Project: **1004**

Project title: **Development and evaluation of aerosol processes in the community aerosol chemistry model HAMMOZ**

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Report period: **2025-07-01 to 2026-06-30**

The aim of this project is the on-going evaluation and coordination of further developments of the aerosol model HAM (Versions 2.2, 2.3) in close collaboration with scientists from the HAMMOZ consortium. 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 and Leipzig, at the Finish Meteorological Institute (FMI), at the Space Research Organization Netherlands (SRON), as well as at the German research institutes MPI Hamburg, TROPOS and GEOMAR. It simulates the lifecycles of the climate-relevant aerosol species including microphysical transformation processes, and their impact on clouds, radiation and climate. The model system includes the global atmospheric climate model ECHAM, the aerosol-microphysics model HAM, and the atmospheric chemistry model MOZART. The role of TROPOS in this project is to bring together the different aspects of the model development and to test the subsequent modifications in the aerosol distribution resulting from the changes of the aerosol parameterisation.

The aerosol-climate model ICON-HAM (Salzmann et al., 2022) was released in 2021. Here, the HAM (version 2.3) aerosol model is coupled to the climate model ICON-A (icon-aes-1.3.00).
At ETH Zurich, a version of ICON-HAM has been developed that is based on icon-2.6.4, i.e. the latest ICON version that contains the physical parameterizations inherited from the ECHAM model (e.g., the convection scheme, the cloud cover scheme, the vertical diffusion scheme and the gravity wave drag parameterizations for sub-grid scale orographic and non-orographic gravity waves). These are necessary to run the model at rather coarse resolutions like r2b4. This version of ICON-HAM has been installed on Levante and can be used for production. The most recent development of ICON-HAM is a code that contains a simplified and, thus, computationally inexpensive version of the HAM aerosol model, HAM-lite (Weiss et al., 2025). It is intended for use at high resolutions (<10 km) and has been further amended enabling the model system to be used in limited-area mode (LAM) (Heinold et al., 2026, under review). TROPOS has the responsibility to prepare and maintain the input data for ECHAM6.3-HAM2.3-MOZ1.0, ICON-HAM and ICON-HAM-lite-LAM. Thus, to enable users to fully explore the different models and configurations, a comprehensive set of input data is maintained and continuously developed on demand of the users.

Computing time granted for the report period was used for

a) <u>Simulation of the Hunga-Tonga-Hunga Ha'apai eruption in 2022</u>
In the framework of a master thesis project at TROPOS in collaboration with the University of Leipzig the eruption of the Hunga-Tonga-Hunga Ha'apai volcano (20.550°S,175.385°W) on 15 January 2022 has been simulated with the aerosol-chemistry-climate model ECHAM6-HAMMOZ (Schultz et al., 2018). This exceptional eruption emitted large amounts of $SO_2$, but also water vapour and sea salt into unprecedented altitude regions up to the mesosphere at about 57 km (Proud et al., 2022).
In addition to a reference simulation taking into account the emissions of $SO_2$, sea salt and water vapour, and a control simulation without the eruption, both of which were performed in the previous allocation period (2024/25), further sensitivity experiments have been conducted. The position of the eruption has been varied from its original location at 20°S closer to the equator (10°S) and to high latitudes (60°S) in order to study the effects on plume development and the spread of the emissions to different latitudinal bands and respective circulation factors.

**Table 1:** Counterfactual ECHAM6-HAMMOZ simulations of the 2022 Hunga-Tonga volcanic eruption.

| Experiment | $SO_2$ | Sea salt | $H_2O$ |
|---|---|---|---|
| Hunga Tonga only SO2 @ 20°S | o | x | x |
| Hunga Tonga only SO2 @ 10°S | o | x | x |
| Hunga Tonga only SO2 @ 60°S | o | x | x |
| Hunga Tonga emitting mineral dust | Dust | x | x |
| Hunga Tonga emitting black carbon | BC | x | x |
| Hunga Tonga emitting org. carbon | OC | x | x |

A conceptual study of the radiative effects of the volcano emitting mineral dust, black carbon or organic carbon instead of sulphate has been added. To this end modifications in the volcanic aerosol emission code became necessary. Table 1 provides an overview of the experiments. The simulations ran for two years each, with a spin-up period of three months, respectively. anthropogenic emissions from the IAMC inventory (Gidden et al., 2019) as prepared for CMIP6 were used. Sea surface temperatures and sea ice concentrations were prescribed to the model as climatologies over the period 2010-2022 taken from the AMIP data set (version 1.1.9).

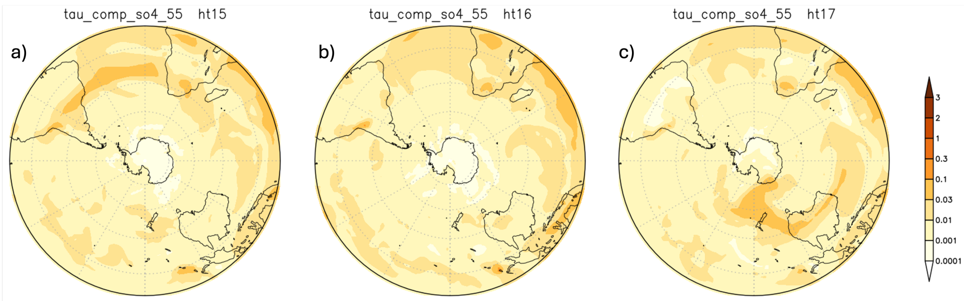


***Figure 1**:* ECHAM6-HAMMOZ simulation of the HT eruption on 15 Jan 2022. South-polar stereographic maps of sulphate AOD with the volcano being situated (a) at 20°S (b) at 10°S, and (c) at 60°S by 175°W.

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