

Project: **1051**

Project title: **Contribution to AerChemMIP with ECHAM-HAMMOZ simulations**

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Report period: **2022-07-01 to 2023-06-30**

Text: maximum of two pages including figures.

The aim of the project 1051 has been the contribution of the ECHAM-HAMMOZ community to the Recent report of Working Group 1 of the Intergovernmental Panel on Climate Change (IPCC/AR6) with a focus on atmospheric aerosol processes. The "Aerosol Chemistry Model Intercomparison Project" (AerChemMIP) was designed to quantify the climate and air quality impacts of aerosols and chemically-reactive gases in the climate models that are used to simulate past and future climate. The resulting dataset citation is Neubauer et al (2019). The model version for which results are provided is MPI-ESM1.2-HAM T63L47GR15.

The CMIP6 Diagnostic, Evaluation and Characterization of Klima (DECK) experiments and the CMIP6 historical and scenario simulations were carried out with interactive aerosol and aerosol-cloud interactions for liquid, mixed-phase and ice clouds in the course of the AerChemMIP project, those calculations have been completed in the previous project phase.. Specific diagnostics had to be implemented in the model as part of the CMIP6 data request to describe the chemical composition of the atmosphere, to evaluate the performance of the models, and to understand differences in behavior between them.

The generated model dataset is published as a referenced dataset :CMIP6.AerChemMIP.HAMMOZ-Consortium.MPI-ESM-1-2-HAM under <https://doi.org/10.22033/ESGF/CMIP6.1621> (Neubauer et al., 2019). The simulation data provides a basis for climate research designed to answer fundamental science questions, and the results were cited by the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC-AR6), e.g. in the estimate of the Multi-model mean Effective radiative forcings (ERFs) due to 3 aerosol changes between 1850 and the recent-past (1995-2014) in Chapter 6 of the report (see e.g. Figure 6.10 therein). Further publications have already used the data of these experiments (e.g. Allen et al., 2020, Mortier et al., 2020, Turnock et al., 2020, Zhang et al., 2021, and others). Further Results of AerChemMip were already presented in a Special Issue of ACP (https://acp.copernicus.org/articles/special_issue1057.html)

Models with detailed representation of microphysics of liquid, mixed-phase and pure ice clouds and their interactions with aerosols like ECHAM-HAMMOZ help to understand how anthropogenic emissions contributed to global radiative forcing during the historical period, uncertainties in forcing estimates, model performance and differences between models. In addition to quantifying the climate impacts, also air quality impacts of the aerosols and its development were subject of AerChemMIP studies. Further analysis utilizing AerChemMIP data which include the MPI-ESM1.2-HAM results are ongoing. At TROPOS, specific interest is on the future projections of aerosol emissions and distribution of natural aerosols such as dust.

Currently a considerable part of the model results remains on the DKRZ server to allow for further post processing and archiving, in addition to the data that were uploaded on the ESGF archive. During the previous project phase from 07/2022 to 04/2023 the CMIP6 and AerChemMIP experiments had been concluded. Only minimal computing hours had been requested, to ensure that further postprocessing could be completed. The data that remained on the server have been successfully migrated from Mistral to the new Levante HPC system. Due to a previous problem with postprocessing, the model output for the histSST experiment had to be reprocessed for the years 2010-2014. This has been achieved utilizing node hours from a different project.

Further post-processing and archiving could unfortunately not be completed the past period due to the long-term sick leave of the scientist who had managed and coordinated the model experiments.

Peer reviewed publications using the results (selected)

Allen, R. J., et al.: Climate and air quality impacts due to mitigation of non-methane near-term climate forcers, *Atmos. Chem. Phys.*, 20, 9641–9663, <https://doi.org/10.5194/acp-20-9641-2020>, 2020.

Mortier, A. et al.: Evaluation of climate model aerosol trends with ground-based observations over the last 2 decades – an AeroCom and CMIP6 analysis, *Atmos. Chem. Phys.*, 20, 13355–13378, <https://doi.org/10.5194/acp-20-13355-2020>, 2020.

Turnock, S. T., et al: Historical and future changes in air pollutants from CMIP6 models, *Atmos. Chem. Phys.*, 20, 14547–14579, <https://doi.org/10.5194/acp-20-14547-2020>, 2020.

Zhang, J., et al: The role of anthropogenic aerosols in the anomalous cooling from 1960 to 1990 in the CMIP6 Earth system models, *Atmos. Chem. Phys.*, 21, 18609–18627, <https://doi.org/10.5194/acp-21-18609-2021>, 2021.

Doherty, R. M., O'Connor, F. M., & Turnock, S. T. (2022). Projections of future air quality are uncertain. But which source of uncertainty is most important? *Journal of Geophysical Research: Atmospheres*, 127, e2022JD037948. <https://doi.org/10.1029/2022JD037948>

Dataset citation:

Neubauer, David; Ferrachat, Sylvaine; Siegenthaler-Le Drian, Colombe; Stoll, Jens; Folini, Doris Sylvia; Tegen, Ina; Wieners, Karl-Hermann; Mauritsen, Thorsten; Stemmler, Irene; Barthel, Stefan; Bey, Isabelle; Daskalakis, Nikos; Heinold, Bernd; Kokkola, Harri; Partridge, Daniel; Rast, Sebastian; Schmidt, Hauke; Schutgens, Nick; Stanelle, Tanja; Stier, Philip; Watson-Parris, Duncan; Lohmann, Ulrike **(2019)**. HAMMOZ-Consortium MPI-ESM1.2-HAM model output prepared for CMIP6 AerChemMIP. Version YYYYMMDD.Earth System Grid Federation. <https://doi.org/10.22033/ESGF/CMIP6.1621>