CENTRAL REGION TECHNICAL ATTACHMENT 95-05

MSP 88D TALES #1[1]

Glenn Lussky[2]
National Weather Service Forecast Office
Minneapolis, Minnesota

1. Introduction

This short paper demonstrates some capabilities of the WSR-88D in terms of providing storm-scale detail during a severe weather event. It is not presumed that the analysis of this event based on the figures presented is flawless. The presumption is that the analysis here can represent the kind of quick study that is possible in a real-time environment, through which the meteorologist can construct their best assessment of the mesoscale processes occurring within an individual storm.

2. Discussion

This case is from the morning of August 19, 1994, around 1000 UTC (5:00 a.m.), of a strong thunderstorm that developed west of Jordan. This storm strengthened and moved southeastward toward Faribault by 1100 UTC (6:00 a.m.). The southeastward movement of this storm represented a strong right-turning component compared with all other shower activity then. Two warnings were issued by Weather Service Office (WSO) in Rochester (RST), Minnesota (Figure 1):

from 5:46 a.m. - 6:15 a.m. for northern LeSueur and northern Rice counties and
from 6:13 a.m. - 7:00 a.m. for Rice and northern Steele counties.

Given the strong right-turning nature of this thunderstorm, we could assume the atmosphere was primed to support a storm with supercellular characteristics. The VAD Wind Profile at 1212 UTC (Figure 2; the most recent profile available when the author began data collection) indicated that the lowest 3 km (10 kft) had a shear profile that could support supercell formation, which

[1]This paper was originally composed to provide early acclimation to the WSR-88D capabilities for the staff at the WSFO MPX. At the time of the event described here, the radar was installed, but not yet accepted.

[2]Currently affiliation, WSO La Crosse, WI.

NNNN>##<A
<ZCZC MSPSVRRST
ETTAA00 KRST 191047
MNC079-131-191115-

BULLETIN - IMMEDIATE BROADCAST REQUESTED
SEVERE THUNDERSTORM WARNING
NATIONAL WEATHER SERVICE ROCHESTER MN
546 AM CDT FRI AUG 19 1994

THE NATIONAL WEATHER SERVICE IN ROCHESTER MN HAS ISSUED A
SEVERE THUNDERSTORM WARNING EFFECTIVE UNTIL 615 AM CDT
FOR PEOPLE IN THE FOLLOWING LOCATIONS...

IN SOUTH CENTRAL MINNESOTA

...NORTHERN LE SUEUR COUNTY...NORTHERN RICE COUNTY

AT 540 AM RADAR INDICATED A SEVERE THUNDERSTORM NEAR HEIDELBERG OR
31 MILES NORTHEAST OF MANKATO. THIS STORM WAS MOVING TO THE EAST
SOUTHEAST AT 20 MPH. THIS STORM WILL MOVE THROUGH MONTGOMERY BY
555 AM. PEA TO GOLFBALL SIZE HAIL WAS REPORTED WITH THIS STORM
NEAR NEW PRAGUE.

SEVERE THUNDERSTORMS PRODUCE DAMAGING WIND...LARGE HAIL...
DEADLY LIGHTNING...AND VERY HEAVY RAIN. FOR YOUR PROTECTION
MOVE TO AN INTERIOR ROOM. PEOPLE IN MOBILE HOMES SHOULD GO
TO A STORM SHELTER.

NNNN>##<A
<ZCZC MSPSVRRST
ETTAA00 KRST 191116 COR
MNC131-147-191200-

BULLETIN - IMMEDIATE BROADCAST REQUESTED
SEVERE THUNDERSTORM WARNING
NATIONAL WEATHER SERVICE ROCHESTER MN
613 AM CDT FRI AUG 19 1994

THE NATIONAL WEATHER SERVICE IN ROCHESTER MN HAS ISSUED A
SEVERE THUNDERSTORM WARNING EFFECTIVE UNTIL 700 AM CDT
FOR PEOPLE IN THE FOLLOWING LOCATIONS...

IN SOUTH CENTRAL MINNESOTA

...RICE COUNTY...NORTHERN STEELE COUNTY

AT 605 AM A SEVERE THUNDERSTORM WAS REPORTED JUST WEST OF FARIBAULT.
AT THIS TIME GOLFBALL SIZE HAIL WAS REPORTED WITH THIS STORM. THIS
STORM WAS MOVING TO THE SOUTH AT 15 MPH AND WILL MOVE THROUGH
OWATONNA BY 640 AM.

REMEMBER SEVERE THUNDERSTORMS CAN PRODUCE TORNADOES WITH LITTLE
OR NO WARNING. STAY INDOORS...REMAIN CALM AND BE READY TO MOVE
QUICKLY TO THE BASEMENT.

Figure 1. Early morning warnings issued by WSO RST on 19 August 1994.

would have been nicely enhanced by the storm-relative flow. It also showed that the profile had weakened during the hour ending at 1311 UTC (i.e., the shear profile had been better at around 1200 UTC). Probably not coincidentally, the convection also weakened during that hour (no additional warnings were in effect, nor was any additional severe weather reported after 1200 UTC (7:00 a.m.)).

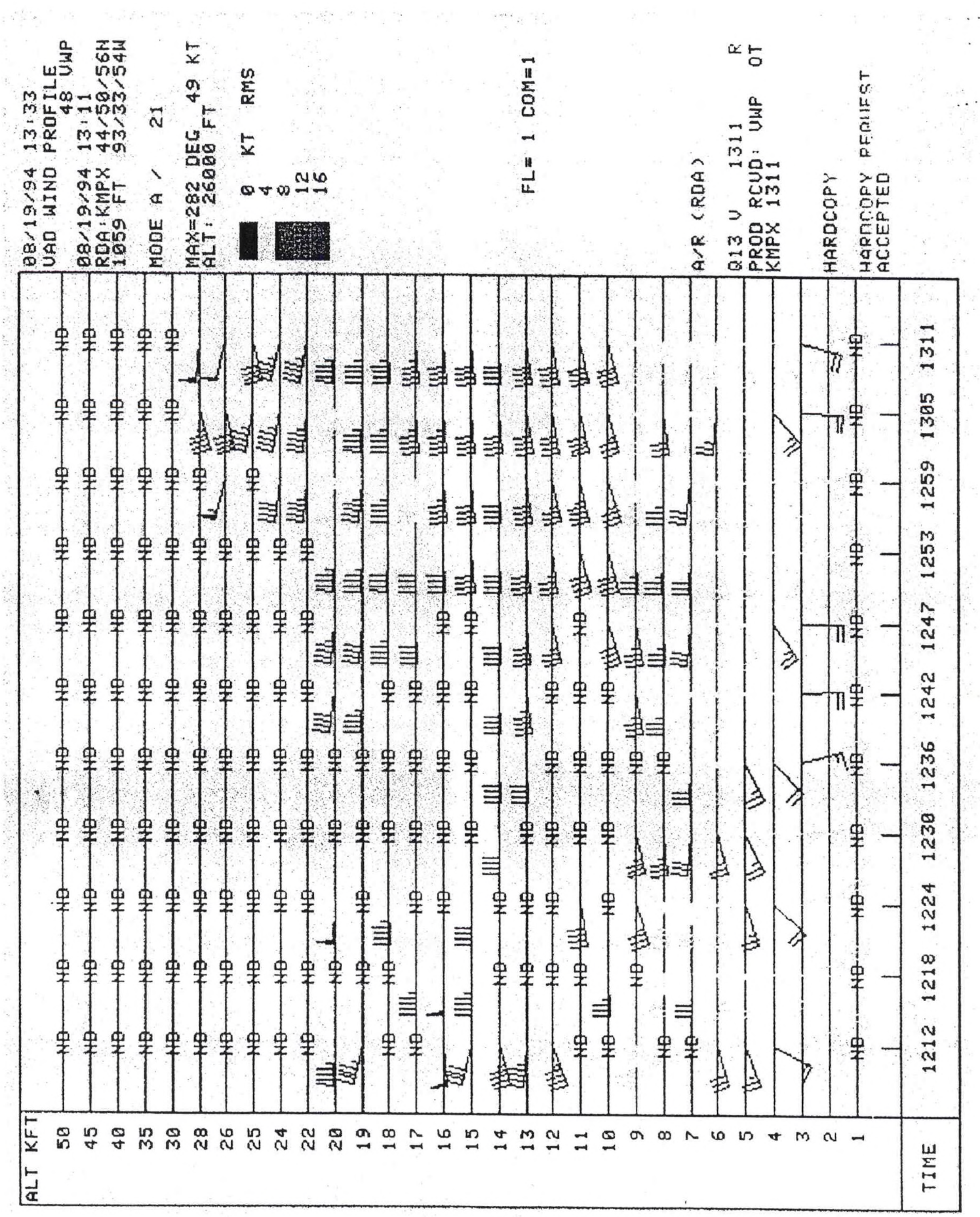

Figure 2. Weather Service Forecast Office (WSFO) in Minneapolis (MPX), Minnesota, WSR-88D VAD Wind Profile (VWP) shortly after the severe weather ended on 19 August 1994. The WSR-88D was located about 30 miles north of the severe storm.

Still, this did not show the shear at 1100 UTC, when the storm was strongest and golf-ball sized hail fell near Faribault. The 1108 UTC 4.3 degree velocity image (Figure 3), however, gives a nice indication of the profile at that time, showing a clear veering (S-shaped) profile, with strong directional shear and substantial speeds at low levels. For instance, the near-surface jet is from 100-110 degrees at 20-26 kts. The cursor readout at that location indicated a height of less than 1500 feet above ground. By 10,000 feet, the winds were out of the west-southwest at 26-36 kts. This confirms that the shear was indeed better at around 1100 UTC than seen between 1200 and 1300 UTC on the 88D-generated profile for those times.

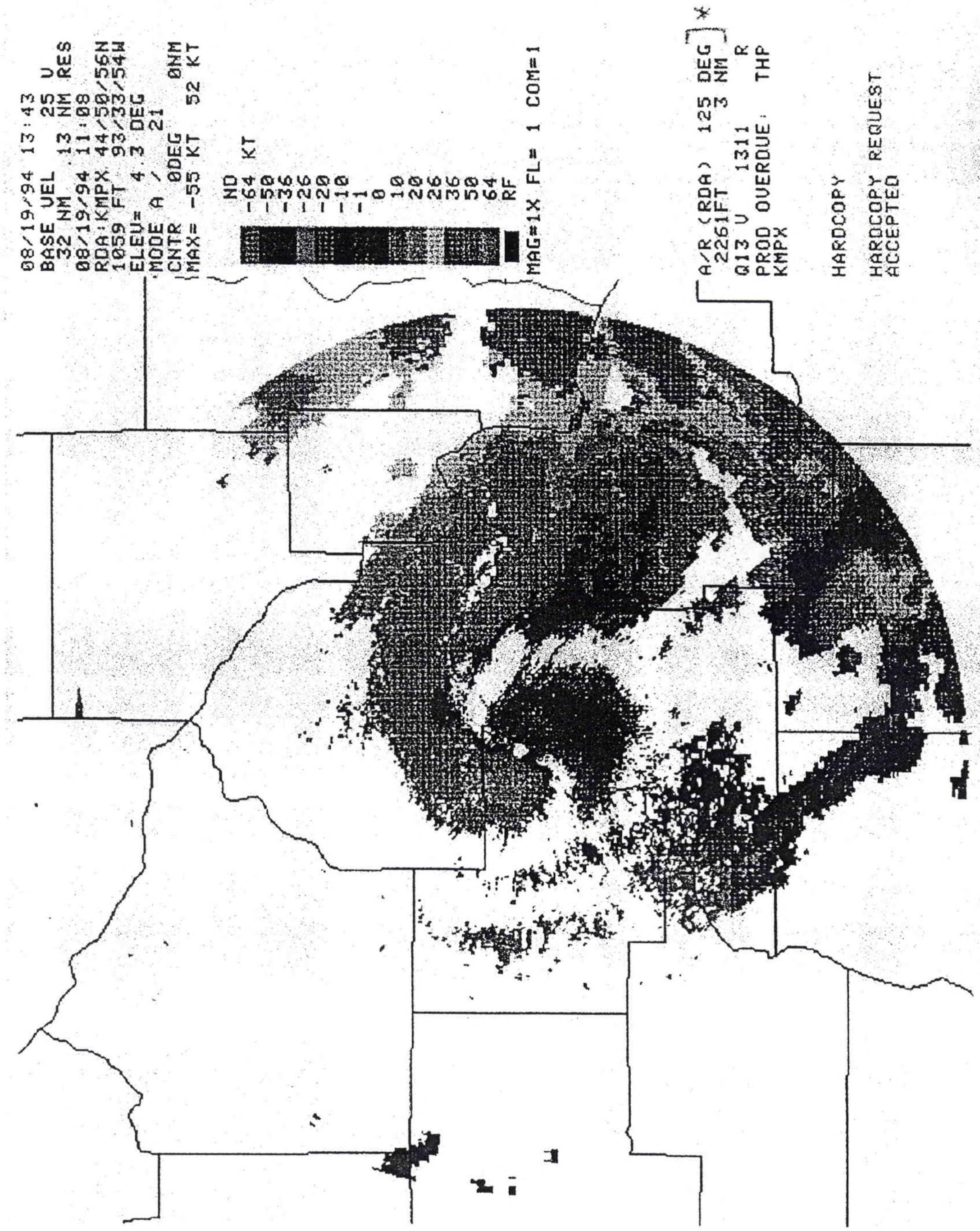

Figure 3. MPX 4.3 degrees Base Velocity, .13 nm resolutions, valid 1108 UTC on 19 August 1994. A clear veering profile is evident, with a low level jet greater than 20 kts from 110 degrees at elevations below 1500 feet AGL.

Examining storm development in terms of its velocity field showed some interesting details. Figures 4 and 5 are four-panel representations showing a blow-up of the area through which the storm moved between 1022 UTC and 1103 UTC. For perspective's sake, each image is centered at 175 degrees/25 nm from the radar, with a beam height of around 1800 feet above ground. Areas toward the top of each image have beam heights around 1000 feet AGL, while heights toward the bottom of each image are nearing 3000 feet AGL.

Starting at 1022 UTC (Figure 4, panel one), the storm was centered just northeast of LeSueur. Inbound flow of 10-20 kts (the dark green) was evident north of Le Center. This flow was moving into the storm. Considering storm motion, (about 310 degrees at 25 mph), storm-relative inflow was probably a healthy 30-40 kts. Strong ground-relative outbound velocities were also evident at low levels at this time, with maximum speeds in the 36 to 50 kt range (the dark red).

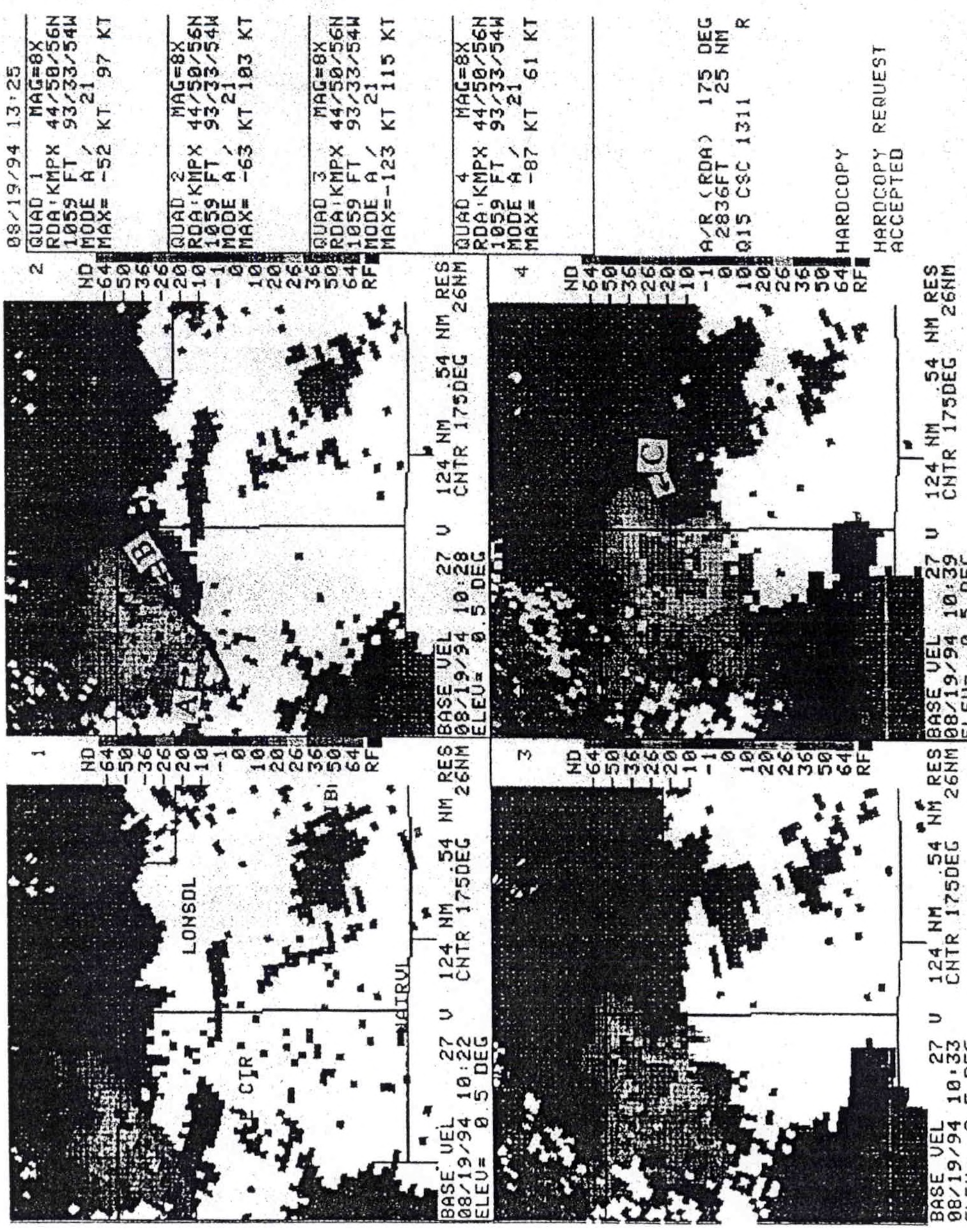

Figure 4. Time sequences of MPX 0.5 degree Base Velocity, .54 nm resolutions, beginning at 1022 UTC and ending at 1039 UTC on 19 August 1994. Areas shown are at eight times magnifications, centered approximately 30 miles south of the radar site.

Panel two, of this figure, shows some southeastward movement of the velocity field, with some strengthening of the outbound values in the main downdraft region of the storm (A). The dark blue boundary drawn on the image approximates the implied location of the outflow boundary. Note also, however, the bright yellow (26-36 kt) outbound flow at B - ahead of the sketched-in boundary. It is not clear where this comes from, but by 1033 UTC (panel three), it appears that the outflow boundary, or perhaps an earlier downdraft pulse, has developed ahead of the storm. This strong outbound flow remains evident at 1039 UTC (panel four).

We could speculate at length regarding what this is and where it came from. For argument's sake, let's assume this was a downdraft pulse that existed at 1022 UTC as well, but was not evident since the flow was primarily perpendicular to the radar beam. Once the outflow advanced ahead of the storm and the storm moved farther eastward, the existence of the pulse outflow became more apparent. While this cannot be proven, this exercise should at least demonstrate the fact that we are looking at radial velocities only, and the impact this has on how we interpret the velocities we see (or do not see).

Note that the 1039 UTC image (panel four) also shows some hint of an inflow notch (C) ahead of the downdraft pulse. The orientation of the outbound and inbound flow near the downdraft/inflow interface suggests some rotation; however, there is no significant gate-to-gate shear to imply anything resembling tornadic rotation. (If we wanted to see a mesocyclone and this storm may have had one, we would generally want to look around 15,000 feet using a higher elevation scan).

The downdraft pulse remains evident through the first two panels of Figure 5 (through 1051 UTC). It becomes barely discernable by 1057 UTC (panel three). It is possible that this pulse had dissipated by that time, while a second strong downdraft pulse (the enhanced outflow at D on panel four) developed. It is also possible that the orientation of the first pulse (now perhaps moving toward the northeast) had become nearly perpendicular to the radar beam. Thus, we cannot say for sure it no longer existed. (In a live situation, we likely would not be worrying about the initial pulse anymore, since it probably would not cause us any operational problems. This discussion is simply to help describe the kind of detail we need to consider when analyzing the velocity fields within a thunderstorm.)

Obviously, it is beneficial to look at more than velocity when analyzing thunderstorms. Relating the velocity fields to what we see in the 3-D reflectivity and other derived products (i.e., VIL, etc.) gives us a much better idea of what is physically going on within the storm.

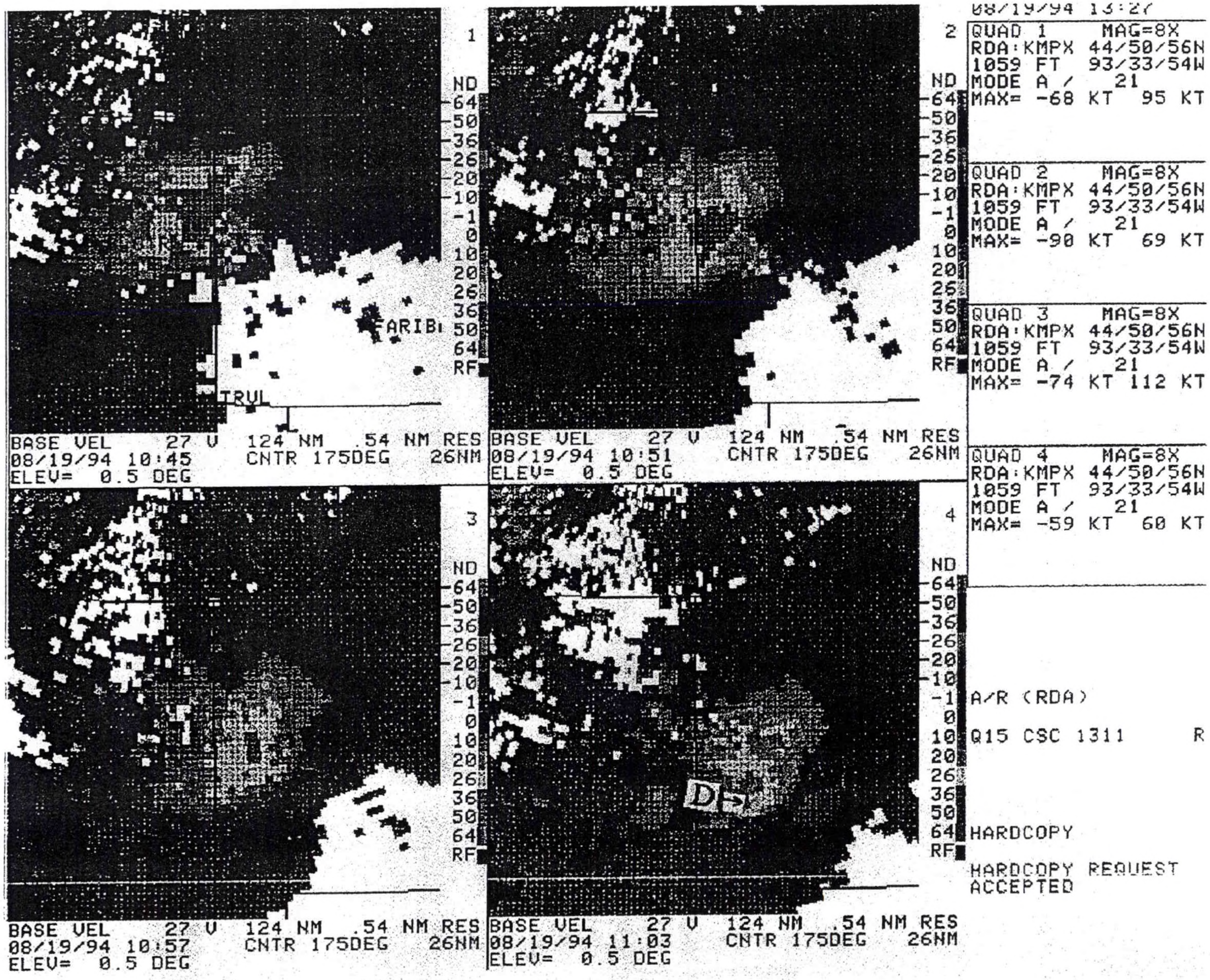

Figure 5. Time sequences of MPX 0.5 degree Base Velocity, .54 nm resolutions, beginning at 1045 UTC and ending at 1103 UTC on 19 August 1994. Areas shown are at eight times magnifications, centered approximately 30 miles south of the radar site.

Figure 6 shows the 0.5 degree base reflectivity (panels one and four), VIL (panel two) and the 0.5 degree velocity (panel three), all valid at 1108 UTC. When using the 88D, you can link the cursors to coordinate locations on each map. Doing this showed that the leading edge of the storm downdraft (E) was aligned perfectly with the high reflectivity outflow "pendant" (F). Clearly, putting these two products together helps the forecaster identify most precisely what the accompanying field represents; much more than either field can do by itself.

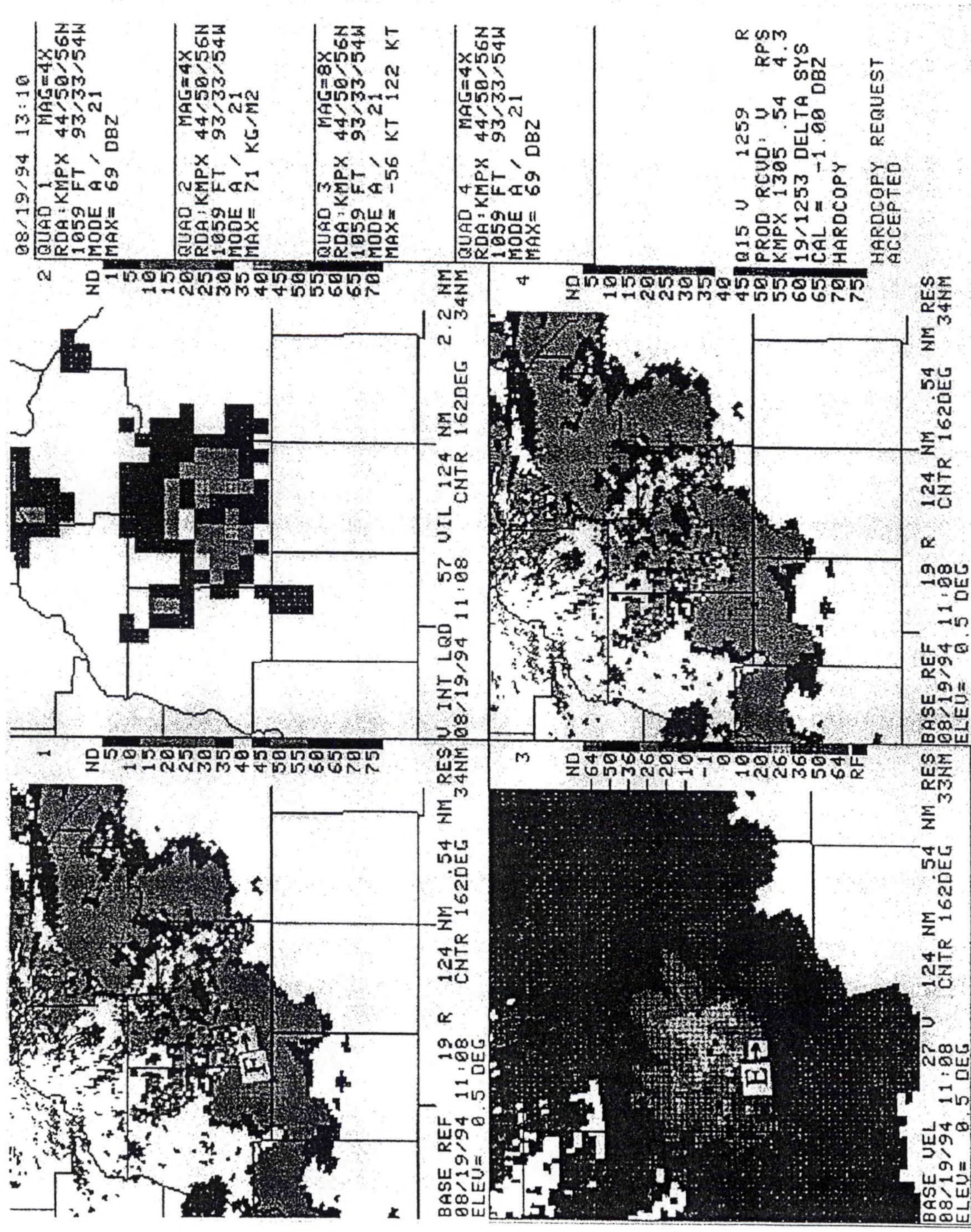

Figure 6. The four-panel representation of the severe storm at 1108 UTC, 19 August 1994, as seen by MPX WSR-88D. Panels one and four show 0.5 degree Base Reflectivity, panel two shows the VIL and panel three shows the 0.5 degree Base Velocity. All panels are centered around 38 miles SSE of the radar. Panel three is depicted at a higher magnification than the other panels.

Finally, the VIL in panel two indicates a maximum value of 71 kg/m^2. This is an extremely high value that should produce near-severe if not severe, hail in all but the most tropical of air masses that exist at MPX. As indicated in the warnings (Figure 1), golf-ball sized hail was falling from the storm near FBL at this time (FBL is almost exactly under the purple pixel representing the 70+ VIL in panel two).

As a matter of information, the strong thunderstorms that developed in the MPX CWA on August 25, 1994 represented one of those very tropical cases for MPX, with a wet-bulb zero around 12,000 feet. That night, no hail fell which met the NWS severe weather criteria until the VIL reached 70. You can expect, during the fall and spring hail seasons, or any time the wet-bulb zero drops into the more prime hail-producing category, a VIL of 40 to 50 might be plenty. The "VIL of the day" will be determined on a case by case basis.

4. Conclusion

This quick summary should give you (the operational forecasters) a better understanding for what can be done with the WSR-88D. Additionally, as was shown for this event, there were important considerations to be aware of when both analyzing the real-time data and applying the WSR-88D products to severe weather warning operations.