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Interactive stratospheric aerosol model experiments suggest a strong impact of climate change on the aerosol evolution and radiative forcing from future eruptions.

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Radiative forcing from stratospheric volcanic sulfate aerosols is a key driver of climate variability. However, climate change may also impact volcanic forcing which remains largely unexplored. Atmospheric processes indeed control virtually all mechanisms that govern volcanic forcing, such as the rise of the volcanic column, the chemical and microphysical evolution of volcanic aerosols and their transport in the atmosphere.

Accordingly, we present novel numerical experiments combining chemistry-climate and volcanic plume modelling to investigate how climate change will affect volcanic forcing. We compare the aerosol evolution and radiative forcing following two eruption cases in two different climates (historical 1990’s and SSP5 8.5 2090’s). We chose two tropical eruptions: i) a strong intensity (i.e., mass flux), Pinatubo-like eruption emitting 10 Tg of sulfur dioxide (SO_2); and ii) a moderate intensity eruption emitting 1 Tg of SO_2, similar to eruptions such as those of Merapi in 2010, Nabro in 2011 or Kelud in 2014, which have had major impacts on the stratospheric aerosol background and are thought to have contributed to the global temperature hiatus in the early 21st century. The chemistry-climate model that we use (UM_UKCA version 11.2) has the capacity to interactively simulate the chemical and microphysical evolution of stratospheric sulfate aerosol given an initial injection of SO_2. Furthermore, we use a plume model to calculate SO_2 injection heights for a given eruption intensity and atmospheric conditions simulated by UM-UKCA.

In our experiments, the peak stratospheric aerosol optical depth (SAOD) of the high-intensity, Pinatubo-like eruption increases by 10% in the SSP5 8.5 2090 climate compared to the historical 1990 climate. Furthermore, the peak global-mean top-of-the-atmosphere radiative forcing of the same eruption increases by 30%. In contrast, the peak SAOD of the moderate intensity eruption decreases by a factor of 4 (with radiative forcing being small compared to simulated natural variability). Our results thus suggest that volcanic forcing will become more extreme and polarized in the future, with the forcing associated with moderate-intensity and relatively frequent eruptions being muted, but the forcing associated with high-intensity and relatively rare eruptions being amplified. We analyze which mechanisms are responsible for the simulated impacts of climate

change on volcanic forcing, and discuss potential additional feedbacks expected in our future ocean-atmosphere coupled simulations.