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

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Abstract

Previous studies have reported enhancements in drift-loss cone electron fluxes linked to powerful VLF transmitters. We examine the significance of the transmitter NWC on the inner radiation belt by combining DEMETER satellite observations with transmitter operation times. We find that enhancements in the \(\sim100-300\) keV drift-loss cone fluxes show a strong correlation to NWC operation and low (night-time) ionospheric absorption, and are only observed downstream of the transmitter. This provides conclusive evidence linking drift-loss cone electron flux enhancements and transmitter operation. Typical transmissions cause a \(\sim400\) times increase in 300 keV drift-loss cone electrons.

1. Background Information

In the more than four decades since the discovery of the Earth's Van Allen radiation belts, it has proved 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 \(L\sim1.5\) 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 [1]. This finding has sparked considerable interest, suggesting practical human control of the radiation belts [2] to protect Earth-orbiting systems from natural and nuclear injections of high energy electrons [3], generally known as Radiation Belt Remediation (RBR).

Satellite observations of quasi-trapped \(\sim100\) keV electrons in the drift-loss cone have reported "spikes" or enhancements in the population fluxes associated with the geomagnetic locations of VLF transmitters [4, 5; and references therein]. Enhancements of drift-loss cone electron fluxes are expected eastward of the transmitter location, with cyclotron resonance taking place on the field line near the ground based 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.

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

2. References


