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ULF wave penetration in the inner magnetosphere related to radiation belt electron acceleration and losses: Observations and model simulations

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Periodic oscillations in the Earth's magnetic field with frequencies in the range of a few mHz (ULF waves) can influence radiation belt dynamics due to their potential for strong interactions with charged particles and in particular, relativistic electrons. We have explored possible relationships between the spatial and temporal profile of ULF wave power with relativistic electron fluxes as well as different solar wind parameters. We used data from multiple ground magnetometer arrays contributing to the worldwide SuperMAG collaboration to calculate the ULF wave power in the Pc5 frequency band (2 – 7 mHz) from for a total of 40 moderate and intense magnetic storms over the last solar cycle 23. During the main phase of both sets of storms, there is a marked penetration of Pc5 wave power to L-shells as low as 2-3. The penetration of ULF waves is deeper into the inner magnetosphere during intense magnetic storms characterised by enhanced post-storm electron fluxes. Furthermore, later in the recovery phase, enhanced Pc5 wave activity was found to persist longer for storms marked by electron-enhanced storms flux enhancement than for those that do not produce such electron flux enhancements. Growth and decay characteristics of Pc5 waves were explored in association with the plasmapause location, determined from IMAGE EUV observations. Pc5 wave power enhancements and relativistic electron acceleration were not only intimately linked, but also restricted beyond the plasmapause. These observations provided the basis for a superposed epoch analysis, the results of which are compared to predictions from the Comprehensive Inner Magnetosphere-Ionosphere (CIMI) model. These simulations are critical for understanding the extent to which ULF wave electric fields are responsible for the observed electron acceleration and for examining the nature of mechanisms responsible for driving such large-amplitude ULF waves in the magnetosphere.

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