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PLANS FOR TESTING THE FEASIBILITY OF SITE-SPECIFIC SCANNING STRATEGIES FOR WSR-88DS

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1. INTRODUCTION

Several Weather Surveillance Radar – 1988 Doppler (WSR-88D) radars, because of their location on mountain tops, overshoot significant meteorological targets affecting communities in nearby valleys. For example, the Missoula, MT WSR-88D (KMSX), Fig. 1, has the same set of volume coverage patterns (VCPs) as the Austin/San Antonio, TX WSR-88D (KEWX); that is, every WSR-88D VCP scans with a lowest elevation angle of 0.5º. Consequently, for the populated Bitterroot River valley 60 km (32 n mi) south of KMSX, the lowest part of the radar beam at the half-power point is 1.64 km (5380 feet) above terrain and often overshoots significant weather targets.

This paper describes a proposed plan to implement optimum scanning strategies at some WSR-88D sites. With a desire to scan at lower elevations, the WSR-88D Radar Operations Center (ROC)—in collaboration with meteorologists and scientists at affected National Weather Service (NWS) Weather Forecast Offices (WFOs), the National Severe Storms Laboratory (NSSL), the Federal Aviation Administration (FAA), the Department of Defense (DoD), and the South Dakota School of Mines—is proposing that some WSR-88Ds collect data using modified VCPs that are best suited for the local meteorological situation. To confirm operational benefits from lower elevation angles, a field test has been proposed for six WSR-88Ds, three located on mountain tops and three located on relatively flat terrain. The field test plan proposal is currently being evaluated within the NWS.

2. BACKGROUND

As WSR-88D Radar Data Acquisition (RDA) sites were being chosen according to numerous selection criteria (Leone et al. 1989), negative elevation angles at some sites were expected to be part of the full production deployment plan (SEA 1993). The Final Supplemental Environmental Assessment document for NEXRAD stated, “Generally, the lower limit of the elevation angle will be set at 0.5º. In a few mountaintop locations, the lower limit may be -0.5º. System operators will routinely choose this limit so that the full strength of the main beam never strikes the ground; otherwise, operation would produce strong clutter signals that would greatly interfere with the desired observations” (SEA 1993, p. 26).

Figure 1- The Missoula, Montana WSR-88D radome is about 4600 feet higher than nearby populated valleys and nearly 8000 feet above sea level.

Fortunately for the proposed project, mountaintop WSR-88D antenna locations were chosen with negative elevation angles in mind. Otherwise, current attempts to optimally lower elevation angles might face even greater challenges. Moving an RDA to gain a better vantage point would be cost prohibitive.

To avoid potentially long delays to the WSR-88D deployment schedule due to public concerns about electromagnetic energy at a few sites, all WSR-88Ds were deployed with the lowest scan angle set at 0.5º.

3. BENEFITS OF SITE-SPECIFIC SCANNING

A National Research Council team examined constraints imposed on the NEXRAD system due to a minimum elevation angle no lower than 0.5°. They wrote, ”This problem is of special concern for radars at high-altitude sites in mountainous areas,” and continued with, “similar difficulties arise in areas subject to intense precipitation from shallow cloud systems, such as places in the lee of the Great Lakes affected by lake-effect snowstorms” (NRC 2005).

A site-by-site analysis will focus on nationwide benefits from lower scanning angles. Some WSR-88Ds possess exceptional detection and coverage capabilities from the standard lowest elevation angle of 0.5º. Alternatively, over relatively flat terrain, a few radars

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could increase detection of distant storms and shallow precipitation using an optimum lowest angle of 0.25º as described by Smith (1998). For radars located on mountain tops, elevation angles below 0.0º could dramatically increase detection of weather phenomena affecting the population centers in the valleys. A cost and benefit analysis is needed for candidate sites to guide implementation decisions.

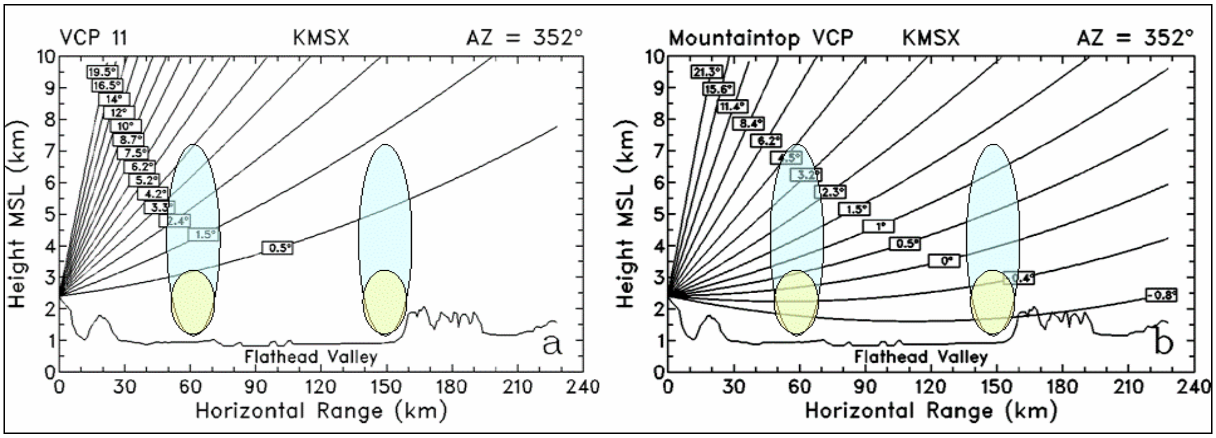

Figure 2 – A vertical cross section of VCP 11 (left) is compared to a simulated Mountaintop VCP for Missoula. Notice that storm features (e.g., tornadic) below 3000 feet are poorly sampled by VCP 11.

Lower elevation angles at some WSR-88D sites could provide operational benefits such as improved severe weather detection and prediction, precipitation estimation, feature detection and tracking, and nowcast forecasting. Data from these lower scans should enhance the warning and decision process. For example:

1) Simulated studies of lower elevation angles have shown that precipitation estimates for some WSR-88Ds could be vastly improved. Regarding the Missoula, Montana WSR-88D, Fig. 2, Brown et al. (2002) said, "Using the lowest elevation angle (0.5°) of the current WSR-88D scanning strategies, simulated rainfall rates detected in valleys progressively decrease from about 80% of the surface value near the radar to only 1% of the surface value at 220 km. However, using an elevation angle of -0.8°, simulated rainfall rates detected at ranges out to 220 km are about 80%-95% of the surface value."

2) Local warning and hourly forecast operations can be more timely and accurate if better estimates of surface rainfall and snowfall rates are available. Detections of outflow and other surface boundaries are also important to the formulation of short-term forecasts. Obviously, better detection, tracking, and monitoring of tornadoes, damaging microbursts, and shallow storms bolster the NWS mission.

3) By simulating negative elevation angles at Missoula, Brown et al. (2002) showed KMSX would be able to detect the onset of arctic blizzards in the surrounding valleys and the presence of shallow lake-effect severe storms 100 km (54 n mi) from the radar.

4) In another simulation, three mountaintop radars that cover Utah and western Colorado would be able to detect flash floods, low-altitude lake-breeze fronts affecting international flight operations, and shallow snowstorms (Wood et al. 2003).

Simulations are not the sole evidence pointing to benefits from site-specific scanning strategies. The pre-NEXRAD network had limited national coverage from WSR-57 and WSR-74 radars. West of the continental divide in the contiguous U.S., radar surveillance was limited to nine radars. The WSR-88D network significantly expanded radar coverage for western states (Serafin et al. 2000). Nonetheless, that limited number of aging WSR-57 radars afforded manual selection of negative elevation angles that detected meteorological targets near the earth's surface.

In Canada, the network of operational Doppler radars effectively use negative elevation angles at some mountaintop sites and have recently applied lower elevation angles in winter months for radars that need to detect shallow snowstorms caused by cold air advection over warm water (Donaldson et al. 2003). Forecasters of the Meteorological Service of Canada are pleased with the increased ability to monitor localized snow, especially at midranges (Brown et al. 2006). NWS forecasters would equally benefit from scanning adjustments to several WSR-88Ds located near the Great Lakes.

In the United States minor relief to the beam overshoot problem has been accomplished. Some FAA Terminal Doppler Weather Radar (TDWR) data has been used since 2005 at a few NWS offices (Stern et al. 2005). The TDWR scans below 0.5° which can reveal the presence of boundaries of forecasting significance.

The NEXRAD Product Improvement (NPI) program plans to operationally deliver data from all TDWR sites for routine operations (Saffle et al. 2005). Of 45 TDWR sites, however, only four radars are located west of the Plains (Vasiloff 2000).

4. A 2006 SURVEY OF WSR-88D USERS

In April 2006 the ROC surveyed 353 WSR-88D users from the NWS (WFO and River Forecast Centers), FAA Center Weather Service Units, and DoD. The primary goal of the survey was to ask WSR-88D operators to subjectively assess the performance and use of WSR-88D meteorological algorithms and products. Survey results are being used to identify algorithm research and forecaster needs.

Of interest to this paper, one question posed to field personnel was *“If you could add a new scanning strategy, what kind of VCP would you envision?”* From 128 individual survey responses to that question, 206 discrete ideas about new scanning strategies were interpreted. Forecaster ideas were then separated into seven categories: 1) Faster, 2) Low-level surveillance, 3) Elevation angles below 0.5°, 4) Range-Velocity (R-V) mitigation, 5) More elevation angles, 6) Novel, and 7) Wait for phased array (Fig. 3).

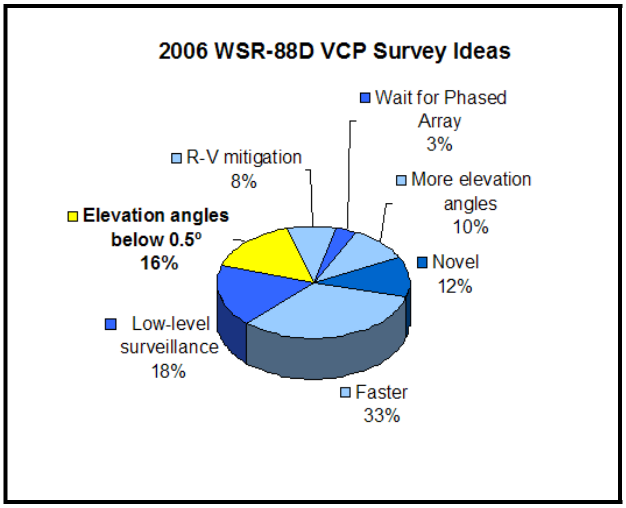

Figure 3 - Seven categories from survey responses for new WSR-88D scanning strategies were established. The percentage of 206 ideas divided among categories from 128 respondents is shown.

Overall, survey respondents showed a sophisticated understanding of VCP design constraints and potential operational benefits to be obtained from new scanning strategies. Field personnel have invested considerable thought about WSR-88D scanning capabilities.

Forecasters and hydrologists at some WSR-88D sites, having experienced radar beam overshoot, believe a solution is possible. Consequently, 32 respondents suggested a new VCP with elevation angles below 0.5°; that was 16% of the VCP ideas found in this survey. Of those requests for lower elevation angles, nine respondents mentioned a specific need for negative elevation angles.

Concern about beam overshoot was not restricted to mountaintop or Great Lakes sites. One forecaster said, “A lower scanning angle would be quite ideal, especially east of the Rockies…” in order to track and monitor tornadic vortices. Another respondent said, “A VCP with a 0.0 or 0.2 degree cut would be very helpful for both convection and lake effect snow in southeast Michigan.”

5. FIELD TEST PLANS

With a goal to improve network radar operations, a plan to test site-specific scanning strategies at a few NWS WSR-88D field offices has been proposed as a first step. The field test plan specifies lowering one or more elevation angles of VCPs at WSR-88D test sites where lower scans might provide the greatest benefit. The proposed field test will quantitatively assess benefits and identify unanticipated technical issues related to deployment of site-specific scanning strategies.

The plan was designed to have little impact on existing operations of the WSR-88D network and external systems while providing new data to the local WFO staff and researchers. Six test sites were chosen to confirm existing theoretical studies that support use of tailored scanning strategies; the field test will allow comparisons between legacy and new VCPs since the old VCP is a subset of the new. Supplemental Environmental Assessments, a costly 9-month venture, will be required for chosen WSR-88D test locations before tests can proceed.

A list of the six proposed NWS test sites and the non-standard elevation angles to be used are:

Test Site	New Elevations
• Missoula, MT (KMSX)	-0.8°,-0.4°,0.0°
• Salt Lake City, UT (KMTX)	-0.4°,0.0°
• Amarillo, TX (KAMA)	+0.2°
• North Webster, IN (KIWX)	+0.2°
• Medford, OR (KMAX)	-0.8°,0.4°,0.0°
• Albuquerque, NM (KABX)	+0.2°

ROC staff will manage the field test if approved and funded. Testing could begin shortly after completion of a successful environmental assessment. We made the first steps to gain authorization and funding by submitting a Statement of Need (SON) and Project Plan into the NWS Operations and Services Improvement Process (OSIP). If approved and funded, field tests will continue for two years in order to thoroughly assess seasonal benefits from lower elevation angles. The test could require less time if compelling benefits are found sooner.

6. SUMMARY

Lower scanning angles at some WSR-88D locations would provide additional data which could result in improved forecasts and local warning performance, particularly at WFOs with their radar at high elevations. A mature test plan involving lowering the lowest scan angle at six sites for two years has been developed. The test is designed to provide verification data needed for a cost/benefit analysis in regard to network-wide implementation of lower scan angles. This implementation could impact WSR-88D agency users and external users by requiring expensive software changes. The results of the field test will need to be weighed against these costs and impacts during the final implementation decision process.

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