Real-time forecast of atmospheric pollutants over Europe and Germany

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ABSTRACT

A real-time forecast system for atmospheric pollutants is presented. The forecast system is based on the EURAD Model (European Air Pollution Dispersion Model). The daily updated forecast of atmospheric constituents for Europe, Central Europe and the German State of Northrhine-Westfalia was tested and is quasi operational since June 2001. The whole forecast system includes the meteorological forecast (MM5) and an updated Emission data base for the above mentioned regions. The results of the forecasts on the different regions are published and are updated every day on the EURAD homepage **www.eurad.uni-koeln.de**.

Introduction

Regional and local air quality models have become an important tool for environmental research and application to environmental assessment and policy questions. On one hand it is important to use air quality models as a tool to understand the simulations carried out with them, and on the other side, evaluated, highly improved models should be used to forecast atmospheric pollutants in an operational state.

Since summer 2001 a real-time forecast system based on the EURAD Model was tested and established to predict the main atmospheric pollutants on different scales in Europe. Fig. 2 describes the forecast system as is was used for these purposes. The EURAD forecast system consists mainly of the mesoscale meteorological model MM5 (PennState/NCAR mesoscale model Version 5), the emission Processor EEM (EURAD Emission Model) and the EURAD Chemistry Transport Model (EURAD-CTM). The initial and boundary data for MM5 are obtained from the global AVN forecast (NCEP) at the start of the forecast cycle (00 UTC). The emission data are interpolated from the EMEP data base in time and space for 3 different regions of interest: Europe(CO), Central Europe (N1) and the German state Northrhine-Westfalia(N2) (Fig. 1). In addition to the predicted gas phase concentrations, aerosol particles are also forecasted during the cycle.

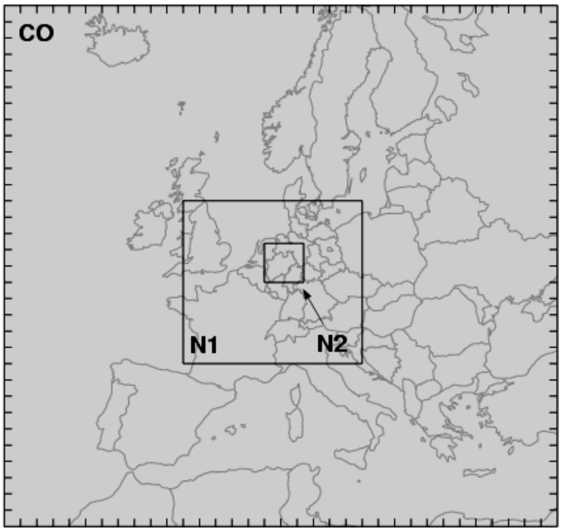

Figure 1: Domains for the forecast system Domain CO has 125 km gridsize, N1 25 km and N2 5 km, respectively.

Objectives

During the last few years, one major goal in environmental research is to establish a forecast system to predict atmospheric pollutants. Since about 15 years the EURAD model was developed and improved for applications within numerous case studies on the regional scale in Europe (e.g. Jakobs et al., 1995; Ebel et al., 1997). The main purpose of the predictions was to answer the following questions: How reliable are the predictions and how can they be improved? Can short-term measures on a local scale confirm an excess of the ozone concentration and other major constituents limits, if such an excess is predicted?

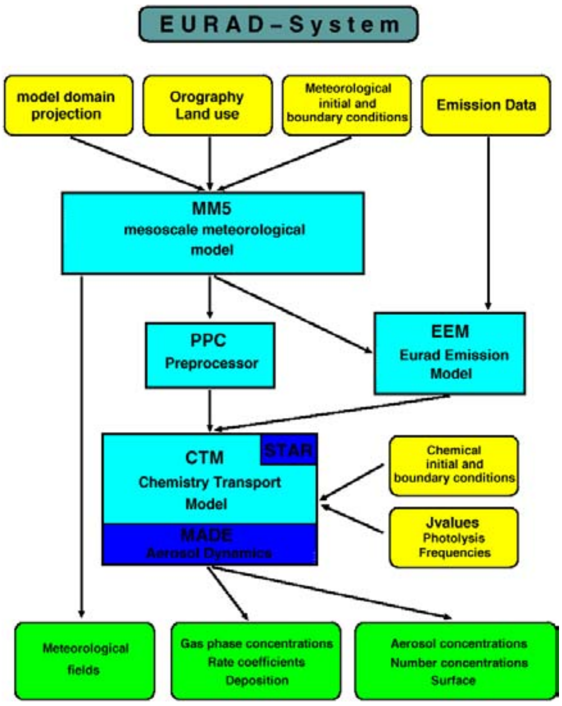

Figure 2: The flowchart of the EURAD air pollution forecast system

Activities

The EURAD air pollution forecast system starts with first tests in spring 2001. It becomes quasi operational in June 2001. The system starts automatically with the download of the AVN global meteorological forecast via ftp at around 03:30 UTC every morning. Then the initial and boundary conditions are prepared for the meteorological model MM5 for the coarse domain (Europe) to predict the meteorological variables for a forecast cycle of 48 hours. Together with the selected emission data for the selected time and domain, the EURAD-CTM predicts the concentrations for the atmospheric constituents. Then the forecast for the first nested domain (Central Europe) continues. Now since November 1 2001 a second nested domain, which covers the region of the German state Northrhine-Westfalia was included in the forecast cycle. In addition, the full aerosol option of the EURAD-CTM was applied for the chemistry transport calculations and the integrated prognostic variable PM_{10} (particle matter with diameter less than 10 micrometer) was included as displayed variable.

With all these improvements it is now possible to predict every day the concentration of atmospheric pollutants within a sufficient time range, e.g. the whole forecast starts at 03:30 UTC and is finished at around 09:00 UTC every morning and the results are updated and displayed on the EURAD web side (www.eurad.uni-koeln.de).

Results

Every day, an extensive amount of data are produced by the EURAD forecast system. This includes the meteorological prediction variables and the concentrations of the atmospheric constituents at all model levels as well. In order to compare later especially the concentrations of air pollutants main effort was done to visualize the near surface concentrations of the main air pollutants O_3, NO_2, SO_2, CO and PM_{10} for the above mentioned domains. For assessment studies the ranges for the concentration thresholds were selected according to the EU directives.

Since photooxidant processes play no important role during winter, as an example the results for the near surface concentrations of O_3, NO_2, SO_2 and PM_{10} are displayed for January 09, 2002. This date was characterised by a blocking High over Central Europe, which allow to accumulate air pollution concentration up to critical levels, especially for particle matter (PM_{10}). Figure 3 and 4 demonstrate this behaviour for the domains of Europe and Central Europe.

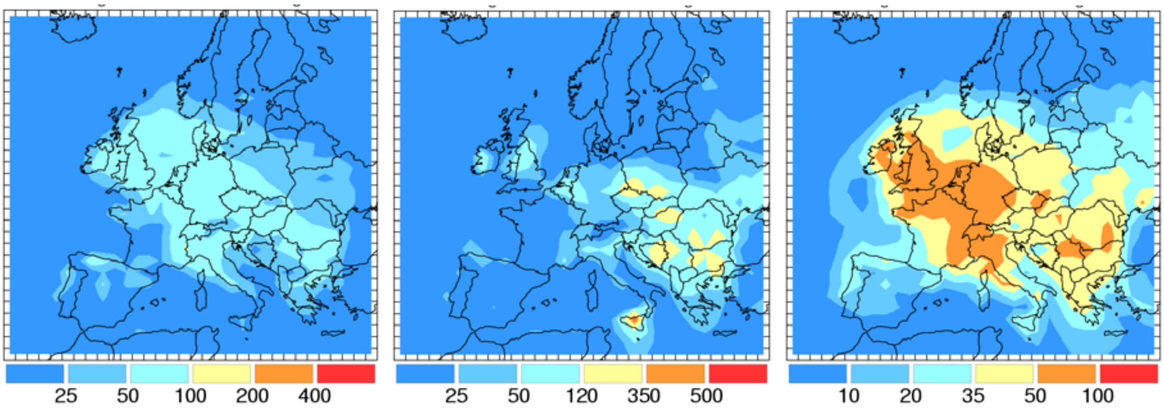

Figure 3: Near surface concentrations of NO_2, SO_2 (daily maximum) and PM_{10} (maximum daily 24 hour mean) at January 9 2002 for Europe. The concentrations are given in µg/m^3.

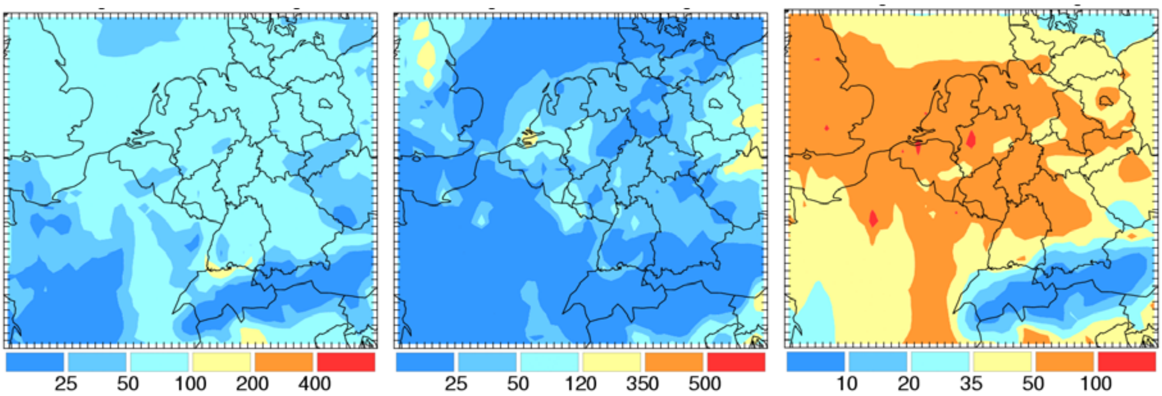

Figure 4: Near surface concentrations of NO_2, SO_2 (daily maximum) and PM_{10} (maximum daily 24 hour mean) at January 9 2002 for Central Europe. The concentrations are given in µg/m^3.

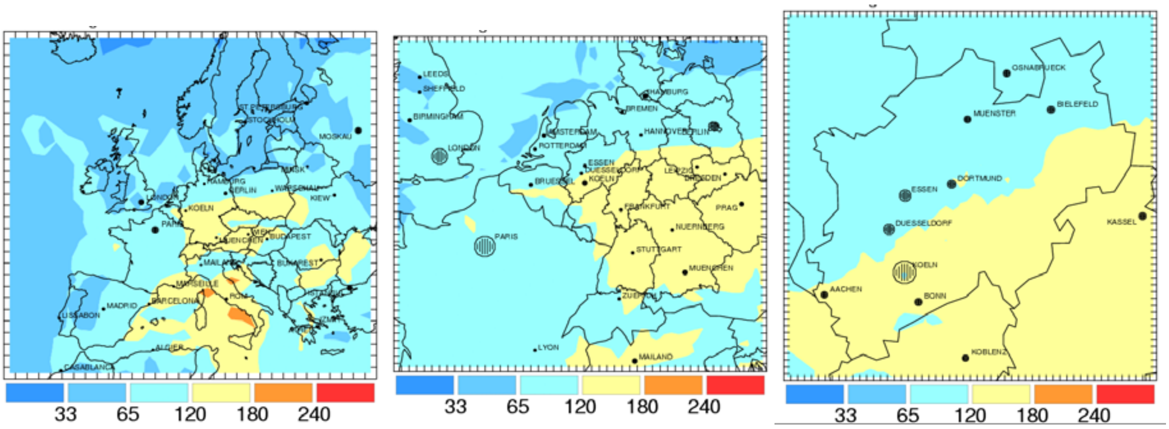

Figure 5: Near surface concentrations of Ozone (daily maximum) at May 17 2002 for Europe, Central Europe and Northrhine-Westfalia. The concentrations are given in µg/m^3.

During springtime, photooxidant processes become more relevant and the first minor summer smog episodes were observed. Fig. 5 demonstrates one of these episodes, where relatively high ozone concentrations were forecasted and observed in Southern and Central Europe. Even in Italy, the prognosted values exceed the 180 µg/m^3 critical value according to the directives of the European Union.

In order to evaluate the forecast system, we recently established a verification tool, where the predicted daily maxima and daily means of the concentrations in the domain N1 are compared with certain measuring sites in the western part of Germany. Fig. 6 displays the comparison of predited and measured concentrations in the region of the City of Cologne during the month of May.

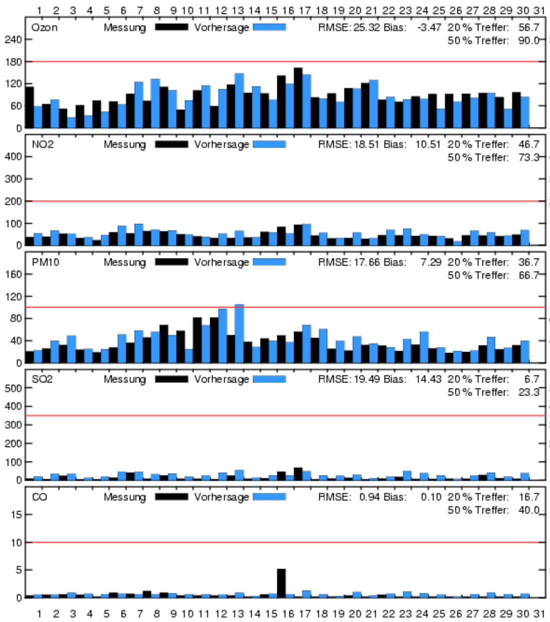

Figure 6: Predicted (blue) and obserded (black) daily maxima of O_3, NO_2, PM_{10}, SO_2 and CO at Cologne during May 2002.

In general, ther is a relative good agreement between observations and predictions (e.g. 90 % of the predicted ozone concentration lay within a 50% interval of the observations). Regarding this findings, one has always taken into account the difficulties when comparing predicted values in a 25 by 25 km grid with a local measuring site.

Conclusions

A new air pollution forecast system based on the EURAD model was established in order to predict every day the concentration of atmospheric pollutants over Europe and Central Europe. The fact, that such a complex model system was developed and established for operational purposes, including a complex aerosol model together with a relatively short computational time, was the main success of these developments. This leads to intensify the efforts in order to produce regular predictions of ozone and other atmospheric pollutants in future.

Acknowledgements

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