



2<sup>nd</sup> SWARM International meeting

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# Effects of tidal oscillations simulated

## in a non-hydrostatic general

## circulation model

Erdal Yiğit

Aaron J. Ridley

University of Michigan, Ann Arbor, USA



# Outline



1. Introduction
2. Global Ionosphere-Thermosphere Model (GITM)
3. Model Results
4. Summary and Future work



# 1. Introduction (i)



- **Internal wave effects on the upper atmosphere!**
  - Irreversible momentum transport
  - Mixing
  - Heating and/or cooling
- Tides:
  - Lower atmosphere dynamics
    - latent heat release
    - Absorption of solar EUV radiation by  $O_3$  and infrared radiation by water vapour
  - Thermospheric tides
    - Variation of solar heating, cooling



# 1. Introduction (ii)



- Small-scale gravity waves (GWs)
  - Generation: Weather, geostrophic adjustment, nonlinear wave-wave interactions, convective activity
  - Propagation into the TI [Yiğit et al. 2008; 2009]
- GCMs :
  - Different vertical extent
  - Varying lower boundary conditions
  - Importance of assessment of lower boundary-induced variability

## 2. GITM (i) (design)

- 3-D nonlinear, non-hydrostatic, coupled GCM
- Altitude coordinate system
- Fully parallel and efficient: Block-based; ghost cells
- Variable model resolution:
  - Horizontal resolution: latitude-longitude blocks
  - Vertical resolution: 54 levels: 1/3 H, 100 km – 600 km
- Small time step: 2-4 s (vs 60 s !)



## 2. GITM (ii)



- Grid stretching:
  - in latitude and/or altitude
- Self-consistent chemistry
- Variable lower boundary forcing
  - MSISE-90
  - Global Scale Wave Model [GSWM, Hagan and Forbes, 2003] :
    - Diurnal migrating (DM) and nonmigrating (DN)
    - Semidiurnal migrating (SM) and nonmigrating (SN)



## 2. GITM (iii) (electrodynamics)



- Electric fields:
  - Flexible: a variety of different models available
  - Low-latitudes
  - High-latitudes
- Magnetic field configuration:
  - Dipole
  - APEX
- Space Weather Modeling Framework (SWMF, Toth et al, 2005)



## 3. Results (i) (model configurations)



- 21-23 December 2002, 0000 UT
- Low  $K_p$ , moderate  $F_{10.7}$
- 8 x 8 latitude-longitude blocks; 9 x 9 latitude-longitudes each block
  - $2.5^\circ \times 5.0^\circ$  latitude x longitude resolution
- Implementation of GSWM data (DM, DN, SM, SN) provided by *Maura Hagan* and *Astrid Maute* (NCAR)

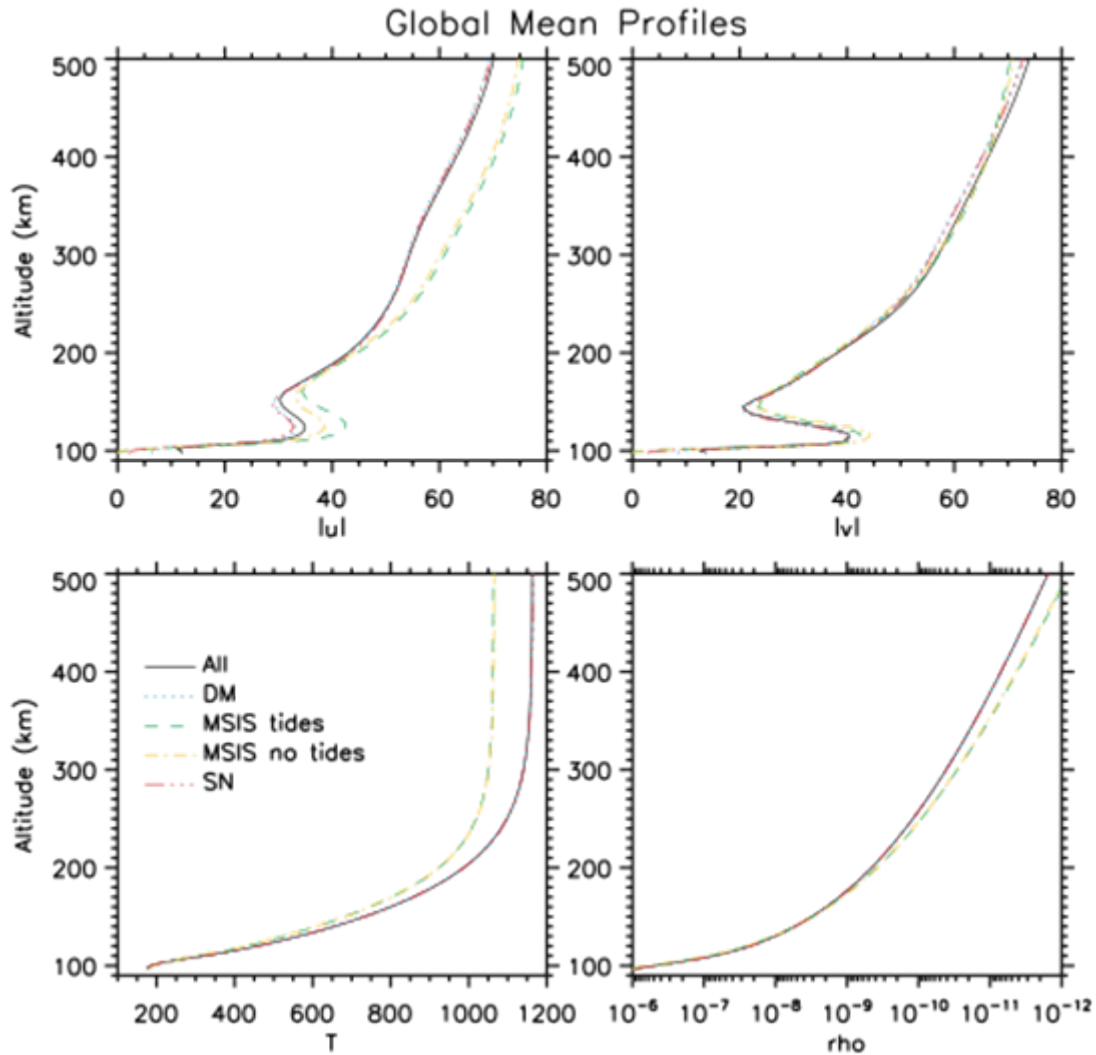


## 3. Results (ii) (simulations)

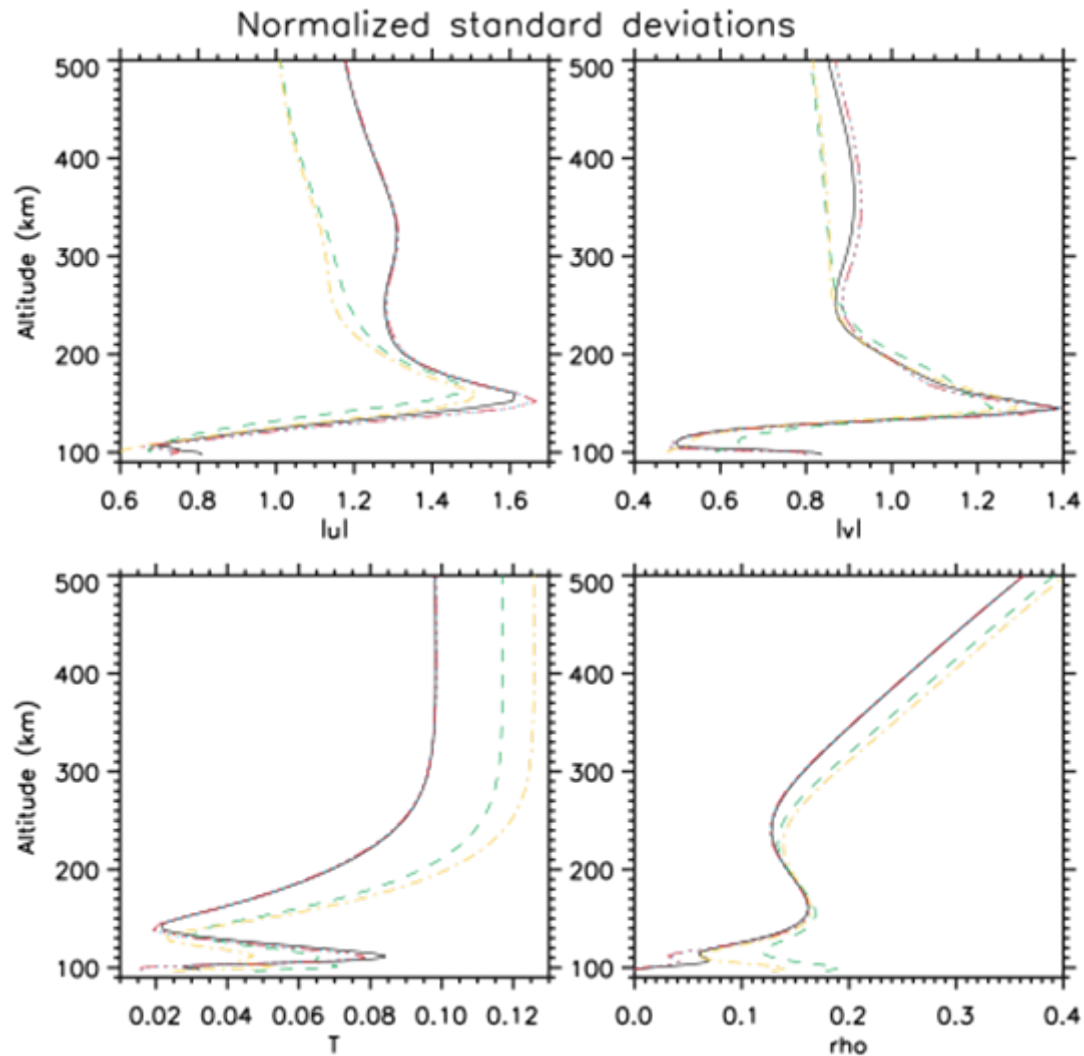


- Model runs with different lower boundary conditions:
  - A) MSISE-90 (with tides)
  - B) GSWM (all tides)
  - C) GSWM DM
  - D) GSWM SN
  - E) MSISE-90 (no tides)

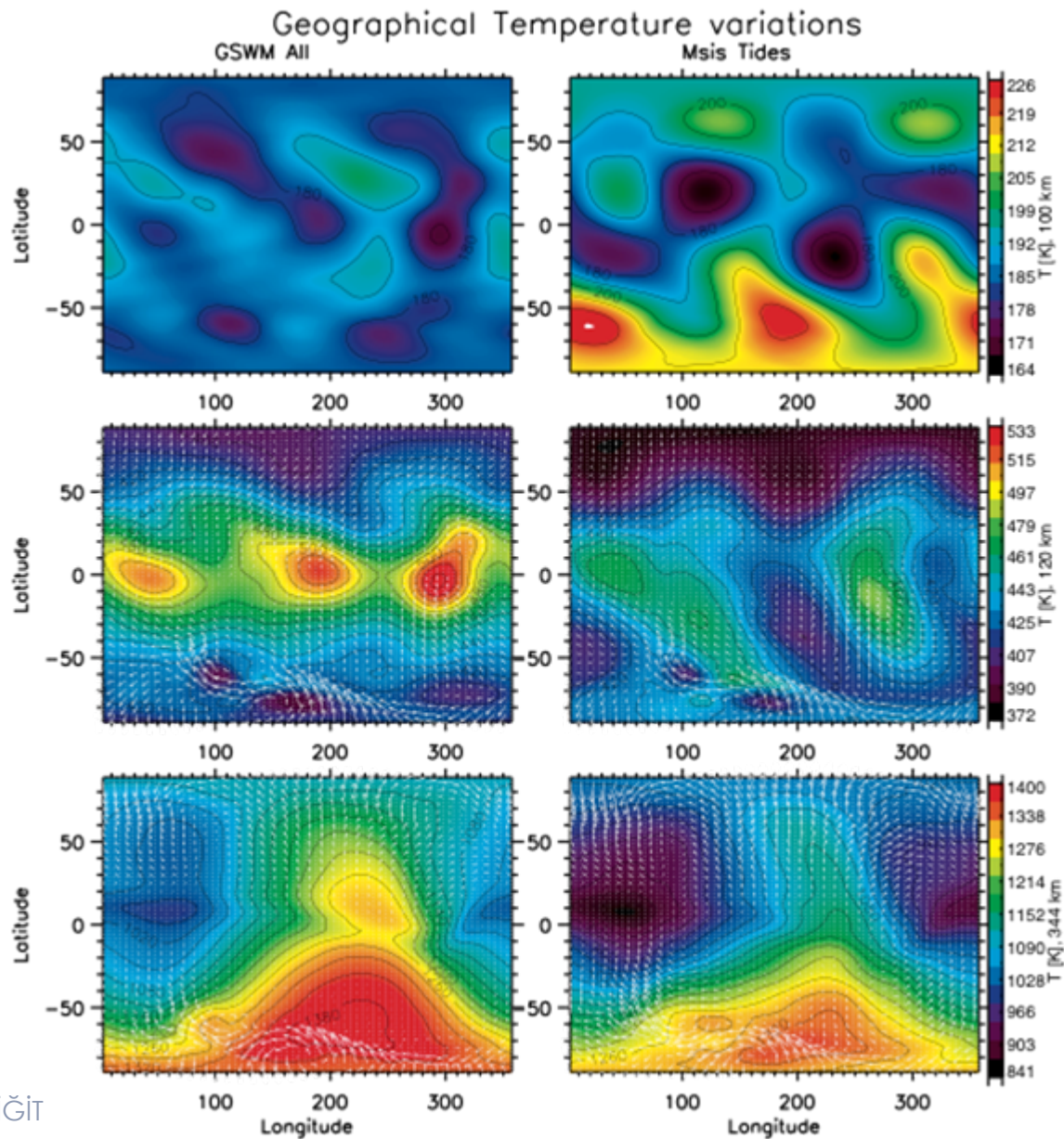
# 3. Results (iii) (global mean)



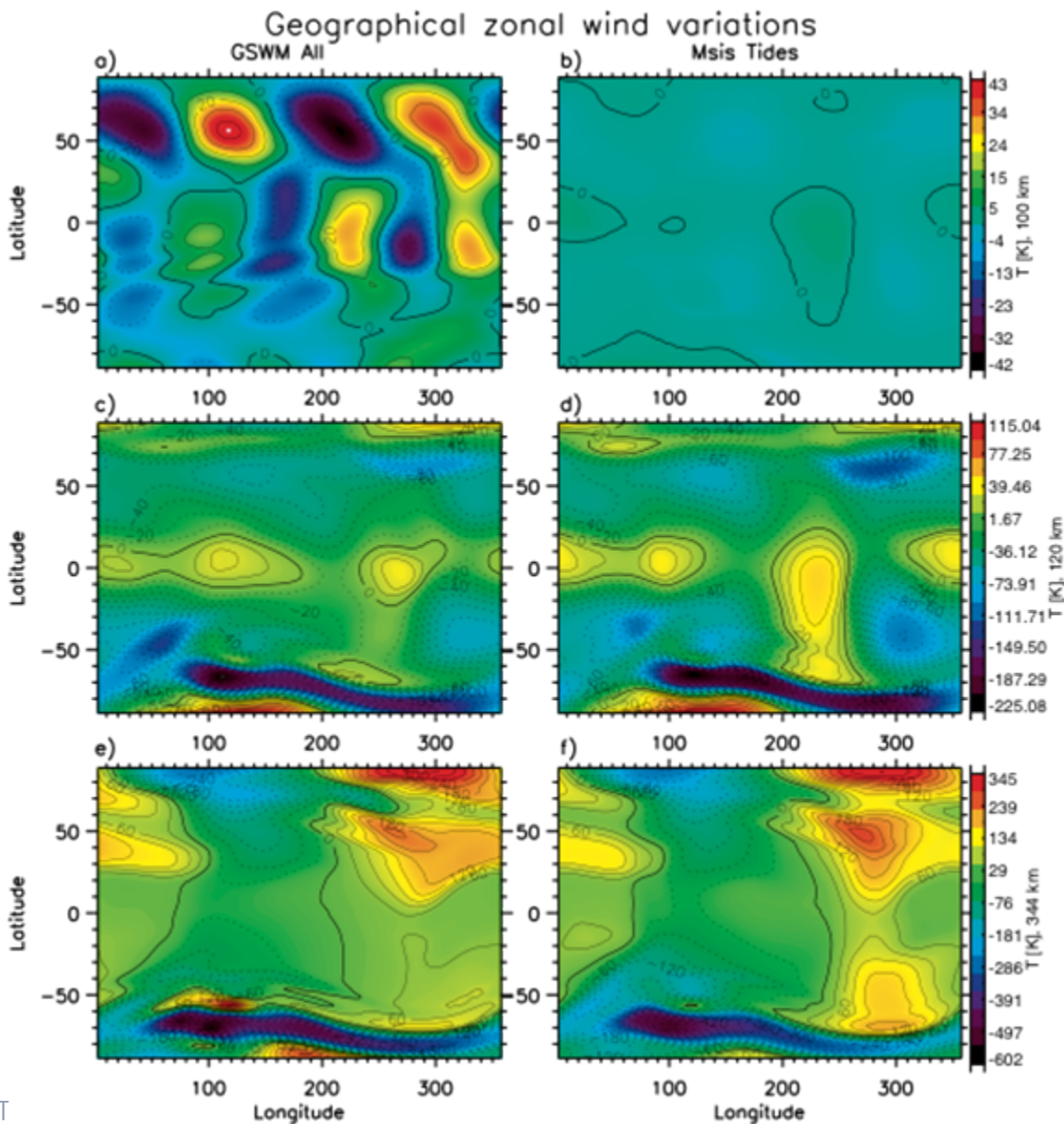
# 3. Results (iv) (standard deviation)



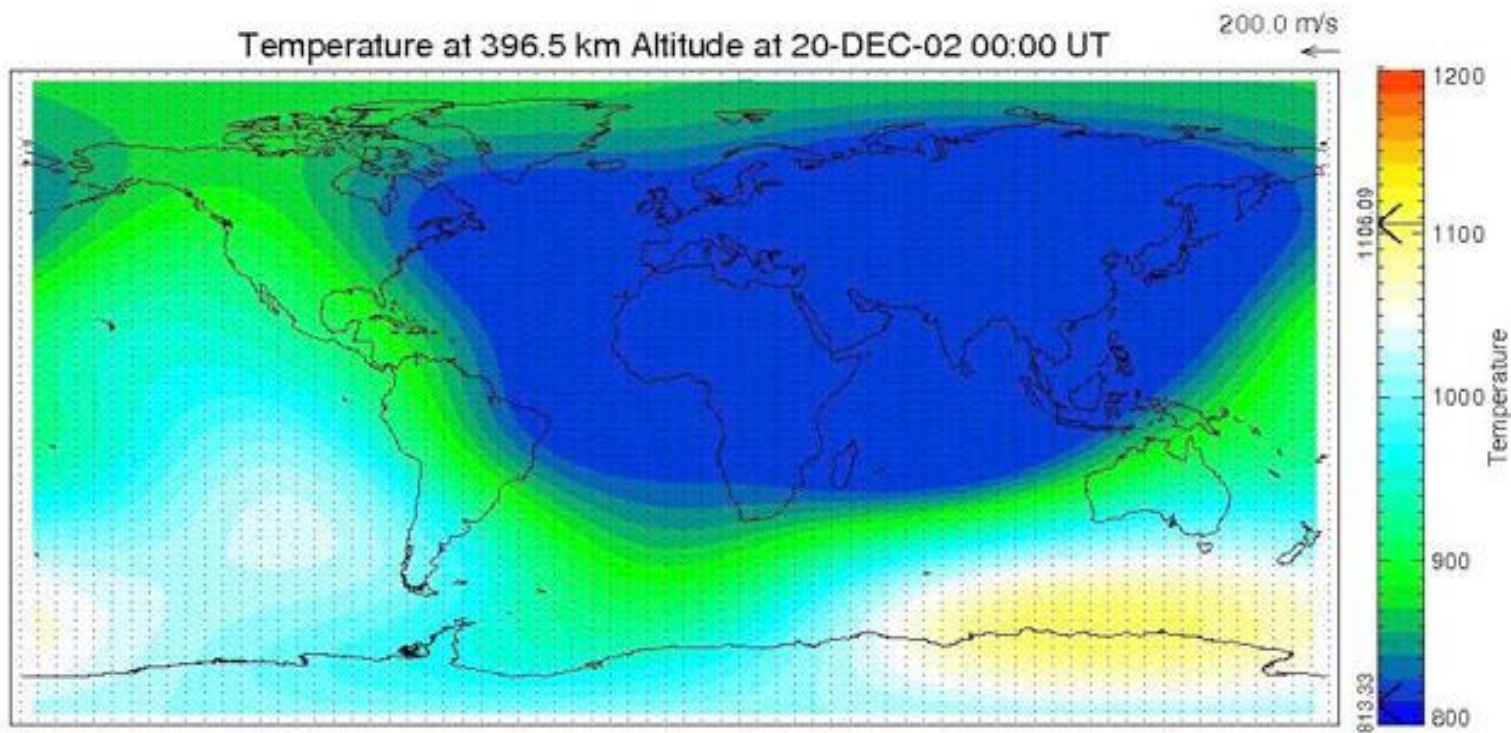
# 3. Results (v) (geographical distribution)



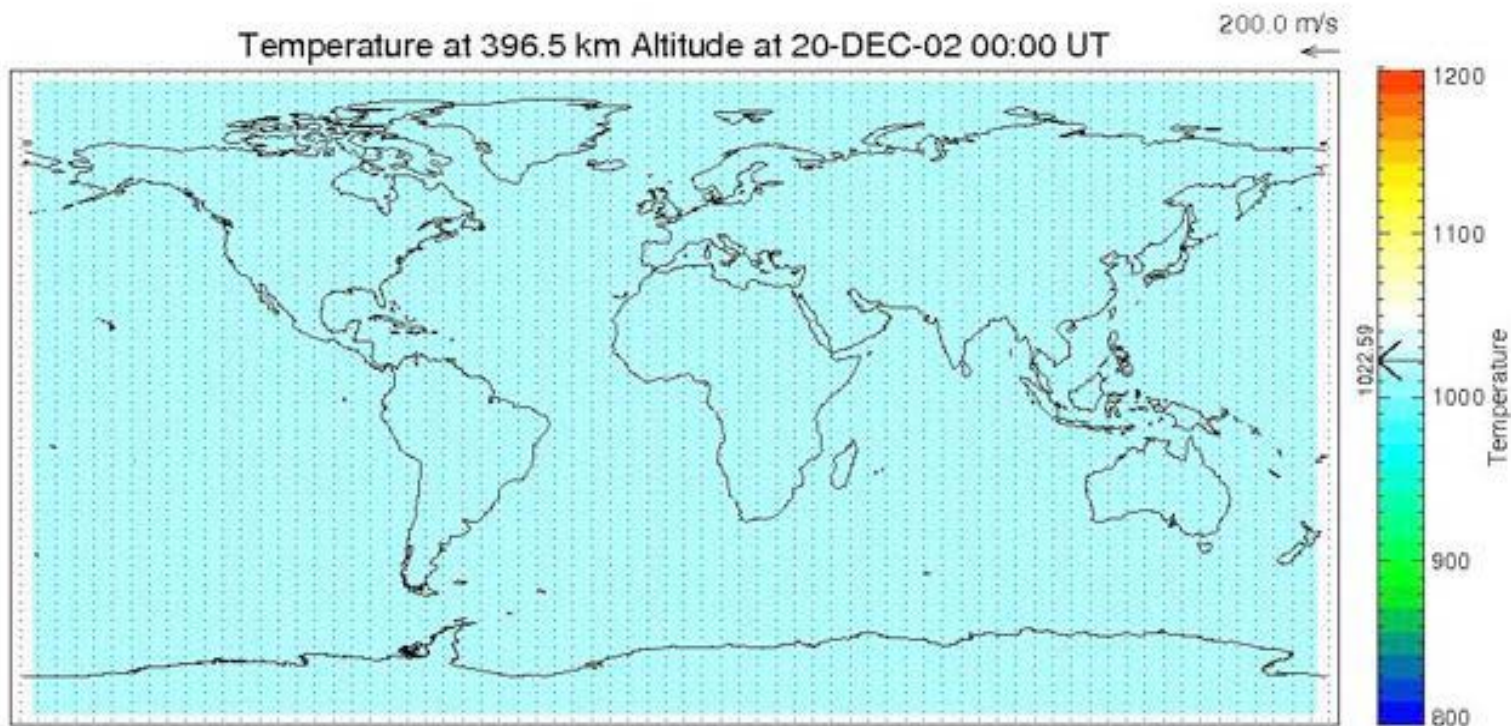
# 3. Results (vi) (geographical distribution)



# MSIS tides



# GSWM all



## 4. Summary & Future Work (i)

- Implementation of GSWM tidal fields in GITM:
  - Significant differences between MSISE-90 (with tides) and GSWM (all tides)
    - $\langle u \rangle$ ,  $\langle v \rangle$ ,  $\langle T \rangle$ ,  $\langle \rho \rangle$ ,
    - $\sigma_u, \sigma_v, \sigma_T, \sigma_\rho$
    - Global morphology of  $T$ ,  $u$  in the lower and upper thermosphere
  - Minor differences between different GSWM tidal components



## 4. Summary & Future Work (ii)



- Long-term runs -> seasonal and day to day variability
- Detailed investigation of individual tidal components.
- Model resolution and variability associated with resolved eddies.
- Variations in  $w$ .