Inner Magnetospheric Electric Field and its Influence on Plasmasphere Erosion and Plasma Sheet Access

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Abstract

The large-scale electric field in the inner magnetosphere is a key driver of many processes and the dynamics of magnetospheric plasmas. During geomagnetic storms, the enhanced convection electric field is responsible for eroding the plasmasphere and for moving the inner edge of the plasma sheet earthward. In this presentation, we show the preliminary results of an examination of the distribution and variations of the inner magnetospheric quasi-static electric field as measured by the Electric Field and Waves (EFW) instruments onboard the twin spacecraft of the Van Allen Probes mission. We investigate the role that the electric field plays in plasmasphere erosion and plasma sheet access to the inner magnetosphere by analyzing the electric field measurements in conjunction with cold plasma density and plasma sheet particle flux measurements. Since the coupling between plasma populations in the magnetosphere is inherently related to the electric field, we expect that the combined measurements of the electric field and plasmas will enhance our understanding of the physical processes that drive the magnetospheric dynamics.

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Motivation

- The electric field in the inner magnetosphere drives a variety of processes key to understanding the plasma dynamics of the magnetosphere, such as plasmasphere erosion and plasma sheet access.

- Accurate prediction of particle fluxes, necessary for space weather applications, requires a realistic model of the electric field.

- The Van Allen Probes mission delivered extensive and high-quality measurements of the electric field, the cold plasma density and plasma sheet particle fluxes, allowing the study of the role of the electric field on these plasma populations.

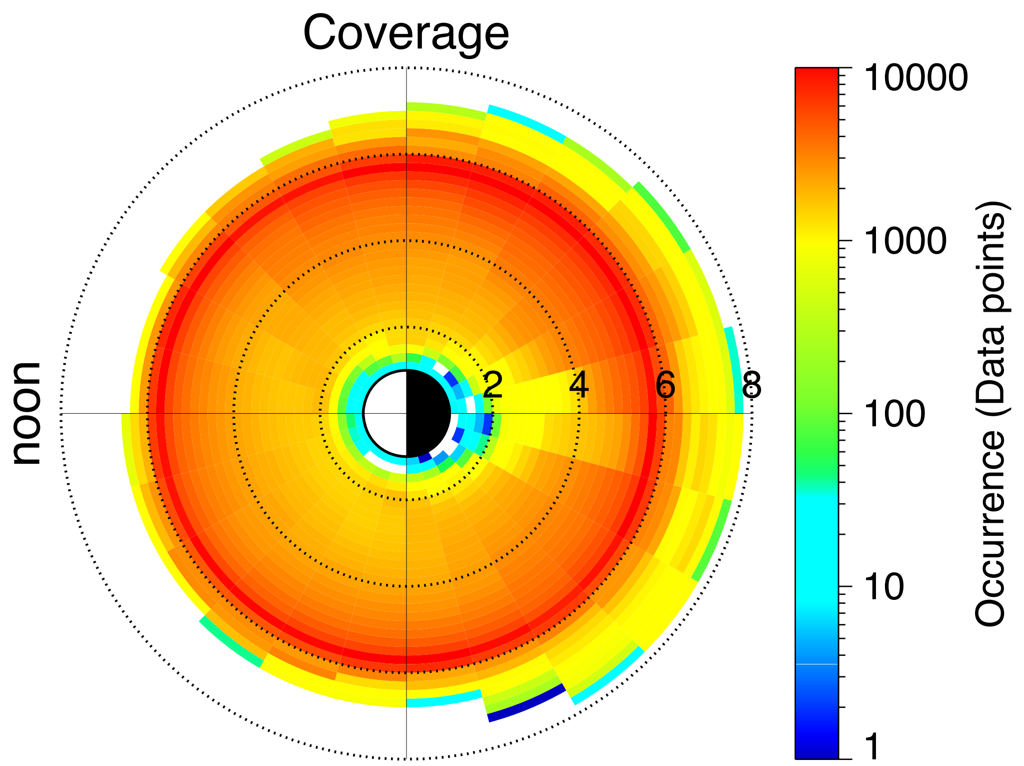
Mission and Instrumentation

Mission:

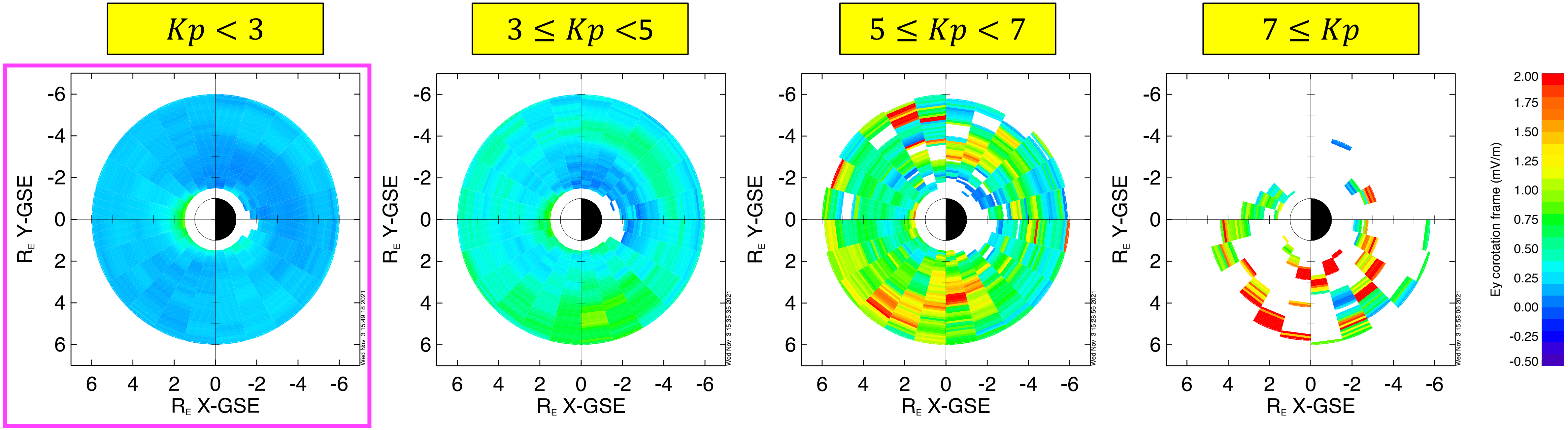
- NASA's Van Allen Probes
- Statistical results from Van Allen Probes A: September 2012 to December 2016 (over 4 years)

Instruments:

- Electric field and cold plasma density: Electric Field and Waves (EFW) instrument
- Particle pressures: Helium, Oxygen, Proton and Electron (HOPE) mass spectrometer



Geomagnetic Activity Dependence of E_Y

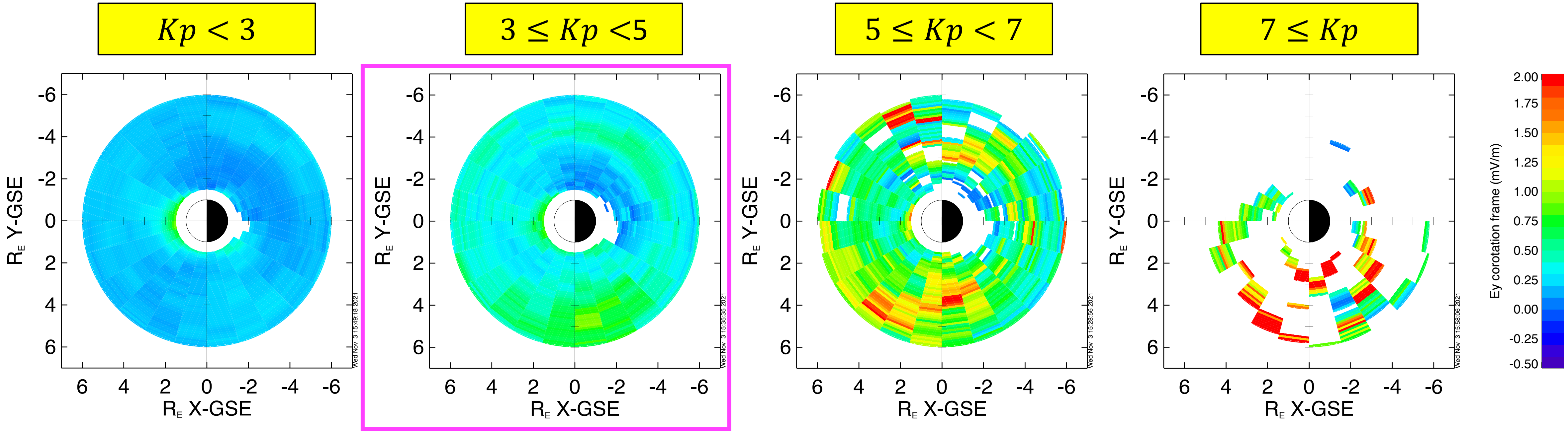


Synoptic maps of the dawn-dusk electric field in the corotating reference frame

<u>Low *Kp* intervals</u> ($Kp < 3$)

- Strongest electric fields (~0.3 mV/m) observed in three regions:
  - ✓ Just after dusk near the RBSP apogee at L=6
  - ✓ In the midnight-dawn sector near L=5
  - ✓ On the dayside near MLT=11 and L=3

Geomagnetic Activity Dependence of E_Y

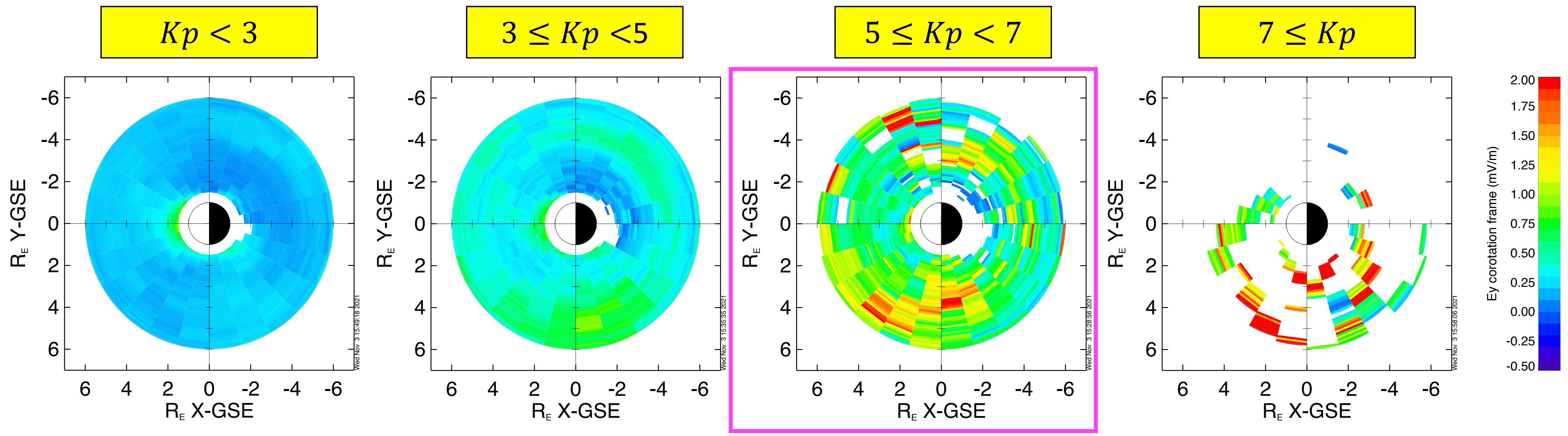


Synoptic maps of the dawn-dusk electric field in the corotating reference frame

<u>Moderate *Kp* intervals</u> ($3 \leq Kp < 5$)

- Strongest electric fields (~1.1 mV/m) observed in region just after dusk near L=4-5
- Midnight-dawn sector enhancement (~0.7 mV/m) observed near L=4, with a sharp drop Earthward in the radial direction

Geomagnetic Activity Dependence of E_Y

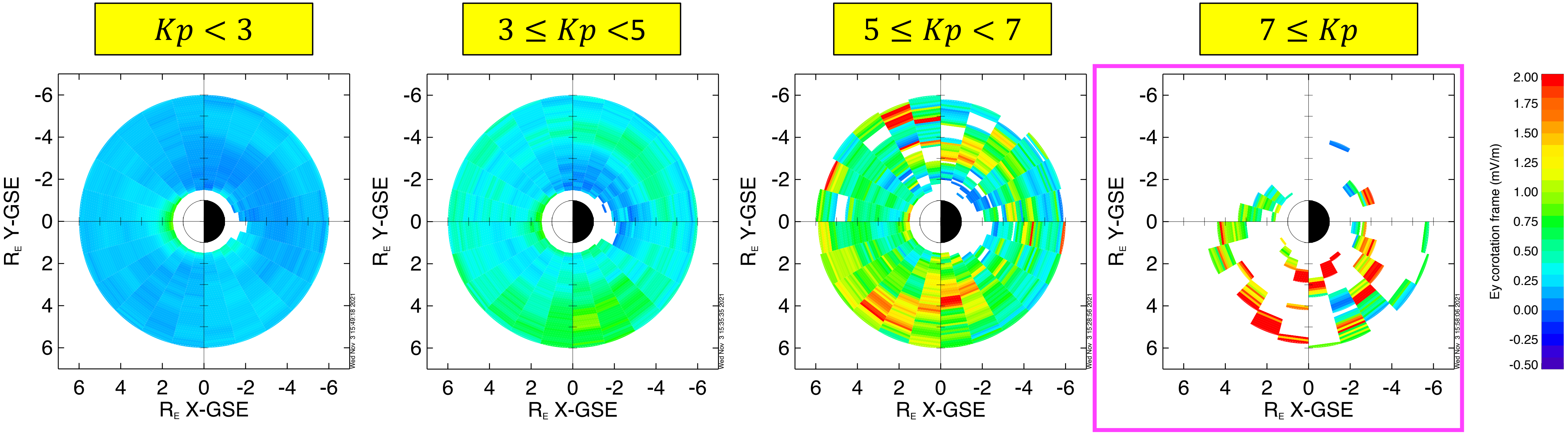


Synoptic maps of the dawn-dusk electric field in the corotating reference frame

Moderate to high *Kp* intervals ($5 \leq Kp < 7$)

- Strong electric fields (~2 mV/m) observed on duskside (MLT=15-20), exhibiting a day-night asymmetry of the radial dependence of E_Y, the enhanced region reaching deeper on the nightside
- Strong dawnside enhancement (~2 mV/m) observed near dawn at L=3-6

Geomagnetic Activity Dependence of E_Y

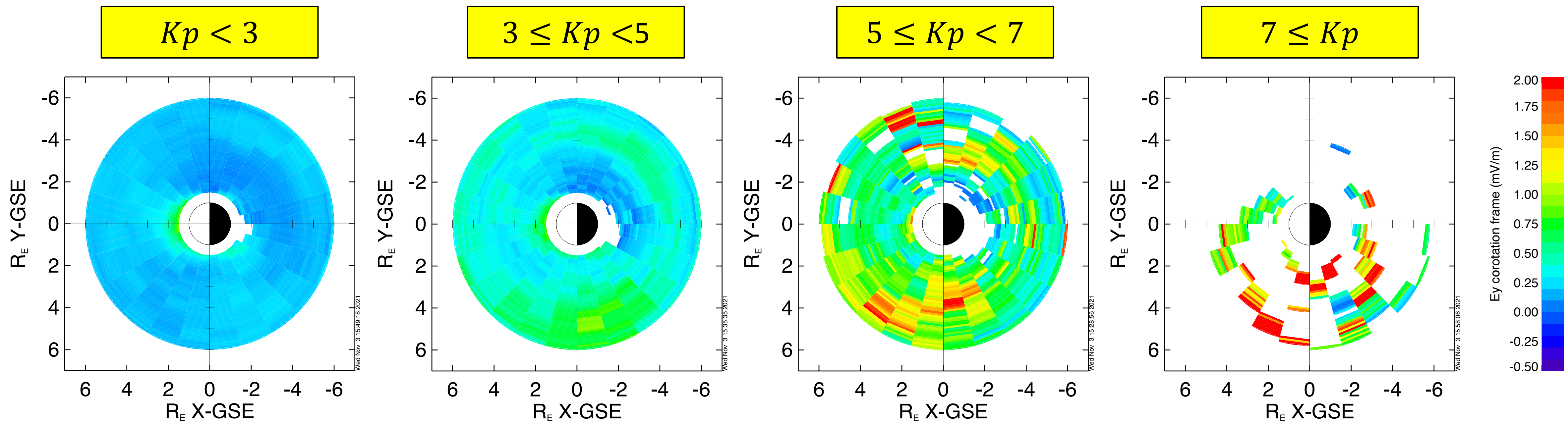


Synoptic maps of the dawn-dusk electric field in the corotating reference frame

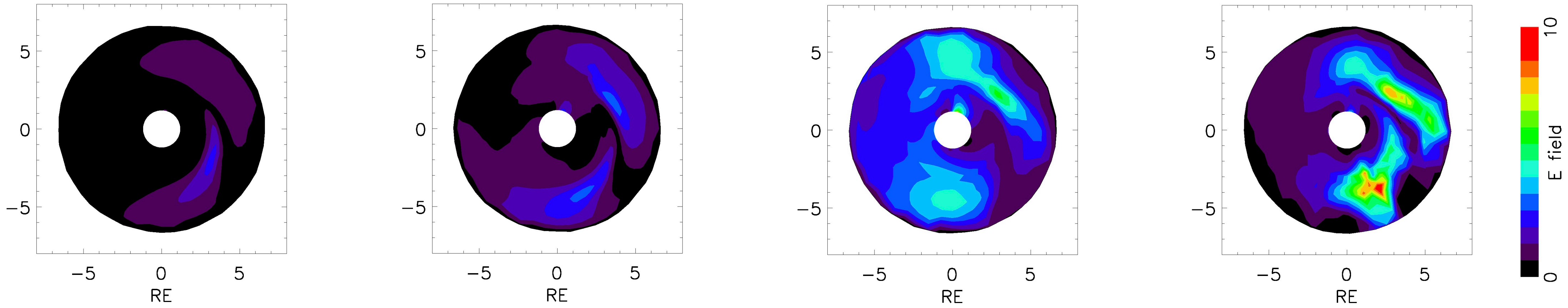
<u>Highest *Kp* intervals</u> ($7 \leq Kp$)

- Coverage mostly restricted to the duskside
- Evidence of duskside strong electric fields (>2 mV/m) occurring close to the Earth (L=2)

Comparison with Simulated Electric Field



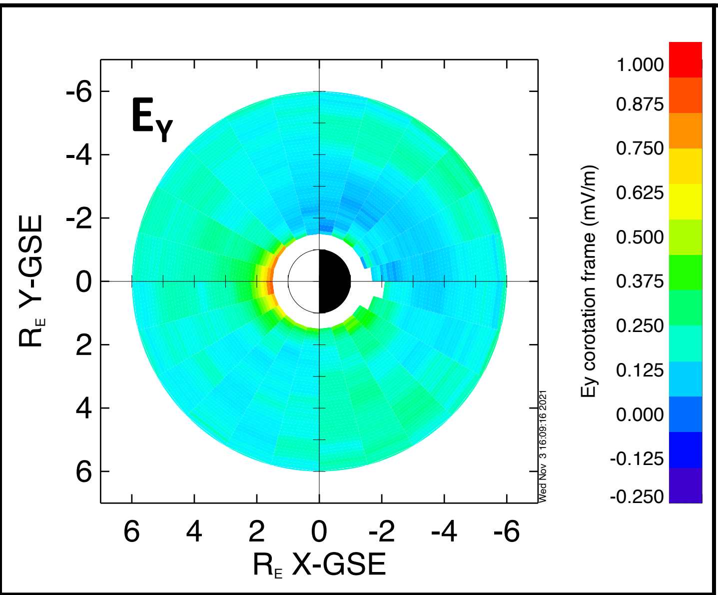
Electric field throughout the September 2017 storm calculated self-consistently with the Comprehensive Inner Magnetosphere-Ionosphere (CIMI) model

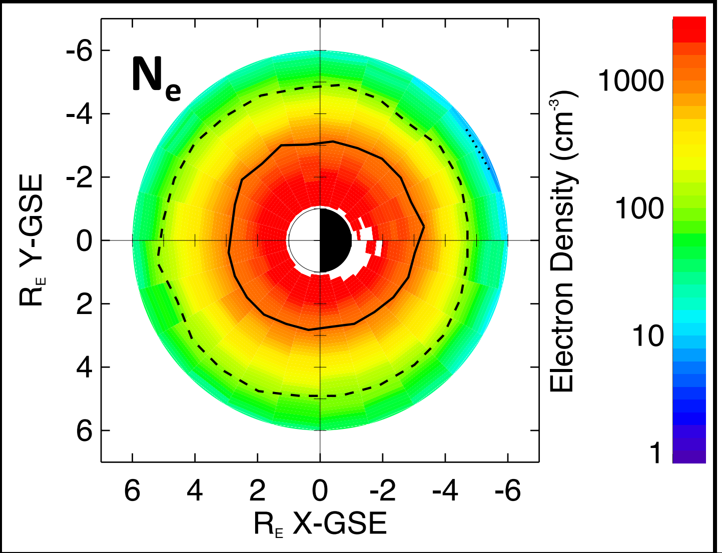


E_Y Influence on the Plasmasphere and Plasma Sheet

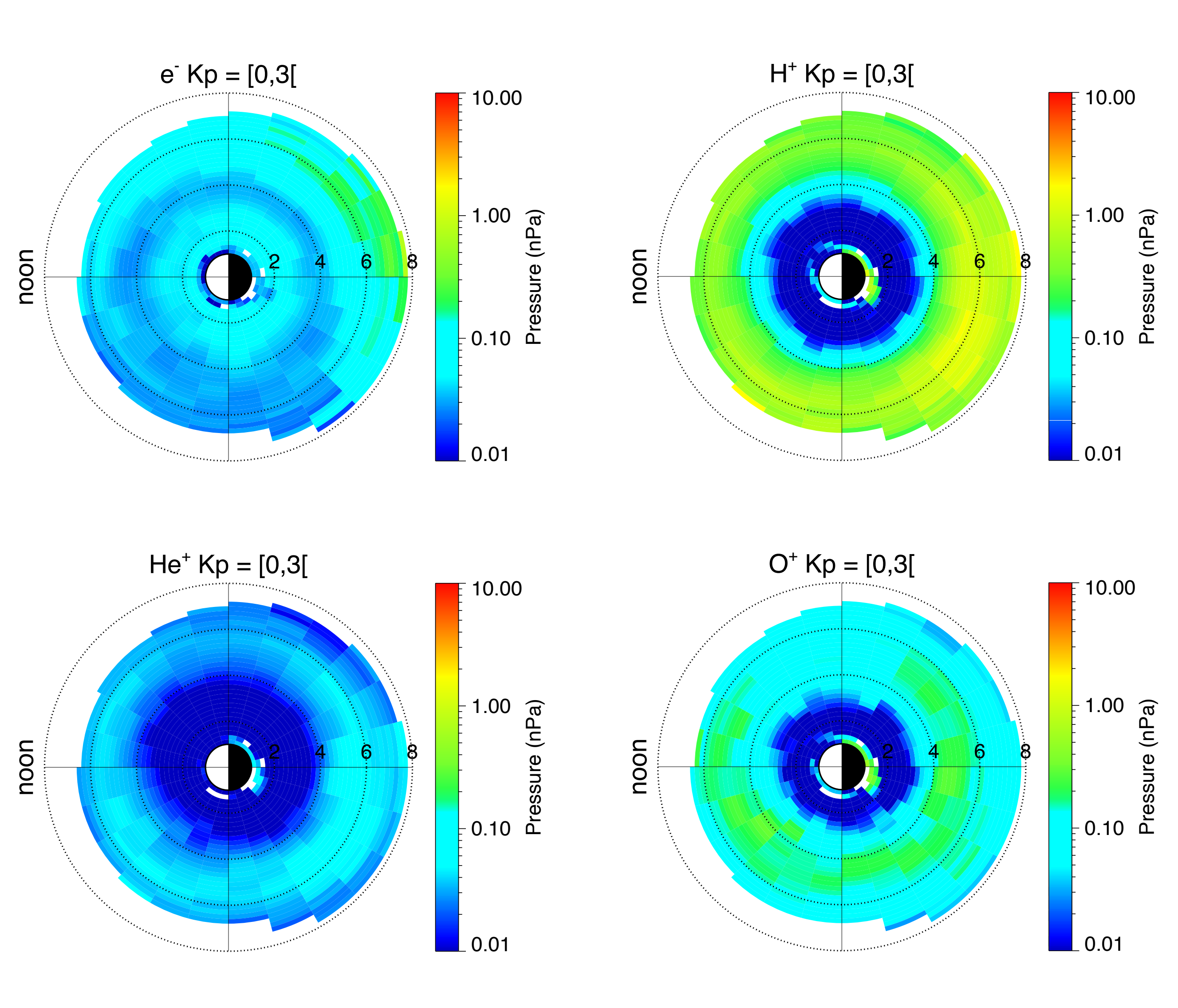
$Kp < 3$

E_Y and N_e





Particle Pressures (100eV-55keV)

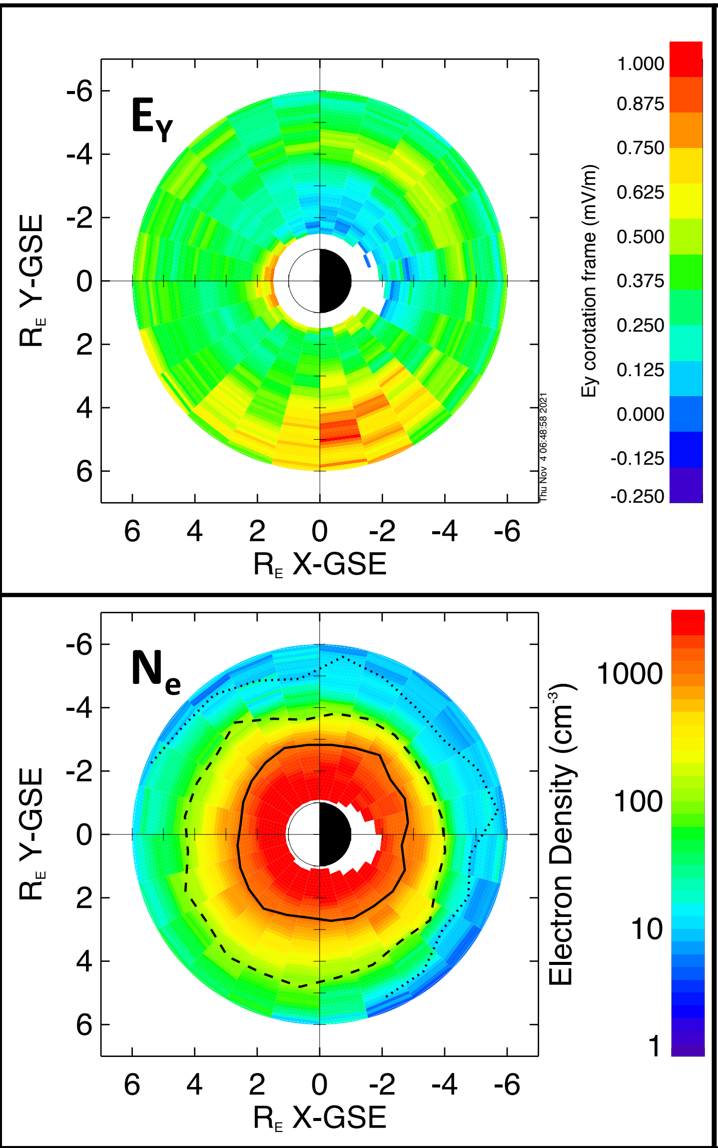


- Region of high N_e confined closer to Earth on duskside
- Overall deeper duskside ion access than dawnside electron access
- Peak O^+ pressure lies deeper, covers wider MLT range, and exhibits stronger gradient in L compared to H^+ and He^+

E_Y Influence on the Plasmasphere and Plasma Sheet

$3 \leq Kp < 5$

E_Y and N_e



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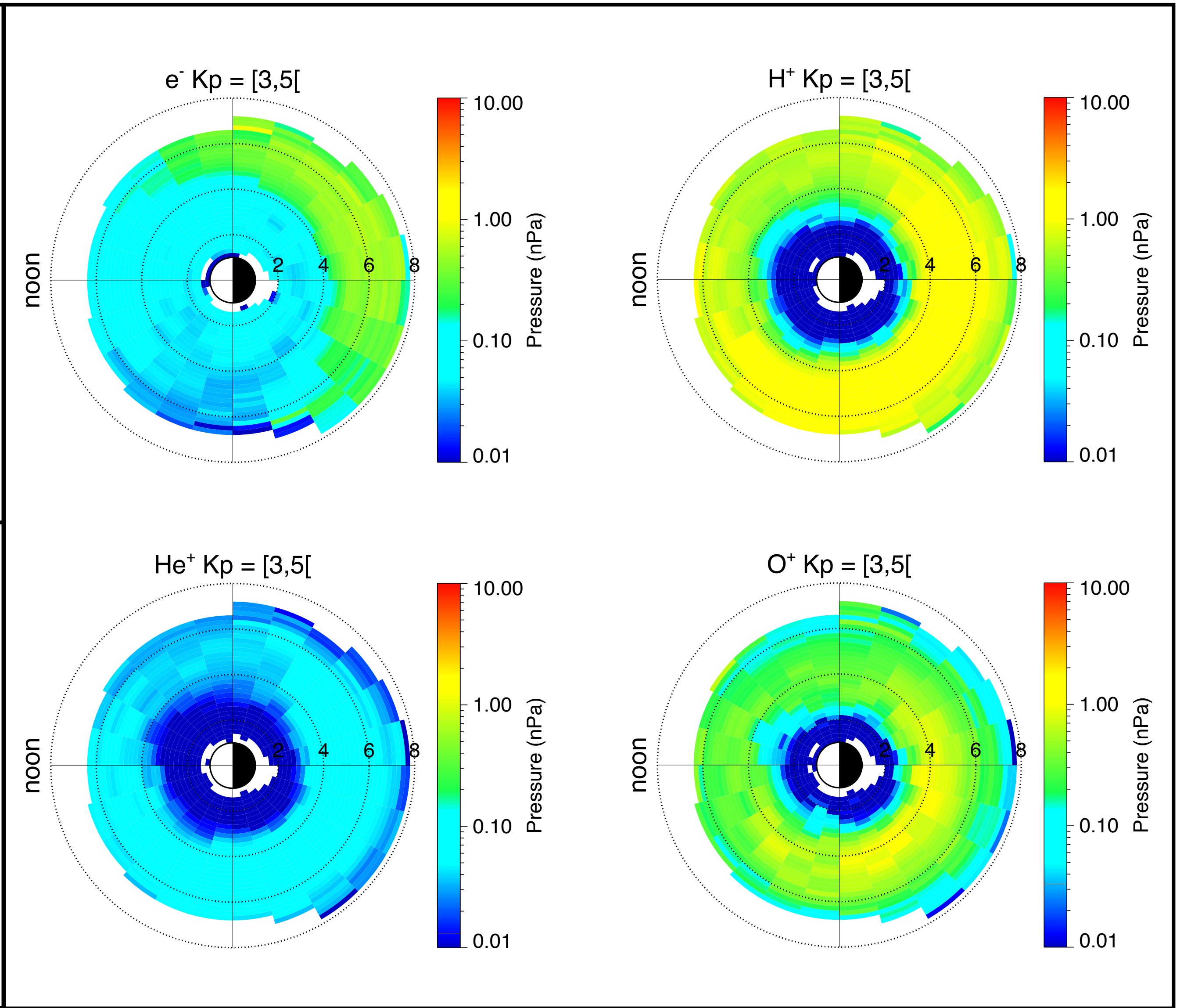
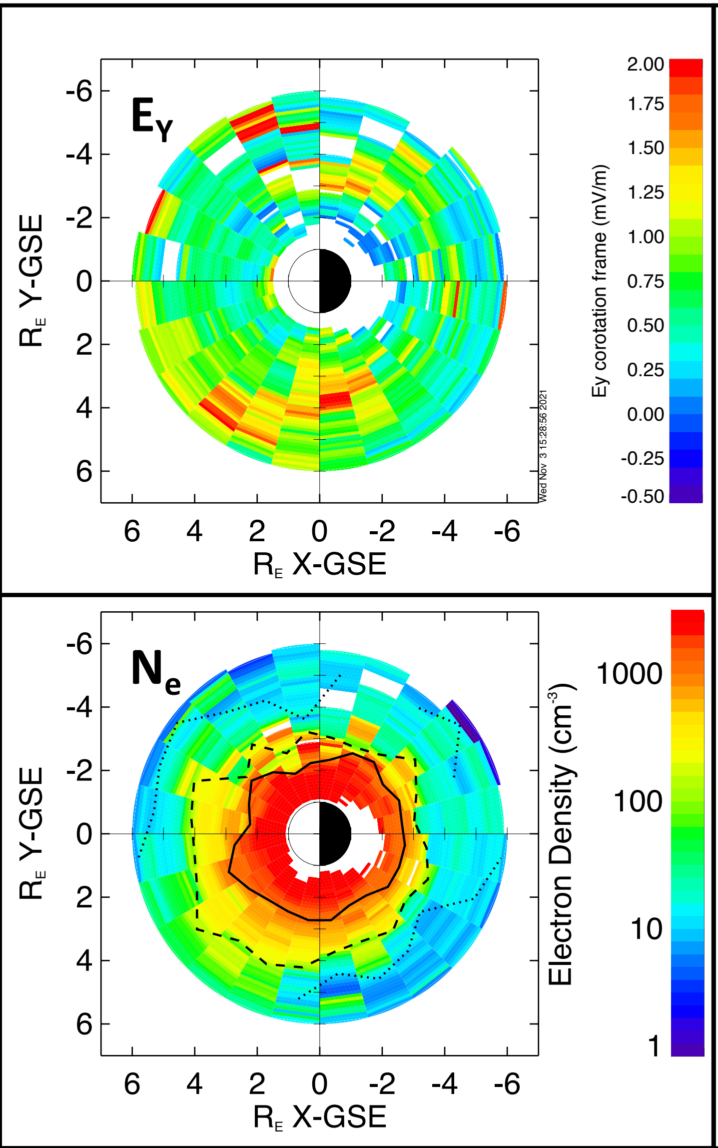


- Region of high N_e confined closer to Earth on duskside
- Peak electron pressure in midnight-dawn sector near L=6
- Similar ion pressure features with enhanced pressures reaching deeper for all ion species

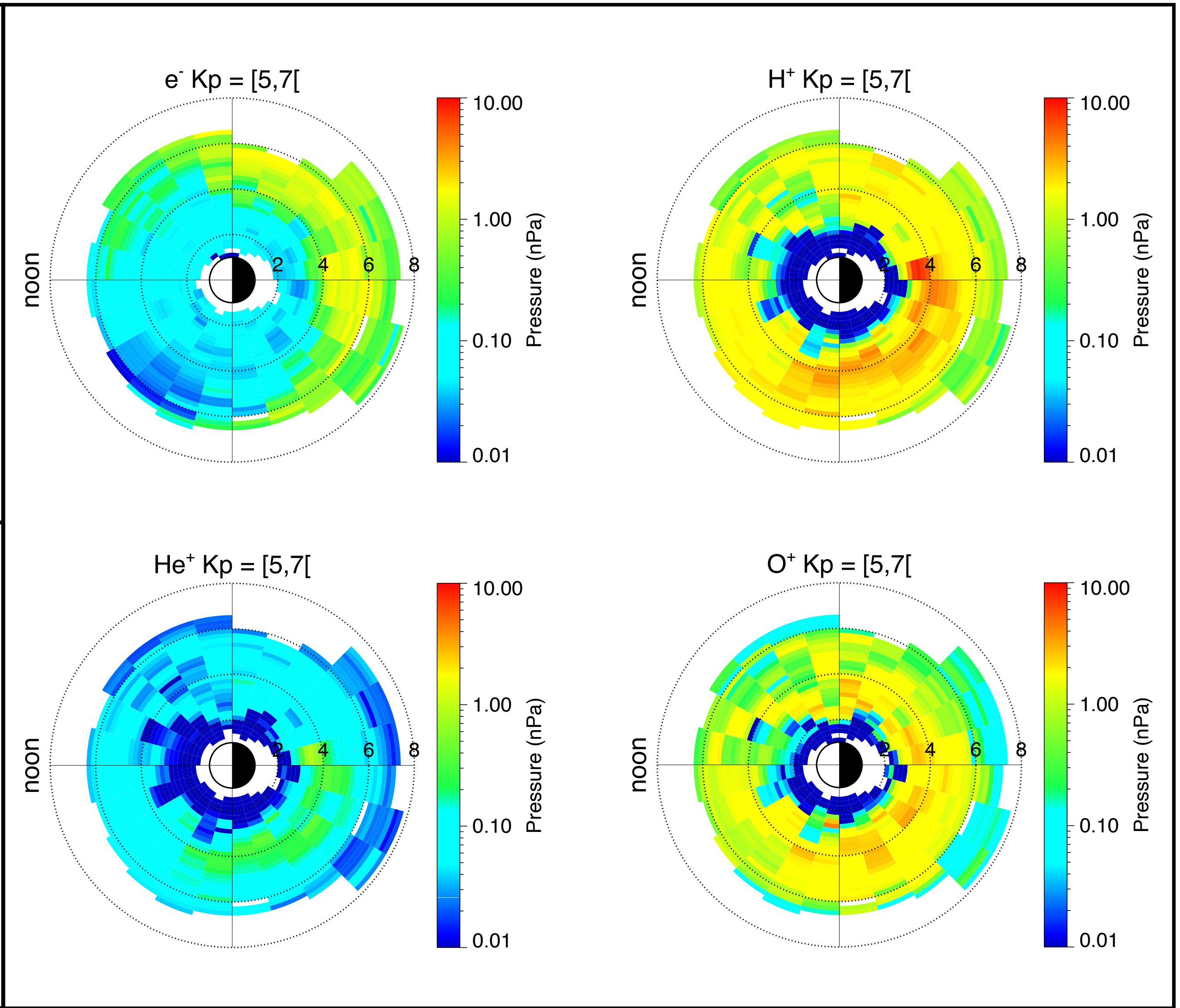
E_Y Influence on the Plasmasphere and Plasma Sheet

$5 \leq Kp < 7$

E_Y and N_e



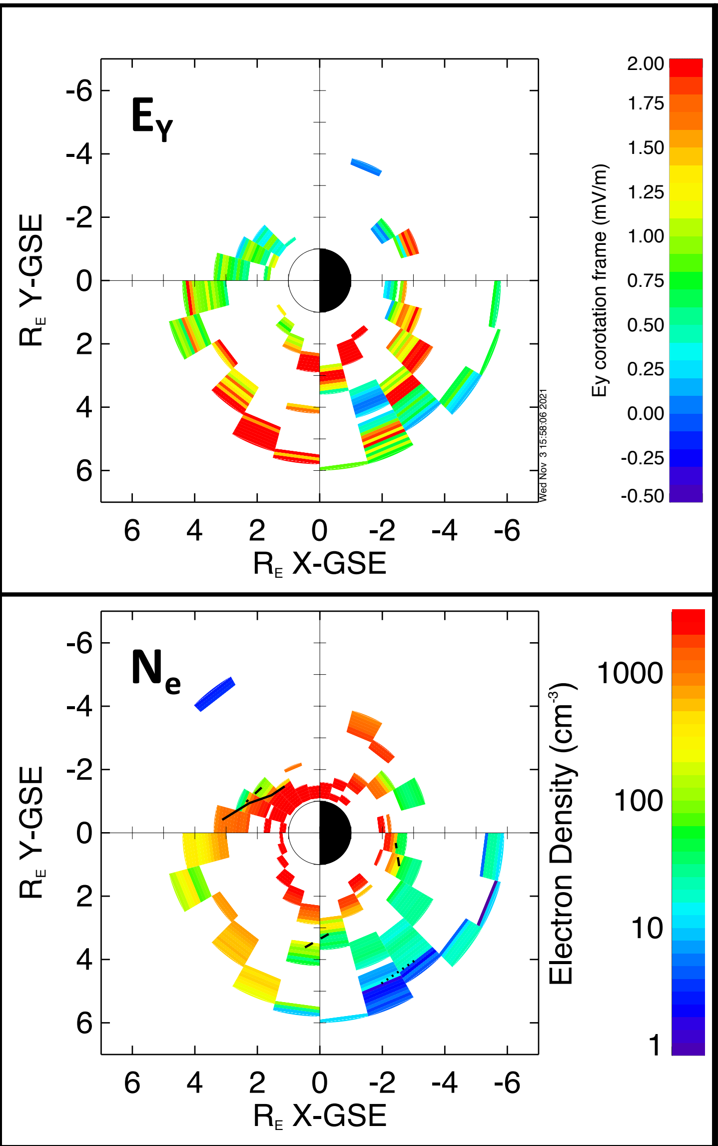
Particle Pressures (100eV-55keV)



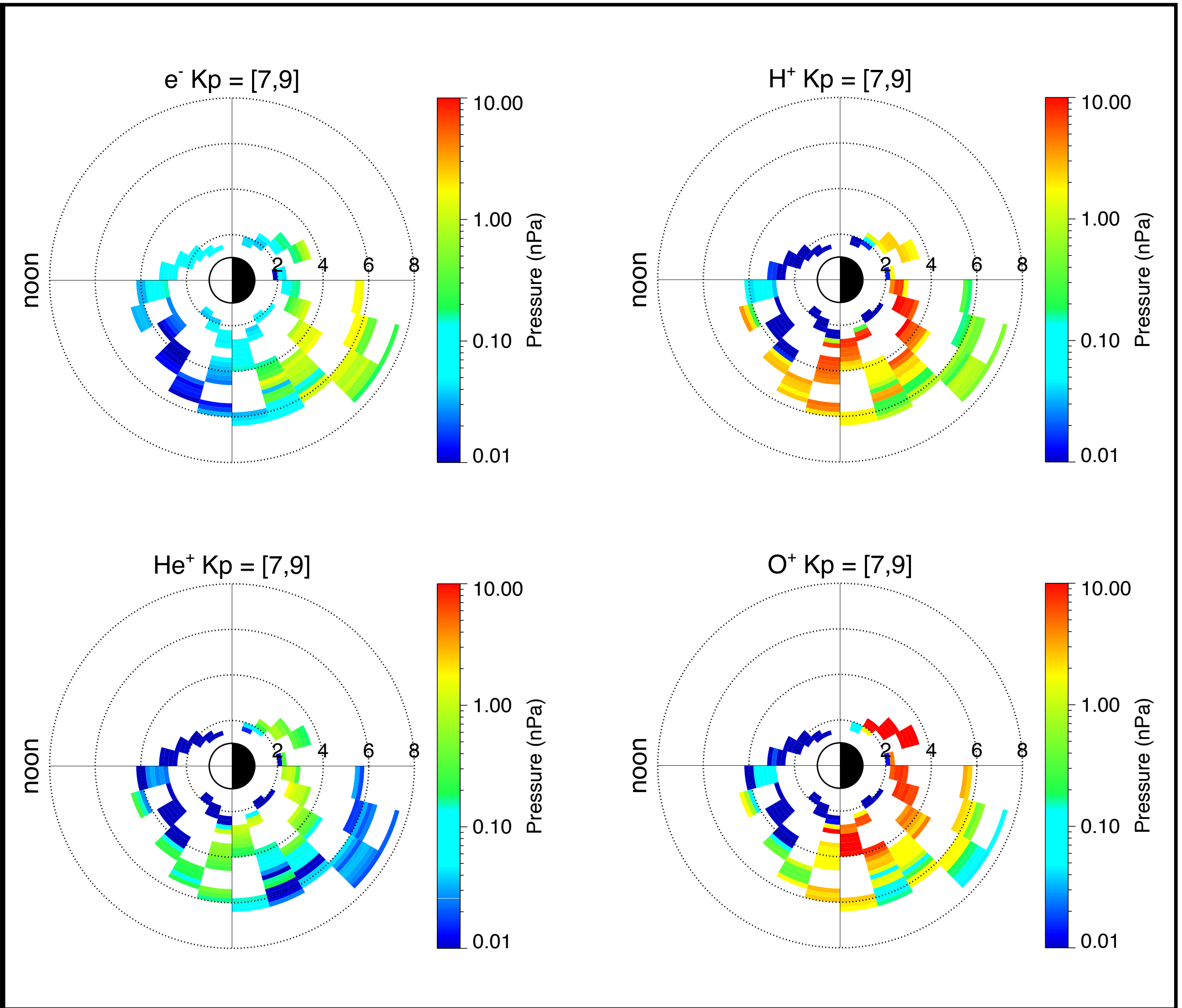
- Structured N_e distribution at all MLTs
- Day-night asymmetry of strong duskside electric fields consistent with peak ion pressures in the dusk-midnight sector.

E_Y Influence on the Plasmasphere and Plasma Sheet

E_Y and N_e



Particle Pressures (100eV-55keV)



$7 \leq Kp$

- Enhanced ion pressures reaching deep (L~2) in the dusk-midnight sector for all ion species

Summary

- A statistical survey of the dawn-dusk electric field, cold plasma density, and plasma sheet particle pressures from NASA's Van Allen Probes mission has been performed.

- The distributions of E_Y show regions of enhanced electric fields near dusk and dawn, with the strongest magnitudes observed near dusk for all activity levels. Modeled electric field distributions are consistent with the observed distributions .

- The distribution of plasmaspheric density displays regions of strong erosion on the duskside, consistent with the stronger, deeper electric fields in this sector.

- The electron and ion plasma sheet access to the inner magnetosphere is consistent with the overall distribution of E_Y.