WACCM-X Development, Validation and Research

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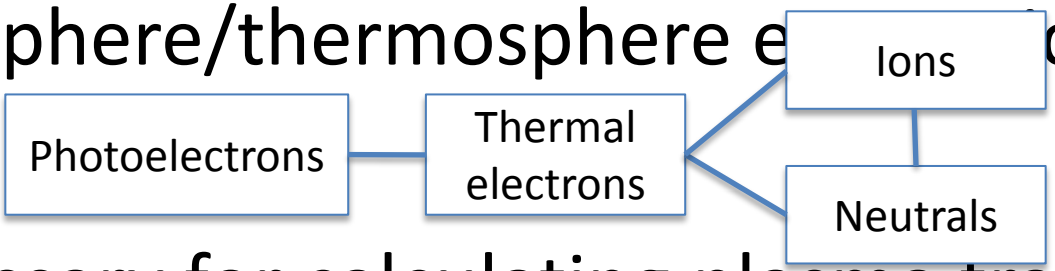
Outline

- WACCM development
  - Electron/ion energy equations.
  - Parameterization of inertial gravity wave for QBO generation.
  - WACCMX merging into the CESM trunk.
- Validation/model comparisons: thermospheric tides.
  - Comparisons with NOAA WAM.
  - Comparisons with observations.
- Non-migrating tides change during SSW.

Electron/Ion Temperature

- Important for quantifying the ionosphere/thermosphere e cs:

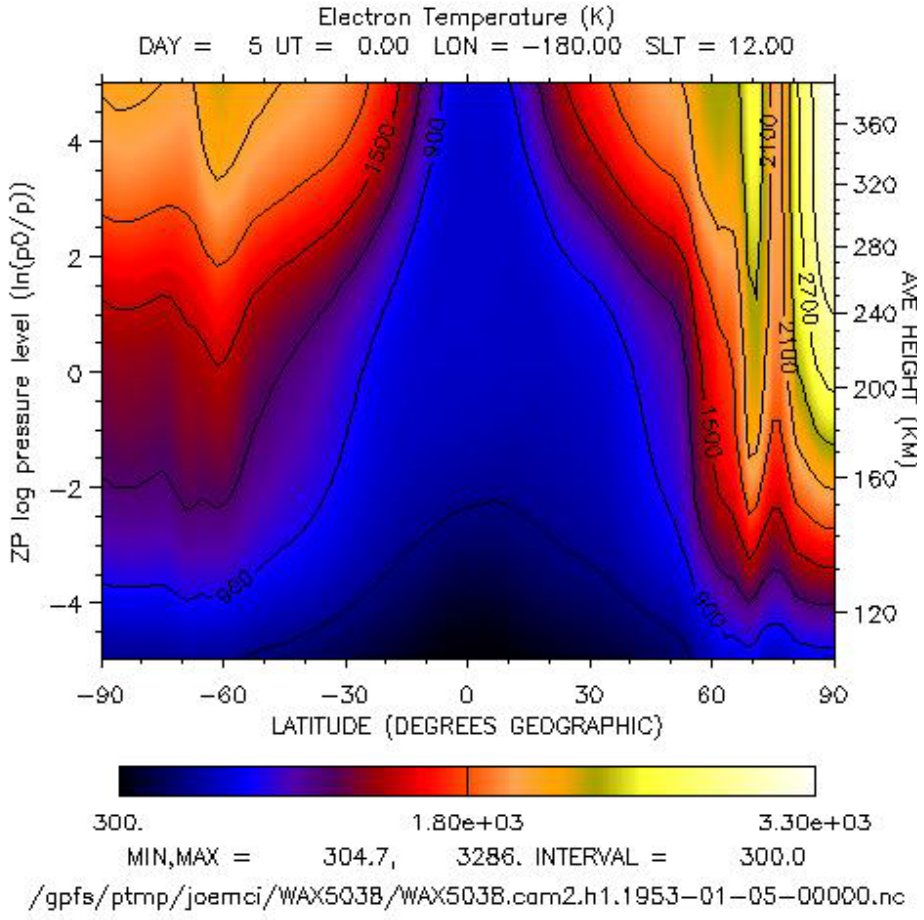


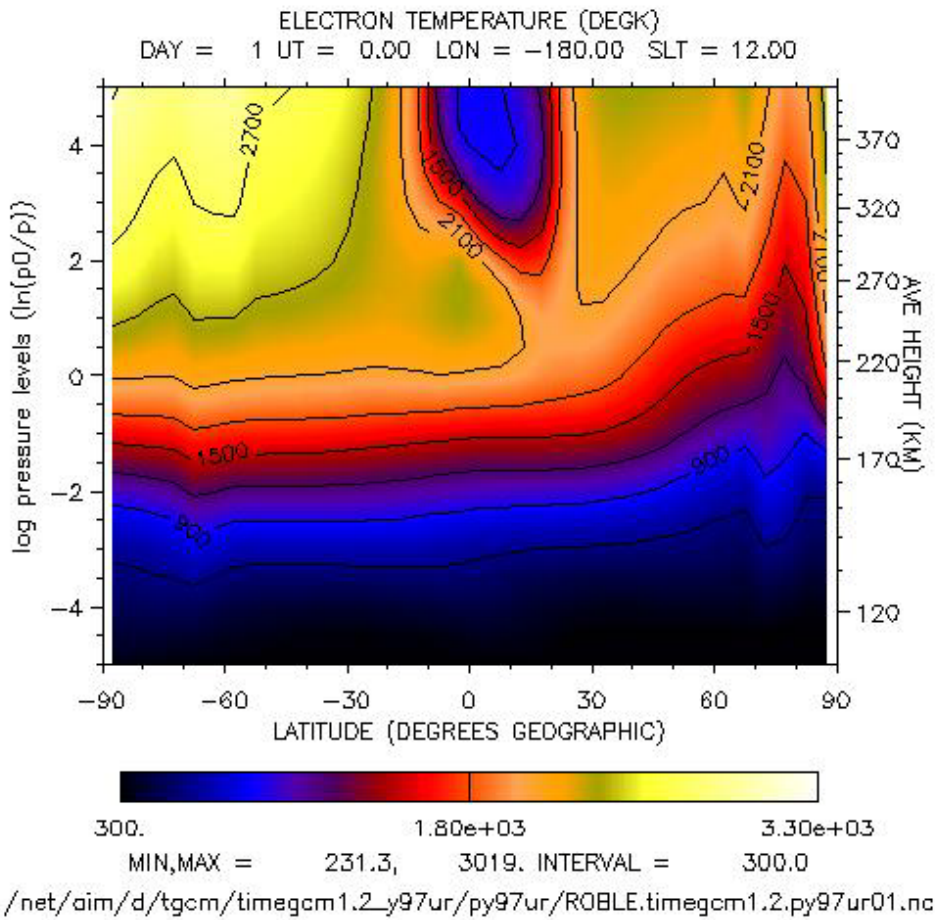
- Necessary for calculating plasma transport, thus the plasma distribution.
- A time dependent solver for

$$\frac{3}{2} n_e k \frac{\partial T_e}{\partial t} = \sin^2 I \frac{\partial}{\partial z}(K_e \frac{\partial T_e}{\partial z}) + Q_e - L_e - \sum_i \frac{\rho_e \nu_{ei}}{m_i} 3k(T_e - T_i) - \sum_i \frac{\rho_e \nu_{en}}{m_n} 3k(T_e - T_n)$$

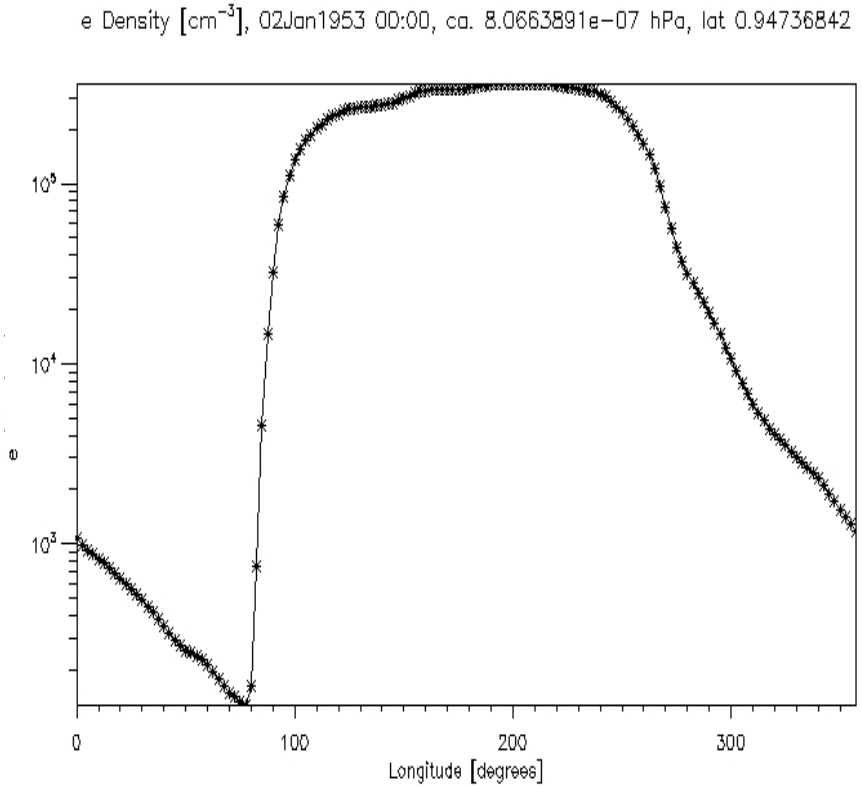
with electron heat flux imposed at the upper boundary.

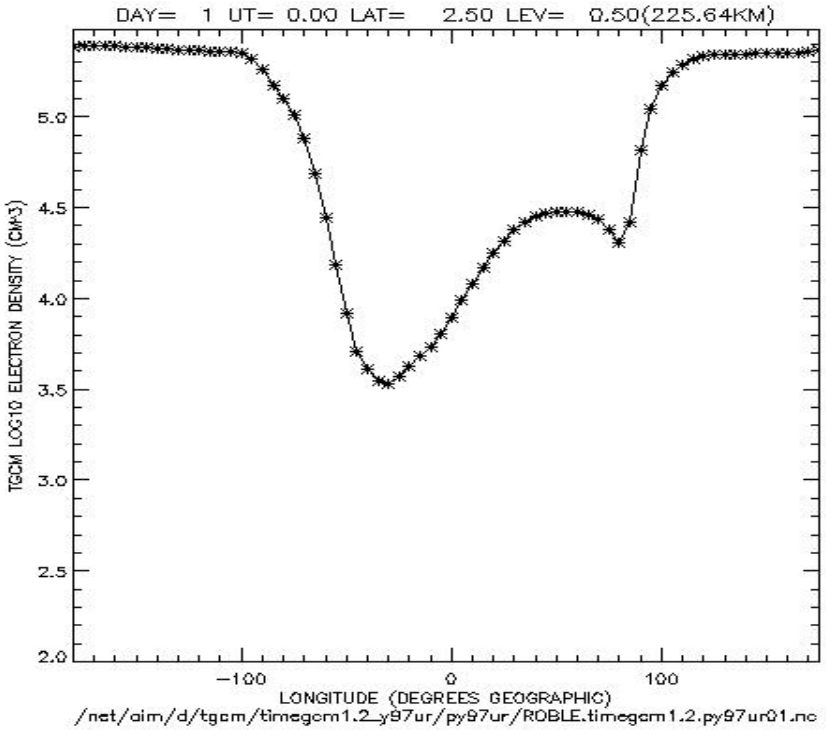
T_e: WACCMX and TIME-GCM 12LT





WACCM-X and TIME-GCM Electron Densities





QBO in WACCM

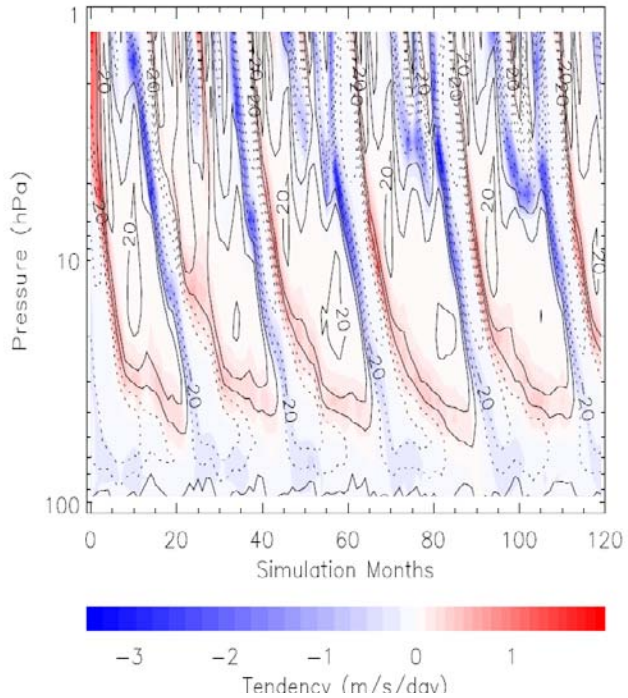
- Need for inertial gravity wave parameterization:
  - The momentum fluxes required to drive mesosphere circulation and QBO are about the same (~10^{-3} hPa)
  - GW breaking altitude ~ $2H\ln(2\pi/\lambda_h A)$: λ_h~100 km, z_b~70km; λ_h~1000 km, z_b~70km-2ln10H~37km
  - IGW not well resolved in WACCM
- Linear Saturation of IGW (*Xue, Liu and Dou, 2011*)

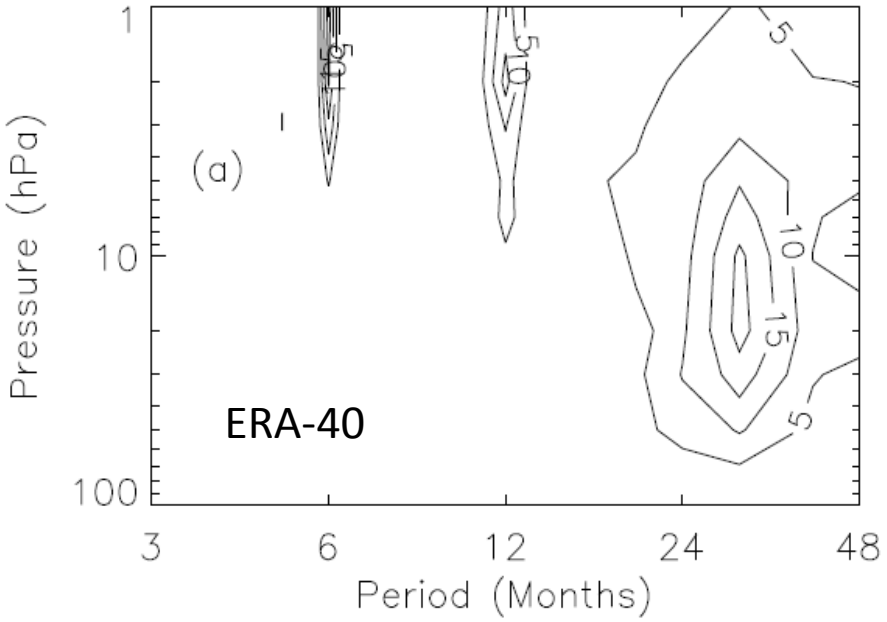
$$Critical\ region: |c-u| \le |f|/k$$

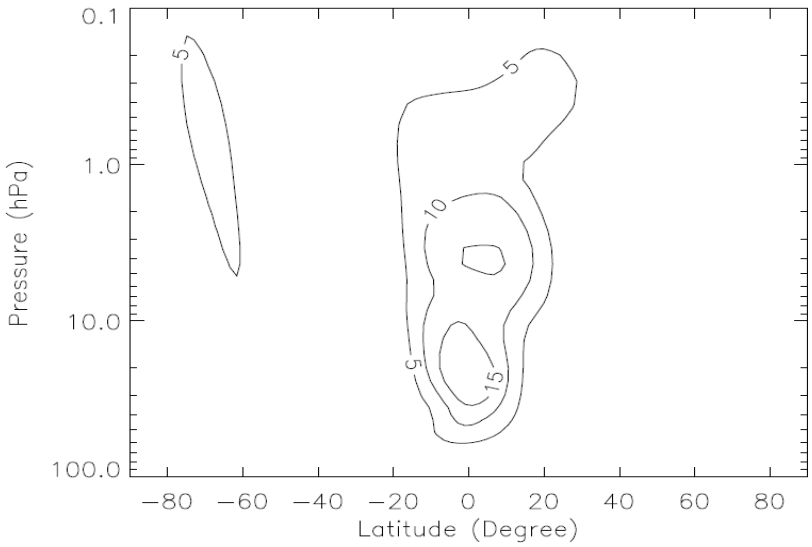
$$Acceleration\ rate: \frac{\partial u}{\partial t} = \frac{k(c-u)^2\sqrt{(c-u)^2-(f/k)^2}}{2NH}$$

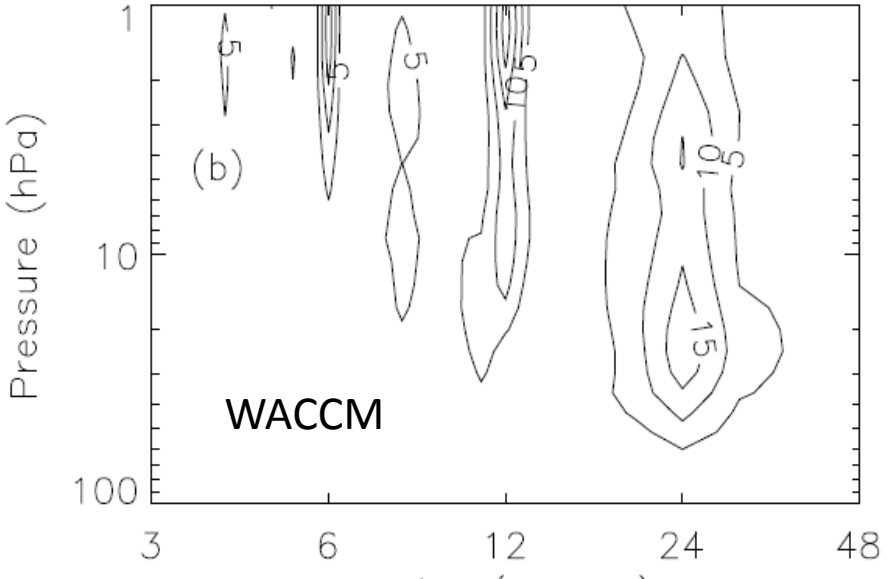
- Parameters used: λ_h=1000 km, τ=10^{-3}hPa, spectral range: -25 to 15 m/s, intermittency factor 0.1.

QBO from WACCM with Parameterized IGW









Merging WACCM-X Into Subversion CAM Trunk

- From a code perspective, WACCM-X is:

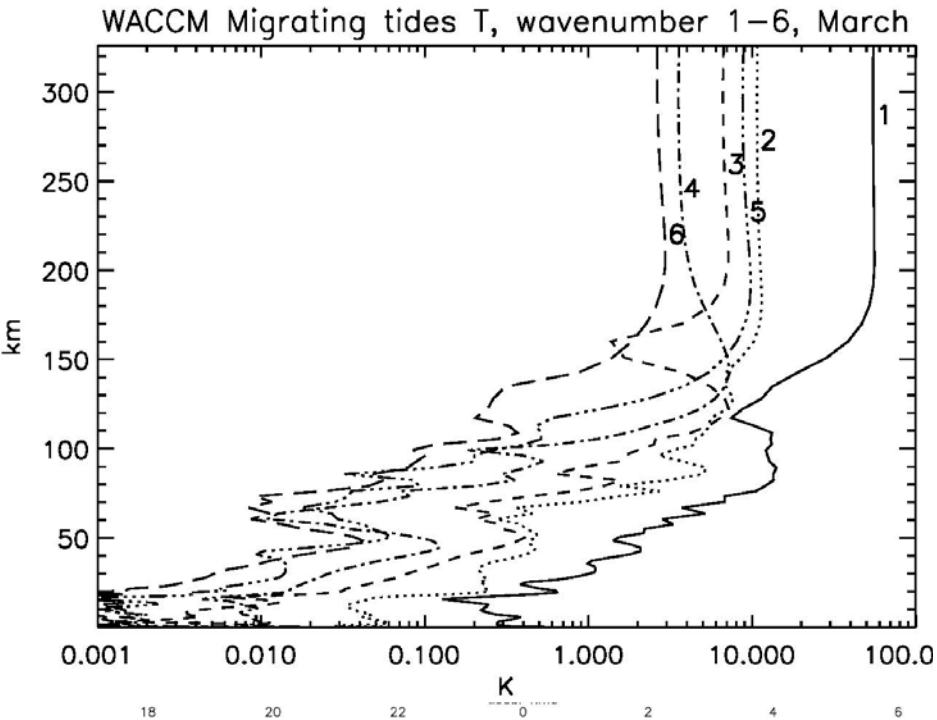
  A modification of 25 physics and chemistry modules

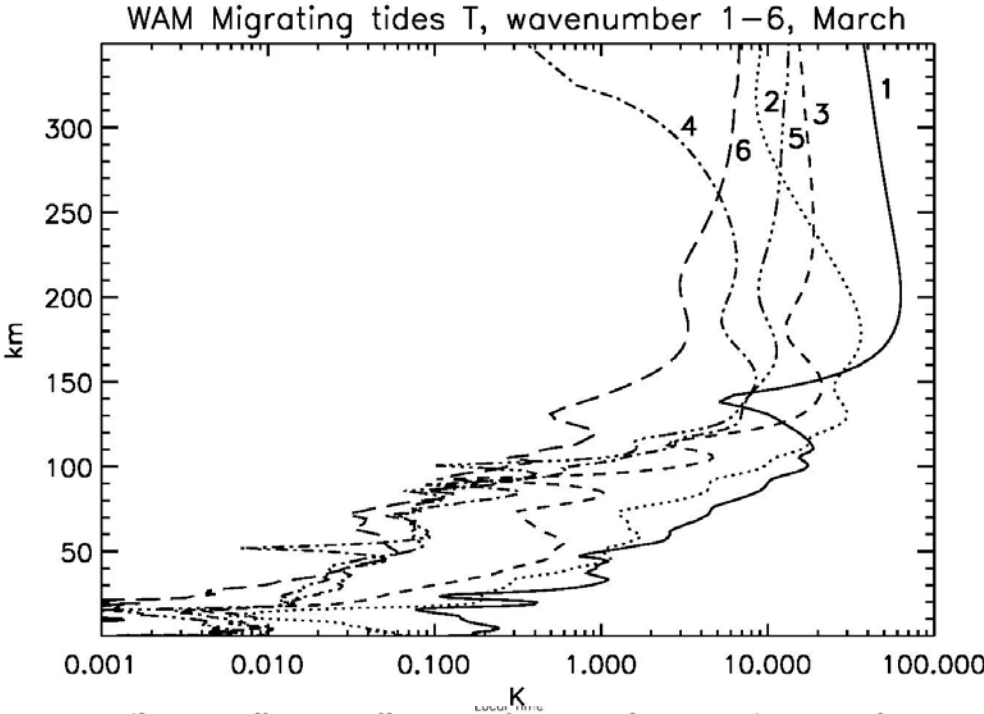
  An addition of 2 directories, 2 new modules, and 2 new XML files
- These were merged with a branch of the CAM trunk (Tag 5.0.38)
- Additional modifications made based on Francis code review
- Regression test then performed on bluefire
- Passed all bit for bit tests except known answer change from WACCM fix
- Currently in queue to be reviewed by Brian for eventual merge to head of CAM trunk

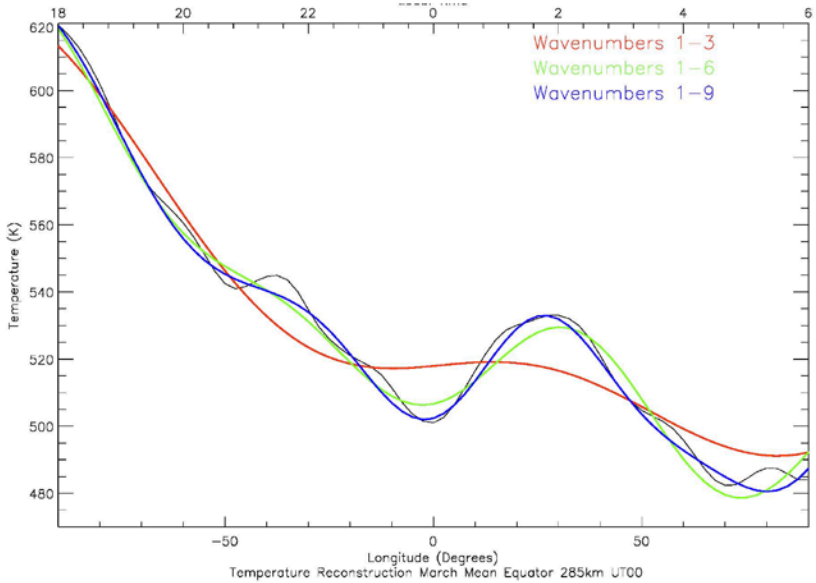
Thermosphere Tides

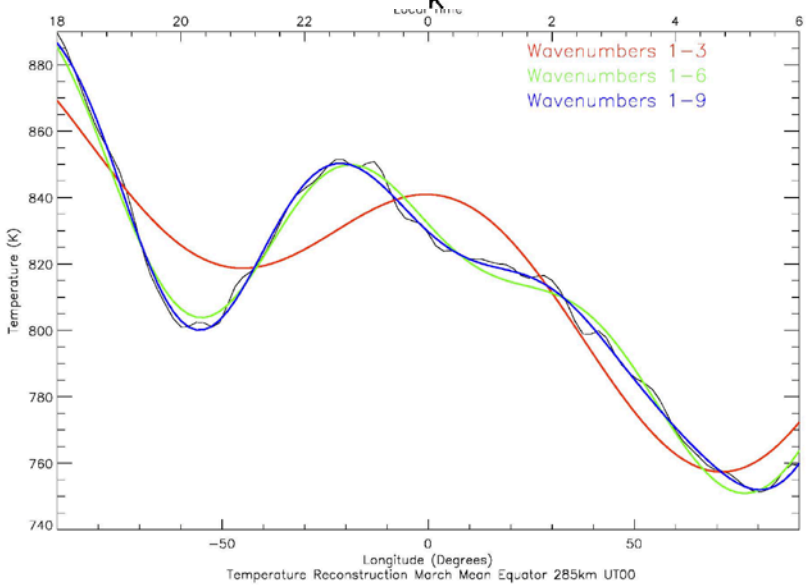
- Migrating tides: WACCM and WAM
- Non-migrating diurnal tides: WACCM and WAM
- Comparison with CHAMP

Migrating Tides

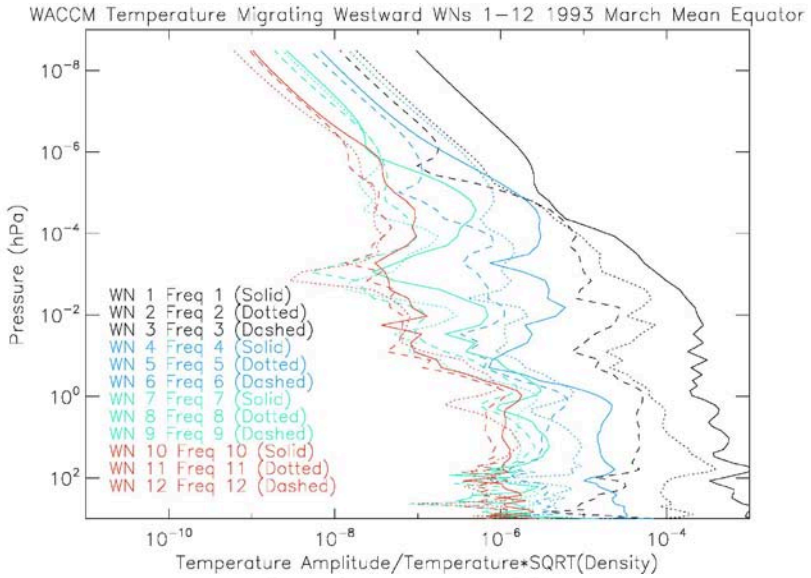


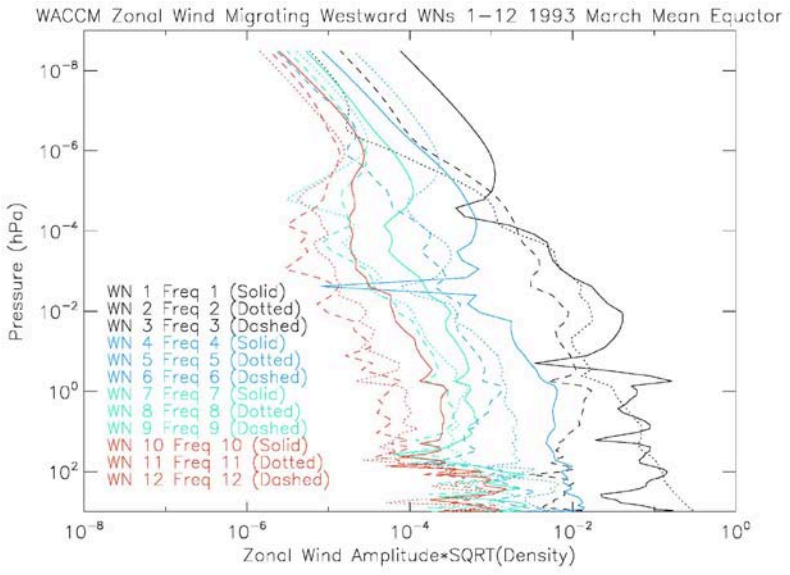


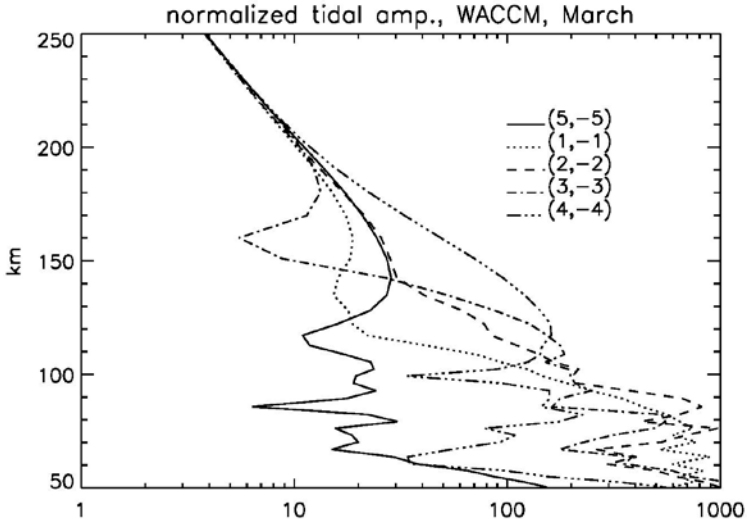


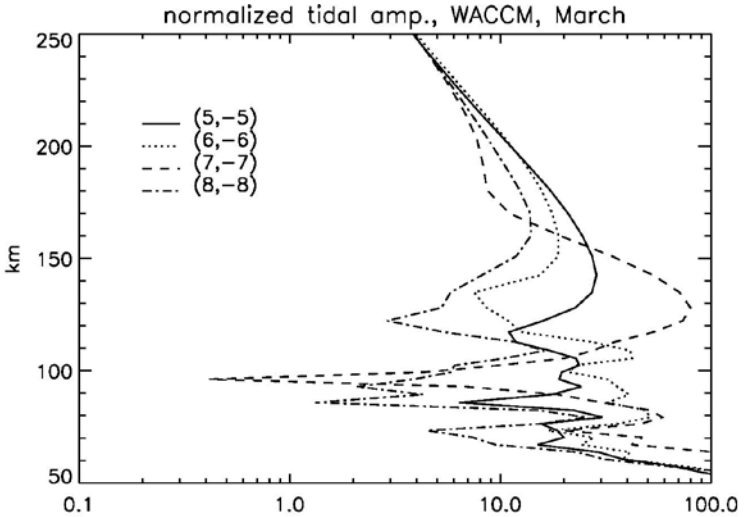


Migrating Tides: Normalized



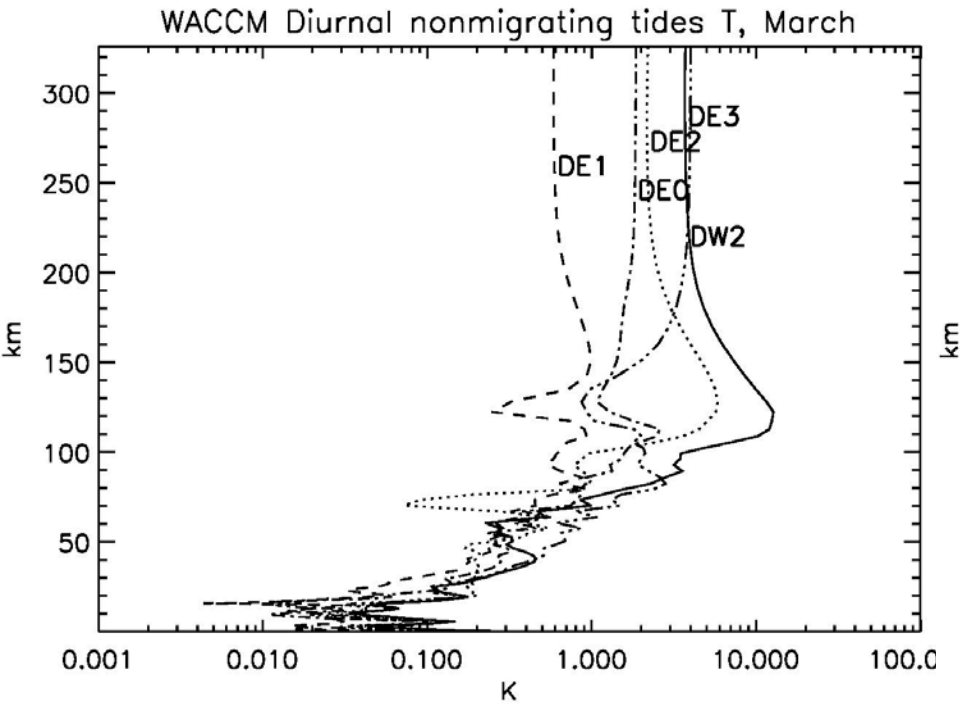


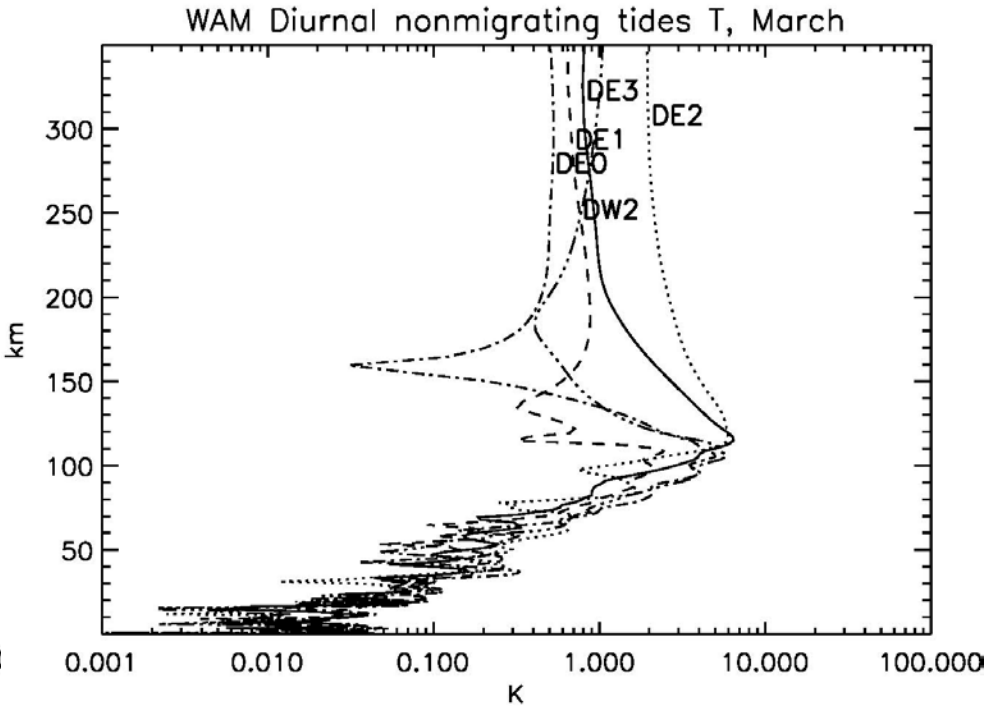




- Thermospheric tides: source and dissipation
- Dissipation: $1/Dk_z^2$ vs wave period

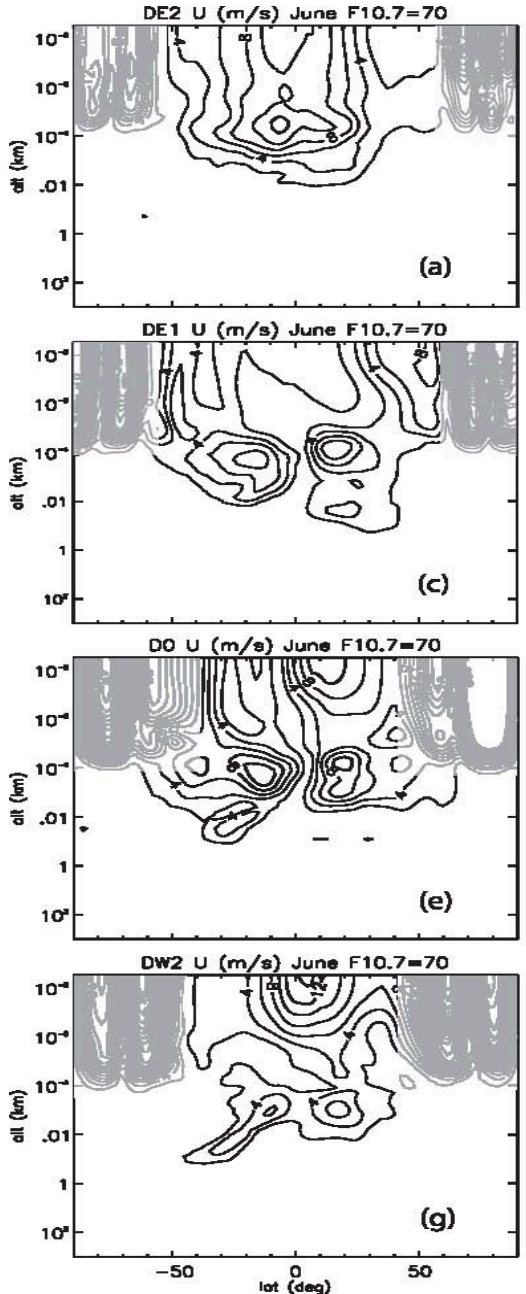
Non-migrating Tides: WACCM and WAM



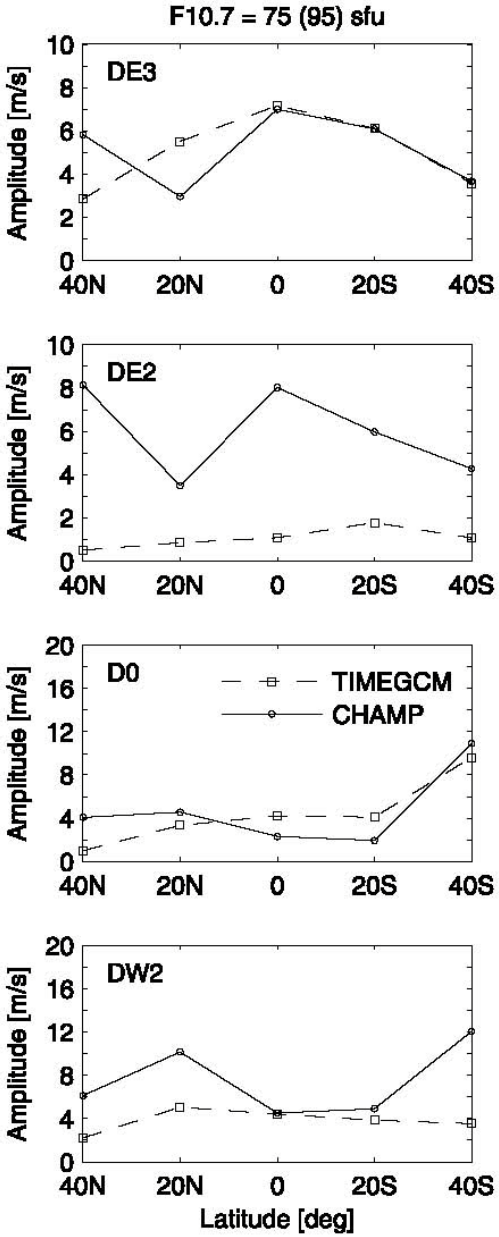


Other Diurnal Non-migrating Tides

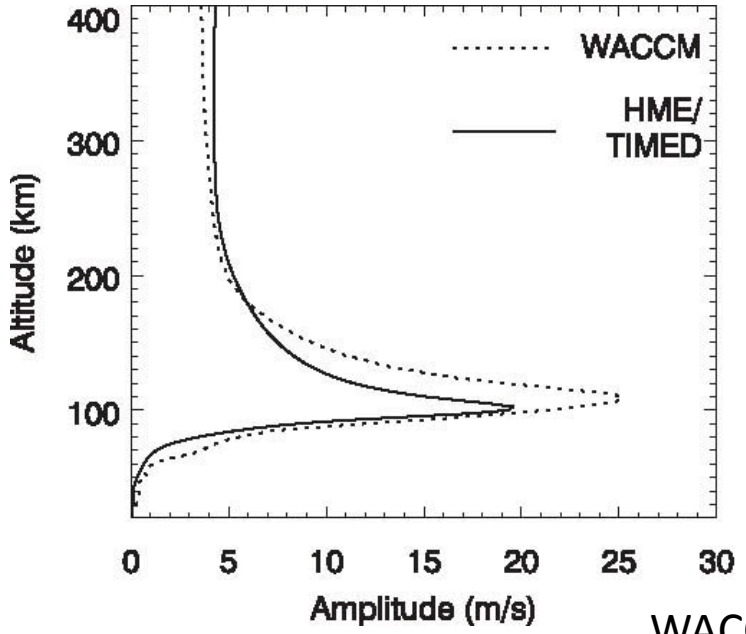
WACCMX (*Liu et al., 2010*)

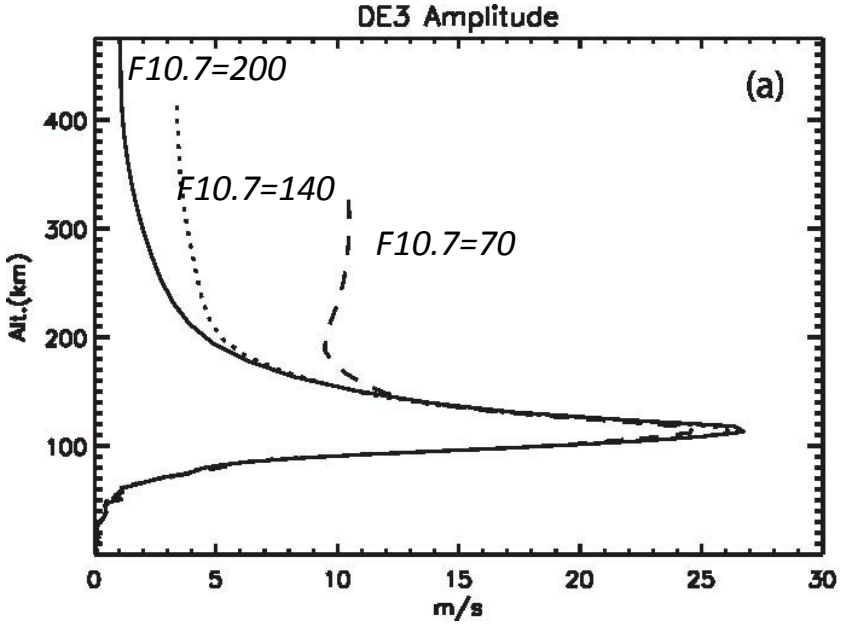


CHAMP 400 km (*Hausler et al., 2010*)

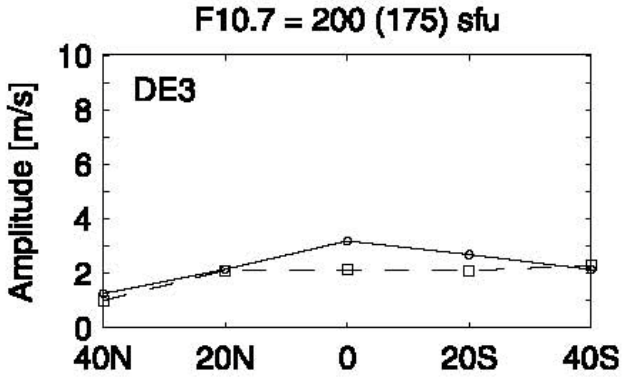


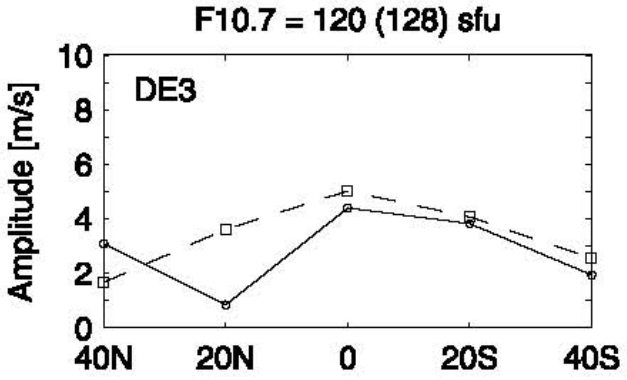
Diurnal Eastward Wavenumber 3

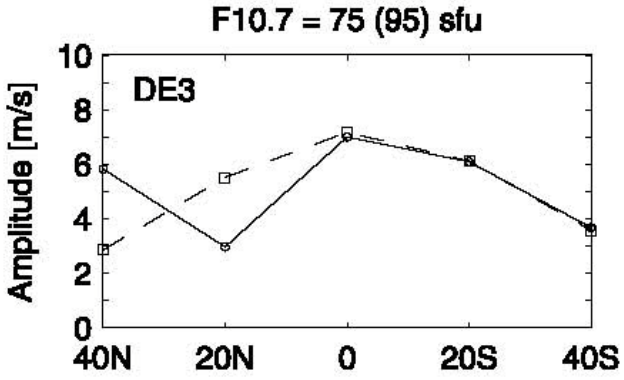




WACCMX *(Liu et al., 2010)*

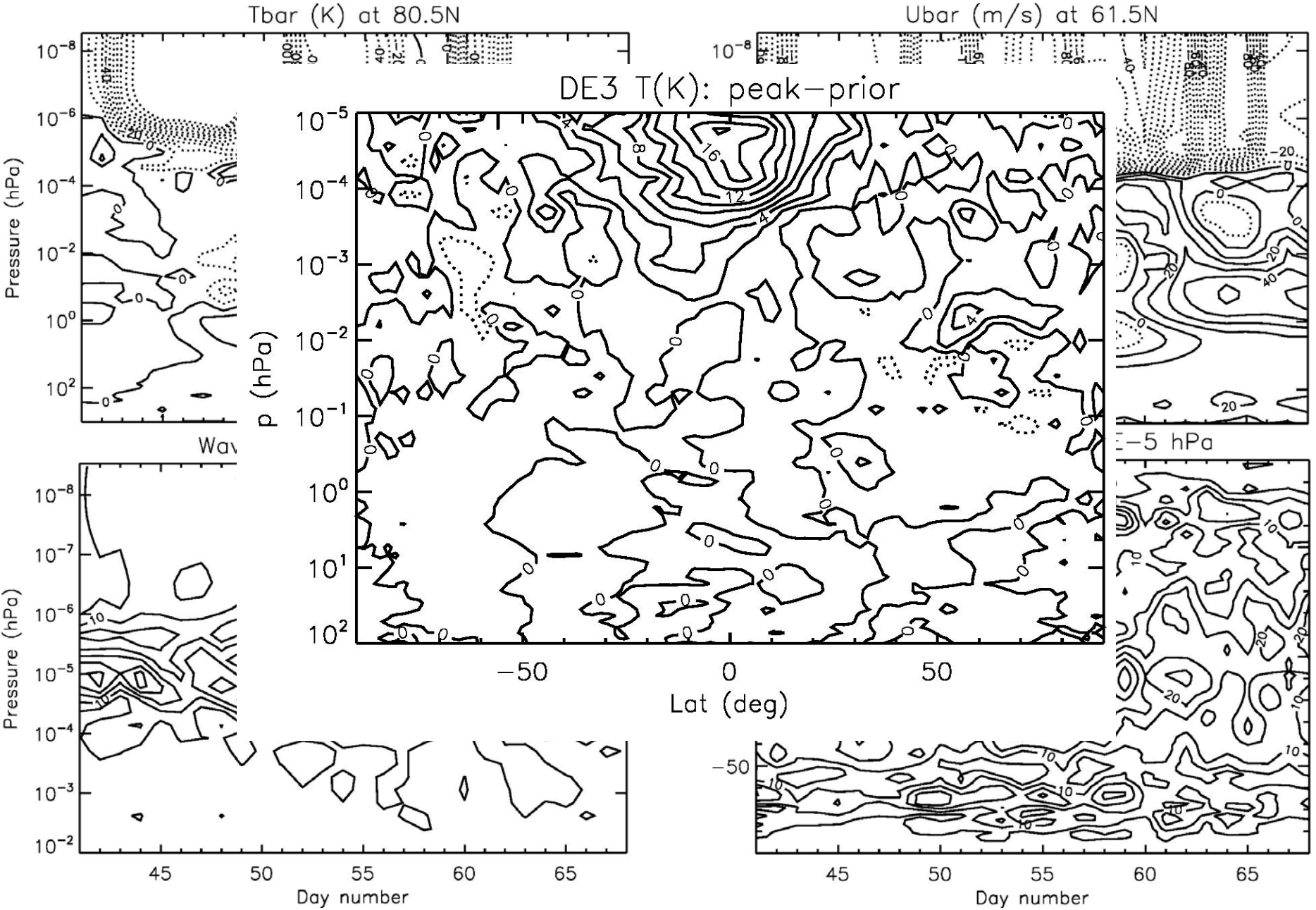




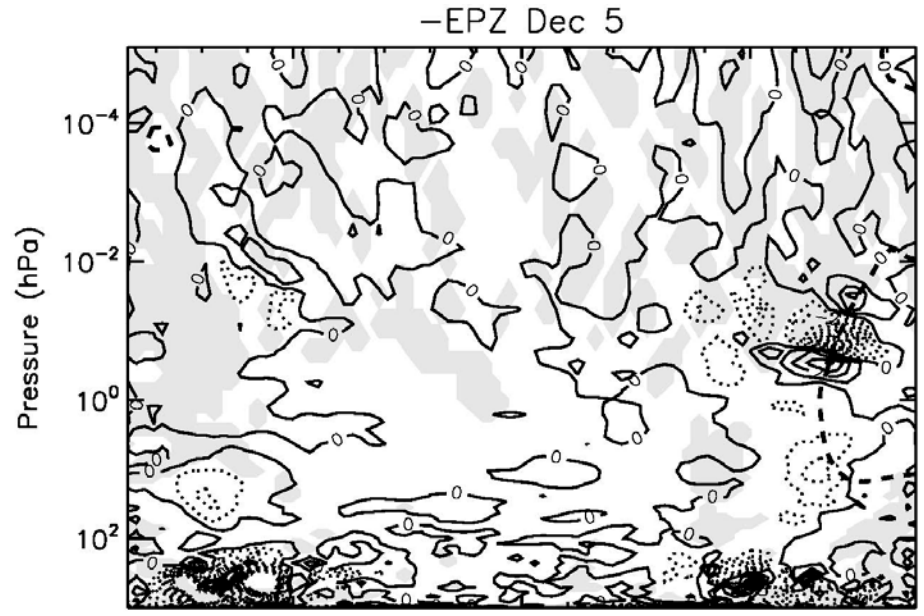


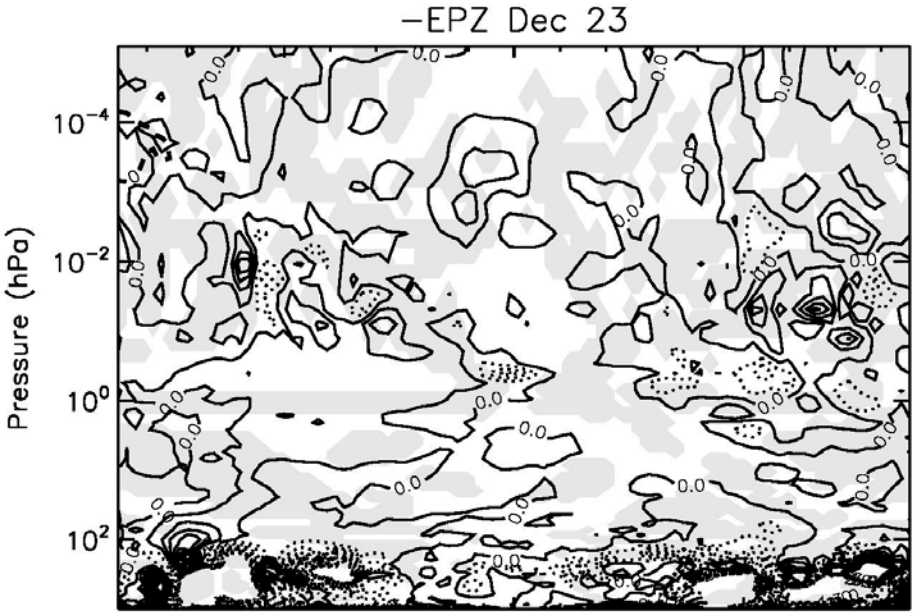
CHAMP DE3 at 400 km (*Hausler et al, 2010*)

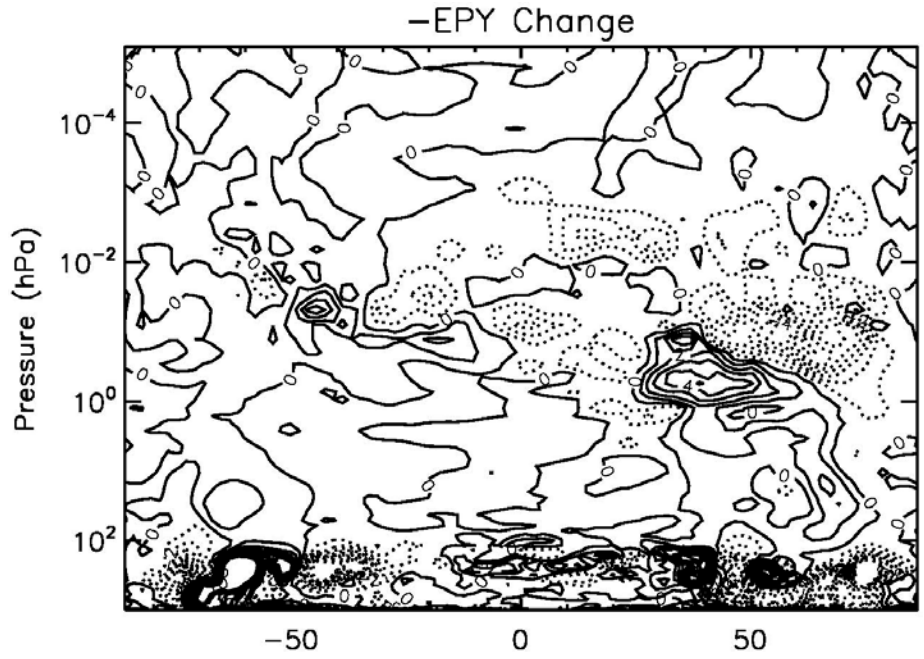
DE3 Change During SSW

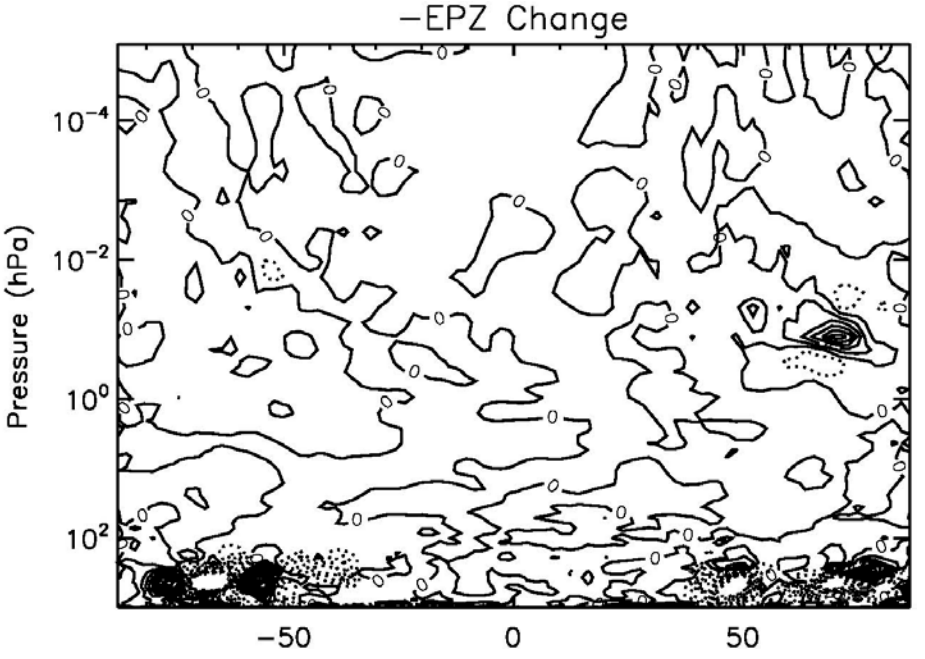


DE3 Diagnostics









Summary

- Electron/ion temperature module developed and being tested.
- IGW developed for QBO generation.
- WACCMX merging in CAM trunk in progress.
- Thermospheric tides from WACCMX generally comparable with WAM and observations.
- WACCMX/WAM both suggest 4.8 hour migrating tides are large in the thermosphere.
- WACCM suggests large change of DE3 during SSW.