Experiments on charge transfer in graupel/crystal collisions

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Abstract

In electric measurements of thunderstorms both on the ground and inside the thunderstorms, it is observed that the charge centers are located in regions where the temperature is less than 0°C [1, 2]. Gaskell et al. [3] carried out studies with airplanes that penetrated inside the clouds to measure charges in individual ice particles; they observed charges of about 100 pC in particles of approximately 1 mm in size. These measurements made in situ suggest that the ice phase intervenes in the process of charge separation inside the clouds.

Cloud electrification is usually explained by the non-inductive mechanism [4-8]. This mechanism assumes that:
(1) micrometer ice crystals collide with millimeter graupel particles and bounce off their surface,
(2) during the brief time of contact, electric charge is separated between the two particles,
(3) electric field is not relevant for charge separation,
(4) the charged ice particles are then carried away to different regions of the cloud due to convective currents and gravitational force.

Laboratory measurements of the interactions between ice crystals and riming ice particles have shown that the charge transfer per rebounding collision could be sufficient to explain thunderstorm electrification. These studies have shown that the magnitude and sign of the charge transferred to riming graupel particles during interactions with ice crystals is sensitive to the cloud microphysical conditions such as the cloud temperature and liquid water content [5, 9-11], distribution of cloud droplet size [12-13], ice crystal size [14], and impact velocity [15]. Furthermore, it was found that the charge transfer per collision increases rapidly with crystal size and impact velocity. These results suggest a strong link between lightning production and the microphysical and dynamical characteristics of the clouds.

The experimental devices used to perform the experiments and the results obtained in the last years will be described in this work.

References

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