7A.3 A GEOGRAPHIC INFORMATION SYSTEM BASED REANALYSIS OF THE 3 DECEMBER 1978 BOSSIER CITY, LOUISIANA TORNADO

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1. INTRODUCTION

One of the strongest tornadoes in ArkLaTex history swept through Bossier City, Louisiana around 1:50 AM CST (0750 UTC) on 3 December 1978. The violent tornado cut a 402 m wide path of destruction across 12.8 km, injuring 266 and killing 2 people. After an exhaustive survey, the tornado was rated an F4 by Dr. Ted Fujita (United States Department of Commerce 1978), with a peak wind estimated near 402 kmh^{-1}.

In order to commemorate the 30th anniversary of this event and remember those who were affected by this devastating storm, the tornado's track was reexamined in fall 2008. Geographic Information System (GIS) software was utilized during the reanalysis to ascertain the effects a similar storm would have 30 years later. This was accomplished through a careful comparison of the updated track maps, census data, and current aerial photographs of the damage areas.

2. METEOROLOGICAL OVERVIEW

2.1 Synoptic Environment

Figure 1 shows a deep, positively-tilted upper-atmospheric trough extending from western North Dakota to Baja California at 0000 UTC on 3 December 1978. The right entrance region of a 250 hPa jet, with wind speeds between 60 and 70 ms^{-1}, was located ahead of the trough axis and poised to affect Northwest Louisiana.

The near-surface environment (not shown) was characterized by unusually warm and moist weather conditions. A strong 850 hPa jet, with wind speeds between 25 and 30 ms^{-1}, resulted in temperatures around 15°C and precipitable water values in excess of 3.5 cm. These values are between 1 and 2 standard deviations above climatological means.

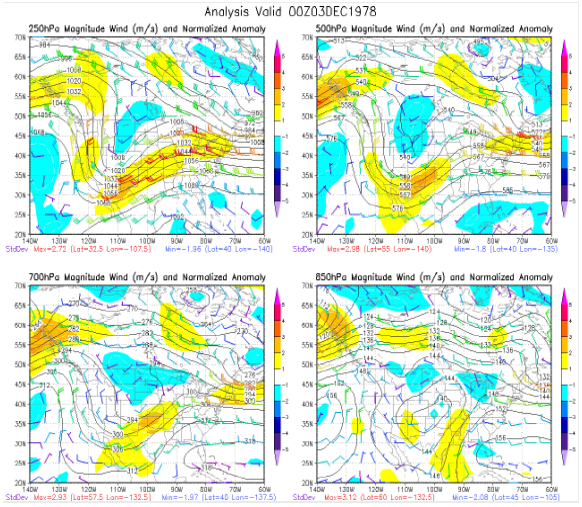

Figure 1. *Depiction of the Upper atmospheric charts valid at 0000 UTC on 3 December 1978. Heights [hPa] and winds [m s^{-1}] are depicted for the 250, 500, 700, and 850 hPa levels. The image depicts the normalized wind speed anomaly for each level in standard deviations from climatological means.*

A strong shortwave trough (not shown) ejected from the deep longwave trough, which stretched from Central Kansas into Northwest Louisiana by 0600 UTC. Thunderstorm development occurred across East Texas as this shortwave trough interacted with a cold front extending from East Texas into the Ohio Valley (Figure 2).

2.2 Mesoscale Environment

An examination of the 1200 UTC sounding from Longview, TX on 2 December (Figure 3) shows a nearly saturated sounding through

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approximately the lowest 1.5 km. A large subsidence inversion was noted above the moist layer, which inhibited convective development over the region during the day. Upon comparison of the 0000 UTC sounding from 3 December (Figure 3), it is noted the base of the subsidence inversion has risen to almost 750 hPa. This lifting of approximately 100 hPa has been attributed to the passage of a shortwave trough.

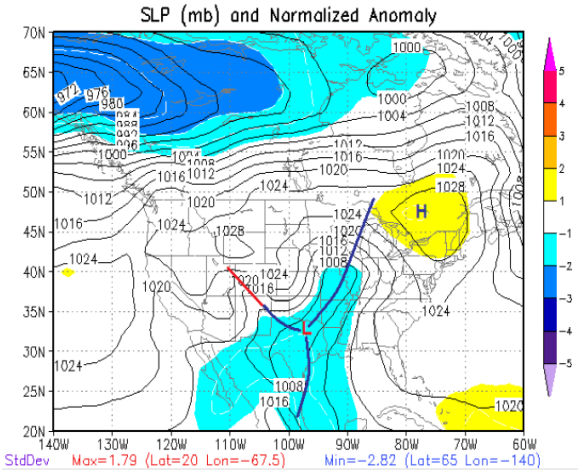

Figure 2. *Depiction of the surface analysis valid at 0000 UTC on 3 December 1978. Surface pressures are contoured every 4 hectopascals. The image depicts the normalized pressure anomaly in standard deviations from climatological means.*

Atmospheric soundings also indicate the strengthening of low-level wind shear and instability parameters prior to the tornado. Crude estimates based on the 0000 UTC sounding suggest a surface to 3 km shear magnitude up to 20 ms^{-1} was available as thunderstorms moved into the region. Instability values were also abnormally high for early December. A lifted index of -6.2° was observed of the 0000 UTC sounding, with a CAPE of 2179 Jkg^{-1}.

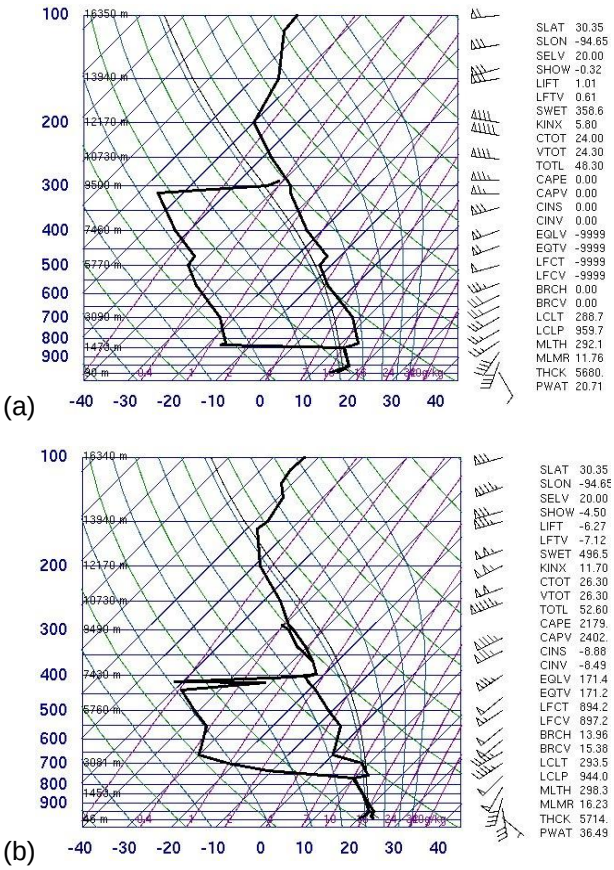

Figure 3. *(a) 1200 UTC atmospheric sounding from Longview, TX on 2 December 1978. Heights shown are in hectopascals, with wind barbs displayed in knots. A listing of accepted atmospheric indices are shown to the right of the image. (b) Same as (a), except valid for 0000 UTC on 3 December 1978. Images courtesy of the University of Wyoming.*

2.3 Radar Depiction

Figure 4 shows a picture from the National Weather Service's WSR-74S radar located in Longview, Texas. The tornado developed from an isolated supercell thunderstorm, located ahead of a pre-frontal squall line. In addition to the tornado in Bossier City, other tornadoes were produced by this long-track supercell thunderstorm in El Dorado, Arkansas and Tunica, Mississippi (United States Department of Commerce 1978).

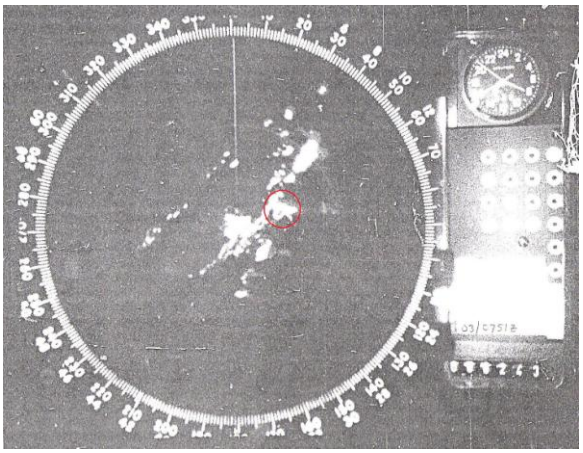

Figure 4. *National Weather Service Longview, TX WSR-74S radar image showing the supercell thunderstorms and pre-frontal squall line. A red circle highlights the supercell thunderstorm responsible for producing the Bossier City, LA tornado. The tornado is on the ground at this time in Bossier City. Image taken at 0751 UTC on 3 December 1978.*

3. GIS ANALYSIS

3.1 Georeferencing

Georeferencing is the process of aligning spatial data (layers that are shape files: polygons, points, etc.) to an image file such as an historical map, satellite image, or aerial photograph. Or in the case of this study, the detailed image of the 1978 tornado track georeferenced to reacquire the data from the image.

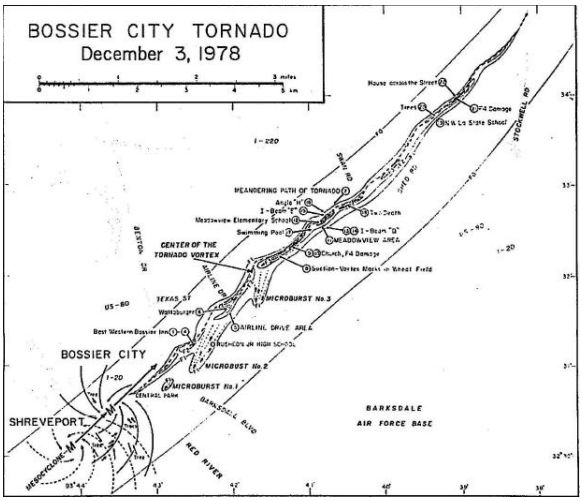

Figure 5. *The result of scanning the Fujita analysis. This will be georeferenced as shown in Figure 6. (From Fujita 1979)*

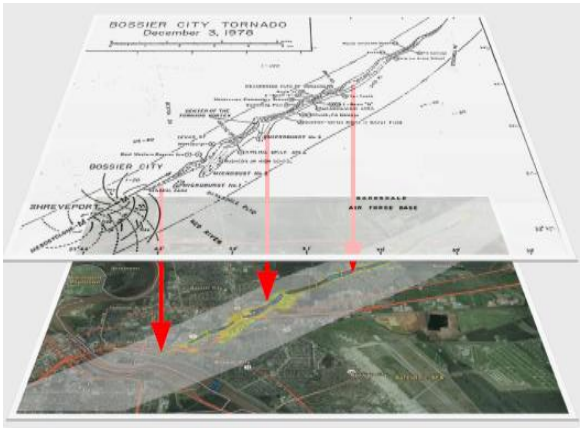

Figure 6. *An illustration depicting the process used in order to re-analyze the track of the 3 December 1978 Bossier City, LA tornado using GIS software. Utilizing the marked locations from Figure 5, the tornado damage path can be georeferenced and a shapefile of the swath can be created. (Modified from Fujita 1979)*

The first step in this process was to scan the image from the *Fujita* (1979) paper as a digital image (Figure 5). Second, georeferencing tools within the ESRI ArcMap software were used to mark locations on the image with real world coordinates. Slowly during this process as points were marked, the image would shift and conform until the image lined up over the exact location of all of the points marked. Lastly, an outline of the damage swath was traced from the image into a newly created shapefile similar to the process shown in Figure 6. The result of this process was to produce a highly detailed polygon shapefile depicting the tornado damage swath (Figure 5).

3.2 Spatial Analysis

Spatial analysis is the process of applying analytical techniques to geographically-referenced data sets to extract or generate new geographical information. The shapefile developed in the georeferencing process can then be used to derive a number of statistics using GIS tools or it can be moved to another location to derive “what if” scenarios of the same tornado in another location. For the purposes of this study, the shapefile of the track was compared against the latest census data using a process called spatial analysis which is shown in Figure 7 where the polygons of the tornado track were used to select census block data which were contained geographically within the boundary of the tornado track.

The final reanalysis track for the 3 December 1978 Bossier City tornado is shown in Figure 8. Through GIS spatial query, it was determined that EF0 or higher winds could potentially impact 21,000 people. Further investigation found that approximately 5,000 people live in the portion of the tornado's track affected by EF2 strength or higher winds.

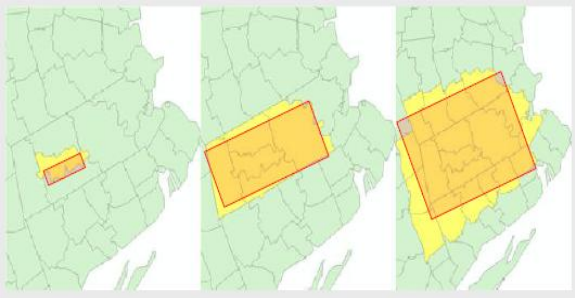

Figure 7. *Three examples illustrating how spatial analysis works. Variables from one geographic area (yellow) can be selected based on the spatial coverage of another.*

4. DISCUSSION

A primary goal of this research was to investigate the effects of the tornado if it occurred some 30 years later. Considerable residential and business growth has changed the landscape in the Shreveport-Bossier City area since this tornado occurred. Many more businesses, such as casinos and fast food restaurants, are now open 24 hours. Partly because of this growth, and businesses operating for longer times during the day, there is a greater volume of traffic on area roadways. These factors suggest the possibility that a violent tornado moving along the same path today has the potential to inflict a greater loss of life and structural damage than in 1978.

There has been much speculation as to why only 2 lives were lost in the 1978 tornado. The time of the tornado's occurrence clearly played a role. In 1978 at 1:50 AM CST (0750 UTC), shopping centers and most restaurants were closed. Schools were not in session. Traffic along Interstate 20 and other major roadways was relatively light. If the tornado occurred during the afternoon or on a weekday, the number of fatalities would likely be much higher. Special events in the local area would also play a role in the number of people visiting the region and staying in area motels.

5. CONCLUSION

Through this research, GIS analysis was demonstrated to be a valuable tool to reanalyze historical weather events. When these historical datasets are used in conjunction with today's societal databases, impacts can be derived if a similar event occurred today.

Based on reanalysis, it is expected many more injuries and fatalities would have occurred and damage would have been more extensive if the tornado had occurred today.

In addition, because of the time of year that this tornado occurred (December), the 30th anniversary of this storm was used by the National Weather Service in Shreveport, LA as an awareness tool for fall and winter tornadoes across the southern United States.

The resultant track information obtained in this study is planned for use in a large scale joint exercise with FEMA and local governments in early 2011.

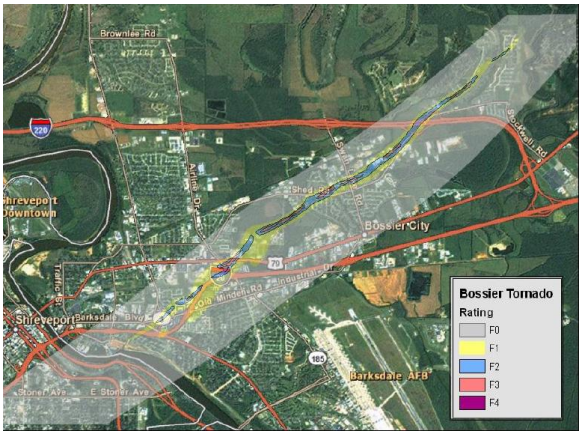

Figure 8. *The result of georeferencing the scanned image and comparing it to recent areal photography.*

6. REFERENCES

Fujita, T.T., 1979: *Preliminary Report of the Bossier City Tornado of December 3, 1978*. Texas Tech University, 33 pp.

United States Department of Commerce, 1978: *Storm Data*. Govt. Printing Office.