REAR-FLANK DOWNDRAFT EVOLUTION IN THE 29 MAY 2004 GEARY, OKLAHOMA TORNADIC SUPERCELL THUNDERSTORM

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I. INTRODUCTION

On 29 May 2004, a high precipitation thunderstorm initiated along a dryline in western Oklahoma and produced over a dozen tornadoes as it propagated across the state. The TELEX project (MacGorman et al. 2008) observed the storm for over 2 hours. During this period, the storm was observed by two mobile Doppler SMART radars (Biggerstaff et al. 2005) that were deployed along a ~42 km baseline oriented nearly parallel to the storm motion. This study focuses on the period from 0011 ~ 0052 UTC, during which 13 volumetric sector scans were collected.

II. METHODS

NCAR software was used to process the data taken with each radar. The data was edited using SOLO and then interpolated in REORDER using a Cressman scheme with a range dependent radius of influence. CEDRIC was used to perform the wind synthesis. The vertical motion was calculated using a variational method with double boundary conditions at the surface and at the echo top. Each volume scan consisted of 18 PPI's and ranged from 0.8° to 33.5° or 58.9° in elevation angle, depending on the range from the radar.

III. RESULTS AND DISCUSSION

Over the observed period the storm went through several cycles during which the rear-flank downdraft (RFD) would form, rotate around the mesocyclone and then occlude and weaken. This paper will focus on an occlusion downdraft within the RFD at 0022 UTC and the precipitation loaded RFD at 0045 UTC.

At 0022 UTC an occlusion downdraft, as described by Klemp and Rotunno (1983), appears to have formed. In our analysis, the RFD intensifies below 2.5 km AGL between 0019 and 0022 UTC in a small area south of the circulation as seen in Figure 1. Klemp and Rotunno showed that a negative vertical gradient of the square of vertical vorticity is proportional to a negative vertical pressure gradient, which would intensify downward vertical motion. Figure 2 reveals a correlated juxtaposition of a negative vertical gradient in vertical vorticity at 0019 and the intensified RFD vertical velocity at 0022 UTC.

Another RFD developed at 0042 UTC and strengthened in the subsequent analyses. This enhancement is likely due to precipitation loading based on the descending area of reflectivity shown in Figure 3. As early as the Thunderstorm Project (Byers and Braham1949), evaporative cooling and precipitation loading were identified as the main buoyancy forcing mechanisms for downdrafts. To quantitatively investigate this feature, a vertical profile of average radar reflectivity over the horizontal area where the vertical motion was less than -10 m/s was considered. This profile was then compared with the same volume for the two preceding analysis, each 3 minutes apart. As seen in Figure 4, the average reflectivity profile increased below 3 km

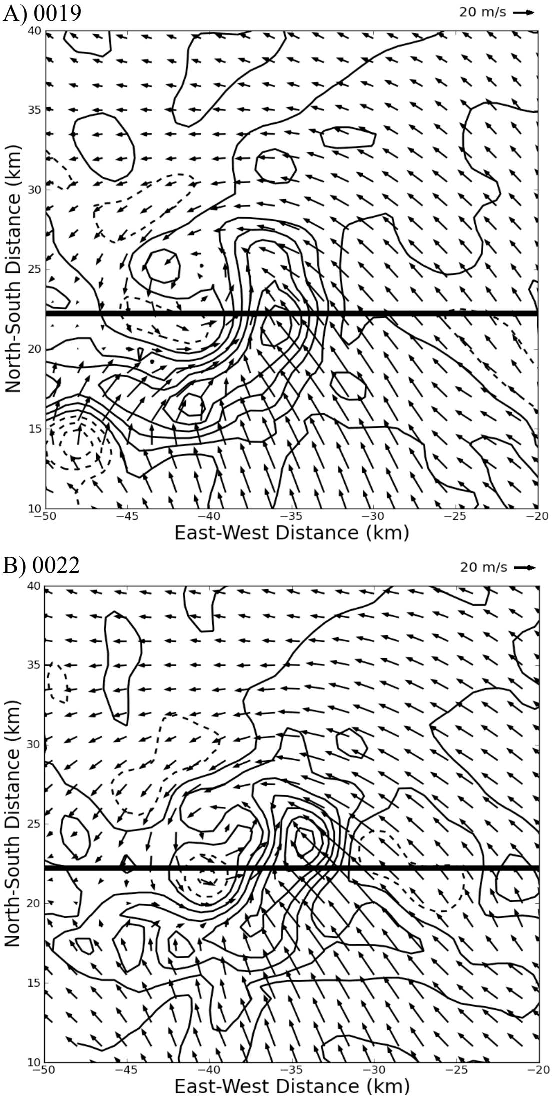

Figure 1: Vertical velocity (contoured every 5 m/s, positive(negative) are solid(dashed)) and storm relative winds are 1.5 km AGL at 0019 and 0022.

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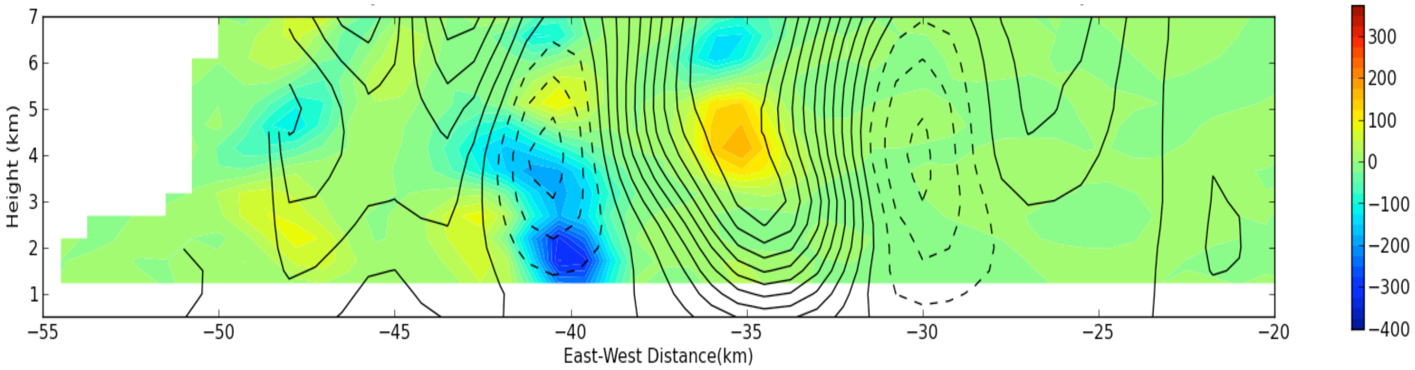
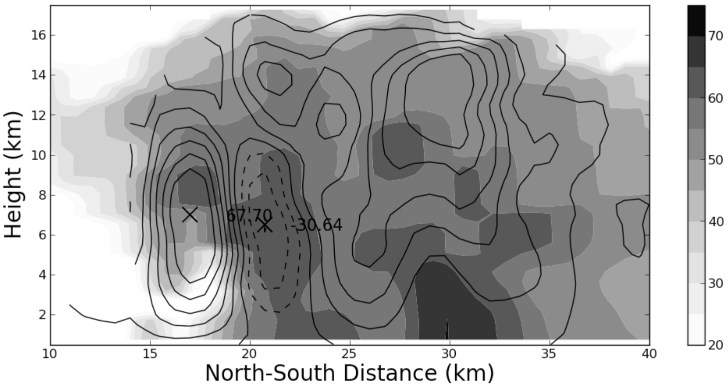


Figure 2: Vertical cross section taken at line in Figure 1 of vertical gradient of vertical vorticity squared ($1x10^{-6}$ s^{-4}/km) at 0019 UTC and vertical motion (contoured every 5 m/s, positive(negative) are solid(dashed)) at 0022 UTC.

A) 0042



B) 0045

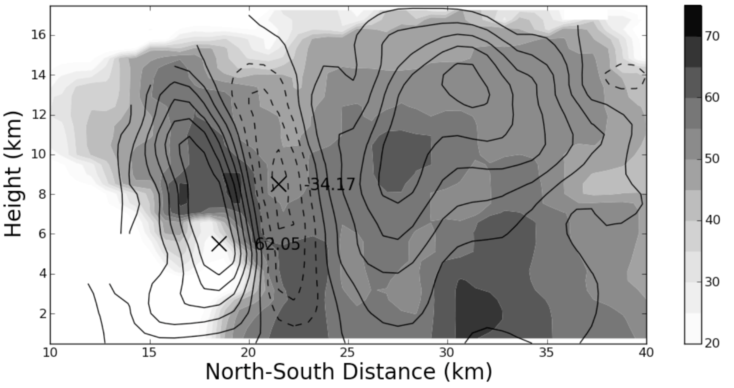


Figure 3: Reflectivity (shaded) and vertical velocity (contoured every 10 m/s, positive(negative) are solid(dashed)).

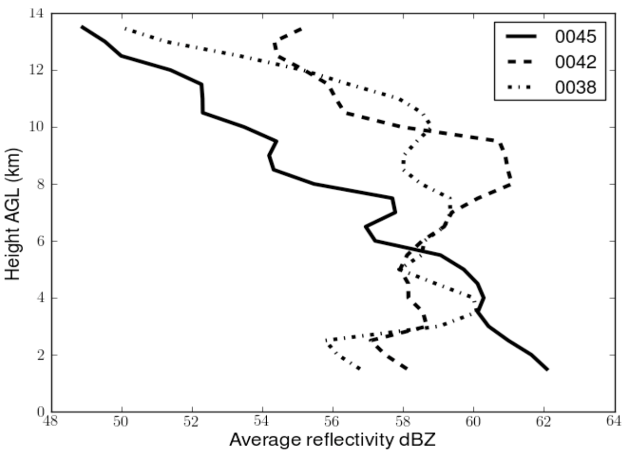


Figure 4: Vertical profile of average radar reflectivity in RFD where w < -10 m/s at 0045 UTC.

between 0042 and 0045 UTC, suggesting an increase in precipitation loading in the RFD. Initiation of downward motion by precipitation loading causes entrainment of the surrounding air into the downdraft, which could change the thermodynamic character of the air in the downdraft. Figure 3 reveals that the RFD is completely surrounded by upward vertical motion which would suggest that the air being entrained into the downdraft was from or inside the storm.

Preliminary trajectory analysis suggests that much of the air in the RFD, both at low levels and mid levels, originated either in the inflow east of the circulation or in the updraft upwind of the RFD, that is to the west. Hence, the air being entrained into the downdraft appears to have originated at lower-levels where the air would be relatively warm and moist. More important, there is an absence of trajectories originating at mid-levels that would be associated with entrainment of dry, cooler environmental air. Studies by Markowski et al (2002) of thermodynamic surface observations of RFDs have shown that tornadic supercells have relatively warmer RFDs, suggesting limited amounts of evaportive cooling versus non-tornadic RFDs. Future trajectory analysis will be refined to further investigate the origins of the air in this RFD.

IV. AKNOWLEDGMENTS

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V. REFERENCES

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