Stratospheric impact on seasonal prediction

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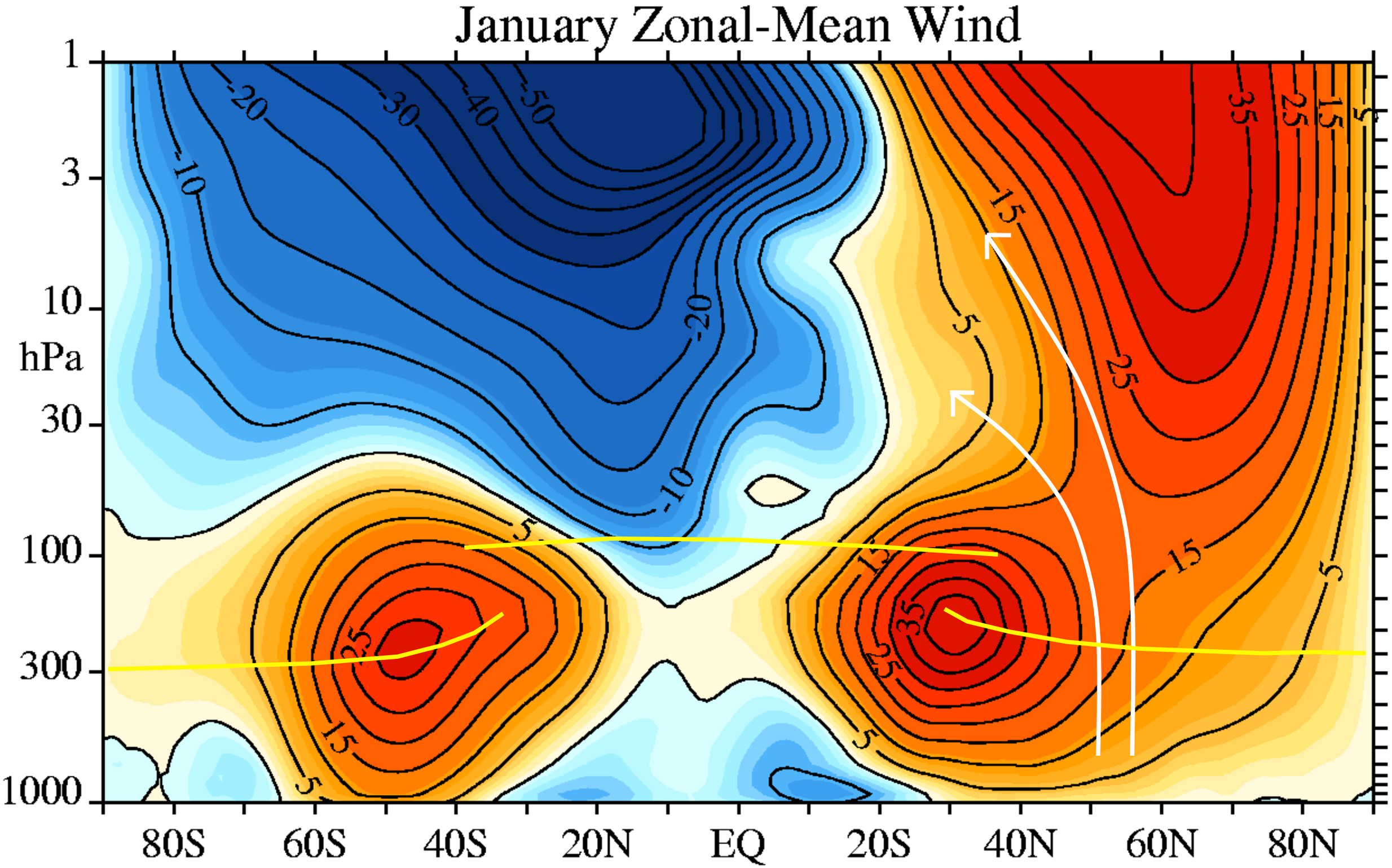
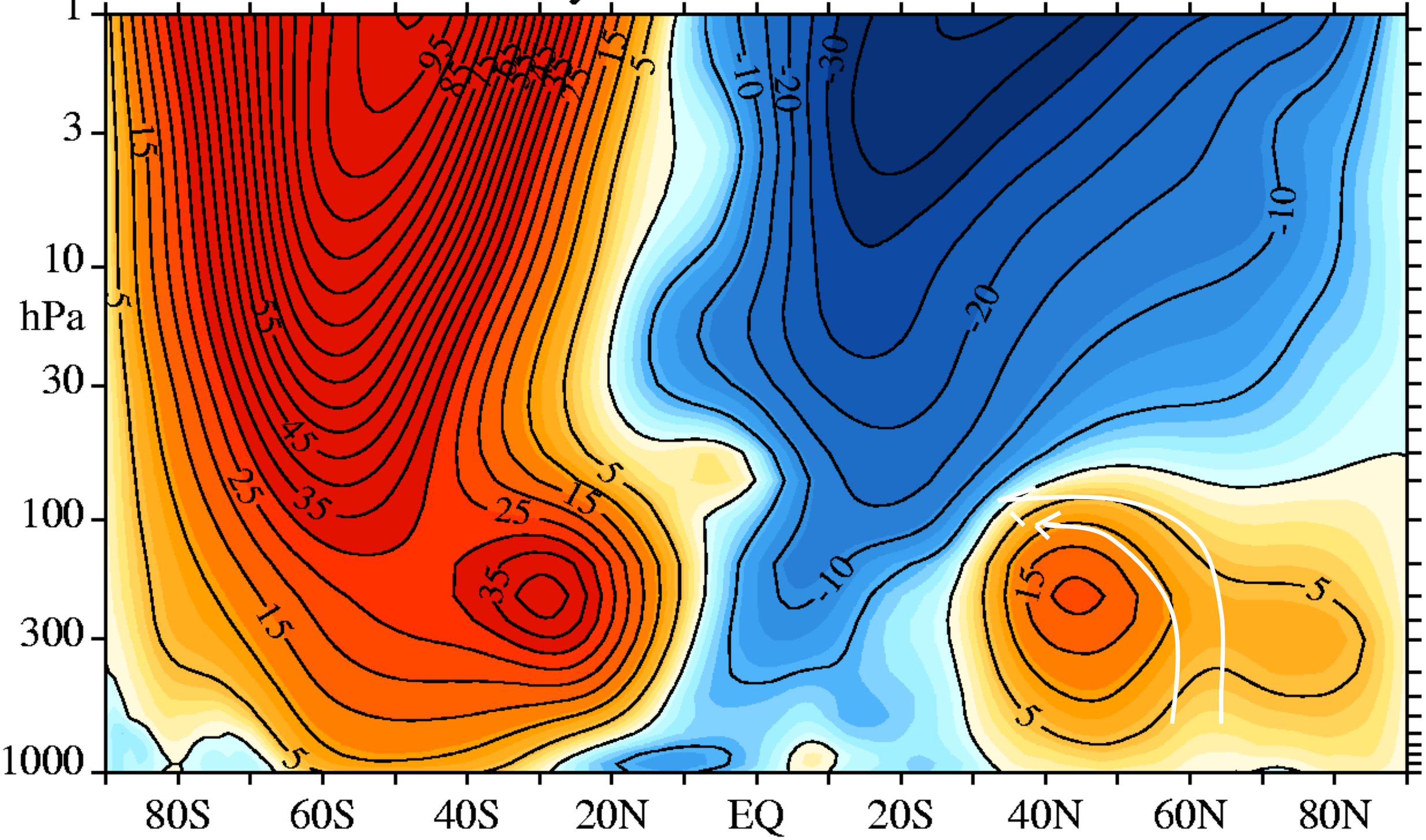
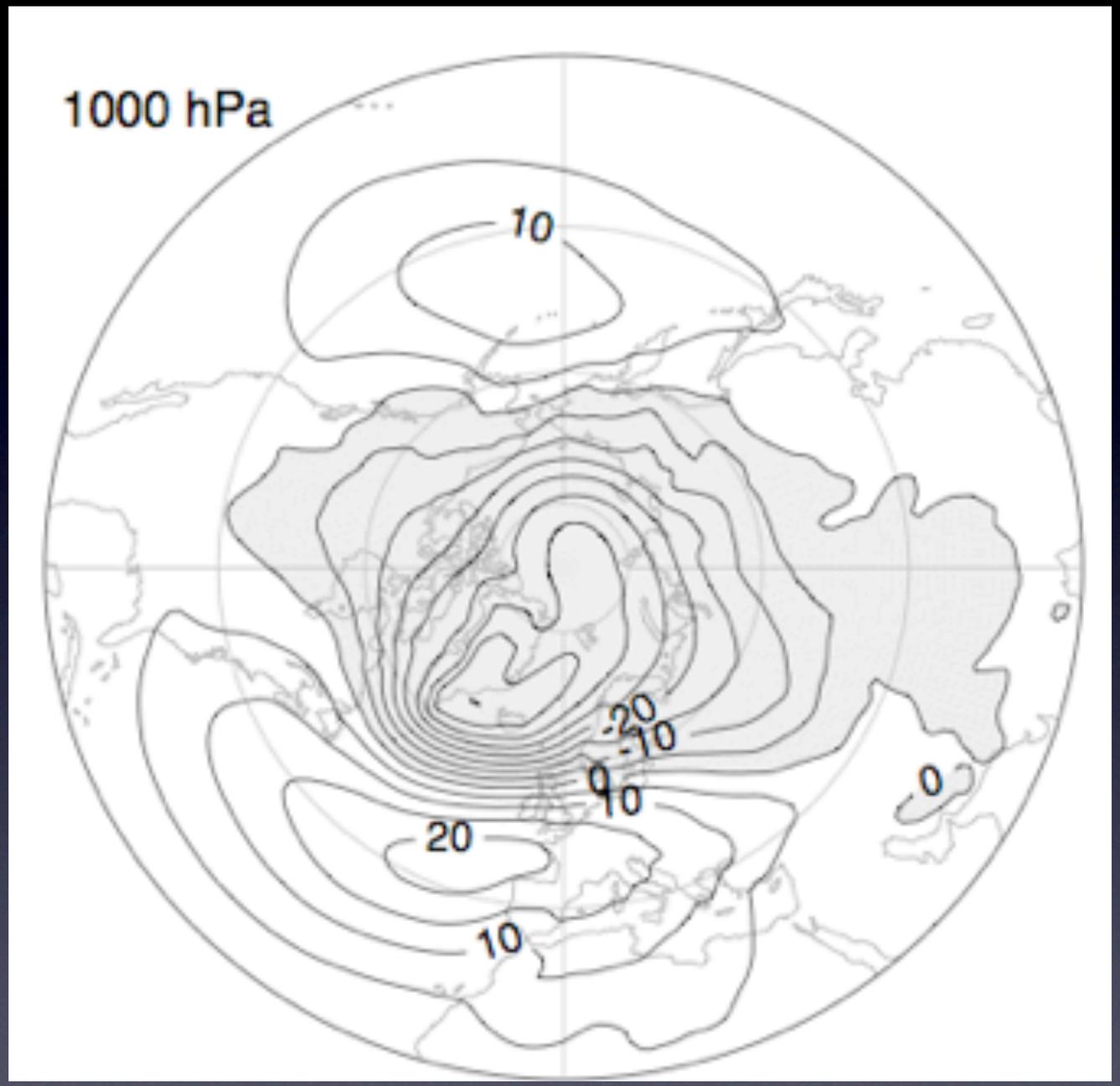

January Zonal-Mean Wind
1
3
10
hPa
30
100
300
1000
80S
60S
40S
20N
EQ
20S
40N
60N
80N
-20
-30
-40
-50
-10
-20
-10
5
25
15
5
35
25
15
5
15
5
25
15
5
35
25
15
5

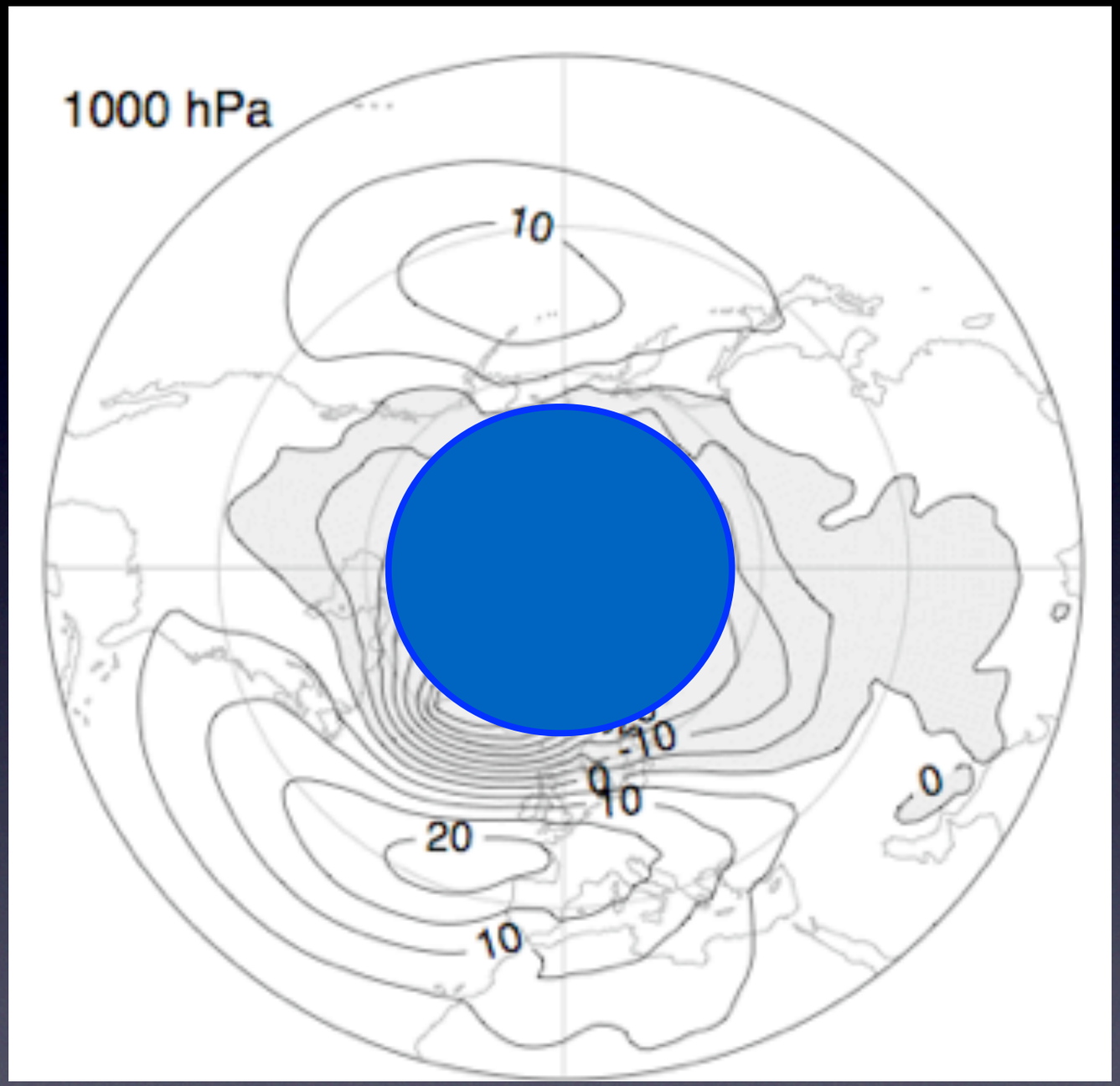
July Zonal-Mean Wind



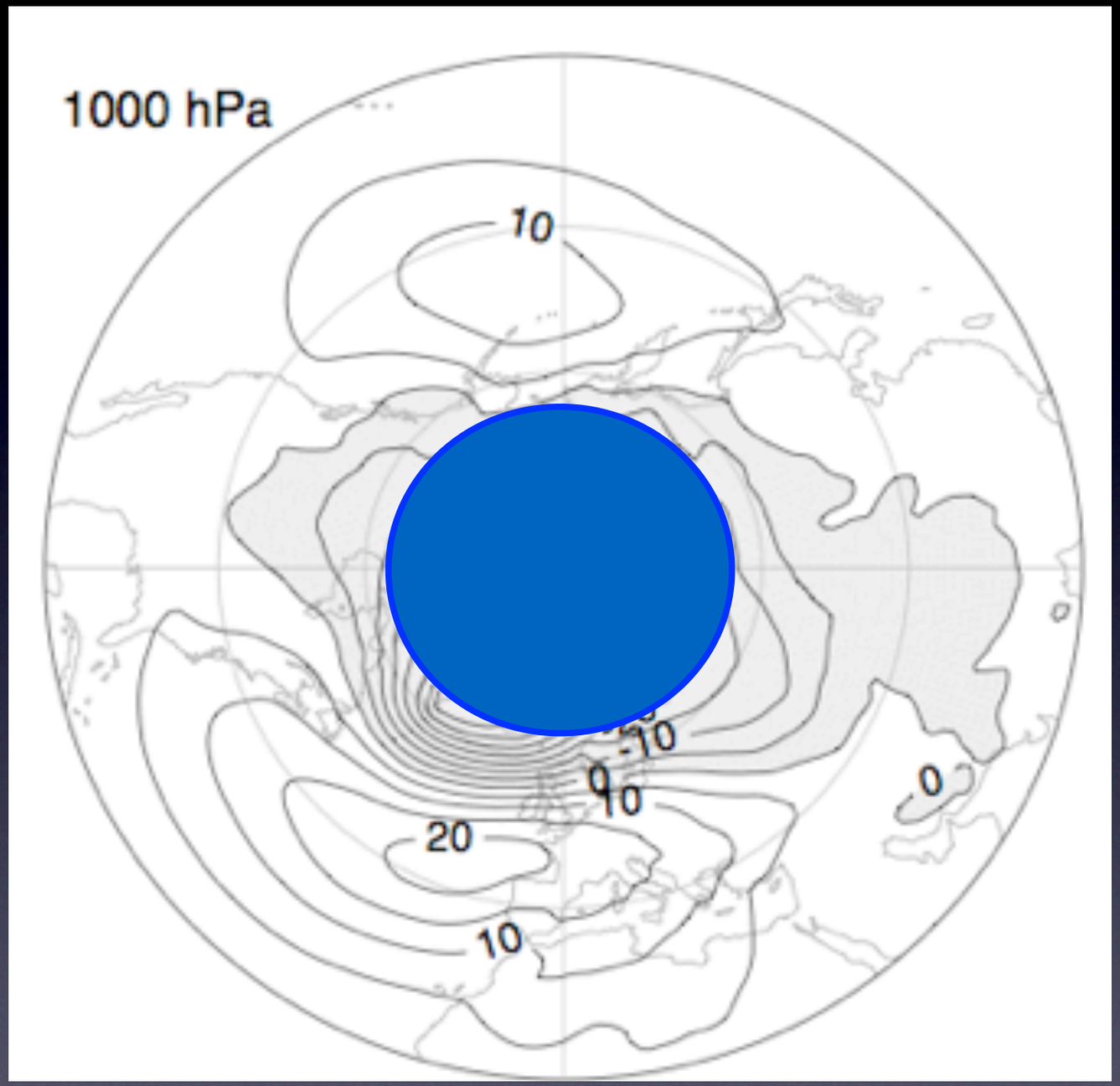
Northern Annular Mode



Northern Annular Mode

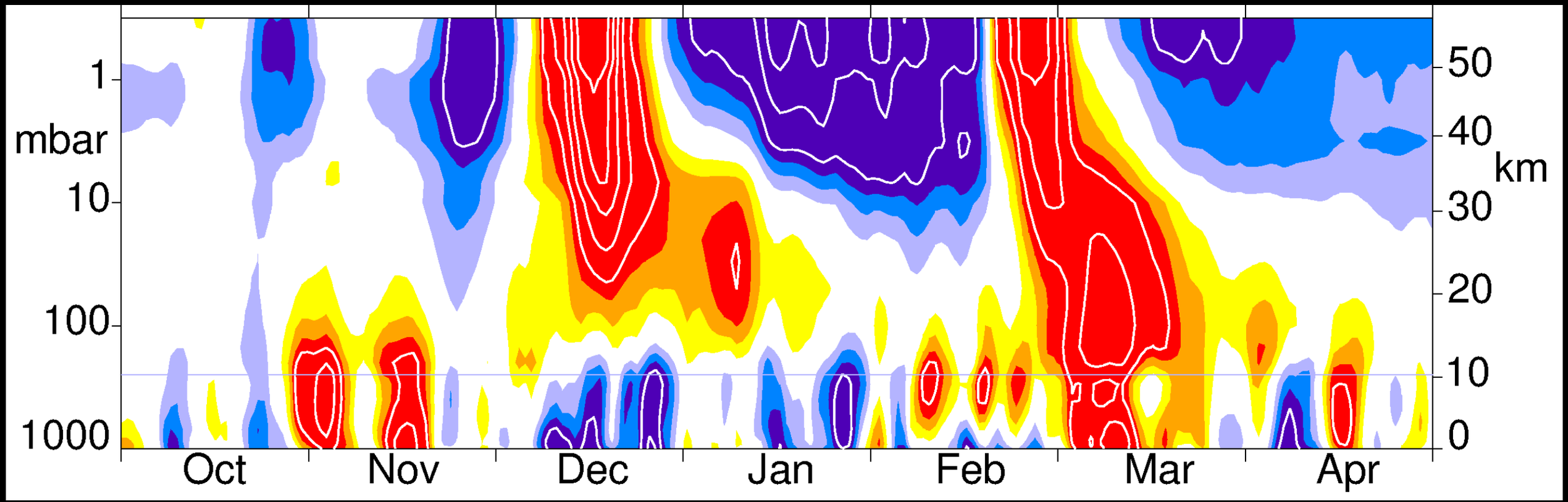


Northern Annular Mode

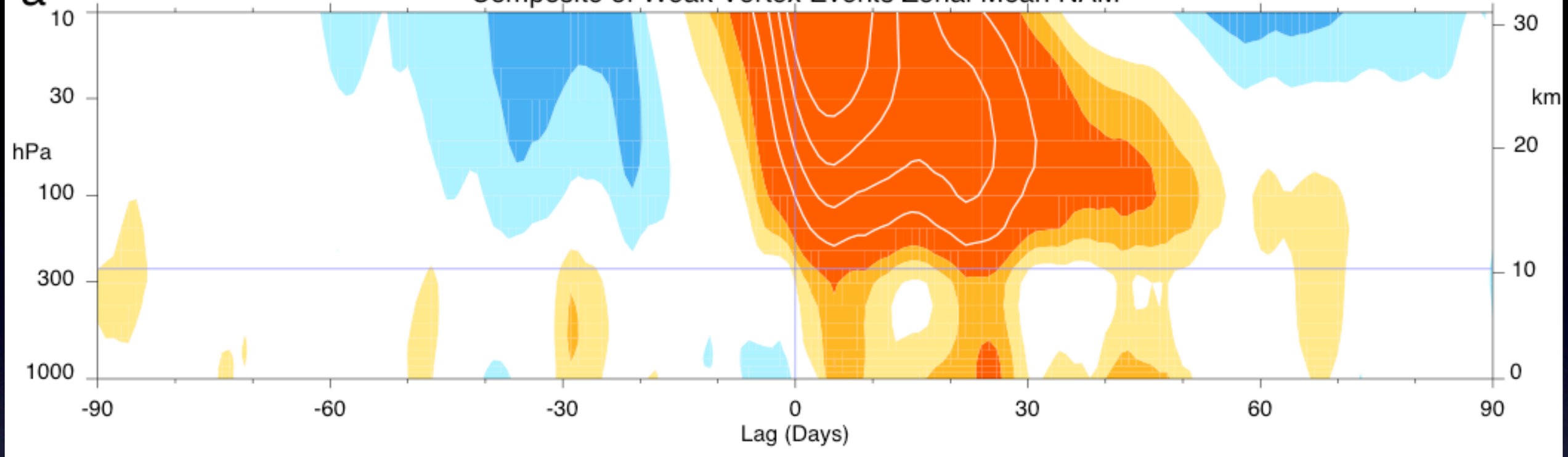


Polar cap average pressure anomaly

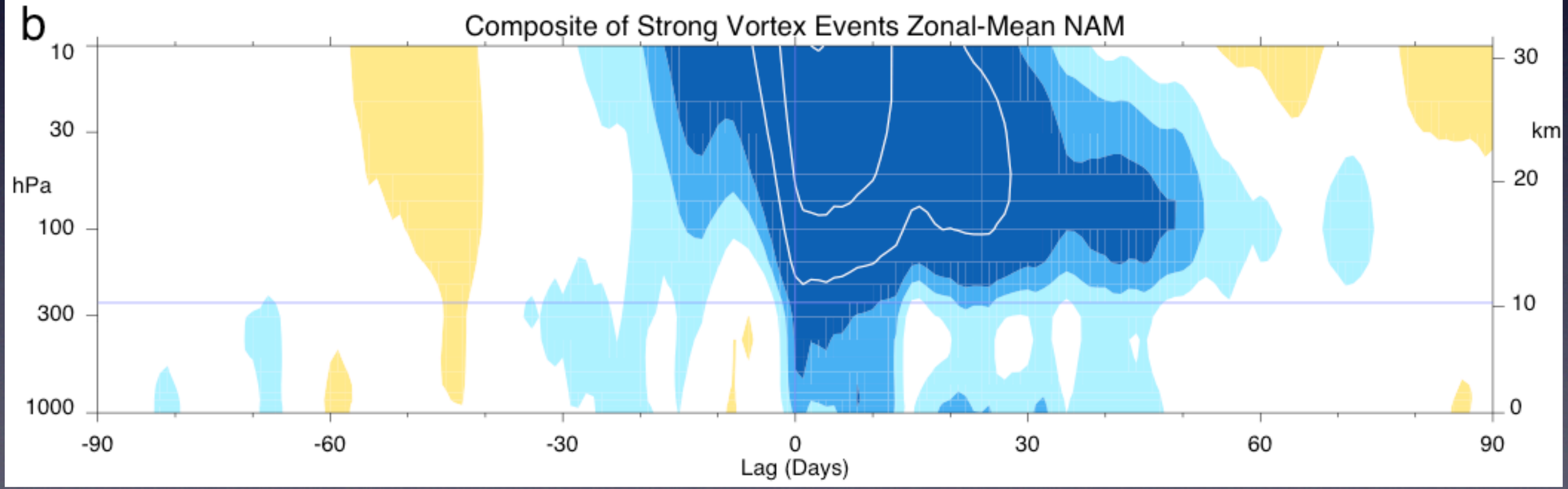
NAM index 1998-1999



a


Composite of Weak Vortex Events Zonal-Mean NAM
10
30
hPa
100
300
1000
30
km
20
10
0
-90
-60
-30
0
30
60
90
Lag (Days)

b


Composite of Strong Vortex Events Zonal-Mean NAM
10
30
hPa
100
300
1000
30
km
20
10
0
-90
-60
-30
0
30
60
90
Lag (Days)

a

Composite of Weak Vortex Events Zonal-Mean NAM

hPa

10
30
100
300
1000

km

30
20
10
0

Weak Vortex Event

-90 -60 -30 0 30 60 90

Lag (Days)

b

Composite of Strong Vortex Events Zonal-Mean NAM

hPa

10
30
100
300
1000

km

30
20
10
0

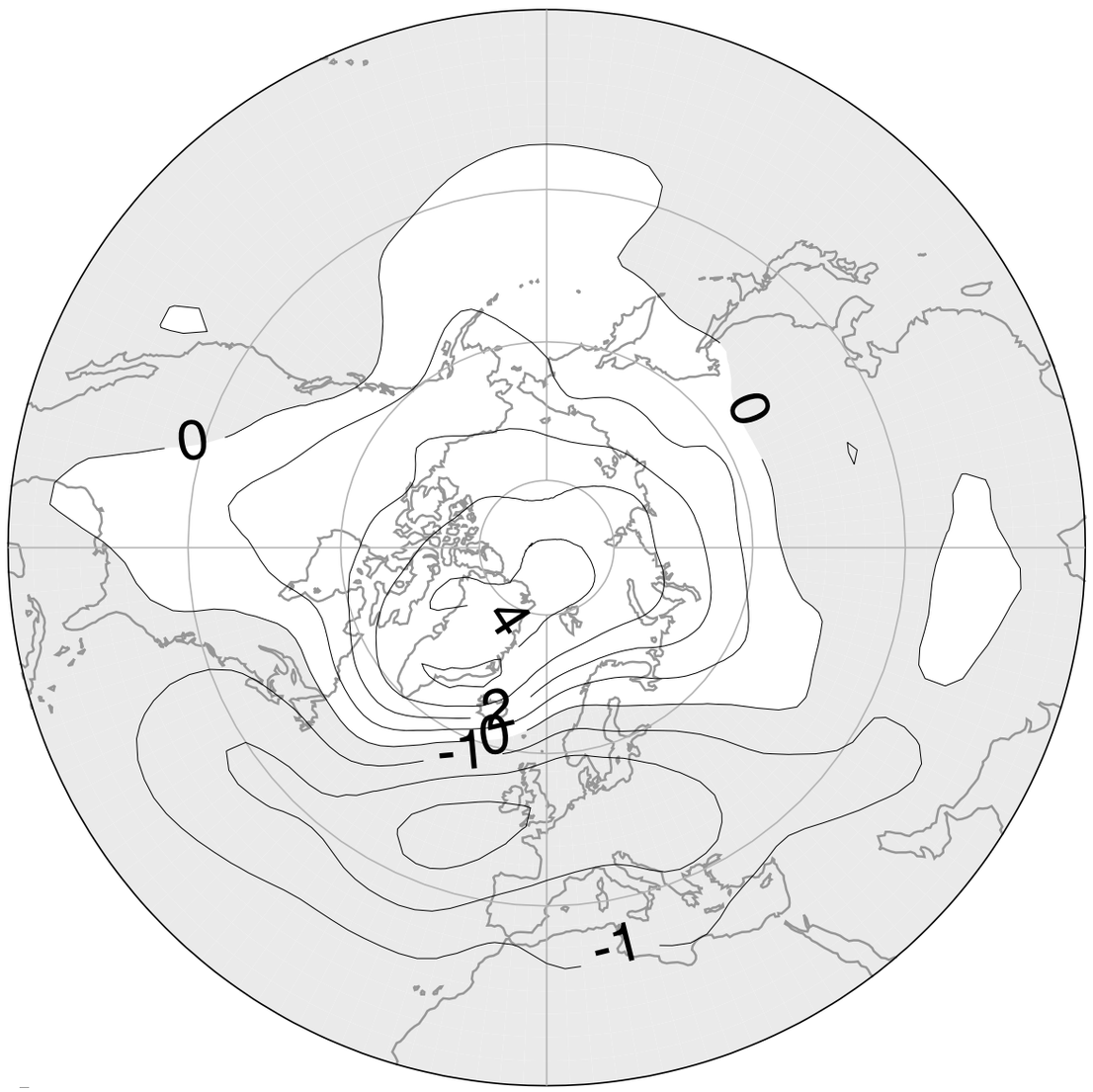
Strong Vortex Event

-90 -60 -30 0 30 60 90

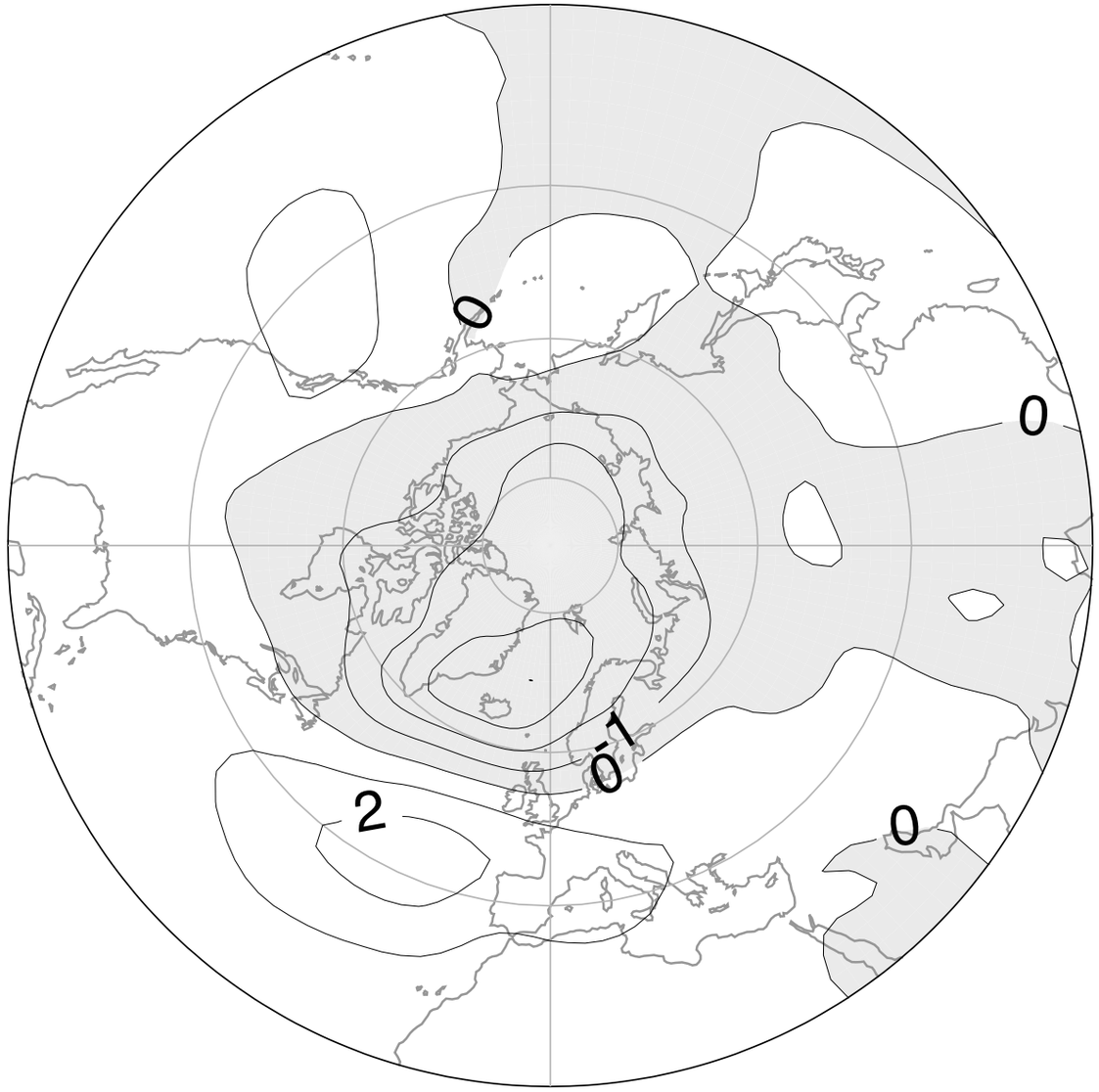
Lag (Days)

Observed Average Surface Pressure Anomalies (hPa)

60 days following sudden warmings



60 days following cold vortex events



PDFs of the AO Index

DJFMA Climatology

Baldwin and Dunkerton, 2001

Weak Vortex
1080 Days

Strong Vortex
1800 Days

60 days following
sudden warmings

-4 -3 -2 -1 0 1 2 3 4

Standard Deviations

Weather Extremes Related to Stratospheric Variability

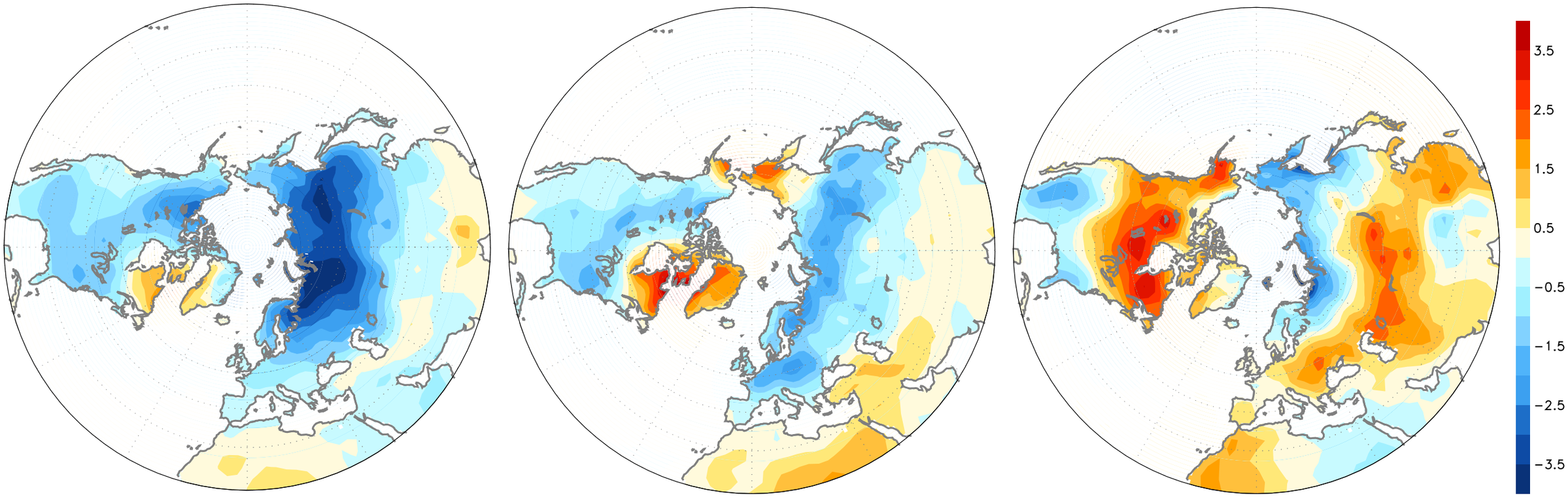
- Severe cold weather at high latitudes is more common during weak vortex events.
- Severe cold events are more common when the QBO is easterly.
- Winter weather extremes (low temperatures, snow, etc.) are much more common during -NAM.
- Atlantic blocking occurs almost exclusively during -NAM.
- Strong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

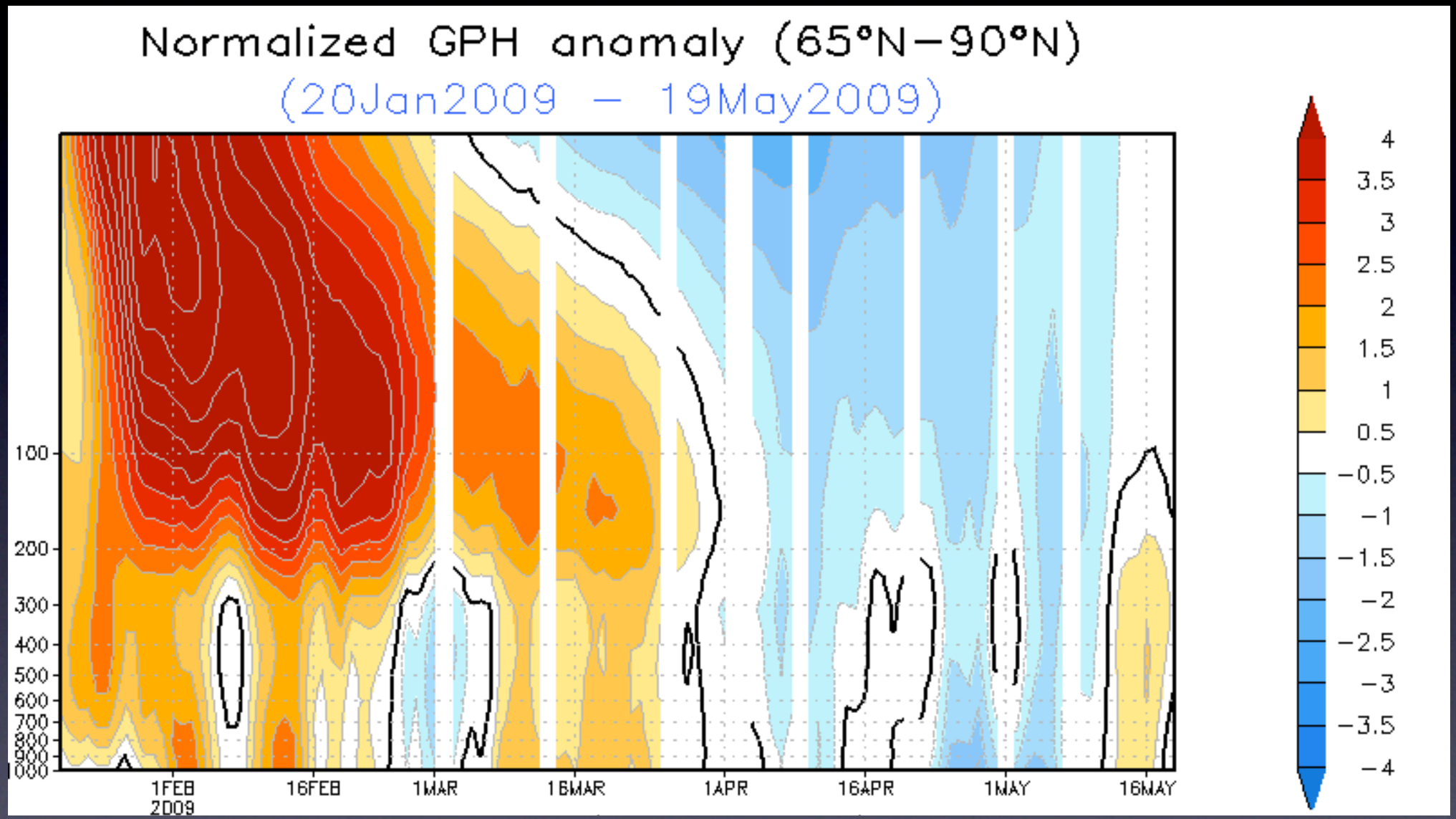
Tropospheric changes

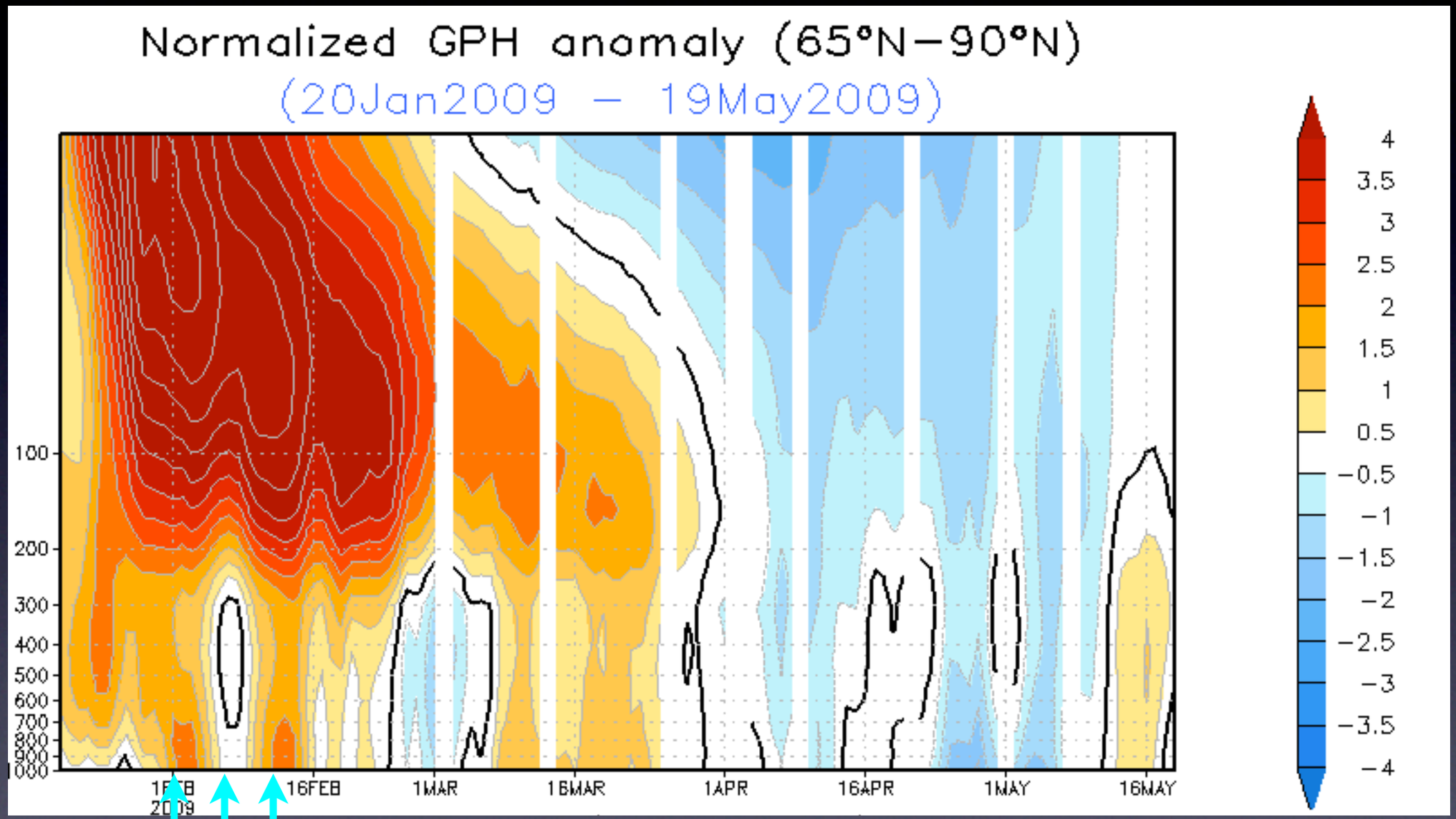
Days 1-60 following stratospheric anomalies

QBO easterly-westerly

ENSO (warm-cold)

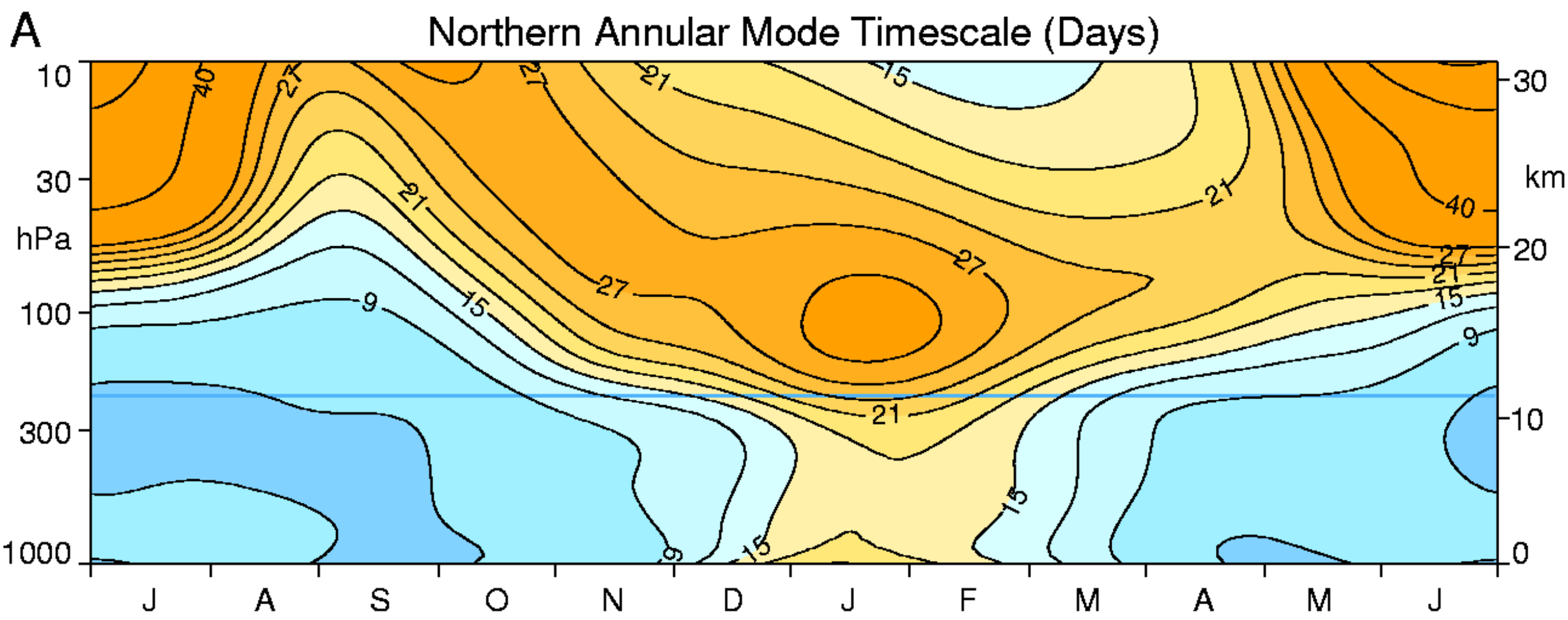


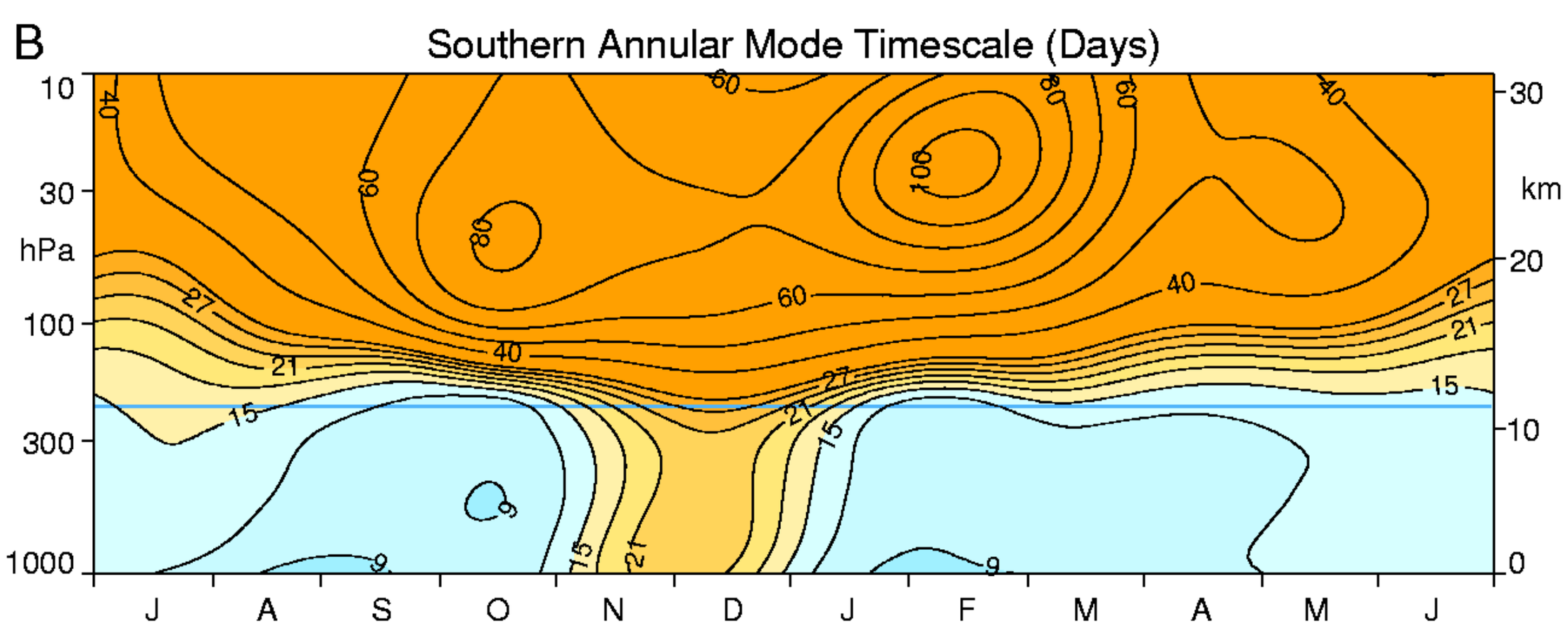

Normalized GPH anomaly (65°N–90°N)
(20Jan2009 – 19May2009)
100
200
300
400
500
600
700
800
900
000
1FEB
2009
16FEB
1MAR
16MAR
1APR
16APR
1MAY
16MAY
4
3.5
3
2.5
2
1.5
1
0.5
−0.5
−1
−1.5
−2
−2.5
−3
−3.5
−4



British Snow Storms

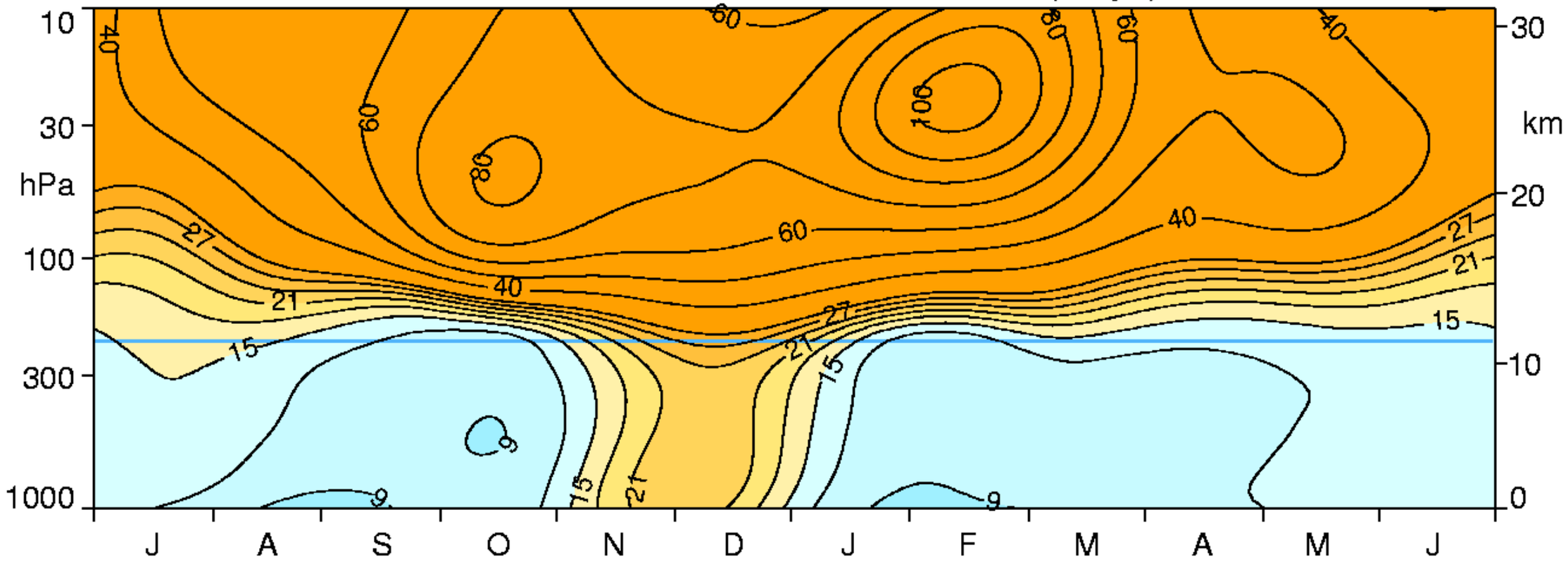
In the troposphere the longest timescale occurs during winter.




B
Southern Annular Mode Timescale (Days)
10
30
100
300
1000
hPa
30
20
10
0
km
J
A
S
O
N
D
J
F
M
A
M
J
9
15
21
27
40
60
80
100

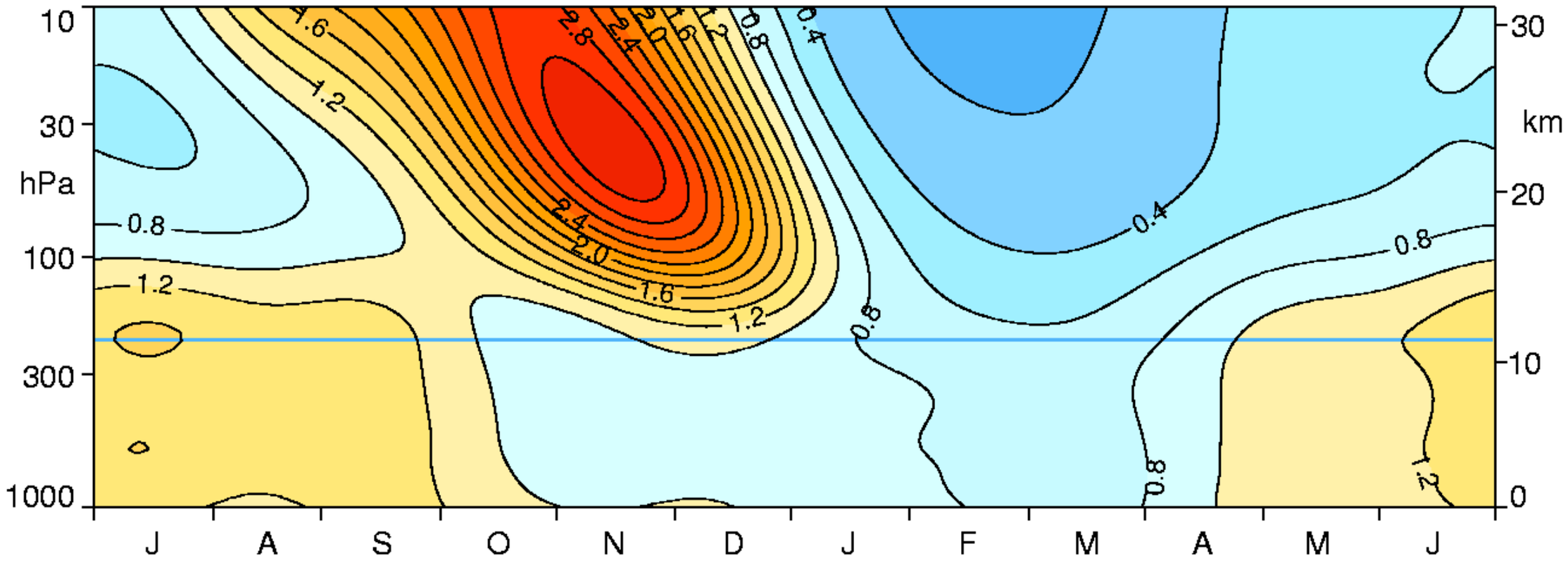
B

Southern Annular Mode Timescale (Days)



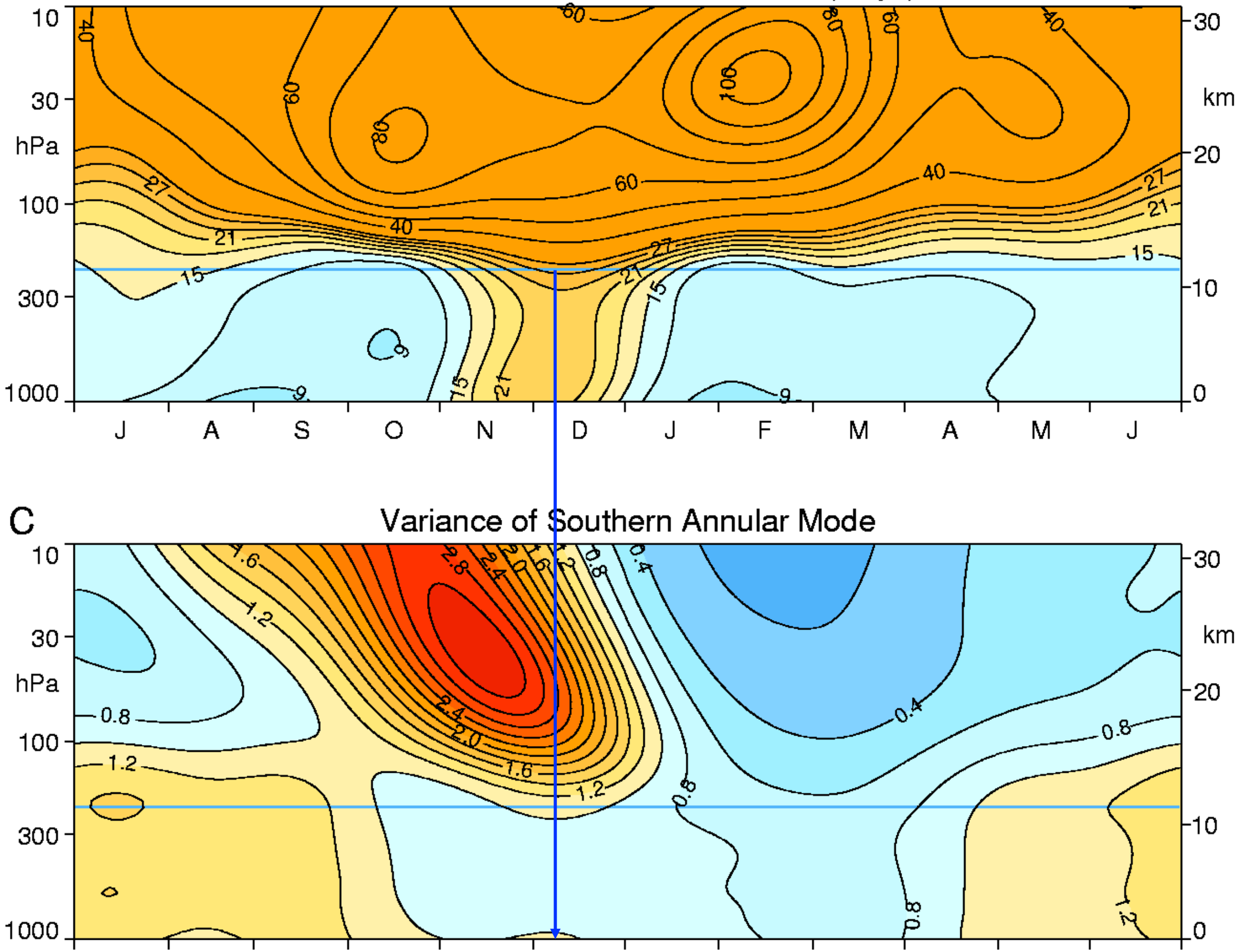
C

Variance of Southern Annular Mode



B

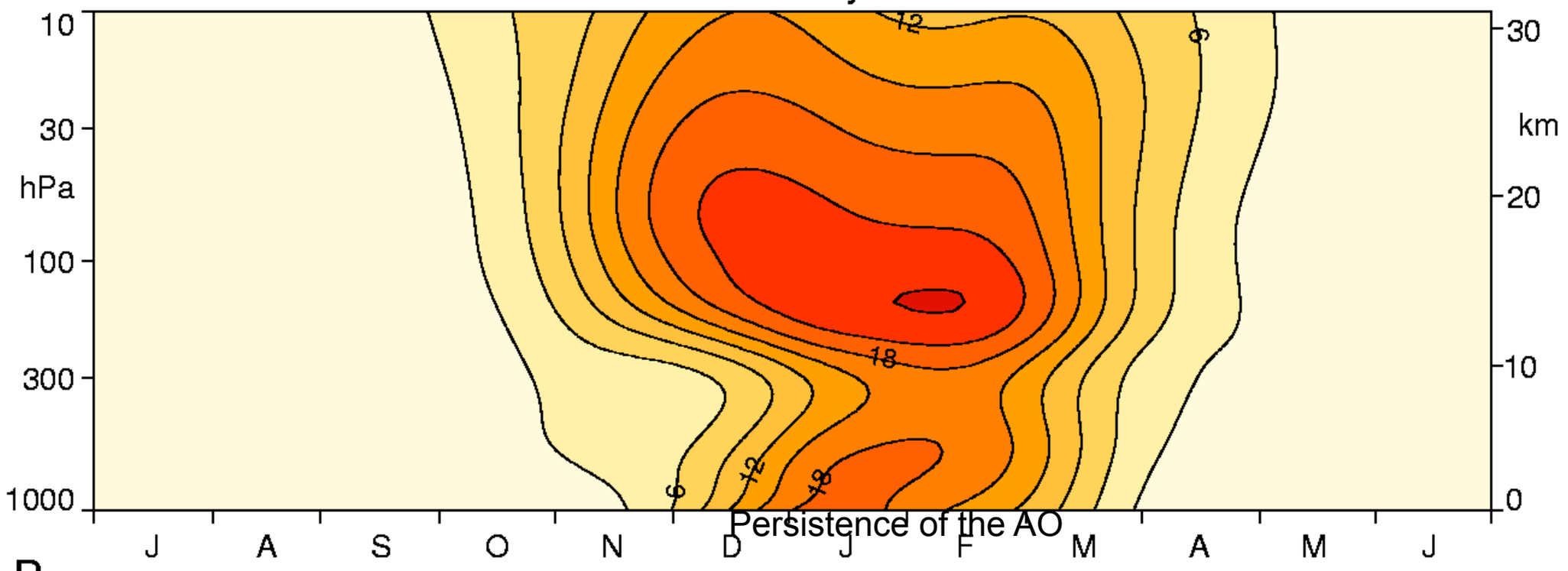
Southern Annular Mode Timescale (Days)



C

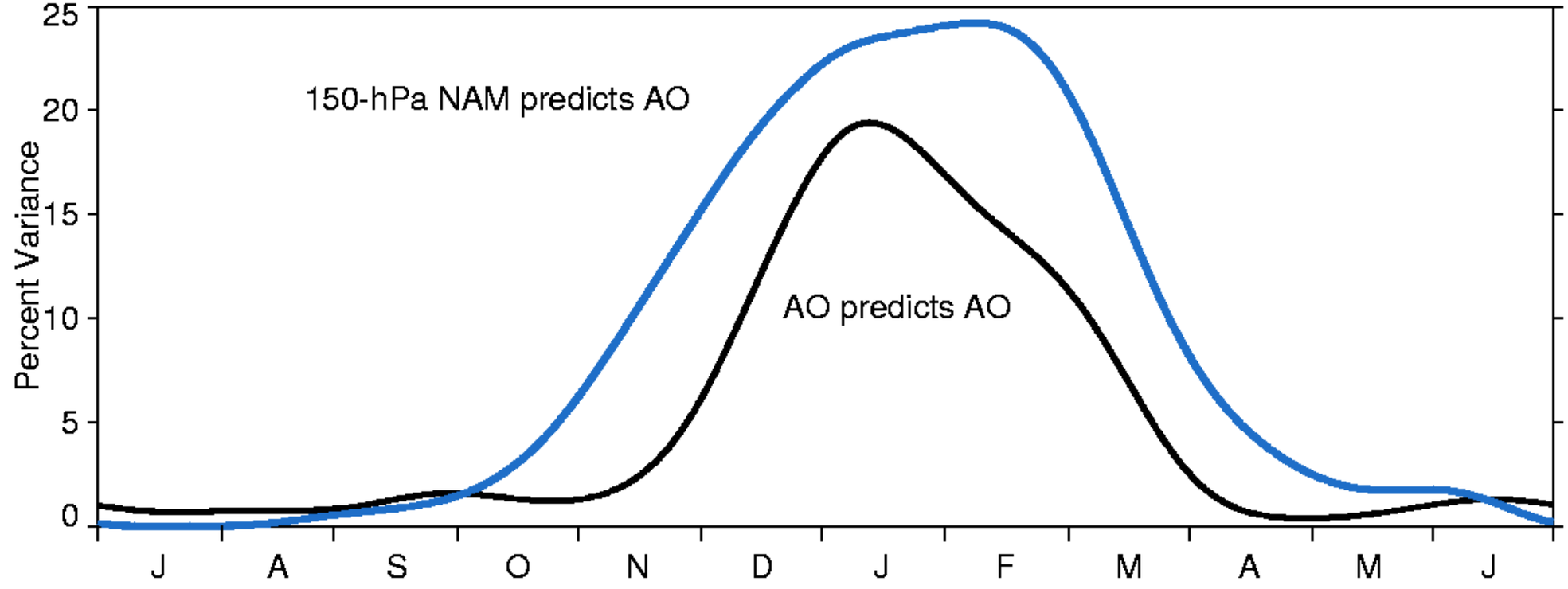
Variance of Southern Annular Mode

A



Persistence of the AO

B



Seasonal Forecast Models

- Maycock et al. *Climate Dynamics* 2009.
- 5 seasonal forecast models. Model lids 5-10 hPa. (ECMWF, Glosea, DePreSys, IfM-Kiel, Meteo-France)
- None of the models do a good job of simulating the stratosphere.
- The models all underestimate stratospheric variability.
- Tropospheric forecast skill (from stratospheric effects) is unlikely to be realized from these models.

“Climate is the average weather”

“Climate is the average weather”

Climate = E(weather)

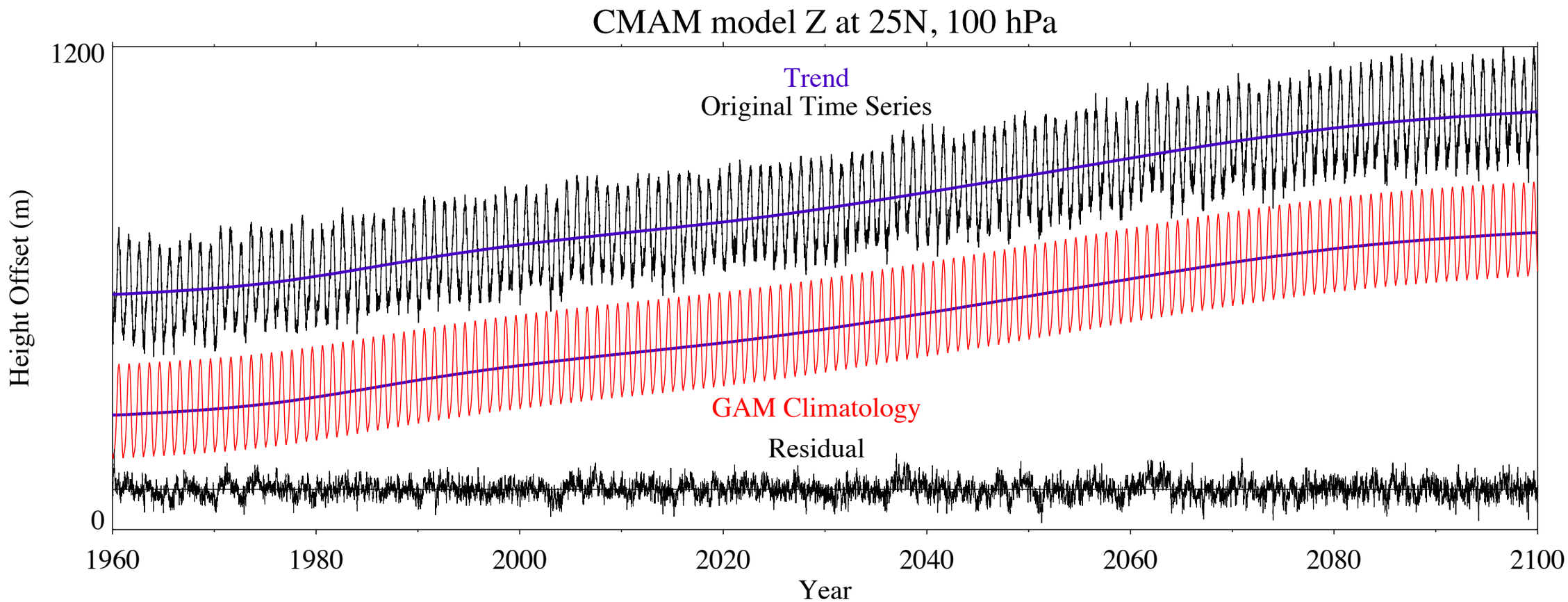
"Climate is the average weather"

Climate = E(weather)

Anomalies are deviations from climatology,
where climatology = E(weather)

Detrending with an Additive Noise Model

A trend does not have to be a straight line!



Conclusions

- Stratospheric variability induces significant high-latitude effects on weather, on a time scale up to two months.
- The surface signature of stratospheric variability looks like the the NAM/AO, and polar cap (>65°) Z is a good proxy for the NAM index.
- Forecast skill is based on atmospheric dynamics, and could be realized through forecast models or statistical methods.
- Seasonal forecast models must be able to simulate stratospheric variability, and the long time scales in the lowermost stratosphere.
- Can stratospheric changes be used on decadal time scales to forecast polar climate changes?