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Recent results and updating of scientific and technical knowledge

Dynamic Modelling

Report by the Co-Chairs of the Joint Expert Group on Dynamic Modelling

1. This report comprises the results of recent work in dynamic modelling and provides a summary of the meeting of the Joint Expert Group, presented here in accordance with item 3.9 of the 2010 workplan for the implementation of the Convention (ECE/EB.AIR/99/Add.2), adopted by the Executive Body at its twenty-seventh session in December 2009.

I. Workplan items common to all programmes

A. Targets and ex post application

2. The Joint Expert Group considered two aspirational targets for 2050 that should be incorporated into policy: no further enrichment of nitrogen (N) in soils resulting from atmospheric deposition, and no further depletion of base cations from soils resulting from atmospheric deposition.

3. The Group noted that the International Cooperative Programmes (ICPs) should be encouraged to take the opportunity to make use of their accumulated experience and knowledge to potentially influence policymaking with respect to air pollution. Target loads had been developed and calculations were available at the European scale. It encouraged the Centre for Integrated Assessment Modelling (CIAM) of the Convention's Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants (EMEP) to undertake at least one run of optimization based on target loads. The Group welcomed the planned call by the Coordination Centre for Effects (CCE) for data for

vegetation modelling and recognized the importance of that effort to achieve better European coverage for dynamic modelling.

B. Robustness

4. The Joint Expert Group welcomed the development of the land cover map based on the Coordination of Information on the Environment (CORINE) programme at 100 m resolution, and of deposition maps at 25 and 10 km resolutions. However, the lack of base cation deposition estimates remained problematic for the dynamic models on ecological impact.

5. For the revision of the 1999 Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone (Gothenburg Protocol), dynamic models had to take climate change and related policies into account in predictions, as they systematically changed the rate of key processes. For example, deposition would be lower under a deposition scenario based on maximum technically feasible emission reductions (MTFR) that included climate policy, rather than under the current MTFR scenario. As a consequence, current predictions with dynamic models might be too pessimistic

C. Links with biodiversity

6. At N limited ecosystems N deposition would lead to carbon sequestration. However, at extremely high N deposition levels plant growth was reduced. Biomass productivity could also be limited by other factors (e.g., trace nutrients, water, energy). The Joint Expert Group urged further research on those factors.

7. The Group welcomed recent developments on model systems such as VSD+ and SPECIES; VEGontoVSD; and the BERN model for both terrestrial and aquatic ecosystems. It also welcomed testing of ForSAFE-VEG model in Switzerland and Sweden on a regional scale and preparation of a user manual and an appendix to be incorporated into the*Manual on Methodologies and Criteria for Modelling and Mapping Critical Loads and Levels and Air Pollution Effects, Risks and Trends*.[1] The Group recommended that a comparative study of the parameterization of the different models be undertaken in the first part of 2010.

8. The Group recognized the need to quantify existing biodiversity targets in relation to the model outputs. Existing targets were defined in various processes, such as the European Union (EU) Habitats Directive, the International Union for Conservation of Nature (IUCN) Red List, Dutch national targets, the Convention on Biological Diversity, and the EU Water Framework Directive.

9. The Group emphasized the need to develop biological models to assess the impact of N as a nutrient for aquatic ecosystems. There was also a need to enhance those aquatic models with internal process feedbacks on key processes from climate change and land management.

10. The Group stressed the need for data from sites with long-term records (decades) to evaluate and test dynamic models.

[1] Produced by the International Cooperative Programme on Modelling and Mapping of Critical Loads and Levels and Air Pollution Effects, Risks and Trends (ICP Modelling and Mapping) and available at: http://icpmapping.org/cms/zeigeBereich/11/manual-english.html.

II. Acidification

11. Observations had shown increasing trends in dissolved organic carbon (DOC) at sites recovering from acidification. It was hypothesized that the acidification might have slowed down decomposition to the extent that soil organic carbon or lake sediments might have accumulated. As recovery continued, that resource became biologically exploitable again.

III. Nutrient nitrogen

12. In general, there were still uncertainties in understanding and modelling of N cycling. Discrepancies between observed and modelled N at individual sites led to uncertainties which needed to be considered when wider spatial applications were undertaken. Some general trends were well predicted, but short-term variations still represented challenges.

13. The carbon-to-nitrogen ratio (C/N) of soil organic matter was readily measurable and characterized the N storage status of the site. In general, C/N was correlated to nitrate leaching, but change in C/N over time was poorly understood. Nevertheless, it was one of the few indicators with some utility in predicting the ecosystem response to changing deposition, land use or climate.

14. The Joint Expert Group noted that over the past 20 years N deposition in Canada had decreased, although droughts had confounded the overall observed chemical response. The observed decrease in nitrate export in response to decreased inputs indicated that N saturation was unlikely in the foreseeable future. Decreasing nitrate export had been noted at sites in Europe as well.

IV. Heavy metals

15. Metal accumulation and leaching could be approximately explained by deposition, weathering, speciation, soil acidity and run-off. Currently available dynamic models were hard to validate due to the slow responses and the paucity of long-time series available. There was a need to establish appropriate space for time analogues.

16. The leaching of nickel (Ni), zinc (Zn) and cadmium (Cd) from soils responded relatively rapidly (within decades) while copper (Cu), lead (Pb) and mercury (Hg) responded more slowly (over centuries). Key controls included metal deposition, acidity status and soil organic matter. The latter one was most likely to be influenced by land use and climate change.

17. Nevertheless, the Joint Expert Group emphasized the importance of ensuring that policy continued to control the release of metals into the environment. Release of heavy metals from soil was a long-term process and that should not detract from efforts to reduce emissions.

V. Cross-cutting issues

A. Terrestrial carbon sequestration

18. Carbon sequestration in response to N deposition was time and space specific. It had to be modelled as a state variable in dynamic models rather than as a constant. A constant value was preferable to ignoring that process completely within a model.

19. The Joint Expert Group supported the approach of using analysis with radioactive carbon isotope (^{14}C) to characterize pool sizes and modelling soil carbon turnover. That could yield information relevant to all models. The Group urged all ICPs to include ^{14}C analysis of soil organic matter at monitored and manipulated sites.

B. Interactions between climate change and air pollution

20. An application of the MAGIC model in Sweden had considered the synergistic effects of land use, climate change and atmospheric deposition under several future scenarios. The results had identified issues associated with the lack of climate interactions and land use feedbacks on the key processes in the model. Other processes might also be significantly affected. Identification, understanding and quantification of climate change impact on processes such as weathering rates and their consideration in dynamic models would further increase credibility of model predictions.

21. The results also indicated that both climate change and land use could offset the predicted recovery, assuming a maximum technically feasible reductions scenario on emissions. Each of them, individually or combined, had a more important role in determining modelled water and soil chemistry response in 2100 than deposition alone

22. The Joint Expert Group recommended investigation of climate change impacts on deposition patterns because it had possible consequences for dynamic model predictions. It urged EMEP to provide historical and future predicted base cation deposition.

C. Biological response

23. Plant available N was important to predict floristic composition. N mineralization was incorporated in some terrestrial dynamic models. Mineralizable N was possibly an index of plant available N but was measured using several different techniques and a consistent methodology needed to be agreed upon.

24. The Joint Expert Group welcomed the development of enhanced utility of the VSD+ model to produce outputs for biodiversity by appending the Swedish VEG model to it, especially the calibration and testing on chrono-sequences and the development of the stand-alone user-friendly version. The VEGontoVSD model required further testing and the issue of up-scaling to European level needed to be addressed. ICP Forests level I and II plots could provide data for such testing.

25. The Group confirmed that dynamic coupled biogeochemical-vegetation models were available to substantiate existing critical limits and to calculate the impact when N limits were not achieved. Some discrepancies in vegetation responses still existed when the models were field tested against observations. The models were clearly improved compared to those used in the past. In addition, dynamic models could simulate the potential response to future climate change and other drivers. At present, they were also the only available tool to assess biological lag times.

26. The Group emphasized that the dynamic models suggested that plant composition responses to N deposition reductions were delayed. The reason was that ecosystems had accumulated N over a long time period and would remain N rich into the future.

27. The Group noted the need to consider interactions between nutrients when assessing biotic response, for example, between N and phosphorous. Increased soil acidification was restricting phosphorous losses to water. The concurrent decrease in N export resulted in reduced lake productivity. Although general trends existed, inherent catchment heterogeneity generated a range of responses.