ZAMG
Zentralanstalt für Meteorologie und Geodynamik

Operational on-line coupled chemical weather forecasts for Europe with WRF/Chem

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1. Introduction

The ZAMG conducts daily Air-Quality forecasts using the on-line coupled model WRF/Chem (Grell et al., 2005). Meteorology is simulated simultaneously with the emission, turbulent mixing, transport, transformation, and fate of trace gases and aerosols. The emphasis of the application is on predicting pollutants over Austria. 2 domains are used for the simulations. The mother domain covers Europe with a resolution of 12 km. The inner domain includes the alpine region with a horizontal resolution of 4 km. 45 model levels are used in the vertical. The model runs 2 times per day for a period of 72 hours and is initialized with ECMWF forecasts.

2. Model configuration

- Meteorological Model: WRF (version 3.4.1) with YSU PBL, Morrison cloud microphysics, Noah land surface model, RRTMG LW and SW radiation module
- Chemistry Model: WRF/Chem, RADM2 (Stockwell et al., 1990) chemical mechanism and MADE/SORGAM (Schell et al., 2001) aerosols including aqueous reactions (chem_opt=11)
- Biogenic Model: MEGAN (Guenther et al., 2006)
- Dust Model: MOSAIC MADE/SORGAM
- Sea salt model: MOSAIC MADE/SORGAM
- Anthropogenic emissions: Different anthropogenic emission inventories are used. The latest local data for Austria provided by federal governments are combined with emission inventories for the other areas covered by the model grids (Europe, parts of Africa and Asia, marine areas, and the missing Austrian regions). For the areas outside Austria, the data are taken from the TNO (Visschedijk et al., 2007) inventory. In addition, some emissions from the EMEP inventory (http://www.ceip.at/ceip) were included for areas not covered by TNO emissions. These areas are located mainly in Africa and Asia.

3. Feedbacks

on-line coupled models allow to consider two-way interactions between different atmospheric processes including chemistry (both gases and aerosols), clouds, radiation, boundary layer, emissions, meteorology and climate. In the operational set-up the following feedbacks/effects between meteorology and air chemistry are enabled:

- direct(radiation)
- indirect (cloud, precipitation)
- semi-direct (wind, temperature, humidity, ...)

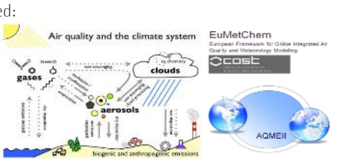

Figure 1: Atmospheric interactions (http://aqmeii-eu.wikidot.com/)

4. Computing performance

As the simulations need very much computing resources the model is running on the HPCF (High Performance Computing Facility) of the ZAMG. In the current set-up 1248 CPUs are used. To avoid MPI-traffic and time for I/O during the computation, every mpi task writes all its output (splitted wrfout and rsl files) into the shared memory filesystem of the compute nodes. After the WRF/Chem integration is finished all splitted netcdf-files are merged and saved on the global filesystem. Our merge-routine is based on parallel-netcdf. With this method the model runs about 30% faster on the SGI-ICEX. The model needs one hour of simulation time for a 24-hour forecast.

5. Emissions

Highly spatially resolved data from the emission inventories of seven regional Austrian administrations are collected. All data sets are provided in different formats, have different spatial resolution on different projections, contain different species, and the emissions are attributed to different source sectors.

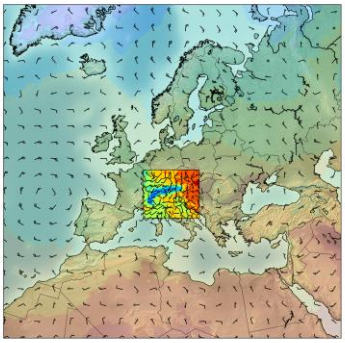

Figure 2: Model domains

The data were incorporated into a modified emission preparation process for the modeling system, which distributes them to the differently resolved grids, harmonizes the emission sectors and supplements missing species. In addition, the new data for Austria had to be combined with emission inventories for the other areas covered by the model grids (Europe, parts of Africa and Asia, marine areas, and the missing Austrian regions).

The other data were taken from the TNO (Visschedijk et al, 2007) inventory. In addition, some emissions from the European Monitoring and Evaluation Programme EMEP (Vestreng et al., 2007) inventory were included for areas not covered by TNO emissions.

6. Evaluation

Hirtl et al. (2014) show that air quality forecasts with WRF/Chem are improved when satellite and ground based particulate matter observations are used. Support Vector Regression technique is applied to derive highly-resolved PM10 initial fields for air quality modeling from satellite measurements of the Aerosol Optical Thickness. Additionally, PM10-ground measurements are assimilated using optimum interpolation. The results show that the ingestion of measurement data (ground and satellite) improves the model forecasts for most of the stations (Fig. 3). Only at stations situated in very complex terrain a high bias is still encountered.

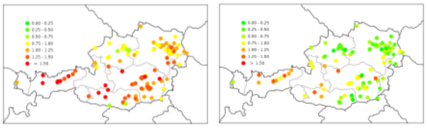

Figure 3: Fractional Bias for all Austrian AQ-stations (PM10, Feb. 2010). Left: only model simulations are considered. Right: data assimilation of PM10 ground measurements and satellite estimates are used.

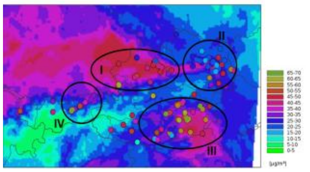

Figure 4: Daily average PM10-concentrations on 14th of February 2010. area: model, dots: ground measurements.

The daily average PM10 concentrations obtained from ground measurements and model run (using ground and satellite data assimilation) are shown in Fig. 4 for a selected day. High PM10 values in the north-west (I) are reproduced by the model and also the decrease towards the east with concentration values between 20 µg/m³ and 30 µg/m³ (II) are well simulated.

The distribution of the elevated concentration values in the south-east in Styria (III) are also reproduced by the model; only the absolute values are under estimated here. Also the elevated values inside the Inn-valley located in Tyrol (IV) can be identified but with lower peaks than measured. The figure also shows that even if the model reproduces the general pattern of the measurements, peaks at single locations are not possible to cover at least with the current resolution (e.g. blue dots in I, or yellow dot in II).

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