Confirming Bottom-Up Tornadogenesis in the 31 May 2013 El Reno, OK Tornado

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Fig. 1: Example of the Tornado Environment Display webtool illustrating video clips from 4 storm chasers at 2305 UTC (shortly after tornadogenesis) on 31 May 2013. KTLX radar data is displayed in the background, coupled with GPS-based chaser locations.

Fig. 2: Photograph of a condensation funnel in contact with the ground at 2302:25 UTC. The radar-observed time for tornadogenesis was sometime during the one minute of 2304. © H. Farrar

Fig. 3 (below): Series of RaXPol reflectivity (dBZ, left panels) and radial velocity (m s^{-1}, right panels) from 0° (upper) and 2° (lower). Note the difference in the radial velocity fields in the vicinity of the developing tornado (arrows) between the two elevations, especially prior to 2303. Beam heights were ~ 20 m and 300 m AGL respectively.

INTRODUCTION AND MOTIVATION

In the early 1970's, results from 'new' Doppler radar data coupled with those from early laboratory and numerical simulations suggested that tornadoes formed from an area of strong rotation embedded within the mid-level mesocyclone, that descended gradually to lower levels until it intersected the surface at which time the vorticity contracted and a tornado formed (Leslie 1971; Smith and Leslie 1978; Brown et al. 1977). More recently, rapid-scan radar data have all but discredited this pervasive yet most likely inaccurate description of tornadogenesis (e.g. French et al. 2013, 2014; Houser et al. 2015). However, one piece of the story that has remained inconclusive (predominately due to the difficulty in acquiring data so low) is: <u>how does the rotation immediately adjacent to the ground evolve prior to and during tornadogenesis</u>? **This work examines the evolution of rotation associated with the famous 31 May 2013 El Reno, OK tornado using rapid-scan mobile radar data (from OU's RaXPol) that were acquired at unprecedentedly low heights (<100 m) in conjunction with visual truth documented by storm chasers and compiled together geosynchronously in the El Reno Project, using the Tornado Environment Display online platform (Fig. 1) developed specifically for the El Reno case (Seimon et al. 2016)**

RESULTS AND CONCLUSIONS:

- There was a discrepancy between visual observations of the tornado and radar-derived tornadogenesis time by about 90 s with the tornado being first observed visually. (Fig. 2) The radar time, which occurred later, was based upon the development of a vertically coherent vortex from a few m AGL through 3 km AGL.
- There was considerable difference in the wind field between the 0° and 2°, especially in the vicinity of the developing TS (Fig. 3).
- There was a general trend for increasing low-level mesocyclone strength just prior to and during the intensification of the near-surface, pretornadic vortex (Fig. 4).
- The radar-based tornado signature (TS) associated with the tornado was first evident in the 0° data (10-20 m AGL) as a pretornadic couplet, about 2 minutes prior to the visual observations of a condensation funnel (Fig. 5).
- The intensification of the TS to ΔV>40 m s^{-1} corresponded with when the condensation funnel was observed
- TED provided valuable data in confirming tornado start time and a visual 'truth'.
- **Bottom-up tornadogenesis is CONFIRMED from this dataset and occurred very rapidly.**
- Other thoughts: Forecasting appears problematic! Small-scale (microscale?) processes are likely important. Friction may play an important role. Our eyes likely deceive us with the top-down idea.

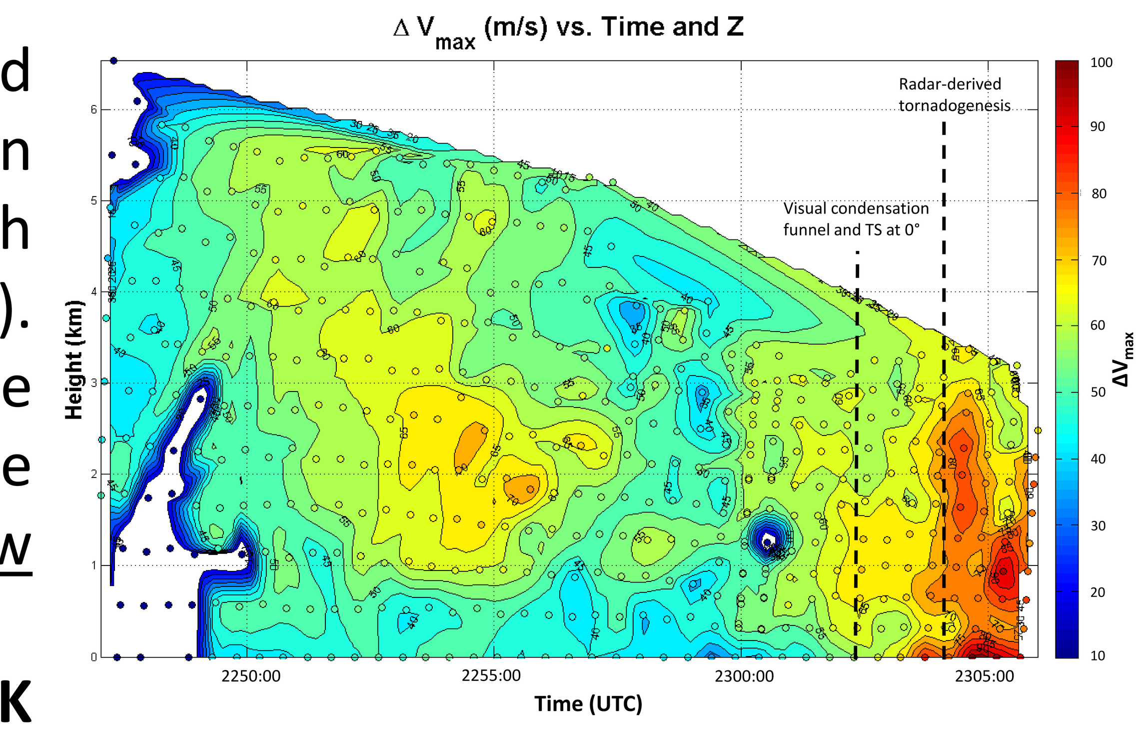

Fig. 4: Time (UTC, x-axis) – height (km, y-axis) plot of the difference between the maximum outbound and inbound velocities (ΔV, m s^{-1}, color fill and dots) associated with the strongest rotation (DOES reflect mesocyclone strength) and the tornado signature (TS) associated with the El Reno tornado.

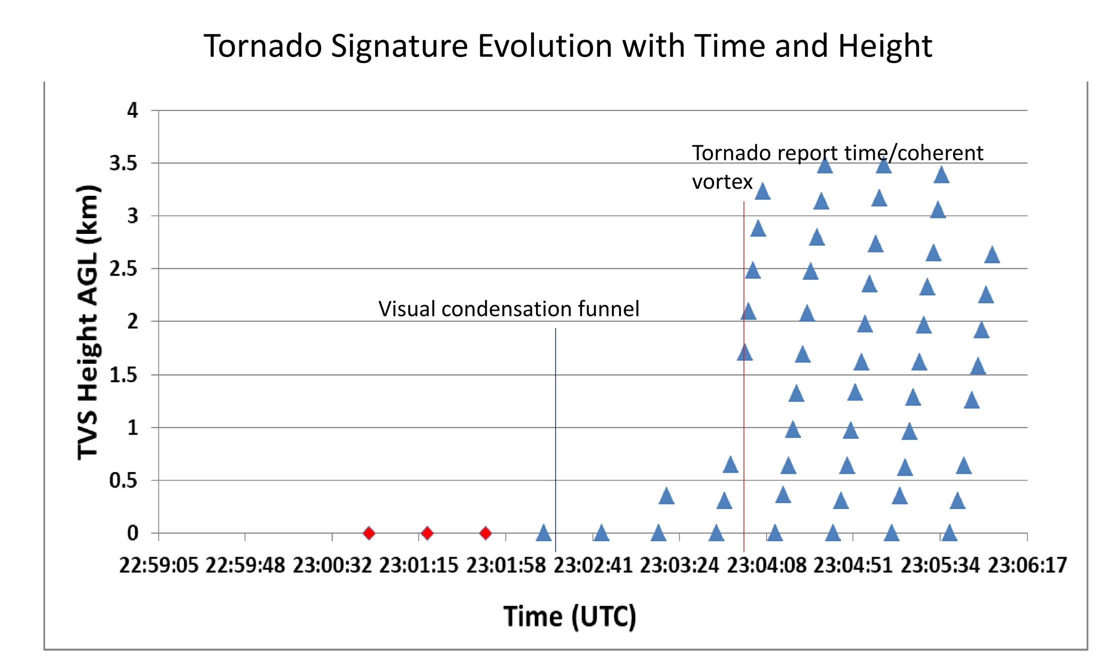

Fig. 5: Time (UTC, x-axis) – height (km, y-axis) plot tracking the TS associated with the El Reno tornado. Red = ΔV<40 m s^{-1}, Blue= ΔV>40 m s^{-1}. Red (blue) line indicates time of tornadogenesis from radar (TED) data.