8A.1 What's new at the National Weather Radar Testbed (Phased-Array)

Douglas E. Forsyth[1]*, James F. Kimpel[1], Dusan S. Zrnic[1], Ron Ferek[2], John F. Heimmer[7], Tom McNellis[3], Jerry E. Crain[4], Alan M. Shapiro[4], Richard J. Vogt[5] and William Benner[6]

[1]National Severe Storms Laboratory (NSSL), [2]Office of Naval Research (ONR), [3]Lockheed Martin Corporation, [4]University of Oklahoma (OU), [5]Tri-Agencies' (Dept. of Commerce, Defense & Transportations) Radar Operations Center, [6]Federal Aviation Administration (FAA), [7]PARTECH

1. INTRODUCTION

For over six years, the National Weather Radar Testbed (NWRT) has continued its role as the multi-function phased array radar testbed (Zrnic, 2007) in Norman, Oklahoma. Developed as a result of a partnership between the National Oceanic and Atmospheric Administration's National Severe Storms Laboratory, the United States Navy's Office of Naval Research, Lockheed Martin Corporation, the University of Oklahoma's Electrical and Computing Engineering Department and School of Meteorology, the Oklahoma State Regents for Higher Education, the Tri-Agencies' (Department of Commerce, Defense and Transportation) Radar Operations Center, the Federal Aviation Administration's Technical Center and Basic Commerce and Industries, Inc, the NWRT continues to provide both meteorological and aircraft data for testing the concept of a multifunction phased array radar system. The progress of the NWRT continues to be reported at the Radar and Interactive Information Processing Systems (IIPS) Conferences (Forsyth, 2007, 2008, 2009) In addition, the NWRT has become an important component in the education of the forthcoming generation of radar meteorologists and engineers.

Each storm season has provided additional data on various severe weather events and an opportunity to demonstrate the advantages of using the phased array radar. We have added new features to the system each year and have continued our planning for implementation of a dual-polarized sub-array for testing the characteristics of a phased array dual polarized weather radar. In this paper, we will describe the present status, future upgrades and research progress including results of additional high temporal volumetric scans of severe storms
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2. CURRENT STATUS

Since 2004, the NWRT has been continually improved and used for testing and comparison studies to determine the effectiveness and applicability of a Phased Array Radar for use as a multi-function radar for weather and aircraft surveillance.

* Corresponding author address: Douglas E. Forsyth, Chief, Radar Research & Development Division, National Severe Storms Laboratory, 120 David L. Boren Blvd, Norman, OK, 73072;
email: Douglas.Forsyth@noaa.gov

During the last two years, the radar data quality has been improved as well as improvements in the digital signal processing. In addition, a new aircraft track processor developed by Basic Commerce Industries along with the FAA was implemented with the help of Department of Homeland Security funding.
Changes in the Digital Signal Processor (DSP) functionality included pulse-pair processing, range unfolding, adding a matched filter and improved data censoring. (Torres, 2009). Also included was an off-line noise measurement and improved infrastructure.

Additional Digital Signal Processor (DSP) upgrades included the ability to process the data in the frequency domain, the addition of staggered Pulse Repetition Time (PRT) for velocity/range dealaising, automatic ground clutter detection and removal and an interference filter (Torres, 2009). A range, noise and DC bias calibration were also added to the NWRT. The system was modified for DSP control in real-time and playback along with the capability of tagging various types of data (i.e. weather, aircraft, calibration, etc.)

The infrastructure improvements included using multiple DSPs, load balancing between processors, a scalable design and self-descriptive messages for platform-independent data handling. The recording capacity of time-series and moment was also improved.

Experiments executed in the Spring 2008 and 2009 included: (Heinselman, 2009)

a. ADAPTS (Adaptive DSP Algorithm for PAR Timely Scans)

b. PARISE (Phased-Array Radar Innovative Sensing Experiment)

b. MPAR Demonstration – Simultaneous collection of aircraft and weather data.

c. Meteorological studies with phased array weather radar and data assimilation using the ensemble Kalman filter.

d. Spaced antenna interferometry experiment.

e. Wind farm studies.

Adaptive scanning was performed for the first time this spring (Spring 2009). The algorithm adapts to the current weather in determining the next scan sequence to perform. A display of the angles being scanned was developed and has proven very useful in seeing how the adaptive algorithm is performing (Figure 1).

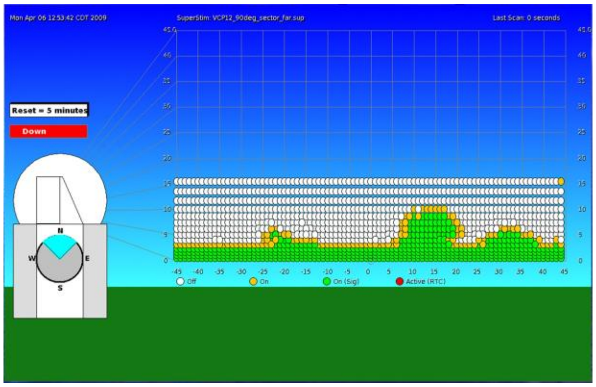

FIGURE 1. User Interface displaying elevation angles being scanned for each azimuth (Green = Being scanned, Yellow = Last Elevation Scanned, White = Not being scanned)

In addition, the radar ran in support of VORTEX-2 (Verification of the Origins of Rotation in Tornadoes EXperiment #2). Since June, the radar has been upgraded with an additional eight receivers and a new archive unit. The multi-receiver system was funded by the National Science Foundation through a grant to the University of Oklahoma (Yeary, 2009). The system has been integrated with the NWRT and is currently being tested.

The new track-processor was completed and installed in May, 2009. The software was implemented on a new PC platform and the tracking was added to the detection software. Data was collected for several cases and comparison with the ASR-9 tracks look good. An example of some aircraft tracks collected with the NWRT is shown in Figure 2. Additional modifications will include clutter mitigation and adding the mono-pulse channels to further improve the resolution of the targets.

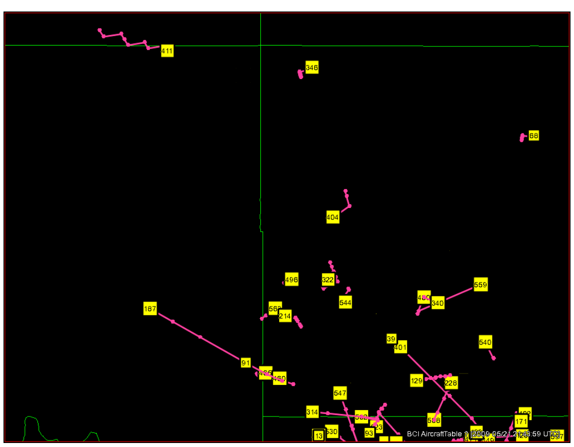

FIGURE 2. Aircraft tracks (Magenta) and IDs (Yellow) as identified by the NWRT Phased Array Radar.

Our studies of data assimilation using the ensemble Kalman filter are very encouraging (Thompson, 2008). The testing has shown the improvement gained by using fast scanning data for model initialization.

Our work in spaced-antenna interferometry has continued (Zhang, 2007). With the implementation of the multi-channel receiver, we will now be able to collect this data more frequently and run additional experiments in real-time.

PARISE (Heinselman, 2009) has been an important element in obtaining user feedback concerning the use of Phased Array data. Based on other studies, the most important improvement that National Weather Service Forecasters would like to see is faster updates. By having the capability to use the NWRT for making simulated warnings, we are able to determine the benefit of phased array technology in improving the warning lead times. Based on survey results of the participants, the Phased Array radar improved the warning lead times by giving the forecasters more confidence in their decisions and allowing them to issue the warnings sooner.

We are also collaborating on a wind farm mitigation study using phased arrays (Palmer, 2009). The wind farm study was also funded by the Department of Homeland Security to determine if phased array technology could help mitigate the effects of wind farms in the detection of severe weather. Although, no mitigation solution was obtained, methods to detect wind turbine clutter in an automatic manner can be achieved.

3. RESEARCH PROGRESS and PLANS

We have continued to look at building a dual-polarized sub-array along with the characteristics of such an array. Several studies were completed by Basic Commerce Industries concerning the radome effects, beam width and design of the radiating elements to meet the cross-polarization requirement of 30db isolation as well as the calibration issues (Staiman, 2009). Research continues in these areas to define a dual-polarized phased array sub-array for testing.

In addition, we are working on more improvements to the Digital Signal Processor (DSP) including the capability to change the PRT in real-time, improving the adaptive scanning capabilities to automatically schedule new scans based on algorithm input. Range oversampling is also being implemented to improve volume scan times. This technique can be tested to determine its effectiveness for both single horn antennas along with phased array antennas.

We plan to continue our work with Lockheed Martin Corporation on implementing a faster real-time controller. This will be accomplished by upgrading to a faster Motorola CPU board.

Additional plans include various data collections on targets of opportunity, along with support for VORTEX-2 next spring (Spring 2010). We will also be collecting data in support of a few electrification studies.

Work continues on the planning of several technical assessments in collaboration with the Federal Aviation Administration to reduce our risks if the program goes to a full prototype. Risk reduction areas include cost, maintenance, dual-polarization capabilities, multi-frequency, multi-face operations and thermal management of the array to name a few.

We have continued to collect data on targets of opportunities and have archived over four terabytes of I&Q data for research purposes. Some of the data has been used to compare the WSR-88D with the NWRT (Brown, 2009) as well as look at low-altitude circulations (Heinselman, 2009). We now have the capability within WDSS-II (Lakshmanan, 2007) to display iso-surfaces in three-Dimensions (3-D) (Figure 3).

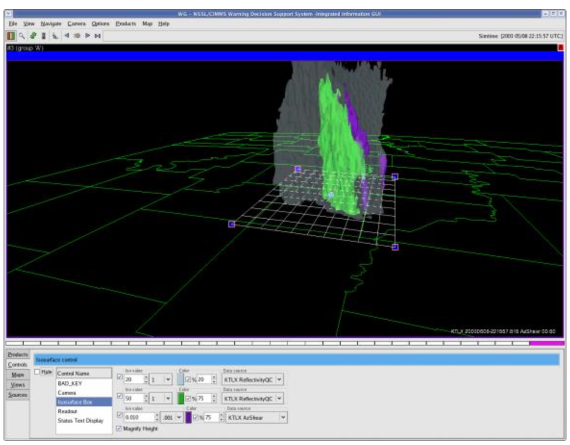

Figure 3. WDSS-II 3D Iso-surface of reflectivity core (green) and mesocyclone vortex (purple)

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