5.6 The AWRP's Advanced Weather Radar Product Development Team

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1. Introduction

The Federal Aviation Administration (FAA) Aviation Weather Research Program (AWRP) recently reorganized what had been the NEXRAD Enhancements product development team (PDT) into the Advanced Weather Radar Techniques (AWRT) PDT. This reorganization extends the weather radar arm of AWRP beyond WSR-88D-only applications to include any appropriate radar system, including the Terminal Doppler Weather Radar and the ASR-9 radar, as well as experimental systems and techniques that directly support other AWRP activities. The AWRT now consists of four major laboratories: the National Oceanic and Atmospheric Administration's National Severe Storms Laboratory and Environmental Techniques Laboratory, the National Center for Atmospheric Research's Research Applications Program, and the Massachusetts Institute of Technology Lincoln Laboratory.

The AWRT primary mission is to develop and apply new and advanced techniques to data from various radar platforms for the benefit of the aviation community. This mission requires that the AWRT work with the FAA and other PDTs to help identify specific weather-related problems faced by the FAA and National Airspace System (NAS) for which weather radar may provide enhanced utility. The AWRT then assesses the current state of the science and performs any additional necessary research on these problems. The end result is an interim product, application or technique that is usually used to develop an end-user product by another AWRP PDT.

As such, the AWRT mission in practice tends to serve other PDTs instead of end users, and so may be properly viewed as a PDT that provides infrastructure to the rest of the AWRP PDTs that have direct responsibility to end users. The AWRT is not unique within the AWRP in this respect, sharing such a role with the Model Development and Evaluation PDT. Other PDTs perform this function as well, as a secondary activity.

Because the AWRT PDT spans four organizations, leadership responsibilities have been distributed among the four organizations (Fig. 1). So far, AWRT PDT research and development efforts directly influence the Model Development and Evaluation, In-Flight Icing, Winter Weather, Turbulence PDTs, along with the National Convective Weather Forecast part of the Convective Weather PDT.

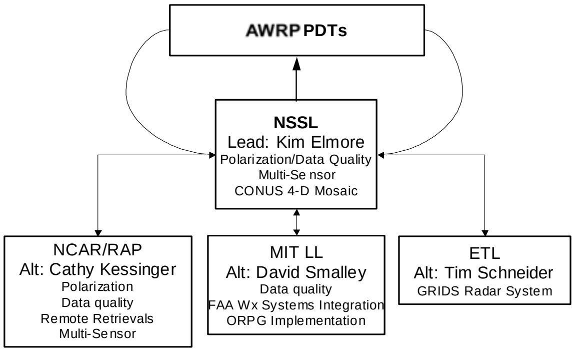

Figure 1. Organization and responsibility of the AWRT PDT.

2. Current Activities

Specific activities within the AWRT PDT are many and diverse, but all share the common link to radar and radiometric remote sensing.

2.1 Polarization

Among the most appealing benefits to aviation users is the data quality improvement available from polarimetric radar over conventional radar. No other technique can match the ability to discriminate between meteorological and non-meteorological returns that polarimetric radars provide. Ground clutter, sea clutter and anomalous propagation are particularly amenable to mitigation through polarimetric techniques, even within precipitation echoes. Various other non-meteorological scatterers can be both categorized and eliminated. For example, biological scatterers can be categorized as ornithological (avian) or entomological (insect), and independently filtered from display, analysis and processing. This capability will enhance the data quality of the Velocity Azimuth Display (VAD) winds, which are commonly contaminated by birds during migratory seasons. Conversely, under certain circumstances, avian echoes might provide useful safety-of-flight information to controllers in high-traffic areas prone to bird strikes. In certain regions, notably the southwestern areas, chaff occasionally poses a major radar echo contaminant. Since chaff moves with the wind, sometimes

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has significant vertical extent, and can generate reflectivity values above 40 dBZ, current mitigation methods are ineffective (Figs. 2 and 3). Fortunately, chaff echoes possess clear polarimetric signatures that make removal straightforward.

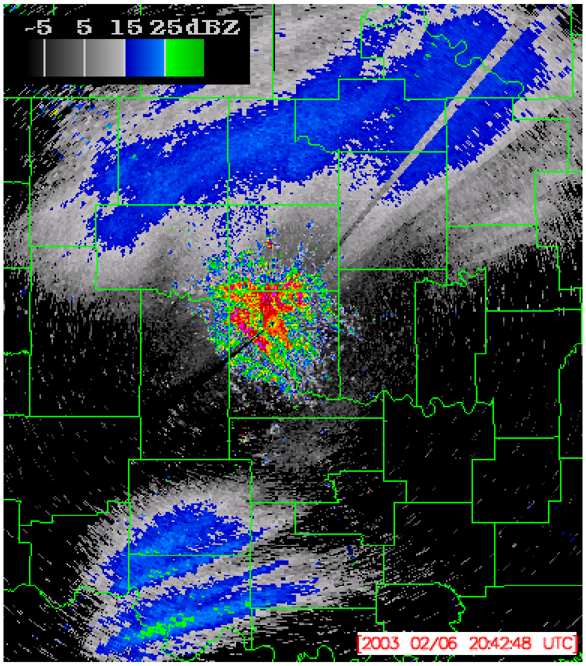

Figure 2. Reflectivity for 6 Feb 2003.

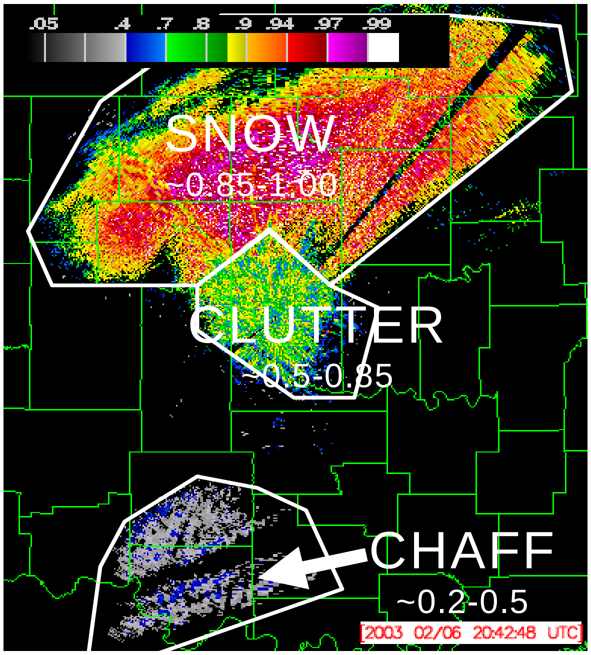

Figure 3. Cross polarization correlation signatures for the reflectivity in Fig. 2.

Polarization work targets several specific areas: discrimination between meteorological and non-meteorological scatterers (including discrimination between birds, insects, chaff, and anomalous propagation), mixed-phase cloud identification, convective updraft signatures, turbulence polarimetric signature detection, freezing level detection, winter precipitation quantification, and freezing rain detection. Additional insight into the AWRT polarization work may be found in Brandes and Ryzhkov (2004), Giagrande and Ryzhkov (2004), Giagrande et al. (2004), Ikeda et al. (2004), Scharfenberg et al. (2004), Scharfenberg and Lakshmanan, (2004), and Zhang et al. (2004).

2.2 Circulation Detection Development

FAA interests can benefit from accurate detection of severe weather signatures such as circulations (mesocyclones). Higher than acceptable false alarm rates associated with the current generation of algorithms detecting these signatures has made their use dubious. The FAA does not typically have a human-in-the-loop to make a value judgement regarding the validity of a severe weather detection. To mitigate this problem, new, more robust and reliable circulation detection algorithms based on a local 2-D linear least squares technique (LLSD, Smith and Elmore, 2004) are being developed. Algorithms that use circulations to diagnose storm severity or estimate storm longevity will be considerably improved by this work (Fig. 4).

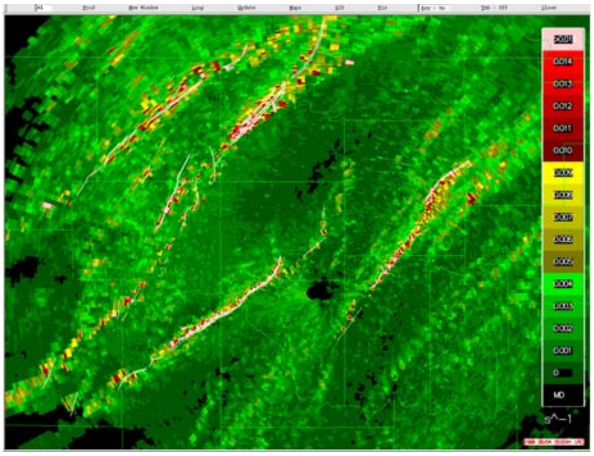

Figure 4. 8 h LLSD accumulated rotation field for May 3, 1999, showing the tracks of vortex centers. Tornado damage tracks are shown as white contours.

2.3 3D National Mosaic

Over the past few years, the AWRT PDT has developed a fully 3D gridded radar reflectivity product. As of 2004, this product now covers the entire CONUS. This 3D mosaic incorporates 154 WSR-88D radars into a unified Cartesian grid that encompass the CONUS from 65ºW to 128ºW in longitude and from 20ºN to 50ºN in latitude. The CONUS 3D mosaic grid has a 1 km x 1 km horizontal spacing with 21 vertical levels starting at 1 km MSL and extending to 17 km MSL. The vertical resolution of the 3D grid below 5 km MSL is 500 m and 1 km above. The CONUS 3D mosaic product cycle updates every 5 minutes.

The 3D CONUS mosaic represents a fundamental paradigm shift in how WSR-88D base-level data are treated and used. While there are examples of using a subset of networked WSR-88Ds for specific tasks or display purposes, this CONUS mosaic holds a unique position in that it is intended to provide a 3D/4D mosaic of the raw WSR-88D data as one network as an end product instead of as individual radars that will be used as a basic data source by other applications. Such an approach has many benefits. The National Convective Weather Forecast portion of the Convective Weather PDT, Winter Weather, In-Flight Icing and Model Development and Evaluation PDTs all have clearly-stated needs for treating the raw WSR-88D data as one network that must be combined for optimal utility.

In the current configuration, all data are ingested at the Center for Analysis and Prediction of Storms (CAPS) and processed on a 15 dual-processor node Linux cluster. The grid is broken into 19 tiles (Fig. 5) to facilitate the parallel nature of the task. More details on the 3D National Mosaic may be found in Langston et al. (2004), Langston and Zhang (2004), Zhang et al. (2004a), Zhang et al. (2004b), and Zhang and Wang (2004).

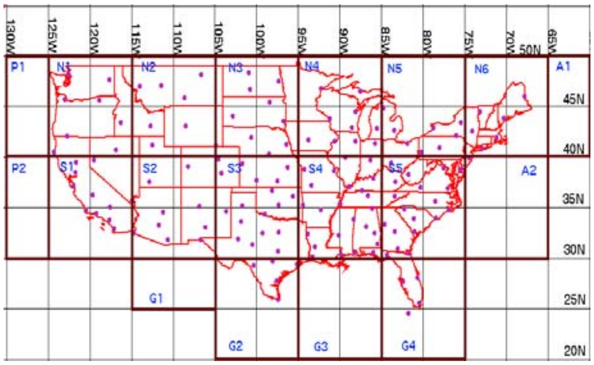

Figure 5. The CONUS domain for the 3D national radar mosaic. The dark red lines delineate the tiles used for processing the national mosaic.

2.4 WARP Support

The Weather And Radar Processor (WARP) is integral to air traffic controller displays. New to controller displays is that WARP uses a radar designed specifically for weather applications. Prior to this, the long-range L-band surveillance radars had been used for weather return display. However, due to the nature of its mission and hardware, the WSR-88D cannot take the same approaches to data quality control as do the long-range L-band radars currently used by air traffic control. New approaches to data quality control need to be developed so the users have confidence in the weather data products displayed to them. Porter (2004) contains examples of current progress.

3. New Tasks for 2005

3.1 GRIDS

To have all weather-radar work within a single PDT, work on the NOAA ground-based remote icing detection system (GRIDS, Schneider, et al., 2004) radar will be moved from within the In-Flight Icing PDT to the AWRT PDT. The GRIDS system has potential applications in the Ceiling and Visibility PDT, the Turbulence PDT, model parameterization development in the Model Development and Evaluation PDT, and may be useful as a baseline for other operational instruments, such as satellite and the WSR-88D. GRIDS evolved out of early experimentation and development at the Environmental Technology Laboratory that applied microwave radiometry and short wavelength radars to cloud studies. After some preliminary work, one obvious conclusion was that this instrumentation clearly had much to offer the in-flight icing community. GRIDS eventually found a home in the AWRP program's In-flight Icing PDT in 2001. After four productive years, in fiscal year 2005, the GRIDS product will be combined with the other AWRP radar research efforts in the AWRT PDT. While the primary focus of the GRIDS project will remain in-flight icing, this realignment will permit the GRIDS project to explore supporting other aviation weather research efforts.

3.2 Common Algorithms for ORDA

The WSR-88D (NEXRAD), Terminal Doppler Weather Radar (TDWR), the ASR-9 with the Weather Systems Processor (WSP), and the ASR-11 with its weather channel are the principal radars used for operational weather services by the Federal Aviation Administration (FAA). Traditionally, the collected data from these radars are analyzed and products produced from their respective radar product generators. With the WSR-88D soon scheduled to begin deployment of its Open Radar Data Acquisition (ORDA) unit, there will be a capability to share algorithmic techniques among the digital signal processors used by these open-systems radars upstream of the radar product generators (Cho et al., 2004). This provides the opportunity to transfer promising techniques developed for one radar platform's ORDA to the others' ORDAs to assess benefit individually or as a networked solution. The development of algorithms for Radar Data Acquisition units provides new opportunities to provide benefit from these FAA weather systems not possible previously.

These techniques will be beneficial in a number of important areas across the radar platforms. Through range-velocity (R/V) mitigation, the extent of quality Doppler data can be increased by using complementary techniques exploiting multiple PRFs or pulse phase coding within tilts or radials. Recently, practical refractivity (N) estimates have been retrieved from phase measurements on stationary ground targets utilizing S-band weather radar. Spatial depictions of the distribution of N estimated from radar provide a new, atypical approach with weather radar for the determination of boundaries since N relates to atmospheric temperature, pressure, and water vapor pressure. These boundaries may be particularly interesting for convective weather initiation applications.

Additional techniques of interest will yield data quality improvement in low signal to noise situations by applying adaptive dwell techniques. The detection of near-surface phenomena to farther ranges can be improved through the use of new surveillance scan strategies that utilize extra, low elevation angles and exploit overlapped tilts to estimate parameters in the lowest portion of the pulse volume. The ability to enhance the quality, range extent, and availability of new data benefit any FAA user of data from these radar platforms.

4. Acknowledgements.

This research is in response to requirements and funding by the Federal Aviation Administration (FAA). The views expressed are those of the authors and do not necessarily represent the official policy or position of the FAA.

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