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

**Cristian Ferradas<sup>1,2</sup>, Scott Thaller<sup>3</sup>, and Mei-Ching Fok<sup>1</sup>**

<sup>1</sup>Geospace Physics Laboratory, NASA Goddard Space Flight Center

<sup>2</sup>Catholic University of America

<sup>3</sup>University of Colorado Boulder



University  
of Colorado  
Boulder

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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.



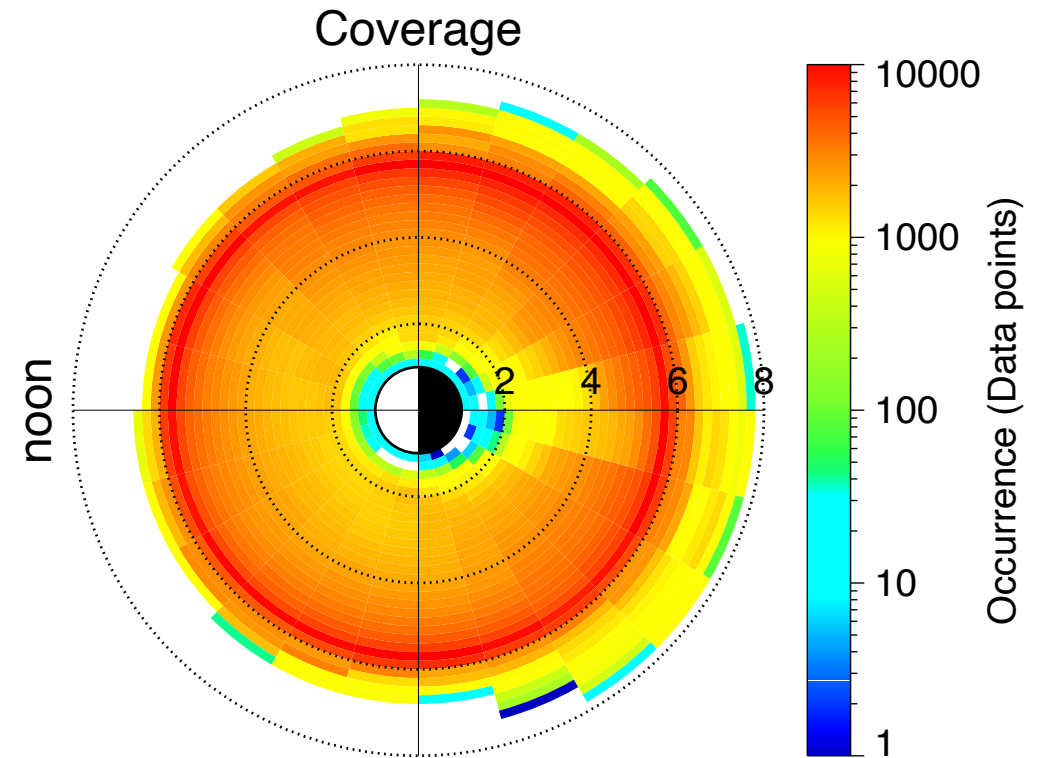
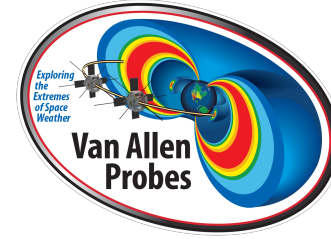
# Mission and Instrumentation

## Mission:

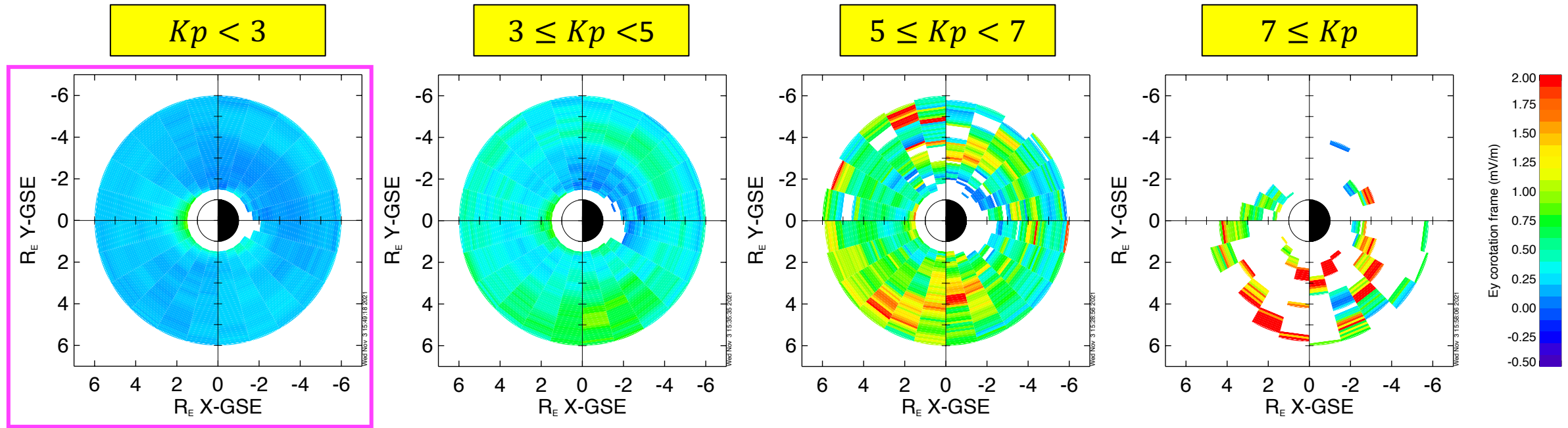
- NASA's Van Allen Probes
- Statistical results from Van Allen Probes A: September 2012 to December 2016 (over 4 years)

## 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 $E_y$

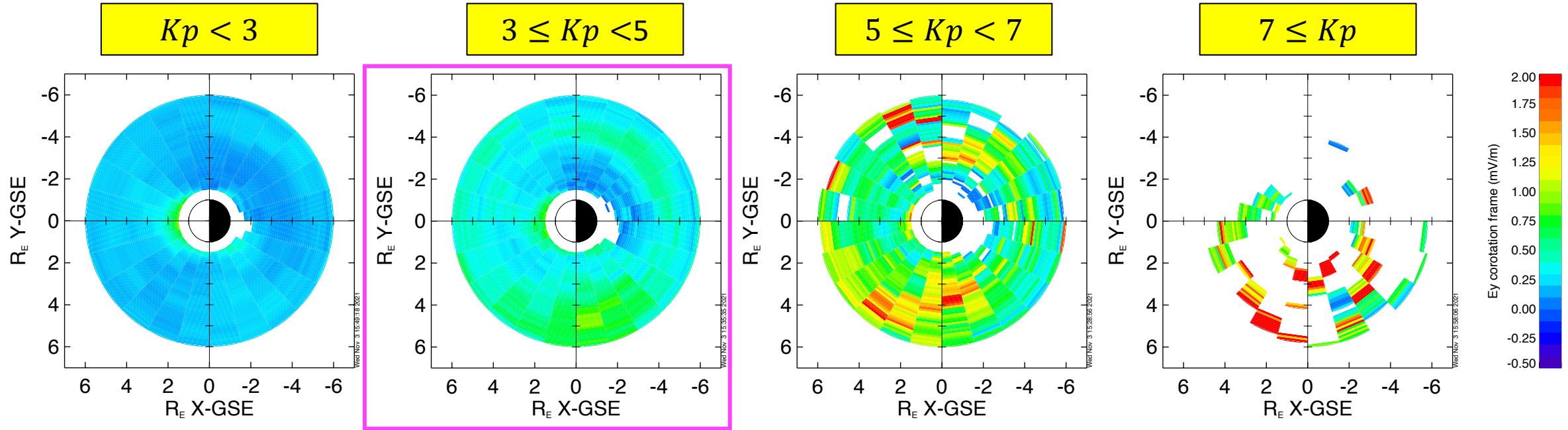


## Synoptic maps of the dawn-dusk electric field in the corotating reference frame

### Low $Kp$ intervals ( $Kp < 3$ )

- Strongest electric fields ( $\sim 0.3$  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 $E_y$

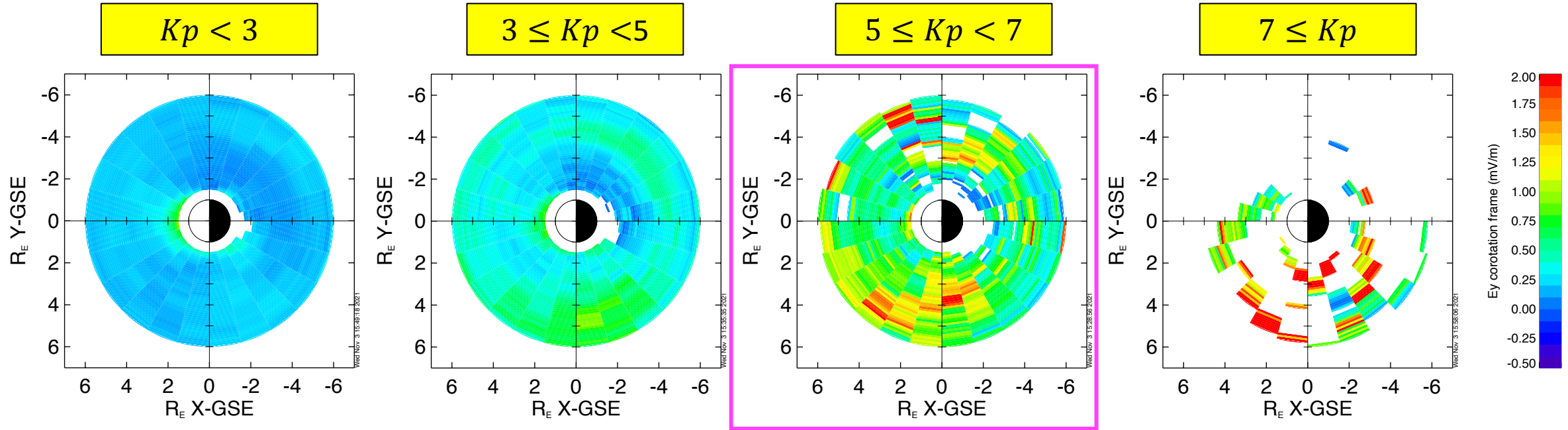


## Synoptic maps of the dawn-dusk electric field in the corotating reference frame

### Moderate $Kp$ intervals ( $3 \leq Kp < 5$ )

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

# Geomagnetic Activity Dependence of $E_y$

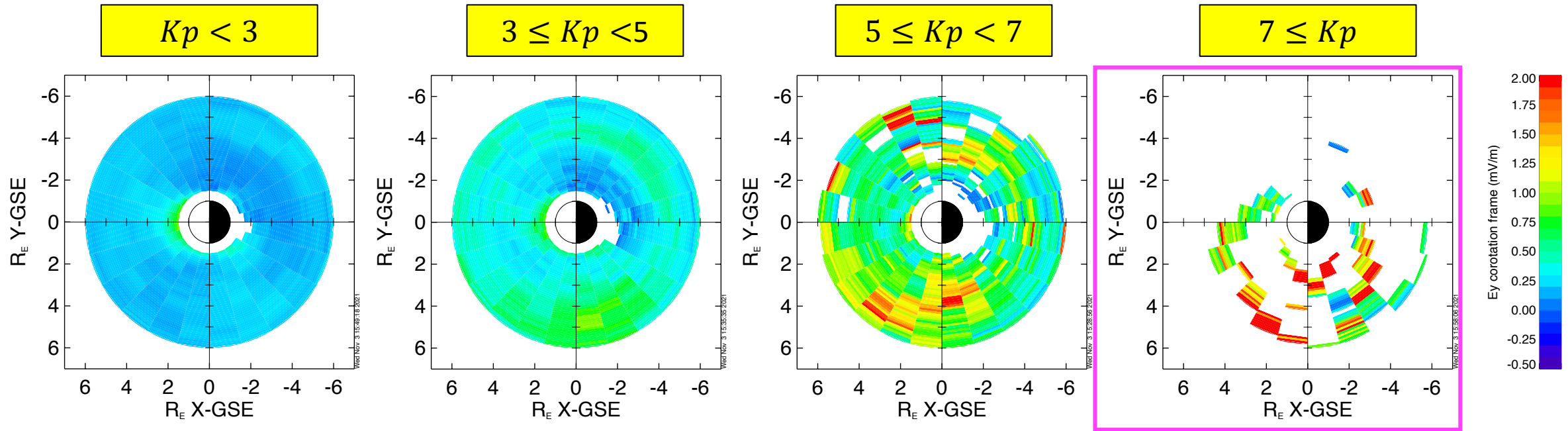


## Synoptic maps of the dawn-dusk electric field in the corotating reference frame

### Moderate to high $K_p$ intervals ( $5 \leq K_p < 7$ )

- Strong electric fields ( $\sim 2$  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 ( $\sim 2$  mV/m) observed near dawn at  $L=3-6$

# Geomagnetic Activity Dependence of $E_y$



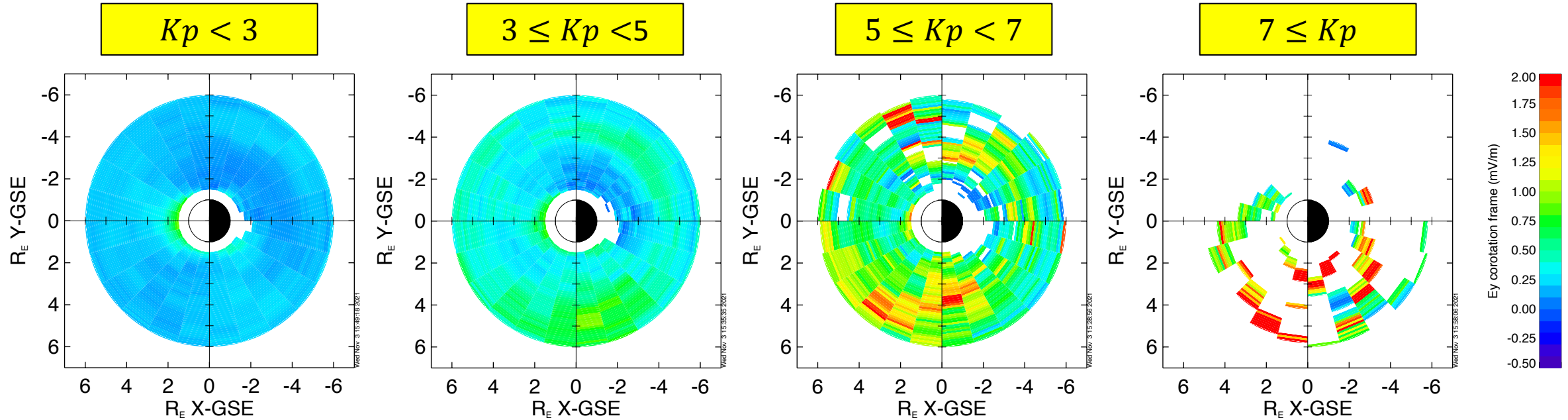
## Synoptic maps of the dawn-dusk electric field in the corotating reference frame

### Highest $K_p$ intervals ( $7 \leq K_p$ )

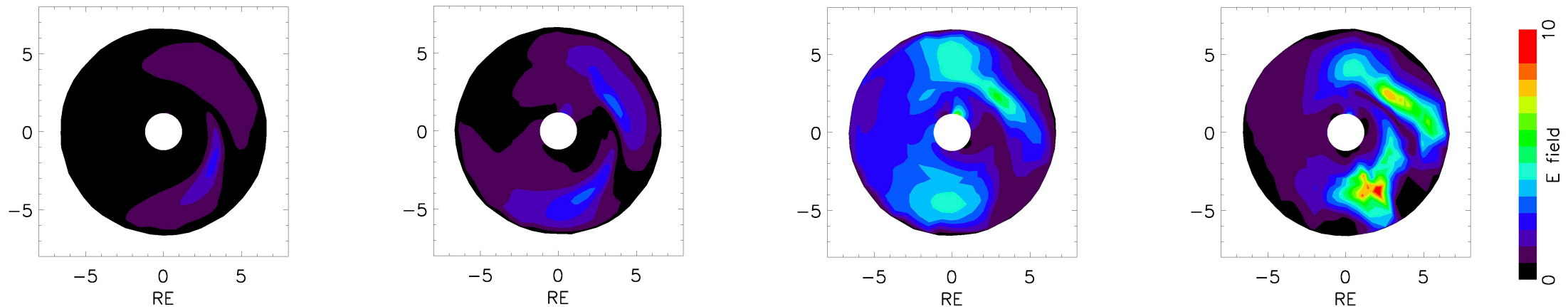
- Coverage mostly restricted to the duskside
- Evidence of duskside strong electric fields ( $>2$  mV/m) occurring close to the Earth ( $L=2$ )



# Comparison with Simulated Electric Field



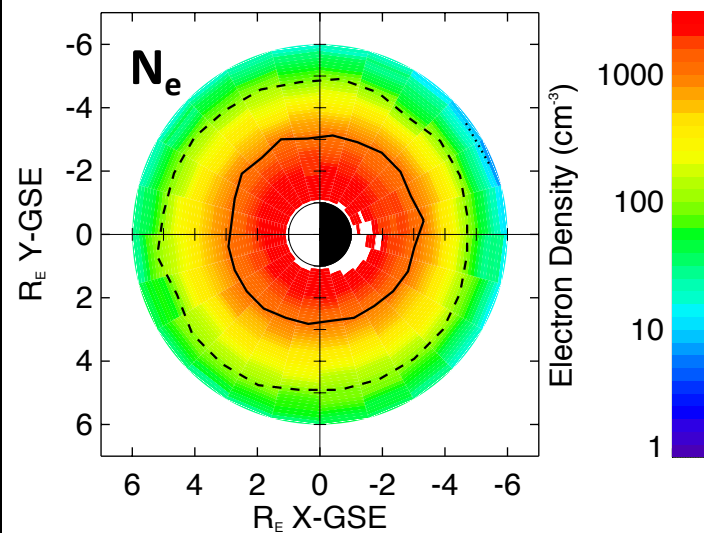
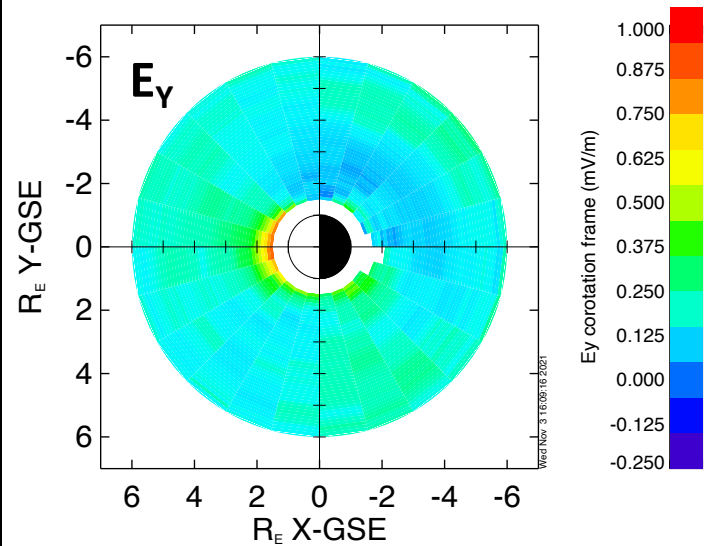
**Electric field throughout the September 2017 storm calculated self-consistently with the Comprehensive Inner Magnetosphere-Ionosphere (CIMI) model**



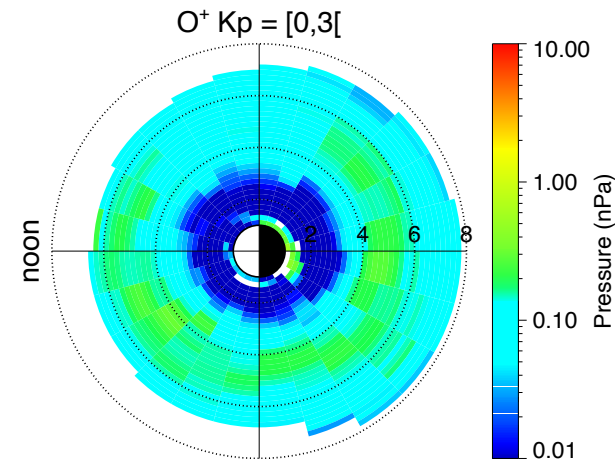
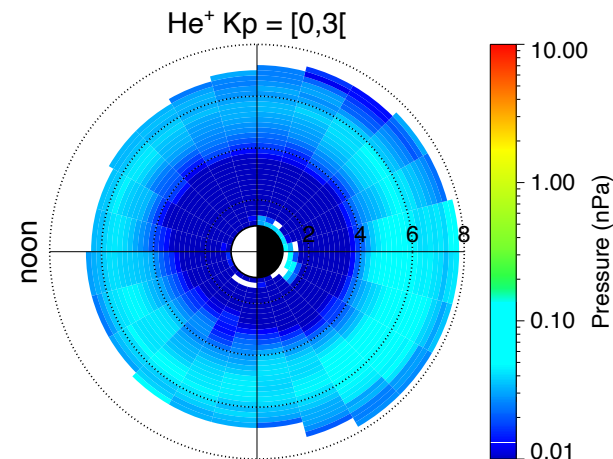
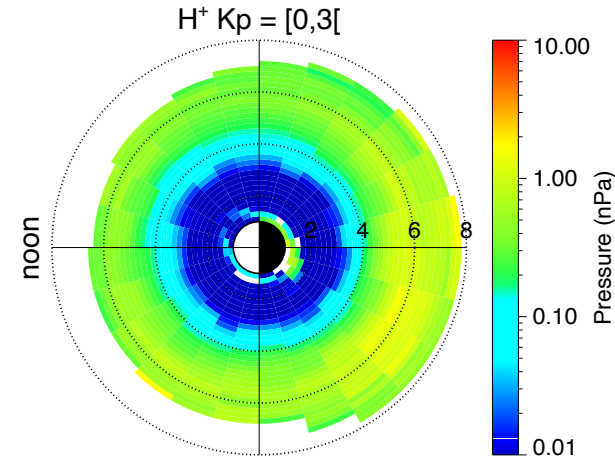
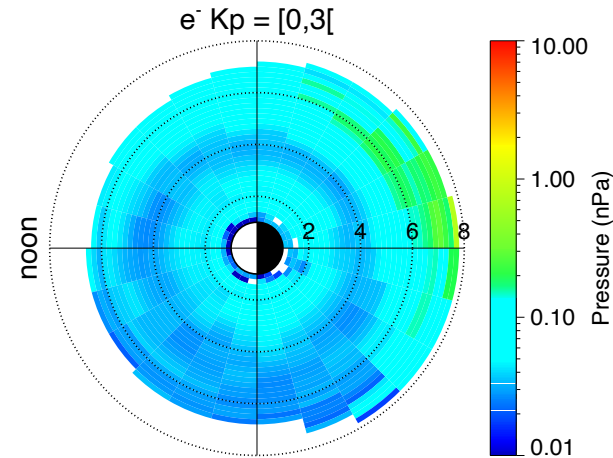
# $E_y$ Influence on the Plasmasphere and Plasma Sheet

$Kp < 3$

$E_y$  and  $N_e$



Particle Pressures (100eV-55keV)

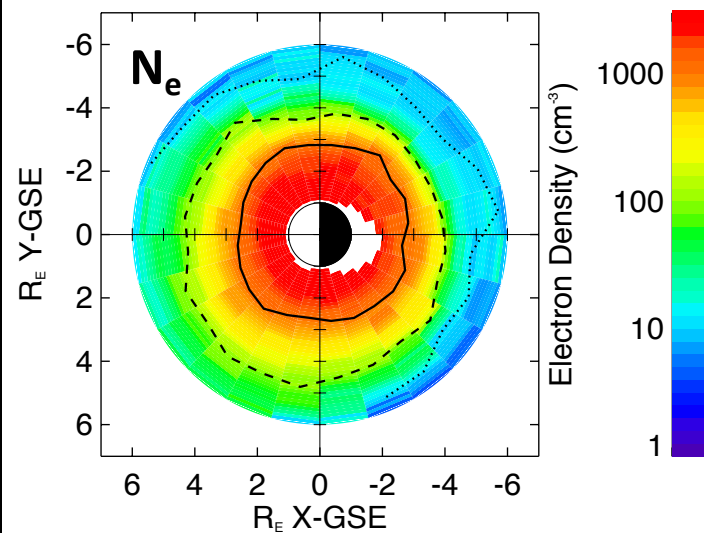
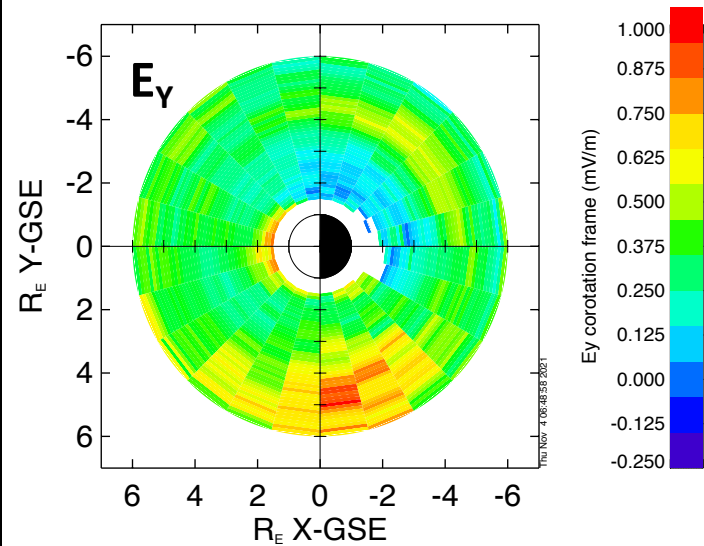


- Region of high  $N_e$  confined closer to Earth on duskside
- Overall deeper duskside ion access than dawnside electron access
- Peak  $\text{O}^+$  pressure lies deeper, covers wider MLT range, and exhibits stronger gradient in  $L$  compared to  $\text{H}^+$  and  $\text{He}^+$

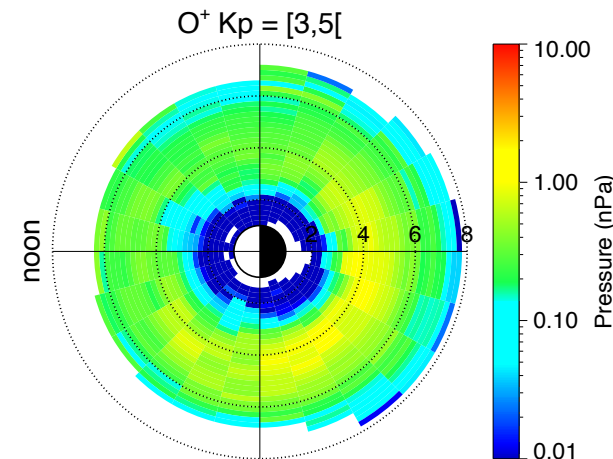
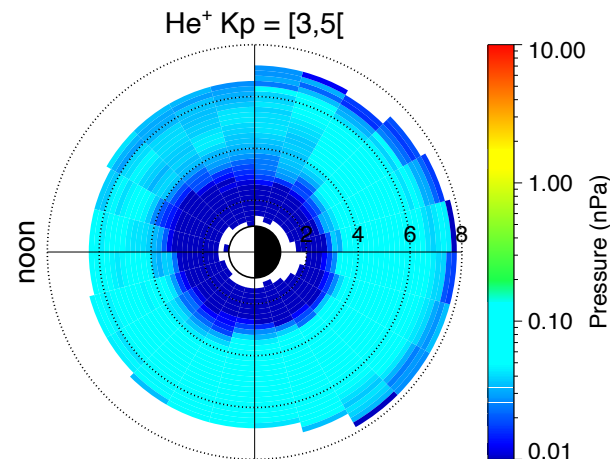
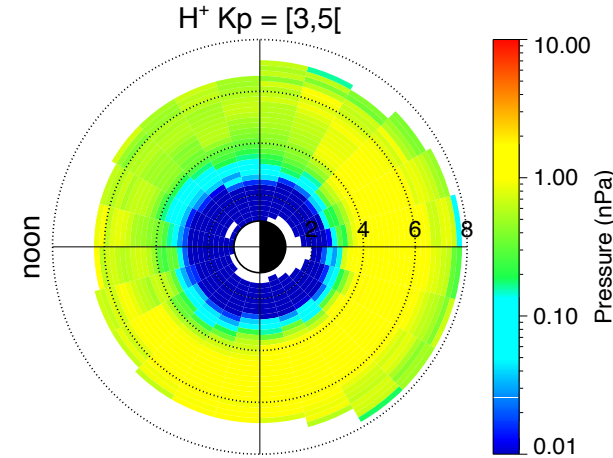
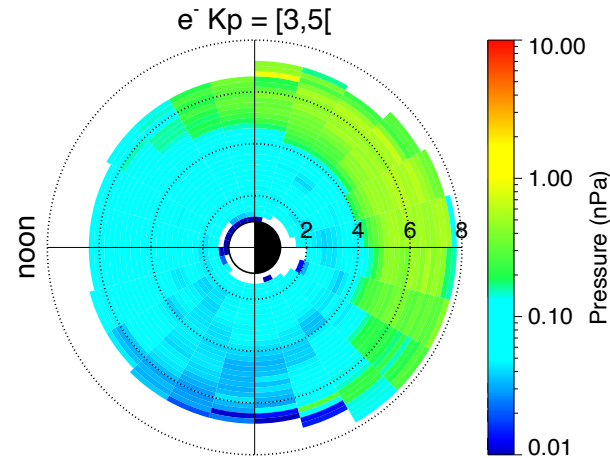
# $E_y$ Influence on the Plasmasphere and Plasma Sheet

$$3 \leq Kp < 5$$

$E_y$  and  $N_e$



Particle Pressures (100eV-55keV)



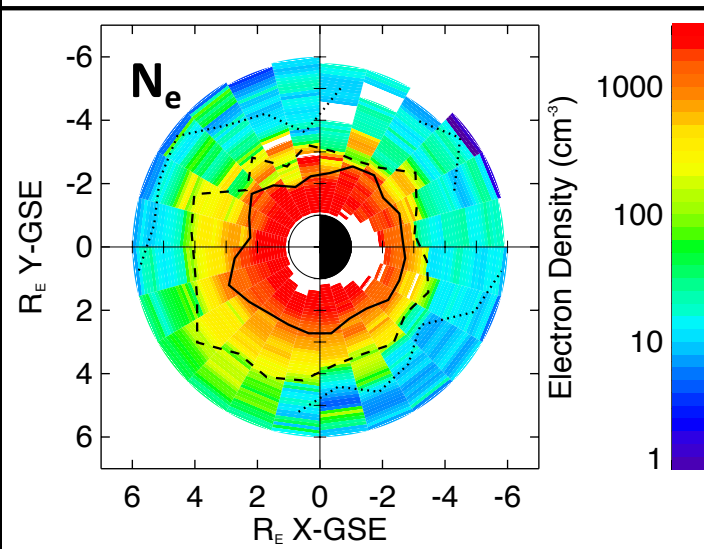
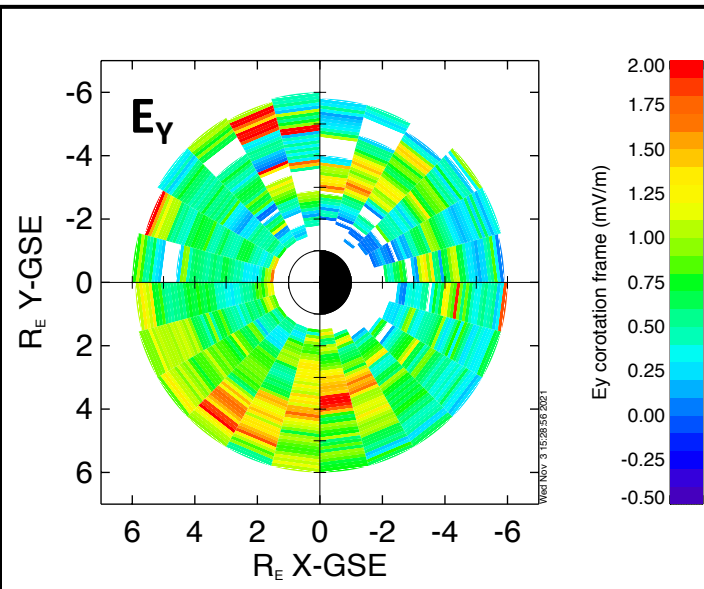
- Region of high  $N_e$  confined closer to Earth on duskside
- Peak electron pressure in midnight-dawn sector near  $L=6$
- Similar ion pressure features with enhanced pressures reaching deeper for all ion species



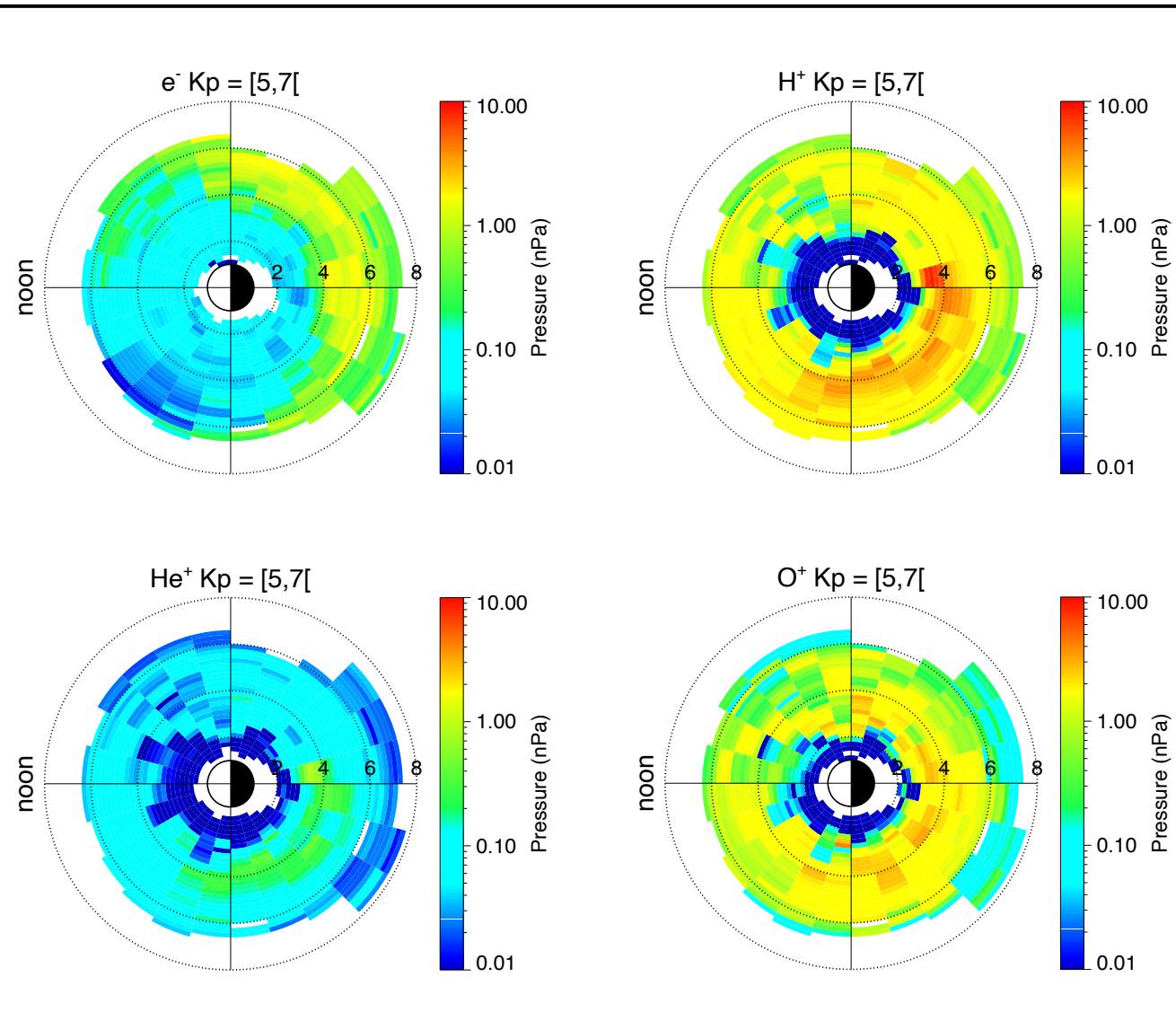
# $E_y$ Influence on the Plasmasphere and Plasma Sheet

$$5 \leq Kp < 7$$

$E_y$  and  $N_e$



Particle Pressures (100eV-55keV)

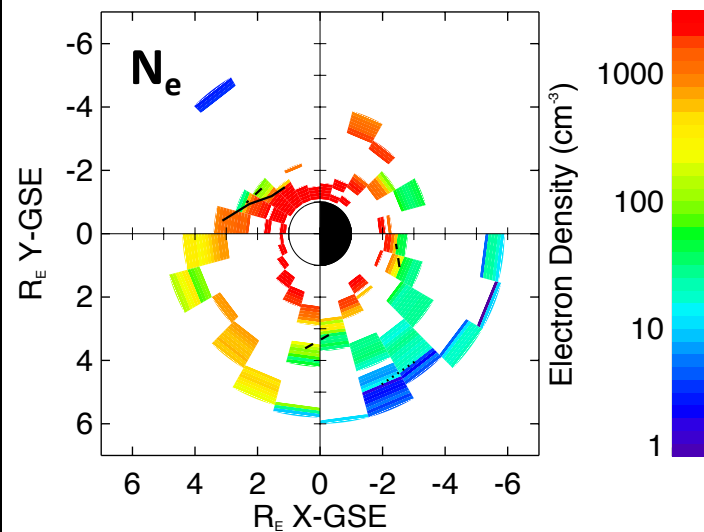
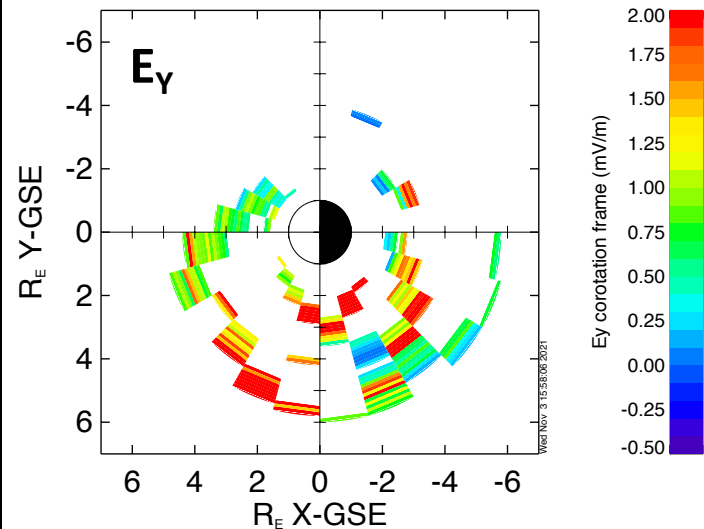


- Structured  $N_e$  distribution at all MLTs
- Day-night asymmetry of strong duskside electric fields consistent with peak ion pressures in the dusk-midnight sector.

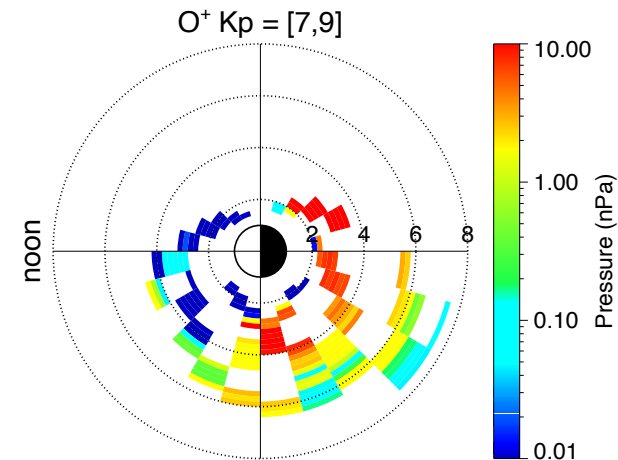
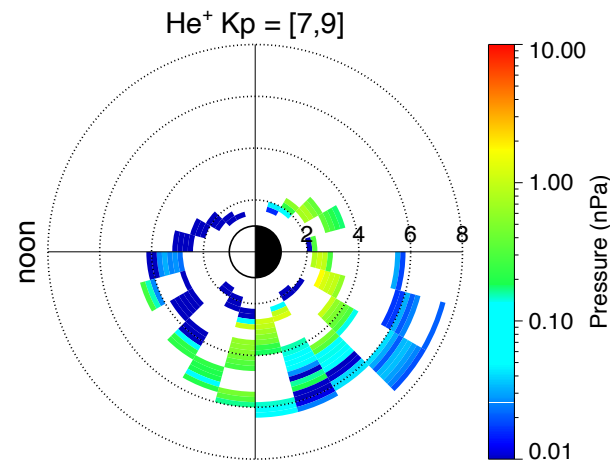
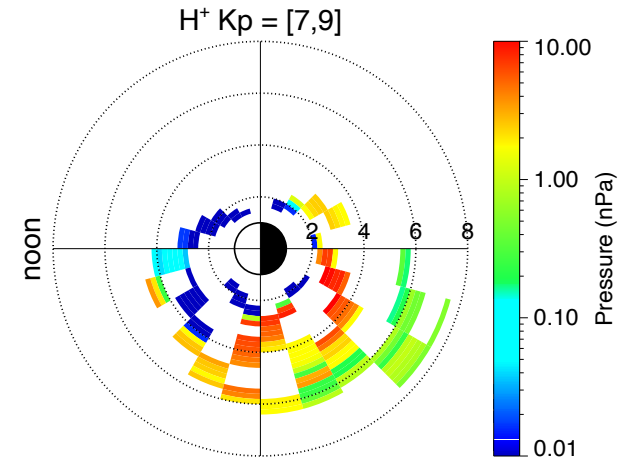
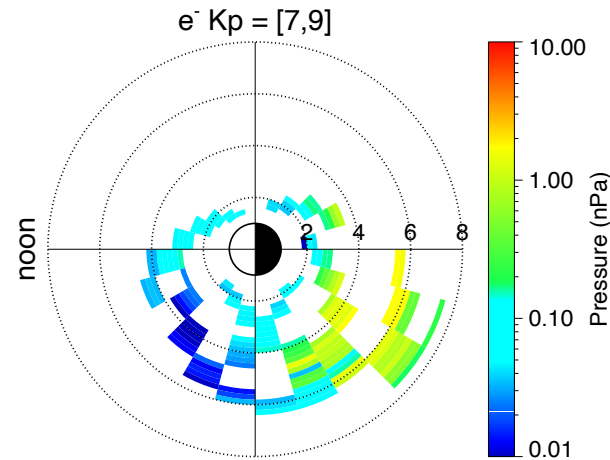
# $E_y$ Influence on the Plasmasphere and Plasma Sheet

$7 \leq Kp$

$E_y$  and  $N_e$



Particle Pressures (100eV-55keV)



- 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  $E_y$ .