P3C.4 **RADAR OPERATIONS CENTER DATA QUALITY INITIATIVE**

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1. BACKGROUND

Data quality (DQ) has always been a primary concern of the Weather Surveillance Radar - 1988 Doppler (WSR-88D) Radar Operations Center (ROC); the WSR-88D Hotline was established to assist field operators and technicians in optimizing the data being collected, processed and distributed by the WSR-88D systems. From the beginning, the ROC was structured to provide assistance on request. This paradigm served customers well through the 90s, when the vast majority of end users of this government-provided data had access to a 24 hour Hotline staffed with WSR-88D-trained Electronics Technicians and Meteorologists.

However, when data distribution was decentralized, and the Next Generation Weather Radar (NEXRAD) Information Dissemination Service (NIDS) contract ended, near real-time radar data began showing up on the Internet in its more basic, unfiltered form. This provided individuals and businesses with unfettered access to this information. Unfortunately, the majority of these users had little or no training to determine the quality of the data they were using.

More recently, Federal Aviation Administration (FAA) Air Traffic Controllers (ATC) were given the ability to have real-time WSR-88D product data piped directly to their control screens (Figure 1) with the deployment of new systems within their organization. Every day, business owners, individuals, and the personnel responsible for safely routing aircraft are using WSR-88D products to make very important personal, financial, and safety related decisions.

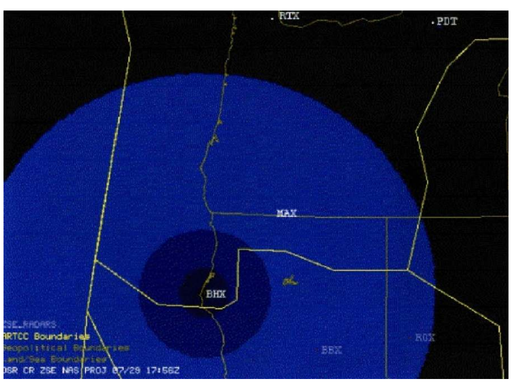

Figure 1. WSR-88D test pattern overlaying air traffic control screen

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Recognizing that changing methods in distribution were completely changing the way government-provided data was used, the ROC recently began implementing a new "Data Quality Initiative" which will take a more aggressive approach to ensuring the data disseminated to the world is of the highest quality possible.

2. SELECTED TOOLS USED TO IDENTIFY DATA QUALITY PROBLEMS

There are several tools and radar products the ROC uses to obtain information concerning WSR-88D data quality. One of the most useful is a national mosaic. With the ability to view several different reflectivity and precipitation products, one can ascertain important information about the quality of the data being generated by the radars.

2.1. Reflectivity Mosaic

The reflectivity product (Figure 2) facilitates a subjective, side-by-side comparison of data from different radar sites. The unfiltered version displays sun spikes, ground clutter,

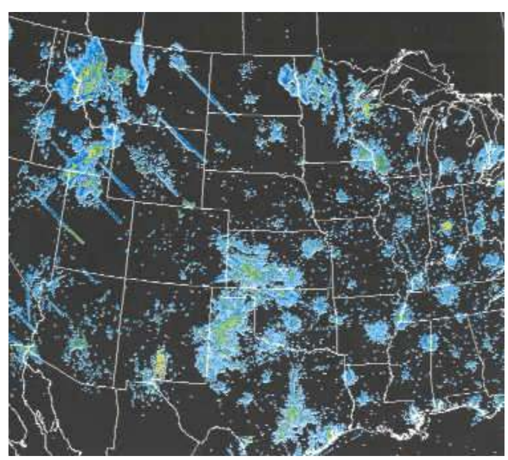

Figure 2. National mosaic of "unfiltered" (unedited) reflectivity

returns caused by anomalous propagation of radar beams, and other radar data artifacts such as “bullseyes” and interference.

2.2 Precipitation Mosaic

The mosaic of precipitation products (Figure 3) provides subtle information about how sites are optimizing their systems’ precipitation algorithms. Sites with accumulated precipitation where none occurred, as well as those with an isolated deficit of precipitation where precipitation did occur, have problems with adaptable parameter and/or clutter suppression settings. Significantly different accumulation amounts at adjacent radars can also provide some information about Z-R relationships being used, as well as radar calibration problems.

Figure 3. National mosaic of 24-hour precipitation

2.3 Radar Reflectivity Comparison Tool (RRCT)

Recently, the National Severe Storm Laboratory provided the ROC with a prototype tool that compares echos from adjacent sites (Gourley et al., 2003). Figure 4 shows the “Domain” screen which is used to compare returned echo equivalent reflectivity (dBZe) from adjacent radar sites. Also available is a time series screen which provides details covering a time period the operator chooses. Viewed over time, this allows for identifying sites with potential calibration issues.

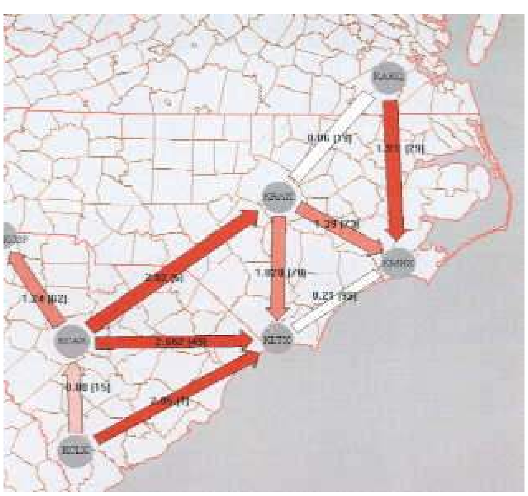

Figure 4. Radar Reflectivity Comparison Tool; Carolina Domain

2.4 Clutter Filter Control (CFC) Products

The CFC products provide a display of the pertinent details of the active ground clutter suppression scheme. The WSR-88D provides for the suppression (reduction) of returned power whose radial velocity is near zero knots within predefined areas. The signal processor uses a bypass map (used to identify areas of known ground clutter return) and operator-defined clutter suppression regions to determine the areas in which to invoke suppression, and the amount of signal reduction to apply.

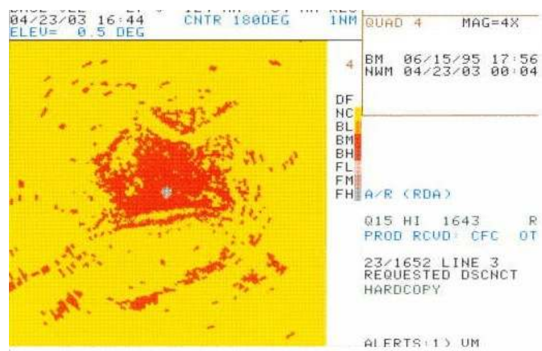

Figure 5. CFC Product depicting an old bypass map

The operator controls the application of clutter suppression to known ground clutter areas and transient areas through the definition of clutter suppression regions.

The dates and times on the CFC products indicate when technicians last generated a bypass map, and when operators last changed their clutter suppression scheme. At the time Figure 5 was obtained, the bypass map was nearly eight years old, and two weeks had passed since operators had interacted with the clutter suppression scheme.

The bypass map shown in Figure 6 was generated by an operator who was experimenting with the bypass map editor. The changes were unintentionally saved and downloaded, and the system used this map to filter clutter for some time before it was observed by a Hotline meteorologist.

Figure 6. Bad CFC Product

Appropriate clutter suppression is one area in which a little effort goes a long way towards optimizing data quality. The most important benefit (of appropriate clutter suppression) is the improved accuracy of the WSR-88D products. Since Clutter suppression occurs prior to the calculation of the base data estimates, proper clutter filtering will result in the base data estimates being more representative of the actual meteorological situation. Consequently, the more accurate the base data estimates, the more reliable the output from downstream processing and algorithms, and as a result, the more accurate base and derived products (Chrisman et al., 1995).

Every so often, the ROC conducts a survey of field sites, to ascertain trends in clutter suppression methods used. Over the years, interesting trends have developed.

Figure 7 shows how bypass map currency has changed since 1996. For example, the purple line shows that when the 1996 survey was conducted, nearly 60% of all bypass maps obtained were "current" (indicating they had been updated within the last year – the ROC recommends updating the maps at least seasonally). Subsequent surveys showed that through the years, fewer maps were "current" and more were found to have been generated two, three, or more years past. Note that in the 2002 survey (blue line) the "current" data point is quite high. This is the result of many sites being instructed to generate new bypass maps, when their new Open Radar Product Generator system was installed. Note also, that for the first time, in 2002, there was a noticeable increase in the number of bypass maps that were greater than five years old.

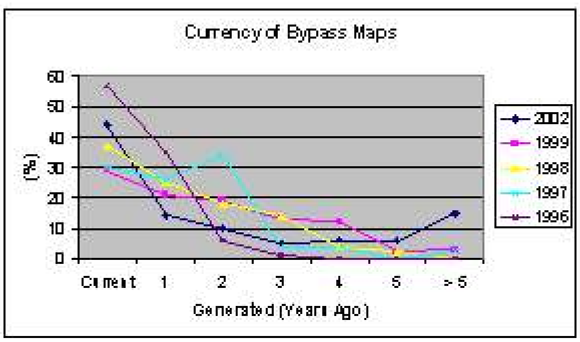

Figure 7. Currency of WSR-88D Bypass Maps

Clutter suppression region modifications follow a similar trend. Early in the program, site operators closely monitored their systems, and updated clutter suppression regularly. Indeed, it was unusual to find sites which had not modified it's clutter suppression within the last 24 hours. Specifically, records indicate that in 1996, 80% of sites had altered their clutter suppression within twenty-four hours of when the CFC product was obtained. The percentage of sites which had not downloaded new suppression definitions within the last two days or more, was near zero. Conversely, in the 2002 survey, only 13% had downloaded new clutter suppression definitions within the last 24 hours, and fully 70% of sites had not changed their clutter suppression scheme in at least two days.

The type of clutter suppression in use at sites is also of interest (Figure 8). Trends are plotted which depict how clutter suppression usage has changed over the last six years. The "All Bins" category, is just that; all bins were selected (identified by the operator as possibly clutter contaminated) and one notch width used to suppress the clutter. The Bypass Map category, which is the recommended method, shows the percentage of time that the bypass map was in use. The "Both" category captures those sites which were using the bypass map and user selected regions, and "Other" describes those results which didn't neatly fit into one of the other three categories.

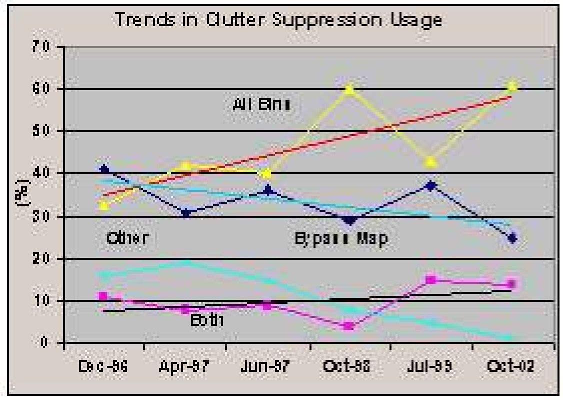

Figure 8. Trends in Clutter Suppression Usage

This information seems to imply that through the years, less and less attention has been given to assuring data quality through appropriate clutter suppression. This is not totally unexpected as newer equipment is introduced, and more is demanded of National Weather Service (NWS), FAA, and Department of Defense (DoD) field personnel; however, the fact remains that as more users and uses of WSR-88D data come on line, data quality is more important now, than ever before.

2.5 Precipitation Products

The WSR-88D precipitation accumulation algorithms execute and automatically terminate based on the areal coverage (precipitation area plus nominal clutter area) of reflectivity data above defined thresholds. To prevent ground clutter returns from initiating or prolonging the accumulation processing, the WSR-88D operator may adjust the nominal clutter area as warranted to account for residual ground clutter returns. As

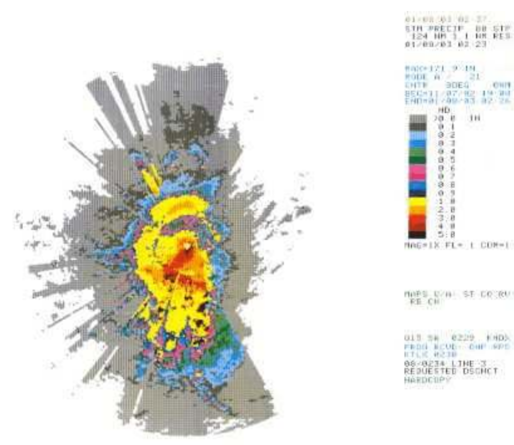

Figure 9. Storm Total Precipitation Product

long as this "detected precipitation" exceeds the defined areal coverage, the precipitation accumulation algorithms continue to compile rainfall over the area.

In the current environment, WSR-88D products are utilized by a myriad of end users, and the precipitation accumulation products are some of the most widely used. For DQ purposes, these products relay quite a bit of information about how a site optimizes the precipitation algorithms/functions. The Storm Total Precipitation product depicted in Figure 9 indicates that precipitation had been nearly continuous for more than two months and 171 inches of precipitation had fallen during that period.

2.6 Spectrum Width (SW) Products

Spectrum Width (SW) is not often used operationally; however, the product provides some insight concerning the quality of velocity data, as well as the system in general. Data quality can be compromised by large biases in width estimates which can be induced by hardware problems, calibration, or system noise (Zittel et al., 2001). Large widths can degrade clutter suppression which will affect all downstream algorithms and products.

Figure 10. Good Spectrum Width Product

Spectrum Width, a measure of the velocity dispersion within the pulse volume (Lemon, 1999), provides an indication to the quality of the velocity data. Figure 10 is an example of a "good" SW product. Generally, atmospheric SW values should be below 8 kts (Fang et al., 2001) so that qualitatively, the

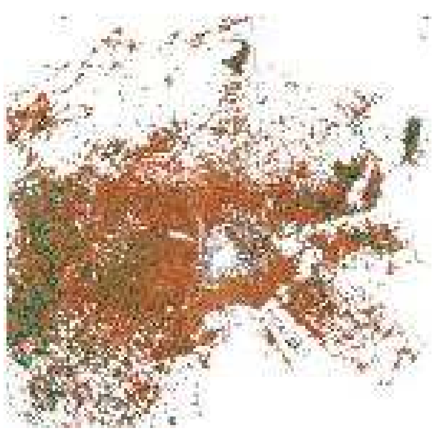

Figure 11. Bad Spectrum Width Product

product appears grey. Higher values are not unusual in and around specific atmospheric and man-made features; however, a SW product having values primarily of 12 and greater (Figure 11) or a product in which high width values are seemingly randomly located, usually indicates the presence of some type of noise or other system problem.

3. SUMMARY

Poor quality data, from sites that appear to be operating nominally, continue to be incorporated into the national archives; continue to be used to make operational decisions in both government and private sectors; and continue to be displayed on the terminals of air traffic controllers. The decrease in data quality over time is most likely a result of a number of factors. In this "Internet era", live radar data is available almost immediately upon generation. Operational forecasters, private users and air traffic controllers could be placed in situations where they could make decisions based on poor information - this is unacceptable.

In an attempt to mitigate these issues, the ROC is implementing a Data Quality program. The initial step in this program was to identify available products and tools that highlight data quality issues. The next step tasks ROC Meteorologists and Electronics Technicians to use these products and tools to systematically assess the quality of the WSR-88D data, and work with sites and NWS regions to resolve observed problems. The NEXRAD Program Management Committee (PMC) has approved the concept, and coordination with PMC agencies and NWS regions is on-going.

4. REFERENCES

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