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1. INTRODUCTION

The WSR-88D Radar Operations Center (ROC) has expanded the role of Level I data as a critical component to providing life-cycle support of the network of WSR-88D systems. WSR-88D Level I data is the recorded output of the digital receiver also known as time series or In-phase (I) and Quadrature (Q) or more commonly just I&Q data.

Time series data represents the most useful form of radar data for signal processing research (Ice, 2005). In addition to research, time series data is used to validate the implementation of signal processing changes, which increases the quality and minimizes potential issues during the transition from research to operations. Recorded time series data also allows testing of signal processing changes independent of limited test bed radar systems. Even when limited test bed radar time is available, desired weather conditions needed to test the signal processing change may not be occurring. Using recorded data removes these challenges.

Some of the major applications of recorded Level I data have included evaluating the effectiveness of the dual polarization upgrade, supporting research to operations efforts, and optimizing the radars' data quality. Some of the past changes to improve data quality and support research to operations include optimizing clutter filtering (Ice, 2007), range and velocity ambiguity mitigation (Saxion, 2005), mitigating ground clutter contamination (Ellis, 2003), and staggered PRT (Saxion, 2009).

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Level I data is currently being used in the development and implementation of Hybrid Spectrum Width and the Cross Polarization Power Technique. Future plans include implementing Wind Turbine Clutter Filtering which is being studied by the University of Oklahoma. Raytheon is using Level I data to create a wind turbine model.

2. LEVEL I RECORDING

The Level I recording system has had many changes since the initial implementation in the Legacy WSR-88D. Through the Data Quality MOU the ROC and National Center for Atmospheric Research (NCAR) collaborated to develop the Archive 1 Data Analyzer (A1DA) which captured the digital output of the Hardwired Signal Processor (HSP) (Saxion, 2011). This initial system provided the ability to record Level I data, but had limitations. Due to the size of the Level I data files and limited storage capacity at the time, it was only used in a limited capacity (Ice, 2005). Furthermore, the Legacy WSR-88D did not provide a playback capability (Rhoton, 2005).

From this initial Legacy A1DA system, the Open Radar Data Acquisition (ORDA) system upgrade provided a new platform to allow modern technology and further improvements to Level I recording. Initially, ROC engineering developed the Level I Record and Playback (LIRP) Utility to work on this new ORDA platform (Rhoton, 2005). In 2004 when the Vaisala/SIGMET Time Series Archive (TS Archive) utility became available, the ROC transitioned to this tool for recording data (SIGMET, 2004). One limitation of the SIGMET TS Archive utility was that it required a SIGMET license. This added licensing cost limited the number of available recorders. The ROC had two laptops that had licenses and were setup to record using the TS Archive utility. These laptops were used for recording data from forecasted weather events. The recorded data was sent to the National Severe Storms

Laboratory (NSSL) to be archived from which the data can be requested.

The Data Quality MOU continued to support Level I recording with the development of NCAR's standalone Ts2File application (Saxion, 2011). This enabled Level I data recording from all WSR-88D radars when it was added to the RDA Build 10.0 baseline. This application provided the capability to locally record 3 Volume Coverage Patterns (VCPs) from any WSR-88D network radar. The site operator could then burn the data to a DVD to be returned to the ROC for analysis.

During the dual polarization upgrade, one of the two Level I recording laptops was installed at the KOUN radar test bed to collect data for later engineering analysis. The second Level I recorder was installed at the KCRI single polarization radar test bed. Since these two radar test beds are located in close proximity, the Data Quality team was able to perform a quantitative sensitivity analysis between the Single Polarization KCRI and the Dual Polarization KOUN to determine the impact of splitting the transmitter power between the horizontal and vertical channels (Ice, 2010). The KOUN Level I data allowed engineers to examine and evaluate the raw data and provide feedback to the dual polarization contractors and ensure that the base moments remained unaffected by the upgrade. More recently Level I data was used by ROC engineers to test the RDA Build 13.0 reimplementation of the Clutter Mitigation Decision (CMD) processing which takes advantage of the new dual polarization variables.

To support ongoing data quality analysis efforts the recorders were setup for continuous recording. The increased demand for Level I data coupled with the continuous recording on two radars drastically increased the workload of managing the Level I recording systems.

In order to standardize the Level I laptops, improve maintainability and reduce licensing costs, three major areas were addressed. First, the recorders were upgraded to use the operating system common to all ROC maintained programs including the RDA baseline. This allows for a standard patch management plan to be applied simplifying the security update process. Second, the TS Archive utility was replaced with the Ts2File application. This removed the limitation of the license allowing for more than two recorders at any given time and provided greater control over maintenance and future enhancements. Finally, a new user interface was

developed to provide recording control and status monitoring. This improved interface also allows for the recorders to be controlled remotely provided that a remote access line is available. With the improved interface and written documentation, these recorders have been sent to the field and were easily controlled by the site technicians.

With the limitation of the number of recorders removed, and the increased work load of monitoring, maintaining, and saving data from two remote radars, redundant recorders were setup at the ROC feeding the Level I data from both KCRI and KOUN into the ROC through dedicated fiber optic cable. The dual polarization upgrade doubled the size of the Level I data files since horizontal and vertical pulses were being received and saved. With this increased size, the number of VCP's that could be written to DVD on site was reduced from three volume scans to one volume scan. Owing to the reduction of local recording capacity from three to one volume scan, Level I recording laptops were sent to the five Dual Polarization Beta Test sites, Vance AFB, OK (KVNK), Phoenix, AZ (KIWA), Morehead City, NC (KMHX), Wichita, KS (KICT), and Pittsburgh, PA (KPBZ) providing up to three days (or 2TB) of Level 1 recording capacity. Thus, in the unlikely event of data quality issues ROC engineering and the Data Quality team had access to the most fundamental radar data for analysis. Additionally, ROC engineering planned to use this data for evaluation of the RDA Build 13.0 re-implementation of CMD owing to the diverse clutter environments at these locations.

With the new feeds and continuous recording, vast amounts of Level I data cases were being collected. With the increased availability of data from KCRI, KOUN, and the Dual Polarization Beta Test sites, the number of requests for data cases from not just the Data Quality team, but other groups increased dramatically. Level I data has been requested from NSSL, NCAR, MIT/Lincoln Labs, University of Oklahoma students, Raytheon, and Barron Services, Inc.

Many rare and noteworthy data cases for single and dual polarization radar were captured and collected through the Dual Polarization Beta test period. These data cases included snow, hail, microbursts, tornadoes, and hurricanes. Snow events from KCRI and KOUN were recorded on March 20th, 2010, February 1st, 2011, and February 9th, 2011 (Oklahoma Blizzard). Tornado events from KCRI and KOUN were recorded on May 10th, 2010, May 20th, 2010, and May 24th, 2011 (Piedmont and El Reno

EF5). KVMX also recorded multiple tornadoes on April 14, 2011. KCRI and KOUN also recorded the June 15th, 2011 micro burst event over the Norman, OK area. The hurricane Irene event was also recorded by the Morehead City, NC (KMHX) radar.

3. CONCLUSION

Recent improvements have greatly increased the capabilities for Level I recording and the amount of Level I data. To continue to provide life-cycle support of the network of WSR-88D radars, evaluating the effectiveness of upgrades, and optimizing the radar's data quality, the use of Level I recorders has already proved to be a vital component. With the increased processing speeds, storage space, and communication bandwidths removing some of the hurdles of Level I data, improvements should be continued to increase the availability of Level I data to ROC engineering, the Data Quality team, and researchers to provide the best data quality possible to enhance commerce and protect property and save lives. The ROC plans to continue to improve the efficiency of the process so that less manpower is needed to manage the data.

4. REFERENCES

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