
Storm mergers. Part II: Observations of merger events from VORTEX2.

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1. Introduction

Supercell mergers present a challenge for observational research. Recent work by Lee et al. (2006) shows a statistically significant connection between supercell mergers and tornadogenesis on a particular outbreak day [see Hastings and Richardson (2010) for discussion], suggesting important changes in storm dynamics may be occurring in association with the merger. Understanding these changes requires data of high spatial and temporal resolution such as that collected by mobile radars. However, few studies of mergers with high-resolution mobile radar have been conducted. The Wurman et al. (2007) study, in which tornadogenesis is observed in close association with a merger, is a notable exception, and the task of sorting out the dynamics seems daunting. The best sampled merger on VORTEX2 occurred on 11 June 2010 over Limon, Colorado. This study represents a preliminary look at the mobile mesonet observations and the general evolution of the storm.

2. Synoptic discussion and early history of storm

A broad mid-upper tropospheric trough was present in the western U.S. on 11 June. The trough was amplifying in time, such that by 1200 UTC 12 June, a cut-off low had formed in southern Nevada. On the east side of the trough, mid-upper tropospheric winds were highly meridional, whereas at low levels, pressure falls in the lee of the Rockies led to the development of low-level flow with a significant easterly (upslope) component. The advection of relatively moist air westward beneath the relatively steep midtropospheric lapse rates that were being advected over the Plains on the east side of the mid-upper tropospheric trough set the stage for a fairly typical High Plains thunderstorm day (Doswell 1980). Moreover, the veering wind profile also had sufficient shear to support the development of supercells. As the surface winds backed to easterly across eastern Colorado, upslope flow aided the initiation of a cluster of thunderstorms along the Front Range, near Colorado Springs. These storms drifted ENE across the Palmer Divide, more or less following US–24.

2340 UTC 11 June 2010

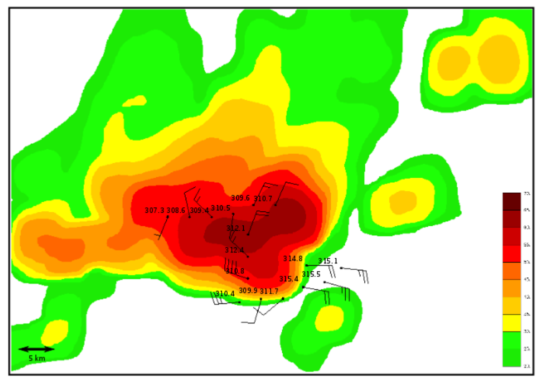

Fig. 1. Mobile mesonet wind observations and virtual potential temperature for the KFTG WSR-88D radar volume beginning at 2340 UTC 11 June 2010, 1.75 km above ground level (AGL).

With sufficient CAPE and shear, the convection took on a supercellular character near Calhan. As the supercell reached the vicinity of Ramah and Simla, the VORTEX2 armada intercepted it shortly after 2300, with mobile mesonets penetrating the storm and mobile radars establishing strategic scanning positions nearby to provide dual-Doppler coverage.

Around 2335, reports of cloud base rotation and rising fractus were relayed by mesonet probes and the field coordination (FC) vehicle. At 2336, the Doppler On Wheels DOW7 reported a weak tornado north of Matheson. The Boulder Weather Forecast Office received a spotter report of a tornado at 2337. Figure 1 shows mobile mesonet wind observations overlaid on WSR-88D data from KFTG (interpolated to a 350 m x 350 m x 350 m grid using a Cressman scheme with REORDER), with station models of virtual potential temperature (θ_v). With inflow air at 315 K, the θ_v deficit in the vicinity of the weak tornado was between -2 and -3 K. By about 2345, the surface circulation

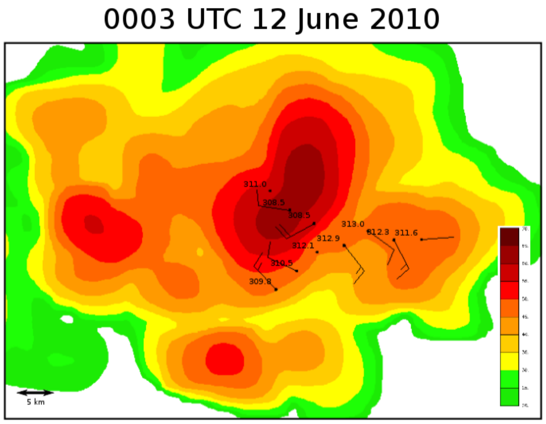

FIG. 2. Mobile mesonet wind observations and virtual potential temperature for the KFTG WSR-88D radar volume beginning at 11 June 2010, 0003 UTC, 1.75 km above ground level.

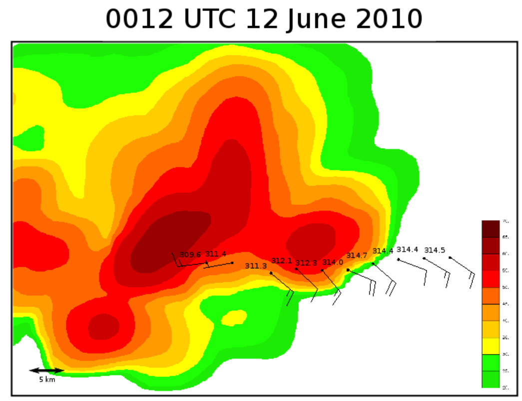

FIG. 3. Mobile mesonet wind observations and virtual potential temperature for the KFTG WSR-88D radar volume beginning at 11 June 2010, 0012 UTC, 1.75 km above ground level.

had weakened to nontornadic intensity.

3. Storm interactions and merger

As the storm approached Limon at 0000 on 12 June, two new cells initiated nearby. One was to the southwest, the other to the east. With these interactions, the mobile assets were redployed to the east in anticipation of the reorganization. This regrouping brought many of the mesonets to a regrouping point east of the storm, near Arriba, allowing them to sample the incipient eastern cell. Radars continued to scan continuously, and ground observations of the previous target storm continued as mesonets encountered traffic and inclement conditions while trying to reach the regrouping point (Figures 2 and 3).

Using a definition for storm merger based on reflectivity criteria [see Hastings and Richardson (2010) for discussion], the eastern cell did not merge with the original cell. Although joined by a contour of 60 dBZ, both cells retain separate identifiable reflectivity maxima, and continue to do so for the next few hours as the supercell eventually became dominated by outflow and re-organized into a quasi-linear convective system.

The southern cell, however, did merge with the original cell. Throughout this process, the supercell motion slowed considerably, causing the storm to become nearly stationary over Limon. The original mesocyclone weakened as rotation developed in the southern storm. As the merger was completed, a new mesocyclone developed to the south, and the new storm continued its east north east movement, producing prodigious amounts of hail and rain in the forward flank. Though no tornado is believed to have occurred in the next several minutes, around 0100 a funnel cloud with strong ground circulation was observed. This tornado cannot be said to have occurred because of the merger with such a separation in time, however this does provide an observation of a supercell that reorganized and maintained strength following a merger.

4. Conclusions

This preliminary analysis has used only mobile mesonet and WSR-88D data. With current analysis techniques including high-resolution multi-Doppler synthesis with a multi-pass Barnes filter (Majcen et al. 2008) and ensemble-Kalman data assimilation, a three-dimensional picture of the evolution of the mid- and low-level vorticity structures during the merger process can be developed. In particular, the disruption of the original mesocyclone and the development of the new one can be examined with some detail. Additionally, the relationship between storm merger as defined by reflectivity criteria, and as defined by dynamic criteria (i.e., updraft merger), can be considered. The modeling results presented by Hastings and Richardson (2010) suggest these definitions are closely related, and this case may provide some observational support for those idealized numerical investigations.

Acknowledgments.

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