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Editorial

Introduction for ozone deposition special issue

This special volume of Atmospheric Environment contains papers based on presentations made at two workshops, held in June and November 2002, to assess new methods for modeling ozone deposition and for assessing the risk of ozone impacts on vegetation. Both workshops were organized under the auspices of the United Nations Economic Commission for Europe (UNECE) Convention on Long-Range Trans-boundary Air Pollution (CLRTAP). The aim of the workshops was to discuss the development and application of new methods of ozone risk assessment for Europe; specifically, the workshops considered whether the AOT40 approach should be replaced by methods based on the flux of ozone through the stomata. The AOT40 approach, first proposed in 1992, was the basis on which the ozone part of the Gothenburg Multi-Pollutant Multi-Effect Protocol was negotiated in 2000, and has also been incorporated into the air-quality directives of the European Union and used in setting air-quality guidelines for Europe for ecological impacts by the World Health Organisation.

The first workshop, held in Harrogate, UK, in June 2002, aimed to assess the current status of models to predict ozone deposition and stomatal flux. This workshop drew three main conclusions: (i) that the AOT40 index provides an incorrect assessment of the regional distribution of the risk of damage to vegetation across Europe; (ii) that flux-based risk assessment methods offer the potential for improved evaluation of risk and should be recommended for future application within the Convention; and (iii) that the deposition and flux algorithm implemented in the new EMEP photochemical model provides an adequate basis for first estimation and application of flux-based critical levels. A summary of the conclusions of this workshop can be found at http://www.york.ac.uk/seiy.

The second workshop, held at Hindas, near Gothenburg, Sweden, in November 2002, discussed revisions of the existing AOT40 based critical levels, including the use of flux-based critical levels. This workshop concluded that substantial progress had been made in developing new critical levels for ozone effects on agriculture, forests and semi-natural vegetation, including those based on ozone flux. Flux-based critical levels were recommended for use with potato, wheat and young beech trees. However, the AOT40 approach was retained for sole application for semi-natural vegetation, is one of three methods recommended for further evaluation for forests, and remains of significance for agricultural crops. The proceedings of this workshop can be found at http://www.ozoneworkshop.ivl.se.

The results of these workshops were linked to two subsequent developments within CLRTAP. Firstly, a new Unified EMEP Model, including a revised ozone deposition module, has been developed (Simpson et al., 2003, at http://www.emep.int/). This model has been judged to be suitable for use in European modeling of the effects of different emission control scenarios on ozone concentrations. Secondly, a revised chapter of the so-called Mapping Manual has been produced—this manual documents the procedures and parameters to be used by member states within the UNECE in calculating and mapping critical loads and critical levels of air pollutants. The revised chapter describes in detail the methods of deriving flux-based critical levels, and flux–response relationships, for wheat, potato and beech, and for modeling flux to these species in different parts of Europe to compare with the concentration-based critical levels. Further information about these methods can be found at http://www.icpmapping.org.

These developments mean that, for the first time, the risk of ozone impacts to vegetation will be assessed using a mechanistic approach which models the flux of the pollutant into the leaf, rather than using relationships between external concentrations, or cumulative exposure, and plant response. However, these models still need critical evaluation and further development, and the approach may need to be substantially modified for ecosystems and climates for which they have yet to be tested. This Special Issue provides an opportunity to present in one volume the important new scientific information on which these developments in ozone risk assessment are based. The papers in this Special Issue all contribute to the process of critical evaluation of either the current status of deposition and flux modeling for ozone, or of understanding of the relationship between ozone flux and impacts on vegetation. By publishing them together in this Special Issue, we hope that readers will be able to more fully understand both the strengths and the limitations of the new approaches to risk assessment which have now been accepted for application, alongside the AOT40 and AOT30 approaches, in Europe.

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The Special Issue is opened by two 'New Directions' pieces that place these two workshops in the wider context of the scientific development of ozone risk assessment methods and the ongoing assessment of policy options for ozone within CLRTAP. The first piece explains the use of scientific data to develop the AOT40 approach to ozone risk assessment and, over the last few years, to develop new approaches with a stronger mechanistic basis, including those based on flux. It also discusses the strengths and weaknesses of these different approaches. The second piece considers these developments from the perspective of their application in European-scale assessment of different emission control scenarios.

The papers in this Special Issue are grouped under three themes. The first group of papers focuses on ozone deposition. These papers include descriptions of new models, comparisons of modeled ozone deposition with field measurements made with micro-meteorological methods, and the incorporation of deposition concepts in new methods of ozone risk assessment. The second group of papers focuses on stomatal responses and ozone impacts in tree species. These papers include evaluations of ozone stomatal flux in mature trees in relation to model predictions, laboratory measurements of stomatal and non-stomatal ozone fluxes, and development of exposure–response and flux–response relationships in chamber studies and in the field. The final group of papers focuses on stomatal responses and ozone impacts in agricultural crops and grasslands, primarily covering exposure–response and flux–response relationships in chamber studies and in the field.

The papers in this Special Issue relate primarily to experimental and field studies in Europe, and to risk assessment methods that have been developed for application within Europe. This reflects the fact that the workshops from which the papers originate were aimed at specific European policy objectives. However, we believe that the data, models and hypotheses in the various papers will be of interest to a much wider international audience. In particular, there is increasing evidence that ozone concentrations in many parts of Asia, Africa and Latin America represent a major threat to the sustainability of crop production and the vitality of forests. There is an urgent need to assess the scale of impact of these increased ozone concentrations. However, the simple application of air-quality guidelines based on mean concentrations or cumulative exposure and derived from experimental data in Europe or North America, may provide very misleading conclusions under the different climatic conditions in other parts of the world. A more mechanistic approach, based on modeled flux to sites of damage within the leaf, should provide a sounder basis for comparison of the risks of ozone damage in different regions of the world. Furthermore, as global background concentrations of ozone are predicted to increase steadily over the next 100 years, we can expect further debates over how best to assess and control its impacts.

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