Correspondence, or lack thereof, between microphysical and electrical boundaries in thunderstorms

Poster 296

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INTRODUCTION

A commonly accepted paradigm is that the dominant mechanism separating electric charge in convective clouds is the non-inductive separation that occurs when ice particles collide and separate. If the separating particles are different in size, one will sediment relative to the other. If small particles on average end up with charge of one sign, and large particles with the opposite, net charge separation will occur over time in the storm. The sign of charge retained by the smaller and larger separating particles varies with cloud liquid water concentration , temperature, cloud water trace solutes, and perhaps other parameters. Another mechanism that is hypothesized to lead to charge separation is melting of aggregates. Tiny fragments released from the outer branches on average carry charge of one sign and remain near the melting level, while the main body of the aggregate carries the other charge as it falls further.

If charge separates in this way, one would expect to find microphysical differences between regions of cloud with net charge of one sign compared to regions of cloud with net charge of the opposite sign. For instance, lower concentrations of predominantly larger particles in regions dominated by charge of one sign and higher concentrations of predominantly smaller particles in regions dominated by the opposite sign.

Here are two examples of airborne electric field measurements . In the first, the instrumented aircraft finds itself alternately above and below a thin undulating layer of positive charge near the melting level. Microphysical properties in the cloud are uniform across the horizontal sheet of positive charge.

In the second, the instrumented aircraft crosses the path of a long looping horizontal lightning discharge. The lightning propagates along an apparent gradient in microphysical properties that can be discerned with a combination of airborne *in situ* and polarimetric meteorological radar observations.

Unfortunately, reliable particle size and charge observations are not available for either of these cases.

An instrumented aircraft passed through a trailing stratiform region in the vicinity of a thin undulating layer of positive charge near the melting level in an Oklahoma MCS. There were balloon soundings of electric field at each end of the pass.

CH 9 - 4 MO ET AL.: ELECTRIC FIELDS IN A STRATIFORM REGION

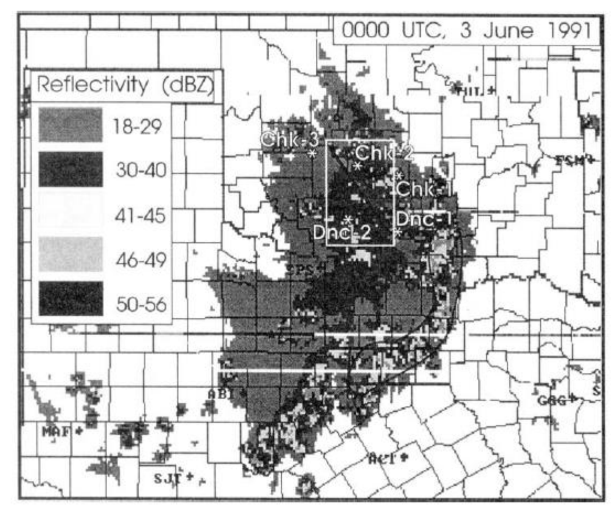

Figure 1. Composite reflectivity depiction of 2–3 June 1991, MCS in central Oklahoma. The soundings were obtained two at a time, at one-hour intervals, from Chk (Chickasha) and Dnc (Duncan), and are located here in a storm-relative sense, assuming a steady state storm structure between 2300 Z and 0100 Z with motion at 35 km/hr toward 105°. The first soundings at the two sites were Chk-1 and Dnc-1, the second soundings were Chk-2 and Dnc-2, and so forth. For purposes of the following discussion, the boxes and various lines superimposed over the political boundaries can be ignored. Reprinted from *Stolzenburg et al.* [1994] with permission.

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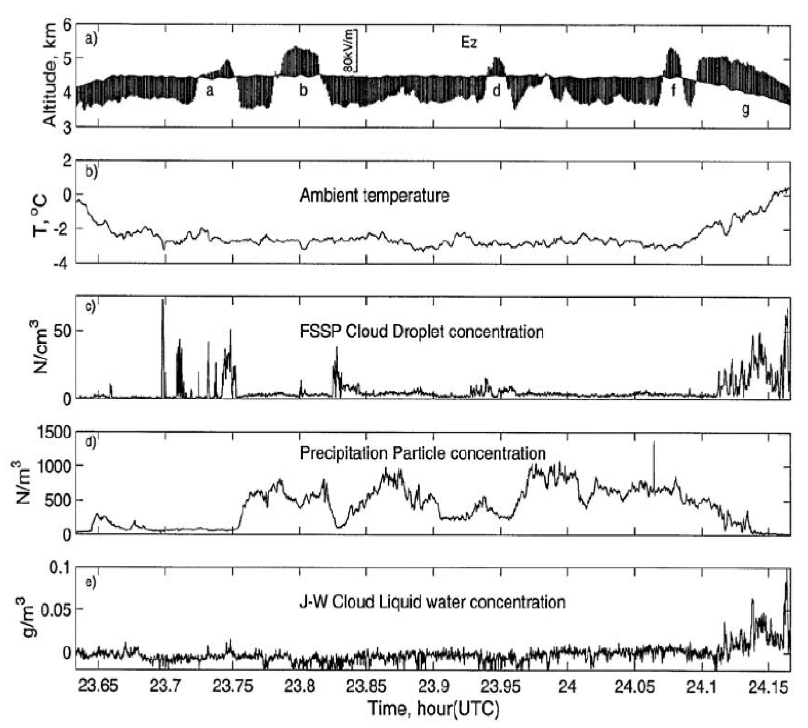
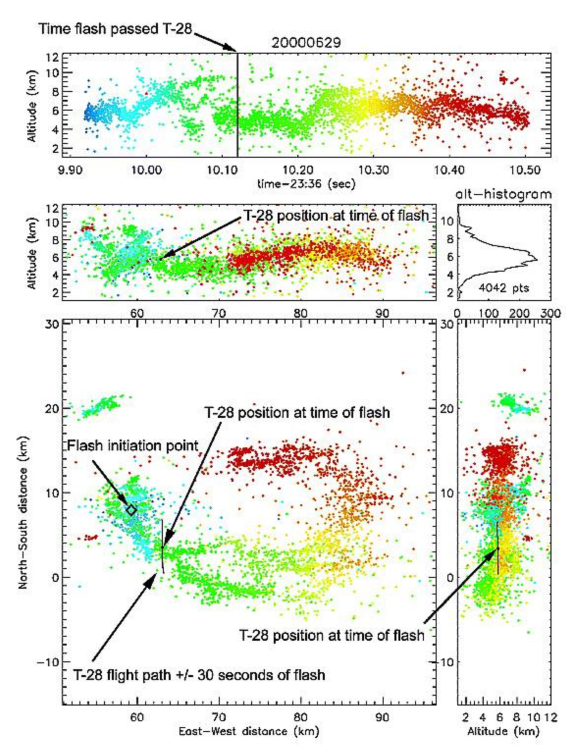


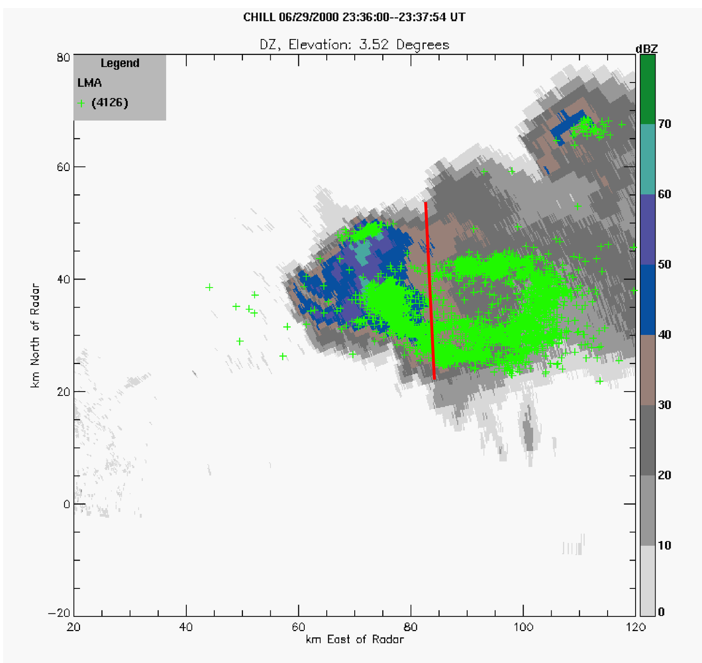
Figure 5. Observations of T-28 (a) E_z, (b) temperature T, (c) FSSP cloud droplet concentration, (d) precipitation particle concentration, and (e) cloud liquid water from Johnson-Williams cloud water meter, are shown during southbound, then northeast-bound, traverses of the stratiform region. See Figure 4a for corresponding flight track.

In this case there was no discernible vertical difference in microphysical characteristics across the charge layer

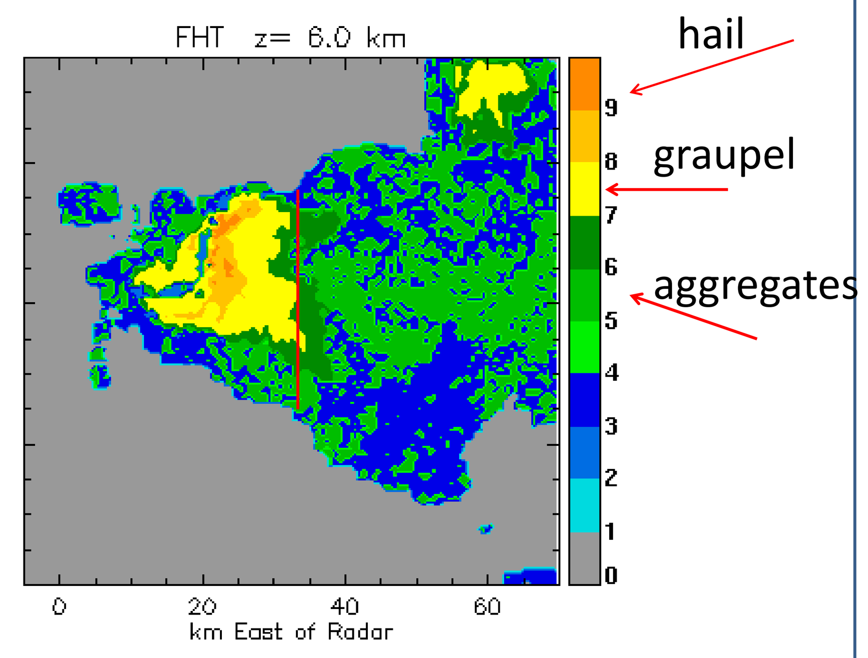
A long looping horizontal discharge through lower downshear anvil region of a Kansas supercell, at -10^{o}C level appears to move along a microphyiscal gradient between predominantly graupel and predominantly aggregates



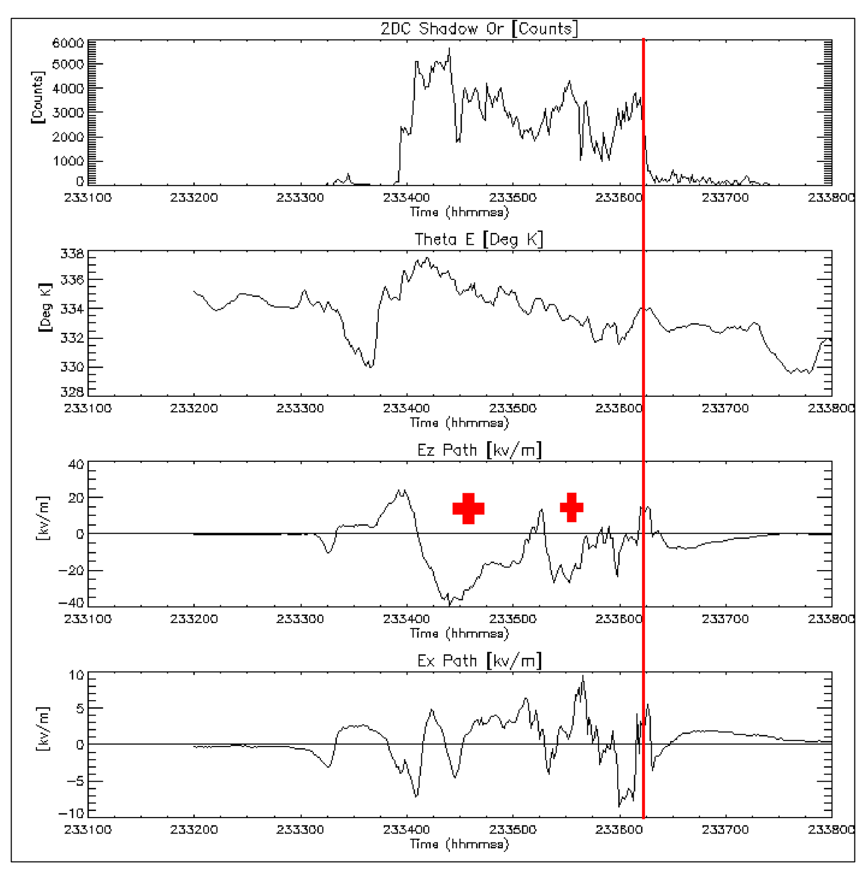
LMA map of discharge



LMA map overlaid on reflectivity.
Aircraft track in red



RADAR-based hydrometeor ID



Ice particle concentration, equivalent potential temperature, and vertical and along-path electric field components as aircraft passes southward across the downshear region of storm. Red line indicates time aircraft intercepted lightning channel. "+"'s indicate inferred positive charge regions.

These plots, and other data, suggest this lightning discharge propagated along a microphysical boundary between a region of positively-charged graupel forming around the updraft in the main storm and falling out to the east, and flanking cells to the north and south containing little precipitation or charge, and a region of snow/aggregates to the west .

An instrument capable of imaging, and determining charge , for the same hydrometeor is needed for further progress in microphysical-electrical studies.

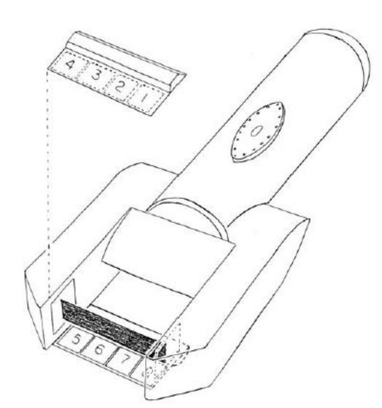


Figure 1. Sketch of High Volume Particle Sensor (HVPS) with the charge detector. The upper half of the charge detector is shown lifted out of position, in order to expose the laser beam (shaded).

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