5.3 NWS Use of FAA Radar Data – Progress and Plans

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1. INTRODUCTION

In the late 1990s, the National Weather Service (NWS) began a joint venture with the Federal Aviation Administration (FAA) to explore the feasibility of using weather radar information from several types of operational FAA radars (Saffle, 2000).

Benefits to the NWS by using FAA weather radar data to complement Weather Surveillance Radar – 1988 Doppler (WSR-88D) data were identified as follows and plans were formed (Saffle, 2001):

- Backup data during WSR-88D outages,
- Low-altitude information at longer ranges of the WSR-88D,
- Improved coverage in the WSR-88D cone of silence,
- Data in areas of incomplete WSR-88D coverage (e.g., where there is beam blockage or ground clutter),
- Different viewing perspectives on storms to better sample radial velocity maxima and storm morphology,
- Improved quality control of WSR-88D data for such problems as anomalous propagation,
- Potential mitigation of obscuration of storms due to range folded echos,
- Improved "best information" mosaics,
- Improved precipitation estimates,
- Facilitate multiple Doppler analyses to provide rectilinear wind fields.

The NWS continues to collaborate with the FAA on projects to ingest data from several FAA radars: Terminal Doppler Weather Radar (TDWR), Air Route Surveillance Radar – Model 4 (ARSR-4) and Airport Surveillance Radar – Model 11 (ASR-11). The characteristics of each of these FAA radar systems are described by Stern (2003). The NWS Office of Science and Technology (OST) developed World-Wide Web server systems which have generated product images from these FAA radars and provided products to selected Weather Forecast Offices (WFOs) for the past four years (DiVecchio, 2003). The NWS has demonstrated that weather data from FAA radars could complement the WSR-88D network.

Recent progress using data from these systems varies by radar. The FAA has implemented changes to the ARSR-4 to improve the detection of low altitude weather. The ASR-11 in Erie, PA was accepted by the FAA and the proof-of-concept demonstration was begun. The new Linux-based TDWR Web server was deployed to additional sites. Most significantly, the NWS will nationally deploy the TDWR Supplemental Product Generator (SPG) described by Istok (2004) to provide TDWR data into the Advanced Weather Interactive Processing System (AWIPS) in a way that allows it to be displayed and fully integrated along with WSR-88D and other weather data. Deployment will begin in the spring of 2005 using AWIPS Operational Build 5 (OB5) software.

This paper will provide an overview, status, and future plans for each of these projects. Examples of current TDWR data products will be presented, along with planned product enhancements.

2. TDWR

The FAA operates 45 TDWRs near many of the largest U.S. airports (see Figure 1). These C-

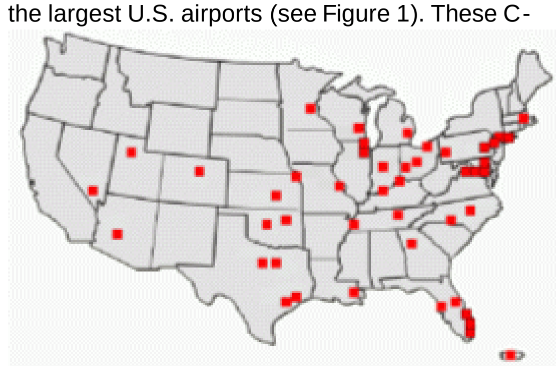

Figure 1 TDWR Site Locations

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band Doppler weather radars provide data similar to the WSR-88D, but at higher spatial and temporal resolution and with different antenna scan strategies. The TDWR automatically changes between two main scan modes, Monitor mode and Hazardous mode, when TDWR algorithms detect a potential hazard near its associated airport. In both modes the scan pattern begins with a long-range (248 nautical mile--nmi), low pulse repetition frequency (PRF), reflectivity-only scan which is used by TDWR algorithms to flag multiple trip echoes. The remaining scans provide reflectivity and Doppler data to the normal (short) range (48 nmi) of the TDWR. In Monitor mode, after the initial three low level scans, the elevation angle consistently increases up to a maximum angle of 60 degrees. However, in the Hazardous mode the TDWR makes a low elevation scan (less than one degree) once per minute and repeats a sequence of aloft scans every three minutes. Figure 2 shows the Hazardous mode scan pattern for the Baltimore-Washington International airport (BWI) TDWR.

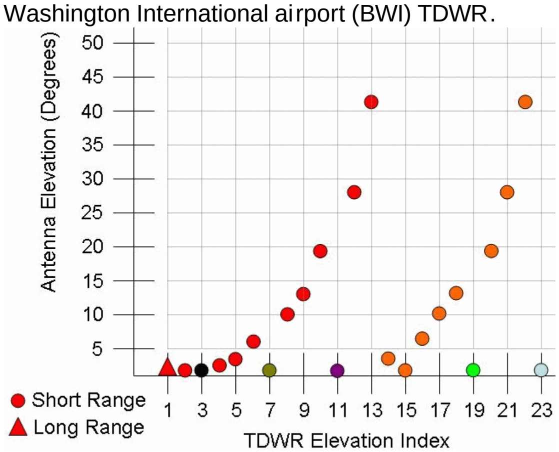

Figure 2 TDWR Hazardous Mode Scan

The TDWR provides reflectivity and Doppler base data at a resolution of one degree azimuth by 150 meters in range. However, the range resolution at the long range, low PRF scan, is 300 meters.

2.1 TDWR Web Server

To demonstrate the utility of TDWR data at WFOs, the NWS OST-developed Web server ingests TDWR base data to generate image files which are viewable from a Web browser. In 2003, the Web server was ported from Solaris to a PC-based Linux platform and enhanced as described by Stern (2004). It is currently in use at the Sterling, VA, Salt Lake City, UT, Phoenix, AZ, Las Vegas, NV, and Greenville-Spartanburg, SC WFOs. The Web server provides reflectivity and velocity base data images for several elevation angles, looping, zoom, cursor readout, and 31-day archive of image files. The user interface is available directly at the Web server and also from the AWIPS Netscape browser, if the Web server is located within the AWIPS network.

A potential new use was found for the TDWR Web server during the onslaught of hurricanes in Florida during 2004. As Hurricane Frances approached Florida, it appeared that the Miami WSR-88D would not be repaired in time after being damaged by an earlier lightning strike. Emergency plans to send a fully customized Web server to the Miami WFO and use a South Florida TDWR as backup were implemented. Shipping of the system was halted at the last minute when personnel in Miami indicated that the WSR-88D would be operational for the landfall.

With the visibility of this new capability, until TDWR SPG is fully deployed, the NWS has subsequently begun compiling plans, equipment and procedures so that customized TDWR Web servers could be quickly sent to a WFO in the event of a failure to a WSR-88D.

2.2 SPG System Development

The TDWR SPG is a system that was introduced by Istok (2004). The SPG ingests TDWR base data and generates products following WSR-88D Interface Control Document (ICD) formats. Using the Common Operations and Development Environment (CODE) (Ganger, 2005), WSR-88D Open Radar Products Generator (ORPG) software was used to develop the SPG. The intent of the SPG is to generate and provide products to AWIPS for display and integration with other weather data. Since the SPG provides products to AWIPS in the same method and format as products are currently provided from the WSR-88D, many of the capabilities available in AWIPS D2D for WSR-88D products will be available for TDWR SPG products. Initially, the SPG will just provide TDWR base products. However, additional algorithms and products will be incorporated in subsequent SPG software builds. Additional engineering details on the SPG are provided by Stern (2005).

The NWS has approved the TDWR SPG system for operational development. AWIPS software changes required for the TDWR SPG are included in AWIPS OB5. Beta testing of SPG is scheduled to begin in March 2005 with full deployment beginning in May 2005 and continuing through September 2006.

The NWS will develop and deploy TDWR SPG systems to WFOs. Once the deployment has completed, Operations and Maintenance (O&M) of SPG systems will be transferred to the Radar Operations Center (ROC), a tri-agency (NWS, FAA, and Department of Defense--DoD) organization with support costs provided by NWS.

2.2.1 SPG System Architecture

The SPG system consists of ORPG software that is tailored to characteristics of the TDWR, a little-endian PC processor, the Linux operating system, and T1 ingest communications equipment.

The SPG system will be on the AWIPS Local Area Network (LAN). The SPG was developed using Linux CODE which was based on the official source code release of WSR-88D RPG Build 6. The SPG will be installed in a standalone cabinet, using an AWIPS equipment rack. The rack space will become available as a byproduct of the AWIPS DX server upgrade.

2.2.2 TDWR and WFO Sites

SPGs will be deployed to WFOs which have TDWR radars within their County Warning Area (CWA). The 45 operational TDWRs will be provided to 34 WFOs. Multiple TDWR SPG systems will be provided to WFOs where the CWA includes more than one TDWR (e.g., Washington D.C., Miami, New York City, Chicago, and others). Initially, SPG products will only be available to the associated WFO. However, repeating multiple one-time product requests (RMR) from a non-associated WFO will be provided in a subsequent software release.

2.2.3 Products and Capabilities

The SPG will provide base reflectivity, velocity, and spectrum width products in both standard (4-bit) and full resolution (8-bit) format. The spatial and temporal resolution of the TDWR data is preserved in the SPG products. That is, the shorter range scans contain a resolution of 150 meters per gate while the long range reflectivity-only scan has a resolution of 300 meters. To take advantage of the 80 meter/second velocity threshold of the TDWR, SPG-generated velocity products will use a one meter/second resolution. The typical value used in the WSR-88D is a half meter/second resolution.

Within the six-minute hazardous mode scan pattern, time stamps of the base data products will vary to distinguish between the repeating scans at the same elevation angle. In figure 2, this is represented by the color of the dots which represent the hazardous mode elevation scans. Products at scans having the same color will have the same time stamp and time will increase by one-minute for each new color.

The AWIPS capabilities for SPG TDWR products are consistent with those provided for WSR-88D products but simpler because of the reduced product suite. The capabilities include routine and one-time product request, zoom, data sampling, image combine/fade, time and all-tilt loops, TDWR and WSR-88D mosaic, storm relative velocity, VR shear, and local AWIPS archive. Figures 3 through 5 provide examples of TDWR SPG products displayed on AWIPS D2D.

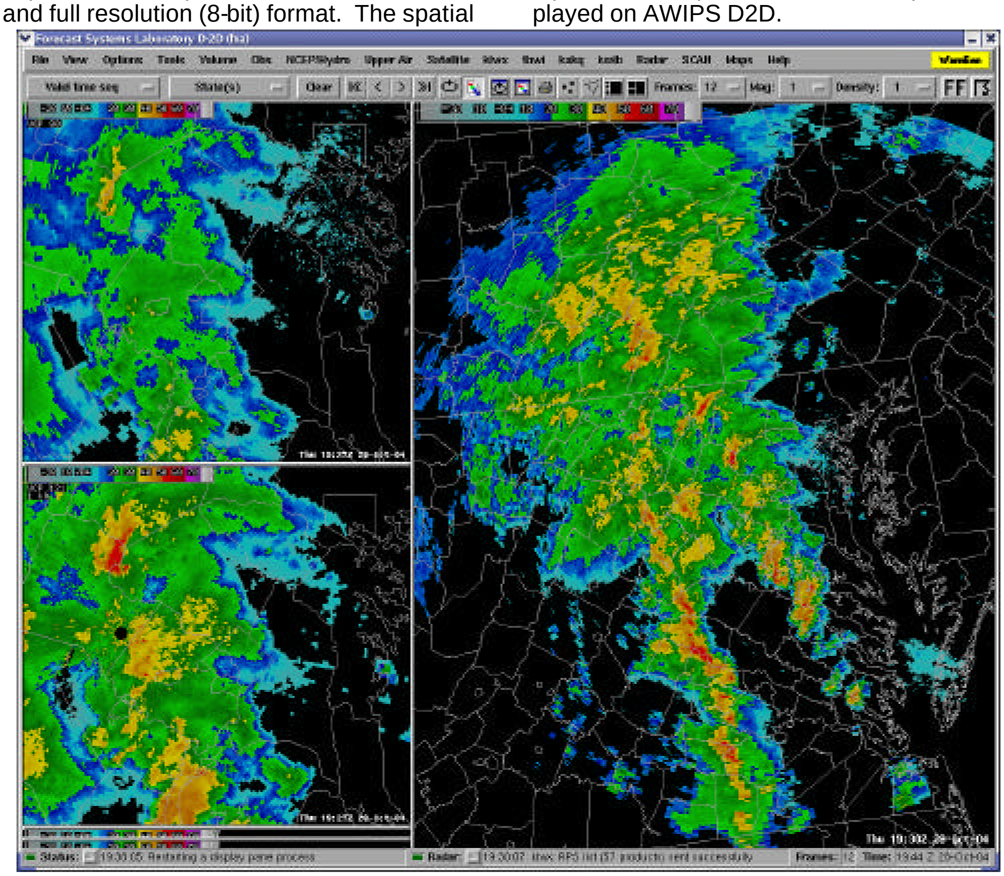

Figure 3 AWIPS D2D 8bit mosaic of WSR-88D and Long Range TDWR Reflectivity in main panel with small panels containing Reflectivity of the same storm viewed separately by WSR-88D and TDWR

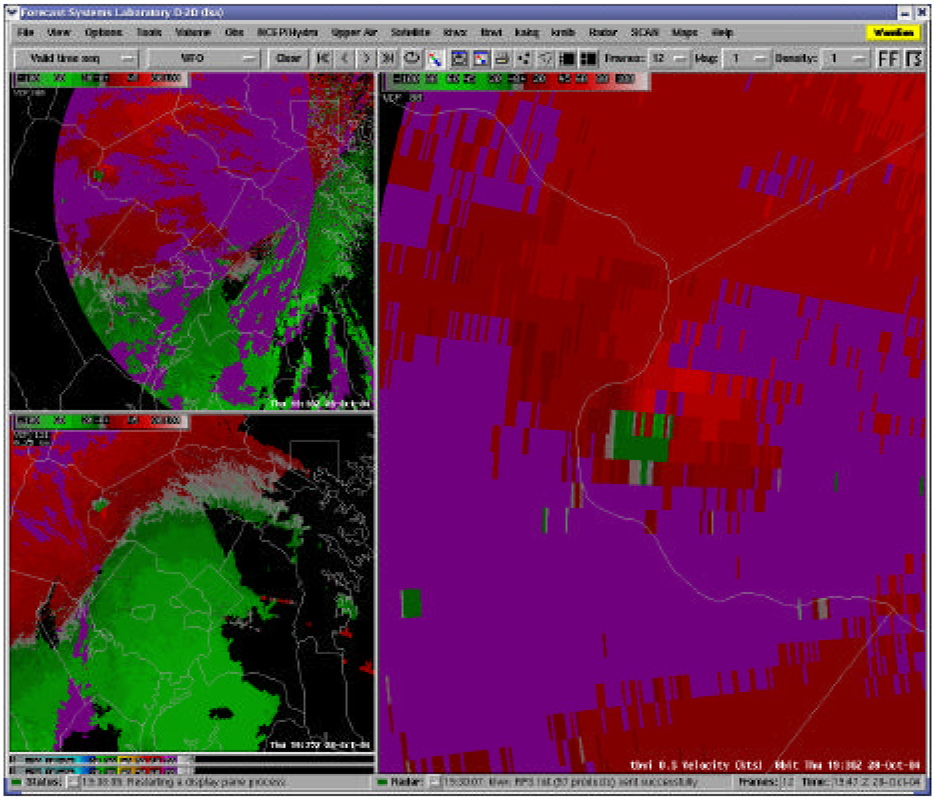

Figure 4 Magnified 8bit TDWR Base Velocity Product in main panel with small panels containing Base Velocity of the same storm viewed separately by WSR-88D and TDWR

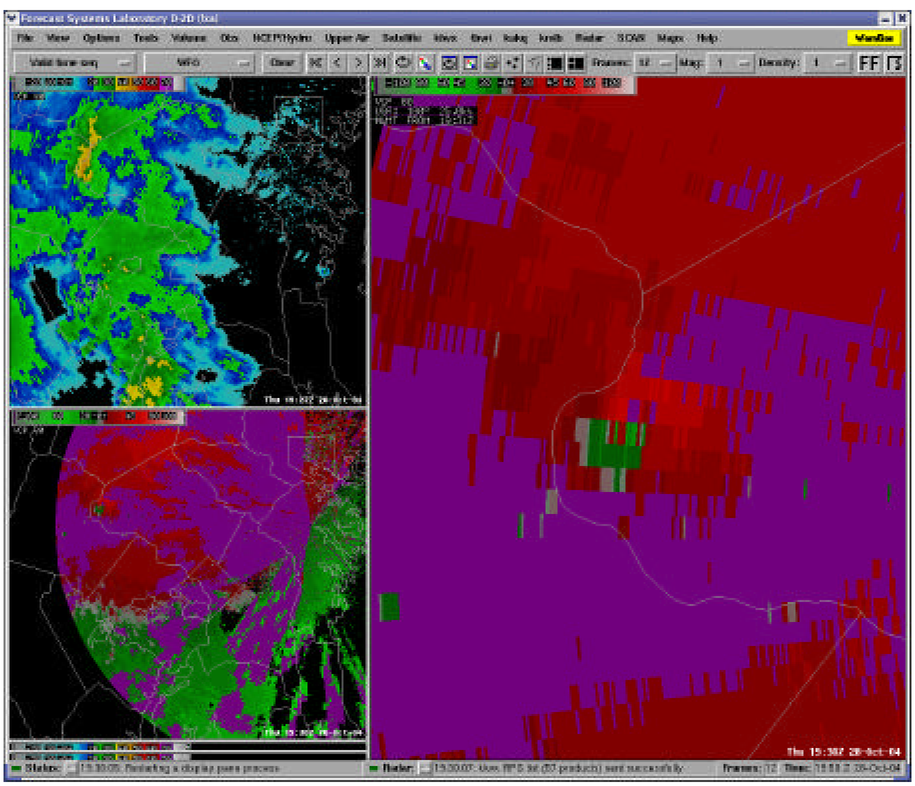

Figure 5 Magnified 8-bit Storm Relative TDWR Velocity Product in main panel with small panels containing TDWR base reflectivity and velocity of the same storm (data from 17 Sept 2004 2230Z)

2.2.4 Future Plans

The capabilities described above provide a foundation for future growth. Algorithm and products which may be easily adapted to TDWR data include composite reflectivity, VIL and VAD algorithms. Areas that require more significant effort to optimize the NEXRAD algorithms to the TDWR data resolution include: storm cell identification and tracking, mesocyclone and tornadic vortex detection, and rainfall accumulation. Additional possible enhancements include: adapting AWIPS SCAN to TDWR products, central collection of products and/or base data, and multiple Doppler radar algorithms.

3. ARSR-4

The ARSR-4 is a long-range surveillance radar system, capable of detecting aircraft at a range up to 250 nmi. There are 43 ARSR-4 units deployed around the periphery of the continental United States as well as Hawaii and other U.S. territories (Figure 6).

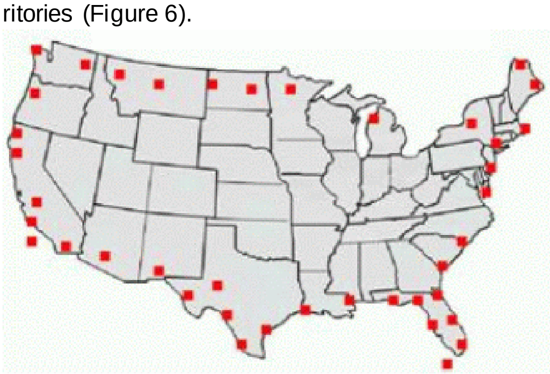

Figure 6 ARSR-4 Site Locations

The ARSR-4 utilizes a 60-foot diameter, L-Band, phased-array antenna, that generates 10 beams which are divided into the upper or “high stack” and the lower or “low stack”. The low stack array contains a weather channel which provides a six-level reflectivity map based on the NWS DVIP (Digital Video Integrator and Processor) standard (US DOC, 1981).

The ARSR-4 reflectivity map is similar to the WSR-88D hybrid scan reflectivity product. That is, at near-in ranges, the highest beam (in the low stack) is used, followed by the next lower beams at middle ranges, until finally the lowest beam is used at longest ranges. An example of this scheme can be seen in Figure 7.

The beam width of the ARSR-4 is 1.41 degrees in the horizontal and 2.2 degrees in the vertical. The range resolution is 0.25nmi out to a range of 250 nmi. The reflectivity information is updated every 36 seconds.

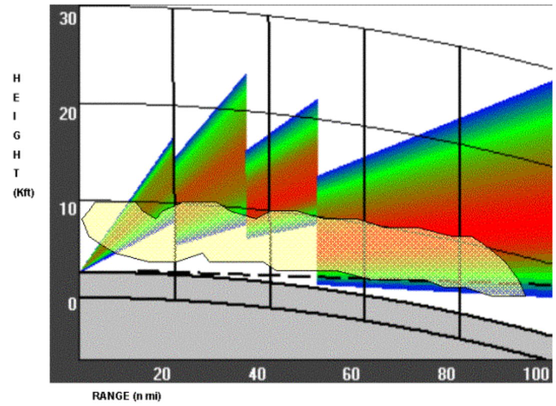

Figure 7 Switch Range Setting Before 2004

3.1 Products and Capabilities

A proof-of-concept project to evaluate NWS use of the ARSR-4 radar has been underway in North Dakota since 1999 (Saffle, 2001). In 2001, the FAA completed modifications to the Watford City, ND ARSR-4 to provide six-level NWS DVIP output. Using an NWS OST developed Web server, ARSR-4 data was assessed at the Bismark, ND WFO during the winter of 2001-2002. Evaluation concluded that the range thresholds used by the ARSR-4 to switch beams were not optimal for low altitude precipitation detection. In 2004, the FAA completed modifications to the ARSR-4 to provide a new set of thresholds and evaluation of ARSR-4 with this new “Switch Range” setting is planned for the 2004-2005 winter season (see Figure 8). Comparing Figures 7 and 8, notice that the red-colored center of each beam used to create reflectivity products now intersects the layers of snow (depicted as yellow hatching) that typically occur between 5,000 and 10,000 feet..

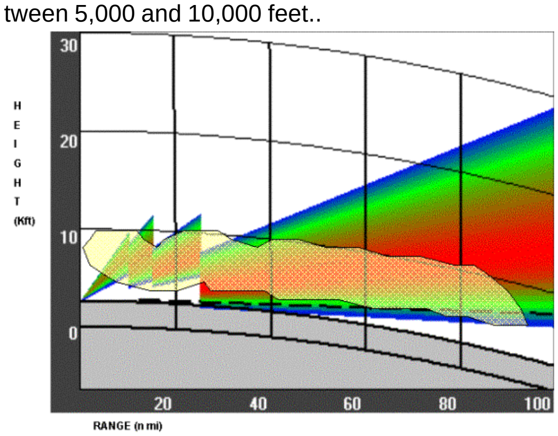

Figure 8 New ARSR-4 Switch Range Setting

The ARSR-4 Web server display system generates reflectivity image files from ARSR-4 base data and provides user access to the images from a browser. Reflectivity data is provided out to a range of 125 nmi and at a resolution of one-quarter nmi in range and 1.41 degrees in azimuth. Images are updated every minute. Time looping of reflectivity images is provided along with data sampling, 14 day archive of image files, system status, and a user manual. Example images from the ARSR-4 web server are provided by Saffle (2001), Stern (2002), and Stern (2003).

3.2 Williston, ND Evaluation Objectives

The objective of the 2004-2005 Williston demonstration is to evaluate the utility of ARSR-4 data using the new switch range settings in NWS winter weather operations in the Williston area, particularly for heavy snow events occurring with low altitude storm tops.

3.3 Future Plans

Similar to the SPG approach being followed for TDWR data, the NWS plans to develop the capability to generate radar products from ARSR-4 data in a form which can be displayed in AWIPS D2D and integrated with WSR-88D radar data and other types of weather data. A six-level reflectivity product could be generated as often as every 36 seconds at a spatial resolution of one-quarter nmi in range by 1.41 degrees in azimuth extending out as far as 250 nmi.

After testing the new switch range setting in North Dakota, the FAA will deploy the new ARSR-4 software, containing the NWS 6-level output and the new switch range scheme, to all radars, which will allow the NWS to use ARSR-4 data from other sites. Immediate benefits will be realized from radars in locations such as Washington State, to complement WSR-88D coverage west of the Cascades.

4. ASR-11

The ASR-11 is a solid-state, S-Band, terminal area air traffic control radar. The FAA and the DoD are currently deploying the ASR-11 at over 200 airports (Figure 9) serving smaller metropolitan areas and military airfields (Raytheon, 2002).

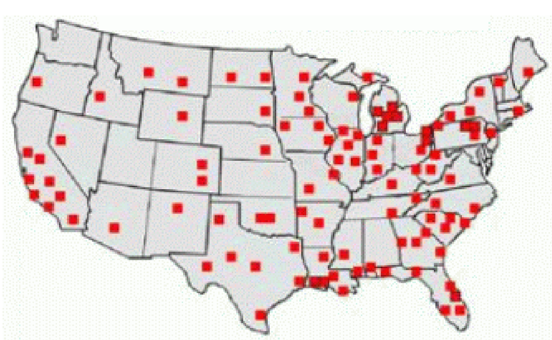

Figure 9 ASR-11 Site Locations

The ASR-11 employs a fan beam antenna with the following dimensions: 1.41 degrees in the horizontal by 4.8 degrees in the vertical. The antenna rotates at 12 RPM and generates a six-level reflectivity map based on the NWS DVIP standard every 30 seconds. The coverage range extends to 60 nmi at a resolution of one-half nmi.

4.1 Products and Capabilities

The ASR-11 Web server display system is modeled after the ARSR-4 Web server. Figure 10 shows a sample image from the Erie, PA ASR-11 Web server. The Web server includes looping, data sampling, 14 day archive of image files, system status, and a user manual.

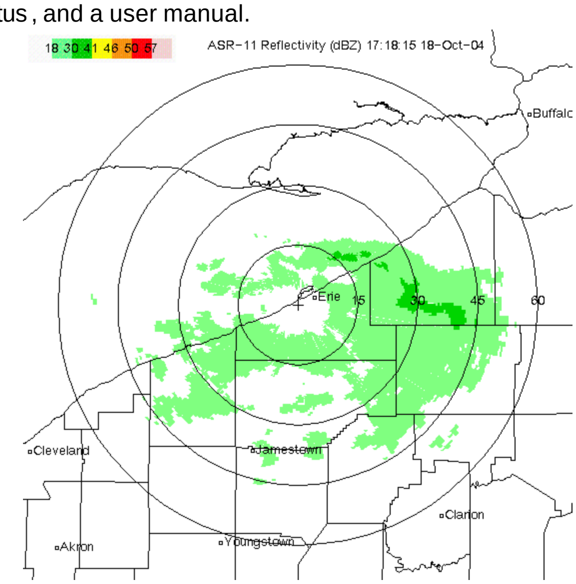

Figure 10 Erie, PA ASR-11 Reflectivity Image

Reflectivity images are provided at one-minute updates which extend out to 60 nmi. The reflectivity data is based on the six-level NWS DVIP standard. The Web server includes looping, data sampling, 14 day archive of image files, system status, and a user manual.

4.2 Erie, PA Evaluation Objectives

The ASR-11 Web server is installed at the Cleveland WFO using data from the ASR-11 in Erie, PA. The FAA accepted this new radar during the summer of 2004. The objectives of the 2004-2005 Erie demonstration are to evaluate the utility of ASR-11 data in NWS lake-effect snow operations in the Erie area, and to determine if the ASR-11 data can replace the Erie WSR-74C data for lake-effect snow.

4.2 Future Plans

As described for the ARSR-4 and TDWR, the NWS plans to develop the capability to generate radar products from ASR-11 data in a form that can be displayed in AWIPS D2D and integrated with WSR-88D radar data and other types of weather data. A six-level reflectivity product would be generated as frequently as every 30 seconds at a spatial resolution of one-half nmi by 1.4 degrees in azimuth with a maximum range of 60 nmi.

Since processing requirements for ARSR-4 and ASR-11 products are modest, it is planned that the SPG could generate them along with the TDWR products for sites with access to multiple types of radar

5. SUMMARY

The NWS continues to make progress on incorporating FAA radar data into NWS operations. The three radar systems discussed provide frequent data updates and are located in areas which can provide complimentary information to WSR-88D data. Radar data assessment projects are in progress for the ARSR-4 at the Bismark, ND WFO and for the ASR-11 at the Cleveland, OH WFO. In 2005, the NWS will begin deploying the SPG system, which when combined with AWIPS OB5 will provide to NWS forecasters TDWR data which is fully integrated with other weather data and the full suite of AWIPS user capabilities.

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