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Simulating Aerosol over Europe with a Limited-Area Regional Climate Model

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Due to their relatively short lifetimes, aerosols are of importance on the regional scale. Their concentration and composition is different in urban, industrial and agricultural areas, biomass burning regions, along ship tracks and in arid places. Hence, it is crucial to use regional climate models (RCMs) which apply sophisticated aerosol and cloud microphysics schemes in order to cope with the enormous complexity and the spatial as well as the temporal heterogeneity of the interactions between aerosols, radiation, clouds and precipitation. Therefore, a new regional modelling framework is being developed within COSMO-CLM in order to simulate aerosol dynamics and their effects on clouds, radiation and precipitation at sufficiently high resolution, also allowing applications on climatological timescales (e.g. the simulation of decadal European temperature and precipitation trends). COSMO-CLM is coupled to the aerosol dynamics module M7 and the 2-moment cloud scheme of Seifert & Beheng (2006). The simulations are driven by ERA-Interim. In addition, the new model setup requires 3D tracer information at the lateral boundaries from a global circulation model (GCM). In this study, we therefore evaluate the performance of the new model setup with respect to aerosol and cloud properties. Furthermore, we compare the new setup with the standard version of the model not including aerosol effects.

Over the evaluation period from 1997 to 2003 the new aerosol modelling framework compares well with the standard version of COSMO-CLM. The monthly and seasonal mean temperature biases for Greater Europe are similar in terms of spatial distribution and the annual cycle. The new model version also reproduces the annual cycle of precipitation, although drier in general than the simulation with the standard setup.

The model is able to reproduce important cloud and aerosol properties. The effective cloud droplet radius as well as the cloud radiative forcing are simulated reasonably in comparison with satellite observations. Aerosol optical depth (AOD) and absorption optical depth are validated against satellite data, showing an acceptable agreement in the annual mean despite an underestimation of AOD in winter and a weak overestimation of the spring peaks related to dust outbreaks from the Saharan desert. Annual mean aerosol burdens as well as wet and dry deposition rates over Europe show similar large-scale patterns as nudged simulations with the GCM ECHAM5-HAM. These results indicate that the new model setup can be considered competitive with previous model versions in terms of its overall climatological performance, but it allows to consider interactively coupled direct, semi-direct and indirect aerosol effects.