Regional air quality studies with EURAD

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New results

Aim of the research

The general aim of the research is the better understanding of dynamical and chemical processes in the troposphere over Europe using a complex modeling system. Recent developments have been focused on atmospheric particles, air pollution forecasts (Jakobs et al., this issue), the development of advanced data assimilation methods (Elbern, this issue) and upper tropospheric physics using satellite data (Ebel et al., this issue). Further aims in model development includes the application of nesting techniques, deposition, gas phase chemistry and numerical methods.

Principal Results

The first annual simulation of the EURAD modelling system including aerosol dynamics and formation of secondary particles (Ackermann et al., 1998; Schell et al., 2001) has been successfully completed. The year 1997 has been selected for the numerical simulation. The nesting option has been used to focus on the region of Nordrhein-Westfalen (NRW) with a horizontal resolution of 5 km. See figures 1 and 2 as examples for results. Episode calculations have been undertaken for a selected strongly urbanized area (1 km resolution) Air pollution forecasts, adjoint modelling techniques and the research for the tropopause region is presented in detail in the contributions of Jakobs et al., Elbern and Ebel et al. as mentioned above.

Main Conclusion

The EURAD modeling system can be used to investigate the air quality in Europe and for strongly urbanized sub-region as required by the EU-directives. The preparation of emission scenarios in relation to the CAFE programme is underway in close contact with the City-Delta initiative. One major problem in model applications is the quality and availability of appropriate emission data for particles.

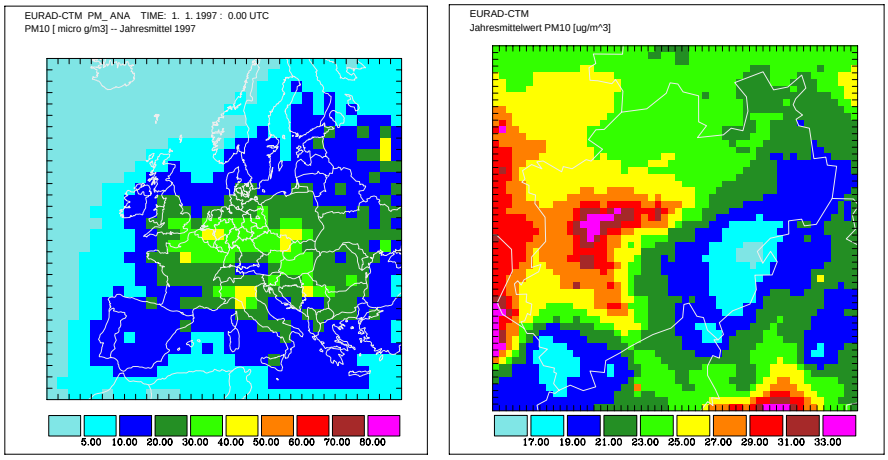

Figure 1a,b: Annual average of PM_{10} for Europe and sub-regions (left: Europe, grid size 125 km; right: Nest 2, NRW, grid-size 5 km)

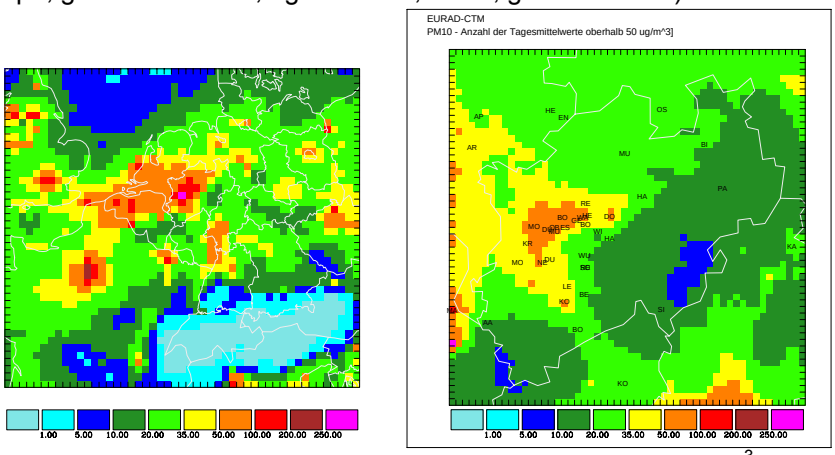

Figure 1c,d: Number of daily averages of PM_{10} exceeding 50 µg/m^3 for 1997. Left: Nest 1, 25 km grid size; right: Nest 2 (NRW). Emission data for N1 based on TNO and EMEP, Emission data for N2 based on LUA, NRW.

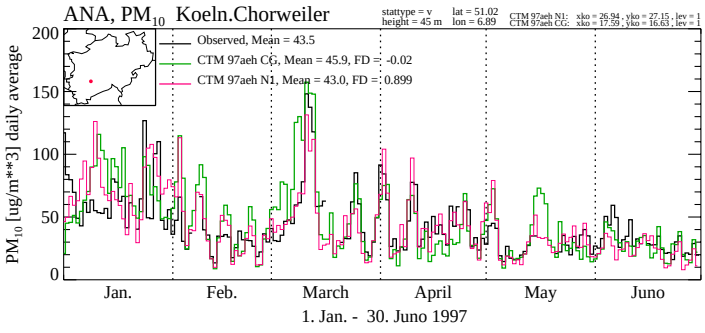

Figure 2: Time series for PM_{10} (green N0, red N1, black observed)

Overview 1996 - 2002

Aims

The general aim of the research is the better understanding of dynamical and chemical processes in the troposphere over Europe using a complex modeling system. Special emphasis is on the support of field experiments and the evaluation of the model based on quality assured observations with the aim to improve the parameterizations of the modeled processes. Model development includes the improvement of the aerosol and cloud modules, the development of advanced data assimilation methods using adjoint modeling techniques, the improvement and application of nesting techniques, deposition, gas phase chemistry and numerical methods. Model application aims on emission scenarios for episodes (summer smog) and on an annual scale (EU directives on air quality).

Principal results

The EURAD modeling system has been evaluated for a summersmog episode in July 1994 based on routine observations of the environmental agency of Nordrhein-Westfalen (LUA) and data obtained during the FLUMOB and BERLIOZ episodes in the Berlin area. Applications to the Milan area and the nearby Alps have been undertaken within the EU-project VOTALP (valley experiment, foehn episode) and for PIPAPO in close cooperation with LOOP (Seibert et al., 2000; Stohl et al., 2000). The nesting capabilities of the modeling system have been extended to consider regional and local effects with horizontal resolutions from 125 km down to 1 km (e.g. Berlin, Dresden, NRW, Milan area). The results of the model simulations have been compared to measurements for the BERLIOZ campaign in several joint studies (Becker et al., 2002; Corsmeier et al., 2002).

The results of model calculations have also be evaluated on the basis of an annual run for 1997 (see fig. 2).

Budget calculations and process analysis for Europe and the Berlin region have been performed (summer episode 1990, FLUMOB, July 1994 and BERLIOZ, July 1998) and for the time period of the VOTALP campaigns (see fig. 4; Memmesheimer et al., 1997).

The interface to the emission data bases available within GENEMIS has been improved considerably. GENEMIS data provided by the IER, University of Stuttgart, have been used to simulate the oxidant formation from the European scale to the urban scale of Berlin; landuse data generated for Europe by the IFU, Garmisch-Partenkirchen, have been used to calculate biogenic emissions.

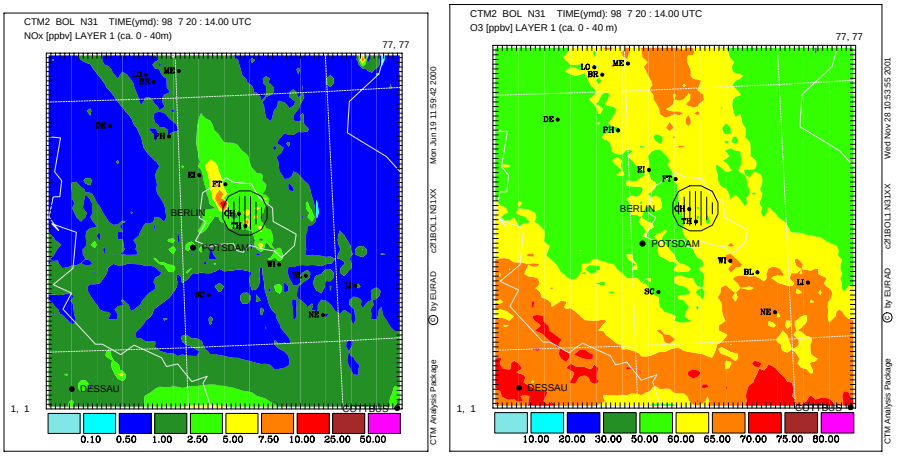

Figure 3a, b: NO_x (left) and ozone (right) concentration (ppbv) on July 20, 1998, 14 UTC for the Berlin area during the BERLIOZ experiment.

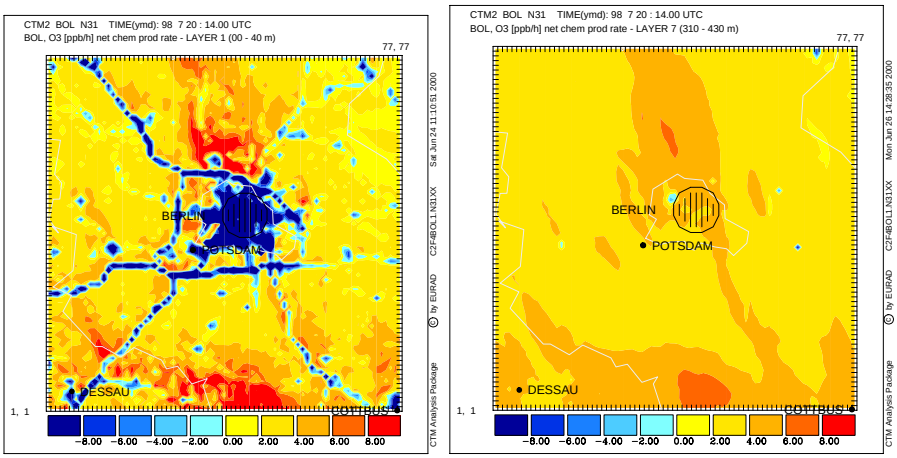

Figure 3c,d: Net chemical production of ozone (ppbv/h) on July 20, 1998, 14 UTC for the Berlin area during the BERLIOZ experiment. The results for layer 1 (about 40 m thick, left) and layer 7 (altitude range about 300 – 400 m, right) are displayed.

The effect of stratosphere-troposphere exchange has been studied for several episodes and with different methods within the framework of VOTALP. The effect of frontal system for the vertical exchange of air pollutants has been investigated based on a summersmog episode in August 1990.

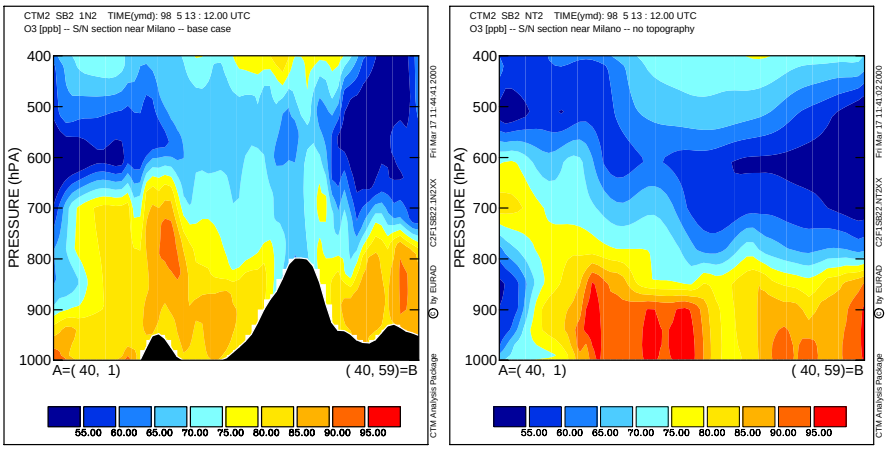

Figure 4a,b: Effect of the alps on ozone concentration during the PIPAPO experiment (Milano region). Left: Ozone with Alps, right: Ozone without Alps.

The EURAD-CTM has been successfully used for the forecast of air pollutants as part of the system of the German Weather Service (Jakobs et al., 2002; Tilmes et al., 2002). Aerosol dynamics and chemistry have been included into the model (Ackermann et al., 1998; Schell et al., 2001). The nesting applications have been sucessfully extended from the European scale into NRW for an annual run (see new results above). The EURAD modelling system had been used in the AMPO programme of the German Umweltbundesamt for the development of air pollution abatement strategies concerning ozone during summer smog episodes.

Main conclusions

The range of applicability of EURAD has been extended considerably during GLOREAM and allow for the preparation and analysis of field experiments (including aerosols) as well as for the
calculation of emission scenarios for air quality regulation policy on different scales. Further developments of the model might focus on the improvement and harmonisation of input data (e.g. particle emissions), highly sophisticated data assimilation methods including nesting and aerosols, cloud-aerosol interaction and permanent evaluation of the model results on an extended time scale (annual, climatological). It has been shown that process studies and budget calculations are an important tool to understand the interaction of dynamics and chemistry and to interpret the chemical state of the atmosphere. The modeling system might be extended to a hemispheric scale to improve the treatment of boundary values for Europe.

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