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Transient Luminous Events: optical emissions from high altitudes to probe the Earth's upper atmosphere

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Transient Luminous Events are short but intense optical emissions from the upper terrestrial atmosphere, driven by the electric fields generated by a tropospheric electric storm. They were first observed in 1989 [1] but they had been predicted by C.T.R. Wilson already in 1925 [2]. Wilson argued that the electric field needed to initiate a discharge (the breakdown field) is proportional to the atmospheric density and therefore decreases exponentially with altitude; meanwhile the electric field created by a charged cloud is roughly dipolar and decays slower. Therefore there exists an altitude where the cloud field surpasses the breakdown field and an electric discharge is initiated.

The combination of modeling and observations of TLEs allows us to quantify their influence in the global atmospheric chemistry and the global electric circuit that connects the surface of the Earth with the ionosphere. But, equally importantly, TLEs serve as natural probes to remotely investigate the atmosphere that surrounds them. In this talk we will survey some recent results on the modelling of TLEs.

1. Sprite beads provide an example of a possible use of TLEs to remotely probe the Earth's mesosphere. Sprites are filamentary discharges, some tens of kilometers wide, appearing at altitudes from about 50 to about 85 km. Sometimes, in the wake of a sprite, luminous spots (beads) persist much longer than the main emissions. These sprite beads reveal underlying inhomogeneities in the atmospheric conductivity [4] whose precise origin is still uncertain.

2. Another path to investigate the mesosphere through TLE observations is to compare observed spectra with kinetic models [5] combined with electrodynamic simulations [6]. For that purpose, we have modeled emissions from terrestrial TLEs: we calculated the expected emissions in the ultraviolet (Lyman-Birge-Hopfield band of molecular nitrogen), in the near UV and visible blue (second positive system of N2) and in the red and near infrared (first positive system of N2).

3. Recent results [7] show that electron detachment from atomic oxygen ions may play a very relevant role in defining the electrical response of the upper atmosphere at timescales of the order of about 10 ms. The traditional models of TLEs, based on a direct extrapolation of air breakdown at atmospheric pressure, have to be updated.

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