LIGHTNING EFFECTS ON THE RADIATION BELTS AND THE LOWER IONOSPHERE

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Energy released in lightning discharges affect the lower ionosphere and the radiation belts in a multiplicity of ways, including directly through heating of ambient electrons via quasi-static and electromagnetic fields, production of upward going energetic electron beams, and indirectly through the precipitation of energetic radiation belt particles. In this paper we review some of these phenomena emphasizing the direct comparison of theoretical predictions and experimental data. The impulsive and transient nature of the causative lightning discharge, especially the fact that it often can be definitively measured, located and characterized, allows such comparison between experiment and measurement in ways that are typically not possible in investigations of other space plasma phenomena. For example, the precise timing of the rapid lateral expansion of elves (as measured from the ground) was first predicted and then measured using the Stanford Fly's Eye instrument, allowing the definitive determination of electron-heating by impulsive electromagnetic signal (EMP) as being the root cause. More recently, the spatial morphology of elves were measured from space, once again with a precision and resolution allowing direct comparison with predictions. Concerning lightning-induced precipitation of energetic radiation belt electrons, satellite measurements in the 1980s allowed direct comparison of theoretically predicted energy spectra, temporal profile, and pitch angle distribution with that measured on a low altitude satellite. Since then, the temporal profile of lightning-induced precipitation events have been regularly measured with ground-based sub-ionospheric VLF technique and comparison of the timing measurement with predictions have allowed the discovery and classification of different types of precipitation involving ducted, non-ducted, and magnetospherically reflecting waves. We present an overview of the direct comparisons between experiment and measurement in the context of lightning-driven effects on the radiation belts and the lower ionosphere, including a discussion of the outstanding (i.e., not yet measured) prediction of the production of upward moving energetic electron beams, driven by intense quasi-static fields.