A NEW OZONE PREDICTION SYSTEM USING OPERATIONAL ALADIN DATA

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INTRODUCTION

The operational regional weather forecast model ALADIN-Austria, which is run at the Central Institute for Meteorology and Geodynamics (ZAMG) is used to implement a forecast system for tropospheric ozone for Austria.

During a hot period in August 2003 the ozone concentrations exceeded air quality thresholds of 180 µg/m³ (Directive 2002/3/EC, March 2002) at a high number of Austrian stations and occasionally 240 µg/m³ were observed. In cooperation with the University of Natural Resources and Applied Life Science in Vienna (BOKU) this period is simulated to test the usability of ALADIN linked to the photochemical transport model CAMx. The results are evaluated with measurements from the Austrian air quality network for that certain period.

The feasibility and limits of this model system with the given resolution to predict average concentrations and possible threshold values in eastern Austria as well as the alpine regions of the country are discussed in view of a future operational use. In summer 2005, the model system is run operationally on a daily basis for the first time.

DESCRIPTION OF THE MODELLING SYSTEM

The new air quality model system consists of three parts that are linked together. The combination of the two major parts, the meteorological input provided by ALADIN and the chemical model CAMx, was implemented for the first time in this study.

CAMx (Comprehensive Air qualtity Model with extensions, http://www.camx.com) simulates the emission, dispersion, chemical reaction, and removal of pollutants in the troposphere by solving the pollutant continuity equation for each chemical species on a system of nested 3D grids. Different chemical mechanisms are implemented in the model. In this study, CBM-IV and SAPRC99 are used and compared. A two grid nesting is used with a coarse grid over Europe and a finer grid for the core area covering Austria with the best possible spatial resolution of 9.6 km (according to the present grid of ALADIN-Austria).

The model needs meteorological fields as input which are supplied by the limited area model ALADIN (http://www.cnrm.meteo.fr/aladin/). It is run twice a day at the ZAMG and renders forecasts for 48 hours. The meteorological fields have a temporal resolution of one hour. The data is provided on 45 model-levels (only the lower 33 are used in CAMx) and has a horizontal resolution of 9.6 km. Fields of wind, temperature, pressure, convective and large scale precipitation, snow cover, solar radiation and specific humidity are extracted directly out of the ALADIN dataset. The other fields, cloud optical depth, cloud water- and precipitation water content have to be parameterised (*Seinfeld*, 1998) from the ALADIN output. For the calculation of the vertical diffusity coefficient the method of *Louis* (1979) is used.

Additionally CAMx needs hourly emission rates for every grid cell. For this study emissions based on the EMEP (*Vestreng et al.*, 2004) dataset are used. The emission data for Austria, the Czech Republic, Slovakia and Hungary are down-scaled from the 50x50 km EMEP grid to 5x5 km and disaggregated to hourly values.

OZONE EPISODE 8.-14.8.2003

The considered episode occurred in August 2003. From the Mediterranean sea to Scandinavia the weather in Europe was dominated by high pressure and stable conditions with hot and dry air masses over middle Europe.

Between 8.8. and 14.8. extensive exceedences of the information (90 ppb) and alarm (120 ppb) thresholds in Austria occurred. Fig. 1 shows the daily maximum ozone concentrations over Europe on four consecutive days. The heavy loaded air mass over south Germany that was established on 11. and 12. August with high ozone concentrations was transported with the westerly flow to the east and made an additional contribution to the high concentrations over Austria on the consecutive days.

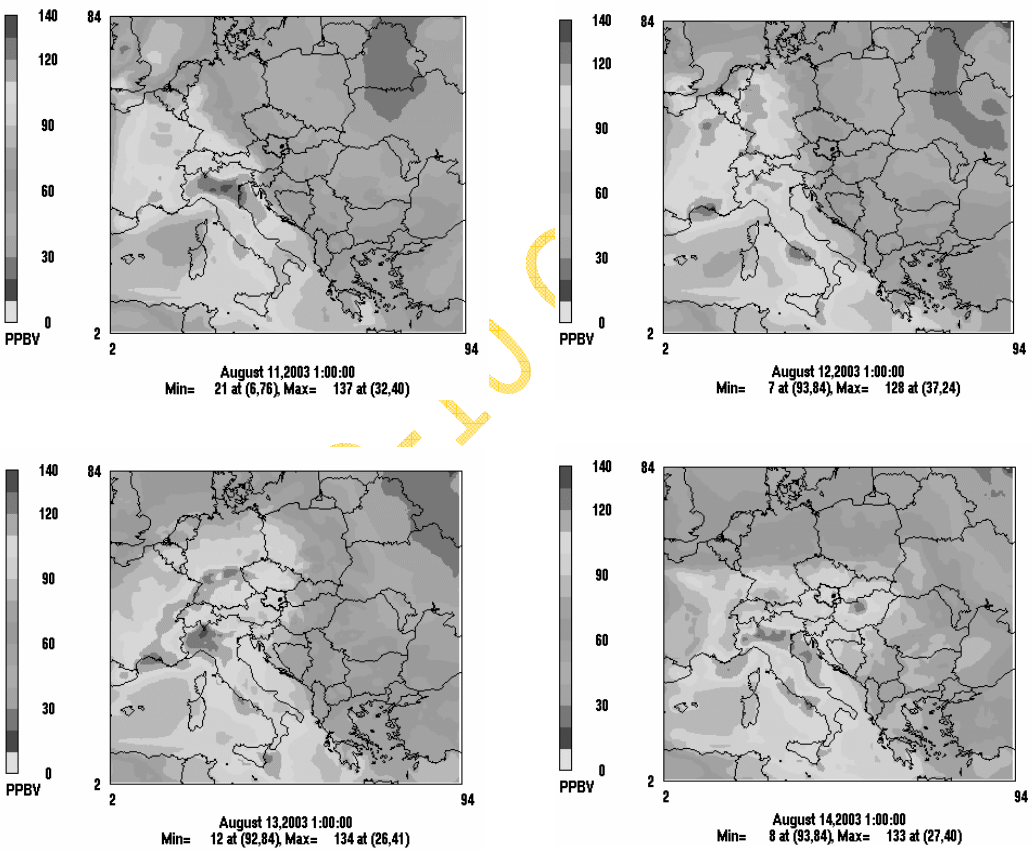

Fig.1; Daily maximum ozone concentrations from 11.8. to 14.8.2003 (coarse grid).

In the following the results at some selected stations are shown and discussed.

The time series in Fig.2 show that the SAPRC99 chemical module produces higher concentrations during daytime than the CBM-IV method and therefore matches the measurements usually better. Regarding the pattern for the station in Salzburg the measured concentrations exceed the information threshold from 8.8. to 14.8. every day at noon. These exceedances are also forecasted by the model. In general the calculated concentrations with the CBM-IV module are about 15 ppb too low.

For stations in the south of the Alps like Klagenfurt the model still predicts values above the information threshold in the night before the 15.8. while the observed concentrations already decreased. A possible explanation is that convective clouds formed and local precipitation occurred in this night. These conditions developed too weak in the model. It is also remarkable that the model results achieved with SAPRC99 exceed the information threshold already on 12.8. while the observation is just below that value. In this case the CBM-IV calculations match the measurements better for the first few days till 12.8., when they underestimate the observations.

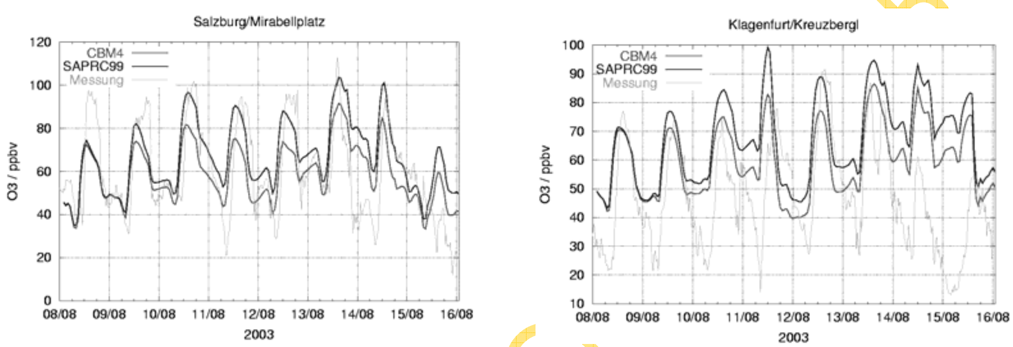

Fig.2; Comparison between measurements and model results of the two chemical mechanisms for the ozone episode 2003.

On 12.8. the observed ozone concentrations reached much higher values than on the previous days at some stations in east Austria (e.g. Klosterneuburg, Mödling) while the model results stayed within the same range and increased not until the next day. Fig.3 shows that on this day the information threshold was exceeded in Klosterneuburg while the model results are far below these values. The respective predictions for NO_2, which is a precursor substance of ozone, compared to the measurements show that the values are very low in the model during that day. There was a strong temperature reduction in the night before which resulted in an inversion. This meteorological condition lead to the high NO_2 concentrations observed and was predicted to weak in the model.

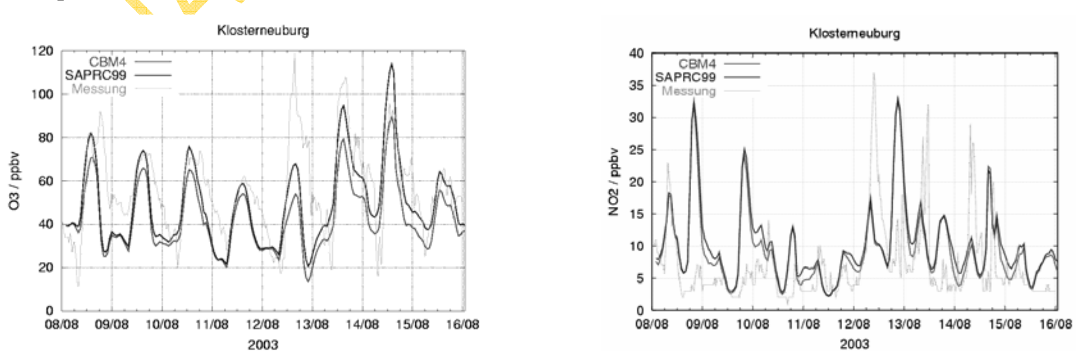

Fig.3; Comparison between measurements and model results of ozone and NO_2 for Klosterneuburg during the ozone episode 2003.

Strong local emissions also influence the results. Fig. 4 shows that the observations at night are much lower than the calculation for the station in St.Valentin though the values during the day are very good. The coarse model grid results in an enlarged mixture of the emissions. The calculations at some stations show a weaker decomposition at night because the emissions are averaged over the whole area of a grid cell.

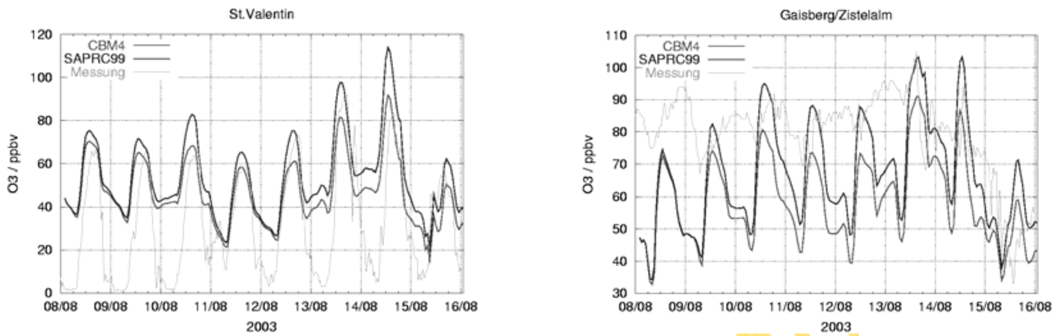

Fig.4; Comparison between measurements and model results of ozone for St.Valentin and Gaisberg during the ozone episode 2003.

It has also to be considered that the horizontal resolution of the model (9.6km) leads to differences between the model altitude and the real altitude of the station. Especially in alpine regions the model grid cannot represent the real orography appropriate. Fig. 4 shows the concentrations at the station Gaisberg/Zistelalm which lies at 1000m over ground. The measurements at some of these stations are compared to model results at grid cells which are representative for a larger region including the valley. This results in a stronger daily pattern especially concerning the minimum concentrations at night simulated by the model.

Essentially for the usability of an ozone modelling system is how good the observed exceedances of thresholds can be forecasted. It was already pointed out that the SAPRC99 mechanism in general produces higher concentrations than the CBM-IV. The questions is which one of the two chemical mechanisms performs better compared to the observations. Fig.5 shows scatterplots of hourly ozone measurements compared to the calculations of the two chemical mechanisms for the stations Enzenkirchen and Lustenau.

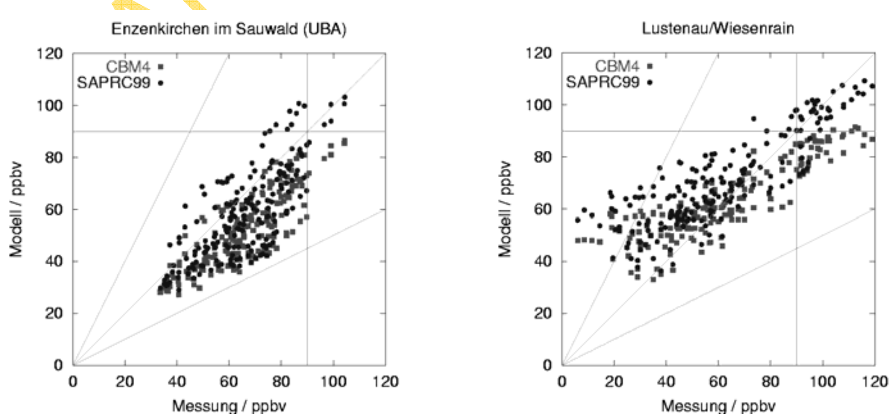

Fig.5; Comparison between measurements and model results of ozone for two stations during the ozone episode 2003. Information thresholds are displayed too.

The points that are in the upper right quadrant represent the cases where observations and model both lie over the information threshold. Comparing the two mechanisms shows that the results with SAPRC99 are better than the CBM-IV that underestimates the measurement in Fig.5. The same results can be found for other locations.

In general the observed maximum concentrations are reproduced very well by the model. The ozone reduction on 15.8. is also forecasted in agreement to the observations at all stations at the end of the episode.

CONCLUSION

The quality of an ozone forecast system based on the chemical model CAMx and the meteorological model ALADIN is evaluated with the ozone measurements of the Austrian air quality network for a hot period in summer 2003. The two chemical mechanisms CBM-IV and SAPRC99 are used and compared.

During the summer 2005 the forecast system ALADIN-Austria/CAMx was installed and tested operationally at ZAMG. Two runs are conducted every day, with the 00 UTC and with the 12 UTC ALADIN forecast data. The ozone forecasts are made for 48 hours. The main differences between the evaluation and the operational run is that 24 to 48 hours forecast fields are used the second day while for the evaluation of the 2003 episode was conducted for the 0 to 24 hours forecast only (excluding the spin off time of 6 hours). Further improvements of the ozone forecasting system are planned. This includes the boundary conditions, the use of operational available total ozone column data obtained from the ECMWF model as well as the improvement of the computation performance.

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