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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 2022 and further development of effects-oriented activities: air pollution effects on materials, the environment and crops: air pollution effects on vegetation

Effects of air pollution on natural vegetation and crops

Report by the Programme Coordination 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 eighth joint session, in accordance with both the 2022–2023 workplan for the implementation of the Convention (ECE/EB.AIR/148/Add.1, workplan items 1.1.1.13, 1.1.1.14, 1.1.1.15 and 1.1.1.16) and the Revised mandate for the International Cooperative Programme on Effects of Air Pollution on Natural Vegetation and Crops (Executive Body decision 2019/17).

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-fifth meeting of the Programme's Task Force (online, 21–23 February 2022).

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 2022–2023 workplan for the implementation of the Convention (ECE/EB.AIR/148/Add.1, workplan items 1.1.1.13, 1.1.1.14, 1.1.1.15 and 1.1.1.16) 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] It presents the outcome of ozone-related activities, the monitoring survey on the concentrations of heavy metals, nitrogen and persistent organic pollutants in mosses, and the thirty-fifth meeting of the ICP Vegetation Task Force (online, 21–23 February 2022). 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, Bangor (United Kingdom of Great Britain and Northern Ireland). ICP Vegetation has over 300 participants in some 63 countries, including outreach to countries not Parties to the Convention.

II. Workplan items

A. Ozone flux-based risk assessment for vegetation for air pollution scenarios (item 1.1.1.14)

2. The ICP Vegetation Coordination Centre provided text contributions for the review of the amended Protocol to Abate Acidification, Eutrophication and Ground-level Ozone (Gothenburg Protocol) summarizing information on scientific advances relevant to understanding ozone impacts in current and future scenarios. In collaboration with the Meteorological Synthesizing Centre-West, the necessary preparation work has been completed in anticipation of the various air pollution scenarios to be used for a review of the Gothenburg Protocol, as amended in 2012 (Executive Body decision 2019/4). Maps and tables summarizing the impacts of ozone on crops, trees and semi-natural vegetation for the years 2005, 2015, 2030 and 2050 will be produced, including for the baseline, Maximum Feasible Reductions and Low scenarios from the Centre for Integrated Assessment Modelling. Significant crop yield losses due to ozone were found for 2005 and 2015 and are still predicted to occur in 2030 and 2050.

3. Flux-response relationships for wheat have been developed based on the coupled photosynthetic-stomatal conductance type of model often used in biogeochemical models, land-surface exchange schemes and Earth system models. This provides an internally consistent method that can be used to constrain future process-based modelling of the ozone effects on photosynthesis and senescence that can consequently be used to estimate ozone influence on carbon allocation and crop growth, development and yield.

B. Review of ozone pollution and climate change impacts on vegetation (focus on implications for calculation and application of flux-based Critical Levels and risk assessment (item 1.1.1.15))

4. Interactions between ozone pollution and climate change will be important considerations in the near future when assessing the impacts on crops and ecosystems. Some interactions alter the exposure of vegetation to ozone, such as accelerated phenological development with increasing temperature resulting in bud-break earlier in the year and consequent exposure of the vegetation to ozone earlier in spring. Changes in meteorological

[1] All Executive Body decisions referred to in the present document are available at www.unece.org/env/lrtap/executivebody/eb_decision.html.

conditions and soil moisture due to climate change will alter ozone fluxes to vegetation via influence on stomatal opening; however, the direction and extent of change depend on the difference between perceived conditions and optimum conditions for each meteorological and soil moisture parameter.

C. State of knowledge report on genetics of crop resilience to ozone and potential for crop breeding (item 1.1.1.16)

5. Different varieties of some commonly grown crops, including wheat, rice and soybean, can vary in their sensitivity to ozone pollution. In addition, some plant physiological traits can confer tolerance to ozone pollution. Genetic variation in sensitivity to ozone can support selective breeding for increased ozone tolerance and may also give co-tolerance to other abiotic or biotic stresses. This is important because many stresses can co-occur. Traits that are likely to give co-tolerance to ozone and other stresses include high levels of leaf anti-oxidants.

D. Call for submission of data on heavy metal, nitrogen and persistent organic pollutants concentrations in mosses to be sampled in 2020/2021/2022 (item 1.1.1.13)

6. In preparation for the moss monitoring survey across Europe and beyond, the “Heavy Metals, Nitrogen and POPs in European Mosses: 2020 Survey: Monitoring Manual”[2] 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 in the Manual. Some sampling was rescheduled for 2022 due to travel and field sampling restrictions in place due to the coronavirus disease (COVID-19) pandemic. Moss samples were collected from >3000 sites in 2020/2021. An additional survey for microplastic content of mosses over a larger area will occur in 2022, with >26 countries indicating their participation.

III. Progress with other core activities

A. Ozone critical levels for vegetation

7. At its thirty-fifth meeting (online, 21–23 February 2022), 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).[3] These chapters contain information on advances in the state of knowledge relevant to ozone impacts on vegetation and for mapping ozone impacts on vegetation. A chapter has been added describing the Deposition of Ozone for Stomatal Exchange (DO_3SE) model parameterization and flux-effect relationship for the crop “sweet potato”, which is grown in some parts of Europe as well as in tropical regions. Sweet potato is sensitive to ozone and shows a reduction in yield with increasing ozone uptake. 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.

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[2] Marina Frontasyeva and Harry Harmens (n.p., 2020). Available at https://icpvegetation.ceh.ac.uk/sites/default/files/ICP%20Vegetation%20moss%20monitoring%20manual%202020.pdf

[3] Till Spranger, Ullrich Lorenz and Heinz-Detlef Gregor, eds. (Berlin, German Federal Environmental Agency, 2004).

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

8. Using institutional funds, the Programme Coordination Centre has engaged with local scientists in developing regions in order to initiate the collection of some observations and data on ozone concentrations and impacts on crops. Ozone diffusion tubes were distributed to sites in Brazil, Ecuador, Ghana, Kenya, Malawi and Zambia to monitor ambient ozone in agricultural/agroforestry regions over a period of three months. These are countries where ozone concentration measurements are scarce. Although the diffusion tubes only reflect the average ozone concentration, rather than the magnitude of peaks and troughs, these can still indicate where ozone might be a cause for concern.

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

9. 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) Further development and application of the ozone-modified photosynthesis-based flux-response models (in collaboration with the Meteorological Synthesizing Centre-West);

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

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

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

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

(g) Review of critical levels of nitrogen oxides for vegetation.

V. Policy-relevant issues, findings and recommendations

10. For information on policy-relevant issues, findings and recommendations, see paragraphs 2 and 8 above.

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

11. 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 Emissions reduction

Commitments Directive,[4] 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, the Task Force on Hemispheric Transport of Air Pollution and the Task Force on Integrated Assessment Modelling. The flux-based ozone 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) Further development and application of the ozone-modified photosynthesis-based flux effect relationships in the EMEP model, in collaboration with the Meteorological Synthesizing Centre-West;

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

VII. Enhancing the involvement of countries in Eastern and South-Eastern Europe, the Caucasus and Central Asia

12. 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, Dubna, the 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

13. ICP Vegetation will pursue and further promote collaboration with African, Asian and South American countries.

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

(a) Production of an online course on “Ozone and Tropical Agriculture” on the “LearnWorlds” platform,[5] which is free for participants from countries receiving official development assistance. The course gives information on impacts of ozone on vegetation and highlights the consequences for crop production;

(b) Production of ozone injury factsheets for crops for plant health doctors as part of the “PlantwisePlus” programme in Africa.[6]

[4] 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.

[5] See https://www.learnworlds.com/?utm_source=google&utm_medium=cpc&utm_campaign=Search-Branded&utm_content=%5BLearnworlds%5D&utm_term=e_learnworlds&gclid=EAIaIQobChMIh6vWsfWu-AIVno5oCR1LqA-JEAAYASAAEgLO5PD_BwE.

[6] See www.plantwise.org.

15. ICP Vegetation will continue to collaborate with the Tropospheric Ozone Assessment Report[7] initiative and to support the implementation of the DO_3SE ozone flux model in the web service architecture.

16. Several countries from outside the United Nations Economic Commission for Europe (ECE) region are participating in the Moss Survey 2020–2022 and/or the additional survey of microplastic deposition to mosses.

IX. Scientific findings: highlights

17. Highlights of the scientific findings of ICP Vegetation are summarized in paragraphs 2, 4, 7 and 8 above.

X. Meetings

18. The thirty-fifth meeting of the Programme Task Force was held online and hosted by the United Kingdom Centre for Ecology and Hydrology (Bangor, United Kingdom of Great Britain and Northern Ireland). The meeting was attended by 135 participants from 36 countries, including some experts from countries from outside the ECE region. Minutes of the meeting are available from the ICP Vegetation website.[8]

XI. Publications

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

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[7] See www.igacproject.org/activities/TOAR.

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