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Volcanically induced stratospheric water vapor changes

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Stratospheric water vapor (SWV) is important not only for stratospheric ozone chemistry but also due to its influence on the atmospheric radiation budget.

After volcanic eruptions, SWV is known to increase due to two different mechanisms: First, water within the volcanic plume is directly injected into the stratosphere during the eruption itself. Second, the volcanic aerosols lead to a warming of the lower stratosphere including the tropopause layer. The increased temperature of the cold point allows an increased water vapor transit from the troposphere to the stratosphere. Not much is known about this process as it is obscured by internal variability and observations are scare.

To better understand the increased SWV entry via the indirect pathway after volcanic eruptions we employ a suite of large volcanically perturbed ensemble simulations of the MPI-ESM1.2-LR for five different eruptions strengths (2.5 Mt, 5 Mt, 10 Mt, 20 Mt and 40 Mt sulfur). Each ensemble consists of 100 realizations for a time period of 3 years.

Our work mainly focuses on the tropical tropopause layer (TTL) quantifying changes in relevant parameters such as the atmospheric temperature profile and the consequent increase in SWV. A maximum increase of up to 4 ppmm in the first two years after the eruption is found in the case of the 40 Mt eruption. Furthermore the large ensemble size additionally allows for an analysis of the statistical significance and influence of variability, showing that SWV increases can already be detected for the 2.5 Mt eruption in the ensemble mean, for single ensemble members the internal variability dominates the SWV entry up to an eruption strength of 10 Mt to 20 Mt depending on the season and time after the eruption. The study is complemented by investigations using the 1D radiative convective equilibrium model konrad to understand the radiative effects of the SWV increase.