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N2O rate of change as a diagnostic of the Brewer-Dobson Circulation in the stratosphere

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The Brewer-Dobson Circulation (BDC) determines the distribution of long-lived tracers in the stratosphere; therefore, their changes can be used to diagnose changes in the BDC. We investigate decadal (2005-2018) trends of nitrous oxide (N2O) stratospheric columns (12-40 km) as measured by four Fourier transform infrared (FTIR) ground-based instruments and by the Atmospheric Chemistry Experiment Fourier Transform Spectrometer (ACE-FTS), and compare them with simulations by two models: a chemistry-transport model (CTM) driven by four different reanalyses, and the Whole Atmosphere Chemistry-Climate Model (WACCM). The limited sensitivity of the FTIR instruments can hide negative N2O trends in the mid-stratosphere because of the large increase in the lowermost stratosphere. When applying the ACE-FTS sampling on model datasets, the reanalyses by the European Centre for Medium Range Weather Forecast (ECMWF) compare best with ACE-FTS, but the N2O trends are consistently exaggerated. Model sensitivity tests show that while decadal N2O trends reflect changes in transport, these trends are less significant in the northern extratropics due to the larger variability of transport over timescales shorter than two years in that region. We further investigate the N2O Transformed Eulerian Mean (TEM) budget in three model datasets. The TEM analysis shows that enhanced advection affects the stratospheric N2O trends more than changes in mixing. While no ideal observational dataset currently exists, this model study of N2O trends still provides new insights about the BDC and its changes thanks to relevant sensitivity tests and the TEM analysis.