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Climate Variability in the Stratosphere during the 20th Century

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The stratosphere exhibits chemical and dynamical variability on different time scales, ranging from day-to-day variability to interdecadal variability and trends. Volcanic eruptions, solar variability, ozone depletion, or El Niño Southern Oscillation (ENSO), affect both troposphere and stratosphere, and it is an open question to what extent the climate effect proceeds via the stratosphere. The current data records as well as model simulations addressing stratospheric chemical climate variability mostly cover the past few decades only, which often is not sufficient to address interannual-to-decadal variability.

Here we present results of transient simulations with the chemistry-climate model (CCM) SOCOL, spanning the whole 20th century. SOCOL is a combination of the middle atmosphere version of ECHAM4 (MPI, Hamburg) and the chemistry-transport model MEZON (PMOD/WRC, Davos). The simulations are carried out in ensemble-mode (9 members) prescribing sea surface temperature, sea ice distribution, volcanic aerosols, solar variability, greenhouse gases, ozone depleting substances, land surface changes, and quasi-biennial oscillation.

The model's performance in reproducing key dynamical and chemical characteristics is validated against various observational and (prior to 1957) reconstructed upper air datasets. It is shown that the amount of internal variability can be a dominating source of year-to-year variations. A multiple linear regression model was applied to zonally averaged fields in order to extract the contributions of different boundary conditions to the modeled variability. The ENSO signal in the northern hemispheric winter shows a deceleration of the zonal flow at high latitudes accompanied by an increase of vertically propagating planetary waves. In the presentation this signal is further compared to idealized model experiments simulating extreme phases of ENSO.