Stratospheric Chemical-Climate Variability During the 20th Century

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Through dynamical and radiative mechanisms and its coupling to the troposphere, the stratosphere plays an important role in affecting the Earth's climate, particularly in context with climate forcings such as solar variability, volcanic eruptions, or ozone depletion. Conversely, tropospheric climate variability can affect stratospheric chemical and dynamical variability. It is therefore important to understand interannual-to-decadal variability of this two-way interaction between stratosphere and troposphere. For this purpose, model-based studies by means of a middle atmosphere chemistry-climate model (CCM) over several decades are needed. To date, no century-long transient simulations have ever been performed with a CCM.

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

We will describe in detail the compilation of the forcings of stratospheric aerosols (GISS, Sato et al.), land surface changes (HYDE, Klein and Goldewijk) as well as the reconstruction of the quasi-biennial oscillation. Furthermore, a validation of the simulated time series against ground-based measurements and reconstructed upper-level fields is presented.

We will focus our analysis on the chemical-climate response after eruptions of St. Maria 1902 and the high-latitude volcano Mt. Katmai 1912 as well as the response to strong El Niño and La Niña events.