UNITED NATIONS

E

Economic and Social Council

Distr.
GENERAL

ECE/EB.AIR/WG.1/2006/11
27 March 2006

Original: ENGLISH

ECONOMIC COMMISSION FOR EUROPE

EXECUTIVE BODY FOR THE CONVENTION ON LONG-RANGE TRANSBOUNDARY AIR POLLUTION

Working Group on Effects

Twenty-fifth session
Geneva, 30 August – 1 September 2006
Item 5 (ix) of the provisional agenda

REPORT ON THE WORKSHOP ON CRITICAL LEVELS OF OZONE: FURTHER APPLYING AND DEVELOPING THE FLUX-BASED CONCEPT

Prepared by the organizers with the assistance of the secretariat

INTRODUCTION

1. The Workshop on Critical Levels of Ozone: Further Applying and Developing the Flux-based Concept took place on 15–19 November 2005 in Obergurgl, Austria. It was organized by Austria's Federal Research and Training Centre for Forests, Natural Hazards and Landscape (BFW).

2. The Workshop was attended by 97 experts from the following Parties to the Convention: Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Italy, the Netherlands, Poland, Slovenia, Spain, Sweden, Switzerland, the United Kingdom and the United States of America. An expert from Australia also attended. The International Cooperative Programme (ICP) on Forests, ICP Vegetation, the EMEP Meteorological Synthesizing Centre – West (MSC-W) and the UNECE secretariat were represented.

I. AIMS OF THE WORKSHOP

3. The overall purpose of the Workshop was to confirm the flux-based approach, and the primary objectives were to:

(a) Further develop methods for applying flux-effect relationships for impact assessments at different geographical levels, including consideration of uncertainties;
(b) Review the provisional flux-based critical level for forest trees, and to consider progress in establishing flux-based critical levels for crops not currently included in the mapping manual;
(c) Assess progress in the development of canopy and stand level ozone flux-effect models and methods for crops and forest trees;
(d) Assess progress in the development of flux-effect models for (semi-)natural vegetation; and
(e) Identify areas of further work for crops, (semi-)natural vegetation and forest trees.

4. The Workshop was opened by Mr. Gerhard Wieser (Austria). He briefly presented the background and main aims of the Workshop.

II. CONCLUSIONS AND RECOMMENDATIONS

A. General

5. The Workshop noted the new evidence for confirmation of the flux-based approach, which had not been available at the previous Workshop in 2002. The confirming data comprised mainly processes at the leaf level, such as stomatal conductance. Progress in the development of flux methodology was presented. It was not yet possible to confirm the flux-effect relationships developed from ozone-exposure experiments with field data, although harmful effects of ozone, such as ozone injury to leaves, have been detected in the field in ambient ozone concentrations.

6. The Workshop agreed that its recommendations would mainly be applicable to the EMEP modelling domain, which covers most of Europe. However, close cooperation should be maintained with ozone researchers in North America.

7. The Workshop proposed the flux-based approach as a common method to assess the risk of effects of ozone on ecosystems in integrated assessment modelling. The quantitative indicator for flux is $AF_{st}Y$, the accumulated stomatal flux of ozone above a flux threshold of Y nmol m^{-2} s^{-1} per unit projected leaf area. However, the flux-based approach could not currently be quantified for effects on semi-natural vegetation; critical levels remained based on the concentration-based approach (AOTX, accumulated ozone concentration over the threshold of X parts per billion (ppb) over a stated time period) for this receptor.

8. There was no new information on crops and forest trees that might necessitate revision of the critical levels currently found in the *Manual on methodologies and criteria for modelling and mapping critical loads and levels and air pollution effects, risks and trends*. New experimental evidence of effects was presented for (semi-)natural vegetation, and the Workshop agreed on a new critical level for communities dominated by perennial species.

9. The Workshop noted the need of the research community to identify main areas of uncertainties in the ozone impact pathway. The defined uncertainties and possible biases should be quantified and clearly communicated to policy-makers. The confirmation activities on measuring effects could be classified according to three main levels: canopy (or ecosystem), leaf and cellular responses. The Workshop recommended encouraged that the ICPs discuss and list relevant impact endpoints that would be meaningful for policy-making. It noted the need to engage national contact points to encourage assessment of ozone risks using the suggested methods, in order to gain experience in local applications.

B. Crops

10. One "model" crop species was suggested for applying the flux-based approach in integrated assessment modelling. It should have a simplified phenology, which was considered a major difficulty in continent-wide mapping, and was assumed to be well-irrigated. Practical ways were identified to define the growing seasons or periods across Europe, using means such as climatological maps, temperature sums and latitude functions. The "model" species could indicate the relative distribution of ozone damage risk across Europe in support of policy-making, using integrated assessment modelling. It should not be used to estimate yield losses.

11. Detailed local-scale applications for specific species and locations were recommended for parallel studies of Europe-wide flux-based approach. The Workshop agreed that concentration-based approach, possibly modified by factors important for the exposure dose, could still be useful on a local scale, but few new data were available. Local climatic data could be used for cultivars within specific climatic regions. The Workshop recognized the problem that ozone concentrations were still not used at canopy height.

12. The need to distinguish random uncertainties from systematic ones was noted. In the concentration-based approach, the latter included the lack of environmental limitations. Systematic uncertainties in the flux approach have yet to be sufficiently well identified.

13. The Workshop agreed that the limitations and uncertainties of existing flux- and concentration-based response relationships for crops should be clarified in the *Mapping manual.* In local applications, existing locally derived relationships should be used; otherwise the limitations of applying the relationships of the *Mapping manual* should be

clearly explained. New data that might be included in future response functions existed, for example, for maize, sugar beets, grapevines, tomatoes and alfalfa.

14. The main limitation for assessing uncertainty was the lack of observations. The potential future use of molecular markers in the validation process was noted.

C. Forest trees

15. The Workshop noted that formulation and parameterization for forest trees had been improved in the EMEP stomatal ozone flux model, partly due to new data sets being available. Models that have been developed and validated for other applications, such as forest growth, climate change and the water cycle, could provide information to improve the EMEP flux model further. A full validation and sensitivity analysis should be conducted within the EMEP flux model development and implementation. The Workshop concluded that the use of the stomatal uptake model was reasonable for risk assessment within the EMEP domain. Other options were required for local assessments.

16. The Workshop considered impact endpoint and the quantitative indicator of negative impacts as important issues. In particular, the appropriateness of the use of growth as a surrogate to represent impacts on natural woodland ecosystems was questioned. Ozone impacts on mature forest trees over a wide geographical area should be verified to support the use of critical levels.

17. The Workshop agreed a quadrant framework, which comprised risk assessment and impacts evaluation on the local and EMEP domain scales. Different approaches were suggested for the four combinations of available methods and geographical scales.

18. The Workshop noted that guidance for assessments at the local scale, defined as national or sub-national, was advisory only. Detailed local-scale risk assessment applications were recommended using the concentration-based (AOTX) approach, the maximum permissible ozone concentration (MPOC) approach or the flux-based approach ($AF_{st}Y$). The application of these approaches should be optimized to local conditions and species. The Workshop made no specific recommendations or advice on local-scale impact evaluation.

19. The Workshop noted the procedure for optimizing emission reductions to protect forests in Europe was to be based only on $AF_{st}1.6$ in integrated assessment models. Maps should be produced on the basis of both $AF_{st}1.6$ and AOT40, but maps based on the latter should be used for selected key scenarios only. The Workshop agreed that the threshold value Y = 1.6 nmol m^{-2} s^{-1} per unit projected leaf area, above which the stomatal flux should be accumulated, was to be retained as no scientific evidence was presented to justify a change.

20. The Workshop recommended estimates of $AF_{st}1.6$ should be made for a "model" tree species representing all forests in the EMEP domain for use in integrated assessment

modelling. The parameterization of the "model" tree stomatal uptake module should be reviewed by appropriate experts, with a focus on additional input data to reflect regional variation.

21. The Workshop agreed the critical level based on $AF_{st}1.6$ should not be used in integrated assessment modelling. The Workshop agreed that ozone uptake to leaves and needles was potentially harmful but that, at present, the uncertainties associated with quantifying the impacts of ozone on forests on the European scale were high.

22. The Workshop agreed the flux-based approach in its present form should only be used for relative risk assessments in support of policy-making. It should not be used to derive quantitative estimates of the negative effects of ozone on forests on this scale; therefore, no specific recommendations or advice can be made on impact evaluation.

23. The Workshop agreed the implementation of the flux-based approach for Europe-wide integrated assessment modelling was to provide a biologically meaningful approach which could enhance the geographical representativity of ozone risks for forests and underlying damage mechanisms. However, high uncertainties were still associated with the formulation, parameterization and validation of the approach and the link between stomatal flux and responses.

24. The Workshop advised that additional text was required in the *Mapping manual* to reflect changes in guidance for integrated assessment modelling and concerns over the use of the flux-based approach. Additional information was required on the estimation of the ozone flux accumulation period in different parts of Europe.

25. The Workshop noted the need appropriate experts on forest trees to prepare concrete proposals on practical modelling details and proposals for changes in the *Mapping manual*. Mr. Per-Erik Karlsson (Sweden) offered to organize experts for this work. The Workshop requested him to report to all appropriate ICP Task Force meetings in spring 2006.

D. (Semi-)natural vegetation

26. The Workshop decided that the concentration-based (AOT40) critical level of 3 ppm.h (parts per million x hours) over three months for communities dominated by annual species was still valid and recommended its continued use.

27. Results from recent studies suggested a new critical level for communities dominated by perennial species. Because of the longer growth period of these communities, the AOT40 should be calculated over a six-month growth period. The Workshop recommended new critical level of an AOT40 of 5 ppm.h over six months to prevent adverse effects. Assessment of the exceedance of this critical level should be based on mean values of AOT40 for five consecutive years.

28. The Workshop agreed AOT40 values for three months (for annuals-dominated communities) and six months (for perennials-dominated communities) should be calculated over the period of active growth, which depends on climatic zones. Revised start and end dates for these periods were suggested to replace the current values in the *Mapping manual*. If a single map was necessary for integrated assessment modelling, the six-month value of 5 ppm.h should be used.

29. The Workshop agreed that receptors were grouped according to the European nature information system (EUNIS) classification of ecosystems. Species-level data suggested the highest risk of adverse effects for dry grassland (E1), mesic grassland (E2), wet grassland (E3), alpine grassland (E4), woodland fringes (E5), dehesa (E7.3) and heathland (F4). For E1 and E2 this classification of sensitivity was supported by experimental evidence of changes in plant community studies.

30. Experimental data were not available to support the development of critical levels based on the flux-based approach for semi-natural vegetation. The Workshop agreed models available to map ozone flux to semi-natural communities were not sufficiently developed and well parameterized for risk assessment at this stage. However, progress had been made in developing a flux model parameterized for productive grasslands dominated by perennial ryegrass (*Lolium perenne*), under different management and nutrient regimes.

III. MAIN FUTURE RESEARCH PRIORITIES

31. The Workshop identified the following priorities for future research:

(a) Establishment of a Europe-wide research network with field sites on plant exposure and ozone deposition studies (which would significantly help flux model validation and development and further research);

(b) Development of epidemiological methods based on crop statistics to study ozone effects;

(c) Detailed specification of the “model” crops for integrated assessment modelling;

(d) Field experiments on trees, including open-release systems, which cover the range of climatic conditions represented across Europe;

(e) Identification of ozone impacts on forest trees using existing databases, including assessment of dose-response indicators other than tree growth;

(f) Gather new data to validate the stomatal flux model for forests of all ages and types in all geographical regions;

(g) Field-release experiments in a range of intact semi-natural vegetation communities to confirm that critical levels are appropriate for field application, including the derivation of dose-response relationships;

(h) New experimental studies to assess interactions between nitrogen deposition and ozone, especially in nutrient-limited communities, and also considering below-ground effects and impacts by nutrient status;

(i) Experimental confirmation of adverse effects in regions where critical levels are exceeded, including bio-indicators, historical impact analysis and evolution of ozone-tolerant genotypes.