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High-Temporal Resolution Observations of Weak-Echo Reflectivity Bands in the 16 May 2017 Wheeler, Texas, Tornado Using the Atmospheric Imaging Radar

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Background

A weak-echo reflectivity band (WRB) is a narrow, cyclonically curved region of low reflectivity (Figure 1a,c), low Z_{DR}, and slightly reduced ρ_{hv} that develops near and circulates around a tornado (Houser et al. 2016). This feature was first seen in the 24 May 2011 El Reno, Oklahoma, tornado, which intensified while the WRB was observed and stopped intensifying when the WRB dissipated suggesting a link between the WRB and tornado intensity. A horizontal vortex approximately collocated with the WRB was visually observed by Houser et al. (2016) and it was hypothesized that the deficit in reflectivity was due to the centrifuging of hydrometeors by the vortex. Observations of radial divergence on the outer edge relative to the tornado (Figure 1d) and radial convergence along the inner edge of the WRB imply vertical motion consistent with a horizontal vortex near or collocated with the feature. The purpose of this study is to investigate AIR observations of WRBs and associated horizontal vortices.

Low-Level Observations

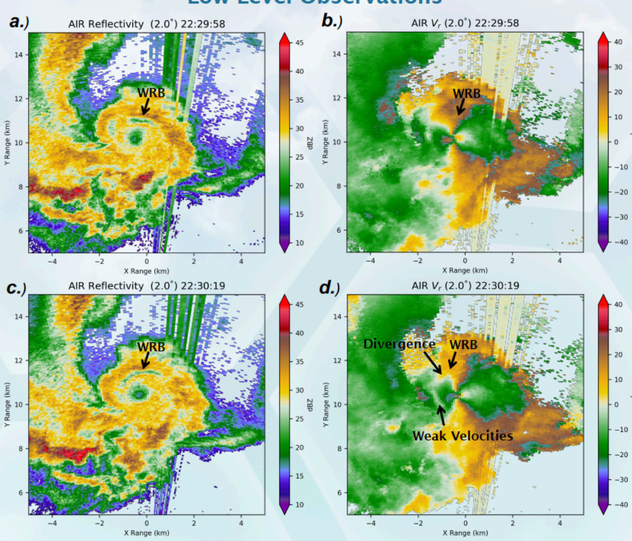
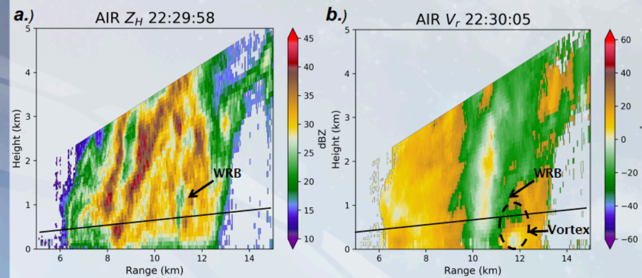


Figure 1- PPIs at 2º elevation of (a,c) reflectivity (dBZ) and (b,d) radial velocity ($m\ s^{-1}$) valid at (a-b) 22:29:58 UTC and (c-d) 22:30:19 UTC.

- A WRB was observed just to the north of the Wheeler tornado in the first AIR volume scan (Figure 1 a-b)
- The WRB rapidly rotated around the tornado in a counter-clockwise direction (Figure 1c)
- Low-level radial divergence was observed near the WRB (Figure 1d) similar to what was seen in Houser et al. (2016)
- A narrow band of weak radial velocities was observed as the WRB began to wrap around the west side of the tornado (Figure 1d), suggesting that much of the velocity within the WRB may be perpendicular to the radar beam and, by extension, the WRB

Vertical Cross Sections



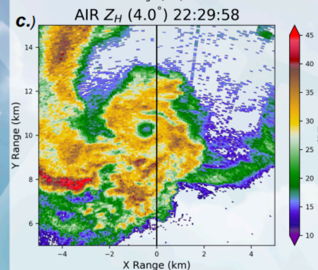


Figure 2- RHIs of (a) reflectivity (dBZ) and (b) radial velocity ($m\ s^{-1}$) and (c) a PPI of reflectivity (dBZ) at 4º elevation, all valid at 22:30:05 UTC. The black line in (c) indicates the reference radial for RHIs shown in (a-b) and the black lines in (a-b) indicates the 4º elevation angle in (c).

- Simultaneous RHIs (Figure 2 a-b) through the WRB confirm the presence of a horizontal vortex with differential velocity of ~30 $m\ s^{-1}$ in the lowest 1 km ARL
- The vortex is displaced to the outside of the WRB in a tornado-relative reference frame, with the WRB collocated with the updraft side of the horizontal vortex
- The initial WRB is at least 1.5 km deep (Figure 2a) and a second WRB sampled later in time is seen through the top of the observation domain at 4 km (Figure 3b)
- The WRB is much deeper than what centrifuging of hydrometeors could account for in isolation, similar to what Tanamachi et al. (2012) noted for the weak echo column
- In fact, there is little or no evidence of centrifuging associated with the horizontal vortex

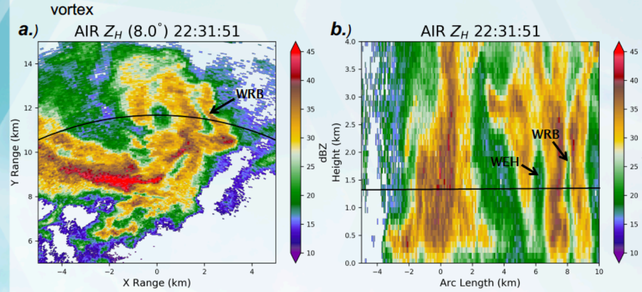


Figure 3- (a) A PPI of reflectivity (dBZ) at 5º elevation and (b) a vertical cross section of reflectivity (dBZ) at constant range valid at 22:31:16 UTC. The black line in (a) is the range of the cross-section in (b).

Temporal Evolution

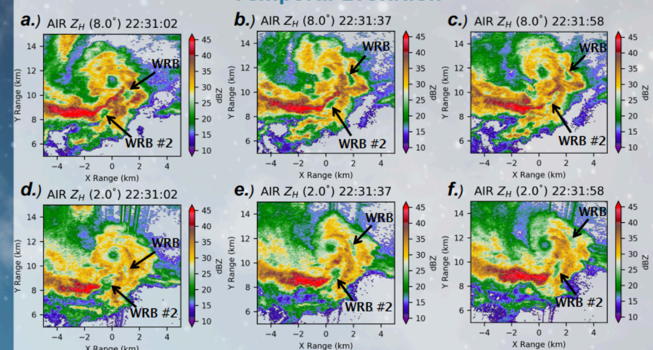


Figure 4- PPIs of radar reflectivity (dBZ) at (a-c) 8º and (d-f) 2º elevation valid at (a,d) 22:31:02, (b,e) 22:31:37, and (c,f) 22:31:58 UTC.

- After the initial WRB decayed, two more WRBs formed either simultaneously or in rapid succession to the south of the Wheeler tornado
- The northern of the two WRBs was not elongated early in its lifecycle but rather was more circular (Figure 4a) before becoming elongated into a more band-like feature (Figure 4b)
- The northern WRB was more visible at upper levels than at lower levels, especially early in its lifecycle (Figure 4a,d)
- The southern WRB (WRB #2) was more visible at low levels than it was as upper levels, especially later in its lifecycle (Figure 4c,f)
- WRB #2 bisected the hook echo early in its lifecycle (Figure 4d,e) before becoming entirely enclosed by higher reflectivity at later times (Figure 4f)

Future Work

- Determine if there was any relationship between the intensity of the Wheeler tornado and the formation or decay of the WRBs
- Analyze the upper level radial velocity field to see if it differs from what is seen at low levels and whether the direction of vertical motion can be inferred
- Determine if there is any relationship between the WRBs and momentum surges that were periodically observed during the dataset
- Further explore the morphology of the WRB, with special focus on vertical evolution and genesis

References

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