Project: 1198 Project title: Aerosol-circulation interactions Principal investigator: Stephanie Fiedler Report period: 2022-11-01 to 2023-10-31

In 2023, we continued our successful research on Aerosol-circulation interactions. Below we will shortly present two highlights of our work in 2023 as well as a condensed listing of our activities using DKRZ resources in 2023.

Highlight 1: Exceptional East Asian dust storm (PhD project of Feifei Mu)

In mid-March 2021, one of the strongest dust storms of the last decade hit East Asia with adverse impacts on socio-economic activities and loss of life. Generally, such dust storms originate from the Gobi Desert owing to strong dust-emitting winds induced by the passage of Mongolian cyclones. Our assessment of the atmospheric dynamics involved in the case in 2021, however, highlights that the passage of the Mongolian cyclone was associated with dust emission in both the Gobi and the Taklamakan desert. The passage of the cyclone favored the formation of Nocturnal Low-Level Jets (NLLJs) in the Taklamakan Desert. Here, the NLLJs induced strong dust emissions in the following morning. We assessed the dynamics as well as the unusual characteristics and the air quality impacts of this dust storm by using DKRZ resources. This work was presented at EGU and is now published (Mu et al., 2023).

A systematic assessment of the East Asian dust activity associated with Mongolian cyclones is currently ongoing with details on dust emission, transport, and optical depth. The aim is to unravel to what extent exceptionally strong dust storms have changed while a negative trend in both mean dust emission and dust storm frequency over East Asia are seen. To that end, we compile a climatology of Mongolian cyclones induced dust storms with the help of high temporal resolution data from multiple sources, and results from an automated detection algorithm for extra-tropical cyclones in ERA5 reanalysis.

Highlight 2: Dust plume recognition (PostDoc project of Franz Kanngießer)

Our work on dust plume reconstruction over North Africa using machine-learning algorithms resulted in a manuscript submitted to AGU Advances (Kanngießer and Fiedler, 2023, in review). This work was based on codes developed by DKRZ's "Climate Informatics and Technologies" research group and used the DKRZ's GPUs. The results of this work were presented to ESA.

We currently continue to study plumes of Saharan dust transported to Europe. To do so we combine information from satellite sensors and ground-based observations, including remote sensing and in-situ observations. The results from combining this plethora of information is validated against reanalysis data and numerical forecasts for assessing the quality of the new product. The results are currently in preparation for a publication (Kanngießer and Fiedler, in prep.).

Other work done in 2023 within project 1198 involving DKRZ resources (in random order):

- Scientific exploitation of previously performed WRF and WRF-chem experiments with DKRZ computing resources (Reyers et al., 2023, Bechi Ferchichi et al., in review)
- Tests of offline dust emission model (Vidya Varma)
- Integration of ICON into ESM-Tools in preparation of planned ICON model simulations in 2024 (Sebastian Wahl).
- CMIP6 and satellite data analyses: Inter-comparison of CMIP6 output (historical, DAMIP, AerChemMIP) and validation against satellite-derived and ground-based observation (Varma and Fiedler, in prep.).

- Analysis of RFMIP-ERF and RFMIP-SpAer model output (Fiedler et al., 2023)
- Analysis of low-level jets based on ERA5 (Weide Luiz and Fiedler, in prep.).
- Data analyses for projects of master and PhD students (Linh Ho, Rovina Pinto, Lisa Weber)

Publications (published or in review)

- Fiedler, S., van Noije, T., Smith, C.J., Boucher, O., Dufresne, J., Kirkevåg, A., Olivié, D., Pinto, R., Reerink, T., Sima, A., Schulz, M.: Historical Changes and Reasons for Model Differences in Anthropogenic Aerosol Forcing in CMIP6. Geophysical Research Letters, 50 (15), DOI: 10.1029/2023GL104848, 2023.
- Mu, F., Weide Luiz, E., Fiedler, S.: On the dynamics and air-quality impact of the exceptional East Asian dust outbreak in mid-March 2021. Atmos. Res. 292, 106846. DOI: 10.1016/j.atmosres.2023.106846, 2023.
- Reyers, M., Fiedler, S., Ludwig, P., Böhm, C., Wennrich, V. and Shao, Y.: On the importance of moisture conveyor belts from the tropical East Pacific for wetter conditions in the Atacama Desert during the Mid-Pliocene. Climate of the Past, 19 (2), pp 517–532. DOI: 10.5194/cp-2022-72, 2023.
- Bechir Ferchichi, K., incl. Fiedler, S. and Mu F.: Genetic diversity of the Atacama Desert shrub Huidobria chilensis in the context of geography and climate, Global and Planetary Change, preprint DOI: 10.1101/2023.09.20.558398, in review.
- Kanngießer, F. and Fiedler, S.: "Seeing" beneath the clouds machine-learning-based reconstruction of North African dust events, AGU Advances, in review.

Publications (in preparation)

- Kanngießer, F. and Fiedler, S.: Reconstructing Saharan dust events in Europe combining satellite, ground-based and in-situ observations, in prep.
- Varma, V. and Fiedler, S.: Anthropogenic Aerosol-Induced Changes in Atmospheric Circulation and Energy Transport: Insights from CMIP6 Simulations, in prep.
- Weide Luiz, E. and Fiedler, S.: Global climatology of low-level-jets: occurrence, characteristics, and meteorological drivers, in prep.

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