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The comprehensive model system COSMO-ART – Radiative impact of aerosol on the state of the atmosphere on the regional scale

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Abstract. A new fully online coupled model system developed for the evaluation of the interaction of aerosol particles with the atmosphere on the regional scale is described. The model system is based on the operational weather forecast model of the Deutscher Wetterdienst. Physical processes like transport, turbulent diffusion, and dry and wet deposition are treated together with photochemistry and aerosol dynamics using the modal approach. Based on detailed calculations we have developed parameterisations to examine the impact of aerosol particles on photolysis and on radiation. Currently the model allows feedback between natural and anthropogenic aerosol particles and the atmospheric variables that are initialized by the modification of the radiative fluxes. The model system is applied to two summer episodes, each lasting five days, with a model domain covering Western Europe and adjacent regions. The first episode is characterised by almost cloud free conditions and the second one by cloudy conditions. The simulated aerosol concentrations are compared to observations made at 700 stations distributed over Western Europe.

For each episode two model runs are performed; one where the feedback between the aerosol particles and the atmosphere is taken into account and a second one where the feedback is neglected. Comparing these two sets of model runs, the radiative feedback on temperature and other variables is evaluated.

In the cloud free case a clear correlation between the aerosol optical depth and changes in global radiation and temperature is found. In the case of cloudy conditions the pure radiative effects are superposed by changes in the liquid water content of the clouds due to changes in the thermodynamics of the atmosphere. In this case the correlation between the aerosol optical depth and its effects on temperature is low. However, on average a decrease in the 2 m temperature is still found.

For the area of Germany we found on average for both cases a reduction in the global radiation of about 6 W m^2, a decrease of the 2 m temperature of 0.1 K, and a reduction in the daily temperature range of −0.13 K.

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