol optical thickness (AOT) images were validated with AErosol RObotic NETwork (AERONET) measurements as well as MODIS MOD04 AOT products. Small root mean square errors (RMSEs) of 0.11 and 0.14 and mean absolute difference (MAD) of 0.07 and 0.11 between ImAero-Landsat AOT, with MODIS MOD04 and AERONET products were observed. By correlating with ground based PM10 concentrations, the ImAero-Landsat method outperforms (r2 = 0.32) than MOD04 AOT products (r2 = 0.23). In addition, the accuracy of estimating PM10 can be improved to r2 = 0.55 when the derived AOT was integrated with meteorological parameters. The accuracy is similar to the results derived from AERONET AOT (r2 = 0.62). This study offers a simple and accurate method to investigate aerosol optical thickness at detailed cityscale. Environmental authorities may use the derived methods for deriving aerosol distribution maps and pinpointing the sources of pollutants in urban areas.

Keywords: *AERONET; Aerosol retrieval; Landsat image; PM10 concentrations.*

A study of aerosol optical properties during ozone pollution episodes in 2013 over Shanghai, China

Chanzhen Shi , Shanshan Wang , Rui Liua, Rui Zhou , Donghui Li , Wenxin Wang , Zhengqiang Li , Tiantao Cheng , Bin Zhou

Source: *Atmospheric Research 153 (2015) 235–249*

Aerosol optical property is essential to the tropospheric ozone formation mechanism while it was rarely measured in ozone-rich environment for a specific study. With the retrieved products of the sun-photometer, a comparative investigation was conducted on aerosol optical depth (AOD), single scattering albedo (SSA) and size distribution during ozone-polluted episodes and clean background. Contrary to expectations, aerosol loading was found to be positively-correlated with ozone concentration: daily averaged AOD at 500 nm in ozone episodes (~0.78) displayed 2.4 times higher than that in clean days (~0.32). Large Ångström exponent (~1.51) along with heavy aerosol loading indicated a considerable impact of fine particles on optical extinction. The dynamic diurnal fluctuation of these parameters also implied a complex interaction between aerosols and photo-chemical reactions. The bimodal lognormal distribution pattern for aerosol size spectra exhibited in both ozone-polluted and clean days. The occurrence of maximum volume concentration (~0.28) in fine mode (radius b0.6 μm) was observed at 3 p.m. (local time), when ozone was substantially generated. Pronounced scattering feature of aerosol was reproduced in high-concentration ozone environment. SSA tended to increase continuously from morning (~0.91 at 440 nm) to afternoon (~0.99), which may be associated with secondary aerosol formation. The scattering aerosol (with moderately high aerosol loading) may favor the ozone formation through increasing solar flux in boundary layer. Utilizing the micro-pulse lidar (MPL), a more developed planet boundary layer (PBL, top height ~1.96 km) was discovered during ozone-polluted days than clean condition (~1.4 km). In episodes, the maximum extinction ratio (~0.5 km−1) was presented at a height of 1.2 km in the late afternoon. The humidity profile by sounding also showed the extreme value at this altitude. It suggested that optical extinction was mainly attributed to the aerosol in middle PBL, where the intense photochemical reactions and hydroscopic growth may occur.

Keywords: *Aerosol; Ozone pollution; Optical property; Extinction profile; Shangha.*

Size distribution of carbonaceous aerosols at a high-altitude site on the central Tibetan Plateau (Nam Co Station, 4730 m a.s.l.)

Xin Wan , Shichang Kang , Yuesi Wang , Jinyuan Xin , Bin Liu , Yuhong Guo , Tianxue Wen , Guoshuai Zhang , Zhiyuan Cong

Source: *Atmospheric Research 153 (2015) 155–164*

The chemical composition and size distribution characteristics of atmospheric aerosols have important effects on the environment, human health and climate change. In this paper, we study the size distribution of carbonaceous aerosols at the remote and pristine site, Nam Co Monitoring and Research Station for Multisphere Interactions, in the inland Tibetan Plateau (TP) based on collected size-segregated aerosols during 2012. The samples were quantified using the thermal/ optical (TOR) method. The overall average concentrations of OC and EC in TSP, PM9.0, PM2.1, and PM1.0 were 4.61 μg m−3 and 0.19 μg m−3 , 4.52 μg m−3 and 0.18 μg m−3 , 2.72 μg m−3 and 0.11 μg m−3 , and 2.11 μg m−3 and 0.09 μg m−3 , respectively. Generally, the highest concentration of OC and EC in different aerosol size occurred during winter. The low level of EC indicated that direct anthropogenic disturbances in the interior of the TP still remain

insignificant. The size distributions of OC and EC concentrations presented bimodal variations. In winter, pre-monsoon, monsoon, and post-monsoon seasons, the peaks for OC were in droplet mode (0.43–0.65 μm) and coarse mode (4.7–5.8 μm); while in the monsoon period, the coarse mode shifted to a smaller size bin (3.3–4.7 μm). The coarse mode may be due to dust particles while the droplet mode may be due to the growth process of particles. For EC, the peaks variations in coarse mode were as same as OC, while the other peaks were complicated: the peaks during winter, pre-monsoon, and monsoon seasons exhibited in droplet mode (1.1–2.1 μm, 0.65–1.1 μm, and 0.43–0.65 μm, respectively), and in post-monsoon period, the peak located in condensation mode. The highest peak concentrations for OC and EC occurred in winter and the pre-monsoon period, while the lowest peak values in the monsoon and post-monsoon periods, respectively. The size distribution variations may be caused by deposition, gas/particles exchange, hygroscopic growth, external mixing, and secondary organic carbon formation. OC/EC ratios in aerosols over the TP mostly exhibit high values, which emphasizes the importance of OC over this region.

Keywords: *Atmospheric aerosols; Organic carbon; Elemental carbon; Size distribution; Tibetan Plateau.*

Size-segregated particulate matter and gaseous emissions from motor vehicles in a road tunnel

Célia A. Alves , Joana Gomes , Teresa Nunes , Márcio Duarte , Ana Calvo , Danilo Custódio , Casimiro Pio , Angeliki Karanasiou , Xavier Querol

Source: *Atmospheric Research 153 (2015) 134–144*

In order to address road traffic emissions, studies need to be performed under realistic driving conditions where the input from other sources is minimised. Measurements in traffic tunnels have been used for quantifying emissions, but so far no study has established emission factors (EFs) for Southern Europe. To fill this gap, a sampling campaign was carried out for one week in the Liberdade Avenue tunnel (Braga, Portugal). The campaign included the monitoring of gaseous pollutants (CO2, CO, NOx) and suspended particulate matter (PM) at two sites, one in the tunnel and another in an urban background location. Organic and elemental carbon (OC and EC) in sizesegregated particles (PM0.5, PM0.5–1, PM1–2.5 and PM2.5–10) were determined by a thermal–optical system, whereas major and trace elements were analysed by ICP-MS and ICP-AES. PM0.5 accounted for 56% of the PM10 mass, while PM2.5–10 represented only 12%. The carbonaceous fraction was concentrated in PM0.5, encompassing 88% of the EC and 67% of the OC present in PM10. Elements attributable to non-exhaust emissions could be divided into two groups. Fe, Ba, Cu, Sb, Sn and Zn, from tyre and brake wear, were more abundant in particles between 1 and 2 μm. Ca, Al, K, Sr and Ti, associated with soil resuspension, were mainly present in particles N2 μm. The average EFs of CO, CO2 and NOx were 212, 4.02 and 1.22 g veh−1 km−1 , respectively, while values of 152 mg PM10 veh−1 km−1 and 133 mg PM2.5 veh−1 km−1 were obtained for the particles. OC and EC emission factor was 39 mg veh−1 km−1 for PM10. The corresponding OC and EC values for PM2.5 were 34 and 38 mg veh−1 km−1 . The EFs are slightly lower than those found for other tunnels, but within the ranges presented by the EMEP/EEA inventory.

Keywords: *Road tunnel; Exhaust gases; Size-segregated particles; OC/EC; Non-exhaust emissions; Emission factors.*

Effects of turbulence on warm clouds and precipitation with various aerosol concentrations

Hyunho Lee , Jong-Jin Baik , Ji-Young Han

Source: *Atmospheric Research 153 (2015) 19–33*

This study investigates the effects of turbulence-induced collision enhancement (TICE) on warm clouds and precipitation by changing the cloud condensation nuclei (CCN) number concentration using a two-dimensional dynamic model with bin microphysics. TICE is determined according to the Taylor microscale Reynolds number and the turbulent dissipation rate. The thermodynamic sounding used in this study is characterized by a warm and humid atmosphere with a capping inversion layer, which is suitable for simulating warm clouds. For all CCN concentrations, TICE slightly reduces the liquid water path during the early stage of cloud development and accelerates the onset of surface precipitation. However, changes in the rainwater path and in the amount of surface precipitation that are caused by TICE depend on the CCN concentrations. For high CCN concentrations, the mean cloud drop number concentration (CDNC) decreases and the mean effective radius increases due to TICE. These changes cause an increase in the amount of surface precipitation. However, for low CCN concentrations, changes in the mean CDNC and in the mean effective radius induced by TICE are small and the amount of surface precipitation decreases slightly due to TICE. A decrease in condensation due to the accelerated coalescence between droplets explains the surface precipitation decrease. In addition, an increase in the CCN concentration can lead to an increase in the amount of surface precipitation, and the relationship between the CCN concentration and the amount of surface precipitation is affected by TICE. It is shown that these results depend on the atmospheric relative humidity.

Keywords: *Turbulence; Collision enhancement; Warm clouds; Precipitation; Bin microphysics.*

Air quality and thermal comfort levels under extreme hot weather

D.K. Papanastasiou , D. Melas , H.D. Kambezidis

Source: *Atmospheric Research 152 (2015) 4–13*

Meteorological (T and RH values) and air pollution data (PM10, NO2 and O3 concentrations) observed in Athens, Thessaloniki and Volos were analyzed to assess the air quality and the thermal comfort conditions and to study their synergy, when extreme hot weather prevailed in Greece during the period 2001–2010. The identification of a heat wave day was based on the suggestion made by the IPCC to define an extreme weather event. According to it, a heat wave day is detected when the daily maximum hourly temperature value exceeds its 90th percentile. This temperature criterion was applied to the data recorded at the cities center. Air quality was assessed at three sites in Athens (city center, near the city center, suburb), at two sites in Thessaloniki (city center, suburb) and at one site in Volos (city center), while thermal comfort conditions were assessed at the cities center. Mean pollution levels during the heat wave days and the non-heat wave days were calculated in order to examine the impact of the extreme hot weather on air quality. For this purpose, the distributions of the common air quality index and the exceedances of the air quality standards in force during the heat wave days and the non-heat wave days were also studied. Additionally, the variation of the daily maximum hourly value of Thom's discomfort index was studied in order to investigate the effect of extreme hot weather on people's thermal comfort. Moreover, the values of the common air quality index and Thom's discomfort index were comparatively assessed so as to investigate their synergy under extreme hot weather

Keywords: *Heat waves; Air quality; Thermal comfort.*

Air pollutant deposition at declining forest sites of the Tanzawa Mountains, Japan

Manabu Igawa, Kyosuke Kojima, Osamu Yoshimoto, Ben Nanzai

Source: *Atmospheric Research 151 (2015) 93–100*

Fir and beech trees have been dying in the Tanzawa Mountains, which are located southwest of the Kanto Plain. We have observed fog characteristics since 1988 in Mt. Oyama, which is isolated from others, located southeast of the Mountains. Acid fog has been frequently observed there. The annual mean pH of the fog has remained roughly constant, but the pH distribution of fog has shifted to higher pH recently, which corresponds closely with the improvement of air pollution at the base of Mt. Oyama. Acid fog is still formed, and it may have affected tree species such as fir and beech, which are sensitive to air pollution. We observed rainy periods and foggy periods using a visibility meter at the mountain top. The canopies at the high altitude are confirmed to be wetted for a long period, which might enhance the air pollutant deposition. We also observed air pollution and wet deposition at Mt. Nabewari, located southwest of the Tanzawa Mountains. The acid gas concentrations are about the same level in the two mountains and are in the order of SO2 N HNO3 N HCl. Comparison of wet deposition at the summit of Mt. Nabewari to that of Mt. Oyama also revealed that they were of similar levels. In the Tanzawa Mountains, fir trees and beech trees are declining by the damage of acid fog, although the high concentration ozone and the other factors may have also affected them.

Keywords: *Forest decline; Acid fog; Tanzawa Mountains; Throughfall Rain.*

The variability of biomass burning and its influence on regional aerosol properties during the wheat harvest season in North China

Lili Wang , Jinyuan Xin , Xingru Li , Yuesi Wang

Source: *Atmospheric Research 157 (2015) 153–163*

The spatial–temporal variation of biomass burning in June during the wheat harvest season in the North China (32–41°N, 111–120°E) and its influence on the regional aerosol optical depth (AOD) and the chemical compositions of size-segregated aerosols in the urban environment were investigated to evaluate the effectiveness of the burn ban policy and the influence on regional pollution. Fire events that occurred in early and middle June accounted for approximately 89% of the events during the month, and fire points located in mid-eastern China (32.5–35.5°N, 114– 120°E) comprised 71%. The occurrences exhibit oscillatory changes with a minimum in 2008 (during the Beijing Olympics) and a peak and explosive growth in 2012. Under high relative humidity and south winds, fire emissions from straw burning combined with high urban/ industrial emissions to produce intensive regional haze pollution in the North Plain. The formation of secondary inorganic particles was intensified due to the interactions of smoke plumes and urban/industrial pollutants in an urban environment. Higher concentrations and percentages (79%) of sulfate, nitrate, ammonium, and organic carbon in the fine particles under high relative humidity conditions contributed to a deteriorated urban visibility. Therefore, stronger management and a comprehensive ban on wheat straw burning in June are urgently needed, especially during years when the south wind is dominant.

Keywords: *Wheat straw burning; North China; AOD; Aerosol chemical compositions.*

Recent changes in extreme precipitation and drought over the Songhua River Basin, China, during 1960–2013

Xiaoyan Song , Songbai Song , Wenyi Sun , Xingmin Mu , Shuangyin Wang , Jiuyi Li , Yi Li

Source: *Atmospheric Research 157 (2015) 137–152*

Based on ten indices of extreme precipitation and one drought index (composite index, CI), the trends in extreme events were investigated using a Mann–Kendall non-parametric method at 39 stations in the Songhua River Basin (SHB) during 1960–2013. The regionally averaged wet-day precipitation (PRCPTOT) increased at a rate of 1.65 mm/year (R2 = 0.28, P = 0.13), in which 82% of the stations experienced increases, but only 4 stations showed significant positive trends. The annual R95 and R99 exhibited slight upward trends at rates of 1.37 (R2 = 0.21, P = 0.27) and 1.28 mm/year (R2 = 0.23, P = 0.23) over the last 54 years; however, there were not significant trends in R95 and R99 at the 0.05 level. PRCPTOT, R95 and R99 showed similar spatial trends, in which positive trends mainly occurred in the northern and southeastern basins. The trends in the maximum 1-day precipitation (RX1day) and maximum 5-day precipitation (RX5day) do not show a prevalent trend (approximately 50% of the stations have a positive trend and the remaining stations have a negative trend). The simple daily intensity index (SDII) significantly decreased at an annual rate of 0.02 mm/d during 1960–2013 (R2 = 0.66, P b 0.01); spatially, 49% of the stations experienced statistically significant decreases at the 0.05 level based on the Mann–Kendall non-parametric test. The regionally averaged heavy (R10mm) and very heavy precipitation days (R20mm) and consecutive wet days (CWD) showed no significant trends during the past 54 years; however, several individual extreme precipitation events, such as the flood of 1998 in the SHB, were well detected by these indices. The regionally averaged consecutive dry days (CDD) significantly increased (R2 = 0.79, P b 0.01) at a rate of 0.22 days/year from 1960 to 2013. All of the stations exhibited statistically significant increases in CDD, excluding the Tongyu station in the western basin. The monthly RX5day values were highest in summer, from June to August, in the SHB; a peak occurred in July (67.5 mm) in the SHB during 1960–2013. The CI peaked in July, with the highest value of 0.2 in the SHB during 1960–2013. However, the two lowest CI values occurred in spring and fall, with values of −0.56 and −0.41, respectively. During April and May, when most of the spring drought events occur, a prevalent trend does not exist; moreover, almost no stations have statistically significant CI increases. In August and September, respectively 79% and 97% of the stations exhibited a CI negative trend, but only 2 and 6 stations showed significant decreases at the 0.05 level. The increasing extreme climate events present a challenge for local water resources management.

Keywords: *Extreme precipitation; Drought; Songhua River Basin.*

Dry deposition, seasonal variation and source interpretation of ionic species at Abali, Firouzkouh and Varamin, Tehran Province, Iran

Masoumeh Javid , Nader Bahramifar , Habibollah Younesi , Seyed Mohammad Taghavi , Raheleh Givehchi

Source: *Atmospheric Research 157 (2015) 74–90*

Using a passive sampler, the results of the analyses of water soluble ions (Na+, Cl−, K+, NH4 +, NO3 −, SO4 2−, Ca2+ and Mg2+) in Abali, Firouzkouh and Varamin stations were registered. Dry deposition fluxes of water soluble ions were collected weekly for 14 months (Oct. 2010 to Dec. 2011). The results showed that the weekly dry deposition mass fluxes ranged from 16.48 to 922.68 mg m−2 day−1, with annual average deposition of 159.37, 124.46 and 237.09 in mg m−2 day−1 in Abali, Firouzkouh and Varamin, respectively.

In Abali, Na+, SO4 2− and NO3 − the dominant ionic species were Na+, SO4 2− and NO3 −, SO4 2−, Ca2+ and NO3 − and SO4 2−, Na+ and Ca2+, accounting for 28%, 23% and 17%, 36%, 25% and 18% and 30%, 20% and 19% of the total mass of ions, in Abali, Firouzkouh and Varamin, respectively. Dry deposition flux of major ions was higher during the dust storm and other weather phenomena. Air mass back trajectories calculated for all three sampling sites on October 2011 (when there was pollution), revealed four sectors of air mass origin: NW to N of Siberia/Russia and Caspian Sea, local, Middle East and W to SW of Oman Sea. Seasonal variation of total ion flux was significant, with the highest depositions observed in winter 2011, autumn 2010 and autumn 2011 and the lowest depositions in spring 2011, spring 2011 and autumn 2010 in Abali, Firouzkouh and Varamin, respectively. These major ions were mainly in the form of Ca(NO3)2, CaSO4, CaCl2, and NaCl. Firouzkouh had the lowest NO3 −/SO4 2− flux value among the two other sampling sites, indicating that the stationary source of the air pollution was the more dominant one. Stationary emissions were still the dominant source in all three sampling sites demonstrated by the NO3 −/SO4 2− ratio being lower than one. NO3 −, SO4 2− and NH4 + were primarily affected by anthropogenic emissions, while SO4 2− might have been partially influenced by the sea. Na+ and K+ were derived from both soil crust and marine sources, but Ca2+ was mainly coming from the soil.

Keywords: *Dry deposition flux; Water soluble ion; Source contribution; Trajectory analysis; PCA.*

Column-integrated aerosol optical properties and direct radiative forcing based on sun photometer measurements at a semi-arid rural site in Northeast China

Yunfei Wu , Jun Zhu , Huizheng Che , Xiangao Xia , Renjian Zhang

Source: *Atmospheric Research 157 (2015) 56–65*

Ground and satellite remote sensing measurements have revealed heavy aerosol loading in China; however, aerosol optical properties and direct radiative forcing in Northeast China – important in climate modeling and remote sensing – have not been widely studied. We studied four years of continuous sun photometer measurements at Tongyu, a typical semi-arid rural site in Northeast China, to better understand column-integrated aerosol optical properties and direct radiative forcing. The annual average aerosol optical depth (AOD) at 500 nm was 0.20 ± 0.26; the Ångström exponent (AE) between 440 and 870 nm was 1.37 ± 0.64; and the single scattering albedo (SSA) at 440 nm was 0.91 ± 0.05. The AOD at this rural site was a quarter of that observed in the polluted North China Plain and Yangtze River Delta regions. Anthropogenic fine-mode particles were the dominant contributor to AOD. The AOD and AE showed generally opposite seasonal variation patterns. Relatively higher AOD values in summer (0.26 ± 0.27) and spring (0.24 ± 0.30) were likely related to long-range transportation of anthropogenic aerosols from southern industrial regions in summer, and the increased contribution of dust events in spring. The minimum AOD (0.16 ± 0.22) was concurrent with the maximum AE (1.75 ± 0.76), observed in winter. On average, the absorption AOD (AAOD) at 440 nm and its absorption Ångström exponent (AAE) between 440 and 870 nm were 0.06 ± 0.03 and 1.04 ± 0.43, respectively. The mean AAE was considerably higher than 1 in autumn and winter, indicating that brown carbon from biomass burning contributed greatly to aerosol absorption. The AAE was lower than 1 in summer and spring, related to the coating of black carbon particles. Large negative aerosol direct radiative forcing was estimated at the bottom of the atmosphere, with relatively lower values estimated at the top of the atmosphere; the means were −26.28 and −9.42 W m−2, respectively. This resulted in a strong cooling effect on the surface, but warming in the atmosphere, potentially impacting the regional climate

Keywords: *Semi-arid; Aerosol optical properties; Radiative forcing.*

δ15N–NH4 + variations of rainwater: Application of the Rayleigh model

Hong-Wei Xiao , Hua-Yun Xiao , Ai-Min Long , Cong-Qiang Liu

Source: *Atmospheric Research 157 (2015) 49–55*

It is generally difficult to measure atmospheric gaseous ammonia concentration and to identify its sources by isotopic technique due to the isotopic fractionation after it enters the atmosphere. In this study, Rayleigh model was successfully used to quantify atmospheric concentration and isotopic composition of gaseous ammonia based on sampling of 20 rain events from October 1st, 2008 to September 30, 2009 in Guiyang, southwest China. The estimated gaseous ammonia concentration was 25.7 ± 36.3 μg/m3 and estimated isotopic composition was −16.8 ± 4.9‰ in Guiyang. The study also showed that estimated enrichment factor was +10.4 ± 4.3‰, inferring that large nitrogen isotopic fractionation occurred during exchange reactions in most of the rain events. The atmospheric ammonium deposition was further estimated to be 38.1 kg/ha/year. However, there is no validation for the approach from an actual gas phase NH3 measurement to examine the model in this study

Keywords: *Rayleigh model; Initial concentration; Enrichment factor; Initial nitrogen isotope; Ammonia.*

Long-range transport and regional sources of PM2.5 in Beijing based on long-term observations from 2005 to 2010

Lili Wang, Zirui Liu, Yang Sun, Dongsheng Ji, Yuesi Wang

Source: *Atmospheric Research 157 (2015) 37–48*

Haze pollution in Beijing is rather deteriorated. Long-term measurement of PM2.5 from 2005 to 2010 at an urban site in Beijing showed very high concentration level with an annual average 74 ± 55 μg/m3 . The contribution of regional sources is one of the most important factors; thus, transport and regional sources of PM2.5 in Beijing are investigated using the trajectory cluster and receptor models (potential source contribution function and trajectory sector analysis). The results indicated that the highest concentrations of PM2.5 (76–120 μg/m3) were associated with south, southeast, and short northwest trajectories, and moderate concentrations (46–67 μg/m3) with long northwest and short north trajectories, and the lowest concentrations (20–33 μg/m3) with long north trajectories. During the relatively polluted periods, the probable locations of regional emission sources were mainly in the south and the west of Beijing and varied according to different seasons. Between 2005 and 2010, the annual mean contribution of 35.5% (32.8 μg/m3) for PM2.5 was attributed to long-distance transportation. The transported contribution percentages from 2005 to 2010 for PM2.5 showed an increasing tendency with a linear rate of 1.2/year

Keywords: *PM2.5; Long-range transport; Trajectory sector analysis; Potential source contribution function (PSCF); Beijing.*

Black carbon radiative forcing over the Indian Arctic station, Himadri during the Arctic Summer of 2012

M.P. Raju , P.D. Safai , S.M. Sonbawne , C.V. Naidu

Source: *Atmospheric Research 157 (2015) 29–36*

The warming of Arctic region has recently gained worldwide attention due to its projected impacts on global climate system. The effect of anthropogenic black carbon (BC) aerosol on snow is of enduring interest due to its role in aerosol radiative forcing and further consequences for Arctic and global climate change. Using an A ethalometer, measurements of BC aerosols were continuously carried out over the Indian Arctic Station, Himadri during the Arctic Summer (23 July to 19 August) of 2012. Monthly mean BC mass concentration during July and August was found to be 0.093 ± 0.046 and 0.069 ± 0.050 μg/m3, respectively. BC mass concentration showed maximum loading during 0800–1600 LT. Transport from distant sources (as observed from air mass back trajectories) apart from some local anthropogenic activities (emissions from shipping and power plant) could be the possible sources for observed BC concentration at Himadri. Using the OPAC and SBDART models, optical properties and aerosol radiative forcing (ARF) in the spectral range 0.2 to 4 μm for composite aerosol and without-BC aerosol at the top of the atmosphere, surface and atmosphere were computed. The presence of BC resulted in positive radiative forcing in the atmosphere leading to warming effect (+2.1 W/m2) whereas cooling was observed at the top of the atmosphere (−0.4 W/m2) and at surface (−2.5 W/m2). BC formed about 57% of atmospheric ARF.

Keywords: *Black carbon; Arctic Summe;r Himadri; Temporal variations; Long range transport; Radiative forcing.*

Integrated evaluation of aerosols during haze-fog episodes at one regional background site in North China Plain

Qi Yuan , Weijun Li , Shengzhen Zhoua, , Lingxiao Yang , Jianwei Chi , Xiao Sui , Wenxing Wang

Source: *Atmospheric Research 156 (2015) 102–110*

To investigate haze-fog (HF) formation mechanisms and transport, trace gases and aerosols in the aged air masses during regional haze episodes were measured at a regional background site in the North China Plain during 4–19 July, 2011. Mixing state of individual particles, soluble ions of PM2.5, and particle number concentrations were studied using transmission electron microscope, ambient ion monitoring, and wide-range particle spectrometer, respectively. Average mass concentration of PM2.5 was 3 times higher on HF days (70 μg/m3) than on clear days (22 μg/m3). The major soluble ionic components (SO4 2−, NO3 −, and NH4 +) in PM2.5 were over 4 times higher on HF days (40.6 μg/m3) than on clear days (9.1 μg/m3). The high sulfur oxidation ratios (SOR) and nitrogen oxidation ratios (NOR) values during HF days suggest that polluted weather favored transformation of SO2 and NOx into sulfates and nitrates compared to clear days. Particle number fraction of the accumulation mode increases from 11% on clear days up to 26% on HF days. Individual particle analysis shows that secondary inorganic particles (e.g., sulfate and nitrate) as the most abundant species likely determine internal mixing of individual particles and almost half of them mixed refractory particles (e.g., metal, fly ash, soot, and mineral) on HF days. These fine refractory particles were likely emitted from coal fired power plants, heavy industries, and urban city in Shandong and Hebei provinces. Our results suggest that aged air masses mostly contain aged particles of long-range transport and some from new particle formation and growth in the regional background atmosphere.

Keywords: *Regional background site; Haze-fog episode; PM2.5; Mixing state; New particle formation.*

Source apportionment of PM2.5 carbonaceous aerosol in Baghdad, Iraq

Samera Hussein Hamad , James Jay Schauer , Jongbae Heo , Ahmed K.H. Kadhim

Source: *Atmospheric Research 156 (2015) 80–90*

Baghdad is the second largest city in the Middle East and suffers from severe air quality degradation due to the high levels of the atmospheric particulate matter (PM). Limited information exists regarding the sources of PM in Baghdad, and the lack of information on sources inhibits the development of control strategies to reduce air pollution. To better understand the nature of fine particulate matter (PM2.5) in Baghdad and the Middle East, a one year sampling campaign to collect PM2.5 was conducted from September 2012 through September 2013, missing August 2013 samples due to the security situation. 24-hour integrated samples collected on a 1-in-6 day schedule were analyzed for the major components, and monthly average samples were analyzed by gas chromatography mass spectrometry (GCMS) methods to measure particle-phase organic molecular markers. The results of organic molecular markers were used in a chemical mass balance (CMB) model to quantify the sources of PM2.5 organic carbon (OC) and PM2.5 mass. Primary sources accounted for 44% of the measured PM2.5, and secondary sources were estimated to make up 28% of the measured PM2.5. Picene, a tracer of coal combustion detected in Baghdad where there is no evidence for coal combustion, can be attributed to burning crude oil and other low quality fuels in Baghdad. Source apportionment results showed that the dominant sources of the carbonaceous aerosols in Baghdad are gasoline (37 ± 6%) and diesel engines (17 ± 3%) which can be attributed to the extensive use of gasoline and diesel powered generators in Baghdad. Wood burning and residual oil combustion contributed to 5 ± 0.4 and 1 ± 0.2% respectively of OC. The unresolved sources contributed to 42 ± 19% of the OC which represented the secondary organic aerosol (SOA) and the unidentified sources.

Keywords: *PM2.5; Carbonaceous aerosol; Sources; Baghdad-Iraq.*

Yak dung combustion aerosols in the Tibetan Plateau: Chemical characteristics and influence on the local atmospheric environment

Pengfei Chena , Shichang Kang , Jiankun Bai , Mika Sillanpää , Chaoliu Li

Source: *Atmospheric Research 156 (2015) 58–66*

The study of the source areas of atmospheric pollutants in the Tibetan Plateau (TP) – one of the most remote regions in the world – has raised a great deal of concern. It is generally considered that the majority of pollutants in this region are transported from outside the TP. This research investigated the water soluble elements and carbonaceous matter from aerosols emitted from yak dung combustion by local residents and re-analyzed previous OC and BC data at Nam Co — a remote area of the TP. The compositions of the water soluble elements of the studied aerosols were similar to those in precipitation and snow samples of the region under investigation. Some heavy metal elements (e.g. Cd and As) even had higher enrichment factor (EF) values (1793 and 2355, respectively) compared to those in precipitation and snow samples, implying that previously reported high EF values for precipitation and snow did not completely reflect the long-range transported pollutants from outside the TP. Accordingly, the contributions of local sources needed to be considered. Organic carbon (OC) and black carbon (BC) accounted for 55.2% and 3.63% of the studied aerosol, respectively. The OC/BC ratio of the studied aerosols was close to the corresponding value for the

outdoor aerosols, further indicating the influence of local sources on the atmosphere of Nam Co. It was proposed that air masses from South Asia cause high BC concentrations in the Nam Co region. It was, however, discovered that air masses from the TP itself also induce high BC concentrations, suggesting that not all the BC of Nam Co was transported from South Asia. Therefore, it is proposed that pollutants of atmospheric aerosols of the Nam Co region were derived from a variety of sources from both the TP and outside. In other words, the influence of yak dung burning by local residents on the atmosphere of the TP cannot be overlooked. Correspondingly, long-range transported pollutants can penetrate into the inland TP only when intensified pollution events occur in South Asia.

Keywords: *Aerosol; Black carbon; Water soluble elements; Organic carbon; The Tibetan Plateau.*

Sulfur isotope and chemical composition of the rainwater at the Three Gorges Reservoir

Qixin Wu , Guilin Han

Source: *Atmospheric Research 155 (2015) 130–140*

Rainwater samples were collected at the Three Gorges Reservoir (TGR) from June 2009 to July 2010 and the pH, major ion concentrations and δ34S values of sulfate were measured. The results indicated that the rain in this region was seriously acidized, 60% of the rain events' pH were lower than 5.0. SO4 2− and NO3 − were the main anions, and their volume weighted mean (VWM) values were 161.9 μeq/L and 65.2 μeq/L, respectively, which accounted for 71%–99% of the total measured anions. Ca2+ and NH4 + were the major cations with VWM values of 108.3 μeq/L and 88.4 μeq/L. Sum of Ca2+ and NH4 + accounted for 25%–94% of the total cations. Analysis of the seasonal variations of the pH showed that the rainwater was more acidized in summer than in the other seasons. Investigations of neutralization factors (NFs) indicated that the acidity of rainwater in winter and spring was neutralized by NH4 + and Ca2+. Studies of the origins of major ions showed that SO4 2− and NO3 − were from coal combustion and fossil fuels, and Na+ and Cl− were from sea sources, while Ca2+, Mg2+ and K+ were from the continental sources. The δ34S values of SO4 2− in rainwater ranged from −2.1‰ to 6.1‰ (mean value of 2.1‰). The δ34S values of SO4 2− in winter were much higher than those in other seasons. Analysis of the δ34S values vs. SO4 2− of rainwater combined with air mass trajectory showed that atmospheric sulfur at TGR was mainly associated with coal combustion and fossil fuels. The lower δ34S values in summer at TGR could be explained by higher contribution of biogenic sulfur.

Keywords: *Major ions; Sulfur isotope; Acid rain; Three Gorges Reservoir.*

PM2.5 chemical composition in five European Mediterranean cities: A 1-year study

Dalia Salameh , Anais Detournay , Jorge Pey , Noemi Pérez , Francesca Liguori , Dikaia Saraga , Maria Chiara Bove , Paolo Brotto , Federico Cassola , Dario Massabò , Aurelio Latella , Silvia Pillone , Gianni Formentone , Salvatore Patti , Alexandre Armengaud , Damien Piga , Jean Luc Jaffrezo , John Bartzis , Evangelos Tolis , Paolo Prati , Xavier Querol , Henri Wortham , Nicolas Marchand

Source: *Atmospheric Research 155 (2015) 102–117*

The seasonal and spatial characteristics of PM2.5 and its chemical composition in the Mediterranean Basin have been studied over a 1-year period (2011–2012) in five European Mediterranean cities: Barcelona

(BCN), Marseille (MRS), Genoa (GEN), Venice (VEN), and Thessaloniki (THE). During the year under study, PM10 annual mean concentration ranged from 23 to 46 μg m−3 , while the respective PM2.5 ranged from 14 to 37 μg m−3 , with the highest concentrations observed in THE and VEN. Both cities presented an elevated number of exceedances of the PM10 daily limit value, as 32% and 20% of the days exceeded 50 μg m−3 , respectively. Similarly, exceedances of the WHO guidelines for daily PM2.5 concentrations (25 μg m−3) were also more frequent in THE with 78% of the days during the period, followed by VEN with 39%. The lowest PM levels were measured in GEN. PM2.5 exhibited significant seasonal variability, with much higher winter concentrations for VEN and MRS, in fall for THE and in spring for BCN. PM2.5 chemical composition was markedly different even for similar PM2.5 levels. On annual average, PM2.5 was dominated by OM except in THE. OM contribution was higher in Marseille (42%), while mineral matter was the most abundant constituent in THE (32%). Moreover, PM2.5 relative mean composition during pollution episodes (PM2.5 N 25 μg m−3) as well as the origins of the exceedances were also investigated. Results outline mainly the effect of NO3 − being the most important driver and highlight the non-negligible impact of atmospheric mixing and aging processes during pollution episodes.

Keywords: *Mediterranean cities; Air quality; Aerosol composition; Pollution episodes; Biomass combustion; Long monitoring campaigns.*

Ground-based measurements of long-range transported aerosol at the rural regional background site of Monte Martano (Central Italy)

Beatrice Moroni , Silvia Castellini , Stefano Crocchianti , Andrea Piazzalunga , Paola Fermo , Francesco Scardazza , David Cappelletti

Source: *Atmospheric Research 155 (2015) 26–36*

Aerosol mass (PM10 and PM2.5) and chemical composition recorded in the 2009 at the rural background station of Monte Martano (MM, Central Italy) are presented in this work. The site, located at 1100 m (asl), features relatively low aerosol mass levels, due to the little influence of local anthropogenic pressure, and is influenced mainly by long-range transport phenomena. Chemical composition of PM10 and PM2.5 at MM is characterized by high levels of organic matter (OM), sulfates and nitrates, followed by crustal material, and ammonia. Sea Spray and elemental carbon (EC) accounted for a minor part of the total PM mass. The mass trends (PM10 and PM2.5) and chemical characteristics (OC, EC, major ions, trace elements) are compared with those of other similar sites in Europe and discussed in the framework of an extensive analysis of back trajectories (BT). As a result, three main advection routes to Central Italy (Northern Africa, West Mediterranean and Eastern Europe) have been individuated on the basis of the BT analysis and show significantly different PM2.5/PM10 and OC/EC ratios. Major ions and trace elements trends are also discussed within this framework, showing that annual averages are more influenced by long-range transport from Eastern Europe, which is the prevalent advection route to MM (and Central Italy) also according to BT analysis. Finally, the data collected allowed to estimate the impact of Saharan dust on PM10 which amounted to 22 μg m−3 per intrusion event (22 events). The impact on PM2.5 resulted in 11 μg m−3 per intrusion event.

Keywords: *Atmospheric aerosol; Long-range transport; Saharan dust; EC/OC.*

Study of carbonaceous species, morphology and sources of fine (PM2.5) and coarse (PM10) particles along with their climatic nature in India

Atar Singh Pipal, P. Gursumeeran Satsangi

Source: *Atmospheric Research 154 (2015) 103–115*

The determination of particulate matter (PM2.5 and PM10) is very important due to its impact on climate, visibility reduction and natural environment. In order to identify their nature and relationship with the major synoptic-scale circulation patterns, particles were collected from Pune atmosphere and were analyzed in terms of morphology, carbonaceous species (organic and elemental carbon) and elemental concentration. Average mass concentrations of PM2.5 and PM10 were 104.57 ± 25.70 μg m−3 and 169.91 ± 60.75 μg m−3 , respectively for the entire study period. This indicates that observed values of PM are substantially higher than NAAQS and WHO standards, respectively. The ratio between PM2.5 and PM10 was calculated and varied from 0.51 to 0.78 indicating abundance of fine particles over Pune during the study period. Carbonaceous analysis results showed that concentrations of OC and EC were 31.25 and 2.73 μg m−3 for PM2.5 while 33.14 and 2.40 μg m−3 for PM10, respectively. The calculated OC/EC ratios were 15.83 and 17.24 for PM2.5 and PM10, respectively indicating abundance of organic carbon which suggests the excess of secondary organic aerosols. The morphological traits such as circularity (b1) and aspect ratio (N1) were determined which indicate that the particles are not perfectly spherical and not elongated in any direction in both size ranges. Effective carbon ratio (ECR) an approach for climate was found to have an average value of 2.42 and 1.74 for PM2.5 and PM10. This clearly indicates that abundance of SOC and lower values of POC and EC could lead to the reduction in atmospheric warming effect due to combustion PM and increases scattering properties of incoming radiations. The monthly air mass backward trajectory cluster analysis was performed which supports the transport of aerosols from the long range transportation as well as the dominance of local sources over SW Indian region. The contribution of local sources was further determined which indicates that motor vehicle is the dominant emitter of carbonaceous aerosols in Pune.

Keywords: *Carbonaceous species; Morphology; SOC and POC ECR Sources; Climatic nature.*

Temporal variability of the visibility, particulate matter mass concentration and aerosol optical properties over an urban site in Northeast China

Hujia Zhao , Huizheng Che , Yanjun Ma , Xiangao Xia , Yangfeng Wang , Peng Wang , Xianchu Wu

Source: *Atmospheric Research 166 (2015) 204–212*

Visibility, particulate matter (PM) mass concentration, and aerosol optical properties data from June 2009 to December 2011 were obtained at Shenyang in Northeast China. The characteristics and relationships between these parameters were statistically analyzed. The results demonstrate that the monthly averaged visibility over Shenyang was higher in spring and autumn but lower in summer and winter, and had an inverse trend to PM and aerosol optical depth (AOD). Higher AOD at 500 nm was found year by year, with the maximum value (1.31 ± 0.45) occurring in June 2011, and the minimum in June 2010 (0.72 ± 0.31). The mean value of the Ångström exponent underwent a notable reduction during the period of 2011, with values less than 1.0 from February to September. The single scattering albedo was consistently around 0.90 during 2009–2011, which was higher in summer but lower in winter. The higher absorption aerosol optical depth at 440 nm in 2011 indicates that there were more absorbing aerosol particles in this period compared with the corresponding absorption Ångström exponent in the same year (about 0.75). The direct radiative forcing at the bottom of the atmosphere increased to −200 W/m2 in 2011, compared with −150 W/m2 from June 2009

to December 2010, suggesting a stronger cooling effect of aerosols at the surface. The positive radiative forcing at the top of the atmosphere in November and December 2009 could have been due to snow cover, which has a large surface albedo that reflects shortwave radiation to the atmosphere.

Keywords: *Visibility; Particulate matter; Aerosol optical properties; Direct radiative forcing; Shenyang.*

Uncertainties in anthropogenic aerosol concentrations and direct radiative forcing induced by emission inventories in eastern China

Wenyuan Chang , Hong Liao , Jinyuan Xin , Zhengqiang Li , Donghui Li , Xiaoye Zhang

Source: *Atmospheric Research 166 (2015) 129–140*

This study quantified the uncertainties in concentrations and direct radiative forcing of anthropogenic aerosols due to emissions in eastern China using a global chemistry–aerosol–climate model. The emission inventories included three global inventories, ACCMIP (Atmospheric Chemistry & Climate Model Intercomparison Project), EDGAR-HTAP (Emission Database for Global Atmospheric Research for Hemispheric Transport of Air Pollution), and EDGAR Version 4.2, and one regional INTEX-B (Intercontinental Chemical Transport Experiment—Phase B) inventory. The uncertainties (a percentage of the standard deviation divided by the mean value across the four inventories) in the regional surface-layer aerosol concentrations due to emissions were 3.9% in sulfate, 40.0% in nitrate, 18.4% in ammonium, 11.1% in POA, 16.7% in SOA and 15.4% in BC. Compared with the ACCMIP model results based on a uniform emission inventory, the impacts of emissions were smaller. One exception is the regional surface-layer nitrate concentration, which had comparable uncertainties due to the emissions (40.0%) and the models (43.8%) because of the complex nitrate chemistry and the highly uncertain NH3 emission. The mean regional aerosol direct forcing at the top of the atmosphere between 1850 and 2006 was −3.6 Wm−2 under all-sky conditions and was enhanced up to −3.83 Wm−2 after the model assimilated the MODIS findmode aerosol optical depth (AOD). The impact of the assimilation of absorption AOD is discussed. The uncertainties in aerosol direct forcing were smaller than those of the ACCMIP inter-model results, but still significant. An accurate emission inventory is essential for quantifying the role of aerosols in regional climate.

Keywords: *Emission uncertainty; Aerosol concentration; Direct radiative forcing; ACCMIP.*

Analysis of the spatio-temporal patterns of dry and wet conditions in the Huai River Basin using the standardized precipitation index

Yi He , Jinyin Ye , Xiaoying Yang

Source: *Atmospheric Research 166 (2015) 120–128*

Located in a transition zone between the northern and southern climates in China, the Huai River Basin is prone to extreme events such as drought and flood. Based on the daily precipitation data at 134 stations between 1961 and 2013, this paper analyzed the spatial and temporal patterns of the dry and wet conditions in the Huai River Basin through the statistical analysis of the rainfall stations' annual and seasonal standard precipitation index (SPI) series. Annual SPI series exhibited a decreasing trend at 86 stations and an increasing trend at the remaining stations. None of the increasing trend was significant, while the decreasing trend was significant at two stations at 5% significance level ($\alpha = 0.05$) and one station at 10% level.

Seasonal-wise, there has been a prevailing trend of drying in spring and autumn, and wetting in summer and winter. The trends in the spring and summer SPI series have been mostly insignificant, while those in autumn and winter, significant ($\alpha = 0.10$) at over 30 stations. The Pettitt test results indicated that the significant transitions ($\alpha = 0.10$) in the autumn and winter SPI series mostly occurred in the middle to late 1980s. Comparison of the average number of dry and wet years between the two sub-periods of 1961–1984 and 1990–2013 suggested a significant increase ($\alpha = 0.05$) in the average number of severely wet years across much of the basin. Overall, significant changes have already occurred in the dry and wet conditions of the Huai River Basin, which could have profound impacts on the food and water safety situation of the region.

Keywords: *Standard precipitation index; Trend analysis; Change point detection; Extreme event; Huai River Basin.*

Influence of operating conditions on chemical composition of particulate matter emissions from residential combustion

E.D. Vicente , M.A. Duarte , A.I. Calvo , T.F. Nunes , L.A.C. Tarelho , D. Custódio , C. Colombi , V. Gianelle , A. Sanchez de la Campa , C.A. Alves

Source: *Atmospheric Research 166 (2015) 92–100*

Wood combustion experiments were carried out in a Portuguese woodstove to determine the effects of biofuel type, ignition technique, biomass load and cleavage, as well as secondary air supply, on the chemical composition of particles (PM10). Two typical wood fuels in the Iberian Peninsula were tested: pine (Pinus pinaster), a softwood, and beech (Fagus sylvatica), a hardwood. PM10 samples were analysed for organic and elemental carbon (OC and EC), levoglucosan and 56 elements. Total carbon (TC) represented 54–73 wt.% of the particulate mass emitted during the combustion process, regardless of wood species burned or operating condition tested. The carbonaceous component of PM10 was dominated by OC. The OC content of PM10 was higher when higher loads were fed into the combustion chamber, for both fuels. EC represented from 8 to 35 wt.% of the particulate mass. OC/EC ranged from 1.1 to 6.1 (avg. 3.0 ± 1.8) for pine combustion and from 1.1 to 3.4 (avg. 2.0 ± 0.8) for beech combustion. The lowest OC/EC ratios for both woods were observed for ignition from the top. Levoglucosan was found in all samples, representing from 3.7 to 7.5 wt.% and from 4.2 to 8.9 wt.% of PM10 emitted from the combustion of pine and beech, respectively. The use of low loads of fuel generated high amounts of levoglucosan either for pine or beech. Altogether, trace elements obtained by ICP-MS and ICP-AES comprised from 0.46 wt.% to 1.41 wt.% and from 0.87 wt.% to 2.36 wt.% of the PM10 mass for pine and beech combustion, respectively. Among elements, K, Ca, Na, Mg, Fe and Al contributed to more than 75% of the total ICP-MS mass. Potassium was the major element in almost all PM10 samples.

Keywords: *Residential combustion; Operating conditions; PM10; OC/EC; Levoglucosan; Trace elements.*

The effect of absorbing aerosols on Indian monsoon circulation and rainfall: A review

S.D. Sanap, G. Pandithurai

Source: *Atmospheric Research 164–165 (2015) 318–327*

Aerosol, an uncertain component of the climate system, has attracted wide attention among the researchers due to its role in hydrological cycle and radiation budget in a changing climate. According to IPCC 5th

assessment report, current understanding of aerosol–cloud–precipitation interaction is low to moderate, as a result they are not well represented in the climate models, and in turn are recognized as major uncertainties in the future climate projections. In South Asian monsoon regions, the aerosol forcing response to water cycle is even more complicated. Substantial amount of transported dust from Middle East countries and adjacent deserts get accumulated over Indian subcontinent (mainly North India and Indo Gangetic Plains; IGP) and further coated with black carbon (BC) produced from local emission, which make the atmospheric physics and chemistry of the aerosol more complex over the region. Here we review earlier studies and recapitulate our current understanding of absorbing aerosols on Indian monsoon circulation and rainfall from observational evidences and variety of numerical model simulations. This review begins with current understanding of the absorbing aerosols and interactions with Indian summer monsoon, followed by discussion on various working hypotheses, observational and modeling perspective, local and remote impacts. The key open questions and suggestions for future research priorities are delineated to improve the current understanding about the relationship between absorbing aerosols and Indian summer monsoon.

Keywords: *Indian summer monsoon; Aerosol and climate; Aerosol observations and modelling; Climatic effects of aerosols.*

Characteristics of 14C and 13C of carbonate aerosols in dust storm events in China

Bing Chen , Dongmei Jie , Meinan Shi , Pan Gao , Zhenxing Shen , Masao Uchida , Liping Zhou , Kexin Liu , Ke Hu , Hiroyuki Kitagawa

Source: *Atmospheric Research 164–165 (2015) 297–303*

In contrast with its decrease in western China deserts, the dust storm event in eastern China, Korea, and Japan shows an increase in frequency. Although the drylands in northeastern China have been recognized as an important dust source, the relative contributions of dust transport from the drylands and deserts are inconclusive, thus the quantification of dust storm sources in downwind area remains a challenge. We measured the 14C and 13C contents in carbonates of dust samples from six sites in China, which were collected for the duration of dust storm events in drylands, deserts, and urban areas. The δ13C of the dryland dust samples considerably varied in a range of −9.7 to −5.0‰, which partly overlapped the desert dust carbonate δ13C ranges. The 14C content of the dryland dust carbonates showed a narrow range of 60.9 ± 4.0 (as an average and 1 SD of five samples) percent modern carbon (pMC), indicating the enrichment of modern carbonate. Dust samples in desert regions contained relatively aged carbonates with the depleting 14C showing of 28.8 ± 3.3 pMC. After the long-range transport of the western China desert dust plume, the carbonates collected at the southern China remained the depletion of 14C (33.5 ± 5.3 pMC) as in the desert regions. On the other hand, the samples of dust storm events at the urban areas of eastern China showed an enrichment of 14C contents (46.2 ± 5.0 pMC, n = 7), which might be explained by the stronger contribution of modern-carbonate-rich dryland dust.

Keywords: *Carbonate aerosols; 14C; Source tracer; Asian dust storm.*

Impacts of mountains on black carbon aerosol under different synoptic meteorology conditions in the Guanzhong region, China

Shuyu Zhao , Xuexi Tie , Junji Cao , Qiang Zhang

Source: *Atmospheric Research 164–165 (2015) 286–296*

The Xi'an City and the surrounding area (the Guan-Zhong—GZ region) in western China have been suffering severe air pollutions during wintertime in recent years. In-situ black carbon (BC) measurement combined with a regional dynamical and chemical model (WRF-Chem model) is used to investigate the formation of a haze episode occurred from Jan. 3rd to Jan. 13th 2013. The results show that the measured BC concentrations exhibit a large day-to-day variability. The impacts of synoptic weather systems, local meteorological parameters and mountain effect on the BC variability are studied. Because the GZ region is surrounded by two major mountains, the Loess Plateau in the north and the Qinling Mountains in the south, especially the peak of the Qinling Mountains higher than 3000 m, we particularly analyze the effects of the Qinling Mountains on the BC pollution. The analysis shows that the BC pollution in Xi'an City and the GZ region is strongly affected by the synoptic weather systems, local meteorological winds and the Qinling Mountains. Under a typical northeast wind condition, winds are blocked by the Qinling Mountains, and BC particles are trapped at the foothill of the mountains, resulting in high BC concentrations in the city of Xi'an. Under a typical east wind condition, BC particles are transported along a river valley and the foothill of the Qinling Mountains. In this case, the mountain-river valley plays a role to accelerate the east wind, resulting in a reduction of the BC pollution. Under a typical calm wind condition, the BC particles are less diffused from their source region, and there is a mountain breeze from the Qinling Mountains to the city of Xi'an, and BC particles accumulate in the city, especially in the north side of the city. This study illustrates that while locating between complicated terrain conditions, such as the GZ region, the mountains play very important roles for the formation of hazes in the region.

Keywords: *Black carbon; Winds; PBL height; Mountain breeze; WRF-Chem.*

Chemical composition of rainwater and the acid neutralizing effect at Beijing and Chizhou city, China

Zhifang Xu , Yao Wu , Wen-Jing Liu , Chong-Shan Liang , Jianpeng Ji , Tong Zhao , Xuan Zhang

Source: *Atmospheric Research 164–165 (2015) 278–285*

The chemical compositions were measured in rainwater samples collected during 2011–2012 from two representative cities, Beijing in north China and Chizhou city in south China. The rainwater was highly acidic with a volume-weighted mean (VWM) pH of 4.56, ranging from 3.77 to 5.67, and about 94% of the samples had pH below 5.0 in Chizhou. The pH values of rainwater in Beijing ranged from 3.78 to 6.62, with a VWM value of 4.85. The predominant ions in the precipitation were SO4 2−, Ca2+ and NH4 + at both sites. The VWM concentrations of ions in rainwater were higher in Beijing, and the SO4 2− concentration of rainwater in Beijing was about twice that in Chizhou. However, due to the weaker neutralization of acidity, the rainwater from Chizhou had relatively low pH values. According to the results of linear regression analysis, the percentage of the potential acidity counteracted by Ca2+ and NH4 + was higher in rainwater in Beijing (90.7%) than that in Chizhou (70.8%). Using Na as an indicator of marine origin, and Al for the terrestrial inputs, the proportions of sea salt and terrestrial elements were estimated from elemental ratios. More than 98% of SO4 2− and Ca2+ in rainwater samples are non-sea-salt origin at both sites. Coal combustion may be the main source of SO4 2−, and local and remote soil dust may be an important source of

Ca2+ in Beijing rainwater. The high concentrations of alkaline ions (Ca2+ and NH4 +) have played an important role to neutralize the acidity of rainwater in Beijing

Keywords: *Rainwater; Chemical composition; Beijing; Chizhou; Neutralization.*

Identification of aerosol types over an urban site based on air-mass trajectory classification

G.V. Pawar , P.C.S. Devara , G.R. Aher

Source: *Atmospheric Research 164–165 (2015) 142–155*

Columnar aerosol properties retrieved from MICROTOPS II Sun Photometer measurements during 2010–2013 over Pune (18°32′N; 73°49′E, 559 m amsl), a tropical urban station in India, are analyzed to identify aerosol types in the atmospheric column. Identification/classification is carried out on the basis of dominant airflow patterns, and the method of discrimination of aerosol types on the basis of relation between aerosol optical depth (AOD500 nm) and Ångström exponent (AE, α). Five potential advection pathways viz., NW/N, SW/S, N, SE/E and L have been identified over the observing site by employing the NOAA-HYSPLIT air mass back trajectory analysis. Based on AE against AOD500 nm scatter plot and advection pathways followed five major aerosol types viz., continental average (CA), marine continental average (MCA), urban/industrial and biomass burning (UB), desert dust (DD) and indeterminate or mixed type (MT) have been identified. In winter, sector SE/E, a representative of air masses traversed over Bay of Bengal and Eastern continental Indian region has relatively small AOD ($\tau p\lambda = 0.43 \pm 0.13$) and high AE ($\alpha = 1.19 \pm 0.15$). These values imply the presence of accumulation/submicron size anthropogenic aerosols. During pre-monsoon, aerosols from the NW/N sector have high AOD ($\tau p\lambda = 0.61 \pm 0.21$), and low AE ($\alpha = 0.54 \pm 0.14$) indicating an increase in the loading of coarse-mode particles over Pune. Dominance of UB type in winter season for all the years (i.e. 2010–2013) may be attributed to both local/transported aerosols. During pre-monsoon seasons, MT is the dominant aerosol type followed by UB and DD, while the background aerosols are insignificant.

Keywords: *AOD; Ångström exponent; Long range transport; Air-mass; Aerosol types.*

Ground-level ozone in urban Beijing over a 1-year period: Temporal variations and relationship to atmospheric oxidation

Zhanshan Wang , Yunting Li , Tian Chen , Dawei Zhang , Feng Sun , Qiang Wei , Xin Dong , Ruiwen Sun , Ning Huan , Libo Pan

Source: *Atmospheric Research 164–165 (2015) 110–117*

Regional ozone pollution has become a major environmental concern in China, especially in densely populated and economically vibrant regions such as North China, including Beijing. To address this issue, surface ozone and its precursors (CO, NO, and NO2) from December 2012 to November 2013 at 12 sites in urban Beijing and 2 sites in suburban Beijing were analyzed. The annual average concentrations of O3, CO, NO, and NO2 in urban Beijing were 45.5 ± 50.2 μg m−3 , 1.5 ± 1.3 mg m−3 , 27.3 ± 42.7 μg m−3 , and 58.3 + 32.0 μg m−3 , respectively. The concentration of ozone was highest during summer, whereas concentrations of its precursors were highest during winter. Diurnal variations in ozone presented as a single-peak curve, with the peak appearing at about 15:00–16:00. Diurnal variations in most ozone precursors

showed bimodal curves; the first peak appeared at about 08:00–09:00, and the second peak appeared at night. Hourly concentrations of ozone on the weekend were higher than those on weekdays between 11:00 and 24:00 in urban Beijing, which was suggestive of a significant weekend effect. This may be because NO inhibition on the weekend is weaker than that on weekdays during the ozone formation phase. Diurnal variations in OX (NO2 + O3) showed a single peak, which appeared at 15:00 or 16:00. The results of correlation analysis among OX, O3, and NO2 suggested that OX was mainly controlled by O3 during the day and by NO2 during the night throughout the year. OX was controlled by NO2 during both the day and night during winter due to the low concentration of O3. The regional transport of ozone along the upwind direction was found in a typical ozone pollution event in summer in Beijing.

Keywords: *Ozone; Beijing; Temporal variations; Regional transport; Weekend effect; Atmospheric oxidation.*

Chemical characteristics of submicron particulates (PM1.0) in Wuhan, Central China

Xiao-Pu Lyu , Zu-Wu Wang , Hai-Rong Cheng , Fan Zhang , Gan Zhang , Xin-Ming Wang , Zheng-Hao Ling , Nan Wang

Source: *Atmospheric Research 161–162 (2015) 169–178*

Submicron particulate matter (PM1.0) samples were collected at a suburban site in Wuhan from Sept., 2012 to Aug., 2013. Concentration, composition, potential sources and acidity of the PM1.0 were investigated. The results indicated that the annual average concentration of PM1.0 was 81.7 μg/m3 , with the highest and lowest values occurring in winter and summer, respectively. Inorganic water soluble ions constituted 48.9% of the PM1.0, and dominated by secondary species in the form of NH4NO3 and NH4HSO4. The high concentration of Pb (128.4 ng/ m3) and greatly enriched Pb, Cd and Se in PM1.0 indicated contribution of coal combustion to PM1.0. Ratios of SO4 2−/NO3 − (1.3) and Cl−/Na+ (2.7) revealed the dominant stationary emissions, further confirming the coal combustion source in Wuhan. According to the chemical and meteorological analyses, biomass burning and stagnant weather were proposed to be the main causes to the haze episodes in autumn and winter, respectively.

Keywords: *PM1.0; Water soluble inorganic ions; Secondary aerosol; Source identification; Enrichment factor; Haze.*

Atmospheric aerosols and their impact on surface solar irradiation in Kerkennah Islands (eastern Tunisia)

A. Trabelsi , M. Saad , M. Masmoudi , S.C. Alfaro

Source: *Atmospheric Research 161–162 (2015) 102–107*

In order to assess the impact of the atmospheric particle load on the characteristics of the surface solar irradiation in Central Tunisia, four measurement campaigns have been carried out in periods selected in each season of 2010/2011 on the Kerkennah Islands. During each of these periods, the direct normal and global horizontal components of solar irradiation were measured, which allows determination of the atmospheric turbidity (Linke turbidity factor, TL, and Angström exponent, β) and of the diffuse fraction (DF) of the irradiation. In parallel, surface aerosols were sampled on filters and subsequently submitted to X-ray

fluorescence (XRF) analysis for determination of their elemental composition and apportionment between the mineral dust (MD), sea salt (SS), and non sea salt sulfate (nSS) species. A significant positive correlation is found between the total aerosol concentration and both TL and DF, which indicates that over the measurement period surface aerosol is representative of the columnar particulate content of the atmosphere. A least square iterative routine used to separate the effects of each aerosol type shows that if on average MD, SS, and nSS explain 4, 19 and 12%, respectively, of the TL values, the increase of the MD concentrations during short-duration dust event is responsible for the largest observed values (TL = 6 on 15 April 2010). Similarly, if on average only about 9% of the global horizontal surface irradiation can be ascribed to aerosols, during the aforementioned dust event this share reaches 28%, 19% of which are due to mineral dust.

Keywords: *Central; Tunisia; Aerosols; Mineral dust; Surface solar irradiation; Linke; turbidity factor; Diffuse; fraction.*

The optical properties of urban aerosol in northern China: A case study at Xi'an

Chong-Shu Zhu , Jun-Ji Cao , Kin-Fai Ho , L.-W. Antony Chen , Ru-Jin Huang , Yi-Chen Wang , Hua Li , Zhen-Xing Shen , Judith C. Chow , John G. Watson , Xiao-li Su , Qi-yuan Wang , Shun Xiao

Source: *Atmospheric Research 160 (2015) 59–67*

Simultaneous measurements of particle scattering coefficient (Bscat) and absorption coefficient (Babs) were conducted at Xi'an from mid-August to mid-October 2012 to estimate the particle single scattering albedo (SSA) and the Ångström coefficients in highly polluted urban air. The hourly averaged Bscat was 272 Mm−1 at 532 nm and 82 Mm−1 at 870 nm, while hourly averaged Babs was 31 Mm−1 at 532 nm and 19 Mm−1 at 870 nm. Similar diurnal variations for Bscat and Babs were observed between the two wavelengths. The averaged SSA was 0.88 at 532 nm and 0.78 at 870 nm. Based on the Ångström coefficients, anthropogenic fine particles show dominant contribution during the sampling period, accompanied by occasional dust events. Moreover, the major contributors to aerosol optical properties are attributed to the mixture of black carbon (BC) and brown carbon (BrC) with non-absorbing components over urban area in northern China. The findings provide useful insights into the factors affecting the visibility in northern Chinese cities and therefore essential knowledge for improving the air quality.

Keywords: *PAX; SSA; Scattering coefficient; Absorption coefficient; Xi'an.*

Assessment of different raindrop size measuring techniques: Inter-comparison of Doppler radar, impact and optical disdrometer

Thumree Sarkar, Saurabh Das, Animesh Maitra

Source: *Atmospheric Research 160 (2015) 15–27*

The performances of three instruments namely, Joss–Waldvogel disdrometer, laser precipitation monitor and micro rain radar, are assessed in terms of their ability to measure rain related parameters and to better understand the dependency of measured parameters on the working principles of the instruments. Twenty one rain events of year 2013 pertaining to South-West monsoon are considered for this study. The raindrop size distributions measured by the three instruments show good agreement only for medium sized (1–3 mm) raindrops and for medium rain rates (up to 30 mm/h). However, the mutual agreements are not very good in

case of large (N5 mm) and very small raindrops (b0.5 mm) as well as for very high rain rates (N30 mm/h) and very high radar reflectivity factor (N40 dB). The radar reflectivity–rain rate relation is also studied using linear regression method which shows distinct differences for these instruments, indicating the high sensitivity of Z–R relation on the instrumental measuring principle.

Keywords: *Drop size distribution; Joss–Waldvogel disdrometer; Micro rain radar; Laser precipitation monitor; Z–R relation.*

Chemical characterization, the transport pathways and potential sources of PM2.5 in Shanghai: Seasonal variations

Mengfei Zhao , Zhongsi Huang , Ting Qiao , Yuankai Zhang , Guangli Xiu , Jianzhen Yu

Source: *Atmospheric Research 158–159 (2015) 66–78*

The 24-h PM2.5 samples were collected at the site of East China University of Science and Technology (ECUST) in Shanghai from 2011 to 2012, representing winter, spring, summer and autumn, respectively. And PM2.5 and its chemical components including organic carbon (OC), elemental carbon (EC), water-soluble organic carbon (WSOC), humic-like substance carbon (HULIS-C) and water-soluble ions were analyzed. The results suggested that the average PM2.5 concentrations were (70.35 ± 43.75) μg/m3 , (69.76 ± 38.67) μg/m3 , (51.26 ± 28.25) μg/m3 and (82.37 ± 48.70) μg/m3 in winter, spring, summer and autumn, respectively. Secondary inorganic ions (sulfate, nitrate and ammonium) were the dominant pollutants of PM2.5 in the four seasons. Total carbon (TC) was an important component explaining above 15% of PM2.5. OC/EC ratios were all above 2 ranging from 4.31 to 6.35; particularly in winter it reached the highest 6.35 which demonstrated that secondary organic carbon (SOC) should be a significant composition of PM2.5. The SOC calculated based on the OC/EC ratio method had stronger correlation with WSOC in summer and autumn (summer: R2 = 0.73 and autumn: R2 = 0.75). The HULIS-C and SOC most significantly correlated in autumn (R2 = 0.83). The data showed that PM2.5 atmospheric aerosols were more acidic in autumn and the concentrations of PM2.5 and its chemical components were much higher. Factor analysis (FA), cluster analysis of air mass back trajectories, potential source contribution function (PSCF) model and concentration weighted trajectory (CWT) model were used to investigate the transport pathways and identify potential source areas of PM2.5 in different seasons. FA identified various sources of PM2.5: secondary aerosol reactions, the aged sea salts and road dusts. The results of cluster analysis, PSCF model and CWT model demonstrated that the local sources in the Yangtze River Delta Region (YRDR) made significant contributions to PM2.5. During winter and autumn long-time transport from the Circum-Bohai-Sea Region (CBSR) and northwestern China including the Inner Mongol had adverse effects.

Keywords: *Carbonaceous components; Humic-like substance carbon (HULIS-C); Acidity Factor analysis (FA); Potential source contribution function (PSCF); Concentration weighted trajectory (CWT).*

SECTION-V
Environmental Science and Pollution Research

Health risk and significance of mercury in the environment

W. C. Li, H. F. Tse

Source: *Environmental Science and Pollution Research, January 2015, Volume 22, Issue 1, pp 192-201, DOI 10.1007/s11356-014-3544-x*

Mercury (Hg) has long been recognised as a global pollutant, because it can remain in the atmosphere for more than 1 year. The mercury that enters the environment is generally acknowledged to have two sources: natural and anthropogenic. Hg takes three major forms in the environment, namely methyl-Hg (MeHg), Hg0 and Hg2+. All three forms of Hg adversely affect the natural environment and pose a risk to human health. In particular, they may damage the human central nervous system, leading to cardiovascular, respiratory and other diseases. MeHg is bioavailable and can be bioaccumulated within food webs. Therefore, several methods of eliminating Hg from the soil and the aquatic system have been proposed. The focus of this article is on phytoremediation, as this technique provides a low-cost and environmentally friendly alternative to traditional methods.

Keywords: *Toxicity; Methylmercury; Remediation; Biogeochemical cycle.*

Association between particulate matter and its chemical constituents of urban air pollution and daily mortality or morbidity in Beijing City

Pei Li, Jinyuan Xin , Yuesi Wang, Guoxing Li, Xiaochuan Pan, Shigong Wang, Mengtian Cheng, Tianxue Wen, Guangcheng Wang, Zirui

Source: *Environmental Science and Pollution Research, January 2015, Volume 22, Issue 1, pp 358-368, DOI 10.1007/s11356-014-3301-1*

Recent time series studies have indicated that daily mortality and morbidity are associated with particulate matters. However, about the relative effects and its seasonal patterns of fine particulate matter constituents is particularly limited in developing Asian countries. In this study, we examined the role of particulate matters and its key chemical components of fine particles on both mortality and morbidity in Beijing. We applied several overdispersed Poisson generalized nonlinear models, adjusting for time, day of week, holiday, temperature, and relative humidity, to investigate the association between risk of mortality or morbidity and particulate matters and its constituents in Beijing, China, for January 2005 through December 2009. Particles and several constituents were associated with multiple mortality or morbidity categories, especially on respiratory health. For a 3-day lag, the nonaccident mortality increased by 1.52, 0.19, 1.03, 0.56, 0.42, and 0.32 % for particulate matter (PM)2.5, PM10, K+, SO4 2−, Ca2+, and NO3 − based on interquartile ranges of 36.00, 64.00, 0.41, 8.75, 1.43, and 2.24 μg/m3, respectively. The estimates of short-term effects for PM2.5 and its components in the cold season were 1 ~ 6 times higher than that in the full year on these health outcomes. Most of components had stronger adverse effects on human health in the heavy PM2.5 mass concentrations, especially for K+, NO3 −, and SO4 2−. This analysis added to the growing body of evidence linking PM2.5 with mortality or morbidity and indicated that excess risks may vary among specific PM2.5 components. Combustion-related products, traffic sources, vegetative burning, and crustal component and resuspended road dust may play a key role in the associations between air pollution and public health in Beijing.

Keywords: *Air pollution; Chemical constituents; Mortality; Morbidity; Particulate matter; PM2.5; Time series; Beijing.*

Aerosol optical properties under the condition of heavy haze over an urban site of Beijing, China

Huizheng Che , Xiangao Xia, Jun Zhu, Hong Wang, Yaqiang Wang, Junying Sun, Xiaoye Zhang, Guangyu Shi

Source: *Environmental Science and Pollution Research, January 2015, Volume 22, Issue 2, pp 1043-1053, DOI 10.1007/s11356-014-3415-5*

In January 2013, several serious haze pollution events happened in North China. Cimel sunphotometer measurements at an urban site of Beijing (Chinese Academy of Meteorological Sciences—CAMS) from 1 to 30 January 2013 were used to investigate the detailed variation of aerosol optical properties. It was found that Angstrom exponents were mostly larger than 0.80 when aerosol optical depth values are higher than 0.60 at the urban region of Beijing during January 2013. The aerosol optical depth (AOD) at the urban region of Beijing can remain steady at approximately 0.40 before haze happening and then increased sharply to more than 1.50 at 500 nm with the onset of haze, which suggests that the fine-mode AOD is a factor of 20 of the coarse-mode AOD during a serious haze pollution event. The single scattering albedo was approximately 0.90 ± 0.03 at 440, 675, 870 and 1,020 nm during the haze pollution period. The single scattering albedo at 440 nm as a function of the fine-mode fraction was relatively consistent, but it was highly variable at 675, 870 and 1,020 nm. Except on January 12 and 18, all the fine-mode particle volumes were larger than those of coarse particles, which suggests that fine particles from anthropogenic activities made up most of the haze. Aerosol type classification analysis showed that the dominant aerosol types can be classified as both "mixed" and "urban/industrial (U/I) and biomass burning (BB)" categories during the heavy haze period of Beijing in January of 2013. The mixed category occurrence was about 31 %, while the U/I and BB was about 69 %.

Keywords: *Aerosol optical property; Haze; Beijing; China.*

The association between air pollutants and morbidity for diabetes and liver diseases modified by sexes, ages, and seasons in Tianjin, China

Ling Tong, Kai Li, Qixing Zhou

Source: *Environmental Science and Pollution Research, January 2015, Volume 22, Issue 2, pp 1215-1219, DOI 10.1007/s11356-014-3432-4*

With the generalized linear model and natural splines (ns), we examined the association between outdoor air pollutants and daily morbidity for diabetes and liver disease stratified by sexes and ages based on 4 years of daily data (2008–2011) in Tianjin, China. Season effects of air pollutants including particulate matter (PM), sulfur dioxide (SO2), and nitrogen dioxide (NO2) were also investigated. An increase of 10 μg/m3 in a 2-day average concentrations of particulate matter with diameters of 10 μm or less (PM10), SO2, and NO2 corresponds to increases in diabetes morbidity of 0.39 % (95 % confidence interval (CI), −0.42–1.12), 0.15 % (95 % CI, −0.25–0.54), and 1.22 % (95 % CI, 0.51–2.96), respectively. As for liver morbidity, the increases were −0.84 % (95 % CI, −2.33–0.62), 0.90 % (95 % CI, 0.50–1.74), and 1.10 % (95 % CI, −2.58–4.78), respectively. The effects were stronger in the cool season than those in the warm season; females and

the elderly were generally more vulnerable to outdoor air pollution. This study possesses scientific implications and instructional significance for local environmental standards and medical policymaking.

Keywords: *Air pollution; Particulate matter (PM); Diabetes; Liver disease; Morbidity; Time-series studies.*

Molecular markers in ambient aerosol in the Mahanadi Riverside Basin of eastern central India during winter

Jayant Nirmalkar, Manas K. Deb, Dhananjay K., Ying I. Tsai , Santosh K. Verma

Source: *Environmental Science and Pollution Research, January 2015, Volume 22, Issue 2, pp 1220-1231, DOI 10.1007/s11356-014-3416-4*

Organic molecular markers are important atmospheric constituents. Their formation and sources are important aspects of the study of urban and rural air quality. We collected PM10 aerosol samples from the Mahanadi Riverside Basin (MRB), a rural part of eastern central India, during the winter of 2011. PM10 aerosols were characterized for molecular markers using ion chromatography. The concentration of PM10 ranged from 208.8 to 588.3 μg m−3 with a mean concentration of 388.9 μg m−3. Total concentration of anhydrosugars, sugar alcohols, primary sugars, and oxalate were found to be 3.25, 5.60, 10.52, and 0.37 μg m−3, respectively, during the study period. Glucose was the most abundant species followed by levoglucosan and mannitol. Significant positive correlation between the molecular markers, anhydrosugars, sugar alcohols, primary sugars, and oxalic acid confirmed that biomass burning, biogenic activity, and re-suspension of soil particles were the main sources of aerosol in the eastern central India study area.

Keywords: *Biomass burning; Anhydrosugars Sugars; Oxalic acid;Temporal variation; Correlation analysis.*

Particulate matter mass and chemical component concentrations over four Chinese cities along the western Pacific coast

Hong Xu, Xiao-Hui Bi , Wei-Wei Zheng, Jian-Hui Wu, Yin-Chang Feng

Source: *Environmental Science and Pollution Research, February 2015, Volume 22, Issue 3, pp 1940-1953, DOI 10.1007/s11356-014-3630-0*

China has witnessed rapid economic growth in the past three decades, especially in coastal areas. Particulate matter (PM) pollution is becoming increasingly serious in China's cities along the western Pacific coast with the rapid development of China's society and economy. This study analyzed PM (PM10 and PM2.5) in terms of their mass and chemical composition in four coastal Chinese cities. The goal was to study the spatial variation and characteristics of PM pollution in sites under different levels of economic development and in diverse natural environments. A distinct trend for concentrations of PM and related chemical species was observed and increased from south to north in Haikou, Ningbo, Qingdao, and Tianjin. Secondary inorganic aerosols, crustal materials, and organic matter dominated the composition of both PM10 and PM2.5. Crustal materials were the most abundant species in the northern coastal areas because these areas have less vegetation cover and lower humidity than southern coastal areas. The presence of high SO4 2−/nitrate (NO3 −) concentrations indicated that the burning of coals gives significant contributions to PM10 and PM2.5. The differences observed in the characteristics of PM pollution in these coastal cities are probably caused by different levels of industrial and urban development.

Keywords: *Chemical characteristics; Coastal area; Mass balance; Particulate matter.*

The impact of a pulsing groundwater table on greenhouse gas emissions in riparian grey alder stands

Ülo Mander, Martin Maddison, Kaido Soosaar, Alar Teemusk, Arno Kanal, Veiko Uri, Jaak Truu

Source: *Environmental Science and Pollution Research, February 2015, Volume 22, Issue 4, pp 2360-2371, DOI 10.1007/s11356-014-3427-1*

Floods control greenhouse gas (GHG) emissions in floodplains; however, there is a lack of data on the impact of short-term events on emissions. We studied the short-term effect of changing groundwater (GW) depth on the emission of (GHG) carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O) in two riparian grey alder (Alnus incana) stands of different age in Kambja, southern Estonia, using the opaque static chamber (five replicates in each site) and gas chromatography methods. The average carbon and total nitrogen content in the soil of the old alder (OA) stand was significantly higher than in the young alder (YA) stand. In both stands, one part was chosen for water table manipulation (Manip) and another remained unchanged with a stable and deeper GW table. Groundwater table manipulation (flooding) significantly increases CH4 emission (average: YA-Dry 468, YA-Manip 8,374, OA-Dry 468, OA-Manip 4,187 μg C m−2 h−1) and decreases both CO2 (average: OA-Dry 138, OA-Manip 80 mg C m−2 h−1) and N2O emissions (average: OA-Dry 23.1, OA-Manip 11.8 μg N m−2 h−1) in OA sites. There was no significant difference in CO2 and CH4 emissions between the OA and YA sites, whereas in OA sites with higher N concentration in the soil, the N2O emission was significantly higher than at the YA sites. The relative CO2 and CH4 emissions (the soil C stock-related share of gaseous losses) were higher in manipulated plots showing the highest values in the YA-Manip plot (0.03 and 0.0030 % C day−1, respectively). The soil N stock-related N2O emission was very low achieving 0.000019 % N day−1 in the OA-Dry plot. Methane emission shows a negative correlation with GW, whereas the 20 cm depth is a significant limit below which most of the produced CH4 is oxidized. In terms of CO2 and N2O, the deeper GW table significantly increases emission. In riparian zones of headwater streams, the short-term floods (e.g. those driven by extreme climate events) may significantly enhance methane emission whereas the long-term lowering of the groundwater table is a more important initiator of N2O fluxes from riparian gley soils than flood pulses.

Keywords: *Alnus incana; Carbon dioxide; Denitrification; Flooding; Gley soils; Groundwater depth; Methane; Nitrous oxide.*

Effects of ambient and elevated CO2 on growth, chlorophyll fluorescence, photosynthetic pigments, antioxidants, and secondary metabolites of Catharanthus roseus (L.) G Don. grown under three different soil N levels

Aradhana Singh, Madhoolika Agrawal

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Catharanthus roseus L. plants were grown under ambient (375 ± 30 ppm) and elevated (560 ± 25 ppm) concentrations of atmospheric CO2 at different rates of N supply (without supplemental N, 0 kg N ha−1; recommended N, 50 kg N ha−1; and double recommended N, 100 kg N ha−1) in open top chambers under

field condition. Elevated CO2 significantly increased photosynthetic pigments, photosynthetic efficiency, and organic carbon content in leaves at recommended (RN) and double recommended N (DRN), while significantly decreased total nitrogen content in without supplemental N (WSN). Activities of superoxide dismutase, catalase, and ascorbate peroxidase were declined, while glutathione reductase, peroxidase, and phenylalanine-ammonia lyase were stimulated under elevated CO2. However, the responses of the above enzymes were modified with different rates of N supply. Elevated CO2 significantly reduced superoxide production rate, hydrogen peroxide, and malondialdehyde contents in RN and DRN. Compared with ambient, total alkaloids content increased maximally at recommended level of N, while total phenolics in WSN under elevated CO2. Elevated CO2 stimulated growth of plants by increasing plant height and numbers of branches and leaves, and the magnitude of increment were maximum in DRN. The study suggests that elevated CO2 has positively affected plants by increasing growth and alkaloids production and reducing the level of oxidative stress. However, the positive effects of elevated CO2 were comparatively lesser in plants grown under limited N availability than in moderate and higher N availability. Furthermore, the excess N supply in DRN has stimulated the growth but not the alkaloids production under elevated CO2.

Keywords: *Elevated carbon dioxide; Nitrogen Oxidative stress; Growth Alkaloids.*

Distribution, mobility, and pollution assessment of Cd, Cu, Ni, Pb, Zn, and Fe in intertidal surface sediments of Sg. Puloh mangrove estuary, Malaysia

Bede Emeka Udechukwu , Ahmad Ismail, Syaizwan Zahmir Zulkifli, Hishamuddin Omar

Source: *Environmental Science and Pollution Research, March 2015, Volume 22, Issue 6, pp 4242-4255, DOI 10.1007/s11356-014-3663-4*

Sungai Puloh mangrove estuary supports a large diversity of macrobenthic organisms and provides social benefits to the local community. Recently, it became a major recipient of heavy metals originating from industries in the hinterland as a result of industrialization and urbanization. This study was conducted to evaluate mobility and pollution status of heavy metals (Cd, Cu, Ni, Pb, Zn, and Fe) in intertidal surface sediments of this area. Surface sediment samples were collected based on four different anthropogenic sources. Metals concentrations were analyzed using an atomic absorption spectrophotometer (AAS). Results revealed that the mean concentrations were Zn (1023.68 ± 762.93 μg/g), Pb (78.8 ± 49.61 μg/g), Cu (46.89 ± 43.79 μg/g), Ni (35.54 ± 10.75 μg/g), Cd (0.94 ± 0.29 μg/g), and Fe (7.14 ± 0.94 %). Most of the mean values of analyzed metals were below both the interim sediment quality guidelines (ISQG-low and ISQG-high), except for Pb concentration (above ISQG-low) and Zn concentration (above ISQG-high), thus suggesting that Pb and Zn may pose some environmental concern. Cadmium, Pb, and Zn concentrations were above the threshold effect level (TEL), indicating seldom adverse effect of these metals on macrobenthic organisms. Pollution load index (PLI) indicated deterioration and other indices revealed the intertidal surface sediment is moderately polluted with Cd, Pb, and Zn. Therefore, this mangrove area requires urgent attention to mitigate further contamination. Finally, this study will contribute to data sources for Malaysia in establishing her own ISQG since it is a baseline study with detailed contamination assessment indices for surface sediment of intertidal mangrove area.

Keywords: *Heavy metals; Pollution assessment; Enrichment factor; Contamination factor; Sediment quality guidelines; Sungai; Puloh; Peninsular; Malaysia.*

Characterization and estimation of human airway deposition of size-resolved particulate-bound trace elements during a recent haze episode in Southeast Asia

Sailesh N. Behera, Raghu Betha, Xian Huang, Rajasekhar Balasubramanian

Source: *Environmental Science and Pollution Research, March 2015, Volume 22, Issue 6, pp 4265-4280, DOI 10.1007/s11356-014-3645-6*

Toxic elements present in airborne particulate matter (PM) are associated with human health effects; however, their toxic characteristics depend on the source of their origins and their concentrations in ambient air. Twenty four elements (Al, B, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, Ga, K, Li, Mg, Mn, Na, Ni, Pb, Se, Sr, Te, Tl, and Zn) in 12 different size fractions of PM ranging from 10 nm to 10 μm were characterized in Singapore during two different atmospheric conditions (smoke haze and non-haze periods) in 2012 for the first time. In addition, their possible sources were identified based on backward air trajectory analysis and principal component analysis (PCA). The health implications of inhalable particles were assessed using a human airway deposition model, the Multiple-Path Particle Dosimetry model (MPPD). The results concerning particle-bound trace elements are interpreted in terms of coarse (PM2.5−10), fine (PM2.5), ultrafine (PM0.01−0.1, 0.01 μm < Dp < 0.10 μm), and nano (PM0.01−0.056, 0.01 μm < Dp < 0.056 μm) particles. The ratios of elemental concentrations measured between the smoke haze episode and the non-haze period in coarse, fine, ultrafine, and nano particles varied from 1.2 (Bi) to 6.6 (Co). Both the PCA and backward trajectory analysis revealed that trans-boundary biomass-burning emissions from Indonesia were primarily responsible for enhanced concentrations of particulate-bound elements during the smoke haze episode. The particle depositions in the respiratory system were higher during the smoke haze episode compared to the non-haze period. The study finds that ultrafine and nano particles present in the atmosphere have higher tendencies to be deposited into the deeper parts of the respiratory system, compared to coarse and fine particles.

Keywords: *Smoke; haze; Biomass burning; Respiratory deposition; Size-resolved; PM; Toxic elements; Principal component analysis.*

Impact of fine particulate fluctuation and other variables on Beijing's air quality index

Bo Chen, Shaowei Lu, Shaoning Li , Bing Wang

Source: *Environmental Science and Pollution Research, April 2015, Volume 22, Issue 7, pp 5139-5151, DOI 10.1007/s11356-014-4024-z*

We analyzed fluctuation in Beijing's air quality over 328 days, based on air quality grades and air quality data from 35 atmospheric monitoring stations. Our results show the air over Beijing is subject to pollution 152 days of the year, or 46.34 %. Among all pollutants, fine particulates, solid or liquid, 2.5 μm or less in size (PM2.5), appeared most frequently as the primary pollutant: 249 days, or 76 % of the sample year (328 days). Nitrogen dioxide (NO2) and coarse particulates (PM10) cause the least pollution, appearing only 7 and 3 days, or 2 and 1 % of the sample year, respectively. In Beijing, fine particulates like PM2.5 vary seasonally: 154.54 ± 18.60 in winter > 145.22 ± 18.61 in spring > 140.16 ± 20.76 in autumn > 122.37 ± 13.42 in summer. Air quality is best in August and worst in December, while various districts in Beijing experience different air quality. To be specific, from south to north and from west to east, air quality tends to improve.

Meteorological elements have a constraining effect on air pollutants, which means there is a linear correlation between the air quality index and humidity, rainfall, wind speed, and temperature. Under a typical pollution scenario, the higher the air quality index (AQI) value, the lower the wind speed and the greater the relative humidity; the lower the AQI value, the higher the wind speed and lower the relative humidity. Analysis of influencing factors reveals that the air pollution is mainly particulate matter produced by burning coal, vehicle emissions, volatile oils and gas, fast development of food services, emissions from the surrounding region, and natural dust clouds formed in arid areas to the northwest. Topography affects the distribution of meteorological conditions, in turn varying air quality over the region from one location to another. Human activities also exercise impact on urban air quality with dual functions.

Keywords: *Air quality index (AQI); Variation characteristics; Temporal and spatial variation; Influencing factors (variables).*

Aerosol characteristics at a rural station in southern peninsular India during CAIPEEX-IGOC: physical and chemical properties

E. S. Bisht , A. K. Srivastava, Prof Ramnath Vij Marg, A. S. Pipal, M. K. Srivastava, A. K. Pandey, S. Tiwari, G. Pandithurai

Source: *Environmental Science and Pollution Research, April 2015, Volume 22, Issue 7, pp 5293-5304, DOI 10.1007/s11356-014-3836-1*

To understand the boundary layer characteristics and pathways of aerosol–cloud interaction, an Integrated Ground Observational Campaign, concurrent with Cloud Aerosol Interaction and Precipitation Enhancement Experiment, was conducted by the Indian Institute of Tropical Meteorology, Pune, under Ministry of Earth Sciences at Mahabubnagar (a rural environment, which is ~100 km away from an urban city Hyderabad in Andhra Pradesh), during the period of July–November 2011. Collected samples of PM2.5 and PM10 were analyzed for water-soluble ionic species along with organic carbon (OC) and elemental carbon (EC). During study period, the average mass concentrations of PM2.5 and PM10 were about 50(±10) and 69(±14) μg m−3, respectively, which are significantly higher than the prescribed Indian National Ambient Air Quality Standards values. The chemical species such as sum of anions and cations from measured chemical constituents were contributed to be 31.27 and 38.49 % in PM2.5 and 6.35 and 5.65 % to the PM10, whereas carbonaceous species contributed ~17.3 and 20.47 % for OC and ~3.0 and 3.10 % for EC, respectively. The average ratio of PM2.5/PM10 during study period was ~0.73(±0.2), indicating that the dominance of fine size particles. Carbonaceous analysis results showed that the average concentration of OC was 14 and 8.7 μg m−3, while EC was 2.1 and 1.5 μg m−3 for PM10 and PM2.5, respectively. The ratios between OC and EC were estimated, which were 6.6 and 5.7 for PM10 and PM2.5, suggesting the presence of secondary organic aerosol. Total carbonaceous aerosol accounts 23 % of PM10 in which the contribution of OC is 20 % and EC is 3 %, while 20 % of PM2.5 mass in which the contribution of OC is 17 % and EC is 3 %. Out of the total aerosols mass, water-soluble constituents contributed an average of 45 % in PM10 and 38 % in PM2.5 including about 39 % anions and 6 % cations in PM10, while 31 % anions and 7 % cations in PM2.5 aerosol mass collectively at study site.

Keywords: *PM; Carbonaceous species; Water-soluble ionic species; OC/EC ratio.*

Methane and CO_2 emissions from China's hydroelectric reservoirs: a new quantitative synthesis

Siyue Li, Quanfa Zhang, Richard T. Bush, Leigh A. Sullivan

Source: *Environmental Science and Pollution Research, April 2015, Volume 22, Issue 7, pp 5325-5339, DOI 10.1007/s11356-015-4083-9*

Controversy surrounds the green credentials of hydroelectricity because of the potentially large emission of greenhouse gases (GHG) from associated reservoirs. However, limited and patchy data particularly for China is constraining the current global assessment of GHG releases from hydroelectric reservoirs. This study provides the first evaluation of the CO2 and CH4 emissions from China's hydroelectric reservoirs by considering the reservoir water surface and drawdown areas, and downstream sources (including spillways and turbines, as well as river downstream). The total emission of 29.6 Tg CO2/year and 0.47 Tg CH4/year from hydroelectric reservoirs in China, expressed as CO2 equivalents (eq), corresponds to 45.6 Tg CO2eq/year, which is 2-fold higher than the current GHG emission (ca. 23 Tg CO2eq/year) from global temperate hydropower reservoirs. China's average emission of 70 g CO2eq/kWh from hydropower amounts to 7 % of the emissions from coal-fired plant alternatives. China's hydroelectric reservoirs thus currently mitigate GHG emission when compared to the main alternative source of electricity with potentially far great reductions in GHG emissions and benefits possible through relatively minor changes to reservoir management and design. On average, the sum of drawdown and downstream emission including river reaches below dams and turbines, which is overlooked by most studies, represents the equivalent of 42 % of the CO2 and 92 % of CH4 that emit from hydroelectric reservoirs in China. Main drivers on GHG emission rates are summarized and highlight that water depth and stratification control CH4 flux, and CO2 flux shows significant negative relationships with pH, DO, and Chl-a. Based on our finding, a substantial revision of the global carbon emissions from hydroelectric reservoirs is warranted.

Keywords: *Hydropower reservoirs; Greenhouse gas (GHG); CO2 emission; Methane emission; Green energy; Carbon budget.*

Ambient air levels and health risk assessment of benzo(a)pyrene in atmospheric particulate matter samples from low-polluted areas: application of an optimized microwave extraction and HPLC-FL methodology

María de la Gala Morales , Fernando Rueda Holgado, Mª Rosario Palomo Marín, Lorenzo Calvo Blázquez, Eduardo Pinilla Gil

Source: *Environmental Science and Pollution Research, April 2015, Volume 22, Issue 7, pp 5340-5349, DOI 10.1007/s11356-014-3722-x*

A new methodology involving a simple and fast pretreatment of the samples by microwave-assisted extraction and concentration by N2 stream, followed by HPLC with fluorescence detection, was used for determining the concentration of benzo(a)pyrene (BaP) in atmospheric particulate matter (PM10 fraction). Obtained LOD, 1.0 × 10−3 ng/m3, was adequate for the analysis of benzo(a)pyrene in the samples, and BaP recovery from PAH in Fine Dust (PM10-like) certified reference material was nearly quantitative (86 %). The validated procedure was applied for analyzing 115 PM10 samples collected at different sampling locations in the low-polluted area of Extremadura (Southwest Spain) during a monitoring campaign carried out in 2011–2012. BaP spatial variations and seasonal variability were investigated as well as the influence

of meteorological conditions and different air pollutants concentrations. A normalized protocol for health risk assessment was applied to estimate lifetime cancer risk due to BaP inhalation in the sampling areas, finding that around eight inhabitants per million people may develop lung cancer due to the exposition to BaP in atmospheric particulates emitted by the investigated sources.

Keywords: *Benzo(a)pyrene; Particulate matter; Microwave extraction; HPLC-FL; Seasonal variation; Risk assessment.*

Association between atmospheric pollutants and hospital admissions in Lisbon

A. M. J. Cruz , S. Sarmento, S. M. Almeida, A. V. Silva, C. Alves, M. C. Freitas, H. Wolterbeek

Source: *Environmental Science and Pollution Research, April 2015, Volume 22, Issue 7, pp 5500-5510, DOI 10.1007/s11356-014-3838-z*

Ambient air pollution is recognised as one of the potential environmental risk factors causing health hazards to the exposed population, demonstrated in numerous previous studies. Several longitudinal, ecological and epidemiological studies have shown associations between outdoor levels of outdoor atmospheric pollutants and adverse health effects, especially associated with respiratory and cardiovascular hospital admissions. The aim of this work is to assess the influence of atmospheric pollutants over the hospital admissions in Lisbon, by Ordinary Least Squares Linear Regression. The pollutants (CO, NO, NO2, SO2, O3, PM10 and PM2.5) were obtained from 13 monitoring stations of the Portuguese Environmental Agency, which provide hourly observations. Hospital admission data were collected from the Central Administration of the Health System and were compiled by age: <15, 15–64, >64 years old. The study period was 2006–2008. Results showed significant positive associations between the following: (1) the pollutants CO, NO, NO2, SO2, PM10 and PM2.5 and circulatory diseases for ages between 15 and 64 years (0.5 % hospital admissions (HA) increase with 10 μg m−3 NO increase) and above 64 years (1.0 % stroke admission increase with 10 μg m−3 NO2 increase); (2) the pollutants CO, NO, NO2, SO2, PM10 and PM2.5 and respiratory diseases for ages below 15 years (up to 1.9 % HA increase with 10 μg m−3 pollutant increase); and (3) the pollutants NO, NO2 and SO2 and respiratory diseases for ages above 64 years (1.3 % HA increase with 10 μg m−3 CO increase).

Keywords: *Air pollutants; Hospital admissions; Health effects; Respiratory diseases;Cardiovascular diseases.*

Air quality modeling in the Oviedo urban area (NW Spain) by using multivariate adaptive regression splines

P. J. García Nieto, J. C. Álvarez Antón, J. A. Vilán Vilán, E. García-Gonzalo

Source: *Environmental Science and Pollution Research, May 2015, Volume 22, Issue 9, pp 6642-6659, DOI 10.1007/s11356-014-3800-0*

The aim of this research work is to build a regression model of air quality by using the multivariate adaptive regression splines (MARS) technique in the Oviedo urban area (northern Spain) at a local scale. To accomplish the objective of this study, the experimental data set made up of nitrogen oxides (NO x), carbon monoxide (CO), sulfur dioxide (SO2), ozone (O3), and dust (PM10) was collected over 3 years (2006–2008). The US National Ambient Air Quality Standards (NAAQS) establishes the limit values of the main

pollutants in the atmosphere in order to ensure the health of healthy people. Firstly, this MARS regression model captures the main perception of statistical learning theory in order to obtain a good prediction of the dependence among the main pollutants in the Oviedo urban area. Secondly, the main advantages of MARS are its capacity to produce simple, easy-to-interpret models, its ability to estimate the contributions of the input variables, and its computational efficiency. Finally, on the basis of these numerical calculations, using the MARS technique, conclusions of this research work are exposed.

Keywords: *Air quality modelling; Air monitoring data; Statistical machine learning; Pollutant substances; Atmospheric fate; Multivariate adaptive regression splines (MARS).*

PM_{10} concentration in urban atmosphere around the eastern Tien Shan, Central Asia during 2007–2013

Shengjie Wang, Mingjun Zhang , María Cruz Minguillón, Xiaoyu Zhang, Fang Feng, Xue Qiu

Source: *Environmental Science and Pollution Research, May 2015, Volume 22, Issue 9, pp 6864-6876, DOI 10.1007/s11356-014-3911-7*

Based on the daily records from 16 cities around the eastern Tien Shan (Tianshan Mountains), central Asia from 2007 to 2013, the spatial pattern and seasonal/interannual variation of urban particulate matter up to 10 μm in size (PM10) concentrations and influencing factors were analyzed. Annual mean PM10 concentrations (±standard deviation) in most cities on the northern slope mainly range from 55 ± 28 μg/m3 to 92 ± 75 μg/m3, and those on the southern slope range between 96 ± 65 and 195 ± 144 μg/m3. PM10 concentrations are maxima in winter on the northern slope, while they maximize in springtime on the southern slope. There is an increasing trend in annual mean concentrations during the period 2007–2013, which is not statistically significant at the 0.05 level. Urban PM10 concentration in the study region is jointly influenced by anthropogenic emission and regional natural processes, especially dust events and precipitation. The northern slope usually has heavy anthropogenic air pollution (mostly in winter) and relatively rich precipitation especially in summer, and the southern slope always suffers more frequent dust events (mostly in spring) and less precipitation. Modeled back-trajectory indicated that the Taklimakan desert source can greatly increase the PM10 concentration on the southern slope, and the mountain ranges may hinder the transport of dust to the northern slope.

Keywords: *Particulate matter; Central Asia; Dust sources; Tien Shan.*

Effects of CO_2 on *Acer negundo* pollen fertility, protein content, allergenic properties, and carbohydrates

M. Silva, H. Ribeiro , I. Abreu, A. Cruz, J. C. G. Esteves da Silva

Source: *Environmental Science and Pollution Research, May 2015, Volume 22, Issue 9, pp 6904-6911, DOI 10.1007/s11356-014-3896-2*

Atmospheric gaseous pollutants can induce qualitative and quantitative changes in airborne pollen characteristics. In this work, it was investigated the effects of carbon dioxide (CO2) on Acer negundo pollen fertility, protein content, allergenic properties, and carbohydrates. Pollen was collected directly from the anthers and in vitro exposed to three CO2 levels (500, 1000, and 3000 ppm) for 6 and 24 h in an environmental chamber. Pollen fertility was determined using viability and germination assays, total soluble

protein was determined with Coomassie Protein Assay Reagent, and the antigenic and allergenic properties were investigated by sodium dodecyl sulfate polyacrylamide gel electrophoresis (SDS-PAGE) and immunological techniques using patients' sera. Also, pollen fructose, sucrose, and glucose values were determined. Carbon dioxide exposure affected negatively pollen fertility, total soluble protein content, and fructose content. The patient sera revealed increased IgE reactivity to proteins of A. negundo pollen exposed to increasing levels of the pollutant. No changes were detected in the SDS-PAGE protein profiles and in sucrose and glucose levels. Our results indicate that increase in atmospheric CO2 concentrations can have a negative influence of some features of A. negundo airborne pollen that can influence the reproductive processes as well as respiratory pollen allergies in the future.

Keywords: *Atmospheric pollution; Respiratory allergies; Pollen germination; Pollen viability; IgE Sugars.*

Environmental risk of combined emerging pollutants in terrestrial environments: chlorophyll *a* fluorescence analysis

Víctor González-Naranjo , Karina Boltes, Irene de Bustamante, Pino Palacios-Diaz

Source: *Environmental Science and Pollution Research, May 2015, Volume 22, Issue 9, pp 6920-6931, DOI 10.1007/s11356-014-3899-z*

The risk assessment in terrestrial environments has been scarcely studied for mixtures of organic contaminants. To estimate toxicity due to these compounds, an ecotoxicological test may be done with the appropriate organism and biomarker. Photosynthesis is principally performed at photosystem II, and its efficiency is affected by any environmental stress. Consequently, the measure of this efficiency may be a good indicator of toxicity if different parameters are employed, e.g., the quantum efficiency of photosystem II and the photochemical quenching coefficient. We did a series of assays to determine the toxicity of two organic contaminants, ibuprofen and perfluorooctanoic acid, using a higher plant (Sorghum bicolor). The results showed more toxicity for the perfluorinated compound and greater sensibility for the quantum efficiency of photosystem II. Regarding the binary combination, three methods were applied to calculate EC50: combination index, concentration addition, and independent action. Synergistic behavior is the principal toxicological profile for this mix. Therefore, the combination index, which considers interactions among chemicals, gave the best estimation to determine risk indices. We conclude that the inhibition of photosynthesis efficiency can be a useful tool to determine the toxicity of the mixtures of organic pollutants and to estimate ecological risks in terrestrial environments.

Keywords: *Combination index; Hazard quotient; Organic compounds; Photosynthesis; Phytotoxicity; Quantum efficiency of PSII.*

Applying land use regression model to estimate spatial variation of PM2.5 in Beijing, China

Jiansheng Wu, Jiacheng Li , Jian Peng, Weifeng Li , Guang Xu, Chengcheng Dong

Source: *Environmental Science and Pollution Research, May 2015, Volume 22, Issue 9, pp 7045-7061, DOI 10.1007/s11356-014-3893-5*

Fine particulate matter (PM2.5) is the major air pollutant in Beijing, posing serious threats to human health. Land use regression (LUR) has been widely used in predicting spatiotemporal variation of ambient air-

pollutant concentrations, though restricted to the European and North American context. We aimed to estimate spatiotemporal variations of PM2.5 by building separate LUR models in Beijing. Hourly routine PM2.5 measurements were collected at 35 sites from 4th March 2013 to 5th March 2014. Seventy-seven predictor variables were generated in GIS, including street network, land cover, population density, catering services distribution, bus stop density, intersection density, and others. Eight LUR models were developed on annual, seasonal, peak/non-peak, and incremental concentration subsets. The annual mean concentration across all sites is 90.7 μg/m3 (SD = 13.7). PM2.5 shows more temporal variation than spatial variation, indicating the necessity of building different models to capture spatiotemporal trends. The adjusted R 2 of these models range between 0.43 and 0.65. Most LUR models are driven by significant predictors including major road length, vegetation, and water land use. Annual outdoor exposure in Beijing is as high as 96.5 μg/m3. This is among the first LUR studies implemented in a seriously air-polluted Chinese context, which generally produce acceptable results and reliable spatial air-pollution maps. Apart from the models for winter and incremental concentration, LUR models are driven by similar variables, suggesting that the spatial variations of PM2.5 remain steady for most of the time. Temporal variations are explained by the intercepts, and spatial variations in the measurements determine the strength of variable coefficients in our models.

Keywords: *Land use regression; Fine particulate matter; PM2.5; Spatiotemporal variation; Outdoor exposure; Air pollution; Beijing.*

Source analysis of global anthropogenic lead emissions: their quantities and species

Jing Liang, Jiansu Mao

Source: *Environmental Science and Pollution Research, May 2015, Volume 22, Issue 9, pp 7129-7138, DOI 10.1007/s11356-014-3878-4*

Lead emissions originate primarily from the anthropogenic lead cycle, and research into their characteristics, such as species type, provides essential information for pollution control. A dynamic model for global lead emissions has been established, and their emissions and temporal accumulations were estimated in this study based on the evolution of the lead cycle over 70 years. An inventory of the emissions species was obtained after identifying their physiochemical transformations. The 2010 emissions were 3.56 Mt, with 65 % coming from waste management and recycling. The main species were PbSO4 (42.5 %), PbO2 (16.2 %), and PbS (8.3 %). Between 1930 and 2010, the total lead emissions were 173.8 Mt, mainly from waste management and recycling (48 %), production (26 %), and use (20 %). The main species were PbSO4, PbO, Pb, and PbS, and together, they accounted for 61.2 % of the total emissions. Over time, species, such as tetraethyl lead and Pb, declined, but PbO2 and PbSO4 increased.

Keywords: *Source; Life cycle; Lead emissions; Quantities; Species; Accumulation.*

Air pollution and unintentional injury deaths in South Korea

Kyoung Hwa Ha, Jaelim Cho, Seong-Kyung Cho, Changsoo Kim , Dong Chun Shin

Source: *Environmental Science and Pollution Research, May 2015, Volume 22, Issue 10, pp 7873-7881, DOI 10.1007/s11356-015-4101-y*

This study aimed to assess the association between exposure to air pollution and unintentional injury deaths in South Korea. Data regarding all unintentional injury deaths (17,566) in seven metropolitan cities from 2002 to 2008 were collected. Using a time-stratified case-crossover study, conditional logistic regression and subgroup analyses were performed after stratification by age, gender, and season. To evaluate immediate and delayed effects of air pollutants, we used both single lag and distributed lag models. The risk was expressed as an odds ratio (OR) per one interquartile range (IQR) of each air pollutant. During the study period, the median (IQR) levels of air pollutants were 0.005 (0.004–0.007) ppm for sulfur dioxide (SO2), 0.02 (0.02–0.03) ppm for nitrogen dioxide (NO2), 0.03 (0.02–0.04) ppm for ozone (O3), 48.3 (34.9–67.0) μg/m3 for particulate matter ≤10 μm in aerodynamic diameter (PM10), and 0.36 (0.1–0.6) ppm for carbon monoxide (CO). All air pollutants, with the exception of PM10 and O3, were significantly associated with an increased risk of unintentional injury deaths; the maximum risk was observed in the distributed lag 1 model for SO2 (OR, 1.119; 95 % confidence interval, 1.022–1.226), NO2 (1.208; 1.043–1.400), and CO (1.012; 1.000–1.024). After stratification of the subjects by age, SO2, NO2, and CO were significantly associated with increased risk of unintentional injury deaths among subjects aged 60 years or older in the distributed lag 1 model, while O3 and PM10 were associated with increased risk among subjects aged 40 to 59 years. However, in subjects younger than 40 years of age, we found no significant associations for any of the air pollutants. Our study suggested evidence for a short-term association between air pollutants and unintentional injury deaths, even at low pollutants levels.

Keywords: *Air pollution; Carbon monoxide; Nitrogen dioxide; Ozone; Particulate matter; South Korea; Sulfur dioxide; Unintentional injury death.*

Identifying sources of Pb pollution in urban soils by means of MC-ICP-MS and TOF-SIMS

Andrés Rodríguez-Seijo, Daniel Arenas-Lago, María Luisa Andrade , Flora A. Vega

Source: *Environmental Science and Pollution Research, May 2015, Volume 22, Issue 10, pp 7859-7872, DOI 10.1007/s11356-014-4027-9*

Lead pollution was evaluated in 17 urban soils from parks and gardens in the city of Vigo (NW Spain). The Pb isotope ratios (207Pb/206Pb, 208Pb/204Pb, 206Pb/204Pb and 208Pb/206Pb) were determined after being measured by MC-ICP-MS. The association of the isotopes (204Pb, 206Pb, 207Pb and 208Pb) with the different components of the soil was studied using TOF-SIMS. The isotopic ranges obtained for the samples were between 1.116 and 1.203 (206Pb/207Pb), 2.044–2.143 (208Pb/206Pb), 37.206–38.608 (208Pb/204Pb), 15.5482–15.6569 (207Pb/204Pb) and 17.357–18.826 (206Pb/204Pb). The application of the three-end-member model indicates that the Pb derived from petrol is the main source of Pb in the soils (43.51 % on average), followed by natural or geogenic Pb (39.12 %) and industrial emissions (17.37 %). The emissions derived from coal combustion do not appear to influence the content of Pb in the soil. TOF-SIMS images show that the Pb mainly interacts with organic matter. This technique contributes to the understanding of the association of anthropogenic Pb with the components of the soil, as well as the particle size of these associations, thus allowing the possible sources of Pb to be identified.

Keywords: *Lead stable isotope;Urban soils; TOF-SIMS; MC-ICP-MS; Three-end-member model; Roadside soils.*

Indoor/outdoor relationships of bioaerosol concentrations in a retirement home and a school dormitory

Sasan Faridi, Mohammad Sadegh Hassanvand, Kazem Naddafi, Masud Yunesian , Ramin Nabizadeh, Mohammad Hossein Sowlat, Homa Kashani, Akbar Gholampour, Sadegh Niazi, Ahad Zare, Shahrokh Nazmara, Mahmood Alimohammadi

Source: *Environmental Science and Pollution Research, June 2015, Volume 22, Issue 11, pp 8190-8200, DOI 10.1007/s11356-014-3944-y*

The concentrations of bacterial and fungal bioaerosols were measured in a retirement home and a school dormitory from May 2012 to May 2013. In the present work, two active and passive methods were used for bioaerosol sampling. The results from the present work indicated that Bacillus spp., Micrococcus spp., and Staphylococcus spp. were the dominant bacterial genera, while the major fungal genera were Penicillium spp., Cladosporium spp., and Aspergillus spp. The results also indicated that the indoor-to-outdoor (I/O) ratios for total bacteria were 1.77 and 1.44 in the retirement home and the school dormitory, respectively; the corresponding values for total fungal spores were 1.23 and 1.08. The results suggested that in addition to outdoor sources, indoor sources also played a significant role in emitting bacterial and fungal bioaerosols in the retirement home and the school dormitory indoor.

Keywords: *Bioaerosol; Indoor/outdoor; Retirement home; School dormitory; Tehran.*

Particulate matter concentration and chemical composition in the metro system of Rome, Italy

C. Perrino, F. Marcovecchio, L. Tofful, S. Canepari

Source: *Environmental Science and Pollution Research, June 2015, Volume 22, Issue 12, pp 9204-9214, DOI 10.1007/s11356-014-4019-9*

Air quality at the main station of the metro system of Rome (Termini hub) has been characterized by the point of view of particulate matter (PM) concentration and chemical composition. Indoor air in different environments (underground train platform and shopping center, metro carriages with and without air conditioning system) has been studied and compared with outdoor air at a nearby urban site. Air quality at the railway station, located outdoor at surface level, has been also considered for comparison. PM chemical characterization included ions, elemental carbon, organic carbon, macro-elements, and the bio-accessible and residual fractions of micro- and trace elements. Train platform and carriages without air conditioning resulted to be the most polluted environments, with indoor/outdoor ratio up to two orders of magnitude for many components. PM mass concentration was determined on filter membranes by the gravimetric procedure as well as from the optical particle counter (OPC) number concentration measurements. The OPC results, taken with the original calibration factor, were below 40 % of the value obtained by the gravimetric measurements. Only a chemical and morphological characterization of the collected dust could lead to a reconciliation of the results yielded by the two methods. Macro-components were used to estimate the strength of the main macro-sources. The most significant contribution is confirmed to derive from wheels, rails, and brakes abrasion; from soil re-suspension (over 50 % at the subway platform); and from organics (about 25 %). The increase in the concentration of elements was mostly due to the residual fraction, but also the bio-accessible fraction showed a remarkable enrichment, particularly in the case of Ba, Zn, Cd, and Ni.

Keywords: *Indoor air quality; Subway; PM macro-sources; Bio-accessible elements; Optical particle counter.*

Air pollution by allergenic spores of the genus Alternaria in the air of central and eastern Europe

Idalia Kasprzyk, Victoria Rodinkova, Ingrida Šaulienė, Olga Ritenberga, Agnieszka Grinn-Gofron, Malgorzata Nowak, Aneta Sulborska, Joanna Kaczmarek, Elzbieta Weryszko-Chmielewska, Elena Bilous, Malgorzata Jedryczka

Source: *Environmental Science and Pollution Research, June 2015, Volume 22, Issue 12, pp 9260-9274, DOI 10.1007/s11356-014-4070-6*

Spores of the genus Alternaria belong to one of the most prevailing constituents of the air in all regions of the world. They form infectious inoculum of numerous plant species as well as severe inhaled allergies. The aim of this study was to compare the biological pollution with Alternaria spores of the air of 12 cities located in central and eastern Europe. The experiment was done in 2010 and it covered the territory of Latvia (LV), Lithuania (LT), Poland (PL) and Ukraine (UA). The spores were counted using an identical method and standard equipment (7-day Lanzoni volumetric sampler) followed by extensive statistical calculations. The timing of the day of maximum concentration changed mainly along the N-S direction and had a positive correlation with latitude. The most important factor determining the increase in Alternaria spore concentration was the temperature, whereas other weather parameters were not related or of low significance. Regardless of geographical location, the first phase of the season (0–0.9 % of Alternaria spores in the air) was the longest (up to 60 days) and the last (97.5 to 99 %) was the shortest (22 days or less). The means of daily concentrations of Alternaria spores ranged from 11 spores m−3 in Klaipeda (LT, Baltic Sea coast) to 187 in Poznan (west PL, agricultural plain). The threshold value of 80 spores m−3 that triggers the first allergy symptoms was exceeded in 8 to 86 days (Vinnitsa, UA, temperate continental, forest-steppes region). There were considerable differences between the highest number of spores per cubic metre of air, varying from 139 in the north (Klaipeda, LT) to 2,295 in central west (Poznan, PL). The biological pollution by Alternaria spores in several places of central and eastern Europe was high; the number of days exceeding the threshold value of 300 spores m−3 connected with serious health problems of atopic people ranged from 0 to 1 on the north (LV, LT) to 29 in central west (Poznan, PL).

Keywords: *Alternaria; Aerobiology; Spatial analysis; Meteorological parameters; Aeroallergen; Biological pollution.*

Emission characteristics of VOCs emitted from consumer and commercial products and their ozone formation potential

Trieu-Vuong Dinh, Su-Yeon Kim, Youn-Suk Son, In-Young Choi, Seong-Ryong Park, Young Sunwoo, Jo-Chun Kim

Source: *Environmental Science and Pollution Research, June 2015, Volume 22, Issue 12, pp 9345-9355, DOI 10.1007/s11356-015-4092-8*

The characteristics of volatile organic compounds (VOCs) emitted from several consumer and commercial products (body wash, dishwashing detergent, air freshener, windshield washer fluid, lubricant, hair spray, and insecticide) were studied and compared. The spray products were found to emit the highest amount of

VOCs (~96 wt%). In contrast, the body wash products showed the lowest VOC contents (~1.6 wt%). In the spray products, 21.6–96.4 % of the VOCs were propane, iso-butane, and n-butane, which are the components of liquefied petroleum gas. Monoterpene (C10H16) was the dominant component of the VOCs in the non-spray products (e.g., body wash, 53–88 %). In particular, methanol was present with the highest amount of VOCs in windshield washer fluid products. In terms of the number of carbon, the windshield washer fluids, lubricants, insecticides, and hair sprays comprised >95 % of the VOCs in the range C2–C5. The VOCs in the range C6–C10 were predominantly found in the body wash products. The dishwashing detergents and air fresheners contained diverse VOCs from C2 to C11. Besides comprising hazardous VOCs, VOCs from consumer products were also ozone precursors. The ozone formation potential of the consumer and commercial spray products was estimated to be higher than those of liquid and gel materials. In particular, the hair sprays showed the highest ozone formation potential.

Keywords: *VOCs; Spray; Ozone formation potential; Consumer product; Commercial product; Monoterpene.*

Levels, potential sources and human health risk of polycyclic aromatic hydrocarbons (PAHs) in particulate matter (PM_{10}) in Kumasi, Ghana

Nesta Bortey-Sam, Yoshinori Ikenaka, Osei Akoto, Shouta M. M. Nakayama, Yared Beyene Yohannes, Elvis Baidoo, Hazuki Mizukawa, Mayumi Ishizuka

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Airborne particulate samples were collected on quartz filters to determine the concentrations, sources and health risks of polycyclic aromatic hydrocarbons (PAHs) in air in Kumasi, Ghana. A total of 32 air samples were collected in Kwame Nkrumah University of Science and Technology (KNUST) campus (pristine site) and city centre (CC). Samples were extracted with 1:2 v/v acetone/hexane mixture prior to GC–MS analyses. The sum of concentrations of 17 PAHs in air ranged from 0.51 to 16 (KNUST) and 19–38 ng/m3 (CC). The concentration of benzo[a]pyrene, BaP, ranged from below detection limit to 0.08 ng/m3 (KNUST) and 1.6 to 5.6 ng/m3 (CC). Chemical mass balance model showed that PAHs in air in Kumasi were mainly from fuel combustion. The total BaP equivalent concentration (BaPeq) in CC was 18 times higher compared to KNUST; based on the European Legislation and Swedish and UK Standards for BaP in air, CC could be classified as highly polluted. Estimated carcinogenicity of PAHs in terms of BaPeq indicated that BaP was the principal PAH contributor in CC (70 %). Health risk to adults and children associated with PAH inhalation was assessed by taking into account the lifetime average daily dose and corresponding incremental lifetime cancer risk (ILCR). The ILCR was within the acceptable range (10−6 to 10−4), indicating low health risk to residents.

Keywords: *Airborne particulate; PAHs; Kumasi; BaP toxic equivalent; Incremental; lifetime cancer risk; Chemical mass balance.*

Spatial modeling of $PM_{2.5}$ concentrations with a multifactoral radial basis function neural network

Bin Zou , Min Wang, Neng Wan, J. Gaines Wilson, Xin Fang, Yuqi Tang

Source: *Environmental Science and Pollution Research, July 2015, Volume 22, Issue 14, pp 10395-10404, DOI 10.1007/s11356-015-4380-3*

Accurate measurements of PM2.5 concentration over time and space are especially critical for reducing adverse health outcomes. However, sparsely stationary monitoring sites considerably hinder the ability to effectively characterize observed concentrations. Utilizing data on meteorological and land-related factors, this study introduces a radial basis function (RBF) neural network method for estimating PM2.5 concentrations based on sparse observed inputs. The state of Texas in the USA was selected as the study area. Performance of the RBF models was evaluated by statistic indices including mean square error, mean absolute error, mean relative deviation, and the correlation coefficient. Results show that the annual PM2.5 concentrations estimated by the RBF models with meteorological factors and/or land-related factors were markedly closer to the observed concentrations. RBF models with combined meteorological and land-related factors achieved best performance relative to ones with either type of these factors only. It can be concluded that meteorological factors and land-related factors are useful for articulating the variation of PM2.5 concentration in a given study area. With these covariate factors, the RBF neural network can effectively estimate PM2.5 concentrations with acceptable accuracy under the condition of sparse monitoring stations. The improved accuracy of air concentration estimation would greatly benefit epidemiological and environmental studies in characterizing local air pollution and in helping reduce population exposures for areas with limited availability of air quality data.

Keyword: *RBF; Particulate matter; Land use; GIS; Environmental modelling; ANN.*

Industrial sources of primary and secondary organic aerosols in two urban environments in Spain

M. Escudero, M. Viana, X. Querol, A. Alastuey, P. Díez Hernández, S. García Dos Santos, J. Anzano

Source: *Environmental Science and Pollution Research, July 2015, Volume 22, Issue 14, pp 10413-10424, DOI 10.1007/s11356-015-4228-x*

In urban areas, primary and secondary organic aerosols are typically considered to originate from vehicular traffic emissions. However, industrial emissions within or in the vicinity of urban areas may also be significant contributors to carbonaceous aerosol concentrations. This hypothesis was tested and validated in two urban areas in Spain. The observed unusual dominance of organic carbon (OC) over elemental carbon (EC), the analysis of the variability of OC, EC and OC/EC and their correlation with transport patterns suggested the presence of OC sources associated with industrial activities. A methodology based on chemical speciation of particulate matter (PM) followed by the application of receptor modelling techniques allowed for the identification of the specific industrial sources of OC, which were linked to primary OC emissions from a grain drying plant (cereal) and to secondary OC formation from paper production activities (paper mills), as well as from urban sources and biogenic emissions. This work presents an integrated approach to identifying and characterizing of industrial sources of carbonaceous aerosols in urban areas, aiming to improve the scarce body of literature currently available on this topic.

Keywords: *Carbonaceous aerosols; OC; EC; POA; SOA; Industrial sources; Paper mill.*

Study of the carbonaceous aerosol and morphological analysis of fine particles along with their mixing state in Delhi, India: a case study

S. Tiwari, A. S. Pipal , Philip K. Hopke, D. S. Bisht, A. K. Srivastava, Shani Tiwari, P. N. Saxena, A. H. Khan, S. Pervez

Source: *Environmental Science and Pollution Research, July 2015, Volume 22, Issue 14, pp 10744-10757, DOI 10.1007/s11356-015-4272-6*

Because of high emissions of anthropogenic as well as natural particles over the Indo-Gangetic Plains (IGP), it is important to study the characteristics of fine (PM2.5) and inhalable particles (PM10), including their morphology, physical and chemical characteristics, etc., in Delhi during winter 2013. The mean mass concentrations of fine (PM2.5) and inhalable (PM10) (continuous) was 117.6 ± 79.1 and 191.0 ± 127.6 μg m−3, respectively, whereas the coarse mode (PM10–2.5) particle PM mass was 73.38 ± 28.5 μg m−3. During the same period, offline gravimetric monitoring of PM2.5 was conducted for morphological analysis, and its concentration was ~37 % higher compared to the continuous measurement. Carbonaceous PM such as organic carbon (OC) and elemental carbon (EC) were analyzed on the collected filters, and their mean concentration was respectively 33.8 and 4.0 μg m−3 during the daytime, while at night it was 41.2 and 10.1 μg m−3, respectively. The average OC/EC ratio was 8.97 and 3.96 during the day and night, respectively, indicating the formation of secondary organic aerosols during daytime. Effective carbon ratio was studied to see the effect of aerosols on climate, and its mean value was 0.52 and 1.79 during night and day, indicating the dominance of absorbing and scattering types of aerosols respectively into the atmosphere over the study region. Elemental analysis of individual particles indicates that Si is the most abundant element (~37–90 %), followed by O (oxide) and Al. Circularity and aspect ratio was studied, which indicates that particles are not perfectly spherical and not elongated in any direction. Trajectory analysis indicated that in the months of February and March, air masses appear to be transported from the Middle Eastern part along with neighboring countries and over Thar Desert region, while in January it was from the northeast direction which resulted in high concentrations of fine particles.

Keywords: *Morphology; Mixing state; Carbonaceous particles; ECR; Al silicates.*

Carbonaceous aerosol composition over northern China in spring 2012

Yuhong Guo

Source: *Environmental Science and Pollution Research, July 2015, Volume 22, Issue 14, pp 10839-10849, DOI 10.1007/s11356-015-4299-8*

The organic carbon (OC) and elemental carbon (EC) collected by eight-stage air samplers over northern China during spring 2012 were determined to characterize the spatial variations, size distributions, and sources of carbonaceous aerosols. OC and EC had high concentration levels and spatial heterogeneity. Higher carbonaceous aerosol loadings were found in urban areas, and high concentrations of OC and EC were found in eastern parts of northern China, including Beijing, Taiyuan in Shanxi Province, Yucheng in Shandong Province, Xianghe in Hebei Province, and Shenyang in Liaoning Province. Except the Cele site, OC and EC at all the sites showed a bimodal distribution, peaking in the size of 0.4–0.7 and 4.7–5.8 μm. Carbonaceous aerosols in the fine mode in the urban areas are mostly presented in smaller sizes than those in the rural/regional background areas. For most sites, mass median aerodynamic diameter (MMAD) values in the fine particles for OC were higher than those for EC with the addition of semi-volatile organics. Good

correlations between OC and EC in all the cities (5 in North China and 1 in northeast China) may suggest the impact of anthropogenic emissions on carbonaceous aerosols in the above regions.

Keywords: *Carbonaceous aerosol; Spring; Size distribution; Spatial variation.*

Identification of aerosol types over Indo-Gangetic Basin: implications to optical properties and associated radiative forcing

S. Tiwari, A. K. Srivastava, A. K. Singh, Sachchidanand Singh

Source: *Environmental Science and Pollution Research, August 2015, Volume 22, Issue 16, pp 12246-12260, DOI 10.1007/s11356-015-4495-6*

The aerosols in the Indo-Gangetic Basin (IGB) are a mixture of sulfate, dust, black carbon, and other soluble and insoluble components. It is a challenge not only to identify these various aerosol types, but also to assess the optical and radiative implications of these components. In the present study, appropriate thresholds for fine-mode fraction and single-scattering albedo have been used to first identify the aerosol types over IGB. Four major aerosol types may be identified as polluted dust (PD), polluted continental (PC), black carbon-enriched (BCE), and organic carbon-enriched (OCE). Further, the implications of these different types of aerosols on optical properties and radiative forcing have been studied. The aerosol products derived from CIMEL sun/sky radiometer measurements, deployed under Aerosol Robotic Network program of NASA, USA were used from four different sites Karachi, Lahore, Jaipur, and Kanpur, spread over Pakistan and Northern India. PD is the most dominant aerosol type at Karachi and Jaipur, contributing more than 50 % of all the aerosol types. OCE, on the other hand, contributes only about 12–15 % at all the stations except at Kanpur where its contribution is ∼38 %. The spectral dependence of AOD was relatively low for PD aerosol type, with the lowest AE values (<0.5); whereas, large spectral dependence in AOD was observed for the remaining aerosol types, with the highest AE values (>1.0). SSA was found to be the highest for OCE (>0.9) and the lowest for BCE (<0.9) type aerosols, with drastically different spectral variability. The direct aerosol radiative forcing at the surface and in the atmosphere was found to be the maximum at Lahore among all the four stations in the IGB.

Keywords: *Aerosol types; Aerosol optical depth; Single-scattering Albedo; Fine-mode fraction; Radiative forcing; Heating rate.*

Characterization and source apportionment of particle number concentration at a semi-urban tropical environment

Md Firoz Khan , Mohd Talib Latif, Norhaniza Amil, Liew Juneng, Noorlin Mohamad, Mohd Shahrul Mohd Nadzir, Hossain Mohammed Syedul Hoque

Source: *Environmental Science and Pollution Research, September 2015, Volume 22, Issue 17, pp 13111-13126*

Principal component analysis (PCA) and correlation have been used to study the variability of particle mass and particle number concentrations (PNC) in a tropical semi-urban environment. PNC and mass concentration (diameter in the range of 0.25–>32.0 μm) have been measured from 1 February to 26 February 2013 using an in situ Grimm aerosol sampler. We found that the 24-h average total suspended particulates (TSP), particulate matter ≤10 μm (PM10), particulate matter ≤2.5 μm (PM2.5) and particulate matter ≤1 μm

(PM1) were 14.37 ± 4.43, 14.11 ± 4.39, 12.53 ± 4.13 and 10.53 ± 3.98 μg m−3, respectively. PNC in the accumulation mode (<500 nm) was the most abundant (at about 99 %). Five principal components (PCs) resulted from the PCA analysis where PC1 (43.8 % variance) predominates with PNC in the fine and sub-microme tre range. PC2, PC3, PC4 and PC5 explain 16.5, 12.4, 6.0 and 5.6 % of the variance to address the coarse, coarser, accumulation and giant fraction of PNC, respectively. Our particle distribution results show good agreement with the moderate resolution imaging spectroradiometer (MODIS) distribution.

Keywords: *PCA-MLR; Particle number; Diurnal variation; Back trajectory; Fire hotspot; Aerosol size distribution.*

Characterization of VOC sources in an urban area based on PTR-MS measurements and receptor modelling

A. Stojić , S. Stanišić Stojić, A. Šoštarić, L. Ilić, Z. Mijić, S. Rajšić

Source: *Environmental Science and Pollution Research, September 2015, Volume 22, Issue 17, pp 13137-13152, DOI 10.1007/s11356-015-4540-5*

In this study, the concentrations of volatile organic compounds were measured by the use of proton transfer reaction mass spectrometry, together with NO x , NO, NO2, SO2, CO and PM10 and meteorological parameters in an urban area of Belgrade during winter 2014. The multivariate receptor model US EPA Unmix was applied to the obtained dataset resolving six source profiles, which can be attributed to traffic-related emissions, gasoline evaporation/oil refineries, petrochemical industry/biogenic emissions, aged plumes, solid-fuel burning and local laboratories. Besides the vehicle exhaust, accounting for 27.6 % of the total mixing ratios, industrial emissions, which are present in three out of six resolved profiles, exert a significant impact on air quality in the urban area. The major contribution of regional and long-range transport was determined for source profiles associated with petrochemical industry/biogenic emissions (40 %) and gasoline evaporation/oil refineries (29 %) using trajectory sector analysis. The concentration-weighted trajectory model was applied with the aim of resolving the spatial distribution of potential distant sources, and the results indicated that emission sources from neighbouring countries, as well as from Slovakia, Greece, Poland and Scandinavian countries, significantly contribute to the observed concentrations.

Keywords: *VOC; PTR-MS; Source apportionment; Unmix; CWT; TSA.*

Passive air sampling for determining the levels of ambient PCDD/Fs and their seasonal and spatial variations and inhalation risk in Shanghai, China

Yajun Tian, Zhiqiang Nie, Shulei Tian, Feng Liu, Jie He, Yufei Yang, Xingrun Wang, Qingqi Die, Yanyan Fang, Qifei Huang

Source: *Environmental Science and Pollution Research, September 2015, Volume 22, Issue 17, pp 13243-13250, DOI 10.1007/s11356-015-4552-1*

The seasonal and spatial variations, compositional profiles, and possible sources of polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans (PCDD/Fs) in ambient air samples in Shanghai of China were investigated by passive air samplers, and the potential inhalation risks posed by these chemicals were evaluated. The following results were obtained: (1) The World Health Organization (WHO) toxic

equivalency (TEQ) values for PCDD/Fs were in the range of 10.8–259 fg m−3 (mean 63.4 fg m−3) in summer and 24.1–154 fg m−3 (mean 83.4 fg m−3) in winter. Atmospheric PCDD/F levels were in the following order: industrial areas > commercial and residential areas > rural areas. (2) 2,3,4,7,8-PeCDF (24 %), 2,3,7,8-TeCDD (16 %), 1,2,3,7,8-PeCDD (13 %), and 2,3,7,8-TeCDF (12 %) were the predominant contributors to the TEQ of PCDD/Fs. (3) There was a slight seasonal trend with higher TEQ values in winter than in summer, which could be related to seasonal variations in the dispersion of PCDD/Fs in ambient air. (4) The children's daily intake was at the lower end of the range for the tolerable daily intake of PCDD/Fs recommended by WHO, which indicates that the inhalation risk of PCDD/Fs for local residents in Shanghai is relatively low.

Keywords: *PCDD/Fs; Atmosphere; Seasonal and spatial variations; Passive sampling; Inhalation risk.*

Characterization of carbonaceous aerosols at Mount Lu in South China: implication for secondary organic carbon formation and long-range transport

Peng-hui Li , Yan Wang , Tao Li, Lei Sun, Xianliang Yi, Li-qiong Guo, Rui-hong Su

Source: *Environmental Science and Pollution Research, September 2015, Volume 22, Issue 18, pp 14189-14199, DOI, 10.1007/s11356-015-4654-9*

In order to understand the sources and potential formation processes of atmospheric carbonaceous aerosols in South China, fine particle samples were collected at a high-elevation mountain site—Mount Lu (29°35′ N, 115°59′ E, 1165 m A.S.L.) during August–September, 2011. Eight carbonaceous fractions from particles were resolved following the IMPROVE thermal/optical reflectance protocol. During the observation campaign, the daily concentrations of PM2.5 at Mount Lu ranged from 7.69 to 116.39 μg/m3, with an average of 58.76 μg/m3. The observed average organic carbon (OC) and elemental carbon (EC) concentrations in PM2.5 were 3.78 and 1.28 μg/m3, respectively. Secondary organic carbon (SOC) concentration, estimated by EC-tracer method, was 2.07 μg/m3 on average, accounting for 45.0 % of the total OC. The enhancement of secondary organic aerosol (SOA) formation was observed during cloud/fog processing, and heterogeneous acid-catalyzed reactions may have contributed to SOA formation as well. Back trajectory analysis indicated that air masses were mainly sourced from southern China during observation period, and this air mass source was featured by highest values of OC and effective carbon ratio (ECR). Relation of carbonaceous species and principal component analysis indicated that multiple sources contributed to the carbonaceous aerosols at Mount Lu.

Keywords: *Carbonaceous aerosols; Free troposphere; Formation mechanism; Long-range transport; Source analysis.*

Effects of urbanization on gaseous and particulate polycyclic aromatic hydrocarbons and polychlorinated biphenyls in a coastal city, China: levels, sources, and health risks

Youwei Hong, Jinsheng Chen , Fuwang Zhang, Han Zhang , Lingling Xu, Liqian Yin, Yanting Chen

Source: *Environmental Science and Pollution Research, October 2015, Volume 22, Issue 19, pp 14919-14931, DOI 10.1007/s11356-015-4616-2*

Gas/particle distributions of polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs) were measured in Xiamen from May 2009 to March 2010 to evaluate the impacts of urbanization on the fate of persistent organic pollutants (POPs) in the atmospheric environment. In a newly developing area (NDA), the concentrations of 16 PAHs (gas + particle) were significantly higher than that a historically urbanized area (HUA) (p value <0.05), while the trend of 28 PCBs was reversed. Diagnostic ratios and principle component analysis (PCA) implied that atmospheric PAHs in the NDA were mainly derived from petrogenic combustion, including mixed sources of vehicle emissions, biomass burning and oil combustion, while pyrogenic combustion (e.g., traffic and coal combustion) was considered the major source of PAHs in the HUA. Atmospheric PCBs in both HUA and NDA were dominated by TriCBs and PeCBs related to the use of commercial mixtures (Aroclors 1242 and 1254). Based on the toxicological equivalent factor (TEF) approach, total benzo[a]pyrene equivalent values in the HUA and NDA were 1.12 and 2.02 ng m−3, respectively, exceeding the standard threshold values (1.0 ng m−3) of China and WHO. Average daily intake of dioxin-like compounds was 0.2 pg kg−1 day−1 in the HUA, which are below the WHO tolerable daily intake level. The results showed that the contribution to the toxic equivalency (TEQ) was dominated by PCB169, PCB105, and PCB81.

Keywords: *PAHs; PCBs; Gas-particle distribution; Urbanization; Sources; Toxicological equivalent.*

Chemical characterization and spatial distribution of PAHs and heavy hydrocarbons in rural sites of Campania Region, South Italy

D. Monaco, A. Riccio, E. Chianese, P. Adamo, S. Di Rosa, M. Fagnano

Source: *Environmental Science and Pollution Research, October 2015, Volume 22, Issue 19, pp 14993-15003, DOI 10.1007/s11356-015-4733-y*

In this paper, the behaviour and distribution patterns of heavy hydrocarbons and several polycyclic aromatic hydrocarbon (PAH) priority pollutants, as listed by the US Environmental Protection Agency, were evaluated in 891 soil samples. The samples were collected in three expected polluted rural sites in Campania (southern Italy) as part of the LIFE11 ECOREMED project, funded by the European Commission, to test innovative agriculture-based soil restoration techniques. These sites have been selected because they have been used for the temporary storage of urban and building waste (Teverola), subject to illicit dumping of unknown material (Trentola-Ducenta), or suspected to be polluted by metals due to agricultural practices (Giugliano). Chemical analysis of soil samples allowed the baseline pollution levels to be determined prior to any intervention. It was found that these areas can be considered contaminated for residential use, in accordance with Italian environmental law (Law Decree 152/2006). Statistical analysis applied to the data proved that average mean concentrations of heavy hydrocarbons could be as high as 140 mg/kg of dry soil with peaks of 700 mg/kg of dry soil, for the Trentola-Ducenta site; the median concentration of analytical results for hydrocarbon (HC) concentration for the Trentola-Ducenta and Giugliano sites was 63 and 73.4 mg/kg dry soil, respectively; for Teverola, the median level was 35 mg/kg dry soil. Some PAHs (usually

benzo(a)pyrene) also exceeded the maximum allowed level in all sites. From the principal component analysis applied to PAH concentrations, it emerged that pollutants can be supposed to derive from a single source for the three sites. Diagnostic ratios calculated to determine possible PAH sources suggest petroleum combustion or disposal practice. Our sampling protocol also showed large dishomogeneity in soil pollutant spatial distribution, even at a scale as small as 3.3 m, indicating that variability could emerge at very short spatial scales.

Keywords: *Heavy hydrocarbons; PAHs; Soil pollution; Waste disposal; Small-scale sampling; Campania rural areas.*

Causal relationship between CO_2emissions, real GDP, energy consumption, financial development, trade openness, and urbanization in Tunisia

Sahbi Farhani , Ilhan Ozturk

Source: *Environmental Science and Pollution Research, October 2015, Volume 22, Issue 20, pp 15663-15676, DOI 10.1007/s11356-015-4767-1*

The aim of this paper is to examine the causal relationship between CO2 emissions, real GDP, energy consumption, financial development, trade openness, and urbanization in Tunisia over the period of 1971–2012. The long-run relationship is investigated by the auto-regressive distributed lag (ARDL) bounds testing approach to cointegration and error correction method (ECM). The results of the analysis reveal a positive sign for the coefficient of financial development, suggesting that the financial development in Tunisia has taken place at the expense of environmental pollution. The Tunisian case also shows a positive monotonic relationship between real GDP and CO2 emissions. This means that the results do not support the validity of environmental Kuznets curve (EKC) hypothesis. In addition, the paper explores causal relationship between the variables by using Granger causality models and it concludes that financial development plays a vital role in the Tunisian economy.

Keywords: *Environmental Kuznets curve (EKC); Auto-regressive distributed lag (ARDL); bounds testing approach; Tunisia.*

Indoor air quality in a restaurant kitchen using margarine for deep-frying

Sait C. Sofuoglu, Melis Toprak, Fikret Inal, Arif H. Cimrin

Source: *Environmental Science and Pollution Research, October 2015, Volume 22, Issue 20, pp 15703-15711, DOI 10.1007/s11356-015-4762-6*

Indoor air quality has a great impact on human health. Cooking, in particular frying, is one of the most important sources of indoor air pollution. Indoor air CO, CO2, particulate matter (PM), and volatile organic compound (VOC) concentrations, including aldehydes, were measured in the kitchen of a small establishment where a special deep-frying margarine was used. The objective was to assess occupational exposure concentrations for cooks of such restaurants. While individual VOC and PM2.5 concentrations were measured before, during, and after frying events using active sampling, TVOC, PM10, CO, CO2, temperature, and relative humidity were continuously monitored through the whole period. VOC and aldehyde concentrations did not increase to considerable levels with deep-frying compared to the background and public indoor environment levels, whereas PM10 increased significantly (1.85 to 6.6 folds). The average

PM2.5 concentration of the whole period ranged between 76 and 249 μg/m3. Hence, considerable PM exposures could occur during deep-frying with the special margarine, which might be sufficiently high to cause health effects on cooks considering their chronic occupational exposures.

Keywords: *Indoor air quality; Restaurant Kitchen; Deep-frying; Margarine.*

Energy analyses and greenhouse gas emissions assessment for saffron production cycle

Amir Abbas Bakhtiari, Amir Hematian, Azin Sharifi

Source: *Environmental Science and Pollution Research, October 2015, Volume 22, Issue 20, pp 16184-16201, DOI 10.1007/s11356-015-4843-6*

Population growth and world climate changes are putting high pressure on agri-food production systems. Exacerbating use of energy sources and expanding the environmental damaging symptoms are the results of these difficult situations. This study was conducted to determine the energy balance for saffron production cycle and investigate the corresponding greenhouse gas (GHG) emissions in Iran. Saffron (Crocus sativus L.) is one of the main spice that historically cultivated in Iran. Data were obtained from 127 randomly selected saffron growers using a face to face questionnaire technique. The results revealed that in 5 years of saffron production cycle, the overall input and output energy use were to be 163,912.09 and 184,868.28 MJ ha−1, respectively. The highest-level of energy consumption belongs to seeds (23.7 %) followed by chemical fertilizers (23.4 %). Energy use efficiency, specific energy, net energy, and energy productivity of saffron production were 1.1, 13.4 MJ kg−1, 20,956.2 MJ ha−1, and 0.1 kg MJ−1, respectively. The result shows that the cultivation of saffron emits 2325.5 kg CO2 eq. ha−1 greenhouse gas, in which around 46.5 % belonged to electricity followed by chemical fertilizers. In addition the Cobb-Douglas production function was applied into EViews 7 software to define the functional relationship. The results of econometric model estimation showed that the impact of human labor, electricity, and water for irrigation on stigma, human labor, electricity, and seed on corm and also human labor and farmyard manure (FYM) on flower and leaf yield were found to be statistically significant. Sensitivity analysis results of the energy inputs demonstrated that the marginal physical productivity (MPP) worth of electricity energy was the highest for saffron stigma and corm, although saffron flower and leaf had more sensitivity on chemicals energy inputs. Moreover, MPP values of renewable and indirect energies were higher than non-renewable and direct energies, respectively.

Keywords: *Energy input; Efficiency Environment Econometric model; GHG emissions; Cobb-Douglas function.*

Spatial distribution of pollutant emissions from crop residue burning in the Punjab and Sindh provinces of Pakistan: uncertainties and challenges

Muhammad Irfan, Muhammad Riaz, Muhammad Saleem Arif , Sher Muhammad Shahzad, Sabir Hussain, Muhammad Javed Akhtar, Leon van den Berg, Farhat Abbas

Source: *Environmental Science and Pollution Research, November 2015, Volume 22, Issue 21, pp 16475-16491, DOI 10.1007/s11356-015-5421-7*

Emissions of gaseous and particulate pollutants from burning of wheat straw, rice straw, cotton straw, and bagasse were studied for the two agricultural-activity-dominated provinces of Pakistan: the Punjab and

Sindh. Emission estimates, inventory, and allocation maps indicated distinct patterns of pollutant emissions in the two provinces. Comparative pollutant emission analysis revealed that the Punjab province produced higher pollutants from agricultural biomass burning than Sindh province. Total emissions from these two provinces were estimated to be 16,084.04 Gg (16.08 Tg) for the year 2006/2007. Wheat straw was found to be the dominant source of CO, CO2, SO2, NOx, and EC emissions in the both provinces. However, for the emissions of CH4, NH3, EC, and OC, the Punjab and Sindh provinces differed markedly for the crop residue share in these pollutant emissions. Rice straw was found to be the largest contributor of CH4 (51 %) and NH3 (65 %) in Sindh province. When total emissions from biomass burning were considered at provincial level, wheat straw and bagasse were the major crop residues which accounted for 72 and 14 % of pollutant emissions, respectively, in the Punjab province, whereas, in Sindh province, the order of crop residue contribution in total emission was as follows: wheat (59 %) > bagasse (19 %) > rice (14 %) > cotton (7 %). Emission inventory data of total pollutants per unit area under cultivation (Mg ha−1) revealed that Sindh province produced higher emissions per hectare for wheat straw, rice straw, and bagasse than the Punjab province.

Keywords: *Crop residue burning; Atmospheric chemistry; Environmental pollution; GIS.*

Characteristics of PM2.5 in Miyun, the northeastern suburb of Beijing: chemical composition and evaluation of health risk

Yang Gao, Xinyue Guo, Cai Li, Huaijian Ding, Lei Tang, Hongbing Ji

Source: *Environmental Science and Pollution Research, November 2015, Volume 22, Issue 21, pp 16688-16699, DOI 10.1007/s11356-015-4851-6*

In recent years, the fine particulate matter pollution has become increasingly serious in Beijing, the capital of China. Being considered as an environment-friendly district of Beijing, current research concerning air pollution in Miyun area was relatively less. From August 24, 2013 to September 29, 2013, 24-h samples were collected in the urban and rural areas of Miyun, Beijing, so as to better understand the sources contributing to PM2.5 and the risk to human health in this district. The data obtained showed that daily PM2.5 mass concentrations ranged from 35.33 to 318.71 μg m−3 in the urban sampling site, which however were between 12.62 and 292.33 μg m−3 in the rural sampling site. At least 23.5 and 41.2 % of the monitoring data, respectively, exceeded the limit value. The mass concentrations of a number of PM2.5 elements fluctuated significantly in the decreasing order of Zn, Ba, Sr, Cu, Pb, Cr, V, Ni, Sb, and Cd. The daily contribution of three cations (NH4 +, K+, and Na+) and four anions (F−, Cl−, NO3 −, and SO4 2−) to PM2.5 mass simultaneously varied from 27.51 to 44.04 % and from 29.54 to 46.14 %. In addition, significant linear correlations between main constituents of the ions (SO4 2−, NO3 −, and NH4 +) at both sites indicated that the majority of NH4 + was probably in the form of ammonium sulfate and ammonium nitrate. The risk levels of carcinogenic heavy metals detected in survey region occurred in the order of Cr, Cd, and Ni, of which, Cr may have a potential risk to the environment. High risk levels of both carcinogenic and non-carcinogenic heavy metals were easy to occur on haze–fog days.

Keywords: *PM2.5; Chemical composition; Health risk; Water-soluble ions; Beijing.*

Fine and ultrafine particles in small cities. A case study in the south of Europe

A. Aranda , Y. Díaz-de-Mera, A. Notario, D. Rodríguez, A. Rodríguez

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Ultrafine particles, PM2.5 and PM10 mass concentration, NOx, Ozone, SO2, back-trajectories of air masses and meteorological parameters were studied in a small city over the period February, 2013 to June, 2014. The profiles of PM2.5 and PM10 particles are provided, showing averaged values of 16.6 and 21.6 μg m−3, respectively. The average number concentration of particles in the range of diameters 5.6–560 nm was 1.2 × 104#/ cm3 with contributions of 42, 51 and 7 % from the nucleation, Aitken, and accumulation modes, respectively. The average number concentration of ultrafine particles was 1.1 × 104#/ cm3. The results obtained are evidence for some differences in the pollution of ambient air by particles in the studied town in comparison to bigger cities. Nucleation events due to emissions from the city were not observed, and traffic emissions amount to a small contribution to PM2.5 and PM10 particles which are mainly due to crustal origin from the arid surroundings and long-range transport from the Sahara Desert.

Keywords: *Aerosol Pollution; Size distribution; Submicron particles; Urban; Nucleation.*

Trends in health burden of ambient particulate matter pollution in Iran, 1990–2010: findings from the global burden of disease study 2010

Parinaz Poursafa, Roya Kelishadi, Anoosheh Ghasemian, Farshad Sharifi, Shirin Djalalinia, Alireza Khajavi, Masoumeh Nejatifar, Hamid Asayesh, Morteza Mansourian, Mostafa Qorbani , Hossein Ansari

Source: *Environmental Science and Pollution Research, December 2015, Volume 22, Issue 23, pp 18645-18653, DOI 10.1007/s11356-015-5545-9*

This paper aims to report the assessment of trends in deaths and disability-adjusted life years (DALYs) attributed to ambient particulate matter (PM) pollution from 1990 to 2010 by sex and age in Iran. We used the data of the Global Burden of Disease (GBD) 2010 Study, and then we extracted its data on Iran for the years 1990, 2005, and 2010. The proportion of deaths and the DALYs caused by specific risk factors were assessed by using the comparative risk assessment and calculating the attributed burden of exposure level to each risk factor compared with the theoretical minimum level of risk exposure. Uncertainties in distribution of exposure, relative risks, and relevant outcomes calculation were disseminated into the estimates of the attributable deaths and DALYs. We found that the age-standardized death rate attributed to ambient PM pollution decreased to 27.90 cases per 100,000 populations from 1990 to 2010 [86, 95 % uncertainty interval (UI) 76–97 to 62; 95 % UI 54–71 per 100,000 populations, respectively]. This was mainly because of greater decrease in cardiovascular diseases (CVDs) than in the other diseases attributed to PM pollution. Despite a decrease in the total DALYs and mortality rate attributed to PM pollution, the death percent increased by 6.94 %, 95 % UI 6.06–7.90 % from 1990 to 2010. The number of the DALYs and death in age groups of more than 70 years increased in 2010 compared to that in 1990. The median percent change of the DALYs and death for all age groups shows that the DALYs and death increased by 6 % (95 % UI 8–19 %) and 45 % (95 % UI 30–60 %), respectively, in 2010 in comparison to that in 1990. The increase in the DALYs and mortality attributable to PM pollution emphasizes the necessity of the effective interventions for improving air quality, as well as for increasing the public awareness to reduce the exposure of vulnerable age groups to PM pollution.

Keywords: *Air pollution; Particulate matter; Burden of diseases; Mortality; Disability-adjusted life years; Iran.*

Residential heating contribution to level of air pollutants (PAHs, major, trace, and rare earth elements): a moss bag case study

Gordana Vuković, Mira Aničić Urošević, Miodrag Pergal, Milan Janković, Zoya Goryainova, Milica Tomašević, Aleksandar Popović

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In areas with moderate to continental climates, emissions from residential heating system lead to the winter air pollution peaks. The EU legislation requires only the monitoring of airborne concentrations of particulate matter, As, Cd, Hg, Ni, and B[a]P. Transition metals and rare earth elements (REEs) have also arisen questions about their detrimental health effects. In that sense, this study examined the level of extensive set of air pollutants: 16 polycyclic aromatic hydrocarbons (PAHs), and 41 major elements, trace elements, and REEs using Sphagnum girgensohnii moss bag technique. During the winter of 2013/2014, the moss bags were exposed across Belgrade (Serbia) to study the influence of residential heating system to the overall air quality. The study was set as an extension to our previous survey during the summer, i.e., non-heating season. Markedly higher concentrations of all PAHs, Sb, Cu, V, Ni, and Zn were observed in the exposed moss in comparison to the initial values. The patterns of the moss REE concentrations normalized to North American Shale Composite and Post-Archean Australian Shales were identical across the study area but enhanced by anthropogenic activities. The results clearly demonstrate the seasonal variations in the moss enrichment of the air pollutants. Moreover, the results point out a need for monitoring of air quality during the whole year, and also of various pollutants, not only those regulated by the EU Directive.

Keywords: *Urban environment; Heating season; Seasonal pollutant variations; Active biomonitoring; Moss bag technique; S. Girgensohnii.*

Influence of road traffic, residential heating and meteorological conditions on PM10 concentrations during air pollution critical episodes

Giovanni Gualtieri, Piero Toscano, Alfonso Crisci, Sara Di Lonardo, Mario Tartaglia, Carolina Vagnoli, Alessandro Zaldei, Beniamino Gioli

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The importance of road traffic, residential heating and meteorological conditions as major drivers of urban PM10 concentrations during air pollution critical episodes has been assessed in the city of Florence (Italy) during the winter season. The most significant meteorological variables (wind speed and atmospheric stability) explained 80.5–85.5 % of PM10 concentrations variance, while a marginal role was played by major emission sources such as residential heating (12.1 %) and road traffic (5.7 %). The persistence of low wind speeds and unstable atmospheric conditions was the leading factor controlling PM10 during critical episodes. A specific PM10 critical episode was analysed, following a snowstorm that caused a “natural” scenario of 2-day dramatic road traffic abatement (−43 %), and a massive (up to +48 %) and persistent (8 consecutive days) increase in residential heating use. Even with such a strong variability in local PM10

emissions, the role of meteorological conditions was prominent, revealing that short-term traffic restrictions are insufficient countermeasures to reduce the health impacts and risks of PM10 critical episodes, while efforts should be made to anticipate those measures by linking them with air quality and weather forecasts.

Keywords: *Particulate matter; Critical episodes; Restriction policy; Anthropogenic sources; Weather conditions.*

Utilization of air pollution control residues for the stabilization/solidification of trace element contaminated soil

Travar, A. Kihl, J. Kumpiene

Source: *Environmental Science and Pollution Research, December 2015, Volume 22, Issue 23, pp 19101-19111, DOI 10.1007/s11356-015-5087-1*

The aim of this study was to evaluate the stabilization/solidification (S/S) of trace element-contaminated soil using air pollution control residues (APCRs) prior to disposal in landfill sites. Two soil samples (with low and moderate concentrations of organic matter) were stabilized using three APCRs that originated from the incineration of municipal solid waste, bio-fuels and a mixture of coal and crushed olive kernels. Two APCR/soil mixtures were tested: 30 % APCR/70 % soil and 50 % APCR/50 % soil. A batch leaching test was used to study immobilization of As and co-occurring metals Cr, Cu, Pb and Zn. Solidification was evaluated by measuring the unconfined compression strength (UCS). Leaching of As was reduced by 39–93 % in APCR/soil mixtures and decreased with increased amounts of added APCR. Immobilization of As positively correlated with the amount of Ca in the APCR and negatively with the amount of soil organic matter. According to geochemical modelling, the precipitation of calcium arsenate (Ca3(AsO4)2/4H2O) and incorporation of As in ettringite (Ca6Al2(SO4)3(OH)12 · 26H2O) in soil/APCR mixtures might explain the reduced leaching of As. A negative effect of the treatment was an increased leaching of Cu, Cr and dissolved organic carbon. Solidification of APCR/soil was considerably weakened by soil organic matter.

Keywords: *Immobilization; Chromium; Copper; Calcium arsenate; Geochemical modelling.*

Effects of ambient PM2.5 on pathological injury, inflammation, oxidative stress, metabolic enzyme activity, and expression of c-fos and c-jun in lungs of rats

Ruijin Li, Xiaojing Kou, Lizhi Xie, Fangqin Cheng , Hong Geng

Source: *Environmental Science and Pollution Research, December 2015, Volume 22, Issue 24, pp 20167-20176, DOI 10.1007/s11356-015-5222-z*

Fine particulate matter (PM2.5) exposure is associated with morbidity and mortality induced by respiratory diseases and increases the lung cancer risk. However, the mechanisms therein involved are not yet fully clarified. In this study, the PM2.5 suspensions at different dosages (0.375, 1.5, 6.0, and 24.0 mg/kg body weight) were respectively given to rats by the intratracheal instillation. The results showed that PM2.5 exposure induced inflammatory cell infiltration and hyperemia in the lung tissues and increased the inflammatory cell numbers in bronchoalveolar lavage fluid. Furthermore, PM2.5 significantly elevated the levels of pro-inflammatory mediators including tumor necrosis factor-α (TNF-α), interleukin (IL)-6, IL-1β, and intercellular adhesion molecule 1 (ICAM-1) and the expression of c-fos and c-jun in rat lungs exposed to higher dose of PM2.5. These changes were accompanied by decreases of activities of superoxide dismutase

and increases of levels of malondialdehyde, inducible nitric oxide synthase, nitric oxide, cytochrome P450s, and glutathione S-transferase. The results implicated that acute exposure to PM2.5 induced pathologically pulmonary changes, unchained inflammatory and oxidative stress processes, activated metabolic enzyme activity, and enhanced proto-oncogene expression, which might be one of the possible mechanisms by which PM2.5 pollution induces lung injury and may be the important determinants for the susceptibility to respiratory diseases.

Keywords: *PM2.5; Rat lung injury; Inflammation; Proto-oncogene; Metabolic enzyme; Oxidative stress.*

SECTION -VI
Journal of Geophysical Research

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Impacts of upwind wildfire emissions on CO, CO2, and PM2.5 concentrations in Salt Lake City, Utah

D. V. Mallia, J. C. Lin, S. Urbanski, J. Ehleringer, T. Nehrkorn

Source: *Journal of Geophysical Research, January 2015, Vol: 120, Pages: 147–166, DOI: 10.1002/2014JD022472*

Biomass burning is known to contribute large quantities of CO2, CO, and PM2.5 to the atmosphere. Biomass burning not only affects the area in the vicinity of fire but may also impact the air quality far downwind from the fire. The 2007 and 2012 western U.S. wildfire seasons were characterized by significant wildfire activity across much of the Intermountain West and California. In this study, we determined the locations of wildfire-derived emissions and their aggregate impacts on Salt Lake City, a major urban center downwind of the fires. To determine the influences of biomass burning emissions, we initiated an ensemble of stochastic back trajectories at the Salt Lake City receptor within the Stochastic Time-Inverted Lagrangian Transport (STILT) model, driven by wind fields from the Weather Research and Forecasting (WRF) model. The trajectories were combined with a new, high-resolution biomass burning emissions inventory—the Wildfire Emissions Inventory. Initial results showed that the WRF-STILT model was able to replicate many periods of enhanced wildfire activity observed in the measurements. Most of the contributions for the 2007 and 2012 wildfire seasons originated from fires located in Utah and central Idaho. The model results suggested that during intense episodes of upwind wildfires in 2007 and 2012, fires contributed as much as 250 ppb of CO during a 3 h period and 15 μg/m3 of PM2.5 averaged over 24 h at Salt Lake City. Wildfires had a much smaller impact on CO2 concentrations in Salt Lake City, with contributions rarely exceeding 2 ppm enhancements.

Comprehensive study of emission source contributions for tropospheric ozone formation over East Asia

Syuichi Itahashi, Hiroshi Hayami, Itsushi Uno

Source: *Journal of Geophysical Research, January 2015, DOI: 10.1002/2014JD022117*

Emission source contributions of tropospheric ozone (O3) were comprehensively investigated by using the higher-order decoupled direct method (HDDM) for sensitivity analysis and the ozone source apportionment technology (OSAT) for mass balance analysis in the comprehensive air-quality model with extensions (CAMx). The response of O3 to emissions reductions at various levels in mainland China, Korea, and Japan were estimated and compared with results calculated by the brute force method (BFM) where one model parameter is varied at a time. Emissions were assessed at three receptor sites in Japan that experienced severe pollution events in May 2009. For emissions from China, HDDM assessed O3 response with a bias of only up to 3 ppbv (a relative error of 4.5%) even for a 50% reduction but failed to assess a more extreme reduction. OSAT was reasonably accurate at 100% reduction, with a −4 ppbv (−7%) bias, but was less accurate at moderate ranges of reduction (∼50–70%). For emissions from Korea and Japan, HDDM captured the nonlinear response at all receptor sites and at all reduction levels to within 1% in all but one case; however, the bias of OSAT increased with the increasing reduction of emissions. One possible reason for this is that OSAT does not account for NO titration. To address this, a term for potential ozone (PO; O3 and NO2 together) was introduced. Using of PO instead of O3 improved the performance of OSAT, especially for emissions reductions from Korea and Japan. The proposed approach with PO refined the OSAT results and did not degrade HDDM performance.

Impacts of urbanization on Indian summer monsoon rainfall extremes

Hiteshri Shastri, Supantha Paul, Subimal Ghosh, Subhankar Karmakar

Source: *Journal of Geophysical Research, January 2015, DOI: 10.1002/2014JD022061*

Urban areas have different climatology with respect to their rural surroundings. Though urbanization is a worldwide phenomenon, it is especially prevalent in India, where urban areas have experienced an unprecedented rate of growth over the last 30 years. Here we take up an observational study to understand the influence of urbanization on the characteristics of precipitation (specifically extremes) in India. We identify 42 urban regions and compare their extreme rainfall characteristics with those of surrounding rural areas. We observe that, on an overall scale, the urban signatures on extreme rainfall are not prominently and consistently visible, but they are spatially nonuniform. Zonal analysis reveals significant impacts of urbanization on extreme rainfall in central and western regions of India. An additional examination, to understand the influences of urbanization on heavy rainfall climatology, is carried with station level data using a statistical method, quantile regression. This is performed for the most populated city of India, Mumbai, in pair with a nearby nonurban area, Alibaug; both having similar geographic location. The derived extreme rainfall regression quantiles reveal the sensitivity of extreme rainfall events to the increased urbanization. Overall the study identifies the climatological zones in India, where increased urbanization affects regional rainfall pattern and extremes, with a detailed case study of Mumbai. This also calls attention to the need of further experimental investigation, for the identification of the key climatological processes, in different regions of India, affected by increased urbanization.

Influence of aerosols in multidecadal SST variability simulations over the North Pacific

Kyung-On Boo, Ben B. B. Booth, Young-Hwa Byun, Johan Lee, ChunHo Cho, Sungbo Shim, Kyun-Tae Kim

Source: *Journal of Geophysical Research, January 2015, DOI: 10.1002/2014JD021933*

The influence of aerosol emissions on North Pacific sea surface temperature (SST) variability during the twentieth century is investigated using a comparison between historical simulations with and without anthropogenic aerosol changes. The historical simulations using the Hadley Global Environment Model version 2 show that there is a common externally forced component in relation to the twentieth century North Pacific SST variability. This matches a number of important temporal and spatial characteristics of the observed multidecadal SST variability from the 1920s to 1990s, which is not found in experiments without aerosol changes. This paper explores both direct and indirect aerosol influences, and finds that in this model the aerosol-cloud interactions dominate the total aerosol forcing of the surface energy budget. These aerosol-cloud processes were not commonly included in most models in the previous (Coupled Model Intercomparison Project phase 3) generation, which may explain why the potential role of aerosols in Pacific variability has not been previously discussed. However, unlike recently reported aerosol drivers of Atlantic SST variability, the aerosol surface radiative forcing pattern does not map directly onto the historical spatial surface radiative and SST changes but is instead modulated by circulation changes to the Aleutian Low. These circulation changes share common features with previously reported studies of natural drivers of Pacific variability, suggesting that both forced and internally generated SST variability may be modulated via the same circulation response.

Comparison of aerosol properties over Beijing and Kanpur: Optical, physical properties and aerosol component composition retrieved from 12 years ground-based Sun-sky radiometer remote sensing data

Zhengqiang Li, Lei Li, Fengxia Zhang, Donghui Li, Yisong Xie, Hua Xu

Source: *Journal of Geophysical Research, February 2015, DOI: 10.1002/2014JD022593*

Aerosol mixtures composed of coarse and fine particles occur frequently in metropolitan areas in the world, especially in developing countries. Beijing, China, and Kanpur, India, are both in Asian monsoon regions and experience strong aerosol loading because of increased economic activities, vehicles, and urbanization. Observations originating from the Aerosol Robotic Network (AERONET) have played a vital role in the field of aerosol study. In order to understand the variations of aerosol optical, physical properties and component composition over Beijing and Kanpur, we focus on AERONET measurements collected at these two sites from 2002 to 2013 and employ a five-component (including black carbon, BC; mineral dust, DU; brown carbon, BrC; ammonium sulfate like, AS; and aerosol water content, AW) aerosol mixture model to retrieve the aerosol component composition. Particle size distribution, spectral characteristics of single-scattering albedo, and refractive indices of the aerosols over Beijing and Kanpur are found to be distinct and with regular seasonal variations. Correspondingly, aerosol components show distinct temporal characteristics at both sites. In Beijing, BC shows a significant decrease from 2002 to 2013 (especially after 2007) with an average declining rate of $0.69\ \mathrm{mg\ m^{-2}\ yr^{-1}}$. Among the five components, BC and BrC are higher during winter and autumn especially at Beijing, while DU and AS are higher during spring and summer at the two sites. With respect to site differences, BC and BrC are usually higher in Beijing in most of the year, while DU and AS are higher in Kanpur especially from April to June. Moreover, AW is similar and quite comparable at two sites.

Estimates of CO2 traffic emissions from mobile concentration measurements

H. L. Maness, M. E. Thurlow, B. C. McDonald, R. A. Harley

Source: *Journal of Geophysical Research, March 2015, DOI: 10.1002/2014JD022876*

We present data from a new mobile system intended to aid in the design of upcoming urban CO2-monitoring networks. Our collected data include GPS probe data, video-derived traffic density, and accurate CO2 concentration measurements. The method described here is economical, scalable, and self-contained, allowing for potential future deployment in locations without existing traffic infrastructure or vehicle fleet information. Using a test data set collected on California Highway 24 over a 2 week period, we observe that on-road CO2 concentrations are elevated by a factor of 2 in congestion compared to free-flow conditions. This result is found to be consistent with a model including vehicle-induced turbulence and standard engine physics. In contrast to surface concentrations, surface emissions are found to be relatively insensitive to congestion. We next use our model for CO2 concentration together with our data to independently derive vehicle emission rate parameters. Parameters scaling the leading four emission rate terms are found to be within 25% of those expected for a typical passenger car fleet, enabling us to derive instantaneous emission rates directly from our data that compare generally favorably to predictive models presented in the literature. The present results highlight the importance of high spatial and temporal resolution traffic data for interpreting on- and near-road concentration measurements. Future work will focus on transport and the integration of mobile platforms into existing stationary network designs.

The effect of aerosols and sea surface temperature on China's climate in the late twentieth century from ensembles of global climate simulations

D. Folini, M. Wild

Source: *Journal of Geophysical Research, March 2015, DOI: 10.1002/2014JD022851*

Over the late twentieth century, China has seen a strong increase in aerosol emissions, whose quantitative role for observed changes in surface solar radiation (SSR), surface air temperature (SAT), and precipitation remains debated. We use ensembles of transient sensitivity experiments with the global climate model ECHAM5 from the Max Planck Institute for Meteorology, Hamburg, Germany, combined with the Hamburg Aerosol Module to examine the effect of aerosols and prescribed, observation-based sea surface temperatures (SSTs) on the above variables. Observations and control experiments agree reasonably well in eastern China in terms of SSR dimming (−6 ± 2 W/m2/decade, 1960–2000; stronger than in models of the Coupled Model Intercomparison Project Phase 5, CMIP5), statistically nonsignificant summer SAT trend (1950–2005), and drying in summer from 1950 to 1990 (−2.5% to −3.5% per decade, essentially via reduction of convective precipitation). Other observed features are not reproduced by the model, e.g., precipitation increase in the 1990s in the Yangtze River valley or, from the 1960s onward, the strong winter warming in northern China and Mongolia and SSR dimming in western China. Aerosol effects are stronger for sulfur dioxide than for black and organic carbon and are more pronounced at lower model resolution. Transient SSTs are crucial for decadal-scale SAT variability over land, especially the strong warming in the 1990s, and, via SST forced reduction of cloud cover, for the ceasing of SSR dimming around the year 2000. Unforced cloud variability leads to relevant scatter (up to ±2 W/m2/decade) of modeled SSR trends at individual observation sites.

Impact of the global warming hiatus on Andean temperature

Mathias Vuille, Eric Franquist, René Garreaud, Waldo Sven Lavado Casimiro, Bolivar Cáceres

Source: *Journal of Geophysical Research, May 2015, DOI: 10.1002/2015JD023126*

The recent hiatus in global warming is likely to be reflected in Andean temperature, given its close dependence on tropical Pacific sea surface temperature (SST). While recent work in the subtropical Andes has indeed documented a cooling along coastal areas, trends in the tropical Andes show continued warming. Here we analyze spatiotemporal temperature variability along the western side of the Andes with a dense station network updated to 2010 and investigate its linkages to tropical Pacific modes of variability. Results indicate that the warming in tropical latitudes has come to a halt and that the subtropical regions continue to experience cooling. Trends, however, are highly dependent on elevation. While coastal regions experience cooling, higher elevations continue to warm. The coastal cooling is consistent with the observed Pacific Decadal Oscillation (PDO) fingerprint and can be accurately simulated using a simple PDO-analog model. Much of the PDO imprint is modulated and transmitted through adjustments in coastal SST off western South America. At inland and higher-elevation locations, however, temperature trends start to diverge from this PDO-analog model in the late 1980s and have by now emerged above the 1σ model spread. Future warming at higher elevation is likely and will contribute to further vertical stratification of atmospheric temperature trends. In coastal locations, future warming or cooling will depend on the potential future intensification of the South Pacific anticyclone but also on continued temperature dependence on the state of the PDO.

An analysis of global aerosol type as retrieved by MISR

Ralph A. Kahn, Barbara J. Gaitley

Source: *Journal of Geophysical Research, May 2015, DOI: 10.1002/2015JD023322*

In addition to aerosol optical depth (AOD), aerosol type is required globally for climate forcing calculations, constraining aerosol transport models and other applications. However, validating satellite aerosol-type retrievals is more challenging than testing AOD results, because aerosol type is a more complex quantity, and ground truth data are far less numerous and generally not as robust. We evaluate the Multiangle Imaging Spectroradiometer (MISR) Version 22 aerosol-type retrievals by assessing product self-consistency on a regional basis and by making comparisons with general expectation and with the Aerosol Robotic Network aerosol-type climatology, as available. The results confirm and add detail to the observation that aerosol-type discrimination improves dramatically where midvisible AOD exceeds about 0.15 or 0.2. When the aerosol-type information content of the observations is relatively low, increased scattering-angle range improves particle-type sensitivity. The MISR standard, operational product discriminates among small, medium, and large particles and exhibits qualitative sensitivity to single-scattering albedo (SSA) under good aerosol-type retrieval conditions, providing a categorical aerosol-type classification. MISR Ångström exponent deviates systematically from ground truth where particle types missing from the algorithm climatology are present, or where cloud contamination is likely to occur, and SSA tends to be overestimated where absorbing particles are found. We determined that the number of mixtures passing the algorithm acceptance criteria (#SuccMix) represents aerosol-type retrieval quality effectively, providing a useful aerosol-type quality flag.

Methane emissions in East Asia for 2000–2011 estimated using an atmospheric Bayesian inversion

R. L. Thompson, A. Stohl, L. X. Zhou, E. Dlugokencky, Y. Fukuyama, Y. Tohjima, S.-Y. Kim, H. Lee, E. G. Nisbet, R. E. Fisher, D. Lowry, R. F. Weiss, R. G. Prinn, S. O'Doherty, D. Young, J. W. C. White

Source: *Journal of Geophysical Research, May 2015, DOI: 10.1002/2014JD022394*

We present methane (CH4) emissions for East Asia from a Bayesian inversion of CH4 mole fraction and stable isotope (δ13C-CH4) measurements. Emissions were estimated at monthly resolution from 2000 to 2011. A posteriori, the total emission for East Asia increased from 43 ± 4 to 59 ± 4 Tg yr−1 between 2000 and 2011, owing largely to the increase in emissions from China, from 39 ± 4 to 54 ± 4 Tg yr−1, while emissions in other East Asian countries remained relatively stable. For China, South Korea, and Japan, the total emissions were smaller than the prior estimates (i.e., Emission Database for Global Atmospheric Research 4.2 FT2010 for anthropogenic emissions) by an average of 29%, 20%, and 23%, respectively. For Mongolia, Taiwan, and North Korea, the total emission was less than 2 Tg yr−1 and was not significantly different from the prior. The largest reductions in emissions, compared to the prior, occurred in summer in regions important for rice agriculture suggesting that this source is overestimated in the prior. Furthermore, an analysis of the isotope data suggests that the prior underestimates emissions from landfills and ruminant animals for winter 2010 to spring 2011 (no data available for other times). The inversion also found a lower average emission trend for China, 1.2 Tg yr−1 compared to 2.8 Tg yr−1 in the prior. This trend was not constant, however, and increased significantly after 2005, up to 2.0 Tg yr−1. Overall, the changes in emissions from China explain up to 40% of the increase in global emissions in the 2000s.

Airborne measurements of the atmospheric emissions from a fuel ethanol refinery

J. A. de Gouw, S. A. McKeen, K. C. Aikin, C. A. Brock, S. S. Brown, J. B. Gilman, M. Graus, T. Hanisco, J. S. Holloway, J. Kaiser, F. N. Keutsch, B. M. Lerner, J. Liao, M. Z. Markovic, A. M. Middlebrook, K.-E. Min, J. A. Neuman, J. B. Nowak, J. Peischl, I. B. Pollack, J. M. Roberts, T. B. Ryerson, M. Trainer, P. R. Veres, C. Warneke, A. Welti, G. M. Wolfe

Source: *Journal of Geophysical Research, May 2015, DOI: 10.1002/2015JD023138*

Ethanol made from corn now constitutes approximately 10% of the fuel used in gasoline vehicles in the U.S. The ethanol is produced in over 200 fuel ethanol refineries across the nation. We report airborne measurements downwind from Decatur, Illinois, where the third largest fuel ethanol refinery in the U.S. is located. Estimated emissions are compared with the total point source emissions in Decatur according to the 2011 National Emissions Inventory (NEI-2011), in which the fuel ethanol refinery represents 68.0% of sulfur dioxide (SO2), 50.5% of nitrogen oxides (NOx = NO + NO2), 67.2% of volatile organic compounds (VOCs), and 95.9% of ethanol emissions. Emissions of SO2 and NOx from Decatur agreed with NEI-2011, but emissions of several VOCs were underestimated by factors of 5 (total VOCs) to 30 (ethanol). By combining the NEI-2011 with fuel ethanol production numbers from the Renewable Fuels Association, we calculate emission intensities, defined as the emissions per ethanol mass produced. Emission intensities of SO2 and NOx are higher for plants that use coal as an energy source, including the refinery in Decatur. By comparing with fuel-based emission factors, we find that fuel ethanol refineries have lower NOx, similar VOC, and higher SO2 emissions than from the use of this fuel in vehicles. The VOC emissions from refining could be higher than from vehicles, if the underestimated emissions in NEI-2011 downwind from Decatur extend to other fuel ethanol refineries. Finally, chemical transformations of the emissions from Decatur were observed, including formation of new particles, nitric acid, peroxyacyl nitrates, aldehydes, ozone, and sulfate aerosol.

Laboratory measurements of emission factors of nonmethane volatile organic compounds from burning of Chinese crop residues

Satoshi Inomata, Hiroshi Tanimoto, Xiaole Pan, Fumikazu Taketani, Yuichi Komazaki, Takuma Miyakawa, Yugo Kanaya, Zifa Wang

Source: *Journal of Geophysical Research, May 2015, DOI: 10.1002/2014JD022761*

The emission factors (EFs) of nonmethane volatile organic compounds (NMVOCs) emitted during the burning of Chinese crop residue were investigated as a function of modified combustion efficiency in laboratory experiments. NMVOCs, including acetonitrile, aldehydes/ketones, furan, and aromatic hydrocarbons, were monitored by proton-transfer-reaction mass spectrometry. Rape plant was burned in dry conditions and wheat straw was burned in both wet and dry conditions to simulate the possible burning of damp crop residue in regions of high temperature and humidity. We compared the present data to field data reported by Kudo et al. (2014). Good agreement between field and laboratory data was obtained for aromatics under relatively more smoldering combustion of dry samples, but laboratory data were slightly overestimated compared to field data for oxygenated VOC (OVOC). When EFs from the burning of wet samples were investigated, the consistency between the field and laboratory data for OVOCs was stronger than for dry samples. This may be caused by residual moisture in crop residue that has been stockpiled in humid regions. Comparison of the wet laboratory data with field data suggests that Kudo et al. (2014) observed the biomass burning plumes under relatively more smoldering conditions in which approximately a few tens of percentages of burned fuel materials were wet.

The role of foehn in the formation of heavy air pollution events in Urumqi, China

X. Li, X. Xia, L. Wang, R. Cai, L. Zhao, Z. Feng, Q. Ren, K. Zhao

Source: *Journal of Geophysical Research, June 2015, DOI: 10.1002/2014JD022778*

The impact of sandwich foehn on air pollution in Urumqi, a gap town located on the northern lee side of the Tianshan Mountains of China, is analyzed. The results show that during days with high pollution, the boundary layer over the city and the down-valley area can be divided into a three-layer structure, with the southeasterly foehn sandwiched between the northwesterly winds on top and the cold air surface pool beneath. The southeasterly foehn at heights between 480 and 2100 m results in a very stable boundary layer structure. In combination with the decoupling between the foehn flow and cold air pool, such boundary layer structure prevents vertical mixing of atmospheric pollutants. In the up-valley area from the northern lee side flank to the southern urban area, the ground-based foehn confronts the thermally driven valley breeze and forms a "minifront," which moves northward in the morning and retreats southward in the afternoon. Although the minifront disappears in the early evening, the wind shear of the mountain breeze between the southern suburb and downtown areas is still remarkable, which is favorable for a convergence line to persist around the city all day long. In this case, air pollutants emitted from the up-valley and down-valley areas are transported toward the urban area. Therefore, the air pollutants accumulate daily, leading to the frequent occurrence of heavy pollution events in Urumqi. This indicates that the sandwich foehn plays a critical role in the formation of heavy air pollution events in Urumqi.

The interactions between anthropogenic aerosols and the East Asian summer monsoon using RegCCMS

T. J. Wang, B. L. Zhuang, S. Li, J. Liu, M. Xie, C. Q. Yin, Y. Zhang, C. Yuan, J. L. Zhu, L. Q. Ji, Y. Han

Source: *Journal of Geophysical Research, June 2015, DOI: 10.1002/2014JD022877*

An online coupled regional climate-chemistry model called RegCCMS is used to investigate the interactions between anthropogenic aerosols and the East Asian summer monsoon (EASM) over East Asia. The simulation results show that the mean aerosol loading and optical depth over the region are 17.87 mg/m2 and 0.25, respectively. Sulfate and black carbon (BC) account for approximately 61.2% and 7.8% of the total aerosols, respectively. The regional mean radiative forcing (RF) is approximately −3.64, −0.55, and +0.88 W/m2 at the top of the atmosphere for the total aerosol effect, the total aerosol direct effect, and the BC direct effect, respectively. The surface direct RF of BC accounts for approximately 31% of the total RF of all aerosols. Because of the total aerosol effect, both the energy budgets and air temperature are considerably reduced in the region with high aerosol loadings, leading to decreases in the land-ocean air temperature gradient in summer. The total column-absorbed solar radiation and surface air temperature decrease by 8.4 W/m2 and 0.31 K, respectively. This cooling effect weakens horizontal and vertical atmospheric circulations over East Asia. The wind speed at 850 hPa decreases by 0.18 m/s, and the precipitation decreases by 0.29 mm/d. The small responses of solar radiation, air temperature, and atmospheric circulations to the BC warming effect are opposite to those of the total aerosol effect. The BC-induced enhancement of atmospheric circulation can increase local floods in south China, while droughts in north China may worsen in response to the BC semidirect effect. The total aerosol effect is much more significant than the BC direct effect. The East Asian summer monsoon becomes weaker due to the total aerosol effect. However, this weakness could be partially offset by the BC warming effect. Sensitivity analyses further indicate that the influence of aerosols on the EASM might be more substantial in years when

the southerlies or southwesterlies at 850 hPa are weak compared with years when the winds are strong. Changes in the EASM can induce variations in the distribution and magnitude of aerosols. Aerosols in the lower troposphere over the region can increase by 3.07 and 1.04 μg/m3 due to the total aerosol effect and the BC warming effect, respectively.

Effects of a changing climate on summertime fine particulate matter levels in the eastern U.S.

Melissa C. Day, Spyros N. Pandis

Source: *Journal of Geophysical Research, June 2015, DOI: 10.1002/2014JD022889*

The chemical transport model PMCAMx is used to examine the effect of climate change on fine (under 2.5 μms) particulate matter (PM2.5) during the summer in the eastern United States. Meteorology from 10 years in the 1990s (present) and 10 years in the 2050s (future) based on the Intergovernmental Panel on Climate Change A2 scenario is used. Anthropogenic pollutant emissions are assumed to remain constant, while biogenic emissions are climate sensitive and, depending on species, increase between 15 and 27% on average. The predicted changes of PM2.5 are modest (increases of less than 10% on average across the domain) and quite variable in space, ranging from +13% in the Plains to −7% in the Northeast. Variability is driven concurrently by changes in temperature, wind speed, rainfall, and relative humidity, with no single dominant meteorological factor. Sulfate and organic aerosol are responsible for most of the PM2.5 change. The improved treatment of organic aerosol using the volatility basis set does not increase significantly its sensitivity to climate change compared to traditional treatments that neglect the volatility of primary particles and do not simulate the chemical aging processes. Future organic aerosol is predicted to be more oxidized due to increases of its secondary biogenic and anthropogenic components. These results suggest that the effects of planned and expected emission anthropogenic emission controls will be more important than those of climate change for PM2.5 concentrations in 2050. Maximum daily 8 h average ozone increases by 5% on average are predicted, with a marked increase in the Northeast, Southeast, and Midwest.

Traffic-related air quality trends in São Paulo, Brazil

Pedro José Pérez-Martínez, María de Fátima Andrade, Regina Maura de Miranda

Source: *Journal of Geophysical Research, June 2015, DOI: 10.1002/2014JD022812*

The urban population of South America has grown at 1.05%/yr, greater urbanization increasing problems related to air pollution. In most large cities in South America, there has been no continuous long-term measurement of regulated pollutants. One exception is São Paulo, Brazil, where an air quality monitoring network has been in place since the 1970s. In this paper, we used an air quality-based approach to determine pollutant trends for emissions of carbon monoxide (CO), nitrogen oxides (NOx), ozone (O3), and coarse particulate matter (PM10), mostly from mobile sources, in the Metropolitan Region of São Paulo for the 2000–2013 period. Mobile sources included light-duty vehicles (LDVs, comprising gasoline- or ethanol-powered cars and motorcycles) and heavy-duty vehicles (HDVs, comprising diesel-powered trucks and buses). Pollutant concentrations for mobile source emissions were measured and correlated with fuel sales by the emission factors. Over the 2000–2013 period, concentrations of NOx, CO, and PM10 decreased by 0.65, 0.37, and 0.71% month−1, respectively, whereas sales of gasoline, ethanol, and diesel increased by 0.26, 1.96, and 0.38% month−1, respectively. LDVs were the major mobile source of CO, whereas LDVs were the major source of NOx and PM10. Increases in fuel sales and in the corresponding traffic volume were

partially offset by decreases in pollutant concentrations. Between 2000 and 2013, there was a sharp (−5 ppb month−1) decrease in the concentrations of LDV-emitted CO, together with (less dramatic) decreases in the concentrations of HDV-emitted NOx and PM10 (−0.25 and −0.09 ppb month−1, respectively). Variability was greater for HDV-emitted NOx and PM10 (R = −0.47 and −0.41, respectively) than for LDV-emitted CO (R = −0.72). We draw the following conclusions: the observed concentrations of LDV-emitted CO decreased at a sharper rate than did those of HDV-emitted NOx and PM10; mobile source contributions to O3 formation varied significantly, LDVs making a greater contribution during the 2000–2008 period, whereas HDVs made a greater contribution during the 2009–2013 period, and decreases in NOx emissions resulted in increases in O3 observations.

Light-absorbing properties of ambient black carbon and brown carbon from fossil fuel and biomass burning sources

R. M. Healy, J. M. Wang, C.-H. Jeong, A. K. Y. Lee, M. D. Willis, E. Jaroudi, N. Zimmerman, N. Hilker, M. Murphy, S. Eckhardt, A. Stohl, J. P. D. Abbatt, J. C. Wenger, G. J. Evans

Source: *Journal of Geophysical Research, July 2015, DOI: 10.1002/2015JD023382*

The optical properties of ambient black carbon-containing particles and the composition of their associated coatings were investigated at a downtown site in Toronto, Canada, for 2 weeks in June 2013. The objective was to assess the relationship between black carbon (BC) coating composition/thickness and absorption. The site was influenced by emissions from local vehicular traffic, wildfires in Quebec, and transboundary fossil fuel combustion emissions in the United States. Mass concentrations of BC and associated nonrefractory coatings were measured using a soot particle–aerosol mass spectrometer (SP-AMS), while aerosol absorption and scattering were measured using a photoacoustic soot spectrometer (PASS). Absorption enhancement was investigated both by comparing ambient and thermally denuded PASS absorption data and by relating absorption data to BC mass concentrations measured using the SP-AMS. Minimal absorption enhancement attributable to lensing at 781 nm was observed for BC using both approaches. However, brown carbon was detected when the site was influenced by wildfire emissions originating in Quebec. BC coating to core mass ratios were highest during this period (~7), and while direct absorption by brown carbon resulted in an absorption enhancement at 405 nm (>2.0), no enhancement attributable to lensing at 781 nm was observed. The efficiency of BC coating removal in the denuder decreased substantially when wildfire-related organics were present and may represent an obstacle for future similar studies. These findings indicate that BC absorption enhancement due to lensing is minimal for downtown Toronto, and potentially other urban locations, even when impacted by long-range transport events.

Characteristics of submicron particulate matter at the urban roadside in downtown Hong Kong—Overview of 4 months of continuous high-resolution aerosol mass spectrometer measurements

Berto P. Lee, Yong Jie Li, Jian Zhen Yu, Peter K. K. Louie, Chak K. Chan

Source: *Journal of Geophysical Research, July 2015, DOI: 10.1002/2015JD023311*

Hong Kong, one of the world's most densely populated cities and an international financial center, has been suffering from traffic-related air pollution. This study presents the first real-time high-resolution aerosol mass spectrometry measurements of submicron nonrefractory particulate matter (NR-PM1) at the urban roadside in Hong Kong from March to July 2013 with the aim to identify major sources, to assess local and

nonlocal emissions, and to characterize trends at different time scales. Organics were dominant, with fresh primary organic aerosol representing two thirds of the total measured organics. Cooking contributions in organic aerosol were assessed directly for the first time in Hong Kong and exceeded those related to vehicles although traffic was still the major PM1 source when elemental carbon was included. These findings were supported by additional measurements including traffic data, elemental/organic carbon, and VOC data. Springtime concentrations were about double of those in summer, due to a strong seasonal transition which affected meteorological conditions and street-level circulation. Local formation of secondary species was not clearly discernible in either season. The elemental composition of organic aerosol remained stable with similar elemental ratios across the covered seasons: OM/OC: 1.49 ± 0.13, O/C: 0.25 ± 0.10, H/C: 1.68 ± 0.08 for spring and OM/OC: 1.43 ± 0.14, O/C: 0.21 ± 0.11, H/C: 1.69 ± 0.08 for summer. Diurnal changes in H/C and O/C as a result of mixing of primary organic aerosol and secondary organic aerosol were evident in the van Krevelen plot.

Sources, transformation, and health implications of PAHs and their nitrated, hydroxylated, and oxygenated derivatives in PM2.5 in Beijing

Yan Lin, Yiqiu Ma, Xinghua Qiu, Ran Li, Yanhua Fang, Junxia Wang, Yifang Zhu, Di Hu

Source: *Journal of Geophysical Research, July 2015, DOI: 10.1002/2015JD023628*

Fine particulate matter (PM2.5) is a significant health issue in Chinese megacities. However, little information is available regarding the PM2.5-bound toxic organics, especially their sources, atmospheric transformations, and health implications. In this study, we assessed the levels of polycyclic aromatic hydrocarbons (PAHs) and their nitrated, hydroxylated, and oxygenated derivatives (i.e., NPAHs, OHPAHs, and OPAHs, respectively) in PM2.5 collected in Beijing over a 1 year period. The median concentration of 23 PAHs, 15 NPAHs, 16 OHPAHs, and 7 OPAHs in PM2.5 was 53.8, 1.14, 1.40, and 3.62 ng m−3, respectively. Much higher concentrations and mass percentages for all species were observed in the heating season, indicating a higher toxicity of PM2.5 during this period of time. Positive matrix factorization was applied to apportion the sources of PAHs and their derivatives. It was found that traffic emissions in the nonheating season, and coal combustion and biomass burning in the heating season, were the major primary sources of PAHs and their derivatives. Secondary formation, however, contributed significantly to the derivatives of PAHs (especially NPAHs and OPAHs) in the nonheating season, suggesting significant impacts of atmospheric transformation on the toxicity of PM2.5.

What controls the seasonal cycle of black carbon aerosols in India?

Rajesh Kumar, M. C. Barth, G. G. Pfister, V. S. Nair, Sachin D. Ghude, N. Ojha

Source: *Journal of Geophysical Research, August 2015, DOI: 10.1002/2015JD023298*

The seasonal variability of black carbon (BC) aerosols in India is studied using high resolution (10 km) BC simulations conducted using the Weather Research and Forecasting Model coupled with Chemistry. The model reproduces the observed seasonality of surface BC fairly well over most parts of India but fails to capture the seasonality in the Himalayas and deviates from the observed BC magnitude at several sites. The errors in modeled BC are attributed to uncertainties in BC emissions and their diurnal cycle, planetary boundary layer height underestimation, and aerosol processes. Model results show distinct but opposite seasonality of BC in the lower (LT) and free troposphere (FT) with BC showing winter maximum and summer minimum in the LT and vice versa in the FT. Our analysis shows that BC seasonality is not driven

by seasonality of the anthropogenic emissions but by changes in the regional meteorology through weakening of the horizontal transport and strengthening of the vertical transport of BC during summertime compared to winter. BC in both the LT and FT comes mostly from anthropogenic emissions followed by biomass burning emissions except during winter when long-distant sources become more important in the FT. BC in the FT is significantly affected by anthropogenic emissions from all parts of India. The source-receptor relationship changes seasonally, but the regional transport remains a significant contributor to BC loadings in the LT of India, highlighting the necessity of considering nonlocal sources along with local emissions when designing strategies for mitigating BC impacts on air quality.

The possible impact of urbanization on a heavy rainfall event in Beijing

Miao Yu, Yimin Liu

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The impact of urbanization on a heavy rainfall event that occurred in Beijing on 21 July 2012 was investigated using version 3.6.1 of the Weather Research and Forecasting Model coupled with a multilayer urban canopy model. High-resolution land use data for Beijing in 2010 with modified urban parameterization were introduced into the model. Evaluation showed that the simulation result generally agreed well with observations. Two sensitivity tests with different urban high-resolution land use scenarios were employed to analyze the impact of urban expansion on this rainfall event. The simulation results confirmed that urbanization expansion played an important role in the distribution and intensity of precipitation for this extreme event. Urbanization led to total precipitation increasing in upstream and downstream directions. The start time of the precipitation process was advanced by 1 h, and the duration became longer due to the influence of urbanization. Moreover, urbanization caused the spatial distribution of precipitation to become more concentrated. The total precipitation amount above 250 mm and the frequency of precipitation intensity above 40 h^{-1} mm are both increased. The results of this study show that urbanization plays a significant role in frontal-type rainfall.

Black carbon concentrations in snow at Tronsen Meadow in Central Washington from 2012 to 2013: Temporal and spatial variations and the role of local forest fire activity

Ian Delaney, Susan Kaspari, Matthew Jenkins

Source: *Journal of Geophysical Research, September 2015, DOI: 10.1002/2015JD023762*

Characterizing black carbon (BC) concentrations in the seasonal snowpack is of interest because BC deposition on snow can reduce albedo and accelerate melt. In Washington State, USA snowmelt from the seasonal snowpack provides an important source of water resources, but minimal work has been done characterizing BC concentrations in snow in this region. BC concentrations in snow were monitored over two winters (2012 and 2013) at Tronsen Meadow, located near Blewett Pass in the eastern Cascade Mountains in Central Washington, to characterize spatial and temporal variations in BC concentrations, and the processes affecting BC concentrations in the snowpack. BC concentrations were measured using a Single Particle Soot Photometer. Snowpit BC concentrations at spatial scales ranging from centimeter to 100 m scales were fairly homogenous during the accumulation season, with greater spatial variability during the melt season due to variable melt patterns. BC concentrations in snow increased in late winter-spring due to

an increase in atmospheric BC concentrations and trapping of BC on the snow surface during melt. However, during a period of intense melt in 2013 BC concentrations decreased, likely caused by meltwater scavenging. In summer 2012 the Table Mountain forest fire burned adjacent to the study site, and BC concentrations in the snowpack in 2013 were far higher than in previous years, with charred trees postfire the likely source of the elevated BC.

Effects of aerosol sources and chemical compositions on cloud drop sizes and glaciation temperatures

Assaf Zipori, Daniel Rosenfeld, Ofir Tirosh, Nadya Teutsch, Yigal Erel

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The effect of aerosols on cloud properties, such as its droplet sizes and its glaciation temperatures, depends on their compositions and concentrations. In order to examine these effects, we collected rain samples in northern Israel during five winters (2008–2011 and 2013) and determined their chemical composition, which was later used to identify the aerosols' sources. By combining the chemical data with satellite-retrieved cloud properties, we linked the aerosol types, sources, and concentrations with the cloud glaciation temperatures (Tg). The presence of dust increased Tg from −26°C to −12°C already at relatively low dust concentrations. This result is in agreement with the conventional wisdom that desert dust serves as good ice nuclei (INs). With higher dust concentrations, Tg saturated at −12°C, even though cloud droplet sizes decreased as a result of the cloud condensation nucleating (CCN) activity of the dust. Marine air masses also encouraged freezing, but in this case, freezing was enhanced by the larger cloud droplet sizes in the air masses (caused by low CCN concentrations) and not by IN concentrations or by aerosol type. An increased fraction of anthropogenic aerosols in marine air masses caused a decrease in Tg, indicating that these aerosols served as poor IN. Anthropogenic aerosols reduced cloud droplet sizes, which further decreased Tg. Our results could be useful in climate models for aerosol-cloud interactions, as we investigated the effects of aerosols of different sources on cloud properties. Such parameterization can simplify these models substantially.

Satellite detection, long-range transport, and air quality impacts of volcanic sulfur dioxide from the 2014–2015 flood lava eruption at Bárðarbunga (Iceland)

Anja Schmidt, Susan Leadbetter, Nicolas Theys, Elisa Carboni, Claire S. Witham, John A. Stevenson, Cathryn E. Birch, Thorvaldur Thordarson, Steven Turnock, Sara Barsotti, Lin Delaney, Wuhu Feng, Roy G. Grainger, Matthew C. Hort, Ármann Höskuldsson, Iolanda Ialongo, Evgenia Ilyinskaya, Thorsteinn Jóhannsson, Patrick Kenny, Tamsin A. Mather, Nigel A. D. Richards, Janet Shepherd

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The 2014–2015 Bárðarbunga-Veiðivötn fissure eruption at Holuhraun produced about 1.5 km3 of lava, making it the largest eruption in Iceland in more than 200 years. Over the course of the eruption, daily volcanic sulfur dioxide (SO2) emissions exceeded daily SO2 emissions from all anthropogenic sources in Europe in 2010 by at least a factor of 3. We present surface air quality observations from across Northern Europe together with satellite remote sensing data and model simulations of volcanic SO2 for September 2014. We show that volcanic SO2 was transported in the lowermost troposphere over long distances and detected by air quality monitoring stations up to 2750 km away from the source. Using retrievals from the Ozone Monitoring Instrument (OMI) and the Infrared Atmospheric Sounding Interferometer (IASI), we calculate an average daily SO2 mass burden of 99 ± 49 kilotons (kt) of SO2 from OMI and 61 ± 18 kt of SO2

from IASI for September 2014. This volcanic burden is at least a factor of 2 greater than the average SO2 mass burden between 2007 and 2009 due to anthropogenic emissions from the whole of Europe. Combining the observational data with model simulations using the United Kingdom Met Office's Numerical Atmospheric-dispersion Modelling Environment model, we are able to constrain SO2 emission rates to up to 120 kilotons per day (kt/d) during early September 2014, followed by a decrease to 20–60 kt/d between 6 and 22 September 2014, followed by a renewed increase to 60–120 kt/d until the end of September 2014. Based on these fluxes, we estimate that the eruption emitted a total of 2.0 ± 0.6 Tg of SO2 during September 2014, in good agreement with ground-based remote sensing and petrological estimates. Although satellite-derived and model-simulated vertical column densities of SO2 agree well, the model simulations are biased low by up to a factor of 8 when compared to surface observations of volcanic SO2 on 6–7 September 2014 in Ireland. These biases are mainly due to relatively small horizontal and vertical positional errors in the simulations of the volcanic plume occurring over transport distances of thousands of kilometers. Although the volcanic air pollution episodes were transient and lava-dominated volcanic eruptions are sporadic events, the observations suggest that (i) during an eruption, volcanic SO2 measurements should be assimilated for near real-time air quality forecasting and (ii) existing air quality monitoring networks should be retained or extended to monitor SO2 and other volcanic pollutants.

Sensitivity of radiative forcing, ocean heat uptake, and climate feedback to changes in anthropogenic greenhouse gases and aerosols

D. Paynter, T. L. Frölicher

Source: *Journal of Geophysical Research, 3 October 2015, DOI: 10.1002/2015JD023364*

We use both prescribed sea surface temperature and fully coupled versions of the Geophysical Fluid Dynamics Laboratory coupled climate model (CM3) to analyze the sensitivity of radiative forcing, ocean heat uptake, and climate feedback to changes in anthropogenic greenhouse gases and aerosols considered separately over the 1870 to 2005 period. The global anthropogenic aerosol climate feedback parameter ($-\alpha$) of -1.13 ± 0.33 Wm-2 K-1 is indistinguishable from the greenhouse gas $-\alpha$ of -1.28 ± 0.23 Wm-2 K-1. However, this greenhouse gas climate feedback parameter is about 50% larger than that obtained for CM3 from a widely used linear extrapolation method of regressing Earth's top of atmosphere imbalance against surface air temperature change in idealized CO2 radiative forcing experiments. This implies that the global mean surface temperature change due to forcing over the 1870–2005 period is 50% smaller than that predicted using the climate feedback parameter obtained from idealized experiments. This difference results from time dependence in α, which makes the radiative forcing obtained by the fixed sea surface temperature method incompatible with that obtained by the linear extrapolation method fitted over the first 150 years after CO2 is quadrupled. On a regional scale, α varies greatly between the greenhouse gas and aerosol case. This suggests that the relationship between transient and equilibrium climate sensitivities obtained from idealized CO2 simulations, using techniques such as regional feedback analysis and heat uptake efficacy, may not hold for other forcing scenarios.

Contribution of brown carbon and lensing to the direct radiative effect of carbonaceous aerosols from biomass and biofuel burning emissions

Rawad Saleh, Marguerite Marks, Jinhyok Heo, Peter J. Adams, Neil M. Donahue, Allen L. Robinson

Source: *Journal of Geophysical Research, October 2015, DOI: 10.1002/2015JD023697*

We present global direct radiative effect (DRE) calculations of carbonaceous aerosols emitted from biomass/biofuel burning addressing the interplay between two poorly constrained contributions to DRE: mixing state of black carbon (lensing) and light absorption by organic aerosol (OA) due to the presence of brown carbon (BrC). We use the parameterization of Saleh et al. (2014) which captures the variability in biomass/biofuel OA absorption. The global mean effect of OA absorption is +0.22 W/m2 and +0.12 W/m2 for externally and internally mixed cases, while the effect of lensing is +0.39 W/m2 and +0.29 W/m2 for nonabsorbing and absorbing OA cases, signifying the nonlinear interplay between OA absorption and lensing. These two effects can be overestimated if not treated simultaneously in radiative transfer calculations. The combined effect of OA absorption and lensing increases the global mean DRE of biomass/biofuel aerosols from −0.46 W/m2 to +0.05 W/m2 and appears to reduce the gap between existing model-based and observationally constrained DRE estimates. We observed a strong sensitivity to these parameters in key regions, where DRE shifts from strongly negative (< −1 W/m2) to strongly positive (> +1 W/m2) when accounting for lensing and OA absorption.

SECTION-VII
Science of Total Environment

Exploring the interaction between O3 and NOx pollution patterns in the atmosphere of Barcelona, Spain using the MCR–ALS method

Amrita Malik , Roma Tauler

Source: *Science of the Total Environment 517 (2015) 151–161*

This work focuses on understanding the behaviour and patterns of three atmospheric pollutants namely, nitric oxide (NO), nitrogen dioxide (NO2), and ozone (O3) along with their mutual interactions in the atmosphere of Barcelona, North Spain. Hourly samples were collected for NO, NO2 and O3 from the same city location for three consecutive years (2010–2012). The study explores the seasonal, annual and weekday–weekend variations in their diurnal profiles along with the possible identification of their source and mutual interactions in the region. Multivariate Curve Resolution–Alternating Least Squares (MCR–ALS) was applied to the individual datasets of these pollutants, as well as to all of them simultaneously (augmented mode) to resolve the profiles related to their source and variation patterns in the atmosphere. The analysis of the individual datasets confirmed the source pattern variations in the concerned pollutant's profiles; and the resolved profiles for augmented datasets suggested for the mutual interaction of the pollutants along with their patterns variations, simultaneously. The study suggests vehicular pollution as the major source of atmospheric nitrogen oxides and presence of weekend ozone effect in the region.

Variation of polycyclic aromatic hydrocarbons in atmospheric PM2.5 during winter haze period around 2014 Chinese Spring Festival at Nanjing: Insights of source changes, air mass direction and firework particle injection

Shaofei Kong , Xuxu Li , Li Li , Yan Yin , Kui Chen, Liang Yuan , Yingjie Zhang , Yunpeng Shan , Yaqin Ji

Source: *Science of the Total Environment 520 (2015) 59–72*

Daily PM2.5 samples were collected at a suburban site of Nanjing around 2014 Chinese Spring Festival (SF) and analyzed for 18 kinds of polycyclic aromatic hydrocarbons (PAHs) by GC–MS. Comparison of PAH concentrations during different periods, with different air mass origins and under different pollution situations was done. Sources were analyzed by diagnostics ratios and principal component analysis (PCA). The threat of PAHs was assessed by BaP equivalent concentrations (BaPeq) and incremental lifetime cancer risk (ILCR). The averaged PAHs for pre-SF, SF and after SF periods were 50.6, 17.2 and 29 ng m−3 , indicating the variations of PAH sources, with reduced traffic, industrial and construction activities during SF and gradually re-starting of them after-SF. According to PAH mass concentrations, their relative abundance to particles, ratio of PAHs (3-ring + 4-ring)/ PAHs(5-ring + 6-ring), mass concentrations of combustion-derived and carcinogenic PAHs, fireworks burning is an important source for PAHs during SF. The ILCR values for Chinese New Year day were 0.68 and 3.3 per 100,000 exposed children and adults. It suggested the necessity of controlling fireworks burning during Chinese SF period which was always companied with serious regional haze pollution. PAH concentrations exhibited decreasing trend when air masses coming from the following directions as North China Plain (63.9 ng m−3) N Central China (53.0 ng m−3) N Shandong Peninsula (46.6 ng m−3) N Northwest China (18.8 ng m−3) N Sea (15.8 ng m−3). For different pollution situations, they decreased as haze (44.5 ng m−3) N fog-haze (28.4 ng m−3) N clear (12.2 ng m−3) N fog day (9.2 ng m−3). Coal combustion, traffic emission, industrial processes and petroleum (only for non-SF holiday periodss) were the main sources of PM2.5 associated PAHs. Fireworks burning contributed 14.0% of PAHs during SF period. Directly measurement of PAHs from fireworks burning is urgently needed for source apportionment studies in the future.

A novel hybrid forecasting model for PM10 and SO2 daily concentrations

Ping Wang , Yong Liu , Zuodong Qin , Guisheng Zhang

Source: *Science of the Total Environment 505 (2015) 1202–1212*

Air-quality forecasting in urban areas is difficult because of the uncertainties in describing both the emission and meteorological fields. The use of incomplete information in the training phase restricts practical air-quality forecasting. In this paper, we propose a hybrid artificial neural network and a hybrid support vector machine, which effectively enhance the forecasting accuracy of an artificial neural network (ANN) and support vector machine (SVM) by revising the error term of the traditional methods. The hybrid methodology can be described in two stages. First, we applied the ANN or SVM forecasting system with historical data and exogenous parameters, such as meteorological variables. Then, the forecasting target was revised by the Taylor expansion forecasting model using the residual information of the error term in the previous stage. The innovation involved in this approach is that it sufficiently and validly utilizes the useful residual information on an incomplete input variable condition. The proposed method was evaluated by experiments using a 2-year dataset of daily PM10 (particles with a diameter of 10 μm or less) concentrations and SO2 (sulfur dioxide) concentrations from four air pollution monitoring stations located in Taiyuan, China. The theoretical analysis and experimental results demonstrated that the forecasting accuracy of the proposed model is very promising.

Short-term effects of air pollution on daily mortality and years of life lost in Nanjing, China

Feng Lu, Lian Zhou, Yan Xu , Tongzhang Zheng , Yuming Guo , Gregory A. Wellenius , Bryan A. Bassig , Xiaodong Chen , Haochen Wang , Xiaoying Zheng

Source: *Science of the Total Environment 536 (2015) 123–129*

The deteriorating air quality in Chinese cities is attracting growing public concern. We conducted analyses to quantify the associations between daily changes in ambient air pollution and mortality in Nanjing, China. Daily mortality, air pollution, and meteorological data from 1 January 2009 to 31 December 2013 were collected. Overdispersed Poisson regression models were used to evaluate the risk of daily non-accidental mortality and years of life lost (YLL) from exposure to respirable particulate matter (PM10) and gaseous pollutants (NO2, SO2). Stratified analysis was conducted to indentify the modifying effect of individual-level factors on the association between air pollutants and mortality. We found that interquartile range (IQR) increases in the two-day average of PM10, NO2 and SO2 were significantly associated with 1.6% [95% confidence interval (CI):0.7%–2.6%], 2.9% (95% CI: 1.7%–4.2%) and 2.4% (95% CI: 1.2%–3.6%) higher rates of non-accidental mortality; and related to YLL increases of 20.5 (95% CI: 6.3–34.8), 34.9 (95% CI: 16.9–52.9) and 30.3 (95% CI: 12.2–48.4) years, respectively; Associations between air pollution and mortality were more pronounced in the warm season than in the cool season. We conclude that the risks of mortality and YLL were elevated corresponding to an increase in current ambient concentrations of the air pollutants, and season may modify the effects of outdoor air pollution in Nanjing.

Exposure to ambient air pollution in Canada and the risk of adult leukemia

Nicholas Winters , Mark S. Goldberg , Perry Hystad , Paul J. Villeneuve , Kenneth C. Johnson , and the Canadian Cancer Registries Epidemiology Group

Source: *Science of the Total Environment 526 (2015) 153–176*

There is a paucity of studies investigating adult leukemia and air pollution. To address this gap, we analyzed data from a Canadian population-based case–control study conducted in 1994–1997. Cases were 1064 adults with incident leukemia and controls were 5039 healthy adults. We used data from satellites and fixed-site monitoring stations to estimate residential concentrations of NO2 and fine particulate matter (PM2.5) for the period prior to diagnosis, starting in 1975 and ending in 1994. We modeled the average annual exposure of each subject. Odds ratios (OR) and their 95% confidence intervals (CI) were estimated using logistic regression, adjusted for age, gender, province, smoking, education, body mass index, income, and self-reported exposures to ionizing radiation and benzene. We found an 'n-shaped' response function between exposure to NO2 and all forms of leukemia: from the tenth percentile to the median (4.51 to 14.66 ppb), the OR was 1.20; 95% CI: 0.97–1.48 and from the 75th percentile to the 90th (22.75 to 29.7 ppb), the OR was 0.79; 95% CI 0.68–0.93. For PM2.5 we found a response function consistent with a linear model, with an OR per 10 μg/m3 of 0.97 (95% CI 0.75–1.26). For chronic lymphocytic leukemia we found response functions that were consistent with a simple linear model, with an OR per 5 ppb of NO2 of 0.93 (95% CI 0.86– 1.00) and an OR per 10 μg/m3 of PM2.5 of 0.62 (95% CI 0.42–0.93). In summary, for chronic lymphocytic leukemia we found no evidence of an association with air pollution and with all forms of leukemia we found weak evidence of an association only at low concentrations of NO2. It is possible that these inconsistent results may have arisen because of unaccounted urban/rural differences or possibly from a selection effect, especially among controls.

Health impact assessment of traffic-related air pollution at the urban project scale: Influence of variability and uncertainty

Chidsanuphong Chart-asa , Jacqueline MacDonald Gibson

Source: *Science of the Total Environment 506–507 (2015) 409–421*

This paper develops and then demonstrates a new approach for quantifying health impacts of traffic-related particulate matter air pollution at the urban project scale that includes variability and uncertainty in the analysis. We focus on primary particulate matter having a diameter less than 2.5 μm (PM2.5). The new approach accounts for variability in vehicle emissions due to temperature, road grade, and traffic behavior variability; seasonal variability in concentration–response coefficients; demographic variability at a fine spatial scale; uncertainty in air quality model accuracy; and uncertainty in concentration–response coefficients. We demonstrate the approach for a case study roadway corridor with a population of 16,000, where a new extension of the University of North Carolina (UNC) at Chapel Hill campus is slated for construction. The results indicate that at this case study site, health impact estimates increased by factors of 4–9, depending on the health impact considered, compared to using a conventional health impact assessment approach that overlooks these variability and uncertainty sources. In addition, we demonstrate how the method can be used to assess health disparities. For example, in the case study corridor, our method demonstrates the existence of statistically significant racial disparities in exposure to traffic-related PM2.5 under present-day traffic conditions: the correlation between percent black and annual attributable deaths in each census block is 0.37 ($t(114) = 4.2$, p b 0.0001). Overall, our results show that the proposed new campus will cause only a small incremental increase in health risks (annual risk $6 \times 10{-}10$; lifetime risk $4 \times 10{-}8$),

compared to if the campus is not built. Nonetheless, the approach we illustrate could be useful for improving the quality of information to support decision-making for other urban development projects.

Control of PM2.5 in Guangzhou during the 16th Asian Games period: Implication for hazy weather prevention

Jun Tao, Leiming Zhang , Zhisheng Zhang , Ruijin Huang , Yunfei Wu , Renjian Zhang , Junji Cao, Yuanhang Zhang

Source: *Science of the Total Environment 508 (2015) 57–66*

To evaluate the effectiveness of the integrated control measures for reducing PM2.5 (aerosol particles with an aerodynamic diameter of less than 2.5 μm) and hazy weather, day- and night-time PM2.5 samples were collected at an urban site in Guangzhou during the 16th Asian Games period in November 2010. PM2.5 samples were subject to chemical analysis for major water-soluble ions, organic carbon (OC), element carbon (EC), and biomass burning tracers–anhydrosugar levoglucosan (LG). In addition, aerosol scattering coefficient (bsp) at dry condition and aerosol absorption coefficient (bap) and visibility at ambient condition were measured. The seven major control measures were effective for reducing PM2.5 mass concentration and improving visibility during the Asian Games period. All monitored air pollutants except PM2.5 satisfied the National Ambient Air Quality Standards (NAAQS). However, daily PM2.5 concentrations still exceeded the NAAQS on 47% of the days and hazy weather also occurred on 80% of the days during this period. One factor causing the high frequency of hazy weather occurrence was the increased relative humidity during the Asian Games period. To avoid hazy weather occurrence, new PM2.5 standard was recommended based on visibility calculations using three available aerosol hygroscopic curves previously obtained for this city. The recommended PM2.5 standard was 63 μg m−3 under dry condition and lower than 42 μg m−3 under humid condition (RH ≥70%). These recommended values were much stricter than the NAAQS value of 75 μg m−3 . To reach the new standard, more rigorous control measures for coal industries should be established in the Pearl River Delta (PRD) region.

Categorisation of air quality monitoring stations by evaluation of PM10 variability

M.A. Barrero , J.A.G. Orza , M. Cabello , L. Cantón

Source: *Science of the Total Environment 524–525 (2015) 225–236*

Air Quality Monitoring Networks (AQMNs) are composed by a number of stations, which are typically classified as urban, suburban or rural, and background, industrial or traffic, depending on the location and the influence of the immediate surroundings. These categories are not necessarily homogeneous and distinct from one another, regarding the levels of the monitored pollutants. A classification providing groups with these features is of interest for air quality management and research purposes, and therefore, other classification criteria should be explored. In this work, the variations of PM10 concentrations in 43 stations in the AQMN of the Basque Country in the period 2005–2012 have been studied to group them according to common characteristics. The characteristic variations in time are synthesised by the autocorrelation function (ACF), with both daily and hourly data, and by the average diurnal evolution pattern of the normalised concentrations on a seasonal basis (Evol-P). A methodology based on k-means clustering of these features is proposed. Each classification gives a different piece of information that has been phenomenologically related with specific dispersion and emission dynamics. The classification based on Evol-Ps is found to be the most

influential one when comparing PM10 levels between groups. A combination of these categorisations provides 5 groups with significantly different levels of PM10, improving the discrimination of the conventional classification. Our results indicate that the time series of the pollutant concentrations contain enough information to provide an objective classification of the monitoring stations in an AQMN.

जहाँ है हरियाली ।
वहाँ है खुशहाली ॥