GMI-MERRA2 Chemistry Transport Model Simulation Explains Variations in Lower Stratospheric Circulation found in Ground-based and Satellite Data Records

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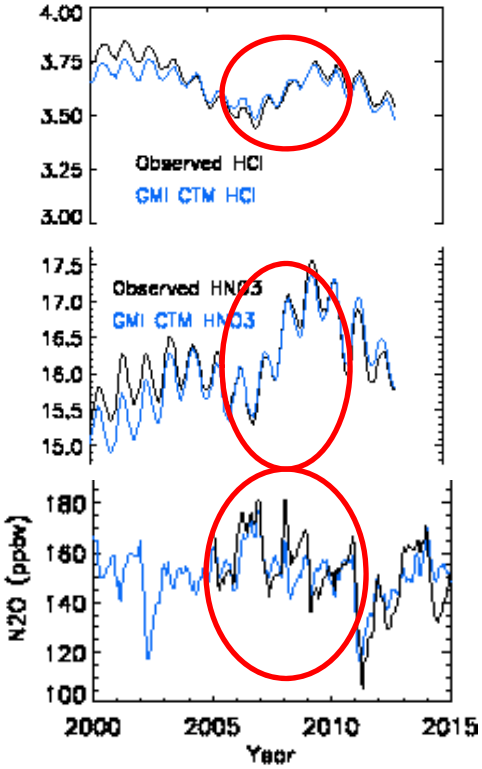
NDACC Observations

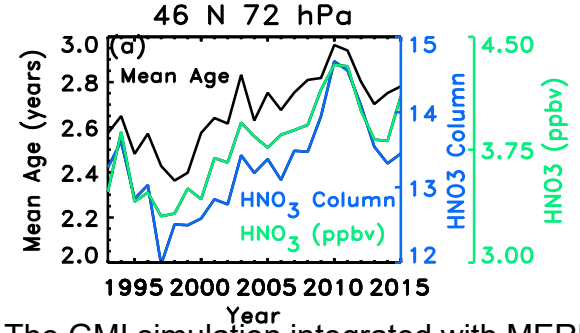
- Monthly averaged HCl columns from Jungfraujoch (46°N) increase from 2007 – 2010
- That's inconsistent with decreases in chlorine-containing source gases (i.e., CFCs)
- HNO_3 shows a similar increase.

MLS Observations

- Monthly MLS N_2O at 46 hPa show a decrease 2007-2010
- HNO3 is produced when N_2O is destroyed, so it is anti-correlated with N_2O.
- The MLS N_2O time series (black) is reproduced by the GMI CTM simulation (blue)



HNO_3, HCl, and N_2O have long lifetimes in the lower stratosphere and are therefore sensitive to variations in the lower stratospheric circulation.
Mean age is a transport tracer that behaves like other long-lived gases (e.g., HNO_3).



The GMI simulation integrated with MERRA2 meteorology shows an increase in mean age from 2007-2010 (above). **This means that the HCl and HNO_3 increases were caused by sampling older air and not by changes in surface source gases.**

Significance: The ground based measurements of HCl and HNO_3 from the NDACC Jungfraujoch station both reveal increases not explained by source gas trends; they are complemented by the Aura MLS global N_2O measurements. Together they provide a consistent picture of lower stratospheric dynamical variations since 2004.
This information provides essential context for interpreting whether HCl is declining in response to the Montreal Protocol. In the future multi-decadal constituent records may identify changes in circulation attributable to climate change.

Douglass, A.R., S.E. Strahan, L.D. Oman, and R.S. Stolarski (2017), Multi-decadal Records of Stratospheric Composition and their Relationship to Stratospheric Circulation Change, Atmos. Chem. Phys., 17, 12081-12096.