EGU21-11203
https://doi.org/10.5194/egusphere-egu21-11203
EGU General Assembly 2021
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ULF Wave Power During Geomagnetic Storms and Implications for Radial Diffusion Processes

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Ultra Low Frequency (ULF) waves drive radial diffusion of radiation belt electrons, where this process contributes to and, at times, dominates energisation, loss, and large scale transport of the outer radiation belt. In this study we quantify the changes and variability in ULF wave power during geomagnetic storms, through a statistical analysis of Van Allen Probes data for the time period spanning 2012 – 2019. The results show that global wave power enhancements occur during the main phase, and continue into the recovery phase of storms. Local time asymmetries show sources of ULF wave power are both external solar wind driving as well as internal sources from coupling with ring current ions and substorms.

The statistical analysis demonstrates that storm time ULF waves are able to access lower L values compared to pre-storm conditions, with enhancements observed within L = 4. We assess how magnetospheric compressions and cold plasma distributions shape how ULF wave power propagates through the magnetosphere. Results show that the Earthward displacement of the magnetopause is a key factor in the low L enhancements. Furthermore, the presence of plasmaspheric plumes during geomagnetic storms plays a crucial role in trapping ULF wave power, and contributes significantly to large storm time enhancements in ULF wave power.

The results have clear implications for enhanced radial diffusion of the outer radiation belt during geomagnetic storms. Estimates of storm time radial diffusion coefficients are derived from the ULF wave power observations, and compared to existing empirical models of radial diffusion coefficients. We show that current Kp-parameterised models, such as the Ozeke et al. [2014]

model, do not fully capture the large variability in storm time radial diffusion coefficients or the extent of enhancements in the magnetic field diffusion coefficients.