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Evaluation of simulated air quality levels over Europe in 2008 and main drivers of uncertainty

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Major gaseous and particulate pollutant levels over Europe in 2008 have been simulated using WRF-CMAQ modeling system in frame of the FP7 CityZen and Eclipse projects. INERIS anthropogenic emissions have been used for Europe while biogenic, dust and biomass burning emissions have been calculated using the MEGAN, GOCART and FINN models, respectively. The model results are compared with observations from EMEP for the surface levels of the major pollutants. Additional comparisons have been conducted with ozone (O_3) soundings, ship-borne O_3 observations in the Western Mediterranean, tropospheric NO_2 vertical column densities (VCD) from SCIAMACHY and aerosol optical depths (AOD) from the AERONET.

O_3 levels are slightly overestimated by 1% on a domain-mean basis with underestimations over western and northwestern Europe (up to 30%) attributed to overestimated NO_x emissions. Simulated tropospheric NO_2 VCDs are overestimated by 40%, particularly over Western Europe. Overestimated O_3 levels are simulated over southern Europe (up to 75%) with overestimations by 26% over the Western Mediterranean Sea. Overestimations of O_3 levels over the southern Europe can be attributed to underestimated anthropogenic NO_x as well as biogenic NMVOC emissions, and to uncertainties in the meteorological simulations. Vertical O_3 levels are generally underestimated in the PBL by 10-20% that can be attributed to overestimations in the tropospheric NO_2 VCDs. Bulk PM_{10} and $PM_{2.5}$ levels are underestimated by up to 60%, particularly in southern and Eastern Europe, suggesting underestimated particulate emissions. Larger differences are calculated for individual aerosol components, particularly for OC and EC. On the other hand, better agreements have been obtained in terms of aerosol species over the urban areas of the East Mediterranean, particularly in nss-SO_4^{2-}, attributed to more detailed and finer resolution emission inventories. Simulated AOD levels underestimate the AERONET observations by 10% on average, with underestimations over 40˚N by 3% on average, attributed to the underestimated anthropogenic emissions and underestimated below 40˚N by 22% on average, suggesting underestimated natural dust emissions. Overall, results show differences in the model performance between northern and southern Europe, suggesting significant differences in the emission inventories in representing both anthropogenic and natural emissions. Additional uncertainties may come from the grid resolution (30 km) and its representativeness of the EMEP stations, which are characterized as remote stations.