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Lightning-induced low frequency electromagnetic waves in planetary atmospheres

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The propagation of Extremely and Very Low Frequency (ELF, VLF) electromagnetic waves in the Earth atmosphere has been used to investigate coupling mechanisms among the troposphere, ionosphere, and magnetosphere. Space weather forecasting models, for example, include not only solar wind effects in the ionosphere and magnetosphere but perturbations from the lower atmospheric layers. Longitudinal ELF standing waves that propagate in the surface-ionosphere cavity, known as Schumann resonances, are used to study thunderstorm and lightning activities, and their relation to climate, as well as ionospheric dynamics. Investigation of transient VLF signals such as sferics, tweeks, and whistlers contribute to assess the ionospheric and magnetospheric processes and dynamics. Similar approaches can be developed for investigating the electric environment of planetary atmospheres.
In this work we review the most significant ELF and VLF wave propagation measurements and models in planetary atmospheres, from Venus to Neptune, including Titan, the largest moon of Saturn. We address atmospheric refractivity effects in the cavity of Venus, present discharging mechanism constraints for various planets, e.g., lightning and transient luminous events, and discuss how the Schumann resonance can be used to estimating the water content in the gaseous giants. Comparative studies in the context of planetary atmospheric electricity are also briefly revisited.

Keywords: lightning, thunderstorm, atmosphere, ionosphere, wave propagation, planetary science