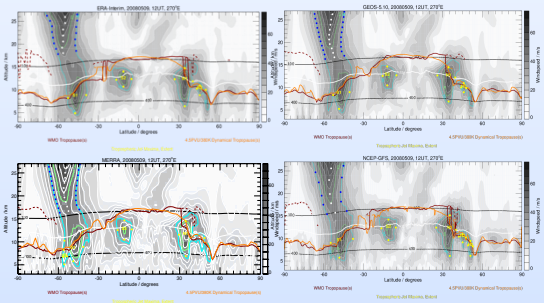
Intercomparison of Upper Tropospheric/Lower Stratospheric Jet and Tropopause Diagnostics in Operational Data Assimilation Products

William H. Daffer[1], Gloria L. Manney[1**,2], Michael J. Schwartz[1]
1 Jet Propulsion Laboratory, California Institute of Technology
2. New Mexico Institute of Mining and Technology
**Now at NorthWest Research Associates

Abstract

The upper tropospheric/lower stratospheric (UTLS) jets are important in defining atmospheric circulation and transport, particularly in the vicinity of the extra-tropical tropopause. We have developed methods for characterizing the UTLS jets and tropopauses from operational assimilated meteorological analyses. Here we describe our methods of identifying and cataloging the jets and tropopauses and present results from several meteorological datasets. These include: GEOS-5.1.0 and GEOS-5.2.0 (on 0.5 x 0.67 degree latitude x longitude grid, 72 model levels from the surface to 0.01hPa); MERRA (the long-term reanalysis from GEOS-5.2.0; same model grid, but potential vorticity (PV) is provided on a reduced resolution pressure-level grid); GEOS-5.7.2 (run on a 0.25 degree horizontal grid, but provided at 0.5 degrees, 72 levels from the surface to 0.01hPa); ERA-Interim (0.75 degree horizontal grid, 60 model levels from the surface to 0.1hPa); NCEP-GFS (provided to us at 0.3125 degree horizontal resolution on a pressure level grid that is coarse compared to the other analyses' model grids). The results below show strong sensitivity of UTLS jets and the tropopause to the data assimilation system (DAS) products that are used to characterize them.

Jet and Tropopause Characterization



A Latitude/Altitude slice along the indicated longitude for four data assimilation systems showing WMO and 3.5 PVU Dynamical Tropopause overlaid on the wind field, as well the locations of the upper tropospheric jets (yellow dots) and the "subvortex jet", that is, the lower reaches of the polar night jet (blue dots show the extent, white the jet core), as identified by our software. The dashed lines show secondary tropopauses for each of the two methods of determining the tropopause used here. Calculations are done on model levels.

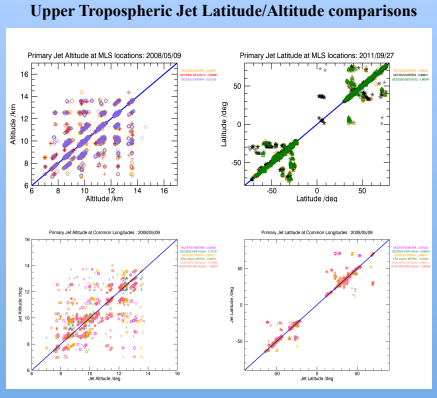
Jet and Tropopause Identification Method

As described by Manney et al. (2011, ACP), an upper tropospheric jet is defined as a windspeed maximum at any level between 100 and 400hPa greater than 40 ms^{-1} (identified using a simple, fast shift based algorithm), and the edges of the jet region where the windspeed exceeds 30 ms^{-1}. Multiple maxima within the same jet region are classified as separate jets only if the distance and decrease in windspeed between them meets certain criteria. Jets in each hemisphere are sorted by strength (lowest number, strongest jet).

Jet and tropopause characterization has been done at the longitudes of all of the Aura Microwave Limb Sounder (MLS) measurements, approximately 3500 locations per day along the orbit track, for analysis of MLS data in conjunction with the UTLS jets. These provide a set of fields from each DAS product interpolated in the same way to the same longitudes, facilitating comparisons.

•The slices above show significant differences in jets and tropopauses from different DAS products.
•Tropopause identification is particularly sensitive to the vertical grid.

Upper Tropospheric Jet Latitude/Altitude comparisons



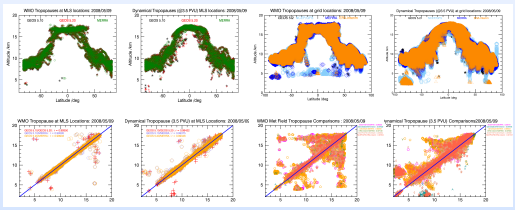
Scatter plots of the altitude (left) and latitude (right) of the primary jet calculated at MLS longitudes for three models: GEOS 5.20, GEOS 5.72 and MERRA, as well as pair-wise comparisons at the common longitudes for NCEP/GFS, MERRA, GEOS 5.1, GEOS 5.2 and ERA-Interim

• Quantization in altitude in comparisons of products from different GEOS versions arises from the ~1km vertical spacing of the model levels in the UTLS; many jet cores are shifted by one model level between different GEOS versions.

• While jet altitudes often disagree between GEOS products, NCEP-GFS and ERA-Interim, no consistent bias is seen.

• In both comparison plots, latitudes typically match well, but with numerous outliers that are far from the 1:1 curve; these typically arise when a different windspeed maximum is selected as the primary jet in different DAS products.

Tropopause Comparisons

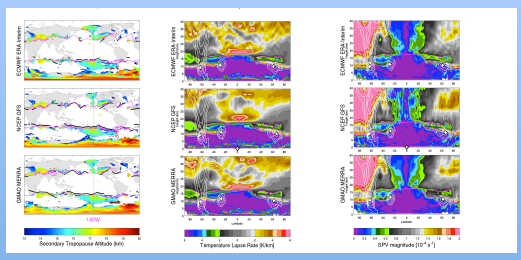


Lat/Alt sections of two tropopause definitions at MLS locations for three GEOS-5 versions (left hand plots) and for each of the analyses(right hand). Lower plots are analysis/analysis scatter plots with the indicated correlation coefficients.

• WMO Tropopause: The point at which the lapse rate drops below 2 K/km and remains so for at least the next 2 kilometers. If, after satisfying this definition, the lapse rate rises above 2 K/km and then falls below again in such a way as to satisfy the preceding, a secondary WMO tropopause occurs.
•Dynamical Tropopauses: The altitude at which the PV profile crosses the 3.5 PVU boundary, except in the tropics (+/- 30 degrees) where a cutoff of the 380K isentrope is enforced.

• Latitude/altitude sections show strong sensitivity of the tropopause identification in the subtropics where the tropopause drops in altitude, and where tropopause folds often occur.
• Outliers in scatter plots are typically in these regions, where the tropopause height is changing rapidly with latitude.

Multiple Tropopause Comparisons



Three analyses: ERA-Interim, NCEP/GFS and MERRA for the same date/time. In the maps on the left, the magenta line is the 13 km WMO tropopause, the black dots show the locations identified as jets by our software and further subclassed as sub-tropical jets by post-processing. The colored fields show the height of the secondary tropopause. The center and right plots, respectively, show the lapse-rate and abs(scaled PV) along the longitude slice at 145W, with windspeed contours in steps of 10 m/s from 30 m/s.

•The general distributions of multiple tropopauses are consistent among the three analyses, but numerous differences in detail are apparent.
•The layer of enhanced static stability between the tropopauses is weaker in MERRA than in the other analyses.
• Low magnitudes of SPV, indicating tropospheric and/or low latitude air, are seen in the upper part of the layer between the double tropopauses. In the NH, this is most apparent in ERA-Interim and NCEP-GFS and least so in MERRA.
•There is more fine-scale structure in NCEP-GFS, which has higher horizontal resolution than the other analyses

Summary and Future Work

• Preliminary comparisons of the characteristics of UTLS jets and the extra-tropical tropopause show substantial sensitivity to which DAS products are used to identify them.
• More extensive comparisons are in progress, including examination of climatological jet/tropopause characteristics in MERRA and ERA-Interim reanalyses.
• The effects of sensitivity in jet/tropopause characterization to which DAS is used on studies of transport in relation to them will be explored.