Update on Stratospheric Water Changes

Karen Rosenlof

NOAA ESRL CSD

Sean Davis, Paul Young

NOAA ESRL CSD & CU CIRES

Dale Hurst

NOAA ESRL GMD & CU CIRES

Stratospheric water vapor trends over Boulder, Colorado: Analysis of the 30 year Boulder record

Dale F. Hurst,[1,2] Samuel J. Oltmans,[2] Holger Vömel,[3] Karen H. Rosenlof,[4] Sean M. Davis,[1,4] Eric A. Ray,[1,4] Emrys G. Hall,[1,2] and Allen F. Jordan[1,2]

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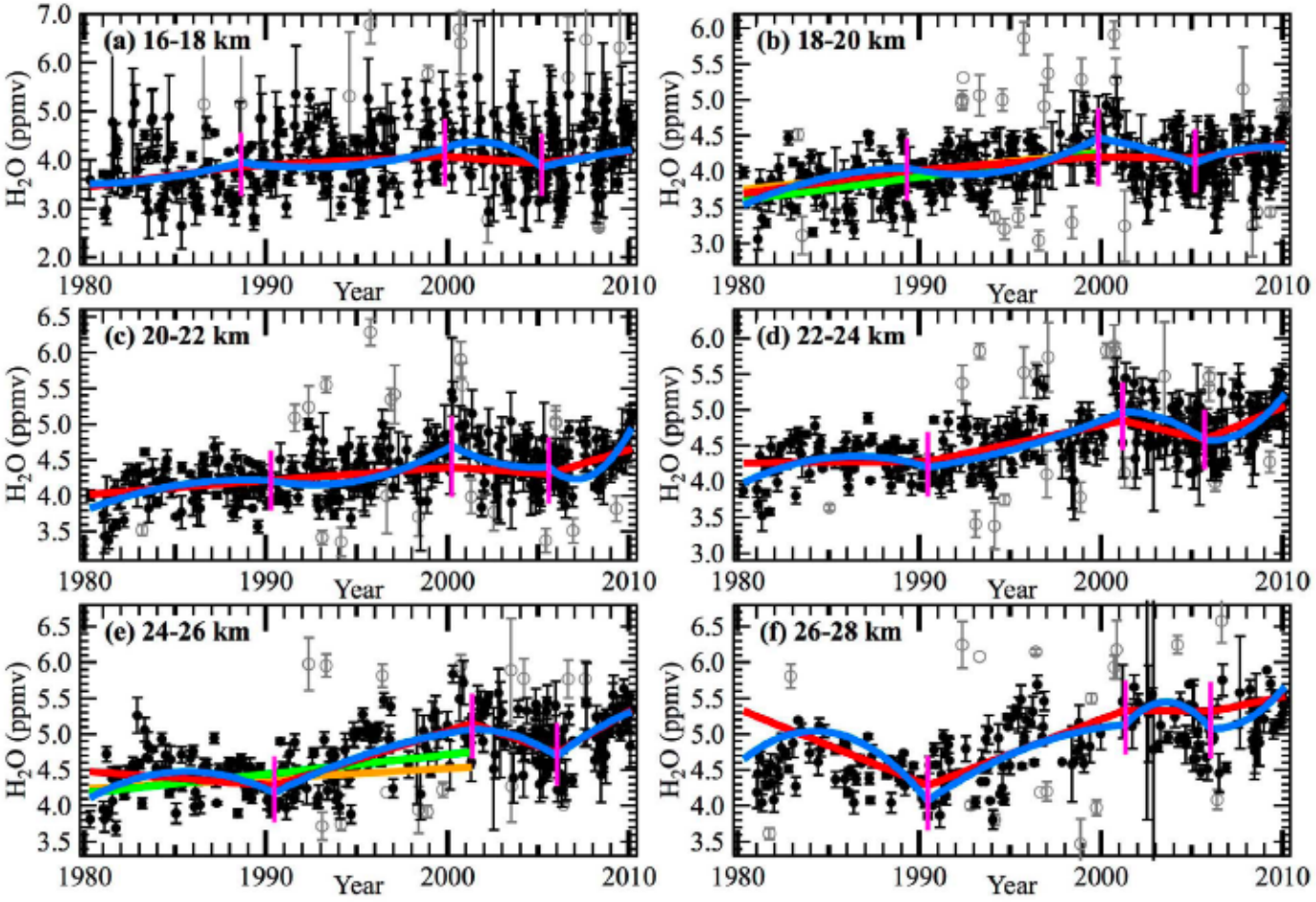


Magenta bars: Change point dates

Red: piecewise continuous linear fits

Blue: piecewise continuous quadratic fits

Green: 1980-2000 results from Scherer et al. 2008

Orange: weighted least squares regression for 1980-2000

Some key results from Hurst et al., 2011, based on Boulder data:

Stratospheric water increased by 1.0 ± 0.2 ppmv (27 ± 6%) during 1980–2010: the trend is not a simple linear increase.

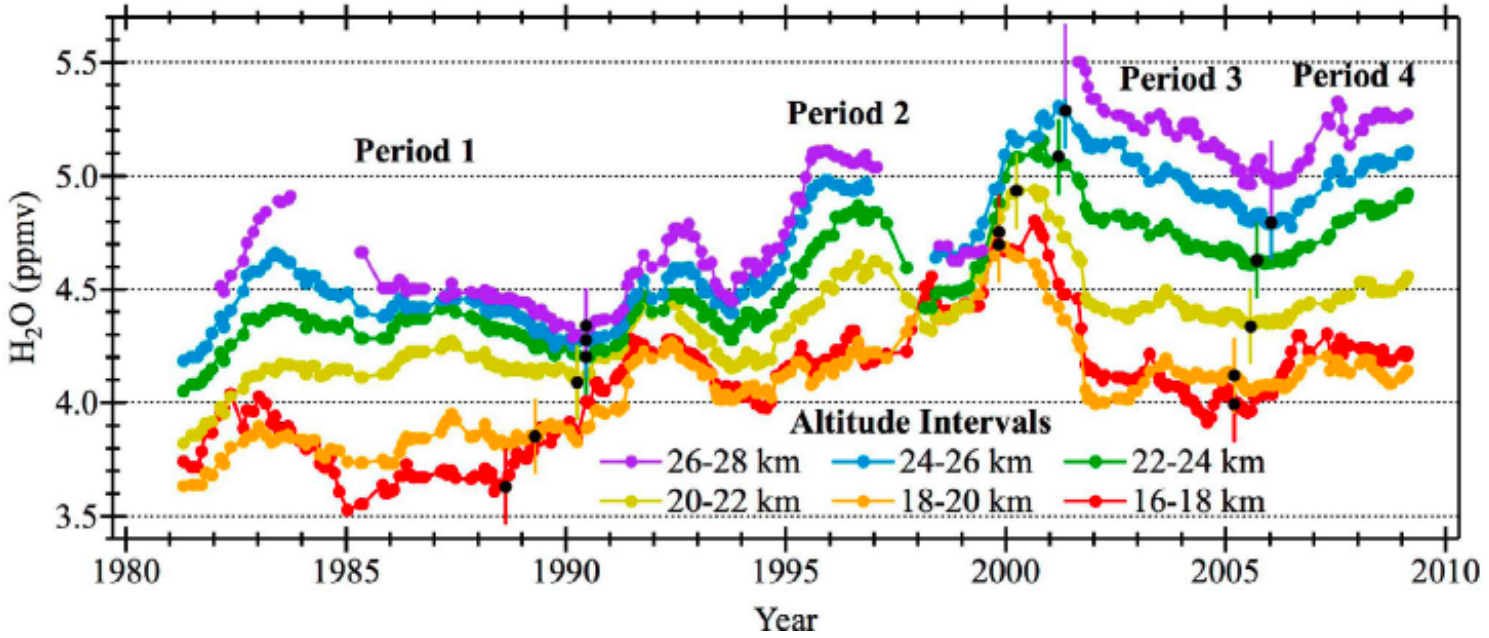
1980-1989: 16-18 km: 0.44 ± 0.13 ppmv
24-26 km: to 0.07 ± 0.07 ppmv

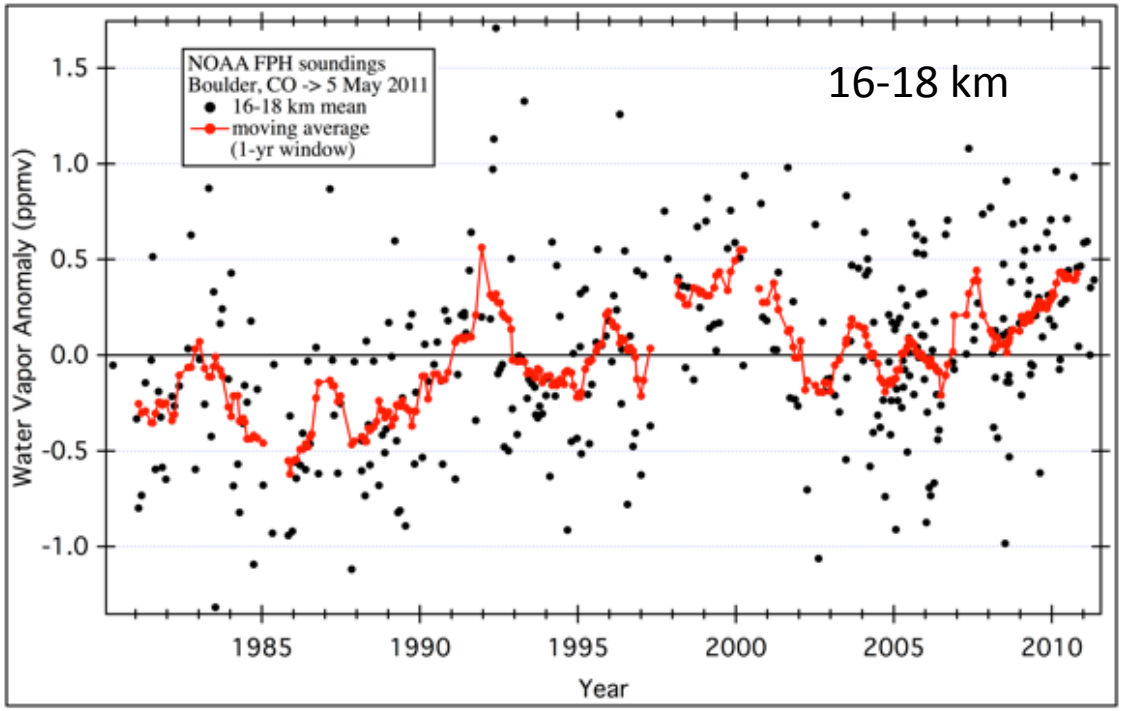
1990-2000: 0.57 ± 0.25 ppmv

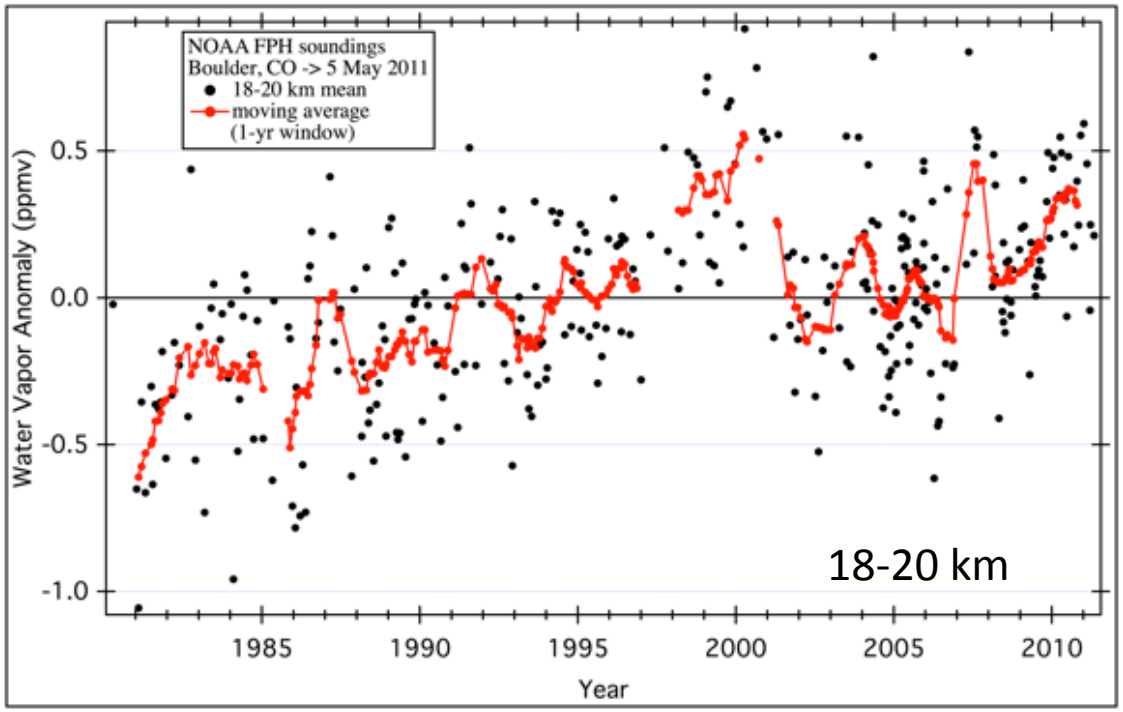
2001-2005: -0.35 ± 0.04 ppmv

2006-2010: 0.49 ± 0.17 ppmv

Methane source can account for ~25% of the stratospheric water vapor increases overall...the fractional amount varies with time period.







More recent Boulder data show a continuation of the increase during the period post 2006 noted in Hurst et al., 2011

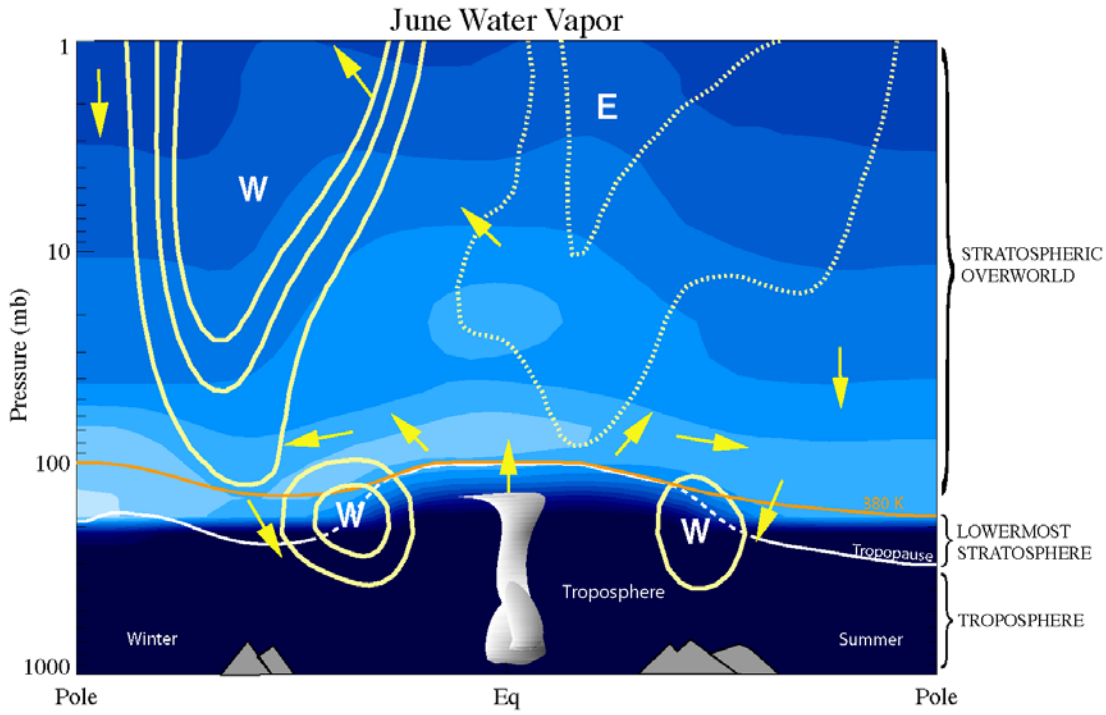
Anomalies from monthly averages for Boulder frostpoint data

Consider the Global Picture for Stratospheric Water Vapor

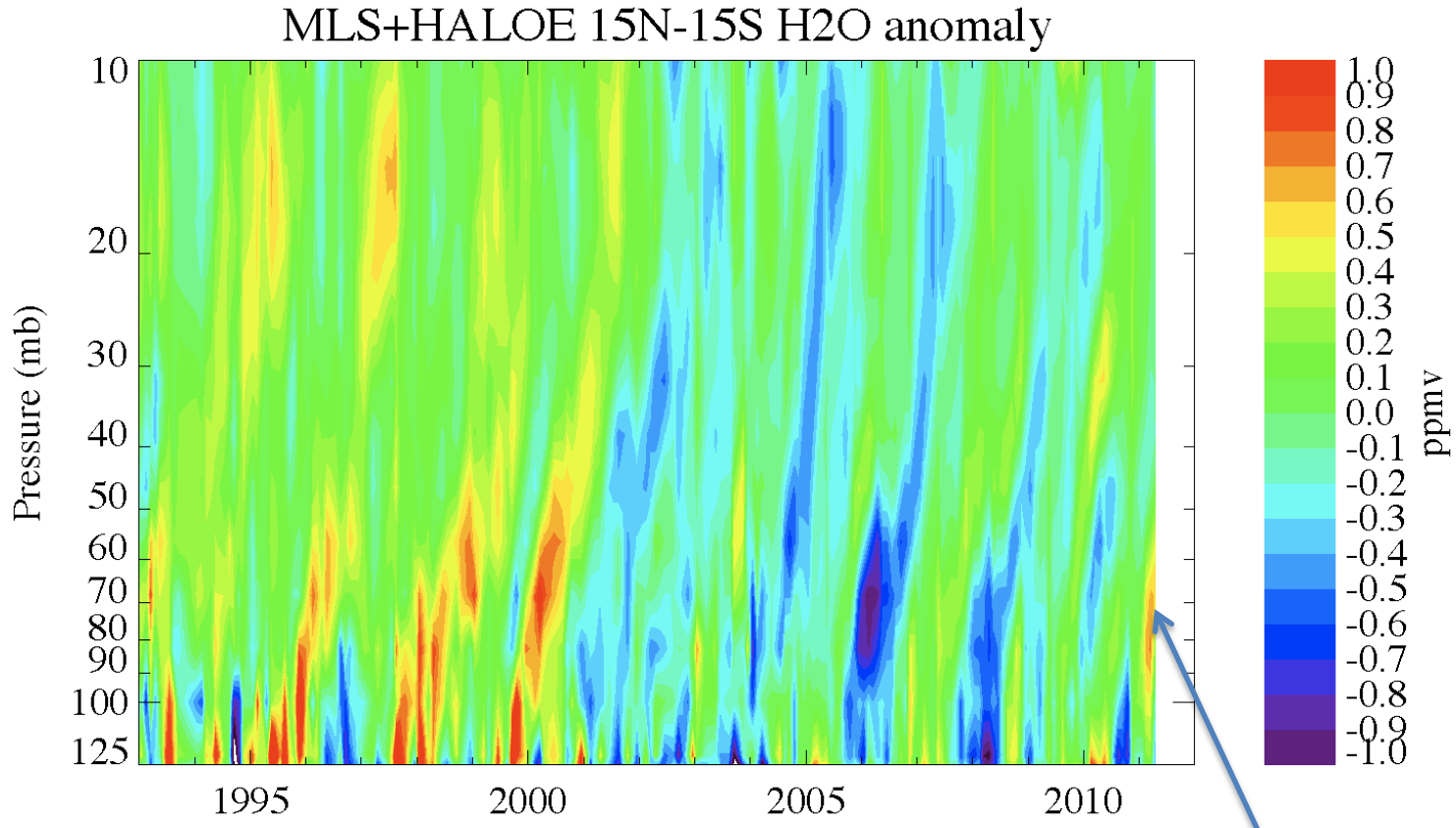
1) Input controlled largely by tropical tropopause temperatures
2) Production due to methane oxidation
3) High latitude loss due to winter time dehydration in polar vortex, more prominent in the SH

To understand the trends and variability seen in the Boulder data, we need to establish trends and variability in input to the stratosphere in the tropics, and in the effective age of air sampled over Boulder (or in trends and variability in mixing between low and high latitudes; this reflects the contribution due to methane oxidation).

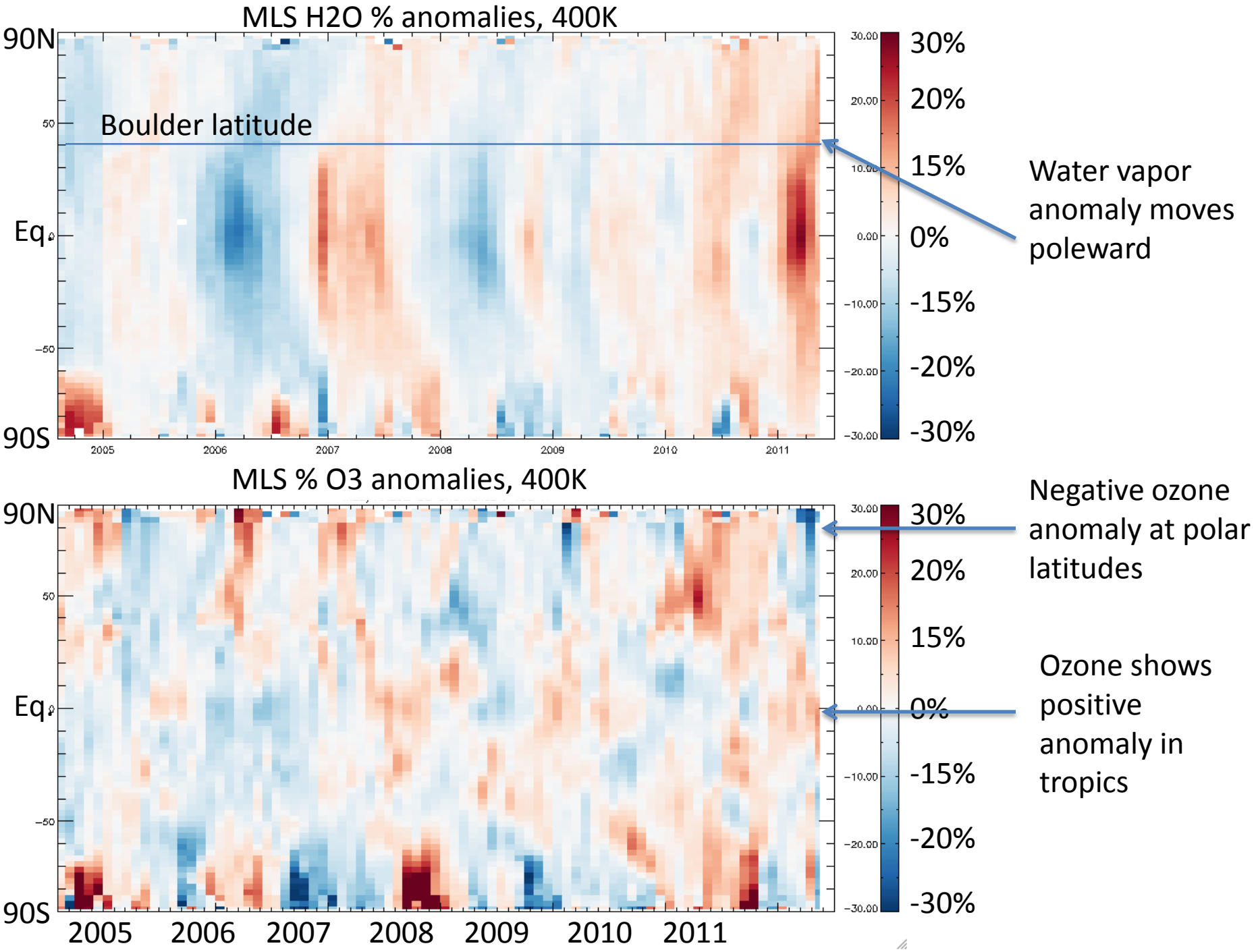
The remainder of this presentation will look at recent changes in tropical input.



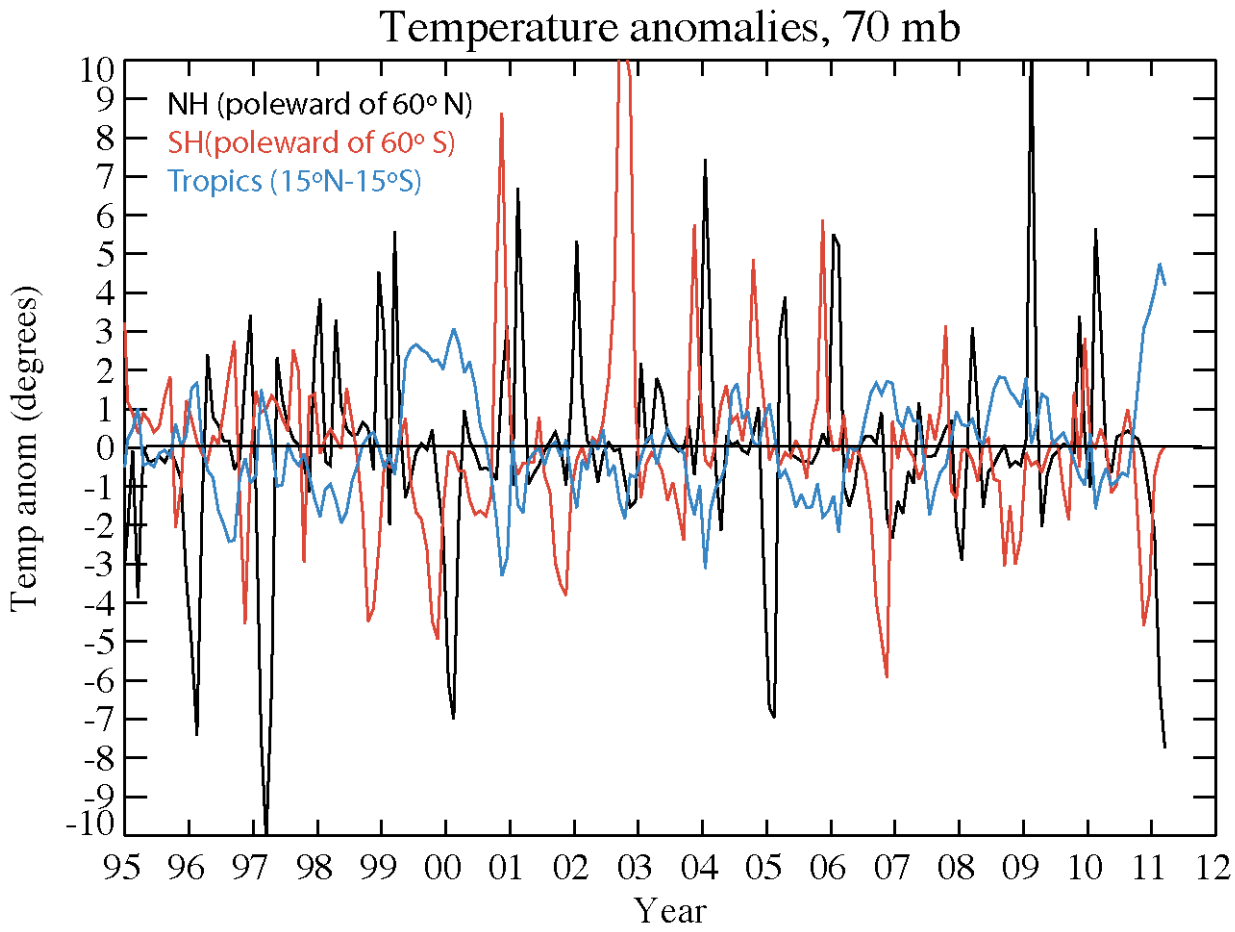
Currently there is a large anomaly in tropical temps and tropical water vapor. Using satellite data + reanalysis output, we can look in some detail at reasons for this anomaly, and assess whether similar processes have occurred in the past.



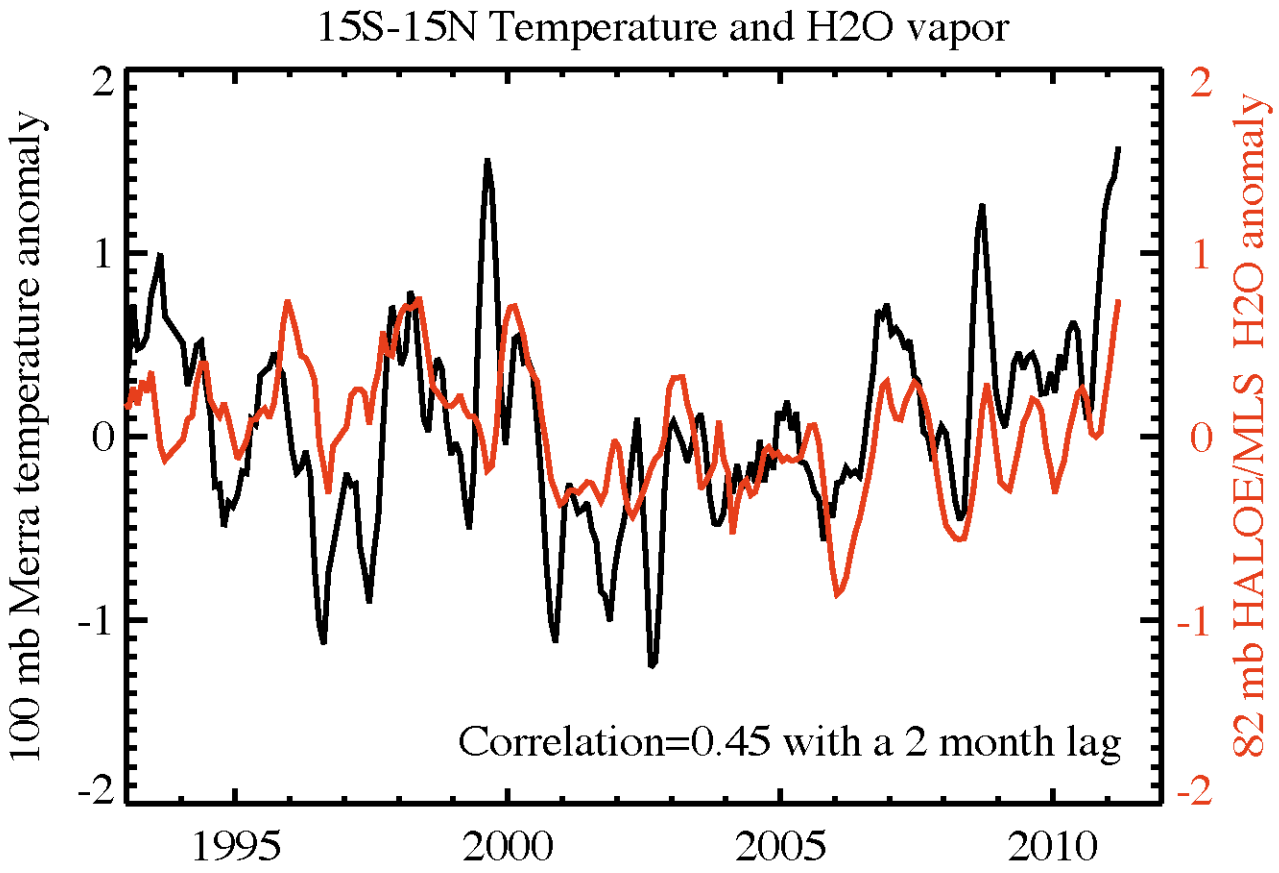
Largest positive anomaly in water vapor in the past decade (~+0.7 ppmv)


MLS H2O % anomalies, 400K
90N
50
Eq
-50
90S
Boulder latitude
2005
2006
2007
2008
2009
2010
2011
30.00
20.00
10.00
0.00
-10.00
-20.00
-30.00
30%
20%
15%
0%
-15%
-20%
-30%
Water vapor anomaly moves poleward
MLS % O3 anomalies, 400K
90N
50
Eq
-50
90S
2005
2006
2007
2008
2009
2010
2011
30.00
20.00
10.00
0.00
-10.00
-20.00
-30.00
30%
20%
15%
0%
-15%
-20%
-30%
Negative ozone anomaly at polar latitudes
Ozone shows positive anomaly in tropics

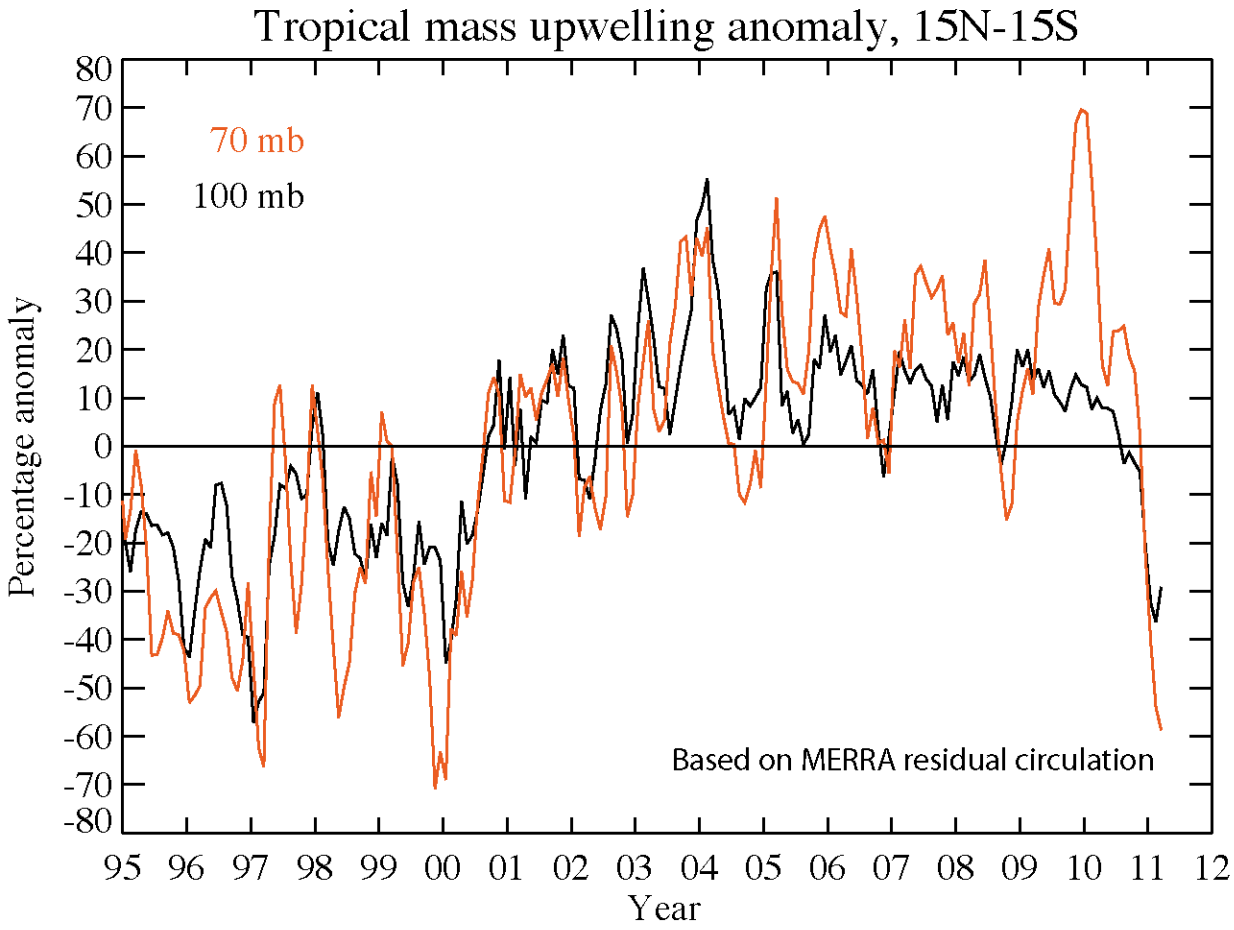
Reason for the anomaly to appear: change in tropical near tropopause temperatures



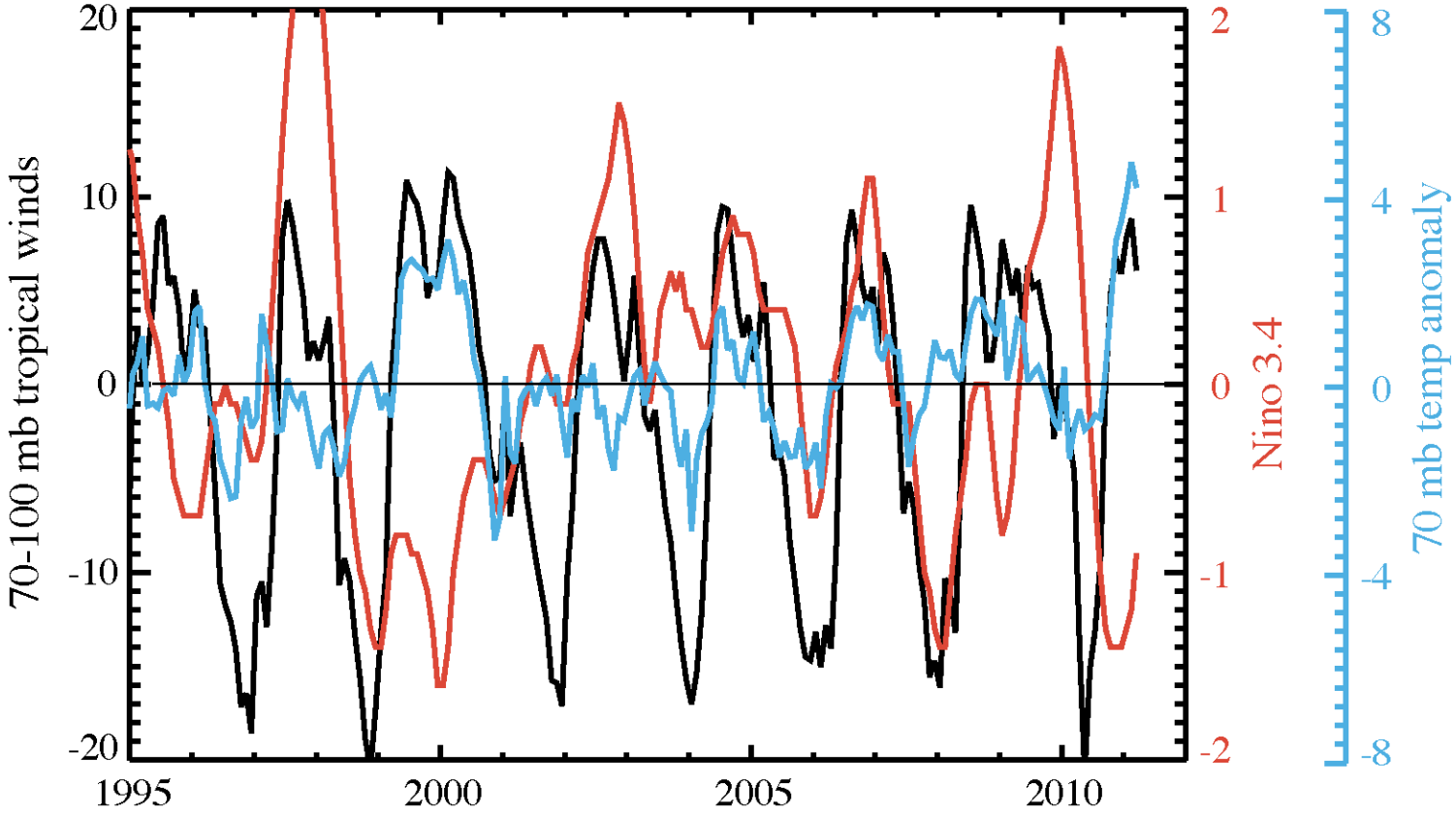
Warm anomaly in tropics, cold anomaly at winter/spring high latitudes, similar to 1999/2000 period.



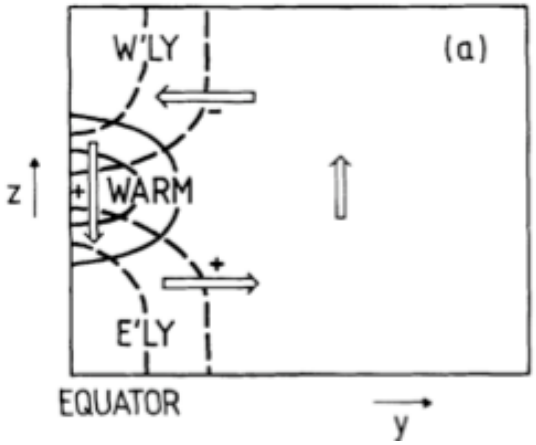
Shows the relation between zonal average tropical near tropopause temperature and 82 mb satellite water vapor



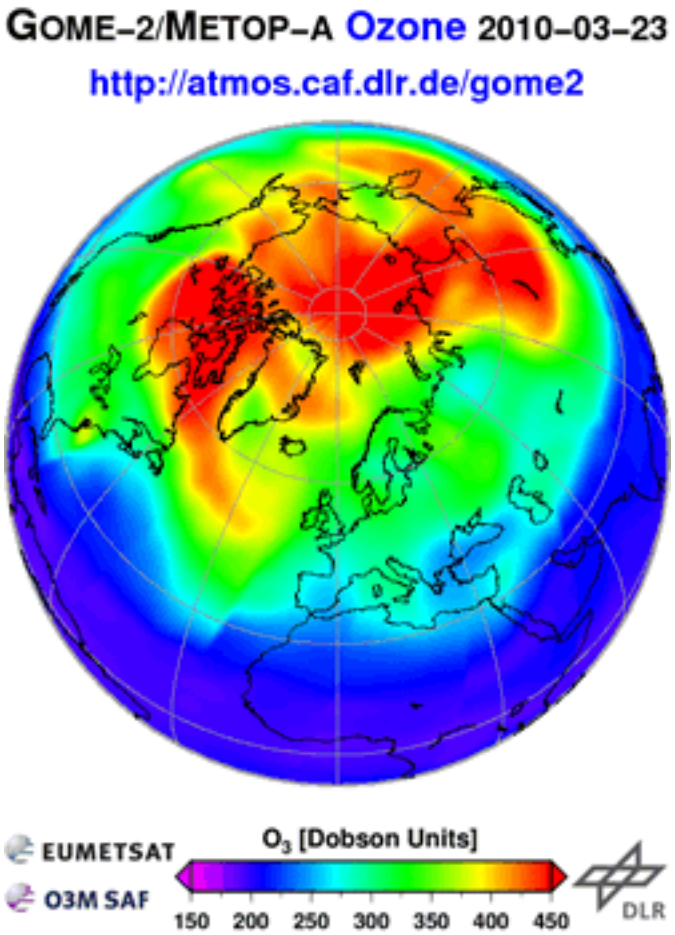
Associated change in the mean meridional circulation, with decreased upwelling in the topics, and decreased downwelling at high latitudes.

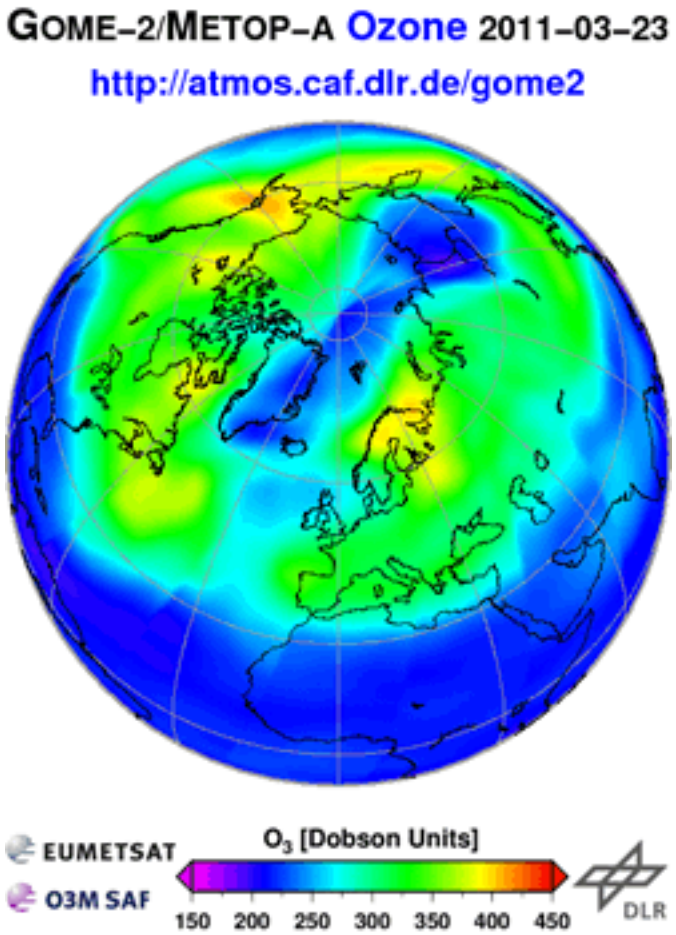


Syncing of warm phase of the QBO (westerlies over easterlies) and La Nina (with less vertical upwelling near the tropopause) results in a warmer tropical coldpoint and a larger value for water entering the stratosphere.



Reduced mean meridional circulation likely was the reason for anomalously low temperatures in the NH polar regions this past winter, resulting in significant ozone loss.





Stratospheric water vapor changes at a given latitude are not well modeled by simple linear trends.

Variations in tropical near tropopause temperatures do a reasonably good job in explaining variability in the stratospheric entry value of water.

The recent tropical near tropopause temperature anomaly is large and has resulted in bringing strat entry values back up to those seen in the 1990s.

This recent tropical anomaly should have recently reached Boulder latitudes.

The associated circulation anomaly likely contributed to the extremely low ozone measured in the Arctic this past winter.