Long-Term Simulation of Particulate Matter over Europe with the EURAD Modeling System

Contribution to subprojects GLOREAM and AEROSOL

E. Friese, H.J. Jakobs, M. Memmesheimer, H. Feldmann, A. Ebel, M.J. Kerschgens

University of Cologne, EURAD-Project, Aachener Straße 201 - 209, 50931 Cologne, Germany
e-mail: ef@eurad.uni-koeln.de

Summary
Long-term air quality simulations with respect to the whole year 1997 have been performed for the European scale with horizontal resolutions of 125 km and 25 km respectively. The Modal Aerosol Dynamics Model for Europe (MADE) is used to provide size resolved hourly concentrations of secondary (SO_4^{2-}, NO_3^-, NH_4^+, SOA) and primary (EC, OC, non-identified material) aerosol species for each grid box. Mixing ratios of gas-phase species are calculated using the RACM mechanism. The amount of wet or dry deposited aerosol and gas-phase species is also available for each horizontal grid cell. A first evaluation of model results has performed for the region of North-Rine-Westfalia. Approximately 65% of the modelled hourly PM_{10}-concentrations are inside a tolerance of 60%. The highest yearly averages of PM_{10}-concentrations (70-80 $\mu g/m^3$) are located over the congested areas of North-Rine-Westfalia and in the vicinity of Paris. The results have been analysed with respect to the EU directives 96/62 and 99/30. In large areas of central Europe the limiting value of 35 days per year with daily averaged PM_{10}-concentrations higher than 50 $\mu g/m^3$ is clearly exceeded.

Introduction
Long-term runs of comprehensive air quality models can provide data which is useful for several purposes. The derived data can be used for the investigation of physical and chemical processes controlling the concentration of atmospheric pollutants. Long-term simulations are more suited for model evaluation than episodic simulations which extend over a few days or weeks only. Another important application is the development of air pollution abatement strategies. The data provided by a long-term run render possible an air quality assessment of the whole area of investigation, in particular for regions where measurements are incomplete. The EURAD modeling system (Hass et al., 1997; Memmesheimer et al., 1997; Jakobs et al., 2001) has been used for a long-term simulation with respect to the year 1997. Analysis of the results with respect to atmospheric particles is given here, photo-oxidants and quasi-operational forecast capabilities are discussed in separate papers (Feldmann et al., this issue; Jakobs et al., this issue).

Objectives
Evaluation and further development of the gas-phase- and aerosol-chemistry-transport modules of the EURAD modeling system are the primary objectives of the current activities. Support for an air quality assessment of the highly polluted region of North-Rhine-Westfalia is the primary goal of the recently performed long-term simulation. The use of the generated data for scientific research projects is proposed.

Activities
The Modal Aerosol Dynamics Model for Europe (MADE; Ackermann et al, 1998) with extensions for aerosol/cloud interactions (Friese et al., 2000) was in preparation for the long-term run completed by the module SORGAM (Schell et al., 2001) which is designed for the

treatment of secondary organic aerosols. In this configuration MADE provides size resolved concentrations of secondary (SO_4^{2-}, NO_3^-, NH_4^+, biogenic and anthropogenic organic) and primary (EC, OC, unidentified particulate matter) aerosol species. The RACM mechanism (Stockwell et al., 1997) has been implemented into the chemistry transport module and is used for the long-term simulation.
The nesting configuration used for the simulation with respect to the year 1997 covers the European scale with a horizontal resolution of 125 km (N0-domain). Most parts of central Europe are covered by the N1-domain with a grid size of 25 km. In the vertical the atmosphere is divided into 23 layers between the surface and 100 hPa. 15 layers are below 3000 m, the lowest layer has a thickness of about 40 m. Model runs for both the N0-domain and the N1-domain are completed. Hourly concentrations of selected gas-phase species and size resolved hourly concentrations of all aerosol species considered are stored for each horizontal grid box and for each layer for the whole year 1997. The amount of wet or dry deposited gas-phase and aerosol species is also available for each horizontal grid cell.

Results

As a first evaluation the model results have compared to measurements at stations from the Environmental Agency of North-Rine-Westfalia. Figure 1 show the percentage per month of modelled hourly PM_{10}-concentrations which are inside a 60% tolerance for two urban stations (Bielefeld, Bonn) and two clean air stations (Eifel, Rothaargebirge) respectively. In Average 50% to 70% of the modelled hourly PM_{10}-concentrations are inside the 60% tolerance. In case of the station Bonn only the results from the N1-domain (125 km horizontal resolution) are significant better than that for the N0-domain (25 km horizontal resolution).

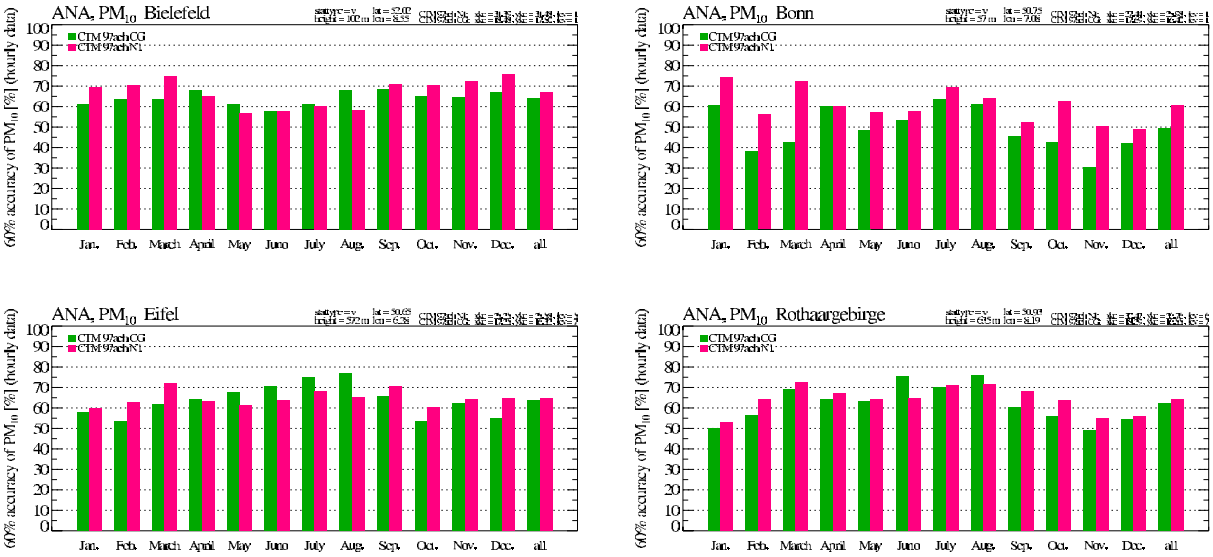

Figure 1: Percentage of modelled hourly PM_{10}-concentrations which are inside a 60% tolerance for four measurement stations from the Environmental Agency of North-Rine-Westfalia. Percentages are depicted for each month and the whole year 1997. Green and red bars are for the N0-domain and N1-domain respectively.

The left part of figure 2 show the yearly average of modelled PM_{10}-concentrations for the near surface layer of the N1-domain. The highest values (70-80 µg/m^3) are located over the congested areas of North-Rine-Westfalia and in the vicinity of Paris. The modelled PM_{10}-concentrations have been analysed with respect to the EU directives 96/62 and 99/30. Based on this analysis the right part of figure 2 show the number of days of the year 1997 on these the PM_{10}-concentration in the near surface layer of the N1-domain is higher than 50 µg/m^3. In large areas of middle Europe the limiting value of 35 days per year is clearly exceeded.

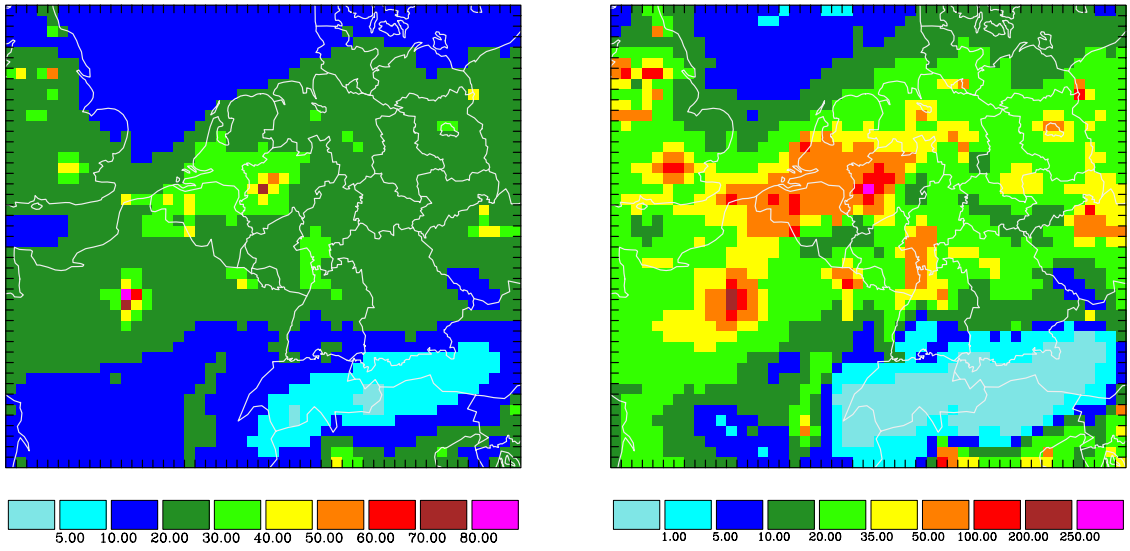

Figure 2: Left: Yearly averaged PM_{10}-concentrations for 1997 in the near surface layer of the N1-domain in $\mu g/m^3$. Right: Number of days of 1997 on these the PM_{10}-concentration in the near surface layer is higher than 50 $\mu g/m^3$.

Conclusions and future plans

The long-term air quality simulations with respect to the year 1997 will be continued with a horizontal resolution of 5 km focussed on the highly polluted region of North-Rine-Westfalia. Because of limiting computational resources simulations with a horizontal resolution of 1 km will be performed for selected areas and episodes only. Modelled TSP-, SO_4^{2-}-, NO_3^-- and NH_4^+-concentrations will be compared to measurements at EMEP stations for an evaluation of the aerosol dynamics model on the European scale.

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