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Evaluating the CALIOPE air quality modelling system: dynamics and chemistry over Europe and Iberian Peninsula for 2004 at high horizontal resolution

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Often in Europe, population exposure to air pollution exceeds standards set by the EU and the World Health Organization (WHO). Urban/suburban areas are predominantly impacted upon, although exceedances of particulate matter (PM10 and PM2.5) and Ozone (O3) also take place in rural areas.

In the frame of the CALIOPE project (Baldasano et al., 2008a), a high-resolution air quality forecasting system, WRF-ARW/HERMES/CMAQ/DREAM, has been developed and applied to the European domain (12km x 12km, 1hr) as well as to the Iberian Peninsula domain (4km x 4km, 1hr) to provide air quality forecasts for Spain (http://www.bsc.es/caliope/). The simulation of such high-resolution model system has been made possible by its implementation on the MareNostrum supercomputer. To reassure potential users and reduce uncertainties, the model system must be evaluated to assess its performances in terms of air quality levels and dynamics reproducibility.

The present contribution describes a thorough quantitative evaluation study performed for a reference year (2004). The CALIOPE modelling system is configured with 38 vertical layers reaching up to 50 hPa for the meteorological core. Atmospheric initial and boundary conditions are obtained from the NCEP final analysis data. The vertical resolution of the CMAQ chemistry-transport model for gas-phase and aerosols has been increased from 8 to 15 layers in order to simulate vertical exchanges more accurately. Gas phase boundary conditions are provided by the LMDz-INCA2 global climate-chemistry model (see Hauglustaine et al., 2004). The DREAM model simulates long-range transport of mineral dust over the domains under study. For the European simulation, emissions are disaggregated from the EMEP expert emission inventory for 2004 to the utilized resolution using the criteria implemented in the HERMES emission model (Baldasano et al., 2008b). The HERMES model system, using a bottom-up approach, was adopted to estimate emissions for the Iberian Peninsula simulation at 4 km horizontal resolution, every hour. In order to evaluate the performances of the CALIOPE system, model simulations were compared with ground-based measurements from the EMEP and Spanish air quality networks. For the European domain, 45 stations have been used to evaluate NO2, 60 for O3, 39 for SO2, 25 for PM10 and 16 for PM2.5. On the other hand, the Iberian Peninsula domain has been evaluated against 75 NO2 stations, 84 O3 stations, 69 for SO2, and 46 for PM10. Such large number of observations allows us to provide a detailed discussion of the model skills over quite different geographical locations and meteorological situations.

The model simulation for Europe satisfactorily reproduces O3 concentrations throughout the year with relatively small errors: MNGE values range from 13% to 24%, and MNBE values show a slight negative bias ranging from -15% to 0%. These values lie within the range defined by the US-EPA guidelines (MNGE: +/- 30-35%; MNBE: +/- 10-15%). NO2 is less accurately simulated, with a mean MNBE of -47% caused by an overall underestimation in concentrations. The reproduction of SO2 concentrations is relatively correct but false peaks are reported (mean MNBE=22%). The simulated variation of particulate matter is reliable, with a mean correlation of 0.5. False peaks were reduced by use of an improved 8-bin aerosol description in the DREAM dust model, but mean aerosol levels are still underestimated. This problem is most probably related to uncertainties in our

knowledge of the sources and in the description of the sulfate chemistry. The model simulation for Europe will be used to force the nested high-resolution simulation of the Iberian Peninsula. The performances of the latter will be also presented. Such high resolution simulation will allow analysing the small scale features observed over Spain.

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