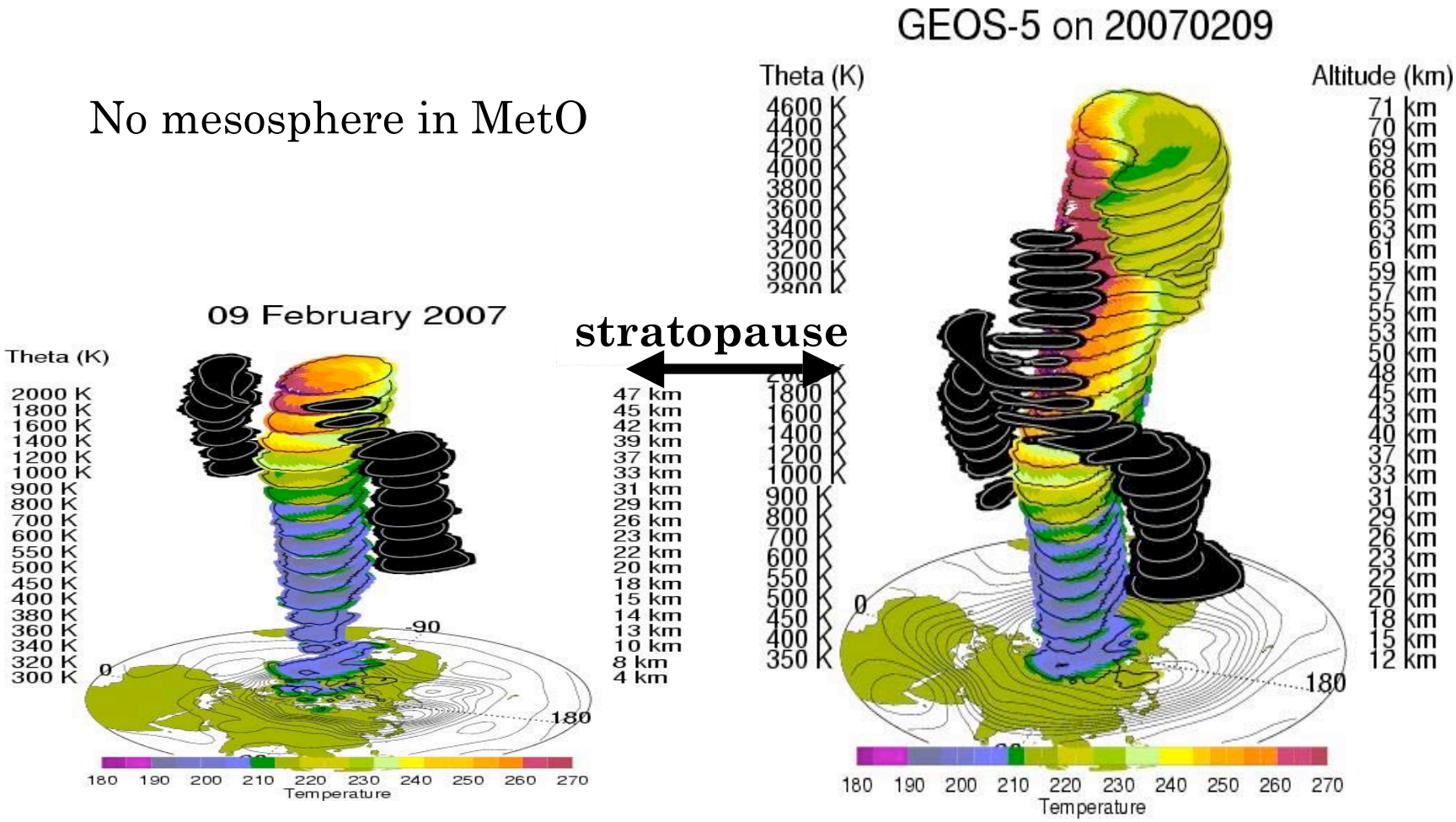
The Mesospheric Polar Vortices

V. Lynn Harvey, C. Randall, S. Pawson, R. Garcia, R. Lieberman, and G. Manney

No mesosphere in MetO



Outline

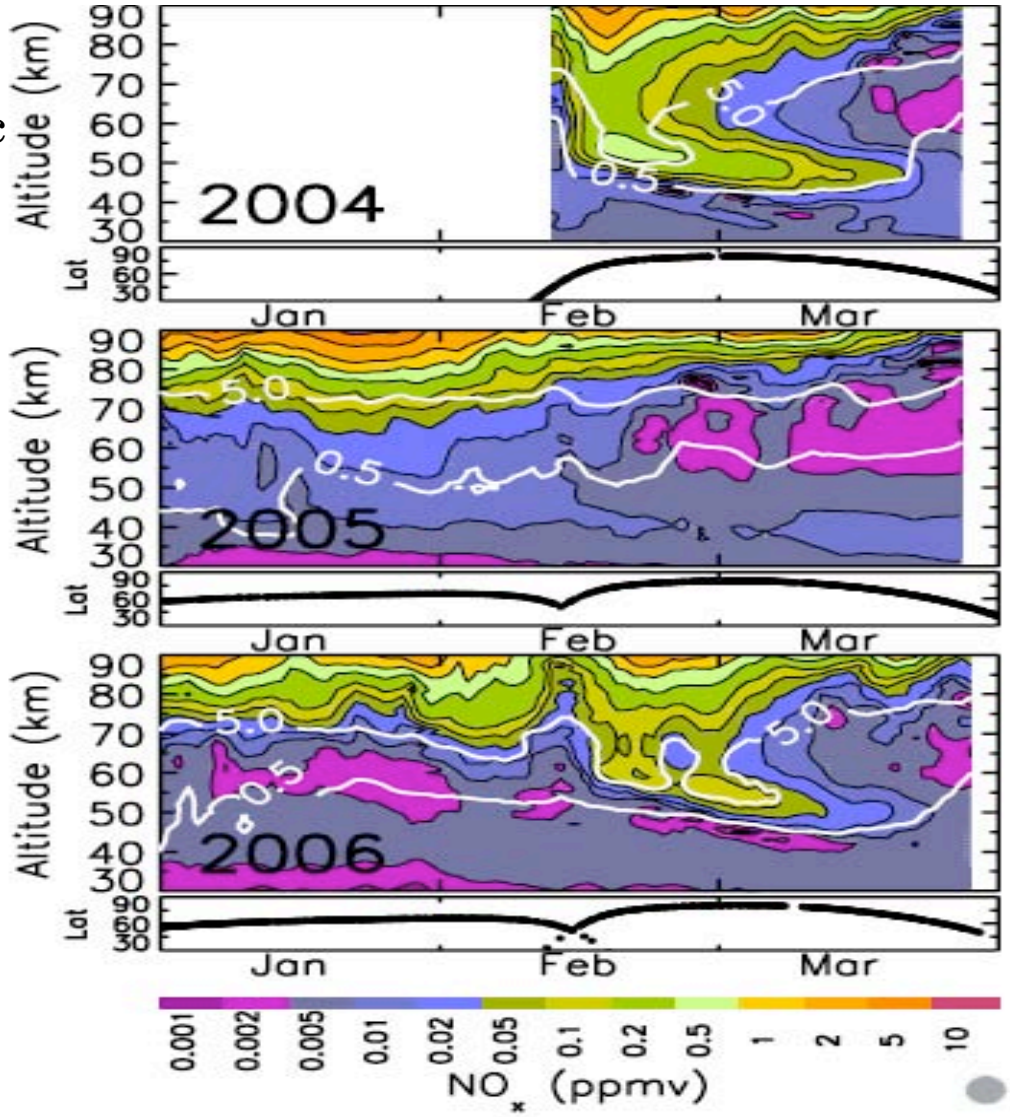
- Motivation
- Models and Data: MetO, GEOS-4/5, WACCM, SABER, and EOS-MLS
- Vortex edge definition based on Q
- Polar vortex zonal mean climatologies in MetO, GEOS-4, WACCM
- SABER vs. GEOS USLM winds
- 3-D vortex structure
- Vortex edge validation exercise using MLS CO
- Future work

Enhanced NO_x in 2006 linked to strong upper stratospheric Arctic vortex

C. E. Randall,[1,2] V. L. Harvey,[1] C. S. Singleton,[1] P. F. Bernath,[1] C. D. Boone,[3] and J. U. Kozyra[4]

High Geomagnetic Activity Oct 2003

Strong Vortex



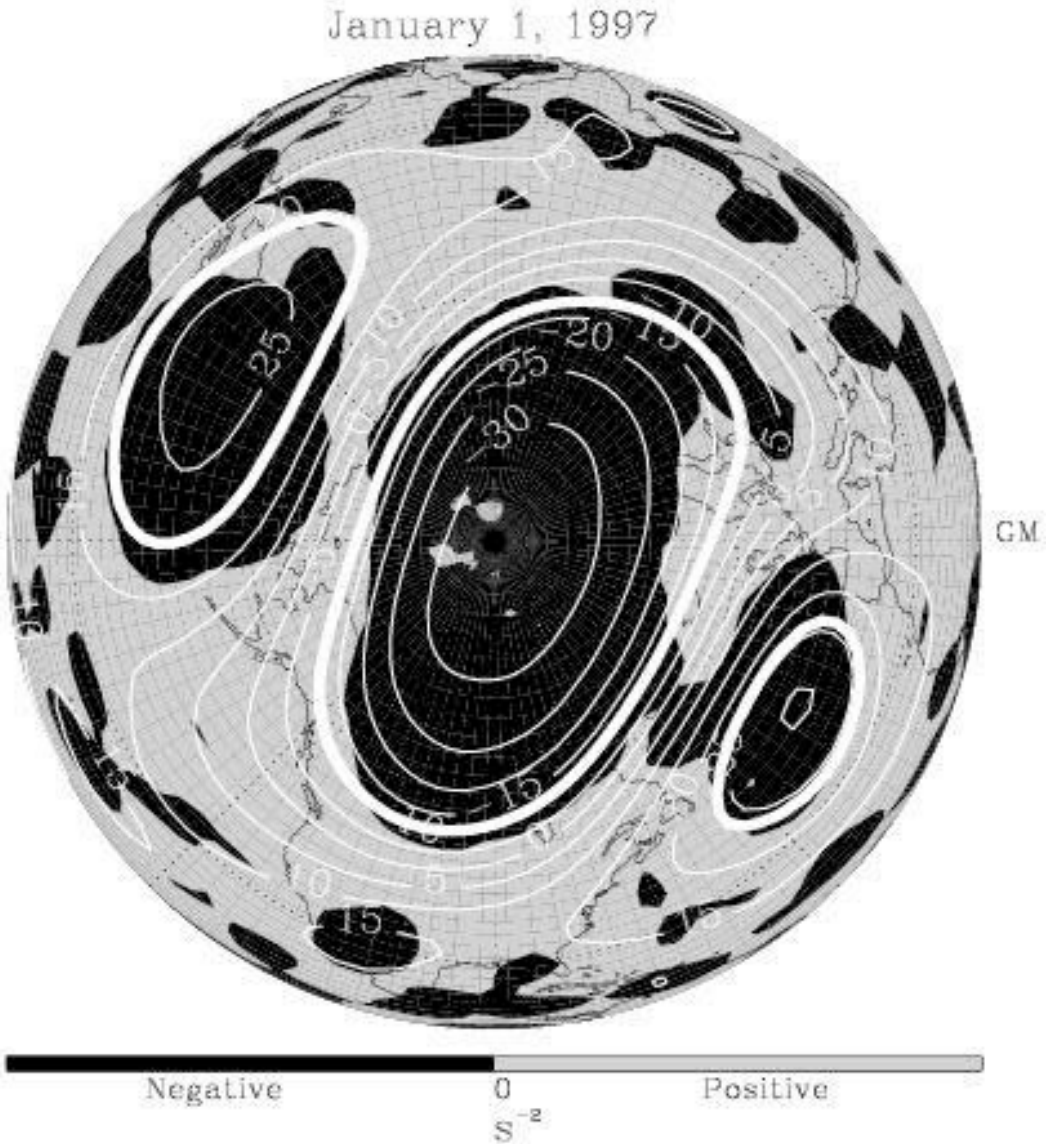
Low Geomagnetic Activity

Strong Vortex

Motivation (for this talk)

- Compare polar vortices in GEOS and WACCM to observations to assess need for data assimilation above the stratopause.

Q, Streamfunction, Arctic Vortex

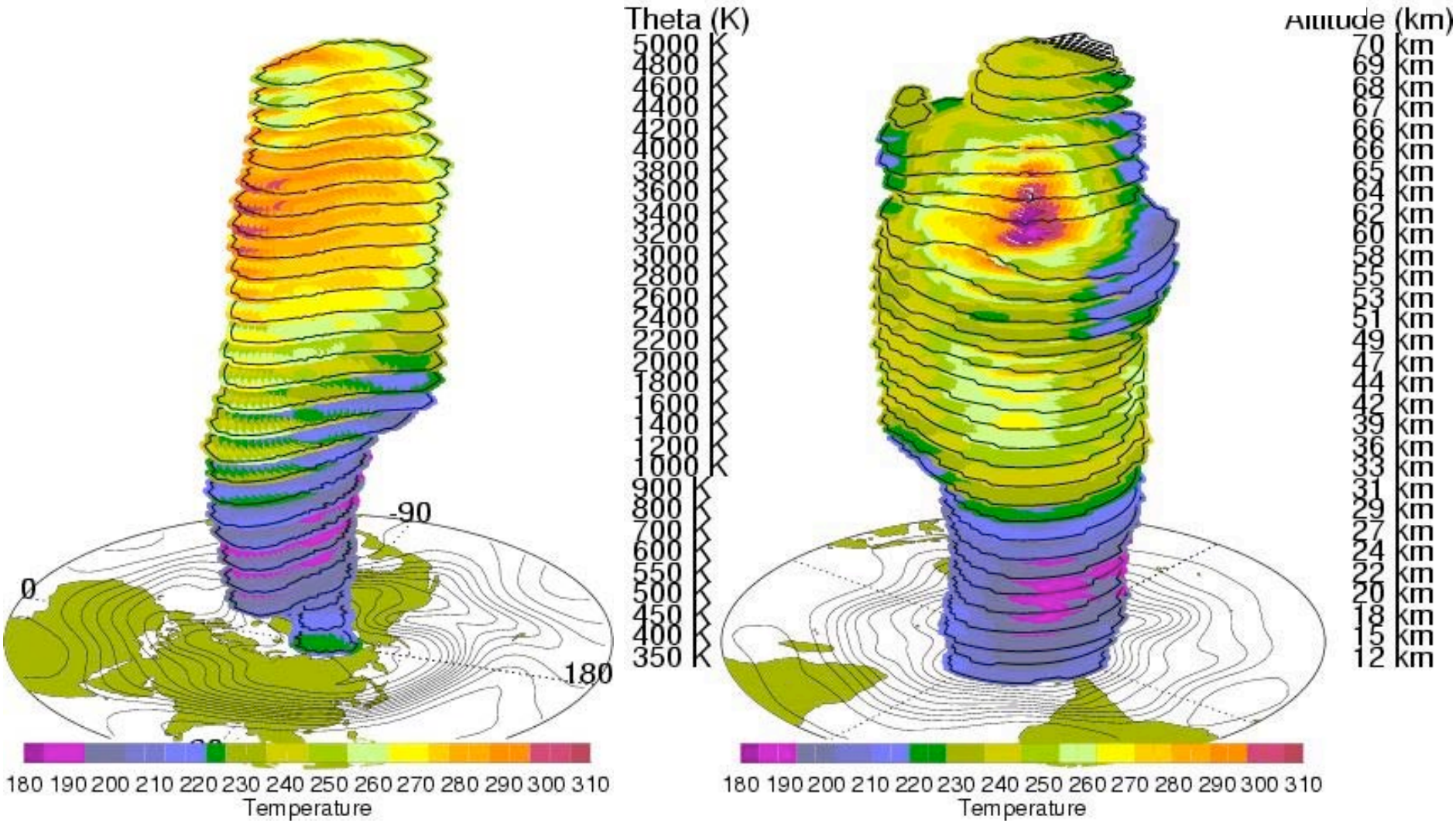


Q is negative where rotation dominates shear. See Tatyana's poster.

GEOS-4 Daily 3D Structure

Arctic
20051207

Antarctic
20040710

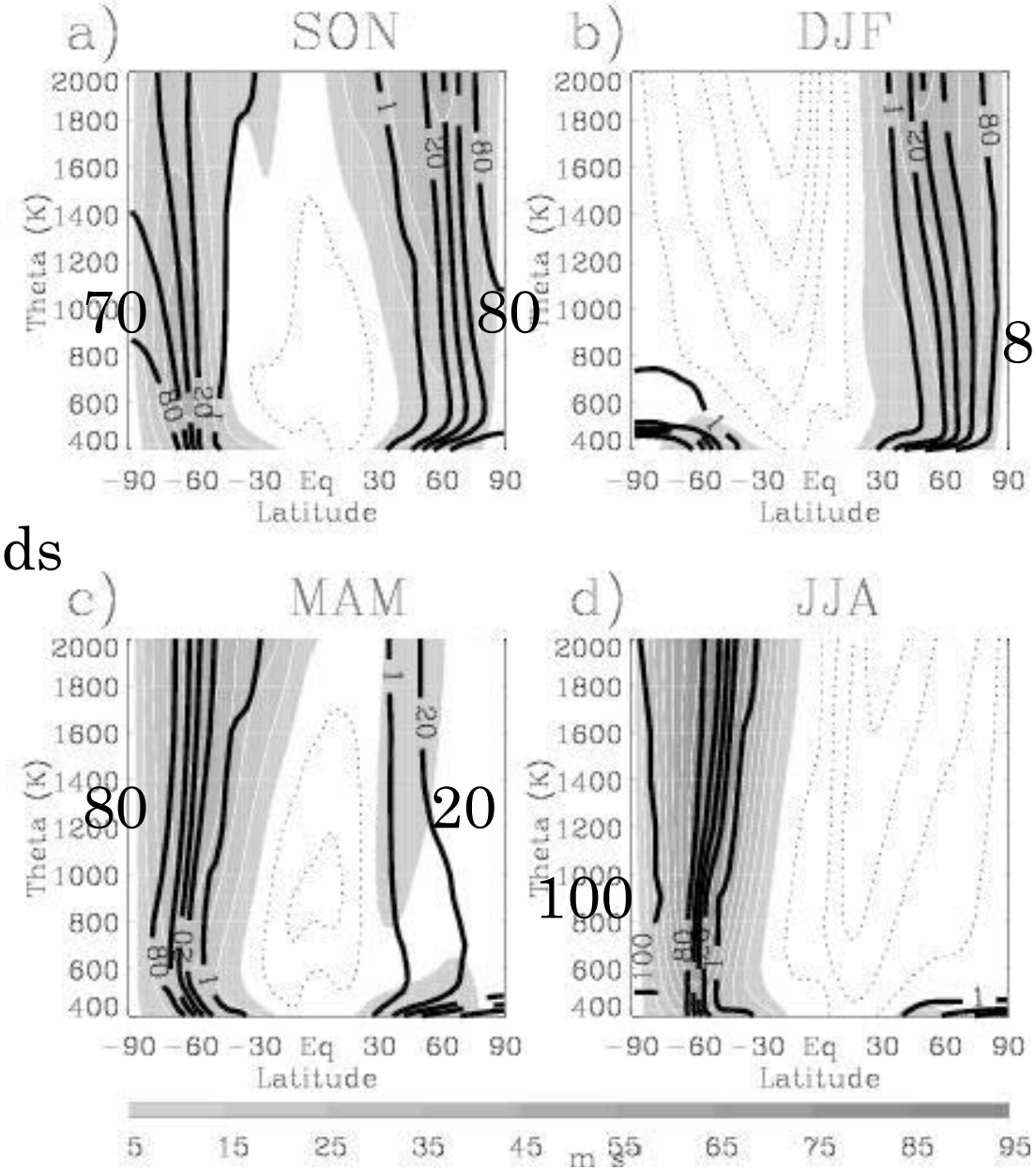


Extends to ~72 km but need ~10 more km to fully resolve polar vortices

MetO Zonal Mean Vortex Frequency

Seasonal
(10-year mean)

Zonal mean
Westerly winds
shaded



70

80

80

80

20

100

Solstice

Antarctic Vortex

July

January

Arctic Vortex

GEOS-4
(3-year mean)

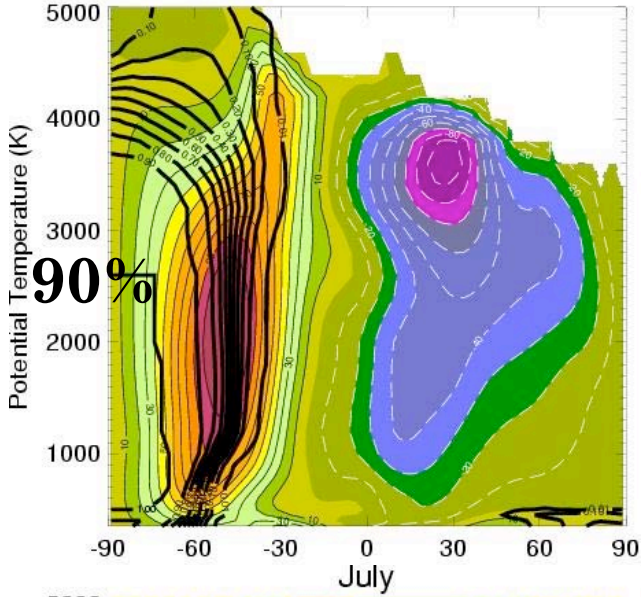
90%

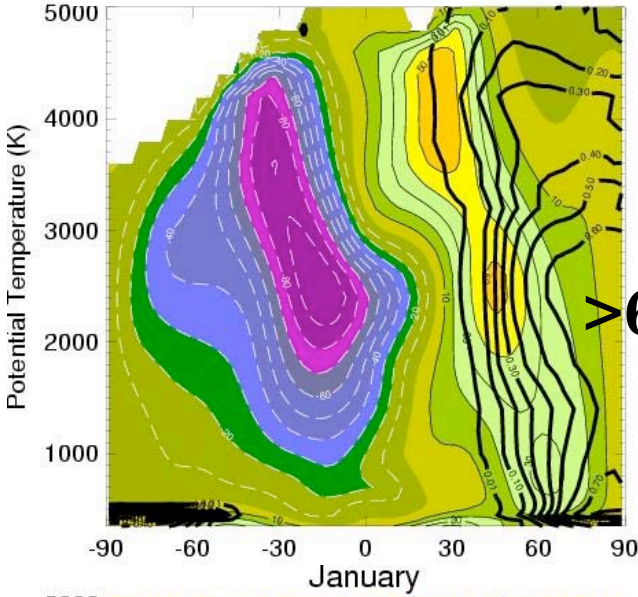
>60%

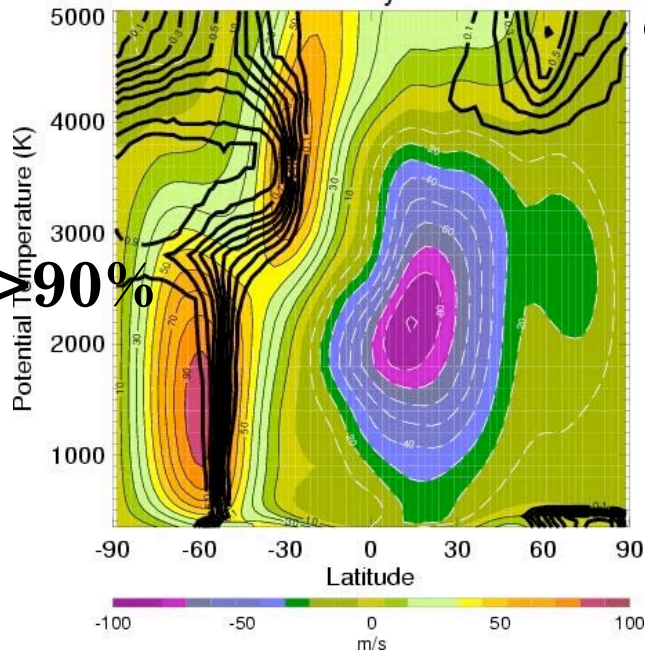
WACCM
(15-year mean)

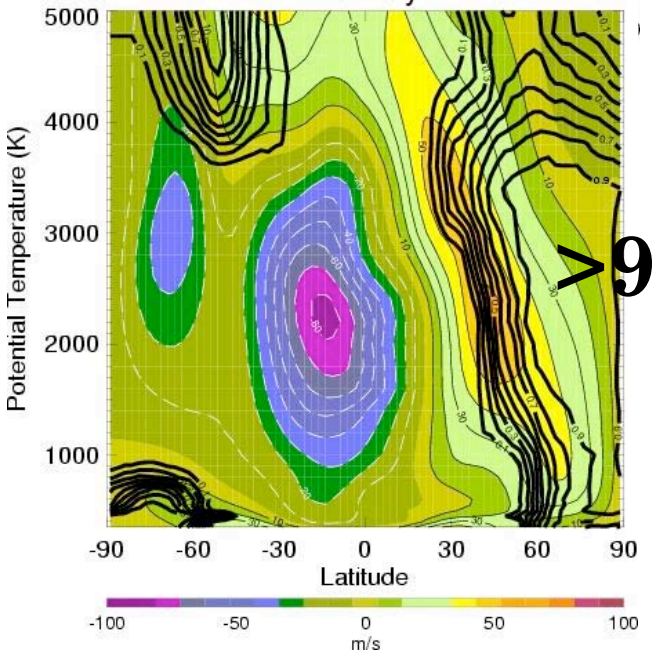
>90%

>90%





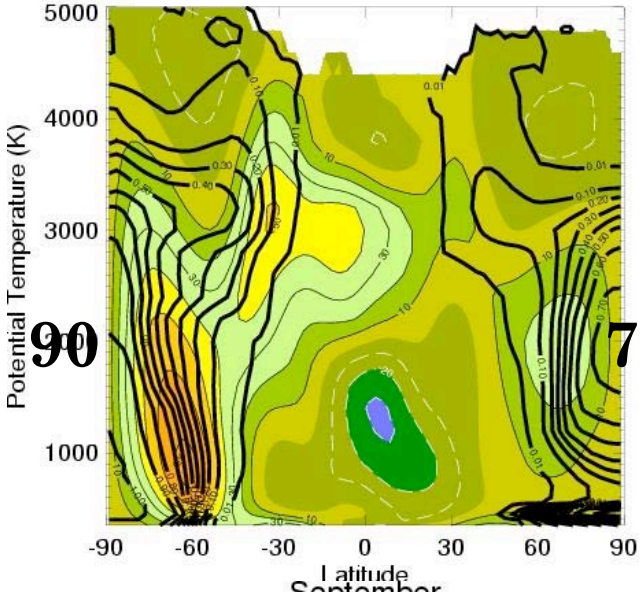




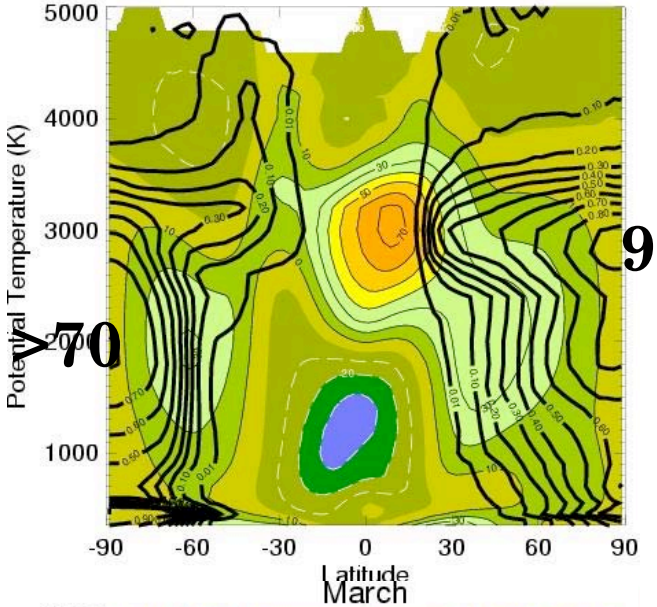
September

March

GEOS-4

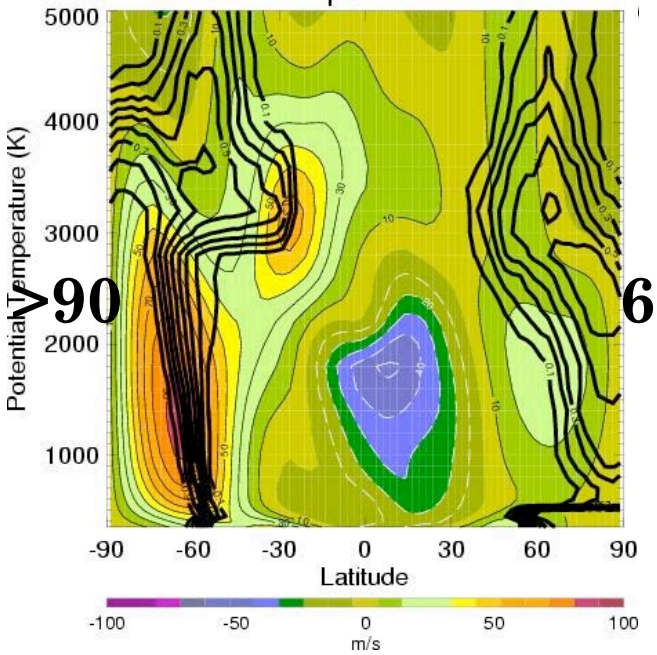


90 70

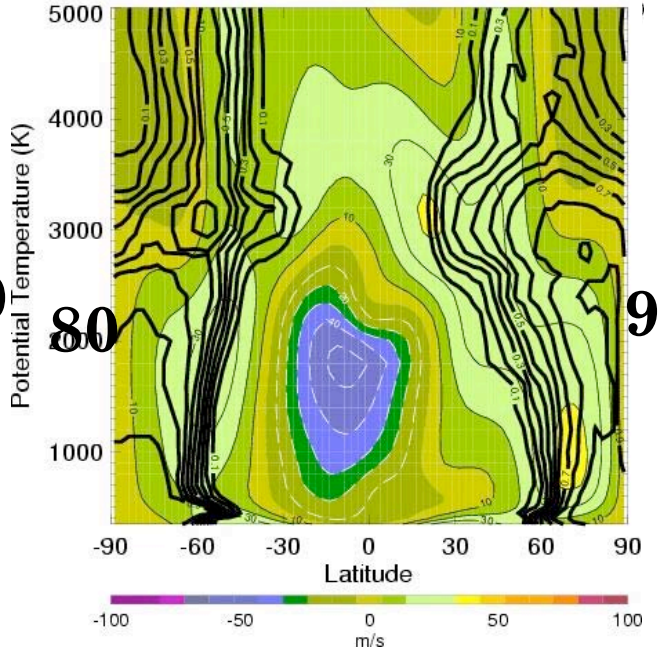


70 90

WACCM

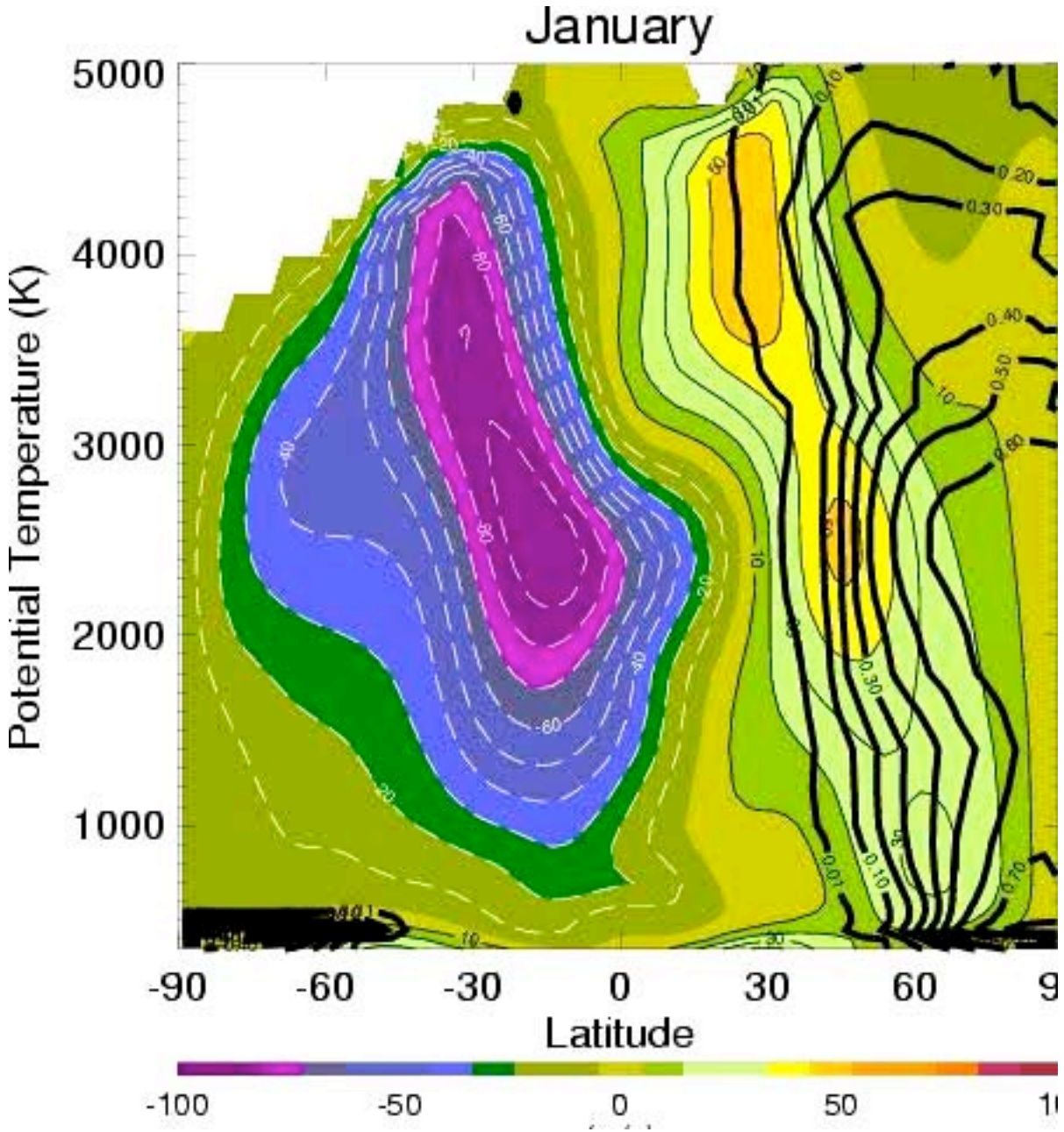


90 60



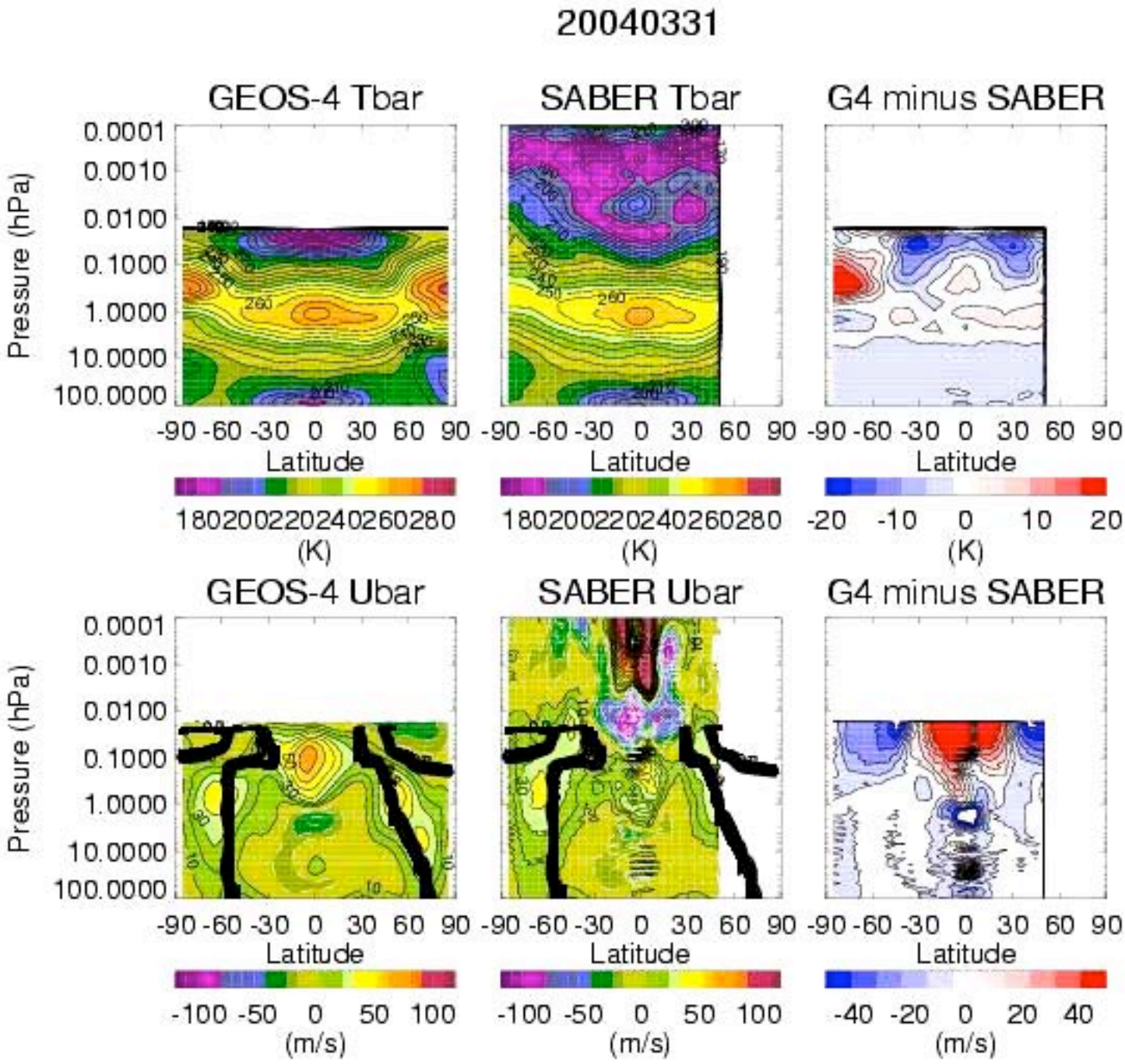
80 90

Equinox is more prone to vortex contamination by SAO

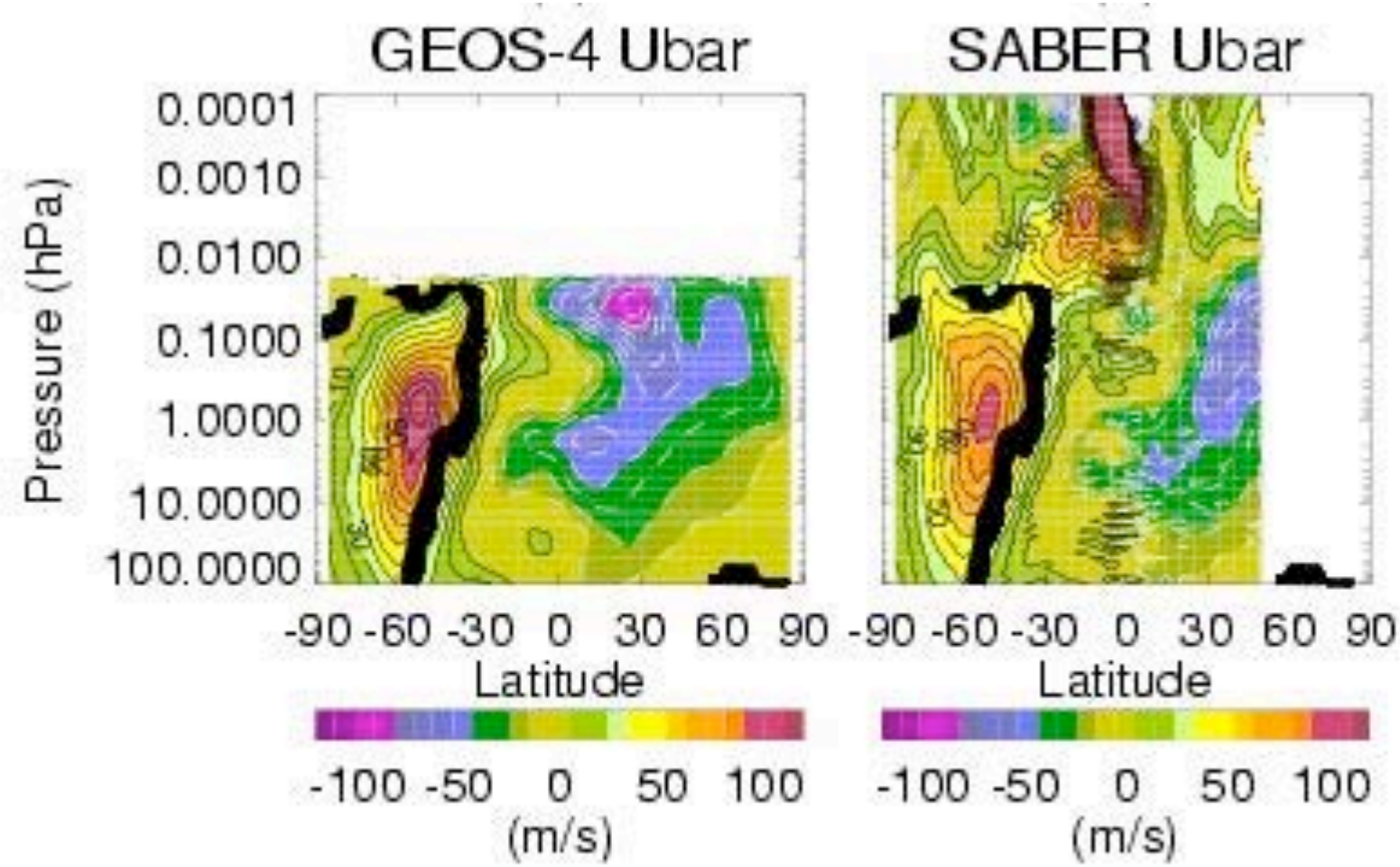

January
Potential Temperature (K)
5000
4000
3000
2000
1000
-90
-60
-30
0
30
60
Latitude
-100
-50
0
50

SABER vs. GEOS USLM winds

- Daily zonal mean zonal wind + vortex edge movie
- Contamination of vortex edge by the SAO similar to in the UTLS by the subtropical jet. Is this feature accurately represented here?
- Should the vortex “close off” above the separated polar stratopause instead of bulge out to low latitudes? Probably.


20040331
GEOS-4 Tbar
SABER Tbar
G4 minus SABER
Pressure (hPa)
0.0001
0.0010
0.0100
0.1000
1.0000
10.0000
100.0000
-90 -60 -30 0 30 60 90
Latitude
180200220240260280
(K)
-20 -10 0 10 20
(K)
GEOS-4 Ubar
SABER Ubar
G4 minus SABER
-100 -50 0 50 100
(m/s)
-40 -20 0 20 40
(m/s)

“Double jet” in USLM

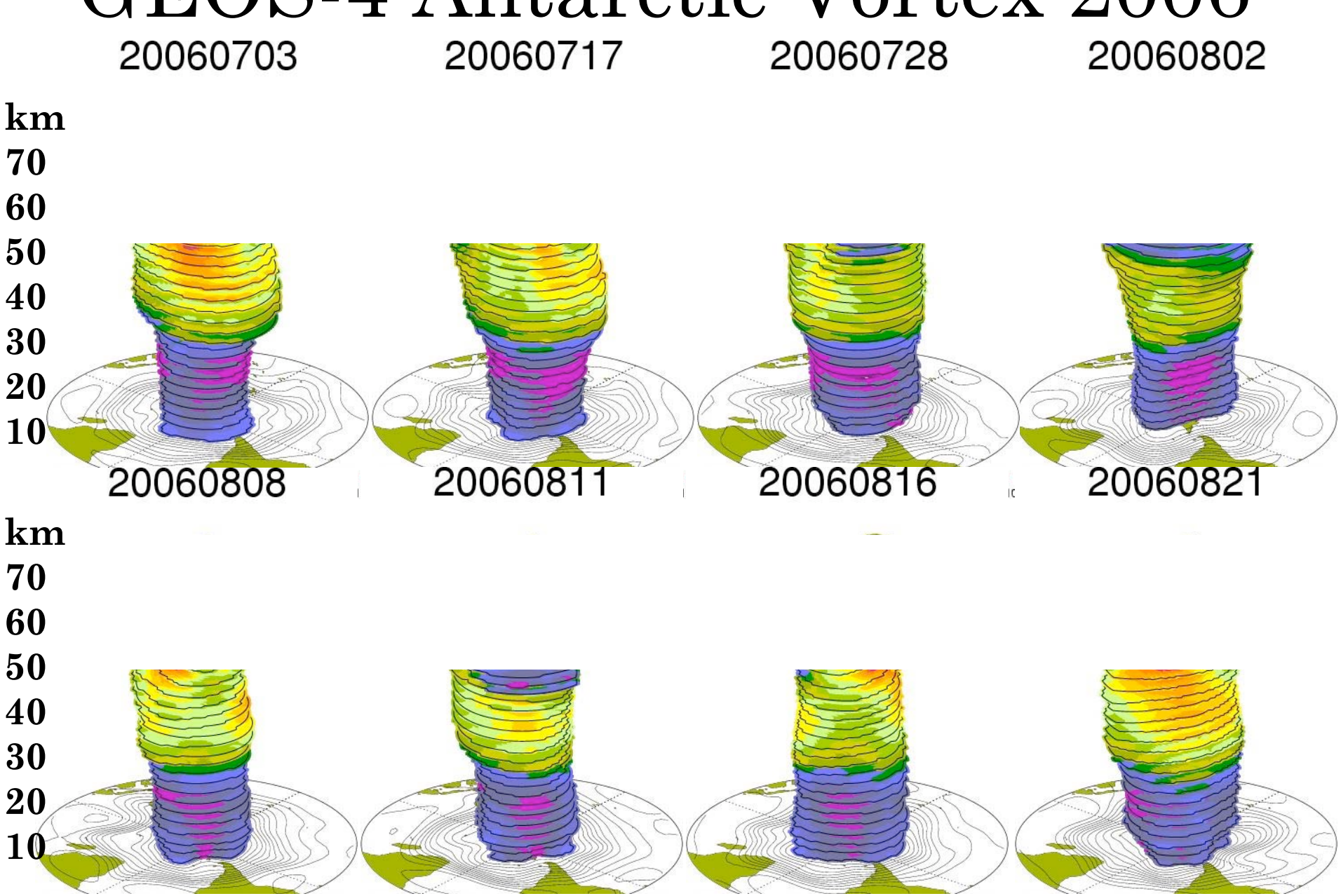


Should the vortex edge follow the jet axis toward the pole?

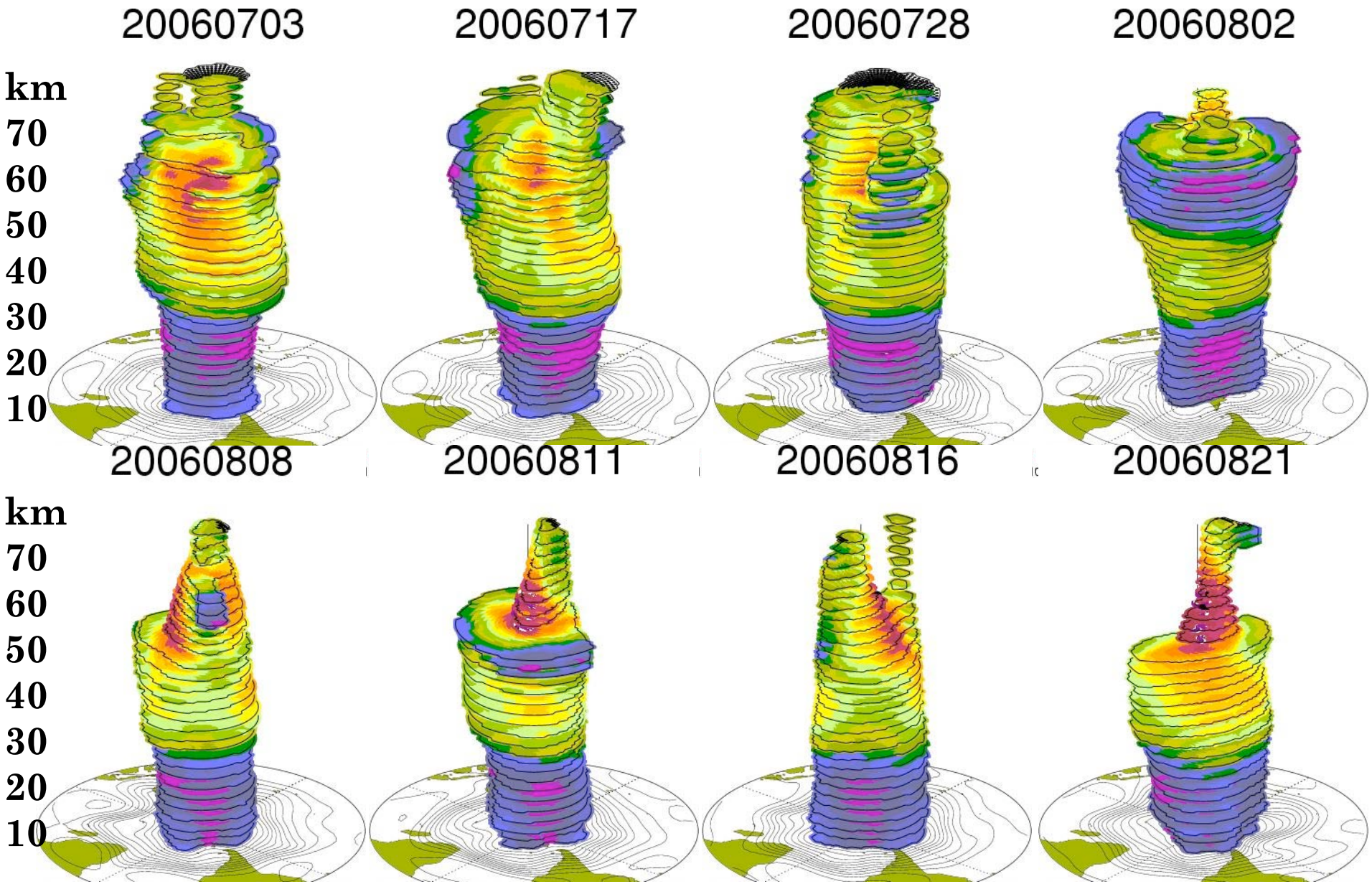
Vortex Edge vs. MLS CO

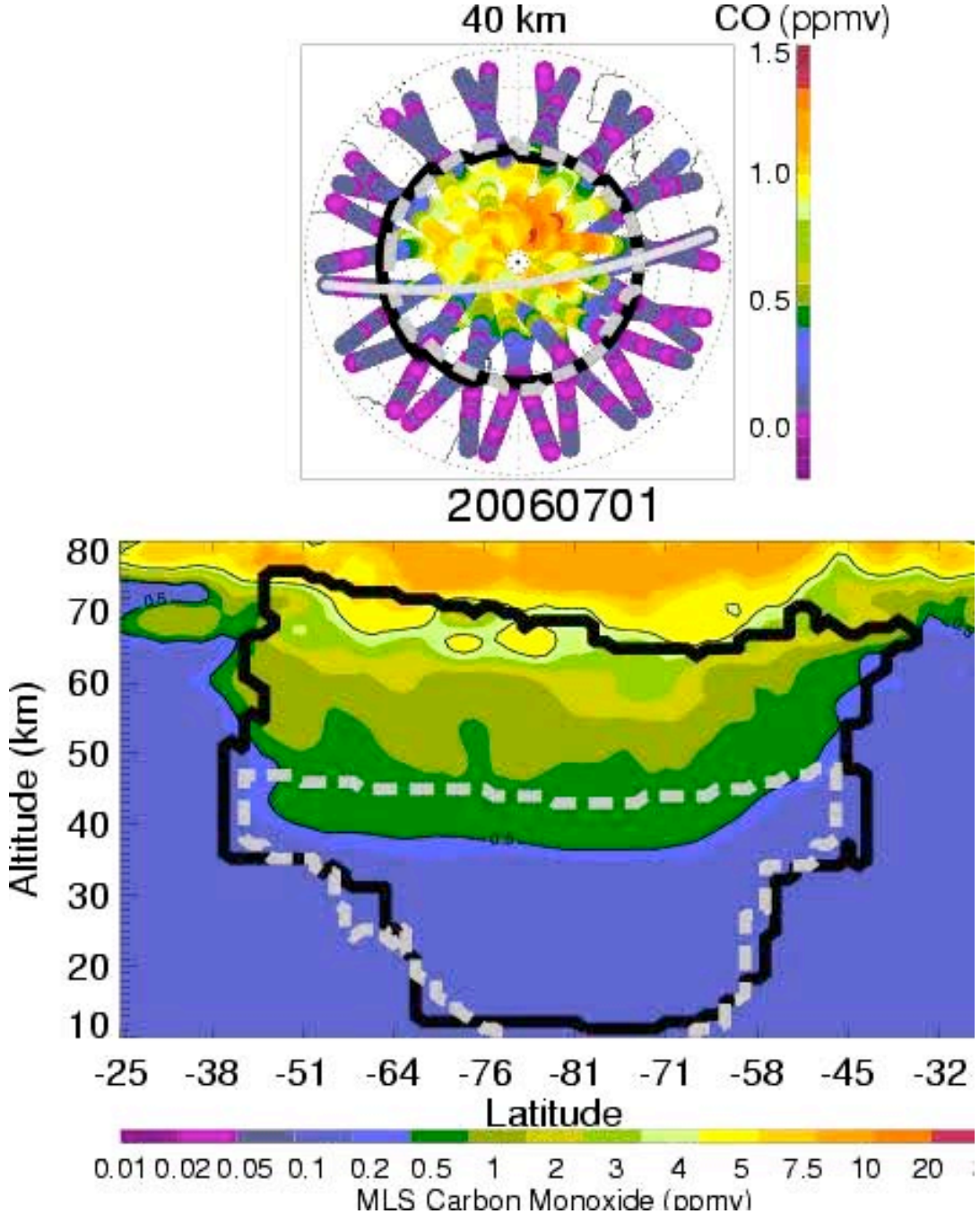
- Quick 3D case study in each hemisphere
- Cross-Polar CO Swaths + Vortex Edge
- This is a vortex edge validation exercise.

GEOS-4 Antarctic Vortex 2006

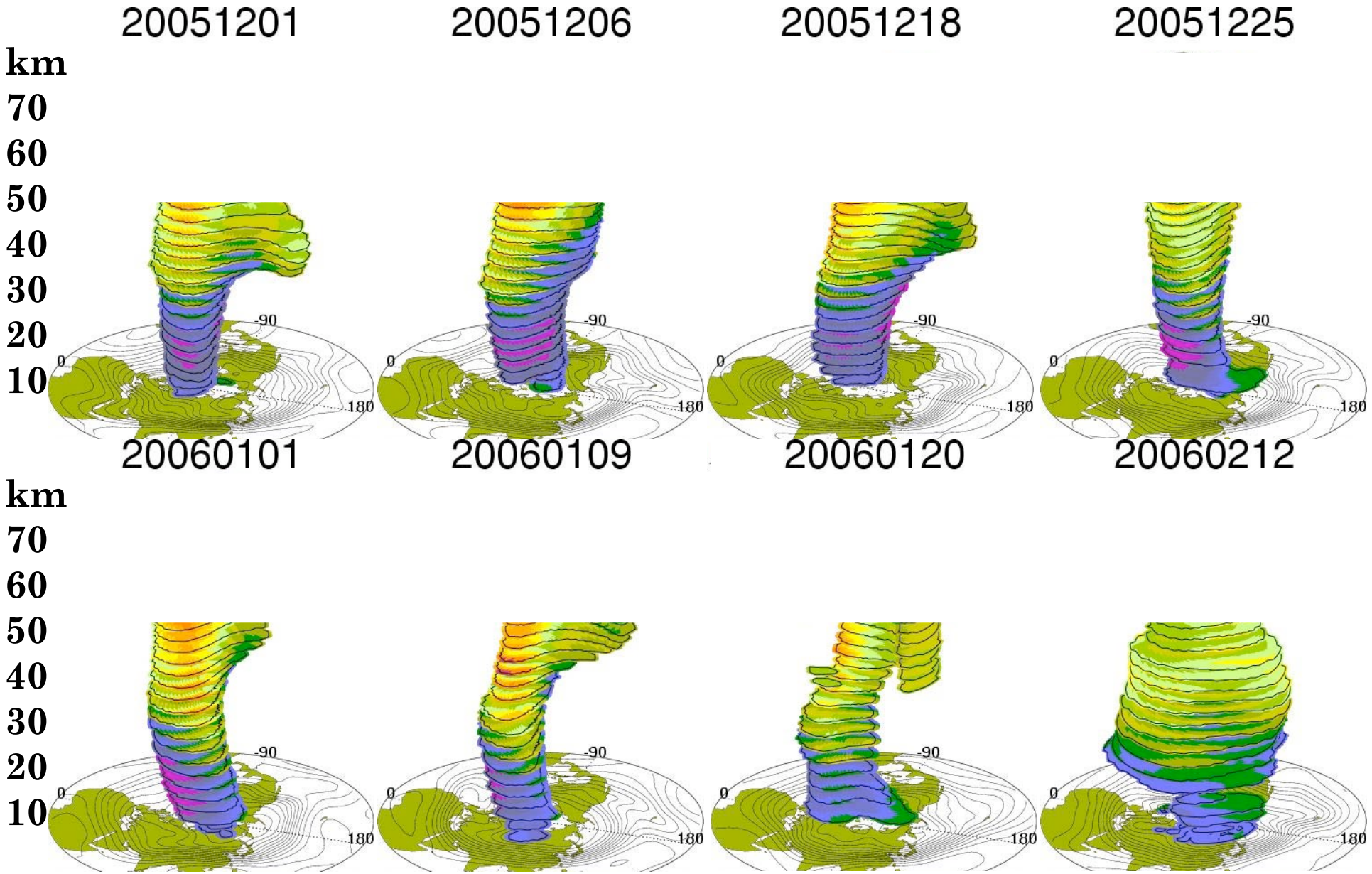


GEOS-4 Antarctic Vortex 2006

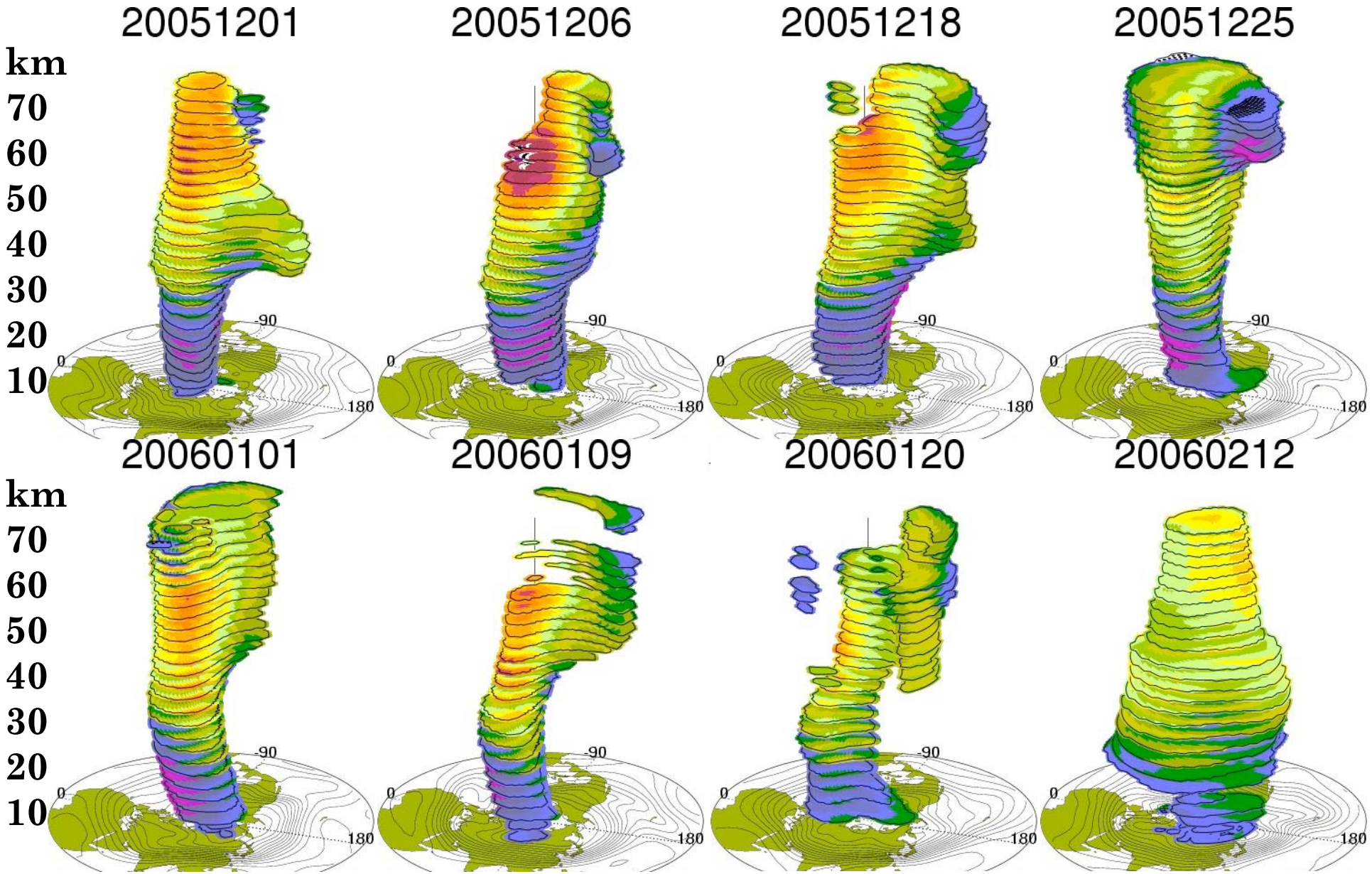


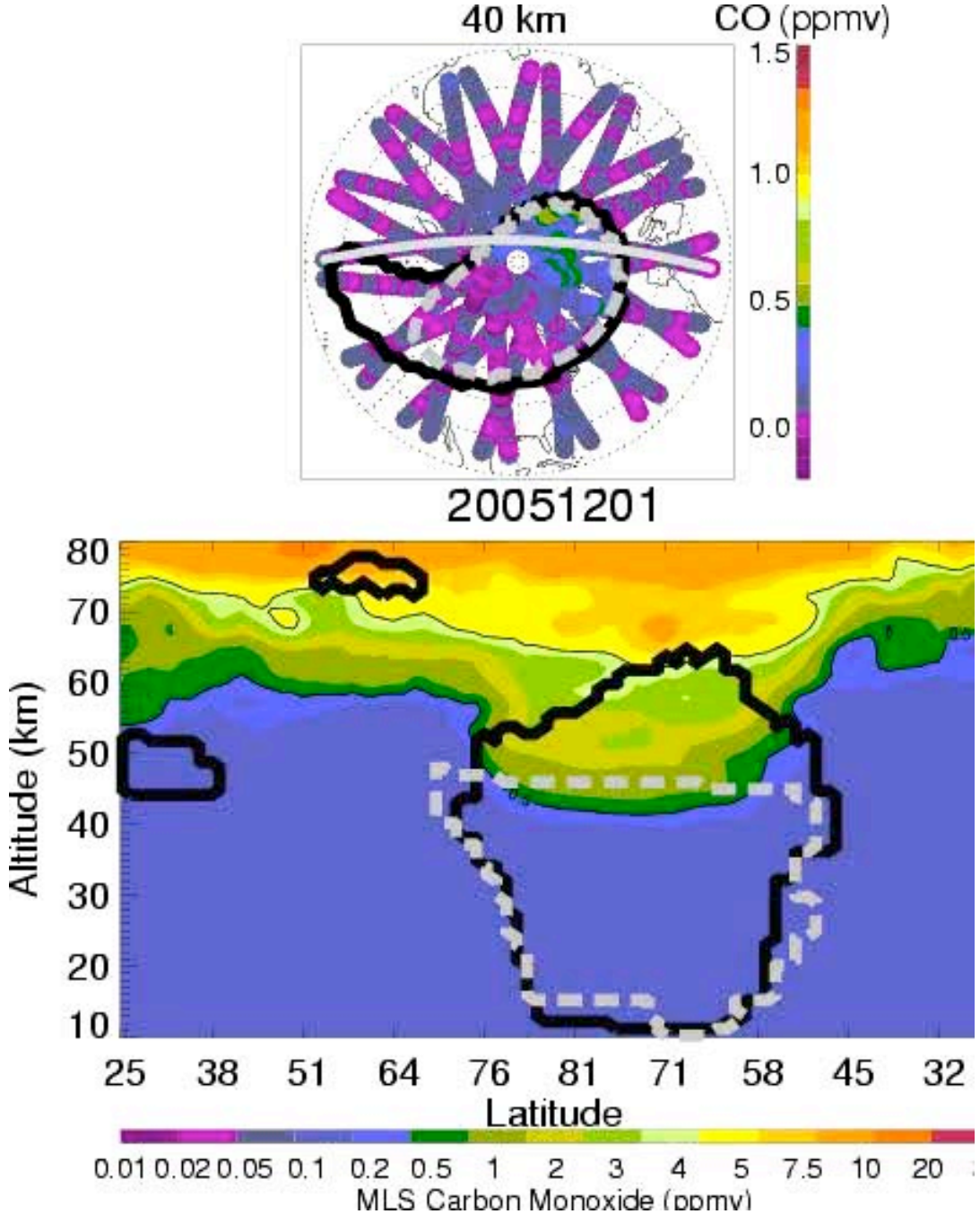

40 km
CO (ppmv)
1.5
1.0
0.5
0.0
20060701
80
70
60
50
40
30
20
10
Altitude (km)
-25 -38 -51 -64 -76 -81 -71 -58 -45 -32
Latitude
0.01 0.02 0.05 0.1 0.2 0.5 1 2 3 4 5 7.5 10 20
MLS Carbon Monoxide (ppmv)

GEOS-4 Arctic Vortex 2005/06



GEOS-4 Arctic Vortex 2005/06




40 km
CO (ppmv)
1.5
1.0
0.5
0.0
20051201
Altitude (km)
80
70
60
50
40
30
20
10
25 38 51 64 76 81 71 58 45 32
Latitude
0.01 0.02 0.05 0.1 0.2 0.5 1 2 3 4 5 7.5 10 20
MLS Carbon Monoxide (ppmv)

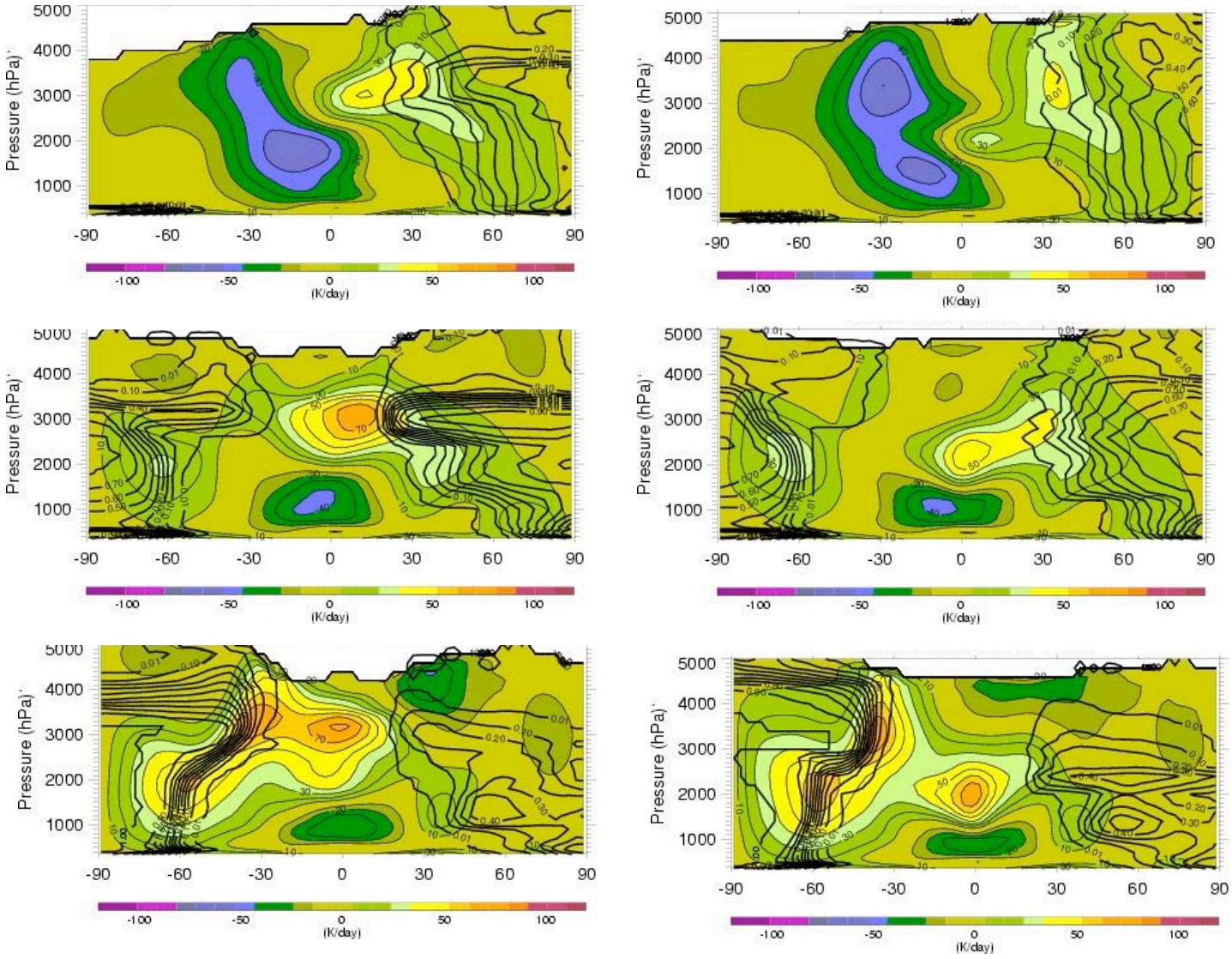
GEOS-4 vs. GEOS-5

2007

Feb

Mar

Apr



Less contamination by SAO in GEOS-5?

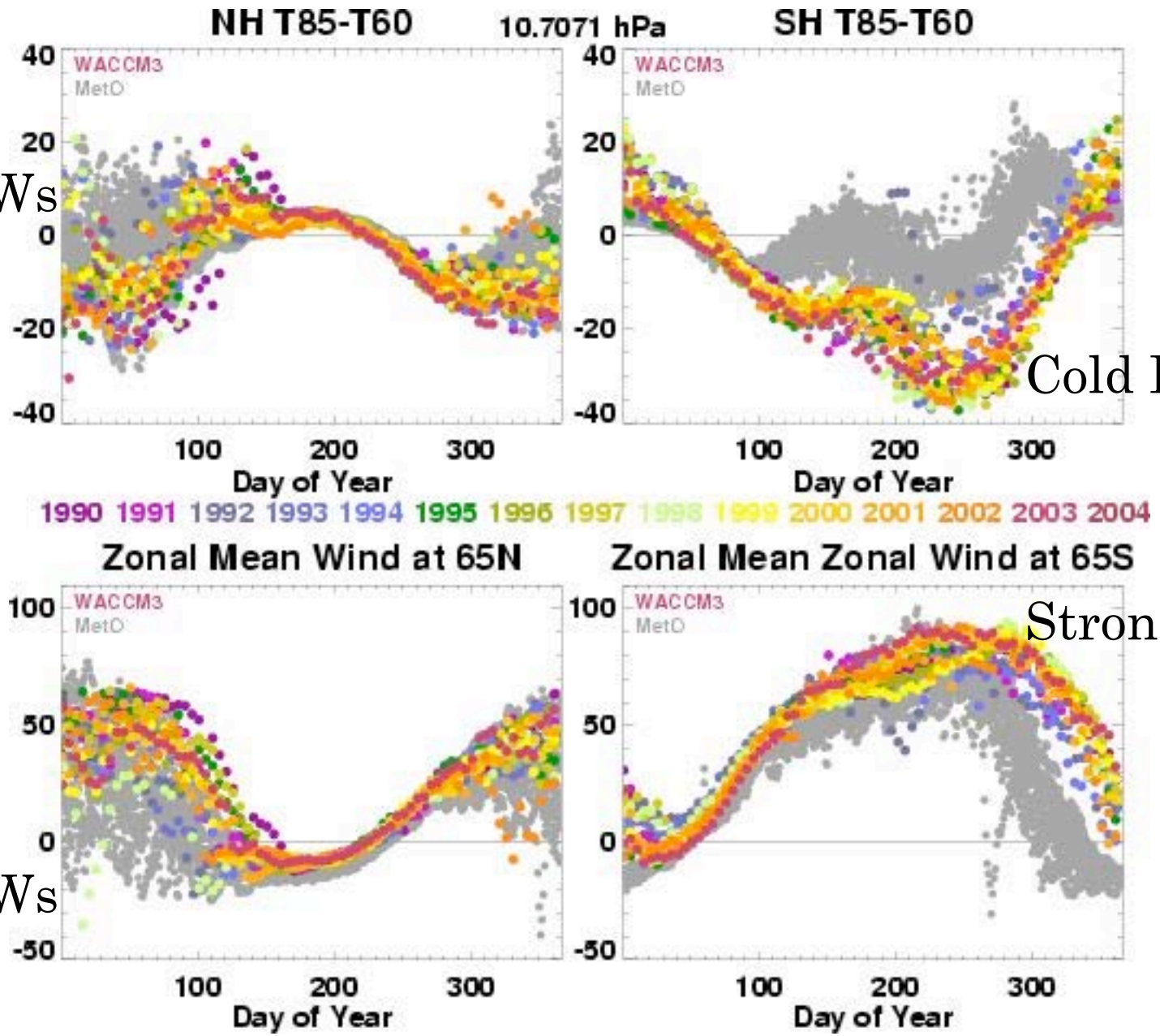
Summary

- MetO -> GEOS -> WACCM vortex climatologies
- Used SABER winds and MLS CO to validate edge definition
- Contamination of vortex edge by SAO
- Top of the polar vortices are some distance above the separated polar winter stratopause.

Future Work

- Improve UTLS and USLM vortex definition to accommodate SAO.
- Compare GEOS and SABER winds to TIDI.
- JGR paper and AGU Special Session

WACCM vs MetO



SSWs

Cold Pole

Strong Jet

SSWs