Increase of relativistic electron flux following the passage of a complex interplanetary structure on 09 Feb 2014

Jose Paulo Marchezi[1,2], Livia Ribeiro Alves[1], Ligia A. da Silva[1], David G. Sibeck[2], Shrikanth Kanekal[2] and Daniel N. Baker[3]

[1]INPE - National Institute for Space Research, Brazil. [2]NASA - Goddard Space Flight Center. [3]Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder. email: jpmarchezi@gmail.com

Goals

- To Analyze the recovery of relativistic outer radiation belt electron flux after the interaction of a complex interplanetary structure with the Earth's magnetosphere.
- To Evaluate the role of each ULF wave frequency range, corresponding to Pc3, Pc4 and Pc5, in accelerating outer radiation belt electrons.

What we've found...

- Injections of low energy electrons concomitant with impulsive ULF waves PC5 frequency range.
- Energization of the electrons up to energies of $\sim$ **1.0** - $\sim$ **3.0** MeV concomitant with a persistent Pc5 signal at the 4.8 - 5.1 L-shell.
- Phase Space Density (PhSD) Van Allen Probes + Themis consistent with acceleration.
- Chorus waves were not detected during this event.

09 February 2014 event

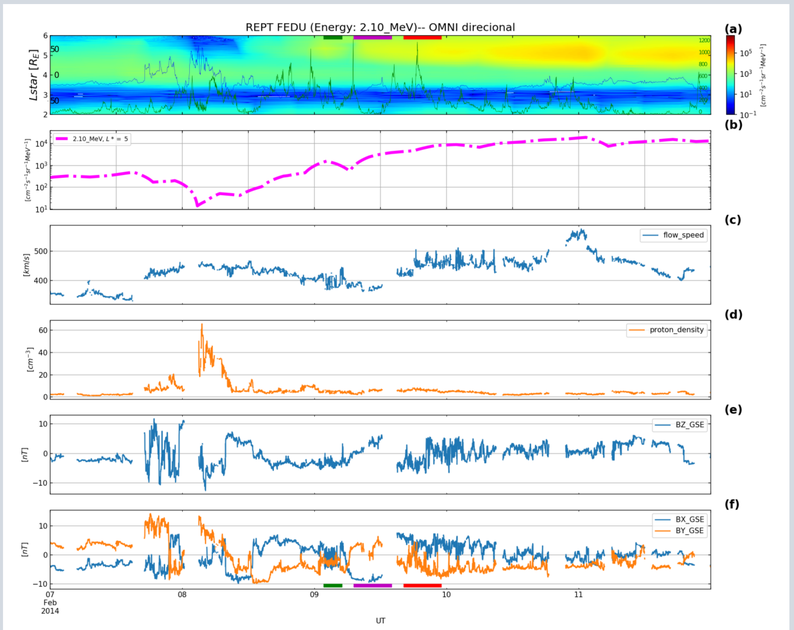

Figure: (a) Electron flux density at **2.10** MeV energy as a function of L* (vertical axes) and time (horizontal axis); (b) **2.10** MeV electron flux density at $L^* = 5.0$ Re; (c) solar wind speed; (d) solar wind proton density; (e) Interplanetary Magnetic Field (IMF) B_z component; (f) B_x and B_y component of the IMF.

- Electron flux densities are from the REPT instrument on board of the Van Allen Probes. The flow speed, Density, Bz, Bx and By are obtained by the Advanced Composition Explorer (ACE) satellite in the Lagrangian L1 point.
- The colored bars on the X-axis represent the first, second and third orbits of the Van Allen Probe A. during 09 February, 2014.
- The period is characterized by the interaction of a complex solar wind structure resulting from the interaction of a Coronal Mass Ejection (CME) followed by a High-Speed Stream (HSS).

Energy with L-star

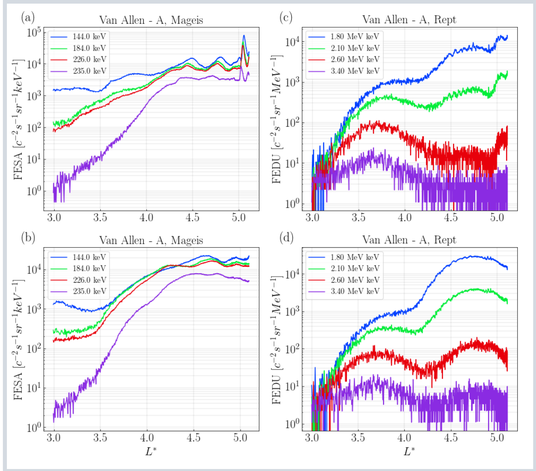

Figure: Low and high energy electrons flux density, corresponding to the second and third orbit in 09 February 2014.

- We can see a bump in the low energy electrons, at $L \approx$ **5** R_E in the upper left panel.
- The high energy electrons have an increase in $L \approx$ **4** R_E up to **5** in the next orbit bottom right panel

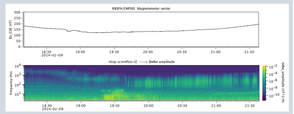

Figure: Bz magnetic field from Emfsis instrument onboard of Van Allen-A and the Power spectral density of the magnetic field in the Chorus wave frequency band.

Flux and Wave signals from 18:10 up to 21:38 UT

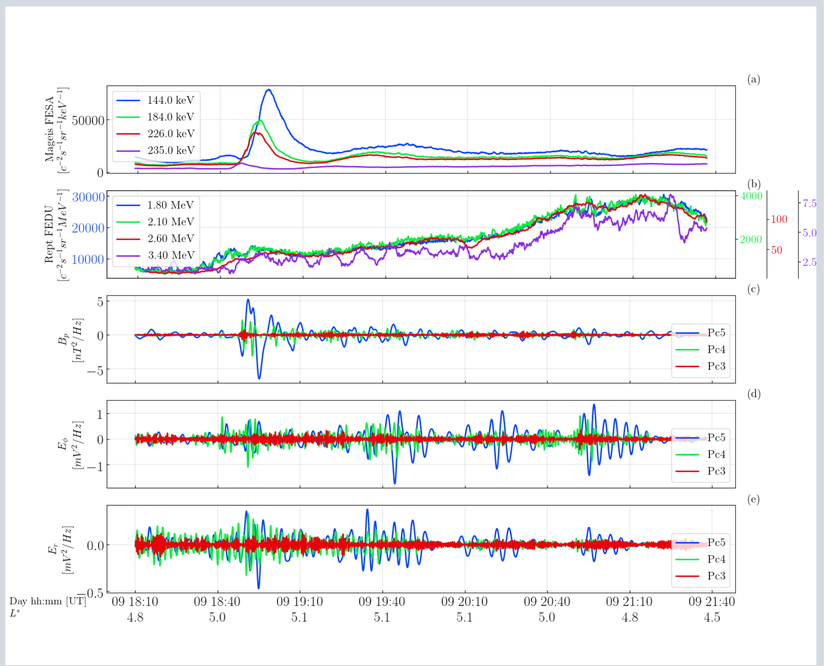

Figure: (a) Mageis electron flux density, the energies goes from **144** keV to **235** keV. (b) Rept relativistic electron flux, energies from 1.8 MeV up to 3.4 meV. (c), (d) and (e) present the B_p, E_{phi} and E_r ULF signal filtered in the frequency band of Pc3, Pc4 and Pc5.

Phase Space Density - PhSD

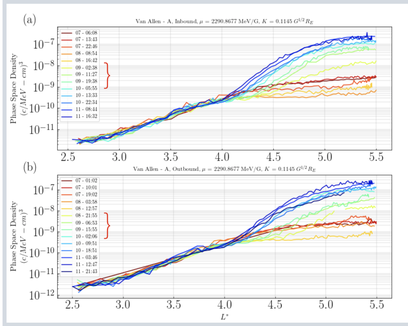

Figure: Time evolution of phase space density radial profiles at fixed first (μ) and second (K) adiabatic invariant for both (a) outbound and (b) inbound parts of the RBSP-A orbit. The legends in Figures a and b show the start day and time (in the dd/hh:mm format) of either the outbound or inbound portions of RBSP-A.

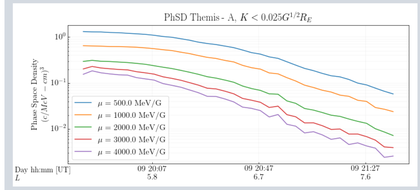

Figure: Time evolution of phase space density radial profiles at $K < 0.025G^{1/2}R_E$ and μ values varying from **1000** up to **4000** MeV/G.

- The Van Allen PhSD show a positive gradient in the PhSD in the orbits after the Feb 09.
- The Themis-D PhSD show a negative gradient for this period.

Discussion

- With frequencies in the same range as those of the particle drift, ultra-low frequency (ULF) waves are known to cause significant changes in the energetic particle flux in the outer radiation belts.
- On 09 February 2014, the ACE satellite detected solar wind plasma and magnetic field perturbations related to an Interplanetary Mass Ejection (ICME) followed by a High Speed Solar Wind Stream (HSS) event.
- We are interested in the period around 18:00 UT, on 09 Feb. 2014, when the outer radiation belt electrons flux exhibited a gradual increase.
- We can see that the Pc5 and Pc4 wave signals have well defined wave packets and persists in the next few hours after the bump in the low energy levels, the Pc3 signal has lower amplitudes.
- The Figures 5 show a positive gradient in the PhSD in the orbits after the Feb 09.
- On the other hand, the Themis-D PhSD shows a negative gradient.
- Both Van Allen Probes and Themis PhSD suggest that the waves can be acting to increase the energy of electrons.

Acknowledgments

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References

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