8B.2 The NATIONAL WEATHER RADAR TESTBED (PHASED-ARRAY) – A Progress Report

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1. INTRODUCTION

We have finished our fourth year of testing of a new research radar called the National Weather Radar Testbed (NWRT). Located in Norman, OK, this 10-cm phased array radar is designed for use in studying and developing a multifunction radar with the capability to perform aircraft tracking, wind profiling and weather detection at the same time (Zrnic, 2007). We have reported on the progress of the NWRT at several Interactive Information Processing Systems (IIPS) conferences, (Forsyth, 2002, 2003, 2005, 2006, 2007, 2008). The NWRT was developed by a government/university/ industry team represented by the co-authors plus the Oklahoma State Regents for Higher Education. The NWRT has been collecting data since May 2004 and several data sets have been collected during the 2008 storm season. Current efforts continue to concentrate on analysis of recently gathered fast scan data, improved signal processing and investigating changes to algorithms in order to run on fast scan data. In this paper, we will describe the present status and research progress, and plans.

2. CURRENT STATUS

Since 2004, the NWRT has been in a research mode for collecting various experiments to demonstrate the advantages of using a phased array weather radar. In order to improve the data quality of the NWRT, several upgrades were made and released in March 2008, just in time for the 2008 storm season in central Oklahoma. Changes included improved Digital Signal Processor (DSP) functionality including 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. The infrastructure improvements included using multiple DSPs, load balancing between processors, a scalable design and self-descriptive messages for platform-independent data handling. We also improved our capacity to record time-series and moment data and to playback archived data.

With these new improvements, a new set of experiments were executed for the Spring 2008 season. A list of these experiments follow: (Heinselman, 2009)

a. PAR Temporal Sampling Sensitivity (PARTSS) 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. Multi-pattern measurements for calibration and sidelobe reduction with the NWRT.

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3. DATA COLLECTION (JAN 08 – DEC 08)

Date	Collection Type	Moment Archived	IQ	Weather / Comments
3/02/08	Thunderstorms	NetCDF		TVS, H, W
3/06/08	Refractivity			
3/07/08	Testing			Ground Clutter
3/10/08	Testing			OU new Receiver
3/15/08	Testing	NetCDF		Ground Clutter
3/17/08	Thunderstorms	NetCDF	51.6 Gbs	Data for Lincoln Labs
3/18/08	Thunderstorms		104.2 Gbs	H, W
3/30/08	Thunderstorms		129 Gbs	
3/31/08	Thunderstorms		96 Gbs	H = Baseball
4/07/08	Thunderstorms		162 Gbs	Supercell
4/10/08	Thunderstorms		259 Gbs	Tornadoes
4/16/08 21:07-21.33	Spring Ops Training	236 Mbs	7.4 Gbs	Thunderstorms NW
4/17/08 21:10-23:53	Cold Front	4.0 Gbs	89 Gbs	No Svr Storms CASA Comparison
4/22/08 00:37-02:00	Refractivity, Dry line	1.3 Gbs	46 Gbs	Thunderstorms SW
4/23/08 12:28-	Thunderstorms	8.2 Gbs		H=1.75"

00:11				
5/01/08 23:11- 08:15	Refractivity & Thunderstorms	5.7 Gbs	196 Gbs	H = 3.5” High winds
5/05/08 21:45- 21:55	Refractivity	252 Mbs	9.2 Gbs	
5/06/08 04:45- 06:29	Thunderstorms	823 Mbs	26 Gbs	Small Hail W=60mph
5/07/08 09:11- 10:37	Thunderstorms	7.8 Gbs	177 Gbs	T, H=1” W=75mph
5/08/08 09:11- 09:27	Thunderstorms		32 Gbs	CASA Comparison DOD Epscor
5/10/08 22:45- 00:22	Thunderstorms	1.8 Gbs	54 Gbs	TVS H=1”
5/13/08 22:07- 01:23	Thunderstorms	3.3 Gbs	105 Gbs	Super Cells H=2”
5/22/08 22:53- 05:36	Thunderstorms		191 Gbs	TVS H-2.75’
5/24/08 19:17- 23:57	Thunderstorms	4.3 Gbs	135 Gbs	TVS
5/25/08 00:03- 06:00	Thunderstorms	2.6 Gbs	80 Gbs	Squall Line
5/26/08 04:10- 06:18	Thunderstorms	2.2 Gbs	69 Gbs	Strong Sheer W=42mph
5/27/08 01:45- 23:15	Thunderstorms	5.0Gbs	240 Gbs	MCS, H= 4.75” W OK, H=2” C OK W=80mph
6/01/08 14:05- 16:23	Thunderstorms	5.2 Gbs	69 Gbs	Supercell
6/03/08 22:50- 23:32	Testing	2.0 Gbs	22 Gbs	
6/05/08 18:29- 23:53	Thunderstorms	9.0 Gbs	299 Gbs	H=1.75” W=75mph
6/06/08 00:04- 19:29	Thunderstorms	1.4 Gbs	50 Gbs	TVS, H = 1.75” W=80mph
6/09/08 00:37- 08:55	Thunderstorms	2.2 Gbs	229 Gbs	W=65mph
6/13/08 18:37- 06:46	Thunderstorms	6.7 Gbs	248 Gbs	
6/16/08 03:45- 01:18	Thunderstorms	3.6 Gbs	262 Gbs	Tornado – Hobart, H = 2.75”
6/18/08 11:52- 14:42	Thunderstorms		85 Gbs	Severe
6/28/08 21:02- 01:18	Testing		5.4 Gbs	
7/12/08 20:58- 23:51	Thunderstorm		99 Gbs	
08/07/08 21:42- 21:58	Microburst		9.8 Gbs	
08/09/08 21:22- 00:54	Microburst		105 Gbs	
08/15/08 00:12- 02:27	Microburst		63 Gbs	
08/29/08 21:40- 00:59	Microburst		100 Gbs	
10/6/08 17:45- 23:00	Thunderstorms		193 Gbs	No rotation H=1.25”
10/14/08 19:00- 21:00	Testing			Multi-Channel Receivers - Yeary
11/05/08 21:00- 22:00	Thunderstorms		68 Gbs	
11/10/08	Transverse Wind			
12/09/08 03:45- 06:00	Thunderstorms		74 Gbs	TVS, H, W=60mph
12/09/08 21:00- 22:00	Winter		5.3 Gbs	
12/27/08 04:00- 16:00	Thunderstorms		119 Gbs	Strong Cold Front, High Winds

Table 1. Summary of Data Collection for 2008. Moment data (Reflectivity, Mean Velocity, and Spectrum Width). I/Q data are raw data collected before moments are calculated. (CASA = Collaborative Adaptive Sensing of the Atmosphere, DOD = Department of Defense, EPSCoR = Experimental Program to Stimulate Competitive Research, Gbs = giga-bytes, Mbs = Mega-bytes, H = Hail, MCS = Mesoscale Convective System, mph = Miles per hour, NetCDF = Network Common Data Form, TVS = Tornadic Vortex Signature, W = Wind)

4. 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.

We have continued our study of adaptive scanning and prepared the NWRT software to handle commands issued by other analysis algorithm software.

Collaborations have continued with the University of Oklahoma on several fronts including the building of the multi-channel receiver suite for the NWRT that is funded by the National Science Foundation (Yeary, 2009). We are also collaborating on a wind farm mitigation study using phased arrays (Palmer, 2009) along with the interferometry experiments (Zhang, 2007).

The Uninterruptible Power Source (UPS) for the NWRT ran into some funding and contract problems this last year, but we are again trying to accomplish this important upgrade.

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 1).

Additional Digital Signal Processor (DSP) upgrades are ongoing and include 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). The NWRT will also add a range, noise and DC bias calibration. The system will be 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.)

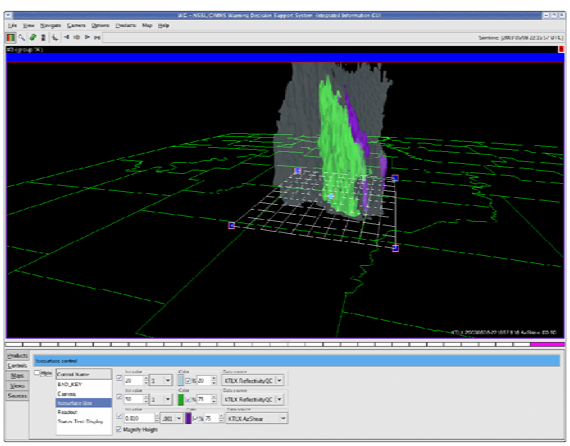

Figure 1. WDSS-II 3D Iso-surface of reflectivity core (green) and mesocyclone vortex (purple)

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