Ozone risk assessment method

Assessing and modeling the risk of ozone exposure for vegetation

A presentation of standard indexes and recent developments

New directions in ozone control policies

- Towards a flux approach to estimate ozone effect on vegetation?
  - **AOT40** index (cumulative exposure of ambient ozone concentrations above 40 ppbv), was adopted within the United Nations Economic Commission for Europe (UNECE). But the **limitations** of indices based on external concentrations have long been recognized.
  - Growing consensus that the effective ozone dose based on **stomatal ozone flux** (rate of ozone uptake through the microscopic stomatal pores into the leaves) represents the **most appropriate** approach for setting future ozone critical levels for vegetation in Europe

- This new flux-based concept should change the assessment of damage pattern in Europe and also widen the needs in control requirements by
  - **Decreasing** the risk for effects in **dry** areas and **increasing** 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.
  - Decreasing the threshold for ozone effects which means that the **areas** with exceedance of critical levels will be **larger**.

Developing new deposition modules

Recent developments focused on the evaluation of new methods for modeling ozone deposition and for assessing the risk of ozone impacts on vegetation

- A new deposition module has been developed and incorporated into the **EMEP** model that estimates stomatal conductance (http://www.emep.int/)
- Preliminary runs indicate that the **spatial patterns** over Europe for daylight AOT40 and for accumulated stomatal flux of ozone may be very **different**.

What about the definition of new indices for vegetation protect?

- A revised chapter of the so-called **Mapping Manual** has been produced (http://www.icpmapping.org) —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. For the first time, the risk of ozone impacts to vegetation will be assessed using a **mechanistic approach**.
- 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.

The EMEP new deposition module

Based on conventional 1D resistance analogy model, the ozone flux density at height z is proportional to the dry deposition velocity, Vd, taking into account both stomatal and non-stomatal pathways

$$V_d(z) = 1/[R_a(z) + R_b + R_s],$$

- Ra is the aerodynamic resistance to turbulent transfer, Rb represents the integrated 'quasi-laminar' resistance, Rs, surface resistance, combines all the processes resulting in final uptake/destruction of ozone

The calculation of Rs is based mainly on

- the **LAI** (Leaf Area Index) and **SAI** (Total surface area of the vegetation)
- but also includes functions of plant species, phenology, air temperature, photon flux density, water vapour pressure deficit and soil moisture.
- The model has **9 representative land cover classes**, complemented by **3** other vegetated and **4** non-vegetated classes.

Meteorological input data for the EMEP model obtained from a dedicated version of the HIRLAM NWP model (Sandnes Lenschow and Tsyro, 2000)

- Surface fluxes of momentum, sensible/latent heat, wind, specific humidity, T(2m).
- Input parameters are derived from these data employing the Monin–Obukhov similarity theory and correcting for the land-cover specific aerodynamic roughness.
- The soil moisture deficit is calculated using the evapotranspiration methodology.

Comments on models?

The major difficulty with this approach is the extensive datasets required

- **Simplification** of the existing algorithms and associated data needs would be extremely valuable.
- Establishing **field validations** of the ozone flux-response relationships currently derived mainly from experimental conditions should be seen as a priority for future research.

Validation and test studies exist. Only a few campaigns up to now => difficult to have general trends. Example of EMEP validations :

- Improvements have been done (needle age factor for coniferous forests, revised ground-surface conductances and deposition velocities…) which resulted in **better agreement although ther are still discrepancies**.
- In general, the parametrization of **non-stomatal deposition** and the performance of the module under **high soil moisture** deficits were identified as key uncertainties requiring future investigation.

What about field studies?

Some findings from experiments :

- Cumulative Ozone Uptake (**CUO**)-biomass response relationship is **higly significant** for coniferous and broadleaf trees, although it provides **weaker** dose-response relationships compared with AOT40.
- Analyses indicate that **AOT40-10ppm.h may not protect** the most sensitive receptors and that critical levels for AOT40 and CUO>1.6 of 5ppm.h and 4mmol/m² are more appropriate.
- For other species, **AOT40 was not the best exposure index** in explaining the response in the flower biomass evolution. Indexes based on averages for different periods from hours to days fitted better (M10, M24, D33) but also indices with a lower cut-off (NUM30, AOT30).
- Studies also indicate that the ozone uptake based approach showed a **high degree of fitting** along a N-S European transect => better and more relevant approach to the quantification of ozone effects on crops than ozone exposure indices.
- AOT concept is **rather inconsistent** with observed forest conditions. In contrast, CUO has the potential of reflecting a physiologically meaningful internal O3 dose experienced by trees.

Anyway, as a general comment, the database for the derivation of critical cumulative ozone fluxes (critical loads) is still extremely inadequate, in terms of period, species, representativity of the whole canopy, representativity of the area. This is mainly because experiments have been based on chamber experiments and monocultures.