9.1 NEXRAD PRODUCT IMPROVEMENT – EXPANDING SCIENCE HORIZONS

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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 B 1988 Doppler (WSR-88D), have been installed at operational locations in the United States and selected overseas sites. The NEXRAD tri-agencies have since established the NEXRAD Product Improvement (NPI) Program 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 subsystem with open system hardware and software (ORPG), and is in the process of a similar replacement of the Radar Data Acquisition subsystem (ORDA). These system upgrades will 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, and the integration of weather data from several FAA radar systems.

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 and plans for WSR-88D enhancements and use of other weather radar systems.

2. CURRENT PROJECTS

2.1 Science Enhancements

The NEXRAD agencies continue to develop and deploy new and enhanced scientific algorithms on the ORPG, and will extend this activity to the ORDA upon its deployment. A general, high level planning schedule of anticipated enhancements is presented in Figure 1.

2.2 ORDA

The ORDA project [2] consists 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 has been installed at five operational sites (Norman, Wichita, Ft. Worth, Pueblo, Laughlin AFB) for beta testing. ORDA deployment will be completed in 2006.

ORDA will enable improvements in data spatial resolution, clutter rejection, and range/velocity ambiguity mitigation. It will also provide the foundation for the addition of Dual Polarization to the WSR-88D.

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, 9], the NEXRAD agencies have approved the initiation of an acquisition program to deploy dual polarization (DP) capability to all WSR-88D units. A development contractor is expected to be selected by the end of FY2006, with deployment anticipated for 2008-2010.

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 TDWR, ASR-11 and ARSR-4 sites in a prototype mode for the past several years [7, 10], and is in the operational development phase of a formal program to acquire data from all TDWR sites for routine operational use [8, 12]. The NWS has developed a Supplemental Product Generator (SPG), based on the WSR-88D Radar Product Generator, to ingest TDWR data and prepare base products in the same format as WSR-88D base products. The NWS plans to deploy SPG to all of the 45 TDWR sites in 2006-2007. The SPG architecture will also be used for operational use of ASR and ARSR-4 radars.

2.5 Software Development Tools

The NWS and FAA are developing software tools to enable scattered development groups to not only collaborate more effectively, but also to enhance the compatibility of their applications with the operational WSR-88D. This project, termed CODE (Common Operations and Development Environment), is designed to provide an Application Programming Interface, underlying software modules, program layout and documentation sup-

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port, and other tools that are compliant with the WSR-88D operational system [4, 5, 6]. Through the use of CODE, the integration of new science into operational systems has been eased, leading to a shorter time period between approval of an algorithm and its operational use. CODE is now the primary development tool for NWS and FAA programmers producing ORPG compliant implementations of new algorithms.

The NWS is working to offer CODE to the broader radar development community. CODE is now supported on PC-Linux platforms [11], and is available to the public from http://weather.gov/code88d/.

3. OPERATIONAL ENHANCEMENTS IN 2005

- ORPG Build 7:
  - Support for deployment of ORDA
  - Greater use of AWIPS WAN for fast distribution of WSR-88D products to multiple WFOs
- ORDA deployment to WSR-88D units at Oklahoma City, Wichita, Ft. Worth, Pueblo, Laughlin AFB
- SPG deployment for FAA TDWR units at:
  - Baltimore-Washington International, MD,
  - Orlando, FL,
  - West Palm Beach, FL,
  - Houston Hobby, TX,
  - Slidell, LA,
  - Salt Lake City, UT,
  - Phoenix, AZ,
  - Las Vegas, NV,
  - Charlotte, NC,
- Prototype ASR-11 deployment at Erie, PA (Figure 5).

4. PREVIOUS OPERATIONAL ENHANCEMENTS

4.1 WSR-88D

$ High resolution (256 data levels) reflectivity and velocity data arrays, Vertically Integrated Liquid Water and Echo Tops

$ User defined layers of maximum Composite Reflectivity,

$ Quality-controlled velocity arrays for NCEP models,

$ Update of Mesocyclone and Tornado Detection algorithm output every elevation cut, instead of only at end of volume,

$ Enhanced Mesocyclone Detection,

$ Use of automatic detection of clutter and 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 same low level angles to mitigate range and velocity folding,

$ Snow Accumulation and Liquid Water Equivalents,

$ Communications to WFOs (LAN, WAN, high speed, higher limit to Routine Product Set List)

5. PLANNED ENHANCEMENTS

5.1 WSR-88D

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. A general schedule, used for planning purposes, is shown in Figure 1. The enhancements include:

$ Improved storm cell identification and tracking (ORPG),

$ Boundaries detection and projection (ORPG),

$ Range - Velocity ambiguity mitigation (ORDA),

$ Clutter identification and mitigation techniques (ORDA, DP),

$ Super Resolution base data (1/4 km by ½ deg) (Figures 6-9),

$ Doppler processing to 300 km (ORDA),

$ Doppler processing of low angle surveillance cuts (ORDA),

$ Provision of spectral data for forecaster analysis, and eventual automated pattern recognition analyses (ORDA),

$ Oversampling and whitening to enable faster scanning and higher resolutions while maintaining accuracy (ORDA),

$ Provision of estimates of water vapor close to the radar via refractivity measurements (ORDA),

$ Improved quantitative precipitation estimation (DP),

$ Classification of types of hydrometeor reflectors (DP),

  $ Rain, hail (possibly size), snow

$ Classification of non-hydrometeor reflectors (DP),

  $ Insects, birds, chaff, clutter/AP

$ Improved data quality input to numerical models (DP),

$ Provision of polarimetric base data and products (Figure 10),

  $ Differential Reflectivity (DP),

  $ Correlation Coefficient (DP),

  $ Differential Phase (DP),

  $ Specific Differential Phase (DP).

5.2 FAA Data

FAA radar data will initially be used to generate base reflectivity, velocity and spectrum width image products similar to those produced for the WSR-88D (Figure 2). More sophisticated use of FAA data will involve multiple Doppler wind field analyses, merging the data with WSR-88D data to produce ›best‹ radar data mosaics, retrieval of vertical wind profiles, and more. The NWS and NSSL will also explore applying Mesocyclone, Tornadic Vortex Signature and other WSR-88D algorithms to FAA data, particularly TDWR data. Examples of VAD Wind Profile (Figure 3) and Composite Reflectivity (Figure 4) products derived from FAA data are shown. The scientific algorithms needed for optimum use of FAA data remain to be developed, offering opportunities for innovative developers. Istok [10] presents a more complete discussion of the status of NWS programs for FAA data use.

6. SUMMARY

In summary, the NEXRAD infrastructure enhancements, dissemination of base data, and development of radar application development tools have combined to offer a heretofore unmatched environment for radar science development and operational implementation. The addition of ORDA, Dual Polarization and data from FAA radars offers further opportunities.

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

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[12] 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

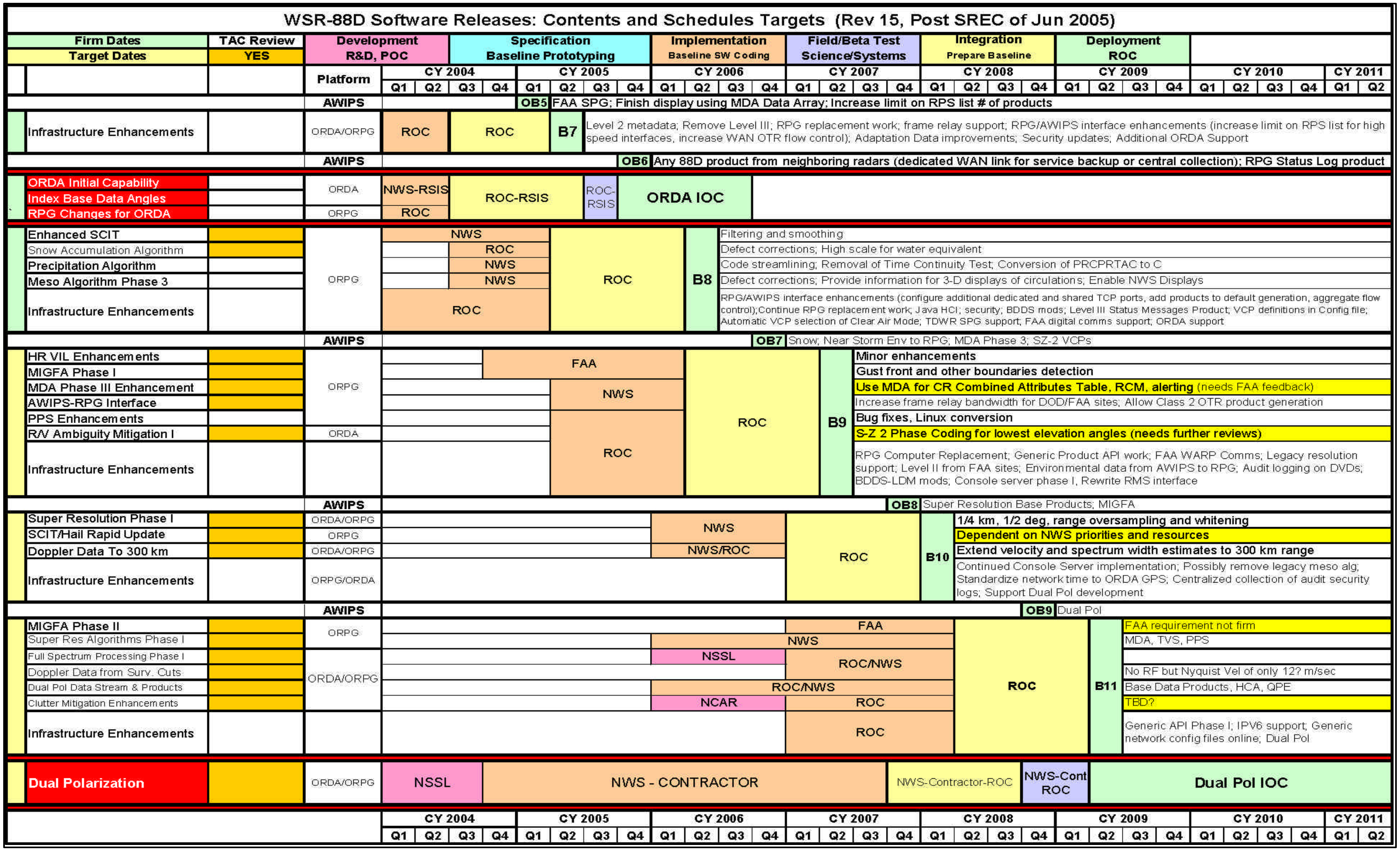


Figure 1 - High Level Planning for WSR-88D Enhancements

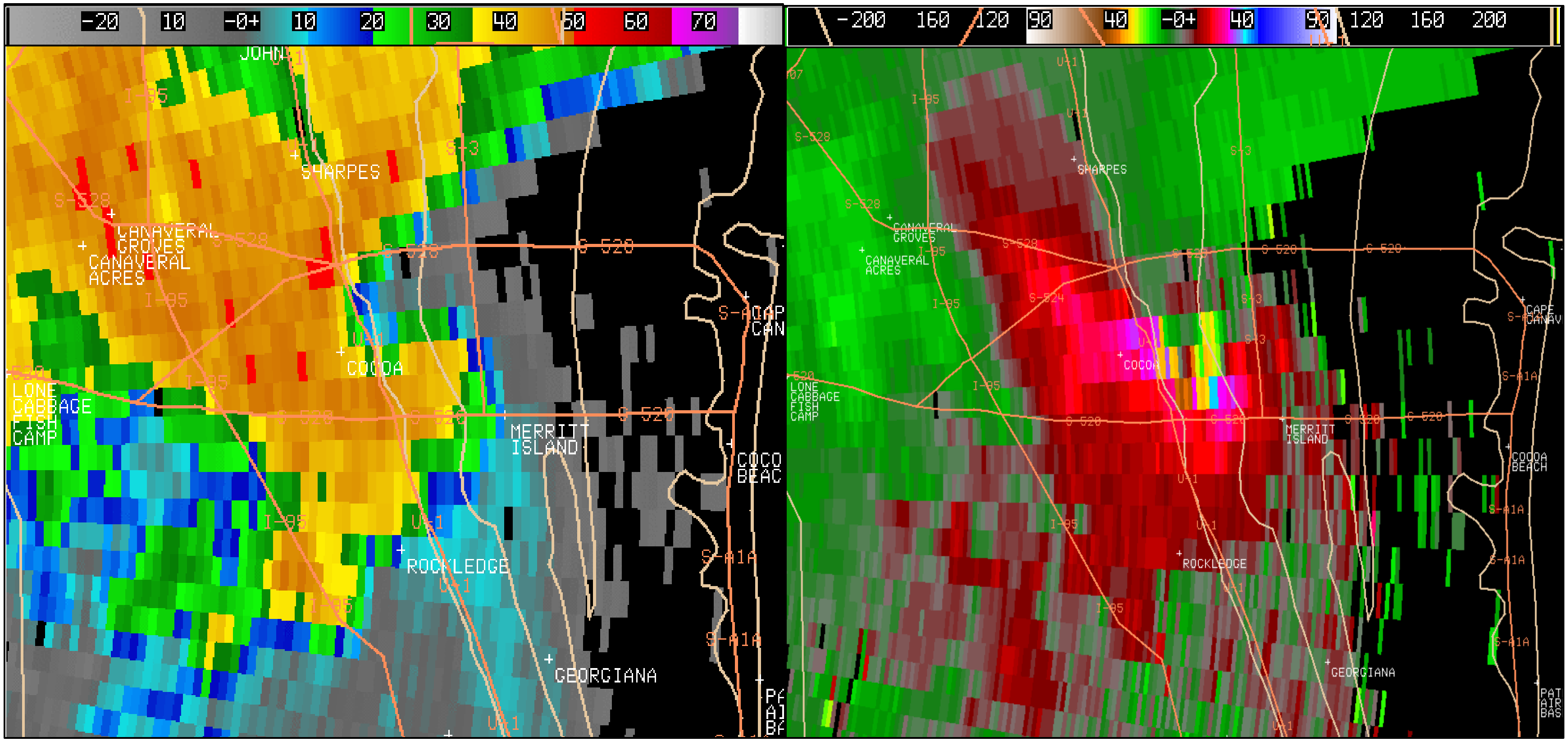


Figure 2 - Orlando FAA TDWR Reflectivity and Velocity Images for Tornado Spawned by Hurricane Wilma

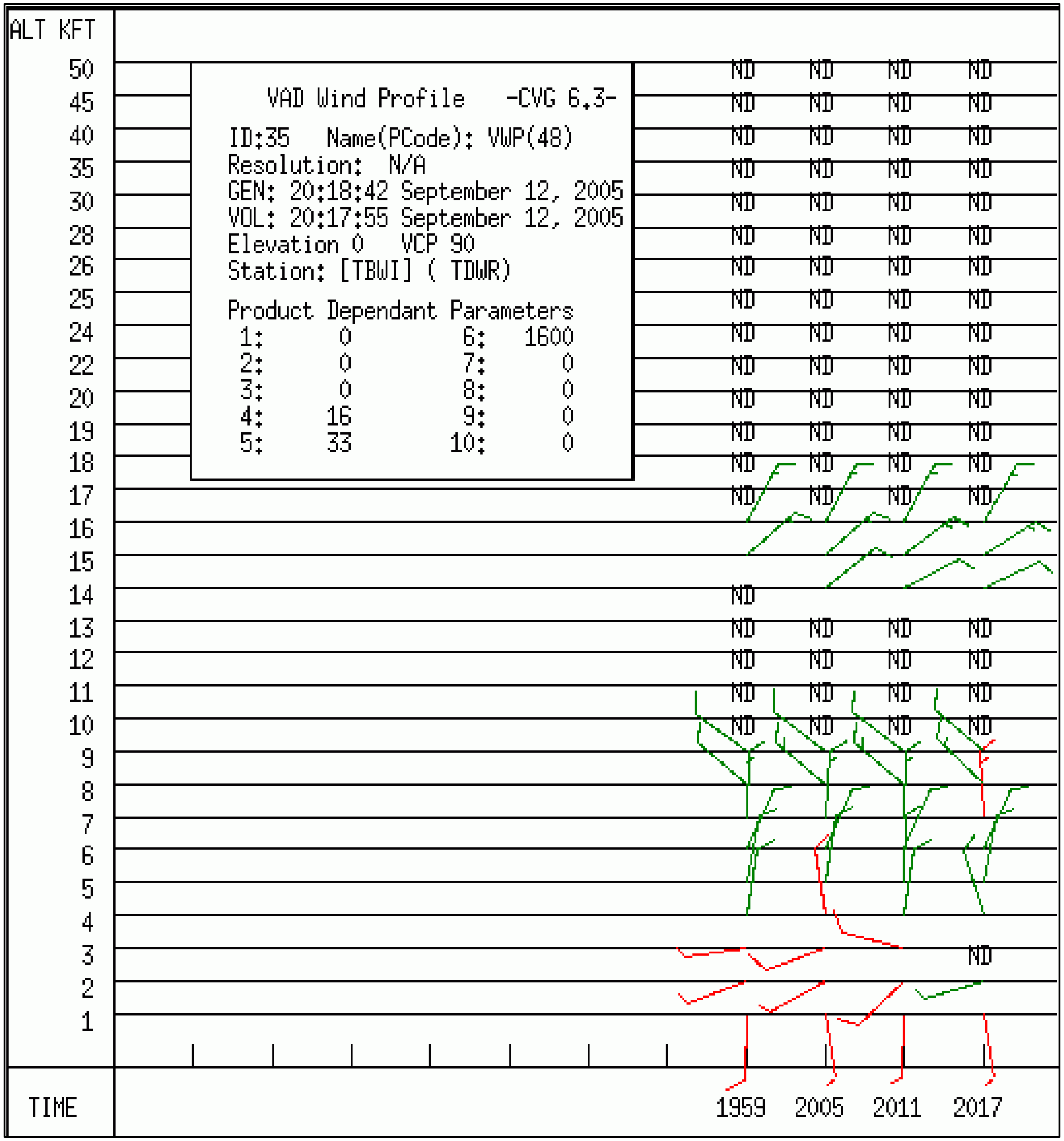


Figure 3 - VAD Wind Profile Derived From FAA TDWR Data

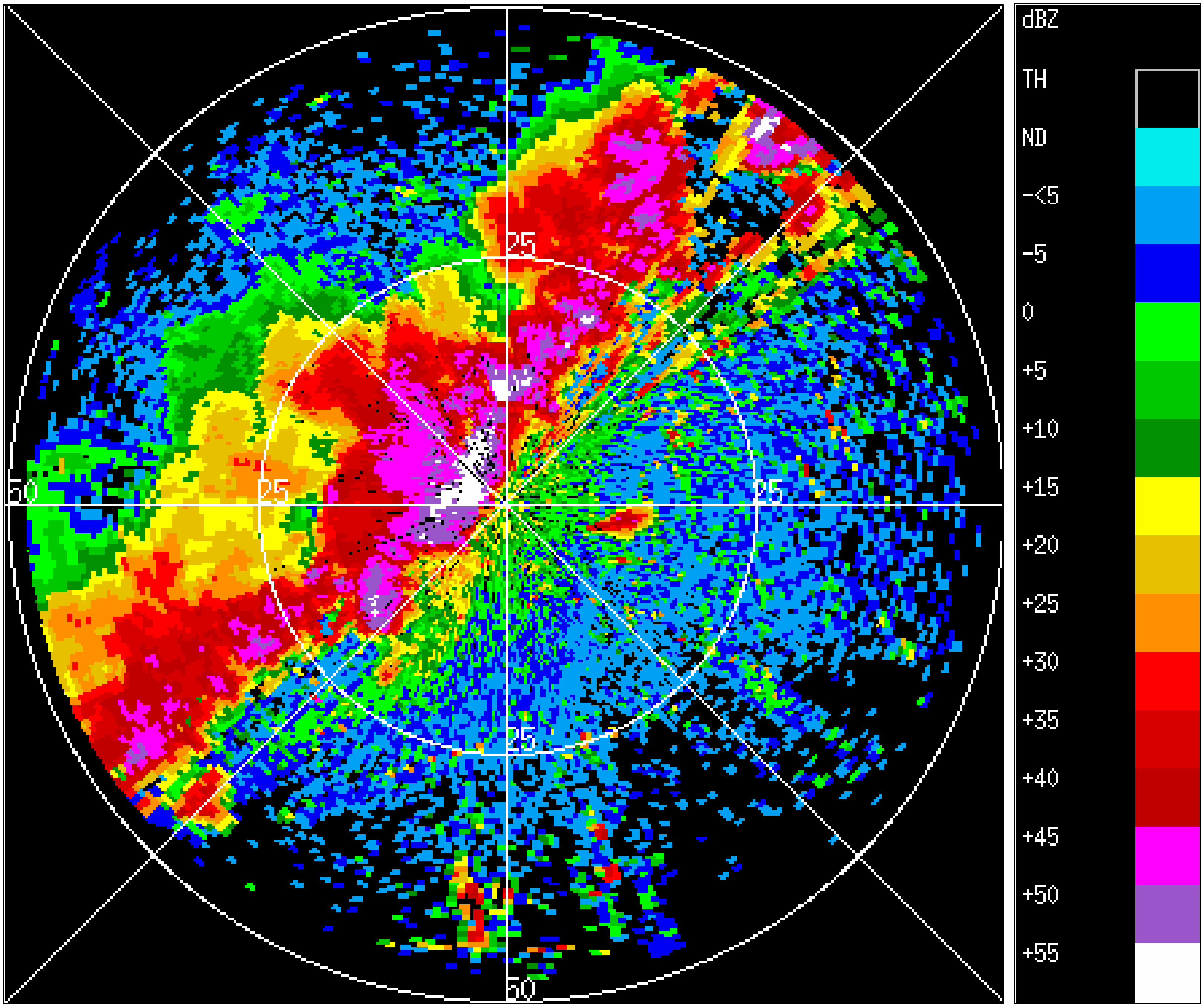


Figure 4 - Layer Composite Reflectivity (0 - 4000 ft) Derived From FAA TDWR Data

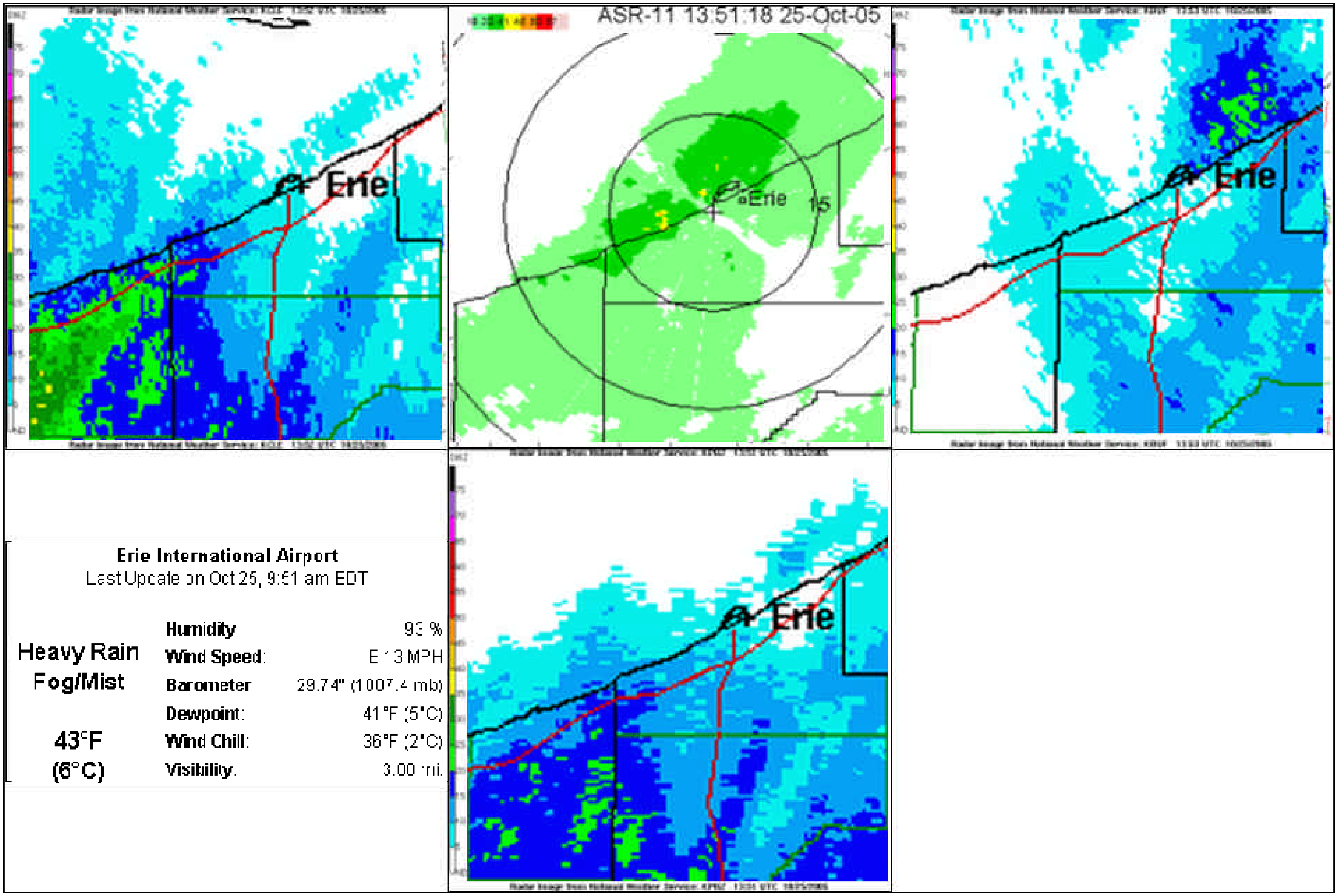


Figure 5 - Enhanced Coverage of Low Altitude Heavy Rain by FAA ASR-11 versus Over-shooting WSR-88D Units

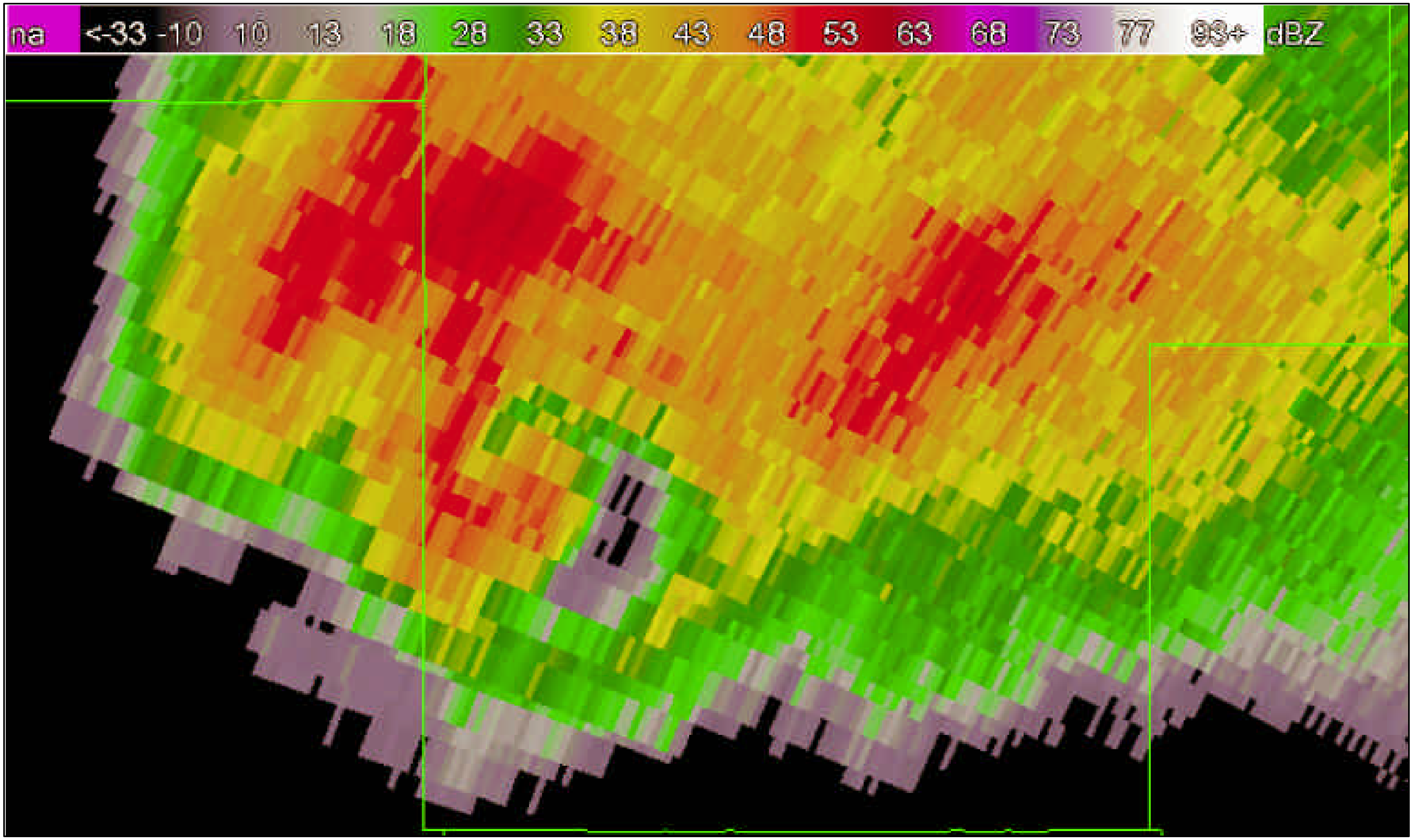


Figure 6 - Super Resolution (1/4 km by 1/2 deg) Reflectivity for Tornadic Storm at Range 112 km

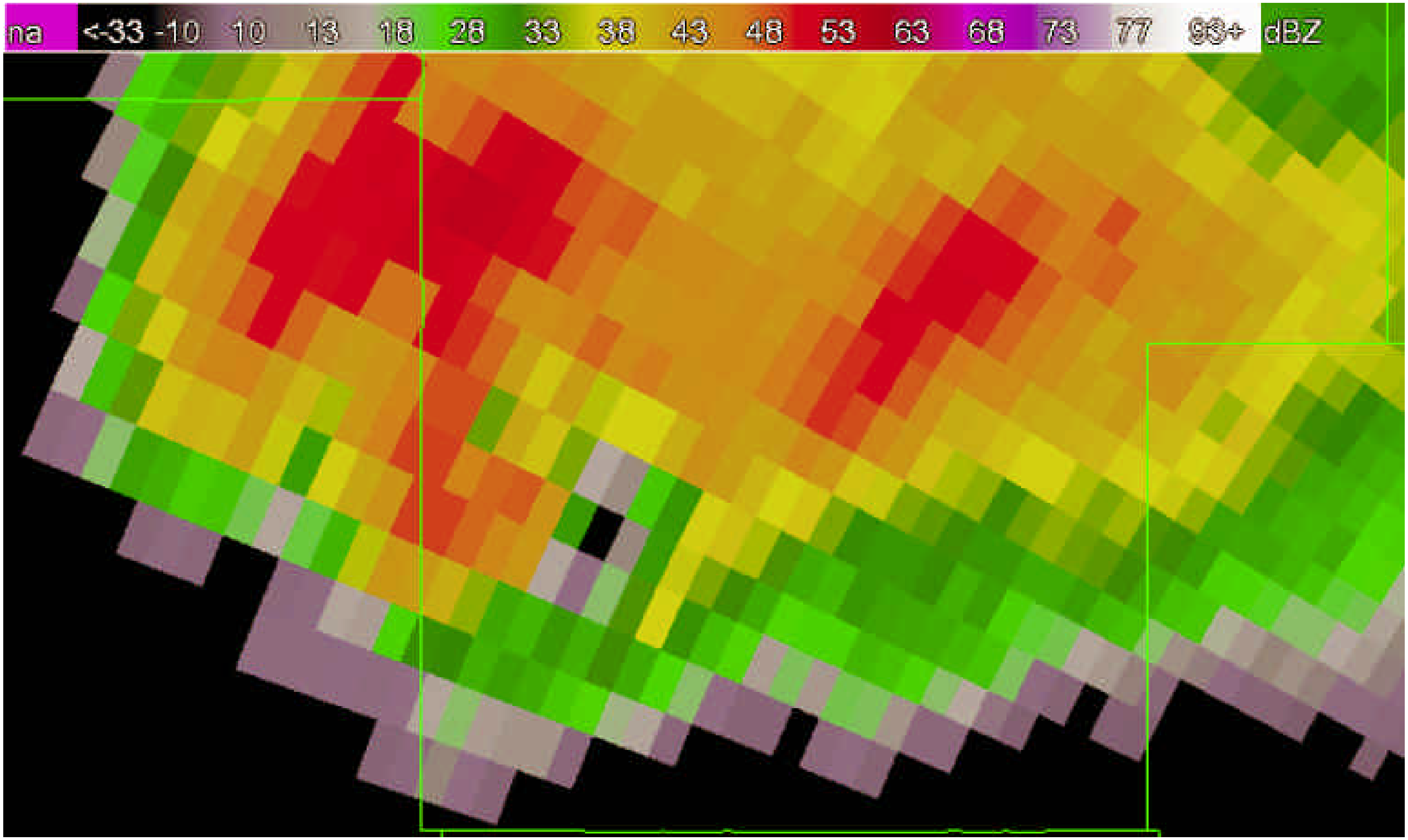


Figure 7 - Standard Resolution (1 km by 1 deg) Reflectivity for Tornadic Storm at Range 112 km

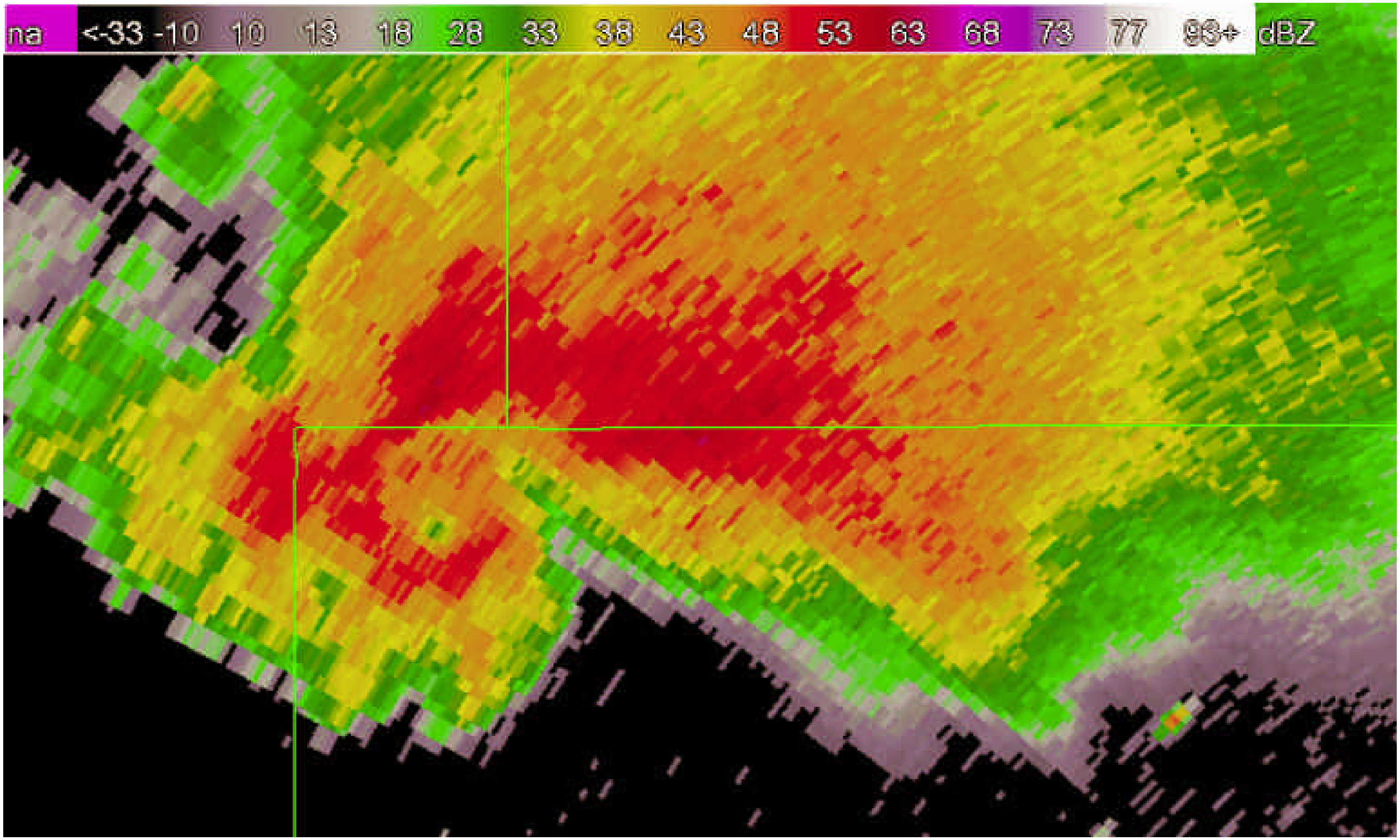


Figure 8 - Super Resolution (1/4 km by 1/2 deg) Reflectivity for Tornadic Storm at Range 86 km

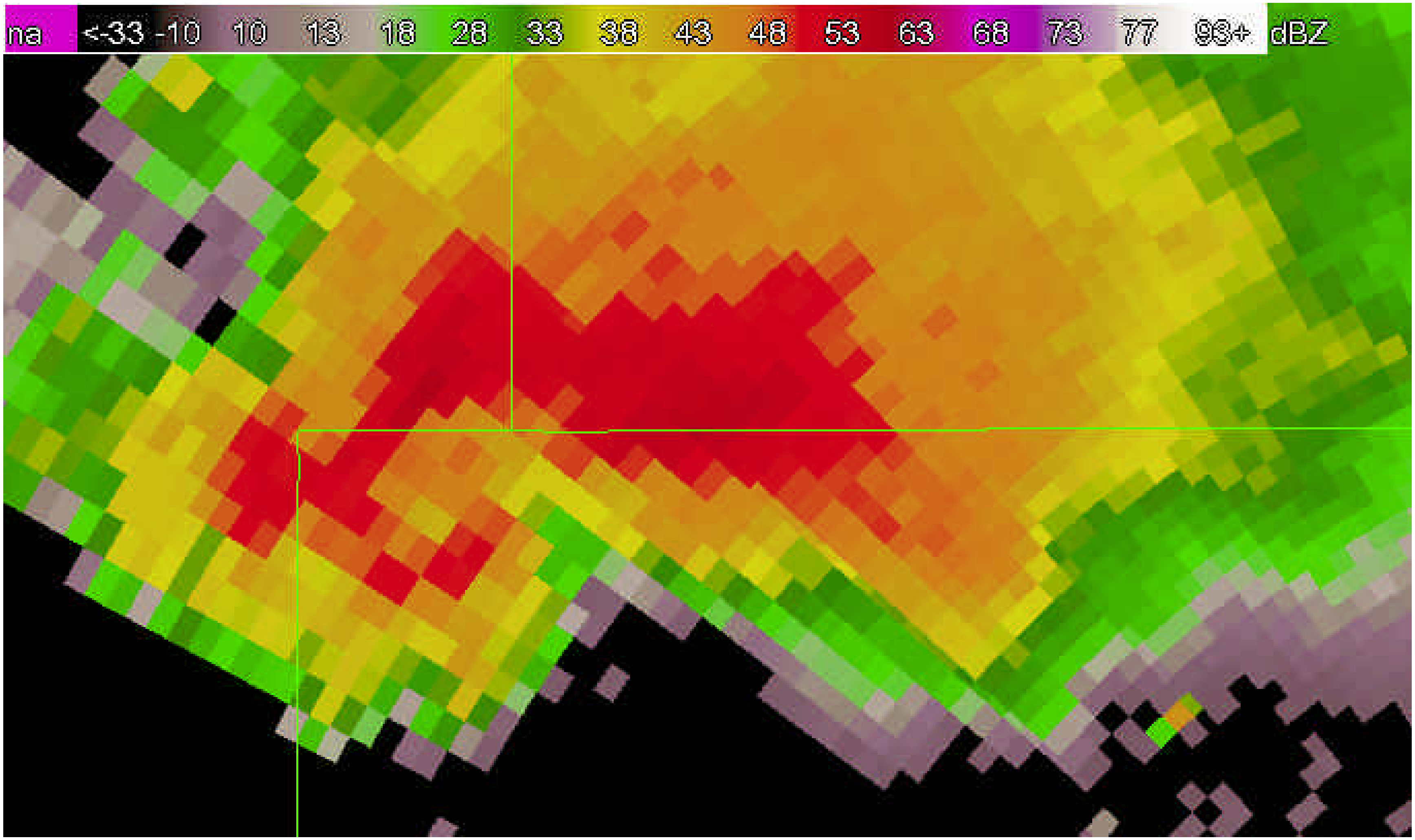
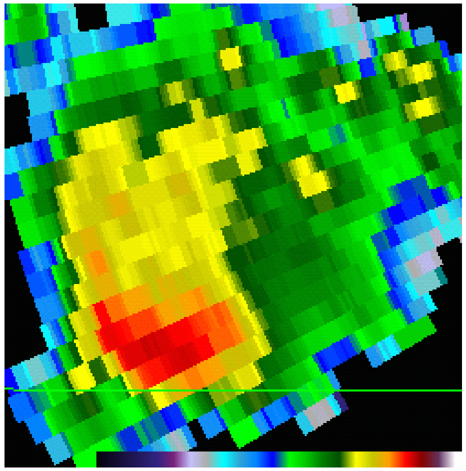
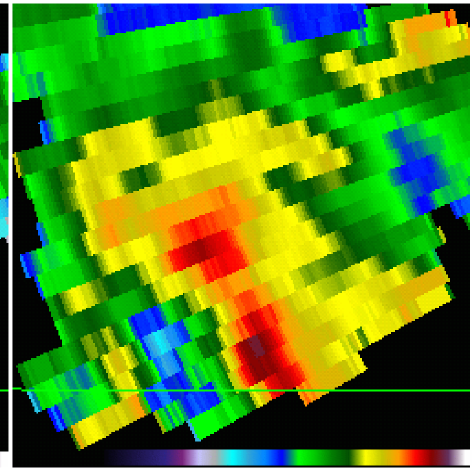


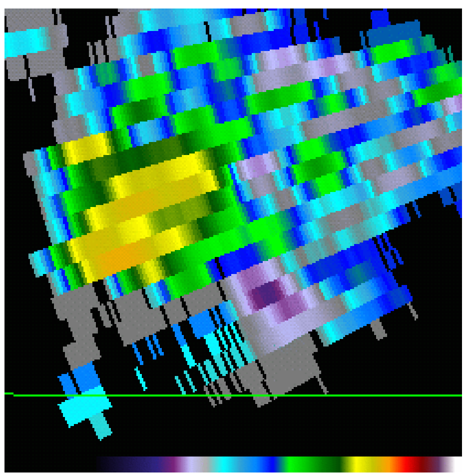
Figure 9 - Standard Resolution (1 km by 1 deg) Reflectivity for Tornadic Storm at Range 86 km



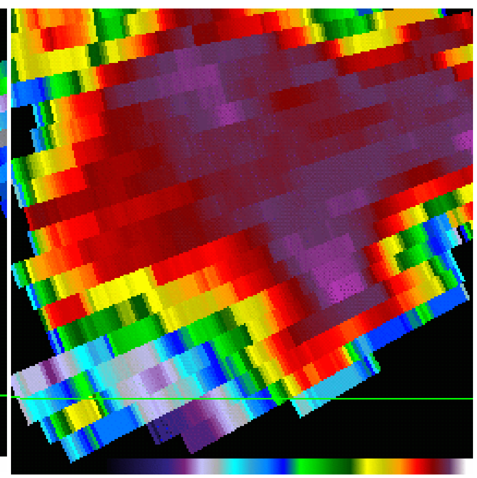
Reflectivity



Differential Reflectivity

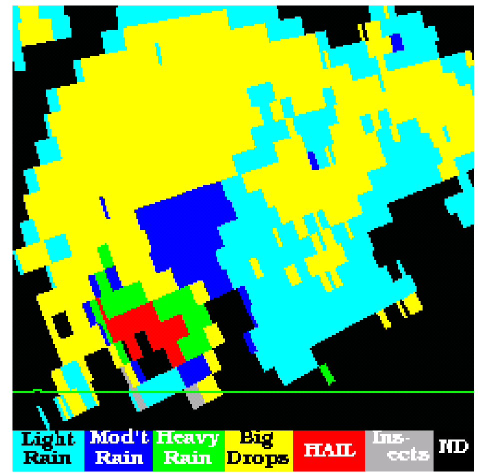


Specific Differential



Correlation Coefficient

Figure 10 - Polarimetric Moments and Hydrometeor Classification



Hydrometeor Classifi-

Traditional reflectivity data indicate many strong storms, but don't distinguish between hail and heavy rain. **(High False Alarm Rate)**

Hydrometeor Classification uses polarimetric data to indicate likely hail storms. **(Lower False Alarm Rate)**