Comparing Differential Reflectivity Arcs Using Phased Array and Conventional Radar Data

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1. Background

- The Weather Surveillance Radar-1988 Doppler (WSR-88D) network is the primary radar system used by the National Weather Service, with the system's lifespan projected to end around 2040 (NWS 2021).
- One candidate for replacement is phased array radar (PAR). The National Severe Storms Laboratory (NSSL) found that PARs better depict rapidly evolving processes in thunderstorms than the WSR-88Ds, such as storm intensification and the evolution of low-level convergence and rotation signatures associated with tornadoes (Heinselman et al. 2008, 2012, 2015; Forsyth et al. 2015). However, little research has been conducted investigating PAR dual-polarization capabilities.
- Differential reflectivity (Z_{DR}) arcs are shallow areas (< 2 km) of high Z_{DR} located along a supercell's forward flank (e.g., Kumjian and Ryzhkov 2008).
- Z_{DR} arcs are an indicator of size sorting within a storm, which, in turn, is the result of a veering storm relative wind profile (Dawson et al. 2014). Therefore, the presence of a Z_{DR} arc is a sign that a low-level mesoscyclone may develop or intensify (Kumjian 2013b).
- A disruption of the Z_{DR} arc can reveal the presence of a relatively cold downdraft within the forward flank of the supercell near the hook echo and may therefore indicate a potential disruption to tornadogenesis (Markowski and Richardson 2014; NWS 2023).

2. Data and Methodology

- The Advanced Technology Demonstrator (ATD) is the first S-band, dual-polarization PAR purposely built for meteorological purposes (Torres and Wasielewski 2022).
- To examine potential dual-polarization PAR benefits, we compared Z_{DR} arcs of two tornadic supercells (from 23 April 2022 and 11 May 2023) using the ATD and KTLX, the nearby WSR-88D in central Oklahoma.
- Qualitatively: data from each radar were subjectively compared to determine potential operational benefits a dual-polarization PAR could bring to the warning decision environment.
- Quantitatively: timeseries of Z_{DR} arc areas from each radar were compared to quantify the improvement PARs bring with data quality and resolution using the Supercell Polarimetric Observation Research Kit (SPORK; Wilson and Van Den Broeke 2022).

3. Results

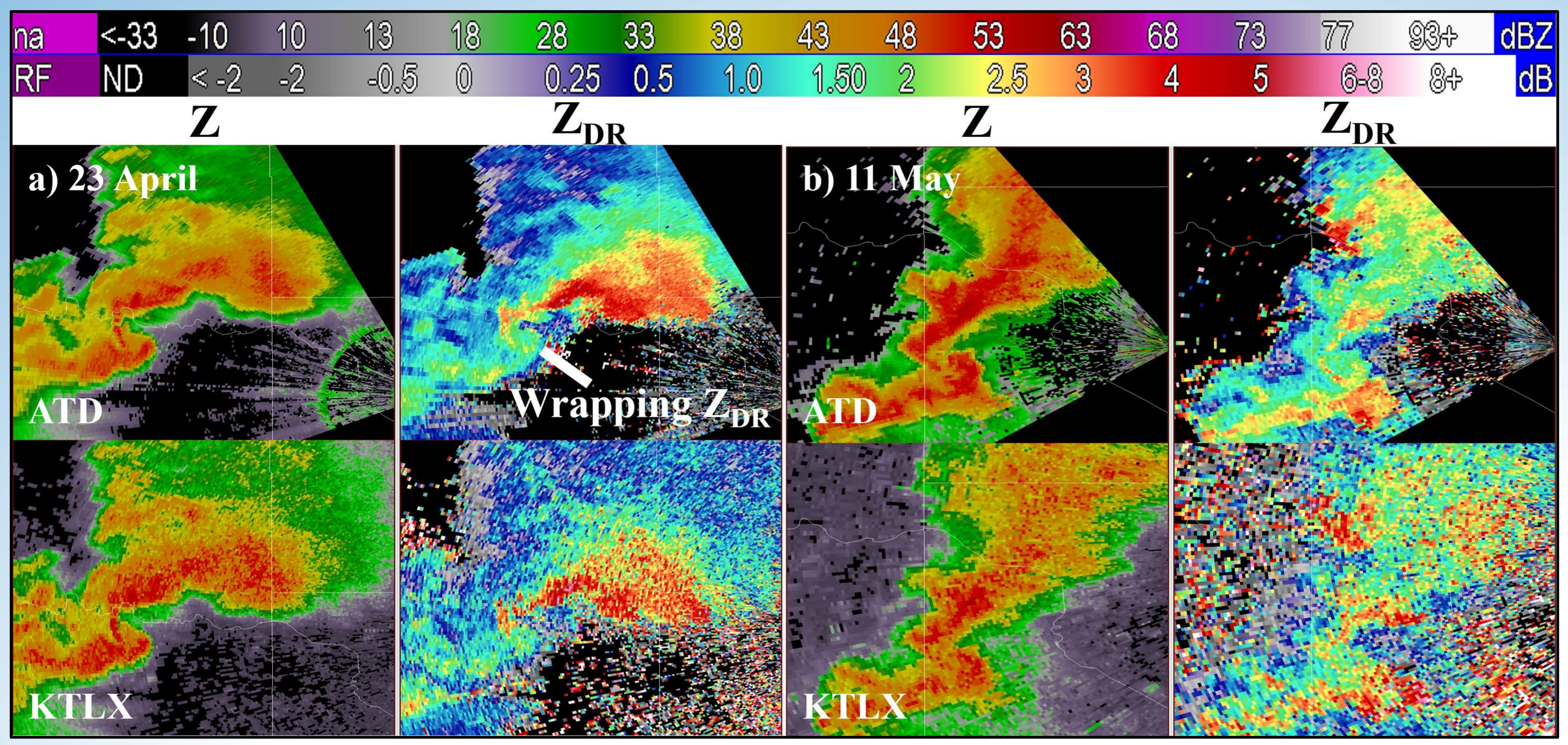


Fig. 1 (above). (a) The line of high Z_{DR} wrapping into the 23 April supercell's hook echo prior to tornadogenesis at 0000 UTC. The top panels of each subplot display ATD imagery and the bottom display KTLX. The left panels show reflectivity (Z) and the right show Z_{DR}. (b) As in (a), but for the 11 May supercell two minutes after tornadogenesis at 0044 UTC.

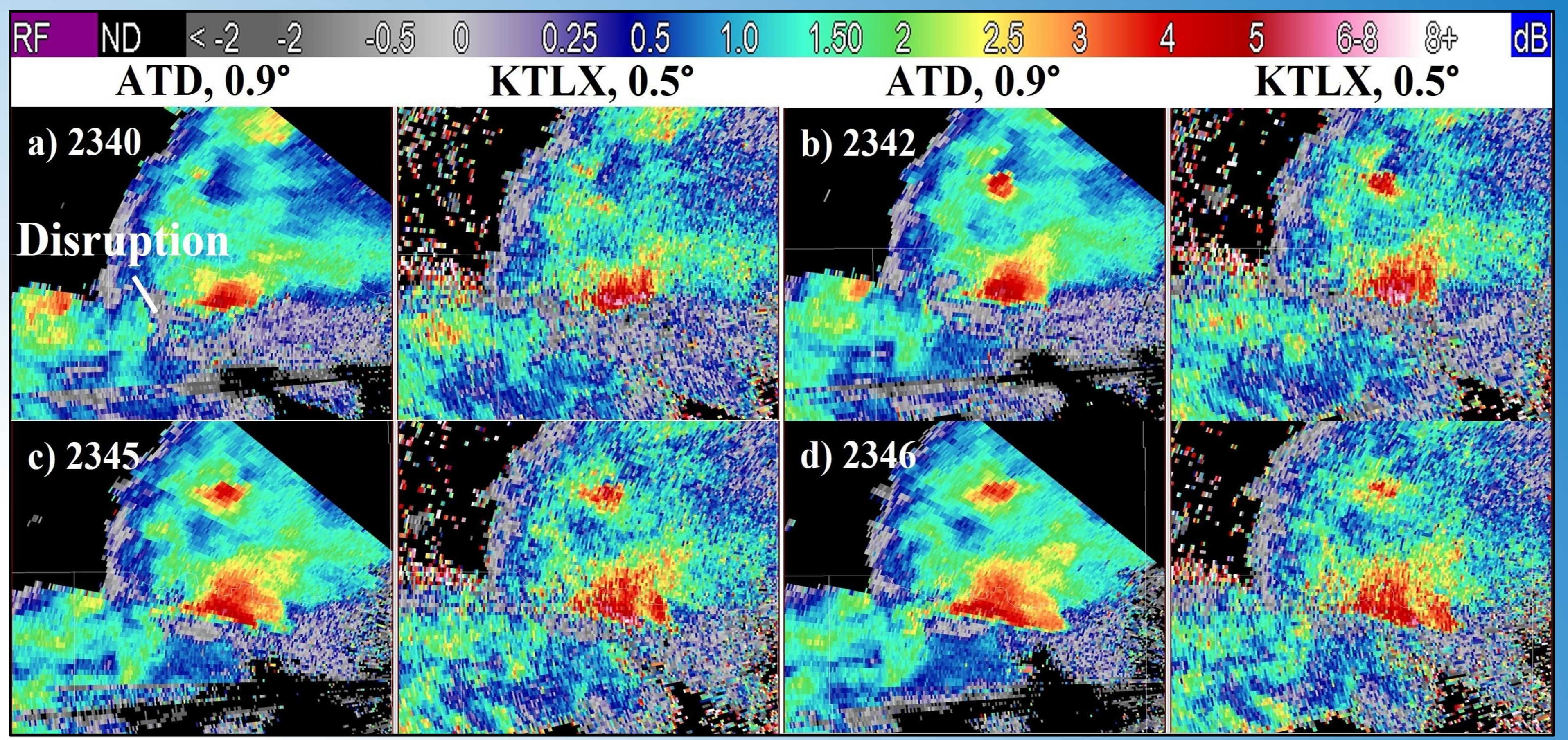


Fig. 3 (above). The evolution of the 23 April Z_{DR} arc disruption (a result of the hail core in Fig. 2) with both radars. (a) ATD imagery is on the left in each subplot and KTLX is on the right for 2340 UTC. (b)-(d) As in (a), but for different times.

Fig. 2 (below). The descent of the 23 April supercell's hail core with the ATD and KTLX. Scans are in chronological order. (a) First scan showing hail core at 3.1°, with Z on the left and Z_{DR} on the right. (b)-(f) As in (a), but for different radar tilts.

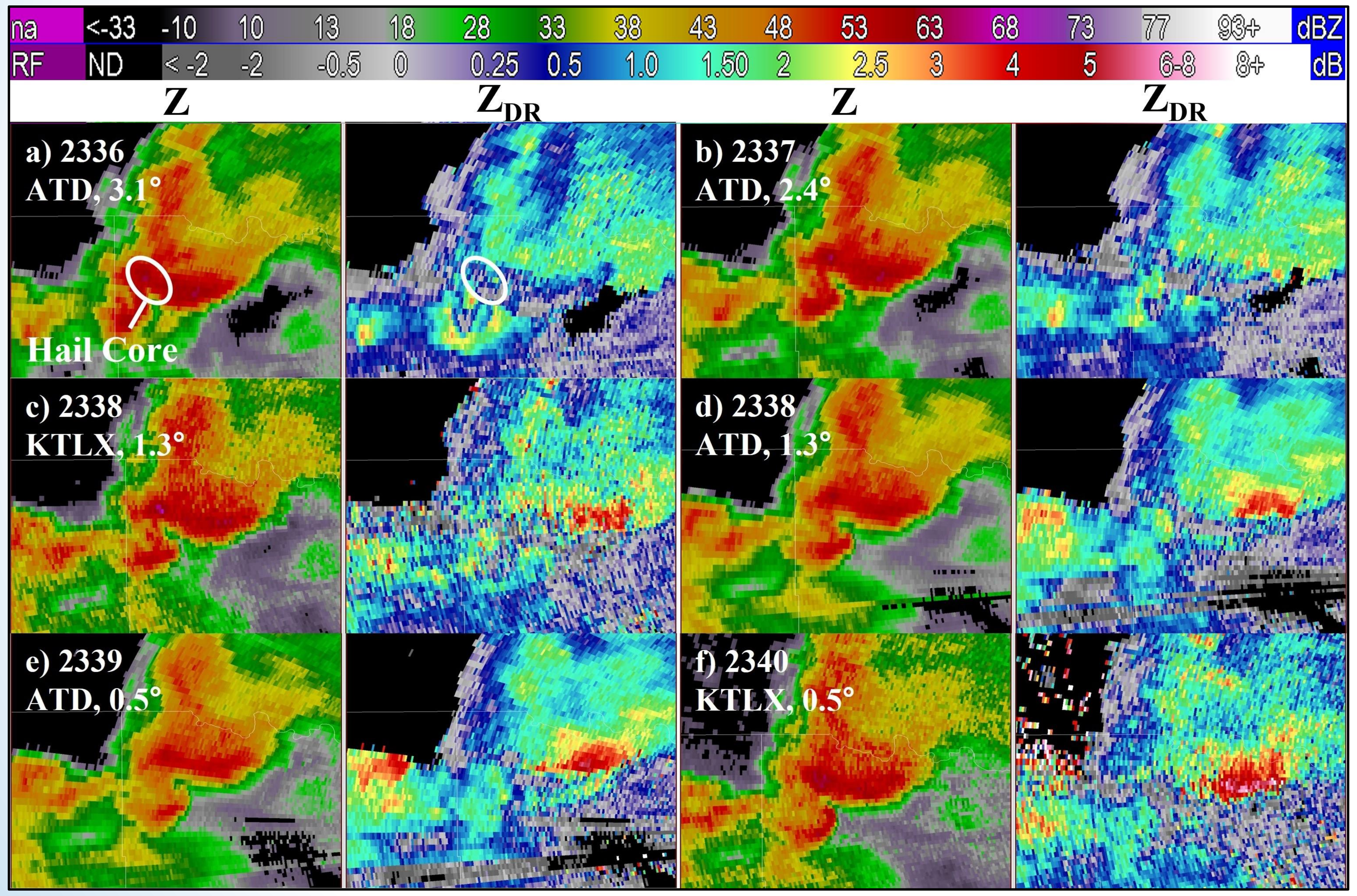
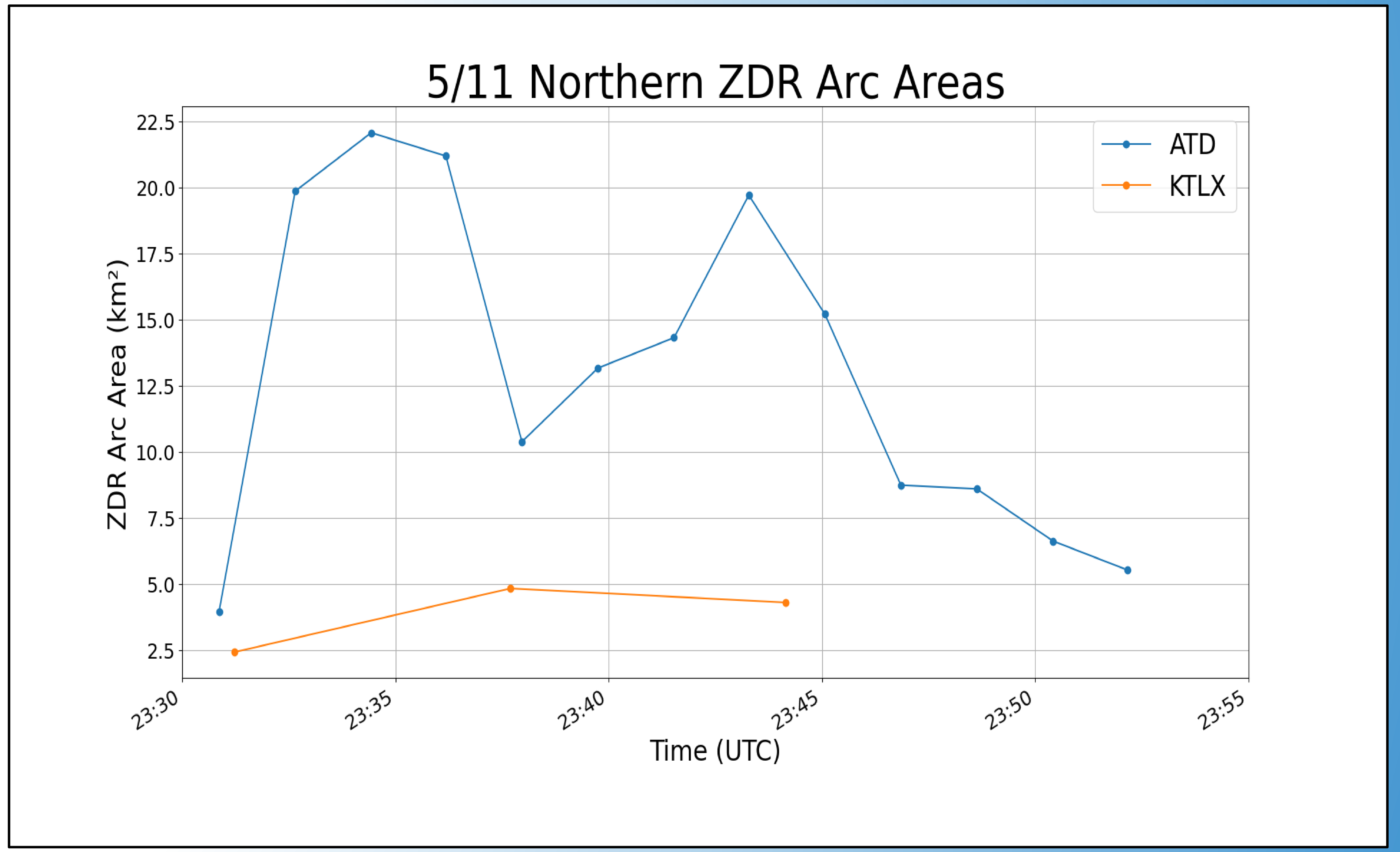


Fig. 4 (below). A time series of the 11 May supercell's Z_{DR} arc areas generated from SPORK output. The blue line represents the ATD Z_{DR} arc and the orange represents KTLX.



4. Conclusions and Notable Takeaways

1. **The ATD features better data quality than KTLX regarding Z_{DR} and other dual-polarization products.** Z_{DR} arcs and their disruptions are generally easier to detect and have smoother textures in ATD data than with KTLX (Figs. 1-3). Subtle dual-polarization signatures, like the wrapping of high Z_{DR} into the hook echo, are better resolved with the ATD (Fig. 1).
2. **The increased temporal resolution of the ATD allowed for both faster updates and detection of dual-polarization signatures than with KTLX.** The ATD detected the 23 April supercell's hail core descent 1.75 min earlier than KTLX and provided a more complete visualization of the hail core overall (Fig. 2). Although the supercell's resulting Z_{DR} arc disruption is visually evident with both radars, the end of the disruption is better defined and was depicted 1.8 min earlier in the ATD data (Fig. 3).
3. **The quantitative analyses conducted by SPORK, particularly with the 11 May case, suggest that the ATD's data quality may increase algorithm's capabilities in automatically detecting Z_{DR} arcs.** Although SPORK struggled to properly depict the ZDR arc for both radars on 11 May, it consistently measured a larger Z_{DR} arc for a longer period with the ATD data (Fig. 5).

5. Acknowledgements and Contact Information

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