Project: **1198**
Project title: **Aerosol-circulation interactions**
Principal investigator: **Stephanie Fiedler**
Report period: **2025-11-01 to 2026-10-31**

Our research has advanced the understanding of aerosol in the climate system, as visible by several publications and conference contributions. Below, we give three examples and briefly summarise additional works using DKRZ resources during the report period.

We used CMIP6 output to investigate how anthropogenic aerosols influenced historical rainfall changes, with focus on the transition from severe droughts in the 1970s and 1980s to wetter conditions in recent decades over the Sahel (marked by rectangle in Fig. 1). The study showed that anthropogenic aerosols primarily drove these changes (AER in Fig. 1) through their influence on the meridional heat transport, while the precipitation response to greenhouse-gases (GHG in Fig. 1) was substantially weaker (Nnamchi and Fiedler, 2026).

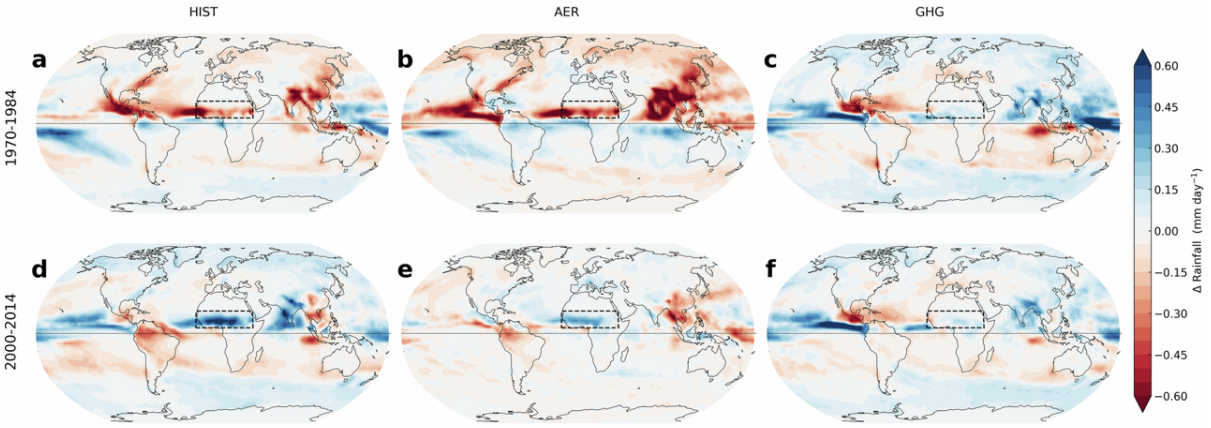

Figure 1: *Shown are the changes in rainfall for the* ***a*****–****c** *1970–1984 and* ***d*****–****f** *2000–2014 periods, based on the* ***a****,* ***d*** *HIST,* ***b****,* ***e*** *AER and* ***e****,* ***f*** *GHG multimodel simulations (Nnamchi and Fiedler, 2026).*

Another study applied a *k*-nearest-neighbours approach to reconstruct the cloud-obscured Saharan dust plume transport towards Europe on 15 March 2022. Combining SEVIRI satellite imagery with ceilometer and photometer observations allows a reconstruction of the plume's spatial extent, where other methods failed (Kanngießer and Fiedler, 2026).

A third study was based on a master thesis and investigated the Northern Hemisphere winter response to the historical Krakatoa and Pinatubo eruptions using multi-member ensembles from 15 CMIP6 models and three reanalysis datasets. The CMIP6 multi-model mean indicates that both eruptions strengthened the polar vortex and promoted a positive phase of the North Atlantic Oscillation during the first post-eruption winter, contributing to warmer winters in parts of northern Eurasia. Although internal variability influenced individual model responses, the simulated changes in surface temperature and circulation show little dependence on the phase of the El Niño–Southern Oscillation (Weber et al., 2026).

As a part of the EU project EXPECT at Heidelberg University, we have updated the anthropogenic aerosol forcing dataset for future scenarios (2023-2100) for use in CMIP7 (Fiedler and Azoulay 2026a; Fiedler and Azoulay 2026b) and their extension until 2500 (Fiedler, S., Leibensperger III, R. J.and Azoulay, A.,2026) for the Simple Plumes (SP) parameterization. This version provides improved estimates of anthropogenic aerosol optical properties and their effects on clouds under seven different future scenarios as planned for CMIP7 experiments.

Further works supported by project 1198

- Data analyses by four PostDocs, three PhD students, and seven master students on topics addressing aerosols, circulation, or both.
- Experiments with an offline dust emission model for CRC-1502 DETECT, which has been completed and is a basis for a new CRC application in preparation.
- AI and machine learning-based project focusing on dust reconstruction and the application of self-organising maps to identify atmospheric circulation patterns (Leuzinger et al; under review).
- Model data analysis for the MiRadOr project (Schrepfer et al, in prep.).
- Setting up ICON model experiments for studying climate forcing and response, partly as contribution to the new AerChemMIP2 protocol (Fiedler et al., 2026)

Publications

- Nnamchi, H.C. and Fiedler, S. *Anthropogenic aerosols override greenhouse gases in Sahel climate change. Commun Earth Environ **7**, 331* https://doi.org/10.1038/s43247-026-03474-3 , 2026
- Kanngießer, F. and Fiedler, S. *Intercomparison case study of data-driven reconstructions of a cloud-obscured Saharan dust plume in Europe. Sci Rep **16**, 17165 (2026).* https://doi.org/10.1038/s41598-026-55422-y, 2026.
- Weber, L., Krüger, K., and Fiedler, S. *On CMIP6 model consensus for the climate response in Eurasian winter to historical volcanic eruptions. Geophysical Research Letters, 53, e2025GL120522.* https://doi.org/10.1029/2025GL120522 , 2026.
- Fiedler, S., O'Connor, F. M., Watson-Parris, D., Allen, R. J., Collins, W. J., Griffiths, P. T., Kasoar, M., Kikstra, J., Kok, J. F., Murray, L. T., Paulot, F., Sand, M., Turnock, S. T., Weber, J., Wilcox, L. J., and Naik, V.: *AerChemMIP2 – unraveling the role of reactive gases, aerosol particles, and land use for air quality and climate change in CMIP7, Geosci. Model Dev., 19, 3477–3508,* https://doi.org/10.5194/gmd-19-3477-2026, 2026.
- Fiedler, S., and Azoulay, A. (2026). *CMIP7 Climate Forcings Dataset: Simple plumes for anthropogenic aerosols in H and VL scenarios (Version SPv2.1) [Dataset]. Zenodo.* https://doi.org/10.5281/zenodo.18713154, 2026.
- Fiedler, S., and Azoulay, A. *CMIP7 Climate Forcings Dataset: Simple plumes for anthropogenic aerosols in HL, M, L, LN, and ML scenarios (Version SPv2.1) [Dataset]. Zenodo*. https://doi.org/10.5281/zenodo.19845296, 2026.
- Fiedler, S., Leibensperger III, R. J. and Azoulay, A. (2026). *CMIP7 Climate Forcings Dataset: Simple plumes for anthropogenic aerosols in extended CMIP7 scenarios (Version SPv2.1) [Data set]. Zenodo.* https://doi.org/10.5281/zenodo.21671953, 2026.

Acknowledgement

We would like to conclude our report by acknowledging the resources provided by DKRZ, as well as the support from the DFG-funded Collaborative Research Centres CRC 1502 “DETECT” and ECMWF project “ForceDestinE” (ECMWF DE 341 IIASA), along with the EU-funded project “EXPECT” (No: 101137656, HORIZON-CL5-2023-D1-01) and the “MiRadOr” project under the funding of “Bundesministerium für Wirtschaft und Energie”. The third-party funding and DKRZ resources are indispensable for conducting our model experiments and data analyses, which form the foundation of our research.

ALIC²E AerosoL In Climate ChangE

INSTITUT FÜR UMWELTPHYSIK

UNIVERSITÄT HEIDELBERG ZUKUNFT SEIT 1386