U.S. NAVAL RESEARCH LABORATORY

The influence of the ionospheric dynamo on the shape of the Plasmasphere

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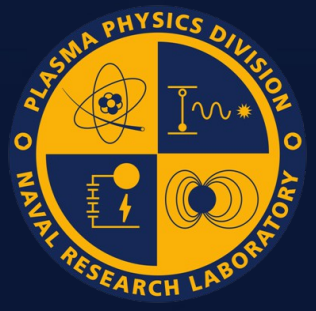
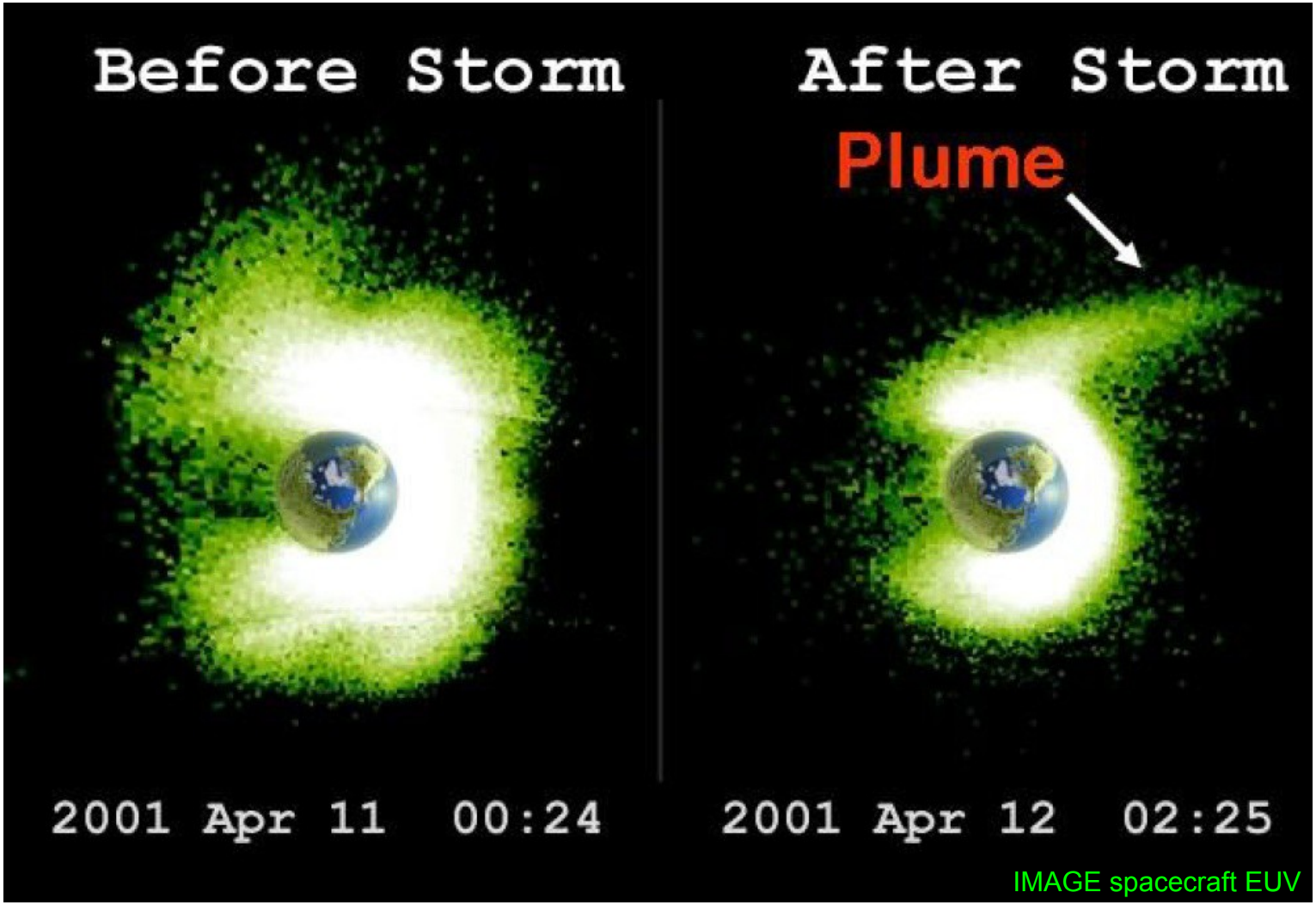


Supported by the NRL base program

Geomagnetic storms shape the plasmasphere

NRL PPD

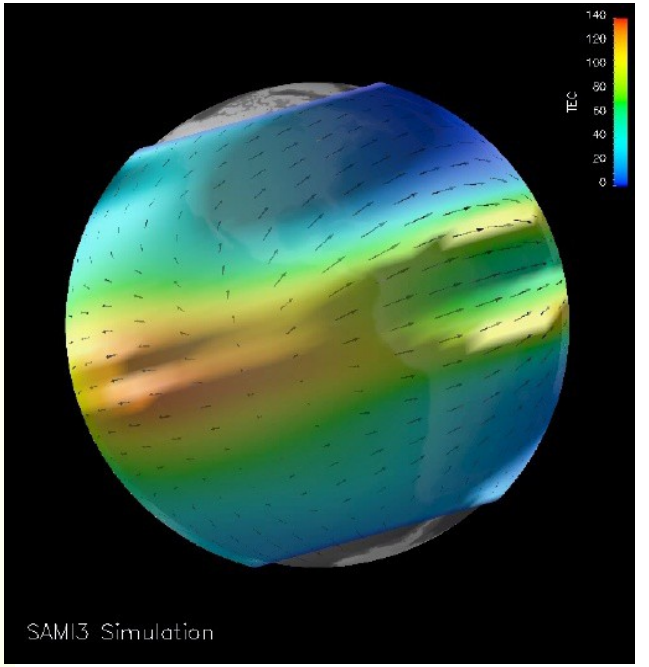


Magnetospheric convection can "carve away" the plasmasphere

NRL SAMI3 Ionosphere/Plasmasphere Model

NRL PPD

- Magnetic field: ~~IGRF-like~~ Non-tilted dipole
- 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 **B**
  - Ion inertia included parallel to **B**
- Neutral species: NRLMSISE00 and ~~HWM93~~ TIMEGCM
- Chemistry: 21 reactions + recombination
- Photoionization: Daytime (EUVAC) and nighttime



SAMI3 is coupled to a magnetosphere potential model and a thermosphere model.

[Huba et al., JGR, 2000; Huba and Joyce, GRL, 2010; Huba and Krall, GRL, 2013]

SAMI3: Ion dynamics and winds

NRL PPD

Direct force:

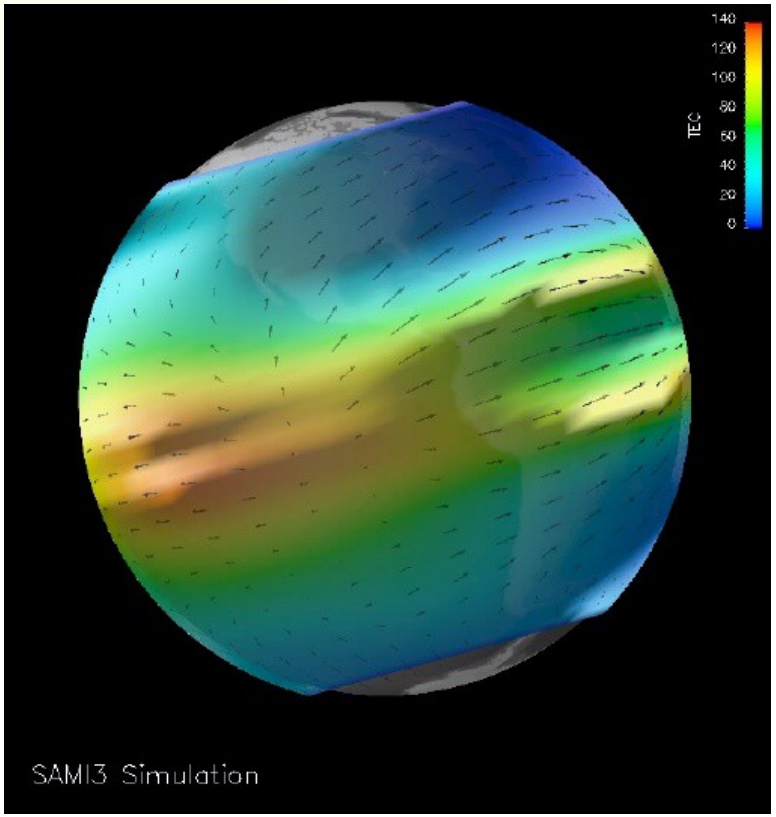
$$\frac{\partial \mathbf{V}_i}{\partial t} + \mathbf{V}_i \cdot \nabla \mathbf{V}_i = -\frac{1}{\rho_i}\nabla \mathbf{P}_i + \frac{e}{m_i}\mathbf{E} + \frac{e}{m_i c}\mathbf{V}_i \times \mathbf{B} + \mathbf{g}$$

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

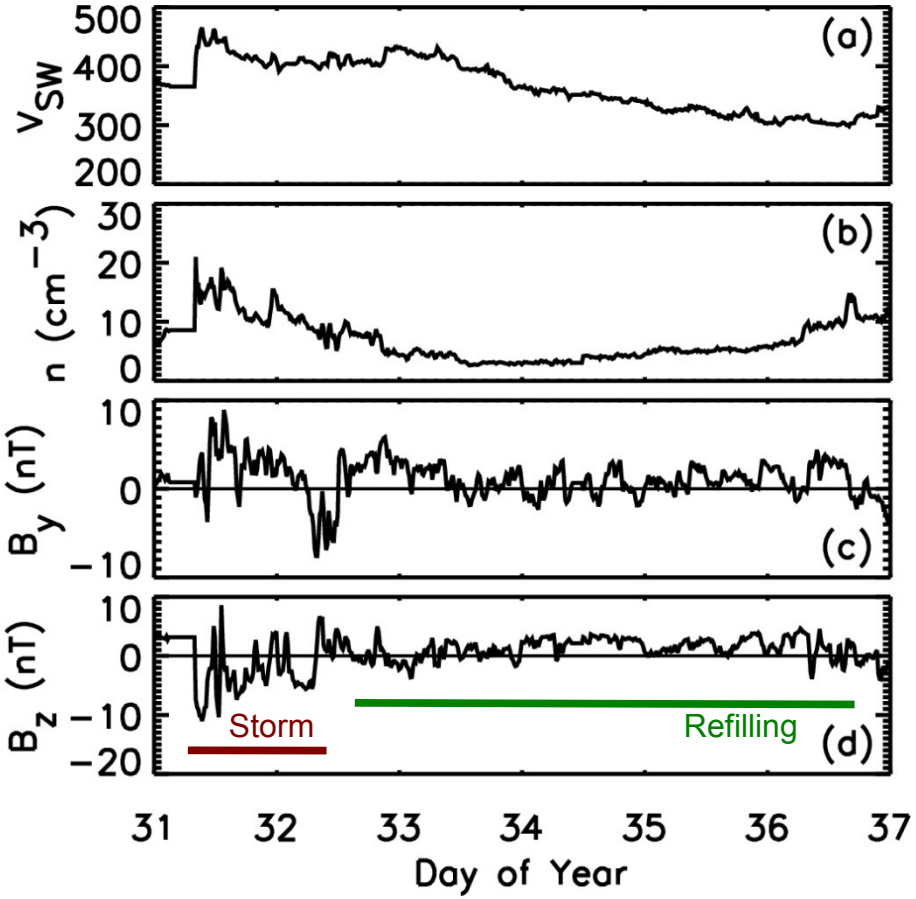
Wind-driven dynamo:

$$\nabla \cdot \Sigma \nabla \Phi = S(g, V_n, J_\parallel)$$

$$\mathbf{E} = -\nabla \Phi$$

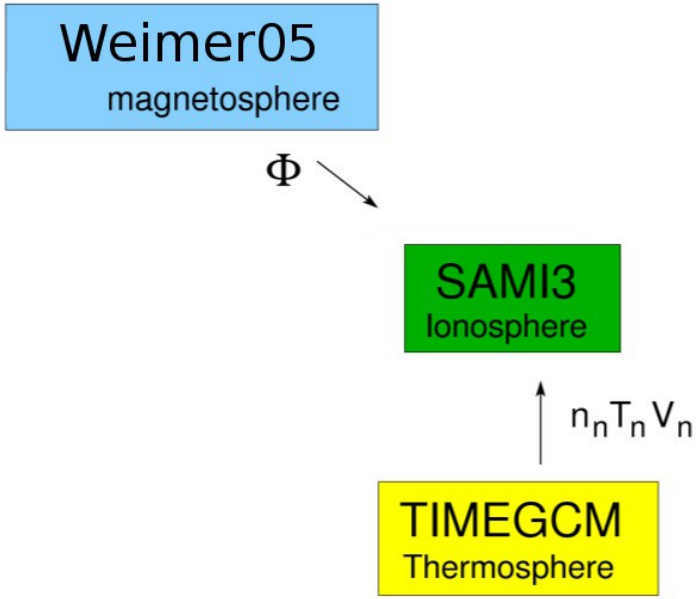


2001 Day 32-36: post-storm quiet period



SAMI3/Weimer 7-day run:

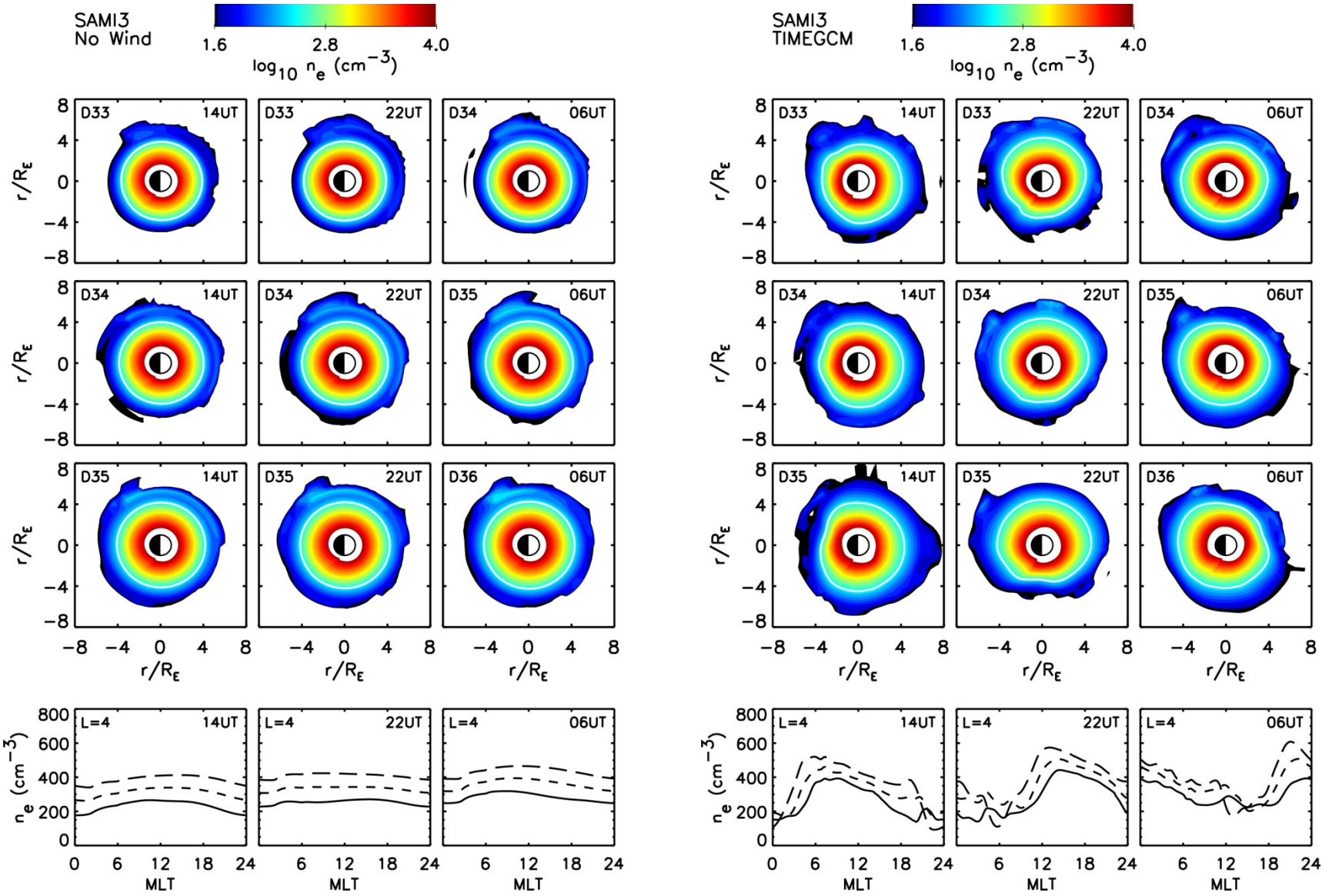
- 1 quiet day (day 30)
- 2 storm days
- 4 refilling days (day 33-36)



Data from CDAWeb/OMNI

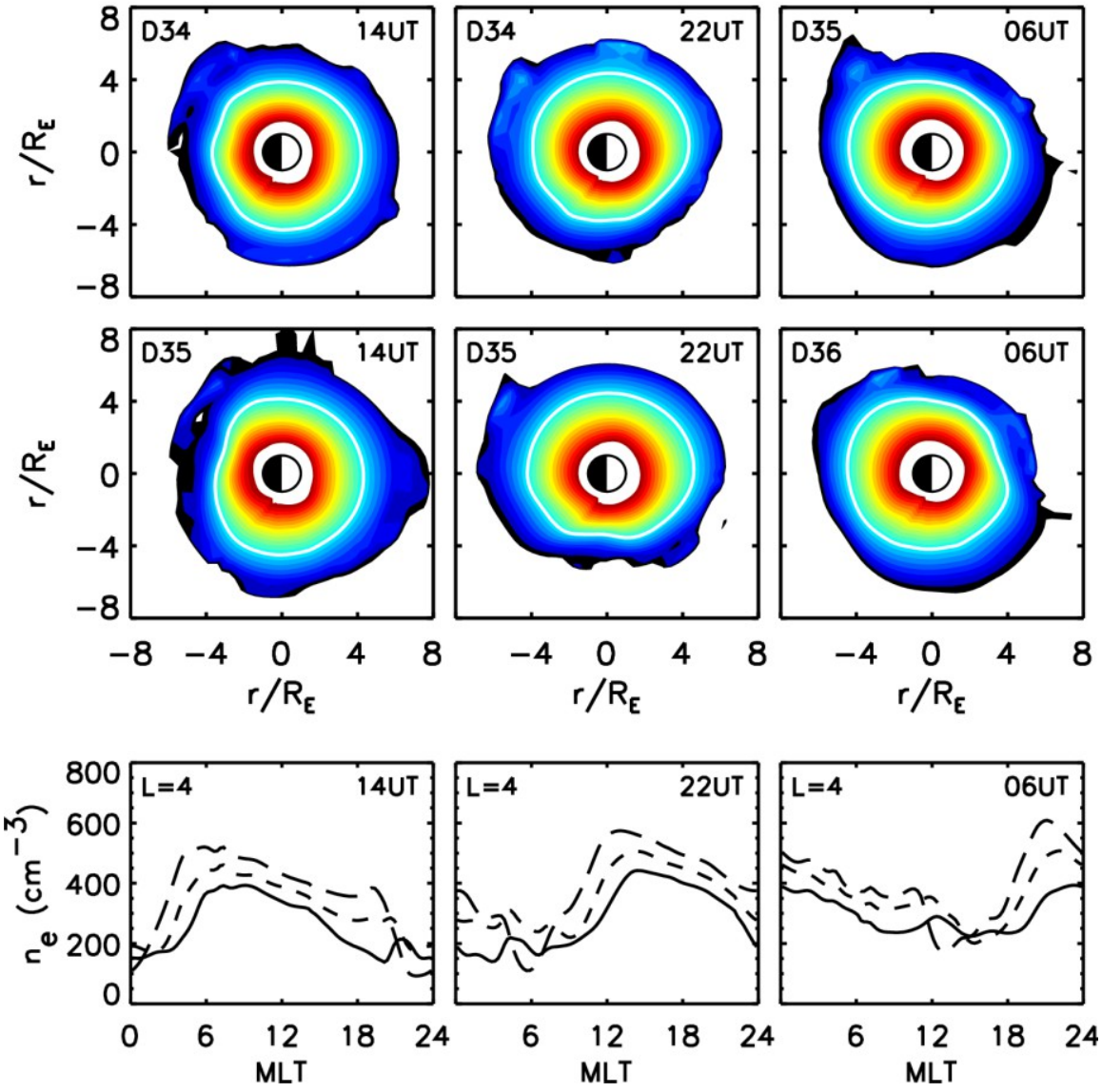
SAMI3: no winds vs. TIMEGCM winds

NRL PPD

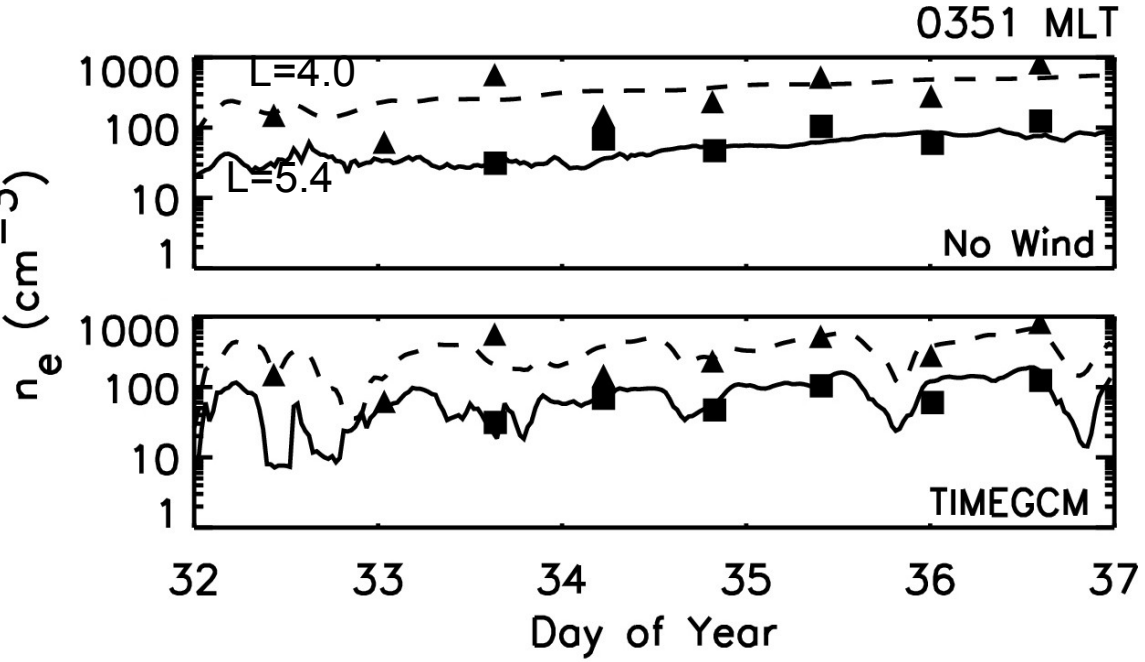


2001 Day 32-36: SAMI3/TIMEGCM

NRL PPD



SAMI3 and IMAGE RPI electron density



No winds → no oscillations

Electron density vs. time at fixed L, MLT, MLAT

Results shown for the no wind case and for SAMI3/TIMEGCM.

Points come from RPI (passive mode) on the IMAGE spacecraft.

We also find that winds inhibit refilling

Direct force vs. wind-driven dynamo

NRL PPD

Direct force:

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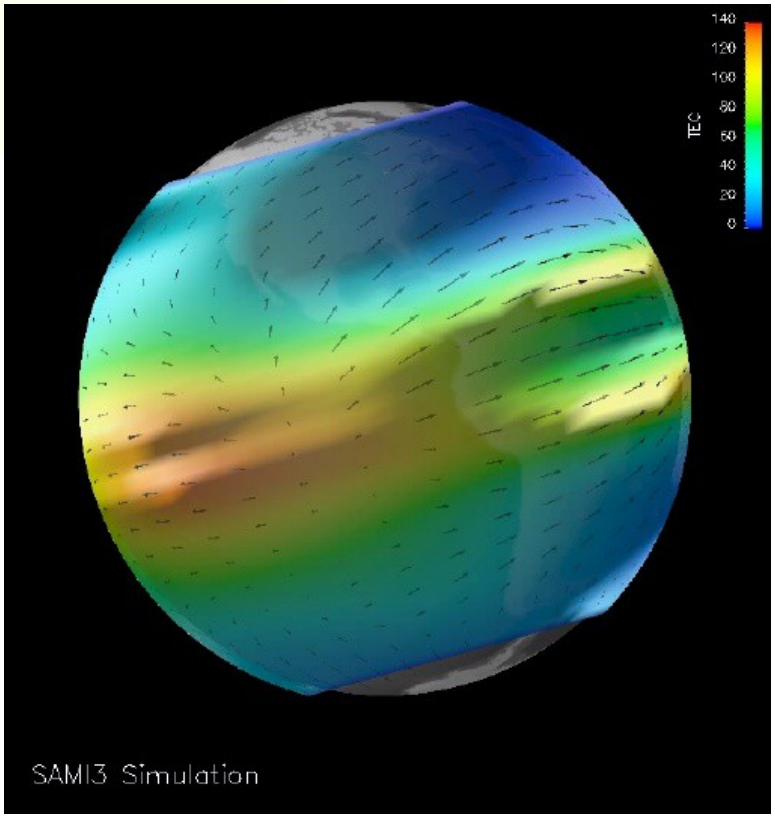
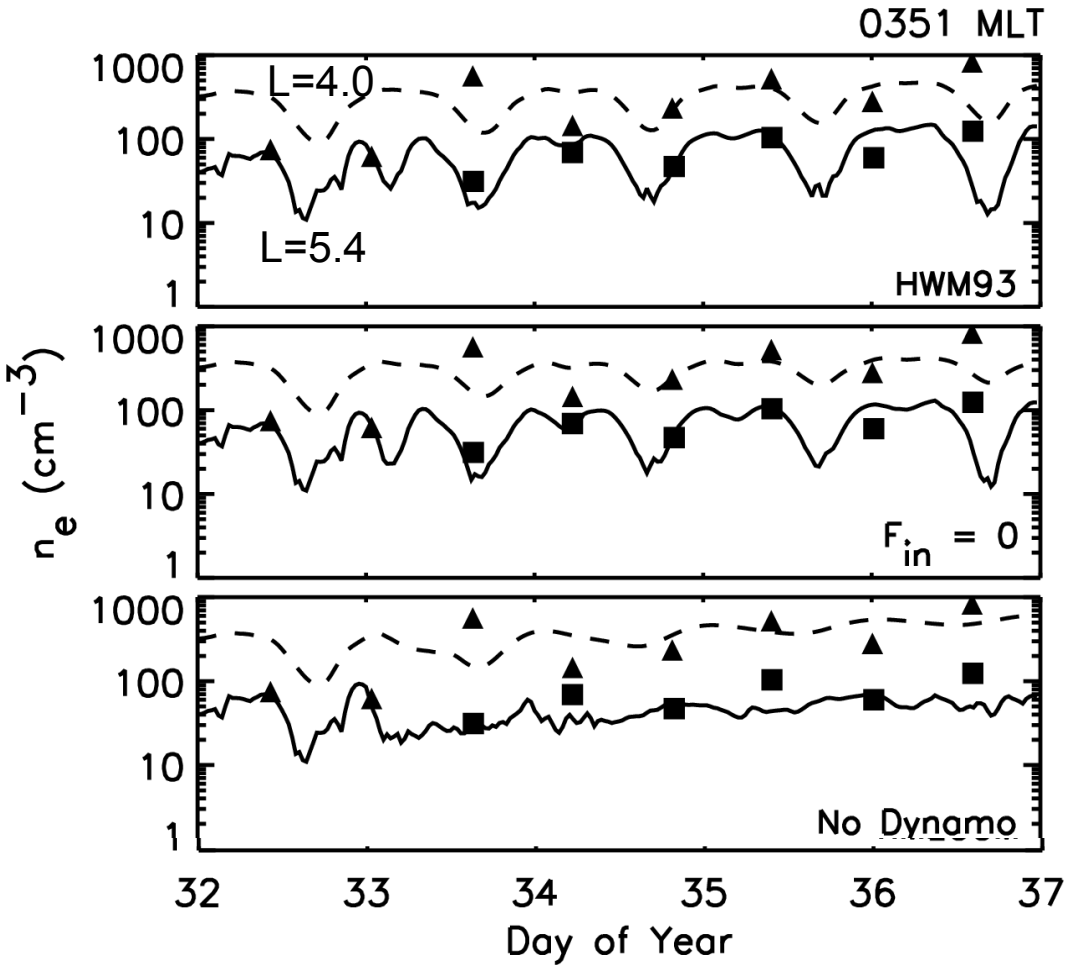


Direct force vs. wind-driven dynamo



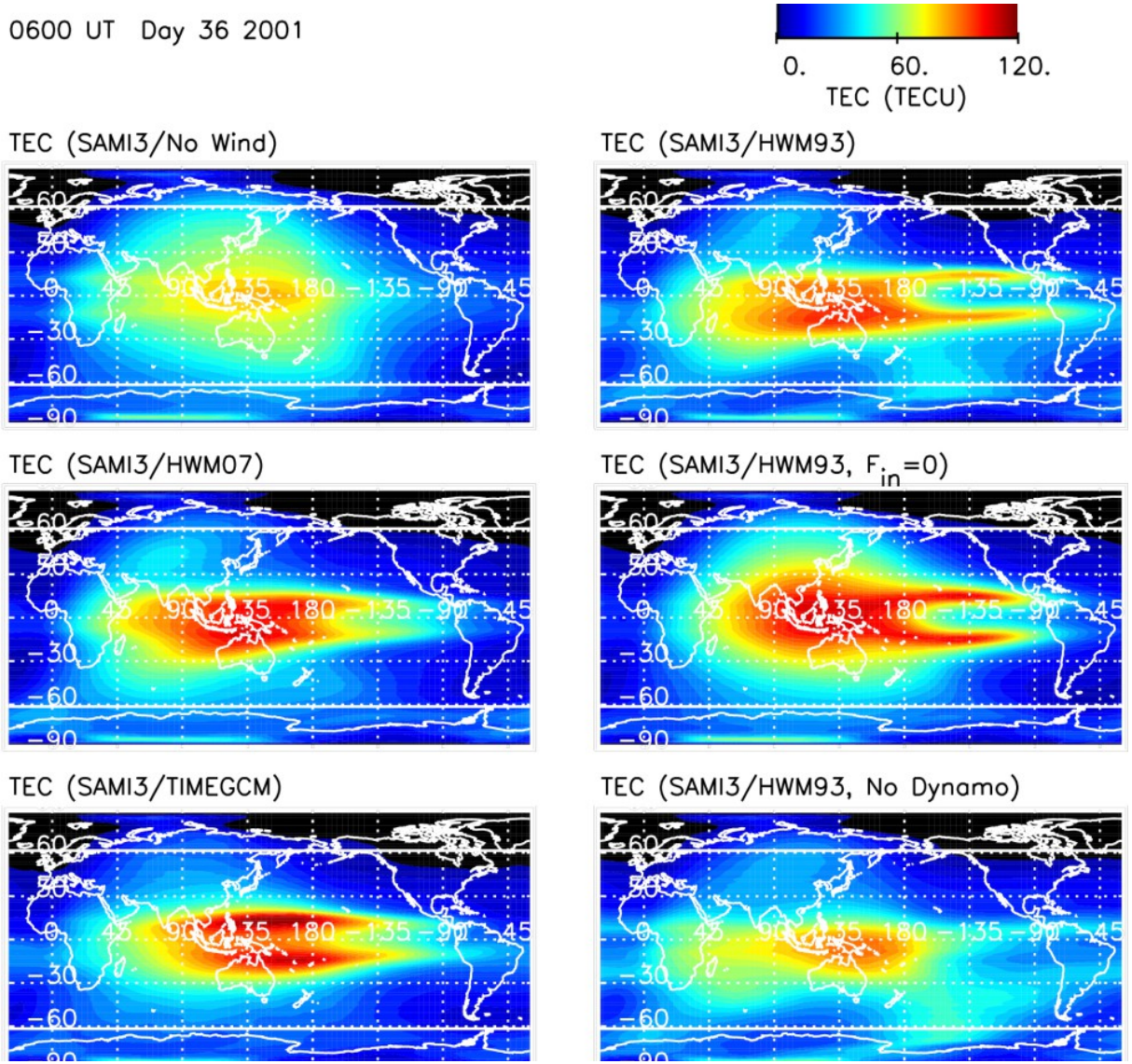
IMAGE/RPI densities are at MLT 03:50

1. SAMI3 with HWM93

2. Without ion-neutral forces, the oscillations persist.

3. Oscillations are gone in the "No Dynamo" case.

TEC maps and winds

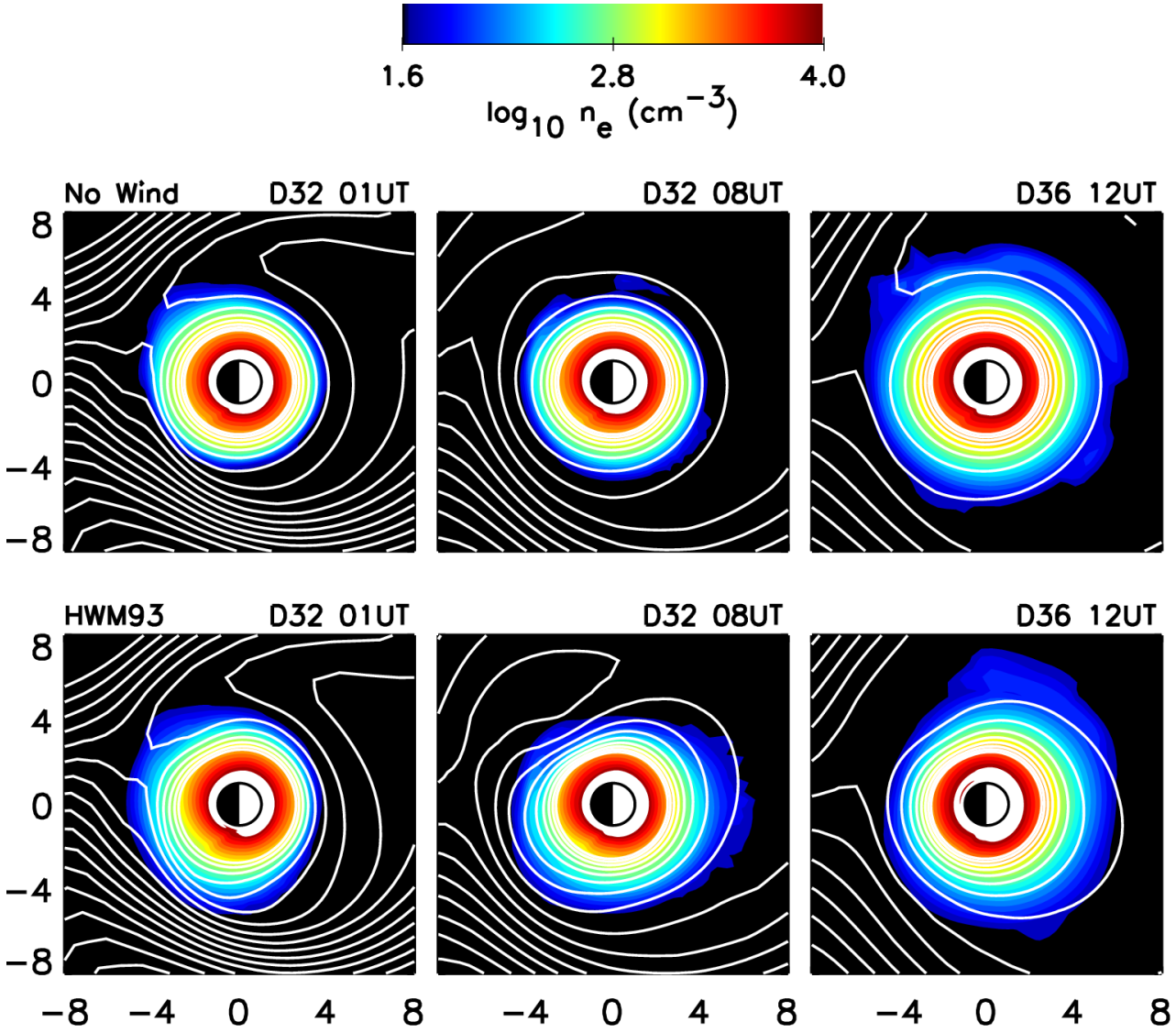


Winds shape the ionosphere as well as the plasmasphere.

Outflow to 3<L<7 is steadier without winds.

Electrostatic potential contours

NRL PPD



Discussion

Winds shape the quiet plasmasphere out to about L=5.

Winds inhibit post-storm refilling of the plasmasphere.

The mechanism seems to be zonal **E** x **B** drifts (shape) and vertical **E** x **B** drifts (refilling).

Assuming all wind models used are valid, use of multiple wind models (HWM93, HWM07, TIMEGCM) is a proxy for day-to-day variability in the winds.

Winds may cause day-to-day variability in the quiet plasmasphere.

[Krall, Huba, Denton, Crowley, Wu, JGR, 2014]