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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 in 2020 and further development of effects-oriented activities

Effects of air pollution on natural vegetation and crops

Report by the Programme Coordinating Centre of the International Cooperative Programme on Effects of Air Pollution on Natural Vegetation and Crops

Summary

The present report is submitted for consideration by the Steering Body to the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe and the Working Group on Effects at their sixth joint session in accordance with the 2020–2021 workplan for the implementation of the Convention (ECE/EB.AIR/144/Add.2, workplan items 1.1.1.9, 1.1.1.21, 1.1.4.7 and 1.4.1–1.4.3) and in accordance with the Revised mandate for the International Cooperative Programme on Effects of Air Pollution on Natural Vegetation and Crops (Executive Body decision 2019/17).[1]

The report presents the outcome of ozone-related activities; the monitoring survey on the concentration of heavy metals, nitrogen and persistent organic pollutants in mosses; and the thirty-third meeting of the Programme's Task Force (Riga, 27–30 January 2020).

[1] Available at www.unece.org/env/lrtap/executivebody/eb_decision.html.

I. Introduction

1. The present report of the International Cooperative Programme on Effects of Air Pollution on Natural Vegetation and Crops (ICP Vegetation) is submitted for consideration by the Steering Body to the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP) and the Working Group on Effects, at the request of the Executive Body for the Convention on Long-range Transboundary Air Pollution in the 2020–2021 workplan for the implementation of the Convention (ECE/EB.AIR/144/Add.2, workplan items 1.1.1.9, 1.1.1.21, 1.1.4.7 and 1.4.1–1.4.3) and in accordance with the Revised mandate for the International Cooperative Programme on Effects of Air Pollution on Natural Vegetation and Crops (Executive Body decision 2019/17).[2] It presents the outcome of ozone-related activities and of the survey on the concentrations of heavy metals, nitrogen and persistent organic pollutants in mosses. The lead country for ICP Vegetation is the United Kingdom of Great Britain and Northern Ireland and the Programme Coordination Centre is located at the United Kingdom Centre for Ecology and Hydrology in Bangor, United Kingdom of Great Britain and Northern Ireland. ICP Vegetation has over 250 participants in some 50 countries, including outreach to countries that are not Parties to the Convention.

II. Workplan items

A. Review interactive impacts of ozone and nitrogen on vegetation (item 1.1.1.9)

2. The review for 2020 had a focus on crops and has been published as a chapter in Scientific Background Document B, available from the ICP Vegetation website.[3] The review concluded that there was no evidence of a requirement to adjust critical levels for ozone effects on crops with respect to nitrogen availability. The relative ozone effects on wheat seed yield and seed protein yield, as well as the positive effect on seed protein concentration, were independent of nitrogen application rate. The negative effect of ozone on seed protein yield, and thus, nitrogen efficiency, was largest in soybean and smallest in rice, with wheat being intermediate. Since the absolute protein concentration of soybean is, on average, much higher than in wheat and rice, this translates into a much larger effect of ozone on absolute soybean protein compared to the cereals, which is very serious considering the important role of soybean as a protein source for food and feed globally.

B. Contribution to improve estimation of the environmental benefits of decreasing ozone through mitigation of methane emissions (item 1.1.4.7)

3. ICP Vegetation participated in the Task Force on Hemispheric Transport of Air Pollution workshop on this subject (online, 22–24 April 2020). Discussions concluded that ozone impacts on vegetation remained an important part of the Task Force on Hemispheric Transport of Air Pollution remit. During the meeting, an outline workplan was discussed and an opportunity for ICP Vegetation to model and map vegetation impacts as a consequence of the various hemispheric transport of air pollution emissions scenarios was identified. That work will take place after the EMEP Meteorological Synthesizing Centre-West has calculated ozone fluxes based on the hemispheric transport of air pollution scenarios.

[2] Available at www.unece.org/env/lrtap/executivebody/eb_decision.html.
[3] See http://icpvegetation.ceh.ac.uk.

C. Ozone flux-based risk assessment for vegetation at various air pollution scenarios (for a potential review of the Protocol to Abate Acidification, Eutrophication and Ground-level Ozone (item 1.4.1)

4. In collaboration with the Meteorological Synthesizing Centre-West, parameterizations for calculation of ozone fluxes (phytotoxic ozone dose) in the EMEP model and in chapter 3 of the *Manual on Methodologies and Criteria for Modelling and Mapping Critical Loads and Levels and Air Pollution Effects, Risks and Trends* (Modelling and Mapping Manual)[4] were aligned to ensure that the latest scientific updates are reflected in the EMEP model. Additional parameters required for upscaling from the leaf to the canopy level were defined, particularly for new species. Parameters such as vegetation height and leaf area index are required to run the EMEP model. This ensures that the necessary preparation work has been completed in anticipation of the various air pollution scenarios to be used for a potential review of the Protocol to Abate Acidification, Eutrophication and Ground-level Ozone (Gothenburg Protocol), as amended in 2012 (Executive Body decision 2019/4).

D. Ozone flux-based risk assessments adapted for vegetation in soil moisture limited areas (item 1.4.2)

5. The Meteorological Synthesizing Centre-West has provided modelled soil moisture index data to ICP Vegetation for comparison with site-specific soil moisture data measured in Italy, Spain, Sweden and Switzerland. Preliminary analysis at a site in Spain indicates that the EMEP-modelled soil moisture index mimics well seasonal and inter-annual variation, but slightly overestimates soil moisture on average. The EMEP-modelled soil model index estimates soil moisture less accurately in spring and summer at the site in Spain. Delivery of the final maps and report is expected at the end of 2020.

E. Test the development and application of photosynthesis-based flux-response models (item 1.4.3)

6. Photosynthesis-based flux response models are used in some terrestrial biosphere models and could be used to estimate the effect of ozone on carbon assimilation and ultimately on crop yield and forest biomass. Potential existing models have been identified and their ability to estimate conductance for stomatal ozone flux indices in relation to risk assessment and estimating damage will be assessed. This is in collaboration with the Meteorological Synthesizing Centre-West, and delivery of the final report is expected in 2021.

F. Call for submission of data on heavy metal, nitrogen and persistent organic pollutants concentrations in mosses to be sampled in 2020/2021 (item 1.1.1.21)

7. In preparation for the moss monitoring survey across Europe and beyond, the moss monitoring manual for the 2020 survey on heavy metals, nitrogen and persistent organic pollutants *Heavy Metals, Nitrogen and POPs in European Mosses: 2020 Survey Monitoring Manual*[5] was completed and is available from the ICP Vegetation website. Some countries will also conduct a pilot study on the use of mosses as biomonitors of microplastics; hence, guidance on monitoring microplastics in mosses was included. Some sampling will be moved to 2021/2022 due to travel and field sampling restrictions in place due to coronavirus disease (COVID-19).

[4] See https://icpvegetation.ceh.ac.uk/get-involved/manuals/mapping-manual.

[5] See https://icpvegetation.ceh.ac.uk/sites/default/files/ICP%20Vegetation%20moss%20monitoring%20manual%202020.pdf.

III. Progress with other core activities

A. Ozone critical levels for vegetation

8. At its thirty-third meeting (Riga, 27–30 January 2020), the ICP Vegetation Task Force reviewed the potential chapters of *Scientific Background Document B*, providing supplementary information to chapter 3 of the *Manual on Methodologies and Criteria for Modelling and Mapping Critical Loads and Levels and Air Pollution Effects, Risks and Trends* (Modelling and Mapping Manual). These chapters contain information on advances in the state of knowledge relevant to ozone impacts on vegetation and for mapping ozone impacts on vegetation. The following new chapters were added: "Interactions between ozone exposure and nitrogen application/accumulation in crops"; and "Guidelines for gap filling in data required for flux modelling". Subjects of future new chapters include: improved phenology for ozone flux modelling in trees; ozone removal by vegetation in urban areas; and impacts of ozone on pasture quality.

B. Update of evidence of ozone impacts on crops in developing regions

9. Using institutional funds, the Programme Coordination Centre has reviewed the literature for evidence of ozone impacts on crops in countries receiving overseas development assistance. There remains a lack of data from Africa, most of Central and South America, the [6]Caucasus and Central Asia. Most data was available from South and East Asia and, since 2000, considerable evidence of ozone impacts on crops has emerged from a limited number of locations in China, India and Pakistan. The reduction of crop yield losses due to ozone in these countries is often in the range of 5–20 per cent, sometimes with losses in excess of 40 per cent being reported. Grain protein was reduced for maize, wheat, mung bean, broad bean and peas, which is an important consideration for future food security. There continue to be uncertainties in predictions of large-scale effects due to differences in cultivar sensitivity and representative parameterization of stomatal flux-based models for these regions.

IV. Expected outcomes and deliverables over the next period and in the longer term

10. Over the next period and in the longer term, ICP Vegetation is expected to work and report on:

(a) Ozone flux-based risk maps for vegetation for various air pollution emission scenarios to support the review of the Gothenburg Protocol, in collaboration with the Task Force on Integrated Assessment Modelling, the Centre for Integrated Assessment Modelling and the Meteorological Synthesizing Centre-West;

(b) Interactive impacts of ozone and nitrogen on (semi-)natural vegetation;

(c) Testing the development and application of photosynthesis-based flux-response models (in collaboration with the Meteorological Synthesizing Centre-West);

(d) Inclusion of ozone damage functions in crop growth models (in collaboration with the Agricultural Model Intercomparison and Improvement Project;

(e) Knowledge transfer of ozone risk assessment methodologies to developing regions;

(f) New evidence of nitrogen impacts on (semi-)natural vegetation to support the review of empirical critical loads for nitrogen, in collaboration with the International

[6] See https://icpvegetation.ceh.ac.uk/sites/default/files/Scientific%20Background%20document%20B%20June%202020.pdf.

Cooperative Programme on Modelling and Mapping of Critical Levels and Loads and Air Pollution Effects, Risks and Trends (ICP Modelling and Mapping);

(g) Review of ozone pollution and climate change impacts on vegetation;

(h) The 2020–2022 survey on heavy metals, nitrogen and persistent organic pollutants concentrations in mosses;

(i) Assessing the suitability of mosses as biomonitors of air pollution in the Eastern Europe, the Caucasus and Central Asia region based on the results of the 2015/16 survey.

V. Policy-relevant issues, findings and recommendations

11. For information on policy-relevant issues, findings and recommendations, see ECE/EB.AIR/GE.1/2020/3–ECE/EB/AIR/2020/3 and paragraphs 2 and 9 of the present report.

VI. Issues for the attention and advice of other groups, task forces or subsidiary bodies, notably with regard to synergies and possible joint approaches or activities

12. Issues for the attention and advice of other groups, task forces or subsidiary bodies include:

(a) Collation of further field-based evidence of the impacts of ozone on vegetation and co-location of sites for the collection of mosses in order to determine their heavy metal and nitrogen concentrations, in collaboration with the International Cooperative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests);

(b) Monitoring of ozone-induced foliar injury and nitrogen concentrations in mosses and calculation of site-specific exceedance of critical ozone-flux-based levels for vegetation, in collaboration with the member States of the European Union and the European Commission, as indicators for reporting under the National Emission Ceilings Directive,[7] and, in that connection, provision of technical support to member States;

(c) Further application of the flux-based ozone risk assessment methodology for vegetation, in collaboration with the Centre for Integrated Assessment Modelling, ICP Forests, the Meteorological Synthesizing Centre-West and the Task Forces on Hemispheric Transport of Air Pollution and Integrated Assessment Modelling. The ozone-flux-based risk assessment methodology should be applied: at a range of scales (from local to global); to a range of vegetation types (including crops); and to current and future air pollution abatement and climate change scenarios, including scenarios agreed to support a review of the Gothenburg Protocol;

(d) Development and testing of the application of photosynthesis-based flux effect relationships in the EMEP model, in collaboration with the Meteorological Synthesizing Centre-West;

(e) Collation of new evidence of nitrogen impacts on (semi-)natural vegetation with the aim of reviewing current empirical nitrogen critical loads, in collaboration with ICP Modelling and Mapping;

(f) Assessment of temporal trends and changes in spatial patterns in heavy metal deposition, in collaboration with the Meteorological Synthesizing Centre-East.

[7] Directive (EU) 2016/2284 of the European Parliament and of the Council of 14 December 2016 on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC, *Official Journal of the European Union*, L 344 (2016), pp. 1–31.

VII. Enhance the involvement of countries in Eastern Europe, the Caucasus and Central Asia

13. In order to further strengthen implementation and ratification of the Protocols to the Convention in Eastern and South-Eastern Europe, the Caucasus and Central Asia, further evidence of air pollution deposition to and impacts on vegetation in the countries of those subregions should be sought through increased participation in the work of ICP Vegetation. This effort is being promoted by:

(a) The Moss Survey Coordination Centre in Dubna, Russian Federation;

(b) Knowledge transfer through meetings or workshops and the publication of reports, the Modelling and Mapping Manual and leaflets in the Russian language;

(c) Encouraging experts from those countries to attend ICP Vegetation Task Force meetings.

VIII. Outreach activities outside the United Nations Economic Commission for Europe region

14. ICP Vegetation will pursue and further promote collaboration with African, Asian and South American countries. An ICP Vegetation-Asia network was established in 2017 to collate new evidence of ozone impacts on crops.

15. Using institutional funds, the Programme Coordination Centre has conducted the following outreach activities:

(a) the development of ozone flux-effect relationships for African bean and wheat varieties and the mapping of bean- and wheat-growing areas in sub-Saharan Africa at risk of adverse impacts of ozone on yield;

(b) the organization and delivery of a training workshop on ozone impacts on crops for African crop scientists (Bangor, United Kingdom of Great Britain and Northern Ireland, 24–26 September 2019);

(c) participation in the fifth Asian Air Pollution Workshop (Varanasi, India, 5–7 November 2019), back-to-back with the organization and delivery of a stakeholder event (8 November 2019) with the local organizers that was attended by 114 participants, including a range of scientists, village elders and local farmers; and

(d) the production of ozone injury factsheets for crops for plant health doctors as part of the “Plantwise” programme in Africa.[8]

16. ICP Vegetation will continue to collaborate with the Tropospheric Ozone Assessment Report[9] initiative and to support the implementation of the DO_3SE ozone flux model into the web service architecture.

IX. Scientific findings: highlights

17. Highlights of the scientific findings of ICP Vegetation are summarized in the 2020 joint progress report on policy-relevant scientific findings (ECE/EB.AIR/GE.1/2020/3−ECE/EB.AIR/WG.1/2020/3) and in paragraphs 2 and 9 of the present report.

[8] See www.plantwise.org.
[9] See www.igacproject.org/activities/TOAR.

X. Meetings

18. The thirty-third meeting of the Programme Task Force was hosted by the University of Latvia, Riga. Minutes of the meeting are available from the ICP Vegetation website.[10]

19. ICP Vegetation held a joint expert workshop by videoconference with the Agricultural Model Intercomparison and Improvement Project on inclusion of ozone damage functions in crop growth models (online, 7 February 2020). Presentations and discussions focused on a number of issues, including:

(a) data sets standardized and made available to crop modellers through a common portal;

(b) the growing number of crop models incorporating ozone algorithms; and

(c) a road map for future joint initiatives.

XI. Publications

20. For a list of ICP Vegetation publications and references for the present report, please visit the ICP Vegetation website.

[10] See https://icpvegetation.ceh.ac.uk.