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EXECUTIVE BODY FOR THE CONVENTION ON LONG-RANGE TRANSBOUNDARY AIR POLLUTION

Steering Body to the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission for Air Pollutants in Europe (EMEP)

Thirtieth session
Geneva, 4 – 6 September 2006
Item 4(h) of the provisional agenda

## HEMISPHERIC TRANSPORT OF AIR POLLUTION

Report and conclusions of a workshop and the second meeting of the Task Force on Hemispheric Transport of Air Pollution prepared by the Co-Chairs with the assistance of the secretariat

## INTRODUCTION

1. This report summarizes the workshop held by the Task Force on the organization of an intercomparison of intercontinental transport models which took place on 30 and 31 January 2006 in Washington, D.C. (part I) and the second meeting of the Task Force on Hemispheric Transport of Air Pollution held in Moscow on 6 to 8 June 2006 (part II).

## I. WORKSHOP ON ORGANIZATION OF INTERCOMPARISON OF INTERCONTINENTAL MODELS

2. The workshop was organized by the Task Force and hosted by the United States Environmental Protection Agency.

3. The workshop was attended by nearly 100 experts from the following Parties to the Convention: Canada, Czech Republic, Denmark, Finland, France, Germany, Italy, the

Netherlands, Russia, Spain, Sweden, the United Kingdom and the United States. Experts from India, Japan, Republic of Korea and the Philippines also participated. Representatives of the European Commission (Environment Directorate-General and the Joint Research Centre (JRC)) attended. Representatives of the EMEP Meteorological Synthesizing Centre-West (MSC-W), Meteorological Synthesizing Centre-East (MSC-E), Chemical Coordinating Centre (CCC) were present. Representatives of the World Meteorological Organization (WMO) attended and a member of the secretariat was present.

4. Mr. T. Keating (United States) and Mr. A. Zuber (European Community), Co-Chairs of the Task Force, chaired the workshop.

## A. Objectives, background information and organization

5. At its first meeting, the Task Force had adopted a number of policy relevant science questions to guide its work (EB.AIR/GE.1/2005/12). The workshop was the first in a series to address the questions. A background document, prepared by a small group of experts led by the Co-Chairs and JRC, was used at the workshop as a starting point.

6. The objectives of the workshop were to:

(a) Develop recommendations about the methods and metrics for quantifying intercontinental source-receptor relationships and characterizing the level of confidence in such estimates. Encourage the development and publication of new comparable research results;

(b) Identify activities or analyses that will facilitate access to data and tools useful for all Task Force participants and for achieving the objectives of the Task Force;

(c) Identify specific coordinated multi-model studies that would explore important differences in model formulations and results;

(d) Develop a plan for the identified studies, including identifying individuals responsible for leading activities and mechanisms for coordination as well as proposing a schedule for producing new research results to feed into a 2009 assessment report.

7. More than 30 poster papers summarizing recent scientific developments in the modelling and monitoring of the intercontinental transport of air pollutants were on display throughout the workshop for viewing and discussion between sessions.

8. The background documents, presentations, posters and a list of participants are available at www.htap.org.

9. The Co-Chairs of the Task Force welcomed the participants and presented the background and objectives of the workshop. The workshop began with a series of plenary presentations and

discussions followed by breakout groups to address specific questions. A final plenary session discussed conclusions and recommended further work to be done.

## B. Summary of main discussion points

10. The first plenary session, entitled “Lessons Learned from Previous Work”, was led by Mr. F. Dentener (JRC), who made a presentation on a previous model intercomparison project ACCENT Photocomp. The workshop took note of the following presentations: Mr. M. Schulz (France) on the Intergovernmental Panel on Climate Change AEROCOM intercomparison; Mr. G. Carmichel (United States) on the Asian MICS intercomparison; Mr. S. Dutchak (MSC-E) on MSC-E’s persistent organic pollutants (POPs) and mercury model intercomparisons; and Ms. L. Tarrason (MSC-W) on the EuroDelta intercomparison.

11. The second plenary session, “Identifying Key Issues for Intercomparison and Assessment”, was led by Mr. Zuber. The session was divided into 5 segments each consisting of an overview presentation and plenary discussion of sets of issues or future tasks identified in the background document. The workshop took note of the following presentations: Mr. R. Derwent (United Kingdom) on source-receptor metrics and methods; Mr. D. Jacob (United States) on scale issues in modelling intercontinental transport; Mr. Carmichael on model diagnostic and performance metrics; Mr. K. Torseth (CCC) on observations available for comparison to models; and Mr. Keating on the availability of emissions information. The workshop agreed to carry over issues identified during each topic discussion to the break out sessions for further consideration.

12. The first set of break out sessions consisted of two discussion groups. One was led by Mr. Derwent and Ms. T. Holloway (country) and considered methods that should be used to establish intercontinental source-receptor relationships. The other group, led by Mr. Carmichael and Ms. A. Fiore (United States), discussed physical and chemical processes that should be addressed in assessing uncertainties in model estimates of intercontinental transport. Discussions resulted in recommendations for specific modelling experiments that were discussed in the second break out session and final plenary session.

13. The second set of break out sessions consisted of two discussion groups. One, led by Mr. Zuber, considered the outlines for the planned 2007 and 2009 assessment reports. The other led by Mr. Dentener, considered organizing future collaborative studies. The latter discussion built upon reports from the first set of break out sessions and the overview of studies proposed in the background document.

14. The final plenary session considered the reports from the break out sessions and agreed conclusions and recommendations.

## C. Conclusions and recommendations

15. The workshop agreed:

(a) The workshop was a useful first step towards a concrete workplan for the intercomparison of models and for deriving source-receptor relationships for intercontinental transport of air pollution;

(b) The background document and workshop presentations and discussions had identified the key issues that needed to be addressed as cooperative work was organized. The issues included the strengths and limitations of methods for deriving source-receptor relationships, the air quality metrics of interest for policy analysis and for model evaluation and development, the role of emissions and meteorological information and the need for observational data for model evaluation;

(c) There was significant interest from experts in participating in cooperative intercomparison and evaluation activities and in contributing to assessment reports.

(d) The details of a workplan for intercomparison and evaluation activities should be developed further with the aim that the plan would be completed for circulation prior to and discussion at the next Task Force meeting scheduled for June 2006 1.

(e) Specific next steps for the intercomparison and evaluation activities should include:

(i) Calculate regional inflow and outflow budgets for North America, Europe, and East Asia using existing global and regional models, with a goal of providing some first input to a 2007 interim assessment report;

(ii) Conduct comparative diagnostic and tracer studies to help interpret the differences in the regional budgets derived in (i);

(iii) Organize future detailed studies focused on specific pollutants, processes, or issues, including inter-annual variability, long-term trends, and climate change;

(f) The organization of model evaluations and intercomparisons required information integration tools and infrastructure to enable sharing of model input data (emission inventories, monitoring data, etc) as well as for the sharing and analyzing the model output results. Several tools had been developed to support previous model intercomparisons, such as the JRC tool developed for EuroDelta. To support the work of the Task Force, a flexible system that was independent of a specific user or model was needed;

(g) An assessment by the Task Force of the transcontinental transport and relevant source-receptor relationships should be finalized by 2009. This was thought timely for providing the Executive Body with answers to the policy-relevant science questions adopted by the Task Force. There was also a need to provide the Steering Body to EMEP with interim reports,

1 By 6 June 2006 a draft workplan for the intercomparison had been circulated for comment, but a final detailed

especially for the review of the Gothenburg Protocol that was planned to be completed by the Executive Body in December 2007. By 2007, the results of the modelling activities discussed at the workshop may be only partly available;

(h) Closely linked to the organization of the model evaluation and intercomparison activities were further workshops on emission inventories and projections planned for October 2006 and the use of integrated observations planned for January 2007;

(i) The outreach activities to countries outside the UNECE region were part of the Task Force's activities and would be pursued by continuing to invite experts from countries outside UNECE as well as through organizing workshops and Task Force meetings outside the region.

(j) Communication and transparency were important components for exchange of information between the experts participating in the Task Force. The Task Force website (www.htap.org ) would be updated regularly to ensure it held the most recent information.

(k) The results of the workshop would be communicated for consideration at the next meeting of the Task Force scheduled for 6 to 8 June 2006 in Moscow.

## II. SECOND MEETING OF THE TASK FORCE

16. The second meeting of the Task Force held in Moscow on 6 to 8 June 2006 was hosted by the Russian Federation and MSC-E.

17. It was attended by more than 70 experts from the following Parties to the Convention: Austria, Canada, Czech Republic, Denmark, European Community, Finland, France, Germany, Italy, the Netherlands, Norway, Poland, Russian Federation, Spain, Sweden, Switzerland, and the United States. From outside the UNECE region, experts from Cambodia, China, Egypt, India, Japan, Republic of Korea, and Thailand participated.

18. Representatives of the European Commission Joint Research Centre (JRC), the World Meteorological Organisation (WMO), the Arctic Monitoring and Assessment Programme (AMAP) as well as from the Centre for Integrated Assessment Modelling (CIAM), Chemical Coordination Centre (CCC), Meteorological Synthesizing Centre-West (MSC-W) and Meteorological Synthesizing Centre-East (MSC-E) of EMEP. The UNECE secretariat was also represented.

19. The meeting was opened by Mr. E. Gorshkov of the Ministry of Natural Resources of the Russian Federation.

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workplan was not yet complete.

20. The meeting was Co-Chaired by Mr A. Zuber (European Community) and Mr. T. Keating (United States) who provided an overview of the Convention and an overview of the aims and work progress of the Task Force.

21. The Task Force took note of the results of the workshop held in Washington in January 2006 and further noted that 29 different groups had provided comments or expressed an interest in participating in the model intercomparison work. The Task Force agreed to continue this effort and to take the results of this effort into account in its future deliberations.

22. It was agreed that the visual presentation materials and extended summaries of the discussion sessions would be made available at www.htap.org.

## A. Persistent organic pollutants

23. Mr. S. Dutchak (MSC-E) introduced the session on the state of science related to the intercontinental transport of persistent organic pollutants (POPs). Mr. Dutchak stressed that the Task Force's efforts on the intercontinental transport of POPs and mercury were highly relevant to the work of the Convention's Task Force on POPs and Task Force on Heavy Metals that reported to the Working Group on Strategies and Review.

24. Mr. A. Gusev (MSC-E) provided an overview of long-range physical and chemical transport processes and emphasized the importance of gas-particle partitioning in intercontinental transport and the uncertainties with the fate of POPs in the arctic region. Mr. K. Torseth (CCC) stressed the importance of long-term monitoring of POPs in air and precipitation and the usefulness of low-cost passive sampling campaigns. Mr. K. Breivik (CCC) drew attention to the lack of information available on emission sources of POPs and the limitations of officially reported data for scientific use.

25. Mr. Sunling Gong (Canada) stressed that transport patterns varied depending on chemical and physical properties and the importance of gas-particle partitioning and aerosol transport for long-range transport. He presented regional budgets for North America, Europe, Asia, Atlantic, and Pacific for some PCBs as estimated by a global model, showing heavy PCBs associated with particle transport and intercontinental transport dominated by light PCBs associated with the gas phase. Mr. P. Bartlett (United States) described the use of a trajectory model to estimate source-receptor relationships between North American emission sources and the Arctic and presented a proposal for future research planned for the international polar year 2007-8 addressing the effects of global climate change on POPs transport to the Arctic. Mr. V. Shatalov (MSC-E) explained the application of the EMEP model to answer the policy-relevant science questions identified by the Task Force. He noted that intercontinental transport of anthropogenic emissions can contribute between 20% and 50% of deposition in different locations in the Northern Hemisphere and the importance of the re-emission of accumulated POPs, which may contribute as much as 70% of deposition in some locations. Mr. I. Holoubek (Czech Republic) outlined work using

active and passive sampling methods to better understand source-receptor relationships and environmental processes.

26. The Task Force concluded:

(a) There is well documented evidence of the intercontinental transport of POPs, such as the accumulation of POPs in the Arctic. There is also observational evidence that decreases in emissions of POPs have decreased deposition.

(b) For intercontinental transport, key processes include gas-particle partitioning and re-emissions of historically deposited POPs.

(c) Key sources of uncertainties in assessing intercontinental transport of POPs include the lack of emissions information, for both direct and re-emitted POPs; observations in air, soil, and water; and characterization of surface-air exchange processes. Overall uncertainty in intercontinental transport estimates vary substantially depending on the specific chemical of interest.

(d) Presently, global emissions inventories and various measurement data are available for PCBs, HCB, and HCHs. In the short term, it is recommended to focus intercontinental modelling activities on these POPs.

(e) Source-receptor relationships for intercontinental transport are dependent on physical-chemical properties of individual POPs, as well as the magnitude and location of emission sources.

(f) Multi-compartment models can provide estimates of source-receptor relationships. Our confidence in these estimates varies across individual POPs due to the availability of emissions and observational data. In addition to currently identified POPs, these tools can also be used to assess the transport potential of candidate POPs.

(g) Further efforts are needed to improve emissions inventories for POPs that are poorly quantified, improve spatial coverage of air and deposition monitoring globally using active and passive sampling, further explore the use of nested regional and global chemical transport models to assess the intercontinental transport, develop the definition of source-receptor relationships taking into account the re-emission of historically deposited pollutants, and take stock of relevant information provided by Stockholm Convention, UNEP, and national programs.

27. The Task Force agreed to continue to address these issues through efforts on model intercomparison and evaluation, emissions inventories and projections, and integration of observations, and to revisit these issues as part of a future meeting.

## B. Mercury

28. Mr. N. Pirrone (Italy) chaired a session on the state of science related to the intercontinental transport of mercury. He stressed the major uncertainties in modelling the dynamics of mercury in the marine boundary layer and the need for improved emissions, chemical kinetics, and ambient observation data. Mr J. Munthe (Sweden) provided an overview of global mercury emissions and examples of emission inventories available, including those for natural sources. Mr. Xinbin Feng (China) summarized information on mercury emissions, transport and deposition in China, and presented evidence that emissions in China were likely to be much higher than many previous estimates had suggested. Mr. O. Travnikov (MSC-E) considered the processes for intercontinental transport of mercury and MSC-E's regional and hemispheric modelling activities including model intercomparisons. He presented estimates of intercontinental contributions to deposition in the EMEP region, North America, and the Arctic, noting that 25-60% of mercury deposited in the EMEP region was from sources outside the region.

29. Mr. R. Bullock (United States) described a model intercomparison study in North America and a modelling study of the impacts of the USEPA Clean Air Mercury Rule, which caps and reduces mercury emissions from coal-fired power stations. Mr. J. Christensen (Denmark) provided an overview of the monitoring and assessment work of AMAP, including a discussion of the Danish Eulerian Hemispheric Model. Ms. A. Dastoor (Canada) provided some preliminary results from an analysis of an intercontinental transport event using the Global/Regional Atmospheric Heavy Metals Model. Mr. G. Keeler (United States) outlined mercury transport and deposition in North America, showing the importance of speciated mercury measurements in the free troposphere and providing an example of the use of receptor modelling for defining source-receptor relationships. Mr. R. Mason (United States) presented aspects of cycling between the atmosphere-sea-terrestrial ecosystems.

30. The Task Force concluded:

(a) Elemental mercury is a long-lived species in the atmosphere, and there is well documented evidence of the intercontinental transport of mercury, such as the accumulation of mercury in the Arctic which has no local sources of mercury. There is also observational evidence that decreases in emissions of mercury have decreased deposition.

(b) For intercontinental transport, a key process is the oxidation of the "global pool" of atmospheric elemental mercury to more reactive species that are washed out or deposited to the surface. The rates and products of mercury oxidation in the atmosphere are not well known. Halogen chemistry plays an important role in rapid oxidation observed in the marine boundary layer and in the Arctic during spring.

(c) Estimates of primary anthropogenic emissions of mercury for the year 2000 are available at the global scale. Estimates for the waste management sector are more uncertain than estimates for other sectors. There is observational evidence that suggests that China's emissions

may be underestimated. The re-emission of mercury accumulated from historical deposition is highly uncertain at the global scale.

(d) Models describe the behaviour of mercury in the environment, including the atmosphere and oceans. However, insufficient knowledge of dry deposition and re-emission limits our confidence in their use in estimating source-receptor relationships for intercontinental transport.

(e) Although some observations of mercury air concentration and wet deposition exist, the spatial coverage, spatial resolution, and chemical speciation of the existing monitoring is insufficient. Further efforts are needed to address these limitations and establish techniques for measuring dry deposition.

31. The Task Force also took note of observational evidence of episodic transport of atmospheric Hg from Asia to North America; the role of the uptake of elemental mercury and accumulation of mercury in vegetation; the need for better representation of air –water exchange in models; the need for measurements of emissions from forest fires and biomass burning and from land and water surfaces, including oceans; and the potential impacts of changes in ozone and aerosol concentrations on mercury cycling.

32. The Task Force agreed to continue to address these issues through efforts on model intercomparison and evaluation, emissions inventories and projections, and integration of observations, and to revisit these issues as part of a future meeting.

## C. Methane as an ozone precursor

33. Ms. A. Fiore (United States) provided information on abating global ozone pollution, and hence decreasing climate forcing, through controls of methane emissions. Mr. J. West (United States) considered the issues further with regard to costs and health benefits resulting from methane controls. Mr. A. Mitra (India) drew attention to methane, CO and ozone for India and neighbouring countries, noting that the main emissions of pollutants were in the main crop-producing region of India.

34. Mr. T. Hanaoka (Japan) presented information on global methane emissions and abatement potential up to 2020 using the “top-down” Asia-Pacific Integrated Model (AIM) and “Enduse” models. Mr. M. Amann (CIAM) outlined projections of methane emissions up to 2030 using the GAINS model (a “bottom-up” model) noting the global model covered 75 countries or country groups. The Task Force noted that global methane emissions were expected to increase in the future but that cost-saving or low cost mitigation measures were available.

35. The Task Force concluded:

(a) Atmospheric methane concentration has more than doubled since pre-industrial times, indicating substantial growth in anthropogenic emissions. Major anthropogenic sources of methane include the energy (coal, oil, and natural gas), wastewater, solid waste, and agricultural (ruminants and rice) sectors. Without mitigation, global anthropogenic methane emissions are expected to continue to increase. Natural methane emissions are highly uncertain, and sensitive to changes in climate.

(b) Methane is a precursor to background tropospheric ozone and its growth since pre-industrial times has contributed to an increase in ozone globally. Future changes in methane emissions are expected to affect ground-level ozone concentrations, including in polluted regions.

(c) Since methane mitigation reduces global background ozone, it offers an opportunity to improve air quality globally, while also decreasing climate forcing. Mitigation efforts would complement ongoing local and regional ozone management. For example, models indicate that a 20% reduction in global anthropogenic methane emissions reduce surface ozone everywhere, globally averaged as ~1 ppbv, as well as decreasing climate forcing of both methane and ozone by approximately 0.15 W $m^{-2}$.

(d) Low-cost and cost-saving options are available to reduce methane emissions, as demonstrated through recent emission reductions in industrialized nations. Analyses of greenhouse gas reduction options suggest that roughly 20% of current global anthropogenic methane emissions can be reduced at low cost through global applications of currently identified measures (particularly in the oil, gas, and waste management sectors).

(e) Future research priorities should include: (1) assessing and reducing uncertainties in the ozone response to methane, through analyses such as multi-model intercomparisons and integration with observations, (2) identification of additional methane mitigation options and associated costs, (3) improved characterization of global methane emissions, (4) analyses of how future global change will affect the tropospheric response to methane. The Task Force could benefit from ongoing research in the climate change and stratospheric ozone communities.

36. The Task Force agreed to continue to address these issues through efforts on model intercomparison and evaluation, emissions inventories and projections, and integration of observations, and to revisit these issues as part of a future meeting.

## D. The 2007 Task Force reports

37. The Task Force agreed to contribute to an interim report aiming to inform the review of the 1999 Gothenburg Protocol. The report would address those pollutants covered by that Protocol (sulphur dioxide, nitrogen oxides, volatile organic compounds, and ammonia), as well as other pollutants of relevance for meeting the objectives of the Protocol, such as particulate matter, methane, and carbon monoxide. The executive summary of the Task Force report would provide

direct input to the main report of the review of the Gothenburg Protocol due to the Executive Body by December 2007. The Task Force report will be published in the UNECE report series. The Task Force agreed to the outline of the report, provided in Annex 1, and the timetable for its production, provided in Annex 2.

38. The Task Force agreed that the participation of experts from countries that are not Parties to the Convention in the work of the Task Force, in general, and the development of the 2007 report, in particular, is very important.

## E. 2007 Draft Work Plan

39. The Task Force agreed:

(a) To draft and finalise the TF HTAP 2007 Interim Report to inform the review of the 1999 Gothenburg Protocol

(b) To further work on the policy-relevant science-questions identified by the 1st Task Force meeting

(c) To continue the model intercomparison and evaluation effort and the development of intercomparison tools and information infrastructure begun at the January 2006 workshop

(d) To continue to work closely with the EMEP centres and other groups under the CLRTAP

(e) To continue its efforts of outreach to experts in countries outside the UNECE

(f) To hold a 3rd Task Force meeting in late May or early June 2007, tentatively in London

(g) To hold two workshops:

Workshop on Integrated Observations for Assessing Intercontinental Transport, Geneva, January/February 2007

A workshop to further preparation of the 2009 TF HTAP Assessment report – October/November 2007

Annex 1 Outline of the 2007 interim report to inform the review of the 1999 Gothenburg Protocol

0. Executive Summary *(as a 1-pg chapter in "Main Report")*

1. Introduction

2. Conceptual Overview of Intercontinental Transport Processes

3. Observational Evidence & Capabilities Related to Intercontinental Transport

    i. field studies, ii. long term, iii. satellite

4. Emission Inventories and Projections for Assessing Intercontinental Transport

5. Estimates of Intercontinental Transport from Global, Hemispheric, and Regional Models

6. Integration of Observations and Modeling for Assessing Intercontinental Transport

7. Activities of the Task Force

8. Synthesis: Conclusions and Recommendations *(submitted as official document to EMEP SB)*

Annex 2 Time table for the 2007 interim report to inform the review of the Gothenburg Protocol

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| July 2006 | Invitation to nominate experts for drafting report |
| Sept. 2006 | List of lead authors, drawn from the list of nominations of experts, posted on www.htap.org for comments. |
| October 2006 | Emissions Workshop (Beijing). Annotated outline posted on www.htap.org for comments. |
| November 2006 | Annotated outline submitted to Working Group on Strategies and Review |
| January 2007 | Observations Workshop (Geneva). First draft of chapters 1 to 6 posted on www.htap.org for comments |
| March 2007 | Redrafted chapters due to Co-Chairs of the Task Force |
| April 2007 | Full draft circulated to the Task Force |
| May/June 2007 | 3rd Task Force Meeting (tentatively, London). Full draft discussed and executive summary adopted by Task Force |

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| Mid June 2007 | Full revised draft submitted for translation for the EMEP Steering Body and executive summary for the WGSR (September 2007) |
| October 2007 | Full draft and executive summary submitted to Executive Body (December 2007) |