Climatology Assessment of Ionosphere/Thermosphere Models in Low Solar Flux Conditions for the CCMC CEDAR Challenge: Status, Lessons Learned, and Future Plans


CEDAR ETI Modeling Challenge, CEDAR Workshop, 25 June 2013, Boulder, CO
Solar Wind and Global TEC and Neutral Density at 400 km

The conditions from 07325-08020 included 5 periods of High Speed Streams (HSS) in the solar wind velocity (Vsw). Kp values were usually >=2 for the HSS and <=1 for slow Vsw. The HSS prompted high daily TEC along 8 longitudes and high 400 km neutral densities in satellite drag data from Emmert [2009, JGR] and in two calibrations of the CHAMP satellite at 2 LTs.
Choose 8 Longitude Slices from GPS TEC

5 deg lat and 5 deg lon bins for 20 min in December solstice 07355. Longitudes chosen: 25E, 90E, 140E, 175E, 200E (160W), 250E (110W), 285E (75W), 345E (15W).
Average the 8 glons for IGS and the 4 ‘good’ ones for MIT to get estimated global TEC from the data to compare with the models. There are obvious differences in TEC baselines, where the two UAM4 lines show approximately 3 TECU between 500 km and 20,100 km.

Because of the difference in baselines of the data, the first metric used is (1) the baseline. The other two metrics are (2) max-min (or the range), and (3) the root mean square rms from the satellite drag observations minus the 58-day averages.

Metrics for Comparison

- **Baseline**
- **Max-min (or range)**
- **Root mean square rms**

**Global TEC 07325-08020**

GITM missing
C/NOFS IVM ion drifts meridional to B, which is vertical at the magnetic equator (Viz, 67 days for all LTs). Also IVM Ti, O+; PLP Ne, Te; VEFI Ui; ~400-800km

CHAMP Cross-track neutral winds (mostly zonal Un +/-65glat, 131 days for all LTs). Also Ne and Te ~400km
Vertical Ion Drift (Viz) Mapped to Magnetic Equator

**December F107 ~ 73**

+/-13 glat win09 400-550 km Zonal vs meridional (Viz) Drifts

**March F107 ~ 120**

+/-13 glat spr12 Zonal vs meridional (Viz) Drifts
Neutral Zonal Winds +/-15glat and Zonal Aves

Obs show superrotation (+E) at the equator and subrotation at higher latitudes. Different March tides at 97 km lb mostly +W. Nudging model with tides and zonal means to 102 km is better.
Average +/-13.1glat for LT vs Longitude and compare to C/NOFS PLP Ne with 3 peaks from DE2 waves from the lower atmosphere. The PLP Ne minimum at -80 (or +280E) shows in all but MIT TEC (but MIT is poor for 90, 250, 345E), but PLP peaks ~ 120E, 210E and 340E are best seen in hmF2.
12-15 LT Ne minus zonal ave at 450 km from C/NOFS PLP and from TIDI/SABER LBC Tides

The best tides are specific daily TIDI/SABER tides for the lower boundary condition (lbc) ~97km. These double resolution runs for specific solar minimum days similar to the C/NOFS PLP periods show 3-5 peaks in Ne ~450 km for December and March similar to the data. Peaks at 50E in the TIEGCM are at a minimum in C/NOFS data, but close to a minor max at 22E.
Only GSWM with non-migrating tides (purple) has 4 peaks in March and December from DE3 for Ne at 450 km. The single resolution CTMT (cyan) and GSWM09 (dark green) tides at the lower boundary have approximately 1 peak, where their double resolution nudged runs have multiple peaks where GSWM09 is ‘best’. DE3 is too big in the December GSWM02 run.
Summary of the CCMC Climatology Study

• Because of data baseline uncertainties, the 3 metrics used were:
  • Baseline (ave over LT or 61-d becomes AV used in RMS)
  • Range (max-min can become R in RMS)
  • Root-Mean Square (RMS)
• Model rankings changed with parameter studied or with different versions of the same parameter.
• Can we include data from C/NOFS, CHAMP, etc for similar ~December solar minimum quiet conditions?
• Study of TIEGCM tides at the lower boundary (~97km) showed the best results to match Ne longitudinal peaks in December or March were double resolution runs (2.5 deg instead of 5 deg glat/glon grid), with improvements in the zonal mean neutral zonal winds when the model was “nudged” with the tides and zonal means from 97 to 102 km.
  • Get output from other models to compare to these observations
  • 8 glons in TEC or Nmf2 is inadequate to find longitudinal structure
  • Should we choose a second period (~Feb-Apr 2012?) to study with finer resolution from the TEC maps, etc?