Evidence for Recent Stratospheric Circulation Changes from Multiple Measurement Sources

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Measured indicators of stratospheric circulation changes have been difficult to attain due to a lack of sufficient long-term stratospheric measurements. Several such datasets do exist however and each of them, such as stratospheric water vapor mixing ratios measured over Boulder, CO, suggest that changes have occurred in the stratosphere over the last 25 years. We show that the changes seen in the measured or measurement-based indicators of stratospheric circulation, including stratospheric water vapor measurements, a residual circulation calculation and age of air estimates, are consistent with each other. Collectively these datasets help to describe the two main features of recent stratospheric circulation changes: (1) a trend of increasing water vapor mixing ratios and age of air from 1980-2000, and (2) a large, persistent shift during the year 2000 towards increased mass flux in the lower stratosphere, decreased water vapor mixing ratios and decreased age of air. Global climate models have been unable to reproduce either the correct trend or the subsequent large shift in the stratospheric circulation. It is likely that these stratospheric changes are driven by changes in tropospheric wave activity that induces changes in both mean circulation and mixing between the tropics and extratropics. We will include a brief analysis of Eliassen-Palm flux divergence statistics calculated from the NCEP Reanalysis dataset as an indicator of wave driving of the stratosphere to begin to analyze the cause of the changes. We will also look for changes in measured stratospheric tracer-tracer correlations that can only occur due to circulation changes. These observed changes in the stratosphere provide a large constraint on global climate models and it is clearly important to more fully understand their causes.

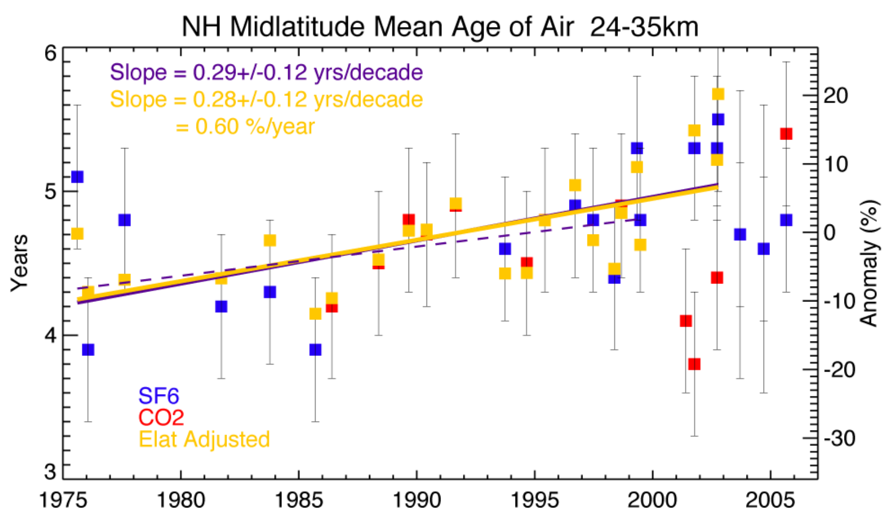

Figure 1. The figure shows mean ages in the 24-35 km altitude range calculated from SF_6 (blue squares) and CO_2 (red squares) measurements taken in various locations in the NH midlatitudes (Engel et al., 2008). Since the equivalent latitudes of the measurements ranged from 28-57°N we adjusted the mean age values by removing the linear fit of mean age vs. elat to reduce any bias in the trend related to measurement location. The yellow squares in the figure are the equivalent latitude adjusted mean ages. The calculated linear fits from 1975-2002 are very similar and are significantly positive whether using the original or elat adjusted mean ages. The main difference is that the goodness of fit is reduced by over 30% in the fit to the elat adjusted ages indicating that the spread in the data is significantly reduced by the equivalent latitude adjustment.