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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 of Air Pollutants in Europe

Working Group on Effects

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Progress in activities of the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe and its workplan for 2024–2025: hemispheric transport of air pollution

Hemispheric transport of air pollution

Report prepared by the Co-Chairs of the Task Force on Hemispheric Transport of Air Pollution

Summary

The Task Force on Hemispheric Transport of Air Pollution under the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe carries out the activities specified in its revised mandate (Executive Body decision 2019/9).[a] During the reporting period, it was also tasked with carrying out the activities assigned to it in the 2022–2023 workplan for the implementation of the Convention on Long-range Transboundary Air Pollution (ECE/EB.AIR/148/Add.1) in particular, workplan items 1.1.4.2–1.1.4.6) approved by the Executive Body at its forty-first session (Geneva, 6–8 December 2021).

In accordance with the Convention workplan, the Task Force is requested to present an annual report on its work to the Steering Body of the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe. The present report summarizes the progress made by the Task Force, presents an overview of its 2023 meetings, and discusses the activities proposed for the 2024-2025 workplan.

[a] Available at https//unece.org/decisions

I. Accomplishments under the 2022–2023 workplan

1. The 2022–2023 workplan for the implementation of the Convention on Long-range Transboundary Air Pollution (Air Convention) (ECE/EB.AIR/148/Add.1) identified a series of activities and expected outcomes or deliverables for the Task Force on Hemispheric Transport of Air Pollution that fall into four main thematic areas that cut across the pollutants addressed by protocols of the Air Convention:

(a) Development and evaluation of global emissions data sets that provide the basis for estimating the impact of extraregional emissions sources (i.e., sources geographically outside the Air Convention) (workplan item 1.1.4.3);

(b) Intercomparison and evaluation of global to regional scale models to improve estimates of source-receptor relationships over intercontinental scales and of health and environmental benefits of mitigating extraregional emission sources (workplan items 1.1.1.6, 1.1.1.14, 1.1.3.3, 1.1.3.5 and 1.1.4.5–1.1.4.6);

(c) Assessment of global scenarios to explore the relative health and environmental benefits of mitigation of extraregional emissions sources (workplan items 1.1.4.2, 1.1.4.4 and 2.1.3);

(d) Outreach and cooperation with other relevant multilateral forums (workplan items 1.3.2–1.3.4 and 1.3.7).

2. Under the first theme, the Task Force completed a new global emissions mosaic, HTAPv3. Applying similar methods as used in constructing the HTAPv1 (2000-2005) and HTAPv2 (2008-2010) mosaics, the new mosaic is a timeseries for 2000-2018 for ozone precursors and particulate matter components and precursors. It was developed from global and regional emissions data sets through the cooperation of the European Commission's Joint Research Centre and a number of national and regional partners.

3. Under the second and third themes, the Task Force demonstrated the use of ozone precursor tagging to estimate the contribution of global methane emissions sources to local ozone concentrations and to demonstrate that maritime shipping emissions on the high seas, as well as in coastal waters, contribute to the long-range transport of ozone. Utilizing results from the Task Force's previous multi-model intercomparisons, along with findings from other cooperative global atmospheric chemistry studies in the literature, the Task Force contributed to the review of the revised Gothenburg Protocol, describing trends in the influence of sources outside the ECE on pollutants covered by the protocol. The Task Force has also engaged with the Working Group on Strategies and Review, the Task Force on Integrated Assessment Modeling, and the Centre for Integrated Assessment Modeling to discuss the development of future policy scenarios for use in assessments of mitigation measures inside and outside the UNECE region.

4. Under the fourth theme, the Task Force has planned and initiated multi-model study of global mercury trends. The study, known as the Multi-Compartment Hg Modeling And Analysis Project (MCHgMAP), is intended, in part, to contribute to the work of the Minamata Convention Open-Ended Science Group to inform that convention's first effectiveness evaluation. The Task Force has also continued to contribute to and coordinate with the World Meteorological Organization's Measurement Model Fusion for Global Total Atmospheric Deposition (MMF-GTAD) project. In planning new work, the Task Force has engaged with experts from the Stockholm Convention on Persistent Organic Pollutants, the Arctic Monitoring and Assessment Program, and various international cooperative science efforts on biomass burning.

II. 2023 Task Force Meetings

5. To review progress and plan future work, the Task Force has organized a number of virtual meetings: 20 January, 18-21 April, and 29 June. The April set of meetings served as our main task force meeting and was divided into four 4-hour-long online sessions. 160 individual experts from 21 countries participated in one or more of the April sessions.

Agendas and presentation materials are available on the Task Force website.[1] Each of the meeting's sessions focused on one of three areas of ongoing and future work: fires, mercury, and ozone and other Gothenburg Protocol pollutants. The progress achieved and next steps in these areas of work are described below.

A. Multi-Pollutant Impacts of Fires

6. The 20 January, 18 April, and 29 June sessions focused on the planning of a multi-pollutant, multi-impact study of the effects of wildfires and agricultural burning. This effort was launched 8 November 2022 with a goal of organizing a multi-model study of the health, ecosystem, and climate impacts associated with fine particles, ozone, mercury, other metals, and persistent organics emitted or mobilized by fires. Cynthia Whaley (Canada) is leading the development of a white paper describing the objectives and design of the study. The paper is expected to be completed in December 2023. Model simulations and analyses are expected to be conducted in the 2024-2027 period.

7. As part of this effort, the Task Force will co-host a virtual workshop with the International Global Atmospheric Chemistry (IGAC) BBurned initiative. The workshop is planned for 7-9 and 14 November 2023 and will bring together the developers of the major global fire emissions inventories to hear about recent updates, understand their methods, discuss current intercomparison results and inventory disagreements, and determine which emissions (or combination of emissions) would be most useful for the HTAP fire modelling project.

8. The 20 January fire session included short presentations about related ongoing work on fire emissions inventories (Sarah-Lena Meyer, Germany), fire trends and forecasting in Thailand (Vanis Surapipth and Kasemsan Manomaiphiboon, Thailand), fire impacts in India (Rupal Ambulkar, India), and evaluating fire plume rise modeling using field study data (Wenfu Tang, United States). Most of the session was dedicated to discussing the outline of the white paper, what topics need to be included, and who might be able to participate.

9. The 18 April fire session was divided into four parts to discuss the key science questions the multi-model study will address, existing key parameters or uncertainties that would inform experimental design, the currently and soon-to-be available observations and model evaluations that would contribute to the multi-model study, and finally the organization of future work.

(a) The first discussion identified five main areas of interest for the HTAP fires study:

- The impact of fires on human health, not only related to exposure to PM2.5 and O3, but also to persistent organic pollutants and metals.
- The impact of climate change on wildfire activity, which was not taken into account in the fire emissions estimates used in CMIP6.
- The link between wildfires and ecosystems, e.g., deposition of fire-related pollutants
- Assessing the impacts of anthropogenic versus natural fires and distinguishing the fraction of wildfires that could be mitigated.
- Distinguishing the impacts of emissions from different sources of biomass. Much of the research in wildfire emissions have focused on the boreal forests, and while the wildfire risk in the tropics may not be as high, it might still be important to characterize the biomass sources in other regions of the world and the potential differences in impacts on global air quality.

(b) The second discussion focused on identifying key parameters or uncertainties to be considered in designing the multi-model study. The discussion focused on:

[1] See http://htap.org.

- Emissions uncertainties, including the need to
    - Develop a common understanding of fire activity.
    - Evaluate different emissions inventory products.
    - Collect information on the fuel, e.g., what is being burned, how much, condition of burn, etc.
    - Allocate fire emissions diurnally.
- Model uncertainties, including the need to
    - Account for variability in meteorology among the different models
    - Compare how the boundary between the free troposphere and the boundary layer is determined in different models, and the role of satellite measurements (e.g., MODIS) or ground-based observations for evaluation.
    - Compare the parameterizations of plume rise, plume height, and plume aging.
    - Define a common set of output parameters.

(c) The third part of the session focused on identifying observational datasets that can be used to evaluate model performance, and selecting the appropriate simulation periods for experiments which could vary depending on the science question being addressed. A table is already under development in the draft white paper, and participants were asked to provide information on available datasets (both in-situ and satellite-based), including the species available, the region covered, and time period. An evaluation strategy was also discussed, including various levels of evaluation, including from operational evaluation (model against observation), diagnostic evaluation (model ability to simulate atmospheric processes), dynamic evaluation (model ability to predict changes in air quality in response to changes in emissions), and probabilistic evaluation (uncertainty in model inputs and process representation).

(d) The final discussion of the session was focused defining modeling experiments around which future work could be organized. The experiments discussed included:

- Type 0: Baseline simulations – a period of approximately 5 years minimum would likely be needed to capture inter-annual variability, with 2015-2020 inclusive as a potential period.
- Type 1: Regional emissions perturbations
- Type 2: Fire process perturbations
- Type 3 (optional): Historical and future simulations with coupled-land atmosphere models.
- Type 4 (optional or based on analysis of existing research): Sensitivity to meteorology/inventory – the possibility of using meteorological reanalysis output for the 2000-2022 period, with the same fire emissions, to separate out the impact of meteorology.

10. A follow-up session on the fire study was held on 29 June 2023. This meeting focused on methods for estimating emissions of non-traditional air pollutants, scenarios for future fire emissions, and necessary linkages between models for different pollutants. The discussion on each of these topics is presented below.

(a) For components of and precursors to fine particles and ozone, there are a number of competing global fire emissions inventories. These will be the focus of the BBurned/HTAP workshop in November 2023. To consider other pollutants, such as metals and persistent organics, these inventories will need to be extended. In the session, the participants discussed the approach being taken to estimate mercury wildfire emissions, using $Hg:CO_2$ emissions ratios. It was noted that similar emissions ratio approaches have been used to estimate fire emissions of iron (an important nutrient) and PAHs, and possibly PCDD/Fs.

It was also noted that the fire study may want to consider the increase in soil dust emissions after fires.

(b) As noted above, the emissions scenarios used in CMIP6 did not consider how natural fire activity, and thus emissions, would change with climate. Douglas Hamilton (United States) presented recent work using six earth systems models with interactive fire models to generate fire emissions estimates consistent with the SSP climate scenario assumptions and calibrated to present day GFED. It was noted that this methodology could be used to generate a set of fire emissions scenarios for the multi-model study, possibly using a recently released updated version of GFED. Ville-Veiko Paunu (Finland) discussed the progress of a European Union-funded project on black carbon in the Arctic that has included an effort to define storylines for future emissions scenarios incorporating different assumptions about policies and human behavior. A report on these storylines, focused on land use change, population change, fire mitigation, etc., is expected in late 2023.

(c) The participants discussed the common inputs or drivers needed by models for different pollutants and the potential for loose coupling between models for common parameters. It was recognized that few modelers who work on persistent organic pollutants were present and that a future dedicated session on this topic should be organized. It was also noted that a major factor affecting the long-range transport of fire emissions is the injection height and plume rise assumed. The ability to represent in-plume chemistry, particularly the partitioning of NOy species was also discussed as being significant. The study design should attempt to estimate the significance of model differences with respect to injection height/plume rise and in-plume chemistry.

11. The drafting of the white paper for the fires study continues and a meeting of POPs modelers is being organized for early Fall 2023.

B. Mercury

9. The 19 April session was focused on global mercury emissions and modelling (work plan items 1.1.4.3 and 1.1.4.5). The first phase of the Task Force's mercury work is intended to contribute to the Open -Ended Science Group (OESG) created for the first Effectiveness Evaluation (EE) of the Minamata Convention on Mercury. Starting in 2022, a group of experts, led by Ashu Dastoor (Canada), was convened to develop a comprehensive "Modelling and analysis options plan to inform the Minamata and Long-Range Transboundary Air Pollution Conventions." The proposed modelling plan, now entitled the Multi-Compartment Hg Modeling and Analysis Project (or MCHgMAP), intends to mechanistically link primary emissions and releases of mercury to levels in large-scale global environments to detect and analyse the spatial patterns and temporal trends of mercury. The 19 April session was divided into two sections:

(a) During the first part of the session, the Task Force received updates on the status of the MCHgMAP options paper, the proposed plan for model simulations, and general progress under the OESG. The MCHgMAP options paper was introduced to the OESG in February and discussed at a recent face-to-face meeting of the OESG in March 2023. The timelines for delivery to the OESG were discussed with the Task Force, as results are expected by Fall 2024. It was clarified that after the OESG's mandate is complete and the EE is delivered, the Task Force's second phase of mercury modelling would continue, focusing on providing input to the review of the heavy metals protocol under the Air Convention. The Task Force also discussed the plan to submit the MCHgMAP options paper to a journal for publication.

(b) The second part of the session focused on prioritizing the policy-relevant science questions and related model simulations to inform the Minamata and Air Conventions, as well as the potential approaches for addressing these science questions, given the timelines of the Minamata Effectiveness Evaluation. The Task Force decided that the most feasible approach for delivery of results by Fall 2024 would be to focus on "baseline" and "nature" level simulations of mercury levels for the years 2010-2020, with potentially additional runs towards levels and trend attribution should there be sufficient time available.

Further modifications to the work plan would be discussed after the Minamata Conference of the Parties meeting in Fall 2023.

C. Ozone and other Gothenburg Protocol Pollutants

10. The objectives of the 20 and 21 April sessions were to take stock of recent and ongoing efforts inside and outside the Convention on global and regional modelling of ozone and its impacts, including the ozone response to changes in methane emissions, and to begin to plan cooperative modeling experiments to examine recent trends and future scenarios of ozone and other pollutants addressed under the revised Gothenburg Protocol.

11. The Task Force took note of a number of relevant ongoing activities in the community:

(a) Kai-Lan Chang (United States) presented the recommendations of the Tropospheric Ozone Assessment Report–II (TOAR-II) statistics working group on the best practices for detecting and quantifying trends in measured and modelled ozone concentration, including the use of nonlinear trend detection methods, the use of quantile regression for trend analysis, the use of calibrated language for communication of the significance of trends instead of simply classifying trends as statistically significant or not, and clear communication of uncertainties. Modelling activities in TOAR II are being organised independently by several different working groups, many of which have a regional focus. Lee Murray (United States) discussed the overall evaluation of ozone simulations in global models in TOAR-II, which will be based on the simulations performed for CMIP6.

(b) Olivia Clifton (United States) presented a comparison conducted under The Air Quality Model Evaluation International Initiative (AQMEII) of ozone deposition schemes in current regional models. Ozone deposition velocities can vary substantially between different models, which can be related to both the simulated stomatal and non-stomatal conductance, as well as differences between land cover types in different models. Future work within this AQMEII activity will continue to analyse the inter-model differences in ozone deposition in terms of these and other process representations. Future work on ozone deposition in general will benefit from more detailed output of ozone deposition pathways for different land cover types.

(c) James East (United States) reported on initial simulations using the HTAPv3 global mosaic emission inventory, which was released in April 2022. Simulations using the hemispheric CMAQ model showed reasonable agreement with observations over the USA. Some issues were identified with the aviation, shipping, and waste sectors, which should be addressed in future updates to the HTAPv3 emissions.

(d) Previous HTAP assessments of ozone source-receptor relationships have used the perturbation method to determine the response of ozone in receptor regions to precursor emissions changes in source regions. In this session, two groups presented alternative methods for ozone source apportionment: “tagging” and “local fractions.” Aditya Nalam (Germany) presented a case study of the contribution of international shipping to ozone in Europe using ozone tagging systems in two global models (CAM-chem and EMAC) in comparison with a perturbation approach performed by the EMEP model. The contributions of international shipping to ozone in Europe calculated with tagging were higher than the sensitivities calculated with perturbation, which is consistent with the nonlinear response of ozone to changes in precursor emissions. Peter Wind (MSC-West) presented the local fractions approach that has been implemented in the EMEP model based on the Path Integral method, which provides the sensitivity of ozone in receptor regions to small changes in precursor emissions in source regions. Further work will continue to explore the additional information on ozone sources which can be obtained using all available ozone source apportionment methods.

(e) Zofia Staniaszek (United Kingdom) presented results from the UKESM forced with methane emissions instead of the standard procedure of forcing with methane concentrations. The emissions-driven simulation underestimates modern methane concentrations, possibly due to an underestimation of methane emissions in emission inventories. The use of emission-driven simulations allows the model to simulate the

transient response of climate and ozone to arbitrary methane emission scenarios, including chemical and climate feedbacks.

(f) Zig Klimont (CIAM) presented emission scenarios used for the review of the revised Gothenburg Protocol (BASELINE, MTFR, and a LOW scenario), as well as a preview of additional scenarios under development. Augustin Colette (TFMM), Willem van Caspel (MSC-West), and Claudio Belis (EC JRC) presented the results of modelling studies using these scenarios, with a focus on the projected future changes of ozone in Europe. All three groups presented a broadly similar picture: the implementation of MTFR measures in Europe alone will likely not be enough to meet the WHO guideline for ozone in Europe; action will be needed to implement MTFR in regions outside the UNECE and also to control methane emissions, mostly outside of the UNECE. Felicity Hayes (ICP-Vegetation) presented the results of modelling the loss in wheat yield due to ozone damage from stomatal deposition. Under the 2050 LOW scenario, wheat yields are improved compared to the 2015 baseline conditions but yield losses of 10-15% are still projected.

12. To help motivate the future work of the Task Force, Till Spranger (WGSR) presented an overview of ongoing discussions in the policy side of Air Convention regarding the response to the recent review of the Gothenburg Protocol. A wide range of possible options are currently under consideration with respect to controlling methane as an ozone precursor, including an amendment of the Gothenburg Protocol to include methane emissions, the introduction of an additional instrument aimed specifically at controlling methane, or softer measures aimed at enhancing capacity building, awareness raising, and cooperation. The Executive Body meeting in December 2023 will include a discussion of next steps in the policy negotiations. Based on the outcome of that meeting, it may be possible to develop emission scenarios exploring more detailed policy options.

13. The Task Forced discussed the experimental design of future modeling studies focused on ozone and other Gothenburg pollutants.

(a) Joshua Fu (United States) reported on the progress of the WMO MMF-GTAD activity, aimed at producing global maps of total atmospheric deposition (sulphur, nitrogen, and ozone) to support policy advice aimed at improving human health, food security, and ecosystems by combining deposition measurements with the output of state-of-the-art models simulating the period for which measurements are available. It was decided that future work organised under the Task Force should take note of the model output deposition fields requested by the MMF-GTAD and provide these.

(b) The participants in the session expressed a strong interest in participating in a large multi-model ensemble exercise aimed at understanding the effects of the latest generation of policy-relevant future emissions scenarios on air quality in the UNECE region and globally. The scope of such an exercise should be similar to the two previous multi-model ensemble exercises organised under the Task Force, but with a stronger focus on producing model outputs needed for computing metrics of interest for the impacts of ozone on human health, crops, and ecosystems. The effects of climate change on future air pollution impacts should also be considered.

(c) Ensemble emulators have been an important part of previous Task Force assessments, allowing rapid assessments of novel scenarios based on source-receptor relationships computed with ensembles of more detailed models. Steven Turnock (United Kingdom) discussed emulators developed using past Task Force modeling experiments and considerations for future work. It was suggested that a follow up session be planned to further discuss the design of ensemble experiments to inform the development of emulators.

III. Proposed activities under the 2024-2025 workplan

14. For the period 2024-2025, the Task Force’s leadership team proposes to organize its work around five interlinked activities:

(a) Continue development and refinement of the HTAPv3 global emissions mosaic, including extending the data set to other pollutants and incorporating information from additional regional-scale inventories.

(b) Conduct multi-model simulations of recent trends and future scenarios of ozone and other Gothenburg Protocol pollutants to inform future policy negotiations and impact assessments, including supporting WMO's MMF-GTAD activity, with a goal of providing initial results in 2025.

(c) Conduct multi-model simulations of mercury trends by 2025 to inform the effectiveness evaluation of the Minamata Convention and continue simulations and analysis beyond 2025 to inform future reviews of the Heavy Metals Protocol.

(d) Plan and initiate multi-model simulations of the multi-pollutant impacts of wildfires and agricultural burning with a goal of providing results in 2026-2027.

(e) Continue to develop and produce emulators for the multi-model ensembles that can be incorporated into integrated assessment models and other decision support tools.

15. The Task Force will continue to coordinate its work with the other subsidiary bodies of the Air Convention and to reach out to coordinate with a wide variety of relevant international cooperative scientific efforts.