Project: **883**
Project title: **Modelling of Saharan mineral dust**
Project lead: **Bernd Heinold**
Report period: **1.1.2018 - 31.12.2018**

Progress Report

The key aim of this DKRZ project is to evaluate and further improve the representation of mineral dust in the aerosol-climate model ECHAM6-HAM2 (Tegen et al., 2018). While the emphasis previously was mainly on the Saharan Desert, the focus has been directed recently to the Eastern Mediterranean, Middle East and Central Asia. These regions are hot spots of today's climate change. Drastic land-use changes in the last century have created new sources of mineral dust. Despite the importance of dust as an important factor for climate and air quality in these regions, there is only little information on its sources, transport pathways and effects, especially for Central Asia. The steep topography in Central Asia and a wide variety of sources influencing the dust distribution in the Eastern Mediterranean make dust modelling a challenge. Uncertainties in global and regional models are mainly due to an insufficient representation of the dynamic surface properties. The aim is to describe the life cycle of mineral dust (emission, transport, deposition) in the 'Dust Belt' region using the latest observational data and model developments. This includes the characterization of long-range transport and local sources, and the exploration of interannual variability and trends with a focus on land cover changes.

The evaluation of the ECHAM6-HAM2 dust simulations for Central Asia continuouses focusing on the Central Asian Dust Experiment (CADEX; Hofer et al., 2017) in 2015 and 2016. CADEX aims to investigate optical and radiative properties of dust aerosol over Central Asia by long-term lidar and sun photometer measurements in the Tajik capital Dushanbe. The model experiments are carried out with the latest model version ECHAM6.3-Ham2.3 in nudged mode at resolution T63L31. The comparison of the model results with coarse-mode AOD retrievals from Dushanbe and surrounding AERONET station shows reasonably good agreement in the amount of dust. The typical seasonality of Central Asian dust with activity peaking during the summer months, however, is more challenging to match (Figure 1). Here, further analysis of potential reasons for the mismatches and appropriate model improvements are required. In particular, the representation of preferential dust sources and near-surface winds in the complex topography of Central Asia needs to be evaluated in more detail.

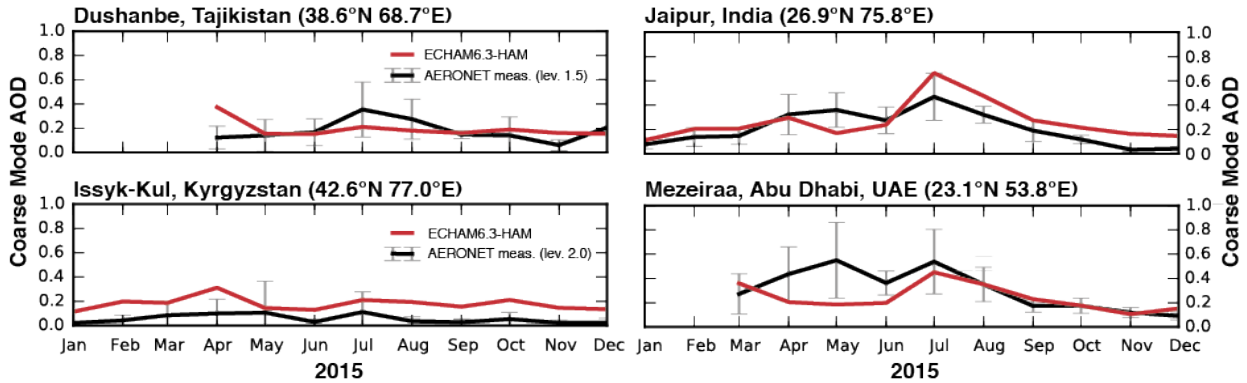

***Figure 1**: Aerosol optical depth (AOD) at Dushanbe, Tajikistan and surrounding AERONET stations. Compared is the AERONET 500-nm coarse-mode data (black line) and the modelled dust AOD from ECHAM6.3-HAM2.3 (red line).*

In addition, we investigate the direct and semi-direct radiative effects (rapid adjustments) of the absorbing aerosol types black carbon (BC) and mineral dust in Central Asia within ECHAM6-HAM2. The study uses free-running simulations at T63L31 with prescribed sea surface temperature and sea ice cover for the years 2004–2010. An evaluation of the modelled absorbing aerosol optical depth against OMI satellite retrievals together with a worldwide analysis of the radiative effects has been published in Tegen and Heinold (2018). The semi-direct effects of the absorbing aerosol are calculated as the residual between the total direct radiative effect and the instantane-

ous direct radiative effect of the aerosol species. The results show that, the direct and semi-direct radiative effects of BC and dust are positive in Central Asia, locally reaching up to 5 W m^{-2}. However, the results for the semi-direct effect are not statistically significant in most locations. Interestingly, for Central Asia, the presence of mineral dust aerosol below a BC aerosol layer enhances the positive radiative effect of BC (Figure 2). This is a direct consequence of the increase in reflectivity due to the relatively brighter dust above the darker surface. However, the overall effect is uncertain and may depend on the model used as well as on the model setup.

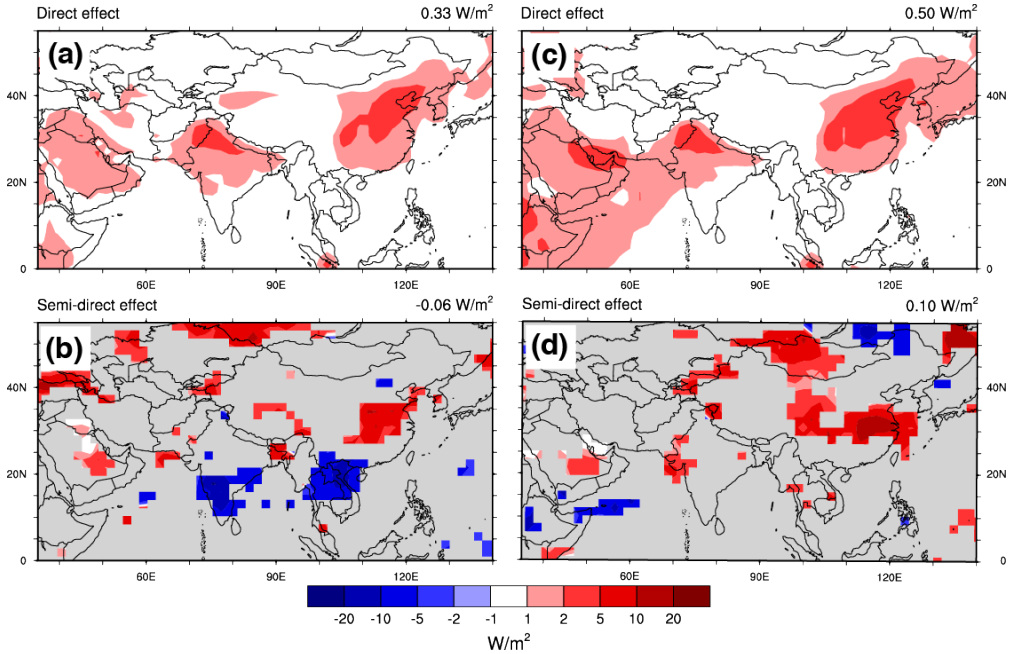

***Figure 2**: (Top): Instantaneous BC radiative effect at TOA for June-July-August from the computation (a) without and (c) considering the radiative impact of mineral dust. (Bottom): semi-direct effect of BC at TOA (b) without and (d) including the dust radiative effect. Grey areas indicate regions where the results are not statistically significant at 95% level.*

Perspectives

The ECHAM6-HAM2 simulations in this study help better characterise the life cycle and climate effects of desert dust in the 'Dust Belt' region. Further model evaluation with latest soil and land-use data at high spatial resolution are planned. A novel approach for dust emission computations will be tested by which black-sky albedo instead of the widely-used roughness length is used.

Utilisation and Publication

The work has been an important part of the preliminary work for a proposed DFG project on desert dust in Central Asia, in which context the results will be published. All relevant model developments and required input data are made available to the scientific community through the HAMMOZ website (https://redmine.hammoz.ethz.ch) and repository.

References

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