13.5 DOPPLER RADAR ANALYSIS OF THE 28 APRIL 2002 LA PLATA, MD TORNADIC SUPERCELL

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1. Introduction

A severe weather outbreak occurred on 28 April 2002 from the Tennessee Valley through the Mid-Atlantic and into the Eastern Great Lakes Region. Explosive convective development occurred across the Ohio and Tennessee Valleys during the early afternoon, reaching the Mid-Atlantic states during the late afternoon and evening hours. Several supercell thunderstorms tracked across the Mid-Atlantic during the afternoon and evening of 28 April 2002. One particularly long-lived supercell tracked from West Virginia across lower southern Maryland during the event, causing several tornadoes during its lifespan. One of these tornadoes touched down in Charles County, Maryland (MD), and strengthened to a Fujita scale rating of F4 intensity as it destroyed a large portion of downtown La Plata, Maryland.

This paper will focus on assessing this supercell's structure, motion and storm characteristics as it tracked through the NOAA/National Weather Service (NWS) Sterling, VA, area of responsibility (roughly from the eastern West Virginia Panhandle to the Chesapeake Bay.

While the terms "cyclic supercell" and "cyclic mesocyclogenesis" are not well understood (Alderman and Droegemeier 2002) the updraft strength and attendant mesocyclone of this particular supercell exhibited a cyclical behavior (Glass and Britt 2002) in its propensity to produce severe weather. Changes in the 3-dimensional reflectivity structure of the storm will be assessed as the storm progressed through its cyclical behavior using multiple elevation tilts from the NWS KLWX Doppler Radar located in Sterling, VA. Storm relative motion and radial velocity data from the KLWX WSR-88D will supplement the reflectivity data. Information derived from WSR-88D algorithm data will also be assessed throughout the event.

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2. Storm Structure and Evolution

Supercell thunderstorms developed and moved through the state of West Virginia during the late morning and afternoon hours on 28 April 2002. During the morning hours, warm advection precipitation associated with a warm front that stretched across the Mid-Atlantic region (Strong and Zubrick 2004) served to stabilize the environment along and north of a surface warm frontal boundary. This boundary was located across the Mid Atlantic Region through the morning hours of 28 April 2002 (Rogowski and Zubrick 2004). The warm front lifted north by early afternoon and allowed for increased mixing and solar insolation over the area that the supercell tracked.

Strong to severe storms moved east into the National Weather Service Sterling (LWX) County Warning Area (CWA) during the mid- to late-afternoon hours on the 28th. Several of these storms exhibited supercell characteristics, with inflow notches and persistent mid-level, and at times low-level mesocyclone signatures. Several updraft cycles were observed. The supercell thunderstorm of interest split into left- and right-moving storms several times while crossing the LWX CWA. Much of the radar examination was completed with data from the Sterling, VA (KLWX) WSR-88D, except as noted.

After moving east of the highest terrain of the Appalachian Mountains, the storm strengthened in intensity moving into Rockingham County, Virginia. The low-level mesocyclone strengthened rapidly and the storm developed a pronounced inflow notch. At 2047 UTC The rotational velocity (V_r) of the velocity couplet strengthened to greater than 40kt, with a diameter of 1nm (Figures 1 and 2). Some of the low-level reflectivity structures may have been masked due to radar sampling issues. The radar was sampling the inflow side of the supercell through the core of the storm and a well-developed 3-body scatter signature was evident. (Lemon 1998) Due to the location of the storm, neighboring radars were too distant to further examine the low level reflectivity or velocity structure. The low-level mesocyclone structure remained strong with the V_r remaining greater than 35kt through 2102 UTC. At 2055 UTC, the storm produced a tornado near Mt. Jackson in west-central Virginia. This tornado was rated F2 on the Fujita scale.

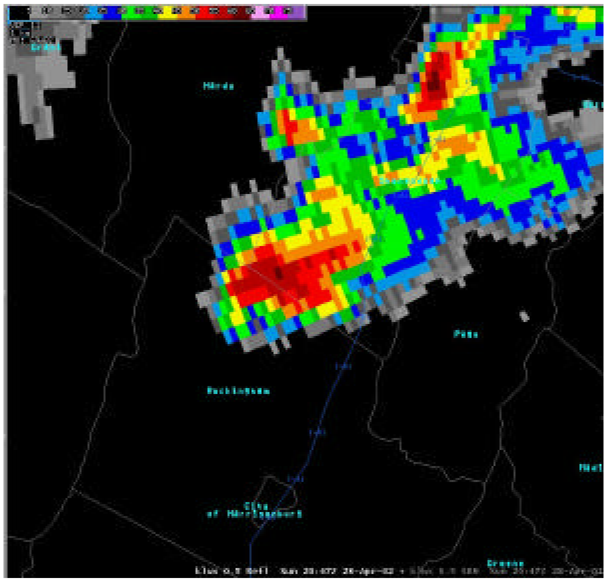

Figure 1. 2047 UTC reflectivity from the KLWX WSR-88D prior to the Mt. Jackson F2 tornado.

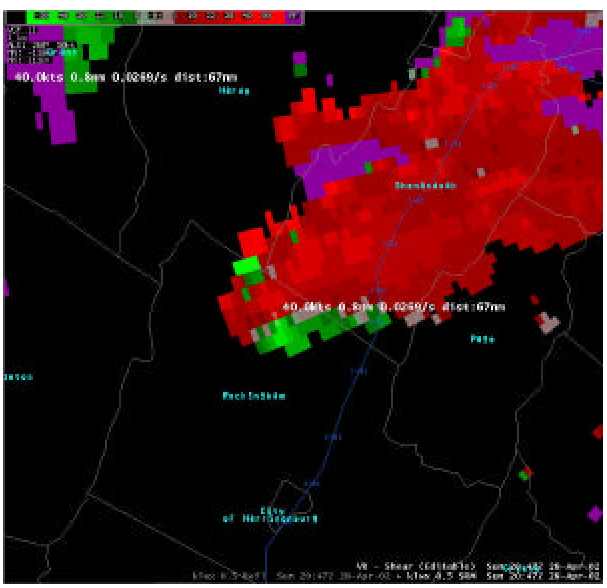

Figure 2. 2047 UTC Storm Relative Motion (SRM) imagery with V_r Shear output overlaid.

The storm continued to progress eastward, splitting several times. As the storm crossed the Blue Ridge mountains, the low-level velocity and reflectivity signatures became less evident, but a mid-level mesocyclone remained. At 2149 UTC, a low level circulation again developed and the storm exhibited a well developed bounded weak echo region (BWER) at the 2.4 degree elevation segment with a well developed mid-level mesocyclone. (Figure 3) Extensive ground survey in this area revealed no evidence of a tornadic circulation.

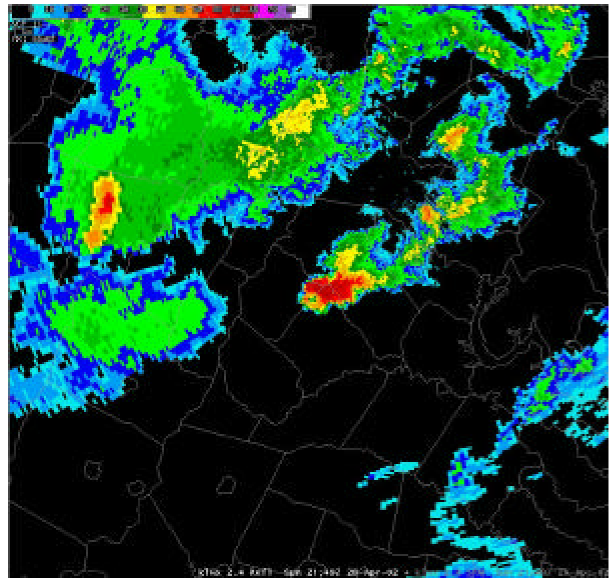

Figure 3. 2149 UTC 2.4 degree Reflectivity slice from KLWX WSR-88D

Between 2200 UTC and 2300 UTC, the storm underwent several complex changes in morphology. Many of these changes can be attributed to the change in the storm scale environment.

At 2215 UTC, 2 updrafts were apparent in the velocity and reflectivity data. In addition, a well formed weak echo region (WER) was observed at the 3.4 degree elevation slice from the KLWX radar. The V_r increased to 40kt in the mesocyclone.

At 2225 UTC, the northern updraft weakened with the southern updraft showing signs of rapid strengthening. Finer scale reflectivity structures were likely obscured due to radar sampling through the main updraft of the storm that was contaminated with hail. Low-level velocity data was partly obscured by range folding.

This rapid updraft strengthening was also observed by the DoD radar at Dover, DE AFB (KDOX) (not shown). Though low-level reflectivity structures were somewhat obscured due to range (the storm was 92 nm from the KDOX radar), a very strong velocity signature was evident. The V_r increased to 55 kt, with a gate-to-gate signature.

Beginning with the 2245 UTC volume scan, a rapid change in the structure of the storm became evident. After several volume scans of repeated updraft cycles, a new updraft rapidly became the dominant updraft. The mesocyclone with this updraft became the tornado-producing updraft as the storm moved into Charles County, Maryland. The first indications of this rapid change in structure came at 2240 UTC when a large echo-free BWER formed at the 3.4 degree elevation slice, and an appendage began to form at the 0.5 degree elevation slice. (Figure 4) This rapid transition continued through 2251 UTC, when the 0.5 degree reflectivity slice showed a well-developed hook echo. (Figure 5) This feature was evident through 2330Z when the storm moved east of the Chesapeake Bay. Also at 2251 UTC, the mid-level BWER showed signs of collapse, a radar feature long-recognized as a precursor of tornadogenesis. (Lemon and Doswell 1979). The tornado touched down at 2256 UTC in northwest Charles county Maryland. The tornado track was continuous through the remainder of Charles and Calvert counties, eventually lifting on the eastern shore of Maryland near Salisbury. The tornado strengthened to a maximum strength of F4 scale in La Plata, MD, in central Charles county.

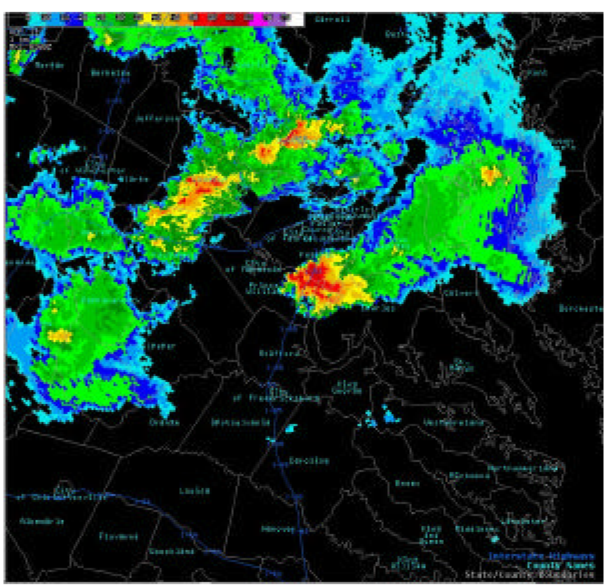

Figure 4. 2240 UTC KLWX 3.4 degree reflectivity.

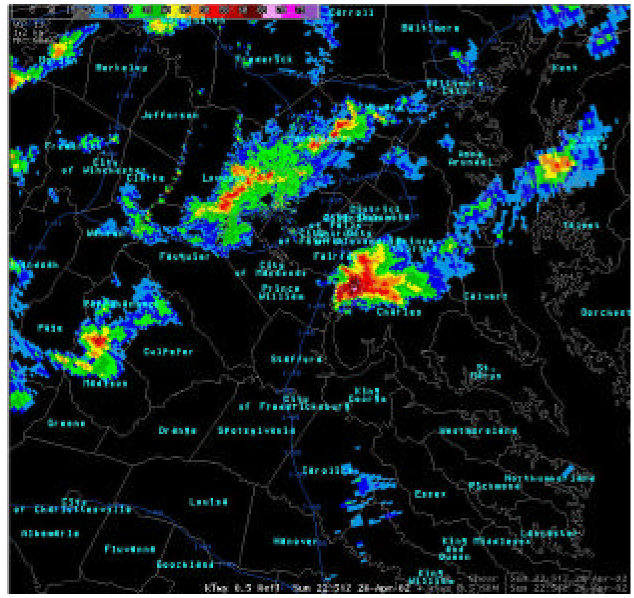

Figure 5. 2251 UTC KLWX 0.5 degree reflectivity.

Strong radar indications were evident through the remainder of Charles and Calvert counties, with a well-developed hook echo and a strong gate to gate velocity signature following the classic case of a steady-state long-lived tornadic supercell thunderstorm.

3. Tornado Detection Algorithm (TDA) analysis

Tornadogenesis with this particular supercell thunderstorm was not well-captured in the WSR-88D TDA (Mitchell et al. 1998). Algorithm performance was likely degraded by the combined factors of velocity range folding, hail contamination and improper dealiasing. The detrimental impacts from these factors resulted in the TDA flagging several false Tornado Vortex Signatures (TVS). The TDA output a TVS for this supercell being studied at 2235 UTC, 2240 UTC, and 2245 UTC. These occurred during a period when the storm was located in Virginia and well west of Charles County, MD. The 2235 UTC TVS was well north of the probable southern flank position of any detectable low-level circulation when compared to reflectivity data (Fig. 6, 7). Also, the TDA TVS centroid position of a possible tornadic circulation remained nearly stationary between 2240 and 2245 UTC over Cherry Hill, VA, in extreme eastern Prince William County, thus providing low confidence of a reliable TVS as determined by the TDA.

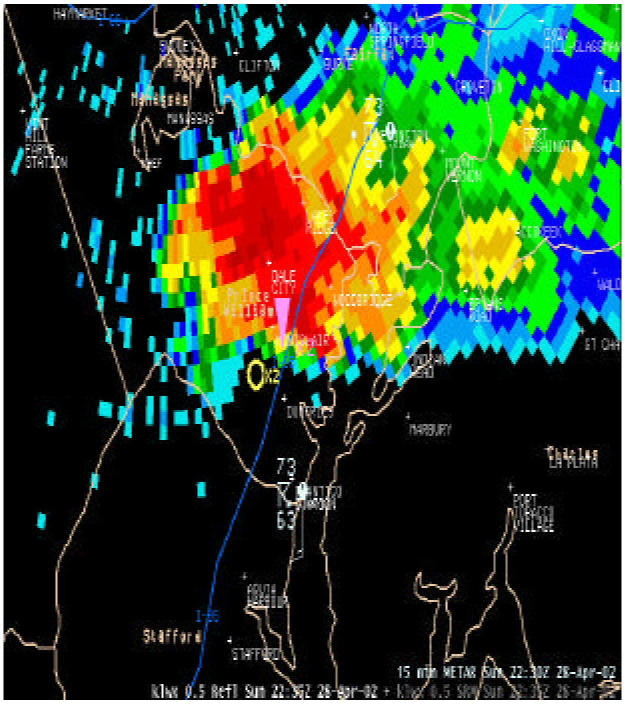

Figure 6. 2235 UTC KLWX 0.5 base reflectivity (TVS shown by inverted triangle) 8X zoom.

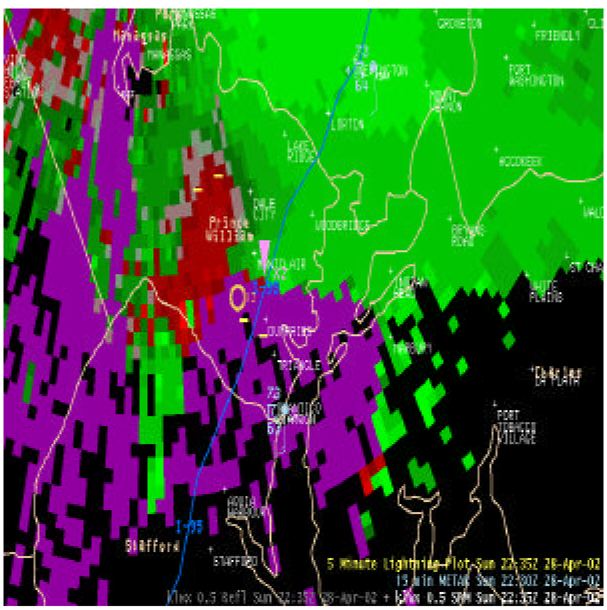

Figure 7. 2235 UTC KLWX 0.5 deg Storm Relative Motion (SRM) 10X zoom.

TDA output correlated well with the actual tornado location for the 2256 UTC scan, discounting the false TVS located several miles to the northwest (Fig. 8). At 2301 UTC, the TDA produced two TVS positions (Fig. 9), both not well correlated with the actual tornado position as one might determine using reflectivity data. (i.e. the tip of the hook echo as depicted in the lowest elevation scan). Except for one volume scan at 2316 UTC, the TDA produced two TVSs for the entire length of the storm's path through Charles County. In most cases, neither of the TVSs was well placed relative to the tornado location as one might determine from the reflectivity signature alone.

A long-lived supercell thunderstorm tracked across the Mid-Atlantic region. This storm exhibited several periods of "cycling" as new updrafts formed and the storm underwent splitting processes. As the storm approached Charles County MD, radar sampling issues (hail contamination, range folding and improper velocity dealiasing) made it difficult to detect the initial stages of intense tornadogenesis that occurred between 2245 UTC and 2256 UTC. WSR-88D TVS algorithm performance do not well capture this transition from non-severe mesocyclone just west of Charles County to an intensely tornadic mesocyclone as it crossed into western portions of Charles County MD. During the most destructive phase (2300-2340 UTC), radar showed a well-developed mesocyclone with a clear hook echo as it moved across Charles and Calvert counties.

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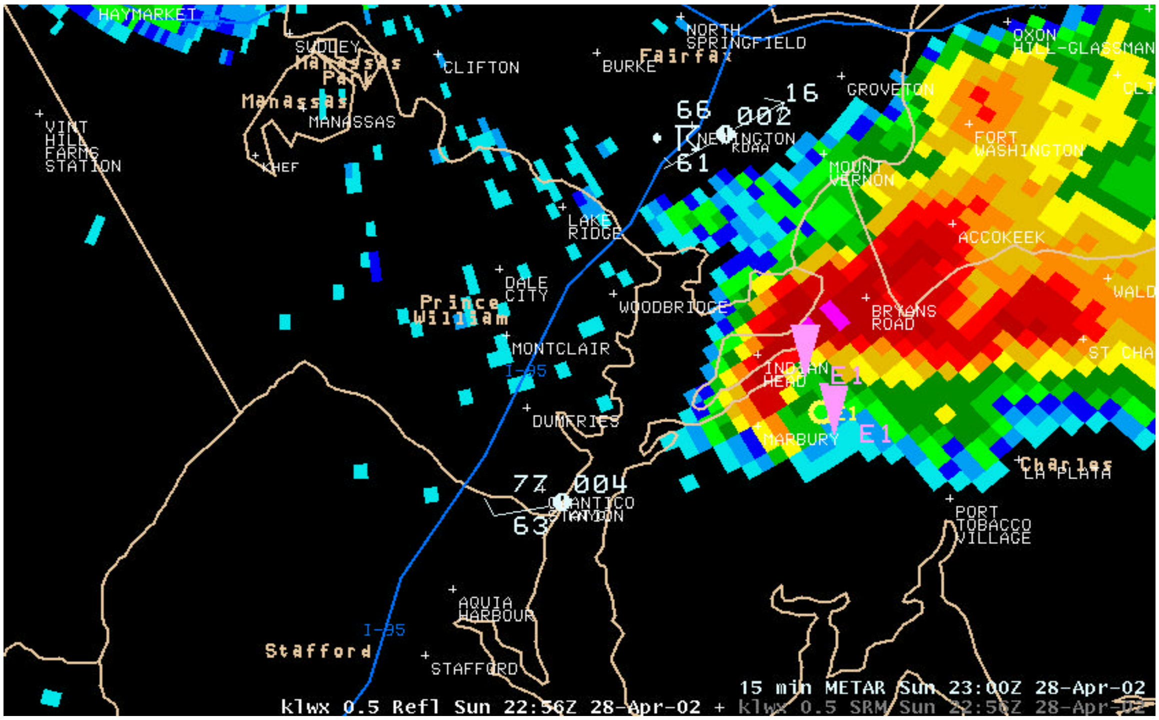

Figure 8. 2251 UTC KLWX base reflectivity 0.5 deg elevation.

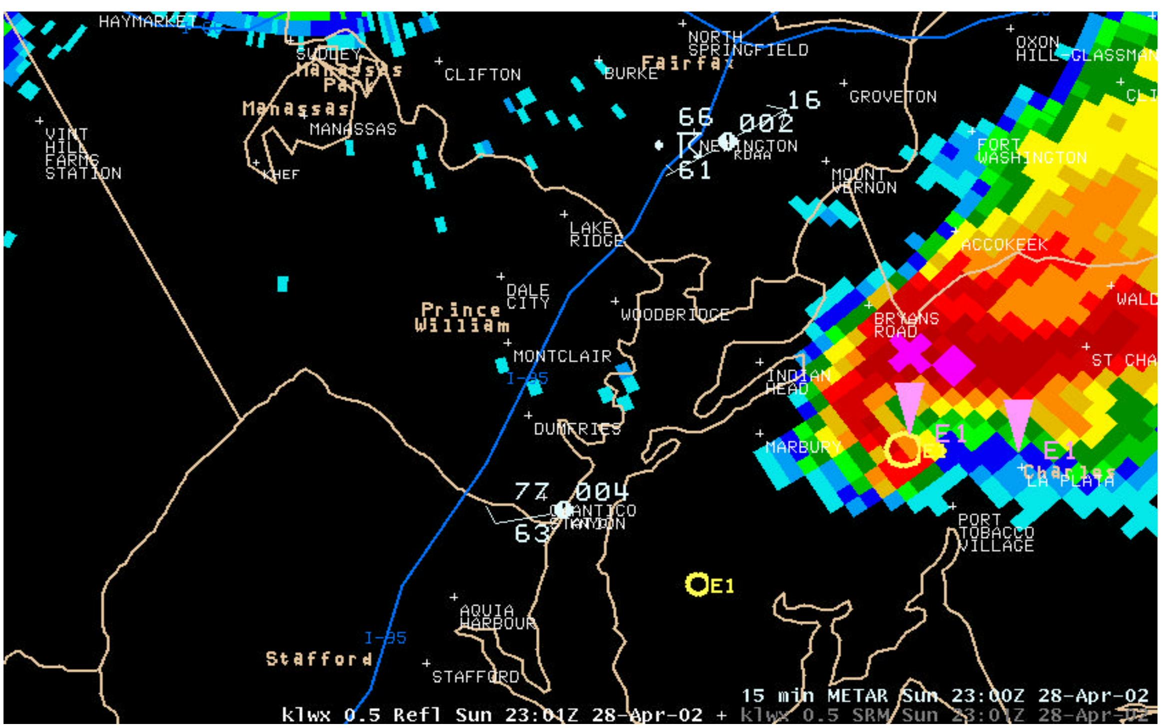

Figure 9. 2301 UTC KLWX base reflectivity 0.5 deg elevation.