Aerial Damage Survey Analysis of the 20 May 2013 Moore, OK Tornado

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Research Objectives

- Document the damage produced by a historical EF-5 tornado.
- Examine relationships among the damage, visual characteristics, and dual-polarization observations of the tornado.
- Make a comparison between independent aerial and ground damage surveys.

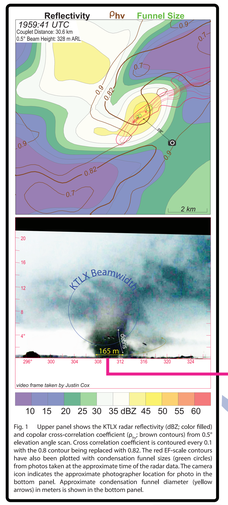
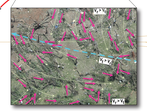
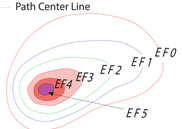


Fig. 1 Upper panel shows the KTLX radar reflectivity (dBZ; color filled) and copolar cross-correlation coefficient (ρ_{hv}; brown contours) from 0.5° elevation angle scan. Cross correlation coefficient is contoured every 0.1 with the 0.8 contour being replaced with 0.82. The red EF-scale contours have also been plotted with condensation funnel sizes (green circles) from photos taken at the approximate time of the radar data. The camera icon indicates the approximate photographer location for photo in the bottom panel. Approximate condensation funnel diameter (yellow arrows) in meters is shown in the bottom panel.



Legend

- 0-5 Combined Aerial and Ground EF Ratings
- Down Telephone Pole
- Debris
- Flow Lines
- Funnel Diameter
- Tree Fall Direction
- Path Center Line



Methods and Data

- Conducted an aerial damage survey. Used ArcGIS to create a point-by-point damage analysis containing attributes such as EF ratings and assessed property values.
- Compared to NWS/NSSL ground survey for consistency.
- Performed photogrammetric analysis to quantify condensation funnel diameter on photos and video provided by amateur storm chasers and news crews.
- Surveyed tree fall directions using aerial photography and Google Earth.

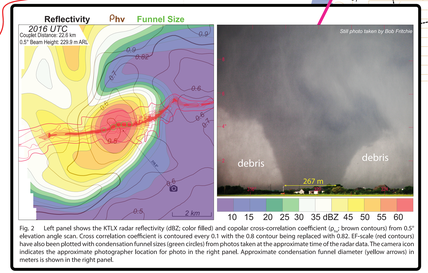


Fig. 2 Left panel shows the KTLX radar reflectivity (dBZ; color filled) and copolar cross-correlation coefficient (ρ_{hv}; brown contours) from 0.5° elevation angle scan. Cross correlation coefficient is contoured every 0.1 with the 0.8 contour being replaced with 0.82. EF-scale (red contours) have also been plotted with condensation funnel sizes (green circles) from photos taken at the approximate time of the radar data. The camera icon indicates the approximate photographer location for photo in the right panel. Approximate condensation funnel diameter (yellow arrows) in meters is shown in the right panel.

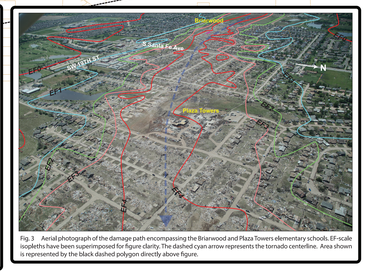


Fig. 3 Aerial photograph of the damage path encompassing the Briarwood and Plaza Towers elementary schools. EF-scale isopleths have been superimposed for figure clarity. The dashed cyan arrow represents the tornado centerline. Area shown is represented by the black dashed polygon directly above figure.

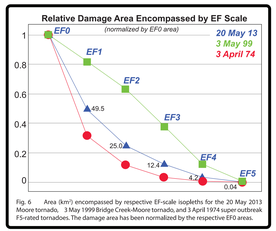


Fig. 6 Area (km²) encompassed by respective EF-scale isopleths for the 20 May 2013 Moore tornado, 3 May 1999 Bridge Creek-Moore tornado, and 3 April 1974 super outbreak F5-rated tornadoes. The damage area has been normalized by the respective EF0 areas.

Research Results

- The damage path length was estimated at 28.1 km. Maximum width was approximately 2.05 km.
- Approximately 4531 structures were damaged by the tornado over an area of 28.6 km^2.
- EF3 and 4 damage was observed within 1.6 km (4 minutes) from the beginning of the damage path.
- The KTLX WSR-88D dual-polarization tornado debris signature (TDS) evolution was not well correlated with the rapid increase in damage at and just after the time of tornadogenesis.
- Near the time of maximum intensity and width, the TDS was well defined and collocated with the damage path and condensation funnel. The spatial scale of the TDS was consistent with that of the low-level mesocyclone.
- Tree fall revealed highly convergent surface flow over the majority of the damage path.
- The condensation funnel width often coincided with EF1, EF2, and EF3 isopleths.
- The relative damage area increased exponentially with decreasing EF-scale.
- The aerial survey contained a low bias for structures rated EF0 and EF1 in the ground survey.

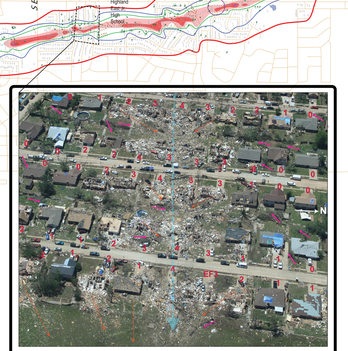


Fig. 4 Aerial photograph of the damage survey analysis with structure-by-structure EF-ratings (red numbers). The tornado centerline (dashed cyan arrow) and tree fall direction (magenta arrows) are shown. Orange arrows indicate the debris track.

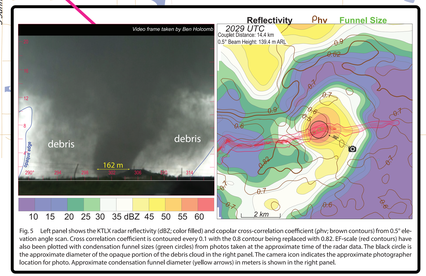


Fig. 5 Left panel shows the KTLX radar reflectivity (dBZ; color filled) and copolar cross-correlation coefficient (phv; brown contours) from 0.5° elevation angle scan. Cross correlation coefficient is contoured every 0.1 with the 0.8 contour being replaced with 0.82. EF-scale (red contours) have also been plotted with condensation funnel sizes (green circles) from photos taken at the approximate time of the radar data. The black circle is the approximate diameter of the opaque portion of the debris cloud in the right panel. The camera icon indicates the approximate photographer location for photo. Approximate condensation funnel diameter (yellow arrows) in meters is shown in the right panel.

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Aerial Versus Ground Survey Structure Rating Comparison

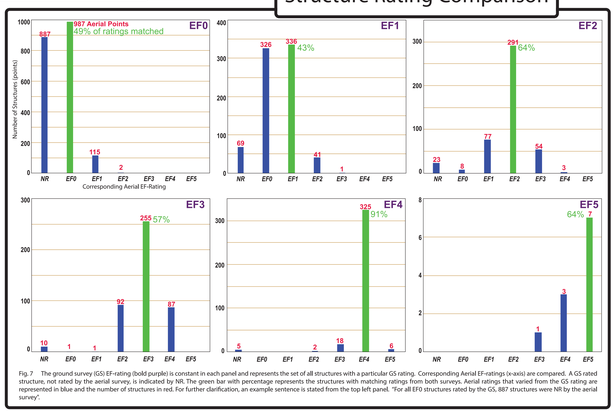

Fig. 7 The ground survey (GS) EF-rating (bold purple) is constant in each panel and represents the set of all structures with a particular GS rating. Corresponding Aerial EF-ratings (x-axis) are compared. A GS rated structure, not rated by the aerial survey, is indicated by NR. The green bar with percentage represents the structures with matching ratings from both surveys. Aerial ratings that varied from the GS rating are represented in blue and the number of structures in red. For further clarification, an example sentence is stated from the top left panel. "For all EF0 structures rated by the GS, 887 structures were NR by the aerial survey".

Acknowledgements

Research results presented herein were supported by the National Science Foundation Rapid Response Research (RAPID) Grant (AGS-1343963). Robert Fritchie, Justin Cox, and Ben Holcomb graciously provided photos and video.