LWPC Modeling of VLF Perturbations from Lightning Induced Energetic Electron Precipitation on Overlapping Paths of Propagation

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Lightning discharges are known to be a source of high amplitude, broad frequency electromagnetic radiation. These electromagnetic waves can cause perturbations in the electron density of the D-region of the ionosphere either by ionization from quasi-electrostatic fields or from induced energetic electron precipitation from the magnetosphere. Because changes in D-region electron density affect the conductivity of the ionosphere, lightning discharges can perturb the amplitude and phase of Very Low Frequency (VLF) communication signals propagating through the Earth-Ionosphere Waveguide (EIW). The effect of these variations is more pronounced during the night because, without the ionizing energy of direct solar radiation, electron densities are much lower at night when compared to daytime electron density levels. Much of the past work in this area has involved unique propagation paths between a single transmitter and receiver. Modeling of such perturbation events often involves uncertainty since the perturbed ionospheric profile cannot be uniquely determined. In this work we focus on two different configurations of overlapping VLF propagation paths. First, when signals from two different VLF transmitters share a common path to a receiver. This setup allows for the geographic area of the overlapping path to be simultaneously diagnosed with two signals with different mode content. Second, when a signal from a single VLF transmitter is on a path that overlaps two different receivers. This setup facilitates the examination of how a lightning event can effect individual modes of propagation from a single transmitter. Observations have shown that a lightning induced perturbation on these overlapping paths can have a large effect on the amplitude or phase of one signal, while leaving the other wave relatively unaffected. The Long Wave Prediction Capability (LWPC) software package is used to simulate this phenomenon by altering the effective conducting height of the ionosphere near the location of a known nighttime lightning strike. Good agreement is found between the simulation and the observations. This shows that by providing additional constraints on the perturbed ionosphere, a more accurate model of how lightning affects nighttime ionospheric electron densities can be reached.