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The volcanic impact on convection and stratospheric ice

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Volcanic aerosol heating perturbs the tropical tropopause layer (TTL) and with it the stratospheric water budget. Whereas the effect of increased cold point temperatures on water slowly ascending into the TTL can be studied using general circulation models (GCM), the robustness of changes in convection after volcanic eruptions in these models is unclear as the TTL is tuned to unperturbed conditions and the simulations highly rely on parametrizations. Estimating the changes in the contributions of temperature effects, overshoots and vertical diffusion after a volcanic eruption or in a geoengineering study accordingly remains a challenge in GCM simulations. The emerging cloud resolving simulations however offer the unique possibility to gain insight into the sensitivity of the TTL to external forcings.

They allow in particular to study potential changes of convection, where two processes counteract each other after volcanic eruptions: the downwards shift of the lapse rate tropopause favoring overshooting convection in combination with increased stability in the TTL region suppressing overshooting convection.

We analyze these effects employing convection-resolving simulations for the atmosphere with the Icosahedral Nonhydrostatic Weather and Climate Model (ICON-A) at 10 km horizontal resolution in two scenarios: a control run and a volcanically perturbed run. The perturbed run has an aerosol layer in the lower stratosphere corresponding to the peak loading of an injection of 20 Tg sulfur using sea surface temperatures from the control run. In addition to a downwards shift of the lapse rate tropopause, we find that the level of neutral buoyancy, based on the temperature difference in convective areas and their surroundings, reaches the TTL more often in the volcanically perturbed simulations. This allows – contrary to previous assumptions - for more overshoots into the region above the tropical lapse rate tropopause.