RAY TRACING TECHNIQUES APPLIED TO SKY WAVE OBSERVATIONS OF LIGHTNING-INDUCED IONOSPHERIC EFFECTS ON SHORT RANGE VLF PATHS

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At locations close (100-km) to a VLF transmitter, observation of the sky wave signal from the transmitter is possible by aligning a proximate magnetic loop antenna to null the ground signal. Previous observations using this arrangement [e.g., Rodriguez et al. 1992], and [Pasko et al., 2002] show a very high degree of temporal variability in received signal amplitude. Consideration of Early/Fast and Lightning-induced Electron Precipitation (LEP) events under these constraints show an unusual number of remarkably large events. For example, we have observed Early/Fast events with positive amplitude changes up to 8 dB and negative amplitude changes as high as 19 dB. In addition we have observed possible LEP events with positive amplitude changes of 5 dB and onset duration of 15 seconds. The recovery signatures of these events are also very unusual, often with non-exponential recovery, or no recovery at all.

Combining the data from previous campaigns with a recent data set (August 2004) of observations at Arecibo, Puerto Rico we analyze four separate instances in which a magnetic loop antenna is deployed with the intent of observing the sky wave. Because the disturbed region must necessarily be nearly overhead the receiver and/or transmitter we can assume the received signal to be in the near and can employ simple ray tracing techniques to determine the evolution of the scattered field from the ionospheric disturbance over time. From these results we can determine whether the anomalous nature of these extraordinarily large events are primarily due to the high inherent variability of the observed amplitude signal or the close proximity of the receiver to the disturbed ionospheric region.

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