12R.3 THE NATIONAL WEATHER RADAR TESTBED (PHASED-ARRAY)

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1. INTRODUCTION

A new national asset for weather radar research is now operational in Norman, Oklahoma. The National Weather Radar Testbed (NWRT) is a 10-cm phased array radar for use in studying and developing faster and more accurate warning, analysis and forecast techniques for severe and hazardous weather and testing multifunction capabilities such as aircraft tracking, wind profiling and weather detection at the same time. As reported at several Interactive Information Processing Systems (IIPS) conferences, (Forsyth, 2002, 2003, 2005), the NWRT was developed by a government/university/ industry team consisting of the National Oceanic and Atmospheric Administration's National Severe Storms Laboratory (NSSL), the Tri-Agencies' (Department of Commerce, Defense & Transportation) Radar Operations Center (ROC), the United States Navy's Office of Naval Research, Lockheed Martin Corporation, the University of Oklahoma's Electrical and Computer Engineering Department and School of Meteorology, the Oklahoma State Regents for Higher Education, the Federal Aviation Administration's William J. Hughes Technical Center and Basic Commerce and Industries, Inc.. The NWRT uses a converted Navy SPY-1A phased array antenna system, thus providing the first phased array radar available on a full-time basis to the meteorological research community. The NWRT became operational in September 2003, but problems with the velocity channel delayed initial data collection until May 2004. Our initial efforts have focused on ensuring that the data is of high quality. Qualitative comparisons with a WSR-88D (KTLX-Twin Lakes, OK) appear to be similar. In this paper, we will describe the system, data quality improvements, recent upgrades, and future plans.

2. SYSTEM OVERVIEW

The components of the National Weather Radar Testbed (NWRT) include the SPY-1A antenna and Antenna Position Programmer (APP), Enclosure, Pedestal and Radome, a WSR-88D transmitter modified to transmit at 3.2 GHz, an Environmental Processor (EP) (Digital Receiver/Signal Processor), and Real-Time Controller (RTC). See Figure 1.

The antenna is a passive array comprised of 4,352 elements with a beam width of 1.5 degrees at the center and 2.1 degrees at +/- 45 degrees from the center of the array. The antenna is tilted 10 degrees in elevation and the center of the array is located 40 feet above ground level. The antenna is mounted on a pedestal capable of rotating the antenna at 18 degrees per second. A 90 degree sector can be scanned in azimuth without moving the pedestal. Elevation scans are accomplished using electronic scanning.

The wavelength is 9.375 cm with a minimum Pulse Repetition Time (PRT) of 800 microseconds. The system has both long and short pulse modes, 4.71 microseconds and 1.57 microseconds, respectively. The sensitivity defined with a SNR=0 dBl is 5.89 dBZ at 50 kilometers.

The EP is comprised of an Ultra SPARC as the host for five SKYbolt II modules each with four Power PC G4 processors. It contains a CD, fixed and removable hard drives along with a Ciprico RAID with 648 Gigabytes of storage. A second EP consists of two SKYbolt II modules and is used for development and I/Q recording.

Figure 1. National Weather Radar Testbed (NWRT) Equipment

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3. DATA QUALITY

When the NWRT began operational testing in September 2003, data quality issues in the velocity channel were identified. Upon closer investigation, the problems were isolated to two areas. One was with the filters for the digital receiver and the other was a hardware characteristic in the SPY 1-A antenna system discovered because of our unique use (weather vs. missiles/aircraft detection). Both of these problems were corrected in time for our data collection of the tornadic storm on May 29, 2004. Team members also solved a couple of additional data quality issues that included beam broadening and a six degree phase error every eighth pulse. The six degree phase error was related to keeping the antenna phase shifters too cool (they like to run at approximately 40 degrees Celsius). Improved temperature regulators were added by Lockheed Martin. An APP failure was also corrected. Since, February 20th, 2005, the NWRT has been very reliable and providing high quality data.

hours as it produced several tornadoes during its lifetime.

Given all the possible differences, the NWRT compares very well with KTLX (i.e. location, reflectivity and velocity pattern, velocity values) and provided the first phased array data to be collected on a tornadic storm.

Comparison of radar data has continued with adjustments to the radar parameters to reduce the number of possible differences. Although the 2005 storm season was relatively quiet, data was collected in March, April, May and June using Volume Coverage Patterns matched closely to the Twin Lakes WSR-88D.

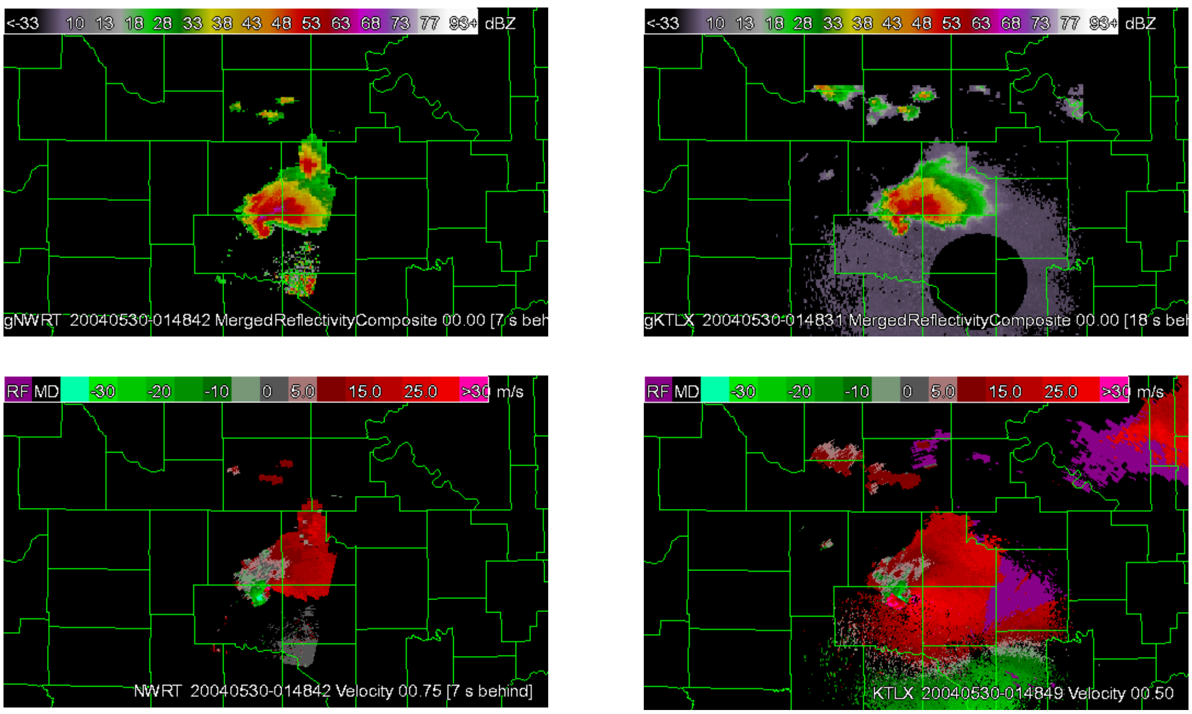

Figure 2. Reflectivity and Velocity Comparison between NWRT (left) and KTLX (right).

After the correction of several velocity channel problems described earlier, an opportunity arose to collect storm data with the NWRT on May 29, 2004. Since the radar does not yet perform range unfolding, we waited for the storms to approach within the first trip before turning on the radar. By 1800 CDT, the tornadic storm was just developing and data were collected on this storm. The array was centered on the storm and then several 90 degree scans were completed electronically. Figure 2. is a comparison of the KTLX data and NWRT data collected at the same time. The storm was tracked for the next several

4. UPGRADES COMPLETED

As a result of funding from the FAA and cost savings in the program, several upgrades to the system have been completed. A backup generator was added to support all equipment in the Radar Facility and the Testbed Control Center. In addition, the limited rotation capability (Forsyth 2002) was replaced with a continuous rotation capability with rotation speeds of up to 18 degrees per second. Also converted was the display system to NSSL's Warning Decision Support

System-II (WDSS-II, Hondl 2002) for subjective comparison of the NWRT with other local radars.

6. FUTURE UPGRADES

A number of modifications to enhance the capability of the radar continue to be studied. The team has started looking at beam multiplexing to increase the speed of our volumetric scans and an adaptive scan capability where the radar algorithms will modify the volume scan strategy in real-time to more frequently revisit areas of highest interest, such as a rapidly developing storm formation. The team is also working on remote control capabilities in order to operate the NWRT from any location on the internet. This capability is needed before NSSL's move to their new facility in April 2006. In order to handle split-cuts, the team is working on radial by radial processing and display vs. the volume processing currently used. The team is in the process of looking at PC distributed processing to handle the Environmental Processing. In addition, the team is looking at adding a transmitter capable of providing dual frequency coded waveforms. Other multi-use applications of the system for wind profiling, aircraft tracking and plume profiling are being explored. The FAA has started working on the aircraft tracking capability and will begin testing in September 2005. Dual polarization capability is another upgrade that will be pursued.

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