Local and Conjugate Ionospheric Disturbances from High Peak Current Oceanic Lightning Events

Nicholas C. Gross*[1], Mark Golkowski[1], Robert C. Moore[2], Benjamin R. T. Cotts[3]

[1]*Electrical Engineering, University of Colorado Denver, Denver, CO*

[2]*Electrical and Computer Engineering, University of Florida, Gainesville, FL*

[3]*Exponent, Bowie, MD*

Very low frequency (VLF) remote sensing is an important tool for investigating D-region ionospheric disturbances due to lightning discharges. While previous works have used VLF remote sensing to identify lightning-induced ionospheric perturbations, little attention has been given to multifaceted disturbances from a single strike including simultaneous observations of effects in the local and conjugate hemispheres. We present a series of high peak current (>100 kA) strikes over the Atlantic Ocean, in which each has caused distinct and geographically separated ionospheric disturbances. These disturbances include so-called Early/Fast events, northern hemisphere lightning-induced electron precipitation (LEP) events, and conjugate region LEP events. The events are observed by monitoring VLF transmissions from Puerto Rico, Maine, and Hawaii on receivers in New York, North Carolina, and Antarctica, respectively.

The LEP mechanism is driven by cyclotron resonant interactions between the lightning induced whistler waves and radiation belt electrons. Using the location and peak current of the lightning strike given by the new GLD360 lightning detection network, we model the electron precipitation characteristics for both hemispheres. Modeling is performed by using the power spectral density of the lightning strike to determine the magnetospheric whistler induced particle precipitation, which in turn an atmospheric backscattering and Monte Carlo model is used to predict lower ionospheric electron deposition, accounting for latitudinal and longitudinal dependence of equatorial loss cone angles. We compare and show agreement of our modeling results with the observed LEP events in both local and conjugate hemispheres. We also compare the observed events to previous work, focusing on peak current threshold for observed LEP events and the onset delay between observed spherics and observed LEP events in both hemispheres. These first simultaneous observations of both direct (Early/Fast) and magnetospherically coupled (LEP) ionospheric disturbances from a single causative lightning strike indicate that future works involving VLF remote sensing need to take into account these multifaceted processes and their unique signatures.