Modeling Very Low Frequency Radio Inputs to the Radiation Belts

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Energetic electrons trapped in the Earth's radiation belts pose a hazard to satellite operations. The dynamics of this population are driven by complex processes, often mediated by a menagerie of plasma waves, especially electromagnetic whistler-mode waves of very low frequency (VLF).

An extensive modeling effort has been undertaken to improve our understanding of the contributions of terrestrial VLF radio sources to the dynamics of the radiation belts. As part of this effort, the Air Force Research Laboratory (AFRL) has supported the creation of a full-wave model capable of calculating the fields in space from terrestrial vertical and horizontal dipole transmitters. We have also created a new time-resolved climatology describing the VLF contributions from lightning. Finally, we have adapted the quasi-geometric optics approach to tracking VLF wave propagation in the magnetosphere in order to resolve issues like caustics that adversely impact canonical ray tracing.

These new tools will be exercised in connection with the upcoming Demonstrations and Science Experiments (DSX) mission scheduled for launch in 2017. DSX will operate in the slot region and make observations of both natural and anthropogenic sources of VLF waves. DSX includes its own VLF transmitter, which will be used to study ambient plasma impacts on antenna radiation and the interactions of the radiated waves with stably trapped electron populations. An extensive suite of space weather instrumentation and space effects experiments will provide diagnostics. These observations will be released to the community for research purposes, and they also will be incorporated into the new generation of radiation belt climatology models used for spacecraft design.