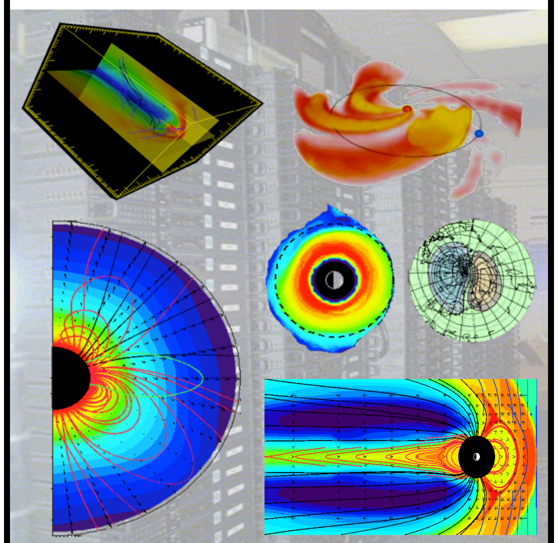
Community Coordinated Modeling Center



Role of drivers on Ionosphere/Thermosphere model results for 2006 event

CCMC : J. Shim, M. Kuznetsova, L. Rastätter, and Y. Zheng

Modelers : M. Codrescu, B. Emery, M. Foerster, B. Foster, A. Ridley, T. Fuller-Rowell, B. Prokhorov

Data providers : A. Coster, L. Goncharenko, L. Lomidze, A. J. Mannucci, L. Scherliess, X. Pi

http://ccmc.gsfc.nasa.gov

NASA Goddard Space Flight Center

- High-latitude Electric Potential Models used for 2006 Dec. event (12/13 -12/15):

1. Weimer 2005 using 15-min averages of the IMF input parameters lagged -5 to -20 min provided by the NCAR and the CCMC
2. AMIE (run with Weimer 96 as the background, Magnetometers, DMSP, and SuperDARN) provided by Aaron Ridley (University of Michigan)
3. AMIE provided by Geoff Crowley (ASTRA)
4. Global magnetosphere models provided by the CCMC :
    - SWMF
    - To be used : OpenGGCM, LFM, and etc.

ftp://hanna.ccmc.gsfc.nasa.gov/pub/GEM-CEDAR/out/high-latitude-drivers/

- Tools for swapping drivers

: based on Kameleon converter and interpolator for 2D ionosphere electrodynamics files to swap high latitude drivers at any position or on any grid with any time resolution

```
call weimer05(angle,swbt,tilt,swvel,swden,exns,eyns)
=> call kameleon_f(current_epoch,exns,eyns)
```

```
call f_timeinterp_timestrtoepoch(time, time_epoch)
call f_timeinterp_addtimestep(tid, cdf_file_path1)
call f_timeinterp_addtimestep(tid, cdf_file_path2)
variable = 'ep'
call f_timeinterp_managemem(tid, time_epoch, variable)
call f_timeinterp_interpolate(tid, time_epoch, variable, 0.0,
    &mlat, gmlt, epot)
```

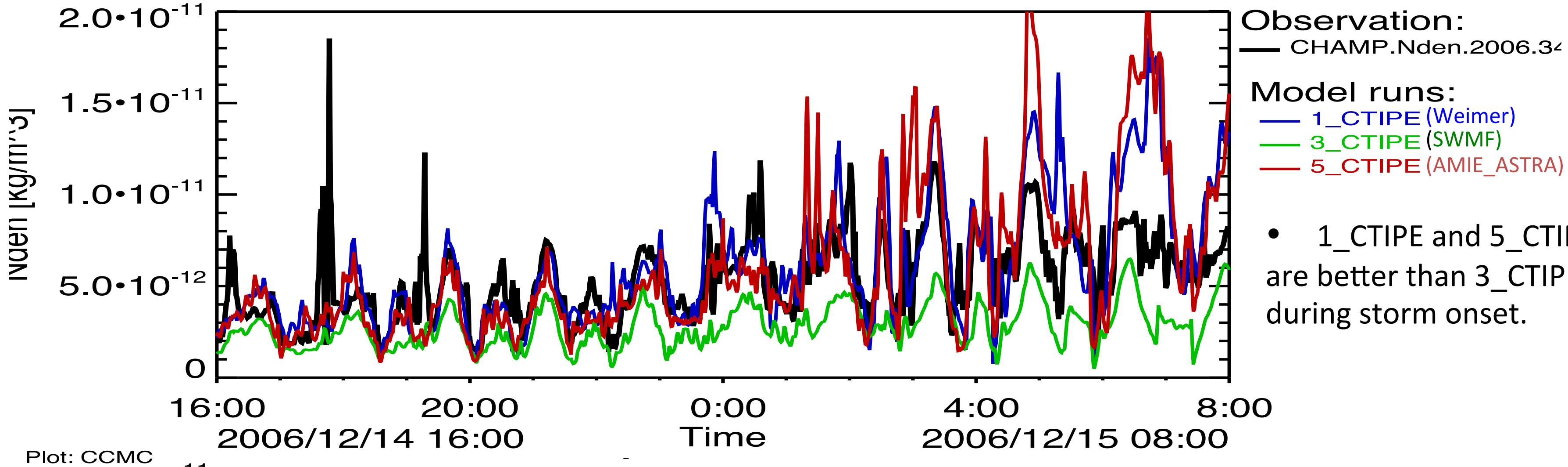
ftp://hanna.ccmc.gsfc.nasa.gov/pub/GEM-CEDAR/out/high-latitude-drivers/

Model Setting

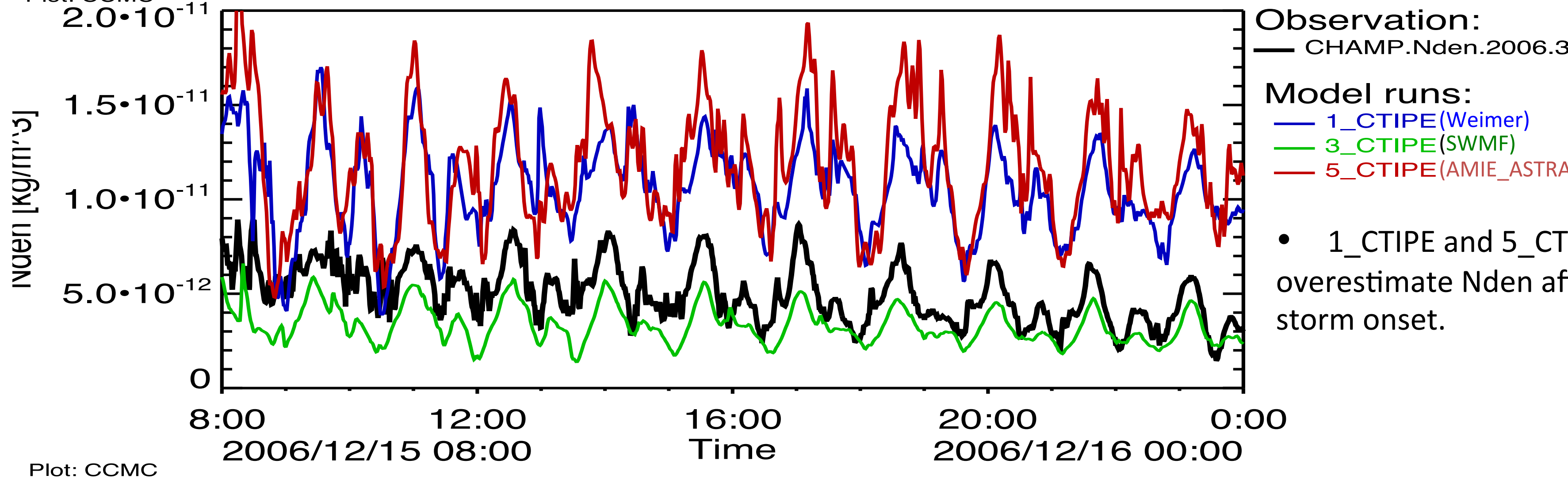
	Model Setting ID	
1	1_CTIPE*	CTIPe driven by Weimer electric potential model
2	3_CTIPE*	CTIPe driven by electric potential from SWMF
3	5_CTIPE*	CTIPe driven by AMIE_ASTRA
4	2_TIE-GCM	TIE-GCM1.94 driven by Weimer electric potential model with dynamic critical co-latitudes
5	5_TIE-GCM	TIE-GCM1.94 driven by AMIE_UM with constant critical cross-over latitudes (fixed at 55 and 70 mlat)
6	6_TIE-GCM	TIE-GCM1.94 driven by AMIE_ASTRA
7	1_UAM	Upper Atmosphere Model (UAM, A.A. Namgaladze et al.) with FAC as external driver (FAC model of Papitashvili et al.)
8	2_UAM	UAM with AMIE_UM electric potentials
9	3_UAM	UAM with Weimer-2005 electric potentials

*Runs performed at the CCMC

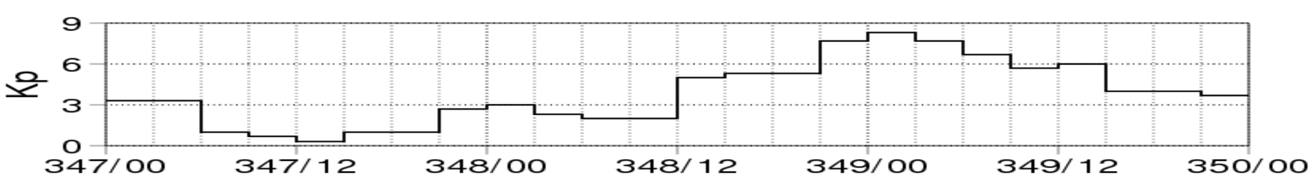
Neutral density at the CHAMP location: CTIPe runs



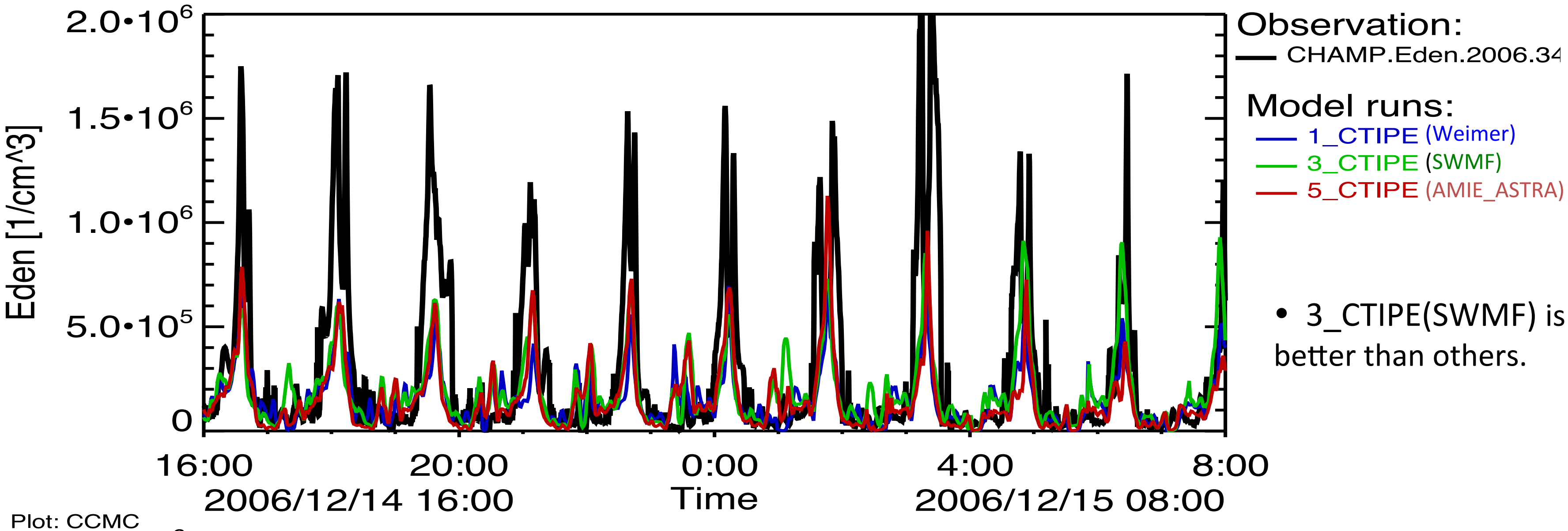
- 1_CTIPE and 5_CTIPE are better than 3_CTIPE during storm onset.



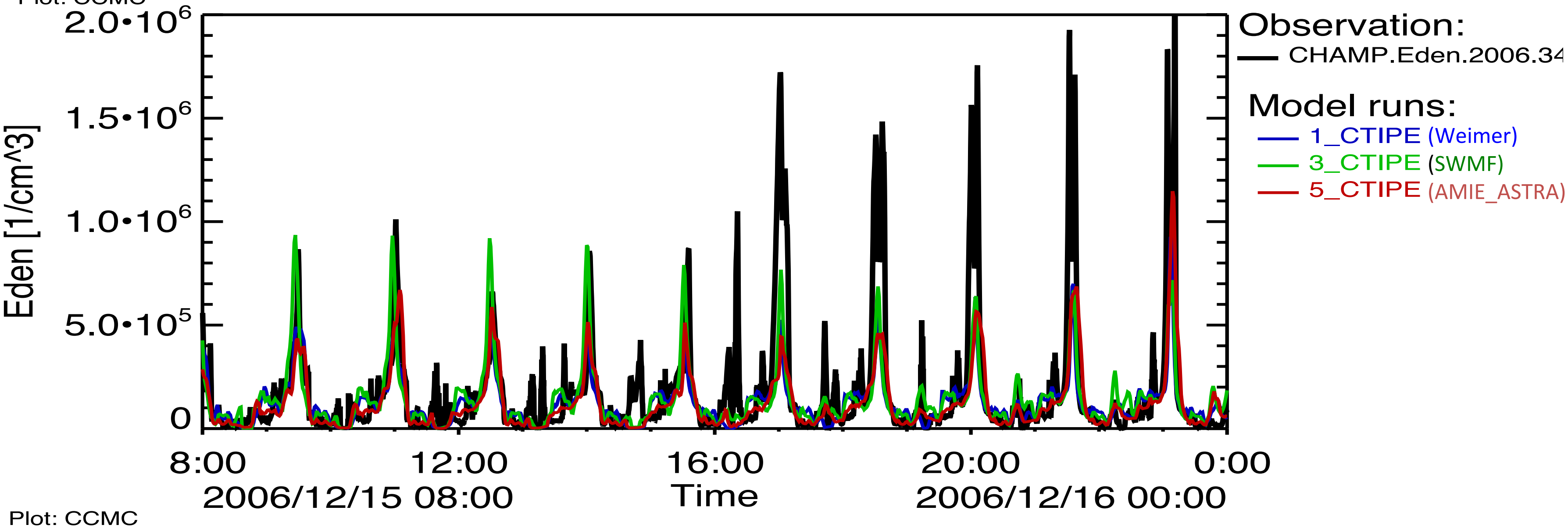
- 1_CTIPE and 5_CTIPE overestimate Nden after storm onset.



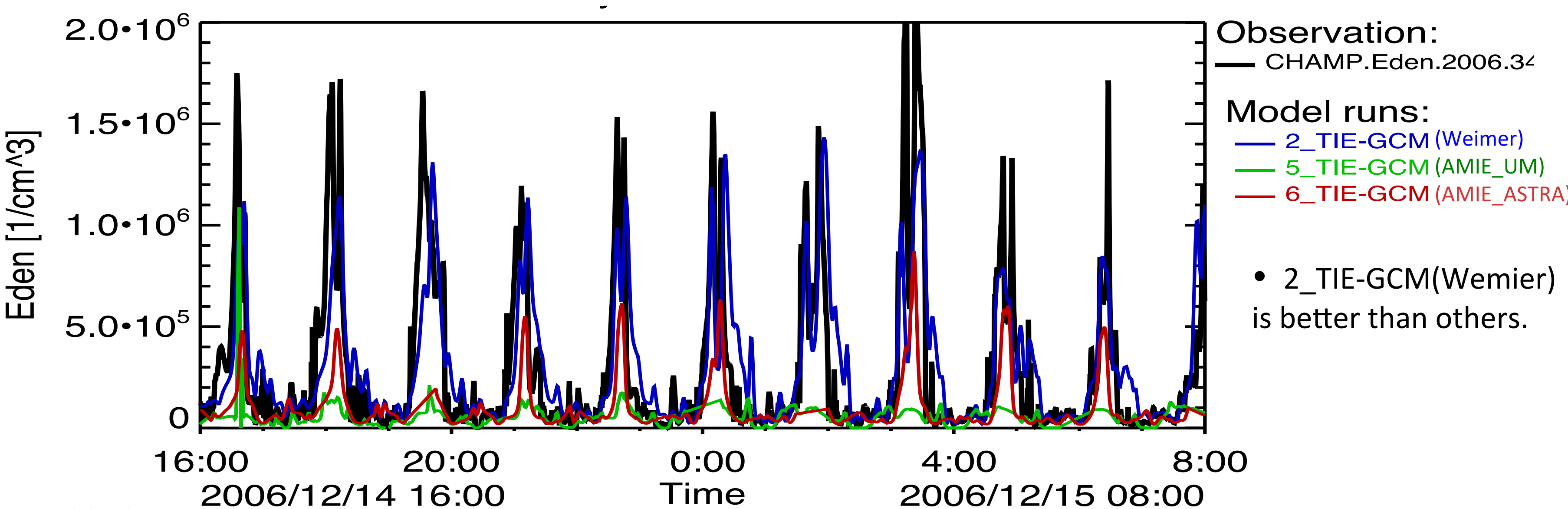
Electron density at the CHAMP location: CTIPe runs



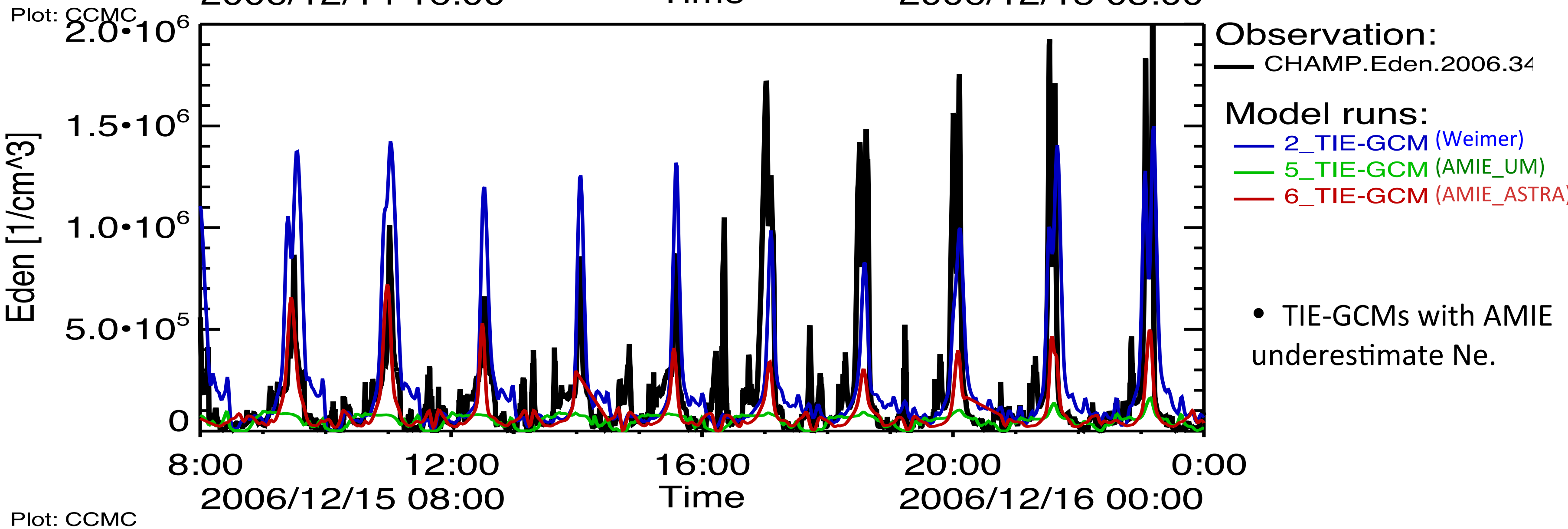
- 3_CTIPE(SWMF) is better than others.



Electron density at the CHAMP location: TIE-GCM runs

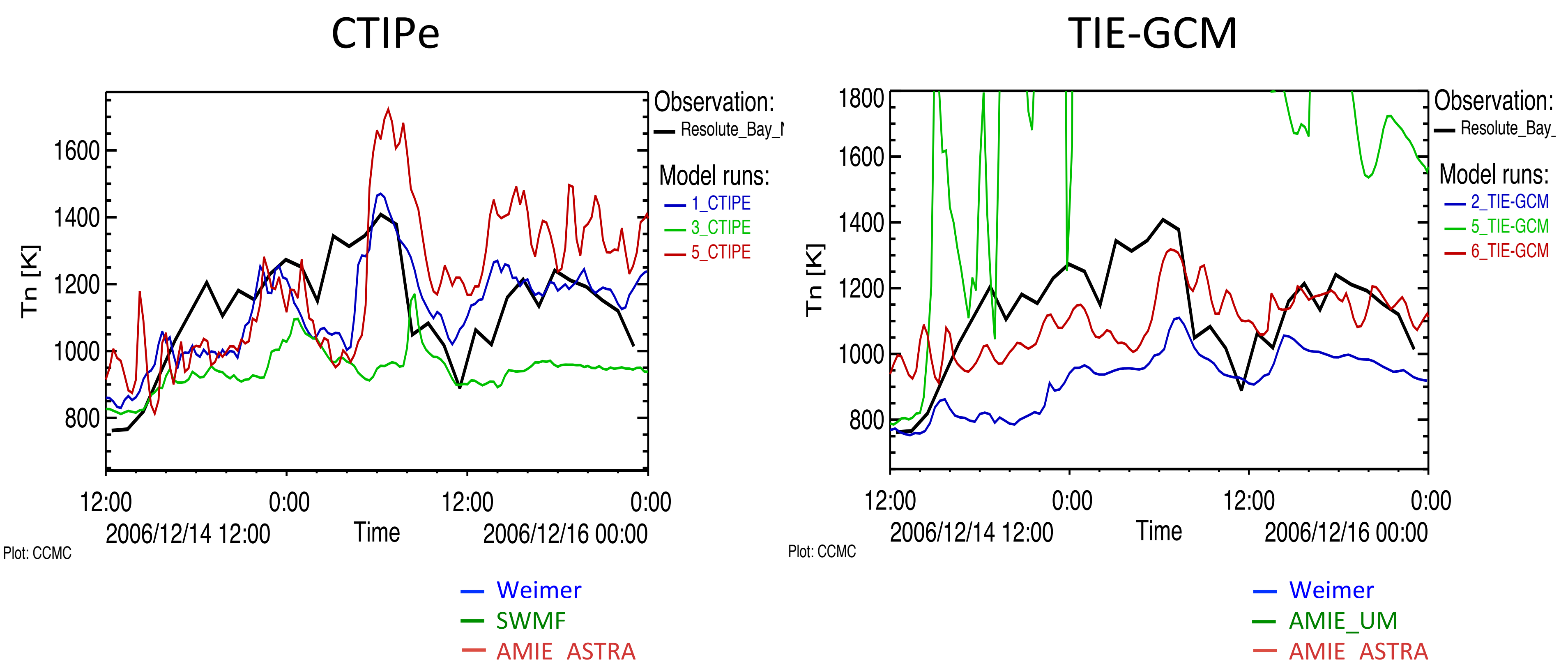


- 2_TIE-GCM(Wemier) is better than others.



- TIE-GCMs with AMIE underestimate Ne.

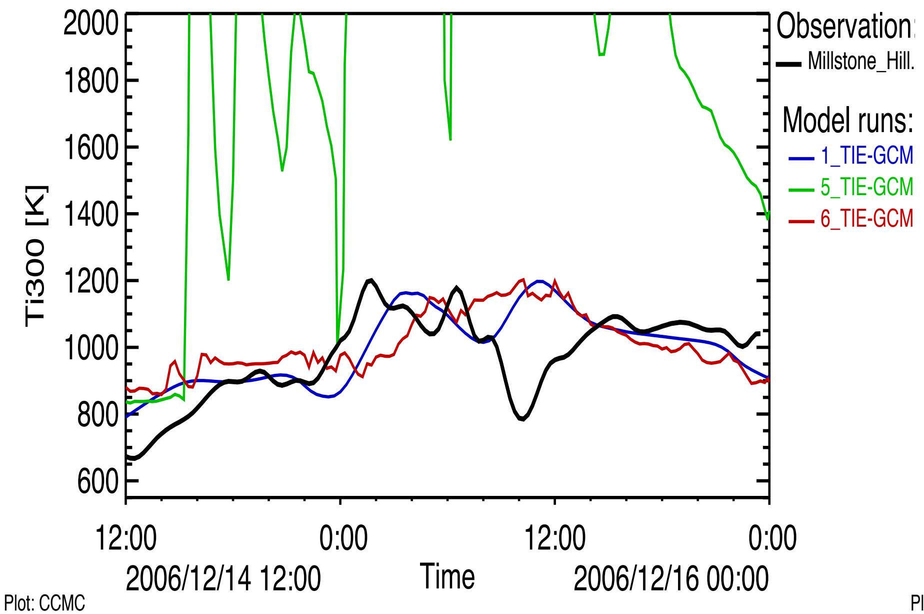
Tn at 250 km in high latitude (Resolute Bay)



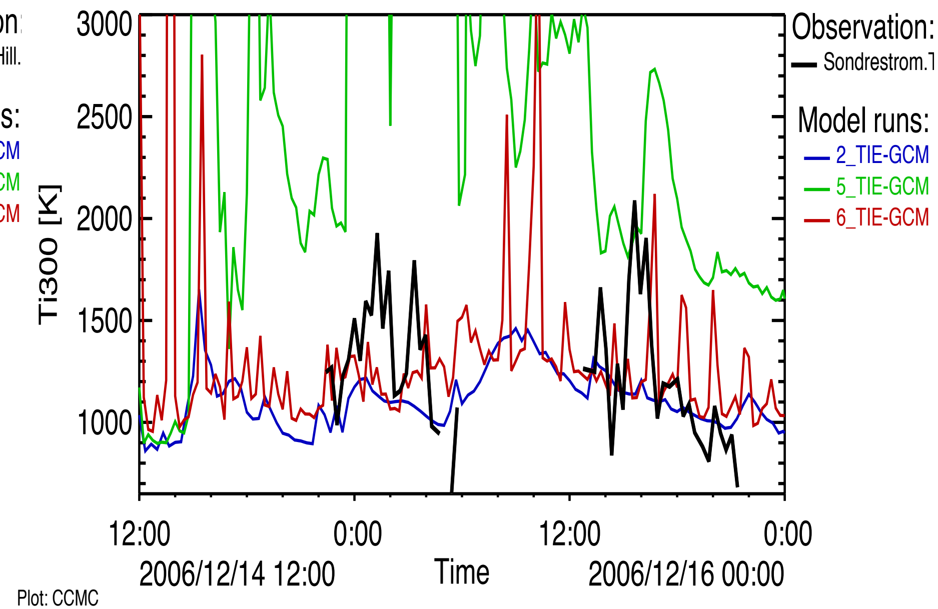
- 3_CTIPE(Weimer) < 1_CTIPE(SWMF) ~ observations < 5_CTIPE(AMIE_ASTRA)
- 2_TIE-GCM(Weimer) < 6_TIE-GCM (AMIE_ASTRA) ~ observations << 5_TIE-GCM(AMIE_UM)
- 5_TIE-GCM(AMIE_UM): largest difference between modeled and observed Tn at 250 km

Ti at 300 km height: TIE-GCM runs

middle latitude (Millstone Hill)



high latitude (Sondrestrom)

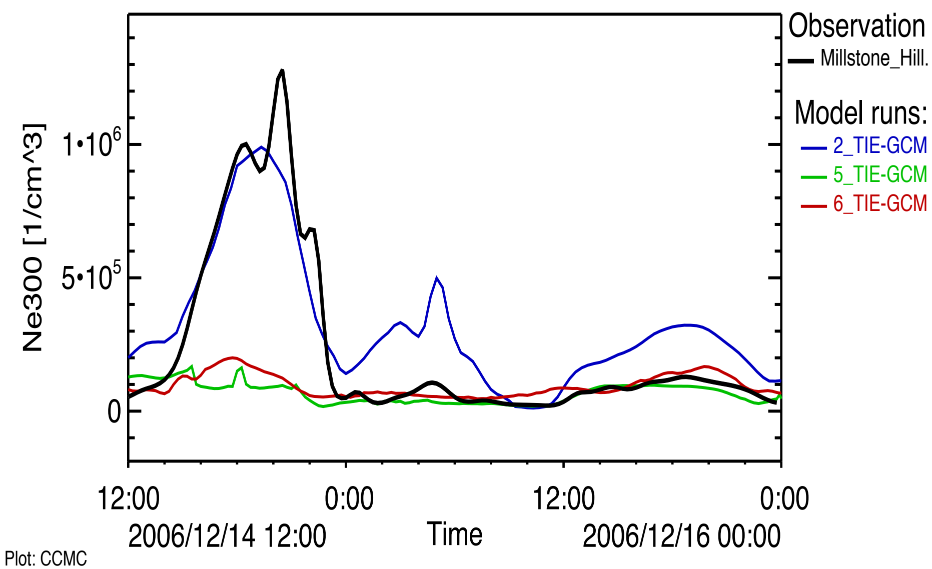


— Weimer
— AMIE_UM
— AMIE_ASTRA

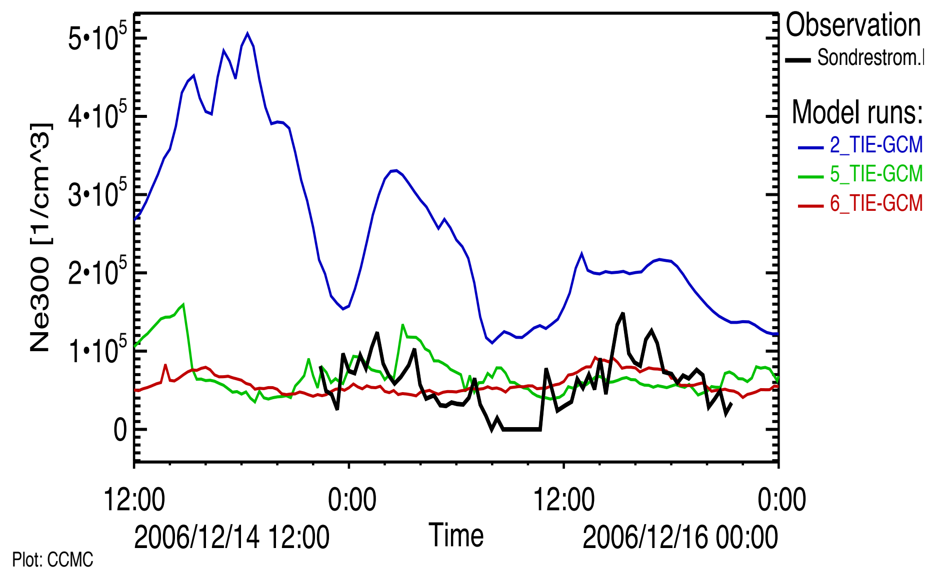
- 2_TIE-CM(Weimer)~ 6_TIE-GCM(AMIE_ASTRA) << 5_TIE-GCM(AMIE_UM)

Ne at 300 km height: TIE-GCM runs

middle latitude (Millstone Hill)



high latitude (Sondrestrom)

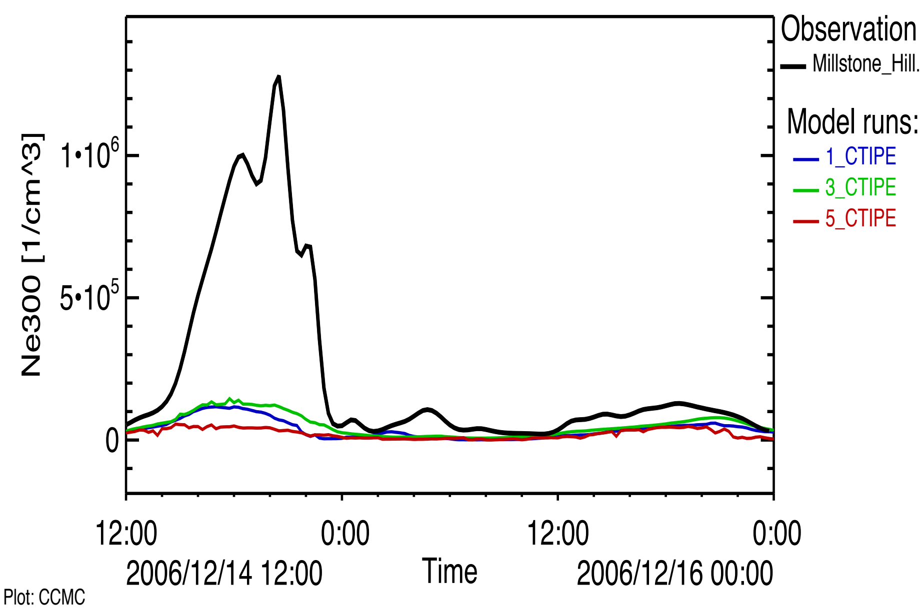


— Weimer
— AMIE_UM
— AMIE_ASTRA

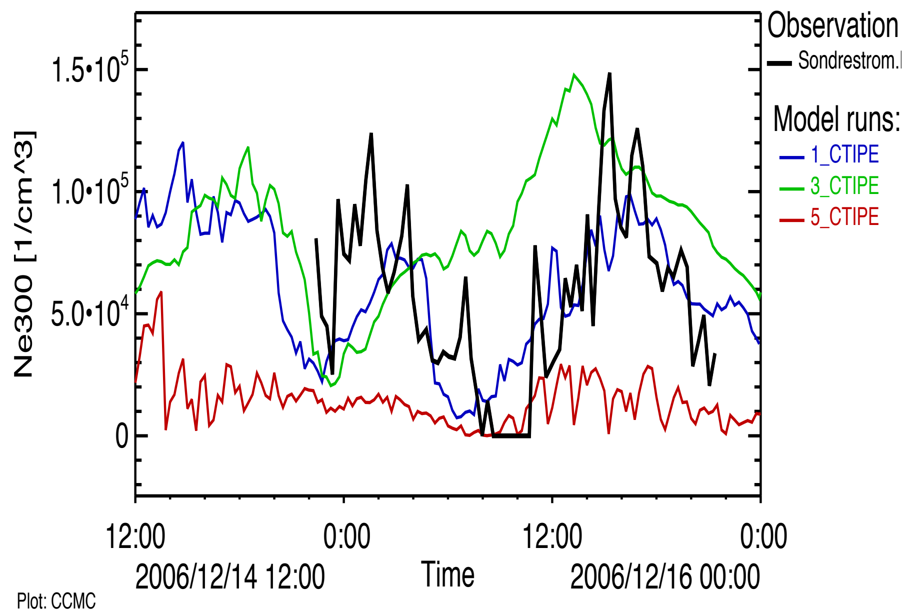
- Difference among TIE-GCMs: during storm onset > during main phase
- 2_TIE-GCM(Weimer) > 5_TIE-GCM ~ 6_TIE-GCM w/AMIE

Ne at 300 km height: CTIPe runs

middle latitude (Millstone Hill)



high latitude (Sondrestrom)

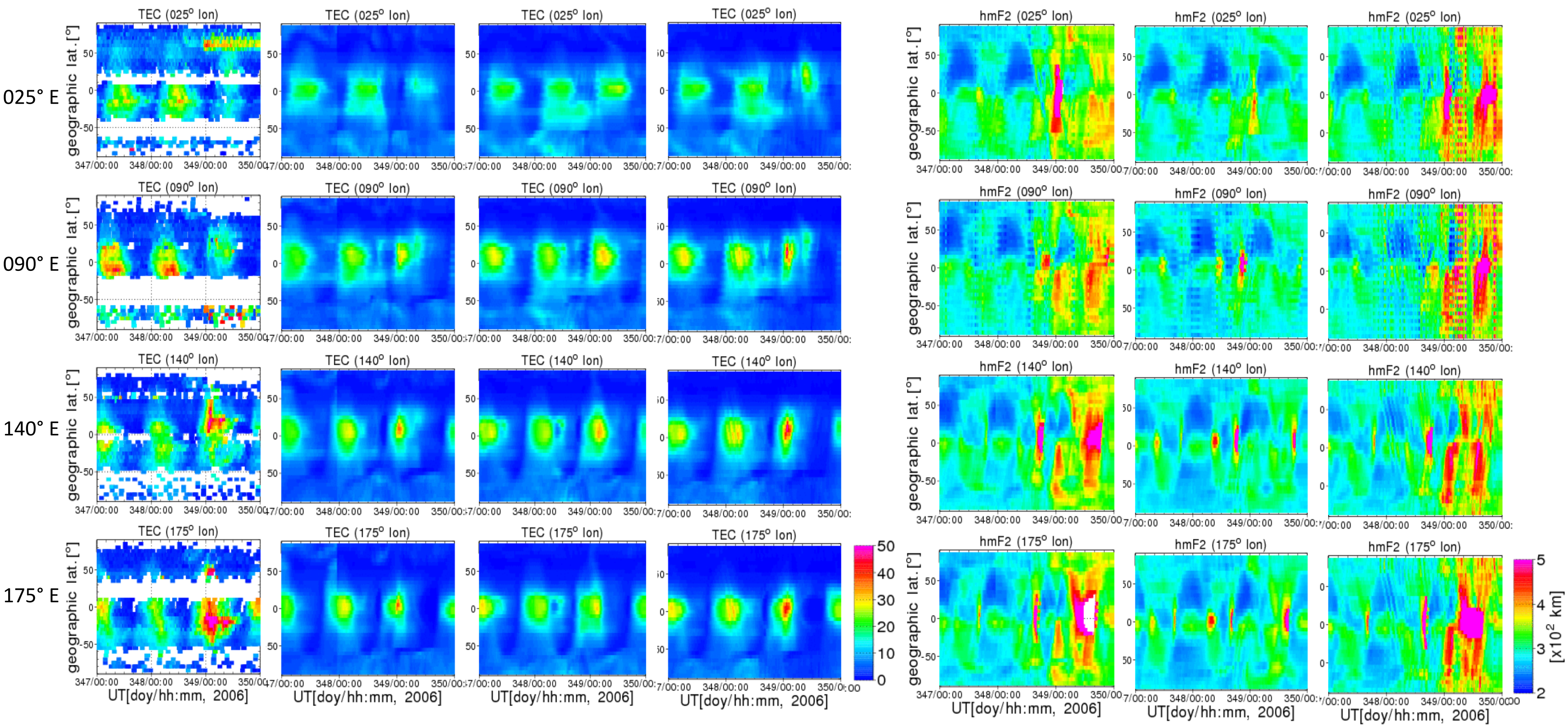


— Weimer
— SWMF
— AMIE_ASTRA

- 5_CTIPE(AMIE_ASTRA) < 1_CTIPE(Weimer)~ observations < 3_CTIPE(SWMF) : during storm main phase

TEC and hmF2 : CTIPe runs

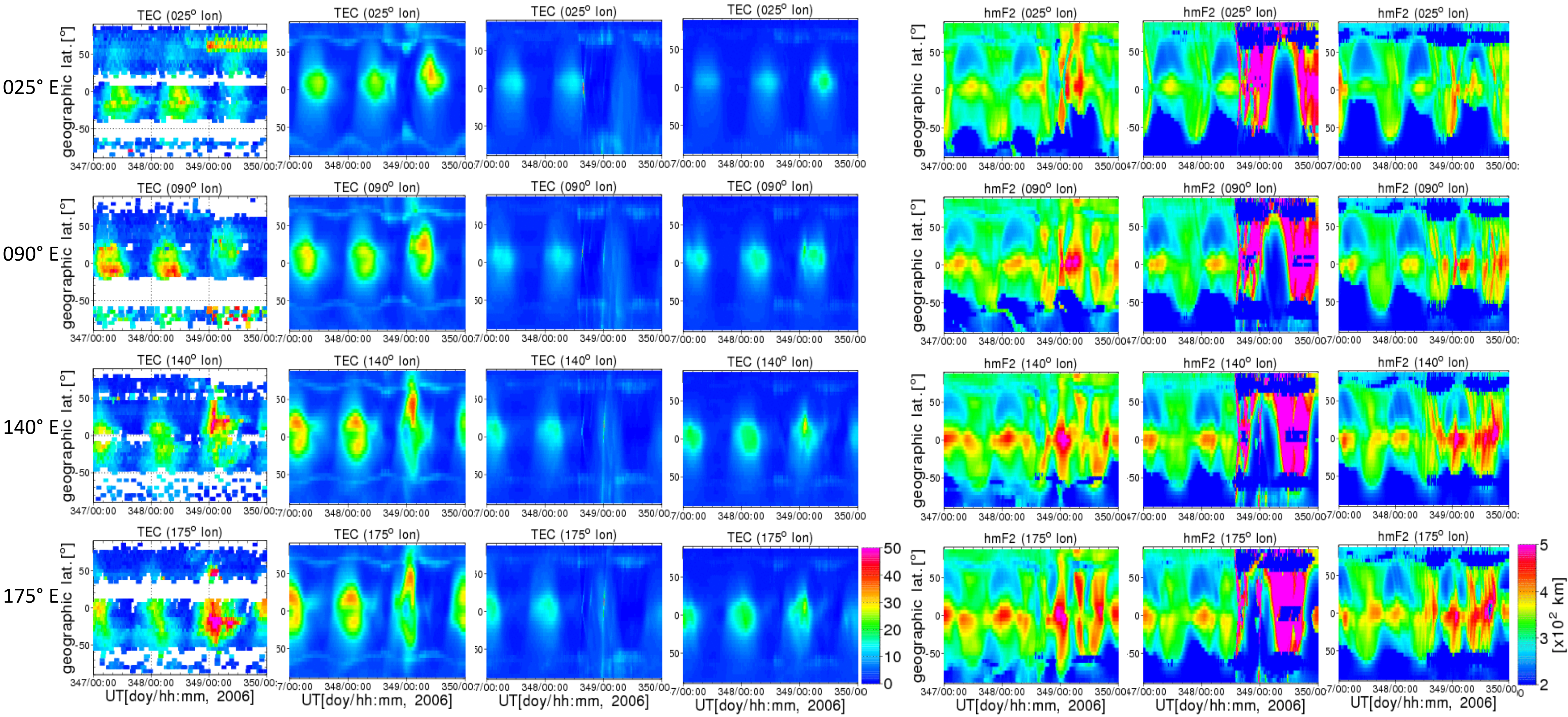
GPS TEC (MIT) **1_CTIPE(Weimer)** **3_CTIPE (SWMF)** **5_CTIPE(AMIE_ASTRA)** **1_CTIPE(Weimer)** **3_CTIPE (SWMF)** **5_CTIPE(AMIE_ASTRA)**



- TEC: 1_CTIPE (Weimer) ~ 3_CTIPE(SWMF) < 5_CTIPE)AMIE_ASTRA) during storm time
- hmF2: 1_CTIPE (Weimer) ~ 5_CTIPE(AMIE_ASTRA) > 3_CTIPE(SWMF) during storm time

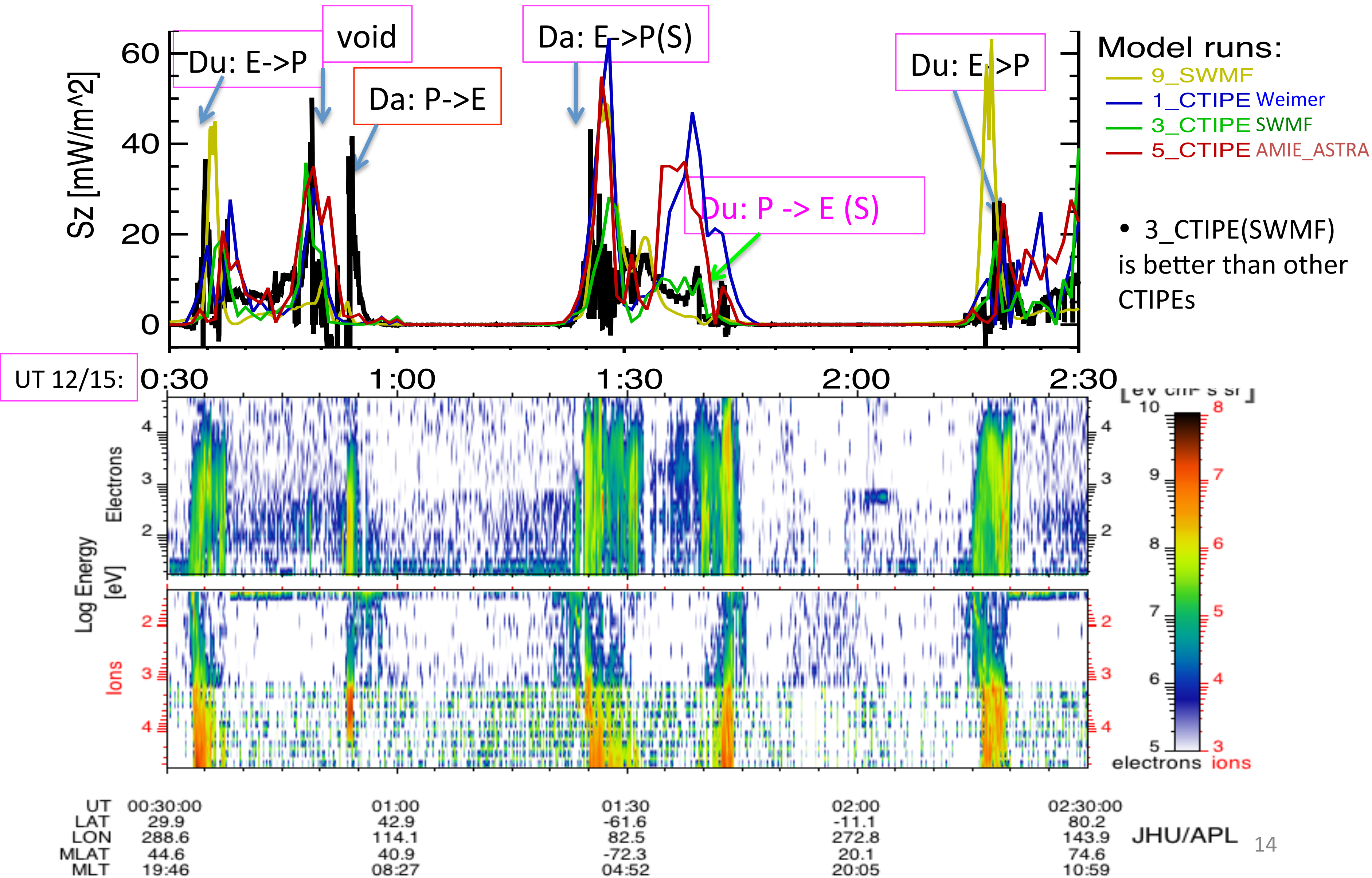
TEC and hmF2 : TIE-GCM runs

GPS TEC (MIT) | **2_TIE-GCM (Weimer)** | **5_TIE-GCM (AMIE_UM)** | **6_TIE-GCM (AMIE_ASTRA)** | **2_TIE-GCM (Weimer)** | **5_TIE-GCM (AMIE_UM)** | **6_TIE-GCM (AMIE_ASTRA)**



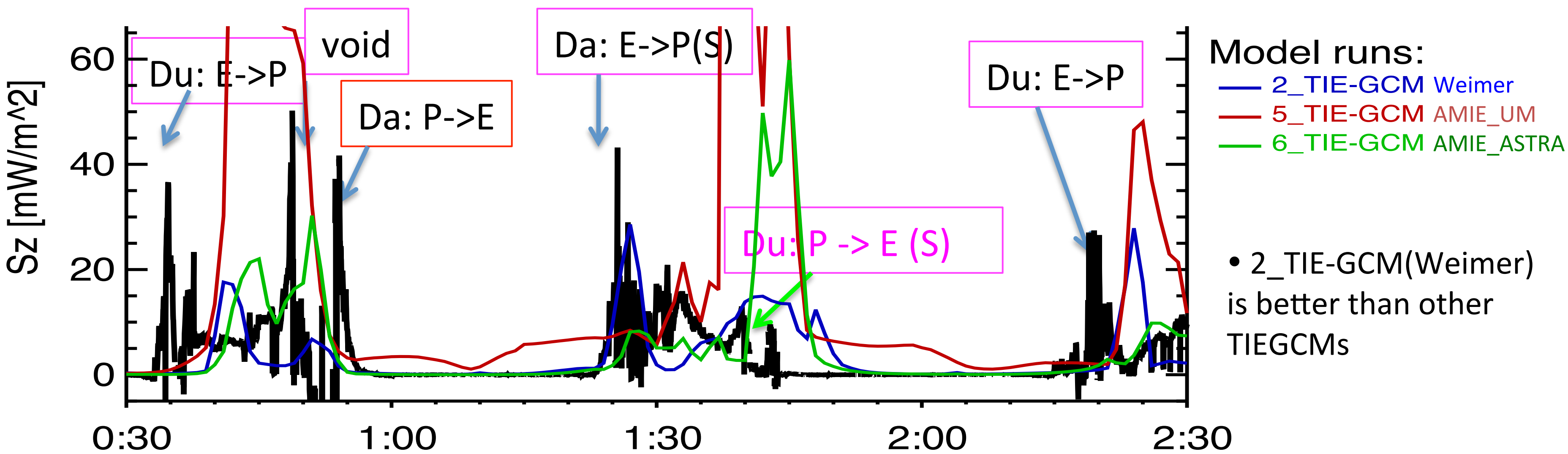
- TEC: 2_TIE-GCM(Weimer) > 6_TIE-GCM(AMIE_ASTRA) > 5_TIE-GCM(AMIE_UM)
- hmF2: 2_TIE-GCM(Weimer) > 5_TIE-GCM(AMIE_UM) > 6_TIE-GCM(AMIE_ASTRA) during quiet time
  2_TIE-GCM(Weimer) ~ 6_TIE-GCM(AMIE_ASTRA) << 5_TIE-GCM(AMIE) for nighttime during main phase

Joule Heating along DMSP tracks: CTIPe runs

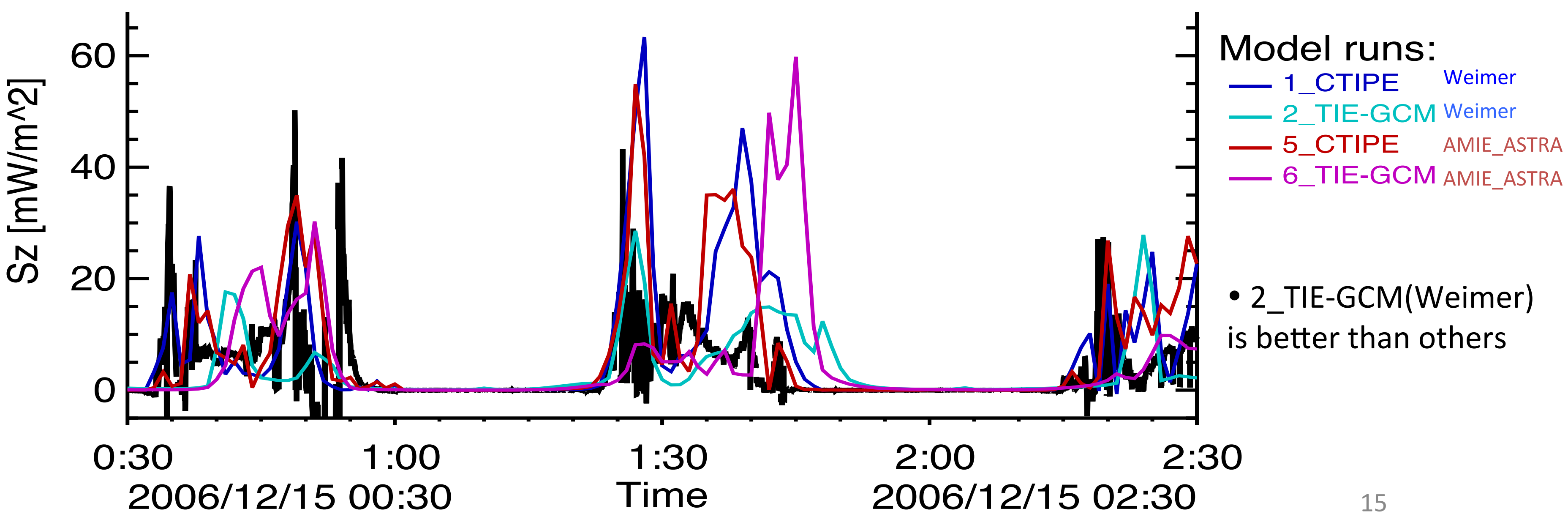


- 3_CTIPE(SWMF) is better than other CTIPEs

Joule Heating along DMSP tracks: TIE-GCM runs

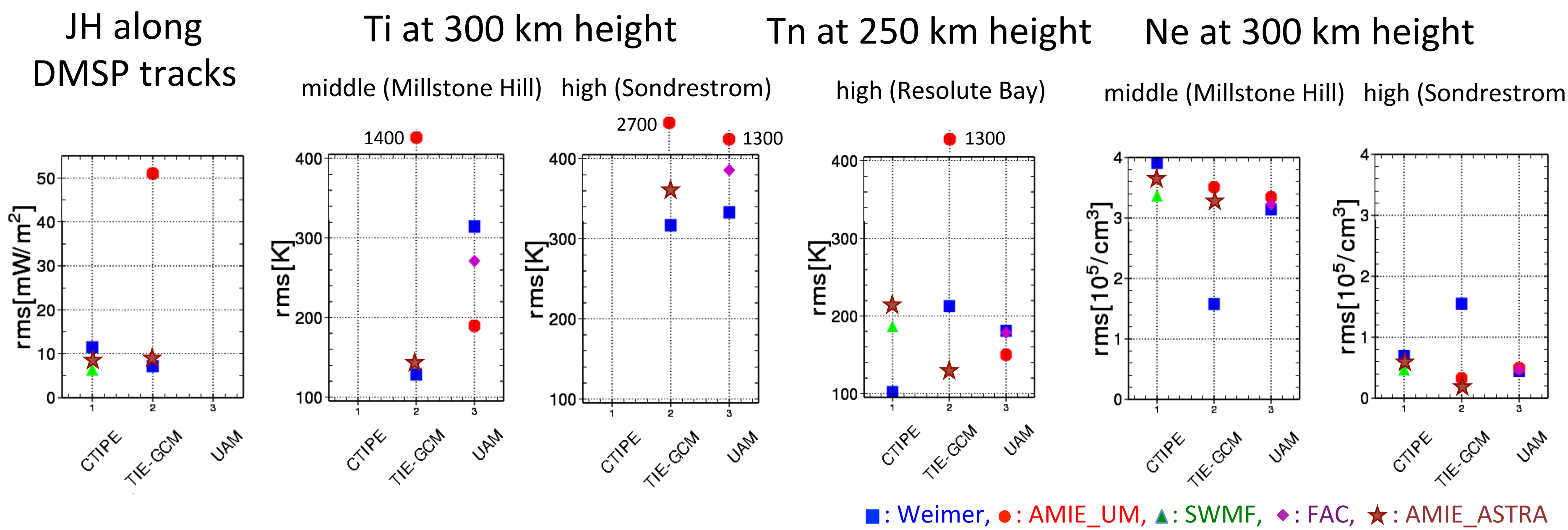


• 2_TIE-GCM(Weimer) is better than other TIEGCMs



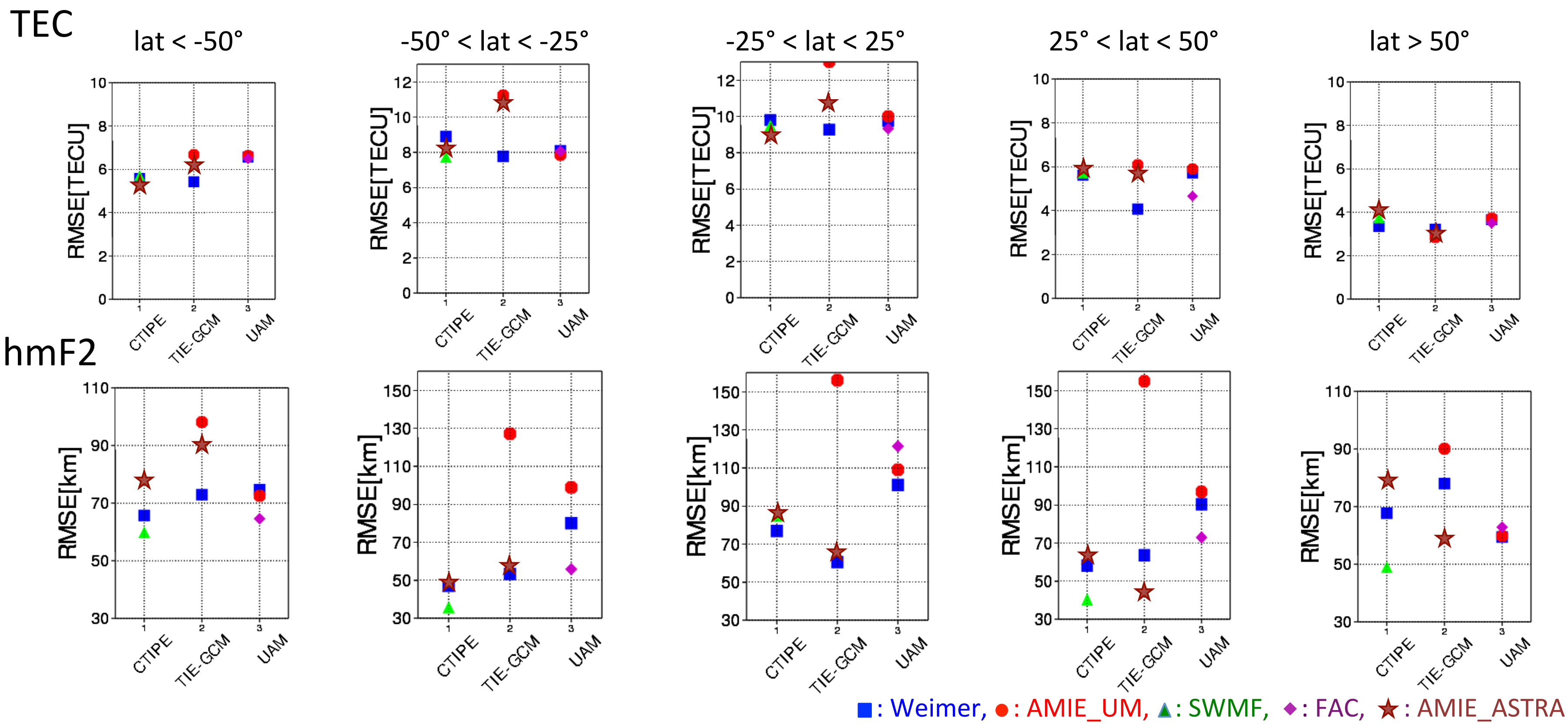
• 2_TIE-GCM(Weimer) is better than others

RMS in predicting Ti, Tn, Ne and Joule Heating



- 2_TIE-GCM(Weimer) is better than 5_TIE-GCM(AMIE_UM) for all cases (Ti, Tn and Ne) except for Ne in high latitude.
- 6_TIE-GCM(AMIE_ASTRA) is better than 5_TIE-GCM(AMIE_UM) for all cases
- 1_CTIPE(Weimer) is better than 3_CTIPE(SWMF) for Tn, but opposite holds true for Ne in both middle and high latitudes and JH.
- 1_CTIPE(Weimer) and 5_CTIPE(AMIE_ASTRA) show similar scores, but 1_CTIPE is slightly better than 5_CTIPE for most cases
- 2_UAM(AMIE_UM) is better than 1_UAM(FAC) and 3_U AM(Weimer) for Tn in high latitudes and Ti in middle latitudes, while 3_U AM(Weimer) is better than the others for Ti in high latitudes.
- For all cases, models with Weimer show the best performance except for 3_CTIPE(SWMF) for JH and 6_TIEGCM(AMIE_ASTRA) for Ne in high latitudes.

RMS in predicting TEC and hmF2



- 2_TIE-GCM(Weimer) is better than TIE-GCMs with AMIE for all cases except for TEC in northern high latitudes.
- Three CTIPEs show similar RMS errors in predicting TEC, while 3_CTIPE(SWMF) has smaller RMS errors in predicting hmF2 than 1_CTIPE(Weimer) and 5_CTIPE(AMIE_ASTRA) except for low latitudes.
- For TEC predicting, there is no significant difference among three UAMs except for in northern middle latitudes. 1_UAM(FAC) produces better hmF2 than the other UAMs in middle latitudes and southern high latitudes.
- For most hmF2 cases, 3_CTIPE(SWMF) is the best except for in low latitudes.

Summary

- For 2006 Dec. event, results of IT models (CTIPe, TIE-GCM, and UAM) with different high-latitude electric potentials (e.g., Weimer05, AMIE, and SWMF) were compared.

- Effect of drivers on IT parameters varies with models:

  - for Ne at 300 km height

    2_TIE-GCM(Weimer) >> TIE-GCMs with AMIE,

    1_CTIPE(Weimer) ~ 5_CTIPE with AMIE

  - for TEC during storm time

    TIE-GCMs with AMIE < 2_TIE-GCM(Weimer),

    5_CTIPE with AMIE > 1_CTIPE(Weimer)

  - for Tn at 250 km height in high latitudes (Resolute Bay)

    5_TIE-GCM(AMIE_UM) >> 2_TIE-GCM(Weimer),

    2_UAM(AMIE_UM) ~ 1_UAM(FAC) ~ 3_U AM(Weimer)

- Sensitivity of models to drivers varies with parameters:
  - Differences between neutral density values at the CHAMP locations from CTIPe runs are lager than differences between electron density values at the CHAMP locations from the model runs.
  - Differences between Tn values at 250 km height in high latitudes from 2_UAM(AMIE_UM) and the other UAMs are much less than differences in Ti values in high latitudes between them.
- Performance of models using different high-latitude drivers in predicting IT parameters depends on parameters and latitudes (in terms of RMS errors):

  for most cases, models with Weimer show the best performance, however
  - 3_CTIPE(SWMF) has smallest RMS errors in predicting hmF2 in most latitude regions and Joule Heating along DMSP tracks.
  - TIEGCMs with AMIE are the best for Ne at 300 km height and TEC in northern high latitudes.

Future Plans

- IT model runs using high-latitude electric potential from various global MHD models such as
  - OpenGGCM
  - SWMF w/o RCM
  - LFM and etc.

- Particle precipitations

- More events