Progress towards a merged satellite upper tropospheric and stratospheric water vapor data set

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Abstract

Vertical profiles of humidity from the upper troposphere to stratosphere have been retrieved from several different limb sounding and solar occultation satellite instruments since the 1980's. Instruments retrieving water vapor include the SAGE and POAM instruments, UARS MLS, UARS HALOE, and most recently, ACE-FTS and Aura MLS, among others. Here, we present ongoing work aimed at combining these measurements into a geographically gridded data set that can be used for quantifying variability and long-term changes in water vapor, and can be used for assessing the radiative impact of changes in upper tropospheric and stratospheric humidity. In this presentation, we describe the process of merging the various data sets, which are gridded into a monthly mean product using both geographic and PV-based equivalent latitude in the horizontal, and pressure and isentropic levels in the vertical. Coincident data taken during overlap periods in the satellite record are used to construct bias corrections for each instrument that can be allowed to vary in both the horizontal and vertical. Detailed comparisons are presented between the satellite retrievals, climatology, and balloon-borne frostpoint hygrometer observations, with the goals of assessing the agreement between the satellite and balloon data, and validating the climatology.

Climatology overview

Equivalent latitude from MERRA

HALOE (v20) | Aura MLS (v3) | SAGE-II (v6.2)

Quality Control

- Remove data with
  - Aerosol, cloud contamination
  - Poor retrieval uncertainty
- MLS UTLS adjustment
- Put SAGE, HALOE on MLS pressure grid

Match MLS/SAGE, MLS/HALOE

- Δx=1000 km, Δt= 12 hours
- Eq. latitude matching if multiple profiles

Calculate HALOE/SAGE offsets

- Relative to MLS
- Offsets(lat, pressure)

Grid data

Resolution:

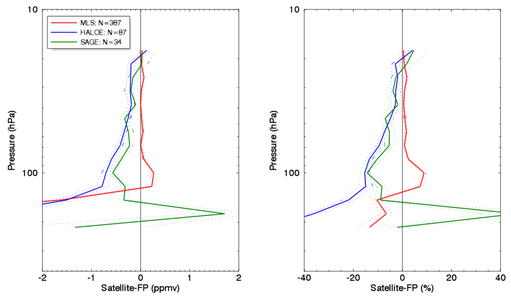
- Monthly-mean (1984 – present)
- Zonal-mean (2.5° lat)
- 32 pressure levels (316 - 0.01 hPa)
- 21 isentropic (300-650 K)
- Geographic and equivalent latitude grids

Information stored (lat, level, time):

- Mean, standard deviation, mean uncertainty
- For each satellite (SAGE, HALOE, MLS), both "raw" and corrected versions
- Combined, weighted mean (SAGE+HALOE+MLS)
- Combined, w/ filling

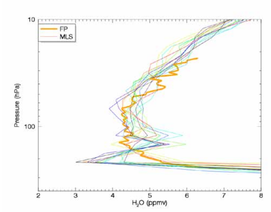
Satellite vs. Frostpoint

- NOAA FPH and CFH sondes from multiple locations
- All data averaged to MLS resolution

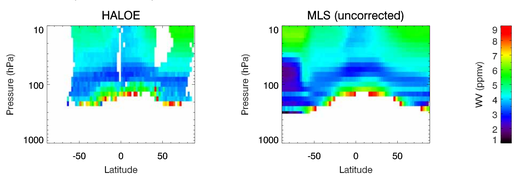


MLS UTLS oscillations

- MLS "oscillations" and "spikes" exist at high latitudes at UTLS levels (~215-121 hPa)
- Plot below shows all MLS points close to one FP sonde from Sodankyla (12/2005)

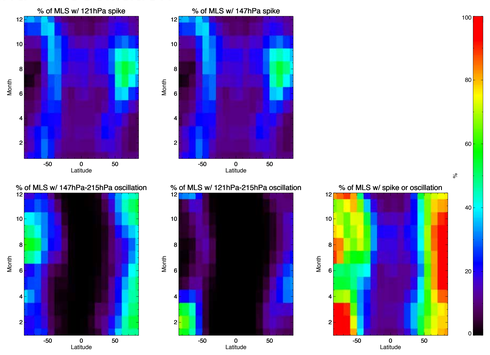


- Unphysical oscillations show up in monthly mean plots (8/2004)



Oscillation/spike definitions:

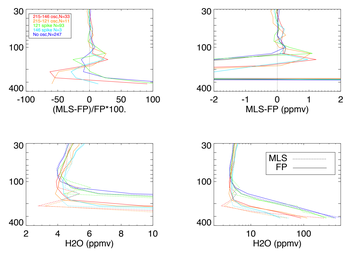
1. 121/215 oscillation: Local minima at 215 hPa + local maxima at 121 hPa
2. 146/215 oscillation: Local minima at 215 hPa + local maxima at 146 hPa
3. 121(146) spike: Local maxima at 121(146 hPa), and no oscillation



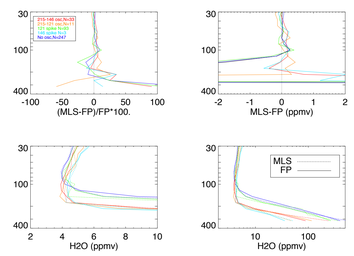
MLS UTLS correction

- "Oscillations" and "146 spike" occur under anomalously dry conditions
  → Interpolate across levels 277,215,146,121 (using 316,177,100)
- For "121 spike", average levels above/below

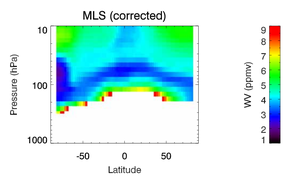
Unorrected



Corrected

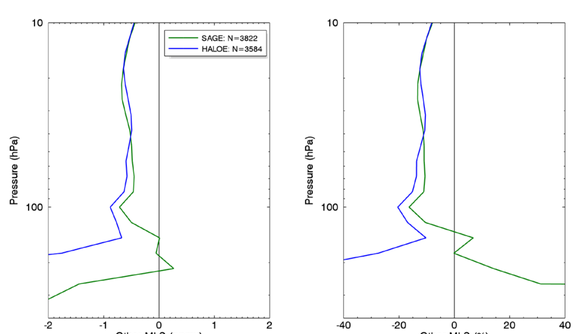


- MLS correction fixes unphysical behavior shown earlier



Satellite vs. Satellite

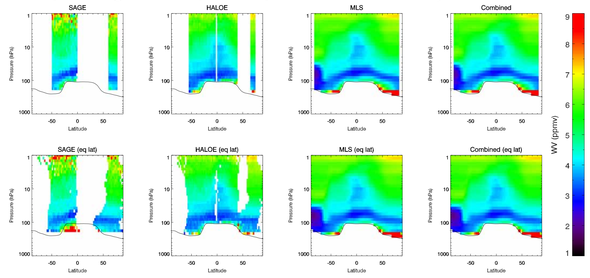
- Plot shows differences between MLS and SAGE/HALOE after applying MLS UTLS corrections and identifying matches during the overlap period (2004-2005)



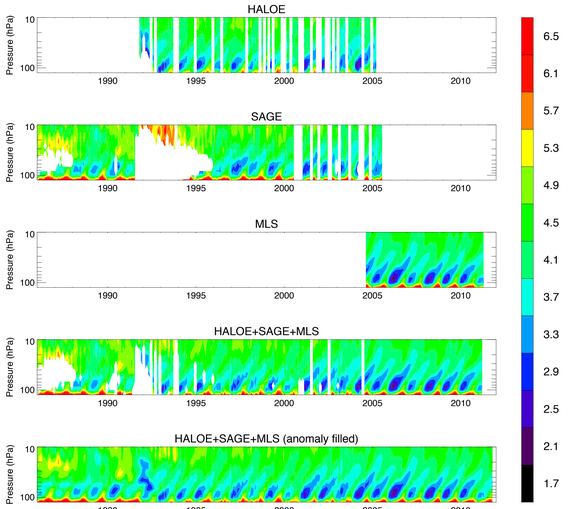
- The mean differences as a function of latitude is used to correct individual SAGE/HALOE profiles before gridding

Climatology examples

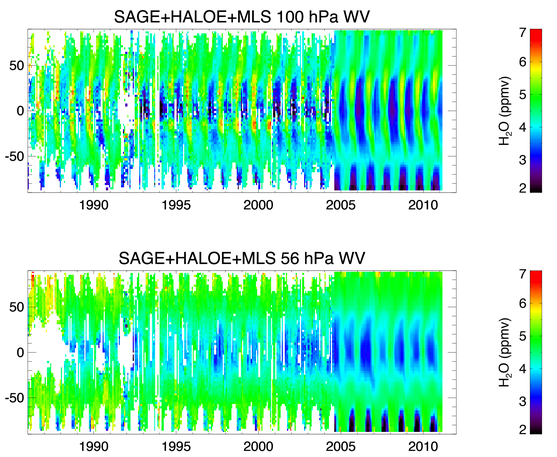
- Monthly-mean cross-sections shown for (8/2004)
- Eq. latitude allows for data filling, and helps in capturing the depth of polar vortex dehydration



- Plot below shows the tropical tape recorder (20°S-20°N) from each satellite, and combined



- Plot below shows WV at 100 hPa and 56 hPa



Conclusions

- MLS shows best agreement with FP sondes
- MLS UTLS oscillations problematic, but correctable
- Combined product useful for studying interannual variability.
- Future work aimed at
  - better data filtering (e.g., Pinatubo)
  - more sophisticated filling (multiple regression?)