6B.1 NEXRAD PRODUCT IMPROVEMENT – UPDATE 2008

Robert E. Saffle*
Noblis, Inc., Falls Church, VA

Michael J. Istok
National Weather Service, Office of Science and Technology, Silver Spring, MD

Greg Cate
National Weather Service, Office of Science and Technology, Silver Spring, MD

1. INTRODUCTION

The Departments of Commerce (National Weather Service), Defense (Air Force Weather Agency), and Transportation (Federal Aviation Administration) initiated the Next Generation Weather Radar (NEXRAD) program to upgrade the weather radar mission support capabilities required by the three agencies. Under NEXRAD, 158 radars, termed the Weather Surveillance Radar-1988 Doppler (WSR-88D), have been installed at operational locations in the United States and selected overseas sites. The NEXRAD tri-agencies established the NEXRAD Product Improvement (NPI) Program in 1996 as a long-term activity to steadily improve WSR-88D science and technology [1]. The NPI program has completed the replacement of the Radar Product Generation (ORPG) and the Radar Data Acquisition (ORDA) subsystems with open system hardware and software. These system upgrades enable the operational implementation of new scientific applications, and signal processing techniques to improve the radar data quality and spatial resolution. Further, the NPI program has begun the implementation of Dual Polarization (DP), and the integration of weather data from several FAA radar systems into NWS operations.

As the reference to FAA data usage indicates, the term NEXRAD has come to encompass all efforts to bring 'next generation' weather radar capabilities to operational use, and NPI is the programmatic vehicle to manage such efforts. WSR-88D improvements comprise only part of the potential projects under an ongoing NEXRAD concept. The NOAA/NWS has formed a Joint Radar Planning Team (JRPT) to help define a 20-year vision for weather radar support to operations, and a 'road map' for logical steps to achieve that vision. The JRPT effort enables NOAA/NWS to better set priorities and plan funding for potential new capabilities such as long range surveillance Phased Array Radar systems and low power short wavelength radar systems to better sample the boundary layer.

This paper is one of a continuing series, and is intended to bring the IIPS community up to date on the status of NPI ongoing projects, plans for WSR-88D enhancements and NWS activities in the use and development of other weather radar systems.

* Corresponding author address: Robert Saffle, Noblis Inc., 1325 East West Highway, Silver Spring, MD, 20910 (robert.saffle@noaa.gov)
The views expressed are those of the author(s) and do not necessarily represent those of the National Weather Service.

2. CURRENT PROJECTS

2.1 Science Implementation

The NEXRAD agencies continue to develop and deploy new and enhanced scientific algorithms on the ORPG, and have extended this activity to the ORDA. A general, high level planning schedule of anticipated enhancements through CY 2012 is presented in Section 5.

2.2 Signal Processing

The ORDA project [2] consisted of the procurement of commercial components to replace the existing RDA Status and Control (RDASC) components, the Signal Processing components, and the analog receiver. The ORDA includes a modern digital signal processor (DSP) and a digital receiver. The ORDA deployment was completed in Oct 2006.

ORDA enables improvements in data spatial resolution, clutter rejection, and range/velocity ambiguity mitigation. It also provides the foundation for the addition of Dual Polarization to the WSR-88D. The first major science enhancement to take advantage of ORDA will be the implementation of a Sachidananda-Zrnic range ambiguity mitigation technique (termed SZ-2) for the lower elevation angles of the WSR-88D Volume Coverage Patterns. SZ-2 was deployed with the WSR-88D software update (Build 9) in spring 2007.

A major data spatial resolution improvement will be deployed in 2008 (WSR-88D Build 10) for the lower, split-cut elevation angles. Termed Super Resolution (SR), this signal processing application will improve base data resolution to ¼ km by ½ degree for all moments, compared to today's 1 km by 1 degree for reflectivity and ¼ km by 1 degree for Doppler. Included with the SR deployment will be an extension of Doppler processing range to 300 km from today's 230 km. The higher resolution, and extended range, data will be included in the Level II central collection and distribution as NOAA/NWS communications upgrades are implemented at each WFO (planned to be roughly coincident with Build 10 deployment).

2.3 Dual Polarization

Based on the National Severe Storms Laboratory (NSSL) successful demonstration of the operational utility of polarimetric data from its WSR-88D [3, 6], the NEXRAD agencies have approved an acquisition program to deploy dual polarization (DP) capability to all WSR-88D units. L3 Titan, with radar engineering support from Baron Services, was selected in Sep 2007 as the main contractor to develop, produce and deploy the DP upgrades. Deployment is anticipated for 2009-2012. Initial products to be available with DP are listed in Section 5, below.

2.4 FAA Radar Data

The FAA operates four radar systems that include channels with capabilities for processing and distributing weather data. These systems are the Terminal Doppler Weather Radar (TDWR), the Airport Surveillance Radar, Models 9 and 11 (ASR-9, ASR-11), and the Air Route Surveillance Radar, Model 4 (ARSR-4). The NWS has been incorporating FAA data from selected FAA ASR-11 and ARSR-4 sites in a prototype mode for the past several years [4, 7], and has conducted limited operational deployment of TDWR ingest systems for 11 TDWR sites [5, 8]. The TDWR systems utilize a Supplemental Product Generator (SPG), based on the WSR-88D Radar Product Generator, to ingest TDWR data and prepare base and derived products (Figures 8, 9, 10, 11) in the same format as WSR-88D base products. The TDWR data have provided valuable, even critical in some cases, information for numerous tornadic events. The NWS will deploy SPG to the rest of the 45 TDWR sites in 2008. The SPG architecture will also be used for operational use of ASR and ARSR-4 radars.

3. OPERATIONAL ENHANCEMENTS IN 2007

- Deployed the Sachidananda-Zrnic (SZ-2) technique for the lower, split cut elevation scans to recover Doppler data from range folded areas (Figure 1).
- Deployed the FAA Machine Intelligent Gust Front Algorithm (MIGFA) for gust front and other boundaries detection.
- Began using the improved mesocyclone algorithm output for Combined Attribute Tables, Radar Coded Message, and automatic alerting.
- Replaced the RPG workstations with PC-Linux systems to provide processing power for science implementations in 2007 and beyond.
- Full spatial resolution products for TDWR base products.
- VAD Wind Profile implemented for TDWR data.
- User Defined Composite Reflectivity Layer product for TDWR data.
- Ingest of RUC model data from AWIPS into the RPG for the radar coverage volume.

4. PREVIOUS OPERATIONAL ENHANCEMENTS

4.1 WSR-88D & FAA Data 2002-2006

- 256 data level products for reflectivity, velocity, Digital Storm Total Precipitation, Vertically Integrated Liquid Water and Echo Tops,
- User defined Composite Reflectivity layers,
- Quality-controlled velocity arrays for NCEP models,
- Update of Mesocyclone and Tornado Detection algorithm output every elevation cut,
- Enhanced Mesocyclone Detection algorithm,
- Improvements in automatic mitigation of AP to improve rainfall estimations,
- VCP 12, faster (4.1 min) and with more low level angles for better vertical resolution at long ranges,
- VCP 121, multiple scans with different PRFs at low level angles to mitigate range and velocity folding,
- Snow Accumulation and Liquid Water Equivalents,
- High speed distribution of radar products to surrounding WFOs to support warning operations,
- SPG deployment for 10 FAA TDWR sites,
- Prototype use of FAA ASR-11 data in Erie, PA, and ARSR-4 data in Williston, ND. Test operations in these locations indicate good capability of the FAA units to detect general snow and Lake Effect Snow.
- Filtering and smoothing of input reflectivity data to improve storm cell identification and tracking.
- Completed deployment of ORDA.
- Collaborated with Lincoln Laboratory on an interim arrangement to provide data from 11 additional TDWR sites to NWS offices.

5. PLANNED ENHANCEMENTS

5.1 WSR-88D & FAA Data 2008-2012

Together, ORPG, ORDA and DP will support the implementation of a number of enhancements that will provide better data and processing capacity for new scientific algorithms. Some enhancements have already been specified, and others are in development. Also, the TDWR data support the implementation of some of the WSR-88D algorithms. The enhancements include:

- Derived products from TDWR data (Storm Cell Tracking, Meso, TVS, rainfall, VIL, ET) (Figure 10) (2008)
- Super Resolution base data (1/4 km by ½ deg) (Figures 2, 3, 4) (2008),
- Doppler processing to 300 km (2008),
- Turbulence algorithm (2008),
- Super Resolution algorithm products (Meso, TVS, rainfall) (2010).
- Improved precipitation estimation (2009),
- Classification of hydrometeor types (Figure 6) (2009),
    - Rain, hail (possibly size), snow
- Classification of non-hydrometeor reflectors (2009),

- Insects, birds, clutter/AP

- Melting Layer (Figure 7) (2009)
- Improved data quality for numerical models (2009),
- Provision of polarimetric base data, base products and derived products (Figure 5) (2009),
  - Differential Reflectivity,
  - Correlation Coefficient,
  - Specific Differential Phase,
  - Polarimetric rainfall rate
- Clutter Mitigation Decision algorithm in ORDA to better determine where to apply GMAP clutter filter(2009),
- Staggered Pulse Repetition Time to mitigate range and velocity ambiguities in higher elevation angles (2009)
  - Implemented in test mode to collect data
- Doppler processing of low angle surveillance cuts (TBD),
- Provision of spectral data for forecaster analysis, and eventual automated pattern recognition analyses (TBD),
- Oversampling and whitening to enable faster scanning and higher resolutions while maintaining accuracy (TBD),
- Provision of estimates of water vapor close to the radar via refractivity measurements (TBD),

6. SUMMARY

In summary, the NEXRAD infrastructure enhancements and dissemination of base data have combined to offer a heretofore unmatched environment for radar science development and operational implementation. The addition of Dual Polarization and data from FAA radars offers further opportunities. Developments such as PAR and boundary layer radars extend such promise well into the future.

On a cautionary note, however, it must be noted that NWS severe weather warning forecasters utilize scientific algorithm products to complement their analyses of base data products. The development community should not ignore the need to develop more efficient, effective ways to ensure a synergy between such human analysis and objective guidance.

5. REFERENCES

[1] NEXRAD Open Systems - Progress and Plans, Saffle, R., M. Istok, L. Johnson, 17th IIPS, Albuquerque, NM, January 2001, paper 3.1

[2] NEXRAD Product Improvement - Current Status of WSR-88D Open Radar Data Acquisition (ORDA) Program and Plans for the Future, Cate, G., R. Hall, M. Terry, 21st IIPS, San Diego, CA, January 2005, paper 5.2

[3] Joint Polarization Experiment (JPOLE) for the WSR-88D Radar: Plans and Progress, Schuur, T., R. Elvander, J. Simensky, R. Fulton, 18th IIPS, paper 5.15

[4] Analysis and Plans for Using FAA Radar Weather Data in the WSR-88D ORPG, Stern, A., P. Pickard, W. Blanchard, B. Bumgarner, M. Istok, 18th IIPS, paper 5.6

[5] Development of the Terminal Doppler Weather Radar Supplemental Products Generator for NWS Operations, Stern, A., M. Istok, W. Blanchard, N. Shen, 21st IIPS, paper 19.13

[6] The Joint Polarization Experiment B A Summary of Dual-Polarization WSR-88D Radar Data Collection and Analysis, T. Schuur, A. Ryzhkov, P. Heinselman, D. Burgess, K. Scharfenberg, 20th IIPS, paper 12.1

[7] NWS Use of FAA Radar Data – Status and Operational Considerations, Istok, M., J. Ferree, R. Saffle, B. Bumgarner, 32nd Radar, paper P10R.10

[8] Initial Deployment of the Terminal Doppler Weather Radar Supplemental Product Generator for NWS Operations, Istok, M., W. Blanchard, N. Shen, B. Klein, A. Stern, 22nd IIPS, paper 9.4

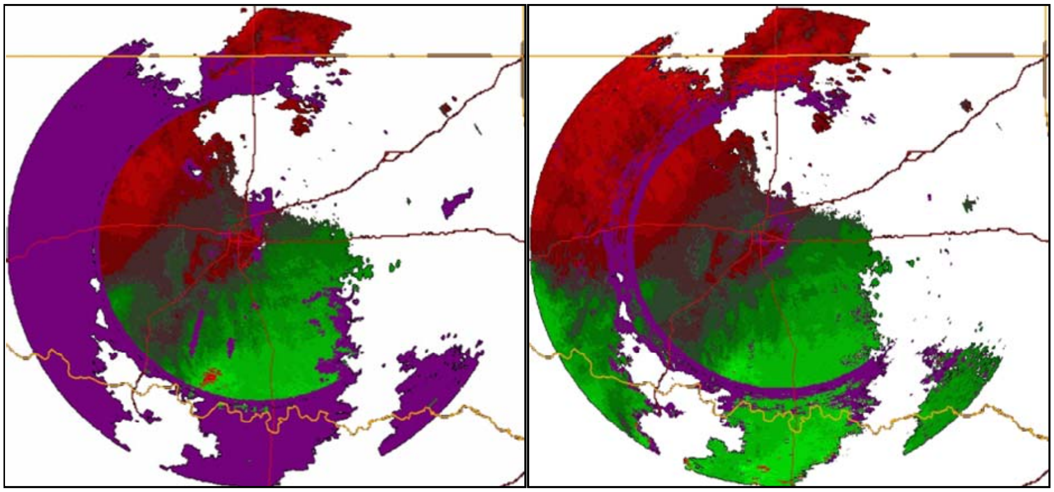


Figure 1. First operational switch to SZ-2: Velocity data: KTLX Mar 30, 2007: 1937 GMT & 1942 GMT.

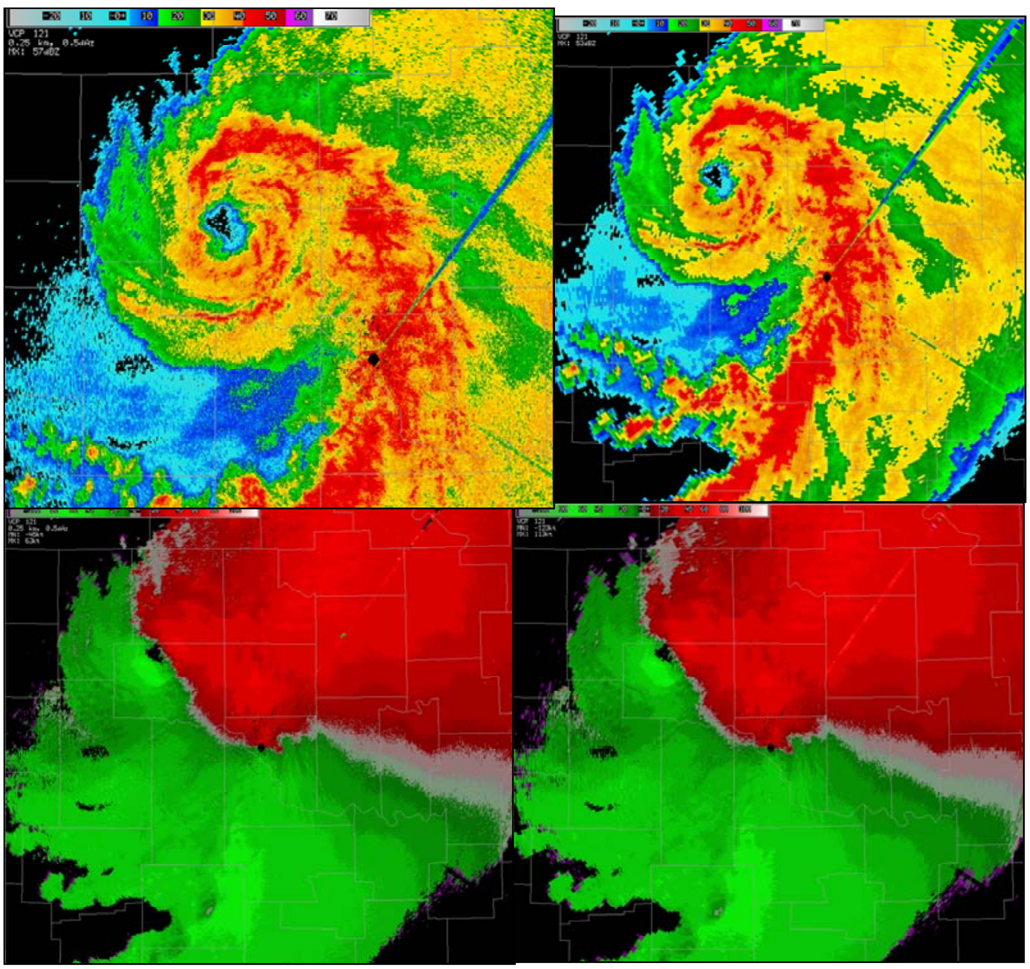


Figure 2. Erin: KCRI: Super Resolution Reflectivity & Base Velocity (left) versus current resolution.

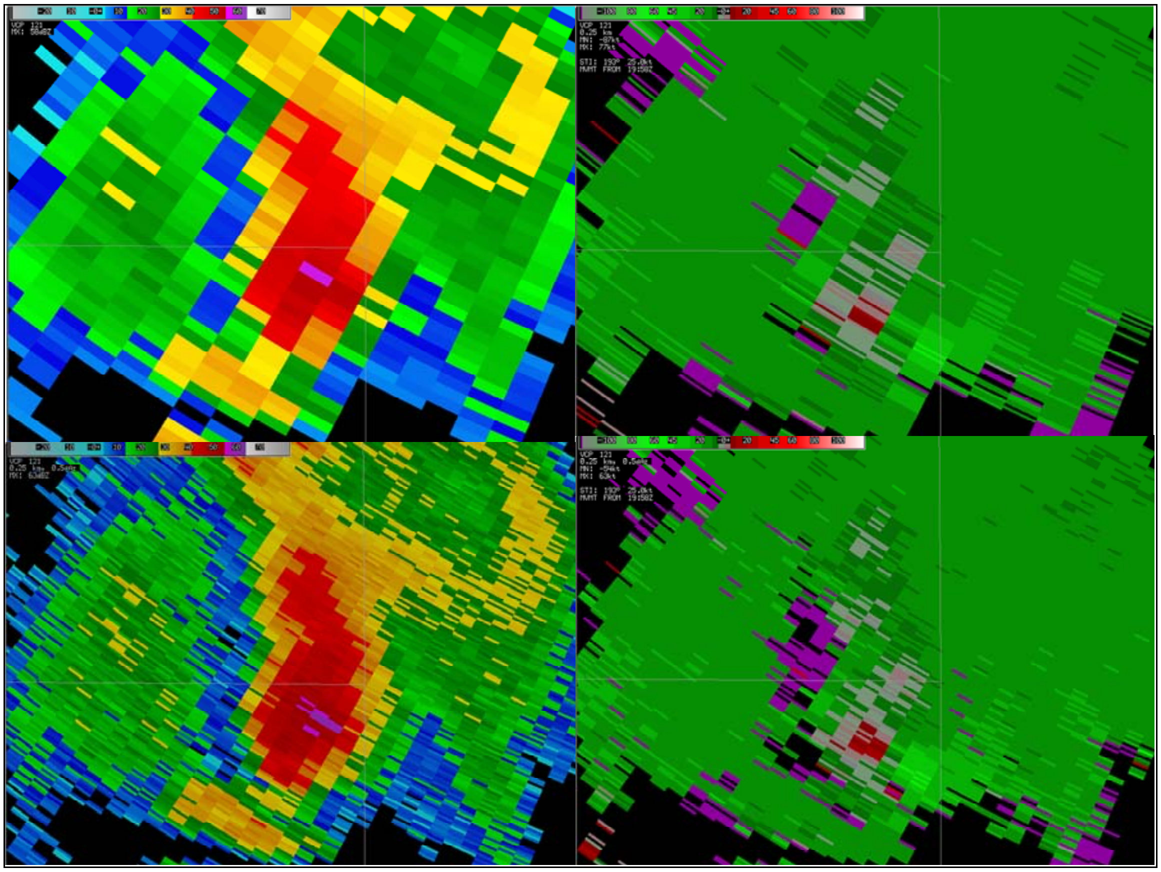
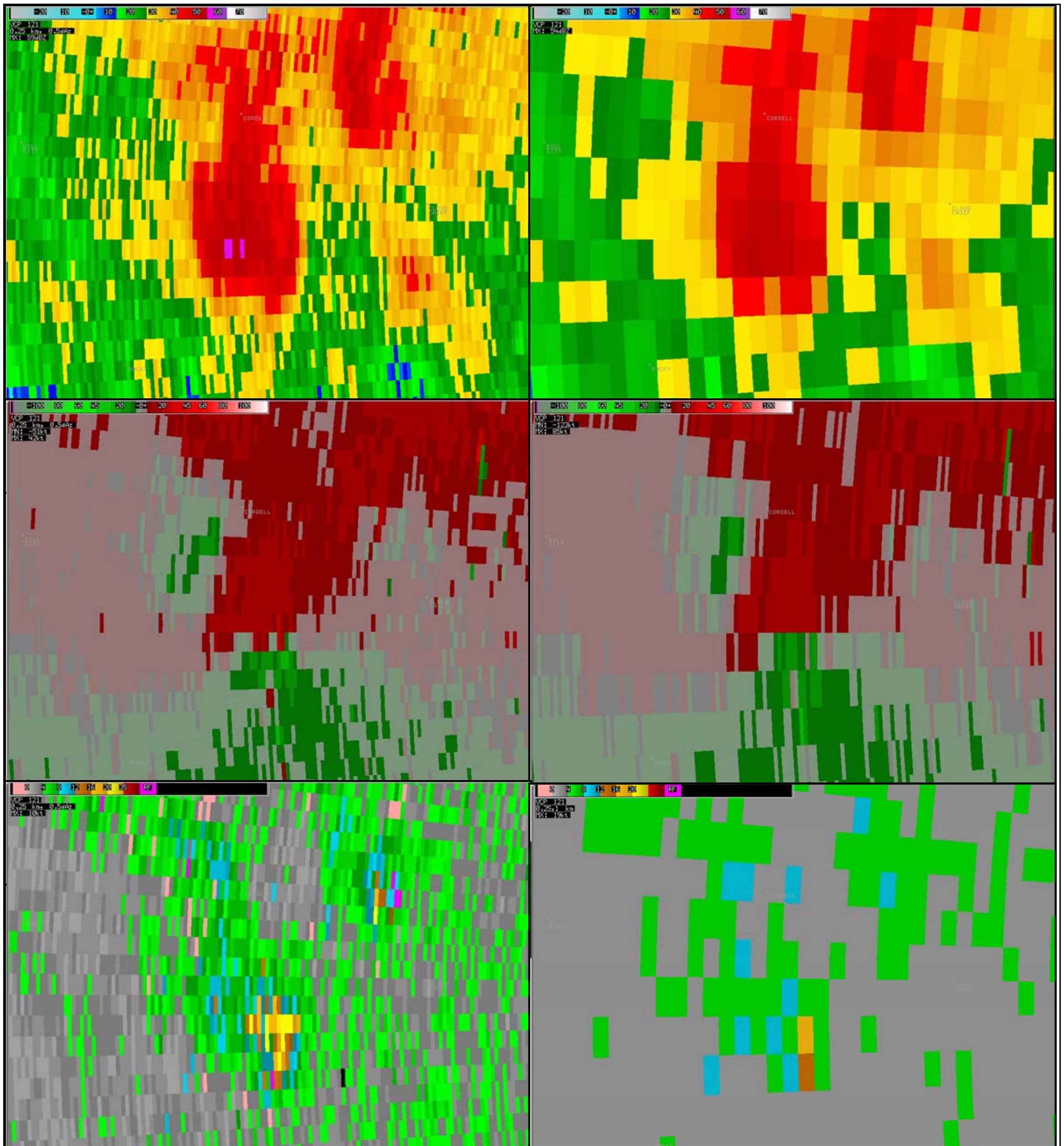


Figure 3. KCRI: Better rotation detection at 100 n mi with SR (lower left & right) vs current resolution.



Tornado Reports (in CSV format)

Time		Location	County	State	Lat	Lon	Comments
2215		11 SSE CORDELL	WASHITA	OK	3515	9891	REPORTED BY THE CORDELL FIRE CHIEF. NO DAMAGE WAS REPORTED WITH THIS TORNADO. (OUN)
2225		7 SSE CORDELL	WASHITA	OK	3521	9893	RELAYED BY KFOR TV. MINOR TREE DAMAGE WAS REPORTED AS A RESULT OF THE TORNADO. TIME IS ESTIMATED. (OUN)

Figure 4. KCRI: Small Tornado at 73 n mi; Super Resolution (left images) vs current resolution.

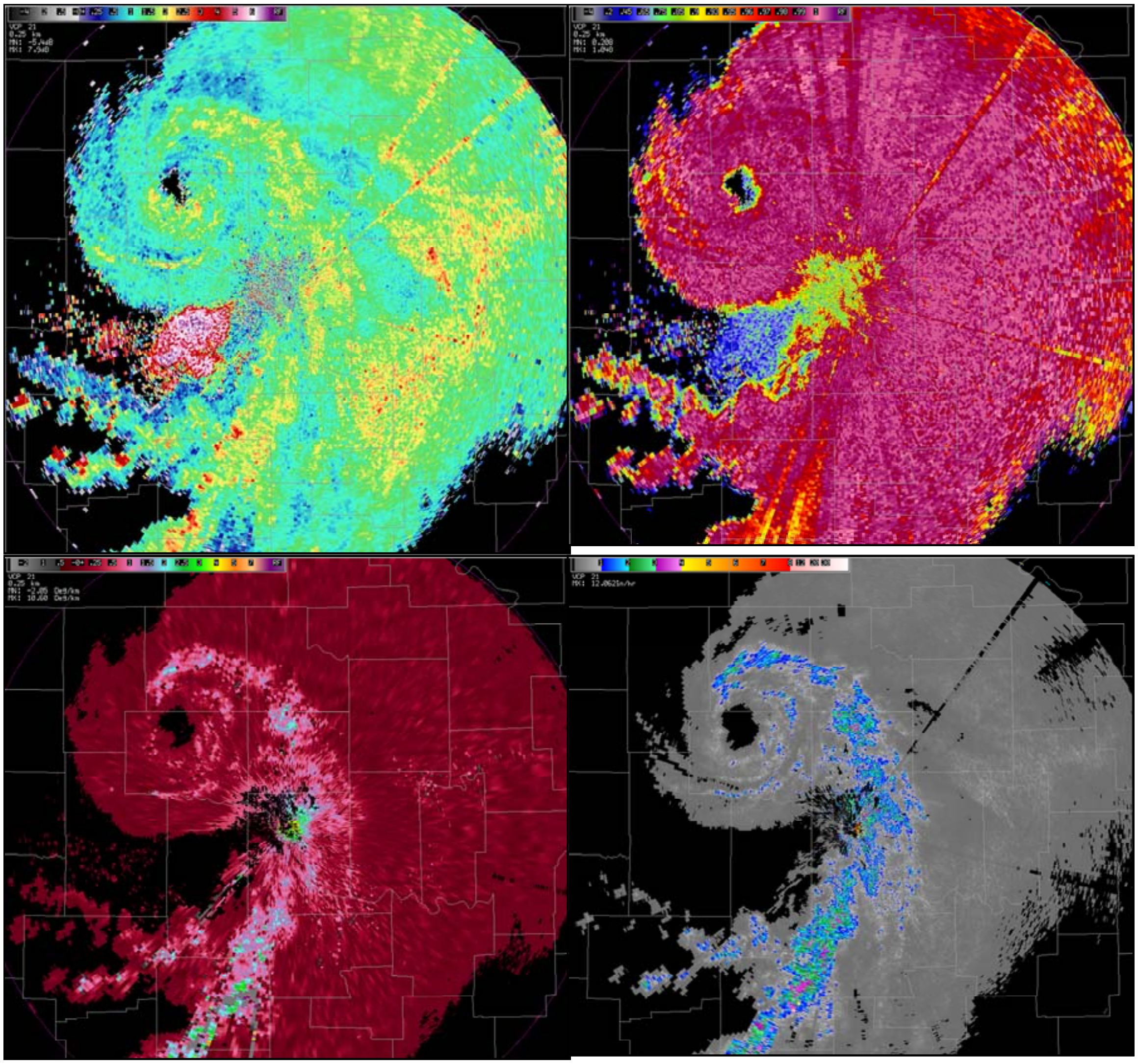


Figure 5. Erin: KOUN Zdr, CC, Kdp, DPR (polarimetric rainfall rate).

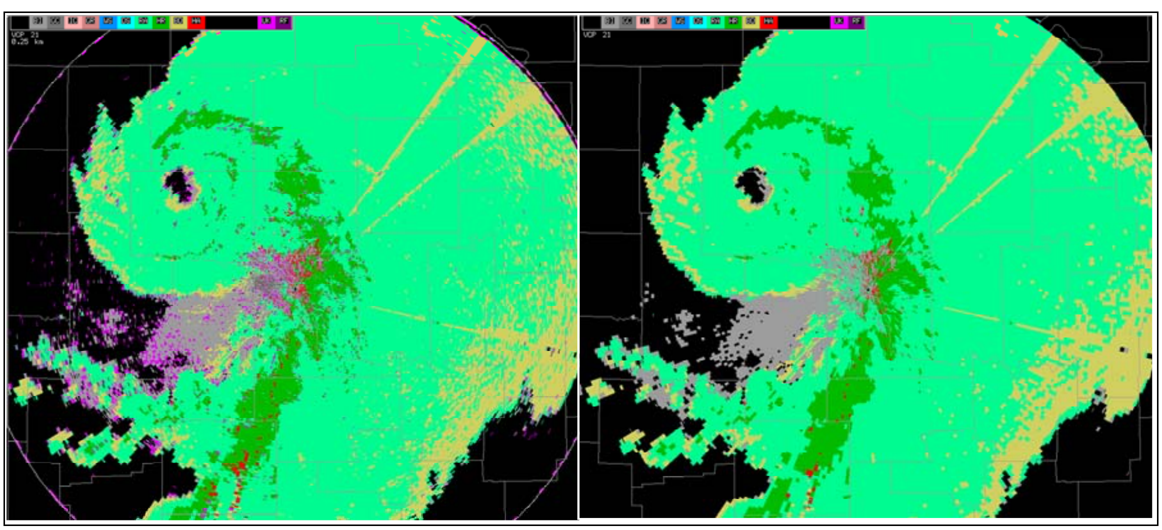


Figure 6. KOUN Hydrometeor Classification: Lowest elevation angle (left) and hybrid of elevations.

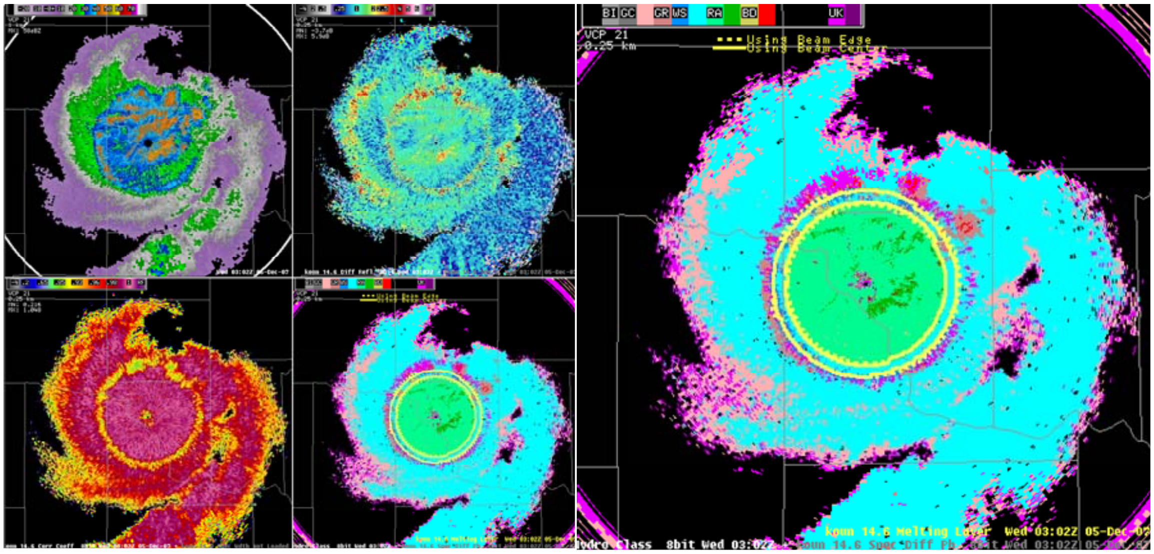


Figure 7. Erin: 14.6 degree KOUN polarimetric data: derived Melting Layer.

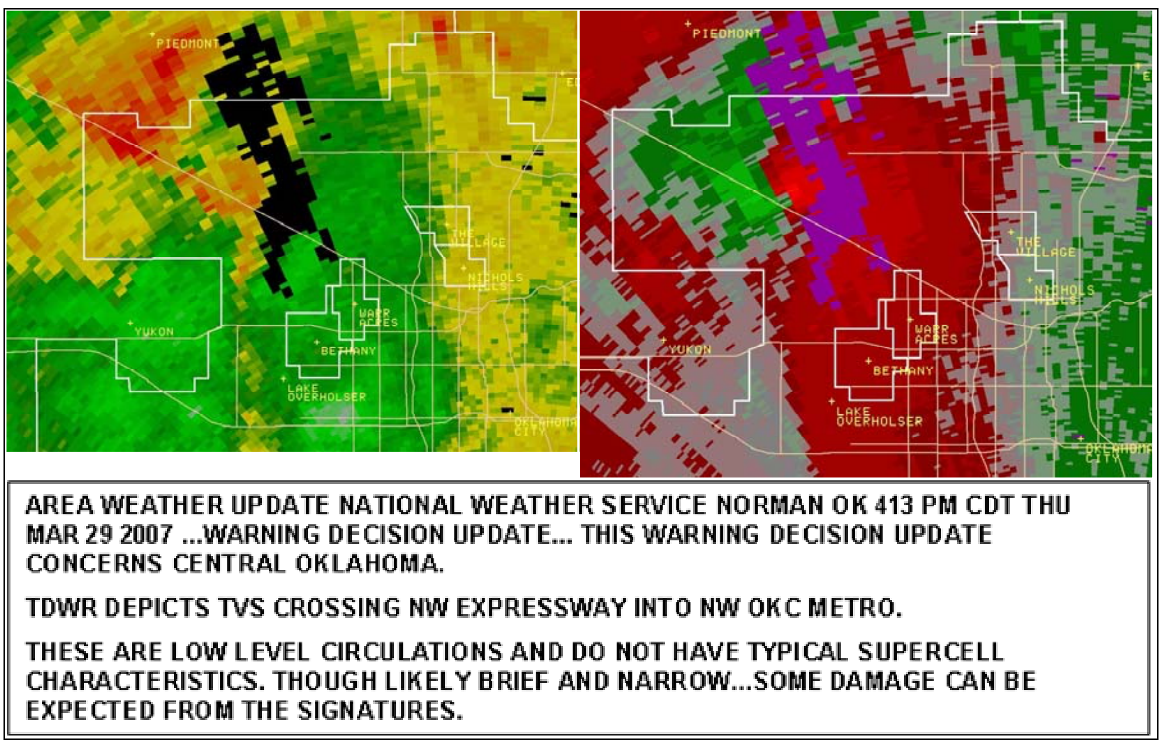


Figure 8. Small tornado in Oklahoma City depicted well with TDWR.

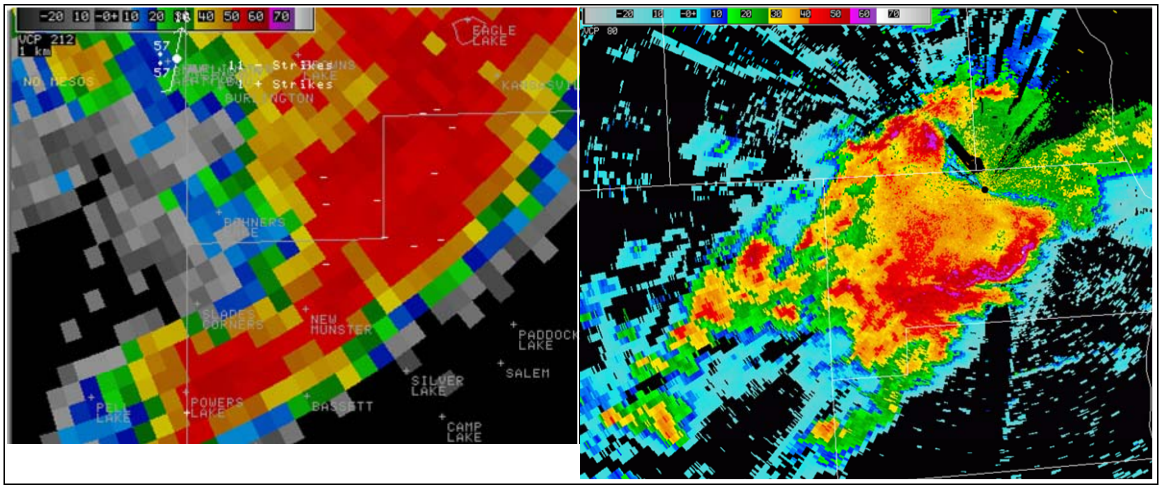


Figure 9. Kenosha Tornado 2213Z: Reflectivity: WSR-88D (left): closer TDWR (right).

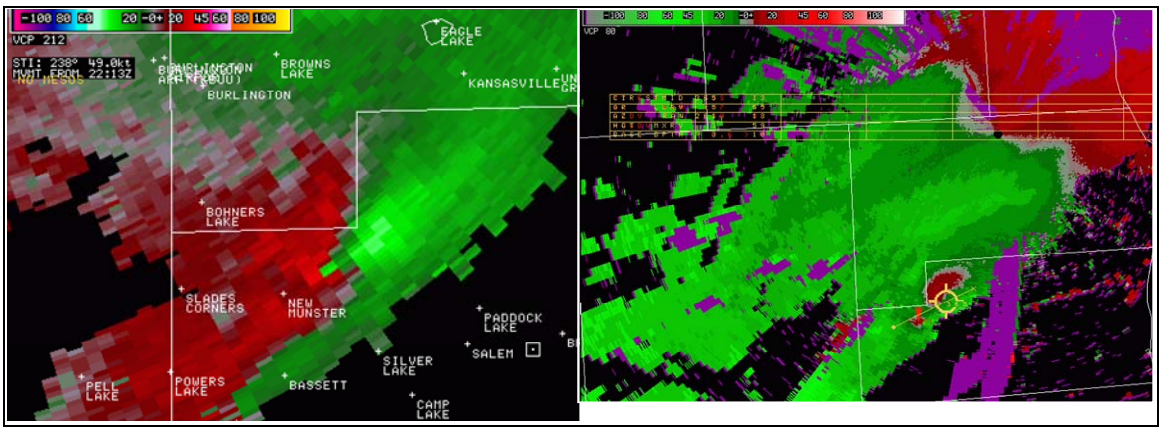


Figure 10. Kenosha Tornado 2213Z: 88D Storm Relative Velocity (left), TDWR Velocity, TVS, Meso.

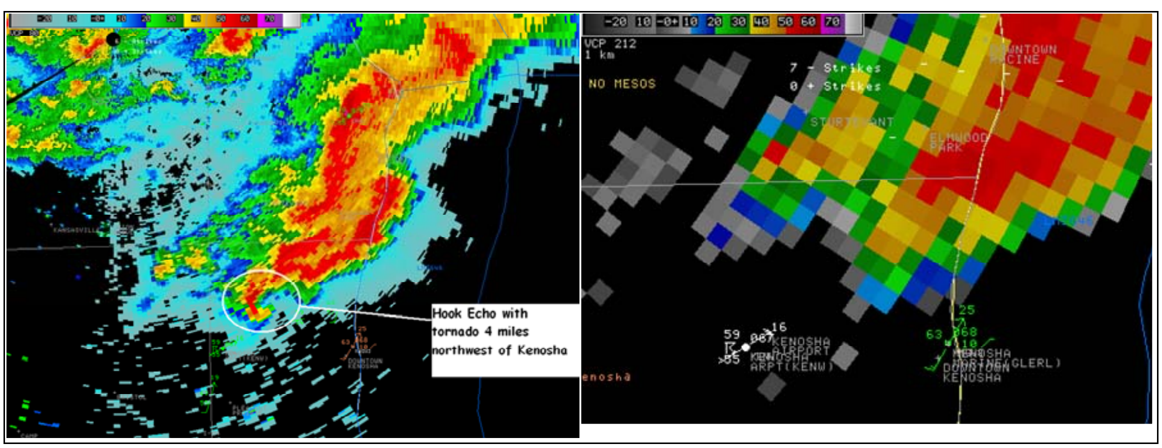


Figure 11. Kenosha Tornado 2237Z: TDWR high spatial resolution (left) vs longer range WSR-88D (2240Z).