Photodetachment Rate of Negative Ions of the Lower Ionosphere due to Optical Emissions from Lightning

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Every second ~45 lightning flashes illuminate the Earth's atmosphere. While optical properties of these flashes have been studied extensively, the possible impacts of the lightning optical pulse on the ionosphere above has not yet been quantified. According to (Morrill et al., J. Atmos. Solar Terr. Phys., 60, 811-829, 1998), most of the optical photons of lightning flashes propagate to the lower ionosphere without significant absorption. Considering the relatively low electron affinitiy of the primary negative ions present in the lower ionosphere, and the dimension, duration, and radiated power of lightning flashes, especially in extreme cases, studying the possible local and global effects of lightning flashes on the electron content of the ionosphere via the photodetachment process poses as an interesting and important problem. Quick and Krider (J. Geophys. Res., 118(4), 1868-1879, 2013) provide a review of the available lightning optical pulse data based on the ground, the satellite, and the high altitude aircraft observations. In spite of the significant difference in the sensing technology, the viewing geometry, the effects of clouds, and the wavelength dependent absorption of light propagating horizontally and vertically in the atmosphere, the authors have been able to demonstrate consistency of different data sets. Approximating the lightning channel as a blackbody radiator (Orville, J. Atmos. Sci., 25(5), 827-838, 1968a), we model the photodetachment effect of the lightning optical pulse on the main negative ions of the lower ionosphere. The photodetachment problem is formulated in terms of the framework introduced in (Janalizadeh and Pasko, J. Geophys. Res., 125(7), e2020JA027979, 2020), and the rate of electron production through photodetachment of O^-, O_2^- , OH^-, and NO_3^- ions is calculated for an extensive range of energies. This is the first quantification of lightning effects on the lower ionospheric electron content through the photodetachment process.