8A.4 A PRELIMINARY SURVEY OF DSD MEASUREMENTS COLLECTED DURING VORTEX2

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1. INTRODUCTION AND MOTIVATION

Motivated in large part by results from the original Project VORTEX (1994-1995) and sub-VORTEX (1999) field campaigns, recent observational (Markowski 2002, Markowski et al. 2002), high resolution idealized numerical simulations (Markowski 2003, Snook and Xue 2008) and simulations based on real data (Dawson 2009) have established a link between relatively warm outflow in the rear flank downdraft (RFD) region of supercells and robust tornadogenesis and maintenance. A primary directive for the VORTEX2 (2009-2010) field campaign was to better characterize the low-level thermodynamic and microphysical environments of supercells, via an integrated dataset of mobile mesonet, polarimetric radar, and surface disdrometer observations. It is hoped that observing the spectrum of microphysical variability within tornadic and nontornadic supercells, particularly the drop size distributions (DSD) of rain, which significantly impact evaporative cooling rates (Dawson et al. 2010, Snook and Xue 2008, Milbrandt and Yau 2006). Evaporative cooling rates in turn modulate cold pool development (see Fig. 1, adapted from Dawson 2009), and thus better observations of DSD variability in supercells will help elucidate the causative mechanisms for warm vs. cold RFD's and their attendant impacts on tornado potential.

To this end, a mobile mesonet van operated by the National Severe Storms Laboratory (NSSL) was equipped with two portable PARSIVEL disdrometer probes (Fig. 2), both of which also contained standard weather sensors (temperature, relative humidity, pressure, and wind). The probes were designed for rapid manual deployment in the region of the storm immediately between the surface circulation center and the forward flank precipitation region, which would then in turn sample the northern part of the hook echo precipitation as the storm passed over the probes. This region of the storm was targeted because the relatively light surface winds typical of this region should improve the accuracy of the drop distribution measurements. After deployment, the mobile mesonet vehicle was driven back and forth between the probes, collecting thermodynamic, wind, and pressure data, from which estimates of the local gradients of these quantities can be derived. During both seasons of the VORTEX2 project, successful deployments of several minutes apiece of one or both probes were made of the hook echo region of several supercells, both tornadic and nontornadic.

The purpose of this study, which is in its preliminary stages, is to examine the variability of the rain DSDs across the supercell spectrum, and to compare these DSDs with co-located polarimetric radar measurements and other disdrometer data that were collected from other parts of the storm. This will involve a robust and detailed multi-pronged (observational, theoretical, and numerical modeling) effort to integrate the wealth of data collected by VORTEX2. In what follows, however, we will present but a brief preliminary overview of one of the datasets collected during the first season of VORTEX2 (Spring 2009), a deployment in the hook echo/updraft region of a significantly tornadic supercell (June 5th, Goshen County, WY).

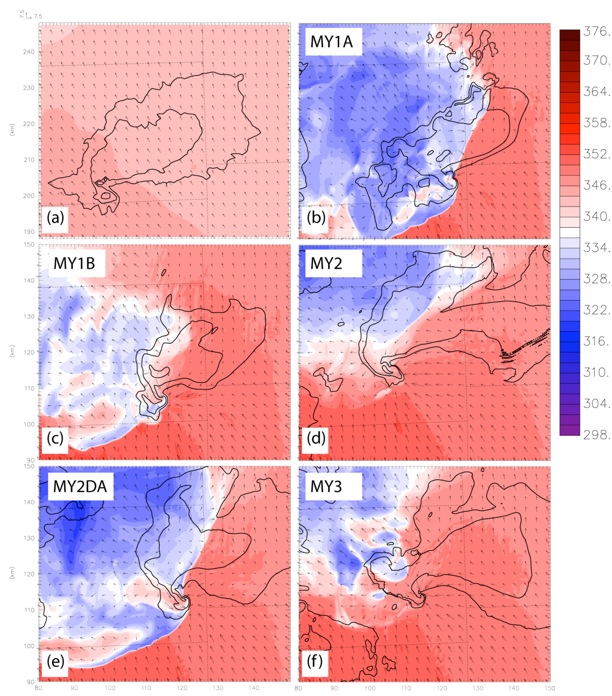

Figure 1. Surface equivalent potential temperature (color fill, K), simulated reflectivity (black contours, 20 dbZ increment) and wind vectors (each unit spacing = 7.5 m s^{-1}) for several different 250-m 1.5 h forecasts (valid 0030 UTC 4 May 1999) of the 3 May 1999 OKC tornadic thunderstorm with different configurations of the Milbrandt and Yau (2005) microphysics scheme. For details, see Dawson (2009). The 2- and 3-moment configurations [(d) and (f), respectively] each exhibited an intense tornado-like vortex at the time of this figure. The observed low-level reflectivity and background mesoscale equivalent potential temperature analysis are shown in panel (a) for reference.

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Figure 2. One of the two Parsivel disdrometer probe packages, seen shortly after a deployment.

2. CASE OVERVIEW

On June 5th, 2009, VORTEX2 intercepted its first significantly tornadic supercell of the project in Goshen County, WY. The storm formed on the high terrain of the Cheyenne Ridge in the late afternoon and subsequently propagated southeastward, producing its first and only long-track tornado beginning at approximately 2152 UTC, and dissipating at 2230 UTC. We will focus on the first deployment in this abstract, in which a roughly 2.5 km east-west baseline was set up along Bear Creek Rd., west of La Grange, WY (Fig. 3). The easternmost probe (latitude 41.6509 °N, 104.3631 °W) was apparently impacted by a large hailstone partway through the deployment that flipped the power switch on the probe, resulting in only a partial dataset. The westernmost probe (latitude 41.6507 °N, 104.3928 °W), however, collected data from 2201-2221 UTC along the northern edge of the rain ball and into the hook echo, as the storm moved ESE, and thus we will present data from this probe in the following section. A swath of very large hail (4.5 in diameter) passed just to the east of the deployment sites.

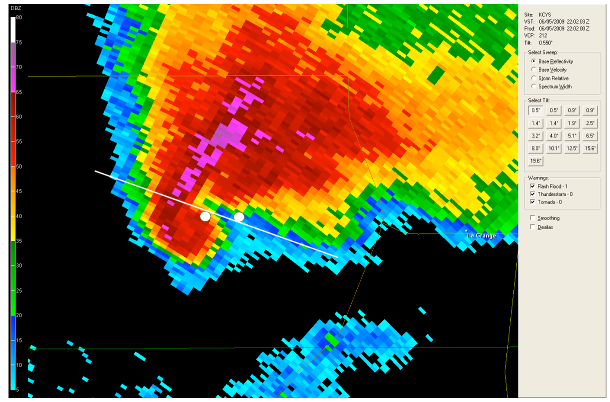

Figure 3. 0.5 ° base reflectivity scan from the KCYS 88D radar at 2202 UTC, near the beginning of data recording for the westernmost probe and during the early stages of the tornado. White circles indicate the locations of the disdrometer probes, and the white line indicates the direction of storm motion.

3. PRELIMINARY SURVEY OF DSD VARIABILITY

In this section we present preliminary results of DSD fits to the 1-min disdrometer data for the 5 June case. Significant variability in time exists in the spectra as the hook echo precipitation region passed over both probes. DSDs are shown for three different times for the westernmost probe in Fig. 4. These are believed to be representative of the rain spectra when the probe was respectively under the wraparound precipitation on the north side of the hook, the center of the hook, and the back side of the hook. The blue and green curves in Fig. 4 are exponential and gamma distribution fits using the method of moments after Zhang et al. (2008) and Tokay and Short (1996), respectively. Other methods of obtaining functional fits are certainly possible and will be pursued in future work. A few of the DSD spectra (including the middle spectrum in Fig. 4) show signs of sparse large drops or small hail, and thus the fitted DSDs must be interpreted with caution. Noteworthy also is the relative lack of large drops in the rain ball and on the back side of the hook. More work is needed to determine the representativeness of these DSD measurements and to account for possible sources of bias. Finally, the calculated values of the exponential intercept parameter N_0 are generally lower, at least in this region of the storm than the Marshall and Palmer (1948) value of 8.0 x 10^6 m^{-4}, the value commonly used in single-moment microphysics parameterizations of deep convection. However, there is considerable variability of the derived N_0 for other deployments and storms (not shown) and therefore no conclusions can yet be drawn at this early stage in regards to the implications for common microphysics parameterizations as applied to simulations of supercell thunderstorms.

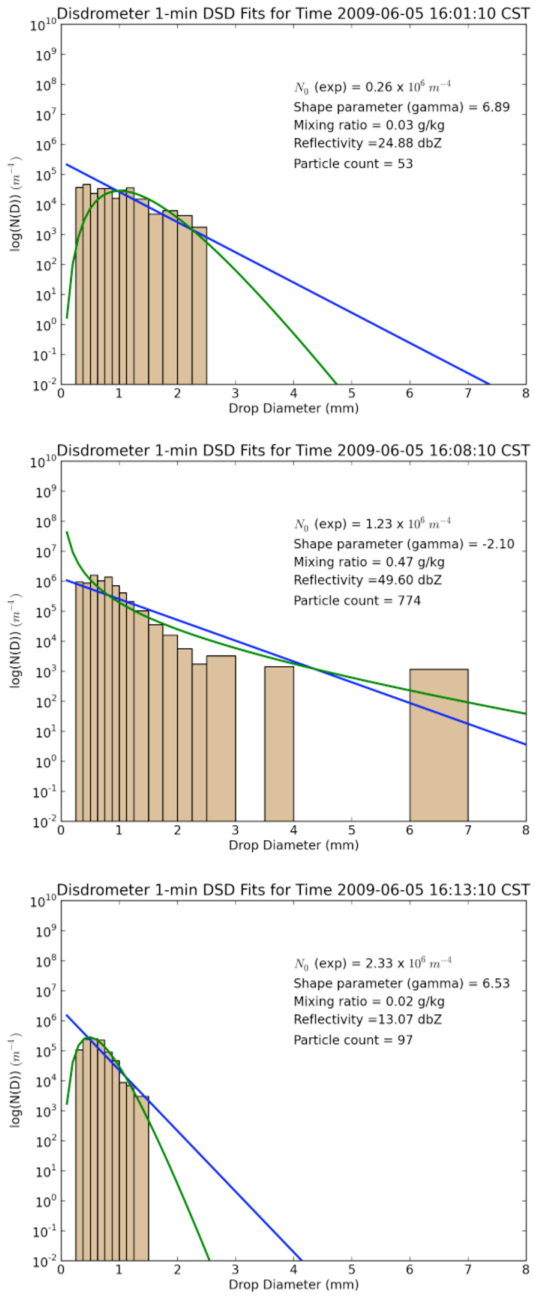

Figure 4. Disdrometer spectra for three separate times during the passage of the storm across the western probe. The three times, from top to bottom, are 1601 CST (2201 UTC), 1608 CST (2208 UTC), and 1613 CST (2213 UTC), and correspond roughly to the time when the probe was on the northern side of the hook echo in the wraparound rain, within the northern part of the hook echo, and on the back side of the hook echo, respectively. Shown are actual disdrometer bins (tan bars) as well as exponential (blue) and gamma (green) distribution fits. Several derived DSD-related quantities are also annotated.

4. FUTURE WORK

In future work, emphasis will be placed on continuing to compile and analyze the DSD data from the many deployments on various storm types during VORTEX2. In particular, we wish to examine bulk evaporative cooling rates derived from the DSDs and compare them to the corresponding observed cooling rates. It is hoped that, combined with mobile mesonet observations of the disdrometer van, as well as the other mesonet vehicles, a cohesive picture of the small-scale near-surface thermodynamic, dynamic, and microphysical environment in the hook echo region of supercells can be developed. We also wish to compare our results broadly to polarimetric radar data that were being simultaneously collected by various X-band and C-band mobile radars during many of the deployments. Finally, as discussed previously, a major long-term goal of this research project is to constrain and improve microphysical parameterizations in numerical models of supercell convection, and to examine the impact of these potential improvements on numerical simulation and prediction of storm behavior and tornadic activity.

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