The PMC Region as an integrator of coupling processes

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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 2\textsuperscript{nd} polar vortex
3. Observations of variability and a new mode of strat-therm coupling
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)
The NAVDAS 3D-var analysis, every 6 hours

(a) Zonal Mean Temp, 80N

(b) Zonal Wind, 60N

(c) Wave 1, 60N

(d) Wave 2

Days since Dec 1, 2009

CAWSES/PMC Trends Workshop May 2012
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
$\rightarrow Z = -7, p = 0.0005 \text{ mb}$
What would a more realistic bottom boundary look like?
January 1\textsuperscript{st}, 2010

**Effect of the cold summer mesopause**

Note the 3 km decrease in geopotential height going towards SP
A 3.5 km height depression corresponds to a cyclonic vortex.
Information flow: What's the best bottom boundary?

- NAVDAS Data assimilation
- 6 hourly output
- 1 hourly output u,v,T,Z
- TIEGCM
- P=0.0005 hPa
- Sfc

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Validate the TIEGCM bottom bndy with OSIRIS temperatures

30 day average (Jan 2010)

Fcs at 0.0005 hpa
Summertime lower thermosphere (90-130 km) resembles the wintertime lower stratosphere: westerly vortex atop a cold pole

Mainly WINDII data
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
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.
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

2.5N, Z = -5 (about 110 km)

Cycles/Day

2.5N, Z=5, from hourly forcing
Comparison of 6 hourly and hourly forcing

From 6 hourly (NAVDAS) forcing

2.5N, Z=-5, from hourly forcing
The NAVDAS 3D-var analysis, every 6 hours
Molecular viscosity leads to height independent perturbations

About 120 km

About 200 km
Check Thermal Wind

Gradient at Lbc

U at ~110 km
Evidence for some skill at 6 hours at mesopause
(about like a 5 day forecast in troposphere)