



# **Climatology and Variability of Upper Tropospheric/Lower Stratospheric Jets from MERRA Reanalysis**

Gloria L Manney(1\*\*,2), William H Daffer(1), Michaela I Hegglin(3),  
Steven Pawson(4), Michael J Schwartz(1), Michelle L Santee(1)

(1)Jet Propulsion Laboratory, California Institute of Technology

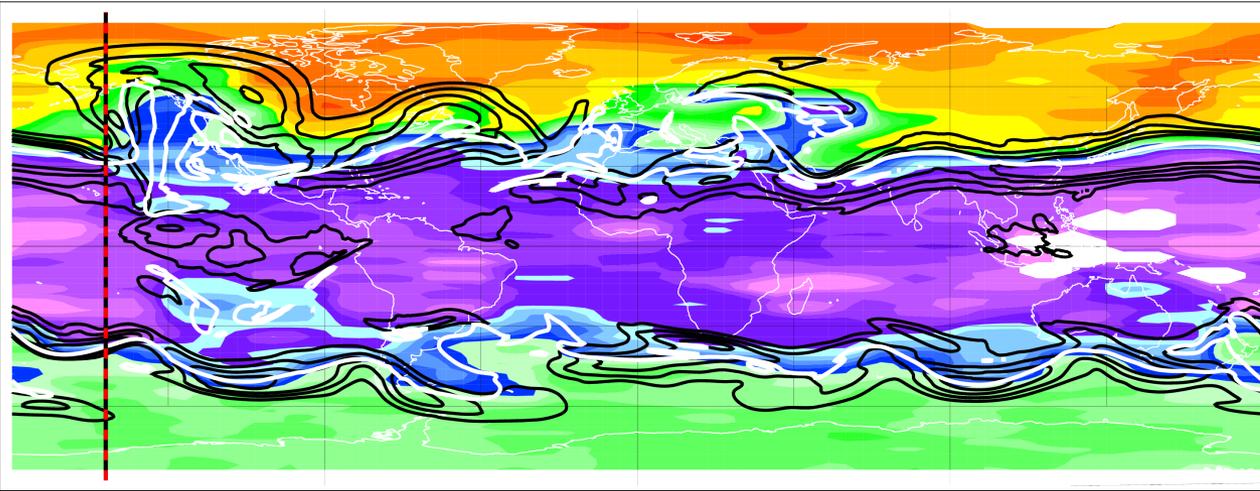
\*\*Now at NorthWest Research Associates

(2) New Mexico Institute of Mining and Technology

(3) University of Reading, UK

(4) NASA/Goddard Space Flight Center

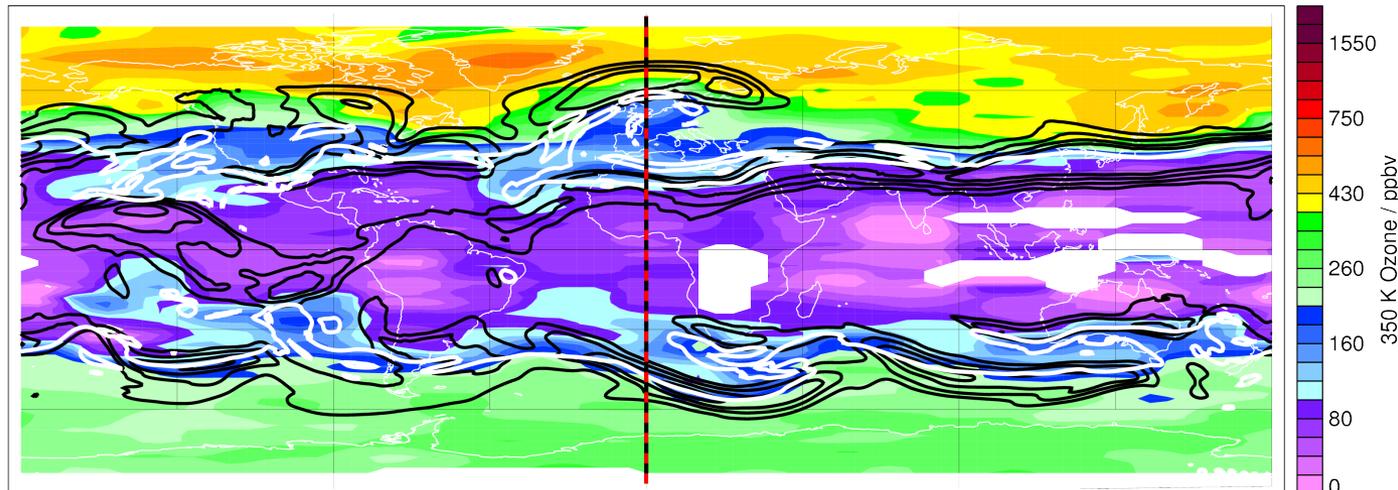
# UTLS Jet Characterization: Motivation



MLS O<sub>3</sub> at 350 K on 14 Jan 2009, just before the record-breaking stratospheric sudden warming [Manney et al., 2009, GRL]

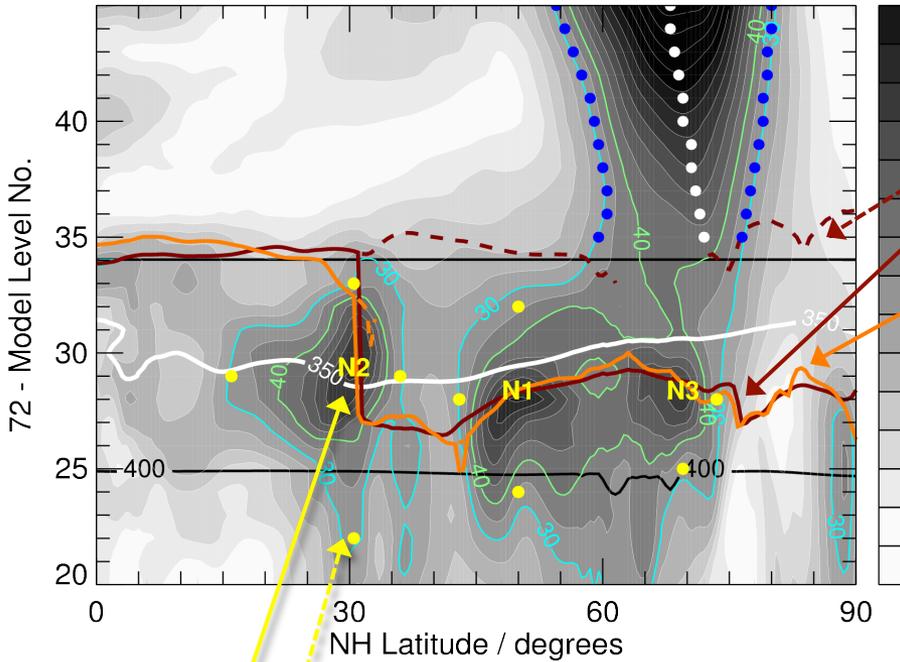
➤ Upper tropospheric jets (UTJs, black overlays) show complex structure in relation to the tropopauses (the white contour is the primary dynamical tropopause) and trace gas measurements from satellites and aircraft

MLS O<sub>3</sub> at 350 K on 26 Dec 2011, during/ prior to strong SSWs



# Jet and Tropopause Characterization from GEOS-5 Analyses

14-01-2009, 12UT, -153°E



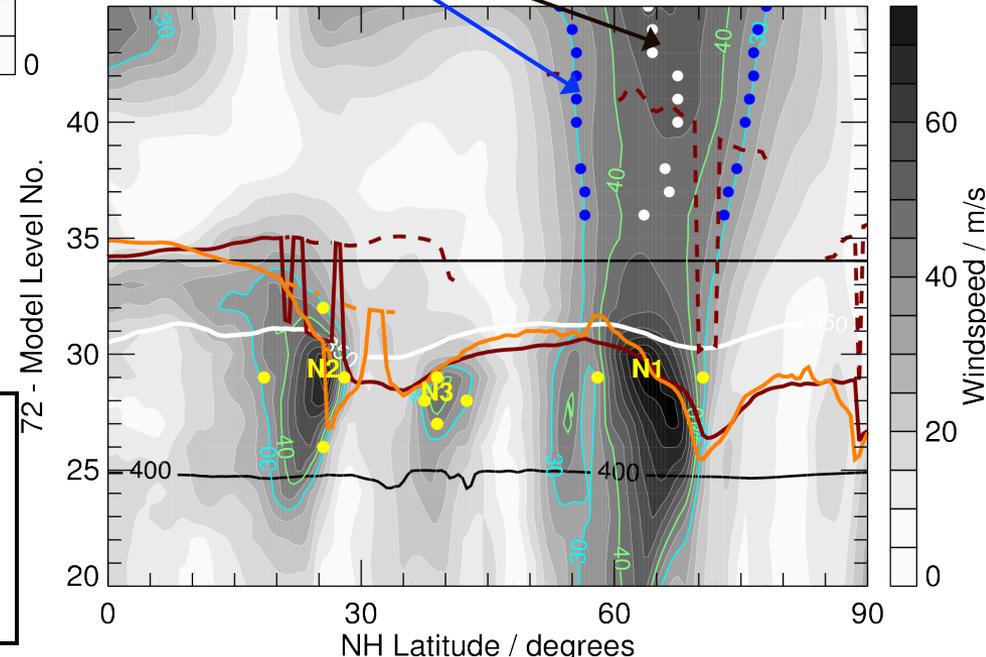
- WMO and 4.5, 3.5, 2.0 PVU tropopauses; multiple values
- Polar night jet (PNJ, demarks vortex and subvortex):
  - ✧ most poleward westerly jet with windspeed >30 m/s

- 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

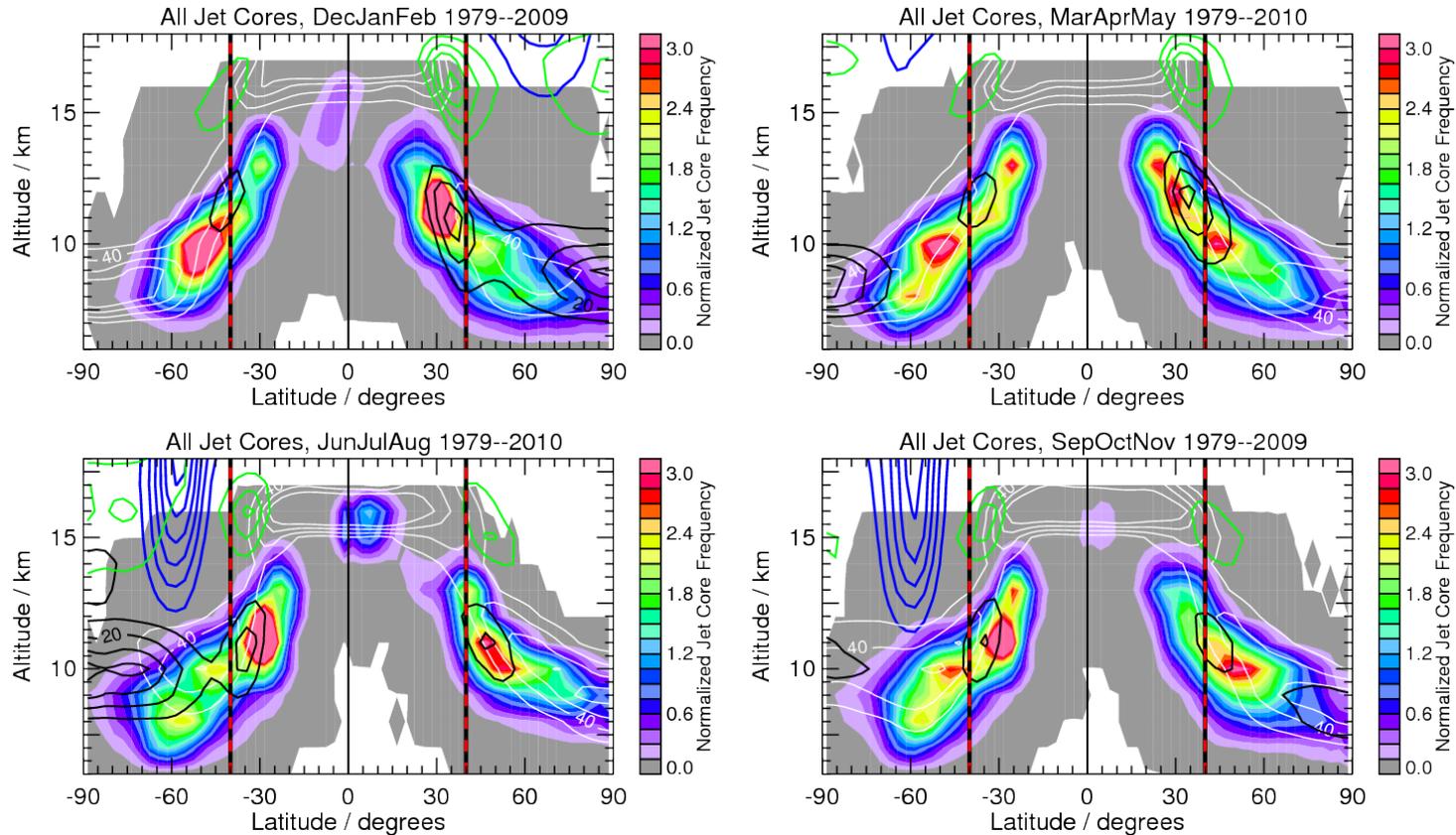
➤ Also used to categorize and compare satellite and aircraft trace gas data

26-12-2011, 12UT, 0°E



# Jet/Tropopause Climatology from MERRA (GEOS-5 Reanalysis)

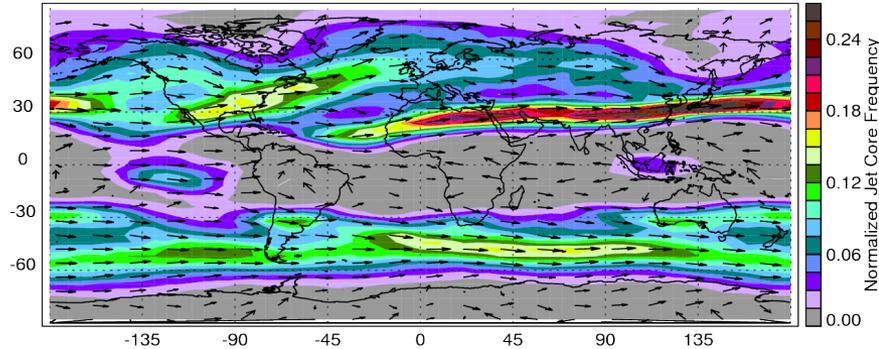
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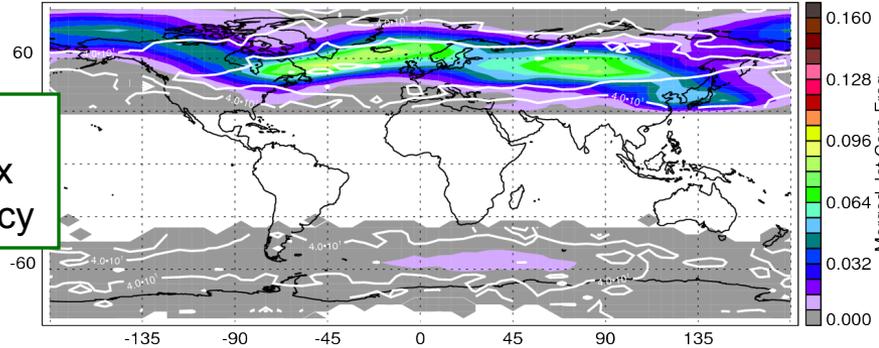
- ◆ Frequency distributions of UT jets (colorfill), subvortex jet (blue), single tropopauses (white), multiple tropopauses (black primary, green secondary)
- ◆ Usually a minimum in UT jet frequency near 40° latitude → used for simple definition of subtropical jet (STJ) and polar jet

# Jet/Tropopause Climatology: Spatial Relationships

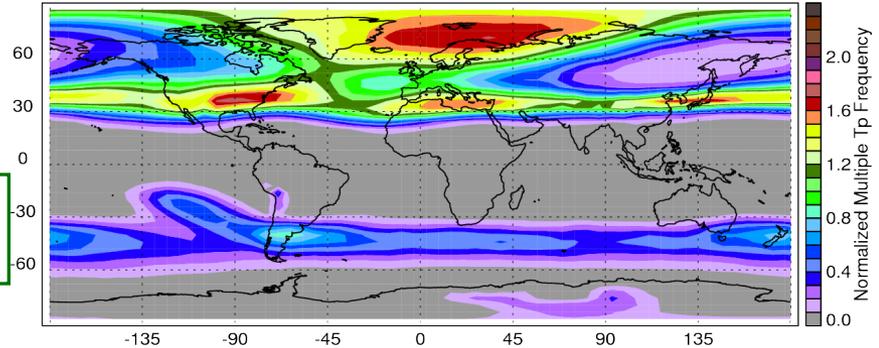
UT Jet frequency



Merged UT & Subvortex Jet frequency

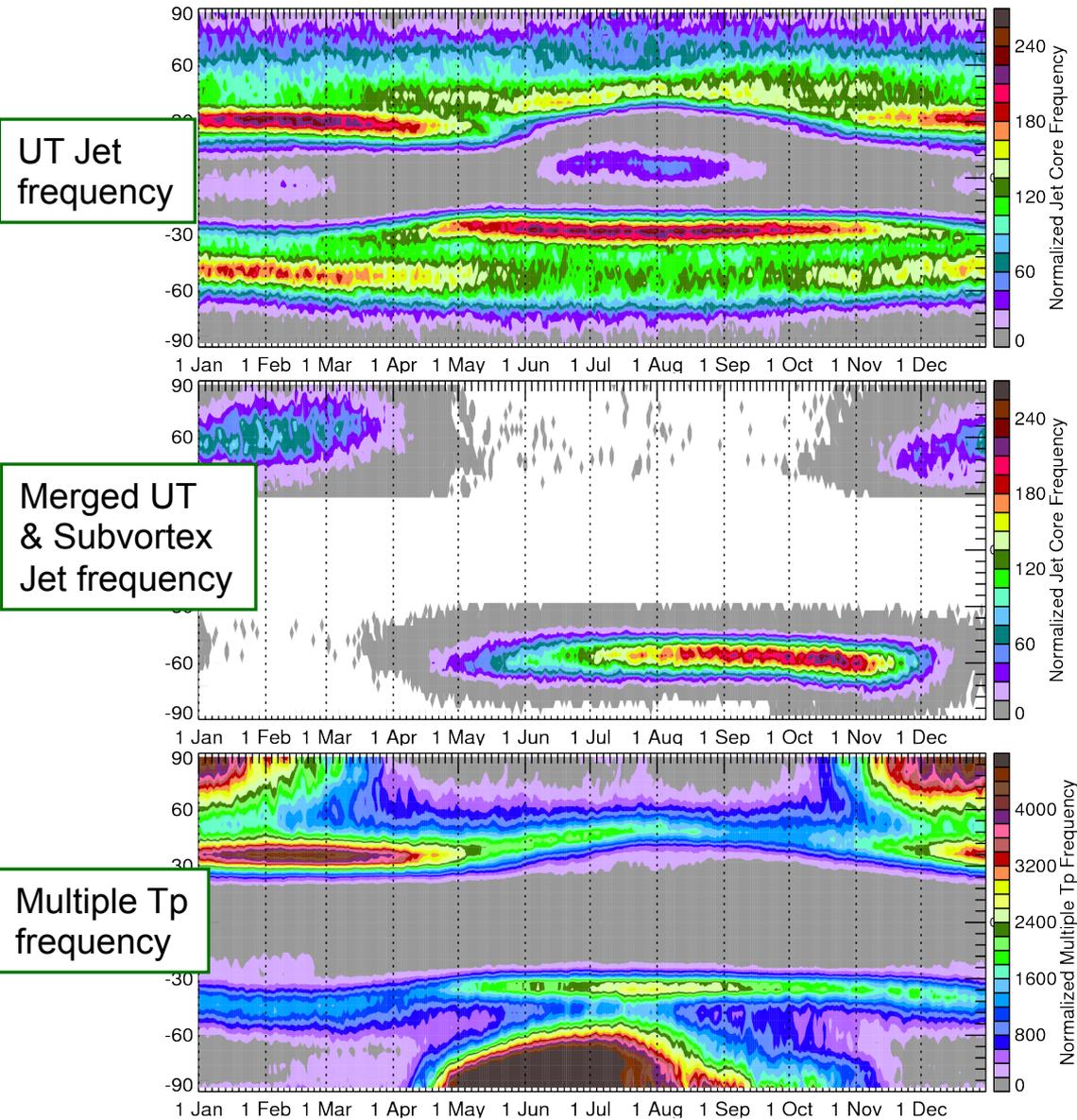


Multiple Tp frequency



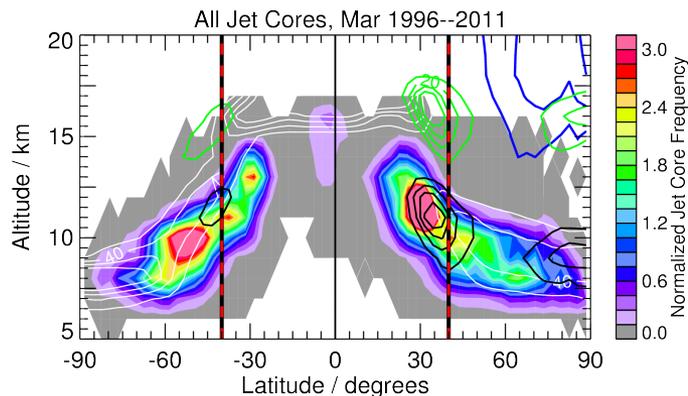
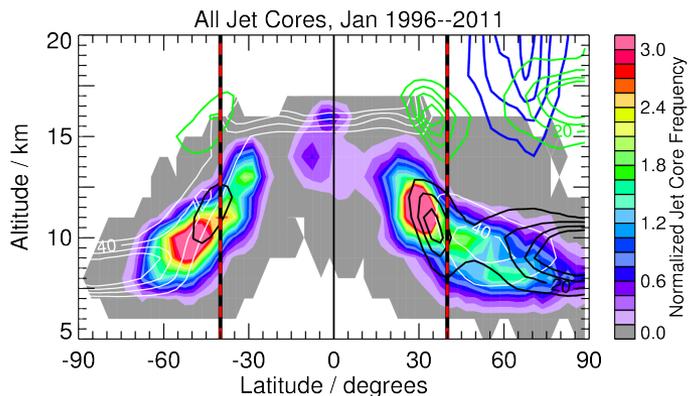
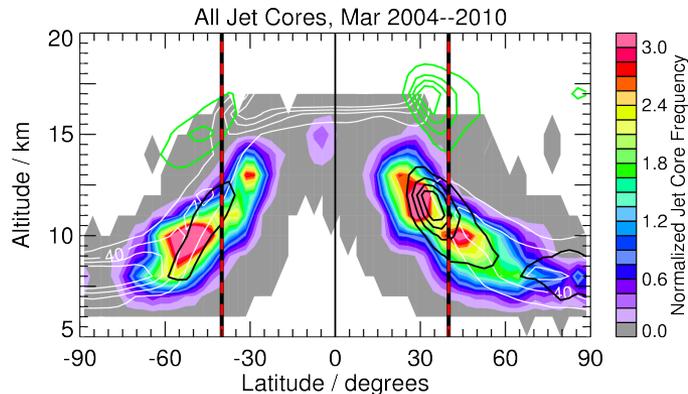
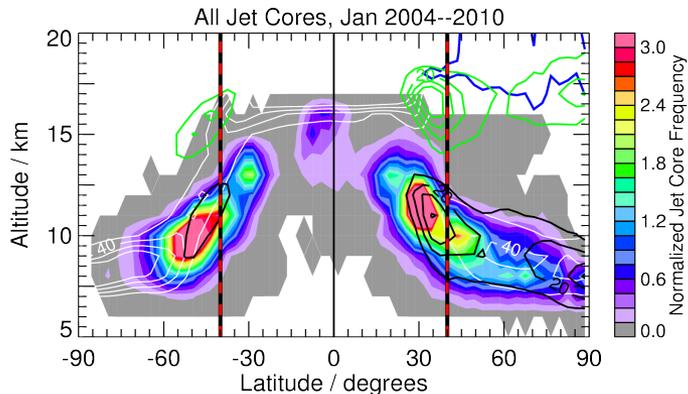
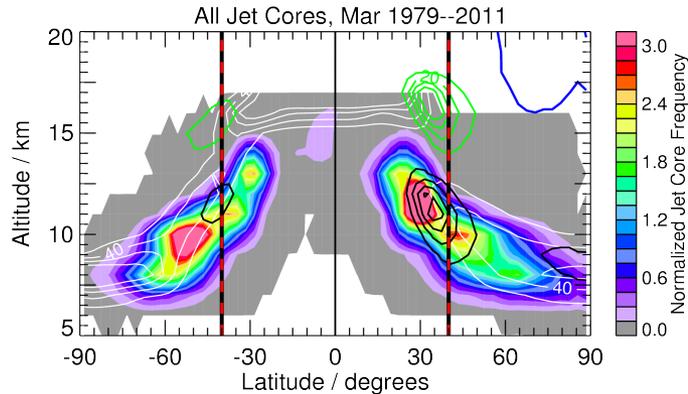
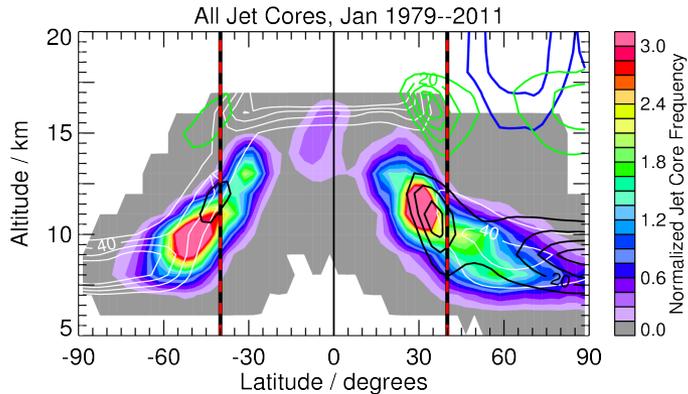
- ◆ DJF UTLS jet and Tp climatology shows recognized features: eg, complex UT jet structure over E Pacific and N America, 'westerly ducts', strong polar UT jet in SH summer
- ◆ Equatorial westerly jet common in E Pacific
- ◆ Subvortex jet merges with UT jet preferentially over N Atlantic, N Europe, Russia
- ◆ Multiple Tps poleward of subtropical UT jet and subvortex jet

# Jet/Tropopause Climatology: Seasonal Evolution



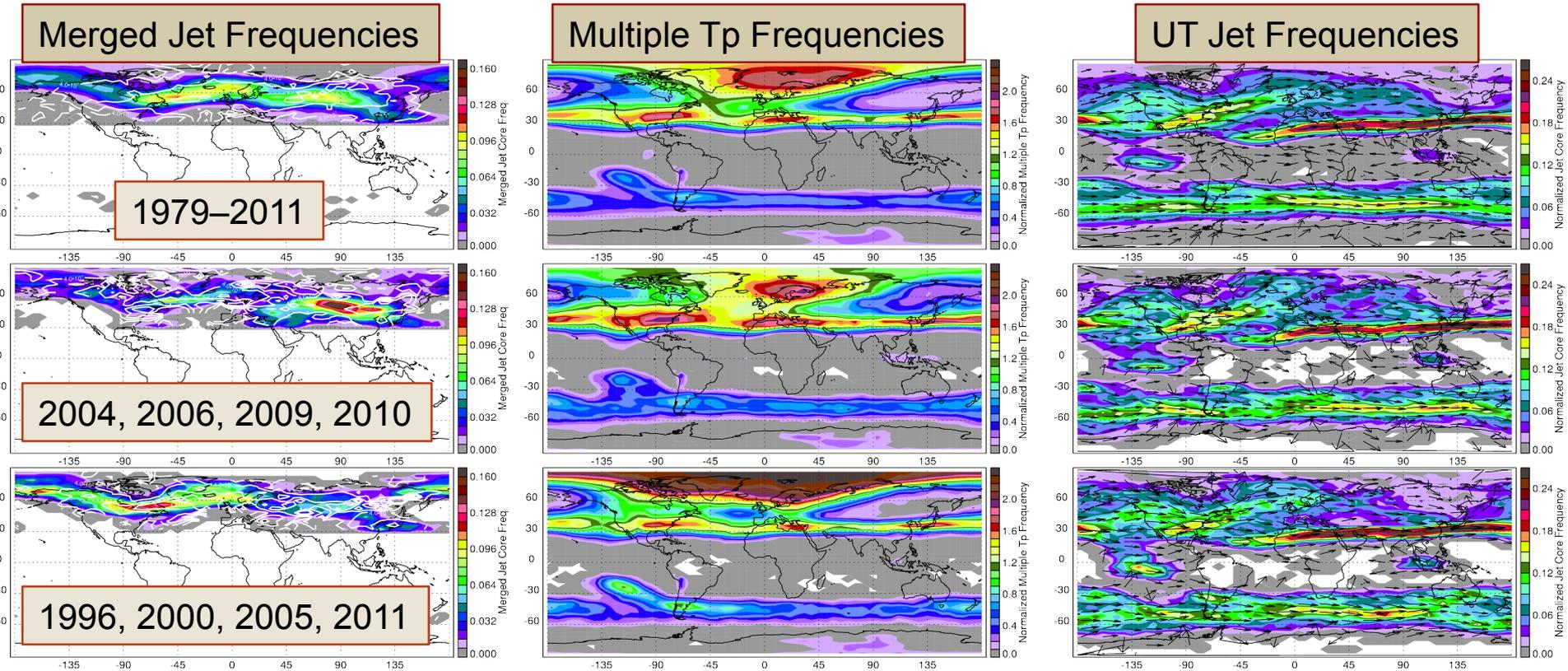
- Climatological (1979–2011) evolution of UT jets, “deep” LS jets, and multiple Tps
- In NH, subtropical UT jet nearly always dominant in zonal mean
- Merged LS and UT jets on NH common in December through February
- Multiple Tps form poleward of subtropical UT jet and subvortex jet

# Jet/Tropopause Variability: Relationship to SSWs



- UT jet frequency (colorfill), subvortex jet (blue), single Tps (white), multiple Tps (black, green)
- Top: 1979-2011 Climatology
- Center: SSW years 2004, 2006, 2009, 2010
- Bottom: Cold vortex years 1996, 2000, 2005, 2011

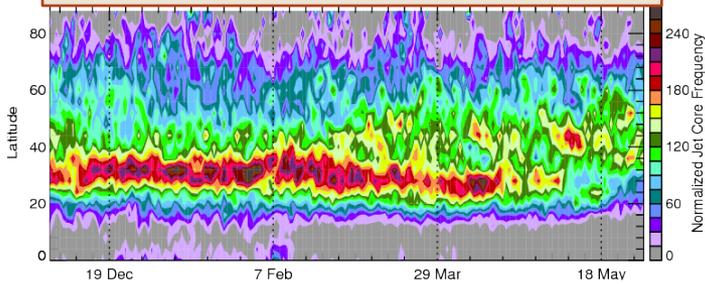
# Jet/Tropopause Variability: Relationship to SSWs



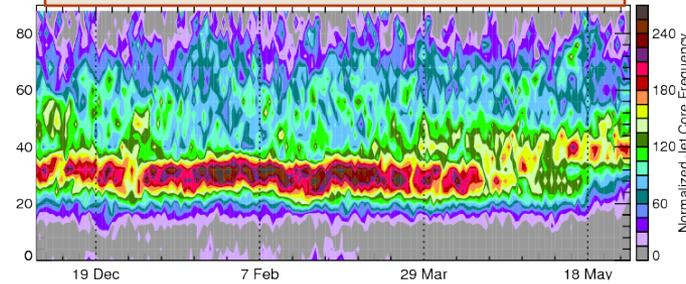
- Distinct differences in merged jet, multiple Tp frequencies, patterns between SSW years (center row) and cold vortex years (lower row)
- Subtle differences between SSW and cold vortex years in UT jet patterns, frequencies

# Jet/Tropopause Variability: Relationship to SSWs

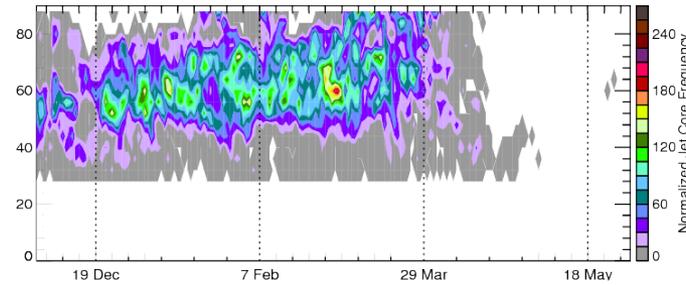
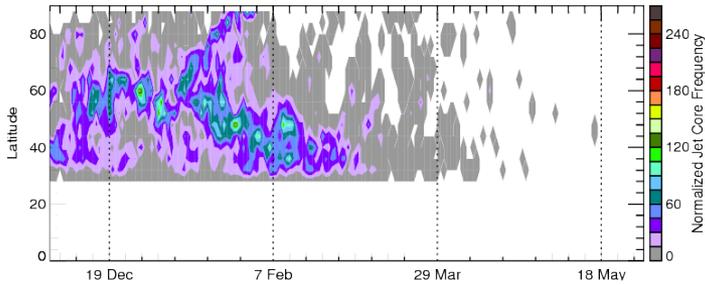
SSW: 2004, 2006, 2009, 2010



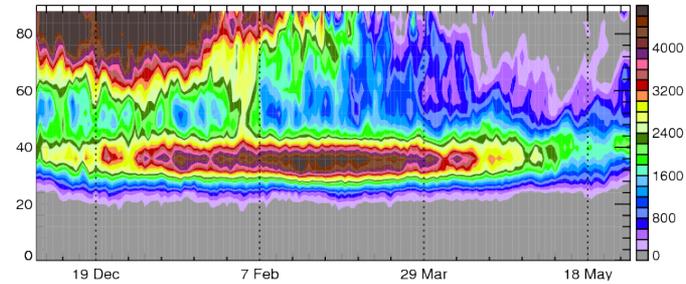
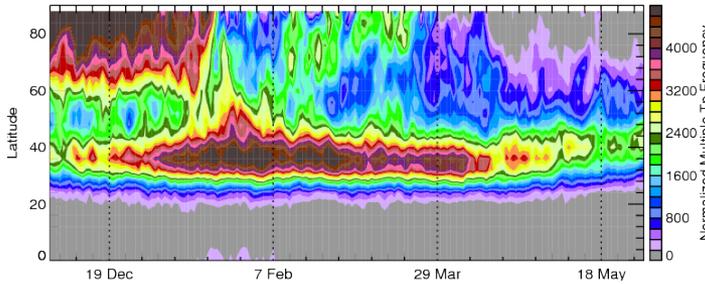
CV: 1995, 1996, 2000, 2005



UT Jet Freq



Merged Jet Freq

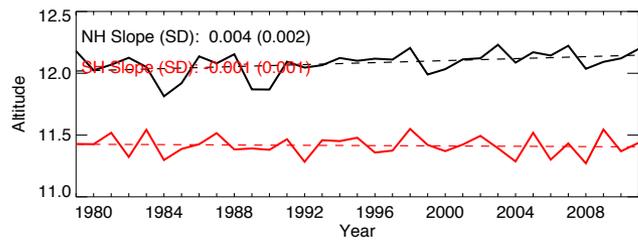
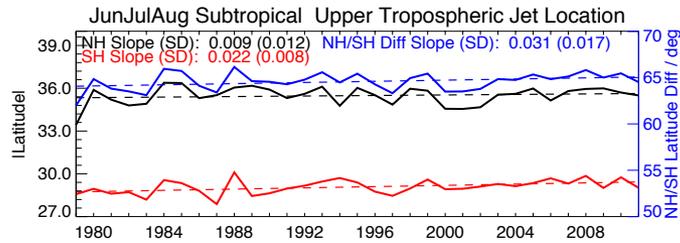
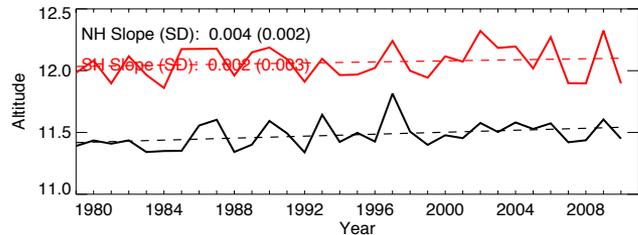
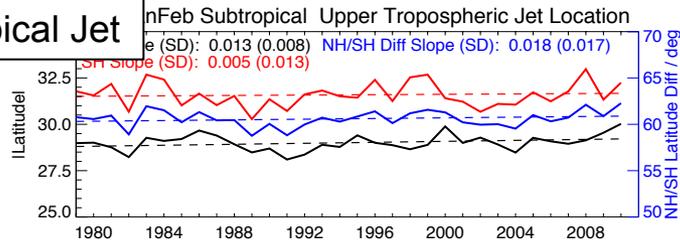


Multiple Tp Freq

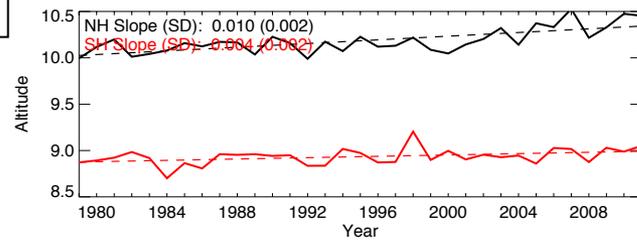
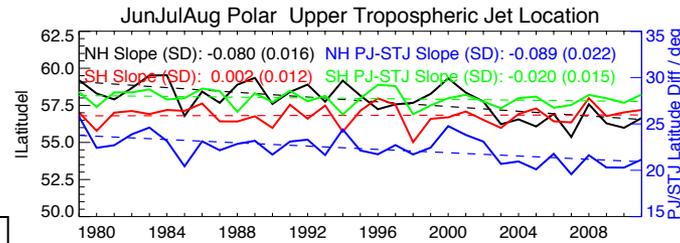
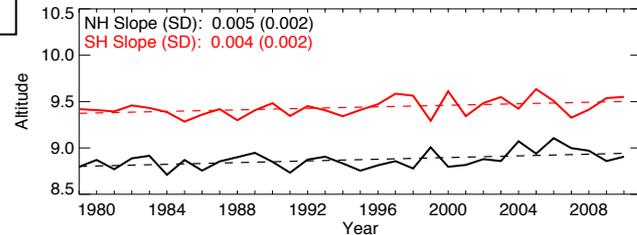
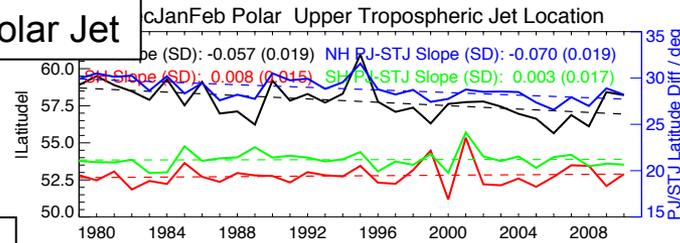
- Distinct differences in merged jet, multiple Tp frequencies, patterns between SSW years and cold vortex years
- Subtle differences between SSW and cold vortex years in UT jet patterns, frequencies

# Jet/Tropopause Variability: Trends?

## Subtropical Jet



## Polar Jet

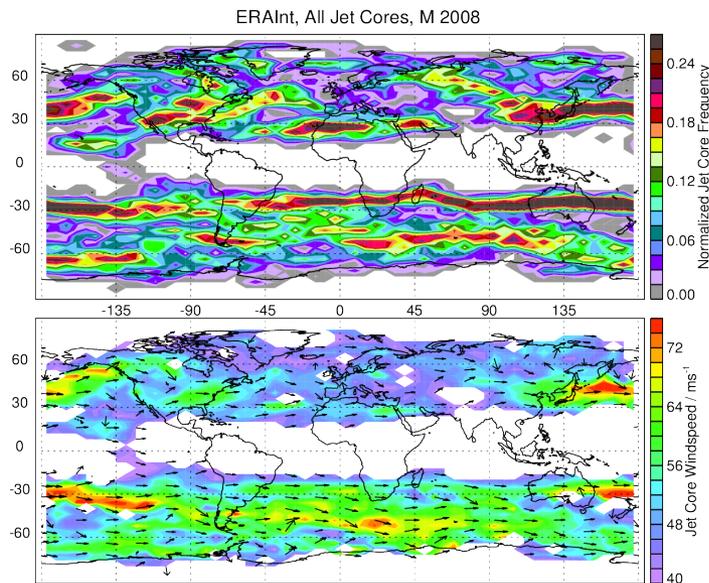
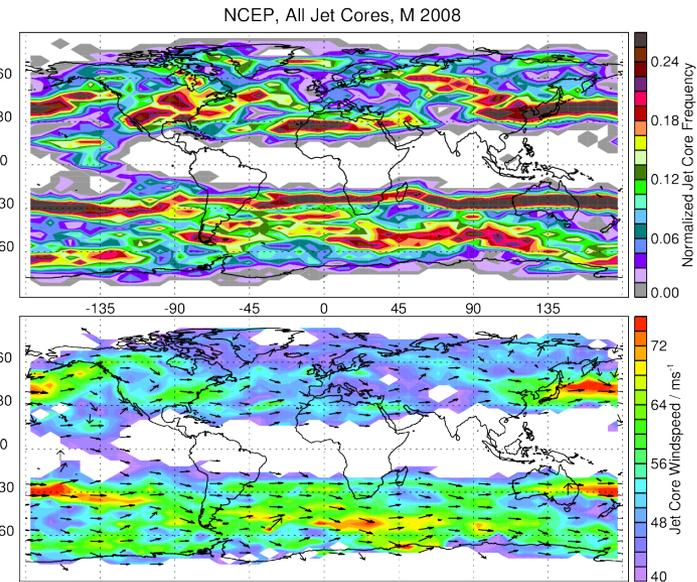
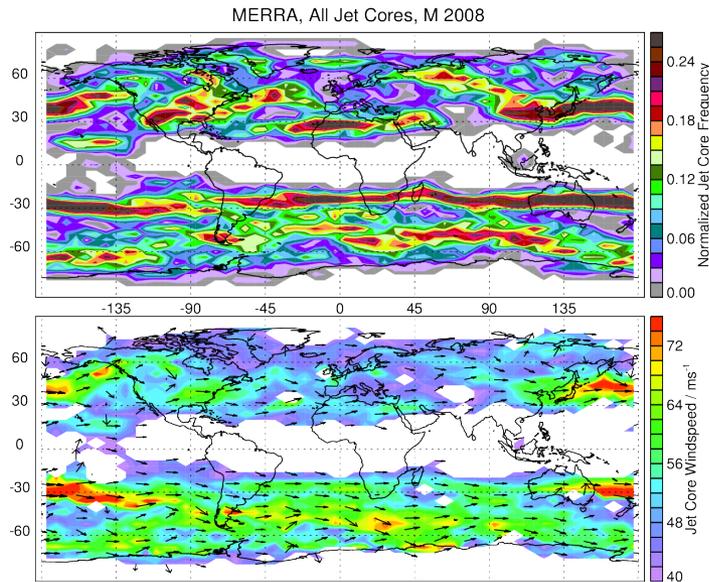


DJF

JJA

- Examining MERRA jet climatology for indications of trends
- Altitudes show significant increase, latitude changes vary with season

# Jet/Tropopause Climatology: Reanalysis Intercomparisons



- ◆ Jet/tropopause characteristics on individual days are sensitive to which re/analysis is used (William Daffer et al poster)
- ◆ Comparisons are being initiated of climatological characteristics
- ◆ Broad agreement is seen between jet frequencies/winds for May 2008 between MERRA, ERA-Interim and the NCEP-GFS analysis, but many differences in detail

## Concluding Remarks

- ◆ The UTLS jets are dominant – and complex – features of the circulation that organize UTLS transport
- ◆ A new identification/classification scheme for the UTLS jets and the tropopauses is being used to develop a comprehensive global climatology and to examine interannual variability and trends in the jets
- ◆ Relationships between the upper tropospheric jets, the subvortex jet, and multiple tropopauses are being characterized, including study of differences in these relationships in years with strong stratospheric sudden warmings
- ◆ A primary application not shown here is examining trace gas transport in relation to the jets and tropopauses (Michael Schwartz will show some of this in relation to multiple tropopauses in the following talk)
- ◆ We are initiating intercomparisons of jet and tropopause characteristics calculated using different (re)analyses and how such differences may affect studies of climatology, trends, and trace gas transport