Validating Equatorial Plasmasphere Simulations with the Van Allen Probes

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Source and Loss of Plasma Density

Convection Potential

Refilling Timescale

\[
E \times B \left| \frac{\partial n_{eq}}{\partial t} \right| \frac{n_{sat} - n_{eq}}{\tau}
\]

Semi-Empirical Approach: Spacecraft database combined with theory

- Volland-Stern & SAPS potential and IRI/MSIS derived ionospheric fluxes
Evolution of Equatorial Plasma Density

Initial Plasmasphere

\[ mL + b \mid \log_{10}(n_{sat}) \mid EMFISIS \]

Empirical Approach: fit and compare model to in situ spacecraft data

- Carpenter & Anderson saturated plasmasphere and EMFISIS density
Pre-Midnight Observed Geomagnetic Storm

**CASE 1:** Inner-magnetosphere parameters

First Week of June 2013: severe erosion of plasmaspheric density

- A long, moderate plateau follows the strong peak in geomagnetic activity
Sunward Surge: formation phase of a plume in response to erosion

- Strengthening of convection narrows plasma duskside-bulge
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Extracting Plasmapause Locations

RBSP-A EMFISIS Observations

Plasmapause Highlight

Post-storm Features: variable and asymmetric plasmapause

- Simulation produces less prominent plasmapause than observed
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Coincidence of Extracted Plasmapause Locations

Plasmapause Encounters: overestimated by simulation in moderate activity

- Asymmetric plasmapause appears during post-storm plateau
CASE 2: Solar Wind Parameters

Post-Midnight Observed Geomagnetic Storm

Third Week of January 2013: moderate erosion of plasmaspheric density

- Abrupt increases in geomagnetic activity are OOM above quiet background
Impact of Geomagnetic Storm on Plasmasphere

Corotation Region Expands: plasma carried around Earth after erosion
- Weakening of convection furthers extent of drift paths closed to Earth
Extracting Plasmapause Locations

Pre-storm Features: variable but symmetric plasmapause

- Simulation better captures steepness of observed plasmapause
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Coincidence of Extracted Plasmapause Locations

Plasmapause Encounters: closely followed by simulation throughout activity

- RBSP A outlier during active time due to density measurement technique
Comparison of Simulation Fidelity

**Pre-Midnight Event**

- **Outbound**
- **Inbound**

**Post-Midnight Event**

- **Outbound**
- **Inbound**

**Difference in Plasma Density:** simulation versus observations

- Better reproduces plasmaspheric density within plasmapause
Discussion of Results

Impact of Convection Parameterization on Plasmasphere

- **Plasmapause Comparison:** solar wind driven versus Kp driven simulation
- Solar wind trial produces more distinct erosion and recovery than Kp trial
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Including the Sub-Auroral Polarization Stream

Duskward Electric Field: observed by EFW and produced by convection
- Strong enhancements coincident with severe plasmasphere erosion

Following Thaller et al. 2015
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Impact of Convection Parameterization on Plasmasphere

Plasmapause Comparison: solar wind driven versus Kp driven simulation

- Kp trial exerts stronger convection on plasmasphere than solar wind trial
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Modifying the Viscous Solar Wind Interaction

Activity Threshold: stronger versus weaker background level

- Quiet time activity level dictates full extent of plasmapause during recovery
First Week of June 2013: case better simulated by stronger activity with the Kp-index

\[ \Delta L_{AVG} = 0.39 \pm 0.05 \]

Third Week of January 2013: case better simulated by weaker activity with the solar wind parameterization

\[ \Delta L_{AVG} = 0.42 \pm 0.06 \]

**RAM-CPL Plasmasphere**: provides evolution of equatorial electron density

Future work will apply self-consistent electric and magnetic fields with RAM