2008 NWRT PAR Demonstration

Updated 6 May 2008 by Pam Heinselman

Photo courtesy of Mark Benner

1. Introduction

The 2008 National Weather Radar Testbed Phased Array Radar (NWRT PAR) Demonstration consists of five experiments. The purpose of this document is to provide an overview of each experiment. A detailed description of the NWRT PAR is available in Zrnić et al. (2007) and a comparative description of NWRT PAR to the WSR-88D is available in Heinselman et al. (2008).

2. Experiment Descriptions

This year the NWRT PAR experiments address a variety of applications including weather surveillance, interleaved weather and aviation surveillance, interferometry techniques, numerical weather prediction, and calibration and sidelobe reduction. These experiments are supported by collaborations between the National Severe Storms Laboratory, the University of Oklahoma Cooperative Institute for Mesoscale Meteorological Studies and School of Meteorology, and Office of Naval Research. Note that VCP details are in a separate Excel file (NWRTScans2008.xls); cited references are located at the end of this document. An overview of each experiment follows.

a. PAR Temporal Sampling Sensitivity (PARTSS) Experiment
Lead: Pam Heinselman

Motivation
Severe and hazardous weather can easily develop within minutes, and such events are difficult to adequately monitor using the current WSR-88D Network. It has been demonstrated that the PAR can provide improved temporal sampling compared to NEXRAD (Yu et al. 2006; Zrnic et al. 2007; Heinselman et al. 2008); however, it remains to develop an optimal scanning strategy under various weather scenarios or even to establish what is meant by "optimal" for such a versatile platform as the PAR.

The primary purpose of this study is to investigate how volumetric sampling near one-min impacts the diagnosis of severe storm precursors and weather detection algorithms.

Goals

- Investigate the impact of temporal sampling on diagnosis of severe storm precursors and severe storm warning process during HWT operations (1–9 pm Monday–Friday)
- Analyze the impact of temporal sampling on severe weather detection algorithms
- Explore the sensitivity of severe weather detection performance to data accuracy
- Compare storm evolution depicted by PAR to that depicted by the WSR-88D and TDWR

Table 1. PARTSS logistics summary.

Data collection period	14 April – 15 June 2008 Focused on forecaster evaluation period 28 April – 06 June 2007 1 pm to 9 pm Monday–Thursday
Target storm types & Domain	Severe storms within 150 km of NWRT PAR. Minimum of one data collection on hail storms, microbursts, straight-line wind events, and tornadic storms.

VCPs	VCP 12 scan strategy that revisits the 0.5° tilt every 25 seconds. Total scan time is 66 seconds.
Data Type	I/Q and Moment Data; Collect in 10 scan chunks
Location	The experiment will be run from the Hazardous Weather Testbed (HWT) when visiting forecasters are here. Otherwise it may be run from either the HWT or the Radar Development Lab.

b. MPAR Demonstration
Lead: Doug Forsyth

Motivation
The current weather surveillance network began operation in 1990 and by 2020 the WSR-88D radar and most of the nation's aircraft surveillance radars will be nearing the end of their design life. Important decisions on replacing, repairing, and upgrading these assets are in the early stages of being made. One of the radar technologies identified for possibly replacing the outdated models is the Multifunction Phased Array Radar (MPAR). The costs of utilizing the new generation radars proposed to replace the outdated radars are significant and the participating federal agencies have not yet made a business decision about whether the costs justify the benefits. Several areas of research and development need to be explored to determine if the MPAR could contribute to the DHS mission.

Goal

- **Simultaneous Weather and Aircraft Surveillance**. A demonstration will be performed using the NWRT to show the phased array radars ability to simultaneously perform weather and aircraft surveillance.

Table 2. MPAR logistics summary.

Data collection period	Spring and summer 2008.
Target storm types & Domain	Convective storms in close proximity of Will Rogers World Airport
VCPs	Interleaved aviation and weather surveillance.
Data Type	I/Q
Location	The experiment will be run from the Hazardous Weather Testbed (HWT) when visiting forecasters are here. Otherwise it may be run from either the HWT or the Radar Development Lab.

c. Meteorological Studies with the Phased Array Weather Radar and Data Assimilation Using the Ensemble Kalman Filter
Lead: Tian-You Yu

Motivation
The long-term goal of this project is to integrate two state-of-the-art technologies, the phased array weather radar (PAR) and the emerging Ensemble Kalman Filter (EnKF) data assimilation method, to optimize the radar performance and improve coastal and marine numerical weather prediction (NWP). This project leverages on the new PAR in Norman, Oklahoma to exploit phased array technology and its applications to improve NWP through EnKF data assimilation with the goal of improving environmental characterization and forecasts to optimize naval operation.

Goals
This project will further enhance the existing collaboration among ONR, National Serve Storms Laboratory (NSSL), and the University of Oklahoma (OU) to achieve the following specific research objectives:

- develop an EnKF framework for optimally assimilating quantitative observations of the atmosphere including the PAR data,
- design a sophisticated radar emulator which will be used to validate innovative processing techniques developed in the project and to design accurate and efficient forward observation operators for assimilating PAR data,
- advance phased array radar technology through the development of novel signal processing techniques and integration of current state-of-the-art technologies to provide high-quality and high-resolution weather measurements, and
- evaluate the impact of scanning strategies including SPY-1 tactical and non-tactical waveforms on data assimilation and NWP using the Observing System Simulation Experiments (OSSE) and Observing System Experiments (OSE).

Optimal scanning strategies of PAR for NWP model initialization will be developed and tested. From OSSE, several scanning strategies based on angular oversampling have been developed and tested. The proposal data collection is important and can be used to further verify these OSSE results.

Table 5. Logistics summary.

Data collection period	1 March to 31 May 2008
Target storm types & Domain	Supecells, multicell storms, bow echo, and squall lines. Storms within the CASA network (complementary to CASA Spring Data collection, and Refractivity project). Ideally, we have data from CASA and PAR at the same time (should involve Jerry Brotzge in the coordination).
VCPs	Overlapped high-resolution vertical sampling with 2 min updates
Data type	I/Q
Location	Hazardous Weather Testbed

e. Spaced Antenna Interferometry Experiment
Leads: Dick Doviak and Guifu Zhang

Motivation
Vector wind, shear and turbulence are important in quantifying and forecasting weather. Wind can be measured either by Doppler or interferometry techniques (Doviak and Zrnic 1993; Briggs et al. 1950). Weather radars such as WSR-88D measure only the Doppler velocity (i.e., the radial component of wind). But a Spaced Antenna (SA) interferometer also measures the crossbeam wind components (i.e., the component parallel to the baseline connecting two receivers), shear, and turbulence as well as the along beam wind component obtained from the mean Doppler (Doviak et al. 1996).

As documented in our recent papers (Zhang and Doviak 2007), spaced antenna interferometry (SAI) allows the NWRT to do many weather measurements that normal weather radars cannot. They are: 1) crossbeam wind measurement, 2) shear detection, 3) turbulence, 4) detection/location of individual targets, and 5) sensing the inhomogeneity of reflectivity field within radar resolution. With the switch receiver that NSSL has built, we alternatively receive signals from the sum and one of the differences (elevation or azimuth) channels to perform the interferometry measurements.

Goals
- Make shear measurements with elevation SAI
- Make crossbeam wind measurement with azimuth SAI

Table 3. ASI logistics summary.

Data collection period	1 January to 31 December 2008
Target storm types & Domain	Stratiform rain region in the north (dual-Doppler lobe formed by KOUN & KTLX) or south over the Kessler farm (where NOAA wind profiler is located). These locations are defined as azimuth Â.
VCPs	A) Shear and turbulence measurements with elevation SAI: a. Fix azimuth angle, point beam at each direction for 20 seconds and change elevation angle from 1.0 to 16 degrees, in steps of 1 degree. Repeat at least once. b. Before and after each experiment perform a sector scan of plus minus 45^{o} in azimuth at each elevation angle using only sum channel and normal data acquisition mode. B) Crossbeam wind measurement with the azimuth SAI: (elevation angle fixed at 0.5, 1.5, 2.5, and 3.5) a. SA measurement at azimuth Â for 20 seconds. b. DBS measurement: sum beam at Â±0.5, Â±1.0, Â±2.0, Â±4.0 and Â±8.0 degree around the SA beam for 10 seconds each. c. Repeat a and b at least once.

	d. Before and after each experiment perform a sector scan of $\pm 45^{o}$ in azimuth at each elevation angle using sum channel and normal data acquisition mode.
Location	Radar Development Lab

e. Multi-pattern Measurements for Calibration and Sidelobe Reduction with the NWRT
Leads: Guifu Zhang and Dick Doviak

Motivation
One unique feature of the NWRT is its dual-scan (mechanical and electrical) capability. This capability has not been explored yet. Sidelobes of the NWRT's radiation pattern, with the main lobe electronically pointed +/- 45 degrees from broadside, is different from that when the beam is steered to broadside. That is, the sidelobe amplitude and phase change as the beam is electronically steered. Therefore, the interference from echoes received through sidelobes will be not as coherent as the echoes received through the mainlobe (after calibration for the different electronic steering directions relative to the broadside). In other words, echoes received through sidelobes will be noisy when the antenna steers at different electronic directions.

Goals
By jointly processing the data recorded for different electronic directions (corresponding to different antenna patterns), we should be able to:

- Calibrate the power
- Distinguish the echoes received through the mainlobe and sidelobes

Table 4. CSR logistics summary.

Data collection period	1 January to 31 December 2008
Target storm types & Domain	Clear day or isolated storm
VCPs	TBD
Location	Radar Development Lab

References

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