

Gravity Waves in the Middle and Upper Atmosphere from WACCM-SE NE120

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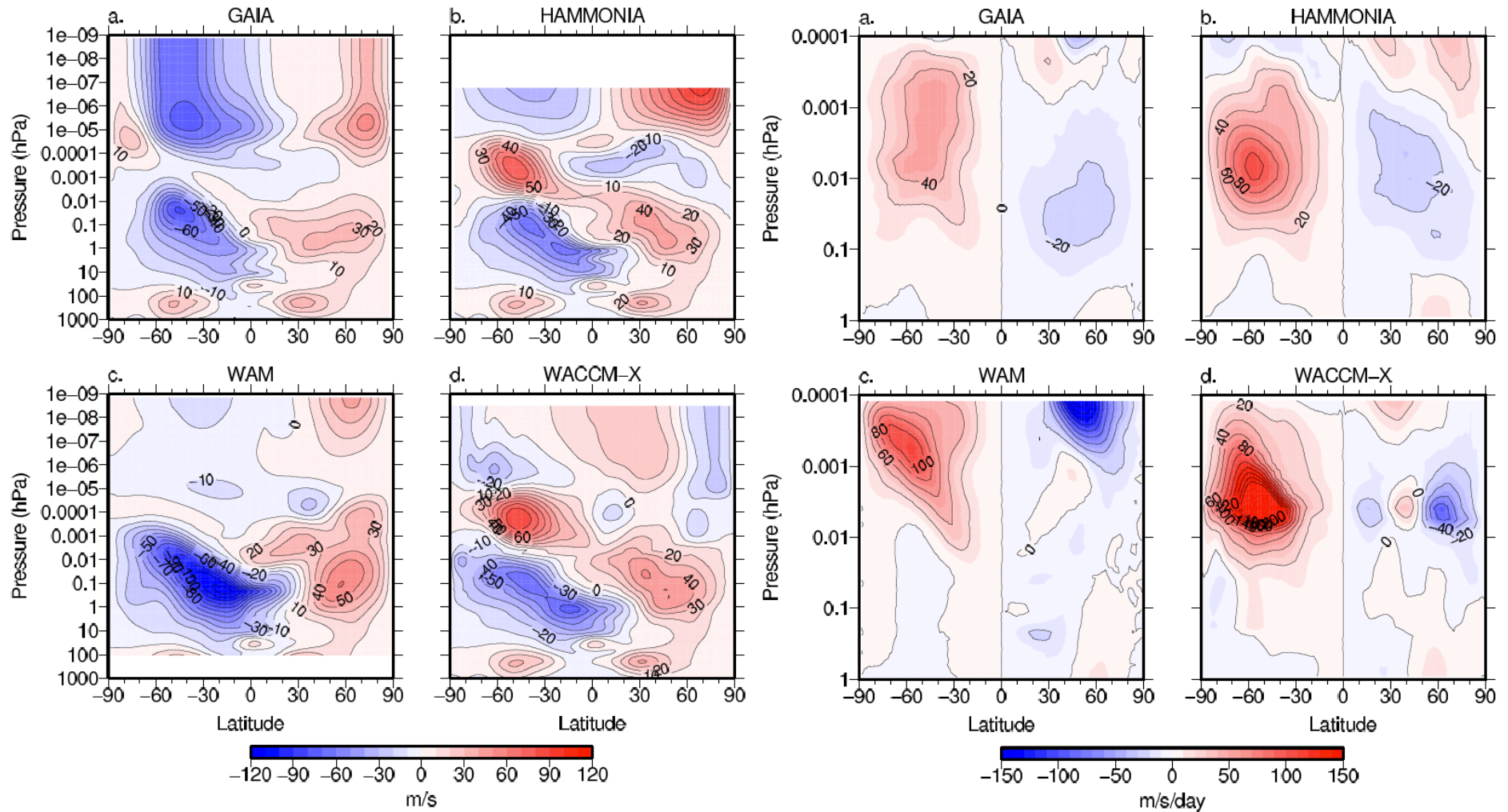
Peter Lauritzen², Mark Taylor³, Nick Pedatella⁴

1. NCAR/HAO, 2. NCAR/CGD, 3. DOE/SNL, 4. UCAR/COSMIC

Motivations

- Gravity wave forcing plays a dominant role in driving MLT circulation, as well as stratosphere QBO.
 - Represented currently by GW parameterization.
 - Source of uncertainties/biases.
- Gravity wave perturbations may directly impact ionospheric variability, including ionospheric irregularities.

GWF: (1) A major driver of MLT dynamics; (2) A major source of uncertainty in MLT.



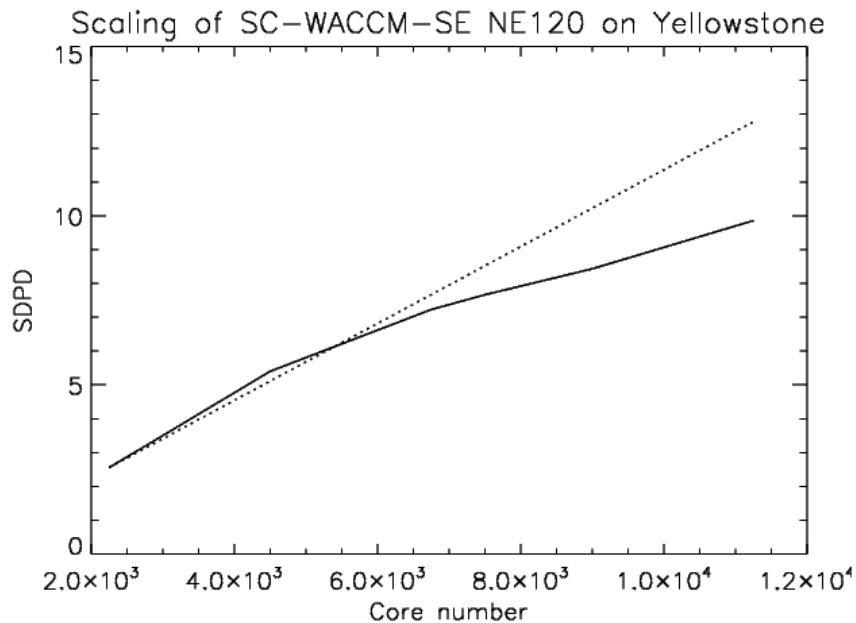
Pedatella et al. (2014)

WACCM-SE Model Setup

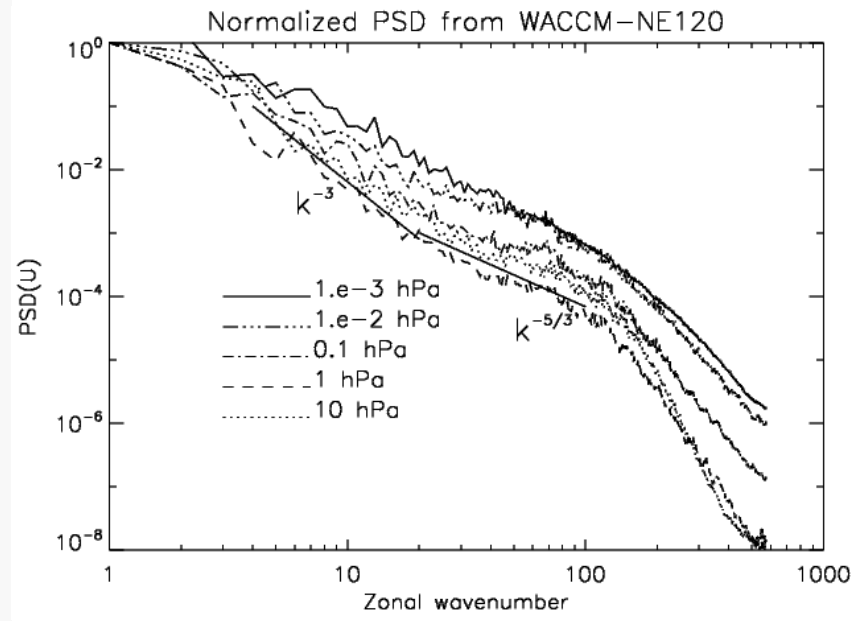
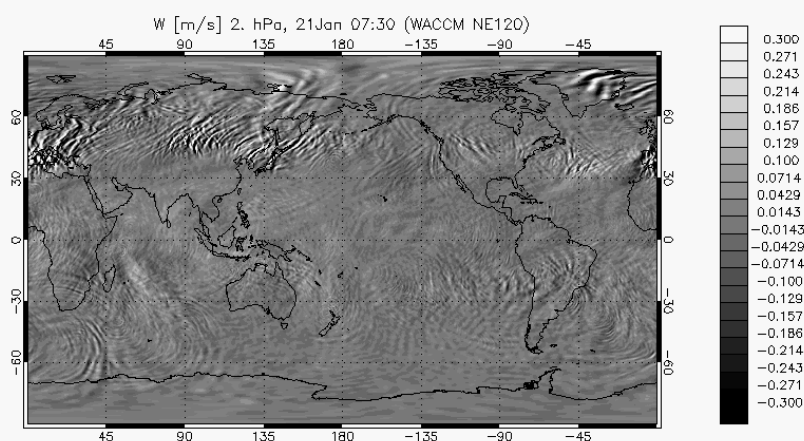
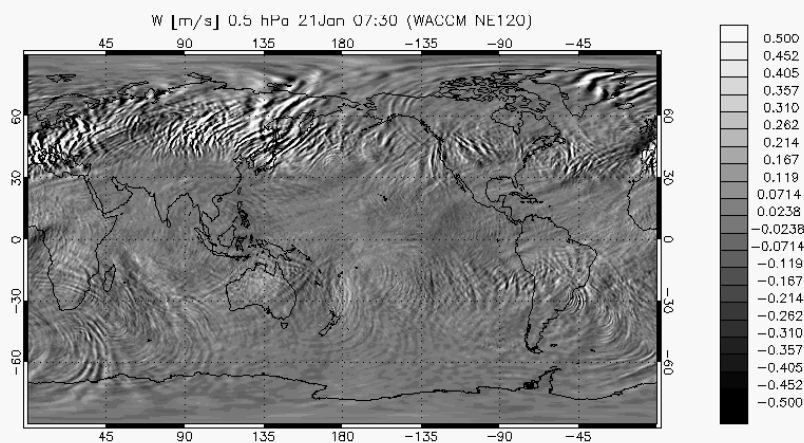
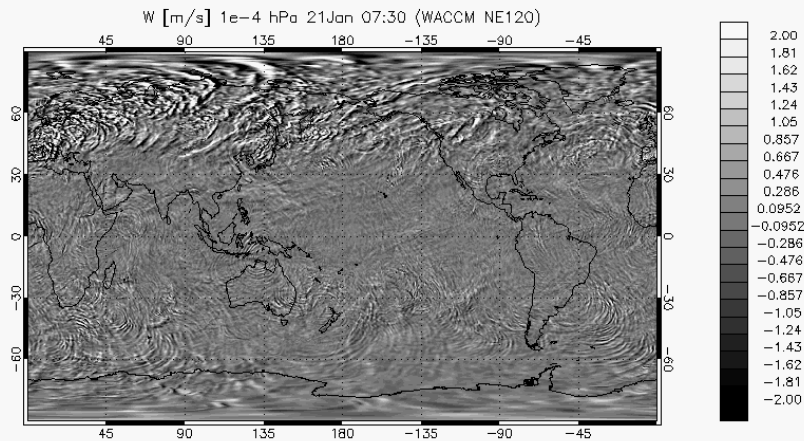
- WACCM-SE with specified chemistry.
- NE120 (~ 0.25 deg) horizontal resolution.
- 0.1 scale height $40-5.9 \times 10^{-6}$ hPa, 0.06-0.016 scale height below: 209 Levels.
- Sponge layer (top 3 scale heights):
 - Horizontal diffusion (second order): effective for smaller scale waves.
 - Rayleigh friction: effective for larger scale waves.
- GW parameterization turned off.
- Transition from RRTMG to WACCM RT set to 0.04hPa (default at 0.0001hPa, though known limit of RRTMG is 0.009hPa)

Model Performance

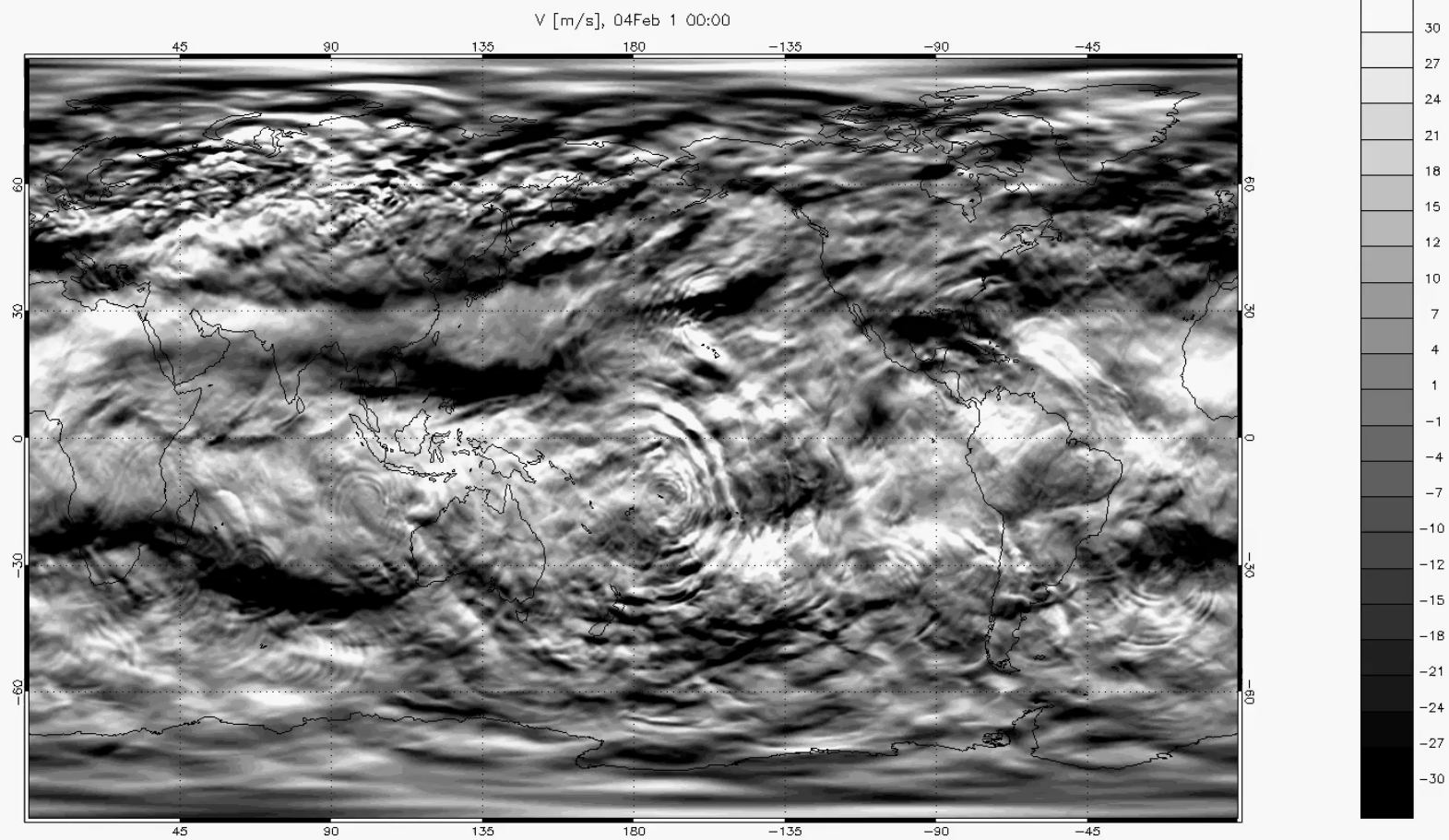
- Scaling with number of processors on Yellowstone:



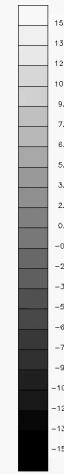
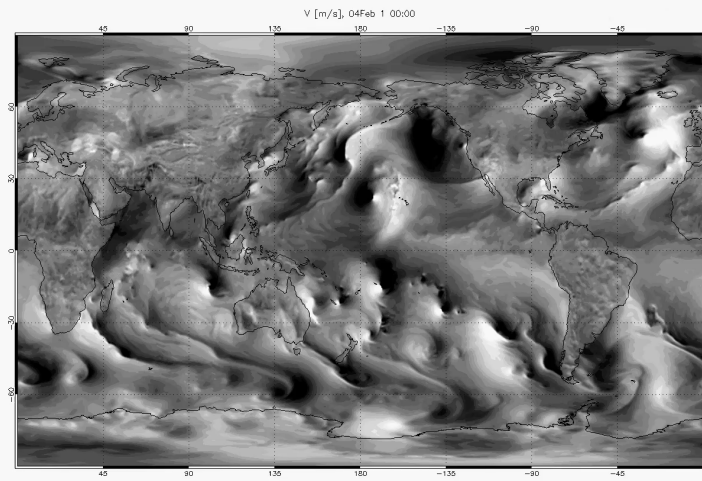
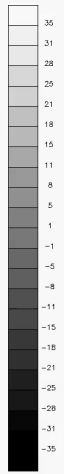
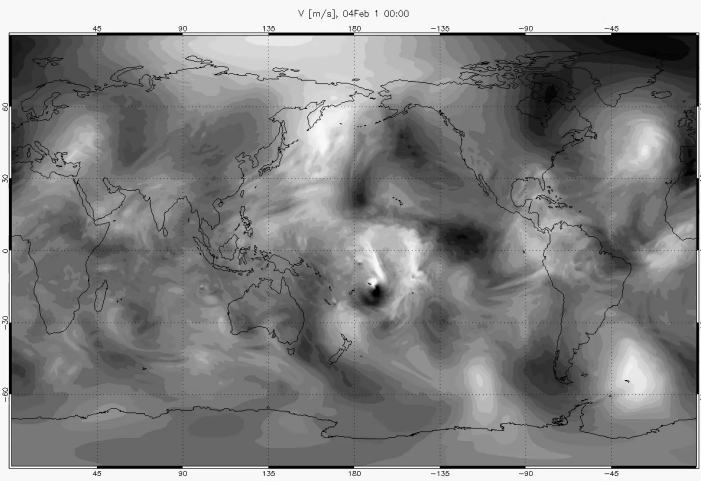
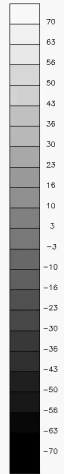
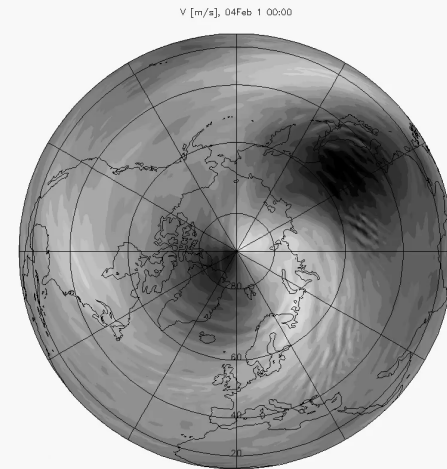
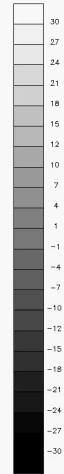
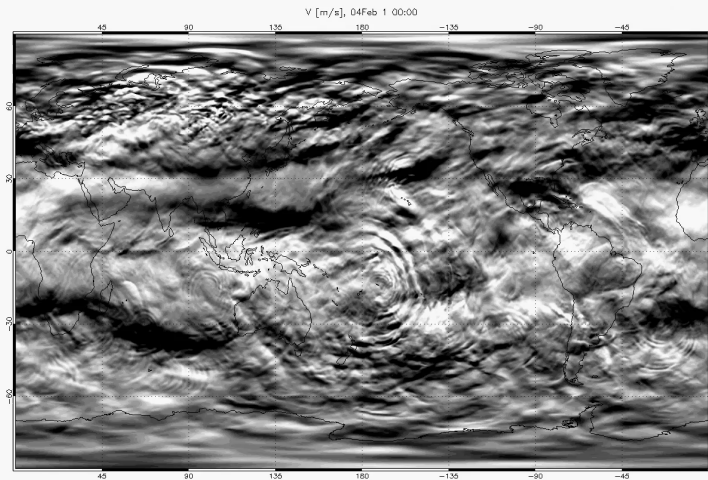
- 20k Core hours for each model day, or 7.3M core hours for each model year (at 4500 cores).



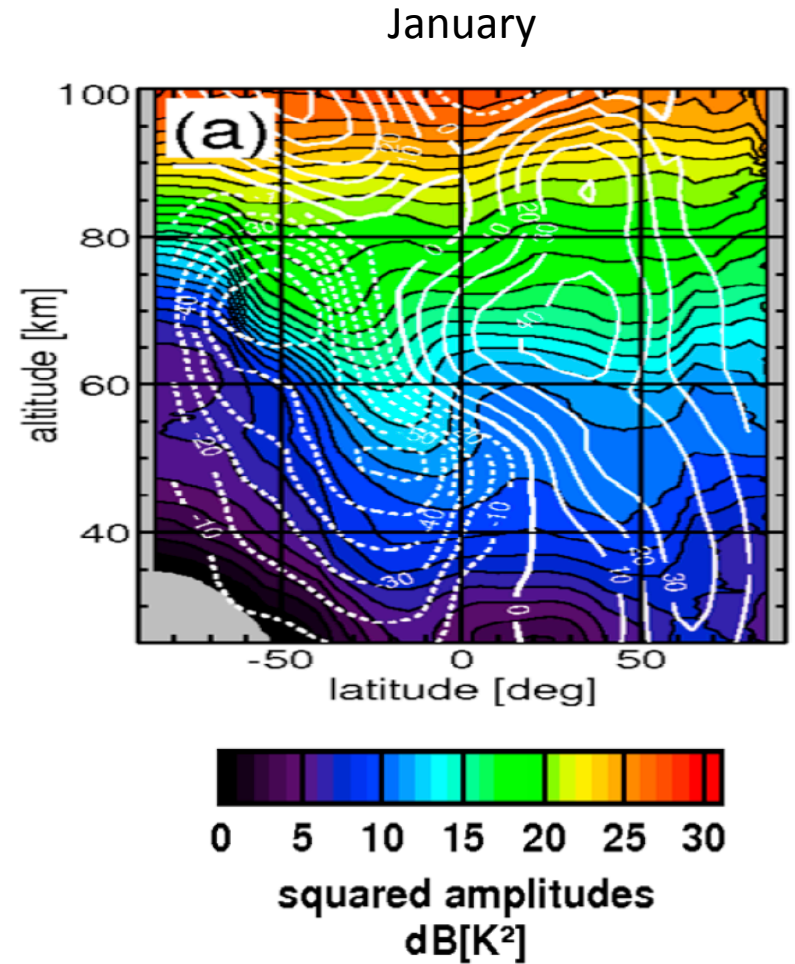
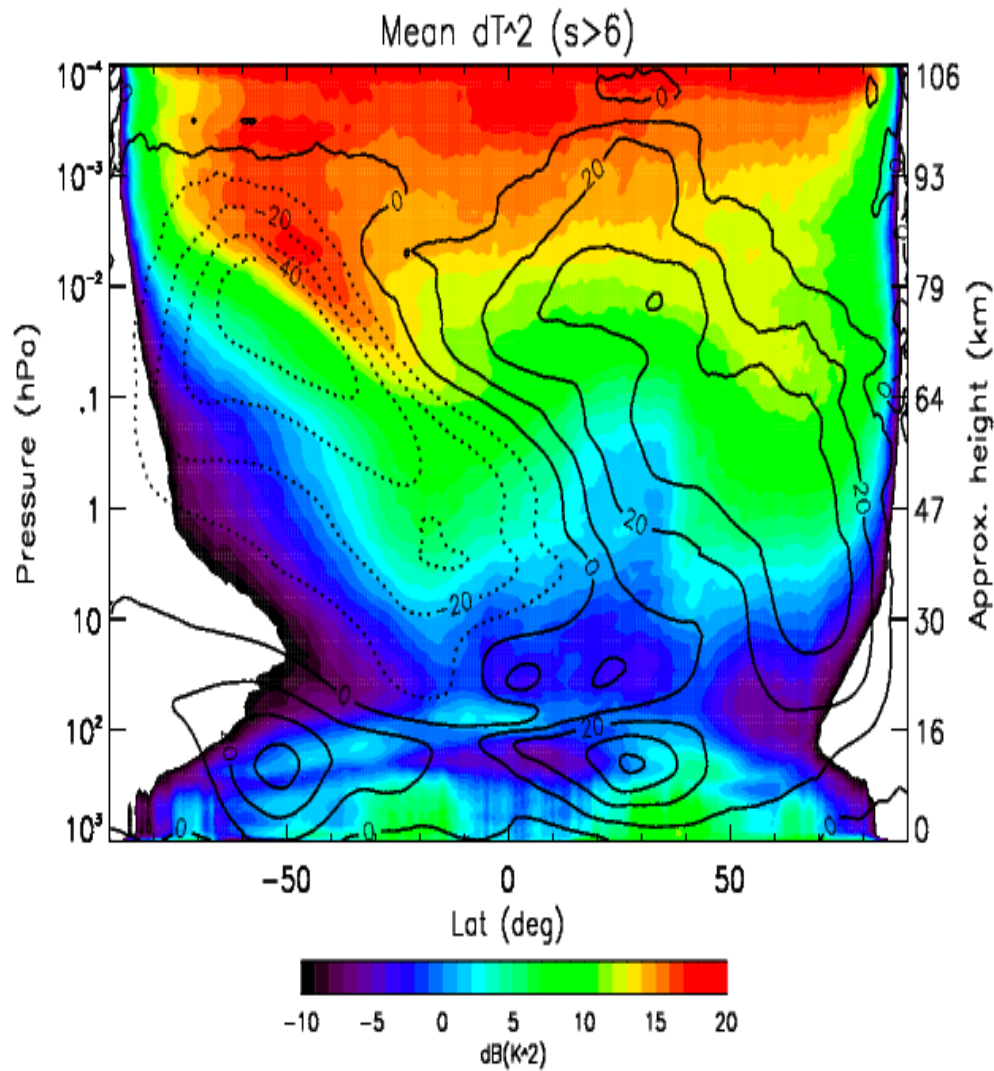
Dynamically Active MLT



Altitude Dependence of Temporal/Spatial Scales

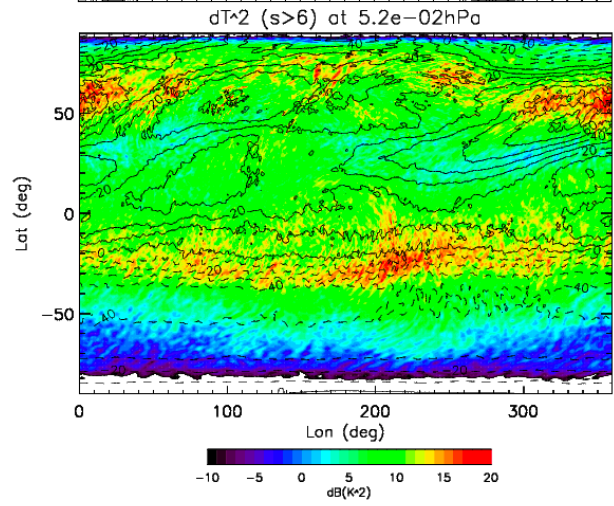
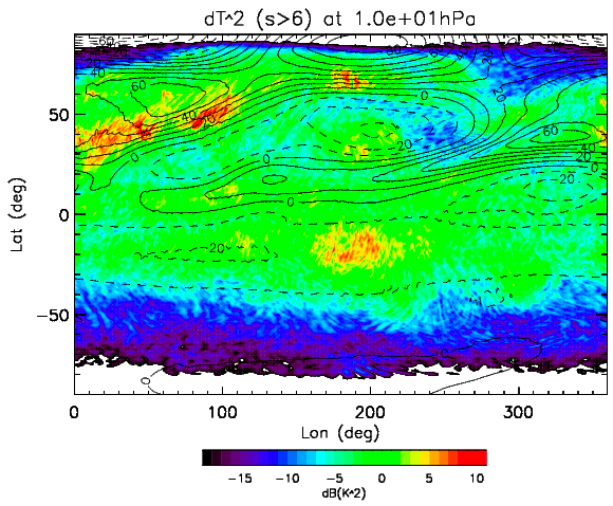
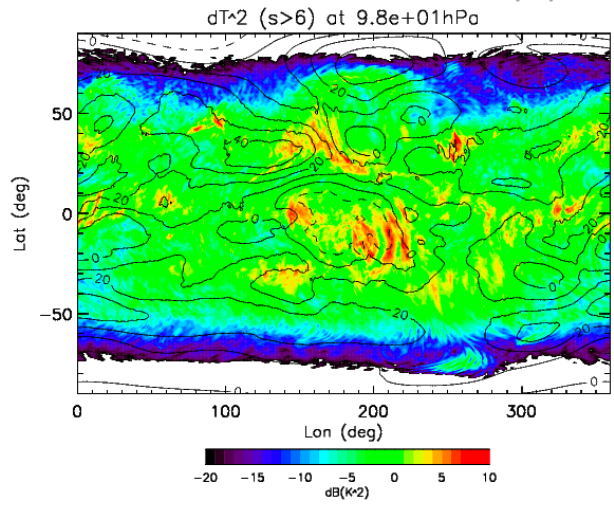
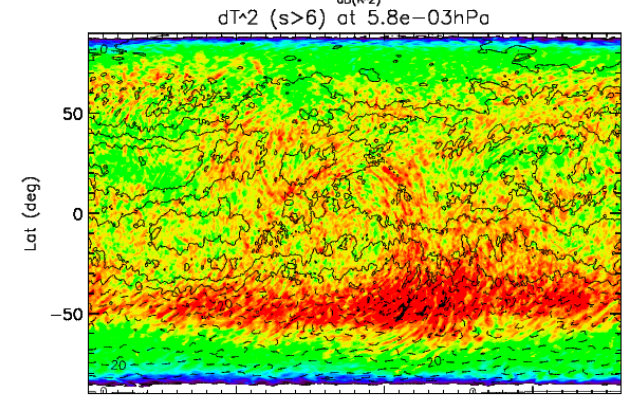
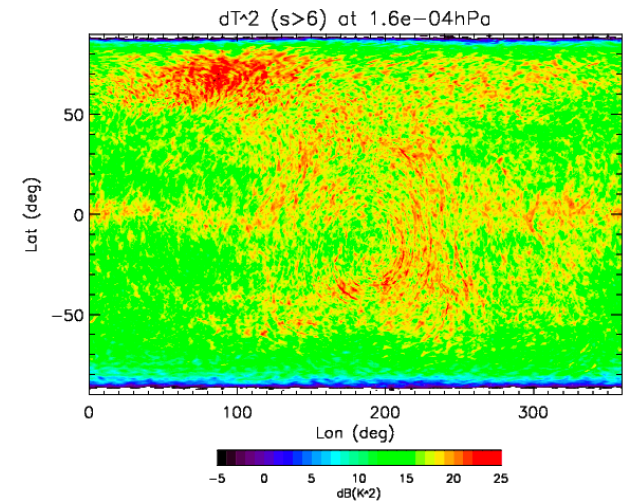
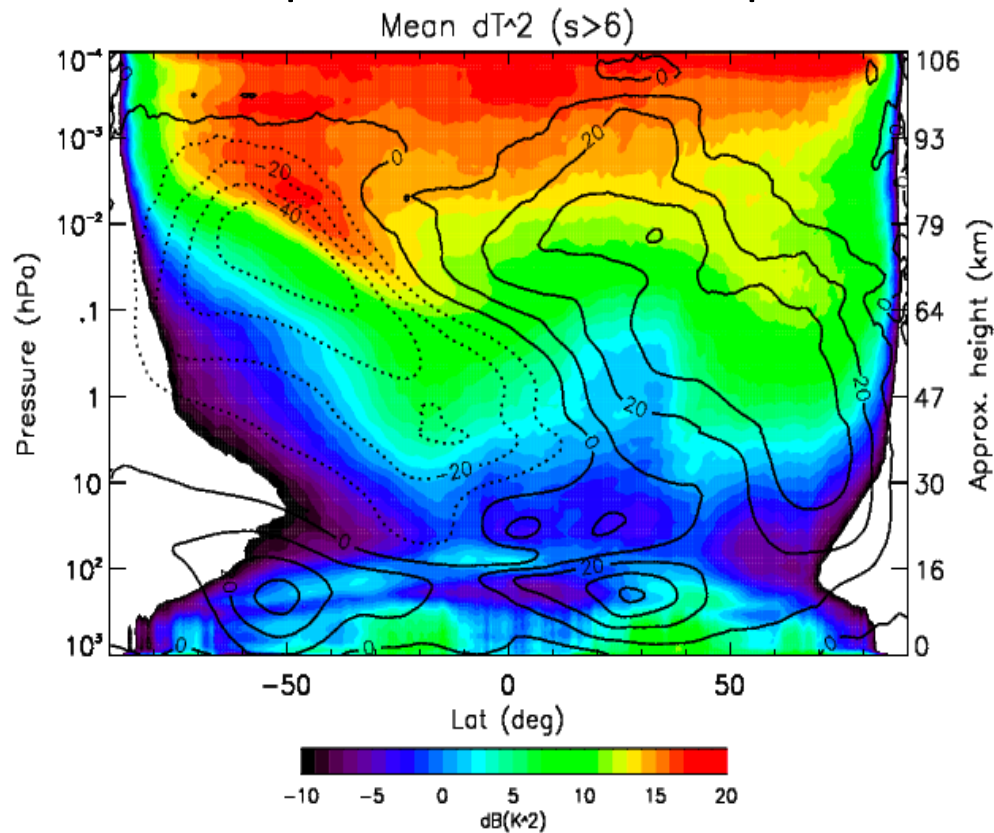


Wave Amplitude: Comparison with SABER

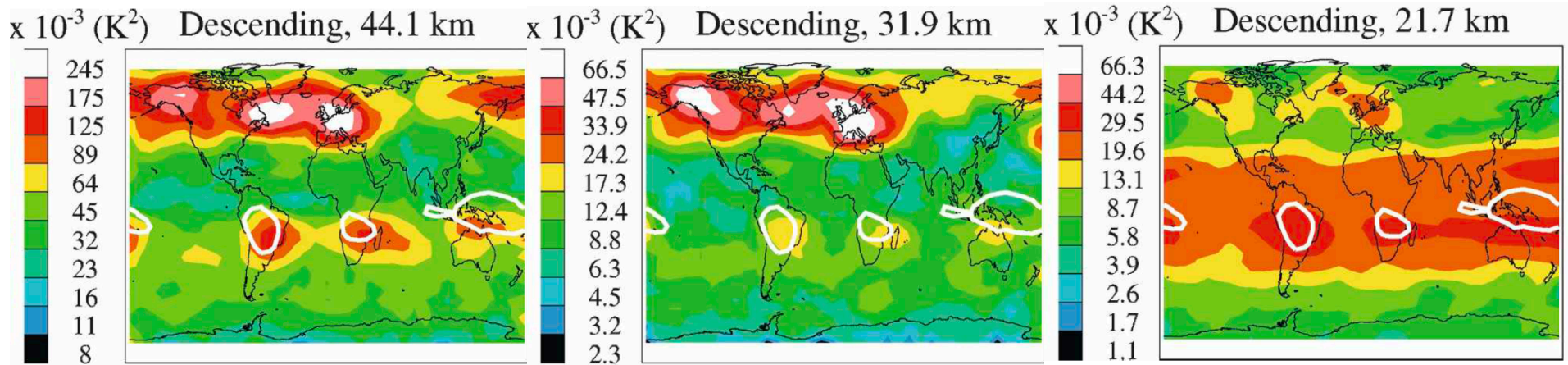
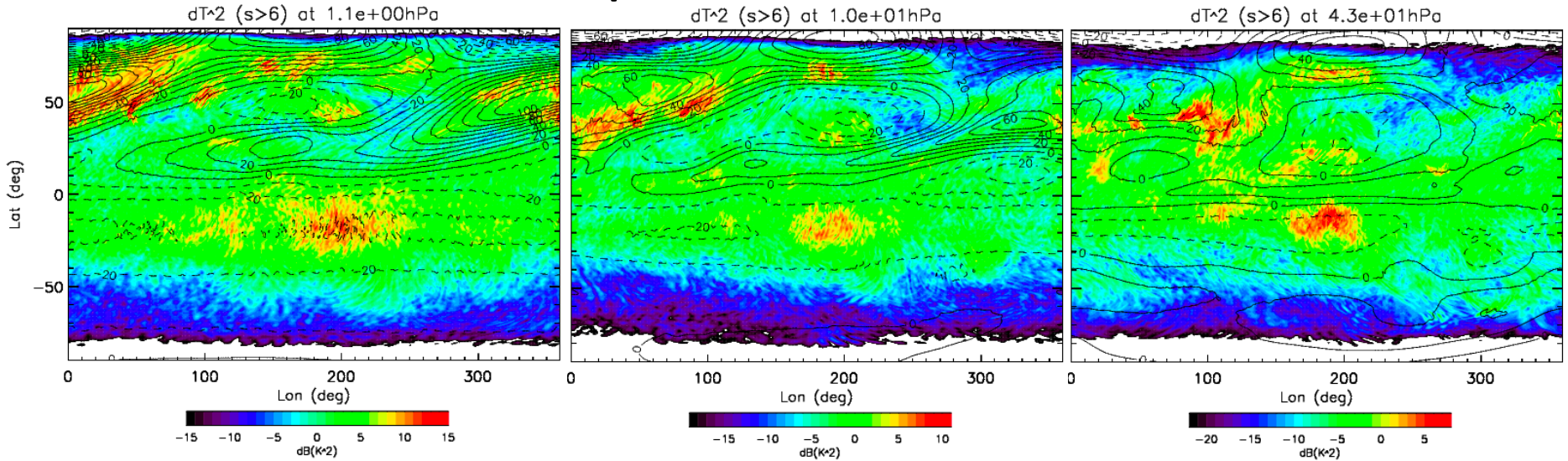


Ern et al., 2011

Wave Amplitude: Altitude Dependence



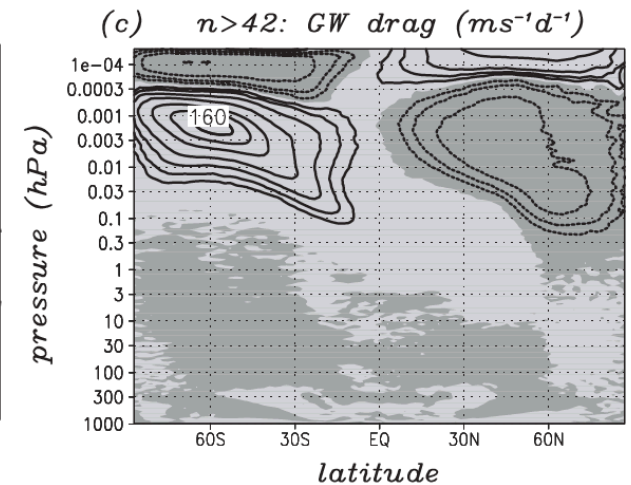
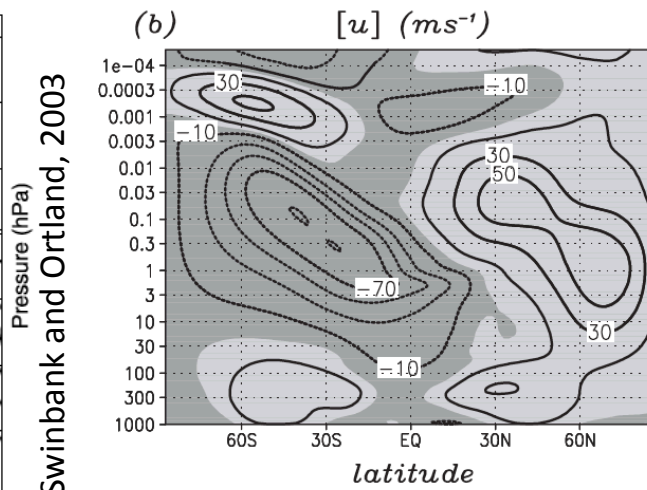
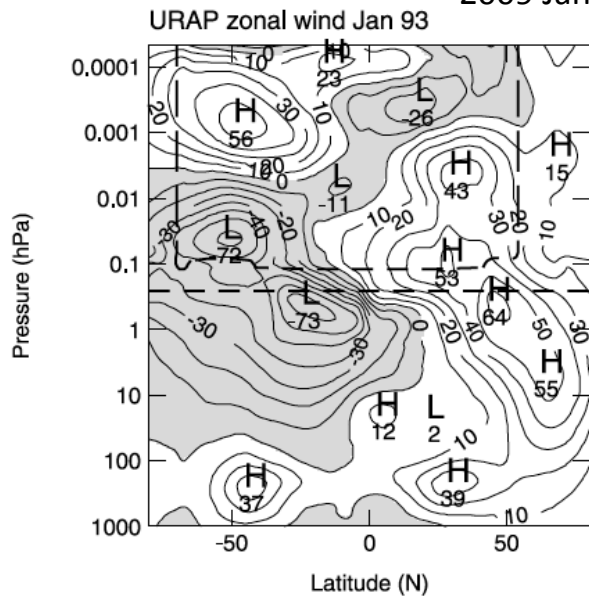
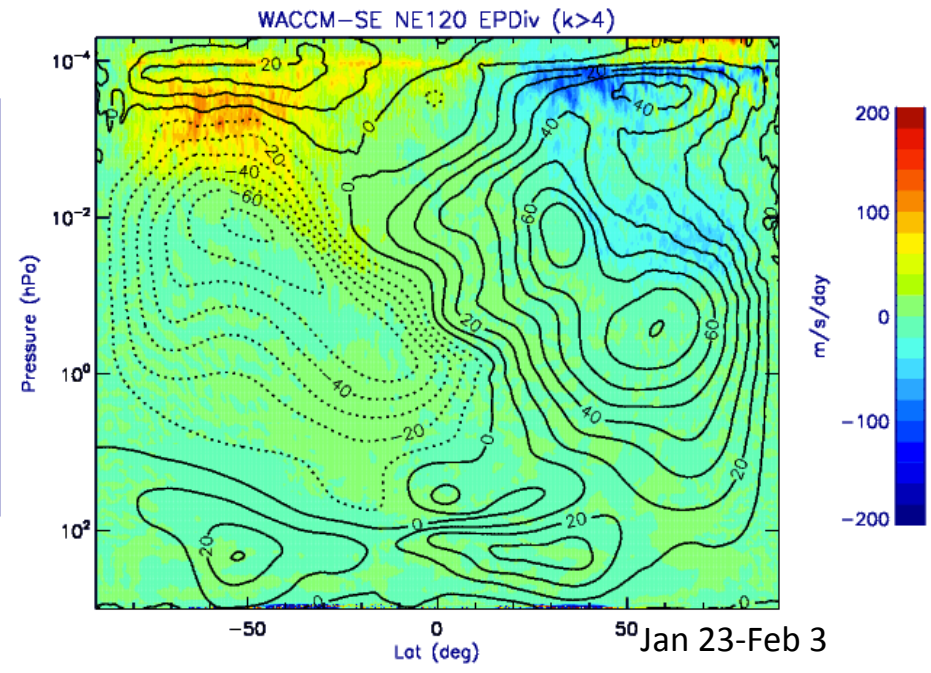
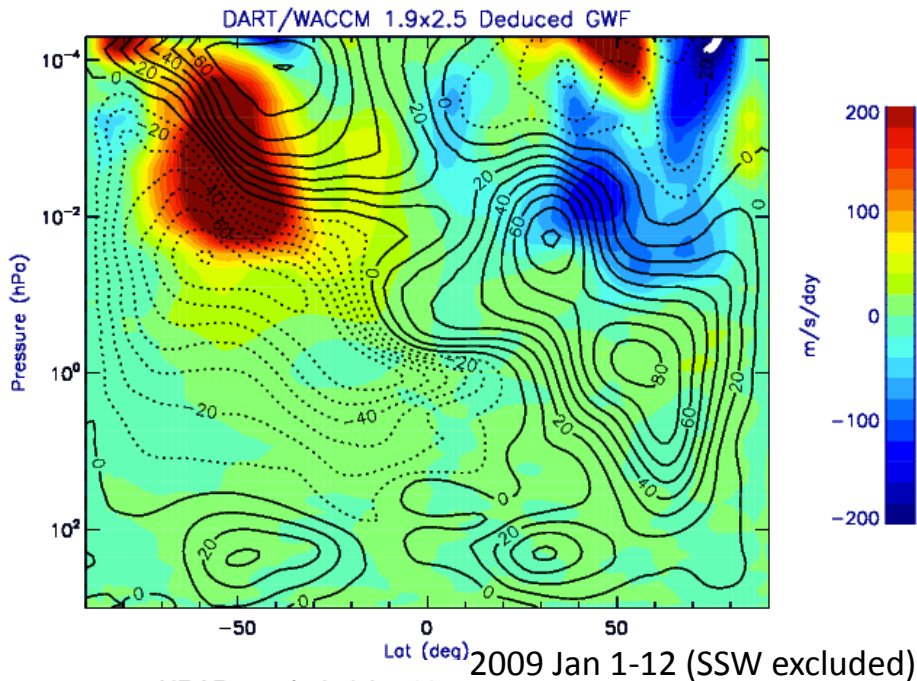
Comparison with MLS



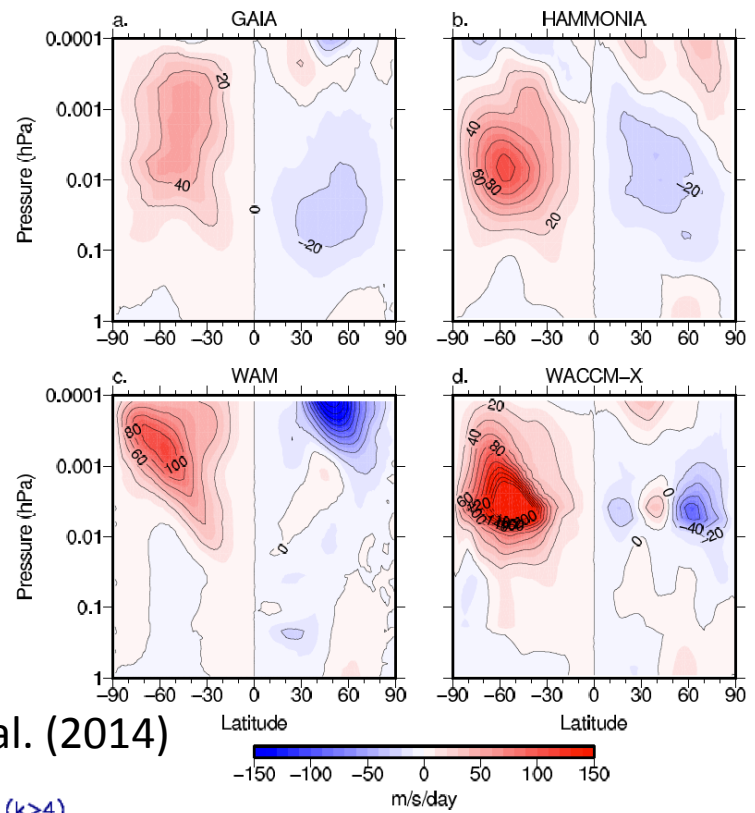
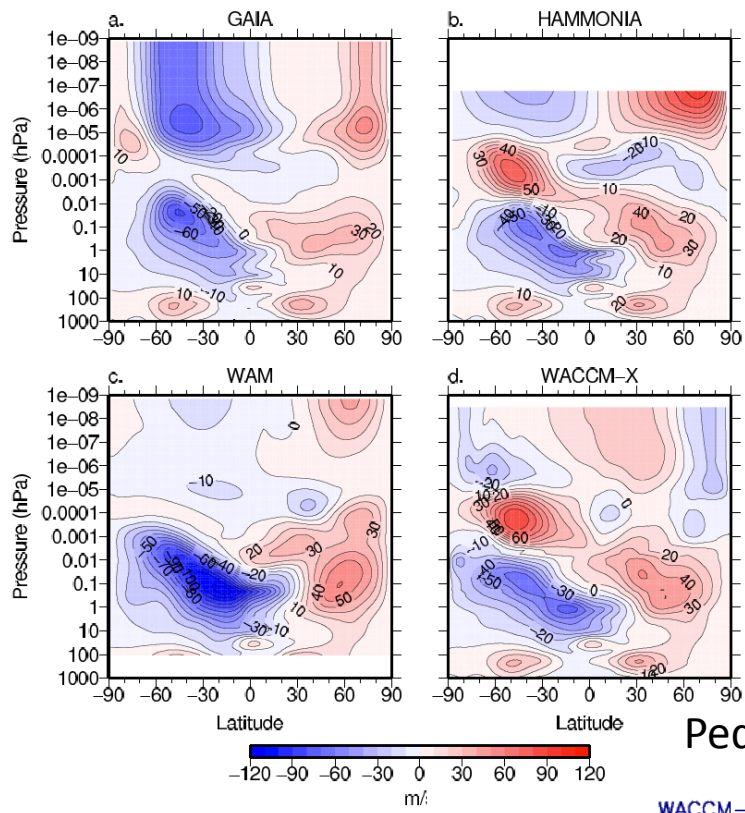
$0.25K^2 \rightarrow -6dB$

Wu and Eckermann, 2008

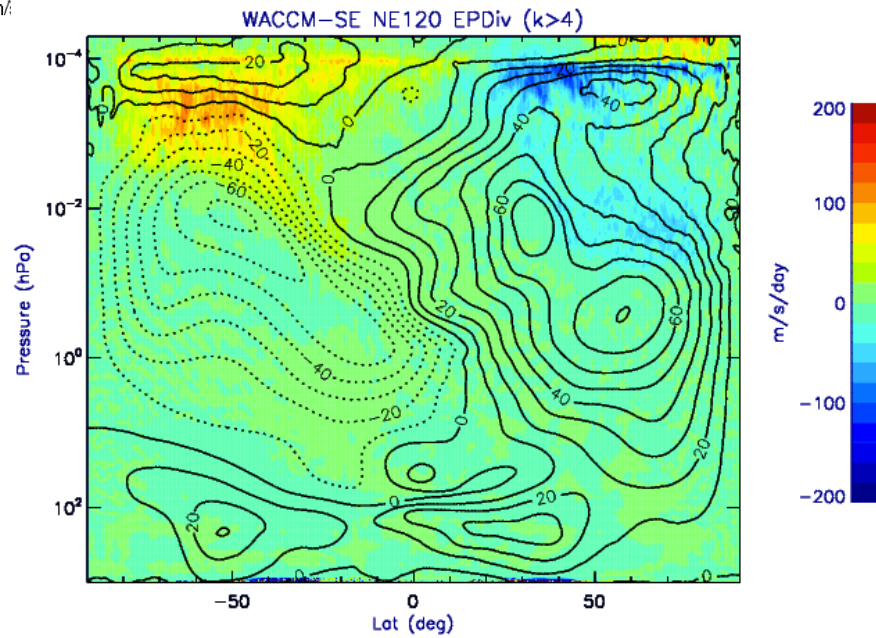
Zonal Wind and GW Forcing



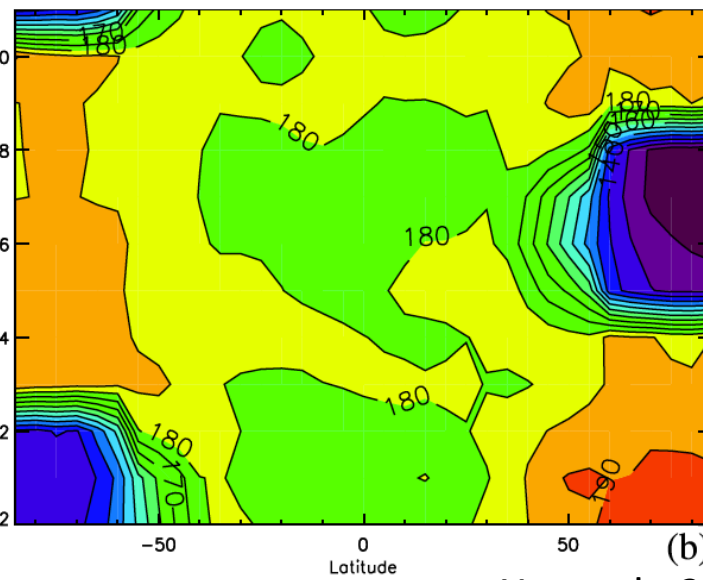
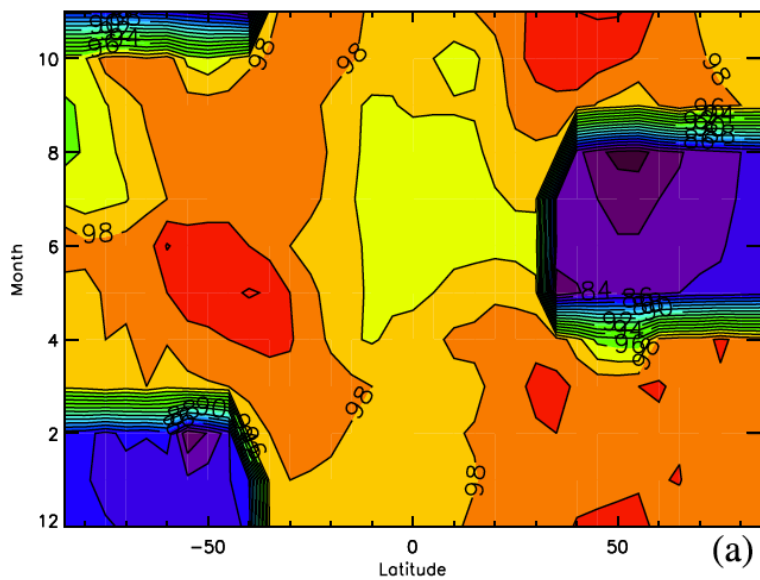
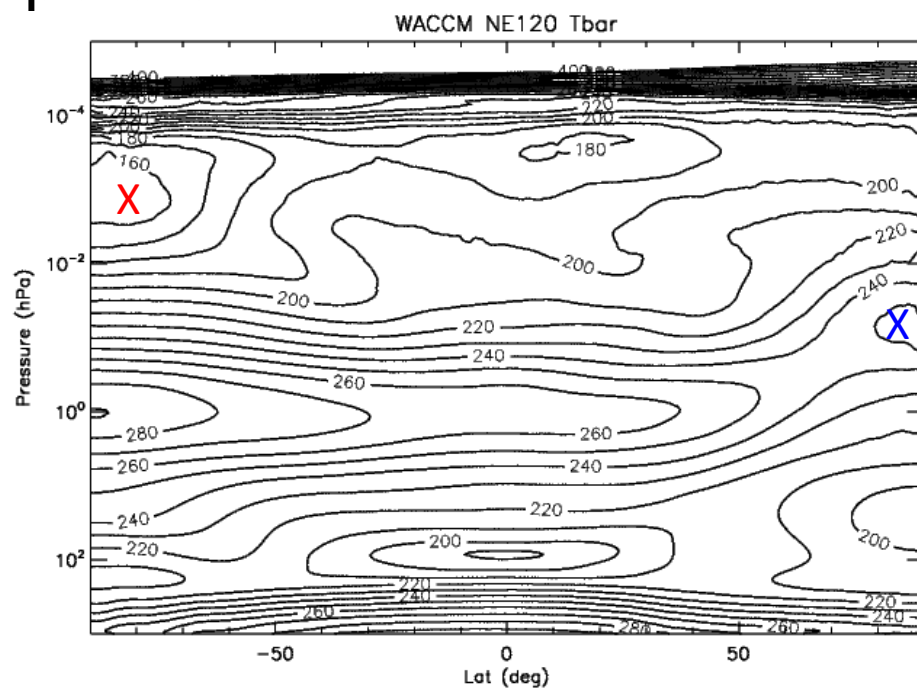
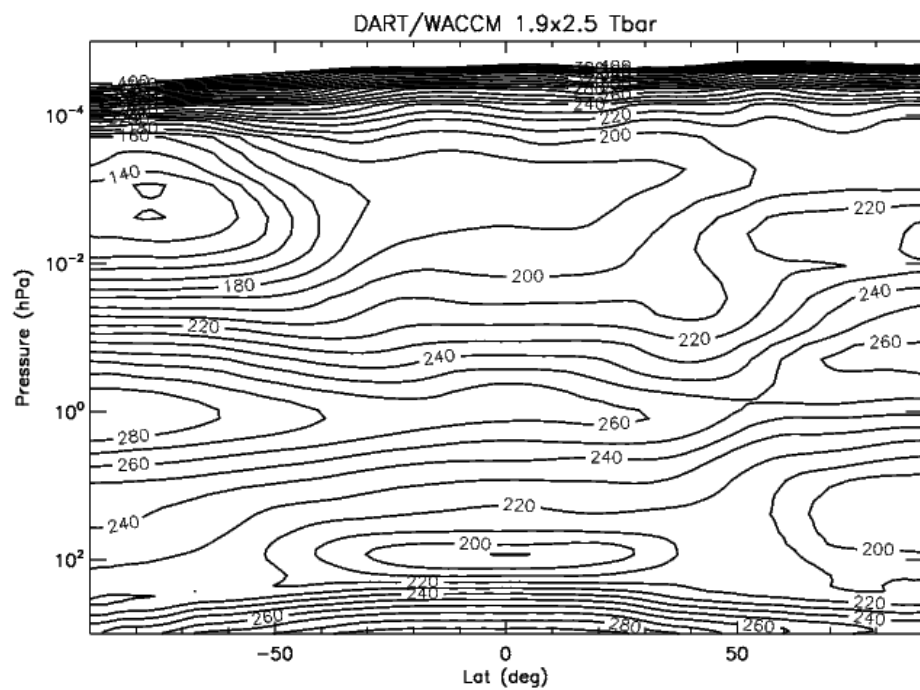
Becker, 2009



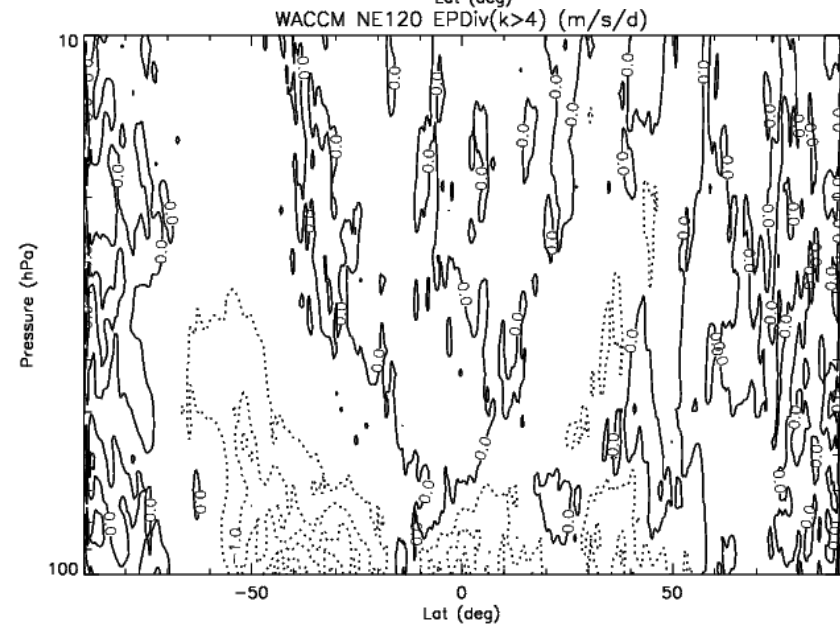
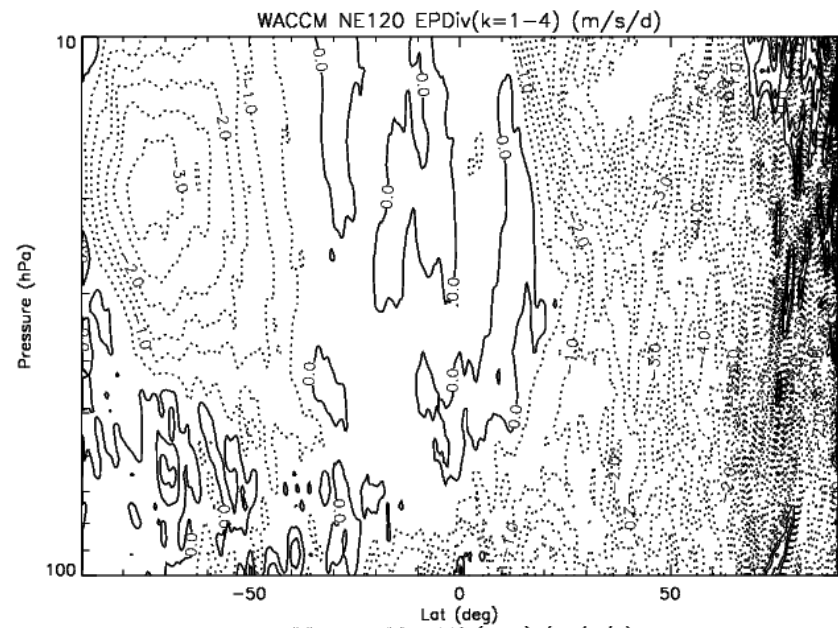
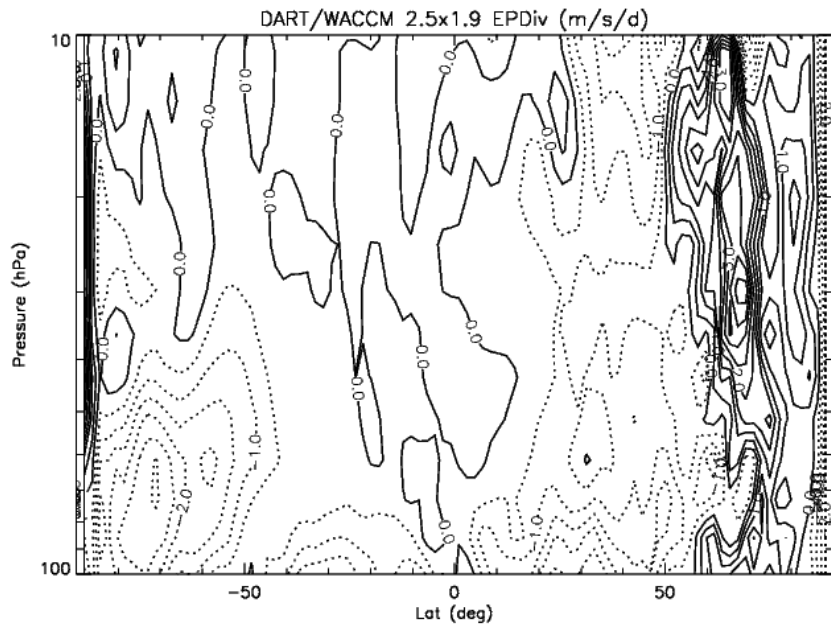
Pedatella et al. (2014)



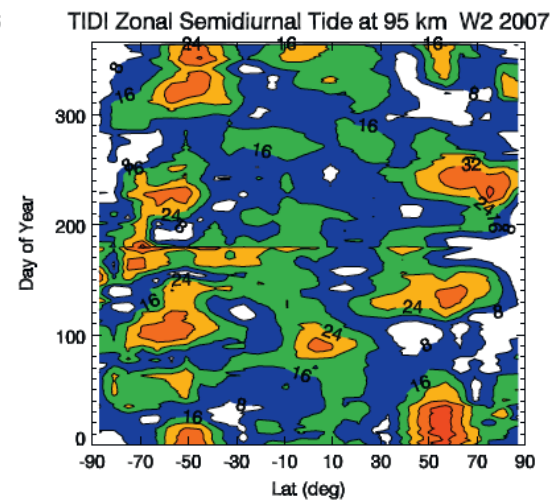
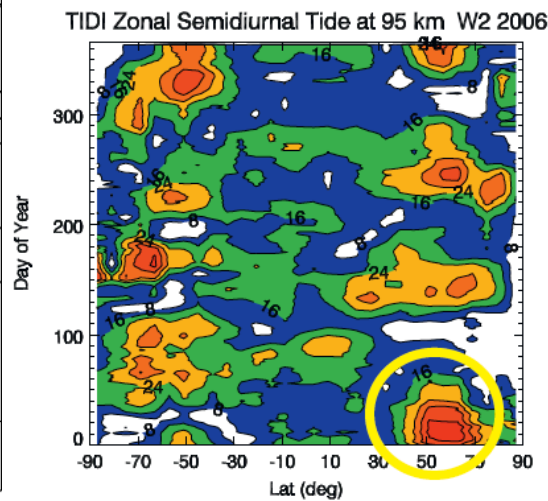
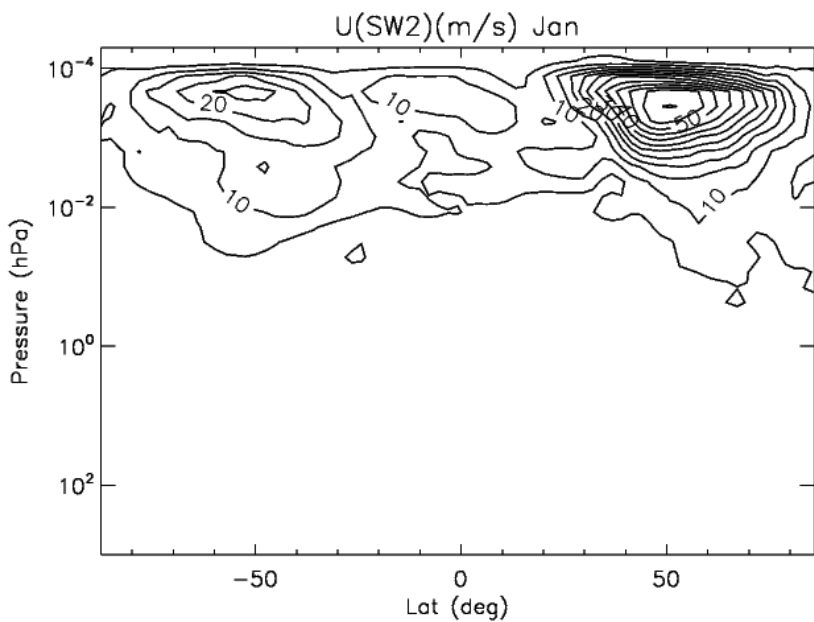
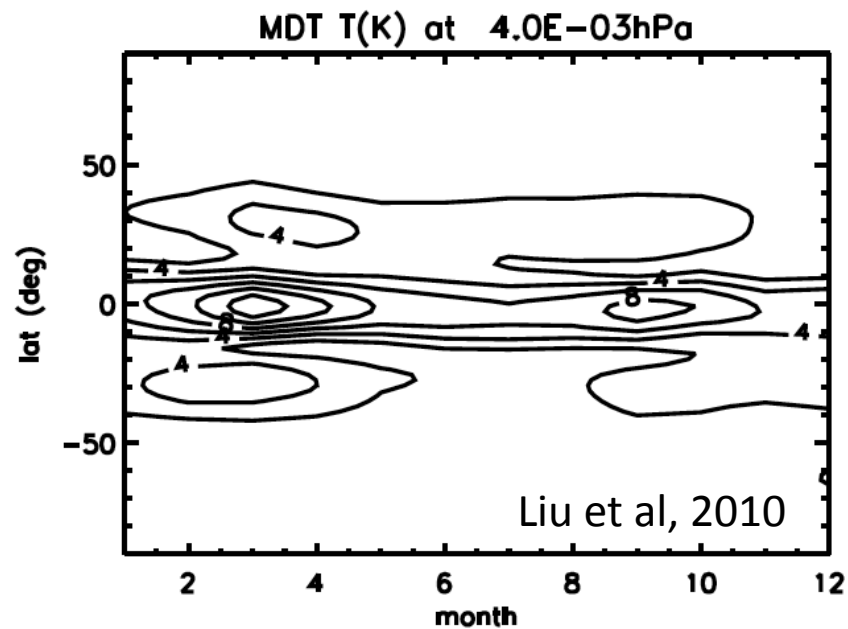
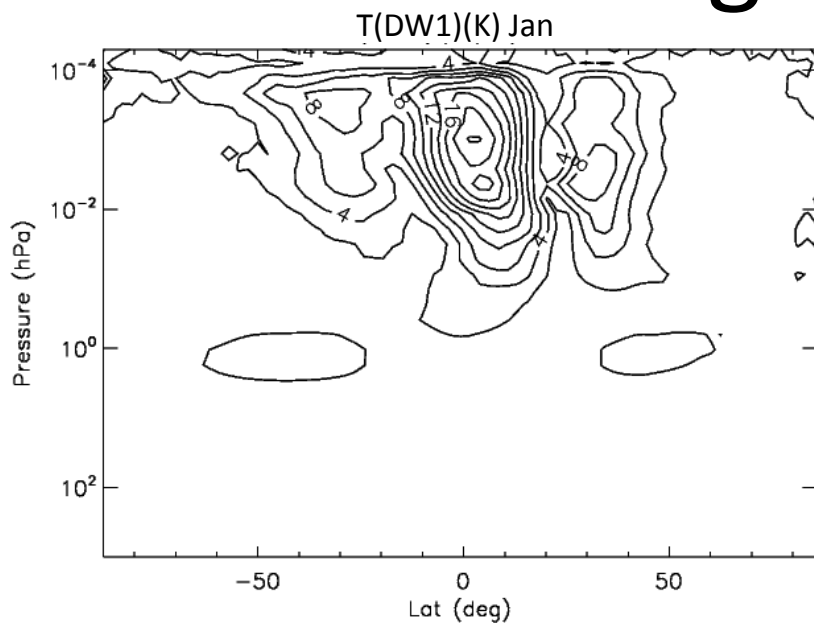
Mean Temperature



Wave forcing in Stratosphere: Mid to High Latitude



Migrating Tides



Wu et al., 2011

Summary and Future Works

- WACCM-SE NE120 feasible.
- Resolved GWs qualitatively similar to satellite observations.
- Resolved GW forcing is not large enough to reverse the winter stratospheric/mesospheric jet.
- Resolved GW forcing can reverse summer stratospheric/mesospheric jet, but still weak. The reversed jet strength and summer mesopause temperature is $\sim 20\text{K}$ too warm.
- Mesopause temperature at mid-latitudes and winter high latitudes agree better with observations.
- Migrating tides stronger and show the correct hemispheric structure in MLT.
- Need to evaluate the “missing waves” and/or “missing forcing” for better parameterization.
- Year-long run underway supported by NSC.