

Lightning-Induced Effects in the Ionosphere and the Radiation Belts

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Electromagnetic Impulses (EMP) released in lightning discharges are now known to produce easily detectable effects in the overlying ionosphere and the radiation belts. It has long been known that energetic electrons are precipitated out of the radiation belts as a result of cyclotron resonance interactions with portion of the energy of lightning-EMP that leaks into the radiation belts, propagating therein as whistler waves. However, recent observations indicate this so-called lightning-induced electron precipitation (LEP) phenomena much more pervasive than previously believed, possibly constituting the major source of loss for the radiation belts at mid-to-low latitudes. For example, large regions of enhanced precipitation are known to be maintained in the ionosphere above major thunderstorms, lasting for the several hour duration of the storms. A more immediate effect of the lightning-EMP is the elves, which are produced as a result of the heating of the overlying D-region by the lightning EMP, producing rapidly expanding disk-like shapes in a narrow range of altitudes. Recent work indicates that such elves may be produced by both CG and IC flashes, and that cumulative build-up effects (e.g., ionospheric attachment holes) may occur as a result of successive EMPs released in spheric bursts. In view of the very large number of active thunderstorms around the globe at any given time, the global effect of such persistent and maintained ionospheric disturbances need to be evaluated. In this paper, we provide a review of effects of lightning-EMPs on the ionosphere and radiation belts, concentrating in particular on LEP events and elves, but also commenting on the so-called Early VLF events, which might be a manifestation of EMP-ionosphere interactions.