The PMC Region as an integrator of coupling processes

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Recent paper in GRL, January 2012

Acknowledgement: **This work was funded by the Office of Naval Research and the NASA/AIM Program**

Outline:

1. *Two* products from NOGAPS-ALPHA → bottom bndy for TIEGCM
   - 6 hourly data assimilation (NAVDAS) (Eckermann et al. JASTP, 2009)
   - 1 hourly forecasts (Siskind et al., GRL, 2012)

2. Thermospheric zonal winds → The atmosphere's 2nd polar vortex

3. Observations of variability and a new mode of strat-therm coupling

Forcing TIEGCM with NOGAPS-ALPHA

TIEGCM:

Thermosphere Ionosphere Electrodynamics- GCM (NCAR model)
bottom boundary p = 5e-4 mb is the very top of NAVDAS
Top boundary about 400-500 km

First cut:

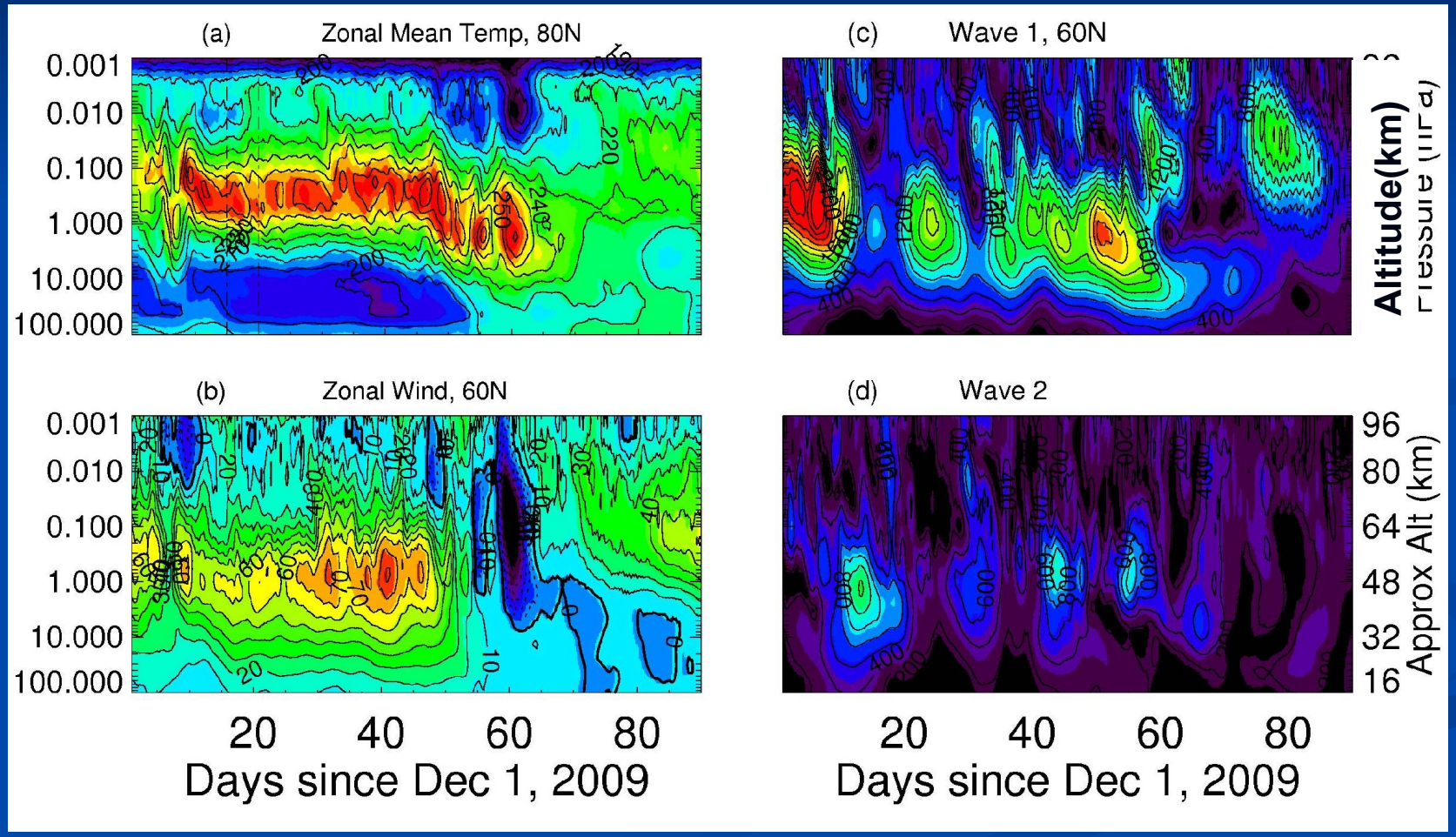
NAVDAS temperatures, u and v winds, heights for January 2010
Compare with standard forcing from: Hagan tidal model (GSWM)- migrating only

Better:

Use forecast model in series of 6 hour forecasts, output every 1 hour
Total of 120 for the 30 days (720 bottom boundary conditions)

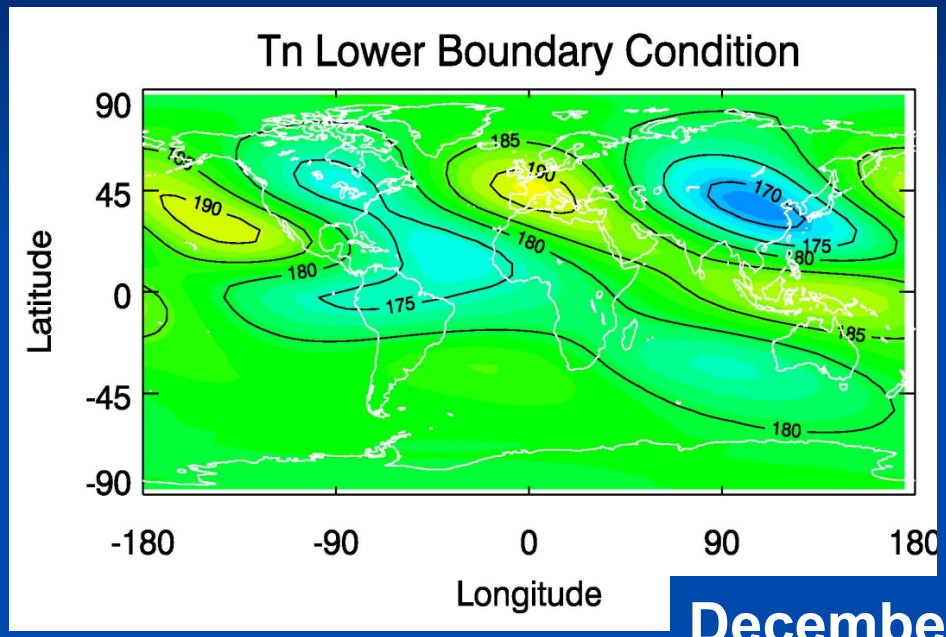
NAVDAS example, NH winter 2009-2010

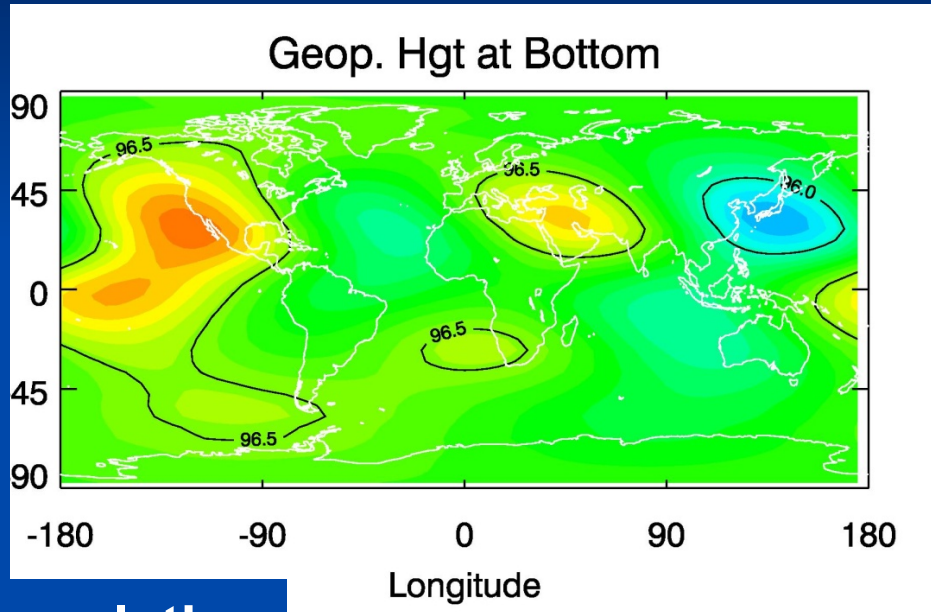
The NAVDAS 3D-var analysis, every 6 hours



NCAR GSWM as bottom boundary

TIEGCM fixed mean geopotential height = 97 km
perturbations from migrating tides

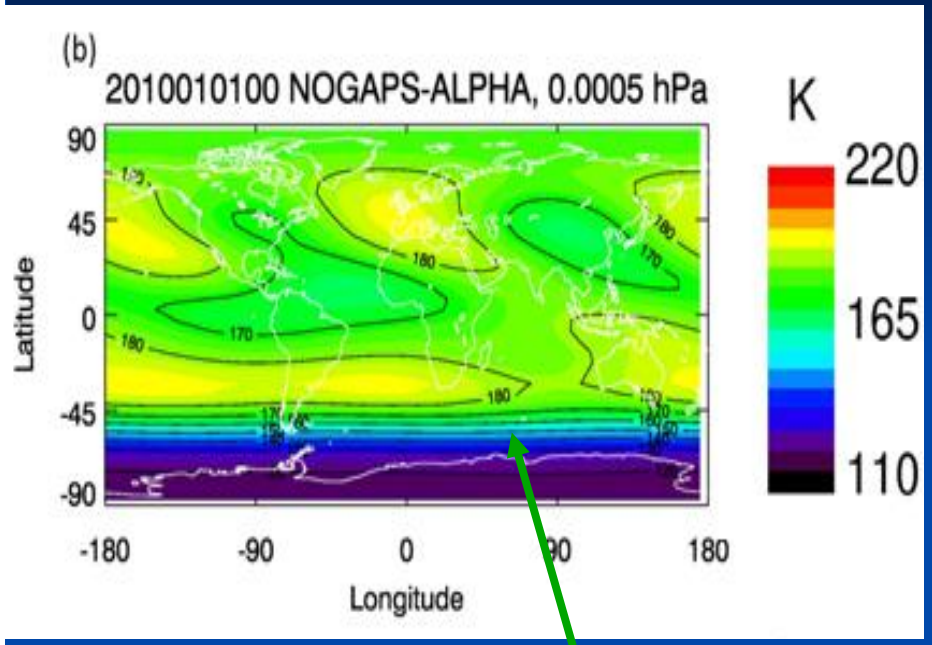


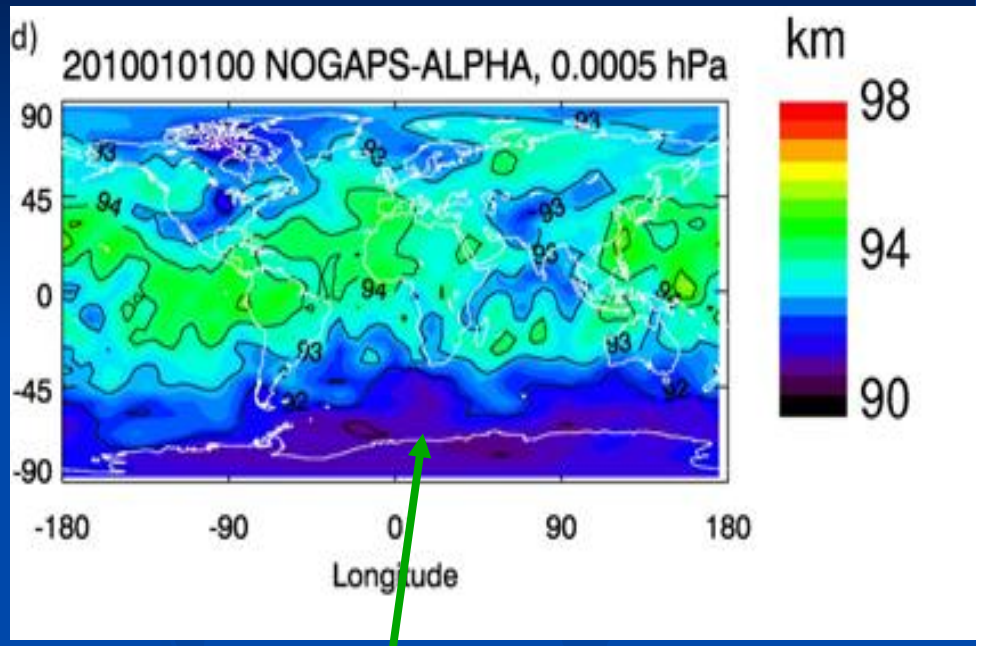


December solstice

NAVDAS top boundary = bottom boundary of TIEGCM
→ Z = -7, p = 0.0005 mb
What would a more realistic bottom boundary look like?

NOGAPS-ALPHA as bottom bndy





January 1st, 2010

Effect of the cold summer mesopause

Note the 3 km decrease in geopotential height going towards SP

Winter Stratospheric Analogue

From Andrews et al., 1987

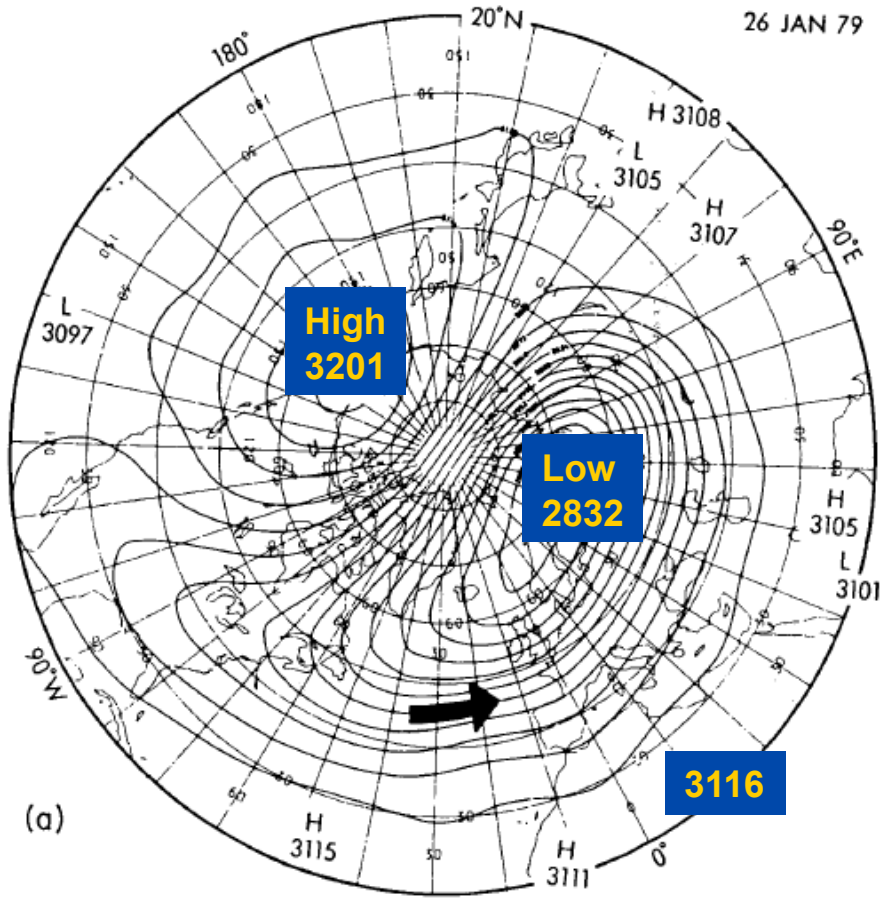
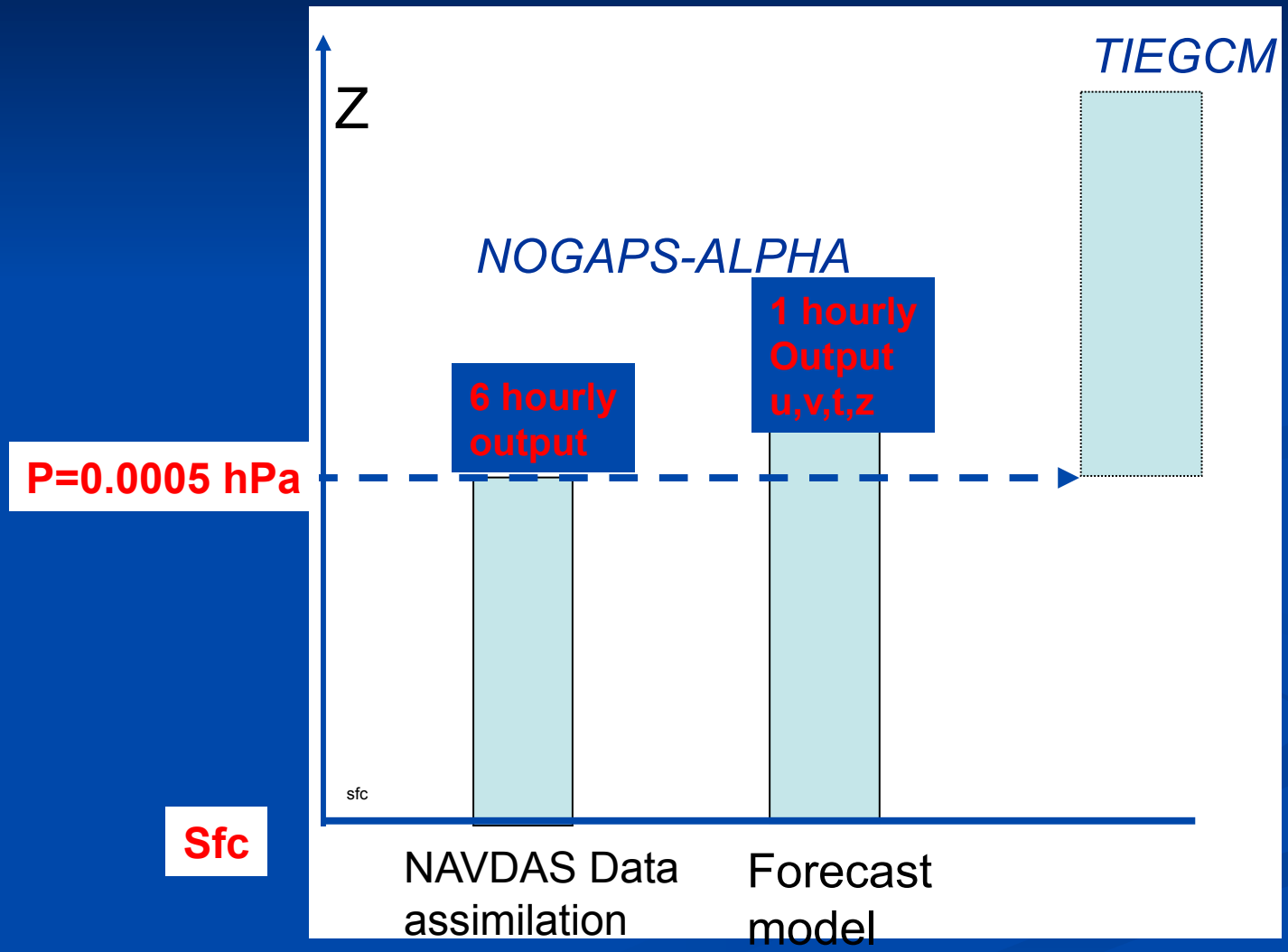


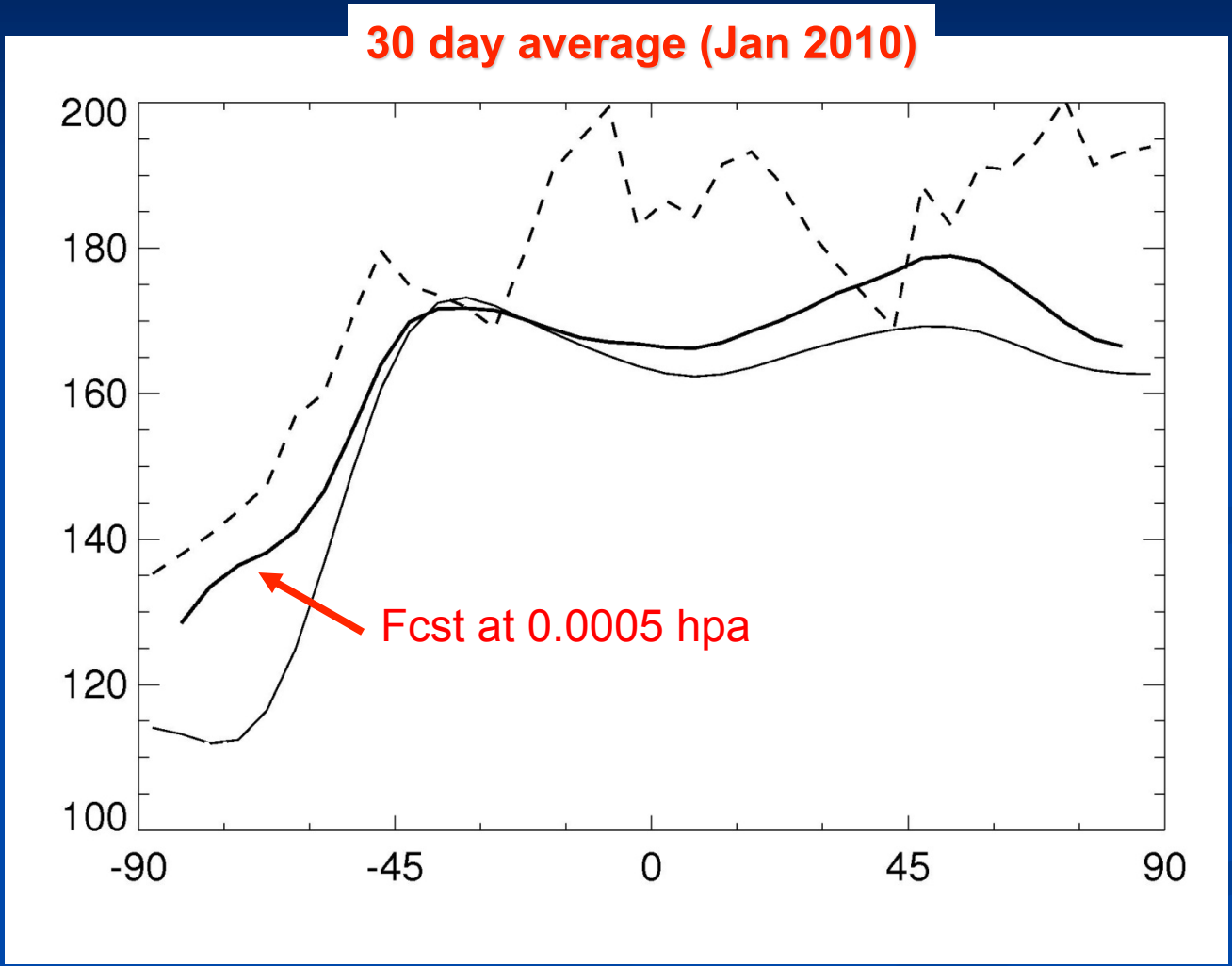
Fig. 5.6. Polar stereographic maps (outer circle: 20°N) of (a) NMC-based analysis of the 10 mb geopotential height (decameters) on January 26, 1979. (b) Coarse-grain estimate of Ertel's potential vorticity divided by gH/p (where H = 6.6 k

A 3.5 km height depression corresponds to a cyclonic vortex.

Information flow: Whats the best bottom bndy?

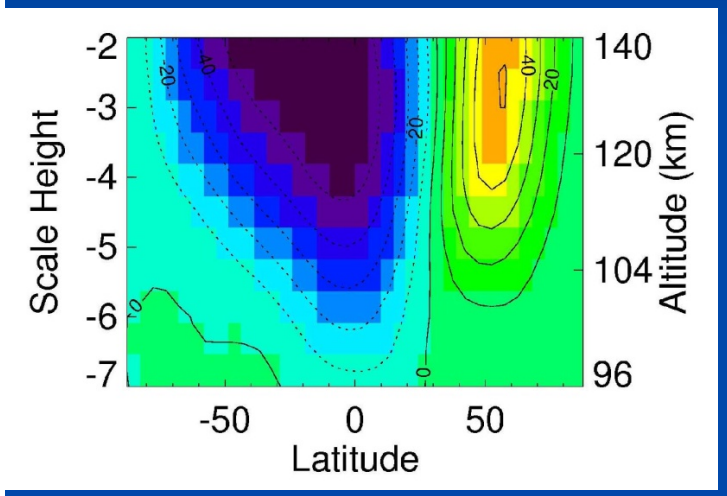


Validate the TIEGCM bottom bndy with OSIRIS temperatures

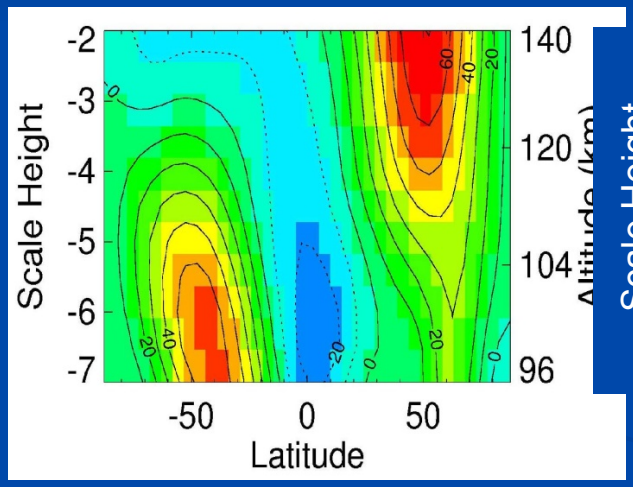


Comparison of zonal mean, monthly ave U, with HWM climatology

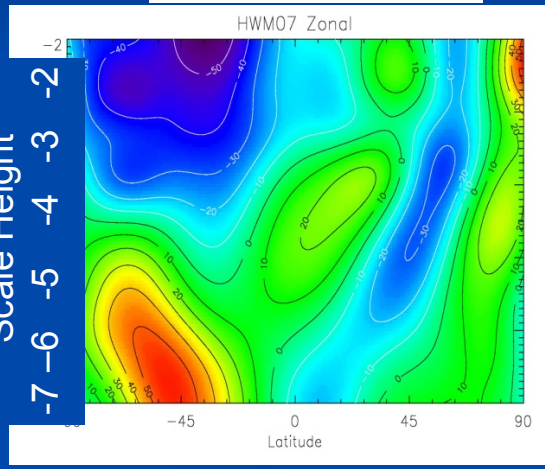
GSWM bottom bndy



NOGAPS-α bottom bndy



DATA (HWM)

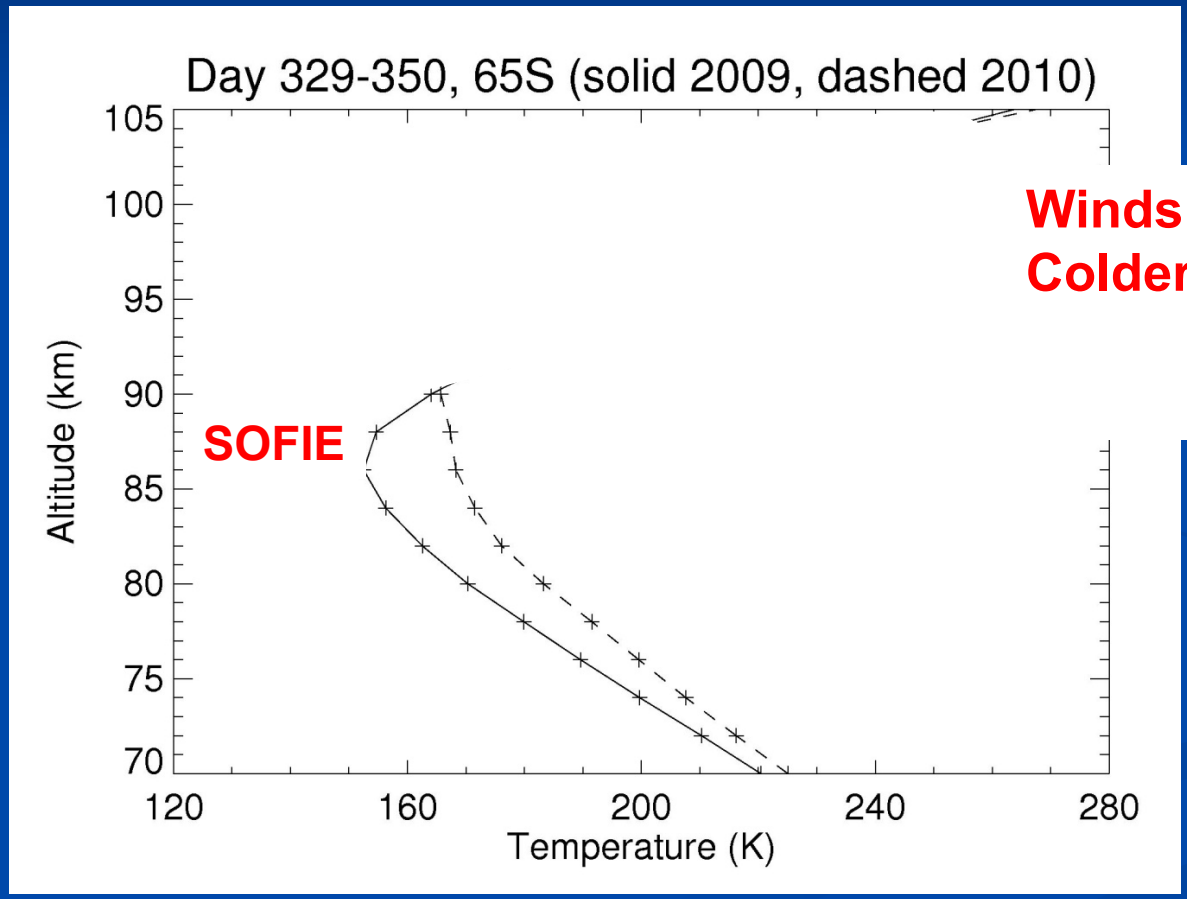


Mainly WINDII data

Summertime lower thermosphere (90-130 km) resembles the wintertime lower stratosphere: westerly vortex atop a cold pole

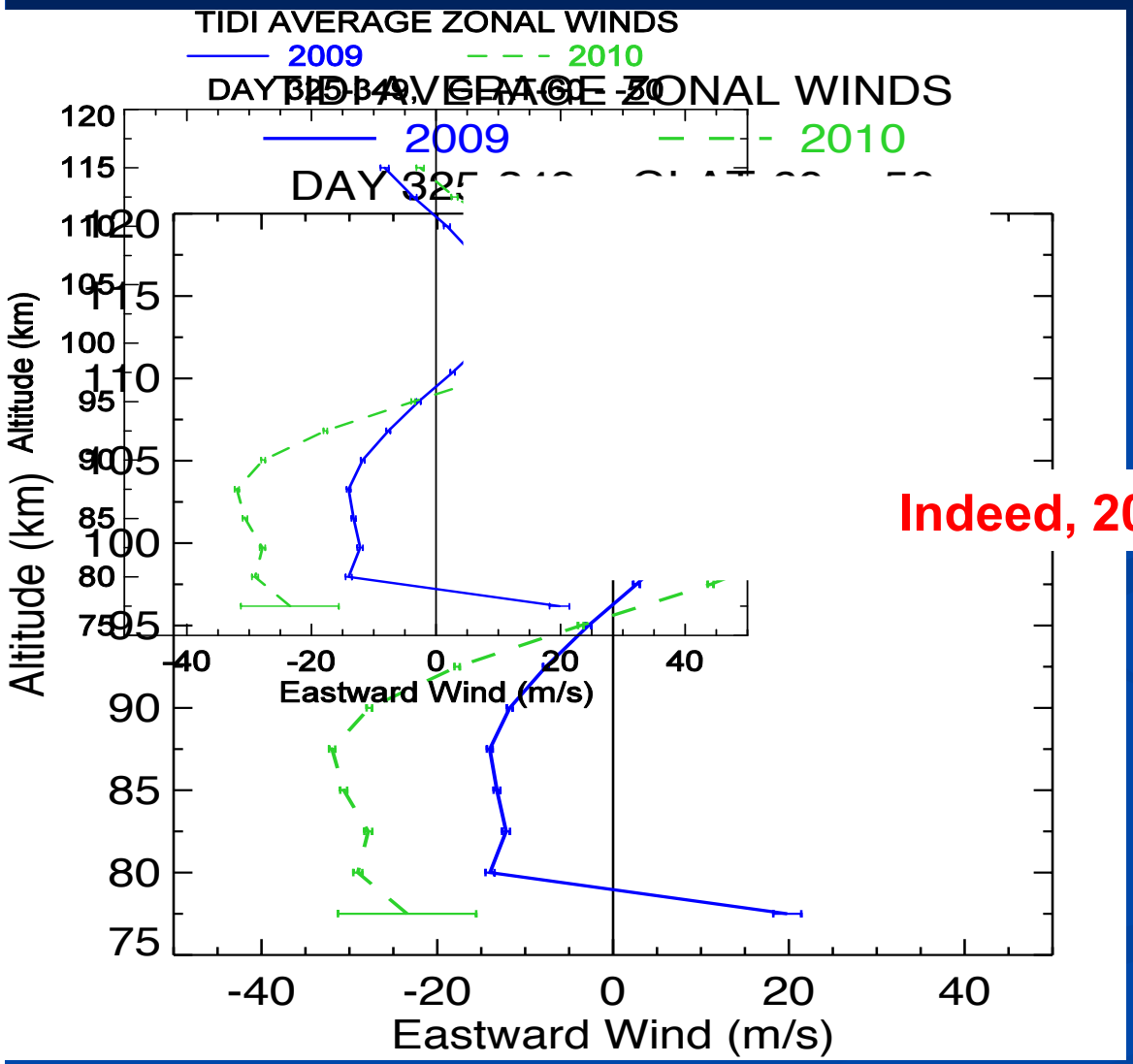
Variations in the SH cold summer onset

Early December onset varies due to underlying stratospheric dynamics



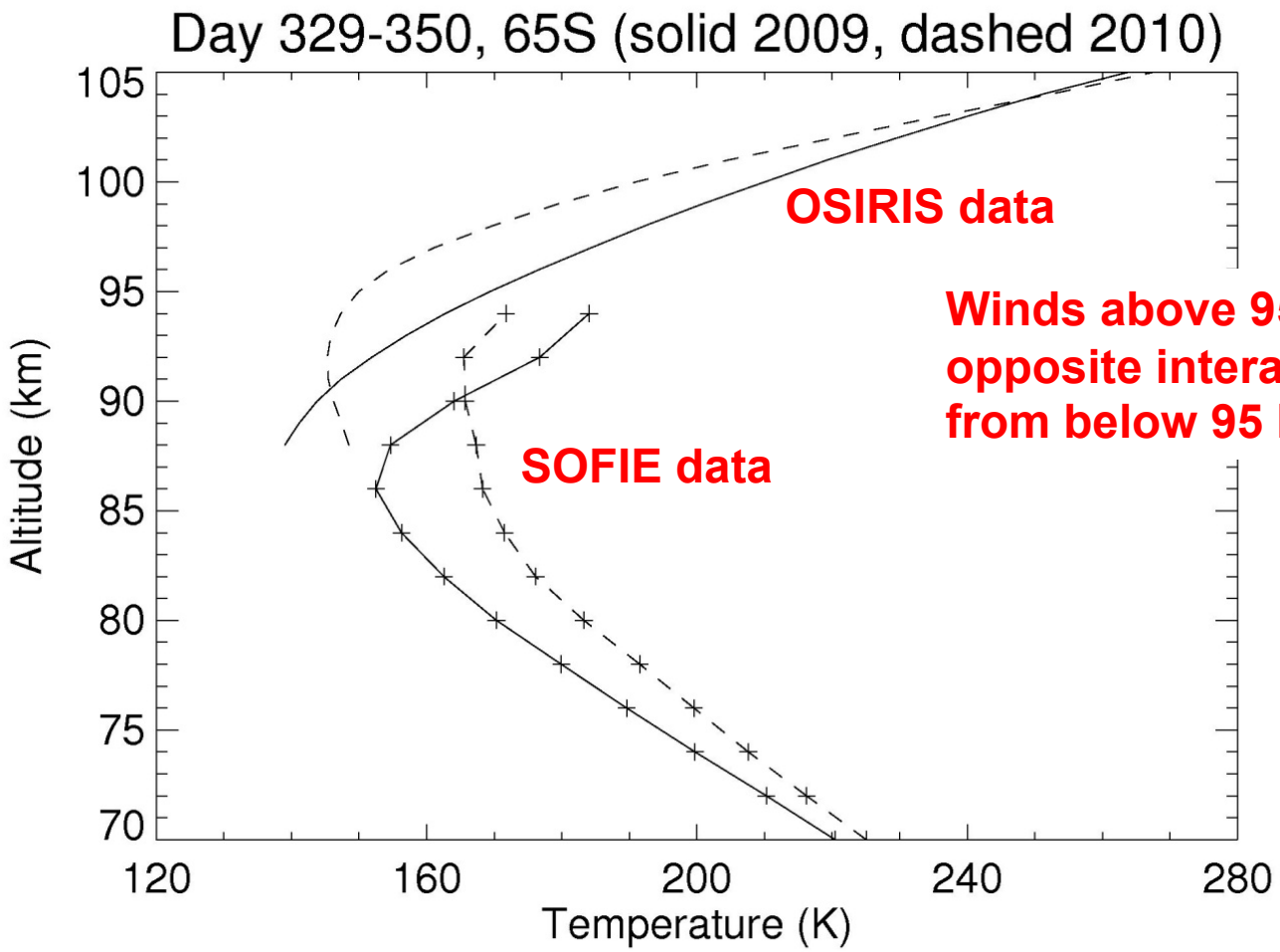
Winds should be affected
Colder pole (i.e. 2009) → faster westerlies or weaker easterlies

TIDI winds consistent with temperature



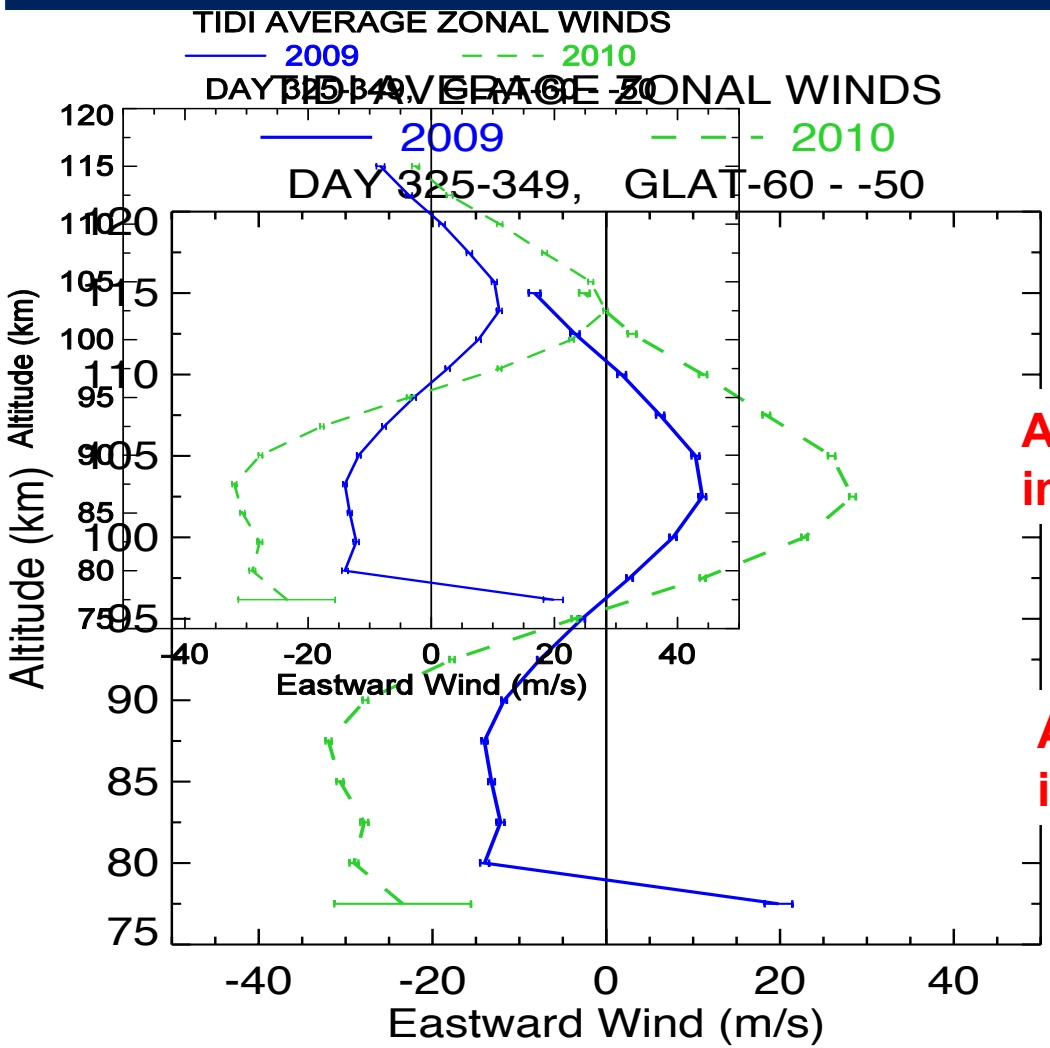
Indeed, 2009 has weaker easterlies

Variability in Cold Summer Mesopause at all altitudes



Winds above 95 km should have opposite interannual variability from below 95 km

Winds up to 115 km balance changing mesopause temps



At 95-100 km, temps were colder in 2010

At 80-85 km, temps were colder in 2009.

Conclusions

Mesospheric temperature structure effects thermospheric winds throughout the domain, including regions where ion-neutral coupling is important. Have identified a 2nd polar vortex for the terrestrial atmosphere

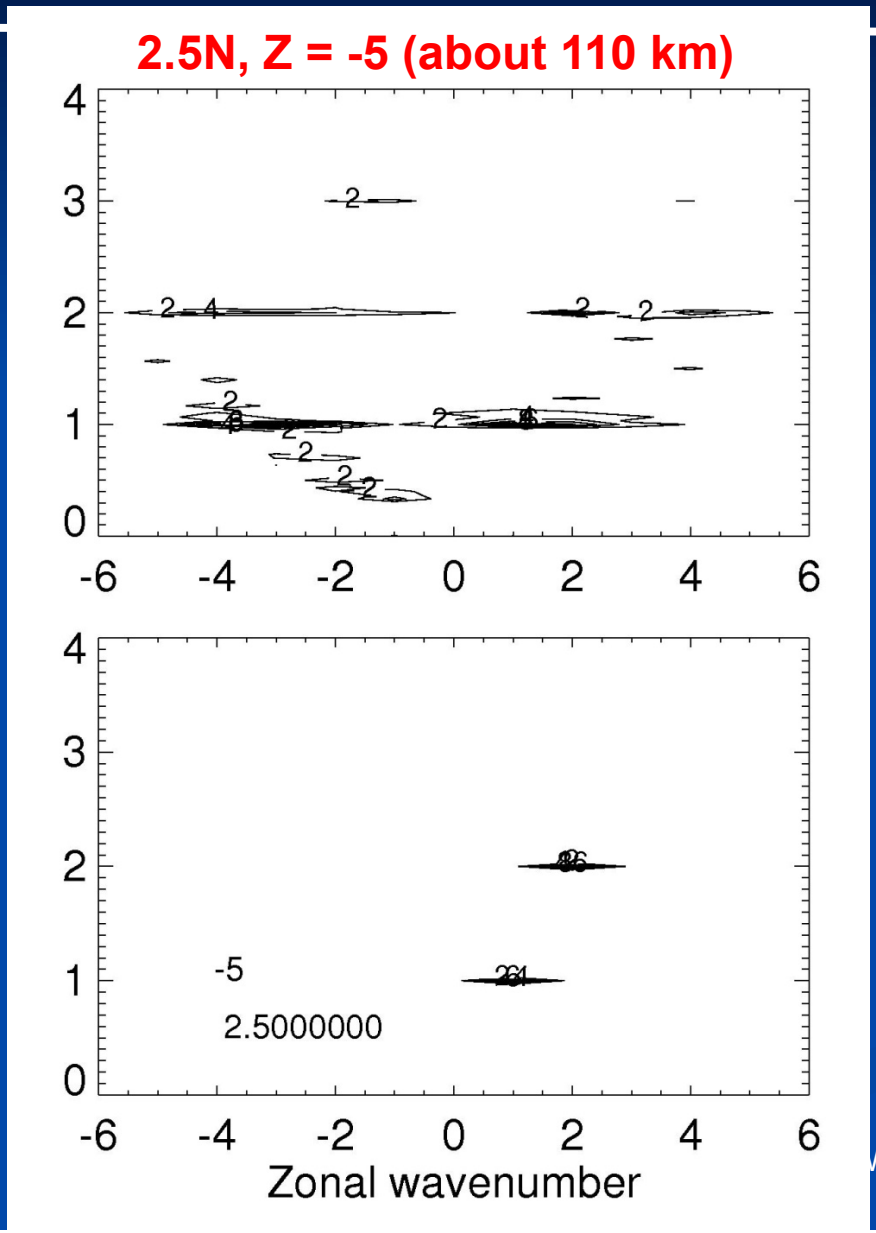
Variability in this structure (linked to the stratosphere) is consistent with TIDI winds up to 115 km.

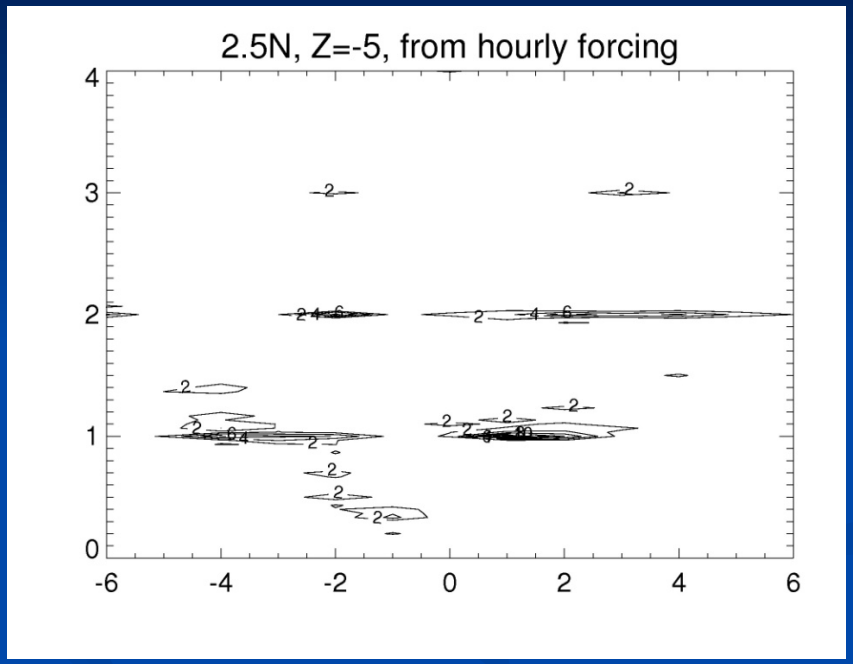
Implication is that stratospheric variability (the Antarctic ozone hole) can thus couple to the thermosphere and via ion-neutral coupling → ionosphere

Understanding mesopause variability is important for space weather

Tides: Examples of Spectra

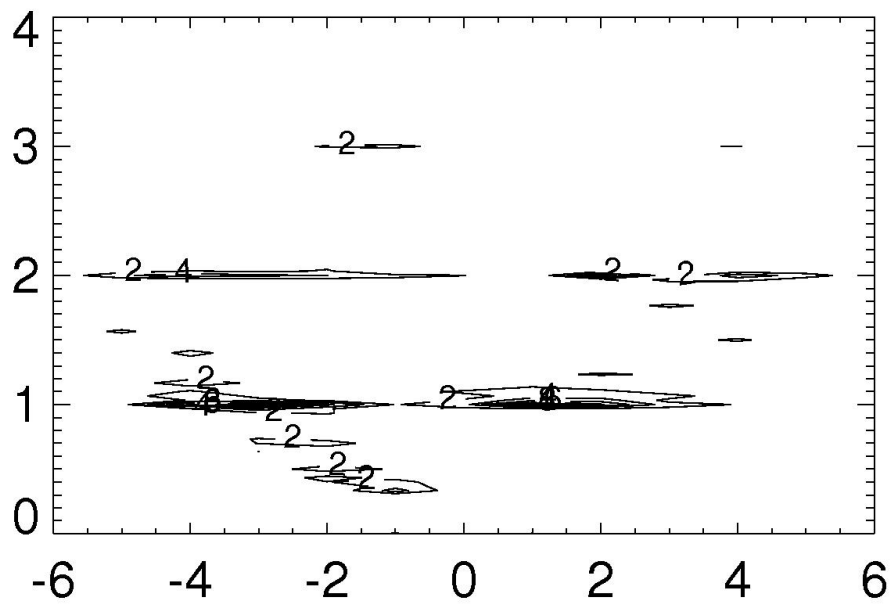
Cycles/Day

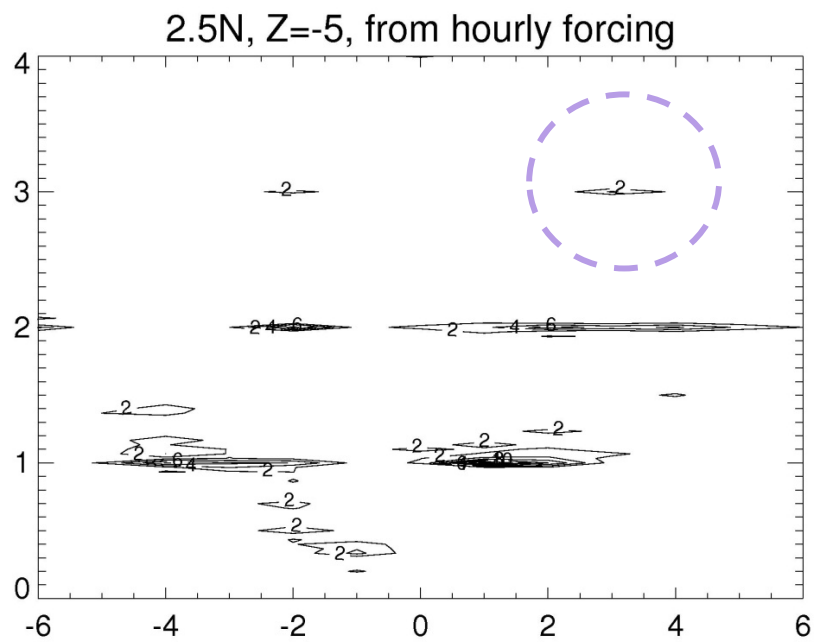




Comparison of 6 hourly and hourly forcing

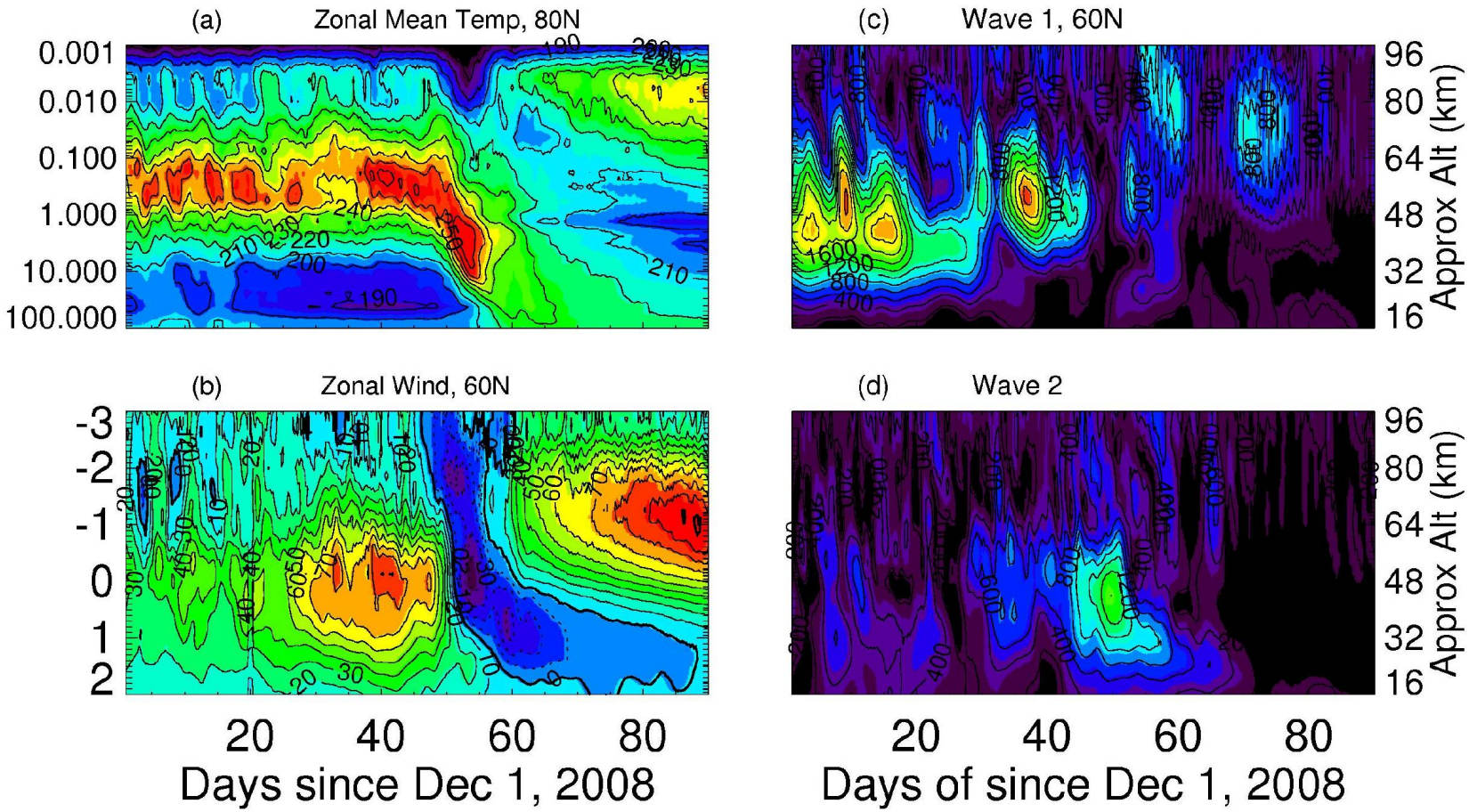
From 6 hourly (NAVDAS) forcing



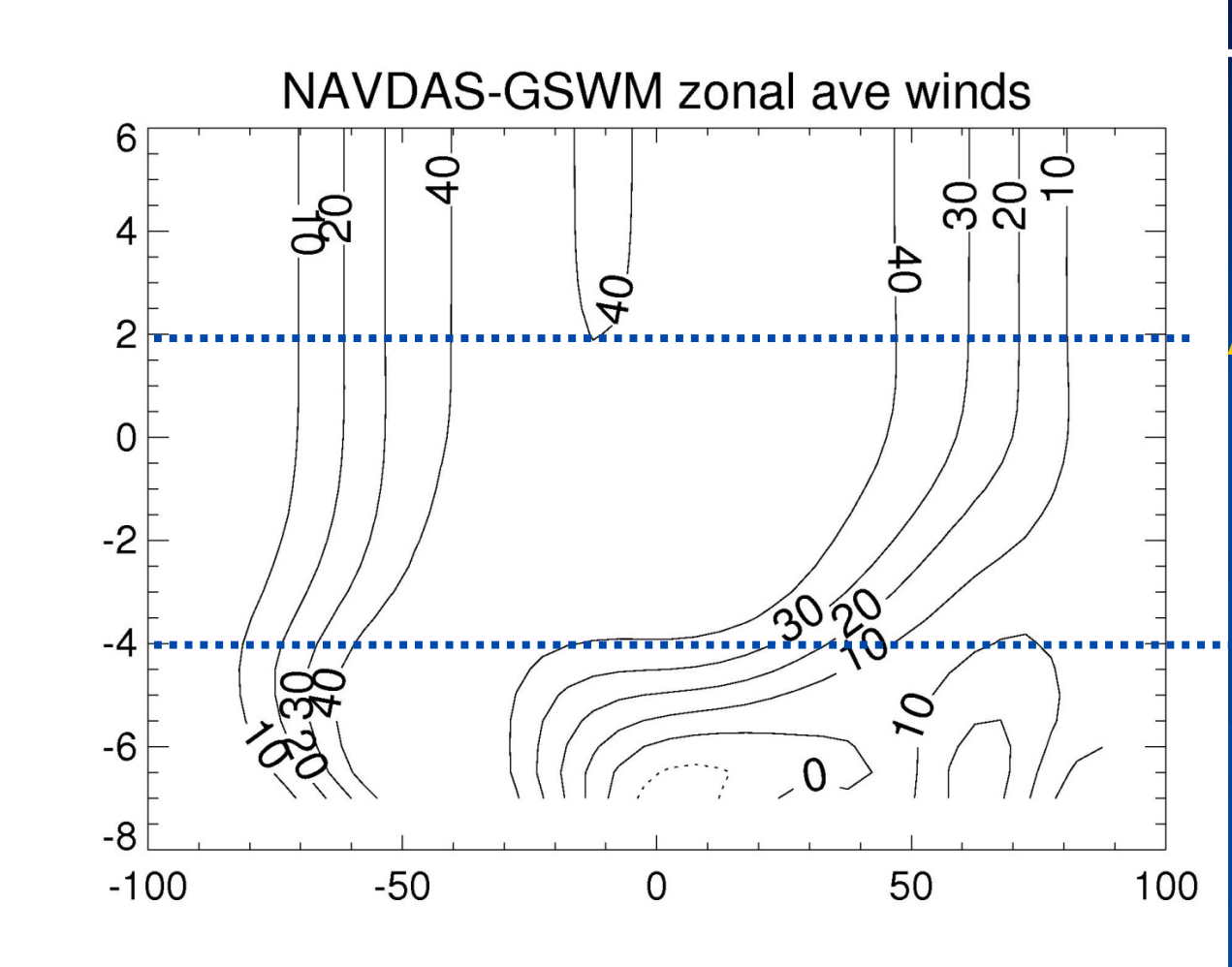


NH winter 2008-2009

The NAVDAS 3D-var analysis, every 6 hours

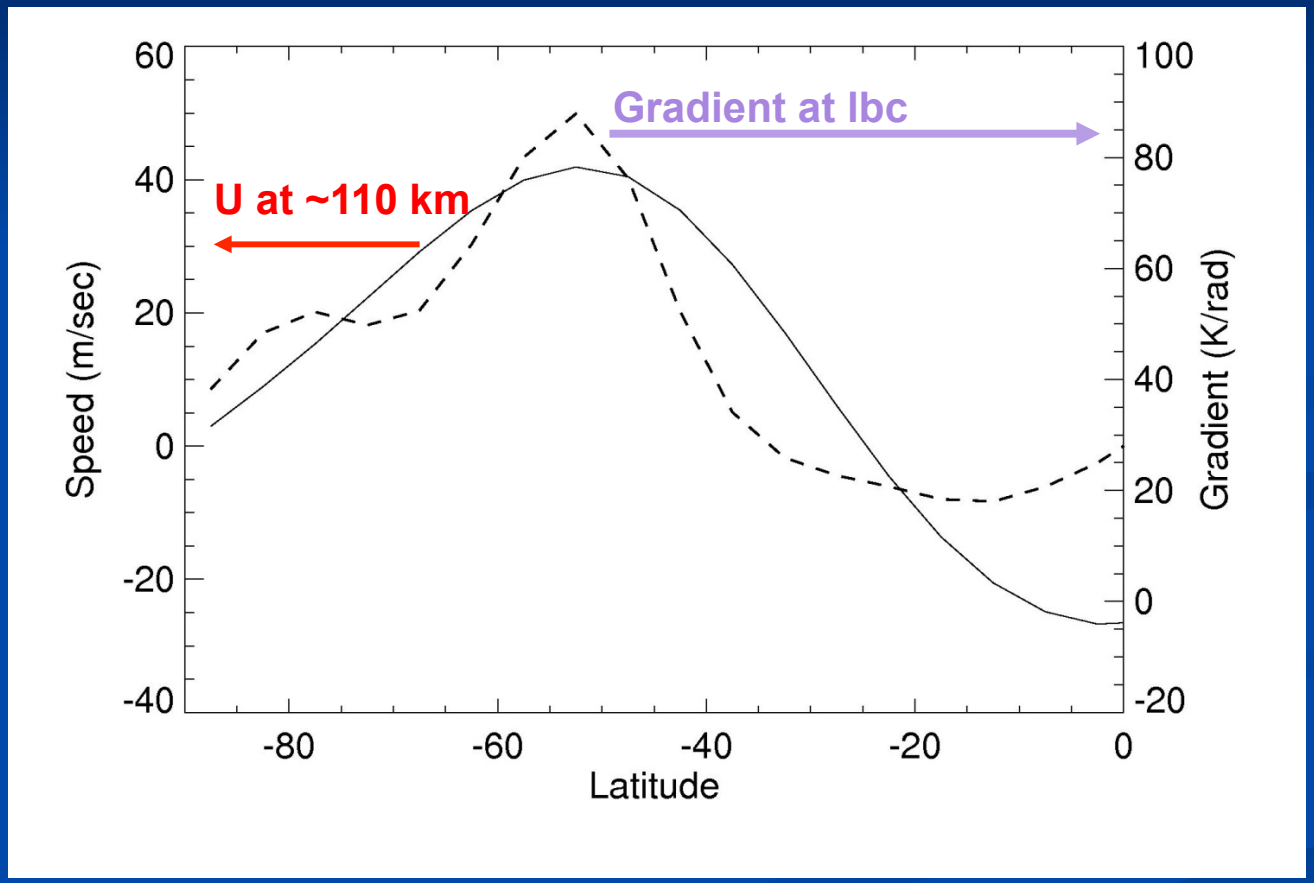


Difference field

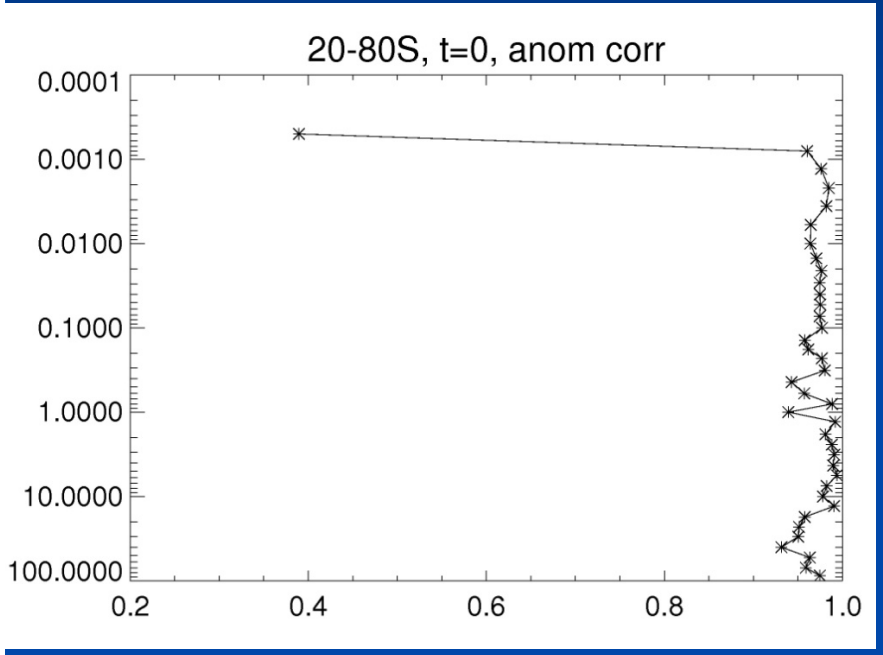


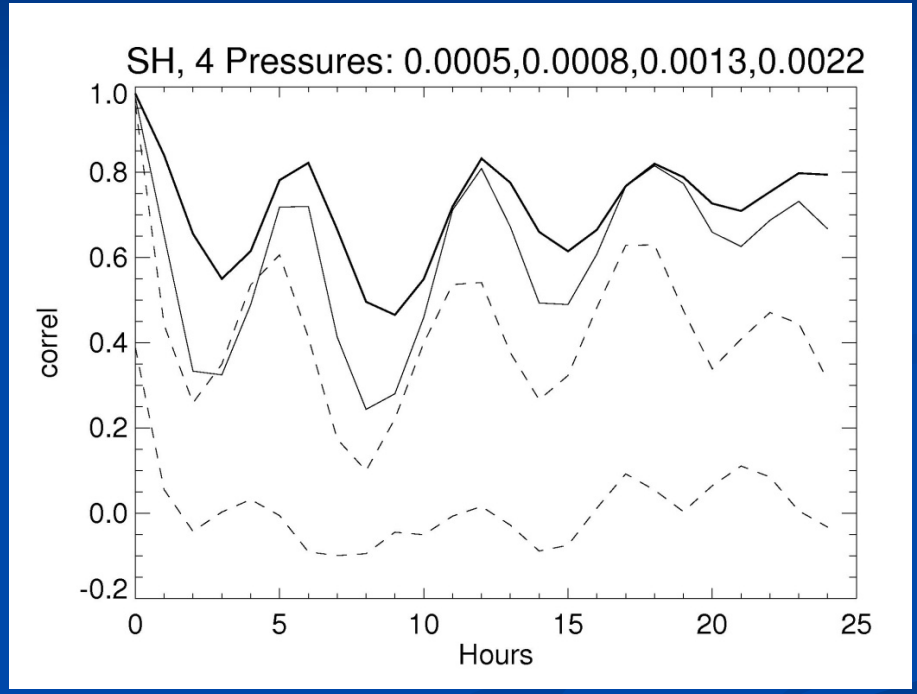
Molecular viscosity leads to height independent perturbations

Check Thermal Wind



Forecast vs. analysis comparison:
a 24 hour forecast run from January 1st, 00UT





Evidence for some skill at 6 hours at mesopause
(about like a 5 day forecast in troposphere)