The Era of Machine Learning in Convective Warning Decision Making is Here

Performance of SPORK Automated Z_{DR} Arc and K_{DP} Foot Analysis in Tornadic Supercells

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(Submitted 25 May 2023)

ABSTRACT

Research over last couple of decades evaluating various Dual-Polarization (DP) fields in supercells, has discovered radar-based features such as the differential reflectivity (Z_{DR}) arc and specific differential phase (K_{DP}) foot. Comparison of these features in both tornadic and non-tornadic supercells has shown improved capability to anticipate low-level mesocyclone intensity changes through the K_{DP} foot to Z_{DR} arc separation vector process (Loeffler et al. 2020) along with the extent of downdraft negative buoyancy (Snook and Xue 2008). Given this capability, NWS forecasters have been exposed to training and simulation material aimed at helping them incorporate these new cutting-edge techniques. Nonetheless, a consistent trend found in forecaster feedback on this material is the assertion that they have limited time and, in some cases, even the desire to improve their skill at manual analysis of these new features. In particular, a common theme heard is that Z_{DR} arc analysis is perceived as being too difficult, highly subjective, and/or time-consuming to assess manually. In contrast, forecasters still appear to recognize the improvement in warning decision making capability found in research with items such as the Z_{DR} arc since feedback mentions a strong desire for automation of things such as the K_{DP} foot to Z_{DR} arc separation vector calculation through machine learning. The Supercell Polarimetric Observation Research Kit (SPORK) algorithm (Wilson and Van Den Broeke 2022) provides a value step in the use of machine learning to calculate the K_{DP} foot to Z_{DR} arc separation vector along with indirect detection of wet-hail Z_{DR} arc disruptions. The NWS Central Region Convective Warning Improvement Project (CWIP) group has reviewed numerous events where SPORK was running and found tremendous potential to improve decision making in supercells. One of these cases from the WFO Dodge City area in May of 2023 reveals an increased risk for tornadogenesis via SPORK analysis starting 15 minutes before NWS Tornado Warning issuance. Further, while K_{DP} foot outlines are found to be consistently good, SPORK can struggle at times with Z_{DR} arc analysis as any larger errors can negatively influence separation vector angle values. Unfortunately, minimal capability exists among most forecasters to find these targets of opportunity where the machine errors happen and human override can occur, given aforementioned forecaster assertion that they have limited time and, in some cases, even the desire to improve their skill at manual analysis. Other machine learning techniques using radar data such as the Tornado Probability Algorithm (TORP; Sandmael et al. 2023) exist and have shown significant improvement in skill over legacy algorithms. All of this illustrates that the era of machine learning providing convective-scale analysis is already here and provides the best path forward for improving warning decision making.