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A SUPERCELL THUNDERSTORM ON THE WSR-88D

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Although the WSR-88D installation in Utah will not occur until 1994, the Salt Lake City WSFO has the opportunity to use the collocated CBRFC's non-associated PUP to gain familiarity with usage of Doppler radar. On the evening of July 21, 1993, members of the staff accessed the WSR-88D radar imagery from the site located in northeast Colorado. This Technical Attachment is intended to describe some of the reflectivity and velocity imagery seen that day in which a classic supercell thunderstorm could be identified. Observers and chase teams in Colorado reported golf ball-sized hail and a number of tornado touchdowns during the evening, including one tornado that was estimated to be nearly 3/4 of a mile wide at the base by spotters.

Supercell thunderstorms (Browning 1964; Lemon and Doswell 1979; Klemp et al. 1981) have been the subject of many research efforts over the years. These storms, which are notable for their longevity, cause a significant percentage of the severe weather in the United States. The research has shown that supercell thunderstorms all share a few common characteristics: 1) the reflectivity cores tilt with height...this allows the updraft and downdraft to coexist for long periods, 2) a bounded weak-echo region or "vault" exists where a strong updraft enters the thunderstorm...precipitation particles have not yet formed in the lower portion of the updraft, hence the lower reflectivity, 3) rotation...this depends on the vertical wind shear of the environment and the storm motion...helicity is a recent attempt to quantify this aspect of thunderstorm morphology. Thunderstorms of this type, with well-organized rotation on the scale of a mesocyclone, have been found to produce surface damage 95 percent of the time and tornadoes 62 percent of the time over the Great Plains (Burgess 1976).

Typically, the above-mentioned characteristics have been difficult or impossible to identify in real-time without Doppler radar. Often, radar-based warnings are issued according to the height of the VIP 5 core, or other similar criteria. Discrimination of severe from non-severe storms is difficult, and tornado prediction is particularly challenging. Successful application of the above concepts of thunderstorm structure to identify a severe supercell thunderstorm and issue a real-time warning were reported by Dunn (1990) using a prototype Doppler radar and a pre-AWIPS workstation.

The ability to identify key aspects of the 3-dimensional structure of thunderstorms can best be seen in the 4-panel imagery display format on the WSR-88D PUP. Figure 1 shows a 4-panel display of reflectivity. The 0.5 degree and 1.5 degree scans on the top of the figure are from 0147 UTC 22 July, and the 2.4 degree and 3.4 degree scans are from 6 minutes earlier. The displays have been zoomed and two thunderstorms can be seen, which are located approximately 50 miles east of the radar. Reflectivities of at least 50 dBZ exist at all four elevation slices in these storms. The left-most storm is the topic of this note (storm "A").

In practice on the PUP, a cursor in one of the panels (of the four) shows up at the same location on the other panels. However, when the screen is printed, the cursor is not visible. An arrow has been drawn and the arrow head represents the same location on each of the four panels to simulate the cursor. On the lowest elevation scan, the arrow head is in a region of low reflectivity, with higher values on both sides. With increasing elevation angle the arrow head is found in higher reflectivity values, with 55-60 dBZ found on the highest tilt. This represents a weak-echo region (WER) and is the likely location of the updraft. Low reflectivity in the lower portion of the storm is surrounded by higher reflectivity including an overhanging region of greater than 55 dBZ. Examination of the location of maximum reflectivity in each of the four panels reveals that the core tilts significantly to the southeast with height. Figure 2 shows two of the same reflectivity panels along with the corresponding velocity images. An "X" has been drawn to simulate the role of the PUP cursor and corresponds to the same location in each panel. In the 1.5 degree scans (left one-half of Figure 2), the location of the weak-echo region in the reflectivity is seen to be along the shear axis separating strong inbound (green) from strong outbound velocities (red, arrows indicate velocity direction). This region of rotation is on the scale of a mesocyclone and indicates the presence of a rotating updraft. The 2.4 degree scan shows a similar rotation signature, indicating the rotation extends for some depth through the storm.

These radar images clearly show this storm has the fundamental characteristics of a supercell thunderstorm: a tilted reflectivity core, a weak-echo region (almost bounded) with significant overhanging reflectivity, and a rotating updraft. The forecasters at Denver were obviously able to see these same features, because numerous radar-based warnings, both severe thunderstorm and tornado warnings, were issued for these storms. Lead times of up to one hour prior to touchdown of the first tornadoes were reported (Ray Wolf, Denver forecaster, personal communication).

The opportunity to view this type of data prior to the installation of our own WSR-88D, is a superb training/education situation for WSFO Salt Lake City forecasters. We can't wait to have our own.

References

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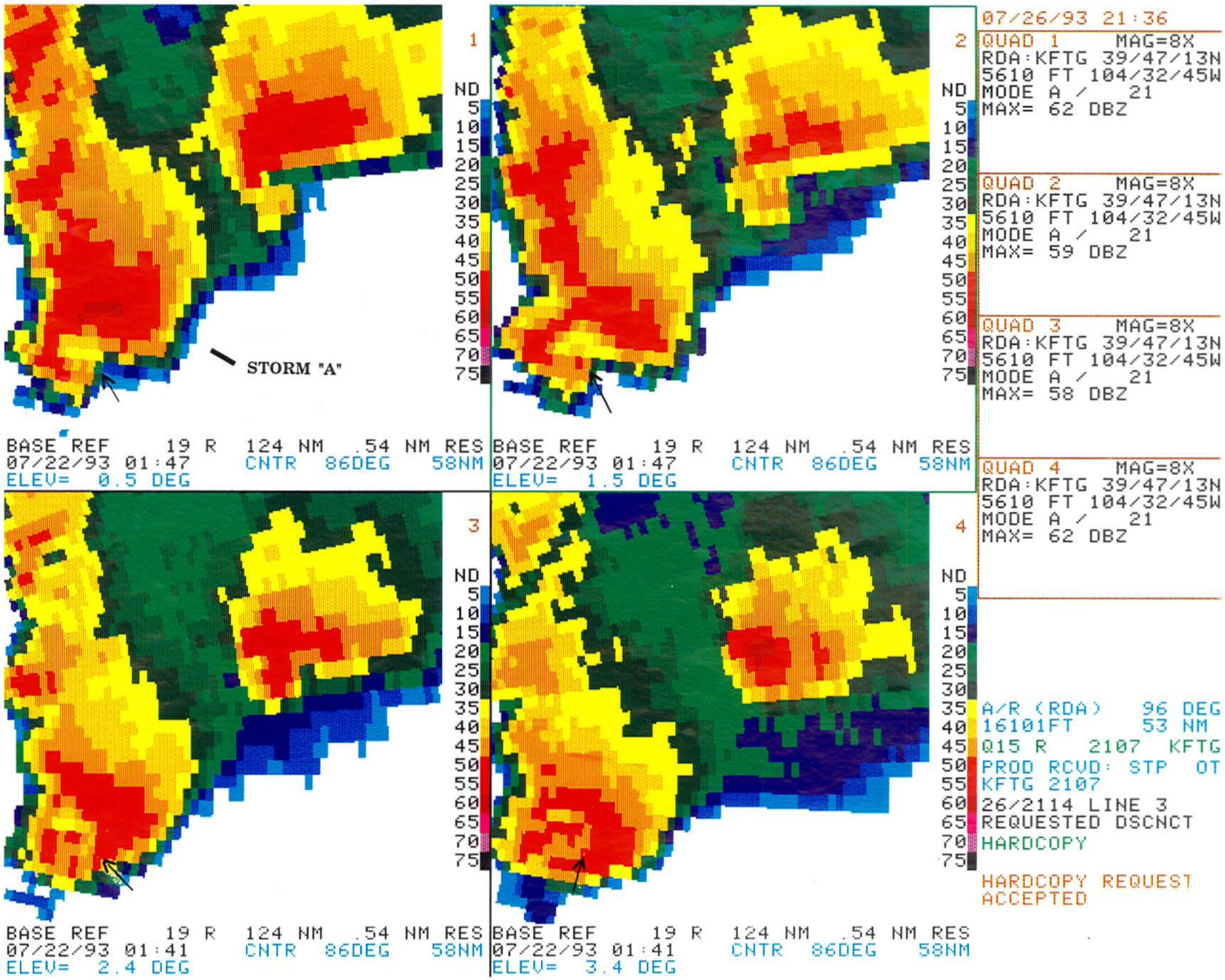
Burgess, D. W. 1976: Single-Doppler radar vortex recognition: Part I-mesocyclone signatures. 17th Conf. on Radar Meteorology (Seattle) AMS Preprint, pp 97-103. Boston: AMS.

Dunn, L. B. 1990: Two examples of operational tornado warnings using Doppler radar data. *Bul. Amer. Met. Soc.*, 71, 145-153.

Klemp, J. B., R. B. Wilhelmson, and P. S. Ray 1981: Observed and numerically simulated structure of a mature supercell thunderstorm. *J. Atmos. Sci.*, 38, 1558-1580.

Lemon, L. R., and C. A. Doswell 1979: Severe thunderstorm evolution and mesocyclone structure as related to tornadogenesis. *Mon. Wea. Rev.*, 107, 1184-1197.


STORM "A"
1
2
3
4
ND 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75
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ELEV= 0.5 DEG
BASE REF 19 R 124 NM .54 NM RES
07/22/93 01:47 CNTR 86DEG 58NM
ELEV= 1.5 DEG
BASE REF 19 R 124 NM .54 NM RES
07/22/93 01:41 CNTR 86DEG 58NM
ELEV= 2.4 DEG
BASE REF 19 R 124 NM .54 NM RES
07/22/93 01:41 CNTR 86DEG 58NM
ELEV= 3.4 DEG
07/26/93 21:36
QUAD 1 MAG=8X
RDA:KFTG 39/47/13N
5610 FT 104/32/45W
MODE A / 21
MAX= 62 DBZ
QUAD 2 MAG=8X
RDA:KFTG 39/47/13N
5610 FT 104/32/45W
MODE A / 21
MAX= 59 DBZ
QUAD 3 MAG=8X
RDA:KFTG 39/47/13N
5610 FT 104/32/45W
MODE A / 21
MAX= 58 DBZ
QUAD 4 MAG=8X
RDA:KFTG 39/47/13N
5610 FT 104/32/45W
MODE A / 21
MAX= 62 DBZ
A/R (RDA) 96 DEG
16101FT 53 NM
Q15 R 2107 KFTG
PROD RCVD: STP OT
KFTG 2107
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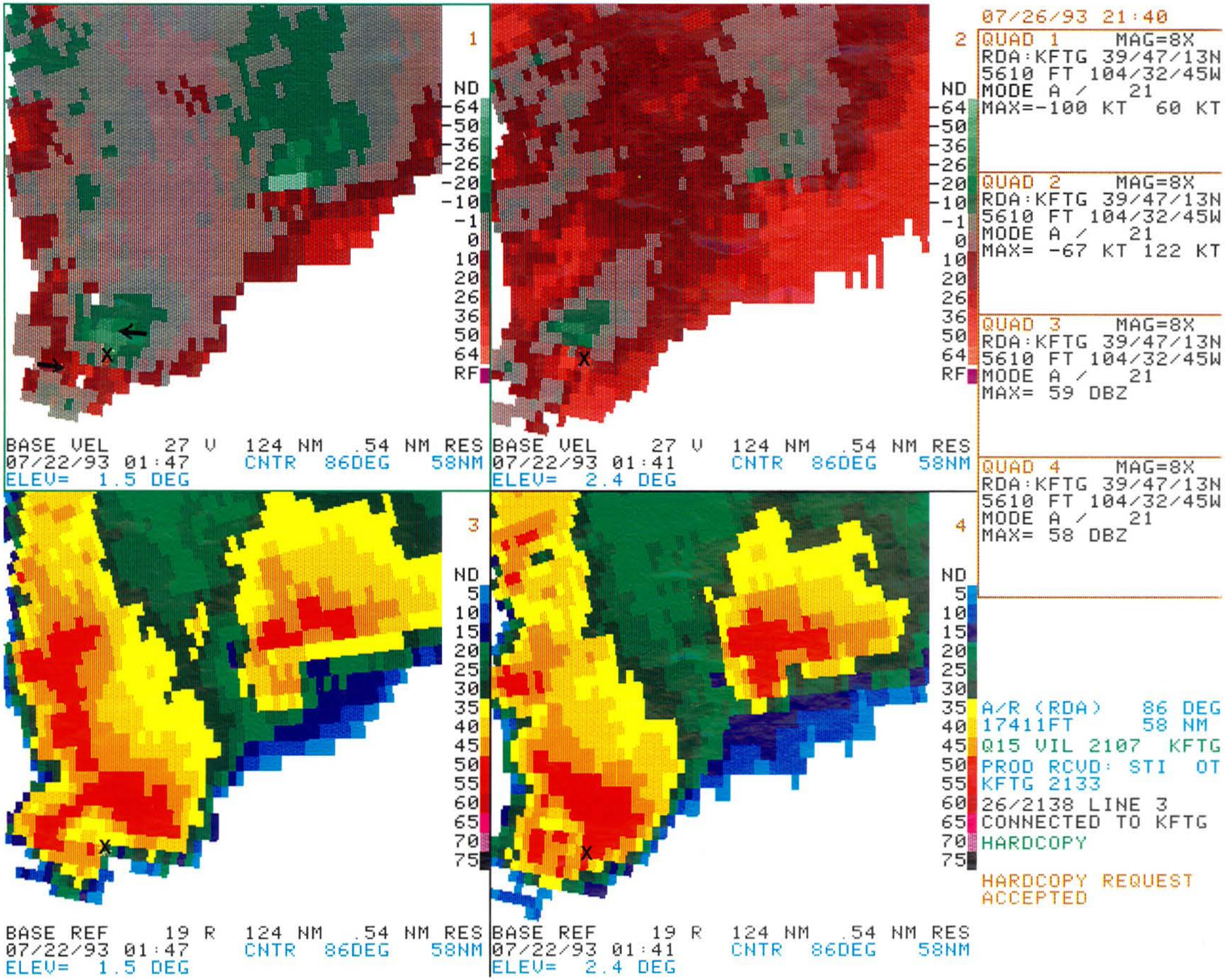
HARDCOPY
HARDCOPY REQUEST
ACCEPTED

Figure 1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MODE A / 21
MAX=-100 KT 60 KT
QUAD 2 MAG=8X
RDA:KFTG 39/47/13N
5610 FT 104/32/45W
MODE A / 21
MAX= -67 KT 122 KT
QUAD 3 MAG=8X
RDA:KFTG 39/47/13N
5610 FT 104/32/45W
MODE A / 21
MAX= 59 DBZ
QUAD 4 MAG=8X
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MODE A / 21
MAX= 58 DBZ
A/R (RDA) 86 DEG
17411FT 58 NM
Q15 VIL 2107 KFTG
PROD RCVD: STI OT
KFTG 2133
26/2138 LINE 3
CONNECTED TO KFTG
HARDCOPY
HARDCOPY REQUEST
ACCEPTED
1
2
3
4
ND -64 -50 -36 -26 -20 -10 -1 0 10 20 26 36 50 64 RF
ND 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75
BASE VEL 27 V 124 NM .54 NM RES
07/22/93 01:47 CNTR 86DEG 58NM
ELEV= 1.5 DEG
BASE VEL 27 V 124 NM .54 NM RES
07/22/93 01:41 CNTR 86DEG 58NM
ELEV= 2.4 DEG
BASE REF 19 R 124 NM .54 NM RES
07/22/93 01:47 CNTR 86DEG 58NM
ELEV= 1.5 DEG
BASE REF 19 R 124 NM .54 NM RES
07/22/93 01:41 CNTR 86DEG 58NM
ELEV= 2.4 DEG

Figure 2