Project: **883**
Project title: **Modelling of Saharan mineral dust**
Project lead: **Bernd Heinold**
Report period: **1.1.2023 - 31.12.2023**

Progress Report

The central aim of this DKRZ project is to evaluate and continuously improve the representation of mineral dust in the aerosol-climate model ECHAM6.3-HAM2.3 (Tegen et al., 2019) and its successor ICON-HAM2.3 (Salzmann et al., 2021). Whereas in the last allocation period, the main focus was on porting ECHAM6.3-HAM2.3 and ICON-A-HAM2.3 to the new Levante supercomputer, in 2023 more scientific topics could be tackled again. And the computing time was largely spent for testing and further development of ICON-HAM2.3.

Part of the computational budget was used to perform long-term (>10-year) simulations with ECHAM6.3-HAM2.3 to study the transport of aerosol, including desert dust, towards the Arctic. For the Arctic drift experiment MOSAiC, in which the German research icebreaker Polarstern drifted across the Arctic Ocean in 2019/2020, the model results were evaluated with respect to aerosol transport by atmospheric rivers (ARs) and put this into a long-term context. ARs are small-scale events of meridional air mass transport that bring moisture and warm air from southerly latitudes. In spring 2020, a positive phase of the North-Atlantic Oscillation (NAO) promoted especially the transport of air masses from the mid-latitudes into the Arctic. The model results now show that Arctic warm air/moisture intrusion events not only appear to be important for water vapour supply in the Arctic, but also represent a significant and so far underestimated source of cloud nuclei. ECHAM6.3-HAM2.3 fields of marine organic and desert dust aerosol were calculated offline into concentrations of potential cloud condensation nuclei (CCNs) and ice nucleating particles (INPs). These show an important contribution of marine aerosols to ice nucleation in particular for the Atlantic sector. In addition, long-travelled dust from Central Asia may play an important role on an event basis (Fig. 1). Ongoing work will aim to statistically estimate the relevance of these dust imports.

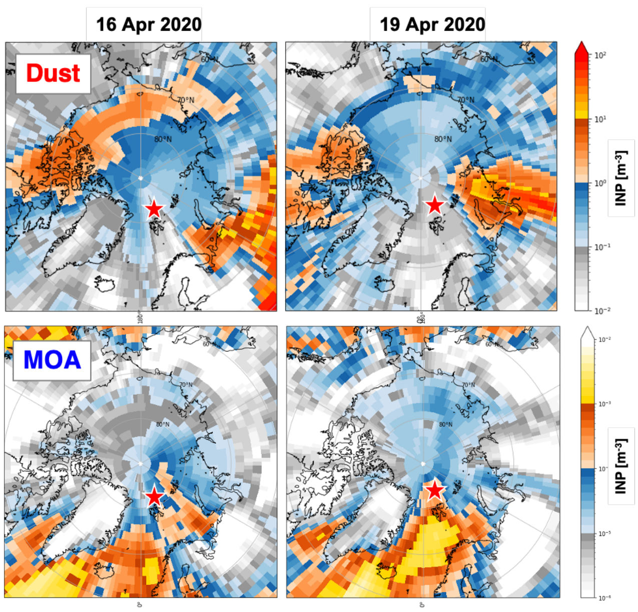

***Figure 1**: Concentration of potential ice nucleating particles (INPs) from marine and desert sources as calculated offline from the ECHAM6.3-HAM2.3 model results of the respective distribution of marine organic aerosol (MOA) and dust.*

Also, with respect to the role of desert dust in atmospheric freezing, cases of dusty cirrus over the Mediterranean and southern Europe have been investigated. So-called dusty cirrus clouds are extended cirrocumulus decks associated with strong dust outbreaks that are often not represented by numerical weather models even with interactive aerosol (Seifert et al., 2023), and therefore also probably not in the aerosol-climate model ICON-HAM2.3. Seifert et al. (2023) had assumed that the dusty cirrus clouds form due to a mixing instability of moist clean air with dry dusty air and had partially eliminated the model deficit with a corresponding sub-grid parameterisation. Here, the question has been tackled whether an underestimation of the modelled moisture transport in lofted Saharan air layers could also be a contributing factor. In collaboration with the Karlsruhe Institute of Technology (KIT), a process study has been started using the model system ICON-ART (Schröter et al., 2018). As a first exercise, the dusty cirrus case from 14 to 18 March 2022 was simulated with a 3-step nested setup for dust transport from North Africa to Europe, starting with the global horizontal grid resolution R03B07 (13 km), a North-African-European domain with grid R03B08 (6.5 km) and a Saharan domain with grid R03B09 (~3 km). In Fig. 2, the comparison of the synthetic and the MSG infrared imagery shows the underestimation of the cirrus cover in the area of the dust plume by the model. The evaluation with radiosonde profiles, however, could not confirm the hypothesis regarding the moisture deficit in the Saharan/Mediterranean air mass. Nevertheless, further model experiments are planned for the upcoming allocation period. In addition, the parameterisation from Seifert et al. (2023) could be tested in the ICON-HAM2.3 framework.

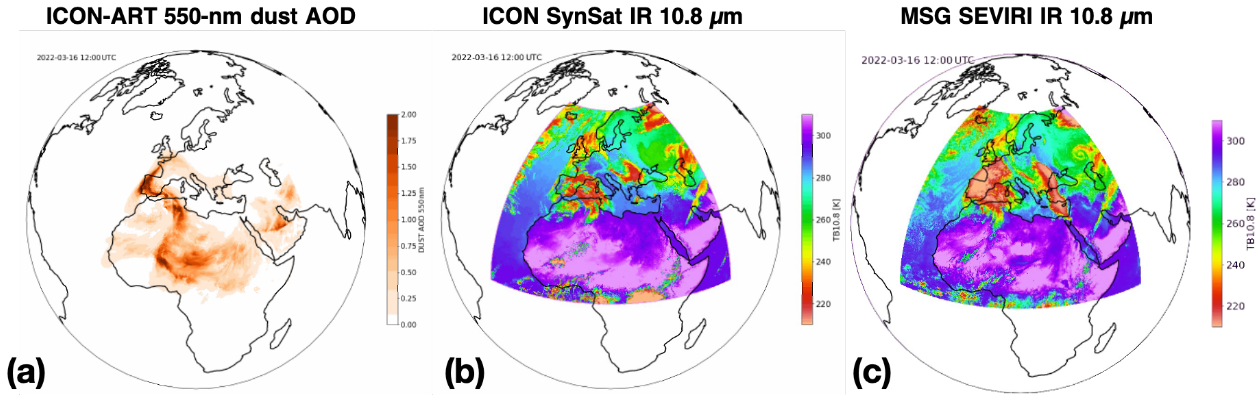

***Figure 2**: Saharan dust outbreak and cloud conditions for 16 March 2022 at 12:00 UTC: (a) map of 550-nm aerosol optical depth (AOD) of Saharan dust plume computed by ICON-ART as well as infrared (IR; 10.8 µm channel) brightness temperature maps based on (b) the infrared simulation from ICON-ART model output and (c) Meteosat Second Generation (MSG) SEVIRI data of EUMETSAT.*

Perspectives

Scientifically, further model studies are planned on the topic of dusty cirrus. Furthermore, the implementation of the novel albedo-based dust emission scheme by B. Baker (ARL) and K. Schepanski (FU Berlin) into the HAM2.3 module is still on the agenda.

Utilisation and Publication

All model developments and required input data are made available to the scientific community through the HAMMOZ website (https://redmine.hammoz.ethz.ch) and repository. The scientific results will be published in open-access journals.

References

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