

NRL SAMI2/3 IONOSPHERE MODEL AT CCMC

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The SAMI2 Open Source Project

Welcome to the SAMI2 Open Source Project

The purpose of this site is to freely distribute the NRL low- to mid-latitude ionosphere code SAMI2 (Sami2 is Another Model of the Ionosphere). It is hoped that the code will be used for research and education, and that the code can be improved through community feedback. The code was originally developed by Drs. J.D. Huba and G. Joyce. Recently, Dr. M. Swisdak has made a number of improvements and corrections.

J.D. Huba
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January, 2007

News

1/07: Release of sami2-0.98

This release improves the SAMI2 model and corrects several problems in sami2-0.97. The changes are described in the file README-0.98

- 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

$$\begin{aligned} \frac{\partial \mathbf{V}_i}{\partial t} + \mathbf{V}_i \cdot \nabla \mathbf{V}_i &= -\frac{1}{\rho_i} \nabla P_i + \frac{e}{m_i} \mathbf{E} + \frac{e}{m_i c} \mathbf{V}_i \times \mathbf{B} + \mathbf{g} \\ &\quad - \nu_{in} (\mathbf{V}_i - \mathbf{V}_n - \sum_j \nu_{ij} (\mathbf{V}_i - \mathbf{V}_j)) \end{aligned}$$

- Ion Temperature

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

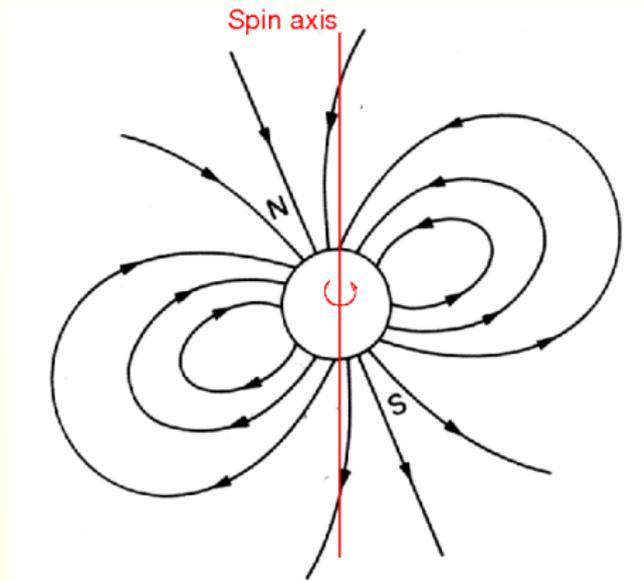
- Electron Momentum

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

- Electron Temperature

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

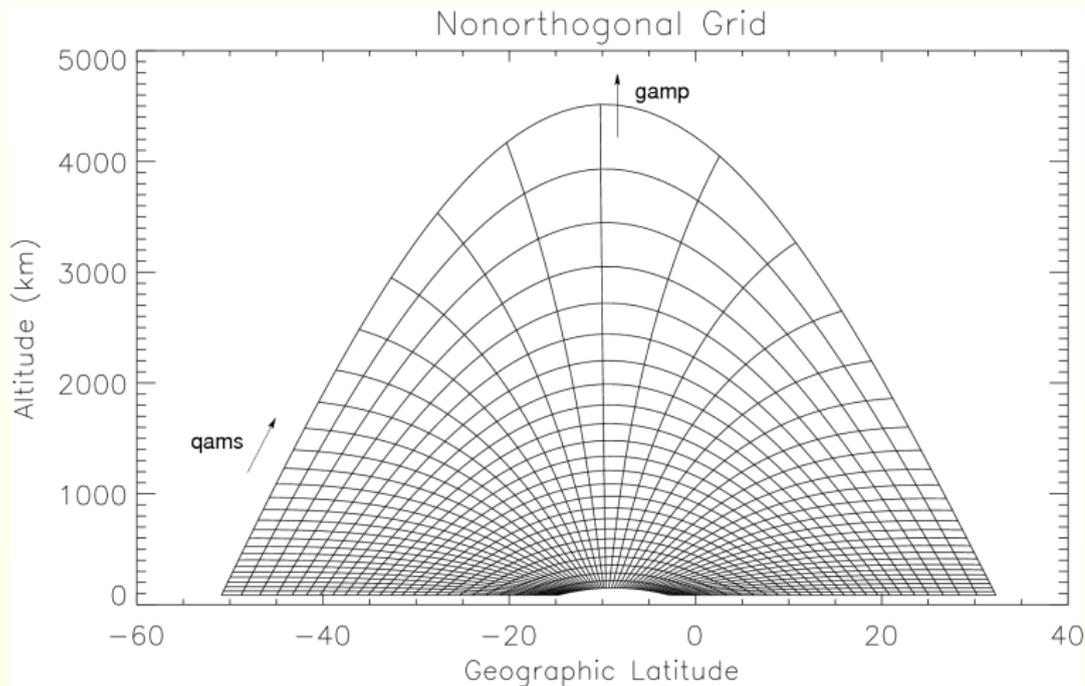
- Low- to mid-latitude:
closed field lines
- Appropriate field: IGRF
- Modeled as IGRF-like:
a dipole field is fit to the IGRF
for the longitude of the
simulation (vary offset and tilt)
- Important assumption:
field lines are equipotentials



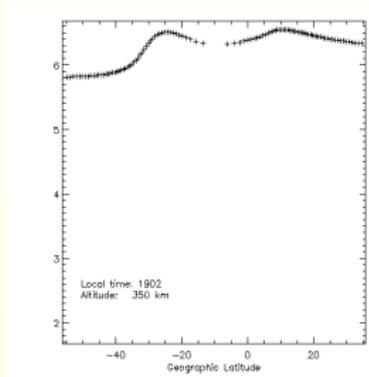
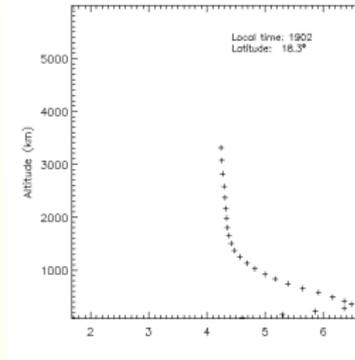
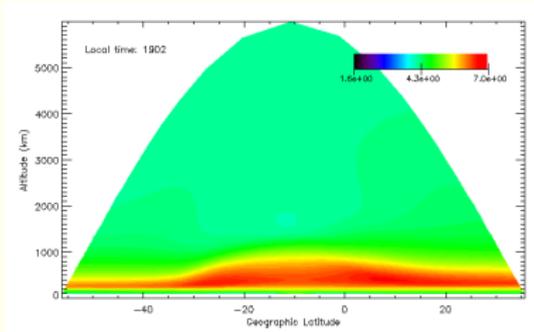
- NRLMSISE-00 (Picone et al)
 - Neutral composition H, He, O, N, N₂, O₂
 - Neutral temperature T_n
- HWM (Hedin)
 - Neutral wind V_n (meridional/zonal)
- Electric field (Fejer/Scherliess)
 - $E \times B$ drift V_E (vertical at magnetic equator)

NONORTHOGONAL EULERIAN GRID

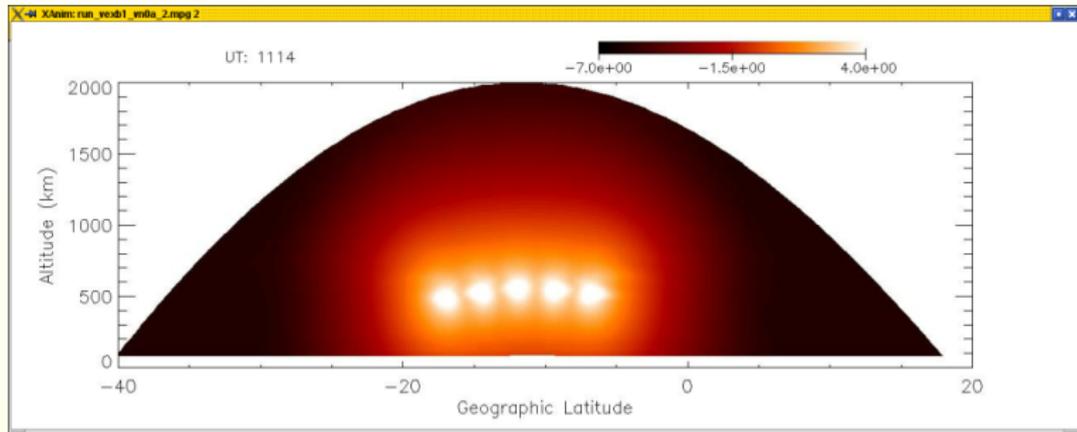
Present grid: '1 zone'



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



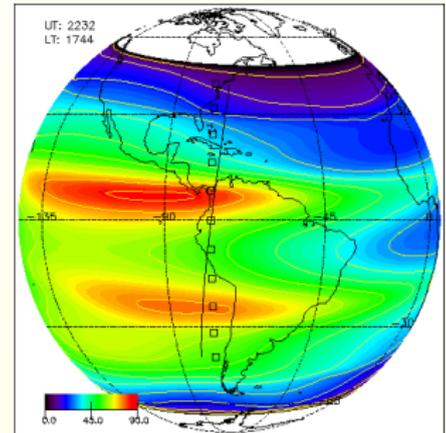
Example: ion dynamics as a function of time



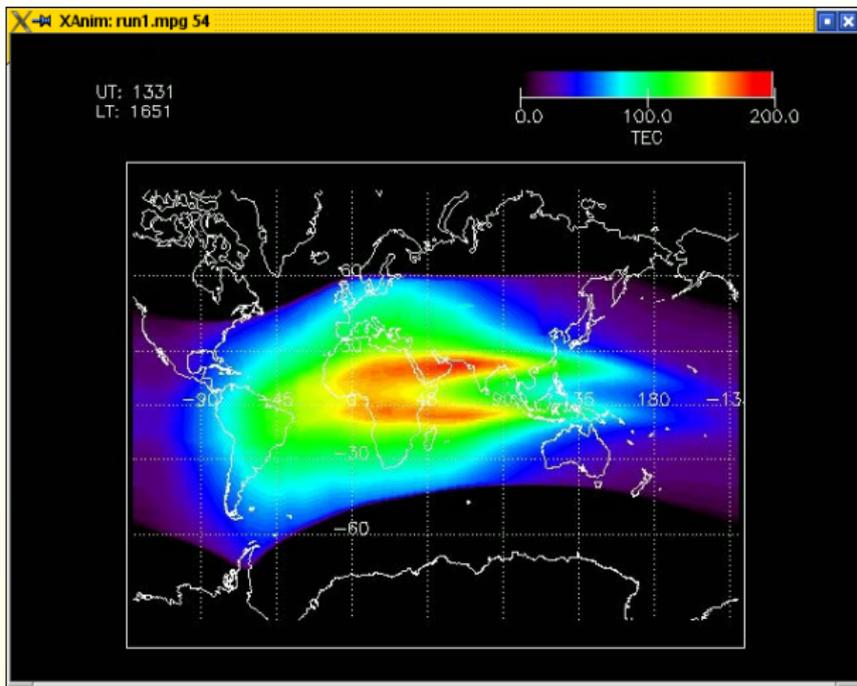
NEW UPGRADE AT CCMC: SAMI3

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, $nmf2$, $hmf2$



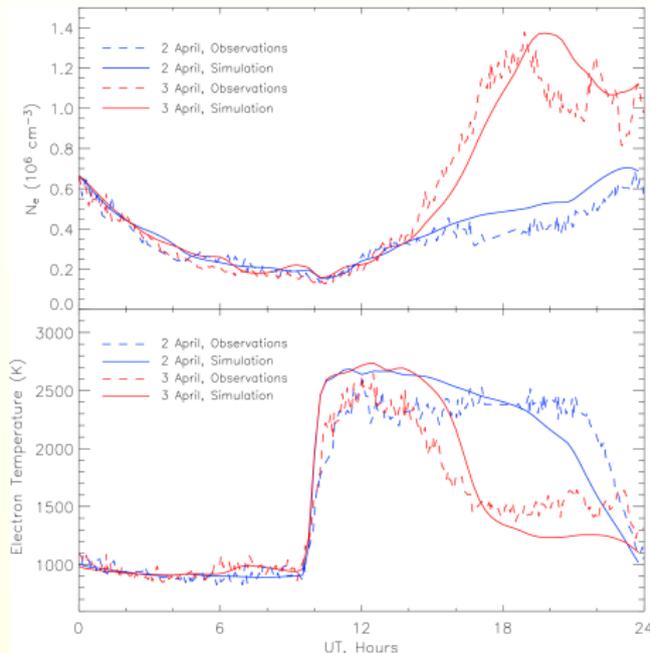
Example: global/temporal change in TEC



SAMI2 T_e MODEL

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

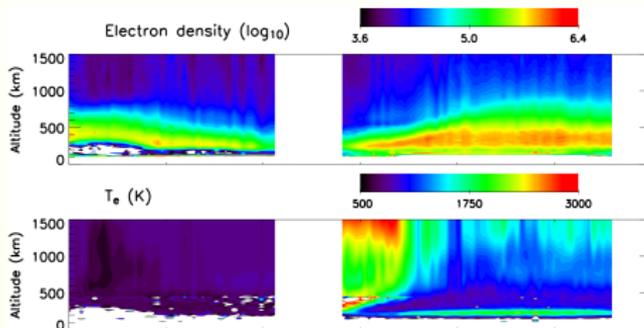
- Q_{phe} based on simple model developed by Bailey (e.g., SUPIM)
- SAMI2 had an adjustable parameter 'cqe' that affects Q_{phe}
- Other comparisons to data suggest another parameter be included, e.g., αQ_{phe}
- Major upgrade by Varney
 - physics based photoelectron physics model
 - computationally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



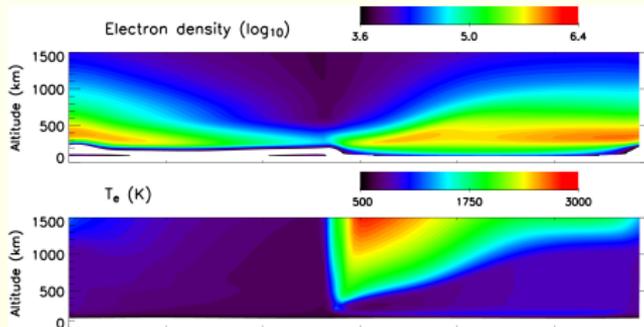
IMPROVE SAMI2 T_e MODEL

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