Peak current of the elves-generating causative CGs

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Abstract

Elve is one type of transient luminous events (TLEs; sprites, elves, electric jets) between thundercloud and the ionosphere. Elves were first discovered in the space shuttle images [Boeck et al., 1992], and later identified by ground observation [Fukunishi et al., 1996].

The generating mechanism of elves is the heating of electrons by the electromagnetic pulses (EMPs) emitted by cloud-to-ground discharge [Inan et al., 1996]. The E-field driven electrons collide with the major species of atmospheric molecules (nitrogen and oxygen), including excitation and ionization, and eventually resulting in the expanding luminous emissions in the lower ionosphere.

Typical altitude of elves is in the range of 80-95 km and their lateral dimensions is 200-500 km. The short luminous duration (~1ms) and severe atmospheric attenuation of short wavelength emission have limited the success in recording the full spectroscopy of elves from ground observation. In 2004, ISUAL experiment on the FORMOSAT-2 has successfully confirmed the existence of FUV emission in elves [Mende et al, 2005].

In this paper, an in-depth study of the ISUAL recorded elves is carried out. Numerical simulation results of elves based on an EMP model of the emissions between 185-800 nm and of their spatial-temporal evolution are presented. To account for the effect of atmospheric attenuation, three major attenuation mechanisms: O2, O3 and molecular Rayleigh scattering are considered.

Numerical results show the elves intensity is a function of the peak current of the causative CG. Among the 105 behind-the-limb elves analyzed in this work, the causative CGs is estimated to be between 170 kA and 400 kA, much larger than peak currents in typical CGs (~30 kA). Therefore, the ISUAL can be viewed as a probe of elves induced by intense lightning events.