P2.5 THE TORNADO OUTBREAK OF 1-2 MARCH 2007 IN THE NATIONAL WEATHER SERVICE TALLAHASSEE FORECAST AREA

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1. INTRODUCTION

Over a period of 12 hours, beginning around midday on Thursday, March 1st, and continuing into the early morning hours of Friday, March 2, 2007, 28 tornadoes were reported across the southeast U.S. The National Weather Service (NWS) Weather Forecast Office (WFO) in Tallahassee issued 57 warnings, 35 of which were tornado warnings. Nine tornadoes were reported across the WFO Tallahassee County Warning Area (CWA). Warnings were issued for two deadly tornadoes, which caused the loss of 15 lives; nine in Enterprise, Alabama and six just north of Newton, Georgia.

This presentation will focus on several aspects of the event, including the weather situation, tornado outbreak, and office performance. The severe weather occurred in two stages. The first stage began during the late morning on Thursday, along a warm front boundary. Several supercell thunderstorm, and tornadoes were reported in extreme southeast Alabama. One in particular was rated an Enhanced Fujita (EF)-4 (McDonald and Mehta 2006) that struck Enterprise, Alabama, resulting in nine deaths, including eight students and teachers at the Enterprise High School. The second round of severe weather developed after sunset, in advance of a fast moving cold front. In our CWA, the most significant event was an EF-2 rated tornado in Baker County, Georgia, which occurred shortly before midnight on Thursday, destroying a number of mobile homes, and killing six.

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2. OVERVIEW

The morning and afternoon of March 1st 2007 was expected to be active, in terms of weather, across a large portion of the continental United States, with heavy snow over the northern Plains, and an anticipated severe weather outbreak across the lower Mississippi Valley and North-Central Gulf coast. The Storm Prediction Center (SPC) highlighted portions of Mississippi, Alabama, Georgia, and Florida as being under a rare "High Risk" for the period. The principal weather maker during the morning hours was a deep middle and upper level trough, and associated 5250 gpm closed low across the mid-section of the country. Through the morning hours, this trough was to become increasingly negatively tilted, as it approached the middle and upper Mississippi valley.

Beneath the upper trough, a deepening 980-985 mb surface low was situated over northern Missouri, and the low would push northeast into Iowa and occlude by the midday hours. A trailing cold front was well defined as it approached the central and southern Mississippi valley by late in the morning. A double warm frontal structure was evident with this system in both the numerical model analysis and observations. The main synoptic warm front was lying west to east well north of the forecast area, across the northern Tennessee and Ohio Valleys. A more meso-scale warm frontal feature extended from the middle Mississippi Valley through central Mississippi, and down into southeast Alabama and the northern Florida Big Bend. This secondary warm front was first recognized by forecasters at the office, due to vigorous isentropic lift convection, which developed around sunrise over southwest Georgia, long before significant convection was expected.

Middle and upper level speed maxima were analyzed rounding the base of the upper trough, and beginning to nudge into the lower Mississippi valley during the morning and early afternoon hours. These features were likely to arrive a bit too late to have had a significant impact on the early tornadic activity in the CWA. In fact, the SPC was also waiting for these dynamics to arrive for the main activity to begin. The early morning convective discussion from March 1st talked about convective initiation over western Mississippi between 1500-1800 UTC with the main activity moving into Alabama during the late afternoon hours and beyond. These upper level dynamics were much more likely to have played a role in the second tornadic/severe weather outbreak that occurred over Georgia and northern Florida during the evening and early morning hours of March 2nd.

3. ROUND 1

Why did the tornadic supercells develop earlier than expected? Certainly, adequate shear, elevated instability, and moisture were available. The 50-kt flow along the 300 K isentrope with 50-mb of ascent, a coincident theta-E ridge, and a highly veered and large shear wind profile provided the ingredients for the early severe convection. The warm front boundary provided the necessary focusing mechanism to initiate the severe convection.

The surface analysis for 1800 UTC is shown in Fig. 1. The warm front boundary separates temperatures in the mid 60s from temperatures in the mid to upper 70s. Dewpoints were in the mid to upper 60s in the warm air. Dewpoints dropped into the upper 50s and lower 60s north of the front. Winds were southerly on both sides of the front, but were much stronger on the warm side.

A low-level 850-mb jet became well established from the north central Gulf of Mexico through central Alabama by the late morning hours per RUC guidance (Fig. 2a). The 0-6-km effective bulk shear for both models was running between 55-65 kts, resulting in adequate shear for organized convection (Fig. 2c). Even more impressive was the 35-40kts of 0-1 km bulk shear shown over southeast Alabama during the 1500-1800 UTC time frame. Sounding and model profiles showed highly veered low level profiles, suggesting enhanced threat of supercells once convection initiated.

Guidance also showed an 850-mb theta-e ridge (Fig. 2a) with its axis from the north central Gulf into the western Florida Panhandle. The nose of this ridge rested right across south-central and southeastern Alabama by midday. Within this zone, very strong isentropic lift was occurring along the 300 K surface, associated with the 850-mb jet, theta-e ridge and meso-scale warm front over the northern Florida Panhandle and southcentral Alabama. The isentropic lift (Fig. 2f) on the nose of the theta-e ridge, was likely the convective initiation source for the late morning/early afternoon storms. Once these storms developed in the high shear environment, they were able to rapidly become super-cellular in nature.

To summarize the situation, a Composite Chart (Fig. 3) was constructed, partially along the guidelines developed by Miller (1972). Attention is drawn to southern Alabama and the Florida Panhandle, where the thermal ridge, moisture ridge, low-level jet, and lifted index (LI) minimum seem to concentrate along the warm front draped across south Alabama.

3.1 The Storms

The first supercells to form and move northeast into our southeast Alabama counties occurred as much as two hours before the Enterprise tornadic supercell, and followed a relatively similar track through Coffee County. These earlier storms were obviously supercellular in nature, with well defined inflow notches and even what could be described as hook echo-like features. Gate-to-gate shear velocities with these storms were enough to prompt the issuance of a two tornado warnings during the late morning hours. At the time of these first storms, it can be seen from surface observations that the meso-scale warm-frontal boundary discussed above was a bit further south during the late morning than it was later, around the time of the Enterprise tornado (likely lying from Washington County to northern Walton and Okaloosa Counties in the Florida Panhandle and then into southwest Covington County in south-central Alabama). This feature caused the earlier supercells in Coffee County, Alabama to pass over a slightly deeper surface stable layer to the north of the boundary. This deeper stable layer was apparently enough to prevent the strong rotation seen at 3-5 kft from reaching the surface.

Increasing low-level flow, combined with diurnal heating began to force the warm front to push north during the early afternoon hours. Supercell thunderstorms continued to form north of the boundary, across Covington County, Alabama and moved northeast. As the supercell that would spawn the Enterprise tornado began to take shape across southern Covington County, the warm front was likely positioned from northern Covington County southeastward into extreme southern Geneva County. The Enterprise supercell was simply in the right place at the right time. The storm was already showing a strong mesocylone signature as it crossed into western Geneva County. Within the next 10 to 15 minutes, the storm crossed over the boundary. The circulation spun up very rapidly along the Geneva County / Coffee County border. Tornadogenesis began at the surface about 10 minutes later in the very shallow stable layer immediately to the north of the boundary.

Figure 4 shows the Ft. Rucker WSR-88D reflectivity and storm-relative mean radial velocity map (SRM) for 1910 UTC. At this time, the developing tornado was just minutes away from destroying portions of the Enterprise High School (see Fig. 5 for aerial photo of destruction at the high school) and cutting a 9-mile path through the city of Enterprise, Alabama and Coffee County. A double structure is evident depicting the mesocyclone rotation as well as the tornadic vortex rotation. At 1910 UTC, the supercell was approximately 23 nm from the KEOX radar. The highest gate-to gate velocity at this time was approximately 100 kts, but rotational velocities (Vr) exceeded 64 kts in the lower four elevation angles. Subsequent analyses of time height of rotational velocities (Fig. 6) showed that greater than 70-kt Vr occurred at the time of tornado formation.

The tornado track (Fig. 7) abruptly ends near the Coffee-Dale County line. About 10 minutes later the mesocyclone began to undergo a core evolution as described by Burgess et al (1982). A second core quickly developed to the southeast of the dissipating core. A new tornado touched down approximately 15 minutes later at 1948 UTC in extreme eastern Dale County. This tornado (see Fig. 8) was named the Echo Tornado, since it passed within one quarter mile of the KEOX WSR-88D radar in Echo, Alabama. The intermittent track (Fig. 7) covered some 37 miles, affecting portions of four counties in southeast Alabama and southwest Georgia, and was rated a high EF-1. Again, Vr exceeded 50 kts (Fig. 6) through a significant depth early in the tornado's life cycle.

4. ROUND 2

The differences in the physics driving the convection and severe weather from the late morning into the early afternoon of March 1st, and the later severe weather during the overnight hours of March 2nd, can also explain why there was a rather lengthy break in activity during the later afternoon hours and much of the evening across our CWA. As the mesoscale warm front continued to push north, the lift associated with the theta-e ridge moved north as well.

With the low-level focus for the convection/severe weather now displaced to the north, our forecast area would have to wait for the mid/upper level dynamics to arrive many hours later, and combine with the pre-cold frontal squall line producing the second tornadic episode later that night.

The surface analysis for 0400 UTC, 2 March is shown in Fig. 9. Temperatures were quite warm, in the mid 70s in the middle of the night. Dewpoints were in the upper 60s in southwest Georgia. Not shown are the shear and instability images. However, the 0-6 km effective bulk shear was between 65 and 75 kts, and LI was in the -5 to -6 C range. Warm moist unstable air was focused in southwest Georgia, where the advancing cold front developed a Quasi-Linear Convective System (QLCS) (Tessendorf and Trapp, 2000), which produces a family of five tornadoes rated from EF-0 to EF-2.

4.1 The Storms

These tornadic storms occurred along the fast moving squall line, and were not as "textbook" in appearance as the earlier activity. Figure 10 shows the Tallahassee WSR-88D reflectivity and SRM at 0440 UTC, 2 March. The tornadic supercell is located in the center of the image, and has somewhat of a globular appearance. A flanking line is beginning to develop on the southern edge of the higher reflectivity. The SRM image is very impressive, showing a gate-to-gate velocity of nearly 100 kts. A tornado had just touched down at the time of this image.

The tornado tracks and mesocyclone times for the evening episode of tornadoes are plotted in Fig. 11. The Newton tornado was on the ground for nearly 30 miles, crossing four counties, and producing six fatalities just north of Newton, Georgia in Baker County. Note the cyclic nature of this long-lived mesocyclone, as it entered the dissipation stage around 0517 UTC in central Worth County. A new supercell/mesocyclone had formed to the southeast some 15 minutes prior to this dissipation time. This new mesocyclone then produced a series of three tornado touchdowns across Worth, Turner, and Tift Counties.

Later in the evening (0700-0800 UTC), three additional tornadoes (two rated EF-0 and one rated EF-1) were reported in the Tallahassee CWA, in south central Georgia and Florida Big Bend.

5. SUMMARY

When the tornadoes and severe thunderstorms are displayed by hour (Fig. 12), it is clear that there were two episodes, separated by approximately nine hours. In Fig. 12, the times of tornadoes are plotted under the hourly time. Note that several tornado warnings were issued early in the second episode, as the squall line entered the western sections of the Tallahassee CWA, but there were no reports of tornadoes as the squall line intensified across extreme southeast Alabama and eastern Florida Panhandle. Table 1 lists the tornadoes that occurred in the CWA, including the EF ratings, path length, and maximum width. Verification is also summarized in Table 1. The office verified 19 warnings out of 35 total. The probability of detection (POD) was 1, which means the office warned on all reported tornadoes. The average lead time on tornado warnings was 19.8 minutes.

This severe weather event has prompted NWS Tallahassee to examine more comprehensive severe weather damage assessment tools including digital techniques. Traditionally, the survey team would make copies of a road map, or even better, a county road map, before leaving the office. In the field, the damage survey team would sketch damage onto the map, make detailed notes, and take photos. Back at the office, the team would manually put the pieces of the damage assessment back together. With improved technology, Global Positioning System (GPS) receivers can save the entire track and points of interest, which can then be "played back". There are cameras with GPS receivers, which can save GPS information for each photo. There is compatible Geographical Information System (GIS) software, which can time match GPS track and photos for detailed survey assessments. Please see our companion paper (Camp 2008), which uses these techniques on the tornado outbreak of 1 March 2007.

6. REFERENCES

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7. ACKNOWLEDGMENTS

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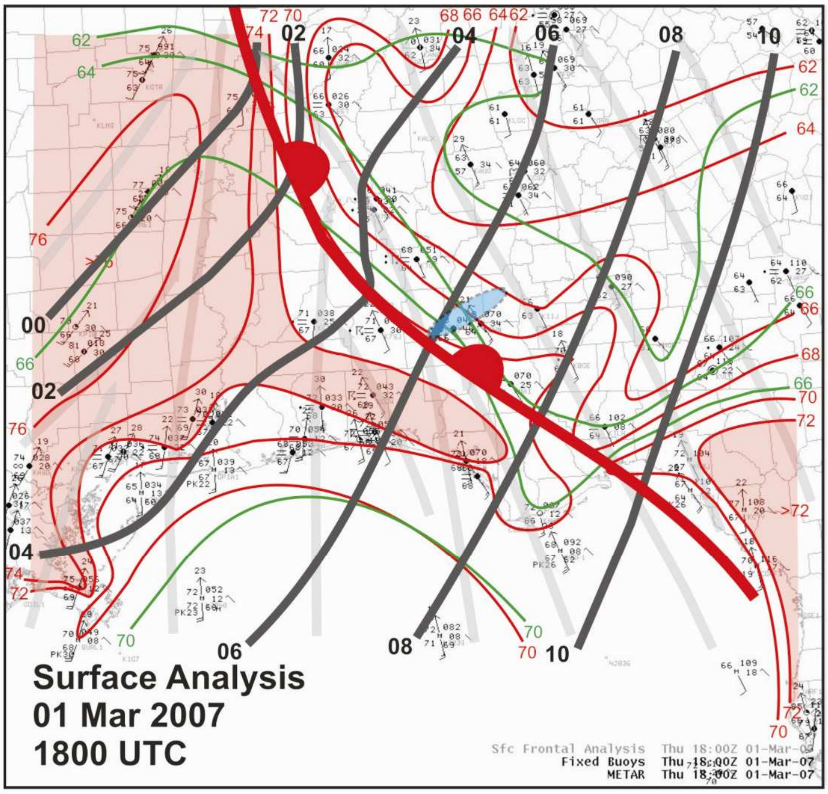

Figure 1. Surface analysis for 1800 UTC, 1 March 2007. The blue shaded area denotes the location of the Enterprise, Alabama tornado.

Composite Chart - 1 March 2007 1800 UTC

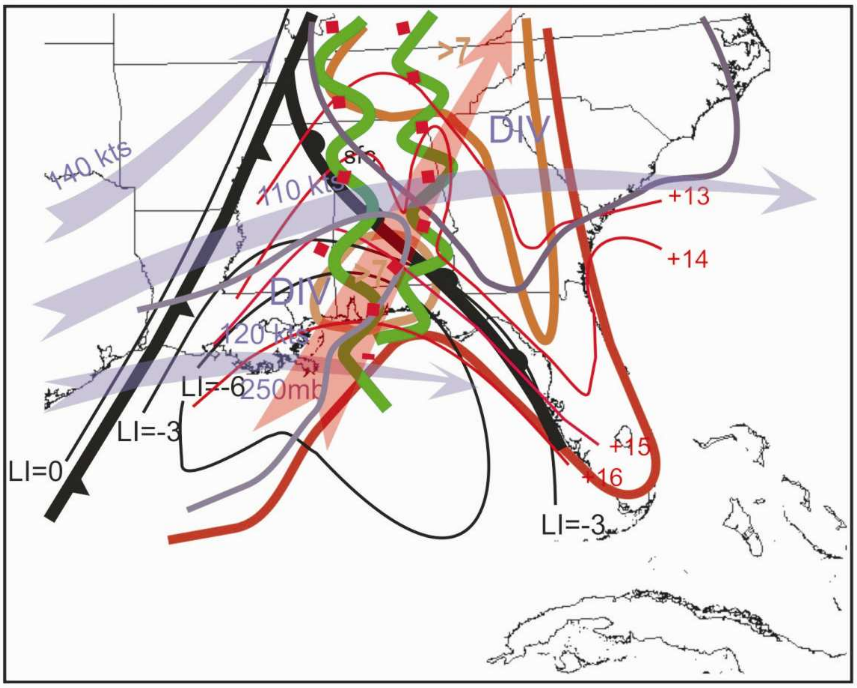

Figure 3. Composite chart for 1800 UTC, 1 March 2007.

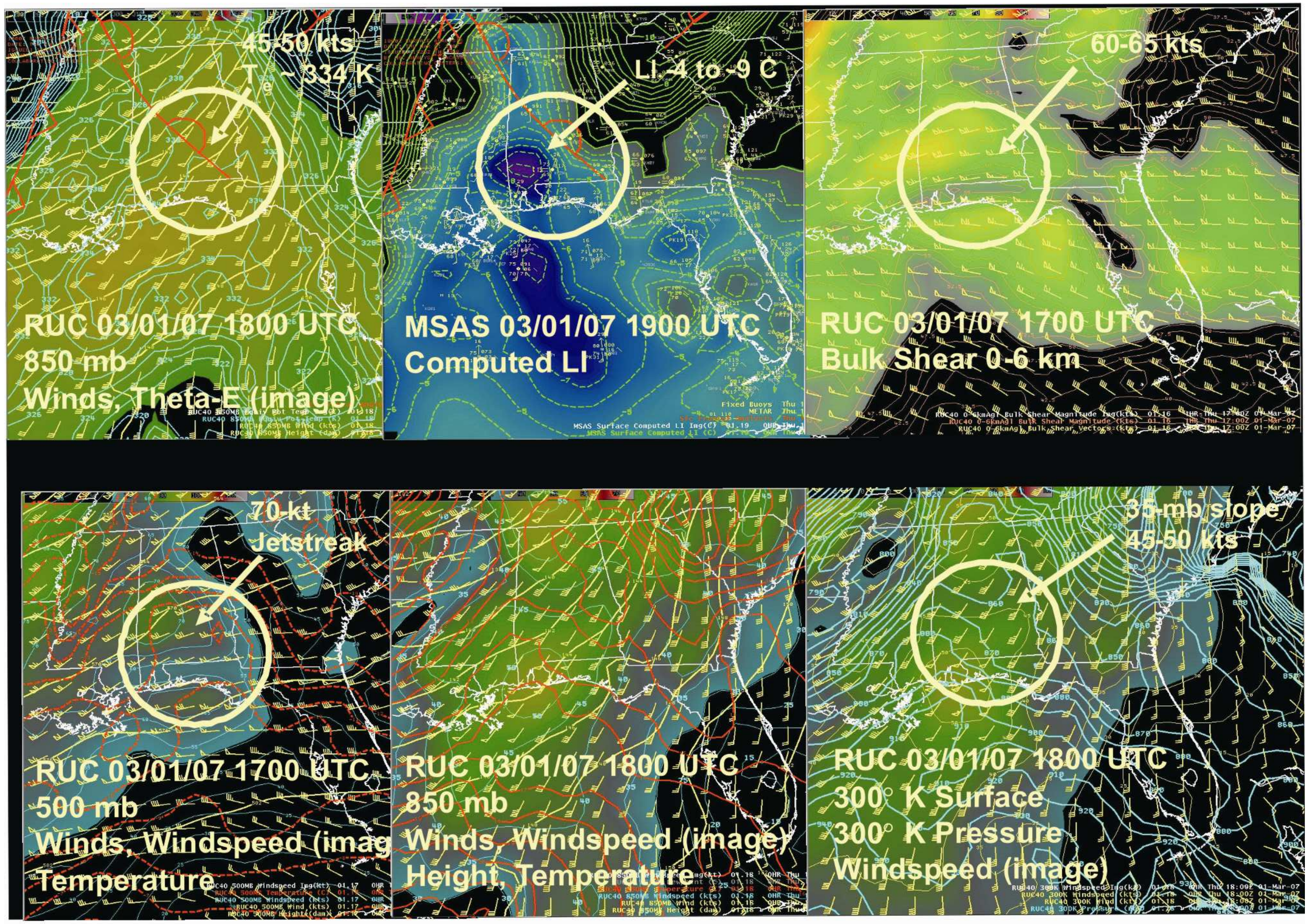

Figure 2. RUC and MSAS analyses on 1 March 2007. a) 1800 UTC RUC 850-mb winds and shaded Theta-E (K), b) 1900 UTC MSAS shaded Lifted Index, c) 1700 UTC RUC 0-6 km bulk shear (shaded), d) 1700 UTC 500-mb height (gpm), temperature (C), winds, and windspeed (shaded), e) 1800 UTC RUC 850-mb height (gpm), temperature (C), winds, and windspeed (shaded), and f) 1800 UTC 300-K isentropic surface with pressure (mb), winds, and windspeed (shaded).

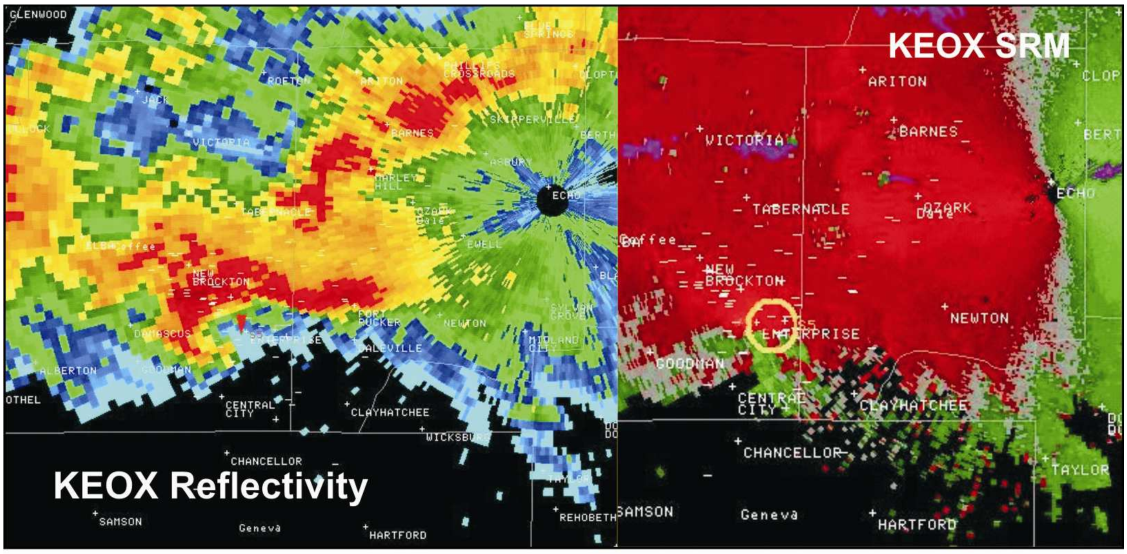

Figure 4. KEOX WSR-88D radar reflectivity (left) and SRM for 1910 UTC, 1 March 2007.

Figure 5. Significant destruction at Enterprise High School where eight were killed.

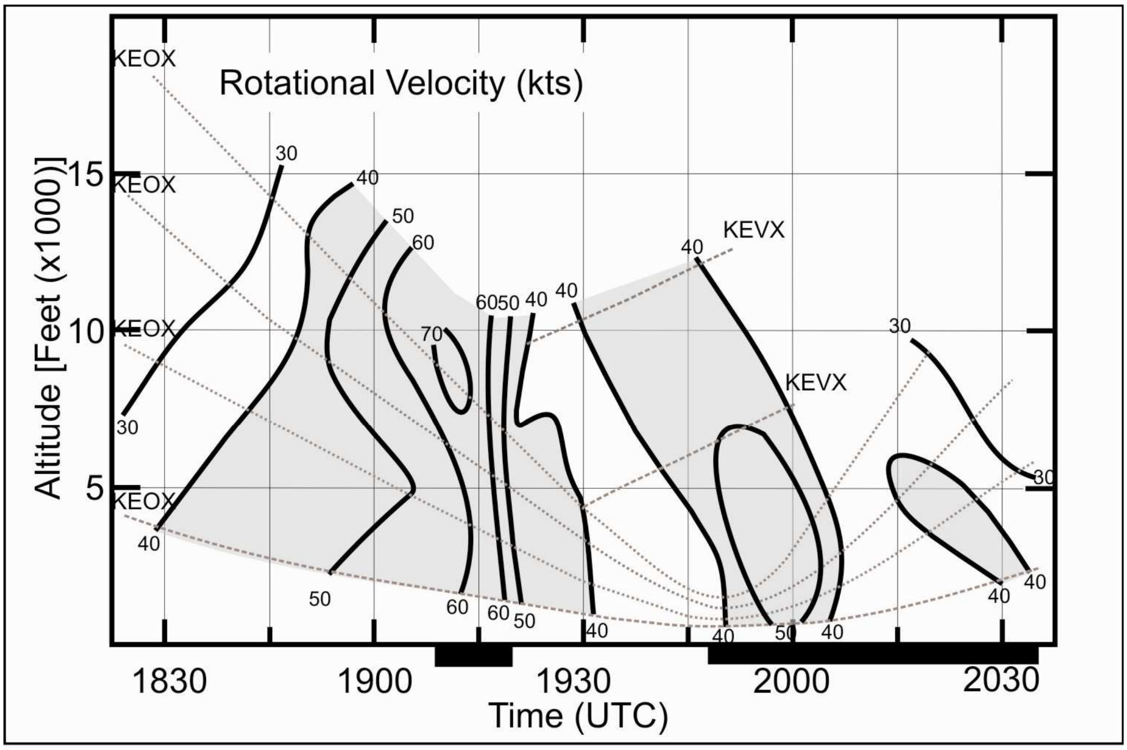

Figure 6. Time-height of rotational velocity of the Enterprise and Echo, Alabama mesocyclones on 1 March 2007 constructed from velocity scans from the KEOX and KEVX WSR-88D radars..

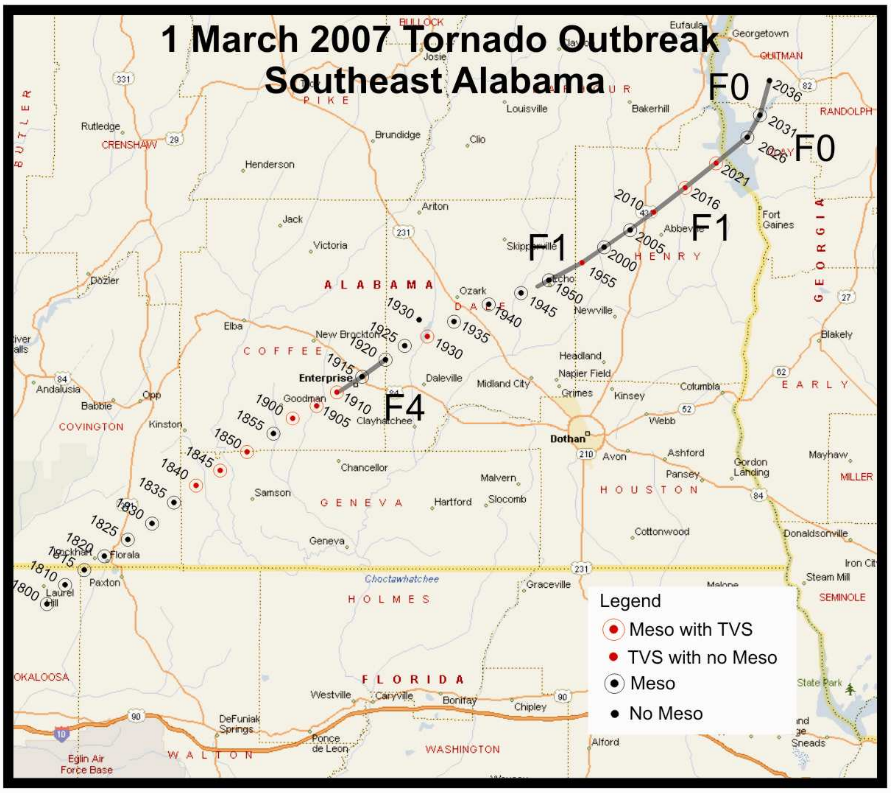

Figure 7. Track and times of Enterprise mesocyclone including shaded tornado tracks on 1 March 2007.

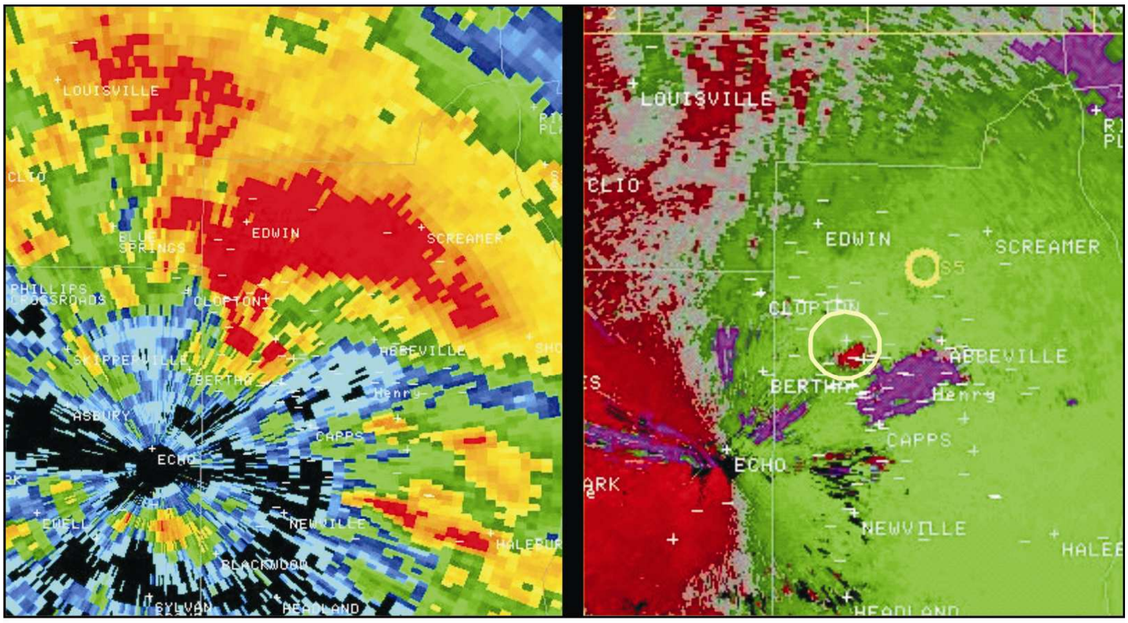

Figure 8. KEOX WSR-88D radar reflectivity (left) and SRM for 2000 UTC, 1 March 2007.

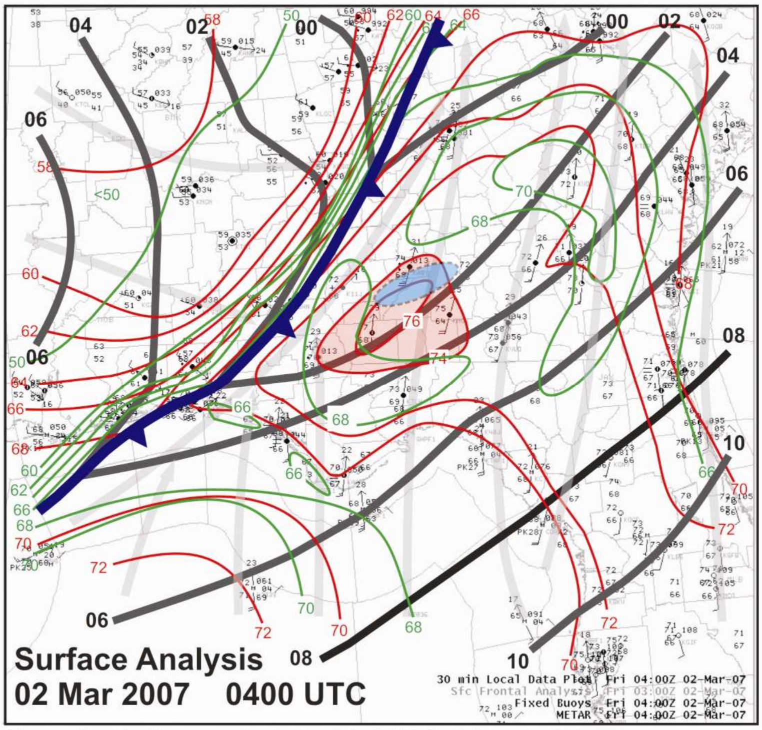

Figure 9. Surface analysis for 0400 UTC, 2 March 2007.

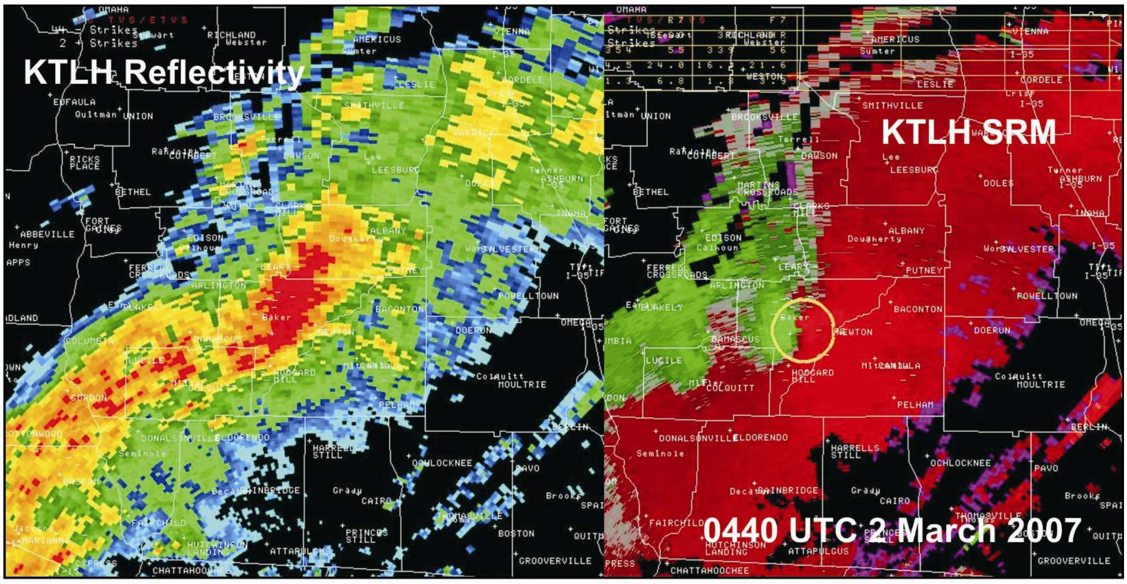

Figure 10. KTLH WSR-88D radar reflectivity (left) and SRM for 0440 UTC, 2 March 2007.

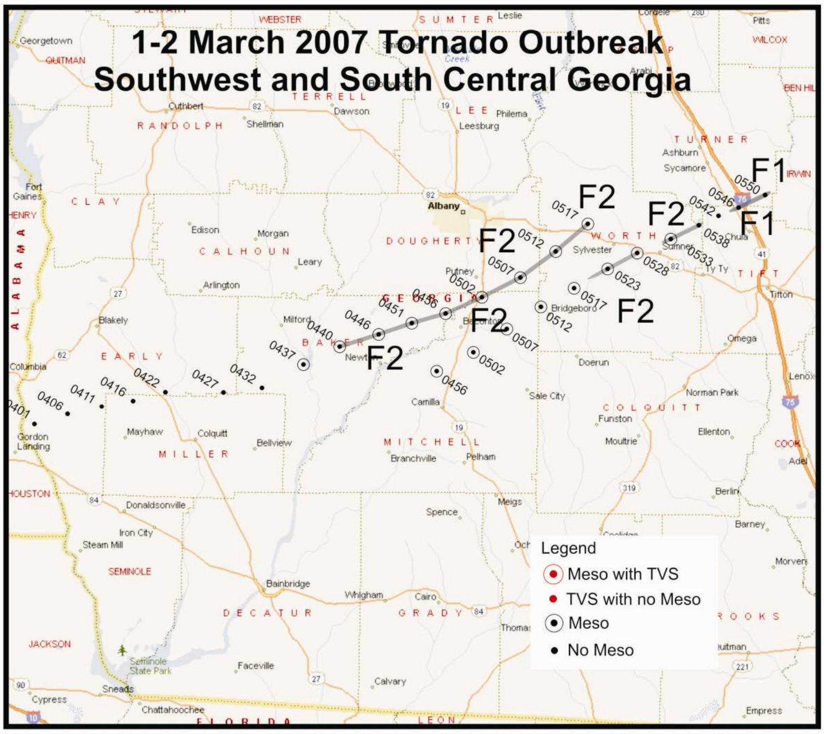

Figure 11. Track and times of southwest Georgia mesocyclones including shaded tornado tracks on 2 March 2007.

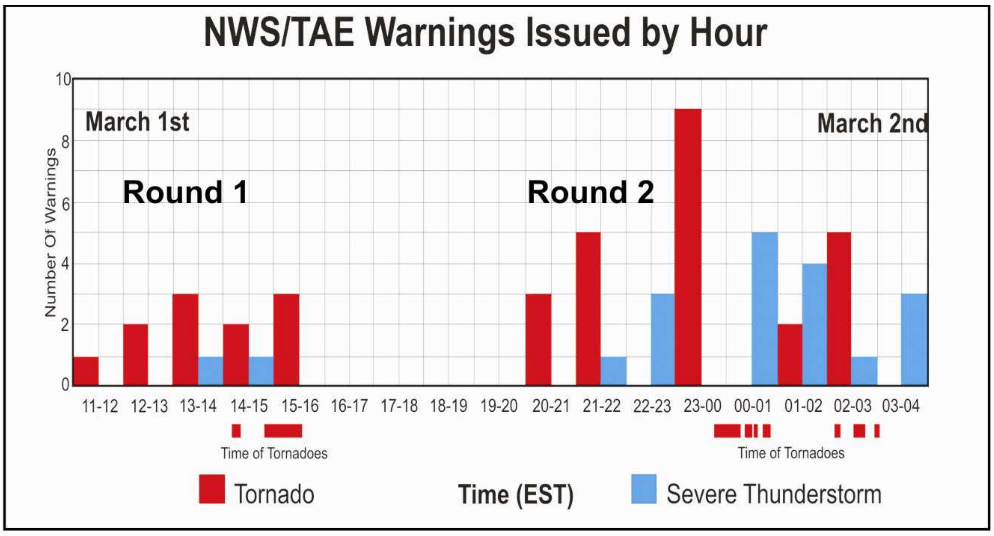

Figure 12. Tornado and severe thunderstorm warnings by hour clearly show two rounds of severe weather.

Tornado Enhanced Fujita (EF) Scale Ratings

EF Scale	Name	Path Length (miles)	Max Width (yds)
EF-4	Enterprise, AL	10	500
EF-2	Newton, GA	30	200
EF-2	Worth Co, GA #2	5	150
EF-2	Worth Co, GA #3	3	150
EF-1 (high)	Echo, AL	37 (intermittent)	150
EF-1	Tift-TurnerCo, GA	8	150
EF-0	Jefferson Co, FL	2	50
EF-0	Cherry Lake, FL	3	50
EF-0	Lake Park, GA	2	50

Severe Thunderstorm Warnings: 19
Verified: 14
Average Lead Time: 24.1 min
POD = 1 FAR = 0.26 CSI = 0.74
SVS:SVR Ratio: 0.8:1

Tornado Warnings: 35
Verified: 19
Average Lead Time: 19.8 min
POD = 1 FAR = 0.46 CSI = 0.54
SVS:TOR Ratio: 1.3:1

Table 1. Summary of EF ratings for the tornadoes that occurred in the WFO Tallahassee county warning area. Tornado and severe thunderstorm warning statistics are also included.