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Examination of Radiation Belt Dynamics during Substorm Clusters: Activity Drivers and Dependencies of Trapped Flux Enhancements

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Dynamical variations of radiation belt trapped electron fluxes are examined to better understand the variability of enhancements linked to substorm clusters. Analysis is undertaken using the Substorm Onsets and Phases from Indices of the Electrojet (SOPHIE) substorm cluster algorithm for event detection. Observations from Low Earth Orbit (LEO) are complemented by additional measurements from Medium Earth Orbit (MEO) to allow a major expansion in the energy range considered, from medium energy energetic electrons up to ultra-relativistic electrons. The number of substorms identified inside a cluster does not depend strongly on solar wind drivers or geomagnetic indices either before, during, or after the cluster start time.

Clusters of substorms linked to moderate (100nT<AE≤300 nT) or strong AE (AE≥300 nT) disturbances are associated with radiation belt flux enhancements, including up to ultra-relativistic energies by the strongest substorms (as measured by strong southward B_z and high AE). These clusters reliably occur during times of high speed solar winds streams with associated increased magnetospheric convection. However, substorm clusters associated with quiet AE disturbances (AE≤100 nT) lead to no significant chorus whistler mode intensity enhancements, or increases in energetic, relativistic, or ultra-relativistic electron flux in the outer radiation belts. In these cases the solar wind speed is low, and the geomagnetic Kp index indicates a lack of magnetospheric convection. Our study clearly indicates that clusters of substorms occurring outside of high speed wind streams are not by themselves sufficient to drive acceleration, which may be due to the lack of pre-cluster convection.

Main point # 1: The occurrence of magnetospheric substorm clusters does not necessarily lead to radiation belt enhancements.
Main point # 2: Substorm clusters during geomagnetically disturbed conditions (AE>100 nT) reliably produce enhancements up to ultra-relativistic energies.
Main point # 3: Whistler mode chorus intensities are larger during strongly disturbed substorm clusters than for moderate disturbances.

This research has recently been accepted for publication in the Journal of Geophysical research: Space Physics [1], building on some of our earlier work [2, 3].

[1] Rodger, C. J., A. T. Hendry, M. A. Clilverd, C. Forsyth, and S. Morley, Examination of Radiation Belt Dynamics during Substorm Clusters: Activity Drivers and Dependencies of Trapped Flux Enhancements, *J. Geophys. Res.*, 126, e2021JA030003, doi:10.1029/2021JA030003 (in press), 2021.

[2] Rodger, C. J., K. Cresswell-Moorcock, and M. A. Clilverd, Nature's Grand Experiment: Linkage Between Magnetospheric Convection and the Radiation Belts, *J. Geophys. Res.*, 121, 171-189, doi:10.1002/2015JA021537, 2016.

[3] Rodger, C. J., Turner, D. L., Clilverd, M. A., & Hendry, A. T. (2019). Magnetic local time-resolved examination of radiation belt dynamics during high-speed solar wind speed-triggered substorm clusters. *Geophys. Res. Lett.*, 46 https://doi.org/10.1029/2019GL083712.