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The Ring Current Response to Different Storm Drivers Using Van Allen Probe Observations

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Introduction / Motivation

- The ring current responds differently to the different solar and interplanetary storm drivers such as coronal mass ejections, (CME's), co-rotating interaction regions (CIR's), high-speed streamers and other structures.
- The resulting changes in the ring current particle pressure change the global magnetic field, which affects the transport of the radiation belts. In order to determine the field changes during a storm it is necessary to understand the transport, sources and losses of the particles that contribute to the ring current.
- The source population of the storm time ring current is the night side plasma sheet. However, it is not clear how these convecting particles affect the storm time ring current pressure development.
- We use Van Allen Probes observations to determine the ring current pressure development through the storm phases.
- We combine observations from storms that are related to different interplanetary drivers, CMEs and CIRs, to determine their effect on the ring current development.

Instrumentation, Data and Orbital coverage

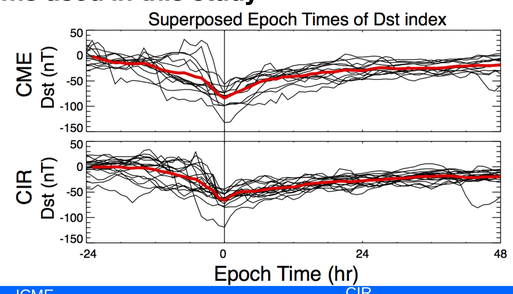
Van Allen Probes A & B

- HOPE H+ & O+ < 60 keV. The pressure calculated from the HOPE data was used with a multiplied factor of 3 to agree with measurements from other instruments.
- MagEIS - All Ions > 60 keV. Pressure calculated with MagEIS data assumed that all ions were H+. This can lead to an underestimation of the pressure if there is significant O+ above 60 keV.

Geomagnetic Storms

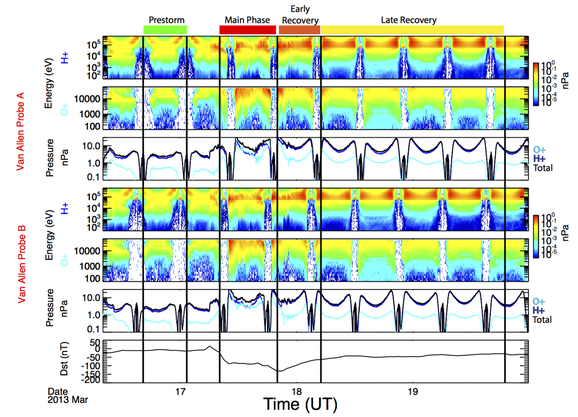
- A list of geomagnetic storms during the VAP era was compiled with the selection criteria requiring a single identifiable storm driver, a single drop and the recovery of the *Dst* – i.e. no two driver or double dip storms – and a minimum *Dst* of -150 nT.

Storms used in this study



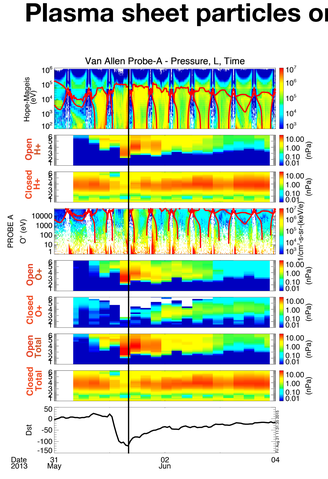
ICME		CIR			
Min Dst date	Dst	Min Dst date	Dst	Min Dst date	Dst
2013-03-17/21:00	-132	2013-03-01/11:00	-55	2013-11-07/12:00	-54
2013-06-07/05:00	-73	2013-03-29/18:00	-61	2013-12-08/08:00	-66
2013-06-29/06:00	-98	2013-05-01/18:00	-67	2014-04-30/10:00	-64
2013-07-06/19:00	-79	2013-06-01/08:00	-119	2014-08-27/20:00	-80
2013-07-14/23:00	-73	2013-07-10/22:00	-47	2015-02-18/00:00	-64
2013-11-09/08:00	-81	2013-08-05/04:00	-44	2015-04-16/23:00	-78
2014-02-28/00:00	-94	2013-08-27/22:00	-54	2015-06-08/08:13	-73
2014-04-12/10:00	-81	2013-10-02/07:00	-67	2015-07-05/06:00	-68
2014-09-12/23:00	-75	2013-10-09/01:00	-62	2015-07-23/08:00	-64
2014-11-10/17:00	-57				
2015-01-07/11:00	-80				
2015-07-13/15:00	-61				
2015-08-16/07:00	-84				

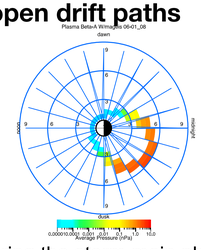
Storm Time Pressure Calculations



- Shown above is a sample storm from our storm list. The pressure energy spectra and total pressure are calculated for each spacecraft with HOPE and MagEIS data.
- In order to do a statistical study on the ring current pressure development we looked the pressure development during each phase of the storm with the following definitions for each phase.
  - Prestorm – 9 hour period (1 orbit) before the onset was determined to start.
  - Main Phase – after the onset and once the *Dst* started to significantly decrease until the min *Dst* was reached.
  - Early Recovery – From minimum to *Dst* until the slope of the increasing *Dst* changed.
  - Late Recovery – From the end of the Early recovery until the *Dst* returned to a pre-storm level
- During the main phase of the storm there is a significant pressure increase in the ring current region.
- For most of the events that we studied the bulk of the O+ pressure is confined within the HOPE instrument energy range.

Plasma sheet particles on open drift paths





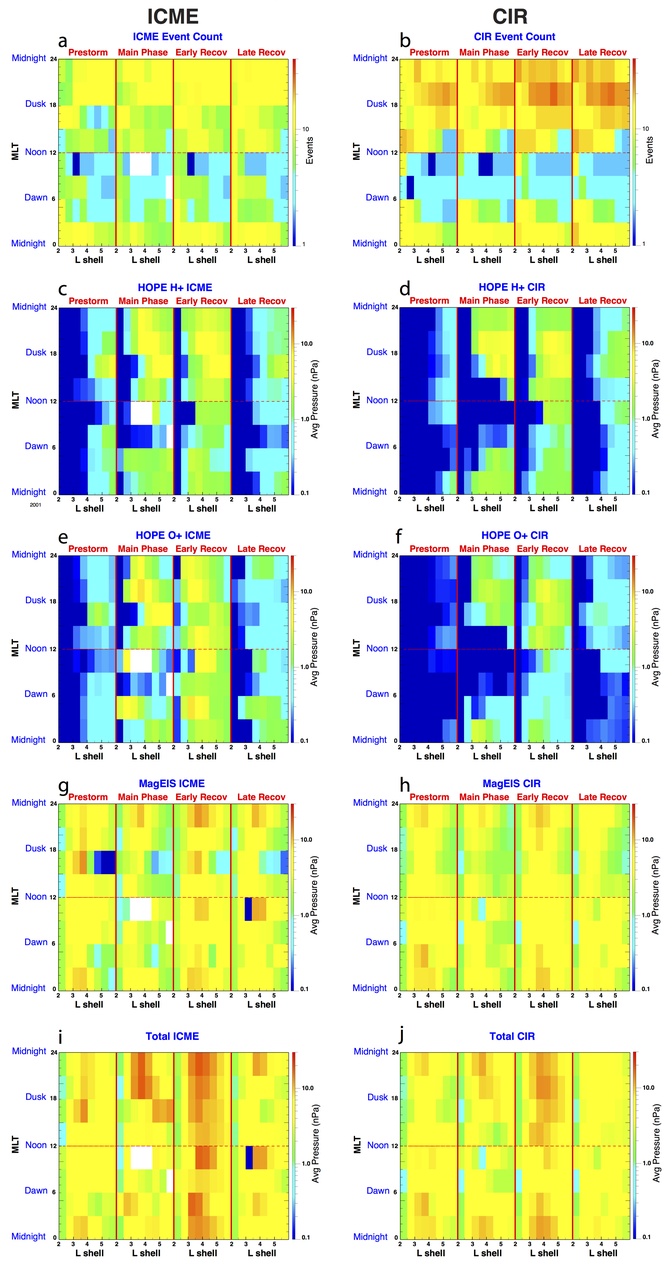
During the storm main phase most of the ring current pressure in the pre-midnight inner magnetosphere, is contributed by plasma particles convecting from the nightside plasma sheet on open drift paths developing a strong partial ring current.

For more, see:
Mouikis et al. Poster #: 2545

Storm Time Ring Current Pressure

The Pressure vs. MLT vs. L shell vs. Storm-phase plots provide a statistical overview of the pressure development in the inner magnetosphere through the storm phases

Each storm was split in four phases.The pre-storm, the main phase, the early recovery and the late recovery. Pressure measurements during each storm phase were binned accordingly in MLT vs. L. The average pressure in each bin is plotted in color.



Summary of Observations

- Plots a & b show the number of Van Allen Probe crossings of each MLT and Lshell bin during a particular storm phase. Fewer storms during 2014 leads to less coverage in the pre-noon sector.
- Plots c & d (H+ below 60 KeV)
  - These particles are typically on open drift paths during storm times.
  - During the main phase of the storm, both types of storms show the development of a clear MLT asymmetry at most L shells, and the development of a partial ring current during the main phase of the storm with a peak in the Dusk/Midnight sector. For the ICMEs the pressure is slightly higher and at lower L shells, compared to CIRs.
  - The MLT asymmetry persists during the early recovery phase in both cases.
- Plots e & f (O+ below 60 keV)
  - This energy range covers the bulk of the O+ pressure contribution.
  - The CIRs show a similar pattern to the H+ pattern. The ICMEs show a stronger O+ contribution to the pressure and a less distinct local time asymmetry
- Plots g & h (>60 keV All-Ion – treated as H+)
  - Most of the time these higher energy particles are on closed drift paths.
  - During the main phase of the storm the pressure contribution decreases, compared to the pre-storm levels, in particular in the outer L shells. The ICMEs show a larger drop compared to the CIRs. However the pressure contribution in the CIRs is similar for all phases.
- Plots i & j show the total ring current pressure development.
  - The total pressure ring current development mostly reflects the changes that are seen in the particles below 60 keV, in particular for the ICMEs. The ICME storms show a pronounced partial ring current built up during the main phase of the storm from these particles.
  - In both cases the ring current becomes symmetric in the recovery phase.

Conclusions

- Using 30 months of Van Allen Probes' data we were able to build a statistical picture of the ring current development during storms.
- The majority of the pressure increase during the main phase comes from particles with energies less than 60 keV.
- In the main phase a strong MLT asymmetry is observed leading to a partial ring current. These particles are likely convecting in on open drift paths.
- During the recovery phase the ring current becomes more symmetric as the particles with energies above 60 keV are enhanced.
- ICME storms studied generated a greater pressure enhancement that reached lower L shell values than CIRs