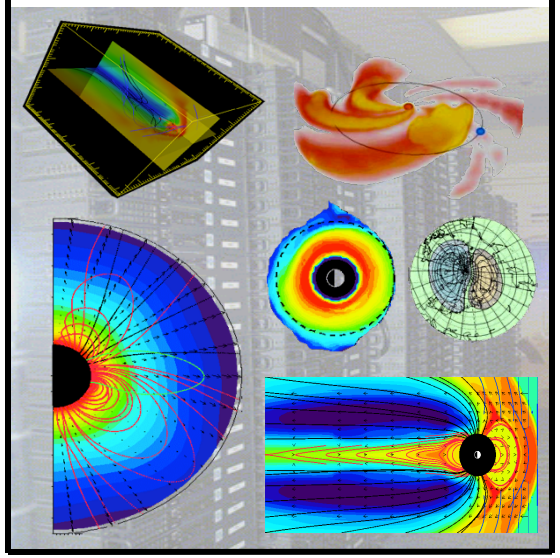
COMMUNITY
COORDINATED
MODELING
CENTER



Systematic Assessment of IT Models
: TEC/NmF2/hmF2 during 2006 AGU Storm

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Modelers :D. Bilitza, M. Butala, M. Codrescu, B. Emery, B. Foster, T. Fuller-Rowell, J. Huba, A. J. Mannucci, X. Pi, A. Ridley, R. Schunk, L. Scherliess, J. Sojka, P. Stephens, D. C. Thompson, D. Weimer, L. Zhu

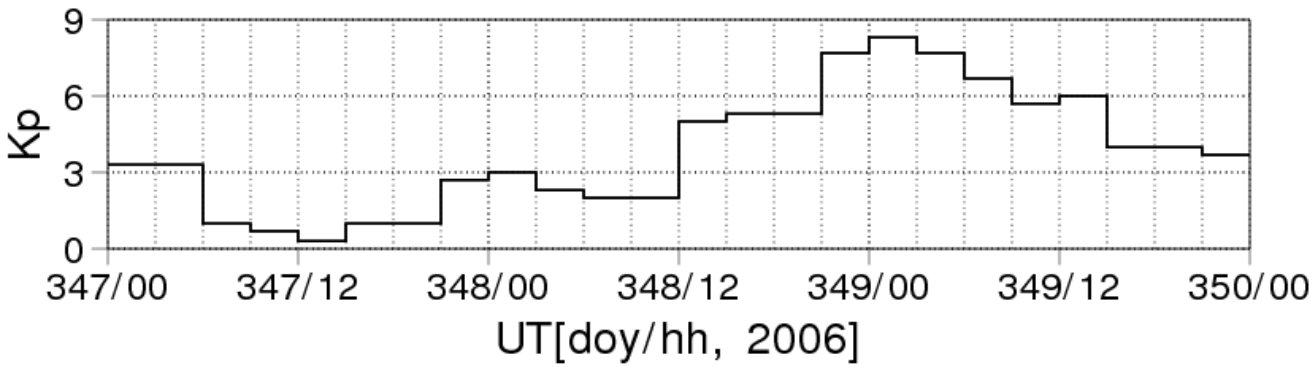
Data providers : A. Coster, L. Goncharenko

http://ccmc.gsfc.nasa.gov

NASA Goddard Space Flight Center

Setup

- Time interval: E.2006.347-2006.349
  (2006/12/13 00:00 UT - 12/15 23:45 UT)



- Physical parameter : global TEC, NmF2, and hmF2

Setup

- Observations :
  - GPS TEC (MIT and JPL)
  - COSMIC Nmf2 and hmF2 (USU)
  - in eight longitude sectors
    : 025-030, 090-095, 140-145, 175-180,
    200-205, 250-255, 285-290, 345-350
  - data bin : 5° lat × 5° lon × 15 min
    36 latitude bins of 5° each from -90 to +90.

Metrics

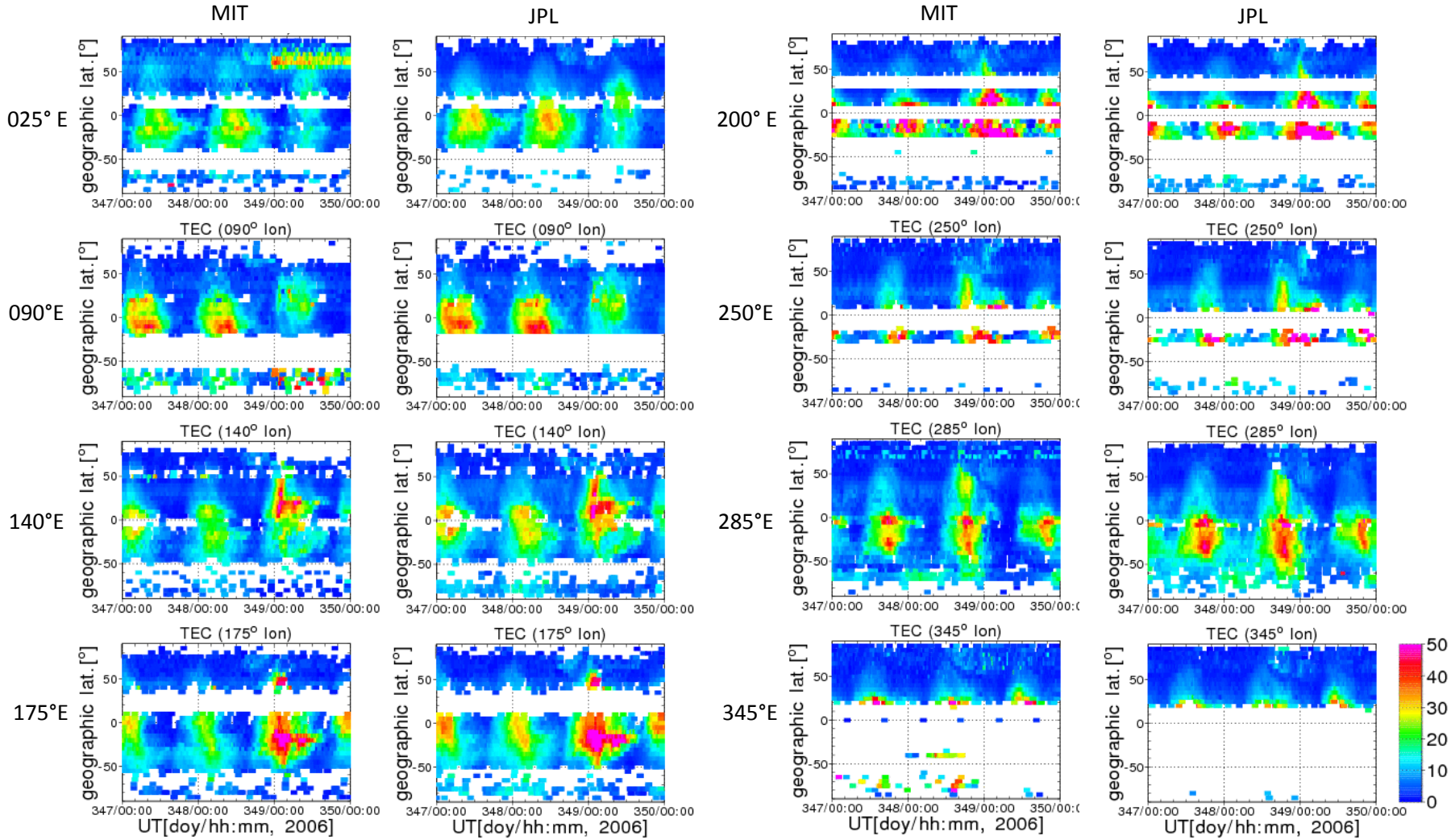
- RMS Error : $\sqrt{\dfrac{\sum (x_{mod} - x_{obs})^2}{N}}$
- Mean Absolute Percentage Error: $\dfrac{\sum \left| (x_{mod} - x_{obs}) / x_{obs} \right|}{N}$
- Ratio of maximum change : $\dfrac{(x_{mod})_{\max} - (x_{mod})_{\min}}{(x_{obs})_{\max} - (x_{obs})_{\min}}$
- Ratio of maximum : $\dfrac{(x_{mod})_{\max}}{(x_{obs})_{\max}}$

Model Setting

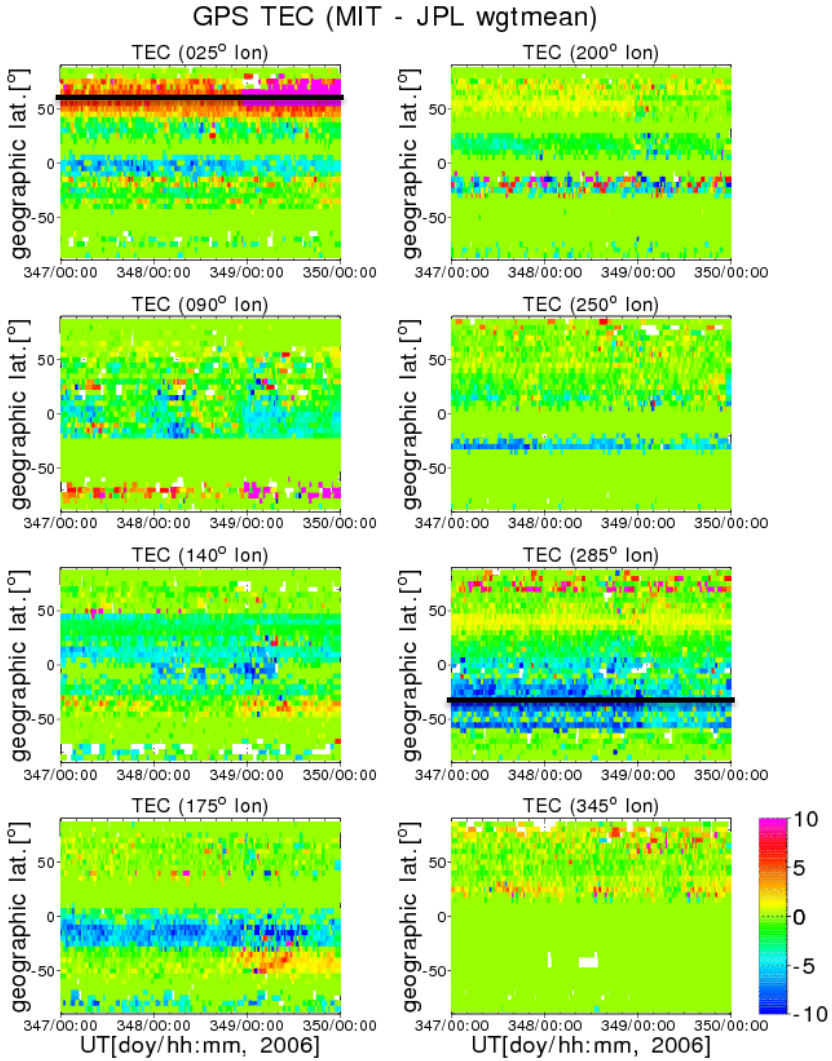
	Model Setting ID	
1	1_IRI*	IRI-2007, empirical ionospheric model
2	1_SAMI3_HWM93*	SAMI3 with the neutral wind model HWM93
3	1_USU-IFM*	IFM driven by F10.7, Kp and empirical inputs for the thermosphere parameters
4	1_CTIPE*	CTIPe driven by Weimer electric potential model, 2°×18°, 15 levels in logarithm of pressure
5	1_TIE-GCM*	TIE-GCM1.93 driven by Heelis electric potential model with constant critical co-latitudes
6	2_TIE-GCM	TIE-GCM1.94 driven by Weimer electric potential model with dynamic critical co-latitudes
7	3_TIE-GCM	TIE-GCM1.94 driven by Weimer electric potential model with dynamic critical co-latitudes and with double resolution
8	1_USU-GAIM*	USU-GAIM23 with GPS TEC observations from up to 400 ground stations

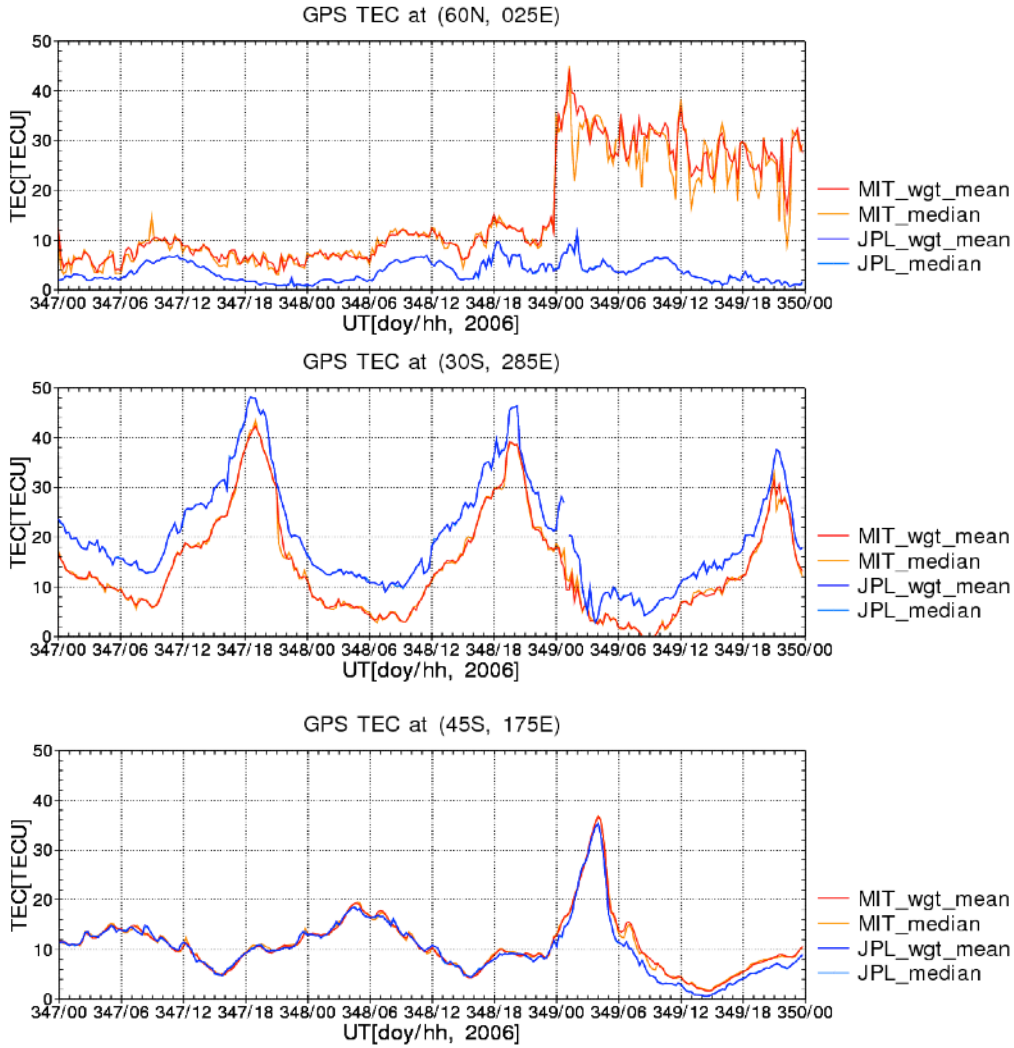
*Runs performed at the CCMC

TEC Measurement



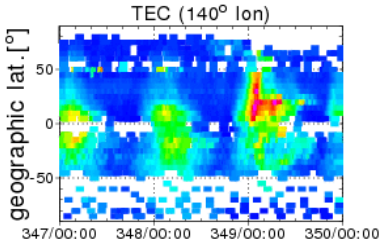
TEC Measurements : GPS TEC MIT & JPL



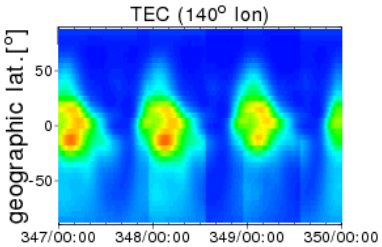


TEC Modeled Values (140°E lon)

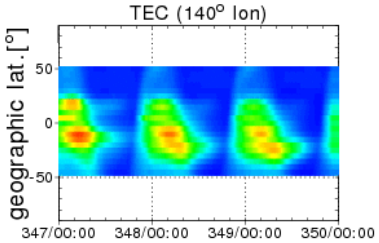
GPS TEC (MIT)



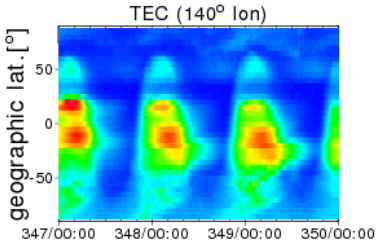
1_IRI



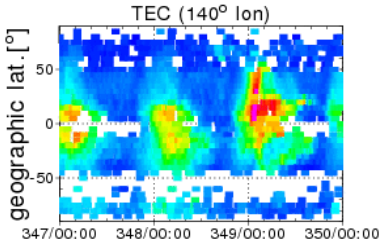
1_SAMI3_HWM93



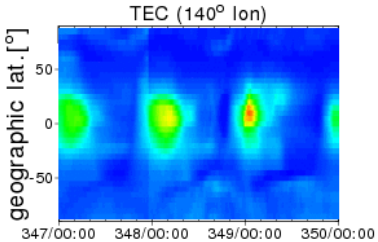
1_USU-IFM



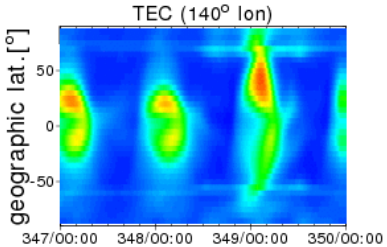
GPS TEC (JPL)

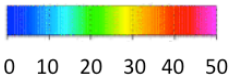


1_CTIPE

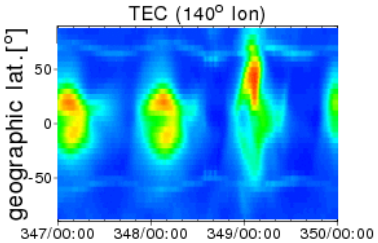


1_TIEGCM

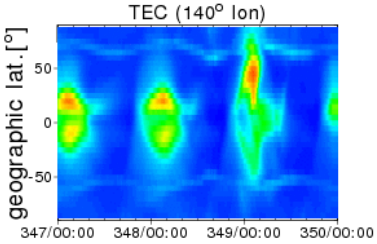




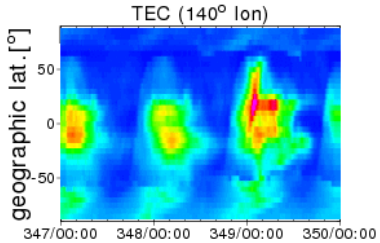
2_TIE-GCM



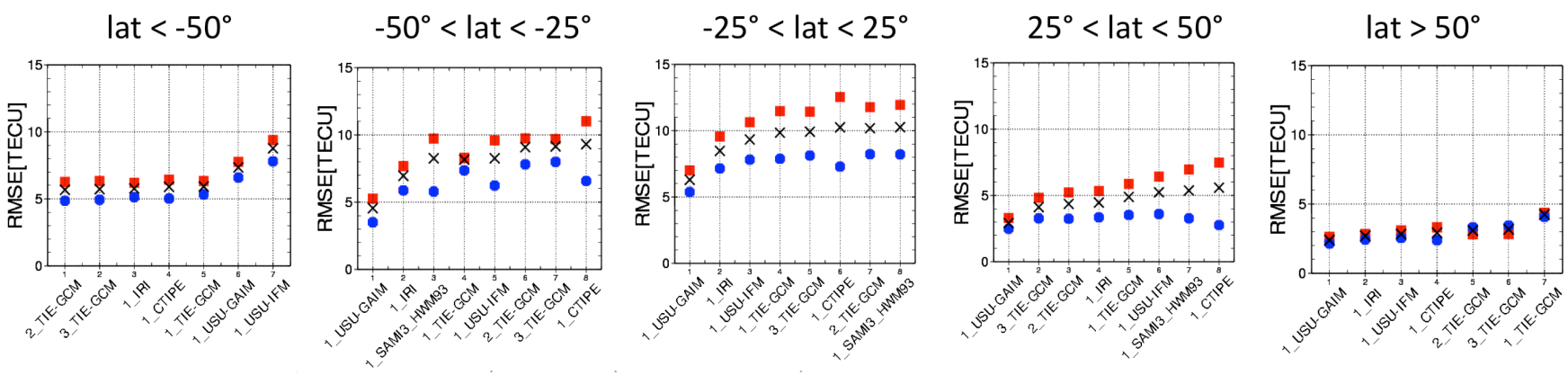
3_TIE-GCM



1_USU-GAIM



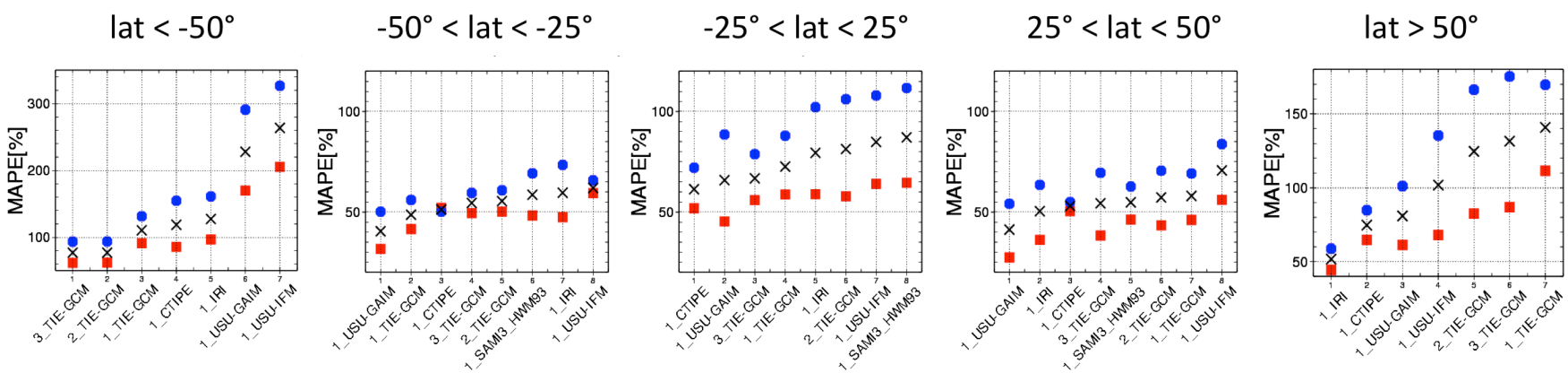
TEC from GPS: RMSE



- the best performing model is located in the extreme left.
- model ranking is arranged by score for 24 hrs (denoted by cross).
- red square : score for daytime (0600-1800 LT)
- blue circle : score for nighttime (1800-0600 LT)

- during the day > during the night
- data assimilation model, 1_USU-GAIM ranks at the top except for the southern high latitudes.
- lowest RMSE during nighttime in the northern middle and high latitudes.
- largest value during daytime in the low latitudes.
- no big difference in RMSE between models for the northern high latitudes

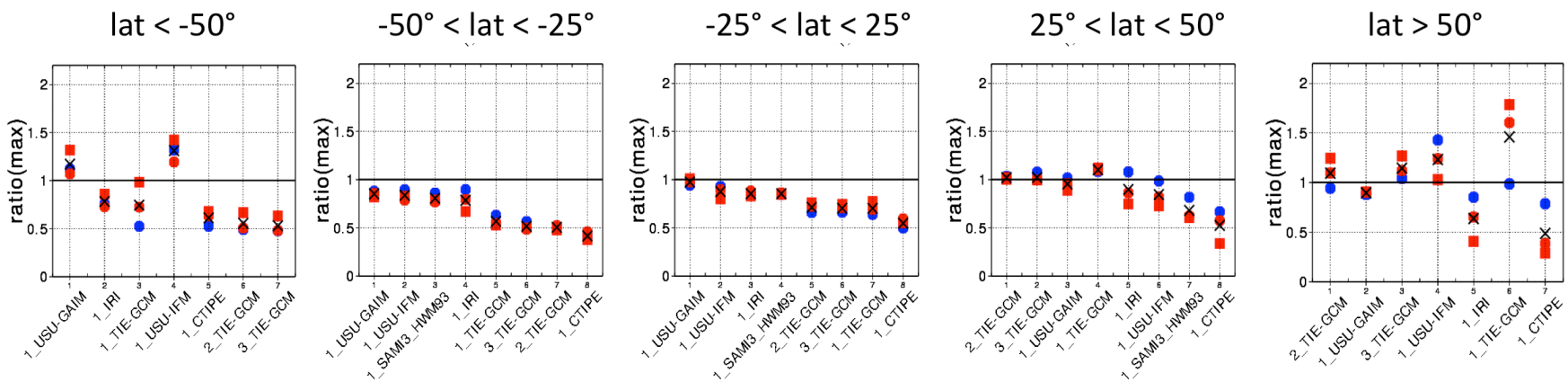
TEC from GPS: MAPE



- the best performing model is located in the extreme left.
- model ranking is arranged by score for 24 hrs (denoted by cross)
- red square : score for daytime (0600-1800 LT)
- blue circle : score for nighttime (1800-0600 LT)

- during the night > during the day
- lowest MAPE in the northern middle latitudes
- largest MAPE in the southern high latitudes
- coupled models rank higher in the southern high latitudes.
- TIE-GCMs < 1_CTIPe for the southern high latitude,
  TIE-GCMs > 1_CTIPe for the northern high latitude

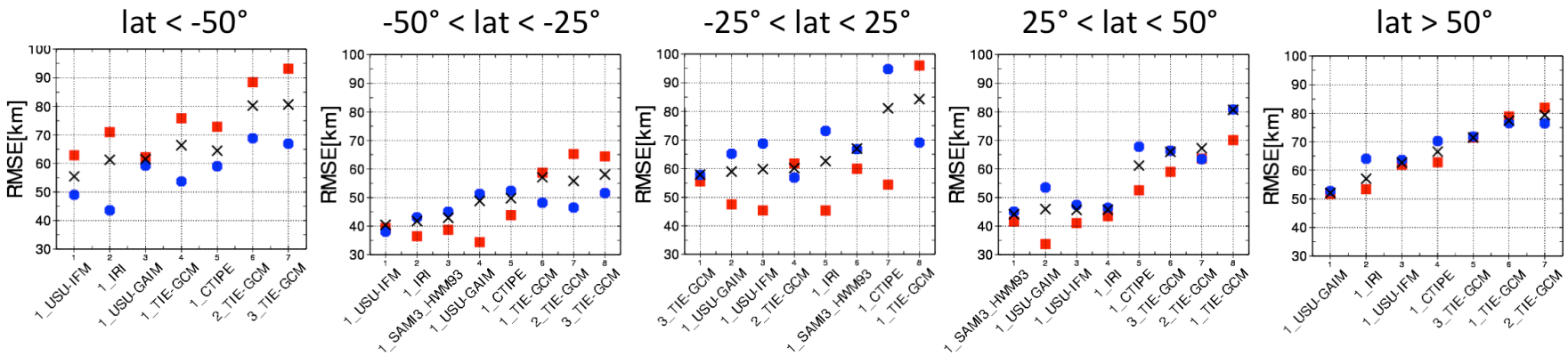
TEC from GPS: ratio(max)



- 24-hr time window
- model ranking is arranged by the average ratio of the three day values (denoted by cross)
- blue circle : ratio of max of the first day (quiet day) of the event (12/13)
- red circle : ratio of the second day (first day of storm) of the event (12/14)
- red square : ratio of the third day of the event (12/15)

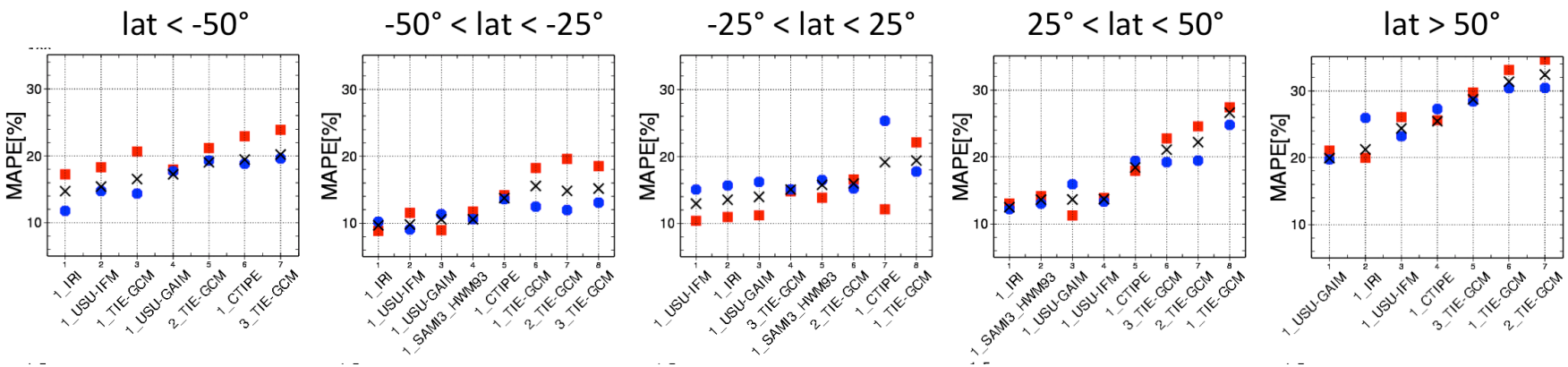
- in most cases underestimate maximum TEC values : models do not cover up to GPS altitude.
- 1_USU-GAIM and 1_USU-IFM : overestimate in the southern hemisphere
- TIE-GCMs and 1_USU-IFM : overestimate in the northern hemisphere

hmF2 from COSMIC: RMSE



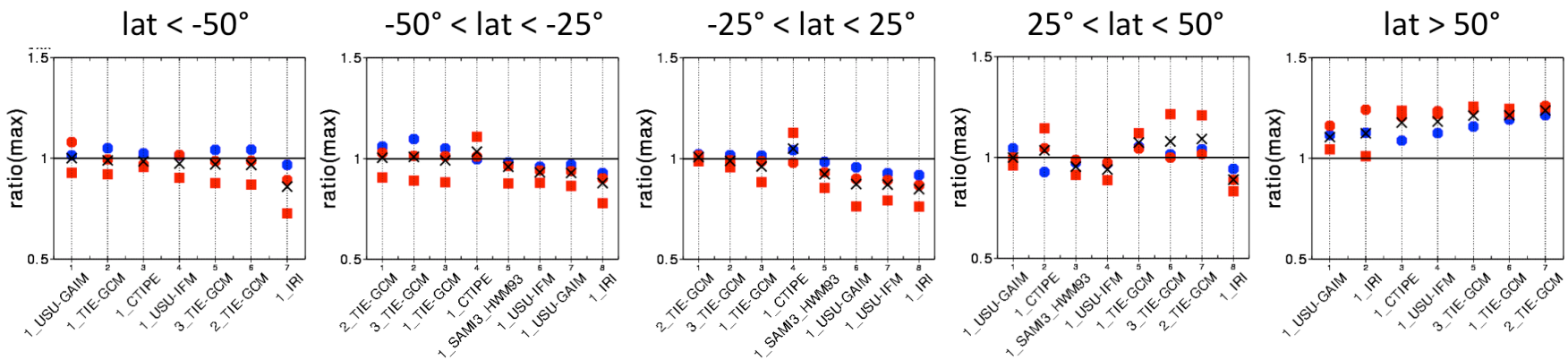
- coupled models rank lower than the others except for 3_TIE-GCM in low latitudes.
- middle latitude during daytime :
  data assimilation < empirical, ionospheric < coupled models
- middle latitude during nighttime :
  empirical, ionospheric < data assimilation < coupled models

hmF2 from COSMIC: MAPE



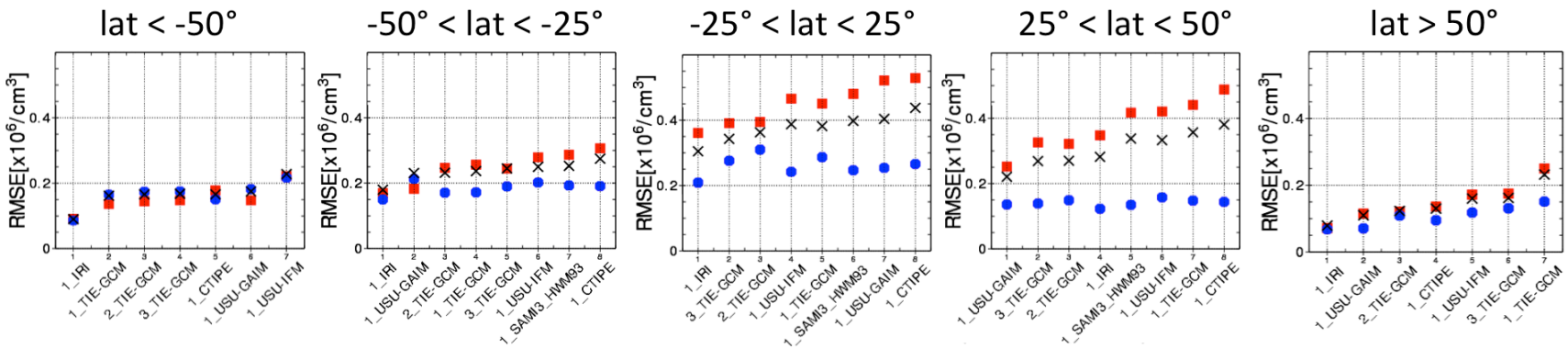
- all models show largest MAPE in the high latitudes of the northern hemisphere and lowest in the southern middle latitudes.
- coupled models rank lower than the others

hmF2 from COSMIC: ratio(max)



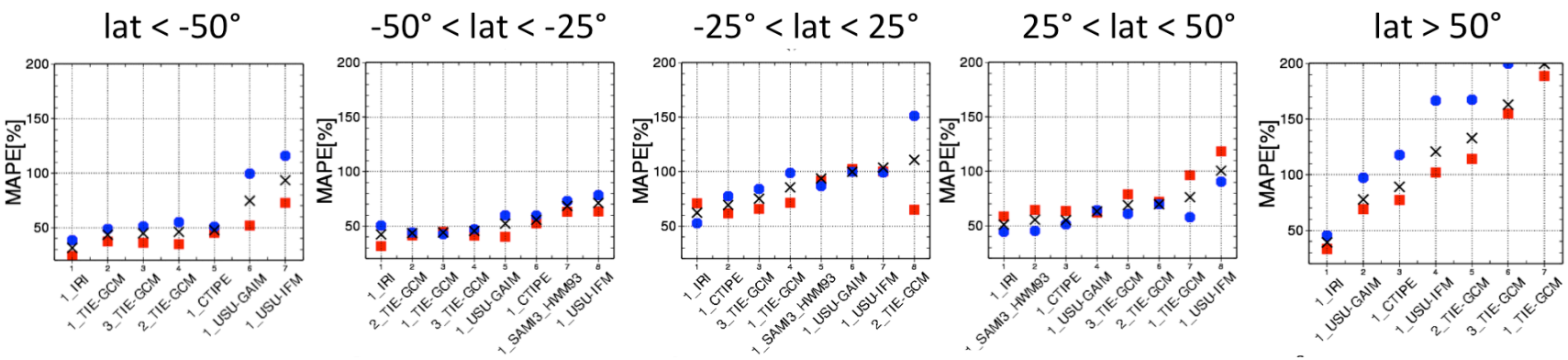
- models tend to underestimate maximum hmF2 during the main phase of the storm in the southern high latitudes and overestimate in the northern high latitudes.

NmF2 from COSMIC: RMSE



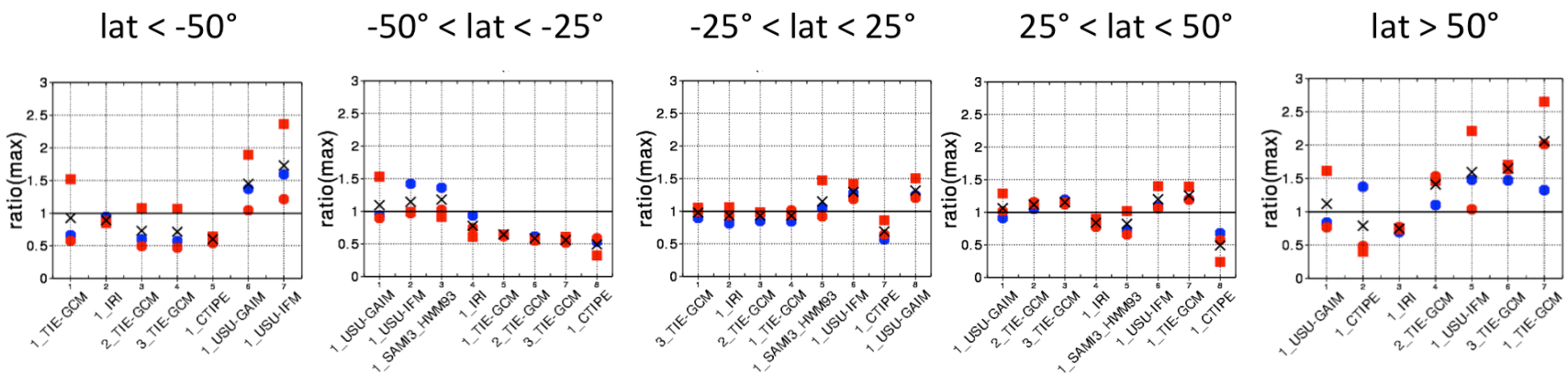
- larger difference between daytime and nighttime RMSE values in the low and the northern middle latitudes.
- similar scores during the night in middle latitudes
- empirical model, 1_IRI shows lowest RMSE for all latitudes except for the northern middle latitudes.

NmF2 from COSMIC: MAPE



- all models show worse MAPE in the low and northern high latitudes than the other latitude.
- 1_IRI ranks at the top.
- MAPE during the night > during the day except for the northern middle latitude
- largest MAPE : nighttime in the northern high latitude

NmF2 from COSMIC: ratio(max)



- physics-based models and data assimilation model show better performance based on the average ratio of max of NmF2 than empirical model.
- 1_IRI and 1_CTIPe : underestimate
- 1_USU-GAIM and 1_USU-IFM : overestimate
- TIE-GCMs : underestimate in the southern hemisphere
  overestimate in the northern hemisphere

Summary

- model performance depends on

  - latitude
  - season
  - local time
  - metrics selection

- none of models ranks at the top for all used metrics.

- establish a baseline for new models and future versions

- COMMENTS and SUGGESTIONS

* poster : SA41B-1857, Halls A-C (Moscone South)