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

Han-Li Liu¹, Joe McInerney¹, Sean Santos²
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 (~0.25deg) horizontal resolution.
• 0.1 scale height 40-5.9x10^{-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
Comparison with MLS

$0.25 K^2 \rightarrow -6 dB$

Wu and Eckermann, 2008
Zonal Wind and GW Forcing
Pedatella et al. (2014)
Mean Temperature

Xu et al., 2007
Wave forcing in Stratosphere: Mid to High Latitude
Migrating Tides

Liu et al., 2010

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 ~20K 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.