On the cause of electron acceleration and loss in the outer Van Allen belt

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Katsavrias, Ch., I.A. Daglis and W. Li (2019), **On the Statistics of Acceleration and Loss of Relativistic Electrons in the Outer Radiation Belt: A Superposed Epoch Analysis**, *J. of Geophys. Res. Space Physics*, 124, doi: 10.1029/2019JA026569

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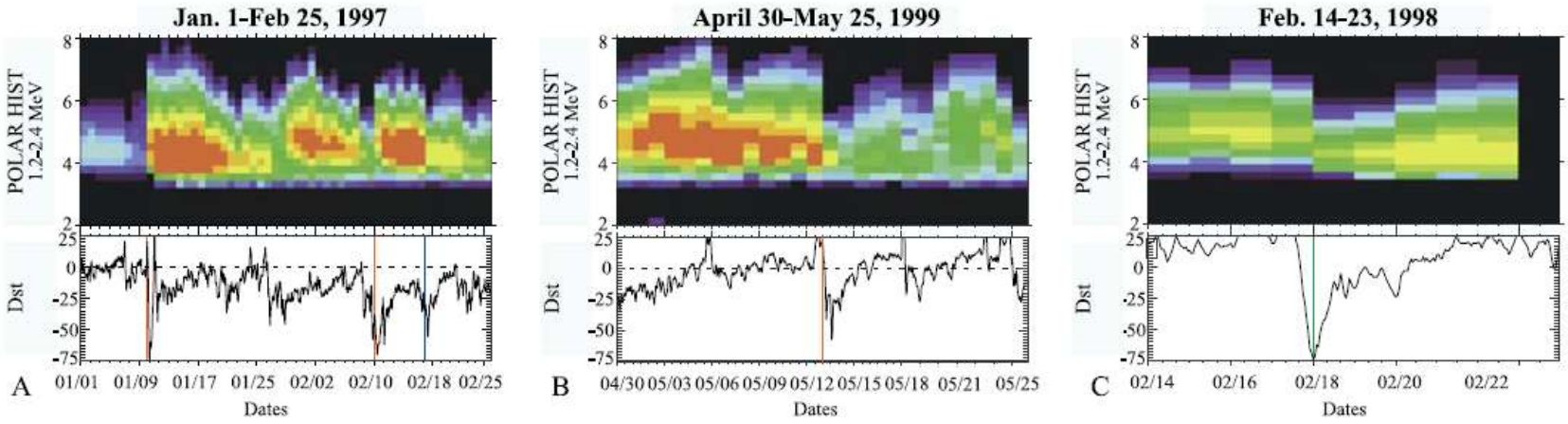
Outline

- Motivation – Goal
- Event Selection
- Data and analysis
- Superposed Epoch Analysis
- Conclusions

Motivation

Assess the contribution of various mechanisms to the variability of the outer Radiation Belt.

- Based on an extensive survey of 276 geomagnetic storms, Reeves et al. 2003, found that about half of all storms result in a net flux increase of relativistic electrons while the rest half resulted in losses or no significant change indicating the complex nature of relativistic electron acceleration and loss.

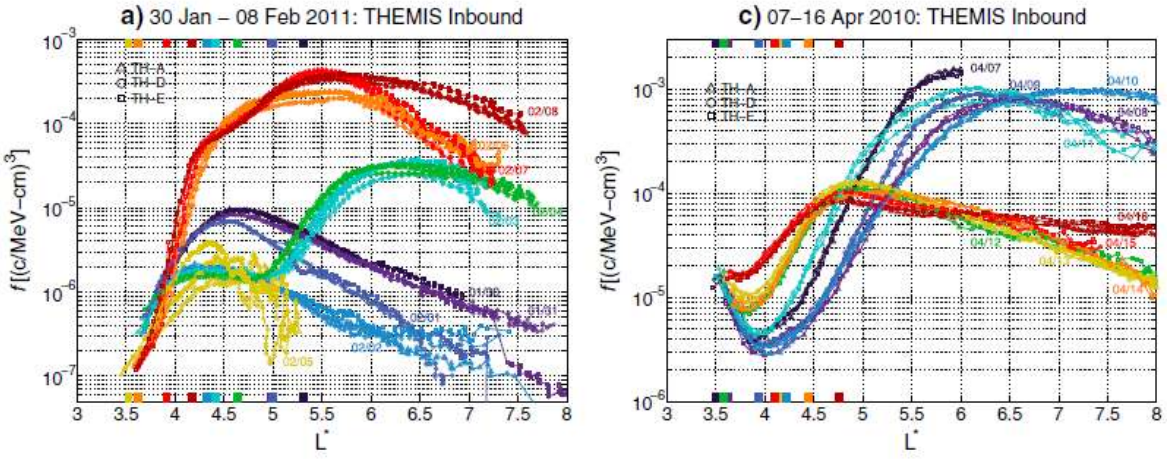


Reeves et al. GRL2003

Acceleration of electrons… How???

Enhancement vs Depletion

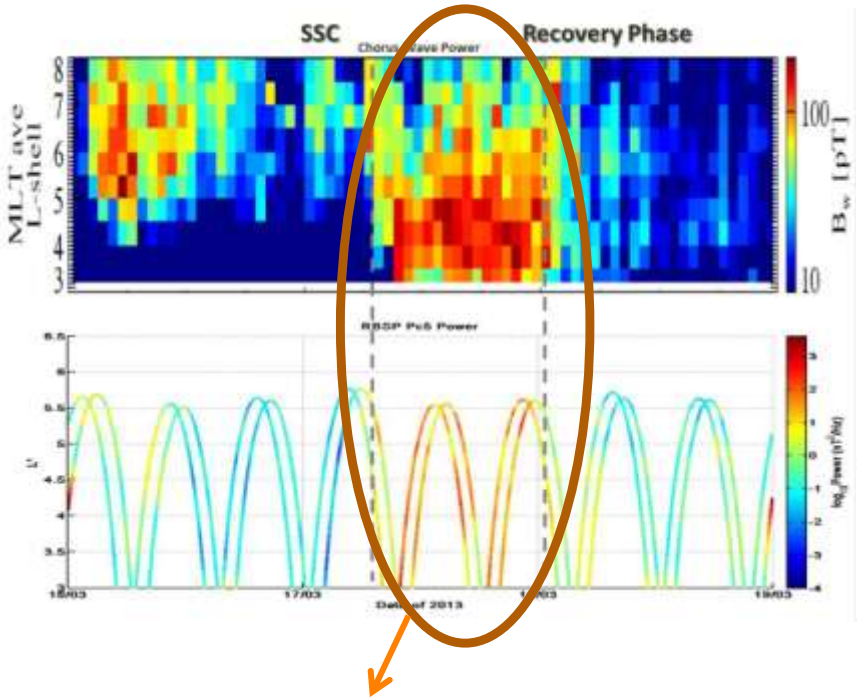
- more enhanced chorus amplitudes at broader ranges in L*
- more prolonged periods of enhanced Pc5 activity
- a smaller range in L* of hiss
- fewer EMIC wave events throughout the period

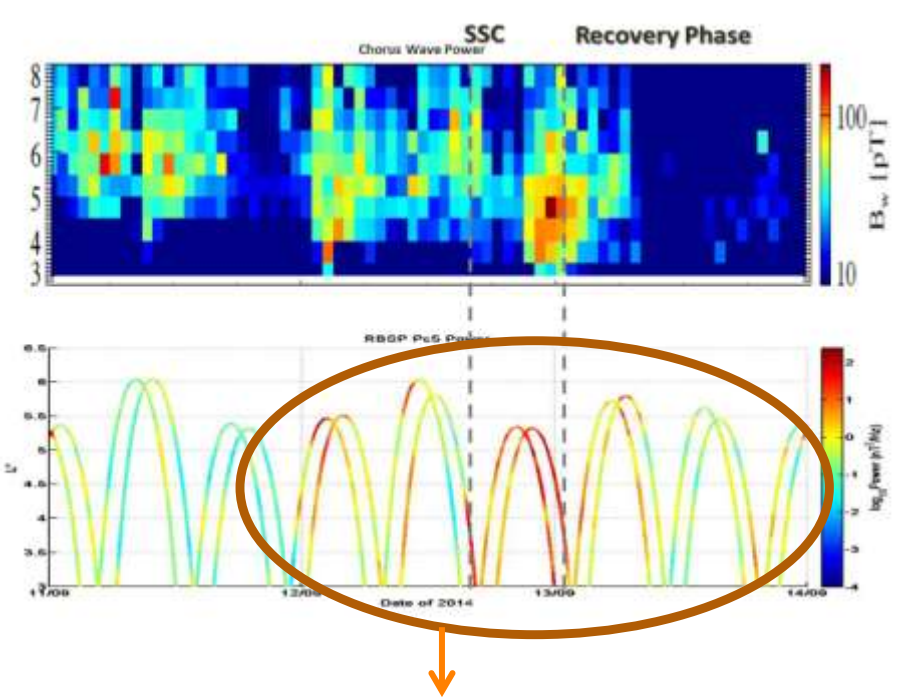


Turner et al. JGR2013

Acceleration of electrons… How???

Enhancement vs Depletion





Simultaneous Enhancement of Pc5 and Chorus Activity

Prolonged enhancement of Pc5 activity

Katsavrias et al. AnnGeo2015

Event Selection

- **Usually statistical studies include only moderate/intense storms (Dst < -50 nT).**

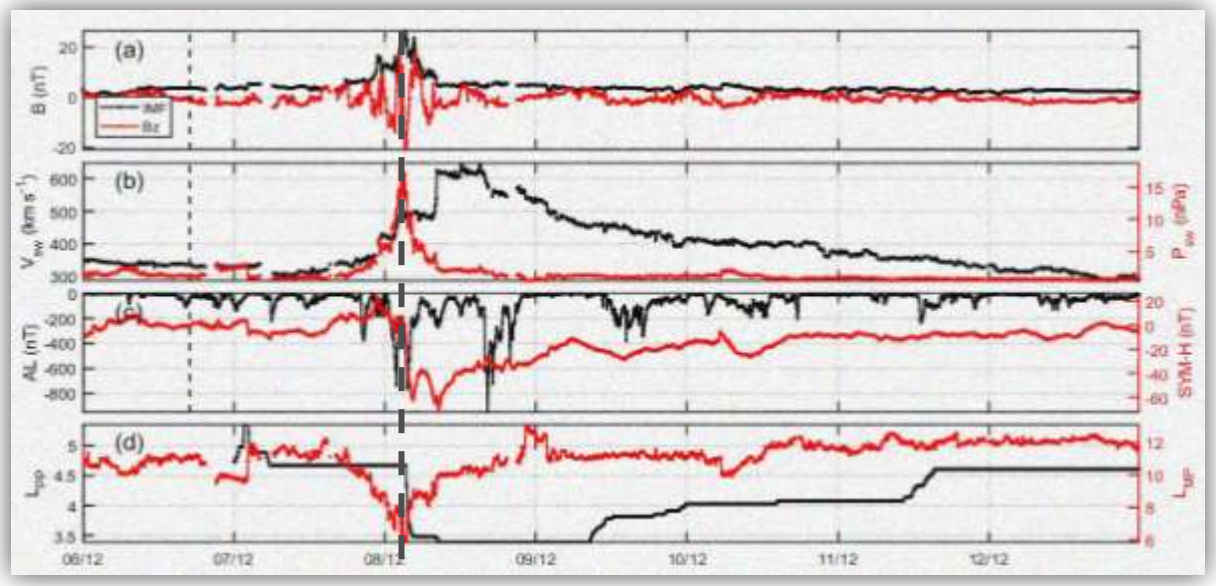
- **Recent papers have shown that weak or even non-storm events can result in significant losses *[Katsavrias et al., GRL2015]* or enhancement *[Schiller et al., GRL2014 & Katsavrias et al., JGR2019]* of the electron population in the outer belt.**

Event Selection

- **Average solar wind conditions at least 12 hours before the start of the event:**

V_{sw} < 400 km/s	P_{sw} < 3 nPa	SYM-H > -20 nT	AL > -300 nT	-5 < Bz < 5 nT

- **71 events during the RBSP era (9/2012 – 4/2018) spanning the maximum/declining phase of Solar cycle 24.**



Data & Analysis

Electron PSD

The electron PSD distribution is calculated from RBSP/MagEIS & REPT differential fluxes as a function of fixed adiabatic invariants using the method described by *Chen et al., 2005, 2007*.

Pc5 waves (2 < f < 7 mHz)

Pc5 wave power is calculated from EMFISIS magnetic field measurements using the method described by *Balasis et al., 2013*.

Lower-band Chorus waves ($0.1f_e < f < 0.5f_e$)

Chorus wave amplitude is estimated from the POES measurements of precipitating electron fluxes using the method described by *Li et al., 2013*.

Data & Analysis

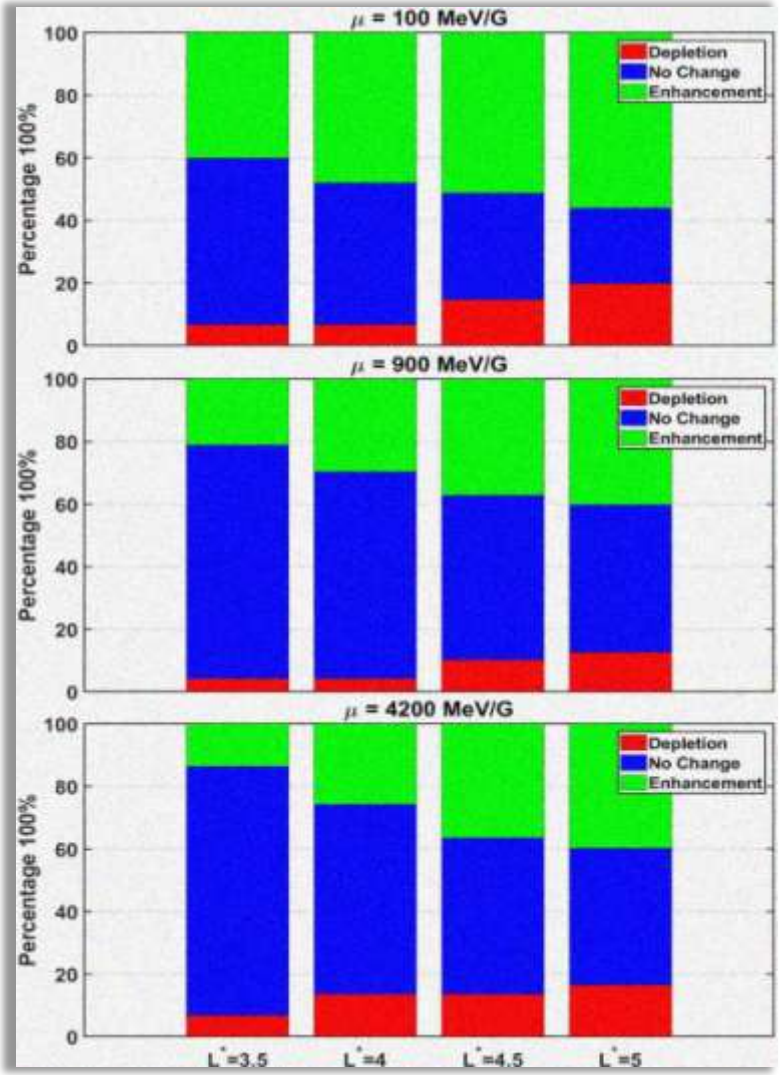
1. **First adiabatic invariant**
   - μ = 100 MeV/G (seed population),
   - μ = 900 MeV/G (relativistic electrons) and
   - μ = 4200 MeV/G (ultra-relativistic electrons).

2. **Second adiabatic invariant**
   - Near-equatorially mirroring electrons ($K < 0.03\ G^{1/2}\ R_E$)

3. **Third adiabatic invariant**
   - L*~3.5 ($3.25 \leq L^* < 3.75$)
   - L*~4 ($3.75 \leq L^* < 4.25$)
   - L*~4.5 ($4.25 \leq L^* < 4.75$)
   - L*~5 ($4.75 \leq L^* \leq 5.25$)

Net Effect Statistics

Enhancements	$PSD_{Post}/PSD_{Pre} \geq 6$
Depletions	$PSD_{Post}/PSD_{Pre} \leq 1/4$
No Change	$1/4 < PSD_{Post}/PSD_{Pre} < 6$



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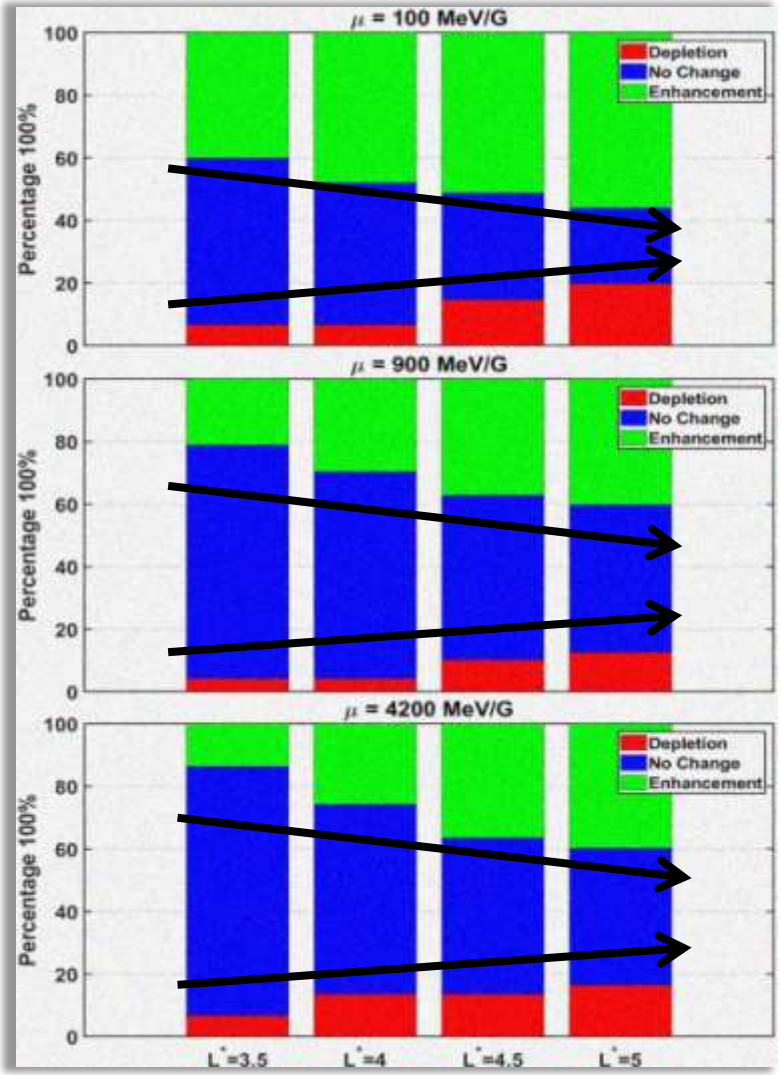
More enhancements and more depletions with increasing L* values.



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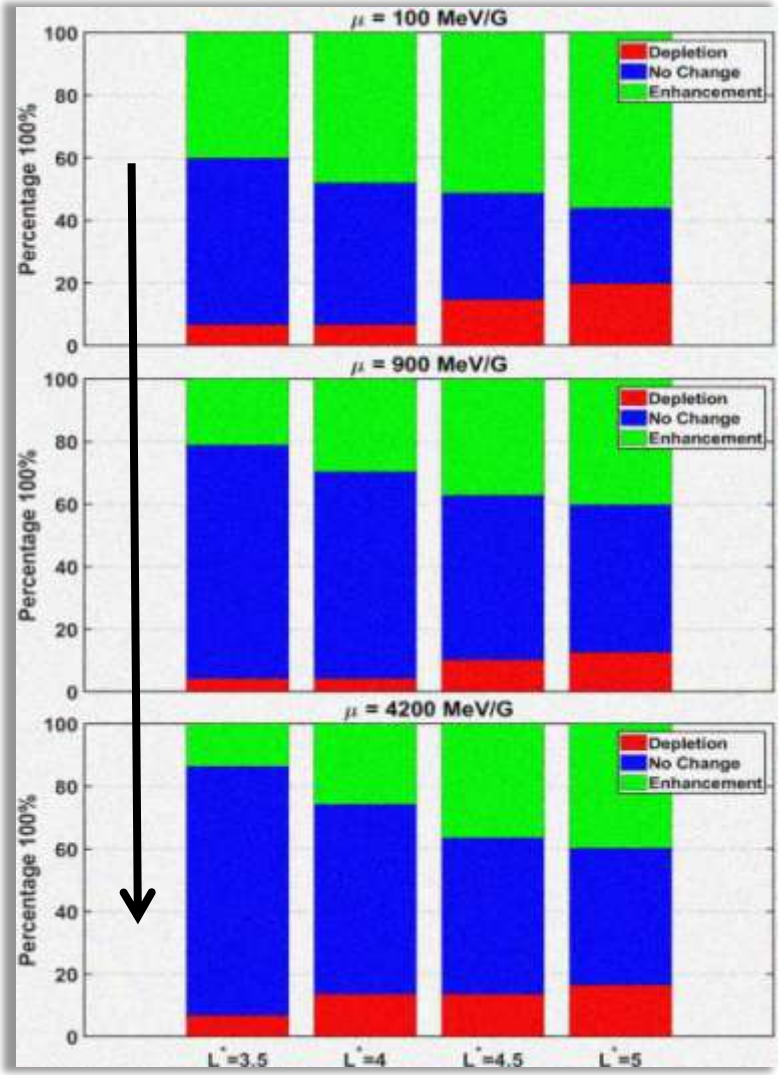
Less enhancements with increasing μ values.



Net Effect Statistics

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Depletions	$PSD_{Post}/PSD_{Pre} \leq 1/4$
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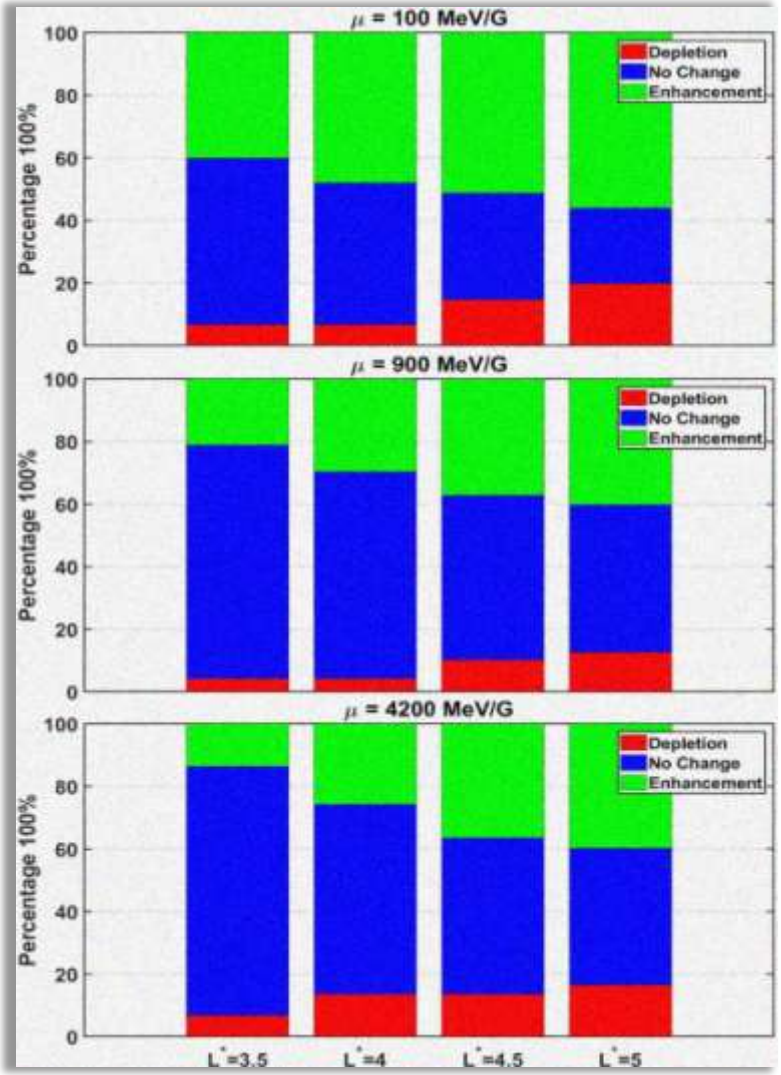
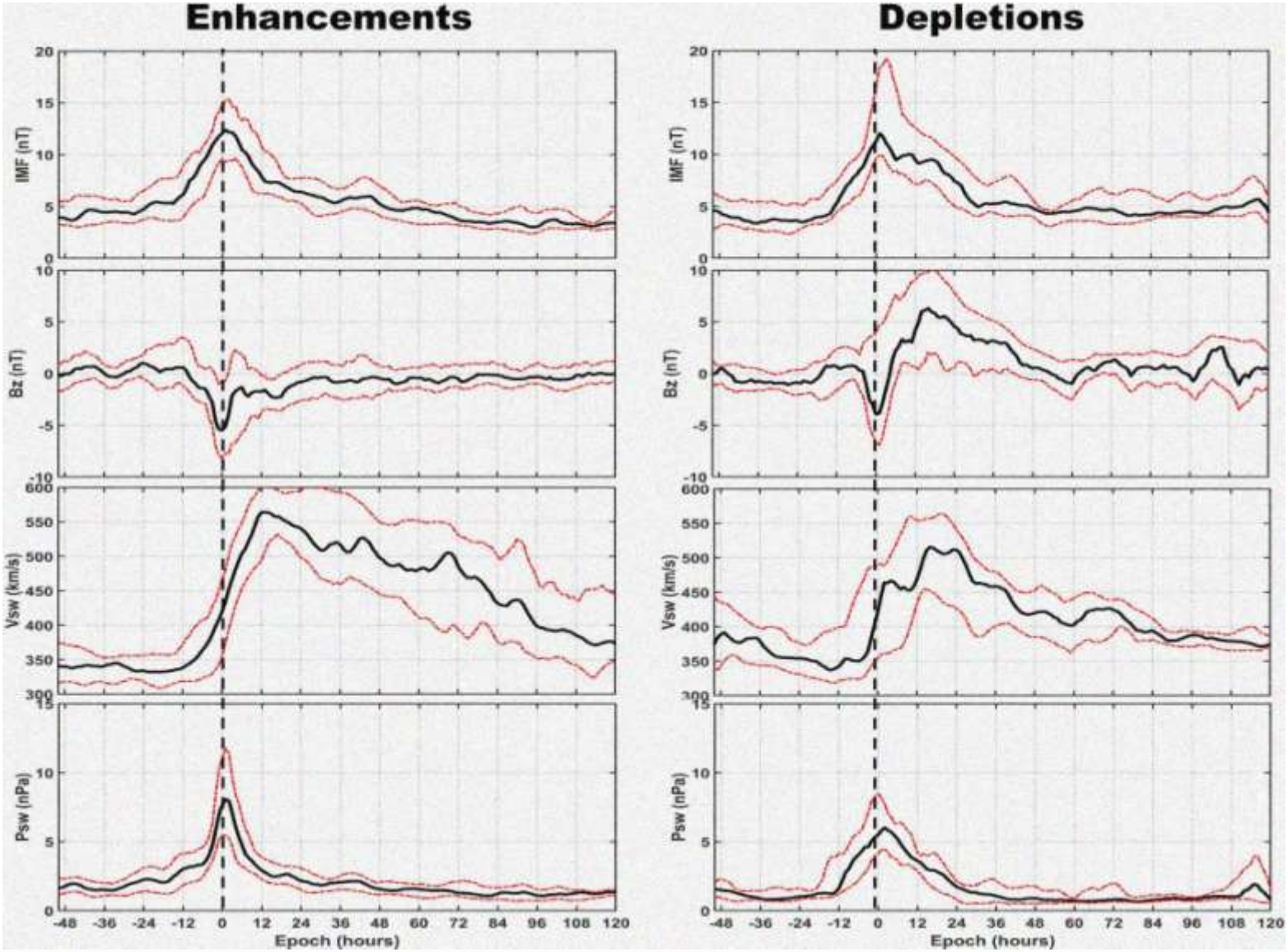
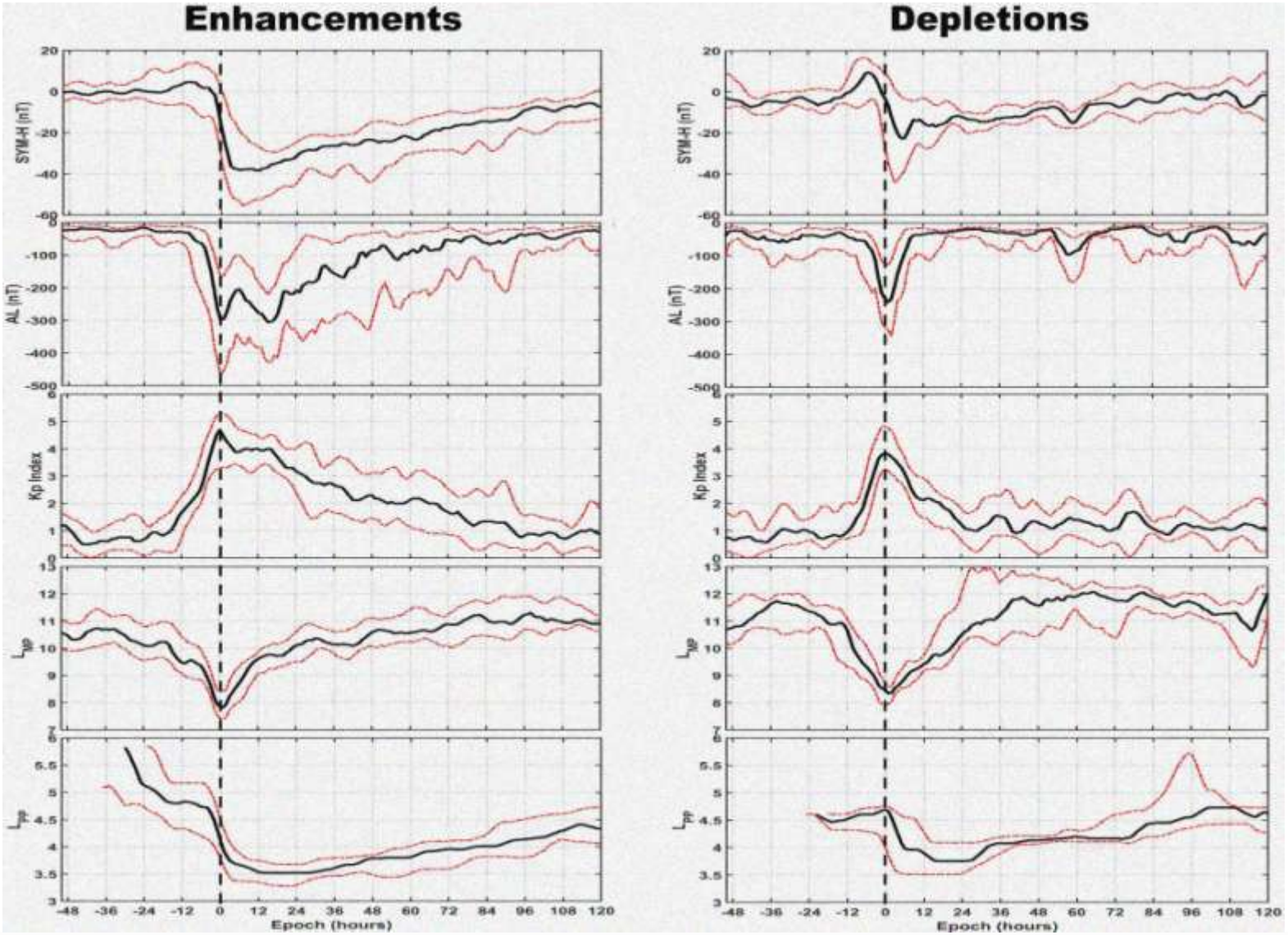
- **20 Events with enhancement of the relativistic (μ = 900 MeV/G) electron population at L*≥4.5**
- **8 Events with depletion of the relativistic (μ = 900 MeV/G) electron population at L*≥4.5**



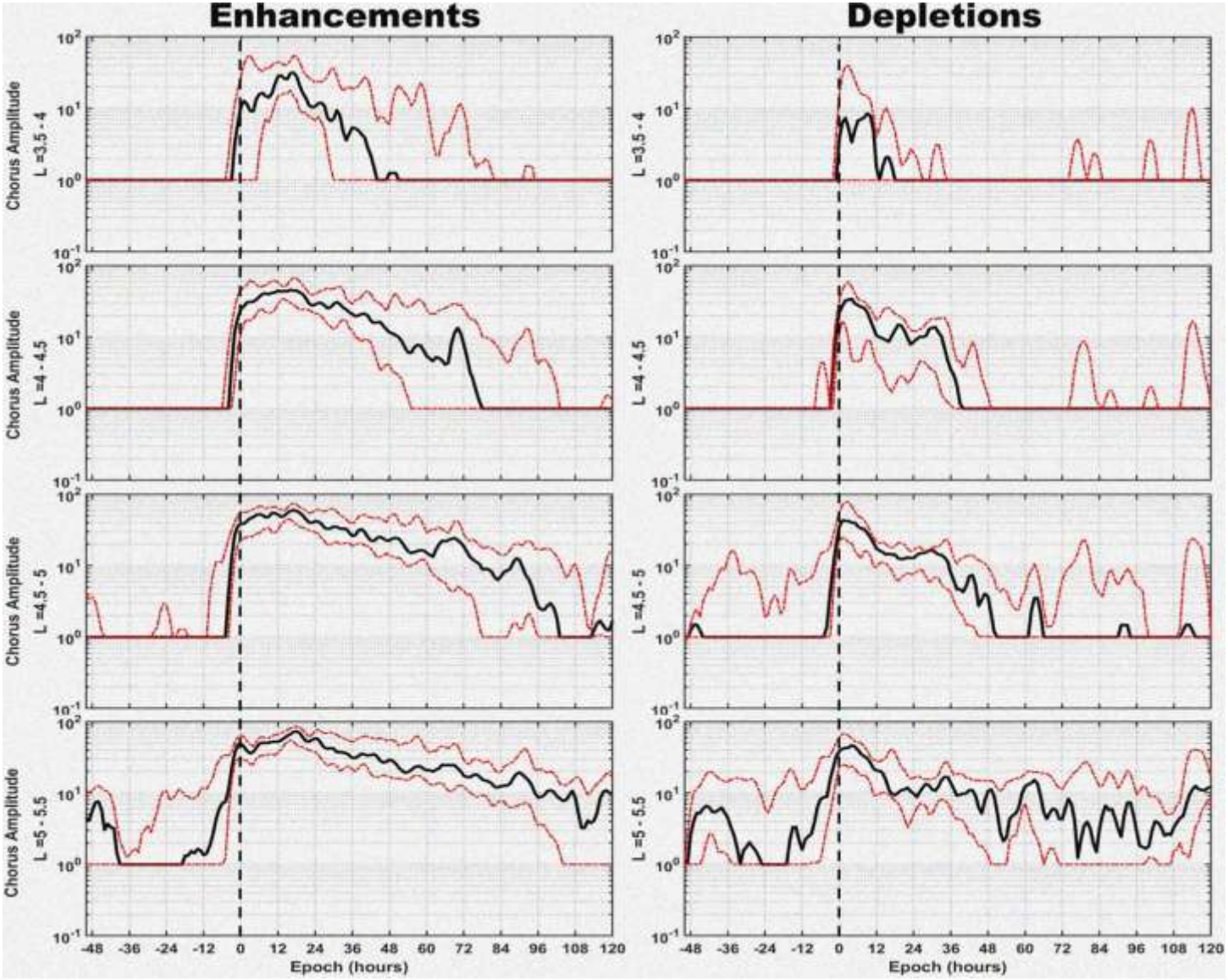
Solar wind parameters



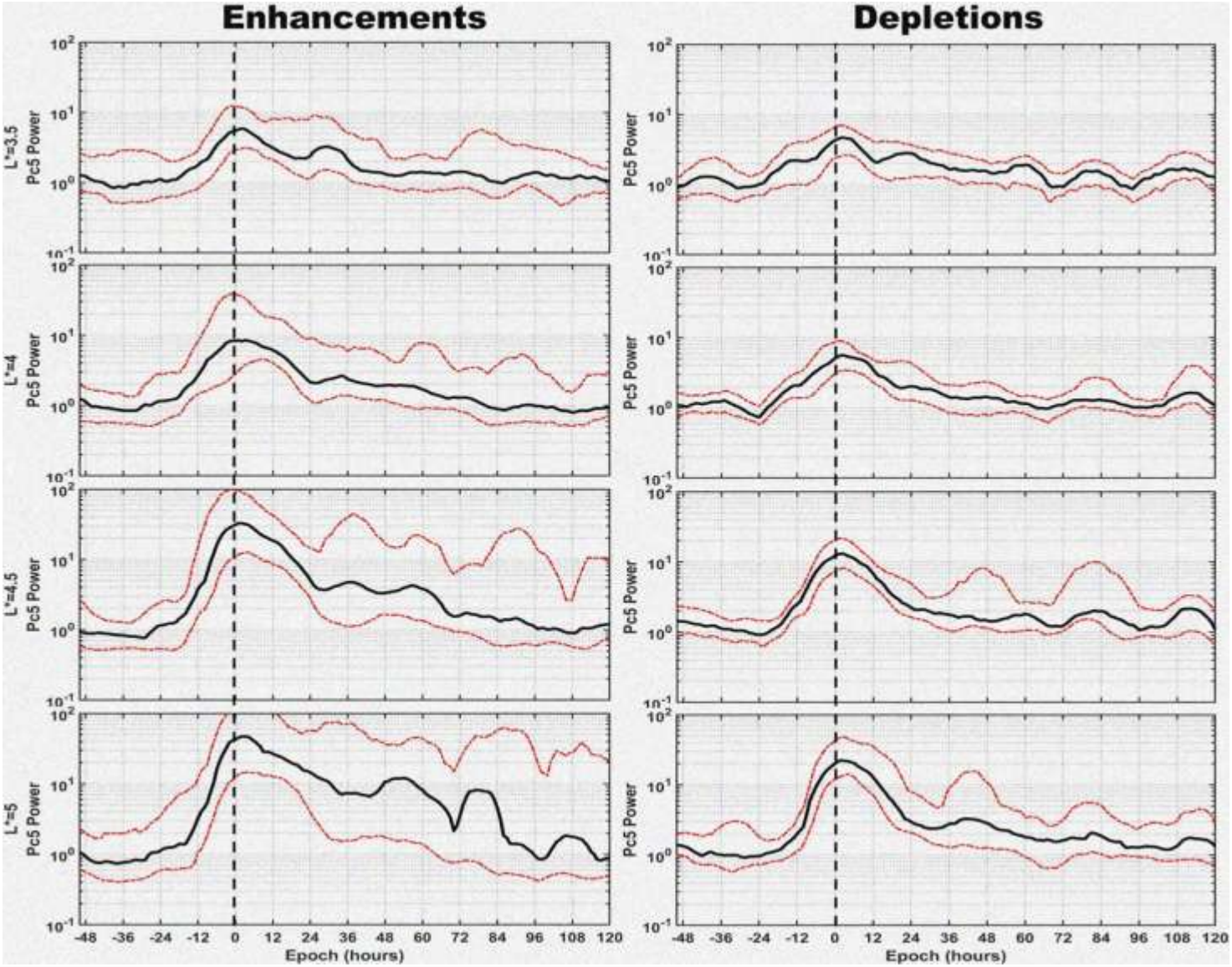
Magnetospheric parameters



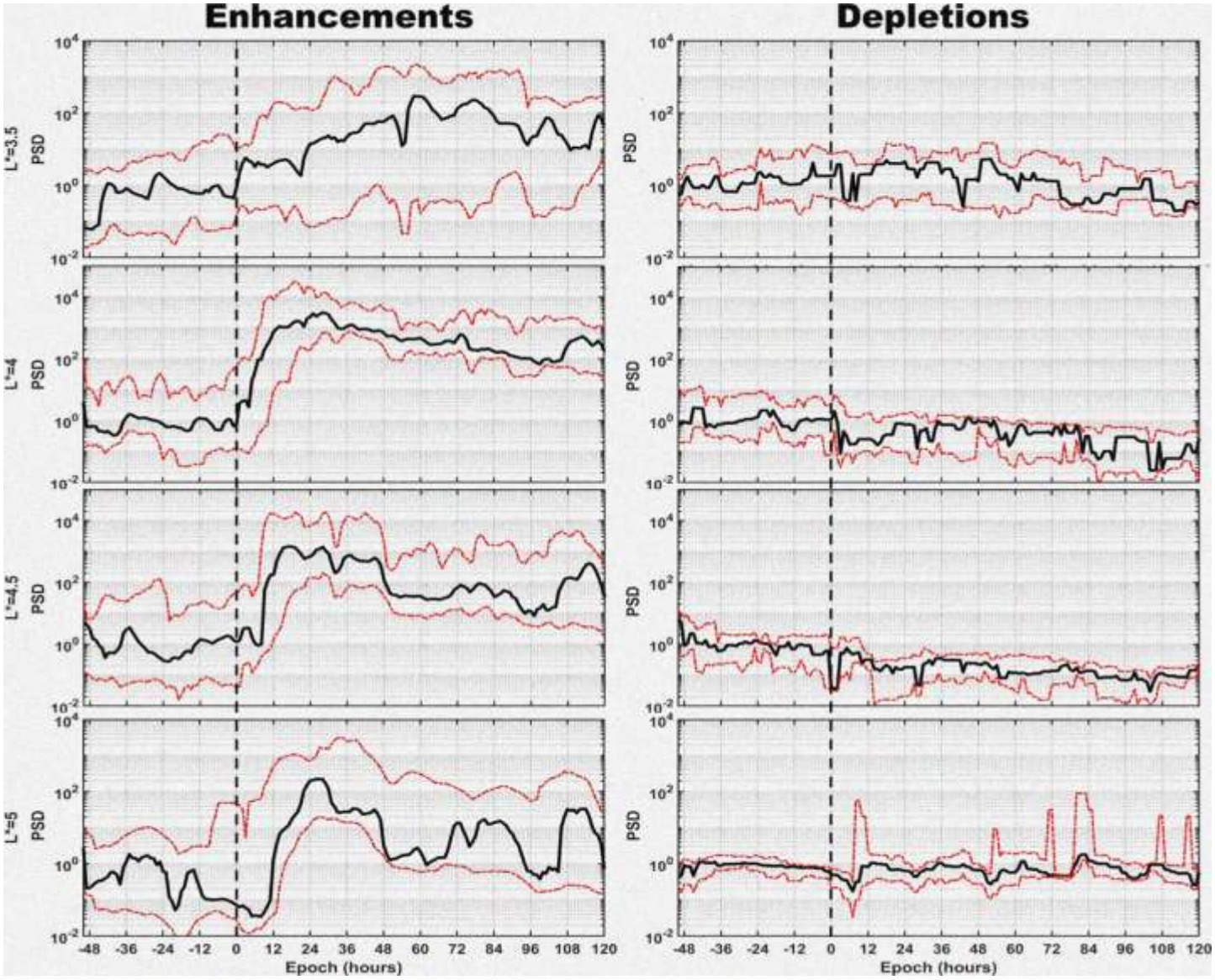
Chorus waves



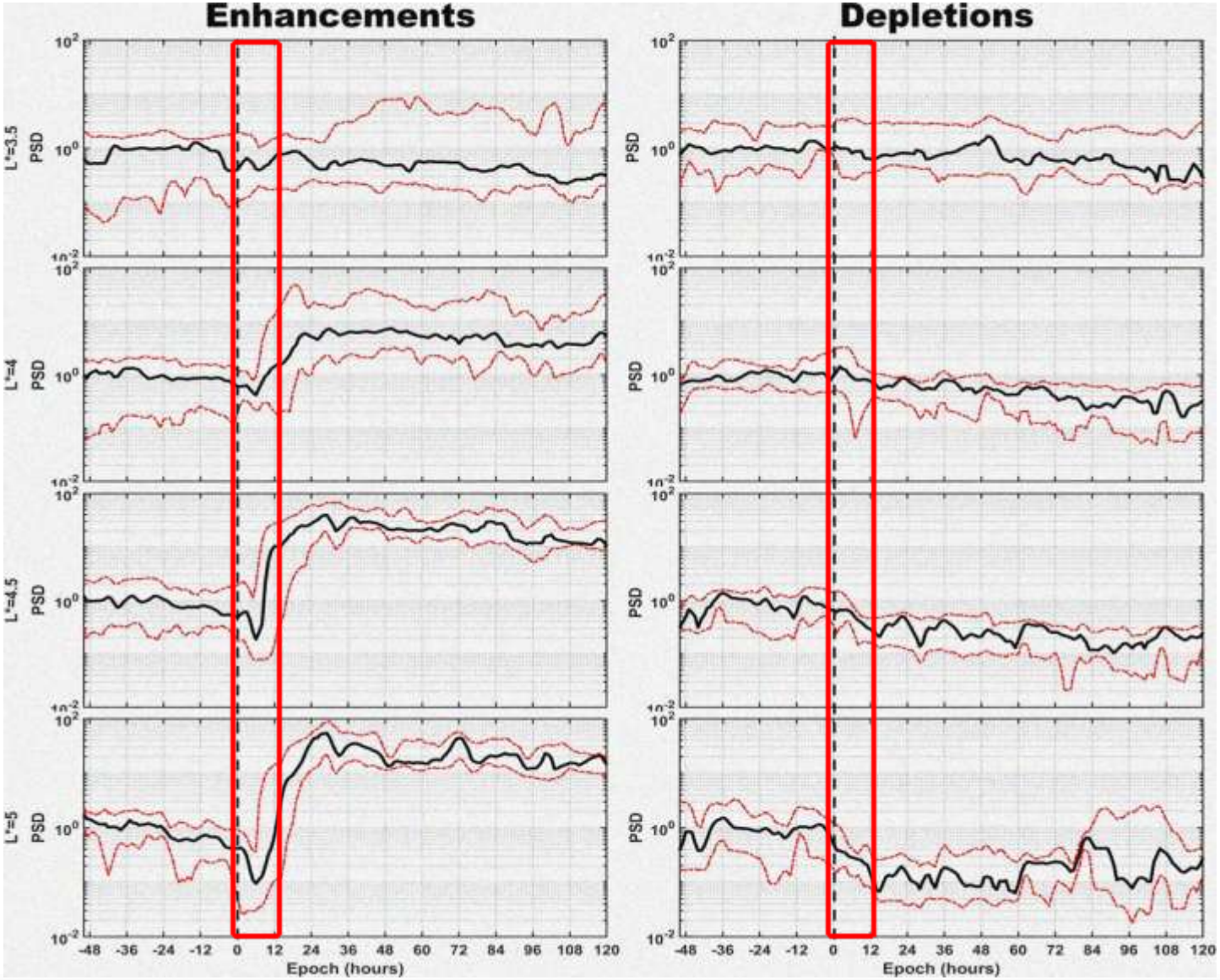
Pc5 ULF waves



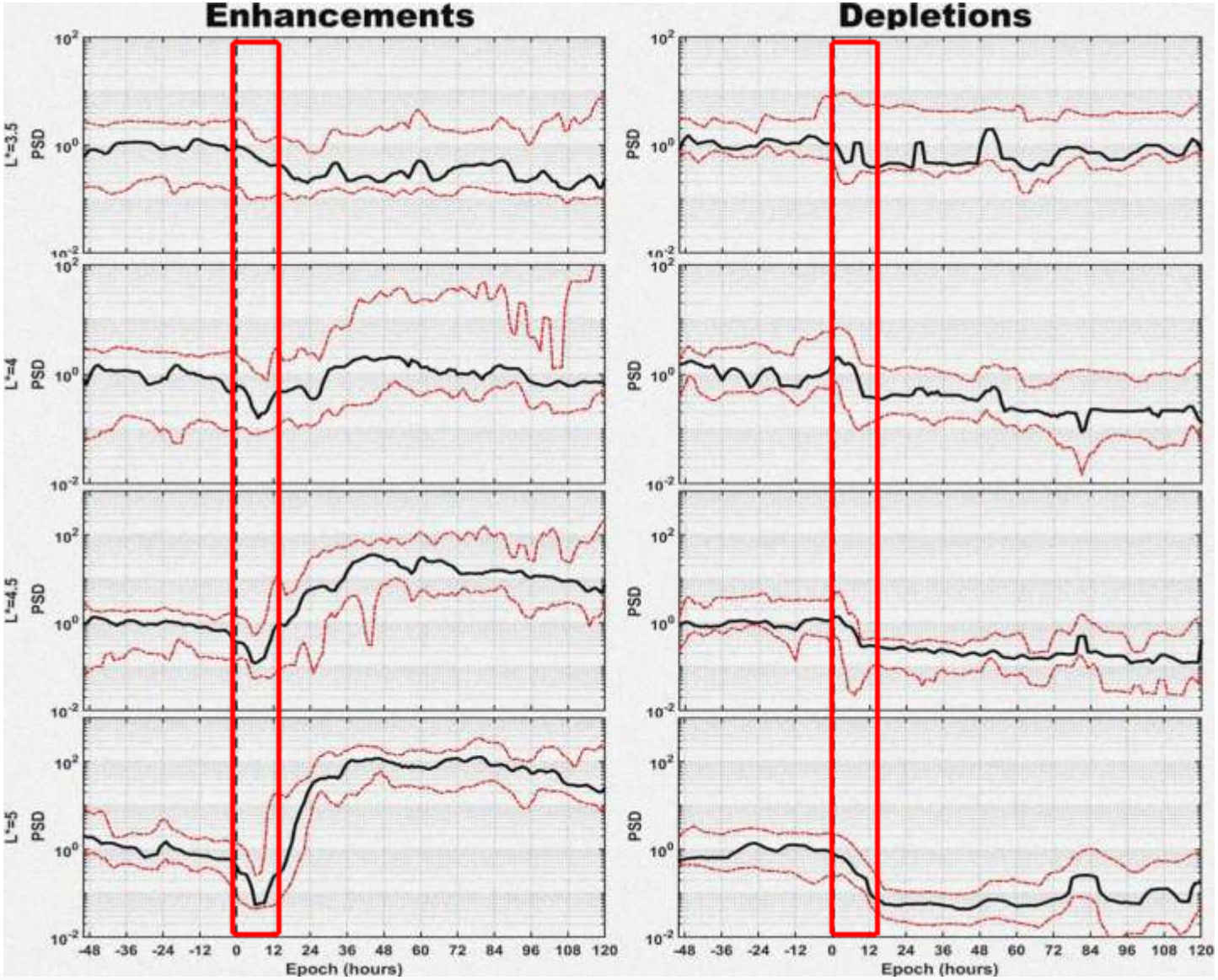
Seed electrons (μ = 100 MeV/G)



Relativistic electrons (μ = 900 MeV/G)



Ultra-relativistic electrons (μ = 4200 MeV/G)



Conclusions

1. The number of enhancement events is μ- and L* dependent.

2. Enhancement vs Depletion events

   i. persistently southward Bz
   ii. large and long–lasting values of solar wind speed
   iii. stronger and long–lasting decrease of SYM-H index
   iv. more intense and prolonged substorm activity
   v. intense and long–lived chorus activity
   vi. longer–lived Pc5 activity

Conclusions

3. **SEA reveals two phases after zero-epoch time.**

   I. **<u>Phase 1</u>: Regardless the net-effect** there are significant **losses** of relativistic electrons due to the synergy of **outward diffusion** and **MP shadowing**.

   II. **Phase 2:**

      a. During **enhancement events**, the existence of **enhanced seed population and chorus activity** can quickly replenish the losses of relativistic electrons.

      b. During **depletion events,** the absence of enhanced seed population renders **the combination of magnetopause shadowing and outward diffusion as the dominant loss mechanism**.

Thank you
for your Attention