Observed composition trends and variability in the upper troposphere / lower stratosphere (OCTAV UTLS)

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The upper troposphere / lower stratosphere (UTLS) is affected by the Brewer Dobson Circulation (BDC) as well as transport across the tropopause and the jets. The effect of changes of dynamics on the distribution of tracers in the UTLS is therefore difficult to detect, since it involves the coupling of transport and mixing processes on very different temporal and spatial scales.

Further complications arise from the short term variability of the tropopause and jet locations, which introduces variability in tracer distributions, which leads to substantial uncertainties for quantitative estimates of future surface temperature changes (Riese et al., 2012). It is therefore essential to account for the dynamically induced variability by, e.g. the tropopause location when looking at trends of trace gas distributions and long-term changes.

The Stratosphere-troposphere Processes And their Role in Climate (SPARC) emerging activity OCTAV- UTLS (Observed Composition Trends and Variability in the UTLS) aims to reduce the uncertainties in trend estimates by accounting for these dynamically induced sources of variability. Achieving these goals by using existing UTLS trace gas observations from aircraft, ground-based, balloon and satellite platforms requires a consistent analysis of these different data with respect to the tropopause or the jets. Therefore, a central task for OCTAV-UTLS is the development of common metrics that are applicable to the different types of data sets to account for the dynamically induced tracer variability. Particularly we will compare different UTLS datasets using geophysically-based coordinate systems including tropopause and upper tropospheric jet relative coordinates derived from the JETPAC tool (Jet and Tropopause Products for Analysis and Characterization).

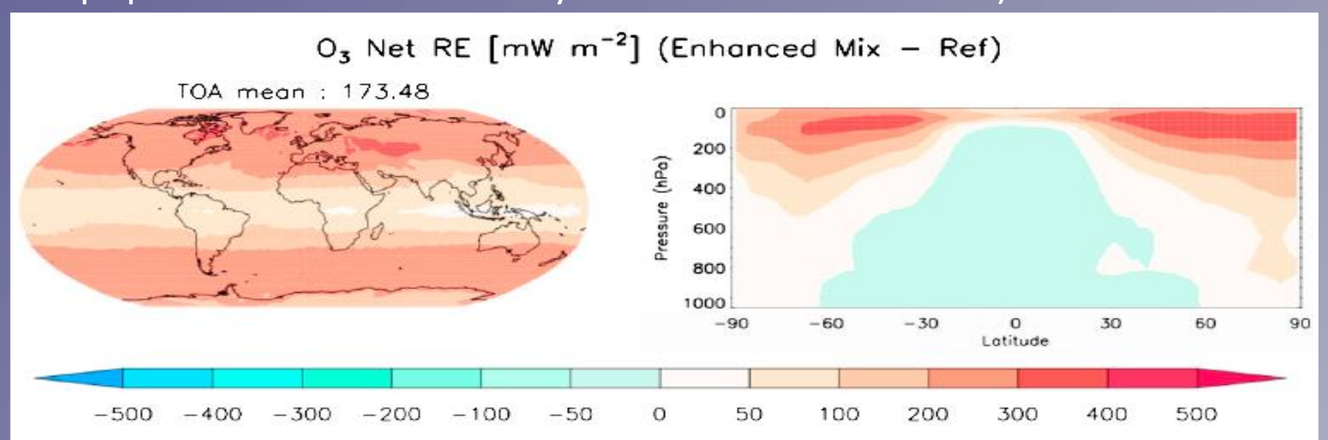


Fig.1: Mixing induced differences of radiative effect from ozone (Riese et al., 2012)

Ozone trends from different data sets differ in the UTLS: Why?

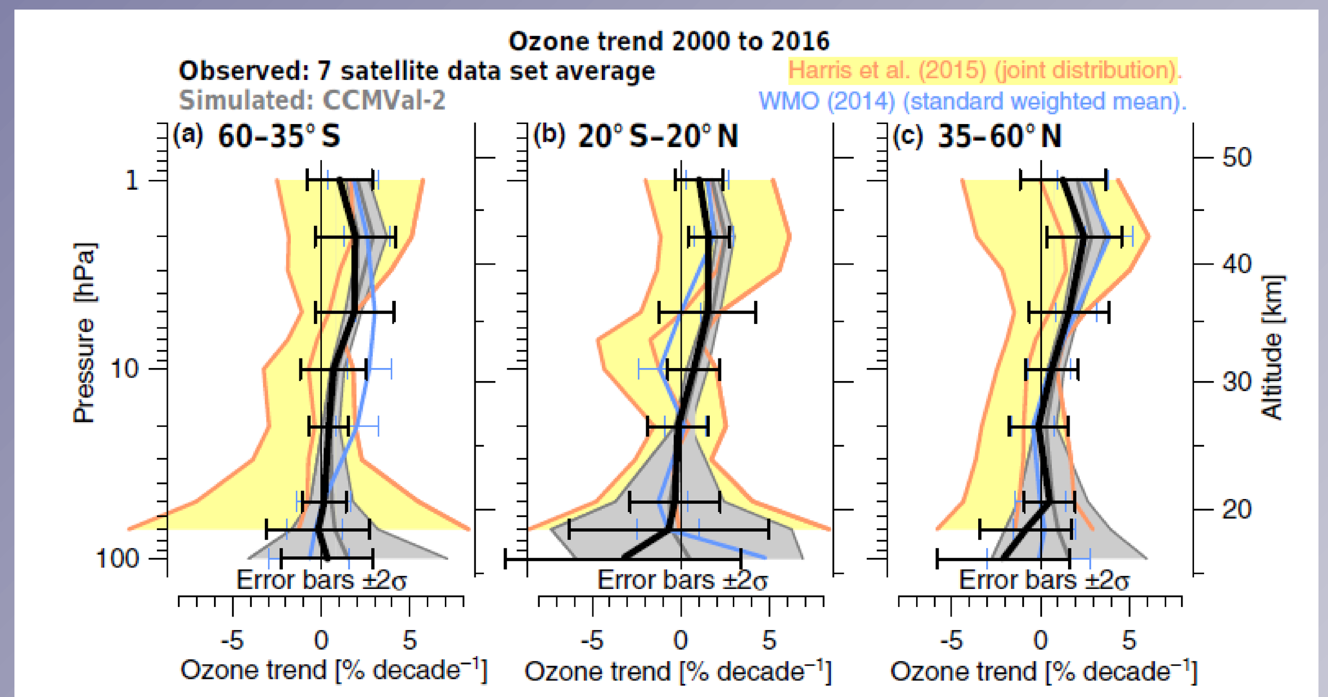


Fig.1: Ozone trends deduced from different data sets (Steinbrecht et al., 2017): substantial increase of uncertainties in the UTLS

Problem: The right coordinate

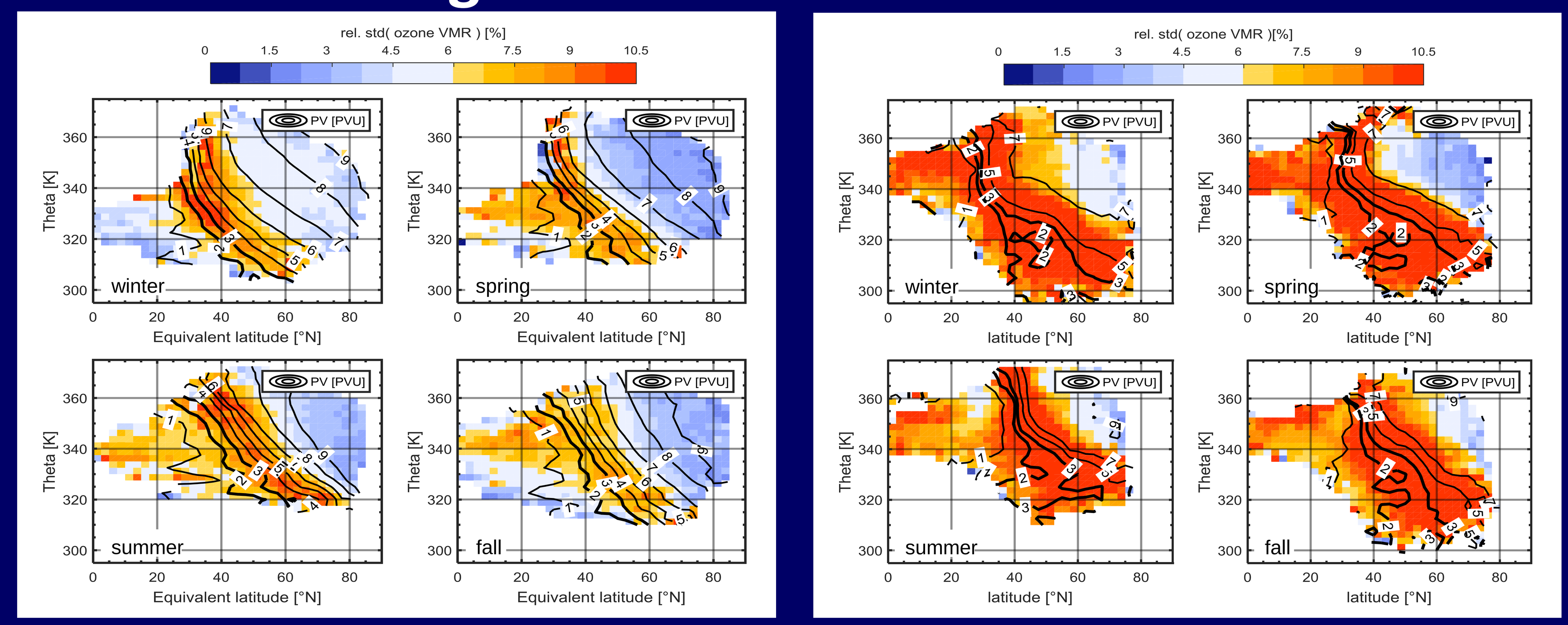


Fig. 2: Ozone climatology over the Northern Atlantic from IAGOS (1995-2008)
Comparison of variability of ozone in different coordinate systems illustrating the effect of using a tropopause based coordinate system (equivalent latitude i.e. PV) compared to surface based coordinates. Ozone variability is significantly reduced, when accounting for reversible tropopause and jet locations by planetary waves.

Methods and Tools: JETPAC

- JETPAC (Jet and Tropopause Products for Analysis and Characterization; *Manney et al*, 2011) as central package to account for variability of tropopause and jet location
- provides tools to analyze trace gases in relation to the upper tropospheric jets and the tropopauses
- consistent reanalysis data sets (MERRA-2, ERA Interim, ERA 5) for all analyses

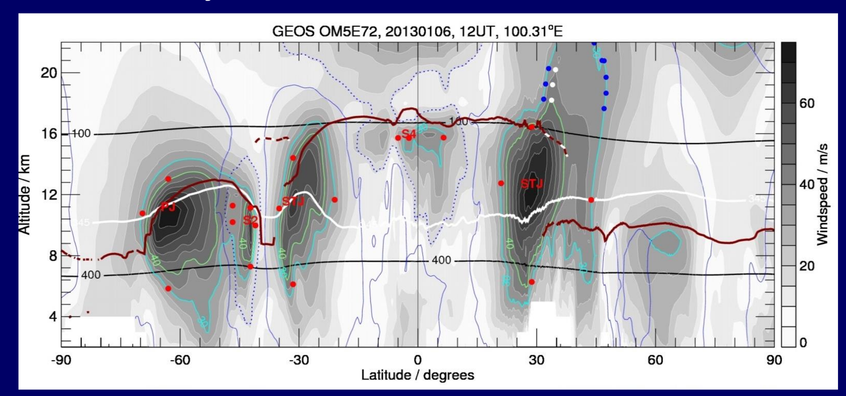


Fig.4: Definitions of JETPAC metrics:
- UT jets: max(windspeed) > 40 ms^{-1} for p = 400 … 100hPa (see *Manney et al* (2011, 2014, 2018))
- subtropical jet (STJ): lowest latitude of westerly jet with z(TP) > 13km (equatorward edge) and drop of z(TP) > 2km across jet

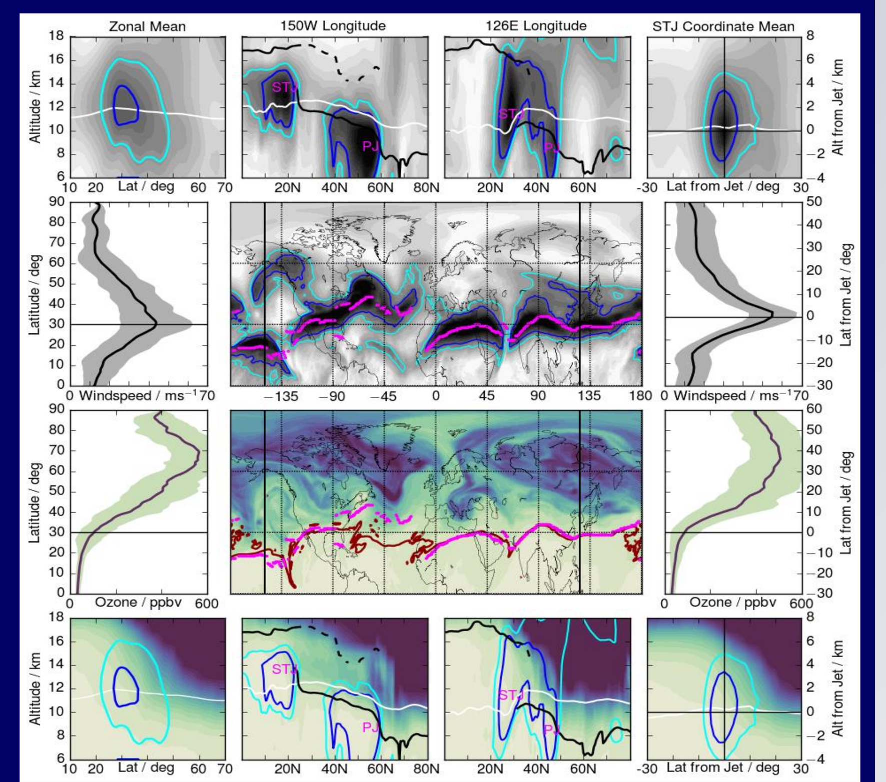


Fig.5 (right): Example of JETPAC analysis: zonal mean ozone (left column) and STJ-referenced (right column): Directly at the tropopause gradients become sharper and variability is reduced

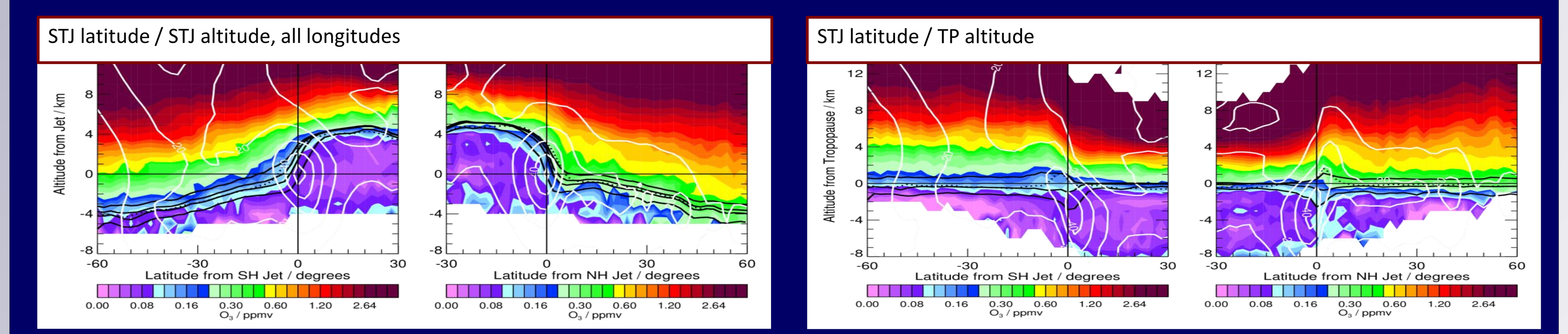


Fig.6 MLS ozone for 9.May 2008 in different coordinate systems: Note the different appearance of ozone isopleths and sharpness of vertical gradients.

Examples: Sampling effects

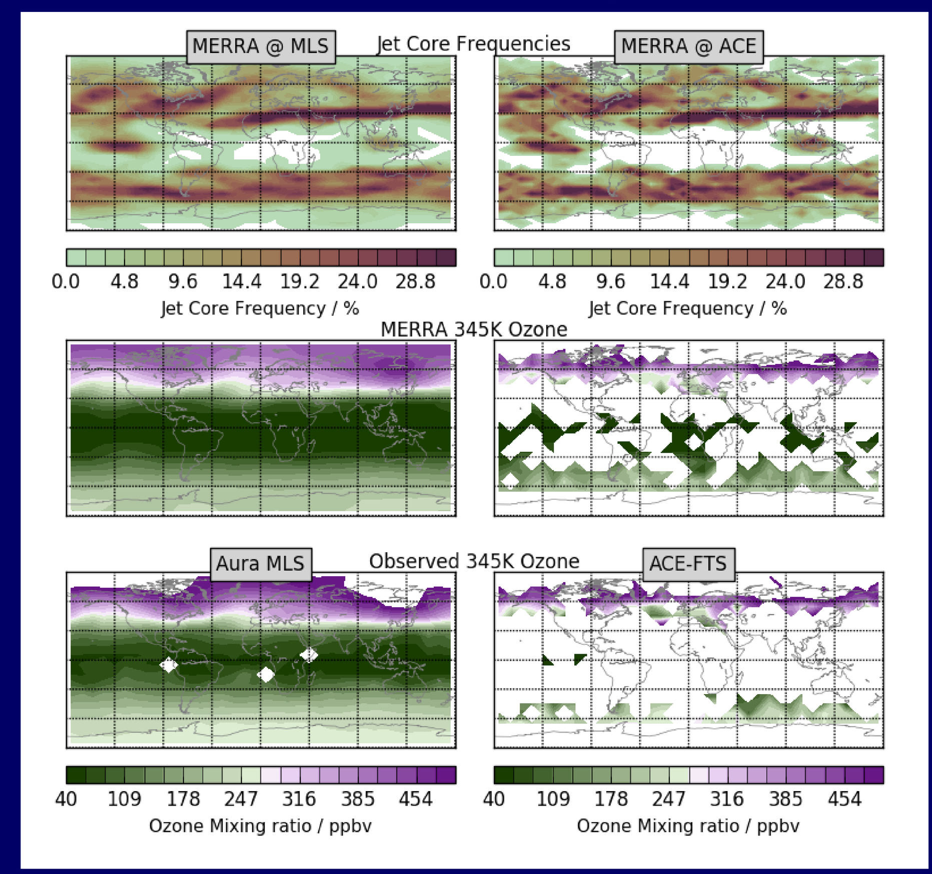
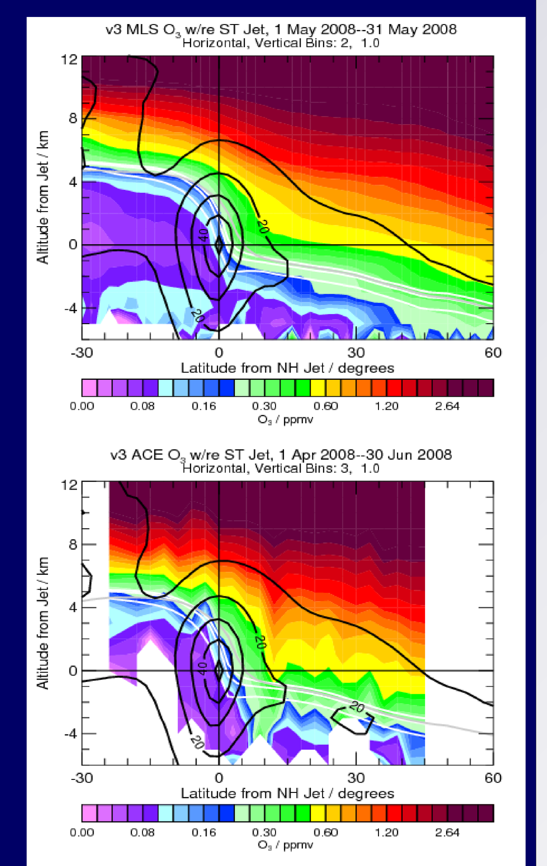


Fig. 7: Left two figure columns:
- jets and ozone from the MERRA-2 reanalysis sampled at the observations locations from MLS and ACE for a three-month period.

Fig.8, right:
- MLS and ACE data mapped in coordinates with respect to the subtropical jet
- demonstrating that sparse coverage of ACE does sample a wide range of the dynamical condition-space surrounding the upper tropospheric jets.



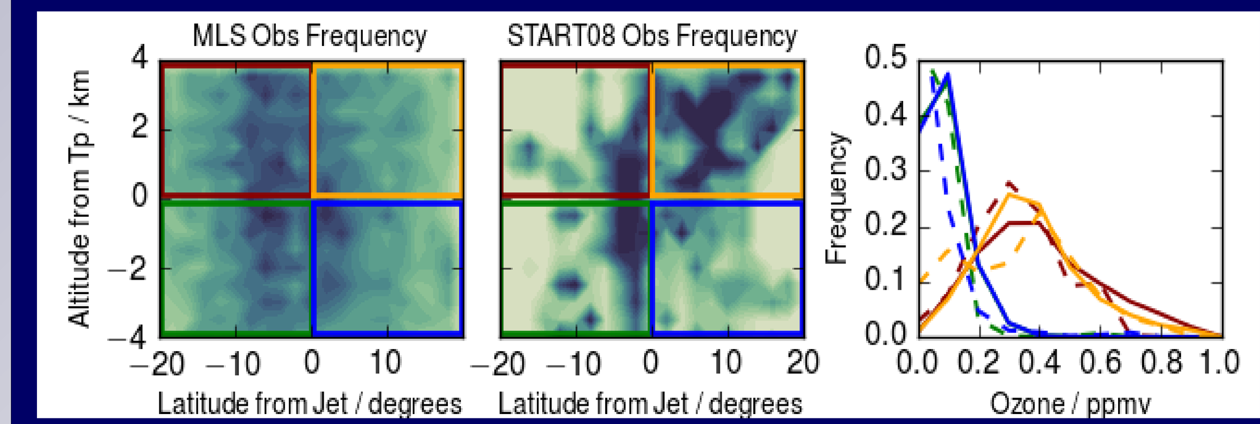


Fig. 9: Comparing satellite and aircraft
Comparison of ozone sampling and distribution relative to the jet using different platforms: satellite (MLS) and aircraft (HIAPER G5). allowing for quantitative comparison despite different sampling.

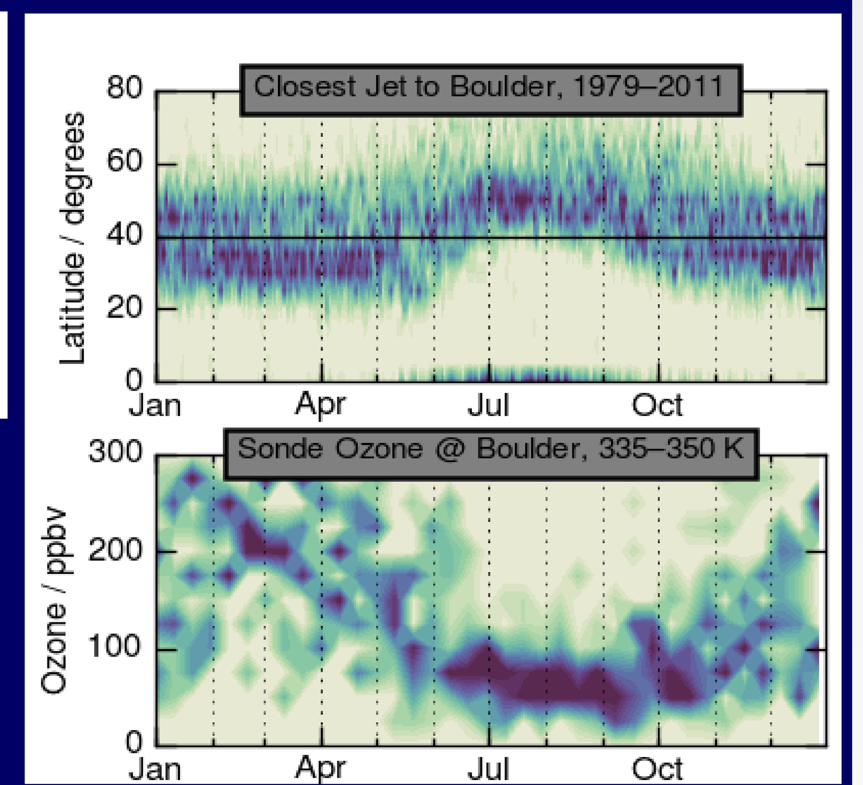


Fig.10, right: JETPAC applied to balloon borne observations
Application of JETPAC analysis and to soundings over Boulder showing the ozone decrease during summer due to the northward movement of the jet during summer and thus tropospheric (subtropical) air over Boulder and more stratospheric air during winter. Note, that this is not accounted for in surface -based trend estimates!

OCTAV-UTLS will…

- account for dynamically induced variability of tracers and trends
- quantify trends and variability in UTLS composition by applying consistent analysis methods to make use of cross platform observations
- identify changes in transport and mixing processes
- help to see how measurement characteristics limits the quantification of trends
- identify future measurement needs to overcome these limitations

References:

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