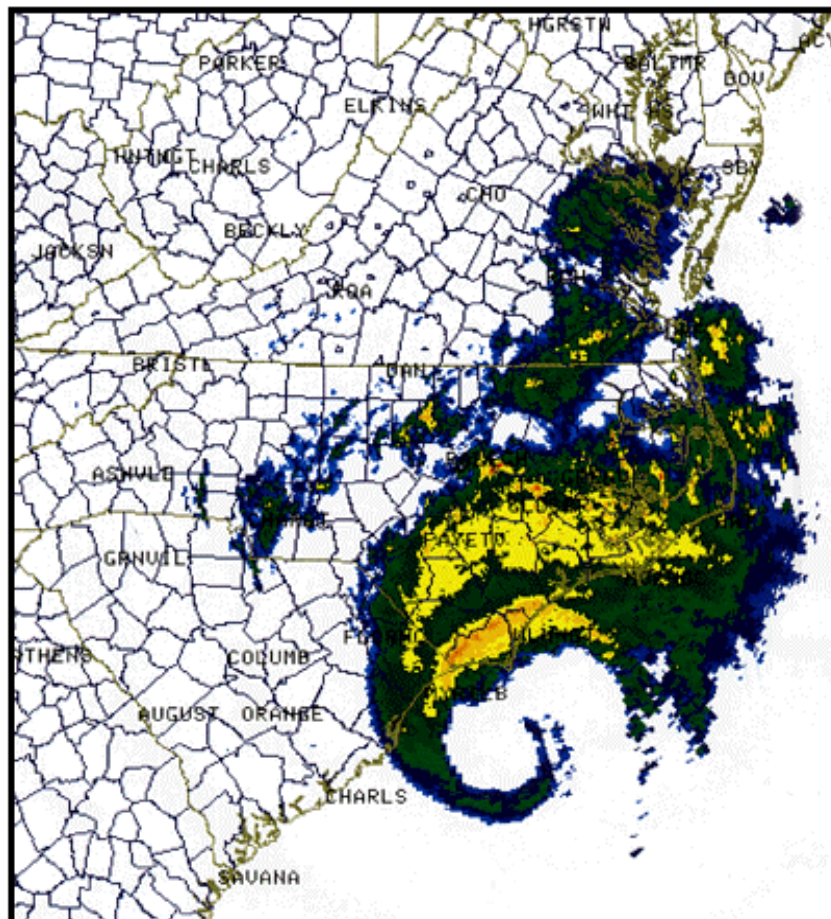


NATIONAL CLIMATIC DATA CENTER

RESEARCH CUSTOMER SERVICE GROUP

A Comparison of NEXRAD Rainfall Estimates with Recorded Amounts



Neal Lott
Meteorologist
National Climatic Data Center



Matthew Sittel
Meteorologist
Orkand Corporation

INTRODUCTION

This study compares NEXRAD-estimated storm-total precipitation with rain-gauge measured total precipitation for five events:

- a. Missouri-Kansas in April 1994, Kansas City NEXRAD site.
- b. Southeast Texas in October 1994, Houston NEXRAD site.
- c. Florida in November 1994 (Hurricane Gordon), Melbourne NEXRAD site.
- d. Louisiana-Mississippi-Alabama in May 1995, Mobile and Slidell NEXRAD sites.
- e. South Carolina-North Carolina-Georgia in August 1995 (Tropical Storm Jerry), Columbia NEXRAD site.

DATA

The hourly and daily precipitation data from the National Climatic Data Center (NCDC) were used to determine actual precipitation (ground truth) during the period in which the storm total precipitation estimates were determined by the NEXRAD level III data. These hourly and daily precipitation amounts are taken from the National Weather Service and cooperative network of weather stations. Across the country, over 8000 of these cooperative stations generally record daily precipitation and maximum/minimum temperature data, with approximately 2500 sites reporting hourly precipitation amounts.

The total amount of NEXRAD-estimated rainfall was determined by magnifying the original NEXRAD images and locating the latitude and longitude of the reporting stations. The computer system used to perform these estimates located the positions in degrees, minutes, and seconds. Since the rainfall estimates were obtained visually from the image, a range and midpoint are shown in this report. The range represents the boundaries of uncertainty in applying a color-coded map to one location. To some extent, this also represents the range of uncertainty a forecaster or hydrologist might encounter.

In addition to the estimated storm total precipitation, the distance from the radar sites to each station was approximated. Using these distances, it was then possible to determine how the actual observed rainfall on the surface compared to that estimated by the NEXRAD system as the distance from the radar site to the observing site increased. Note that the outer limit of NEXRAD for estimating precipitation is 124 nautical miles, while the distance from radar site to each station is shown in Tables 1-6 in statute miles. This accounts for some stations being over 124 (statute) miles in distance.

DISCUSSION

The five events were chosen due to their extensive and damaging nature, and due to the availability of one or more NEXRAD sites with good areal coverage. All five events were at least somewhat convective in nature, so this study is more reflective of radar performance in convective situations. However, since most damaging flood events tend to be at least partly convective, we felt it appropriate to focus on the five included in this report.

The tables and figures show the estimated difference between actual (rain-gauge measured) rainfall and NEXRAD-estimated rainfall. In 80% of the 220 stations checked, the NEXRAD estimates were too low, sometimes by a factor of 2 to 3. The best performances overall appear in the May 95 event with the Mobile NEXRAD site along with the Apr 94 event with the Kansas City site, while the worst overall was the Oct 94 event with the Houston NEXRAD site. This report will not attempt to delve into explanations of this performance, as the National Severe Storms Laboratory and others are already conducting such studies. We can report that some sites have changed their precipitation processing parameters (adaptable parameters) to attempt to improve the rainfall estimates.

Additional findings include:

- a. Concentric circles on some storm-total displays (especially Houston), possibly due to the algorithms used to adjust for distance from the radar site.
- b. No significant correlation between distance of station (rain gauge) from radar site vs. departure of radar-estimated rainfall from the actual (rain gauge) amount. In other words, as distance from the site increases, we generally did not find a deterioration in NEXRAD performance (rainfall estimates) for these five events.
- c. The NEXRAD-estimated rainfall (for the six sites) fell an average of 2.9 inches below the actual amounts recorded by the rain gauges. The best (closest) were the Kansas City site with an average of near 0.0 (some below and some above zero) and Mobile with a -.2 inch average, while the greatest departure was Houston with an average of -8.2 inches. Stated as a percentage, the NEXRAD-estimated rainfall averaged 69% of the actual measured amounts. The best (closest) were the Kansas City and Mobile sites with 102% and 98%, respectively. The lowest were Columbia and Houston with 43% and 46%, respectively.
- d. The percent of stations overall whose measured amounts fell within the NEXRAD-estimated range ('range of estimates' on tables) was 27%. Again, the two 'best' sites were Kansas City and Mobile with 60% and 46%, respectively. The lowest were Columbia and Houston with 2% and 0%, respectively.

TABLES AND FIGURES

The five heavy rain events and their associated tables and figures are listed below. The figures showing the total measured precipitation have the NEXRAD radar site location plotted on the map for reference. We were careful to ensure that the times for NEXRAD-estimated storm total precipitation coincided with the times for the rainfall from the cooperative stations. Additional NEXRAD images (such as hourly rainfall) were also studied during this process.

a. Missouri-Kansas on April 10-11, 1994 (Kansas City NEXRAD site)--Table 1, Figures 1-3. Heaviest measured rainfall--8.60 inches. Rainfall associated with quasi-stationary front.

b. Southeast Texas on October 15-20, 1994 (Houston NEXRAD site)--Table 2, Figures 4-6. Heaviest measured rainfall--26.37 inches. Rainfall associated with quasi-stationary front and 'training' thunderstorms.

c. Florida on November 14-18, 1994 (Melbourne NEXRAD site)--Table 3, Figures 7-9. Heaviest measured rainfall--10.93 inches. Rainfall associated with Hurricane Gordon, with most rain falling in 2-day period.

d. Louisiana-Mississippi-Alabama on May 8-13, 1995 (Mobile and Slidell NEXRAD sites)--Tables 4-5, Figures 10-13. Heaviest measured rainfall--24.99 inches. Rainfall associated with slow-moving cold front and tropical moisture.

e. South Carolina-North Carolina-Georgia on August 23-29, 1995 (Columbia NEXRAD site)--Table 6, Figures 14-16. Heaviest measured rainfall--15.13 inches. Rainfall associated with Tropical Storm Jerry, with most rain falling in 2-day period.

SUMMARY

This report should provide researchers with additional data and information in studies of NEXRAD performance and algorithm-enhancement. The Mobile site performance was encouraging in light of the extensive and prolonged nature of that event. Of course, some of the other events showed that further work and improvements are needed.

The recently issued National Disaster Survey Report on Tropical Storm Alberto (National Weather Service, December 1995) touched on the underestimation problem and the need to incorporate automated rain gauge data into NEXRAD estimates. This report echoes that finding. Of course, we expect that adjustments in adaptable parameters as mentioned earlier will also improve the estimates.

For additional meteorological data, NEXRAD data/images, or other information, please contact NCDC: phone 704-271-4800, fax 704-271-4876, email 'orders@ncdc.noaa.gov'. Also, this report and a great deal of other information and data can be found on our WWW homepage -- <http://www.ncdc.noaa.gov>.

Finally, many thanks to NCDC's John Kobar and Bob Boreman for their expert assistance in selection and use of the NEXRAD level III data.

Guide to NEXRAD Tables:

The following statistics are shown for individual stations in each case:

station: location of precipitation (rain gauge) report.

lat. de/mi: latitude of the station, in degrees and minutes (North).

long. de/mi: longitude of the station, in degrees and minutes (West).

(mi.) dist: distance, in statute miles, from the station to the radar site.

prec. tot.: total precipitation, in inches, received at the station.

range of estimates: the range (lowest and highest) of storm total precipitation as estimated from the storm total precipitation plots (NEXRAD).

avg. est.: the average of the lowest and highest estimates of total precipitation (NEXRAD)--i.e., the midpoint of (range of estimates) rounded to tenths.

avg. - obs.: the average estimate (NEXRAD) of total precipitation minus the total precipitation actually received at the station--calculated by subtracting (prec. tot.) from the arithmetic midpoint of (range of estimates).

ir (in range): if the precipitation total is within the NEXRAD-estimated bounds, a 'Y' for yes is shown, otherwise an 'N' for no is shown.

The following summary statistics are shown for each NEXRAD site:

averages: arithmetic average values are listed for the total precipitation received, average estimate (NEXRAD), and the station-by-station difference between the two values (avg. - obs.).

NEXRAD est. as % of measured: average NEXRAD estimate divided by the average precipitation total at all stations, expressed as a percentage.

distance/difference correlation: the correlation of the differences between average estimate and total precipitation received, and the distance from each station to the radar site--i.e., an expression of the tendency for radar performance to decrease with increasing distance from the radar--indicated by a positive correlation.

% of stns. with prec. in est. range: percent of stations with total precipitation between the lowest and highest NEXRAD-estimated values.

TABLE 1 KANSAS CITY, MO (KEAX) April 10-11, 1994

station	lat. de mi	long (mi.) de mi	dist	prec tot.	range of estimates	avg. est.	avg.- obs.	ir
UNITY VILLAGE, MO	38 57	94 24	12	0.90	0.1 2.0	1.1	0.2	Y
ELM, MO	38 52	94 02	13	1.40	1.0 2.0	1.5	0.1	Y
STANLEY, KS	38 49	94 40	21	0.90	0.1 1.0	0.6	-0.4	Y
SHAWNEE 2S, KS	38 59	94 43	27	0.70	0.1 1.0	0.6	-0.2	Y
DREXEL, MO	38 29	94 36	28	1.50	1.0 2.0	1.5	0.0	Y
HILLSDALE LAKE, KS	38 40	94 54	35	0.80	1.0 2.0	1.5	0.7	N
CLINTON, MO	38 24	93 46	38	3.50	4.0 6.0	5.0	1.5	N
KEARNEY 2E, MO	39 22	94 20	38	0.70	1.0 2.0	1.5	0.8	N
KANSAS CITY WSMO AP, MO	39 19	94 43	42	0.46	0.1 1.0	0.6	0.1	Y
SMITHVILLE LAKE, MO	39 23	94 33	42	0.70	0.1 1.0	0.6	-0.2	Y
APPLETON CITY, MO	38 12	94 02	43	2.80	4.0 6.0	5.0	2.2	N
OTTAWA, KS	38 37	95 17	56	1.00	1.0 2.0	1.5	0.5	Y
MARSHALL, MO	39 07	93 13	60	1.70	3.0 6.0	4.5	2.8	N
BLUE MOUND, KS	38 06	95 01	63	2.00	2.0 3.0	2.5	0.5	Y
PERRY LAKE, KS	39 07	95 25	65	0.20	0.0 0.1	0.1	-0.2	N
NEVADA SEWAGE PLANT, MO	37 51	94 24	66	8.60	7.0 13.0	10.0	1.4	Y
POMONA LAKE, KS	38 39	95 34	71	0.60	0.1 1.0	0.6	0.0	Y
TOPEKA WSO AIRPORT, KS	39 04	95 38	75	0.16	0.0 1.0	0.5	0.3	Y
UNIONTOWN, KS	37 51	94 58	76	2.10	2.0 3.0	2.5	0.4	Y
POMME DE TERRE DAM, MO	37 55	93 19	80	3.60	3.0 5.0	4.0	0.4	Y
STOCKTON DAM, MO	37 42	93 47	80	3.70	3.0 4.0	3.5	-0.2	Y
MELVERN LAKE, KS	38 30	95 42	80	0.80	0.1 2.0	1.1	0.3	Y
NEW FRANKLIN 1W, MO	39 01	92 46	81	3.00	7.0 8.0	7.5	4.5	N
PATTONSBURG 2S, MO	40 02	94 08	84	0.60	0.1 1.0	0.6	0.0	Y
IOLA 1W, KS	37 55	95 26	88	1.50	2.0 4.0	3.0	1.5	N
HORTON, KS	39 40	95 31	89	0.30	0.0 0.1	0.1	-0.3	N
JOHN REDMOND LAKE, KS	38 15	95 45	89	1.30	1.0 3.0	2.0	0.7	Y
BOLIVAR 1NE, MO	37 36	93 25	95	3.80	2.0 4.0	3.0	-0.8	Y
LOCKWOOD, MO	37 23	93 57	99	2.70	2.0 3.0	2.5	-0.2	Y
MOBERLY, MO	39 24	92 26	106	2.00	2.0 4.0	3.0	1.0	Y
COLUMBIA WSO AP, MO	38 49	92 13	110	3.24	2.0 3.0	2.5	-0.7	N
MILLER 1E, MO	37 13	93 49	112	2.70	0.1 2.0	1.1	-1.7	N
JEFFERSON CITY WATER PLANT, MO	38 35	92 11	113	3.70	3.0 5.0	4.0	0.3	Y
LONG BRANCH RESERVOIR, MO	39 44	92 29	114	0.90	0.1 1.0	0.6	-0.4	Y
TORONTO LAKE, KS	37 45	95 56	116	1.30	1.0 2.0	1.5	0.2	Y
SPRINGFIELD WSO AP, MO	37 14	93 23	118	1.81	0.1 1.0	0.6	-1.3	N
FULTON, MO	38 51	91 57	124	3.10	0.1 2.0	1.1	-2.1	N
SPRING CITY, MO	36 59	94 32	126	3.80	0.1 2.0	1.1	-2.8	N
MCCREDIE EXPERIMENT STN, MO	38 57	91 54	127	2.72	0.1 1.0	0.6	-2.2	N
MOUND VALLEY 3WSW, KS	37 11	95 27	129	3.50	2.0 4.0	3.0	-0.5	Y
VIENNA 2WNW, MO	38 12	91 59	130	3.00	0.1 1.0	0.6	-2.5	N
SENECA, MO	36 51	94 37	136	2.70	0.1 1.0	0.6	-2.2	N

averages:	2.06	2.1	0.0
NEXRAD est. as % of measured:			102%
distance/difference correlation:			0.34
% of stns. with prec. in est. range:			60%

TABLE 2 HOUSTON WSO, TX (KHGX) October 15-20, 1994

station	lat. de mi	long (mi.) de mi	prec dist tot.	range of estimates	avg. est.	avg.- obs.	ir
HOUSTON WSO, TX	29 28	95 05	0 4.34	0.1 1.0	0.6	-3.8	N
HOUSTON DEER PARK, TX	29 43	95 08	17 18.98	7.0 9.0	8.0	-11.0	N
HOUSTON PORT, TX	29 45	95 17	22 21.23	7.0 9.0	8.0	-13.2	N
BAYTOWN LAB, TX	29 50	95 00	25 25.66	10.0 11.0	10.5	-15.2	N
HOUSTON WESTBURY, TX	29 40	95 28	26 15.54	6.0 7.0	6.5	-9.0	N
HOUSTON HEIGHTS, TX	29 47	95 26	30 10.33	3.0 5.0	4.0	-6.3	N
HOUSTON SAN JACINTO DAM, TX	29 55	95 09	31 21.73	7.0 8.0	7.5	-14.2	N
HOUSTON INDEP HEIGHT, TX	29 52	95 25	33 8.18	3.0 4.0	3.5	-4.7	N
HOUSTON SPRING BRANCH, TX	29 48	95 30	33 9.39	3.0 5.0	4.0	-5.4	N
HOUSTON NORTH HOUSTON, TX	29 53	95 32	39 12.28	4.0 5.0	4.5	-7.8	N
LIBERTY, TX	30 03	94 48	43 26.37	10.0 11.0	10.5	-15.9	N
HOUSTON BARKER, TX	29 49	95 44	45 8.23	3.0 4.0	3.5	-4.7	N
NEW CANEY 2E, TX	30 08	95 11	46 18.24	6.0 7.0	6.5	-11.7	N
CYPRESS, TX	29 58	95 42	50 8.30	3.0 5.0	4.0	-4.3	N
NEW GULF, TX	29 16	95 54	51 13.30	3.0 4.0	3.5	-9.8	N
ANAHUAC, TX	29 47	94 17	52 10.31	5.0 7.0	6.0	-4.3	N
TOMBALL, TX	30 06	95 37	54 14.82	5.0 8.0	6.5	-8.3	N
CLEVELAND, TX	30 22	95 05	61 23.40	11.0 13.0	12.0	-11.4	N
BEAUMONT RESEARCH CTR, TX	30 04	94 17	62 19.20	10.0 13.0	11.5	-7.7	N
WHARTON, TX	29 19	96 06	62 13.05	8.0 9.0	8.5	-4.6	N
CONROE, TX	30 20	95 29	64 23.42	13.0 15.0	14.0	-9.4	N
SEALY, TX	29 47	96 08	66 11.12	6.0 8.0	7.0	-4.1	N
PIERCE 1E, TX	29 14	96 11	68 14.73	8.0 10.0	9.0	-5.7	N
COLDSPRING 5SSW, TX	30 32	95 09	73 13.96	9.0 11.0	10.0	-4.0	N
MONTGOMERY, TX	30 23	95 42	73 20.71	11.0 15.0	13.0	-7.7	N
DANEVANG 1W, TX	29 03	96 14	75 10.17	3.0 5.0	4.0	-6.2	N
DACUS, TX	30 26	95 47	78 18.18	9.0 11.0	10.0	-8.2	N
KOUNTZE, TX	30 23	94 18	78 19.69	8.0 10.0	9.0	-10.7	N
WILDWOOD, TX	30 33	94 27	83 14.71	7.0 9.0	8.0	-6.7	N
LIVINGSTON, TX	30 44	94 56	87 14.98	6.0 8.0	7.0	-8.0	N
RICHARDS, TX	30 33	95 51	87 16.68	8.0 9.0	8.5	-8.2	N
COLUMBUS, TX	29 43	96 32	88 6.30	2.0 3.0	2.5	-3.8	N
HUNTSVILLE, TX	30 43	95 33	90 13.52	6.0 7.0	6.5	-7.0	N
BRENNHAM, TX	30 10	96 24	92 15.19	5.0 7.0	6.0	-9.2	N
SPEAKS 2S, TX	29 17	96 42	98 13.53	6.0 7.0	6.5	-7.0	N
EDNA HIWAY 59 BRIDGE, TX	28 58	96 41	102 18.28	5.0 7.0	6.0	-12.3	N
KIRBYVILLE, TX	30 37	93 55	105 12.00	5.0 6.0	5.5	-6.5	N
SOMERVILLE DAM, TX	30 20	96 32	105 16.99	6.0 8.0	7.0	-10.0	N
CORRIGAN, TX	31 00	94 47	106 25.98	5.0 7.0	6.0	-20.0	N
TOWN BLUFF, TX	30 48	94 11	106 8.80	4.0 6.0	5.0	-3.8	N
COLLEGE STATION FAA AP, TX	30 35	96 22	108 16.91	5.0 6.0	5.5	-11.4	N
GROVETON, TX	31 04	95 08	110 16.83	7.0 8.0	7.5	-9.3	N
CROCKETT, TX	31 18	95 27	128 5.86	2.0 5.0	3.5	-2.4	N
LUFKIN 2, TX	31 23	94 43	133 10.66	4.0 6.0	5.0	-5.7	N
averages:			15.05		6.9	-8.2	
NEXRAD est. as % of measured:						46%	
distance/difference correlation:						-0.09	
% of stns. with prec. in est. range:						0%	

TABLE 3 MELBOURNE WSO, FL (KMLB) November 14-18, 1994

station	lat. de mi	long (mi.) de mi	dist	prec tot.	range of estimates	avg. est.	avg.- obs.	ir
MELBOURNE WSO, FL	28 07	80 39	0	7.80	3.0 6.0	4.5	-3.3	N
VERO BEACH 4W, FL	27 39	80 25	35	8.33	5.0 7.0	6.0	-2.3	N
TITUSVILLE, FL	28 37	80 49	36	8.70	6.0 8.0	7.0	-1.7	N
FORT DRUM 5NW, FL	27 35	80 50	38	6.43	2.0 4.0	3.0	-3.4	N
ORLANDO WSO MCCOY, FL	28 27	81 19	46	5.85	3.0 5.0	4.0	-1.9	N
FORT PIERCE, FL	27 28	80 21	48	4.71	3.0 4.0	3.5	-1.2	N
SANFORD EXPERIMENT STN, FL	28 48	81 14	59	8.15	5.0 7.0	6.0	-2.2	N
STUART 1N, FL	27 13	80 15	66	6.50	4.0 5.0	4.5	-2.0	N
WINTER HAVEN, FL	28 01	81 44	66	4.43	1.0 3.0	2.0	-2.4	N
CLERMONT 7S, FL	28 27	81 45	70	4.82	3.0 4.0	3.5	-1.3	N
DE SOTO CITY, FL	27 22	81 31	73	2.22	1.0 2.0	1.5	-0.7	N
BARTOW, FL	27 54	81 51	74	1.79	0.1 2.0	1.1	-0.7	Y
LISBON, FL	28 52	81 47	86	4.21	3.0 5.0	4.0	-0.2	Y
MOORE HAVEN LOCK 1, FL	26 50	81 05	92	3.33	1.0 3.0	2.0	-1.3	N
BUSHNELL 2E, FL	28 40	82 05	94	2.35	1.0 2.0	1.5	-0.9	N
ARCADIA, FL	27 14	81 51	95	2.98	1.0 2.0	1.5	-1.5	N
CLEWISTON US ENGINEERS, FL	26 45	80 55	95	4.12	1.0 3.0	2.0	-2.1	N
ST. LEO, FL	28 20	82 16	99	1.83	0.1 2.0	1.1	-0.8	Y
BELLE GLADE EXP STN, FL	26 39	80 38	101	5.68	3.0 5.0	4.0	-1.7	N
WEST PALM BEACH WSO, FL	26 41	80 07	104	7.34	5.0 8.0	6.5	-0.8	Y
CRESCENT CITY, FL	29 26	81 31	105	3.95	2.0 4.0	3.0	-1.0	Y
LOXAHATCHEE NWR, FL	26 30	80 13	114	10.93	5.0 7.0	6.0	-4.9	N
OCALA, FL	29 12	82 05	114	1.81	0.1 1.0	0.6	-1.3	N
TAMPA WSCMO AIRPORT, FL	27 58	82 32	114	0.19	0.0 1.0	0.5	0.3	Y
PUNTA GORDA 4ESE, FL	26 55	82 00	116	1.16	0.1 1.0	0.6	-0.6	N
BRADENTON, FL	27 27	82 28	119	0.98	0.1 1.0	0.6	-0.4	Y
IMMOKALEE 3NNW, FL	26 28	81 26	123	3.76	1.0 2.0	1.5	-2.3	N
FORT MYERS FAA/AP, FL	26 36	81 52	128	1.77	0.1 1.0	0.6	-1.2	N
VENICE, FL	27 06	82 26	129	0.68	0.1 1.0	0.6	-0.1	Y

averages:	4.37	2.9	-1.5
NEXRAD est. as % of measured:			65%
distance/difference correlation:			-0.41
% of stns. with prec. in est. range:			28%

TABLE 4 MOBILE WSMO. LA (KMOB) May 8-13, 1995

station	lat. de mi	long (mi.) de mi	prec dist	range of tot. estimates	avg. est.	avg.- obs.	ir
MOBILE WSO AIRPORT, AL	30 41	88 15	0	10.42 8.0 10.0	9.0	-1.4	N
BAY MINETTE 3NNW, AL	30 55	87 47	31	10.73 10.0 13.0	11.5	0.8	Y
BILOXI, MS	30 23	88 59	48	14.39 10.0 15.0	12.5	-1.9	Y
WIGGINS, MS	30 52	89 08	54	5.44 6.0 8.0	7.0	1.6	N
GULFPORT NAVAL STATION, MS	30 23	89 08	56	8.93 10.0 13.0	11.5	2.6	N
HATTIESBURG, MS	31 19	89 18	76	2.71 3.0 6.0	4.5	1.8	N
POPLARVILLE EXP STN, MS	30 51	89 33	78	5.35 6.0 10.0	8.0	2.7	N
BAY ST. LOUIS NASA, MS	30 22	89 35	82	16.91 17.0 21.0	19.0	2.1	N
PICAYUNE, MS	30 31	89 42	87	21.94 17.0 23.0	20.0	-1.9	Y
SLIDELL WSFO, LA	30 15	89 46	95	23.10 17.0 21.0	19.0	-4.1	N
SLIDELL WSMO, LA	30 20	89 49	96	24.01 19.0 21.0	20.0	-4.0	N
ABITA SPRINGS FIRE TOWER, LA	30 26	90 03	108	24.99 19.0 23.0	21.0	-4.0	N
COVINGTON 4NNW, LA	30 32	90 07	111	11.35 10.0 17.0	13.5	2.2	Y
CHALMETTE, LA	29 58	89 58	114	3.87 10.0 15.0	12.5	8.6	N
FRANKLINTON 5SW, LA	30 47	90 13	117	6.91 3.0 8.0	5.5	-1.4	Y
PRENTISS 3NW, MS	31 37	89 55	118	1.74 1.5 6.0	3.8	2.0	Y
BURAS, LA	29 20	89 31	120	1.00 0.5 1.5	1.0	0.0	Y
METAIRIE, LA	29 59	90 08	122	16.71 10.0 15.0	12.5	-4.2	N
MONTICELLO, MS	31 33	90 06	125	1.95 1.5 3.0	2.3	0.3	Y
HAMMOND 5E, LA	30 30	90 22	127	5.90 3.0 6.0	4.5	-1.4	Y
PONCHATOULA 4SE, LA	30 25	90 23	128	8.53 6.0 13.0	9.5	1.0	Y
NEW ORLEANS WSCMO, LA	29 59	90 15	129	15.38 10.0 15.0	12.5	-2.9	N
AMITE, LA	30 42	90 32	136	8.46 6.0 8.0	7.0	-1.5	N
KENTWOOD, LA	30 56	90 31	136	2.70 1.0 3.0	2.0	-0.7	Y
averages:			10.56		10.4	-0.2	
NEXRAD est. as % of measured:						98%	
distance/difference correlation:						0.09	
% of stns. with prec. in est. range:						46%	

TABLE 5 SLIDELL WSMO, LA (KLIX) May 8-13, 1995

station	lat. de mi	long (mi.) de mi	prec dist tot.	range of estimates	avg. est.	avg.- obs.	ir
SLIDELL WSMO, LA	30 20	89 49	0 24.01	8.0 10.0	9.0	-15.0	N
SLIDELL WSFO, LA	30 15	89 46	6 23.10	5.0 8.0	6.5	-16.6	N
ABITA SPRINGS FIRE TOWER, LA	30 26	90 03	14 24.99	8.0 12.0	10.0	-15.0	N
BAY ST. LOUIS NASA, MS	30 22	89 35	14 16.91	4.0 8.0	6.0	-10.9	N
PICAYUNE, MS	30 31	89 42	14 21.94	8.0 12.0	10.0	-11.9	N
COVINGTON 4NNW, LA	30 32	90 07	22 11.35	6.0 10.0	8.0	-3.4	N
CHALMETTE, LA	29 58	89 58	26 3.87	5.0 8.0	6.5	2.6	N
METAIRIE, LA	29 59	90 08	30 16.71	6.0 10.0	8.0	-8.7	N
PONCHATOULA 4SE, LA	30 25	90 23	33 8.53	5.0 10.0	7.5	-1.0	Y
HAMMOND 5E, LA	30 30	90 22	34 5.90	4.0 5.0	4.5	-1.4	N
NEW ORLEANS WSCMO, LA	29 59	90 15	35 15.38	8.0 12.0	10.0	-5.4	N
FRANKLINTON 5SW, LA	30 47	90 13	38 6.91	3.0 6.0	4.5	-2.4	N
POPLARVILLE EXP STN, MS	30 51	89 33	39 5.35	3.0 6.0	4.5	-0.9	Y
GULFPORT NAVAL STATION, MS	30 23	89 08	41 8.93	5.0 6.0	5.5	-3.4	N
AMITE, LA	30 42	90 32	49 8.46	4.0 6.0	5.0	-3.5	N
BILOXI, MS	30 23	88 59	50 14.39	6.0 8.0	7.0	-7.4	N
RESERVE 4WNW, LA	30 05	90 37	50 11.70	6.0 10.0	8.0	-3.7	N
WIGGINS, MS	30 52	89 08	55 5.44	2.5 4.0	3.3	-2.2	N
LIVINGSTON, LA	30 30	90 45	56 6.19	3.0 5.0	4.0	-2.2	N
KENTWOOD, LA	30 56	90 31	58 2.70	1.5 2.5	2.0	-0.7	N
GONZALES, LA	30 14	90 55	65 6.55	4.0 5.0	4.5	-2.1	N
THIBODAUX 3ESE, LA	29 46	90 47	69 13.74	5.0 8.0	6.5	-7.2	N
BURAS, LA	29 20	89 31	71 1.00	0.6 1.5	1.1	0.1	Y
DONALDSONVILLE 4SW, LA	30 04	91 02	74 6.83	8.0 10.0	9.0	2.2	N
HATTIESBURG, MS	31 19	89 18	74 2.71	1.5 2.0	1.8	-1.0	N
HOUMA, LA	29 35	90 44	75 2.30	2.0 4.0	3.0	0.7	Y
ST. GABRIEL, LA	30 16	91 06	76 3.68	3.0 6.0	4.5	0.8	Y
BATON ROUGE WSO AP, LA	30 32	91 08	79 4.97	3.0 4.0	3.5	-1.5	N
PLAQUEMINE 2N, LA	30 19	91 14	83 3.98	2.0 4.0	3.0	-1.0	Y
MONTICELLO, MS	31 33	90 06	85 1.95	1.0 2.5	1.8	-0.2	Y
PRENTISS 3NW, MS	31 37	89 55	88 1.74	1.0 2.0	1.5	-0.2	Y
BAYOU SORREL LOCK, LA	30 08	91 19	90 3.86	2.5 4.0	3.3	-0.6	Y
MORGAN CITY, LA	29 41	91 11	92 12.18	5.0 8.0	6.5	-5.7	N
MOBILE WSO AIRPORT, AL	30 41	88 15	96 10.42	4.0 8.0	6.0	-4.4	N
ST. FRANCISVILLE, LA	30 46	91 23	97 4.09	1.0 2.0	1.5	-2.6	N
FRANKLIN 3NW, LA	29 49	91 33	109 6.14	4.0 6.0	5.0	-1.1	N
NEW IBERIA, LA	29 59	91 47	119 3.98	2.0 4.0	3.0	-1.0	Y
BAY MINETTE 3NNW, AL	30 55	87 47	127 10.73	3.0 5.0	4.0	-6.7	N
LAFAYETTE FCWOS, LA	30 12	91 59	129 5.36	1.5 3.0	2.3	-3.1	N
LIBERTY 5W, MS	31 10	90 53	134 1.85	1.5 3.0	2.3	0.4	Y

averages:	8.77	5.1	-3.7
NEXRAD est. as % of measured:			58%
distance/difference correlation:			-0.57
% of stns. with prec. in est. range:			28%

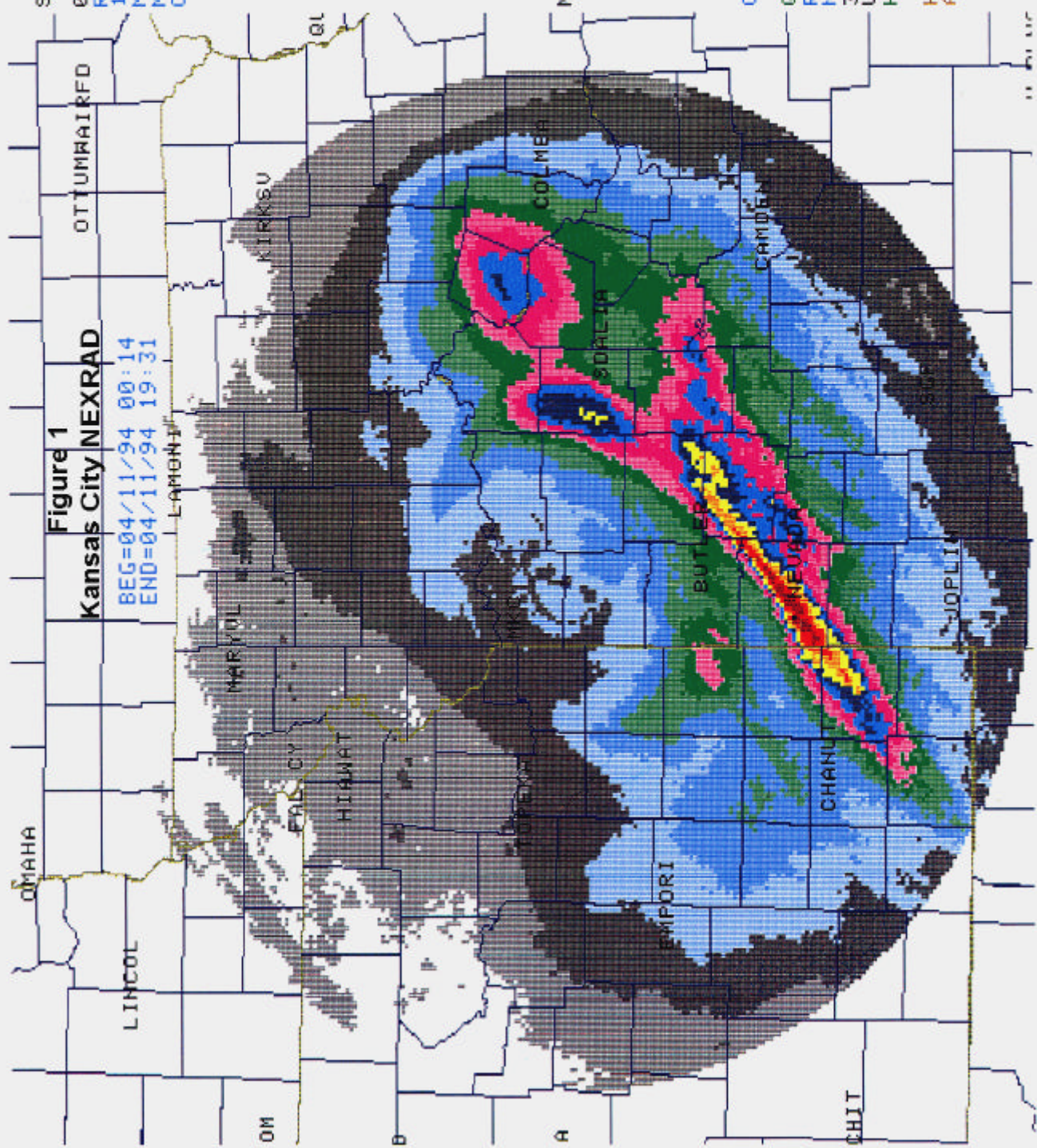
TABLE 6 COLUMBIA, SC (KCAE) August 23-29, 1995

station	lat. de mi	long (mi.) de mi dist	prec tot.	range of estimates	avg. est.	avg.- obs.	ir
COLUMBIA UNIV OF SC, SC	33 59	81 01 6	6.03	1.5 5.0	3.3	-2.8	N
BATESBURG, SC	33 54	81 32 23	5.10	2.0 4.0	3.0	-2.1	N
WINNSBORO, SC	34 22	81 05 28	4.32	1.5 2.5	2.0	-2.3	N
ORANGEBURG 2, SC	33 30	80 52 34	9.69	5.0 8.0	6.5	-3.2	N
NEWBERRY, SC	34 17	81 37 36	5.14	0.6 2.5	1.6	-3.6	N
AIKEN 4NE, SC	33 36	81 41 40	4.64	2.5 4.0	3.3	-1.4	N
MANNING, SC	33 41	80 14 54	4.55	2.0 4.0	3.0	-1.6	N
BRANCHVILLE 6S, SC	33 11	80 48 55	11.30	3.0 4.0	3.5	-7.8	N
MCCORMICK 9E, SC	33 55	82 09 59	6.17	2.5 3.0	2.8	-3.4	N
LOCKHART, SC	34 47	81 28 60	7.18	1.5 2.5	2.0	-5.2	N
AUGUSTA WSO AIRPORT, GA	33 22	81 58 63	3.66	1.5 2.5	2.0	-1.7	N
LAURENS, SC	34 30	82 02 64	8.26	1.5 4.0	2.8	-5.5	N
PAGELAND, SC	34 45	80 24 68	3.33	1.0 3.0	2.0	-1.3	N
FORT MILL 4NW, SC	35 01	81 00 74	7.02	2.0 4.0	3.0	-4.0	N
KINGSTREE 1SE, SC	33 39	79 49 77	6.95	4.0 6.0	5.0	-2.0	N
FLORENCE FAA AP, SC	34 11	79 43 81	4.99	3.0 5.0	4.0	-1.0	Y
CHARLOTTE WSO ARPT, NC	35 13	80 56 88	6.13	1.0 4.0	2.5	-3.6	N
MILLEN 4N, GA	32 52	81 58 89	5.64	2.5 3.0	2.8	-2.9	N
GRNVL/SPART WSO AP, SC	34 54	82 13 90	14.85	4.0 6.0	5.0	-9.9	N
WADESBORO, NC	34 58	80 04 92	4.27	1.5 3.0	2.3	-2.0	N
CHESNEE 7WSW, SC	35 07	81 58 93	8.20	2.0 3.0	2.5	-5.7	N
CHARLESTON WSO AP, SC	32 54	80 02 95	9.59	4.0 8.0	6.0	-3.6	N
LOUISVILLE 1E, GA	33 01	82 24 97	6.61	3.0 4.0	3.5	-3.1	N
RIDGELAND 5NE, SC	32 32	80 54 98	7.09	4.0 6.0	5.0	-2.1	N
FOREST CITY 6SW, NC	35 16	81 56 102	6.05	1.5 2.5	2.0	-4.1	N
DILLON, SC	34 25	79 23 104	6.79	2.0 4.0	3.0	-3.8	N
CLEMSON UNIV, SC	34 41	82 49 109	5.70	0.3 1.0	0.7	-5.1	N
LAURINBURG, NC	34 45	79 27 110	5.60	2.0 2.5	2.3	-3.4	N
MCCLELLANVILLE, SC	33 05	79 29 111	8.69	3.0 6.0	4.5	-4.2	N
EDISTO ISLAND 3SW, SC	32 28	80 20 111	8.19	2.5 4.0	3.3	-4.9	N
LEXINGTON 1NW, GA	33 53	83 08 115	4.77	0.3 1.0	0.7	-4.1	N
SWAINSBORO, GA	32 35	82 22 118	9.08	2.5 4.0	3.3	-5.8	N
CONWAY, SC	33 50	79 03 118	9.19	4.0 6.0	5.0	-4.2	N
HILTON HEAD, SC	32 13	80 45 121	15.13	4.0 6.0	5.0	-10.1	N
CARNESVILLE 4N, GA	34 27	83 14 125	5.26	0.3 1.0	0.7	-4.6	N
SAVANNAH WSO AIRPORT, GA	32 08	81 12 125	12.37	4.0 5.0	4.5	-7.9	N
SALISBURY, NC	35 41	80 29 125	5.35	0.3 1.0	0.7	-4.7	N
ROSMAN, NC	35 09	82 49 127	5.74	1.0 1.5	1.3	-4.5	N
MORGANTON, NC	35 45	81 41 128	2.87	0.6 1.0	0.8	-2.1	N
LUMBERTON 3SE, NC	34 37	78 59 130	3.60	2.0 2.5	2.3	-1.4	N
SWANNANOVA 2SSE, NC	35 34	82 23 132	6.67	2.0 3.0	2.5	-4.2	N
averages:			6.87		3.0	-3.9	
NEXRAD est. as % of measured:						43%	
distance/difference correlation:						0.31	
% of stns. with prec. in est. range:						2%	

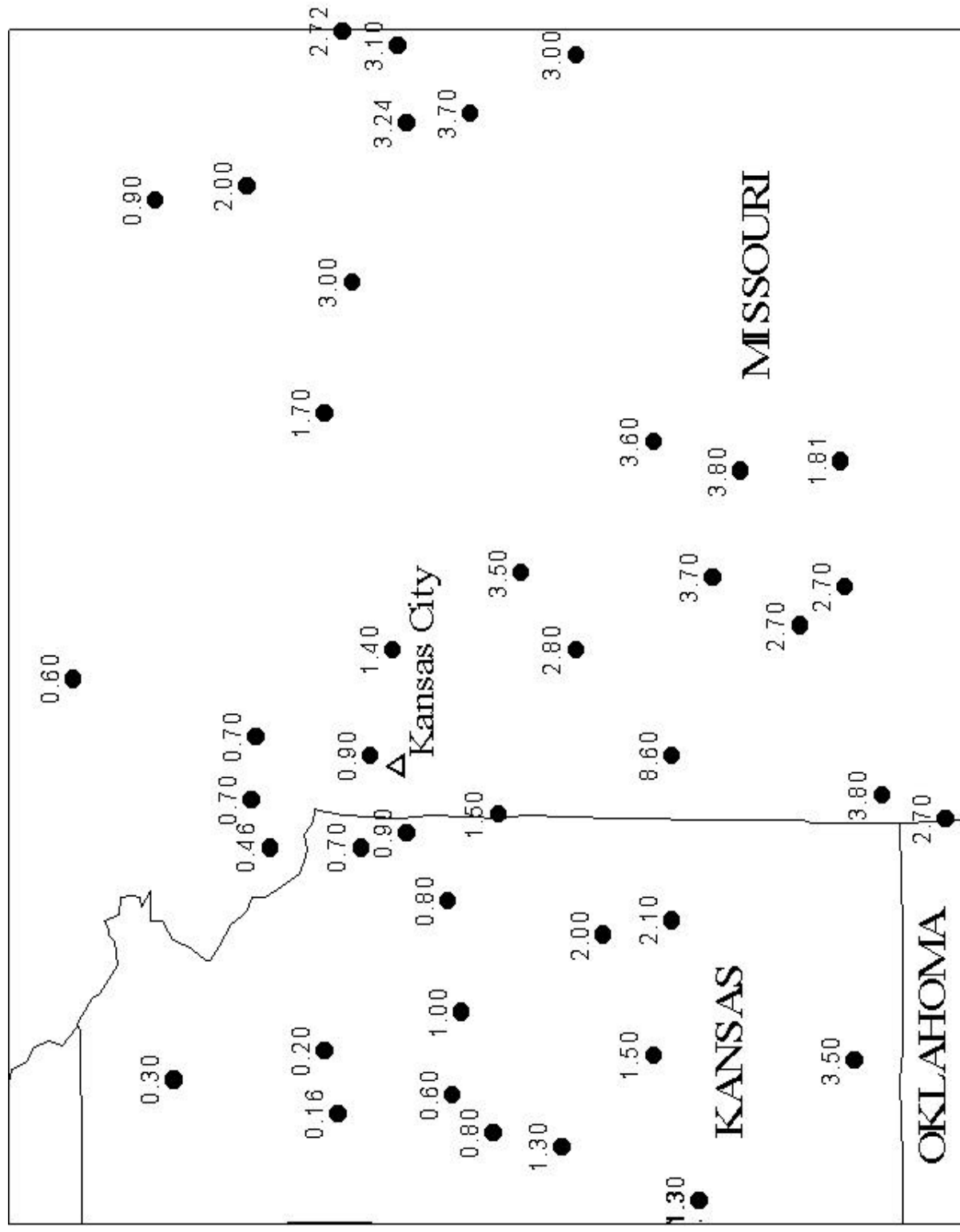
Figure 1
Kansas City NEXRAD

BEG=04/11/94 00:14
 END=04/11/94 19:31

STM PRECIP 80 STP
 124 NM 1.1 NM RES
 04/11/94 19:29
 RDA: KEAX 38/48/35N
 1098 FT 94/15/50W
 MAX= 15.0 IN
 MODE A / 21
 CNTR 0DEG 0NM

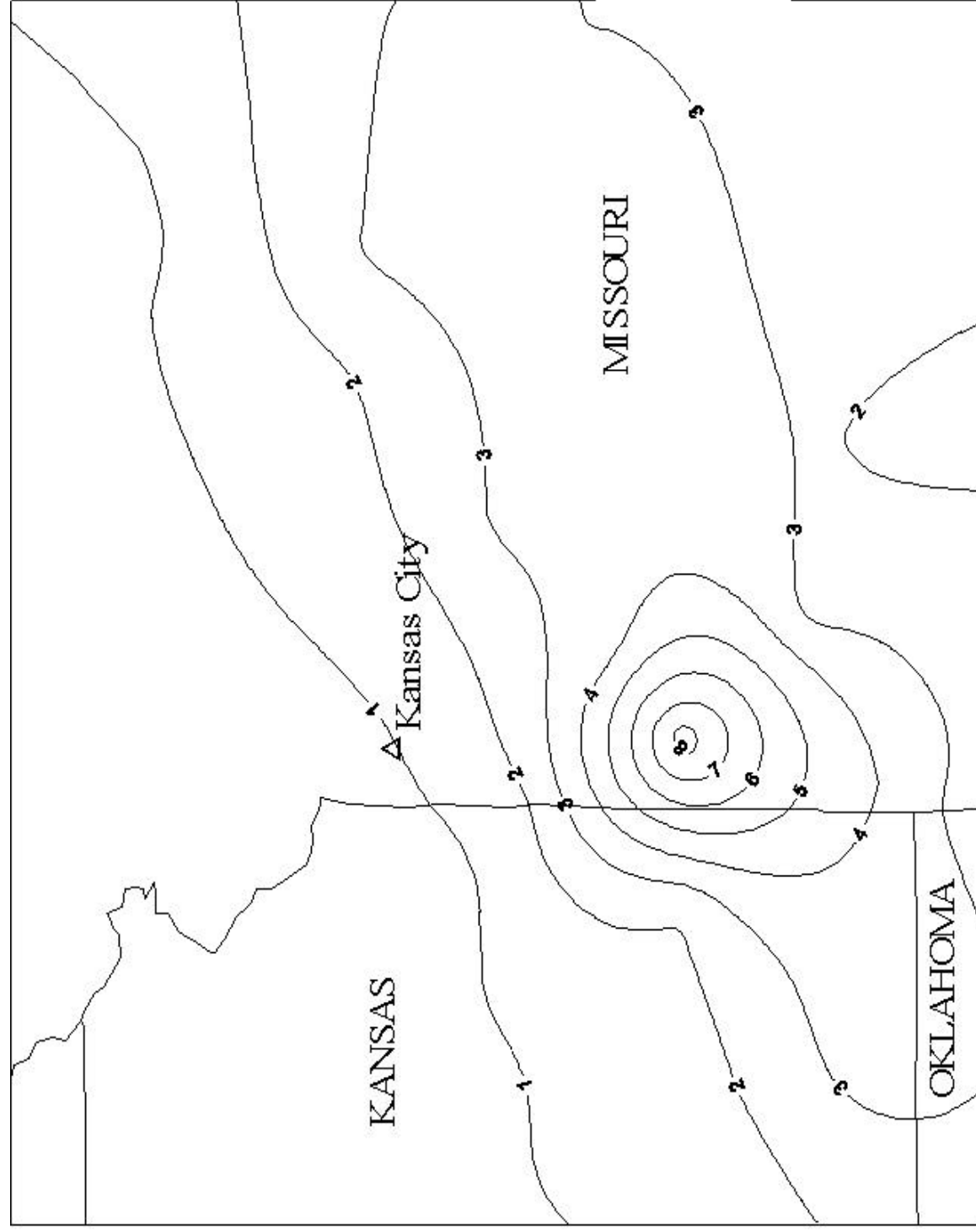


CUR. L/L
 QUEUE EMPTY
 RPG KRAK LINE BUSY
 NO REQUEST SENT
 30/1310 ARCHIVE
 UNIT 1 READ DONE
 HARDCOPY
 HARDCOPY REQUEST
 ACCEPTED



Total Precipitation (inches), April 10-11, 1994

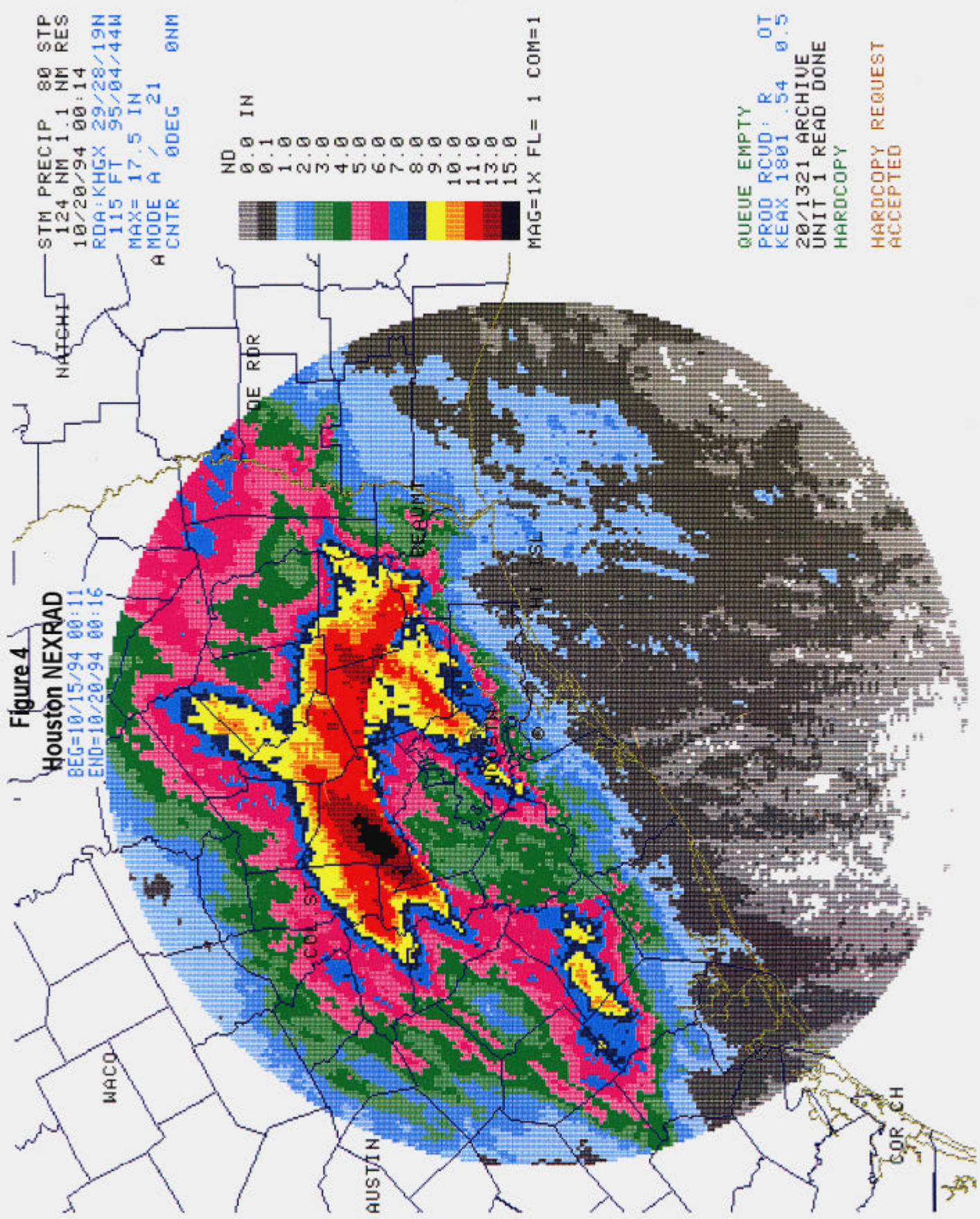
Figure 2.

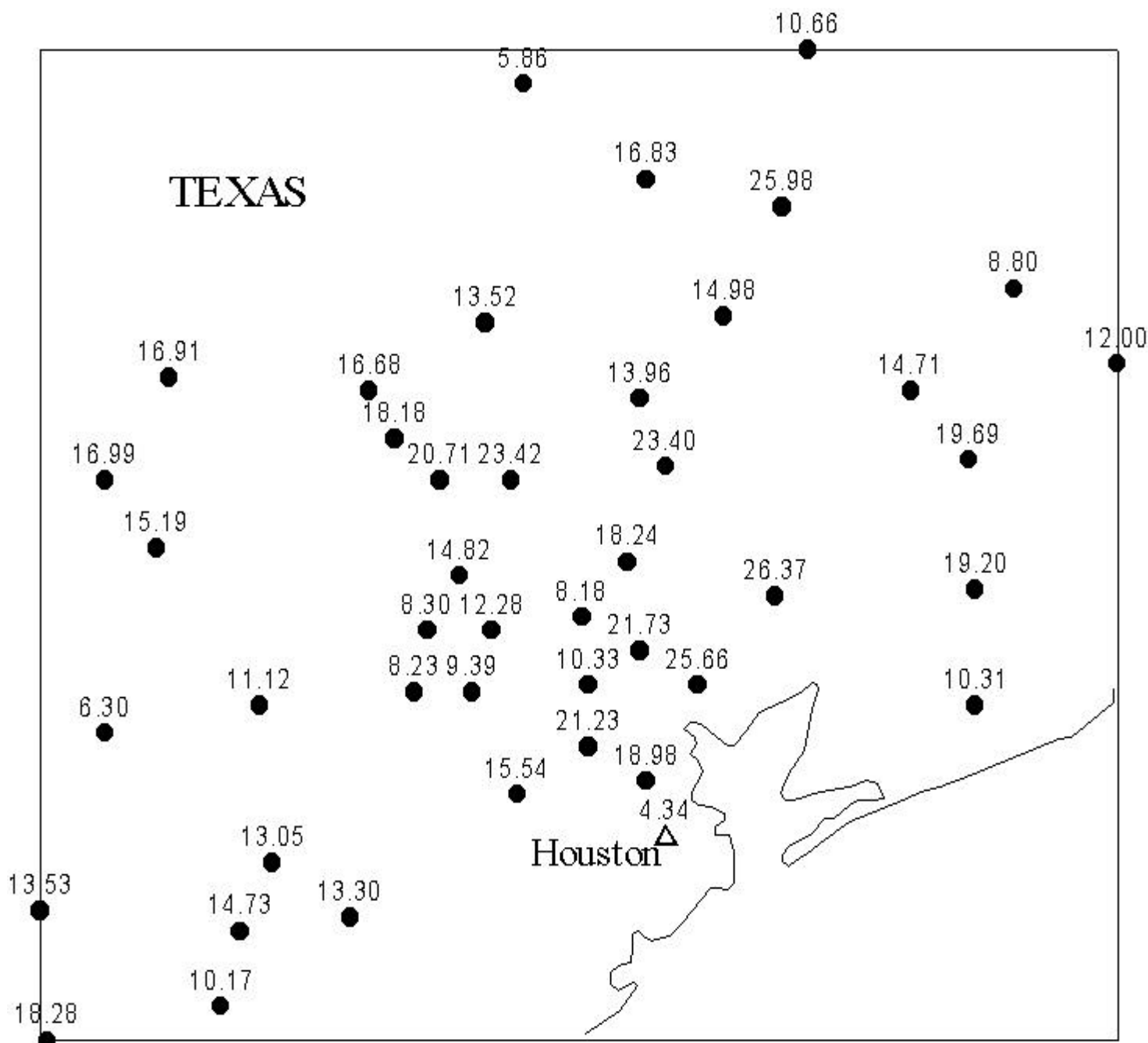


Total Precipitation (inches), April 10-11, 1994

Figure 3.

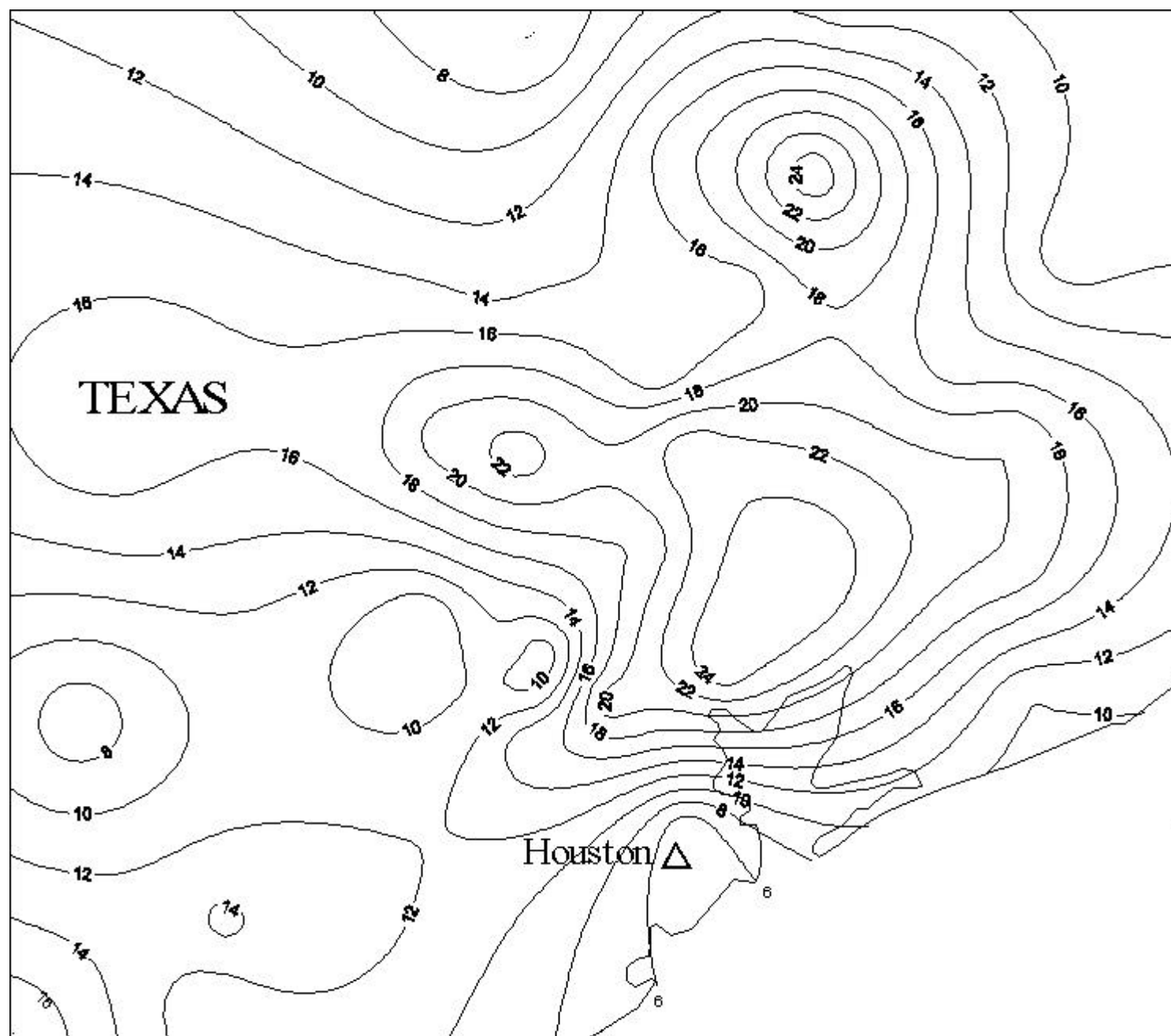
Figure 4
Houston NEXRAD
 BEG=10/15/94 00:11
 END=10/20/94 00:16





Total Precipitation (inches), October 15-20, 1994

Figure 5.



Total Precipitation (inches), October 15-20, 1994

Figure 6.

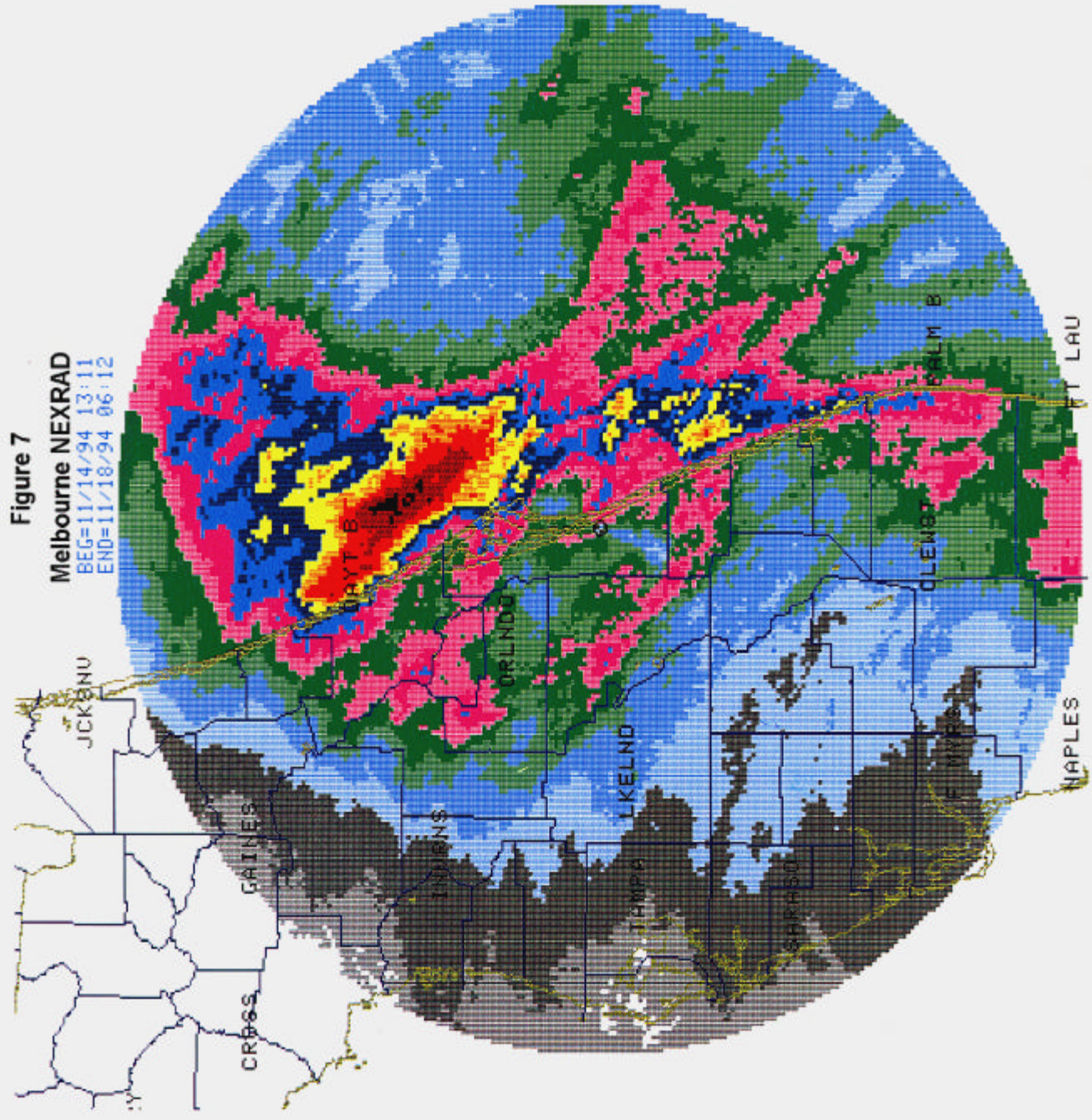


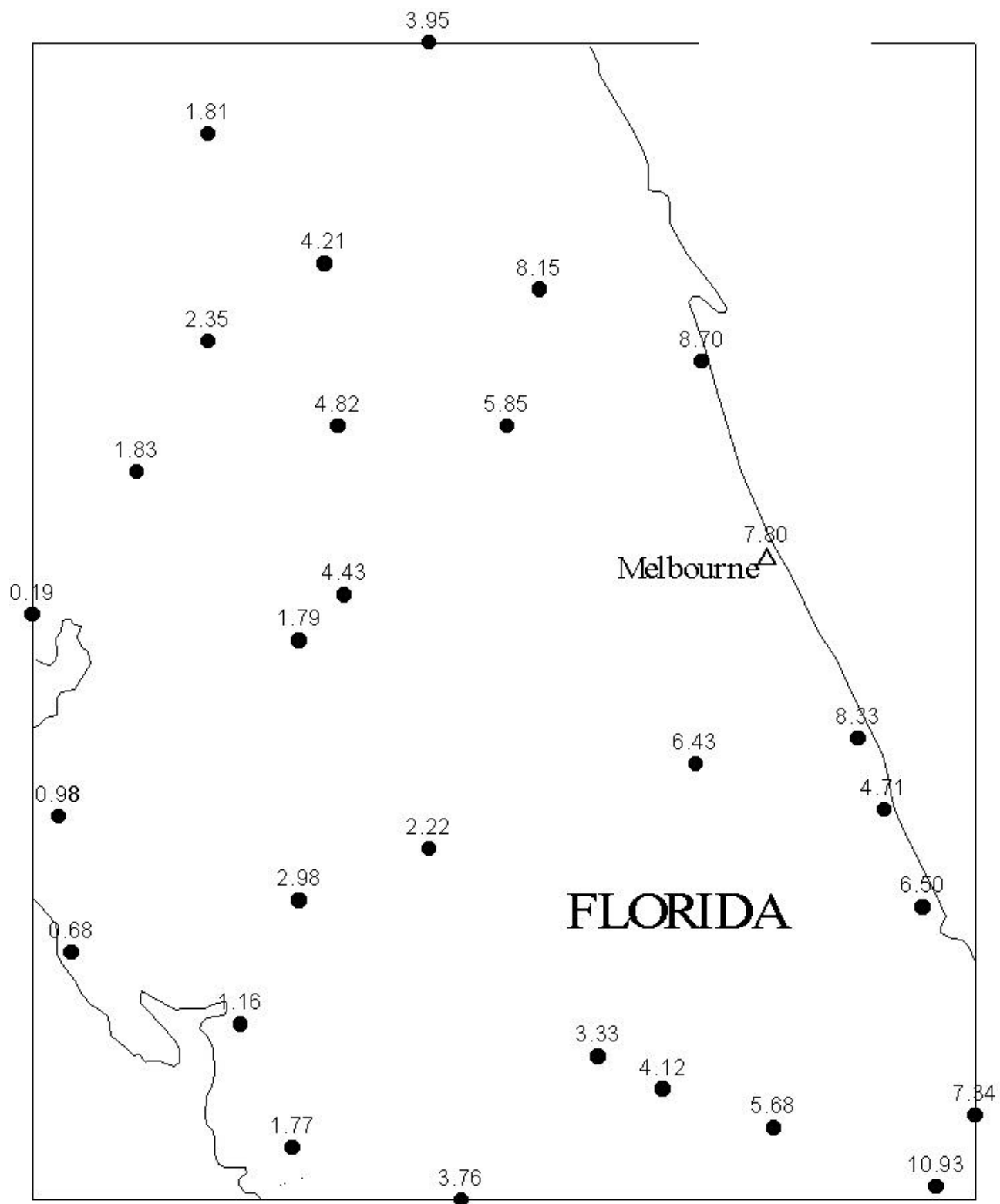
Figure 7
Melbourne NEXRAD
BEG=11/14/94 13:11
END=11/18/94 06:12

STM PRECIP 80 STP
124 NM 1.1 NM RES
11/18/94 06:10
RDA:KMLB 28/06/46N
116 FT 80/39/14W
MAX= 16.6 IN
MODE A / 21
CNTR 0DEG 0NM



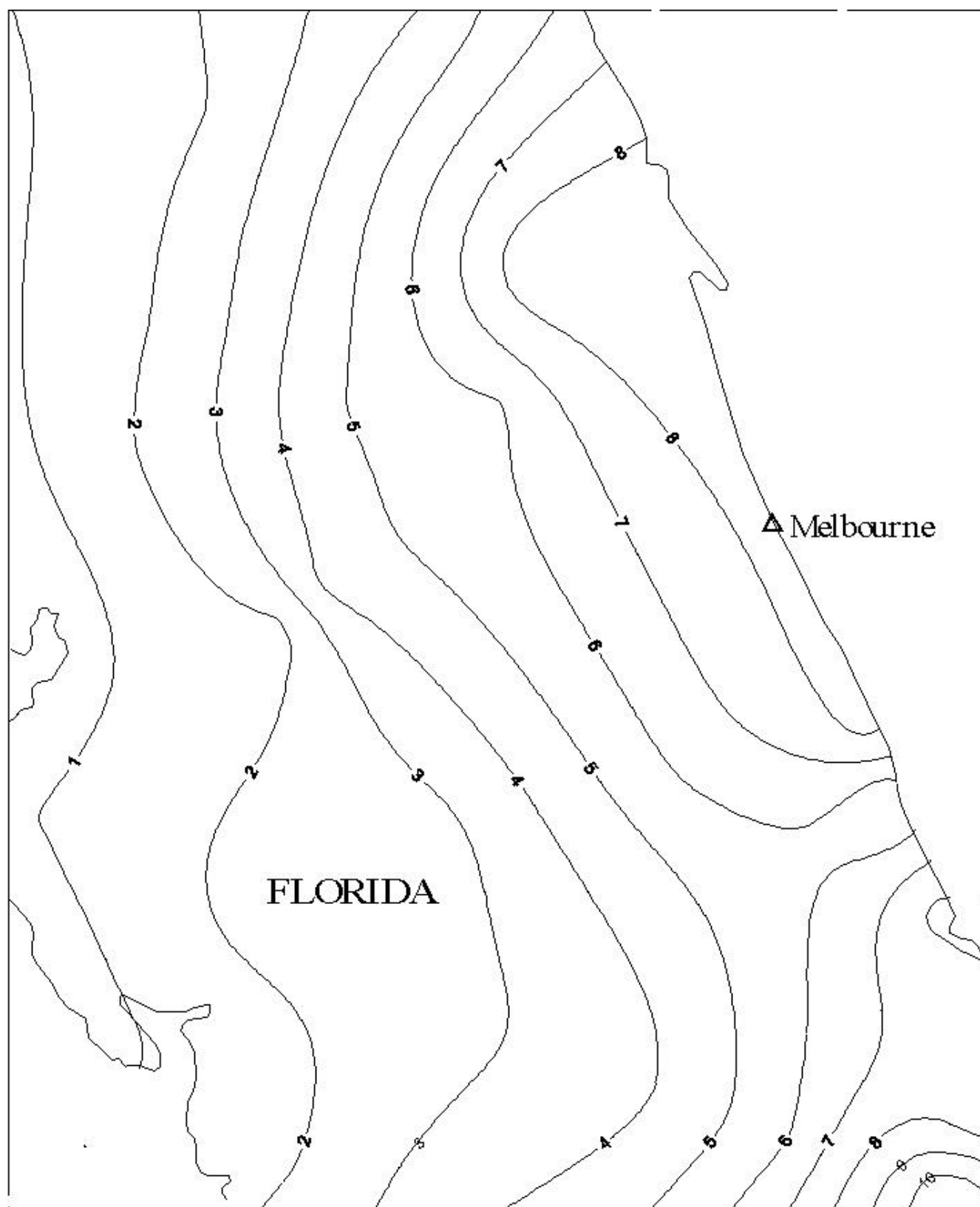
MAG=1X FL= 1 COM=1

QUEUE EMPTY
REQUEST VOID: R
KMRX .54 0.5
18/0929 ARCHIVE
UNIT 1 READ DONE
HARDCOPY
HARDCOPY REQUEST
ACCEPTED



Total Precipitation (inches), November 14-18, 1994

Figure 8.



Total Precipitation (inches), November 14-18, 1994

Figure 9.

Figure 10

Mobile NEXRAD

BEG=05/08/95 18:48
-END=05/13/95 04:29

STM PRECIP 80 STP
124 NM 1.1 NM RES
05/13/95 04:27
RDA:KMOB 30/40/44N
289 FT 88/14/24W
MAX= 23.7 IN
MODE A / 21
CNTR 0DEC 0NM

ND
>0.0 IN
0.5
1.0
1.5
3.0
6.0
8.0
10.0
13.0
15.0
17.0
19.0
21.0
23.0
25.0



MAG=1X FL= 1 COM=1

QUEUE EMPTY
PROD RCUD: R 0T
KRAX 1746.54 0.5
13/1416 ARCHIVE
UNIT 1 READ DONE
HARDCOPY
HARDCOPY REQUEST
ACCEPTED

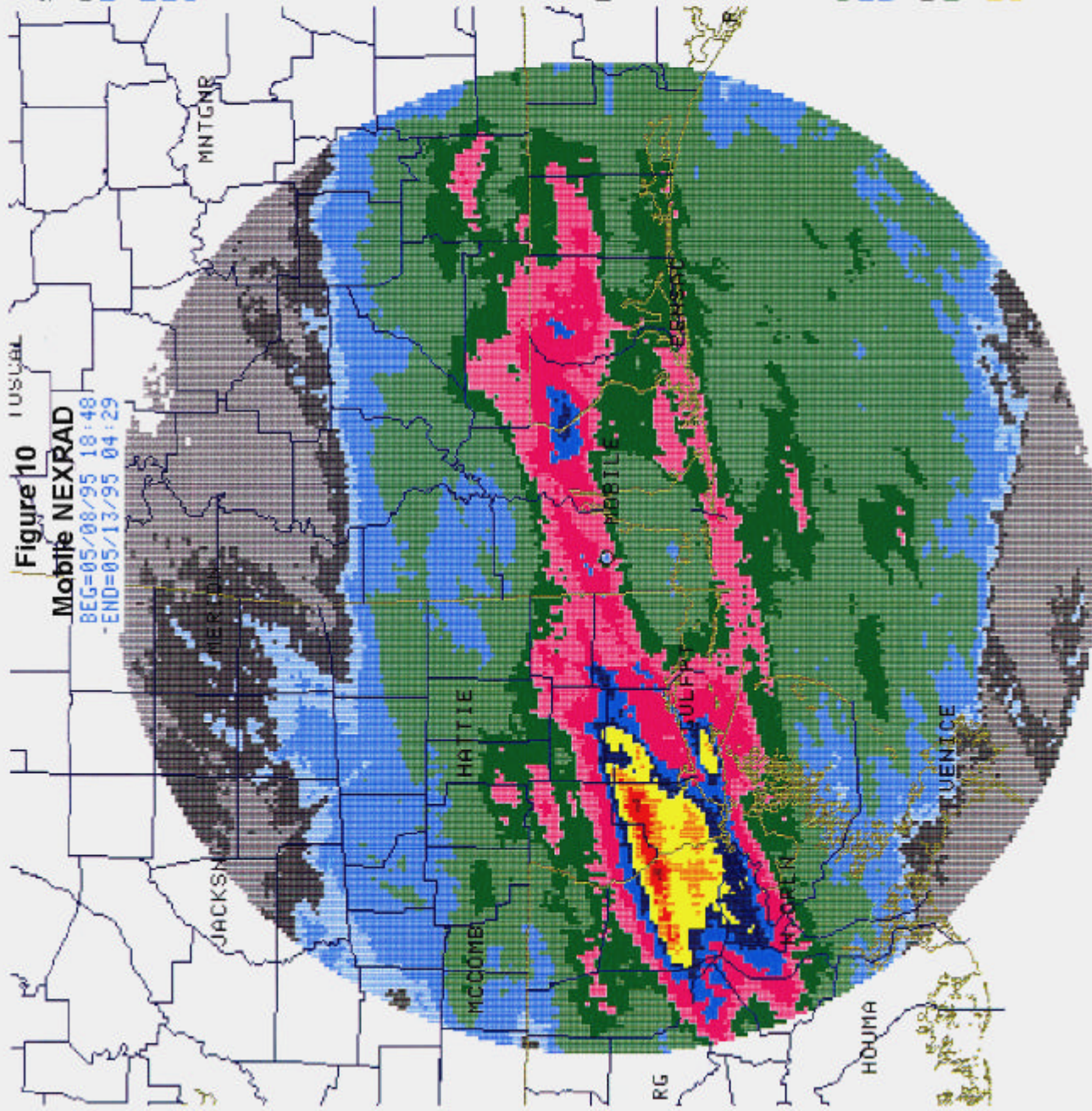


Figure 11

Slide# NEXRAD

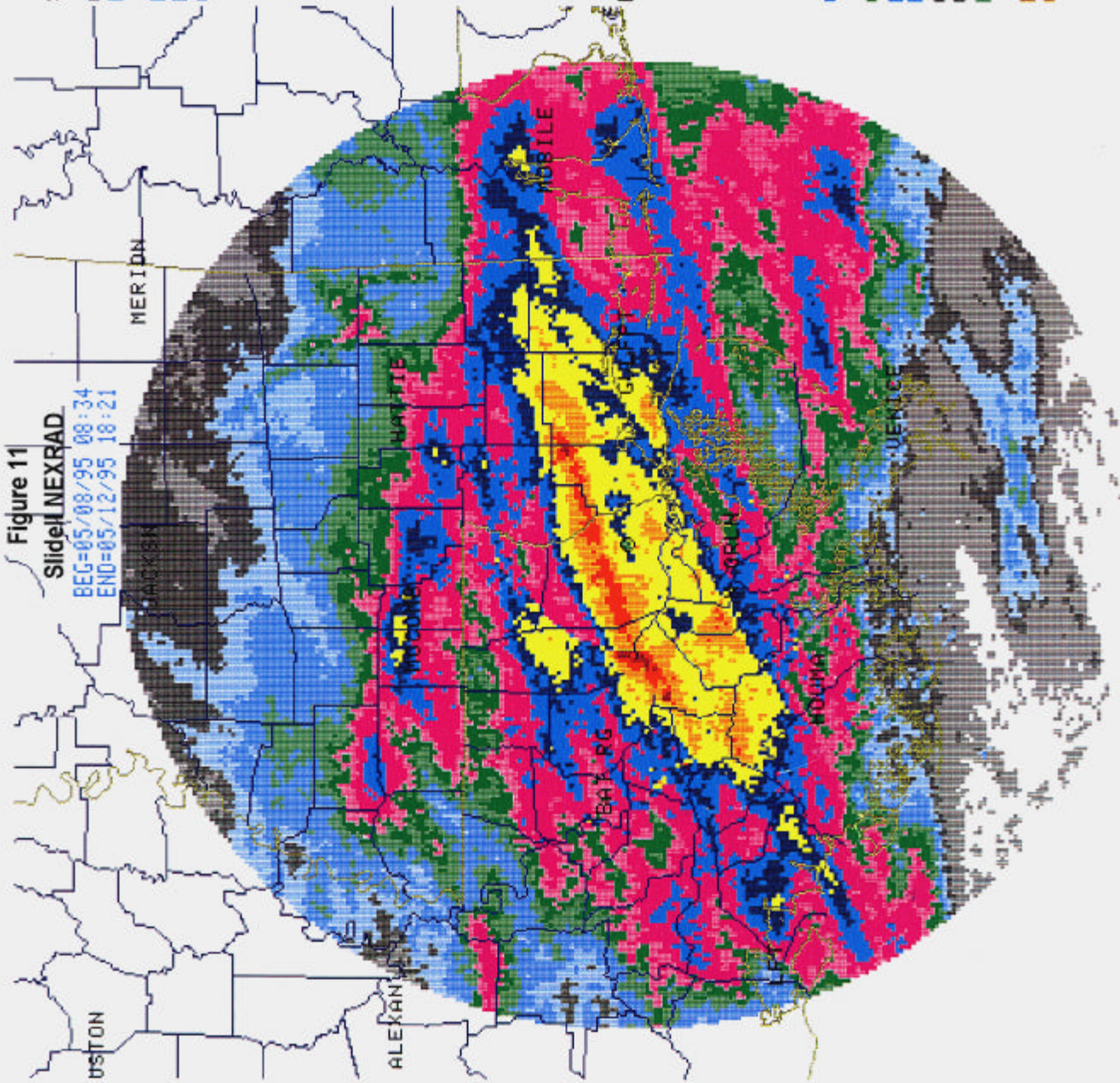
BEG=05/08/95 08:34
END=05/12/95 18:21

STM PRECIP 80 STP
124 NM 1.1 NM RES
05/12/95 18:19
RDA:KLIX 30/20/13N
138 FT 89/49/29W
MAX= 13.9 IN
MODE A / 21
CNTR 00DEG 0NM

ND
>0.0 IN

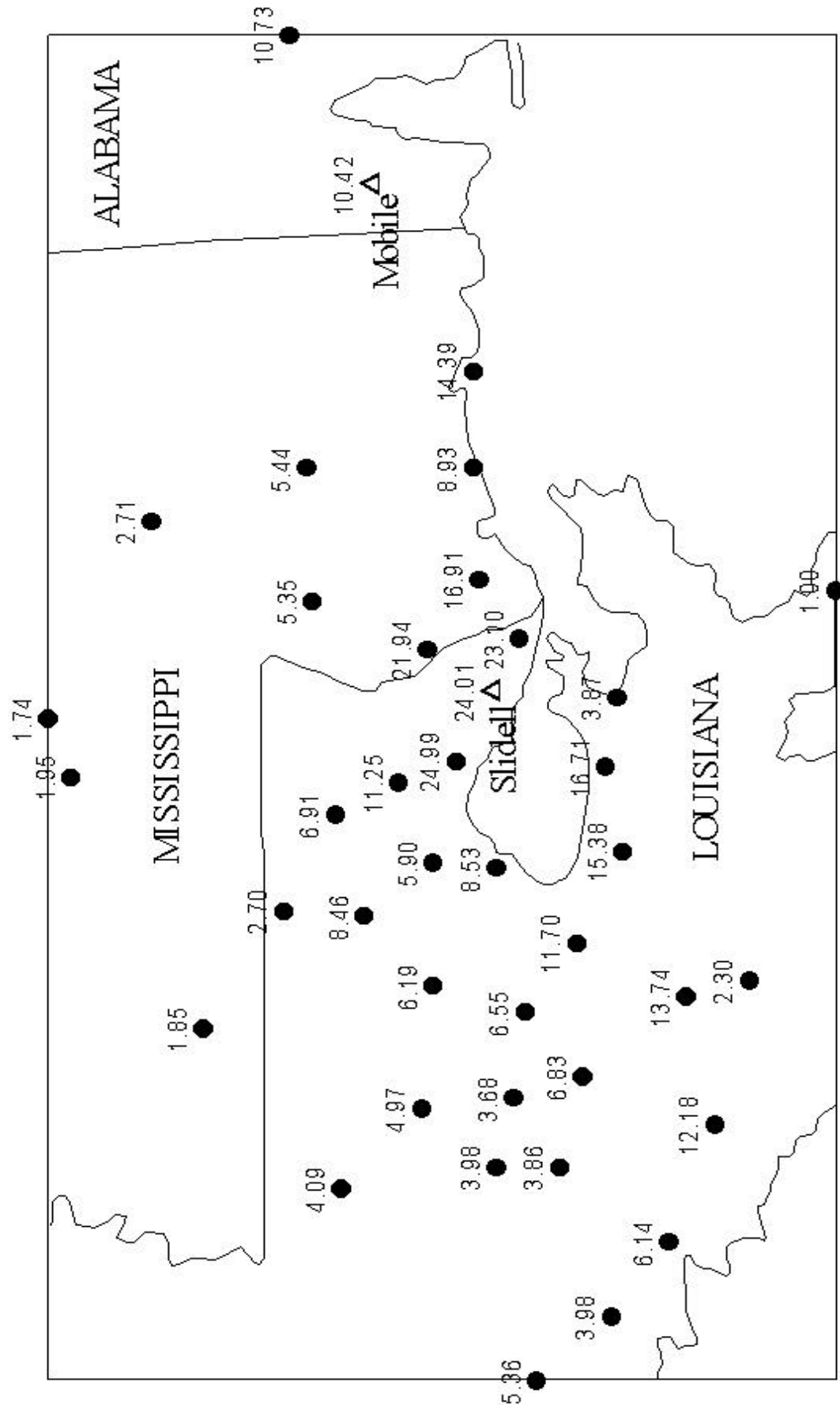


MAG=1X FL= 1 COM=1



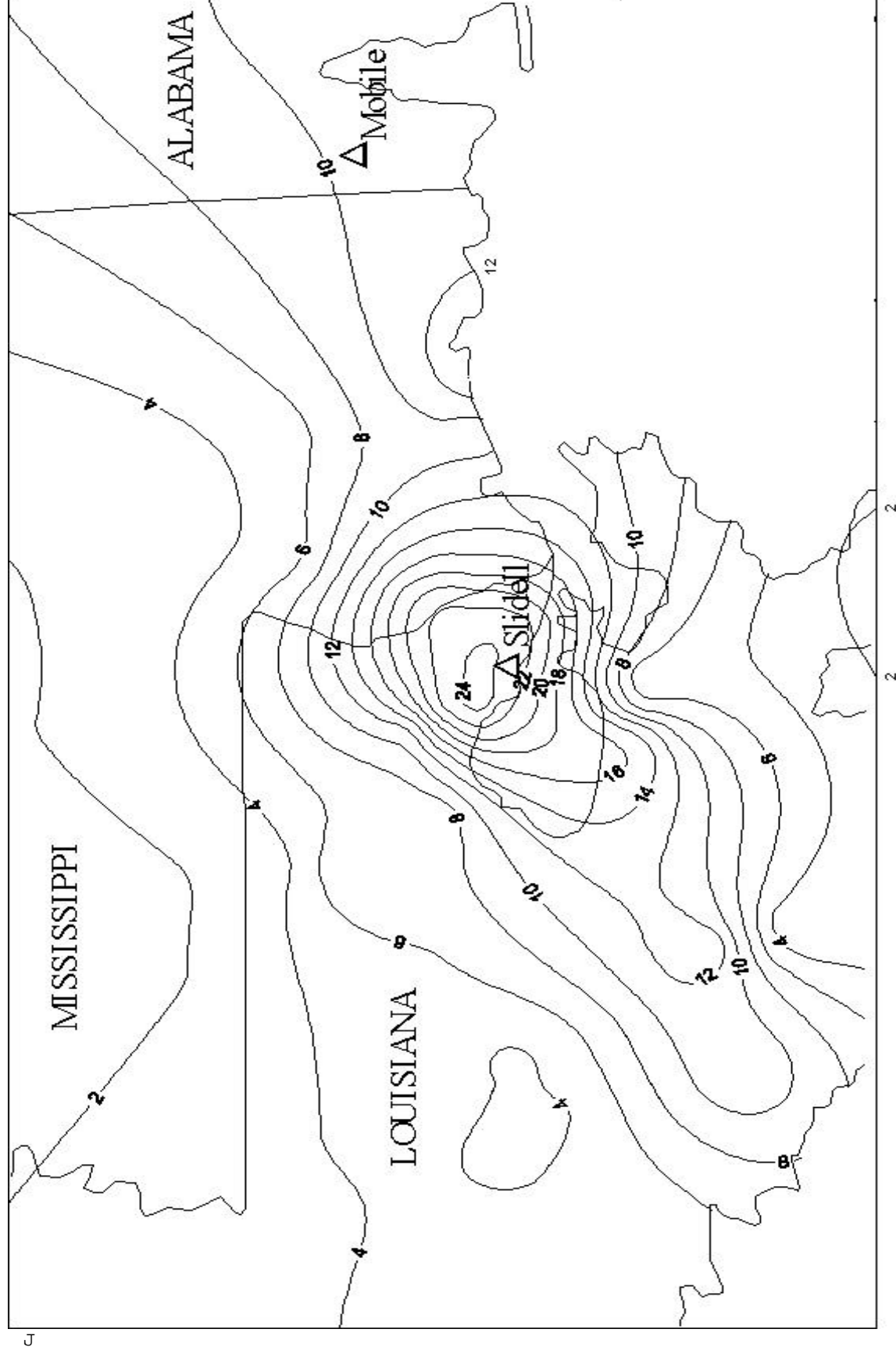
A/R (RDA)

005 U 1929 KEAX
PRODUCT LIST
RECEIVED FROM KGSP
01/1441 LINE 2
CONNECTED TO KGSP
HARDCOPY
HARDCOPY REQUEST
ACCEPTED



Total Precipitation (inches), May 8-13, 1995

Figure 12.



Total Precipitation (inches), May 8-13, 1995

Figure 13.

Figure 14

Columbia NEXRAD

BEG=08/23/95 06:58
END=08/29/95 02:14

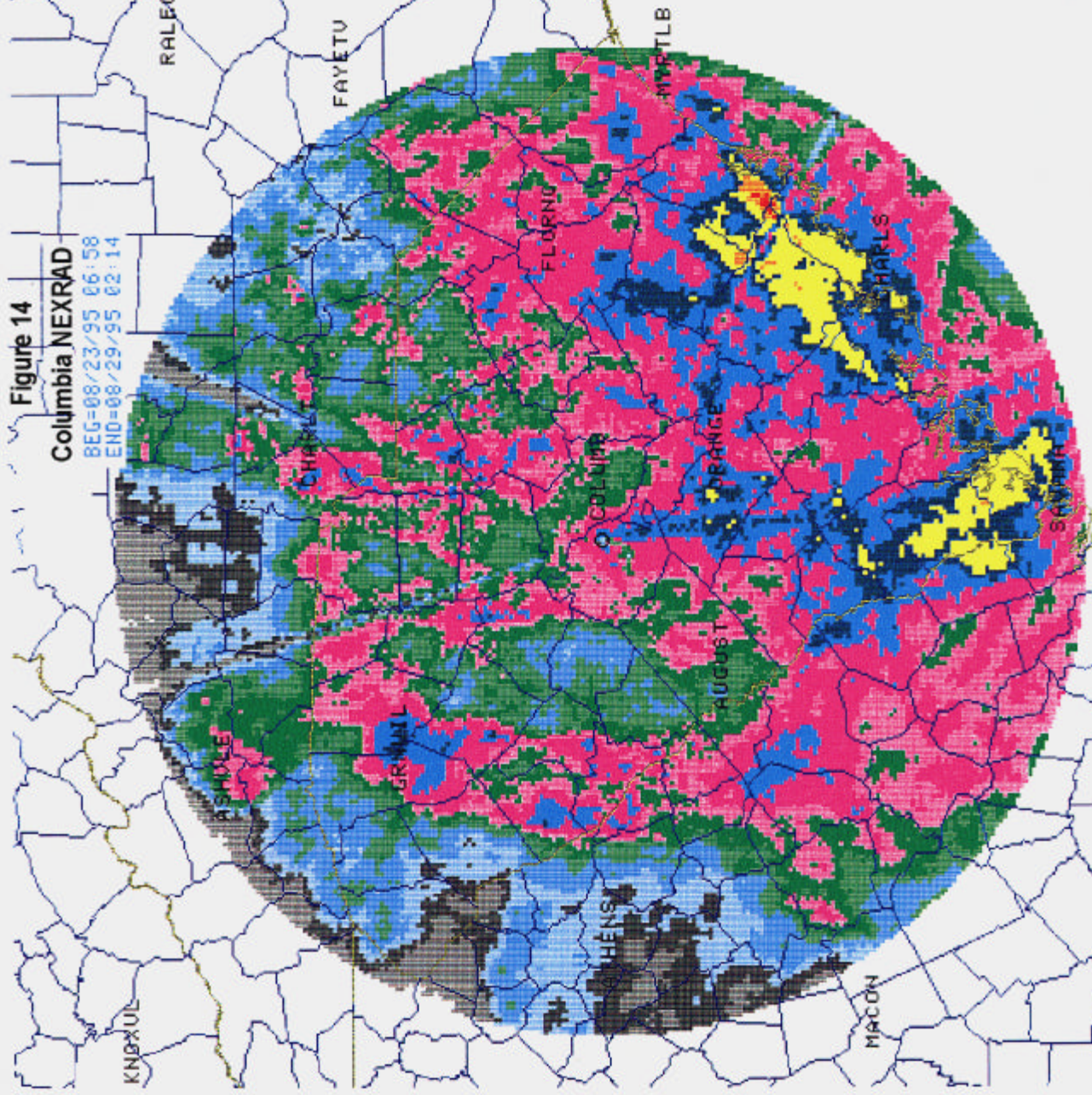
STM PRECIP 80 STP
124 NM 1 1 NM RES
08/29/95 02:11
RDA:KCAE 33/56/56N
344 FT 81/07/08W
MAX= 10.9 IN
RALEGG MODE A / 21 0NM
CNTR 0DEG

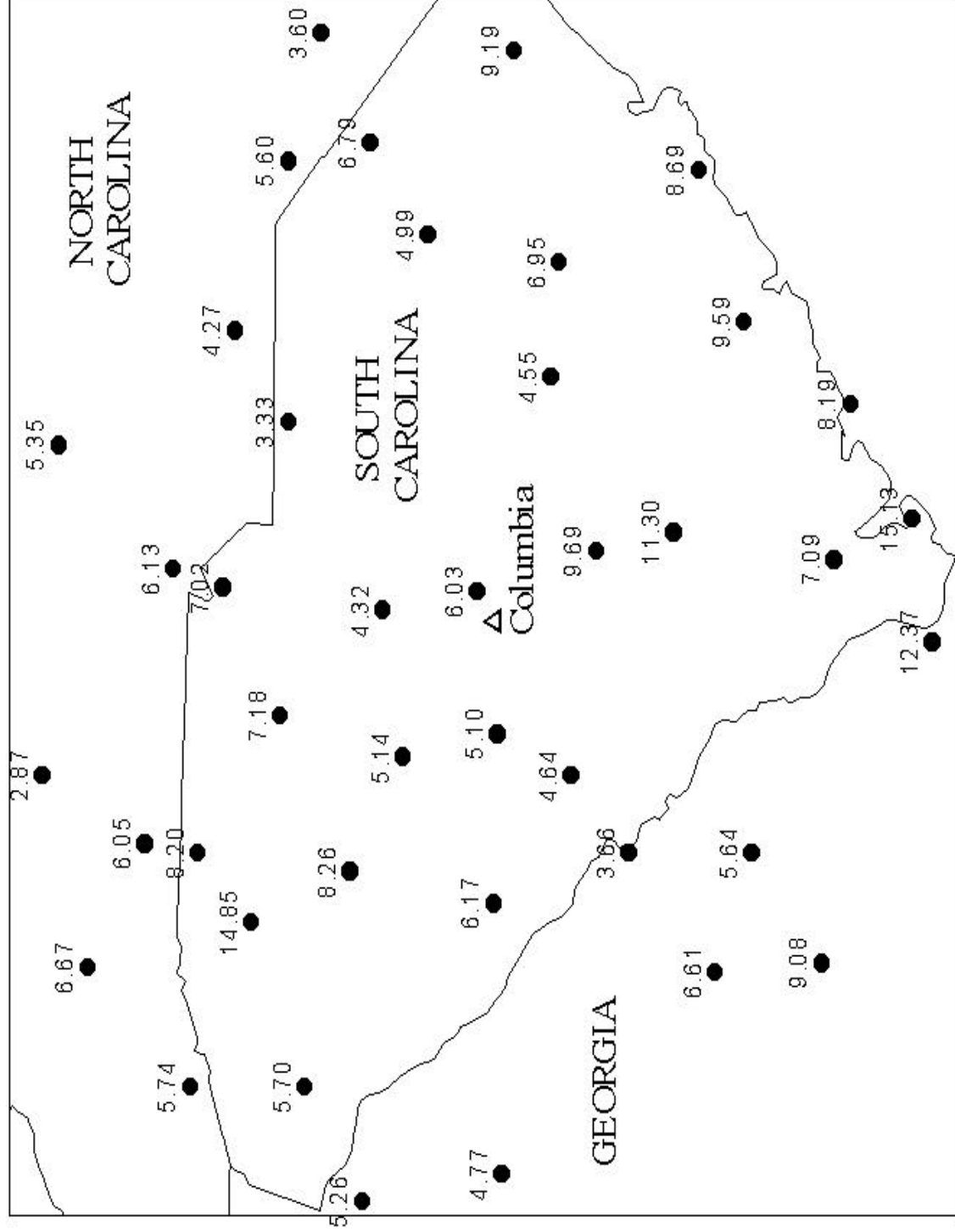
ND
>0.0 IN



MAG=1X FL= 1 COM=1

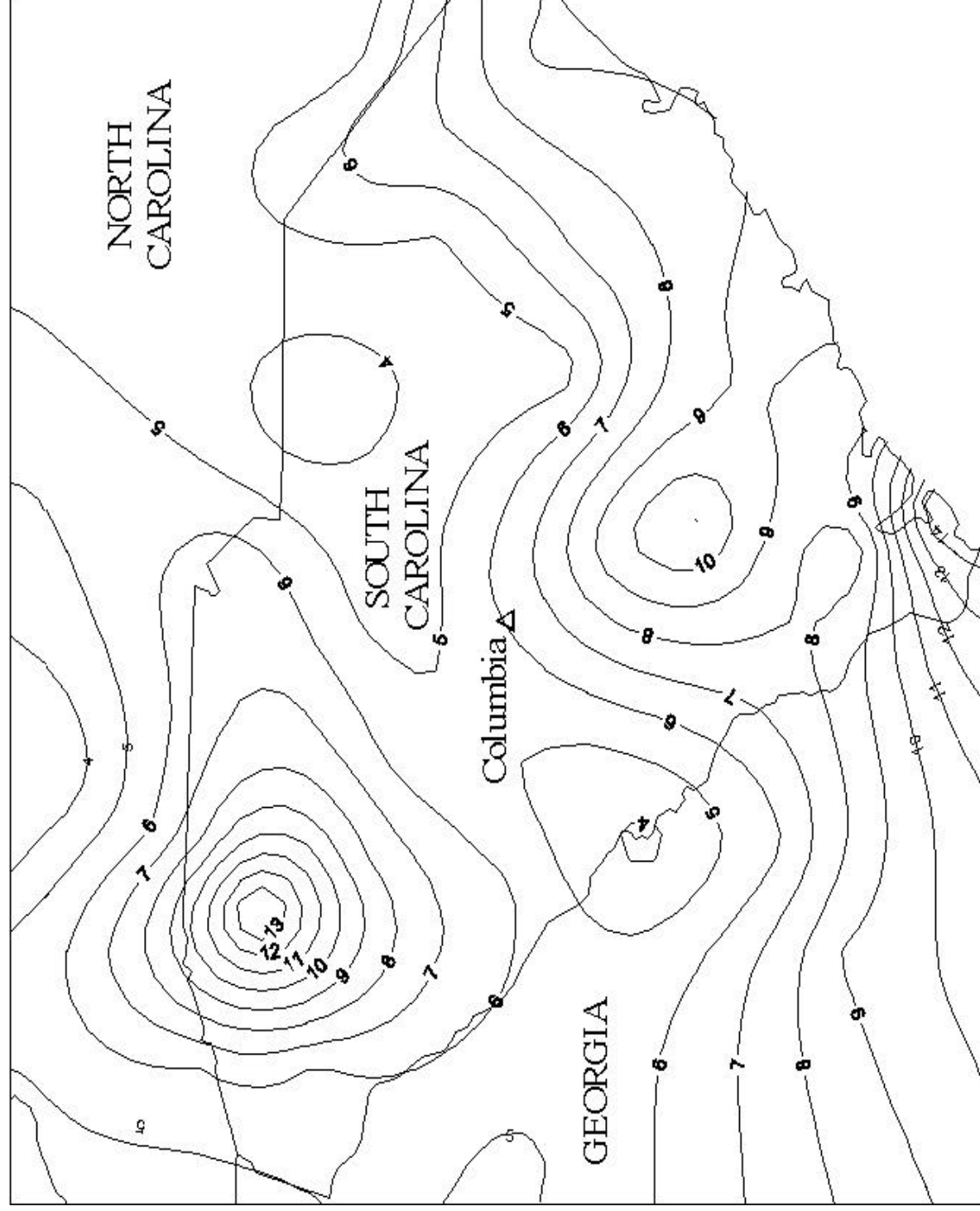
Q10 R 1527 KGSP
RPG KCAE NO ANSWER
NO REQUEST SENT
05/1140 ARCHIVE
UNIT 1 READ DONE
HARDCOPY
HARDCOPY REQUEST
ACCEPTED





Total Precipitation (inches), August 23-29, 1995

Figure 15.



Total Precipitation (inches), August 23-29, 1995

Figure 16.