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DEVELOPING, MODELLING AND MAPPING OF CRITICAL LOADS AND THEIR INPUT DATA

Addendum

HARMONIZATION OF LAND-COVER INFORMATION FOR APPLICATIONS UNDER THE CONVENTION AND REPORT ON THE EXPERT WORKSHOP ON CRITICAL LOADS OF HEAVY METALS

Summary reports prepared by the organizers in consultation with the secretariat

I. HARMONIZATION OF LAND-COVER INFORMATION FOR APPLICATIONS UNDER THE CONVENTION

Introduction

1. A joint meeting of experts on the harmonization of land-cover information for applications under the Convention was held on 10 March 2004 in Laxenburg, Austria. It was organized by the Coordination Center for Effects (CCE) and the Centre for Integrated Assessment Modelling

(CIAM). The organizers had invited experts from key areas of land-cover data use in modelling and mapping activities under the Convention. The meeting was attended by ten participants. The International Cooperative Programme (ICP) on Modelling and Mapping of Critical Loads and Levels and Air Pollution Effects, Risks and Trends (ICP Modelling and Mapping), CCE, CIAM, the Meteorological Synthesizing Centre-West (MSC-W) of EMEP and the Stockholm Environment Institute (SEI) were represented, as was the UNECE secretariat. The meeting was chaired by Mr. J.P. Hettelingh (CCE).

2. The main objective of the meeting was to review and discuss the main land-cover data available and used in the activities under the Convention, and to identify methods to arrive at a harmonized land-cover data set. The land-cover information should preferably be the same for all areas in air pollution assessment work, and it should be available to all interested Convention bodies. Specifically, procedures for the generation and evaluation of the land-cover data should be agreed. During 2003 several bodies under the Convention addressed the issue of defining a common land-cover data set. In 2003 the Task Force of ICP Modelling and Mapping had asked CCE to respond to the needs of the Convention by organizing an expert meeting.

3. A background document for the expert meeting was prepared by CCE. It presented the similarities and differences of three land-cover data sets: CORINE (Coordination and Information on the Environment), PELCOM (Pan-European Land Cover Monitoring Project) and SEI. The CORINE land-cover map is the European Union (EU) standard data set for land-cover applications, compiled from the Member State inventories in a programme of the European Commission and the European Environment Agency. The PELCOM database was produced in an EU research project in 1996-1999. The SEI land-cover map was developed in 1994 for use in modelling impacts of various air pollutants at the continental scale and has been updated since.

4. The Meeting agreed that a sufficient number of the Convention's bodies using land-cover information in their work were represented, and it was thus in a good position to forward suggestions for harmonization. After plenary presentations and a review of the data set comparisons, it was felt that a way could be found to satisfy the Convention's needs for land-cover information. The Meeting agreed unanimously on its main conclusions and recommendations.

A. Conclusions

5. The EUNIS (European Nature Information System) classification of ecosystems was found to be a sound basis for providing a harmonized classification system for all land-cover data sets. It was a classification system for defining different habitat types but did not have a geographical reference itself. The information in all three land-cover data sets could be relatively well converted to a selection of 10 EUNIS level 1 classes, and 22 level 2 classes. To cover the anticipated needs for the activities under the Convention a more detailed selection, and possibly

extension, of the EUNIS classification system would be necessary; this should be consistent with a common soil map. In particular, information would be required, for example, on soil moisture regimes, altitude and temperature and precipitation climates, pollutant-sensitive species or communities, and land-cover types important for emission and pollutant dispersion modelling. The Meeting agreed that the relevant bodies and centres of the Convention should be consulted to ensure that all appropriate cover types were identified for distribution mapping.

6. In the land-cover comparison made for the meeting, the CORINE data were compared with PELCOM and SEI data at a range of spatial resolutions. Using the highest resolution available, i.e. 250 m x 250 m of CORINE data, large differences were found between maps in the frequency and location distribution of the cover types.

7. Similar comparisons were made for the 50 km x 50 km grid, the same as used in the EMEP Eulerian model. These achieved generally similar results, indicating that at a regional scale the maps were consistent in their identification of both the frequency and location of the distribution of cover types at this coarser spatial resolution. The results were seen to infer consistency between the land-cover data sets; however, significant differences between the maps in some geographical areas were noted. Expecting the needs for higher resolution deposition activities in the future, it was considered advisable to revisit and explore in more detail these inconsistencies.

8. The CORINE data had the advantage of representing "official" data as they were delivered by countries to the EU and thus should have priority. PELCOM provided a geographically larger, and very consistent, database, but had the disadvantage that no updates were planned. SEI provided the largest geographical coverage and had the greatest detail in terms of number of categories.

9. The EMEP modelling domain extended beyond Europe and it was not fully covered by any of the three land-cover data sets. CORINE had the most limited spatial coverage of the three datasets. Currently, the EMEP model employed 17 basic land-use classes for deposition work, and made a number of assumptions about forest speciation in order to derive biogenic volatile organic compound (VOC) emissions. Ancillary information had been necessary to satisfy the EMEP modelling needs.

10. Current EMEP Eulerian modelling needed to include soil maps, which were not addressed by the land-use data involved in this intercomparison. These data were important for soil moisture calculations in deposition and flux modelling, and for estimating wind-blown dust in particulate matter modelling. Additional future needs could include, inter alia, land use for a much greater area to take into account recent new Parties to the Convention, to cope with hemispheric

modelling activities, detailed forest-species data, and data on plant leaf area, height, biomass and phenology.

B. Recommendations

11. The Meeting agreed that:

(a) A new data set, merging CORINE and SEI data, should be produced. For those countries where CORINE data existed, CORINE data should form the basis of the merged map. For other countries, SEI data should be used ("horizontal" merging). In addition, SEI (and other suitable data sets where they existed) should be used to provide more detail (e.g. for types of forest and agricultural crops) within the CORINE area ("vertical" merging). This latter information was required, inter alia, for the assessment of biogenic emissions and for ecosystem-specific deposition and ozone flux modelling;

(b) The vertical improvements in the short term should satisfy the needs of near future modelling and mapping work. In the longer term, data set improvements should take into account anticipated refinements of, for example, EMEP modelling;

(c) While a tentative merging of the CORINE and SEI land-cover data sets had already been performed by EMEP/MSC-W, using CORINE data in areas where they were available. CCE, in consultation with SEI, should make available an improved, horizontally merged harmonized data set as the basis for the Convention's activities and further refinement;

(d) Parties to the Convention should be involved in the evaluation of harmonized data. The consultation should include, inter alia, the national focal centres (NFCs) of ICPs;

(e) MSC-W should conduct robustness tests on the use of different land-cover information on atmospheric model outputs and deposition and effects estimates;

(f) Mechanisms should be explored to enhance the use of harmonized land-cover information in all activities under the Convention;

(g) Further updating of the harmonized land-cover data set should be planned; in the first instance, there should be collaboration between ICP Modelling and Mapping, CCE, SEI and MSC-W, provided that sufficient funding was available;

(h) Additional information from other sources should be continuously incorporated into this harmonized land-use data set.

II. REPORT ON THE EXPERT WORKSHOP ON CRITICAL LOADS OF HEAVY METALS

Introduction

12. The workshop on critical loads of heavy metals took place in 4-5 March 2004 in Potsdam, Germany. It was organized and hosted by the German Federal Environment Agency and sponsored by the German Ministry of the Environment, Nature Conservation and Nuclear Safety.

13. The workshop was attended by 42 experts from 16 countries (Austria, Belarus, Belgium, Czech Republic, Finland, France, Germany, Italy, Latvia, Netherlands, Norway, Russian Federation, Spain, Sweden, Switzerland and United Kingdom). The Chairman of the Working Group on Effects, the Chairman of the Expert Group on Heavy Metals under the Working Group on Strategies and Review, and the Chairman of ICP Modelling and Mapping were present, as were the UNECE secretariat and representatives or contact persons from ICP Waters, ICP Forests, ICP Integrated Monitoring and ICP Vegetation. Minutes were made available on the web site www.icpmapping.org.

A. Background and objectives

14. The 1998 Protocol on Heavy Metals entered into force on 29 December 2003. To provide scientific input on potential long-term effects of lead (Pb), cadmium (Cd) and mercury (Hg) on human health and the environment, including their geographical extent, for a review of the Protocol starting at the twenty-second session of the Executive Body, results would be required in spring 2005 (EB.AIR/WG.1/2003/2). The expert panel on critical loads of heavy metals, working under ICP Modelling and Mapping, drafted a new chapter on critical loads of heavy metals to the Mapping Manual of ICP Modelling and Mapping (hereafter called "draft manual 5.5"). The draft manual 5.5 was to be finalized before the twentieth meeting of the Task Force of ICP Modelling and Mapping in May 2004.

15. The objectives of the workshop were to:

(a) Gain agreement on the proposed revision of the critical limits methodology (including transfer functions) as one essential scientific basis for the critical loads approach for heavy metals, described in the new draft manual 5.5;

(b) Discuss the results of test applications of the revised methodology in different countries, draw conclusions and recommendations from these results for the further approach;

(c) Gather information on data availability and the readiness of countries to participate in a second mapping exercise on critical loads of heavy metals;

(d) Identify necessary amendments to the draft manual 5.5;

(e) Prepare a message for the Expert Group on Heavy Metals on the appropriateness of available methods for policy use.

B. Structure of the meeting

16. A series of key presentations on the scientific background of the revised methodology were made in plenary. They focused, in particular, on the philosophy and the principles of critical loads calculations of heavy metals, similarities and differences with risk assessment approaches of the

EU, the receptors and effects addressed by critical loads, methods for the derivation of critical limits, transfer functions and chemical speciation of metals in soil solutions and waters as well as specific aspects of mapping critical loads and levels of mercury. Experiences gained by NFCs in application of the revised methodologies and the partitioning of heavy metals were presented.

17. The presentations were first discussed in plenary. The workshop participants then divided into three working groups:

(a) First working group: scientific background;

(b) Second working group: application of the revised critical loads method for heavy metals;

(c) Third working group: general aspects and link to policies.

Following the group discussions, conclusions and recommendations were discussed and agreed in plenary.

C. Results, conclusions and recommendations

18. During the discussions participants appreciated that the scientific soundness of the derivation of critical limits and transfer functions, the chemical speciation models and the general critical loads methodology had been further improved since the last mapping exercise for Cd and Pb in 2002. It was stressed that uncertainties in input data or parts of the models did not question the scientific soundness and applicability of the critical loads approach for heavy metals as a whole. The workshop also took note of the need for close cooperation with other ICPs and experts within and outside the Convention.

1. Scientific background

19. With respect to the use of transfer functions, the workshop's participants agreed that:

(a) The Cd and Pb transfer functions from total to reactive to free metal activity were considered sufficiently robust for use, although some further work was required. The applicability of the transfer functions to calcareous soils was confirmed, although in the high pH range higher uncertainties might occur due to dissolved metal concentrations near the detection limit. Two types of transfer functions were considered essential to applying the approach:

(i) Transfer functions to calculate free ion activity from reactive soil metal, to calculate critical limits for ecotoxicological effects;

(ii) Transfer functions to calculate reactive soil metal from total soil metal, for NFCs not having measured the reactive soil metal available;

(b) In relation to the use of the Pb and Cd transfer functions from reactive to total dissolved metal concentrations, it was recommended to use the "reactive metal – free ion –

WHAM-MTC model" approach. The calculation of pore water dissolved metal from soil reactive metal was required to estimate the plant metal uptake for food crops. This method would provide consistency with the approach taken for ecotoxicological effects;

(c) The most promising method for estimating field dissolved organic carbon (DOC) was the published information relating soil carbon-nitrogen ratio (C:N ratio) to DOC flux. The pore water DOC concentration was needed as input to the WHAM-MTC model. Existing data, including the ICP Forests database, should be examined to further investigate the validity of this approach. The flux-weighted annual average DOC concentration should be used where a DOC concentration was required for the calculations;

(d) Consideration of streams alone for critical loads purposes would also provide sufficient protection for lakes, since settling losses would reduce dissolved metal concentrations in lakes relative to streams, and metal losses by sediment settling did not need to be considered in the Mapping Manual. Furthermore, transfer functions for soils could be used in oxic streams to calculate the metal concentrations on suspended particles. The preceding discussion on the scientific validity of methods for describing metal removal from the water column in lakes was discussed, including the application of the reactive metal – free ion transfer functions to aquatic sediments. Metal loss by precipitation of sulphides was deemed not to contribute to settling losses in oxic lakes;

(e) Input from NFCs on the scientific validity of the transfer functions for mercury was requested. It was considered that the transfer functions were acceptable but the transfer function for calculation of fish mercury from dissolved mercury in the draft manual 5.5 were to be updated.

20. Regarding ecotoxicological critical limits for Cd and Pb the workshop agreed that:

(a) The free ion critical limit approach for soil Cd and Pb was a robust methodology. Concern was, however, expressed regarding the influence of low toxic end points on the limits, particularly for Pb, in the light of the high degree of critical load exceedances found for Pb by some NFCs. Critical limits would be split into agricultural and non-agricultural soils, excluding in both cases plants or crops that do not occur in these systems. The toxicological databases would be compared with those collated under the EU risk assessment procedures and to remove tests specifically rejected by the EU;

(b) For dissolved Cd and Pb in surface waters, the use of the free ion critical limits for soils was not robust enough due to the lack of toxicity data particularly for low pH waters. The limits for Cd (function of water hardiness) and Pb from the EU risk assessment procedures would be used. If corresponding limits for Pb were not available, since the assessment process was ongoing, the existing limit given in table 9 of the draft manual 5.5 was to be used. The method for the use of the free ion critical limits for freshwaters would be provided additionally for exploratory use by NFCs, if desired.

21. It was also agreed that the inclusion of standstill loads should be discontinued and the related text deleted in draft manual 5.5. Critical limit exceedance was agreed to be a superior alternative for examining current pollution problems. However, the determination of critical limit exceedance was not part of critical loads calculations and should therefore not be included in the main body of the manual 5.5 but in a separate annex.

2. Application of the revised critical loads method for heavy metals

22. With regard to uncertainties in input data of the WHAM-MTC model the workshop came to the following results:

(a) Consistent recommendations for default values of DOC needed to be provided in the draft manual 5.5. Tables 5 and 6 in appendix 3 to the draft manual 5.5 should be simplified and should include non-forest soils. An improved approach to existing tables would be derived from strong relations between DOC flux and C:N ratio (see also the conclusions of the first working group);

(b) For inter-conversion of pH measurement values, the recommendations in the Mapping Manual should be used. Errors may occur due to using representative values for soil types/series. The effect of 0.5 pH unit uncertainty, greater at low pH, could be assessed;

(c) The default value for pCO_2 should be changed to 15 times atmospheric, for consistency with Mapping Manual chapter 5.3 on acidification. This requires an adaptation of the graph in the figure on p. 42 in the draft manual 5.5, annex 1, in which the relationship of pH and pCO_2 in the presence of $CaCO_3$ was shown;

(d) It was not possible to include uncertainties due to seasonal variation. This, as well as the other limitations of the current methodology should be clearly stated in the Mapping Manual;

(e) The look-up tables (annex I to the Mapping Manual) should stay as they were and not be simplified. For countries with large amounts of data, look-up tables were not very efficient; those countries were recommended to use the WHAM W6-MTC model to get the data or to ask for support to calculate the values.

23. In discussing the list of limitations for sites that allowed critical load calculations (page 4 of the draft manual 5.5), and the workshop concluded that:

(a) The weathering of heavy metals was no longer included in the critical loads equation, and therefore was not a reason for excluding sites. An evaluation of weathering input should be done when the concentration of the metal related to critical limit for the site was evaluated. High geogenic inputs should be considered when interpreting critical loads exceedances;

(b) The possibilities for sites having negative water balance were discussed. Even if the average water balance over one year was negative, limited leaching might occur seasonally. The water balance in the top soils should be considered in more detail in these dry areas. Calculations could be made for seasons with positive water balance, but then standardization was needed across Europe. Alternatively, run-off data could be used in some areas, although this would include groundwater flows. It was recommended to discuss the issue with hydrologists and scientists from dry (Mediterranean) areas in order to find a suitable solution;

(c) Sites with reducing conditions in surface horizons should be excluded. Such conditions hardly occurred in the top soil, unless it was under water. If it was the case permanently, there would be no leaching. A clarification was needed in the new draft manual 5.5.

24. The workshop considered it important to compare actual total or reactive concentrations with soil metal concentrations equivalent to free-ion critical limits in maps. Development of dynamic models for heavy metals had been initiated in several countries to estimate accumulation times before reaching a steady state and to predict future changes of heavy metal concentrations in soils and waters. These activities were to be further developed.

3. General aspects and links to policies

25. With regard to policy links, the workshop concluded that:

(a) Effects-based methodologies were available for Pb, Cd and Hg, but their applicability for policy purposes was yet to be agreed. The science behind the critical load approach of heavy metals was well developed and sound, however up to the workshop's two more scientifically oriented working groups to judge this indepth;

(b) Countries should be encouraged to take part in the work on critical loads of heavy metals. In the forthcoming mapping of critical loads of heavy metals 18-20 countries were expected to participate. This would provide a sufficient database for integrated assessment modelling;

(c) The draft manual 5.5 should be simplified for use, e.g. by describing some scientific issues outside the Mapping Manual. The updated draft manual 5.5 was to be distributed to NFCs before the twentieth meeting of the ICP Modelling and Mapping;

(d) Hg should not be treated separately from Cd and Pb, although some specific aspects should be considered in calculations for aquatic ecosystems. The approach for terrestrial ecosystems was not very different from the one for Pb and Cd. For reasons of effectiveness of work it was recommended to keep the approaches and data needs as close as possible to the critical loads methodology;

(e) There was no need to take explicitly the minimum of critical loads for soils and surface waters for mapping. Distribution functions of critical loads values should be derived for

each EMEP grid cell from the available results in the countries. Critical loads maps related to human health effects and ecosystem effects should be produced separately;

(f) There were several points for cooperation with the soil thematic strategy group of the European Commission, in particular its contamination working group. The ICPs were invited to suggest monitoring parameters for the soil monitoring directive under preparation. Information on metal inputs from fertilizing agricultural land could be obtained from the EU concerted action AROMIS;

(g) The databases related to climate change should be visited to improve available information on the transport of organic substances. Various programmes, including ICP Forests, ICP Integrated Monitoring, Intergovernmental Panel on Climate Change (IPCC) and Carbo-Europe project, could be contacted.

D. Overall conclusions from the workshop

26. There was a strong proposal by the workshop for using of effects-based approaches for Pb, Cd and Hg as scientific input to the review of the Protocol on Heavy Metals.

27. The science behind the critical loads approach of Pb, Cd and Hg including critical limits, transfer functions, chemical speciation and the critical load approach itself was considered sound. While the free ion critical limit approach for soil Cd and Pb was accepted as robust enough, this was not yet true for surface waters due to a lack of toxicity data. For these ecosystems the use of limits (Pb, Cd) from the EU risk assessment procedures was recommended. The transfer functions for all three metals were considered robust enough for use, although some further work was required. Uncertainties in input data could be reduced within the next year, but they needed further investigation. The limitations of the methodologies should be clearly stated in the draft manual 5.5.

28. An agreeable updated, shortened and more balanced version of the draft manual 5.5 would be available by the twentieth meeting of the Task Force of ICP Modelling and Mapping. The standstill loads should be excluded as well as all background information and methodologies which were not essential for calculating the critical loads.