P4.7 **A Preliminary Assessment of the Environmental and Radar Characteristics of Tornadic and Non-tornadic Mesovortices Associated with QLCSs**

Ray Wolf*
NOAA/National Weather Service
Davenport (Quad Cities), Iowa

## 1. Introduction

Tornadoes spawned from mesovortices associated with quasi-linear convective systems (QLCSs) pose a great challenge to meteorologists attempting to provide warning lead time (see, e.g., Wolf 2002). These circulations develop rapidly in a non-descending mode (Trapp and Davies-Jones 1997), and frequently create discrete, enhanced damage paths in additional to the general area of wind damage that accompanies severe squall lines (Atkins et al. 2005, Wolf 2000). Radar sampling issues, both temporal and spatial, are especially limiting in these events relative to classic supercells producing tornadoes in a descending mode.

Studies of the 29 June 1998 derecho by Atkins et al. (2004) (hereafter A2004) and the 10 June 2003 bow echo (Atkins et al. 2005) (hereafter A2005) suggest it may be possible to discriminate between tornadic and non-tornadic mesovortices associated with QLCSs using WSR-88D data. Specifically, they noted that tornadic mesovortices tend to have stronger rotational shears ($V_r$) in the low-levels (0-3km AGL)and longer life spans than their non-tornadic counterparts. In addition, the tornadic mesovortices tended to form coincident with or after development of the rear-inflow jet. This study evaluates several severe QLCS cases and numerous mesovortices to determine if the results of A2004 and A2005 can be generalized to other cases.

## 2. Methods

This study focuses exclusively on radar-observed mesovortices occurring along the leading edge of QLCSs. Squall line cases from eastern Iowa and northern Illinois where the occurrence of at least one tornadic mesovortex was documented are reviewed. All but highly transient mesovortices (1 or 2 volume scans, approximately 8-10 minutes) within the squall lines were analyzed to determine a number of factors including: lifespan, rotational velocities, circulation depth, development mode (descending or non-descending), apex-relative location, damage produced (if any), occurrence or not of a tornado(es), presence of a reflectivity hook echo and/or rear-inflow notch, and proximity to a frontal or convective boundary. Mesovortex rotational velocities were calculated as in A2005, i.e. $V_r = (V_{max}-V_{min})/2$. On the QLCS-scale, information including the presence of a rear-inflow jet, QLCS developmental phase (Rasmussen and Rutledge 1993), and QLCS mode (Parker and Johnson 2000) was collected.

Two quality issues exist with the data used in this study. First, radar characteristics due to range and time to complete a volume scan can result in sampling limitations due to the mesovortices non-descending development mode, small scale, and rapid development time. The radar can miss the early development of storms far from the radar due to beam overshooting, and the broader beam width at those distances may average out the strength of the mesovortex. Close to the radar, the cone of silence will limit evaluation of the vertical depth of the mesovortex. Data from neighboring radars can help alleviate both issues.

Second, known limitations exist to the StormData database (McCarthy 2003.). To limit this issue, cases were selected from the years 1998-2006 when local awareness of the tornadic potential of these mesovortices and efforts to survey these events increased. Even so, determining whether damage was produced by a tornado or straight line when conducting storm surveys can be challenging for fast moving squall lines and weak tornadoes.

*Corresponding author address:* Ray Wolf
NOAA/National Weather Service, 9050 Harrison St., Davenport, Iowa 52806. e-mail: ray.wolf@noaa.gov

## 3. Results

All of the events studied thus far have occurred during the warm season (May-August), and all but one event occurred during the daytime. Eighteen mesovortices were analyzed, six of which produced tornadoes. All developed in a non-descending mode. Most of the circulations developed late in the intensifying stage or in the mature stage of the squall line. The preliminary results presented here support the findings of A2004 and A2005, though the thresholds between tornadic and non-tornadic events are lower in this study than in A2004.

Tornadic mesovortices generally were stronger than their non-tornadic counterparts. The maximum rotational velocities for two consecutive volume scans were averaged to minimize sampling issues. These values ranged from 11 to 26 m/s. Five of eight circulations of 17 $ms^{-1}$ or stronger were tornadic while one of nine circulations weaker than 17 $ms^{-1}$ were non-tornadic. Mean $V_r$ shear values were 19 $ms^{-1}$ for tornadic circulations and 15 $ms^{-1}$ for non-tornadic circulations. These values are lower than what was observed in A2004 for the 29 June 1998 derecho (25 and 20 $ms^{-1}$ respectively). The higher values found in A2004 may be a result of the extreme instability and other differing synoptic-scale environmental conditions associated with that extreme event compared the cases studied here.

Tornadic mesovortices tended to result from deeper circulations than non-tornadic mesovortices. Five of eight circulations of a depth of 6 km or greater were tornadic while only one of ten of less than 6 km was tornadic. Mean depths were 7 km and 5 km, respectively. Tornadic mesovortices were also longer lived than non-tornadic mesovortices. Five of nine circulations which existed for 26 minutes or longer were tornadic while only one of eight existing for less than 26 minutes produced a tornado. Mean values were 29 minutes and 19 minutes, respectively. These values are shorter than what was noted in A2004 (76 and 32 minutes, respectively) and A2005 (56 and 12 minutes, respectively).

Tornadoes occurred at all points along the squall line. Three occurred on the apex, two north of and one to the south of the apex. Either a convective or frontal boundary was associated with all tornadic mesovortices, but several non-tornadic mesovortices also occurred near the intersection of the squall line and a boundary. Thus, this factor alone is not sufficient for segregating tornadic from non-tornadic circulations. Likewise, all tornadic and many non-tornadic events had reflectivity indicated hooks, or areas of enhanced outflow on the convective scale relative to the line, so this feature alone is not sufficient to delineate tornadic from non-tornadic events. Rear inflow notches on the convective scale were not frequently observed, and when they were observed, they did not provide any utility in determining tornadic potential.

## 4. Conclusions

These results are preliminary and several additional cases are being analyzed to add to these results. In addition, a more rigorous statistical analysis is needed before drawing strong conclusions, as there is some overlap in the values of the three main parameters (vortex strength, depth, and lifespan) between tornadic and non-tornadic mesovortices.

It is possible that thresholds for tornadic and non-tornadic mesovortices vary from event to event and depend on background environmental conditions. In addition, it may be necessary to look at a combination of three main parameters, trends (A2005), and subjective analysis of other radar indicators (i.e., pattern recognition) as well as background environmental conditions to have the greatest chance to warn with useful lead time.

Thus far, it appears that tornadic mesovortices tend to be stronger, deeper, and longer lived than their non-tornadic counterparts. While strength and depth criteria may be useful for warning decision making, lifespan may not increase lead time since tornadoes occur before this parameter is known.

**5. References**

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