TTL COOLING AND DRYING DURING THE JANUARY 2013 STRATOSPHERIC SUDDEN WARMING

Stephanie Evan; LACy/CNRS
Karen Rosenlof; NOAA ESRL CSD
Troy Thornberry; CIRES, University of Colorado & NOAA ESRL CSD
Andrew Rollins; CIRES, University of Colorado & NOAA ESRL
Sergey Khaykin; LATMOS/CNRS

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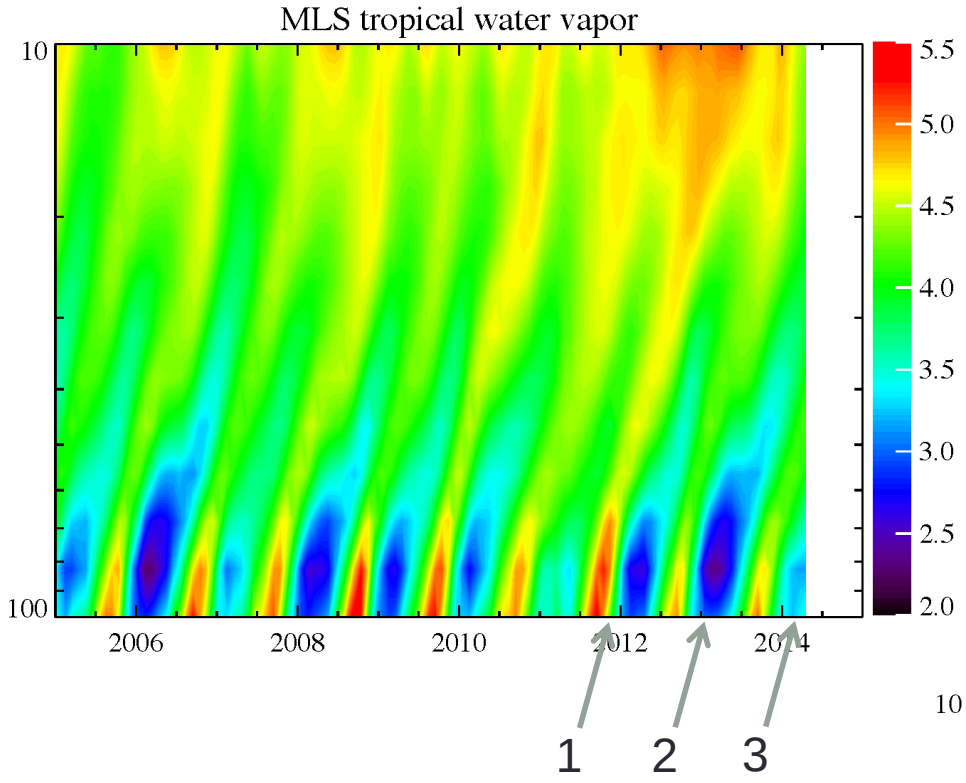
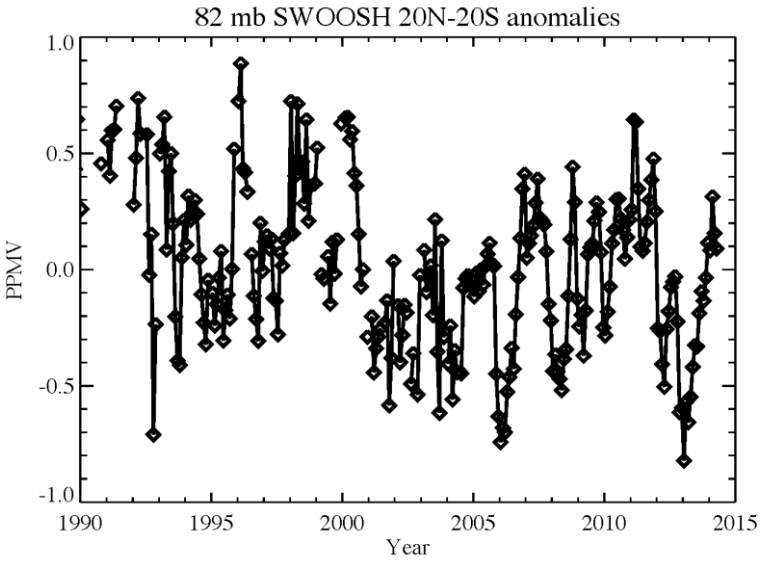
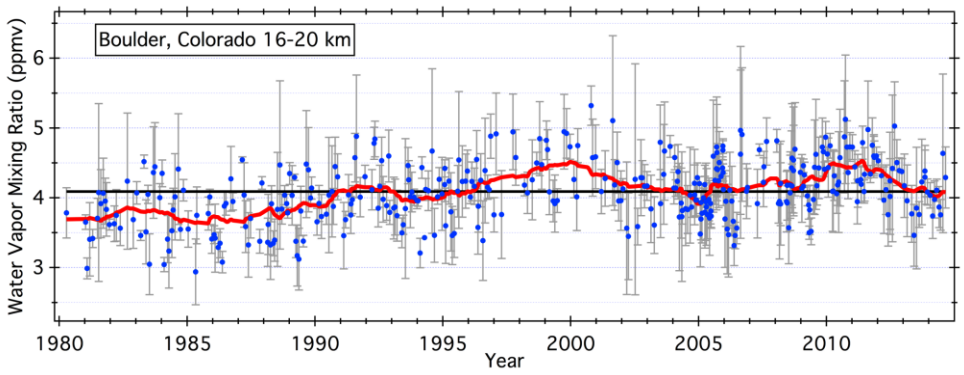
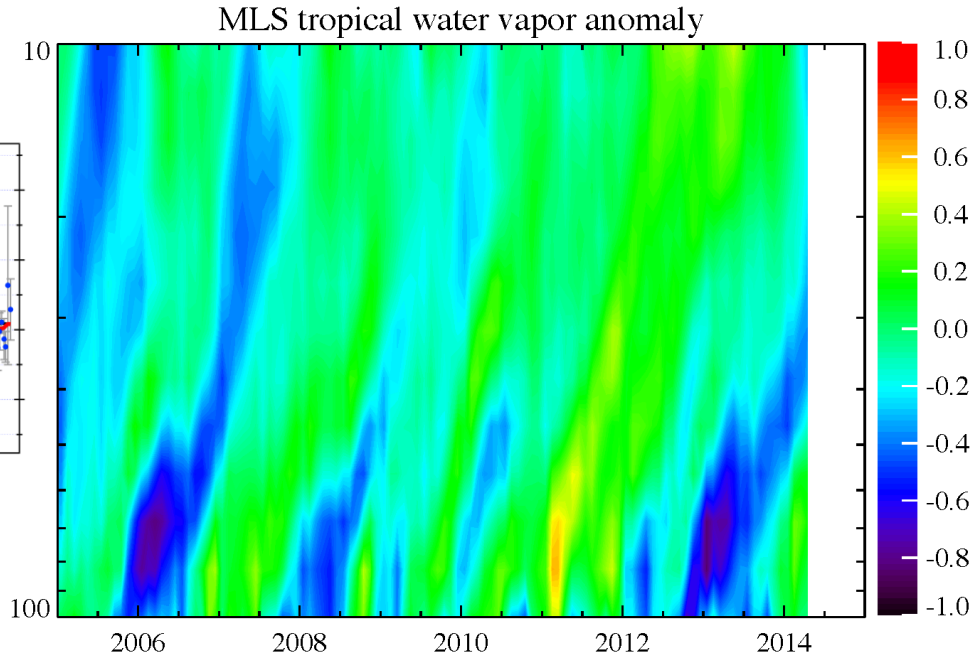

MLS tropical water vapor
10
100
2006
2008
2010
2012
2014
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1
2
3

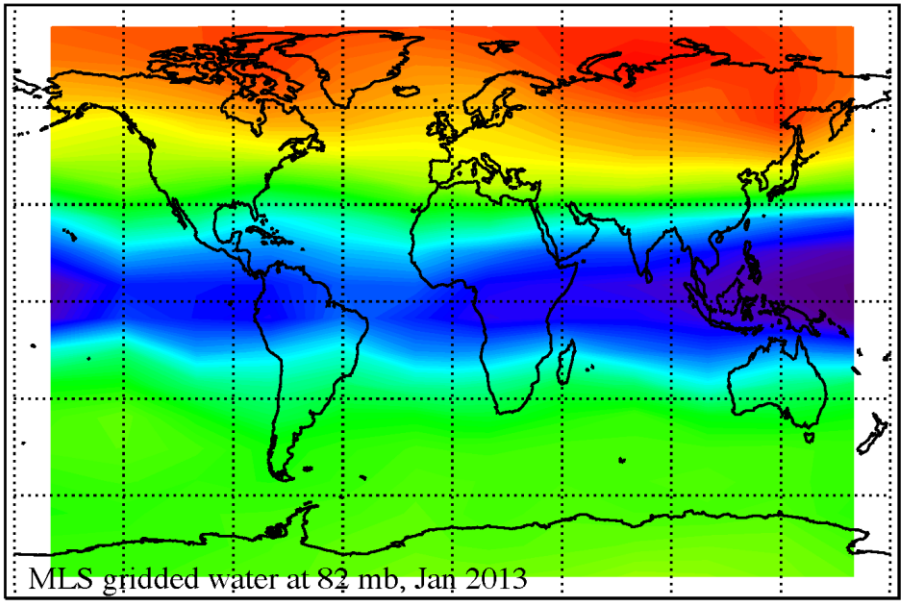

82 mb SWOOSH 20N-20S anomalies
PPMV
1.0
0.5
0.0
-0.5
-1.0
1990
1995
2000
2005
2010
2015
Year

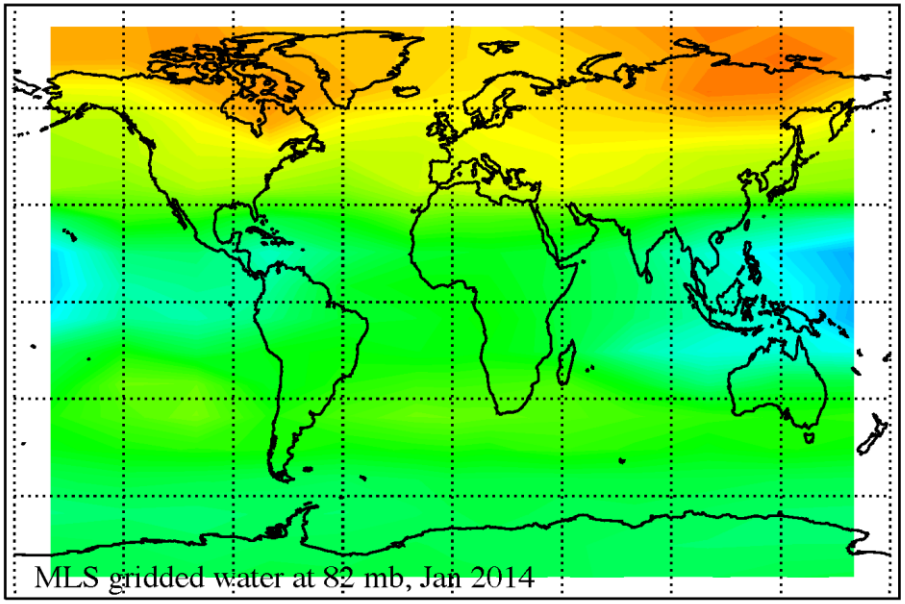

Boulder, Colorado 16-20 km
Water Vapor Mixing Ratio (ppmv)
6
5
4
3
1980
1985
1990
1995
2000
2005
2010
Year

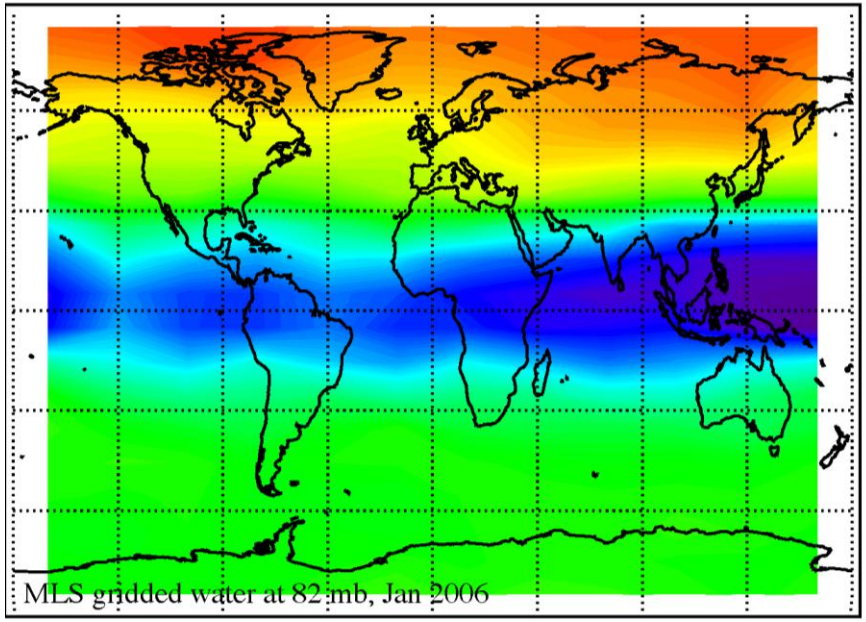

MLS tropical water vapor anomaly
10
100
2006
2008
2010
2012
2014
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0

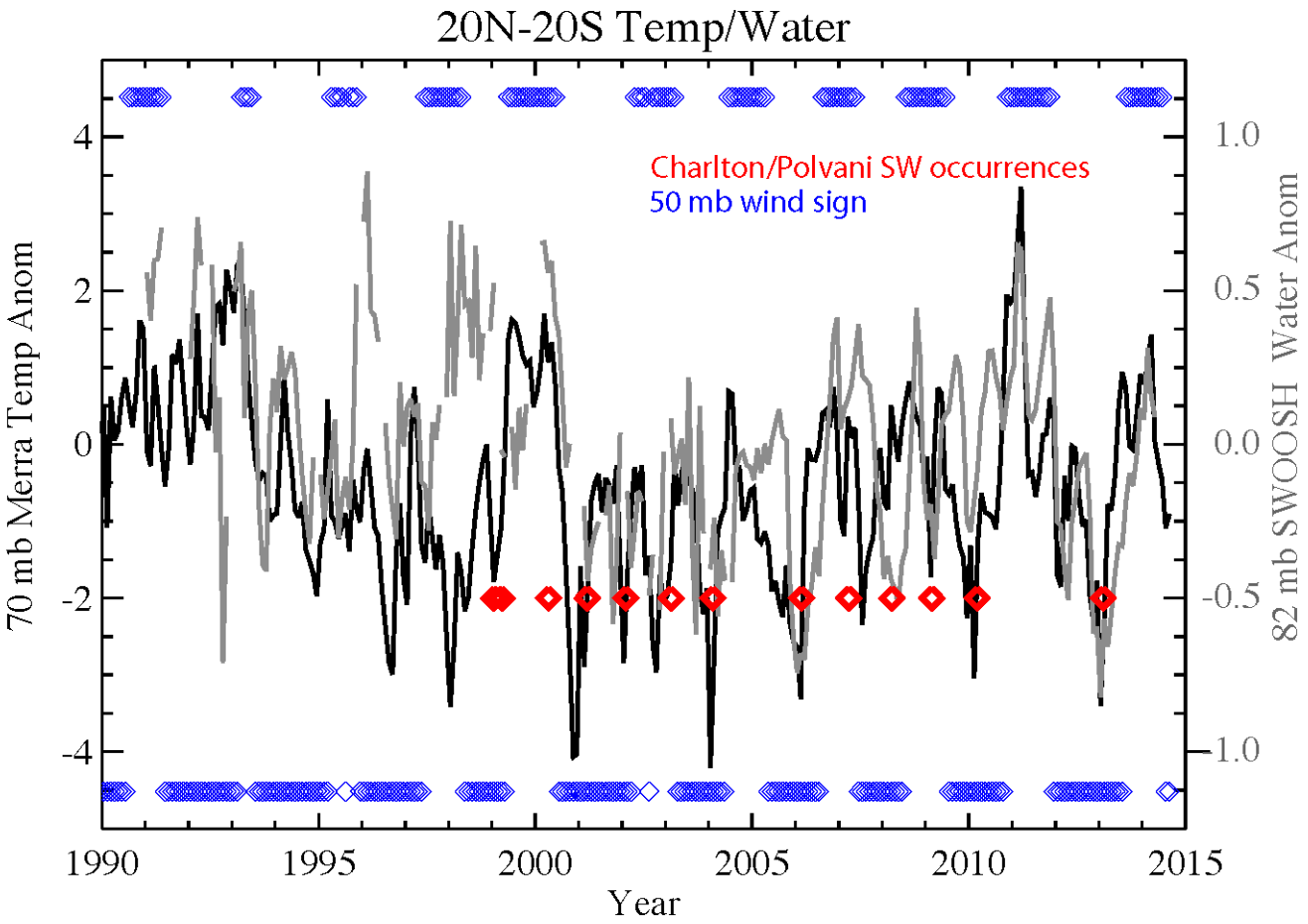
Contrasting 2013 with 2014, using gridded MLS water vapor at 82 mb.

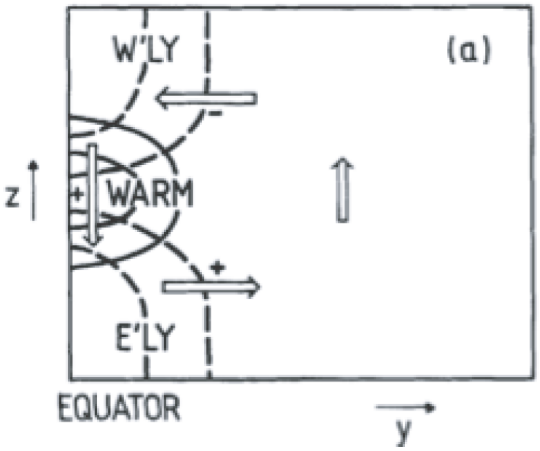
Note: 2006 is similar to 2013





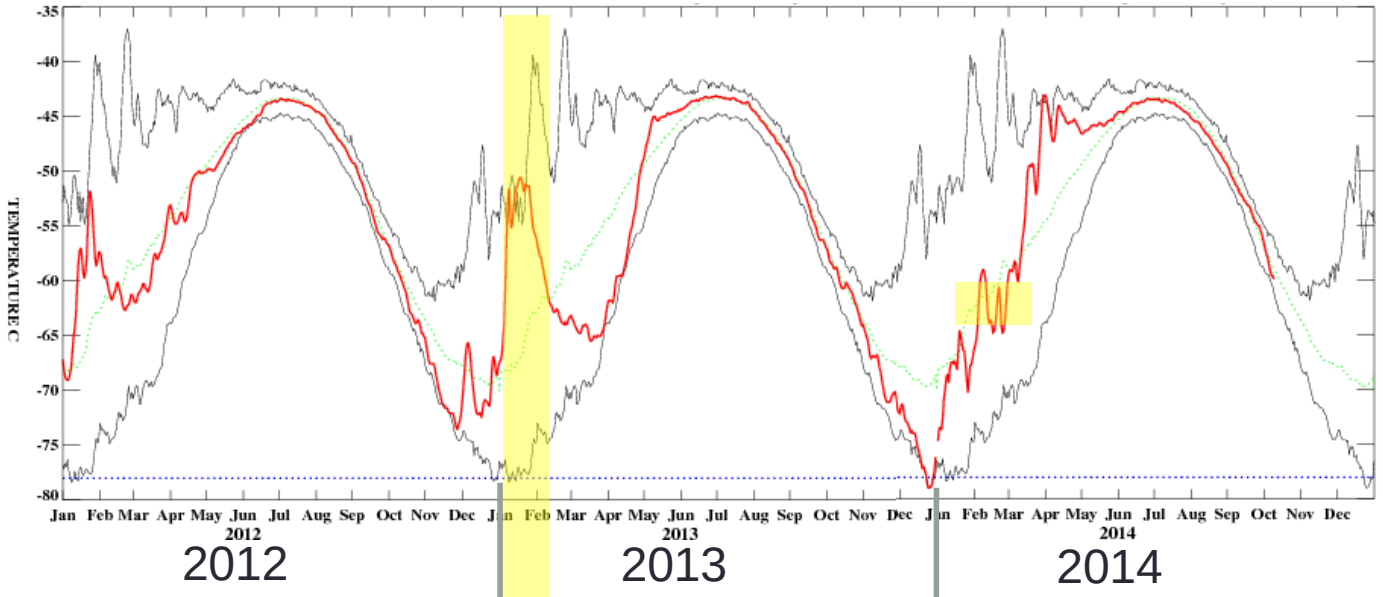




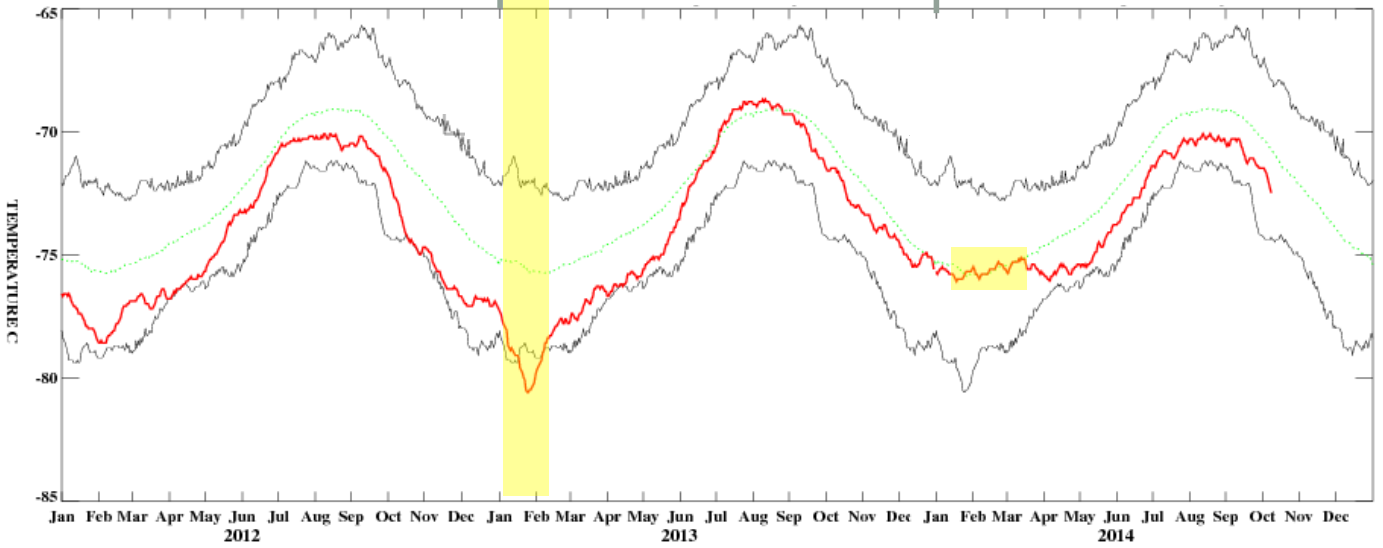


Plumb&Bell 1982

30 mb 65N-90N Temps



70 mb 25S-25N Temps



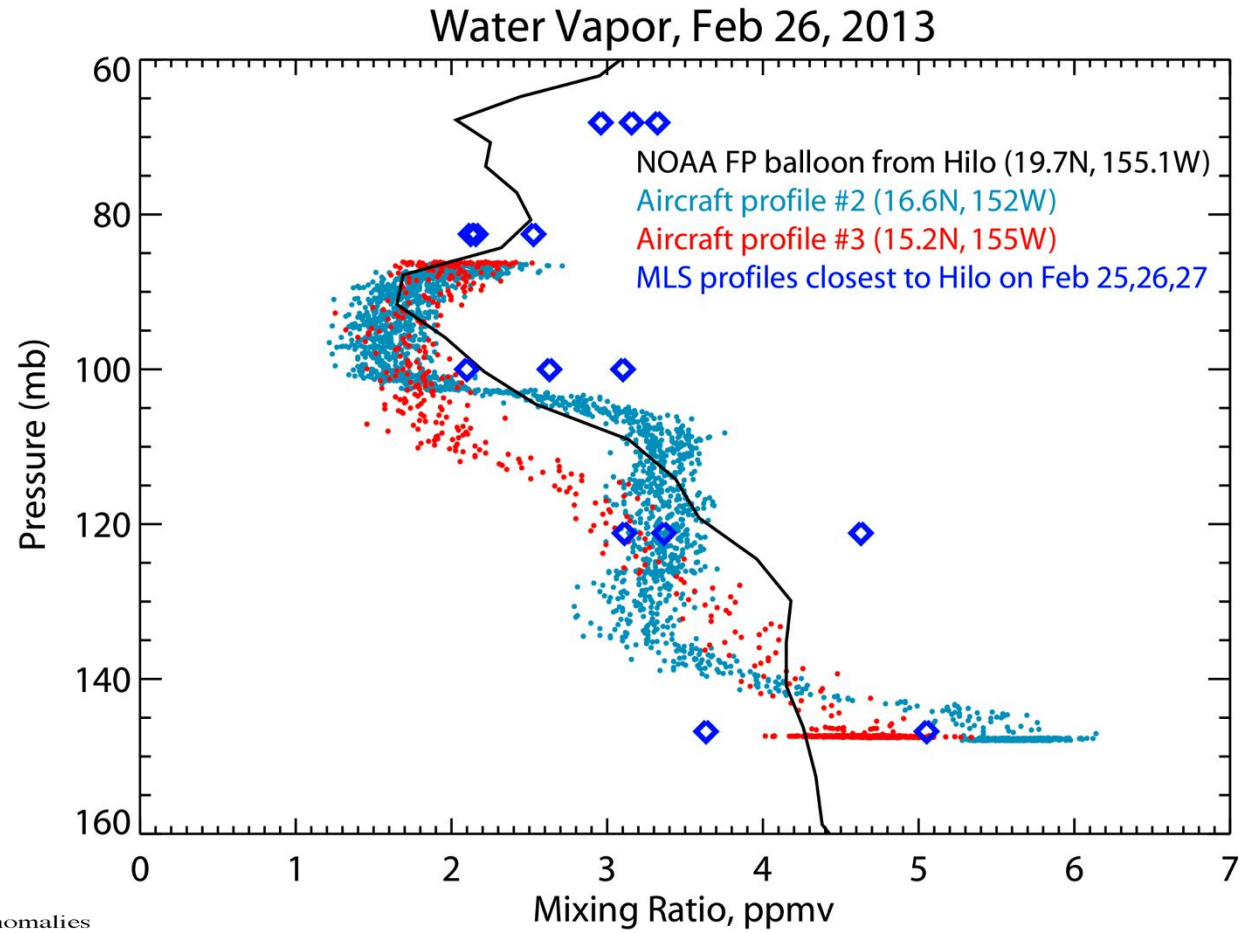
Data from NOAA CPC

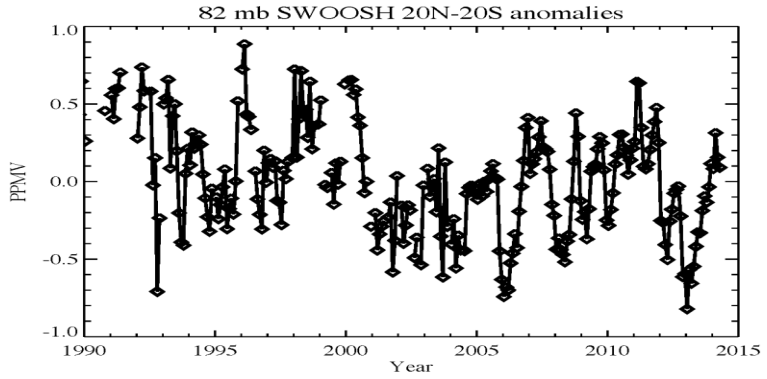
The 2013 case was a strong event that apparently impacted zonally averaged water vapor, and, conveniently with aircraft data to back up the satellite observations of very low stratospheric water vapor.

Stephanie's paper looks at this event in detail:
Examining the relation between tropical tropopause cooling, the SSW, and convective activity in the Western Pacific.

1) Verify that satellite measurements are reasonable

Note: MLS 82 mb tropical zonal average for Jan 2005-2014 is 3.13 ppmv; value for 2013 is 2.56 ppmv





Aircraft data: from NOAA_Water (Thornberry, Rollins, Gao)
Balloon data: NOAA_FPH, launched from Hilo (Hurst)

During winter 2012/2013, conditions were similar to that in winter 2005/2006

1) Easterly shear (cold) phase of the QBO
2) Major Sudden Stratospheric Warming
3) Strong convection over the western Pacific

SSW = rapid temperature increase in the polar vortex over a few days in winter; they are preceded by an increase in wave activity from the troposphere; these waves break in the stratosphere and strengthen the mean meridional circulation…downwelling with warming at high latitudes, upwelling with cooling in the tropics.

Tropical link:
Gomez-Escolar et al., 2014, JGR, show that enhanced tropical cooling in the lower stratosphere occurs preferentially during the QBO easterly sheer phase.

Several studies have also shown that a SSW may enhance tropical convection (Kodera, Eguchi, Yoshida and Yamasaki)

Change in wave activity -> changes mean meridional circulation and cools tropical lower stratosphere (as well as warming the polar stratosphere)-> change in TTL static stability -> possible impact on convection

Stephanie's hypothesis:

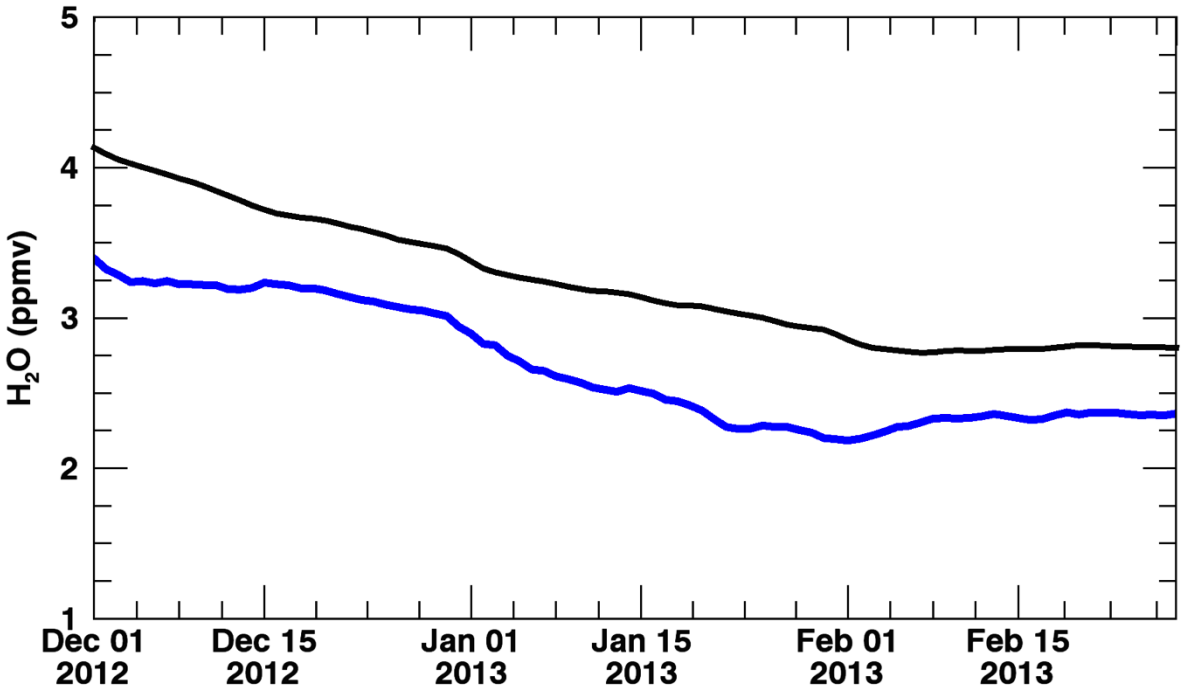
2013 low water vapor values were a result of the **combined effects of the SSW, changes in convection and the QBO**

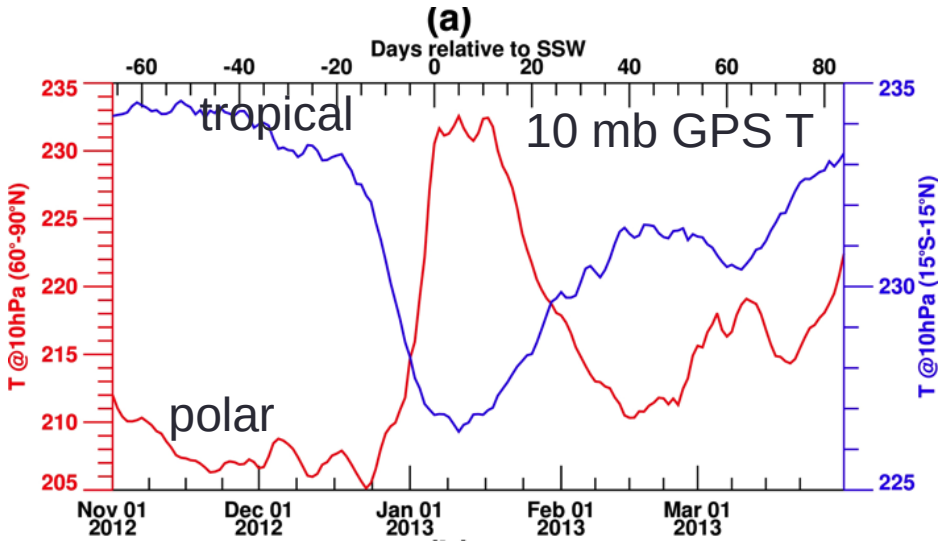
Black line: MLS tropical average H_2O at 82 mb

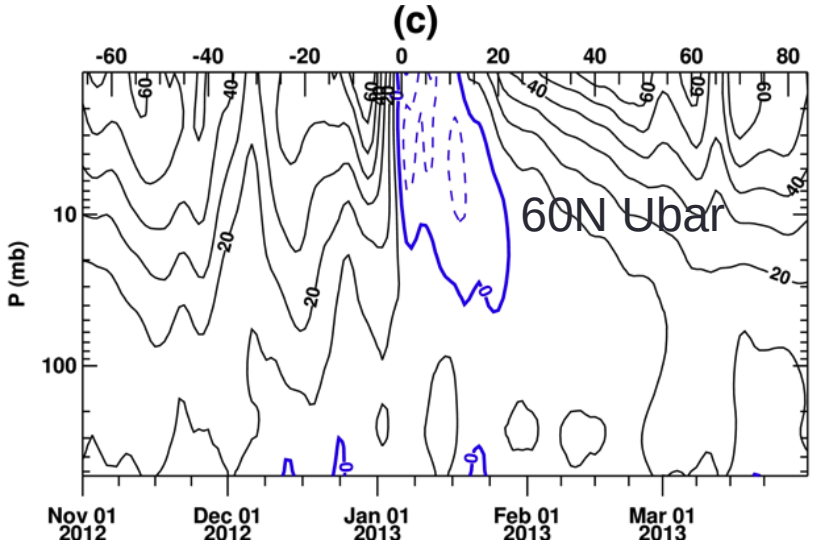
Blue line: 2012/2013 winter

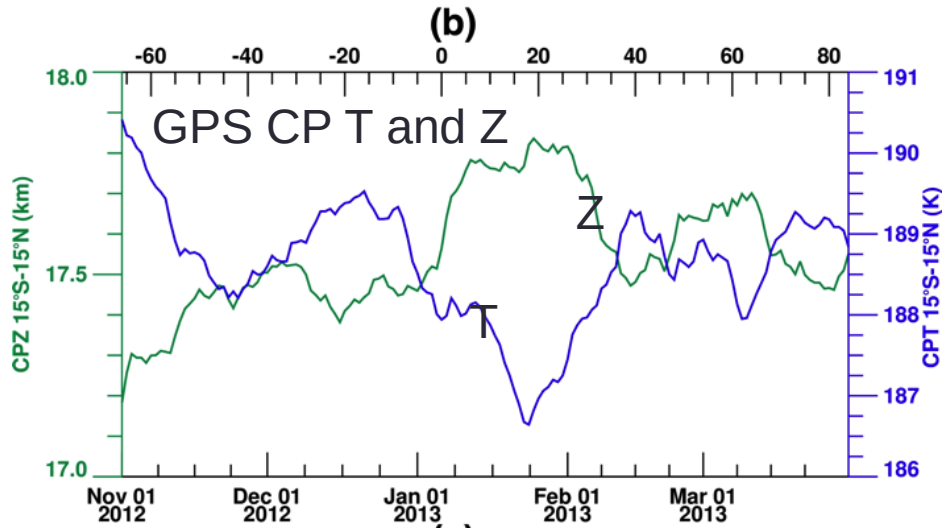
Daily values plotted

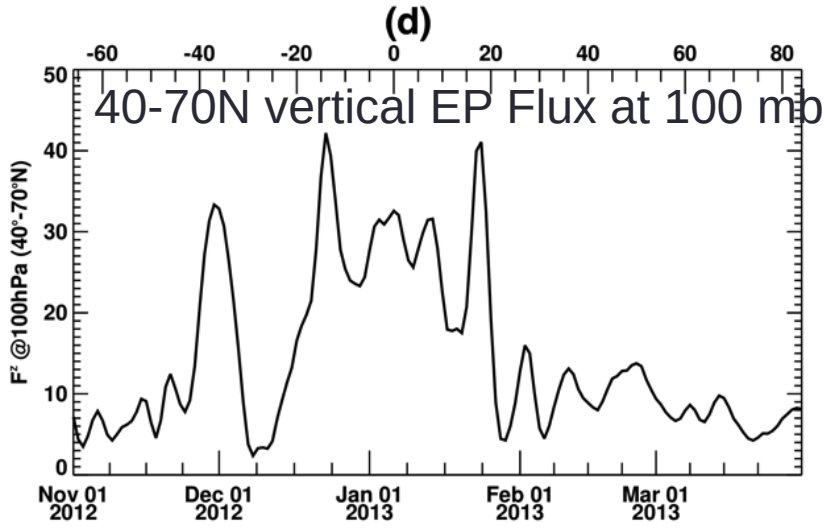
2012/2013 starts out low (due to QBO) and has accelerated drying (due to SSW of Jan 6)





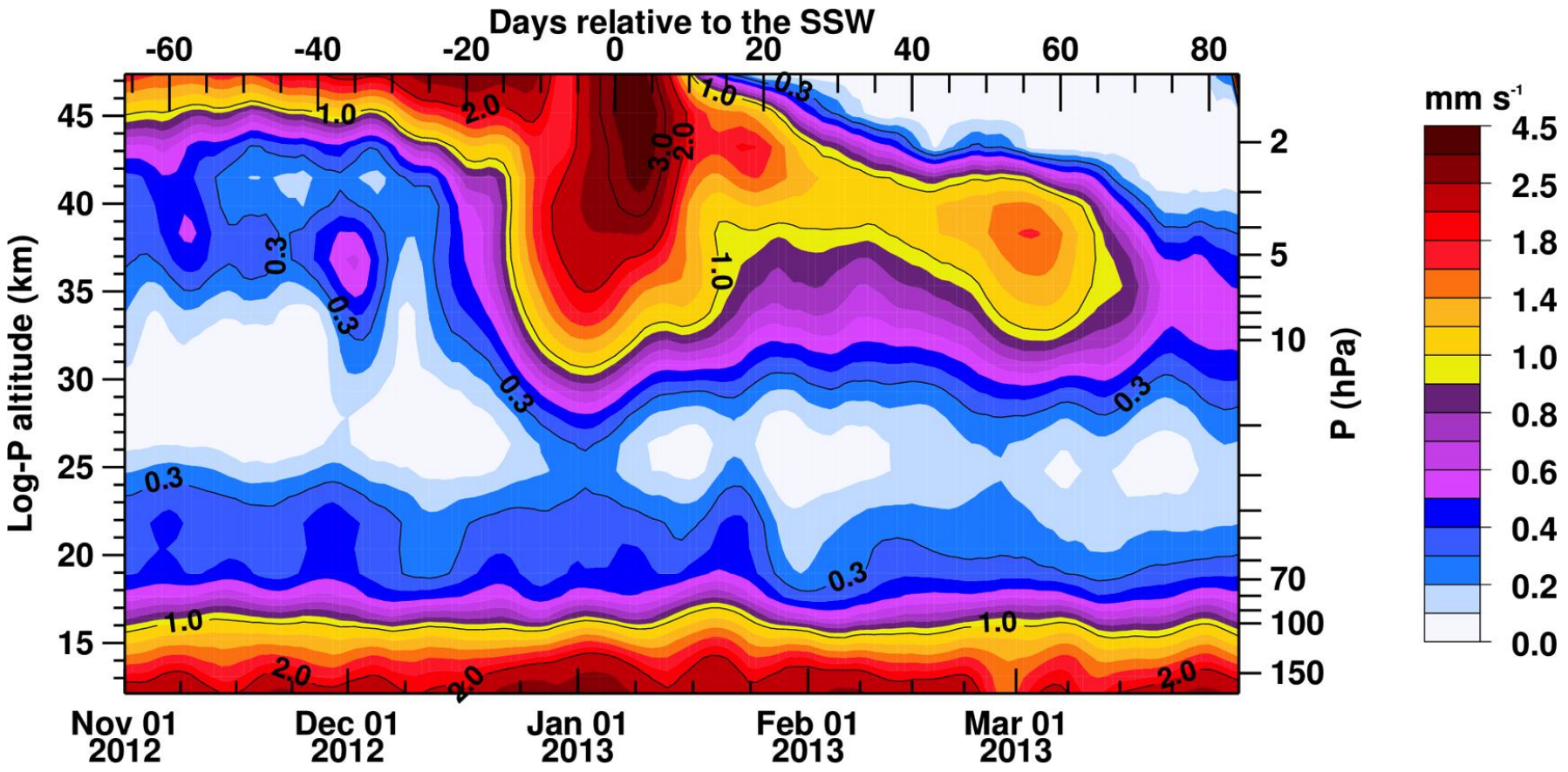






Day 0 = Jan 6, 2013

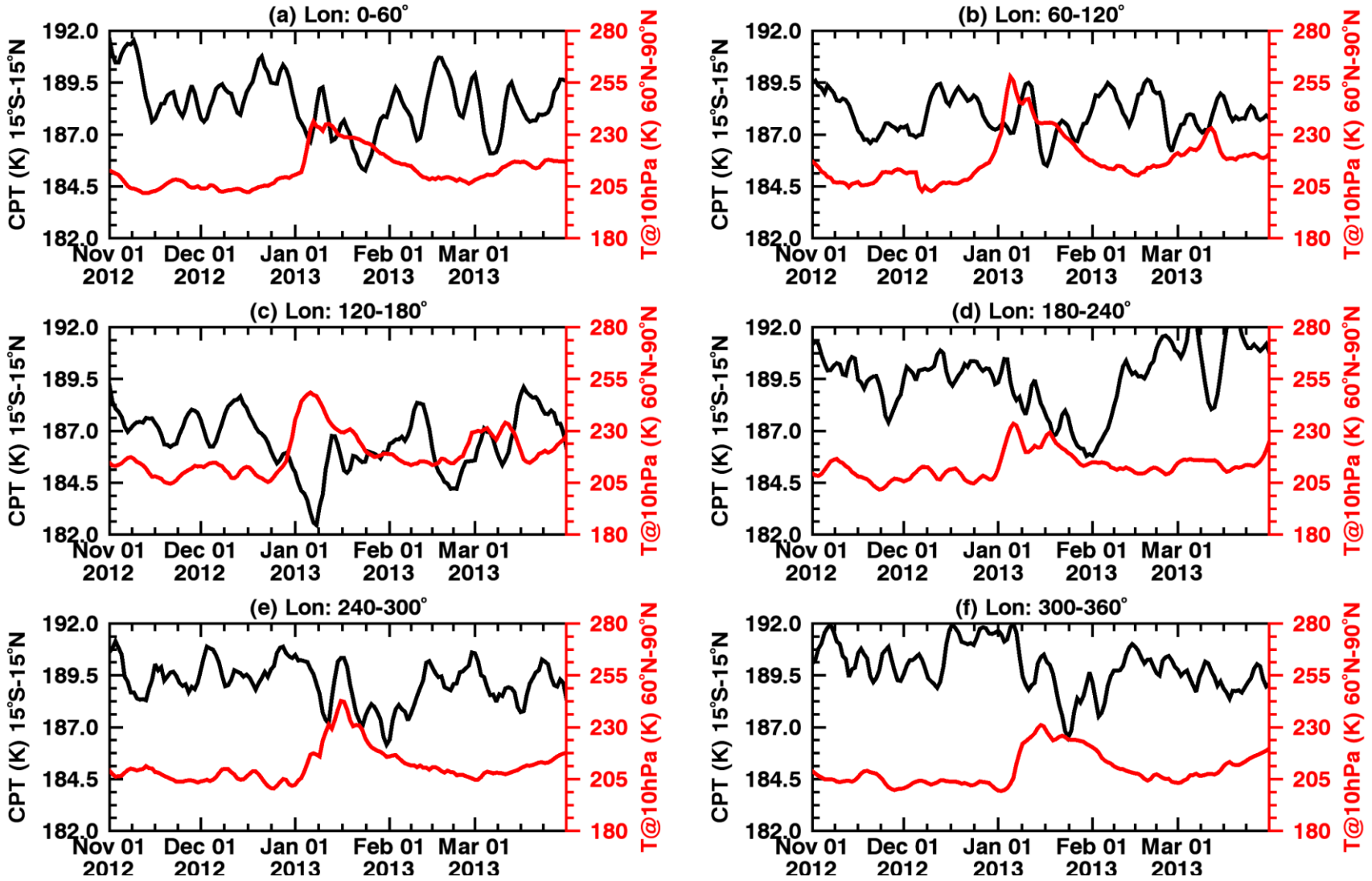
Time series of the tropical (15N-15S) wbarstar



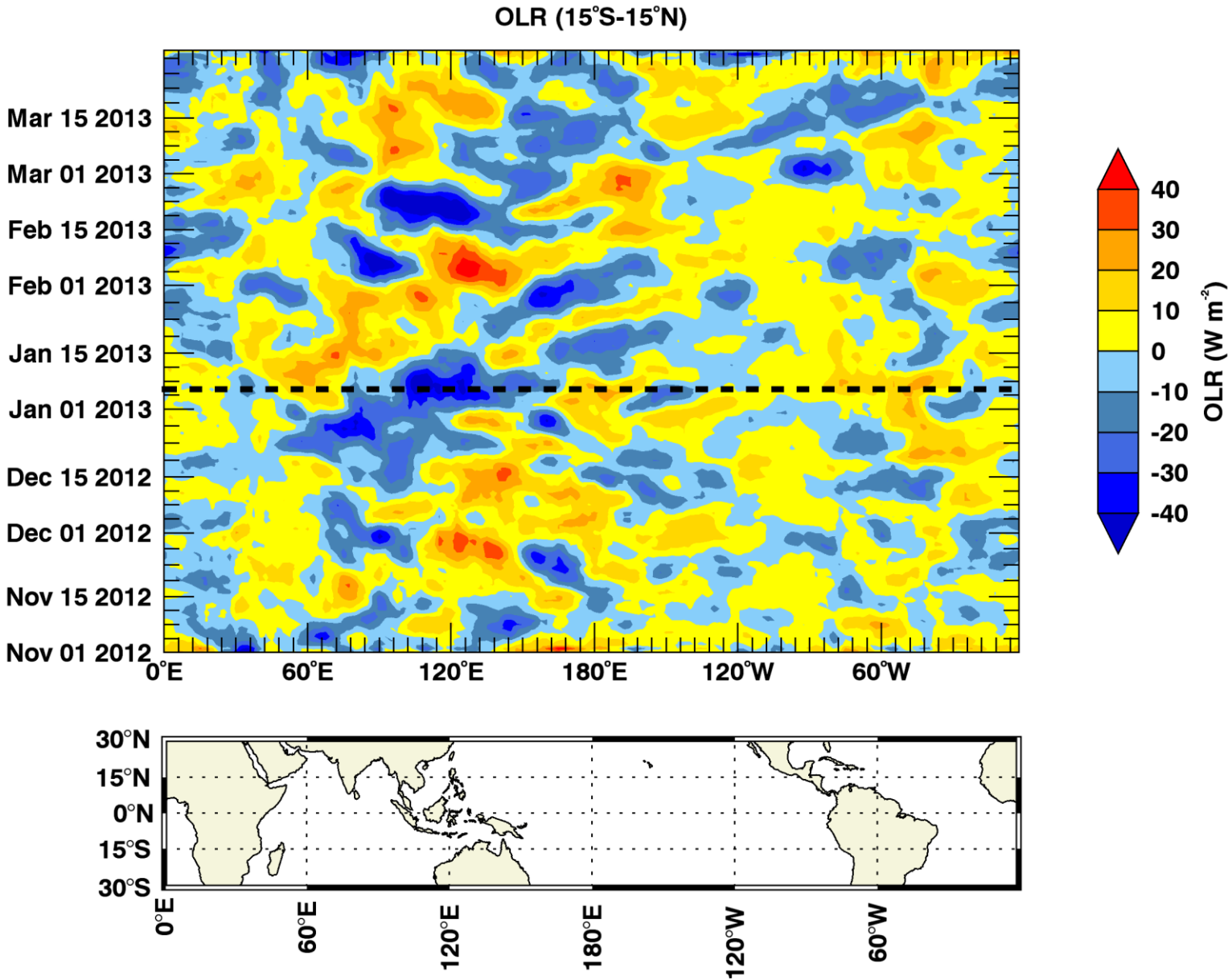
Enhancement of 150-70 mb upwelling due to subtropical wavebreaking.

Now a longitudinally resolved view: larger tropical temperature response in the western Pacific (panel c), greater increase in polar temperature from 60-180 degrees longitude.

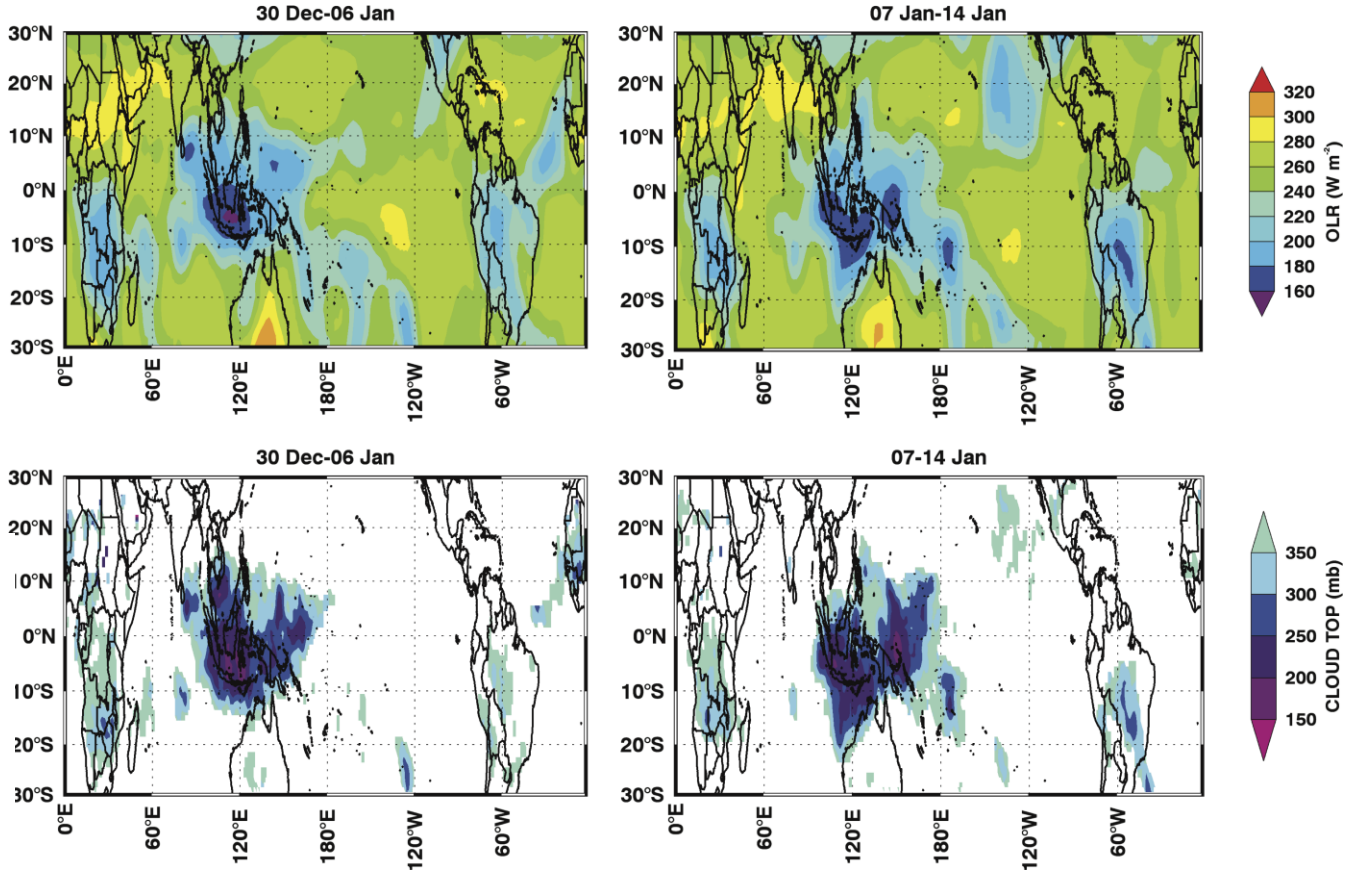
Red, 10 mb polar, black CPT tropics



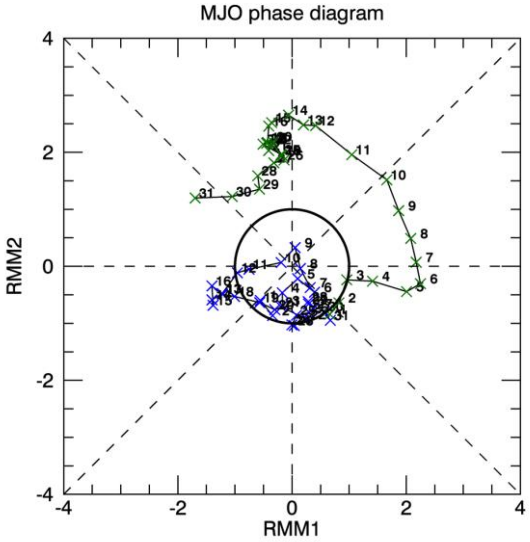
Daily tropical OLR anomalies, blue=active convection, this strengthens at time of SSW, and at the longitude band of maximum polar warming.



OLR and MODIS cloud top pssr, before and after the SSW



MJO phase diagram



Blue: Dec Green: Jan

Southward shift of convective activity consistent with Kodera, Eguchi, and Yoshida and Yamazaki studes.

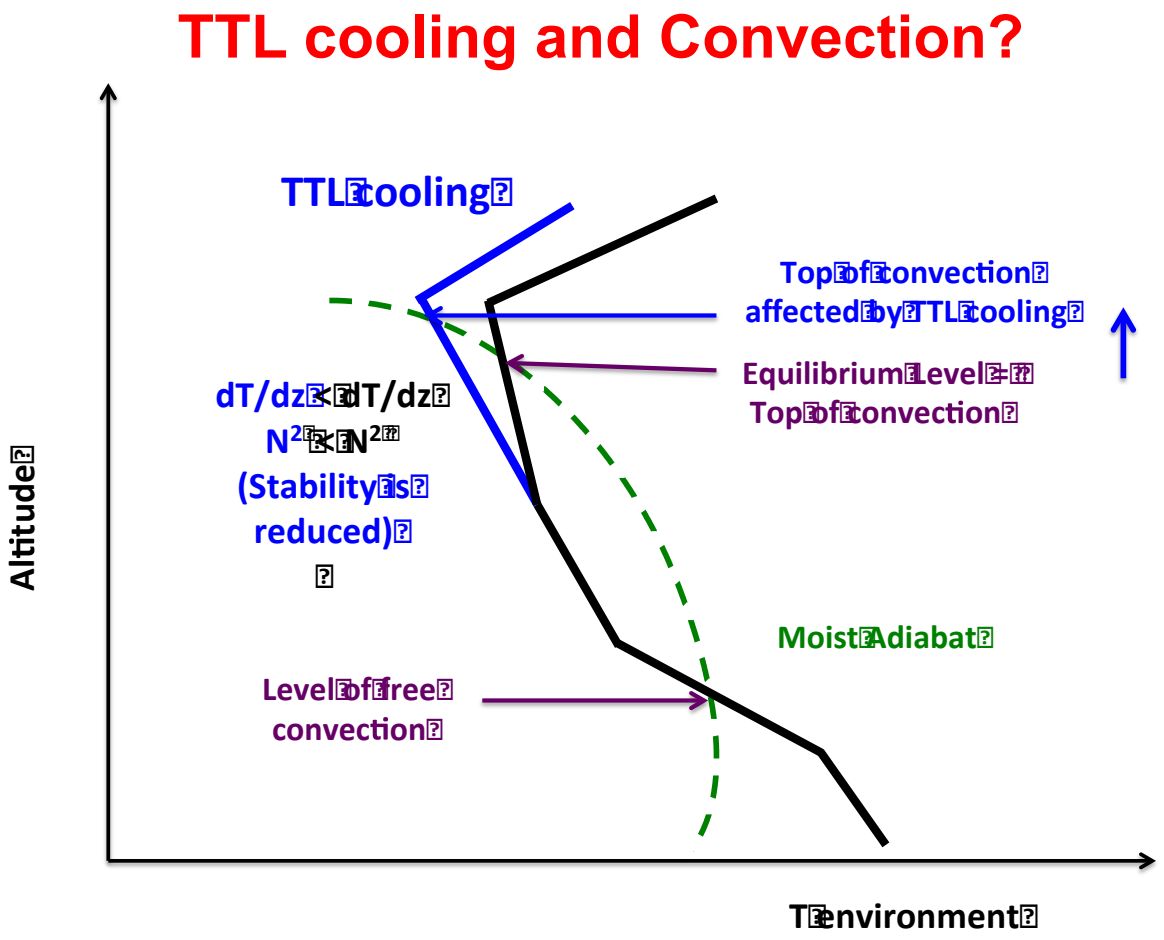
Before SSW: enhanced mid latitude wave activity

This increases strength of the mean meridional circulation

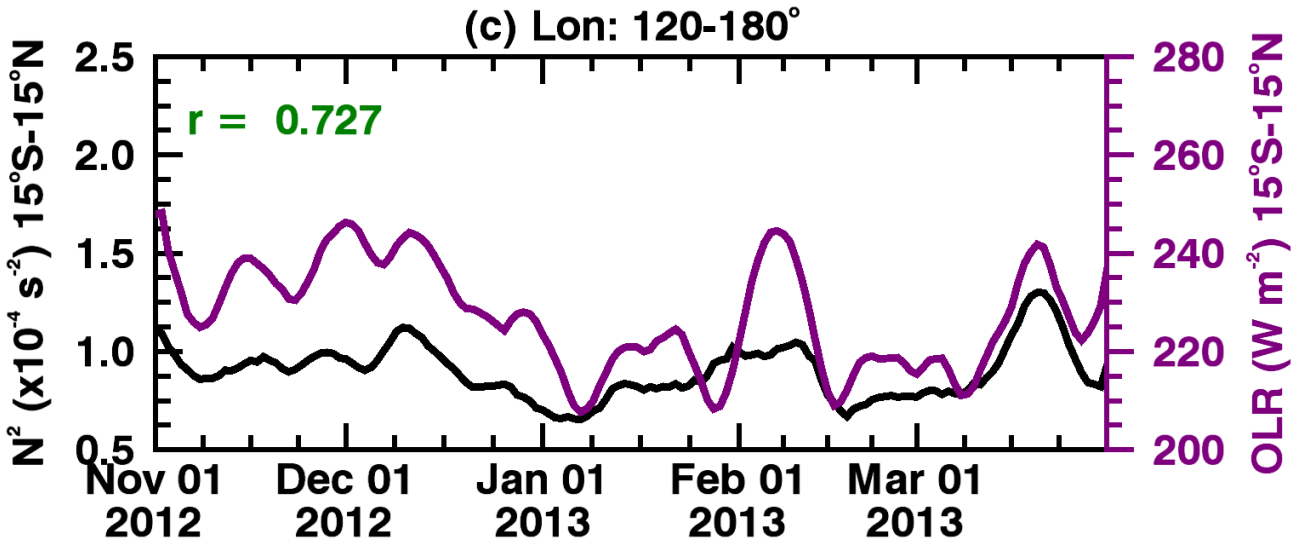
Cools UTLS

Changes static stability

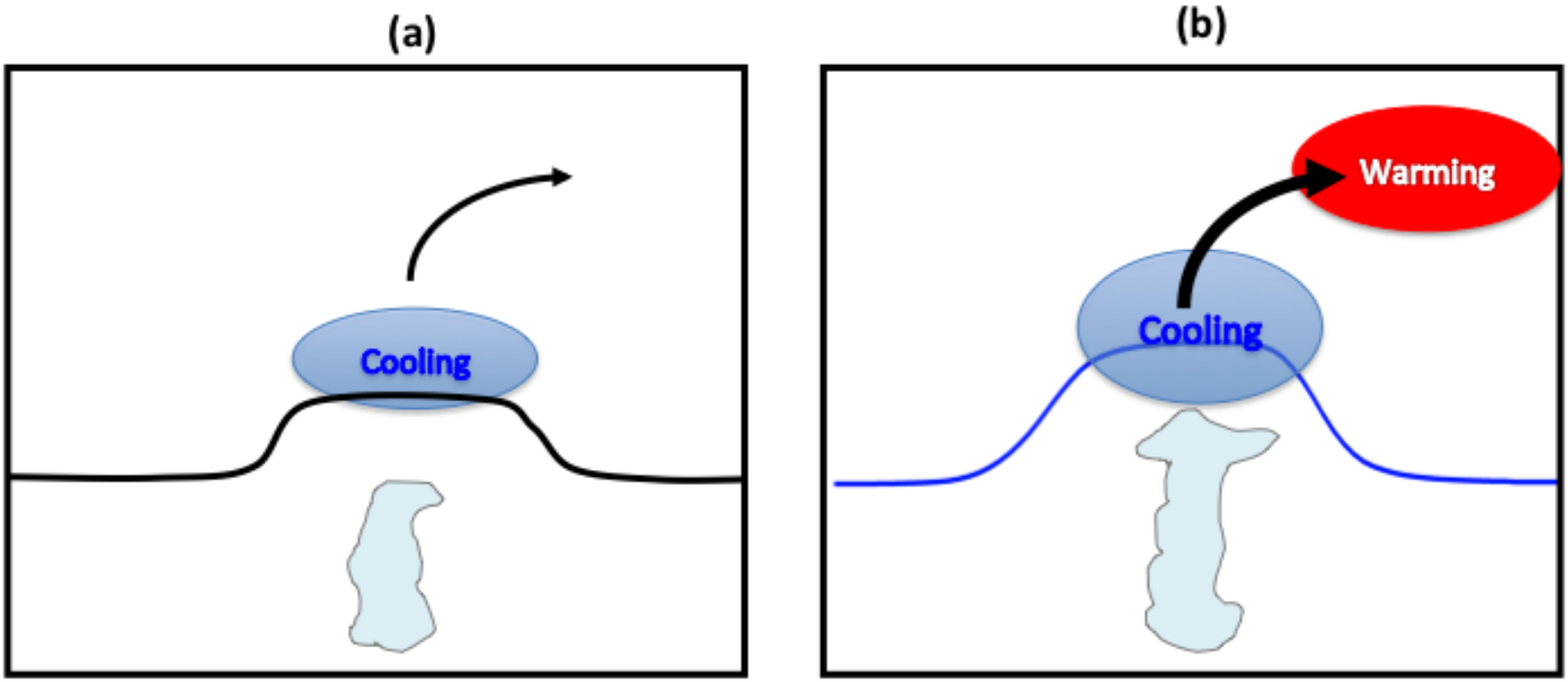
Changes height convection can reach



OLR (purple) N^2 (black), 13-16 km (UT), 120-180 longitude region that has the with largest tropical temperature cooling.



Change in convection with the SSW



Higher, colder cloud tops, leads to enhanced drying of air entering the stratosphere.