Geophysical Research Abstracts
Vol. 19, EGU2017-6357, 2017
EGU General Assembly 2017

3D modeling of lightning-induced electromagnetic pulses on Venus, Jupiter and Saturn

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Atmospheric electricity is a common phenomenon in some planets of The Solar System. We know that atmospheric discharges exist on Earth and gaseous planets; however, some characteristics of lightning on Saturn and Jupiter as well as their relevance on the effects of lightning in the atmospheres of these planets are still unknown. In the case of Venus, there exist some radio evidences of lightning, but the lack of optical observations suggests exploring indirect methods of detection, such as searching for lightning-induced transient optical emissions from the upper atmosphere. The Akatsuki probe, currently orbiting Venus, is equipped with a camera whose temporal resolution is high enough to detect optical emissions from lightning discharges and to measure nightglow enhancements.

In this work, we extend previous models [1,2] to investigate the chemical impact and transient optical emissions produced by possible lightning-emitted electromagnetic pulses (EMP) in Venus, Saturn and Jupiter. Using a 3D FDTD ("Finite Differences Time Domain") model we solve the Maxwell equations coupled with the Langevin equation for electrons [3] and with a kinetic scheme, different for each planetary atmosphere. This method is useful to investigate the temporal and spatial impact of lightning-induced electromagnetic fields in the atmosphere of each planet for different lightning characteristics (e.g. energy released, orientation).

This 3D FDTD model allows us to include the saturnian and jovian background magnetic field inclination and magnitude at different latitudes, and to determine the effects of different lightning channel inclinations. Results provide useful information to interpret lightning observations on giant gaseous planets and in the search for indirect optical signals from atmospheric discharge on Venus such as fast nightglow transient enhancements related to lightning as seen on Earth. Furthermore, we underline the observation of electrical discharges characteristics as a powerful tool to obtain information about planetary atmospheres, such as density profiles of electrons or other components. Our model may also be useful to extend some studies about the chemical impact of EMP pulses in the terrestrial atmosphere [4].
References
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