P11.1 USING A GIS TO COMPARE THE MAY 3, 1999 OKLAHOMA CITY TORNADO DAMAGE PATH WITH WSR-88D SIGNATURES

Valerie K. McCoy* and Gregory J. Stumpf

NOAA/National Severe Storms Laboratory, Norman, Oklahoma
Cooperative Institute for Mesoscale Meteorological Studies, University of Oklahoma, Norman, Oklahoma

1. INTRODUCTION

A Geographic Information System (GIS) was used to relate known tornado damage path of the 3 May 1999 Oklahoma City F5 tornado to low-altitude radar vortex signatures remotely sensed with Weather Surveillance Radar 1988-Doppler (WSR-88D) data from Twin Lakes, Oklahoma (KTLX). Burgess et al. (2002) compared the strength and location of radar signatures to that of the tornado damage path. We further their work, doing a direct comparison of the width of the vortex signature in WSR-88D to the width of the tornado damage path using digital data and the GIS.

2. DATA

WSR-88D data from KTLX between the period 2331 UTC 3 May 1999 to 0042 UTC 4 May 1999 was processed along almost all of the entire path of the 38-mile long tornado that passed through the OKC metro area. Tornado path information developed by the National Severe Storms Laboratory (NSSL; Speheger et al. 2002) was digitized in a GIS courtesy of the North Central Texas Council of Governments (COG). Digitized street data from Oklahoma, Cleveland, and Grady Counties, obtained from OKC Dept. of Public works are also used.

3. ANALYSIS

3.1 Preparing tornado path data.

During the several weeks following the 3 May 1999 tornado, teams from the NSSL, the National Weather Service, the Storm Prediction Center, the University of Oklahoma, and the Radar Operations Center, surveyed the various tornado paths in Central Oklahoma. The NSSL surveyed the tornado that affected the OKC metro area in greater detail, and developed maps of contoured "F-scale" damage intensity along the 38-mile path. The data were then transferred from hand drawn contours to PowerPoint contours overlaid on digital street atlas maps. These analog data were then digitized, courtesy of the North Central Texas COG for a GIS study relating the impact of the Central Oklahoma tornado outbreak had one occurred over the Dallas-Fort Worth Metroplex. Rae and Stefkovich (2000) transposed the central Oklahoma digital tornado path data over the Dallas/Fort Worth Metroplex. Using an urban GIS containing information about appraisal records, land use classifications, demographic data, building locations, and traffic flow, they were able to assess the potential social and economic impact of a similar outbreak of tornadoes over another major metropolitan area in Tornado Alley. These digitized data were then shared with the NSSL, and made available for our project. We brought the data into a common coordinate system, and set the legends to contour the F-scales (Fig. 1).

3.2 Converting WSR-88D Doppler radar data into ArcView polygon coverages.

The first step was to output the raw WSR-88D into tabular format that ArcView could handle. The data had to be stored as point data, with the longitude, latitude, polygon ID, and value. For each radar sample volume, the four corners of the volume were saved. The code was written such that the lat/lon corners of adjacent sample volumes were

**Correspondence information:* 1313 Halley Circle, Norman, OK 73069, valerie.mccoy@noaa.gov

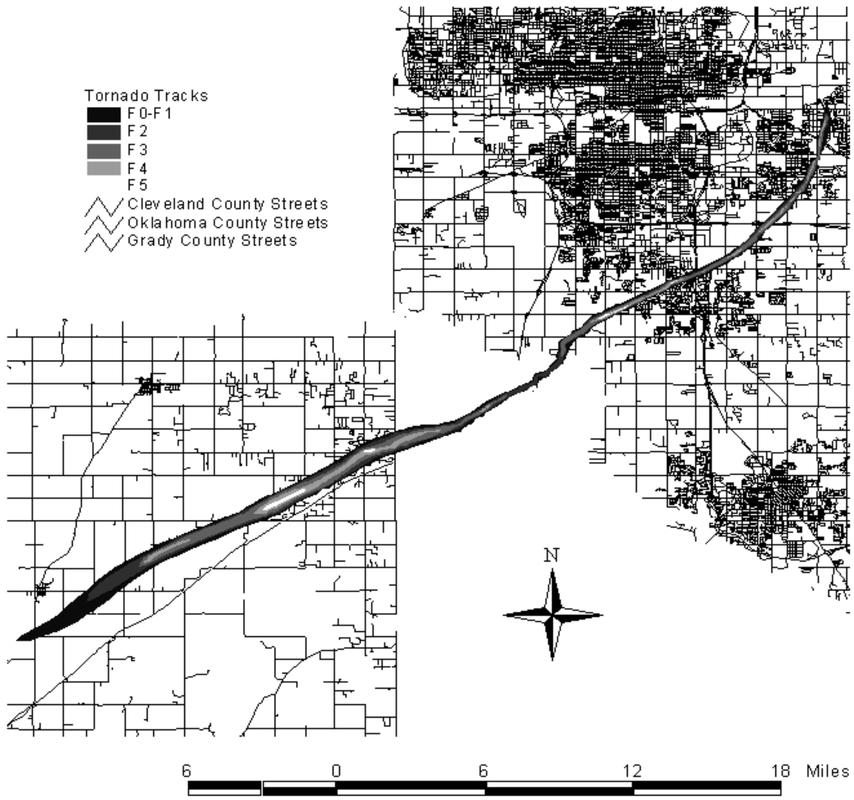

Figure 1. Digitized tornado track.

matched, to avoid slivering. Then, this table was input into ArcView, and a series of steps was taken to convert these data into ArcView polygon coverages. The 0.5° elevation tilt Doppler velocity data from the KTLX WSR-88D were digitized for 15 volume scans (5 minute update rate) encompassing the time of the OKC tornado (from Amber in Grady County to Midwest City in Oklahoma County). Some of the radial velocity data had to be manually dealiased to remove velocity ambiguities. The reflectivity data were digitized for one volume scan (0022 UTC 4 May 1999).

3.3 Create color tables for the radar data.

Once the radar coverages were developed, we created the color tables (legends) for both types of coverage (velocity and reflectivity). The color tables were developed to match the Hue-Saturation-Value (HSV) colors and the attribute ranges of the NSSL Warning Decision Support System (WDSS) Radar and Algorithm Display System (RADS; Eilts et al., 1997).

3.4 Create coverages corresponding to the path of the low-altitude radar vortex signatures.

For each of the 15 volume scans, the maximum inbound and outbound velocities of the 0.5° vortex signatures were obtained manually from the radar data, but using the NSSL Mesocyclone Detection Algorithm (Stumpf et al. 1998) as guidance. From the manual vortex identification we drew a circle centered halfway between the maximum inbound and outbound velocities with a diameter equal to the distance between the centers of these two velocities.

To create a polygon coverage corresponding to the path swept out by these circles, the following steps were taken:

a. Determine the angle of the radar vortex path from one volume scan to the next. The path is the line segment connecting the centroids of the two vortex circles.

Figure 2. Digitized reflectivity image (0022 UTC 4 May 1999) with street and tornado track overlays.

b. Draw the diameter segment perpendicular to the path line for each of the two vortex circles.
c. Determine the pair of points, for each of the two vortex circles, where the "perpendicular-to-the-path" diameters intersect the circle.
d. Use both pairs of points for each of the two radar vortices, four points total, to create a trapezoid polygon.

We created 14 trapezoid polygons, corresponding to the 14 path segments between the 15 volume scans.

4. Results

The first radar volume scan that we converted to a polygon coverage was for 0022 UTC 4 May, when the F5 tornado was in the residential Eastlake Subdivision in southwest OKC. Figure 2 shows the digitized WSR-88D reflectivity data superimposed with the tornado damage path, showing the "hook echo", comprised of very high reflectivities (presumably caused by the large quantities of debris lofted by the tornado) (Burgess et al., 2002).

Figure 3 (a-c) shows the entire tornado path with the radar-vortex polygons. The figure also shows every 3rd volume scan of velocity data for reference. There is good spatial correspondence between the path of the damage and of the radar vortex, as both show the small curves in the path. Also of note, the first half of the path, the radar vortex is about as wide as the tornado damage itself (which was approximately 1 mile wide, about the maximum limit for tornado size). Just as the tornado first crossed I-44 in McClain County about halfway along the path) the tornado shrinks in size to about 1/3 its diameter. But remarkably the radar vortex remains about the same diameter. As the tornado moves into and through the metro area, it slightly enlarges again (about 1/2 mile wide), and eventually curves to the north and dissipates or ropes out. During this later half, the vortex remains about 1 mile wide until the final 10-15 minutes of the tornado when it too begins to narrow.

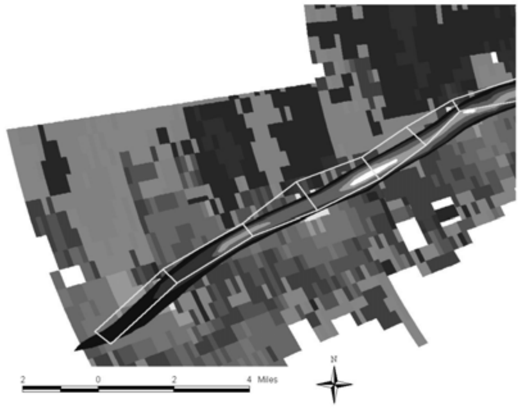

Figure 3-a. The beginning of the tornado track with digitized Doppler velocity image with MDA polygon and tornado track overlays.

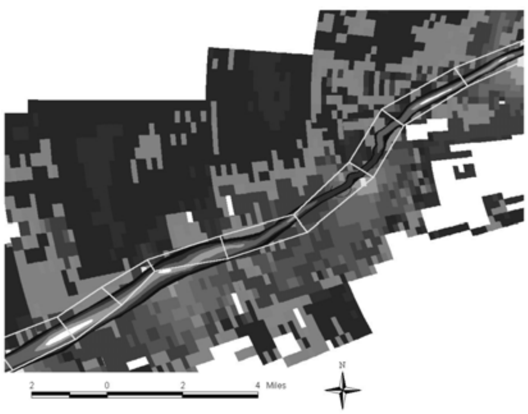

Figure 3-b. The middle of the tornado track with digitized Doppler velocity image with MDA polygon and tornado track overlays.

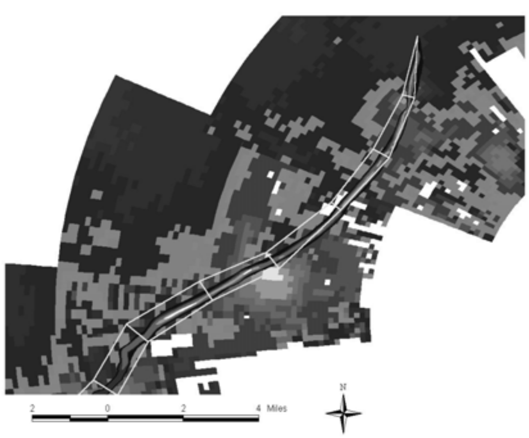

Figure 3-c. The end of the tornado track with digitized Doppler velocity image with MDA polygon and tornado track overlays.

5. Conclusions

This project is only the beginning of what could be a much larger study to relate tornado damage paths to information obtained from remote sensors, such as radar data. Work carried out by Burgess et al. (2002) represents the first step toward such a study (their comparisons were done without using GIS). Our project is the next step in this work. Future work could include the analysis of the radar data at higher elevation angles, a comparison of radar-vortex strength to F-scale intensity, and similar analyses on other tornado events. These studies can go a long way in providing insight as to how the WSR-88D actually does observe tornadoes and tornadic storms, given its sampling limitations. Eventually, with the phased-array radar soon to be deployed at NSSL, more complete 3-dimensional images of tornadic storms can be used to further understand these relationships.

Acknowledgments

Thanks go to Ami Arthur of the NSSL for helping with the conversion of the radar data to ArcView coverages. Thanks go to Scott Rae of the North Texas Council of Governments for digitizing the NSSL damage survey F-scale information.

References

Burgess, D. W., M. Magsig, J. Wurman, D. Dowell, and Y. Richardson, 2002: Radar observations of the 3 May 1999 Oklahoma City tornado. Submitted to *Wea. Forecasting*.

Rae, S., and J. Stefkovich, 2000: The tornado damage risk assessment predicting the impact of a big outbreak in Dallas-Fort Worth, Texas. *Preprints*, 20th Conf. on Severe Local Storms, Orlando, Amer. Meteor. Soc., 295-296.

Speheger, D. A., C. A. Doswell III, and G. J. Stumpf, 2002: The tornadoes of 3 May 1999: Event verification in central Oklahoma and related issues. *Wea. Forecasting*, **17** (in press).

Stumpf, G. J., A. Witt, E. D. Mitchell, P. L. Spencer, J. T. Johnson, M. D. Eilts, K. W. Thomas, and D. W. Burgess, 1998: The National Severe Storms Laboratory mesocyclone detection algorithm for the WSR-88D. *Wea. Forecasting*, **13**, 304-326.