Project: **959**

Project title: **eVolv2k: Ice core-based volcanic forcing of climate variability for the past 2000 years**

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Report period: **2016-01-01 to 2016-12-31**

The focus of eVolv2k is the production of the next-generation of volcanic climate forcing for climate models, based on improved data and improved implementation of the forcing within climate models. The project also aims to use the new forcing in climate model simulations to investigate decadal-scale climate variability related to volcanic forcing.

Work in 2016 focused largely on the development, testing, and first scientific applications of the Easy Volcanic Aerosol (EVA) forcing generator (Toohey et al., 2016) and a volcanic forcing database for the past 2500 years (Toohey and Sigl, 2016). Further work involved performing simulations of the 1815 Tambora eruption with the MAECHAM5-HAM volcanic aerosol model, in collaboration with the VolMIP project.

(1) Development of EVA and reconstructed forcing sets

The Easy Volcanic Aerosol (EVA) forcing generator produces stratospheric aerosol optical properties as a function of time, latitude, height and wavelength for a given input list of volcanic eruption attributes (Toohey et al., 2016). EVA is based on a parameterized three-box model of stratospheric transport, and simple scaling relationships used to derive mid-visible (550 nm) aerosol optical depth and aerosol effective radius from stratospheric sulfate mass. Pre-calculated look up tables computed from Mie theory are used to produce wavelength dependent aerosol extinction, single scattering albedo and scattering asymmetry factor values. First comparisons show good agreement between EVA-based reconstructions of the radiative properties of volcanic aerosols from eruptions over the past decades with satellite observations (Fig. 1).

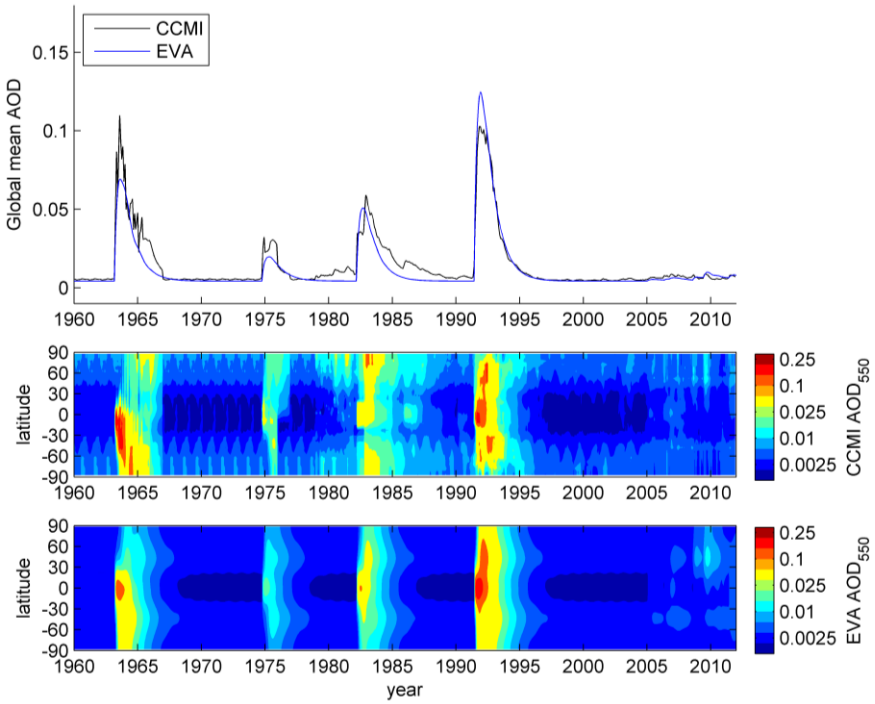

Fig 1: Aerosol optical depth (AOD) at mid-visible (550 nm) wavelength from the CCMI and EVA reconstructions (Toohey et al., 2016). Global mean AOD is shown in the top panel, while zonal mean values are below. The CCMI data are based on satellite, ground-based observations and model simulations (Eyring and Lamarque, 2013).

First tests of a prototype EVA version were performed with the MPI-ESM, focussing on the 1800-1830 time period, when 2 major eruptions occurred (1809 and 1815). The resulting

temperature anomalies, reaching a maximum global mean cooling of 1°C, are similar to prior experiments (Zanchettin et al., 2013). These simulations were voluntarily performed under the ESM1 general project (mh0469) project, and were therefore did not consume resources granted to eVolv2k (bm0959).

A volcanic forcing data set has been developed for the past 2500 years, specifically for use in the Paleo-Modelling Intercomparison Project phase 4 (Kageyama et al., 2016). The forcing "package" includes the EVA forcing generator along with reconstructed estimates of the sulfur dioxide (SO_2) injections by major volcanic eruptions, based on interpretation of ice cores (Toohey and Sigl, 2016). A document describing the SO_2 injection estimation method, and the resulting reconstructed radiative forcing and its implications is currently in preparation (Toohey and Sigl, in preparation). Furthermore, a prototype volcanic forcing data set was developed for the full Holocene, for use in a special MPI-M initiative aimed at simulating the climate of the Holocene with MPI-ESM.

(2) VolMIP Tambora simulations

In cooperation with project ALARM-II (part of Miklip-II Module B), simulations of the 1815 Tambora eruption were performed with the MAECHAM5-HAM model, according to the standardized specifications set by the VolMIP project (Zanchettin et al., 2016). Within eVolv2k, these simulations will be used to explore issues related to the transport and deposition of sulfate to polar ice sheets, in order to better interpret ice core sulfate observations. Consistent with prior studies, the sulfate deposition shows similar spatial structure to ice core results corresponding to Tambora (Fig. 2).

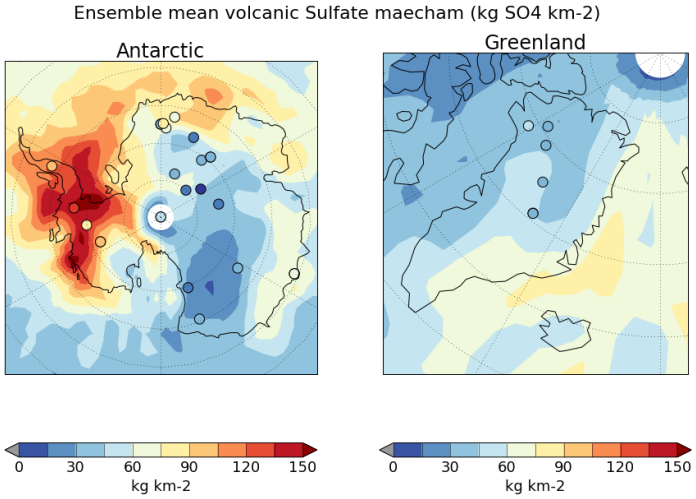

Fig 2: MAECHAM5-HAM simulated sulfate deposition to Antarctica and Greenland (colored contours) compared to ice core measured fluxes resulting from the 1815 Tambora eruption. Model results have been scaled to highlight the correlation of simulated and observed spatial variability in deposition.

(3) DKRZ resource use in 2016

Given the research time invested into unforeseen opportunities in 2016, including the construction of a prototype Holocene volcanic forcing database, a number of simulations planned for 2016 within the project were not performed. Some of these experiments are currently in progress, and some are postponed until 2017.

References

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