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SAN JOAQUIN VALLEY HAIL EVENT
DECEMBER 13, 1995

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Introduction

Thunderstorms with hail are an infrequent occurrence in California's San Joaquin Valley. Due to the infrequent occurrence of hail, there is little objective experience with traditional radar-based prediction, such as VIL of the day, dBZ, echo top and storm top divergence. On December 13, 1995, several severe thunderstorms occurred with instances of 3/4 to 1 inch hail. This Technical Attachment summarizes:

1) A chronological examination and documentation of the corresponding Doppler radar signatures of the severe storms' occurrence; and most importantly,

2) The critical thought processes and actions of the radar meteorologist in determining threshold parameters for the purposes of warning and statement issuances for area customers.

This December 1995 event was the first severe weather observed since the San Joaquin Valley WSR-88D was commissioned. There were four storms of interest which will be discussed in detail. Three severe thunderstorm warnings for four counties were issued for two of these storms. There were not any misses (unwarned events) during that day. Three of the warnings were verified, producing a false alarm ration (FAR) of .25 percent, a probability of detection (POD) of 1 and a critical success index (CSI) of .75.

In general, the potential for large hail is related to the size and strength of the updraft. Radar signatures related to strong updrafts include large weak echo regions (WER), strong storm top divergence, and seasonally large values of VIL. Thus, hailstorms are usually associated with large, intense radar echoes. The height at which falling hail begins to melt has a significant impact on the size and amount (if any) of hail that reaches the surface (Vasiloff 1997).

Overview

In determining the "problem of the day", 12Z upper-air soundings from Oakland and Vandenberg Air Force Base were not available due to power outages at their offices. These data were greatly missed for the computation of stability indices, convective temperature determination, and other variables. Thus, forecasters had to prepare for this day's events based on gridded model information, RAMSDIS imagery, surface weather observations, and Doppler radar data.

Data Analysis

At 1:45 p.m. Pacific Standard Time (PST), a 40-mile wide line of thunderstorms developed in the western portion of the San Joaquin Valley. The line was about 50 miles wide and extended from 20 miles west of Merced (MER) to 25 miles southwest of Bakersfield (BFL). Individual thunderstorm movement was to the northeast at 20-25 miles an hour. Most of the storms contained heavy rain showers, winds gusts to about 30 mph, and pea-sized hail.

Doppler radar indicated that stronger storms in the line had tops ranging from 15 to 20 kft. The typical VILs were10 to 20 kg/m^2 with a few peak VIL values of 25 kg/m^2 in stronger radar reflectivity echoes. The stronger radar reflectivities ranged from 55 to 65 dBZ. Radar velocity signatures from these storms were weak and did not indicate any rotation. At this point, surface and radar observations gave no indication that rotation or tornadic activity would occur.

Storm I

Some characteristics of Storm I included a maximum VIL of 34 kg/m^2, a maximum dBZ value of 62, echo tops of 29 kft, and a weak storm top divergence delta-v of 32 knots. These peak values lasted only one volume scan and diminished rapidly thereafter (Fig. 1).

Criteria for severe weather based on radar alone were not yet established, but this storm would eventually strengthen. At 2:15 p.m., a weather spotter reported pea-sized hail and 25 to 30 knot winds just north of the City of Bakersfield around 2:00 p.m.

Storm II

The next development of concern was a storm cell in Madera and southern Merced Counties between 2:00 and 2:10 p.m. (Fig. 2a). Several radar signatures were interesting. Storm movement was east-northeast at 20 knots. The storm formed what looked like a bow echo, with a rear notch indicative of dry air intrusion directly behind the storm. This occurred 25 miles west of the city of Chowchilla. During the previous volume scan, this storm reached a maximum reflectivity of 50 dBZ. No warning was issued on this storm as radar velocity and VIL signatures were not strong enough. The lack of spotter reports of high wind or severe weather reinforced this decision. One-half hour later at 2:50 p.m. a spotter near Chowchilla in Madera County reported winds of 25-30 mph, heavy rain showers, lightning, and pea-size hail. The VIL on this storm only reached 20 to 25 kg/m^2 and maximum storm tops were 20 kft.

Storm III

Having estimated preliminary severe criteria per the aforementioned storms, Storm III initially located 25 miles southwest of Hanford (see Fig. 2b) became the first storm for which an SVR was issued. At 2:03 p.m., the following radar signatures were observed and continued for more than two volume scans:

-VIL of 37 kg/m^2;
-Composite reflectivity maximum of 67 dBZ which increased to 69 dBZ by 2:18 p.m.
-Storm top of 29 thousand feet; and
-a WER.

Besides the above signatures, Storm III also indicated a couple of other classic hail-producing storm signatures, including a small pendant at the 2.4 degree elevation slice (Fig. 3). The storm center was collapsing as denoted by lower reflectivity surrounded by higher values. The storm track was forecast to move through the city of Hanford (host site of the San Joaquin Valley WSR-88D radar) between 2:40 and 2:50 p.m. PST. One inch hail was reported by one of the staff meteorologists at home at 2:55 p.m. on the north side of Hanford. Storm top divergence was difficult to determine in this storm because of the close proximity to the radar. Storm III's persistence also played an important role in the decision to issue a SVR at 2:23 p.m. PST lasting 45 minutes (through 3:15 p.m.) for Kings County. This was verified by a one-inch hail report in the City of Hanford at 3:00 p.m., a 37-minute lead time for this storm. At 2:46 p.m., the warning was extended 45 minutes into Fresno and Tulare Counties. Three-fourths inch in Fresno County verified this storm at 3:25 p.m., a 39-minute lead time. There was no verification in Tulare County.

Storm IV

Two separate but merging storms southwest of Bakersfield were observed with VILs of 30 and 25 kg/m^2, storm tops of 20 kft , and maximum reflectivity of 55 to 60 dBZ. Storm tracking indicated the cells would merge approximately 10 miles south of Bakersfield. [Merging cells similar to these were associated with a severe thunderstorm event in southeast Michigan in 1994 (Reference #1).] After these storms merged, the maximum VIL was 37 kg/m^2, reflectivity maximum was 61 dBZ, storm top was 31 kft, and storm top divergence (delta-V) was 60 knots at its peak (Fig. 4).

A SVR was issued at 3:15 p.m. and verified at 3:30 p.m. with a one-inch hail report in Bakersfield.

Discussion

The establishment of the VIL of the day by using spotter reports in real time to calibrate the radar observations greatly aided in the issuance of SVR products during this event. A SVR was issued for each of Storms III and IV with a corresponding 30 to 45 minute verification lead time on the 3/4 inch hail events.

In reviewing the radar storm total precipitation, an interesting phenomenon was noted. The largest hail and strongest storms are usually expected to contain the largest rainfall amounts. This is not always true. A few hail stones produce much larger reflectivity than many small drops, but may produce less rain at the ground. The largest hail amounts occurred with light amounts of rainfall. One inch hail fell near the city of Hanford with very little precipitation, compared to a storm in Bakersfield that produced only 3/4 inch hail with a much larger area of one inch rainfall amounts. Compared to actual precipitation reports, the storm total precipitation map displayed an excess of actual total rainfall in the areas which reported rain because the radar precipitation reports hail contaminated indicated predominantly by the blue shaded colors in this instance. Bright banding could be an explanation for heavier amounts of rainfall in the vicinity of Bakersfield. Radar scanning problems could be a source of this problem, but will have to be explained in further research.

Conclusion

Due to the agricultural nature of much of the central and southern San Joaquin Valley, there are many sparsely populated areas, and especially along the valley's westside. Thus, the formation of severe storms there provides little capability for the confirmation of radar reports from weather spotters. That is why it is important to determine and verify criteria for severe weather based on radar as early into the event as possible. Any subsequent storms with similar radar signatures and qualities can be acted upon quicker and with more confidence thereby providing more warning lead time.

Until the spring of 1995, the San Joaquin Valley had been almost totally dependent on spotters for storm information. Now the WSR-88D enables NWSO San Joaquin Valley to provide more specific warnings with greater confidence and lead time.

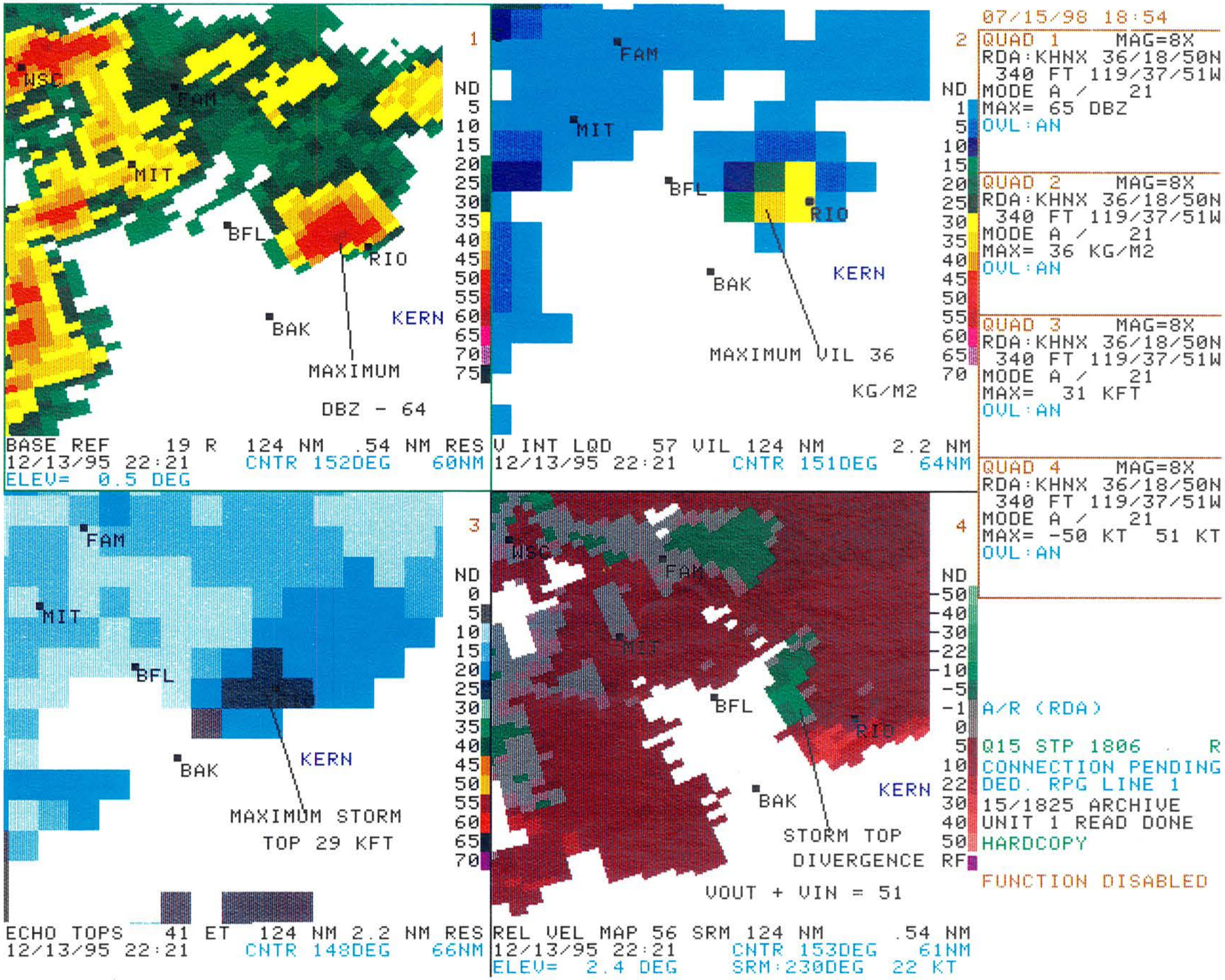
Acknowledgments

Acknowledgment must still be given to our spotters who alert us and confirm our radar observations. Their work is deeply appreciated. Many times during a storm outbreak, it is a spotter report which gives us the confidence to issue that warning or not. The author would also like to thank Steve Vasiloff, Larry Greiss, and Dan Gudgel, for their reviews of this Technical Attachment.

References

Presentation to the Southeast Michigan Chapter of the American Meteorological Society entitled "Merging cell Monroe county producing large hail". This was presented by Dick Wagenmaker (SOO) WSFO Pontiac, MI and Ed Fenelon (SOO) WSO Marquette, MI.

Vasiloff and Adams, 1997. High Reflectivity/Non-Severe Thunderstorm in Complex Terrain. NWS Western Region Technical Attachment TA 97-10. http://www.wrh.noaa.gov



07/15/98 18:54
QUAD 1 MAG=8X
RDA:KHNX 36/18/50N
340 FT 119/37/51W
MODE A / 21
MAX= 65 DBZ
OVL:AN
QUAD 2 MAG=8X
RDA:KHNX 36/18/50N
340 FT 119/37/51W
MODE A / 21
MAX= 36 KG/M2
OVL:AN
QUAD 3 MAG=8X
RDA:KHNX 36/18/50N
340 FT 119/37/51W
MODE A / 21
MAX= 31 KFT
OVL:AN
QUAD 4 MAG=8X
RDA:KHNX 36/18/50N
340 FT 119/37/51W
MODE A / 21
MAX= -50 KT 51 KT
OVL:AN
MAXIMUM
DBZ - 64
BASE REF 19 R 124 NM .54 NM RES
12/13/95 22:21 CNTR 152DEG 60NM
ELEV= 0.5 DEG
MAXIMUM VIL 36
KG/M2
V INT LQD 57 VIL 124 NM 2.2 NM
12/13/95 22:21 CNTR 151DEG 64NM
MAXIMUM STORM
TOP 29 KFT
ECHO TOPS 41 ET 124 NM 2.2 NM RES
12/13/95 22:21 CNTR 148DEG 66NM
STORM TOP
DIVERGENCE
VOUT + VIN = 51
REL VEL MAP 56 SRM 124 NM .54 NM
12/13/95 22:21 CNTR 153DEG 61NM
ELEV= 2.4 DEG SRM:230DEG 22 KT
A/R (RDA)
Q15 STP 1806 R
CONNECTION PENDING
DED. RPG LINE 1
15/1825 ARCHIVE
UNIT 1 READ DONE
HARDCOPY
FUNCTION DISABLED

Figure 1

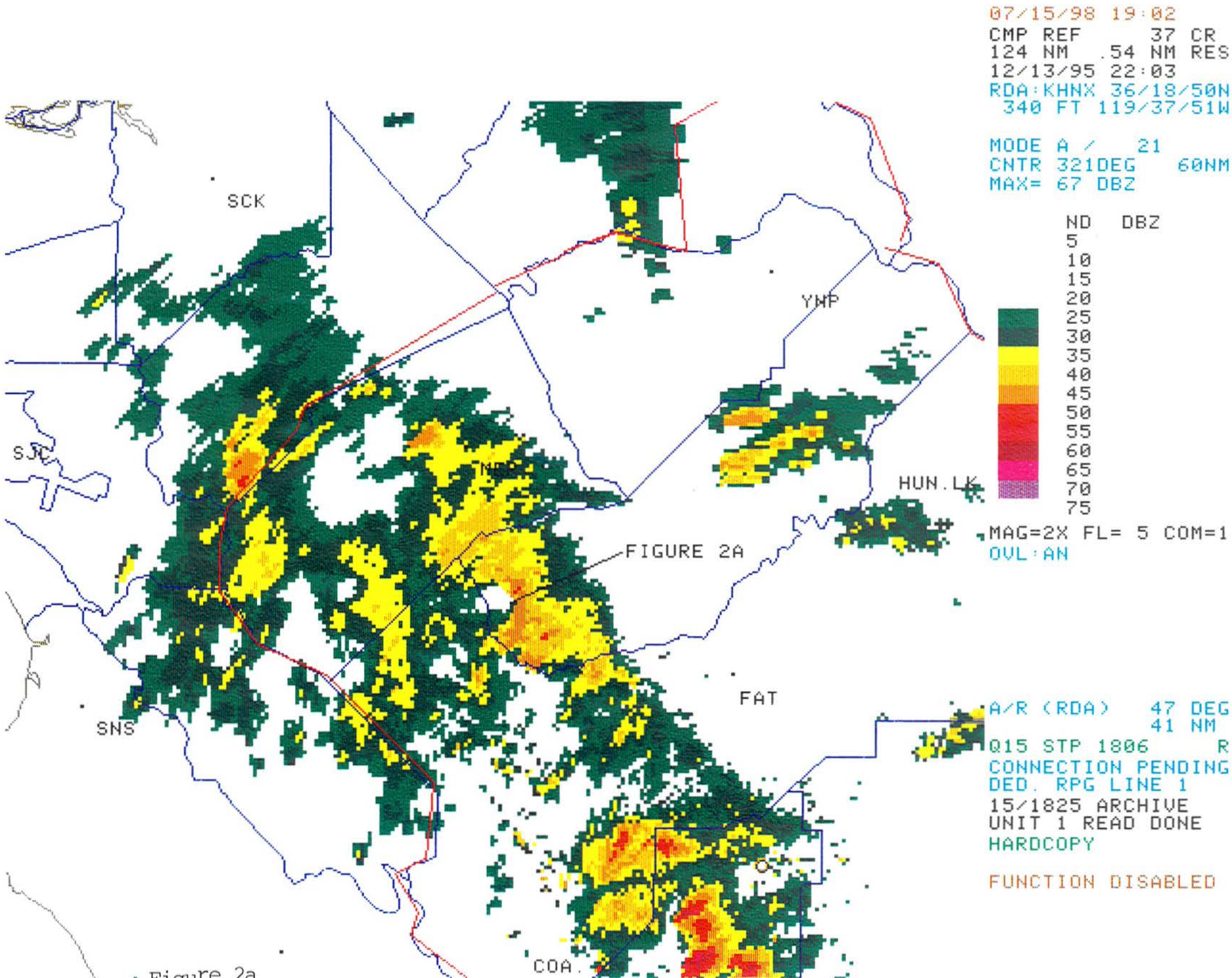
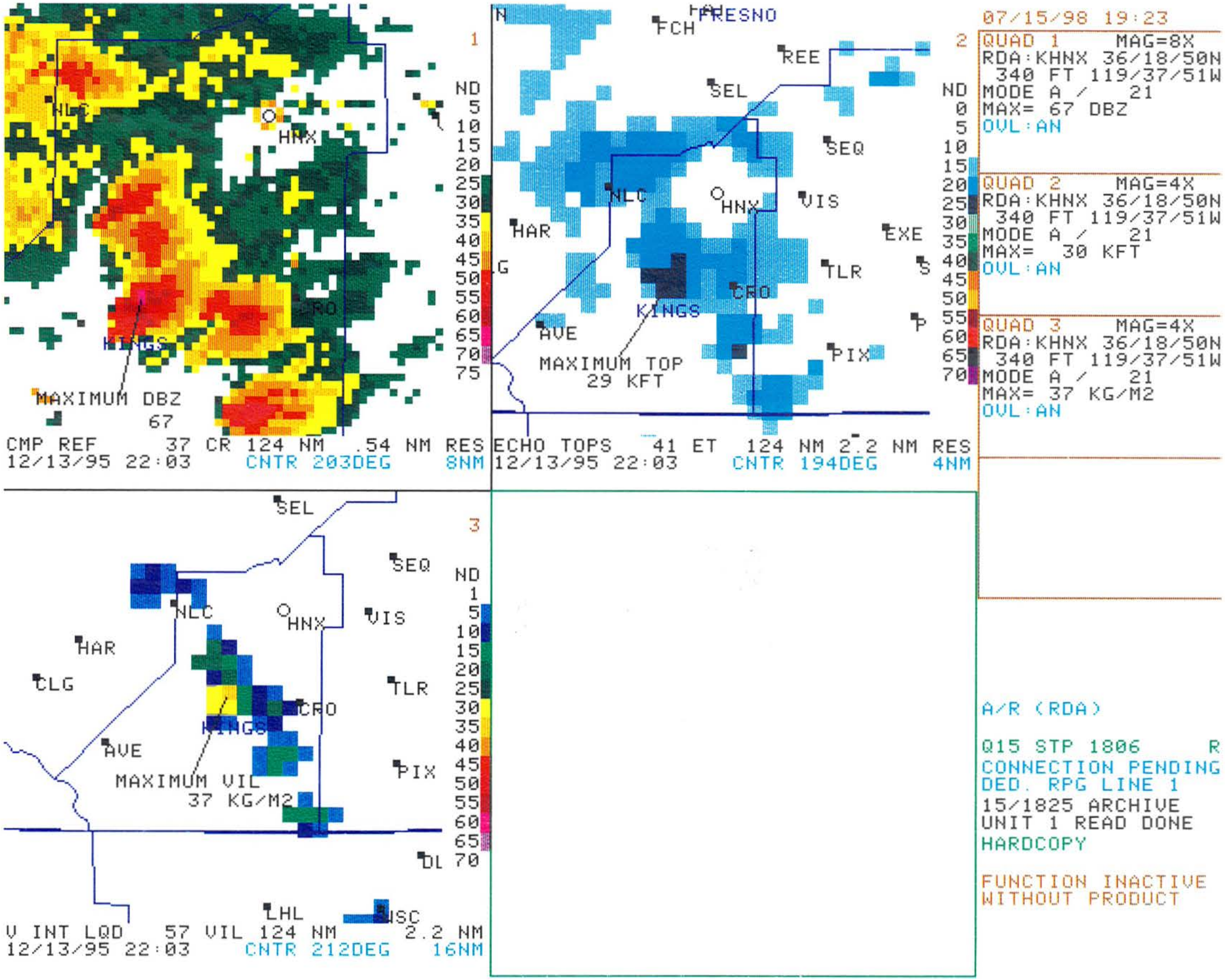

07/15/98 19:02
CMP REF 37 CR
124 NM .54 NM RES
12/13/95 22:03
RDA:KHNX 36/18/50N
340 FT 119/37/51W
MODE A / 21
CNTR 321DEG 60NM
MAX= 67 DBZ
ND DBZ
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
MAG=2X FL= 5 COM=1
OVL:AN
A/R (RDA) 47 DEG
41 NM
Q15 STP 1806 R
CONNECTION PENDING
DED. RPG LINE 1
15/1825 ARCHIVE
UNIT 1 READ DONE
HARDCOPY
FUNCTION DISABLED
SCK
YNP
SJC
HUN.LK
FIGURE 2A
FAT
SNS
COA

Figure 2a



MAXIMUM DBZ
67
CMP REF 37 CR 124 NM .54 NM RES
12/13/95 22:03 CNTR 203DEG 8NM
ECHO TOPS 41 ET 124 NM 2.2 NM RES
12/13/95 22:03 CNTR 194DEG 4NM
MAXIMUM TOP
29 KFT
FRESNO
KINGS
V INT LQD 57 VIL 124 NM 2.2 NM
12/13/95 22:03 CNTR 212DEG 16NM
MAXIMUM VIL
37 KG/M2
07/15/98 19:23
QUAD 1 MAG=8X
RDA:KHNX 36/18/50N
340 FT 119/37/51W
MODE A / 21
MAX= 67 DBZ
OVL:AN
QUAD 2 MAG=4X
RDA:KHNX 36/18/50N
340 FT 119/37/51W
MODE A / 21
MAX= 30 KFT
OVL:AN
QUAD 3 MAG=4X
RDA:KHNX 36/18/50N
340 FT 119/37/51W
MODE A / 21
MAX= 37 KG/M2
OVL:AN
A/R (RDA)
Q15 STP 1806 R
CONNECTION PENDING
DED. RPG LINE 1
15/1825 ARCHIVE
UNIT 1 READ DONE
HARDCOPY
FUNCTION INACTIVE
WITHOUT PRODUCT

Figure 2b

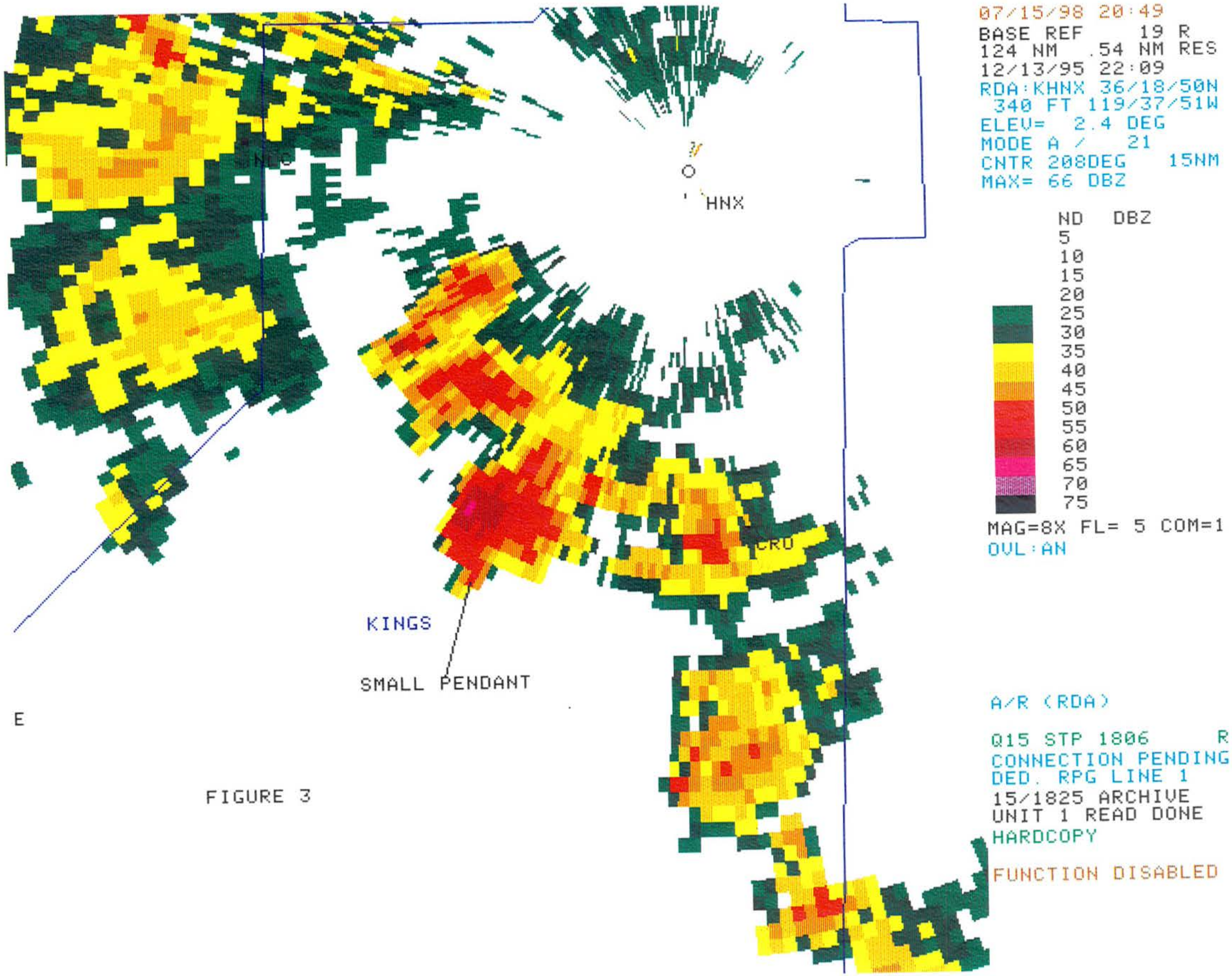

07/15/98 20:49
BASE REF 19 R
124 NM .54 NM RES
12/13/95 22:09
RDA:KHNX 36/18/50N
340 FT 119/37/51W
ELEV= 2.4 DEG
MODE A / 21
CNTR 208DEG 15NM
MAX= 66 DBZ
ND DBZ
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
MAG=8X FL= 5 COM=1
OVL:AN
HNX
CRU
KINGS
SMALL PENDANT
E
A/R (RDA)
Q15 STP 1806 R
CONNECTION PENDING
DED. RPG LINE 1
15/1825 ARCHIVE
UNIT 1 READ DONE
HARDCOPY
FUNCTION DISABLED

FIGURE 3

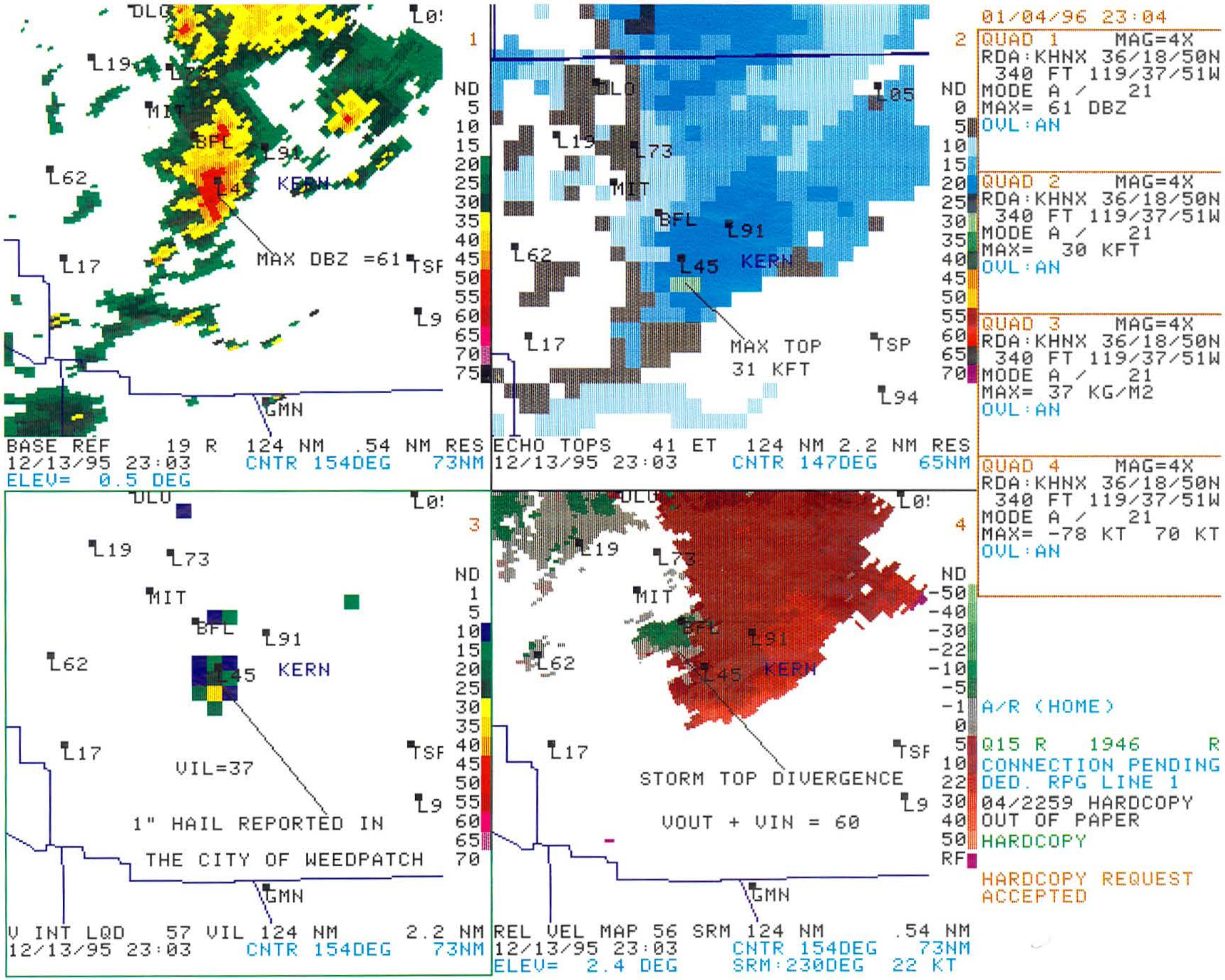

01/04/96 23:04
QUAD 1 MAG=4X
RDA:KHNX 36/18/50N
340 FT 119/37/51W
MODE A / 21
MAX= 61 DBZ
OVL:AN
QUAD 2 MAG=4X
RDA:KHNX 36/18/50N
340 FT 119/37/51W
MODE A / 21
MAX= 30 KFT
OVL:AN
QUAD 3 MAG=4X
RDA:KHNX 36/18/50N
340 FT 119/37/51W
MODE A / 21
MAX= 37 KG/M2
OVL:AN
QUAD 4 MAG=4X
RDA:KHNX 36/18/50N
340 FT 119/37/51W
MODE A / 21
MAX= -78 KT 70 KT
OVL:AN
MAX DBZ =61
KERN
BASE REF 19 R 124 NM .54 NM RES
12/13/95 23:03 CNTR 154DEG 73NM
ELEV= 0.5 DEG
MAX TOP
31 KFT
ECHO TOPS 41 ET 124 NM 2.2 NM RES
12/13/95 23:03 CNTR 147DEG 65NM
VIL=37
1" HAIL REPORTED IN
THE CITY OF WEEDPATCH
V INT LQD 57 VIL 124 NM 2.2 NM
12/13/95 23:03 CNTR 154DEG 73NM
STORM TOP DIVERGENCE
VOUT + VIN = 60
REL VEL MAP 56 SRM 124 NM .54 NM
12/13/95 23:03 CNTR 154DEG 73NM
ELEV= 2.4 DEG SRM:230DEG 22 KT
A/R (HOME)
Q15 R 1946 R
CONNECTION PENDING
DED. RPG LINE 1
04/2259 HARDCOPY
OUT OF PAPER
HARDCOPY
HARDCOPY REQUEST
ACCEPTED

Figure 4