Project: **883**
Project title: **Modelling of Saharan mineral dust**
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Progress Report

The evaluation and continuous improvement of the representation of mineral dust in the aerosol-climate model ECHAM6-HAM2 (Tegen et al., 2019) is the key aim of this DKRZ project. The focus is mainly on the so-called Dust Belt region, reaching from the Saharan Desert over the Eastern Mediterranean and Middle East to Central Asia. In the past 30 to 60 years, major land-use changes and water exploitation have taken place in the Middle East and Central Asia, which, in combination with climate change, have increased dustiness. Despite the importance of dust for climate in these regions and globally, there is only little information on its sources, transport pathways and effects, especially for Central Asia. The model uncertainties are mainly caused by an insufficient representation of the dynamic surface properties. In addition, a steep topography in parts of the Dust Belt make dust modelling a challenge. The aim is therefore to better understand the life cycle of mineral dust from the Dust Belt region using the latest observational data and model developments. Special focus has to be on considering the recent, essentially man-made land cover changes and anthropogenic dust sources.

As in 2018, comprehensive model experiments were carried out with ECHAM6-HAM2 to investigate Central Asian dust. The simulations were performed with the latest model version ECHAM6.3-HAM2.3 in nudged mode at resolution T63L31. The model results were evaluated using lidar and sun photometer observations for the period of the CADEX remote-sensing campaign in Tajikistan in 2015–2016 (Hofer et al., 2017). The comparison with sun photometer measurements shows reasonable agreement for the average amount of dust in Tajikistan, but a significant weakness of the model in reproducing the seasonality of local dust with maximum activity in summer. However, a good agreement in seasonal variability is found for Kyrgyzstan to the north-east, where the annual evolution of modelled dust matches well the observations with a distinct spring maximum. The misrepresentation of local near-surface winds in the complex topography of Central Asia is the likely reason for the mismatches, but also inaccuracies and lacking details in surface property data could be the reason. Here, it is expected that implementing the new global map of sediment supply by B. Baker (ARL) and K. Schepanski (TROPOS), which uses black-sky albedo to consider surface roughness elements and has currently been tested with surprisingly great success in NOAA's global aerosol model.

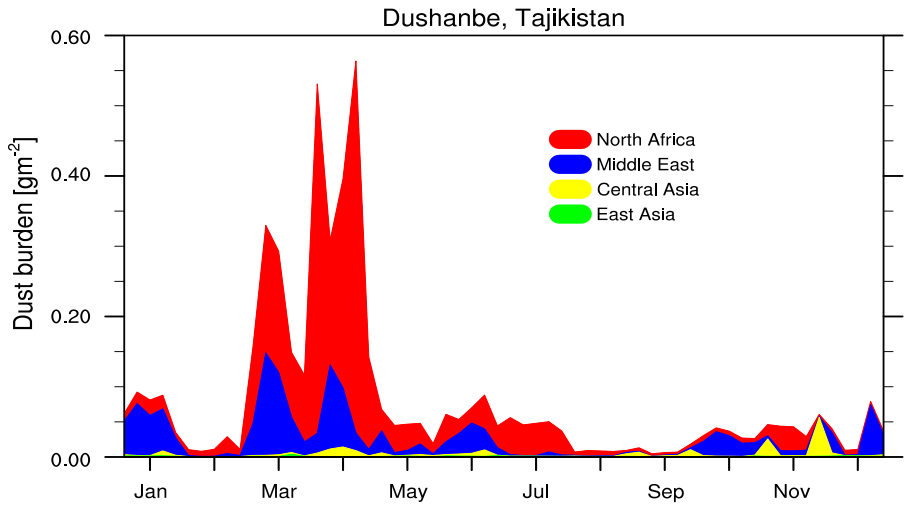

***Figure 1**: Mineral dust source apportionment at Dushanbe in Tajikistan for the annual cycle. Shown is the dust burden averaged over the years 2015 and 2016 as computed by the ECHAM6.3-HAM2.3 model.*

In addition, a source attribution experiment was carried out, where the main relevant dust source regions: Central Asia, Middle East, North Africa, and East Asia are alternately switched off in separate simulations. The results show a major contribution to the dust load in Central Asia from

Arabia and North Africa throughout the year (Tab. 1). In the model, local sources contribute from spring to autumn (Fig. 1). In Tajikistan, the relative contribution of dust from local or regional sources is largest in summer and autumn months in accordance with observations. The results underline the importance of considering long-range transport and local atmospheric dynamics and surface characteristics for modelling dust in Central Asia (Heinold and Tegen, 2019).

***Table 1**: Annual dust emissions in Tg per source region averaged from 2015 to 2016 from ECHAM6.3-HAM2.3 results.*

	North Africa	E- / Asia	Arabia	Central Asia
DJF	357	117	80	8
MAM	370	170	73	20
JJA	148	51	16	2
SON	109	119	12	9
Year	**984**	**457**	**181**	**39**

In addition, a substantial part of the granted computing resources was used to test the new aerosol-climate model system ICON-A-HAM2.3. For an initial comparison between ICON-A-HAM2.3 and the predecessor ECHAM6.3-HAM2.3, a setup with similar resolution was chosen (ICON: R2B04 (~160 km)/L47; ECHAM: T63L47). The simulations were performed in free-running mode for periods of up to 5 years. The first dust results from ICON-A-HAM2.3 show a reasonable distribution of activated dust sources and transport while the total amount of emitted dust is still significantly underestimated. This will require further adjusting the parameters in the dust emission scheme, which will be the focus of the upcoming allocation period.

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, which is based on black-sky albedo instead of roughness lengths and has currently being tested in NOAA's global aerosol model by B. Baker (ARL) and K. Schepanski (TROPOS).

Utilisation and Publication

The work was presented at the international dust conference CADUC 2019 in Dushanbe, Tajikistan. Further publication in peer-reviewed journals is planned. 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

Heinold, B. and Tegen, I.: Modelling mineral dust in the Central Asian region, Central Asian DUst Conference (CADUC 2019), Dushanbe, Tajikistan, Ed. Altausen, D., Abdullaev, S. and Hofer, J., E3S Web of Conferences, Volume 99, 02012, doi:10.1051/e3sconf/20199902012.

Hofer, J., Althausen, D., Abdullaev, S. F., Makhmudov, A. N., Nazarov, B. I., Schettler, G., Engelmann, R., Baars, H., Fomba, K. W., Müller, K., Heinold, B., Kandler, K., and Ansmann, A.: Long-term profiling of mineral dust and pollution aerosol with multiwavelength polarization Raman lidar at the Central Asian site of Dushanbe, Tajikistan: case studies, Atmos. Chem. Phys., 17, 14559-14577, https://doi.org/10.5194/acp-17-14559-2017, 2017.

Tegen, I., Neubauer, D., Ferrachat, S., Siegenthaler-Le Drian, C., Bey, I., and co-authors: The global aerosol–climate model ECHAM6.3–HAM2.3 – Part 1: Aerosol evaluation, Geosci. Model Dev., 12, 1643–1677, https://doi.org/10.5194/gmd-12-1643-2019, 2019.