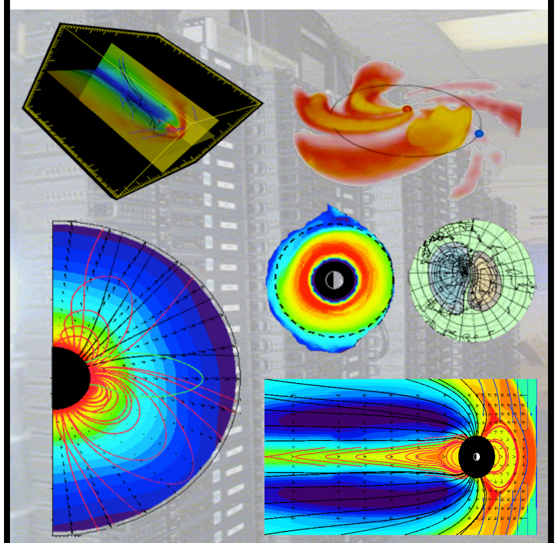
Community Coordinated Modeling Center



Effects of high-latitude drivers on Ionosphere/Thermosphere parameters

CCMC : J. Shim, M. Kuznetsova, L. Rastätter, D. H. Berrios

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Data providers : A. Coster, L. Goncharenko, L. Lomidze,
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http://ccmc.gsfc.nasa.gov

NASA Goddard Space Flight Center

Setup

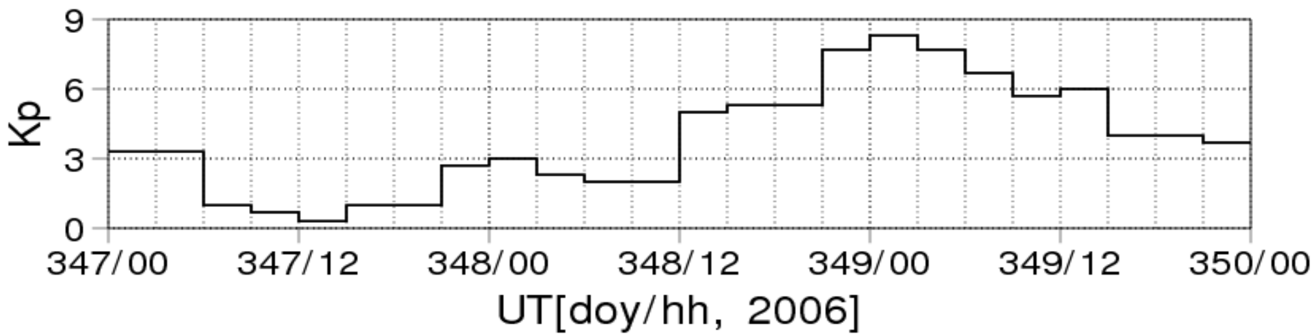
- High-latitude Electric Potential Models used for the study:

  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. 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/

- Time interval: E.2006.347-2006.349

(2006/12/13 (347) 00:00 UT - 12/15 (350) 00:00 UT)



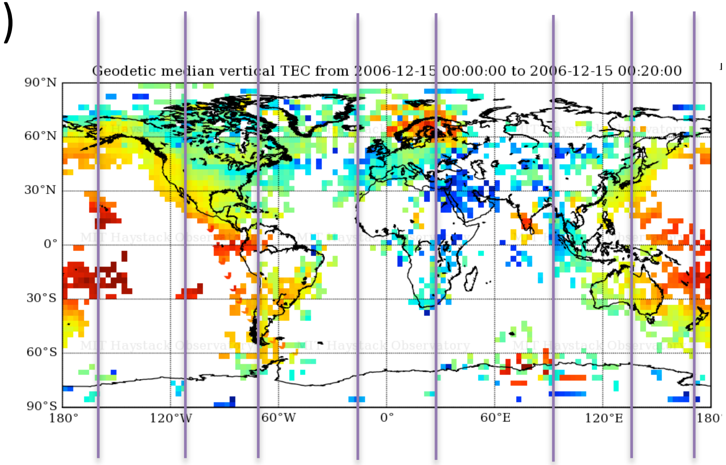
- Physical parameter :
  - global TEC, NmF2, and hmF2
  - Ne and Ti
  - Tn

- # Observations:

  - global (eight 5° geographic longitude sectors)
    - GPS TEC (provided by MIT and JPL)
    - COSMIC NmF2 and hmF2 (USU)

    data bin : 5° lat × 5° lon × 15 min

    (36 latitude bins of 5° each from -90 to +90)



  - neutral temperature (Tn) at 250 km
    obtained by Fabry-Perot Spectrometer
    : Resolute Bay, Canada (74.4° N, 94.5° W; 82.49° N)

  - electron density (Ne) and ion temperature (Ti) at 300 km
    obtained by ISRs
    : Millstone Hill (42.62° N, 71.49° W; 52.30° N),
    Sondrestrom (66.99° N, 50.95° W; 75.61° N)

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

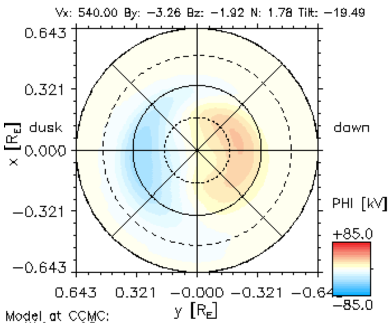
*Runs performed at the CCMC

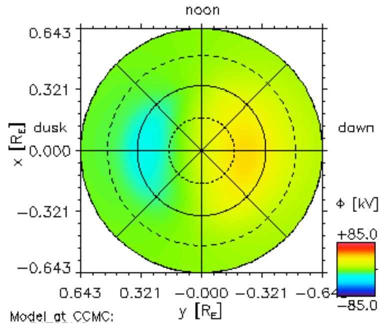
Blue : Weimer, Red: AMIE, Green: SWMF, Magenta: FAC

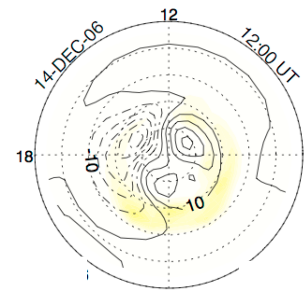
Electric Potential (northern hemisphere)

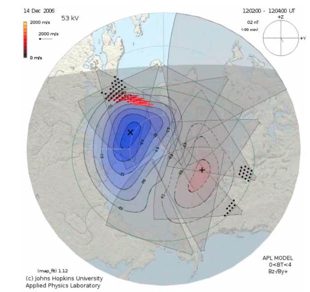
Weimer05 | SWMF | AMIE | superDARN

12/14 12:00



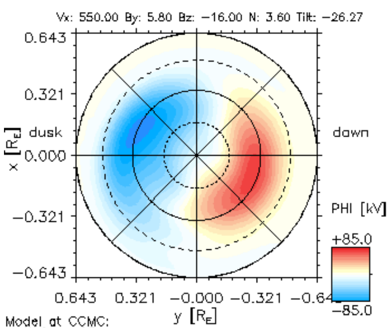


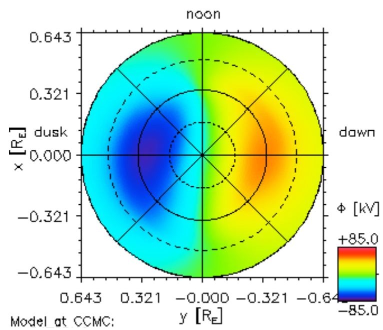


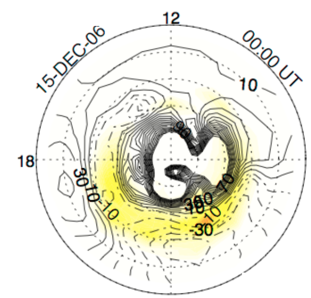


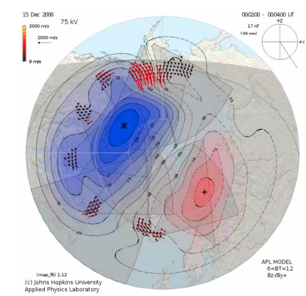
Min: -38.5 Max: 32.2 | Min: -20.9 Max: 41.1 | Min:-56 Max:44 | CPCP:53

12/15 00:00



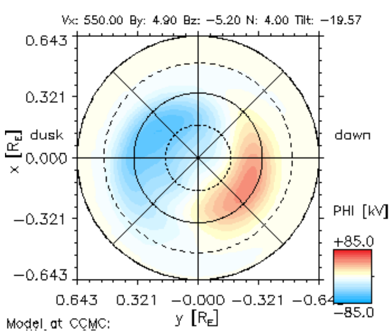


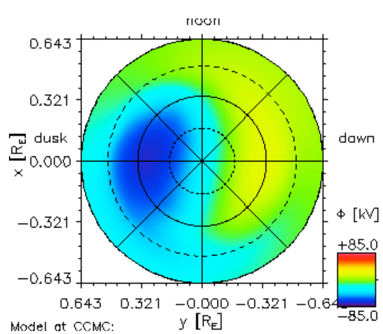


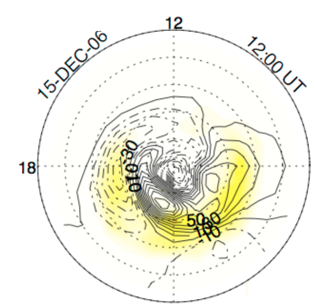


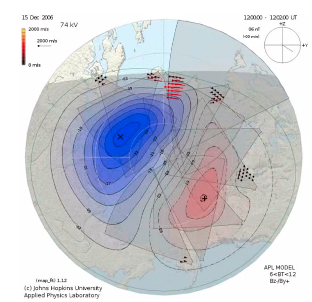
Min: -89.1 Max: 75.9 | Min: -73.9 Max: 53.0 | Min:-80 Max:454 | CPCP:75

12/15 12:00





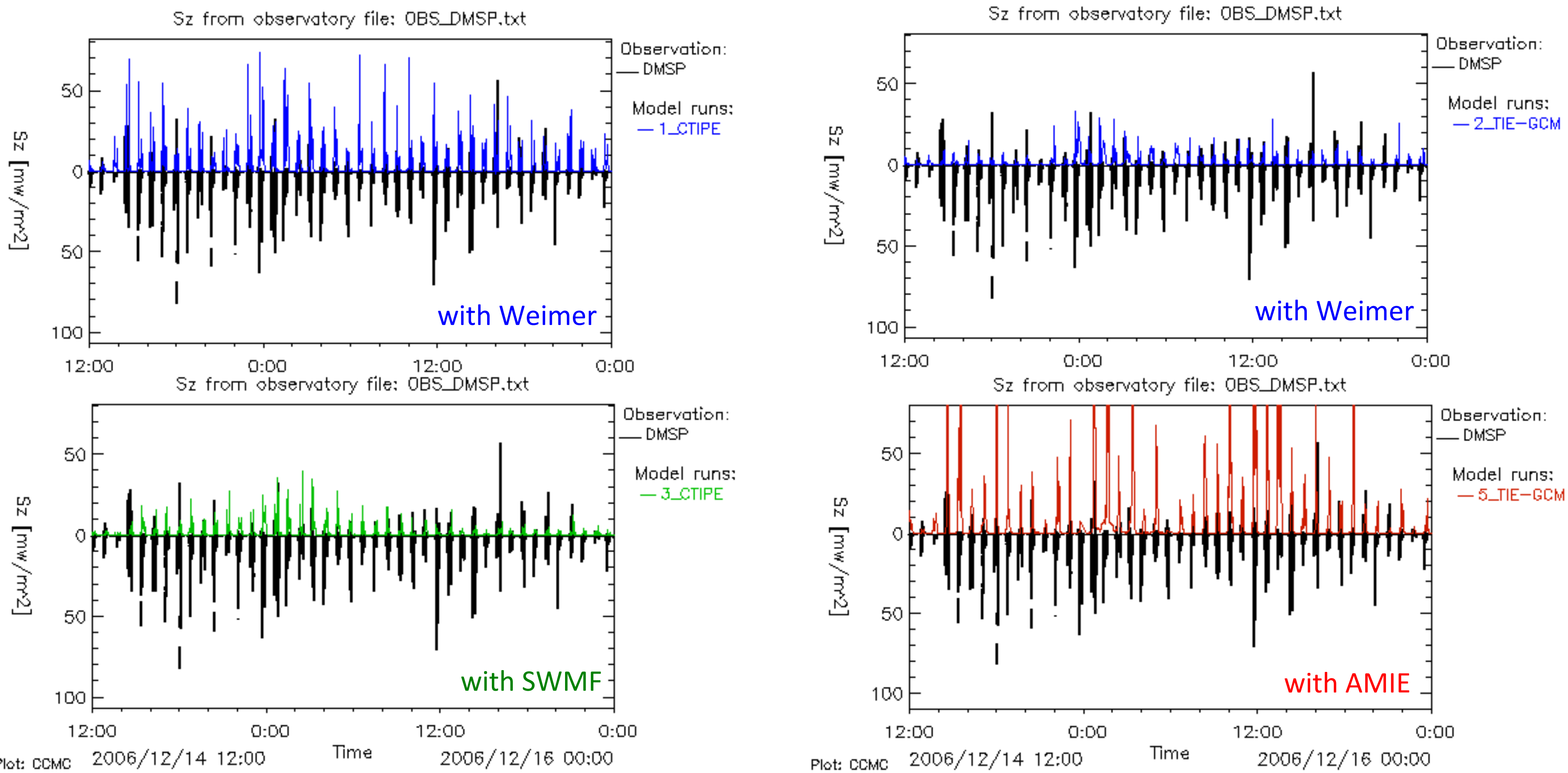




Min: -61.9 Max: 51.5 | Min: -71.1 Max: 21.7 | Min:-85 Max:110 | CPCP:74

Joule Heating along DMSP tracks

CTIPe TIE-GCM



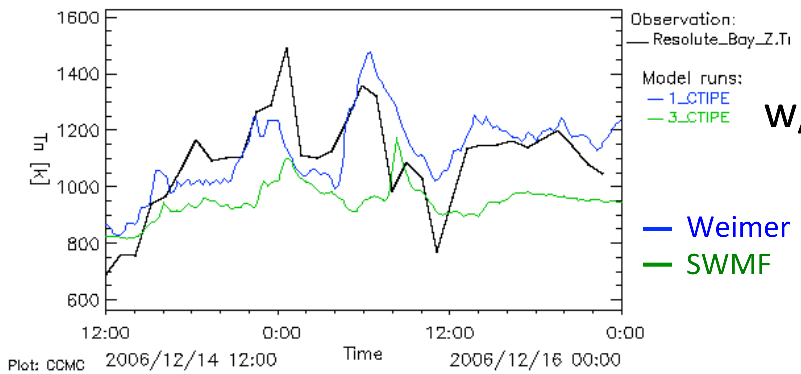
- 3_CTIPE(Weimer) < 1_CTIPE(SWMF)
- 5_TIE-GCM(AMIE) >> 2_TIE-GCM(Weimer)

Tn at 250 km in high latitude (Resolute Bay)

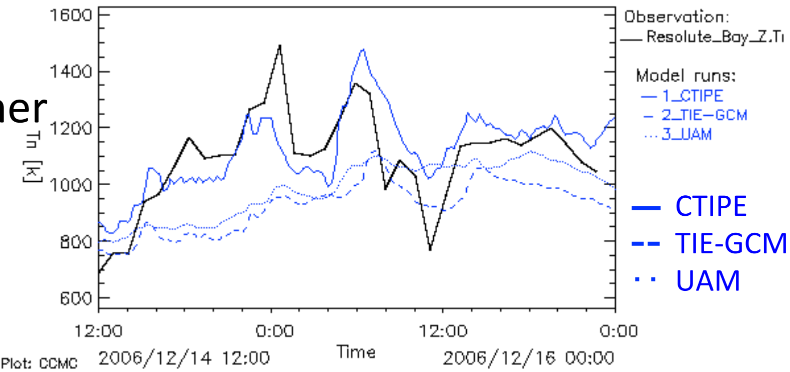
same model with different drivers

same driver used in different models

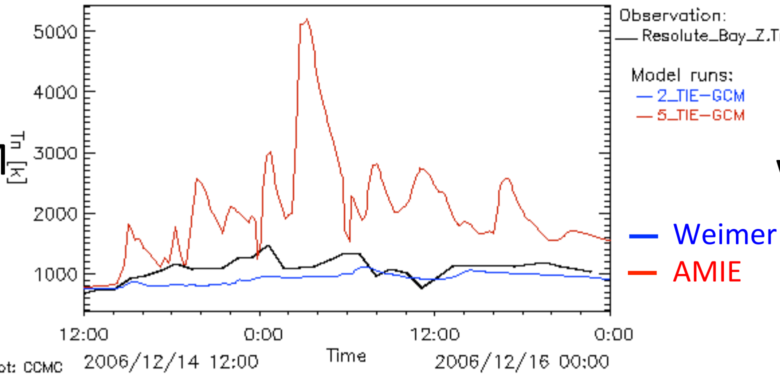
CTIPe



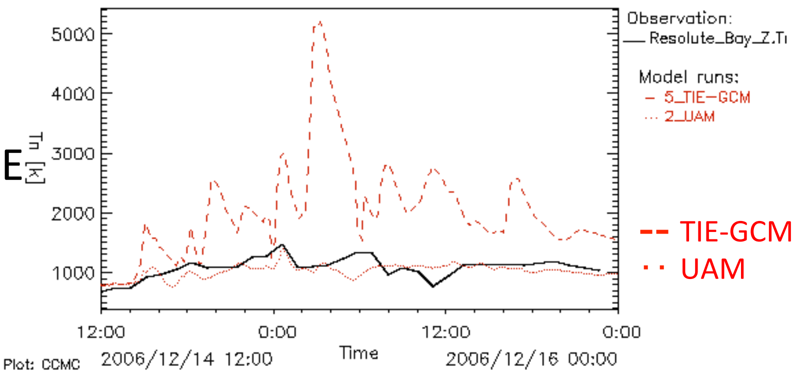
w/ Weimer



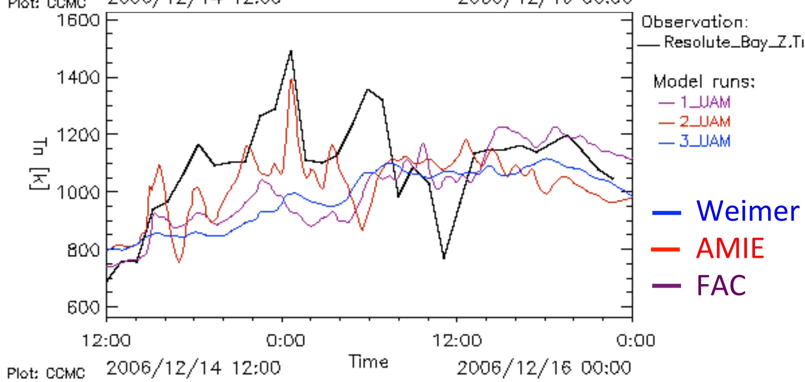
TIE-GCM



w/ AMIE



UAM

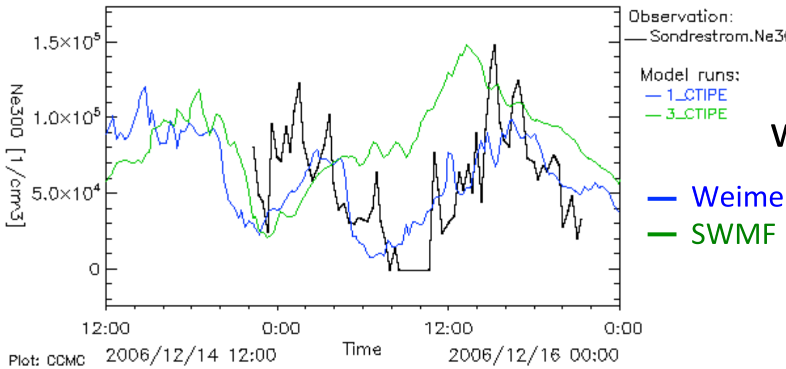


- 3_CTIPE(Weimer) < 1_CTIPE(SWMF) ~ observations
- 2_TIE-GCM(Weimer) << 5_TIE-GCM(AMIE)
- 2_UAM(AMIE) > 1_UAM(FAC), 3_UAM(Weimer)
- 5_TIE-GCM(AMIE): largest difference between modeled and observed Tn at 250 km

Ne at 300 km in high latitude (Sondrestrom)

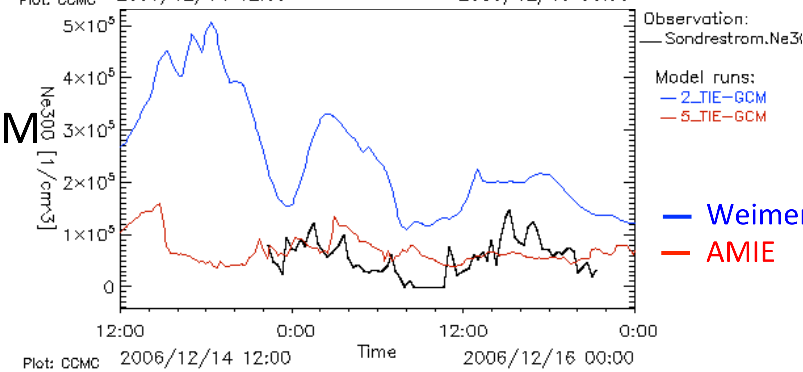
same model with different drivers

CTIPe



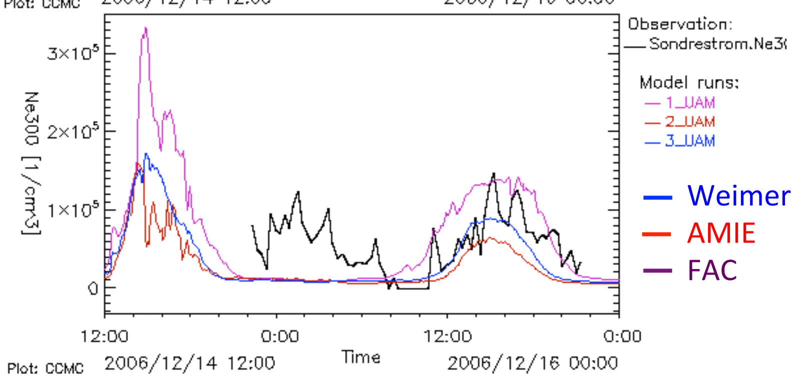
Weimer
SWMF

TIE-GCM



Weimer
AMIE

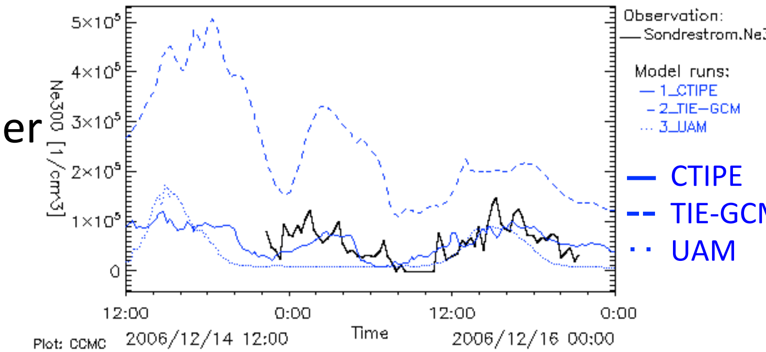
UAM



Weimer
AMIE
FAC

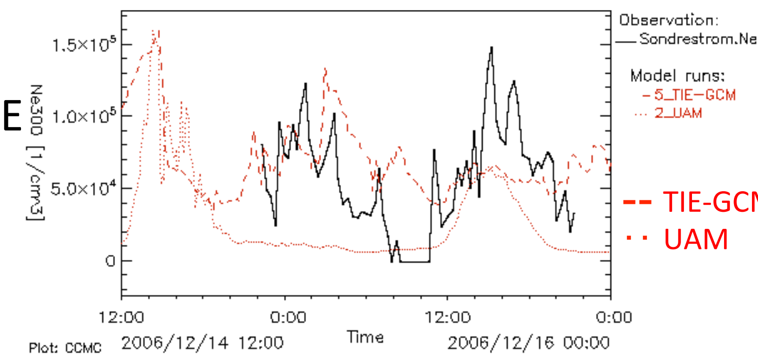
same driver used in different models

w/ Weimer



CTIPE
TIE-GCM
UAM

w/ AMIE



TIE-GCM
UAM

- 1_CTIPE(Weimer) < 3_CTIPE(SWMF) during storm main phase
- 2_TIE-GCM(Weimer) > 5_TIE-GCM(AMIE)
- 1_UAM(FAC) > 3_UAM(Weimer) ~ 2_UAM(AMIE)

RMS in predicting Ti, Tn, Ne and Joule Heating

JH along DMSP tracks

Ti at 300 km height

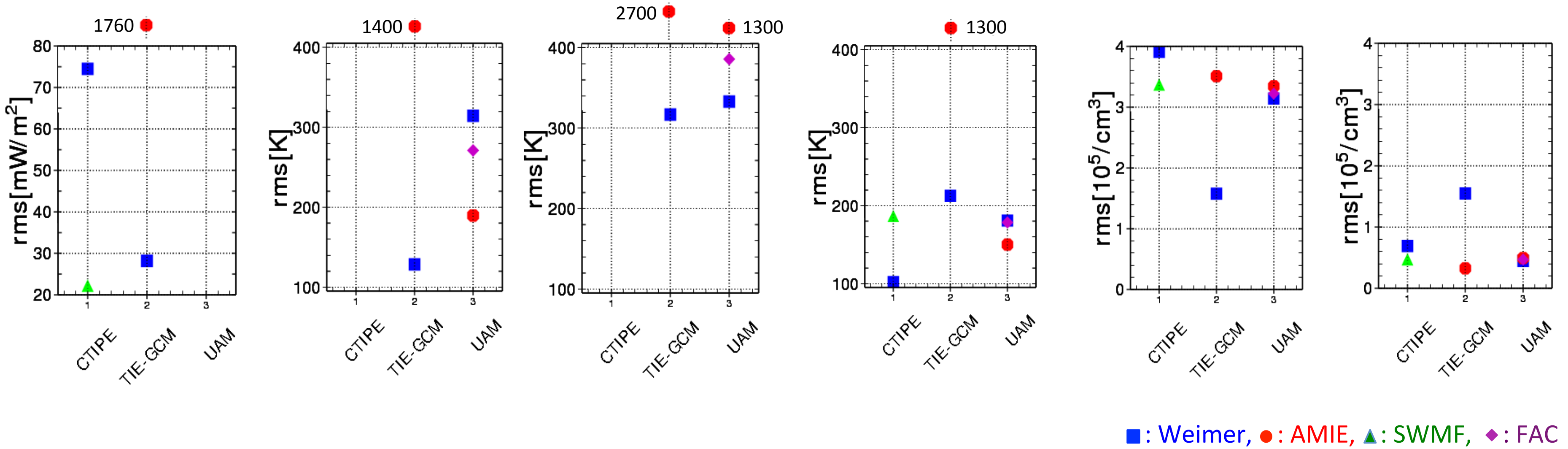
middle (Millstone Hill) high (Sondrestrom)

Tn at 250 km height

high (Resolute Bay)

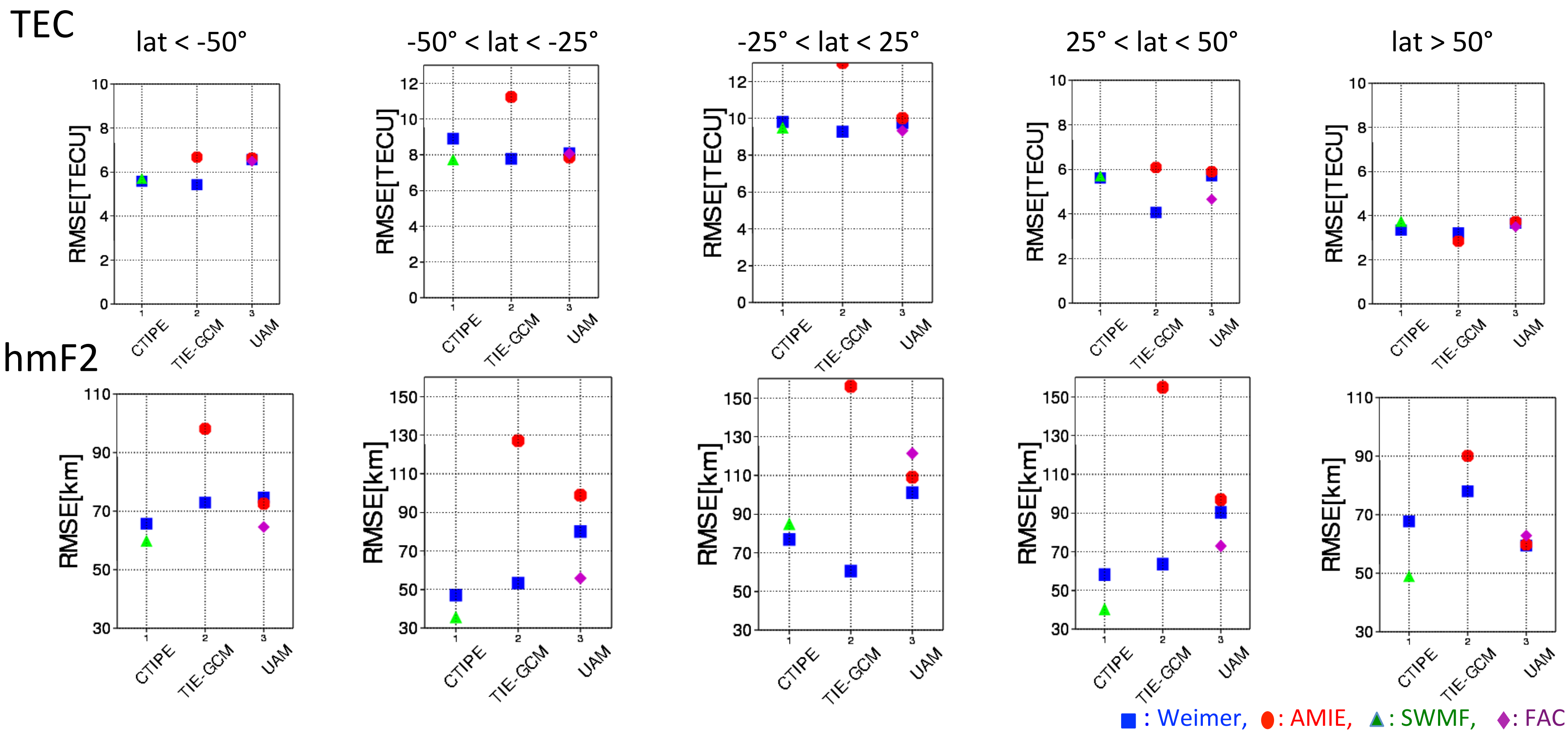
Ne at 300 km height

middle (Millstone Hill) high (Sondrestrom)



- 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.
- 2_TIE-GCM(Weimer) is better than 5_TIE-GCM(AMIE) for all cases (Ti, Tn and Ne) except for Ne in high latitude.
- 2_UAM(AMIE) 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 5_TIEGCM(AMIE) for Ne in high latitudes.

RMS in predicting TEC and hmF2



- 3_CTIPE(SWMF) and 1_CTIPE(Weimer) show similar RMS errors in predicting TEC, while 3_CTIPE(SWMF) has smaller RMS errors in predicting hmF2 than 1_CTIPE(Weimer) except for low latitudes.
- 2_TIE-GCM(Weimer) is better than 5_TIE-GCM(AMIE) for all cases except for TEC in northern high 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 TEC cases, 2_TIE-GCM(Weimer) is the best, while 5_TIE-GCM(AMIE) is the best in northern 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.
  - CPCP : AMIE > Weimer05 > SWMF

- Effect of drivers on IT parameters varies with models:
  - for Tn at 250 km height in high latitudes (Resolute Bay)

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

    2_UAM(AMIE) ~ 1_UAM(FAC) ~ 3_U AM(Weimer)
  - for TEC

    5_TIE-GCM(AMIE) << 2_TIE-GCM(Weimer),

    2_UAM(AMIE) ~ 3_UAM(Weimer) > 1_UAM(FAC)

- Sensitivity of models to drivers varies with parameters:
  - Differences between Tn values at 250 km height in high latitudes from 2_UAM(AMIE) 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.
  - 5_TIEGCM(AMIE) is 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.

- Ensemble run using various global MHD models

- More events