Project: **1093**

Project title: **Revisiting the volcanic impact on atmosphere and climate – preparations for the next big volcanic eruption (VolImpact)**

Principal investigator: **Christian von Savigny**

Report period: **2025-11-01 to 2026-10-31**

The major goal of **VolIMpac**t is to improve the scientific understanding of the volcanic influence on atmosphere and climate (von Savigny et al., 2020). It is divided into five individual science projects. Below, we summarize the main contributions of the different sub projects over the last year. Due to the serious budget costs about 68% part of the originally planned work for 2026 could not be performed. The overall goal was that at least the PhD students could complete their work.

VolPlume contributions

High-resolution Large Eddy Simulations (LES) with a grid spacing of 600m were performed with ICON-ART to investigate the combined effects of plume dynamics, cloud microphysics, plume chemistry and aerosol dynamic processes for the case of the 2010 Eyjafjallajökull eruption (Iceland). We focused on the early stage and the processes within a distance of about 100km to the volcano. Although the effects on the SO2 oxidation were small (<10%), we found a large mobilization of iron in aged ash plumes. These findings are important because dissolved iron sedimenting into the ocean may increase phytoplankton growth as reported in previous publications.

Furthermore, we continued investigating the 2022 Hunga eruption, which we have intensively studied in the past two years with a focus on early plume development and atmospheric wave generation (see previous reports; Bruckert et al. 2026, in review). This year, we concentrated on the effects of the plume on the mesoscale circulation. High temporal resolution output data (30sec) from ICON-ART LES simulations and station-based meteorological observations show that the strong updrafts in the Hunga plume caused a pressure deficit at the surface which leads to an inflow of air from the surrounding environment.

VolARC contributions

To answer the reviewers' questions about the statistics of the model and satellite data comparison of the volcanic cloud evolution after the Manam and Sarychev eruptions (Pohl et al., 2026), we ran additional simulations with the ECHAM-HAM aerosol microphysical model. We increased the output frequency and repeated some previous simulations.

VolCloud contributions

In 2026 we performed simulations with ICON-ART focusing on the interaction of volcanic aerosols and clouds after the eruption of the Raikoke volcano in 2019. These simulations have been run on a 5 km grid over 3.5 days after the eruption. Three different simulations, one without an eruption, one with the emission of volcanic SO2 only and one with the emission of both volcanic SO2 and ash were compared to identify the effects of the aerosols separately. The results for the SO2-only emission with sulfate, created from volcanic SO2, acting as a cloud condensation nuclei (CCN) show a 40% increase in the condensation of cloud droplets, and a 10% decrease in the homogeneous freezing of cloud ice but no impact on the heterogeneous freezing rate. Volcanic ash, acting as an ice nucleating particle (INP), leads to a 25% decrease in the condensation of cloud droplets, another 10% decrease in the homogeneous freezing and an increase by a factor of 5x10^5 in the heterogeneous freezing rate due to volcanic ash inside the plume area. Sulfate leads to a decrease of the average size of cloud droplets by 40% and volcanic ash leads to a decrease of the size of ice particles by a factor of 0.05. This corresponds well with the theoretical expectations of more, but smaller hydrometeors when aerosols are present.

Another simulation with the plume amplified by a factor of 10 has been compared to those simulations to quantify the impact of aerosol concentrations. This amplification leads to an increase of the total mass of frozen hydrometeors, but shows only a small impact on liquid hydrometeors.

Additionally, simulations with an idealized mineral dust background have been run to analyze the effects of background INPs compared to volcanic ash. Those results show that especially for warmer temperatures, heterogeneous freezing due to mineral dust creates the majority of ice hydrometeors whereas volcanic ash is the main source of INPs in very high concentrated areas of the plume and at temperatures below -33 °C.

Finally, a study on internally mixed aerosols, which are ash aerosols coated with sulfate, has been started. Those mixed aerosols also act as INPs but with a decreased efficiency compared to uncoated ash. The analysis is still ongoing and will be finished in the last quarter.

VolDyn contributions

During the report period, we summarized our latest HAMMONIA modeling result in a manuscript. Initially, we applied for computing time and disc space to perform additional post-processing that might be requested during the peer review process. The manuscript, however, is not yet submitted and none of the allocated resources were used.

VolClim contributions

We have extended the large ensemble of idealized volcanic eruptions (EVA-ENS, Azoulay et al, 2021;Timmreck et al 2024) with sensitivity experiments that consider different eruption seasons. These have been often asked by the reviewers. We did this for one eruption strength (40 Tg S) at three different locations and for three different seasons resulting in a 900 member ensemble of a 5 year MPI-ESM simulation. This work was however only possible as we did the experiments in November/December 2025 using allocated computing time resources for 2025. The analysis of the EVA-ENS simulations is still ongoing and a few papers are in preparation. The start of the long time arching of the data has been postponed to the last quarter of this year due to the transition of the archival system.

References

Azoulay, A., H. Schmidt and C. Timmreck (2021), The Arctic polar vortex response to volcanic forcing of different strength, J. Geophys. Res., 126, e2020JD034450. https://doi.org/10.1029/2020JD034450

Bruckert, J., Bierbauer, S., Böttinger, M., Horváth, Á., de Lozar, A., Muth, L., Hoshyaripour, A., Convective dynamics drive plume ascent and atmospheric wave generation during the 2022 Hunga eruption, 2026, in review for Nature Communications - Earth & Environment

Pohl, C., Niemeier, U., Rozanov, A., Wrana, F., and von Savigny, C.: Evaluating SCIAMACHY-retrieved and ECHAM-simulated stratospheric aerosol characteristics by their comparison after volcanic eruptions, EGUsphere [preprint], doi.org/10.5194/egusphere-2026-578, 2026.

Timmreck, C., D. Olonscheck, A. Ballinger, R. d'Agostino, S.-W. Fang, A. P. Schurer and G. C. Hegerl, (2024), Linearity of the climate response to increasingly strong tropical volcanic eruptions in a large ensemble framework, J. of Climate, 37, 2455–2470, https://doi.org/10.1175/JCLI-D-23-0408.1.