Project: 1198

Project title: Aerosol-circulation interactions

Principal investigator: Stephanie Fiedler

Report period: 2023-11-01 to 2024-10-31

We have continued our successful research on Aerosol-circulation interactions. Below we present three examples of our work in 2024 as well as a short listing of other activities using DKRZ resources in 2024.

Global climatology of low-level jets

We have completed the analysis for the first global climatology of low-level jets, which are wind speed maxima a few hundred meters above the surface (Weide Luiz and Fiedler, 2024). The work is based on ERA5 reanalysis data and an automated detection algorithm for low-level jets (Fiedler et al., 2013). The spatial pattern of the occurrence of low-level jets highlight their global occurrence with some areas like coastal upwelling regions being particularly favourable for their formation. The results inspire further research using ship-based measurements of wind speed profiles that we will collect in the tropical Atlantic from January to March 2025 thanks to two newly funded expeditions with RV METEOR as part of the data collection of Experiments with the Portable Observatory for Dust Transport (EXPORT) of the PI.

Response of circulation to aerosol forcing

As part of CRC 1502 Project B02: “Towards a better understanding of moisture responses to radiative forcing”, we have analysed observational data and CMIP6 output from the historical experiments, and single-forcing experiments for aerosols from AerChemMIP and DAMIP. The analyses involved approximately 14 different models and more than 450 individual simulations. Results from the analyses suggest a response of the northward heat transport to spatial patterns of aerosol radiative effects with implications for Arctic Amplification (Varma and Fiedler, in prep). Further studies are now underway that build on the data workflows created for this study and inspire also the AerChemMIP2 experiment protocol for CMIP7 models (Fiedler et al., in prep.).

AI-based reconstruction of dust observations

Our work on dust plume reconstruction using machine-learning algorithms was published in AGU Advances (Kanngießer and Fiedler, 2024). We continued our work on reconstructing an extreme dust plume transported to Europe in March 2022 by combining satellite, ground-based remote sensing, and ground-based in-situ observations. We compared our reconstruction results against reanalysis data and archived dust forecasts (Kanngießer and Fiedler, in prep.). The focus is on dust plume reconstructions at a high temporal resolution of 15 min during daytime in and around the Bodélé depression, a major dust source of global relevance. Results from the dust reconstructions were presented to EUMETSAT and are used in a follow-up student project in physics.

Other work done in 2024 within project 1198:

- Development of a revised scaling for the simple plumes parameterization for the historical period began for CMIP7, including ICON simulations with diagnostic calls to the radiation scheme to compute the instantaneous radiative forcing of anthropogenic aerosols (Fiedler et al., in prep).
- Data analyses by five PostDoc, four PhD students, and four master students on topics addressing aerosols, circulation, or both.
- Ongoing experiments with an offline dust emission model for CRC 1502.

Project-based publications

- Bayr, T., Lübbecke, J. F., and Fiedler, S.: Is El Niño-Southern Oscillation a tipping element in the climate system? *Geophysical Research Letters*, 51, e2023GL107848. https://doi.org/10.1029/2023GL107848, 2024.
- Bechir Ferchichi, K., Böhnert, T., Ritter, B., Harpke, D., Stoll, A., Morales, P., Fiedler, S.**,** Mu**,** F., Bechteler, J., Münker, C., Koch, M.A., Wiehe, T., and Quandt, D.: Genetic diversity of the Atacama Desert shrub Huidobria chilensis in the context of geography and climate, *Global and Planetary Change*, 104385, https://doi.org/10.1016/j.gloplacha.2024.104385, 2024.
- Kanngießer, F. and Fiedler, S.: "Seeing" beneath the clouds - machine-learning-based reconstruction of North African dust events, *AGU Advances*, 5, e2023AV001042, https://doi.org/10.1029/2023AV001042, 2024.
- Luiz, E. W., and Fiedler, S.: Global climatology of low-level-jets: Occurrence, characteristics, and meteorological drivers. *Journal of Geophysical Research: Atmospheres*, 129, e2023JD040262. https://doi.org/10.1029/2023JD040262, 2024.
- Scheele, R., and Fiedler, S.: What drives historical and future changes in photovoltaic power production from the perspective of global warming? *Environ. Res. Lett*. 19 (1), DOI 10.1088/1748-9326/ad10d6, 2024.

Acknowledgments

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