SimRadar –A U.S.-Japan collaborative effort to develop a polarimetric radar simulator for tornado studies

David J Bodine[1], *Boonleng Cheong[1], Takashi Maruyama[2], Caleb Fulton[1,3], Sebastian Torres[1,3,4], Robert Palmer[1,5], Howard Bluestein[5], Arturo Umeyama[1,3], Javier Lujan[1,3], Zach Wienhoff[5], Casey Griffin[1,5]

1. Advanced Radar Research Center, University of Oklahoma, 2. Disaster Prevention Research Institute, Kyoto University, 3. School of Electrical and Computer Engineering, University of Oklahoma, 4. National Severe Storms Laboratory, NOAA, 5. School of Meteorology, University of Oklahoma

Understanding the polarimetric characteristics of tornadoes and associated debris is critical to remotely detecting tornadoes and characterizing their damage severity, developing methods to mitigate debris-induced bias of radar wind measurements, and evaluating the three-dimensional distributions of tornadic debris to understand hazards posed to structures by airborne debris. Modeling polarimetric radar signatures is challenging because the electromagnetic characteristics and aerodynamic behavior of debris are complex. To address these challenges, a collaborative effort between scientists and engineers at the University of Oklahoma and Kyoto University was initiated to simulate polarimetric radar signatures of tornadoes using high-resolution tornado simulations, wind tunnel measurements of debris aerodynamic properties, and debris radar cross section (RCS) measurements and simulations. Kyoto University has collected wind tunnel measurements of the drag and moment force coefficients for different debris types, which are used to compute the trajectories and orientations of debris in the simulated tornado using a six-degree-of-freedom model. The polarimetric RCSs for each debris element are determined and time series and moment data for each range gate are computed based on the specified radar geometry.

Using these data, an extensive effort is underway to develop a database of simulated polarimetric tornado debris signatures (TDSs). The database will encompass simulated TDSs for a wide range of tornado debris types and tornado flow structures. A wind-based debris flux model has also been implemented to more accurately represent the increase in debris fluxes with attendant increases in wind speed. In this presentation, we will summarize the polarimetric radar simulator and the past studies completed to date, including analyses of common alignment of debris, spectral analyses of polarimetric signatures, and comparisons with mobile radar and NEXRAD data. Examples of simulated TDSs from the new database will be highlighted, including simulations of multi-vortex tornadoes that reproduce polarimetric signatures noted in mobile radar data. Future work to deeply explore the simulated TDS database will be discussed.

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