Project: **769**

Project title: **Alert for LARge volcanic eruptions in Medium term climate prediction (ALARM)**

Project lead: **Claudia Timmreck**

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The central goal of the MiKlip ALARM project is to study the response of the climate system to volcanic aerosol perturbations and the effects of past historic volcanic eruptions. The allocated data resources for the corresponding HLRE project 769 were essential for the continuation of the data analysis of work carried out in MiKlip I/ALARM and the preparation of scientific papers.

1.1 Simulation of a future volcanic eruption

A two-step modelling approach has been applied to consider the effect of large volcanic eruptions in the MiKlip decadal prediction system. In a first step the formation of volcanic sulfate aerosol and its optical parameters (Aerosol optical depth (AOD), effective radius (Reff)) were calculated from the initial stratospheric SO_2 injection with the middle atmosphere version (Niemeier et al., 2009) of the aerosol climate model ECHAM/HAM (Stier et al., 2005). This includes a module of aerosol microphysics and a parameterized stratospheric chemistry module. In a second step AOD and Reff were used as monthly mean forcing in the decadal prediction system. Three Pinatubo forecasts with the baseline-1 (b1) version of the MiKlip prediction system (Pohlmann et al., 2013; Marotzke et al, 2016) were performed. Two experiments addressed a Pinatubo like eruption in 2013 one with the MR and one with the LR version and an additional b1-LR experiment a Pinatubo like eruption in 2015. The experiments show a strong dependence of post volcanic Northern Hemisphere winter climate from the resolution (not shown) and the background conditions (Figure 1). Further analysis is ongoing (Timmreck et al., in prep. for Clim. Dyn.).

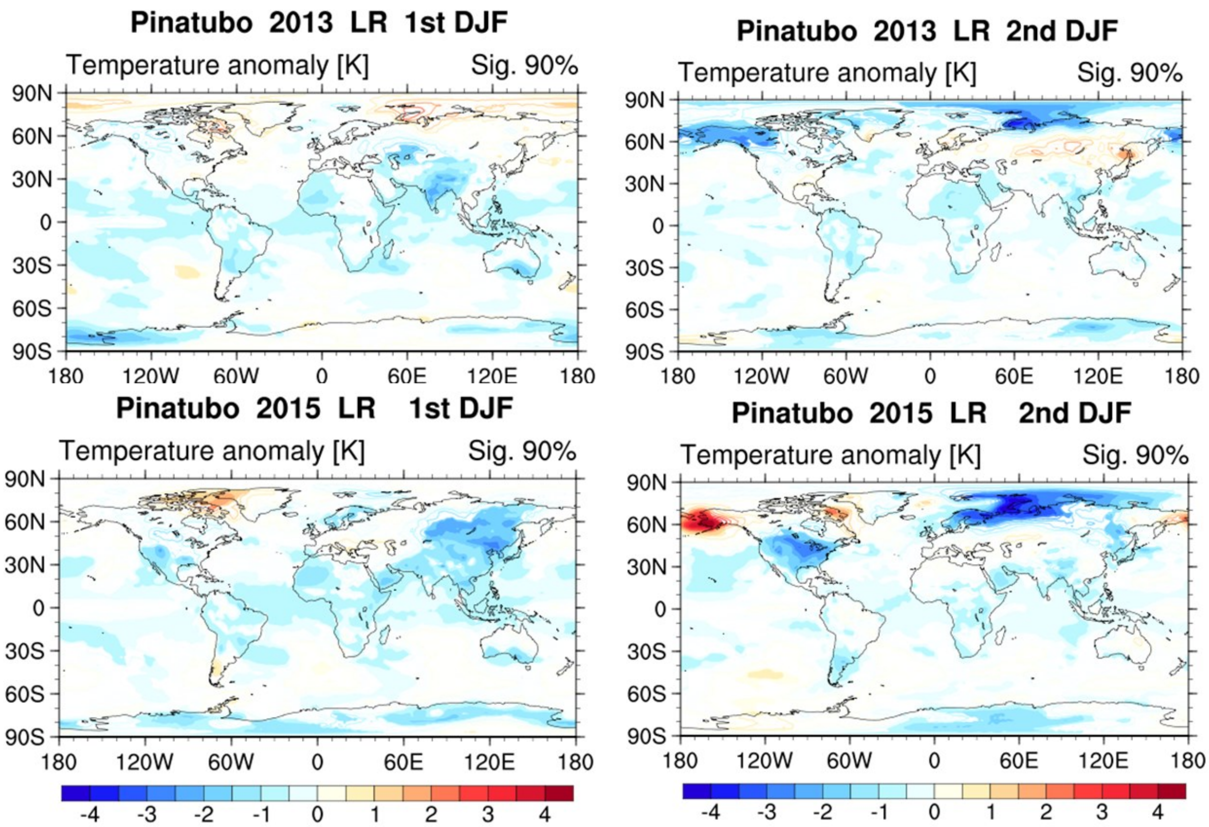

Figure1: DJF surface air temperature anomalies for the 1st (left) and 2nd (right) post volcanic winter for a Pinatubo like eruption in 2013 and 2015. Ensemble mean of baseline-1 LR forecast simulations. The shaded regions are significant at the 90% level.

1. 2 Analysis of the historic 100 member ensemble

We are currently analysing the 100-member ensemble of historical (1850–2005) simulations performed with the Max Planck Institute Earth System Model (MPI-ESM). In a first study we have concentrated on the stratospheric temperature and wind response in the 1st post volcanic Northern Hemisphere (NH) winter (Bittner et al, 2016b). It is shown that state of the art climate models are capable to simulate such a strengthening, but this evidence depends crucially on the number of ensemble members involved. Our results show that an ensemble larger than what is provided by the CMIP5 models is needed to detect a statistically significant NH polar vortex strengthening. The most robust signal can be found when only the two strongest eruptions over the historical period are considered in contrast to including smaller eruptions to increase the sample size. For these two eruptions, the mean of 15 CMIP5 shows a statistically significant strengthening of the NH polar vortex (Bittner et al., 2016b). The work is in line with the outcome of another ALARM study where we could show that the MPI-ESM can reproduce the observed stratospheric response in NH winter if the volcanic forcing is strong enough (Bittner et al. (2016a).

At present we are analysing the post volcanic climate anomalies in the 100 member ensemble dependent on the ENSO state depend and in a further study we look into the differences in the atmospheric dynamical response between a tropical and a NH high latitude eruption (Toohey et al. in prep for ACP).

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