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NEW DIRECTIONS

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New Directions: Recent research findings may change ozone control policies ☆

The signing of the Gothenburg Protocol in December 1999 under the Convention on Long-Range Transboundary Air Pollution was a large step forward in the use of science-based relations between emissions and effects as a tool for optimising air pollution control strategies in Europe. The Protocol was directed towards several effects (acidification, terrestrial eutrophication and ozone effects to vegetation and human health) and included national emission ceilings for sulphur dioxide, nitrogen oxides, volatile organic compounds and ammonia. For all compounds, except for ammonia, European emissions will be reduced by more than 40% between 1990 and 2010. Recent emission inventories show that emission control is well under way and, except for nitrogen oxides, the objectives for 2010 seem to be achievable. Emissions of nitrogen oxides are decreasing but not as fast as expected.

Since the signing of the protocol in 1999, the policy development has taken new directions. First, it is worth noting that the policy map for Europe is changing due to a more active role of the European Commission. The Commission is presently developing a common air pollution strategy for Europe including both local and transboundary air pollution under the name of Clean Air For Europe (CAFÉ, http://europa.eu.int/comm/environment/air/cafe/index.htm). The Commission is expected to present a thematic strategy in mid-2005 including, in addition to addressing the air pollution problems and effects in the Gothenburg protocol, proposals on measures to combat effects to human health from particles and nitrogen dioxide. In fact, health effects are expected to be the main focus of the coming strategy.

Even if health effects have become a main focus, environmental effects are still included in the strategy development. Acidification and ozone effects to vegetation will still be part of the policy development, and the integrated assessment modelling will take into account these effects in the strategy development.

When the Gothenburg protocol was developed, it was already realised that the concepts for critical loads and levels and the calculation of exceedance maps for acidification, eutrophication and ozone effects contained simplifications that would be hard to defend in a more far-reaching strategy. One of these simplifications, that of using a too simple concept for calculating ozone effects to vegetation, is elaborated in this Special Issue. But even the concept for the quantification of the effects of acid deposition is undergoing a development. There are two major improvements for the assessment of acidification. The first is a better representation of the actual deposition. In the development of the Gothenburg Protocol, grid deposition was calculated as a mean deposition over the grid, which led to a severe underestimation of the deposition to forested areas. For the new strategy, the deposition will be calculated for different ecosystems separately, giving a much better estimate of the real deposition, in particular to forests. A recent inter-comparison between modelled and monitored deposition now shows good agreement (Westling and Knulst, "Comparison of modelled and monitored deposition fluxes to different ecosystems in Europe"; a background paper presented at the EMEP workshop in Oslo, November 2003).

The other improvement concerns the inclusion of dynamic aspects in the critical loads concept. The concept used for the Gothenburg Protocol did not take into account the status of the ecosystems; i.e., whether there were any effects at the ecosystems or not. Since many areas in Europe are severely damaged by acidification, it has, from the policy point of view, been increasingly important to develop the critical loads concept to include the time for recovery of the damaged ecosystems. The ultimate objective should be to achieve a recovery from acidification to a satisfactory base saturation in soils, and a status in lakes whereby fish and other acid-sensitive organisms can survive without liming. The inclusion of these new concepts — an ecosystem specific deposition and recovery — will increase the control requirements even further compared to the concepts and values used in the Gothenburg Protocol.

The new flux-based concept for the calculation of critical levels for ozone and the estimation of ozone

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effects to vegetation, as described in this Special Issue of Atmospheric Environment, will, in the same way as for acidification, change the assessment of damage pattern in Europe and also widen the needs in control requirements. There are two elements in the new concept that are of particular importance to highlight in relation to policy. The first is that the flux-based concept will, in comparison with AOT40 (Fuhrer et al., 2003, Environmental Pollution 97, 91–106), decrease the risk for effects in dry areas and increase it in humid areas. In the European perspective, the relative importance of ozone pollution may increase in Central and Northern Europe in comparison with the Mediterranean areas. The second effect is a decrease in the threshold for ozone effects which means that the areas with exceedance of critical levels will be larger.

The application of the new air pollution concepts is made in a changing air pollution climate. The influence from European emissions is decreasing and sources outside Europe are becoming more important. This is particularly true for ozone. When the regional ozone problem and its effects to vegetation were first brought up on the policy agenda about 20 years ago, Europe was repeatedly facing ozone episodes with concentrations in the order of 200–250 $\mu g\,m^{-3}$ (100–125 ppb). Due to European control of NOx and VOC, peak concentrations are today substantially lower and seldom exceed 200 $\mu g\,m^{-3}$ (100 ppb). Instead, the Northern hemispheric ozone background has increased and background concentrations are today reaching concentrations where we can expect significant negative impact on vegetation over large parts of the Northern Hemisphere.

If the entire Northern Hemisphere is facing an increase in ozone concentrations of a few $\mu g\,m^{-3}$, this may have larger impact on vegetation than a decrease in peak concentrations of 10–30 $\mu g\,m^{-3}$. From this point of view, there is a need to continue scientific research on ozone effects to vegetation. The interest should also be broadened, not only to include the impact of air pollution on vegetation health and production, but also the impact on carbon sequestration, which was recently shown by Loya et al. (2003, Nature 425, 705–707). If the problem of regional air pollution is expanding from continental scales to a hemispheric scale, this may also influence the overall strategy for the control of air pollution. This problem has recently been highlighted by Holloway et al. (2003, Environmental Science and Technology 37, 4535–4542).

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