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THE FLORIDA LIGHTNING AND RADAR EXPERIMENT: THE LIGHTNING WORK STATION, SUPPORT AND RESEARCH PROGRAMS

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THE FLORIDA LIGHTNING AND RADAR EXPERIMENT:
The Lightning Work Station, Support and Research Programs

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I. INTRODUCTION

The deployment of lightning detection systems accelerated in the late 1980's, giving researchers the ability to study lightning patterns over much of the country. And, with the next generation of observing technology (NEXRAD, GOES NEXT, etc.) just over the horizon, current lightning research will aid in the utilization of these new tools.

In order to prepare for this new technology and to gain a better understanding of lightning in a tropical or subtropical environment, the National Weather Service Forecast Office (WSFO) in Miami, Florida began accessing a regional lightning detection network early in 1988. Programs were developed to retrieve, display, analyze and archive the lightning information while enhanced radar data was collected for later study.

The project, known as FLARE or the Florida Lightning and Radar Experiment, has several objectives. First, Florida has more lightning related deaths than any other state. In addition, thunderstorms over peninsular Florida occur in a far different environment than the more frequently studied "Midwest" storms. It is hoped to find where lightning most often occurs with respect to thunderstorm cell structure and if different atmospheric parameters such as temperature or moisture tend to limit or enhance lightning activity.

Other objectives of the project include comparing lightning frequencies and locations to radar echoes and severe weather events. This may produce useful lightning signatures that can be identified and used to enhance the public, aviation and marine warning programs. Also, lightning frequencies per Manually Digitized Radar blocks (MDR's) will be correlated with radar intensities to determine if radar levels and lightning frequencies have a relationship that can be used operationally. This information may ulimately be used as a building block (or algorithm) for use with Doppler radar.

FLARE can be broken down into five major components: the lightning detection system, automation programming, the lightning work station, support programs and research programs. This paper serves to document the project with a brief description of each component.

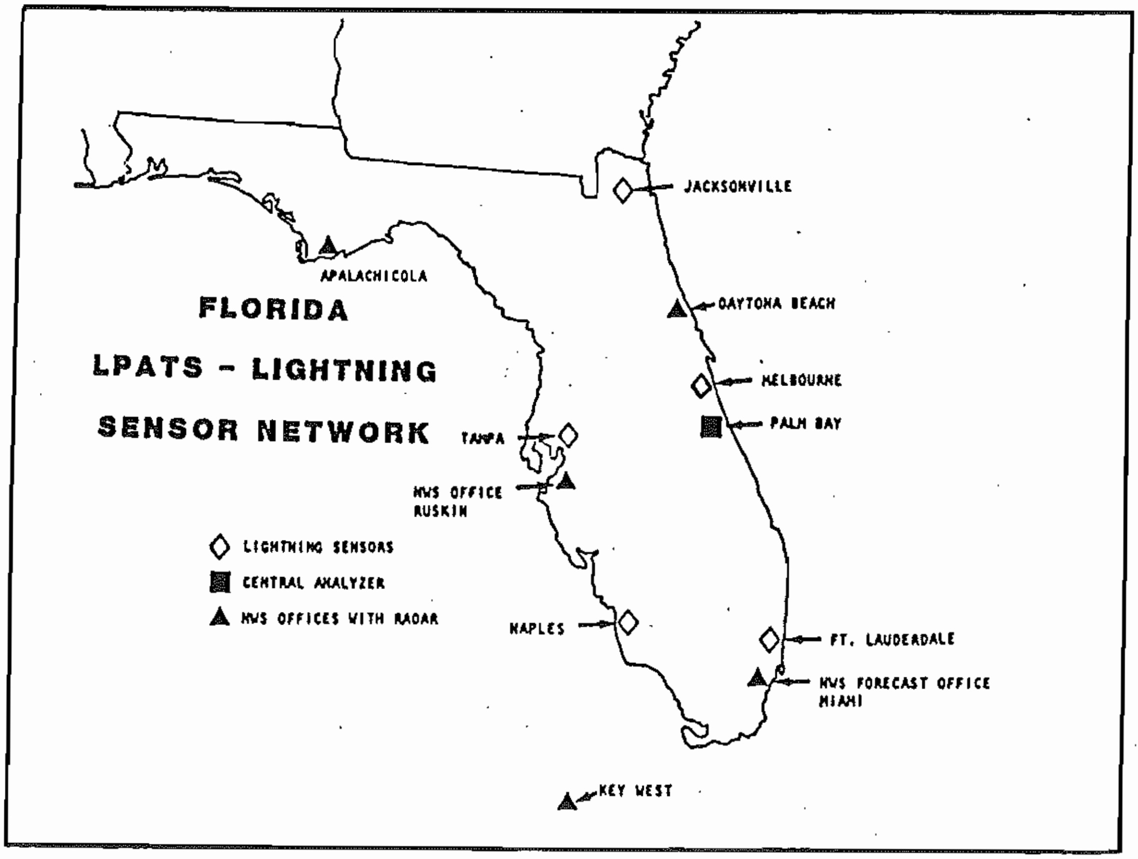
II. THE LIGHTNING DETECTION SYSTEM

The lightning detection system used in the FLARE project is the Lightning Position and Tracking System (LPATS) of Atmospheric Research Systems, Inc. of Palm Bay, Florida.

LPATS uses a "Time-Of-Arrival" technique to locate cloud-to-ground lightning strokes. Each stroke produces an electromagnetic pulse which is detected by several of the five LPATS sensors located in the State of Florida (figure 1). At the moment of stroke detection, each sensor samples the LORAN-C Long-Range Navigation System for clock synchronization thereby determining the pulse's "time-of-arrival" at each sensor site. This information is fed into the system's central analyzer (located in Palm Bay), where calculations determine the lightning stroke location. Because information is sent from different sensors, redundant calculations produce a stroke accuracy to within a kilometer or better over most of Florida. Data is then sent to the user, usually within about 3 seconds from the time of detection. Currently, up to 5000 strokes per hour can be accumulated in the central analyzer.

Data from the central analyzer reaches the WSFO via a dedicated FTS phone line connected to a modem and an IBM XT compatible computer. The data transfer rate during the first year of operation (1988) was set at 300 baud. An upgrade to 1200 baud is set for the 1989 season.

Figure 1...The Florida Lightning Detection and NWS Radar Network



III. AUTOMATION PROGRAMMING

It was determined during the planning stages of the project that to have an effective data archiving tool, the FLARE software had to be executed automatically. This is accomplished by loading several macros (a list of computer interpreted instructions) into the computer and having a "timer" subprogram redirect system activities at pre-selected time intervals. Each macro is set up to act in a cycle, so that when a task is completed, the main program retakes "control" of the computer's activities.

The main macro produces a "lightning dump cycle". This can be initiated as little as once per hour for the data archive function, or as often as every five minutes during active thunderstorm events. The ability also exists to cycle at any other time through a manual switch in the Work Station program (see section IV).

A subsection of the Work Station program constantly monitors the computer's "internal clock". Upon recognizing certain time intervals, the system sets up flags which redirects the computer to perform certain tasks and to take certain job paths (figure 2).

Upon the initiation of a cycle, the system first checks the flags to determine whether to start or terminate a dedicated phone link with the LPATS central analyzer or to communicate with the Automation of Field Operations and Services (AFOS) computer. AFOS is used as an operational data base for accessing and archiving radar and surface observations.

If the system has not been redirected, the lightning dump cycle begins by dialing the central analyzer. Asynchronous communications are accomplished by using a program called ASCOM. ASCOM is linked to its own set of instructions which will allow for up to three redials if the first dial is not successful (usually because of busy FTS circuits). If no connection is made after the third redial, the system aborts the remainder of the macro and returns to the Work Station mode to wait for the next polling time or data analysis.

Once the data link has been made, the system time is sampled to determine if the incoming data should be stored as an hourly archive file. If so, an archive flag is set and a new macro (with an archive filename and path) is created to copy the data file to the archive disk, verify that the transfer took place, and check to be sure that the archive disk is not full.

Increments of lightning data from one minute to an hour can be requested from the central analyzer. The computer "waits" as the continuous stream of data fills the input buffer. Once the system recognizes two seconds of silence, the buffer is dumped to a temporary disk file, the data link is terminated and if the flag was set, the archive macro executes.

Data decoding is very fast using Turbo Pascal. The binary lightning information is manipulated and transformed into points of latitude and

WORK STATION JOB STREAM

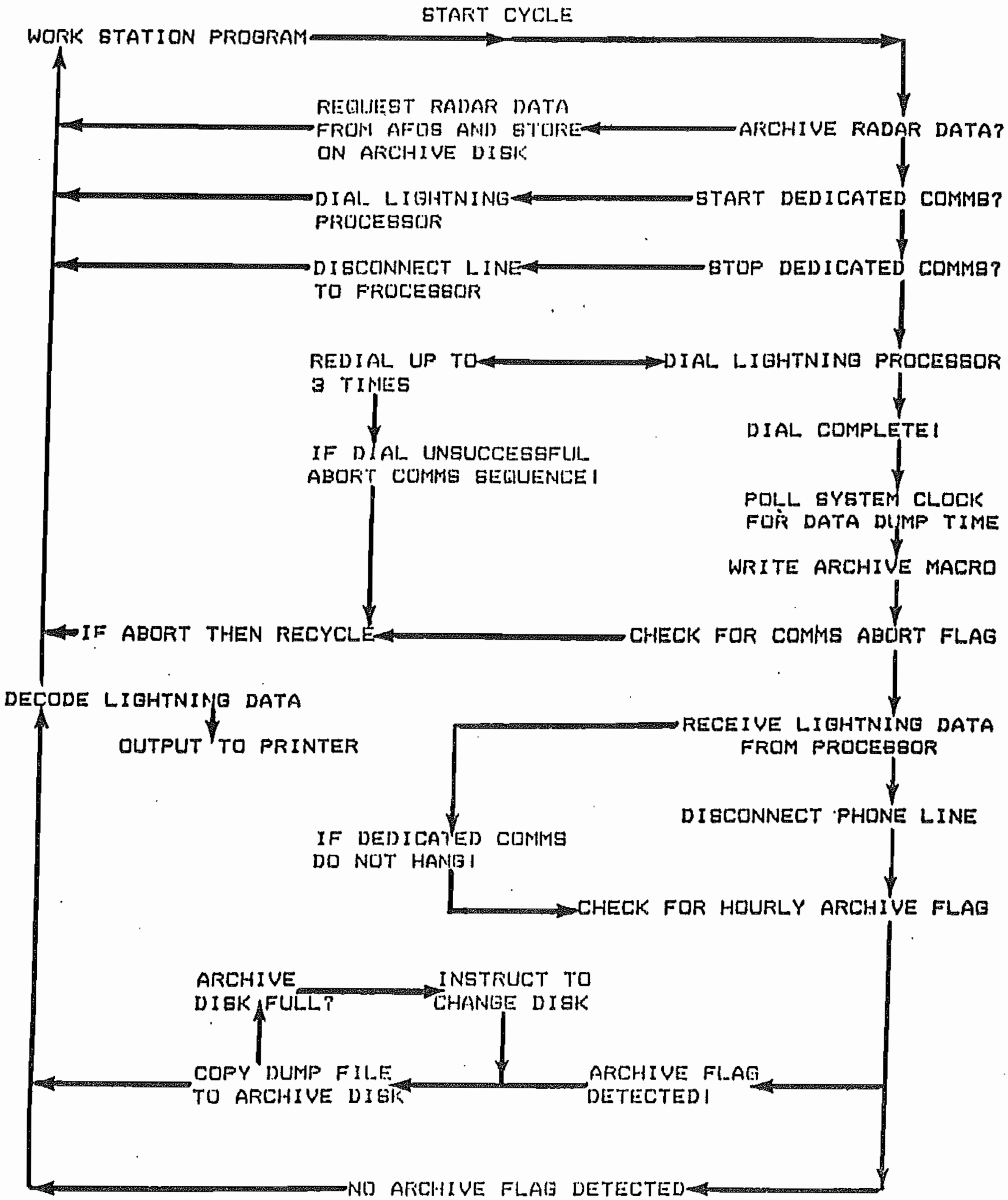


Figure 2

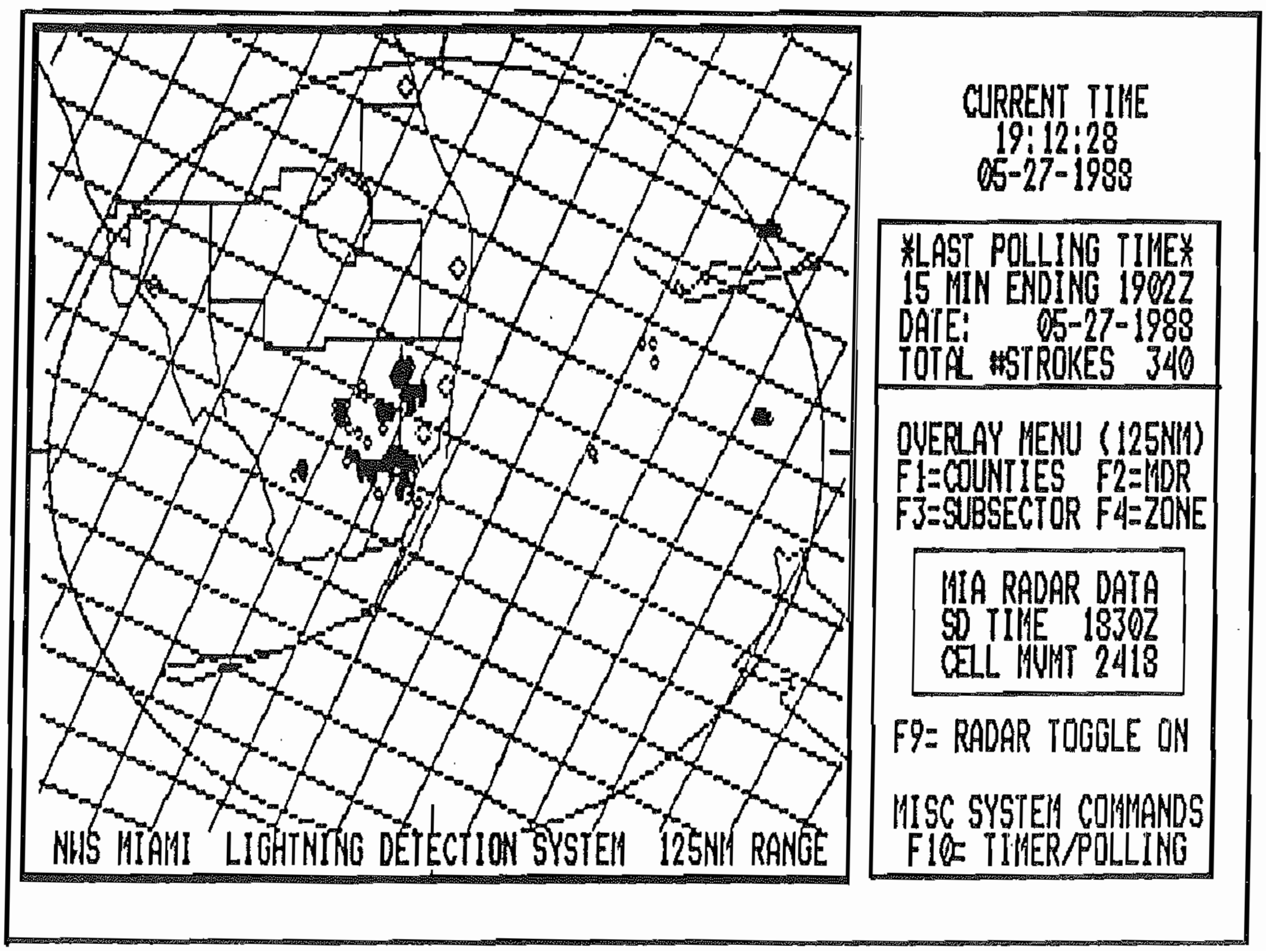
WORK STATION PROGRAM DECISION TREE

longitude (to a thousandths of a degree) while keeping track of the time that the strokes occurred. Upon completion (usually less than 30 seconds), a file containing the most current 15 minutes worth of lightning data is stored on the system disk.

At this point, the system completes the cycle by reloading the Work Station program. If lightning was detected and stored on the data disk, each stroke is transformed into screen coordinates and plotted on a map similar to the WSFO Miami radar overlay (figure 3). To alert forecasters that lightning has been detected, the computer sounds six short beeps. The system then goes into a stationary mode waiting for the next polling cycle to begin, or for commands from the Work Station menu.

Other subordinate macros are used in the system. These include alert tones and instructions for changing full archive disks, and for decoding archived radar observations. Current radar information is displayed on the same screen as the plotted lightning information and indicates the observation time, cell movement, and all echo tops and locations.

Figure 3...Main Work Station Display with Forecast Zone Boundaries and the MDR Grid overlayed on the Lightning Display Screen.



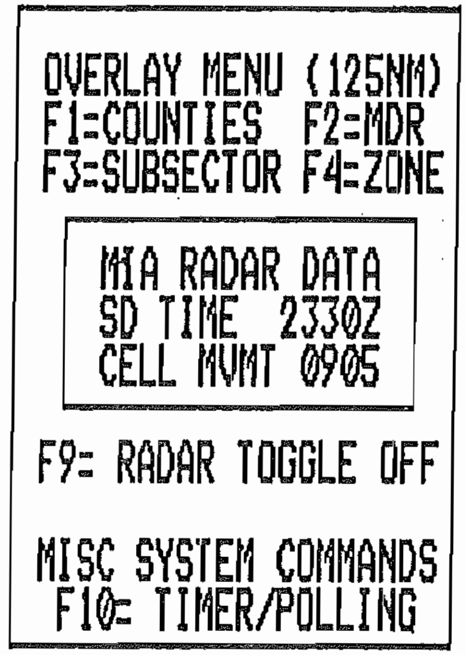
IV. THE WORK STATION PROGRAM

The Work Station program is the heart of the automation programming as it is used as both a system organizer and data analyzer. Main screen graphics use high resolution features to simulate a radar screen displaying all echo top information as well as lightning stroke locations. The screen is divided into "windows" that display other pertinent information such as the system date and time, the total number of lightning strokes decoded, and the latest radar cell movements.

The analysis portion of the program is menu driven. Each menu is manipulated by the use of function keys (F1 through F10). As each function is performed, a portion of the screen clears and instructions for the next operation are displayed.

THE MAIN MENU

The initial screen of the Work Station program contains an area known as the main menu (figure at center right). The main menu is divided into three sections; the overlay section, the radar display toggle control, and the miscellaneous command section.



The overlay section consists of four functions that allow different graphic maps to be overlayed on the main lightning display screen. By pressing the function key, F1, county boundaries can be overlayed over a map of the southern Florida peninsula (figure 4). This covers all of the counties in the WSFO's area of warning responsibility. Function key, F2, controls the Miami MDR grid overlay (figure 3). This allows forecasters to compare lightning frequencies in the same grid as encoded radar information. Key F3 is a special key that controls the subsector grid overlay and menu (figure 5A). This function is described in detail in the next section. And finally, function key, F4, is used to overlay the south Florida public forecast zones on the main display screen (figure 3). Any of the overlay maps can be used in combination with any other overlay graphic.

In the center of the main menu is a box that displays the latest Miami Radar Data ("MIA RADAR DATA"). Just below the title is the "SD TIME". This is the time that the last Miami radar observation was taken in "Z" or Universal Coordinated Time. The radar cell movement ("CELL MVMT") is displayed using a four digit format. The first two digits represent the direction in degrees (x 10) from which the echoes were moving. The last two digits represent the speed of echo movement in knots. The function key, F9, is used to toggle the echo top data on or off the main screen. Echo tops are depicted by a box and a line leading

FLORIDA LIGHTNING AND RADAR EXPERIMENT

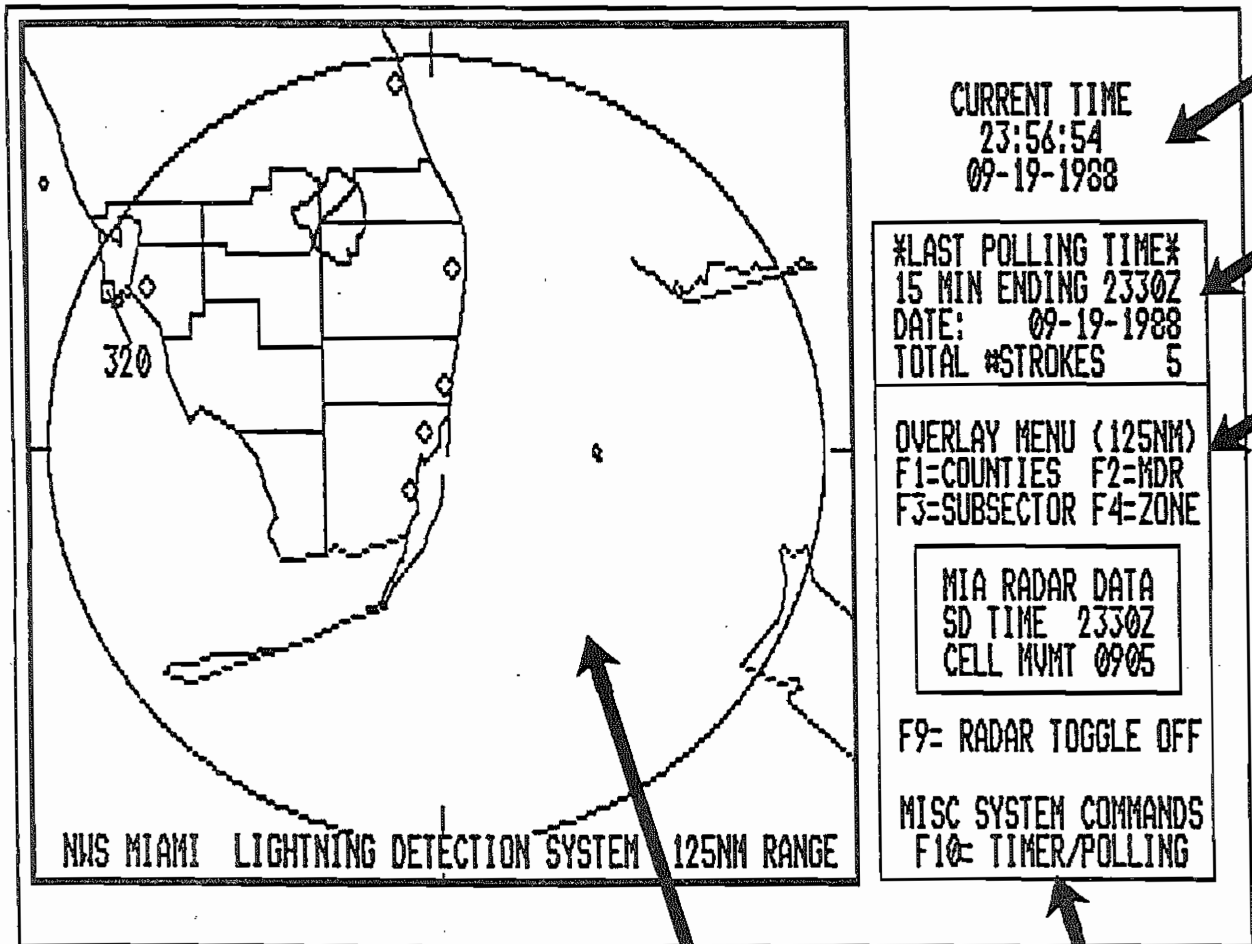


Figure 4...Main Lightning Display

THE WORK-STATION PROGRAM CONSTANTLY MONITORS AND DISPLAYS THE CURRENT UNIVERSAL DATE AND TIME.

THE DATA POLLING WINDOW DISPLAYS THE POLLING INTERVAL, DATE/TIME STAMP AND TOTAL NUMBER OF DECODEI LIGHTNING STROKES FROM THE LATEST DATA SAMPLE.

THE WORK-STATION MAIN MENU FUNCTION KEYS F1-F4 OVERLA MAP OUTLINES ON THE MAIN DISPLAY WINDOW. THE F3 KEY ALSO STARTS THE ZOOM MENU.

THE LATEST MIAMI RADAR OBSERVATION TIME AND ECHO SPEED ARE DISPLAYED WITHIN THE MAIN MENU. RADAR STATU REMARKS SUCH AS PPINE, PPINA OR PPIOM REPLACE THE CELL MOVEMENT WHEN NEEDED.

FUNCTION KEY F9 ACTS AS A TOGGLE FOR DISPLAYING OR CLEARING THE RADAR ECHO TO INFORMATION ON THE MAIN DISPLAY WINDOW.

THE MAIN LIGHTNING DISPLAY SCREEN IS A REPLICA OF THE MIAMI WSR-57 RADAR OVERLAY (125 NAUTICAL MILE RANGE).

FUNCTION KEY F10 STARTS THE MISCELLANEOUS SYSTEM COMMAND MENU. OPTIONS INCLUDE THE UPDATING OF THE SYSTEM DATE OR TIME AND POLLING INTERVALS.

LIGHTNING WORK STATION PROGRAM

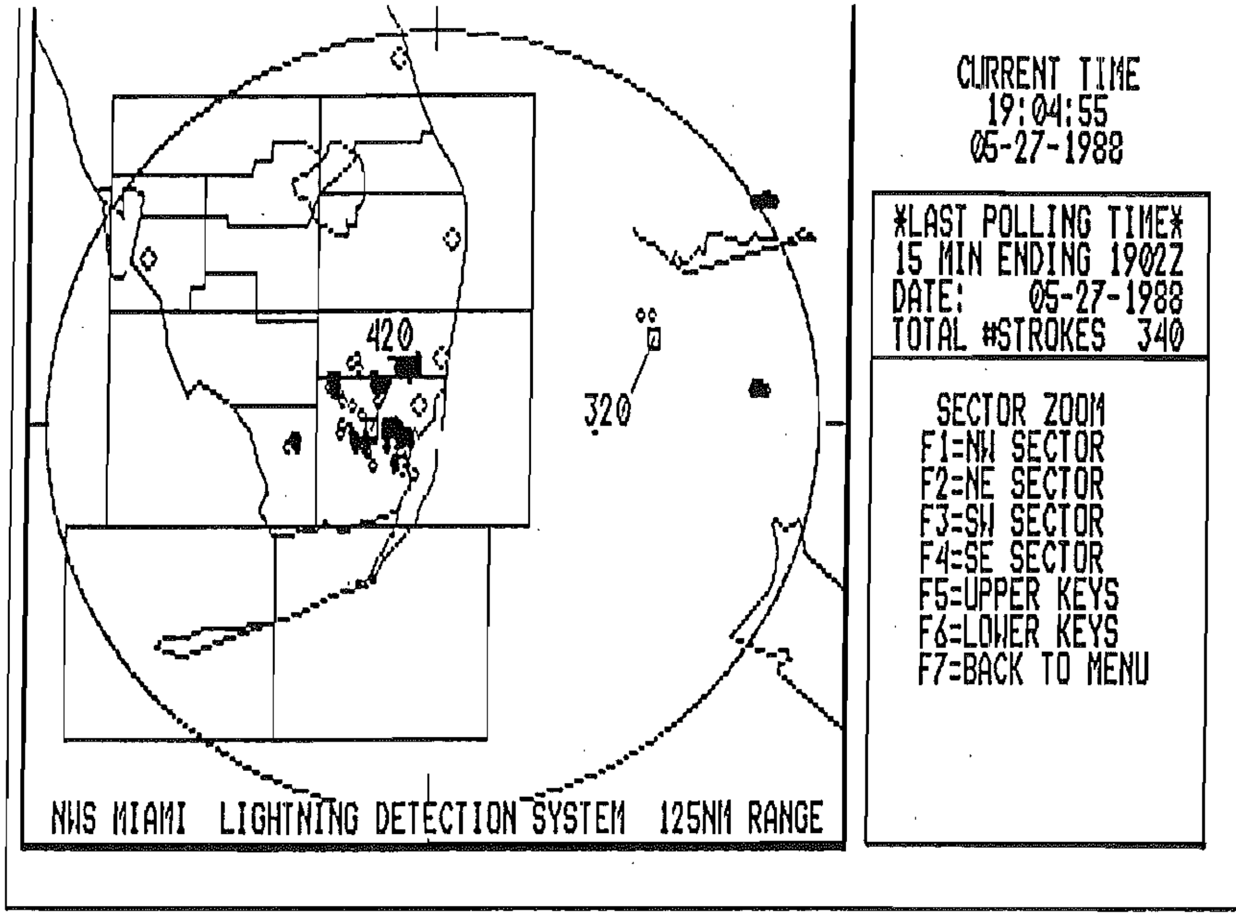
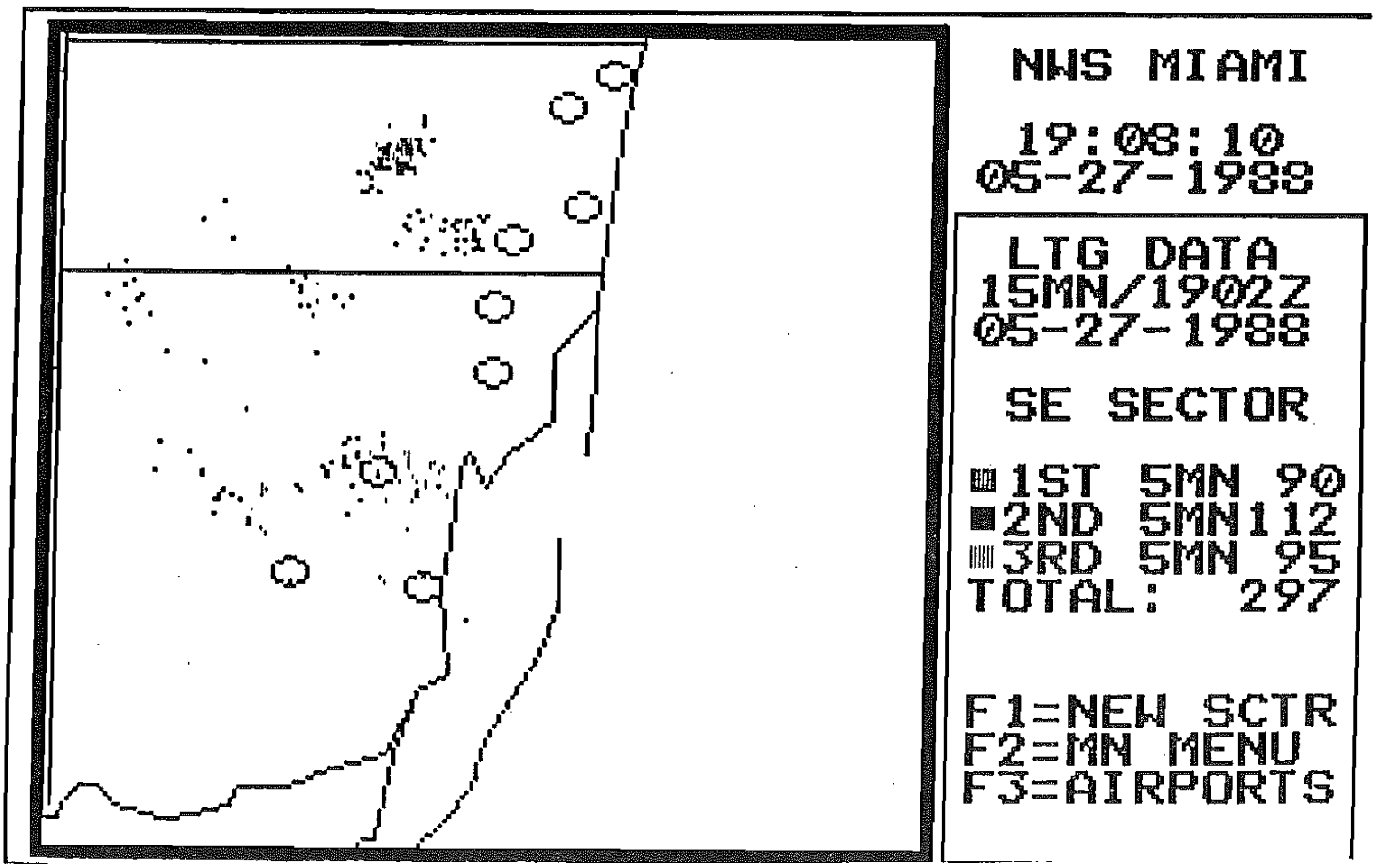


Figure 5A (Top)...Main Screen with Subsector Grid Overlay and Sector Zoom Menu.
Figure 5B (Bottom)...Sector Zoom of Top Figure's Southeast Sector.



to the echo top label. These labels are in units of feet (x 100).

The function key, F10, is located at the bottom of the main menu. This option is used to display the miscellaneous system commands. These commands are used to update the system date or time, change polling intervals, clear the main screen or to produce an instant (manual) dial. These options are described in the section titled Miscellaneous System Commands.

SUBSECTOR ANALYSIS SECTION

The Work Station program has the capability to divide the main display screen into subsectors and zoom in on a particular area for greater detail. This option can be initiated by pressing main menu function key, F3. Once the subsector menu has started, a series of six sectors will overlay on the main display screen. Each sector covers a portion of the WSFO's county warning area of responsibility, the backup warning areas for adjacent Weather Service Offices and all adjacent coastal waters (figure 5A).

Taking the place of the main menu on the display screen is the "sector zoom" menu. This menu allows for the selection of any of the six sectors by using function keys F1 through F6. An escape to return back to the main menu is provided through function key, F7.

Sectors are set up over the south Florida peninsula using compass directions. Hence, the sector containing the Fort Myers Metropolitan Area (upper left box) is the northwest (NW) sector and the Miami/Fort Lauderdale Metroplex (middle right) is the southeast (SE) sector. The two lower sectors are slightly shifted west to cover the Florida Keys and the adjacent waters. These sectors are labelled "Upper Keys" (bottom right box) for the portion of the keys located closest to the mainland and the "Lower Keys" (bottom left box) which includes Key West.

Once a sector has been selected, the zoom sequence begins. The screen resets to medium resolution color graphics and land and county outlines for the chosen sector appear. Figure 5b illustrates lightning data in the southeast (Miami/Fort Lauderdale) subsector. The large circles are the major southeast Florida airports which is an overlay option enabled by pressing subsector function key, F3.

The subsector option sorts the most current fifteen minutes worth of lightning data into three 5 minute increments. Each increment is displayed in a different color: red for the first five minutes, white for the second and blue for the third. The colorizing of data allows for the determination of lightning stroke densities and thunderstorm movements. A window on the right of the subsector screen shows the lightning frequency breakdown and allows for quick determination of lightning trends and the overall sector stroke totals.

All timing functions continue to operate in the subsector mode so that normal data polling and archiving will continue uninterrupted without returning to the main screen. If returning to the main screen is desired, this option is accomplished by pressing function key, F2. To choose another subsector for analysis, press function key, F1, to redisplay the subsector menu.

MISCELLANEOUS SYSTEM COMMANDS

Pressing main menu function key, F10, starts the miscellaneous system command menu. This menu acts as a system utilities procedure allowing for the updating of different program parameters such as the system date and time or lightning cycle (polling) intervals.

The miscellaneous system command menu (figure at top right) contains six options. The current system polling interval is shown just below the function options.

```
F1= INSTANT DIAL
F2= CHANGE POLL TIME
F3= CHANGE SYS  TIME
F4= CHANGE SYS  DATE
F5= RESET/CLR SCREEN
F6= RETURN TO MENU

  CURRENT INTERVAL
     15  MINUTES
```

Function key, F1, controls a command called "instant dial". This command bypasses the system clock and allows for an instant escape from the Work Station program which allows the system to perform a lightning dump cycle.

Function key, F2, is used to change the system polling time interval. This option clears the menu window and displays the list of polling times that are available (figure at lower right). Interval function key, F1, labelled "archive mode", configures the system to poll the LPATS central analyzer once per hour, on the hour, for the archive dump. Keys F2 through F4 set the polling interval to every 30, 15 or 10 minutes respectively.

```
CHOOSE INTERVAL
F1 = ARCHIVE MODE
F2 = 30 MIN
F3 = 15 MIN
F4 = 10 MIN
F5 = 5 MIN/FAST SCAN
F6 = BACK TO MENU
```

Function key, F5, labelled "5 MIN/FAST SCAN", configures the system to remain in dedicated asynchronous communications with the central analyzer. Every five minutes, the system will request a lightning dump for display on the main screen. The hourly archive is still performed on the hour. Dedicated communications will be terminated only when the polling interval is changed back to one of the options in keys F1 through F4.

The system also contains an automatic procedure to "step up" or "step down" the polling interval. If the system is set for archive mode, F1, or 30 minute polling, F2, during a period of minimal convective activity, the system will automatically step the polling interval up to 15 minutes if lightning is detected during a routine polling. Also, if a suspect area develops on radar, the instant dial function of the miscellaneous command menu will step up the interval to 15 minutes if lightning is detected. Once lightning is no longer detected, the system automatically steps down to the preset polling interval. This procedure aids the forecaster by alerting personnel to increased lightning activity and also saves money on long distance calls when lightning is not found or expected.

Function key, F6, is used to escape from the polling interval menu and returns the system back to the main menu.

Miscellaneous system commands F3 and F4 are used to update the time and date of the computer's internal clock. Both must always be in "Z" or Universal Coordinated Time. Formatting directions are provided with each option (see example below). Should an illegal entry be encountered, the system will beep and display an error message while waiting for a correction to be entered. To escape from this option without changing the chronological parameters, press the return key without entering new data.

```
CHANGE SYSTEM TIME              CHANGE SYSTEM DATE
USE ONLY UTC TIME
FORMAT:  HH:MM:SS               FORMAT:  MM-DD-YEAR
ENTER :                         ENTER :
PRESS RETURN TO EXIT            PRESS RETURN TO EXIT
```

The final two commands on the miscellaneous system menu are function keys, F5 and F6. Key F5 is used to clear and reset the main lightning display screen. This option is useful when map or grid overlays are no longer wanted on the main screen and only lightning data is desired. The resetting procedure is very fast because all of the lightning and map coordinates have been retained in the system memory. Function key, F6, is used to return to the main menu without choosing options F1 through F5.

THE LIGHTNING WARNING GRID

In addition to being a data gathering tool for research, the FLARE software has the capability of being a near real-time lightning warning system for the WSFO. With over two million people inhabiting the narrow stretch of land between the Atlantic and the Everglades, this is the first time that the NWS has had the means to locate, report and alert persons in the metropolitan areas of Dade and Broward counties and the adjacent coastal waters for frequent cloud-to-ground lightning.

Upon reaching a predetermined lightning frequency threshold, the FLARE software automatically sends a matrix of lightning information to the system printer. Lightning data is sorted into grid blocks 0.05 degrees per side (3.1 nautical miles north/south by 2.8 nautical miles east/west). The output is formatted into a strike frequency table as seen in figure 6. A transparent overlay containing grid outlines, coastal and county boundaries, airport locations, and major roadways fits

WSFO MIAMI LIGHTNING DETECTION SYSTEM/HIGH RESOLUTION GRID

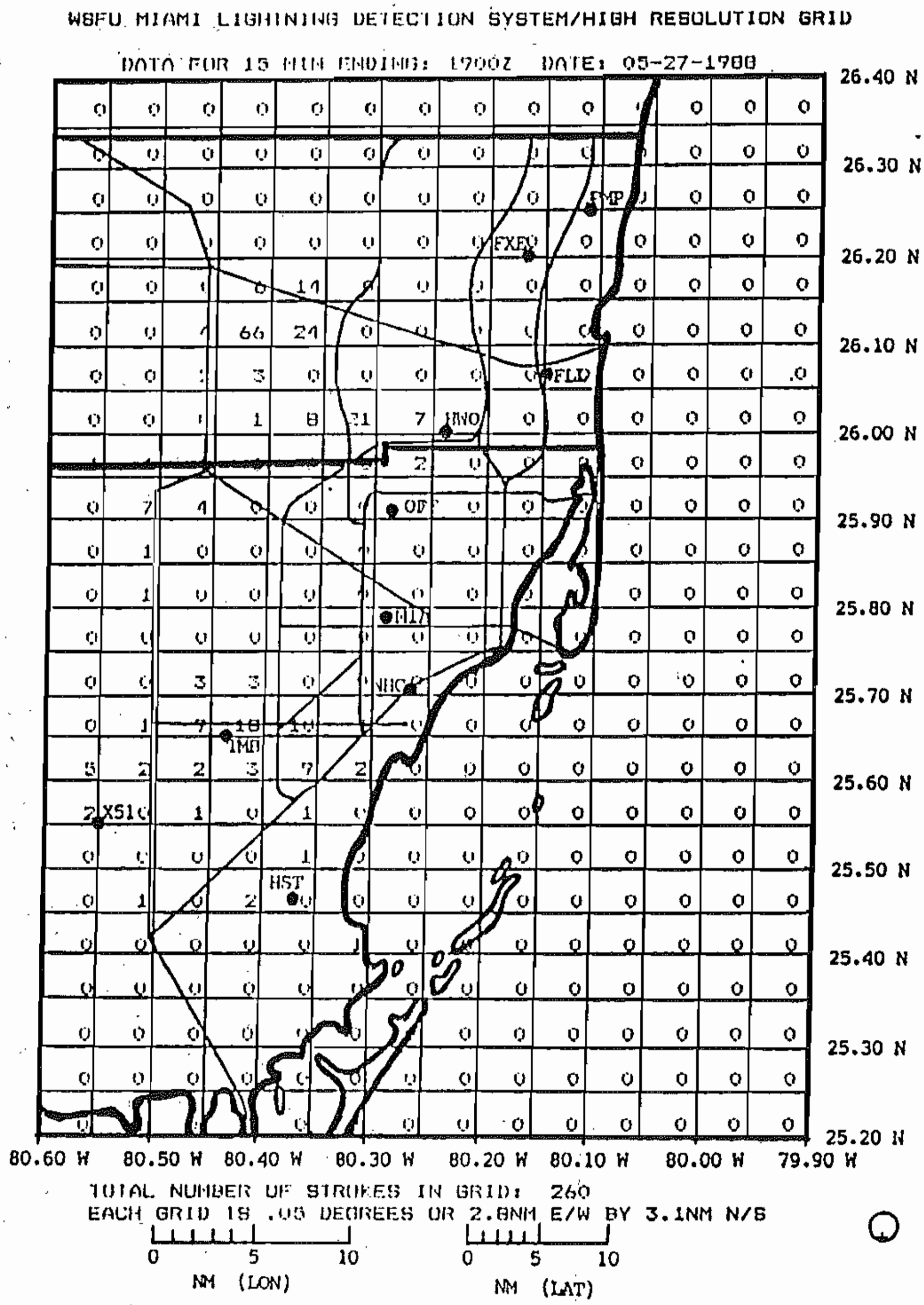


Figure 6...The FLARE Lightning Warning Grid. Formatted Output of Lightning Strike Frequencies with Geographical Overlay.

over the output to immediately locate areas of lightning activity. Using radar echo movements and intensity trends, and the lightning trends in the Work Station subsector analysis program, an approximation for forecasting lightning activity can be made.

IV. DATA ARCHIVING

FLARE software supports the automatic archiving of lightning, radar, and surface data. All data is archived on 5.25 inch diskettes. All archive functions are verified for a satisfactory transfer or an error routine is initiated.

Lightning data is archived in the subpartition LTGDATA on an hourly basis. The data is stored in an encrypted binary format that allows for maximum space utilization. Data for the entire Florida network is included (south Georgia, Florida except the western panhandle and the adjacent coastal waters) so that data is available for Weather Service Offices across the state, if they wish to include lightning data in a significant weather event study.

The radar observation (SD) from Miami is archived on an hourly basis at 40 minutes past each hour. The data is stored on the archive disk under the subpartition RADAR and includes both the polar coordinate and digital portions of the radar observation.

An hourly surface observation collective is created by AFOS at 10 minutes past each hour for about a dozen locations across south Florida. This data is used to establish a "ground truth" about lightning reports when doing later research. The data is archived on the archive disk under the subpartition SURFACE and is aquired at the same time as the radar data.

In addition to the collection of data by the FLARE computer, the Hurricane Research Division of the Atlantic Oceanographic and Meteorological Laboratory (HRD/AOML) has located a radar data recorder in the radar room of the Miami WSFO. This device records the actual Plan Position Indicator (PPI) sweep from the Miami WSR-57 Radar on computer tape and provides a high resolution playback ability for later research.

The radar unit of the Miami WSFO also supported the FLARE project by taking special observations at half hourly intervals whenever echoes were within 125 nautical miles of the radar. At these times, the five highest echo tops were recorded on a special form which included the cell AZRAN, maximum intensity value (VIP) and echo height. Figure 7 illustrates the reporting constraints that the unit worked under for the project.

Finally, all upper air observations for central and south Florida (Tampa, West Palm Beach and Key West) were archived both in alphanumeric and graphic formats. Hodographs produced by the AFOS program CONVECT were also saved.

Figure 7.

GUIDELINES FOR OPERATING THE LPATS SYSTEM AND TAKING OFFTIME/ADDITIONAL RADAR OBSERVATIONS FOR THE MIAMI, FLORIDA WSFO EVALUATION OF THE UTILITY OF LIGHTNING DATA

OPERATING THE LPATS SYSTEM

1. Radar personnel will turn the LPATS system on when ANY echo is within 125 nm OR echoes are forecast to move within 125 nm of the radar during the hour. (LPATS polling time will default to 30 min.)

2. Radar personnel will turn the LPATS system off when the scope goes PPINE or no echoes are observed within 125 nm of the radar.

3. Polling times can be changed at any time according to radar operator or forecaster discretion.

Instructions for activating the LPATS, changing disks, etc., will be at the LPATS system location behind the Aviation Forecaster desk.

INTERMEDIATE/ADDITIONAL RADAR OBSERVATIONS

1. Between H+50 and on the hour the radar operator will take an intermediate observation when echoes are within 125 nm of the radar site. Radar observers will record at a minimum the Max Top/Azran of the 5 cells with the highest VIP levels (e.g., VIP 4 - 2 tops, VIP 3 - 3 tops). Encode this information on the separate encoding sheet.

2. At the time of the scheduled radar observation, the radar operator should also record on the separate encoding sheet the cells with the 5 highest VIP levels, as above in (1).

3. An intermediate observation will be encoded if the radar observation contains RW and LPATS indicates that lightning exists in it. This observation should be taken as soon as possible after noting that lightning exists. Encode the Max Top/Azran and VIP information from the cell(s) involved and record on the separate encoding sheet.

THESE INTERMEDIATE OBSERVATIONS SHOULD NOT BE CONFUSED WITH SPECIAL CRITERIA RADAR OBSERVATIONS.

WARNING MODE

1. During the wet season, an intermediate observation will be encoded and the LPATS polling time will be increased to at least 15 minutes if:

   a.) Cell movement falls within 160 degrees thru west to 030 degrees at any speed with a VIP level of 3 or higher, or

   b.) Cell movement falls within 035 degrees thru east to 155 degrees at a speed of 25 kts or greater and any VIP level.

2. During the dry season, an intermediate observation will be encoded and the LPATS polling time will be increased to at least 10 minutes if any cell movement is 25 kts or greater at a VIP 2 or higher.

V. SUPPORT PROGRAMS

Several support programs have been developed to help analyze operational or archived lightning data. However, the two major programs are the LPATS High Resolution Lightning Decoder and the Tampa Bay-RADAP Comparison Programs.

The LPATS High Resolution Lightning Decoder (LTGDEC) is a program that allows the user to define a grid anywhere in the state of Florida, select the grid decoding intervals (such as 0.1 or 0.05 degrees in degrees of Latitude/Longitude) and display the output to a printer in a matrix format (figure 8). This program is particularly useful when a subjective scan of a large area is desired to determine if significant lightning was observed and a high resolution study of a particular subset of data is then required. Another useful item is that the high resolution grid can be moved along with an advecting cell for a close inspection of the lightning life cycle.

The Tampa Bay-RADAP Comparison Programs decode lightning data and output the information in a RADAP grid. RADAP is an enhanced radar processing package on the Tampa Bay WSR-57 Radar that "takes control" of horizontal and vertical scanning functions for certain time intervals and produces high resolution intensity and echo top output. The system also creates estimated rainfall total data and vertically integrated liquid moisture (VIL) data.

Figure 9 shows a map of central Florida with several grids. The large box delineates the area that is decoded using the program TBWDECODE. Output from this program, shown in figure 10, displays lightning strokes over the entire RADAP grid. Because of size limitations, lightning frequencies are encoded using a scale located at the top of the output (i.e. zero strokes are encoded with a zero, 1-10 strokes are encoded with a one, etc.). This scale can be changed when significant lightning frequency thresholds are determined.

Figure 11 shows output from the program RADAP. This program takes the RADAP grid and divides the area into four overlapping boxes. Actual lightning strokes per RADAP grid box are then output.

VI. RESEARCH PROGRAMS

At the time of this writing two research programs have been written for the FLARE project. The first is called MDR_DECODER. This program takes archived lightning, radar, and manually encoded echo top data and relates the information to a common MDR grid. This allows for the direct comparison of lightning frequencies per MDR grid block to actual encoded radar intensity (DVIP) values (figure 12). Also, the location of the manually encoded radar tops (AZRAN's) are converted to latitude and longitude coordinates and are sorted into the respective MDR blocks.

The second set of research programs were written by Mike Black and Peter Dodge of HRD/AOML. These programs decode the information that was

Figure 8...Output from the LPATS High Resolution Decoder

WSFO MIAMI LIGHTNING DETECTION SYSTEM/DATA DECODER

DATA DATE: MAY2788 DECODE START: 15 END: 30 FOR HOUR ENDING 00Z

GRID BOUNDS NW POINT: 26.600N 81.000W SE POINT: 25.400N 80.300W
GRID INTERVAL 0.05 DEGREES - TOTAL STROKES DECODED 181

26.60N														
	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26.55N														
	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26.50N														
	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26.45N														
	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26.40N														
	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26.35N														
	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26.30N														
	0	0	0	0	0	0	0	0	0	0	0	0	0	7
26.25N														
	0	0	0	0	0	0	0	0	0	0	0	0	1	48
26.20N														
	0	0	0	0	0	0	0	5	0	0	0	0	6	0
26.15N														
	0	0	0	0	0	1	0	0	0	0	0	0	0	0
26.10N														
	0	0	0	0	0	2	1	0	0	0	0	0	0	0
26.05N														
	0	0	0	0	0	0	5	2	4	0	0	0	0	0
26.00N														
	0	0	0	0	0	0	1	0	0	0	0	0	0	0
25.95N														
	0	0	0	0	0	0	0	0	0	0	0	0	0	1
25.90N														
	0	0	0	0	0	0	0	0	0	0	0	0	0	2
25.85N														
	0	7	1	0	0	0	0	0	0	0	0	0	0	1
25.80N														
	16	12	8	3	0	0	0	0	0	0	0	0	0	0
25.75N														
	3	8	0	0	0	0	0	0	0	0	0	0	0	0
25.70N														
	0	0	0	0	0	0	0	0	0	1	1	0	0	1
25.65N														
	1	0	0	0	0	0	0	0	0	0	13	2	0	1
25.60N														
	0	0	0	0	0	0	0	0	0	5	7	0	2	0
25.55N														
	0	0	0	0	0	0	1	0	0	0	1	0	0	0
25.50N														
	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25.45N														
	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25.40N ^														^
	81.00W													80.30W

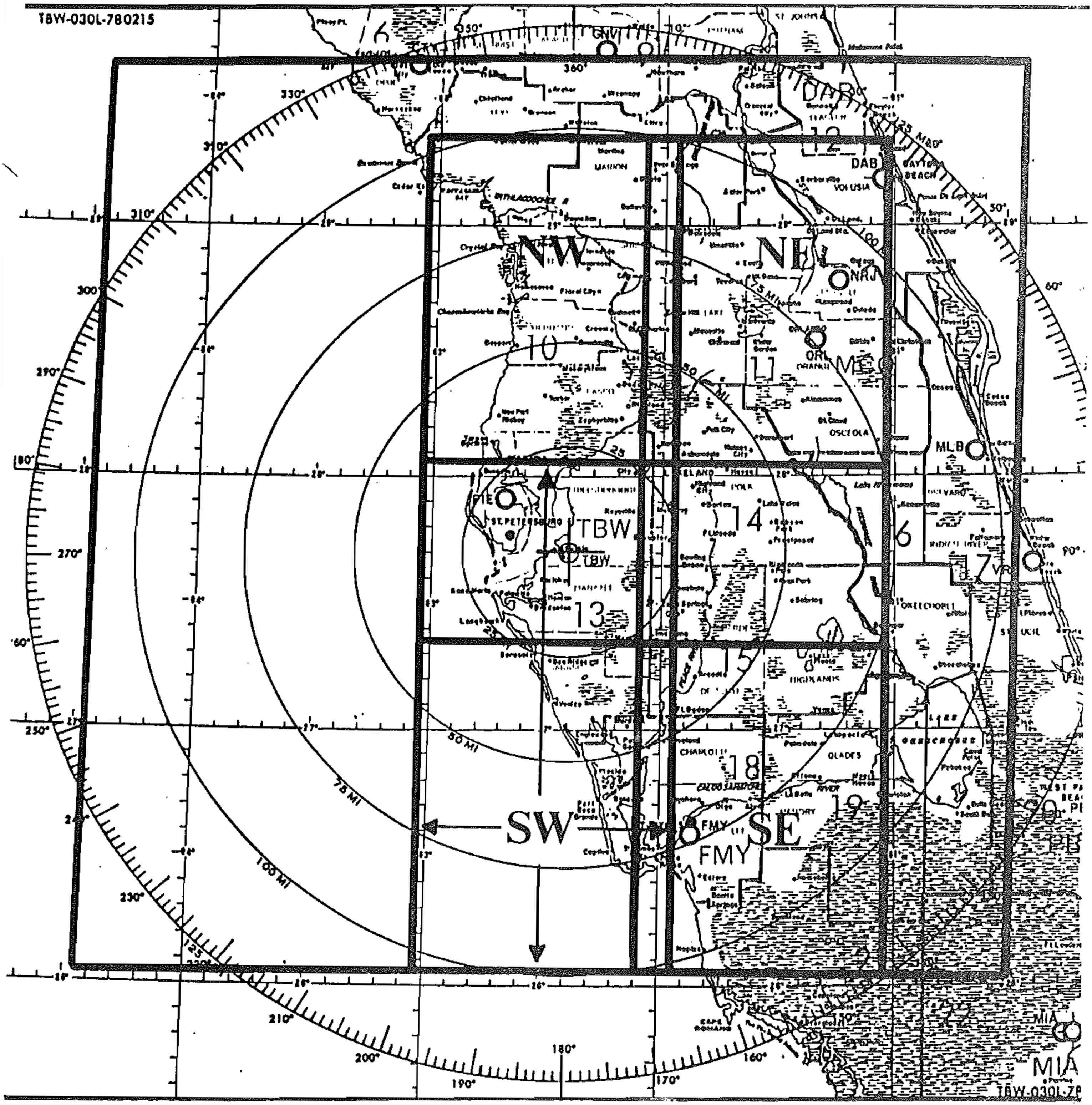


Figure 9...Decoding Grids for the Tampa Bay-RADAP Comparison Programs. The outer square represents the bounds of the 125 NM RADAP Grid. The subsectors cover the Tampa Bay WSO County Warning Area of Responsibility.

Figure 10...Encoded Lightning Data on the RADAP GRID.

```
                TBW LIGHTNING FREQUENCY MAP BASED ON RADAP II GRID
                   DATA FOR 15 MINUTES ENDING 0400Z MAY-25-88

     LIGHTNING TOTALS  0   1-10 11-20 21-30 31-40 41-50 51-60 61-70 71-80 >80
               VALUES  0    1     2     3     4     5     6     7     8    9

     108  96  84  72  60  48  36  24  12   0  12  24  36  48  60  72  84  96 108
      .W...W...W...W...W...W...W...W...W...*...E...E...E...E...E...E...E...E...E

120N 00000000000000000000000000000100000010000001110001000000000000000000000000
115N 00000000000000000000000000000000000100000001010000000000000000000000000000
110N 00000000000000000000000000000000000000000001010000000000000000000000000000
105N 00000000000000000000000000001000000110101111110000001000000000000000000000
100N 00000000000000000000000000000000000010000111110100100100000000000000000000
 95N 00000000000000000000000000000001100000000011200000000000000000000000000000
 90N 00000000000000000000000000000000000000000101110000000010000000000000000000
 85N 00000000000000000000000000000000000000000111100000000000000000000000000000
 80N 00000000000000000000000000000000000000000110110000000000000000000000000000
 75N 00000000000000000000000000000000000010010011110000000000000000000000000000
 70N 00000000000000000000000001000000000001001112220000000000000000000000000000
 65N 00000000000000000000000000000000000001100011121000000000000000000000000000
 60N 00000000000000000000000000000000000010001241110010000000000000000000000000
 55N 00000000000000000000000000000000000000101111000001000000000000000000000000
 50N 00000000000000000000100000000000000011000100000000000000000000000000000000
 45N 00000000000000000000000100000000000010000000000000000000000000000000000000
 40N 00000000000000000010000000000000000011011101010000000000000000000000000000
 35N 00000000000000000000000000000000100010111212110000000000000000000000000000
 30N 00000000000000000000100000001000110001351123100000000000000000000000000000
 25N 00000000000100000000000000000000100102672341000000000000000000000000000000
 20N 00000000000000000000000000000001000012421100000000000000000000000000000000
 15N 00000000000000000000000000000000000111100000000000000000000000000000000000
 10N 00000000000000000000000000000001111100000000000000000000000000000000000000
  5N 00000000000000001000000000000001211000000000000000000000000000000000000000
  0* 00000000001011110000000000000001110000000000000000000000000000000000000000
  5S 00000000001010101000000000001000000000000000000000000000000000000000000000
 10S 00000000000100000000000000000000000000000000000000000000000000000000000000
 15S 00000000000000000000000000000000000000000000000000000000000000000000000000
 20S 00000000000000000000000010000000000000000000000000000000000000000000000000
 25S 00000000000000000000000000000000000000000000000000000000000000000000000000
 30S 00000000000000000000000000000000000000000000000000000000000000000000000000
 35S 00000000000000000000000000000000000000000000000000000000000000000000000000
 40S 00000000000000000000000000000000000000000000000000000000000000000000000000
 45S 00000000000000000000000000000000000000000000000000000000000000000000000000
 50S 00000000000000000000000000000000000000000000000000000000000000000000000000
 55S 00000000000000000000000000000000000000000000000000000000000000000000000000
 60S 00000000000000000000000000000000000000000000000000000000000000000000000000
 65S 00000000000000000000000000000000000000000000000000000000000000000000000000
 70S 00000000000000000000000000000000000000000000000000000000000000000000000000
 75S 00000000000000000000000000000000000000000000000000000000000000000000000000
 80S 00000000000000000000000000000000000000000000000000000000000000000000000000
 85S 00000000000000000000000000000000000000000000000000000000000000000000000000
 90S 00000000000000000000000000000000000000000000000000000000000000000000000000
 95S 00000000000000000000000000000000000000000000000000000000000000000000000000
100S 00000000000000000000000000000000000000000000000000000000000000000000000000

     108  96  84  72  60  48  36  24  12   0  12  24  36  48  60  72  84  96 108
      .W...W...W...W...W...W...W...W...W...*...E...E...E...E...E...E...E...E...E

                     TOTAL NUMBER OF STROKES IN GRID:   948
```

Figure 11...Quantitative Output from a subsector of figure 10.

TBW - HIGH RESOLUTION LIGHTNING FREQUENCY MAP BASED ON RADAP II GRID
DATA FOR 15 MINUTES ENDING 0400Z MAY-25-88

	33 W	30 W	27 W	24 W	21 W	18 W	15 W	12 W	09 W	06 W	03 W	00 *	03 E	06 E	09 E	12 E	15 E	18 E	21 E	24 E
100N	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	5	3	8	4	1
95N	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	5	1	10	17	0
90N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	4	1	2
85N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	6	2	1	0
80N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	2	0	1	1
75N	0	0	0	0	0	0	0	0	0	0	2	0	0	3	0	0	4	1	10	1
70N	0	0	0	0	0	0	0	0	0	0	0	3	0	0	1	1	6	19	20	11
65N	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	8	4	6	14
60N	0	0	0	0	0	0	0	0	0	0	1	0	0	0	4	19	31	9	6	3
55N	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	9	10	2	0	0
50N	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	2	0	0	0	0
45N	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0
40N	0	0	0	0	0	0	0	0	0	0	1	2	0	1	2	6	0	2	0	4
35N	0	0	0	0	0	0	1	0	0	0	1	0	2	5	7	11	5	16	6	5
30N	0	0	1	0	0	0	1	1	0	0	0	7	25	48	6	4	13	22	3	0
25N	0	0	0	0	0	0	1	0	0	1	0	13	53	65	14	25	35	2	0	0
20N	0	0	0	0	0	2	0	0	0	0	8	16	31	13	2	2	0	0	0	0
15N	0	0	0	0	0	0	0	0	0	3	7	7	1	0	0	0	0	0	0	0
10N	0	0	0	0	0	1	3	6	6	6	0	0	0	0	0	0	0	0	0	0
5N	0	0	0	0	0	4	14	1	1	0	0	0	0	0	0	0	0	0	0	0
0*	0	0	0	0	0	2	1	2	0	0	0	0	0	0	0	0	0	0	0	0
5S	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10S	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15S	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20S	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TOTAL NUMBER OF STROKES IN NW GRID: 868

Figure 12...Output from the Research Program, MDR_DECODER.

FLORIDA LIGHTNING AND RADAR EXPERIMENT
NATIONAL WEATHER SERVICE FORECAST OFFICE MIAMI FLORIDA

MDR LIGHTNING ANALYSIS SUMMARY

DATA FOR DATE: OCT 02 1988-TIME PERIOD: 2320 - 2335Z

MDR GRID (20NM X 20NM)/ CENTER BASED AT MIAMI FL (25.71N/80.29W)
M/FFF WHERE M=ACTUAL RADAR ENCODED VIP, FFF=LTG FREQUENCY PER MDR BLOCK

	G	H	I	J	K	L	M	N	O	P	Q	R	S
G	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000
H	0/000	0/000	0/000	3/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000
I	0/215	9/012	0/000	3/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000
J	9/055	4/087	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000
K	9/050	4/040	4/176	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000
L	0/000	0/024	0/003	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000
M	0/000	0/000	0/000	4/000	2/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000
	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000
O	0/000	0/000	3/000	0/000	0/000	0/000	0/000	0/000	0/000	2/000	2/000	0/000	0/000
P	0/000	0/000	2/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000
Q	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000
R	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000
S	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000	0/000

TOTAL NUMBER OF STROKES DECODED DURING TIME PERIOD: 692

FLARE SPECIAL RADAR TOP INFORMATION

#	MAX CELL VIP	ECHO TOP (FTx100)	LAT (N)	LON (W)	MDR BLOCK
1	4	500	26.913	81.359	KI
2	4	360	26.535	81.331	LI
3	4	360	26.493	81.277	LJ
	4	360	26.756	81.709	LH
	4	330	26.142	81.219	MJ

archived on the radar PPI recorder and presents the actual PPI presentation in a printed output showing radar intensity levels as gray shades. A second program was developed to take the archived lightning information and overlay the lightning stroke positions directly on the printed PPI output. Examples of this output are in figure 13.

VII. ACKNOWLEDGMENTS

The author would like to thank the following persons for their contributions to the project. Credit should first go to the man who envisioned the project, Paul Hebert (MIC WSFO MIA). Without his leadership and support, this project would have stalled in its infancy. Without help from Southern Region Headquarters, the project would have been without a computer, and for a time Weather Service Headquarters financed a dedicated FTS line. Ray Fagen of the National Hurricane Center contribued at the beginning with his programming expertise, and Mike Black and Peter Dodge of AOML/HRD produced post-processing routines for the project. And last but not least, Ray Biedinger (DMIC WSFO MIA), managed the day-to-day decisions required for a project of this size. His enthusiasm and desire to learn exemplify the best in NWS management.

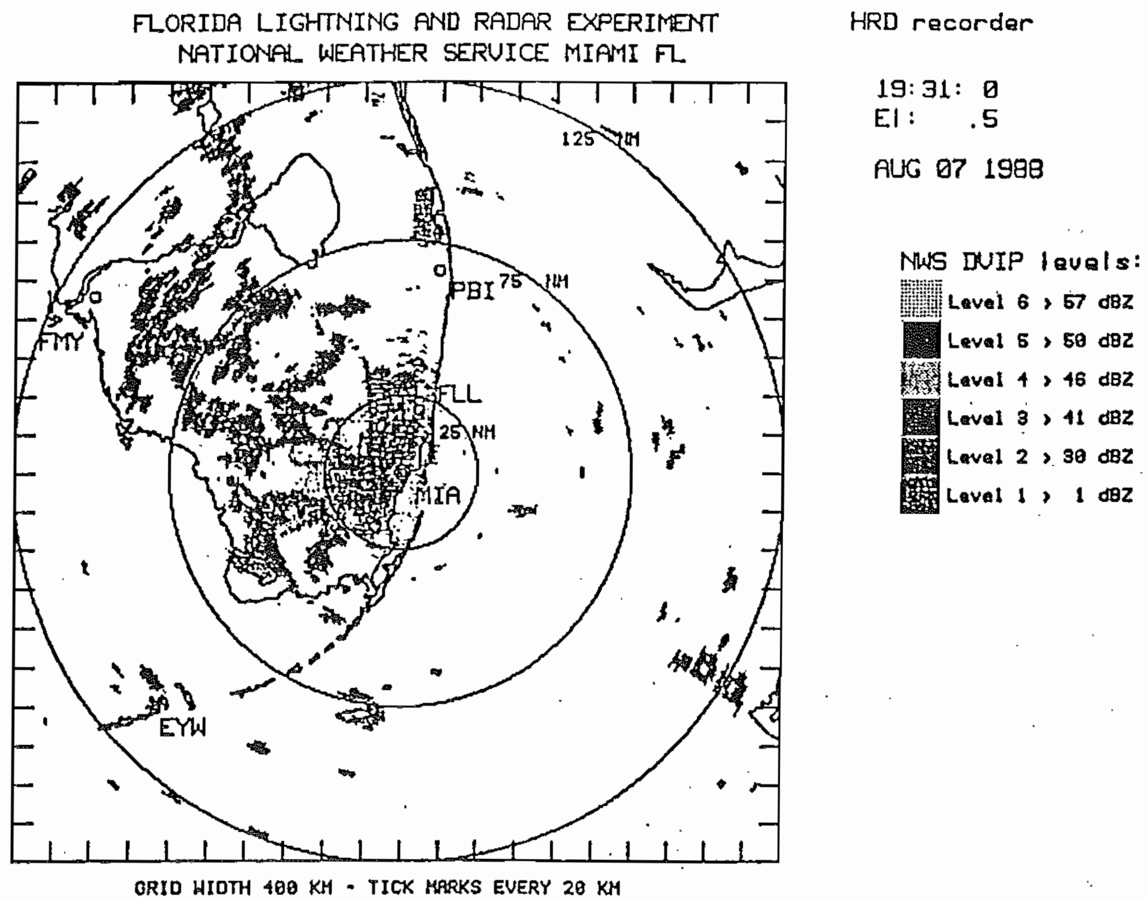
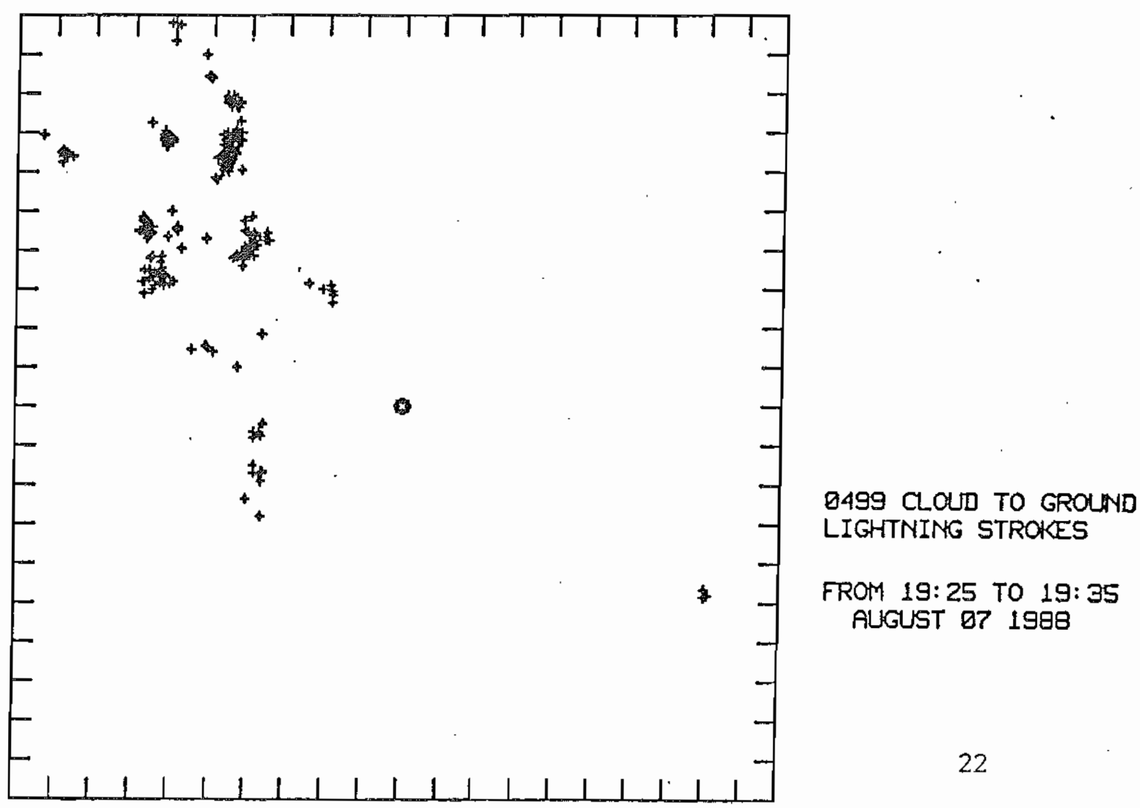


Figure 13...(Top) Plan Position Indicator data (PPI) can be saved on computer tape, and then reproduced in this format for research purposes.
(Bottom) Lightning Strike data that can be directly overlayed on the top figure to subjectively see stroke position vs. echo (DVIP) position.



APPENDIX A - SYSTEM TROUBLESHOOTING

The FLARE software has proven to be a very reliable way to gather and archive radar and lightning data. However, in the event of possible problems, a troubleshooting guide follows.

1). The computer will not stop making a variable pitch alarm, and a list of instructions popped up on the screen (figure A1).

This indicates that the archive disk (lower disk drive) is full and the archive system could not verify a completed data transfer. Simply follow the instructions on the screen (figure 7). Fresh archive disks are located in the disk storage box next to the computer.

2). What if there are no more formatted archive disks?

Ask the DMIC for a box of new disks. Go to the marine IBM/ABT and place the new floppy diskette in the "A" disk drive. Quit Superwriter, and at the "C" prompt, type NEW_DISK and follow the instructions.

If the batch file NEW_DISK is not available, follow these directions:

```
type:    FORMAT A:
         PRESS RETURN TO BEGIN FORMATTING.
```

If you want to format more than one disk, place a new diskette in the "A" drive at the prompt and continue the formatting at the prompt. When formatting has completed continue with the following:

```
type:    MD A:\LTGDATA    (press RETURN)
type:    MD A:\RADAR      (press RETURN)
type:    MD A:\SURFACE    (press RETURN)
```

This sequence must be performed on ALL newly formatted disks. To return the computer to Superwriter, perform the following:

```
type:    HELP          (press RETURN)
type:    1             (press RETURN)
```

This process creates the subdirectories needed for FLARE data archiving. If the formatting routine indicates that the disk has bad blocks or that sectors cannot be formatted, do not attempt to use the disk as an archive disk.

3. If after placing a new archive disk in the archive (lower) drive, the computer continues to sound the "archive full" alarm.

In this case, the system needs to be reset. Without changing the new archive disk, simply press the white RESET button located near the main power switch. Follow the screen instructions for system initialization.

4. During the data decoding program, the system started to beep and it was not trying to archive.

The printer was taken off line. Simply go to the printer and press the "ON LINE" button, Output will immediately follow and the beeping will cease.

5. If the office just suffered a power "surge", or switched to/from emergency generator power, the system will likely need resetting.

If the power was off long enough for the entire system to power down, the system disk has an auto-executable macro that will reload the system software. All the operator needs to do is answer the questions about the system date and time (ALWAYS enter "Z" date and time!). If the system was knocked down by a strong surge and is sitting at the "A" prompt, it is best to press the RESET button by the main power switch. During any power change, there is a high potential that data stored in volatile memory may be garbled. It is always advisable to reset the system after a power change.

6. The system has not been able to get fresh lightning data from the central analyzer for some time. Is there a problem with the programming?

Not likely, because of its track record. However, there may be a problem with the FTS line or circuit. Personnel can check by turning up the volume knob located on the back of the modem. This will allow operators to listen as the modem opens the phone circuit, checks for a dial tone, dials the number to the analyzer and waits for the carrier signal. If it has been determined that there is a line problem, consult the station duty manual for instructions on reporting FTS line problems.

7. If the system disk goes bad after several months of constant use.

Backup system disk #1 is located in the archive disk box next to the computer. Place this disk into the top drive and press the RESET button. Place the old system disk in its jacket and leave the disk and a note explaining the problem with the ASM, DMIC or project manager. (System backup #2, and the system master disk are on file with the DMIC. These should not be used if backup #1 fails in case there is a hardware failure. This should be brought to the attention of the electronic technicians, DMIC and the project manager.)

8. While working with the Work Station program, a prompt showing a break in the procedure occurred.

Every effort has been made to "debug" the programs. However, if something does happen to "crash" the program, write the message from the screen down (including the line number that trapped the program), and explain what was pressed to lead to the problem. Leave this note with the DMIC or project manager. To restart the program, move the cursor to the bottom left portion of the screen by use of the down arrow. Once there, type RUN and press the RETURN key. This should restart the program. If this fails, press the RESET button and follow the instructions for system startup.

9. Pressing the reset button did not restart the system. What next?

The system can be totally "powered down" by turning off the main power switch next to the RESET button. The power switch for the modem is a small toggle on the back panel of the modem. If turning the system off, waiting a few minutes, then turning it back on does not help, turn the system off again and wait for the DMIC, program manager and electronics technicians to check the system out.

10. How does one stop the program?

Attempt to stop the computer only when the main lightning screen is displayed. Stopping the system during a cycle may leave the phone connected or data files open on the disk. To stop the system, press the key F10 key on the main menu. On the miscellaneous system command menu, press the key F1 for instant dial. IMMEDIATELY PRESS DOWN THE CONTROL KEY AND PRESS THE LETTER C. The system will ask if you want to abort the batch file. Respond with a Y and press RETURN. The operating system prompt "A" will now appear and the FLARE software will remain idle. Restart the macro by typing FLARE.

Figure A1...Instruction Screen for Changing the Archive Disk.

ARCHIVE DISK IS FULL! PLEASE FOLLOW THESE INSTRUCTIONS

1. Press FUNCTION KEY F1 to STOP alert tone.
2. Open door to BOTTOM disk drive.
3. Take out ARCHIVE DISK. Note the archive DISK NUMBER.
4. Open the DISK STORAGE BOX next to this computer and Take out the NEXT SEQUENTIALLY NUMBERED DISK.
5. Place the new disk in the BOTTOM drive and CLOSE the door. Place the old disk in the empty jacket and replace at the REAR of the DISK STORAGE BOX.
6. Press FUNCTION KEY F10 to CONTINUE operations.

Figure A2: Program LTGDEC Graphic Data Input Screens.

```
FLORIDA LIGHTNING AND RADAR EXPERIMENT
** LIGHTNING DECODER PROGRAM **

USE THE BACKSPACE KEY TO ERASE ERRORS

ENTER THE LIGHTNING FILENAME (INCLUDE DRIVE I.D. OR SUBDIRECTORY IF NEEDED)
     FILENAME:  MAY2788.00Z     ** STATUS OK **

ENTER THE GRID SPACING INTERVAL IN HUNDREDTHS OF A DEGREE [I.E. .05 OR .10]
     GRID INTERVAL:  0.05 DEGREES

ENTER THE NORTHWESTERN-MOST POINT IN YOUR GRID [IN DEGREES]
     LATITUDE: 26.600     LONGITUDE: 81.000

PRESS RETURN TO CONTINUE:
```

Screen 1:

- a) Input Filename
- b) Input Grid Spacing Interval
- c) Input the Northwest point of Grid (in (Degrees of Latitude & Longitude)

```
FLORIDA LIGHTNING AND RADAR EXPERIMENT
** LIGHTNING DECODER PROGRAM **

INPUT MINUTE TO START DECODING     ===> 0

ENTER TIME STEP INCREMENT (I.E. 5 OR 10 MIN ) ===> 15

INPUT MINUTE TO END DECODING       ===> 60
```

Screen 2:

- a) Input Decode Start Time
- b) Input Time Step Increment
- c) Input Decode Stop Time

```
FLORIDA LIGHTNING AND RADAR EXPERIMENT
** LIGHTNING DECODER PROGRAM **

DATA INPUT FILE:          MAY2788.00Z             FILESIZE:     9984 BYTES
NORTHWEST GRID COORD:     LAT 26.600  LON 81.000  FILEPOINTER:  78 RECORDS
DECODE INCREMENT:         0.05 DEGREES            MINUTE MARKER 5

START TIME:  0  END TIME:  60   STEP INCREMENT:  15

DECODING PASS # 1
```

Screen 3:

- a) Decoder Status
- b) Output is spooled to printer

```
DATA QUALITY CONTROL PROGRAM        FILENAME: MAY2788.00Z

CHECKING DATA FOR FILE: MAY2788.00Z
MINUTE MARKER  1   TOTAL STROKES    0   CHANGE 0 *
MINUTE MARKER  2   TOTAL STROKES   32   CHANGE 32
MINUTE MARKER  3   TOTAL STROKES   49   CHANGE 17
MINUTE MARKER  4   TOTAL STROKES   72   CHANGE 23
MINUTE MARKER  5   TOTAL STROKES   82   CHANGE 10
MINUTE MARKER  6   TOTAL STROKES  105   CHANGE 23
MINUTE MARKER  7   TOTAL STROKES  114   CHANGE 9
MINUTE MARKER  8   TOTAL STROKES  135   CHANGE 21
MINUTE MARKER  9   TOTAL STROKES  155   CHANGE 20
MINUTE MARKER 10   TOTAL STROKES  184   CHANGE 29
MINUTE MARKER 11   TOTAL STROKES  211   CHANGE 27
MINUTE MARKER 12   TOTAL STROKES  229   CHANGE 18
MINUTE MARKER 13   TOTAL STROKES  234   CHANGE 5
MINUTE MARKER 14   TOTAL STROKES  256   CHANGE 22
MINUTE MARKER 15   TOTAL STROKES  270   CHANGE 14
MINUTE MARKER 16   TOTAL STROKES  287   CHANGE 17
MINUTE MARKER 17   TOTAL STROKES  309   CHANGE 22
MINUTE MARKER 18   TOTAL STROKES  324   CHANGE 15
MINUTE MARKER 19   TOTAL STROKES  346   CHANGE 22
MINUTE MARKER 20   TOTAL STROKES  364   CHANGE 18
MINUTE MARKER 21   TOTAL STROKES  390   CHANGE 26
MINUTE MARKER 22   TOTAL STROKES  416   CHANGE 26
MINUTE MARKER 23   TOTAL STROKES  436   CHANGE 20
MINUTE MARKER 24   TOTAL STROKES  463   CHANGE 27
MINUTE MARKER 25   TOTAL STROKES  500   CHANGE 37
MINUTE MARKER 26   TOTAL STROKES  540   CHANGE 40
MINUTE MARKER 27   TOTAL STROKES  585   CHANGE 45
MINUTE MARKER 28   TOTAL STROKES  640   CHANGE 55
MINUTE MARKER 29   TOTAL STROKES  682   CHANGE 42
MINUTE MARKER 30   TOTAL STROKES  725   CHANGE 43
MINUTE MARKER 31   TOTAL STROKES  786   CHANGE 61
MINUTE MARKER 32   TOTAL STROKES  823   CHANGE 37
MINUTE MARKER 33   TOTAL STROKES  874   CHANGE 51
MINUTE MARKER 34   TOTAL STROKES  941   CHANGE 67
MINUTE MARKER 35   TOTAL STROKES  992   CHANGE 51
MINUTE MARKER 36   TOTAL STROKES 1060   CHANGE 68
MINUTE MARKER 37   TOTAL STROKES 1109   CHANGE 49
MINUTE MARKER 38   TOTAL STROKES 1161   CHANGE 52
MINUTE MARKER 39   TOTAL STROKES 1195   CHANGE 34
MINUTE MARKER 40   TOTAL STROKES 1206   CHANGE 11
MINUTE MARKER 41   TOTAL STROKES 1224   CHANGE 18
MINUTE MARKER 42   TOTAL STROKES 1285   CHANGE 61
MINUTE MARKER 43   TOTAL STROKES 1356   CHANGE 71
MINUTE MARKER 44   TOTAL STROKES 1414   CHANGE 58
MINUTE MARKER 45   TOTAL STROKES 1489   CHANGE 75
MINUTE MARKER 46   TOTAL STROKES 1538   CHANGE 49
MINUTE MARKER 47   TOTAL STROKES 1591   CHANGE 53
MINUTE MARKER 48   TOTAL STROKES 1622   CHANGE 31
MINUTE MARKER 49   TOTAL STROKES 1654   CHANGE 32
MINUTE MARKER 50   TOTAL STROKES 1697   CHANGE 43
MINUTE MARKER 51   TOTAL STROKES 1767   CHANGE 70
MINUTE MARKER 52   TOTAL STROKES 1816   CHANGE 49
MINUTE MARKER 53   TOTAL STROKES 1872   CHANGE 56
MINUTE MARKER 54   TOTAL STROKES 1919   CHANGE 47
MINUTE MARKER 55   TOTAL STROKES 1919   CHANGE 0 *
MINUTE MARKER 56   TOTAL STROKES 1964   CHANGE 45
MINUTE MARKER 57   TOTAL STROKES 2029   CHANGE 65
MINUTE MARKER 58   TOTAL STROKES 2077   CHANGE 48
MINUTE MARKER 59   TOTAL STROKES 2138   CHANGE 61
MINUTE MARKER 60   TOTAL STROKES 2169   CHANGE 31
MINUTE MARKER 61   TOTAL STROKES 2212   CHANGE 43
MINUTE MARKER 62   TOTAL STROKES [illegible]   CHANGE [illegible]
```

Figure A3: CK_DATA Output.

The total number of lightning strokes detected per minute are displayed and accumulated.

If no change is detected from one minute to the next, a '*' will appear next to the line (i.e. minute #55).

APPENDIX B - PROGRAM DOCUMENTATION

Section I). LPATS High Resolution Lightning Decoder

Program Code Name: LTGDEC.PAS
Compiled Name: LTGDEC.COM

Language: Turbo Pascal (Version 3.0)
Purpose: To enable the forecaster, both in operations and in research, to produce gridded quantitative lightning output.

Input Files: Data File of form MMMDDYY.XXZ

Where MMM = 3 letter identifier for the month
DD = 2 letter identifier for the day
YY = 2 letter identifier for the year
XX = 2 letter identifier for the hour
Z = common letter to denote Z time.

Examples of input filenames:
MAY2489.01Z = Data for May 24, 1989 for the time period 00z-01z.

B:\LTGDATA\MAY2489.01Z = Same time period as above except file is located in a subdirectory on the B drive.

NOTE: When compiling this program, the following files MUST be resident on disk: GRAPH.P and GRAPH.BIN

Output: Data is output directly to printer. See Figure 8 in the text for output example.

Instructions for use:

Set the computer in the directory where LTGDEC.COM resides.
Be sure that the printer is ON-LINE.
Type the command: LTGDEC (Press Return)

Follow the instructions on the graphic screen (see figure A2).
1). Enter the Data Filename.
2). Enter the Grid Decoding Interval.
3). Enter the Coordinates of the Northwest point of the Decoding Grid in Latitude and longitude (if needed to 3 significant digits).
4). Enter the time to start decoding (In the file MAY2489.01Z, an entry of '0' would mean that decoding would begin with data at 00Z. An entry of '15' would begin decoding at 0015Z.

5). Enter the Time Step Increment. This allows for multiple output grids to be produced off of the same decoded file.
6). Enter the time to stop decoding.

Example: Start time 0...Step Increment 15...Stop time 60. This would produce 4 gridded outputs of time intervals: 00-15, 15-30, 30-45, and 45-60 minutes.
Example: Start time 15...Step increment 15...Stop time 30. This would produce 1 gridded output of time interval: 15-30.

When completed, the computer will return to the DOS prompt. To restart the program, type LTGDEC.

Section II). RADAP Comparison Programs

Program Code names: RADAP.PAS
TBWDECODER.PAS
Compiled Names: RADAP.COM
TBWDECODER.PAS

Language: Turbo Pascal (Version 3.0)
Purpose: To enable forecasters at the Tampa Bay (TBW) Weather Service Office to:

1). Compare gridded lightning output directly with RADAP output (Program RADAP).
2). Produce High Resolution output using the RADAP decoding grid (Program TBWDECODER).

Input Files: Data File of form MMMDDYY.XXZ

See Section I, Input Files for details on this filename.

NOTE: When compiling this program, the following files MUST be Resident on disk: GRAPH.P and GRAPH.BIN

Output: Data is output directly to printer. See Figures 10 and 11 in the text for output examples.

Instructions for use:

Set the computer in the directory where RADAP.COM or TBWDECODER.COM reside. Be sure that the printer is ON-LINE. Type the command: RADAP or TBWDECODER to start the programs.

Follow the instructions on the graphic screen.
1). Enter the Data Filename.

If TBWDECODER is running, choose the decoding sector (NW, NE, SE, or SW...See Figure 9 for map background).
2). Enter the time to Start Decoding.
3). Enter the Time Step Increment.
4). Enter the Time to Stop Decoding.

For examples on steps 2-4, see Section I, Instruction section. When the program is completed, the computer will return to the DOS prompt. To restart the program, type the program name.

Section III). Data Check Program

Program Code Name: CK_DATA.PAS
Compiled Name: CK_DATA.COM

Language: Turbo Pascal (Version 3.0)
Purpose: To indicate where possible bad blocks of data may be in the data input file. Occasionally, noise from the phone line or interference from nearby electrical storms will produce a bad block of data. When consistent lightning is known to have occurred, this program will locate and flag all markers that have a stroke count of zero (see Figure A3).

Input Files: Data File of form MMMDDYY.XXZ

See Section I, Input Files for details on this filename.

Output: Data is output directly to printer. See Figure A3 for an example.

Instructions for use:

Set the computer in the directory where CK_DATA resides.
Be sure that the printer is ON-LINE.
Type the command: CK_DATA (Press Return)

1). Enter the data Filename.
2). Output is spooled to the printer.

When completed, the computer will return to the DOS prompt. To restart the program, type CK_DATA.

VI). Lightning Decoder Research Programs

Program Names: MDR_DECODER.PAS
AUTO_DECODER.PAS

```
Compiled Name:  MDR_DECODER.COM
                AUTO_DECODER.COM

Language:   Turbo Pascal (Version 3.0)
Purpose:    To correlate lightning and radar data into a similar
            frame of reference to study lightning strokes per
            MDR block and radar echo tops versus lightning
            frequency.

Data Files:  SET_UP_FILE ... Must be located on same disk as
                              .COM program file. Contains ASCII
                              data to direct program flow. Use
                              following format:

                              Line 1: Program Drive Name
                              Line 2: Data Drive Name/Subdir
                              Line 3: Radar Drive Name/Subdir
                              Line 4: Manual Tops Drive/Subdir
                              Line 5: Archive Drive/Subdir

             MDRDATA      ... Contains MDR grid labels.
             MDRGRID.DAT  ... Contains MDR Subgrid.
             MDRGRID2.DAT ... Contains MDR Main Grid.
             YINTCPT.DAT  ... Contains MDR Decode Grid Coords.

Input Files:  1). Lightning Filename in Format:  MMMDDYY.XXZ
                  (i.e. MAY2788.00Z)-Uses Coded Lightning data.
              2). Radar Filename in Format:      MMMDDXX.30Z
                  (i.e. MAY2723.30Z)-Uses Actual Radar SD.
              3). Manual Top Filename in Format: MMM.DAT
                  (i.e. MAY.DAT)-Uses the following Format:
                  012330 3 320 65 480 2 340 60 330
                  where 012330 is the SD Date/Time Group
                        3      is the DVIP Value
                        320    Radar Azimuth
                        65     Radar Range
                        480    Radar Echo Top (x 100 feet)
                  Up to 10 tops can be decoded at once.
```

AUTO_DECODER.PAS differs from MDR_DECODER.PAS only by the fact that AUTO_DECODER.PAS will step through 23 consecutive hours worth of data starting at 00z through 23z. Because the calendar day changes with the last radar observation and hourly lightning archive, the MDR_DECODER.PAS must be used. (i.e. Lightning Archive Filename: MAY2788.00z while Radar Filename: MAY2623.30Z)

Both programs use a menu display for data entry (figure A4). As lightning strokes are decoded, they are displayed on a map of south Florida for visual verification.

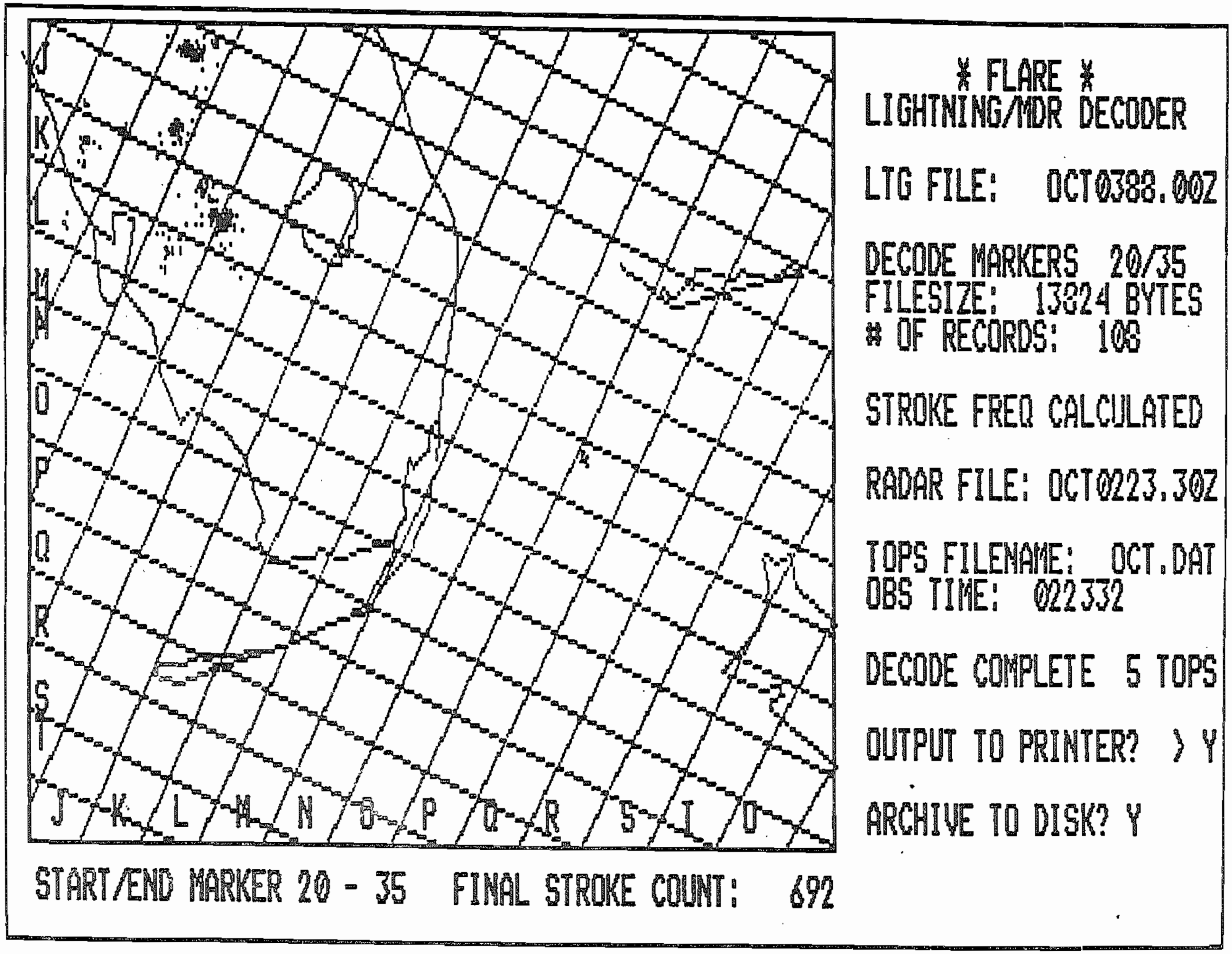


Figure A4: Graphics Display of the MDR_DECODER and AUTO_DECODER Programs.