12B.7 A NEW WSR-88D SCANNING STRATEGY: RESULTS OF FIELD TESTS

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1. INTRODUCTION

During 2004, a new scanning strategy or volume coverage pattern (VCP) will be added to the suite of VCPs 11, 21, 31, and 32 currently in use with the Weather Surveillance Radar - 1988 Doppler (WSR-88D). At the time of this writing, it appears that the scanning strategy will be called VCP 12 (Fig. 1). VCP 12 has the same number of elevation angles as VCP 11, but elevation angles are moved downward to increase the vertical sampling density at lower angles. Also, antenna rotation speed is increased so a volume scan is completed in 4.1 min instead of 5.0 min. The faster rotation speed leads to a slight degradation of data quality, but data quality satisfies WSR-88D specifications.

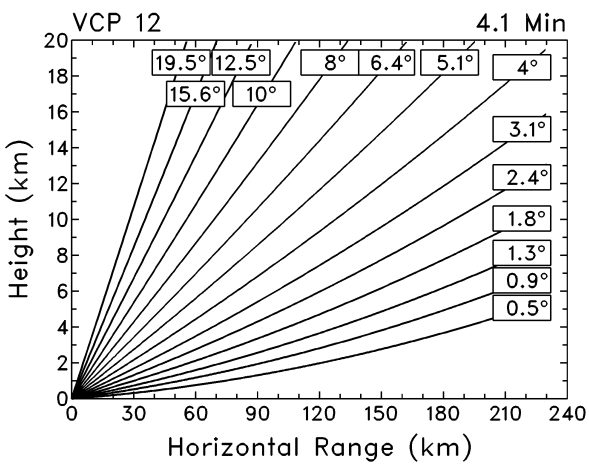

Fig. 1. VCP 12 elevation angles plotted as a function of range and height.

During the past several years, experimental versions of VCP 12 using testbed WSR-88Ds have been compared with VCPs 11 and 21 using nearby operational WSR-88Ds. This paper discusses the results of some of these comparison studies.

2. COMPARISON PROCEDURES

Field tests of experimental versions of VCP 12 (called VCP Gamma) and other experimental VCPs were conducted during 1999-2001 in Oklahoma and during 2002 in Mississippi. The field tests consisted of running VCP Gamma on testbed WSR-88Ds KCRI (ROC) and KOUN (NSSL) in Norman, OK and KBIX at Keesler Air Force Base, MS. Output from severe storm algorithms using testbed radar data were compared with algorithm output using data from nearby operational WSR-88D KTLX for the Norman radars and from WSR-88Ds KLIX (Slidell, LA), KJAN (Jackson, MS), and KMOB (Mobile, AL) for KBIX. Only results of the 2002 Mississippi test are presented in this paper.

Algorithm comparisons were made for storms that were roughly equidistant from each pair of testbed and operational radars. Since the three operational WSR-88Ds surrounding KBIX were at least 75 km (40 n mi) from KBIX, comparisons were limited to medium to far ranges. For example, the geographic distribution of percentage differences in distance from KLIX and KBIX are shown in Fig. 2. The darkest shading indicates locations where the distances from the two radars are within 10% of each other. For this study, we used the 10% area for making the comparisons.

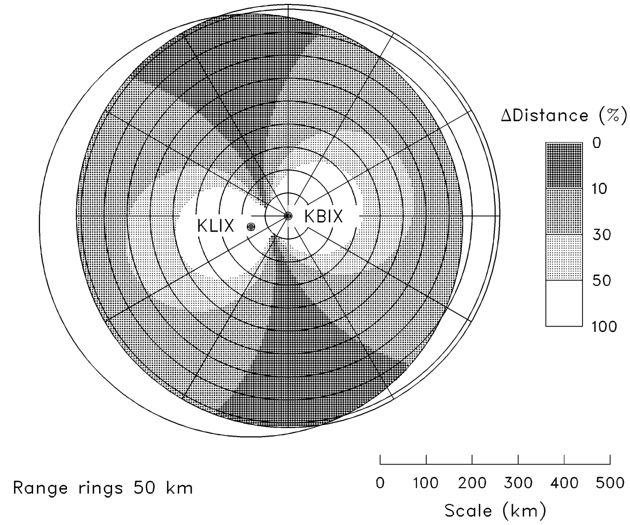

Fig. 2. Geographic distribution of percentage differences in distance from KBIX and KLIX within 460 km (250 n mi) of both radars. The blank region within 50 km of each radar represents the "cone of silence" where no comparisons were made.

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3. COMPARATIVE RESULTS

In addition to VCP Gamma, several other experimental VCPs were used during the field tests. The one that was used most was VCP Beta, which extends only to 8.1° elevation and has slightly denser spacing than VCP Gamma (12 instead of 10 elevation angles from 0.5° to 8.1°). Storms beyond 120 km (65 n mi) from a radar are completely sampled by VCP Beta.

a. Mesocyclone identification

On 29 April 2002, several mesocyclones were identified by the Mesocyclone Detection Algorithm within 230 km (125 n mi) of KBIX. Two of these mesocyclones were roughly equidistant from KBIX and one or more of the nearby WSR-88Ds. Figure 3 shows tracks of a circulation identified by KBIX, KMOB, and KJAN that briefly produced a mesocyclone signature. (At the times of the mesocyclone signatures, range differences were about 10% or less; however, the differences were greater than 10% along other portions of the tracks.) The algorithm identified a circulation in the KBIX Doppler velocity field (VCPs Beta and Gamma) about 20 min before one was identified in the KMOB data (VCP 21) and 35 min before one was identified in the KJAN data (VCP 11). The mesocyclone signatures occurred at slightly different times for the three radars, with the circulation reaching mesocyclone strength (Rank 5) 12-16 min earlier in the KBIX data. The circulation tracks based on the three radars are very similar. Following the 2054 UTC volume scan, the KBIX mode of operation was changed, so continuity on

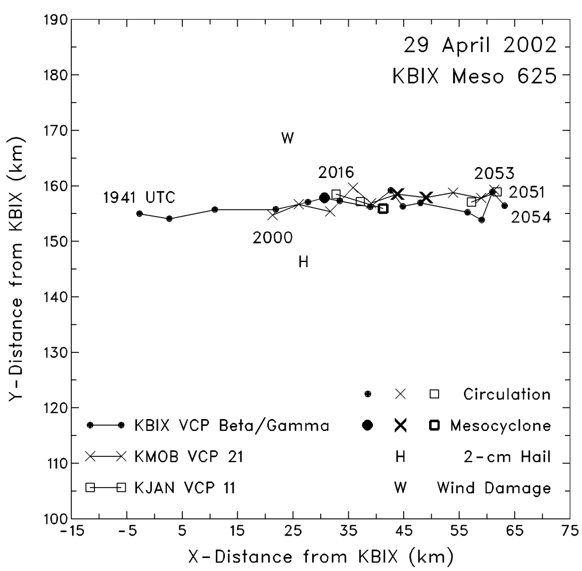

Fig. 3. Tracks of the circulation that produced Mesocyclone 625 (KBIX) as seen by three radars. Larger symbols along the track indicate the identification of mesocyclone signatures. The KJAN track has a break in it. Locations of damaging wind and hail reports from Storm Data *are noted.*

the circulation was lost and no data from the other radars were plotted.

A second mesocyclone occurred a couple of hours later (Fig. 4). The algorithm identified a circulation in the KBIX Doppler velocity field (VCP Beta) 16 min before one was identified in the KLIX data (VCP 21) and the identification lasted 10 min longer with VCP Beta. The detected strength of the circulation reached Rank 5 about 10 min earlier with VCP Beta.

In summary, experimental VCPs, with more closely spaced lower elevation angles, can identify circulations 15-35 min earlier and mesocyclones 10-15 min earlier than current VCPs at medium and far ranges. These findings have important implications for earlier severe storm and tornado warnings.

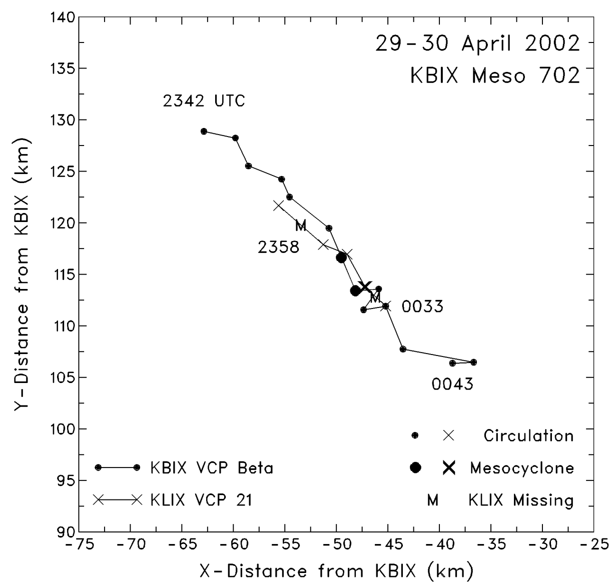

Fig. 4. Track of the circulation that produced Mesocyclone 702 (KBIX) as seen by KBIX and KLIX. Bolder symbols along the tracks indicate identification of mesocyclone signatures.

b. Maximum reflectivity

The evolution of maximum reflectivity within a cell was obtained from the Storm Cell Identification and Tracking (SCIT) Algorithm. Plotted in Fig. 5 are curves showing reflectivity evolution in KBIX Cell 33 on 4 May 2002 based on measurements from KBIX (VCP Beta) and KMOB (VCP 21). Average distance from the two radars varied from 140 to 150 km (75-80 n mi). The SCIT algorithm identified the cell 12 min earlier with VCP Beta. Overall lifetime of the identified cell was 17 min longer with VCP Beta than with VCP 21.

Plotted in Fig. 6 are curves showing temporal variation of maximum reflectivity associated with the early portion of KBIX Cell 5 on 29 April 2002 at greater average ranges of 170-190 km (90-100 n mi). The SCIT Algorithm identified the storm over 35 min earlier with KBIX using VCP Beta than with KMOB using VCP 21. By the time KMOB began to identify the storm, the hail algorithm

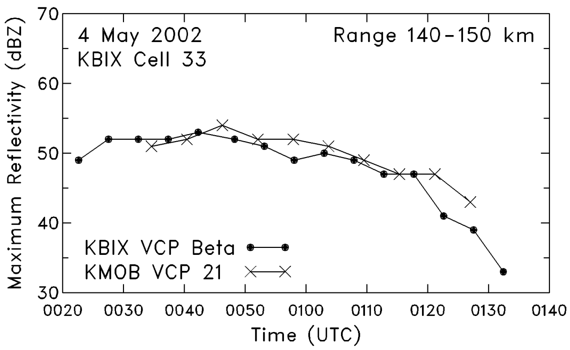

Fig. 5. Temporal variation of maximum reflectivity within a cell roughly equidistant from KBIX and KMOB on 4 May 2002.

using VCP Beta had been indicating for 25 min that the storm had up to 70% probability of producing hail (not shown). Note that the finer vertical resolution of VCP Beta at this range produces less temporal variation in maximum reflectivity values compared with VCP 21 after 1910.

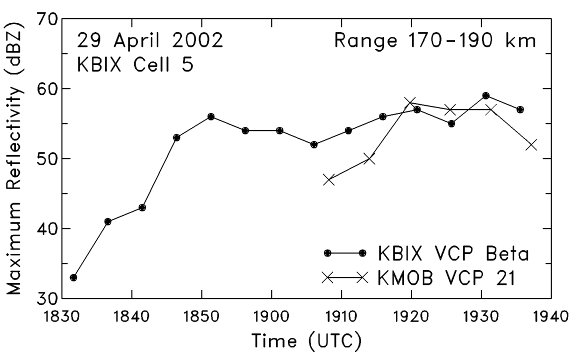

Fig. 6. Temporal variation of maximum reflectivity within a cell roughly equidistant from KBIX and KMOB on 29 April 2002.

c. *Cell tracks*

Two relatively long-lived cells were in suitable locations to be tracked by KBIX and one of the other radars. Figure 7 shows tracks of one cell, which was a long-lived hailstorm on 9 May 2002 that moved from west-central to central Mississippi; locations of *Storm Data* reports of hail are indicated. Range from KBIX and KLIX decreased from 320-340 km (170-180 n mi) to 260-270 km (140-145 n mi) as the storm moved east-southeastward. The storm cell was identified about 20 min longer using VCP Beta (KBIX) than using VCP 21 (KLIX). Even though a long-lived hailstorm should consist of a number of cells, the SCIT Algorithm identified only one cell in the KBIX data and two cells in the KLIX data during the storm's three-hour lifetime. With the radar beam being so broad (half-power beamwidth of 4-6 km or 2-3 n mi), there evidently was not sufficient resolution to resolve individual cell evolution.

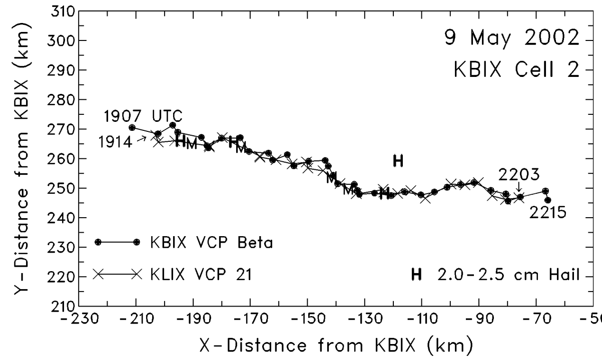

Fig. 7. SCIT tracks of a cell based on KBIX and KLIX data. Missing KLIX data are indicated by M's. There are four plotted hail reports, three partially hidden along the track.

Figure 8 shows tracks of a severe storm in northeastern Mississippi identified by the SCIT Algorithm using KBIX and KMOB data. At 2028 UTC (beginning of a KBIX data tape), SCIT identified the storm using data collected with VCP Beta. Since maximum reflectivity at that time was 56 dBZ, the storm obviously had been in existence for some time. When observers in the control room changed from VCP Beta to VCP 11 for three volume scans, SCIT no longer identified the storm (Fig. 8 shows interpolated positions in parentheses). When KBIX resumed using VCP Beta, the storm was again identified. However, it was not until 2100--likely 45-60 min after the storm formed--that SCIT identified the storm with the KMOB radar using VCP 21. At 2100 the storm was already severe, with a report of 60 mph winds at 2105.

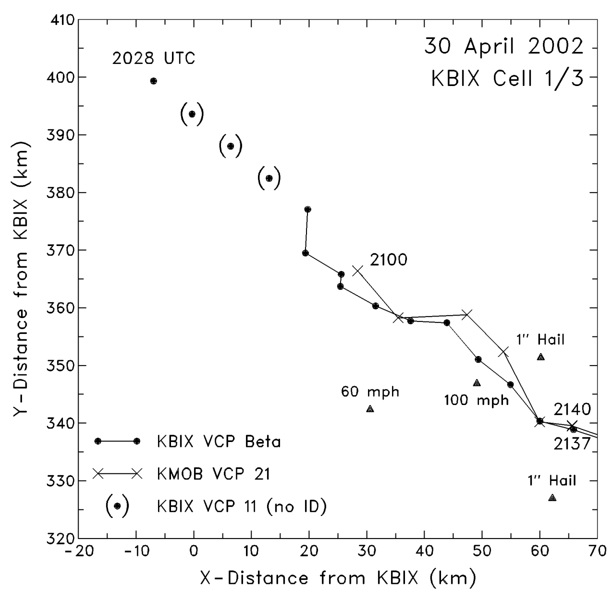

Fig. 8. SCIT tracks of a severe storm based on KBIX and KMOB measurements. Triangles indicate the locations of severe weather reports associated with the storm. Dots in parentheses are linearly interpolated positions.

During the next 40 min there were reports of 100 mph winds at Columbus Air Force Base and of 1 in (2.5 cm) hail elsewhere.

The reason for there initially being no SCIT identification of the storm with VCPs 11 (KBIX) and 21 (KMOB) is due to the fact that storm top was at about 1.4° elevation. SCIT requires data at two elevation angles in order to identify a storm; with VCPs 11 and 21 there were measurements at the lowest elevation angle (0.5), but none at the next elevation angle of 1.5°. However, with VCP Beta, there were measurements at the three lowest elevation angles of 0.5, 0.9, and 1.3°. The storm was not identified by the algorithm with KMOB using VCP 21 until after the storm moved close enough to the radar for the storm to be detected at two elevation angles.

Data collected in this storm clearly indicate that the finer vertical resolution of VCP Beta makes the difference between algorithm identification and nonidentification of distant storms. The capability to make finer resolution measurements at lower elevation angles (as exemplified by VCPs Beta and Gamma) becomes especially crucial when one WSR-88D is inoperative and a radar farther away is required to provide the information needed for preparing warnings.

d. Hail

Comparisons were made for three parameters from the Hail Detection Algorithm (HDA): maximum hail size, probability of hail (POH), and probability of severe hail (POSH). Figure 9 shows the evolution of these three HDA parameters over a three-hour period within a severe thunderstorm that was 140-190 km (75-100 n mi) from KBIX. The closeness of agreement between the POH curves is remarkable. POH values differ by no more than 10% for the KBIX-KMOB portion of the curves (up through 2000) and are in complete agreement along the KBIX-KJAN portion of the curves, where POH values remained a constant 100%. Except for a brief time period from about 1940 through 2000, the POSH curves rarely differed by more than 10%. The most obvious differences between pairs of curves in Fig. 9 are for maximum hail size. It is common to find differences of 1 in or more, which suggests that the computation of maximum hail size is more sensitive to VCP elevation angles than the other parameters.

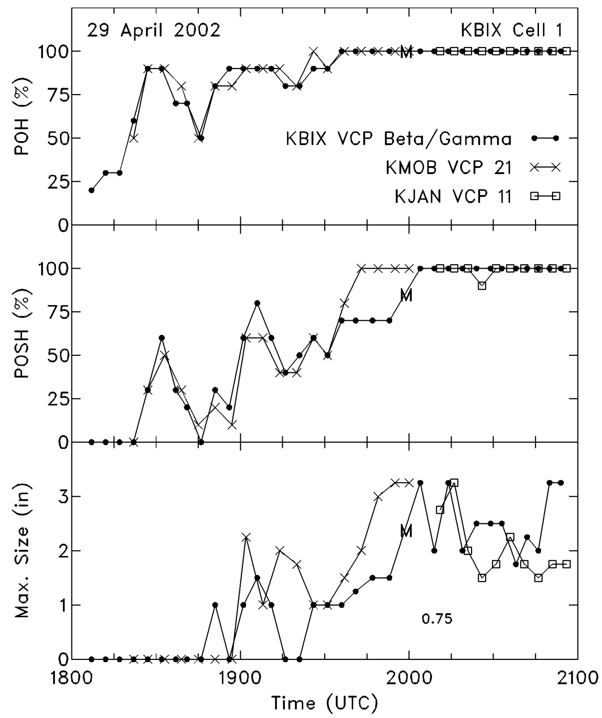

Fig. 9. Temporal variation of POH, POSH, and maximum hail size. Comparisons between KBIX and KMOB are made through 2000 and between KBIX and KJAN thereafter. The only Storm Data *hail report was for 0.75 in (2 cm) hail at 2010 UTC 10 km south of the cell track.*

4. CONCLUDING DISCUSSION

A basic characteristic of VCP 12 is closer spacing of lower elevation angles. This characteristic leads to a number of advantages for the forecaster. For example blocking of lower elevation angles by terrain produces underestimates of surface precipitation rates because the lowest useable elevation angle is a considerable distance above ground. Current VCPs place the first useable elevation angle 0.9-1.0° above the highest blocked angle, whereas VCP 12 places the first useable elevation angle only 0.4-0.5° above the highest blocked angle. Thus, measurements closer to the ground would result in more realistic estimates of surface precipitation rates. The precipitation advantages could not be confirmed during the field tests because the current precipitation algorithm accepts only elevation angles specified by current VCPs 11 and 21.

The comparisons presented here clearly show advantages of VCP 12 (through VCPs Beta and Gamma) over current VCPs, especially at mid and far ranges. With greater vertical data density at lower elevation angles associated with VCP 12, a developing storm and its associated rotation characteristics are identified by the algorithms up to 10-35 min earlier because vertical continuity requirements are satisfied sooner. This means that information about mesocyclone and tornadic vortex signatures and parameters such as storm location and tracking, maximum reflectivity, vertically integrated liquid (VIL), probability of hail and severe hail, expected maximum hail size, etc. become available to forecasters much earlier in a storm's lifetime.

5. ACKNOWLEDGMENTS

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