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Use of Ground-Based and Satellite Observations of HNO_3, HCl and N_2O to Quantify Ozone Sensitivity to Stratospheric Circulation Change

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Stratospheric chlorine levels are declining slowly as a consequence of regulations on production of chlorine containing ozone depleting substances (ODSs) imposed by the Montreal Protocol and its amendments. Detection of ozone column increases and attribution of these increases to chlorine decrease is challenging, as variations in stratospheric circulation on interannual and longer time scales may produce trends in ozone and other constituents that satisfy statistical significance criteria but are not appropriately interpreted as ozone recovery.

We use a simulation of stratospheric composition, made with the Global Modeling Initiative Chemistry and Transport Model (GMI CTM) using meteorological fields from the Modern-Era Retrospective Analysis for Research and Applications (MERRA) that reproduces many aspects of observed constituent behavior. For example, the seasonal and interannual variation of GMI CTM constituents including O_3, N_2O, HCl, and HNO_3 closely follows that of observations from the Microwave Limb Sounder (MLS) on NASA's Aura satellite (mid-2004 – ongoing) and ground-based column observations at stations in the Network for Detection of Atmospheric Composition Change (1990s - ongoing). However, the differences between simulated HNO_3 and HCl columns and NDACC data drift as the simulation progresses, and the systematic differences apparent in the 1990s decrease and are minimal from $\sim$2000 onward. These differences/drifts indicate a limitation in using the reanalysis meteorological fields for determining trends, at least for the period prior to 2000.

For the period after 2000, we can use the simulation and observations of constituents other than ozone to quantify the ozone variability that is caused by circulation changes on time scales of one to several years. This will help clarify the time interval required in order to identify an ozone increase due to chlorine decrease separate from natural variability and climate change.