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THE JOINT POLARIZATION EXPERIMENT - AN OVERVIEW OF INITIAL DATA COLLECTION WITH A POLARIMETRIC WSR-88D RADAR

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1. INTRODUCTION

In the Spring of 2002, several years of effort on the NOAA research WSR-88D radar culminated in the generation and display of dual polarization radar data and products. As part of the Joint Polarization Experiment (JPOLE) operational demonstration, these data and products were delivered in real-time to operational forecasters at the Norman, OK National Weather Service forecast office. Data and products delivered include radar reflectivity (Z), differential reflectivity (Z_{DR}), correlation coefficient (ρ_{HV}), differential phase (Φ_{DP}), specific differential phase (K_{DP}), a hydrometeor classification product, and a variety of polarimetric rainfall rate and accumulation estimates.

Plans for the JPOLE operational demonstration have been discussed earlier by Schuur et al. (2001) and Schuur et al. (2002). In this paper, we provide examples of the first polarimetric WSR-88D data and products, present initial impressions of the utility of the polarimetric upgrade to the radar, and discuss future plans for the JPOLE operational demonstration. Long term goals include the collection of verification data sets sufficient to conduct a thorough analysis of the polarimetric WSR-88D data quality and engineering design.

2. THE KOUN WSR-88D RADAR

The polarimetric KOUN WSR-88D radar was configured from several autonomous subsystems, most of which were not specifically designed for the project. First, a manufacturer was contracted to design and build a custom frequency offset generator that produced intermediate frequency (IF) signals that differ from the existing IF. This hardware was installed and connected to the Sigmet RVP7 processor, which requires the two offset IF signals. The Sigmet processor was then connected in a passive mode to the radar and software developed to transfer Sigmet data onto the local area network so that it could be further manipulated to produce hydrometeor classes and rain amounts. The proposed polarization scheme uses simultaneous transmission and reception of horizontally and vertically polarized echoes. Because it has not been tested, much time has been devoted to engineering evaluation and calibration.

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Polarimetric algorithms to process the raw data and generate hydrometeor classification and rainfall estimation products were developed for the NSSL Warning Decision Support System-Integrated Information (WDSS-II) display system. The WDSS-II display system is described in detail by Hondl (2002).

3. INITIAL DATA COLLECTION

During the spring of 2002, polarimetric KOUN radar data were collected for several precipitation systems. In this section, we present and discuss KOUN polarimetric data and results from the Hydrometeor Classification Algorithm (HCA) for an MCS that passed over central Oklahoma on 16 June 2002. The HCA used for this operational test has 5 meteorological and 2 non-meteorological categories. The meteorological categories include 1) light rain, 2) moderate rain, 3) heavy rain, 4) hail, and 5) big drops. The non-meteorological categories include 1) anomalous propagation, and 2) birds and insects. These data and products were displayed in real-time at the Norman, Oklahoma National Weather Service Office. During the event, an NSSL observer assisted NWS forecasters in the analysis and interpretation of the dual polarization radar data and products.

3.1 Hydrometeor Classification

Fig. 1 shows 0.5° base scan data extending to a range of approximately 300 km. At this time, the MCS was beginning to enter its dissipative stage, with the convective line still producing heavy rainfall but very little hail. The region of heavy rainfall, as indicated by both large Zs and K_{DP}s, is clearly evident in the HCA output (Fig. 1f) in the SW corner of OK (along the convective line). The HCA also indicates an extensive region classified as “big drops” along the leading edge of the convective line. This feature is particularly evident in SW Oklahoma, where Z_{DR}s often exceed 4 dB. Regions of big drops are common features at the leading edge of convective cells. Our ground-based observations with a video disdrometer indicate that the high Zs associated with these large, but relatively sparse drops can often lead to overestimation of rain by as much as a factor of ten if a Z-R relation is used. An extensive region of light to moderate rain is indicated by the HCA in the MCS trailing stratiform region.

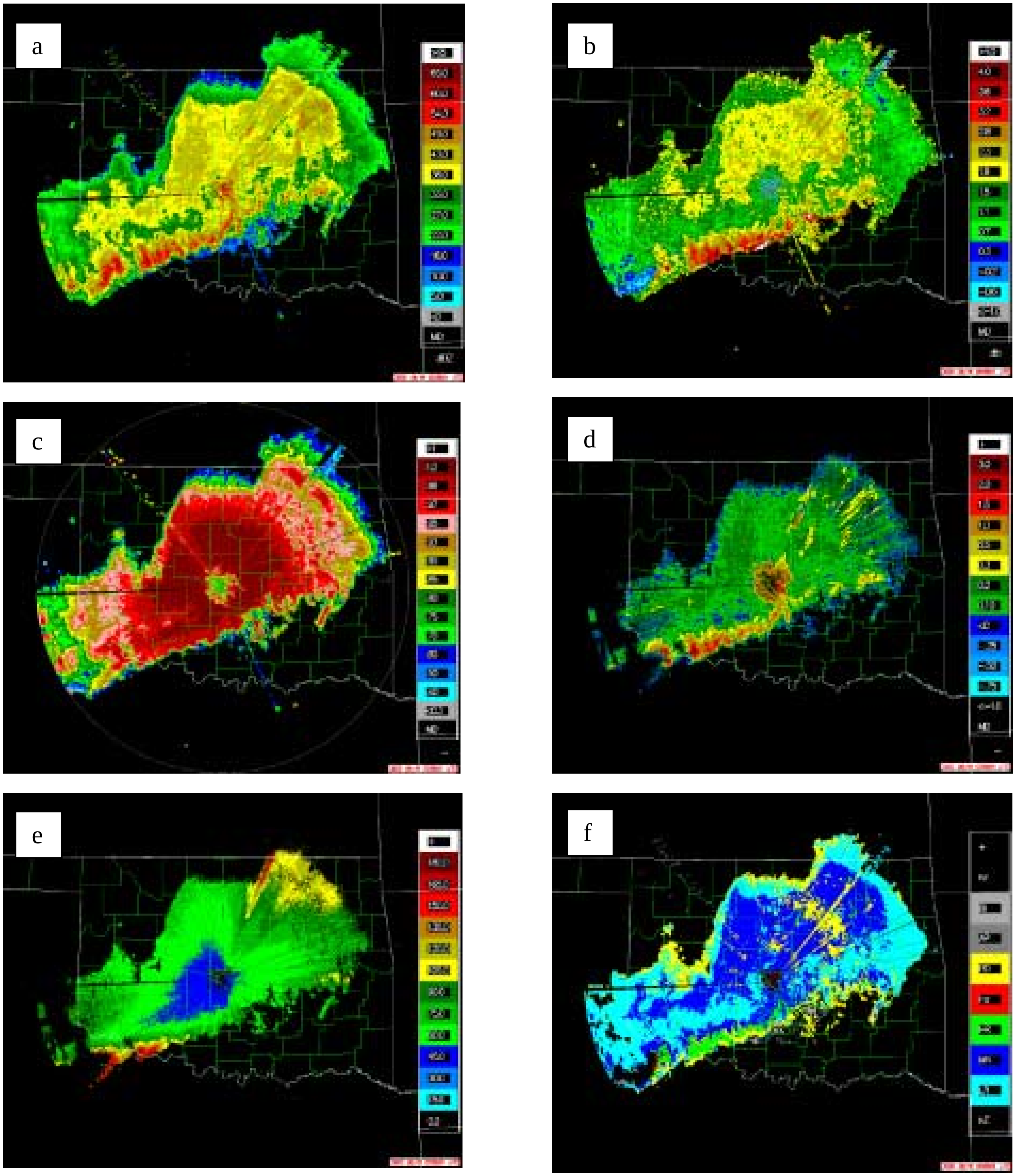

Figure 1: KOUN WSR-88D a) reflectivity, b) differential reflectivity, c) correlation coefficient, d) specific differential phase, e) differential phase, and f) polarimetric hydrometeor classification for the June 16, 2002 MCS at 0300 UTC. The HCA used for these early tests has 5 meteorological and 2 non-meteorological categories. The meteorological categories include 1) light rain (LR), 2) moderate rain (MR), 3) heavy rain (HR), 4) hail (Ha), and 5) big drops (BD). The non-meteorological categories include 1) anomalous propagation (AP), and 2) birds and insects (BI).

A region of big drops is also indicated by the HCA in NW Oklahoma. When comparing this region to the large Z_{DR}s in Fig. 1b and low ρ_{HV}s in Fig. 1c, it is clear that this “big drop” feature is an indication of large, wet aggregates that are associated with the stratiform bright band. Our experimental eleven-class HCA, which includes several ice categories, has a bright band category that indicates this feature quite well. This classification scheme will be added to the suite of real-time polarimetric KOUN algorithms this fall after additional refinement and testing is completed. At ranges beyond the bright band feature, Z_{DR} decreases and ρ_{HV} increases, indicating a deep region of dry snow/ice at levels above the bright band.

The utility of polarimetric radar to identify regions of hail was also well demonstrated by data collected in the 16 June 2002 MCS. Fig. 2 shows KOUN reflectivity (Z), differential reflectivity (Z_{DR}), correlation coefficient (ρ_{HV}), and results from the Hydrometeor Classification Algorithm (HCA) for a hail core in NW Oklahoma at 0045 UTC, a time when convection in the leading line was at its most intense stage. At times, Zs associated with this hail core reached 69 dBZ. The most notable polarimetric feature associated with this intense hail core, as identified by the HCA (Fig. 2d), is a significant local minimum in the Z_{DR} (Fig. 2b) in a region that appears to be collocated with the highest reflectivity core. This region is also characterized by a significant drop in ρ_{HV} (Fig. 2c).

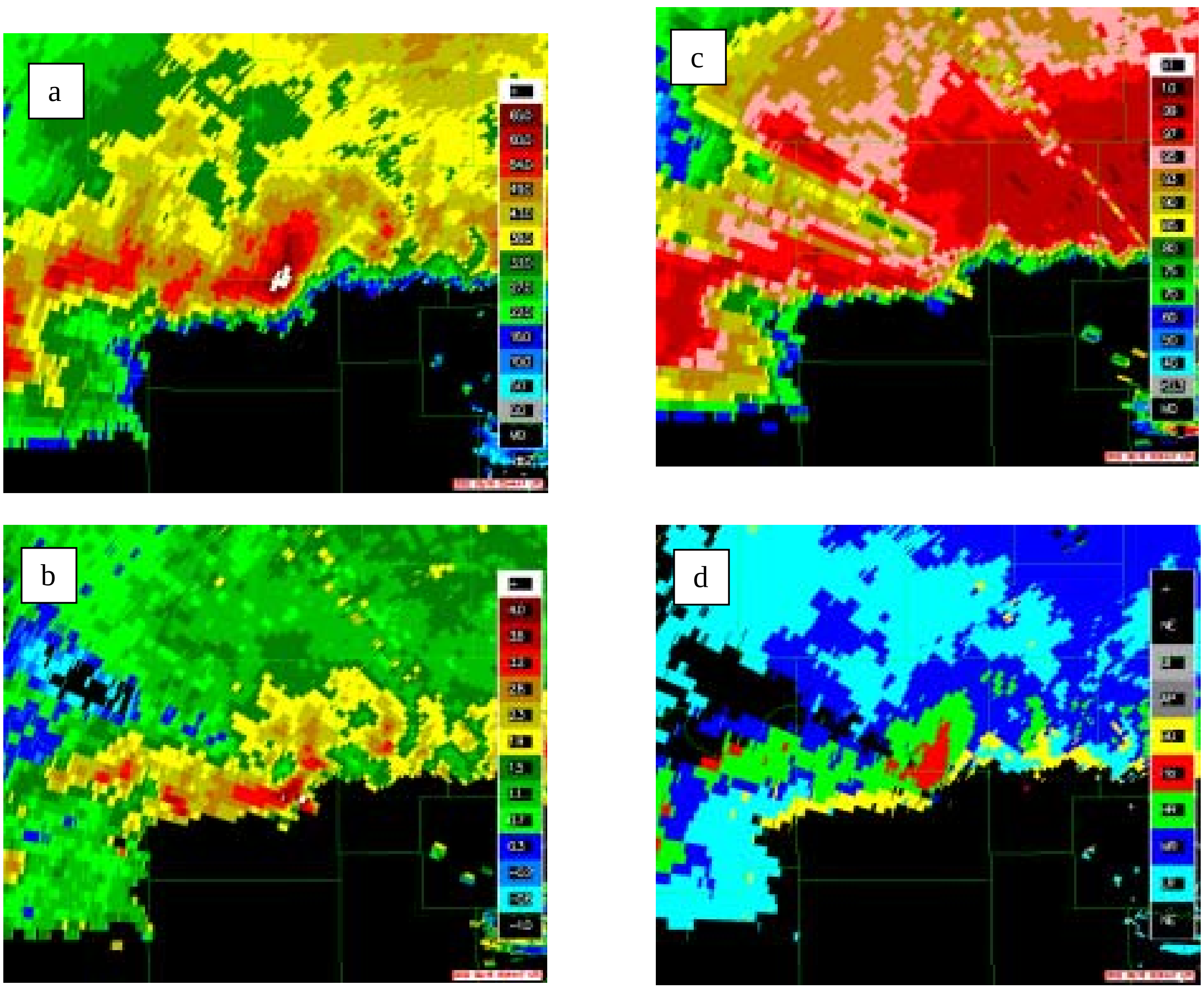

Figure 2: KOUN WSR-88D a) reflectivity, b) differential reflectivity, c) correlation coefficient, and d) polarimetric hydrometeor classification for the June 16, 2002 MCS at 0045 UTC.

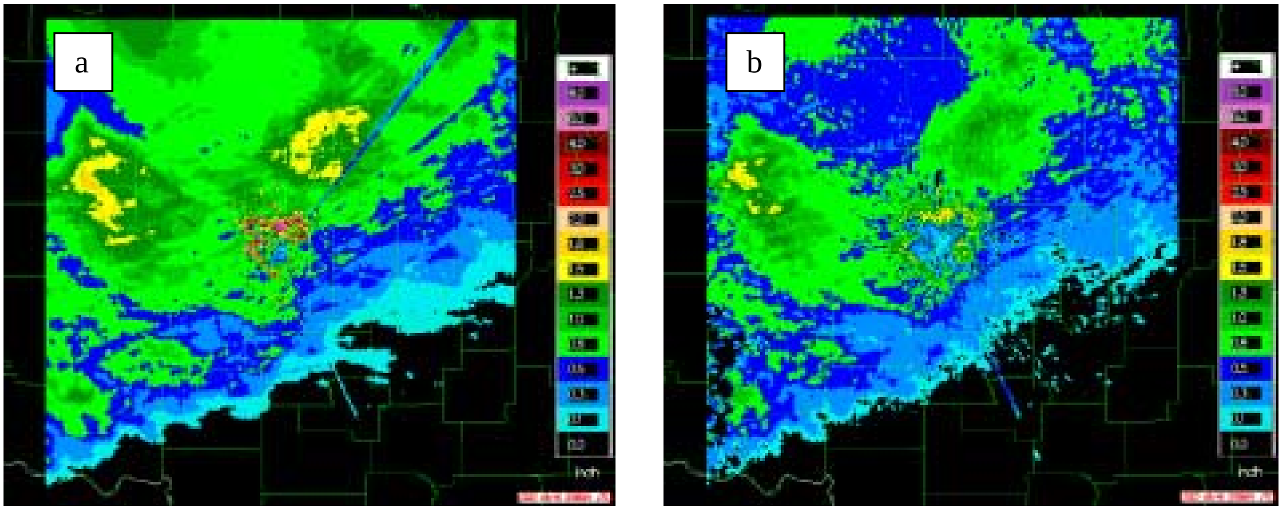

Figure 3: KOUN WSR-88D 3-hour rainfall accumulation using a) a Z-R relation, b) polarimetric K_{DP} relation.

3.2 Rainfall Estimation

A feature evident in several panels of Fig. 1 (particularly the hydrometeor classification panel) is a sector of severe blockage at an azimuth of approximately 40°. This blockage is caused by the NWS KCRI test and development radar, which is located approximately 250 m to the NW of the KOUN radar. Blockage represents a significant rainfall estimation problem for several regions of the country, particularly in the mountainous western states. Fig. 3, however, shows how these rainfall estimation problems can be mitigated by polarization estimation techniques, which are largely immune to blockage. Fig. 3a shows 3-hour rainfall accumulation using the standard NWS Z-R relation; Fig 3b. shows 3-hour rainfall accumulation using a polarimetric K_{DP} relation. In addition to demonstrating better overall agreement with ground-based observations obtained from Oklahoma mesonet stations (not shown), the comparison clearly demonstrates the relative immunity of the polarimetric estimator to blockage.

4. JPOLE OPERATIONAL DEMONSTRATION

The JPOLE operational demonstration began in the spring of 2002 with the delivery of the first polarimetric KOUN radar data and products to forecasters at the Norman, OK NWS (an example of which is presented and discussed in Section 3). Prior to this initial data delivery, a training seminar was held for the NWS forecasters. An NSSL observer was then scheduled to assist NWS forecasters with the analysis and interpretation of the polarimetric radar data and products for each precipitation event.

While the number of events delivered in Spring of 2002 was limited, overall data quality for several of those events was quite good. In particular, the HCA showed great utility at identifying regions of hail and contamination from non-meteorological scatterers (such as birds, insect, and anomalous propagation). Real-time comparisons of conventional and polarimetric rainfall estimation with data from the Oklahoma Mesonet suggested that the polarimetric algorithm outperformed the conventional algorithm, particularly for events that included hail. The presence of the nearby KCRI WSR-88D tower in the NE sector (see Fig. 3) also provided an opportunity to demonstrate the relative immunity of the polarimetric estimator to blockage.

Over the next year, JPOLE operational demonstration objectives can be broken down into two broad categories: 1) evaluating the engineering design and data quality of a polarimetric WSR-88D radar, and 2) examining the benefits of polarimetric radar data to operational meteorologist, hydrologists, and aviation users.

4.1 Engineering Design and Data Quality

The operational demonstration will provide an opportunity to evaluate critical engineering and data quality issues. For example, radar data quality must be assessed through a detailed comparison with verification data sets, the radar scanning strategy evaluated to assess compatibility with requirements of the existing WSR-88D radar system, and the simultaneous transmission mode (Doviak et al., 2000) examined to calibrate polarimetric radar measurements, establish and verify engineering specifications, and investigate short and long term stability. Future work will include introducing cold-season hydrometeor types (Fall of 2002), the collection of verification data sets, and refinement of existing classification schemes.

4.2 Benefits to Operational Users

In addition to addressing engineering and data quality issues, JPOLE will continue to examine the benefits of the polarimetric radar data and products to operational meteorologist, hydrologists, and aviation users. This will be accomplished by conducting a thorough evaluation of the polarimetric radar rainfall and hydrometeor product performance, both in real-time with the collaboration of operational forecasters, and in post-analysis where a more detailed analysis of the data and products will be possible. Product comparisons will be of fundamental importance to the test and evaluation of the polarimetric KOUN WSR-88D radar's capabilities.

5. JPOLE FIELD CAMPAIGN

Plans are also being made to conduct a JPOLE field campaign in the Spring of 2003. The JPOLE field campaign, which will complement the JPOLE operational demonstration, is a multi-agency project designed to advance numerous meteorological and hydrological objectives. Broadly, these objectives include improving the physical understanding of polarimetric data interpretation, improving rainfall estimation and hydrometeor classification and quantification techniques, and investigating the use of polarimetric radar data in distributed hydrologic and storm-scale prediction models.

6. SUMMARY

In the Spring of 2002, several years of effort on the NOAA research WSR-88D radar culminated in the generation and display of dual polarization radar data and products. As part of the JPOLE operational demonstration, these data and products were delivered in real-time to operational forecasters at the Norman, OK National Weather Service forecast office. An NSSL observer assisted operational forecasters in the analysis and interpretation of the dual polarization data and products. A preliminary evaluation indicates that polarimetric hydrometeor classification and rainfall estimation algorithms outperform conventional algorithms. Work will continue to improve existing hydrometeor classification and rainfall estimation techniques, develop algorithms for winter precipitation, and facilitate the transfer of polarimetric radar technology to operational meteorologists, hydrologists, and aviation users.

A more comprehensive overview of the JPOLE operational demonstration and field campaign objectives can be found on the JPOLE web site, located at: http://www.nssl.noaa.gov/JPOLE/.

7. REFERENCES

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