Feedback between dust particles and atmospheric processes over West Africa during dust episodes in March 2006 and June 2007

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We used the comprehensive model system COSMO-ART to quantify the impact of mineral dust on the radiative fluxes, the temperature and the feedback between dust particles and their emissions. We simulated two dust storms over West Africa in March 2006 and in June 2007. Simulations with and without coupling of the actual dust concentration with the radiative fluxes and the thermodynamics were carried out for each case. The model results for the 2006 case were compared with observations of the AMMA campaign.

At the surface the shortwave radiative effect of mineral dust can be described by a linear relation between the changes in net surface radiation and the aerosol optical depth (AOD). For an AOD at 450 nm of 1 the average shortwave radiation reduction amounts −140 W m−2 during noon. The longwave radiative effect of mineral dust is nonlinear, with an average increase of +70 W m−2 for an AOD (450 nm) of 1. At the top of the atmosphere the effect of the dust layer with an AOD of 1 on radiative fluxes is not as significant as at the surface. It is slightly positive for the shortwave and approximately 26 W m−2 for the longwave radiation.

The height range and the extension of the dust layer determine the effect of dust particles on the 2 m temperature. When the dust layer is attached to the surface and lasts for several days it leads to an increase of the surface temperature even during daytime. In case of an elevated dust layer there is a decrease in 2 m temperature of up to 4 K during noon.

It is shown, that the temperature changes caused by mineral dust may result in horizontal temperature gradients which also modify near surface winds. Since surface wind thresholds decide the uptake of dust from the surface, a feedback on total emission fluxes is established. The coupled model provides an increase in the total emission fluxes of dust particles by about 16% during the dust storm in March 2006 and 25% during the dust episode in June 2007.

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