

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

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## What

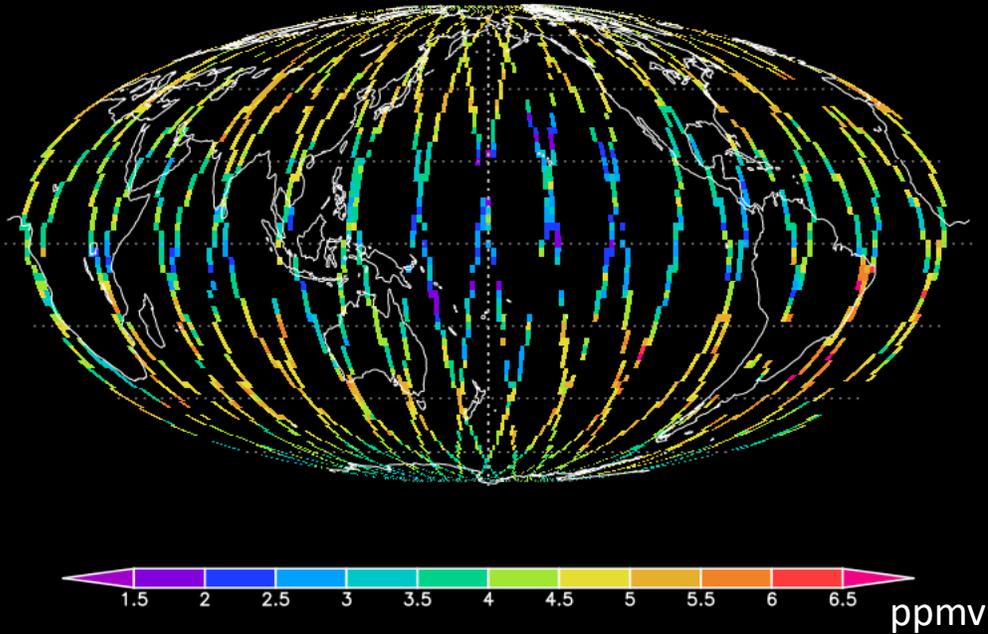
- A significant extension of NASA GMAO's GEOS Data Assimilation System to include assimilation of several stratospheric constituents beyond ozone
- Currently assimilating: water vapor, HNO<sub>3</sub>, HCl from **MLS**
- Planning: N<sub>2</sub>O and potentially ClO

## Why

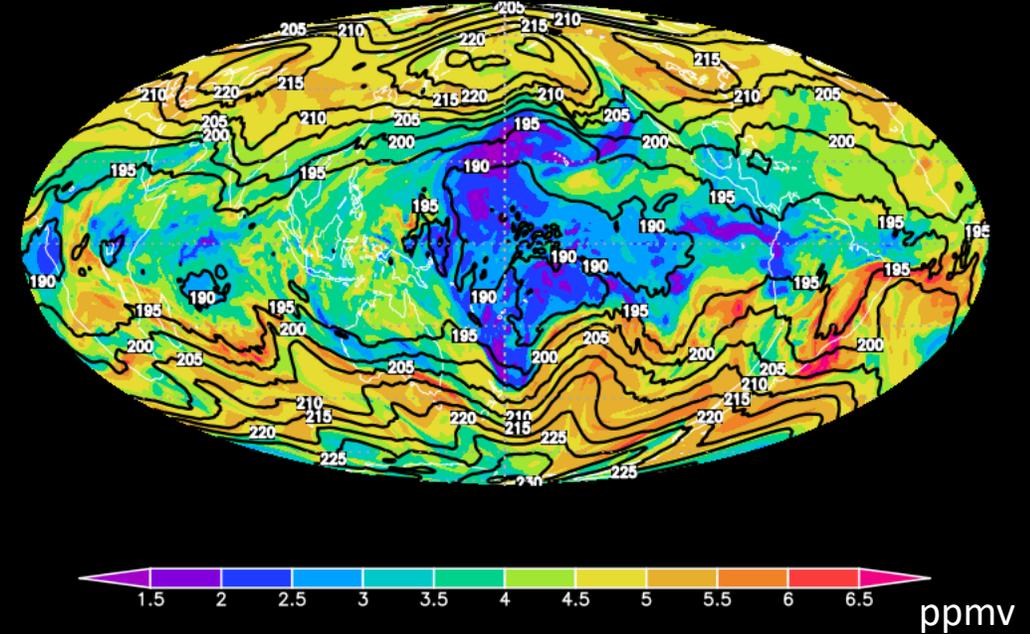
- To produce a mission-long reanalysis of the stratosphere for chemistry, composition and transport studies. Note, one such reanalysis exists: BASCOE Reanalysis of Aura MLS v2 (BRAM2)

**This talk: water vapor analysis**

MLS water vapor at 100 hPa, 2 Jan 2016



Assimilated MLS water vapor and MERRA-2 temperature at 100 hPa, 2 Jan 2016



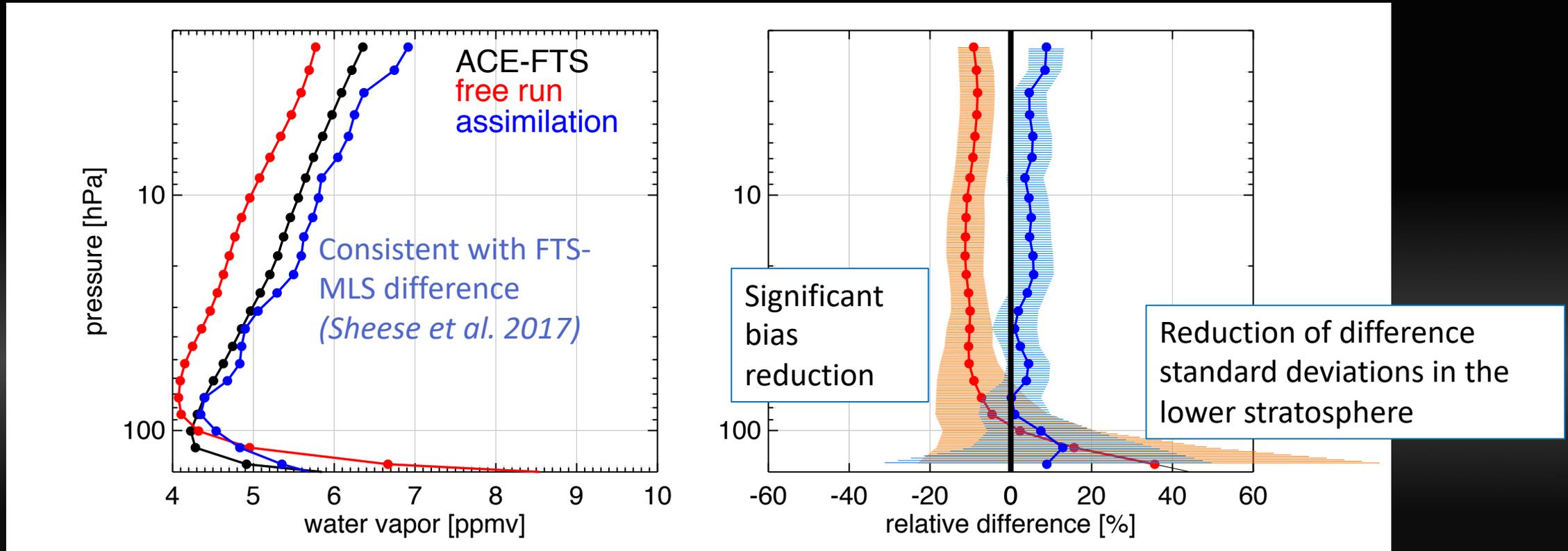
Data assimilation is a Bayesian method of combining and propagating information from observations in space and time using the governing equations and error estimates.

## 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 chemistry model, 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, HNO<sub>3</sub>, and HCl data from MLS and total ozone from OMI

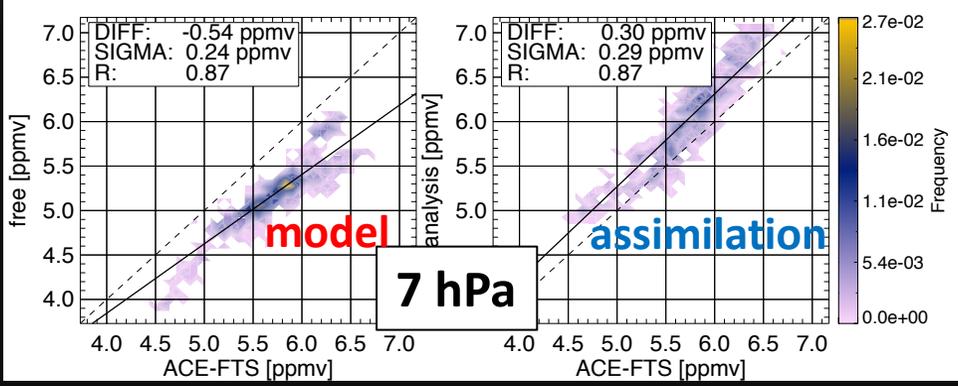
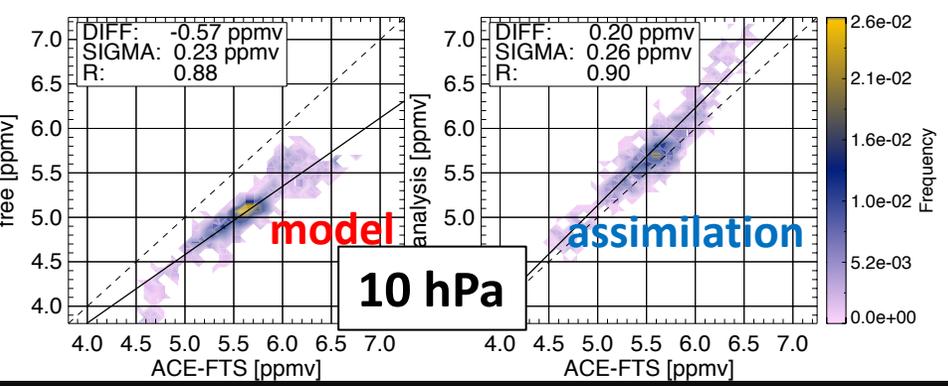
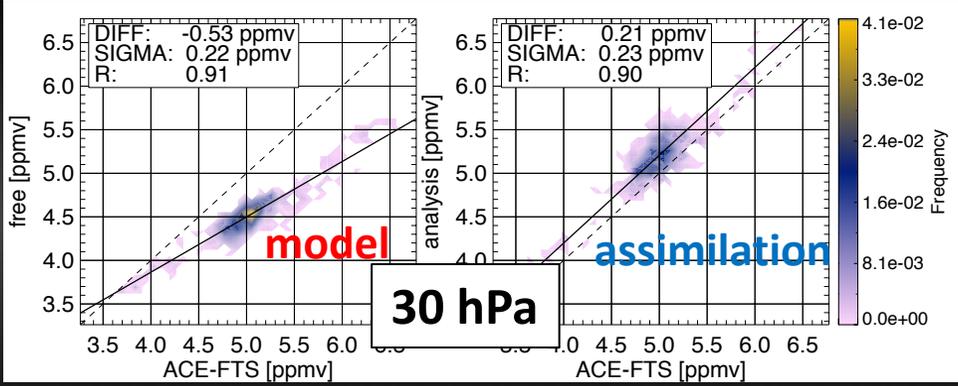
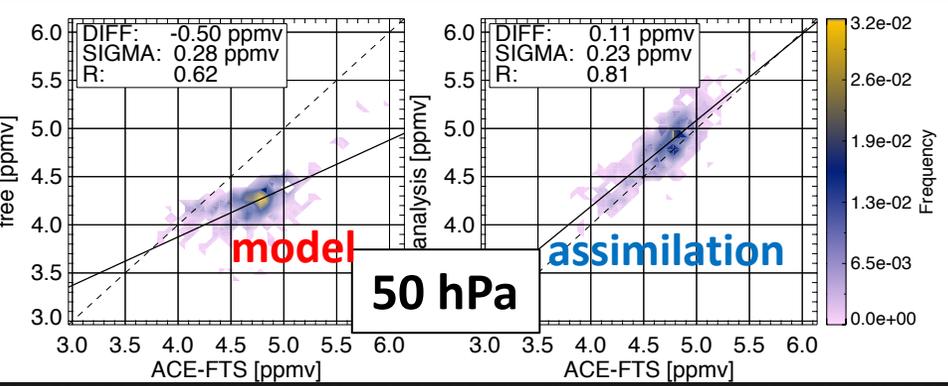
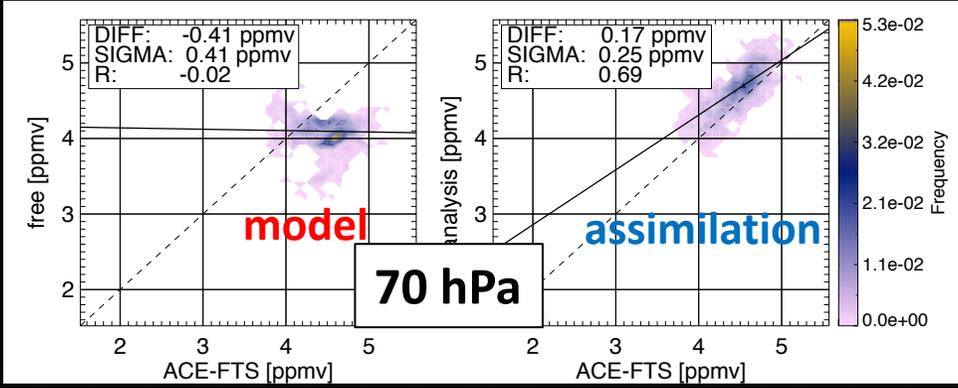
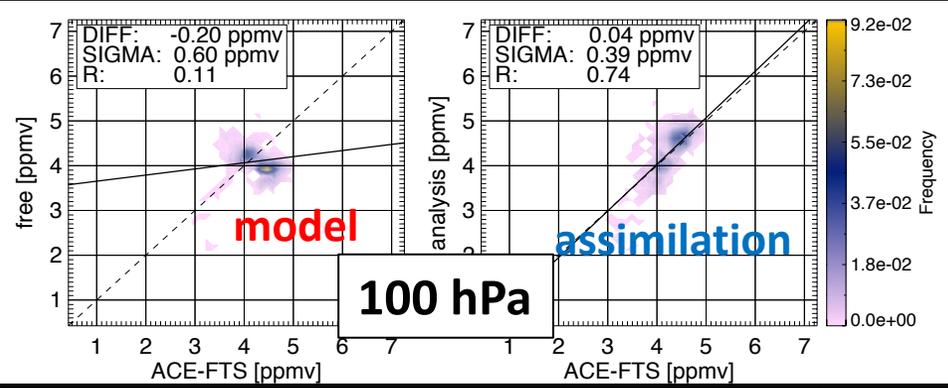
This talk

## Preliminary validation



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



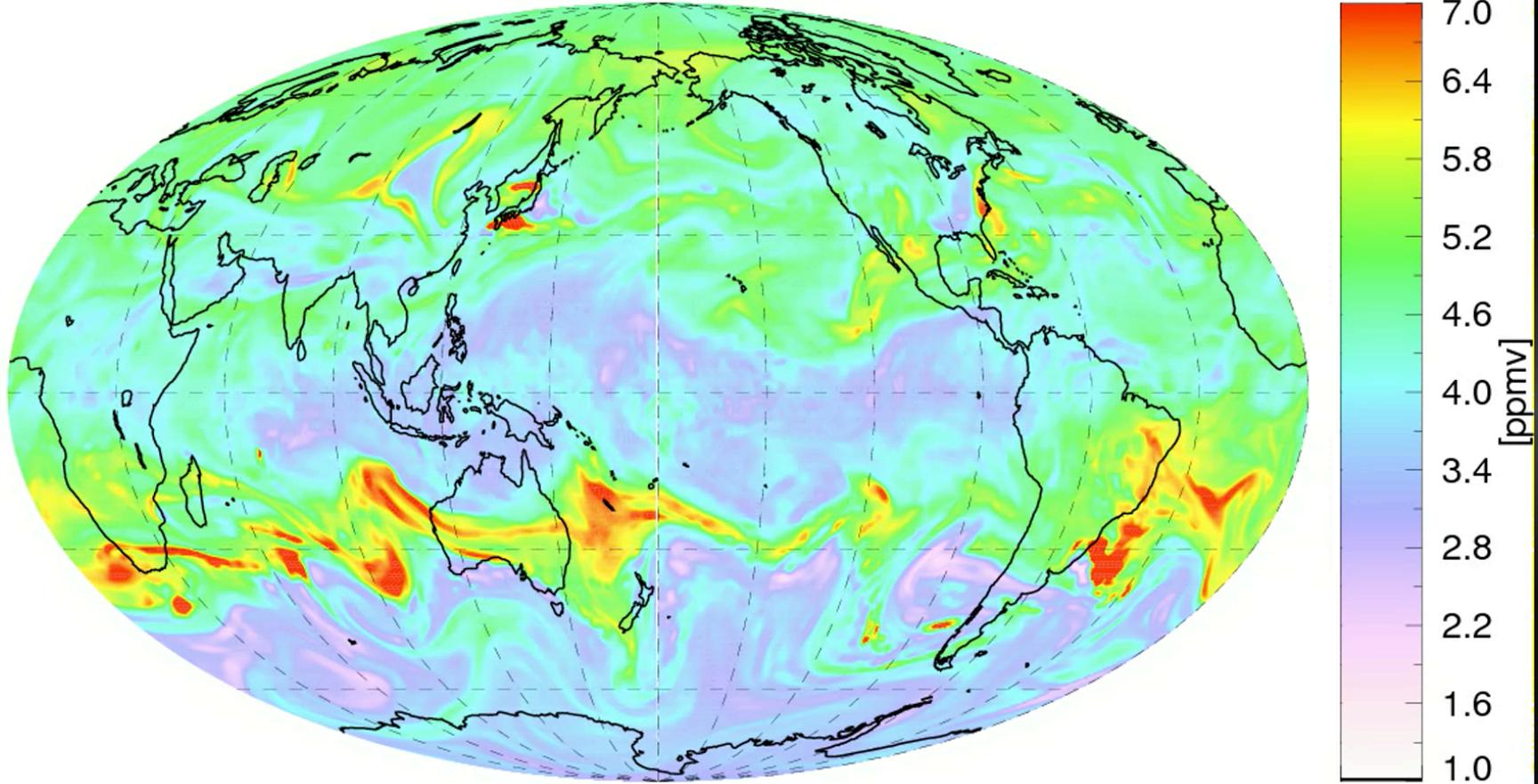
Joint probability distributions: ACE-FTS vs. free run and ACE-FTS vs. assimilation.

Large positive impact of the assimilation on all statistics at pressures > 50 hPa

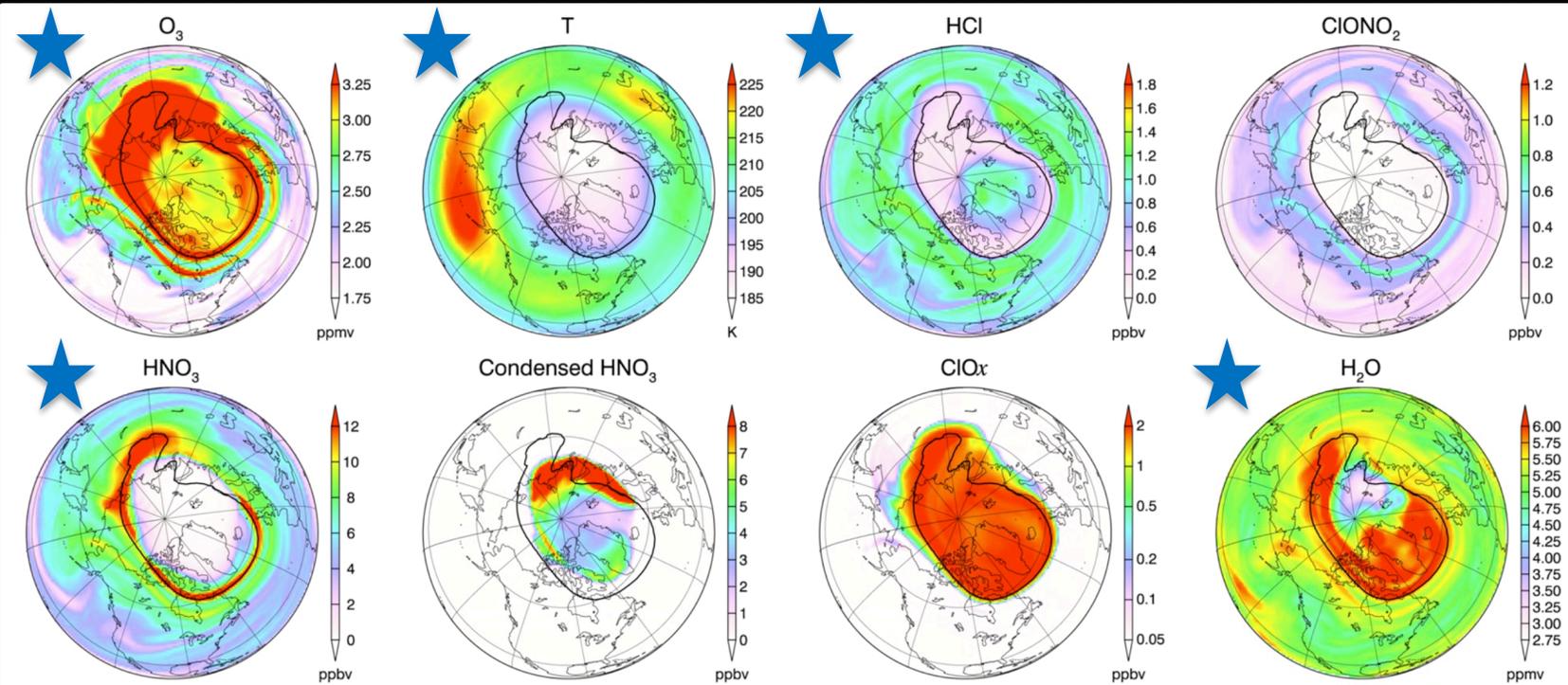
Assimilation improves the mean at all levels compared to the model

# Water vapor on the 380-K isentrope

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



## 480-K isentrope, 1 January 2016



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

★ *Assimilated field*

## Ongoing work

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