Analysis of Dynamics and Transport in the Upper Troposphere/Lower Stratosphere Relative to the Jets Using Satellite Data

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UTLS Jet Characterization: Motivation

MLS O$_3$ at 350 K on 14 Jan 2009, just before the record-breaking stratospheric sudden warming (Manney et al., 2009, GRL)

- Upper tropospheric jets (UTJs, black overlays) show complex structure in relation to the tropopauses (the white contour is the primary dynamical tropopause) and trace gas measurements from satellites and aircraft.

MLS O$_3$ at 370 K on 15 Nov 2006, when the stratospheric vortex and subvortex are decaying.
Jet and Tropopause Characterization from GEOS-5 Analyses

- Polar night jet (PNJ, demarks vortex and subvortex):
  - most poleward westerly jet with windspeed >30 m/s

- WMO and 4.5, 3.5, 2.0 PVU tropopauses; multiple values

- Upper tropospheric jets (UTJs):
  - Core: windspeed maxima >40 m/s
  - Edge: windspeed below 30 m/s

Classification scheme is used to examine jet climatology and variability
Also used to categorize and compare satellite and aircraft trace gas data
UTJ and PNJ Variability and Climatology

- PDFs of jet core frequency as a function of latitude and altitude show interannual variations, especially in NH winter UTJ (colors) and SH spring PNJ (contours).
- Subtropical jet (STJ) defined as the strongest jet equatorward of 40° latitude for the coordinate transformation in the following slides.
Dynamical Fields in Jet Coordinates

Equivalent latitude, $\theta$ (dashed grey), windspeed (white), tropopause (black lines), with respect to STJ

- Below ~4-8 km from the STJ core, $\text{EqL and } \theta$ do not form a horizontal / vertical grid
- In this region, jet coordinates divide air masses differently than $\text{EqL}/\theta$ coordinates

Temperature and frequency of static stability $> 4.8x10^{-4}$ s$^{-2}$ (magenta)
- We are examining numerous dynamical fields in jet coordinates
- Regions of high static stability shown here are consistent with the climatological TIL (e.g., Birner, 2006; Grise et al., 2010)
9 May 2008 MLS O₃ along orbit track vs distance from 4.5 PVU tropopause
- Stratospheric intrusions equatorward of the subtropical jet
- O₃ minima indicative of tropospheric air poleward of jet near 380 K, above the extratropical tropopause

9 May 2008 NH MLS O₃ in jet coordinates
- Suggestion of stratospheric intrusions both poleward and equatorward of jet
- Lower O₃ above tropopause near 20° and 35° poleward of jet suggests tropospheric intrusions (more prominent in plot limited to North American sector, not shown)
Future Work: MLS and ACE-FTS Jet Coordinate Climatologies

MLS v3.3 May 2008

ACE-FTS v3.0 Apr—Jun 2008
Summary

- A simple scheme has been developed to identify and characterize upper tropospheric and lower stratospheric jets.
- We are using this jet characterization in analyses and comparisons of satellite and aircraft trace gas data, focusing on transport and mixing processes in the extra-tropical tropopause region.
- MLS data appear to capture some stratospheric and tropospheric intrusions despite coarse resolution.
- Characterizing satellite trace gas data in jet coordinates will provide a framework for examining the role of UTJs and the PNJ in transport and STE, and for comparison with dynamical fields.
- Mapping satellite and aircraft data (e.g., Winter Storms O$_3$, shown at right) in jet coordinates will facilitate comparisons and combined studies.