# THE JOINT POLARIZATION EXPERIMENT – AN OPERATIONAL DEMONSTRATION OF THE POLARIMETRIC KOUN WSR-88D RADAR

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## 1) INTRODUCTION

In the spring of 2003, the National Weather Service (NWS) Office of Science and Technology tasked the National Severe Storms Laboratory (NSSL) with providing data collection and analysis to support a WSR-88D dual-polarization decision briefing to the NEXRAD Program Management Committee (PMC). This decision briefing, which is expected to occur in the mid-November 2003 timeframe, will come at the end of a year long data collection and operational demonstration project, hereafter referred to as the Joint Polarization Experiment (JPOLE), which was designed to evaluate the engineering design of the polarimetric KOUN WSR-88D radar and demonstrate the utility of polarimetric radar data and products to operational users. In this paper, we provide examples of the polarimetric data and products and present initial impressions of the utility of the polarimetric upgrade to the WSR-88D radar.

## 2) DATA COLLECTION AND ANALYSIS

The two primary operational benefits of polarimetric radar are 1) improved rainfall estimation, and 2) the ability to remotely classify both meteorological (precipitation type) and non-meteorological (ground-based and biological) scatterers. Data collection with the KOUN radar began in the late spring of 2002. Since then, we have collected data that span a wide variety of precipitation systems (widespread warm- and cold-season rainfall, isolated convective cells, supercell thunderstorms, tornadoes, Mesoscale Convective Systems, and winter storms) and non-meteorological echoes (AP, birds, insects, and chaff). A comprehensive summary of this data set is presented on the WWW at: http://cimms.ou.edu/~heinsel/jpole/database.html. In total, data have been collected and archived for approximately 80 days of observation.

Ongoing analyses at the NSSL demonstrate the ability of the polarimetric KOUN radar data to provide improved rainfall estimates and hydrometeor identification. Some of this work is reported elsewhere in this preprint volume [e.g., Ryzhkov et al (2003), Giangrande and Ryzhkov (2003), Ryzhkov and Zrnic (2003)]. Two of these papers focus on

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rainfall estimation with the polarimetric WSR-88D radar data. Ryzhkov et al (2003) used a 20 day (40 hour) subset of the KOUN data set and rain data from the USDA Agricultural Research Service micronetwork to compare conventional ($R(Z)$) and polarimetric ($R(K_{DP})$, $R(K_{DP},Z_{DR})$, $R(Z,Z_{DR})$, and $R(Z, K_{DP}, Z_{DR})$) rainfall estimates over the Little Washita watershed. Their study provides statistical evidence of the superiority of the polarimetric rainfall estimates over the conventional estimates. Giangrande and Ryzhkov (2003) examined rainfall estimation as a function of range. By comparing conventional and polarimetric rainfall estimates with the Oklahoma Climatological Survey (OCS) rain gage mesonetwork, they concluded that polarimetric rainfall estimates outperform $R(Z)$ estimates to a range of 200 km.

Analyses of the KOUN data set also demonstrate the radar's ability to classify hydrometeor type and discriminate between meteorological and non-meteorological echoes. Here we present three examples that demonstrate the KOUN data quality and discrimination and classification capabilities. Figure 1 shows a supercell thunderstorm that produced an F4 tornado over Moore and southern Oklahoma City, OK on May 8, 2003. In agreement with the results of Ryzhkov et al (2002), a preliminary analysis of this data set (and a similar data set from northern Oklahoma City on May 9, 2003) suggests the possibility that polarimetric signatures can be used for tornado detection. In this figure, low $Z_{DR}$ and low $\rho_{HV}$ in the vicinity of the confirmed tornado suggests the detection of airborne debris. Figure 2 shows a severe hail storm that occurred over south-central, OK on May 14, 2003. The radar reflectivity associated with this storm was often > 65 dBZ. Very low (and occasionally negative) $Z_{DR}$ combined with low $\rho_{HV}$ on the southern edge of the high reflectivity core indicates a region of very large hail. Higher $K_{DP}$ to the north, however, indicates the likelihood of a rain/hail mixture. Finally, we show results of the Hydrometeor Classification Algorithm (HCA) for a precipitation event on October 6, 2002. For this case, the precipitation echo, which consisted of both convective and stratiform rain, was often embedded within returns from anomalous propagation and biological (birds and insects) scatterers. Figure 3 clearly demonstrates the ability of the algorithm to discriminate between meteorological and non-meteorological echoes.
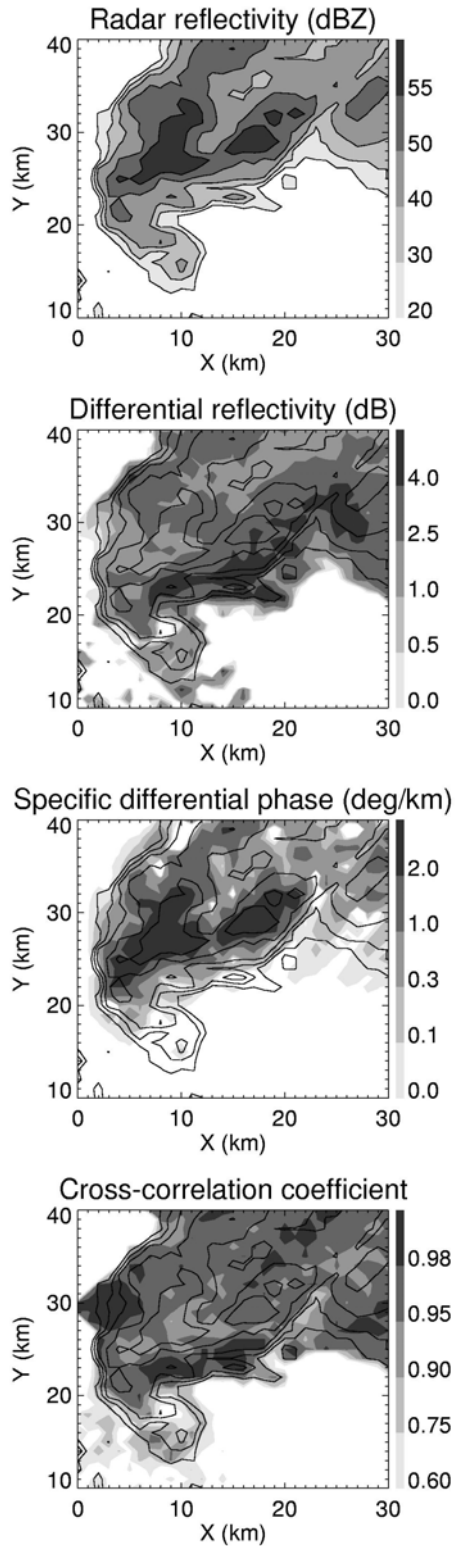
**Figure 1.** Polarimetric KOUN WSR-88D radar reflectivity (dBZ), differential reflectivity (dB), specific differential phase (deg/km), and cross-correlation coefficient for a tornadic, supercell thunderstorm over central Oklahoma on May 8, 2003.
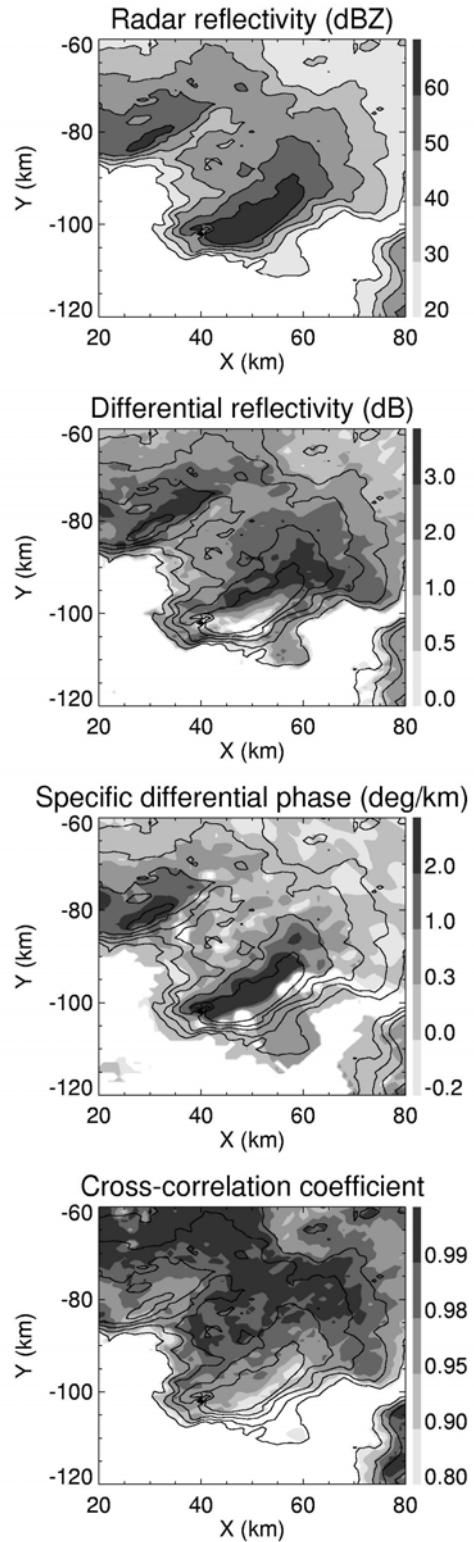
**Figure 2.** Polarimetric KOUN WSR-88D radar reflectivity (dBZ), differential reflectivity (dB), specific differential phase (deg/km), and cross-correlation coefficient for a severe hail storm over south-central Oklahoma on May 14, 2003.
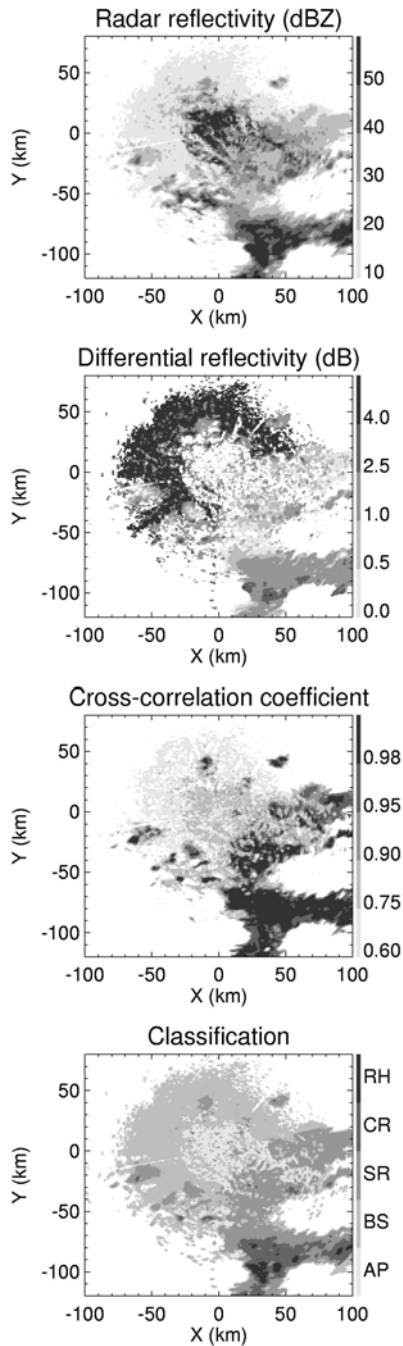
**Figure 3.** Polarimetric KOUN WSR-88D radar reflectivity (dBZ), differential reflectivity (dB), cross-correlation, and results of the Hydrometeor Classification Algorithm (HCA) for precipitation embedded within AP and bird and insect returns on October 6, 2002. HCA categories are rain/hail (RH), convective rain (CR), stratiform rain (SR), biological scatterers (BS), and anomalous propagation (AP), respectively.

A detailed analysis of hydrometeor classification for a winter storm event is presented by Ryzhkov and Zrnic (2003).

### 3) OPERATIONAL DEMONSTRATION

As part of the JPOLE data collection effort, polarimetric 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 Z, $Z_{DR}$, $\rho_{HV}$, $\Phi_{DP}$, $K_{DP}$, a hydrometeor classification product, and a variety of polarimetric rainfall rate and accumulation estimates. The operational delivery of the KOUN radar data and products during the spring of 2003 JPOLE intense observation period is discussed in more detail by Scharfenberg et al (2003).

Forecaster input is of vital importance to the evaluation of WSR-88D radar products. NSSL observers were therefore scheduled to assist NWS forecasters in the analysis and interpretation of the polarimetric radar data and products for much of the fall 2002 and spring 2003 data collection. Operational feedback for each case was then provided by forecaster evaluation forms. In several cases, polarimetric data and products provided input that was used in the warning decision process. Examples of two such events are presented in this preprint volume by Miller and Scharfenberg (2003) and Scharfenberg and Maxwell (2003).

### 4) CONTINUED ALGORITHM DEVELOPMENT

A key part of the JPOLE effort is the continued refinement and development of polarimetric rainfall and hydrometeor classification algorithms. In addition to the rainfall verification data from the ARS micronetwork and OCS mesonetwork discussed in the previous section, surface-based measurements of hail and in situ aircraft measurements of cloud microphysical properties were also made in the spring of 2003. Ongoing analyses of these data will be used to validate the results of the HCA and improve algorithm performance.

### 5) CONCEPTS OF OPERATIONS EVALUATION

In addition to the collection and analysis of data, the JPOLE operational demonstration presented an opportunity to evaluate critical engineering and data quality issues. For example, radar data quality is being assessed through a 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. More specifically, the engineering design and data quality objectives of the operational demonstration are:

- Demonstrate the accuracy of KOUN reflectivity, velocity, and spectrum width measurements through comparisons with conventional WSR-88D radar data
- Demonstrate the accuracy of KOUN polarimetric measurements through comparisons with high-quality research polarimetric radar data
- Demonstrate that polarimetric precipitation estimation and hydrometeor classification products can be collected with acceptable antenna rotation rates (all previous research results were obtained with relatively slow scan strategies)
- Perform tests to ensure minimal degradation in VCP times, and no degradation in ground clutter filtering, anomalous propagation filtering, and velocity dealiasing
- Evaluate the value of alternate $\rho_{HV}$ and $L_{DR}$ scans (and limits to any of the variables)

## 6) SUMMARY

The National Severe Storms Laboratory has been conducting the Joint Polarization Experiment (JPOLE), which is designed to evaluate the engineering design of the polarimetric KOUN WSR-88D radar and demonstrate the utility of polarimetric radar data and products to operational users. Ongoing analyses of the data demonstrate statistical evidence of the superiority of the polarimetric rainfall estimates over the conventional estimates. Examples presented in this paper also demonstrate the radar's data quality and ability to identify echo type for a variety of meteorological and non-meteorological scatterers.

As part of the JPOLE operational demonstration, polarimetric WSR-88D radar 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. Data and products from the polarimetric radar were used in the warning decision process during several precipitation events.

Results of the ongoing analyses will be combined with user evaluations from the JPOLE operational demonstration to support a WSR-88D dual-polarization decision briefing to the NEXRAD Program Management Committee (PMC) in the mid-November 2003 timeframe.

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