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How many ensemble members are needed to identify a significant impact of volcanic eruptions?

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Large tropical volcanic eruptions are assumed to cause a strengthening of the northern hemispheric stratospheric polar vortex. The downward propagation of this volcanic signal would then cause the observed winter warming pattern in Northern Eurasia. Several studies have indicate that state-of-the art climate models as represented in the recent CMIP5 activity in general fail at reproducing already the strengthening of the vortex in the first post eruption winters. Here we analyze the dynamical response of the atmosphere to large tropical volcanic eruptions as simulated in a large (100 member) ensemble of CMIP5 historical simulations (1850-2005) with the Max Planck Institute-Earth System Model (MPI-ESM). In this large ensemble, a post-volcanic vortex strengthening can easily be identified. We analyze stratospheric temperature and wind responses in the first NH winter with respect to the question how big an ensemble needs to be in order to obtain statistically significant signals. It becomes clear that the northern hemisphere winter stratosphere due to its natural and forced variability is the atmospheric time and region where the largest ensemble size is needed. Furthermore we show that using more but weaker volcanic eruptions may make the identification of signals more difficult than using few very large eruptions and confirm this by reanalyzing the multi-model CMIP5 data set