P1.9

Interactive Mesoscale Analysis Utilized in Assisting Local Decision Makers: A Review of the 24 March 2005 Supercell

J. Brad McGavock*, Robert B. Darby, Steven F. Piltz

1. INTRODUCTION

Severe weather associated with various convective modes affected eastern Oklahoma and northwest Arkansas the evening of 24 March 2005. Of interest was the evolution of an isolated supercell that tracked across portions of southeastern Oklahoma. The supercell developed and maintained a strong anti-cyclonic mesocyclone from its initiation through the midpoint of its lifecycle. As this anti-cyclonic supercell reached its peak in organization, a weak mid level cyclonic circulation couplet became identifiable on the KSRX (Fort Smith, AR) Weather Surveillance Radar 88 Doppler (WSR-88D). The resultant storm structure was, for a time, very complex with a low-level reflectivity structure falsely suggestive of a highly organized supercell with a cyclonic mesocyclone. With time, a weak low-level cyclonic mesocyclone evolved within the storm. Immediately prior to its final dissipation, the storm structure became more consistent with supercell conceptual models. This transitional phase was sampled by both KTUL (Tulsa, OK) and KSRX WSR-88D data.

Interactive mesoscale analysis techniques employed real-time at the National Weather Service office in Tulsa (WFO Tulsa) revealed a negative storm-relative helicity (SRH) environment in advance of the storm into southeast Oklahoma. These values, calculated using an observed storm motion, transitioned through a sharp gradient from negative to positive along the storm's path. This suggested a potential for the storm to exhibit uncommon behavior and was brought to the warning team's attention during the early stages of the event. This potential was also relayed to partners via forecast discussions and instant messaging, with an emphasis toward storm spotter groups within the potentially affected counties. The evolution of the supercell, along with the corresponding mesoscale analysis graphics, will be shown. Additionally, forecast discussions issued during the event will be shown, with emphasis drawn to verbiage suggesting storm spotter strategies.

2. UTILIZING GFE

The National Weather Service's (NWS) Graphical Forecast Editor (GFE; Forecast Systems Laboratory 2001) is being utilized at WFO Tulsa not only to generate forecast products, but also as an interactive mesoscale objective analysis tool. The latter utilizes computer scripts to incorporate observed data with numerical model output to generate environmental parameters classically associated with severe local storm forecasting, such as instability, helicity, and shear. These data are produced on a 5 km x 5 km grid, where the integrity of the observed values is maintained. Variations on the parameters can also be calculated and displayed, such as SRH computed to the lifting condensation level (LCL) rather than to an arbitrary height. The parameters are produced by a combination of editable surface data and forecast fields from numerical models (McGavock, et. al. 2004). Thus, a forecaster can produce either an analysis of the current hour (as is done by other schemes that mix observed surface data with model data from higher levels), or produce forecast fields, adjusting for biases in model surface data. The SRH calculations are unique in that a user-defined storm motion grid is utilized, instead of an assumed motion as is often done, with this input of particular interest during the 24 March 2005 event.

3. 24 MARCH 2005 OVERVIEW

3.1 Synoptic Pattern

The synoptic pattern associated with the 24 March 2005 event was typical for an early spring southern plains severe weather event. A fast moving shortwave trough moved into the plains during the afternoon with a 110 knot jet maximum at 250 hPa spreading through north-central Texas. Surface low pressure developed over southwestern Colorado during the morning hours and progressed eastward during the day along an advancing cold front. A weakly defined warm front extended southeastward from the surface low into southeast Oklahoma. The surface low was located over north-central Oklahoma by 00Z March 25 with the attendant dryline located along the Interstate 35 corridor from north-central Oklahoma into north-central Texas (Figure1).

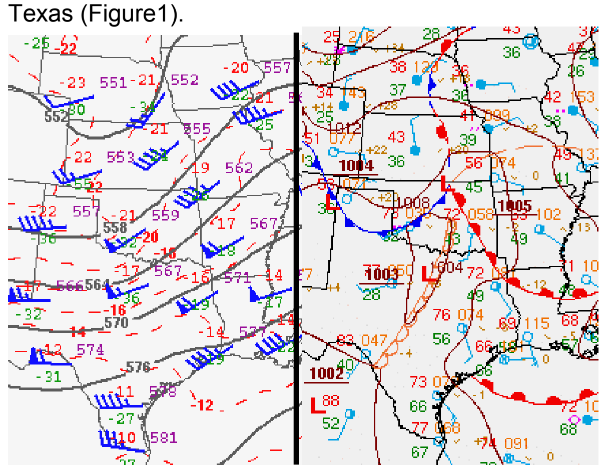

Figure 1: 00Z 25 March 2005 500 hPa and surface analysis (obtained from the SPC)

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A narrow ribbon of surface based instability was located along and immediately east of the dryline by late afternoon with deep layer shear profiles over southern Oklahoma and north-central Texas supportive of supercell thunderstorms (Thompson et. al. 2003). Forecast uncertainties regarding the magnitude and coverage of severe weather revolved around the lack of low-level moisture and the resultant impact on available instability. Surface dewpoints ranged from the upper 40s to low 50s °F within the warm sector, with the associated surface temperatures warming into the lower to mid 70s °F. The 00Z March 25 KFWD and KOUN observed soundings revealed surface-based Convective Available Potential Energy (CAPE) values of 1579 J/kg and 904 J/kg, respectively (KOUN was in close proximity to the dryline by 00Z).

3.2 Mesoscale and Radar

Two distinct areas and modes of thunderstorm activity occurred within the WFO Tulsa County Warning and Forecast Area (CWFA), outlined in Figure 2, during the first half of the 24 March 2005 event. Thunderstorms across the northern portions of the CWFA were focused along an approaching cold front and in a region of lesser deep layer shear. Initial thunderstorms to affect the southern half of the CWFA developed over north-central Texas along the dryline and tracked northeastward. Deep layer shear across this region was supportive of supercell thunderstorms with one such supercell being the focus of this paper. Additionally, wind profiles were such that a large degree of variability was noted within the storm-relative helicity (SRH) calculations based on observed storm motions. GFE, utilized as a mesoscale analysis tool, made diagnosing this highly variable element (Markowski, et al. 1998) more efficient by controlling storm motion input to the SRH calculations. WFO Tulsa issued mesoscale forecast discussions during the event and incorporated data obtained via the GFE analysis techniques. These discussions attempted to anticipate short-term convective trends, along with providing assistance in the deployment of local storm spotter groups.

The initial supercell crossed the Oklahoma Texas state line along the Red River and was anti-cyclonic with a northeastward motion of approximately 45 kts (Figure 2). This storm brought attention to the potential SRH variability and was the subject of the initial mesoscale forecast discussion (Figure 3), which also addressed potential storm spotter challenges. The difficulty in correctly assessing the mesoscale environment was evident in the differing solutions offered between the local GFE SRH calculations and that provided by the Storm Prediction Center's (SPC) Hourly Mesoanalysis Graphics (Figure 4), and further highlights the influence of storm motion on SRH calculations.

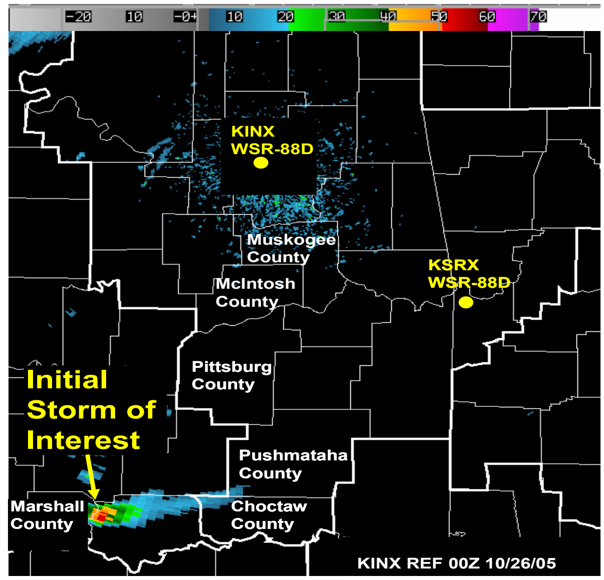

Figure 2: 2359Z KSRX 0.5° Reflectivity (CWFA's outlined)

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AREA FORECAST DISCUSSION
NATIONAL WEATHER SERVICE TULSA OK
550 PM CST THU MAR 24 2005

.MESOSCALE DISCUSSION...
FOR INTERESTS IN PITTSBURG...
PUSHMATAHA AND CHOCTAW COUNTY
MONITORING THE SUPERCELL CROSSING THE
RED RIVER INTO MARSHALL COUNTY
OKLAHOMA...0 TO 6 KM SHEAR OF 60 KNOTS
OF STORM-RELATIVE HELICITY CALCULATED
TO THE LCL OF -100 M2/S2 WOULD SUPPORT
AN ANTICYCLONIC CIRCULATION WITH
INFLOW ON THE NORTH SIDE OF THE CELL.
SPOTTER POSITIONS WILL HAVE TO BE
ADJUSTED ACCORDINGLY.
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Figure 3: 2350Z Mesoscale Discussion

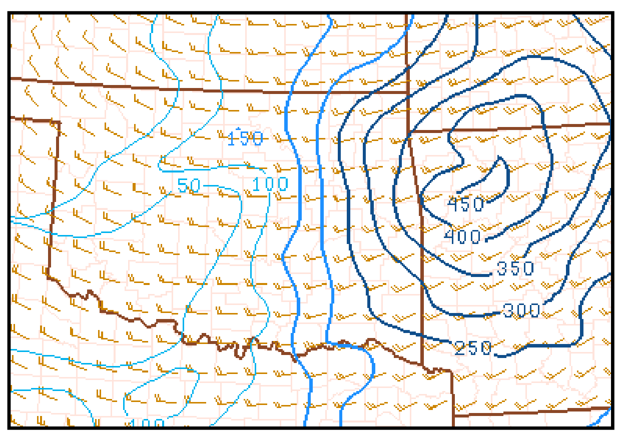

Figure 4: SPC Analysis 00Z March 25 2005 0-1km SRH with Storm Motion Vectors (kts)

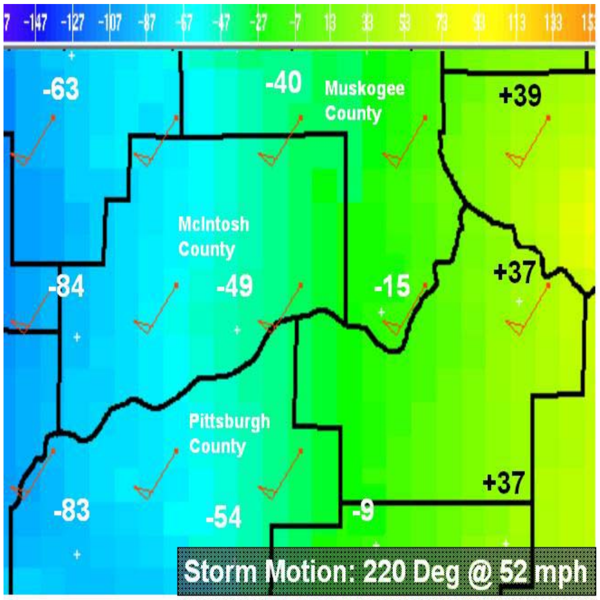

Figure 5: 01Z Storm-relative Helicity (0-LCL) with Storm Motion Vectors (mph)

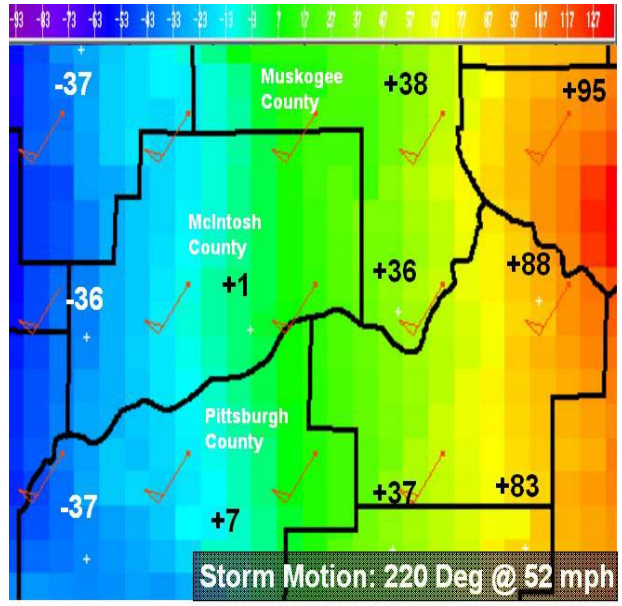

Figure 6: 01Z Storm-relative Helicity (0-1km) with Storm Motion Vectors (mph)

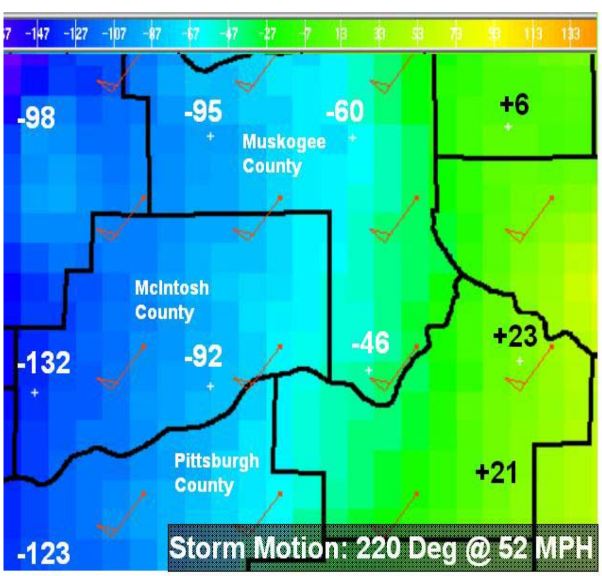

Figure 7: 02Z Storm-relative Helicity (0-LCL) with Storm Motion Vectors (mph)

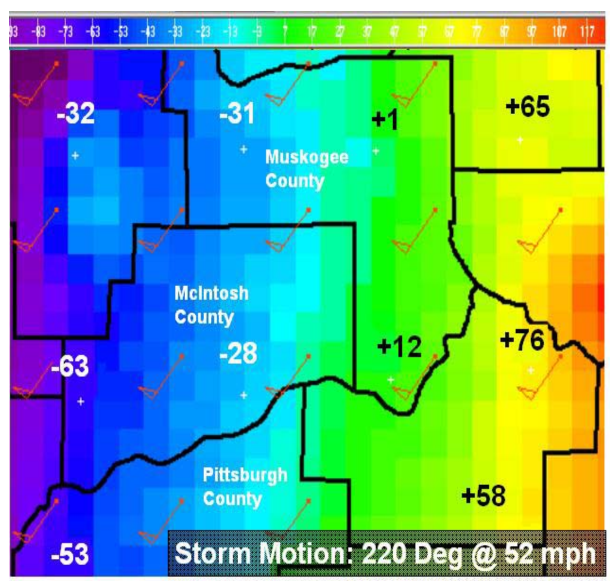

Figure 8: 02Z Storm-relative Helicity (0-1km) with Storm Motion Vectors (mph)

A second anti-cyclonic supercell developed north of the initial storm and moved into northern Pittsburgh County. The evolution of this storm is the focus of this paper. At 01Z, SRH calculations revealed a gradient from negative to positive values along the path of the supercell, with this gradient evident within both the 0-LCL and 0-1 km layers (Figures 5 and 6). The resultant effect on storm behavior was uncertain at the time. This uncertainty, along with the potential outcome, was shared with users via forecast discussions (Figure 9 and 13). Emphasis toward storm spotter groups was again included in the discussions, suggesting spotter deployment strategies within this highly variable environment.

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AREA FORECAST DISCUSSION
NATIONAL WEATHER SERVICE TULSA OK
656 PM CST THU MAR 24 2005

.MESOSCALE DISCUSSION...
MESOSCALE OBJECTIVE ANALYSIS GRIDS AT
00Z SHOW THAT THE ATMOSPHERE IN EASTERN
OKLAHOMA IS WEAKLY UNSTABLE WITH
RESPECT TO A SURFACE PARCEL ALONG AND
WEST OF HIGHWAY 75 / INDIAN NATION
TURNPIKE.  SHEAR FROM 0 TO 6KM IS 45 TO
65 KNOTS OVER ALL BUT OSAGE...PAWNEE
AND CREEK COUNTIES WHERE VALUES ARE
MORE IN THE MIXED CELL MODE RANGE OF 30
TO 40 KNOTS.

<deletia>

CELLS IN IN SOUTHEAST OKLAHOMA ARE
MOVING FROM A NEGATIVE STORM-RELATIVE
HELICITY ENVIRONMENT TO A POSITIVE ONE.
FOR NOW ANTICYCLONIC STRUCTURE IS STILL
NOTED ON TWO OF THE CELLS.  IT WILL BE
INTERESTING TO FOLLOW THE PROGRESS OF
THE CELLS IN THIS ENVIRONMENT...ITS
LIKELY THAT SUBSEQUENT CELL SPLITS WILL
FAVOR THE CYCLONIC UPDRAFT AND THE
ANTICYCLONIC ONES WILL DISSIPATE.
SPOTTERS NEAR THE STORMS SHOULD BE
ALERT TO INFLOW AND UPDRAFTS ON BOTH
THE NORTH AND SOUTH SIDES OF THE MAIN
CLOUD TOWER.
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Figure 9: 0156Z Mesoscale Discussion

The supercell at 0122Z was tracking across northern Pittsburgh County into southern McIntosh County and had attained a strong anti-cyclonic mesocyclone (Figure 10). A weaker cyclonic circulation was also noted aloft paired alongside the anti-cyclonic circulation (Klemp, 1987). This paired circulation couplet was persistent with time, though the cyclonic circulation remained weak.

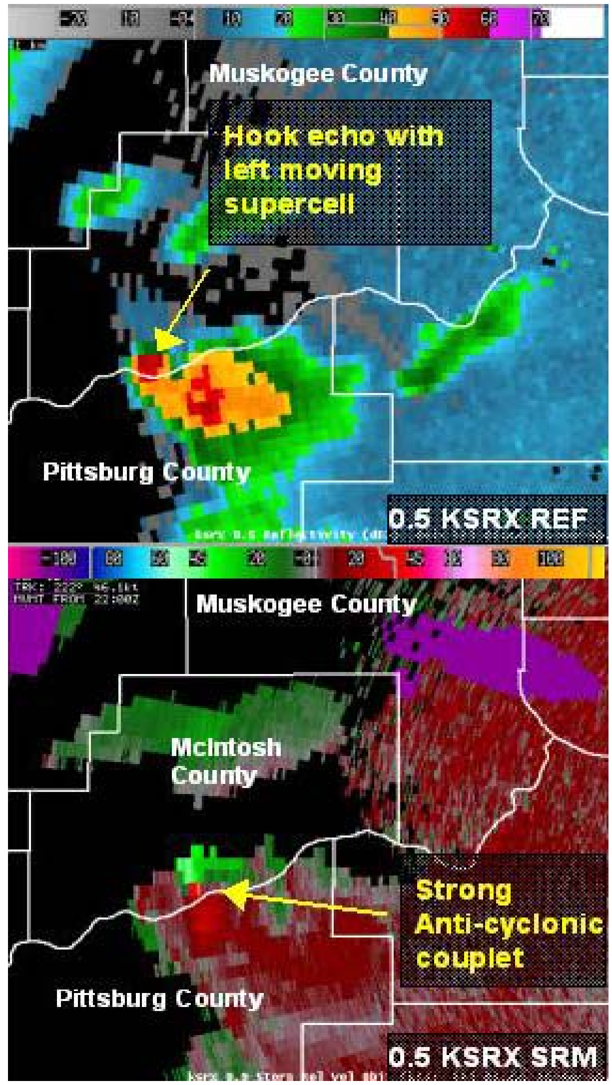

Figure 10: 0122Z KSRM 0.5° Reflectivity and Storm-relative Velocity (Storm Motion 222 @ 46 kts)

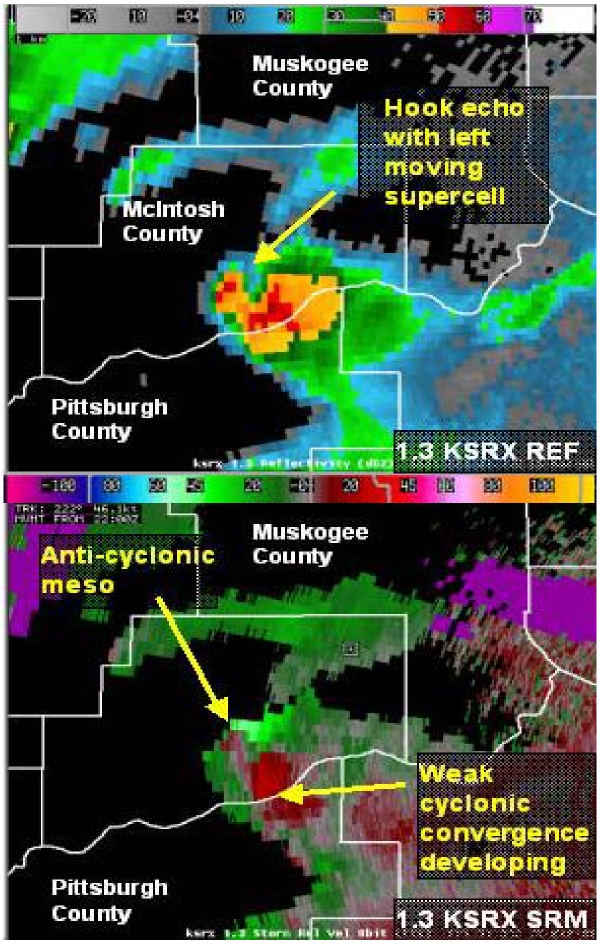

Figure 11: 0131Z KSRX 1.3° Reflectivity and Storm-relative Velocity (Storm Motion 222 @ 46 kts)

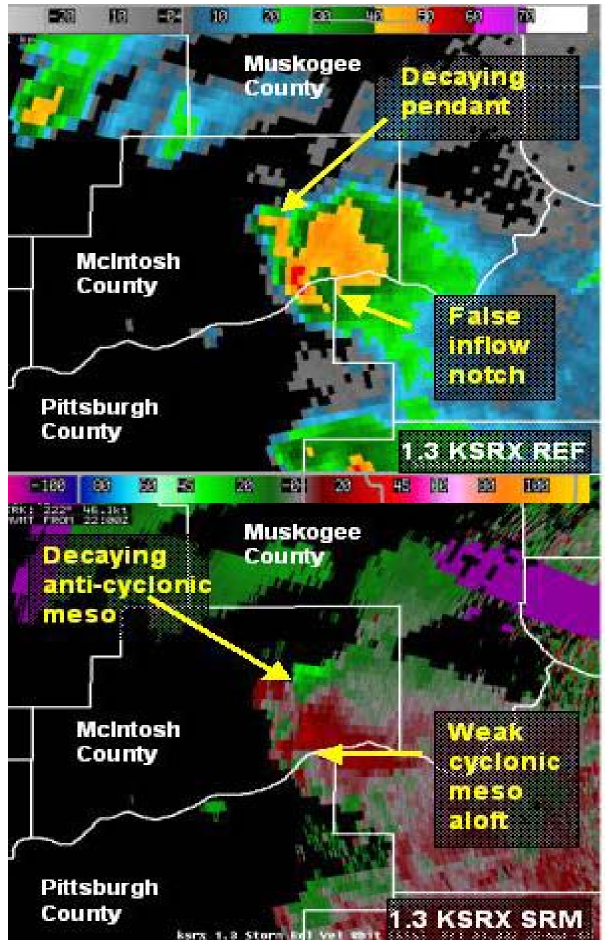

Figure 12: 0139Z KSRX 1.3° Reflectivity and Storm-relative Velocity (Storm Motion 222 @ 46 kts)

The 1.3° KSRX data, approximately 3.3 km above ground level (agl), at 0131Z (Figure 11) showed a weakening anti-cyclonic circulation along the storm's northern flank, with weak cyclonic convergence noted along the storm's southwestern flank. The corresponding reflectivity data maintained the anti-cyclonic hook echo, while the precipitation shield along the southern flank showed initial signs of deformation associated with the weak, yet persistent, cyclonic circulation.

0139Z KSRX data show a continued complex evolution of the storm, as two distinct appendages are evident within the reflectivity data (Figure 12). The northern appendage is associated with the weakening anti-cyclonic mesocyclone, while the southern appendage appears to have resulted from precipitation cascading along the upshear side of the weak mid-level cyclonic circulation. The low-level storm-relative velocities within the region of the southern appendage are non-descript. The lack of significant low-level convergence suggests the absence of a strong updraft along the storm's southern flank, despite a reflectivity pattern that is often associated with a low-level storm-relative inflow pattern.

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AREA FORECAST DISCUSSION
NATIONAL WEATHER SERVICE TULSA OK
749 PM CST THU MAR 24 2005

.MESOSCALE DISCUSSION...
IMPRESSIVE ANTICYCLONIC SUPERCELL IS
MOVING NORTHEAST AT 45 KNOTS ACROSS
MCINTOSH COUNTY.  WE HAVE RECEIVED
REPORTS OF HALF DOLLAR SIZE HAIL WITH
THE CELL.  WE ARE ONLY CALCULATED
SR-HELICITY TO THE LCL OF AROUND
0...BUT UNDOUBTEDLY THE STORM IS IN A
NEGATIVE HELICITY ENVIRONMENT.  THE
HELICITY BECOMES MORE POSITIVE IN
MUSKOGEE COUNTY...SO THE CELL MAY LOSE
SOME ORGANIZATION IN THE NEXT HOUR.
WE DID SEE AN ANTICYCLONE UPDRAFT DIE
AS THE CYCLONIC SPLIT BECAME MORE
DOMINANT...SO THE ENVIRONMENT IS QUITE
INTERESTING.  SPOTTERS ON THE MCINTOSH
COUNTY STORM SHOULD BE POSITIONED
NORTH OF THE CELL TO VIEW THE UPDRAFT.
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Figure 13: 0149Z Mesoscale Discussion

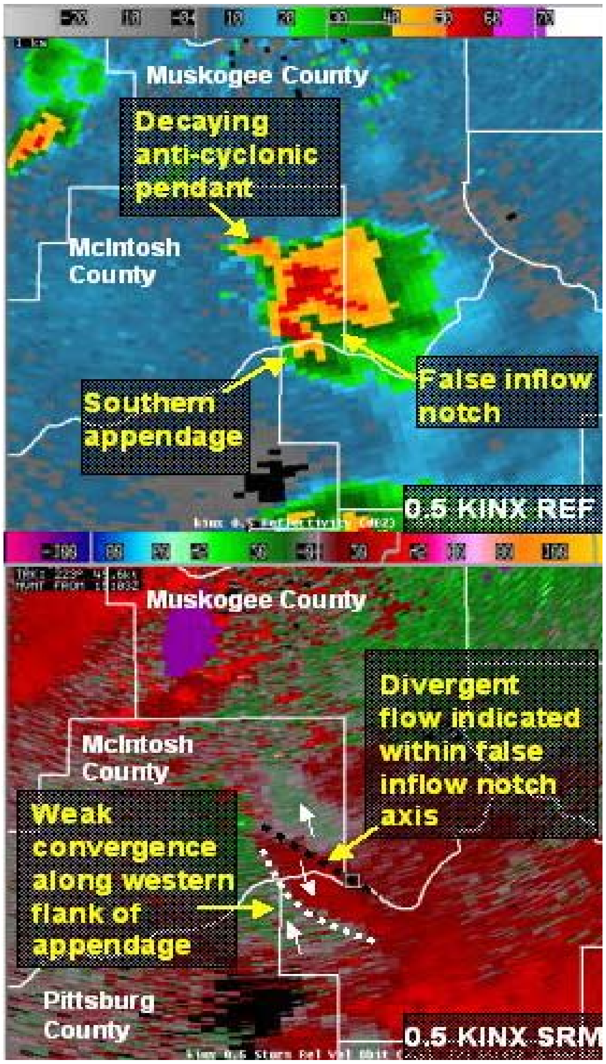

Figure 14: 0147Z KINX 0.5° Reflectivity and Storm-relative Velocity (Storm Motion 222 @ 46 kts)

This evolution continues into the 0147Z KINX data as the northern appendage loses definition and the anti-cyclonic mesocyclone decays (Figure 14). Concurrently, the southern appendage attained a reflectivity structure often associated with a dangerous cyclonically rotating supercell; however, the velocity data sampled low-level divergent flow within a region suggestive of an inflow notch per the corresponding reflectivity data. It is therefore characterized as a false inflow notch with similar radar characteristics described by Houze, et al., 1993. KSRX velocity and reflectivity data at this time revealed only a weak mid-level cyclonic circulation with a weak updraft region correlating to a small elevated reflectivity core (not shown).

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AREA FORECAST DISCUSSION
NATIONAL WEATHER SERVICE TULSA OK
758 PM CST THU MAR 24 2005

.MESOSCALE DISCUSSION...
MCINTOSH COUNTY STORM HAS JUST
TRANSFORMED BACK TO A CYCLONIC-UPDRAFT
DOMINATED STORM AS THE ANTICYCLONIC
UPDRAFT WEAKENED AND APPEARS TO BE
DISSIPATING AS THE CELLS MOVES INTO A
MORE POSITIVE SR-HELICITY ENVIRONMENT.
WHILE THE CELL IS ELEVATED AND A
TORNADO RISK APPEARS LOW...SPOTTERS
SHOULD STILL MONITOR THE STORM
CLOSELY... MONITORING BOTH THE NORTH
AND SOUTH SIDES OF THE MAIN CLOUD
TOWER.
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Figure 15: 0158Z Mesoscale Discussion

The 0218Z KINX data (Figure 17) show the original anti-cyclonic mesocyclone weaker on the storm's northern flank, while a cyclonic mesocyclone has become established extending into the low-levels. The 02Z GFE mesoanalysis suggests the storm had completed its movement through the negative to positive helicity zone (Figures 7 and 8) and was likely ingesting positive SRH values less than 100 m^2/s^2. The low magnitudes of available SRH, along with limited instability, likely inhibited the development of a stronger cyclonic mesocyclone. The storm weakened rapidly after attaining a broad cyclonic low-level mesocyclone and lost supercellular characteristics by 0245Z. This trend was noted, along with uncertainty regarding the rate of decay, in the 0242Z mesoscale discussion (Figure 16).

The morphology of this storm was complex, and the associated storm-scale dynamics are beyond the scope of this paper. The complicated radar presentation was likely as equally challenging to external partners, especially storm spotters operating after sunset. However, real-time forecast discussions issued during the storm's complex evolution utilized data obtained via GFE and highlighted the potential for abnormal storm structure, while emphasizing potential storm spotter strategies (Figures 9, 13, and 15).

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AREA FORECAST DISCUSSION
NATIONAL WEATHER SERVICE TULSA OK
842 PM CST THU MAR 24 2005

.MESOSCALE DISCUSSION...
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THE MORE CELLUAR CONVECTION IN
SOUTHEAST OKLAHOMA HAS BEEN LOSING
ORGANIZATION ON THE WHOLE...BUT WILL
LIKLEY NOT DISSIPATE GIVEN THE
ELVATED INSTABILITY...AND WE EXPECT
THEM TO BE A HAIL THREAT FOR AT
LEAST A COUPLE OF MORE HOURS AS
THEY TRACK NORTHEAST.
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Figure 16: 0242Z Mesoscale Discussion

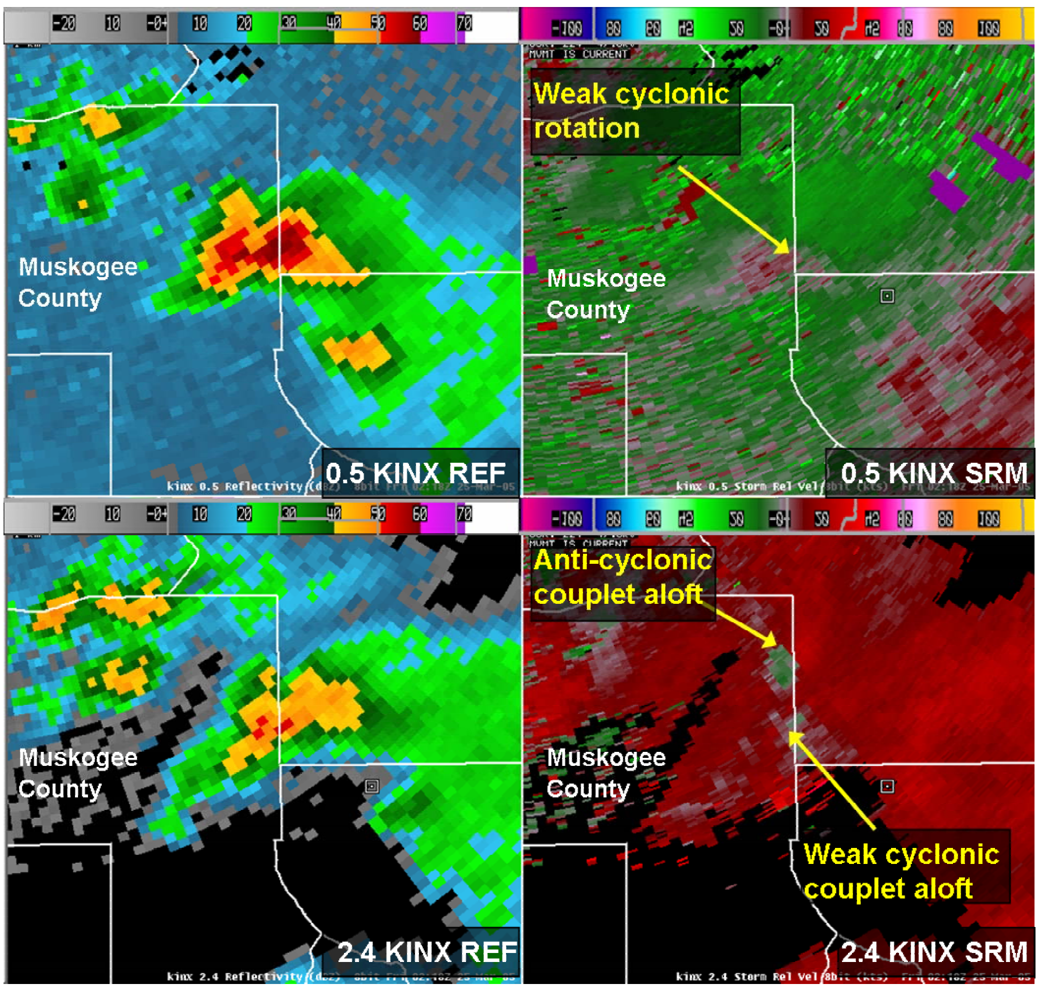

Figure 17: 0218Z KINX 0.5° and 2.4° Reflectivity and Storm-relative Velocity (Storm Motion 222 @ 46 kts)

4.0 SUMMARY

The 24 March 2005 severe weather event provided an opportunity to utilize SRH forecasts within a highly variable mesoscale environment and convey anticipated convective trends to local partners. This information was relayed via local forecast discussions and instant messaging and included suggested storm spotter strategies. These suggested strategies correlated to the yearly SkyWarn storm spotter training material and offered a real-time pre-warning connection between WFO Tulsa meteorologists, local decision makers, and storm spotters.

GFE is utilized by WFO Tulsa to assist in diagnosing the mesoscale environment, and this practice proved to be a valuable tool during this severe weather event. The interactive nature of GFE allowed for efficient and effective diagnosis of the SRH environment during this event, made possible by real-time adjustments for observed storm motions. Additionally, the WFO Tulsa warning team benefited from this information by realizing the high variability associated with this particular mesoscale environment, thus improving situational awareness while becoming more accepting of atypical storm structure.

5.0 ACKNOWLEDGEMENTS

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