19.5 PROGRESS REPORT ON 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. As reported at previous Interactive Information Processing Systems (IIPS) conferences, Forsyth, (2002, 2003), the NWRT was developed by a government/university/ industry team consisting of the National Oceanic and Atmospheric Administration's National Severe Storms Laboratory, 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 Engineering Department and School of Meteorology, the Oklahoma State Regents for Higher Education, and the Federal Aviation Administration's William J. Hughes Technical Center. The NWRT uses a converted Navy SPY-1 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 data quality improvements, recent upgrades, future plans and present some examples of the first tornadic data set obtained with this new national facility.

2. SYSTEM OVERVIEW

The components of the National Weather Radar Testbed (NWRT) include the SPY-1A antenna and beam programmer, 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).

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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 the minimum Pulse Repetition Time (PRT) is 800 microseconds. The system has both a long and short pulse mode, 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.

3. DATA QUALITY

When the NWRT began operational testing in September 2003, data quality issues in the velocity channel were identified. Upon closer investigations, 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. missle/aircraft detection). Both of these problems were corrected in time for our data collection of the tornadic storm on May 29, 2004. At this writing, team members are still investigating a couple of data quality issues that include some beam broadening and a six degree phase error every eighth pulse. Further investigation has determined that the six degree phase error is related to the antenna temperature and is being addressed by Lockheed Martin to implement a fix.

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.

5. TORNADIC STORM DATA COLLECTION

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 1. is a comparison of the KTLX data and NWRT data collected at the same time. The storm was tracked for the next several hours as it produced several tornadoes during its lifetime. Since that time, using software developed to compare adjacent radars, an objective comparison between KTLX and the NWRT was completed. See Figure 1. As expected when comparing two radars, several differences can be contributed to multiple causes, some that can be corrected and some that cannot because of the inherent differences in the two radar's characteristics. Possible sources of difference include:

1. Data collected at slightly different times and accuracy of times.
2. Different Radar locations.
3. Ground Clutter
4. Second Trip echoes.
5. Polarization (Horizontal (KTLX) vs. Vertical (NWRT)).
6. Range resolutions (1km (KTLX) vs. 244m (NWRT))
7. Sensitivity (-10 dBZ (KTLX) vs. 5.89 dBZ (NWRT))
8. Calibration errors
9. Different Beam Widths
10. Different Elevation Angles
11. Different PRT (Dwells).

Given all the possible differences, the NWRT compares very well with KTLX and provided the first phased array data to be collected on a tornadic storm.

Comparison of radar data will continue with adjustments to the radar parameters to reduce the number of possible differences.

6. FUTURE UPGRADES

A number of modifications to enhance the capability of the radar continue to be studied. Future plans include 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. 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 February 2005. Dual polarization capability is another upgrade that will be pursued.

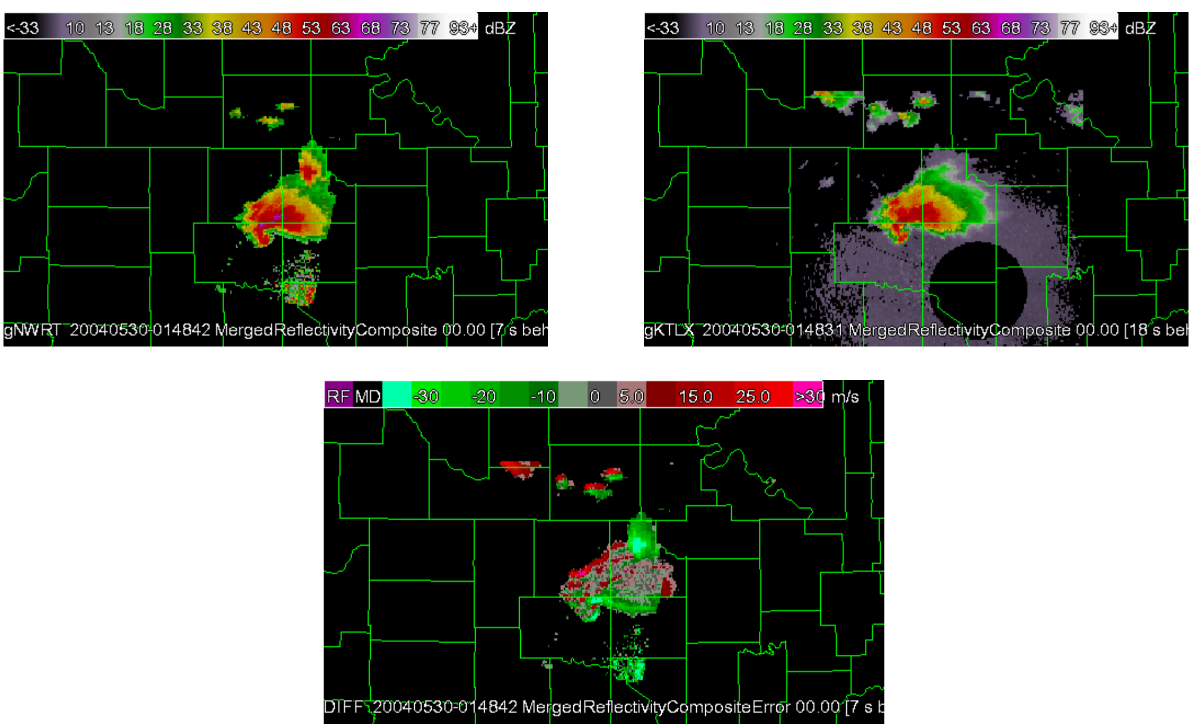

Figure 1 Reflectivity Comparison between NWRT (upper left) and KTLX (upper right). Difference field is bottom display of reflectivity values above 20 dbZ.

7. ACKNOWLEDGMENTS

We acknowledge the support of our various organizations in funding and helping to implement this national facility. We especially acknowledge the dedicated work of Bob Staples, Mark Benner, Chris Curtis, and Wayne Sabin, Tim Maese, Jim Melody, Paul Baumgarder, Tim Hughes, John Petree and Mark Campbell for their work on improving the data quality. A special thank you to Mike Schmidt, Richard Wahkinney, and the ROC radar folks lead by B. Ballard for their work on the transmitter. We are especially thankful to Rick Adams and John Thompson who got the system back on line after a computer failure on May 29, 2004 that allowed the data collection on the Tornadic storm. Thanks to Kurt Hondl and Rick Adams for preparing the data and producing the comparisons of the May 29th tornadic data.

8. REFERENCES

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