Mechanism of Fast Air Heating and Infrasound Generation by Sprites

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Sprites are electrical discharges transversing the middle atmosphere, between 40–90 km altitude. They are generated by the the electric fields produced by cloud-to-ground lightning in underlying thunderstorms. Therefore, sprites represent optical evidences of the electrical coupling between troposphere and the mesosphere/lower ionosphere regions. In the last decade, another evidence of the above mentioned coupling has been discovered. *Farges et al.* [GRL, 32, L011813, 2005] have correlated optical observations with infrasound signatures produced by sprites. The main characteristics of infrasound from sprites are a chirp-inverted signature (at 0.1–9 Hz frequency range) and amplitudes of 0.01–0.1 Pa, as measured at ground at distances of the order of 400 km. Sprites manifest themselves as growing streamer tree discharges, where many individual streamers have a common origin point, that can be observed as a bright core [e.g., *Li and Cummer*, JGR, 116, A01301, 2011, Figure 2]. Although individual streamers transport low electrical current, the total electrical current flowing through the sprite body can be sufficiently large to produce Joule heating and excitation of vibrational states in nitrogen molecules. In this work, we introduce a first-principles model to quantify the air heating in sprites. The model describes the coupling between chemistry and gas dynamics in a non-equilibrium plasma. The model accounts for fast air heating due to quenching of excited electronic states of nitrogen molecules [*Popov*, JPD, 44, 285201, 2011]. We provide parametric dependences of air heating and pressure perturbation amplitudes on sprite characteristics, such as available current, electric field, and channel radius. This modeling study is the first step towards connecting the well-known optical [e.g., *Stenbaek-Nielsen and McHarg*, JPD, 41, 234009, 2008] and electrical [e.g., *Cummer et al.*, GRL, 25, 8, 1998] properties of sprites to their infrasound signatures [e.g., *Farges et al.*, 2005; *de Larquier and Pasko*, GRL, 37, L17804, 2010].