The mechanism of polar vortex strengthening after large tropical volcanic eruptions as simulated in the MPI-ESM

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State-of-the-art climate models that have participated in the recent CMIP5 model intercomparison activity do, on
average, not produce the strengthened northern hemispheric (NH) polar vortex after historical large tropical vol-
canic eruptions as suggested by observations. Here, we study the impact of volcanic eruptions of different strength
on the NH winter stratosphere in the MPI-ESM Earth system model. We compare the dynamical impact in en-
semble simulations of a very large Tambora eruption in 1815 with the response to the two largest eruptions of
the CMIP5 historical simulations (Krakatau, 1883; and Mt. Pinatubo, 1991). The mechanism, of the strengthen-
ing of the vortex can clearly be identified in the simulations for the Tambora eruption. An increased meridional
stratospheric temperature gradient is often assumed to be the cause of the vortex strengthening. The position of
the maximum temperature anomaly gradient is located, however, at approximately 30°N, far away from the polar
vortex. Hence, the vortex strengthening is caused only indirectly by the changed temperature gradient which first
produces a subtropical wind anomaly in early winter. This leads planetary waves propagating more equatorward
caus ing finally the vortex strengthening. The simulated response to the weaker eruptions of Krakatau and Pinatubo
is also a slight average strengthening of the polar vortex, but individual ensemble members differ strongly in-
dicating that internal variability can mask the impact on the polar vortex in the NH post-eruption winter under
such moderate eruption strengths. The large forcing of the Tambora eruption does not only cause a mean vortex
strengthening but also a reduction of the ensemble variability of the vortex.