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# HIGH-RESOLUTION DUAL-DOPPLER ANALYSIS OF A CYCLIC SUPERCELL

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## 1. INTRODUCTION

During the afternoon of 29 May 2001, two mobile 3-cm Doppler on Wheels (DOW) radars (Wurman et al. 1997; Wurman 2001) intercepted a cyclic supercell near Kress, TX. High-resolution data were collected by both radars for approximately an hour until a technical problem precluded further data collection. Due to the close proximity of the storm to the radars, data favorable for a dual-Doppler synthesis were confined to about 2255-2310 UTC. The time period chosen for synthesis contained three cyclic mesocyclones, although no tornadoes were produced. However, the storm produced a tornado with winds of 52 m/s (recorded by DOW3) two hours after the synthesis, as well as a few more weaker tornadoes later that evening.

The analysis of this case will focus primarily on the cyclic nature of the mesocyclones, including their formation, maintenance, and dissipation. Previous observational research (Burgess et al. 1982; Dowell and Bluestein 2002) has yielded conceptual models of cyclic formation based on single Doppler data and airborne dual-Doppler syntheses. A comparison of these models to data synthesized from high-resolution ground-based radars will be conducted. In addition, a quantitative analysis of the vorticity tendency terms will also be compared to previous research, including cyclic-mesocyclogenesis models (e.g., Adlerman et al. 1999).

A secondary area of interest will be the evolution of the associated rear-flank downdrafts (RFDs). Recent work (Markowski et al. 2002, 2003) has outlined the importance of certain RFD characteristics in relation to tornadogenesis. Therefore, RFD structure, including extent and magnitude, will be analyzed with respect to locations of the parent mesocyclones.

The main hypotheses that will be tested include: 1) that similar processes outlined in previous research apply to cyclic mesocyclogenesis in this storm, and 2) that certain characteristics of the vorticity tendency terms may help explain mesocyclone evolution and possibly the lack of tornadogenesis.

## 2. DATA PROCESSING

Before the synthesis process could be completed, editing of the data was necessary to remove or fix any erroneous data using the NCAR software package SOLO II. Edited items included ground clutter and blockage from power poles or any other tall objects nearby, and range/velocity folding. Also, all radar sweeps were rotated to true North.

The NCAR REORDER software was then used to interpolate data onto a cartesian grid using an isotropic Barnes scheme chosen to retain small scale motions but still reduce noise. The grid spacing was set to 100 m in both the horizontal and vertical. REORDER was also used to correct for advection of the storm during each volume scan using an estimated mean storm motion.

The final step of post-processing was to synthesize the three dimensional wind field using the NCAR CEDRIC software. The vertical velocities were obtained by integrating the mass continuity equation starting at the surface with w = 0. Other derived fields were generated using the synthesized three-dimensional winds.

## 3. PRELIMINARY RESULTS

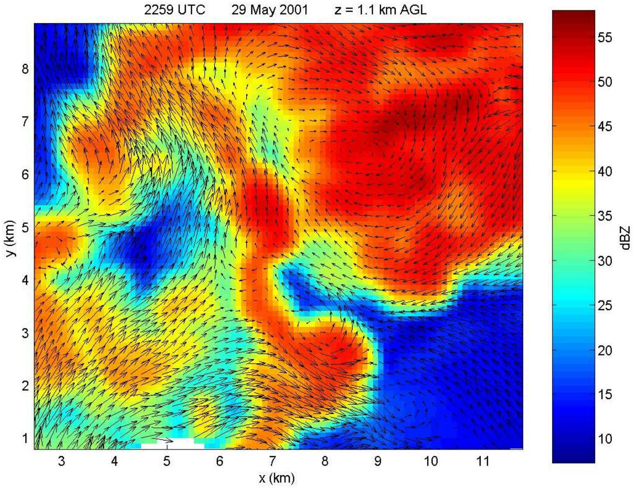

Figure 1: Reflectivity with horizontal wind vectors plotted at every other grid point centered on the rear-flank of the storm. Wind vector length equal to grid spacing is 4 m/s. A total of three mesocyclones at different stages of life can be identified (x=9.5, y=1.5; x=8, y=3; and x=4, y=6.5).

When analyzed at cloud base height, the cyclic formation of mesocyclones provides a striking resemblance to the conceptual models of Burgess et al. (1982) and Dowell and Bluestein (2002). When compared to time $t_0 + 2\triangle t$ of Fig. 13 in Dowell and Bluestein (2002), Fig. 1 exhibits almost identical characteristics, with the exception of the forward-flank boundary orientation. However, near the ground (Fig. 2),

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[∗] *Corresponding Author Address*: Jeffrey Beck, Texas Tech University, Atmospheric Science Group, Lubbock, TX 79409-2101 j.beck@ttu.edu there is no evidence of rotation associated with the oldest or newest mesocyclones (vortices 1 and 3 with respect to the schematic of Dowell and Bluestein (2002)).

Further near-ground analysis indicates the absence of a forward-flank boundary as well as illustrates an undocumented linear wind shift feature which exists throughout a majority of the synthesis. Judging by the location of surface divergence patterns, this feature appears to be associated with the convergence of air from successive RFDs and environmental air (Fig. 2).

Structural analysis of the rear-flank linear wind shift reveals that the feature is limited to about 1 km in depth. East of the surface convergence, a line of horizontal vorticity exists oriented parallel to the wind shift line from SSE to NNW (Fig. 3). Downdrafts can be seen on either side of the surface convergence area, corresponding to the RFD regions of the storm. The resulting updraft contained speeds of greater than 10 m/s and extended upward to the vertical limit of the synthesis.

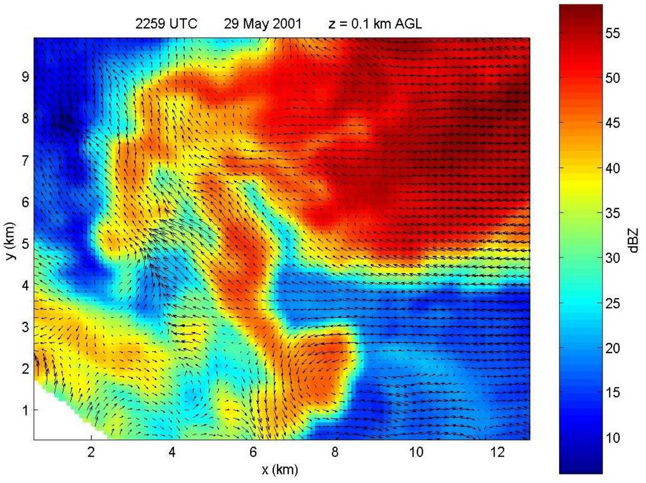

Figure 2: Same as Fig. 1 except at z = 0.1 km. Linear wind shift feature and lack of forward-flank wind shift is evident.

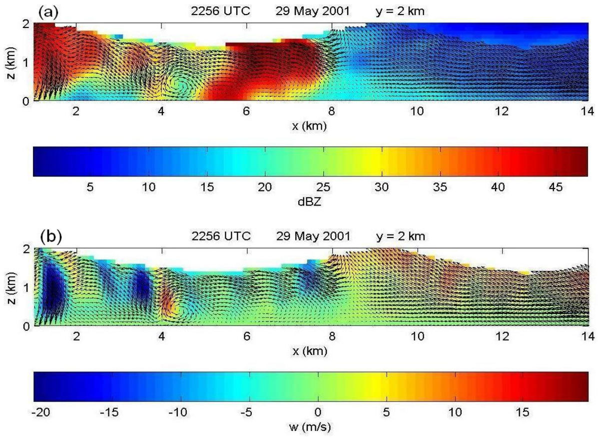

Figure 3: X-Z cross sections at y = 4 km from 2256 UTC (X-Y plot not shown). Wind vector length equal to grid spacing is 6.5 m/s. (a) U-W wind vectors with reflectivity. (b) U-W wind vectors with a pseudocolor plot of vertical velocity.

Another relatively undocumented process in cyclic supercells is that of hook echo reflectivity evolution. Most research has focused on the analysis of cyclic vortex evolution, ignoring hook echo reflectivity patterns during cycling. A distinct pattern of hook echo decay and regeneration is apparent in this storm. The low-level reflectivity fields display the hook wrapping up into the forward flank precipitation as the occluded mesocyclone separates from the main updraft. As the new mesocyclone forms on the leading edge of the rear-flank gust front, westerly momentum transports precipitation eastward and begins the development of a new hook.

## 4. DISCUSSION

Initial results indicate a number of similarities between this cyclic supercell and previous conceptual models. In addition, a few unique, undocumented features have been identified, likely due to the high-resolution of the dataset. Further analysis of these features is pending.

As in the McLean, Texas storm in Dowell and Bluestein (2002), there is an area of trailing convection that existed throughout the synthesis time period. The existence of this convection could have potentially affected the strength of the rear-flank outflow and conclusions based on analysis of the RFD region will take this into account.

The vertical extent of the synthesis is limited due to the close proximity of the area of interest to the radar baseline. The southern edge of the synthesis domain (location of the mesocyclones) is limited to 2-3 km in height. This limitation makes conclusions about the continuity of the main updraft and mid-level properties of the mesocyclones difficult to establish. Even so, the analysis of this storm may yield important results pertaining to small scale features present during cyclic processes. It provides an excellent opportunity to analyze the evolution of low-level vorticity tendency terms, and hopefully will help to supplement a small but growing number of conceptual models of cyclic mesocyclogenesis.

## 5. ACKNOWLEDGMENTS

We appreciate the input of Dr. David Dowell and thank both him and Herb Stein for their video documentation of the storm. We also thank the DOW/ROTATE crew of 2001. This research is supported by NIST (Department of Commerce NIST/TTU Cooperative Agreement Award 70NANB8H0059).

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