5.15 JOINT POLARIZATION EXPERIMENT (JPOLE) FOR THE WSR-88D RADAR: PROGRESS AND PLANS

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1. INTRODUCTION

The open systems development and polarimetric upgrade to the KOUN WSR-88D radar has been a tri-agency effort supported by the National Weather Service (NWS), Federal Aviation Administration (FAA), and Air Force Weather Agency (AFWA). As this work nears completion, plans are being made to conduct the Joint Polarization Experiment (JPOLE), which will include the first operational test of weather radar polarimetry. In addition, JPOLE will provide an opportunity to investigate many complementary hydrological and meteorological scientific objectives. This paper describes the goals and present plans for the JPOLE project.

2. JPOLE OVERVIEW

The overarching goals of JPOLE are to test the engineering design and determine the data quality of a polarimetric WSR-88D radar, demonstrate the utility and feasibility of the radar, and to collect data and information that will allow for a cost/benefit analysis to be performed. In July of 2000, an initial JPOLE planning meeting was held at the National Severe Storms Laboratory (NSSL) in Norman, Oklahoma. At that meeting, plans were made for an experiment that will essentially consist of two phases: a multi-seasonal test and evaluation period (using local facilities for the collection of verification data sets, to begin in the spring of 2002), and an intense observation period (using both local and community-wide facilities for the collection of verification data sets, to begin in the spring of 2003). The first phase will emphasize a demonstration of the utility of the polarimetric KOUN WSR-88D radar, and a test and evaluation of its engineering design and data quality. In addition, the second phase will address broad scientific objectives.

Since a long-term goal of JPOLE is to transfer polarimetric radar technology to an operational setting, plans were also made to begin introducing operational forecasters to polarimetric radar data and products prior to the start of KOUN WSR-88D polarimetric radar data collection. Over the past year, NSSL has therefore begun delivering real-time polarimetric radar data and products from the NSSL Cimarron radar (located approximately 40 km northwest of KOUN) to forecasters at the Norman, Oklahoma NWS Forecast Office. Plans for the future development of these products will be presented in more detail later in this paper.

A second JPOLE planning meeting is scheduled for October of 2001 (after the submission deadline for this paper). In that meeting, efforts will be made to refine the operational requirements and scientific objectives (as listed here) and to begin making plans for the field phase portion of the experiment.

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3. JPOLE OPERATIONAL DEMONSTRATION

The JPOLE operational demonstration objectives and requirements 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.

3.1 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. More specifically, the engineering design and data quality objectives of the operational demonstration are to

- 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 ρ_{HV} and L_{DR} scans (and limits to any of the variables)

3.2 Benefits to Operational Users

In addition to addressing engineering and data quality issues, JPOLE also seeks to examine the benefits of polarimetric radar data to operational meteorologist, hydrologists, and aviation users. This will be accomplished by conducting an evaluation of the performance of polarimetric radar rainfall and hydrometeor products. As such, operations during both field phases (covering both warm and cold season precipitation) will focus on the collection of data sets that can be used for a detailed comparison of conventional and polarimetric radar products. This evaluation will completed both in 1) real-time with the collaboration of operational forecasters, and 2) post-analysis where a more detail analysis of polarimetric algorithm performance can be made. More specifically, the product performance evaluation objectives are to

- Improve Quantitative Precipitation Estimation (QPE)
- Use QPE to improve operational hydrologic forecasts (especially for flash flood events)
- Discriminate hail from rain and gauge hail size
- Identify precipitation type in winter storms (dry/wet snow, sleet, rain)
- Identify biological scatterers (and their effects on the wind measurements)
- Identify the presence of chaff (and its effect on precipitation measurements)
- Identify areas of ground clutter and anomalous propagation
- Provide improved initial conditions and constraints to numerical models for short term forecasts
- Investigate the feasibility of identifying aircraft icing conditions

Product comparisons will be of fundamental importance to the test and evaluation of the polarimetric KOUN WSR-88D radar's capabilities. As such, it is imperative that real-time data collection be conducted in collaboration with operational hydrologists, meteorologists, and aviation users, whose insight will be of vital importance to the evaluation of WSR-88D radar products.

4. PRODUCT DEVELOPMENT AND DELIVERY

In preparation for the full WSR-88D radar test, the NSSL began to introduce polarimetric radar data and products (from the polarimetric NSSL Cimarron radar) to forecasters at the Norman, Oklahoma NWS Forecast Office in the spring of 2001. As part of the NSSL Warning Decision Support System – Integrated Information (WDSS-II) software package, a polarimetric Hydrometeor Classification Algorithm (HCA) provided detailed information on the occurrence of severe hail, location of anomalous propagation, and presence of biological (birds and insects) scatterers. Information on rain rate intensity was also provided by the algorithm.

An example of the HCA output from the spring 2001 operational test, as displayed by WDSS-II, is shown in Figure 1.

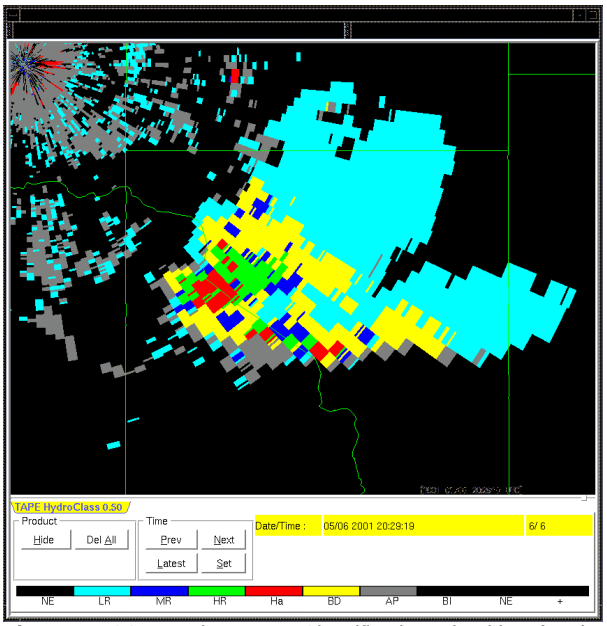

Fig. 1 WDSS-II Hydrometeor Classification Algorithm for the May 6, 2001 hail storm.

Figure 1 depicts the classification for a quasi-stationary, severe storm that produced 2 cm hail on May 6, 2001. The warm-season HCA categories shown in this figure are LR=light rain, MR=moderate rain, HR=heavy rain, Ha=hail, BD=big drops, AP=ground clutter and anomalous propagation, and BI=birds/insects. For this case, the HCA clearly depicts a large hail region surrounded by both heavy and moderate rainfall. A large region of rainfall wherein the drop size distribution is dominated by a deficit of small drops was also indicated by the HCA. These "big drop" regions, which can be attributed to drops that originate as melting hail aloft (and fall to ground while still containing ice cores) or the result of coalescence growth in the convective updraft (and fall to ground before significant drop breakup occurs) are characteristic of regions where radar-based rain rate is commonly overestimated. All fields showed remarkable temporal consistency from one sweep to the next.

During each precipitation event, NSSL scientists sat with NWS forecasters and assisted them in the use of the WDSS-II display and the interpretation of the polarimetric data and products. After each event, forecasters would fill out a short, web-based evaluation form. This information would then be used by scientists to improve algorithm performance and by software developers to improve WDSS-II functionality.

Future enhancements to this delivery/display system will include a classification package that will be better suited for classifying hydrometeor types in winter

precipitation events (such as snow, sleet, and freezing rain) and the addition algorithms that will focus on providing improved polarimetric precipitation accumulation estimates. Plans also call for switching the WDSS-II polarimetric data feed from the NSSL Cimarron radar to the KOUN WSR-88D radar in the spring of 2002.

5. JPOLE INTENSE OBSERVATION PERIOD

While JPOLE is primarily designed to be an operational demonstration project, the infrastructure provided by the operational test and evaluation requirements present a unique opportunity to also investigate several complementary hydrological and meteorological scientific objectives. In the spring of 2003, plans are therefore being made to conduct a more extensive JPOLE Intense Observation Period (IOP) in central Oklahoma. The primary goals of this IOP are to 1) collect dense, ground-based and airborne verification data sets that can be used to assess the KOUN radar data and product quality, and 2) collect high-quality, hydrological/meteorological data sets that can be used to investigate several scientific objectives, which are crucial towards advancing knowledge that will lead to future improvements of polarimetric radar algorithms. The JPOLE operational demonstration data collection will extend into the IOP. In turn, verification data sets collected as part of the IOP will be used to better assess the accuracy of the polarimetric KOUN WSR-88D radar data and products.

Since the first JPOLE planning meeting, scientists from a number of educational institutions and government agencies have submitted scientific objectives that are being combined into a JPOLE Science Overview Document. This document will serve as a template for the design and future operations plan of the JPOLE IOP. Preliminary plans call for the deployment of several ground-based and mobile facilities to central Oklahoma for the spring of 2003. These include, a research polarimetric radar that can be strategically placed in central Oklahoma to provide both a source of high-quality data that can be used for a comparison with the KOUN radar data (as well as provide input for hydrological distributed modeling studies), research aircraft to provide in situ microphysical data, and ground based rain gauge networks, disdrometers, and hail chase vehicles. More specific JPOLE IOP objectives are to

- Improve physical understanding of polarimetric signatures
- Collect data that can be used to evaluate the accuracy of operational precipitation and hydrometeor identification algorithms
- Investigate the effect of natural drop size distribution variability on conventional and polarimetric rainfall estimators
- Investigate the effect of drop oscillations and canting angles on conventional and polarimetric rainfall estimators
- Investigate how microphysical information derived from polarimetric radar measurements can be used in cloud resolving models
- Examine the microphysical basis for drop size distribution variability in both cold and warm season precipitation events
- Investigate how improved precipitation estimates from polarimetric rainfall measurements can be used to initialize hydrologic models.
- Measure streamflow and runoff and conduct hydrologic modeling studies
- Investigate how input data uncertainties influence flood prediction, the maximum time/space scales required to accurately simulate a flash flood, and the basin characteristics that are most important in transforming rainfall into runoff
- Assess how Ka-band (hydrometeor identification) and X-band (precipitation) measurements can be used to improve interpretation of polarimetric S-band radar data

6. SUMMARY

The Joint Polarization Experiment will represent the first operational test of the polarimetric KOUN WSR-88D radar. Data collection during JPOLE will be used to conduct detailed comparisons of conventional and polarimetric radar products, which will be of fundamental importance to the test and evaluation of the radar's capabilities. Additional facilities available during a proposed Intense Observation Period will provide much needed verification data sets that will allow for a detailed investigation of several hydrological and meteorological scientific objectives. Critical engineering and data quality issues will also be examined.

In preparation for JPOLE, the NSSL WDSS-II system has been used to deliver real-time polarimetric radar data and products from the NSSL Cimarron radar to forecasters at the Norman, Oklahoma NWS Office. Work is currently progressing to further coordinate real-time data collection with operational hydrologists, meteorologists, and aviation users, whose insight will be of vital importance to the evaluation of WSR-88D radar products.

7. REFERENCES

Doviak, R. J., V. Bringi, A. Ryzhkov, A. Zahrai, and D. Zrnic, 2000: Considerations for polarimetric upgrades to operational WSR-88D radars. *J. Atmos. Oceanic Tech*., **17**, 257-278.