Whistler Observations on DEMETER Compared with Full Electromagnetic Wave Method Simulations

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Terrestrial Very Low Frequency (VLF, 3-30 kHz) electromagnetic radiation, which may play an important role in the lifetimes of Van Allen radiation belt electrons, is injected into Earth's plasmasphere from two primary sources: man-made VLF transmitters and lightning discharges. Recent studies have called into question the early models of VLF transionospheric absorption, which directly affects the power injected into the plasmasphere from those two sources, leaving open the possibility of unaccounted for physics strongly damping the waves. However, in a subsequent study, simulations using a frequency domain Full Wave Method (FWM) finite element numerical code were shown to predict within 10 dB the electric and magnetic field amplitudes as measured by the DEMETER satellite as it passed over a number of VLF transmitters across the world at a wide range of geomagnetic latitudes. Since that study, we have applied the same FWM code to lightning discharges. Specifically, we compare observations of whistlers—the VLF waves from lightning that propagate through the ionosphere—measured on the DEMETER satellite with FWM simulations of lightning discharges. In addition, we use data from the National Lightning Detection Network (NLDN) to glean information about each whistler's source lightning discharge needed to make the comparison: The lightning discharge times are correlated with the whistler occurrence times to pair each whistler with its parent lightning stroke, which thereby provides us with the source peak current amplitude and location. Being a frequency domain method, the FWM code is not as well-suited to simulating impulsive (broadband) lightning discharges as it is narrowband VLF transmitters. Therefore, we have also developed a parallel Finite Difference Time Domain (FDTD) code that shows agreement with our frequency domain FWM code and provides much faster simulations of broadband pulses.