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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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Item 14 of the provisional agenda
Progress in activities in 2019 and further development of effects-oriented activities

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 fifth joint session, as requested by the Executive Body for the Convention on Long-range Transboundary Air Pollution in the 2018–2019 workplan for the implementation of the Convention (ECE/EB.AIR/140/Add.1, items 1.1.1.12–1.1.1.16).

The report presents the outcome of ozone-related activities, the 2015−2016 survey on the concentration of heavy metals, nitrogen and persistent organic pollutants in mosses and the thirty-second meeting of the Task Force of the International Cooperative Programme on Effects of Air Pollution on Natural Vegetation and Crops (Targoviste, Romania, 8–21 February 2019).

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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, as requested by the Executive Body for the Convention on Long-range Transboundary Air Pollution in the 2018−2019 workplan for the implementation of the Convention (ECE/EB.AIR/140/Add.1, items 1.1.1.12−1.1.1.16). It presents the outcome of ozone-related activities and of the 2015−2016 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 Centre for Ecology & 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. Improving and validating the soil moisture index in the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe model (item 1.1.1.12) and ozone flux maps adapted for soil moisture-limited areas (item 1.1.1.15)

2. The EMEP 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 seasonal and inter-annual variation well, but slightly overestimates soil moisture on average. The EMEP-modelled soil moisture index estimates soil moisture less accurately in spring and summer at the site in Spain. The next step is to gather information on the response of leaf pores to the new soil moisture index, in order to parameterize the model for ozone uptake by vegetation. Once this has been done, flux maps adapted for soil-moisture-limited areas can be produced (delivery of item 1.1.1.15 is expected in 2020).

B. Final report of the 2015−2016 survey on heavy metals, nitrogen and persistent organic pollutant concentrations in mosses (item 1.1.1.14)

3. In 2015/16, in general, the highest concentrations of heavy metals in mosses were found in Eastern and South-Eastern Europe. The highest nitrogen concentrations in mosses were generally observed in Central Europe. Between 1990 and 2015, lead and cadmium concentrations in mosses declined by 81 per cent and 64 per cent, respectively. Concentrations of other heavy metals (arsenic, chromium, copper, iron, nickel, vanadium and zinc) also declined, ranging from 9 per cent for chromium to 58 per cent for vanadium. Concentrations of mercury in mosses, however, have not changed since 1995. Nitrogen concentrations in mosses did not change significantly between 2005 and 2015.

C. Monitoring manual for 2020 survey on heavy metals, nitrogen and persistent organic pollutant concentrations in mosses (item 1.1.1.16)

4. The moss monitoring manual for the 2020 survey on heavy metals, nitrogen and persistent organic pollutant concentrations in mosses has been completed and is available

from the ICP Vegetation website.[1] A number of countries will also conduct a pilot study on the use of mosses as biomonitors of microplastics, hence, some guidance on monitoring microplastics in mosses was included.

III. Progress with core activities

A. Ozone critical levels for vegetation

5. At its thirty-second meeting (Targoviste, Romania, 18–21 February 2019), the ICP Vegetation Task Force adopted Chapter 6 of Scientific Background Document A, providing information complementing 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).[2] Chapter 6 contains information on ozone flux model parameterizations and associated flux-effect relationships for selected (semi-)natural vegetation species.

B. Ozone impacts on wheat yield in Europe: modelled trends for 1990−2010

6. In collaboration with the European Topic Centre on Air Pollution and Climate Change Mitigation of the European Environment Agency, ICP Vegetation contributed to an assessment of the trends of ozone impact on wheat yield in Europe between 1990 and 2010, using both concentration (AOT40 - the sum of the differences between the hourly mean ozone concentration (in parts per billion (ppb)) and a threshold value of 40 ppb during daylight hours, accumulated over a stated time period) and flux-based Phytotoxic Ozone Dose (the accumulated plant uptake (flux) of ozone during a specified growth period) for the crop species wheat above a threshold of 6 nanomoles per square metre per second (nmol m^{-2} s^{-1}) (POD_6SPEC) metrics. Based on the modelled AOT40, calculated wheat yield losses declined significantly from 18.2 per cent to 10.2 per cent between 1990 and 2010, whereas, according to the flux-based metric, losses did not change significantly, i.e. losses were 14.9 per cent and 13.3 per cent in 1990 and 2010, respectively. Compared with EMEP measured data, the downward trend of AOT40 is overestimated by the models (Eurodelta-Trends ensemble of six chemistry transport models), especially for the period 1990−2000. A change in ozone profile between 1990 and 2010 (i.e. lower peaks, higher background concentrations) contributes to the difference in modelled trends. POD_6SPEC appears to be better reproduced by the models than AOT40.

C. Ozone impacts on global wheat yield: predictions for 2030 under current legislation

7. In collaboration with EMEP/Meteorological Synthesizing Centre-West, ICP Vegetation evaluated the impact of full implementation of current air quality legislation on wheat yield in 2010 and 2030. The 2010 and 2030 emissions from the European Union ECLIPSE project were used to calculate the Phytotoxic Ozone Dose above an ozone flux threshold of 3 nmol m^{-2} s^{-1} (POD_3IAM) and wheat yield losses due to ozone, assuming no change in climate and wheat production between 2010 and 2030. Annual wheat yield losses due to ozone were similar for 2010 and 2030 due to rising emissions of methane and stable emissions of nitrogen oxides between 2010 and 2030. Hence, abatement of ozone precursor emissions remains a priority for the future. The highest percentage yield and production losses were estimated for South and Eastern Asia (yield loss of 9.2 per cent and 9 per cent and production loss of 28.9 million tons and 28.3 million tons in 2010 and 2030, respectively), followed by the region of Eastern Europe, the Caucasus and Central Asia

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

(yield loss of 7.8 per cent and 7.2 per cent and production loss of 8.2 million tons and 7.5 million tons in 2010 and 2030, respectively). The percentage yield loss was similar in Europe and North America, i.e. USA and Canada (approximately 6.6 per cent and 5.5 per cent in 2010 and 2030, respectively), but the production loss was about twice as high in Europe
(12.8 million tons and 10.8 million tons in 2010 and 2030, respectively). Approximately two thirds of the total wheat production loss due to ozone occurred in developing countries.

IV. Expected outcomes and deliverables in the next two years and beyond

8. In the next two years and beyond, ICP Vegetation is expected to work and report on:

(a) The development of ozone-flux maps adapted for soil-moisture-limited areas (in collaboration with the Meteorological Synthesizing Centre-West);

(b) New evidence of ozone impacts on crops in developing regions (and impacts on global food production in the longer term);

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

(d) Ozone flux-based risk maps for vegetation for various air pollution emission scenarios (in collaboration with the Meteorological Synthesizing Centre-West);

(e) Interactive impacts of ozone and nitrogen on vegetation;

(f) New evidence of nitrogen impacts on (semi-)natural vegetation, in collaboration with the International Cooperative Programme on Modelling and Mapping of Critical Levels and Loads and Air Pollution Effects, Risks and Trends (ICP Modelling and Mapping);

(g) The 2020 survey on heavy metals, nitrogen and persistent organic pollutant concentrations in mosses.

V. Policy-relevant issues, findings and recommendations

9. See ECE/EB.AIR/GE.1/2019/3–ECE/EB/AIR/WG.1/2019/3 and paragraphs 3, 6 and 7 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

10. 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 European Union National

Emission Ceilings Directive[3] 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 EMEP Centre for Integrated Assessment Modelling, ICP Forests, the Meteorological Synthesizing Centre-West and the EMEP Task Forces on, respectively, Hemispheric Transport of Air Pollution and Integrated Assessment Modelling. The ozone-flux-based risk assessment methodology should be applied globally to a range of vegetation types (including crops) and to future air pollution abatement and climate change scenarios;

(d) Development and testing 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 EMEP Meteorological Synthesizing Centre-East.

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

11. 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 countries of Eastern Europe, the Caucasus and Central Asia to attend meetings of the ICP Vegetation Task Force.

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

12. 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.

13. Using institutional funds, the Programme Coordination Centre has carried out, or will carry out, the following outreach activities:

(a) The Programme Coordination Centre has developed ozone flux-effect relationships for African bean and wheat varieties and has mapped bean and wheat growing areas in sub-Saharan Africa at risk of adverse impacts of ozone on yield;

(b) In September 2019, the Programme Coordination Centre will organize a training workshop on ozone impacts on crops for African crop scientists;

[3] 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.

(c) The Programme Coordination Centre will participate in the Fifth Asian Air Pollution Workshop (Varanasi, India, 5–7 November 2019) and organize a stakeholder event (8 November 2019) with the local organizers.

14. ICP Vegetation will continue to collaborate with the Tropospheric Ozone Assessment Report[4] initiative and to support the integration of the Deposition of Ozone for Stomatal Exchange (DO_3SE) model into the web service architecture.

IX. Scientific findings: highlights

15. Highlights of the scientific findings of ICP Vegetation are summarized in the 2019 joint progress report on policy-relevant scientific findings (ECE/EB.AIR/GE.1/2019/3−ECE/EB.AIR/WG.1/2019/3) and in paragraphs 3, 6 and 7 of the present report.

X. Meetings

16. The thirty-second meeting of the Programme Task Force was held in Targoviste, Romania, from 18 to 21 February 2019. The meeting, hosted by Valahia University of Targoviste, was attended by 79 experts from 31 countries, including: Belarus, Georgia, Kazakhstan, Republic of Moldova, Russian Federation, Tajikistan and Ukraine. Minutes of the meeting are available from the ICP Vegetation website.[5]

17. ICP Vegetation and ICP Forests held a joint expert workshop on "Assessing and estimating ozone impacts on forest vegetation – opportunities for improved cooperation" in Birmensdorf, Switzerland, on 12 April 2019. The meeting was supported by the Swiss Federal Office for the Environment. Presentations and discussions addressed a number of issues, including:

(a) Data availability and needs, endpoints and approaches;

(b) Potential common projects and publications;

(c) Road map for joint initiatives.

XI. Publications

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

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

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