

Air quality modeling with the EURAD model

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1 Introduction

Air quality modeling with comprehensive mesoscale chemistry-transport models is a demanding task, in particular with respect to the specific requirements of air quality regulations and planning. Specific scientific problems are the appropriate treatment of photo-oxidant formation, aerosols and clouds, and long-term runs for the growing season or even one year. Considerable efforts have been undertaken to use global, regional and urban-scale models to estimate the impact of emission reductions on ozone levels or other atmospheric constituents of environmental relevance (Moussiopoulos et al., 1997; Brücher et al., 2000; Jonson et al., 2000). Evaluation of models is a very important issue in the context of application of models as a reliable tool for the planning of air pollution abatement strategies (Bultjes, 1999). With respect to a better understanding of atmospheric processes it is important to have a good knowledge of the processes controlling the atmospheric concentration fields. This helps to analyse and to understand the reasons for changes in concentrations on the basis of the governing processes as large-scale transport, turbulent mixing, deposition and net chemical production.

Some examples for numerical simulations with the European Air Pollution Dispersion Model EURAD (Hass et al., 1995; Jakobs et al., 1995; Memmesheimer et al., 1997) will be given. The examples presented show model results for environmentally relevant pollutants as ozone, nitrogen oxides and particles (e.g. PM₁₀). Comparison with observed values will be done partly along the guidelines of the European Community for data quality objectives with respect to modelling.

2 The EURAD Modeling System

The EURAD modeling system has been applied to simulate acid deposition, photo-oxidant formation, precursor concentrations and atmospheric particles. The nesting option allows for the coupling of the European Scale to smaller scale regions of specific interest (Jakobs et al., 1995). The Modal Aerosol Dynamics Model for Europe (MADE) has been implemented into the EURAD-System (Ackermann et al., 1998; Friese et al., 2000) to account for the treatment of atmospheric particles. Highly sophisticated data assimilation schemes have been developed to improve the performance of the model and the analysis of observed values (Elbern, this issue; Elbern and Schmidt, 2001). The NCAR/PennState mesoscale model MM5 is usually applied to calculate the meteorological fields. Other meteorological models as for example the Local Model (LM) of the German Weather Service (DWD) can be used to provide the EURAD-CTM with meteorological input data needed (Jakobs et al., 2001). The model has been compared with observations and participated in model comparison and evaluation studies (Ebel et al., 2000a, b; Hass et al., 1997; Tilmes et al., 2001). Emission data as needed by the specific model application have to be supplied by possible users of the model. However, emissions for the European scale can be generated from emission data bases available (e.g. EMEP or TNO data bases) within the EURAD system.

3 Results and Discussion

Several examples of application of the EURAD modeling system will be shown with specific emphasis on photo-oxidant formation in the urban plumes of Berlin and Milano as well as aerosol

modeling in a strongly polluted area (North-Rhine-Westfalia). The spatial resolution of the model can be selected optional. In the results shown here it extends from the surface up to 100 hPa (also 10 hPa is possible), the number of vertical layers used is usually between 15 and 30, depending on the application. The lowest layer is between 20 and 70 m thick depending on the actual model design. The nesting option is used to resolve regions of specific interest horizontally. Figure 1 show an example for the area of Berlin ("BERLIOZ", Berlin Ozone Experiment). This simulation has been carried out with a mother domain and three nest levels. Horizontal resolutions are 54 km for the European scale, 18, 6, and 2 km respectively for the nested domain.

Further applications include the impact of the alps on air pollution, in particular the role of the strongly industrialized Po-Valley (LOOP-, and VOTALP campaigns). In this case the role of the Alps has been investigated.

Applications to a set of emission reduction scenarios have been calculated (Tippke et al., 1999) with emphasis on reduction during summer smog episodes. The overall conclusion was that long-term measures to reduce precursors of ozone are more effective compared to measured limited in time and space. However, measures limited in time and space might help to improve the situation until the long-term measures will be effective.

With respect to the EU directive 96/62 and the daughter directive 99/30 a simulation has been carried out focussed on Nordrhein-Westfalen. The model design used is based on three nest levels with horizontal grid resolution of 125 km (N0; Europe), 25 km (N1, Central Europe), 5 km (N2, Nordrhein-Westfalen) and 1 km (sub-domain(s) within Nordrhein-Westfalen). The EURAD-MADE system has been used for this study, i.e. modelling of atmospheric particles is included. Preliminary results for N1 (25 km grid resolution) are shown in figure 2, in particular a comparison with observations for SO₂, NO_x, PM₁₀ and ozone. The hit rate for the Nest 1 simulation (23 vertical layers) is shown in table 1.

Table 1 Hit rate of simulated daily averaged concentrations compared with observations from the LUQS network operating in Nordrhein-Westfalen. Presented is the hit rate for an allowed model uncertainty of 50% (EU directive). All values are percentages.

<i>Run</i>	<i>NO2</i>	<i>NOx</i>	<i>SO2</i>	<i>PM10</i>	<i>O3</i>
N0-15	80.00	57.78	26.37	100.00	57.58
N0-23	83.33	70.00	26.37	100.00	78.79
N1-15	92.22	75.56	36.36	97.83	81.82
N1-23	91.11	81.11	34.07	97.83	86.36

4 Conclusions

Several applications of the EURAD modeling system to scientific and policy oriented problems have been presented. The modeling system is under a permanent process of evaluation on the basis of operationally monitoring systems as well as measurements of atmospheric processes during field experiments (e.g. BERLIOZ, VOTALP, LOOP). First tests have been undertaken to test the model's performance with respect to the data quality requirements of the EC directive 96/62 and its daughter directive 99/30 for the state Nordrhein-Westfalen. It could be shown that the model results for a test episode in August 1997 are in a quit good agreement with the observations for the region of Nordrhein-Westfalen even with a horizontal grid resolution of 25 km. An exception is SO₂ which might strongly be influenced by local point sources not presented in an appropriate way in the emission inventory or 'old' emission data not appropriate to the year 1997.

BERLIOZ: OZONE, July 20, 1998, 14 UTC

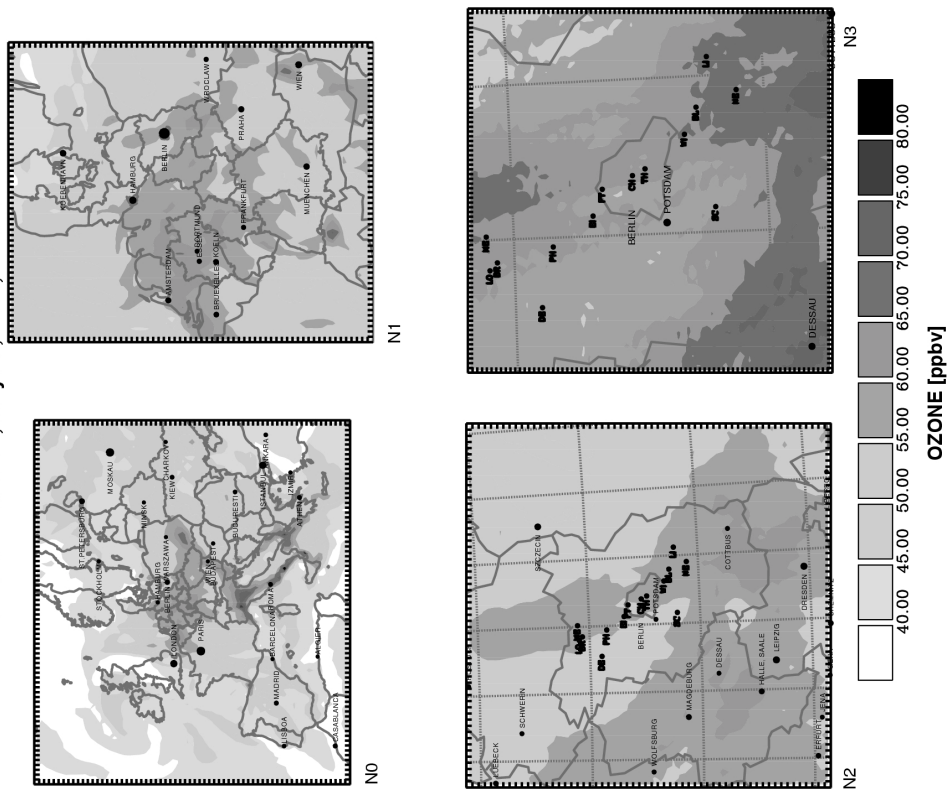


Figure 1: Application of nesting with the EURAD system. The ozone concentration as simulated by the model is displayed for the lowest layer of the model (about 40 m thick). The results for N0 (grid size 54 km), N1 (grid size 25 km), N2 (grid size 10 km) and N3 (grid size 2 km) are shown for the first intensive measurement phase of the Berlioz Ozone Experiment BERLIOZ.

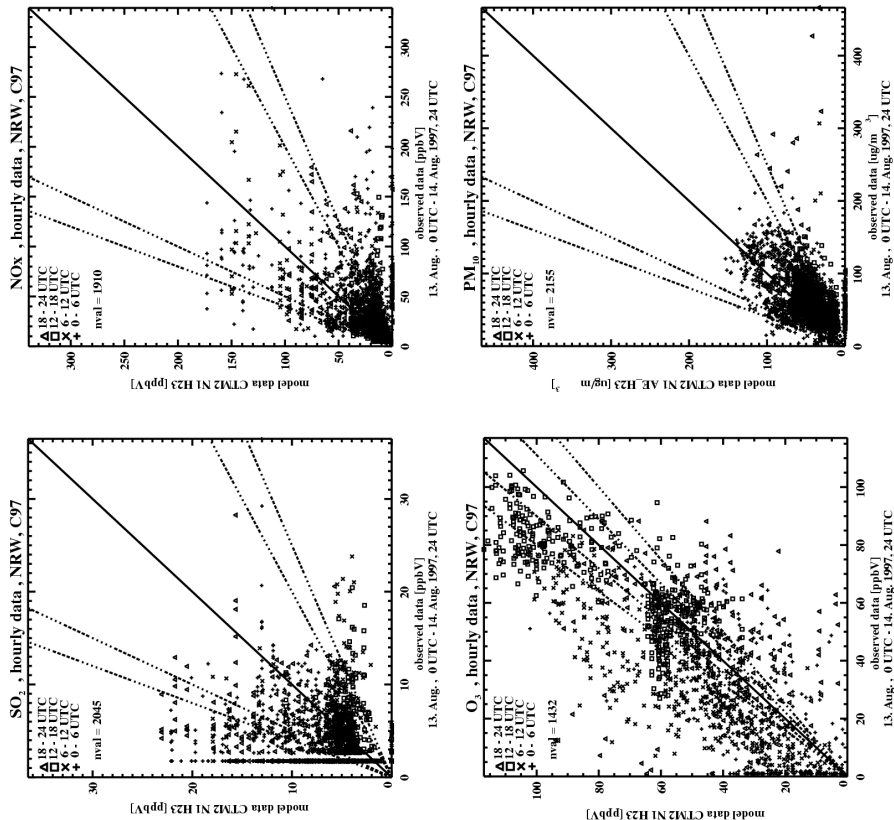


Figure 2: Scatter plots for SO₂, NO_x, ozone and PM₁₀ for the TEMES operational network of Nordrhein-Westfalen (hourly values for a two-day episode in August 1997). The model results have been obtained from a simulation with a grid size of 25 km. The lowest layer is about 40 m thick. Indicated in the plots are the 50% and 60% range of deviations between observations and modeled concentrations for SO₂, NO_x and PM₁₀ and 10% and 20% for ozone, respectively. The 60% uncertainty limit is required in the EC directives 96/62 and 99/30 for modeling.

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