An investigation of tornadic debris signatures in damaging tornadoes using observations and simulations of Doppler spectra

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In recent years, several high spatiotemporal resolution datasets have been collected by a rapid-scan, X-band, polarimetric Doppler radar (RaXPol) probing close-range, strong tornadoes. In many of these cases, strong divergence signatures were observed during periods of heavy debris loading, followed by alternating intervals of convergence and divergence with periodic shedding of debris from the vortex. These observations were often accompanied by significant deviations in the tornado’s track and substantial changes in intensity. While these observations have prompted questions regarding the possible effects of debris on the behavior of tornado vortices, the inability of typical Doppler radar observations to distinguish between the flow of air and the flow of debris in a tornado has hindered obtaining answers to these questions.

Doppler and polarimetric spectra can be created from these observations using time series of raw, I/Q data. Since the deviation of the motion of debris from the motion of air is greater than the deviation of the motion of hydrometeors from the motion of air, polarimetric spectra may theoretically allow for the decomposition of air and debris motions within strong tornadoes if there are a sufficient number of collected samples. In this presentation, the method of computing spectra in a frequency-hopping radar will be detailed and I/Q data generated using a polarimetric Doppler radar simulator will be shown in an attempt to assess the ability of Doppler and polarimetric spectra to capture different flow regimes within a strong tornado. The radar simulator used in this study (SimRadar) emulates the collection of I/Q radar data and trajectories of hydrometeors and several types of tornado debris, which allowsus to evaluate the effects of heavy debris loading on the radar signal. SimRadar analyses of a controlled simulation will be examined, and results will be compared to I/Q data collected by RaXPol.

At the time of this writing, RaXPol I/Q data have been successfully collected and analyzed/verified only during the pre-tornadic phase of a supercell, in 2018. During the 2019 storm season, currently in progress, we hope to collect additional I/Q data from close-range observations of supercell tornadoes. If available,Doppler spectra computed from those data will also be presented.

Keywords: tornado, tornado debris signature, mobile, rapid-scan, polarimetric Doppler radar