Project: **1051**

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

Principal investigator: **Ina Tegen**

Report period: **2017-07-01 to 2018-06-30**

The aim of this project is the preparation of the contribution of the ECHAM-HAMMOZ community to the next assessment report of the Intergovernmental Panel on Climate Change (IPCC/AR6) with a focus on atmospheric aerosol processes. It comprises the ECHAM-HAMMOZ contribution to the Aerosol Chemistry Model Intercomparison Project (AerChemMIP) that is designed to quantify the climate and air quality impacts of aerosols and reactive gases (https://wiki.met.no/aerocom/aerchemmip/start). Furthermore the ECHAM-HAMMOZ contribution to the Coupled Model Intercomparison Project Phase 6 (CMIP6) DECK (Diagnostic, Evaluation and Characterization of Klima) and CMIP historical simulations, which provide a basis for characterising CMIP model simulations, are part of this project.

During the phase from 07/2017 to 04/2018 preparatory simulations were carried out that include the calibration of uncertain model parameters (model tuning) of the fully coupled model MPI-ESM-HAM for participation in CMIP6/AerChemMIP. During this time period problems in the CMIP6 forcing data (stratospheric aerosol optical depth) and in the land model of MPI-ESM-HAM (JSBACH) became known. This required to repeat some of the tuning simulations. The originally planned atmosphere only and mixed-layer ocean simulations to characterize the equilibrium climate sensitivity and the effective radiative forcing due to anthropogenic aerosol could be shifted to a large part to a computer cluster in Switzerland, leaving more resources for the parameter tuning of MPI-ESM-HAM. Furthermore the preparation of the necessary input datasets for the present-day and historical (1850-2014) emission fields of the chemical species required for HAMMOZ has been done during this time period.

We could make use of all requested node hours during 07/2017 to 04/2018. In total about 2500 years could be simulated with MPI-ESM-HAM (T63L47GR15). A large part of the simulations was required for the parameter tuning, but also three longer (200-300 years) pre-industrial control simulations and five historical simulations (1850-2014) could be carried out to test for drifts in the global ocean temperatures and warming during the historical time period. Three different parameter settings were used for the longer pre-industrial control simulations and the historical simulations and for one parameter settings a mini-ensemble (3 ensemble members) for the historical time period was done, to differentiate changes due to natural variability and parameter tuning.

A first evaluation showed that the pre-industrial control simulation and the historical simulations with MPI-ESM-HAM have an overall reasonable climate. The simulations of radiation, cloud and aerosol fields at present day are similar to atmosphere-only ECHAM6.3-HAM2.3 simulations, observations and re-analysis data. Although MPI-ESM-HAM has some biases - e.g. too few clouds in marine stratocumulus regions - these biases are not larger than in atmosphere-only ECHAM6.3-HAM2.3 simulations and are also known from other coupled climate models. The simulations of ocean currents and sea surface temperature in MPI-ESM-HAM shows similar skills and biases as the CMIP5 simulation of MPI-ESM-LR. Compared to CMIP5 models, the effective radiative forcing due to anthropogenic aerosol in MPI-ESM-HAM has an average global mean strength of -1 Wm^{-2}. One highlight of MPI-ESM-HAM is the simulation of Arctic sea ice. The simulation of Arctic sea ice and current Arctic sea ice trends in MPI-ESM-HAM are similar as in the CMIP5 models selected by Massonnet et al. (2012), which simulate the present day Arctic sea ice well.

In the time period 05/2018 to 06/2019 we want to address a low bias in historical warming and biases in regional dust emissions via further parameter fine-tuning and other changes in the model configuration. Furthermore we plan to implement the extensive diagnostics required for CMIP6/AerChemMIP into MPI-ESM-HAM.