Cloud electrification process

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Abstract

The electrification of clouds is a result of the relative displacement of positive and negative electric charge at the molecular scale and the subsequent macroscopic separation of opposite charge by air and particle motions.

Observations within thunderstorms reveal the existence of electric charges carried on precipitation, cloud particles, aerosol particles and free ions; these particles are present in varying concentrations and move with their own terminal velocities as well as being transported by the complicated convective air currents of the thunderstorm. The complexity is further increased because the charged precipitation and cloud particles may be present as liquid water or in many different ice forms. Therefore, it must be established which of these charges are responsible for the high electric fields required to initiate lightning, and then we can consider how these charges are acquired and separated.

All of the inferred locations for negative charge are in regions of the cloud colder than 0°C, a result that has been frequently cited as evidence for a precipitation-based charging mechanism involving the ice phase [1, 2]. In situ charge measurements of precipitation are reviewed in order to assess the contribution of precipitation particle motions to electrification [3, 4].

The number of possible processes is large. For example, the charges on a particular hydrometeor could have been gained by collisions with the many other different types of liquid and frozen particles, or the hydrometeor could have acquired the charge on melting, freezing, or by the capture or release of free ions or charged aerosol particles. A survey of the literature reveals that nearly all these processes have been investigated to some degree and found to result in a finite exchange of charge [5].

This work is concerned with the many studies contributing to a description of the main charge centers in thunderclouds, with the evidence that cloud temperature is influencing electrical structure and with the main cloud electrification mechanisms. Laboratory studies concerning with the microphysics of charge transfer will be described and discussed. The experimental devices used to perform the experiments and the results obtained in the last years will be also described in this work.

References

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