National Aeronautics and Space Administration

MLS/START08 Comparisons and Large-Scale Context for START08 from MLS and ACE-FTS Satellite Data

GL Manney[1,2], MI Hegglin[3], WH Daffer[1], RA Fuller[1], E Atlas[4], C Boone[5], KP Bowman[6], T Campos[7], DT Cuddy[1], R-S Gao[8], D Hurst[8], A Lambert[1], NJ Livesey[1], SD McLeod[5], L Pan[7], WJ Read[1], ML Santee[1], PA Wagner[1], KA Walker[3,5], A Weinheimer[8], S Wofsy[9]

[1] Jet Propulsion Laboratory, California Institute of Technology; [2] NM Institute of Mining and Technology; [3] University of Toronto; [4] University of Miami; [5] University of Waterloo; [6] Texas A&M University; [7] National Center for Atmospheric Research; [8] NOAA [8] Harvard University

1 Introduction

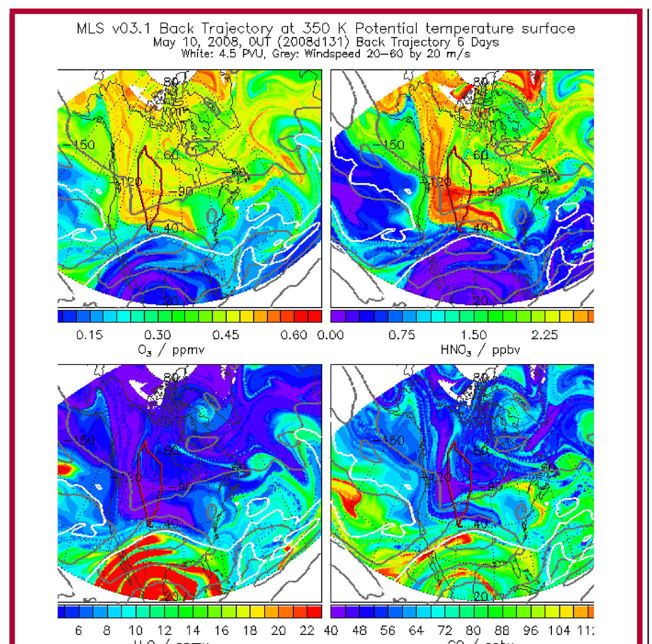

Figure 1. Reverse Domain Filling (RDF) trajectory maps at 350 K initialized with v3 MLS (left to right, top to bottom) O_3, HNO_3, CO, and H_2O data 6 days before 00UT 9 May 2008, near the ending time of START08 RF09. Red contour shows RF09 flight track. Grey contours are windspeeds of 20, 40 and 60 ms^{-1}, white contour is PV of 4.5 PVU.

In support of the Stratosphere-Troposphere Analyses of Regional Transport (START08) campaigns in April, May and June 2008, ozone, water vapor, nitric acid, and carbon monoxide fields in the upper troposphere/lower stratosphere (UTLS) from the Aura Microwave Limb Sounder (MLS) were mapped and analyzed to provide global context for the START08 flights. Figure 1 shows RDF trajectory maps initialized with version 3 (v3, from preoperational processing under assessment by the MLS team) MLS data 6 days earlier, showing the fine-scale structure in the region of a START08 flight suggested by the MLS data. MLS v3 O_3, HNO_3, CO and H_2O are all useful in the upper troposphere/lower stratosphere (UTLS); strong biases in version 2 MLS data are significantly improved in v3. To relate smaller-scale features seen in chemical tracers measured during START08 flights to large-scale transport represented in MLS fields, we use information derived from the Goddard Earth Observing System-Version 5 (GEOS-5) assimilated meteorological analyses for high-resolution trajectory calculations and to characterize the tropopauses and UTLS jets (See Manney et al talk, Monday afternoon). ACE-FTS (Atmospheric Chemistry Experiment-Fourier Transform Spectrometer) data for April through June 2008 are also compared with the START08 fields.

2 START08 and MLS V3 Profile and Correlation Comparisons

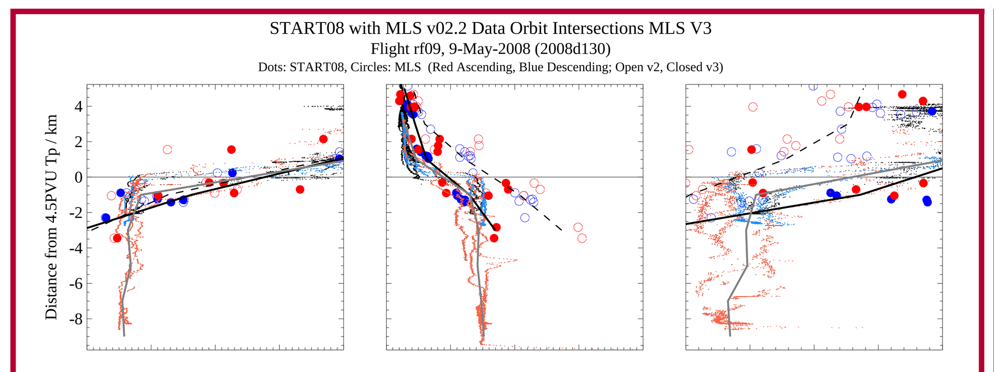

Figure 2. START08 RF09 measurements (small dots) with MLS v2 (open circles) and v3 (large filled circles) measurements from profiles within 50 km of the START08 flight track on the same day. Red and blue points are from ascending and descending MLS orbits, respectively, and red and blue START08 points those within 50 km of the MLS orbit track. Heavy black and grey lines are MLS (v2 dashed, v3 solid) and START08 2-km average values. Vertical coordinate is 4.5 PVU dynamical tropopause derived from GEOS-5 data.

- MLS measurements taken near the START08 flight tracks (within 50 km on the same day) (Figure 2) capture the sharp tracer gradients across the tropopause
- The high bias in MLS v2 CO at the lowest retrieval levels is mitigated in v3
- A low bias in v2 HNO_3 (compared here with START08 NO_y - 1.2NO) in the UTLS is also reduced in v3
- MLS and START08 values agree quite well given the crudeness of the coincidence and comparison method

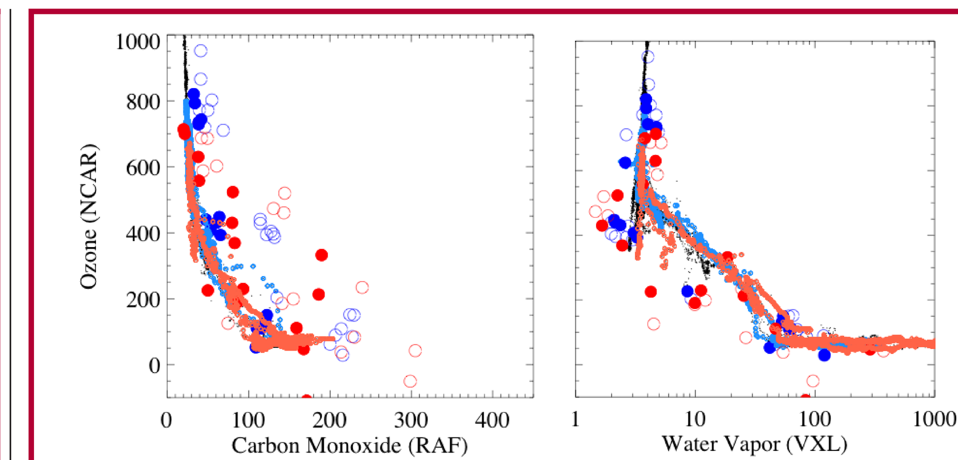

Figure 3. Scatterplots of MLS (large circles, open v2, filled v3) and START08 (small dots) CO (left) and H_2O (right) versus O_3 during RF09. Color coding is as in Figure 2.

- Comparison of "coincident" MLS and START08 measurements of CO and H_2O scattered versus O_3 (Figure 3) also show generally good agreement for v3 MLS data
- Correlations of START08 CO and H_2O with O_3 are compared with those from MLS v3 data in the extended NA region on the same day as the START08 flight in Figure 4
- Both H_2O and CO show good overall agreement between MLS and START08
- MLS does not always represent the mixing region near and just above the tropopause well, probably because of resolution limitations
- START08 measurements typically do not extend high enough to fully define the stratospheric branch of the correlation plots

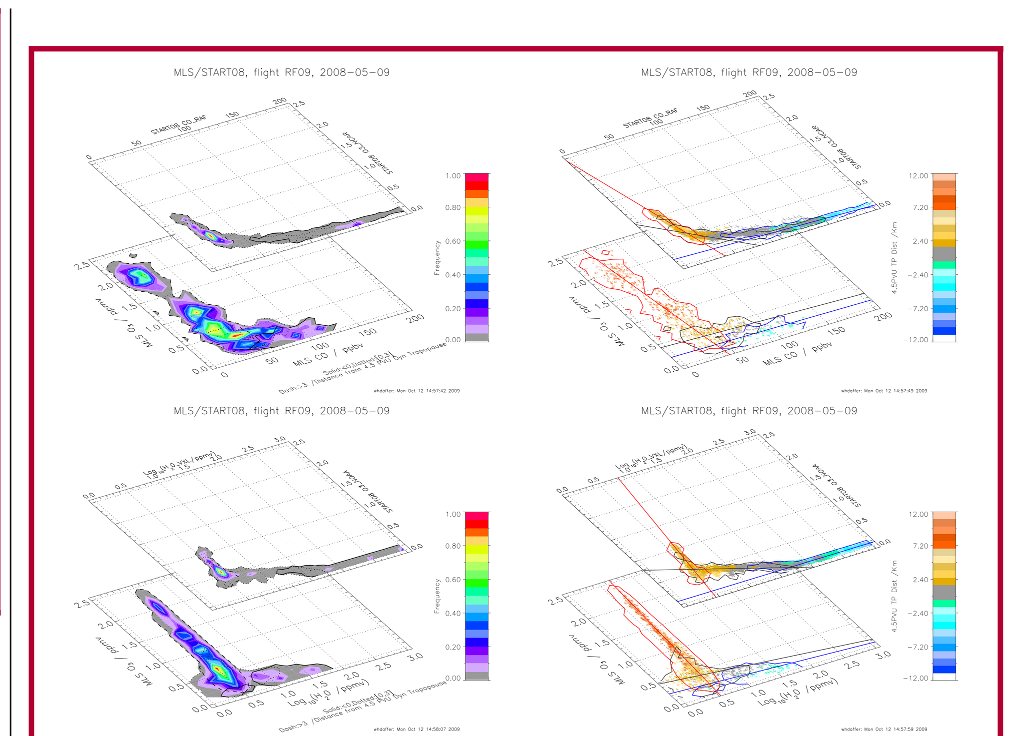

Figure 4. Examples of START08 CO-O_3 (top, RF09) and H_2O-O_3 (bottom, RF11) correlations (top planes in each panel) compared with similar plots for MLS measurements in the "extended North American" region (bottom planes, all MLS data from 215 to 68hPa, 30 to 60°N, -150 to -30°E). PDF plots on the left have overlaid contours showing points below (solid), 0 to 3 km above (dotted) and >3 km above (dashed) the 4.5 PVU dynamical tropopause. Scatterplots (left) show orange colors above the tropopause, blue colors below. Overlaid lines are fits to the points below (blue), 0 to 3 km above (grey) and >3 km above (orange) the 4.5 PVU dynamical tropopause.

3 MLS-Initialized Trajectory Modeling and START08

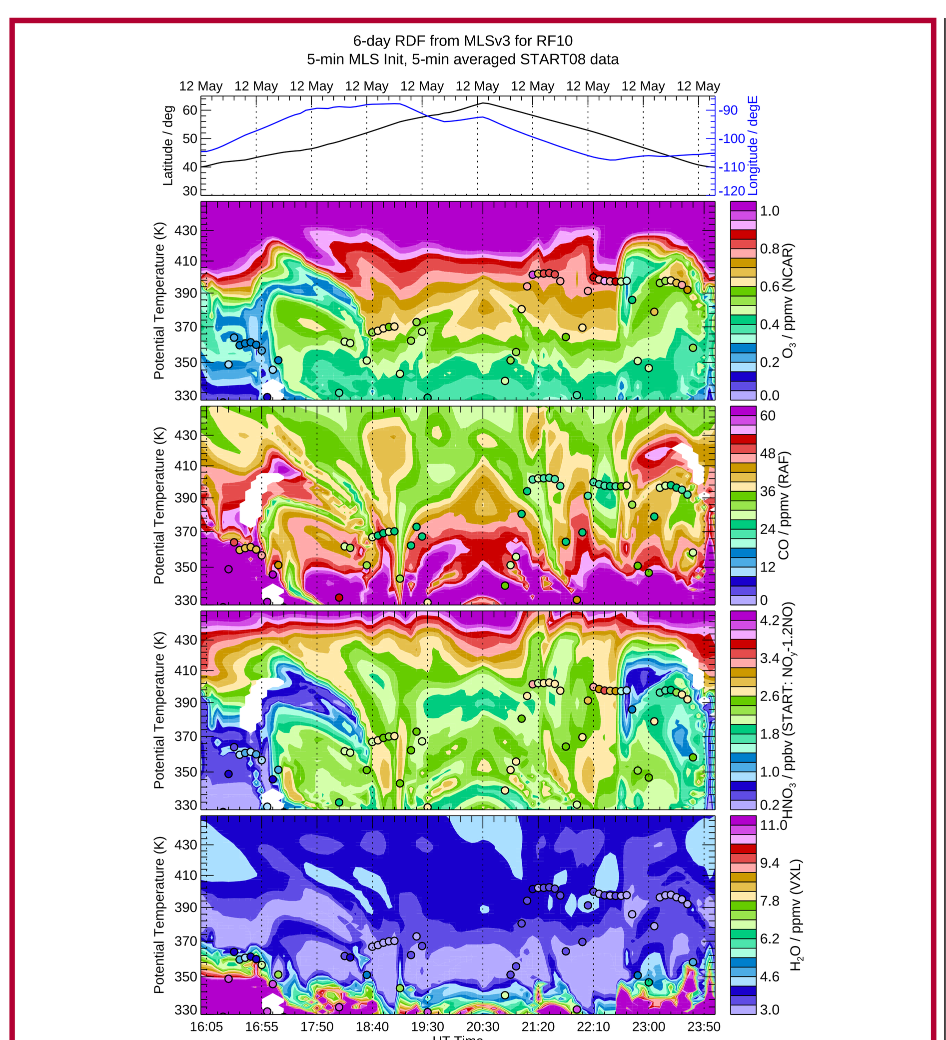

Figure 5. Reverse Trajectory (RT) calculations for profiles at 5-min averaged START08 locations iniitialized with gridded v3 MLS (top to bottom) O_3, CO, HNO_3, and H_2O data 6 days before the flight day. Parcels are started on 100 levels equally spaced in log-θ between 330 and 530 K. 5-min averaged START08 data are overplotted in circles (NO_y - 1.2NO is plotted over HNO_3).

- Reverse trajectory (RT, eg, Manney et al, 1996, JGR) calculations are being used to model high-resolution profile structure at START observation locations based on MLS v3 data (Figure 5)
- Comparison with 5-min averaged START08 data shows similar variations, but this qualitative comparison is difficult to assess

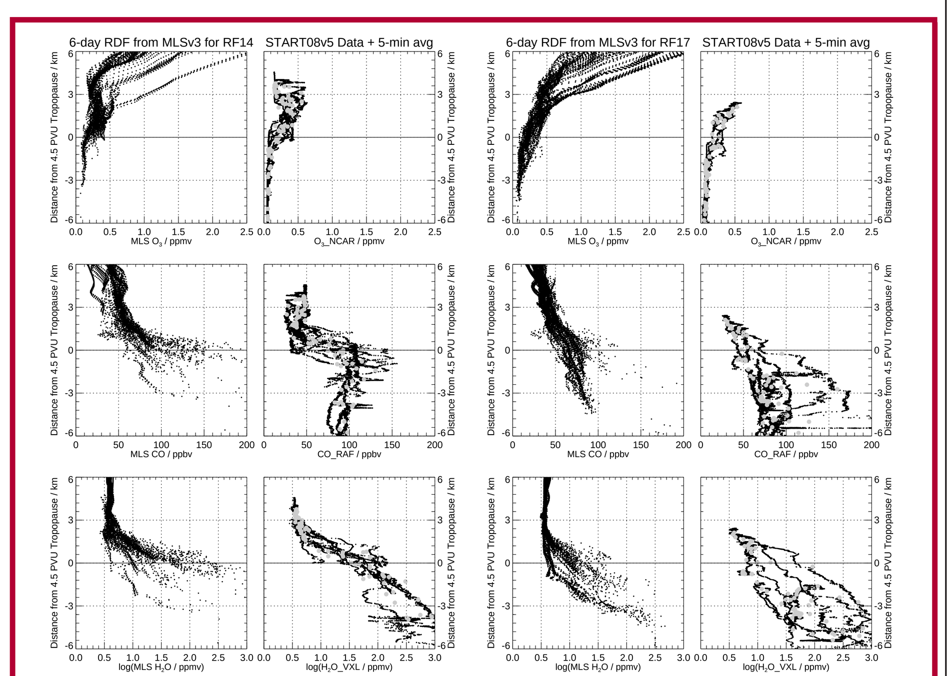

Figure 6. Profiles of (top to bottom) O_3, CO and H_2O from (left) MLS-Initialized RT calculations and (right) START08 data for (left page) RF14 and (right page) RF17. Large grey dots on START08 plots are 5-min averaged data.

- "Profile" plots relative to the tropopause from MLS RT calculations Figure 6) agree fairly well with START08
- Sharp gradients above the tropopause are reproduced (eg, RF17)
- MLS RT fields show hints of multiple branches of values as in START08 (eg, RF14 CO and H_2O)

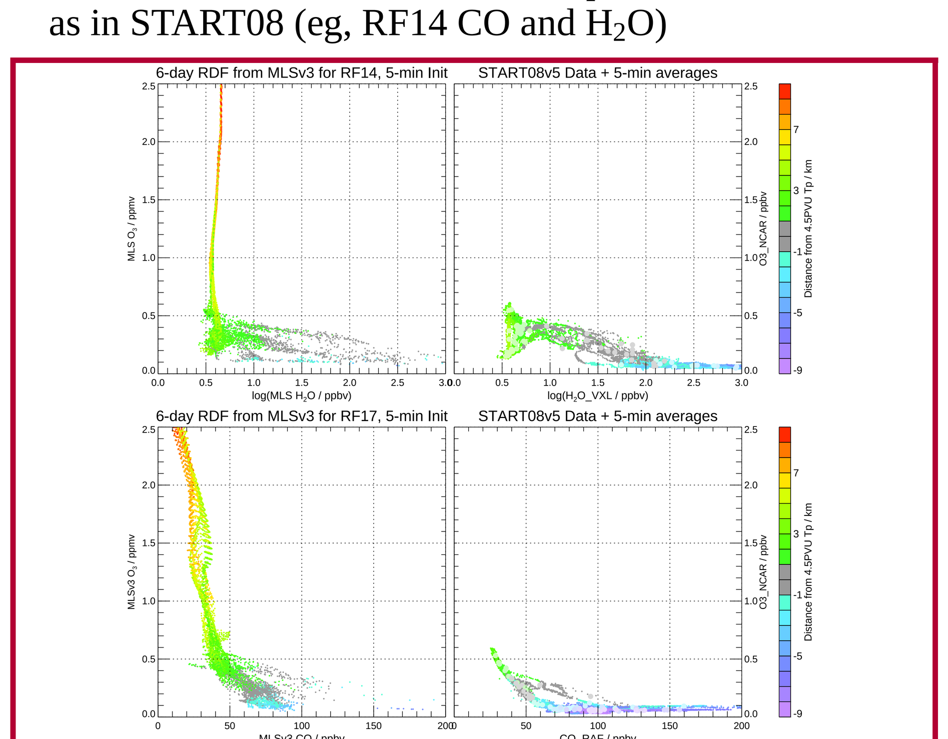

Figure 7. Correlation plots of MLS RT and (top) RF14 H_2O-O_3 and (bottom) RF17 CO-O_3. Color coding is distance from the 4.5 PVU dynamical tropopause, with -1 to 1 km in grey.

- H_2O-O_3 correlation plots (Figure 7, left) show a very low-O_3, low-H_2O branch similar to that in START08
- CO-O_3 correlation plots (Figure 7, right) from MLS RT calculations show evidence of two branches seen in RF17 START08 measurements

4 START08/ACE-FTS Comparisons

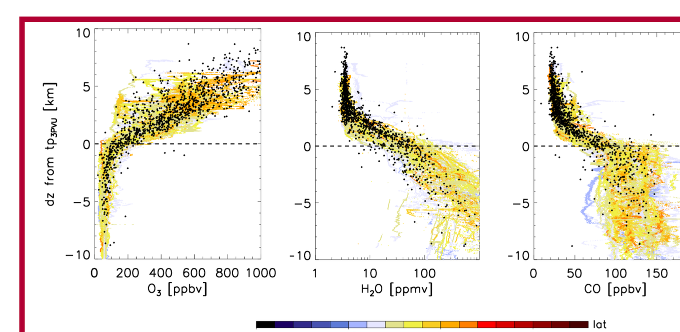

Figure 8. START08 measurements from all flights, color-coded by latitude, with all ACE-FTS v2 (black dots) measurements between 30 and 70°N during April, May and June 2008 overlaid.

- Because of the sparse sampling of the solar occulation instrument ACE-FTS, all ACE-FTS v2 measurements in the 30–70°N latitude range during April, May and June 2008 are compared with the START08 measurements (Figures 8, 9)
- ACE-FTS measurements show very good consistency with those from START08
- ACE-FTS shows low O_3 values 0-5 km above the tropopause Figure 8) consistent with those in START08 that may represent intrusions of tropospheric air

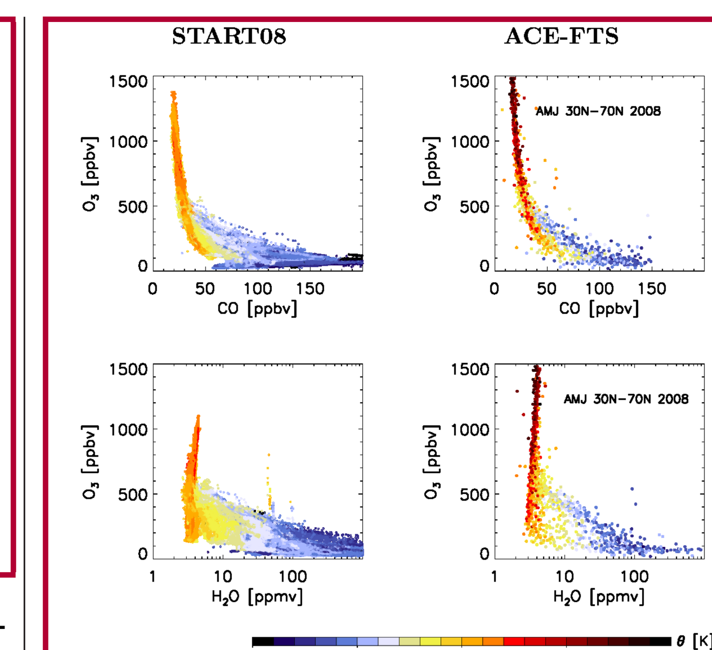

Figure 9. CO-O_3 (top) and H_2O-O_3 correlation plots from (left) all START08 flights and (right) all ACE-FTS v2 data from 30 to 70°N during April, May and June 2008.

- The ACE-FTS correlations show clear tropical ("L" in H_2O-O_3, lower branch in CO-O_3) and extratropical branches that are also apparent in individual START08 flights but smeared out in this presentation of all flights

5 Summary

- Both MLS and ACE-FTS data show good consistency with the START08 measurements
- Biases in v2 MLS CO and HNO_3 in the UTLS are mitigated in MLS v3
- ACE-FTS v3 processing is just beginning and is being used to update those comparisons
- Further analysis of these data will help to provide a more detailed assessment of consistency between START08 and satellite data
- Satellite and aircraft (including START08 data) are being analyzed in relation to the upper tropospheric jets to provide further insight into the processes controlling the consistent features seen in the datasets, and to develop global trace gas climatologies in the UTLS that provide context for regional aircraft measurements (Manney et al talk, Monday afternoon)