SA41B-1856: Systematic Climatology Assessment of Ionosphere/Thermosphere Models During November 2007 to January 2008

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Climatology Study for the Ionosphere-Thermosphere

.The CEDAR Electrodynamics-Thermosphere Ionosphere (ETI) Climatology Challenge selected the year of ISR observations (March 2007 – March 2008) at the first CEDAR ETI Challenge Workshop in the summer of 2009.

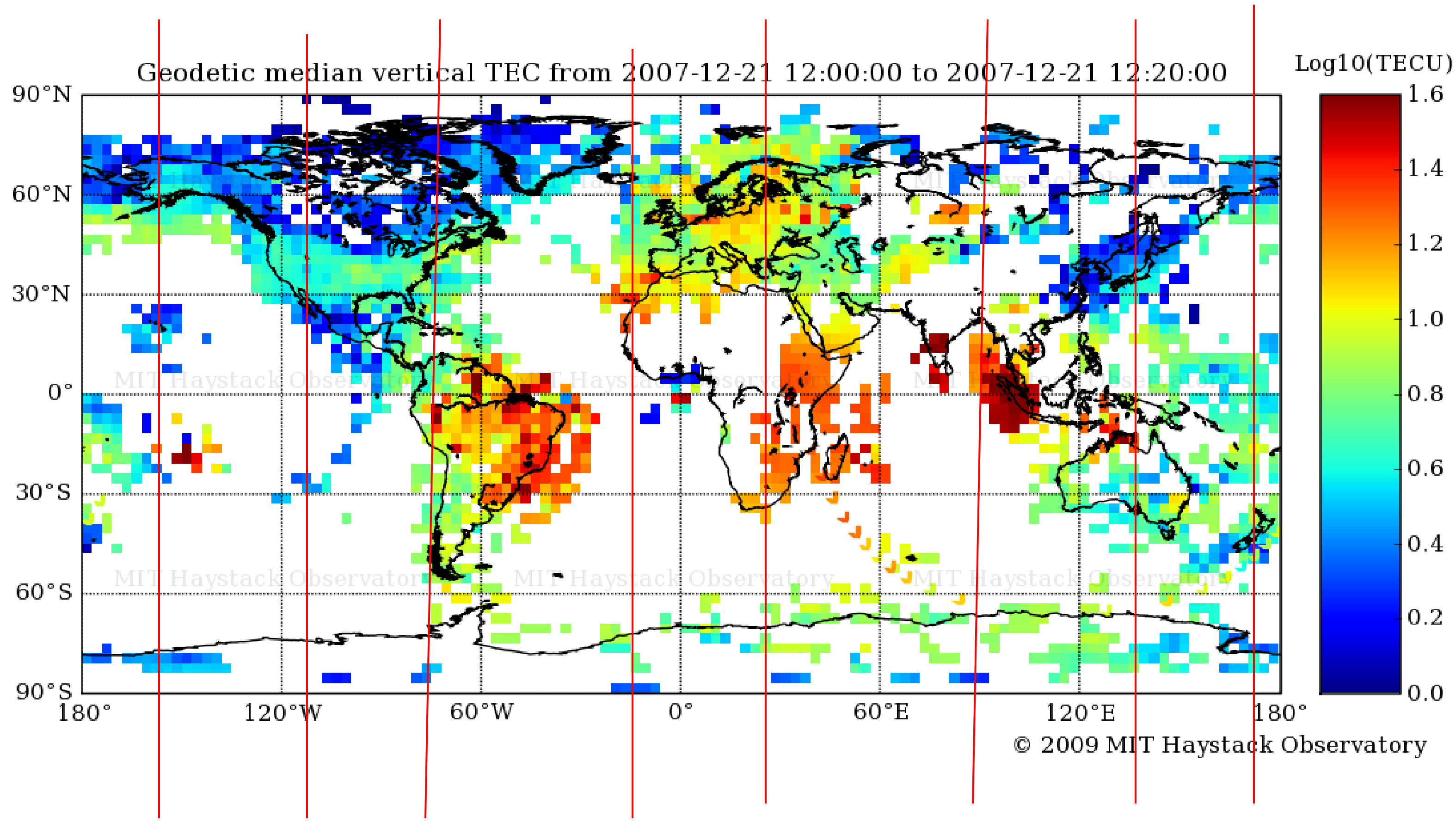
. This first Climatology Challenge centers on GPS Total Electron Content (TEC) around the solar minimum December solstice (07355) for +/-30 days to avoid a sudden stratospheric warming (SSW) January 22-23, 2008.

. Data sets: MIT GPS TEC, USU COSMIC NmF2 and hmF2, NRL satellite drag daily global neutral density at 400 km.

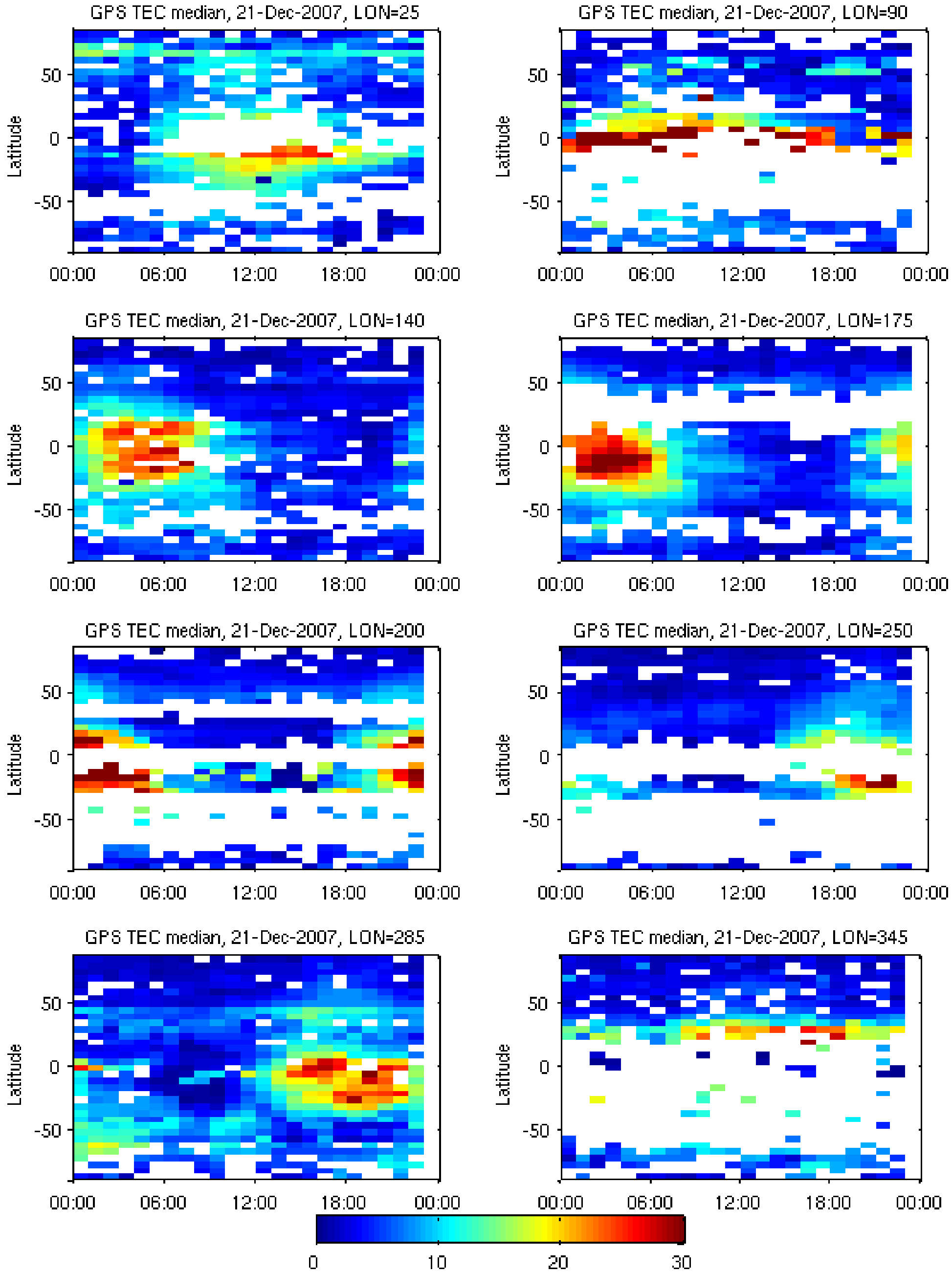
. Empirical model of the equatorial vertical drift (Scherliess and Fejer, JGR, 104, 6829-6842, 1999.

. Model runs: IRI, CTIPE, TIEGCM (Heelis Kp, double resolution Weimer 2005 with TIMED lower boundary)

Choose 8 Longitude Slices from GPS TEC



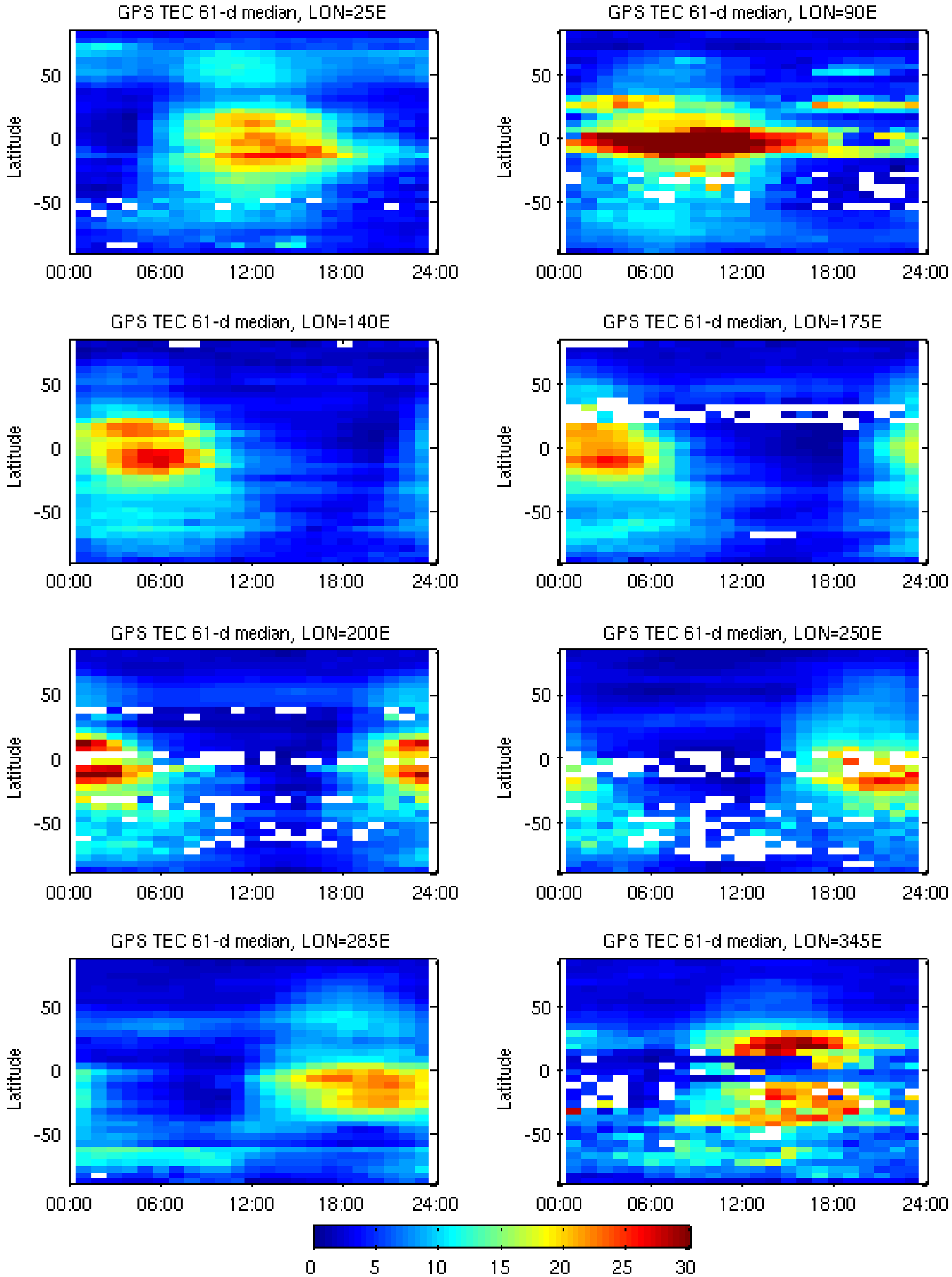
5 deg lat and 5 deg lon bins for December solstice 07355. Longitudes chosen: 25E, 90E, 140E , 175E, 200E (160W), 250E (110W), 285E (75W), 345E (15W).



Hourly coverage of the 8 longitude slices for 21 December 2007 from MIT GPS TEC analysis.

Minimum number of bins 446 for 345E, maximum 727 for 140E.

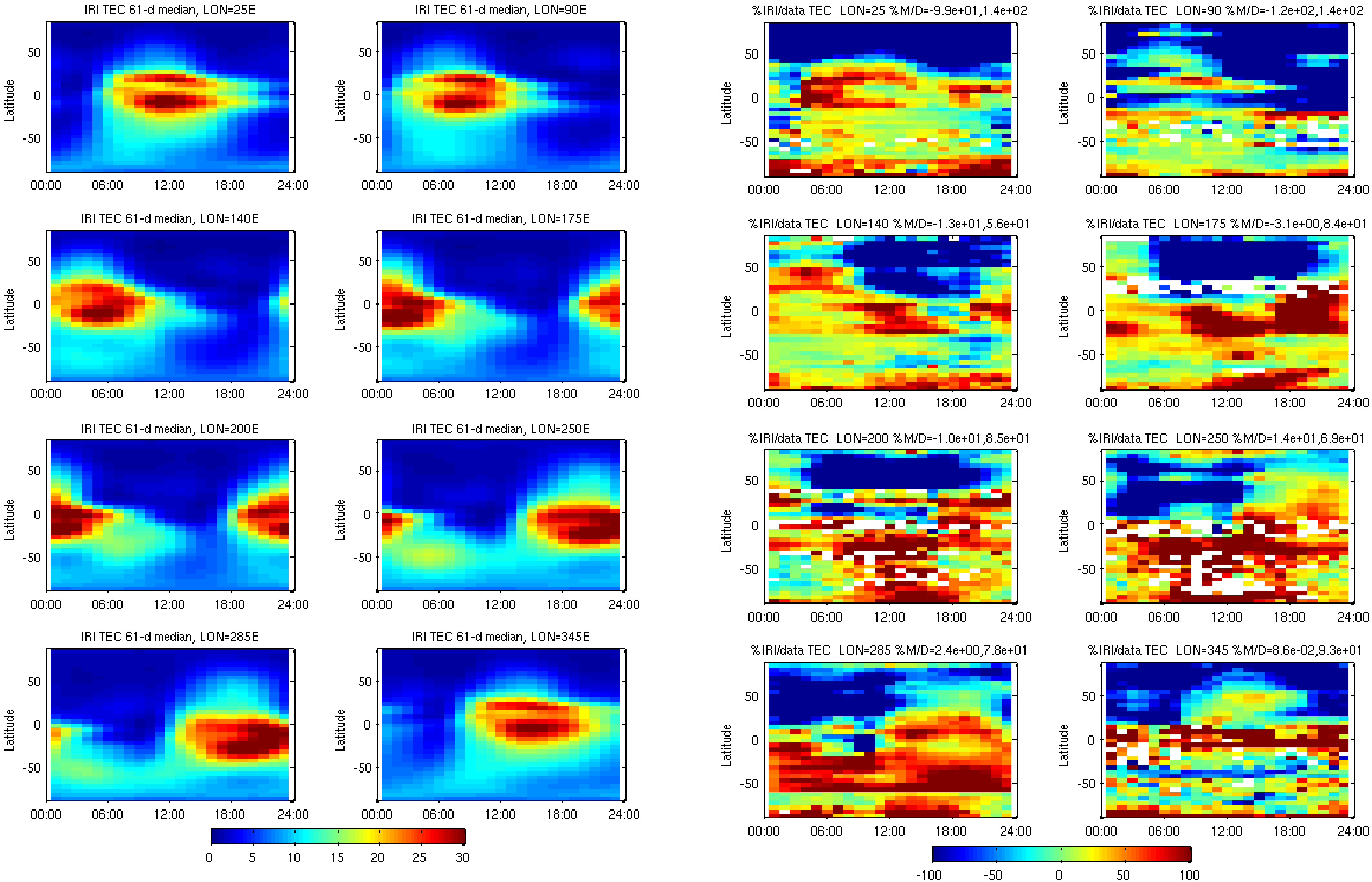
Can see daily low latitude maxima.



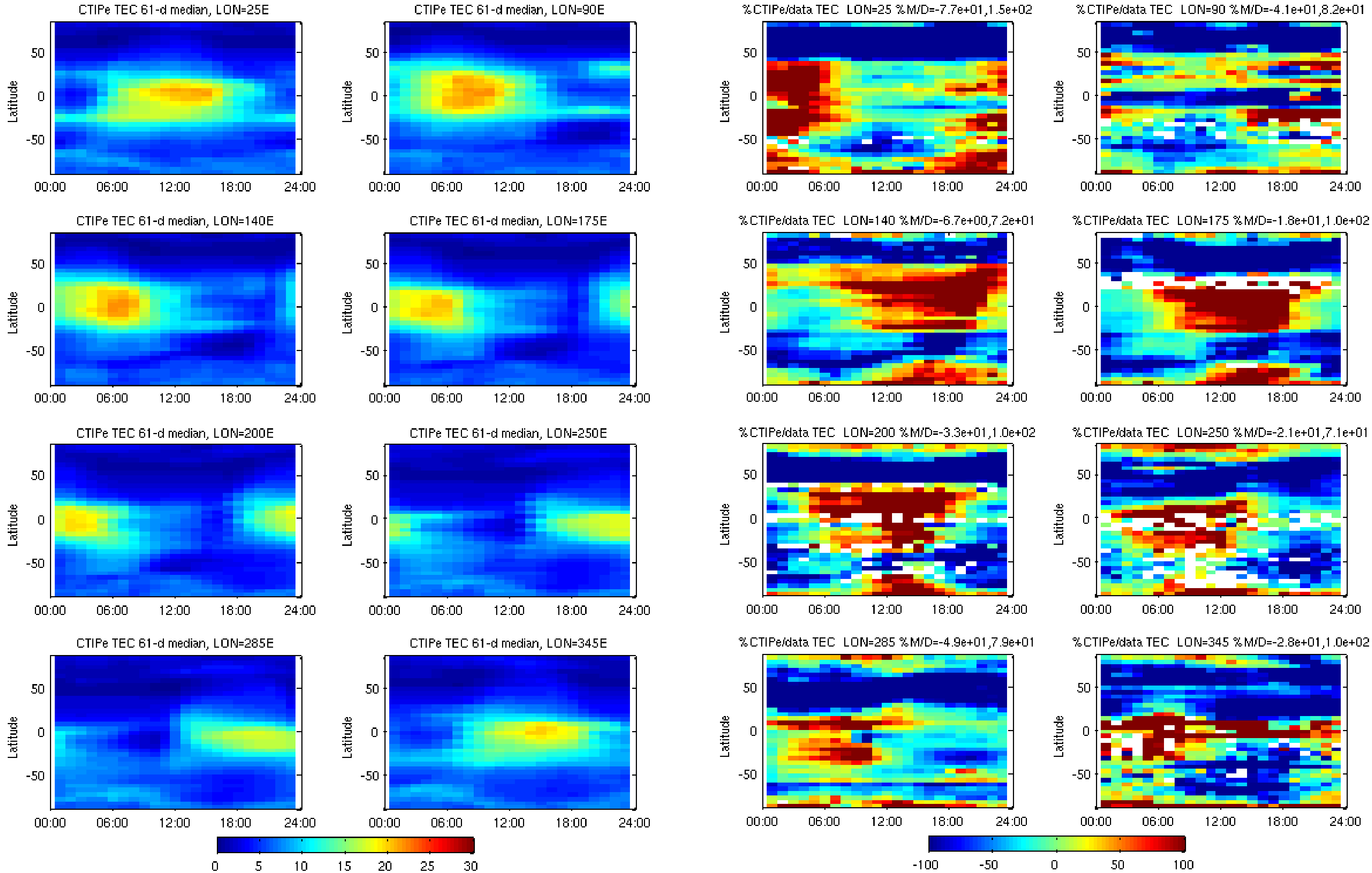
Climatology as medians for 61 days from MIT GPS TEC from 07325 (21 Nov) to 08020 (20 Jan).

The winter (NH) anomaly expects daytime midlatitude NmF2 to be higher than summer (SH) as for 25E and 285E, but usually TEC is larger in the summer (SH) daytime midlatitudes.

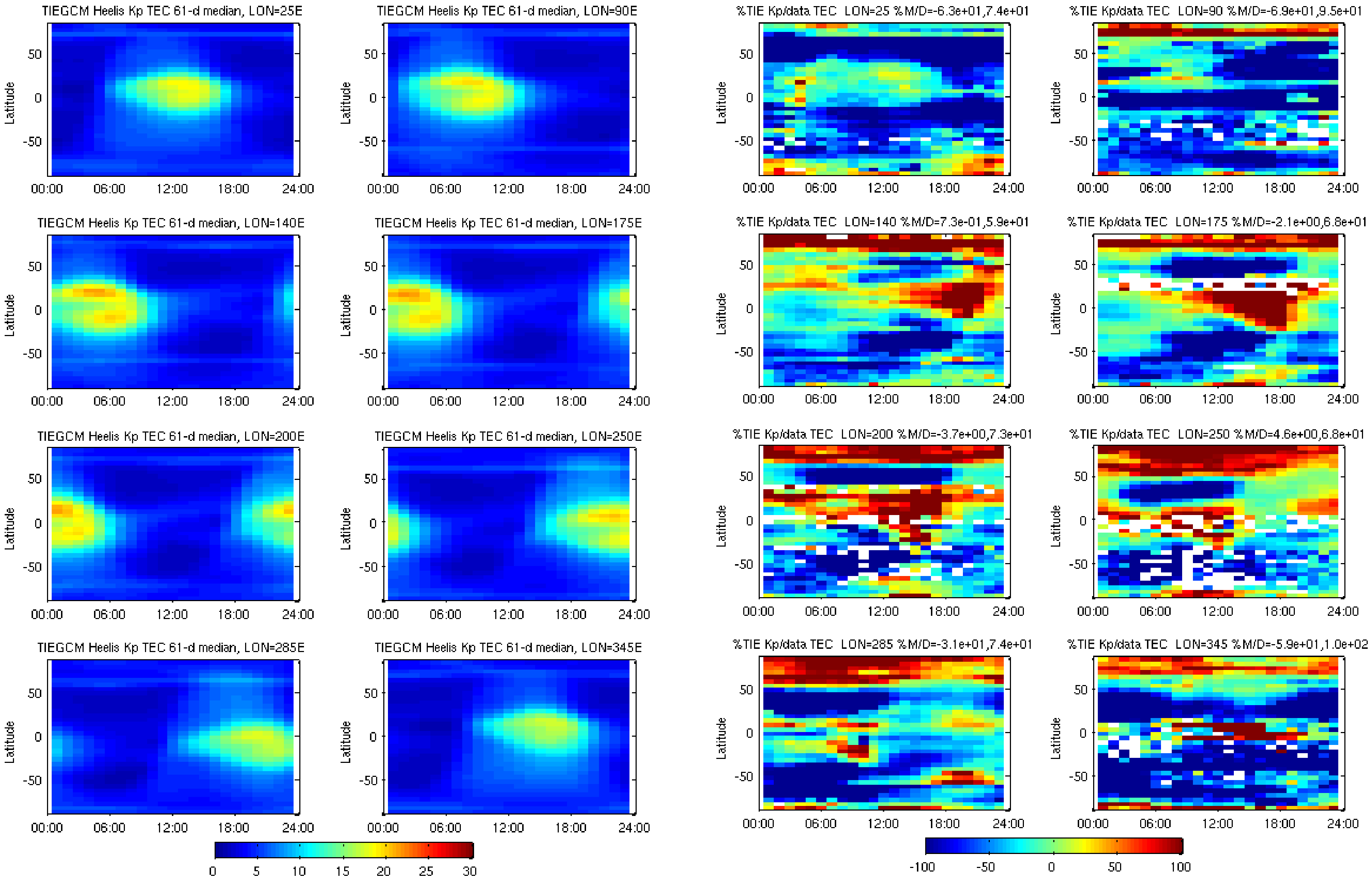
Low latitude night TEC and winter pole TEC lowest.



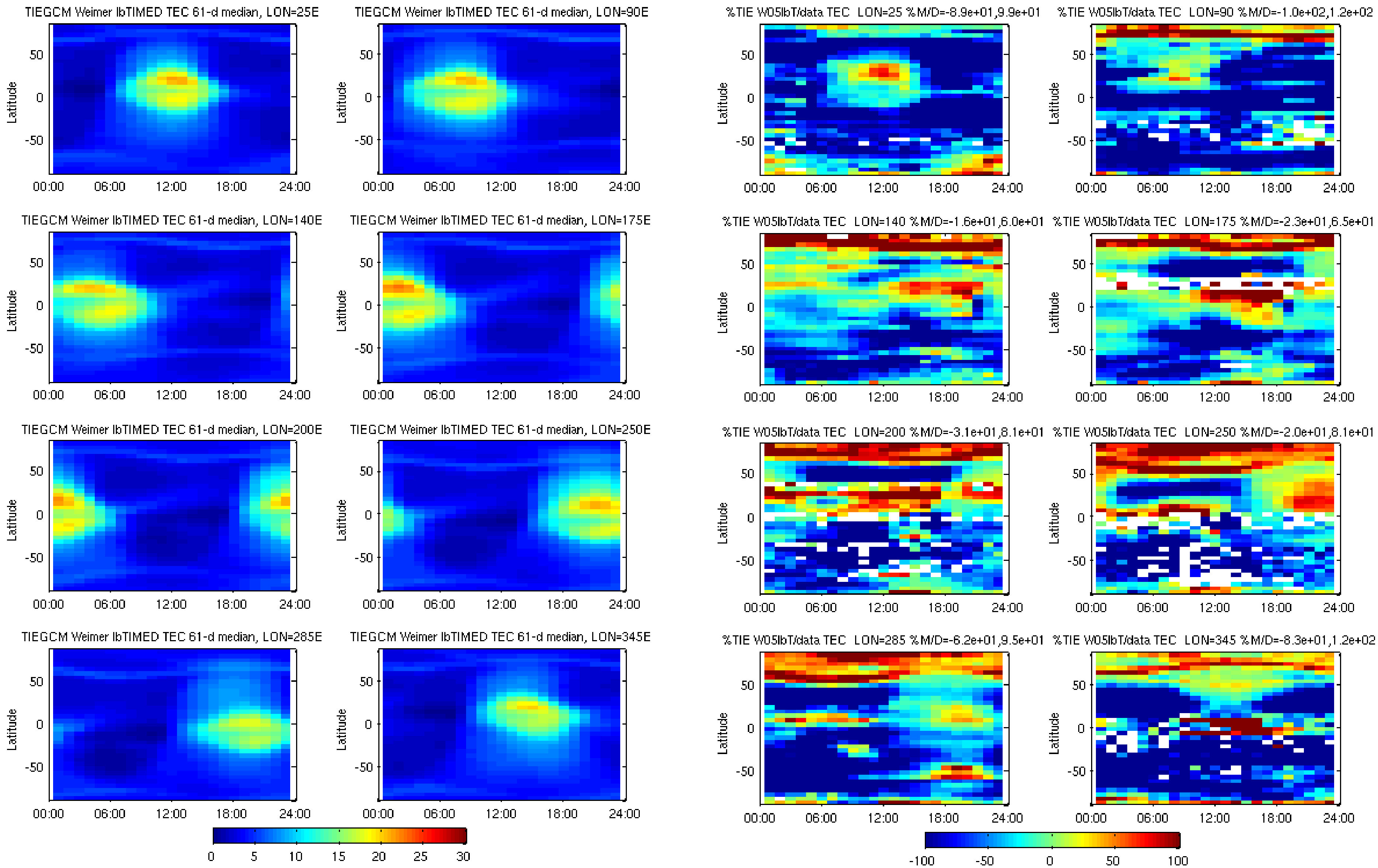
IRI model TEC and %model/data shows IRI overestimates morning day and summer night TEC and underestimates winter night TEC.



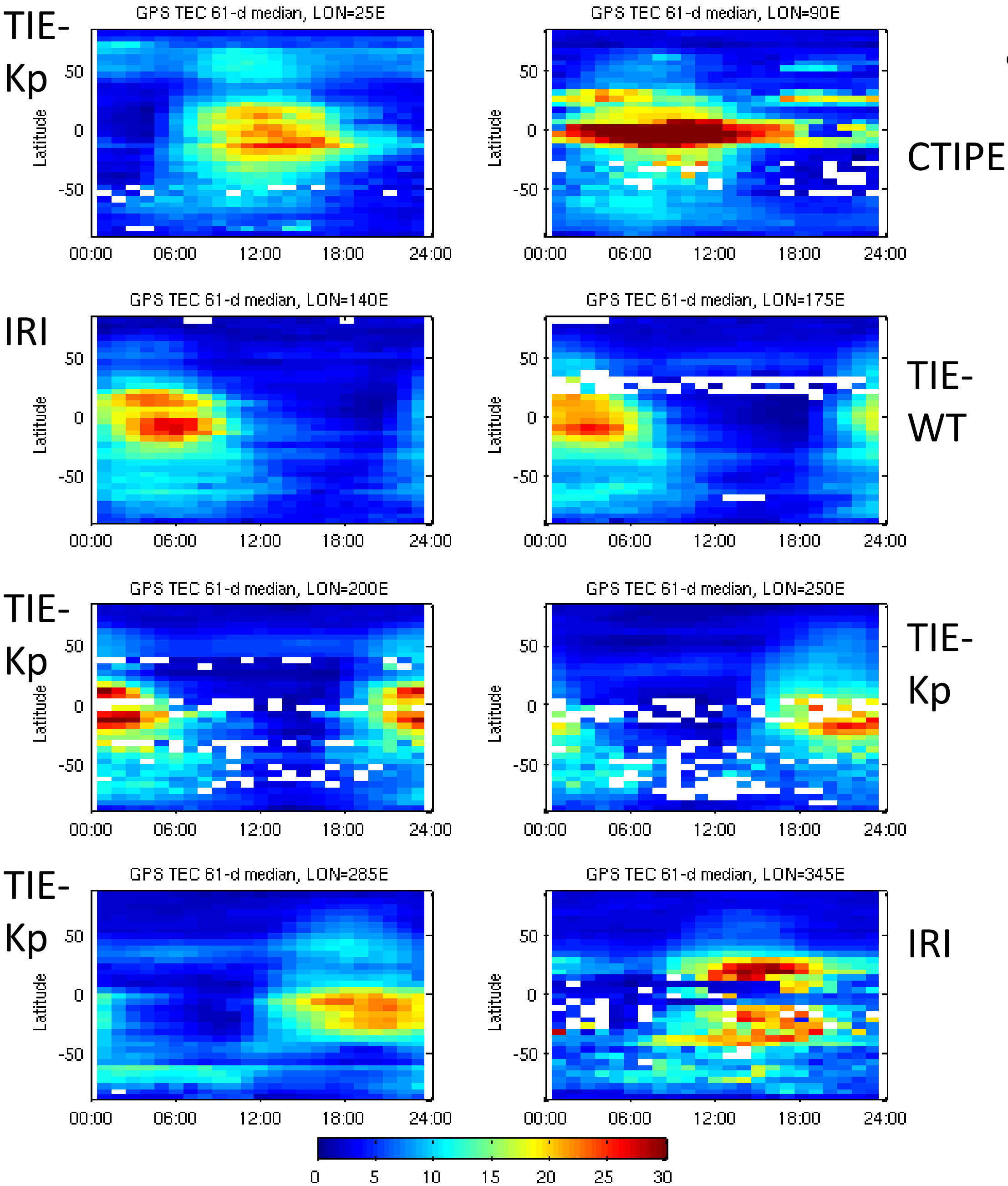
CTIPE TEC and %model/data shows CTIPE overestimates night TEC except in the winter high latitudes where TEC is underestimated.



TIEGCM Heelis Kp model and %model/data shows TIEGCM/Kp overestimates lowlatitude pre-dawn, high latitude winter, and underestimates midlatitude night TEC.



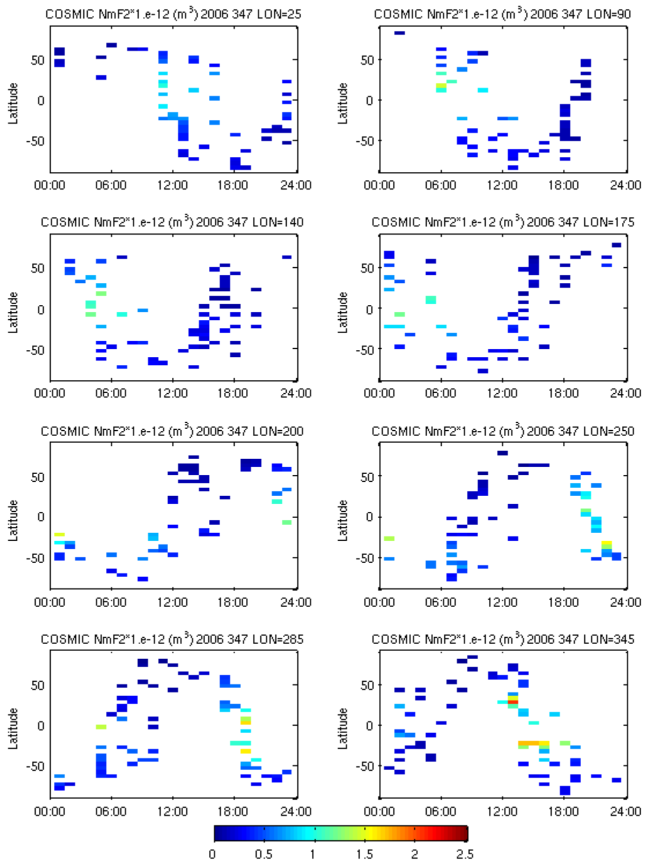
TIEGCM double resolution Weimer 2005 with TIMED lower boundary conditions and %model/data shows this TIEGCM is similar to the Kp TIEGCM.

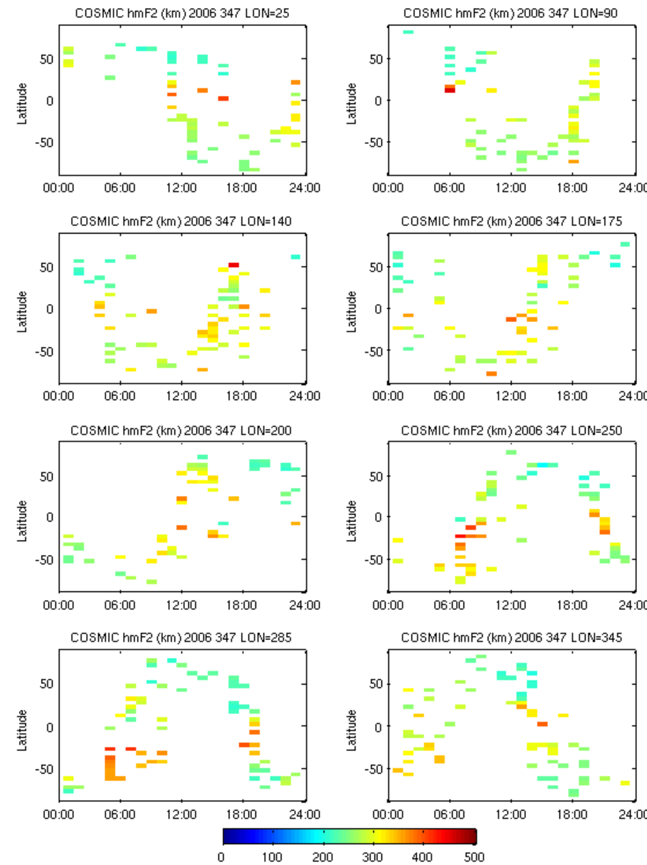


Summary of TEC Climatology

1) All models show different regions of overestimation and underestimation of the 'real' GPS TEC.
2) All models did best for at least 1 lon (IRI 2 lons, TIE-Kp 4 lons)
3) Average absolute value percent deviations: IRI 93%, CTIPE 94%, TIE-Kp 76%, TIE-WT 90%

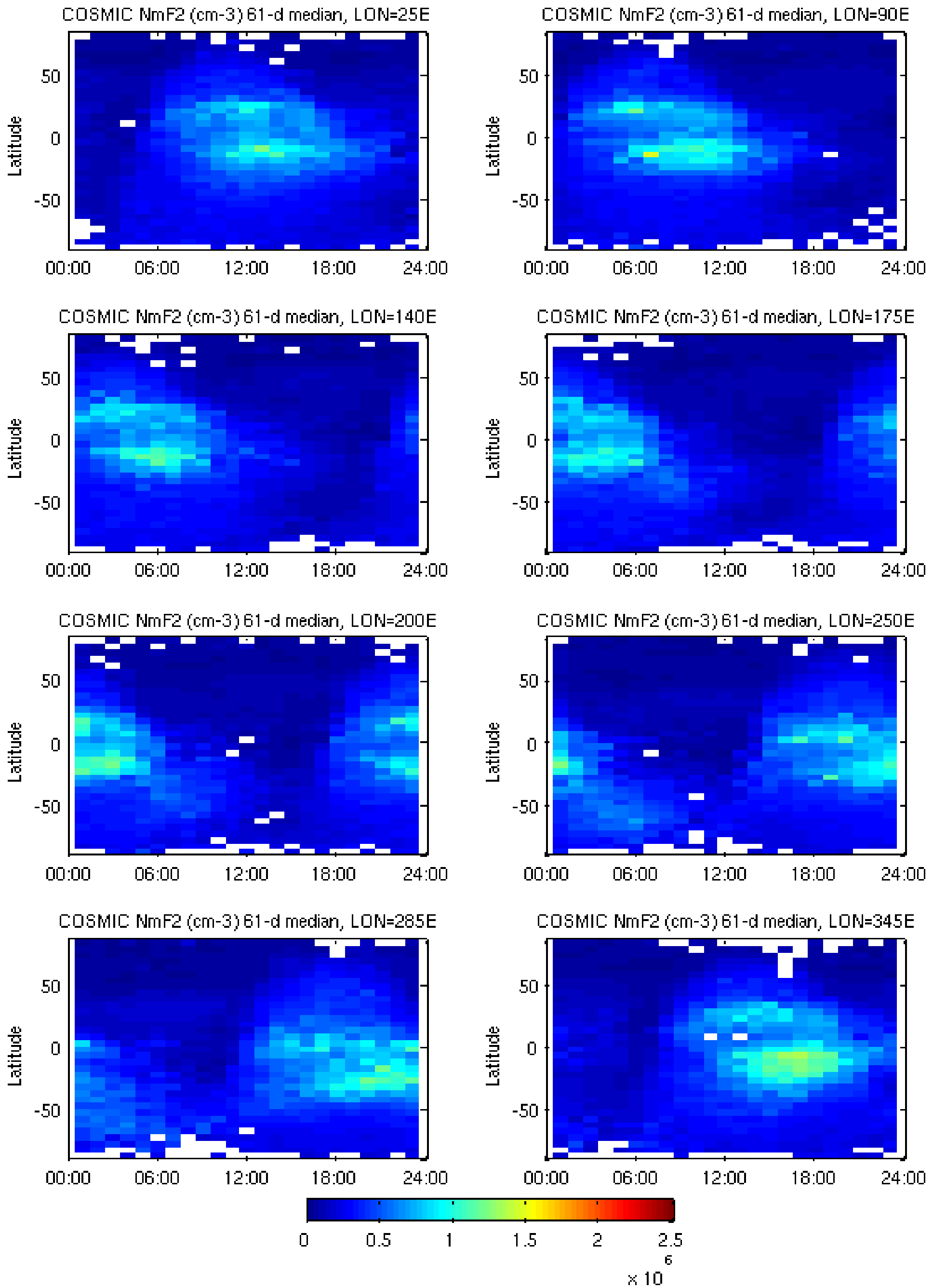
COSMIC NmF2 and HmF2





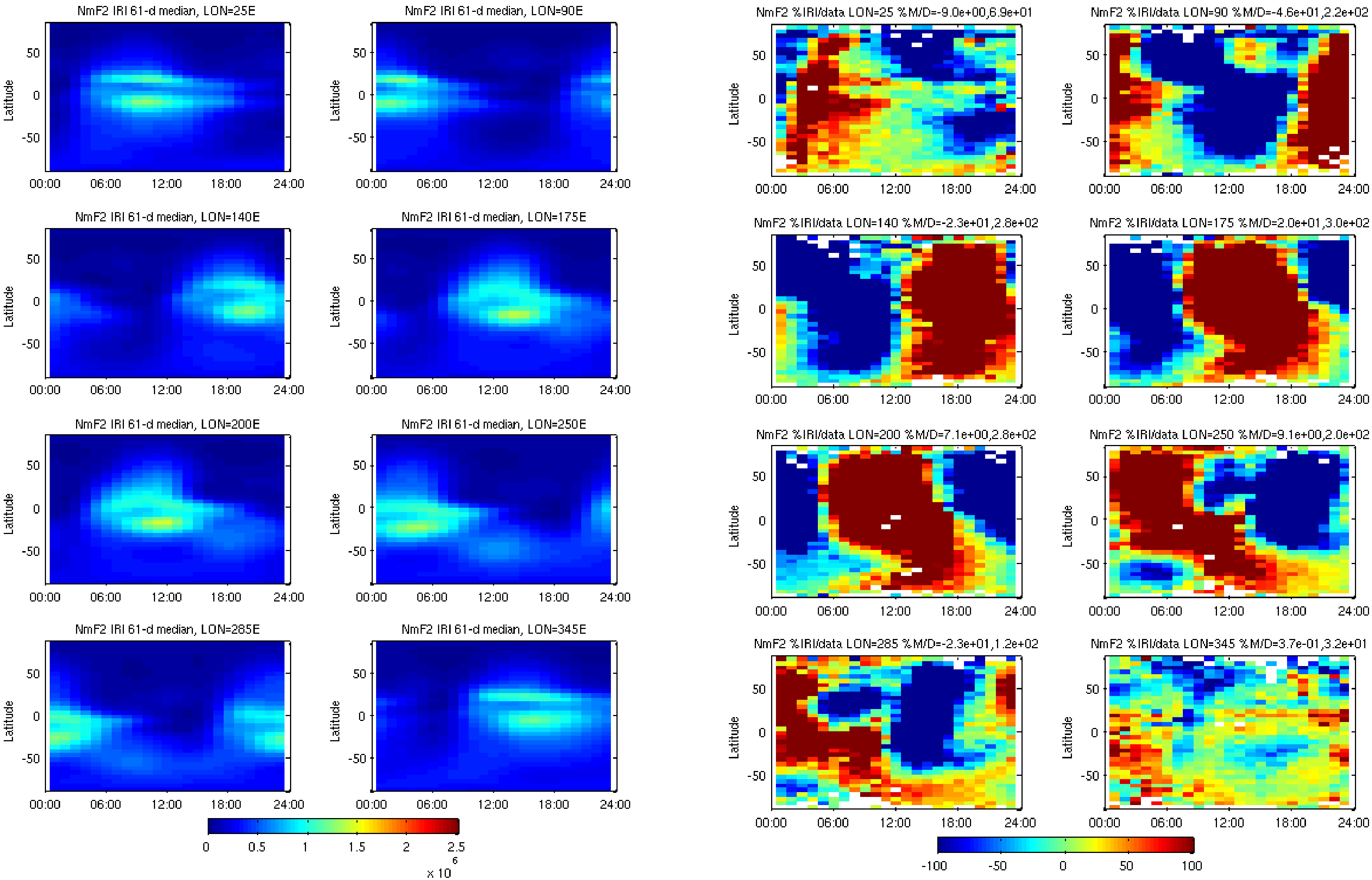
For 15 min averages of 5x5 glat/glon bins on Dec 13, 2006, a 24-h lon period has 96*36=3356 total bins. GPS TEC fills 34-79% of the bins, while COSMIC fills 2% (~60).

COSMIC Climatology

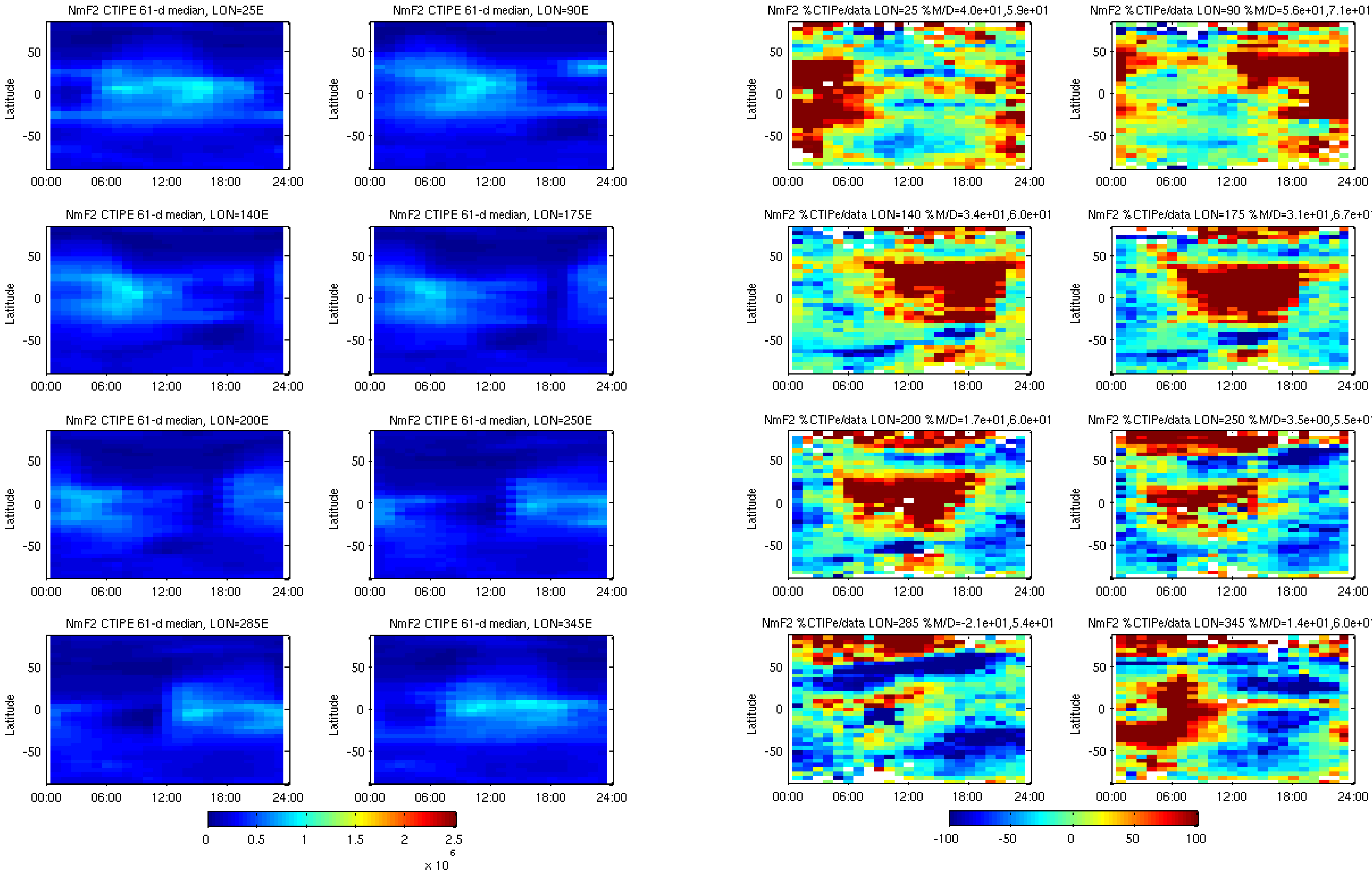


Use 5 deg lat by 25 deg lon bins over 61 days gives nearly complete maps with 1-20 points in each bin.

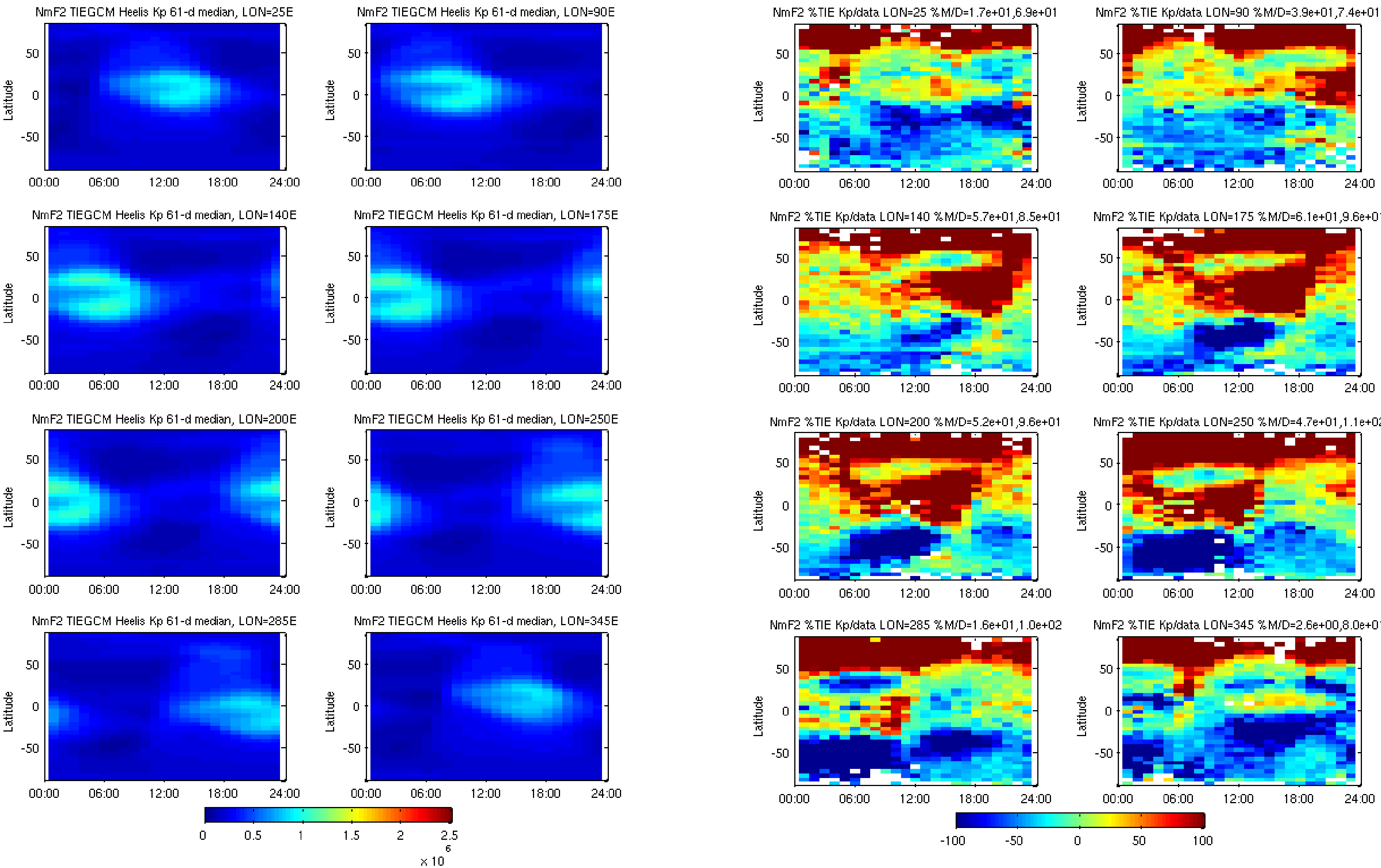
Similar to TEC plot showing 2 low latitude daytime maxima.



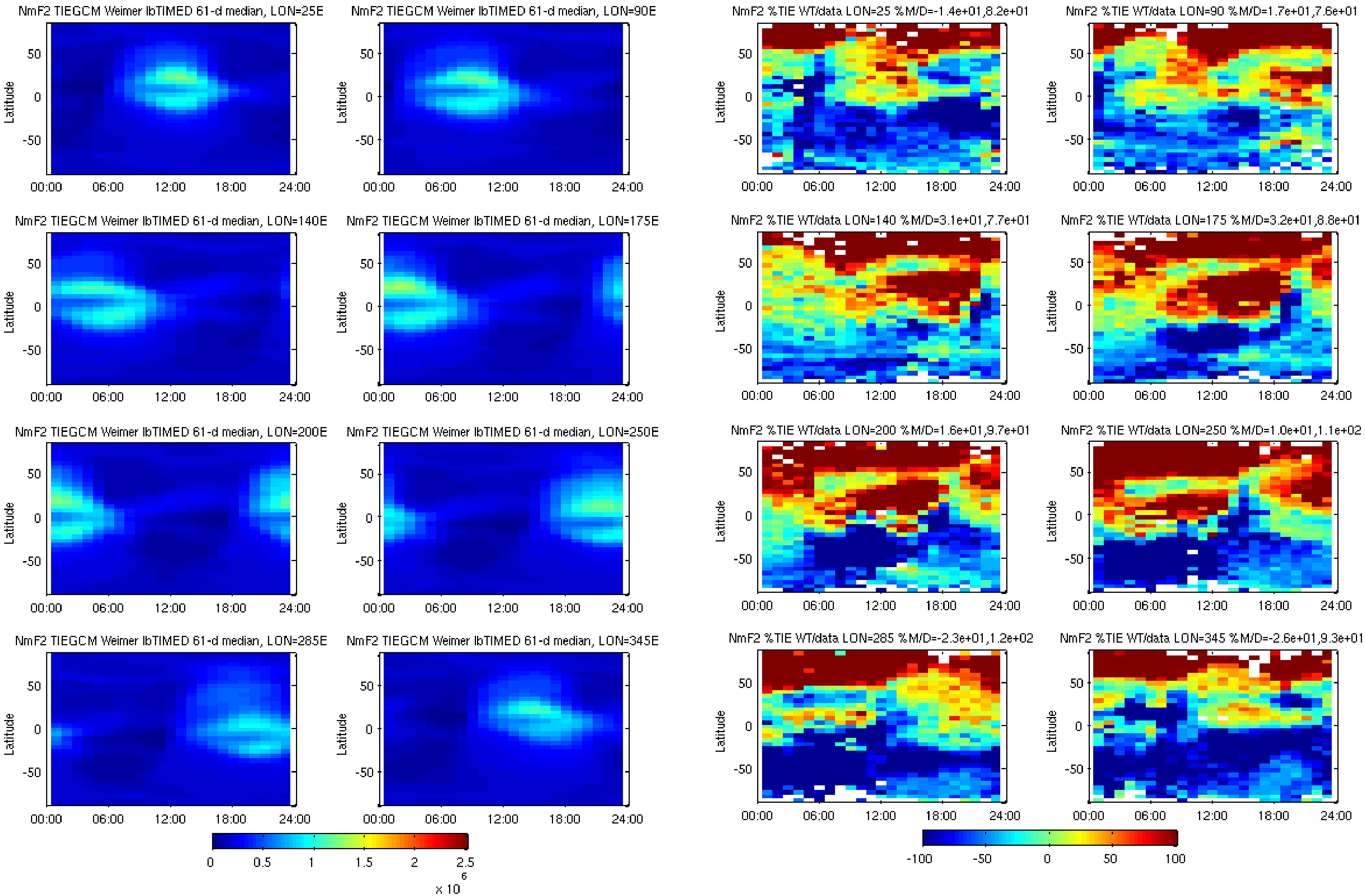
IRI NmF2 and %model/data shows IRI overestimates daytime NmF2 especially in the winter NH and underestimates nighttime NmF2.



CTIPE NmF2 and %model/data shows CTIPE overestimates night NmF2 (like TEC) and high lat winter and underestimates in night trough.

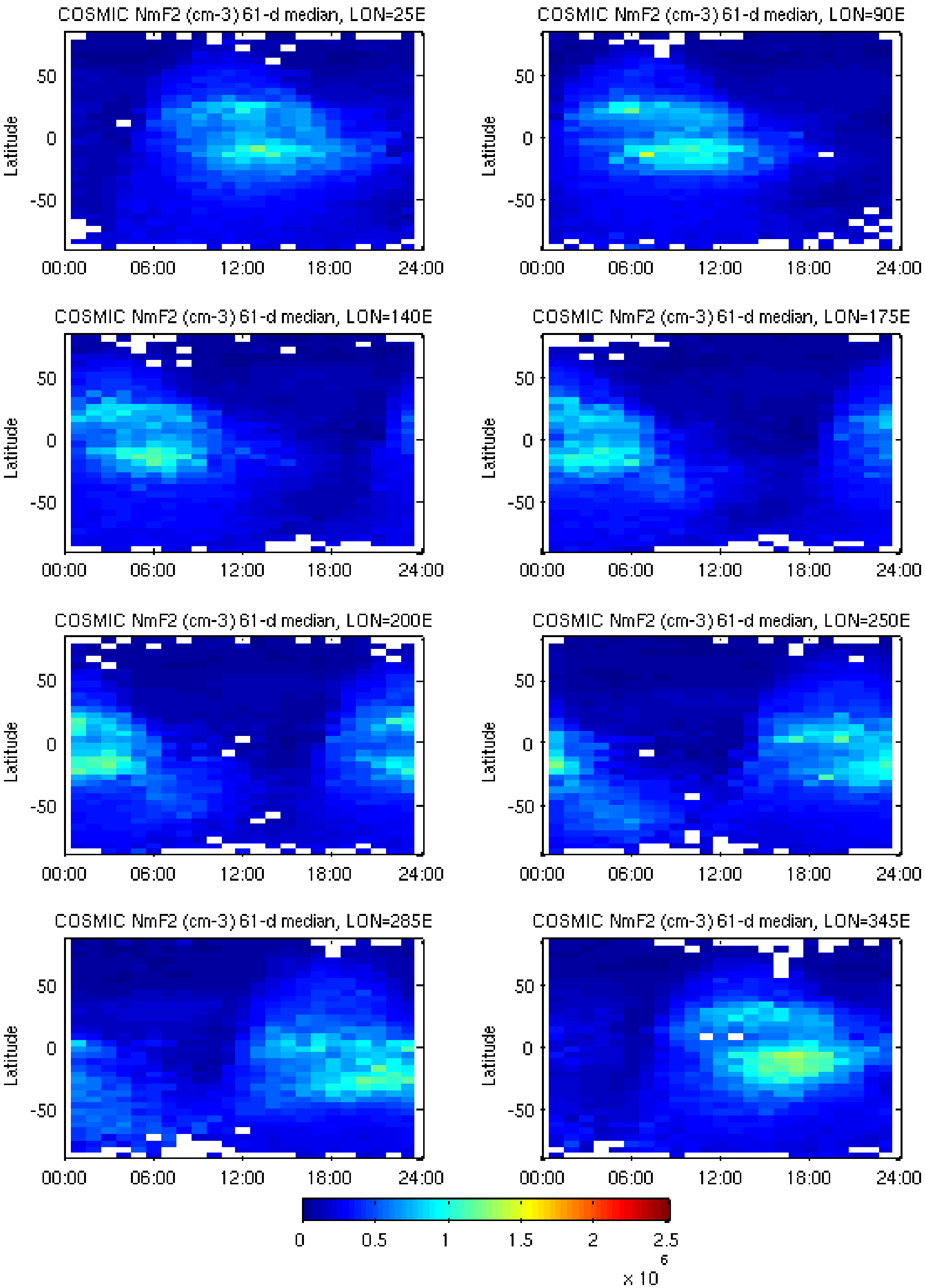


TIEGCM Heelis Kp model and %model/data shows TIEGCM Kp overestimates (as TEC) lowlatitude pre-dawn, high latitude winter NH, and underestimates midlatitude summer SH mostly at night.



TIEGCM double resolution Weimer TIMED lower boundary and %model/data shows this TIEGCM is similar to the Kp TIEGCM.

CTIPE for 7 of 8



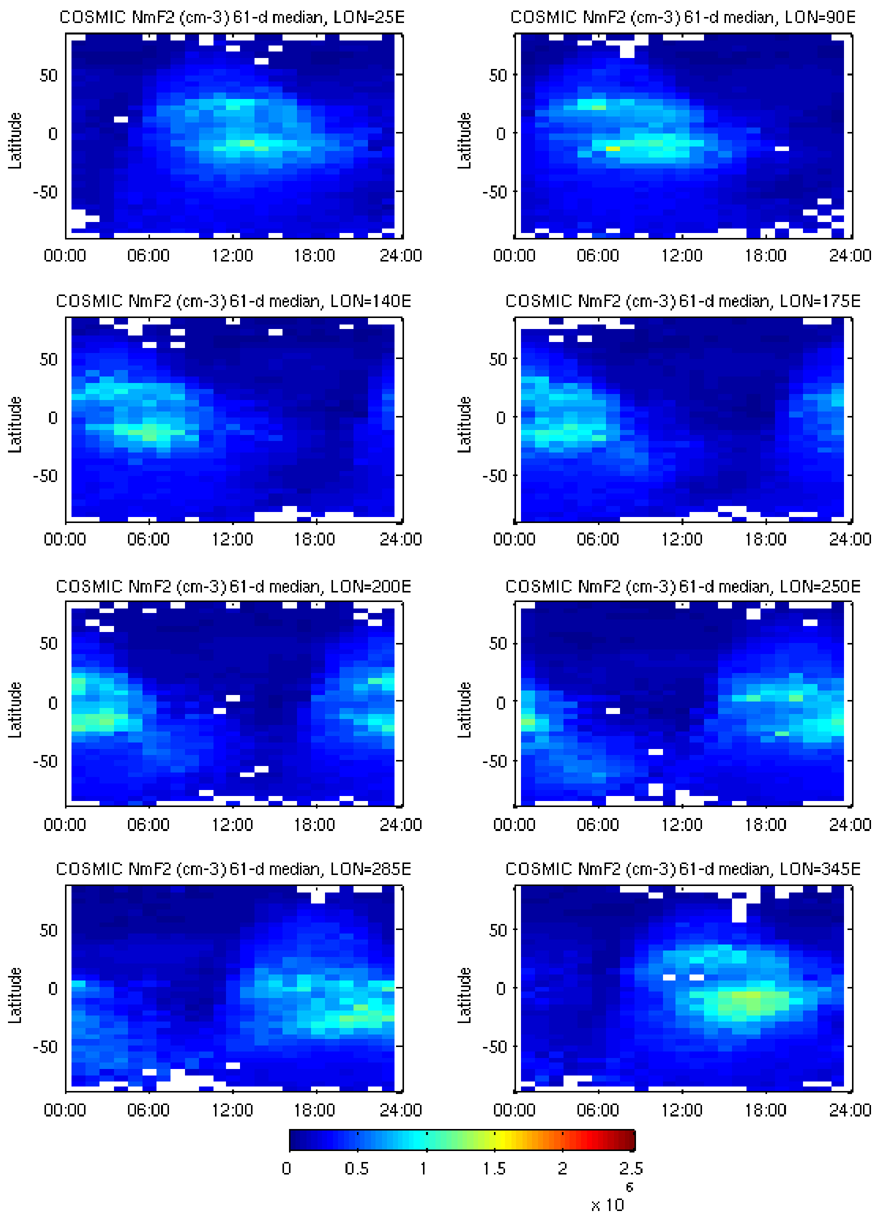
IRI

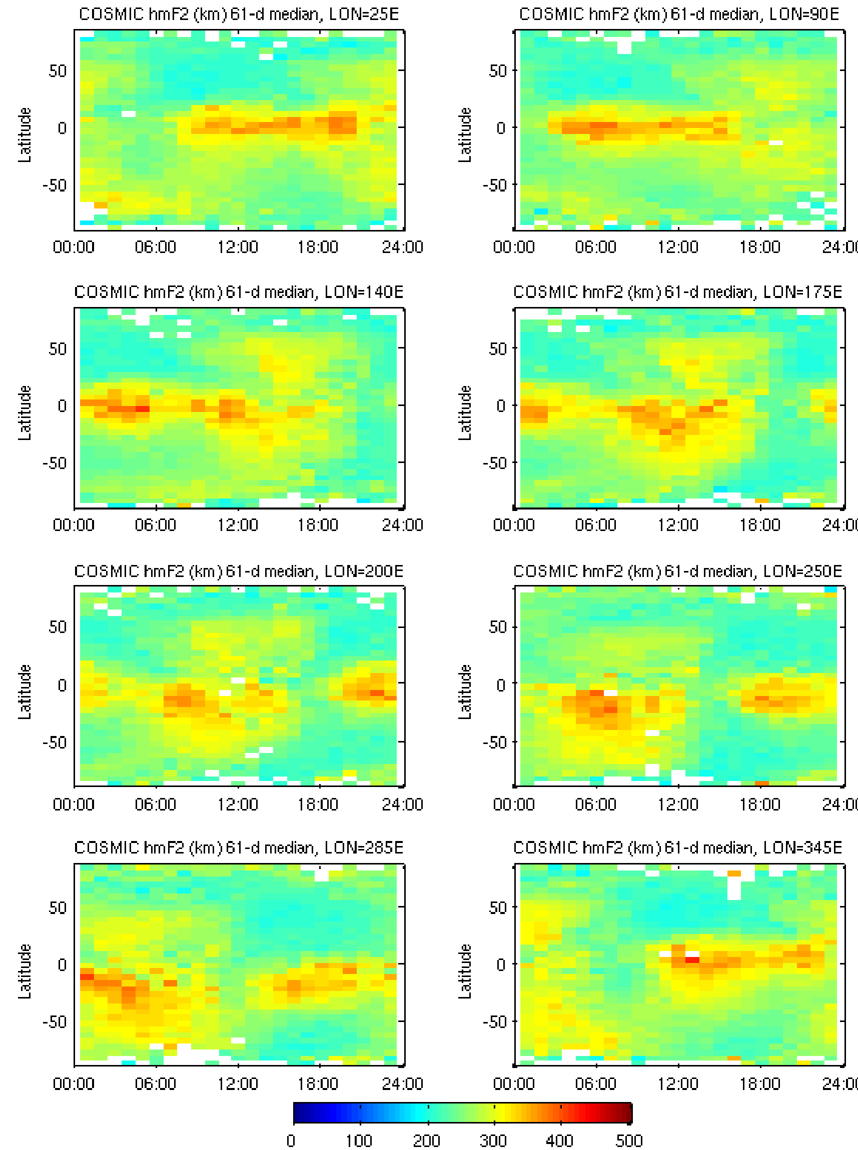
Summary of NmF2 Climatology

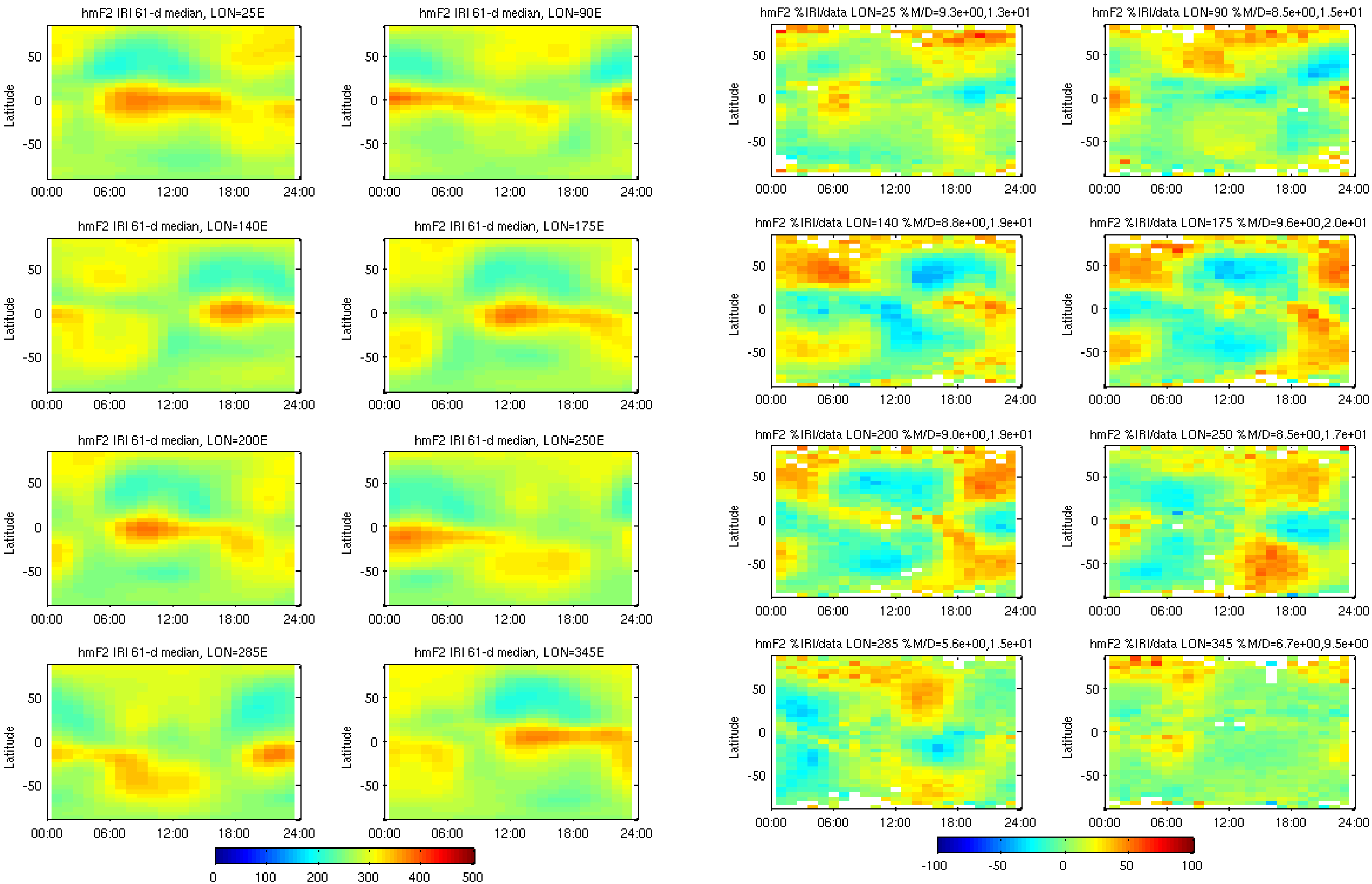
1) The regions of over- and under- estimates for NmF2 was sometimes the same as for TEC and often different.
2) CTIPE was the clear winner, with the best for 7 longitudes, with IRI doing best for 345E.
3) Average absolute percent deviations: IRI 188% (factor of 3!), CTIPE 61%, TIE-Kp 89%, TIE-WT 93%.

COSMIC HmF2 Climatology

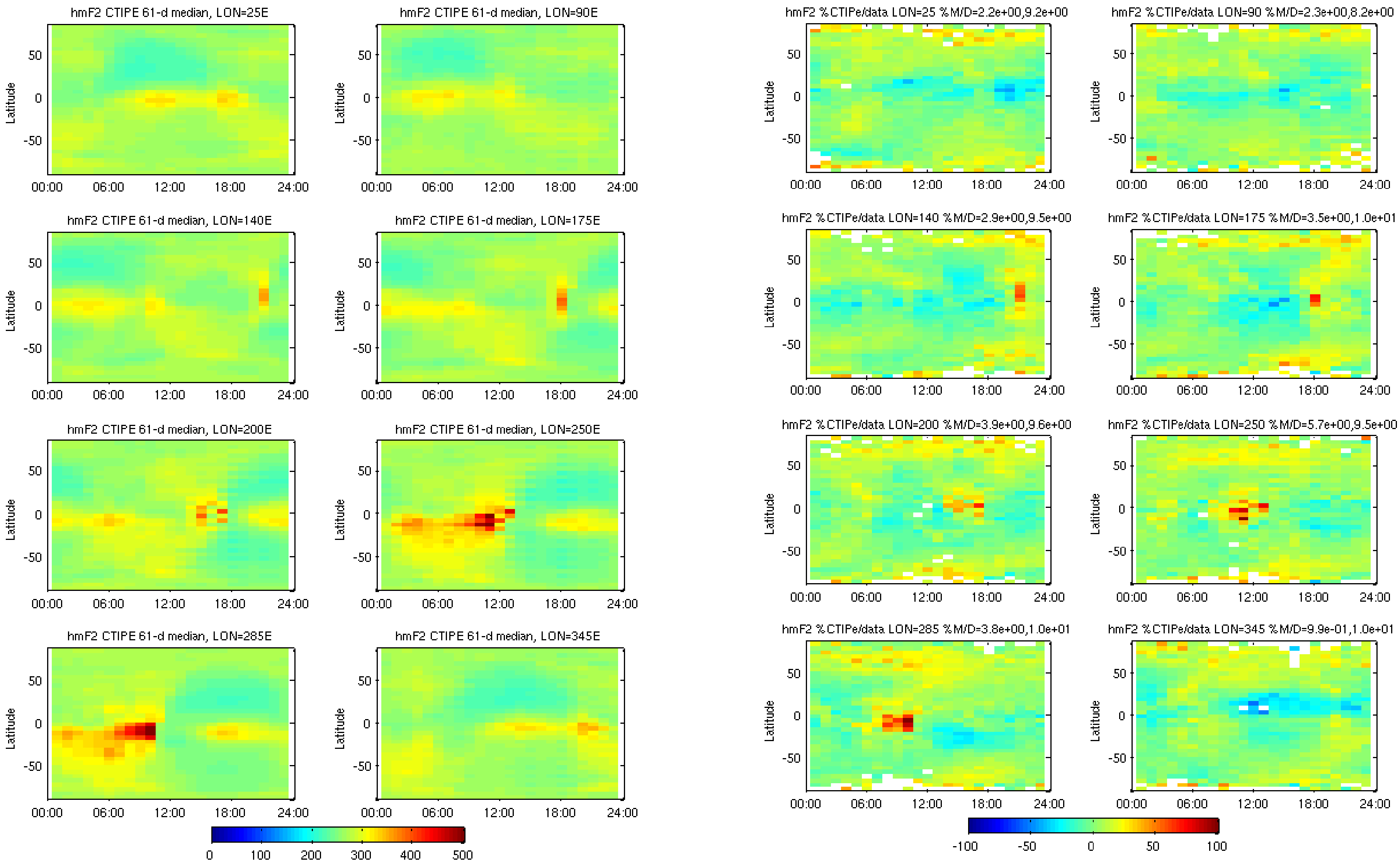
Hmf2 high at equator and night and low at dawn and winter day.



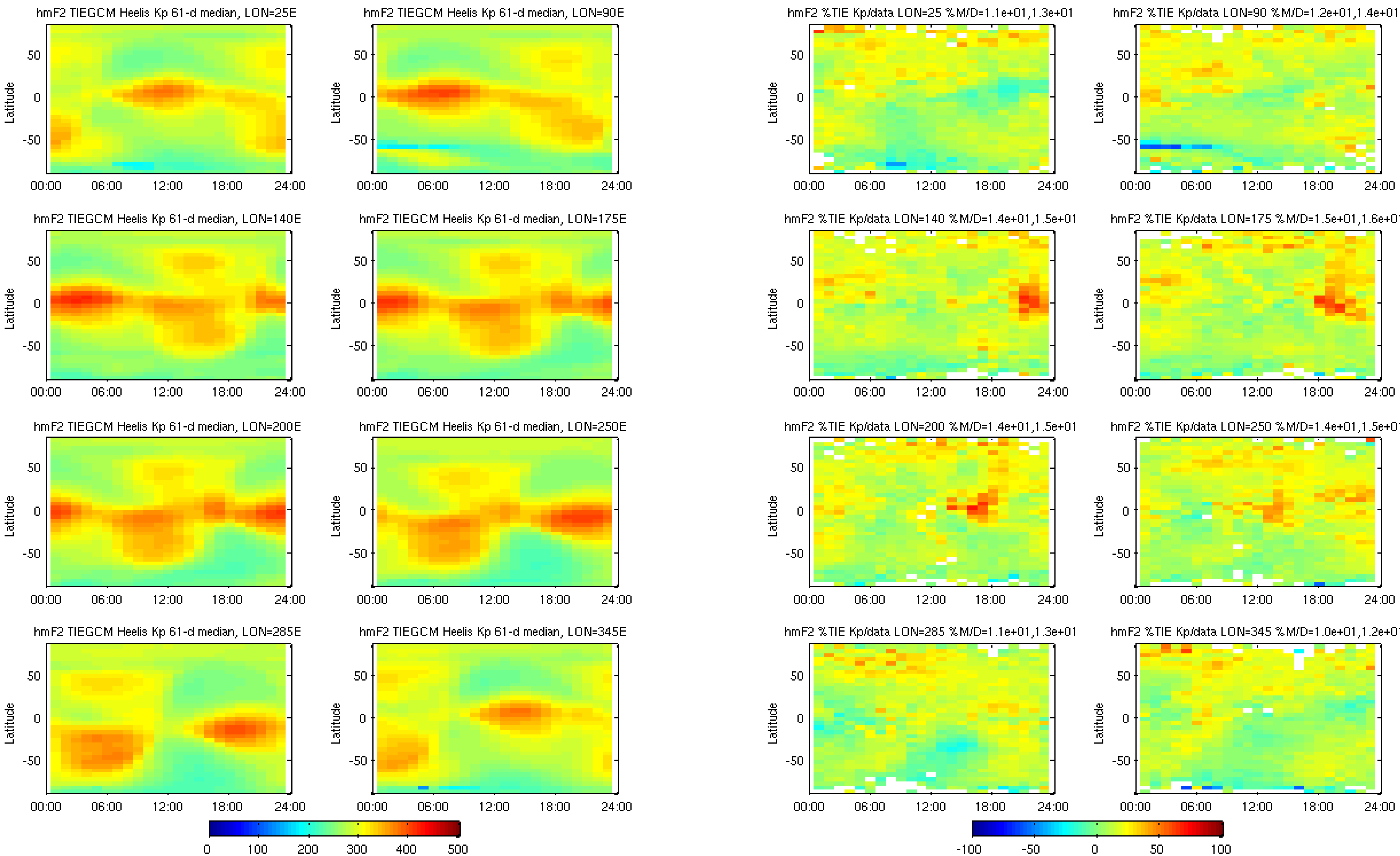




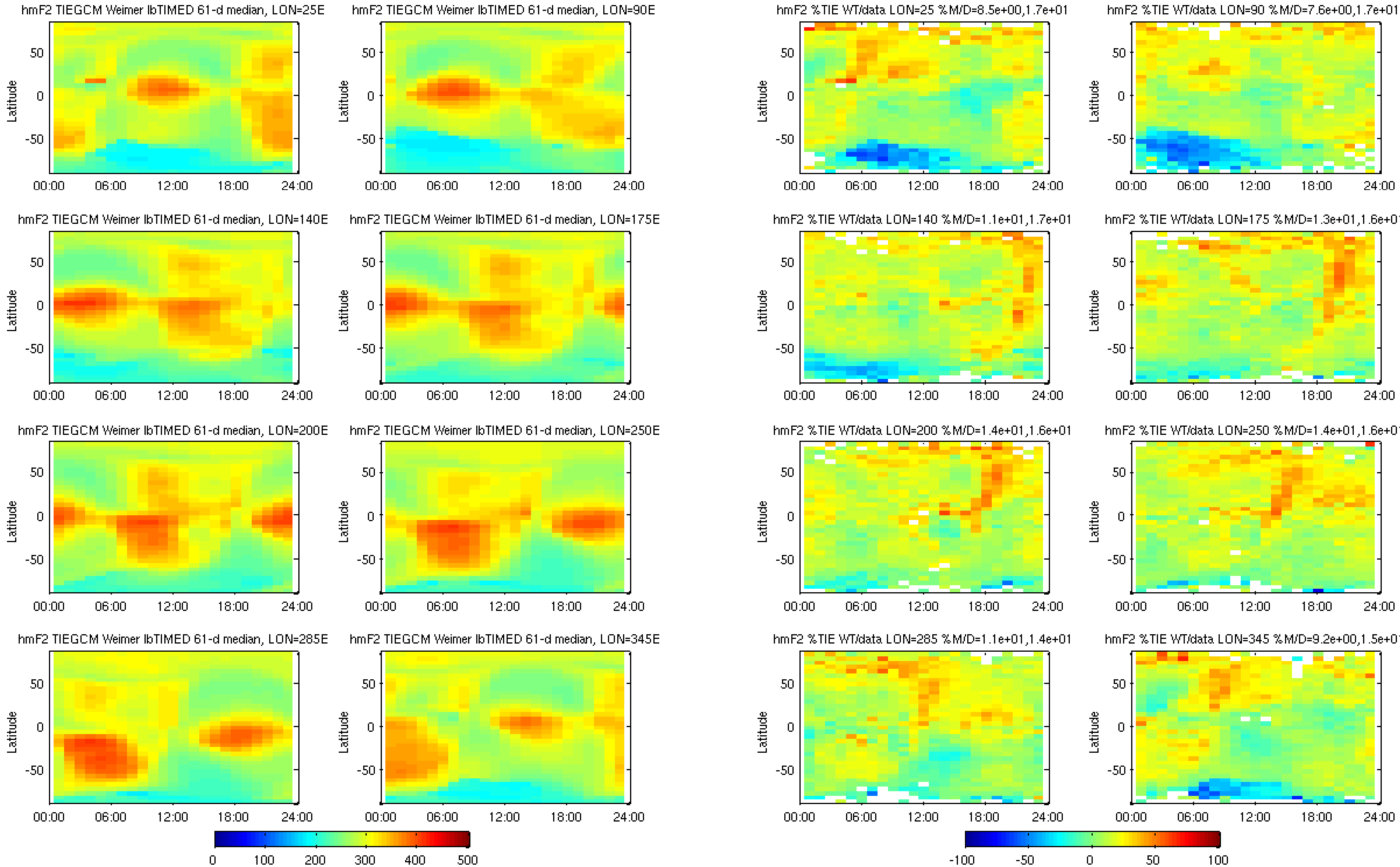
IRI model hmF2and %model/data shows IRI overestimates night hmF2 especially in the winter NH and underestimates midlatitude day hmF2.



CTIPE model hmF2 and %model/data shows CTIPE overestimates pre-dawn low-latitude hmF2.



TIEGCM Heelis Kp model hmF2 and %model/data shows TIEGCM-Kp overestimates pre-dawn low-latitude hmF2.

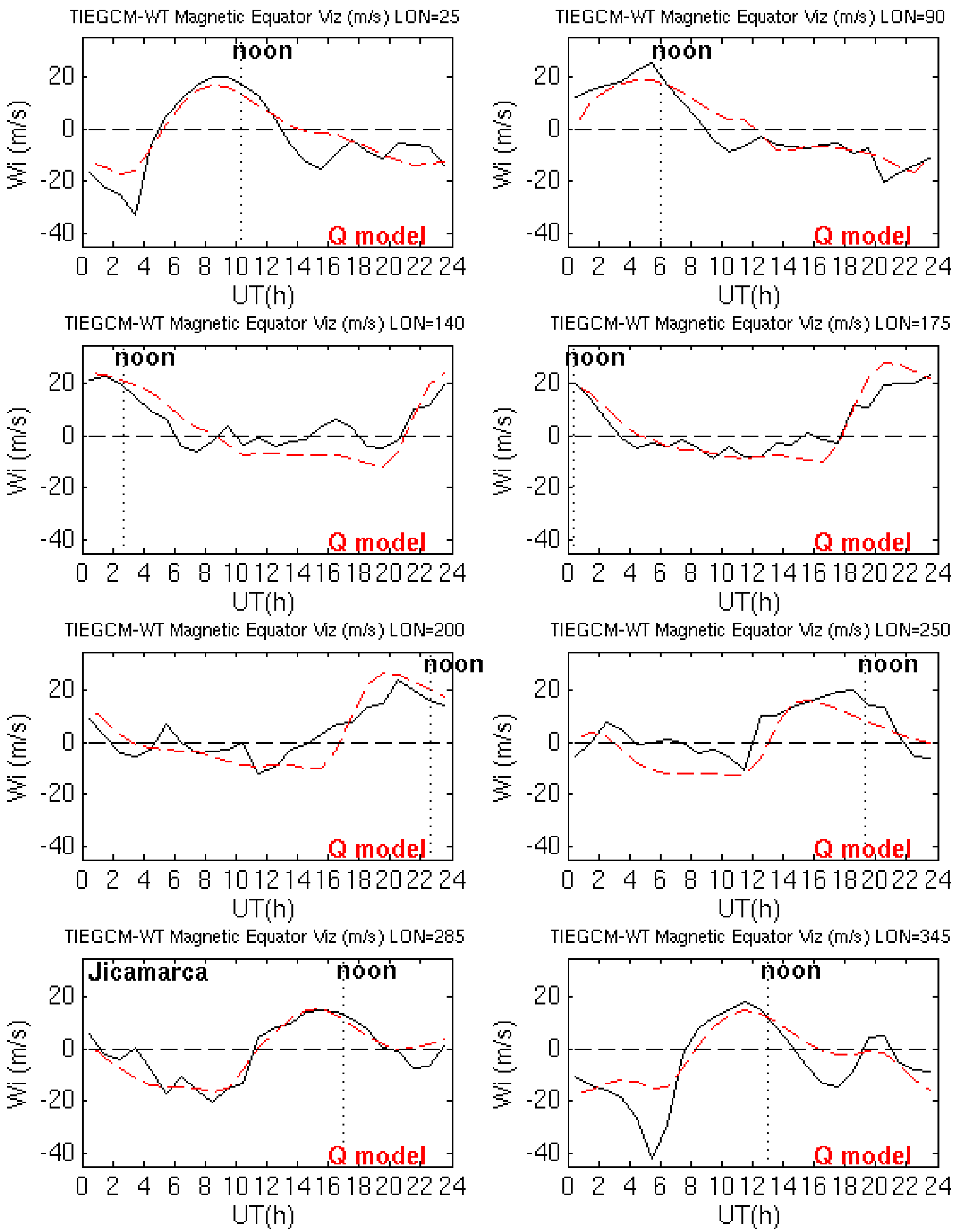


TIEGCM Weimer 2005 and TIMED lower boundary hmF2 and %model/data shows TIEGCM-WT overestimates pre-dawn hmF2 in the winter NH, and underestimates in high-lat summer SH pre-noon.

Summary of HmF2 Climatology

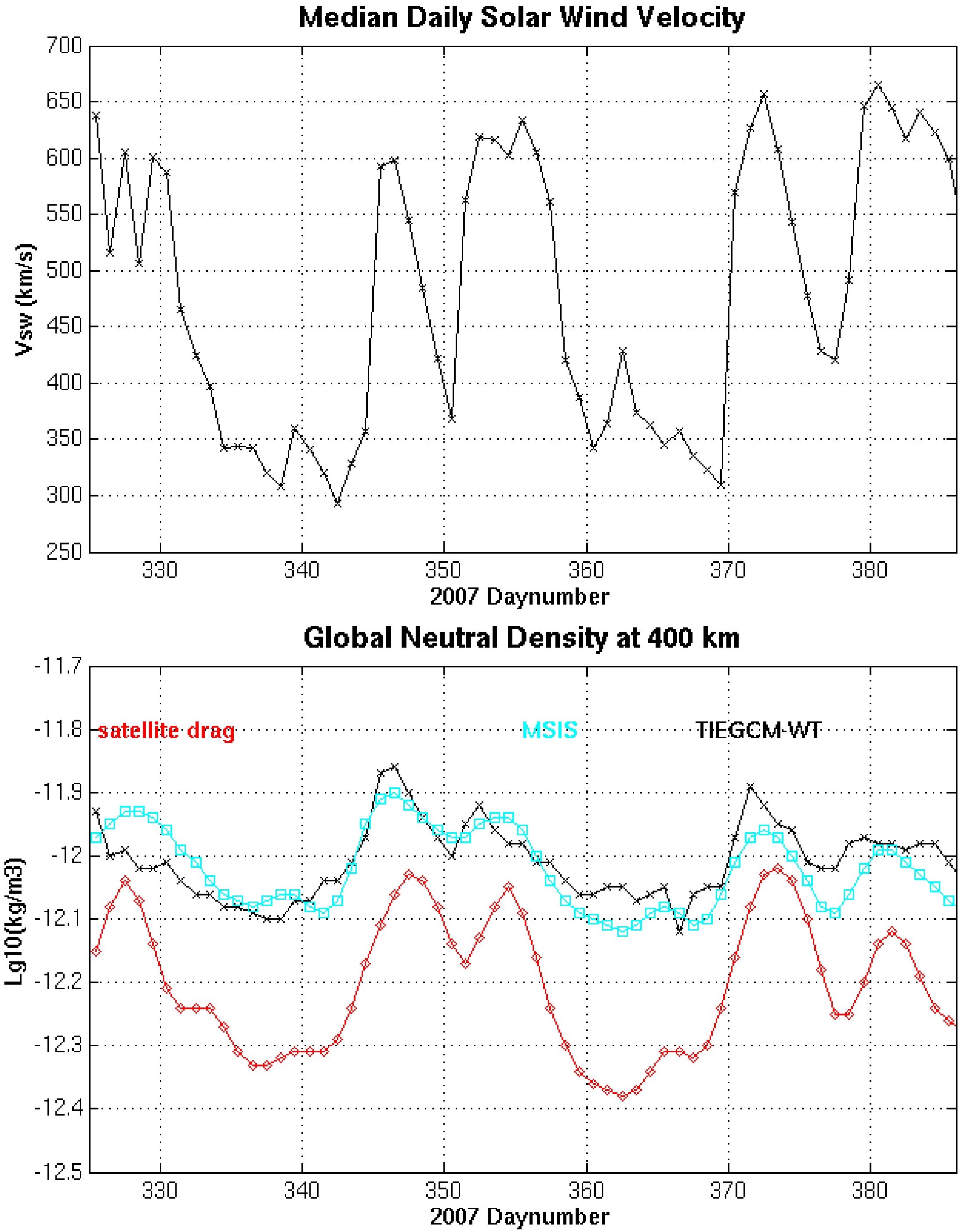
1) CTIPE was the clear winner, with the best for 7 longitudes, with IRI doing best for 345E – same as for NmF2
2) Average absolute percent deviations: IRI 15.9%, CTIPE 9.5%, TIE-Kp 14.1%, TIE-WT 16.0%
3) These are much lower than the approximate factor of 2 for NmF2 and TEC, but a 15% error in hmF2 is about 0.15*300 km ~ 45km error.

Vertical Ion Drift at the Equator



Can calculate the median vertical ion drift from the models and compare it to the quiet-time model as a function of LT and longitude at the magnetic equator. Later compare with Jicamarca data.

Results for TIEGCM Weimer TIMED lower boundary is fairly good.



Global Neutral Density at 400 km

Daily global densities from satellite drag data from1967-2007 described by Emmert [2009, JGR] were expanded to 2010. The values for 07355-08020 are plotted in red, with MSIS in cyan and TIEGCM Weimer with TIMED lower boundary conditions in black. The peaks correlate well with peaks in the solar wind speed from high-speed streams (HSS).

Summary of the First CCMC Challenge Climatology Study for the Ionosphere-Thermosphere

. 8 longitudes for 2 months work well for MIT GPS TEC and USU COSMIC NmF2 and hmF2

. The IRI TEC, NmF2, and hmF2 are no better than the first-principle models, and are often worse.

. Average differences for TEC and NmF2 are a factor of 2.

. CTIPE was the clear winner for 'best' NmF2 and hmF2, while TIEGCM Heelis Kp was marginally 'best' for TEC.

. NRL satellite drag daily global neutral density at 400 km varies with solar wind velocity. TIEGCM Weimer/TIMED agreed better with MSIS at larger values.

. TIEGCM Weimer/TIMED equatorial vertical drifts agree with the empirical quiet-time model of Scherliess and Fejer [JGR, 1999].

. More data sets and models are welcome for the future climatology CCMC Challenge at the 2012 CEDAR Workshop.

Sign-Up Sheet to Participate

- Name, email: Model or data are welcome

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