NRL SAMI3 IONOSPHERE/PLASMASPHRE MODEL: STATUS

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SAMI2/3 AT CCMC

- magnetic field: IGRF-like
- interhemispheric: low- to mid-latitude ($\pm 60^\circ$)
- Nonorthogonal, nonuniform fixed grid
- seven (7) ion species (all ions are equal):
  H^+, He^+, N^+, O^+, N_2^+, NO^+, and O_2^+
  - solve continuity and momentum for all 7 species
  - solve temperature for H^+, He^+, O^+, and e^-
- Plasma motion
  - $\mathbf{E} \times \mathbf{B}$ drift perpendicular to **B**
  - Ion inertia included parallel to **B**
- neutral species: NRLMSISE00 and HWM93
- chemistry: 21 reactions + recombination
- photoionization: Daytime (EUVAC) and nighttime

- ion continuity

$$\frac{\partial n_i}{\partial t} + \nabla \cdot (n_i \mathbf{V}_i) = P_i - L_i n_i$$

- ion velocity

$$\frac{\partial \mathbf{V}_i}{\partial t} + \mathbf{V}_i \cdot \nabla \mathbf{V}_i) = -\frac{1}{\rho_i} \nabla \mathbf{P}_i + \frac{e}{m_i} \mathbf{E} + \frac{e}{m_i c} \mathbf{V}_i \times \mathbf{B} + \mathbf{g}$$

$$-\nu_{in}(\mathbf{V}_i - \mathbf{V_n}) - \sum_j \nu_{ij} \left(\mathbf{V}_i - \mathbf{V}_j\right)$$

- ion temperature

$$\frac{\partial T_i}{\partial t} + \mathbf{V}_i \cdot \nabla T_i + \frac{2}{3} T_i \nabla \cdot \mathbf{V}_i + \frac{2}{3} \frac{1}{n_i k} \nabla \cdot \mathbf{Q}_i = Q_{in} + Q_{ij} + Q_{ie}$$

- electron momentum

$$0 = -\frac{1}{n_e m_e} b_s \frac{\partial P_e}{\partial s} - \frac{e}{m_e} E_s$$

- electron temperature

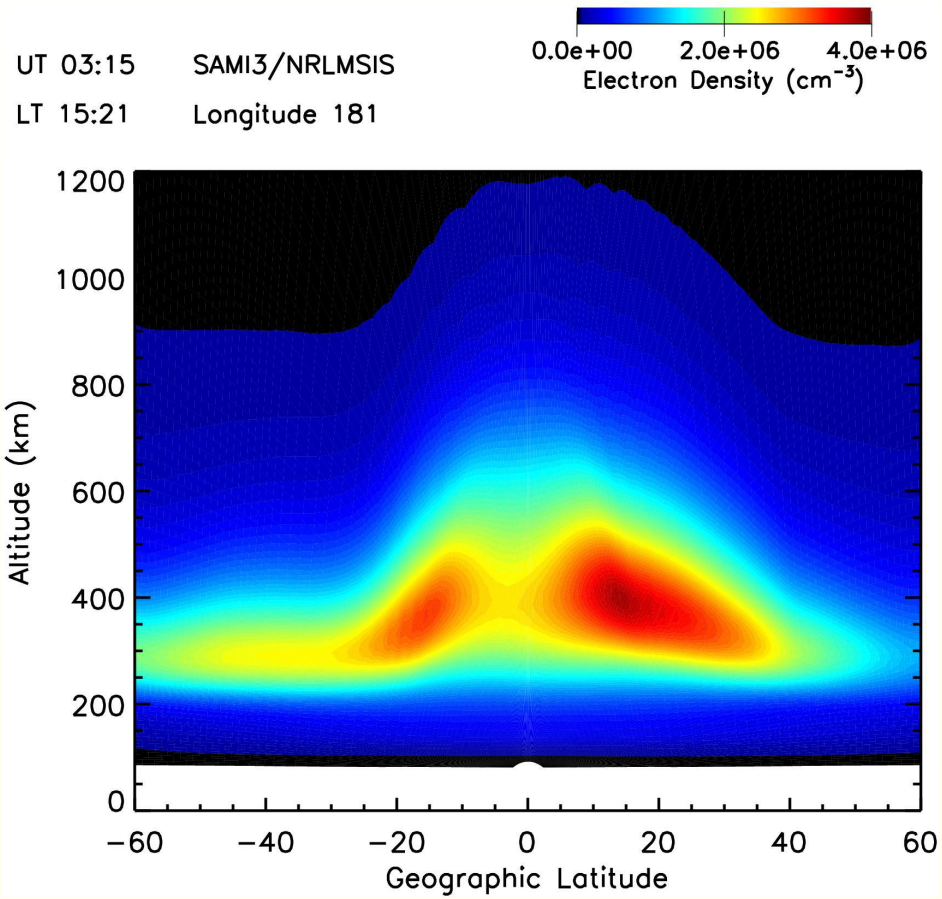
$$\frac{\partial T_e}{\partial t} - \frac{2}{3}\frac{1}{n_e k} b_s^2 \frac{\partial}{\partial s} \kappa_e \frac{\partial T_e}{\partial s} = Q_{en} + Q_{ei} + Q_{phe}$$

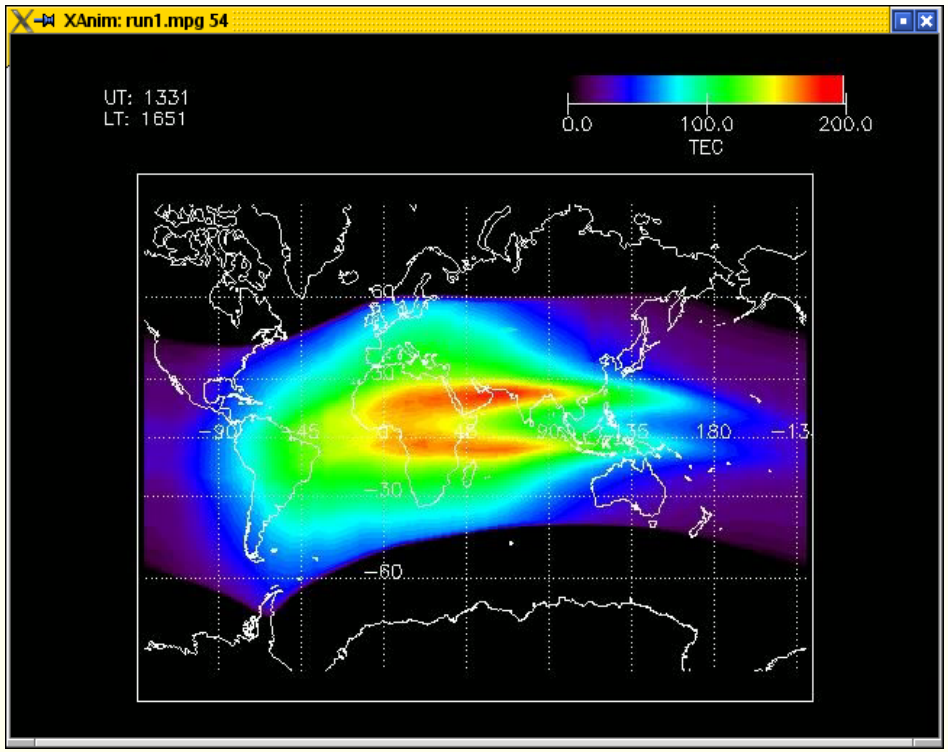
EMPIRICAL MODELS

- NRLMSISE-00 (Picone et al)
  - neutral composition H, He, O, N, N_2, O_2
  - neutral temperature T_n
- HWM93 (Hedin)
  - neutral wind V_n (meridional/zonal)
- electric field (Fejer/Scherliess)
  - $E \times B$ drift V_E (vertical at magnetic equator)

EXAMPLE OUTPUT

SAMI2 (electron density contour); SAMI3 (TEC)





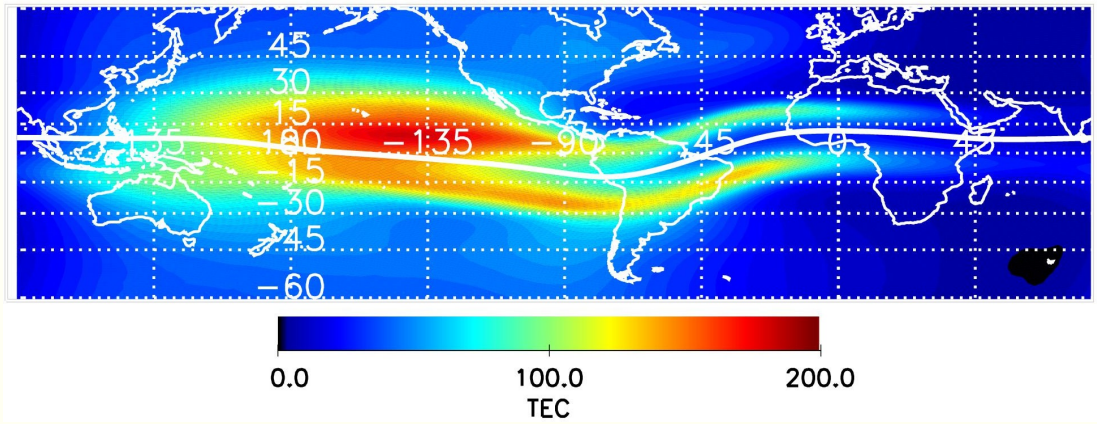
CURRENT STATUS

- neutral composition/wind/temperature:
  - TIEGCM
  - TIMEGCM
  - GITM
- neutral wind dynamo electric field (replaces Fejer/Scherliess)
- magnetic field:
  - tilted/non-tilted dipole
  - IGRF: Richmond Apex Model (with Gang Lu)
- interhemispheric: low- to high-latitude ($\pm 88^\circ$)
- high latitude potential:
  - analytical: Volland-Stern-Maynard-Chen
  - empirical: Weimer
  - data-driven: AMIE
- SAMI3/RCM

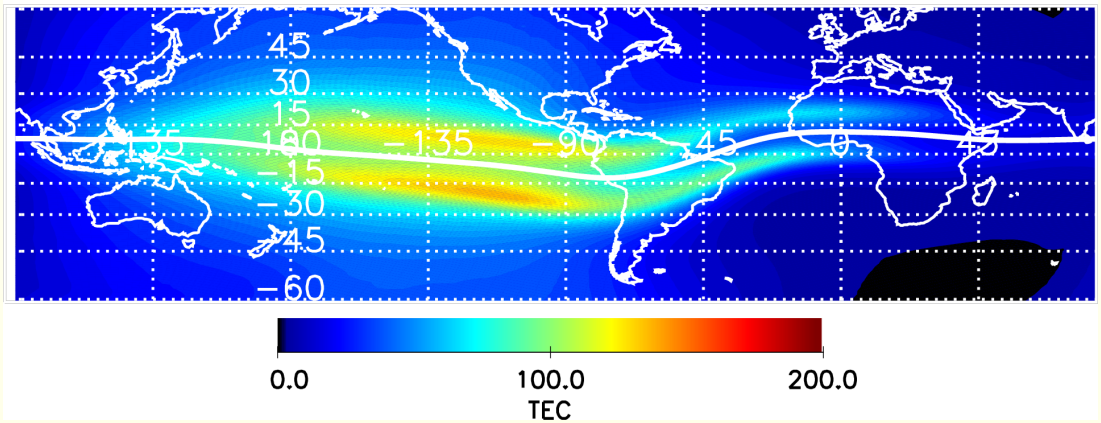
SAMI3/APEX MODEL

direct comparison: empirical vs model

MSIS/HWM14

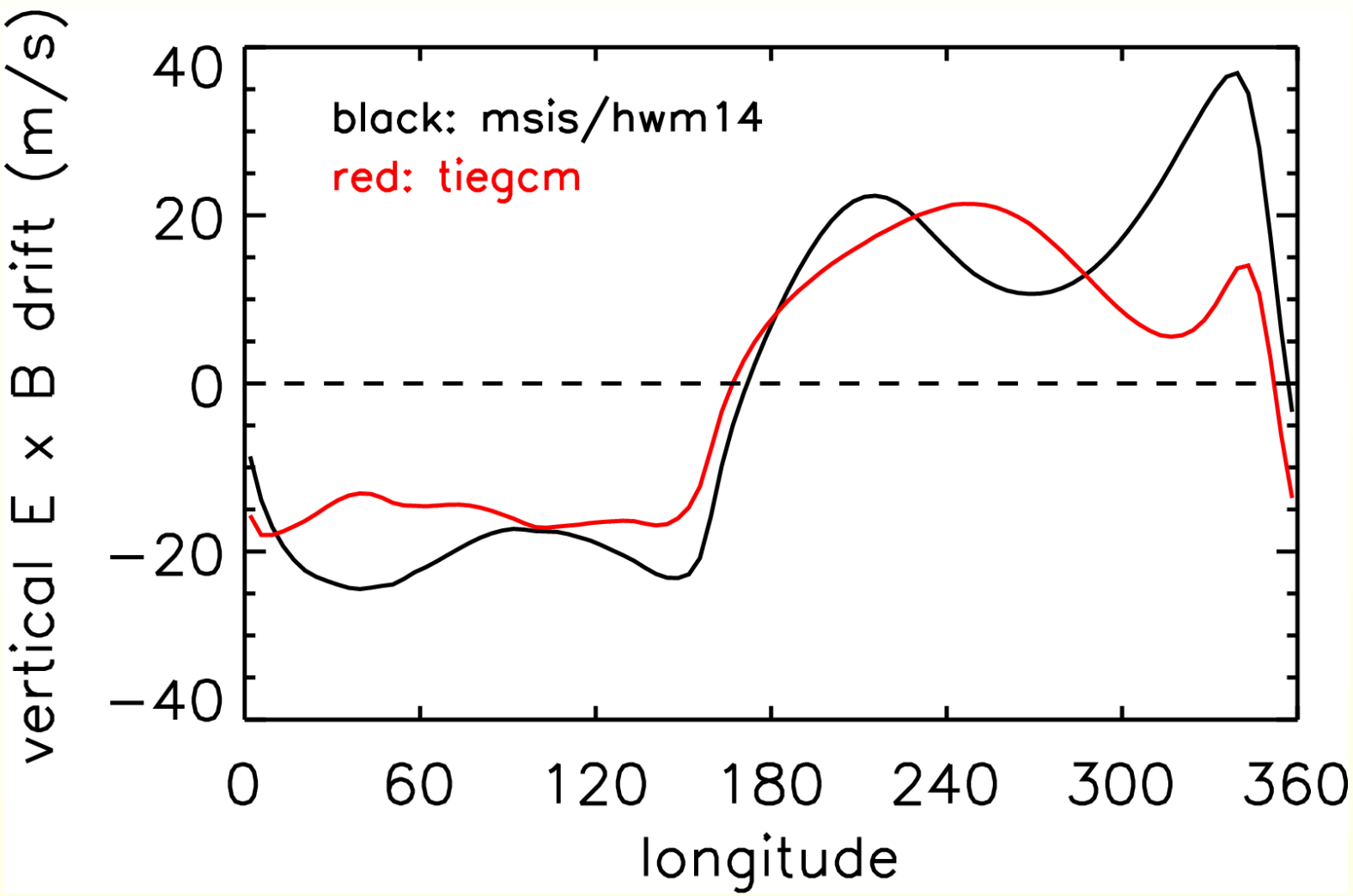


TIEGCM



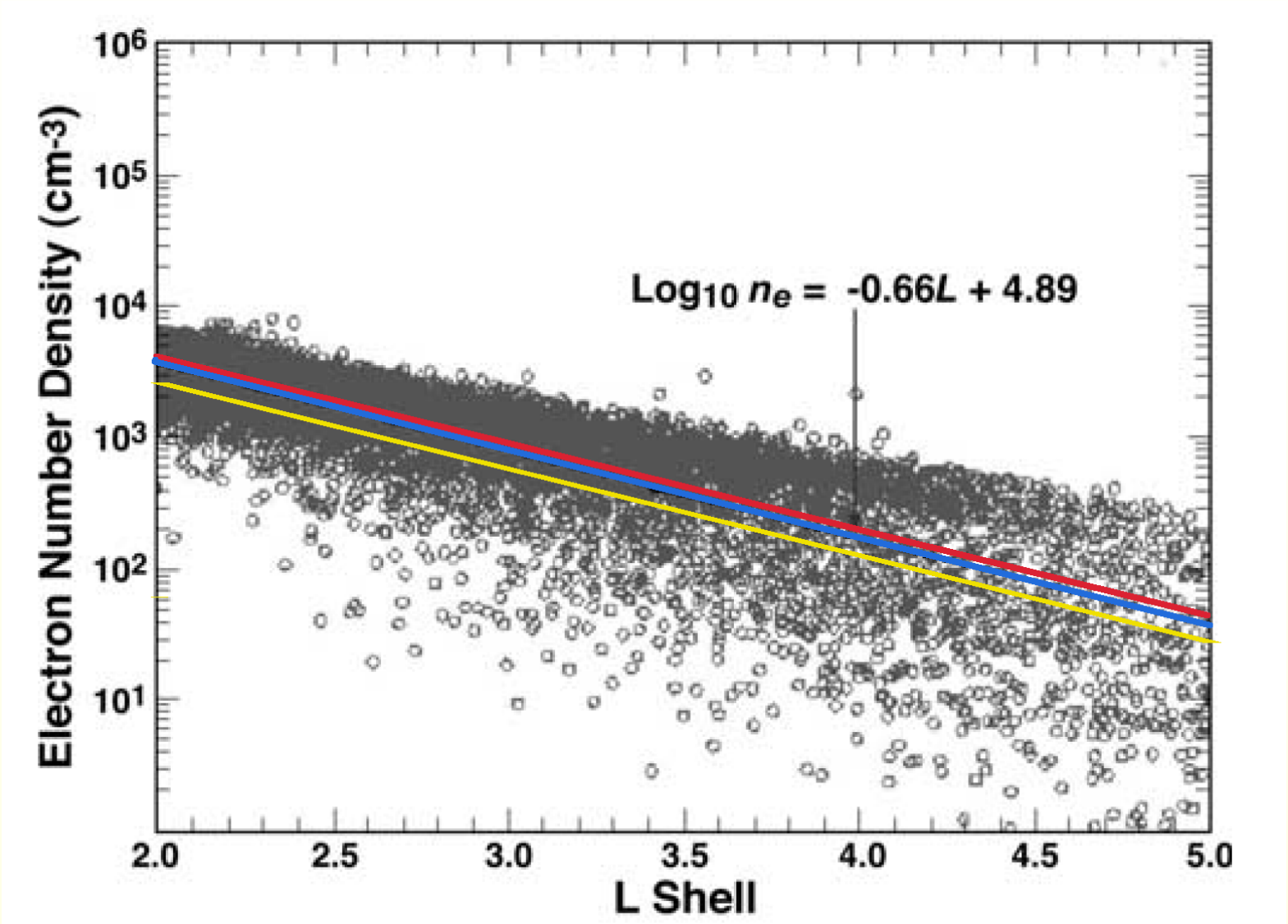
SAMI3/APEX MODEL

vertical E × B drift at 325 km



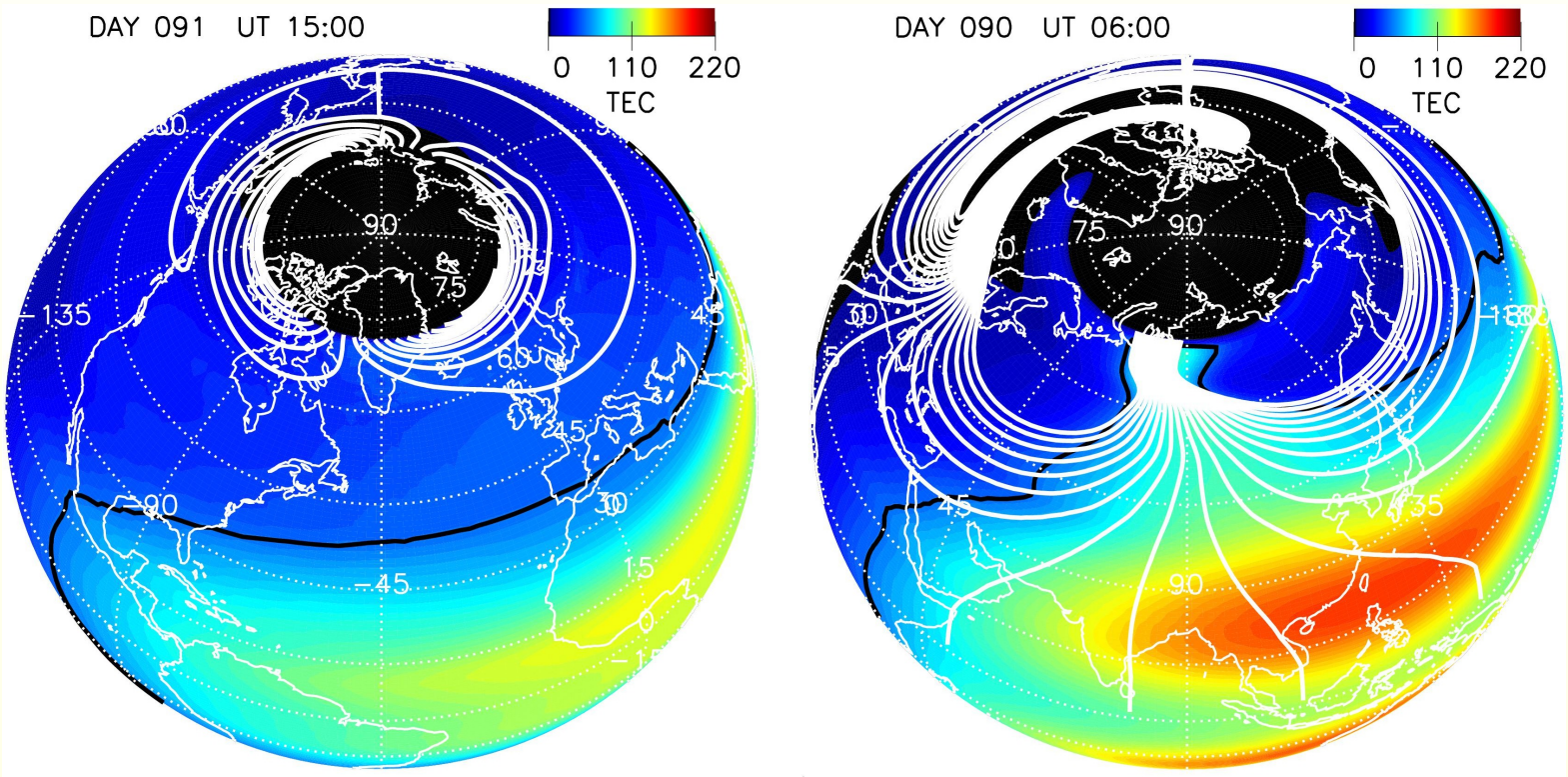
EQUATORIAL ELECTRON DENSITY

comparison of SAMI3 to data (Berube et al., JGR, 2005)



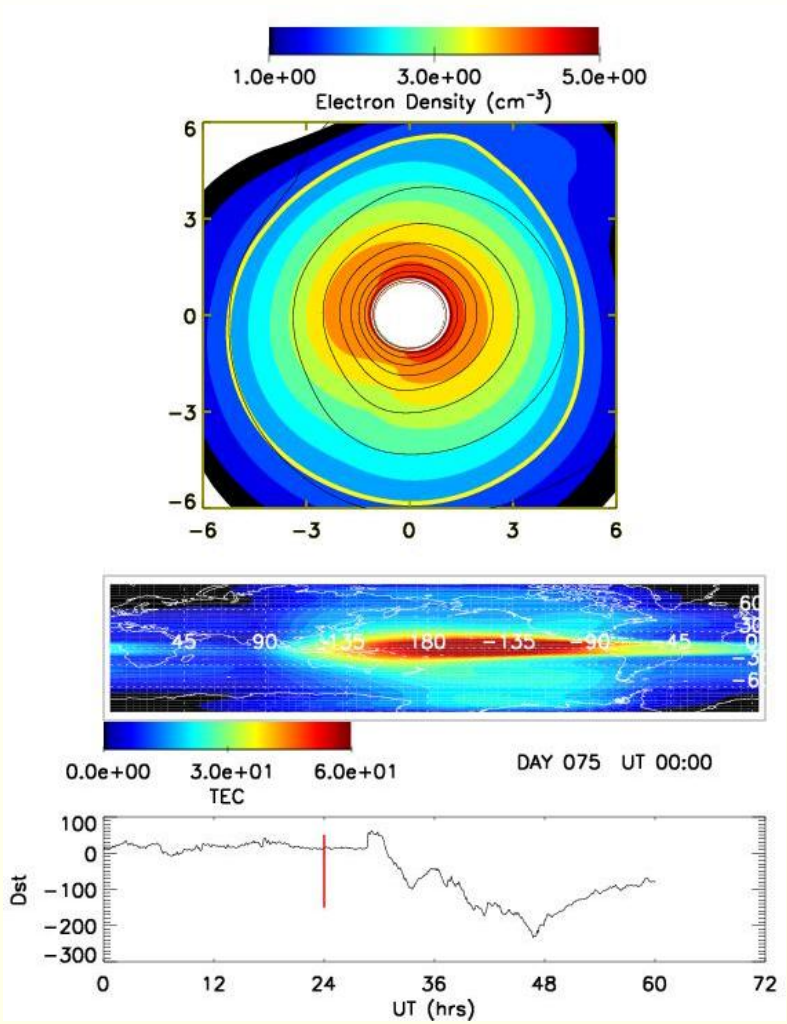
SAMI3/RCM COUPLED MODEL

$$\nabla \cdot (\underbrace{\Sigma}_{\text{SAMI3}} + \underbrace{\Sigma_a}_{\text{RCM}})\nabla\Phi = S(\underbrace{V_n}_{\text{HWM}}, \underbrace{J_{\parallel}(t)}_{\text{RCM}})$$



MARCH, 2015 STORM

day 076 00:00 UT



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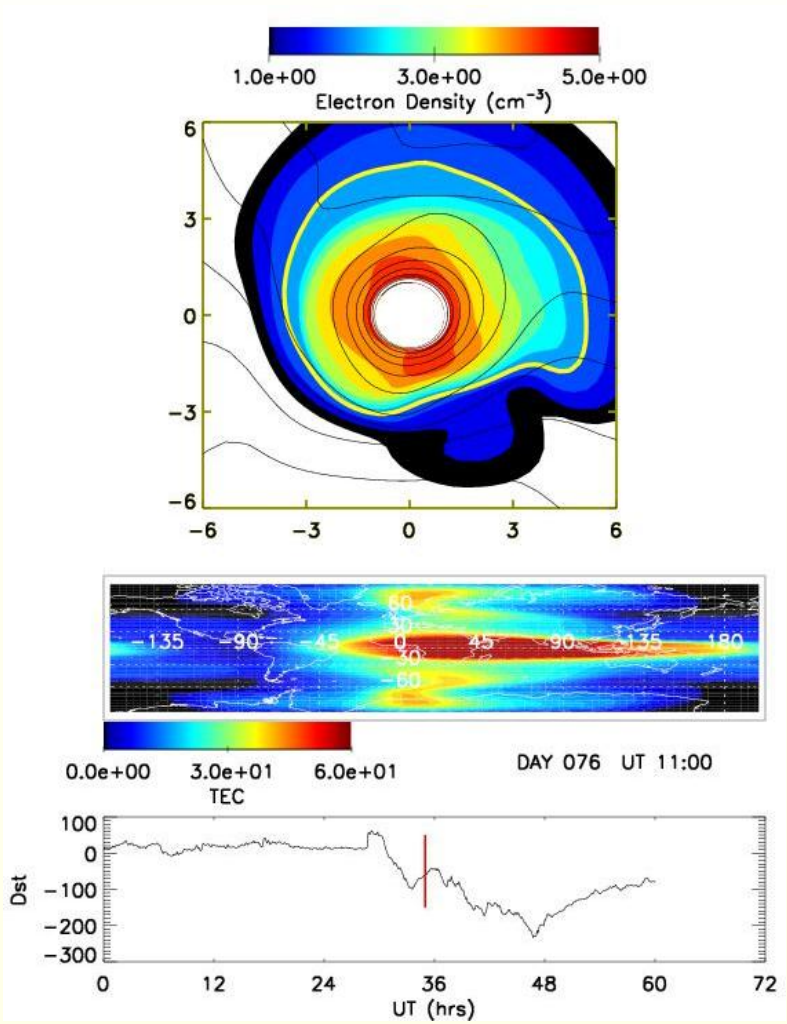

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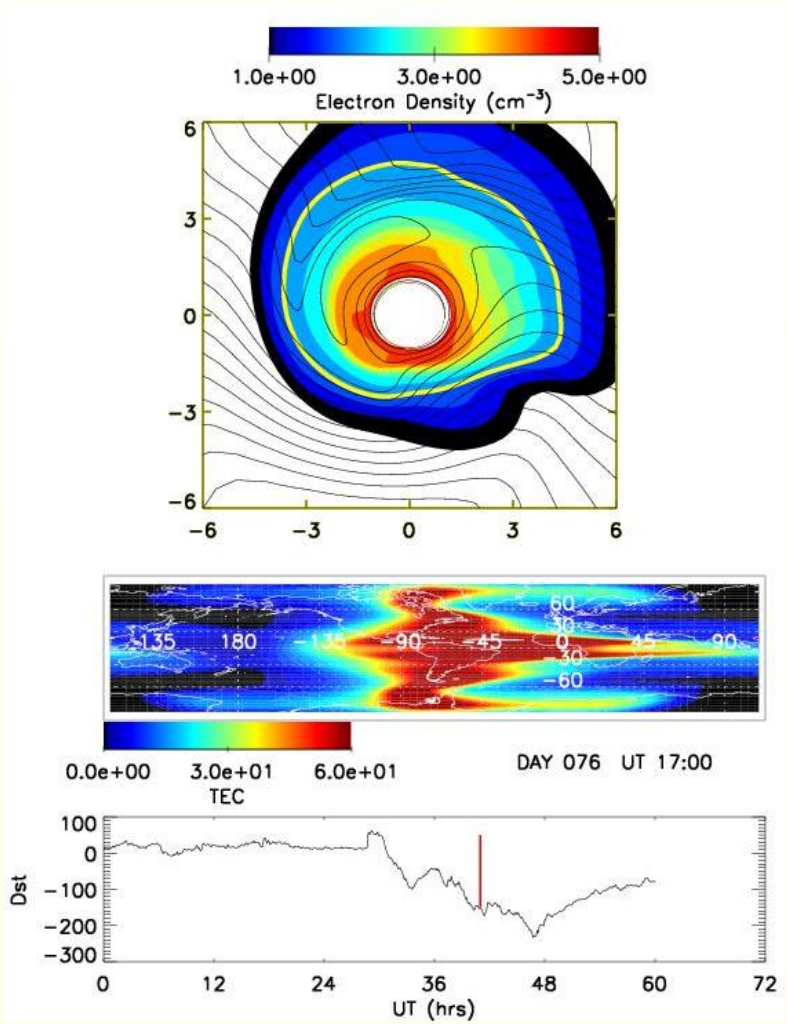

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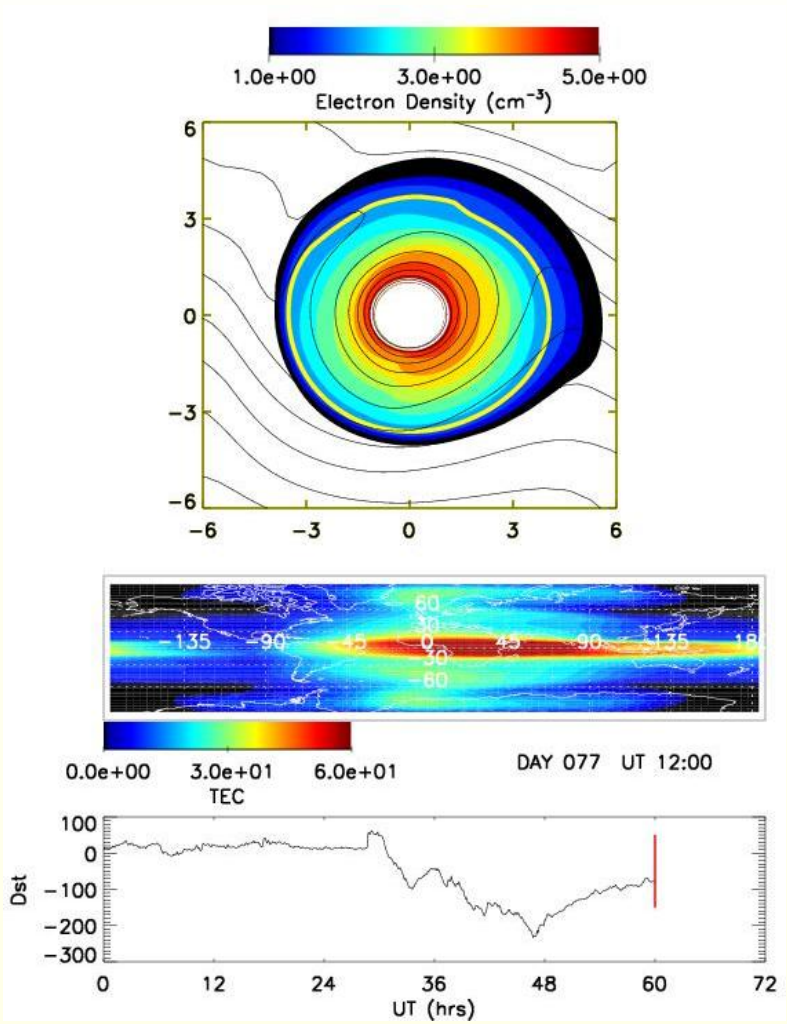

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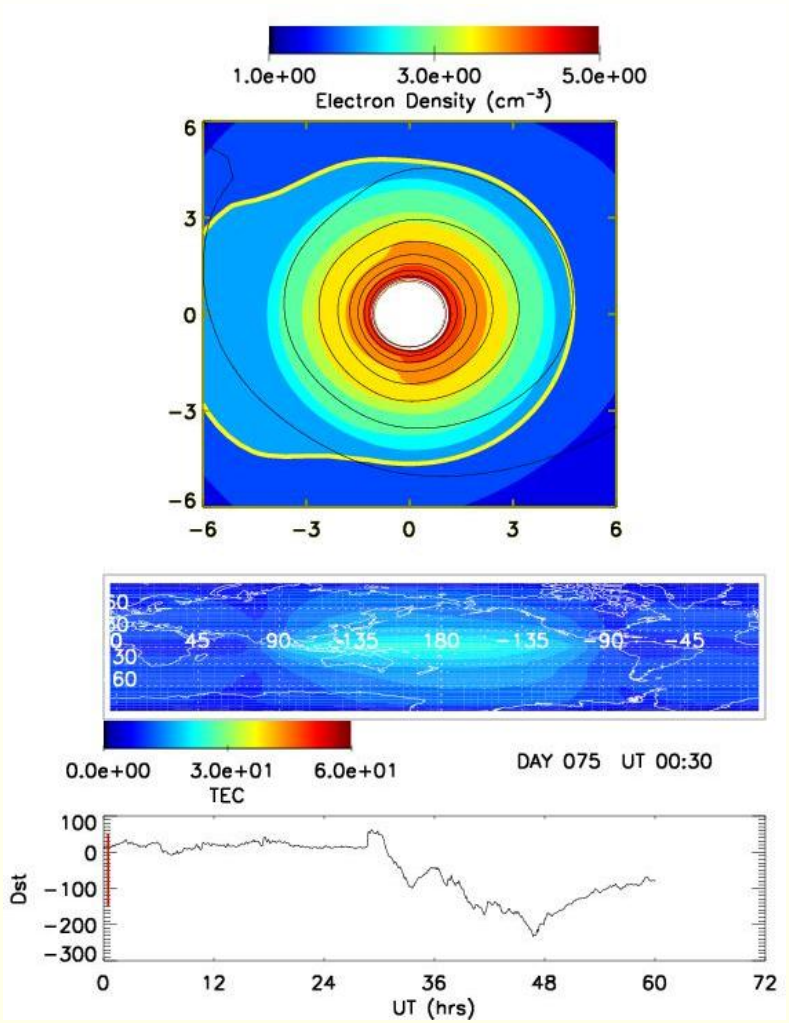

FUTURE UPGRADES AT CCMC: SAMI3

- SAMI3 ionosphere/plasmasphere model
  - apex magnetic field with Weimer potential
  - coupled SAMI3/RCM model (dipole field)
- ongoing project: couple SAMI3/CIMI model