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Rapid-Scan Observations of Tornadogenesis, Intensification and Decay from a Mobile Radar

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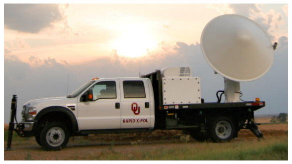

Fig. 1: The RaXPol mobile radar. (Copyright J. Snyder)

ABSTRACT

On 24 May, 2011, the University of Oklahoma mobile, Rapid-Scan, X-band, polarimetric radar (RaXPol) (Fig. 1, table 1) collected data during the dissipation of a tornado, the subsequent generation of a second tornado, and the intensification of the second tornado to EF-5 strength, with maximum radial velocities of 124 m s^{-1} observed (Figs. 2, 3). This is the first time that observations of these processes were collected with such high temporal resolution (17 s volume updates over 9 elevation angles) and adequate spatial resolution to resolve the tornado-scale evolution. The evolution of the size and intensity of the velocity couplet (ΔV) associated with both tornadoes is investigated and storm-scale features associated with tornado decay and tornadogenesis are examined.

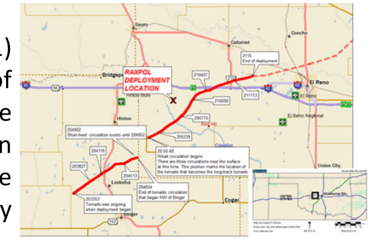

Fig. 2: Map of tornadoes and RaXPol deployment location

Parameter	Value
Center Frequency	9.73 GHz +-20 MHz
Transmit Power	20 kW peak, 200 W ave.
Transmit Pulse Width	0.1 – 40 us
Transmit Polarization	Equal Power V&H
Antenna type	Dual-linear Polarized Parabolic Reflector
Antenna Diameter	2.4 m
Antenna 3 dB Beamwidth	1.0°
Range Sample Resolution	75 - 150 m for this dataset
Pedestal Type	Elevation over Azimuth
Pedestal Scan Rate	180 ° s^{-1} Azimuthal; 36° s^{-1} Elevation
Range Gate Spacing	15-30 m

Table 1: Technical specifications of RaXPol (Pazmany and Bluestein 2011)

CONCLUSIONS

1) Tornado 1 began weakening and ultimately dissipated shortly after achieving its maximum low-level ΔV.
2) Dissipation was not monotonic with time; there were several short-lived pulses of reintensification, particularly aloft. Weakening aloft appeared slightly to lag low-level weakening (Figs. 4a, 5a).
3) Tornado 1's diameter of ΔV (DMW) decreased over time, independent of the tendency in ΔV strength (Fig. 4b).
4) There was a failed attempt at tornadogenesis at ~ 20:48, when rotation increased aloft but not at the surface.
5) During genesis of tornado 2, strong rotation appeared nearly simultaneously between heights of 500 m and 3 km AGL, and increased simultaneously at all levels. **There was no evidence of a descending tornadic vortex signature** (French 2012). **Tornadogenesis was not a result of the dynamic pipe effect** (Trapp 1997).
6) In both tornadoes, velocities aloft intensified more rapidly than at low-levels.
7) Separate rear-flank gust front surges appeared to be associated with the demise of tornado 1, and the genesis of tornado 2 (Figs 6a, 6b). The first displaced tornado 1 from the central hook region, the second appeared to provide strong horizontal shear that was associated with the spin-up of tornado 2.
8) The DMW contracted just before the genesis of tornado 2 and gradually increased during intensification (Fig 7b).
9) Near-surface (60 – 100 m AGL) ΔV values during tornado 2 displayed very rapid changes (O 30-50 m s^{-1}) over 2-4 second increments, but the overall low-level ΔV trend reached a quasi steady-state only 7 minutes after genesis.
10) The radial velocity around the tornado became more symmetric as the tornado intensified (Fig. 6c)

Fig. 3: Photographs of tornadogenesis and rapid intensification/growth taken from RaXPol deployment location.

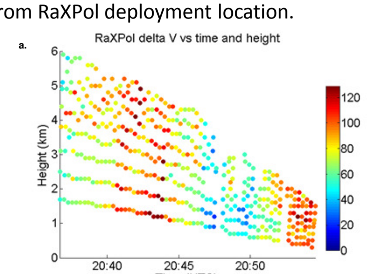

Fig. 5: Time (abscissa) - height (km) (ordinate) plots of the velocity couplet when volumetric data were collected. a) During the dissipation of tornado 1 and genesis of tornado 2.

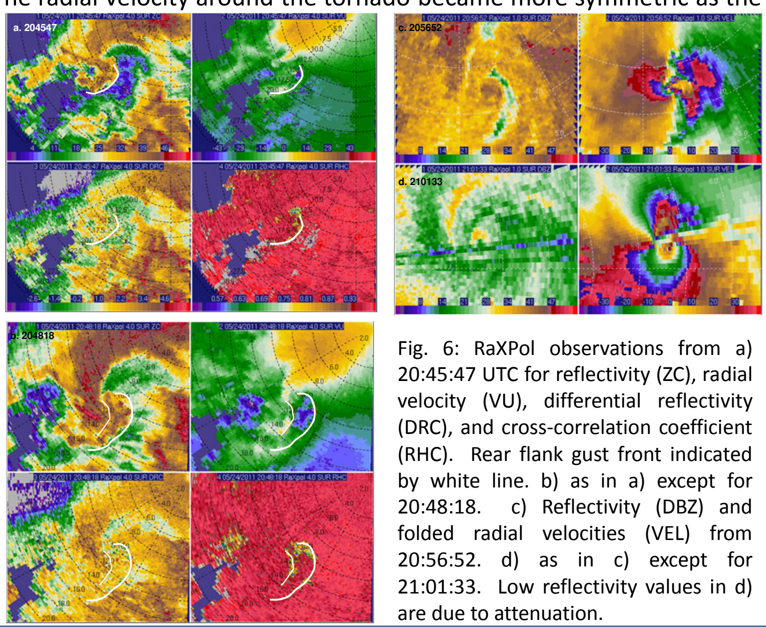

Fig. 6: RaXPol observations from a) 20:45:47 UTC for reflectivity (ZC), radial velocity (VU), differential reflectivity (DRC), and cross-correlation coefficient (RHC). Rear flank gust front indicated by white line. b) as in a) except for 20:48:18. c) Reflectivity (DBZ) and folded radial velocities (VEL) from 20:56:52. d) as in c) except for 21:01:33. Low reflectivity values in d) are due to attenuation.

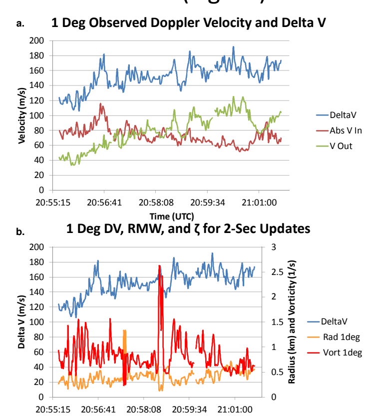

Fig. 7: Observations collected at 1 degree elevation angle every 2 seconds. a) Changes in ΔV, the corresponding absolute values of the outbound and inbound velocities and b) corresponding changes in the DMW and vertical vorticity

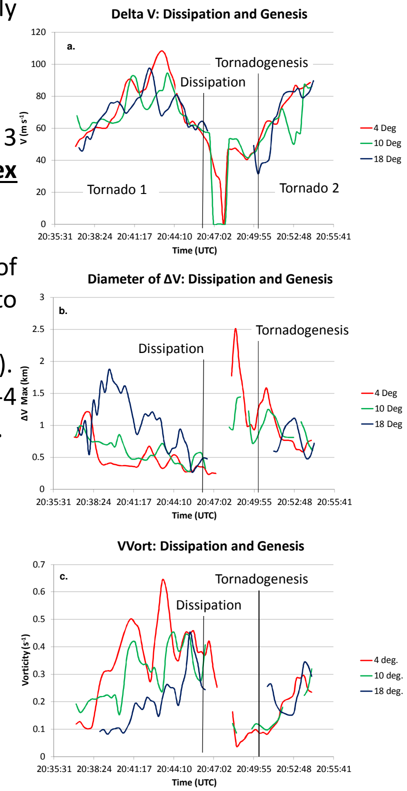

Fig. 4: Filtered changes in a) ΔV (m s^{-1}) (max outbound value – max inbound value), b) Radius of maximum winds (km) (determined from ΔV location), c) Estimated vertical vorticity (2* ΔV/DMW), prior to and during the dissipation of the first tornado (B1) and the genesis of the second tornado (B2) over the indicated times and elevation angles. Dissipation and genesis times denoted are defined by Δ exceeding 40 m s^{-1} at the lowest elevation angle .