ANALYSIS AND DETECTION OF TORNADOES ASSOCIATED WITH HURRICANE EMILY

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1. INTRODUCTION

Hurricane Emily was the second major Hurricane to form during the record breaking 2005 Atlantic tropical cyclone season. Emily's life cycle spanned nearly 10 days (11-21 July). Hurricanes often experience rapid changes in intensity as they pass over land masses in the Caribbean and Gulf of Mexico. Emily was a small hurricane that strengthened to a Category 4 on the Saffir-Simpson scale (Simpson, 1974) before making landfall on the Yucatan Peninsula of Mexico. Emily weakened as she moved over the higher terrain in the Yucatan, emerging in the Gulf of Mexico as a Category 1 hurricane.

Emily continued to intensify moving slowly west northwest with a forward speed averaging 10 mph. Emily regained Category 3 status prior to landfall with sustained winds of 125 mph (110 kts). Emily's final landfall was near San Fernando, Tamaulipas, Mexico or 80 statute miles south of Brownsville, TX (Figure 1).

Past studies have shown that tropical cyclones that originate in the Atlantic tend to produce more tornadoes that tropical cyclones that originate within the Gulf of Mexico (Verbout et al. 2005). Since Emily originated in the Atlantic, increased tornadic activity at landfall might have been anticipated.

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As an intense tropical cyclone, Hurricane Emily's effects on the United States were not as devastating as they would have been had Emily made landfall closer to Brownsville. This study will examine the life cycle of Hurricane Emily. The formation and detection of tornadic development associated with the outer spiral rainbands will also be explored. The observations and justification for Emily's damage potential at landfall will be presented. Finally, a hypothesis and explanation for the limited amount of physical damage in the Deep South Texas will be examined.

2. OVERVIEW: GENESIS TO LANDFALL

On 10 July a tropical disturbance and associated mesoscale convective complex (Maddox, 1980) were observed 1280 miles east of the Lesser Antilles, by the National Weather Service (NWS) Tropical Prediction Center (TPC). This tropical wave was classified as Tropical Depression Five (TD #5) based on satellite intensity estimates by hurricane specialists at TPC. TD #5 became Tropical Storm Emily as of the 03 UTC 12 July advisory issued by TPC (Figure 2). Emily continued to move west northwest at 10 kts slowly strengthening. The initial environment near Emily was relatively dry with unfavorable shear. However, hurricane forecast model guidance suggested that conditions would become favorable for Emily to develop into a major hurricane (Category 3 or greater) by 15 July.

Emily increased rapidly becoming a major hurricane at 21 UTC 14 July over the Caribbean Sea (445 miles SE of Santo Domingo, Dominican Republic) with sustained winds of 132 mph (115

kts) and a minimum central pressure of 968 hPa. Emily reached maximum intensity 17-18 July while approaching the Yucatan Peninsula. At 00 UTC 17 July maximum sustained winds were 155 mph (135 kts) with higher gusts and a minimum central pressure of 929 hPa was reported. Emily maintained Category 4 status through landfall 50 miles southeast of Cozumel, Mexico. As Emily moved across the mountainous terrain of the Yucatan, rapid weakening occurred. Emily emerged in the Gulf of Mexico as a Category 1 hurricane at
18 UTC 18 July.

Continuing on a west northwest track Emily regained Category 3 status in the western Gulf of Mexico (19 July) with sustained winds of 125 mph (110 kts) and a minimum pressure of 945 hPa. Emily continued moving west northwest until making landfall approximately 75 miles south of the border between the United States and Mexico. Emily passed over San Fernando, Tamaulipas, Mexico as a Category 3 hurricane at 13 UTC 20 July. Although Emily did not make landfall on the Texas coast, the effects of Hurricane Emily were observed throughout portions of Deep South Texas.

Upon landfall, Hurricane Emily began to rapidly weaken in the higher terrain of the Sierra Madre Oriental in northeast Mexico. The final advisory for Emily was issued by TPC at 15 UTC on 21 July. The mid and upper level circulations were still evident; however the low level circulation was less defined with diminishing convection.

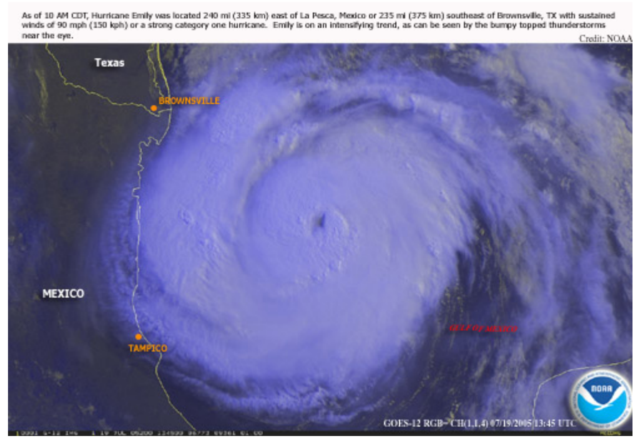

Figure 1. *Hurricane Emily(Cat. 3) prior to landfall. (13 UTC 20 July)*

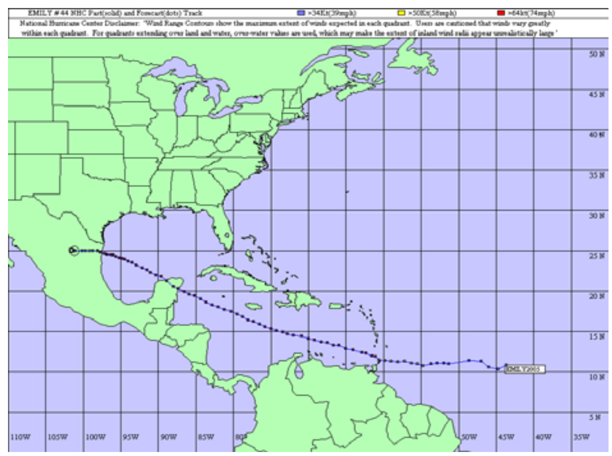

Figure2. *Track of Hurricane Emily July 10-21. Source: Hurrevac 2000.*

3. OBSERVATIONS

3.1 Warm Gulf Surface Waters

The relationship of hurricane intensification to three physical processes: 1) synoptic scale influences, 2) storm scale internal dynamics, and 3) ocean-atmosphere dynamics has been investigated in depth (e.g., Bennett and Patrick 1999). Hurricane Emily intensified from Category 1 to Category 3 as it passed over the warm waters of the relatively shallow western Gulf of Mexico prior to landfall (Figure 3).

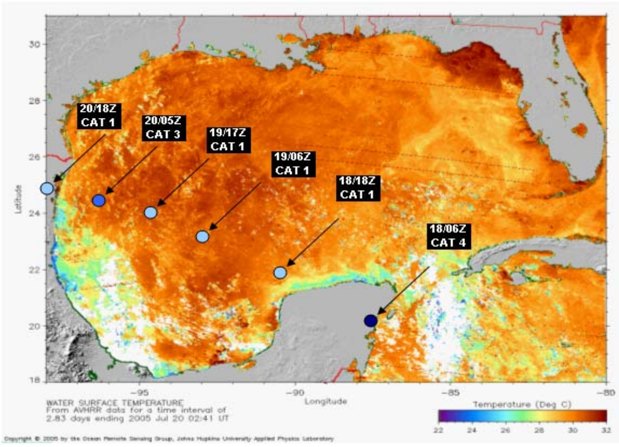

Figure 3. *Gulf of Mexico 3.5-day averaged SSTs at landfall of Hurricane Emily. Warm water facilitated rapid intensification prior to landfall. (John Hopkins Univ. Appl. Physics Lab, 2005)*

Most of the intensification is attributed to the warm state of the SST, since a large scale 500 hPa ridge over the southeast United States was the primary synoptic feature in the region, steering Emily into northeast Mexico.

3.2 Brownsville WSR-88D Radar

Figure 4 is a composite reflectivity image from the Brownsville WSR-88D which shows the position of Emily's eye at landfall. It also shows the outer spiral bands moving onshore in Deep South Texas.

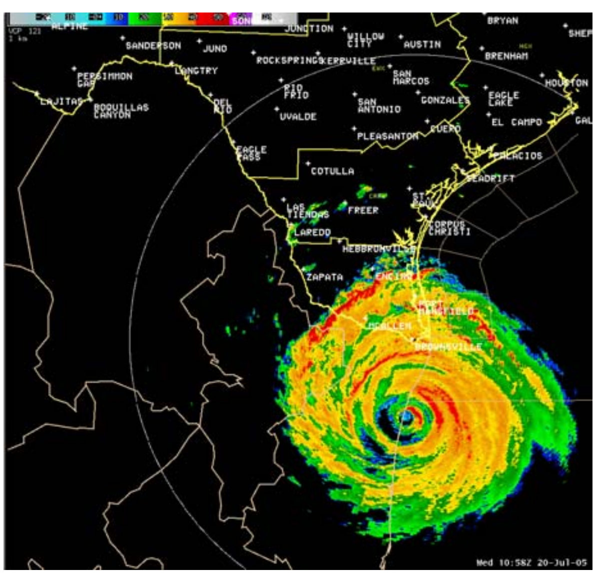

Figure 4. *Reflectivity Image of Hurricane Emily at 1058UTC 20 July, during landfall near San Fernando, MX.*

Many atmospheric scientists have studied tropical cyclones and it is generally accepted that the "right front quadrant" of a tropical cyclone, outside the area of sustained, gale force winds is typically a favorable place for tornado formation during and shortly after landfall Anthes (1982).

According to Novlan and Gray, (1974) approximately 25% of hurricanes which make landfall over the United States spawn tornadoes. Most of the tornadoes occur with strong hurricanes. Although Emily did not make landfall in the United States, the right front quadrant at landfall did impact the southernmost eight counties of Texas (Deep South Texas).

The outer rainbands made landfall beginning around 11 UTC 20 July. The first convective band was characterized by radar reflectivity values of 35-55 dbZ. The associated velocity data showed a rotational velocity couplet of 7.97 ms^{-1} , 27 miles north of the Brownsville WSR-88D at 1142 UTC 20 July. At 1135 UTC 20 July, law enforcement and local media relayed reports of a weak tornado near Rio Hondo, TX. This observation is consistent with data from Spratt et al. (1997). Figure 5 is an example of the rotational couplet and proximity of the band to the radar at landfall.

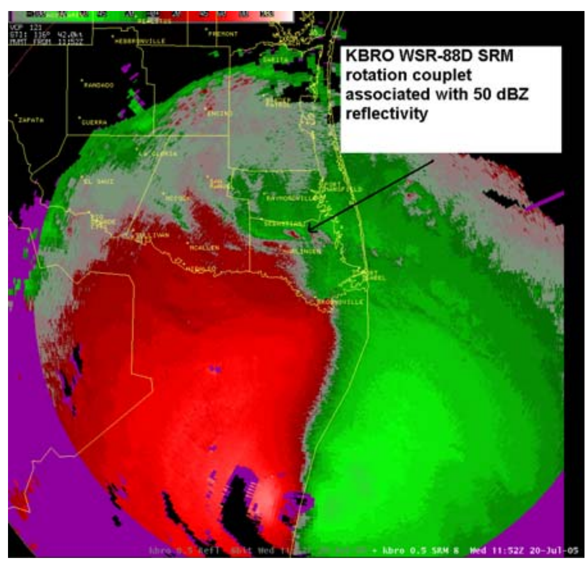

Figure 5. *Velocity couplet signature associated with 50 dBZ reflectivity near Harlingen, TX 1140-1150 UTC 20 July.*

Additional reflectivity and rotational couplet signatures were observed from South Padre Island to McAllen, TX through 00 UTC 21 July. Interestingly, video documentation of a tornado was received from near Hebbronville, TX (123 miles from KBRO). This tornado occurred along the extreme northern edge of the reflectivity shield from hurricane Emily. A study by Weiss (1987) showed that 74% of post landfall tornadoes reported from 1964-1983 were associated with outer band convection. Additional tornadoes were report across the western half of the NWS Corpus Christi County Warning Area.

4. DAMAGE ASSESSMENT

Shortly after Hurricane Emily made landfall, two teams of meteorologists from Brownsville conducted separate damage surveys. Minor flooding effects were noted by both teams, and several instances of wind damage were noted (i.e. trees down, minor roof damage, etc). A mobile home was destroyed near Rio Hondo, TX consistent with F0 damage on the Fujita (1971) tornado damage scale. Tropical storm force winds were recorded by NWS observation platforms at the Brownsville/South Padre Island and Rio Grande Valley International Airport in Harlingen.

All tornado damage was estimated at F0, which is consistent with previous studies of tornadoes in tropical cyclones that indicated such tornadoes are typically weak, of short duration and have relatively short paths.

5. CONCLUSIONS

Hurricane Emily was a dangerous tropical cyclone that generated several rainband tornadoes. The characteristics of Emily were more typical of a tropical cyclone originating in the Atlantic, rather than originating in the Gulf of Mexico. The tornadic production of Hurricane Emily closely resembled that of other tropical cyclones that made landfall in the United States. Finally, the limited property damage (United States) can be attributed to the compact nature of Hurricane Emily and the position of the eye at landfall (80 miles south of Brownsville). The residents of Deep South Texas were indeed fortunate that Hurricane Emily was relatively small and followed its forecast track south of the region, thus producing only minor damage in the Deep South Texas.

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