Statistical Storm-Time Examination of MLT Dependent Plasmapause Location Derived from IMAGE EUV

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The following study describes:

(1) An automated procedure to extract the plasmapause location from IMAGE EUV data
(2) MLT dependent plasmapause during intense storms between the years 2000 and 2002
(3) Validation of the results using the Goldstein et al. [2003] manually extracted data
(4) Comparison between the plasmapause location for the solar wind drivers
(5) Evidence that the extension and timing of the plume based on solar wind driver

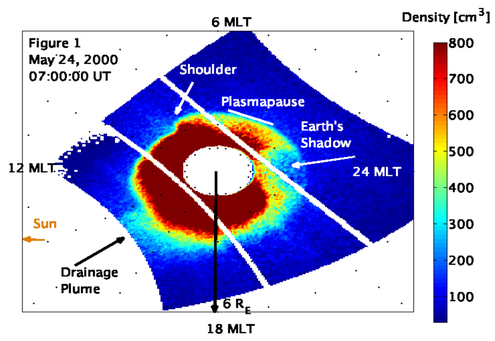
1. Introduction

Plasmasphere: High density plasma originating from the ionosphere that corotates with Earth
Plasmapause: (1) Radial distance from the Earth at which the plasma density drops off rapidly. **(2)** The boundary between convection and corotating plasma
Plume: During a storm the plasmapause moves earthward and thermal ions outside are convected sunward
Corotating Interaction Region (CIR):
High-speed solar wind that forms where the leading edge of the high-speed stream interacts with the preceding slower solar wind.
- Plasma is heated and compressed causing high dynamic pressure and a rapidly fluctuating **B**

Interplanetary coronal mass ejection (ICME): May contain sheath and/or magnetic cloud structures
- **Sheath (SH):** Can be described like a CIR.
  - Plasma is heated and compressed causing high dynamic pressure and a rapidly fluctuating **B**
  - **Magnetic Cloud (MC):** Strong **B** that rotates through a large angle

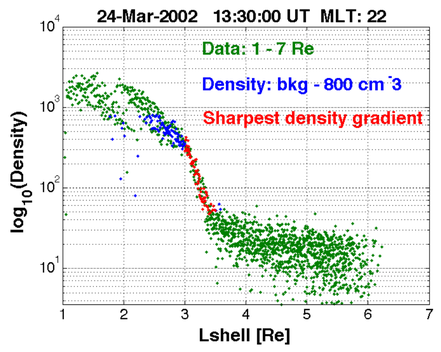
2. Observations

IMAGE Spacecraft: Completed an elliptical polar orbit with an apogee of 7.2 R_E every 14.2 hours
IMAGE EUV: detected EUV photons with a wavelength of 30.4 nm that have been resonantly scattered by singly ionized helium
Manually Determined Plasmapause location: Goldstein et al. [2003] used IMAGE EUV data to manually define the plasmapause as the outermost sharp edge of the snapshot where the brightness of the He^+ emissions drops off abruptly at a given MLT.
Complications: (1) Bias caused by visualization choices. **(2)** Meticulous **(3)** Time consuming

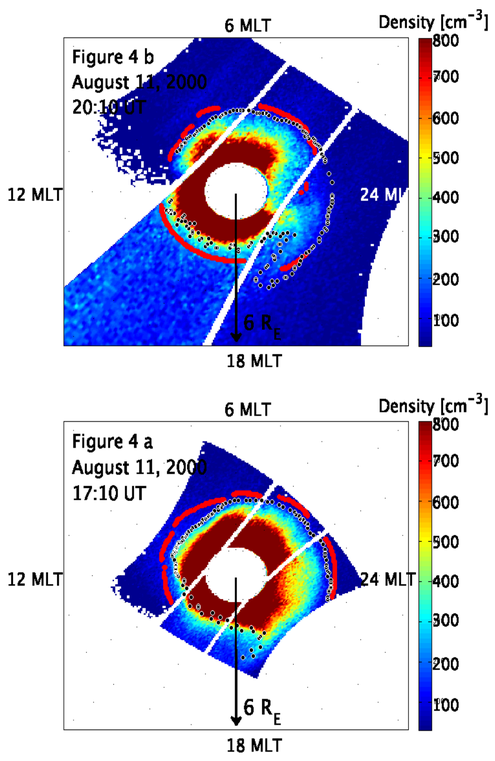


3. Extraction

The automated plasmapause extraction method consists of five steps:
(1) Unusable data is removed. An observation is excluded if the image has < 20% coverage at any UT.
(2) Radial distance is defined: [1.5 – 7 R_E]
(3) He^+ density is defined: [40 – 800 R_E]
(4) Largest density gradient at each MLT is found. For each time step
(5) Plasmapause results are filtered. Keep only data within the 90th percentile of the L-shell distribution and then completing a running average in MLT



4. Comparison

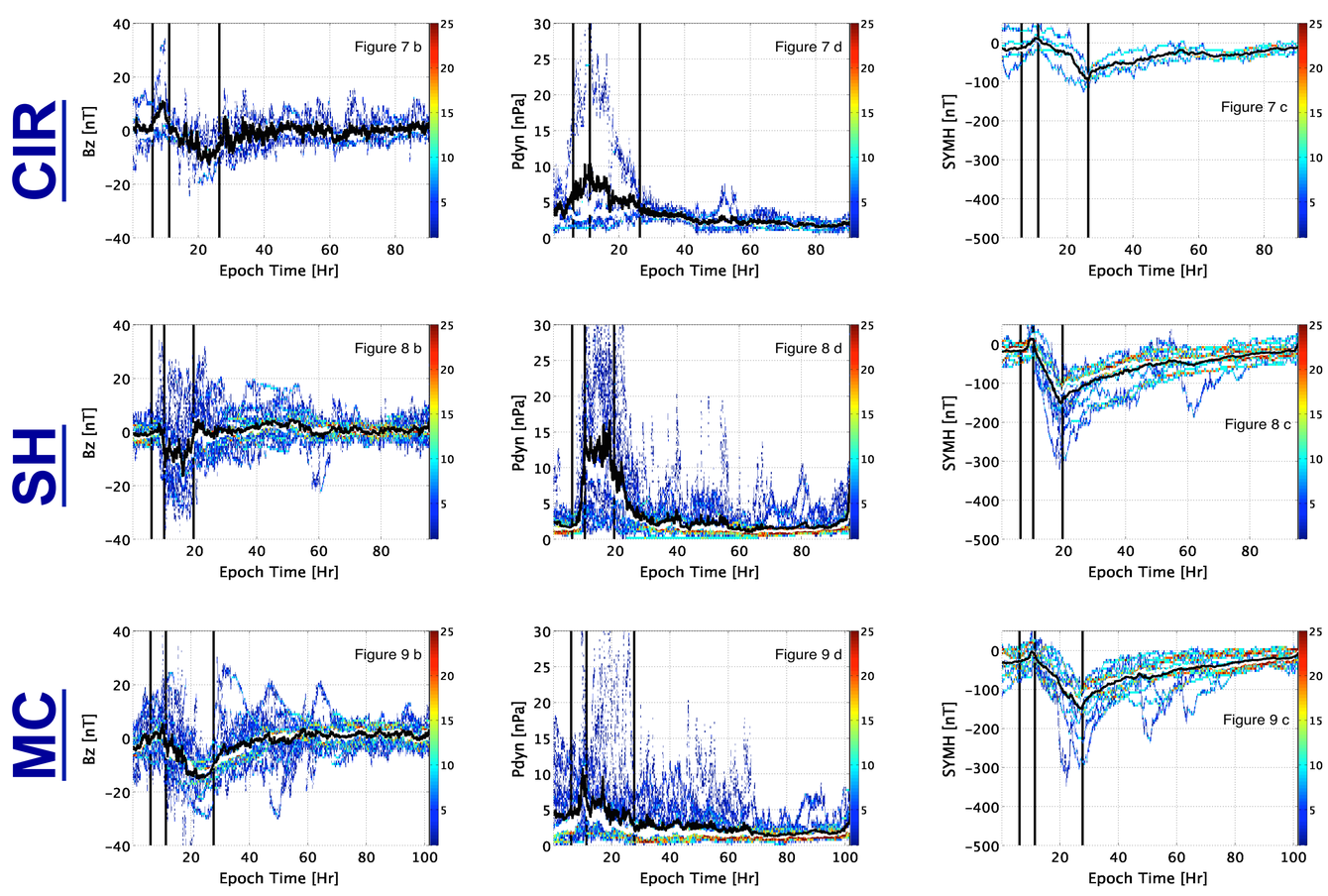


To quantify the quality of the automatically extracted plasmapause data we compare to manually found data [*Goldstein et al*. [2003].
Automated results are shown in red
Manual results are shown in black
- The results are in good agreement
- Manual results tend to be Earthward of the automated locations
- Manual results highlight features that are difficult to see with this color bar
- The automated result drifts Earthward due to the Earths shadow
- While the automated method can only select one edge the manual method can select multiple edges.
- This is important when considering the plume

5. Storms $Dst_{min} \leq$ -100nT Superposed along the Normalized timeline

Data for all storms with peak < -100.
- The start or end of each storm phase are used as epoch markers (black vertical lines)
- Each individual storm phase is linearly interpolated to the average duration of that phase

Average Duration	CIR (h)	SH (h)	MC (h)
Main Phase	15.3	9.4	16.3
Recovery Phase	64.0	76.1	74.0
Number of Storms	4	12	13



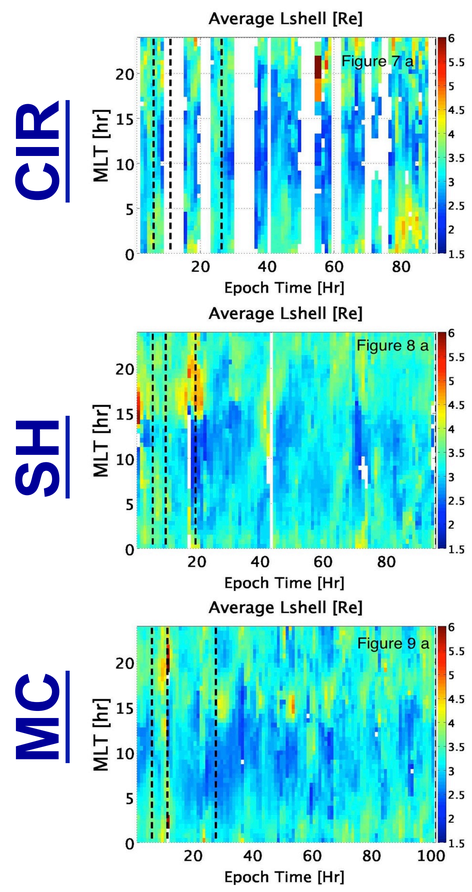
- The color describes the density of superposed data in 10 minute (x) bins and 100 bins (y).
- The black and white over-laid provides the mean and median, respectively.

IMF Bz
- Similar for all three
- More negative for MC
- Less fluctuation for MC

Solar Wind Dynamic Pressure
- Different enhancement time
- Different Magnitudes

SYM-H
- Less negative peak for CIR
- Shorter Main phase for SH
- Only 4 CIRs

Plasmapause

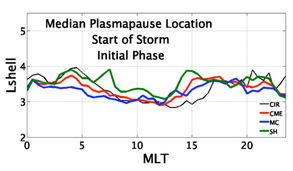


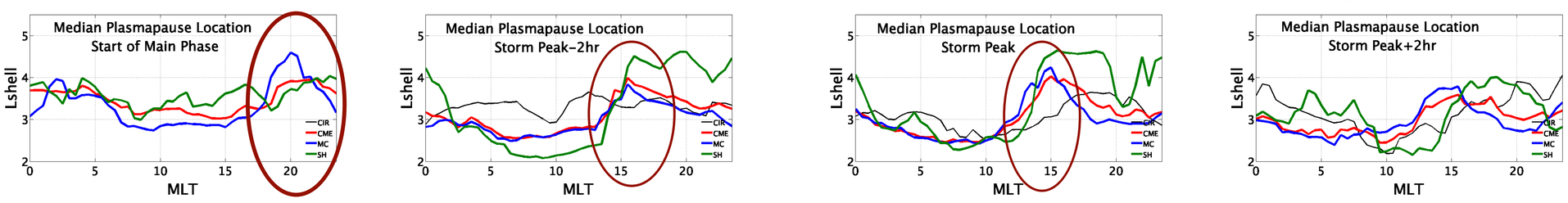
Average Plasmapause Lshell
30 minute (x) and 100 bins (y)
- Only 4 CIRs
- Validates Plasmapause data
- Plume formation times differ
- Smaller plume for CIR
- Variation in convection

6. Average Plasmapause

Plasmapause Lshell at distinct storm times
- Color defines solar wind driver

At the beginning of the initial phase
- The plasmapause is between 2.75 and 4 R_E





Start of Main Phase
- Plume forms for MC-driven storms

Two hours before the storm peak
- The plasmapause is further Earthward on the dayside and extends further from Earth around the evening sector for Sheath-driven storms
- Stronger convection for SH-driven storms
- Plasmapause is sunward on the dayside for CIR-driven

At the storm peak
- Distinguished plume for all CMEs
- Less pronounced plume for CIRs

Two hours after the peak
- Plume is less prominent for all types of storms
- Too early to see refilling

Summary

- Presents an automated procedure to extract the plasmapause
- Shows MLT dependent plasmapause locations for 25 intense storms
- Validates the results
- Examines the plasmapause location as a function of solar wind drivers
- Finds that the plume forms earlier for MC-driven storms and is wider in MLT for SH-driven storms