Towards a multispecies reanalysis of the stratosphere: doing chemistry with the MLS data and the GOES StratChem model

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What

• A significant extension of NASA GMAO’s GEOS Data Assimilation System to include assimilation of several stratospheric constituents beyond ozone
• Currently assimilating: water vapor, HNO$_3$, HCl from MLS
• Planning: N$_2$O and potentially ClO

Why

• To produce a mission-long reanalysis of the stratosphere for chemistry, composition and transport studies. Note, one such reanalysis exists: BASCOE Reanalysis of Aura MLS v2 (BRAM2)

This talk: water vapor analysis
Data assimilation is a Bayesian method of combining and propagating information from observations in space and time using the governing equations and error estimates.
Data assimilation system

- This work uses a version of the GEOS general circulation model with a stratospheric chemistry model driven by MERRA-2 meteorology; GMAO analyses to date have used a simple parameterized chemistry scheme.

- The family chemistry scheme, StratChem:
  - 51 transported and 17 derived species
  - 149 gas-phase and 39 photolysis reactions
  - Reaction rates follow the recommendations in *JPL 2015*
  - Includes a PSC scheme and heterogeneous reactions

- Currently assimilating ozone, water vapor, HNO3, and HCl data from MLS and total ozone from OMI.
Consistent with FTS-MLS difference (Sheese et al. 2017)

Assimilation: a considerable improvement w.r.t. ACE-FTS

Note: the large difference standard deviations in the lower stratosphere are within ACE-FTS uncertainties estimated by Sheese et al., 2017
Joint probability distributions: ACE-FTS vs. free run and ACE-FTS vs. assimilation.

Improvement in all statistics at pressures > 50 hPa

The mean improves at all levels
Water vapor on the 380-K isentrope

Analysis water vapor, 2015-12-10 : 00 UTC
Ongoing work

- Assimilation of additional species: HNO$_3$, HCl, N$_2$O, potentially ClO
- Assessing the performance of the GEOS-StratChem model: chemistry and transport
- Assessing the impact of HNO$_3$ and HCl assimilation on reactive nitrogen and chlorine budgets
- Comparison with the Belgian reanalysis, BRAM

**Chlorine activation, denitrification, dehydration and ozone depletion from the MLS data assimilation experiment**

**Assimilated field**