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Response of different regional online coupled models to aerosol-radiation interactions

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The importance of aerosol-meteorology interactions and their representation in online coupled regional atmospheric chemistry-meteorology models was investigated in COST Action ES1004 (EuMetChem, http://eumetchem.info/). Case study results from different models (COSMO-Muscat, COSMO-ART, and different configurations of WRF-Chem), which were applied for Europe as a coordinated exercise for the year 2010, are analyzed with respect to inter-model variability and the response of the different models to direct and indirect aerosol-radiation interactions. The main focus was on two episodes - the Russian heat wave and wildfires episode in July/August 2010 and a period in October 2010 with enhanced cloud cover and rain and including an of Saharan dust transport to Europe.

Looking at physical plausibility the decrease in downward solar radiation and daytime temperature due to the direct aerosol effect is robust for all model configurations. The same holds for the pronounced decrease in cloud water content and increase in solar radiation for cloudy conditions and very low aerosol concentrations that was found for WRF-Chem when aerosol cloud interactions were considered. However, when the differences were tested for statistical significance no significant differences in mean solar radiation and mean temperature between the baseline case and the simulations including the direct and indirect effect from simulated aerosol concentrations were found over Europe for the October episode. Also for the fire episode differences between mean temperature and radiation from the simulations with and without the direct aerosol effect were not significant for the major part of the modelling domain. Only for the region with high fire emissions in Russia, the differences in mean solar radiation and temperature due to the direct effect were found to be significant during the second half of the fire episode - however only for a significance level of 0.1. The few observational data indicate that the inclusion of aerosol radiative effects improves simulated temperatures in this area.

In summary, the direct aerosol effect leads to lower temperatures and PBL heights for all seasons whereas the impact of the aerosol indirect effect on temperature and pollutant concentrations over Northern Europe was found to depend strongly on the season. It cannot be generalized whether the inclusion of aerosol radiative effects and aerosol cloud interactions based on simulated aerosol concentrations does improve the simulation results. Furthermore, assumptions how aerosol optical properties are calculated, i.e. on the aerosol's mixing state have a strong effect on simulated aerosol optical depth and the aerosol effect on incoming solar radiation and temperature. The inter-model variation of the response of different online coupled models suggests that further work comparing the methodologies and parameterizations used to represent the direct and indirect aerosol effect in these models is still necessary.