P3.2 **The Rosita Valley, TX Tornado: 24 April 2007**

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1. Introduction

On 24 April 2007, a tornadic supercell crossed the Rio Grande striking the Rosita Valley community located just south of Eagle Pass, TX. The rain-wrapped tornado traveled about 6 km into the U.S. and had a damage path nearly 800 m wide (Fig. 1). More than one hundred homes, including many manufactured homes, were damaged or destroyed. Seven people lost their lives, six of them in manufactured homes. The authors conducted ground surveys after the tornado while an aerial survey was performed by the Southwest Texas Regional Advisory Council (STRAC). The National Weather Service rated the tornado EF-3 on the Enhanced Fujita scale with peak three second wind gusts around 67 ms^{-1} at 10m above the ground.

This paper will show how the EF-scale ratings were determined from the analysis of building damage. Correlations were made between the degree of damage in residences and manufactured homes.

There were many forecast challenges with this event. Northern Mexico has few surface and upper air stations leaving forecasters to wait and see what develops on the satellite and radar imagery. A study of satellite and radar images revealed that the supercell that produced the Rosita Valley tornado developed over the Serranias del Burro Mountains in northern Mexico. The generation of supercells over the higher terrain in Mexico has been documented previously by Edwards (2006). A comparison was made between the weather situation in this case and the Edwards study.

This case also presented challenges with regard to warning dissemination. While severe thunderstorm and tornado warnings were issued for the supercell before crossing into the U.S., none of the television or radio stations broadcasted the warnings. Stations claimed that they never received the warnings, although they were part of the Emergency Alert System. Also, the Rosita Valley area was in an area of poor reception for NOAA (National Oceanic and Atmospheric Administration) weather radio and the area was void of tornado sirens.

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Figure 1. Still image from video of rain-wrapped tornado (on right) in Mexico just before crossing into the U.S. Source: unknown.

2. Weather Situation

At 1200 UTC (Universal Time Code) on the day of the Rosita Valley tornado, a deep mid- and upper-level trough of low pressure was moving through the southern Rockies (Fig. 2). At 500 mb, a jet streak around 31ms^{-1} (60 kts) rounded the base of the trough extending from El Paso to Midland to Amarillo. A closed low was positioned in northern New Mexico along with a cold pool of -24°C.

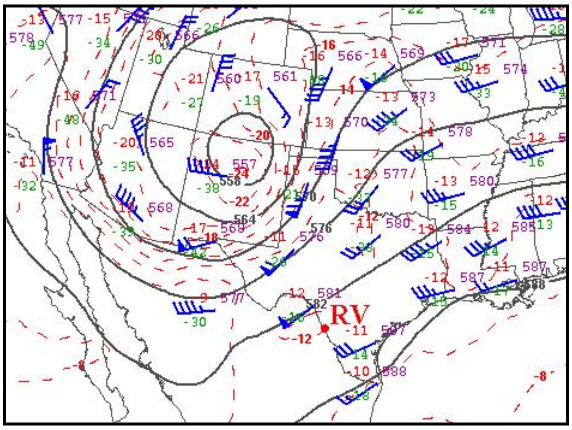

Figure 2. 500mb map at 1200 UTC on April 24, 2007, 12 hours before the Rosita Valley (RV) tornado. Wind speeds are in knots, temperatures in degrees Celsius. Source: Storms Prediction Center.

The nearest sounding to the Rosita Valley area was Del Rio (DRT), TX located about 80 km to the northwest. The 1200 UTC sounding from Del Rio on the day of the tornado showed a pronounced capping inversion around 800mb with deep low-level moisture below this level (Fig. 3). CIN (convective inhibition) was 104j/kg. A 23 ms^{-1} (45 kts) low-level jet was displaced to the east of Del Rio traveling through central Texas.

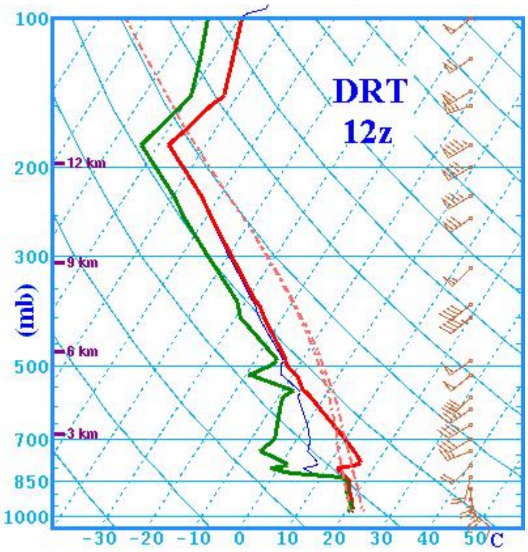

Figure 3. 1200 UTC sounding from Del Rio, TX on April 24, 2007 showed a pronounced capping inversion. Temperature (red) and dewpoint (green) are in Celsius, wind speeds are in knots. Source: Storms Prediction Center.

With the approach of the upper trough, lee cyclogenesis already had occurred in eastern Colorado on the morning of 24 April 2007. By 1200 UTC, a surface low pressure center had developed along the Colorado-Kansas border north of Elkhart, KS. A pronounced dryline boundary was located across western Texas extending into the eastern Texas panhandle (Fig. 4). Ahead of the dryline, dewpoints in excess of 20°C had moved up the Rio Grande into the Rosita Valley area. At 1300 UTC, the Storms Prediction Center (SPC) issued a moderate risk of severe storms for later that day across the eastern half of Kansas and Oklahoma extending down to central Texas (Fig. 5).

By 1700 UTC, the unstable air mass coupled with strong forcing aloft ignited a squall line over central Oklahoma and north-central Texas. The SPC issued tornado watches from Kansas to central Texas. The tail end of the squall line quickly built southward to near Junction, TX then moved northeastward into northern Texas.

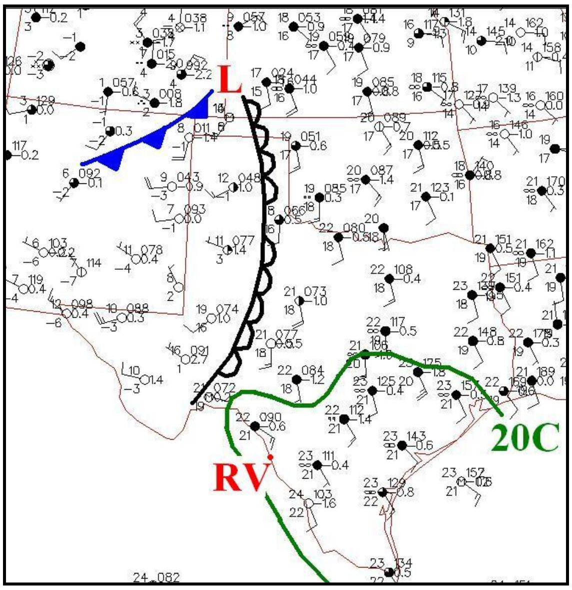

Figure 4. Surface weather map at 1200 UTC on April 24, 2007 with surface low along the Kansas-Colorado border and dryline (scalloped line) extending southward through west Texas. High dewpoints had moved up the Rio Grande into the Rosita Valley (RV) area. Source: Plymouth State Weather.

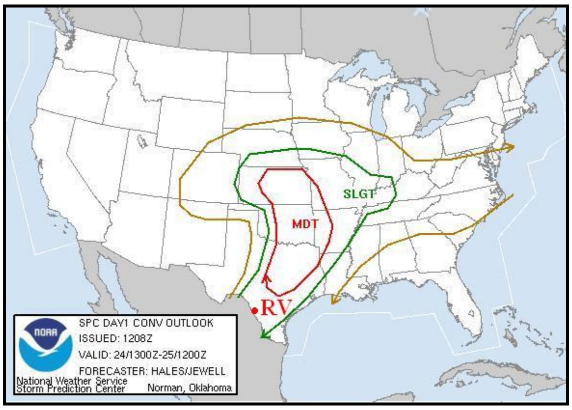

Figure 5. Forecast risk areas at 1300 UTC by the Storms Prediction Center.

Anticipating that additional storms would develop along the dryline in central Texas, the SPC issued PDS (particularly dangerous situation) tornado watch box #179 at 2100 UTC. Maverick County, which included the towns of Rosita Valley and Eagle Pass, were located at the southern end of this tornado watch box (Fig. 6).

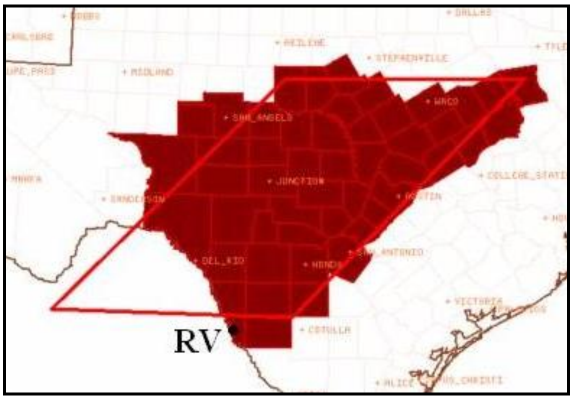

Figure 6. Outline of PDS tornado watch #179 in Texas with affected counties shaded in red. Rosita Valley (RV) location is shown. Source: SPC.

At 2330 UTC, the Austin-San Antonio National Weather Service issued a severe thunderstorm warning for Maverick County until 0015 UTC. The statement indicated that a severe storm was northwest of Eagle Pass moving to the southeast and likely contained a tornado over Mexico. It was expected that the tornado would pass 8 to 13 km south of Eagle Pass. The SPC also issued a mesoscale discussion at 2344 UTC stating that a "very intense heavy-precipitation supercell with cyclic mesocylones may be producing tornadoes and very large, damaging hail just west of the river in Mexico" and would move south and southeast of Eagle Pass.

Then at 2351 UTC, the severe thunderstorm warning was upgraded to a tornado warning as the supercell approached the U.S. border. The tornado struck Rosita Valley around 2355 UTC.

3. Comparison with Edwards study

Edwards (2006) studied 13 events where supercells developed over the higher terrain of northern Mexico. He found that supercells were more likely to develop when west-southwest flow aloft was associated with synoptic-scale troughs over western or central U.S. Such was the case in this study.

Edwards also developed a composite sounding based on the 13 events in his study. We compared the 0000 UTC sounding at Del Rio (Fig. 7) with the composite sounding developed by Edwards (see Table 1). We found that the air mass in this case was more unstable than the composite sounding with higher surface-based and mean-layer convective available potential energies (CAPEs). There also was higher convective inhibition (CIN) than on the Edwards composite sounding suggesting that storms would not have developed had they not had low-level forcing (i.e. an orographic source.)

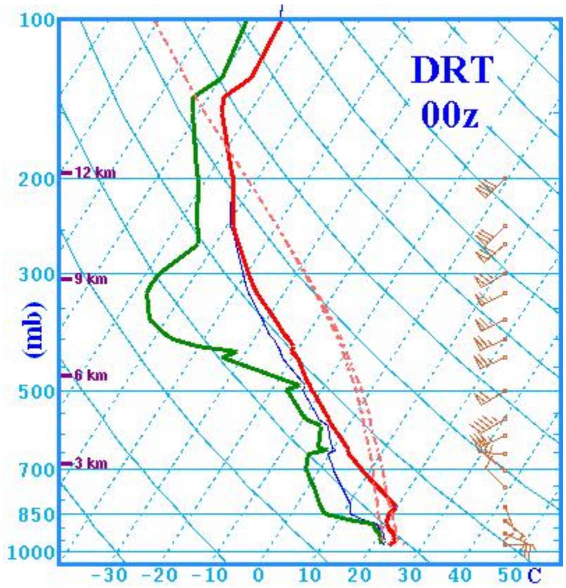

Figure 7. 0000 UTC sounding from DRT on April 25, 2007. Temperature (red) and dewpoint (green) are in Celsius, wind speeds are in knots. Source: SPC.

TABLE 1
COMPARISON OF DEL RIO, TX SOUNDING TO EDWARDS COMPOSITE SOUNDING

Sounding parameters	Del Rio 0z-4/25/07	Edwards Composite
Sfc-based CAPE (J/kg)	3207	2709
Sfc- CIN (J/kg)	-91	-70
Sfc-500 LI (C)	-10	-8
Mean layer CAPE (J/kg)	3741	2046
Mean layer CIN (J/kg)	-237	-105
Wet Bulb Zero Hgt (ft)	10760	9567
Sfc-3km LR (C/km)	6.4	6.7
3km-6km LR (C/km)	7.4	7.7
DCAPE (J/kg)	731	1236
BRN shear (m^2/s^2)	91	63
4-6 km SR wind (kt)	290/41	225/21

4. Satellite imagery

During the afternoon, the dryline moved slowly southeast down the Rio Grande. Meanwhile, visible and infrared satellite showed that the high clouds associated with the synoptic-scale storm system outran the surface dryline. As a result, high dewpoint surface air was exposed to clear skies and solar heating resulting in a very unstable atmosphere. Enhanced satellite imagery showed the storm that spawned the Rosita Valley supercell developed rapidly in clear air (Fig. 8).

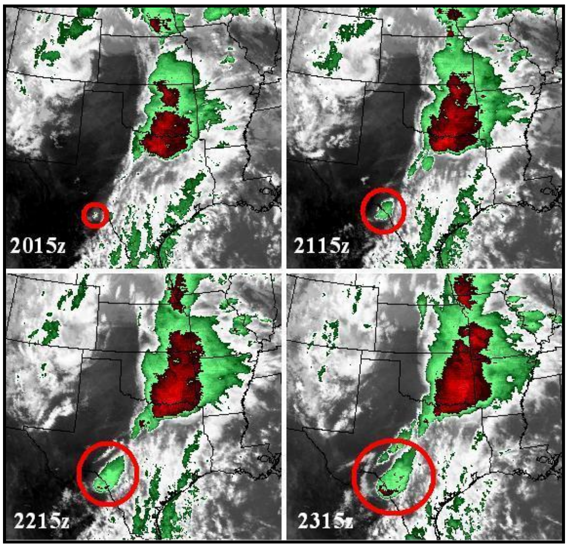

Figure 8. Color enhanced infrared satellite imagery showing explosive development of the storm (circled) that spawned the Rosita Valley, TX tornado. Source: NOAA.

The GOES-12 satellite was in rapid scan operations during this event and produced images at five-minute intervals. Apparent in the 10.7 µm Infrared (IR) images was a very pronounced overshooting top and "enhanced-v" signature typical with supercells (Fig. 9).

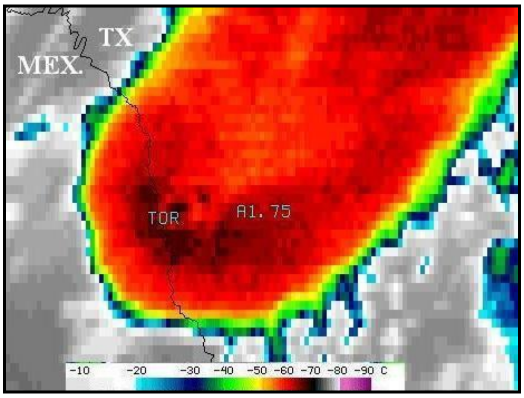

Figure 9. Color enhanced infrared satellite imagery at 0015 UTC on April 25, 2007 just after the tornado struck Rosita Valley, TX. Source: CIMMS.

5. Radar imagery

Analysis of radar imagery from Del Rio, TX revealed that the first radar echo appeared over the Serranias del Burro Mountains in northern Mexico at 1959 UTC, at a range of 80 km southwest from the radar (Fig. 10). The storm developed in a sparsely populated area where the ground elevation was approximately 1km. The echo quickly intensified reaching 50 dBz in just 15 minutes and moved to the northeast at 40 km/hr.

At 2048 UTC, the storm split. The right split slowed in forward speed while the left split raced off to the northeast toward Del Rio. Between 2126 and 2148 UTC, another cell that came off higher terrain merged into the flank of the initial storm. A large reflectivity core greater than 50 dBz became evident with a sharp gradient in reflectivity along the inflow side of the storm. The resulting supercell turned southeast with a forward speed of about 30 km/hr and continued to intensify as it moved into higher dewpoint air at lower elevations.

The first hook echo developed at 2247 UTC, about 40 km northwest of Rosita Valley, and lasted until 2313 UTC when the hook wrapped into the forward flank downdraft. It is unknown whether a tornado developed during this time. The storm traveled over ranchland northwest of Piedras Negras during this time. Then, a second hook echo quickly developed at 2322 UTC evolving into a classic "figure 6" echo by 2338 UTC. A tornado traveled through Piedras Negras, just west of Eagle Pass then crossed the Rio Grande into the U.S. Tornado damage occurred in Piedras Negras as noted by many photographs and videos on the Internet. However, the length and extent of the tornado damage track in Mexico is not currently known.

WSR-88D radar reflectivity showed a rain wrapped hook echo at 0004 UTC while the tornado was in progress at Rosita Valley, TX (Fig. 11). Gate-to-gate shear was about 41ms^{-1} (80kts). The hook echo signature and strong gate-to-gate shears lasted for 54 minutes from 2322 to 0016 UTC as the storm traveled to the east-southeast. The supercell then evolved into a mesoscale convective system (MCS) producing damaging winds along a 300 km swath in southern Texas.

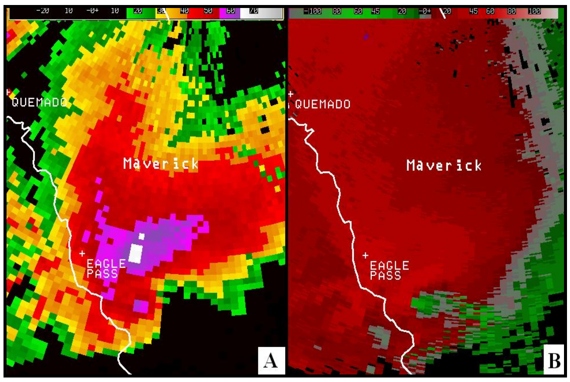

Figure 11. WSR-88D images at 0004 UTC on April 25, 2007 at the time the tornado was traveling through Rosita Valley, TX: a) base reflectivity, and b) base radial velocity. Source: NOAA.

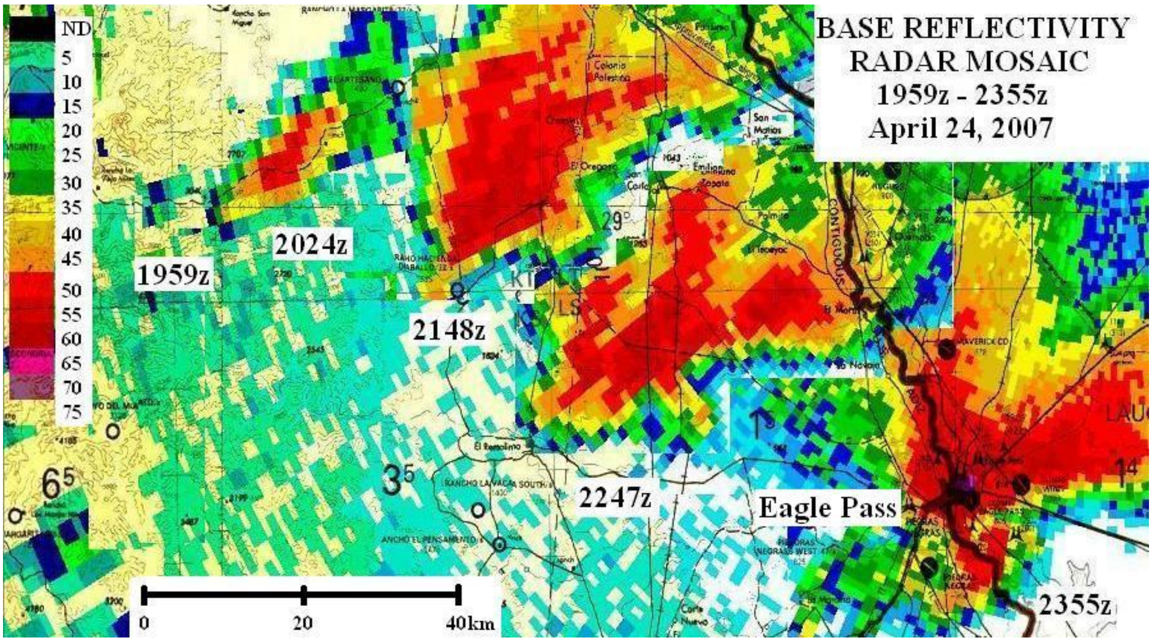

Figure 10. WSR-88D base reflectivity mosaic overlaid on a topographic map showing a time history of the supercell that produced the Rosita Valley, TX tornado. Source: NOAA/Tim Vasquez.

6. Warning Dissemination

There were problems with warning dissemination for this event. According to the USA Today (2007), the local cable television station and local radio station did not broadcast the storm warnings prior to the tornado striking Rosita Valley, although both stations apparently subscribed to the Emergency Alert System (EAS) and the EAS had disseminated the warning. Therefore, the public's last option to receive warning from the National Weather Service was via NOAA weather radio. Unfortunately, the Rosita Valley area was located at the outer ranges of the weather radio transmission sites at Del Rio and Carrizo Springs, TX (Fig. 12). According to NOAA (2008), reception of the radio signal was "possible, but unreliable" for the Rosita Valley area. Also, there were no tornado sirens in the area.

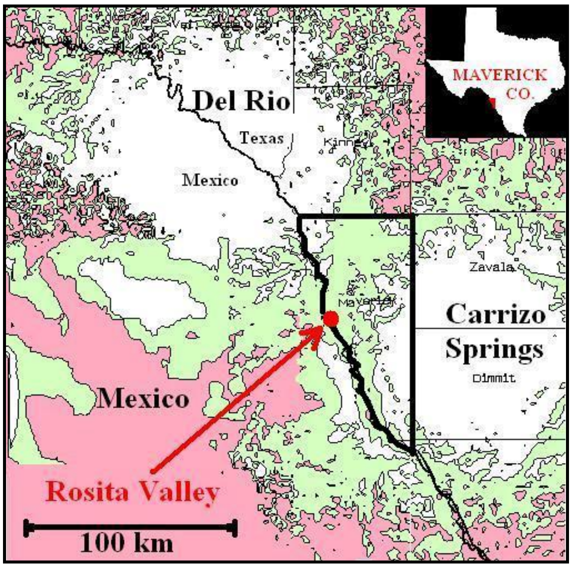

Figure 12. NOAA Weather radio coverage map for Maverick County (outlined). White areas indicate reliable coverage, green areas possible but unreliable coverage, and red areas are unlikely to receive a signal. Source: NOAA.

7. Tornado Damage Path

Our damage survey revealed that the Rosita Valley tornado traveled approximately 6 km in the U.S. and extended up to 800 m wide. More than one hundred homes including many manufactured homes were damaged or destroyed. The tornado track was oriented northwest-to-southeast with a gradual turn to the east toward the end of the path (Fig. 13).

EF-scale numbers were assigned to houses based on increasing severity of the damage. Degrees of damage (DOD) descriptions were followed in accordance with those developed by the Wind Science and Engineering Center (2006). Homes were rated EF-0 if they had some damage to their roof coverings and/or lost some of their vinyl or metal siding (DOD=2). A rating of EF-1 was assigned to those homes that lost most of their roof covering and/or had minor structural damage to the roof such as displaced gable ends or loss of some roof decking (DOD=4). Homes were rated EF-2 if they lost most of their roof structure but the walls remained standing (DOD=6). A rating of EF-3 was given to homes that lost most of their walls (DOD=8).

The first building damage in the U.S. was to a wood-framed residence with brick veneer exterior located on a bluff overlooking the Rio Grande (Fig. 14). The entire roof and most exterior walls were removed. Also, the attached two-car garage was destroyed. Close examination revealed wood bottom plates were bolted to the concrete slab foundation. Failure of the wall framing occurred when the studs pulled out of their straight-nailed connections to the wall bottom plates (Fig. 15). The home was assigned an EF-3 rating with a DOD of 8. Peak three second wind gusts were estimated to be around 67 ms^{-1} at 10m above the ground.

Interestingly, two pickup trucks remained on site. Both vehicles were pushed laterally to the southeast with one vehicle coming to rest in the front yard. Two small trees also remained intact in the front yard. A cyclone fence was rolled up and deposited on the driveway.

The tornado continued southeast just south of Arce Lane through a mixture of wood-framed residences and manufactured homes. Several residences lost their roofs and manufactured homes were flipped, rolled, or lofted.

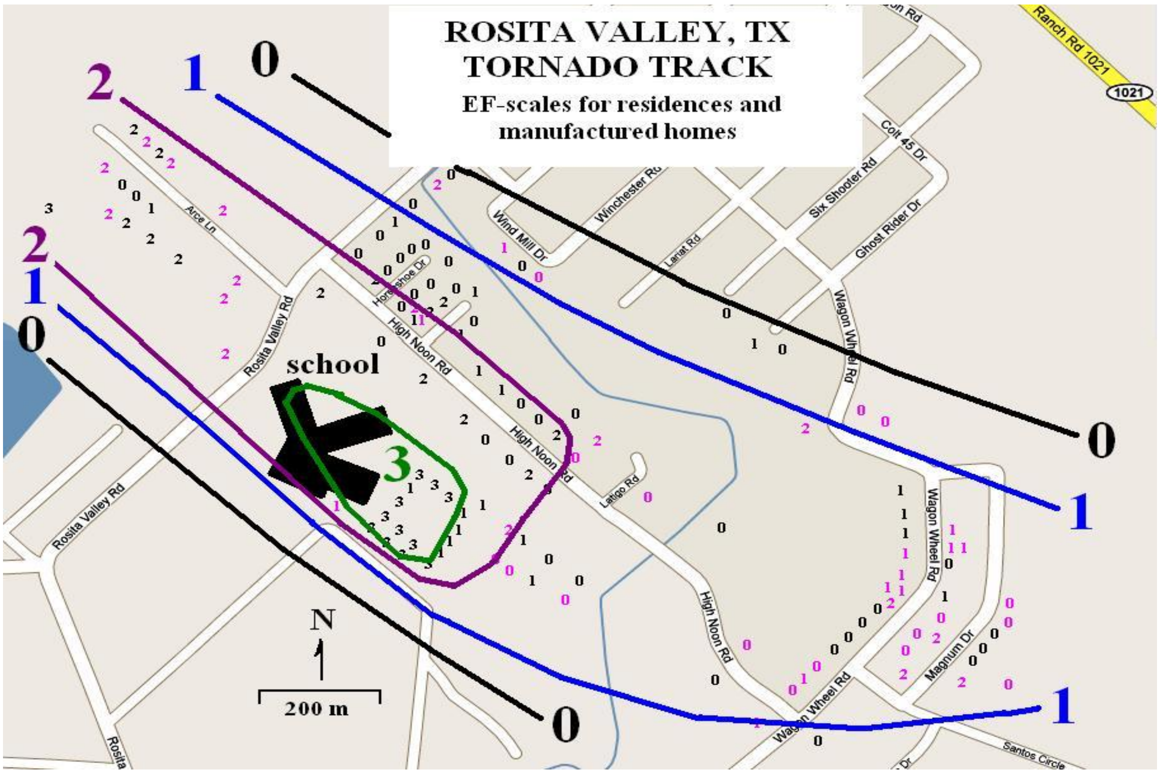

Figure 13. Plot of EF-scale damage to wood-framed homes (black numbers) and manufactured homes (purple numbers) with contours added.

Figure 14. Aerial view of the first house struck by the Rosita Valley tornado looking southeast. This home was rated EF-3 (DOD=8).

Figure 15. Failure of the wall framing occurred when the studs pulled out of their straight-nailed connections to the wall bottom plates. Note wall bottom plates were anchored to the concrete slab foundation.

Manufactured homes consisted of wood-framed structures mounted on steel undercarriages. Some manufactured homes had their steel frames anchored to the ground whereas other manufactured homes were not anchored. Regardless, manufactured homes performed poorly in EF-2 winds (DOD=8) and offered no protection to occupants. Wall framing typically separated from the floors as the unit rolled (Fig. 16). Manufactured homes were rated EF-0 if they lost roof shingles or decking (DOD 1 and 2). An EF-1 rating was assigned to homes that shifted or rolled off their foundations or lost their roofs (DOD 3 to 5). Homes that were completely destroyed (i.e. all walls down) were rated EF-2 (DOD $\geq$ 6).

There was considerable variation in the performance of manufactured homes depending on the direction of the wind. We saw several examples where homes that were broadsided by the wind were destroyed whereas homes parallel to the wind remained on their supports (Fig. 17).

Figure 16. One of several flipped manufactured homes rated EF-2 (DOD=8). The original location of the home was in the upper left corner of the picture.

Figure 17. Variation in the performance of manufactured homes related to the orientation to the wind. Two manufactured homes (yellow boxes) were destroyed when broadsided by the strongest winds while other manufactured homes parallel to the wind remained.

Table 1 presents a summary of EF-ratings to 83 wood-framed houses and 44 manufactured homes in the Rosita Valley tornado. Note there were no EF-3 ratings to manufactured homes as they were destroyed in EF-2 winds.

TABLE 1
SUMMARY OF HOUSING DAMAGE
IN THE ROSITA VALLEY TORNADO

EF-rating	Wood-Framed homes	Manufactured homes	TOTAL
0	38	16	54
1	20	11	31
2	13	17	30
3	12	-	12
TOTAL	83	44	127

The tornado crossed Rosita Valley Road and struck the Rosita Valley Elementary School (Fig. 18). This one-story, steel-framed structure lost a significant amount of its steel-clad roof panels. Wind breached the building pushing windward walls inward and leeward walls outward. The damage was rated EF-3 with a DOD of 8. Homes east of the school also sustained EF-3 damage. Then, the tornado turned gradually to the east and crossed Wagon Wheel Road. The tornado dissipated in open ranchland lifting prior to Highway 1021.

Figure 18. Aerial view of the Rosita Valley Elementary School looking southeast. This steel-framed structure lost a considerable amount of its metal roof and wall cladding.

SUMMARY

The supercell that produced the Rosita Valley tornado initially developed in the Serranias del Burro Mountains in northern Mexico. As Edwards (2006) noted, this source region has been a "hot spot" for the initiation of severe convection. Recently, another supercell developed over these mountains and struck the Eagle Pass area on 15 May 2008. This storm, like its predecessor on 24 April 2007, moved to the right of the upper flow enhancing its surface-based inflow of warm, moist air.

On 24 April 2007, SPC forecasters recognized the potential threat of tornadoes crossing the Rio Grande into the U.S. The local National Weather Service issued severe thunderstorm and tornado warnings for the area prior to the Rosita Valley tornado. However, there were problems with the dissemination of these warnings. Local television and radio stations did not broadcast the warnings, and Rosita Valley was in an "unreliable area" for NOAA weather radio. It was clear to the authors that more education of severe weather awareness is needed in this area. Although tornadoes may be rare in this arid climate, severe storms are common. The authors believe that NOAA weather radios should be promoted and a transmitter installed at Eagle Pass.

In our damage survey, we found numerous manufactured homes that rolled, tumbled, or vaulted while nearby vehicles and wood-framed houses remained intact. Unfortunately, seven people lost their lives in this tornado of which six people died in manufactured homes. It must be emphasized that manufactured homes are not tornado shelters and occupants must seek alternative shelter, if they have time.

ACKNOWLEDGEMENTS

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