P440: ATMOSPHERIC CONDITIONS THAT LED TO THE ROMA, TEXAS FLOODS OF AUGUST 2008

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1. INTRODUCTION

During the week of 17-24 August 2008, torrential rains fell on multiple occasions in a small area along the Rio Grande River in Deep South Texas, including southern Zapata and southwestern Starr Counties (Figure 1). Bias corrected Doppler radar estimates indicated that more than 15 inches (381 mm) of rain fell over the City of Roma (herein referred to as Roma) with similar rainfall across communities to the east on the United States side of the river, and to the west on the Mexican side of the river. Significant flash flooding affected nearly 1000 homes, required more than 200 evacuations, and caused more than $5 million in property damage. The episode was considered a 100 year flood event for some areas. The estimated rainfall in a single week was close to *annual averages* for the area.

A series of upper level disturbances moved across northern Mexico and the southwest United States. These disturbances ejected from a pronounced (for August) long wave trough extending from the Rockies into northwest Mexico. As each disturbance approached southern Texas, a low-level south to southeast jet core developed. Each jet core transported very moist tropical air across the higher terrain of the Rio Grande Plains toward the eastern slopes of the Sierra Madre Oriental. The entire border region from Del Rio to McAllen, Texas, received heavy rainfall. Southwestern Starr and extreme southern Zapata County, Texas, and Ciudad Miguel Alemán, Tamaulipas Province (Mexico) experienced torrential-rain producing thunderstorms on five separate days.

Figure 1. Relief map of Deep South Texas, northeastern Mexico, and the adjacent Gulf of Mexico. Study area is shaded in purple.

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2. AUGUST 18TH: THE MCS

The initial event had the character of a Mesoscale Convective System (MCS) (American Meteorological Society, 2000). Contributing factors included:

- A deep, warm and moist air mass
- A hint of 250 mb divergence
- An 500 mb short wave
- A pronounced 850 mb jet
- The proximity of a stationary front across Southeast and Central Texas.

During the pre-dawn hours, thunderstorms developed rapidly in Starr County, with heaviest rainfall initially across ranchland north of the Rio Grande. Soon after daybreak, the storms coalesced into an MCS. Heavy rains would begin shortly after 1200 UTC (7 AM CDT), then become torrential, inferred by radar reflectivity above 50 dbZ reconciled with rainfall totals and the onset of flooding near Rio Grande City. Precipitation intensity was greatest below the freezing level, located at 4731m (Figure 2); yet, the core updraft was strong enough to produce cloud top temperatures lower than -75C (Figure 3).

Torrential rains would continue for more than 3 hours in Roma, Escobares, and Garceño, resulting in widespread flooding. The rains overwhelmed urban drainage systems in Roma, and rapidly filled two normally dry arroyos. Fast moving water overflowed Arroyo Roma, rising several feet above streets, and flooding property with anywhere from inches to five feet of water.

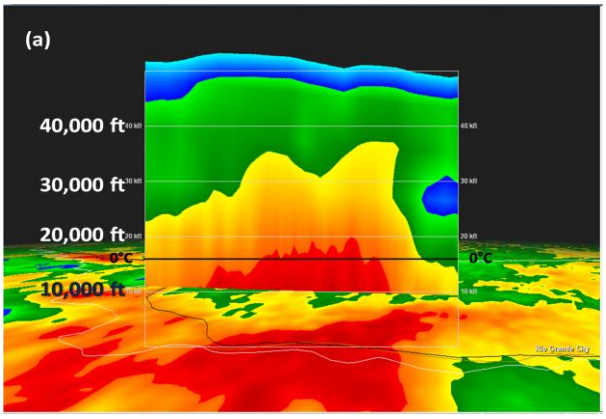

Figure 2a. Reflectivity cross section, 1447 UTC (947 CT) 18 August 2008, for Roma through Garceño. 0C isotherm denoted by black line, at 4731m (15521 ft).

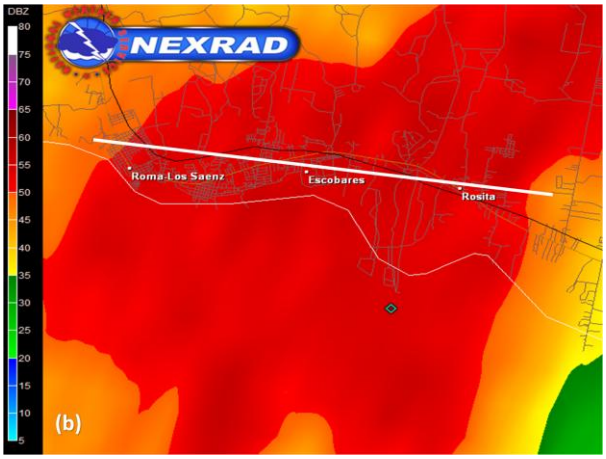

Figure 2b. Cross section location in Figure 2a (white line), overlaid with 0.5° base reflectivity data, beam height ranging from 2952m (right) to 3267m (left).

Local officials intimated that urban development likely played a role in how water moved once the arroyo flooded; the flow's behavior was more chaotic through the city, affecting locations that were not described in the flood plain prior to recent updates provided by the Federal Emergency Management Agency in 2009 (FEMA, 2009). Arroyo Los Morenos also overflowed, flooding Escobares. Arroyo Quiote, which flows toward the Rio Grande east of Garceño, spilled up to 3 feet of water across Federal Highway 83, the main thoroughfare between Laredo and the Rio Grande Valley. Rainfall estimates, based on reconciled radar data with nearby observations, were upwards of 12 in. (305 mm).

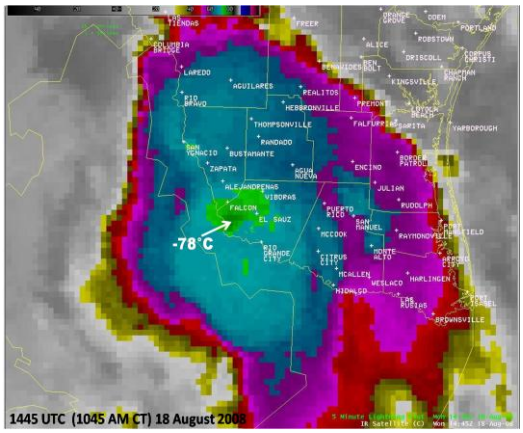

Figure 3. Infrared satellite image of Starr County MCS at 1445 UTC 18 August 2008.

3. AUGUST 22ND: ANOTHER ROUND

A second, well defined short wave (Figure 4) moved across Chihuahua State in northern Mexico and into Southwest Texas during the mid morning of 22 August 2008. A notable 250 mb jet core of >50 kt was evident to the east of the vorticity center. In the lower levels, a less focused but still pronounced 850 mb jet was importing more deep tropical moisture into the Upper Rio Grande Valley. Daytime heating, orography, and atmospheric instability initiated convection across the northern Sierra Madre Oriental by late afternoon. Storms formed concurrently in eastern Starr County and drifted west. The Sierra Madre clusters maintained intensity while moving into increasingly moisture rich air over the Rio Grande Plains. By sunset, outflow boundaries from each cluster collided and formed a nearly stationary multi cell cluster from southwest Starr into Zapata County (Figure 5).

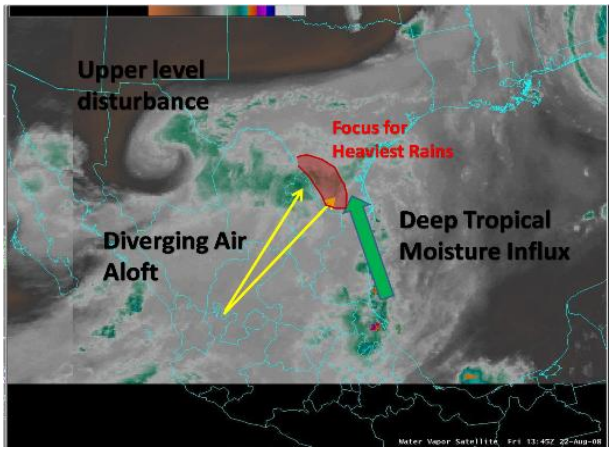

Figure 4. Annotated water vapor satellite depiction of features leading up to the 22 August 2008 second round of torrential rain in southwest Starr County.

Two to three hours of nearly stationary torrential rains dropped radar estimated totals of at least 7 to 9 in. (178 to 229 mm) on both sides of the U.S./Mexican border (Figure 6). The heaviest rainfall, estimated at 9 in. or more, fell in Ciudad Miguel Alemán, adjacent to Roma. Rainfall estimated dropped off sharply from Roma to Garceño, ranging from 2 to 5 in. (51 to 127 mm). Widespread street flooding affected the north portion of Roma along the bend of Grant Street, but no structures were threatened; the highest rainfall fell just west of Arroyos which had flooded just four days earlier.

One might conclude that disaster was averted from Roma to Garceño by a mere 15 km. Nine or more inches of rain falling onto areas still recovering from the 18 August MCS might have been devastating for these communities.

4. AUGUST 24TH: TWO MORE CLUSTERS

The remnant of the original long wave trough that spawned each short wave had one last punch left. A weakness in the upper level flow between Tropical Depression Fay across the Southeast U.S. and some moisture flowing northeast from Tropical Storm Julio

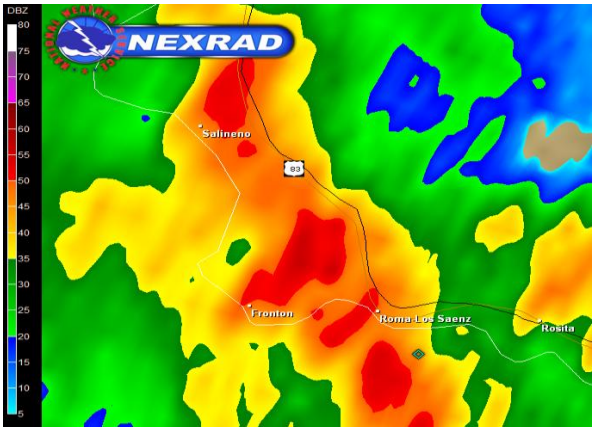

Figure 5. 0.5° Base Reflectivity image for Southwestern Starr County and Ciudad Miguel Alemán (southwest of Roma-Los Saenz), 0056 UTC 23 August, showing highest levels (>50 dbZ) west of areas that received heavy rainfall on 18 August.

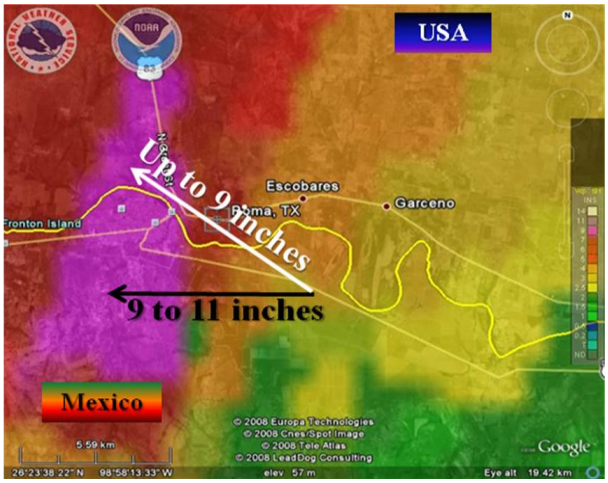

Figure 6. Radar-estimated rainfall for 22 August (Central Time). Actual values based on some hail contamination may have been 2 inches lower in the magenta and purple colored area. Map background courtesy of Google.

helped more thunderstorms redevelop on three more occasions between 23 and 24 August. During the afternoon of 23 August, locally heavy rains fell along Federal Highway 83 in Zapata County. After dark, another resurgence of the 850 mb jet and a continuing divergent flow at 300 mb (Figure 7) may have aided the formation of more storms before daybreak in the Upper Rio Grande Valley, west of the El Sauz Ranch (Starr County) near the origination point of Arroyo Los Morenos. An estimated 4 to 6 inches of rain fell into the previously full Arroyo Los Morenos which overflowed once more, flooding at least six homes in Escobares before sunrise. A morning lull was followed by an outbreak of late afternoon storms in Roma (Figure 8).

These rains, estimated to be another 4 inches or more, aggravated waterlogged Roma, as eight or nine neighborhoods flooded and more than a dozen residents evacuated during the dark of a Sunday evening.

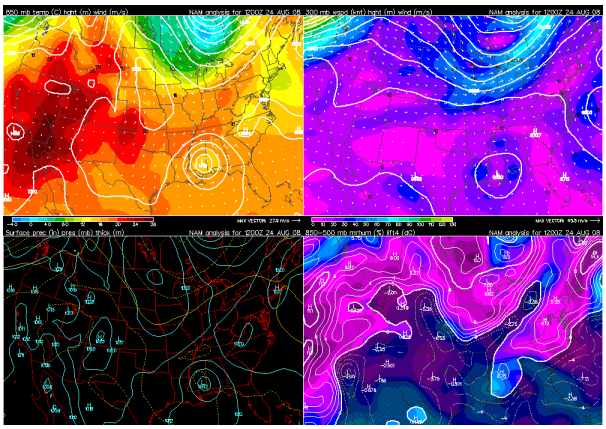

Figure 7. 4-panel synoptic charts, 12 UTC 24 August 2008. Upper left: 850 mb height, relative humidity, and wind. Upper Right: 300 mb height and wind. Bottom left: Surface Pressure (mb) and 1000-500 mb thickness. Bottom right: 850-500 mb mean relative humidity.

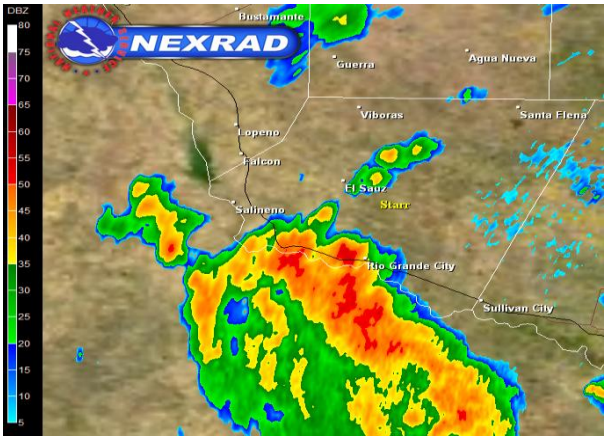

Figure 8. 0.5° Base Reflectivity image for Southwestern Starr County, 2120 UTC 24 August, showing highest levels (>50 dbZ) moving back into Roma through Rio Grande City.

5. SUMMARY AND CONCLUSIONS

The period of 18 through 24 August, 2008 in southwestern Starr County, Texas, will be remembered by local residents as the week it didn't stop raining. Meteorologically, multiple short waves moved across South Texas, inducing 250 to 300 mb divergence and aiding the influx of rich, low level Θe air on south/southeasterly winds. Each event was unique. On 18 August, a large, slow moving MCS dropped at least 12 in. (305 mm) of rain. Four days later, organized storms collided along the U.S./Mexico border, leading to prolonged torrential rains just west of the Roma-

Escobares-Garceño area and sparing them a potential flood disaster. Additional weak mid and upper level energy combined with a continued influx of moisture on 23 and 24 August to bring more downpours to the same areas.

What made this episode unusual was the combination of meteorological outcomes and serendipity. Starr and Zapata County are located at the edge of the humid subtropical and semi-arid steppe region based on the Köppen-Geiger Climate Classification (Kottek, et. al., 2006). Annual rainfall averages around 20 in. (508 mm); a little more than 2 inches (51 mm) is the August average (U.S. Department of Commerce, 2001). In 2008, August climate station records for Rio Grande City and Falcon Dam were 10.28 in. (261 mm) and 11.21 in. (285 mm), respectively – at least *5 inches lower* than monthly totals in Roma! One can only marvel at the unknown, but likely very small, probability of multiple convective events occurring several days apart over such a tiny area.

Figure 9 shows the estimated and measured episode totals for all of Deep South Texas.

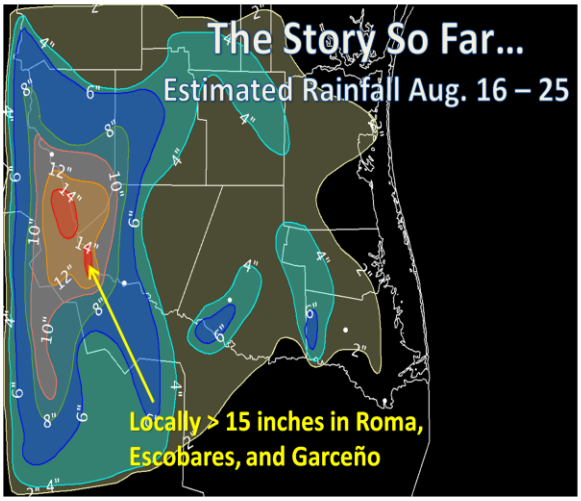

Figure 9. Measured and estimated rainfall for the period 16 through 25 August 2008. Most of the rain fell between the 18 and 24 August.

Additional research on this event may help answer other questions. Does slight upslope flow favor the location of the Upper Rio Grande Valley and Rio Grande Plains for intense convective events in certain synoptic conditions? Did the residual surface and low level moisture from Tropical Storm Dolly and earlier rains from other disturbances in July enhance the ability of the atmosphere to dump heavier rainfall than what might normally be expected with similar disturbances tracking over drier surface conditions?

Societal impact and threat communication studies are other avenues worth exploring. Discussions with emergency management officials in Roma found that after the significant flooding on 18 August, residents were more vigilant when heavy rain was in the forecast later that week and into the weekend. Conversely, the last of the torrential rains occurred on a Sunday afternoon and evening, when most residents were at home; timing alone may have contributed to the high number of rescues. Other factors to consider are how people receive, understand, and act on the weather message. Cultural differences and possible language barriers along the U.S. Mexico border can provide a starting point to uncover how and why people take certain actions prior to, during, and after a weather hazard (Ruin, et. al, 2009).

Applied research into these topics, along with the experience of analyzing the August 2008 Starr County floods should improve operational forecasters' situational awareness in future rare events. Communicating the threat clearly and with plenty of time for residents to prepare will ensure that lives and property are protected.

6. REFERENCES

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