14.6 IMPLEMENTATION OF A HYDROMETEOR CLASSIFICATION ALGORITHM FOR CONSUMER-ORIENTED DUAL-POLARIZATION RADAR PRODUCTS

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1. INTRODUCTION

Weather Decision Technologies Inc. (WDT) specializes in transferring state-of-the-science meteorological algorithms and data from research to operations. The result is the most advanced weather content, delivered to a wide variety of end-users including industries and the general consumer. Since WDT's inception, one of its core strengths has been and remains expertise in the area of meteorological radar exploitation. Now, WDT continues to lead the way bringing new, cutting-edge products derived from dual-polarized WSR-88D radar data directly to end users .

WDT's team of radar meteorologists has begun implementing a Hydrometeor Classification Algorithm (WHCA) utilizing dual polarized (dual-pol) data that will become available in the near future. The WHCA will initially be patterned after the version made available to the National Weather Service in Build 12.1 of the WSR-88D Radar Product Generator. WDT will process dual-pol data in real-time and make it available directly to consumers via its unique iMap web-based display tools. Immediate benefits from dual-pol data are expected particularly in enhanced automated quality control of radar data. In the future, WDT will continue to refine and enhance its dual-pol processing capability by adding a suite of new products, including improved quantitative precipitation estimates (QPE), detection of hail, melting layers, and dangerous aircraft icing regions.

Additionally, WDT will be extending the algorithms beyond the baseline versions used by the NWS to include use of other input data such as satellite data and numerical weather prediction information.

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2. HYDROMETEOR CLASSIFICATION ALGORITHM

2.1. Description

Current development of the HCA is based on the most recent version of an algorithm recommended by the National Weather Service for initial deployment throughout the WSR-88D network as described in Park et al. 2009 (Park09). This HCA (PHCA) classifies each radar data bin as one of ten different hydrometeor or non-hydrometeor species or classes (ground clutter, biological scatterers, rain, heavy rain, big drops, rain/hail, wet snow dry snow, graupel, and ice crystals). A fuzzy logic system is used to process input polarimetric variables (Z, Z_{DR}, ρ_{hv}, K_{DP}, SD(Z), SD(Φ_{DP})) and assign a class to each radar data bin. A range of values for each input variable is quantified with a membership function. The membership functions are summed for each input variable for a particular output class. The class or hydrometeor species with the largest summed value is assigned to the radar bin. A comprehensive description of the fuzzy logic system including membership functions and weights can be found in Park09. Two aspects of PHCA that have not yet been developed within WHCA are confidence vectors and detection of the melting layer to help discriminate between species such as dry snow and rain.

Although initial development on the WHCA will be very similar to that described in Park09, development on WDT's own HCA will allow for full control of all aspects of the HCA and customization in the future. This is especially beneficial in rapidly moving research to operations.

2.2. Validation

Initial examination of the WHCA is possible through use of KOUN WSR-88D data. KOUN was upgraded to dual-pol capability in early 2010 and data have been archived at NCDC since May 9, 2010. Comparisons between WHCA and PHCA output are possible using the Hydrometeor Classification Data Array Product #165 of the ORPG Build 12.1.

One of the anticipated benefits for WDT radar operations from utilizing dual-pol data is enhanced quality control of radar reflectivity. WDT uses the Warning Decision Support System Integrated Information (WDSS-II) system (Lakshmanan et al. 2007) to ingest and analyze radar data and produce products for clients. WDSS-II contains a neural net quality control algorithm (QCNN) for removal of non-hydrometeor returns (Lakshmanan et al. 2010). One of the challenging quality control scenarios for QCNN occurs when a convective line overlays an area of biological scatter. This can result in degraded identification of non-hydrometeors and reduce the quality of subsequent radar products.

Thus, one of the first case studies that has been examined is a broken line of convection that propagates over KOUN's location and coexists with a large region of biological scatter (Figure 1, top). PHCA results are shown in Figure 1 (middle) identifying the biological scatter shown in gray, a large rain shield in lighter green west of the radar, big drops shown in tan and heavy rain in dark green. Figure 1 (bottom) shows that the WHCA also identifies the biological scatter region and rain shield. However, there are differences in the identification of big drops and heavy rain. Rather than scattered along the leading edge of convection, big drops are clustered within WHCA especially near regions of heavy rain.

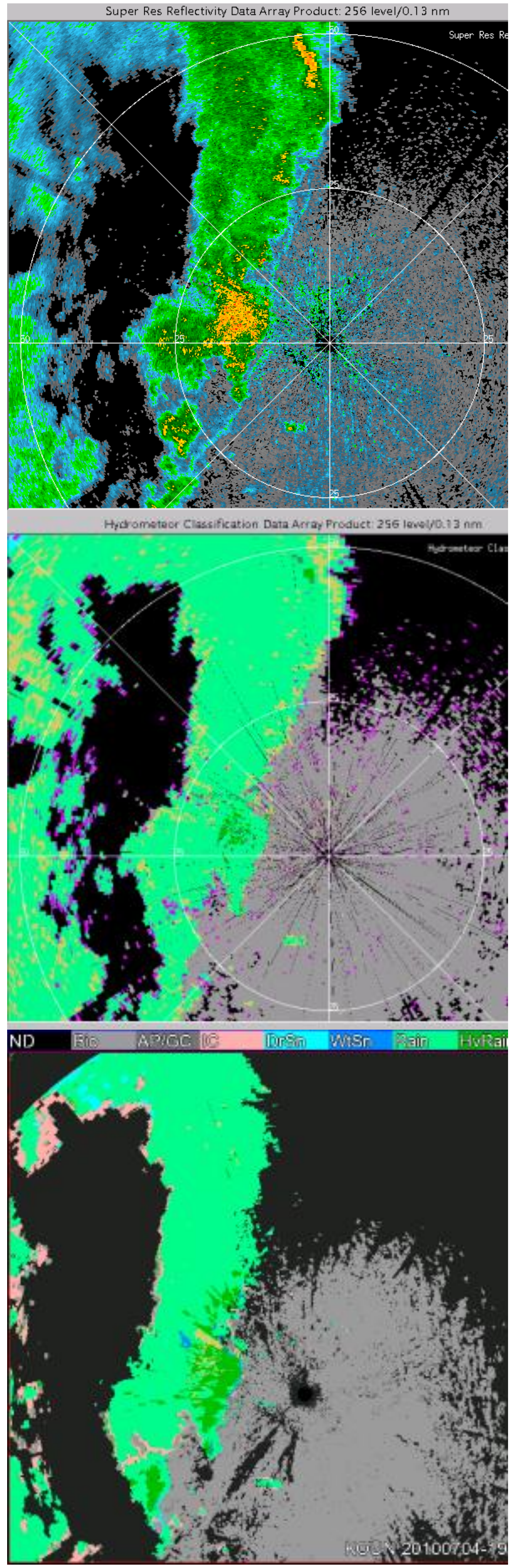

Figure 1. Super Res Reflectivity Data Array Product #153 (top) and Hydrometeor Classification Data Array Product #165 (middle) output from the ORPG Build 12.1 for KOUN on July 4, 2010 at 1927 UTC. WHCA output at the same valid time (bottom).

The region of heavy rain is larger within the WHCA. Similar results are also found at other times as the convective line progressed eastward.

By identifying hydrometeor and non-hydrometeor regions, the WHCA can be used to provide quality control measures for reflectivity data. Figure 2 (top) shows the reflectivity field for KOUN on July 5, 2010 at 0301 UTC. The raw reflectivity field has a large region of biological scatter centered on the radar. Embedded within the biological scatter field are small rain showers and a region of anomalous propagation northwest of the radar. Figure 2 (middle) shows the reflectivity after the QCNN algorithm has been applied. QCNN removes some of the biological scatter field, although pockets of non-hydrometeors remain as well as some AP. Figure 2 (bottom) displays the resulting reflectivity field when removing all non-hydrometeor returns identified by the WHCA. The dual-pol QC method is superior to the QCNN method in this instance and similar results are seen for other volume scans of this event. This provides an optimistic outlook on the capability of using dual-pol data to greatly enhance quality control measures for radar products.

3. SUMMARY AND FUTURE WORK

WDT has developed a Hydrometeor Classification Algorithm to begin utilizing dual-pol data that will become available over the next two years throughout the WSR-88D network. Initial examination of the WHCA is currently underway through comparison with the PHCA of Park09 that has been deployed to the WSR-88D network as part of ORPG Build 12.1. Development of the WHCA is continuing with plans to incorporate either a melting layer detection algorithm or numerical weather prediction output for better discrimination between output classes such as dry snow and rain. Currently, WDT anticipates using the enhanced quality control capabilities of the WHCA to improve operational radar products for clients.

In addition to enhancing the quality of radar mosaics, single-site dual-pol data will be made available through WDT's iMap

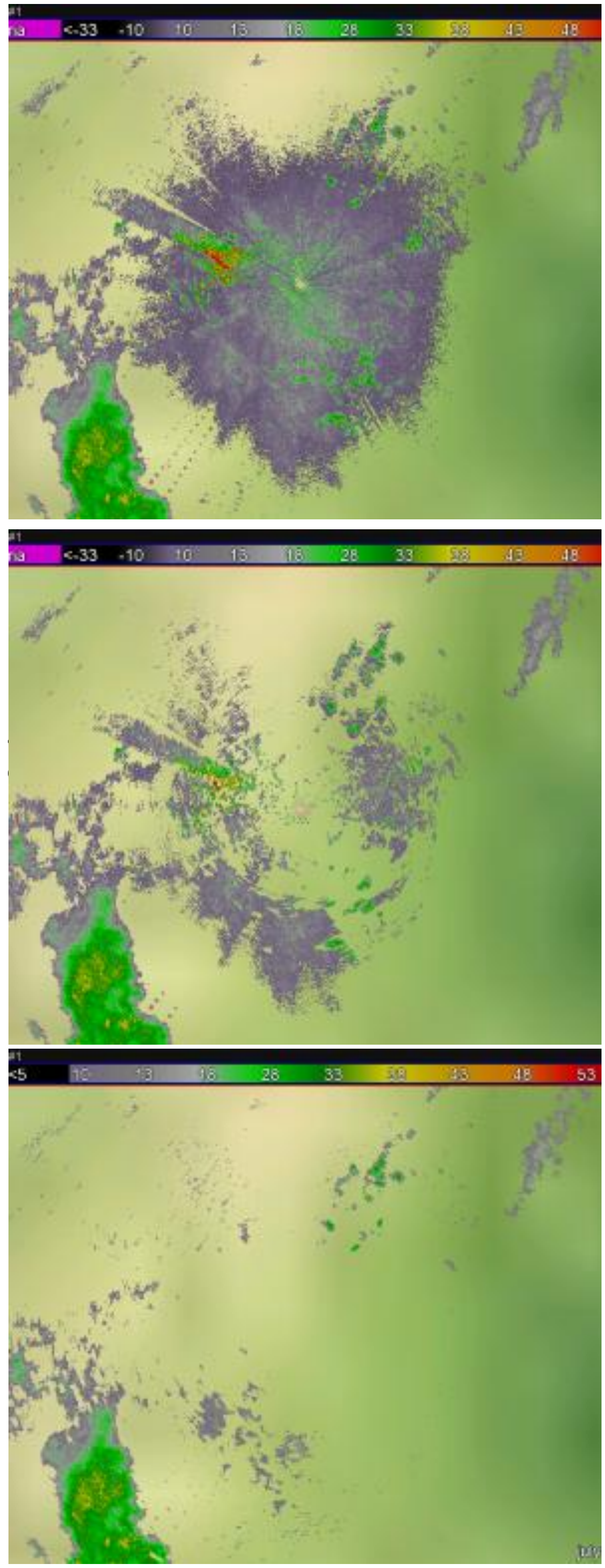

Figure 2. KOUN raw reflectivity (top) on July 5, 2010 0301 UTC. Results of applying the QCNN quality control algorithm (middle) and the dual-pol quality control algorithm (bottom) are shown

technology (Figure 3). iMap is an advanced interactive mapping application to view weather and other geo-located data on the Internet. iMap utilizes Google Maps and is interactive with a fully navigable world base map populated by a proprietary WDT tile server (VandenHeuvel et al. 2011) and data feeds.

Once initial development of the WHCA has concluded, WDT can take advantage of having full control of its own classification scheme and provide further customization by quickly moving research in to operations. Examples of further development include additional output classes of hail (i.e. big vs. small) (Kumjian 2011), tornado detection through polarimetric precursors (Kumkian and Ryzhkov 2008) and lofted debris (Ryzhkov et al. 2002), and enhanced QPE (Gourley). WDT also plans to examine how a multiple radar (mosaic) approach to hydrometeor identification can improve accuracy over single radar identification. The merits of utilizing multiple sensor input (satellite, NWP, etc.) in conjunction with dual-pol radar observations will also be examined.

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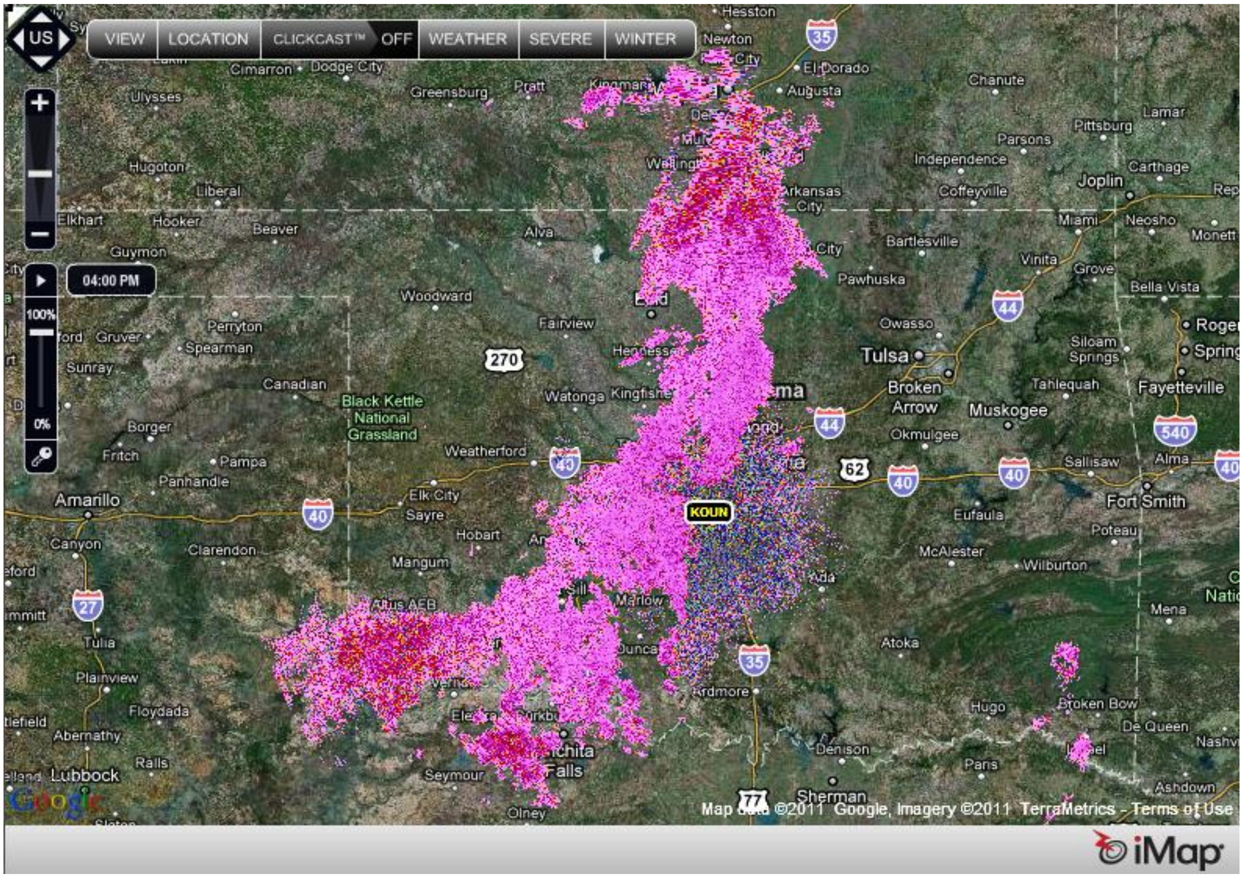

Figure 3. KOUN correlation coefficient data from July 4, 2010 2201 UTC displayed with WDT's iMap technology.