Project title: Contribution to AerChemMIP with ECHAM-HAMMOZ simulations

Project contributors:

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Project overview

Tropospheric aerosol interacts with the different compartments of the Earth system and is one of the main uncertainty factors in the determination of direct and indirect radiative forcing of climate. The causes for the uncertainties in quantifying the various roles of aerosols in the climate system range from uncertainties in emissions, transport, chemical and cloudmicrophysical processes and feedback processes between aerosols and biosphere and ocean. The contribution of absorbing aerosol is of particular interest for the aerosol composition since this aerosol type contributed to positive radiative forcing of the atmosphere and is considered as a major 'short-lived climate pollutant'. Modelling aerosol as interactive part of the climate system is required to understand its role in the decadal variation of surface solar radiation, temperature, and precipitation. In turn, the complex and highly variable composition of atmospheric aerosol in space and time requires thorough evaluation of the modelled aerosol distribution with a range of observations.

The Aerosol Chemistry Model Intercomparison Project (AerChemMIP) is designed to quantify the climate and air quality impacts of aerosols and reactive aases (https://wiki.met.no/aerocom/aerchemmip/start; Collins et al., 2017). The aim of AerChemMIP is to answer the following scientific questions: 1. How have anthropogenic emissions contributed to global radiative forcing and affected regional climate over the historical period? 2. How might future policies (on climate, air quality and land use) affect the abundances of aerosols and other near-term climate forcers and their climate impacts? 3. How can uncertainties in historical near-term climate forcer emissions be mapped onto pre-industrial to presentday changes? 4. How important are climate feedbacks to natural emissions, atmospheric composition, and radiative forcing? These questions will be addressed through targeted simulations with CMIP6 climate models that include an interactive representation of tropospheric aerosols and atmospheric chemistry. These simulations build on the CMIP6 Diagnostic, Evaluation and Characterization of Klima (DECK) experiments, the CMIP6 historical simulations, and future projections performed elsewhere in CMIP6, allowing the contributions from aerosols and/or chemistry to be quantified.

The well-established global aerosol-chemistry-climate model ECHAM6-HAMMOZ is jointly developed by partners from several European universities and research institutes. The model code is hosted at the ETH Zurich where it is made accessible to the research community; partners include scientists at the Universities of Oxford, Helsinki and Munich, as well as at the research institutes MPI Hamburg, FZ Jülich, TROPOS and GEOMAR. It simulates the lifeclyles of the climate-relevant aerosol species including microphysical transformation processes, and their climate impact. The current release includes the global atmospheric climate model ECHAM (current version 6.3), the aerosol-microphysics model HAM (current version 2.3), and the atmospheric chemistry model MOZART (current version 1.0). The model is continuously developed to take into account advances in understanding of aerosol processes from laboratory and field studies.

Range of planned work from the scientific view

The aim of the project is the preparation of the contribution of the HAMMOZ community to the next assessment report of the Intergovernmental Panel on Climate Change (IPCC/AR6) with a focus on atmospheric aerosol processes. The CMIP6 Diagnostic, Evaluation and Characterization of Klima (DECK) experiments and the CMIP6 historical simulations will be done with interactive aerosol and aerosol-cloud interactions for liquid, mixed-phase and ice clouds as a basis for the Aerosol Chemistry Model Intercomparison Project (AerChemMIP). Later also the AerChemMIP simulations will be done to quantify the climate and air quality impacts of aerosols. 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.

During the period 07/2016 to 06/2018 it is planned to carry out preparatory simulations that include the tuning of the fully coupled model MPI-ESM-HAM for participation in CMIP6/AerChemMIP. A final parameter tuning will be done using the CMIP6 boundary conditions with the latest version of MPI-ESM-HAM that is based on ECHAM6.3, HAM2.3 and MPIOM. For this the fully coupled model MPI-ESM-HAM will be run under pre-industrial conditions. The main tuning targets are the pre-industrial global mean temperature and surface energy balance. For this purpose, 2-10 years of simulations will be carried out for different tuning parameter set(s) over 200 years are done to test for drift in the ocean. Furthermore the equilibrium climate sensitivity and the effective radiative forcing due to anthropogenic aerosol will be determined for different parameter settings by carrying out mixed-layer ocean (MLO) simulations as well as atmosphere only simulations with ECHAM6.3-HAM2.3.

References

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