Three-Dimensional Forward Modeling of Lightning-Induced Electron Precipitation from the Radiation Belts

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Pitch-angle scattering by radio waves in the VLF (3-30kHz) band is thought to be a major loss mechanism for energetic radiation-belt electrons. Resonant interactions with Whistler-mode VLF waves can alter the reflection altitude of trapped electrons 100keV - 1MeV; when a particle reflects at a low enough altitude, it can be removed from the magnetosphere through collisions with ionospheric constituents. Terres- trial lightning provides a natural and constantly-occurring source of VLF waves. Here we present a three-dimensional forward model of lightning-induced electron precipitation (LEP) due to resonant pitch-angle scattering from a single lightning stroke.

Previous efforts (Lauben 1998, Bortnik 2006) have used two-dimensional raytracing combined with analytical expressions of pitch-angle scattering to forward model precipitation from a single stroke as a function of input and output latitude. However these models are limited in geospatial accuracy by their use of ideal plasmasphere and magnetic field models. We expand on these techniques by incorporating three- dimensional raytracing through a realistic plasmasphere and magnetic field model, to better capture the spatial dependence of LEP.

We then combine our end-to-end model of the LEP process with terrestrial lightning activity data from the GLD360 sensor network to construct a realtime geospatial model of LEP-driven energy deposition into the ionosphere. We explore global and seasonal statistics, provide precipitation estimates across a variety of magnetospheric conditions, and compare the total impact to other magnetospheric loss processes. The completed model is well-suited for comparison with satellite electron flux measurements, such as those from the Arase mission.

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