Vertical Behavior of TADs/TIDs Using SAMI3 Driven by GITM

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Abstract

We investigate the behavior of Traveling Atmospheric/Ionospheric Disturbances (TADs/TIDs) during storm time using model results from SAMI3 (SAMI Is Another Model of the Ionosphere). SAMI3, by default, uses MSIS for the neutral atmosphere which does not generate disturbances. Thus, we need a 3D model capable of generating disturbances and chose the results from Global Ionosphere/Thermosphere Model (GITM). We first show how GITM can reliably produce TADs in the case of a simulated extreme storm and how these results drive TID propagation in SAMI3. The simulated storm is used to establish a control and eliminate the variabilities introduced by substorms within a larger storm. We can then apply the GITM/SAMI3 simulations to a real storm and investigate the vertical behavior of TIDs in order to attempt to link what is seen in the ionospheric total electron content (TEC) from Global Navigation Satellite System (GNSS) satellites to what is seen in ion density measurements made from the DMSP satellites in the topside ionosphere.

Methodology

GITM Background:

- Coupled Ionosphere-Thermosphere model
- Typically run from 100-600km
- Does not assume hydrostatic equilibrium to more realistically capture auroral heating
- Geographic grid, stretched in altitude

SAMI3 Background:

- Physics-bases Ionosphere model
- Can be run from 90km -> 6Re
- Does not model neutrals, relies on an external model (typically MSIS; GITM in our work) for thermosphere
- Grid traces magnetic field lines

Versions of SAMI3 & GITM that are fully coupled is under development. Currently, we are using GITM outputs for several neutral species densities and the zonal & meridional neutral winds as inputs into SAMI3.

Our GITM run info:

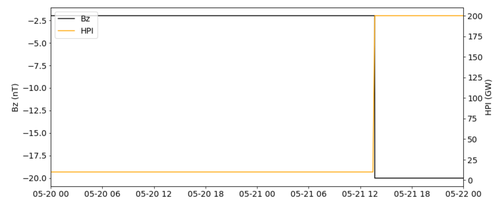
- 4°x1° longitude x latitude, 50 altitudes
- Data output every 5 minutes

Our SAMI3 run info:

- 80 magnetic longitudes, 72 altitudes (field lines), 256 grid cells along each field line
- Data read from GITM and output every 5 minutes.

Simulated Storm

- Used to establish a baseline and isolate disturbances caused by the main storm phase from those generated from substorms.
- Low DST background for a month.
- IMF conditions were kept quiet until 13:40 UT on the ”storm” day and then Bz was taken from -2.5 to -20 nT and HPI was taken from 10 to 200 GW, both as a step function, shown below.



Results

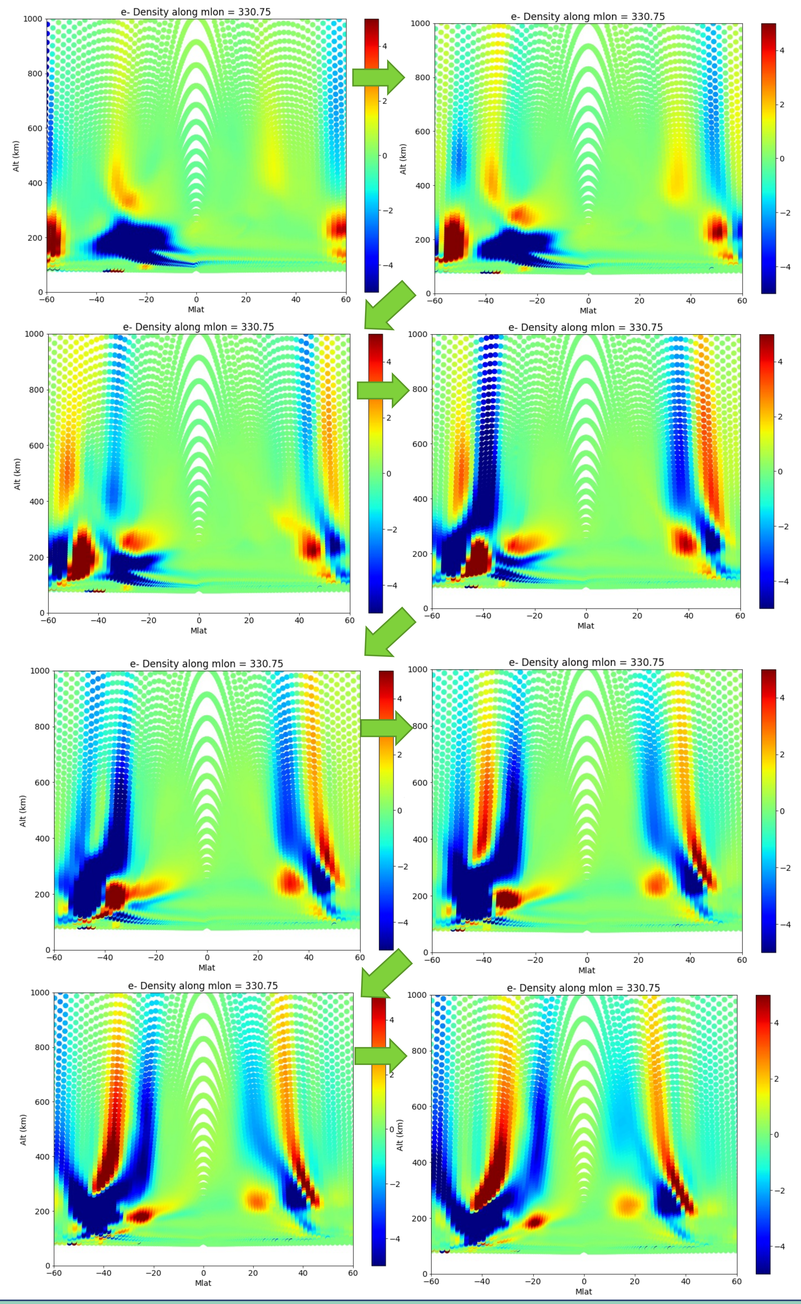
Below images show SAMI3 outputs along a single magnetic longitude

- Color represents % above 30-minute background
- Enhancement forms near high latitude
- Propagates toward magnetic equator
- The density enhancement is present along the entire magnetic field line

At high-alt, TIDs may appear ahead of those at lower alts

➢ Images are 10 minutes apart, with the first plot occurring about an hour after storm onset.

➢ Storm onset is just before local noon

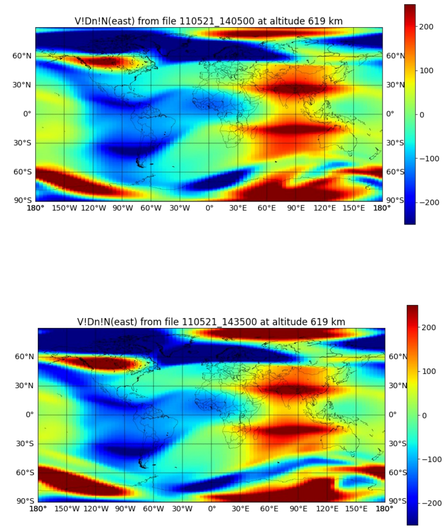


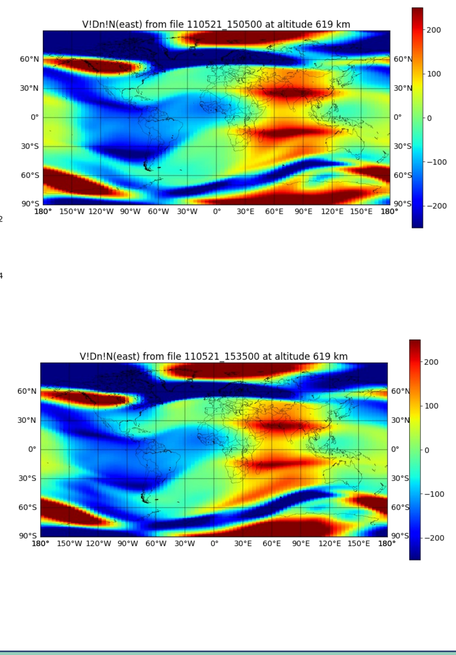
Neutral winds are expected to be the main driver of TIDs

- Below: the eastward neutral wind from GITM.
- The hemispheric asymmetries as well as the local time dependence of these traveling disturbances is evident.

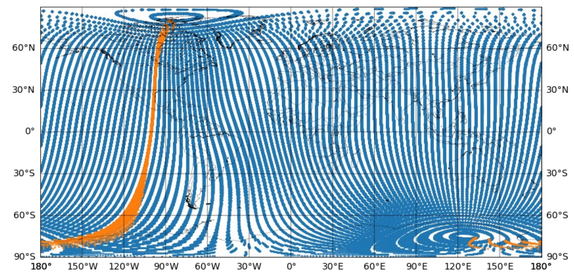
➢ These plots are shown every 30 minutes.

➢ The magnitude of the TADs from GITM simulations are about 50% over background



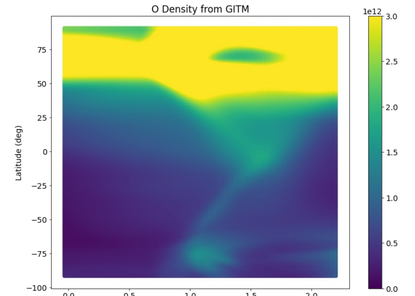


Results Continued



The map above shows the locations of all the points in the SAMI3 grid below 1000 km. The orange line represents Mlon=330°, the locations of the plots to the left. The vertical lines and apparent smearing is a result of SAMI3 using a magnetic coordinate system for its grid.

Scan this QR code to see animations of the plots shown.



Above is a keogram made using GITM outputs at 300° longitude. TAD is seen about 1 hour after storm onset.

Conclusions

- SAMI3, when seeded by GITM, shows that TIDs are formed as a result of the neutral wind and density perturbations.
- TIDs seen in SAMI3 reach DMSP altitudes.
- TID propagation speed and wavelength in the models is consistent with what is shown in delta TEC data from GNSS

References

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