ENVIS NEWSLETTER

Acid Rain and Atmospheric Pollution

Indian Institute of Tropical Meteorology, Pune

(A Project of the Ministry of Environment and Forests, Govt. of India)

Editor's Desk:

We are happy to bring in focus this special issue of ENVIS Newsletter of IITM at the end of the year 2008. This issue is special in regards of the GURME International workshop on "Air Quality Forecasting" which was organized by Indian Institute of Tropical Meteorology (IITM, Pune) from 8 – 12th December 2008. This workshop was sponsored jointly by the World Meteorological Organization (WMO, Geneva) and IITM, Pune. The major aim of the workshop was to provide opportunities to expose the advanced air quality modeling systems to meet the future challenges involving high resolution meteorological data and emission inventory of chemical pollutants. Thus in the current issue we have tried to cover some of the important topics related to air pollution forecasting, its importance and other details related to the conducted workshop.

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International Workshop on "Air Quality Forecasting (AQM)" at IITM, Pune (December 8-12, 2008)

Our country has a good coordinated system to forecast the weather and climate and it is very well taken care of by the India Meteorological Department for rainfall especially during the monsoon session. However, forecasting of "Air Pollution Level" is equally important for the protection of our environment. Air Quality Forecast is required to provide information to the public operationally to help them better manage their health and welfare (heat stress, comfort, pollen, flight operations, large scale pollution /fire events, etc.). World wide efforts in this direction have already taken speed and are on the go, but we are lagging behind in the air pollution forecasting system in India.

Considering all of the above points, the ENVIS center of the Indian Institute of Tropical Meteorology (IITM), Pune in association with the WMO (World Meteorological Organization, Geneva, Switzerland) organized the Workshop on "**Air Quality Forecasting**" from 8 - 12th December 2008, at IITM, Pune, India. This is the first time in our country that such an event focusing on air quality forecasting modeling system is organized. In this workshop, all the leaders and pioneers working in air quality forecasting modeling gathered to strengthen our efforts where our group of "Urban Air Pollution and Transport Modeling" is actively engaged in developing such models. This international workshop was jointly sponsored by IITM, Pune and the World Meteorological Organization (WMO) (United Nations nodal agency for weather and climate).

There were around 50 delegates from 6 different countries (Indian and other South Asian countries including Nepal, Bhutan, Sri Lanka and Maldives) attending the workshop. These were mostly from academia (47%) and governmental institutions (45%), while the rest of the participants (8%) were from the industry. The workshop was inaugurated by Dr. Shailesh Nayak, Secretary, MoES, Govt. of India. The training was imparted by a team of leading

experts in the field which includes Prof. Greg Carmicheal (Univ. of IOWA, USA) who is the chair of GURME-SSC (WMO) and considered to be "heir apparent" in air quality forecasting model development and the chief of environmental division of WMO, Geneva, Dr. (Mrs.) Liisa Jalkanen graced the occasion. Other experts include Prof. Calori Giuseppe (Italy), Dr. Steve Peckham (NOAA, Boulder, CO, USA), Dr. Sarath Guttikunda (University of Iowa, USA), Prof. (Mrs.) Kalpana Balakrishnan (Director, WHO collaborating centre for occupational health, Chennai medical institute,Chennai), Dr. Chhemendra Sharma (National Physical Laboratory, New Delhi, India) and Dr. Gufran Beig (IITM, Pune, India)

Aim and Objectives: As mentioned above, the major aim of the workshop was to provide opportunities to expose the advanced air quality modeling systems to meet the future challenges. Invited experts provided overviews on

comparative modeling paradigms for various scales, environmental challenges, and technologies for advancing open community-based modeling to support opportunities for assessing and forecasting air quality. The workshop consisted of a series of plenary presentations of modeling tools by invited experts pioneered in air pollution model development with detailed chemistry and actively engaged in forecasting. The workshop also included discussion on the complexities of the atmospheric chemistry, transport and deposition processes underlying the modeling requirements and meteorological aspects needed as an essential tool for air pollution modeling and forecasting. Further, a plenary discussion session focused on how WMO could most effectively support efforts in air quality forecasting in our region was also included. Several other import factors that influence the choice of the model to be used and the types of data needed to support the model were also discussed.

The broad objectives covered in the workshop were as follows:
- Obtain an overview of the current operational air quality forecasting tools and their requirements, including measurement needs.
- Obtain an overview of current status of relevant research that can be expected to improve operational models in the next few years.
- Develop recommendations for the direction of improving air quality forecasting.
- To present the above information in such a way that is useful for NMHS's that are

starting or developing their air quality forecasting activities.

About GURME (WMO)

The World Meteorological Organization (WMO) established GAW (Global Atmospheric Watch) Urban Research Meteorology and Environment programme (GURME) on the request of National Meteorological and Hydrological Services (NMHS's), at the 1999 WMO Congress. The goal was to enhance the air pollution prediction capabilities to handle meteorological and related aspects of urban pollution. This workshop was organized under the auspices of this project GURME along with IITM. The most relevant way to meet the GURME objectives was by helping in conducting workshops. GURME therefore started to help organizing a series of Air Quality Forecasting Workshops since then. The other details regarding GURME can be found at: http://www.cgrer.uiowa.edu/people/carmichael/GURME/GURME.html

Scientific Summary of AQM-Workshop

A brief outline of the workshop, aim and objectives are given elsewhere in this newsletter. This article summarizes the salient features of scientific discussion of this workshop. As this workshop was targeted to transfer the knowledge and train the young generation about the air quality impact on climate change, most of the lectures were in the form of tutorials.

Inaugural Session:

Director IITM, welcomed all the delegates and explained his desire to debate on the delicate question: the relationship of monsoon precipitation with air pollution, more importantly, the impact of air pollution on rainfall variability. The workshop was inaugurated by the Secretary, Dr. Shailesh Nayak, Ministry of Earth Sciences, Government of India.

Extract of the Inaugural address by Dr. Shailesh Nayak, MoES (GoI) :

He started his address by thanking the World Meteorological Organization (WMO) for cosponsoring the GURME-2008 workshop on such an important topic (pollution) at IITM, Pune because the IITM is well known for its contribution on climate change and overall atmospheric sciences not only in India but for the entire region. He mentioned that the guest faculty of this workshop will help us to enhance our capability for developing the observational system of pollutants as well as developing better understanding of physical and chemical processes and ultimately the modeling. This will improve our forecasting skill for this region which is very important step towards capacity building. He elaborated on the question as to why we need all this? Human being has started interacting with various Earth processes since ages. He mentioned that when the fire was invented, pollution on the earth started. However, the pollution was not a serious issue at that time as nature was able to assimilate its ill effects. But it is during the last 100 to 150 years and especially during the past 30 years we have seen dramatic rise in air pollution which significantly started affecting the Earth processes. The air pollution not only affects our health but also the vegetation. Earth radiation reduced dramatically during the last 30 years and as a result the less photosynthesis activity which is affecting our agriculture. Government of India realized the special importance of this aspect and other related issues and created the ministry of earth sciences to deal with.

Whether it is mining of thermal power plants or bio-fuel burning, all affect our atmosphere and these pollutant emissions change the chemistry of the atmosphere. We need to develop the observing system for monitoring these pollutants. We are committed to develop such kinds of networking systems and we are in the process of doing it. However, the advance models will help us in providing the optimal observing system. In our country, the capacity to build the forecasting skill is limited but we need to develop it for the benefit of stakeholders. In this contest, the present workshop will be very useful and help us in achieving our target.

Inaugural Key Note Talks :

There were two key note talks on the inaugural day of the workshop. The first key note talk was delivered by the guest of honor, Prof. Greg Carmichael (Chairman of the international scientific program committee). In his keynote talk, he talked about the global reach of the regional / local air pollution and its impact on the air quality, climate and health. He mentioned that mega cities have large environmental footprints and regional control strategies are needed to meet local air quality targets. He added that large uncertainties are associated with aerosol emission assumptions and discussed about the implications of high aerosol loading on urban environments and beyond. The reduction of aerosol impact on air quality and climate with the help of control strategies which involves altering the balance between absorbing and scattering aerosol is the need of the hour. The reduction in aerosols is a big challenge but Beijing Olympics were an important example where control measures were adopted on the above mentioned line. He stressed on the needs of developing new approaches to integrate satellite data with chemical transport models and emission inventories for improved air quality modeling, since satellites offer increasing capacity to monitor air pollution from space. Finally Prof. Carmichael highlighted on the point that models are an integral part of air quality analysis and management and envisaged an integrated assessment of modeling and observations.

The other overview keynote talk was delivered by Dr. Gufran Beig on the topic "Air Pollution Management and Modeling - Indian Perspective". In this talk, Dr. Beig spoke on the air quality concerns, trends, air chemistry modeling, the current status of air quality in India, regulatory measures and the need for establishment of an air quality forecasting system in our country. Dr. Beig highlighted the trends in the different species like Ozone which has an increasing trend of 0.5-1% /year in India, NO_2, CO, PM2.5 etc. over the Indian region. He

mentioned that proper monitoring, emission inventory, source apportionment, air pollution exposure and health impacts are essential for an accurate assessment of air quality. He discussed the different kinds of control strategies adopted over India with special focus on the gasoline benzene reduction program, the gasoline lead phase-out program, the vehicle emission norm schedule, the diesel sulfur reduction program and the impact of these interventions on air quality of Delhi. He stressed on the necessities and essential requirements for air quality forecasting and stated that a thorough understanding of how the meteorological processes influence air pollution in an area is needed to forecast the processes that affect air quality and its prediction. At the end, Dr. Beig discussed about the air pollution modeling efforts in India involving the application of global and regional chemistry transport models, several initiatives and leads his group at IITM, Pune has taken-up towards building an improved India specific emission inventory and the current status of the new Indian national emission inventory which is now gridded to finer resolution. Finally he provided a roadmap towards building the capability to predict short term pollution level on a wider but local scale in a few years time at IITM.

In her lecture, Dr. Liisa Jalkanen (WMO Secretariat) gave an overview of the GURME project of WMO which was the lead sponsor of the workshop. She discussed its missions, objectives and the tasks scheduled for the strategic planning period 2008-2015. She mentioned about the GAW Station Information

System (GAWSIS Online) which is comprehensive information on all GAW stations. She highlighted the different kinds of observations, monitoring and measurements involved in this project with special focus on Shanghai as an example case. She added that GURME is focused on air quality forecasting and mentioned the important findings from the AQF workshops conducted under this project earlier. The inaugural session was concluded with vote of thanks delivered by Dr. Beig as a convener.

Scientific Sessions:

After the inaugural function, scheduled session program of the workshop started. It was also started with a presentation by Prof. Greg Carmichael who outlined details of deliberations going to be held during the workshop period. He spoke on improving predictions of air quality keeping the analysis and forecasting perspectives in mind. He discussed about the process of developing, operating, and improving an air quality (AQ) forecasting program, the different scales associated with air quality prediction and the types of users who would be benefited from the knowledge of air quality forecasting. In his talk on 'Meteorological aspects of air pollution' Prof. Greg Carmichael mentioned about the meteorological processes that influence air quality like sunlight, transport, clouds and precipitation etc. across different range of scales. He stated that fronts and air masses can cause rapid changes in air quality levels within a few hours of passage, particularly cold fronts and temperature inversions are important because they suppress vertical dispersion of pollution and often trap pollution near the surface where we live. He discussed how winds can affect pollution through horizontal dispersion and transport of pollutants, smoke and dust from global to local scales and the impact of clouds and precipitation on pollutants such as ozone, PM2.5 etc. Finally he summarized the meteorology associated with good as well as bad air quality and briefly discussed the different products like weather

charts, HYSPLIT trajectories, satellite data etc. which can be useful for forecasting air quality.

On the second day in his talk entitled "Air Quality Modeling (AQM) overview", Prof. Greg Carmichael stated that models are an integral part of air quality studies and they play a critical role in linking emissions to aerosol and trace gas distributions and subsequent effects. He stressed upon the need to build upon what is done for further improvement of air quality prediction by comparisons of predictions with observations, by process studies and by model inter-comparison studies. Prof. Carmichael pointed out that emissions are the largest single source of uncertainty and mentioned experiments such as TRACE-P as an example. He focused on the impacts of global composition on regional air quality and added that the effects of boundary conditions are significant in improving predictions when we consider global-regional-urban nesting of CTMs. He also noted that an assessment of continental inflow/outflow requires unified modeling/measurement strategy to accurately characterize coupling between the continental

boundary layer, free troposphere, and long-range transport and that model resolution, transport and removal also contribute to differences. Lastly he spoke about the Model Inter-comparison Study in Asia (MICS-Asia) involving nine different regional models which were aimed at evaluating the model performance to make an international common understanding in order to improve air pollution modeling in East Asia.

In his second talk on the same day, Prof. Carmichael spoke on "Air Quality Modeling applications". He mentioned that models are an integral part of the ABC studies. The footprints from mega-cities can be large and regional transport comprises a major fraction of PM2.5 and ozone in urban centers and is key to devising control strategies. Urbanization impacts atmospheric physics through increased temperature, decreased wind speed etc. which in turn affects air quality. The future climate change can have a significant influence on Ozone in the first half of this century and the mean ozone concentration can increase up to 6 ppbv, about 20% in the future as projected by the CCSM produced global climate change scenario (A1B). Prof. Carmichael discussed about the effect of increasing resolution on model predictions and stated that the high-resolution simulation yielded different results not only due to the improved resolution of emissions, but also due to the terrain / landuse and wind field. At the end, he added that aerosols are a key component in urban environments, impacting chemistry and physics and due to the complexity and uncertainties in calculating the sources, formation, transport and removal of aerosols in the atmosphere, a closer integration of observations and models is needed.

On the third day Dr. Steven Peckham talked on the topic entitled "Overview of the WRF/Chem modeling system". He spoke on the details of the chemistry component which is online and completely embedded within the model WRF. He discussed the chemistry packages, aerosol modules, dust and sea-salt modules and the photolysis packages which are considered in the WRF/Chem model. Dr. Peckham highlighted the one dimensional plume model which is a part of the WRF/Chem modeling system. He also spoke about the global PM emissions data set for WRF/Chem and the use of chemical data from global chemistry model (GCM) for boundary conditions. He ended his talk with a list of the several aerosol related works currently ongoing for WRF/Chem.

In his second talk on the same day titled "WRF

/Chem tutorial Part 1," Dr. Steven Peckham spoke about setting up and running the

meteorological component of the WRF/Chem modeling system. He discussed about running the WRF real-data cases, the basic namelist options and the frequently encountered run-time errors.

On the fourth day Dr. Steven Peckham gave an idea about setting up, compiling and running the chemistry module of the WRF/Chem model in his talk entitled "WRF /Chem tutorial Part 2". He discussed the flow diagram of the WRF/Chem Model System and how to incorporate emission data from different sources in to the WRF /Chem Model. Dr. Peckham also spoke about the chemistry initial and boundary conditions for the WRF /Chem Modeling System.

On the last day Dr. Steven Peckham spoke on evaluation of real-time air quality and weather predictions using the WRF-Chem model in his talk entitled "Real time air quality forecasts using WRF/Chem". He discussed about the real Time AQ forecast domains and the different field programs involved in the validation of meteorological and chemical fields using the real time WRF-Chem.

On the same day Prof. Greg Carmichael spoke on chemical weather prediction in his talk titled "Air Quality Forecasting". He mentioned that forecasting air quality is an important activity in air quality management and a closer integration of observations and models is required for a regional-scale chemical analysis for air quality modeling. He discussed about the simple and advanced data assimilation methods, their applications involving satellite data and CTM's and the challenges in chemical data assimilation. Prof. Carmichael added that intensive field experiments (e.g., ICARTT) provide our best efforts to comprehensively observe a region and data assimilation produces an optimal state space and that ensemble-based chemical data assimilation techniques can complement the variational tools. In AQ predictions emissions are a major source of uncertainty and data assimilation can produce optimal estimates (inverse applications). He ended his talk with a summary of the future directions for improving air quality predictions.

In his talk titled "AQ Forecasting examples" Dr. Giuseppe Calori spoke on different examples of air quality forecast systems like the Rome air quality forecast system and the Turin air quality forecast system. He discussed the purpose and context, computational domains, architechture, emission inventory, chemical boundary conditions associated with these air quality forecast systems. Dr. Calori also talked about the verification of the AQF's against measurements and multiple air quality in forecast systems. He cited several other air quality forecast systems as example cases like the AQFS at Beijing, Paris, Oslo etc. He stressed on the needs for public awareness and communication depending on the audience and forecast purposes. Dr. Calori ended his talk with a discussion on the forecast for industrial sites focussing on the PRIOLO industrial complex. (Contributed by Sompriti Roy and Gufran Beig, IITM, Pune)

Wireless Air Pollution Digital Display System at IITM

The problem of air pollution has attracted special attention in India due to its tremendous increase in size of population, industrialization and urbanization. The major air pollutants of concern are identified as sulfur dioxide, nitrogen dioxides, ozone, CO and SPM, (suspended particulate matter) such as dust,

fumes, mist, and smoke. The concentration of these in and near the rural as well as urban areas cause severe pollution to the surroundings. The largest sources of human-created air pollution are energy generation, transportation, and industries that use a great deal of energy sources. Air pollution is a major environmental health problem affecting the developing and the developed countries alike. National ambient air quality standards are mainly based on health impact. The pollutants that are inhaled have a serious impact on human health affecting the lungs and the respiratory system; they are also taken up by the blood and pumped all round the body. These pollutants are also deposited on soil, plants, and in the water, further contributing to agriculture crops and human exposure. Ambient air, even around sub-urban areas has recorded several episodes of high pollutant levels surpassing the critical level. Maximum reductions in yield and quality of seeds are recorded at sites showing the highest O_3 concentrations.

The most effective way to reduce the growing pollution is to make the public aware of the critical limits of pollutants and their adverse impacts, so that steps can be taken by the

common public on their own initiative. The ENVIS team at IITM, Pune decided to take steps in making people aware of the pollutant levels at IITM. In this regard, Dr. Shailesh Nayak, Secretary, Ministry of Earth Sciences, Govt. of India inaugurated the "Wireless Radio Frequency Pollution Digital Display System" at IITM for the awareness of the common man. It displays the level of all the above listed pollutants on real time directly from the ozone pollution laboratory situated in IITM premises through wireless transmission of data. The critical values of these pollutants proved to be hazardous for human health are also displayed along with the present level so that a person can understand how frequently the dangerous level is surpassed at a particular time.

HONOUR

Dr. Gufran Beig, Co-ordinator of the ENVIS center at IITM, Pune has been elected as the "FELLOW" of the Indian Academy of Sciences, Bangalore with effect from January 2009. The Indian Academy of Sciences, founded in 1934 by Professor C.V. Raman, Nobel Laureate, endeavours by all means at its disposal to promote the progress and uphold the cause of science, both in pure and applied branches. The Academy has laid the responsibility on all its Fellows, individually and collectively, of promoting original research and of disseminating science knowledge to the community. Science seeks and discovers, cutting across sectarian, national and ideological frontiers. It fosters co-operation and generates a value system which nurtures man's highest capabilities and aspirations.

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