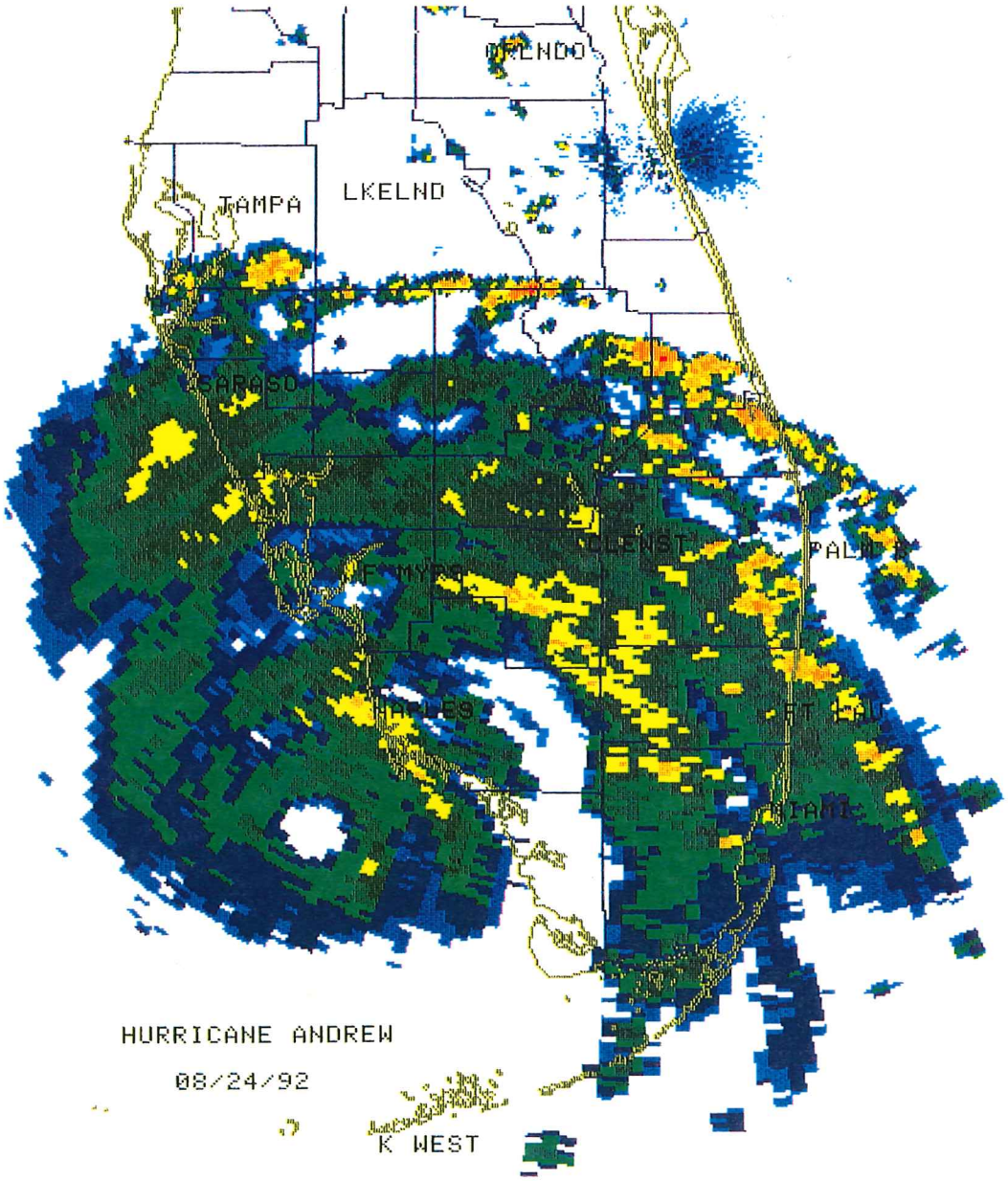
RADAR WEATHER OBSERVATIONS
(WSR-88D; WSR-57; WSR-74S)



NEXRAD (WSR-88D) RADAR

The Next Generation Weather Radar system (NEXRAD) will consist of approximately 160 Weather Surveillance Radar-1988 Doppler (WSR-88D) throughout the United States and selected overseas locations. This system is a joint effort of the United States Departments of Commerce, Defense, and Transportation to meet the needs of the participating agencies. Level III products will be recorded at 114 sites as stations are commissioned and sent to the National Climatic Data Center (NCDC) for archiving. Table 1 contains a list of National Weather Service sites from which Level III products will be available. Figure 1 is a map of all NWS Nexrad sites. Contact NCDC for information on the availability of Nexrad Level III products from any NWS site. The first WSR-88D was installed in 1990 near Oklahoma City, Oklahoma, and the last will be completed in 1996.

WSR-88D systems generate three meteorological quantities: reflectivity, mean radial velocity, and spectrum width. From these quantities, computer processing generates numerous meteorological analysis products.

Three functional components make up the WSR-88D. Radar Data Acquisition (RDA), Radar Product Generator (RPG) and the Principal User Processor (PUP) (See Figure 2). The RDA consists of a tower, pedestal, antenna, fiberglass radome, klystron transmitter, receiver, status and control processor, and signal processor. The RPG calls upon algorithms that convert base data from the RDA into hundreds of meteorological and hydrological products (39 categories) of various resolutions, data level intervals, and elevation angles in both graphic and alphanumeric form. Selected products are stored on a Write Once Read Many (WORM) optical disk that is sent to the National Climatic Data Center for archive and distribution to customers. This retrieval takes place at a PUP that displays products generated at the RPG. The PUP consists of a microcomputer with graphics tablet, system and application terminals, color graphics printer, color graphic monitors and communication system. Color graphics can be used to display products such as reflectivity, mean radial velocity, echo top height, and precipitation accumulation amounts. Hard copies and acetate overlays are made from the color graphics printer to be sent to customers.

A volume scan strategy is selected automatically by the RDA or manually by the operator and determined by operational needs so that the WSR-88D may continually scan the environment in a sequence of pre-programmed 360 degree azimuthal sweeps at various elevation angles. Four separate scan strategies are used now with the possibility of others being implemented in the future.

Volume Coverage Pattern 11 (VCP 11) is a precipitation mode. VCP 11 is short pulse, 14 elevation angles with a 5 minute update rate using separate surveillance and doppler scans at the 2 lowest

angles. The lowest seven angles are contiguous (See Figure 3). The resulting data are used in algorithms to determine storm tracks, shear and mesocyclones. Other algorithms determine precipitation amounts and obtain wind profiles.

Volume Coverage Pattern 21 (VCP 21), a second precipitation mode, is used to observe more distant storms; it uses a short pulse, 9 elevation angles and a 6 minute update rate. There are separate surveillance and doppler scans at the two lowest elevation angles with the lowest five angles being contiguous (See Figure 4).

Volume Coverage Pattern 31 (VCP 31) is a clear air mode and is used to detect early formation of convective precipitation, air mass discontinuities and to obtain wind profiles. It is long pulse, 5 elevation angles with a 10 minute update rate. There are separate surveillance and doppler scans on the lowest three elevation angles (See Figure 5).

Volume Coverage Pattern 32 (VCP 32) is the same as VCP 31 but with a short pulse (See Figure 5).

Precipitation mode is automatic upon detection of precipitation at any elevation angle, or it may be manually selected at times. Return to clear air mode must be manually selected at the Unit Control Position. Three precipitation categories are available.

Precipitation category 1 - significant precipitation detected.

Precipitation category 2 - small amounts of precipitation detected.

Precipitation category 0 - no precipitation for 1 hour.

The capability exists to design additional VCPs to optimize performance of the WSR-88D for particular locations or weather scenarios.

There are a total of 24 level III products routinely available from NCDC which include 7 graphic products in clear air mode, 11 in precipitation mode, 5 graphic overlays and 1 alphanumeric product. Digital precipitation and radar coded message are products that are unavailable from NCDC at this time. Each product will include state, county & city background maps. Level III graphic products are available only as color hard copy, gray scale hard copy or acetate overlay copies. A list of these products appears in Federal Meteorological Handbook (FMH) No. 11, part A, pages 5-3 and 5-4, and a complete description of each product is in FMH-11, part C, pages 2-1 through 2-101. A brief description and possible uses of these products are included in Table 2. Also, a color example

of base reflectivity appears in Figure 6 along with an explanation of the legend that will accompany each product, Figure 7.

Level II data are digital base data output from the RDA's signal processor in polar format. The current level II recording media is reusable 8 mm tape that can hold approximately 4.7 gigabytes of data per tape. The amount of time it takes to fill a level II tape is dependant upon the scan strategy used. Contact NCDC for the location of Nexrad level II stations and data availability.

For a further understanding of WSR-88D Doppler radar, please refer to FMH-11 (Parts A through D):

FMH-11 Part A System Concepts, Responsibilities, and Procedures
FMH-11 Part B Doppler Radar Theory and Meteorology
FMH-11 Part C Products and Algorithms
FMH-11 Part D Unit Description and Operational Analysis

REFERENCES

1. Federal Meteorological Handbook-11

   Part A System Concepts, Responsibilities, and Procedures
   Part B Doppler Radar Theory and Meteorology.
   Part C WSR-88D Products and Algorithms.
   Part D WSR-88D Unit Description and Operational Applications.

2. "Recording, Archiving, and Using WSR-88D Data" American Meteorological Society Bulletin April 1993, Timothy D. Crum, Ron L. Alberty, and Donald W. Burgess.

3. "A Description of the Initial Set of Analysis Products Available from the NEXRAD WSR-88D System" American Meteorological Society Bulletin July 1993, Gerard E. Klazura and David A. Imy.

NEXRAD SITE NAME CHANGES/ADDITION

In an effort to minimize confusion concerning NEXRAD site locations and to reduce name length, several site names have been modified or changed, and an additional site added, since Table I and Figure I were composed. A revised site location list and map will be produced when all NEXRAD sites have been commissioned. In the list below, the added site is indicated by an *.

The changes/addition are:

ORIGINAL SITE NAME	MODIFIED SITE NAME
ALPENA, MI	GAYLORD, MI
BOSTON/TAUNTON, MA	BOSTON, MA
BROOKHAVEN (NEW YORK CITY), NY	NEW YORK CITY, NY
CARIBOU, ME *	*HOULTON, ME
CINCINNATI/DAYTON, OH	CONCINNATI, OH
FORT WORTH/DALLAS, TX	DALLAS/FORT WORTH, TX
DAVENPORT (QUAD CITIES), IA	DAVENPORT, IA
DENVER/FRONT RANGE, CO	DENVER, CO
GRAND ISLAND (HASTINGS), NE	HASTINGS, NE
KNOXVILLE/MORRISTOWN, TN	KNOXVILLE, TN
LANDER/RIVERTON, WY	RIVERTON, WY
LINCOLN (CENTRAL ILLINOIS), IL	LINCOLN, IL
MILWAUKEE (SULLIVAN TOWNSHIP), WI	MILWAUKEE, WI
MONTEREY (SAN FRANCISCO BAY), CA	SAN FRANCISCO, CA
NEW ORLEANS/SLIDELL, LA	NEW ORLEANS, LA
PLEASANT HILL (KANSAS CITY), MO	KANSAS CITY, MO
STERLING (WASHINGTON DULLES), VA	STERLING, VA
TWIN LAKES/NORMAN, OK	OKLAHOMA CITY, OK

10/96

Table 1

WSR-88D SITES

STATION	CALL
ABERDEEN, SD	KABR
ALBANY, NY	KENX
ALBUQUERQUE, NM	KABX
ALPENA, MI	KAPX
AMARILLO, TX	KAMA
ATLANTA, GA	KFFC
AUSTIN/SAN ANTONIO, TX	KEWX
BILLINGS, MT	KBLX
BINGHAMTON, NY	KBGM
BIRMINGHAM, AL	KBMX
BISMARCK, ND	KBIS
BOISE, ID	KCBX
BOSTON/TAUNTON, MA	KBOX
BROOKHAVEN (NEW YORK CITY), NY	KOKX
BROWNSVILLE, TX	KBRO
BUFFALO, NY	KBUF
BURLINGTON, VT	KBTV
CEDAR CITY, UT	KICX
CHARLESTON, SC	KCLX
CHARLESTON, WV	KRLX
CHEYENNE, WY	KCYS
CHICAGO, IL	KLOT
CINCINNATI/DAYTON, OH	KILN
CLEVELAND, OH	KCLE
COLUMBIA, SC	KCAE
CORPUS CHRISTI, TX	KCRP
DAVENPORT (QUAD CITIES), IA	KDVN
DENVER/FRONT RANGE, CO	KFTG
DES MOINES, IA	KDMX
DETROIT, MI	KDTX
DODGE CITY, KS	KDDC
DULUTH, MN	KDLH
EL PASO, TX	KEPZ
ELKO, NV	KLRX
EUREKA, CA	KBHX
FLAGSTAFF, AZ	KFSX
FORT WORTH/DALLAS, TX	KFWS
GLASGOW, MT	KGGW
GOODLAND, KS	KGLD
GRAND RAPIDS, MI	KGRR
GRAND FORKS, ND	KMVX
GRAND JUNCTION, CO	KGJX
GRAND ISLAND (HASTINGS), NE	KUEX
GREAT FALLS, MT	KTFX
GREEN BAY, WI	KGRB
GREER, SC	KGSP
HOUSTON, TX	KHGX
INDIANAPOLIS, IN	KIND
JACKSON, MS	KJAN
JACKSONVILLE, FL	KJAX
KEY WEST, FL	KEYW
KNOXVILLE/MORRISTOWN, TN	KMRX
LA CROSSE, WI	KARX
LAKE CHARLES, LA	KLCH
LANDER/RIVERTON, WY	KRIW
LAS VEGAS, NV	KESX
LINCOLN (CENTRAL ILLINOIS), IL	KILX
LITTLE ROCK, AR	KLZK
LOS ANGELES, CA	KVTX
LOUISVILLE, KY	KLVX
LUBBOCK, TX	KLBB
MARQUETTE, MI	KMQT
MEDFORD, OR	KMAX
MELBOURNE, FL	KMLB
MEMPHIS, TN	KNQA
MIAMI, FL	KAMX
MIDLAND/ODESSA, TX	KMAF
MILWAUKEE (SULLIVAN TOWNSHIP), WI	KMKX
MINNEAPOLIS, MN	KMPX
MISSOULA, MT	KMSX
MOBILE, AL	KMOB
MONTEREY (SAN FRANCISCO BAY), CA	KMUX
MOREHEAD CITY, NC	KINS
NASHVILLE, TN	KOHX
NEW ORLEANS/SLIDELL, LA	KLIX
NORFOLK/RICHMOND, VA	KAKQ
NORTH PLATTE, NE	KLNX
OMAHA, NE	KOAX
PADUCAH, KY	KPAH
PENDLETON, OR	KPDT
PHILADELPHIA, PA	KDIX
PHOENIX, AZ	KIWA
PITTSBURGH, PA	KPBZ
PLEASANT HILL (KANSAS CITY), MO	KEAX
POCATELLO, ID	KSFX
PORTLAND, ME	KGYX
PORTLAND, OR	KRTX
PUEBLO, CO	KPUX
RALEIGH/DURHAM, NC	KRAX
RAPID CITY, SD	KUDX
RENO, NV	KRGX
ROANOKE, VA	KFCX
SACRAMENTO, CA	KDAX
ST. LOUIS, MO	KLSX
SALT LAKE CITY, UT	KMTX
SAN ANGELO, TX	KSJT
SAN DIEGO, CA	KNKX
SAN JOAQUIN VALLEY, CA	KHNX
SEATTLE, WA	KATX
SHREVEPORT, LA	KSHV
SIOUX FALLS, SD	KFSD
SPOKANE, WA	KOTX
SPRINGFIELD, MO	KSGF
STATE COLLEGE, PA	KCCX
STERLING (WASHINGTON DULLES), VA	KLWX
TALLAHASSEE, FL	KTLH
TAMPA, FL	KTBW
TOPEKA, KS	KTWX
TUCSON, AZ	KSRX
TULSA, OK	KINX
TWIN LAKES/NORMAN, OK	KTLX
WICHITA, KS	KICT
WILMINGTON, NC	KLTX
YUMA, AZ	KYUM

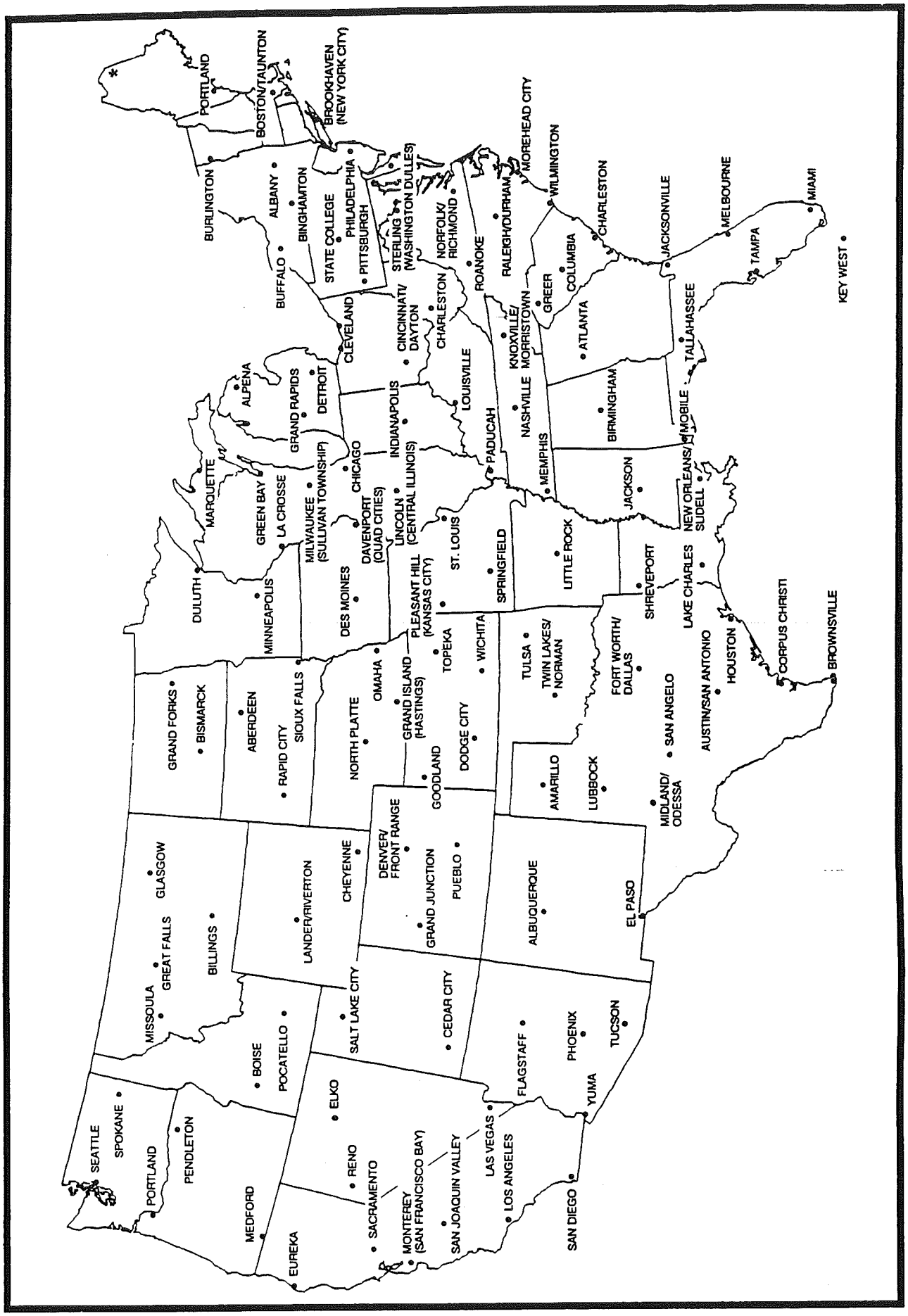

PORTLAND
BOSTON/TAUNTON
BROOKHAVEN (NEW YORK CITY)
BURLINGTON
ALBANY
BINGHAMTON
STATE COLLEGE
PHILADELPHIA
BUFFALO
PITTSBURGH
STERLING (WASHINGTON DULLES)
NORFOLK/ RICHMOND
ROANOKE
RALEIGH/DURHAM
MOREHEAD CITY
WILMINGTON
CLEVELAND
CINCINNATI/ DAYTON
CHARLESTON
GREER
COLUMBIA
CHARLESTON
ALPENA
GRAND RAPIDS
DETROIT
INDIANAPOLIS
LOUISVILLE
KNOXVILLE/ MORRISTOWN
ATLANTA
JACKSONVILLE
MELBOURNE
TAMPA
MIAMI
KEY WEST
MARQUETTE
GREEN BAY
LA CROSSE
MILWAUKEE (SULLIVAN TOWNSHIP)
CHICAGO
LINCOLN (CENTRAL ILLINOIS)
PADUCAH
NASHVILLE
MEMPHIS
BIRMINGHAM
MOBILE
TALLAHASSEE
DULUTH
MINNEAPOLIS
DES MOINES
DAVENPORT (QUAD CITIES)
ST. LOUIS
SPRINGFIELD
LITTLE ROCK
JACKSON
NEW ORLEANS/ SLIDELL
GRAND FORKS
BISMARCK
ABERDEEN
RAPID CITY
SIOUX FALLS
NORTH PLATTE
OMAHA
GRAND ISLAND (HASTINGS)
PLEASANT HILL (KANSAS CITY)
TOPEKA
WICHITA
TULSA
TWIN LAKES/ NORMAN
SHREVEPORT
LAKE CHARLES
HOUSTON
CORPUS CHRISTI
BROWNSVILLE
GOODLAND
DODGE CITY
AMARILLO
FORT WORTH/ DALLAS
AUSTIN/SAN ANTONIO
SAN ANGELO
LUBBOCK
MIDLAND/ ODESSA
GLASGOW
MISSOULA
GREAT FALLS
BILLINGS
LANDER/RIVERTON
CHEYENNE
DENVER/ FRONT RANGE
GRAND JUNCTION
PUEBLO
ALBUQUERQUE
EL PASO
BOISE
POCATELLO
SALT LAKE CITY
CEDAR CITY
FLAGSTAFF
PHOENIX
TUCSON
YUMA
SEATTLE
SPOKANE
PORTLAND
PENDLETON
ELKO
RENO
SACRAMENTO
MONTEREY (SAN FRANCISCO BAY)
SAN JOAQUIN VALLEY
LAS VEGAS
LOS ANGELES
SAN DIEGO
MEDFORD
EUREKA

Figure 1

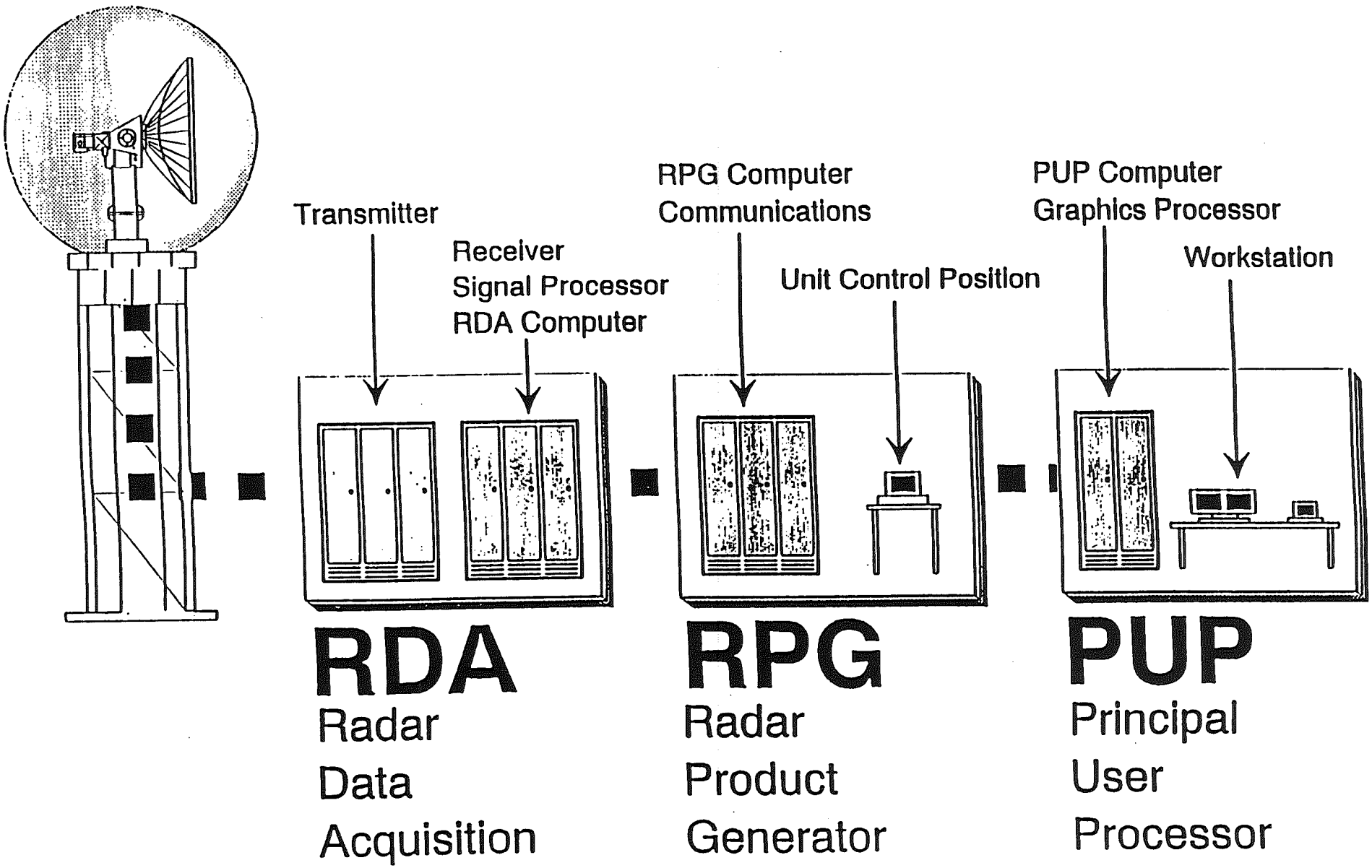
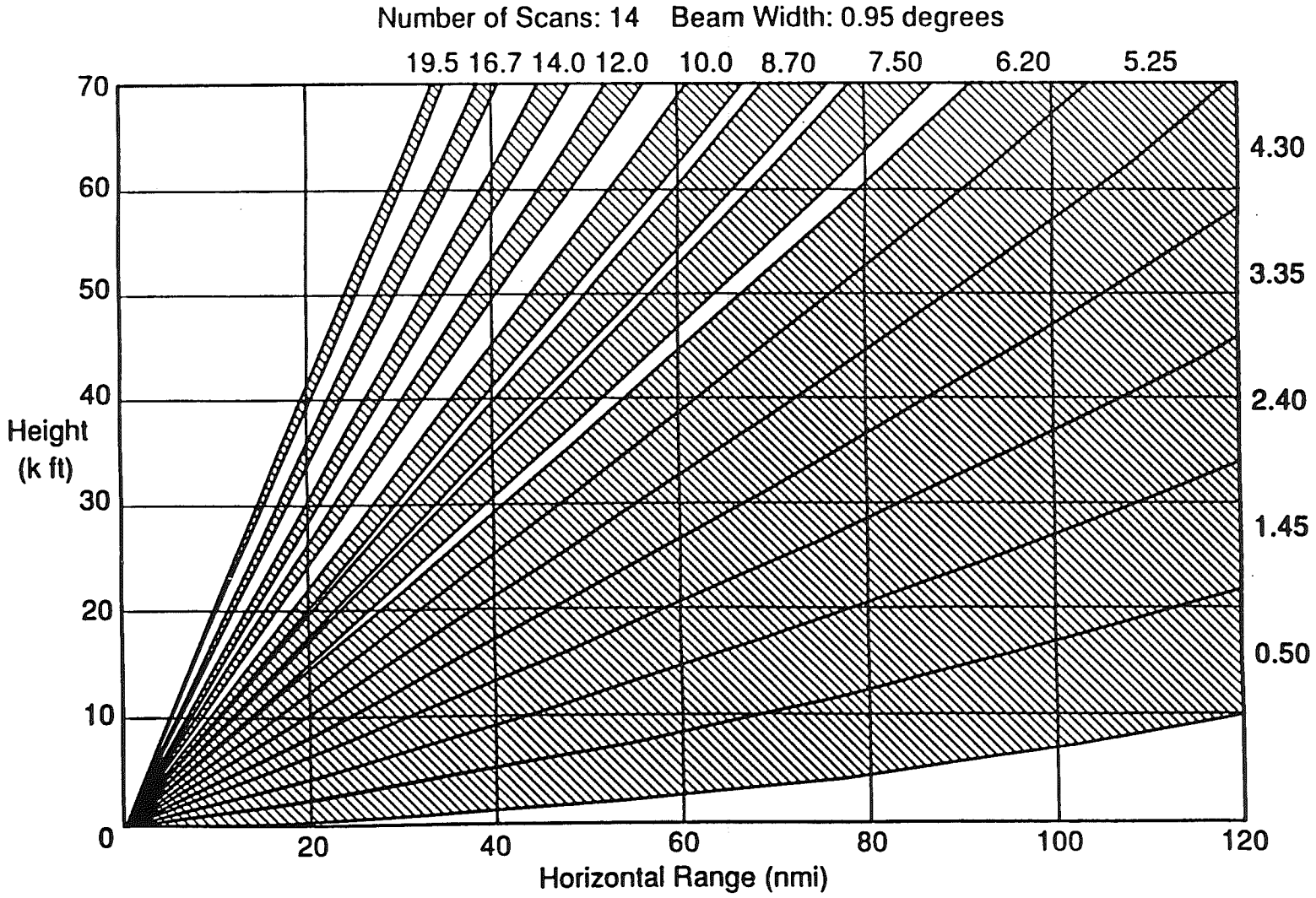
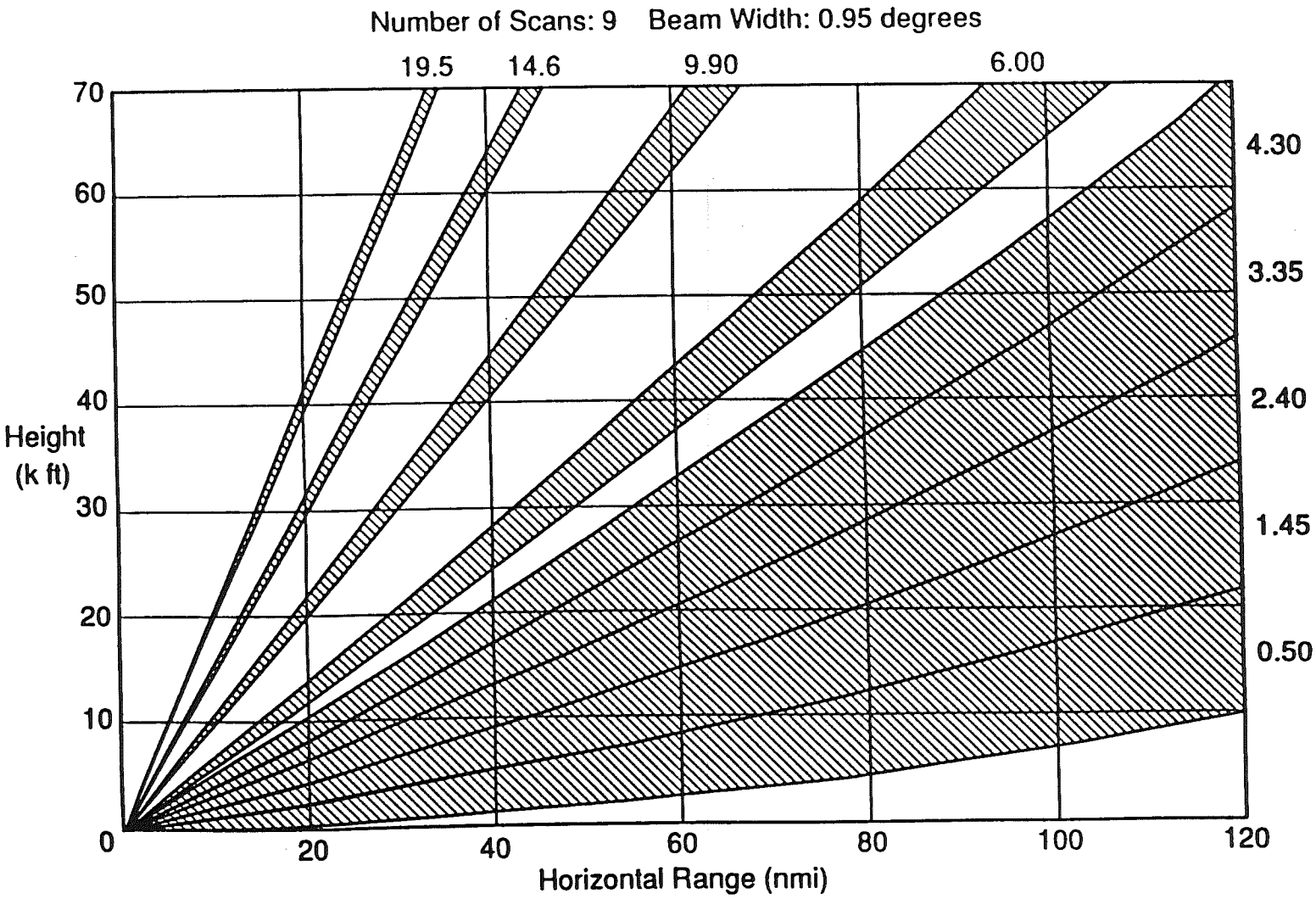

Transmitter
Receiver
Signal Processor
RDA Computer
RPG Computer
Communications
Unit Control Position
PUP Computer
Graphics Processor
Workstation
RDA
Radar
Data
Acquisition
RPG
Radar
Product
Generator
PUP
Principal
User
Processor

Figure 2



Precipitation/Severe Weather Scan
Volume Coverage Pattern 11

Figure 3



Alternative Scan
Volume Coverage Pattern 21

Figure 4

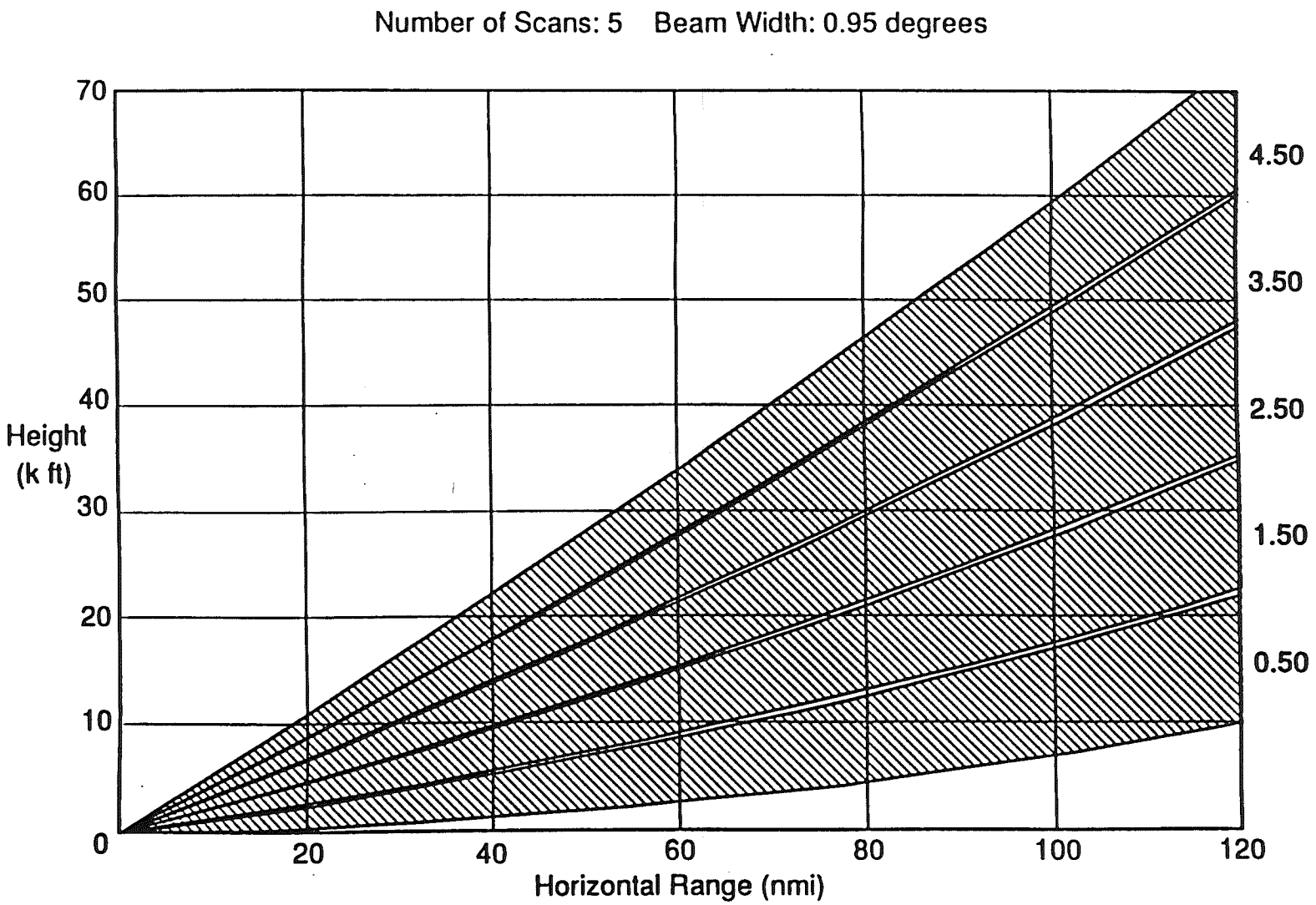


Figure 5

Clear Air Scan
Volume Coverage Patterns 31 and 32

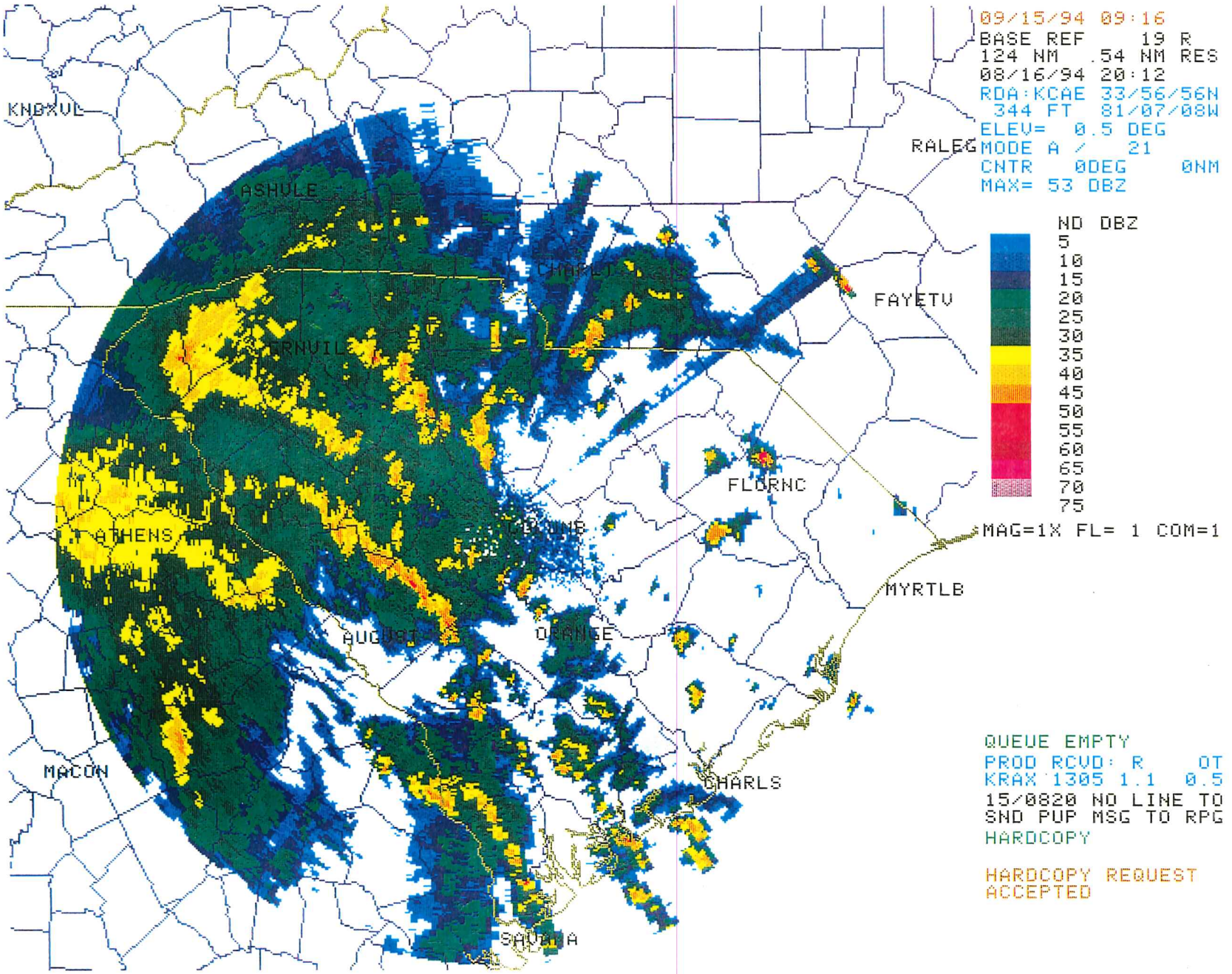
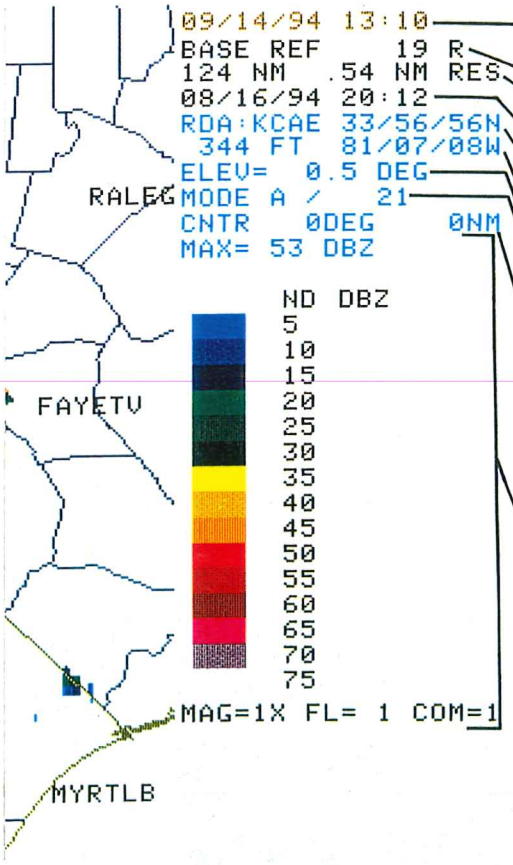

09/15/94 09:16
BASE REF 19 R
124 NM .54 NM RES
08/16/94 20:12
RDA:KCAE 33/56/56N
344 FT 81/07/08W
ELEV= 0.5 DEG
MODE A / 21
CNTR 0DEG 0NM
MAX= 53 DBZ
ND DBZ
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
MAG=1X FL= 1 COM=1
KNBXVL
ASHVLE
RALEG
FAYETV
FLORNC
MYRTLB
ATHENS
AUGUST
MACON
CHARLS
QUEUE EMPTY
PROD RCVD: R OT
KRAX 1305 1.1 0.5
15/0820 NO LINE TO
SND PUP MSG TO RPG
HARDCOPY
HARDCOPY REQUEST
ACCEPTED

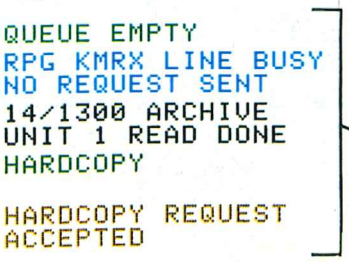
Figure 6

KEY TO WSR-88 DOPPLER RADAR (NEXRAD) PRODUCTS

All products have common information provided in the upper right hand corner of each product. The key to this information is given here.

The vertical color code can vary from product to product. The services of a consulting meteorologist to interpret this code, and the image itself, is advised. The information given in the lower right hand corner pertains to product generation and is irrelevant to the user of the product.





MONTH/DAY/YEAR LOCAL TIME product was generated at NCDC

NAME and NUMBER of product

RANGE and RESOLUTION in Nautical Miles (NM) of product

MONTH/DAY/YEAR UTC TIME Actual time product was recorded

CALL SIGN (Kxxx) of obs. site and LATITUDE (deg/min/sec) (RDA = Radar Data Acquisition)

ELEVATION of obs. site (MSL) and LONGITUDE (deg/min/sec)

ELEVATION of RADAR BEAM

MODE A (precip mode) or MODE B (clear air mode) / VOLUME SCAN PATTERN

RADAR BEAM ORIGINATION POINT (Ø DEG Ø NM) = centered at radar site

COLOR CODE varies with products. Interpretation can be provided by consulting meteorologists.

Information pertaining to product generation - irrelevant to user.

TIME CONVERSION TABLE: LST to UTC (COORDINATED UNIVERSAL TIME)

STANDARD TIME ZONE	To Convert LST to UTC Add	i.e. 1200 LST EQUALS
Atlantic Standard Time	4 hours	1600 UTC
Eastern Standard Time	5 hours	1700 UTC
Central Standard Time	6 hours	1800 UTC
Mountain Standard Time	7 hours	1900 UTC
Pacific Standard Time	8 hours	2000 UTC
Alaska/Hawaii Standard Time	10 hours	2200 UTC

Figure 7

NEXRAD LEVEL III PRODUCTS

*Base Reflectivity (R)
Base Spectrum Width (SW)
*Base Velocity (V)
Composite Reflectivity (CR)
Echo Tops (ET)
**Hail Index Overlay (HI)
**Mesocyclone Overlay (M)
One-hour Precipitation (OHP)
Severe Weather Probability Overlay (SWP)
Storm Structure (SS) (Alphanumeric product)
*Storm Total Precipitation (STP)
**Storm Tracking Information Overlay (STI)
**Tornadic Vortex Signature Overlay (TVS)
VAD Wind Profile (VWP)
Vertically Integrated Liquid (VIL)

*Nexrad Level III products making up the standard package
**Overlay Products that will be accompanied by alphanumeric read-out

<u>*Base Reflectivity</u> (R) - A display of echo intensity measured in dBZ. This product is used to detect precipitation, evaluate storm structure, locate boundaries and determine hail potential.

<u>Base Spectrum Width</u> (SW) - A measure of velocity dispersion within the radar sample volume. The primary use of this product is to estimate turbulence associated with mesocyclones and boundaries.

<u>*Base Velocity</u> (V) - A measure of the radial component of the wind either toward the radar (negative values) or away from the radar (positive values). Negative values are represented by cool colors (green) while positive values are represented by warm colors (red). This product is used to estimate wind speed and direction, locate boundaries, locate severe weather signatures and identify suspected areas of turbulence.

<u>Composite Reflectivity</u> (CR) - A display of maximum reflectivity for the total volume within the range of the radar. This product is used to reveal the highest reflectivities in all echoes, examine storm structure features and determine intensity of storms.

<u>Echo Tops</u> (ET) - An image of the echo top heights color coded in user-defined increments. This product is used for a quick estimation of the most intense convection and higher echo tops, as an aid in identification of storm structure features and for pilot briefing purposes.

**Hail Index Overlay (HI) - A product designed to locate storms which have the potential to produce hail. Hail potential is labelled as either probable (hollow green triangle) or positive (filled green triangle). Probable means the storm is probably producing hail and positive means the storm is producing hail.

**Mesocyclone Overlay (M) - This product is designed to display information regarding the existence and nature of rotations associated with thunderstorms. Numerical output includes azimuth, range, and height of the mesocyclone.

One-hour Precipitation (OHP) - A map of estimated one hour precipitation accumulation on a 1.1 X 1.1 nmi grid. This product is used to assess rainfall intensities for flash flood warnings, urban flood statements and special weather statements.

Severe Weather Probability Overlay (SWP) - A measure of a storms relative severity as compared with those storms around it. The values are directly related to the horizontal extent of vertically integrated liquid (VIL) values greater than a specified threshold. This product is used as a quick identification of the strongest storms.

Storm Structure (SS) (Alphanumeric product) - A table displaying information on storm attributes which include maximum reflectivity, maximum velocity at lowest elevation angle, storm overhang, mass weighted storm volume, storm area base and top, storm position and storm tilt.

*Storm Total Precipitation (STP) - A map of estimated storm total precipitation accumulation continuously updated since the last one-hour break over the entire scope. This product is used to locate flood potential over urban or rural areas, estimate total basin runoff and provide rainfall data 24 hours a day.

**Storm Tracking Information Overlay (STI) - A product which shows a plot of the past hours movement, current location, and forecast movement for the next hour or less for each identified thunderstorm cell. This product is used to determine reliable storm movement.

**Tornadic Vortex Signature Overlay (TVS) - A product which shows an intense gate to gate azimuthal shear associated with tornadic-scale rotation. It is depicted by a red triangle with numerical output of location and height.

VAD Wind Profile (VWP) - A graphic display of wind barbs plotted on a height staff in 500 ft or 1000 ft increments. The current (far right) and up to 10 previous plots may be displayed simultaneously. This product is an excellent tool for meteorologists in weather forecasting, severe weather and aviation.

Vertically Integrated Liquid (VIL) - The water content of a 2.2 X 2.2 nmi column of air which is color coded and plotted on a 124 nmi map. This product is used as an effective hail indicator, to locate most significant storms and to identify areas of heavy rainfall.

NETWORK (WSR-57) AND LOCAL WARNING (WSR-74S) RADARS

NCDC will also continue to archive radar weather observations from WSR-57 and WSR-74S radar sites. As the WSR-88D stations are commissioned, the WSR-57 and WSR-74S stations will be decommissioned. It is possible that there will be a gap between commissioning and decommissioning when no data will be available. By the end of 1996, the National Weather Service radar observation network should consist entirely of WSR-88D's. The following pages refer to the WSR-57 and WSR-74S forms and procedures.

Observation Forms

Radar Forms (MF 7-60, formerly WBAN-60 and WBAN 610-3) are used for recording radar weather observations at approximately 110 National Weather Service radar stations located throughout the United States. See Table 3 for a condensed explanation of the RAREP (Radar report) code, together with an example copy of the report form MF 7-60 (Table 4). Figure 8 is a map of the National Weather Service radar observational network as it existed in April 1983.

Records are available in this general form beginning in the late 1950's. Form MF 7-60 provides for the entry of detailed information about the character, type and intensity of precipitation, direction and distance of the echoes from the station, movement of the echoes, maximum height of tops of cells, and pertinent remarks. An upward pointing arrow indicates the beginning of the digital section of the observation which gives additional information on echo locations and intensities. Observations are taken about 35 minutes past the hour throughout the day and night and more frequently during severe weather. Additional special observations are taken in case of aircraft accidents.

Radar Photography

There were 59 National Weather Service radar observing stations with camera-equipped Weather Surveillance Radar (WSR-57 or WSR-74S) that provide photographs of the Plan Position Indicator (PPI) scope on 16-mm film. When echoes are visible, pictures are taken at least every 5 minutes and sometimes as often as every 40 seconds.

A function lamp display is shown to the right of the PPI scope on 16-mm photos. This display provides the viewer with pertinent information about the radar function settings, range, etc. at the time of the photo. On 35-mm photos, this information is available by means of a coded lamp system which is around the outside perimeter of the PPI scope. A plaque displayed just below the lamp display on 16-mm film and just below the clock on 35-mm film gives the international call sign, year, and film roll number. On all 35-mm photos, and some 16-mm photos, the Julian date is indicated in the center of the clock. All photos have a film frame number

shown on a counter below the plaque. See table 5 for detailed explanation of these displays.

WSR-57 and WSR-74S Radar Products Available at the National Climatic Data Center

Paper copies for Form MF 7-60 can be furnished in actual size (11 by 17 inches) or 8 1/2 by 13 inches. These forms are also available on microfiche beginning with January 1982. Copies of the radar film can be supplied in either 16-mm or 35-mm size. Glossy prints (8 by 10 inch size) of individual film frames can also be furnished (See Figure 9). Cost estimates for providing any of these records will be furnished upon request.

Overlays and Grid Maps

For users of radar data who wish to plot the observations, radar overlays and/or grid maps will be useful. A radar overlay shows the geographic features and political boundaries of the radar station. Radar grid maps mark the grid boxes around the station and are necessary to plot the digital section of the observation. Both these overlays and grid maps are available in either 125 or 250 nautical mile ranges for most stations.

RADAR ANALYSIS CHARTS

General. Hourly charts of radar echo intensity contours are generated by computer using radar observations collected on the RAWARC circuits. Where possible, echo movements, heights of bases and tops, locations of line echoes, precipitation types and intensity trends, remarks and operational status are plotted. Weather watch boxes are drawn as issued by the National Severe Storms Forecast Center in Kansas City. See Figure 10.

Plotting procedures.

Radar echo intensity contours. Contours are drawn for VIP (Video Integrator and Processor) levels 1, 3, and 5. All areas inside the level 1 contour are shaded.

Weather watch boxes. These boxes are drawn on the chart using heavy dashed lines. The warning number is enclosed in a rectangle and positioned as closely as possible to the northeast corner of the box. If there is no room at the northeast corner of the box, the warning number is offset and connected to the watch box by a line. The warning number is also printed at the bottom of the chart together with the valid time under a lable reading "WEATHER WATCH BOXES". In case no weather watch box messages are received, "NONE" is printed at the bottom of the map.

Line echoes. Lines and fine lines are indicated on the chart by short line segments resembling zippers. If the echo coverage of the line is 8/10 or greater, the ends of the line have "SLD" plotted next to them. Fine lines are represented by zippers which are half the usual width, which is 0.05 inch.

Tops and bases. Tops and bases are plotted in 3-figure groups representing height in 100's of feet. Tops are underlined and bases are overlined. Where it is necessary to offset heights for reasons of insufficient space, a line is drawn from one end of the underline or overline to a small black square at the proper location.

Movements. Cell movements are represented by arrows with points but no barbs. Movement speed in knots is plotted at the arrow tip as a two-digit group.

Line and area movements are represented by arrows with barbs in the usual fashion; i.e., 1/2 barb represents 5 knots, 1 barb represents 10 knots and a pennant represents 50 knots.

If movements cannot be plotted at the locations where they are reported, they may be moved to a nearby location.

Precipitation types. The precipitation types and changes of intensity associated with an echo system are plotted at the geographic center of the system if possible, or near the system otherwise. Since intensity itself may be obtained from the map contours, only the change of intensity is explicitly plotted with the precipitation type. Thus, TRW+ may not mean an intense thundershower, but does mean one which is new or increasing in intensity.

Remarks. Important phenomena (currently HAIL, HOOK, and LEWP) are plotted inside rectangles. Where it is necessary for reasons of space to offset these notations, a line is drawn from a small black square at the actual location to the nearest corner of the rectangle enclosing the notation. Other phenomena mentioned in remarks are plotted where space is available if they are standard remarks as listed in Federal Meteorological Handbook (FMH) No. 7, Weather Radar Observations.

Exceptions: None of the following remarks are plotted: TORNADO, CENTER, EYE, SPRL BAND or anything else related to hurricanes.

Operation contractions. ROBEP, ARNO, RHINO and STC are plotted as such. PPINE, PPINA and PPIOM are abbreviated to NE, NA and OM respectively and are plotted in larger letters. Network stations not received at NMC will be plotted NA together with their call letters.

Thinning and offsetting. Items are sorted according to their grid cell locations and duplicates are deleted. If two echo heights are reported for the same grid cell, only the higher will be kept. If two cell movements (or two area movements, or two line movements) are reported for the same grid cell, only the more rapid of the two is kept. If more than one report of a given precipitation type is made for a given cell, only the report with the greater change in intensity is kept.

Following this, the remaining items are assigned priorities. Items with the highest priority are plotted first. Where space permits, items are plotted at their exact location. However, if an intensity contour would be cut or if a previously-plotted item would be overlaid, an attempt will be made to offset the item to an empty area. This offsetting is indicated for more critical items by drawing a line from the item to a small black square at the actual location.

The priority of items (in decreasing order) is as follows: HOOK, HAIL, LEWP, tops and movements with adjustments for height and speed, precipitation types from TRW+ down to ZL-, remarks and operational status.

For each echo system, precipitation types, movements, tops and remarks are positioned by converting the associated direction-distance groups to vector form and finding the geographic mean position. Remarks such as HAIL which have their own associated directions-distance groups are located with respect to the reporting station.

This code is explained in the National Weather Service Radar Code User's Guide.

Analysis and message decoding.

Analysis grid. The grid used for analysis of radar echo intensities is an 89 by 113 polar stereographic grid which is aligned with the LFM grid. Spacing is 47.625 km at 60°N and 59.25 km at 30°N.

Intensities are reported from each radar station on a grid which is actually a subset of the 89 by 113 grid but with a local coordinate system for the convenience of the observers. (In this system, the radar site is always in cell MM, cell AA is toward the upper left and cell YA is toward the lower left.) Thus the intensity analysis is easily performed for any cell by taking the highest intensity reported by any station for the cell. Stations closer to the cell than 125 nautical miles are used in preference to stations farther away. Cells not seen by any radar are left blank.

Reporting codes. Currently two radar reporting codes are in use within the continental United States:

Western region reporting code. ARTCC radar sites are composited at a few centers using remoted displays and are encoded in a special digital code in which movements, tops, precipitation type and remarks are given with reference to the local grid system. These reports are readily decoded and plotted by computer. This code is explained in the first edition of the NWS Digital Radar Code User's Guide dated January 1977.

National Weather Service network and local warning radar reporting code. Outside of the western region, radar stations use the existing SD code which has been modified by adding digital intensity groups on the end. Thus intensities are encoded and decoded in the same fashion in either reporting code.

References

National Weather Service Radar Code User's Guide. U.S. Dept. of Commerce, NOAA, NWS, Silver Spring, MD February 1978.

Weather Radar Observations, Federal Meteorological Handbook No. 7, U.S. Dept of Commerce, Washington, DC.

For additional information, please contact:

National Climatic Data Center
Federal Building
151 Patton Avenue, Room 120
Asheville, NC 28801-5001
Phone: 704-271-4800
Fax: 704-271-4876
Internet: orders@ncdc.noaa.gov

CONDENSED EXPLANATION OF THE RADAR REPORTING CODE

LOCATION IDENTIFIER	TIME	ECHO CONFIGURATION	AREAL COVERAGE	PRECIPITATION TYPE	INTENSITY	INTENSITY TREND	ECHO LOCATION	ECHO MOVEMENT	ECHO TOP
EEW	1735	AREA	6	TRW	+	/+	8/80 182/80 90W	C2325	MT 300 AT 191/55

DIGITAL LOCATIONS AND INTENSITIES

IM22 JK2232 KK2321 LL3132 ML2023 NM1 OM231 PM 221

DECODED REPORT

At 1735 GMT the Neenah Wisconsin radar shows an area five tenths covered by thunderstorms. These thunderstorms are intensifying and some of them have reached heavy intensity. The area extends from 80 n.mi. at 8° to 80 n.mi. at 182°. The area is 90 n.mi. wide. Individual thunderstorms are moving through the area at 25 knots. The highest echo top is 30,000 feet. It is located 55 n.mi. from Neenah at 191°. The digital section of the observation shows the maximum intensity of the echoes observed in the grid boxes in rows I through P.

TIME OF OBSERVATION

The time of observation is reported in Greenwich Mean Time (GMT). Regular observations are taken at 35 minutes past the hour. Special observations may be taken at any time.

AREAL COVERAGE

The areal coverage in tenths is reported with a one or two digit number.

ECHO CONFIGURATION

CONFIGURATION	DEFINITION	CONTRACTION
Isolated echo	Independent convective echo	CELL
Area of echoes	A group of related echoes	AREA
Line of echoes	A line of related convective echoes	LN
Elevated Stratiform echoes	An area of stratiform precipitation aloft	LYR
Fine Line	A narrow nonprecipitation echo associated with a meteorological discontinuity	FINE LN
Spiral band area	Curved lines of echoes associated with hurricanes, or tropical storms	SPRL BAND AREA
Hurricane Eye	The central area of a hurricane	EYE
Center	The central area of a hurricane or tropical storm. Less well organized than an eye	CNTR

PRECIPITATION TYPE SYMBOLS

R	Rain	ZR	Freezing Rain
RW	Rain Shower	ZRW	Freezing Rain Shower
L	Drizzle	ZR	Freezing Drizzle
S	Snow	SW	Snow Shower
IP	Ice Pellet	IPW	Ice Pellet Shower
A	Hail		

The letter "T" is put before any precipitation type when thunder is believed to be occurring with the precipitation.

PRECIPITATION INTENSITY SYMBOLS

-	Light	X	Intense
no symbol	Moderate	XX	Extreme
+	Strong	U	Unknown
++	Very Strong		

Intensity symbols aren't used with drizzle, snow, ice pellets, or hail.

INTENSITY TREND

TREND	SYMBOL	TREND	SYMBOL
Increasing	+	Unchanged	NC
Decreasing	-	New	NEW

ECHO LOCATIONS

1. If the echoes are in a line or rectangular area, the direction and distance are given to each of the end points. The width of the area, or line, is also reported.
2. For irregular shaped areas, the directions and distances to the salient points are reported.
3. For isolated cells and circular areas, the direction and distance to the center of the cell, or area, is reported along with the diameter.

MOVEMENT

The direction from which the echoes are moving is reported in tens of degrees. Speeds are reported in knots. A letter identifying the type of movement precedes the direction. "A" means area movement, "C" means cell, and "L" means line.

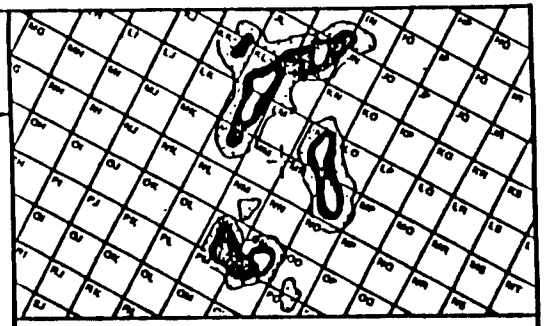
ECHO TOPS

The heights of echo tops are reported in hundreds of feet above mean sea level. The direction and distance to the top is also given.

REMARKS

Any appropriate remarks are encoded following the echo tops. Such things as radar indications of severe weather and comment which clarify the observations are included as remarks.

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL WEATHER SERVICE
SILVER SPRING, MD. 20910



OPERATIONAL STATUS CONTRACTIONS

Operational status contractions are encoded with the remarks. The following contractions are used.

CONTRACTION	MEANING
PPINE	No echoes detected
PPIOM	Radar out of service for maintenance
PPINA	Radar observation not available
ROBEPS	Radar operating below performance standards
RHINO	RHI Scope inoperative. Height not available
ARNO	A/R scope inoperative.

DIGITAL LOCATIONS AND INTENSITIES

The digital section of the observation is based on a grid with boxes that are about 22 n.mi. on a side. Each grid box is identified by two letters. The first identifies the row containing the box and the second the column. Rows are lettered from North to South, columns from West to East.

The digital section of the observation is made up of one or more groups. The first two characters in each group are grid box identifiers. The next character is a number which represents the maximum observed echo intensity in that box. Any following numbers represent intensities in the following grid boxes in the row. The rows are encoded from North to South and the columns from West to East. The intensities are encoded using the following numbers.

CODE NUMBER	INTENSITY
0	no echoes
1	light
2	moderate
3	strong
4	very strong
5	intense
6	extreme
8	unknown (believed severe)
9	unknown

Table 3

NF 1-26
16-750

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL WEATHER SERVICE

PAGE 7

WEATHER RADAR OBSERVATIONS

STATION: WSO, GALVESTON TX (GLS) | RADAR AND DVIP CALIBRATION DATE-TIME: 73 1530 | MDS: 10CRMA | FILM ROLL: 84-17 ON DATE-TIME: 7/1 0600 | COUNTER: 813 | OFF DATE-TIME: | COUNTER: (1083) | MONTH: JULY | YEAR: 1984

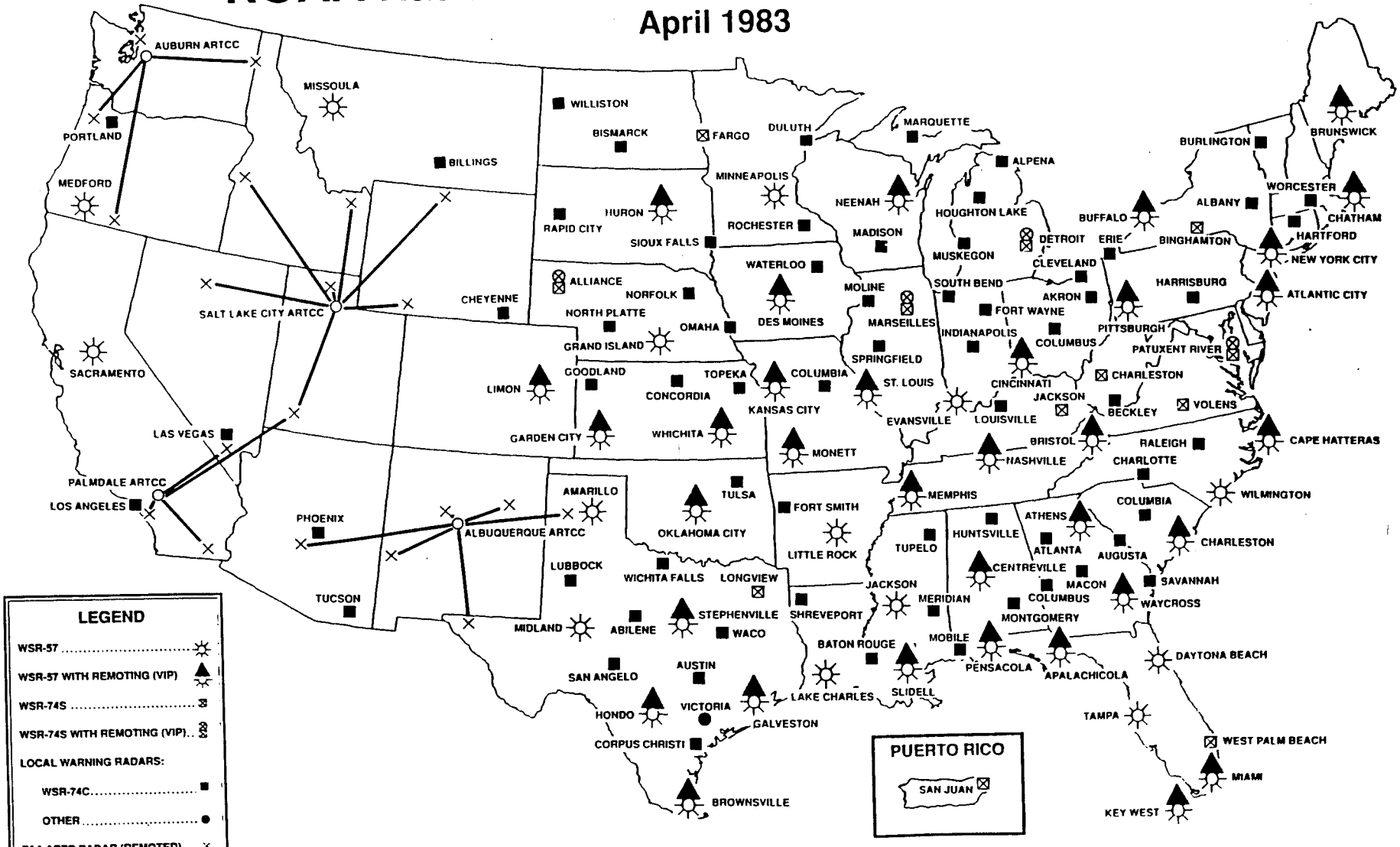
TYPE OF RADAR: WSR-57 (10CM) | RADAR AND DVIP CALIBRATION DATE-TIME: | MDS: | FILM ROLL: ON DATE-TIME: | COUNTER: | OFF DATE-TIME: | COUNTER: | DATE-TIME: 04 0525 TO DATE-TIME: 04 2026

1 DATE	2 TIME	3 CONFIGURATION	4 COVERAGE TYPE INTENSITY	5 TREND	6 LOCATION	7 TORN TIAL SYES	8 MOVEMENT OVRTKN	8 MOVEMENT CELLS	9 TOPS	10 (LCH TROP UNT) REMARKS	11 INT.
04	0625	AREA	STRW+ / MOD		200/90 170/160	25W			300 AT 189/103	(CAMECA 1/8 ORGO)	LC
/		1 RM3 SN2 CD /							AT		LC
04	0726	AREA	2TRW+ / MOD		226/45 183/105	30W		C1720	290 AT 186/81		LC
/		1 FM1 GN3 RM2 CD							AT		LC
04	0827	AREA	2TRW+ / —		235/45 186/50	20W		C1705	4700 AT 207/57		LC
/		1 OL1 PM4 GM2 CD							AT		LC
04	0925	AREA	1RW+ / —		67/70 202/60 259/52			C1725	260 AT 67/61		LC
/		1 L03 NL2 NL2/OL2 CD							AT		LC
04	1026	AREA	ITRW+ / MOD		15/50 179/20	100W		C1815	810 AT 324/41		LC
/									280 AT 64/63		LC
/		1 KP3 LL 30002 NL2			RM3 CD				AT		LC
NW	1126	AREA	2TRW+ / MOD		198/60 186/185 180/200			C1820	920 AT 173/87		LC
/		1 FM1 GN33 RO2 CD							AT		LC
04	1227	SR LN	ITRW++ / MOD		166/25 176/120	D10		C1820	410 AT 173/80	(LCH TROP 469)	LC
/		AREA	ITRW++ / —		SW/45 109/130 184/210 205/190			C1820	360 AT 111/84		LC
/		1 L04 MP2 NW/2WAY			2 ON3 PM4 GN14 RO3 SO3 CD				AT		LC
04	1325	AREA	2TRWX / MOD		75/60 187/175	100W		C1915	360 AT 104/89		LC
/		1 LC2 MR4 ON2 PM			103 CD3 RO3 CD				AT		LC
04	1426	AREA	2TRW+ / —		132/40 178/105 219/50			C2506	280 AT 170/53		/
/		CELL	ITRW / MOD		71/105	08			260 AT	(CREEW OK)	/
	/	↑ KR2	OO2 PM13		QN2 RN2 CD				AT		R
04	1525	AREA	1RW / —		63/140 146/85 204/70 11/70				180 AT 16/63		/
	/	↑ JN2 OO2	KO2 OO2		PM12 CD				AT		R
04	1626	AREA	2TRW++ +		58/145 69/140 178/70 5/35			C2415	310 AT 49/83		/
	/	↑ ER3	JP3 JKN32		LN2 ON3 PN4 CD				AT		R
04	1725	AREA	2TRW++ / NC		21/110 68/235 187/95			C2510	360 AT 41/60		/
	/	↑ J03	KN24 NN1		ON4 CD				AT		R
04	1825	SR AREA	2TRW++ / +		27/185 74/190 176/70 346/65			C2012	550 AT 46/71	LCH TROP 469	/
	/	↑ H02-01	ID 12		JN242 KN232 LM2 NN3 PN2 CD				AT		R
04	1925	SR AREA	2TRWX / NC		33/200 72/190 182/65 343/40			C2112	530 AT 31/96	LCH TROP 468	/
	/	↑ H0 114	I0524 JN		333 KM3122 LM41 NO1 PN1 CD				AT		R
04	2026	SR AREA	3TRWX / NC		47/190 35/70	65W		C2312	510 AT 45/103	LCH TROP 469	/
	/	AREA	ITRW++ / +		312/55 142/110	55W		C1908	460 AT 130/105		/
	/	↑ H043	I0253 / JN		3032 LL22 NO1 ON3 PR5 CD				AT		R

Table 4

NOAA National Weather Service Radar Network

April 1983



As WSR-88 units are commissioned, WSR-57 and 74S will be decommissioned.

Figure 8

Legend for 35-mm Radarscope Photographs

Light Position	Indication
35°	250-mile range
45°	125-mile range
55°	50-mile range
65°	25-mile range
95°	66-db attenuation
105°	33-db attenuation
115°	24-db attenuation
125°	12-db attenuation
135°	6-db attenuation
145°	3-db attenuation
215°	Spare - unassigned
225°	Linear receive
235°	Logarithmic receiver
305°	STC
315°	Long pulse
325°	Short pulse

Legend for Function Lamp Display
WSR-57 & WSR-74

* Signal Attenuation: Indicates strength of signal attenuated out in order to measure echo intensity.

* Radar Range: Indicates the maximum range of echo detection.

Receive Function: STC-Range normalization. Used in LIN mode if available. Prevents overestimation of echo strength of targets close to the receiver. VIP - Displays echo intensity at another location on the console. Used in Log mode.

Transmit Function: S - short pulse operation
L - long pulse operation

any X denotes spare lamps.

* Signal attenuation incremented differently between radar sets.
* Radar Range: KM for WSR-74 NM for WSR-57

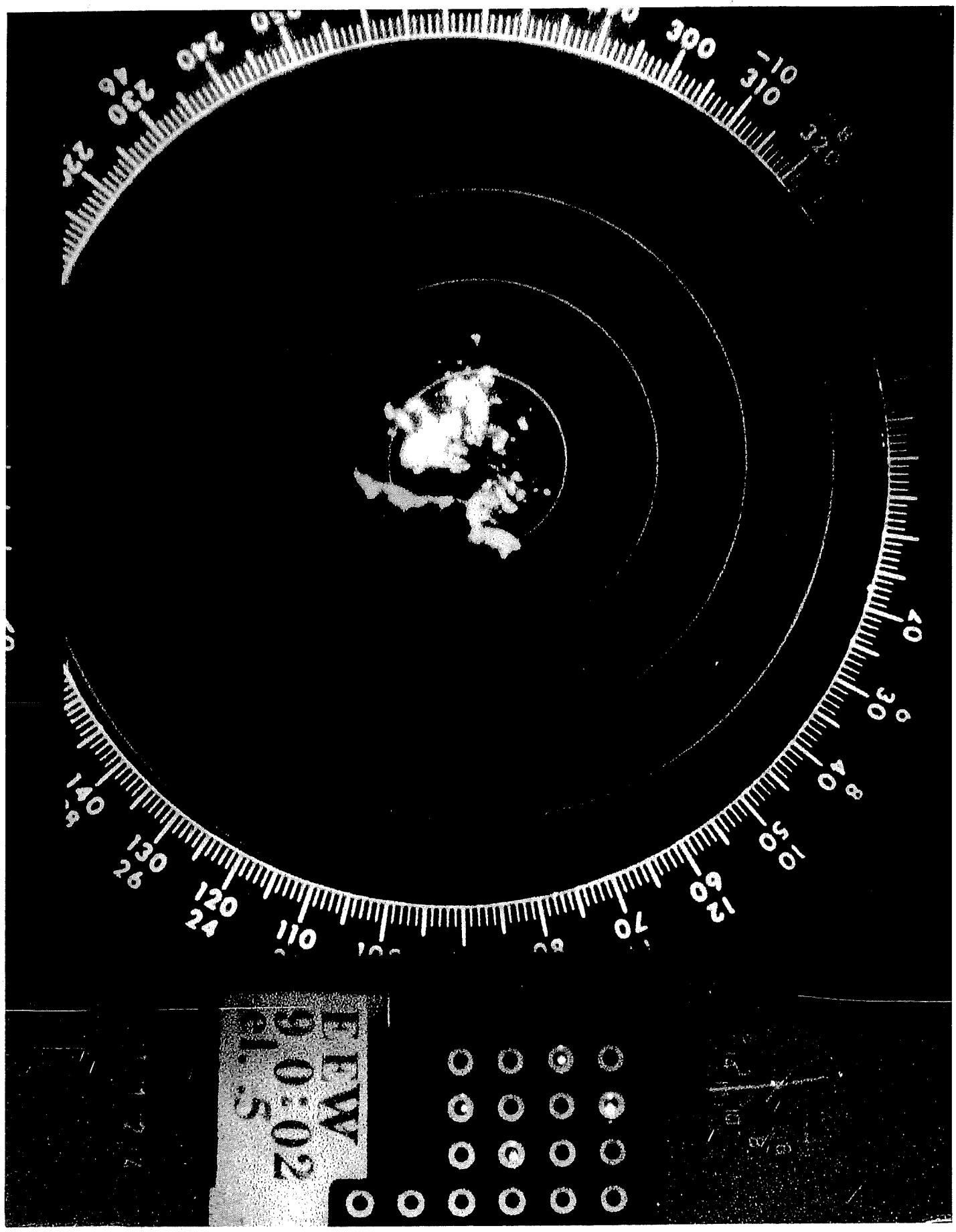


Figure 9

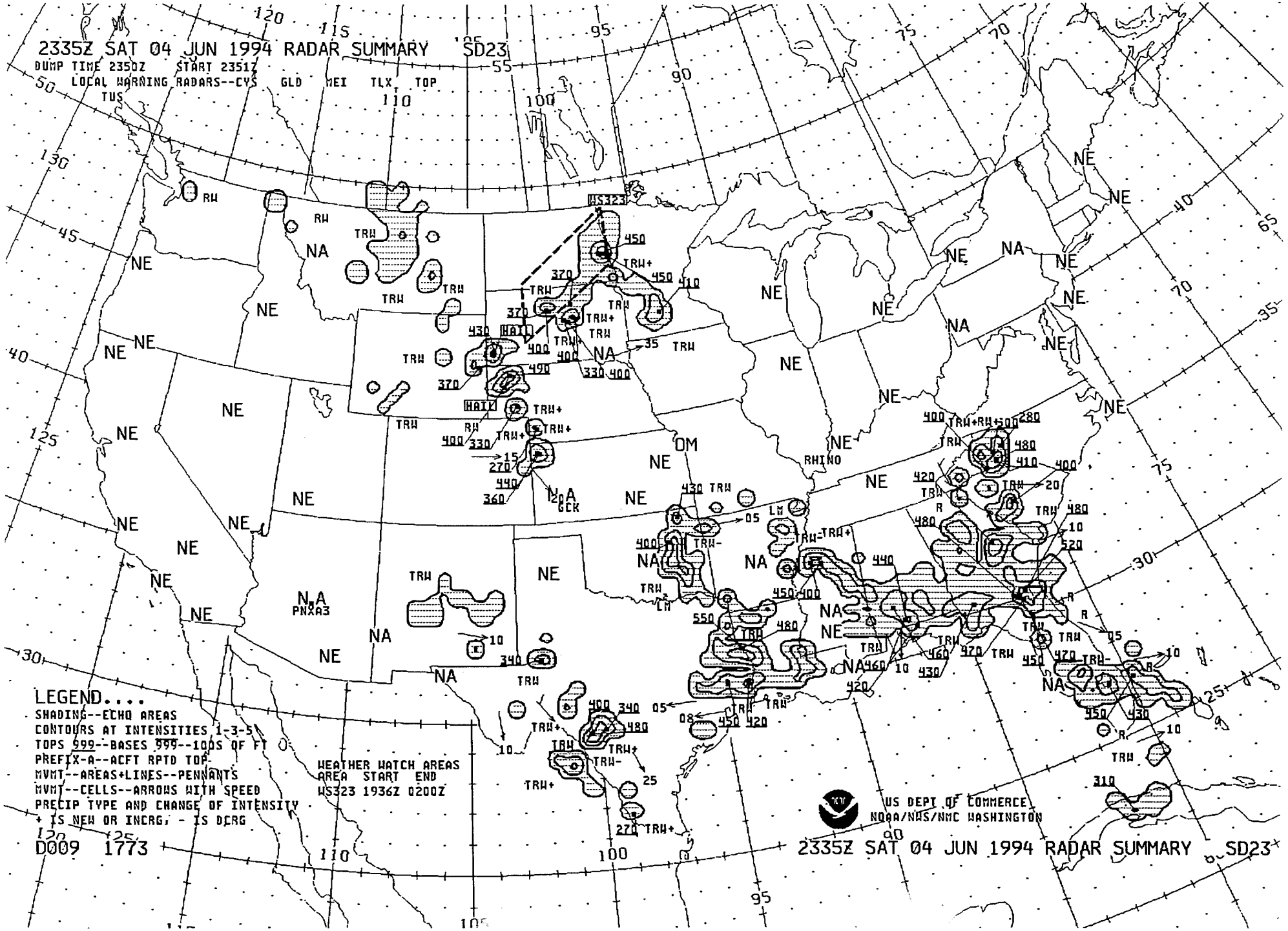

2335Z SAT 04 JUN 1994 RADAR SUMMARY SD23
DUMP TIME 2350Z START 2351Z
LOCAL WARNING RADARS--CYS GLD MEI TLX TOP TUS
LEGEND....
SHADING--ECHO AREAS
CONTOURS AT INTENSITIES 1-3-5
TOPS 999--BASES 999--100S OF FT
PREFIX-A--ACFT RPTD TOP
MVMT--AREAS+LINES--PENNANTS
MVMT--CELLS--ARROWS WITH SPEED
PRECIP TYPE AND CHANGE OF INTENSITY
+ IS NEW OR INCRG, - IS DCRG
WEATHER WATCH AREAS
AREA START END
WS323 1936Z 0200Z
US DEPT OF COMMERCE
NOAA/NWS/NMC WASHINGTON
D009 1773
2335Z SAT 04 JUN 1994 RADAR SUMMARY SD23

Figure 10