Polar vortex responses to solar, volcanic and ENSO forcing in a large ensemble of historical simulations

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The Arctic stratospheric polar vortex is characterized by large intra-seasonal and interannual variability. This variability is partly internal, but also factors external to the Arctic stratosphere, like solar variability, volcanic aerosols, ENSO variability and the QBO have been shown to influence the state of the polar vortex. Due to only about half a century of reliable stratospheric data the unambiguous identification and quantification of the responses to individual forcings is difficult. In this presentation we analyze responses to the first three of the above-mentioned factors in a large ensemble of simulations with a comprehensive Earth system model. We have performed a 100-member ensemble of historical CMIP simulations (i.e. the period 1850-2005) with the Max Planck Institute Earth System Model (MPIESM1.1) that combines the atmospheric general circulation model ECHAM6.3, the ocean model MPI-OM and the land and vegetation model JSBACH. We analyze solar, volcanic and ENSO signals in stratospheric temperature and zonal winds using multilinear regression analysis. Probability density functions are presented to illustrate the spread of signals in the single ensemble members. It is shown that on average over the full ensemble, the model response is relatively similar to what has been analyzed from observations. Individual ensemble members, however, show very different responses that may even appear statistically significant. This sheds light at the same time on the difficulty to evaluate model performance even from relatively long simulations of about 150 years, and on the difficulty of an exact quantification of responses in the real atmosphere.