Project: **960**

Project title: **StratoClim Stratospheric and upper tropospheric processes for better climate predictions**

Project lead: **Claudia Timmreck**

Report period: **2017-01-01 to 2017-12-31**

The central goal of the MPI contribution to StratoClim is to investigate the climate impact of upper tropospheric and stratospheric aerosol. For 2017, CMIP6 (Coupled Model Intercomparison Project, Phase 6, Eyring et al., 2016) related work was planned in the frame of the “Model Intercomparison Project on the climate response to Volcanic forcing” (VolMIP, Zanchettin et al; 2016). In VolMIP different time scales are considered: the seasonal-to-interannual atmospheric response to a 1991 Pinatubo-like volcanic eruption (volc-pinatubo) and the long-term (up to the decadal time scale) climate response to very strong volcanic eruptions, like the 1815 Tambora eruption (volc-long). In this project the VolMIP volc-long experiments will be performed

Different from the original plan in 2017, the VolMIP MPI-ESM runs could not be carried out in 2017 because the MPI-ESM PiControl run and the scripting environment for CMIP6 were not available. There are now expected for late 2017/early 2018. This will be the start of the VolMIP volc-long experiments in StratoClim. In 2017 preparatory work for VolMIP has been carried out. We have tested the sensitivity of climate in the early 19th century to various volcanic forcing estimates using estimated uncertainties in volcanic stratospheric injections and the volcanic forcing generator EVA (Toohey et al., 2016). MPI-ESM ensemble simulations have been performed (under project 960 and 764) and compared to climate reconstructions for the time period. Our results show that a combination of volcanic forcing and internal variability most likely led to the climate evolution of the early 19th century. The range of volcanic forcing uncertainties is similar to the range of internal variability. The reconstructed temperature anomalies lie in general, within the range of simulated temperature anomalies incorporating uncertainties in the volcanic forcing (Figure 1). However time between the two eruptions is colder and the signal of the 1809 eruption is weaker in the reconstructions.

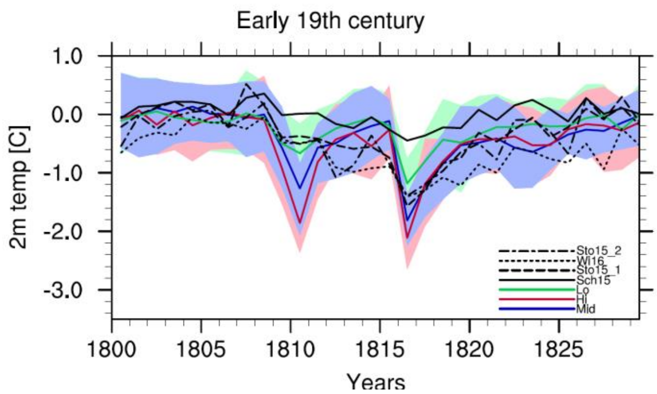

Figure 1: Northern Hemisphere summer land temperature anomalies simulated with the MPI-ESM using the three forcing reconstructions (Lo, Hi, Mid) based on the evolv2k reconstruction (Toohey and Sigl, 2017) compared to temperature reconstructions (Wi16: Wilson et al., 2016; Sch15: Schneider et al., 2015; Sto15 (1,2): Stoffel et al. (2015). The shaded regions indicate the envelope of the simulated anomalies.

In addition, StratoCLIM will simulate unperturbed and enhanced stratospheric aerosol loading under present and future conditions with the global aerosol model ECHAM5-HAM. In another VOLMIP prestudy the volcanic aerosol size distribution after the Tambora eruption was simulated with a well defined emission protocol (60 Tg SO_2, over 24 hours, equator, 22-26 km). Results of the ECHAM5-HAM study in comparison with other global models reveal large differences for example in the sulfur burden (Fig 2, Marshall et al., 2017). It is therefore important to understand the differences in the inter-model spread. StratoCLIM will therefore also contribute to the international SSiRC (Stratospheric Sulfur and its Role in Climate, http://www.sparc-ssirc.org) stratospheric aerosol model intercomparison project ISA-MIP (Timmreck et al, to be submitted, 2017), which aims to address existing uncertainties and differences among the models with respect to aerosol radiative forcing and its climate response. Unfortunately the planned simulations for the ISA-MIP experiments had to be postponed as well, as the experimental design has only recently be completely fixed. They will be carried out in 2018.

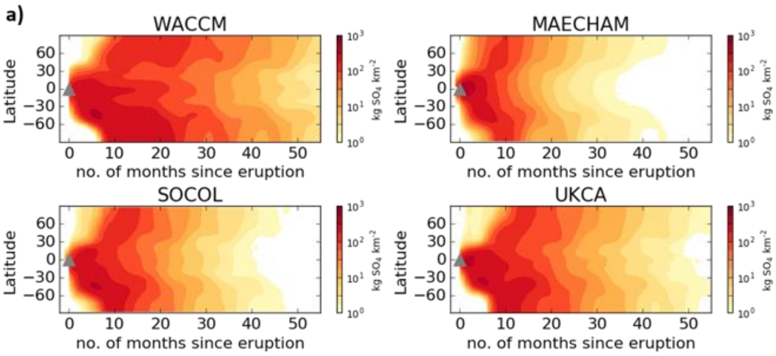

Figure 2: Zonal mean monthly mean atmospheric sulfate burdens [kg SO_4 km-2] in the aftermath of a Tambora eruption simulated with different global aerosol models and a well-defined emission protocol. The grey triangle marks the start of the eruption (1 April 1815). (Figure from Marshall et al., 2017).

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