WSR-88D TVS Parameter Study

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1. Introduction

A Tornadic Vortex Signature (TVS) detection by the WSR-88D TVS algorithm is a rare event. The TVS algorithm searches through mesocyclones found by the 88D mesocyclone algorithm. So: no meso - no TVS.

Next, a shear criterion must be met. The default parameter is 72/hr. This number is equal to approximately 20 m/s/km (read meters per second per kilometer where kilometers measure the AZIMUTHAL distance between two range gates). This shear value is difficult to reach because the TVS algorithm uses the maximum inbound and outbound radial velocities within the mesocyclone. These maxima may be separated by a distance large enough that the resultant shear is below the threshold. Thus, the TVS algorithm may overlook stronger shear regions in the event that the locations of weaker velocities are close enough to produce shear that exceeds the threshold.

Recently, the WSR-88D has given TVS parameter change authority to the Unit Radar Committee (URC). This was discussed at a meeting of the URC for the Salt Lake City KMTX radar resulting in a recommendation of testing various TVS shear thresholds.

The National Severe Storms Laboratory has provided a software system for use on WFO HP UNIX machines that is capable of replaying archive level-II data through the 88D algorithms, including the TVS algorithm. This system is called the WSR-88D Algorithm Testing and Display System (WATADS). Results from WATADS do not exactly match the 88D algorithm but are sufficiently close for this study.

Data from 29 May 1996 are used in this study. There was at least one confirmed tornado along with severe storm outflow. The 88D TVS algorithm was run with different shear thresholds. This paper documents the results of three different runs of the algorithm shear thresholds of 70/hr, 30/hr, and 18/hr (minimum allowable). The mesocyclone algorithm was untouched.

Shear calculations have been made using the WATADS data examination function where a click of a mouse button prints out data values on the screen. This type of data examination is a good approximation of processing done by the TVS algorithm although small errors/discrepancies may exist.

2. Results

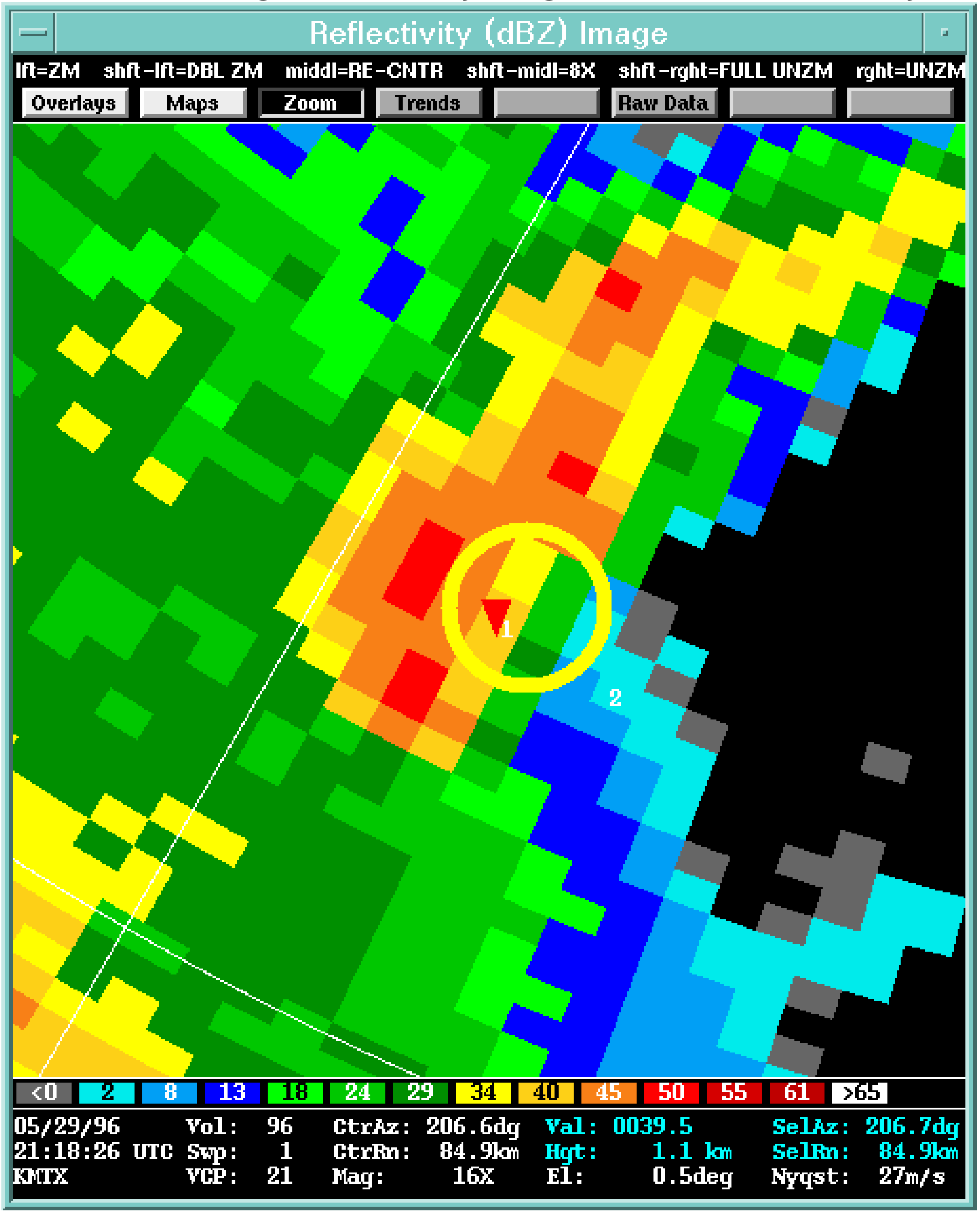
Between 2030 UTC 29 May and 0100 UTC on 30 May, there were 9 mesocyclone detections by the 88D mesocyclone algorithm. With the TVS shear threshold of 72/hr, there were no TVS detections. The TVS algorithm was run with the threshold reduced to 30/hr with no detections. Finally, running the algorithm with the threshold reduced further to 18/hr (the minimum threshold), two TVS's were detected.

2.1 TVS #1

The first TVS occurred at 2118 UTC. The 0.5 deg reflectivity image (Fig. 1) indicates a high-

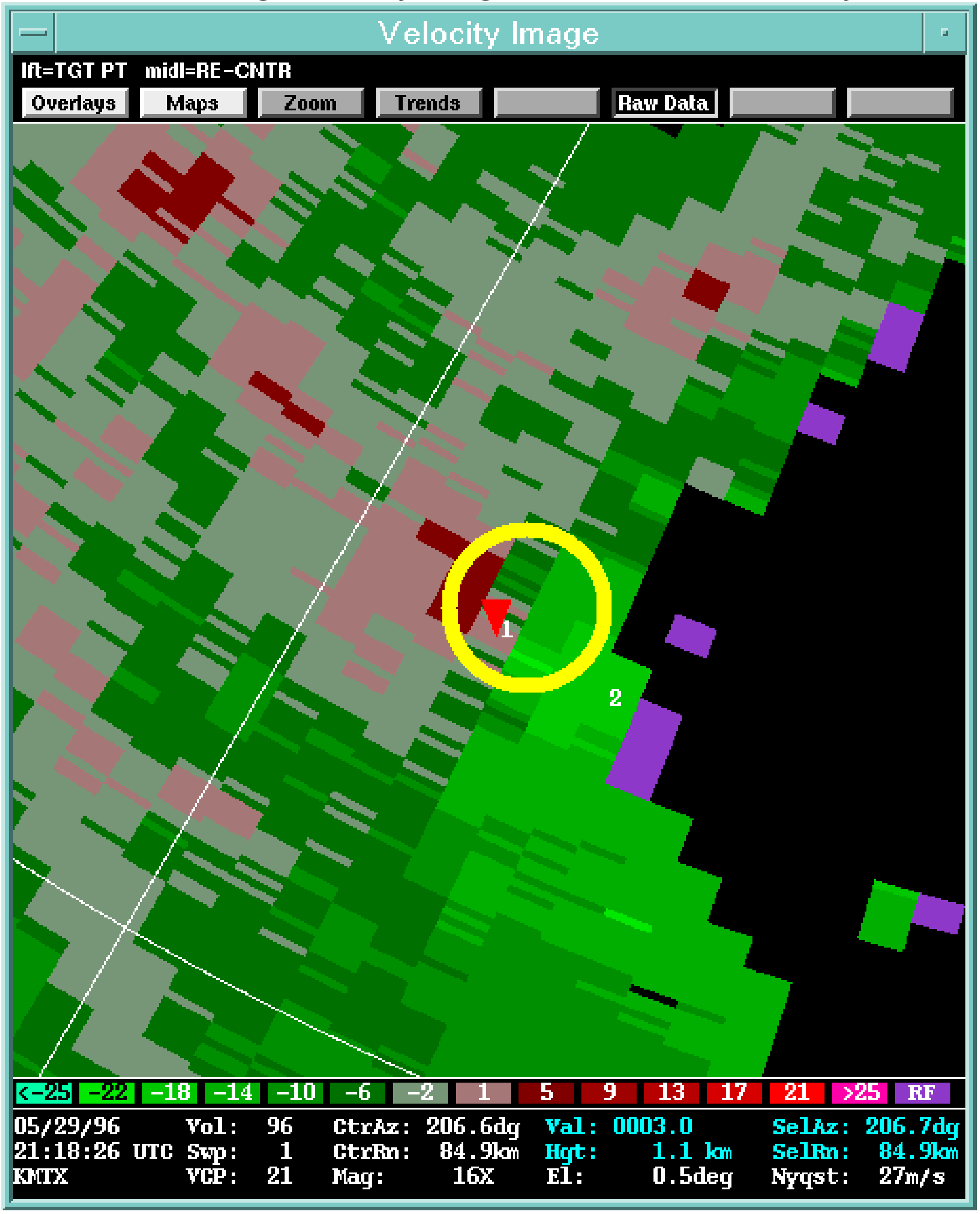
reflectivity storm located southwest of the radar at 45 nm (85 km) range. The yellow ring and red triangle indicate 88D algorithm detections of a mesocyclone and TVS, respectively. There was no confirmation of a tornado with this storm.

FIGURE 1. 0.5 deg reflectivity image at 2118 UTC on 29 May 1996.



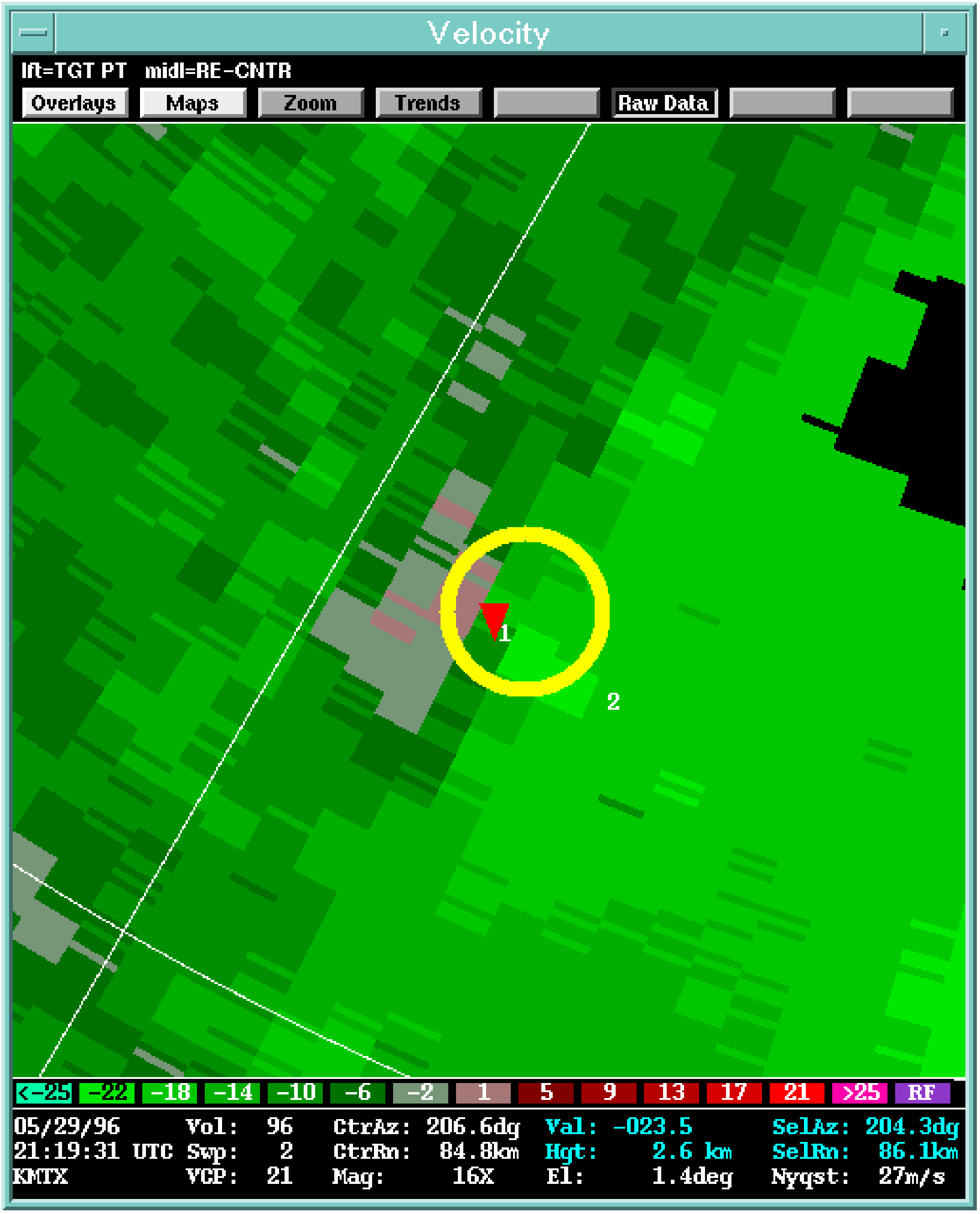
Radial velocity data at 0.5 degrees elevation angle are shown in Figure 2. While there is no indication of a TVS, the maximum inbound and outbound velocities support the algorithm's detection. The maximum inbound velocity (bright green range gate to the southeast of the triangle) is 22 m/s and the corresponding outbound is 4.5 m/s (located southwest of the triangle). Please note that these data points are NOT on adjacent radials but are separated by one azimuth. At 85 km (45 nm) the velocity maxima are separated 2 degrees or approximately 2.8 km (1.5 nm) in azimuth. This results in a shear of 26.5 m/s/2.8 km which is equal to 9.5 m/s/km, or 34.3/hr.

FIGURE 2. 0.5 deg velocity image at 2118 UTC on 29 May 1996.



Recall that the TVS algorithm was run with a threshold of 30/hr with no detections. So the immediate question is why was there no detection. It is because at the next higher tilt (1.4 deg; Fig. 3) there are slightly stronger velocities but separated by 3 azimuths. Thus, the shear at 1.4 deg is 24 m/s over 4.2 km which is 20.6/hr, less than the threshold of 30/hr, and less than the 34.3/hr value at the 0.5 deg tilt.

FIGURE 3. As in Fig. 2 except for 1.4 deg elevation angle.



2.2 TVS #2

The second TVS is somewhat removed from a reflectivity core at 2251 UTC (Fig. 4). Velocity data indicate strong outflow southeast of the radar with azimuthal shear along the 143 deg radial (Fig. 5).

FIGURE 4. 0.5 deg reflectivity image at 2251 UTC on 29 May 1996.

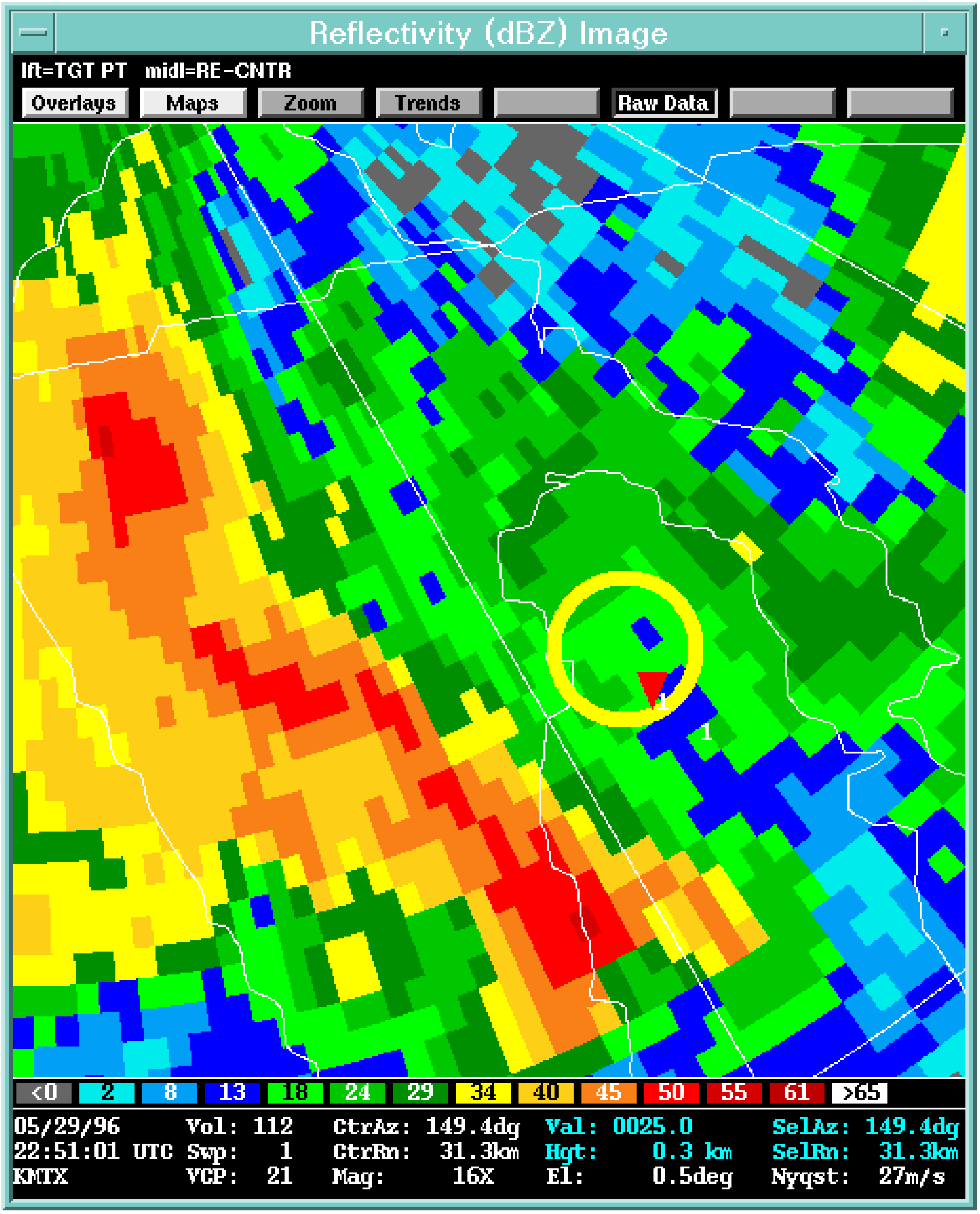
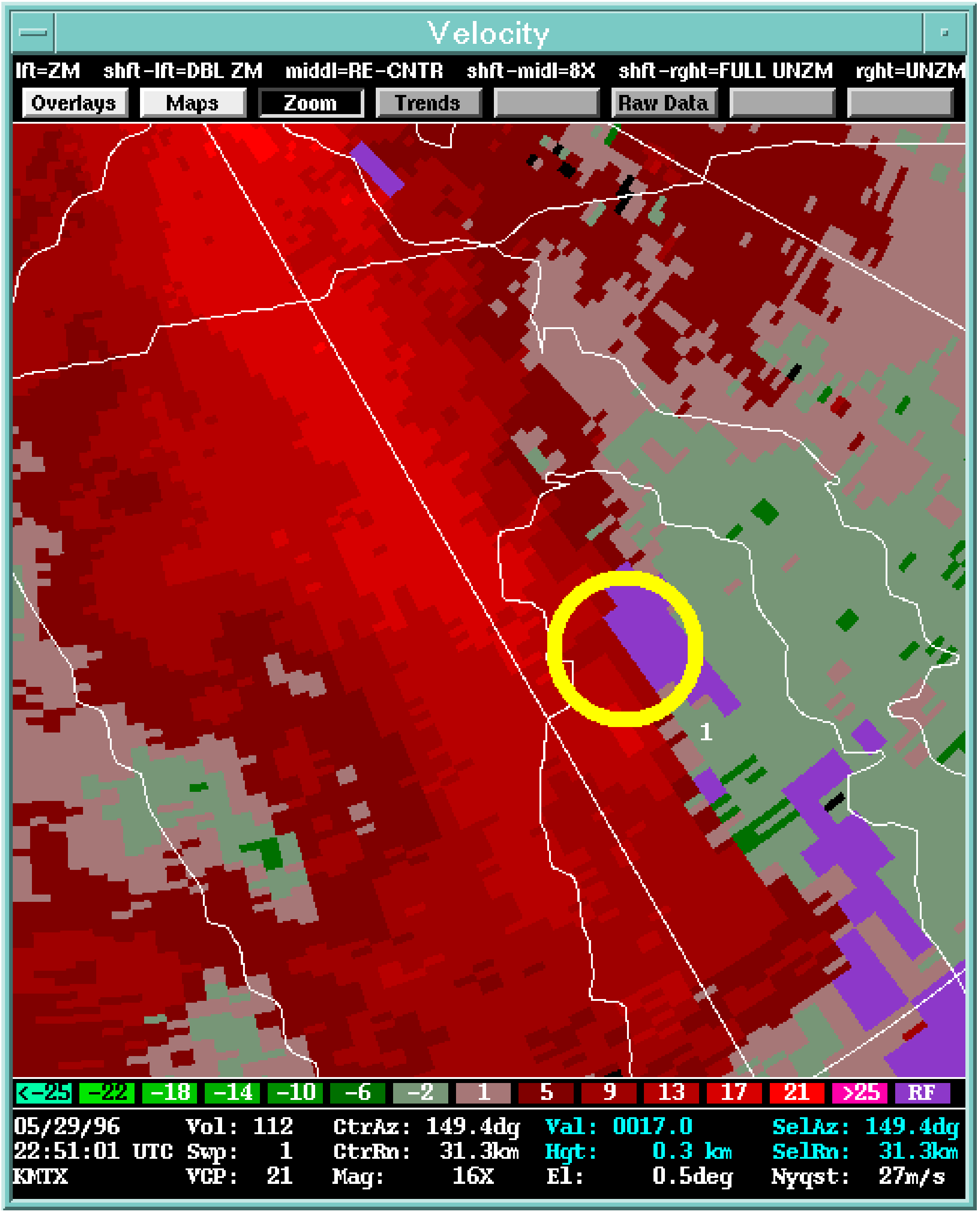


FIGURE 5. 0.5 deg velocity image at 2251 UTC on 29 May 1996. The TVS icon overlay is not shown so the underlying data can be seen.



Inspection of reflectivity and velocity data at 2.4 deg (Figs. 5 and 6) indicates that the mesocyclone detection is northwest of a stronger circulation that is accompanied by a hook-shaped echo. However, within the "detected" mesocyclone, the strongest shear anywhere in the volume is at this tilt. A small gate-to-gate velocity signature can be seen just inside the southest part of the yellow circle. The associated shear is 17 m/s over ~1 km azimuthal distance is 60/hr, much greater than the 30/hr threshold. However, a detection did not result from the 30/hr run because the strongest inbound and outbound velocities were at the 1.5 deg tilt and were separated by over 4 deg: 22 m/s over 4.4 deg (.63 km beamwidth at 38 km range) is 28.6/hr.

FIGURE 6. 2.4 deg reflectivity image at 2253 UTC on 29 May 1996.

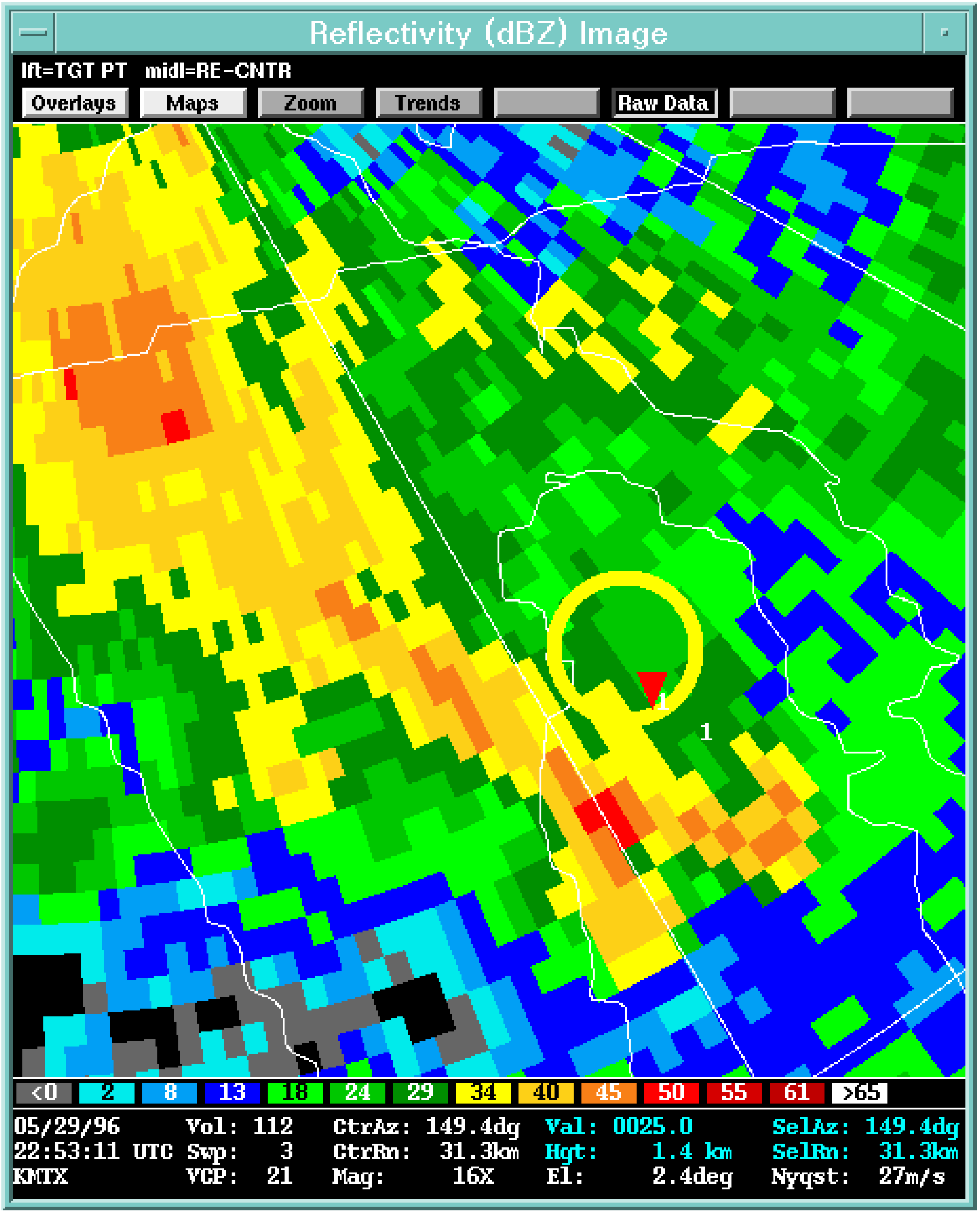
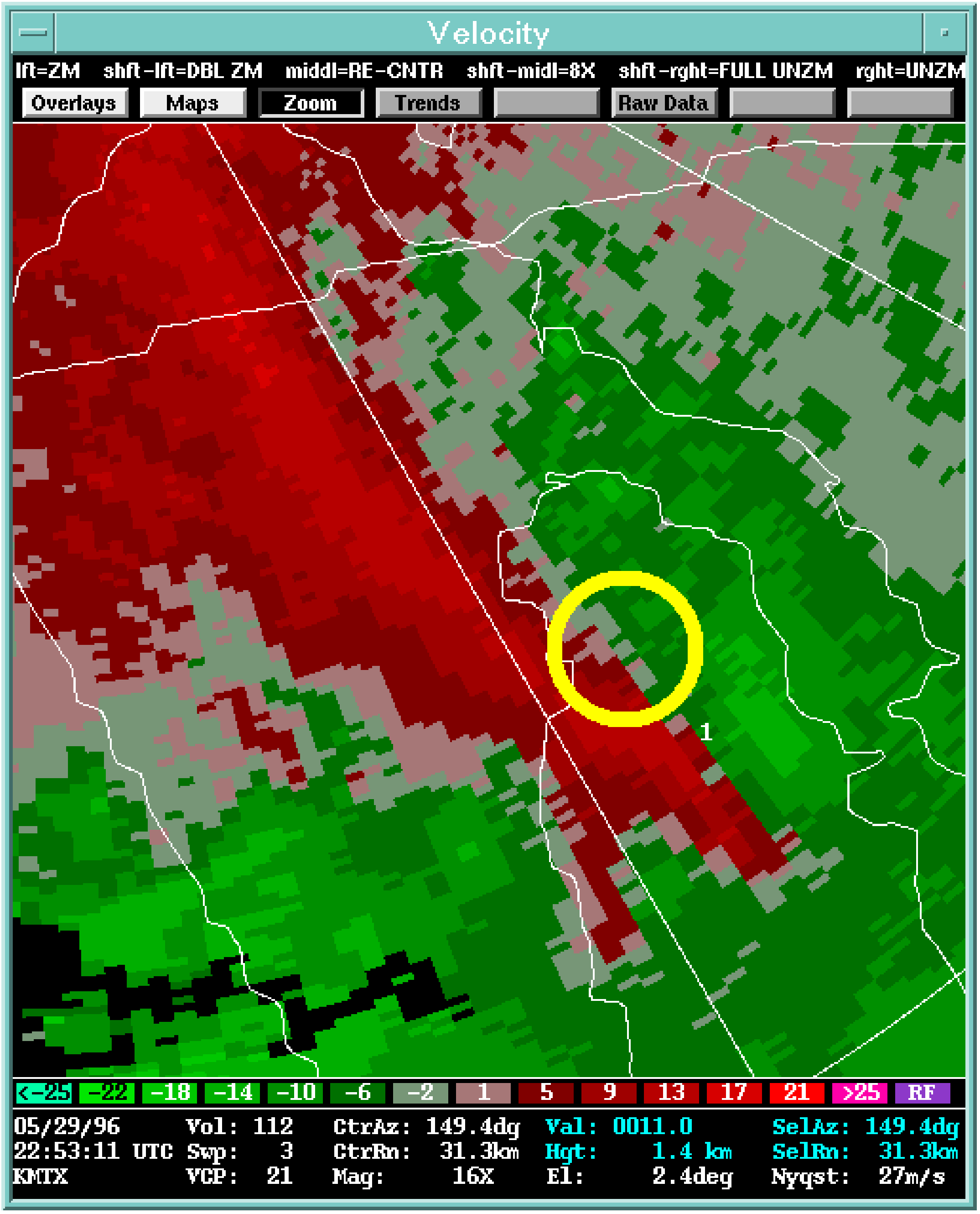


FIGURE 7. 2.4 deg velocity image at 2253 UTC on 29 May 1996. The TVS icon overlay is not shown so the underlying data can be seen.



2.3 North Ogden tornado

Unfortunately, there is no verification for either TVS detection so the significance of the detections is unknown. The first occurred over a desert area and the second an island in the Great Salt Lake. However, some guidance may be obtained by comparing the TVS shears to the shear associated with a F1 tornado in North Ogden around 2330 UTC. Reflectivity and storm-relative velocity at 0.5 deg from the volume scan that began at 2324 UTC are shown in Figs. 8 and 9, respectively. The velocity signature believed to have been associated with the tornado can be seen just below the "1" by the yellow circle in Fig. 9. Here the shear is 18 m/s over one degree in azimuth (.63 km) or 102/hr! This HINTS that 72/hr should be adequate to "pick out" important shears and that the 2 previously-discussed TVS detections are false alarms.

`FIGURE 8. 0.5 deg reflectivity image at 2324 UTC on 29 May 1996.`

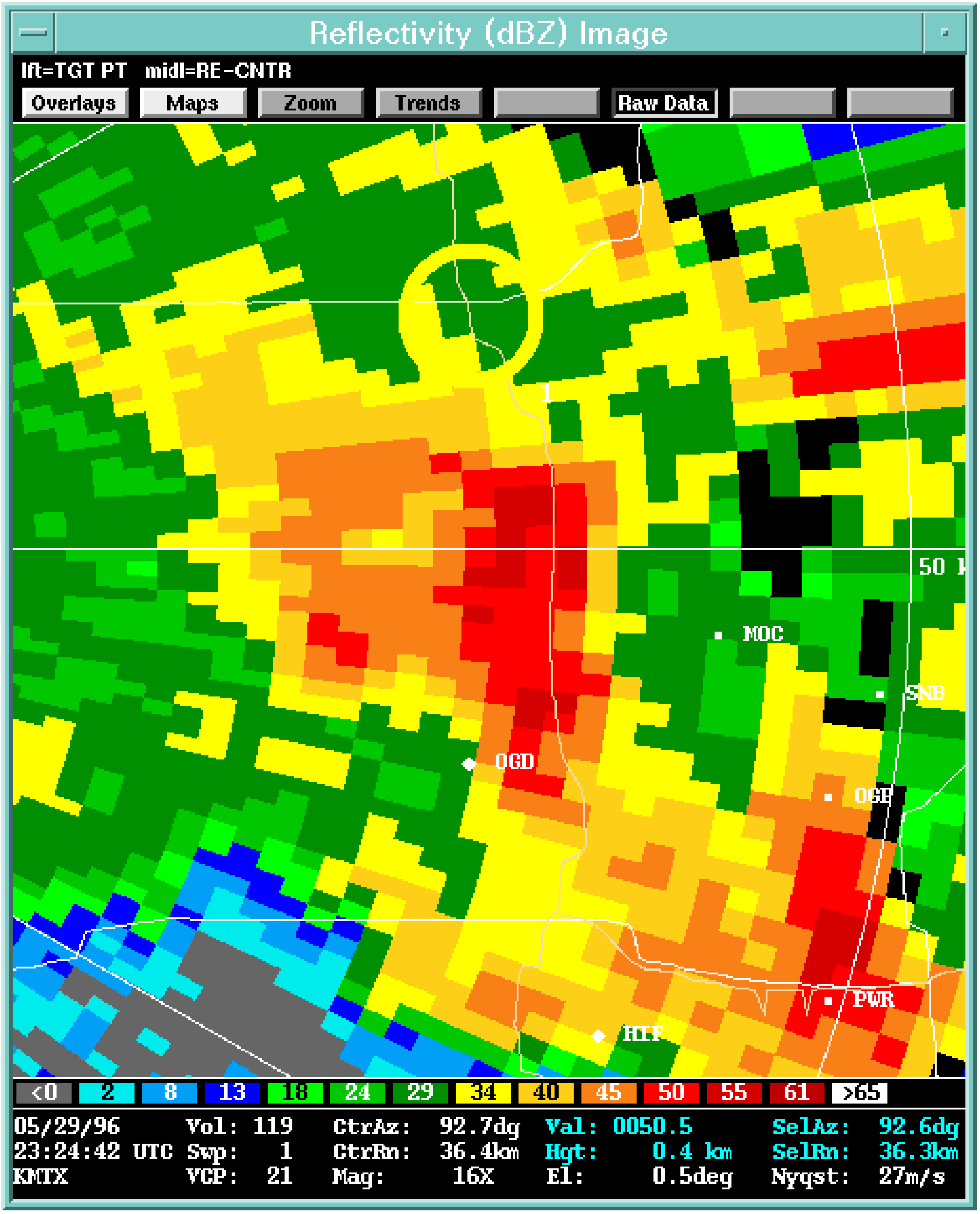
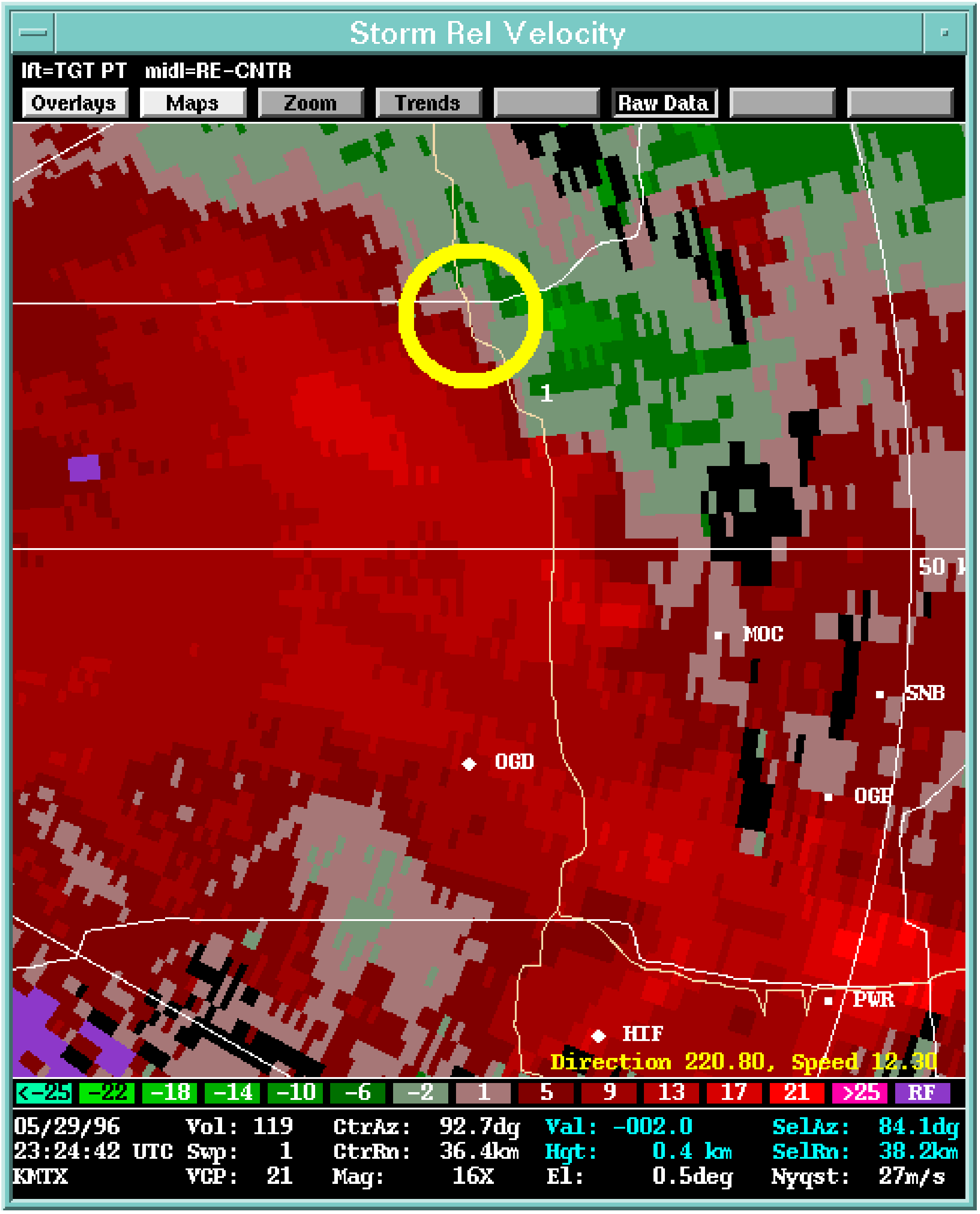


FIGURE 9. 0.5 deg storm-relative velocity image at 2324 UTC on 29 May 1996. A storm motion of 24 kts from 220 deg was subtracted.



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3. Summary

The WSR-88D TVS algorithm was run three different times with shear thresholds of 72/hr, 30/hr, and 18/hr (minimum allowable setting). The only detections were with the minimum threshold run. The first detection had a shear of 20.6/hr and the second had a shear of 27/hr. Of either detection, the first had the most potential of being associate with a tornado since the strongest shear was at the lowest tilt. The second detection was most likely associated with shear along a gust front (although it appears that there was a rotating updraft not far from the detection).

The shear associated with a verified F1 tornado was 102/hr, much stronger than the 72/hr default setting. This tentatively indicates that the TVS detections at the lower thresholds are likely false alarms. Also, a TVS was not detected at the time of the tornado because the signature was too far away from the mesocyclone detection.

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