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Application of the WRF-Chem model for the simulation of air quality over Cyprus

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The fully coupled WRF-Chem (Weather Research and Forecasting with Chemistry) model is used to simulate air quality over Cyprus. Cyprus is an island country with complex topography, located in the eastern corner of East Mediterranean region, affected year-long by local, regional and long range transported pollution. An extensive sensitivity analysis of the model performance has been performed over the area of interest with three domains of respective grid spacing of 40, 8 and 2 km. Different configurations have been deployed regarding horizontal resolution, simulation timestep, boundary conditions, NO_x emissions and speciation method of emitted NMVOCs (Non Methane Volatile Organic Compounds). The WRF-Chem model simulated hourly concentrations of air pollutants for a month-long period (July 2014) during which measurements are available over 13 stations (4 of which background stations, 1 industrial and 8 urban/traffic stations). The model was initialized with meteorological initial and boundary conditions (ICBC) using NCAR-NCEP's F Global Forecast System output (GFS) at a 1o x1o spatial resolution. The ICBC for the chemical species are derived from the MOZART global model results (2.5o x 2.5o). Both ICBCs datasets are updated every 6 hours. The emission inventory used in the study is the EDGAR-HTAP v2 dataset with a horizontal grid resolution of 0.1o $\times$ 0.1o, while an additional dataset with speciated NMVOCs (instead of summed volatile species) is also tested.
The diurnal cycle of the atmospheric concentrations of ozone averaged over the island, exhibits a maximum of 114 μg/m3 when the boundary conditions are derived from MOZART and 94 μg/m3 when the boundary conditions are not included (local background and production), suggesting a constant inflow of ozone from long range transport of about 20 μg/m3. The contribution of pollution from regional sources is more pronounced at the western border due to the characteristic summer time north-northeasterly etesian flow that brings southward the pollution produced or accumulated over Eastern Europe, the Black sea and major upwind megacities (Istanbul, Athens etc). Ozone concentrations are overestimated in all stations indicating a possible overestimation of ozone from the global model (MOZART) that has also been discussed in other studies over neighbouring countries, or an excess of ozone production in the parent domain that includes all Eastern Mediterranean. Model results are influenced by the speciation of NMVOCs with the pre-speciated emission dataset resulting in lower ozone values by an average of 5 μg/m3. Lowering NO_x emission brings ozone levels closer to observations; however this does not account for the overestimation of ozone since the respective comparison of NO_x levels reveals strong underestimation of NO_x (both NO and NO_2) even before reducing them. Horizontal, vertical and temporal resolutions show smaller impact on changing the modelled patterns of ozone concentrations. The discrepancies between modelled and observed ozone over the main Cypriot urban areas point at the need for more detailed emission inventories, either in terms of spatial resolution and/or validation of absolute emitted values, and adjustments in the use of boundary conditions from global models.