Exercises: Storm-time IT Reponses using CTIPe runs with artificial conditions

Runs with artificial conditions

Run Number	Key Words	Model	Model Version	Event Date	DoY at Start
Equinox_storm_011216_IT_1	SSW16, with artificial conditions for storm time, equinox	CTIPe	2.0	March 21, 2010	80
Equinox_quiet_011216_IT_1	SSW16, with artificial conditions for quiet time, equinox	CTIPe	2.0	March 21, 2010	80

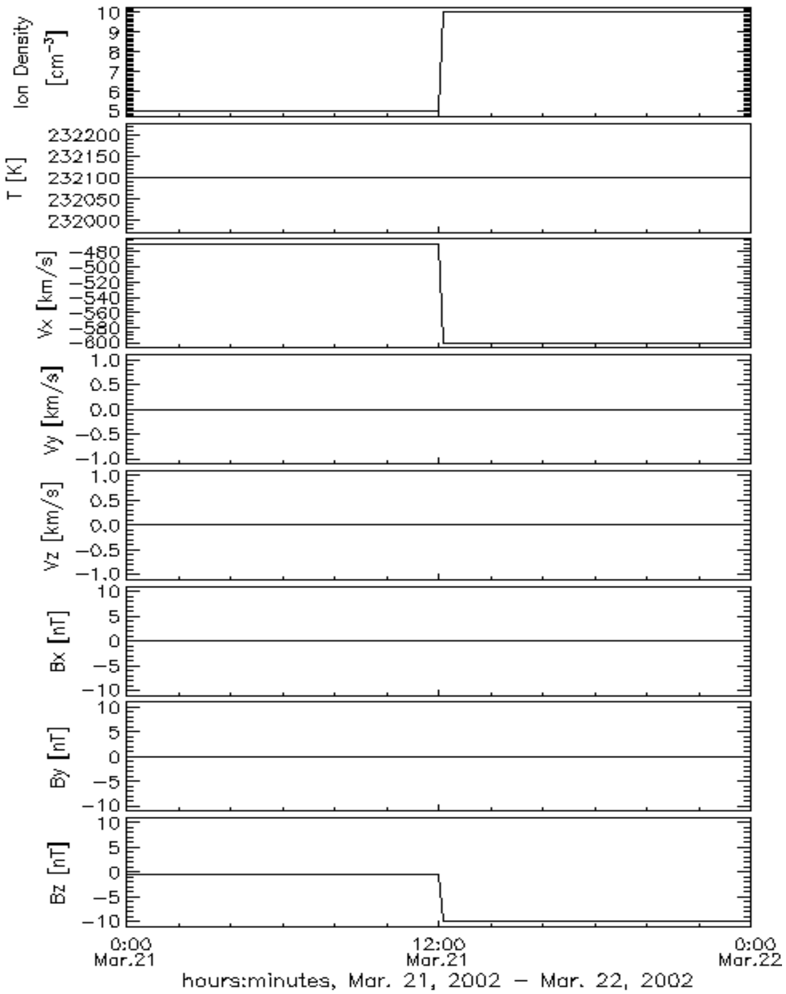
- **Thermosphere/Ionosphere Lab** (Tim Fuller Rowell, NOAA): http://ccmc.gsfc.nasa.gov/support/ILWS/TUTORIALS/Fuller-Rowell_Helio_Lab2010.pdf

CTIPe Model

Coupled Thermosphere Ionosphere Plasmasphere Electrodynamics Model:

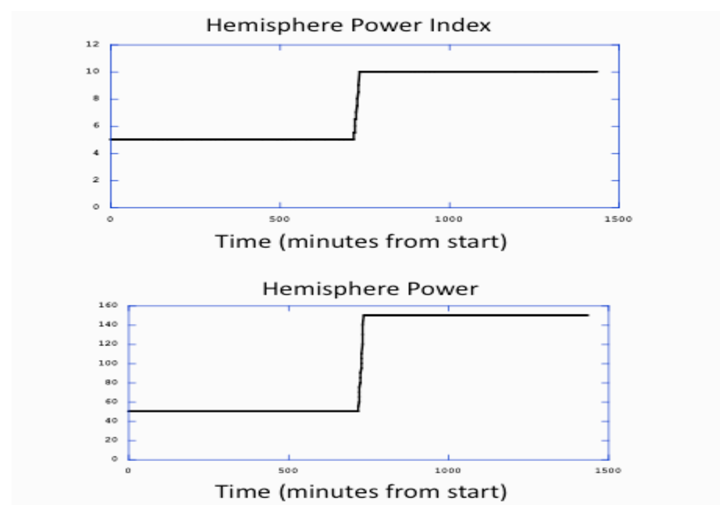
- Forcing: solar UV and EUV, Weimer electric field, TIROS/NOAA auroral precipitation, tidal forcing
- Example model output parameters on pressure levels
  - plasma density N_e [m^{-3}], TEC [TECU]
  - neutral wind [m/s] (meridional Vn_lat positive south, zonal Vn_lon positive east, vertical Vn_IP positive up),
  - temperature T_n [K],
  - mean molecular mass Rmt [amu], mass density rho [kg/m^3],
  - height of pressure level H [m]
  - Joule heating Pjoule [J/(kg s)], height-integrated Joule heating Wjoule [mW/ m^2]
  - rd(variable): change in variable = storm time – quiet time
- Approximate altitudes: pressure level 1 (80km, lower boundary), level 3 (90km), level 5 (103km), level 6 (110km), level 7 (120 km, E-region ionosphere), level 8 (135km), level 9 (160km), level 12 (300 km, F-region ionosphere)
- Model outputs also on height levels

Generic Magnetospheric Forcing



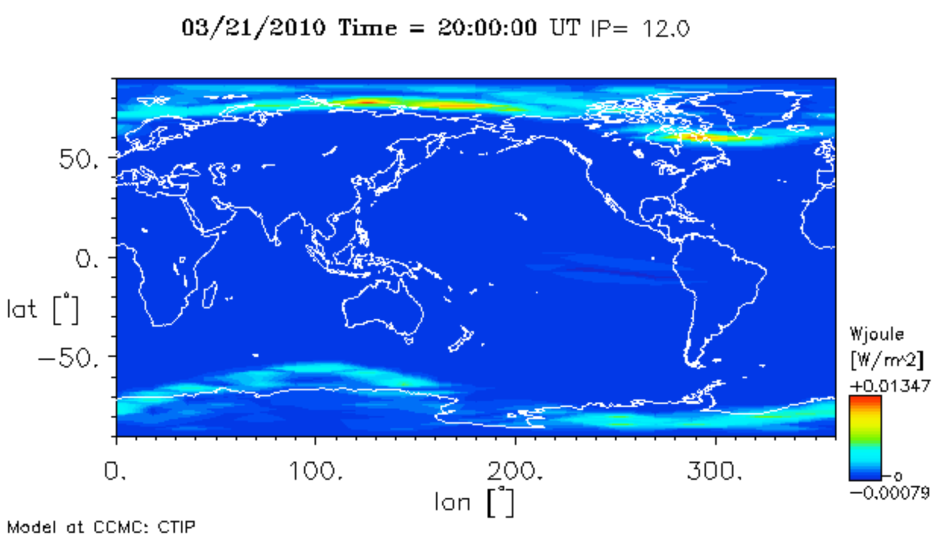
Generic equinox storm:

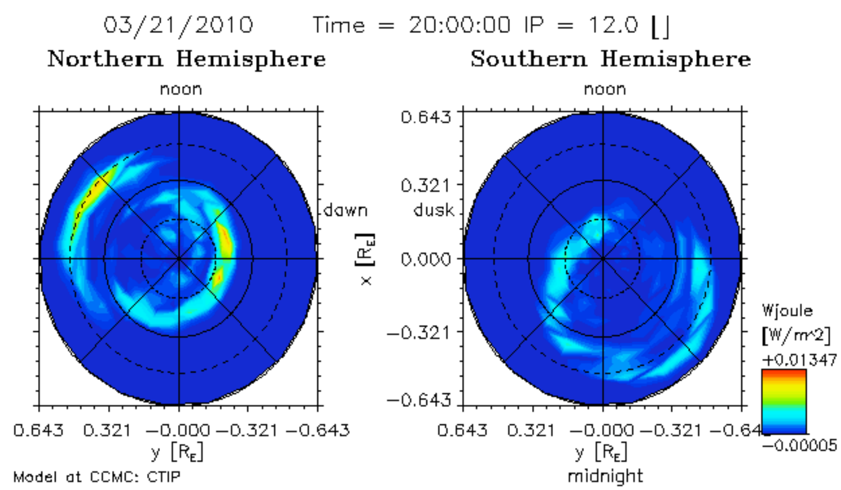
- 12 hr increase in magnetospheric sources (Bz= -10 nT, |Vx|= 600 km/s, n= 10/cm^3, HPI=10, HP=150 GW), Kp~8, and return to quiet levels (Bz= -0.42 nT, |Vx|= 470 km/s, n= 5/cm^3, HPI=5, HP=50) for recovery.
- Storm commence at 12UT on 03/21.
- Moderate solar activity F10.7~150.



Exercise 1: Magnetospheric Energy Deposition by Joule Heating

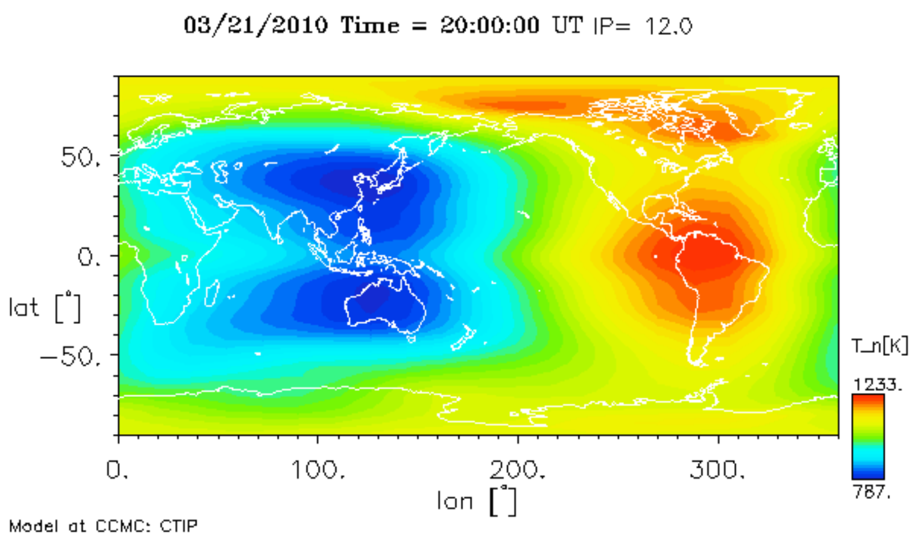
- Below is an example of magnetospheric energy deposition into ionosphere-thermosphere (IT) system from Joule Heating for a quiet time period (Bz= -0.42 nT, |Vx|= 470 km/s, n= 5/cm^3, HPI=5, HP=50). Use the CTIPe equinox simulation of a generic storm. Plot the height-integrated Joule heating (Wjoule) and Joule heating change (rdWjoule) across the globe or polar regions as in the example below. What is the typical peak magnitude of the magnetospheric energy deposition by Joule Heating during a storm? What is the typical percentage increase?

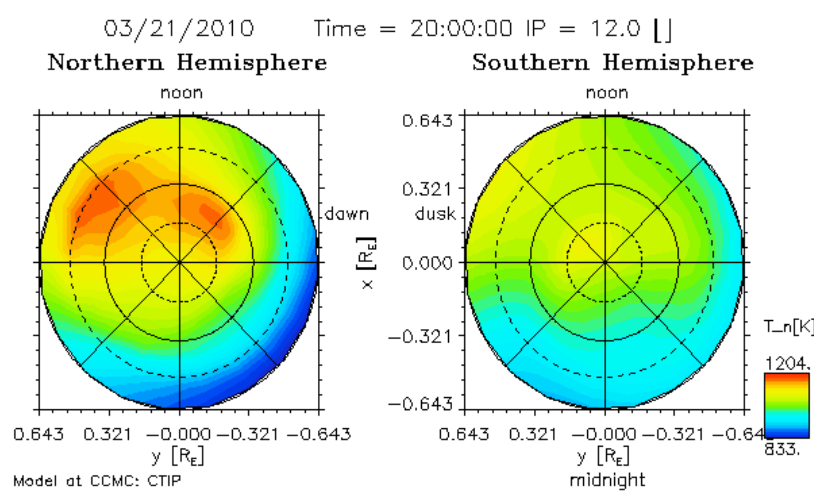




Exercise 2: Temperature Changes during Storms

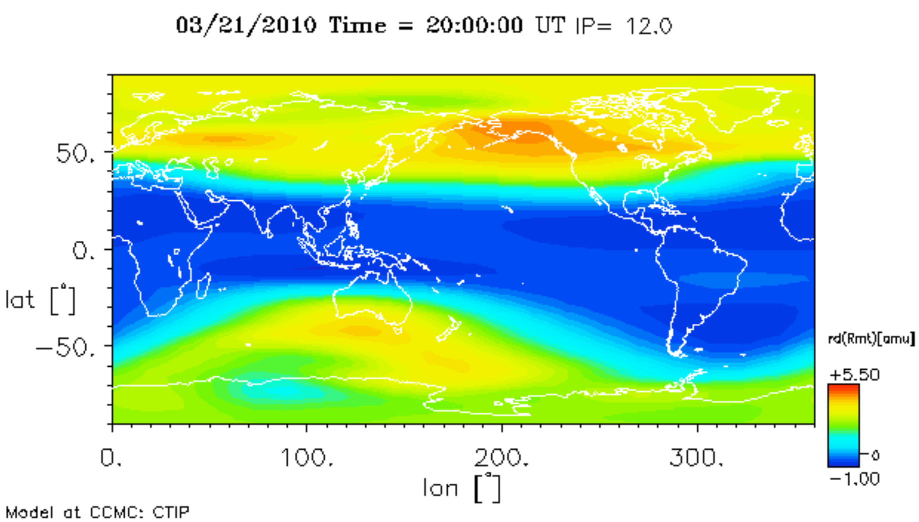
- The magnetospheric energy from Joule heating raises the temperature as well as the neutral density of the thermosphere. What is the typical peak temperature increase in the upper thermosphere during a geomagnetic storm (50K, 100K, 500K, 1000K.?). Plot the temperature change (rdT_n) on pressure level 12 across the globe 8 hours after storm onset using the equinox generic storm simulation and compare with the temperature before the storm, or quiet case, as in the example below. What is the typical percentage increase (5%, 10%, 50%, 100%?).

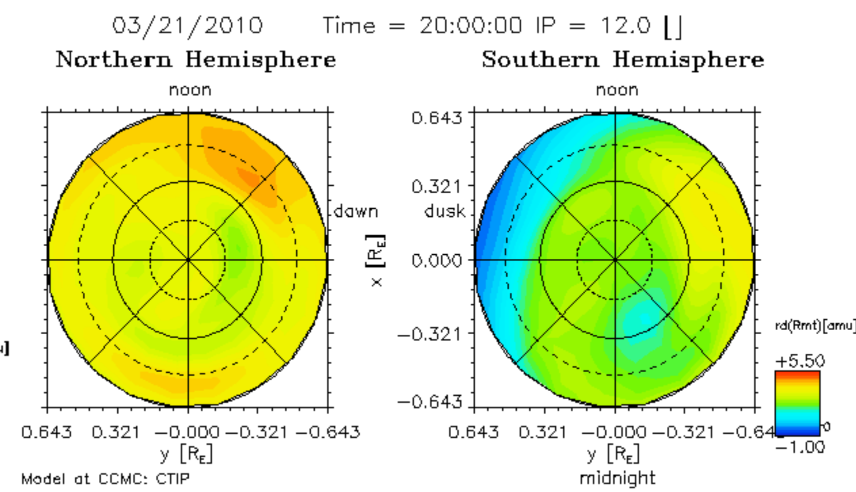




Exercise 3: Neutral Composition Response during Storms

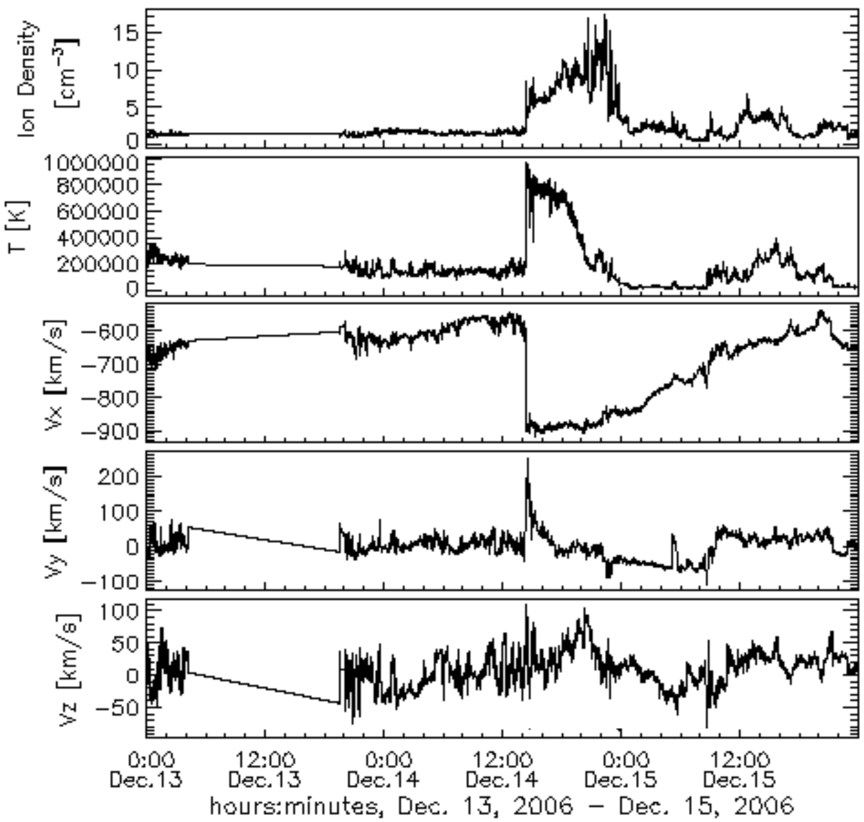
- Compare the neutral composition response (change in mean molecular mass, rd_Rmt) after 8 and12 hours in the equinox generic storm case at pressure level 12.
- Which neutral parameter at mid and high latitude has the strongest correlation with plasma density changes (temperature, mean mass composition, meridional winds, zonal winds)? Compare change in NmF2, rd(NmF2) or TEC (rdTEC) with changes in neutral parameters.

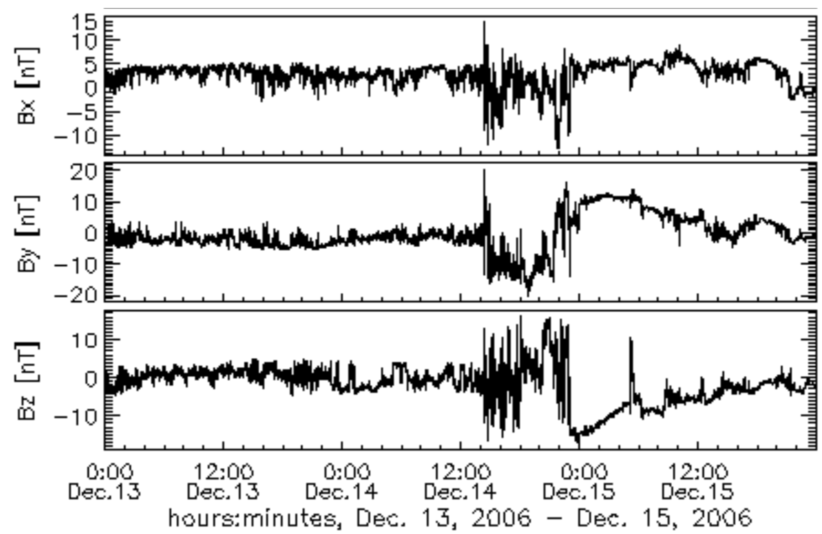




Exercise 4: 2006 AGU Storm event

- Use the "real" storm simulation (GEM_CEDAR_091815_IT_2), 2006 Dec event, to see if the same physical processes appear to be operating. Repeat Exercise 1-3 for 2006 Dec event. How easy is it to interpret simulation of real events rather than generic storms?





Solar wind plasma data and IMF data during 2006 Dec. event

Exercise 5: Effects of high latitude drivers on IT system

- Use the "real" storm simulations of CTIPe, GEM_CEDAR_091815_IT_2 (with Weimer2005 electric potential) and GEM_CEDAR_100215_IT_1 (with electric potential obtained from SWMF). Compare the height-integrated Joule heating (Wjoule) of the two simulations using "polar plot" as in the example below.
- Compare the IT parameters (temperature, neutral mass density, NmF2, TEC, and etc.) and changes in the parameters (rdTn, rd(rho), and etc) of the two simulations with different high-latitude electric potential models.