

The Utility of Considering Dual-Polarization Radar Signatures in the Tornado Warning Process

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Prior research (Crowe et al. 2012) has shown that the combined radar signatures of differential reflectivity (Zdr) and specific differential phase (Kdp) helped identify regions of enhanced lower-tropospheric shear/tornadic potential, within varied thunderstorm environments across the southern United States in 2010-2011. The specific radar signatures included an arc-shaped region of enhanced Zdr, typically located along the front inflow side of the storm; as well as an enhanced area of Kdp, typically located deeper into the mesocyclone, and left of the aforementioned Zdr arc/maximum.

Other earlier work (Kumjian and Ryhkov 2007, 2008a, and 2009; Romine 2008; Crowe 2010) demonstrated that the physical reasoning for the development/locations of Zdr arcs, as well as Zdr/Kdp maxima, involved preferential drop size sorting. Conceptually, both relatively high values of Zdr and low values of Kdp on the forward (typically eastern) side of the mesocyclone imply a smaller concentration of large rain drops. Such large drops would tend to fall more rapidly, thus decreasing their residence time in the storm. Conversely, both relatively high values of Kdp and low values of Zdr imply a higher concentration of smaller rain drops. Such smaller drops would have a greater residence time in the storm, thus having a better opportunity to be advected by the strongly sheared flow into the rear (typically western) portions of the mesocyclone.

Based on the initially promising results (Crowe et al. 2012), a number of events in the Northeastern United States featuring favorable synoptic environments for tornadic supercells, in which tornado warnings were issued and/or tornadoes occurred, were interrogated from 2012-2014. For these cases, qualitative storm-scale assessments were made on the relative positions of Zdr arcs/maxima versus Kdp maxima, and also specific separation distances in nautical miles (nmi) between the two. For tornadic storms, an evolution featuring a separation between Zdr arcs/maxima and Kdp maxima, with the Kdp maxima typically juxtaposed to the rear/left of the Zdr arcs/maxima, was quite common. For non-tornadic storms, Zdr and Kdp maxima were either collocated for the life cycle of the mesocyclone, or the Kdp maxima were displaced slightly to the right/eastern sides of Zdr maxima.

From 2003-2013, the probability of detection (POD) for all tornado warnings across the contiguous United States was approximately 0.71, while the false alarm ratio (FAR) was approximately 0.77. These statistics, particularly the high FAR, indicate a general lack of skill in discriminating between tornadic and non-tornadic storms. One of the main goals of this work is to improve the ability to differentiate between the two by incorporating strategies to assess dual-polarization radar parameters in real-time warning operations.