

Positive streamer initiation from raindrops in thundercloud fields - DTU Orbit (09/11/2017)

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The threshold field for the electric gas discharge in air is $\approx 26 \text{ kVcm}^{-1} \text{ atm}^{-1}$, yet the maximum field measured (from balloons) is $\approx 3 \text{ kVcm}^{-1} \text{ atm}^{-1}$. The question of how lightning is stimulated is therefore one of the outstanding problems in atmospheric electricity. According to the popular idea first suggested by Loeb and developed further by Phelps, lightning can be initiated from streamers developed in the enhanced electric field around hydrometeors. In our paper, we prove by numerical simulations that positive streamers are initiated, specifically, around charged water drops. The simulation model includes the kinetics of free electrons, and positive and negative ions, the electron impact ionization and photon ionization of the neutral atmospheric constituents, and the formation of space charge electric fields. Simulations were conducted at air pressure 0.4 atm, typical at thundercloud altitudes, and at different background electric fields, drop sizes, and charges. We show that the avalanche-to-streamer transition is possible near drops carrying 63–485 pC in thundercloud fields with intensity of $10 \text{ kVcm}^{-1} \text{ atm}^{-1}$ and $15 \text{ kVcm}^{-1} \text{ atm}^{-1}$ for drops sizes of 1 mm and 0.5 mm, respectively. Thus, the electric field required for the streamer formation is larger than the measured thunderstorm fields. Therefore, the results of simulations suggest that second mechanisms must operate to amplify the local field. Such mechanisms could be electric field space variations via collective effects of many hydrometeors or runaway breakdown. ©2016. American Geophysical Union.

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Authors: Babich, L. P. (Ekstern), Bochkov, E. I. (Ekstern), Kutsyk, I. M. (Ekstern), Neubert, T. (Intern), Chanrion, O. (Intern)

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