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Impacts of Strong Volcanic Eruptions on the northern hemisphere winter in the CMIP5 MPI-ESM simulations

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Strong tropical volcanic eruptions (SVE) inject huge amounts of sulfur-dioxide (SO_2) into the stratosphere. Over chemical reactions and microphysical processes the SO_2 converts to sulfate aerosols which scatter incoming short-wave radiation and absorb longwave and near infrared radiation therefore produce cooling of the surface as well as heating of the stratosphere. Because the bulk of the volcanic cloud is centered in the tropics and because of larger insolation, the tropical stratosphere warms more than the stratosphere in higher latitudes and therefore enhance the equator-to-pole temperature gradient. This leads to a strengthening of the polar vortex and via downward propagation to a positive phase of the North Atlantic Oscillation (NAO). In the CMIP5 simulations with the coupled atmosphere-ocean-biogeochemistry Max-Planck Earth System Model (MPI-ESM) we investigate the impacts of SVE on the northern hemispheric winter season. This applies to historical eruptions from 1850 onwards as well as more recent eruptions like El Chichon in 1982 or Mt. Pinatubo eruption in 1991 which can be compared to re-analysis data sets. Two model configurations with different vertical resolution are used to analyze anomalies in various variables, for example surface temperature, surface pressure and geopotential height. Influences of other atmospheric features like the El Nino Southern Oscillation (ENSO) or the Quasi-biennial Oscillation (QBO) are taken into account to investigate to which extent different states of the atmosphere have an impact on the volcanic signal.

While a signal of volcanic aerosols is clearly visible in stratosphere, the effects on the surface remain small and in large parts non-significant in an average over all simulated historical eruptions. The expected change to a more positive phase of the NAO in the first winter after the SVE is not simulated and therefore the volcanic winter warming pattern is not visible on average. In this study we investigate why in some cases there is apparently no volcanic signal recognizable on the surface and how the downward propagation depends on the season and the strength of the volcanic eruption.