Geophysical Research Abstracts
Vol. 21, EGU2019-2659, 2019
EGU General Assembly 2019

Dynamics of ions in thunderclouds and lightning initiation

Dmitry Iudin (1,2), Vladimir Rakov (3), Artem Syssoev (1,2), Alexey Bulatov (1,2)

(1) Institute of Applied Physics of RAS, Nizhny Novgorod, Russian Federation (iudin@ipfran.ru), (2) Space Research Institute of RAS, Moscow, Russian Federation (iudin@ipfran.ru), (3) University of Florida, Gainesville, USA (rakov@ece.ufl.edu)

In this work we postulate that the process of quasi-electrostatic energy relaxation in thundercloud starts with small-scale Townsend avalanches in the vicinity of colliding hydrometers and then proceeds to larger spatial scales, culminating in the formation of hot lightning seed channel. We represent the lightning initiation scenario as a sequence of two transitions of discharge activity to progressively larger spatial scale: the first one from small-scale Townsend avalanches to mesoscale streamer discharges; and the second one from streamers to large-scale system of hot channels. We suggest a physically grounded refinement of the breakdown field concept and postulate the existence of ion production centers, whose appearance is caused by electric field bursts accompanying hydrometeors collisions or near collisions in turbulent thundercloud environment. We present a new mechanism of streamer generation in thunderclouds based on the instability of cloud environment in respect with the ion concentration increase due to the presence of ion production centers. The ion production centers are activated sequentially, each one passing through the residual ion spot left behind by the previously established center. The ion spot, through the effective electron detachment in the elevated electric field, leads to the rise in seed electron population just before the field amplitude reaches the breakdown value, immediately resulting in a higher level of electron and positive ion production when the next center is activated. The resultant stochastic relief of the volume charge density of ions provides local electric field enhancements and increase in pre-ionization level that are sufficient for the initiation and development of streamers. The proposed mechanism does not require the presence of super energetic cosmic ray particles, unrealistic potential difference in the cloud, or unreasonably long streamers originating from a single hydrometeor, unrealistically large hydrometeors and considerable “preionization” of unknown origin. The lightning initiation mechanism that we suggest in this study requires only one condition: the rate of occurrence of ion production centers per unit time in a unit volume should exceed the critical level of 10^{-1} m-3s^{-1}, which is easily achieved in a typical thundercloud. Indeed, hydrometeor collision rates three and even four orders of magnitude higher than this value have been reported from observations.