Summary of the First WMO/GAW GURME Air Quality Forecasting Workshop

Kuching, Malaysia 14-17 August 2000

I. Overview

The 1st WMO/GAW GURME Air Quality Forecasting Workshop was hosted by the Malaysian Meteorological Service and held in Kuching, Malaysia during 14-17 August 2000. The meeting was attended by 26 participants from 18 different countries. WMO established the GAW Urban Research Meteorology and Environment (GURME) Project in 1999 in response to requests from National Meteorological and Hydrological Services (NMHSs). GURME Workshops in Beijing in November 1999 and Moscow in December 1999 launched the project. In these workshops it was recognized that one important aspect of GURME involves enhancing the capabilities to provide meteorological and air quality forecasts of urban environments.

Figure 1. Workshop participants in front of the Kuching Hilton.

The objectives of this 1st WMO/GAW GURME Air Quality Forecasting Workshop were: (i) to familiarize the participants with the different options for urban forecasting; (ii) to present a spectrum of forecasting tools and to discuss appropriate uses (including examples of model applications and their limitations and technical and data support requirements; and (iii) to help NMHSs in their deliberations on what role to undertake in urban forecasting and in identifying suitable systems for use in support of their activities.

The workshop structure included presentations of modeling tools by experts actively engaged in air pollution forecasting, reports of on-going activities and future plans by participants representing their various countries, and working group and plenary discussion sessions focused on how GURME could most effectively support NMHSs efforts in air quality forecasting. The Workshop presentations and discussions focused on: (a) applications of air

quality forecasting, (b) descriptions of available approaches and their data, personal and computing requirements, and (c) mechanism to assist users in meeting their modeling needs.

The meeting began with welcoming words by Dr. Lim Joo Took, Director General of the Malaysian Meteorological Service, and Liisa Jalkanen from the WMO Secretariat, followed by an opening address by the Honorable Malaysian Minister of Science, Technology and Environment, Datuk Law Hieng Ding.

Figure 2. The Honorable Malaysian Minister of Science, Technology and Environment, Datuk Law Hieng Ding with his GAW shirt along with Dr. Lim Joo Took, Director General of the Malaysian Meteorological Service and Liisa Jalkanen from the WMO Secretariat.

II. Synopsis of Major Discussions

The major themes to emerge during the Workshop revolved around a few specific questions: What model is needed? How to start? and How can GURME help? The sense and direction of the discussion of these issues are presented below.

What model is needed?

The answer to this question is complicated and depends explicitly on defining what the objectives are for air quality forecasting, and what resources are available to support the undertaking. The motivation for air quality forecasting was discussed by a working group, and their deliberations identified the primary motivation for forecasting to be the provision of useful information for such activities as:

- Public warnings, control of emissions of certain industries, and restrictions on vehicular transport in adverse conditions;
- Provision of data on case studies used to assist in development and testing of alternative air pollution management strategies or for siting new power plants or industrial sites;

- Archiving of results to allow investigation of long-term problems such as risk of exposure to cancer-related pollutants such as benzene, and other issues such as acid deposition and nutrification of water bodies.

A number of models were presented at the Workshop and they represent a sampling of the contemporary models that are being developed and used in a variety of air quality forecasting and other air pollution activities. These models have been used extensively in applications in such cities as Oslo, Copenhagen, Sydney, and London. Applications using these models are now taking place in Asia and other regions. For example, NILU AirQUIS examples from Yantai, and other areas were discussed. It was also reported that the Swedish (SMHI) MATCH model will be installed and training activities conducted in Malaysia (Kuala Lumpur) for regional problems. The TAPM model from CSIRO was demonstrated at the meeting, with applications in Australia and Southeast Asia.

The participants at the meeting also discussed a variety of models that can support air quality forecasting activities, pointing out that each has its strengths and weaknesses, and summarized the available approaches and their data and computing requirements (see Table 1).

Table 1. Air quality forecasting modeling approaches and requirements.

MODEL	Surface data	Emissions data need	Use local met. Data	Use air qual data	Use synoptic data	Need mesoscale model data	Need data to make model		Hard-ware needs
Statistical			X	X	X				
Expert system				X	X		X		
Box		X	X	X		X			
Trajectory (regional) (local)		 (X) (X)	 X X		X	 X			 PC PC
Multi-source Gaussian		X	X			(X)			PC
Prognostic:@									
AirQUIS	X	X	(X)			X	X		
Thor	(X)	X			X	X			WS
TAPM	Supplied	X			X				PC
MM5/CTM	X	X							WS
NAME		X							WS
AAQFS		X			X				SuperC

@ These are the models presented at the meeting and further information can be found on their websites. AirQUIS (Norway) (www.nilu.no/informasjon/airquis.html), THOR (Denmark)

http://luft.dmu.dk/AtmosphericEnvironment/Thor/inf.html, TAPM (Australia) (www.dar.csiro.au/res/aq/TAPM), NAME (UK), AAGFS (Australia).

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 discussed:

Regional vs urban scale.

The spatial scale for modelling needs to be clearly defined, as the spatial scale strongly determines the meteorological and other data requirements. The participants at the Workshop identified clear needs for forecasting at the regional level for issues related to large-scale haze and acid deposition, and for forecasting air quality within urban areas. Adequate resolution of important geographic and meteorological features (sea breeze, mountain/ valley winds) is required for successful forecasting. A related issue is that the detail of a pollution forecast needs to be high enough to resolve source-receptor relationships.

Computing requirements for modeling.

Air pollution forecasting requires consideration of computing resources. The most comprehensive approaches (e.g., running a photochemical model in conjunction with a mesoscale meteorological model) require substantial high performance computing resources. However, many approaches can be operated on PCs provided that weather forecast data are available on the Internet. For example, the TAPM model from CSIRO includes all the necessary GIS information needed to operate it anywhere in the world. It is a PC-based 3-D prognostic model for air pollution.

Air pollution forecasting requires reliable access to data.

For a prognostic system that calculates fine-scale weather and air pollution, it is essential that access to synoptic forecast data is possible. One issue identified was the different models for data access/availability. For example, data from ECMWF are available, but usually at a substantial fee, whereas data from NCEP are free but are likely to become hard to access as demand increases.

The other major data need is an emissions inventory. This is very important, and the quality of the inventory will determine to a large extent the quality of the forecast. For forecasts of chemically reactive pollutants, high quality is paramount.

Quality of a Forecast.

Adequacy of the quality also varies greatly and depends critically on the availability of information and the uses to which it is put. High forecast accuracy is required if the predictions can lead to the closure of a city for a day to alleviate forecast high pollution!

Verification.

For the reasons identified above, there is a need for data that are of adequate quality. This data is needed for the forecasting activity and in the evaluation stages.

How to Start?

Another major discussion topic revolved around the fact that for many countries there does not yet exist emission inventories and monitoring data upon which to base detailed air quality modelling efforts. Yet there is a clear need and interest in undertaking modelling efforts to help in the better management of their atmospheric environments. Modelling does not need to wait for new data, recognising that some progress can be made using what is already available. Support for monitoring might be forthcoming if the potential of the possible information can be demonstrated. A schematic flow diagram of the processes involved in modelling and monitoring is shown below. These steps can be performed in parallel; e.g., learn model application, commence emissions inventory development, start process of monitoring to acquire data for verification studies. These are synergistic activities, and in some cases a monitoring program may stimulate a modelling activity, and in other cases a modelling activity may help identify the necessity of new/better measurements.

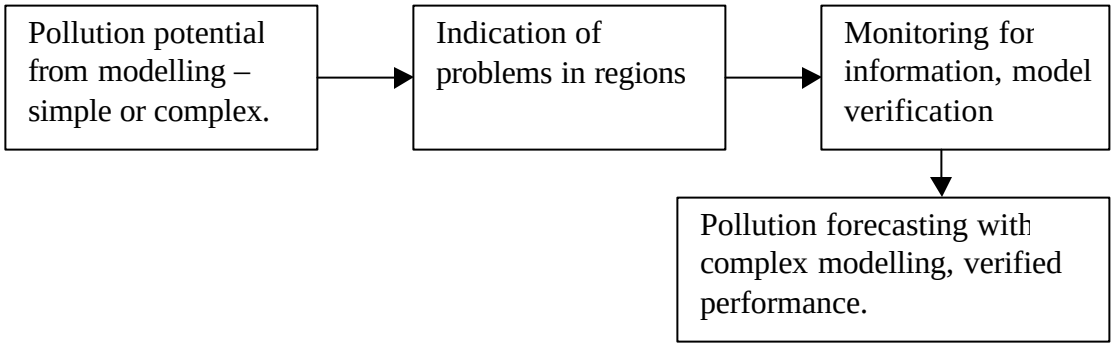

Figure 2. Schematic of the interactive processes involved in air quality forecasting.

The workshop participants also discussed a variety of issues related to their needs as they begin to undertake modeling activities.

Current activities/plans.

The workshop participants discussed the present state of their activities in urban issues. **China**: Growing problem of mobile sources. Modeling activities focused now on statistical methods but beginning 3-d modeling effort. **Vietnam**: No activity yet, but monitoring is beginning. **Malaysia**: Primary pollutants are a priority, and are concerned with both regional and local problems. Working with Sweden to add a regional modeling capability. **Myanmar**: Monitoring is just starting. Air pollution is becoming of growing concern, and computers are still rather limited. **Thailand**: Air quality related to mobile and industrial sources is a concern. No forecasting activities yet. They recently obtained a Super Computer, but personnel are limited. **India:** No forecasting activity as yet, presently a lack of coordination of different authorities, but measurement activities are underway. **Pakistan**: The NMHS plans a new directive in air pollution, with a focus on particulates. **Indonesia**: They are actively involved in monitoring. At present modeling using statistical methods, but would like to use other air pollution models, and are concerned with both local pollution and regional haze issues. **Singapore**: Concerned with both local and regional issues, including photochemical smog. **Philippines**: Concerned with motor vehicles and particulates. No modeling capabilities now but are working with Norway to add this capability.

In-house capabilities.

It was made very clear that Institutions want to have in-house capabilities in using the models. All the services have availability to GTS, have some numerical weather prediction (NWP) skills, and access to large-scale forecast products and to the Internet. Air quality modelling should be able to be build on this base.

Collaboration.

The success in air pollution forecasting is made easier if agencies can be brought together to undertake the work. For example, in Australia, the new pollution forecasting system involves collaboration between Bureau of Meteorology, two divisions of CSIRO, and two environment protection agencies. The complexity of the system makes such multi-organization arrangements necessary. Furthermore, while there are many free modeling tools available, to use them requires expertise and this may need to be developed through partnerships. However these require funding and opportunity to participate in projects. Accepting that partnerships are an excellent means of acquiring information on possibilities and resources, and in acquiring also the skills to undertake the work, what are the major barriers? Funds! It may be necessary to identify institutions and individuals that are willing to support countries and cities to identify the problems and to define the need for models.

Training.

The complexity of the initiative on air pollution forecasting is substantial. It is clear that many participants are burdened by the need for substantial training and technology transfer. The development of local expertise and facilities is essential. Otherwise the systems become a black box that cannot be maintained. However, it is important to face the need for substantial local resources to succeed in forecasting. Realism is required.

How can GURME help?

The final plenary session of the meeting focused on how GURME can be most effective in providing assistance in the area of air pollution forecasting. The GURME program was identified as an important undertaking by the WMO. The participants stated that GURME provides an international framework and motivation for NMHCs to pursue their interests in air pollution modeling, and obtain the necessary resources. Facilitation, even within a single country, is an important contribution. For an agency to be able to say it has the backing of WMO, in collaboration with WHO, could well open doors in other agencies to allow progress.

There was strong sentiment among the participants that the emphasis should be placed on providing training programs rather than models, since training is essential in being able to effectively apply models. More workshops and a resource-rich web site were identified as worthwhile activities. The workshops should strive to have more basic tutorial information on air quality issues (e.g., basic presentation of different modeling techniques, basic atmospheric chemistry, etc.) and most importantly contain more demonstrations and hands-on activities.

The GURME web site contains a great deal of information, which will be available to experts and user countries. A preliminary site is available at:

www.cgrer.uiowa.edu/people/carmichael/GURME/GURME.html. Suggestions as to how to improve the site included: Adding a list of possible personal contacts who share a common interest in urban issues; and developing stronger linkages with other programmes going on in the region (acid rain etc.), which are also interested in and working on the emission inventories on a regional scale. The desire to provide additional information on air quality modelling, tutorials and demonstrations, on the site was also strongly endorsed. GURME should also post case studies on the site. Emphasis should be placed on examples of applications at urban and at regional scales, and in tropical regions. Along these lines, there was valuable information regarding air quality forecasting generated specifically for this Workshop, and this material can be found at http://www.cgrer.uiowa.edu/people/carmichael/GURME/Urban_Norway.pdf and http://www.cgrer.uiowa.edu/people/carmichael/GURME/prediction.pdf. Complete details of GURME can be found at http://www.cgrer.uiowa.edu/people/carmichael/GURME . However it is important to note that GURME cannot rely solely on the Internet, as in several agencies represented at the workshop, access to the web is still quite difficult.

It was pointed out that as WMO moves into the smaller scale air pollution problems like the urban areas, it was pointed out that it is necessary to use other institutions than the traditional meteorological offices. WMO/GURME should actively issue a questionnaire to find out who wants to follow up the workshop. It may also be possible to have an interactive part of the web site, where discussions could be undertaken. A simple approach should be to make us of communications by e-mail between those interested in urban issues.

III. Summary & Recommendations

The Workshop concluded with a final discussion of the major points and recommendations. The Workshop concluded that:

- There is keen interest in air quality forecasting activities.
- The NMHSs have an important role to play.
- Many of the participants were not yet in the position to determine what modelling activity is needed to support their anticipated applications.
- The overwhelming need is to develop expertise in the different countries.
- There is a clear need to help the NMHSs develop a better understanding of what models can be used, their limitations and possibilities.
- GURME should actively apply/demonstrate models in tropical environments (as many of the models presently in use have been developed and used in mid-latitude applications). A pilot project in the tropics was one strategy identified.
- The success of GURME and air quality forecasting capabilities within the NMHSs relies ultimately on technology transfer.

- The mechanisms of training are critical and must include:
  - Partnerships
  - Access & self help by providing of tools and information
  - Training and information exchange through workshops
  - Funding and twinning arrangements

- It is very important to keep/place the NMHSs Permanent Representatives (PRs) in the loop in all aspects of GURME.

- Training should consider making use of Regional Training Centers such as that at ISPRA.

- Future workshops should have a clear regional focus, with more hands-on and demonstration elements, and that demonstrations should use local data and numerical weather prediction products.

Agenda

First *GURME* Forecasting Workshop

Kuching, Malaysia
14-17 August, 2000
Hotel Hilton Kuching

Hosted by the Malaysian Meteorological Service

Provisional Agenda

Sunday, 13 August

20.00 Dinner hosted by Minister of Science, Technology and Environment

Monday, 14 August

Opening of Workshop

09.00 Welcoming words by Dr. Lim Joo Tick

09.10 Welcome by the Representative of WMO (Liisa Jalkanen)

09.20 Opening address by Minister of Science, Technology and Environment

09.35 Press Conference/*Tea/Coffee break*

Morning session
Chairman: Dr Lim Joo Tick

10.15 Introduction of participants

10.30 Overview of the Global Atmosphere Watch (GAW) Programme
Liisa Jalkanen, WMO

11.00 Urban Environment Issues and Challenges
Greg Carmichael, *GURME* SAG chair, USA

11.30 Urban air pollution problems and health
Dato' Dr A Bakar Jaafar, WHO

12.00 The DMU-ATMI THOR air pollution forecast system – an integrated

operational forecast system on regional and urban scale
Jorgen Brandt, Denmark

Lunch 12.30 – 13.30

Afternoon session
Chairman: Greg Carmichael

13.30 The DMU-ATMI THOR air pollution forecast system – ongoing development and the future
Jesper H. Christensen, Denmark

14.00 Australian Air Quality Forecasting System
Kamal Puri, Australia

15.00 Prognostic Air Pollution Modeling: Alternatives and needs
Peter Manins, Australia

Tea/coffee break 15.45-16.15

16.15 A Model System for Urban Air Pollution Forecasting
Tao Shuwang, China

16.35 Heavy Rainfall Forecast for Hanoi area by statistical methods
Hoang Phu Cuong, Vietnam

17.00 Discussion on items that have come up during the day's session

17.45 Adjourn for the day

Tuesday, 15 August

Morning session
Chairman: Leong Chow Peng

9.00 Regional dispersion calculations with the MATCH model
Magnuz Engardt, Sweden

10.00 Air Quality Forecasts in Urban Areas of Norway
Bjarne Sivertsen, Norway

Tea/coffee break 10.30 - 11.00

11.00 Air Quality Forecasting in the UK
Paul Mason, UK

11.30 An Overview of APRU Research Activities and some Fundamental Problems of Mixing Height Evolution in the Tropics
Abu Samah Azizan, Malaysia

12.00 The Future Plan of The Urban Environmental Research in Beijing
Zhang Zhu, China

12.20 Roshydromet GURME Pilot Project "Meteorological Servicing for the Sustainable Development of the Moscow Megapolis"
Alexei Liakhov, Russian Federation

Lunch 12.45 – 13.45

Afternoon session
Chairman: Peter Manins

13.45 Impact of urbanization and air pollution over major cities of India
A. K. Srivastava, India

14.15 Comparison of meteorological conditions between urban and rural area in Mandalay City
Min Han, Myanmar

14.35 Dry season in Bangkok
Taweewat Ninpetcharat, Thailand

14.50 Tropospheric and stratospheric ozone position in Pakistan
Muhammad Ajmal Shad, Pakistan

Tea/coffee break 15.20-15.50

15.50 Philippines Clean Air Act of 1999
Rosalina G. de Guzman, Philippines

16.20 Performance of Passive Samplers in the Tropics
Leong Chow Peng, Malaysia

16.35 Carbonaceous Aerosols in Urban Atmospheres : Experience in Singapore
Rajasekhar Bala, Singapore

17.10 Discussion

17.45 Adjourn for the day

Wednesday, 16 August

Morning session
Chairman: Paul Mason

09.00 Work in groups on specific subjects to be given at workshop

Tea/Coffee break 10.30 - 11.00

11.00 Reports from groups, discussion

Lunch 12.30 – 13.30

Afternoon session

14.00-17.30 Visit to Sarawak Cultural Village

20.00 Dinner hosted by Director General, Malaysian Meteorological Service

Thursday, 17 August

Morning session

9.00 Continue work in groups

Tea/Coffee break 10.30 - 11.00

11.00 Continue work in groups

Lunch 12.00 – 13.00

Afternoon session

13.00 Wrap up-discussion

15.00 Closure of meeting

List of Participants

Papers by NILU & CSIRO