**INTRODUCTION**

Local acceleration of relativistic electrons in the outer radiation belt to relativistic energies.  This mechanism strongly depends on the solar wind and on the source and seed electron populations downstream of the magnetopause. 

Thus, the intensity of electrons in the outer Van Allen belt is highly fluctuation. 

At that end we can calculate the electron phase space density (PSD) for three values of the first subinvariant L corresponding to source and seed electron.

Furthermore, we perform a superseded epoch analysis of 28 geospace disturbance events. 

20.30.80 found in enhancement and 8 depletion of relativistic electron PSD.

**EVENT SELECTION AND SUPERPOSED EPOCH ANALYSIS**

The events need to emerge after at least 12 hours of quasi-stationary solar wind conditions, reaching \( V_{SW} > 400 \text{ km/s} \) \( \Phi = \ell \text{ MeV} \). 

They comprise of two storms and non-convex events, having either CMEs or SIAs as drivers. 

These 71 events in the Van Allen Probes (RAP) [2010-2015], spanning the maximum/midlaunch phase of Solar Cycle 24. 

The selected events are based on the work of Katsavrias et al. [2017], and Kasaros et al. [2019].

**Figure 1.** Example of solar wind properties, magnetospheric parameters and indices, and the selection of key time, \( t_e \), for a selected event (27 Feb. - 5 Mar. 2010). \( t_{MDI} \) and \( t_{MDR} \) calculation is based on Fok et al. [2003].

**EVENT CATEGORIES**

From the 71 events of the studied database, we study only the 20 events resulting in enhancement and 8 events resulting in depletion of the average PSD for relativistic electrons of \( \mu = 50 \) [MeV/c], at L=4.5, based on the results of Katsavrias et al. [2010]; and Kasaros et al. [2019], respectively.

**SOLAR WIND PARAMETERS**

- **IMF** \( [nT], B \text{ [nT]}, V_{SW} \text{ [km/s]}, P_{SW} \text{ [nPa]} \)

**Figure 3.** Enhancement events are caused by disturbances showing a stepwise increased IMF, and prolonged negative \( B_z \), and highly increased and long lasting \( V_{SW} \), with values reaching over 500 [km/s], together resulting in enhanced magnetic reconnection at the dipole magnetopause.

**GEOMAGNETIC INDICES**

- \( SYM-H \text{ [nT]}, AL \text{ [nT]} \)

**MAGNETOSPHERIC PARAMETERS**

- \( L* \), \( L \text{ [nT]} \), \( L_{eq} \text{ [nT]} \)

**Figure 4.** Enhancement events are characterized by prolonged negative \( SYM-H \) and \( AL \) indices, resulting in enhanced and long prolonged storm and substorm activity, and a significantly suppressed plasmapause reaching under 4 L*.

**CHORUS WAVE AMPLITUDE**

**Figure 5.** Chorus wave amplitude inferred from FOES electrons (10–100 keV) precipitation [2013] and correlated with substorm activity (AL index). 

**Figure 6.** PPS wave power inferred from MIW. 

**P3S WAVE POWER**

**Figure 7.** Normalized P3S wave power.

- **ELECTRON PSD FOR**
  - **SOURCE ELECTRON**
    - \( \mu \geq 10 \text{ [MeV/c]} \), \( E \geq 10 \text{ [keV]} \)

**Figure 7.** Source electrons of \( \mu = 10 \text{ [MeV/c]} \), \( E = 10 \text{ [keV]} \)

**Figure 8.** Source electrons of \( \mu = 10 \text{ [MeV/c]} \), \( E = 10 \text{ [keV]} \), \( L = 4.5 \text{ [L*]} \)

- **ELECTRON PSD FOR**
  - **SEED ELECTRON**
    - \( \mu = 10 \text{ [MeV/c]} \), \( E = 100 \text{ [keV]} \)

**Figure 9.** Normalized PSD for \( \mu = 10 \text{ [MeV/c]} \), \( E = 100 \text{ [keV]} \), \( L = 4.5 \text{ [L*]} \)

- **REFERENCES**

**CONCLUSIONS**

- **The geospace disturbances that lead to enhancement events are preceded by a two-step increase in P3S, prolonged negative \( B_z \), and a highly increased and long lasting \( V_{SW} \) reaching over 500 km/s, together resulting in enhanced magnetic reconnection at the dipole magnetopause.**

- **This leads to statistically stronger and more prolonged storm and substorm activity, and a significantly enhanced plasmapause reaching under 4 L*. The chorus and P3S wave activity is more prolonged and during enhancement events, especially at the region of 4-5.**

- **Regarding the source electrons of \( \mu = 10 \text{ [MeV/c]} \), we have shown that they can be considered negligible for the excitation of waves or the production of relativistic electrons.**

- **In contrast, the source electrons of \( \mu = 10 \text{ [MeV/c]} \) seem to get injected to the inner magnetosphere, sparking prolonged and more prolonged enhancement events. This combination indicates that only electrons with energy larger than their lower energy limit may be held accountable, defining a cut-off energy of \( E = 10 \text{ [keV]} \).**

- **Regarding the seed electrons of \( \mu = 10 \text{ [MeV/c]} \), we showed that they can set as a proxy for the appearance of relativistic electrons. The appearance of these electrons does not depend on the appearance of source electrons alone, but additional mechanisms are required, so they either get directly injected from the plasma sheet as an effect of substorm activity, or they are comprised by diffused electrons previously located at larger L*, source electrons or other.**

- **Overall, the effect of VLF waves on the acceleration of electrons to relativistic energies seems to be determined by the abundance of seed electrons, mostly at \( L = 4.5 \), the nominal heart of the outer radiation belt.**