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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

Second joint session*
Geneva, 13–16 September 2016
Item 14 of the provisional agenda
Progress in activities in 2016 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 being submitted for consideration by the second joint session of 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 in accordance with the request of the Executive Body for the Convention on Long-range Transboundary Air Pollution in the 2016–2017 workplan for the implementation of the

* The Executive Body to the Convention agreed that, as of 2015, the Working Group on Effects and the Steering Body to the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe should meet jointly, to achieve enhanced integration and cooperation between the Convention's two scientific subsidiary bodies (ECE/EB.AIR/122, para. 47 (b)).

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Convention (ECE/EB.AIR/133/Add.1, items 1.1.1.1, 1.1.1.5, 1.1.1.7, 1.1.1.11 and 1.1.1.12) and the informal document approved by the Executive Body for the Convention at its thirty-fourth session, “Basic and multi-year activities in the 2016–2017 period” (items 1.1.1–1.1.3, 1.1.6, 1.1.7 and 1.8.1–1.8.3).

The report of the International Cooperative Programme on Effects of Air Pollution on Natural Vegetation and Crops presents the results of an evaluation of effects of air pollutants on (semi-)natural vegetation and crops, further development of flux-based risk assessment methods, global application of the flux-based approach for impacts of ground-level ozone on crops, and progress with the European moss survey 2015/2016 on heavy metals, nitrogen and persistent organic pollutants. The report also presents the results of the twenty-ninth meeting of the Programme Task Force held in Dubna, Russian Federation from 29 February to 3 March 2016.

Contents

I. Introduction

1. The present report of the International Cooperative Programme on Effects of Air Pollution on Natural Vegetation and Crops (ICP Vegetation) is being submitted for the consideration of 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 (WGE) in accordance with the request of the Executive Body for the Convention on Long-range Transboundary Air Pollution in the 2016–2017 workplan for the implementation of the Convention (ECE/EB.AIR/133/Add.1, items 1.1.1.1, 1.1.1.5, 1.1.1.7, 1.1.1.11 and 1.1.1.12) and the informal document approved by the Executive Body for the Convention at its thirty-fourth session, “Basic and multi-year activities in the 2016–2017 period” (items 1.1.1–1.1.3, 1.1.6, 1.1.7 and 1.8.1–1.8.3). The report presents the results of an evaluation of effects of air pollutants on (semi-)natural vegetation and crops, global application of the flux-based approach for impacts of ground-level ozone on crops, and progress with the European moss survey 2015/2016 on heavy metals, nitrogen and persistent organic pollutants. The results of the workplan items common to all the International Cooperative Programmes (ICPs) under the Convention are also presented. The lead country for ICP Vegetation is the United Kingdom of Great Britain and Northern Ireland, with the Programme Coordination Centre at the Centre for Ecology and Hydrology in Bangor. ICP Vegetation has over 250 participants in ca. 50 countries, including outreach to countries that are not Parties to the Convention.

II. Workplan items common to all International Cooperative Programmes

A. Priorities for monitoring and other collection of data on effects by Parties (workplan item 1.1.1.1)

2. An overview of the priorities for monitoring and modelling effects reported by ICP Vegetation, according to the Guidelines for Reporting on the Monitoring and Modelling of Air Pollution Effects (ECE/EB.AIR/2008/11),[1] was provided in document ECE/EB.AIR/WG.1/2014/8.

B. Set up contact group to compare WGE exposure measurements and modelled and monitored exposure by EMEP (workplan item 1.1.1.7)

3. A group was set up between EMEP Meteorological Synthesizing Centre-West and ICP Vegetation to discuss options for regional parameterization of the stomatal ozone flux model incorporated in the EMEP model, to calculate the phytotoxic ozone dose for Mediterranean vegetation. Outcomes of the EMEP model will be compared with national scale modelling in the Mediterranean region. First discussions were held at an ICP Vegetation expert workshop in Deganwy, United Kingdom, in June 2016.

[1] The Guidelines were adopted by the Executive Body at its twenty-sixth session (ECE/EB.AIR/96/Add.1–ECE/EB.AIR/WG.1/2008/16/Rev.1, decision 2008/1).

C. Assess the long-term trends in air pollution and its adverse effects (workplan item 1.5.1)

4. The ICP Vegetation Programme Coordination Centre provided text and editorial support for the WGE report “Trends in ecosystem and health responses to long-range transported atmospheric pollutants”.[2] The ICP Vegetation reported on the lack of trends between 1999 and 2010 in ozone concentrations, fluxes and effects on vegetation, as described in further detail in ECE/EB.AIR/GE.1/2015/15–ECE/EB.AIR/WG.1/2015/8 and in the brochure “Changing ozone profiles in Europe: implications for vegetation”. The ICP Vegetation also reported on the decline in cadmium (51 per cent), lead (77 per cent), mercury (14 per cent) and other metal concentrations in mosses between 1990 (1995 for mercury) and 2010, as described in further detail in ECE/EB.AIR/WG.1/2013/13 and a previous report.[3]

D. Assess scientific and policy outcomes within the Convention over the past few decades, including scientific understanding, trends and achievements under the 1999 Protocol to Abate Acidification, Eutrophication and Ground-level Ozone (Gothenburg Protocol), and outline future challenges (workplan item 1.5.2)

5. The ICP Vegetation Programme Coordination Centre provided text for the Convention report[4] “Towards Cleaner Air: Scientific Assessment Report 2016”. It contributed to Chapter 4 on “Ozone trends and impacts on health and crops yields” (see paragraph 4). The report highlights that long-term risks for vegetation (but also human health) due to ground-level ozone pollution continue to exist in many United Nation Economic Commission for Europe (ECE) countries. Although peak ozone exposure has declined since the 1990s (through reductions in precursors), background ozone concentrations are not declining. As emissions of ozone precursors in other parts of the northern hemisphere contribute substantially to ozone concentrations in Europe and North America, co-ordination beyond the ECE region is needed to reduce ozone levels in Europe further.

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[2] http://www.unece.org/environmental-policy/conventions/envlrtapwelcome/publications.html.

[3] Harmens, H., Norris, D., Mills, G. and the participants of the moss survey (2013). Heavy metals and nitrogen in mosses: spatial patterns in 2010/2011 and long-term temporal trends in Europe. ICP Vegetation Programme Coordination Centre, CEH Bangor, UK. http://icpvegetation.ceh.ac.uk/publications/

[4] http://www.unece.org/env/lrtap/welcome.html

III. Workplan items specific to the International Cooperative Programme on Effects of Air Pollution on Natural Vegetation and Crops

A. Evaluate effects of ground-level ozone on (semi-)natural vegetation and crops in the current and future climate, individually or co-occurring with nitrogen (workplan item 1.1.1.11)

6. A brochure was produced on “Field evidence of ozone impacts on vegetation in ambient air (2007–2015)”. The brochure was an update of a previous report[5] published in 2007. The updated field-based evidence of ozone impacts on vegetation has confirmed previous assessments showing that ozone damage to vegetation is widespread across Europe. The spatial pattern of observed impacts is better related to accumulated ozone fluxes to vegetation than to accumulated ground-level ozone concentrations. Impacts include visible leaf injury (as recorded through a web-based smart-phone application)[6] and reduced vegetation biomass and crop yield. Effects of ambient ozone have been frequently recorded in many European countries and parts of the United States of America. Field assessments are often on an ad hoc basis and lack of a record does not necessarily mean that ozone is not causing visible injury in a country or region. There is a general need to broaden coverage of assessments worldwide as ozone pollution is a global problem, particularly in the northern hemisphere. Planting ozone-sensitive plant species in so-called ‘ozone gardens’[7] is a useful, low cost tool for demonstrating the occurrence of ozone-induced visible leaf injury.

7. A brochure was produced on “Impacts of ozone pollution on biodiversity”. The ozone sensitivity of the European Nature Information System (EUNIS)[8] habitats (level 2) was determined from the relative sensitivity of component species present in the ICP Vegetation database. Subsequently, Natura 2000 grassland habitats at risk from ozone impacts were mapped across Europe, based on the phytotoxic ozone dose (POD_1) for grasses (modelled by the Meteorological Synthesizing Centre-West) and habitat area (data provided by the Coordination Centre for Effects) (see table). Risk is highest in regions with high ozone fluxes (POD_1) and relatively large grassland areas (see figure). A review of the literature showed that current ambient ozone levels are sufficiently high enough to change plant community composition, flowering and seed production at the species level. However, there is a lack of field-based evidence for the impacts of ozone on plant species diversity, especially in biodiversity hotspots such as the Mediterranean Basin. Hence, further study is needed on the impacts of ozone on biodiversity.

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[5] Hayes, F., Mills, G., Harmens, H., Norris, D. (2007). Evidence of widespread ozone damage to vegetation in Europe (1990–2006). ICP Vegetation Programme Coordination Centre, Centre for Ecology and Hydrology, Bangor, UK.

[6] http://icpvegetation.ceh.ac.uk/record/index.

[7] http://icpvegetation.ceh.ac.uk/manuals/experimental_protocol.html and http://science-edu.larc.nasa.gov/ozonegarden/pdf/Bio-guide-final-3_15_11.pdf

[8] http://eunis.eea.europa.eu/.

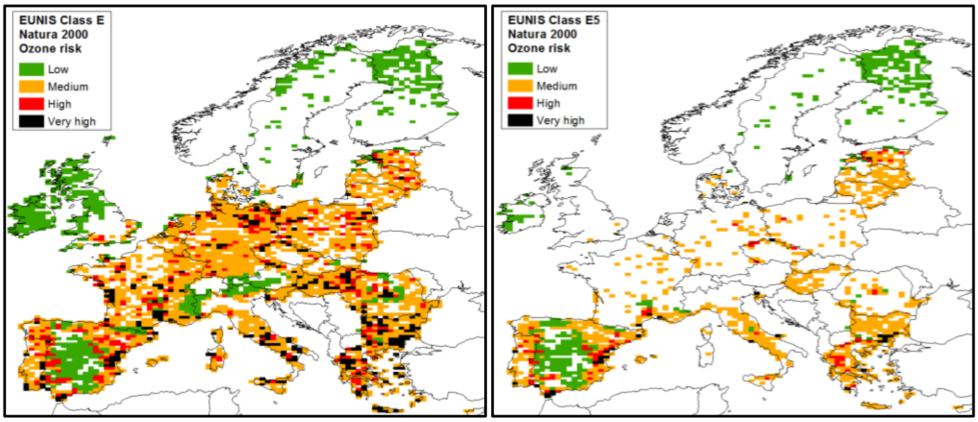
Table

Matrix for calculating the risk of ozone impact on grasslands, based on the phytotoxic ozone dose (POD_1) for grass and the grassland area (per cent) per grid cell (0.5^o (longitude) by 0.25^o (latitude)). POD_1 was calculated over a six months period (April - September).

Grassland area in grid cell (%)	POD_1 grass (mmol m^{-2})	<5	5 - 15	15 - 20	20 - 25	25 - 30	>30
	RISK	**1**	**2**	**3**	**4**	**5**	**6**
0.5 – 5	**1**	**1**	**2**	**3**	**4**	**5**	**6**
5 - 10	**2**	**2**	**4**	**6**	**8**	**10**	**12**
>10	**3**	**3**	**6**	**9**	**12**	**15**	**18**

Figure

Risk of ozone impact on (left) grasslands (EUNIS class E) and (right) woodland fringes (EUNIS class E5) in Natura 2000 areas.



8. The first global stomatal flux-based assessment of ozone impacts on wheat yield revealed a global annual yield loss due to ozone of 9.4 per cent between 2010 and 2012, which equates to an annual economic loss of $24.3 billion globally. Economic losses were highest in Central Europe, Eastern USA, Western China and Northern India, all important wheat growing areas. Yield losses predicted with the concentration-based metrics were much larger than those predicted with the flux-based metric.

B. Conduct the European moss survey 2015/16 (workplan item 1.1.1.12)

9. The first data from the 2015/16 moss survey have been submitted to the new Moss Survey Coordination Centre in the Russian Federation. Almost 40 countries are expected to submit data on heavy metal concentrations in mosses, including nine countries from South-Eastern Europe, seven countries from Eastern Europe, the Caucasus and Central Asia (Azerbaijan, Belarus, Georgia, Kazakhstan, Moldova, Russian Federation and Ukraine) and six countries from other parts of Asia and Africa (India, Mongolia, South Africa, South Korea, Thailand and Vietnam). Some countries will also report on nitrogen concentrations in mosses and on selected persistent organic pollutants (POPs).

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) Revised ozone risk assessment methods; (b) Revision of 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); (c) Report on ozone risk assessment based on new ozone flux models and critical levels for vegetation (in collaboration with the Meteorological Synthesizing Centre-West); (d) Ozone impacts on food production — raising awareness for crop growers and breeders; (e) Ozone impacts on forests (in collaboration with the International Cooperative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests); (f) Ozone impacts on Natura 2000 areas — case studies; (g) The 2015/2016 European moss survey on heavy metals, nitrogen and persistent organic pollutants; (h) Moss monitoring manual for the 2020 moss survey; (i) Protocol for data access and usage. ICP Vegetation will organise the next ozone critical level workshop in Spain in the autumn of 2016.

V. Policy-relevant issues, findings and recommendations

11. The first global stomatal flux-based assessment of ozone impacts on wheat yield revealed a global yield loss due to ozone of 9.4 per cent, which equates to an economic loss of $24.3 billion globally. Economic losses are highest in Central Europe, Eastern USA, Western China and Northern India, all important wheat growing areas.

12. In many parts of central and Southern Europe, Natura 2000 grassland habitats are at risk from impacts of ozone pollution. Risk is highest in regions with high ozone fluxes (phytotoxic ozone dose) and relatively large grassland habitat area. Further study is needed on the impacts of ozone on biodiversity.

13. Updated field-based evidence of ozone impacts on vegetation has confirmed previous assessments showing that ozone damage to vegetation is widespread across Europe. The spatial pattern of observed impacts is better related to accumulated ozone fluxes to vegetation than to accumulated ground-level ozone concentrations. Northern hemispheric cooperation is required to reduce the risk of ozone impacts on vegetation in Europe, with an important role for methane emission abatement.

14. Transfer of the Moss Survey Coordination Centre to the Russian Federation has enhanced participation of countries in Eastern Europe, the Caucasus and Central Asia and several other Asian countries in the 2015/16 survey to monitor heavy metal and nitrogen deposition to vegetation using mosses.

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

15. Many of the issues that were identified in recent years for the attention and advice of other groups, task forces and subsidiary bodies are still valid for the near future. Of particular importance are:

(a) Collation of further field-based evidence for the impacts of ozone on vegetation, including epidemiological studies, in collaboration with ICP Forests;

(b) Further development of the ozone risk assessment methodology for and its application to vegetation, and setting critical levels in collaboration with ICP Forests and Meteorological Synthesizing Centre-West;

(c) The assessment of temporal trends and spatial patterns in past and predicted future ground-level ozone concentrations in a changing climate, and associated (risk of) impacts on vegetation (including crops) at the European and global scale, in collaboration with the Meteorological Synthesizing Centre-West, the Task Force on Measurements and Modelling, the Task Force on Hemispheric Transport of Air Pollution and ICP Forests. There is a need to apply the ozone flux-based risk assessment methodology globally for a range of vegetation types;

(d) Assessment of the interactive risk of impacts of ozone and nitrogen pollution on vegetation (including biodiversity) and ecosystem services (including valuation) in a changing climate (i.e. warmer and dryer climate, enhanced carbon dioxide concentration, more extreme events) in collaboration with the International Cooperative Programme on Modelling and Mapping of Critical Levels and Loads and Air Pollution Effects, Risks and Trends, ICP Forests, the Task Force on Integrated Assessment Modelling/Centre for Integrated Assessment Modelling, the Meteorological Synthesizing Centre-West, and the Task Force on Reactive Nitrogen;

(e) Assessment of future temporal trends and changes in spatial patterns in heavy metal deposition in collaboration with the Meteorological Synthesizing Centre-East. Potential application of the data on heavy metal and nitrogen concentrations in mosses sampled at ICP Forests sites in the assessment of the state of forests at those sites, in collaboration with ICP Forests.

VII. Recommendations to further strengthen implementation and ratification of the Protocols in Eastern Europe, the Caucasus and Central Asia, as well as South-Eastern Europe

16. To further strengthen implementation and ratification of the protocols to the Convention in Eastern Europe, the Caucasus and Central Asia, as well as South-Eastern Europe, further evidence of air pollution deposition to and impacts on vegetation in countries of the sub-region should be sought through increased participation in the work of ICP Vegetation. The latter is promoted by:

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

(b) Knowledge transfer through the publication of reports, the Modelling and mapping manual and leaflets in the Russian language;

(c) Encouraging experts from those countries to attend the ICP Vegetation Task Force meeting and where possible arrange financial support for participation;

(d) Encouraging countries of the sub-region to identify and support the participation of ozone experts in ICP Vegetation.

VIII. Scientific and technical cooperation with relevant international bodies

17. The ICP Vegetation will continue and further stimulate collaboration with Asian, South-American and African countries. The Chair of the ICP Vegetation was invited as a keynote speaker to the first Asian Air Pollution workshop in Tokyo, 31 October–2

November 2015. Asian experts are keen to continue collaboration in the future and acknowledged that the close collaboration between scientists and policy makers within the framework of the Convention is an excellent example that should be developed in Asia too.

18. The ICP Vegetation contributes to the “Tropospheric Ozone Assessment Report (TOAR): Global metrics for climate change, human health and crop/ecosystem research”. This is an activity of the International Global Atmospheric Chemistry Project (IGAC; see also para. 5).[9] Data collection has been completed and the chapter on vegetation metrics is being led by the head of the Programme Coordination Centre for the ICP Vegetation. Further details can be found in document ECE/EB.AIR/GE.1/2015/8–ECE/EB.AIR/WG.1/2015/8.

IX. Scientific findings: highlights

19. Highlights of scientific findings of ICP Vegetation are summarized in document ECE/EB.AIR/GE.1/2016/–ECE/EB.AIR/WG.1/2016/3 and in section V above.

X. Meetings

20. The twenty-ninth meeting of the Programme Task Force was held in Dubna, Russian Federation from 29 February to 3 March 2016. The meeting was hosted and supported by the Joint Institute for Nuclear Research (JINR). The meeting was attended by 90 experts from 33 countries. Minutes of the meeting are available from the ICP Vegetation website.[10]

21. The second expert workshop on “Epidemiological Analysis of Air Pollution Effects on Vegetation”, was held in Hindås, Sweden, from 23 to 24 November, 2015. The workshop was organized by the Swedish Environmental Research Institute (IVL) and the Gothenburg University and was funded by the Swedish research programmes “Biodiversity and Ecosystem Services in a Changing Climate” and “Swedish Clean Air and Climate”, and by the Swedish Environmental Protection Agency.

22. Back to back with the above workshop, an expert workshop was held on “Methodology for Ozone Critical Levels Analysis” in Hindås, Sweden, from 24 to 25 November, 2015, again supported by the Swedish research programmes “Biodiversity and Ecosystem Services in a Changing Climate” and “Swedish Clean Air and Climate”, and by the Swedish Environmental Protection Agency. This was followed by a second expert workshop on “Dose-Response Functions for Deriving Critical levels” in Deganwy, United Kingdom, from 7 to 9 June, 2016. The second workshop was organized by the ICP Vegetation Programme Coordination at the Centre for Ecology and Hydrology, Bangor and was funded by the Swiss Federal Office for the Environment. Decisions were made on methodological approaches and background documents to be prepared for the ECE ozone critical levels workshop to be held in in Madrid, Spain in November 2016.

[9] http://www.igacproject.org.
[10] http://icpvegetation.ceh.ac.uk/.

XI. Publications

23. For a list of ICP Vegetation publications and references for the present report, please visit the ICP Vegetation web site.[11]

[11] http://icpvegetation.ceh.ac.uk/publications/