Ozone Deposition Modelling in a Portuguese Coastal Zone

A contribution to subproject GLOREAM

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Summary

The deposition of pollutants from the atmosphere to ecosystems is the cause of some present environmental problems: acidification, eutrophication and, indirectly, ground level ozone. Related with these issues is the critical loads/levels concept, widely accepted in Europe as basis for pollution control strategies. The knowledge of atmospheric deposition on ecosystems is needed to set up this methodology.

Therefore, it was done a parameterisation of the deposition module of the system of models MAR IV. This system is adequate to simulate the transport, dispersion and removal of pollutants, including ozone production for mesoscale application. The ozone surface resistance (*Rc*) parameterisation was applied to Lisbon region and the model's performance was assessed with ozone deposition experimental data observed in the study area during the fieldwork LisbEx 97.

The simulations were performed using measured values for the ozone surface resistance at a station called Baldios and a literature value (measured in chamber experiments). The minimum *Rc* measured value, 382 $h.m_{-1}$, has demonstrated to give better simulations results in terms of ozone depositions fluxes. The influence of parameterisation became evident with the good fit between modelled results and measured data.

Based on an empirical method described by the Stockholm Environmental Institute report a Critical Load map, for non-forested areas, was calculated for Portugal. The methodology is based on the kind of soil and its buffer capacity to acid compounds. The results show that around 70% of the country is in sensitive areas, reinforcing the need for the application of this concept.

Introduction

The critical load/level concept has been worked out since the 1980's and is based on a dose-effect relation. It assumes that different ecosystems have different capacities to receive atmospheric pollutants without dangerous modifications that can introduce changes into the ecological equilibrium or direct damage to the vegetation. The maximum pollutant quantity that each system can handle without consequences is called "critical load" or "critical level" depending if the pollutants are considered to have cumulative effects (like acidity and eutrophication) or direct effects (like the effect of ozone on vegetation) (Bull, 1991).

The Gothenburg Protocol for Acidification, Eutrophication and Ozone reduction includes the critical load concept into a broad integrated evaluation methodology. Figure 1 shows the critical load/level concept application and the role of critical load/level maps on the development and implementation of pollution control strategies.

Concerning the regional effects of atmospheric pollution it is necessary to analyse the results of two evaluation processes:

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- To determine the ecosystems sensitivity to atmospheric pollution through the implementation of critical load maps;
- To evaluate atmospheric pollutants levels in space and time through the analysis of air pollutants concentration and deposition maps.

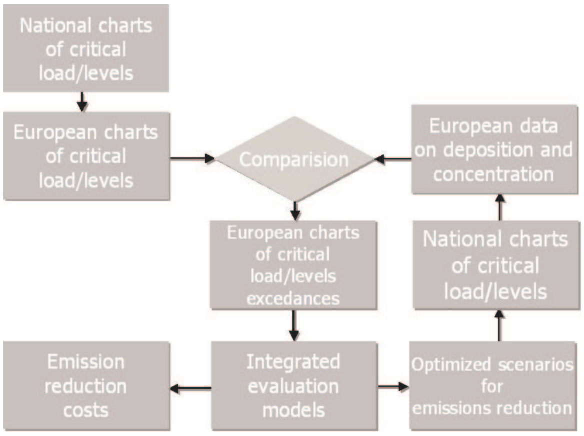


Figure 1. Critical loads and abatement strategies (adapted from UBA, 1996).

The methods applied to the critical loads calculation relays on simple estimations resulting from empirical data, balance and dynamical models (UNECE, 1989).

In the United Kingdom it is in use a simple method to create a critical load map for acidifying pollutants based on the soil type data. This methodology relays on the geological classifications for definition of sensitivity classes of different regions to an atmospheric pollutant. For example, and concerning the soil capacity to absorb sulphur compounds the working group UN/ECE/Nordic Council divides soil types into five classes (UBA, 1996). The soil mineralogy and minerals controlling lixiviation characterise these classes.

The atmospheric pollutants deposition is part of the chain in which emissions are related both with concentration and critical levels with direct effects and wet and dry deposition and critical loads with indirect effects.

Objectives

In this work the main objectives were the construction of a critical load map based on the simple method of soil type classification over Portugal and air pollutants deposition maps over a region of interest.

Activities

The critical load map over Portugal was constructed based on the Stockholm Environment Institute (SEI) methodology (Cinderby *et al*., 1998) which indicates that the best method for calculation critical loads on a coarse grid is the one based on the soil neutralising capacity, although vegetation and climate are considered important parameters influencing the ecosystems response to acid deposition. Nonetheless the available information concerning these parameters is considered to be scanty.

Concerning soil processes that influences soils buffer capacity two are of major importance: minerals meteorization (the most important one) and interchange of cations within the soil, measured has Cations Interchange Capacity (C.I.C).

Based on the SEI's work, five soil sensitivity classes was defined according with to soil type, base saturation and CIC average value and soil classes defined by FAO (1990) (see Table 1).

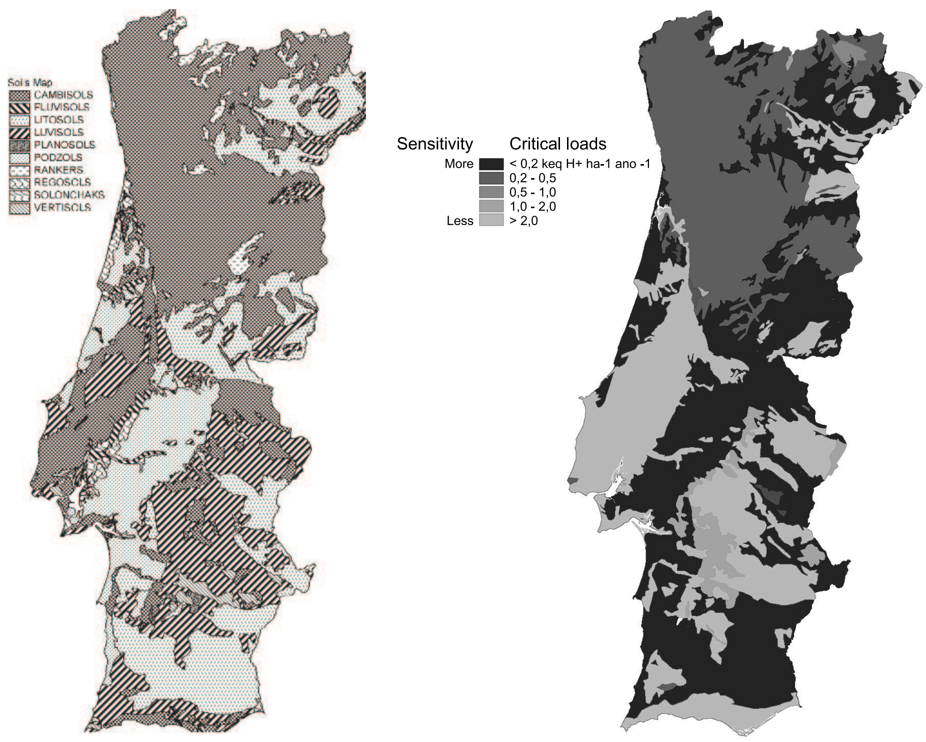
Concerning air pollutants deposition maps, a model system – MAR IV system, was applied to a coastal zone, including the Great Lisbon Area. The modelling area has 200 x 200 km, with a space resolution of 4 x 4 km. This application was already described in the GLOREAM Annual Report 2000 (Borrego *et al*, 2000) as well the sensitivity analysis done to the MAR IV model System, namely on the dry deposition module parameterisations. Briefly, the surface resistance parameter (*Rc*) was under consideration, and four values for it were taken on it parameterisations into the model runs, one from literature and the other three from measured data acquired during the LisBex 97 air quality campaign.

Table 1. Sensitivity classes settle by SEI ($meq.m^{-2}.ano^{-1}$).

1 – more sensitive	2	3	4	5 - less sensitive
Less than 25	Between 25 and 50	Between 50 and 100	Between 100 and 200	More than 200

Results

In the construction of a critical load map for Portugal it was used a Soil Map for Portugal that includes information about soil types found in this country (Figure 2a), soil types were defined according the FAO scheme for the European Soils Map.



a) **b)**

Figure 2. **a)** Portugal soils map, **b)** Portugal critical loads map (adapted from Valinhas, 2000).

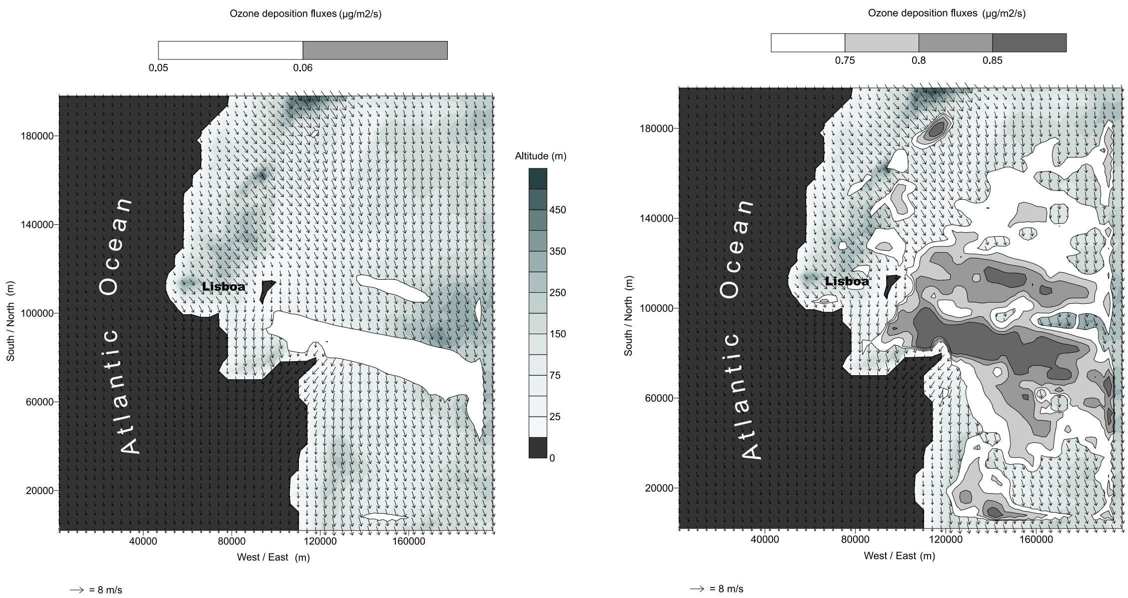
Then, the Portuguese soil types were classified according to soil sensitivity classes defined in the previous table This classification was applied to the Portuguese case resulting in the critical loads map for acidity presented in Figure 2b.

The comparison between figures 3 a) and b) confirms *Rc* influence in the ozone model mass balance. In fact, where there are higher ozone concentrations it can be seen that the related deposition fields, in numerical value and dispersion patterns, are less expressive.

Conclusions

A parameterisation of the deposition module of the system of models MAR IV was done. This system is adequate to simulate the transport, dispersion and removal of pollutants, including ozone production for mesoscale application. The surface resistance parameterisation was applied to Lisbon region and the model's performance was assessed with deposition experimental data observed in the study area. The comparison between ozone concentration fields and deposition fields shows a clear response of the model to the surface resistance parameterisation. In fact, the influence of this variable in ozone model mass balance is consistent with the ozone fields presented for the two numerical applications.

An empirical method was applied to estimate critical loads for acidity for continental Portugal. The results show that around 70% of the country is in sensitive areas reinforcing the need for the application of this concept. The possibility of new parameterisations applications in the deposition module of MAR IV as well as the need of more experimental data on surface resistance leaves an open door to more research work. Also, the integration of deposition in the critical loads concept provides other developments in this subject.



a) b)

Figure 3. Ozone deposition and wind fields at 10 m at 17 h for a) *Rc* literature value and b) *Rc* mean value obtained during LisbEx 97 (adapted from Valinhas, 2000).

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