Implementation of Spectral Gravity Wavefield to the Global Ionosphere Thermosphere Model (GITM)

Cissi Lin, Yue Deng, Cheng Sheng

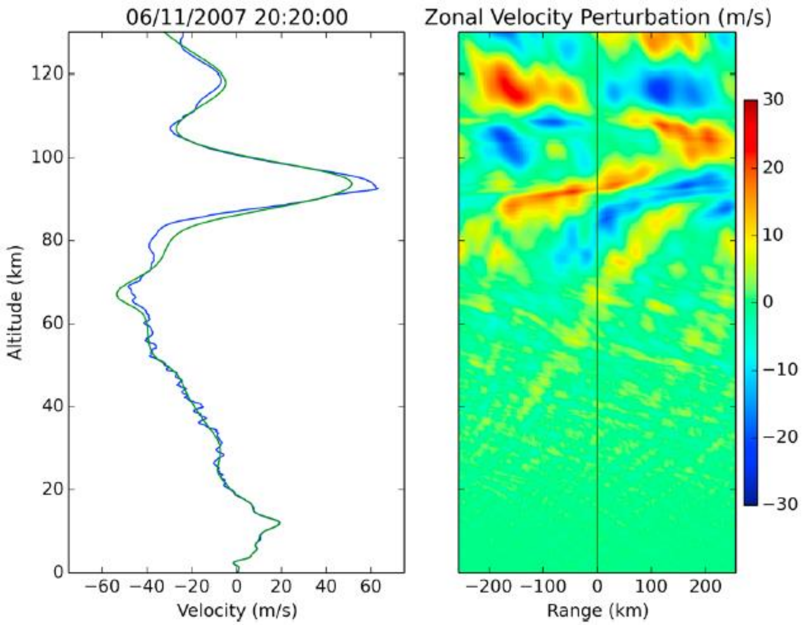
University of Texas at Arlington

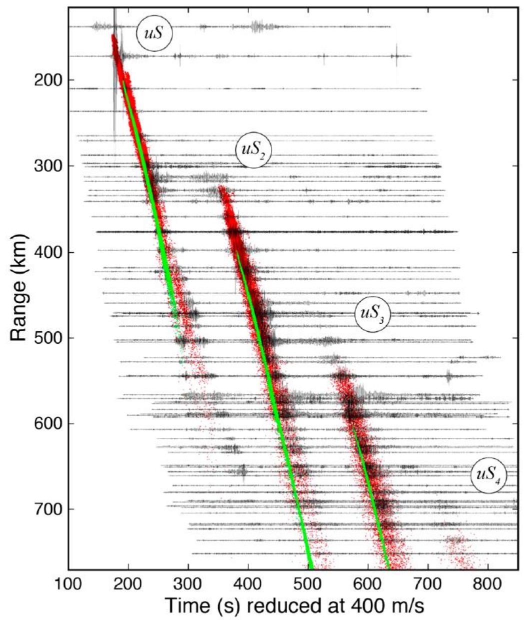
Douglas Drob

Naval Research Laboratory

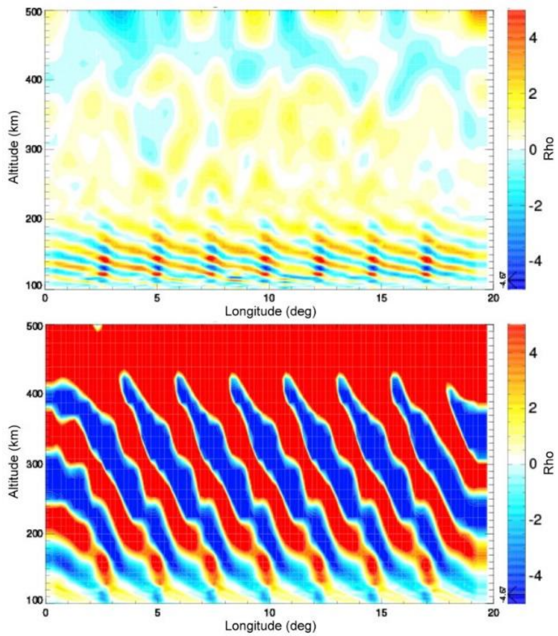
$$\lambda_n = 4\pi H \sqrt{\frac{\omega_B^2}{\omega^2} - 1}$$

$$\lambda_h = 4\pi H \frac{\omega_B}{\omega}$$





[Hedlin & Drob, 2014]



[Deng & Ridley, 2014]

Model Highlights

- **Spectral Gravity Wavefield**

✓ Fourier gravity wave ray tracing

✓ Stochastic **background** perturbation fields (0-180 km) for temperature, pressure, density, and three wind components

[Drob et al., 2013]

- **Global Ionosphere Thermosphere Model (GITM)**

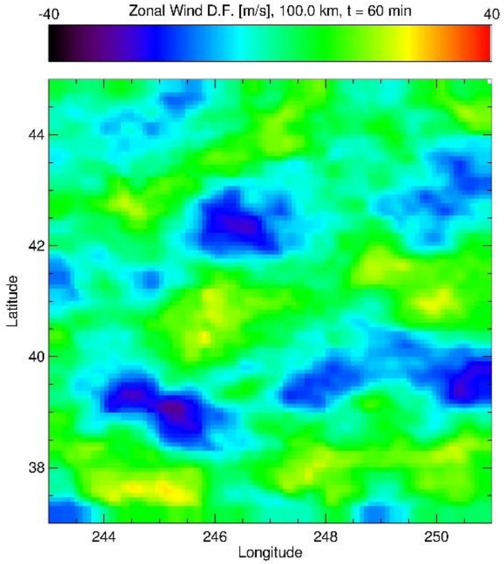
✓ non-hydrostatic solutions

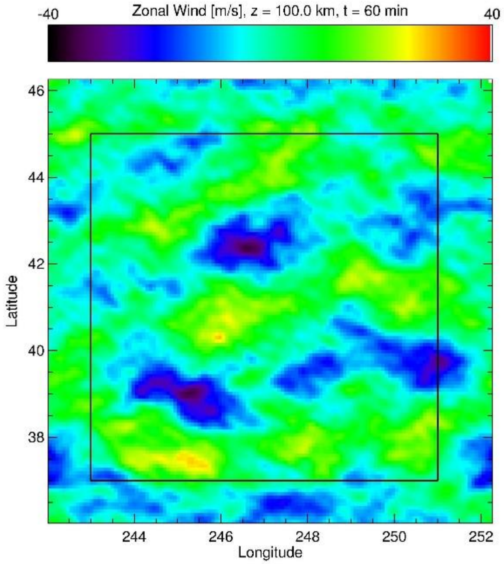
✓ flexible 3D resolution

[Ridley et al., 2006]

Implementation of Gravity Wavefields

- Spectral model (0–180 km) v.s. GITM (100–650 km)
- Horizontal grid size: 0.08°x0.08°
- Vertical grid size: 0.15 of the scale height, <1 km at the lower thermosphere
- Time-varying Gravity wavefields of u ($\pm$40 m/s), v ($\pm$40 m/s), and w ($\pm$10 m/s) are implemented separately at the lower boundary layers below 100 km.

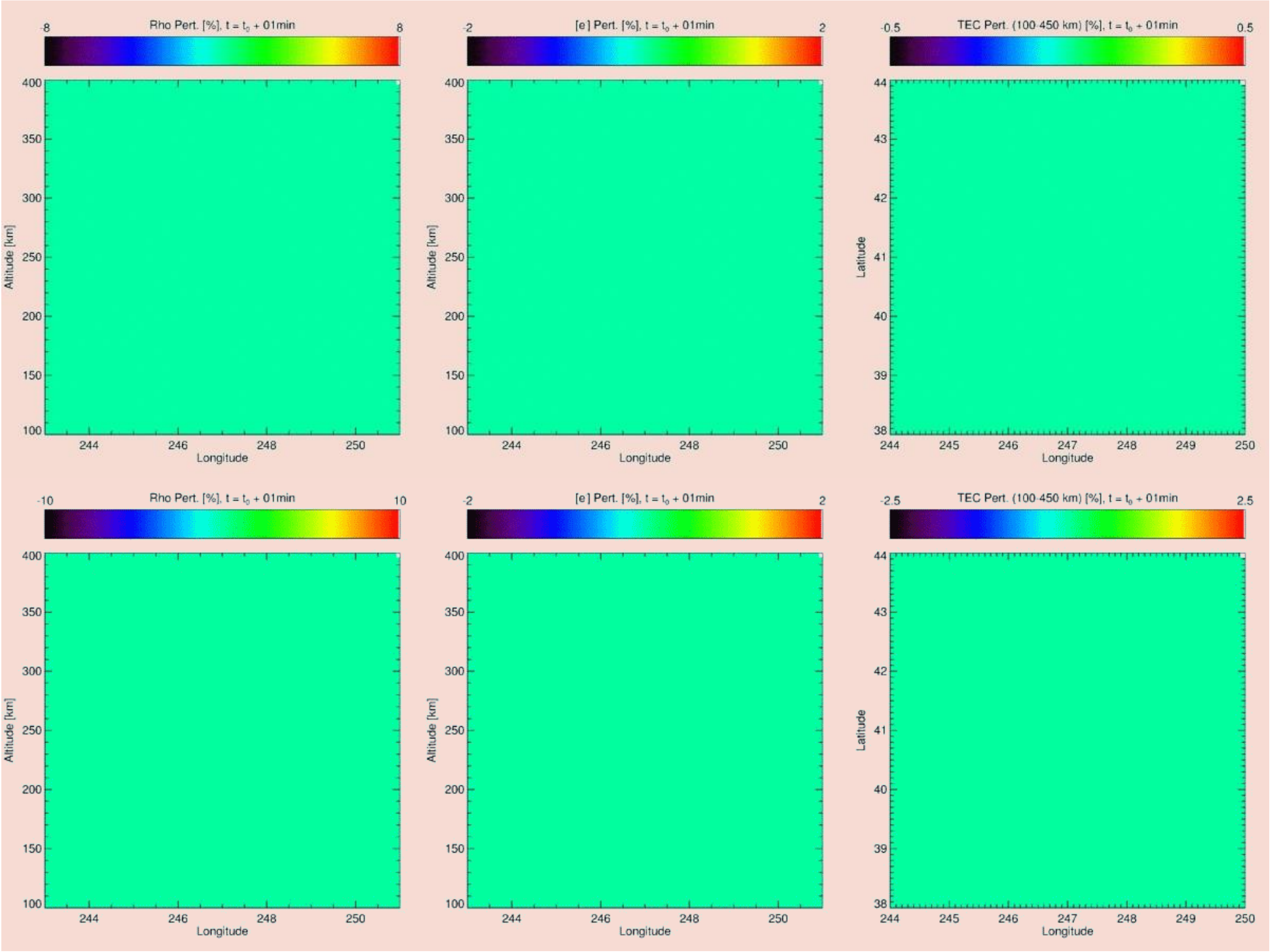




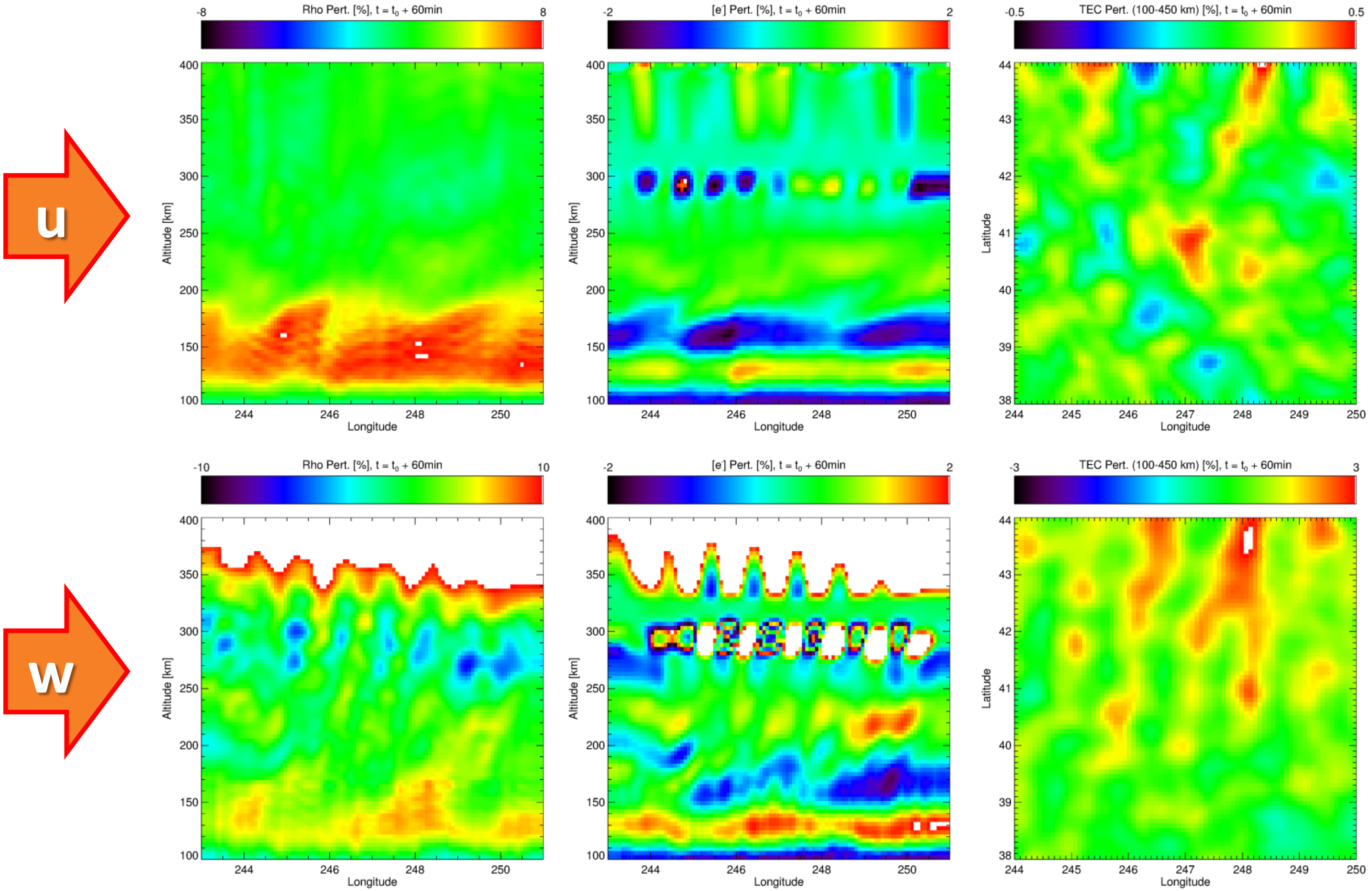
Rho, [e-], & TEC

u

w


Rho Pert. [%], t = t_0 + 01min
-8
8
-10
10
[e] Pert. [%], t = t_0 + 01min
-2
2
TEC Pert. (100-450 km) [%], t = t_0 + 01min
-0.5
0.5
-2.5
2.5
Altitude [km]
Latitude
Longitude

Rho, [e-], & TEC


u
w
Rho Pert. [%], $t = t_0 + 60$min
[e⁻] Pert. [%], $t = t_0 + 60$min
TEC Pert. (100-450 km) [%], $t = t_0 + 60$min
Altitude [km]
Latitude
Longitude

Energy Dissipation & Wave Damping (?)

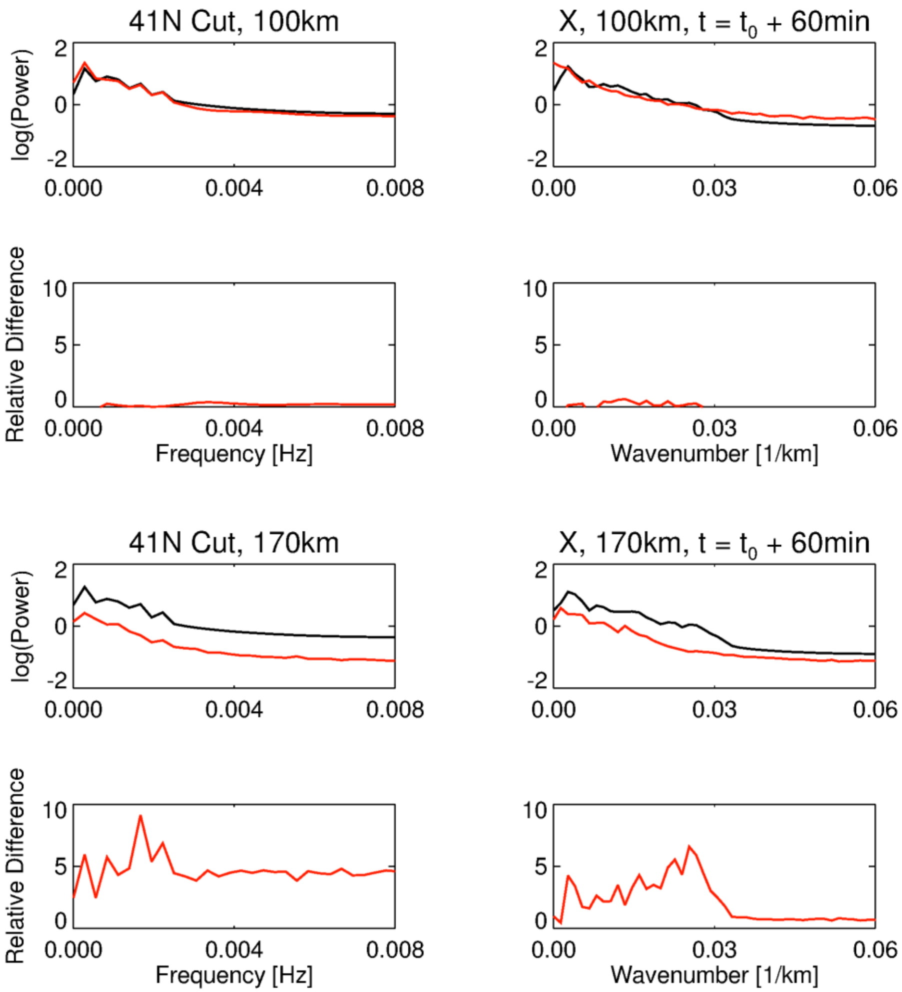
- Multi-species diffusive separation
- Power spectra: The difference between two fields at 100 km is small. Waves appear to be subject to lower damping propagating in the spectral model (black curves). The difference between two models are estimated at the bottom of both figures as

$$\text{Relative Difference} = \frac{P_{SW} - P_{GITM}}{P_{GITM}}$$

- Damping is parameterized as a complex vertical wavenumber with

$$m_i \cong -\nu m^3/\hat{\omega}$$

- Weaker damping may be partially owing to the fact that ion-drag damping is ignored to the first order and nonlinear wave-wave interaction and radiative damping are not yet included in the spectral model.



Summary, Conclusions, & Future Work

- The background sub-grid gravity waves are incorporated into wavefields and implemented at the lower boundary of GITM.
- Horizontal wind components result in changes of neutral density within 8% and electron density within 2%. Variation caused by vertical wind perturbation is about 3–6 times higher than by the horizontal wind.
- TIDs appear to be formed with the background wavefields.
- The comparison of wave propagation in the two models shows weaker damping in the spectral model. Ion-drag, non-linear wave-wave interaction, radiative damping…?
- Our future work is to further increase the vertical resolution in GITM and to investigate and explain the observed differences regarding to moment flux and energy dissipation.
- Poster: COUP-05 (MLT), Tuesday 4-7 PM, Jun 23 (yesterday, so please come talk to me!)

References

- [1] Deng, Y. and A. J. Ridley (2014), Simulation of non-hydrostatic gravity wave propagation in the upper thermosphere, Ann. Geophys., 32, 443–447, doi:10.5194/angeo-32-443-2014

- [2] Drob, D. P. et al. (2013), Method for specifying GW for infrasound propagation, J. of Geophys. Res., 118, 3933–3944, doi: doi:10.1029/2012JD018077

- [3] Hedlin M. A. H. and D. Drob (2014), Statistical characterization of atmospheric gravity waves by seismoacoustic observations, J. Geophys. Res. Atmos., 119, 5345–5363, doi:10.1002/2013JD021304

Thanks!