P5.2 MICROPHYSICAL PROPERTIES AND EVOLUTION IN ANVILS OF FLORIDA THUNDERSTORMS

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Introduction

The microphysical properties and their evolution in anvils originating from thunderstorms have long been of great interest in the study of radiational heat transfer in the atmosphere. Anvils also transport large amounts of water mass in the upper troposphere and lower stratosphere and have a significant role in the earth's water cycle. Recent interest in microphysical processes in anvils near Kennedy Space Center is inspired by the need to understand the temporal and spatial decay of electric fields and microphysical properties in active and decaying anvils. *In situ* measurements in thunderstorms anvils have frequently been avoided in order to study the most dynamically active portions of convective storms. Consequently, little observational data exist from anvil regions of convective storms.

During June 2000 and late May through June 2001, field campaigns were conducted to obtain simultaneous *in situ* airborne measurements of electric fields and microphysical content in anvils and anvil debris clouds near Kennedy Space Center using the University of North Dakota Citation jet aircraft. The microphysical measurements provide a comprehensive look at the entire particle spectrum from a few microns to more than a centimeter. The probes include the PMS-FSSP (3 to 55 microns), the PMS-1D-C ($\tilde{2}0$ to 600 microns), the PMS-2DC ($\tilde{3}3$ to 1000 microns), the SPEC Cloud Particle Imager ($\tilde{1}5$ to 1000 microns), and the SPECHigh Volume Precipitation Spectrometer, HVPS, ($\tilde{0}.4$ to 45 mm). This paper will present ice particle data collected on June 13, 2000 when the aircraft made 7 flight legs along the outflow axis of a decaying and nearly stationary thunderstorm.

Flight summary

June 13, 2000 provides an excellent case in which the Citation investigated the anvil of an isolated, electrically active thunderstorm for over three hours starting at a time when the storm was still producing lightning through the time when the fields had decayed to a couple of KV/m. The flight track of the Citation is shown in figure 1. Beginning at 2040 until 2220 UTC, the Citation performed a series of constant level east-west passes through the electrically active core of the thunderstorm between the altitudes of 8.0 and 11. km. After 2220 the lightning activity of the thunderstorm had diminished significantly, the Citation began a series of 7 northeast-southwest constant level flight legs along the axis of the outflow anvil beginning at the central core of the thunderstorm to the downwind edge of the anvil at altitudes of 11 km and descending to 9.5 and 8. km.

Ice particle analysis

Data analyses of the 7 northeast-southwest flight legs were performed. The 2DC particle analysis generally followed the work of Heymsfield and Parish (1978), allowing for the virtual reconstruction of incomplete images. For unknown reasons the HVPS probe during the 2000 campaign did not function properly. In order to perform the HVPS analysis only a portion (approximately 25%) of the 256 optical array diodes could be used. Simple tests were used to determine if a particular HVPS diode could be accepted. The tests summed the total occulted count within a HVPS buffer for each diode. If a diode's total count either exceeded five times the mean count or five times the variance for the buffer the diode was considered inactive and that portion of the array would use an adjacent acceptable diode. This method proved to be an efficient method of removing streaker images. The HVPS periodic mask buffer was not be utilized because it is written to infrequently. In all cases distortion effects for the 2DC and HVPS were accounted for. These distortion effects were caused by the true air

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speed being different from the probe clock operation speed and occurred when the aircraft speed exceeded a probe's clock speed limit or when icing occurred on the pressure pitot sensor that controlled the probe clock speed.

In figure 2 is shown a vertical cross section of the available radar data along the flight leg 1 with the ploted aircraft track. This figure shows that the first leg to be above the maximum reflectivity level/ Figures 3,4,5,and 6 show time series plots of the total number concentration at various size intervals for the FSSP, 2DC and HVPS probes for the outgoing legs 1, 3, 5, and 7. Each of these legs originate near the thunderstorm core and extend to the downwind edge of the anvil. Flight leg 1 was at 11 km (-40°C). Flight legs 3 and 5 were at 9.5 km (-31°C)and flight leg 7 was at 8. km (-21°C). These plots show the number concentrations decreasing with distance from the thunderstorm core.

In figure 7 some selected particle spectra are shown for flight legs 1, 3 and 7. The plots illustrate how the largest particles are present near the core and not near the anvil's downwind edge.

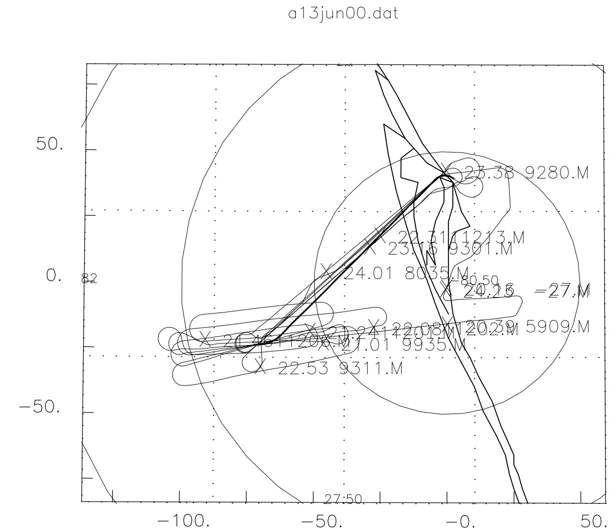
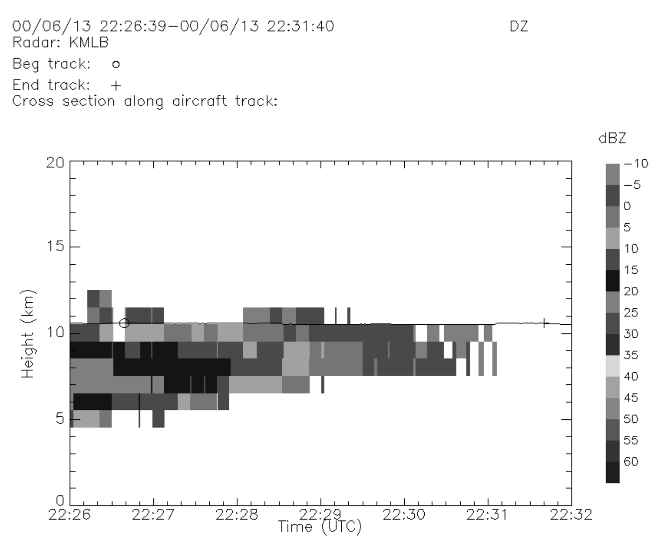


Figure 1: Aircraft track. With the outline of the eastern coast of Florida and 50 km radial rings from a WSR74C radar at Patrick Airforce Base.

Preliminary Results

Preliminary findings indicate that the aggregation process was active at all observed levels of the storm, even at cold temperatures. Selective size sorting occurred away from the thunderstorm core, resulting in a significant modal shift to smaller size particles toward the downwind edge of the anvil. Note that the concentrations are dominated by the smallest particles. From CPI images most of these smaller particles appear to be frozen cloud droplets and they persist even to the downwind edge of the anvil.



REFERENCES

Heymsfield, Andrew J., Joanne L. Parrish, 1978: A Computational Technique for Increasing the Effective Sampling Volume of the PMS Two-Dimensional Particle Size Spectrometer. *J. Appl. Meteor.*, **17** , 1566-1571.

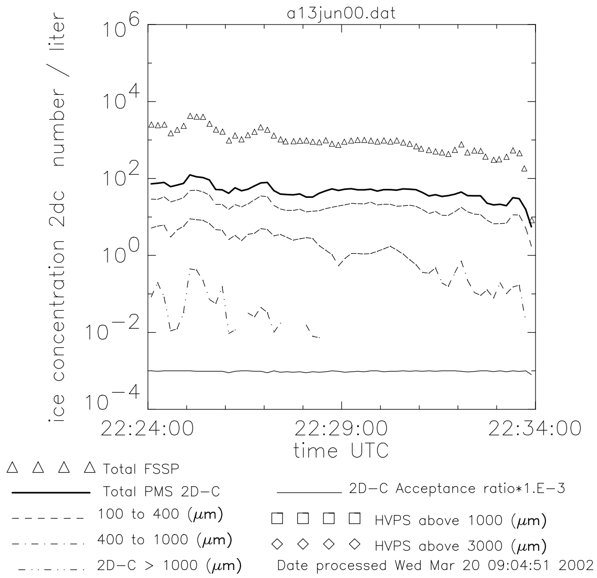


Figure 2: Particle time history plots. NW-SE flight leg 1 at 11 km (-40°C) level.

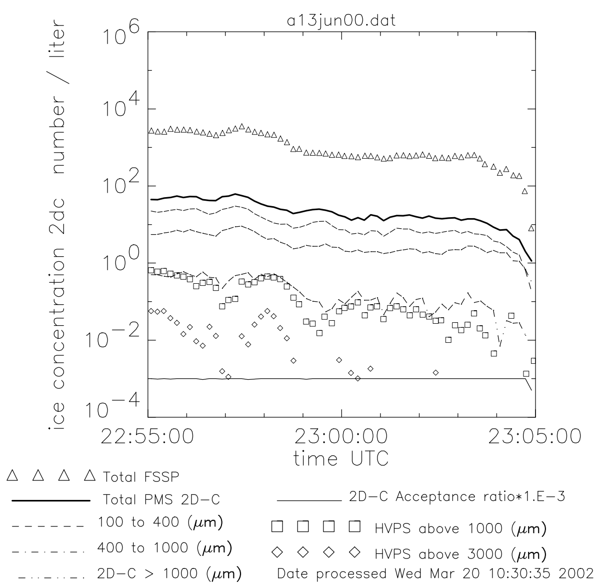


Figure 3: Particle time history plots. NW-NE flight leg 3 at 9.5 km (-31°C) level.

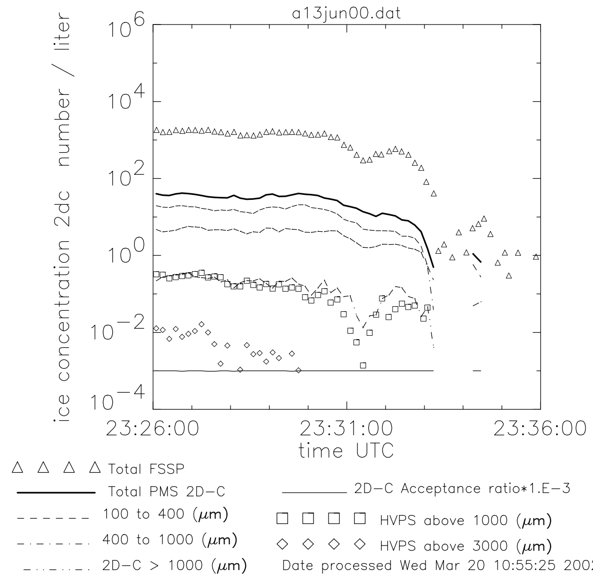


Figure 4: Particle time history plots. NW-NE flight leg 5 at 9.5 km (-31°C) level.

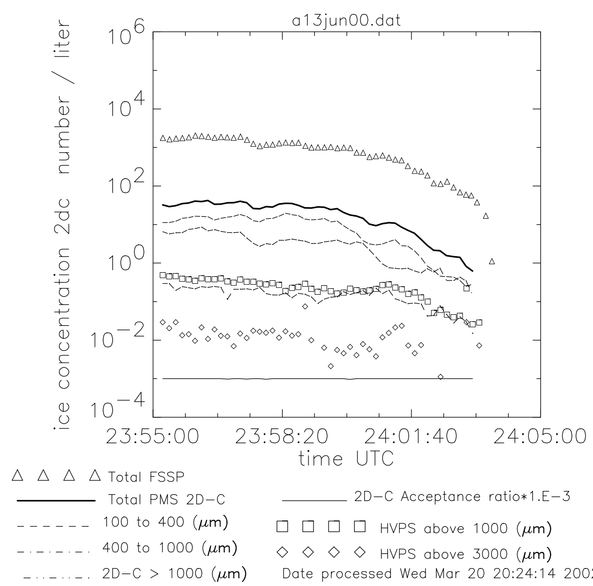


Figure 5: Particle time history plots. NW-NE flight leg 7 at 8 km (-21°C) level.

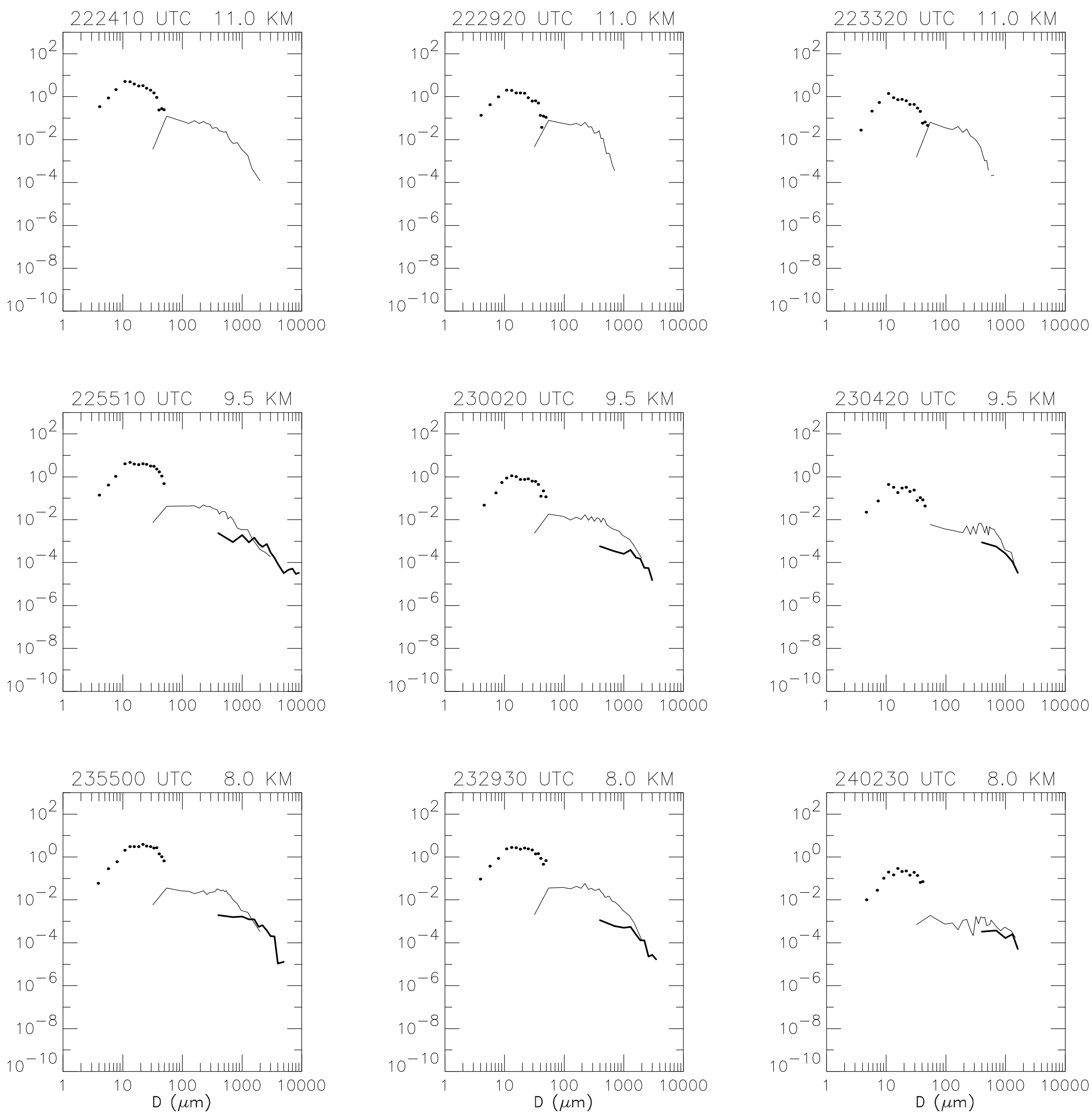


Figure 6: Composite spectral plots for selected points along flight legs 1 (top 3 panels) flight leg 2 (middle 3 panels) and flight leg 7 (bottom 3 panels) with the left side panels near the thunderstorm core and the right side panels near the anvils downwind edge. No HVPS data was accepted during flight leg 1. Dotted line - FSSP data. Thin solid line - 2DC data. Thick solid - HVPS data.