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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 3 of the provisional agenda
Progress in activities in 2017 and further development of effects-oriented activities

Dynamic modelling*

Report by the Chair of the Joint Expert Group on Dynamic Modelling

Summary

The present report is 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 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 Convention (ECE/EB.AIR/133/Add.1, item 1.1.1.24).

The report presents a summary of the progress in dynamic modelling of ecosystems effects by acidification, heavy metals and nutrient nitrogen including the interactions between climate change and air pollution, biological responses and terrestrial carbon sequestration from the sixteenth meeting of the Joint Expert Group on Dynamic Modelling (Sitges, Spain, 26-28 October 2016).

* The present document is being issued without formal editing.

I. Introduction

1. The sixteenth meeting of the Joint Expert Group on Dynamic Modelling under the Working Group on Effects was held from 26 to 28 October 2016 in Sitges, Spain.

2. Eighteen experts from the following Parties to the Convention on Long-Range Transboundary Air Pollution (Convention) attended the meeting: Austria, Canada, Czechia, Denmark, Finland, Iceland, the Netherlands, Norway, Spain, Sweden, Switzerland, the United Kingdom of Great Britain and Northern Ireland, and United States of America. The International Cooperative Programme (ICP) on Assessment and Monitoring of the Effects of Air Pollution on Rivers and Lakes (ICP Waters), the International Cooperative Programme on Integrated Monitoring of Air Pollution Effects on Ecosystems (ICP Integrated Monitoring), the International Cooperative Programme on Modelling and Mapping of Critical Levels and Loads and Air Pollution Effects, Risks and Trends (ICP Modelling and Mapping), the Task Force on Integrated Assessment Modelling, and the Bureau of the Working Group on Effects were also represented.

3. The meeting was chaired by Mr. F. Moldan (Sweden). It was organized by the Swedish Environmental Research Institute (IVL, Sweden).

II. Aims and organization

4. The aims of the Joint Expert Group meeting were to examine progress in dynamic modelling of ecosystem effects by acidification, heavy metals and nutrient nitrogen including the interactions between climate change and air pollution, biological responses and terrestrial carbon sequestration. The aims were in accordance with the 2016-2017 workplan for the implementation of the Convention (Addendum) (ECE/EB.AIR/133/Add.1 item 1.1.1.24).

III. Conclusions and recommendations

5. The Joint Expert Group applauds the 2016 Scientific Assessment Report.[1]

6. The Joint Expert Group notes that the Executive Body and the Working Group on Effects plan continued work on science- and effects-based assessments in support of air pollution policies. The amended Protocol to Abate Acidification, Eutrophication and Ground-level Ozone (Gothenburg protocol) has 2020 as the target year. New developments in monitoring, mapping and modelling since 2010, should be brought into play to underpin and justify policies for air pollution reductions.

7. The Joint Expert Group agrees with the Working Group that the simultaneous effects of air pollution, climate change and land-use change (both synergistic and antagonistic) will have to be considered in future work. Dynamic models address just such interactions.

8. The Joint Expert Group recognises that elaborate models can only be used at a few sites that have intensive data, whereas for regional applications more simplified models must be used.

[1] Rob Maas, R. and Peringe. Grennfelt (eds), *Towards Cleaner Air, Scientific Assessment Report 2016* (Oslo, 2016).

9. The Joint Expert Group expresses concern over the future of the Coordination Centre for Effects and urges the Executive Body to find a solution.

10. The entire set of methods for calculating and mapping critical loads can be applied to the countries in Eastern Europe, the Caucasus and Central Asia as a regional extension.

11. The Joint Expert Group applauds the revision of the Modelling and Mapping Manual[2] now in progress.

12. The Joint Expert Group notes that the United States of America is working on using critical loads mapping to underpin future policy on air pollution.

13. The Joint Expert Group notes that the International Institute for Applied Systems Analysis is working on an emission model for mercury and that ecosystem effects data are needed for this development.

A. Impact of nitrogen as a nutrient in terrestrial and freshwater systems including the impact on biodiversity

14. The Joint Expert Group applauds the use of empirical and experimental data to evaluate critical loads estimates for semi-natural ecosystems.

15. The Joint Expert Group is pleased to see good progress in development and testing of terrestrial biodiversity models. The PROPS model is being evaluated against very extensive and large datasets.

16. The Joint Expert Group applauds the evaluation of the PROPS model on Norwegian data, including the observed and modelled changes over time. Perhaps a Scandinavian PROPS version might be more successful in explaining the observed data.

17. One remaining difficulty in plant species modelling is that the present-day species composition may reflect past (and unmeasured) soil conditions and thus past nitrogen and sulphur deposition.

18. The Joint Expert Group notes that progress has been made in the use of the Habitat Suitability Index (HIS), the indicator agreed at the Coordination Centre for Effects meeting in Rome 2015. Here the choice of species to be included in the HSI is important and affects the results.

19. Other factors (such as light conditions) could explain the scatter between the observed and modelled HSI and plant species occurrences.

20. The Swiss National Focal Centre for ICP Modelling and Mapping initiated a revision of the parameter table of the Swedish ground vegetation simulation model on the basis of the indicator value system developed by Landolt[3] with the intention to improve the internal consistency of the parameterization. Drivers were limited to three climatic parameters (soil humidity, temperature and light availability) and two chemical drivers (soil acidity, soil nitrogen) and competition and plant response functions were simplified. The revised version of the biodiversity critical loads Veg-CL model (called VeCH) was applied

[2] A first version of the Modelling and Mapping Manual was published in 1993. It has since been updated three times: in 1996, 2004 and again in 2016. The full text of the 2016 version is available as online, by chapter, from the website of the International Cooperative Programme on Modelling and Mapping of Critical Levels and Loads and Air Pollution Effects, Risks and Trends: http://icpmapping.org/Latest_update_Mapping_Manual

[3] Landolt E. Oekologische Zeigerwerte zur Schweizer Flora. Verooffentlichechungen Geobotaniches Institut ETH, Stiftung Ruebel 64. S. 1-208.

to 22 forest sites and predicted reasonably coherent behaviour of the vegetation composition with increasing and decreasing nitrate as well as hydrogen ion concentration in the soil solution. On the other hand, VeCH was, as earlier Veg-CL versions, unable to reproduce current observed plant compositions on the site level as well as on the regional level.

21. Biodiversity critical loads were calculated in compliance with the procedure outlined by the Coordination Centre for Effects for the same sample sites using VeCH-CL, Veg-CL and PROPS-CL models. Since plant response to varying drivers often differs substantially among the three models, resulting critical loads functions only rarely compared. Generally, VeCH returned for a given protection level lower sulphur and nitrogen critical loads than Veg and PROPS models. Irrespective of the model, only protection levels above 80 per cent of maximum HSI (HSImax) led to a systematic lowering of sulphur critical loads of acidity (CLmaxS). The nitrogen critical loads of biodiversity (CLNmax) from VeCH was mostly lower than the nitrogen critical loads of acidity (CLmaxN) while Veg and PROPS nitrogen critical loads of biodiversity (CLNmax) were less restrictive (protection levels 70 per cent of HSImax and higher required to get a systematic reduction of CLmaxN). All models predict higher values for CLNmax than for nitrogen critical loads of eutrophication (CLeutN; formerly CLnutN; which is calculated in Switzerland by an obviously very restrictive leaching criterion) irrespective of the protection level applied.

22. The Joint Expert Group notes that there are several possible indicators of changes in soil nitrogen availability that can be used as proxies to explain changes in biodiversity (plant species occurrences). In use at present are soil carbon to nitrogen ratio (C/N), soil solution nitrate (NO_3) concentration, nitrogen deposition, cumulative nitrogen deposition over time, ammonium (NH_4) in soil solution, total nitrogen in soil solution. All of these suffer from shortcomings, and probably the best approach is to use more than one indicator.

23. Dynamic models are needed to explore the plant responses to different future scenarios, but empirical approaches may be sufficient for estimating critical loads (CLeutN). Both must assume that the habitat does not otherwise change, as altered plant community will necessarily alter the soil chemistry over the long term.

24. The Joint Expert Group notes that there have been further expansion and development of the integrated dynamic forest ecosystem ForSAFE model, and look forward to application and evaluation of this new version of the model to data-intensive sites.

B. Recovery of air pollution affected ecosystems

25. The Joint Expert Group notes that even with full implementation of the amended Gothenburg protocol in 2020, the freshwater acidification problem will not be solved in acid-sensitive regions such as southern Norway and southwestern Sweden.

26. The responses of plant species to changes in nitrogen deposition are subject to time lags, both in response to increasing nitrogen deposition (damage delay time) and to decreasing nitrogen deposition (recovery delay time). Present-day plant communities may be the result of earlier environmental factors, such as the peak in sulphur dep during the 1970s (this is called extinction debt). Future decreases in nitrogen deposition may only slow the “damage” rate.

27. The Joint Expert Group stresses that nitrogen as a nutrient is still a threat over large areas, and nitrogen deposition in ecosystems is still exceeded - the environmental problem still exists.

C. Interactions between air pollution, climate change and land use

28. The Joint Expert Group appreciates the application of dynamic modelling to evaluate the future acidification of freshwater ecosystems given scenarios of air pollution, land-use and climate change. These “confounding factors” affect the recovery of freshwater ecosystems following the large decreases in sulphur deposition over the past 20-30 years. As acid deposition declines, these confounding factors become more important or even dominant in explaining observed changes in surface waters.

29. The Joint Expert Group applauds the efforts by ICP Integrated Monitoring to apply various dynamic models to ICP Integrated Monitoring sites, across the gradients of climate, vegetation and sulphur and nitrogen deposition in Europe.

30. The Joint Expert Group stresses that dynamic modelling give opportunities to look at multiple factors simultaneously, and to explore complicated future scenarios of multiple stressors on ecosystems.

D. Interactions between nitrogen, carbon and phosphorous

31. The Joint Expert Group stresses that dynamic modelling of nutrients (nitrogen) and carbon in soil/streams can be improved by including phosphorus. Nitrogen-rich sites may be limited by phosphorus availability. The issue is further complicated since the phosphorus availability is pH dependent.

32. The Joint Expert Group appreciates the evaluation of long-term monitoring data in Czechia with respect to the responses of soil solution and streamwater to changes in sulphur and nitrogen deposition. Nitrate concentration in these sites (as well as sites elsewhere) is very responsive to decreases in nitrogen deposition. Nitrate concentrations in streamwater are apparently controlled by biological processes in the terrestrial ecosystem, and phosphorus may be part of the explanation.

33. The Joint Expert Group notes that one of the great dilemmas for plant species models is the use of carbon to nitrogen ratio and nitrate concentration in soil solution as drivers of change for plant species. The carbon to nitrogen ratio responds very slowly to changes in nitrogen deposition, while the nitrate concentration in soil solution is very difficult to model with current dynamic models.

34. The carbon to nitrogen ratio in soil is habitat specific and may reflect past land-use rather than present-day plant composition. The rate and direction of change are also important factors.

E. Assessment of ecosystem services

35. The Joint Expert Group notes that ecosystem service concept become an important tool for policy decisions. Dynamic modelling applications are vital for defining the magnitude and long term changes of ecosystem services such as nitrogen retention, carbon storage, etc. The Joint Expert Group recognizes that monetarizing ecosystem services is beyond its expertise.

F. Interfacing with global scale models

36. The Joint Expert Group stresses that strong interactions among soil variables exists, notably strong linkage between soil pH and soil carbon.

37. Dynamic modelling can take into account effects of changing soil acidity on the capacity of soils to sequester carbon. Dynamic models are capable to address the interaction among climate change effects and air pollution effects on soil carbon dynamics.

38. The Joint Expert Group advises to further extent the dynamic modelling from site-specific scale to regional/global scale.

G. Dynamic modelling in international policies

39. Dynamic models are at the interface between science and policy, and provide good support for policy. They pull together information from monitoring, experiments and modelling and visualisation of dynamic modelling outputs can customised for presentations in policy relevant ways.

40. The Joint Expert Group notes that model applications and further development are greatly aided by consideration of new and ongoing monitoring data, in many cases gathered under the auspices of ICPs.

41. The Joint Expert Group notes with satisfaction that the new estimates of historical sulphur and nitrogen deposition provided by EMEP are now being used in dynamic modelling applications.

42. The Joint Expert Group notes that the 2015-17 call for data by the ICP Modelling and Mapping entails call for biodiversity critical load information. About 10 countries have expressed interest in submitting such data as compared to 2 countries in the previous call. This suggests that good progress has been made in using models (including dynamic models) to estimate terrestrial plant responses to air pollution.

43. The Joint Expert Group thanks and applauds the Coordination Centre for Effects for developing and providing additional modelling tools to facilitate the preparation of data by the various countries.

H. Consistency in approach under different international policies and Conventions

44. The Joint Expert Group notes with satisfaction that work is proceeding apace in Canada and the United States of America regarding application of dynamic models and efforts in North America to apply dynamic models for terrestrial biodiversity. These applications help to evaluate the usefulness of the various models now in operation in various countries in Europe.

45. The Joint Expert Group notes that the Working Group on Effects strongly encourages more cooperation between groups. Interactions between several of ICPs on dynamic modelling applications are logical and exemplify the usefulness of such cooperation.

46. In response to more complex and specific demands for scientific knowledge dynamic models become more sophisticated. Consequently, the need for data on additional ecosystem processes increases and becomes acute.

47. The Joint Expert Group applauds the coupling of dynamic modelling work done in conjunction with the Convention and points out that much is also relevant to work

mandated by the European Commission as part of the European Union Water Framework Directive.[4]

IV. Future of the Joint Expert Group on Dynamic Modelling and workplan for 2017

48. The Joint Expert Group notes that funding on all fronts is necessary to continue ongoing and new work on dynamic modelling related to the Convention and urges policy makers to provide funding in support of the science-based work asked for.

49. The Joint Expert Group recommends stressing that carbon dioxide emissions can be considered as a long range air pollutant and argues for further linking with policies to mitigate climate change.

50. The Joint Expert Group concludes that further meeting in 2017 according to 2016-2017 workplan is desirable and that Joint Expert Group should continue the effort to integrate dynamic modelling expertise across all Convention bodies and also to provide links to modelling groups outside the Convention.

[4] Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for the Community action in the field of water policy, O.J. (L 327).