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THE CORPUS CHRISTI, TEXAS
TORNADOES OF OCTOBER 24, 2002

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I. INTRODUCTION

During the early afternoon hours of October 24, 2002, a mini-supercell produced a family of tornadoes that moved through the northwest portion of the city of Corpus Christi, Texas. Three tornadoes produced significant damage resulting in 26 injuries and 1 fatality, and property losses amounting to around $85 million. Two of the three tornadoes were rated as F2 and this event marked the first tornado related fatality in the history of the city. These tornadoes occurred in an area of the country where significant tornadoes are extremely uncommon. This paper will present a brief review of the tornado climatology for South Texas (WFO Corpus Christi County Warning Area) with emphasis on Nueces County. It will then analyze the synoptic and mesoscale features that led to a favorable environment for the development of the strong tornadoes. An examination of radar data will look at the warning and situational awareness issues related to this event.

II. TORNADO CLIMATOLOGY FOR SOUTH TEXAS COASTAL BEND

Tornadoes are not a rare occurrence over South Texas. However, the intensity of the tornadoes that occurred on October 24, 2002 has rarely been seen in this part of Texas. Figure 1 shows the WFO Corpus Christi (CRP) County Warning Area (CWA) and can be used as a reference to visualize locations presented throughout this paper.

FIGURE 1. MAP OF WFO CORPUS CHRISTI, TEXAS CWA – 15 COUNTIES

In comparing the National Climatic Data Center database of Storm Data, the official record of tornadoes in South Texas, to the extensive research of significant tornadoes by Grazulis (1993), there are discrepancies that should be addressed. Since 1950, Storm Data lists 47 significant (F2 or greater) tornadoes for the WFO Corpus Christi County Warning Area, with 9 tornadoes being rated as intense as F3 on the Fujita scale.

In reference to Grazulis, only 21 significant tornadoes occurred since 1950, and none were rated with an F3 intensity. According to Grazulis, only the disastrous F4 tornado that struck Goliad in 1902 which killed 114 people and injured 250, has reached a F-scale intensity higher than F2 in South Texas. Most of the discrepancies occurred before 1980. Reasons for the discrepancies could be that errors were made in rating tornadoes previous to the Fujita scale implementation in 1971 and emphasis on training in damage surveys did not occur until the 1980s with better warning preparedness programs in the National Weather Service. For purposes of this paper in reference to significant tornado climatology, all references were made to the findings by Grazulis.

Early severe thunderstorm and tornado reporting, or lack thereof, was likely a function of several well known factors: (a) limited or no radar or satellite coverage before the 1960s, (b) the lack of existing or established communication networks during the early part of the 20th century, (c) unpopulated areas that did not lend themselves to eyewitness reporting of severe storms, and (d) non existence of an outreach program and few emergency manager positions in place to assist in severe weather reporting. Even today, many areas of South Texas are sparsely populated resulting in a lack of eyewitness tornado reporting.

FIGURE 2. TORNADOES + TRACKS ACROSS SOUTH TEXAS … 01/01/50 – 12/31/03

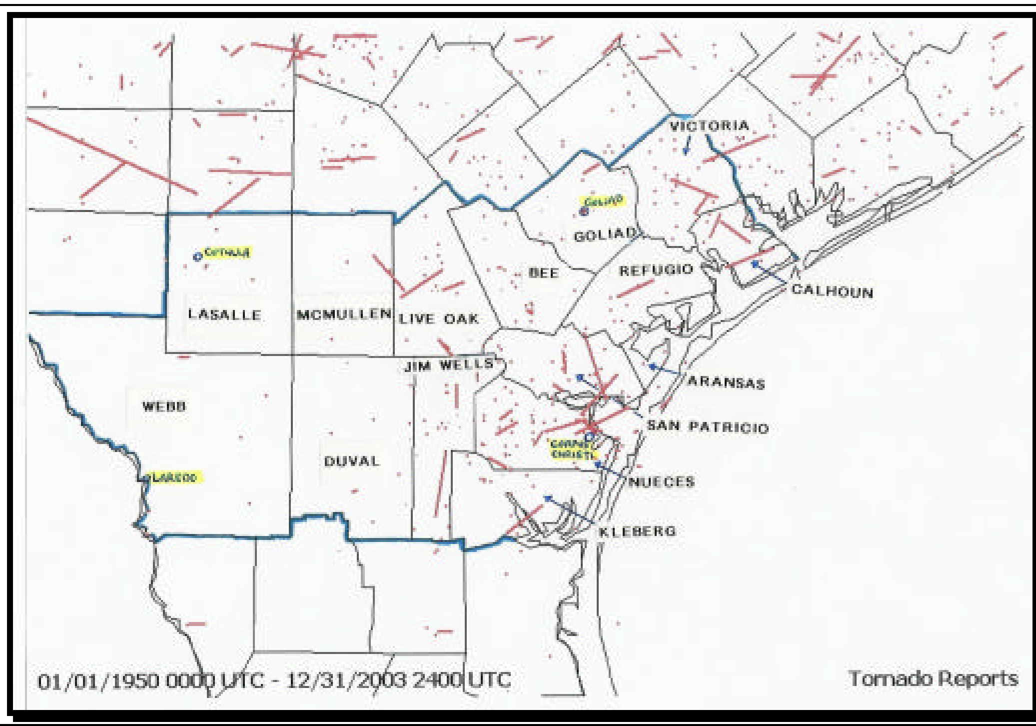


Figure 2 shows the number of and track of tornadoes across South Texas according to the Storm Prediction Center Severe Weather database from 1950 through the end of 2003. The graphic suggests issues related to population density that played a role in the number of tornadoes that were reported compared to what may have actually occurred. Note that counties with larger population figures (eastern half of the CWA) report most of the tornadoes shown, while less populated areas in Webb, La Salle, Duval, and McMullen Counties provide less opportunities for observation and reporting of damage to mainly open stretches of land and property.

FIGURE 3. TORNADOES SINCE 1950 FOR CORPUS CHRISTI CWA

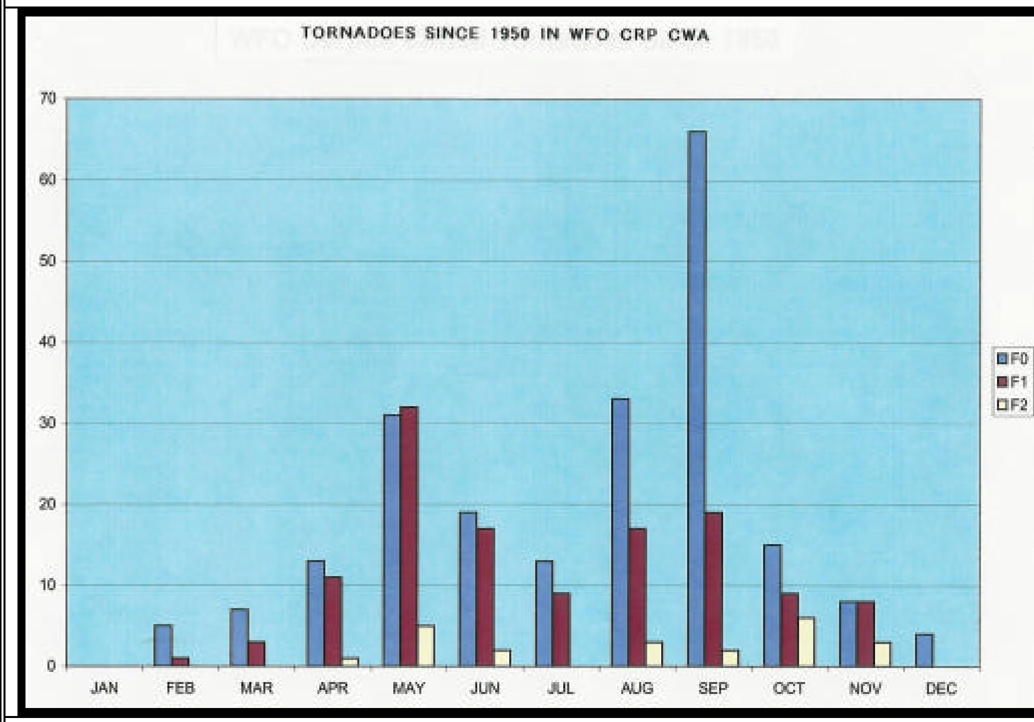


Figure 3 shows the annual distribution of tornadoes and their intensities (Fujita scale). The frequency graph shows that the majority of the tornadoes that impact the WFO CRP CWA are F1 or weaker. The documented F2 tornadoes are rare.

There are two peak periods of tornado occurrence in the Corpus Christi CWA. The month of May peaks with just over 60 tornadoes or an average of one tornado per year in that month. Activity during this period of time is related to the normal spring severe weather season that affects most of Texas. A more active period is seen in August and September. However, note that while the number of tornadoes reported increase, most are in the F0 category. The increased tornado activity during these two months can be attributed to tropical systems including Hurricanes Carla (1961), Beulah (1967), Celia (1970), Allen (1980), and Gilbert (1988). According to Spalding (1997), about 23 percent of all tornadoes were associated with tropical cyclones during the period from 1950 to 1994. The monthly maximum is skewed to September by the number of tornadoes (42) associated with Hurricane Beulah in 1967.

Table 1 shows the dates, locations, number of injuries and fatalities for each significant tornado event (F2 or greater) within the Corpus Christi CWA. Since 1900, the months of October and May have recorded the highest number of F2 tornadoes.

DATE	COUNTY/ CITY	INJURED	DEAD	F SCALE
05/18/1902	Goliad / Goliad	250	114	F4
05/01/1912	Webb	3	1	F2
03/24/1922	Nueces	-	-	F2
03/30/1935	Jim Wells	7	1	F2
06/12/1935	Nueces	0	0	F2
05/16/1938	San Patricio	0	0	F2
10/23/1953	Nueces/ Port Aransas	0	0	F2
10/22/1954	San Patricio/ 10N Taft-Portland	25	0	F2
06/06/1955	La Salle/ Encinal	0	0	F2
05/10/1959	Live Oak/ Clegg	0	0	F2
10/16/1960	San Patricio/ 3S Sinton-4NW Sinton	0	0	F2
10/16/1960	Nueces/ SW Corpus Christi	3	0	F2
11/02/1961	Calhoun/ Port Lavaca	0	11	F2
11/08/1963	Refugio/ 8SE Woodsboro – 4NW Refugio	0	3	F2
05/18/1965	Refugio/ Refugio – 9NE Refugio	0	0	F2
05/18/1965	Duval/ 10N San Diego	0	0	F2
09/20/1967	Calhoun/ 1N Port Lavaca	1	0	F2
09/20/1967	Aransas/ Fulton Beach – Copano Village	3	0	F2
11/05/1968	Victoria/ Victoria	2	0	F2
06/24/1970	Nueces/ Bishop	15	1	F2
08/03/1970	Live Oak/ Lake Corpus Christi	2	1	F2
04/27/1972	Nueces/ Corpus Christi	0	0	F2
05/15/1980	Live Oak/ 13W George West – George West	0	0	F2
08/09/1980	Nueces/ Bishop	3	0	F2
08/10/1980	Jim Wells/ Alice	1	0	F2
10/24/2002	Nueces/ NW Corpus Christi	20	1	F2
10/24/2002	Nueces/ N Corpus Christi – 3NW N.Beach	0	0	F2

TABLE 1.

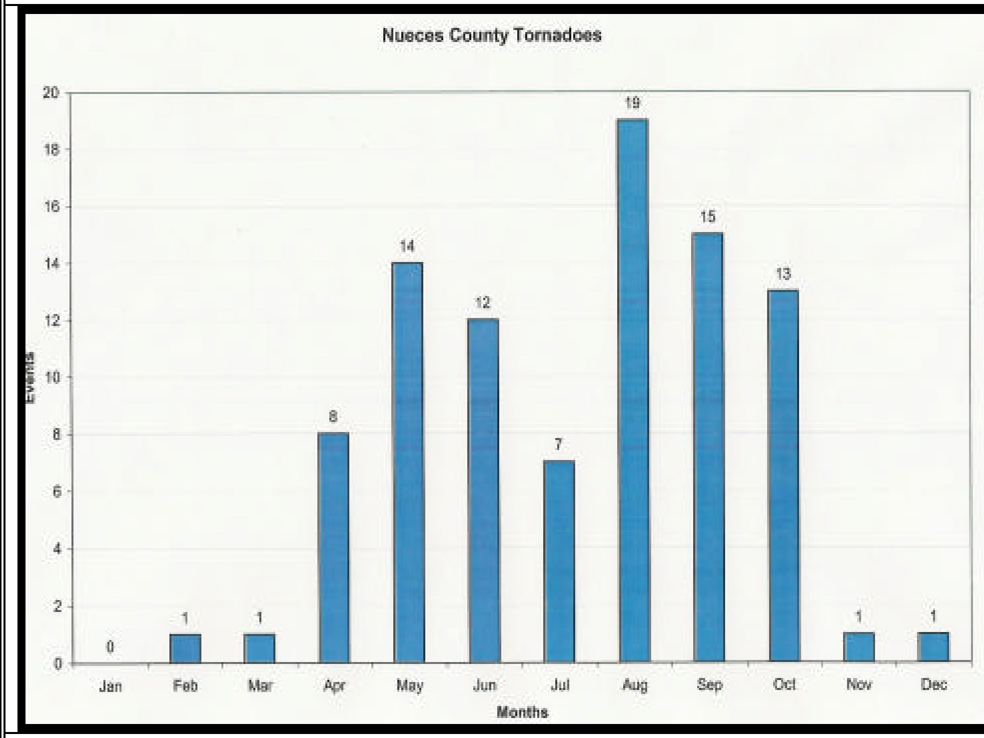
List of F2 or greater tornadoes within the WFO Corpus Christi CWA according to Grazulis (1993) except for the 2002 tornadoes

III. HISTORICAL TORNADO RECORD FOR NUECES COUNTY

Within the WFO Corpus Christi CWA, Nueces County has the most tornado reports with 92 tornadoes recorded since 1950. Of this number, 7 were rated F2 including the 2 tornadoes that were part of the family of tornadoes on October 24, 2002. These numbers are approximately one quarter of the reports in the CWA for both significant tornadoes and total number of tornadoes. Only one other fatality associated with a tornado has occurred in Nueces County since 1900. This occurred in Bishop, southwest of Corpus Christi, on June 24, 1970.

Figure 4 shows the monthly distribution of tornadoes in Nueces County. Note that there is a very significant peak during the tropical cyclone season during the months of August and September. For non-tropical cyclone related tornadoes, the peak month occurs in May with a total of 14 recorded cases, and October is close behind with 13 tornadoes recorded.

FIGURE 4. TORNADO FREQUENCY FOR NUECES COUNTY IN SOUTH TEXAS



IV. ANALYSIS OF PRE-STORM ENVIRONMENT

A. Early Morning

Upper air analysis at 12 UTC on October 24, 2002 showed a trough at 500 mb over the southwestern United States with a strong shortwave trough lifting to the northeast out of southern New Mexico and southwest Texas (Figure 5). The 06 UTC RUC model data indicated a weaker short wave trough moving out of the Big Bend and northeast Mexico. A developing mesoscale convective vortex within an area of convection moving into the Texas Hill Country was associated with this weaker shortwave. An axis of higher moisture was located from Deep South Texas along the Rio Grande River into the Permian Basin within a southeast flow of 25 to 30 knots at 850 mb (Figure 6).

FIGURE 5. 500 MB 12 UTC 10/24/2002
HEIGHT (BLACK) AND TEMPERATURE. (DASH RED).

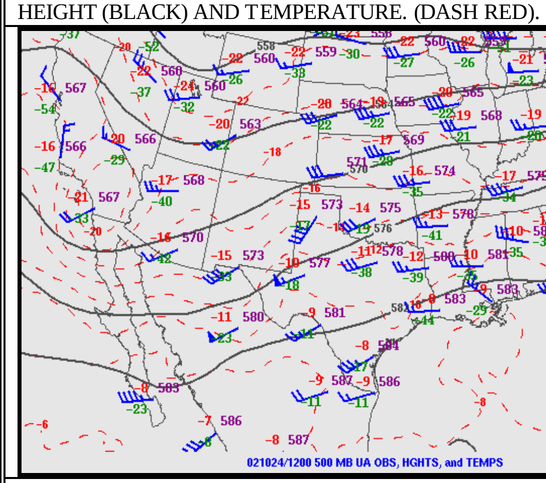
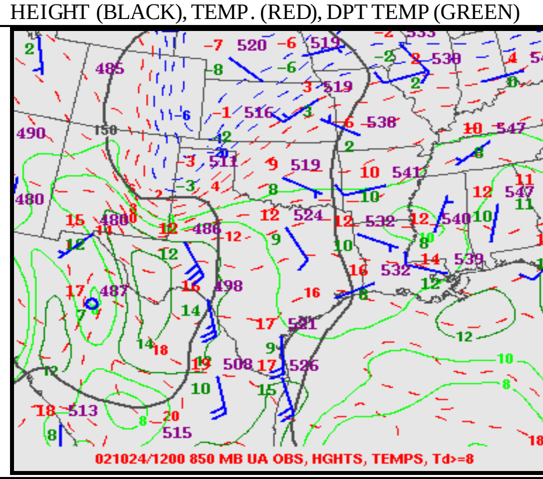


FIGURE 6. 850 MB 12 UTC 10/24/2002
HEIGHT (BLACK), TEMP. (RED), DPT TEMP (GREEN)



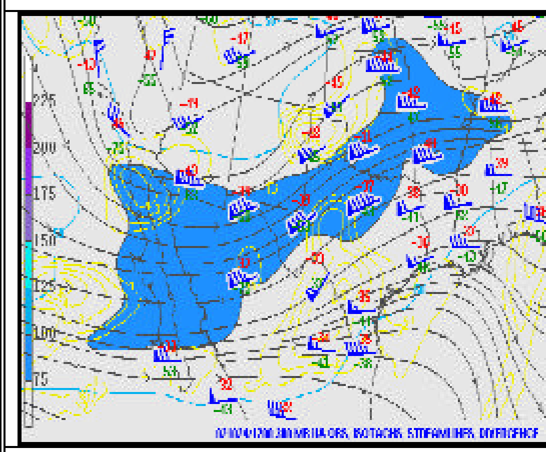


Figure 7. 300 MB 12UTC 10/24/2002
Streamlines (black) and divergence (yellow).

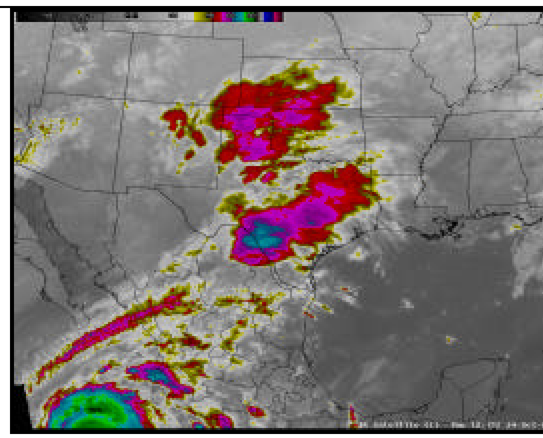
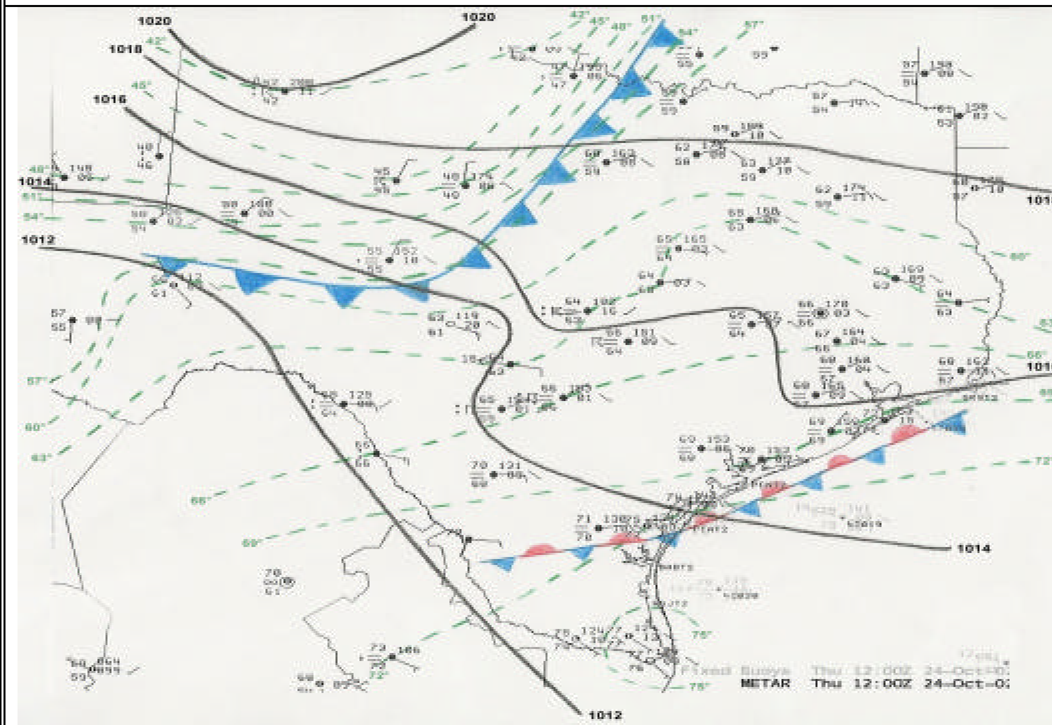


Figure 8. 1215 UTC IR Satellite Image. 10/24/2002

A jet streak of 70 to 80 knots at 300 mb was located across southern Baja California into northern Mexico (Figure 7). The upper level flow pattern was strongly divergent over northeast Mexico into South Texas. Infrared satellite imagery showed this jet streak was emanating from the major Hurricane Kenna off the coast of southwest Mexico (Figure 8). The 12 UTC upper air maps from SPC are shown in this analysis.

The surface analysis at 12 UTC (Figure 9) more clearly indicated a boundary was located from the upper Texas coastal waters into the Coastal Bend with easterly winds behind the boundary from Corpus Christi to Laredo. Southeast winds and dewpoint temperatures in the middle to upper 70s F were present over the coastal sections of Deep South Texas south of the front. A stronger cold front was analyzed from northeast Oklahoma to the Concho Valley in Texas.

FIGURE 9. 12 UTC SURFACE ANALYSIS 10/24/2002



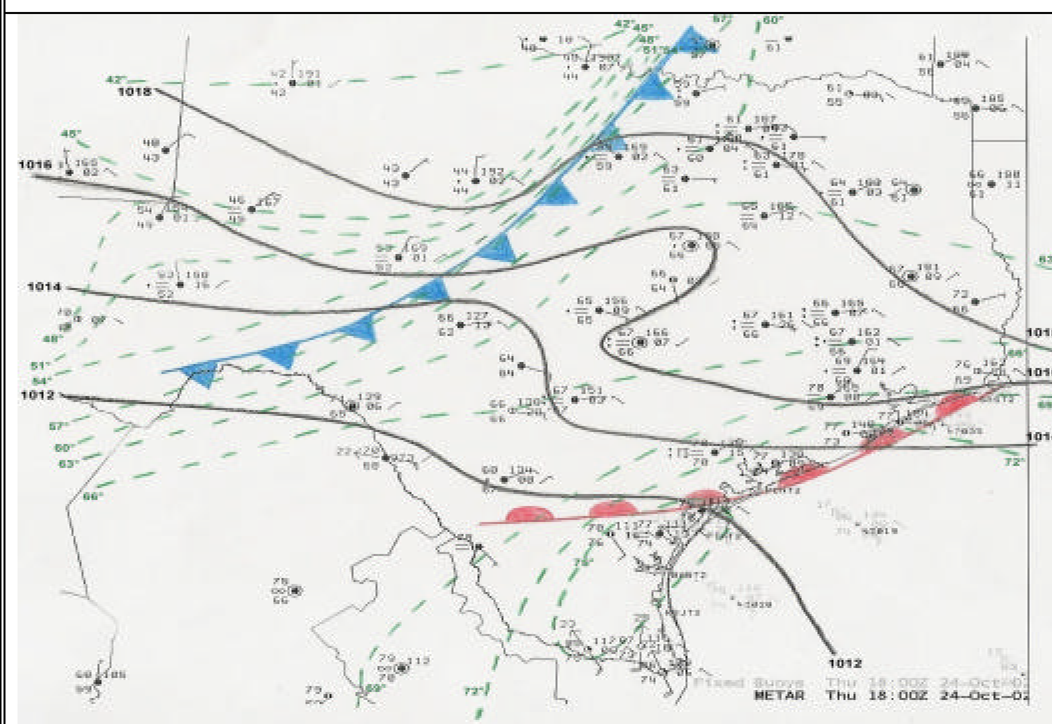


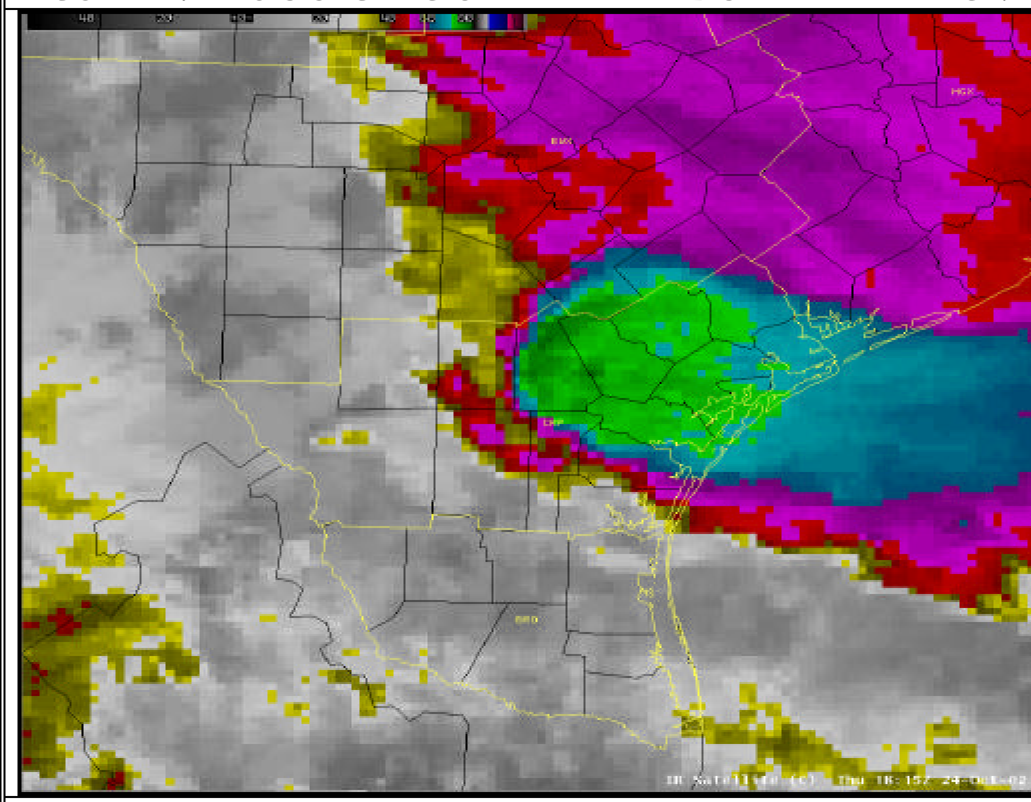
Figure 10. 18 UTC SURFACE ANALYSIS 10/24/2002

A developing Mesoscale Convective System (MCS) was over the northern Rio Grande Plains and western Hill Country at 12 UTC. This activity was occurring in a region of strong 850 mb warm air advection north of the stationary surface boundary and therefore elevated above the boundary layer. Scattered convection was occurring over Deep South Texas and the nearby coastal waters within the boundary layer.

B. Early Afternoon

By 18 UTC, the boundary previously south of the Coastal Bend had moved slowly to the north (Figure 10). The boundary was now located from the upper Texas Coast south of Houston to the northern portions of the Coastal Bend from Port O'Connor to Encinal. A weak trough of low pressure had moved into the Coastal Bend as the winds became southeast and dewpoint temperatures rose to the middle 70s F. While the temperatures in Deep South Texas warmed into the upper 80s F, the dewpoint temperatures remained in the middle 70s F, thus producing a strong conditionally unstable airmass in the warm sector that was weakly capped around 700 mb (Figure 13).

FIGURE 11. 1815 UTC REGIONAL INFRARED SATELLITE IMAGE.



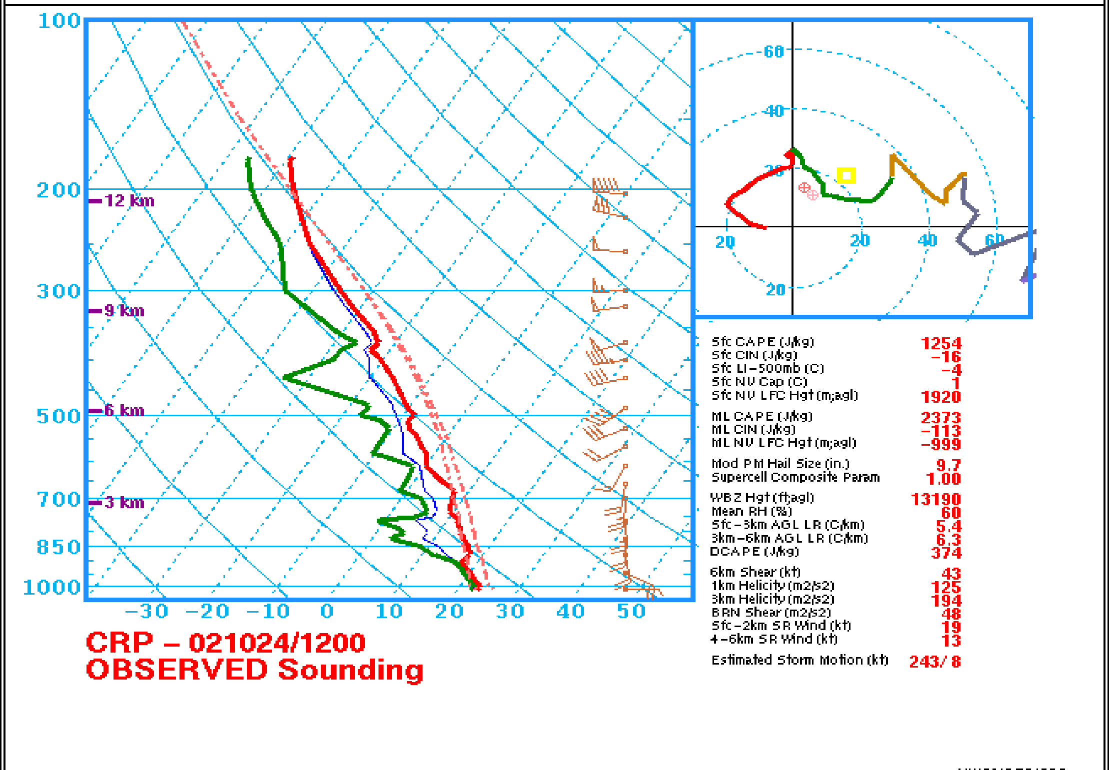
The MCS continued to move to the east into south-central Texas and the northern portions of the WFO CRP CWA by 18 UTC. The MCS tracked just north of the boundary. The strongest activity remained northwest of Corpus Christi as was evident on the 18 UTC Infrared satellite image (Figure 11). Scattered thunderstorms along the Lower Texas Coast were moving northward into the Coastal Bend.

V. SOUNDING ANALYSES

A. Early Morning – Unmodified

The 12 UTC sounding at Corpus Christi (CRP) showed strong veering in the low levels north of the boundary (Figure 12). Comparing the CRP sounding with the Brownsville (BRO) sounding (Figure 13) showed 0-3 km helicity (194 m2/s2) over the Coastal Bend was significantly stronger than over Deep South Texas (91 m2/s2). Davies-Jones, et al. (1990) showed breakpoint helicity values associated with weak (F0-F1) and strong (F2-F3) tornadoes were 150 and 300 m2/s2, respectively. As for instability, the BRO sounding was much more unstable than the CRP sounding with surface based CAPE values near 3950 J/kg compared to around 1250 J/kg for CRP.

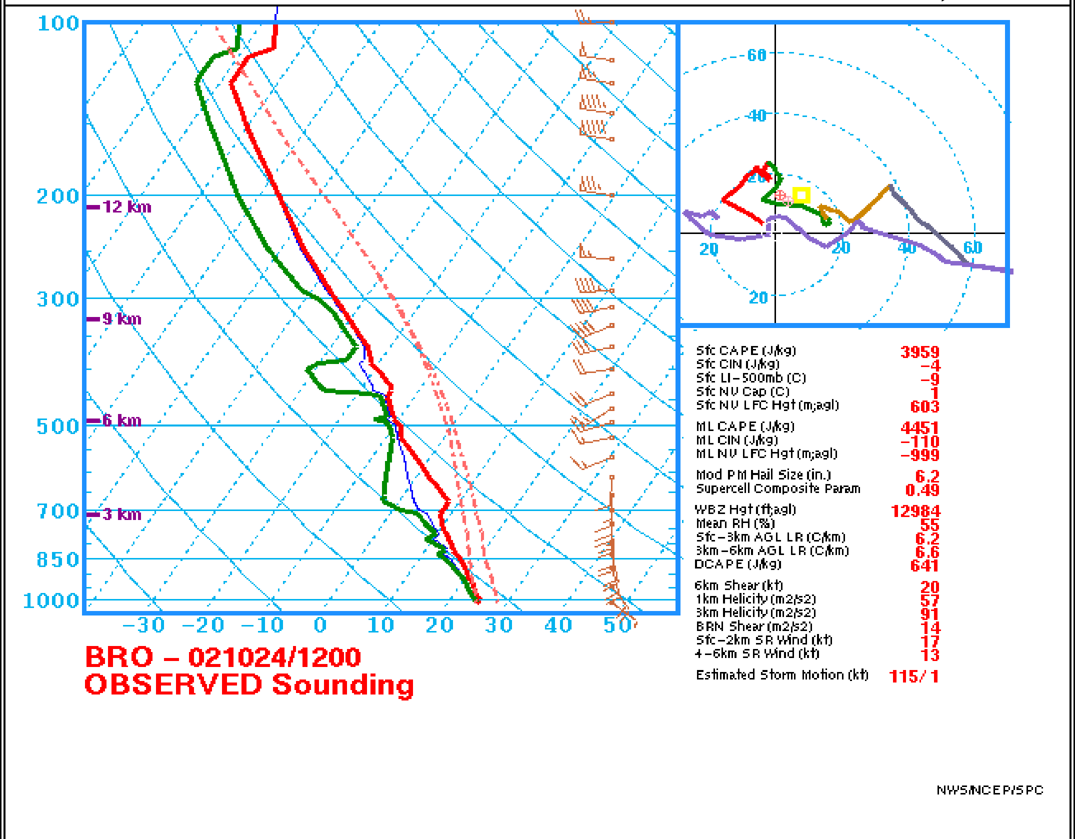
FIGURE 12. SKEW-T AND HODOGRAPH FOR CORPUS CHRISTI, TX



The BRO sounding showed steeper surface to 3 km lapse rates than CRP along with higher low level equivalent potential temperature (theta-e). The low level moisture was deeper over the Lower Rio Grande Valley, to approximately 800 mb, with the precipitable water values at 2.1 inches. The moisture depth was more modest over the Coastal Bend with low level moisture depth up to 900 mb and a precipitable water value around 1.7 inches.

At 18 UTC, the more unstable airmass over Deep South Texas had advected into the Coastal Bend with temperatures approaching 80 F and dewpoint temperatures in the middle to upper 70s F. Modifying the 12 UTC CRP sounding, surface based Convective Available Potential Energy (CAPE) values increased to around 3200 J/kg.

FIGURE 13. SKEW-T AND HODOGRAPH FOR BROWNSVILLE, TX.



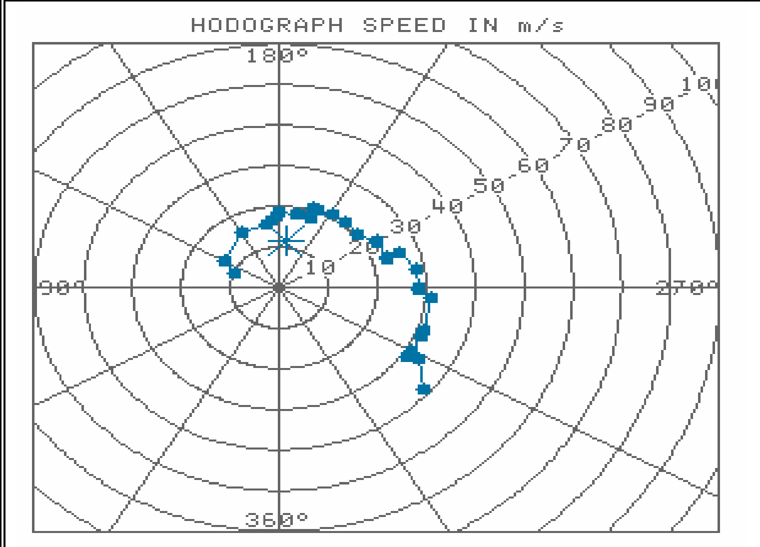
B. Early Afternoon – Modified Sounding

The wind profile from the 12 UTC sounding on October 24, 2002 supported the development of tornadic activity. The hodograph showed strong directional wind shear in the lowest kilometer with winds veering significantly with height. Davies-Jones (1984) showed that mesocyclones formed within an environment where the storm-relative low level winds are strong (10 m/s or higher) and veer with height (at least 90 degrees in the lowest 3 km AGL). Johns and Doswell (1992) discussed the need for sufficient dry air in the downdraft entrainment layer to support downdraft development and the generation of low level baroclinic vorticity necessary for tornadogenesis. Both the 12 UTC CRP and BRO soundings showed a layer of drier air near 800 mb and near 700 mb, respectively.

The 0-6 km shear at Corpus Christi continued to increase as the stronger mid-level winds approached from the west with the short wave trough and as the low level flow increased over the Coastal Bend to near 35 knots at 850 mb. The 0-3 km helicity was also increasing over the region as the low level flow increased.

Figure 14 is a modified hodograph using winds from the VAD Wind Profile from the KCRP radar at 19 UTC. The blue asterisk is the storm motion of 190 degrees at 21 knots exhibited by the supercell.

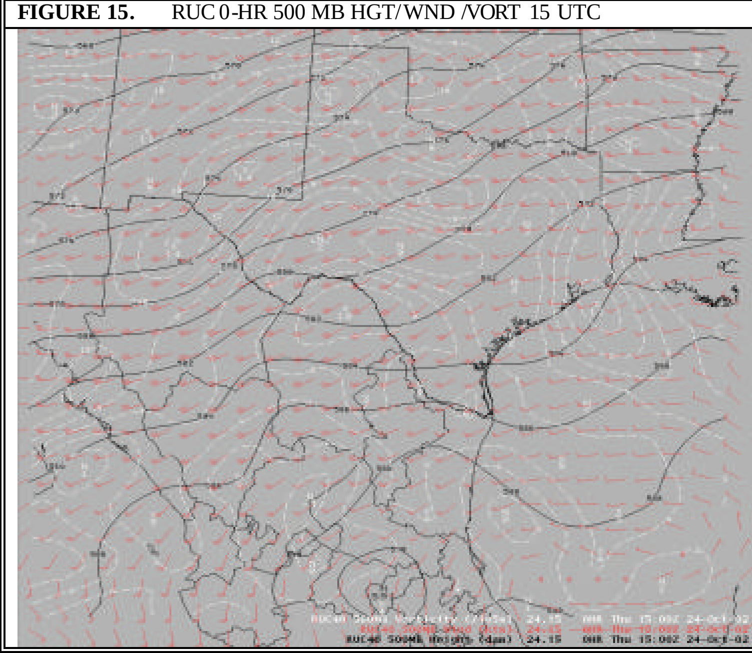
FIGURE 14. MODIFIED HODOGRAPH FOR 19 UTC FOR CORPUS CHRISTI. UNITS ARE IN M/S. THE 0-3 KM SHEAR LAYER ENDED AT 210 DEGREES.



VI. NUMERICAL MODEL ANALYSIS

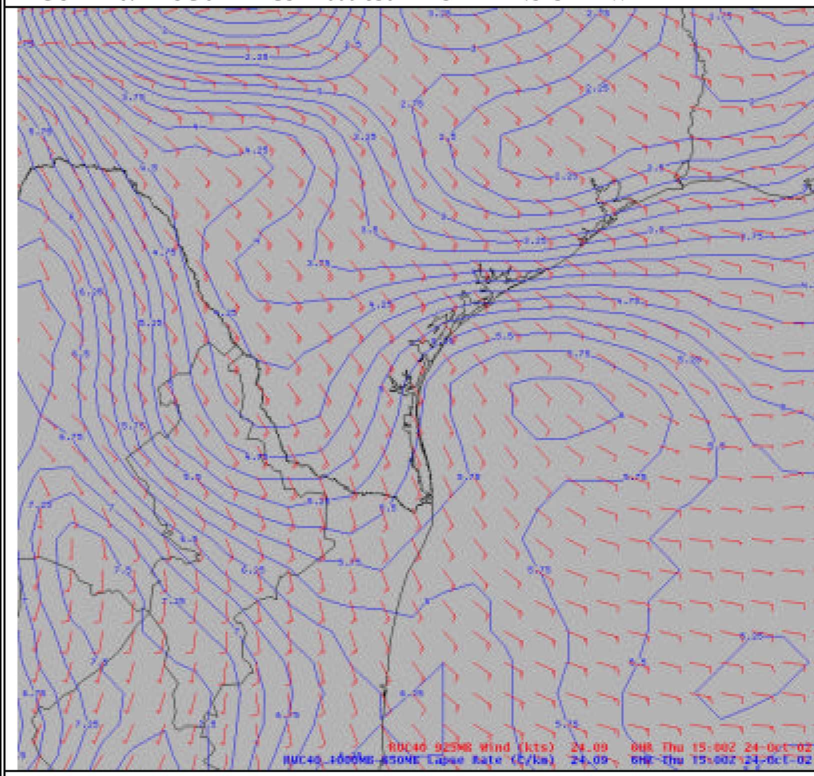
The AVN and RUC (Figure 15) models had a better forecast position and strength of the 500 mb short wave trough moving into the northern Rio Grande Plains at 15 UTC.

FIGURE 15. RUC 0-HR 500 MB HGT/WND/VORT 15 UTC



The Eta and NGM models were too weak with the short wave trough and too far west. Therefore, these models strongly under forecast the strength of the mid-level winds over South Texas.

FIGURE 16. RUC 6-HR FCST 1000-850 LAPSE RATE/925 MB WIND



However, all models depicted the short wave trough moving northeast into Central Texas by 18 UTC. The models did not handle the strength and movement of the MCS and the associated mesoscale convective vortex very well. The southern line of convection associated with the MCS showed development to the south-southwest indicative of an upwind-propagating MCS. Using the Corfidi (2003) method for forecasting MCS motion for upwind-propagation, the expected movement of the MCS would be to the east into South Texas. With the models erroneously moving the short wave trough into Central Texas, the mid-level wind field over South Texas by the early afternoon was under forecast and the 0-6 km shear values were stronger than the models depicted. The environmental shear was favorable for the development of supercells over South Texas.

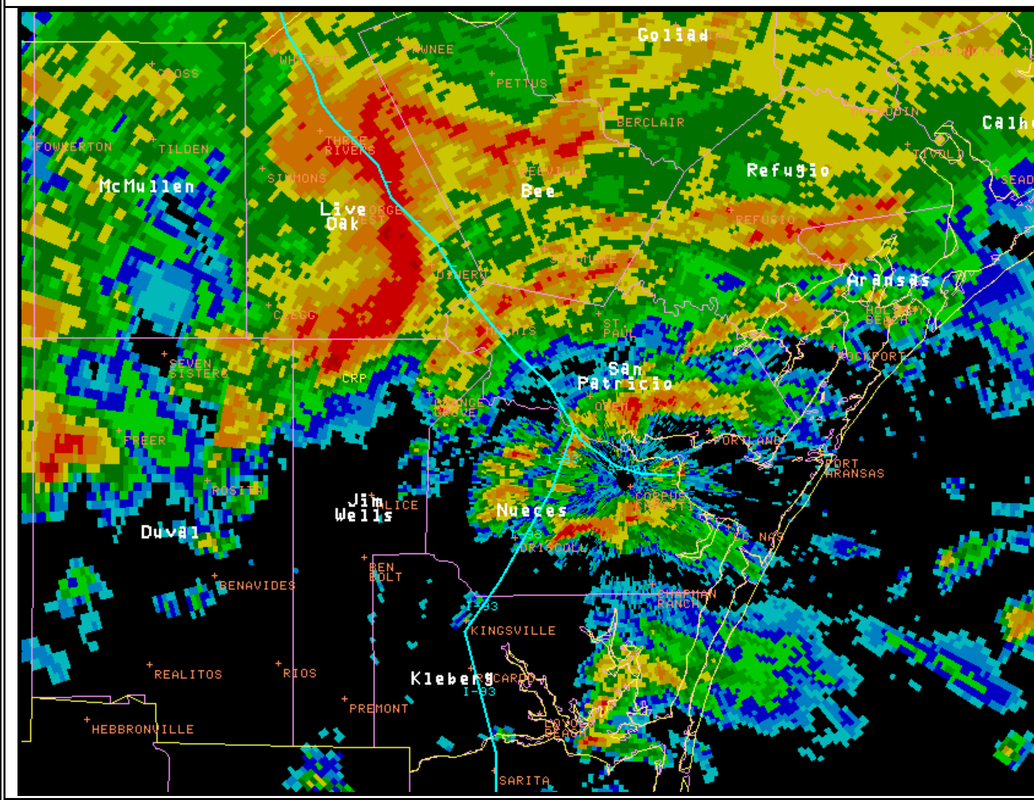
The AVN model was the preferred model with regards to the low level flow at 925 mb over South Texas. The AVN model also was better with the forecast of the higher 1000 to 850 mb lapse rates over Deep South Texas and the nearby offshore waters (Figure 16).

Therefore, the AVN had a better depiction of the stronger instability residing to the south of the Coastal Bend. The Eta model was notably too weak with the instability fields over South Texas during the morning, with CAPE values less than 1000 J/kg. The AVN and RUC models showed the surface theta-e ridge moving into the Coastal Bend by 18 UTC.

VII. RADAR ANALYSIS

A concern during the morning and early afternoon was the advancing Mesoscale Convective System (MCS) moving east across South Texas. At 18 UTC the strongest thunderstorms with the MCS were moving east at 35 knots across Live Oak County (Figure 17).

FIGURE 17 - KCRP REFLECTIVITY IMAGE FOR 1758 UTC 10/24/2002.

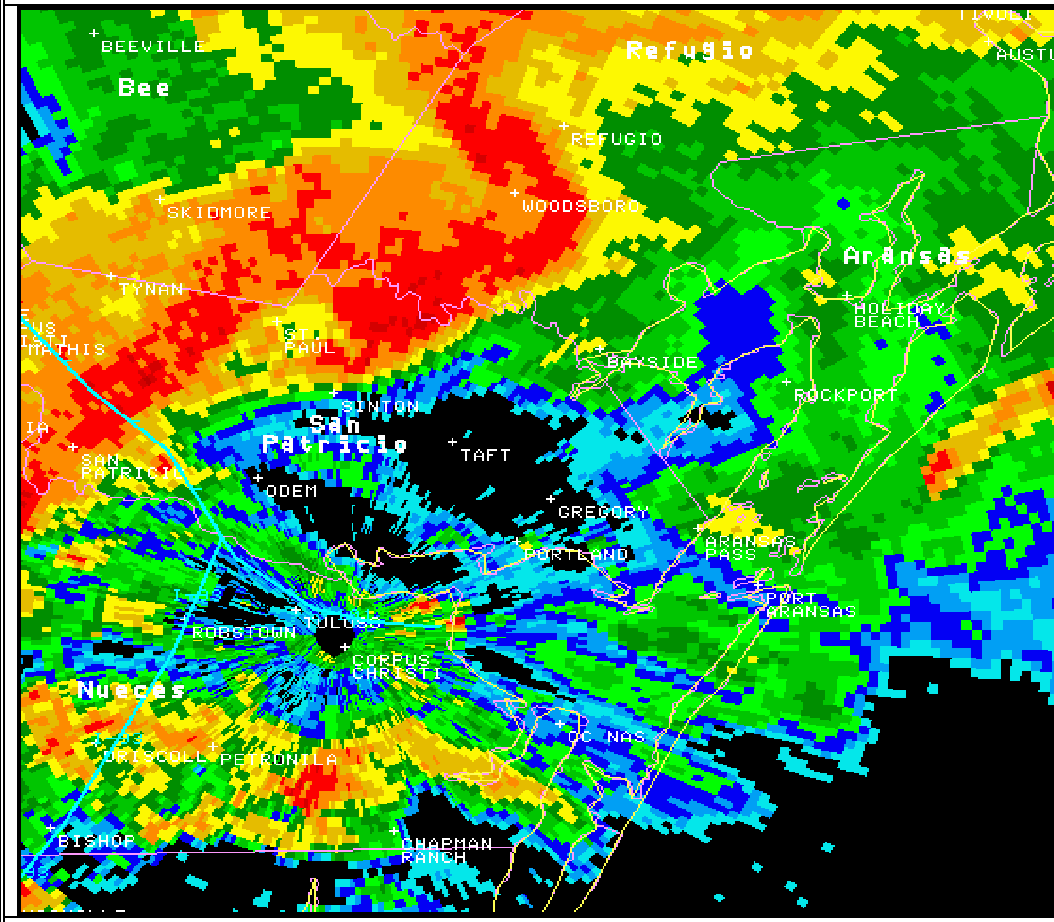


Light blue line from Live Oak County to Corpus Christi represents Interstate 37 while the line that branches south is US Highway 77.

The line of thunderstorms began to bow as it moved east into Southern Bee and Western San Patricio Counties at 1830 UTC. The mini-supercell over Baffin Bay moved north to the upper reaches of Alazan Bay. The cell exhibited a weak echo region as the rotational velocity (Vr) increased to 21 knots up to a depth of around 12 thousand feet.

By 1900 UTC, the line of thunderstorms bowed coincident with a rear inflow notch, and a cyclonic rotating vortex developed as the storm moved into southern Refugio County (Figure 18). The mini-supercell moved into the south central portion of Nueces County south of the Corpus Christi International Airport. Radar indicated convergent rotation on the 0.5 degree slice while the rotational velocity increased to around 26 knots from 1500 to 10000 feet (not shown).

FIGURE 18. KCRP 0.5 DEGREE REFLECTIVITY AT 19 UTC

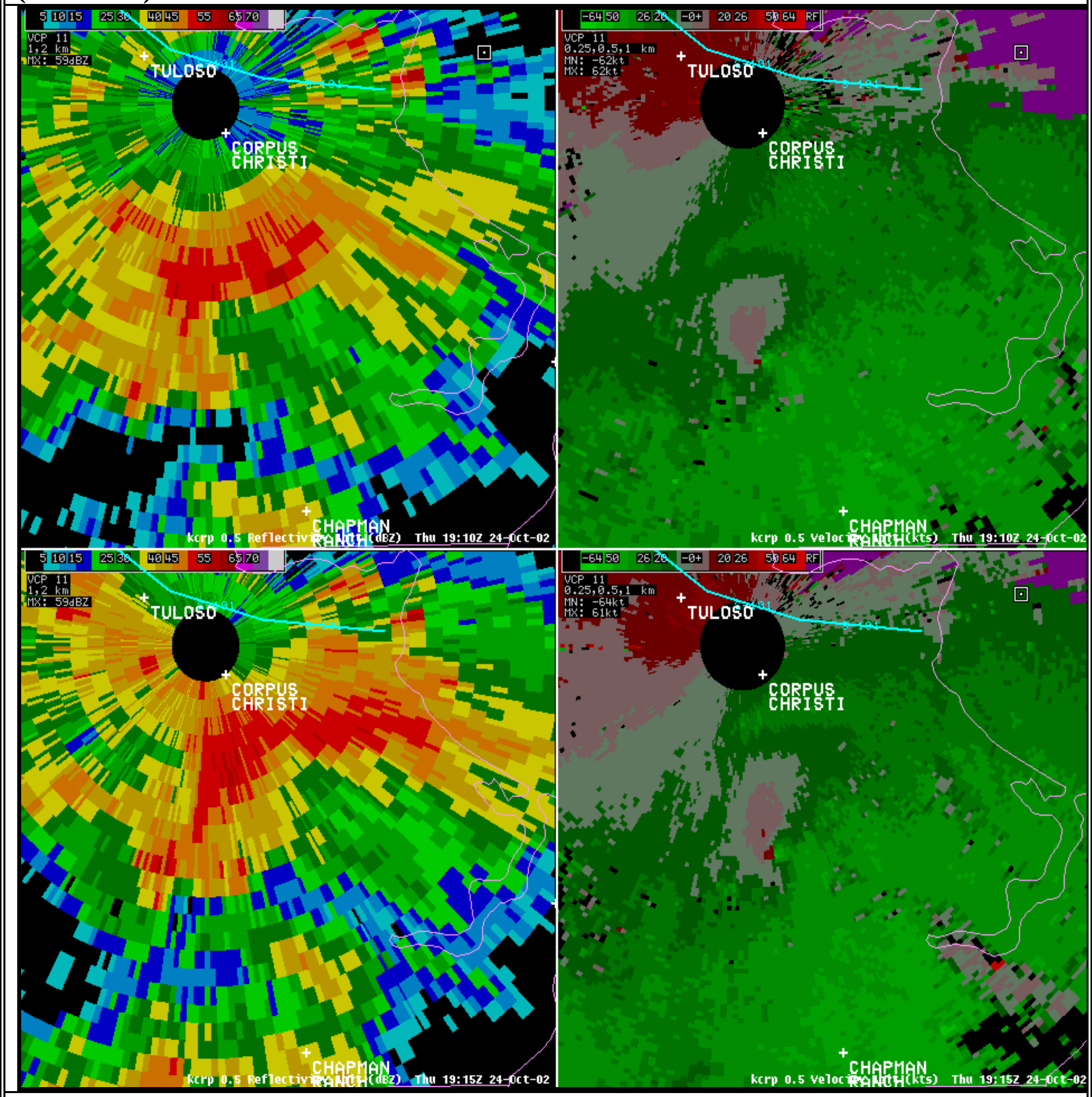


Interstate 37/ US Highway 77 shown in light blue

At 1910 UTC, the broad circulation associated with the bookend vortex on the storm in Refugio County increased to 50 knots rotational velocity (Vr) (not shown). A Tornado Vortex Signature with gate-to-gate Vr of 36 knots was indicated on the 0.5 degree Velocity image with the storm south of the airport. Vr increased to 30 to 35 knots through the depth of the mesocyclone up to 12 thousand feet. The strong mesocyclone continued through the 1915 UTC scan with the 0.5 degree Velocity image showing Vr had increased to 40 knots.

At 1915 UTC, the reflectivity increased to above 50 dBZ at the tip of the hook echo (Figure 19). This is possibly indicative of debris within the tornado. The first report of a tornado was at 1919 UTC, but radar data suggest the tornado likely formed shortly before 1910 UTC about 9 miles south of the Corpus Christi International Airport.

FIGURE 19 -- KCRP 0.5 DEG. Z/V COMBINATION 1910 UTC (TOP) AND 1915 UTC (BOTTOM).

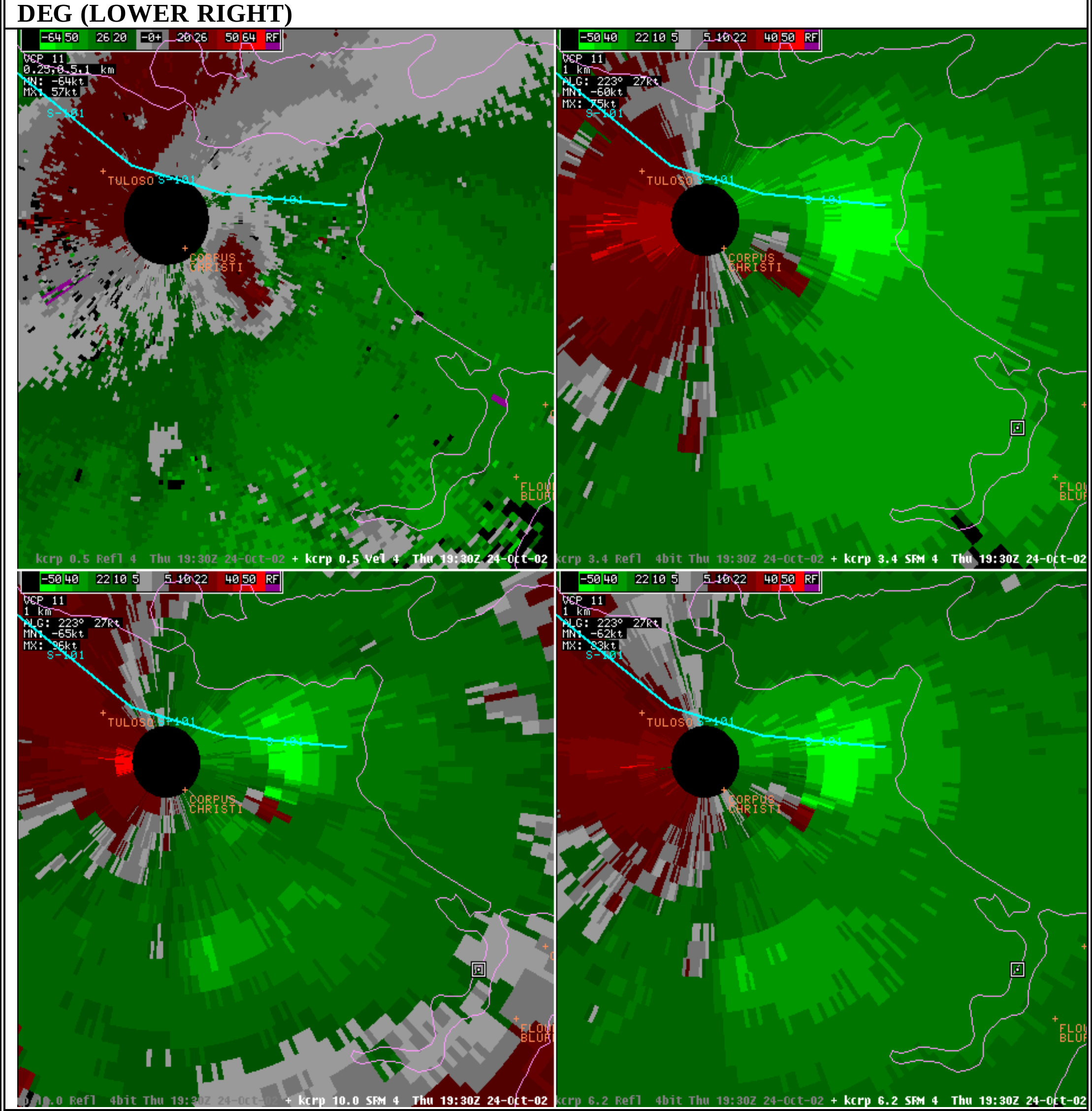


Thin blue line is Interstate 37 that runs south of Nueces Bay down to the Bayfront.

As the mini-supercell passed within 5 nm of the radar, reflectivity (Z) display of the cell became more difficult to discern due to the lower resolution Z data. However, the higher resolution Velocity data clearly showed the tornadic circulation. The Velocity data was also better than the Storm Relative Motion (SRM) product since the SRM was using a storm motion of 220 degrees at 28 knots rather than the deviated motion of 190 degrees at 21 knots by the mini-supercell. The rotational signature weakened below 1500 feet at 1920 UTC and this weaker rotation continued through the 1925 UTC scan. The first tornado dissipated around 1928 UTC about 5 miles southeast of the airport.

However, the strong rotation continued above the near ground circulation with Vr values between 35 and 45 knots within the supercell between 1500 to 8000 feet. At 1930 UTC, the rotation increased on the 0.5 degree Velocity image with Vr values around 37 knots. The SRM products showed increasing low-level inflow backed to the east in the region north of the supercell (Figure 20). The SRM images at 1930 UTC showed east winds increasing to greater than 50 knots between 1500 and 5000 feet. (The SRM images utilized a storm motion slightly different than that of the mini-supercell.)

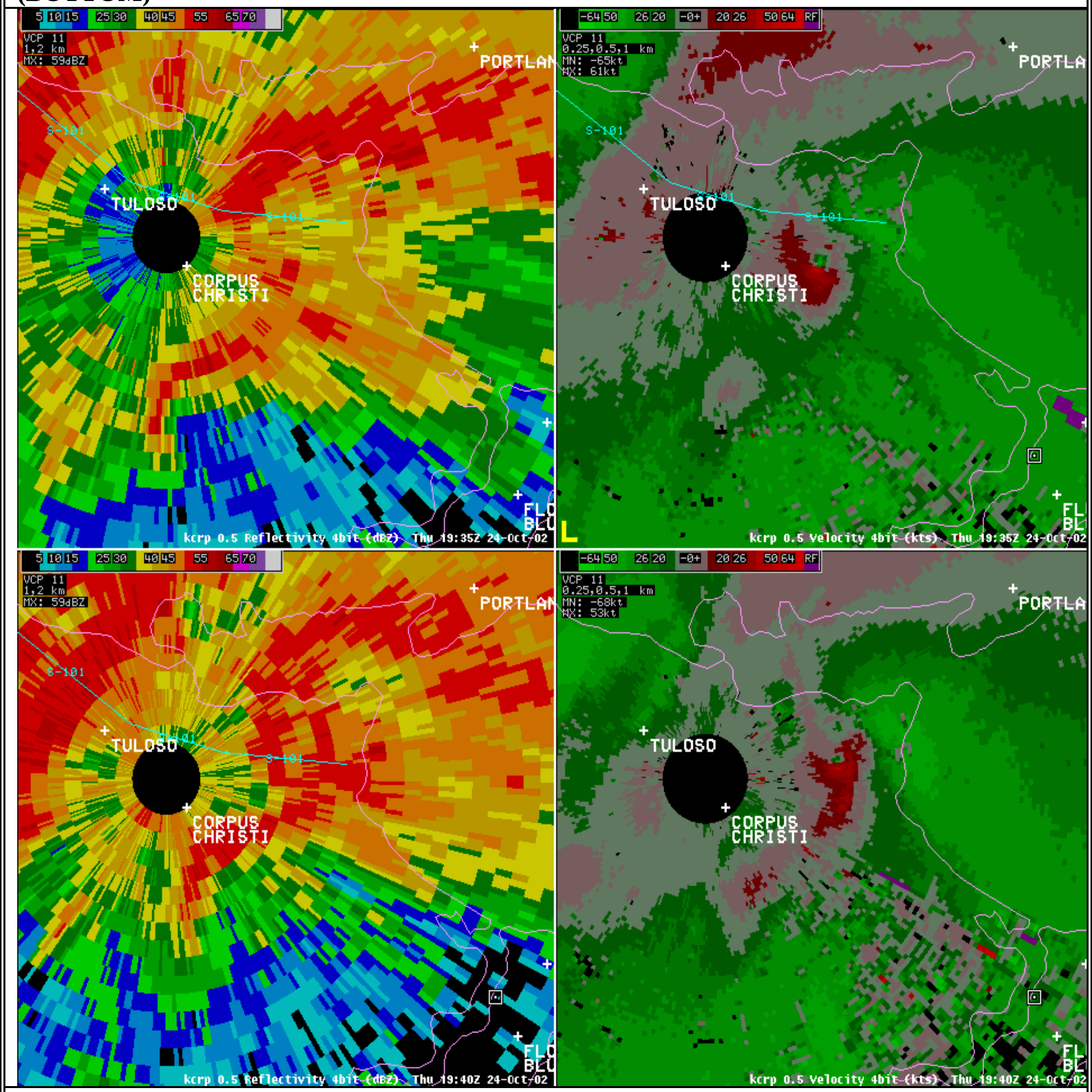
FIGURE 20 - KCRP 1930 UTC … 0.5 DEG. VELOCITY IMAGE (UPPER LEFT). STORM RELATIVE MOTION AT 3.4 DEG. (UPPER RIGHT), 6.2 DEG (LOWER LEFT) AND 10 DEG (LOWER RIGHT)



This intensification continued into the 1935 UTC and 1940 UTC scans as Vr increased to 50 knots. The diameter of the circulation decreased to around 0.2 nm (Figure 21). Between 1500 and 9000 feet, the Vr values increased to greater than 45 knots (according to archived SRM products on the higher elevation angles).

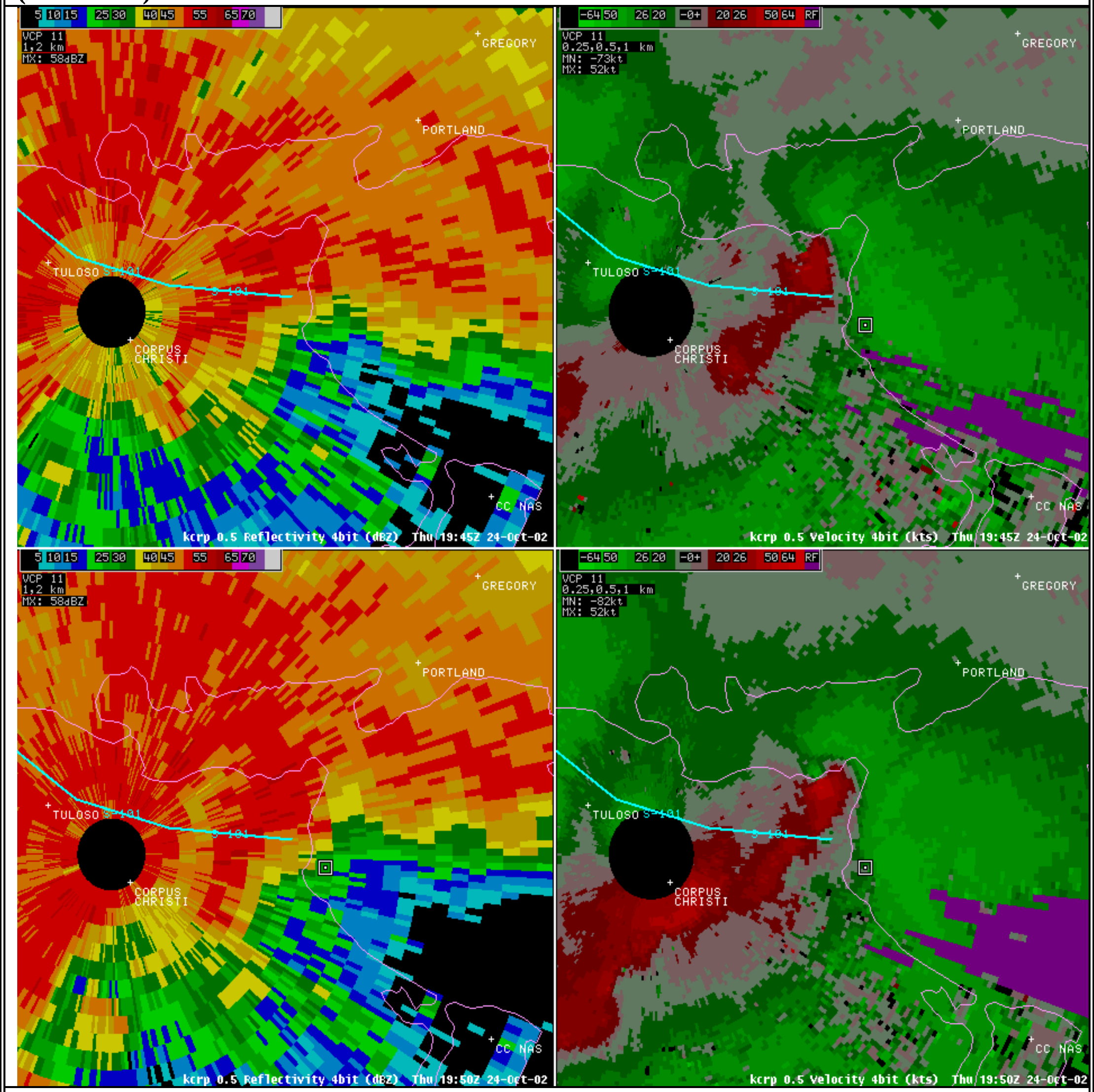
The second tornado formed at 1932 UTC, about 4 miles east southeast of the airport, and caused extensive damage at the West Campus of Del Mar College that was rated as F2 damage. Damage surveys and spotter reports indicated this tornado dissipated and a third tornado formed just south of Interstate 37 around 1940 UTC. Note the second cell south of the airport exhibited signs of rotation (Figure 21).

FIGURE 21 0.5 DEGREE Z/V COMBINATION AT 1935 UTC (TOP) AND 1940 UTC (BOTTOM)



By 1945 UTC, velocity data showed the rotational signatures had weakened slightly below 2 thousand feet. However, at 1950 UTC the Vr at the 0.5 degree angle increased back to 50 knots as the supercell moved into Nueces Bay (Figure 22).

FIGURE 22. KCRP 0.5 DEGREE Z/V COMBINATION 1945 UTC (TOP) AND 1950 UTC (BOTTOM)

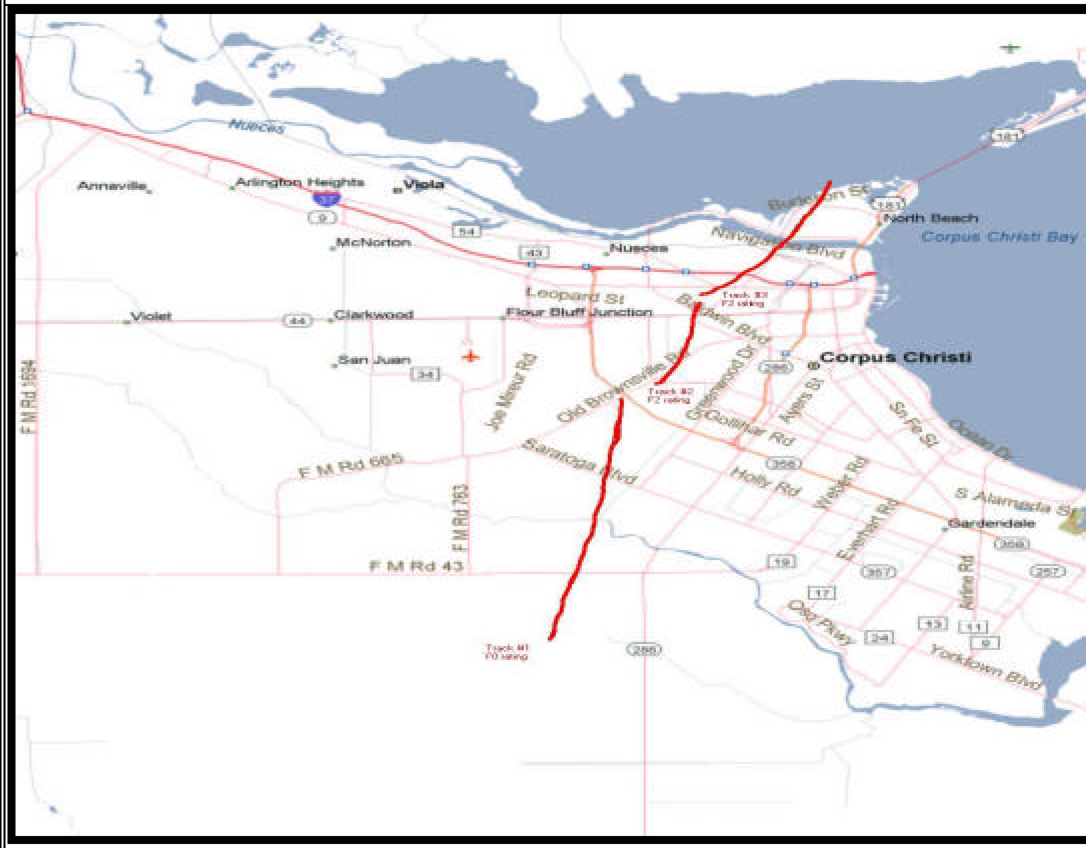


The third tornado damaged a grocery store and a refinery before moving into Nueces Bay. The damage associated with this tornado was rated as F2 damage. The tornado dissipated by 1955 UTC over Nueces Bay as the storm merged with the line of thunderstorms that moved into Corpus Christi.

VIII. BRIEF DESCRIPTION OF THE TORNADO PATHS

The track of the tornadoes that moved across the city of Corpus Christi can be seen in Figures 23 and 24. The three tornadoes were produced by the mini-supercell that moved just east of the Corpus Christi International Airport. The first report of tornado was about 9 miles south of the Corpus Christi airport at 1919 UTC. Radar data suggests the time of the initial tornado was likely around 1910 UTC. It was located just south of the small London community where an elementary school is located on Farm to Market Road 43.

FIGURE 23: TRACKS OF ALL THREE TORNADOES

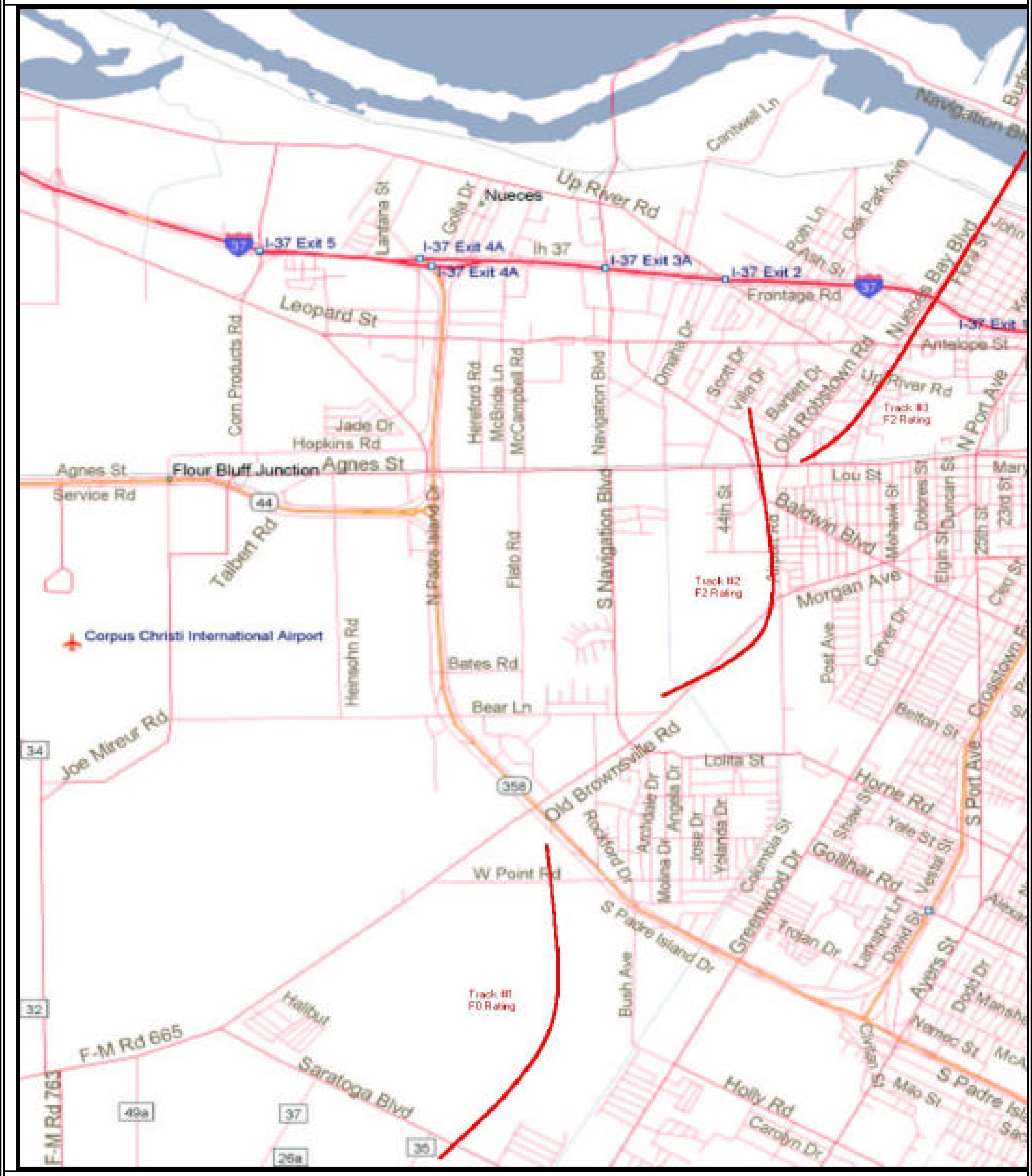


The tornado was estimated to be less than 50 yards wide, traveled through mainly open land, and tracked about seven miles before dissipating just southeast of the intersection of Old Brownsville Road and Padre Island Drive at approximately 1928 UTC. It did minimal damage during its nine minute existence and was rated an F0 on the Fujita Scale.

The next tornado formed four minutes later at 1932 UTC just to the east of where the first tornado had dissipated, near Navigation Boulevard and Old Brownsville Road. It moved northeast into the Del Mar College West Campus where the most extensive damage to property occurred. This tornado, which was rated as an F2 tornado, had a path length of 2 ½ miles and was 100 to 200 yards wide. One fatality was directly associated with this tornado on the campus of Del Mar College.

The final tornado formed at 1940 UTC just south of Driscoll Middle School just as the second tornado was dissipating and became an F2 tornado as it damaged the H.E.B. grocery store and the U. S. Post Office on Leopard Street. Moving to the northeast, the tornado hit Refinery Row where it did significant damage to the Citgo Refinery before moving into Nueces Bay. The third tornado had the largest base at nearly 400 yards wide.

FIGURE 24. CLOSE UP VIEW OF TORNADO TRACKS ACROSS CORPUS CHRISTI



The October 24, 2002 tornadoes that hit Corpus Christi resulted in 1 fatality and 26 injuries (14 injured at Del Mar College). Property damage included 4 single family and 15 multi-family homes destroyed, 73 single home and 21 multi-family units received major damage, and a total of just over 115 other residential structures received minor to slight damage.

Additionally, there were 60 businesses that ceased operations because of the tornadoes and 15 other businesses that suffered major damage. An estimated 350 people became unemployed as a result of the tornadoes that moved across Corpus Christi, Texas. Total damage was estimated at over $85 million. Figures 25 and 26 show some of the damage.

RESIDENTIAL PROPERTY DAMAGE	DAMAGE TO REFINERY
	
Figure 25	**Figure 26**

IX. SUMMARY

A. Forecast Issues

The changes in the environment leading up to this event were crucial in determining the potential for tornadogenesis. The utility of the model data was limited in helping to evaluate the kinematic and thermodynamic fields over South Texas as all of the models moved the short wave trough associated with the MCS well north of the Coastal Bend during the afternoon of October 24, 2002. The models depicted a decreased shear profile in the 0-6 km layer with the erroneous track for the MCS. An analysis of 12 UTC upper air and sounding data indicated the possibility of supercell thunderstorms. The airmass was expected to be increasingly unstable over the Coastal Bend as the front retreated to the north. CAPE values were expected to be from 2500 to 3000 J/kg. The AVN and RUC models depicted the instability parameters adequately during the event. The RUC model's handling of the unstable airmass over the Lower Texas Coast and the increasing low to mid level shear is indicated by the energy-helicity index analysis at 17 UTC and 18 UTC.

The RUC model showed EHI values near Baffin Bay that supported an increasing potential for tornadogenesis. RUC values were near 4.00 at 17 UTC (Figure 27) decreasing to 3.25 at 18 UTC. According to Davies (1993), significant tornadoes are more likely with EHI values of greater than 2.5, and strong tornadoes occur with values of 3.0 to 3.9.

RUC ANALYSIS AT 17 UTC	RUC ANALYSIS AT 18 UTC

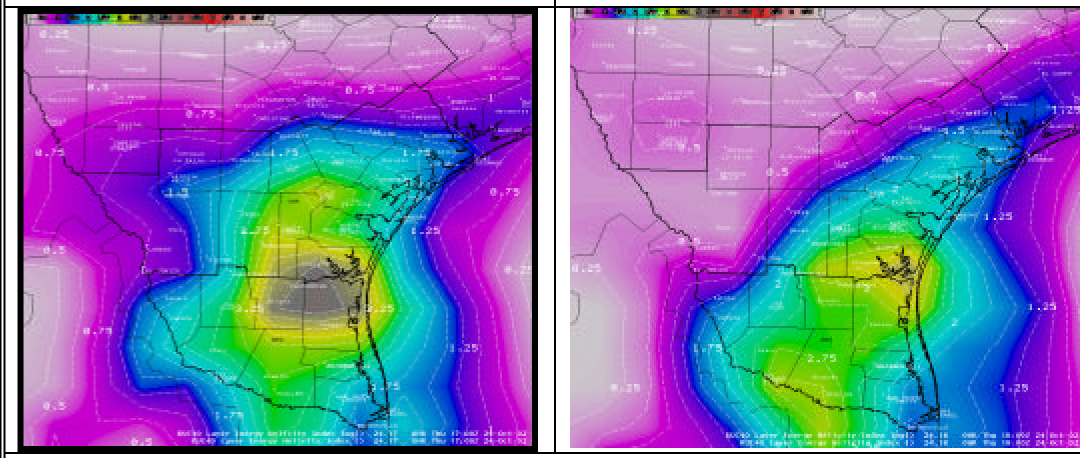


Figure 27 – EHI

By 18 UTC, the 0-3 km shear profile was becoming increasingly favorable for supercell thunderstorms as a trough of low pressure moved into the Coastal Bend in advance of the MCS and backed the surface winds to southeast. Four small cells exhibited low level rotation on the 1758 UTC reflectivity image near Mathis, just north of Nueces Bay, near Driscoll, and over Baffin Bay. This last cell over Baffin Bay would eventually produce the tornadoes. The low level rotation indicated the 0-3 km storm relative helicity (SRH) was sufficient for supercells and weak tornadogenesis.

Significant cloud cover over the region prevented the atmosphere from reaching its maximum instability. However, analysis of the 12 UTC Brownsville sounding indicated very steep lapse rates in the very moist 1000-850 mb layer. This implied a stronger distribution to CAPE in the lower levels of the atmosphere. Research by McCaul (1991) and Rasmussen (2003) indicated higher CAPE within the 0-3 km layer was associated with tornado producing supercells compared to non-tornado producing supercells. With a decreased overall depth to the CAPE profile, storms that developed were low topped with echo tops generally reaching only 30 to 35 thousand feet. However, with sufficient shear and low level CAPE fields, mini-supercells developed over the southern Coastal Bend. Grant and Prentice (1996) defined mini-supercells as mesocyclones with lesser rotational velocities, smaller diameters, and shallower depths compared to the mesocyclones in the Plains region but with the same attributes such as hook echoes and weak echo regions.

With the formation of low topped mini-supercells, storm motion of these cells was different than predictions used by using the 0-6 km mean wind and expectations that supercells would generally deviate to the right of the mean wind. The shallow mini-supercells moved with the 0-3 km mean wind to the north instead of the northeast or east.

Surface pressure falls and backing low level flow increased over the Coastal Bend as the MCS approached between 18 UTC and 20 UTC and the mini-supercell moved north. Research completed by Rasmussen (2003), Markowski, et al. (2003), and Thompson, et al. (2003) point towards the importance of higher storm relative helicity within the lowest 1 km as a discriminating factor for the development of significant tornadoes.

By 1910 UTC, a weak tornado formed south of the Corpus Christi International Airport (KCRP), but the wind in the 0-1 km layer responded to the isallobaric falls that were increasing east of KCRP (5 mb 3-hourly fall at KNGP at 20 UTC). By 1930 UTC, the near surface winds backed to east and increased substantially to above 40 knots according to velocity data from KCRP radar. The surface to 1 km winds veered 90 degrees, increasing the 0-1 km layer shear in advance of the supercell. Even though the shallow mini-supercell was moving to the left of the 0-6 km mean wind, the supercell would have realized an enhancement of the 0-1 km storm-relative helicity. The significant increase in the near surface winds and pressure falls suggest the formation of a low pressure area in the inflow region of the mini-supercell similar to the model simulations performed by Brooks and Wilhelmson (1990) for large low level curvature shear.

Another favorable factor for tornadogenesis was the low Lifting Condensation Level exhibited over the Coastal Bend. Temperatures were in the upper 70s F with dewpoint temperatures in the middle 70s F. Rasmussen and Blanchard (1998) and Thompson (2003) showed LCL heights were significantly lower in significant tornado producing supercells compared to supercells that formed weak tornadoes. Photographs taken of the tornado 4 miles to the east of KCRP radar (not shown) indicated a very low cloud base associated with this supercell. Markowski, et al. (2002) concluded environments with high boundary layer relative humidity are more likely to contribute higher buoyancy within the rear flank downdraft necessary for the genesis of significant tornadoes.

B. Warning Issues

This event proved to be a challenging one in regards to situational awareness in the warning environment. The emphasis was placed on the advancing MCS into the WFO CRP forecast area during the morning hours. The bowing line segment even exhibited a book end vortex as it moved into Refugio County at the same time as the mini-supercell was developing the first tornado in Nueces County - a brief tornado occurred with the book end vortex in central Refugio County. However, the focus quickly shifted to the mini-supercell as the base velocity data indicated the increasing threat of a tornado south of the airport.

Post reviews of the event indicated that the Mesocyclone and TVS algorithms were not set properly to detect shallow or mini-supercells. Throughout the entire event, the radar algorithms did not detect a Mesocyclone or a TVS. The depth of the mesocyclone was too shallow (generally less than 10 thousand feet), and the size of the circulation on the 0.5 degree slice was too small for the algorithms to detect using the default values for typically tall mesocyclones of the Southern Plains. This event reiterates the need for emphasis on the base velocity and reflectivity products in the warning environment. The changes in the surface pressure field also point toward the reliance upon a “mesoscale analyst” to stay abreast of the changes occurring on a smaller scale that can lead to enhancement of supercells and possible tornadogenesis.

X. CONCLUSIONS

The October 24, 2002 Corpus Christi tornado event provided meteorologists with a challenge that required them to use new technologies and meteorological knowledge to forecast an event that is not common in South Texas. The local climate records shown are not totally against the development of tornadoes, but having a family of tornadoes was novel. The existence of tornadoes in Corpus Christi in late October, although rare, was not without precedence. After analyzing all of the data and severe weather parameters, this study found that South Texas was in a favorable environment for severe thunderstorms and tornadoes on this day. Mesoscale influences enhanced the low level shear that led to the development of strong tornadoes in Corpus Christi on October 24, 2002.

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