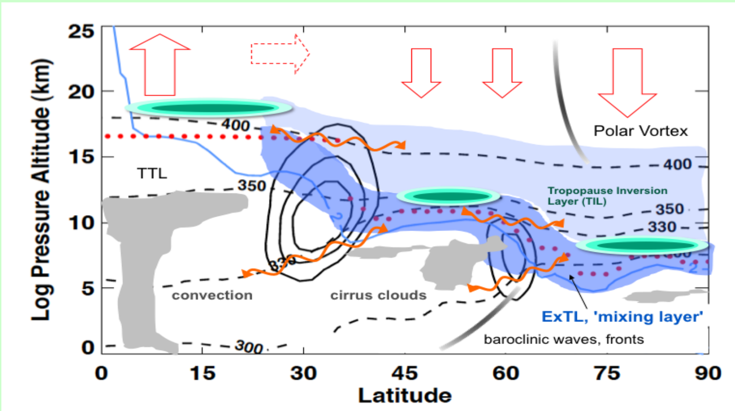
(1) NWRA NORTHWEST RESEARCH ASSOCIATES "unencumbered science"
(2) NEW MEXICO TECH SCIENCE • ENGINEERING • RESEARCH UNIVERSITY
(3) NOAA CIRES
(4) JOHANNES GUTENBERG UNIVERSITÄT MAINZ JG|U

An Overview of OCTAV-UTLS (Observed Composition Trends And Variability in the UTLS)

Gloria L Manney[1,2], Irina Petropavlovskikh[3], Peter Hoor[4]
and
Adam Bourassa, Geir Braathen, Kai-Lan Chang, Michaela I. Hegglin, Natalya Kramarova, Daniel Kunkel, Zachary D. Lawrence, Thierry Leblanc, Nathaniel J. Livesey, Luis Millán Valle, Gabriele Stiller, Susann Tegtmeier, Valerie Thouret, Christiane Voigt, Kaley A. Walker

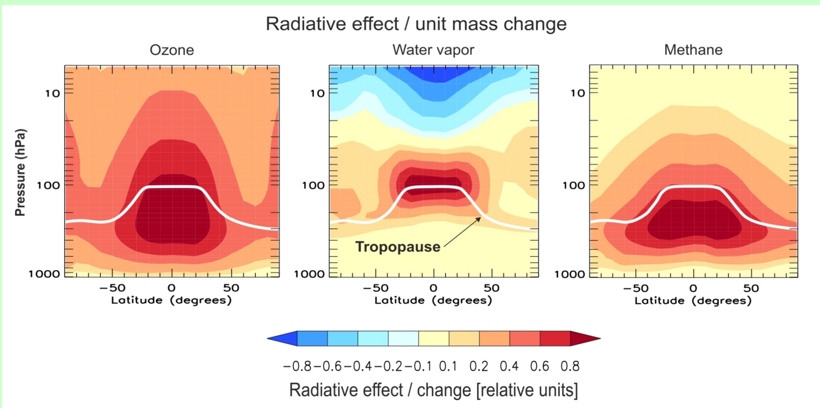
Background

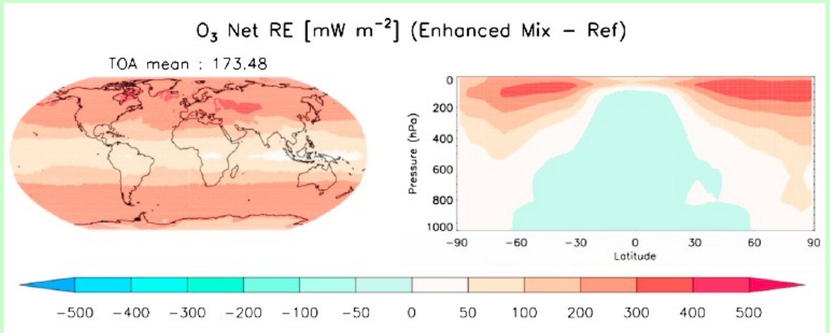


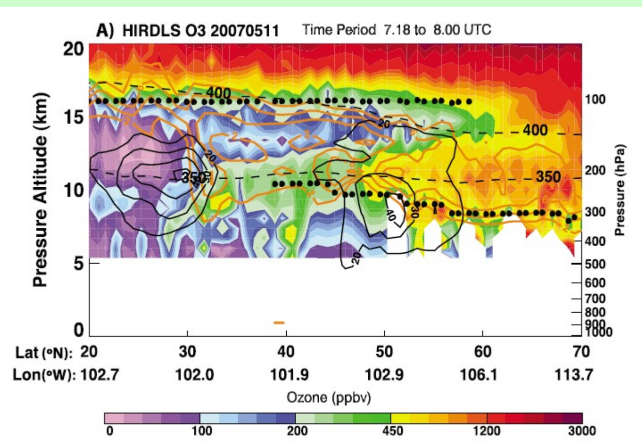
Many processes on a wide range of spatial and temporal scales influence the structure and composition of the upper troposphere / lower stratosphere (UTLS) (Gettelmann et al, 2011)

The most important radiatively active trace gases, including ozone, water vaopr, and methane, have their largest radiative effects in the UTLS, thus knowing their distributions and evolution is critical

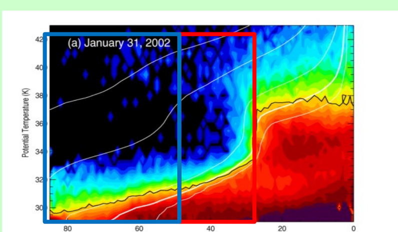
Modeling the radiative effect of these trace gases have been shown to depend critically on the parameterization of mixing, thus knowledge of small scale structure in trace gases is critical (Riese et al, 2012)



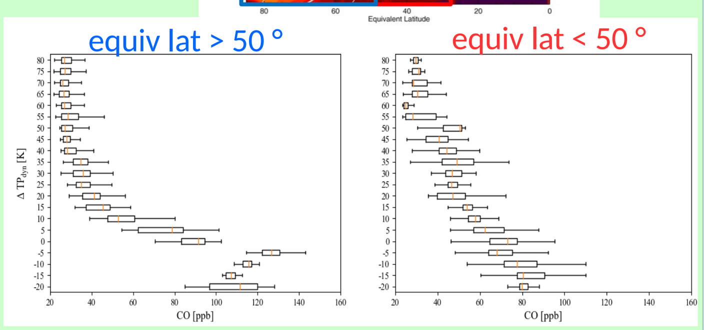


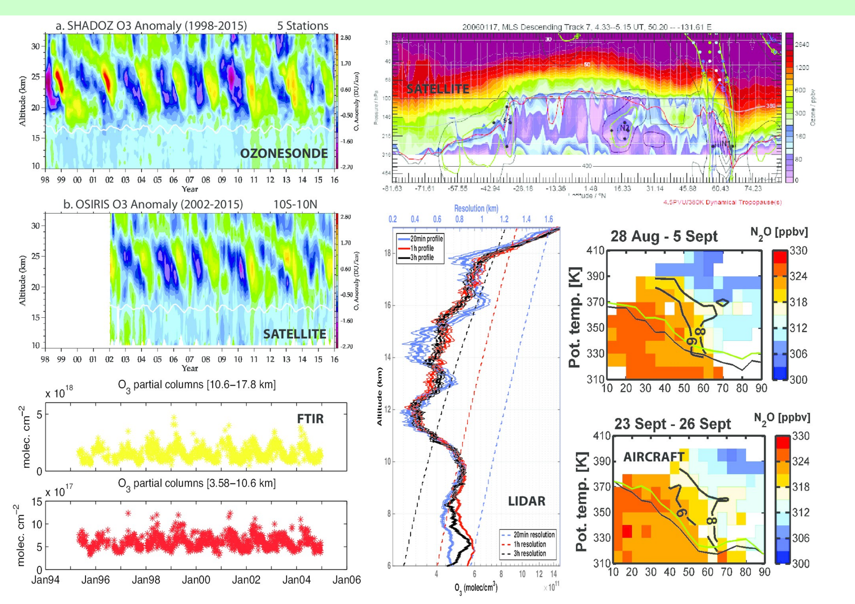


Many variations in UTLS trace gases (such as the ozone measurements shown here from the HIRDLS satellite instrument) are associated with variations in the tropopause (black dots) and upper tropospheric jet streams (black contours) (Pan et al, 2009)



Both vertical and horizontal distance from the subtropical jet and the tropopause are critical in determining trace gas distributions, as seen in CO observations here, showing greater influence of tropical / tropospheric air in measurements taken near the subtropical jet (A. Mayer, Thesis)

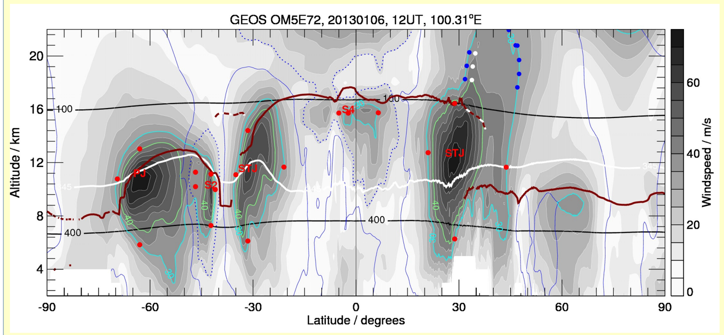




Extensive UTLS composition measurements are available for the past 10–15 years, from platforms with diverse spatial and temporal sampling, resolution, and accuracy/precision. We want to use these measurements to get maximum information about processes controlling UTLS trace gases on multiple scales.

For OCTAV-UTLS, we will develop unified geophysically-based metrics and apply them consistently to data from different measurement platforms. We will use these metrics to assess our ability to diagnose and understand UTLS composition trends and variability, and to recommend future UTLS measurement needs.

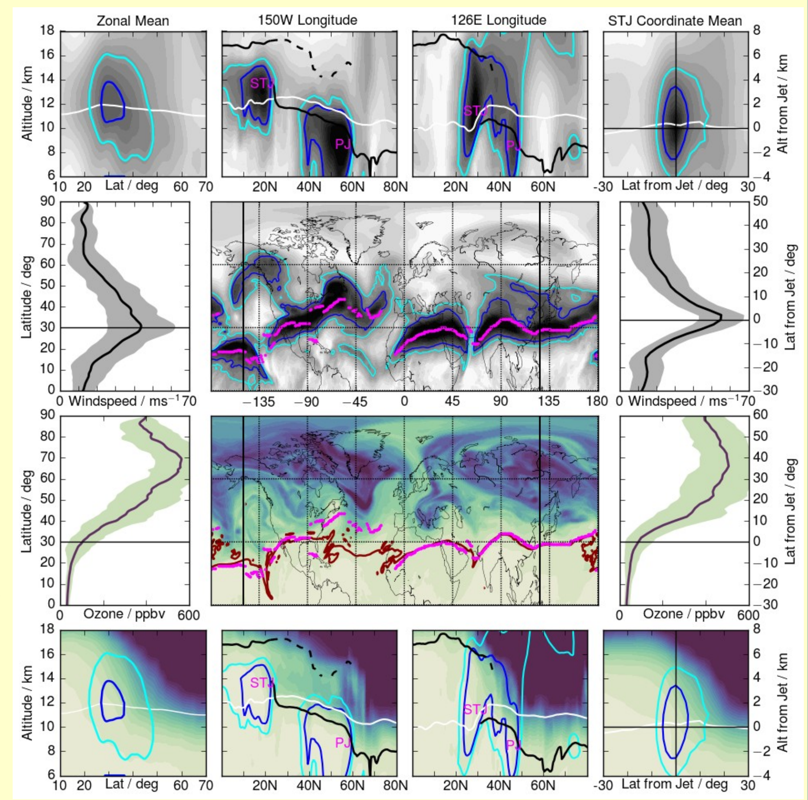
Methods / Tools

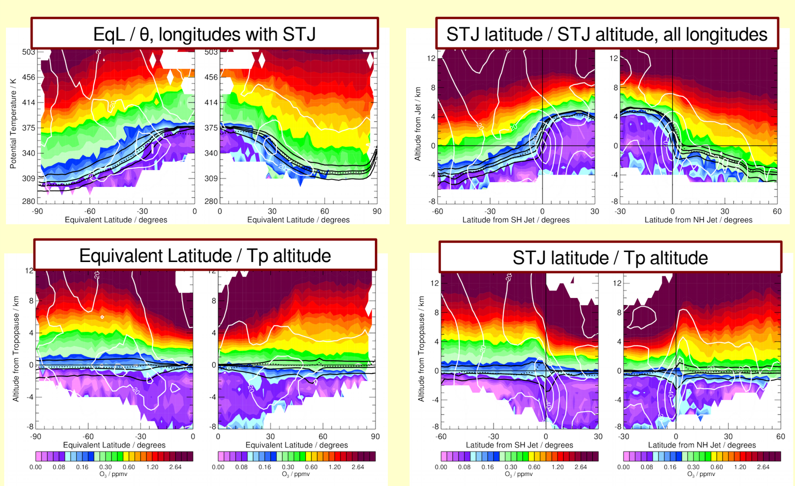


JETPAC (Jet and Tropopause Products for Analysis and Characterization; *Manney et al,* 2011) provides tools to analyze trace gases in relation to the upper tropospheric jets and the tropopauses

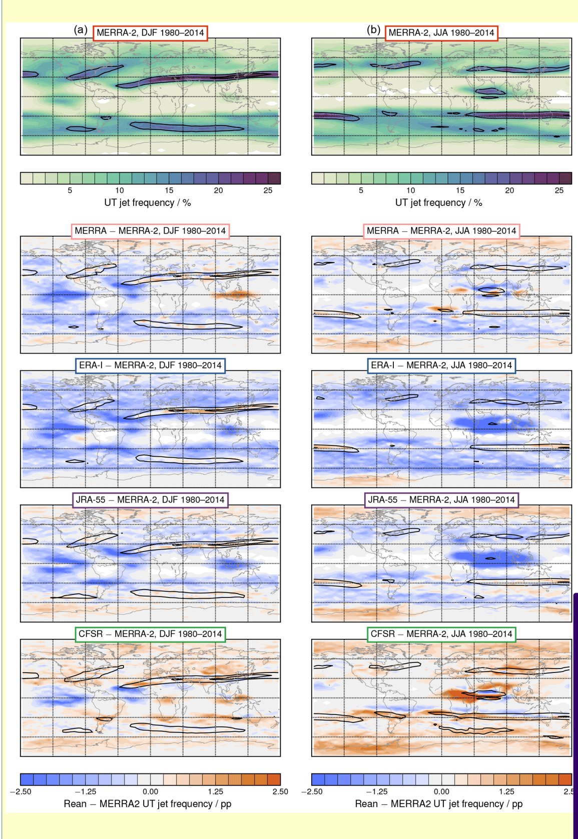
- ➢UT jets are identified between 400 and 100hPa as windspeed maxima >40m/s; further details are given by *Manney et al* (2011, 2014, 2017a).
- ➢The subtropical jet (STJ) is identified as the lowest latitude westerly jet with tropopause altitude >13km at its equatorward edge, and across which the tropopause altitude drops by over 2km
- ➢STJ and PJ changes are considered separately, and their variability and changes are examined as a function of region and season.

Zonal means (left panels) artificially smooth sharp dynamical features such as the jets and tropopause and trace gas gradients related to them because of strong regional variations in those fields in the UTLS. In contrast mapping in dynamical coordinates, such as the distance from the subtropical jets (right panels) preserves sharp gradients and allows us to distinguish between variability related to the asymmetric circulation and that caused by physical processes in the atmosphere.



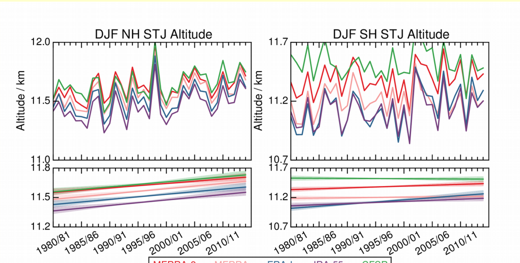


JETPAC products facilitate mapping trace gas data into coordinate systems relative to the upper tropospheric jets, the tropopauses, and equivalent latitude, as shown in the examples to the left. Using different geophysical coordinate combinations can highlight variability due to different processes.

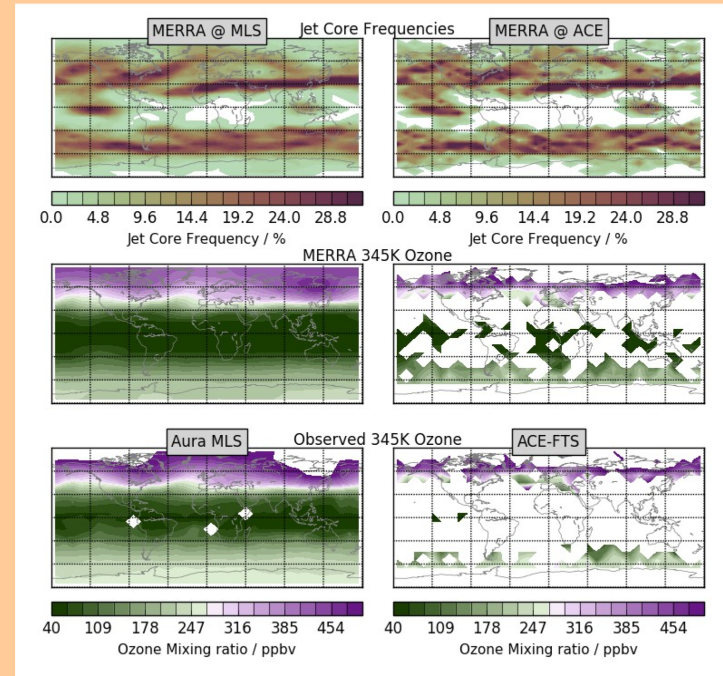


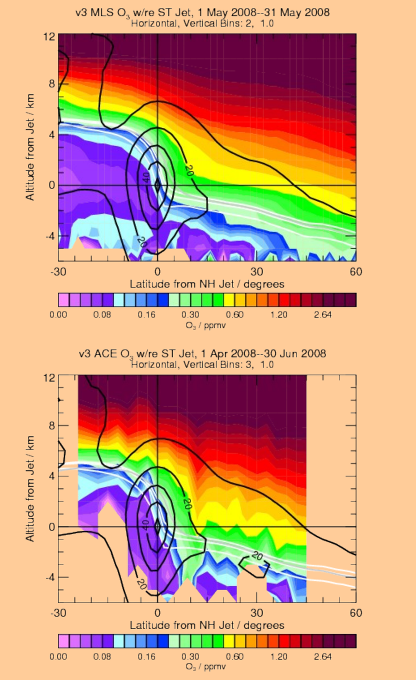
Because reanalyses are needed to define geophysical coordinates, the UTLS results from the SPARC Reanalysis Intercomparison Project (S-RIP) are critical – e.g., to select appropriate reanalysis products to use, and to understand how composition variability and trends may depend on those choices: The left example compares UT jets distributions in reanalyses (Manney et al, 2017); the example below assesses robustness of UT jet trends in reanalyses (Manney & Hegglin, 2017).

All OCTAV-UTLS evaluations will be done consistently with the same reanalyses

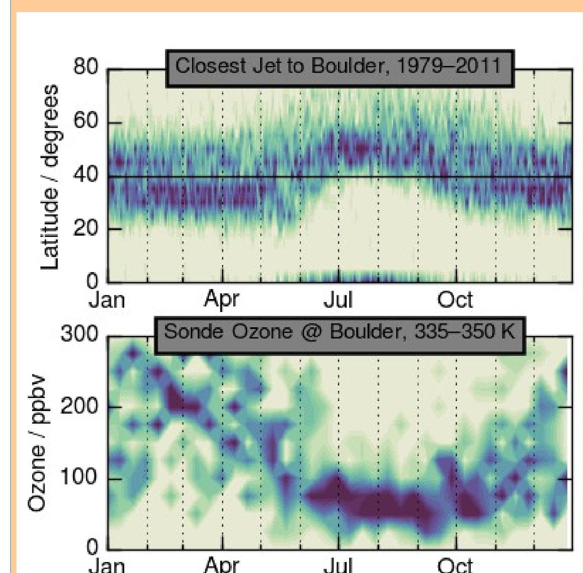


Examples



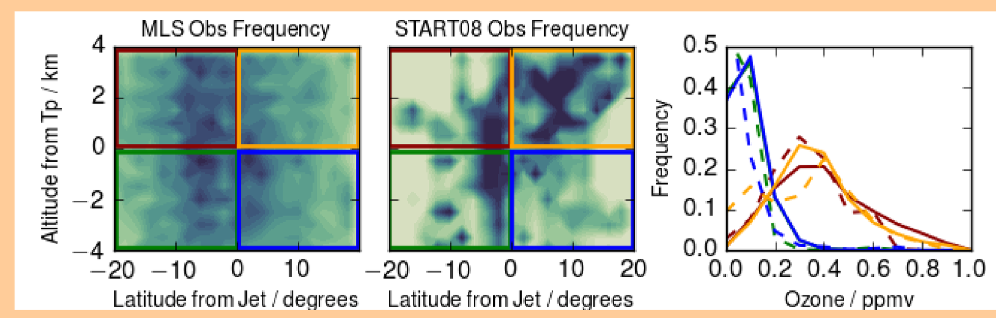


The left figure above shows how the jets and ozone from the MERRA-2 reanalysis are sampled by MLS and ACE for a three-month period. On the right, MLS and ACE data mapped in coordinates with respect to the subtropical jet are shown, demonstrating that sparse coverage of ACE does sample a wide range of the dynamical condition-space surrounding the upper tropospheric jets.



Knowledge of the locations of measurements with respect to the jets and tropopause facilitates interpretation of those measurements: The example to the left shows ozone sonde measurements at Boulder, CO compared with the position of the subtropical jet with respect to Boulder, indicating tropical / tropospheric air over Boulder in summer and midlatitude, often stratospheric, air over Boulder in winter.

Evaluating measurements in broad regions with respect to the jets and tropopause can aid in comparing measurements with widely differing resolution and spatio-temporal sampling, such as the START08 aircraft and MLS satellite measurements shown below.



OCTAV-UTLS will quantify trends and variability in UTLS composition using all available observations; identify changes in transport and mixing processes; understand how measurement characteristics limit our ability to quantify trends; and identify future measurement needs to overcome these limitations.

References:

Gettelmann et al., The extratropical upper troposphere and lower stratosphere, *Rev. Geophys.*, 2011.

Manney et al., Jet characterization in the upper troposphere/lower stratosphere (UTLS): Applications to climatology and transport studies, *Atmos. Chem. Phys.*, 2011.

Manney et al., Climatology of Upper Tropospheric / Lower Stratospheric (UTLS) Jets and Tropopauses in MERRA, *J. Clim.*, 2014.

Manney et al., Reanalysis comparisons of upper tropospheric/lower stratospheric jets and multiple tropopauses, *Atmos. Chem. Phys.*, 2017

Manney & Hegglin, Seasonal and regional variations in long-term changes in upper tropospheric jets from reanalyses, *J. Clim.*, 2017 (in press).

Pan, et al., 2009, Tropospheric intrusions associated with the secondary tropopause, *J. Geophys. Res.*, 2009

Riese, M., et al., Impact of uncertainties in atmospheric mixing on simulated UTLS composition and related radiative effects, *J. Geophys. Res.*, 2009

Author Contact Information: manney@nwra.com; irina.petro@noaa.gov; hoor@uni-mainz.de