5B.1 NEXRAD PRODUCT IMPROVEMENT – UPDATE 2007

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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 – 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. The WSR-88D should be considered just the first project 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 will enable 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.

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 through CY 2011 is presented in Figure 1.

2.2 ORDA

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 will be deployed with the WSR-88D software update in Spring 2007.

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 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 in 2007, with deployment anticipated for 2009-2011. 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-

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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 10 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 products in the same format as WSR-88D base products. The NWS plans to deploy SPG to the rest of the 45 TDWR sites in 2006-2007, pending availability of funds. The SPG architecture will also be used for operational use of ASR and ARSR-4 radars.

3. OPERATIONAL ENHANCEMENTS IN 2006

- Completion of deployment of ORDA,
- Pre-smoothing of reflectivity input to Storm Cell Identification and Tracking to reduce cell fragmentation,
- Taking advantage of Lincoln Laboratory access to data for 11 additional TDWR sites to provide products from those sites to WFOs on an interim basis until SPG units are deployed to all TDWR sites.

4. PREVIOUS OPERATIONAL ENHANCEMENTS

4.1 WSR-88D & FAA Data 2002-2005

- 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 (Figure 5).

5. PLANNED ENHANCEMENTS

5.1 WSR-88D & FAA Data 2007-2011

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:

- Boundaries detection and projection (RPG, 2007),
- Range-Velocity ambiguity mitigation (Figure 11) (2007),
- Derived products from TDWR data (VWP, meso, TVS, rainfall, +) (Figures 3,4) (2007-2008)
- Super Resolution base data (1/4 km by ½ deg) (Figures 6-9) (2008),
- Doppler processing to 300 km (2008),
- Turbulence algorithm (2008),
- Super Resolution algorithm products (meso, TVS, rainfall) (2009).
- Improved precipitation estimation (2009),
- Classification hydrometeor types (Figure 10) (2009),
  - Rain, hail (possibly size), snow
- Classification of non-hydrometeor reflectors (2009),
  - Insects, birds, chaff, clutter/AP
- Improved data quality for numerical models (2009),
- Provision of polarimetric base data and products (Figure 10) (2009),
  - Differential Reflectivity,
  - Correlation Coefficient,
  - Differential Phase,
  - Specific Differential Phase.
- Doppler processing of low angle surveillance cuts (2010),
- Clutter identification-mitigation techniques (2011),
- Provision of spectral data for forecaster analysis, and eventual automated pattern recognition analyses (2011),
- Oversampling and whitening to enable faster scanning and higher resolutions while maintaining accuracy (2011),
- Provision of estimates of water vapor close to the radar via refractivity measurements (Figure 12) (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

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[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

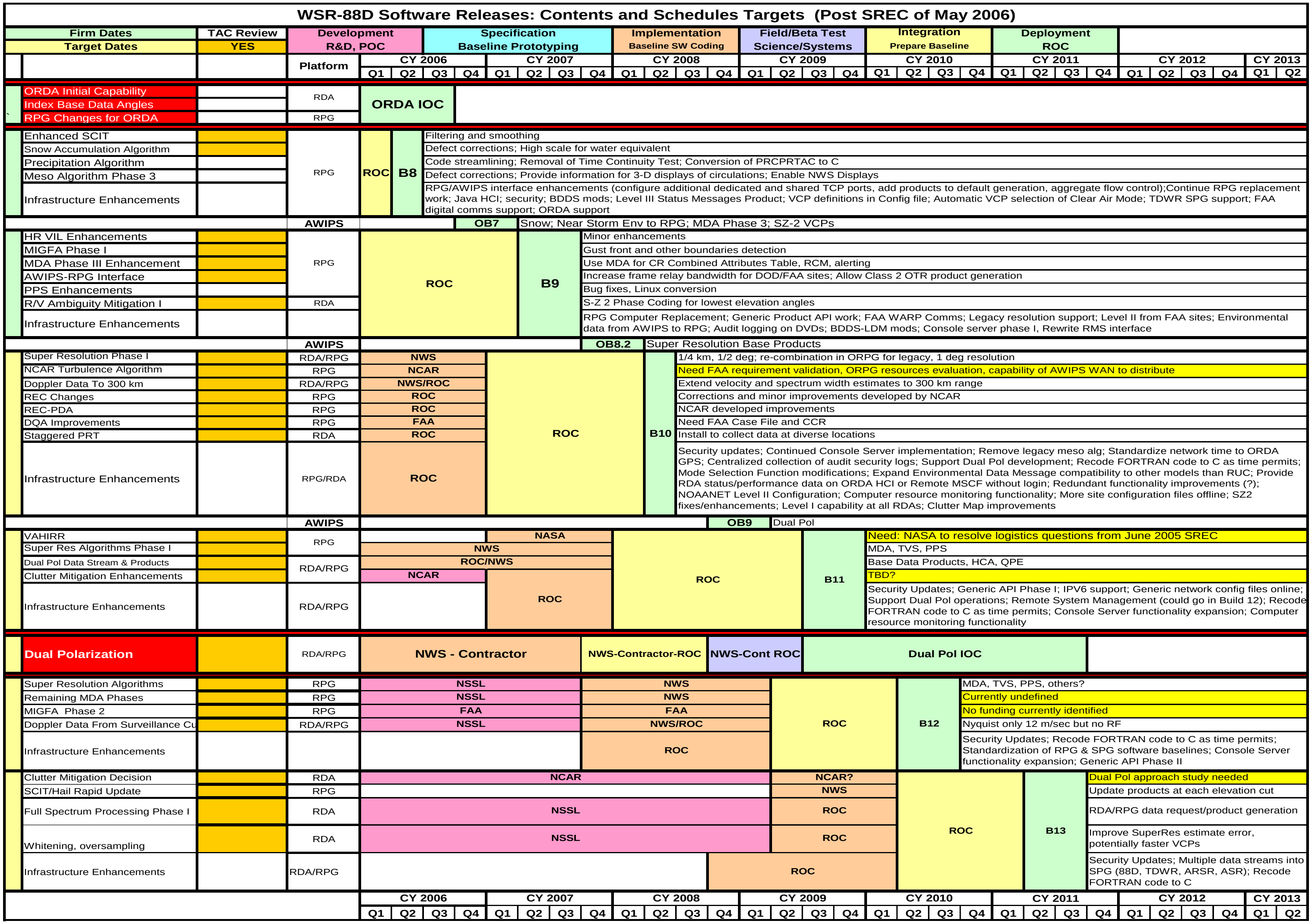
[4] Analysis and Plans for Using FAA Radar Weather Data in the WSR-88D ORPG, Stern, A., P. Pickard, W. Blanchard, B. Bumgarner, M. Istok, 18th IIPS, paper 5.6

[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 – 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



WSR-88D Software Releases: Contents and Schedules Targets (Post SREC of May 2006)

	TAC Review	Platform					
ORDA Initial Capability		RDA	ORDA IOC				
Index Base Data Angles							
RPG Changes for ORDA		RPG					
Enhanced SCIT	🟧	RPG	ROC			B8	Filtering and smoothing
Snow Accumulation Algorithm	🟧						Defect corrections; High scale for water equivalent
Precipitation Algorithm							Code streamlining; Removal of Time Continuity Test; Conversion of PRCPRTAC to C
Meso Algorithm Phase 3	🟧						Defect corrections; Provide information for 3-D displays of circulations; Enable NWS Displays
Infrastructure Enhancements							RPG/AWIPS interface enhancements (configure additional dedicated and shared TCP ports, add products to default generation, aggregate flow control);Continue RPG replacement work; Java HCI; security; BDDS mods; Level III Status Messages Product; VCP definitions in Config file; Automatic VCP selection of Clear Air Mode; TDWR SPG support; FAA digital comms support; ORDA support
		AWIPS				OB7	Snow; Near Storm Env to RPG; MDA Phase 3; SZ-2 VCPs
HR VIL Enhancements	🟧	RPG	ROC			B9	Minor enhancements
MIGFA Phase I	🟧						Gust front and other boundaries detection
MDA Phase III Enhancement	🟧						Use MDA for CR Combined Attributes Table, RCM, alerting
AWIPS-RPG Interface	🟧						Increase frame relay bandwidth for DOD/FAA sites; Allow Class 2 OTR product generation
PPS Enhancements							Bug fixes, Linux conversion
R/V Ambiguity Mitigation I	🟧	RDA					S-Z 2 Phase Coding for lowest elevation angles
Infrastructure Enhancements							RPG Computer Replacement; Generic Product API work; FAA WARP Comms; Legacy resolution support; Level II from FAA sites; Environmental data from AWIPS to RPG; Audit logging on DVDs; BDDS-LDM mods; Console server phase I, Rewrite RMS interface
		AWIPS				OB8.2	Super Resolution Base Products
Super Resolution Phase I	🟧	RDA/RPG	NWS	ROC		B10	1/4 km, 1/2 deg; re-combination in ORPG for legacy, 1 deg resolution
NCAR Turbulence Algorithm	🟧	RPG	NCAR				Need FAA requirement validation, ORPG resources evaluation, capability of AWIPS WAN to distribute
Doppler Data To 300 km	🟧	RDA/RPG	NWS/ROC				Extend velocity and spectrum width estimates to 300 km range
REC Changes	🟧	RPG	ROC				Corrections and minor improvements developed by NCAR
REC-PDA	🟧	RPG	ROC				NCAR developed improvements
DQA Improvements	🟧	RPG	FAA				Need FAA Case File and CCR
Staggered PRT	🟧	RDA	ROC				Install to collect data at diverse locations
Infrastructure Enhancements		RPG/RDA	ROC				Security updates; Continued Console Server implementation; Remove legacy meso alg; Standardize network time to ORDA GPS; Centralized collection of audit security logs; Support Dual Pol development; Recode FORTRAN code to C as time permits; Mode Selection Function modifications; Expand Environmental Data Message compatibility to other models than RUC; Provide RDA status/performance data on ORDA HCI or Remote MSCF without login; Redundant functionality improvements (?); NOAANET Level II Configuration; Computer resource monitoring functionality; More site configuration files offline; SZ2 fixes/enhancements; Level I capability at all RDAs; Clutter Map improvements
		AWIPS				OB9	Dual Pol
VAHIRR	🟧	RPG	NASA	ROC		B11	Need: NASA to resolve logistics questions from June 2005 SREC
Super Res Algorithms Phase I	🟧		NWS				MDA, TVS, PPS
Dual Pol Data Stream & Products	🟧	RDA/RPG	ROC/NWS				Base Data Products, HCA, QPE
Clutter Mitigation Enhancements	🟧		NCAR				TBD?
Infrastructure Enhancements		RDA/RPG	ROC				Security Updates; Generic API Phase I; IPV6 support; Generic network config files online; Support Dual Pol operations; Remote System Management (could go in Build 12); Recode FORTRAN code to C as time permits; Console Server functionality expansion; Computer resource monitoring functionality
Dual Polarization	🟧	RDA/RPG	NWS - Contractor	NWS-Contractor-ROC	NWS-Cont ROC	Dual Pol IOC	
Super Resolution Algorithms	🟧	RPG	NSSL	NWS	ROC	B12	MDA, TVS, PPS, others?
Remaining MDA Phases	🟧	RPG	NSSL	NWS			Currently undefined
MIGFA Phase 2	🟧	RPG	FAA	FAA			No funding currently identified
Doppler Data From Surveillance Cu	🟧	RDA/RPG	NSSL	NWS/ROC			Nyquist only 12 m/sec but no RF
Infrastructure Enhancements				ROC			Security Updates; Recode FORTRAN code to C as time permits; Standardization of RPG & SPG software baselines; Console Server functionality expansion; Generic API Phase II
Clutter Mitigation Decision	🟧	RDA	NCAR	NCAR?	ROC	B13	Dual Pol approach study needed
SCIT/Hail Rapid Update	🟧	RPG		NWS			Update products at each elevation cut
Full Spectrum Processing Phase I	🟧	RDA	NSSL	ROC			RDA/RPG data request/product generation
Whitening, oversampling	🟧	RDA	NSSL	ROC			Improve SuperRes estimate error, potentially faster VCPs
Infrastructure Enhancements		RDA/RPG		ROC			Security Updates; Multiple data streams into SPG (88D, TDWR, ARSR, ASR); Recode FORTRAN code to C

Figure 1 High Level Planning for WSR-88D Enhancements

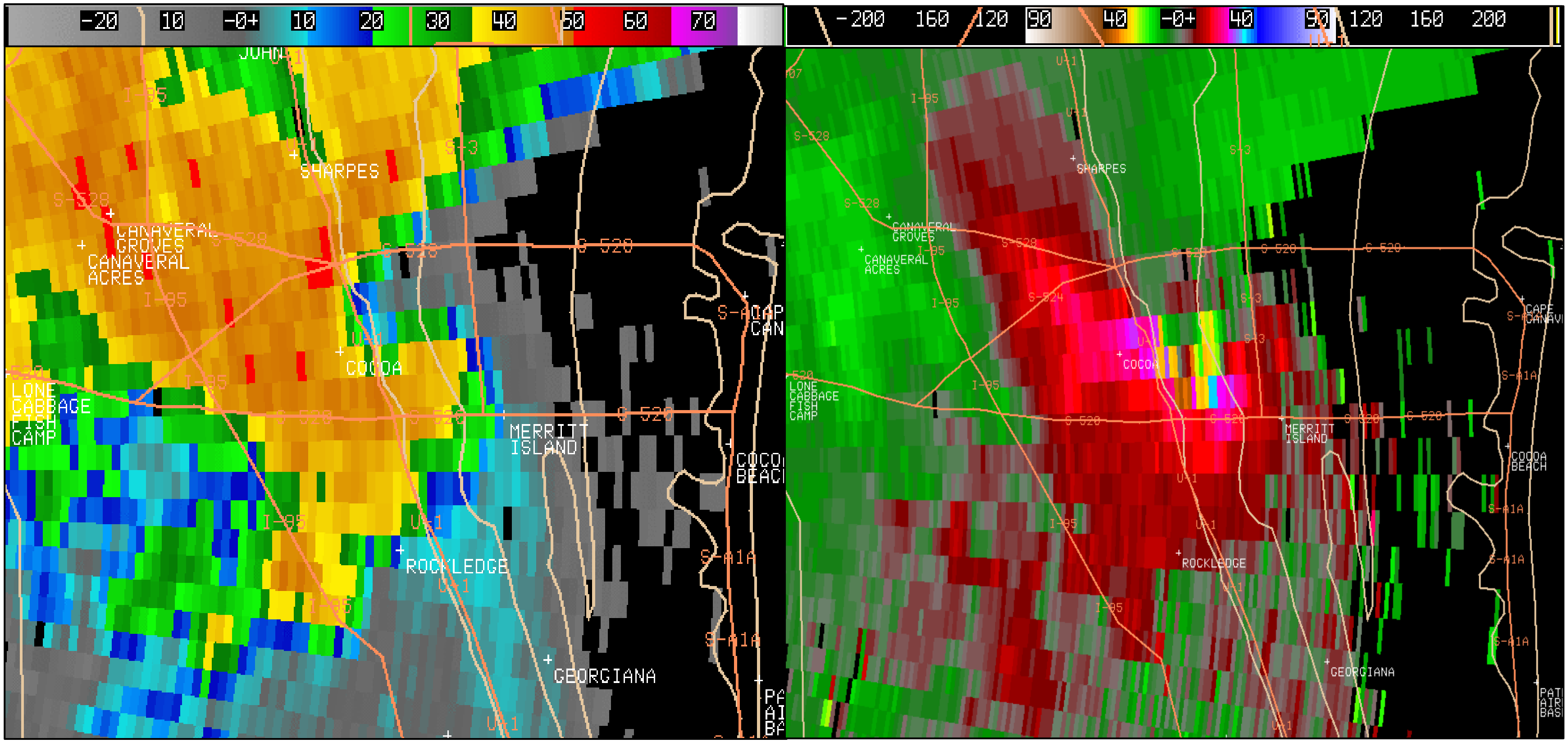
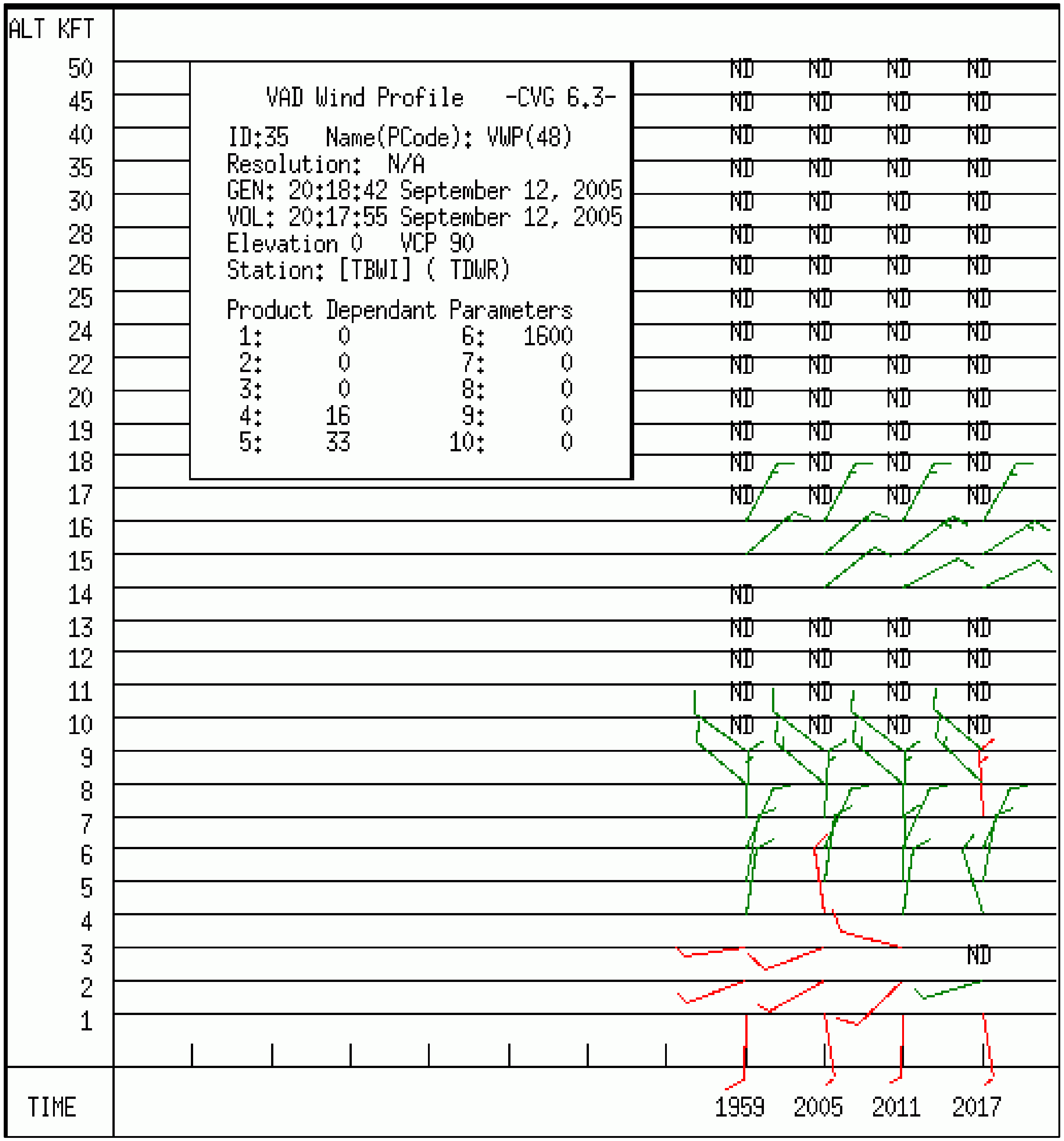


Figure 2 - Orlando FAA TDWR Reflectivity and Velocity Images for Tornado Spawned by Hurricane Wilma



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VAD Wind Profile    -CVG 6.3-

ID:35   Name(PCode): VWP(48)
Resolution:  N/A
GEN: 20:18:42 September 12, 2005
VOL: 20:17:55 September 12, 2005
Elevation 0   VCP 90
Station: [TBWI] ( TDWR)

Product Dependant Parameters
 1:       0          6:   1600
 2:       0          7:      0
 3:       0          8:      0
 4:      16          9:      0
 5:      33         10:      0
```

Figure 3 - VAD Wind Profile Derived From FAA TDWR Data

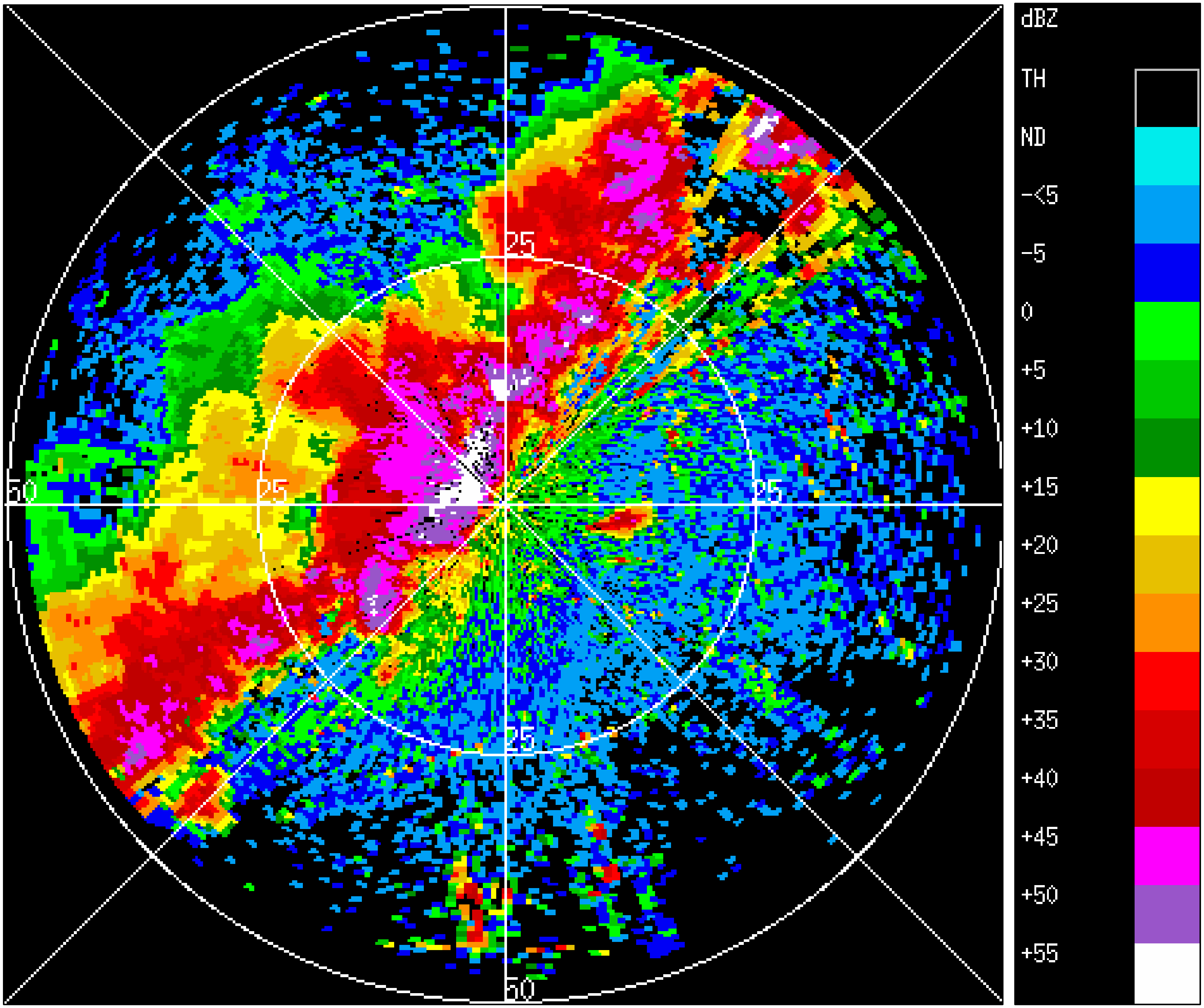


Figure 4 - Layer Composite Reflectivity (0 - 4000 ft) Derived From FAA TDWR Data

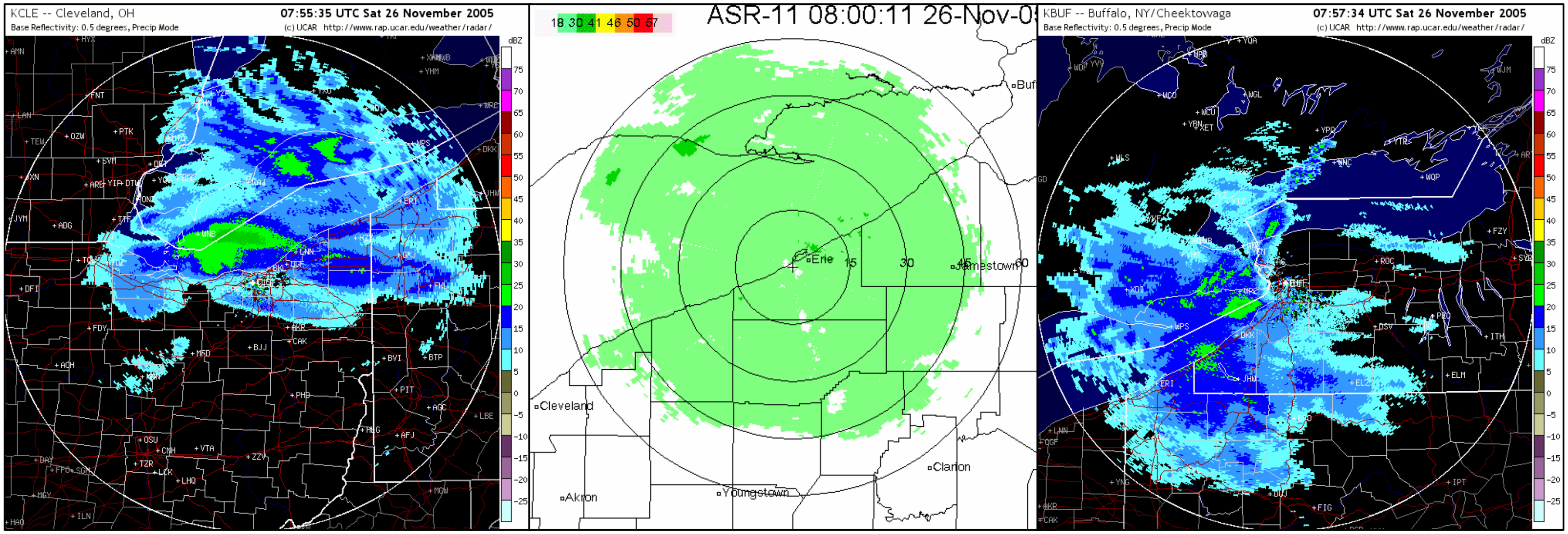


Figure 5 - Enhanced Coverage of Lake Effect Snow by FAA ASR-11 versus Over-shooting WSR-88D Units

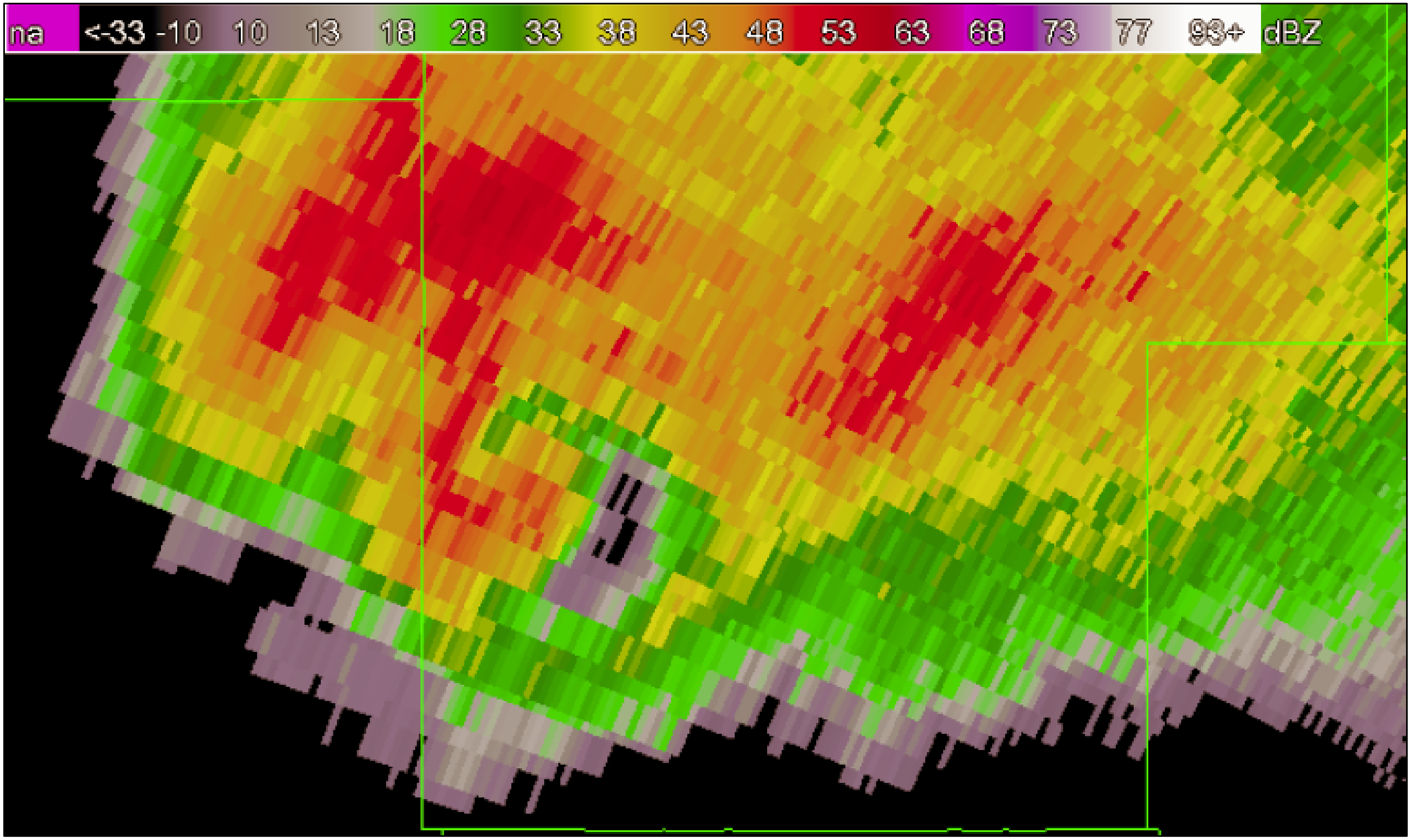


Figure 6 - Super Resolution (1/4 km by 1/2 deg) Reflectivity for Tornadic Storm at Range 112 km

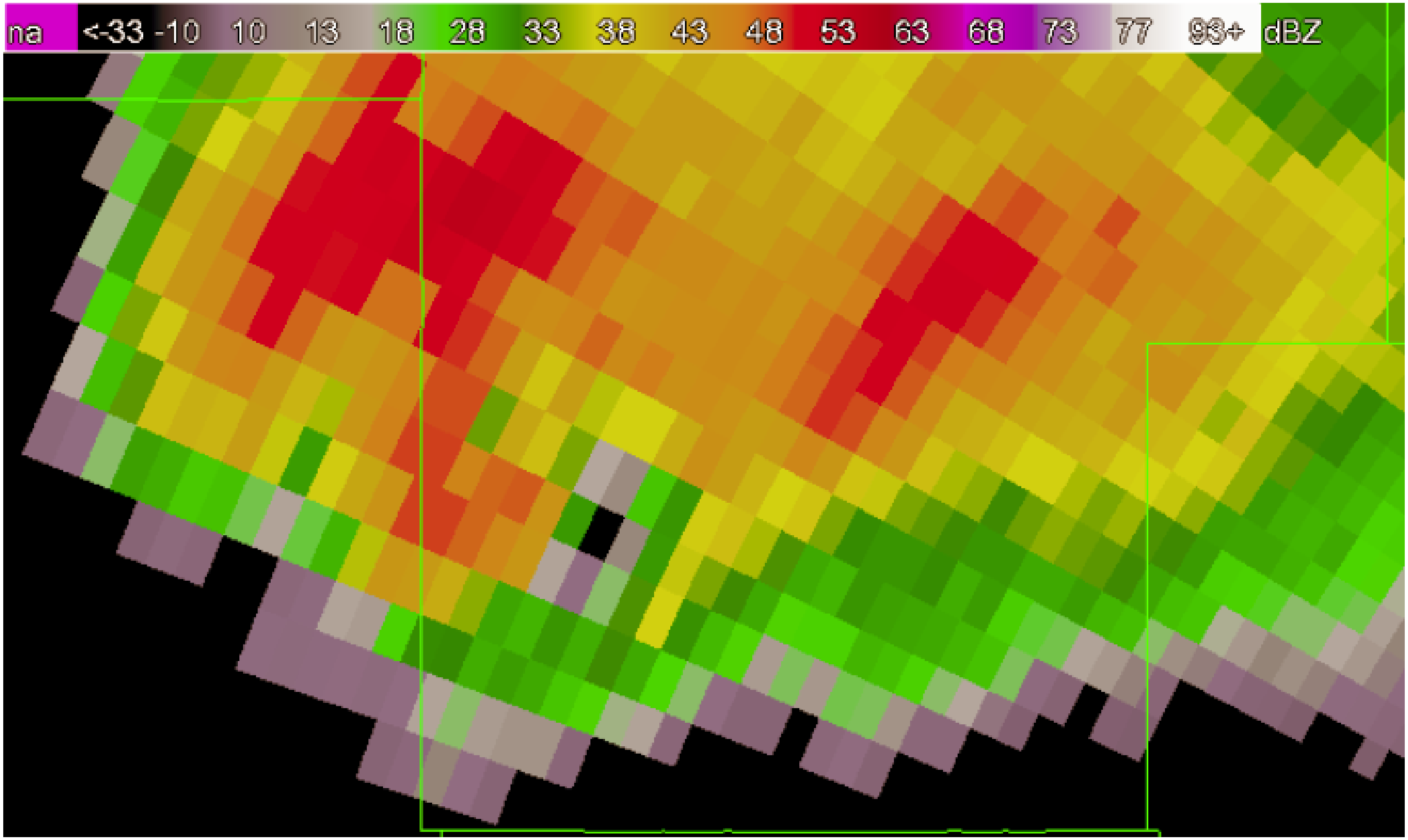


Figure 7 - Standard Resolution (1 km by 1 deg) Reflectivity for Tornadic Storm at Range 112 km

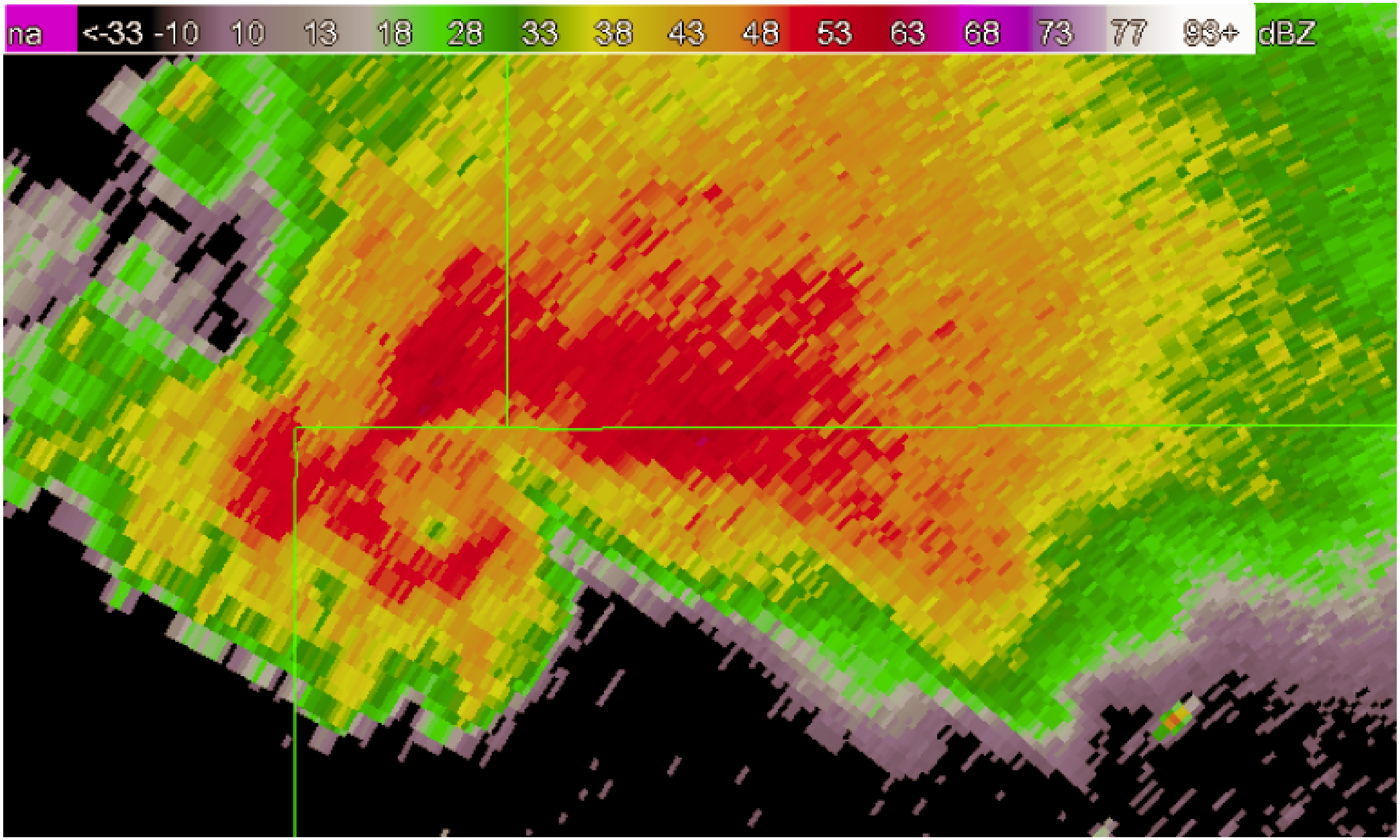


Figure 8 - Super Resolution (1/4 km by 1/2 deg) Reflectivity for Tornadic Storm at Range 86 km

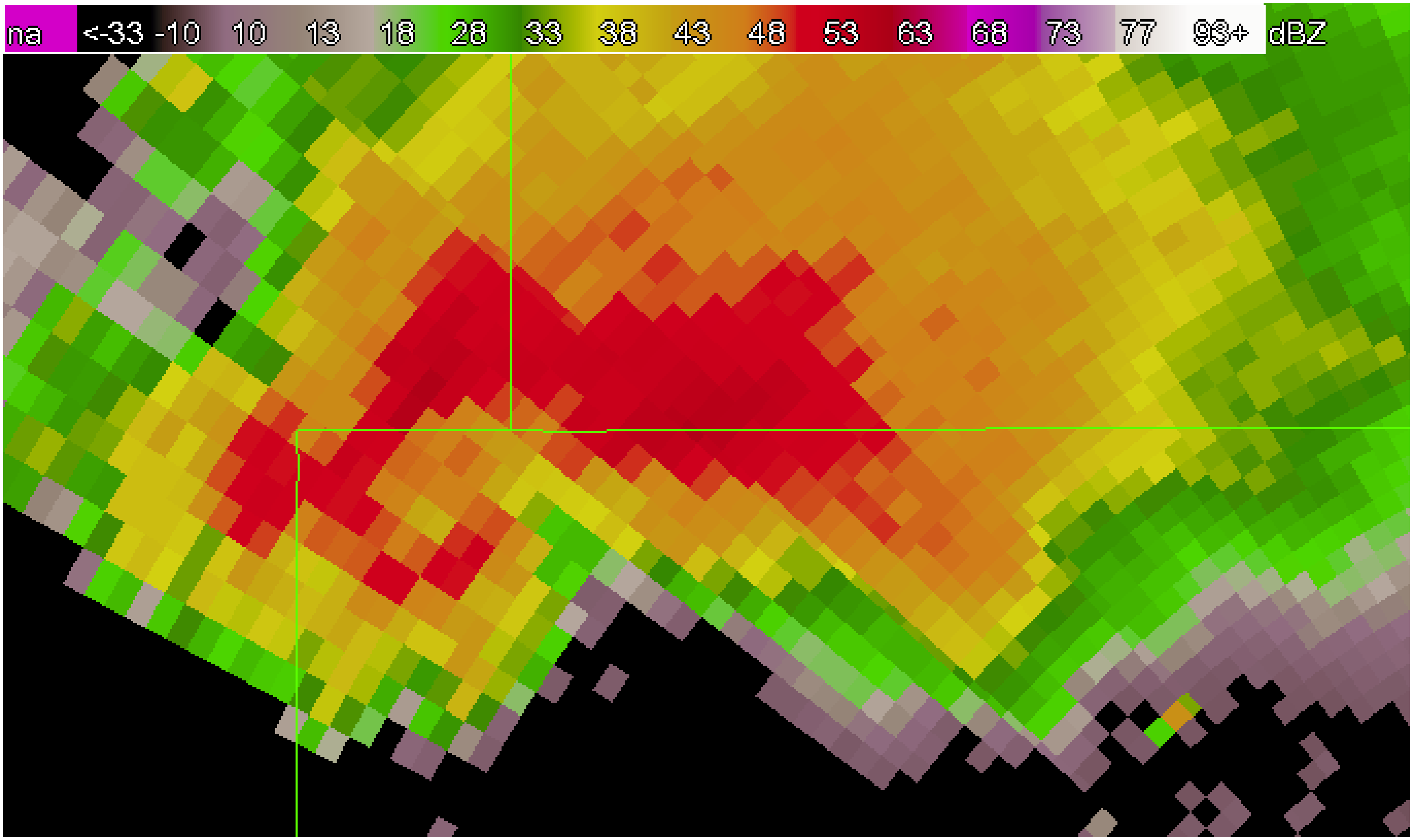
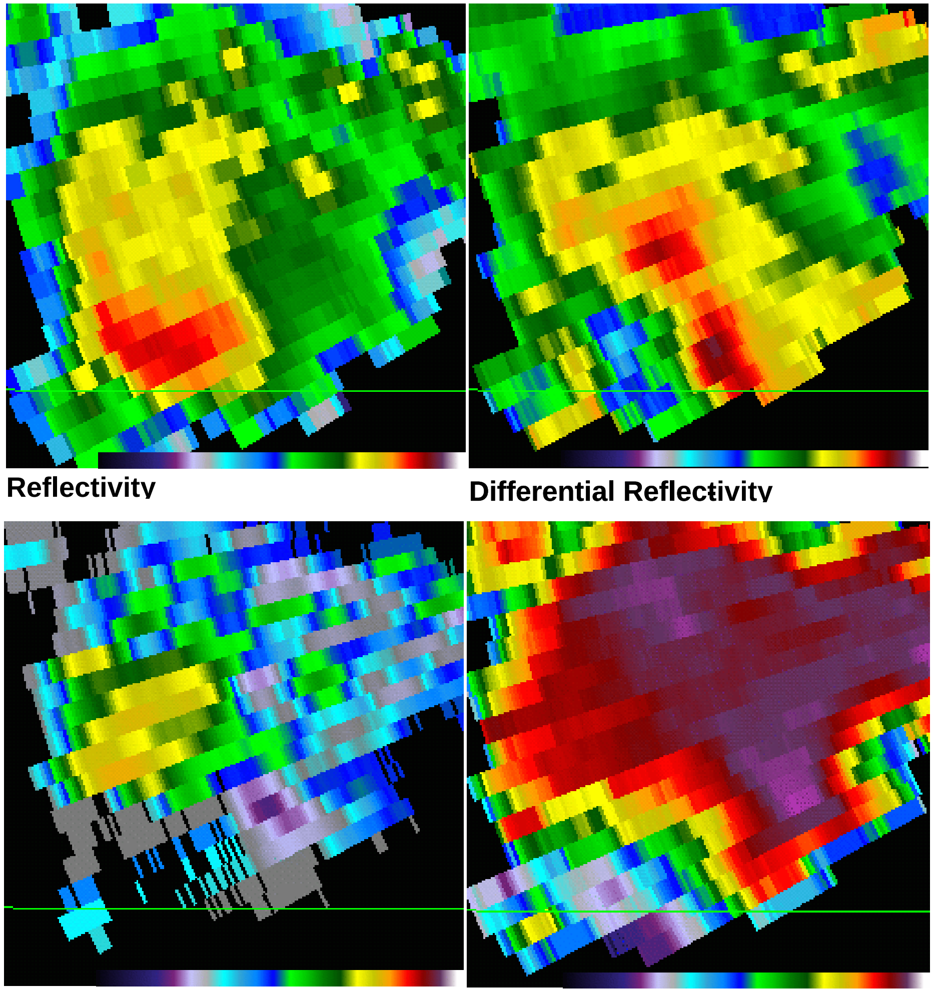


Figure 9 - Standard Resolution (1 km by 1 deg) Reflectivity for Tornadic Storm at Range 86 km



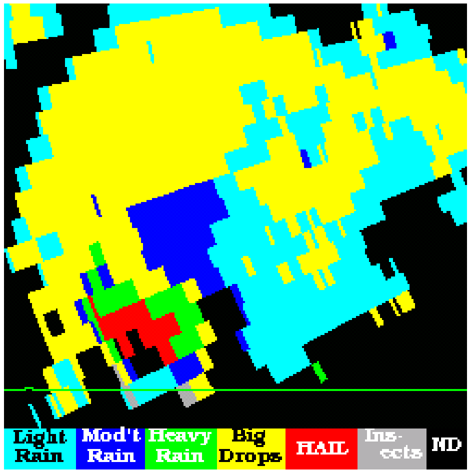
Reflectivity

Differential Reflectivity

Specific Differential

Correlation Coefficient

Figure 10 - Polarimetric Moments and Hydrometeor Classification

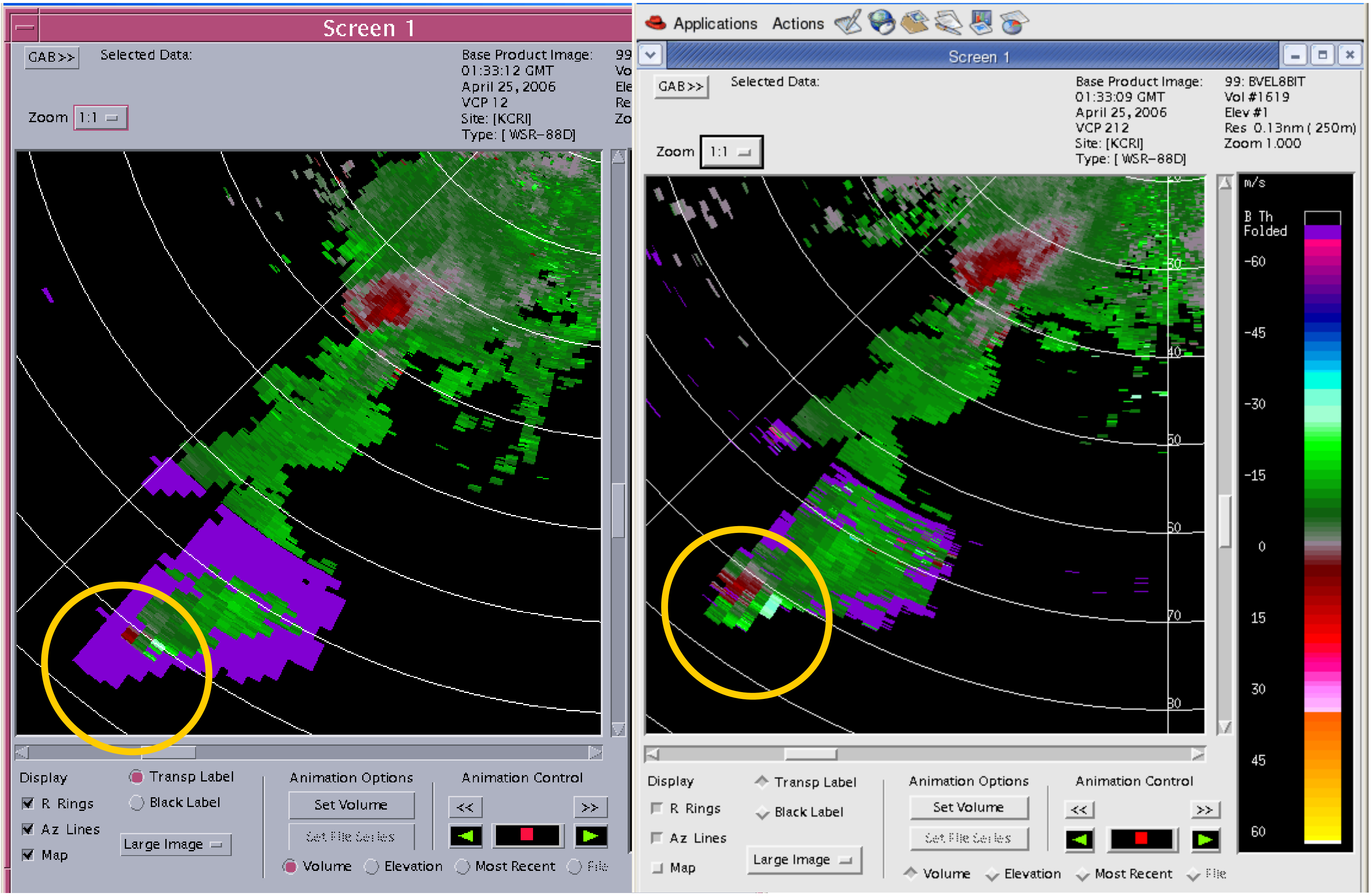


Hydrometeor Classifi-

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)

KTLX “12” 0133Z KCRI “212” 0133Z



Selected Data:

Base Product Image:
01:33:12 GMT
April 25, 2006
VCP 12
Site: [KCRI]
Type: [WSR-88D]

99
Vo
Ele
Re
Zo

Selected Data:

Base Product Image:
01:33:09 GMT
April 25, 2006
VCP 212
Site: [KCRI]
Type: [WSR-88D]

99: BVEL8BIT
Vol #1619
Elev #1
Res 0.13nm (250m)
Zoom 1.000

Figure 11 – SZ-2 (right image) recovery of velocity information in the area of a rotation couplet, compared to current processing (left image).

Denver WSR-88D Refractivity

Evolution of moisture along the stationary convergence zone

25 August 200

16:07-20:32 UT

~30 min interval

Denver
WSR-88D

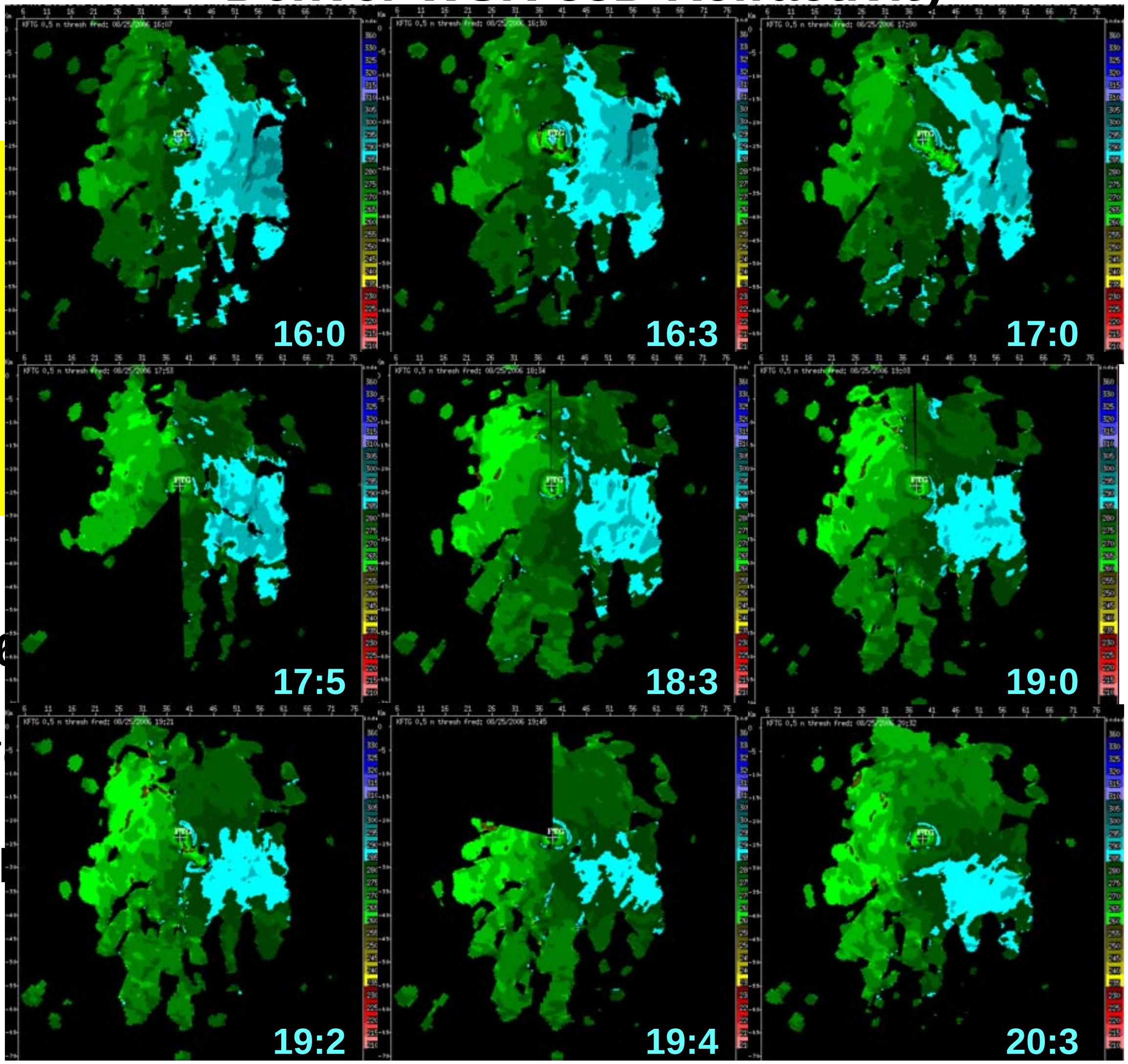


Figure 12 – Moisture information derived from WSR-88D refractivity measurements (Rita Robert, NCAR).