LONG-TERM SIMULATION OF PARTICULATE MATTER OVER EUROPE WITH A COMPREHENSIVE AIR QUALITY MODEL SYSTEM

M. MEMMESHEIMER, E. FRIESE, H. J. JAKOBS, H. FELDMANN, A. EBEL, M.J. KERSCHGENS

Rhenish Institute for Environmental Research (RIU), EURAD-Project, University of Cologne
Aachener Strasse 201 – 209, D-50931 Cologne, Germany

Keywords: Aerosol Modelling, Regional numerical simulation, Air Pollution abatement strategies.

INTRODUCTION

Comprehensive air quality models (AQMs) have been developed during the last decades to simulate the transport, chemical transformation and deposition of air pollutants on the regional scale. The first applications of AQMs had been performed on episodes, e.g. for the investigation of photo-oxidant formation. In recent years the formation of secondary particles and particle dynamics has been included into the models (Binkowski, 1999; Schell et al., 2002). The rapid development of modern information technology now allows the application of comprehensive AQMs on an annual time scale well as short-term prediction (chemical weather forecast). Long-term runs can provide data which are useful for several purposes.Physical and chemical processes controlling the concentrations of air pollutants can be studied. This led to a better understanding of processes in the atmosphere and supports the analysis of measured data. The modelling systems can also be applied as a tool to develop optimised air pollution abatement strategies. The results of the models allow the assessment of air quality in regions where observations are incomplete or missing. In tis paper the results of a long-term run carried out with the European Air Pollution Dispersion Model (EURAD, Jakobs et al., 2002) and first experiences with short-term chemical weather forecasts are discussed with special emphasis on atmospheric particulate matter over Europe. Strongly polluted areas as North-Rhine-Westphalia have been considered in detail using nesting techniques.

MODEL DESCRIPTION

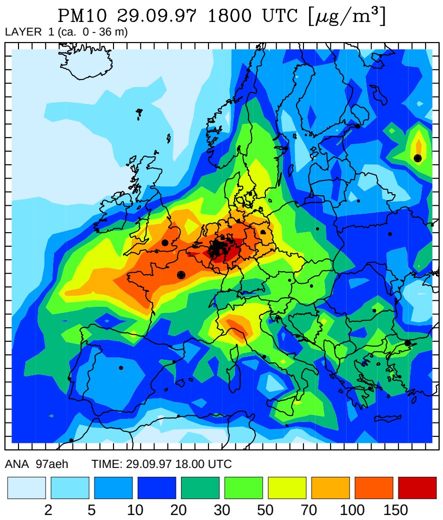
The chemistry-transport model of EURAD (EURAD-CTM) is used to perform the calculation of transport, chemical transformation and deposition of air pollutants. Meteorological fields are provided by the mesoscale meteorological model MM5, transport is modelled within the CTM by solving the 3-D advection and diffusion equation. Gas-Phase chemistry is handled with the RACM chemical mechanism, dry deposition is treated with a resistance model, cloud process are parameterized following Binkowski, 1999, and Friese et al., 2000. The Modal Aerosol Dynamics Model MADE has been applied with extensions to account for the formation of secondary organic aerosols (Schell et al., 2002). 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 calculations have been performed for the year 1997 using a one-way nesting scheme. The European Scale is covered with a horizontal grid resolution of 125 km (N0), an intermediate N1 with 25 km, and a resolution of 5 km has been applied to simulate the region of North-Rhine-Westphalia (N2). For episodes of particular interest a further nest (N3) has been used. In the vertical the atmosphere is divided into 23 layers between the surface and 100 hPa. 15 layers are below 3000m, the lowest layer is about 40 m thick. Model runs for the N0, N1, and N2 area have been completed. All concentrations in the gas-phase and the aerosol phase have been stored on an hourly basis for 1997. Wet or dry deposition of gas-phase and aerosol species is stored. Results have been compared with measurements on the European as well as on the local scale.

The modelling system also provides daily short-term predictions which are made available to the public by internet (www.eurad.uni-koeln.de). Data and graphics from the forecast are stored in a data archive which is also available on the EURAD web site.

RESULTS AND CONCLUSIONS

Model results have been analysed with respect to the requirements of the EU directives on air quality on PM_{10} and other air pollutants, compared with observations, and analysed with respect to the contribution of different sources to the total mass of the particulates. Examples are shown in the figures below.
The long-term calculations have been successfully finished and the short-term prediction is made available to the public via internet. Emission scenarios show the importance of long-range transport even for PM_{10} in NRW. The EURAD modelling system can be used as a tool for the optimisation of air pollution abatement strategies as well as for scientific purposes to investigate the transport of particulate matter and its formation on the regional scale. Future plans aim on further evaluation of the model results, development of 4DVar data assimilation schemes using information from satellites and lidar systems, and the extension of the modelling system to the hemispheric scale to account for intercontinental transport.



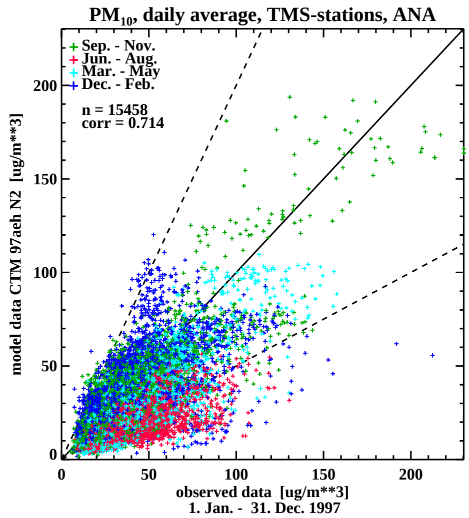


Figure 1: Left: Example for high concentration of particle mass over Europe during Sept. 29, 1997; right: scatter plot of observed and calculated averages of PM10 for measurements sites in North-Rhine-Westphalia.

ACKNOWLEDGEMENTS

This work was supported by the Environmental Agency of North-Rhine-Westphalia (LUA) and the BMBF within the AFO2000 programme. Thanks also to EMEP, TNO, and the Ford Research Center.

REFERENCES

Binkowski, F.S. (1999) Aerosols in MODELS-3 CMAQ, in Science Algorithms of the EPA Models-3 Community Multiscale Air Quality (CMAQ) Modelling System, EPA 600/R-99-030, EPA.

Friese, E., M. Memmesheimer, I.J. Ackermann, H. Hass, A. Ebel and M.J. Kerschgens (2000). A study of aerosol/cloud interactions with a comprehensive air quality model. *J. Aerosol Sci.,* **31**, Suppl 1, 54-55.

Jakobs, H.J., S. Tilmes, A. Heidegger, K. Nester, G. Smiatek (2002). Short-term ozone forecasting with a network model system during summer 1999. *J. Atmos. Chem* **, 42**, 23 – 40.

Schell, B., I.J. Ackermann, H. Hass, F.S. Binkowski, A. Ebel (2002). Modeling the formation of secondary organic aerosol within a comprehensive air quality modeling system. *J. Geophys. Res*., 106, 28275 - 28293. µg/m³.