Validation of satellite ozone-depleting substance measurements with airborne platforms

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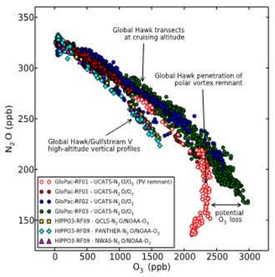
1. GMD airborne ODS measurements

Motivations:

1. to better understand the dynamic coupling processes by which many longer-lived ODS's with tropospheric sources are cycled through the stratosphere where they decay and interact with O_3;
2. to assist the role of satellites in this effort by providing validation measurements at a range of altitudes.

This poster presents some comparisons of satellite and aircraft measurements made during the Hiaper Pole-to-Pole Observations (HIPPO) and Global Hawk Pacific (GloPac) campaigns (**1a**).

1a. GMD (+other) airborne measurements of N_2O, O_3 over the northern Pacific in April 2010 during GloPac and HIPPO-3. Instrument info is available in the lower right hand corner of the poster.

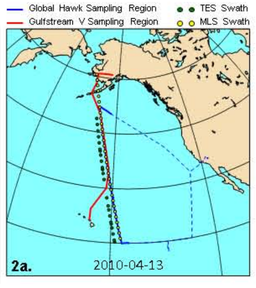


Impediments to clean comparisons/effective validation:

- Satellite precision
- Aircraft coverage – especially of the vertical, as aircraft prefer to "cruise" at constant altitude
- Aircraft/satellite spatial resolution disparities
- Spatial/temporal coincidence of measurements
- Atmospheric gradients/advection

2. Aura-MLS (O_3, N_2O), Aura-TES (O_3, CH_4) comparisons with NASA Global Hawk and NSF/NCAR Gulfstream V

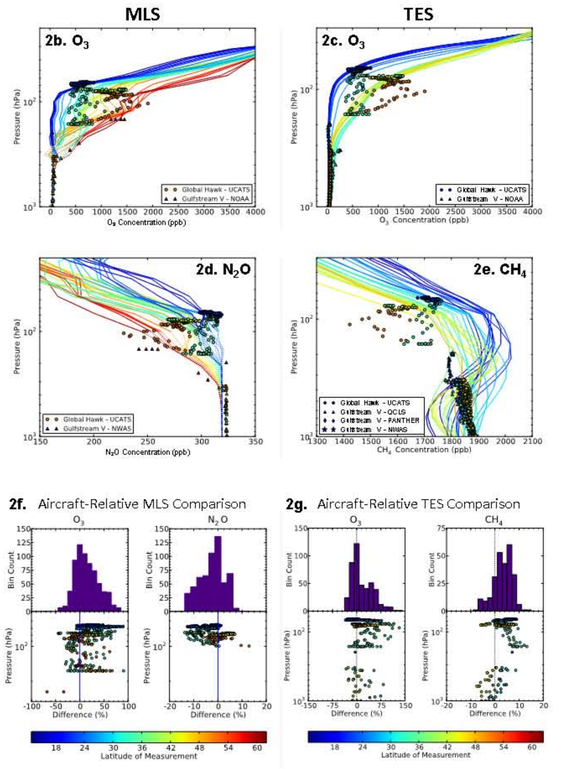
- Coordinated GloPac/HIPPO-3 research flights overlapping beneath Aura satellite overpass on April 13, 2010 (**2a**).
- Transit times along the Aura swath from 15° to 60° N were 12 minutes for the satellite and 7 hours for the aircraft.
- Direct comparisons are shown in **2b-2g**.



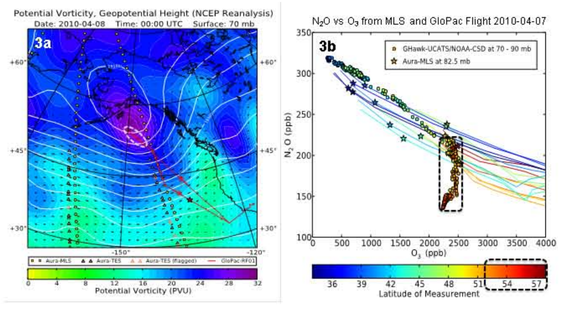
Effects folded into histogram biases and spreads:

- Rapidly transitioning gradients near tropopause with widely varying tropopause height between 15° and 60° N
- Very large spatial resolution differences
- Lack of temporal coincidence along the swath
- Altitude dependencies are collapsed

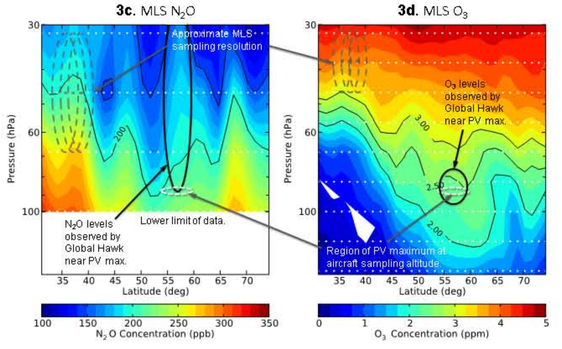
- Satellite accuracy and precision



3. Satellite resolution and precision (Aura-MLS)



GloPac – the Global Hawk sampled a polar vortex remnant with high potential vorticity (**3a**), low N_2O, and low attendant O_3 concentrations (**1a**, **3b**).



Vertical slices of MLS N_2O and O_3 along an intersecting Aura swath from 8 hours earlier are pictured in **3c** and **3d**.

- The O_3 slice (**3d**) is consistent with sampling from the Global Hawk near the PV maximum (**3b**).
- The N_2O slice (**3c**) is not so consistent, especially near the PV maximum.

Why the difference?

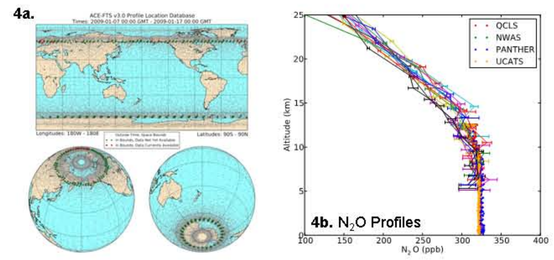
- Reported relative precision estimates are 4x better for O_3 than for N_2O in the PV max region (2.5% vs 10%, though N_2O is off by as much as 80% here).
- Vertical resolution is 2x better for O_3.

Conclusion: feature may be too small/sharp for detection by the MLS N_2O channel.

This speaks to the need for a more broad-based, statistical approach to validation (and also hints at why we don't show HIRDLS comparisons).

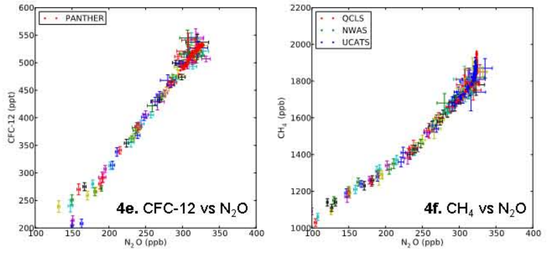
4. SCISAT-1 Atmospheric Chemistry Experiment Fourier Transform Spectrometer (ACE-FTS)

- Solar absorption technique, with number and quality of daily retrievals (30 max) dependent on orbital beta angle.
- Sparseness leads to *very significant coincidence issues* for aircraft comparisons.



Gulfstream V comparisons over Alaska during HIPPO-1

- *Qualitative* comparisons in 57-67° N latitude band due to shortage of ACE-FTS/GV coincidences over Alaska (**4a**).
- Vertical profiles of N_2O, CFC-12, CH_4 shown in **4b-4d**.



- Stratospheric decay relationships between these molecules are well-behaved (**4e**, **4f**) and compare favorably throughout this latitude band *despite coincidence issues*.

5. Going Forward

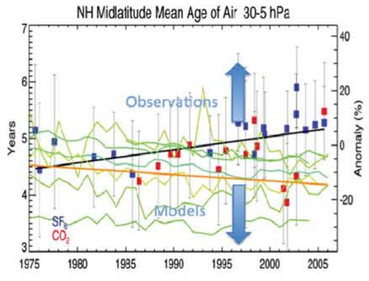
What would help:

- Better coverage (esp. vertical) in the validation data
- More broad-based, statistical, zonal average approach
- Latitudes carefully chosen for avoidance of transitional regions between stratospheric zones (tropical pipe, "surf zone", polar vortex)
- Comparisons of stratospheric decay relationships permit the loosening of coincidence constraints

AirCore

- Seasonal, stratospheric monitoring at targeted latitudes
- Regular stream of data for ongoing satellite validation
- Low-cost complement to conventional airborne campaigns (less episodic with enhanced vertical coverage)
- Deep, vertical measurements of N_2O, CFC-12, CFC-11, CFC-113, H-1211 and SF_6 (also P, T, O_3) with up to 5 mb vertical resolution in the stratosphere (*feasibility demonstrated in the lab)*
- Range of photolytic decay rates for direct exploration of stratosphere/troposphere coupling and dynamics (**5a**)

5a. A strengthening of the Brewer-Dobson circulation is predicted by numerous modeling studies in contrast to the available observations.



Aircraft Instrumentation

- **PANTHER** – Peroxy Acetyl Nitrate and other Trace Hydrohalocarbons ExpeRiment (GMD, 6-channel, in situ GC)
- **UCATS** – UAS Chromatograph for Atmospheric Trace Species (GMD, 2-channel, in situ GC)
- **NWAS** – NOAA Whole Air Sampler (GMD airborne flask sampling package)
- **NOAA O_3** – NOAA/CSD in situ O_3 monitor
- **QCLS** – Quantum Cascade Laser Spectrometer (NSF/Harvard in situ N_2O, CH_4 monitor)

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