High-Temporal Resolution Observations of Tornadogenesis Using the Atmospheric Imaging Radar

Casey B. Griffin[1,3], David J. Bodine[1], Andrew Mahre[1,2], James M. Kurdzo[1,2], Javier Lujan[1], and Robert D. Palmer[1,2]

[1]Advanced Radar Research Center, University of Oklahoma, Norman, OK, U.S.A.

[2]School of Meteorology, University of Oklahoma, Norman, OK, U.S.A.

[3]University of Nebraska, Lincoln, NE, U.S.A.

Background

Rapid-scan radars are uniquely qualified to interrogate the vertical evolution of rotation during tornadogenesis (Houser et al. 2015; French et al. 2013). Both French et al. (2013) and Houser et al. (2015) found that rotation with tornadic intensity first developed below 1 km and then intensification occurred simultaneously in the lowest 1-3 km. French et al. (2013) documented upward intensification of the vortex above 3 km, whereas in Houser et al. (2015) intensification of rotation above 3 km coincided with tornadogenesis in the lowest 3 km. This study documents tornadogenesis in the 23 May 2016 Woodward, OK, supercell using the Atmospheric Imaging Radar (AIR, Kurdzo et al. 2017). The nearly simultaneous volumetric data collection by the AIR provides a unique opportunity to interrogate vertical structure without having to account for translation or evolution of the tornado between elevation scans.

23 May 2016 Woodward, Oklahoma, Tornadic Supercell

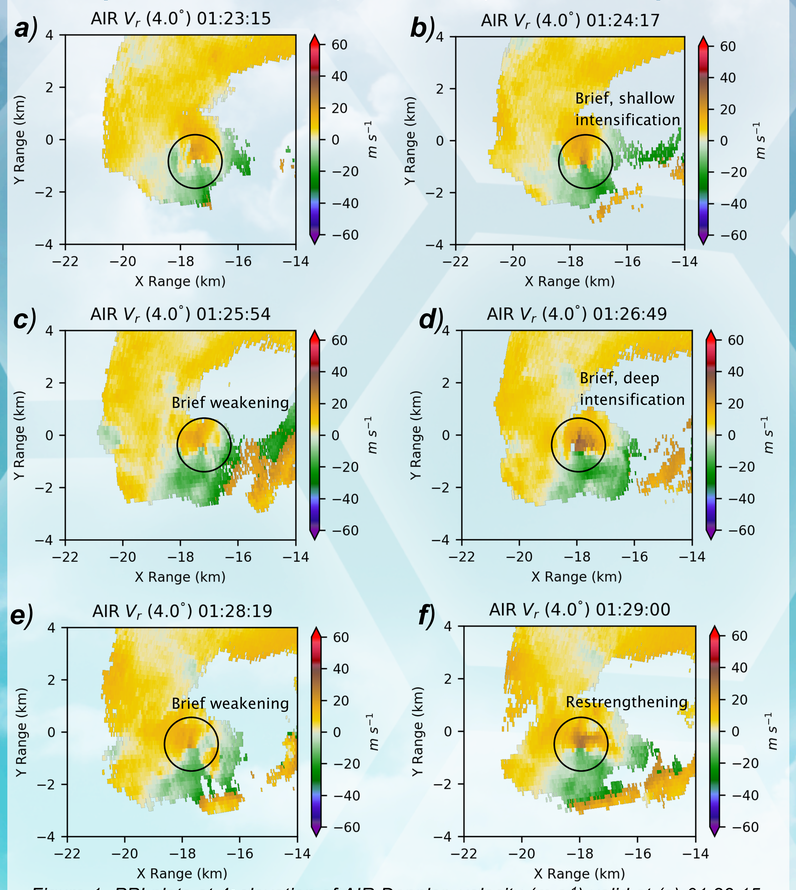

Figure 1- PPI plots at 4° elevation of AIR Doppler velocity (m s⁻¹) valid at (a) 01:23:15, (b) 01:24:17, (c) 01:25:54 UTC, (d) 01:26:49, (e) 01:28:19, and (f) 01:29:00 UTC.

23 May 2016 Woodward, Oklahoma, Tornadogenesis

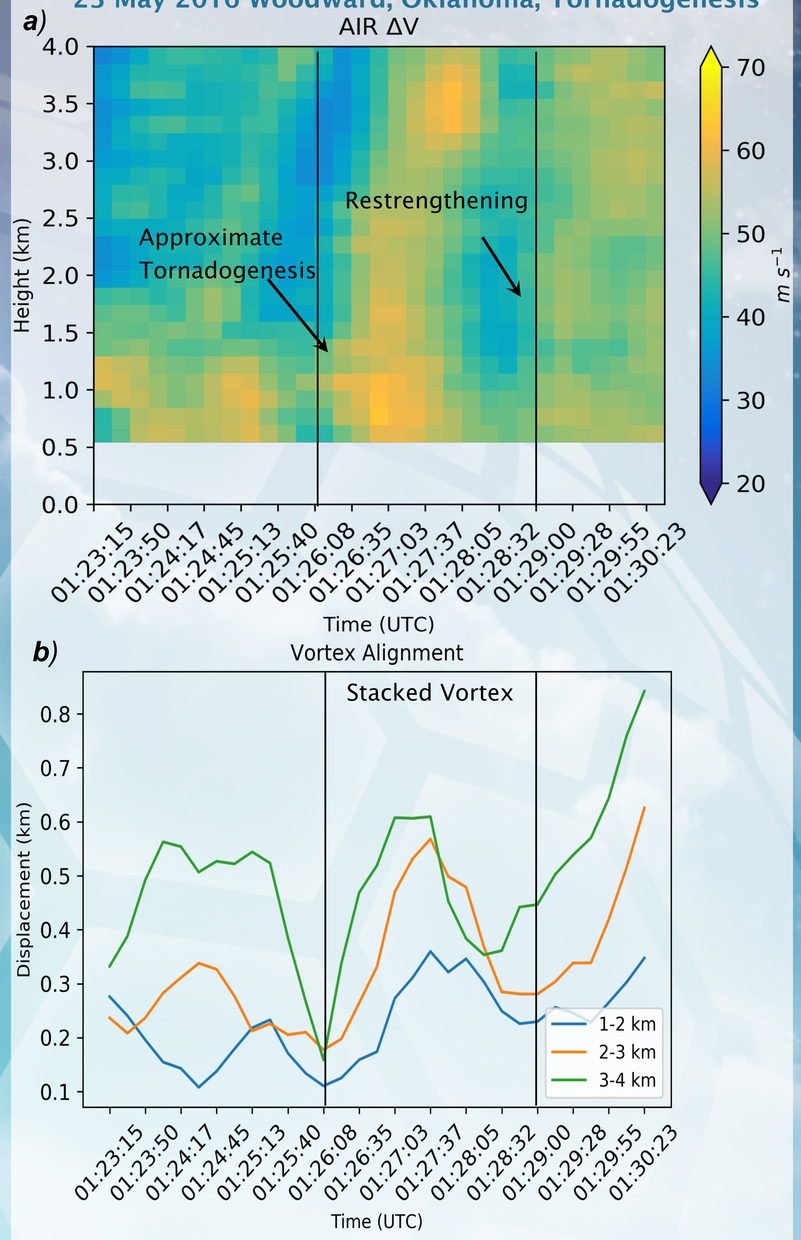

Figure 2- (a) Time-height plot of maximum ΔV (m s⁻¹) and (b) the distance between the mean position of the Woodward tornado in the lowest 1 km and the mean position of the vortex between 1-2 km (blue), 2-3 km (orange), and 3-4 km (green).

- The intensification of rotation during tornadogenesis occurred approximately simultaneously in the vertical in the lowest 2.5 km and upward above 2.5 km (Figure 2a)
- Prior to reported tornadogenesis, a 2 minute period of strong rotation ($\Delta V > 60$ m s^{-1}) was observed in the lowest 1 km ARL
- At 0125 UTC, the low-level vortex weakened before intensifying back above 60 m s^{-1} 90 s later, at the time when the tornado was first reported
- At 1 km ARL, values of ΔV greater than 50 m s^{-1} persisted during the time when the vortex below 1 km weakened
- At 0126 UTC, just prior to tornadogenesis, the vortex became vertically stacked with the horizontal distance between the mean vortex location in the lowest 1 km and the mean vortex locations between 1-2 km, 2-3 km, and 3-4 km all decreasing to less than 200 m (Figure 2b)
- The stacked nature of the vortex was short lived, which may have contributed to the brief nature of strong ΔV
- A second tornadogenesis/restrengthening phase occurred around 0128 UTC, which coincided with another period of vertical vortex alignment
- This second intense period persisted despite increasing displacement of the low-level vortex from the mesocyclone

Future Work

- Extend the Woodward analysis to include data collected before and after the shown period, which includes the remainder of the tornado lifecycle
- Compare the track of the vortex at different elevations
- Perform similar analysis on tornadogenesis failure cases to determine if any differences exist in mesocyclone behavior between failure and genesis cases

References

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Contact the Author

If you have any questions regarding this work, please contact the author via email at casey.griffin@unl.edu

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