19.6 AN EXAMINATION OF THE MESOSCALE ENVIRONMENT OF THE JAMES ISLAND MEMORIAL DAY TORNADO

STEVEN B. TAYLOR
NOAA/NATIONAL WEATHER SERVICE FORECAST OFFICE
CHARLESTON, SC

1. INTRODUCTION

A cluster of severe thunderstorms moved across portions of south coastal South Carolina during the early morning hours of 30 May 2006. Around 1135 UTC, a severe thunderstorm spawned an F-1 tornado in the James Island community of Charleston, SC. The tornado produced wind and structural damage as it moved rapidly NE through several residential neighborhoods. The tornado was on the ground for approximately 0.1 mi before it emerged into the Atlantic Ocean as a large waterspout near the entrance to the Charleston Harbor.

Timely tornado warnings were issued by the NOAA/National Weather Service Forecast Office (WFO) in Charleston, SC (CHS), despite the event occurring during a climatologically rare time of day. This study will concentrate on the mesoscale factors that supported the genesis of the tornado and its parent severe thunderstorm. Radar data generated by the KCLX WSR-88D will also be presented.

2. SYNOPTIC ENVIRONMENT

The synoptic environment supported the development of scattered convective precipitation across much of the coastal areas of the Carolinas and Georgia. At 0800 UTC 30 May, a well defined surface frontal boundary extended from southern AL through southern GA into the SC Midlands with a weak frontal wave noted between KVDI and KAMG (Fig. 1). This baroclinic boundary was located on the southern flank of weak cold air damming that was ongoing across the piedmont areas of NC and SC (Fig. 2). South of the boundary, the atmosphere was moderately unstable with SBCAPE values in excess of 2400 Jkg^{-1} and a lifted index of -5 ^{o}C as noted by the adjusted 1100 UTC RUC sounding for James Island, SC (Fig. 3).

Meanwhile, an upper level cyclone was situated across SE TX. Ahead of the upper low, a SW to NE oriented 70 kt subtropical jet extended from the central Gulf of Mexico through SC. The ageostrophic circulation associated with the jet's left front quadrant was situated over southern SC aiding in broad synoptic lift across the region. This upward motion across the quasi-stationary frontal boundary coupled with differential positive vorticity advection (DPVA) associated with a weak shortwave trough crossing SC and GA aided in the development of scattered showers and thunderstorms. These conditions also induced weak cyclogenesis along the front near the vicinity of KVDI. By 1200 UTC the surface low was located between KNBC and KCHS. This low and its influences on the kinematic environment as well as the eventual position of the surface frontal boundary will prove to be the main contributing factors leading to the development of the James Island tornado.

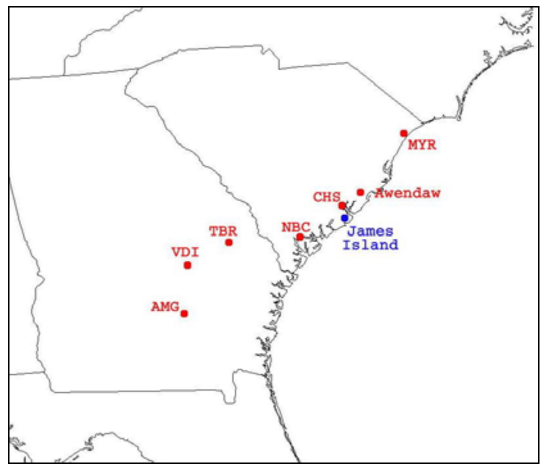

Fig 1. Map of eastern SC/GA

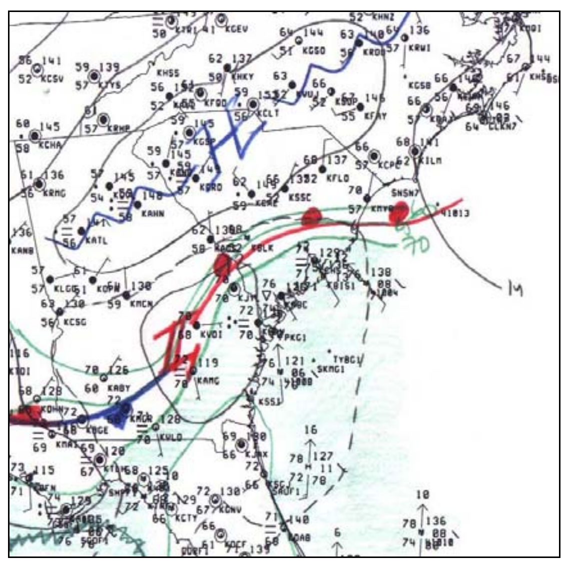

Fig. 2. Surface Analysis valid 0800 UTC 30 May 2005.

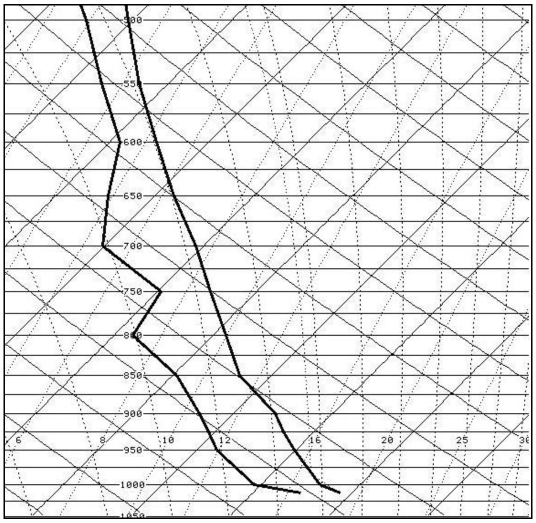

Fig. 3. Adjusted RUC Forecast Sounding for James Island, SC valid 1100 UTC 30 May 2005.

3. MESOSCALE ENVIRONMENT

The threat for severe weather gradually increased between 0800 UTC and 1100 UTC as the atmosphere across coastal SC slowly destabilized. At 0800 UTC, the first indication of cyclogenesis appeared in surface observations across interior SE GA where 3-hour pressure falls of 2 $mbhr^{-1}$ were noted with a secondary maximum of 1-2 $mbhr^{-1}$ centered over the middle SC coast near KCHS. Ahead of the developing low, winds were slowly backing across coastal SC, thus allowing advection of low-level moisture off the Atlantic. It is at this time the KCLX WSR-88D and the national lightning detection network first detected the initiation of several strong convective cells with cloud to ground along the Savannah River.

By 1000 UTC, the baroclinic boundary had drifted S and was located along a line from KMYR to just N of KCHS to KTBR. Surface dewpoints had pooled in the warm sector from the upper 60s to the lower to mid 70s as low-level moisture advection continued. LAPS calculated lift indices dropped to as low as -6 ^{o}C and SBCAPES had increased to 2600 Jkg^{-1} owing to increased low-level moisture. The coverage of thunderstorm activity continued to expand and surface moisture flux convergence increased to 40 gkg^{-1} along the Charleston County coast. (Fig. 4).

The developing surface low was located just E of KTBR at 1000 UTC. Output from the KCLX WSR-88D VAD Wind Profile (VWP) and surface observations along the lower SC coast suggested the atmosphere was becoming increasingly sheared as surface winds backed with the approaching surface low. LAPS adjusted soundings verified this with 0-1 km helicity values approaching 200 m^2s^{-2} and Energy Helicity Indices (EHI) approaching 1.5 (Fig. 5). According to Davies (1993), an EHI greater than 1.0 tends to support the development of strong tornadoes.

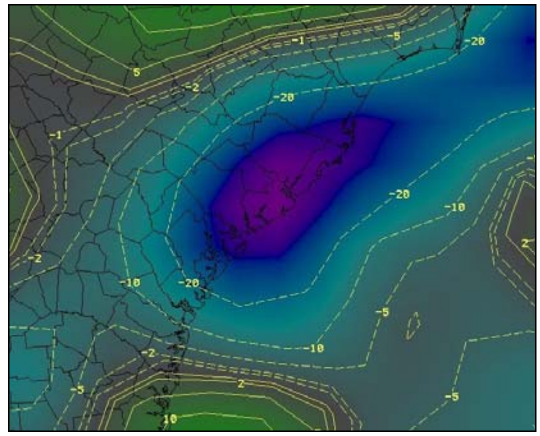

Fig. 4. 1000 UTC LAPS Surface Moisture Flux Convergence. Values greater than 35 gkg^{-1} are purple.

By 1100 UTC, about 30 minutes prior to the initial tornado touchdown, the front had settled along a line from Reidsville, GA through Hardeeville, SC to KCHS and Awendaw, SC. The associated surface low had also moved to a position near KNBC and the KCLX 0.5 degree base reflective imagery showed a line of strong convection organizing and moving NE through the warm sector. Instability ahead of the line continued to favor convective development with SBCAPE values holding around 2600 Jkg^{-1} and LI values as high as -6 ^{o}C.

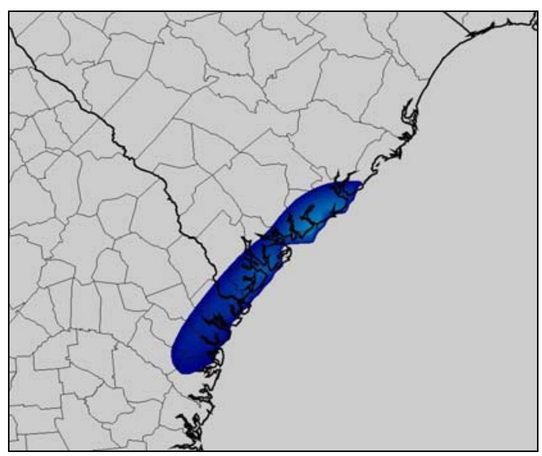

Fig. 5. 1000 UTC LAPS Energy Helicity Index Analysis. Blue colored areas denote EHI values greater than 1.0. Note the values along the lower Charleston County coast are near 1.5.

Atmospheric conditions along coastal SC, particularly along the Charleston County coast in the vicinity of the frontal boundary, continued to become increasingly favorable for tornadoes. The adjusted 1100 UTC LAPS sounding for James Island using 1130 UTC surface mesonet observations and data from the KCLX VWP showed 0-1 km helicity values had increased to 250 m^2s^{-2} with calculated EHI values of 3.9. The associated hodograph showed a well defined cyclonic curvature. (Fig. 6).

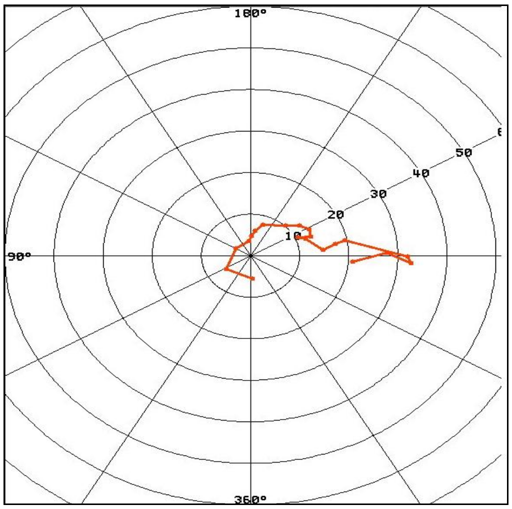

Fig. 6. 1130 UTC LAPS adjusted hodograph.

4. RADAR ANALYSIS

A broken line of scattered strong thunderstorms began to develop in the warm sector across western Charleston County by 1056 UTC. The line continued to advance to the E/NE with average storm motions around 20 KT and approached the central portions of Charleston County near the community of John's Island by 1109 UTC. It is at this time that the KCLX 0.5 degree storm relative velocity (SRM) product first indicated broad, weak low-level rotation with the southern most storm in the line about 4 miles west of John's Island.

The 1113 UTC and 1117 UTC 0.5 degree SRM products continued to track the velocity couplet as it moved quickly through James Island. By this time, two discreet cells had developed within the line. Vertical cross sections and four panel analyses of the 0.5, 1.5, 2.4 and 3.4 degree reflectivity products of the James Island storm suggested the storm was obtaining supercellular characteristics with a developing weak echo region (WER). Wicker and Cantrell (1996) showed that mini supercells do have very similar characteristics of the larger supercells that affect the Great Plains. This includes the presence of hook echoes, weak echo regions (WER) and bounded weak echo regions (BWER).

By 1122 UTC, SRM and base reflectivity products indicated the storm near James Island was becoming stronger and more organized. The 0.5 degree base reflectivity began to show a definitive hook echo and vertical reflectivity cross sections now showed the presence of a well defined BWER. At 1124 UTC, forecasters made the decision to issue a Tornado Warning (TOR) for Charleston County valid until 1200 UTC based on current radar trends and knowing that the mesoscale environment in the Charleston area was highly conducive for tornado development.

Forecasters continued to track the tornadic supercell as it approached the community of James Island, located about 3 miles to the S and SW of downtown Charleston. By 1134 UTC, radar showed a well defined hook echo approaching the community from the W and by 1143 UTC (Fig. 7) the hook echo was located near the northern part of the community near Harbor View Road. No reports of damage had been received from low law enforcement officials by this time. The cell continued to move E/NE and emerged into Atlantic very near Fort Sumter in the Charleston Harbor entrance around 1145 UTC.

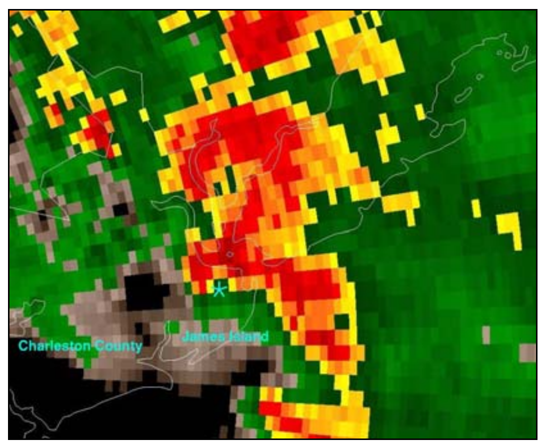

Fig 7. 1143 UTC KCLX 0.5 degree Base Reflectivity.

At 1150 UTC, law enforcement officials reported a large waterspout near the Fort Sumter and the TOR was extended until 0815 UTC as it appeared the tornado could briefly brush the Sullivans Island area. The tornado/waterspout eventually crossed the frontal boundary that was located just to the N of the Charleston Harbor, became elevated and eventually dissipated in the cold sector; however the line of strong thunderstorms continued to move NE across the remainder of Charleston County producing gusty winds. By 1300 UTC, the surface low and the associated warm sector that was in place across coastal SC had pushed offshore, thus ending the risk for severe weather.

5. CLIMATOLOGY

The James Island Memorial Day tornado occurred during a climatologically rare time of day based on a local tornado climatology study for the WFO Charleston County Warning and Forecast Area (CWFA). According to Brueske et. al. (2002), during the period of 1958 to 1993, minimal tornado activity was observed between 0600-1400 UTC. Figure 8 shows a relative tornado minimum during this time. The James Island tornado first touched down around 1143 UTC (643 EST).

Although the tornado did occur during a climatologically unfavorable time of day, Breuske et. al. (2002) found that April and May are the most favored times of the year for tornado development across the WFO CHS CWFA.

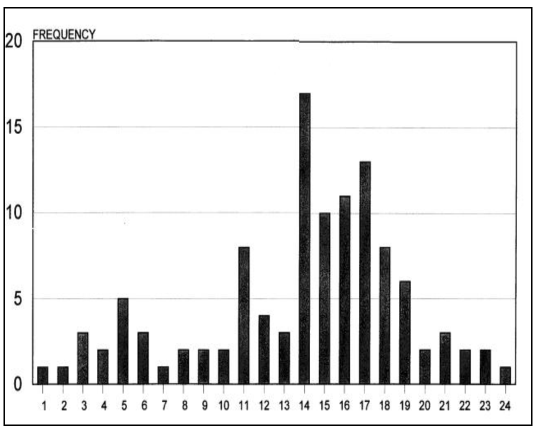

Fig. 8. Hourly (EST) distribution of tornados in the WFO CHS CWFA (Breuske et. al, 2002).

6. DAMAGE ASSESSMENT

A damage survey team from WFO Charleston, SC, surveyed the James Island area later in the day and found that a tornado did touchdown in several parts of the community. A total of five touchdowns occurred at various lengths, but it was determined that the tornado was on the ground for at least 0.1 mi.

The worst damage occurred just off of Harbor View Road where the tornado severely damaged many trees, including several large grand oak trees. High winds partially destroyed a porch and ripped vinyl siding as well as gutters off several homes. Minor roof damaged occurred to at least one house. Interviews with local residents visually confirmed the tornado and described it was a long, thin funnel.

Although most of the damage throughout James Island was consistent with that of an F-0 tornado with winds of 50-60 mph, the most severe damage occurred near Harbor View road. This damage was classified as F-1 damage with winds estimated to be near 90 mph.

The damage team estimated the initial tornado touch down occurred around 1135 UTC this yielded a lead time of approximately 18 minutes.

7. CONCLUSIONS

The thermodynamic setup across the Charleston, SC area was favorable for the development of strong to severe thunderstorms during the morning of 30 May 2006. Much of the region was in the warm sector of a cold air damming event that was ongoing across NC and central SC. Weak low pressure, induced by an approaching shortwave trough along a strong baroclinic boundary front, helped to back winds across the warm sector as the cyclone approached the area, providing a favorable kinematic environment for the development of tornadoes.

Despite being a climatologically unfavorable time of day, forecasters were cognizant of the placement of mesoscale features across coastal SC. As severe thunderstorms developed and entered an increasingly sheared environment, timely tornado warnings were issued for Charleston County with lead times of approximately 18 minutes.

Forecasters are reminded that situational awareness is critical prior to and during convective initiation.

8. REFERENCES

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8. ACKNOWLEDGEMENTS

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