CHARGE SEPARATION IN SEVERE STORM CONDITIONS

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I. INTRODUCTION

Researchers often classify thunderstorms in three categories: stratiform and winter storm, ordinary thunderstorm, and severe storms or super hailstorm, distinguished on the basis of lightning flash rate, updraft speed, liquid water content (LWC), predominant electrical polarity of the cloud, etc. Stratiform and winter storm are shallow with low updrafts, low LWC, and, in general, with conditions for slow particle growth. Ordinary thunderstorms have a more important vertical development with higher LWCs and updrafts leading to the formation of graupel pellets. The severe storms have large LWCs and updraft speed which can produce big hailstones and have tendency to produce copious +CG lightning.

Laboratory studies have shown that the magnitude and sign of the charge transfer to riming graupel particles during interactions with ice crystals depend on the cloud temperature, liquid water concentration, cloud droplet size distribution, ice crystal size and impact velocity [Reynolds et al., 1957; Takahashi 1978, Jayaratne et al., 1983; Saunders et al., 1991; Pereyra et al., 2000; Avila and Pereyra, 2000; Bürgesser et al., 2006].

Measurements of charge transfer in ice-ice collisions at high liquid water content are complex due to the difficulty of dissipating the large amount of latent heat released during the vapour condensation.

II. MEASUREMENTS AND RESULTS

The electrical charge separation during collisions between ice crystals and a fixed target growing by riming was measured. Each experiment consisted on the measurement of the electric current for two different liquid water contents, which was rapidly varied (in around 10 s) during each run. This sudden change of the liquid water content during a run allows the study of the behaviour of the charge transfer at different LWC since all the other variables (impact velocity, ambient temperature, cloud droplet spectrum, ice crystal sizes and concentration) involved in the charge separation process are expected to remain approximately constant.

The measurements were carried out by using a wind tunnel mounted inside a cold room and connected to two separated chambers. One of them is the cloud droplet chamber (CDC) where a cloud of supercooled water droplets is produced and another one is the ice crystal chamber (ICC) where a cloud of ice crystals is generated. The device is based on the arrangement used by Pereyra et al 2000, Pereyra and Avila 2002 and Bürgesser et al 2006.

The temperatures of both chambers are measured by thermistors. The charge transferred during the crystal/graupel collisions is detected by a sensitive current amplifier capable of detecting currents larger than 1 pA. The input of the amplifier is connected to the target and its output is recorded. The speed of the airflow past the target was controlled by adjusting the power to an air pump and measured by a Pitot tube; the measurements were conducted at a constant velocity of 8 ± 0.5 m s^{-1}; the ambient temperatures was varied between –10 and –30°C. Also, the cloud droplet size distribution was the same for all the experiments described here.

In this work we describe in detail the experimental device used for the measurements and present the results of the variations of the magnitude and sign of the charge transfer for two different LWCs, usually one of them was less than 2 g/m^3 corresponding to values of ordinary thunderstorms and the other one was for high LWC (>5 g/m^3) corresponding to values of severe thunderstorms.

III. AKNOWLEDGMENTS

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