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DAILY FORECAST OF AIR QUALITY OVER EUROPE WITH THE EURAD MODEL SYSTEM

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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**.

Key Words: Air Quality Forecast, Air Quality Modeling, Ozone Concentration, Suspended Particulate Matter

1. 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. 1 describes the forecast system as it was used for these purposes. The EURAD Air Quality 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 GFS 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 (N0), Central Europe (N1) and the German state Northrhine-Westfalia (N2) (Fig. 2). In addition to the predicted gas phase concentrations, aerosol particles are also forecasted during the cycle.

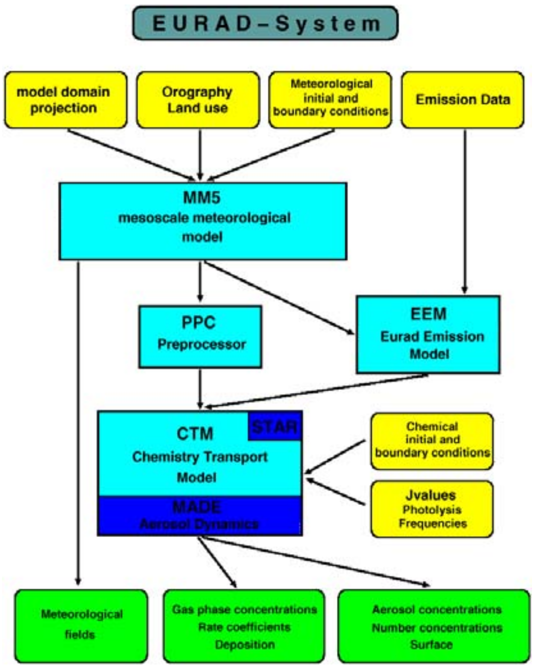

Figure 1. The flowchart of the EURAD Air Quality Forecast System

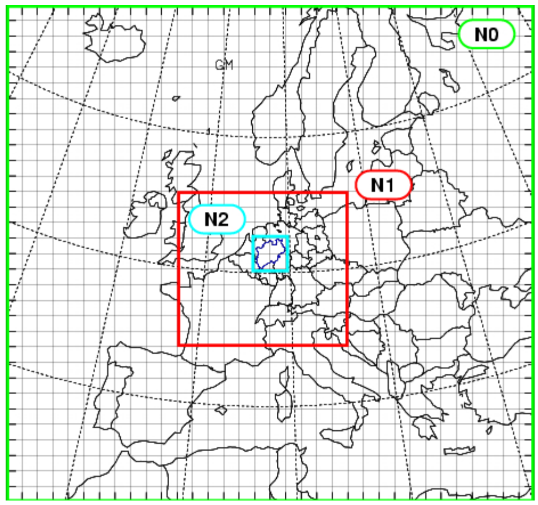

Figure 2. Domains of the EURAD Air Quality Forecast System

2. OBJECTIVES AND ACTIVITIES

During the last few years, one major goal in environmental research is to establish a forecast system to predict atmospheric pollutants (Jakobs et al., 2002). 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, Elbern and Schmidt, 2001). 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?

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 GFS 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 72 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. 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 08:30 UTC every morning and the results are updated and displayed on the EURAD web side (www.eurad.uni-koeln.de).

3. RESULTS

Every day, an extensive amount of data is 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 photo oxidant processes play no important role during winter, as an example the results for the near surface concentrations of PM_{10} are displayed for February 09, 2002 (Figure 3). This date was characterized by a blocking high over Central Europe, which allow accumulating air pollution concentration up to critical levels (higher than 50 µg/m^3 for the maximum 24h running mean).

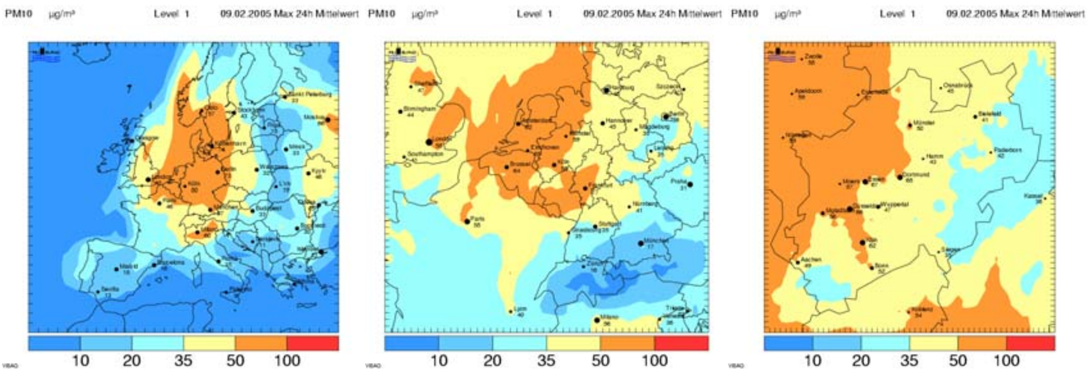

Figure 3. Near surface concentrations (maximum 24h running mean) of PM_{10} (µg/m^3) for the different domains at 09 February 2005.

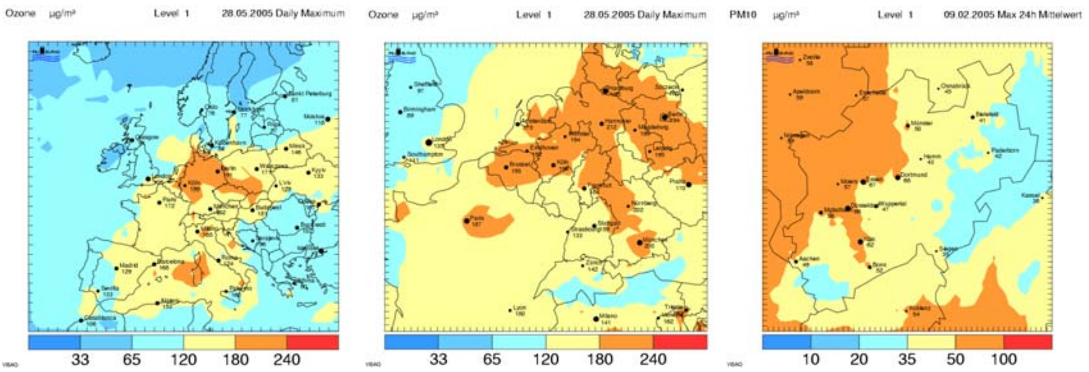

Figure 4. Near surface concentrations (daily maximum) of Ozone (µg/m^3) for the different domains at 28 May 2005.

During springtime, photo oxidant processes become more relevant and the first minor summer smog episodes were observed. Fig. 4 demonstrates one of these episodes, where relatively high ozone concentrations were forecasted. The thresholds for the information level according to EU directives (180 µg/m^3) were exceeded for main parts of Central Europe.
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 of Germany. The forecast values are taken as first guess for a 2-d variational data assimilation procedure to calculate analyzed fields for the near surface concentrations. Fig. 5 displays the comparison of predicted, observed and analyzed concentrations in the region of Germany for a selected day with high ozone concentration.

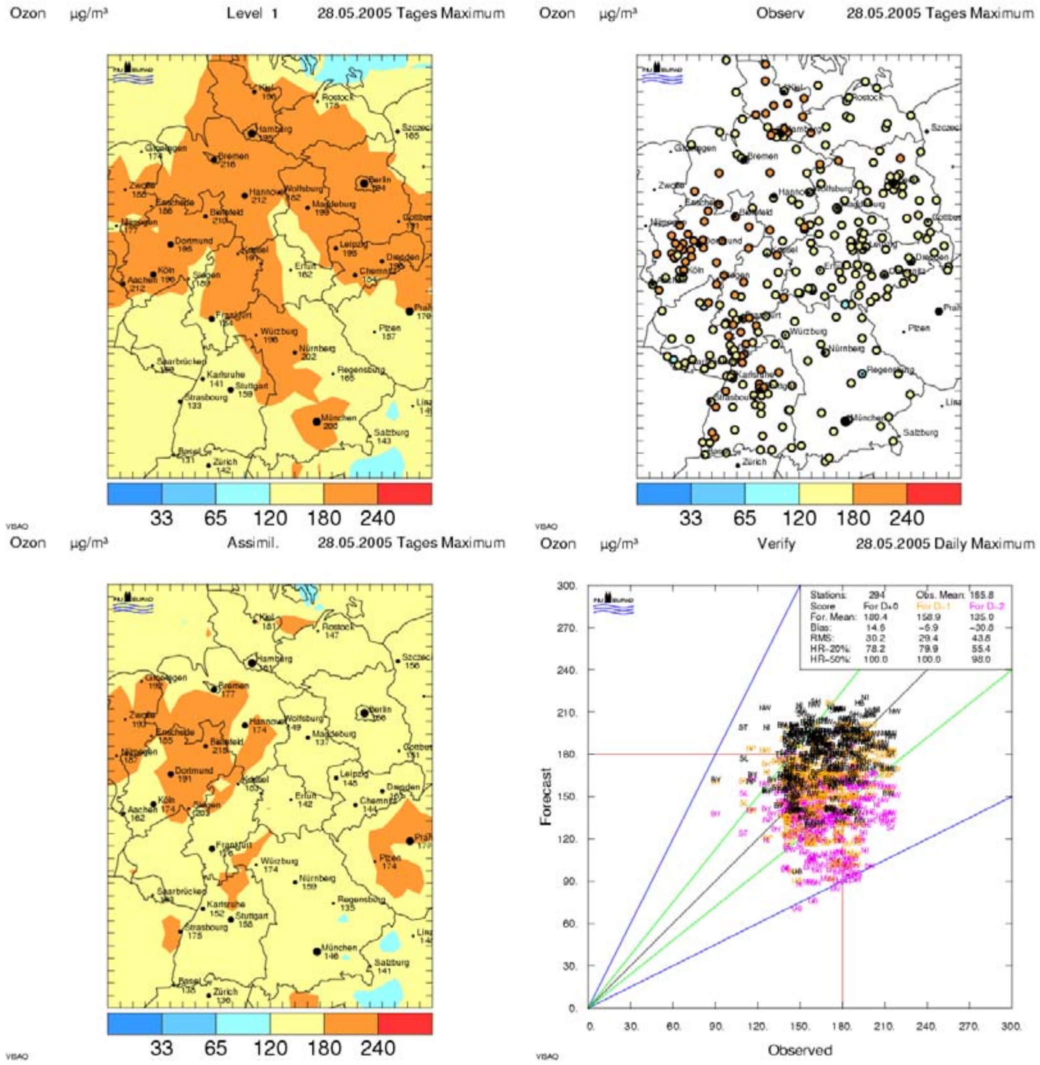

Figure 5. Validation of the forecast: Daily maximum of ozone for 28 May 2005. upper left, forecast; upper right, observation at stations; lower left, analysis; lower right, scatter diagram for forecast at the same day (D+0), a day before (D-1) and a 2 days before (D-2).

This Figure demonstrates the relative good performance of the prediction of the near surface ozone concentrations at days with high critical levels. In general, there is a relative good agreement between observations and predictions (e.g. almost 100 % of the predicted ozone concentration lay within a 50% interval of the observations and around 80% lay within a 20% interval of the observations). An intensive evaluation of the whole year 2005 will follow up in the near future.

4. CONCLUSION

A new air quality forecast system based on the EURAD model was established in order to predict every day the concentration of atmospheric pollutants over Europe, Central Europe and the German state of Northrhine-Westfalia. 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. It can be easily used for assessment studies and good be an appropriate tool for policy making institutions.

5. ACKNOWLEDGEMENTS

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