Time-Evolution of VLF Transmitter-Induced Precipitation of Electron Radiation

Robert T. Newsome* and Umran S. Inan
Space, Telecommunications, and Radioscience Laboratory, Stanford, CA, 94305, http://www-star.stanford.edu

We present evidence of highly variable temporal structure in VLF transmitter-induced precipitation of radiation belt electrons revealed by the use of a new analytical tool termed "windowgrams". The existence of a temporal variation in these precipitation signatures sheds light on how the parameters that govern such precipitation can vary with time, and we investigate in particular the dynamics of trapped electron pitch angle distribution as suggested by the time-varying precipitation signatures.

Specifically, we examine data from an active experiment performed by imposing an on/off keying modulation on the 21.4 kHz NPM VLF transmitter in Lualualei, Hawaii and searching for a similar perturbation pattern in subionospheric VLF data from VLF paths passing through the NPM-induced precipitation region. Earlier work (U. S. Inan et al, Geophys. Res. Lett., 34, 2007) reported evidence of NPM-induced electron precipitation in the form of a peak in the received VLF amplitude spectrum that matched the NPM on/off keying frequency.

With the windowgram technique, we observe the time evolution of the strength of this frequency component over the entire duration of the keying period (typically 30 min or 60 min). The windowgram technique involves plotting the strength of the keying frequency component (relative to the strength of the neighboring frequency components) in the VLF record over a range of different window sizes and locations. We find that the magnitude of the induced precipitation is usually not uniform throughout the duration of the experiment. Rather, the precipitation amplitude evolves in time.

This new realization and further use of the windowgram technique provides insight into the near-bounce-loss-cone pitch-angle distribution of trapped electrons arriving at NPM longitudes in the course of their eastward drift across the Pacific Ocean. We explore the dynamics of the pitch angle distribution of a population of trapped electrons as they drift eastward through the illumination region of the NPM VLF transmitter using a simple longitude-dependent model of wave-driven pitch angle diffusion. We find that time variations in an observed precipitation signature can be caused by pitch angle diffusion through the drift-to-bounce loss cone gap, population depletion due to long-term precipitation, and pitch angle distribution dependence on longitude.