GEM 2014

Initial results of storm-time IT responses using OpenGGCM-CTIM global magnetosphere-ionosphere-thermosphere coupling model

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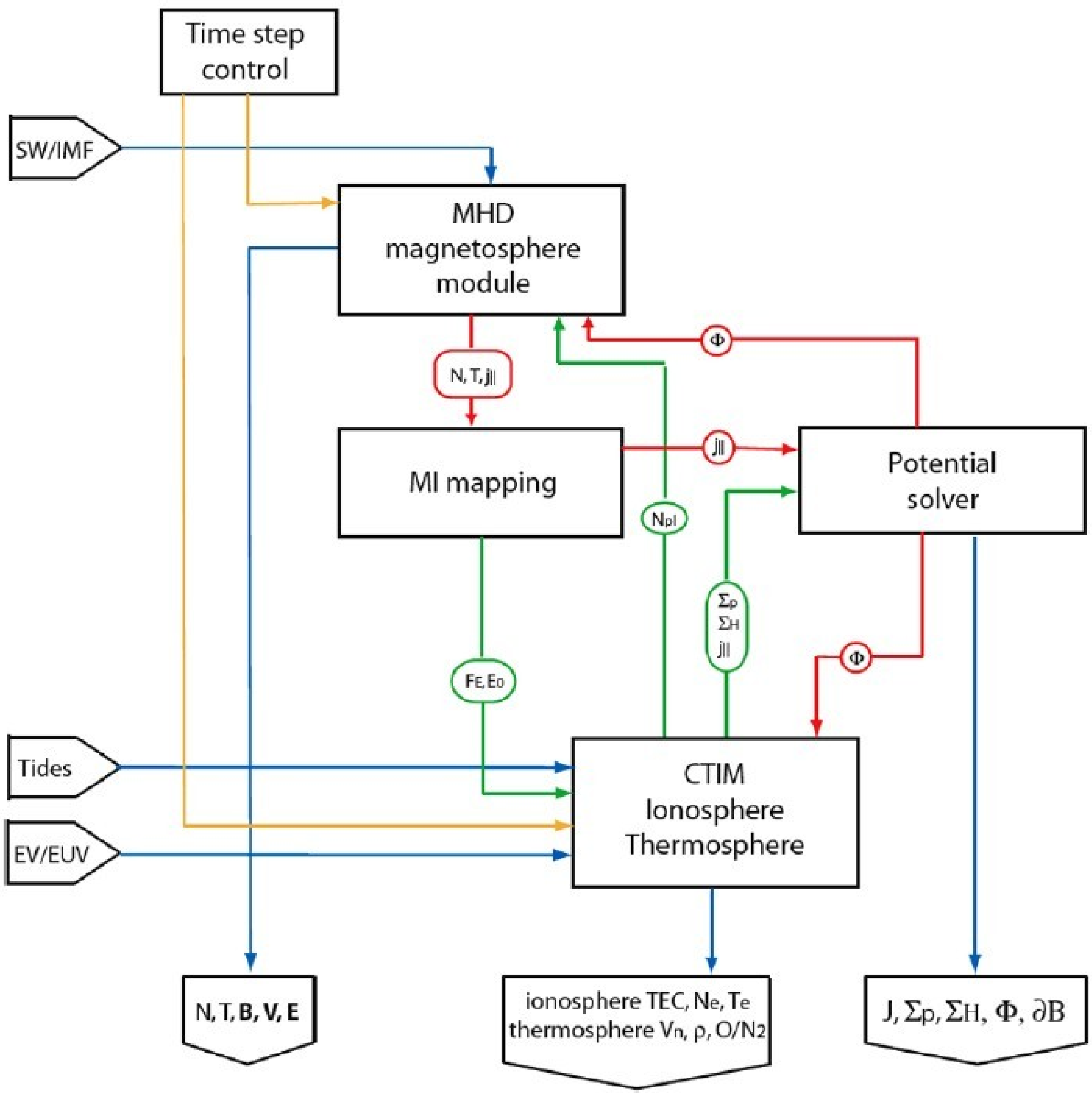
Purpose of this study

1. Test the OpenGGCM-CTIM coupling model
2. Understand the importance of magnetospheric energy input to predict storm-time IT system.

Model 1: OpenGGCM-CTIM



Two-way coupled magnetosphere-ionosphere-thermosphere model.

Current conservation

$$\nabla \cdot \underline{\Sigma} \cdot \nabla \Phi = -J_{||} \sin I$$

OpenGGCM calculates the magnetosphere part by solving resistive MHD equations with solar wind input.

CTIM calculates the ionosphere and thermosphere by solving both neutral and ion fluid equations self-Consistently.

OpenGGCM coupled with CTIM provides realistic ionospheric potential patterns because the CTIM calculates the ionospheric conductance more accurately.

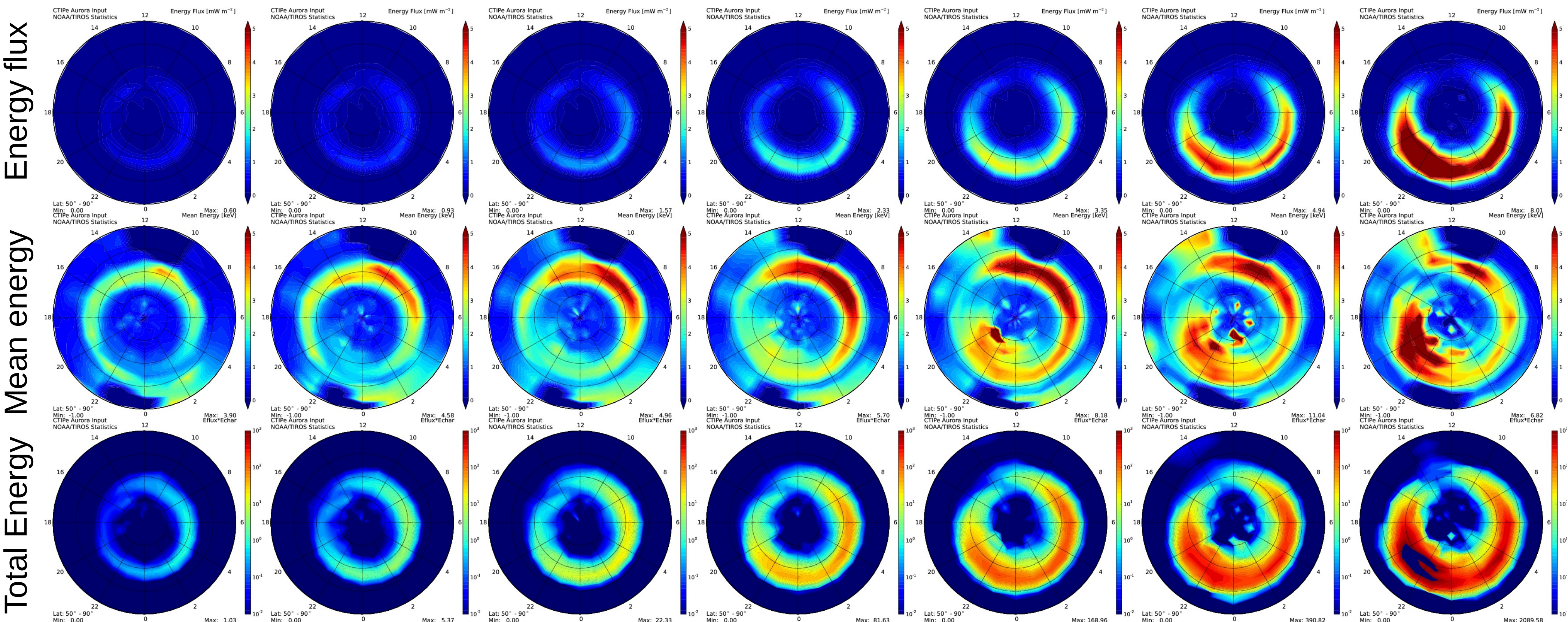
Model 2: CTIPe

- The latest version of CTIM.
- Dynamics of a low- and mid- latitude ionosphere, a plasmasphere, and global dynamo electric fields are added to this version.
- Magnetospheric energy input:

    Electric field from Weimer 2005

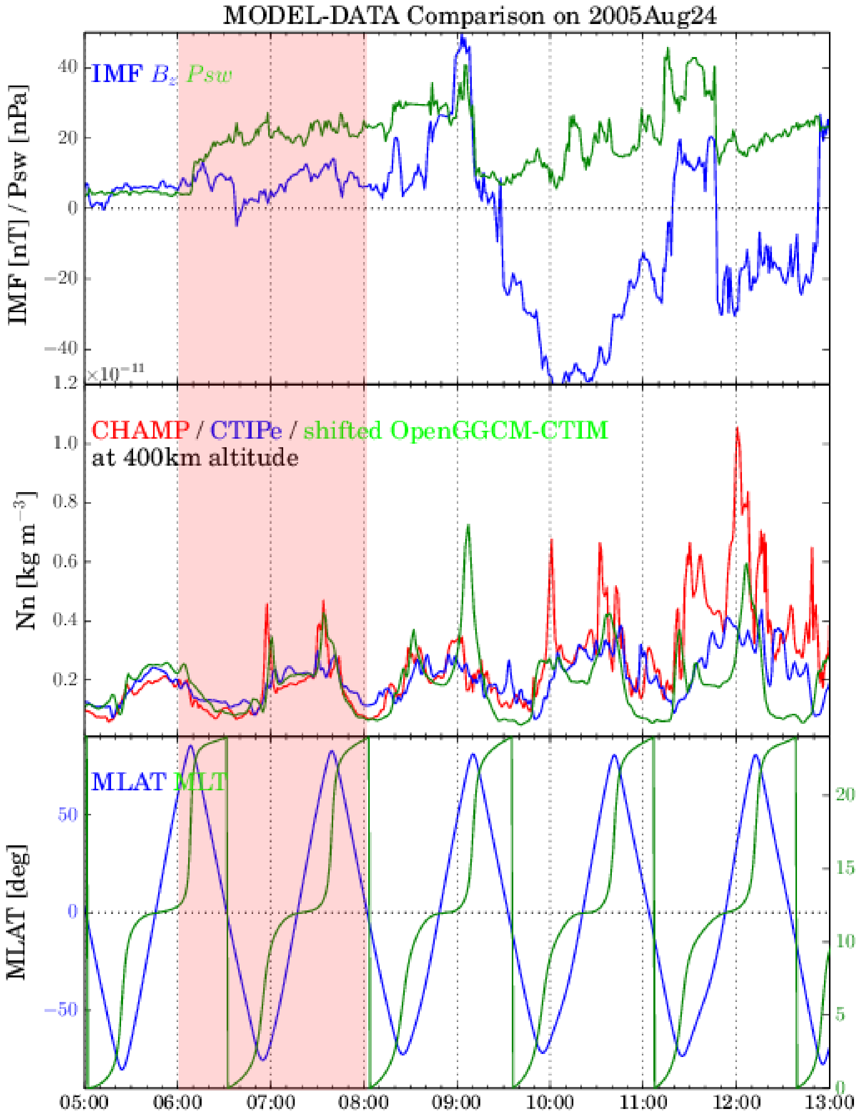
    Auroral precipitation from NOAA/TIROS Statistics

Aurora activity level : low ──────► high

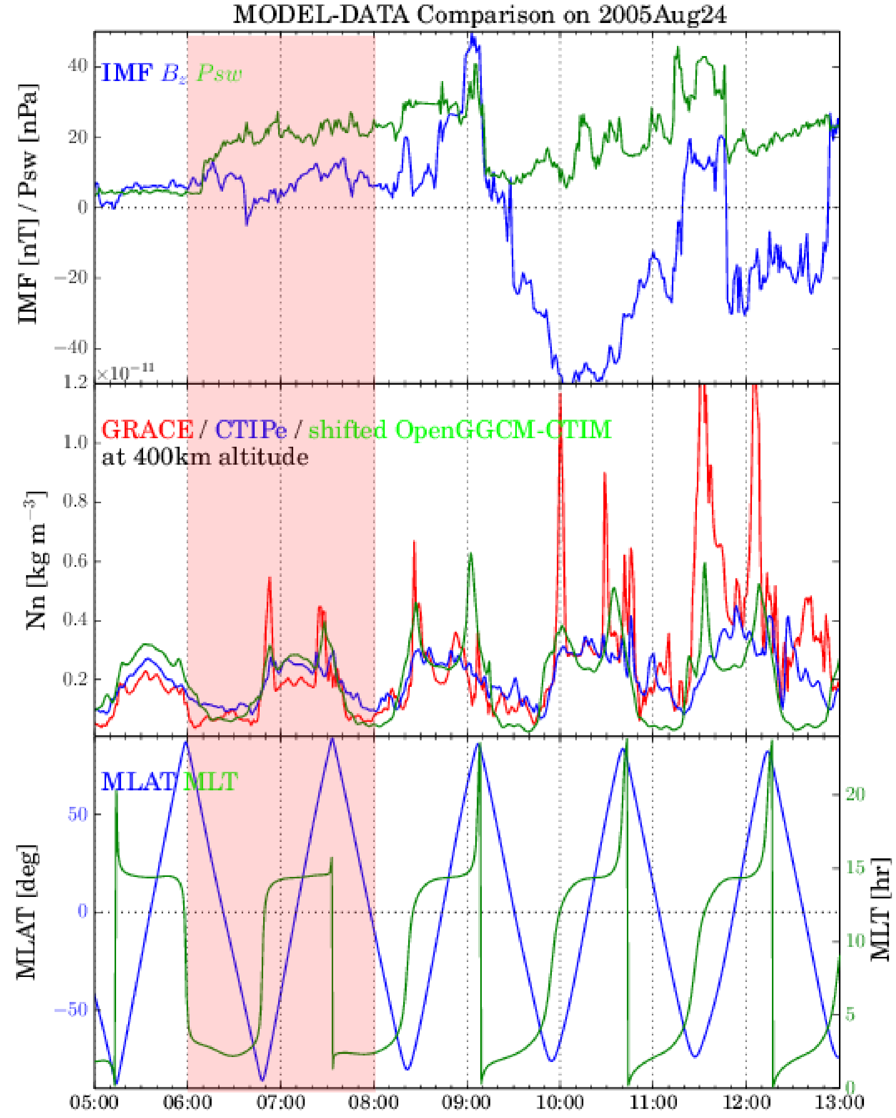


2005-08-24 CME STORM

Comparison with CHAMP data

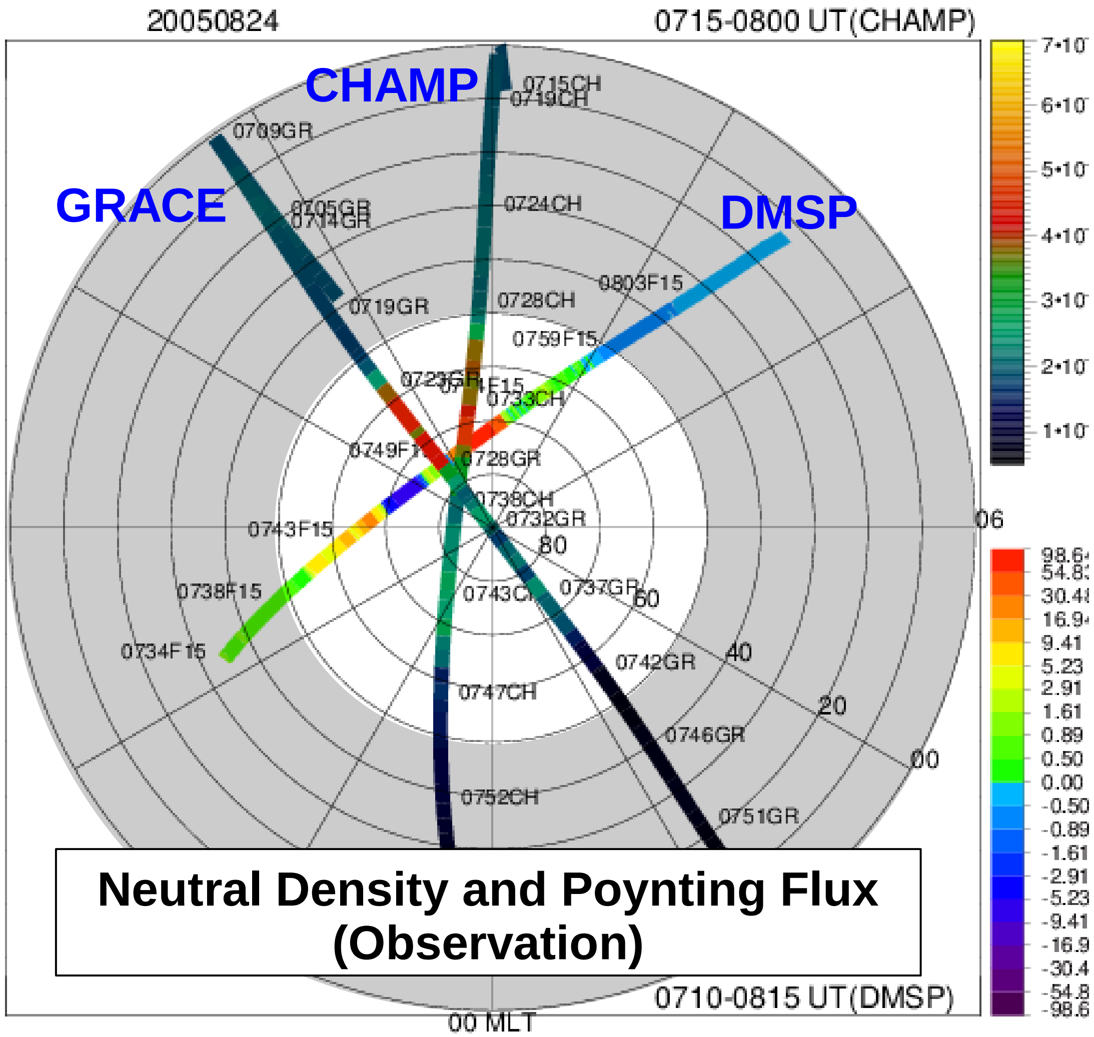


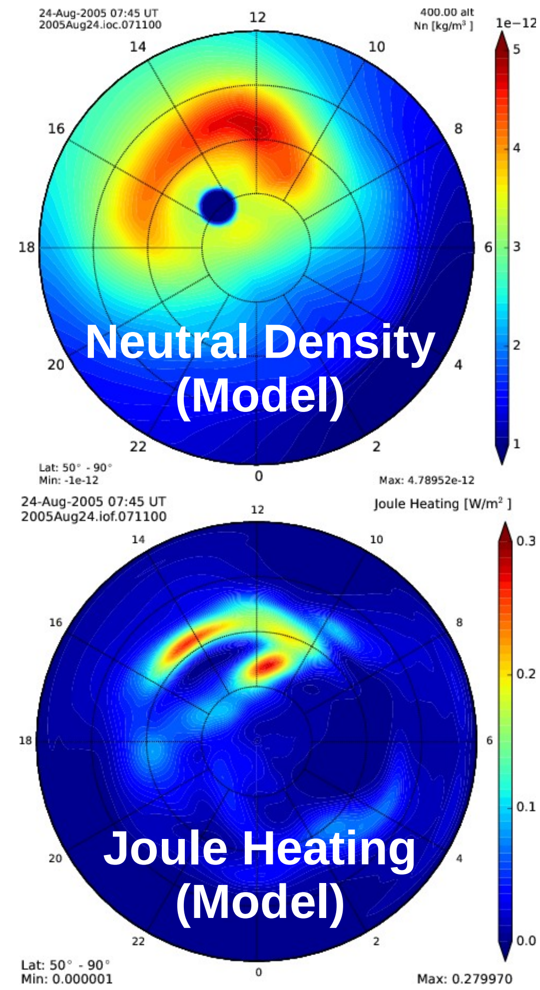
Comparison with GRACE data



OpenGGCM-CTIM shows enhancement of high-latitude neutral density during the strong Psw period and the early storm phase.

MODEL-DATA comparison





Observations from CHAMP, GRACE, and DMSP match with the model calculation of neutral density and Joule heating.

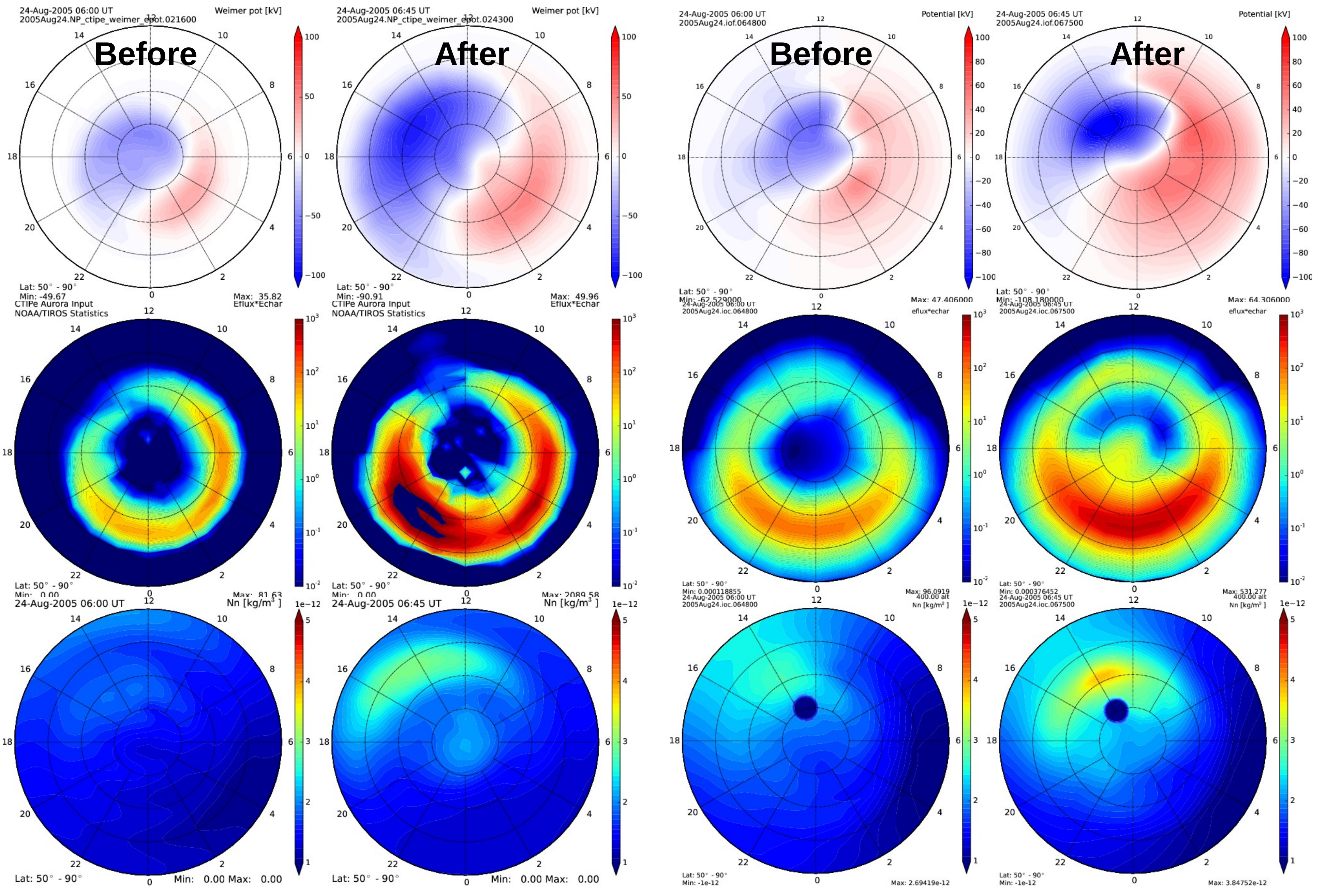
Model-Model comparison of Psw impact

CTIPe | **OpenGGCM-CTIM**

Electric potential

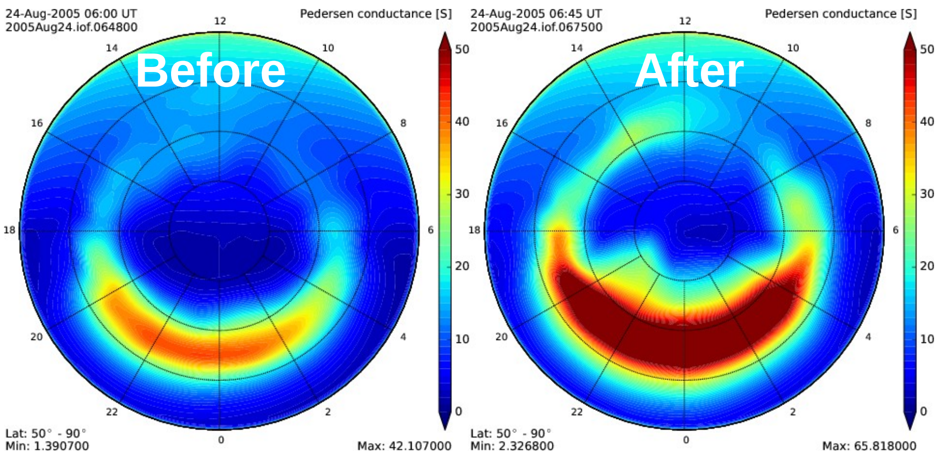
Aurora power

Neutral Density

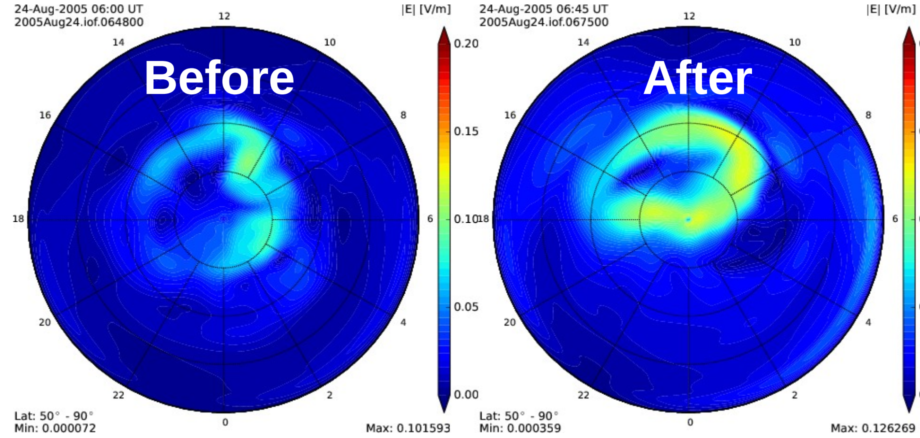


Thermosphere Heating after P_{sw} impact

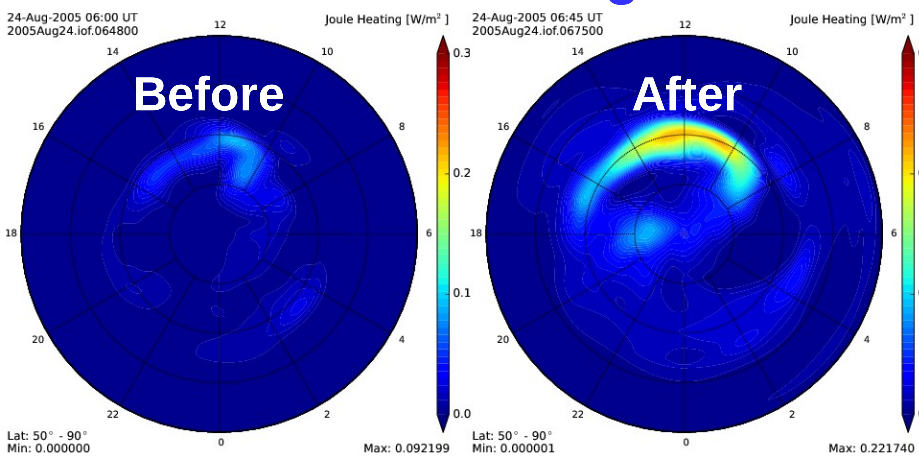
Pederson Conductivity



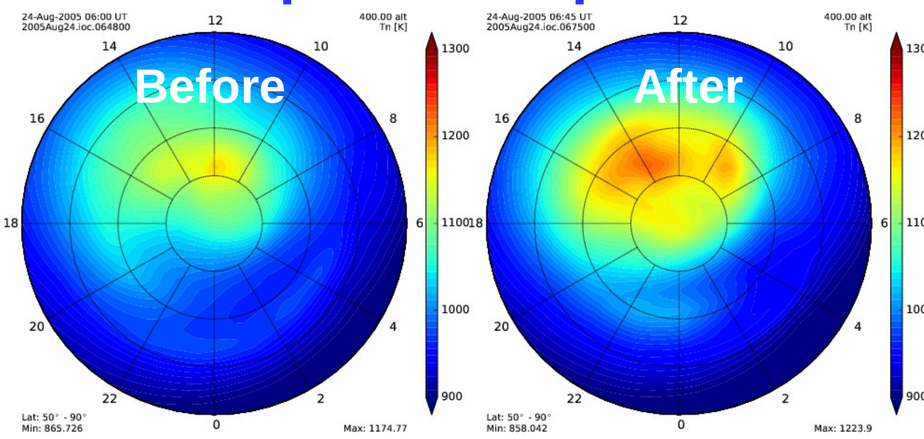
Total Electric Field



Joule Heating



Thermosphere Temperature



Enhanced electric field and Pederson conductivity heat the dayside thermosphere, initiating upwelling of neutrals and increasing neutral density of this region.

SUMMARY

- We simulate a geomagnetic storm on Aug 24, 2005 using OpenGGCM-CTIM in order to test storm-time IT responses.
- OpenGGCM-CTIM reproduces high-latitude neutral density peaks, showing a good agreement with CHAMP and GRACE observations.
- Both electric field and aurora precipitation increases during the compression period, heating thermosphere via joule heating and initiating neutral upwelling. This leads to neutral density enhancement at high latitude.

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OpenGGCM-CTIM

- Two-way coupled magnetosphere-ionosphere-thermosphere model.

- OpenGGCM calculates magnetosphere and planar ionosphere by solving resistive MHD equations with solar wind and IMF input.

- CTIM calculates global thermosphere and high-latitude ionosphere three-dimensionally by solving neutral and ion fluid equations.

- OpenGGCM-CTIM magnetospheric energy input

  - Electric potential from current conservation:

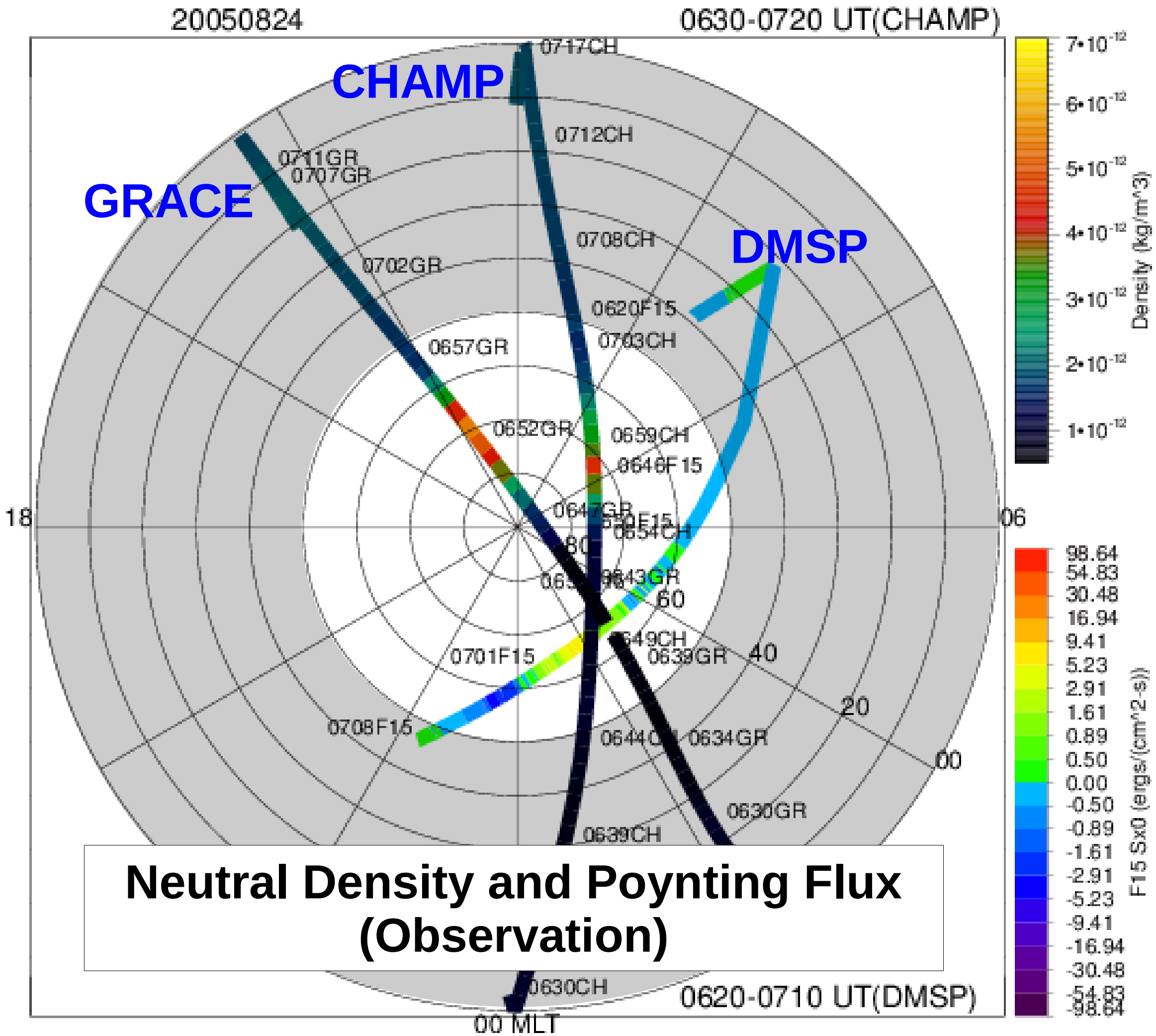
$$\nabla \bullet \underline{\underline{\Sigma}} \bullet \nabla \Phi = -J_{||} \sin I$$

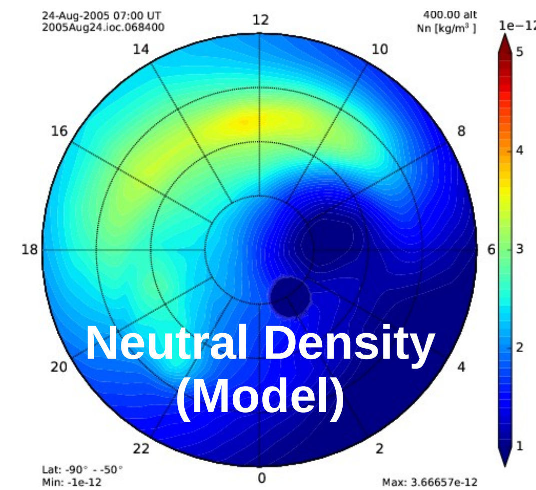
  - Aurora precipitation

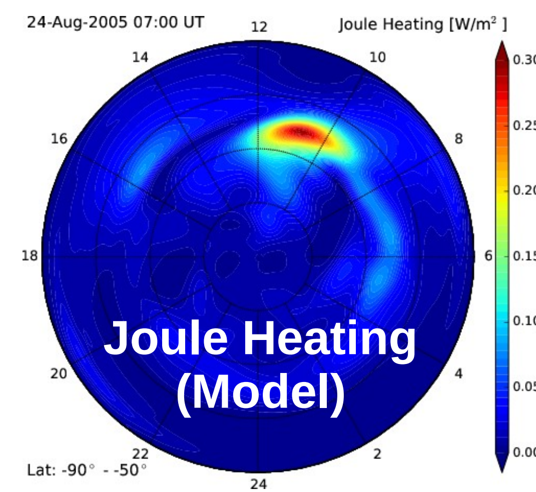
    Diffuse aurora : $F_E = n_e \, (kT_e/2\pi m_e)^{0.5}$, $E_0 = kT_e$

    Discrete aurora : $F_E = \Delta\Phi_{||} \, J_{||}$, $E_0 = e \, \Delta\Phi_{||}$

Model-DATA comparison







OpenGGCM-CTIM and satellite observations show a good agreement of high neutral density regions.