GROUND-BASED VLF TRANSMITTER SIGNALS OBSERVED FROM SPACE: DUCTED OR NONDUCTED?

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Abstract

The principal loss mechanism for electrons from the inner radiation belt and slot region is atmospheric precipitation. Several studies have shown that ducted and nonducted VLF waves can precipitate radiation belt energetic electrons. Here we investigate the propagation of VLF communication transmitter signals using plasma wave instruments onboard the CRRES and DEMETER satellites in order to determine if nonducted transmitter signals are significant in radiation belt loss processes. We investigate strong transmitter signals observed in the ionosphere directly above the transmitter, in the magnetosphere near the geomagnetic equator, and in the ionospheric region geomagnetically conjugate to the transmitter.

Background Information

High energy electrons trapped in the Earth's Van Allen radiation belts are distributed into two belts divided by a relatively low flux region known as the 'electron slot region' at L~2.5. The principal source and loss mechanisms that control the radiation belt electrons are still under investigation, although the losses are known to be due to a combination of several mechanisms, including coulomb collisions, and resonant wave-particle interactions with plasmaspheric hiss, lightning-generated whistlers, and man-made transmissions. Potential damage to orbiting satellites could be mitigated by enhanced removal of the energetic electrons through accelerated loss rates, possibly driven by ground-based VLF communication transmitters. The topic is generally known as Radiation Belt Remediation (RBR), providing some level of human control of the trapped electron populations in the radiation belts.

In this study we investigate the nighttime propagation of VLF communication transmitter signals using plasma wave instruments onboard the CRRES and DEMETER satellites. We investigate the regions where strong transmitter signals are observed in the ionosphere directly above the transmitter, in the magnetosphere close to the geomagnetic equator, and in the ionospheric region geomagnetically conjugate to the transmitter. Using these observations we discuss the propagation characteristics in terms of the proportions of ducted or nonducted signals, and thus characterize the likely impact of nonducted VLF transmitter signals on the radiation belt populations.

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