RADIATION BELT PRECIPITATION DUE TO MAN-MADE VLF TRANSMISSIONS: SATELLITE OBSERVATIONS

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In the more than four decades since the discovery of the Earth's Van Allen radiation belts, it has proven difficult to confirm the principal source and loss mechanisms that control radiation belt particles. It has been recognized for some time that the loss of radiation belt electrons in the inner belt beyond L~1.5 is dominated by pitch angle scattering in wave-particle interactions with whistler mode waves, although there has been uncertainty as to the relative importance of different wave types. Relatively recent theoretical calculations have led to the rather surprising conclusion that manmade VLF transmissions may dominate losses in the inner radiation belts. This finding has sparked considerable interest, suggesting practical human control of the radiation belts to protect Earth-orbiting systems from natural and nuclear injections of high energy electrons, generally known as Radiation Belt Remediation (RBR).

While strong correlations between drift-loss cone enhancements and transmitter locations have been shown previously, particle enhancements have yet to be tied directly to VLF wave observations. The occurrence frequency of drift loss cone enhancements above transmitters has also previously been unknown.

In this paper we combine wave and particle observations from the DEMETER satellite with ground based VLF recordings to examine the significance of the transmitter NWC on the inner radiation belt.

Enhancements of drift-loss cone electron fluxes are observed eastward of the transmitter location, with cyclotron resonance taking place on the field line near the VLF transmitter location, followed by the eastward drift of electrons towards the South Atlantic Anomaly. Transmitters located under a nighttime ionosphere are favoured, due to the lower ionospheric absorption. 95% of orbital passes which met these conditions showed evidence of an interaction. A positive correlation exists between transmitter operation and the presence of such enhancements. Typical transmissions cause a ~400-fold increase in 300 keV drift-loss cone electrons.

These observations provide conclusive evidence linking drift-loss cone electron flux enhancements and transmitter operation. Numerical magnitudes and occurrence rates experimentally detected here should allow a validation of models for wave and particle dynamics in the radiation belts.

Wave-particle, VLF, transmitter.

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