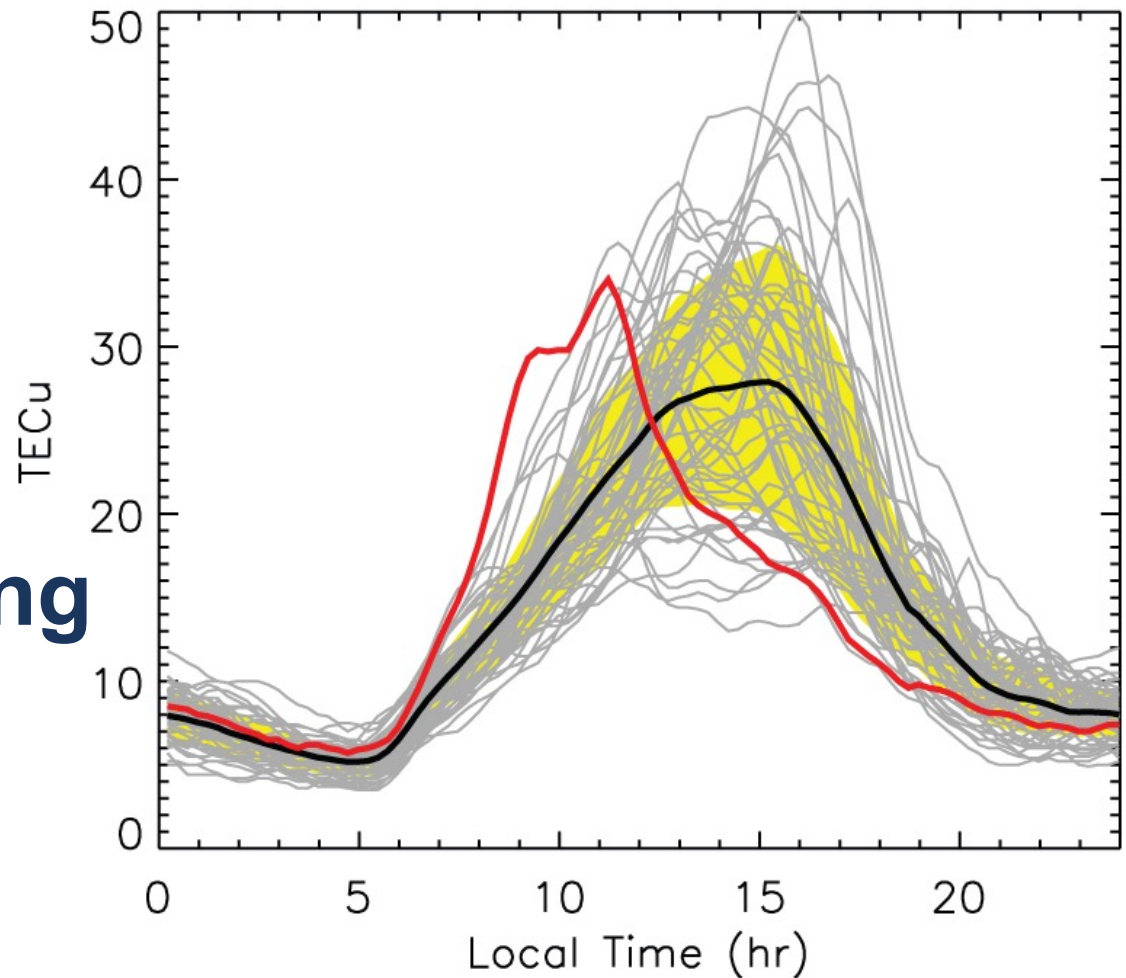


# Thermosphere- Ionosphere Coupling at NRL

F. Sassi – NRL  
S.E. McDonald – NRL  
D. Drob - NRL  
J. Tate – CPI  
C. Metzler - NRL



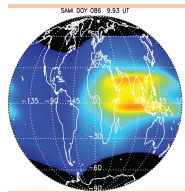
McDonald et al. (2015)

# Overarching Questions

- What type of **dynamics** reaches the lower thermosphere and is conducive to coupling the ionosphere properties with the neutral behavior?
- How is **composition** variability in the MLT affecting the characteristics ionospheric layers?
- Is there a benefit of including **weather** to improve HF radio-wave propagation?
- What observational data is available for model **validation** on short- & long-term, and global scales?
- The NRL example ...

# Bottom-side Ionosphere Weather Modeling

How do environmental conditions (chemistry, solar drivers, and meteorology) affect radio-frequency wave propagation?



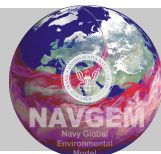
**SAMI3**

Physics-based model of the ionosphere.  
Dynamics and chemistry of 7 ion species from 85 km to > 20,000 km

Full Coupling



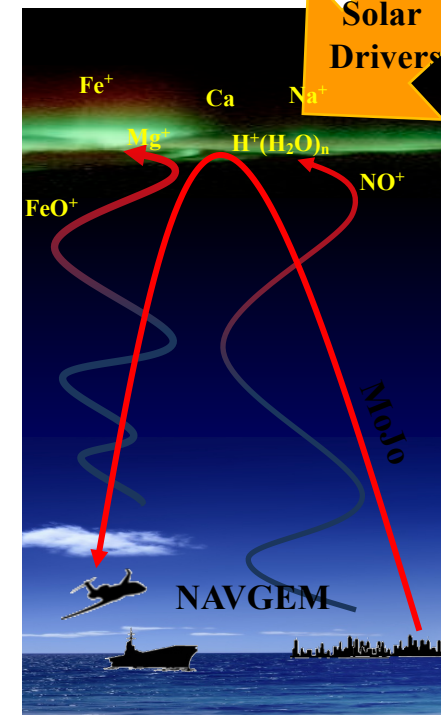
Global climate-chemistry model  
Solves dynamics, physics and chemistry globally from ground to ~500 km



NAVGEN: Operational Navy Analysis  
(ground to ~92 km)  
4DVAR Hourly data assimilation products



NRL-SAMI3



MoJo

Radio-wave propagation code.  
Includes updated dispersion and attenuation.  
Capable of using observations & model data.  
Produces ionograms (WSBI) for verification.

# Model Data Validation

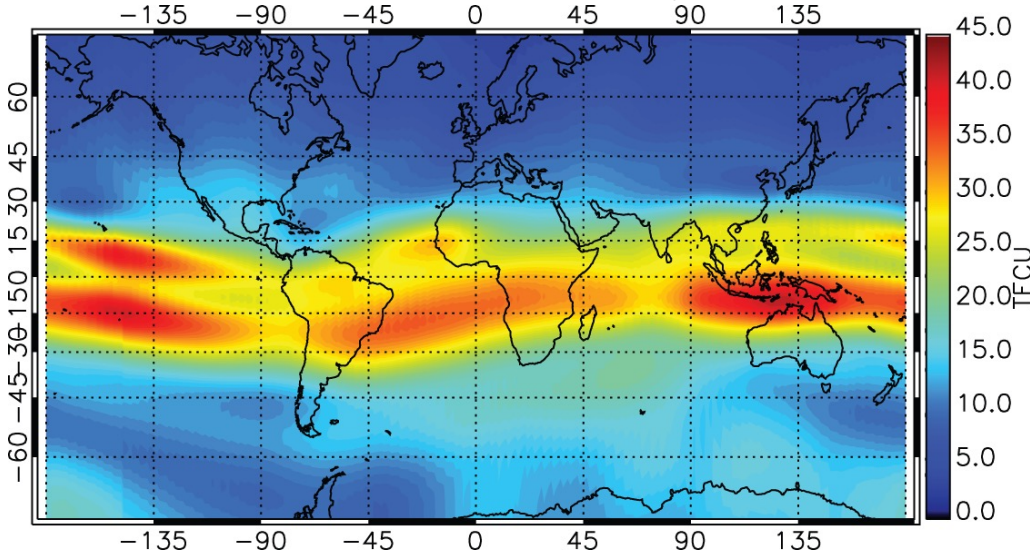
How can we validate model data?

What type of datasets we need to properly validate thermosphere-ionosphere forecasts?

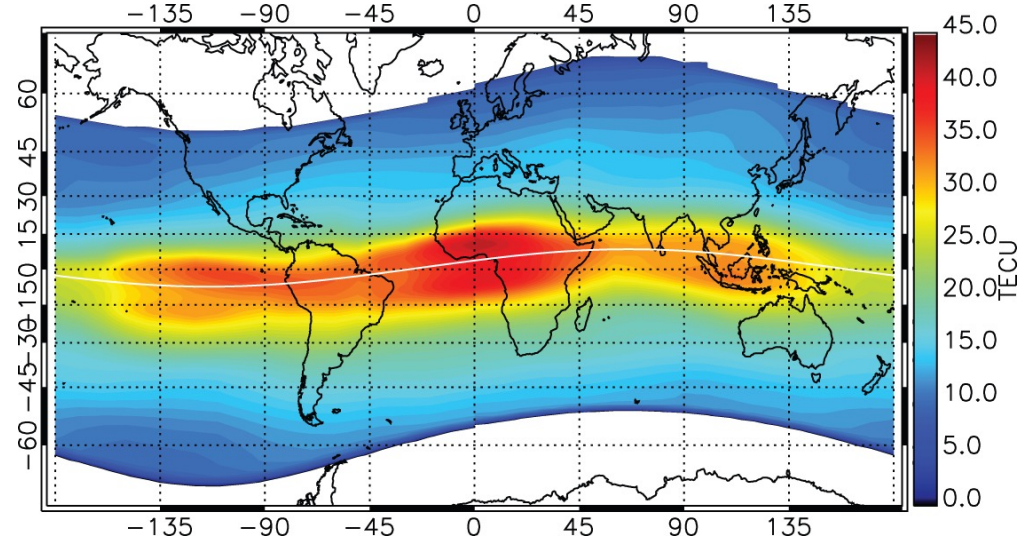
What time scales?

# TEC – Spatial Structure at LT = 14:00

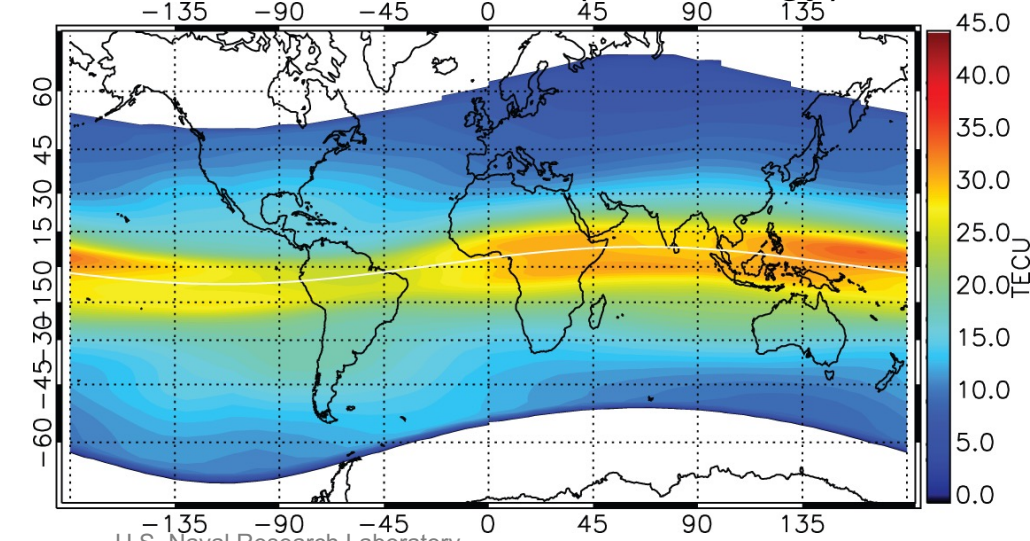
JPL TEC 20 – 29 January 2010



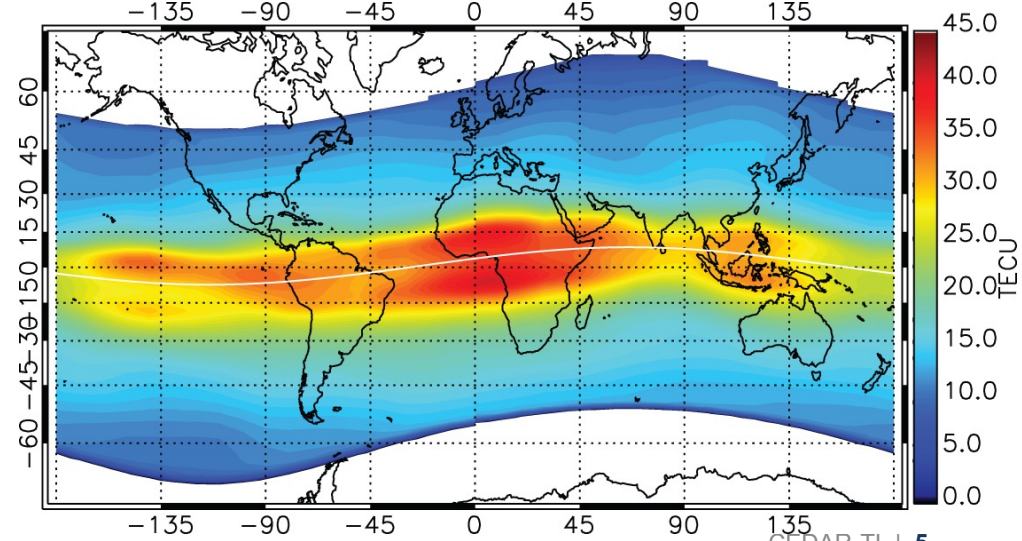
SAMI3/SD-WACCM-X with NOGAPS



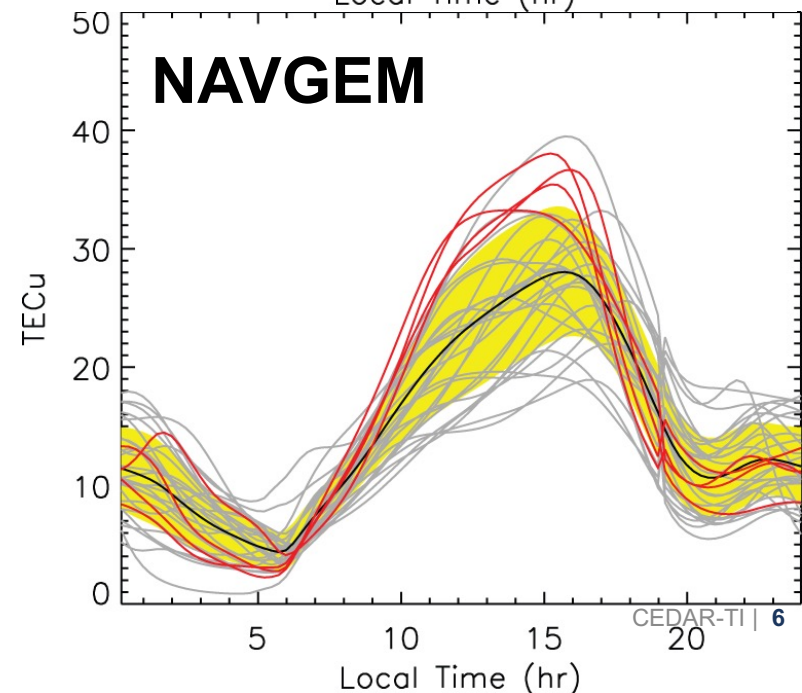
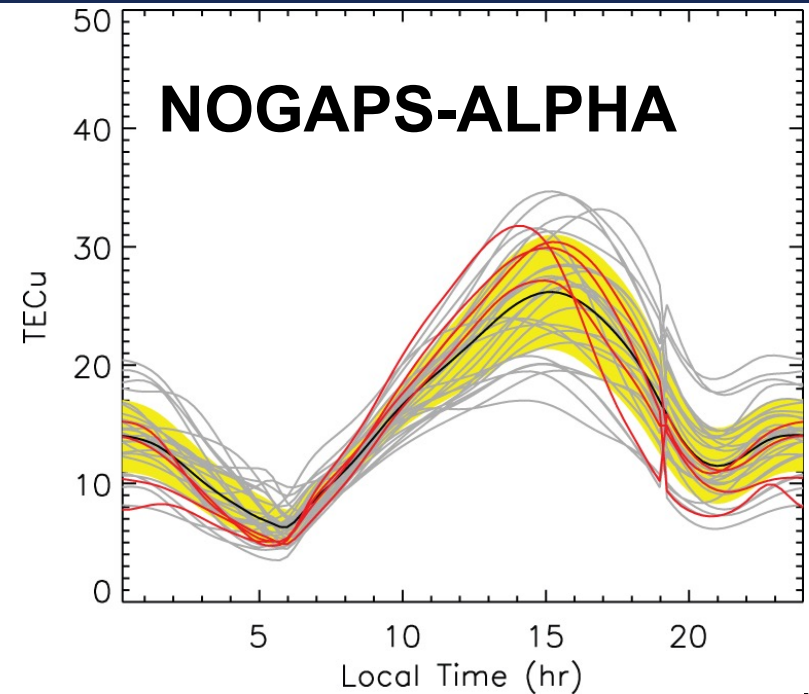
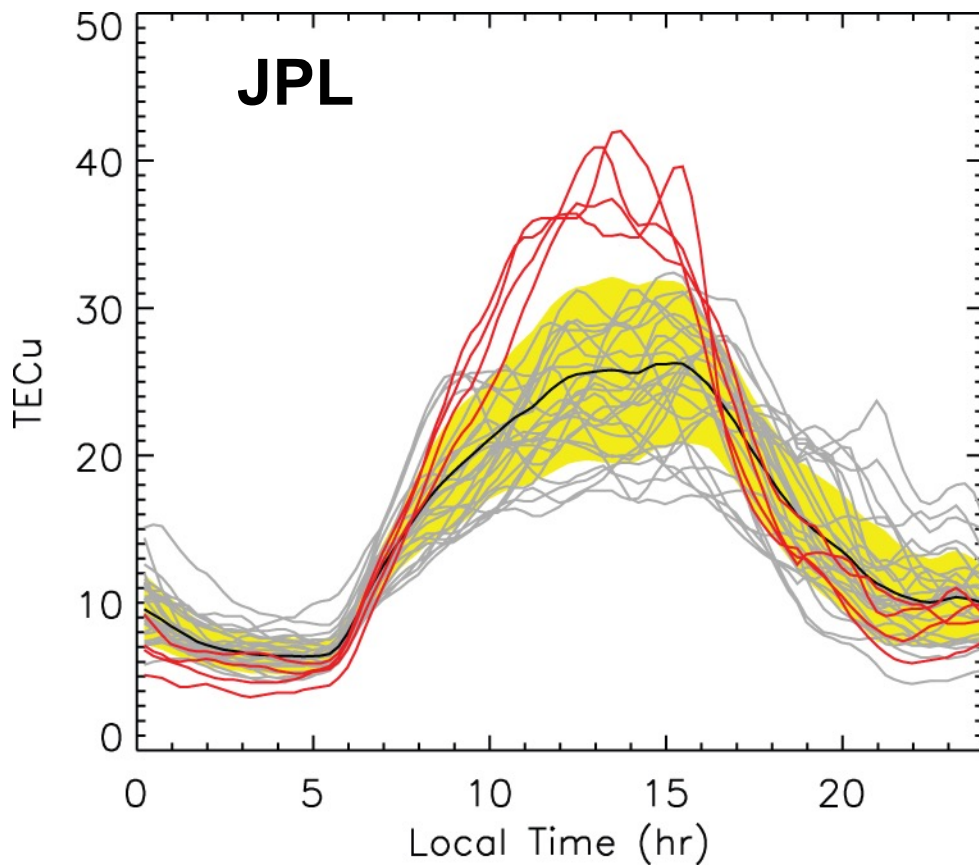
SAMI3/HWM/MSIS (climatology)



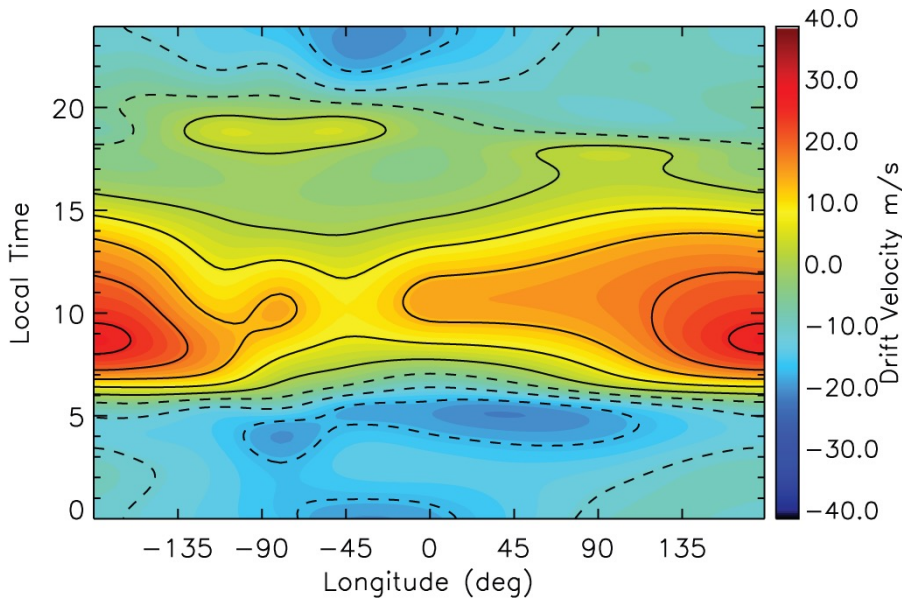
SAMI3/SD-WACCM-X with NAVGEM



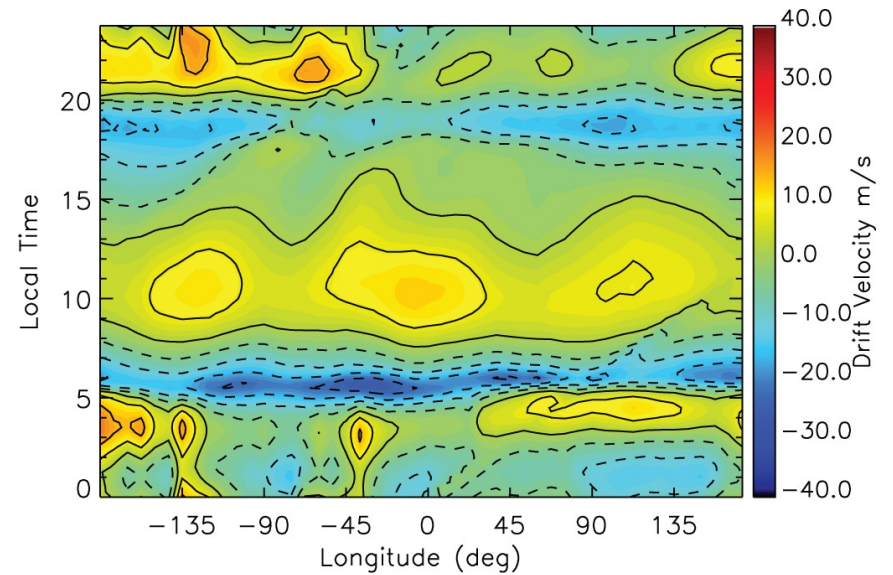
# TEC – Daily 2-31 Jan 2010



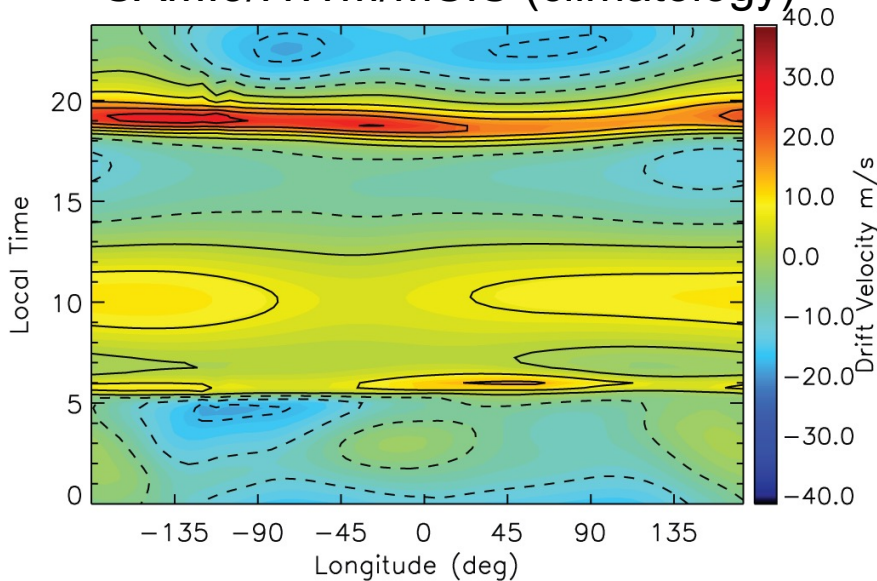
### Scherliess-Fejer: January



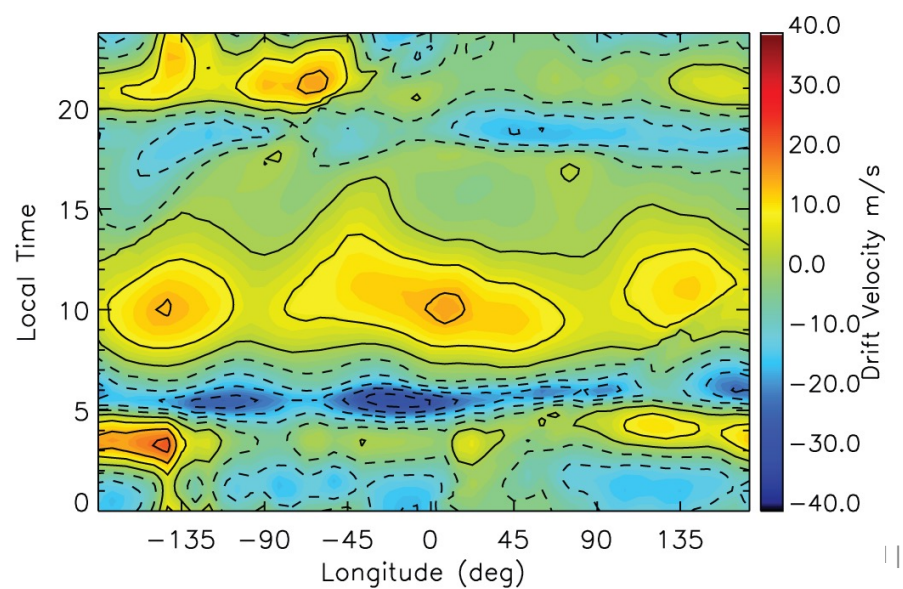
### SAMI3/SD-WACCM-X with NOGAPS forcing



### SAMI3/HWM/MSIS (climatology)

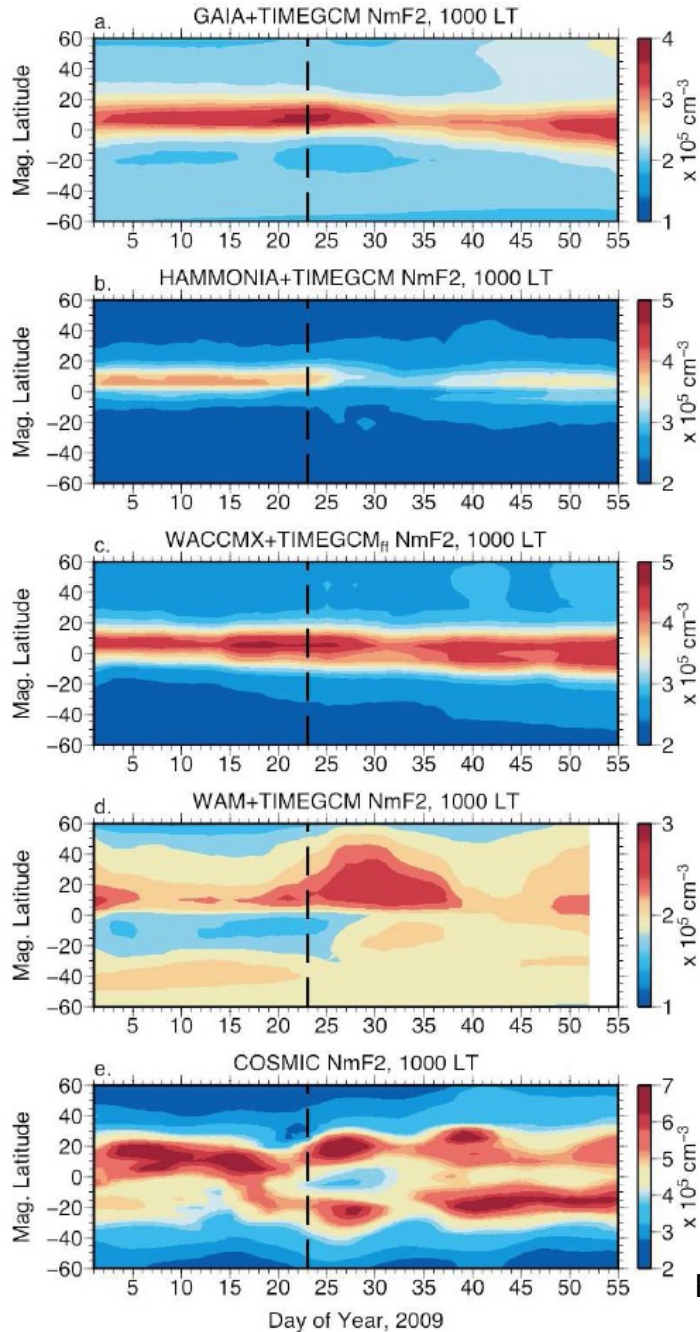


### SAMI3/SD-WACCM-X with NAVGEM forcing



# Vertical Structure

nmF2



MODELS

COSMIC

Pedatella et al. (2016)



# Final Thoughts

- Thermosphere-Ionosphere Interactions:
- **Scientific challenges:** Coupling the ionosphere with the thermosphere ( $z_{top} \sim$  exobase) that includes weather from the lower atmosphere
- **Computational challenges:** Achieving code efficiency and accuracy
- **Validation challenges:** We need to validate our model simulations (!) both on short-time scales (vis a vis role of tides, migrating and non-migrating), and long-time scales (vis a vis role of composition changes). We also need global datasets. And we need a common and established way to compare models to observations.
- **Let's get started with the interesting stuff ...**

We thank the Chief of Naval  
Research for supporting this activity