# APPENDIX 5a

## JOINT EXPERT GROUP MEETING ON DYNAMIC MODELLING

**Summary report on the fifth meeting prepared by the organisers**

## I. INTRODUCTION

1. The fifth meeting of the Joint Expert Group on Dynamic Modelling took place on 28-29 October 2004 in Sitges (Spain). It was organised by the Swedish programme on International and National Abatement Strategies for Transboundary Air Pollution (ASTA programme) in cooperation with the Centre for Ecology and Hydrology (United Kingdom).

2. The meeting was attended by 21 experts from the following Parties to the Convention: Canada, Denmark, Finland, Germany, Ireland, Norway, Poland, Sweden, Switzerland and the United Kingdom. The International Cooperative Programmes (ICPs) on Integrated Monitoring (ICP IM), Modelling and Mapping (ICP M&M) and Waters (ICP Waters), as well as the Coordination Center for Effects (CCE at the National Institute for Public Health and the Environment, Bilthoven, Netherlands) were represented. A Vice-Chairman of the Working Group on Effects attended and a member of the secretariat was also present.

3. The meeting was co-chaired by Mr Alan Jenkins (United Kingdom) and Mr Filip Moldan (Sweden).

## II. AIMS AND ORGANIZATION OF THE MEETING

4. The objectives of the meeting were to:

(a) Review the technical problems encountered with the 2003 (first) call for dynamic modelling outputs and suggest possible fixes;
(b) Consider the CCE plans for the forthcoming 2004 (second) call for dynamic modelling outputs;
(c) Review the requirement and options for providing dynamic model outputs to integrated assessment models;
(d) Assess the options for using dynamic modelling for scenario analysis and to review the status of dynamic modelling of nutrient N and heavy metals;
(e) Determine the suitability of existing models for assessing the joint impacts of emission reductions and climate change.

5. The meeting was conducted in a series of plenary sessions addressing four topics:

(a) Response to the 2003 call;
(b) Technical issues:
- *Nitrogen*
- *Consistency with critical loads*
- *Coverage and representativity*
- *Presentation of results*

(c) Beyond the next call:

- *Climate change impacts*
- *Dynamic modelling of Nutrient N and Heavy Metals*
- *Biological responses*

(d) Future developments.

## III. CONCLUSIONS AND RECOMMENDATIONS

6. The Joint Expert Group agreed on 30 conclusions and recommendations here grouped into six sections.

### A. Response to the 2003 Call

7. The JEG reviewed the response to the 2003 call for data and applauded the progress achieved. At the same time the group urged more countries to respond to the new (2004) call especially with respect to target load (TL) functions for surface waters.

8. The JEG agreed with the proposed CCE specifications for the target load reporting planned for the call for Dynamic Modelling (DM) outputs in 2004.

9. The JEG agreed on the use of the critical load (CL) function at sites where there are no calculated TLs. At EMEP grid scale, combination of the two provides the best available material for the assessment of the whole area. It is however, desirable, to design a way to indicate which squares are based on TLs and CLs.

10. The JEG recommend the CCE call for a list of nine variables including Ca and $NO_3$ concentrations in soil or surface waters and C/N ratio of the humus layer in years 1990, 2010, 2030, 2050 and 2100.

11. The JEG recommended that dynamic models be run using two emission scenarios in the coming call for the data: CLE (Gothenburg protocol) and “background”. In the “background”, sulphur and nitrogen deposition beyond 2020 will be set to natural background levels as defined by EMEP.

12. The JEG agreed that future (beyond 2020) base cation and nitrogen uptake should be assumed constant for the target load calculation. Long term uptakes are already used for CL calculations.

13. The JEG recommended the use of present day data to identify ecosystems on which DM are not needed in response to the call for data, because the soils or surface waters are not currently damaged with respect to the chemical target. Since agreed emission reductions to 2010 will take the pollutant deposition flux lower, these sites can be considered to be protected in the future.

14. The group urged the CCE to include scenario analysis from the two deposition scenarios defined by the call in their planned report on the response to the 2004 call. The group also recommended that NFCs should further explore the dynamic modelling outputs on a national level.

15. The JEG encouraged better national awareness of NFCs in individual national research project activities with associated dynamic modelling outputs which could be utilised in response to the call for data.

16. The JEG urged all ICPs and their NFCs to include ICP monitoring sites when reporting CLs and TLs to CCE for consistency checking and validation assessment.

17. The JEG reminded NFCs of the requirement to use consistent models for CLs and TLs in their response to the 2004 call.

18. The JEG noted the potential of the "half-time" concept for communicating DM results to end-users. The JEG recommended all ICPs to further explore the use of the "half-time" concept to display recovery changes and to illustrate differences between scenarios.

19. The JEG requested a better insight into the results of DM work done in Canada and recommend the CCE to seek ways to include these in their assessment of the 2004 call for data.

## B. Modelling nitrogen dynamics

20. The JEG applauds and recommends the suggestion for an expert workshop on the subject of N dynamics in terrestrial systems. The workshop should include the consequences of N deposition and climate change**.**

21. The JEG encouraged the ICPs Forest, Vegetation, Integrated Monitoring and Waters to examine the results from their DM efforts with respect to N variables and to evaluate whether these outputs are sufficient to predict the biological response with respect to "N as a Nutrient" (eutrophication).

22. The JEG acknowledged that present approaches to the representation of broad scale N dynamics are simplifications, and urged the development of mechanistic descriptions that can be incorporated into DM.

23. The JEG recommends that each country contributing to the call should parameterise N dynamics in the manner each determines best suited for the individual country. The country-specific protocol should thus be appropriate for the ecosystems of interest, the data availability and model selected. Appropriate guidance on parameterisation of N dynamics is available in the Dynamic Modelling Manual.

## C. Interactions with climate change

24. The JEG recognised the need for developing empirical relationships between observed climate change variables and observed effects. The JEG recommended that ICP-IM assess the need for dynamic models to be revised and modified to incorporate key climate change driven processes and preferably to include internal feedbacks and dependencies.

25. The JEG noted output from the EU EUROLIMPACS project showing that the potential effects of future climate change are of the same magnitude and occur over a similar time period as those expected in response to emission reduction agreements (Gothenburg Protocol) and, therefore, must be considered. Potential effects of land use and management

are also confounding factors potentially affecting damage and recovery from air pollutants. The synergistic and combined effect of these factors require evaluation by ICP Waters, ICP Forests, ICP Vegetation and ICP IM.

26. The JEG noted that whereas biogeochemical (acidity) DM applications to date are generally on an annual time step, effects in terrestrial and aquatic ecosystems are often manifest over shorter time scales (days, weeks, months). This is particularly important for evaluation of future climate change response and such shorter term responses will need to be considered in the future by all relevant ICPs.

27. The JEG expressed concern that new information arising from ongoing climate change research may not be readily available for work with respect to DM modelling of impacts on acidification processes.

## D. Heavy metals

28. The JEG agreed that soil organic matter dynamics and acidity are key to modelling heavy metals (HM). The group concluded that the expertise exists, the databases are available and that it is feasible to do the first trials of DM of HM at least for Cd, Pb, Zn and Hg. The group highlighted that dynamic models are available and could be used to undertake scenario studies.

## E. Ecological responses and targets

29. The JEG noted that models for N as a nutrient have been developed but their outputs need to be checked for consistency with observed data on successional changes and loss of species. For the forthcoming call, however, there will not be sufficient time to apply these models extensively. ICP Vegetation should consider the potential of these models for impacts evaluation.

30. The JEG highlighted the importance of terrestrial biological responses in relation to the next generation of model development and in particular, the incorporation of key feedback mechanisms that link ecological response with biogeochemical cycling.

31. In terrestrial ecosystems the targets for biodiversity are not explicit and do not link closely to biogeochemical model outputs. The Group encouraged ICP Vegetation and the wider scientific community to explore targets for biodiversity and the detection of change. This might be best explored by means of a workshop.

32. Recent research on aquatic ecosystems indicates that ANC damage thresholds for zooplankton, phytoplankton and benthic invertebrates may be lower than those for fish. ICP Waters should give further consideration to identifying appropriate response targets for these biota and their inclusion in effects based evaluation.

## F. General

33. The JEG gave their support to the work plan of the WGE, 2004-2006. However, except for acidity, most of the deliverables are rather optimistic with the outcome dependent on funding being available. It was noted that the WGE included work-plan elements for the JEG for September 2004 to August 2005 as:

- develop a method for assessing site-specific simulation results within a regional context;
- formulate and evaluate an agreed description of nitrogen processes for dynamic models;
- support the calculation of critical loads and simulation with dynamic models at monitoring sites of all ICPs;
- develop an agreed methodology for the application of DM in setting deposition targets;
- evaluate the synergies in dynamic modelling work carried out in different ICPs.

34. The JEG identified that a further meeting in 2005 would be beneficial to review the outcome of the 2004 call for data and in order to design the best strategy for further employment of dynamic models in the work of CLRTAP and CAFE. Three major areas where progress requires review are the links between biological and chemical modelling, the interactions between air pollution, climate change and land use and the yet unresolved issue of future impact of N deposition. The JEG felt that any advice from WGE/EB on priorities is desirable in order to distribute the existing resources among these issues, since progress will be inevitably in proportion to the devoted resources.

35. The JEG reviewed and endorsed a short description of the potential for use of DM within the framework of LRTAP and CAFÉ (Annex 1) for wide distribution to NFCs, ICPs, WGE, EB and more widely within the EU.

36. The JEG emphasised the need for better synergy between EU CAFÉ and LRTAP activities. The multi-pollutant and sectoral nature of CAFÉ results in a limited overlap with the work of the Convention but this should not present an obstacle in making full use of existing results of DM in the work of both CAFÉ and CLRTAP.

Annex 1

## **Dynamic Modelling of Acidification in Support of the CLRTAP**

The link between emission of sulphur and nitrogen and acidification of soils and surface waters is understood. The impact of the chemical changes on biota is also sufficiently understood such that chemical targets aimed at protecting aquatic or terrestrial biota have been established as the basis for international agreements on emission reductions within the UNECE and EU. These targets are converted, with the aid of (steady-state) models, into *critical loads* and emission reductions are aimed at reducing the level by which these are exceeded across Europe. The link between the deposition of acidifying pollutants and the loss of or damage to biota, however, is not immediate.

The soil cation exchange capacity (CEC) provides a buffer which delays the onset of soil and surface water acidification. Just as the damage to biota is delayed beyond the onset of acid deposition, so the recovery from acidification will also be delayed. The models used to determine critical loads consider only the steady-state condition in which the chemical and biological response to a change in deposition is complete. Dynamic models, on the other hand, attempt to estimate the time required for a new (steady) state to be achieved. These models can also provide a prediction of chemical status at any point in the future in response to any emission scenario. This note describes the possibilities and limitations of using dynamic models to define the limits and timescales of the recovery processes as an extension to the previously used static approaches (critical loads) and thus provide information on recovery times as a strategy/policy tool.

With critical loads (steady-state situation) only two cases are distinguished when comparing them to deposition: (1) the deposition does not exceed the critical load, and (2) the deposition exceeds the critical load. In the first case, no problem is perceived and no reduction in deposition is deemed necessary. In the second case there is, by definition, an increased risk of damage to the ecosystem. In this respect, a critical load serves as a warning as long as there is exceedance, since it indicates that deposition should be reduced. This is the basis on which the Gothenburg Protocol was negotiated. A conclusion often drawn from this simple analysis is that acidification of soil and surface water is fully reversible and that reducing deposition to (or below) the critical load immediately removes the risk of 'harmful effects' and that the chemical parameter (e.g. an Al:Bc ration in soils or an [ANC]-limit in surface waters) that links the critical load to the biological effect(s), immediately attains a non-critical ('safe') value and that there is immediate biological recovery as well. In reality, however, the removal of the risk of further damage does not necessarily imply that chemical or biological recovery will occur, at least not in the short term. One major reason is that the reaction to changes in deposition is delayed by (finite) buffers, such as the CEC in catchment soils. These buffers can delay the attainment of a critical chemical parameter and it might take decades, or even centuries, before a (new) equilibrium (steady state) is reached (see Fig.1). These finite buffers are not included in the critical load formulation, since they do not influence the steady state, but only the time to reach it. It is also likely that the desirable chemical target will be achieved prior to a new steady state and so the concept of equilibrium becomes irrelevant. Dynamic models, therefore, are needed if we wish to estimate the times involved in attaining a certain chemical state in response to given emission scenarios. In addition to the delay in chemical recovery, there is likely to be a further delay before the 'original' biological state is reached, i.e. even if the chemical criterion is met (e.g. [ANC]>0), it will take time before full biological recovery is achieved, e.g., as a result of the dispersion characteristics of species. The possibility remains, however, that the original biological status will not be recovered, but this possibility is inherent in both steady-state and dynamic approaches.

Given the observed delays in ecosystem responses, two related questions arise for which steady-state models provide no answer: (a) When will ecosystems recover in response to the agreed emission reductions and (b) Which deposition reductions are necessary to achieve recovery within a given time? Dynamic models can be readily used to provide an estimate of the future soil or surface water chemistry in response to existing or planned emission reductions, and thus the timing of recovery.

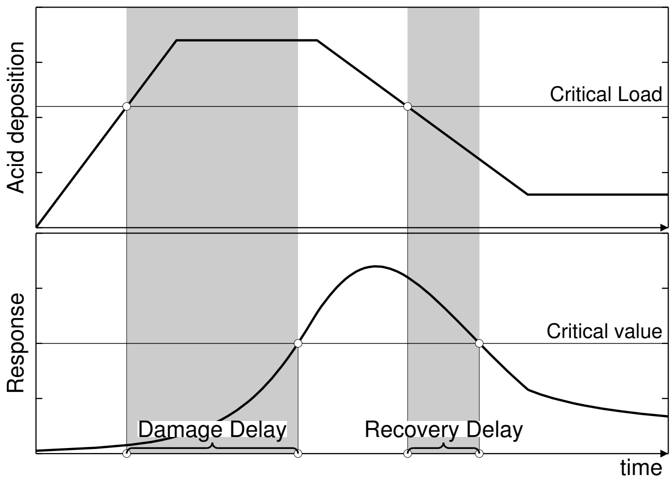


***Figure 1****: Typical past and future development of the acid deposition effects on a soil/lake (chemical or biological) variable in comparison to the critical values of this variable and the critical load derived from it. The delays between the (non)exceedance of the critical load and the (non)violation of the criterion are indicated in grey.*

In this respect, dynamic models have been used to assess the ANC in surface waters across Europe in response to the Gothenburg Protocol scenario (see Fig. 2).

They can also be used to answer the second question: The ecosystem response within a given time frame defines the concept of a *target load*. Target loads depend on the characteristics of the ecosystem (like critical loads) but also on the timetable for deposition reduction (the *target year*), and thus are not unique for a given ecosystem. Because of their explicit dependence on time, target loads can be produced only by dynamic models.

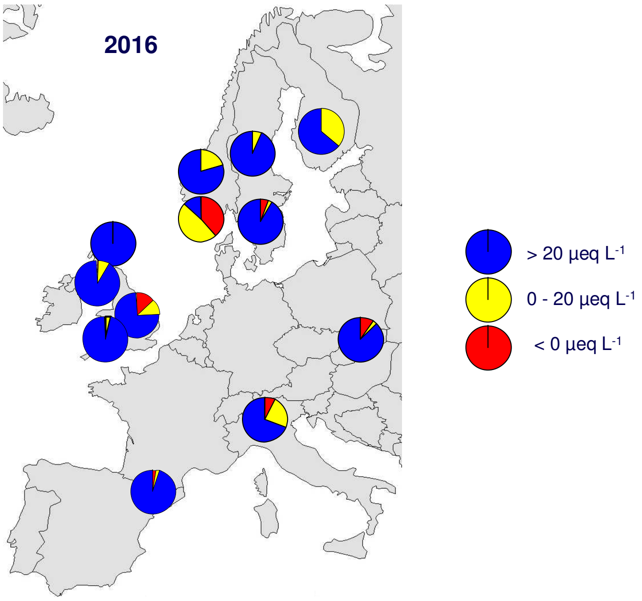


***Figure 2****: Predicted surface water ANC concentration for 2016 in acid sensitive regions under currently agreed deposition reductions expressed in three ANC classes. (Source; Jenkins et al., 2003. Hydrol. Earth Syst. Sci. 7,447-456).*