3B.6 AN EXAMINATION OF A TORNADO PRODUCING SUPERCELL BEHIND THE LEADING EDGE OF THE MAY 8TH, 2009 HISTORIC WIND STORM IN SOUTHERN MISSOURI

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1. INTRODUCTION

On the morning of May 8th, 2009, a large mesoscale convective system (MCS) formed over central Kansas and then moved across the southern third of Missouri into the lower Ohio River valley during an eight hour period. Post-storm surveys revealed the damage was caused by large swaths of straight-line winds estimated to be as high as 55 m/s and more than 20 tornadoes. Supercells were observed within the MCS in the bowing segment to the south of an unusually intense line end vortex (Fig. 1). These storms were responsible for producing at least seven tornadoes which produced EF-2 or EF-3 damage.

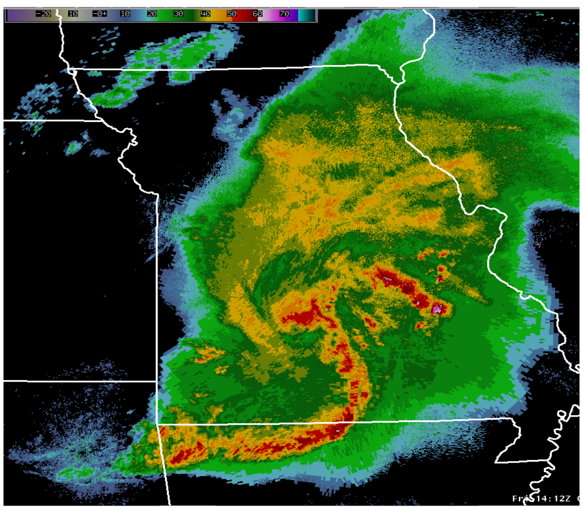

Fig. 1. Radar mosaic at 1412 UTC.

One of the supercells produced at least three tornadoes, including two that produced EF-2 damage. While this storm initially developed in a favorable surface based environment on the leading edge of the derecho, its tornado production occurred while a new line of cells rapidly developed approximately 20 km ahead of it (Fig. 2). This study examines how the near storm environment remained favorable for tornadogenesis despite what appears to be its atypical location within the MCS.

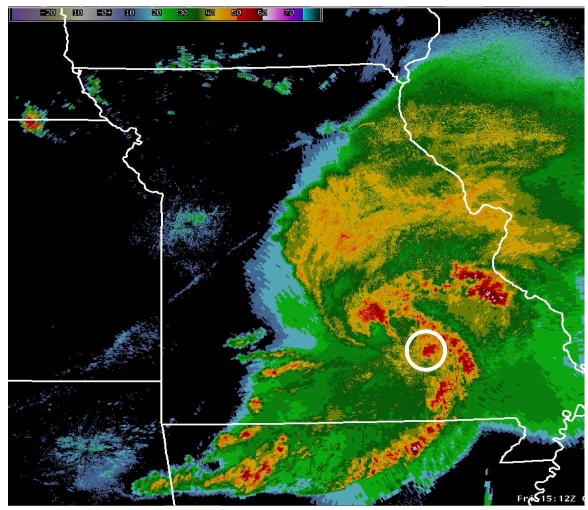

Fig. 2. Radar mosaic at 1512 UTC. The studied supercell is highlighted in the white circle.

2. ENVIRONMENTAL CONDITIONS

Thunderstorms initially developed over central Kansas around 0600 UTC along an east-to-west oriented quasi-stationary front that lay under the broad axis of a 25 m/s nocturnal low level jet. The thunderstorms became organized and propagated to the east-southeast as the low level jet veered during the night. Deep-layer (0-6 km) shear over Kansas during the night was around 25 m/s which favored storm organization. The environment to the south of the front was very unstable with MLCAPES $\geq$2000 J/kg partially owing to 700-500 mb lapse rates of 8°C/km along the Kansas/Oklahoma border.

Similar conditions were observed over southern Missouri during the mid-morning hours when the tornadic supercell that is the focus of

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this paper was observed. The lower atmosphere was quite moist with dewpoints in the lower 20s°C over southern Missouri causing lifting condensation levels (LCL) only between 500 and 750 meters above ground level (AGL) (Fig. 3). The mean-layer convective available potential energy (MLCAPE) near the path of the supercell was around 1500 J/kg (Fig. 4) indicating that the atmosphere was moderately unstable through a deep layer. These numbers fall within previous studies of proximity soundings near significant tornadoes by Thompson et al. (2003) that examined a large dataset of RUC2 analysis, and Craven and Brooks (2004) that examined a large set of observational soundings. Comparing the MLCAPE to the surface-based CAPE (Fig. 5), much of the instability was elevated over Missouri except for a narrow region directly ahead of the original line. This narrow wedge is directly on the nose of the path of the supercell.

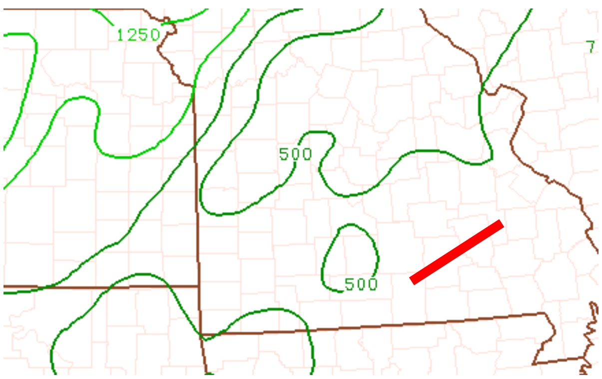

Fig. 3. Storm Prediction Center mesoanalysis of LCL (m AGL) at 1500 UTC on May 8, 2009. The red line is the approximate path of the supercell.

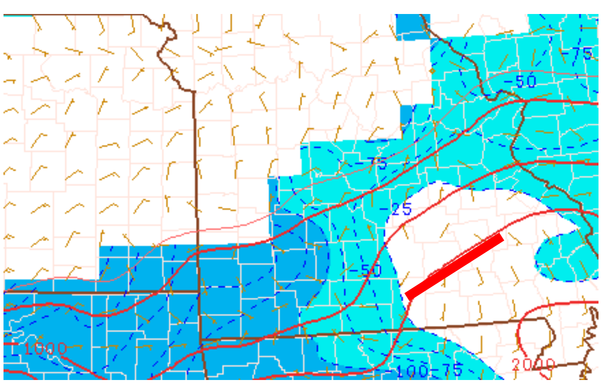

Fig. 4. Same as Fig.3, except for MLCAPE.

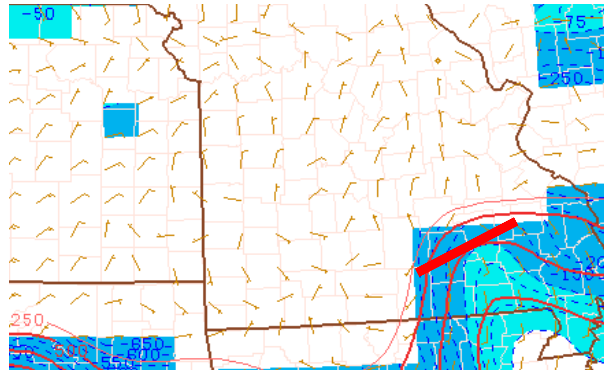

Fig. 5. Same as Fig. 3, except for SBCAPE.

Deep-layer shear was more than sufficient for storm organization that resulted in the MCS and also updraft rotation with greater than 25 m/s of 0-6 km bulk shear across southern Missouri as depicted in figure 6 (Weisman and Klemp, 1982). Moreover, the 0-1 km bulk shear between 10-15 m/s was sufficient for strong tornadogenesis within the supercells (Fig. 7).

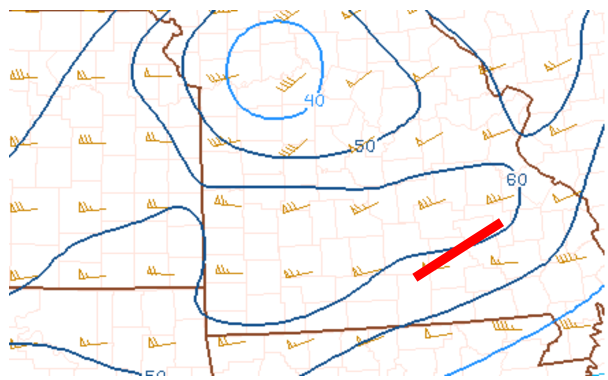

Fig. 6. Same as Fig. 3, except for 0-6 km bulk shear.

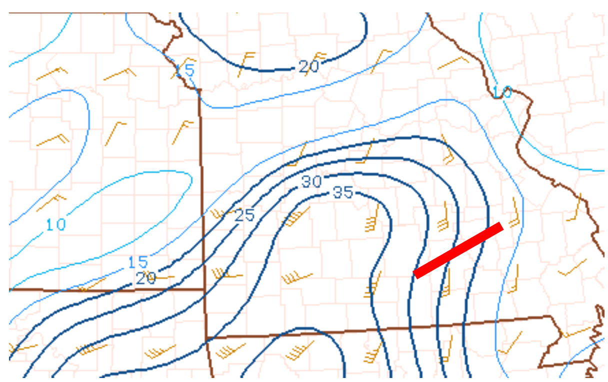

Fig. 7. Same as Fig 3, except for 0-1 km bulk shear.

3. RADAR AND SURFACE OBSERVATIONS

As the MCS moved into southwest Missouri it showed an unusual morphology, with a leading stratiform structure over northern part of the bow echo transitioning to trailing stratiform over the southern part. Radar mosaics (not shown) displayed a continuous line of >50 dBz reflectivity within the bow. As the MCS moved eastward into south-central Missouri, there was no longer a solid line of >50 dBz reflectivity. Instead it exhibited a continuous arc of >40 dBz reflectivity with a few discrete cells of higher reflectivity embedded within the line (Fig 1.). These discrete cells exhibited cyclonic rotation and were responsible for producing a number of tornadoes across southwest and south-central Missouri.

The storm that is the focus of this study matured into a supercell around 1429 UTC near Mountain View, Missouri (Fig 8.). Observations were examined at this same time from the Commercial Agriculture Program of Missouri University Extension, the Interagency Remote Automated Weather Stations (RAWS), and Automatic Position Reporting System as a Weather Network (APRSWXNET) to determine the direction of the surface winds around the storm. The wind at the Mountain Grove, Missouri agricultural station had already veered from the west-southwest while winds at Salem and Big Springs remained out of the south and southeast.

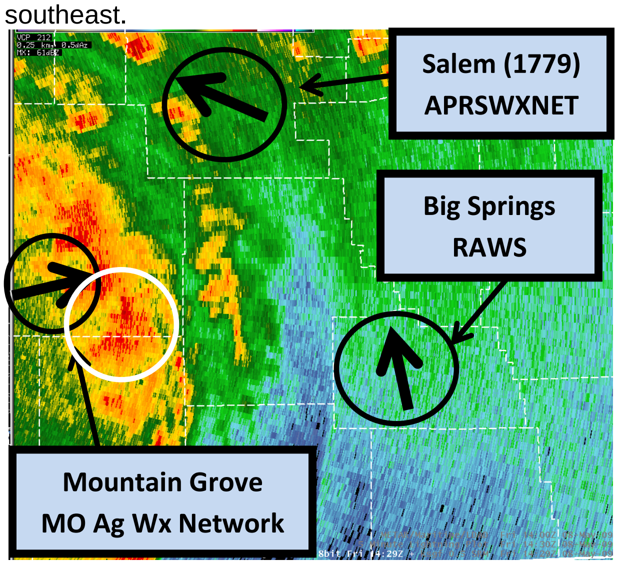

Fig. 8. 0.5° Reflectivity from the KSGF WSR-88D at 1429 UTC. Black arrows are which way the surface wind direction is blowing from. The labels indicate the source of the wind information. The white circle is the supercell.

Temperature and dewpoint information from these sites (not shown) all showed low dewpoint depressions which confirms the low LCLs seen from the SPC mesoanalysis in Fig. 3.

The storm became quickly tornadic around 1435 UTC in the moist and highly sheared lower troposphere. Figure 9 shows that cell was now behind a small band of storms that had developed ahead of the supercell. The Mountain Grove wind was westerly while winds were easterly farther north in Salem. In figure 10, strong rotation is observed coincident to the location of one of the tornado tracks found in the damage surveys. The storm remained tornadic until almost 1500 UTC.

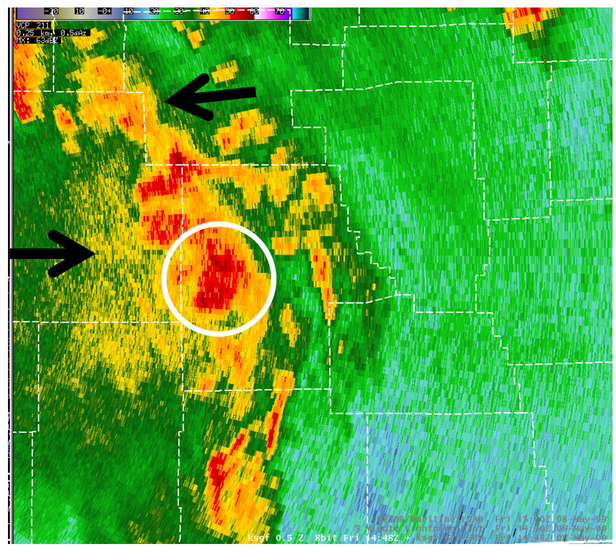

Fig 9. Same as Fig. 8, except 1448 UTC.

By 1508 UTC, the leading, intensifying line of storms further accelerated to the northeast of the supercell (Fig. 11). The wind direction at the Sinkin RAWS station which was north of the storm remained just east of south. This station is within the narrow wedge of SBCAPE seen in the 15Z mesoanalysis (Fig. 5).

By 1518 UTC, the supercell still maintained its discrete structure as it was now almost 20 km behind the leading edge of the intensifying line (Fig. 12). This line of storms did not influence the wind direction at the Carr Creek RAWS station which also reported a south-southeast wind. This was at a location that was directly in the inflow region of the storm. This was also at the time when the storm was in a brief second tornadic phase that started around 1518 UTC. Figure 13 shows an intense couplet during this time.

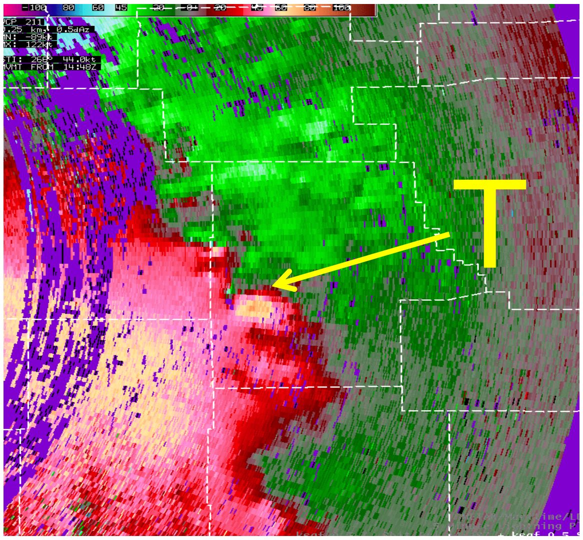

Fig. 10. 0.5° Storm-Relative Velocity from the KSGF WSR-88D at 1448 UTC. The yellow “T” points to location of tornado at that time.

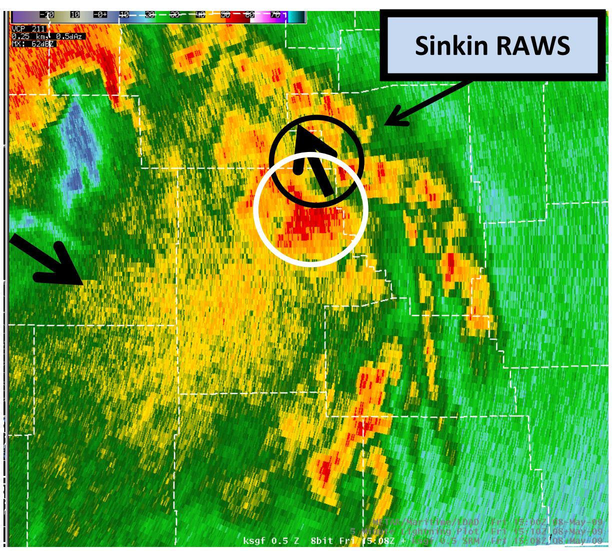

Fig. 11. Same as Fig. 8, except at 1508 UTC.

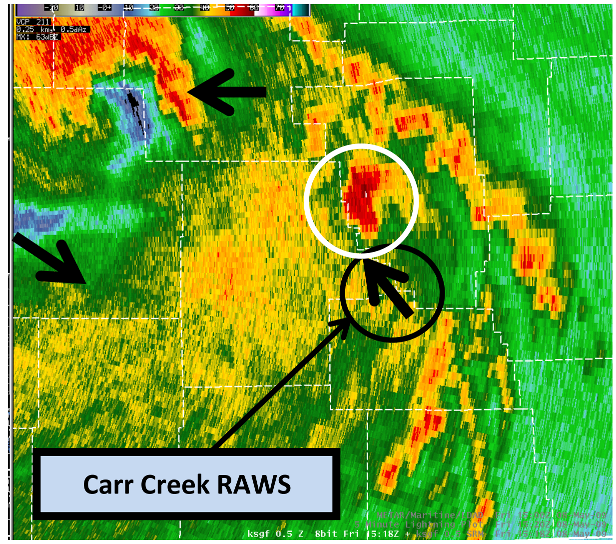

Fig. 12. Same as Fig. 8, except for 1518 UTC

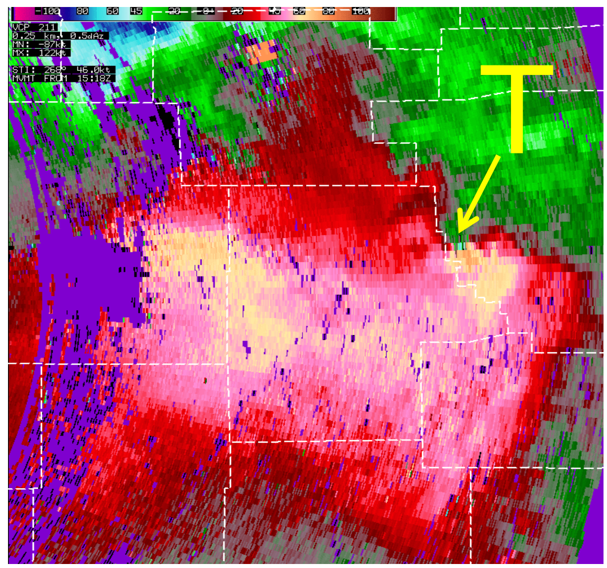

Fig. 13. Same as Fig. 10, except for 1518 UTC.

The supercell then showed diminished reflectivity and lost any notable mid-level rotation. It then accelerated and and merged with the line around 1600 UTC.

4. DISCUSSION AND CONCLUSIONS

The MCS of May 8th 2009 produced tornado and widespread wind damage along its path. The environmental conditions were suitable for a well-organized MCS as well as discrete storms that produced tornadoes. It did not fit the accepted conceptual model in its morphology as it moved across southern Missouri. This includes the precipitation location pattern change over southwestern Missouri and its dominance of discrete storms embedded within an arc of weaker reflectivity.

The tornadic supercell also presents a warning challenge as it remained surface based even though on a cursory examination of the radar it appears to have developed behind the leading edge of the convective line. Further examination of the radar imagery revealed that a new line of storms developed ahead of the supercell, and surface observations confirmed that the surface wind direction was not influence by this line. As a result, the supercell's inflow remained surface based and capable of producing significant tornadoes.

Federal and state maintained Automated Surface Observing Systems (ASOS) and Automated Weather Observing Systems (AWOS) did not provide the high-resolution spatial or temporal data needed to examine the inflow layer of this supercell. Forecasters should constantly interrogate multiple datasets including mesonet data to most accurately interpret the severe weather threat from any storm during warning operations.

5. ACKNOWLEDGEMENTS

The authors thank Doug Tilly (NWS St. Louis) for his help in obtaining the radar imagery for this paper. We also thank Pat Guinan (Missouri State Climatologist) for providing 5-minute wind data from the Missouri Agricultural Weather Station at Mountain Grove. Finally the authors extend their gratitude to Wes Browning (MIC, NWS St. Louis) for administrative and scientific support.

6. REFERENCES

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