Nature's Grand Experiment: Linkage Between Magnetospheric Convection, Substorms, and the Radiation Belts

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The solar minimum of 2007-2010 was unusually deep and long-lived. In the later stages of this period the electron fluxes in the radiation belts dropped to extremely low levels. The flux of relativistic electrons (>1 MeV) was significantly diminished, and at times were below instrument thresholds both for spacecraft located in geostationary orbits and also those in low-Earth orbit. This period has been described as a natural "grand experiment" allowing us to test our understanding of basic radiation belt physics and in particular the acceleration mechanisms which lead to enhancements in outer belt relativistic electron fluxes.

Here we test the hypothesis [1] that processes driven by magnetospheric convection initiate repetitive substorm onsets, which in turn triggers enhancement in whistler mode chorus that accelerates radiation belt electrons to relativistic energies. Conversely, individual substorms would not be associated with radiation belt acceleration. Contrasting observations from multiple satellites of energetic and relativistic electrons with substorm event lists, as well as chorus measurements, shows that the data are consistent with the hypothesis.

We show that repetitive substorms are associated with enhancements in the flux of energetic and relativistic electrons and enhanced whistler mode wave intensities. Our finding is consistent with the recent RBSP case studies [2], which suggested that substorms were the trigger for chorus which lead to acceleration of radiation belt electrons to relativistic energies. However, in our study we see a two stage chorus wave power enhancement, the first starts slightly before the repetitive substorm epoch onset, suggesting that magnetospheric convection leading the chorus activity may be the trigger. This conclusion requires some care, as the second and strongest enhancement in chorus is very slightly after the onset, complicating the picture.

During the 2009/2010 period the only relativistic electron flux enhancements that occurred were preceded by repeated substorm onsets, consistent with enhanced magnetospheric convection and repetitive substorms as a trigger for outer radiation belt electron acceleration. This work has been recently published in JGR [3].

References

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Rodger, C. J., K. Cresswell-Moorcock, and M. A. Clilverd, *J. Geophys. Res. Space Physics*, 121, 171–189, doi:10.1002/2015JA021537 (2016).

Keywords: outer radiation belt, electron acceleration, coupling processes, whistler mode chorus

