## Abstract

An ability to reliably predict and anticipate future changes to the climate system depends on the adequacy of our understanding of the processes involved in climate change. Explosive volcanic eruptions are unique natural experiments that provide unprecedented insight into many of these key processes. Understanding how the climate system responds to volcanic forcing not only tests our understanding of processes determining climate change, it also facilitates the interpretation of past climate records, and thus motivates long-standing interest in volcanic effects on the climate system.

The overarching goal of the proposed research unit is to improve our understanding of how the climate system responds to volcanic eruptions. It achieves this objective by building on and exploiting important recent advances in models and measurements. Advances of the observation system comprise the availability of daily near-global observations of multi-spectral aerosol extinction from the first global and continuous limb-scatter instruments OSIRIS, SCIAMACHY and OMPS-LP. These are exploited to deliver much better information about the evolution of volcanic plumes and their impact on stratosphere and climate. In addition, the recently launched SAGE III/ISS and the upcoming satellite missions EarthCARE and ALTIUS will provide high resolution observations of aerosols and clouds. Recent improvements in modelling capabilities enable now the possibility to perform simulations at unprecedented high spatial resolutions, which finally allow linking the mesoscale evolution and dynamics of volcanic eruptions with larger-scale circulation systems. When combined with state of-the-art aerosol and cloud microphysical models, these approaches offer the opportunity to link eruptions directly to their climate forcing. In addition, they provide the chance to integrate simulations of volcanic processes over a broad range of scales within a single model. Further, the recent development of a volcanic forcing generator provides an efficient method for testing the influence of parameters relevant for the volcanic forcing in an Earth system model environment. The modelling advances make it possible to study for the first time the effects of volcanic eruptions consistently over the full range of spatial and temporal scales involved, addressing the initial plume development of explosive eruptions, the variation of stratospheric aerosol particle size and radiative forcing caused by volcanic eruptions, the response of clouds, the effects of volcanic eruptions on atmospheric dynamics, as well as their climate impact.

The ambitious research program of the VolImpact research unit is beyond the capabilities of a single research group, because it requires expertise in a variety of complementary disciplines including aerosol microphysical modelling, cloud physics, climate modelling, global observations of trace species, clouds and stratospheric aerosols. Results from our proposed research unit will improve the understanding of the response of the Earth system to external forcing, facilitate much better prediction of climatic consequences of future volcanic eruptions, and uniquely improve our understanding of the historical record and of key processes relevant to climate change more generally. In addition, our research will guide the design of instruments needed to adequately observe and document future volcanic eruptions. As a result, society will be in a better position to exploit these natural experiments to test our understanding of the climate system.