NRL SAMI2/3 IONOSPHERE MODEL AT CCMC

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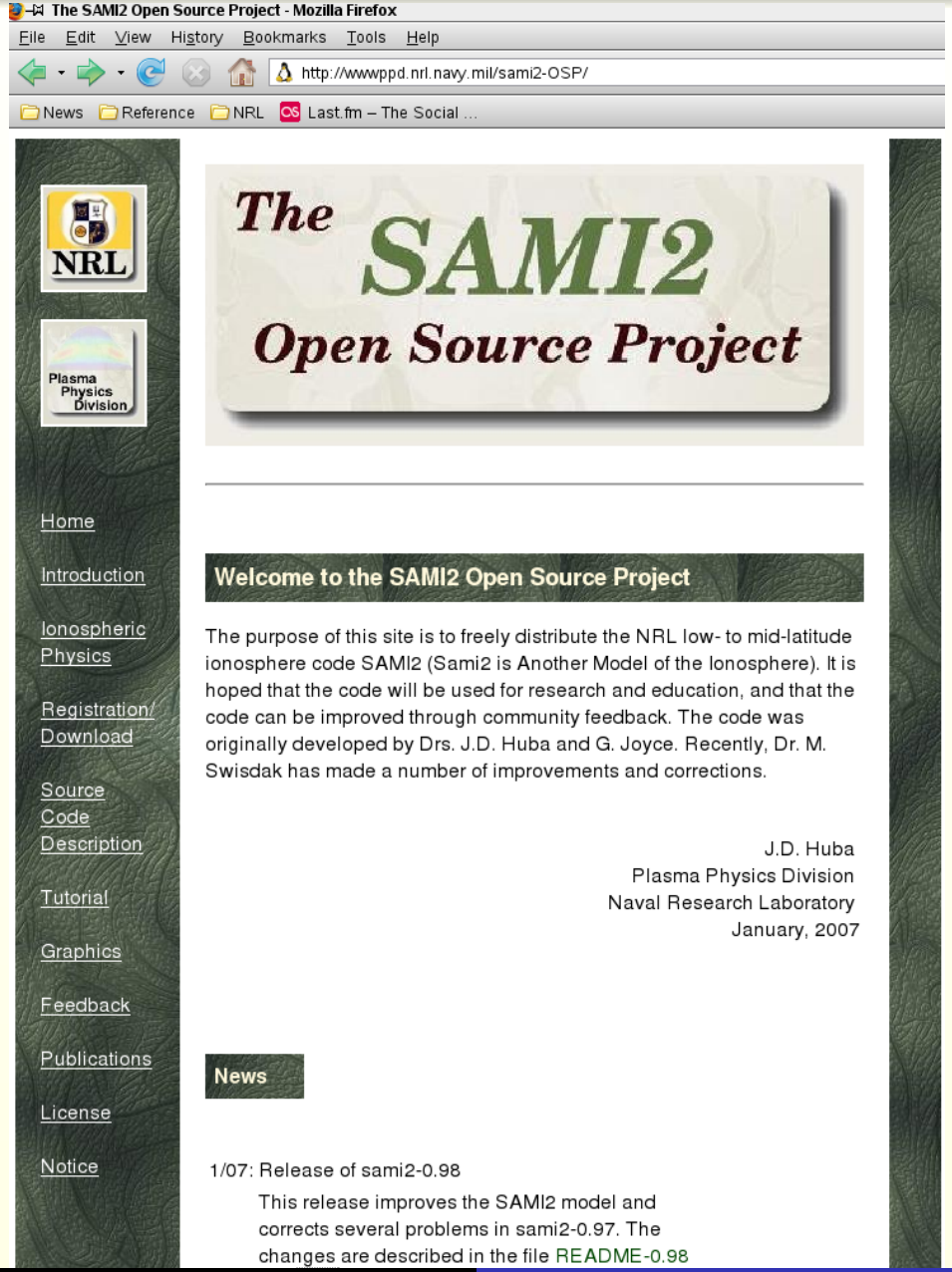
SAMI2 VERSION AT CCMC

sami2-0.98



SAMI2 AT CCMC

- Magnetic field: IGRF-like
- Interhemispheric
- 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 $\mathbf{B}$
  - Ion inertia included parallel to $\mathbf{B}$
- 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

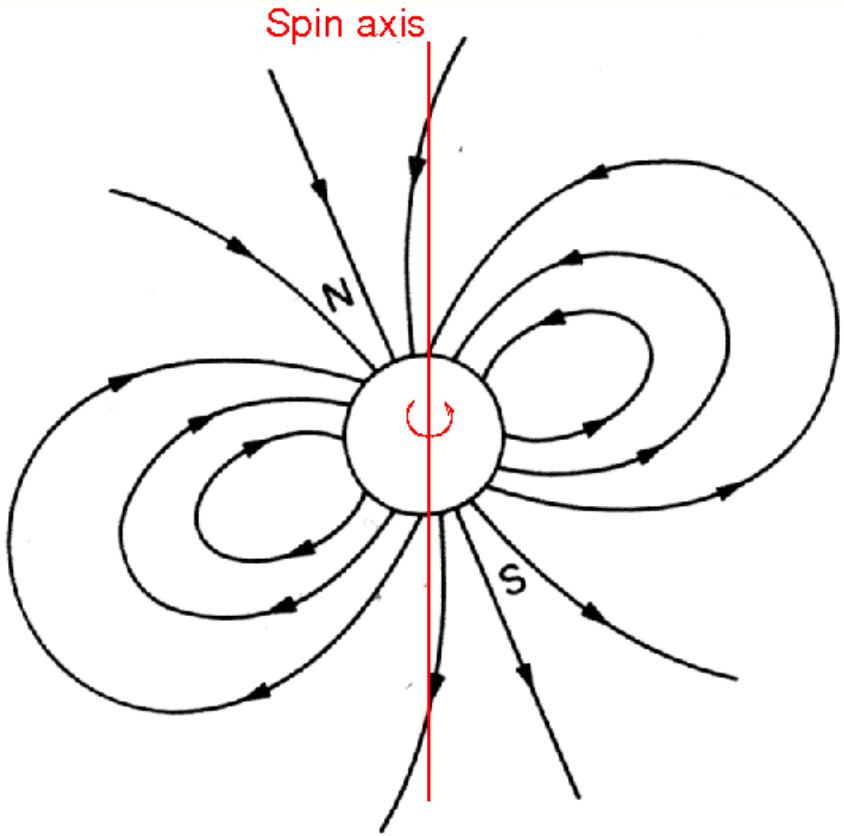
$$0 = -\frac{1}{n_e m_e} b_s \frac{\partial P_e}{\partial s} - \frac{e}{m_e} E_s$$

- Electron Temperature

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

MAGNETIC FIELD

- Low- to mid-latitude:
  closed field lines
- Appropriate field: IGRF
- Modeled as IGRF-like:
  a dipole field is fit to the IGRF for the longitude of the simulation (vary offset and tilt)
- Important assumption:
  field lines are equipotentials

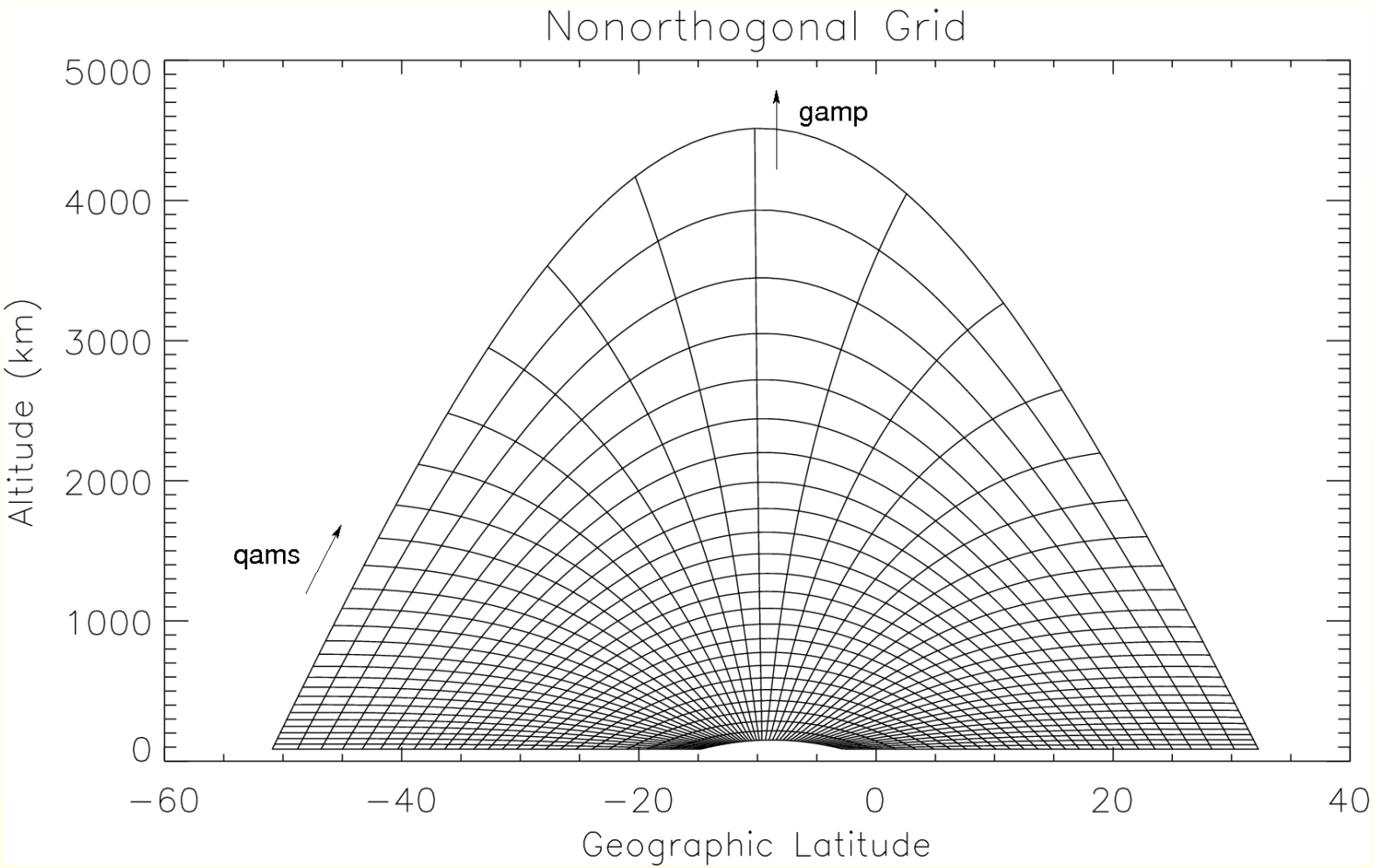


EMPIRICAL MODELS

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

NONORTHOGONAL EULERIAN GRID

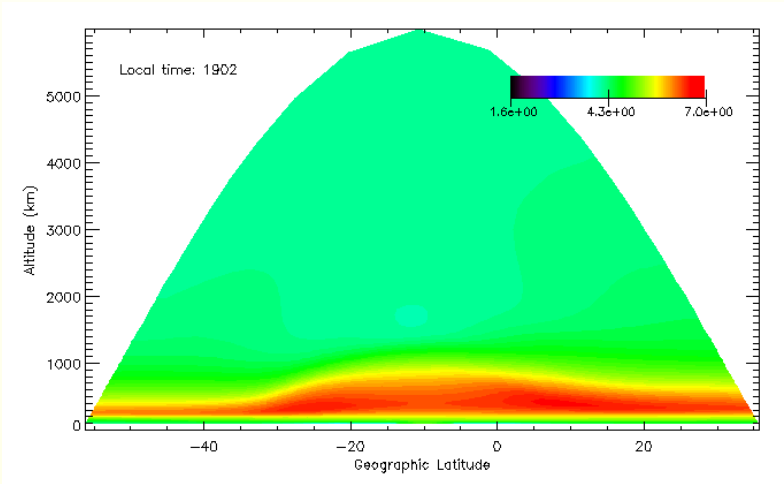
Present grid: '1 zone'

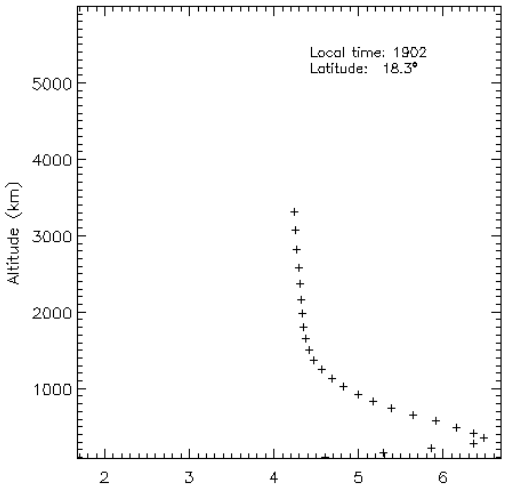


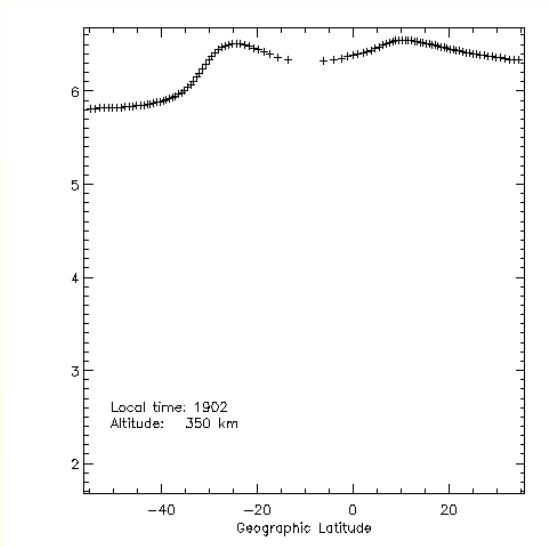
CCMC OUTPUTS

Electron and ion densities

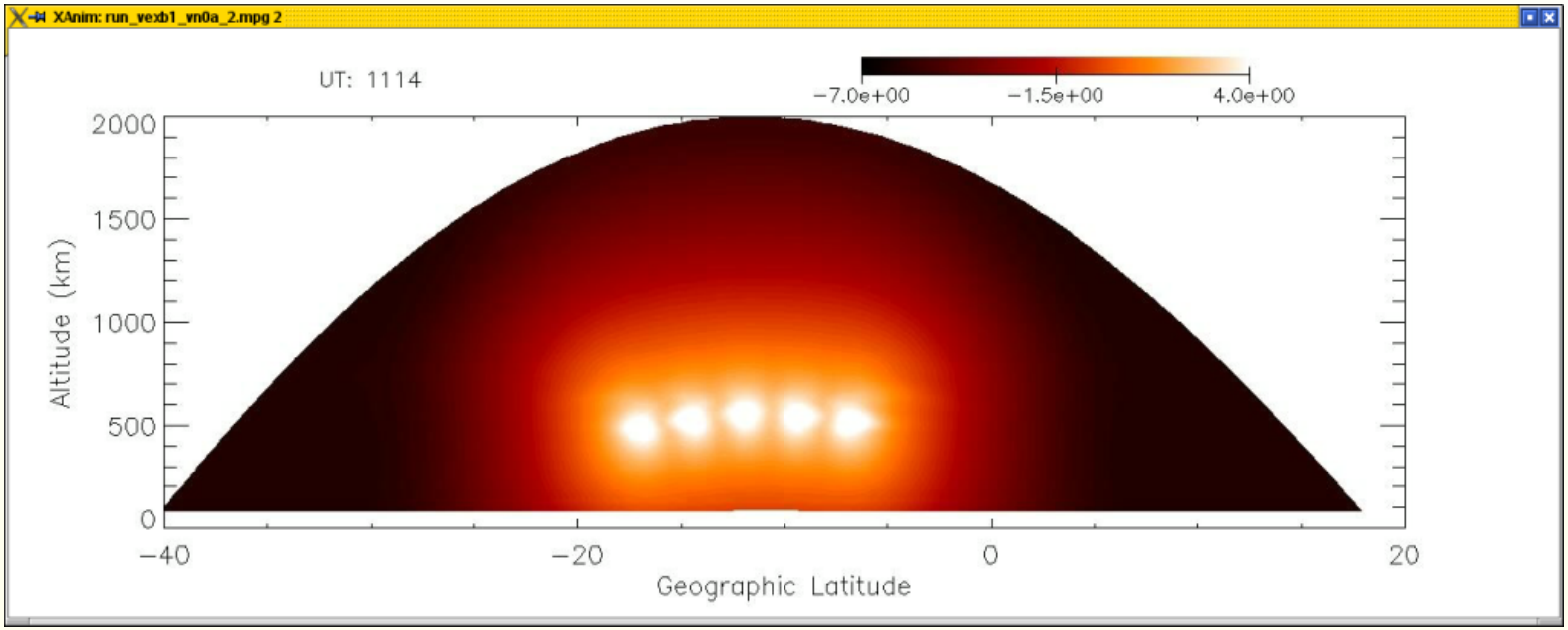
- 2D color contour plot
- 1D line plot (altitude/latitude)







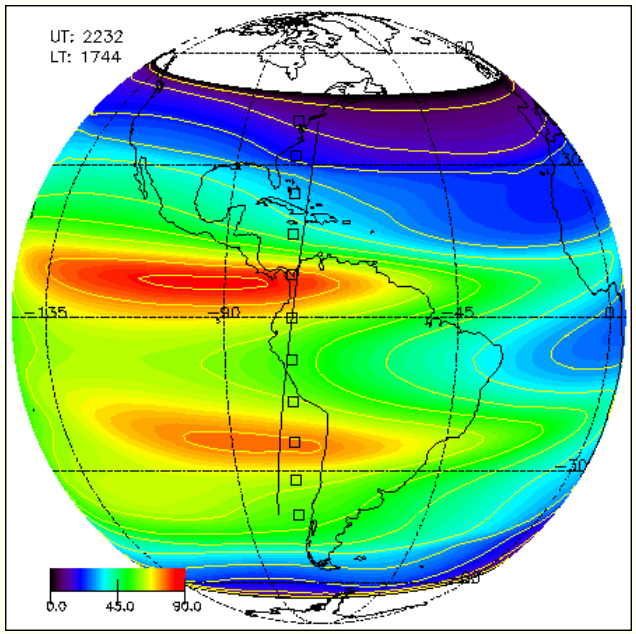
Example: ion dynamics as a function of time



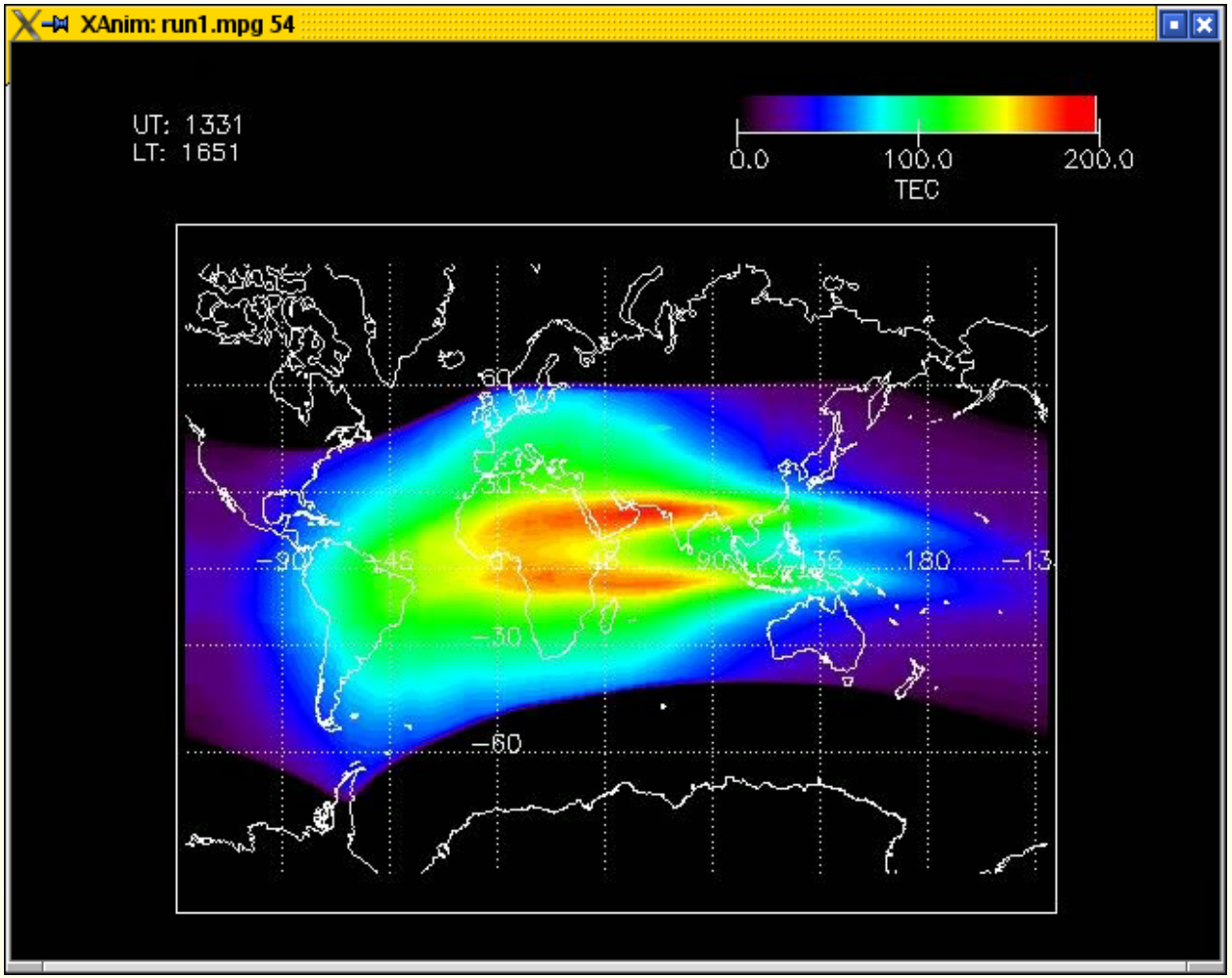
NEW UPGRADE AT CCMC: SAMI3

Modeling the near-earth space environment

- Global low- to mid-latitude ionosphere model
- IGRF-like magnetic field
- Zonal drifts
- Parallelized with MPI:
  Requires Beowulf cluster
- Nominal longitudinal resolution:
  $2^\circ - 4^\circ$
- Outputs: TEC, $nmf2$, $hmf2$



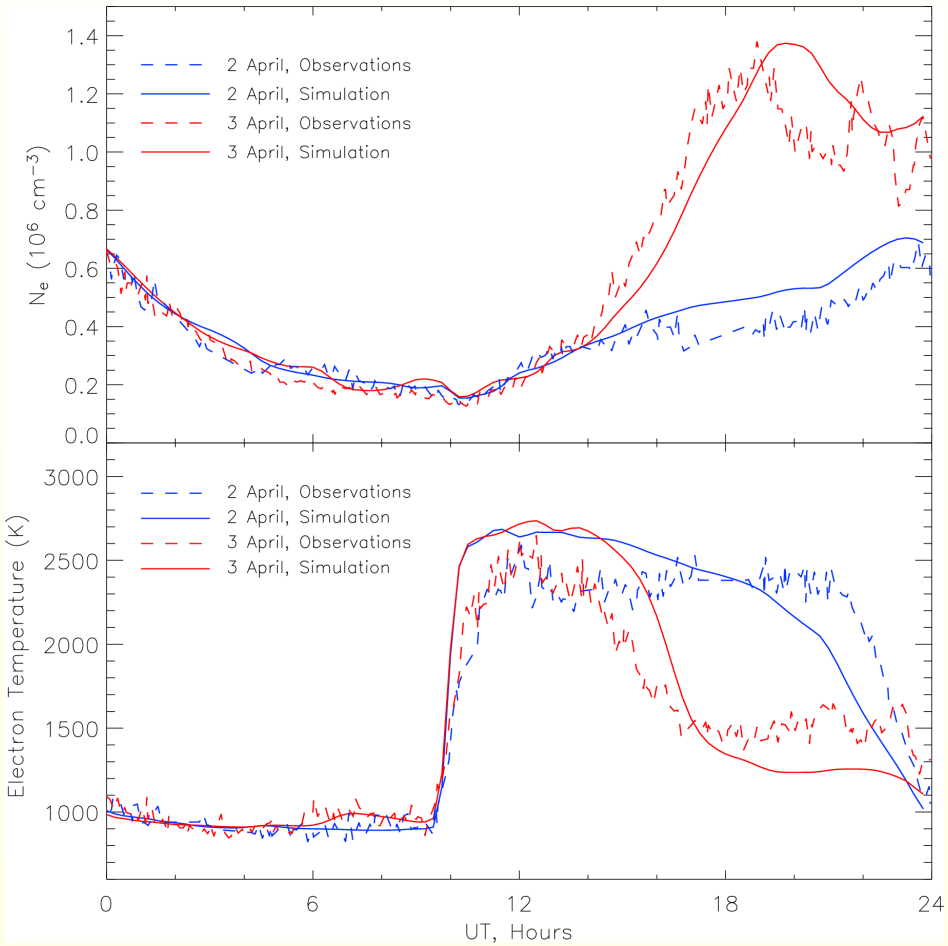
Example: global/temporal change in TEC



SAMI2 T_e MODEL

Comparison to Millstone Hill data (Swisdak et al., GRL, 2005)

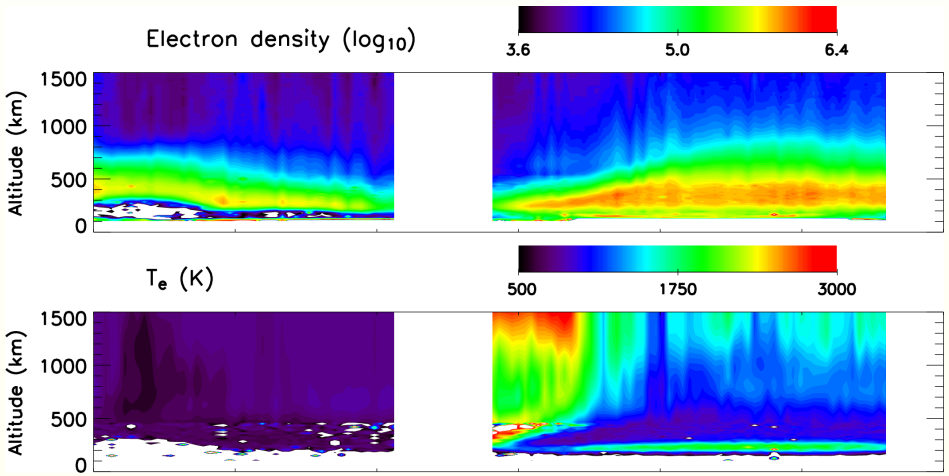
- Q_{phe} based on simple model developed by Bailey (e.g., SUPIM)
- SAMI2 had an adjustable parameter 'cqe' that affects Q_{phe}
- Other comparisons to data suggest another parameter be included, e.g., αQ_{phe}
- Major upgrade by Varney
  - physics based photoelectron physics model
  - computationally expensive



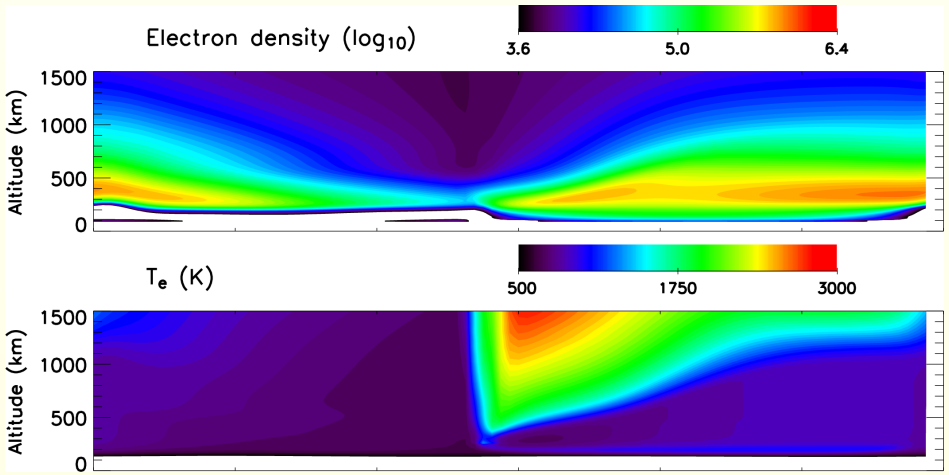
IMPROVE SAMI2 T_e MODEL

Photoelectron heating term had to be modified: $\alpha = 0.2$

Jicamarca data



SAMI2



NEXT SAMI3 UPGRADE AT CCMC

- global SAMI3 ($\pm 89^\circ$ magnetic latitude)
- electrostatic potential
  - self-consistent low-latitude dynamo potential HWM07 to provide neutral wind
  - high-latitude potential: Weimer
- ETA: late spring/early summer