V Reunión de Ciencias Planetarias y Exploración del Sistema Solar (CPESS5)

Modeling lightning impact on the upper atmospheres of Venus and giant gaseous planets

F.J. Pérez-Invernón[1], A. Luque[1], F.J. Gordillo Vázquez[1]
[1]Instituto de Astrofísica de Andalucía (IAA), CSIC, PO Box 3004, 18080 Granada, Spain

Lightning discharges are common in some planets of the Solar System. The Voyager and Cassini spacecraft detected optical signatures of lightning in gaseous giant planets, while Venus Express and Pioneer Venus spacecraft recorded electromagnetic signals on Venus that could be produced by lightning. In this work, we model the chemical and electromagnetic impact of lightning in the upper atmosphere of Jupiter, Saturn and Venus. We investigate the expected optical signals produced by lightning in the upper atmopshere of these planets.

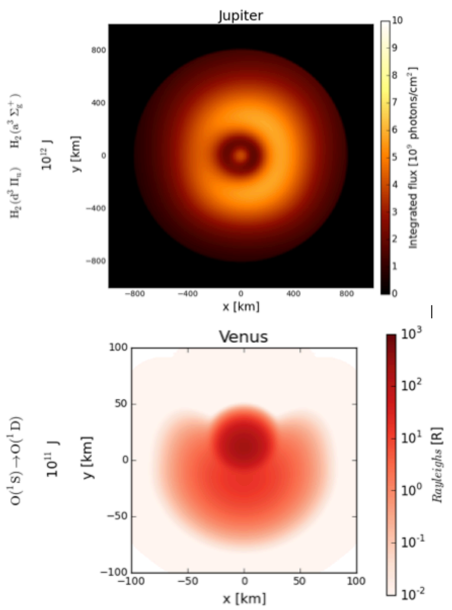

Figure 1: Some of the calculated optical emissions in the upper atmospheres of Jupiter and Venus for a vertical (top panel) and an oblicue (bottom panel) lightning discharge as seen from a probe orbiting these planets.

We use two different approaches to obtain the chemical impact of lightning. On the one hand, we use a 2D model in cylindrical coordinates to study the impact of the quasi-electrostatic field produced by vertical intra-cloud discharges in the mesosphere of Venus [1]. This model couples a Poisson equation solver for the electric field with species continuity equations, together with advection-diffusion of electrons, obtaining the characteristics of possible optical halo-like emissions in Venus. These emissions are mainly produced by radiative de-excitation of molecular nitrogen and atomic oxygen, causing a transient increment in the O I (557 nm) green airglow emissions.

On the other hand, we use a 3D Finite-Difference Time-Domain (FDTD) model to solve the Maxwell equations for the electromagnetic field produced by different intra-cloud lightning in Venus, Jupiter and Saturn, based on results of our previous 2D model [2]. The FDTD model includes species continuity equations and the Langevin equation for electrons, enabling us to calculate elve-like emissions caused by electromagnetic pulses (EMP) on these three planets depending on a number of parameters like channel discharge inclination, latitude, atmospheric characteristics and total released energy by each lightning.

According to our results, lightning with total energy released three orders of magnitude greater than typical terrestrial discharges could produce optical emissions in the mesosphere of Venus, providing an indirect method to probe the existence of venusian lightning. The Akatsuki probe of JAXA, orbiting Venus since Dec 2015, is equipped with a high-temporal resolution camera (LAC) able to measure the predicted increase on airglow emissions as a consequence of lightning. However, the orbital distance of this spacecraft could be insufficient to detect these events.

Finally, we propose the observation of optical signatures produced by lightning in the upper atmosphere of giant planets as a tool to study atmospheric electricity features of their atmospheres.

References

[1] Pérez-Invernón, F. J., Luque, A., & Gordillo-Vázquez, F. J., **JGR**, *121*(7), 7026-7048, 2016.

[2] Luque, A., Dubrovin, D., Gordillo-Vázquez, F. J., Ebert, U., Parra-Rojas, F. C., Yair, Y., & Price, C., **JGR** *119*(10), 8705-8720, 2014.