GURME Expert Workshop on Air Quality Forecasting
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Cuernavaca, Mexico

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GURME, the GAW Urban Research Meteorology and Environment project, is a new WMO activity under the auspices of the Global Atmospheric Watch (GAW). It was initiated at the 1999 WMO Congress at the request of the National Meteorological and Hydrological Services (NMHS) with the goal of enhancing the capabilities of the NMHSs related to urban air pollution.

One important objective of GURME is to build "capacity" related to meteorological and air quality (AQ) forecasting for urban environments. Towards this objective GURME is organizing a series of AQ forecasting workshops. The first GURME regional workshop on AQ forecasting was held 14-17 August 2000 in Kuching, Malaysia, and two more are planned. GURME has also sponsored three pilot projects: one in Moscow; one in Beijing; and one focused on the use of passive samplers for air quality monitoring.

GURME organized an expert workshop in Cuernavaca, Mexico during October 2002. The objectives of the workshop were to:

- obtain an overview of the current operational air quality forecasting tools and their requirements, including measurement needs;
- obtain an overview of the 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; and
- present the above information in such a way that it is useful for NMHSs that are starting or developing their air quality forecasting activities.

A breadth of perspectives were sought -- from those with on-going AQ efforts and those with interests in initiating and/or expanding activities. The 25 invited participants who attended this 2.5-day workshop represented the WMO and 11 countries (Australia, Canada, Chile, China, Denmark, Malaysia, Mexico, Russia, Spain, U.K., and U.S.A.) The organizing committee for the workshop consisted of Prof. Greg Carmichael (U. Iowa), Dr. Liisa Jalkanen (WMO/GAW), Prof. Paul Mason (U.K. Met Office), Profs. Luisa and Mario Molina (MIT), and Dr. Pai-Yei Whung (NOAA).

Cuernavaca is a lovely city located about an hour south of Mexico City. Mexico City is itself a sobering example of the need for GURME. The area of Mexico City is ~ 40 times larger today than it was in 1910, and with this growth has come serious pollution. Four talks at the workshop dealt with various aspects of how Mexico is trying to deal with the problem. For example, the Mexican one-hour standard for ozone is 110 ppb, but this standard is exceeded in Mexico City about 300 days per year on average. Legislation exists for an "Atmospheric Contingency Program", which goes into "watch" status when O_3 levels reach 232 ppb and which "activates" at 281 ppb of O_3 with the immediate imposition of activity restrictions on industry and vehicles; more stringent restrictions are imposed if levels rise to 355 ppb.

Mexico City is not alone. For example, Rainer Schmitz (U. of Chile) noted that Santiago, Chile typically exceeds the Chilean standards for both PM_{10} and CO about 60 days per year and exceeds the ozone standard about 140 days per year. There are other similarities between the Chilean and Mexican situations: (a) like most of the world's countries, neither country's weather service makes operational numerical weather forecasts; (b) cooperation between the national weather service and the national environmental agency poses challenges; (c) both Santiago and Mexico City have very strong, small-scale topographic influences (which pose problems for meteorological models); (d) the emission inventories for both cities are of limited quality; and (e) neither country has a national emissions inventory. It is worth noting that the requirement for interagency collaboration in order to establish an air-quality forecasting system was mentioned by nearly every participant at the workshop, since virtually no NMHS or other agency in the world has the responsibility for all four of the required functions for AQ forecasting: weather forecasting; ambient air-quality monitoring; emission-inventory preparation; and air-quality modelling.

Other workshop presentations described a variety of operational air-quality forecasting approaches that are currently being used; they ranged from knowledgeable forecasters (Mexico City), to linear-regression-based statistical forecasts (Santiago), to a city-wide box model (Beijing), to complex chemical transport models or CTMs (Australia, Canada, Spain, U.S.A.). For example, Weidong Liu (Meteorological Bureau, Beijing) and Alexei Liakhov (Hydrometeorological Bureau, Moscow) gave progress reports on the GURME pilot projects in Beijing and Moscow, respectively. Georg Grell (NOAA, USA) talked about his work with "MM5AQ" in providing real-time ozone forecasts for two recent field experiments, TexAQS 2000 and NEAQS 2002, and about the effort to include an on-line AQ forecasting component in the new U.S. WRF meteorological model. Pai-Yei Whung (NOAA, USA) described NOAA's plans for national operational ozone forecasts beginning in 2004.

Mike Moran's (Meteorological Service,Canada) presentation described Canada's national air-quality forecasts of air pollution-potential, total column O_3, UV index, and ground-level O_3 using the Canadian operational NWP model and a CTM. He also covered an earlier approach based on nonlinear regression, which was useful because statistical approaches are likely to be more appropriate for many countries trying to begin an AQ forecasting program. In fact, a good statistical model may be very hard for a CTM to beat provided a sufficient measurement data base is available to develop the statistical model. For example, Richard McNider (U. Alabama at Huntsville, USA) showed evaluation results from summer 2002 of the performance of the CTM forecasts vs. CART-based forecasts for O_3 in Birmingham, Alabama. Both models demonstrated skill, but overall the nonlinear statistical model performed better.

Peter Manins (CSIRO, Australia) described the Australian Air Quality Forecasting System, which issues twice-daily forecasts of both primary and secondary pollutants (including SO_2, CO, NO_x, O_3, $PM_{2.5}$, and PM_{10}) for the Melbourne and Sydney airsheds at a grid spacing of 1 km. The system was first demonstrated during the 2000 Sydney Olympics. Alexander Baklanov (DMI, Denmark) made a strong plea for "urbanizing" both meteorological and air-quality models. His argument was that as spatial resolution continues to improve, both

types of model need to account more realistically for the unique surface characteristics of cities. He went on to describe a new EU project named FUMAPEX (Integrated System for Forecasting Urban Meteorology, Air Pollution, and Population Exposure), whose goal is to improve meteorological and dispersion forecasts for urban areas.

Sasha Madronich (NCAR, USA) talked about a new regional field program named MIRAGE (Megacity Impacts on Regional and Global Environments) being planned for Mexico to study the impact of the Mexico City urban plume on the surrounding region, including the Gulf of Mexico. He also mentioned a possible emission-control disbenefit for Mexico City that arises from the radiative coupling between O_3 and PM. Mexico City has a significant PM problem as well as an O_3 problem. The aerosol burden in Mexico City has been estimated to reduce surface photolysis rates for NO_2 by 10-30%, which in turn likely has the effect of reducing O_3 levels by several tens of ppb. As a consequence, some control measures to reduce PM levels in Mexico City could have the undesired side effect of increasing O_3 levels.

Following the presentations, a number of break-out and plenary sessions were held to develop recommendations for additional research directions and for NMHSs intending to launch AQ forecasting activities. The working groups were asked to identify research needs and priorities to advance air quality forecasting capabilities, and to address these issues from both a science and an operations perspective. Specifically they discussed: What are the science issues that need to be addressed to advance our capability to forecast air quality? and What are the major issues/barriers (e.g., methods, verification, measurements, dissemination) to providing air quality forecasts?

Some of the important workshop findings include:

- There is growing experience and interest in air quality forecasting;
- Air quality forecasting and management share a common science-base;
- Improvements in AQ forecasting will come from: 1. Better understanding of local situations and of key processes (e.g., local winds, boundary-layer dynamics); 2. Increasing accuracy in the meteorological forecasts; 3. The act of doing – increased experience will lead to enhanced capability; 4. Improvements in emission estimates;
- Resolution matters in many circumstances - But there are limits to when increasing resolution increases forecast quality and we need to understand this better;
- Simple statistical models can outperform complex numerical models at present in AQ-data-rich cities - but there are additional reasons to pursue numerical grid-based models;
- Emissions data are an important but not a limiting factor in beginning AQ forecasting;
- Tools commonly used to improve meteorological forecasts need to be explored in the air quality forecasting arena (e.g., data assimilation, ensemble forecasts);
- Satellites as a key element of air quality forecasting systems is an important topic as they hold promise for providing key information that can be used anywhere around the globe;
- There are barriers (perceived and real) to initiating and sustaining AQ forecasting activities;
- There are a variety of tools for forecasting air quality, but the many tools can present a confusion of choice when deciding how to get started in forecasting;
- It is of critical importance to define the reasons why air quality forecasting activities are undertaken, and to define the roles of the end-users and the various institutions involved.

The Workshop recommended that GURME:•Provide a “roadmap” through the *confusion of choice* in terms of tools;

•Continue to emphasize capacity building, and undertake additional capacity building/ training initiatives focused on air quality forecasting;

•Assist in fostering national coordination, specifically focused at interfacing the Meteorological and AQ communities;

•Articulate and advocate the necessary and complementary roles of research and operations;

•Expand the number of pilot projects;

•Increase their efforts to mobilize necessary resources.

Further details of this workshop and other GURME activities can be found on the website http://www.wmo.ch/web/arep/gaw/urban.html.