Geophysical Research Abstracts
Vol. 15, EGU2013-9348, 2013
EGU General Assembly 2013

On the Electric Breakdown Field of the Mesosphere and the Influence of Electron Detachment

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The breakdown field of the atmosphere, E_k, is commonly understood as the field value at which the ionization rate equals the attachment rate of electrons to neutrals. This description has worked well for the lower atmosphere and has been applied to the discharges of the mesosphere, the sprites and giant jets, with much success. However, in the dilute mesosphere, where neutral densities are 4-5 orders of magnitude lower than at sea level, the process of electron associative detachment from negative atomic oxygen ions is also important and provides an additional source of free electrons. We show that the introduction of the detachment process allows for electron avalanche growth for any electric field magnitude, provided the exposure time is long enough. The concept of a threshold field therefore itself breaks down. For realistic source electric fields, the threshold may be as low as 0.7 E_k, which relaxes the requirement on the field magnitude for initiation of sprites. We find that the detachment process does not affect the time delays of sprites, as has been proposed by others, and that detachment may decrease the conductivity of streamers.