Van Allen Probes Observations of the Ring Current Response to Different Storm Drivers

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Introduction / Motivation

- The Ring Current responds differently to different solar and interplanetary storm drivers.
- The resulting changes in the ring current particle pressure effect the global magnetic field which controls the transport of the radiation belts.
- In order to determine the field changes during a storm throughout the magnetosphere it is necessary to understand the transport, sources, and losses of the particles that contribute to the ring current.
- The ring current energy spectra depends not only on local processes, but the entire history of the ions along their respective drift paths.
- Using models and RBSP data we can monitor the way in which particle pressure accumulates in the ring current and what particle populations are the major contributors to the pressure in the storm time ring current.

Instrumentation

- In this study we use data predominantly from the Van Allen Probes. The primary data used come from the HOPE, MAGEIS, and EMFISIS instruments of both Van Allen Probes.
- The HOPE pressure was calculated **using a factor of three** in order to match the Cluster/CODIF and RBSPICE calibrations for this time period.
- The comparable local times covered by the Van Allen Probes during the storm times studied are shown in the polar plasma beta plots below.

Model Convection Boundaries

- Using a combination of the (U, B, K) formulation introduced by Whipple [1978] and observed spectra, we analyze particle drift trajectories and their access to the inner magnetosphere.
- This way we can determine which particles we observe with the instruments on the VAPs come from the plasma tail on open drift paths and those that are part of the closed drift path Ring Current.
- The (U, B, K) formulation uses a particles total energy in terms of a Volland-Stern electric potential and magnetic field as:

$$W = qU + \mu B$$

- If energy and *μ* are conserved, then all particle drift trajectories in the (U, B, K) space are straight lines with the slope of -*μ/q*. The Volland-Stern potential has the form

$$U(r,\phi) = -\frac{a}{r} - E_0 r^{\gamma} \sin\phi$$

- Where *a* is the corotation constant, *r* is the distance from the center of the Earth, E_0 is the convection constant, and γ is the shielding parameter. For simplicity only equatorially mirroring particles are considered. A shielding parameter of 2, and the *Kp* dependent Maynard and Chen parametrization for the convection field is used in this study.
- We can determine which energies of ions have access to any point in the inner magnetosphere via either open or closed drift paths by using the extrema of our potential in (U, B, K) space [Korth et al., 2001].

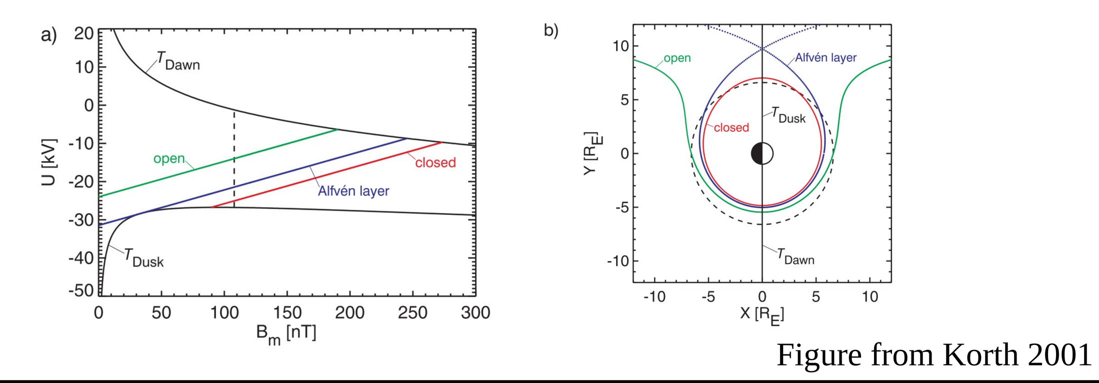
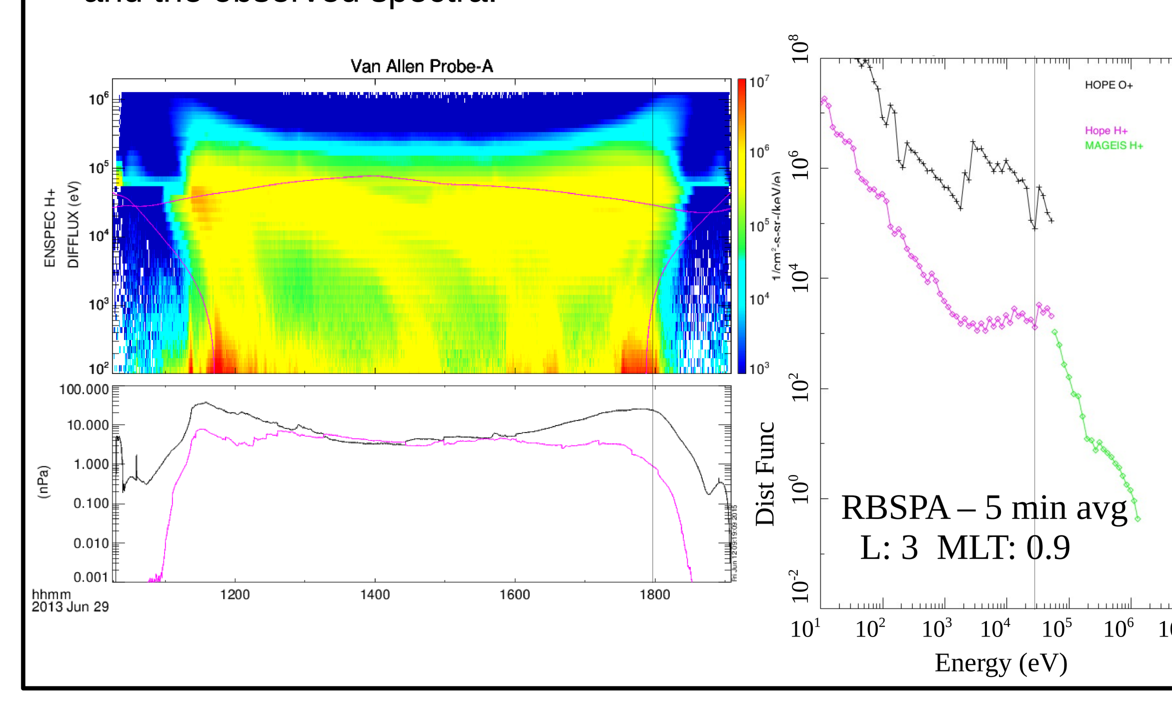


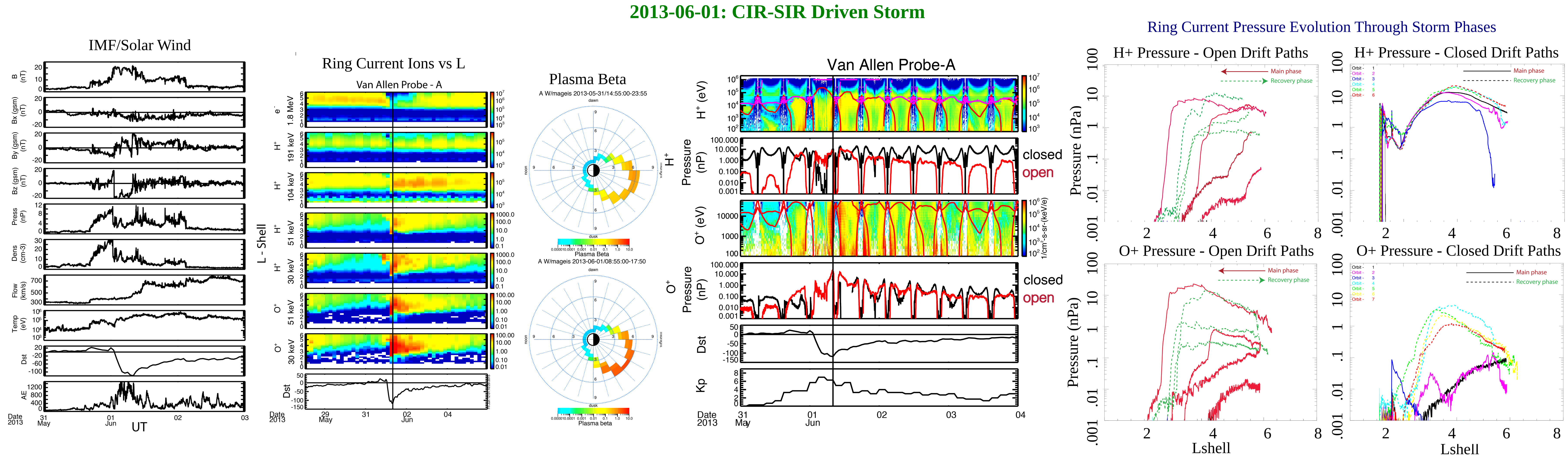
Figure from Korth 2001

Model Data Comparison

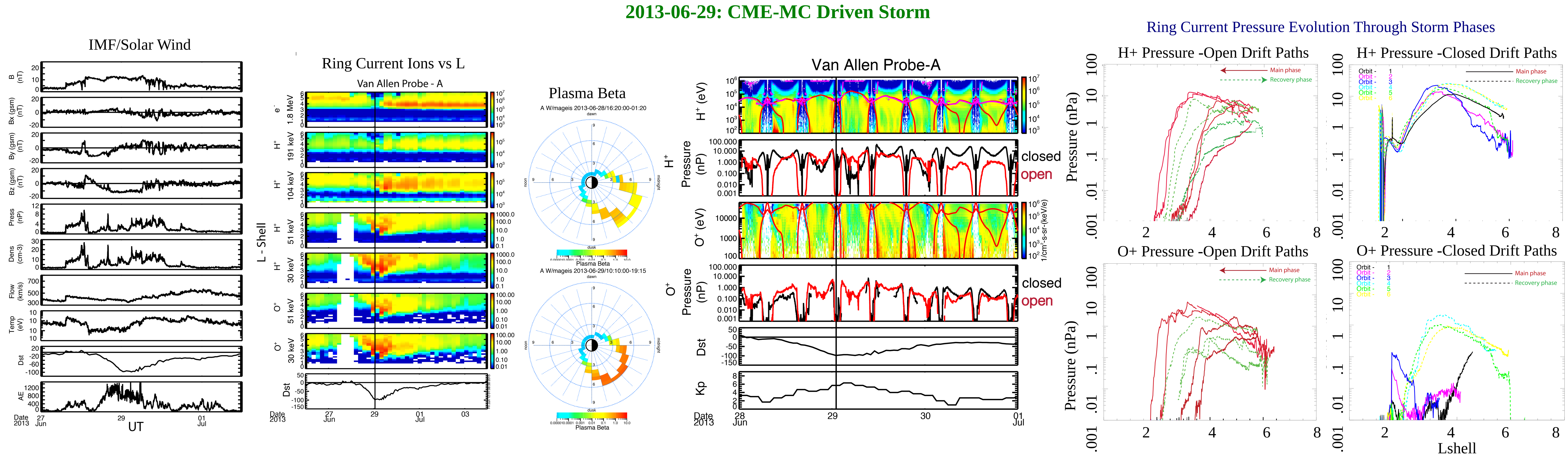
- The simple convection model seems to be mostly consistent with the observations during the quiet times in the nightside.
- However, during disturbed times the modeled prediction of the upper cutoff energy between open and closed drift paths does not match the observed spectra.
- The modeled prediction typically does not respond strongly enough during storm times, and underestimates the upper cutoff energy between open and closed drift paths.
- This would result in an underestimated contribution to the ring current pressure from particles on open drift paths.
- Since the observed spectral signatures reflect on the entire history of the ions along their drift paths, certain spectra features can indicate where the actual energy cutoff boundary is.
- The figure below shows a comparison between the model prediction and the observed spectra.



2013-06-01: CIR-SIR Driven Storm

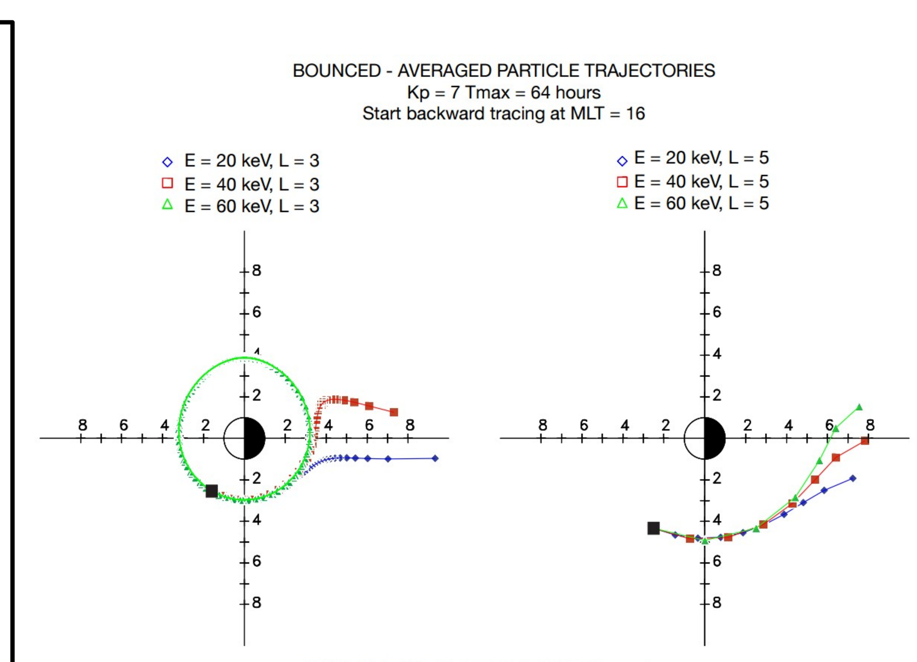


2013-06-29: CME-MC Driven Storm



Summary

- We have shown that during the storm main phase most of the ring current pressure, in the pre-midnight inner magnetosphere, is contributed by plasma particles, H+ and O+, convecting form the nightside plasma sheet on open drift paths, developing a strong partial ring current.
- The particles can reach as deep as a L ~ 2 and their pressure contribution compares to the local plasma pressure.
- During the recovery phase, if these particles are not lost at the magnetopause, some will become trapped and will contribute to the symmetric ring current.
- The Volland-Stern dipole field model, underestimates the energy cutoff between the open and closed drift paths.
- The two storms that we studied, a CME and a CIR, showed no differences in terms of plasma access and pressure contribution. However, the radiation belt response was dramatically different.



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