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A case study on the aerosol-meteorology feedback for Europe with WRF/Chem

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A main topic of the investigations with online coupled meteorology-chemistry models, such as WRF/Chem is the feedback of air pollution on meteorology. For the current case study three WRF/Chem simulations for Europe and the North Atlantic are compared: a baseline case without any aerosol feedback on meteorology, a simulation with the direct effect of aerosol on radiation included, and a simulation including the direct effect as well as the indirect aerosol effect. An episode covering June and July in 2006 was considered. WRF/Chem's 3-modal MADE/SORGAM aerosol module was applied for this investigation, which was motivated by the AQMEII (Air Quality Model Evaluation International Initiative) model inter-comparison exercise.

For the simulation including just the direct effect, the aerosol-radiation induced changes in temperature, boundary layer height, and clouds ("semi-direct effect") were found to dominate after some time. Over Central Europe the mean reduction of global radiation due to aerosol extinction alone was mostly 3 – 7 W m^{-2}, but changes in cloud cover due to semi-direct effects resulted in monthly mean changes of $\pm$ 50 W m^{-2}.

The inclusion of the indirect aerosol effect resulted in an up to 70% lower cloud water content and a significantly higher mean rain water content over the North Atlantic. The simulated low cloud droplet and CCN concentrations there are a result of the low aerosol concentrations in this area. However, model analysis suggests these results are sensitive to boundary conditions and a possible underestimation of aerosol sources over the North Atlantic. In spite of the higher aerosol concentrations over continental Europe, the inclusion of the indirect aerosol effect also results sometimes in smaller cloud droplet numbers than the fixed droplet number that is assumed in the absence of aerosol–cloud interactions. The agreement between observed and simulated global radiation over Europe was found to be better for cloudy conditions when the indirect effect was taken into account. Regional changes in precipitation of $\pm$ 100% were simulated over the European continent. For the simulation not including the indirect aerosol effect these changes are almost entirely due to semi-direct effects developing during the considered two months episode. As a consequence of the changes in cloud cover, boundary layer height, and precipitatation simulated changes in near surface ozone and PM10 by up to 10% and up to 40 %, respectively, were found over Europe.