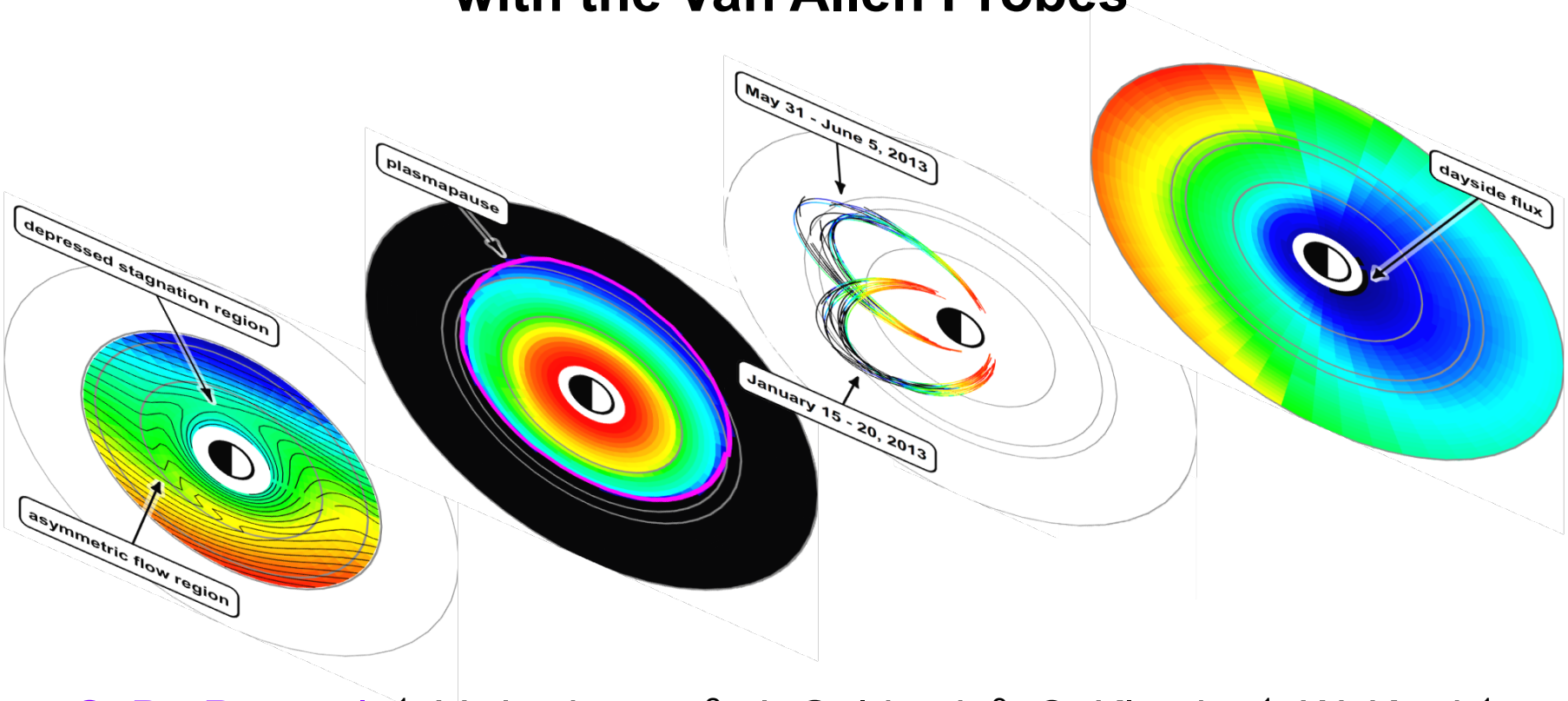
Validating Equatorial Plasmasphere Simulations with the Van Allen Probes

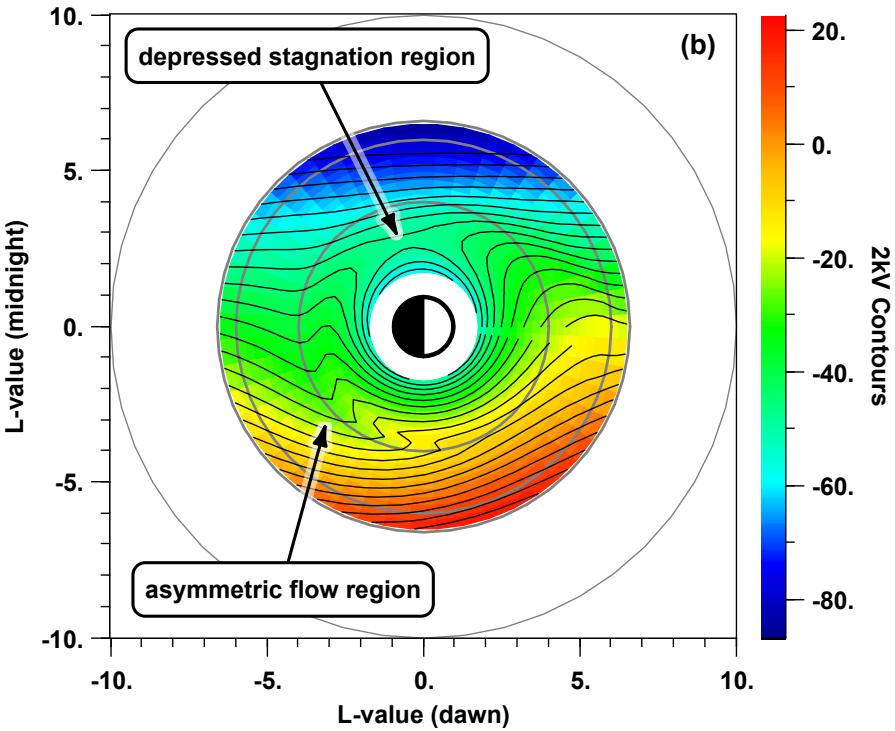


S. De Pascuale[1], V. Jordanova[2], J. Goldstein[3], C. Kletzing[1], W. Kurth[1], S. Thaller[4], and J. Wygant[4]

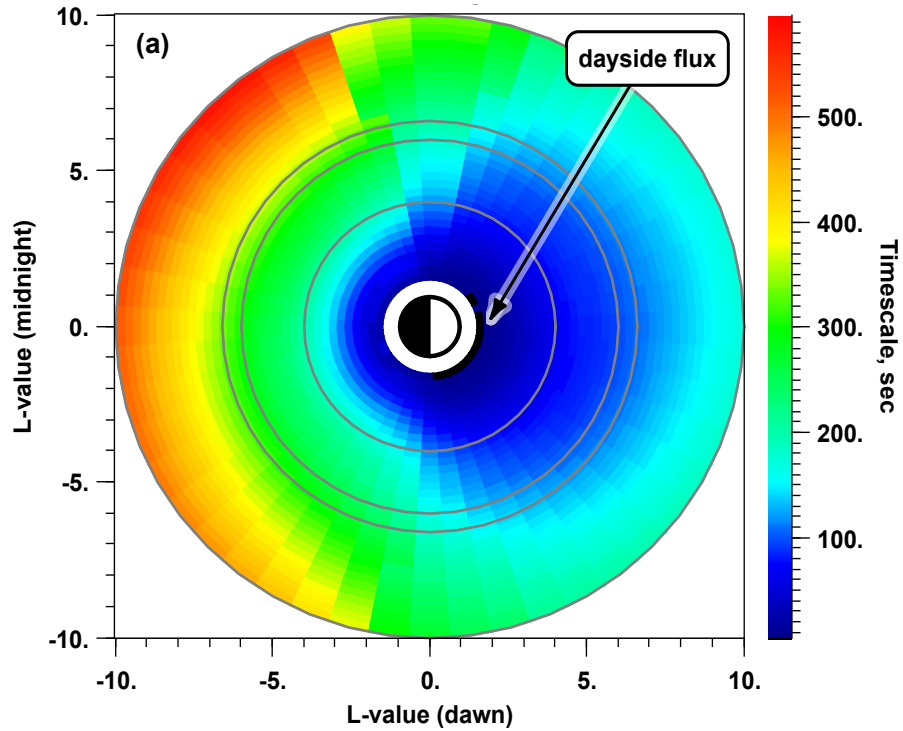
(1) University of Iowa, (2) Los Alamos National Laboratory, (3) Southwest Research Institute, (4) University of Minnesota

Source and Loss of Plasma Density

Convection Potential



Refilling Timescale



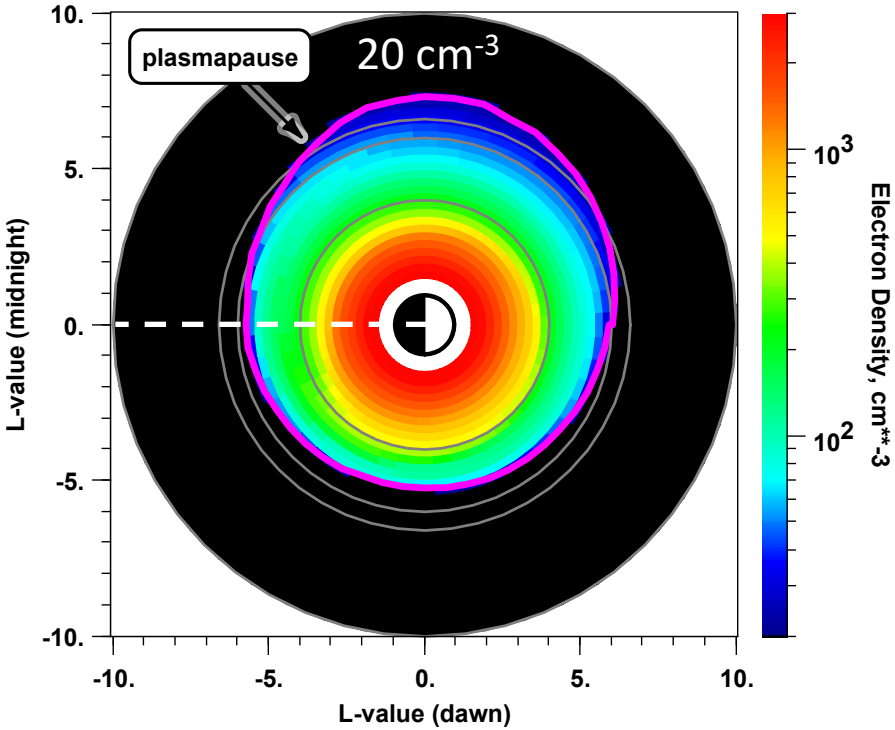
$$\mathbf{E} \times \mathbf{B} \mid \frac{\partial n_{eq}}{\partial t} \mid \frac{n_{sat} - n_{eq}}{\tau}$$

Semi-Empirical Approach: Spacecraft database combined with theory

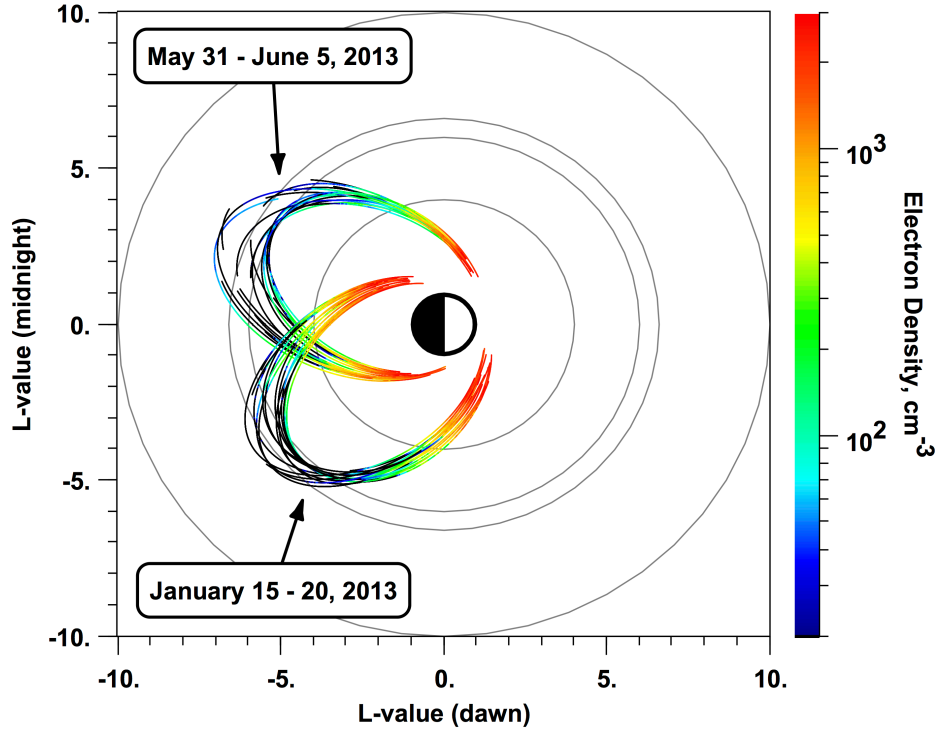
- ❑ Volland-Stern & SAPS potential and IRI/MSIS derived ionospheric fluxes

Evolution of Equatorial Plasma Density

Initial Plasmasphere



RBSP-A Observations



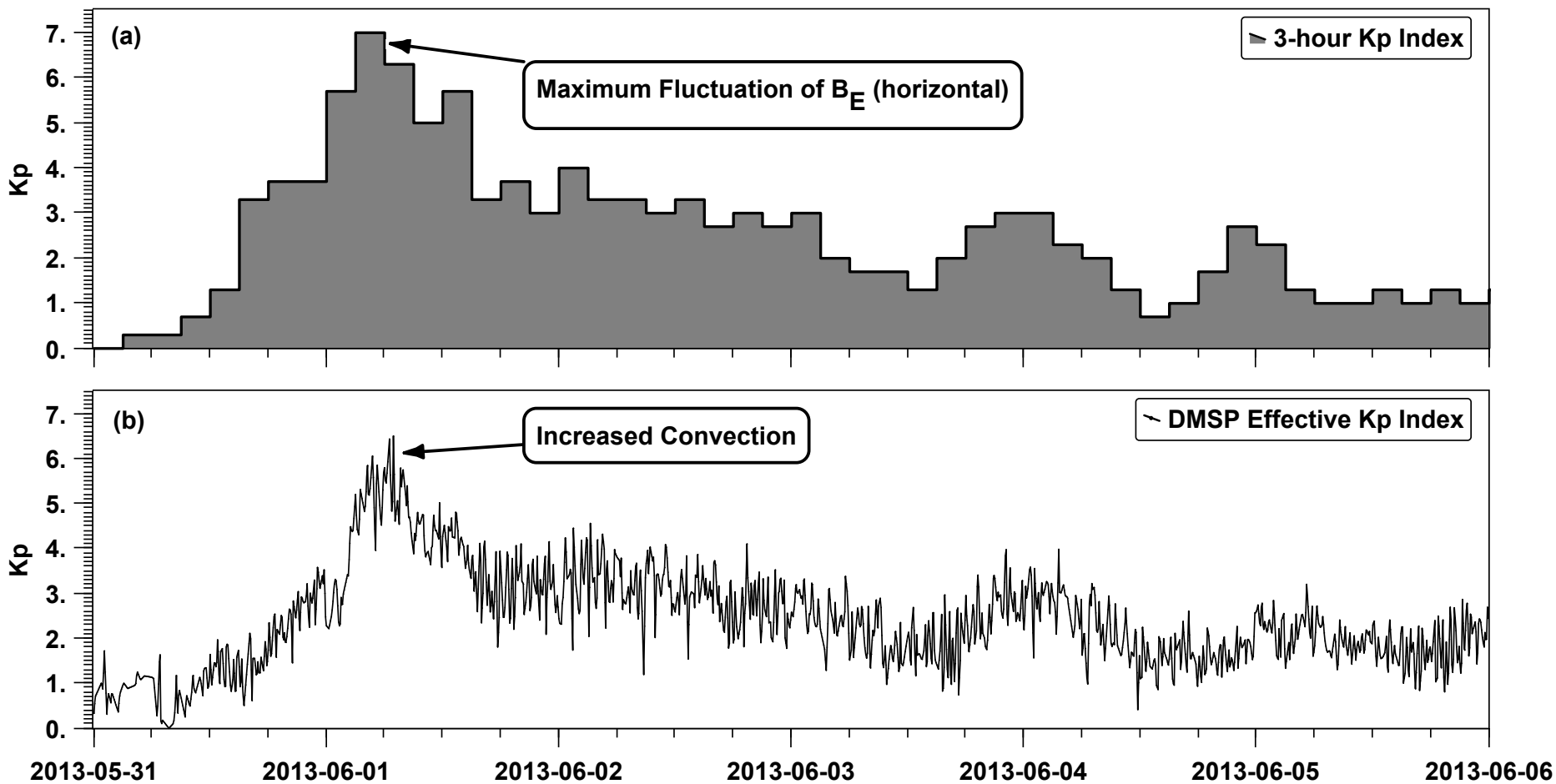
$$\underline{mL + b} \mid log_{10}(n_{sat}) \mid EMFISIS$$

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

- ❑ Carpenter & Anderson saturated plasmasphere and EMFISIS density

CASE 1: Inner-magnetosphere parameters

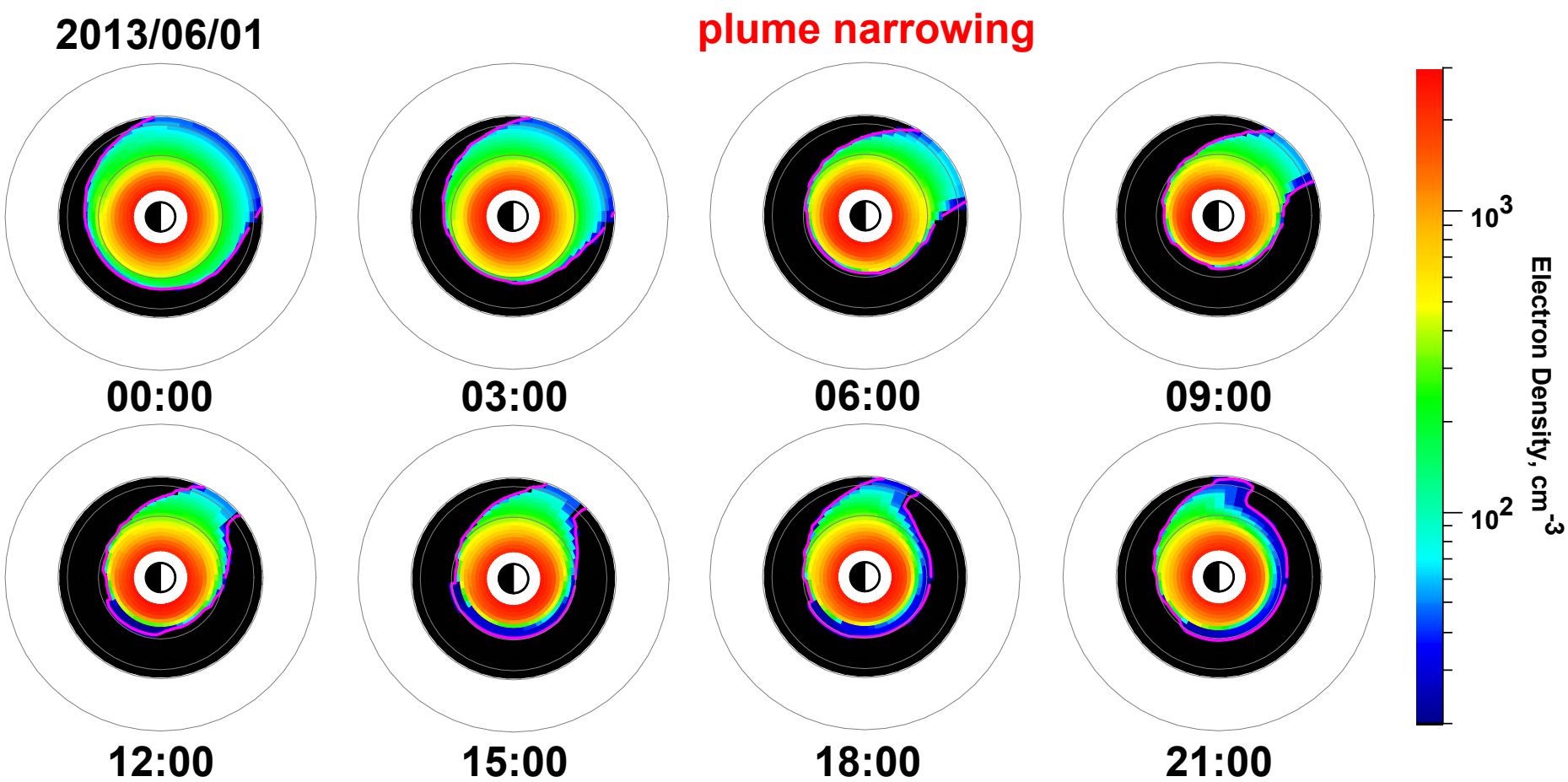
Pre-Midnight Observed Geomagnetic Storm



First Week of June 2013: severe erosion of plasmaspheric density

- A long, moderate plateau follows the stong peak in geomagnetic activity

Impact of Geomagnetic Storm on Plasmasphere

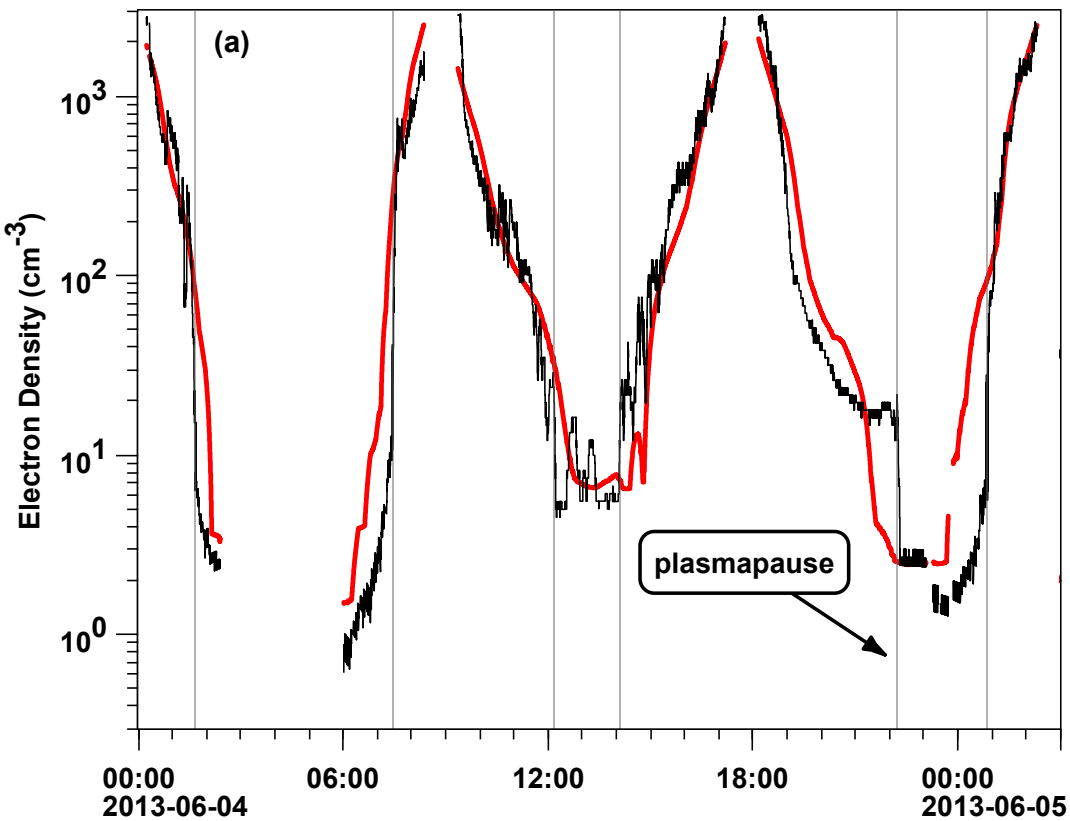


Sunward Surge: formation phase of a plume in response to erosion

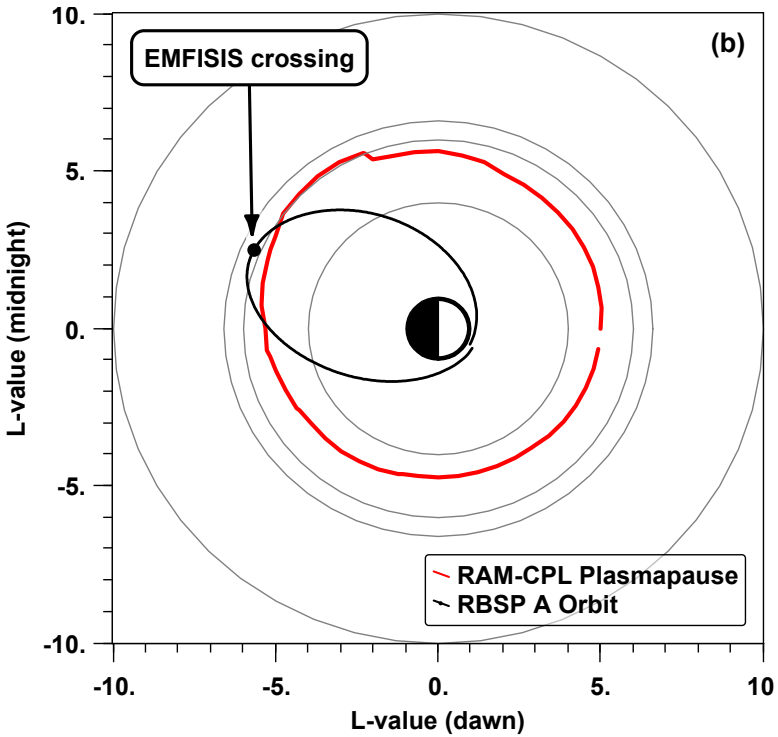
- Strengthening of convection narrows plasma duskside-bulge

Extracting Plasmapause Locations

RBSP-A EMFISIS Observations



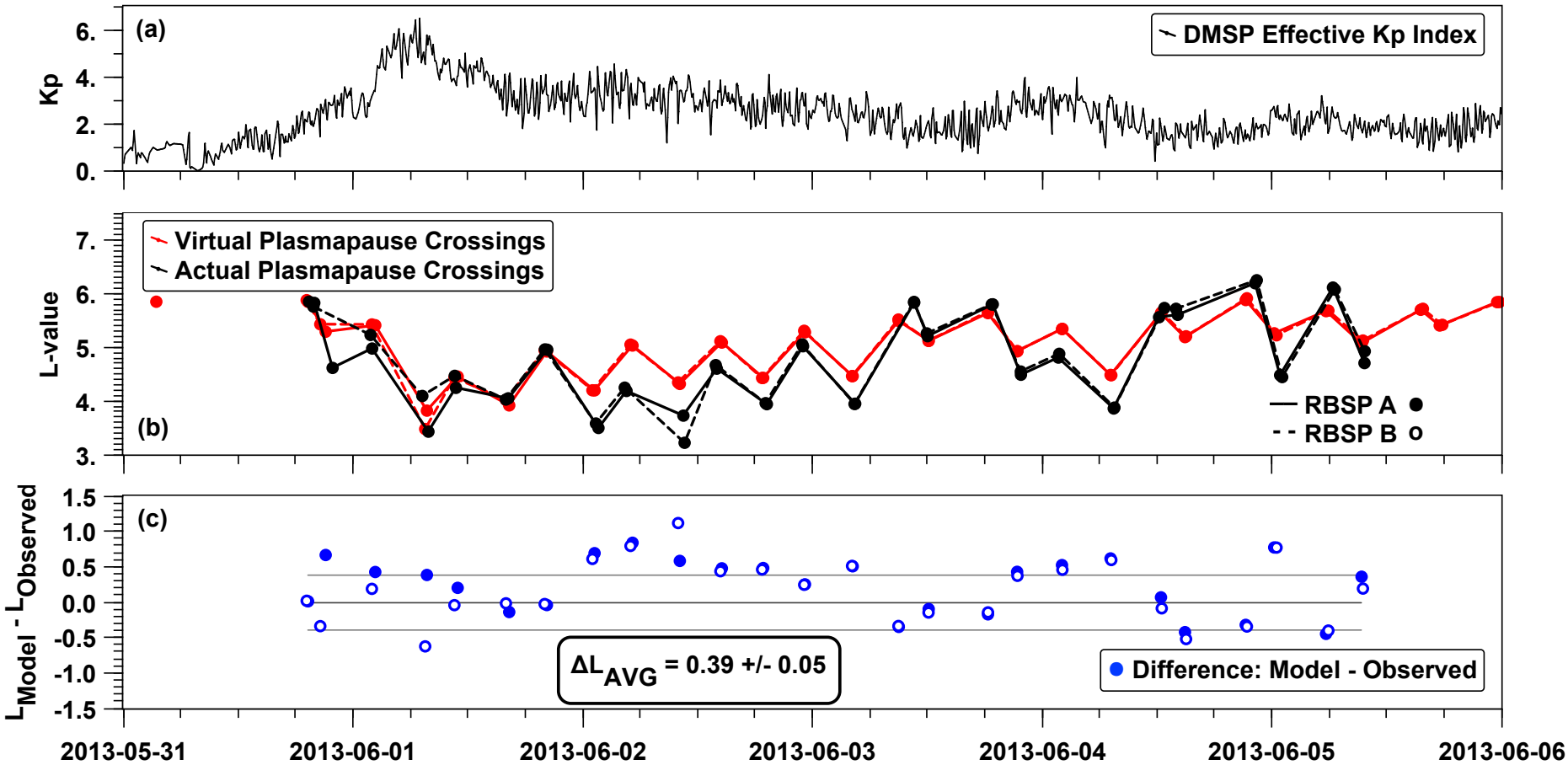
Plasmapause Highlight



Post-storm Features: variable and asymmetric plasmapause

- ❑ Simulation produces less prominent plasmapause than observed

Coincidence of Extracted Plasmapause Locations

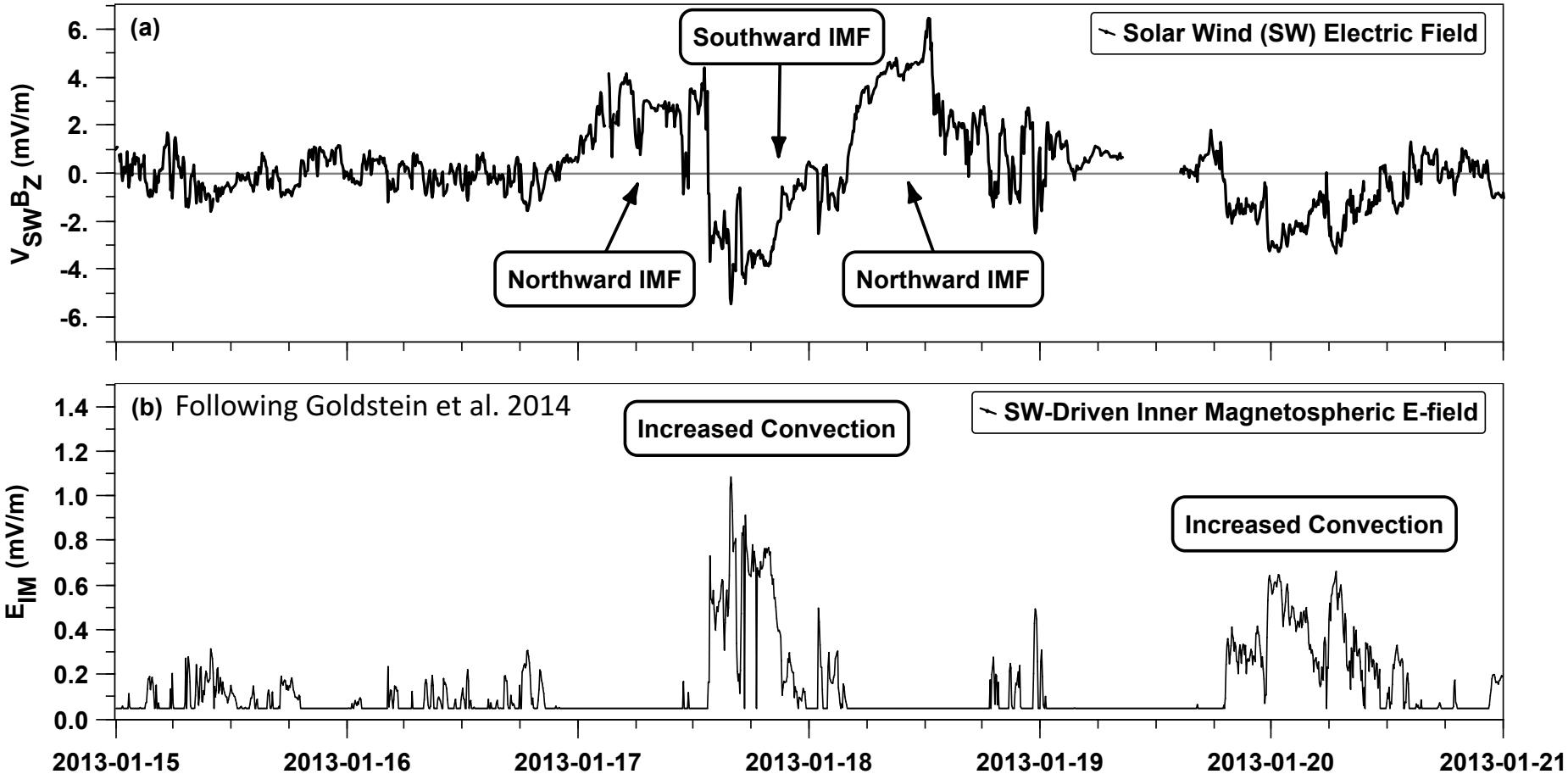


Plasmapause Encounters: overestimated by simulation in moderate activity

- ❑ Asymmetric plasmapause appears during post-storm plateau

CASE 2: Solar Wind Parameters

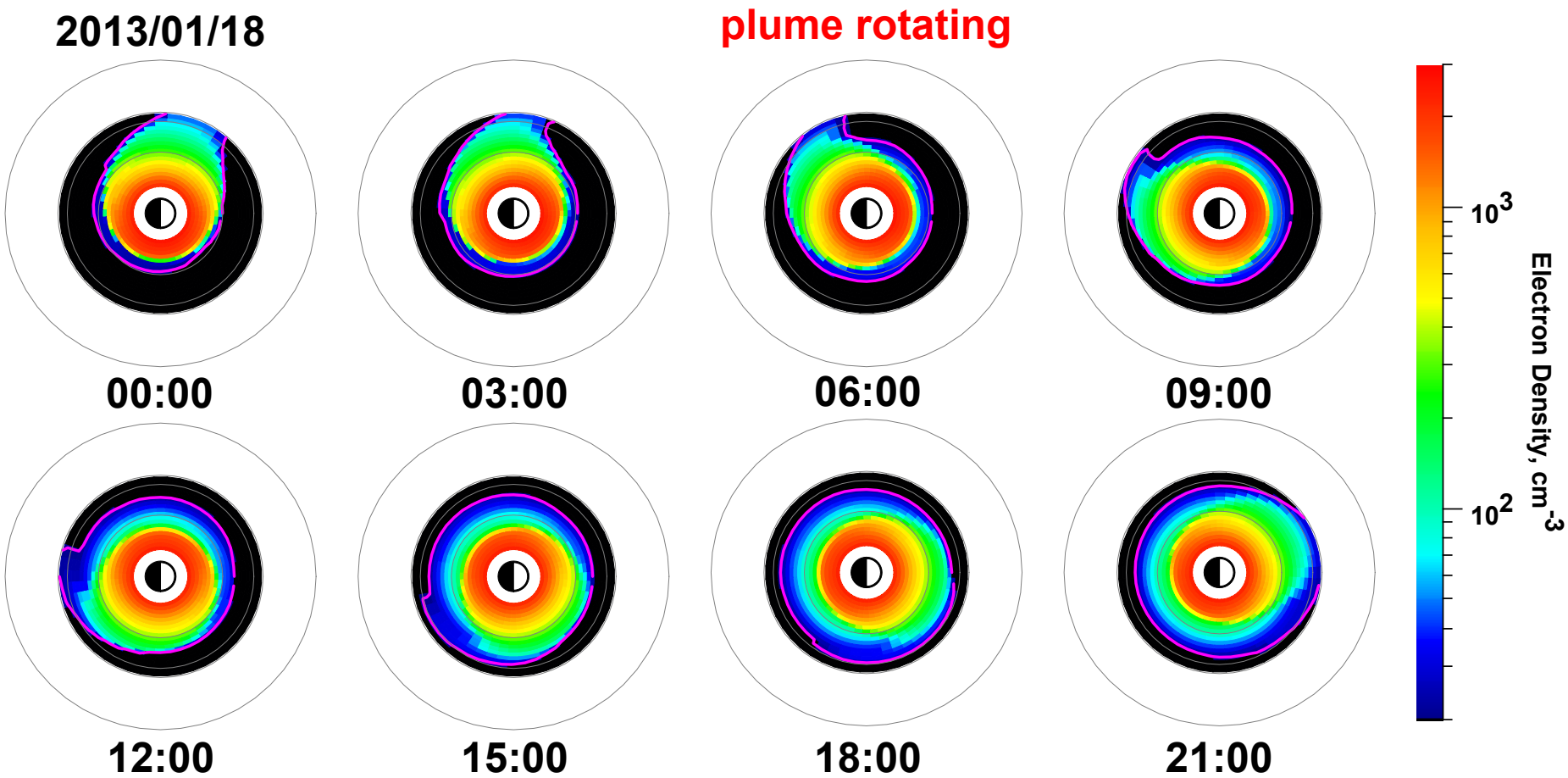
Post-Midnight Observed Geomagnetic Storm



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

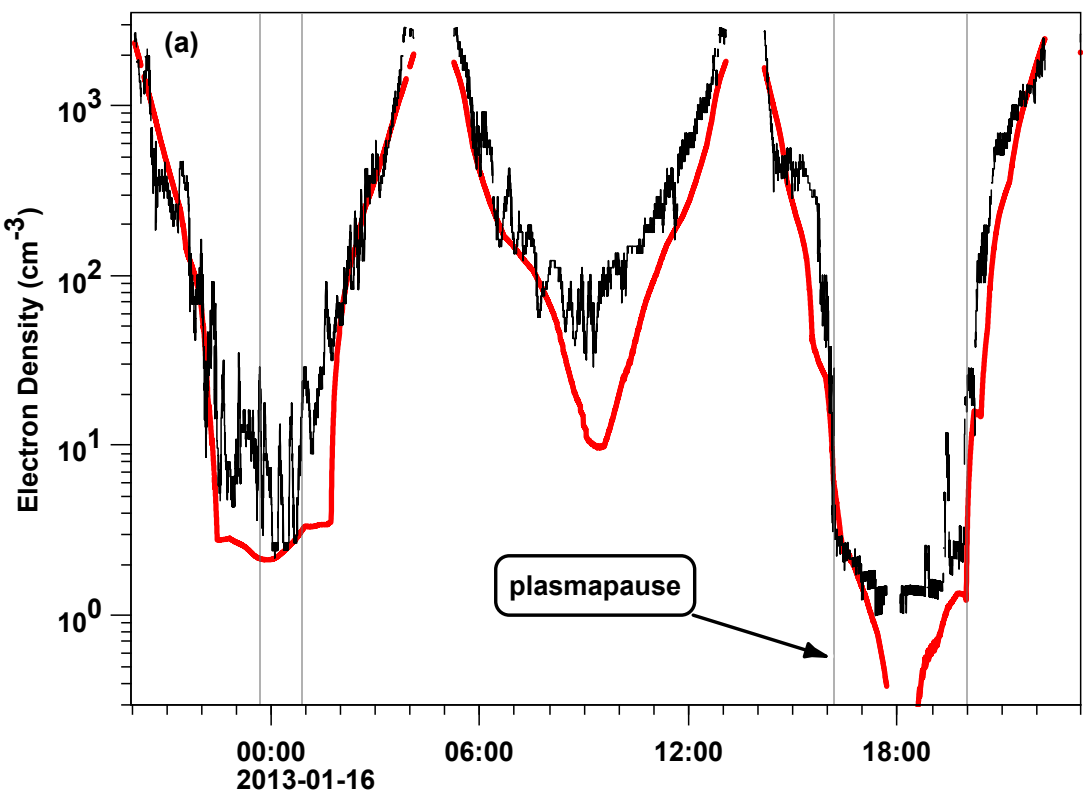


Corotation Region Expands: plasma carried around Earth after erosion

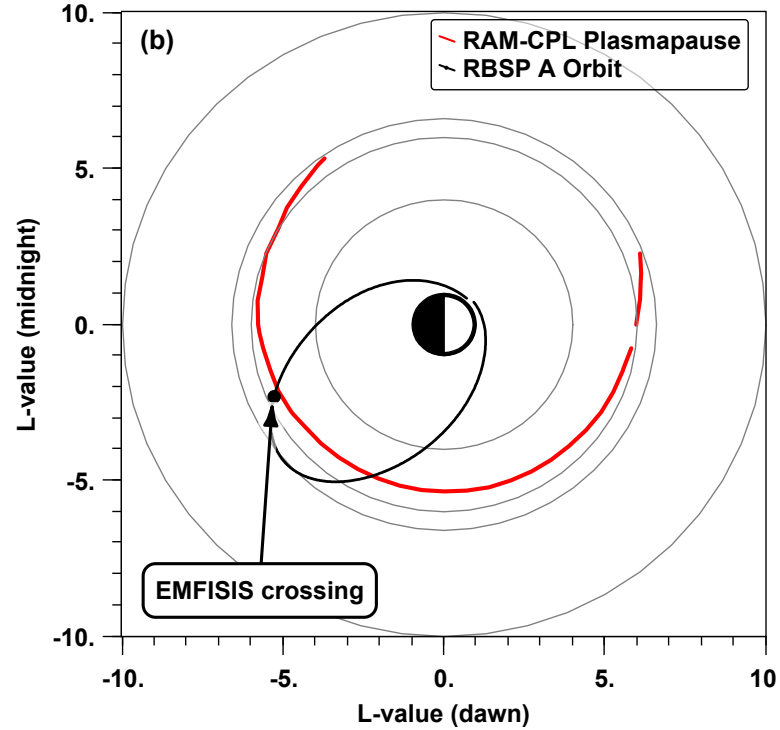
- Weakening of convection furthers extent of drift paths closed to Earth

Extracting Plasmapause Locations

RBSP-A EMFISIS Observations



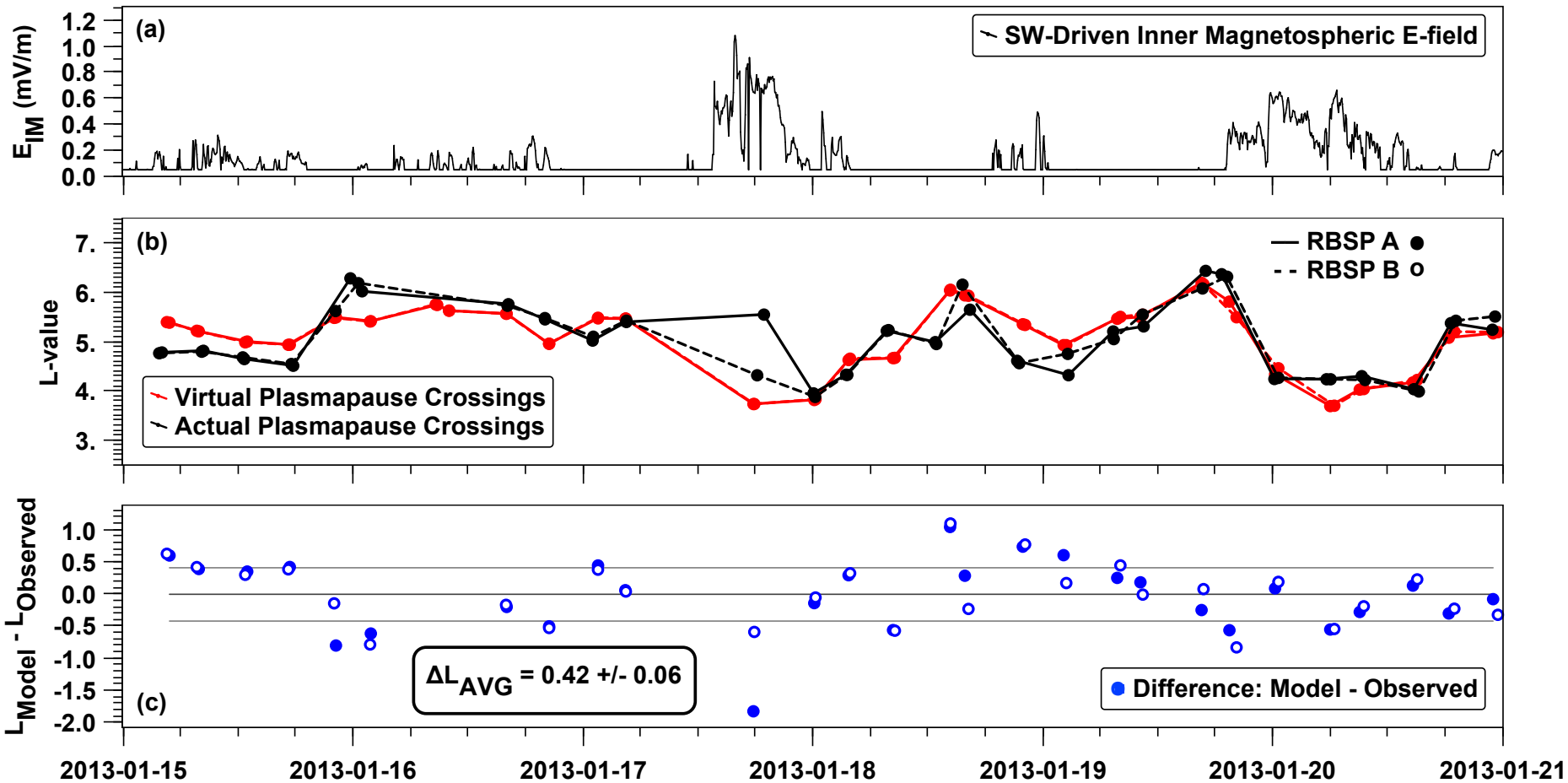
Plasmapause Highlight



Pre-storm Features: variable but symmetric plasmapause

- ❑ Simulation better captures steepness of observed plasmapause

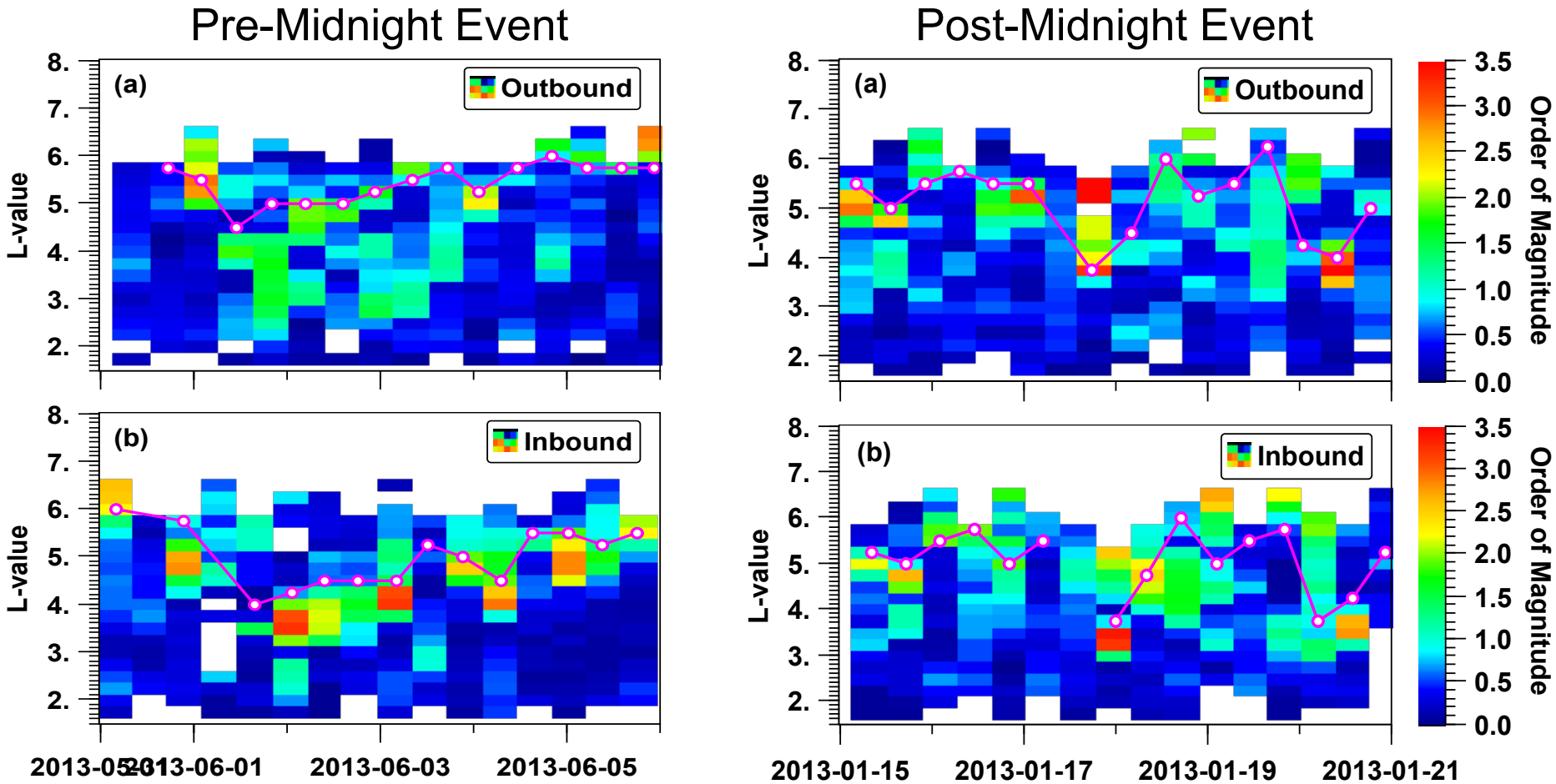
Coincidence of Extracted Plasmapause Locations



Plasmapause Encounters: closely followed by simulation throughout activity

- RBSP A outlier during active time due to density measurement technique

Comparison of Simulation Fidelity

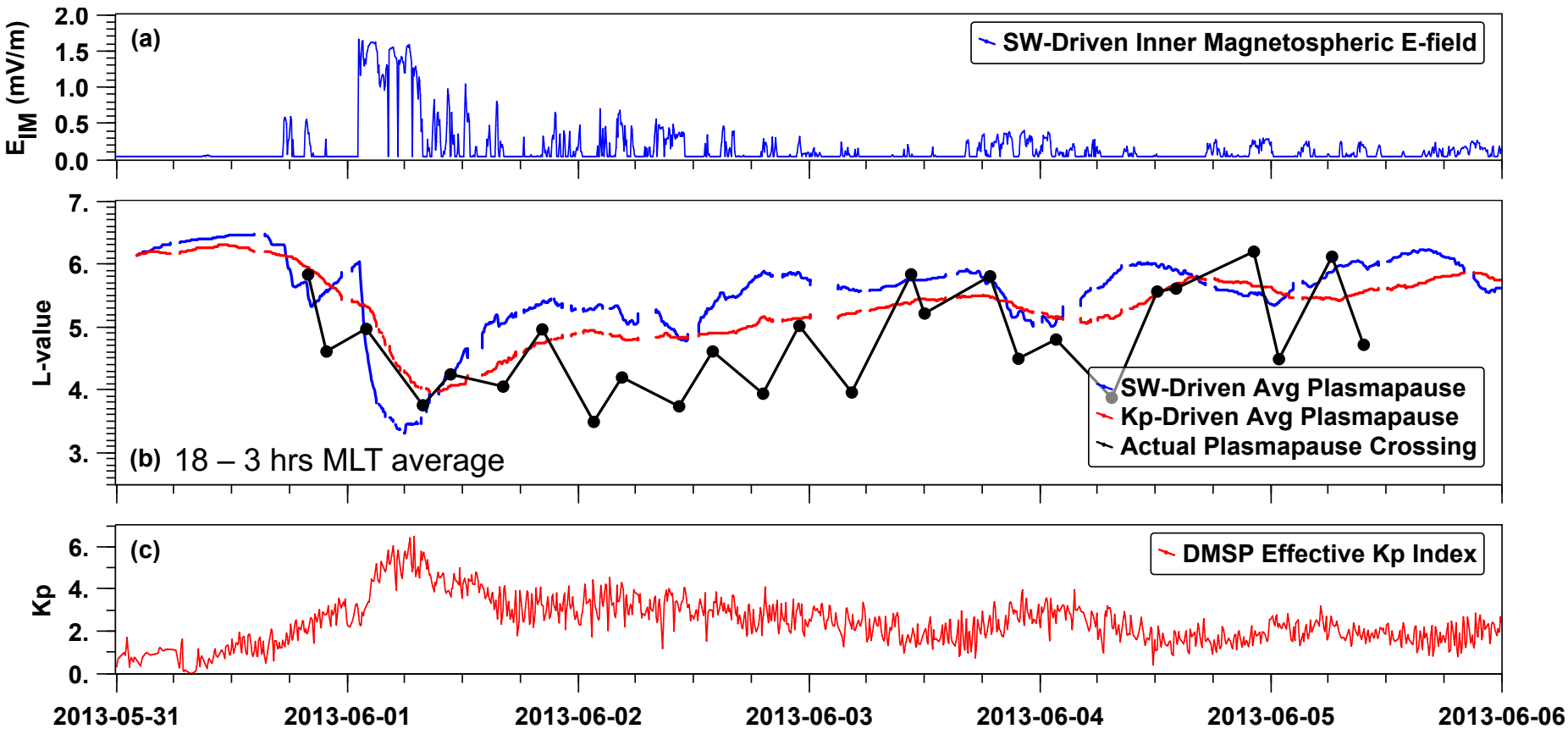


Difference in Plasma Density: simulation versus observations

- ❑ Better reproduces plasmaspheric density within plasmapause

Discussion of Results

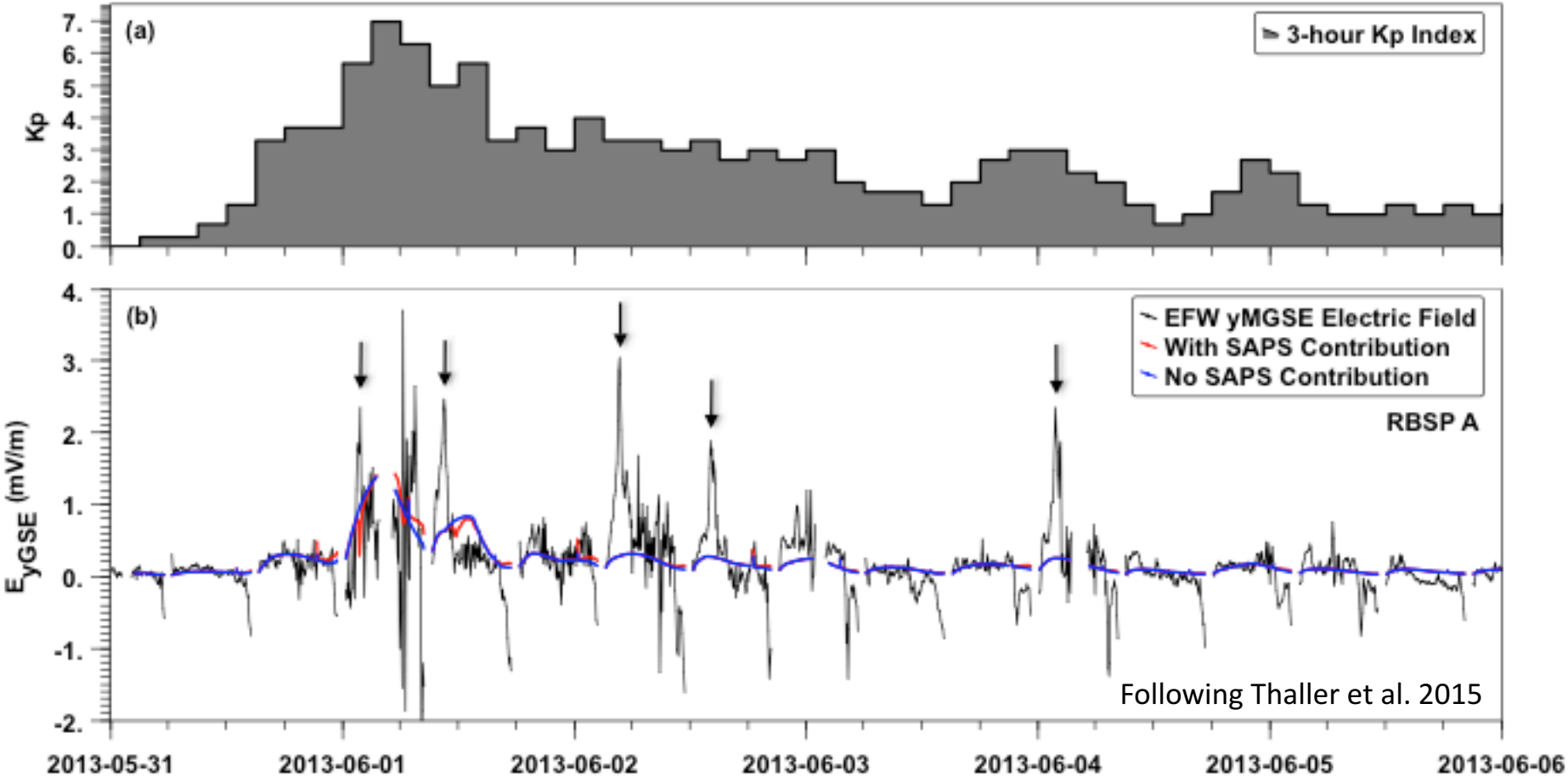
Impact of Convection Parameterization on Plasmasphere



Plasmapause Comparison: solar wind driven versus Kp driven simulation

- ❑ Solar wind trial produces more distinct erosion and recovery than Kp trial

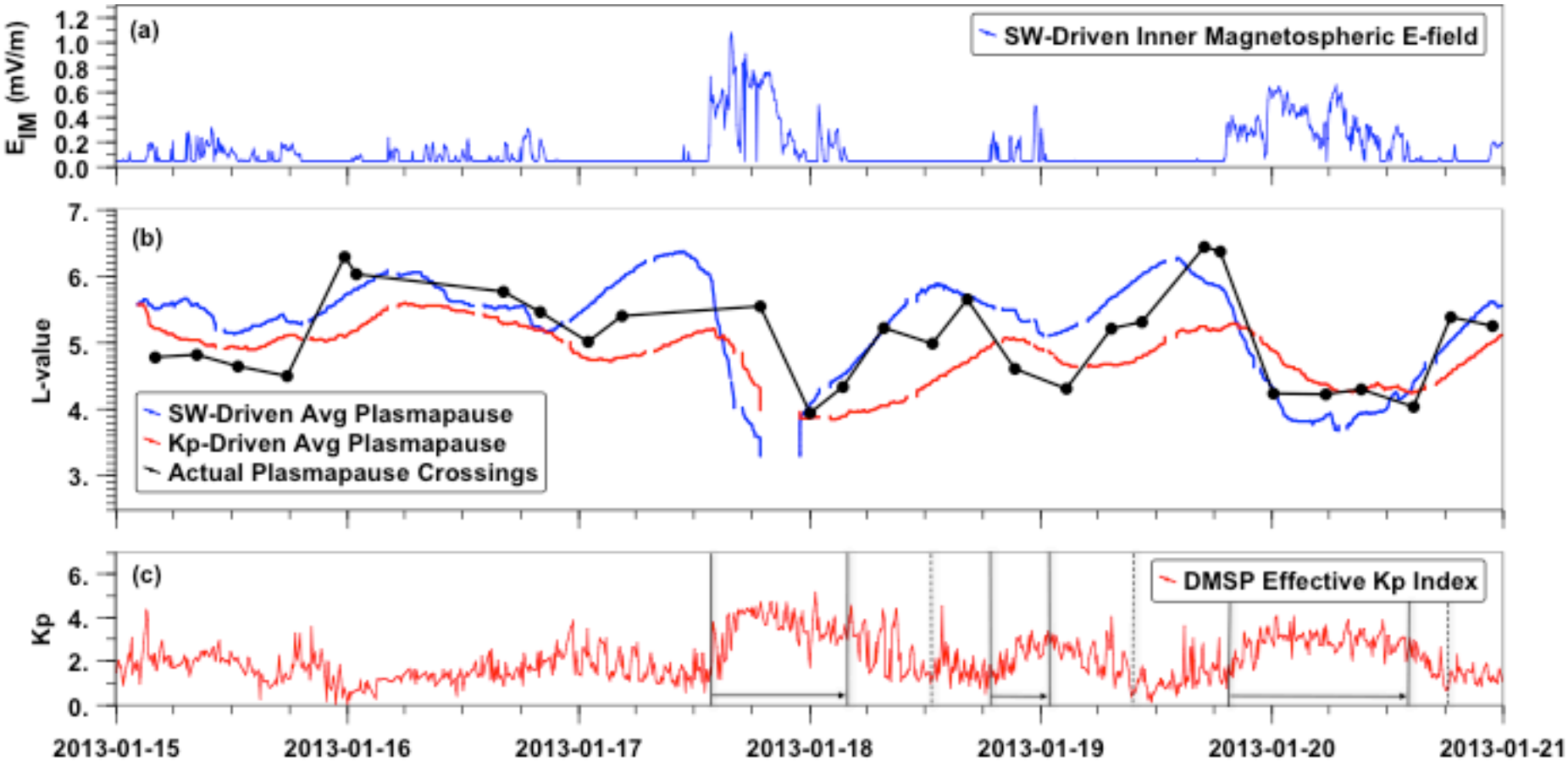
Including the Sub-Auroral Polarization Stream



Duskward Electric Field: observed by EFW and produced by convection

- Strong enhancements coincident with severe plasmasphere erosion

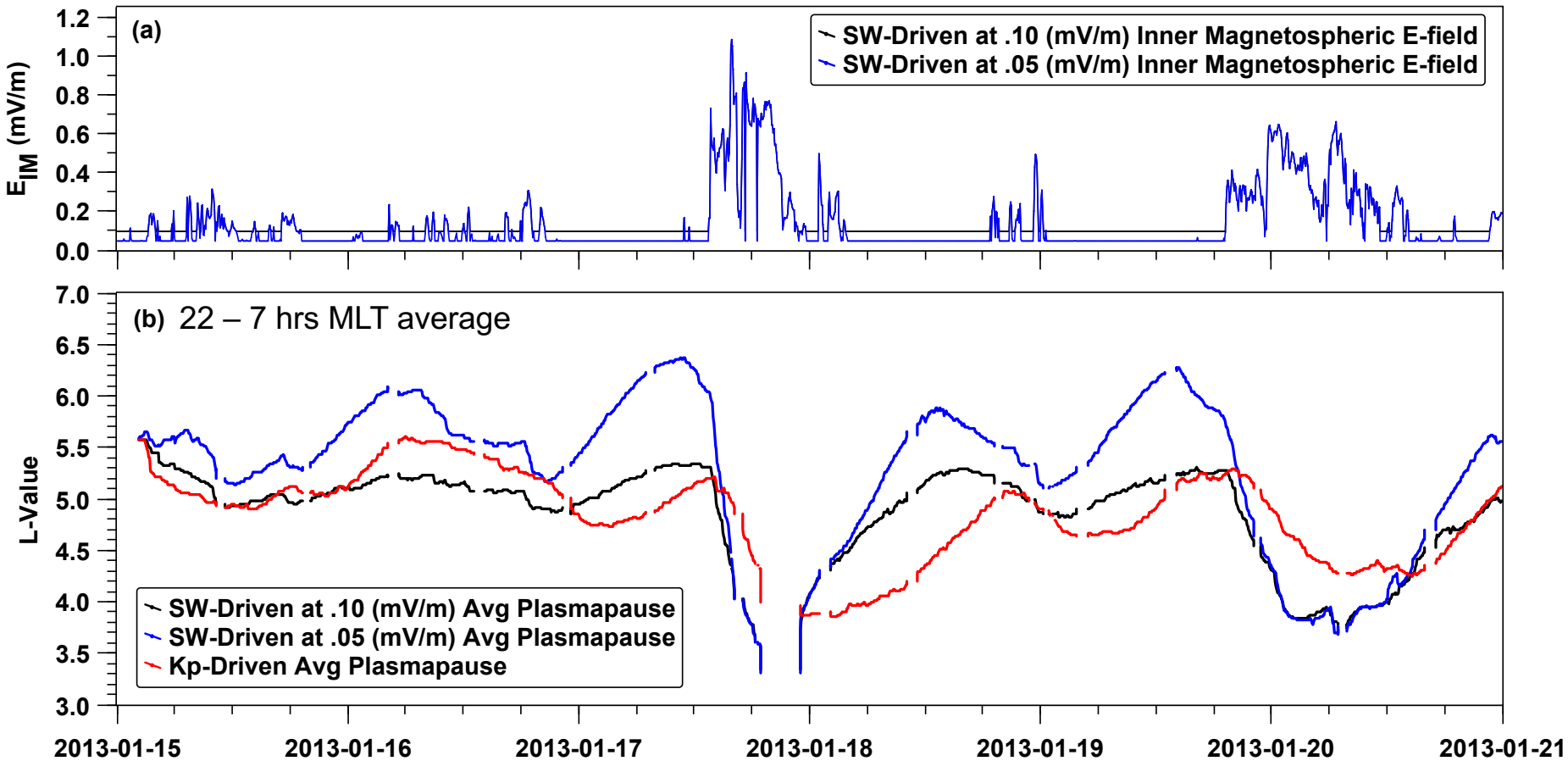
Impact of Convection Parameterization on Plasmasphere



Plasmapause Comparison: solar wind driven versus Kp driven simulation

- Kp trial exerts stronger convection on plasmasphere than solar wind trial

Modifying the Viscous Solar Wind Interaction



Activity Threshold: stronger versus weaker background level

- Quiet time activity level dictates full extent of plasmapause during recovery

Summary & Conclusions

First Week of June 2013: case better simulated by stronger activity with the Kp-index

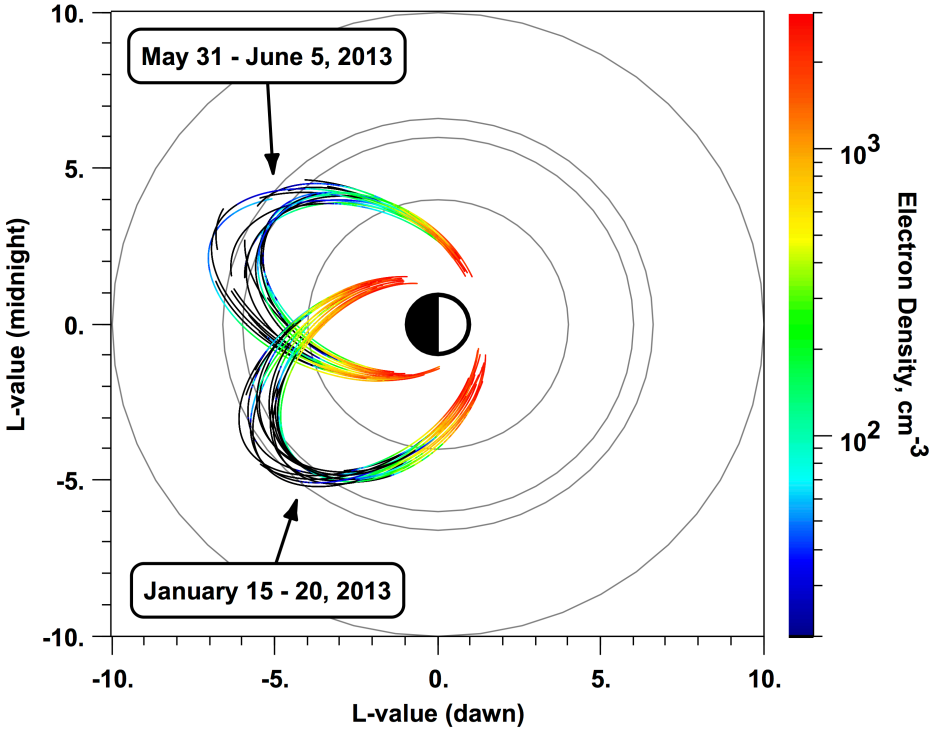
<u>plasmapause difference:</u>

$$\Delta L_{AVG} = 0.39 \pm 0.05$$

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

<u>plasmapause difference:</u>

$$\Delta L_{AVG} = 0.42 \pm 0.06$$



RAM-CPL Plasmasphere: provides evolution of equatorial electron density

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