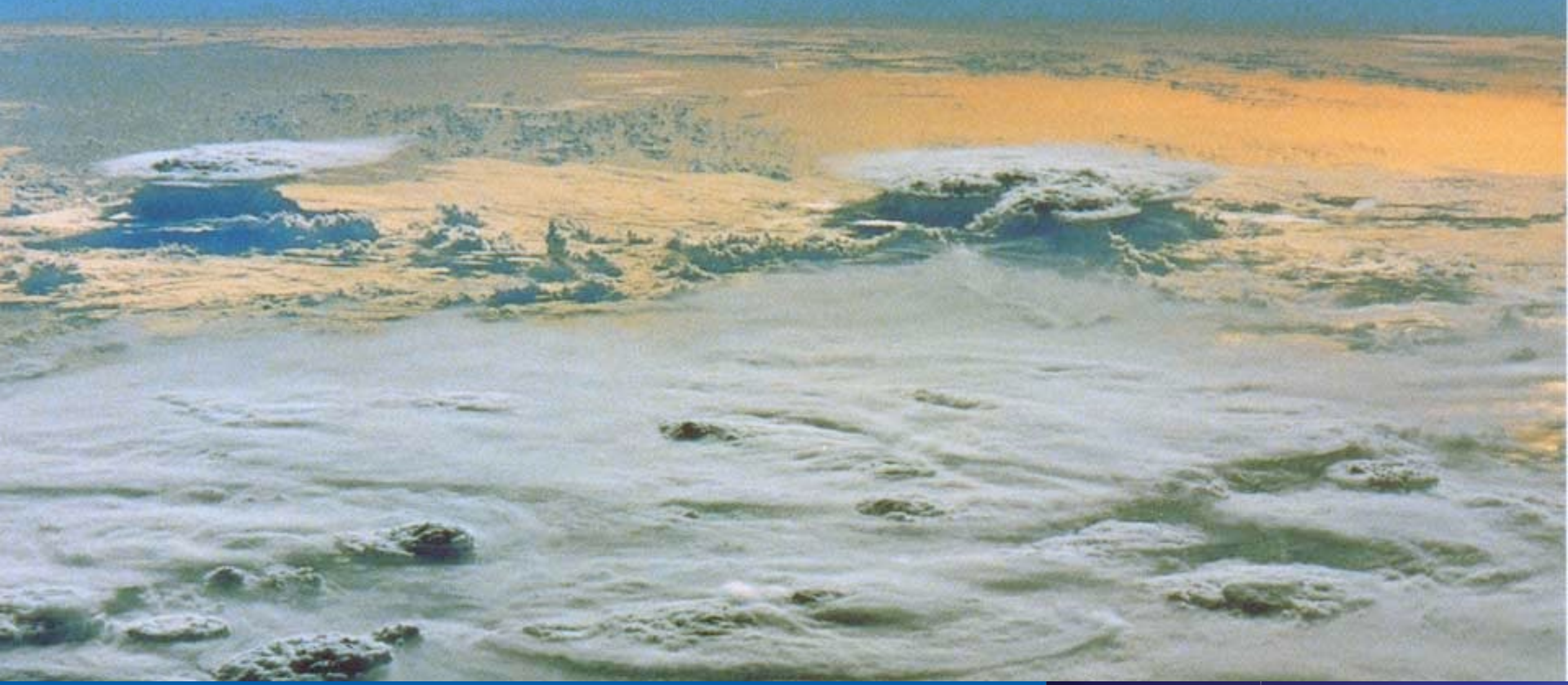
# Stratospheric Processes: Influence on Storm Tracks and the NAO

Mark P. Baldwin



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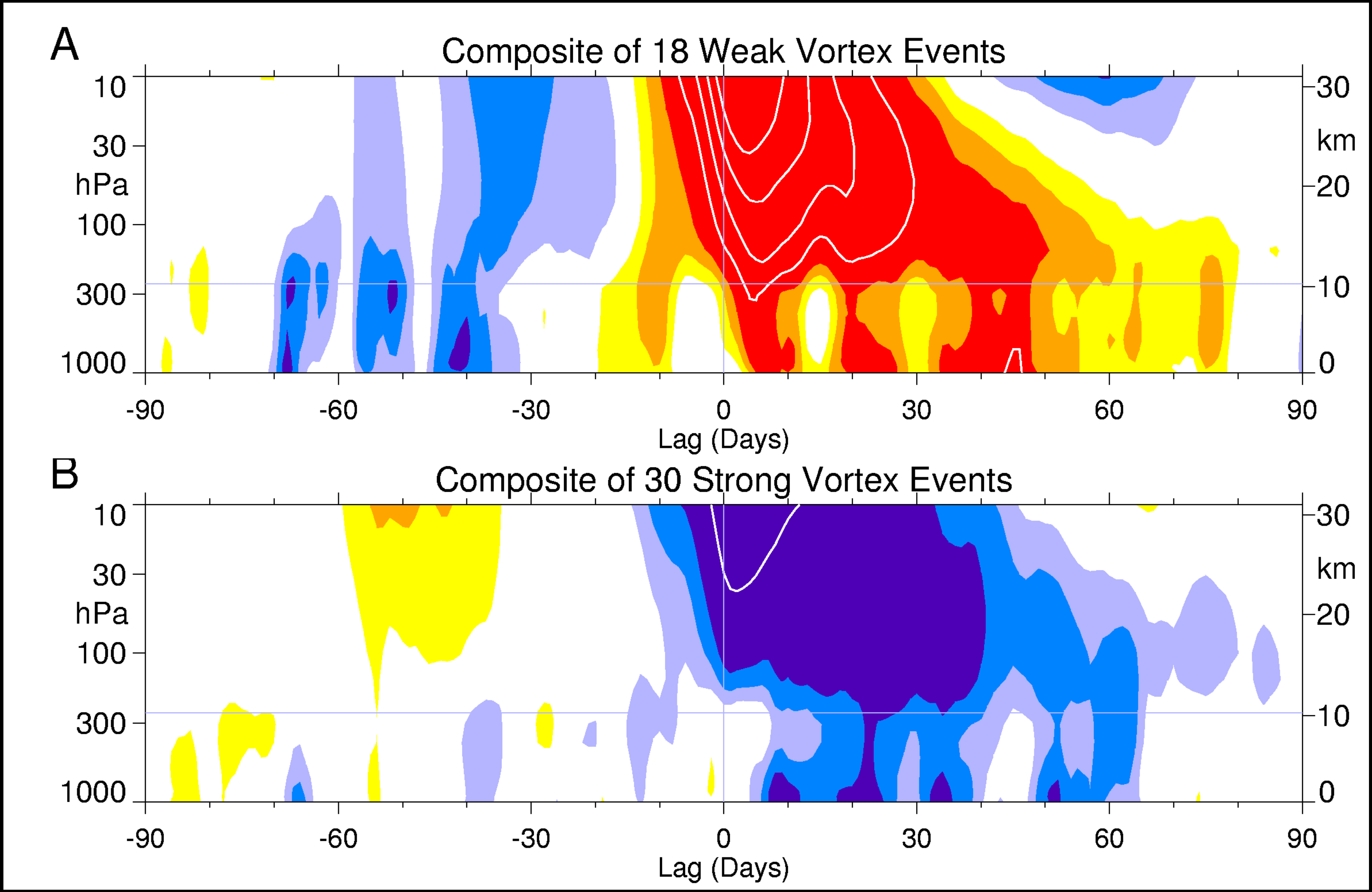
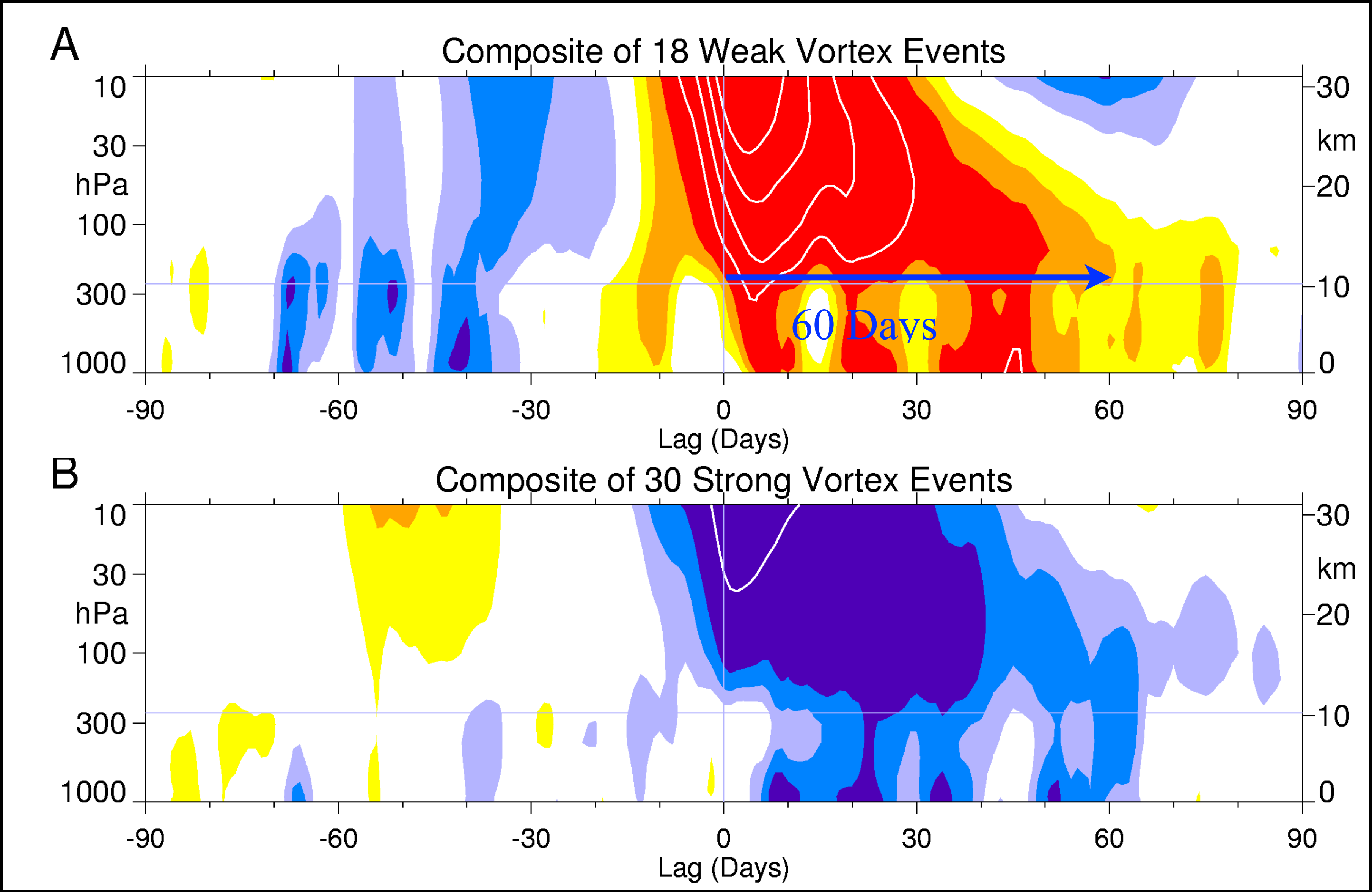



(From Baldwin and Dunkerton, *Science* 2001)

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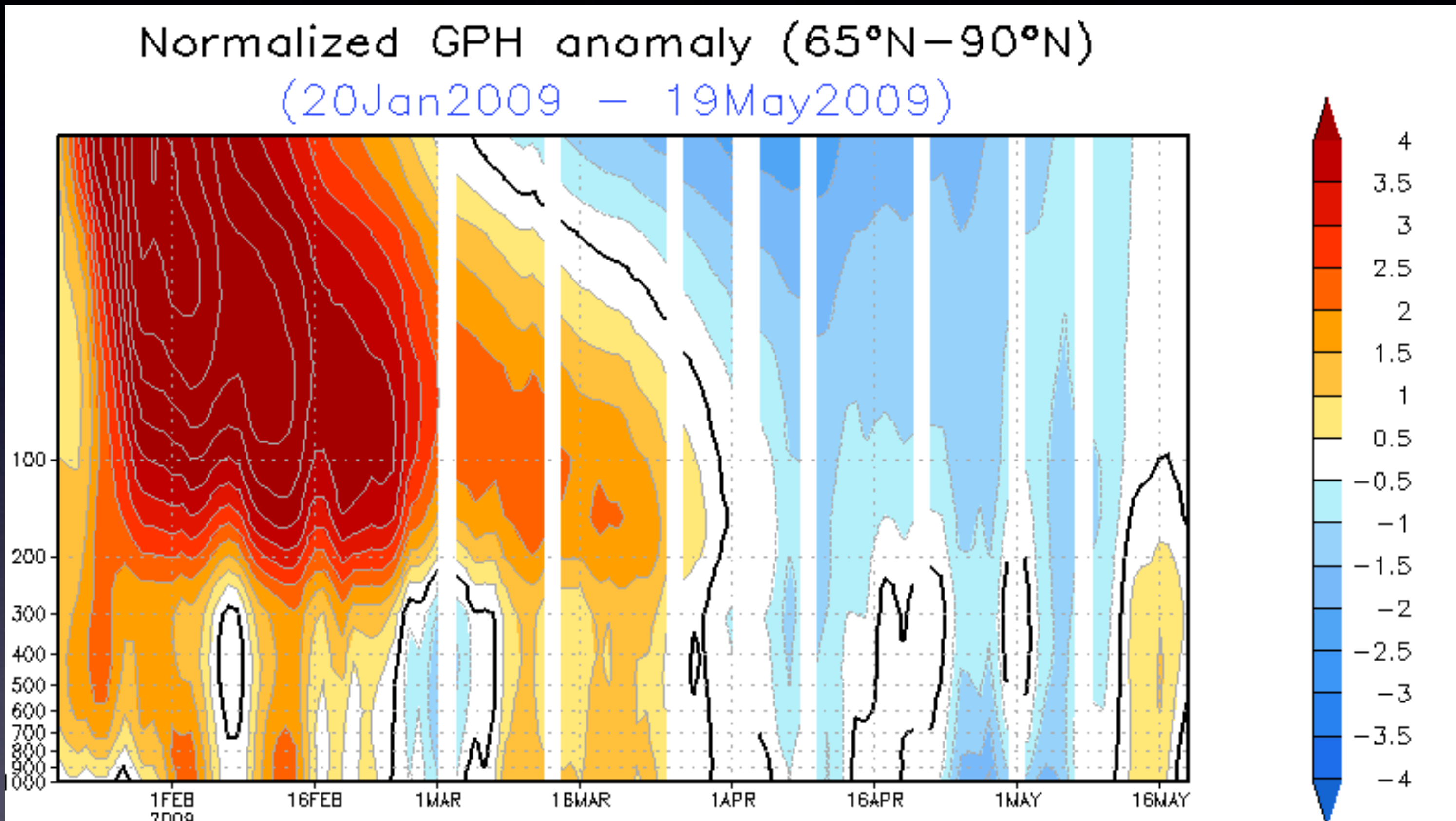
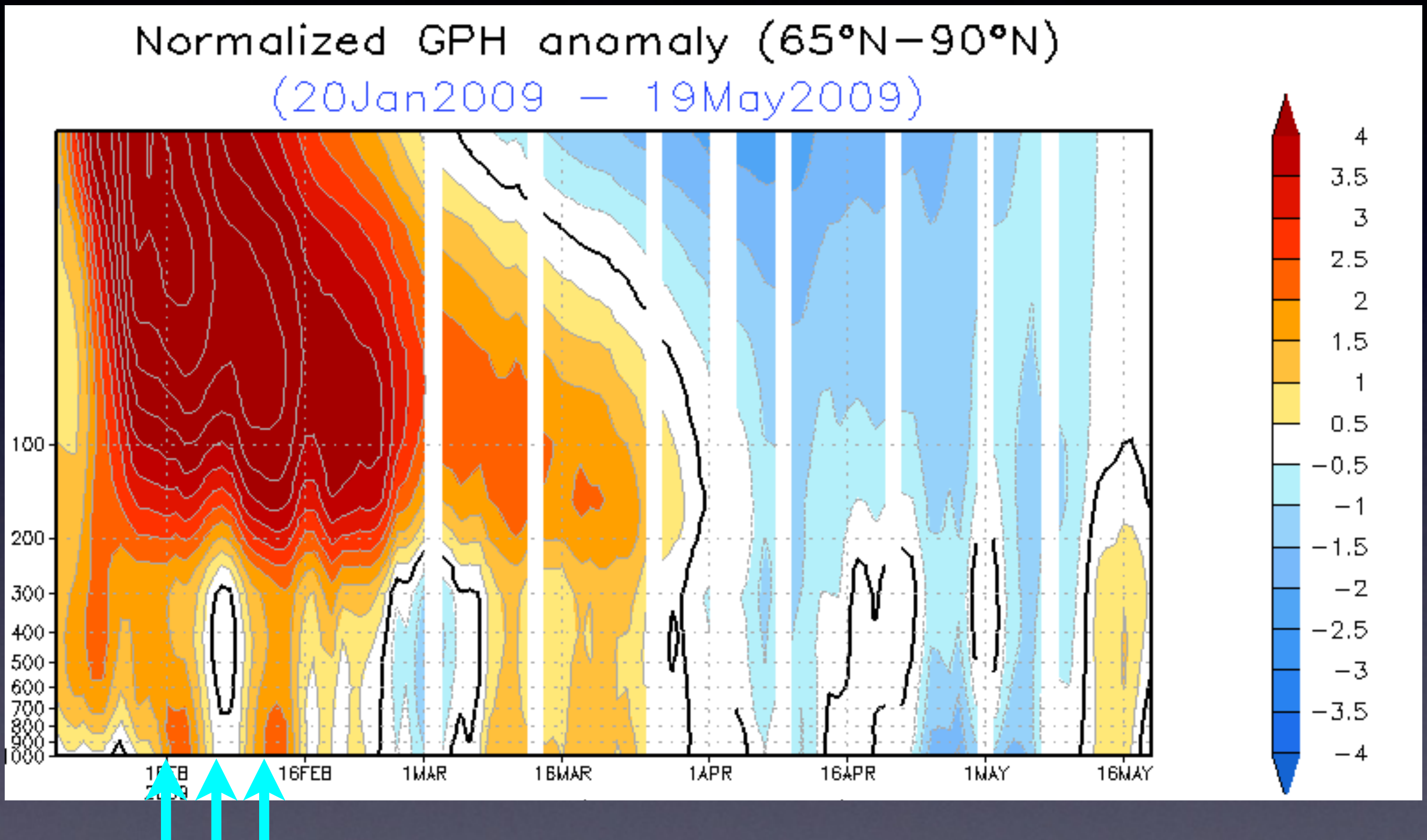
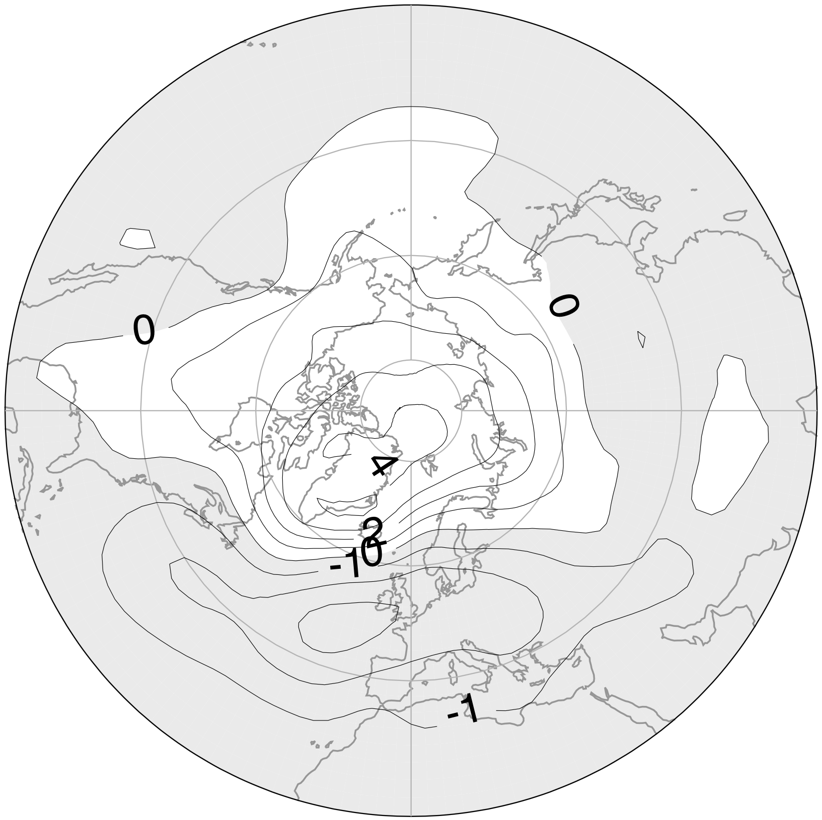

Normalized GPH anomaly (65°N–90°N)
(20Jan2009 – 19May2009)
100
200
300
400
500
600
700
800
900
1000
1FEB
2009
16FEB
1MAR
16MAR
1APR
16APR
1MAY
16MAY
4
3.5
3
2.5
2
1.5
1
0.5
−0.5
−1
−1.5
−2
−2.5
−3
−3.5
−4



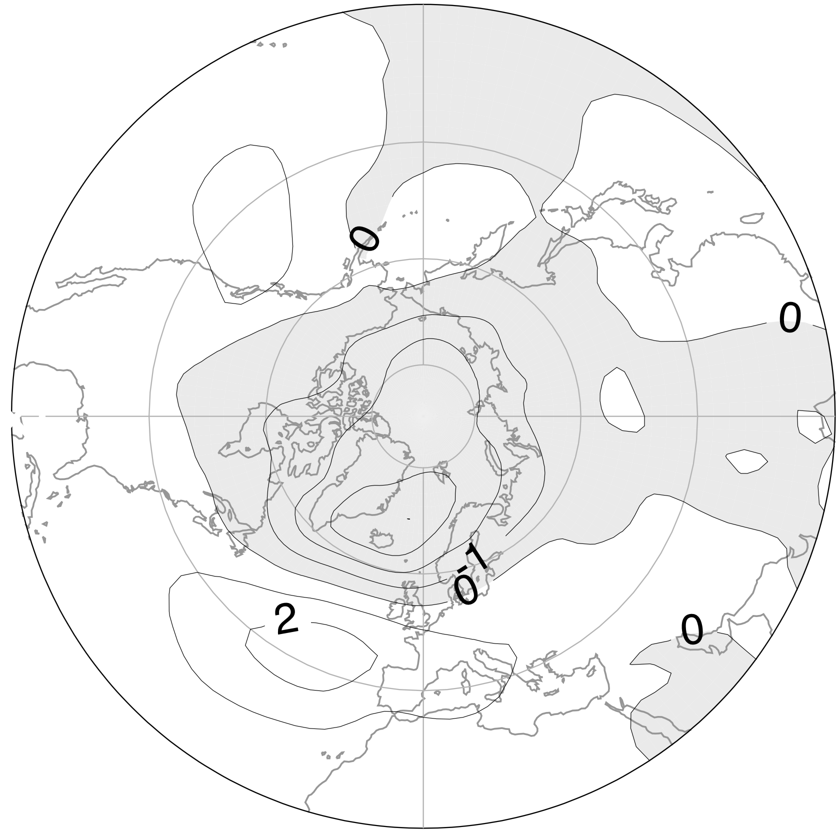

British Snow Storms

# Observed Average Surface Pressure Anomalies (hPa)

60 days following weak stratospheric winds

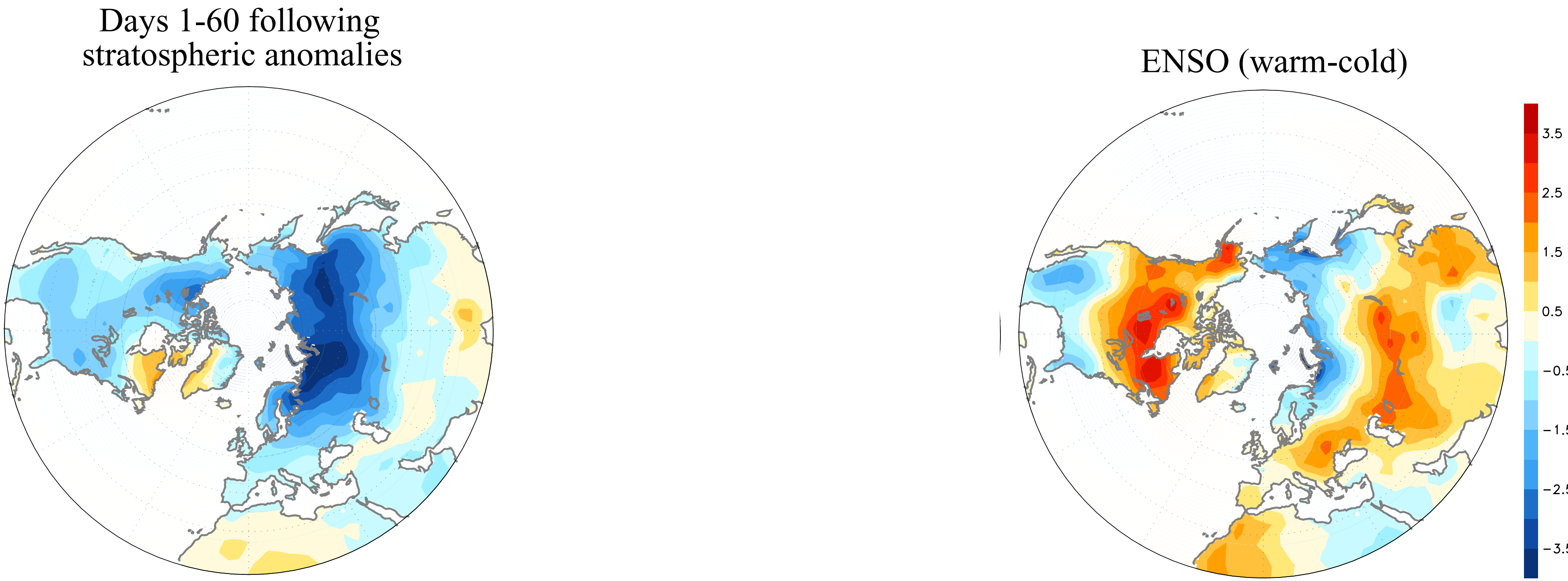



60 days following strong stratospheric winds




From Baldwin and Dunkerton., 2001

# Surface temperature anomalies




From Thompson et al., *J. Climate* 2002

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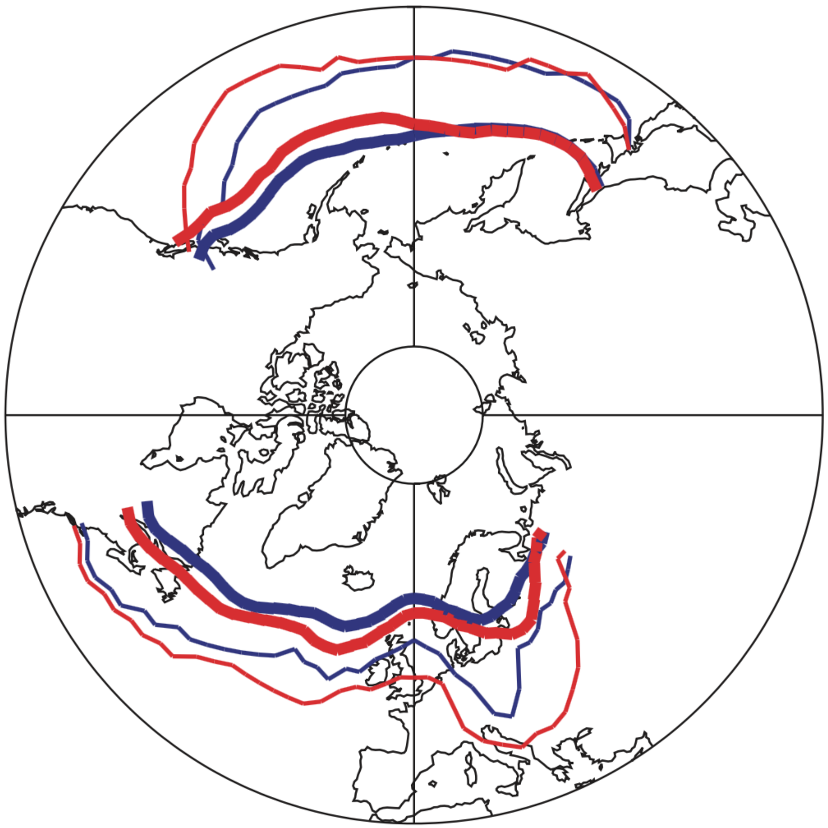
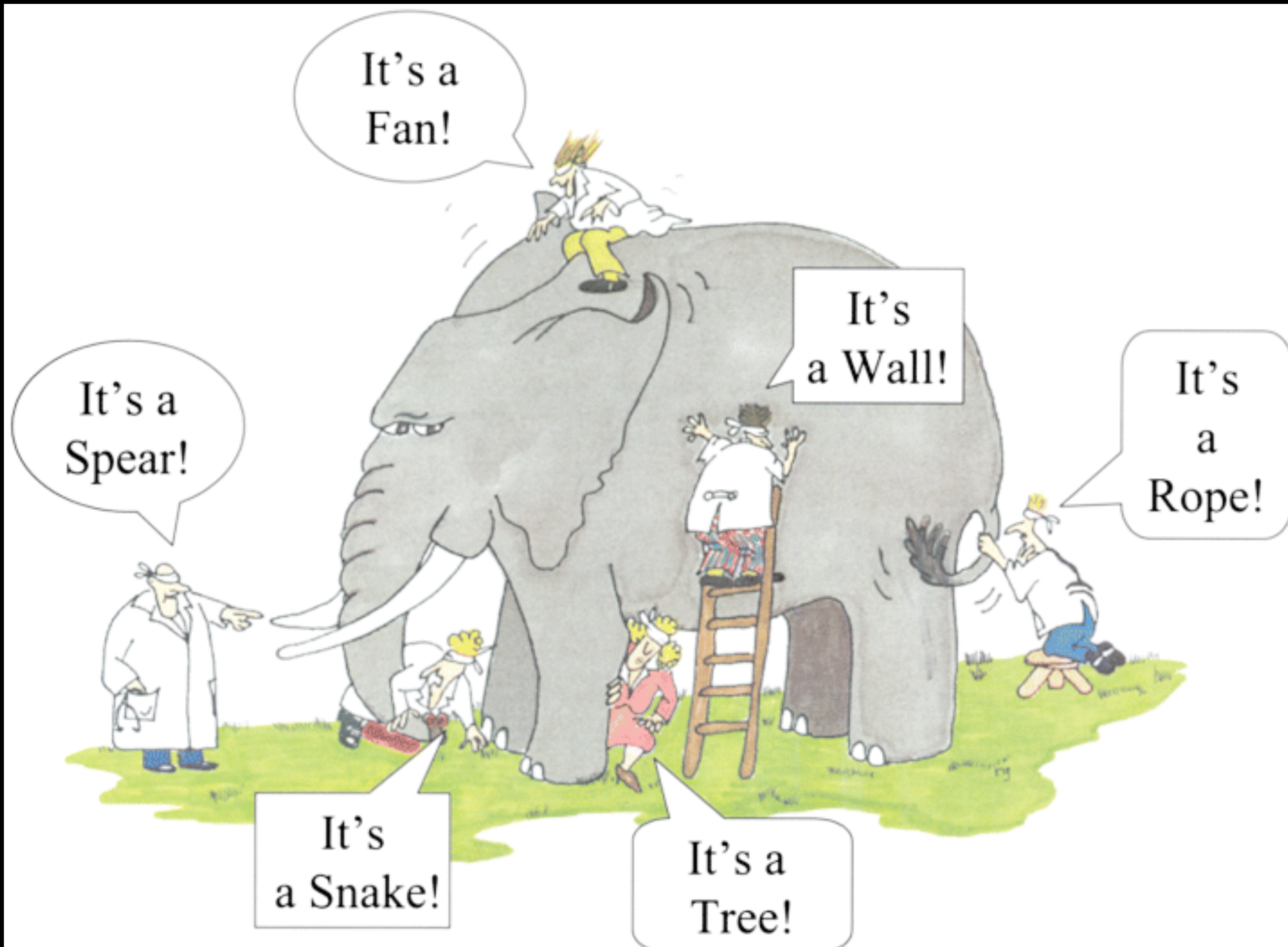


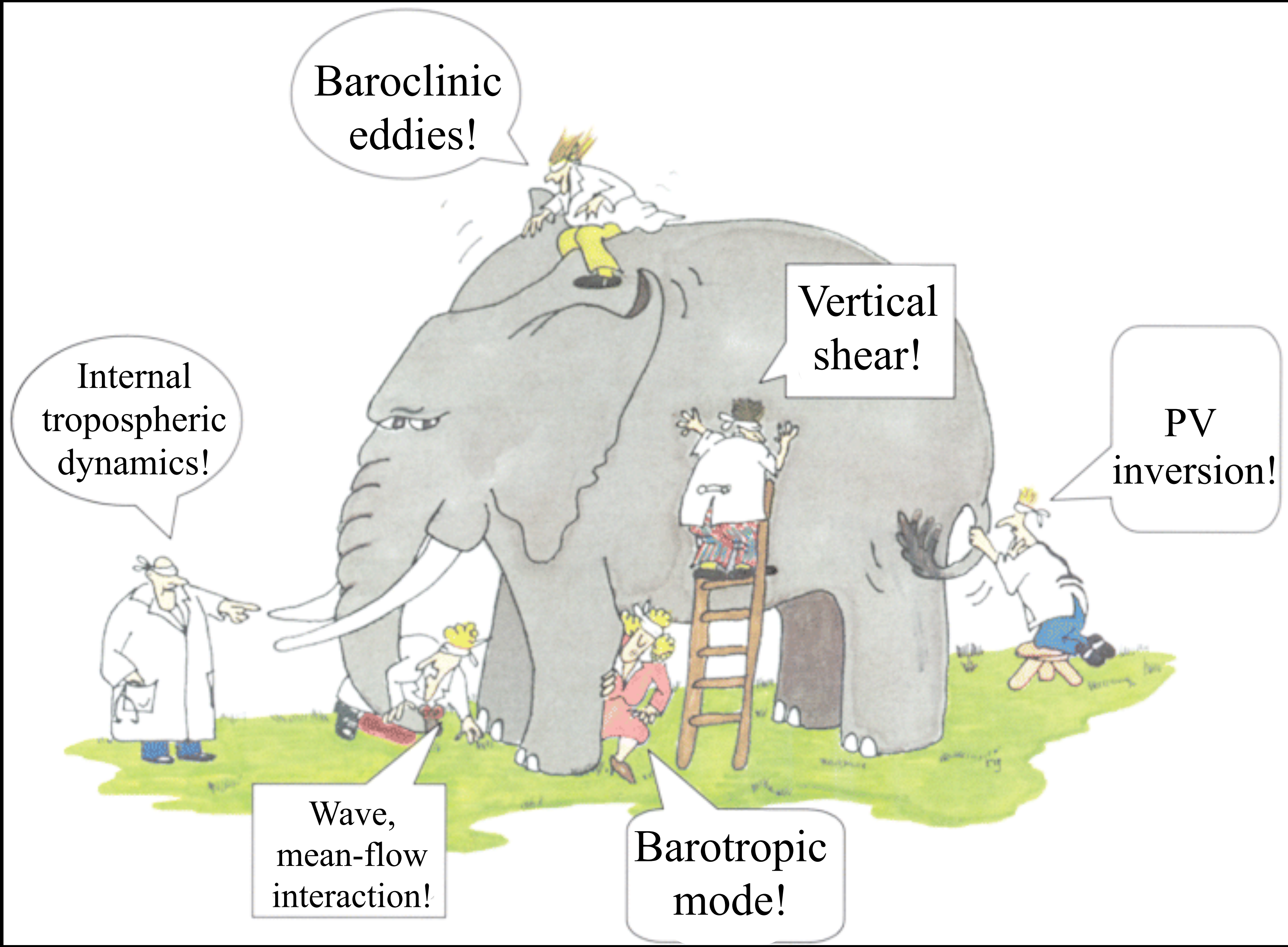

**Fig. 5.** Average latitudes of surface cyclones (defined as closed low-pressure centers less than 1000 hPa) in the Atlantic and Pacific sectors for the 1080 days during weak vortex regimes (thick red lines) and the 1800 days during strong vortex regimes (thick blue lines). The thin lines indicate the lowest latitude at which a cyclone frequency of one per two weeks is expected. The data span 1961–1998, and each data point represents the average of a 15° band in longitude.

From Baldwin and Dunkerton, 2001

# Weather Extremes Related to Stratospheric Variability

- Severe cold weather at high latitudes is more common during weak vortex events.
- Winter weather extremes (low temperatures, snow, etc.) are much more common during weak vortex events.
- Atlantic blocking occurs almost exclusively during weak vortex events.
- Strong winds and ocean wave events are much more common during strong vortex events.


It's a Fan!
It's a Spear!
It's a Wall!
It's a Rope!
It's a Snake!
It's a Tree!


Baroclinic eddies!
Vertical shear!
Internal tropospheric dynamics!
PV inversion!
Wave, mean-flow interaction!
Barotropic mode!

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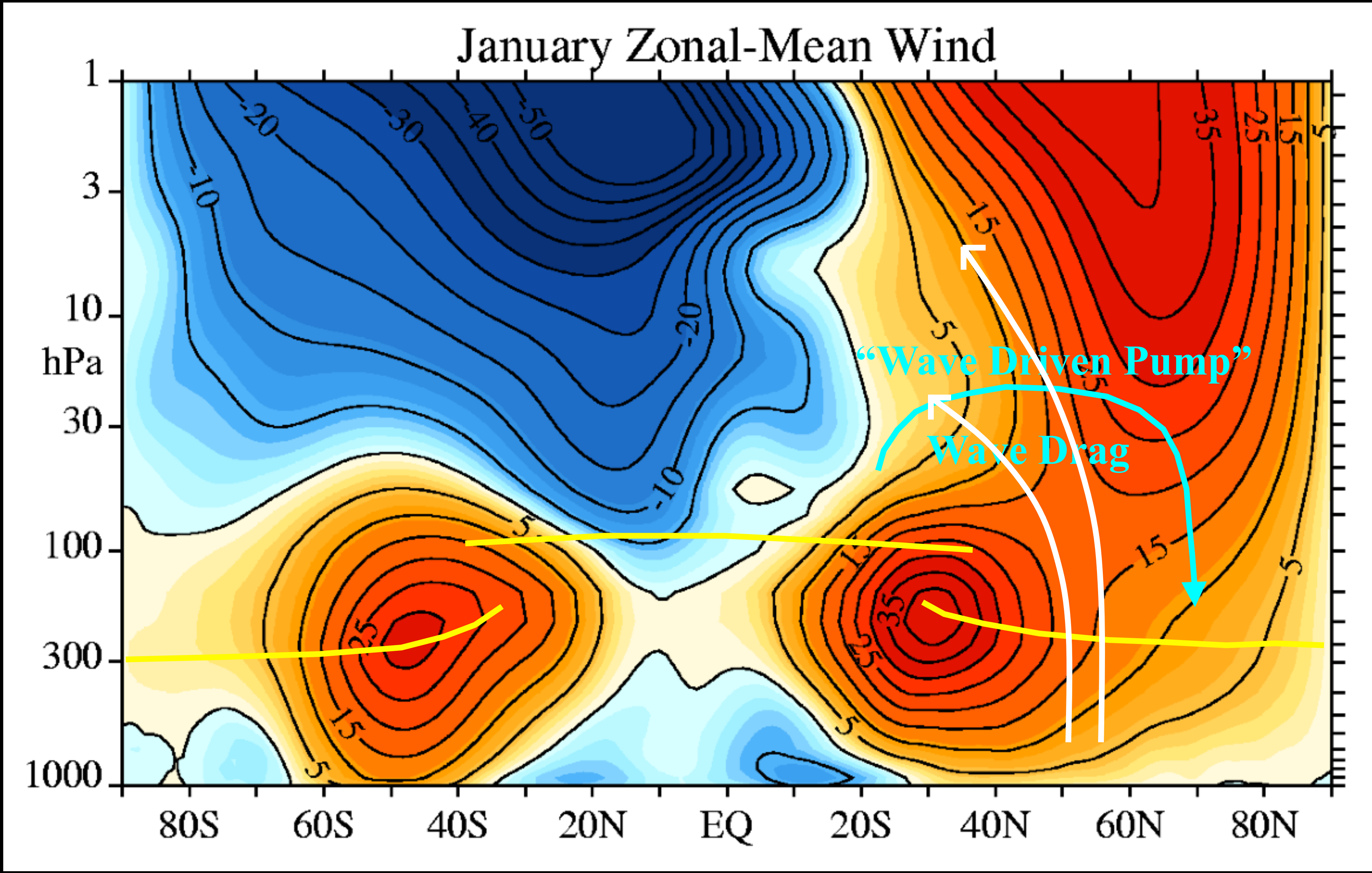
- Ambaum and Hoskins (*JClim* 2002) used "PV thinking" to explain how stratospheric PV anomalies affect surface pressure.




Anomalous wave drag leads to variations in vortex strength

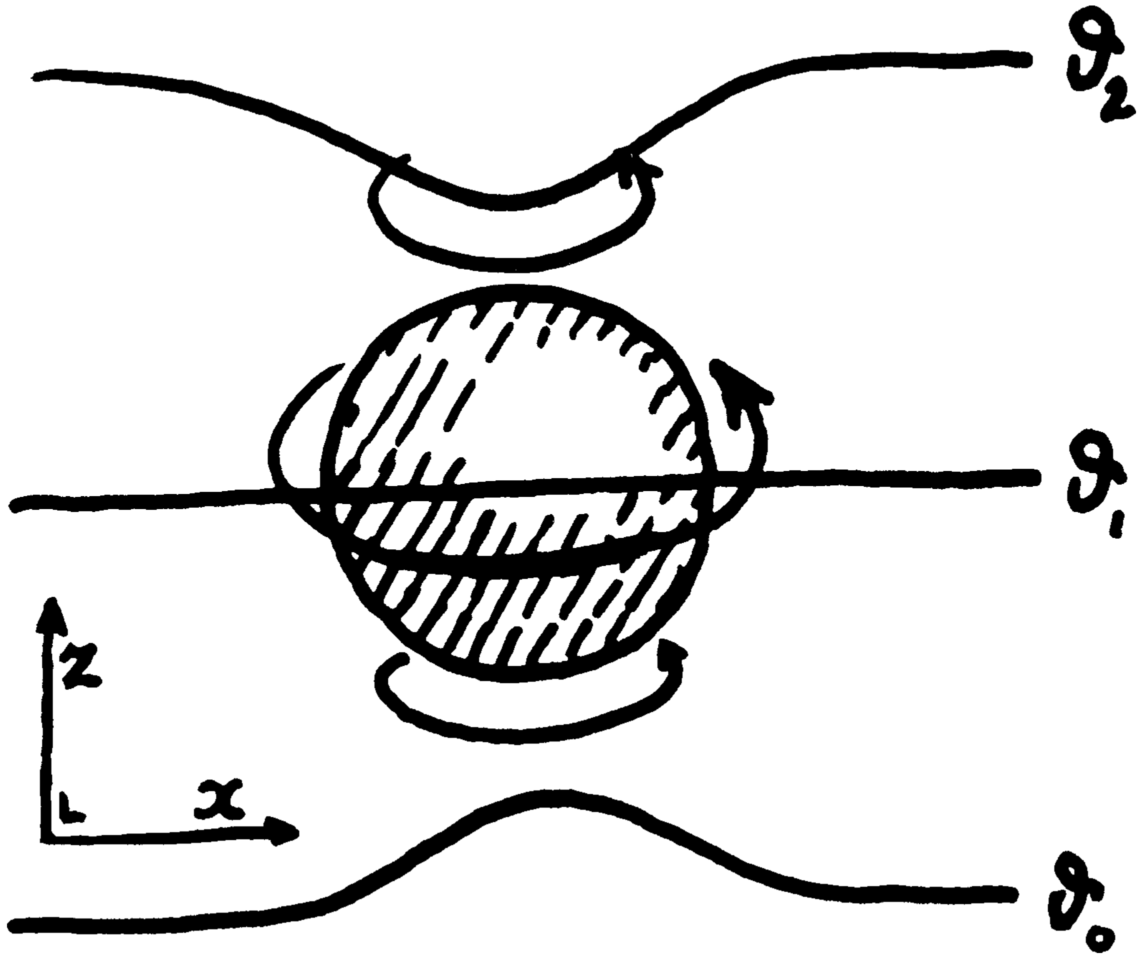
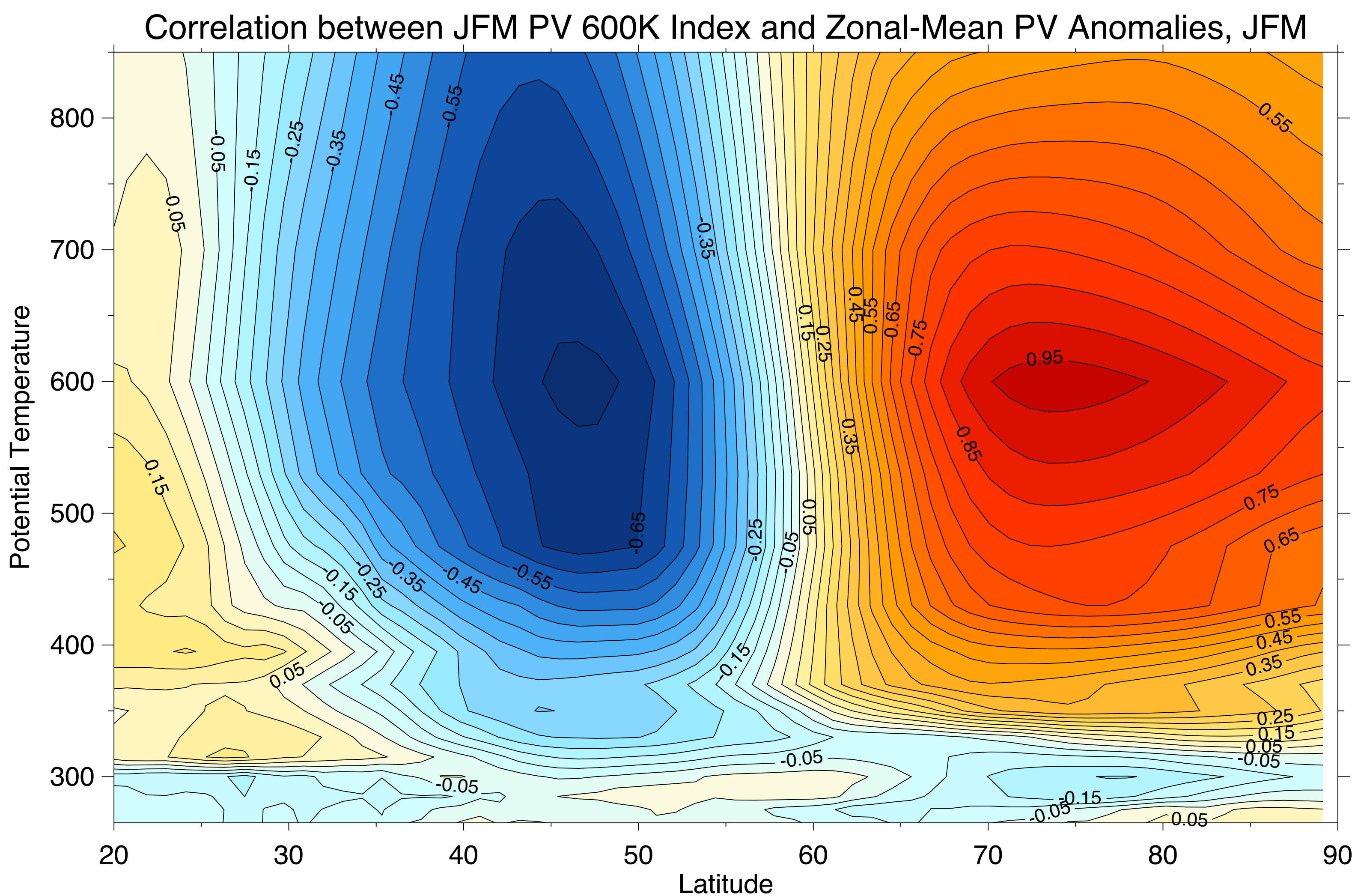


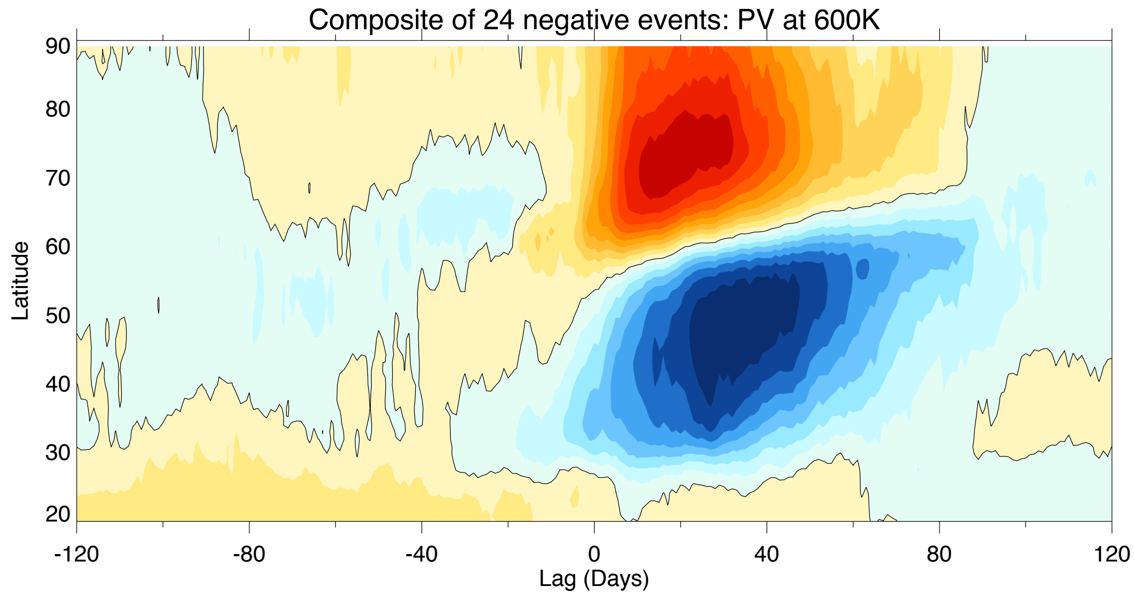

FIG. 4. Schematic of the bending of isentropic surfaces (labeled $\theta_0$, $\theta_1$, and $\theta_2$) toward a positive potential vorticity anomaly. The arrows represent winds associated with the potential vorticity anomaly, becoming weaker away from the anomaly.

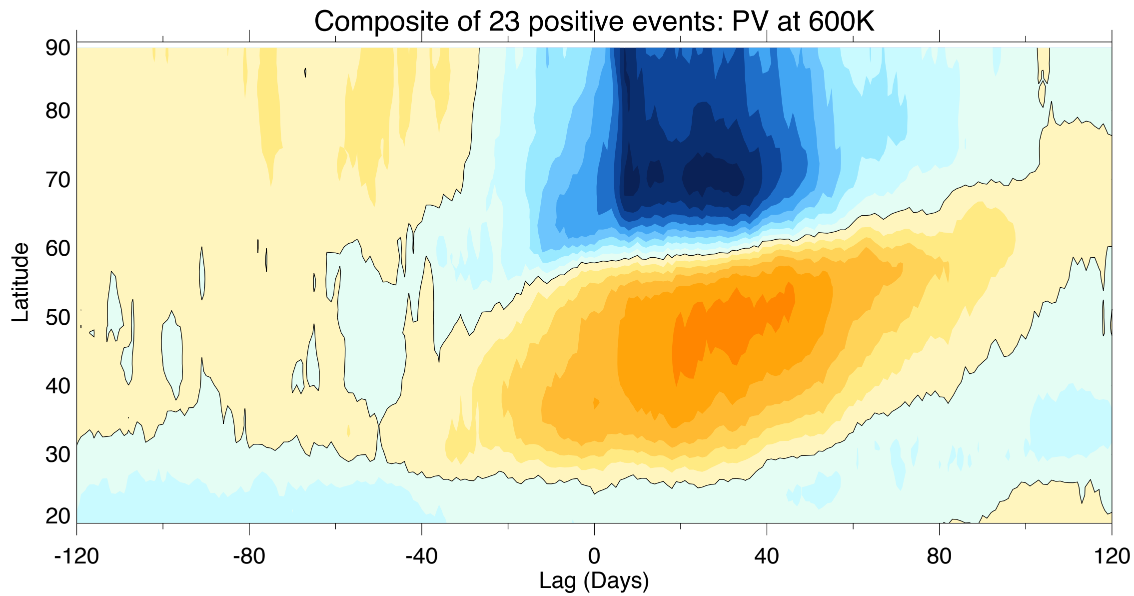
Diagram from Ambaum and Hoskins *J Climate* (2002).

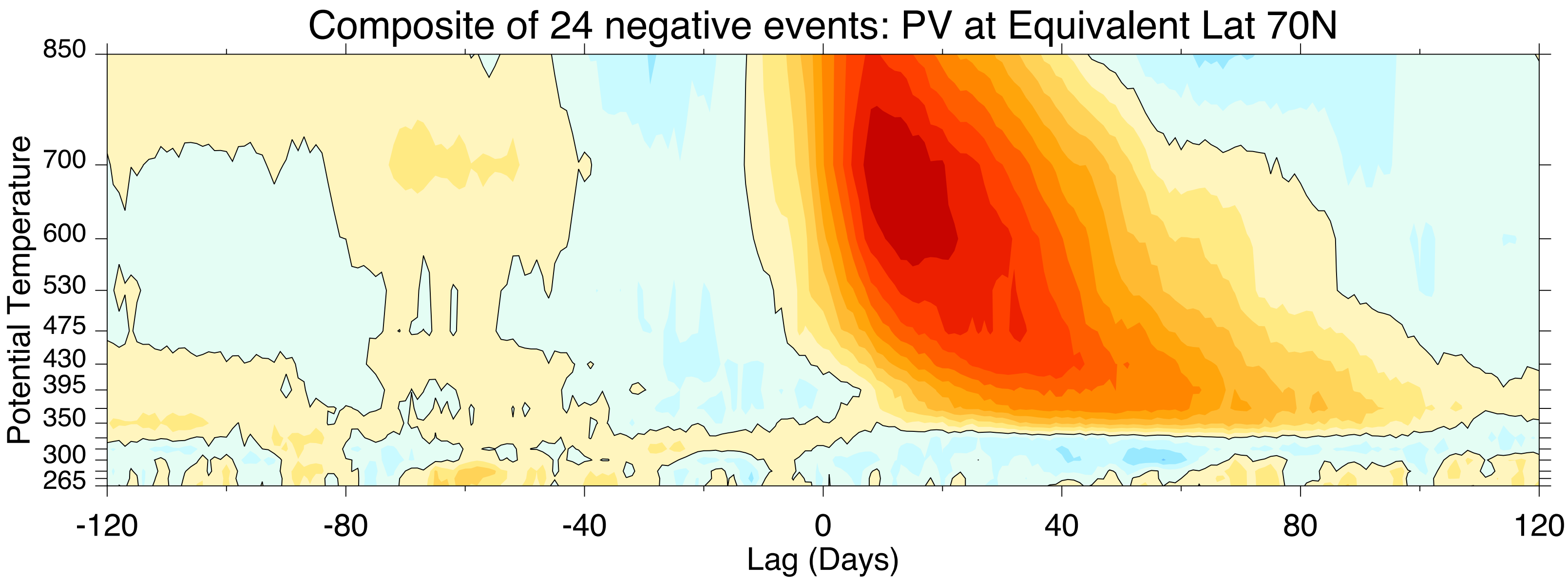
## Polar cap "PV600K Index" ~20-25 hPa

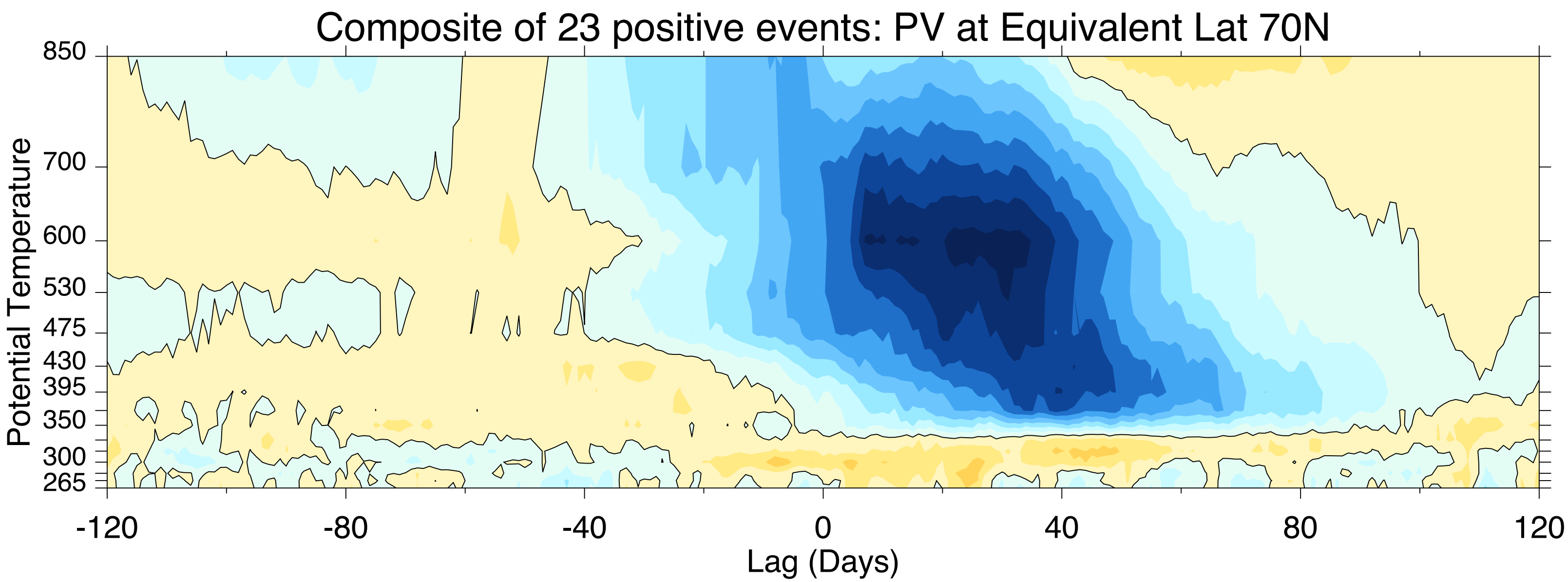



**Create an index of vortex strength as defined by PV at 600K (20-25 hPa).**

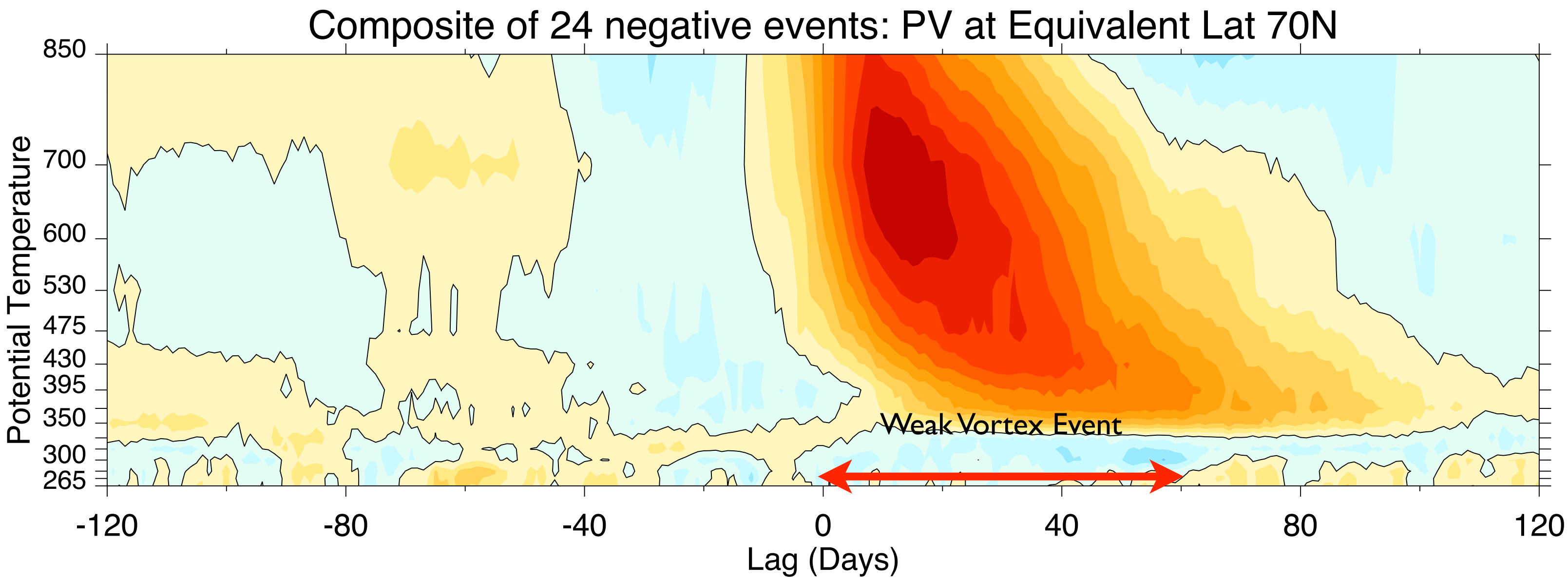

Composite of 24 negative events: PV at 600K
Latitude
90
80
70
60
50
40
30
20
-120
-80
-40
0
40
80
120
Lag (Days)

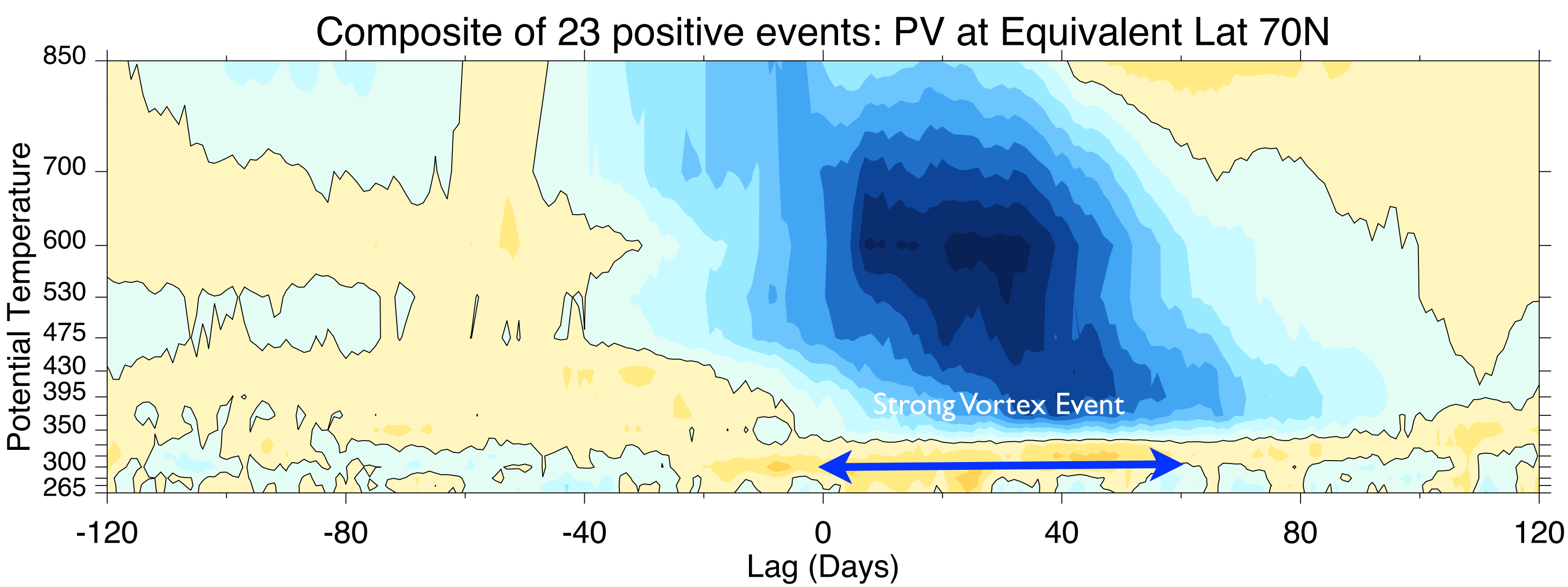

Composite of 23 positive events: PV at 600K
Latitude
90
80
70
60
50
40
30
20
-120
-80
-40
0
40
80
120
Lag (Days)




From Baldwin and Birner, in prep.

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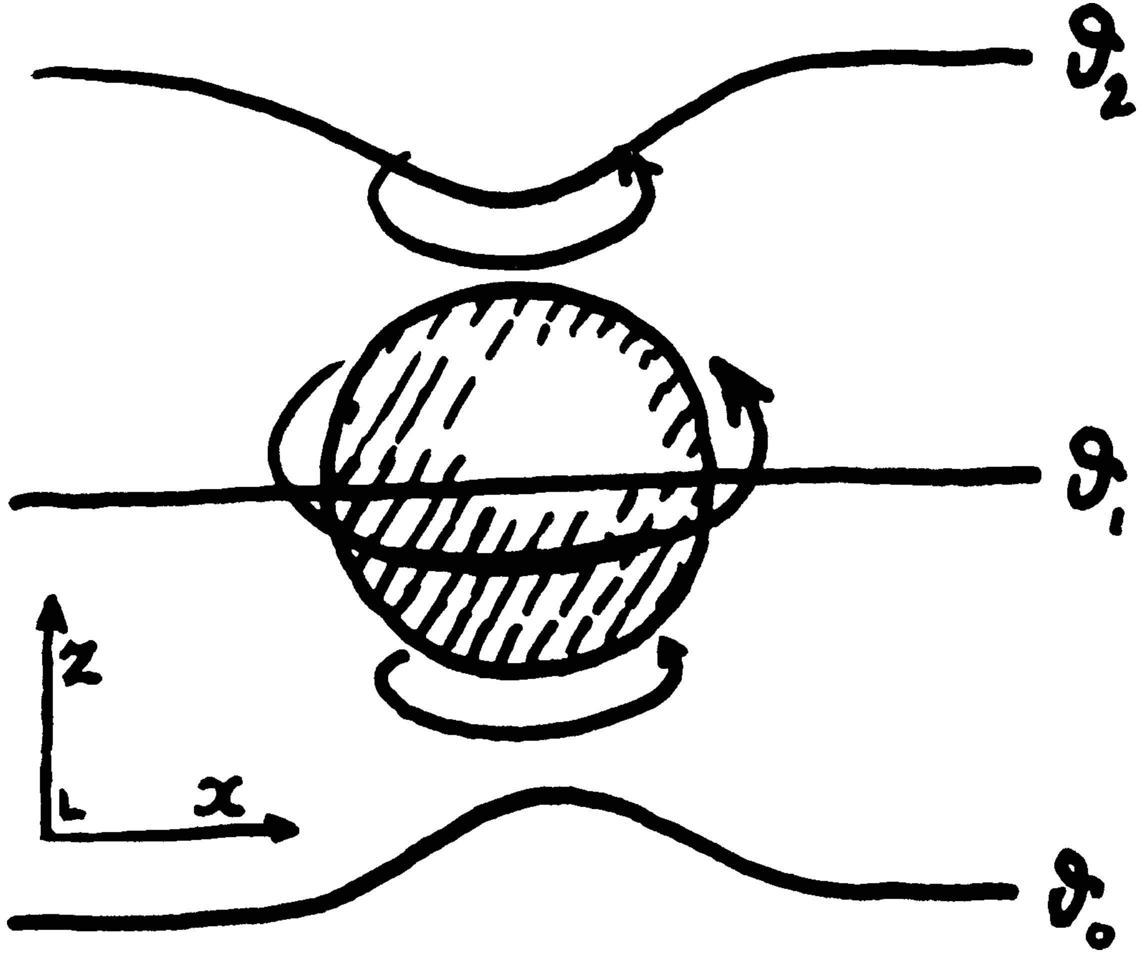


FIG. 4. Schematic of the bending of isentropic surfaces (labeled $\theta_0$, $\theta_1$, and $\theta_2$) toward a positive potential vorticity anomaly. The arrows represent winds associated with the potential vorticity anomaly, becoming weaker away from the anomaly.

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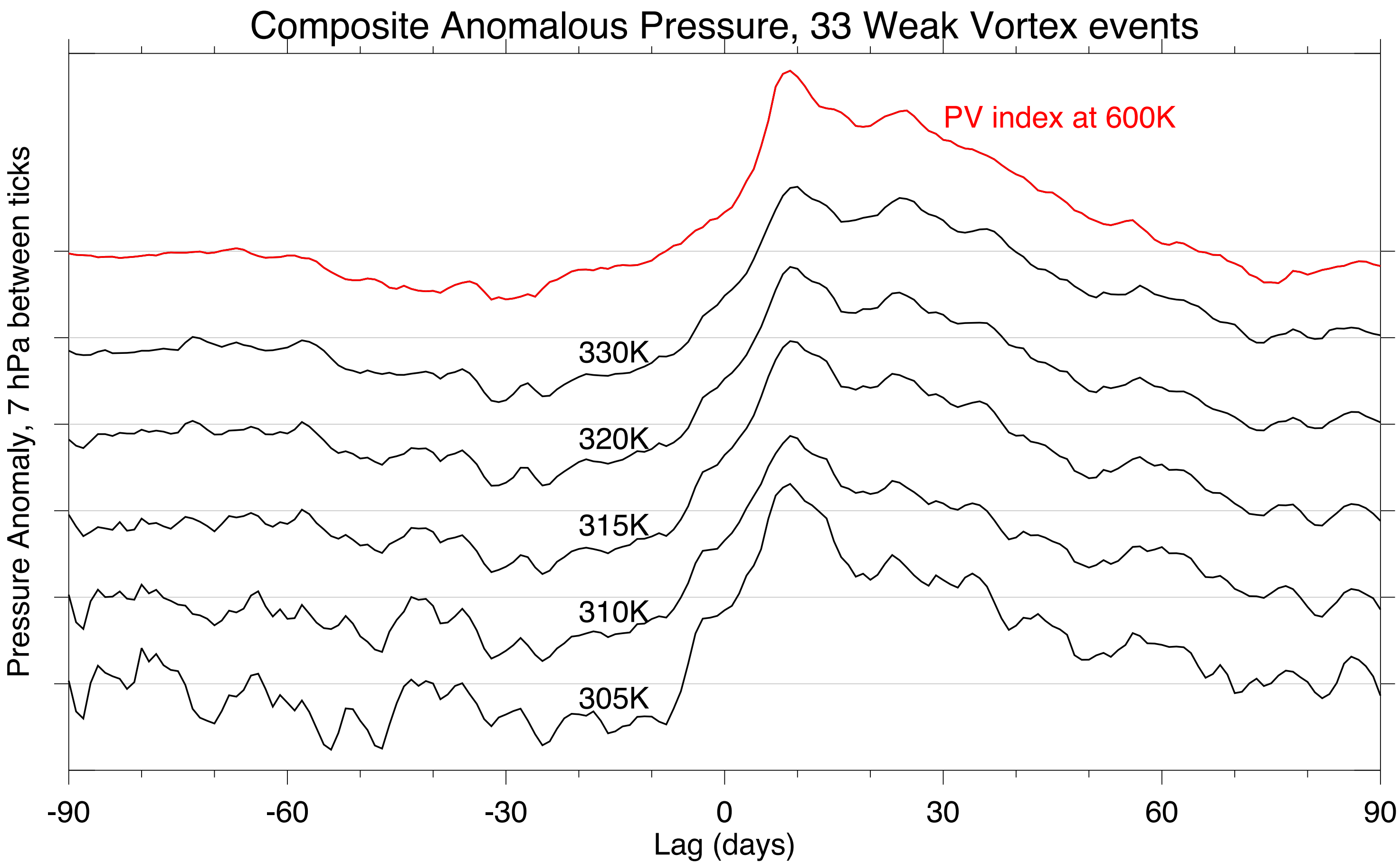
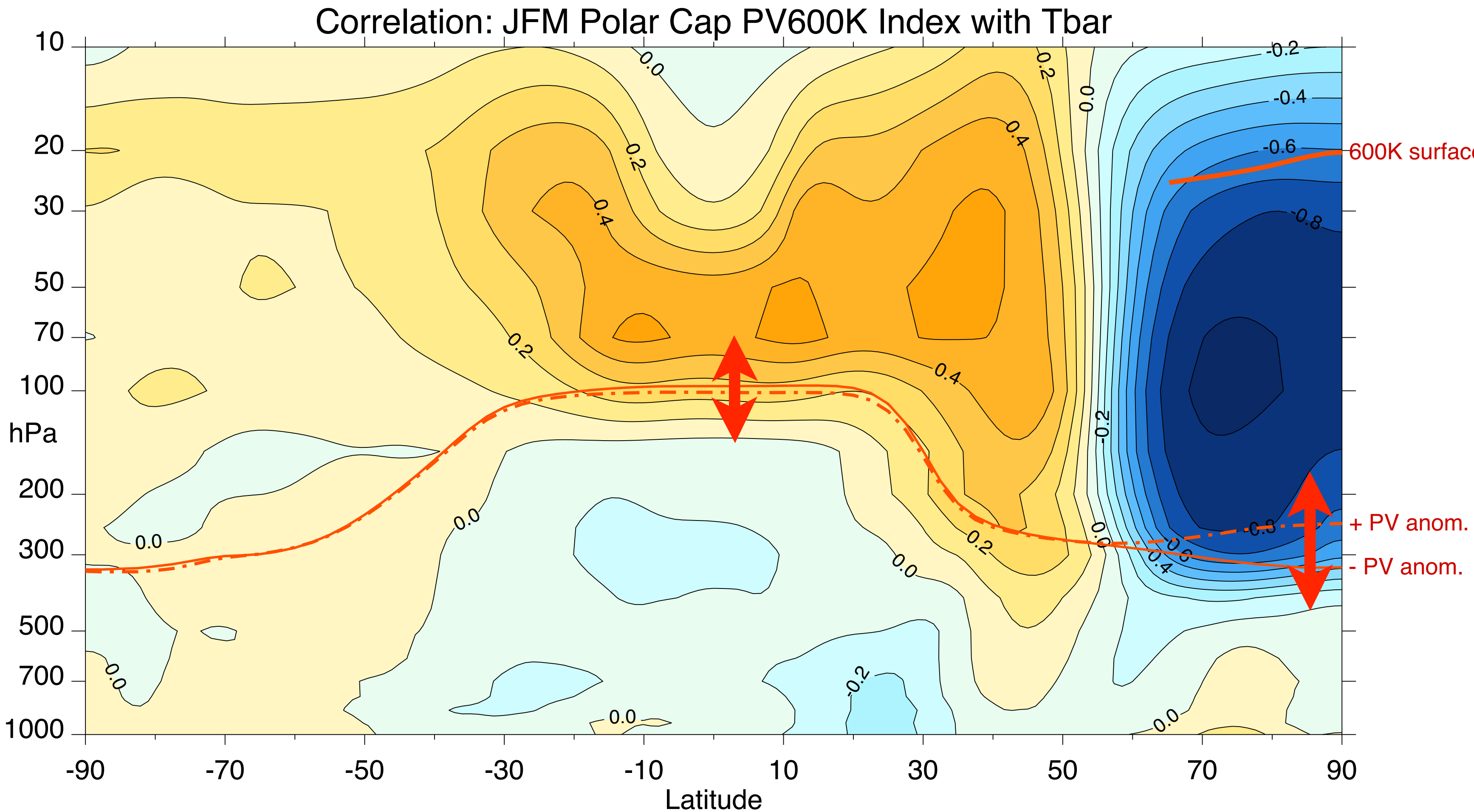


Composite Anomalous Pressure, 33 Weak Vortex events
PV index at 600K
330K
320K
315K
310K
305K
Pressure Anomaly, 7 hPa between ticks
-90
-60
-30
0
30
60
90
Lag (days)




Correlation during winter (JFM) between the 600K PV index and zonal-mean temperature. The JFM daily correlation between PV530 and polar cap tropopause T anomalies is 0.90.

From Baldwin and Birner, *in prep.*

# Effects on baroclinic eddies

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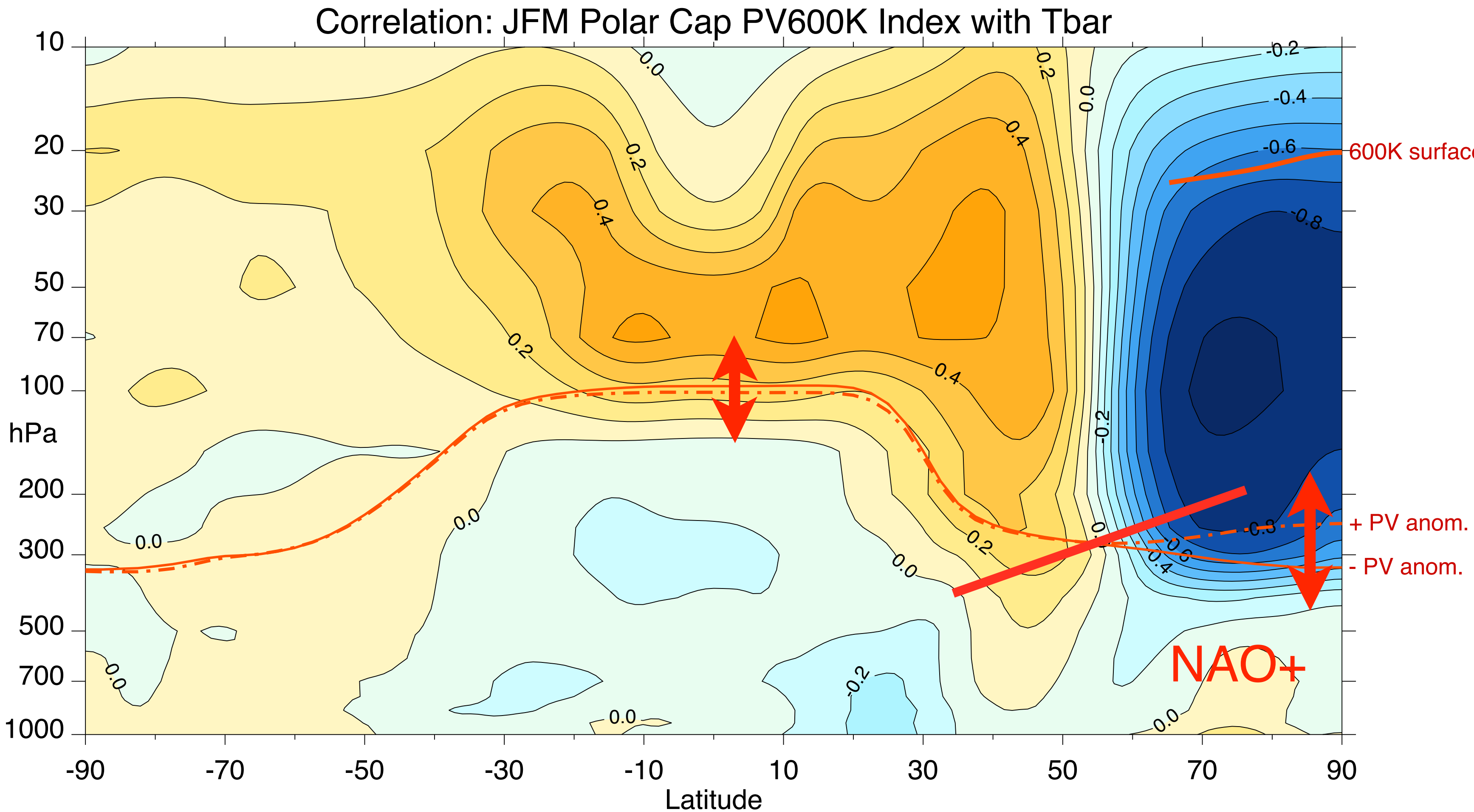


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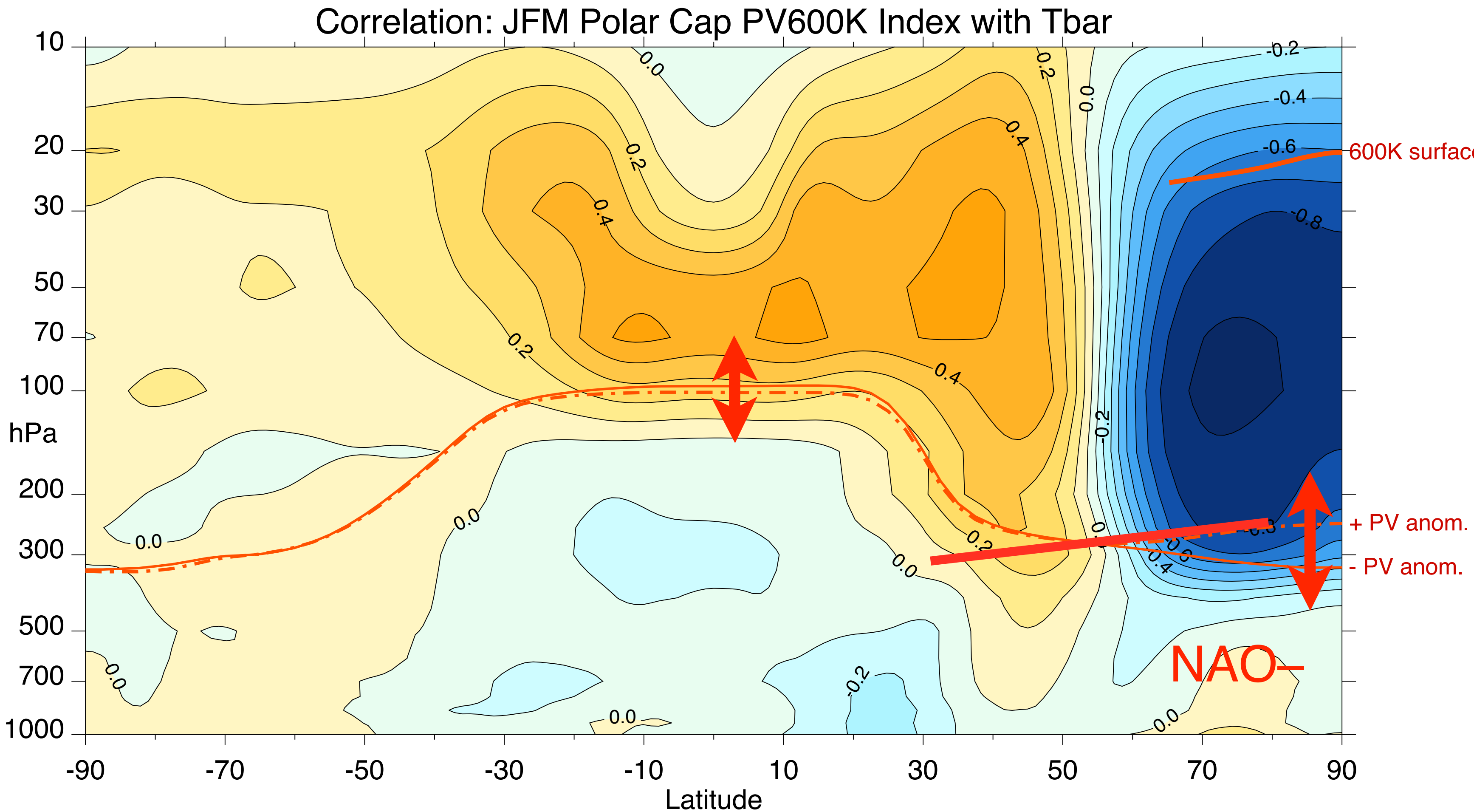


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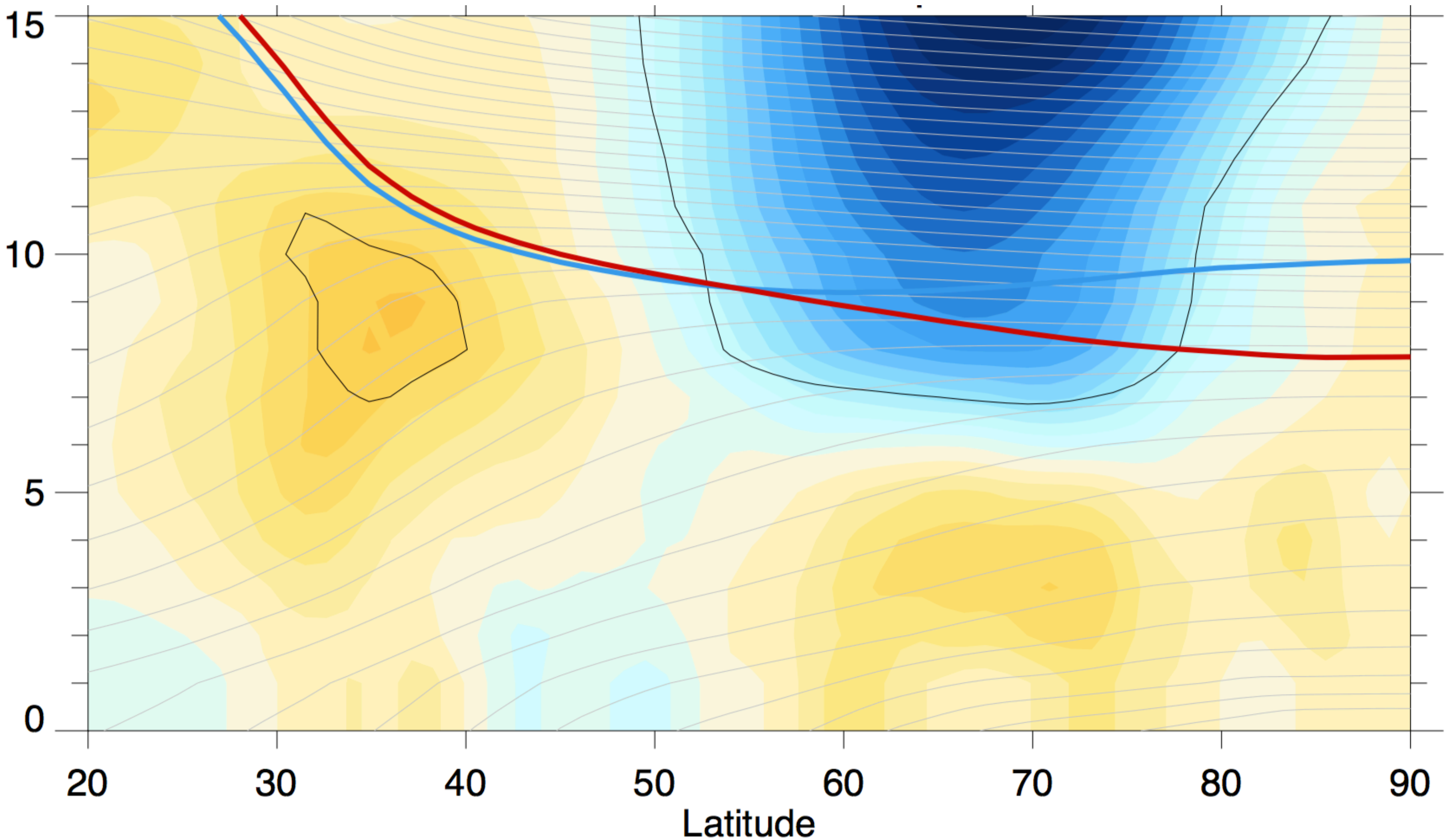
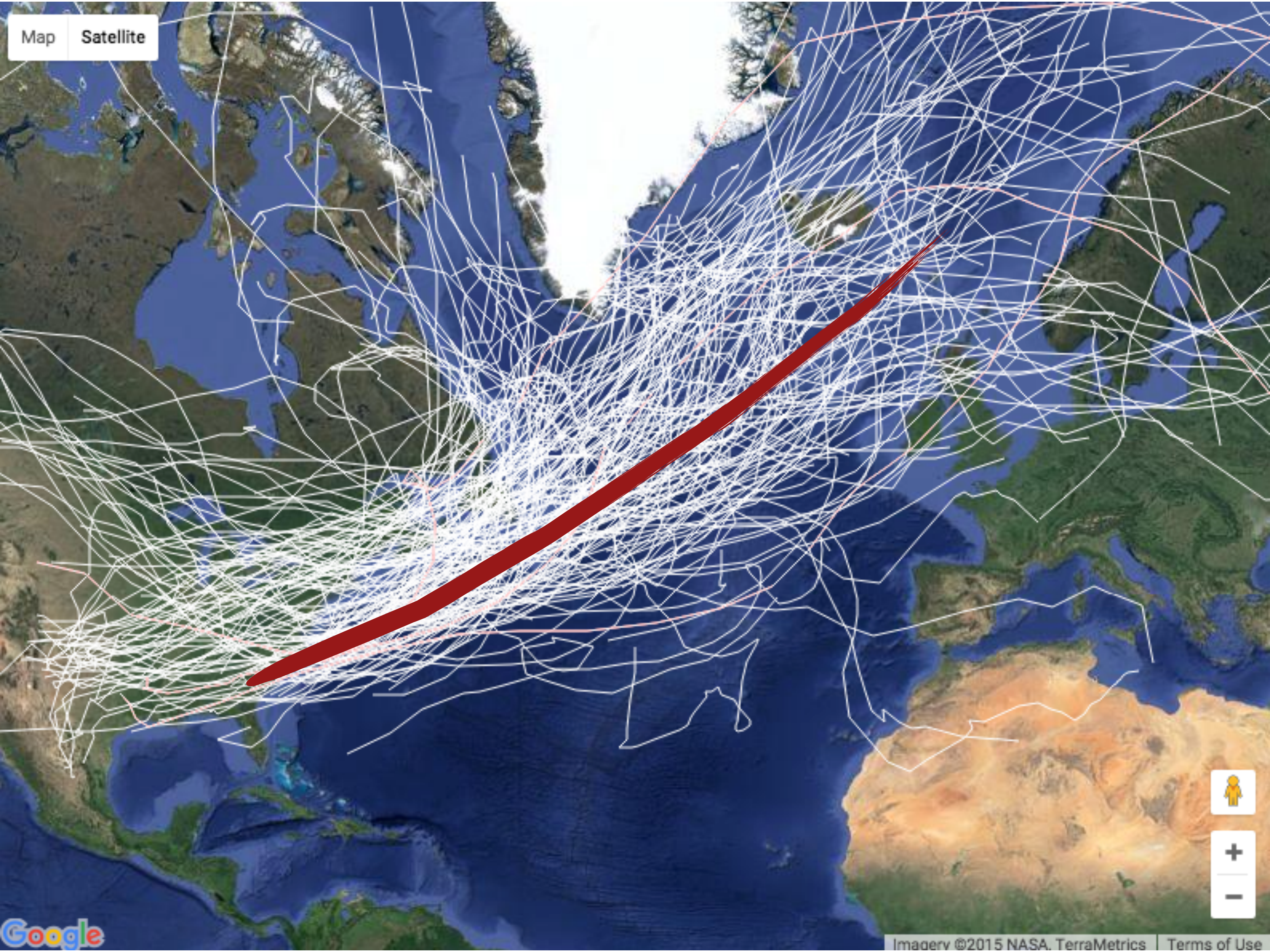
# Anomalous Baroclinicity (slope of isentropic surfaces)

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Satellite
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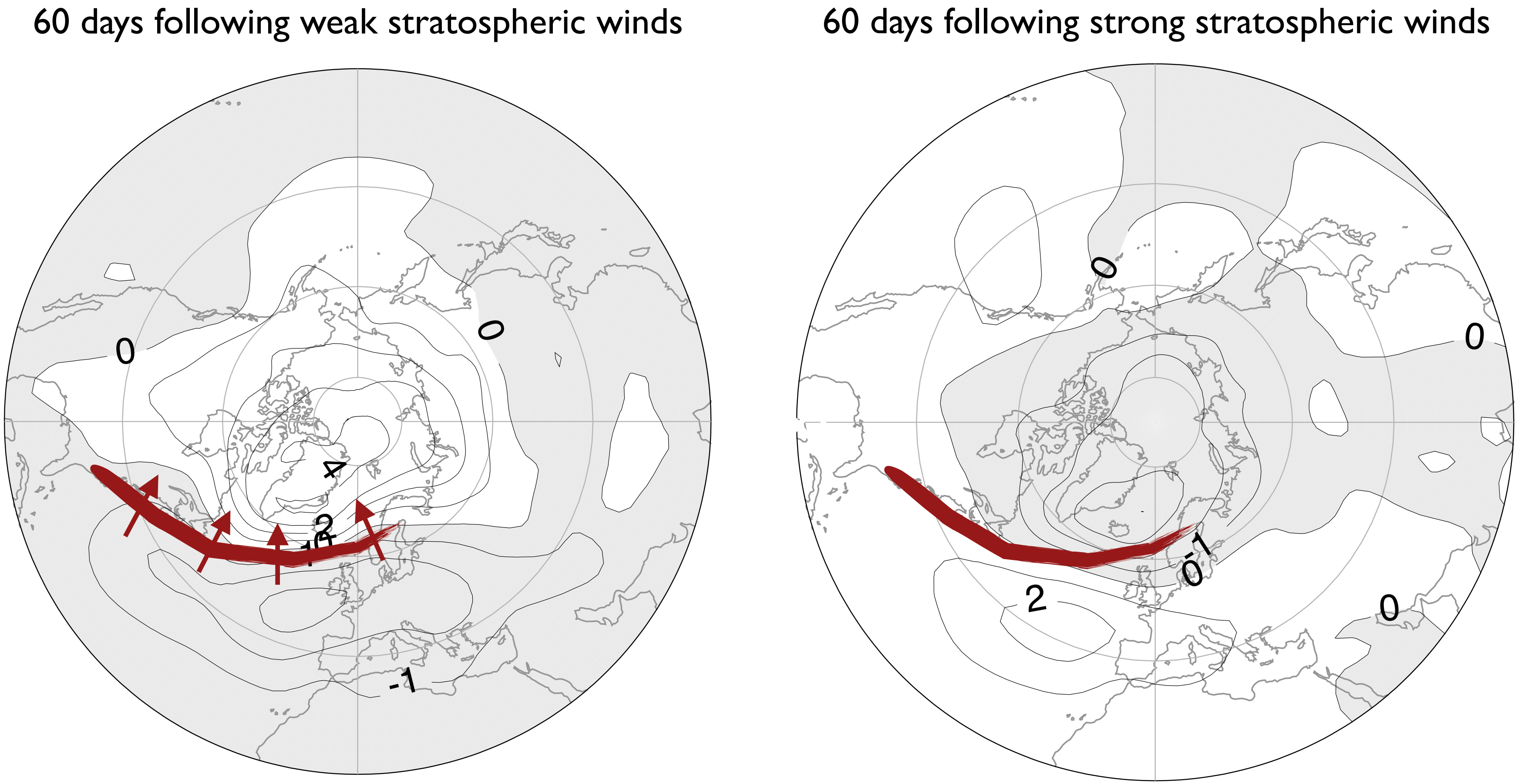


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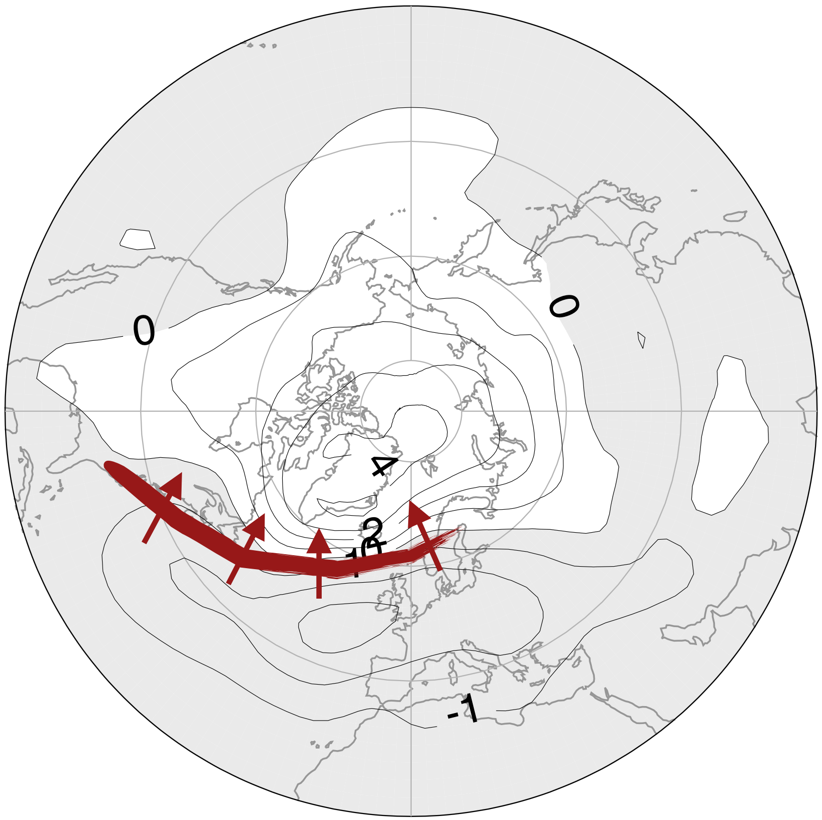


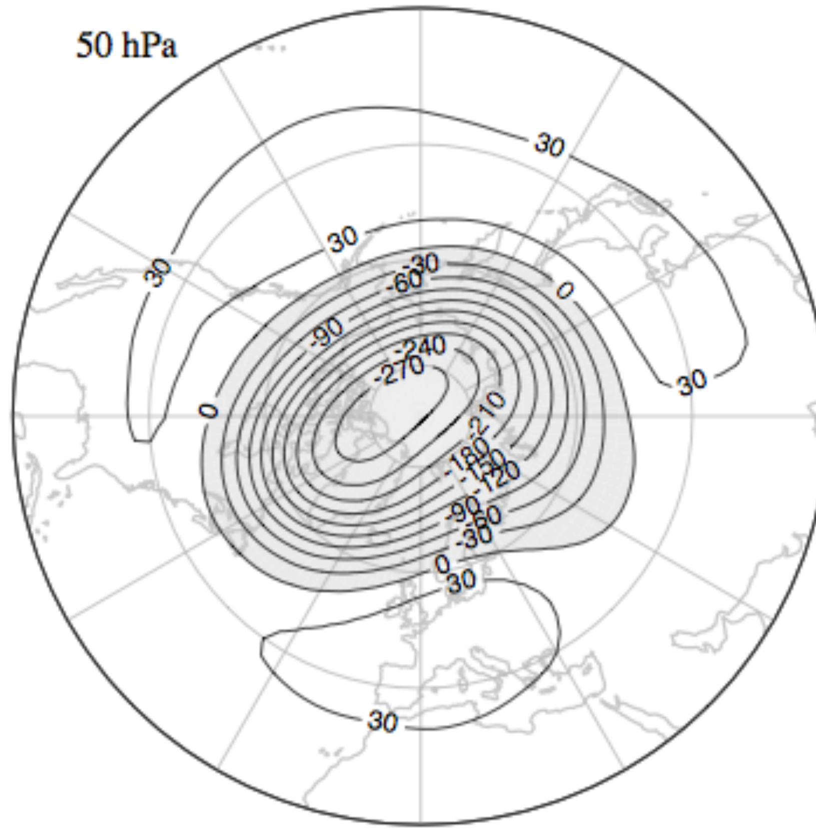


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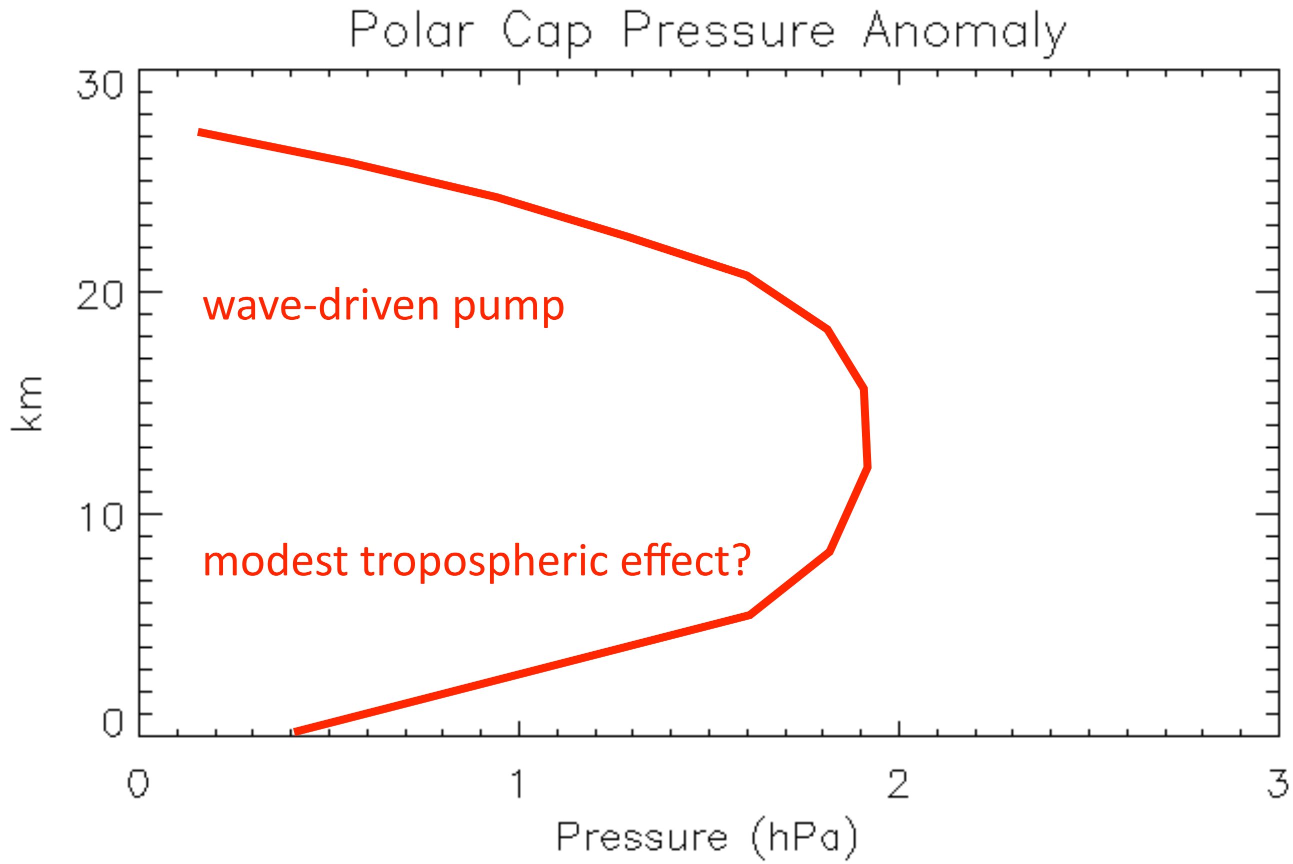
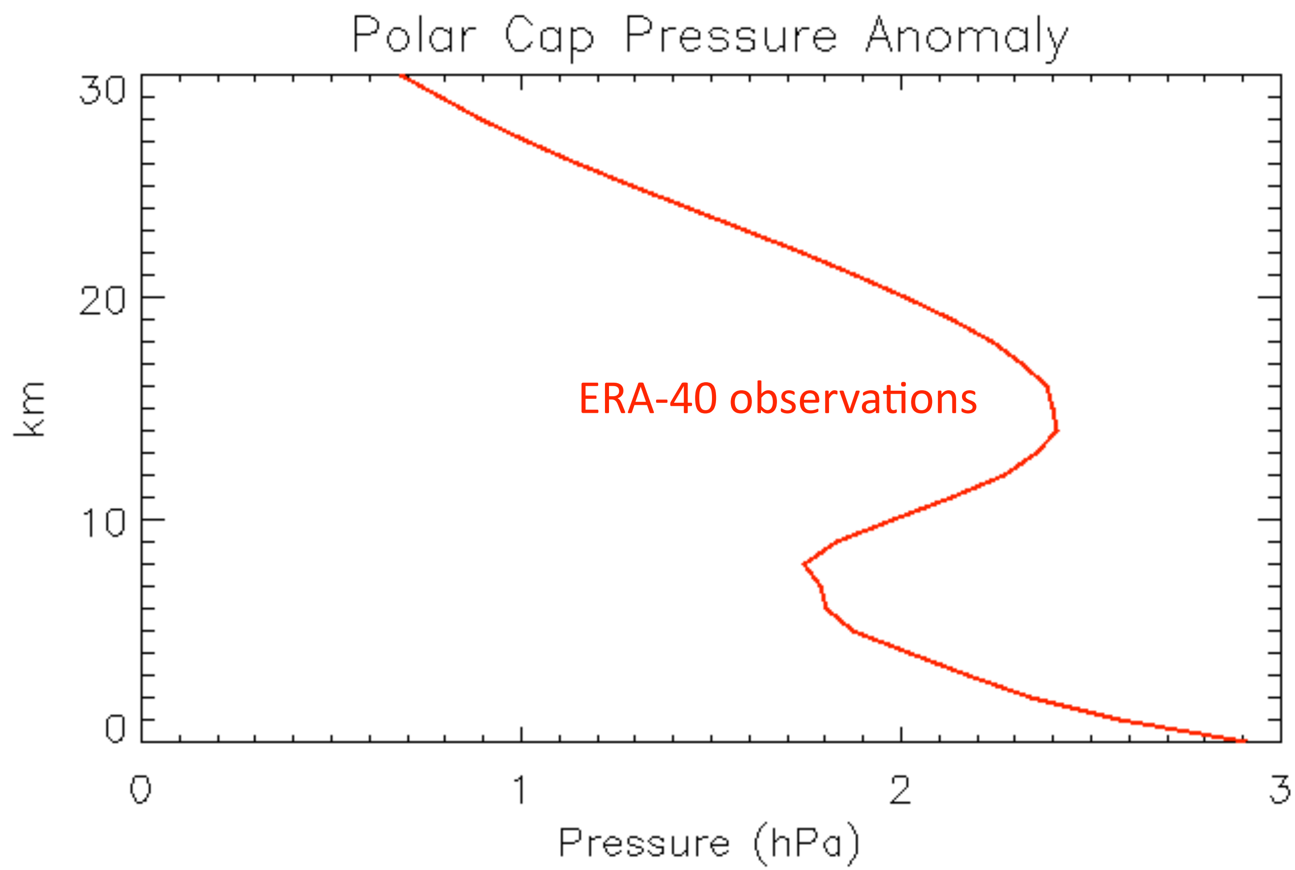
# Movement of mass by the wave-driven pump



# Diagnostic for observations or models

Regression between PV600K index and Polar Cap p’



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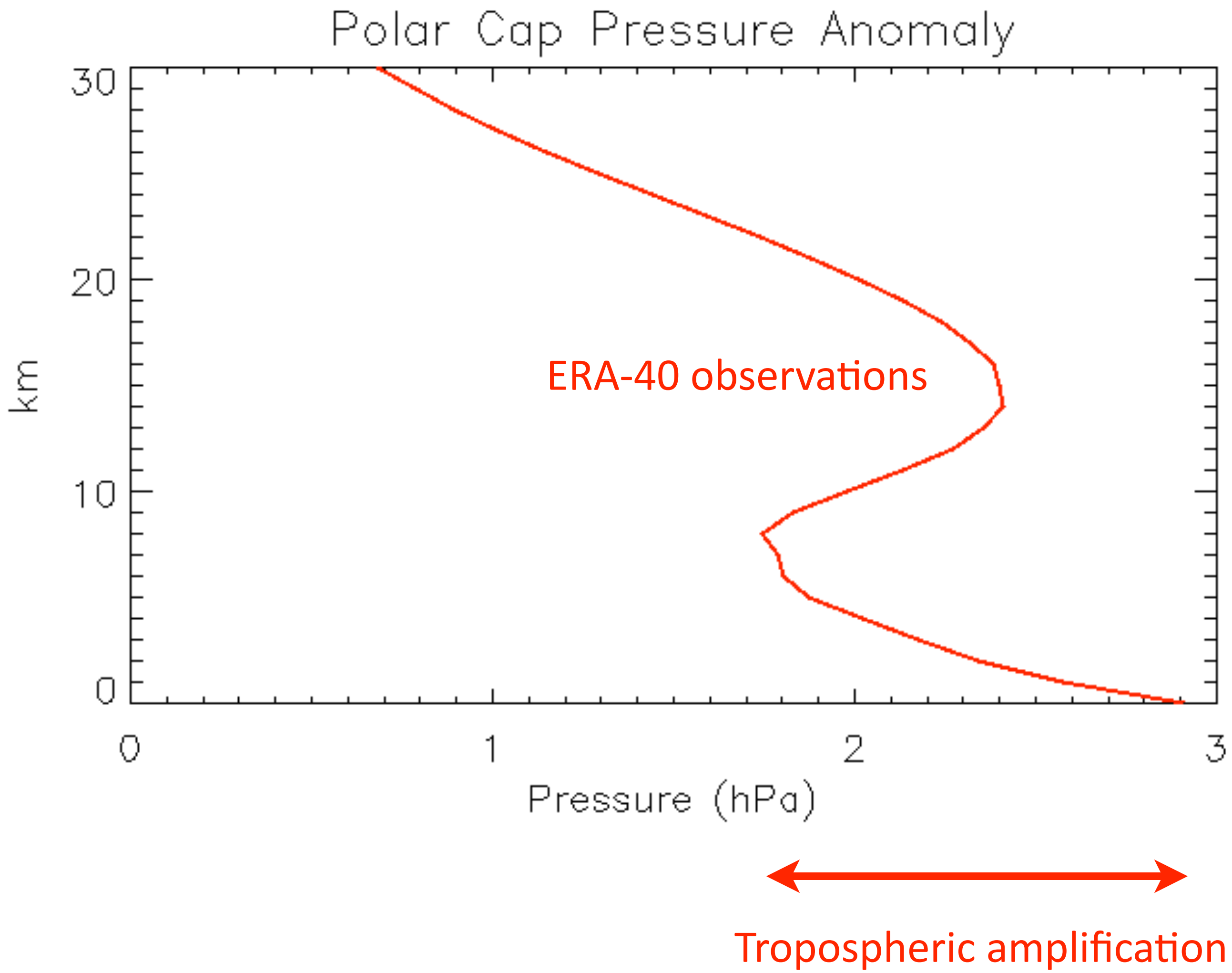

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