TF HTAP WORKSHOP ON
Global and Regional Modelling for Assessing Hemispheric Air Pollution
Forschungszentrum Juelich, Germany
17 to 19 October 2007

Summary of the co-chairs: Terry Keating and André Zuber

Introduction

The Task Force on Hemispheric Transport of Air Pollution (TF HTAP) has the objective to provide the UNECE Convention on Long Range Transboundary Air Pollution (CLRTAP) with a fuller understanding of intercontinental transport of air pollution in the Northern Hemisphere. In pursuing this objective, the TF HTAP is organizing a series of workshops, cooperative analyses, and assessment reports focused on a number of policy-relevant science questions adopted by the Task Force.

The TF HTAP workshop in Juelich, 17-19 October, 2007 particularly addressed issues related to global and regional modeling of the transport and transformation of air pollution on the hemispheric scale. It was hosted by the Forschungszentrum Juelich (FZJ).

It was attended by more than 60 experts from the following Parties to the Convention: Canada, Belgium, the European Community, France, Germany, Italy, the Netherlands, Norway, Poland, Russian Federation, Spain, Sweden, Switzerland, the United Kingdom and the United States. From outside the UNECE region, experts from India, Japan and Thailand participated. Representatives of the UNECE Secretariat; EMEP's CCC, MSC-W, and MSC-E; JRC; and WMO also participated.

Objectives and organization of workshop

The main objectives of the workshop were to report on progress on the ongoing model intercomparison, and to plan further experiments to inform the TF HTAP's 2009 Assessment Report. In particular, the workshop aimed at identifying next steps that would link regional and global modeling efforts to improve the assessment of intercontinental transport of air pollution, enable an assessment of the impact of climate change and future emission scenarios on intercontinental transport, and improve model evaluation and uncertainty characterization.

The meeting was organized into the main sessions:

1. Presentation and discussion of the model experiments performed for Chapter 5 of the 2007 Interim Report[1].
2. Regional scale modeling and hemispheric transport
3. Future source receptor relationships: climate change and emission scenarios
4. Planning and prioritization of future experiments

Introductory presentations[2]

Mr. A. Wahner, Director of FZJ's Institute of Chemistry and Dynamics of the Geosphere-Troposphere, opened the workshop and gave a general outline of the activities of the research center. He also wished the workshop success in its endeavor to advance scientific findings in intercontinental transport of air pollution. The meeting was co-chaired by Mr A. Zuber (European Community) and Mr. T. Keating (United States). Mr Keating informed the meeting of the objectives of the TF HTAP, progress so far, and the draft roadmap leading up to the 2009 Assessment Report, which is to inform the LRTAP Convention on issues of intercontinental transport of air pollution by ozone, fine particles, mercury and persistent organic pollutants. He emphasized the mutual reinforcing roles of observations,

[1] Available on the TF HTAP webpage www.htap.org

[2] The presentations and other support material from the workshop are available on the TF HTAP webpage www.htap.org

modelling, and emission inventories to meet our objectives to provide an improved understanding of these issues.

Presentation and discussion of the model experiments performed for Chapter 5 of the interim report

The first part of the session on results obtained in SR1 and TP1 experiment with global models was chaired by Mr. O. Wild. Presentations were made Mr. F. Dentener, Mr. M. Schultz and Mr. M. Schulz.

It was concluded that the information from the first experiments had been useful for the HTAP 2007 Interim Report and that several of the findings based on the common methodology are to be considered as new scientific findings. It had *inter alia* been found that for ozone and fine particles the contribution of intercontinental transport is small but significant in comparison to policy objectives, such as air quality standards. It had also been established that there are some differences in import sensitivities between the models and between the studied regions. There is also a clear conclusion that intercontinental transport of ozone and fine particles in relative terms is more important for the column loadings (relevant for climate change) than for the surface air quality.

The workshop participants recommended that the completed experiments be properly documented and the results be published in science journals. It was also recommended that the extensive database jointly hosted by the FZJ and the JRC IES be explored further. Further analysis could examine seasonality, resolution dependence, linearity of concentration responses, sensitivities to individual precursors or components (NOx, VOC, CH4, carbonaceous particles, deposited N), receptor or source analyses in specific regions (like the Arctic, North Africa, South Asia/East Asia border), the role of individual pollution transport events and contributions to high concentration episodes, and impacts of different source types (i.e. for particles, dust, biomass burning, and anthropogenic components), and the role of stratosphere-troposphere exchange.

The workshop participants also recognized an overall need to evaluate and benchmark the models performance with observational data. It was recommended that some experiments be repeated for other years to allow comparison and evaluation of models with intensive field campaigns, such as the ICARTT campaign in 2004 or for CALIPSO observations in 2006. A number of concrete experiments were also suggested to allow systematic evaluation of key processes (TP1x), including additional diagnostics to look at different types of aerosols. The workshop participants recognized the need to coordinate these further model efforts with other initiatives like AEROCOM[3], AC&C[4], and EUCAARI[5].

Analysis of individual model results

The second part of the session on analysis of individual models was chaired by Mr. F. Dentener. Presentations were made by Mr. M. Sanderson, Mr. J.E. Jonson, Mr. K. Cuvelier, Mr. T. Nagashima Mr. H. Bian and Mr. G. Beig.

The workshop participants concluded that long range transport of nitrogen species (NOy and NOx) is key to the formation of ozone in the middle troposphere and that deposition of those components is a governing factor of the atmospheric concentrations (Sanderson). The first efforts of comparing vertical profiles of modelled ozone indicate some significant differences between models and between models and observations, differences being larger in summer than winter. Also the perturbation experiments indicated differences in response in the ozone vertical profiles, with some regions being influenced by NOx titration (Jonson).

Also research groups not participating in the HTAP model intercomparison provided information to increase our understanding of the changing atmosphere. Monitoring and regional/global modelling efforts (including updates of emission inventories) in Asia clearly show the long range influence of changing atmospheric emissions in the region (Nagashima, Beig). The evaluation of

[3] http://nansen.ipsl.jussieu.fr/AEROCOM/aerocomhome.html
[4] http://www.igac.noaa.gov/ACandC.php
[5] http://www.atm.helsinki.fi/eucaari/index.php?option=com_content&task=blogcategory&id=28&Itemid=72

satellite Aerosol Optical Thickness data considered for model evaluation was shown to depend strongly on the relative humidity and resolution of the model. It was shown that AOT is particularly sensitive over the mid latitudes and land-sea boundaries (Bian).

The workshop participants recommended that the nitrogen deposition processes be further clarified and that model differences and uncertainties be assessed and with the aim of improved understanding. For ozone vertical profiles more models are welcome to provide such information and more quantitative evaluations could be done. For such benchmarking, the HemiTap tool provided by the JRC is useful but it may require inclusion of further parameters or observational data. Expert groups that do yet participate in the modelling and other activities of the TF HTAP could positively contribute to the increased understanding and to the HTAP 2009 assessment report.

Future emission scenarios and climate change

The session was chaired by Mr. G. Carmichael. Presentations were given by Mr. M. Engardt, Mr. O. Stein, Ms. G. Zeng, Ms. R. Doherty, Mr. P. Hess, Mr. H. Tost, Mr. F. Dentener, and Mr. D. Shindell.

The workshop participants concluded that several research efforts in the Europe Union and the United States have addressed how climate change scenarios by the end of this century could influence air quality, particularly at the local and regional scales. These studies have shown that the difference in the regional climate scenarios is decisive for the overall uncertainty for assessing air quality, but most model results indicate increased ground level ozone and secondary PM at the regional level in a warmer climate with constant air pollution emissions. There are also uncertainties in quantifying key atmospheric processes, such as the stratosphere-troposphere exchange rates and the effects of fully coupled model feed-back loops.

The study of air pollution in heat waves, such as the one in Europe in the summer 2003, could be used to assess likely impacts of increased temperatures on biogenic emissions, dispersion and chemistry in a changing climate.

The results from modelling so far show some rather large differences between models and between models and observations (Stein). Global model studies also indicate that the O_3 reductions in source regions are amplified in the future climate and that transport of O_3 to receptor regions seems weakened in the future climate (Zeng). In the few studies made so far of the future air pollution emissions and climate scenarios up to 2050, there is a tendency that air emission changes are more influential on (changes of) intercontinental transport than climate induced changes (chemistry and transport patterns/path ways) (Zeng and Doherty).

The workshop participants recommended that longer runs are needed to exclude any noise from inter-annual variability, although the influence of inter-annual variability is small when comparing the differences between model sensitivities for source-receptor relationships. More studies are needed on the evolution of transport pathways with changing climate. Further experiments should probably use large climate changes (with a bearing to 2100) and large emission perturbations. Key processes for long range transport of air pollutants, including stratopshere-troposphere exchange, deposition processes, lightning, biomass burning, have to be properly included in the climate models. Further work is needed to understand the predictive nature of relationships between temperature, water vapor, and the various pollutant concentrations of interest (O_3, CO, aerosols, ...). Future studies should be performed with fully coupled chemistry-climate models, although off-line models will be able to study some key processes.

HTAP and regional modelling

The session was chaired by Mr. J. Fu. Presentations were made by Ms. L. Rouil, Ms. T. Holloway, Ms. Y. Zhang, Mr. J. Fu and Mr H. Jakobs.

The workshop participants concluded that regional models have been applied in different parts of the world (Europe, Asia, North America) to assess regional and local air quality, regional export flows of air pollution, and the effectiveness and impacts of emission reductions. Results from the EuroDelta comparison of regional models suggest that the baselines of the regional models are different, but they show rather similar responses at the regional scale to perturbations in emission reductions. The differences are rather apparent for deposition patterns and for urbanised areas depending on the treatment of the key processes such as vertical exchange processes, titration in vicinity of sources, and depending on differences in boundary conditions (Rouil). Results from the MICS-Asia comparison of regional models have demonstrated the impact of using global models to provide boundary conditions to drive regional models. Further work is planned to examine and the impact of the temporal resolution of the boundary conditions and the spatial resolution of regional model simulations on estimates of regional inflow and outflow (Holloway, Fu).

Several regional models now assimilate air pollution data and meteorology in the forecasting of air pollution over the time frame of several days. These new methods allow a much improved treatment of uncertainties in the underlying data on emissions and parameterised key processes. However, model inter-comparisons, diagnosis and evaluations have to done on different scales and for different model parameters in order to actually improve our understanding (Zhang).

The workshop participants recommended that regional models be used to improve our understanding of the importance of grid resolution in estimating intercontinental transport and to assess sub-grid effects of the global models. The linkage of global models to regional/local models may allow the assessment of air quality impacts at finer scales, such as the urban scale, and its relation to intercontinental transport. Aggregation, from the fine resolution to the coarse, may also help in parameterization of sub-grid processes.

Specific problems that could be addressed jointly between global and regional models include parameterization and evaluation of key processes such as vertical mixing and exchange, convection and deposition processes, and provision of boundary conditions from global models to regional ones. Such efforts can be done within the regional frameworks in Europe through the EMEP TF MM, in Asia through the MICS-Asia Phase III and in North America through the bilateral US-Canada co-operation programmes.

Benchmark datasets

The session was chaired by Mr. D. Parrish. Presentations were made by Mr. J. de Laat, Mr. B.Dils, Mr. K. Torseth, and by Mr R. Husar.

The workshop participants concluded that key air pollution observations from satellites are now becoming widely available. Improved satellite observation products for CO, PM, NO2 and methane have been used for evaluation of models and in inverted modelling to assess source strengths and transport flows. Ground based and vertical profile observations are available from a large variety sources within regional organisations/projects like EMEP, EUSAAR, ACCENT, GEOMON, EANET and NARSTO, and from global organisations like WMO. Some collated and consistent datasets for NOx, CO and PM (AOT) are already in use for benchmarking model performance at the regional and global scales. Recent new contracts will improve the availability of such datasets, through work at NILU to create a reference database of observations from surface site and at NASA to create a reference database of observations from aircraft campaigns.

The workshop participants recommended to continue the integration of observations and other information in suitable formats and that these are made easily available for model evaluation and analysis through standard protocols (such as a Web Coverage Service) on the internet. The development of these integrated observational data sets has to be done through close interaction between modelling and observation groups in order to define the user needs and the appropriate

formats. Part of the work has to be devoted to proper documentation of relevant information and to QA/QC.

Multi-species analysis

Also this session was chaired by Mr. D. Parrish. Presentations were given by Mr. D. Parrish and Mr. D. Shindell.

The workshop participants concluded that concentration ratios of different pollutants in air parcels, such as different hydrocarbons, provide an internal chemical clock that can be used to study physical and chemical atmospheric processes at time scales relevant for intercontinental transport. Observations from remote sites or aircrafts can be favourably compared to models (Parrish).

In the Arctic, several types of data from remote observation sites or proxy data from ice cores (BC, sulfates, etc) can be used to evaluate models; so far the models indicate a large spread for aerosols, that is substantial for gases too. These data can be used for source apportionment. Europe appears to be contributing to a large extent to the air pollution levels in the Arctic, but North America contributes most of the pollution to Greenland (Shindell).

The workshop participants recommended that such multiple datasets be explored to assess the chemical and physical processes that govern the life time of individual components and that the detailed observations of individual species with varying life times be used for model evaluation.

Planning of experiment sets 3/4 and publication plans

This session was chaired by Mr. M. Schulz. Presentations were made by Mr. O. Wild, Ms. I. Bey, Mr. G. Carmichael, Mr. P. Hess, Ms. R. Doherty, Mr. J. Fu, Mr. T. Keating and Mr. F. Dentener.

The presentations showed that, although much progress has been made to date, many interesting issues remain to be more explored within the first two phases and for the Experiment Sets 3 and 4. Some issues from Experiment Set 1 that require further exploration are nonlinearities in the chemistry, long-term responses through CH_4, and impacts of stratospheric ozone. These experiments could be done in such a way that selected models would do some but not all runs to reduce the amount of running CPU time (Wild). A series of diagnostic tracer simulations were identified to help explain the differences observed in Experiment Set 1 runs SR1-6. The highest priority is for all participating models to perform an extended series of tracer runs (TP1x), including tracers that more closely mimic the atmospheric lifetime of CO, some hydrocarbons, sulfate, Hg, and POPs. High temporal resolution output could be used when comparing with observational data from intensive field campaigns such as ICARTT (2004). In addition, simulations of emission pulses could be used to study continental outflow estimates and to compare to field campaign periods (TP2). Finally, a set of experiments is needed to transition from the highly constrained tracer simulations to more realistic scenarios which allow variability in OH and emission fields (TP3). (Wild)

Experiment Set 3 could include new simulations to compare model predictions to observations from the 2004 ICARTT campaign. In particular, the experiments could examine specific transport events associated with biomass burning or anthropogenic plumes to discern differences in the transport processes and their representation in the models (Bey).

Efforts to link global and regional modelling have already started within the MICS-Asia and will be coordinated with the activities of the TF HTAP. These include the evaluation of the effects of resolution and boundary conditions (from global models) on regional ozone and PM predictions and the evaluation of resolution and boundary conditions on source-receptor relations for East Asia (Carmichael). Regional models can also be invited to participate in the TP1x, TP2, and the ICARTT simulations. (Fu)

Experiment Set 3 could also include some coordinated experiments comparing dry deposition processes. Such an effort could be coordinated with other ongoing efforts to better understand dry deposition processes, including IGAC/DEBITS, ACCENT/BIAFLUX, and ESF/VOCBAS projects (Dentener). The model experiments for set 4 aims at assessing uncertainties in source-receptor relationships and the impact of future emission scenarios and climate change. Given that studies to date suggest that climate change may decrease the importance of long-range transport, that changes in transport due to meteorological changes are small, and that multiple years of simulation are necessary to address interannual variability, the impact of climate change on intercontinental transport may be best assessed by a limited number of models capable of fully coupled chemistry-climate simulations. 2050 may be a good future year to examine, as the various available emission scenarios are relatively similar up to this time. Further work is needed to review the available global emission scenarios and identify appropriate assumptions for Experiment Set 4. Exploration of future scenarios and climate impacts should be coordinated with the IGAC/WCRP AC&C project and other efforts contributing to IPCC Assessment Report AR5. (Hess and Doherty). USEPA will fund an analysis of the available future emissions scenarios to identify a set of possible assumptions for simulations in Experiment Set 4 (Keating).

The planning of future activities also has to include modelling and observations relevant for the assessment of intercontinental transport of Hg and POPs. A specific meeting is planned for April 2008 in Rome. For the finalisation of the roadmap, the co-chairs will draft an update taking into account the revised plans of the modelling experiments and other lines of work that have to fit together.

The next steps

A number of science papers are already in preparations or planned. These are outlined in annex 1.

A number of coordinators were identified for future model experiments, see annex 2. These coordinators will finalise the design of the experiments with other experts and invite all modelling groups to participate. The future experiments should make full use of the existing servers, wikis, and discussion lists.

A road map to the HTAP 2009 assessment report is under preparation (see annex 3). The road map will include milestones for invitations to participate, drafting of outlines and texts, and reviewing the drafts. The road map is to be finalized in April 2008 with the goal of finalizing the assessment report by the LRTAP Executive Body meeting in December, 2009. To achieve this schedule, all modelling runs will essentially have to be finalized by late 2008 and analysis finalized by June 2009 in order to influence the content of the 2009 report.

The next meetings of the TF HTAP are planned for 7-11 April 2008 (Rome), June 2008 (USA) and October 2008 (Asia). At these meetings further discussion on the analysis and further model runs may take place.

Annex 1: Proposed Papers (updated October 2007)

Topic	Lead Author
Surface O3/S-R relationships	Arlene Fiore
NOy deposition studies	Mike Sanderson
Transport to the Arctic	Drew Shindell
Transport processes, TP1/SR1	Martin Schultz
Vertical profiles of O3	Jan Eiof Jonson/Michael Gauss
Analysis of S-R for aerosol	Michael Schulz
Surface PM	Mian Chin
Process (or event) analysis	Isabelle Bey/Mat Evans
TP1x and NMHC ratios	David Parrish?
Regional aspects	
Future climate	
Future emissions/linearity issues	Oliver Wild
Emissions uncertainty	
Hg	Nicola Pirrone
POPs	Sergey Dutchak

Annex 2: Experiment Leaders

Experiments	Leader
SR1-6 S/R Sensitivities	Frank Dentener
TP1x: Fixed Tracers	Martin Schultz/Oliver Wild
TP2: Pulse Experiments	Oliver Wild/Martin Schultz
TP3: Transition to Realism	Martin Schultz/Oliver Wild
Dust/Burning Sources	Michael Schulz
ICARRT Analysis	Isabelle Bey/Mat Evans
Climate Change Impacts	Ruth Doherty/Peter Hess

Annex 3: Draft Road Map to HTAP 2009 Assessment Report

Outline

Part 1: O_3, PM, and Deposition
Part 2: Hg
Part 3: POPs
Part 4: Synthetic Summary for Policy Makers

Milestones

Mar 2008	Invitation to participate
Jun 2008	Final plan and list of authors
Aug 2008	First Annotated Outline
Nov 2008	Revised Annotated Outline
Feb 2009	Internal Draft of Parts 1-3
May 2009	First Review Draft of Parts 1-4, Exec Sum
Jun 2009	Major Review Meeting
Aug 2009	Revised Review Draft of Parts 1-4, Exec Sum
Sep 2009	Finalize Executive Summary
Nov 2009	Finalize Parts 1-4
Jan 2010	Printing