Geophysical Research Abstracts
Vol. 12, EGU2010-10656, 2010
EGU General Assembly 2010

Effect of stratospheric conductivity changes on quasi-electrostatic fields in lower ionosphere produced by lightning and on sprite occurrence

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One of mechanisms of electrical coupling between the troposphere and the lower ionosphere is realized by strong quasi-electrostatic fields (QSF) formed above thunderstorms after lightning discharges. Until now a lot of investigations are devoted to the effects of these electric fields in the lower ionosphere where they cause electron heating and changes of the ionospheric parameters. The red sprite is presumably driven by post-lightning quasi-static fields which are large enough to cause electrical breakdown and exist long enough to initiate and maintain a net of streamers developed during a sprite existence. The occurrence of a sprite depends on the parameters of the causative lightning discharge, as well as of the atmospheric conductivity profile. In order to examine the conditions for sprite realization, QSF are theoretically studied by different authors. Our earlier studies show that the conditions for an initial breakdown are easier satisfied at altitudes where the relaxation time is close to the discharge time, and that the conductivity profile has a key role in the sprite formation. In this report we study theoretically the role of the stratospheric conductivity and of its variations under different conditions. Besides the presumable 11-year small variations of the stratospheric conductivity profile during a solar cycle due to modulation of the galactic cosmic ray flux, shorter and much larger conductivity changes occur by another reasons. According to recent investigations, the stratospheric conductivity at middle and high latitudes can be considerably decreased within a relatively thin layer centred at about 40 km due to aerosol density enhancements, especially after large volcano eruptions (twice or even much more, according to some authors). In such case, a considerable amount of spatial charges is induced at the top of the layer, where the conductivity decreases sharply, which can influence the QSF in the upper regions. Here we study the QSF in the lower ionosphere produced by a positive cloud-to-ground lightning discharge by different stratospheric conductivity profiles and examine the ability for a sprite occurrence. This study is based on the continuity equation for the density of the Maxwell's current. Two cases of stratospheric conductivity are considered: with an unmodified profile, and with a significantly decreased conductivity at altitudes 30-50 km. We show that this modification has a small effect on the intensity of the temporal QSF peak in the lower ionosphere. On the other hand, in the case of modified conductivity, the quasi-electrostatic field relaxes slower: it remains longer large enough to maintain a streamer, than in the case of unmodified conductivity. The horizontal dimension of the quasi-electrostatic fields shows a slight increase.