Impact of mineral dust particles on radiation and cloud coverage

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Motivation

In April and May 2014 major mineral dust events occurred over Western Europe. In all cases the origin of the dust was the Saharan desert. At Deutscher Wetterdienst (DWD), additionally to the standard COSMO model chain, the model system COSMO-ART [1,2] was used to forecast the dust load and to investigate the impact of dust particles on temperature and cloud properties. Moreover, we addressed the question how this dust event modified surface radiation and therefore the production of photovoltaic power (PV).

Model Framework

Aerosol
- Calculation of mass and number concentrations of three dust modes

Cloud Processes [2]
- Activation of aerosol particles applying Köhler theory and updraft PDFs [3]
- Comprehensive full two-moment cloud microphysics [4]

Emissions
- Dust emissions calculated online [5]

Simulation of the dust event

1. Modelling of the mineral dust episode with the operational setup.
2. Sensitivity studies with a two moment microphysics scheme:
   CTRL NO interaction with radiation & NO interaction with clouds
   Fback interaction with radiation & interaction with clouds

Impact on temperature forecast

Operational COSMO forecast (03.04.14 12 UTC)

In the areas with high dust load the operational run overestimates T_{2m}.

COSMO-ART forecast, fully interactive (Fback):

T_{2m} and ΔT_{2m} (mod–obs)

The COSMO-ART FBack run shows a decrease of T_{2m} in areas with high dust load, but over Germany mainly an underestimation.

Impact on clouds, radiation, and temperature

Fback 03.04.14 12 UTC  Fback-CTRL

Mineral dust particles are good ice nuclei. That means that ice nucleation happens at higher temperature than required for homogeneous ice nucleation. Compared to CTRL (prescribed aerosol, left) run Fback leads to a remarkable increase of the vertically integrated ice crystal number density in areas with high dust load (right).

Impact on photovoltaic power

During the dust event in May calculations for Hohenpeissenberg (47°48’N, 11°E) gave a reduction of the solar radiation at the surface (left) and a reduction of the photovoltaic power, the latter by 20% (right). Germany has very ambitious plans for using renewable energy in the future. This requires high quality forecast of the expectable photovoltaic power. As mineral dust events happen quite frequently over Europe COSMO-ART enables most probably an improvement of the PV forecasts during such situations.