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Influence of Thunderstorms on the Structure of the Ionosphere over North America

Omar Nava, Daniel Emmons, and Robert Loper
Air Force Institute of Technology, Wright-Patterson Air Force Base, United States (Omar.Nava@afit.edu)

Accurate characterization of the ionosphere in response to thunderstorms has important implications for the effective use of high-frequency (HF) communications in civilian and military operations, to include emergency services, amateur radio, aviation, and over-the-horizon radar. This study investigates changes in the structure of the ionosphere in response to strong convective activity and cloud electrification associated with thunderstorms in North America. Superposed epoch analysis is applied to surface weather observations and ionosonde data at Eglin Air Force Base, Florida from 2005 to 2016 and Boulder, Colorado from 2010 to 2016. Our findings indicate that lightning noticeably modifies the structure of the ionosphere, generating statistically significant measurements of several key parameters compared to clear-sky observations. During thunderstorms, an increase in the critical frequency of the sporadic E layer (foEs) and a decrease in the height of the maximum E layer electron density (hmE) were both observed. It is hypothesized that enhanced electron densities (i.e. conductivities) in this region associated with the global atmospheric electrical circuit may either facilitate lightning initiation or develop as a result of strong convective activity or a combination of both. Furthermore, no significant difference in the height of the maximum F2 layer electron density (hmF2) and vertical ionospheric total electron content (ITEC) between thunderstorm and clear sky days was noted, implying that cloud electrification only seems to modulate the structure of the lower ionosphere. Seasonal and diurnal influences between the thunderstorm and clear-sky cases are also presented. Results of this research may lead to the development of a parameterization scheme to incorporate thunderstorm and cloud electrification effects into global and regional ionosphere models. Because troposphere-ionosphere coupling has been poorly addressed, analysis of the electrodynamic connection between the lower and upper atmospheres has important implications for both space physics and atmospheric science communities.