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HIGH-RESOLUTION TDWR EVOLUTION OF THE NEWCASTLE-MOORE, OKLAHOMA TORNADO OF 20 MAY 2013

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INTRODUCTION

On the Monday afternoon of 20 May 2013, a tornado touched down west of Newcastle, Oklahoma at 1956 UTC, rapidly intensifying and attaining EF4 intensity within 3 minutes and about 1 km (0.5 mi) from touchdown. The deadly tornado stayed on the ground for 39 minutes over a 27-km (17-mi) path, tearing through a heavily populated section of Moore, killing 23 people and injuring scores of people. Between 2016 and 2018 UTC, the EF5 tornado was most intense. After 2018 UTC, it abruptly shrank in size, reducing EF5- to EF2-strength before becoming a thin rope tornado. The tornado eventually dissipated around 2035 UTC. The 20 May 2013 tornado followed a roughly similar track to the Bridge Creek-Moore tornado of 3 May 1999.

OBJECTIVES

The objectives of this study are twofold:

a. to provide detailed information on the high-resolution Doppler velocity fields in and around the tornado, and
b. to compare estimates of tornado rotational velocity and core diameter with tornado damage survey estimates in terms of EF ratings.

RADAR CHARACTERISTICS

Oklahoma City, Oklahoma Terminal Doppler Weather Radar (TOKC) is located in the northwest section of Norman, Oklahoma. Radar characteristics are shown in Table 1.

TABLE 1. TOKC Operating Characteristics

Wavelength	5 cm
Transmitted Peak Power	250 kW
Half-power Beamwidth	0.5°
Effective Beamwidth	1.2°
Nyquist Velocity	16 to 22.5 m s^{-1}
PRF	5.6 to 5.65 GHz
Range Gate Spacing	150 m
Azimuthal Gate Spacing	1.0°

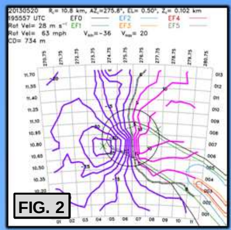


FIG. 2

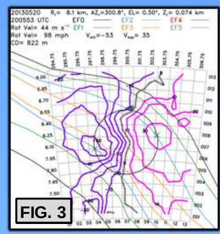


FIG. 3

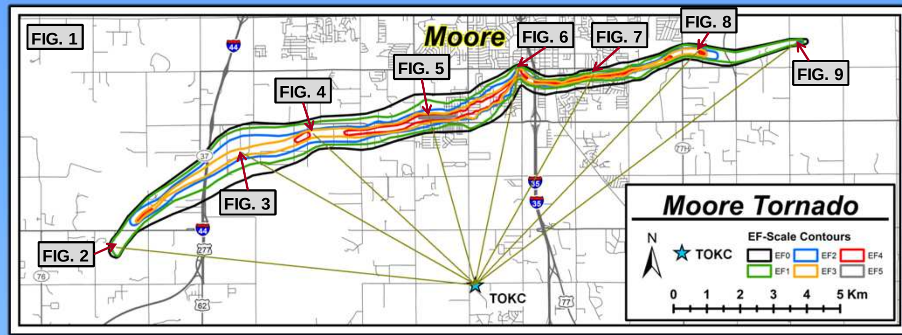
FIGURE CAPTIONS

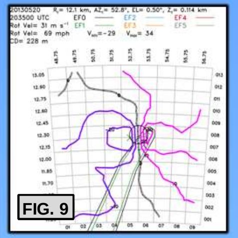
FIG. 1. Damage survey compiled by a National Weather Center (NWC) team for the Moore, Oklahoma tornado of 20 May 2013. The EF-ratings along the damage path are contoured according to different colors. The blue star shows the location of TOKC. The radial distances (R_c) from TOKC to the center grids of Doppler velocity patterns superimposed on colored, contoured damage (EF-ratings) paths are indicated by Figs. 2-9.

FIGS. 2-9. Magenta (blue) contours, respectively, represent positive (negative) ground-relative Doppler velocities – flow away from (toward) the radar. Zero Doppler velocity represents flow perpendicular to the radar viewing direction, as indicated by a thin white contour superimposed on a thick black contour. Date (yyyymmdd) and time (UTC) of data collection are indicated. Rotational velocity (Rot Vel) is calculated as the average of extreme positive (V_{max}) and negative (V_{min}) Doppler velocity values across the estimated tornado core diameter (CD, a black circle). The center range (R_c), azimuth (AZ_c), elevation angle (EL) and height (Z_c), as shown at the top, represent the center grid.

METHODOLOGY

- TOKC data were processed between 1901 and 2100 UTC, thus providing good radar data that were continuous during the tornado's life.
- For data editing, we used the Solo radar data editing software (Oye et al. 1995), now it its third version (Solo3; https://www.eol.ucar.edu/software/solo3).
- A 2-D contouring technique was created to display data in radar coordinates (range and azimuth grids) to retain peak Doppler velocity values that would have been lost if using an objective analysis scheme.

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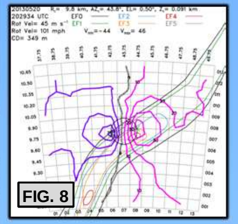
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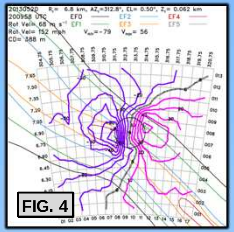
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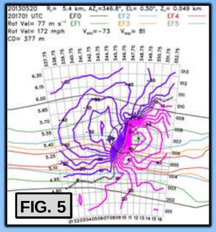
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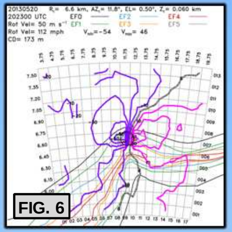
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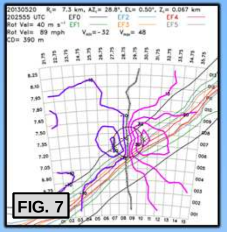
FIG. 7

PRELIMINARY RESULTS

Based on Figs. 2-10, the preliminary results are presented as follows:

- A *tornado signature* (TS) is a vortex signature of extreme Doppler velocity values (of opposite sign, green X's) separated by one to a few beamwidths in the azimuthal direction, which arises when the tornado is within a few kilometers of a radar and the tornado is larger than the radar beam.
- The high-resolution Doppler velocity data gathered from lowest-elevation (0.5°) scans are compared to ground damage survey Enhanced Fujita (EF) scale estimates obtained from the NWC team.
- Most Doppler velocity peaks (green X's) are not at the same range from TOKC because target motion in the tornado vortex is slightly divergent, resulting from debris centrifuging.
- The TS center tracked a few hundred meters farther north than the centerline of the damage survey due to stronger winds on the south side of the tornado contributed by the added translational motion of the tornado.
- TOKC measured the strongest rotational velocities exceeding 75 m s^{-1} in the lowest 50 m AGL (Figs. 5 & 10) when the tornado was closest (5.4 km) to the radar at 2017 UTC and at a time when the tornado was intense.
- Evolution of estimated core diameter (CD) and rotational velocity (RV) in relation to the varying EF ratings is shown in Fig. 10.

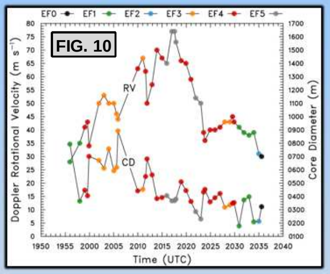

Fig. 10. Evolution of tornado core diameter (CD) and rotational velocity (RV) in relation to the varying (colored circles) EF ratings.

CONCLUSIONS AND FUTURE WORK

The Moore, Oklahoma tornado of 20 May 2013 afforded the opportunity to:

a) document detailed information on the evolution of high-resolution Doppler velocity fields in and around the tornado at proximity to the TOKC, and
b) implement comparisons between a damage survey and Doppler velocity measurements.

This study is part of our ongoing research to continue documentation of detailed information on the evolution of the high-resolution Doppler velocity and reflectivity fields surrounding the tornado at all elevation angles.

The Special Symposium on Severe Local Storms:
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