Vertical De-coupling of the Middle Atmosphere by Broken Planetary Waves

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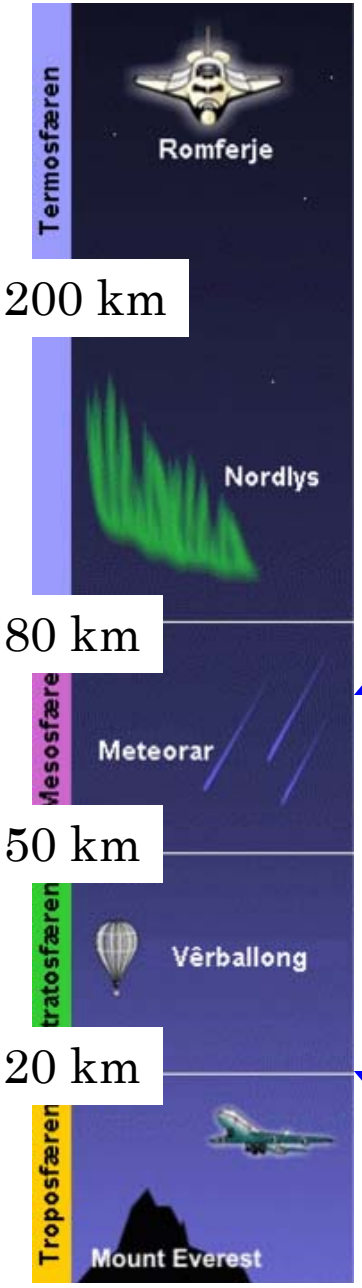
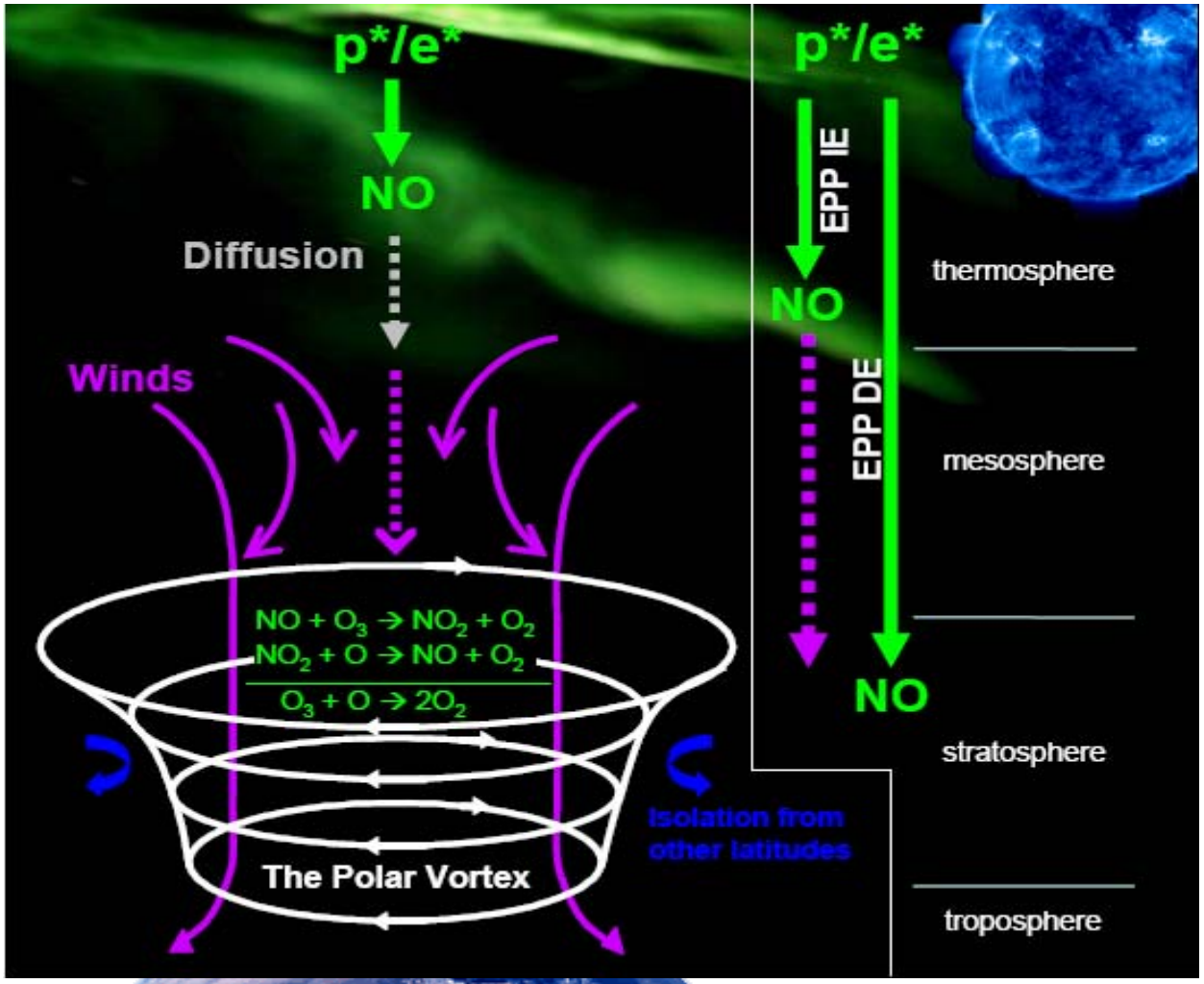
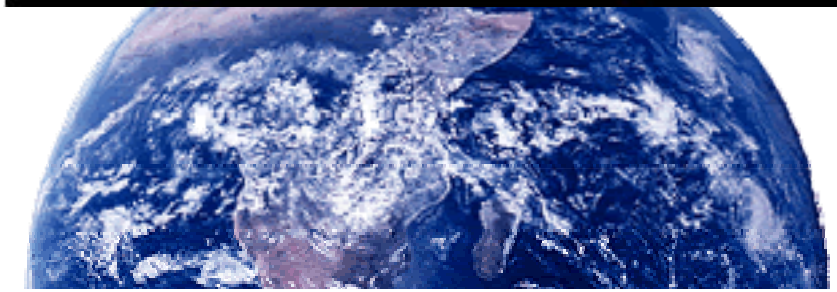
- Polar Vortex and Stratospheric Warmings
- Motivation:
  - NSF Stratosphere-Mesosphere Coupling in IPY
  - Vertical transport of EPP NO_x
- Vertical De-coupling during SSW 2009
- NO_x Descent and Arctic Vortex Area 2004-2009
- January-February 2009 3-D Movie

Stratospheric Polar Vortex



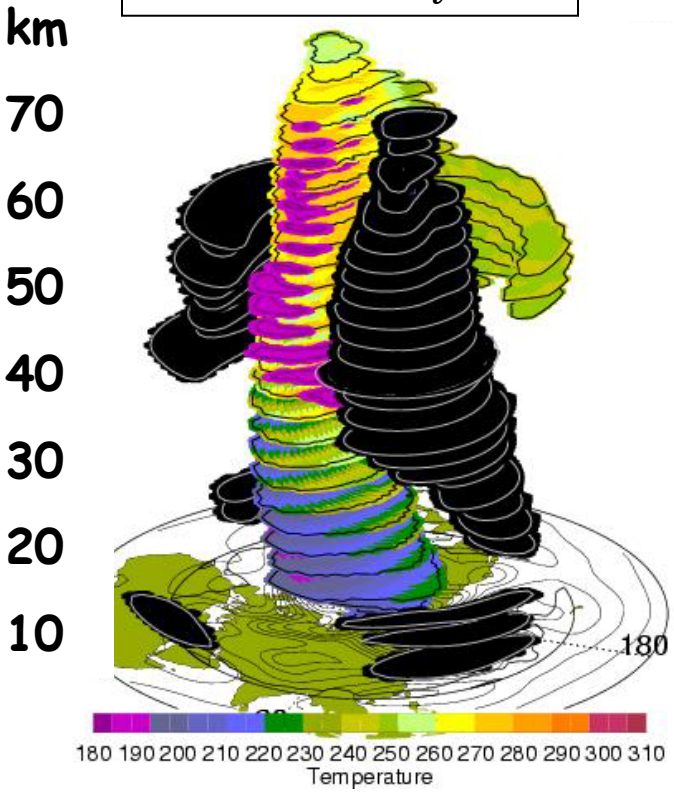




Winter phenomenon
No sun for O_3 -> cold strat
Circumpolar Low Pressure
Polar night westerly jet
Descent from meso/thermo

Sudden Stratospheric Warmings

Arctic Vortex and Aleutian Anticyclone



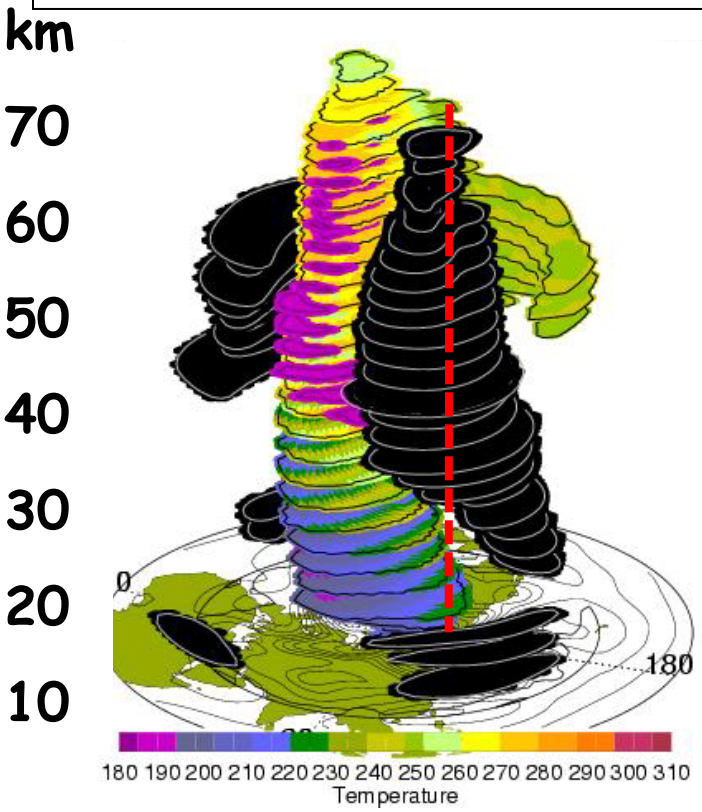
- First discovered by Richard Scherhag in 1952
- **Major disruptions of the polar vortex**
- Upward propagation of PW from troposphere.
- **PW amplify with altitude and break to form closed anticyclonic vortices.**
- ← **3-D representation :** NH E Asia 10-70 km
- Stratopause descends and warms.

ΔT65° C ~150° F
1 week -40 to 110
Siberia to Sahara

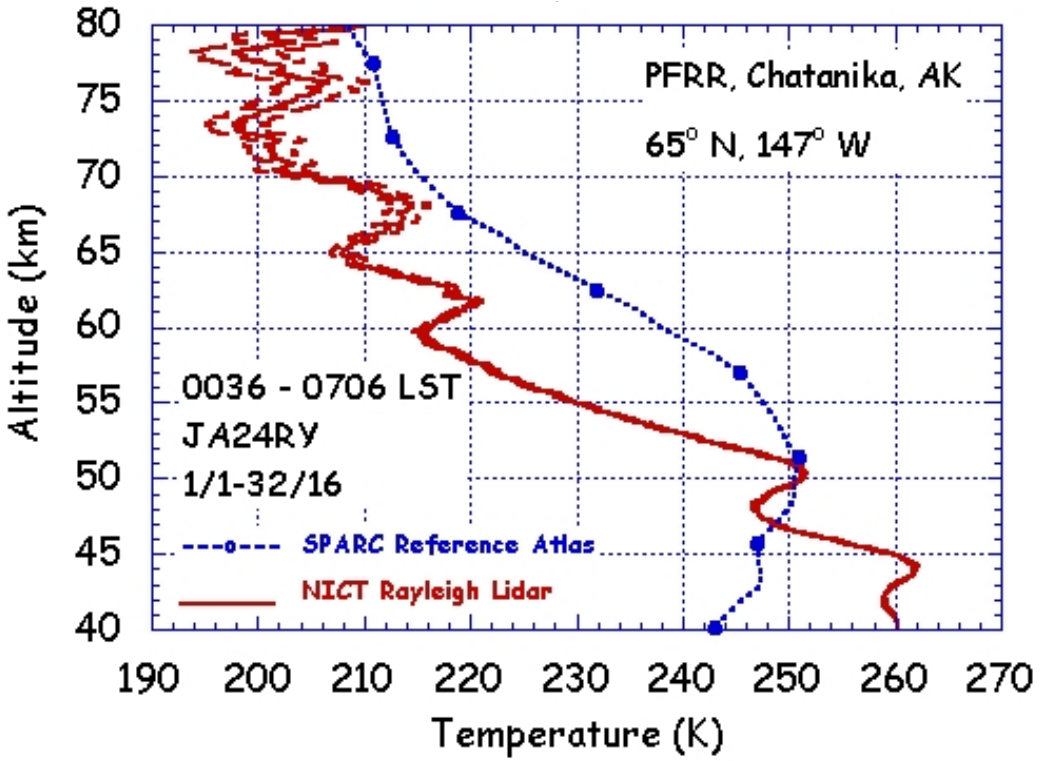
Vortex is not usually a cylinder
Next – IPY effort provides global context for lidars

24 January 2008

Vortex and Anticyclone



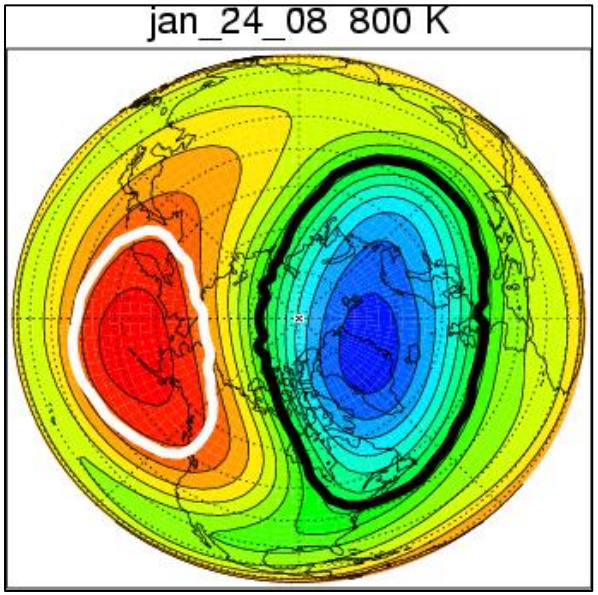
Temperature Profile



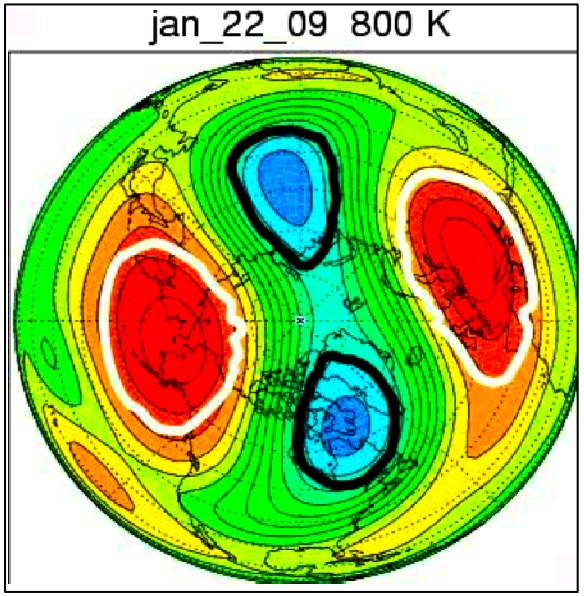
Use global vortex/anticyclone info to interpret single-site lidar profiles.
Lidar profile is in the anticyclone – low & warm stratopause, cold mesosphere

Two General Types of SSWs

- (1) Vortex *displaced* from pole
  - a.k.a. "Minor", "Wave 1", or Canadian
  - One anticyclone
  - WMO definition: 10 hPa polar T warmer than midlatitudes

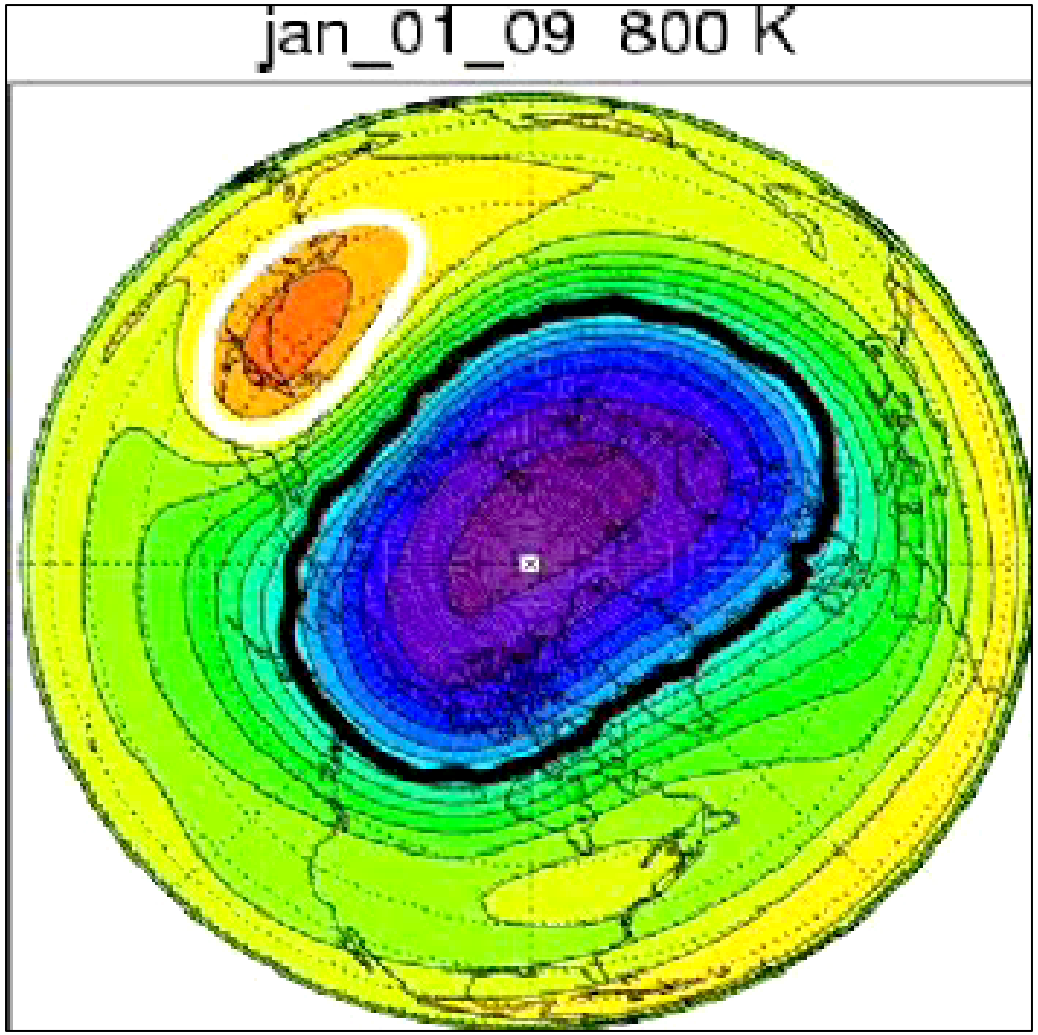


- (2) Vortex *split*
  - a.k.a. "Major", "Wave 2"
  - Two anticyclones
  - Defn: (1) and 10 hPa easterlies



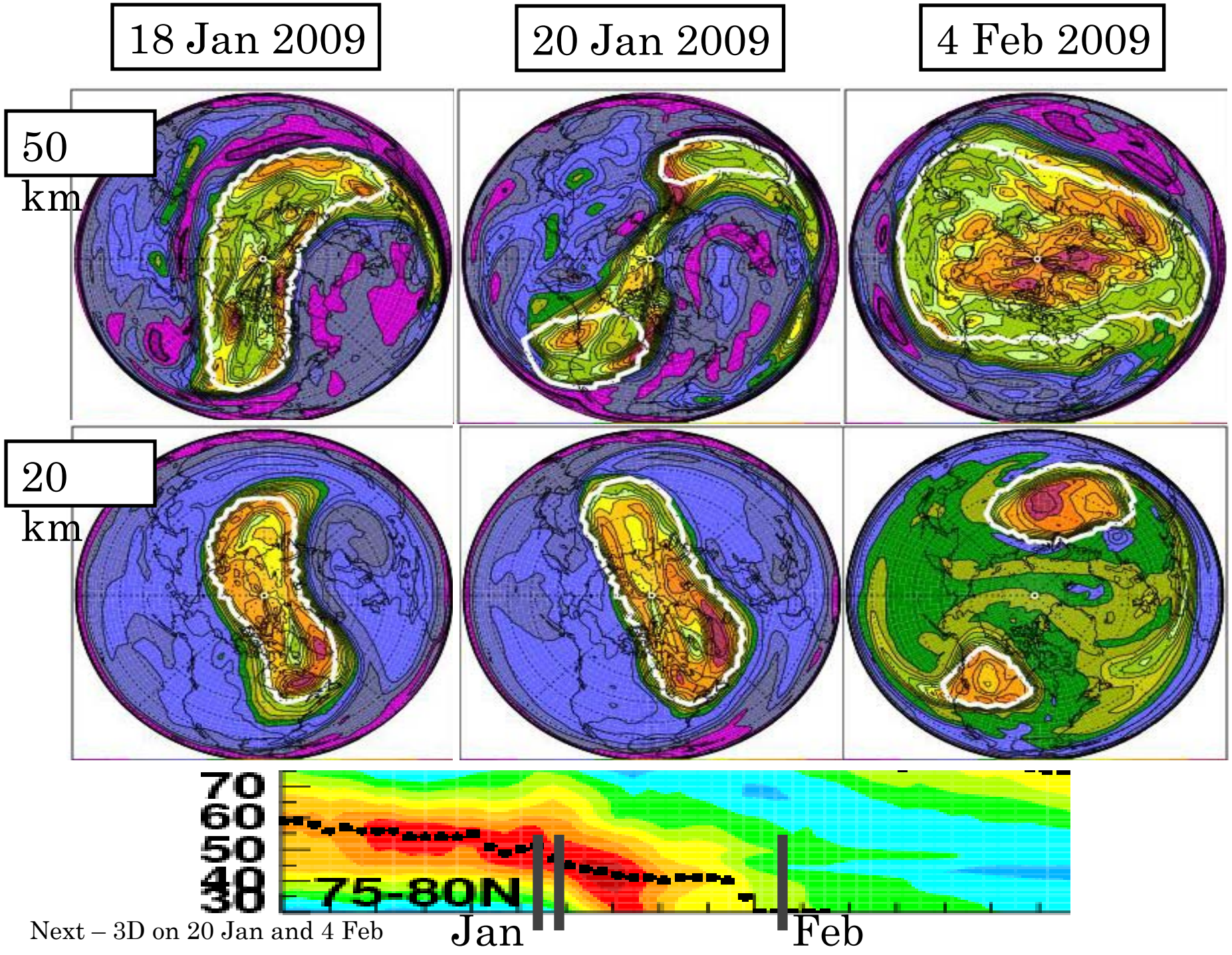
Vortex (anticyclone) edge in black (white)
Next – January 2009 polar movie

Jan 2009 Geopotential Height ~30 km

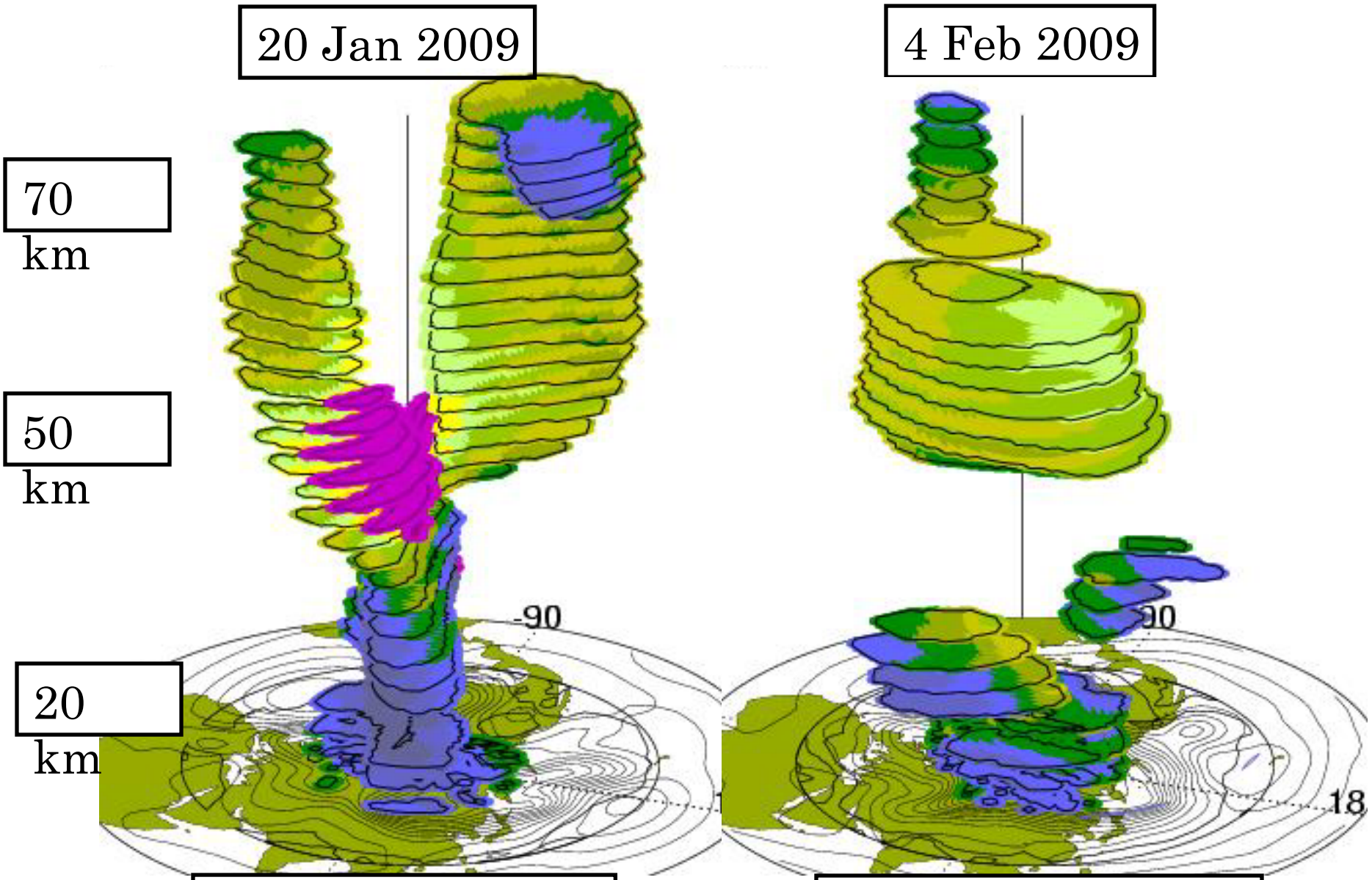


UK MetO
Type (2)

Next – 2009 De-coupling above and below

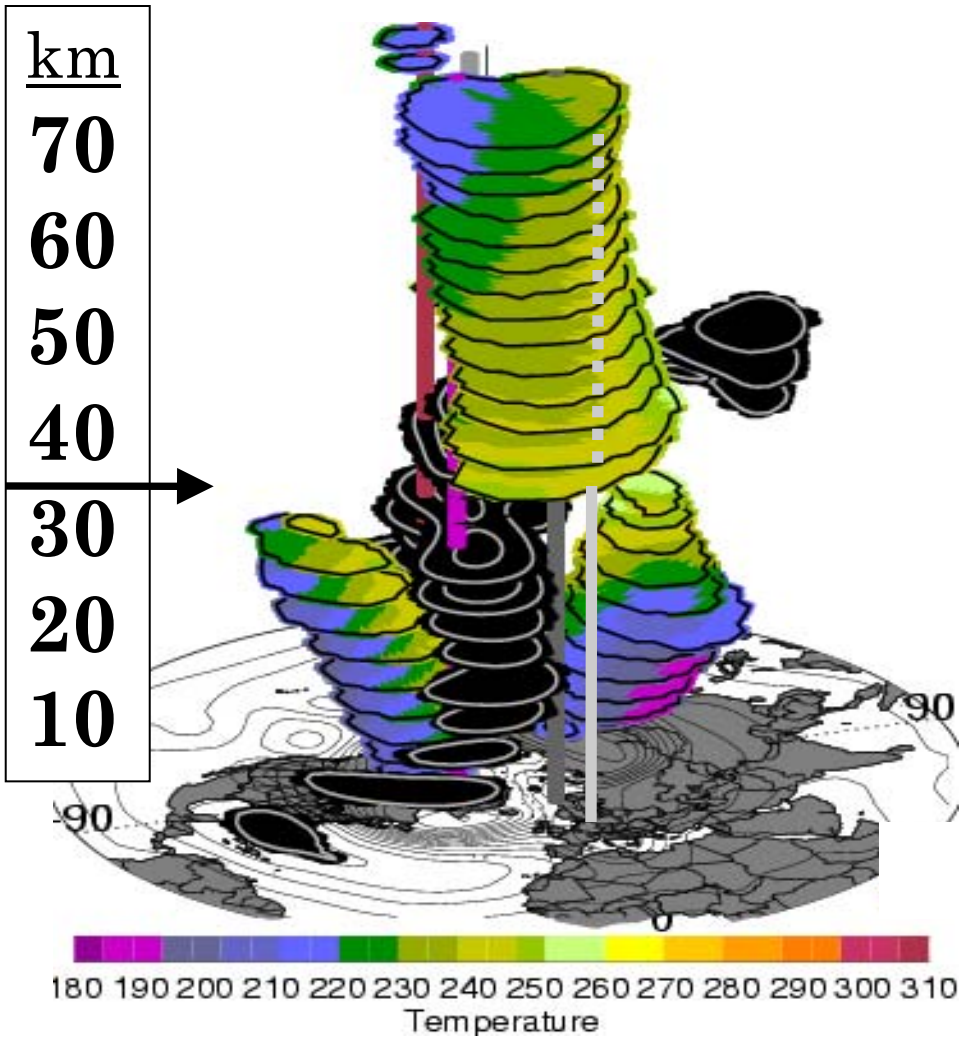


Next – 3D on 20 Jan and 4 Feb



Next – add anticyclones on day between 27 Jan

Vertical De-coupling on Jan 27th 2009



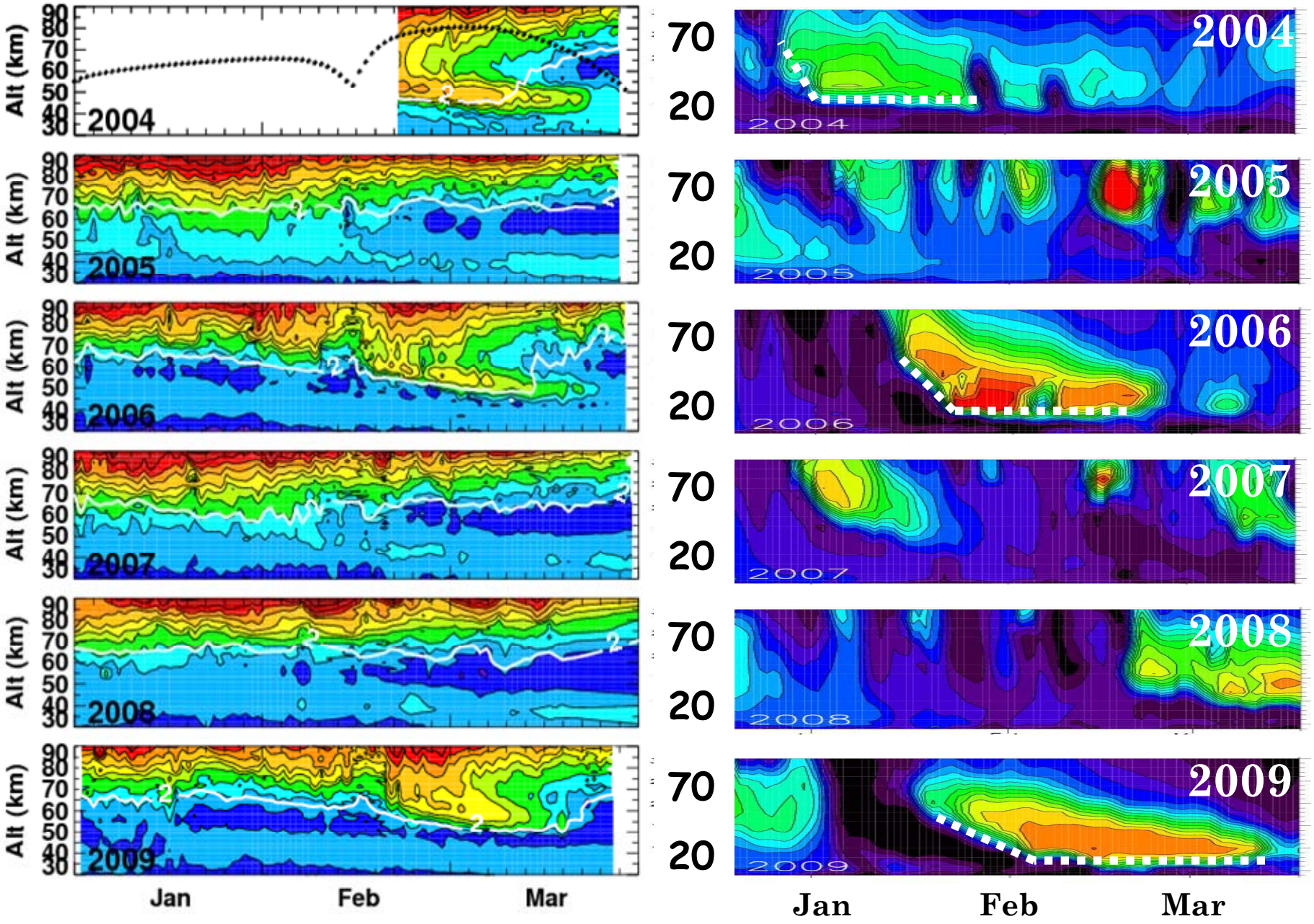
20 Jan
4 Feb

Eureka (80N, 86W)
Norway (69N, 16E)
Greenland (67N 51W)
Alaska (65N, 147W)
Germany (54N,12E)

NH. GM view. 10-70 km. Vortex is de-coupled at 40 km. Situation persists for 3 weeks.
Next – 2004 – 2009 altitude-time vortex area

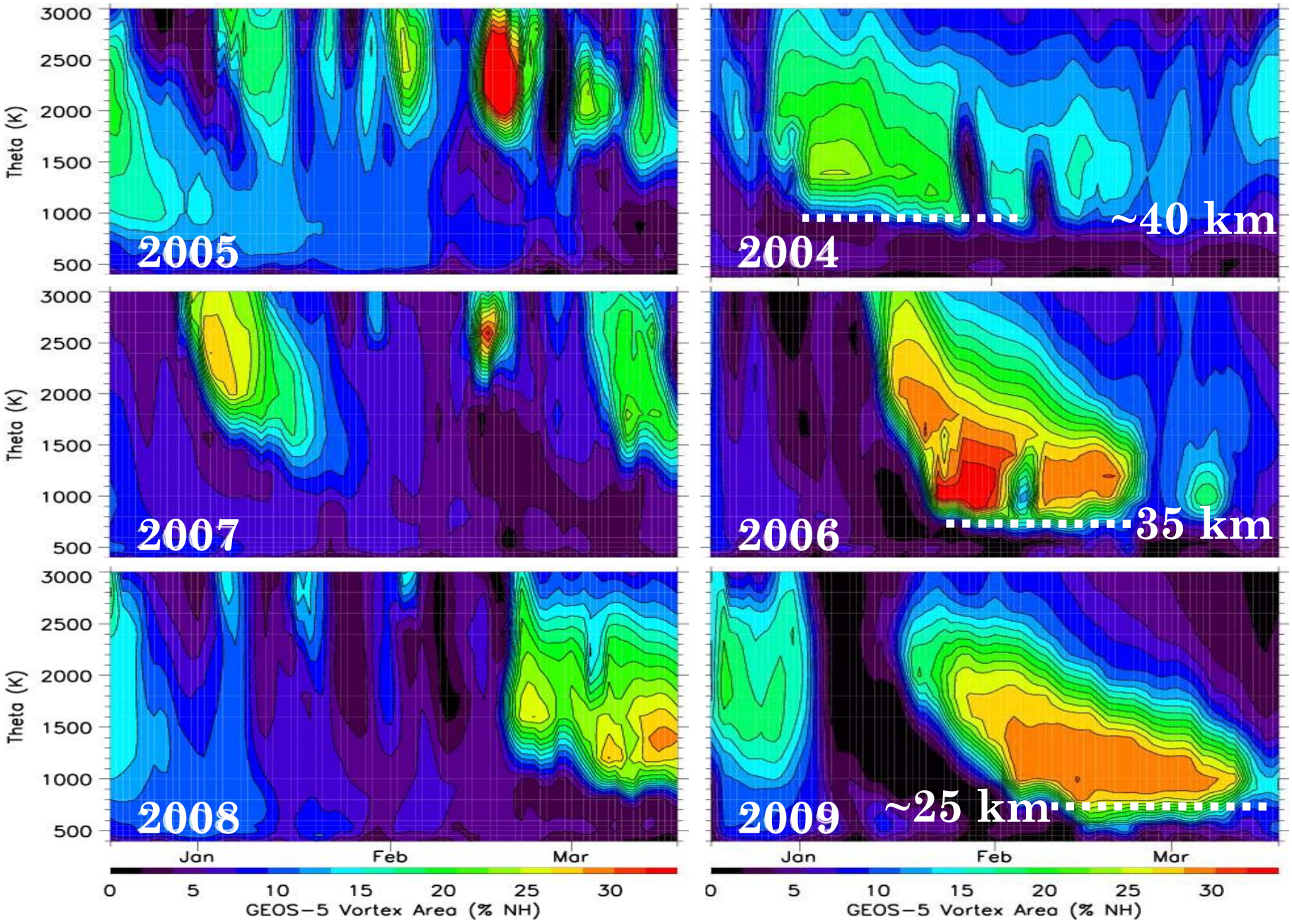
ACE NO_x

Vortex Area

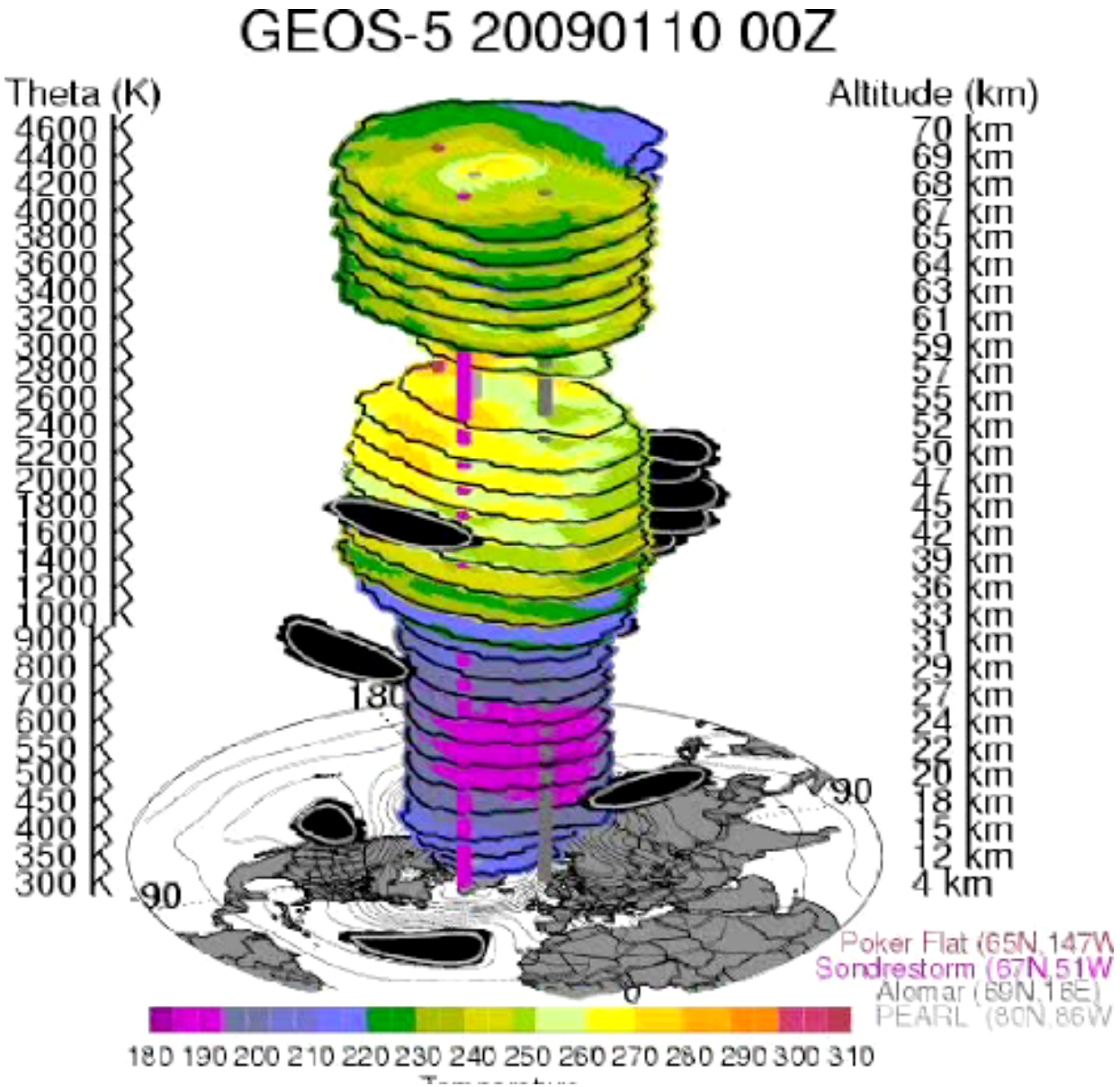


Low NO_x Years

High NO_x Years



Jan 10th to Feb 10th 2009

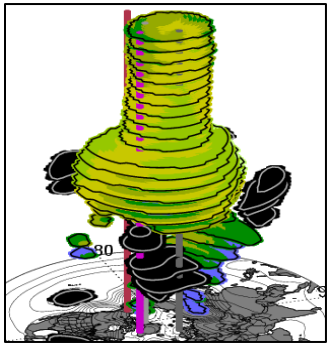


Summary

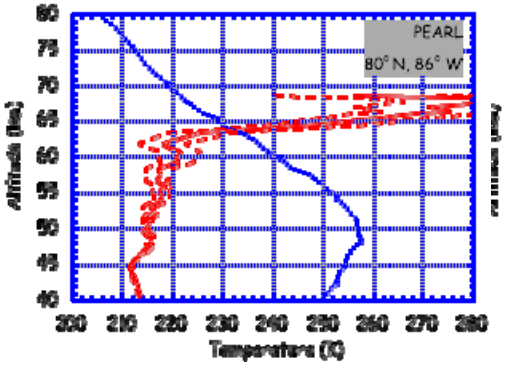
- Descent of NOx when vortex is strong
- But - broken PWs during SSWs temporarily de-couple the vortex between 25 and 40 km
- 3-D view illustrates synoptic evolution of vortex de-coupling in the stratosphere
- **3-D vortex/anticyclone info 1957-2009**

Thank You!

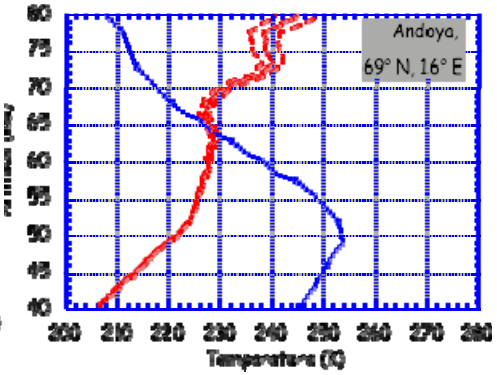
Feb 10

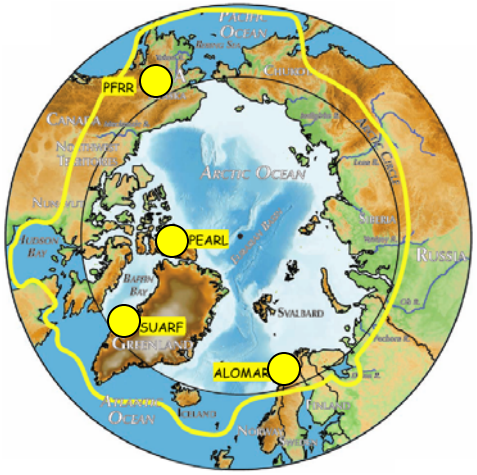


Feb 10 80°N

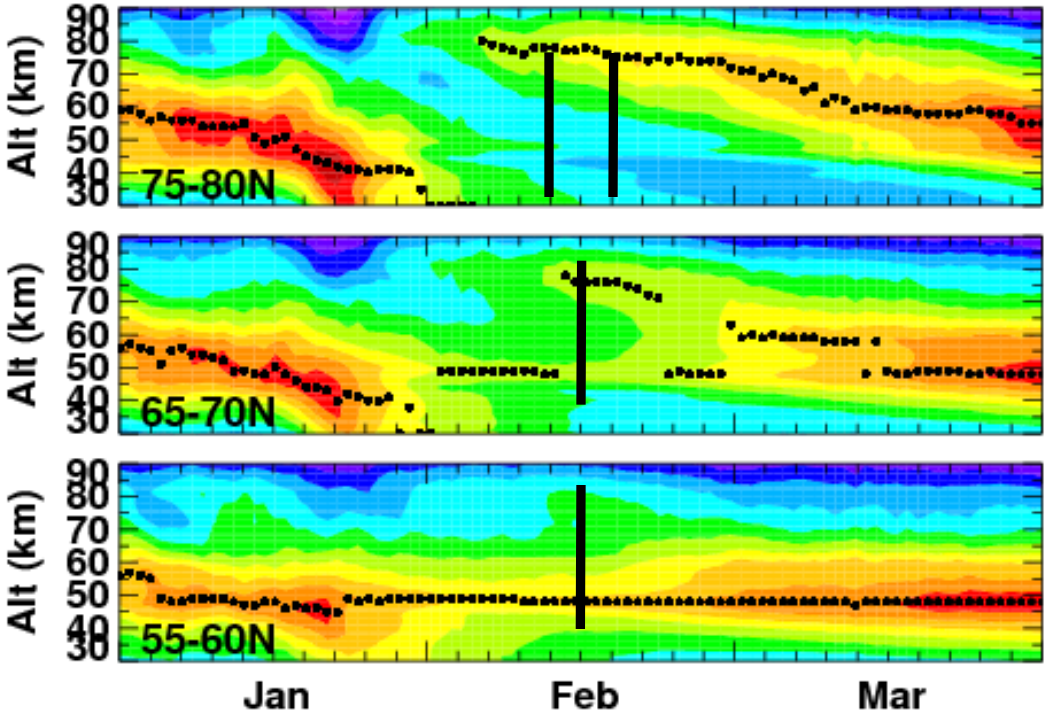


Feb 19 70°N



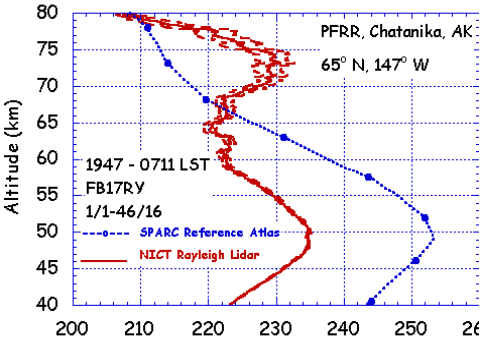


2009
MLS

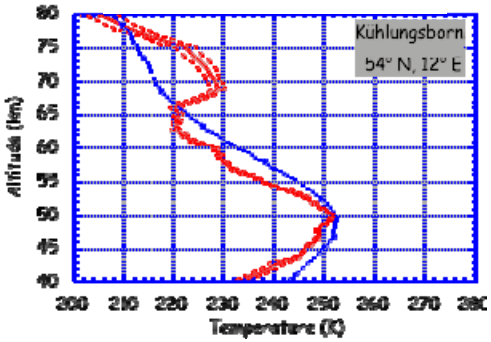


Randall et al. 2009

Feb 15 65°N



Feb 15 55°N



1-D single-site profiles. 2-D altitude time sections at different latitudes. Next show polar panels at 30 km and 50 km. Then 3-D and 4-D.

Feb 20th to 27th 2008