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TECHNIQUES DEVELOPMENT LABORATORY

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**REVISED RADAP II ARCHIVE DATA  
USER'S GUIDE**

Melvina McDonald and Robert E. Saffle

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1. INTRODUCTION

In 1971, the National Weather Service (NWS) began the Digitized RADar EX-periment (D/RADEX) to improve the operational use of radar data through computer processing (McGrew, 1972). The primary purpose of D/RADEX was to demonstrate the utility of digital reflectivity data in weather forecasting operations; D/RADEX was programmed for automatic preparation of low level reflectivity and rainfall accumulation products. The early stages of D/RADEX involved four sites: Kansas City, Missouri (August 1971); Oklahoma City, Oklahoma (October 1971); Fort Worth, Texas (December 1971); and Monett, Missouri (February 1972), as shown in Fig. 1. Through its lifetime, many advanced meteorological and hydrological products were developed under D/RADEX including echo tops, vertically integrated liquid water content (Green 1971), severe weather probability (Saffle 1976), storm structure, and rainfall accumulation.

In 1983, positive evaluation of the results of D/RADEX resulted in transferring the system to quasi-operational status and renaming it RadAr Data Proces-sor, version II (RADAP II). The RADAP II network consisted of the twelve sites shown in Fig. 2. The sites were Amarillo, Texas (AMA); Binghamton, New York (BGM); Nashville, Tennessee (BNA); Charleston, West Virginia (CRW); Garden City, Kansas (GCK); Wichita, Kansas (ICT); Jackson, Kentucky (JKL); Limon, Colorado (LIC); Oklahoma City, Oklahoma (OKC); Pittsburgh, Pennsylvania (PIT); Tampa Bay, Florida (TBW); and Monett, Missouri (UMN).

Most RADAP II sites collected extensive archives of digital volumetric reflectivity data. Three years (1985 through 1987) of RADAP II data archives were documented by McDonald and Saffle (1989). This Office Note updates the previous document and contains a detailed listing of the data available from March 3, 1985, until the conclusion of the data collection on September 30, 1992. These archives have been used to document the statistical relationship between VIL and severe local storm occurrence (McGovern et al. 1992; Breidenbach et al. 1992, 1993a, and 1993b), and between VIL and large hail (Winston and Ruthi 1986; Kitzmiller and Breidenbach 1993). The Severe Weather Potential (SWP) algorithm currently operational within the WSR-88D system was developed with RADAP II VIL data (Kitzmiller et al. 1992 and 1994). Through further development and testing, a new second generation SWP algorithm was developed to extend the operational range of the present WSR-88D SWP algorithm (Breidenbach et al. 1994). Operational applications of precipitation estimates have been described by Saffle (1988) and by Davis (1993).

2. DATA QUALITY CONTROL

Based on the strength of the signal returned from a target, the current NWS weather radar receivers estimate the equivalent reflectivity factor (in

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$\text{mm}^6\text{m}^{-3}$ ) that would be representative of such a signal. This reflectivity factor quantity is called "Z" and can range from about  $5 \times 10^1 \text{ mm}^6\text{m}^{-3}$  to about  $5 \times 10^5 \text{ mm}^6\text{m}^{-3}$ . The receiver then calculates the logarithm of each estimated value of Z; the dynamic range of Log Z is about 1.7 to 5.7. To simplify further processing of the data, the Log Z values are scaled upwards by a factor of 10 ( $10 \text{ Log Z}$ ); these values are commonly referred to as dBZ values. The RADAP II system utilizes dBZ values for calculations and archiving.

The RADAP II system performed several quality control procedures on each scan of radar reflectivity data before that scan was passed to any other task, including archiving. The first of these procedures combined a range normalization ( $1/R^2$ ) with a correction of the data for attenuation due to absorption by atmospheric gases. This correction is a linear function that increases with distance and reaches a maximum corrective value of +3 dBZ for data at a range of 126 n mi.

Next, in order to mitigate the effects of normal ground clutter, a hybrid base-level scan was generated by merging higher elevation angle scan data out to a given range with 0.5 degree elevation angle scan data from that range out to 126 n mi. Both the higher elevation angle and the range of its use are site-adaptable and vary from site to site. These values are included in the header data for each scan, as shown in Section 4.

Finally, each scan was processed to remove isolated point targets by requiring a given nonzero data value to be adjacent to at least two other nonzero data values. During this filtering procedure, a further check was made to determine whether a given data value exceeded the maximum of its adjacent neighbors by more than about 16 dBZ. If so, the data value was changed to that of the neighborhood maximum.

### 3. DATA COLLECTION

Although two types of radars (WSR-57 or WSR-74S) were used in the RADAP II network, they shared the common characteristics of a 2.2 deg beam width and a 10 cm wavelength. The RADAP II sites scheduled base-level and tilt-sequence (volumetric) observations of reflectivity every 10 or 12 min. These observations were built from input scans of data consisting of 180 radials covering 360 deg of azimuth under the radar umbrella. The radials are centered on even azimuths, cover a range from 10 to 126 n mi, and contain a data value for each nautical mile of range (Fig. 3). The data values range from 0 to 15 with each nonzero value representing a RADAP II category of radar reflectivity. The nominal reflectivity thresholds for the categories and the latitudes and longitudes are given in Table 1 and Table 6, respectively. As previously noted in Section 2, a base-level observation is a hybrid of a scan taken at an elevation angle of 0.5 deg for data at farther ranges and one taken at a site-adaptable higher elevation angle for data near the radar site. In contrast, a volumetric observation consists of a series of single elevation angle scans starting at 0.5 deg elevation and extending, in vertical steps of two degrees, to the top of the existing echoes or to 22.0 deg, whichever comes first. Within the volumetric observation, the 0.5 deg scan does not contain any data taken at a higher elevation angle.

In 1984, the NWS began archiving RADAP II data to support the development of reflectivity-based operational algorithms that could be tested at RADAP II sites and later implemented on future NWS radar systems. The data were first

written to floppy diskettes at each RADAP II site and later transferred to a central location for final archiving to IBM compatible 9-track magnetic tapes. The RADAP II data for the period April 1985 through March 1987 were archived to tape under contract. In April 1987, the diskettes were transferred to NWS Headquarters for sorting, decoding, coding and final archiving to tape.

In order to increase the utility of the RADAP II archive for snowfall research, the cool season base-level data have been coded since 1986 according to category thresholds that cover, in 2-dBZ steps, the reflectivity range 18-46 dBZ (Table 1). Nominally, the cool season is November 1 through March 1, but individual sites will vary somewhat. Volumetric observations taken during the cool season were coded according to the warm season category thresholds in Table 1. Thus, the cool season archive will enable research both on frozen precipitation and on severe convective events that might occur during that season.

#### 4. ARCHIVE DATA TAPES

The data tapes are 9-track, nonlabeled (NL), high density (6250 bpi) magnetic tapes. They are written with an unformatted FORTRAN write statement using a variable spanned (VS) record format and a maximum record length of 32,756 bytes. Each tape contains one file of data for one RADAP II site. Each record has two logical parts representing one scan of data. Part 1 contains thirty-four 16-bit words of header parameters which describe the station and data characteristics for the scan (Table 2). Part 2 has a variable number of 16-bit words and contains the radial reflectivity category data for each scan in the form shown in Table 3.

The RADAP II archive tapes can be read with a FAST FORTRAN I/O (FFIO) package subroutine called FFGET(BUF,N,L,&END,&ERR), where FFGET reads a record from FORTRAN unit "N" into contiguous locations starting at "BUF." The length of the record in bytes is returned in "L." At end-of-file (EOF), transfer will be made to statement number "END" and errors to statement number "ERR." The FFIO package is available at the NOAA Computer Center to HDS 9000 users and will automatically be included in programs executed under the NFORV procedure. For non-FFIO users, the data tapes can be read with basic FORTRAN unformatted read statements or with any other compatible utility.

#### 5. DECODING ARCHIVED DATA

Table 4 represents a sample formatted display of the alphanumeric value of each byte of one record. Note that each record corresponds to one 360° observational scan of data. A graphical display of all of the scan data in this record is presented in Fig. 4. Table 2 contains the information that allows line 1 of this record to be decoded to reveal the following information:

ISTAT	= OKC
IYR	= 87
IJUL	= 123
IMMDD	= May 3
ITIME	= 1000 GMT
IELEV	= 0.5 deg
IRINT	= 1.00 n mi
IMERGR	= 60 km
IMERGA	= 2.9 deg

IALT = 1300 ft above msl  
 IOBFLG = 0 (base elevation observation)  
 IDRFLG = 0 (clockwise rotation)  
 IAPFLG = 0 (no AP present)  
 ISNFLG = 0 (no snow)  
 NVAL = 5248  
 NONZIP = 3222  
 IMEAN = 5  
 ISTDEV = 99 (standard deviation not calculated)  
 ITRESH(15) = 18,25,30,36,39,41,43,44,46,48,49,51,53,55 & 57  
 (warm season threshold values)

Lines 2 through the end-of-record (EOR) are coded reflectivity category values listed by azimuth. The coding method records (1) the azimuth of the radial with nonzero values, (2) the number of runs at that azimuth, and, for each run at the azimuth, (3) the number of range bins in the run and (4) the reflectivity category value of the run. Azimuths that contain only zeros as reflectivity category values are not coded in an observational record. The user should assume zeros for any noncoded azimuths. A run is defined as a group of range bins with identical reflectivity category values along an azimuth, i.e., a new run starts when the reflectivity category value changes. The total sum of all range bins per radial (10-126 n mi) will always be equal to 116. For example, if a series of 8 range bins along a radial contained the reflectivity values 22221144, there would be 3 runs detected with reflectivity category values of 2, 1, and 4, respectively. This series of 3 runs would then be coded as 42, 21, and 24; where the first number indicates the number of range bins in the run (the run length) and the second the reflectivity category value of the run. As a further example, a portion of Table 4 has been decoded according to the format shown in Table 3 to reveal the following information:

<u>Azimuth</u>	<u>Number of runs</u>	<u>Run</u>	<u>Range Bins</u>	<u>Reflectivity Category value</u>
0	53	1	32	0
		2	1	1
		3	1	0
		4	2	1
		5	1	0
		6	1	1
		7	1	2
		8	1	4
		9	1	2
		10	1	4
		11	1	13
		12	4	15
		13	1	13
		.	.	.
		.	.	.
		48	2	9
		49	1	3
		50	1	4
		51	2	6
		52	3	1
		53	1	0

## 6. AVAILABLE ARCHIVED DATA

The RADAP II data archive contains data from March 1985 through September 1992 for twelve RADAP II sites, as indicated in Appendix A. In 1985, the RADAP II network consisted of nine sites and gradually increased to 12 sites by 1988, as shown in Table 5. During the early development stages of D/RADEX, the National Weather Service Headquarters archived and saved 1983 OKC data for experimental purposes. After the initiation of the RADAP II archive system in 1984, these data were added to OKC's data archive. Appendix A contains individual listings of archived RADAP II data collected for each site. The sites are listed alphabetically by their call letters (AMA, BGM, ... , UMN). Appendix B contains a monthly/daily display of all RADAP II sites. In Appendix B, the sites are displayed vertically and the days are displayed horizontally for the years 1985 through 1992.

## 7. WHERE TO REQUEST DATA

The National Climatic Data Center (NCDC) will maintain and handle all requests for the RADAP II data archive. To receive RADAP II data, interested parties should contact NCDC. When requesting copies of archive RADAP II data tapes, address all correspondence to:

National Climatic Data Center (NCDC)  
Attn: User Services Branch  
Federal Building  
Asheville, NC 28801-2696

or call the Customer Service Section on (704) 271-4800.

## 8. ACKNOWLEDGEMENTS

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Table 1. Nominal values of reflectivity thresholds for archived RADAP II data for base-level scans for warm and cool seasons. The actual values used for a given archive scan are included in the header data for that scan. All tilt-sequence scans are archived with warm season category thresholds regardless of the season.

RADAP II category	Warm Season threshold (dBZ)	Cool Season threshold (dBZ)
1	18.5	18
2	24.5	20
3	30.0	22
4	35.5	24
5	38.5	26
6	41.0	28
7	43.0	30
8	44.0	32
9	46.0	34
10	47.5	36
11	49.0	38
12	51.0	40
13	53.0	42
14	55.0	44
15	57.0	46

Table 2. Header information (Part 1) of a RADAP II archive data record.

Bytes	Parameter	Description
1-4	ISTAT	Station identifier. 3 characters + a blank. Two 16-bit words (ISTAT(2)) (left-justified).
5-6	IYR	Last two digits of the year.
7-8	IJUL	Julian date.
9-10	IMMDD	Calendar date (MM=month & DD=day).
11-12	ITIME	Hour and minute (HHMM). GMT
13-14	IELEV	Elevation angle (scaled by 10). Deg
15-16	IRINT	Range interval (scaled by 100). n mi
17-18	IMERGR	Ending range for merging higher elevation data with base elevation data. Km
19-20	IMERGA	Elevation angle of the higher elevation data used for merging with base elevation data. (scaled by 10). Deg
21-22	IALT	Station elevation above msl. Ft
23-24	IOBFLG	Type of observation scan. 0=base Level      1=volumetric
25-26	IDRFLG	Rotational direction of antenna during data collection. 0=clockwise      1=counter clockwise
27-28	IAPFLG	Operator indication of <u>A</u> nomalous <u>P</u> ropagation (AP). 0=None      1=Some
29-30	ISNFLG	Operator indication of snow. 0=none      1=some
31-32	NVAL	Number of 16-bit words in the input record. Contains the header information (1-34) + coded reflectivity values (35-NVAL).
33-34	NONZIP	Number of nonzero reflectivity values.
35-36	IMEAN	Mean of the nonzero reflectivity values.
37-38		Reserved for future use.
39-68	ITRESH	Threshold reflectivity values. dBZ Fifteen 16-bit words (ITRESH(15)).

Table 3. Specification of coded reflectivity data (Part 2) of a RADAP II archive data record.

Element	Parameter	Description
1	IRADAZ(1)	Azimuth of first radial with nonzero data
2	NGROUP(1)	Number of groups (runs) at this azimuth
3	NBIN(1,1)	Number of bins (run length) in the first run
4	IDVIP(1,1)	RADAP II category value of the first run
5	NBIN(2,1)	Number of bins in the second run
6	IDVIP(2,1)	RADAP II category value of the second run
.	.	.
.	.	.
.	.	.
1+(NGROUP(1)*2)	NBIN(NGROUP(1),1)	Number of bins in the last run
2+(NGROUP(1)*2)	IDVIP(NGROUP(1),1)	RADAP II category value of the last run
3+(NGROUP(1)*2)	IRADAZ(2)	Azimuth of the second nonzero azimuth
4+(NGROUP(1)*2)	NGROUP(2)	Number of runs at this azimuth
5+(NGROUP(1)*2)	NBIN(1,2)	Number of bins in the first run
6+(NGROUP(1)*2)	IDVIP(1,2)	RADAP II category value of the first run
.	.	.
.	.	.
.	.	.
NVAL-1	NBIN(NGROUP(n),n)	Run length of last run of last radial
NVAL	IDVIP(NGROUP(n),n)	Run value of the last run of last radial





Table 5. Number of months of data available in the RADAP II seasonal archives. The warm season is defined as March through August and the cool season as September through February.

RADAP II sites	Start date	1985		1986		1987		1988		1989		1990		1991		1992	
		Warm	Cool	Warm	Cool	Warm	Cool	Warm	Cool	Warm	Cool	Warm	Cool	Warm	Cool	Warm	Cool
AMA	4/85	4	4	3	0	6	6	6	6	6	6	6	5	5	6	6	1
BGM	6/88							3	6	6	6	6	6	6	6	6	1
BNA	4/86			5	5	6	6	6	6	6	6	6	6	6	6	6	1
CRW	3/85	6	5	6	6	6	6	6	6	6	6	6	6	6	6	6	1
GCK	4/85	4	0	4	5	6	6	4	6	3	2	2	0	0	0	0	0
ICT	4/85	5	3	0	2	5	6	6	6	6	6	6	6	6	6	6	1
JKL	5/86			4	6	5	6	6	6	5	1	6	6	4	4	0	1
LIC	4/85	5	6	6	1	2	4	5	6	6	6	6	6	6	6	5	1
OKC	4/85	5	4	5	5	6	6	6	6	6	6	6	6	6	6	6	1
PIT	6/85	3	3	6	5	6	6	4	6	6	6	6	6	6	6	6	1
TBW	4/85	3	5	4	2	5	6	6	6	6	6	5	6	6	6	6	1
UMN	4/85	3	4	5	2	2	6	6	6	6	6	6	6	6	3	4	0

Table 6. The latitudes and longitudes for the RADAP II sites.

RADAP II SITE	LATITUDE (DEG N)	LONGITUDE (DEG W)	ELEVATION (FT MSL)
Amarillo, Texas . . . . .	35° 14'	101° 42'	3604
Binghamton, New York . . . . .	42° 13'	75° 59'	1638
Charleston, West Virginia . . . . .	38° 22'	81° 36'	982
Garden City, Kansas . . . . .	37° 56'	100° 43'	2882
Jackson, Kentucky . . . . .	37° 36'	83° 19'	1357
Limon, Colorado . . . . .	39° 11'	103° 42'	5562
Monett, Missouri . . . . .	36° 53'	93° 54'	1435
Nashville, Tennessee . . . . .	36° 15'	86° 34'	585
Oklahoma City, Oklahoma . . . . .	35° 24'	97° 36'	1304
Pittsburgh, Pennsylvania . . . . .	40° 32'	80° 14'	1183
Tampa Bay, Florida . . . . .	27° 42'	82° 24'	43
Wichita, Kansas . . . . .	37° 39'	97° 27'	1339

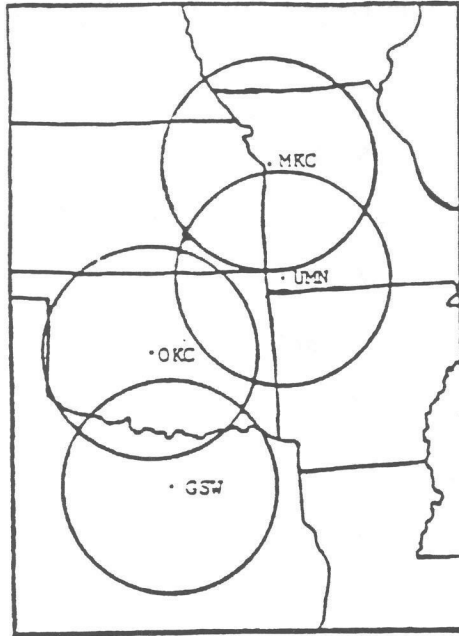


Fig. 1. D/RADEX Test Bed.

## RADAP II SITES

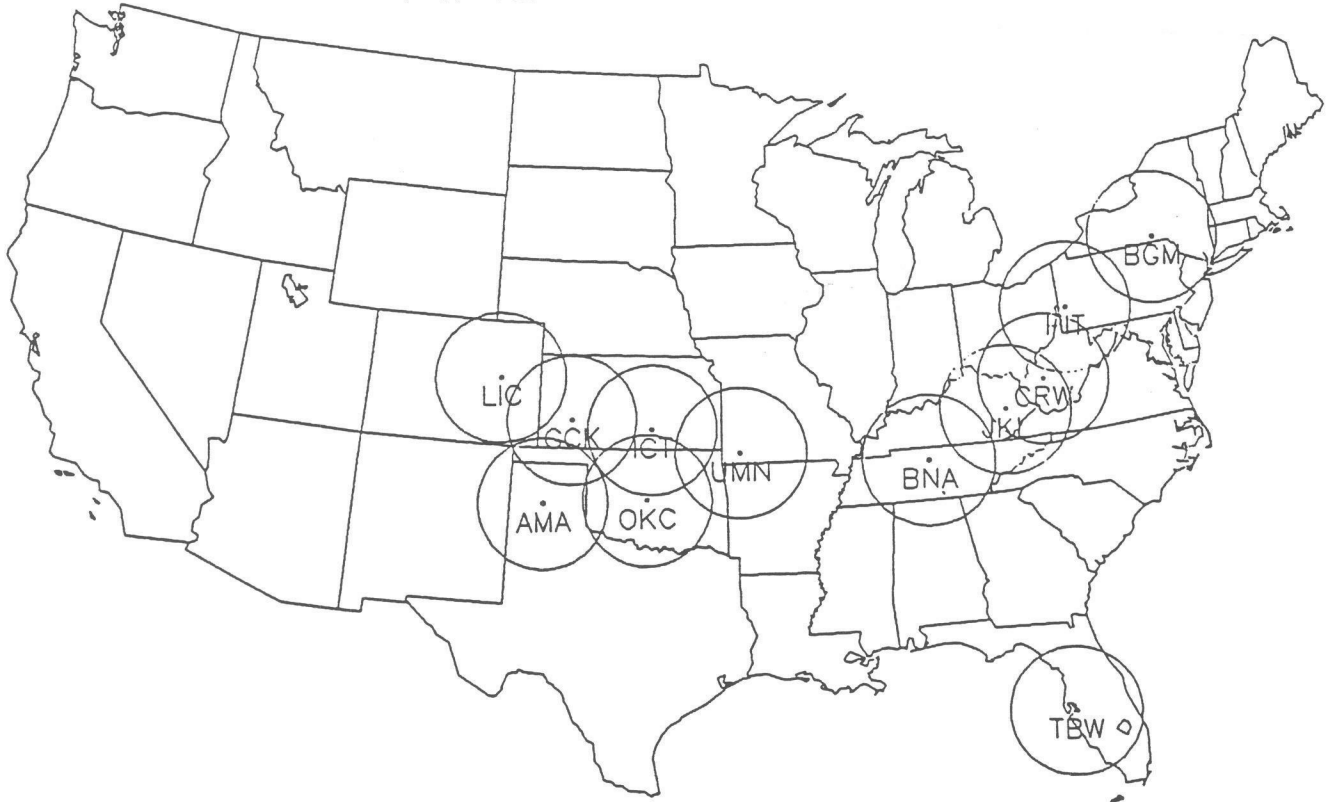


Fig. 2. RADAP II network. Circles represent 125 n.m. surveillance region.



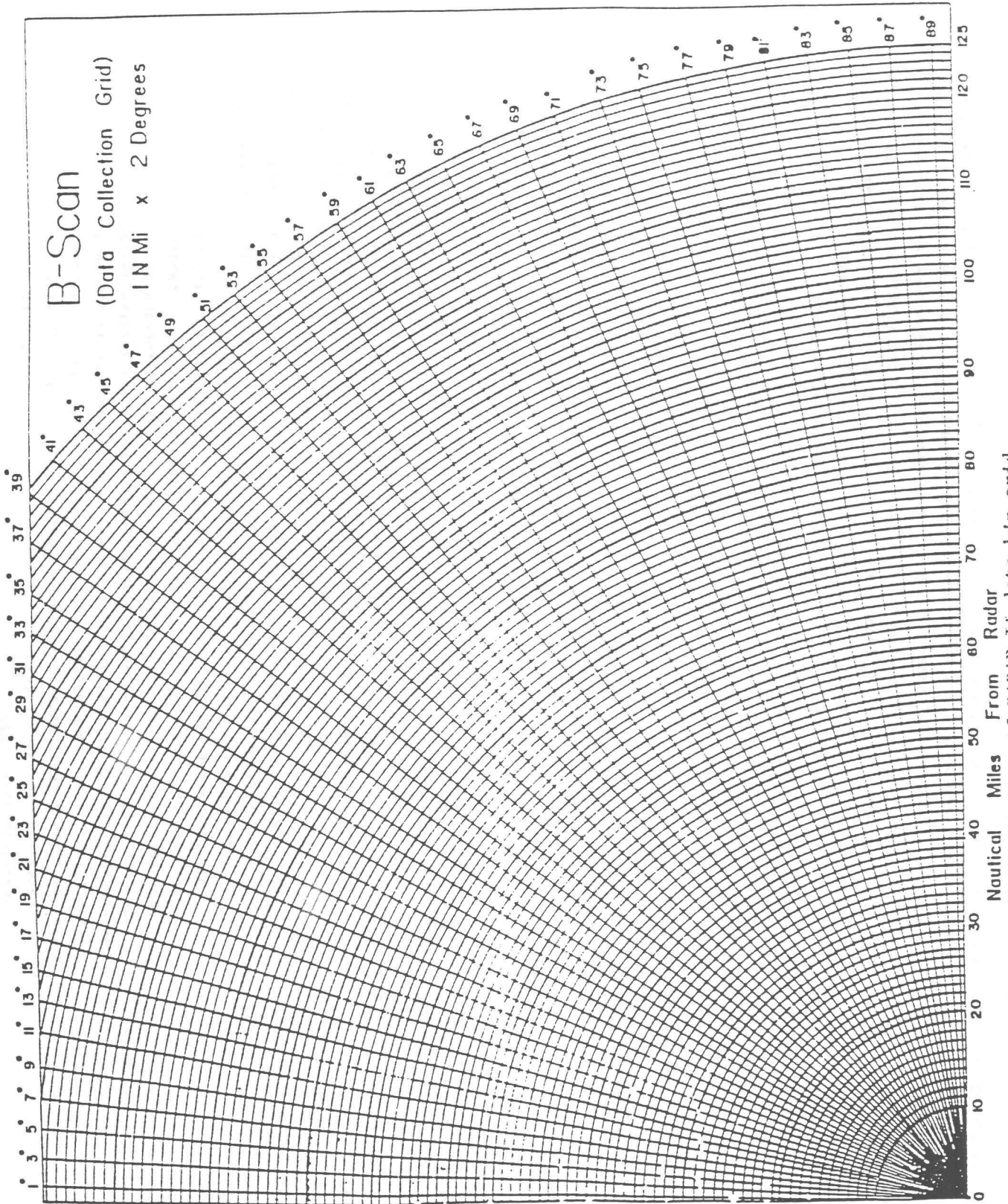


Fig. 3. Diagram illustrating geometry of RADAR II data bin grid.







# APPENDIX A

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## Amarillo, Texas (AMA)

Apr/15-30/85  
May/1-31/85  
Jun/1-5, 9-12, 14-16, 18-25/85  
Aug/9, 25-31/85  
Sep/1-14, 16-30/85  
Oct/1-31/85  
Nov/1, 13-18/85

Feb/5-20/86  
Mar/10-11, 20-29/86  
Apr/1-12, 17-19/86  
Jun/2-15/86

Apr/10, 12-22/87  
May/3-20, 22-28/87  
Jun/4-5, 8-12, 18-19, 29-30/87  
Jul/1-17, 25, 28-31/87  
Aug/1-7, 10-12/87  
Sep/15/87  
Oct/23-26/87  
Nov/5-19, 21, 23-30/87  
Dec/1-2, 6-7, 10-19, 21-31/87

Jan/1-29/88  
Feb/2-6, 14-15/88  
Mar/19,31/88  
Apr/1-24/88  
May/16-21, 24-31/88  
Jun/1-2/88  
Jul/18-31/88  
Aug/1-31/88  
Sep/1-30/88  
Oct/1-7, 9-17, 20-25/88  
Nov/4-6, 8-12, 14-30/88  
Dec/1-13, 16-19, 22-31/88

Jan/1, 6-7, 9-10, 18-19, 24-28, 30-31/89  
Feb/5, 8, 11-19, 22-26/89  
Mar/1-10, 12-17, 21, 23, 25-31/89  
Apr/1-29/89  
May/1-6, 8, 10-13, 15-20, 22-31/89  
Jun/1-30/89  
Jul/1-31/89  
Aug/1-31/89  
Sep/1-30/89  
Oct/1-31/89  
Nov/1-12, 14-20, 23-30/89  
Dec/1-24/89

# APPENDIX A

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## AMA

Jan/3-12, 16-21, 23-31/90  
Feb/1-10/90  
Mar/2-31/90  
Apr/1, 3-14, 17-25, 27-30/90  
May/1-6, 9-31/90  
Jun/1-3, 5-9, 11-18, 21-22/90  
Jul/9-11, 16-19, 21-29, 31/90  
Aug/1-24, 31/90  
Sep/2-8/90  
Nov/5-21, 23, 25-30/90  
Dec/1-8, 10-21, 24-29, 31/90

Jan/1-12, 14-17, 22-26, 29-31/91  
Feb/1-28/91  
Mar/1-24, 26-31/91  
Apr/1-30/91  
May/1-7, 9-14, 16-30/91  
Jun/6-30/91  
Jul/1-5, 8-13, 17-19, 21-30/91  
Oct/24-31/91  
Nov/1-30/91  
Dec/1-6, 17-28, 30-31/91

Jan/1-30/92  
Feb/4-19, 21-29/92  
Mar/1-22, 24-29, 31/92  
Apr/1-26, 30/92  
May/1-4, 8-31/92  
Jun/1-12, 19-27, 30/92  
Jul/1, 3-31/92  
Aug/1-10, 14-31/92  
Sep/1-30/92

# APPENDIX A

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## Binghamton, N.Y. (BGM)

Jun/21-26/88  
Jul/18-31/88  
Aug/1-7, 10-18, 21-31/88  
Sep/1-10, 12-30/88  
Oct/1-5, 7-10, 17-25, 27-31/88  
Nov/1-21, 23-28/88  
Dec/6-27/88

Jan/9-31/89  
Feb/2-28/89  
Mar/1-21, 27-29, 31/89  
Apr/1-17, 21-30/89  
May/1, 3, 9-31/89  
Jun/1-3, 5-30/89  
Jul/1-16, 31/89  
Aug/1-31/89  
Sep/1-22/89  
Oct/14-18/89  
Nov/25, 27-29/89  
Dec/12-31/89

Jan/1, 3-21, 24-31/90  
Feb/1-22, 24-28/90  
Mar/10-12, 14-31/90  
Apr/1-10, 17-30/90  
May/3-5/90  
Jun/28-30/90  
Jul/1, 3-10, 12-18, 20-31/90  
Aug/1-11, 13-27/90  
Sep/7-19, 21-22, 26-30/90  
Oct/1-19, 23-28/90  
Nov/29/90  
Dec/21, 23-29/90

Jan/1-3, 7-9, 14-15, 22-30/91  
Feb/10-14, 17-22, 25-27/91  
Mar/1-16, 18-23, 25-30/91  
Apr/1, 11-13, 15-22, 24-29/91  
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Jun/1, 3-17, 19-23, 25-28/91  
Jul/5-14, 16-31/91  
Aug/1-4, 6, 13-19, 22-25, 30-31/91  
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May/1-18/92  
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Jul/1, 13-31/86  
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Sep/3-14, 16-20, 23-30/86  
Oct/1, 6-31/86  
Nov/1-14, 18-24, 28-30/86  
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Sep/7-13/87  
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Jul/21-31/88  
Aug/1-31/88  
Sep/1-30/88  
Oct/1-2, 4-14, 16-31/88  
Nov/1, 3-30/88  
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Mar/7-8, 11-31/89  
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May/1-5, 17-31/89  
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Jul/1-8, 10-31/89  
Aug/1-31/89  
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May/1-31/91  
Jun/1-8, 10-26, 29-30/91  
Jul/1-26, 29-31/91  
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Sep/19-30/91  
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Jul/1-3, 7-9, 11-24, 26-27, 29/86  
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Mar/1, 3-4/87  
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Jun/1, 3-4, 11-26, 30/87  
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Aug/1-9, 27-30/87  
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Jun/6, 9, 16-26, 29-30/88  
Jul/1, 3-4, 7, 11-15, 17-23, 25-28, 30-31/88  
Aug/1-4, 9, 11-21, 23-30/88  
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Jul/1-7, 13-26/89  
Aug/1-2, 4-6, 11-31/89  
Sep/1-2, 4-16, 18-27, 29-30/89  
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Apr/1-7, 9-23, 25-30/90  
May/1-22, 24-31/90  
Jun/1-30/90  
Jul/1-3, 5-6, 8-31/90  
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Sep/1-13, 19, 21-24, 26-30/90  
Oct/1-5, 7-19, 22-23/90  
Nov/9-10, 13-30/90  
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Jul/1-10, 12-31/91  
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Nov/1, 3, 5-23, 25-30/91  
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Oct/21-23/86  
Dec/3-4, 6-9, 14, 21, 23-31/86

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Apr/16/87  
May/11-31/87  
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Aug/1-31/87  
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Jun/2/88  
Jul/23-24, 26-30/88  
Aug/3-6, 8-18, 21-22, 24-25/88  
Sep/1-2, 15-16/88  
Nov/10, 13-17, 19-22/88

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Feb/3, 9-10, 21-28/89  
Mar/1-31/89  
Apr/1-15, 17-24, 26-29/89  
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Feb/3-16, 19-21, 28/90  
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Jul/1-5, 7-11, 14-15, 17-23, 29-31/85  
Aug/10-15, 17-19, 23-24, 27-29/85  
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Aug/2-8, 10-13, 16-31/87  
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Oct/8-11, 14-17, 28-31/87  
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May/1-12, 23-31/88  
Jun/1-2, 4-30/88  
Jul/1, 19-31/88  
Aug/1-10, 12-19, 23-31/88  
Sep/1-5, 9-25, 30/88  
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Mar/3-5, 7, 10-12, 14-17, 19-21, 23-31/89  
Apr/1-15, 17, 19-20, 22-30/89  
May/1-4, 8-18, 20-22, 24-27, 30-31/89  
Jun/1-30/89  
Jul/1-31/89  
Aug/1-7, 9-27, 29/89  
Sep/9-10, 12-13, 15-17, 20-30/89  
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Jun/1-27/90  
Jul/2-5, 8-9, 11-21, 23-31/90  
Aug/1-11, 13-15, 17-31/90  
Sep/1, 3-5, 7, 9-14, 16-30/90  
Oct/1-5/90  
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Sep/1, 4, 7-8, 11-12, 18-20, 24, 26-30/86  
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Nov/7-9, 11, 15, 18-19, 23-26/86  
Dec/1-3, 8, 11, 24-26/86

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May/2-4, 12, 14-15, 17-20, 25-27, 30-31/87  
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Aug/5-10, 14-17, 23-31/87  
Sep/4-8, 10-13, 16-19, 25-26/87  
Oct/6, 10-11, 19-20, 26-27/87  
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Apr/1-8, 10-18, 21-30/88  
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Jul/1, 3-5, 8-31/88  
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Oct/2-7, 9-31/88  
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Mar/1-2, 5-6, 11-18, 27-31/89  
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May/1-2, 8-10, 12-27, 29-31/89  
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Nov/14-27, 29-30/90  
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Feb/1, 4-7, 22-24/91  
Mar/5-7, 13, 15-17, 21-23, 28-31/91  
Apr/4-9, 16-19, 22-23, 25-30/91  
May/1-7, 9/91  
Aug/9-11, 15, 19, 21-30/91  
Sep/3-10, 12-13, 18-25, 27-30/91  
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Jul/1-10, 12, 31/87  
Nov/17-30/87  
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Jul/19-21, 24-31/88  
Aug/1-15, 17-31/88  
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Oct/1-31/88  
Nov/1-4, 7-19, 22-30/88  
Dec/1-13, 15-31/88

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Feb/27-28/89  
Mar/1-2, 6-7, 9-11, 13-31/89  
Apr/1-4, 9-17, 24-27/89  
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Mar/1-4, 6-25, 29-31/90  
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Jun/1-30/90  
Jul/1-31/90  
Aug/1-29, 31/90  
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Dec/1-3, 8, 11-13, 18-20, 22-23, 26-27, 31/91

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Oct/1-4, 6-14, 17-25, 27-30/85  
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Aug/7-9, 15, 28-29/86  
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Oct/1-3, 5, 7-11, 13-31/87  
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Apr/1, 4-6, 8-10, 14-17, 19-20, 22-26, 28-29/88  
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Jan/1-12, 14-31/89  
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Jun/1-13, 15-17, 19, 21-27/89  
Jul/3-4, 7-8, 10, 12-19, 21-27/89  
Aug/4-7, 10-31/89  
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Oct/2, 6, 9-10, 12-14, 16-18, 27-28/89  
Nov/6, 8-11, 20-24, 29-30/89  
Dec/1-7, 12-16, 19, 22-26, 28-31/89

Jan/1-8, 14-19, 29, 31/90  
Feb/1-5, 7-11, 13-18, 20-23, 26-28/90  
Mar/1-17, 19-31/90  
Apr/1, 3-30/90  
May/1-7, 10-27, 29-31/90  
Jun/1, 16-17, 19-30/90  
Jul/1-5, 8-12, 15-31/90  
Aug/1-22, 27, 29-31/90  
Sep/2-4, 6-8, 10-11, 13, 16-21, 24-30/90  
Oct/1-9, 14-22, 25-28/90  
Nov/2-13, 18-23, 26-28, 30/90  
Dec/1-2, 4-7, 12-20, 24-30/90

Jan/2-10, 14-21/91  
Feb/1-5, 12-25, 28/91  
Mar/1-17, 20-31/91  
Apr/1-3, 5-9 11-28, 30/91  
May/1-16, 18-31/91  
Jun/1-30/91  
Jul/1-8, 11-31/91  
Aug/1-6, 8-13, 16-21, 23-31/91  
Sep/1-22/91  
Oct/1-2, 6-18, 21-26, 28-30/91  
Nov/5-30/91  
Dec/1-14, 19-28, 31/91

Jan/1-8, 10-18, 21-28, 31/92  
Feb/1-29/92  
Mar/1-5, 7-31/92  
Apr/1-6, 8-30/92

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OKC

May/1-23, 25-31/92  
Jun/1-30/92  
Jul/2-8/92  
Aug/5, 11-26, 30-31/92  
Sep/1-10, 17-27, 30/92

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## Pittsburgh, Pa. (PIT)

Jun/11-12, 17-18, 21-30/85  
Jul/1-28, 30-31/85  
Aug/1-5/85  
Oct/18-31/85  
Nov/9-26/85

Feb/3-7, 13-16, 18-28/86  
Mar/1-2, 5-10/86  
Apr/4-6, 16-20, 25-29/86  
May/1, 9-16/86  
Jun/1-2, 6-7, 10-11, 15-16/86  
Jul/24-25/86  
Aug/7-8, 10-11, 18-23/86  
Sep/16-19, 22-24, 27-28, 30/86  
Oct/1-5/86  
Nov/7-11, 17-18, 20-30/86  
Dec/2-11, 14-22/86

Feb/7-23, 26-28/87  
Mar/1-3, 9-11, 15-18, 20-25, 27-31/87  
Apr/2-17, 24-27/87  
May/25/87  
Jun/8-26, 28-30/87  
Jul/7-13/87  
Aug/26-31/87  
Sep/1-9, 11-22, 24-26/87  
Oct/7-31/87  
Nov/1-10, 16-20, 22-29/87  
Dec/1-16, 18-20, 22-31/87

Jan/1-9, 12-31/88  
Feb/1-2/88  
Mar/1-10, 12-13, 15-20, 22-24/88  
Apr/3-4, 20-22, 28/88  
May/1-25, 29-31/88  
Jun/1-9, 18-19, 26-29/88  
Jul/2-4, 6-30/88  
Aug/1-6, 8-21/88  
Sep/18-19, 29-30/88  
Oct/1-8, 11-31/88  
Nov/1-5, 7-10, 13-22, 24-30/88  
Dec/1-2, 6-14, 19-21, 23-24/88

Mar/12-15, 17-20, 25-31/89  
Apr/2-6, 8-11, 15-19/89  
May/2-5, 11, 14-16, 19-20, 23, 25-30/89  
Jun/9, 14-18, 21-24, 26-28/89

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## PIT

Jul/2-5, 7-8, 24-25, 28-31/89  
Aug/4-5/89  
Sep/5-12, 14-18, 20, 23-26/89  
Oct/2, 6-8, 10-11, 14, 16-19/89  
Nov/14-18, 24-28/89  
Dec/4-8, 11-15, 20-31/89

Jan/1-6, 8, 19/90  
Feb/3-4/90  
Mar/17-21, 26-27, 29-30/90  
Apr/1, 4-8, 10-15, 17-18, 20-22, 28-30/90  
May/15-16, 25-29, 31/90  
Jun/1, 3-6, 8-9, 15-19, 21-30/90  
Jul/1-6, 8-11, 15-16, 18-26, 29-31/90  
Aug/1-8, 12-13, 18-26, 29/90  
Sep/8-9, 12-15, 19-30/90  
Oct/4, 7-8, 10-12, 14-23, 26-28/90  
Nov/3-12, 17-19, 21-22, 27, 29-30/90  
Dec/3, 6-10, 14-31/90

Jan/1-6, 8-13, 16-17, 19-21, 24-31/91  
Feb/1-3, 5-8, 10-15, 18-22, 24-28/91  
Mar/1-5, 7-13, 15-21, 27-28/91  
Apr/1-3, 19-20/91  
May/5-9, 13-31/91  
Jun/1-2, 9-10, 30/91  
Jul/1-31/91  
Aug/1-4, 6-23, 25-31/91  
Sep/2-8, 13-21, 23, 25-26/91  
Oct/10-11, 14-16/91  
Nov/1-8, 10-24/91  
Dec/2-4, 6-10 12-14, 16-17, 23, 25-31/91

Jan/3, 7-10, 13-20/92  
Feb/11-29/92  
Mar/6-14, 17-20, 23-24, 27-31/92  
Apr/7, 10-30/92  
May/1-10, 12-20, 22-31/92  
Jun/10-14, 23-24, 27-30/92  
Jul/1, 3-6, 8-15, 21-23/92  
Aug/4-7, 27-31/92  
Sep/1-9/92



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## Tampa Bay, Fla. (TBW)

Apr/28-30/85  
May/1-16, 18-27, 30-31/85  
Jul/1-3, 5, 8-20, 22-23, 25, 29-31/85  
Aug/1-14, 16-24, 30-31/85  
Sep/1, 6-27, 30/85  
Oct/1, 7-23, 25-31/85  
Nov/1-30/85  
Dec/1-31/85

Jan/4-25, 30/86  
Mar/1-8, 12-13, 26-31/86  
Apr/1-30/86  
Jul/1-26, 30-31/86  
Aug/4-9, 11-15, 18-21, 25-31/86  
Oct/1-11/86  
Nov/7-26, 29-30/86

Mar/28-31/87  
Apr/2-14/87  
May/4-21, 31/87  
Jun/1-4, 18-20, 27-28/87  
Jul/3-21/87  
Sep/12-30/87  
Oct/11-31/87  
Nov/1-20, 23-30/87  
Dec/1, 3-8, 11-30/87

Jan/4-21/88  
Mar/9-30/88  
Apr/1-9, 11-30/88  
May/1-2/88  
Jun/26/88  
Jul/9-31/88  
Aug/1-30/88  
Sep/1-30/88  
Oct/1-7, 11-23, 25-28/88  
Nov/1-5, 8-23, 26-28/88  
Dec/1-28, 30-31/88

Jan/1-12, 18-22, 24-28, 30-31/89  
Feb/3, 5-8, 10-14, 23-29/89  
Mar/1-8, 10-24, 27-31/89  
Apr/1-11, 13-19, 21-22, 24-25, 29-30/89  
May/1-3, 8, 10-11, 15-16, 18-19, 22-26, 29/89  
Jun/6-30/89  
Jul/4, 7-27, 29-31/89  
Aug/9, 18-27, 30-31/89

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## TBW

Sep/1-18, 21-30/89  
Oct/1-8, 10-27/89  
Nov/2-11, 14-30/89  
Dec/1-9, 21-31/89  
Jan/1-4, 9, 11-13, 15-18, 22-26, 29-31/90  
Feb/1-5, 7-23, 26-28/90  
Mar/1-6, 8-9/90  
May/21-31/90  
Jun/1-5, 11-13, 15-19, 26-28/90  
Jul/1-11, 18-29, 31/90  
Aug/3-15, 29-31/90  
Sep/1-2, 5-30/90  
Oct/1-31/90  
Nov/1-2, 5-24, 26-28, 30/90  
Dec/1, 4-12, 23-24, 27-31/90

Jan/1-2, 4-12, 14-20, 22-29, 31/91  
Feb/3, 5-28/91  
Mar/1-8/91  
Apr/5-12, 14-20, 22-30/91  
May/1-6, 8-10, 12-21, 24, 26-31/91  
Jun/1-11, 13-14, 17-19, 23-30/91  
Jul/1-20, 24-31/91  
Aug/1-31/91  
Sep/1-30/91  
Oct/1-31/91  
Nov/1-9, 12-26, 29-30/91  
Dec/1-31/91

Jan/1-11, 13-14, 19-24, 27-31/92  
Feb/1-29/92  
Mar/1-31/92  
Apr/1, 3-4, 6-30/92  
May/1-31/92  
Jun/1-30/92  
Jul/1-31/92  
Aug/1-22/92  
Sep/1-19, 22/92

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## Monett, Mo. (UMN)

Apr/1-2, 19, 22/85  
May/9-11, 13, 17-22, 24-25, 27-31/85  
Jun/1-10/85  
Oct/23-31/85  
Nov/1-30/85  
Dec/1-31/85

Jan/1/86  
Apr/11-21, 27-30/86  
May/1-31/86  
Jun/1-15, 18-19/86  
Jul/4-17, 25-31/86  
Aug/1-2, 7-9, 12-24, 26-31/86  
Sep/1-11, 13-22/86

Jan/13-14, 16-19/87  
Jun/14, 23/87  
Aug/3-7, 10-11, 13-31/87  
Sep/1-26/87  
Oct/20-21, 23-28, 31/87  
Nov/1-2, 5-30/87  
Dec/16-19, 21, 24-25, 29-31/87

Jan/1-12, 14-16, 19-31/88  
Feb/1, 12-17/88  
Mar/3-8, 10-12, 17-31/88  
Apr/1-12, 21-24, 27-29/88  
May/1-31/88  
Jun/1/88  
Jul/10-31/88  
Aug/1-5, 8-12, 19, 22-31/88  
Sep/16-24, 26-30/88  
Oct/1-4/88  
Dec/7-9, 11-31/88

Jan/1-31/89  
Feb/2-3, 28/89  
Mar/1-31/89  
Apr/1-18, 20-30/89  
May/1-26, 28-29/89  
Jun/1-16, 20-30/89  
Jul/1-31/89  
Aug/1-2, 17-31/89  
Sep/1-9/89  
Oct/31/89  
Nov/1-13, 16-30/89  
Dec/1-15, 19-31/89

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## UMN

Jan/1-31/90  
Feb/1/90  
Mar/3-13, 24-30/90  
Apr/1-3, 9-10, 13-26/90  
May/8-16, 21-22, 29-31/90  
Jun/1-26/90  
Jul/5, 10-31/90  
Aug/1, 5-31/90  
Sep/1, 13-19, 21-30/90  
Oct/1-31/90  
Nov/1-10, 14-24, 26-28, 30/90  
Dec/1-3, 5-30/90

Jan/12-25, 28-29/91  
Feb/1-6, 8-16, 24-28/91  
Mar/1-3, 6-10, 12-17, 20-23, 25-27, 29/91  
Apr/3-4, 6-9, 11-30/91  
May/1-5, 7-8, 10-31/91  
Jun/1-14 17-18, 20, 22-23, 28-29/91  
Jul/1-5, 10-14, 16-25, 27-29, 31/91  
Aug/1-2, 4-14, 16-21, 23-31/91  
Sep/1-8 10-13/91

Jan/21-22, 27-28/92  
Feb/1-14, 16-29/92  
Mar/1-31/92  
Apr/1-4, 6-30/92  
May/1-29, 31/92  
Jun/1-19/92











# APPENDIX B

JULY 1985

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
AMA																																
BGM																																
BNA																																
CRW	X	X	X	X	X	X	X	X	X	X															X	X	X	X	X	X	X	
GCK																																
ICT	X	X	X	X	X		X	X	X	X	X		X	X		X	X	X	X	X	X								X	X	X	
JKL																																
LIC	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
OKC	X	X	X	X	X				X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
PIT	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
TBW	X	X	X		X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X								
UMN																																

AUGUST 1985

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
AMA									X																X	X	X	X	X	X	X	
BGM																																
BNA																																
CRW	X	X			X	X	X	X	X	X	X				X	X	X	X	X	X					X	X	X				X	
GCK															X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
ICT										X	X	X	X	X	X	X	X	X	X					X	X			X	X	X		
JKL																																
LIC	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
OKC	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
PIT	X	X	X	X	X																											
TBW	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X						X	X
UMN																																



























































# APPENDIX B

## JANUARY 1990

AMA			X	X	X	X	X	X	X	X	X	X				X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X	X
BGM	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X				X	X	X	X	X	X	X	X	X
BNA	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X
CRW	X	X	X	X	X	X	X									X	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X
GCK																X	X	X	X						X									
ICT	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X									X	X	X	X
JKL																																		
LIC	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X
OKC	X	X	X	X	X	X	X	X							X	X	X	X	X	X											X			X
PIT	X	X	X	X	X	X		X												X														
TBW	X	X	X	X				X		X	X	X			X	X	X	X						X	X	X	X	X			X	X	X	
UMN	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31			

## FEBRUARY 1990

AMA	X	X	X	X	X	X	X	X	X	X																								
BGM	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X	X	X	X	X					
BNA	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X																			
CRW	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
GCK			X	X	X	X	X	X	X	X	X	X	X	X	X			X	X	X														
ICT	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
JKL									X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
LIC	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
OKC	X	X	X	X	X		X	X	X	X	X		X	X	X	X	X	X		X	X	X	X			X	X	X						
PIT			X	X																														
TBW	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
UMN	X																																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31			



































