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Evaluation of Chemistry-Climate Models using NDACC observations.

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The variability of the stratospheric chemical composition occurs in a broad spectrum of timescales, ranging from day to decades. Some of this variability involves chemistry-climate interactions and is driven by well identified forcings such as the quasi-biennial oscillation (QBO), El Niño-Southern Oscillation (ENSO), volcanic aerosols, solar activity, and changes in halogen loading. The purpose of this study is to estimate the contributions of different forcings in the variability and long-term trend of the stratospheric chemical composition and to test how well 3-D chemistry-climate models (CCMs) can reproduce these relationships. The CCMs were integrated from 1960 to 2006 and forced with time-varying observations of stratospheric volcanic aerosols, solar spectra at the top of the atmosphere, sea surface temperatures (SSTs), sea ice cover (SIC) and GHGs and CFCs concentrations. In our study, we carry out multivariate regression (MLR) analyses on long time series of observations and CCM simulations using CCM forcings (quantified with proxies) as explanatory variables. The observational data is taken from the international NDACC (Network for the Detection of Atmospheric Composition Changes) data series and the CCM simulations are taken from the CCMVal-2 REF1 database. The focus is on the O_3, HCl, N2O, HNO_3, $ClONO_2$, NO_2, and CH4 columns. The aim is to check the consistency between observations and model simulations and identify the driving factors in the evolution of the stratosphere over several NDACC measurement sites. The MLR results for CCMs and NDACC observation are compared. Overall, there is a reasonably good agreement between model and NDACC regression results. In both datasets, a much higher fraction of the variability is explained by the proxies in the tropics than in the extratropics, in particular polar regions. For ozone, the QBO and solar signal dominate in the tropics whereas the trend signals appears to be more important in the polar regions For tracer species (N2O, CH4), the dominant term in the variance is the trend while for NO_2 the variance is dominated by the aerosol effect. The results are found to be strongly dependent on the length of the data series. Sensitivity studies allow us to estimate the minimum length required for estimating reliably the influences of the various forcing.