Preliminary investigation of long-term changes in the stratospheric N2O abundances as a proxy for the Brewer-Dobson Circulation in a climate model, dynamical and chemical reanalyses and observations.

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The Brewer-Dobson Circulation (BDC) is a wintertime stratospheric circulation characterized by upwelling of tropospheric air in the tropics, poleward flow in the stratosphere, and downwelling at mid and high latitudes, with important implications for chemical tracer distributions, stratospheric heat and momentum budgets, and mass exchange with the troposphere. Nitrous oxide (N2O) is continuously emitted in the troposphere, where has no sinks, and transported into the stratosphere, where is destroyed by photodissociation. The lifetime of N2O is approximately 100 years, which makes it an excellent long-lived tracer for transport studies in the stratosphere.

In this study, we investigate the long-term N2O changes in the stratosphere using a number of different datasets. We analyze the simulation from the state-of-the-art Chemistry-Climate Model WACCM (period: 1990-2014), together with the BASCOE Chemistry-Transport Model driven by five dynamical reanalyses (ERA5, ERA-Interim, JRA-55, MERRA, MERRA-2, period: 1996-2014), and the chemical reanalysis of Aura Microwave Limb Sounder version 3 (BRAM3, period: 2004-2013). We will also compare those gridded data to ground-based observations from Fourier transform infrared spectrometer at the Jungfraujoch station in the Swiss Alps.

The long-term trends of the N2O concentration are investigated using the Dynamic Linear Model (DLM). The DLM is a regression model based on the Bayesian inference, which allow fitting atmospheric data with four main components: a linear trend, a seasonal cycle, a number of proxies (solar cycle, ENSO, QBO ?) and an autoregressive process. DLM has the advantage that the trend and the seasonal and regression coefficients depend on time; DLM can therefore detect changes in the recovered trend, and modulations of the amplitude of the regressors with time.

Early results show that the datasets exhibit hemispheric differences in the long-term N2O changes in the lower stratosphere. In the Southern Hemisphere, the DLM fit of the N2O concentrations increases across the datasets, but the resulting trend is statistically significant only in limited regions of the stratosphere. In the Northern Hemisphere, the N2O fit does not change significantly in the considered period, resulting in a near-zero trend. These hemispheric differences are in line with previous studies of transport that identify different long-term trends of tracers and mean age of air between the hemispheres.
The fit through the DLM allows the amplitude of the seasonal cycle component to vary in time. Preliminary results indicate that the time variations depend on the hemisphere in the extratropical regions. In the Southern Hemisphere, the datasets generally show a constant amplitude of the seasonal cycle throughout the considered periods, with the largest values in the high latitudes in response to the polar vortex. In the Northern Hemisphere, the inter-annual variations of the seasonal cycle amplitude are stronger, with BRAM3 showing the largest modulations. In addition, larger differences arise in the amplitude of the seasonal component. WACCM simulates large amplitudes of the seasonal cycle, while the reanalyses show smaller values. A more detailed analysis of the results will include ground-based observations, and the extension of the CTM runs to a longer period that matches the length of the WACCM run.