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Preliminary Memphis FAA/Lincoln Laboratory Operational Weather Studies Results

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16. Abstract

During 1984 and 1985 M.I.T. Lincoln Laboratory, under the sponsorship of the Federal Aviation Administration (FAA) conducted a measurement program in the Memphis, Tennessee, area to study low-level wind shear events and other weather phenomena that are potentially hazardous to aircraft operations, with particular emphasis on those issues related to the Terminal Doppler Weather Radar (TDWR). The principal sensor for the measurement program was the S-band FAA-Lincoln Laboratory Testbed Doppler Weather Radar (FL2) which incorporates many of the functional features of the TDWR. Both FL2 and a C-band Doppler Weather Radar operated by the University of North Dakota (UND) obtained reflectivity, mean velocity and spectrum width measurements with a radar geometry and scan sequences to facilitate determining the surface outflow features of microbursts at the anticipated TDWR ranges. A 30-station network of automatic weather stations (mesonet) collected 1-min averages of temperature, humidity, pressure, wind speed and direction, and total rainfall, plus the peak wind speed during each minute; this system operated from about March through November 1984 and 1985. Finally, the UND Citation aircraft operated two 3-week periods during 1985, collecting thermodynamical, kinematical and microphysical data within and around selected storms in the area as well as providing *in situ* truth for locations and intensity of turbulence.

This report describes the principal initial results from the Memphis operations, stressing the results from 1985 when the FL2 radar was fully operational. These results are compared to those from previous studies of wind-shear programs, e.g., NIMROD near Chicago, JAWS and CLAWS near Denver. During 1985, 102 microbursts were identified in real time along with 81 gust fronts. One of the dominant results is that most microbursts in the mid-south are wet; that is, they are accompanied by significant rainfall. This is in contrast, for example, to the results from Denver where more than half of all microbursts have little or no appreciable rain reaching the ground. Aside from this major difference, microbursts near Memphis were similar to those found elsewhere in the country in terms of wind shear magnitude. The report also gives more representative results from the aircraft operations and discusses the effectiveness of the ground-clutter filters used on the FL2 radar.

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ABSTRACT

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This report describes the principal initial results from the Memphis operations, stressing the results from 1985 when the FL2 radar was fully operational. These results are compared to those from previous studies of wind-shear programs, e.g., NIMROD near Chicago, JAWS and CLAWS near Denver. During 1985, 102 microbursts were identified in real time along with 81 gust fronts. One of the dominant results is that most microbursts in the mid-south are wet; that is, they are accompanied by significant rainfall. This is in contrast, for example, to the results from Denver where more than half of all microbursts have little or no appreciable rain reaching the ground. Aside from this major difference, microbursts near Memphis were similar to those found elsewhere in the country in terms of wind shear magnitude. The report also gives more representative results from the aircraft operations and discusses the effectiveness of the ground-clutter filters used on the FL2 radar.

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LIST OF ACRONYMS

AP	Anomalous Propagation
ASR	Airport Surveillance Radar
CDT	Central Daylight Time
CFT	Common Radar Data Format
CHILL	University of Chicago/Illinois State Water Survey
CIDF	Lincoln Laboratory Common Instrument Data Format
CLAWS	Classify, Locate and Avoid Wind Shear Project
CWP	Central Weather Processor
CWSU	Central Weather Service Unit
DIFAX	Digital Facsimile
FAA	Federal Aviation Administration
FIR	Finite Impulse Response
FL-2	FAA/Lincoln Laboratory Testbed Doppler Radar
FLOWS	FAA/Lincoln Laboratory Operational Weather Studies
GOES	Geostationary Operational Environmental Satellites
INS	Inertial Navigation System
JAWS	Joint Airport Weather Studies
LAWS	Low-Altitude Wind Shear
LLWAS	Low-Level Windshear Alert System
mesonet	Mesoscale network (of weather stations)
MIT	Massachusetts Institute of Technology
NCAR	National Center for Atmospheric Research
NEXRAD	Next Generation Radar
NIMROD	Northern Illinois Meteorological Research on Downbursts
NWS	National Weather Service

PPI	Plan Position Indicator
PRF	Pulse Repetition Frequency
PROBE	Portable Remote Observations of the Environment (name for automatic weather stations)
RHI	Range Height Indicator
RRWDS	Radar Remote Weather Display System
TDWR	Terminal Doppler Weather Radar
UND	University of North Dakota
USAF	United States Air Force
UT	Universal Time
WSI	Weather Service International

PRELIMINARY MEMPHIS FAA/LINCOLN LABORATORY
OPERATIONAL WEATHER STUDIES RESULTS

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1. INTRODUCTION

During 1984 and 1985, MIT Lincoln Laboratory, under the sponsorship of the Federal Aviation Administration (FAA), carried out a data-collection program in the Memphis, Tennessee, area in support of the FAA's programs to detect hazardous aviation weather (especially low-altitude wind shear, or LAWS) using pulse Doppler weather radar. Low-altitude wind shear comes in at least two ways, as microbursts and as gust fronts; this report primarily deals with microbursts but touches upon gust fronts as well at some points. The objectives of the 1984-85 FLOWS (FAA/Lincoln Laboratory Operational Weather Studies) program were to:

(1) Determine the characteristics of LAWS in the humid environment characteristic of the southeast portion of the United States (and to contrast the Memphis LAWS characteristics with those noted in earlier measurement programs in Denver and Chicago (Fujita, 1985) and Oklahoma (Klingle, 1985; Uyeda and Zrnic', 1986)

(2) test certain advanced radar features (especially filters for clutter suppression) which would be utilized in an operational system;

(3) provide data on the performance of algorithms for the detection of other aviation weather hazards (especially turbulence); and

(4) determine operational characteristics for Doppler radar (scanning strategy, on-airport/off-airport location, etc.).

The results from these measurements will be used to develop automatic weather hazard detection capabilities which can be tested (and refined) in subsequent FLOWS programs and then utilized in the NEXRAD (NEXt generation RADar) and terminal Doppler weather radar (TDWR) programs.

This report describes:

(1) the principal characteristics and geometry for the FLOWS sensors,

(2) the data collection periods, including individual summaries for the various days on which low-altitude wind shear was detected during measurements, and

(3) very preliminary microburst analysis results based on observations made during Doppler radar measurements in 1985 as well as automatic weather station observations made during 1984 as an aid to decision making for upcoming LAWS measurements and to facilitate the dissemination of the FLOWS results to the meteorological community.

Chapter 2 describes the principal sensors and data collection procedures for 1984 and 1985. The 1984 FLOWS data were principally obtained by a network of automatic weather stations. Summary results from the 1984 mesonet data analysis are discussed in Chapter 3 to provide background for the 1985 radar data results. This chapter also looks at the comparison between the 1984 mesonet results and those from Project JAWS (Denver) and NIMROD (Chicago). Chapter 4 describes salient characteristics of the 100+ LAWS events (principally microbursts) detected in real time by the radar operators with particular emphasis on those features of significance for TDWR design and siting. Chapter 5 presents very preliminary results on turbulence detection results using the NEXRAD/Central Weather Processor (CWP) algorithms. The final chapter summarizes the salient initial results and discusses the procedures for subsequent indepth analyses.

2. FLOWS SENSORS AND DATA COLLECTION

Data to study low level windshear events came from several sources. These include: Radar, both the Lincoln Lab FL2 radar and the University of North Dakota radar, a surface network of weather stations composed of 30 automatic stations operated by Lincoln Lab and six Low Level Windshear Alert System stations (LLWAS) operated by the FAA around the Memphis airport, the University of North Dakota Citation aircraft, and other standard meteorological data sources.

2.1 Roles and Missions of Various Sensors

Because of our goals of determining the ability of radar to remotely detect windshear events, radar is the primary tool used in the program. The mesonet, on the other hand, provides "ground truth" on events that occurred over it. By comparing what was detected by the radar and the mesonet, we can determine the extent to which a radar can detect windshear events. The aircraft is another means of determining "truth", but in regions within storms well above the ground. Aircraft data are particularly useful in verifying the characteristics of regions in which the radar detects turbulence. The utility of radar to remotely detect turbulence is another area of major concern to the FAA and those interested in aircraft safety.

Besides the emphasis on windshear detection during the season (both microbursts and gust fronts), we also collected data for a number of other purposes. One of these was to study how well the clutter filters used by FL2 were working. From February through November we collected a number of special tapes just of ground clutter. Part of this was to see if there are detectable differences through the year which depend upon how many leaves are on the trees in the area. And finally, we collected a fair amount of data specifically to study the detectability of turbulence by radar.

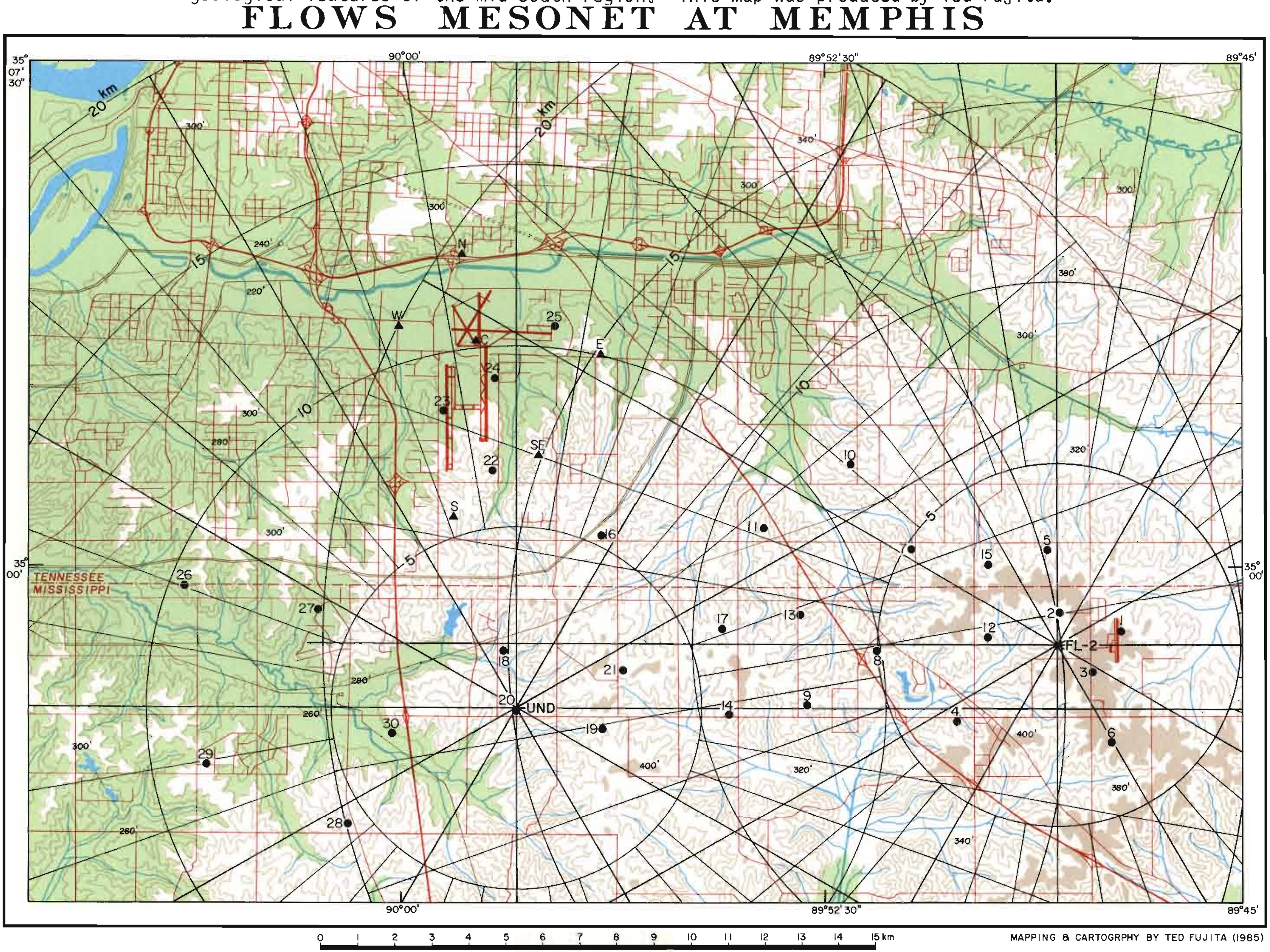
2.2 Mesonet and Radar Geometry

Figure 2.1 is a map of the FLOWS mesonet at Memphis along with the locations of the FL2 and UND radars, the Memphis International Airport, and various other features of the region in and around the field site at Olive Branch, Mississippi. The mesonet station locations shown are those as used during the 1985 field season. The major differences between these locations and those used during 1984 were that

(1) only stations 1-25 were available from the start of operations in early 1984 until about the first of August 1984; stations 26-30 were added at that time; and

(2) the following stations were moved to their present locations as follows:

Figure 2.1 Map of the Memphis area showing the locations of the FL2 and UND radars, the 25 mesonet stations, the Memphis International Airport, and various roads and geological features of the mid-South region. This map was produced by Ted Fujita.



Station Number	Distance Moved (km)	Direction Moved (deg)	Date Moved
4	9.4	toward 230	Feb '85
27	1.6	toward 80	Fall '84

The spacing of the mesonet stations was chosen to try to insure that any microburst that occurred over the network would be detected. Earlier studies of microbursts in the Denver and Chicago areas showed that microbursts are typically only 3 or 4 km across when they first reach the ground; consequently, our weather stations were placed closer together than this. The actual distance between stations is not perfectly uniform but varies from place to place because of practical constraints of locating stations in a well populated metropolitan/suburban region. The average spacing between any one station and its nearest neighbor is 2.3 km (with a standard deviation of 0.7 km); the closest two stations are 1.3 km apart while the furthest stations are 4.2 km apart. These spacings should guarantee that all but the very smallest microbursts will be detected. On the other hand, the disadvantage of close spacing between stations is that, with only 30 stations available, the overall size of the network is moderately small. Our mesonet had an overall east-west extent of about 26 km with a north-south extent of 13 km.

The placement of the radars at Olive Branch (FL2) and Southhaven (UND), Mississippi, was based on three considerations. One was to give good coverage from both sites of the Memphis airport. Both the FL2 and UND radars could be construed to be an "off-airport" radar in the TDWR context. However, the UND radar was located almost exactly south of the two main runways at the airport so that it would be in a good position to detect the component of wind that an aircraft might experience headed either toward the north or south on takeoff or landing. Another consideration was that the radars and mesonet be located in such a way that each system would provide data that would augment data from the other. In reality, the radar sites were chosen first, and the mesonets were located to support the radar observations. And finally, the two radars can be operated in concert to provide dual-Doppler data. The regions of best dual-Doppler coverage are generally north and south of the baseline connecting the two radars (but not along the baseline itself). The northern dual-Doppler region includes some of the mesonet stations as well as the Memphis airport.

2.3 Data Collection Platforms and Operational Procedures

2.3.1 Doppler Weather Radars

2.3.1.1 FL2 Radar

The FL2 radar is an S-band Doppler radar assembled by Lincoln Laboratory using components from a variety of sources. The transmitter and basic components of the receiver are from a standard air-traffic surveillance ASR-8 radar. The antenna pedestal came from an earlier FAA project and the antenna reflector was built to Lincoln Laboratory's specifications by Hayes and Walsh. The antenna was modified to have the same diameter as the NEXRAD systems. The processing, clutter filter, display and recording systems were largely designed and built in-house by the Lab. Table 2.1 lists the main features of the FL2 radar system while Fig. 2.2 is a photograph of the radar before the radome was installed to cover the antenna.

The FL2 radar commenced operations during August 1984 but was struck by lightning twice on the same day late in August, putting it out of commission until late November; no useful weather data were collected with it during 1984. During 1985 the FL2 radar started meteorological data collection on 4 March and continued until 27 November, collecting a total of 963 tapes during the season. All of the radar results which follow are based on data collected during the 1985 field season.

2.3.1.2 UND Radar

The University of North Dakota radar is a C-band weather radar built by Enterprise Electronics Corporation, Enterprise, Alabama, with Doppler processor, recording and display systems built by Sigmet, located in Acton, Massachusetts, and by UND staff members. Table 2.1 also lists the characteristics of the UND radar. Figure 2.3 shows the UND radar site with its radome-covered antenna on top of a 70-ft tower provided by Lincoln Lab.

The UND radar became operational during the middle of 1984 and collected 153 tapes between 15 July and 11 September. During 1985 it was operational from 1 April through 23 September, collecting 310 tapes.

2.3.1.3 Radar Operations

The primary purpose of our radar data collection was to gather data on windshear events in the mid-South region of the country. To meet this requirement, we attempted to operate whenever there were potential wind-producing storms within the area. There were no rigid specifications regarding the start or stop of operations; rather, the decision to operate was made subjectively throughout the season based on a number of criteria. These included the storm's location, intensity, speed and direction of movement and storm type.

Once an operation commenced, the mode of radar operation was also subjectively determined by the operations personnel. In general, the goal was to get complete coverage of a storm cell or a number of adjacent cells, scanning from the bottom to the top within about a 2- to 3-min period and with as high a spatial resolution as possible.

The most frequently used method of collecting data was to do a sector scan of a storm. In a sector scan, the antenna cuts the storm azimuthally at constant elevation, the elevation is incremented, the antenna scans back in the opposite direction, and this whole process repeated to cover the storm from bottom to top. The size of the elevation step is a function of the desired volume scan time, the rate of antenna motion, the number of

Table 2.1
Features of the FL2 and UND radars

Parameter	Units	FL2	UND
Antenna			
Diameter	ft	28	8
Beamwidth	deg	0.96	1.5
Polarization		horizontal	horizontal
Rotation rate			
Maximum	deg/s	30	24
Typical	deg/s	5 to 8	5 to 20
Adaptive scans (PPI, sector scan, RHI)		yes	yes
Transmitter			
Source		klystron	magnetron
Frequency	MHz	2880	5549
Band		S	C
Peak power	MW	1.1	0.25
Signal waveform		uncoded pulse	uncoded pulse
Pulse length	us	0.65	0.6
Pulse repetition rate	1/s	700-1200	250-1100
Receiver			
Band width	MHz	1.3	0.3
Sensitivity time control		no	yes
Minimum detectable signal	dBm	-107	-114.9
Minimum detectable reflectivity (at 50 km range)	dBz	-5.5	-6
Noise figure	dB	4	1.5
Signal Processor			
A/D converter	bits	12	10
Clutter filtering		yes	yes
Number of range gates		800	226
Range-gate spacing	m	120, 240	250, 500

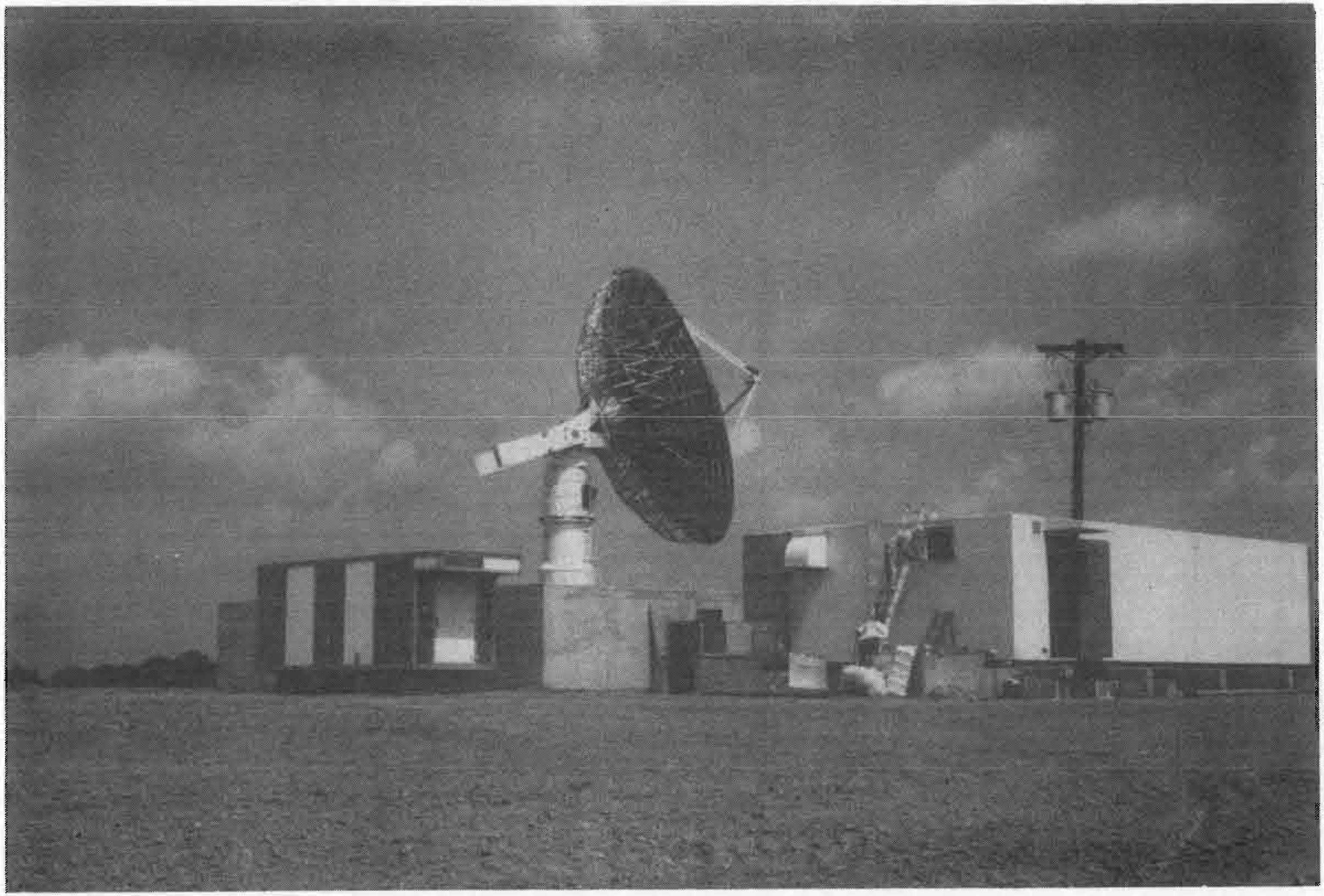


Figure 2.2 Photograph of the FL2 radar site at Olive Branch, Mississippi.

Figure 2.3 Photograph of the UND radar site at Southaven, Mississippi.

elevation angles used, and the azimuthal width of the sector. Because of processing constraints during 1985, we were limited to a maximum scan rate of 5.5 deg/s most of the time. This, in turn, limited our volume scans to contain no more than 6 or 8 elevation scans. By limiting our azimuth widths to cover only a single storm or limited portions of adjacent storms, we were generally able to meet our volume scan time goals.

In addition to the detail provided by concentrated sector scans, we also collected full circle PPI's occasionally to provide an overview of the larger-scale meteorological situation. These 360-deg scans were typically done at only one or two elevation angles; any more than this took more time than was usually desirable.

About midway through the field season it became apparent to radar data users at the Lab that it was desirable to collect some of our data in RHI mode. In this mode the antenna cuts the storm from bottom to top, the antenna changes azimuth slightly, scans back down at the new azimuth, and this sequence is repeated a number of times. Again, the various parameters under the control of the radar operator are balanced to cover as much of the storm as possible in the desired time with the best possible resolution. Since most storms, especially clusters of storms, are much wider than they are tall, RHI data collection is more time-consuming and less efficient than using PPI's because the antenna has to spend more time turning around. On the other hand, convective storms live and die in the vertical; they only get wider because they are getting taller or merging together. RHI's sample a storm in its natural coordinate system - the vertical; PPI's do not; so there are distinct advantages to collecting data using RHI's.

Another disadvantage to collecting data in RHI mode is that it becomes difficult to keep track of where the most important part of the storm is. Thus, just as in sector scan mode, we frequently interspersed full-circle PPI scans and/or sector scans between a series of RHI scans to provide the required overview for aiming the next set of RHI's.

2.3.1.4 Summary of 1985 Radar Data Collection

Figure 2.4a shows the number of tapes collected each month, the number of hours of data collection each month, and (Fig. 2.4b) the number of days each month on which data were collected. During February and March we were into a gear-up stage during which the various parts of the radar became operational. From April and onwards, the variations shown in the figure were due primarily to meteorological variations in the area. The hours of operations each day are shown on Fig. 2.5. The typical operational day had several hours of data collection, the average being 5.0 hrs. The longest period of operation occurred during the passage of Hurricane Danny and actually lasted more than 24 hr but over two separate days.

As should be expected, the distribution of the hours of operations during a day were strongly peaked during mid to late afternoon. Figure 2.6 shows this distribution (solid line) along with the number of microbursts

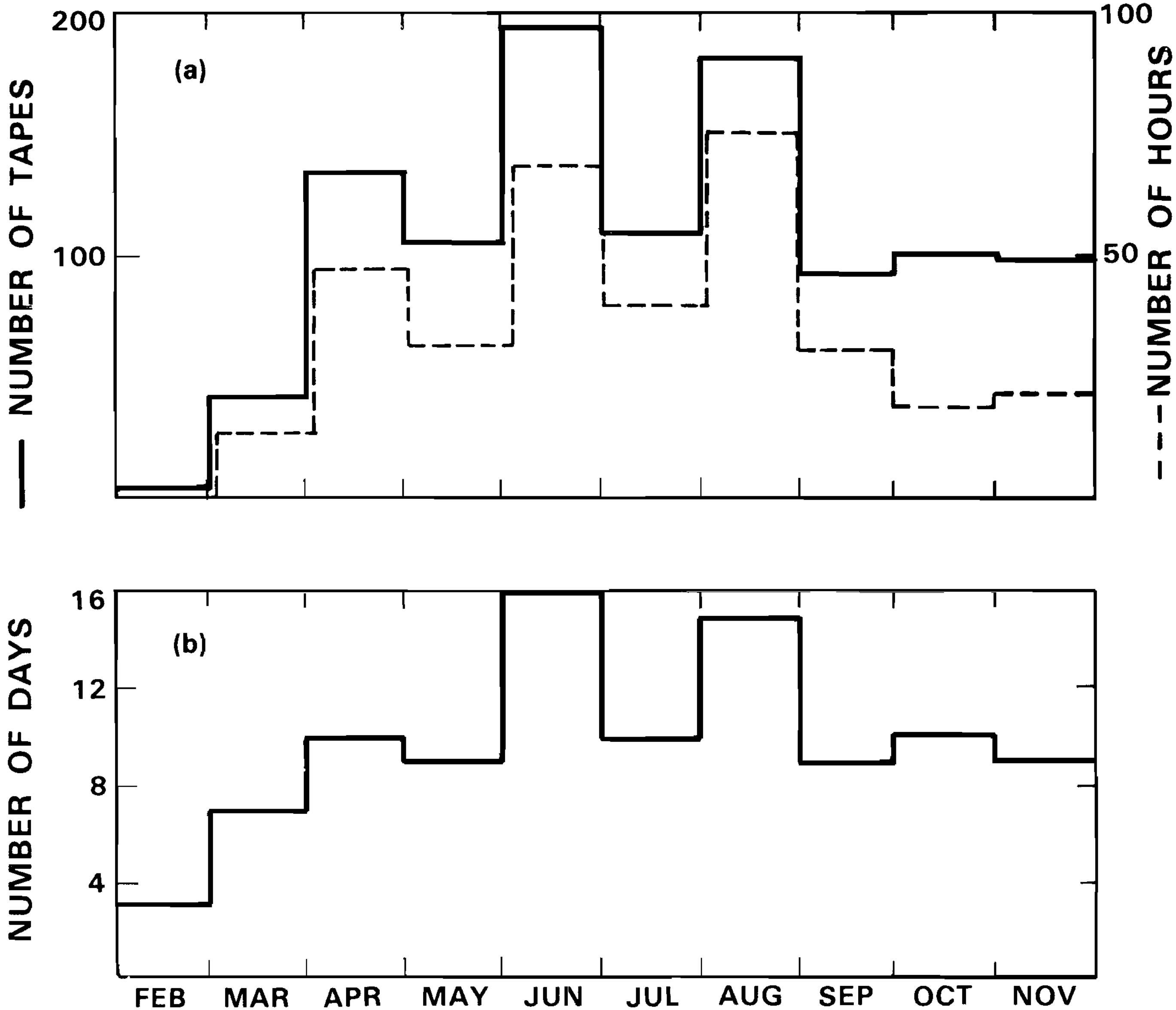


Figure 2.4 Distribution of (a) the number of tapes collected (solid line), the hours of radar data collection (dashed line) and (b) the number of days of data collection for each month during 1985.

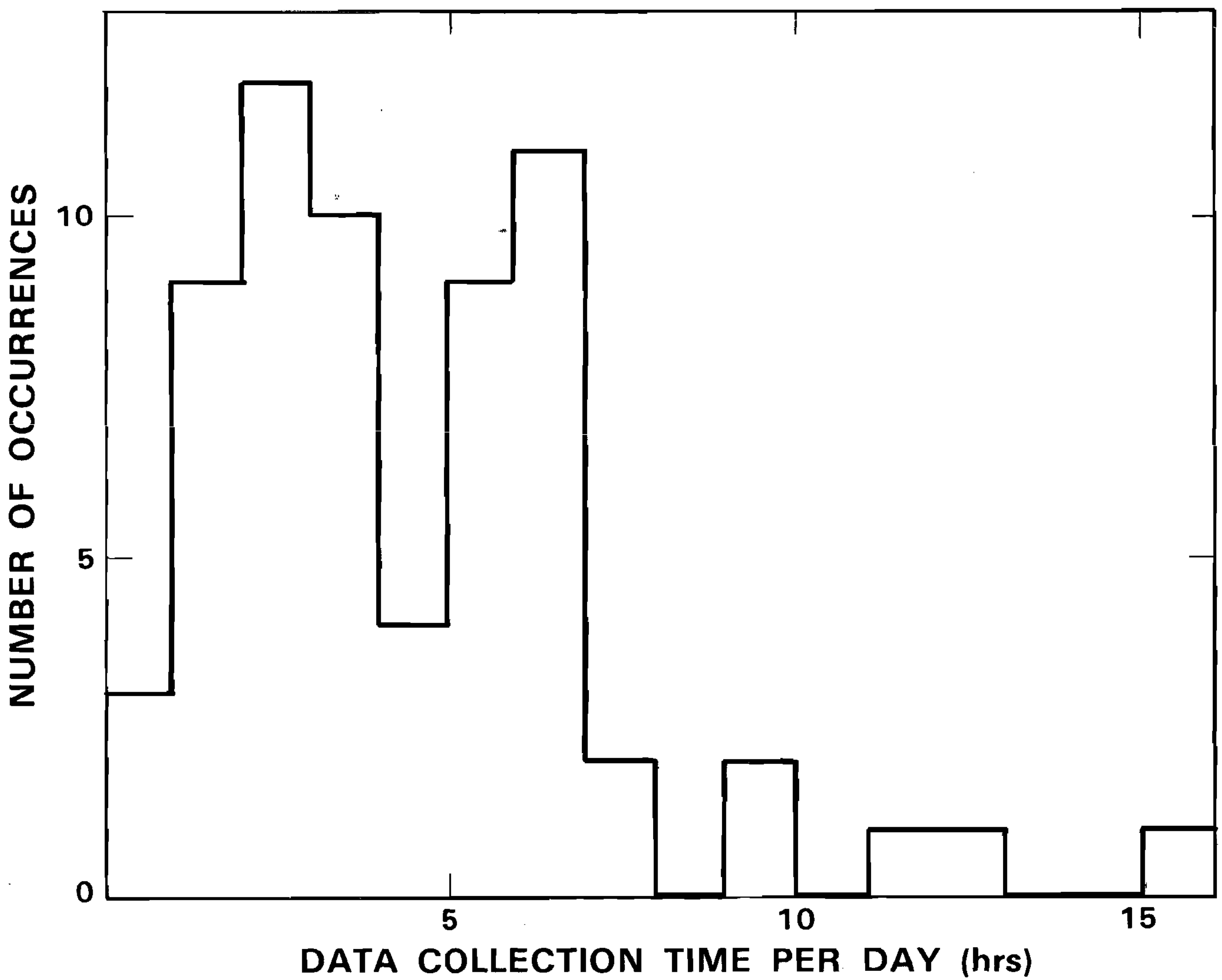


Figure 2.5 Distribution of the number of hours the radar was operated per day from April through September 1985.

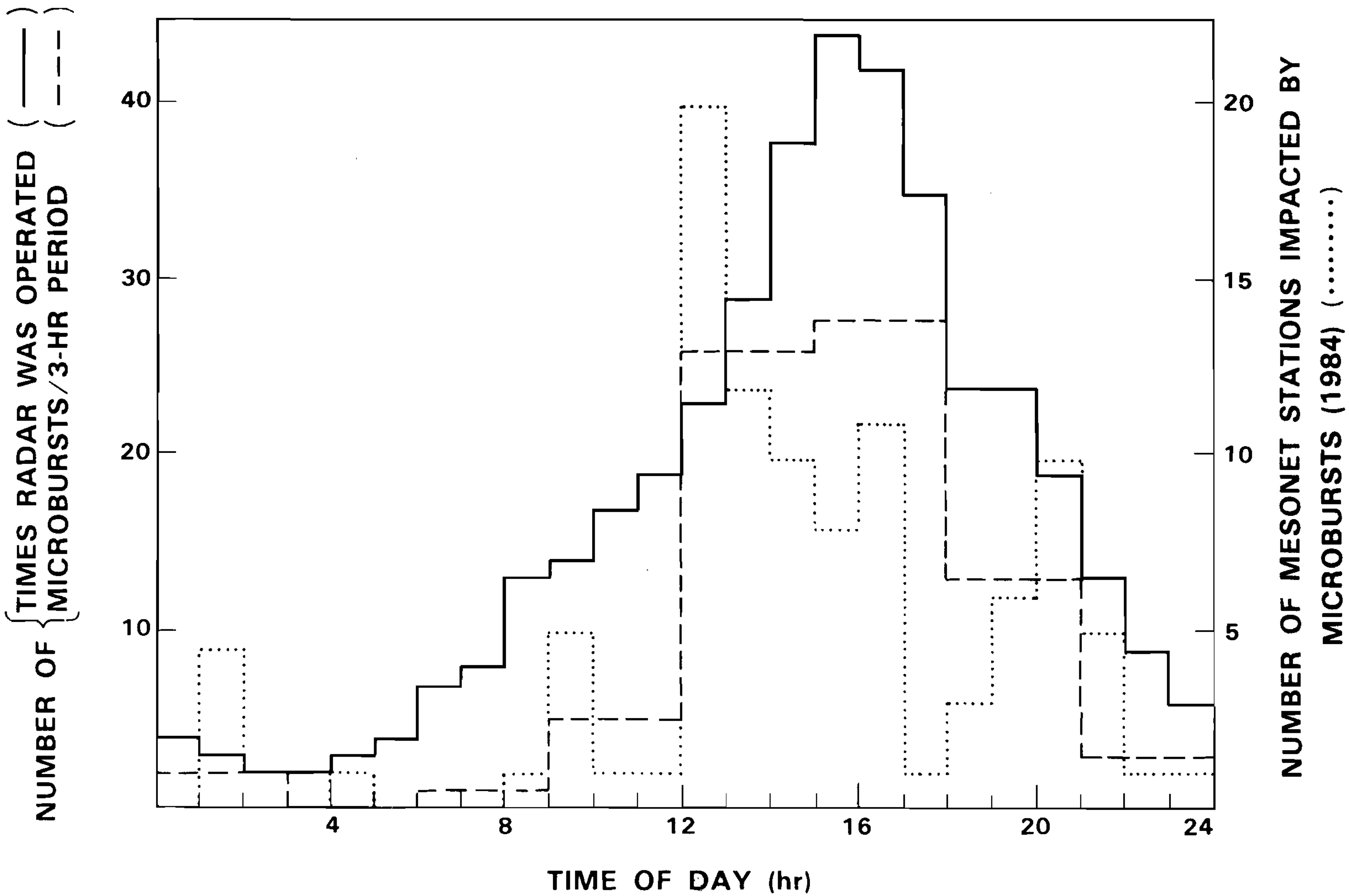


Figure 2.6 Diurnal variation of the number of times the radar was operated each hour of the day (solid line), the number of microbursts detected by the radar in each 3-hr interval (dashed line), and the number of mesonet stations impacted by microbursts during 1984 (dotted line).

during each 3-h period from the 1985 daily summaries (dashed line) and the number of mesonet stations impacted by microbursts during 1984 (dotted line). Afternoon convection is apparently a dominant source of microbursts. There were microbursts, however, during the middle of the night as well, so no period of the day or night could really be considered microburst free in the Memphis area.

Before covering the positive results of the 1985 season, there were a number of times when we did not collect data for one reason or another. It is useful to examine these to see what kinds of problems arise in a field program. Table 2.2 summarizes these problems, separating the causes into hardware problems, software problems, forecasting problems, and operator error. Undoubtedly, data were probably lost on other occasions not listed in the table, but it contains the major events; any missing from the list are likely represented by similar problems already there. In general, the radar operated quite reliably throughout the season. We were fortunate in that a couple of the major down periods coincided with periods of fair weather, so few weather events were lost. It would be difficult to collect data on a research program 100% of the time without having redundant supplies of both hardware and personnel. Such was not the case at Olive Branch.

2.3.2 Mesonet

As noted earlier, the mesonet is used to provide "truth" for the surface characteristics of various low altitude windshears as well as to provide knowledge of the principal thermodynamic variables for use in studies of the LAWS generation mechanisms. This section provides an overview description of the mesonet sensor features, data processing and summary results since April, 1984. An indepth treatment of the mesonet system features is given in Wolfson, DiStefano and Forman (1986). Figure 2.7 shows a mesonet station from the Memphis area.

2.3.2.1 Description of Sensors

Each of the 30 automatic weather stations are equipped with a set of six meteorological sensors:

(1) The wind speed sensor (cup anemometer) is mounted on a cross arm along with the wind directional sensor (wind vane). The cross arm height on the stations are 6.8 meters above the ground.

(2) The temperature and relative humidity sensors are located in the temperature-relative humidity probe which is situated on one corner of the weather station inside a vane aspirator. This vane aspirator shields the probe from direct sunlight, and provides good airflow over the sensors at most times.

(3) Another sensor that the weather stations have is used for measuring pressure (a barometer). It is located inside the large white armored box which hangs on one side of the station triangle.

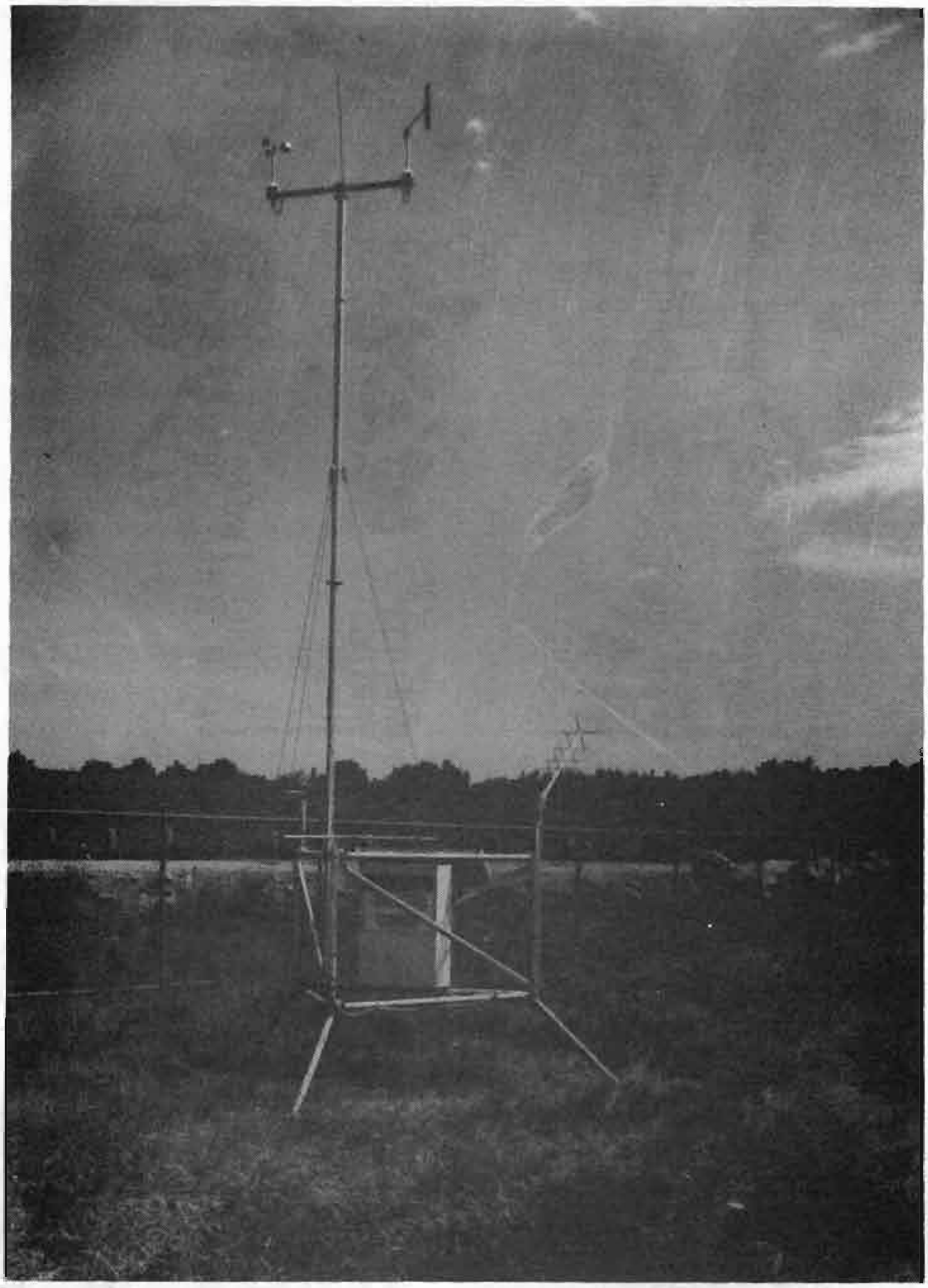


Figure 2.7 Photograph of one of the mesonet stations near Memphis.

Table 2.2
Missing Radar Data

CAUSE	DATES	DATA LOST
HARDWARE		
AIR CONDITIONER COMPRESSOR	3-6 MAY	NONE (DRY WX)
ANTENNA COUPLER	6-7 MAY	~3 HRS
ANTENNA OPERATIONAL AMPLIFIER	9 MAY	NONE (DRY WX)
ANTENNA PROBLEM	22 MAY	NONE?
GENISCO DISPLAY	MAY-AUG	LITTLE TO NONE
TRANSMITTER KLYSTRON	5-10 JUL	COUPLE HOURS
INSTALLATION OF FUJITSU DISK	15 JUL	<1 HR
POWER SURGES	16, 17 JUL	13 MIN, 1 HR
RADIO ANTENNA BEING INSTALLED	16 JUL	1/2 HR
SOFTWARE		
ROUTER DIED	VARIOUS	FEW MIN EACH TIME
BPD PAUSED	VARIOUS	FEW MIN EACH TIME
LOST RECORDING SYSTEM	10 JUN	>17 MIN
LOST CONTROL OF 3250	27 JUN	~1 HR
ZOOMED TO INVALID LOCATION	19 JUL (+ OTHER TIMES)	SEVERAL MIN
MISSING RAYS OF DATA ON DISPLAYS	VARIOUS JUL, AUG	UNKNOWN
METEOROLOGY (FORECASTING)		
STORM REINTENSIFIED AFTER OPERATIONS ENDED	1 MAY	~1 HR
NEW LINE OF TRW'S FORMED	13 MAY	~1 HR
NO NWS WAKE-UP CALL	11, 18 JUN; 24, 25 AUG	~4 HR
UNFORECAST EVENING TRWS	11 AUG	1-2 HR?
COCKPIT ERROR		
OVERWROTE 1 TAPE		13 MIN

(4) The last sensor that the stations are equipped with is the rain gage. This is used to measure precipitation and is located approximately 10' from the stations' main structure.

Table 2.3 shows the ranges and the resolutions of these various sensors. Each sensor is sampled once every 7 s and the samples averaged over a 1-min period to produce average and peak values for the minute. The average values and peak wind speed for each 1-min period are stored in the weather station microprocessor and telemetered to ground (via the GOES satellite) once per minute. Since these stations were developed by upgrading the Bureau of Reclamation PROBE stations (Wolfson, et al., 1984), they will be referred to as PROBE stations in the subsequent discussion.

Six LLWAS sensors, in the vicinity of the Memphis International Airport, help to complete the mesonet. They are equipped with propellor anemometers which measure only wind speed and direction. Data from these instruments were digitally recorded and are available for analysis from both 1984 and 1985.

2.3.2.2 Data Collection Periods and Measurement Success

During 1984, mesonet data collection began in early April and continued through until late November. The only time during this period that 100% of the raw data were missing was during August 27. This occurred when the ground station, which receives the data, went down for maintenance. No windshear data were lost this day, for the weather was fair and calm over the Memphis area.

Table 2.4 shows the average percentage of missing data for each sensor in 1984. The raw data missing is the representation of missed transmissions, and the percentage of missing data after editing is the total of all missed data (corresponding to missing transmissions plus the editing out of the bad data). Note that for the entire 1984 data collection season, an average of only 2.1% of the data were not recorded.

A few sensors were shown to have anomalously high missing percentages as compared to others. The barometric pressure sensor is the most pronounced with 21% of its data edited out. Part of this poor record was due to the fact that they were not deployed until June, 30-40 days into the data collection period. Zeroes were transmitted during this time period, which had to be edited out. Problems were also seen with the performance of the relative humidity sensors. Measurements of well above 100% were sometimes recorded. Often times, when the readings were very high (approximately 120%), they would suddenly drop to extremely low values of approximately 4%, and at this point were rejected as bad data. Also, the percentage of missing raw data for the precipitation sensors were higher than the other sensors because station No. 22 was without a sensor from July through November.

During 1984, the LLWAS system, which is located at the Memphis International Airport, showed 4.5% of its possible recorded data as missing. This was due to either bad data or calm winds (which were flagged bad).

Table 2.3

Mesonet Probe Sensors

Sensor	Parameter(s) Measured	Range	Resolution
Cup anemometer	Wind speed	0.2 to 54 m/s	0.05 m/s
Wind vane	Wind direction	0° to 360°	2.5°
Vaisala humicap	Relative humidity	0 to 100%	2%
Thermistor	Temperature	-20 to +80°C	0.1°C
Barometer	Pressure	*900 to 1100 mb	0.1 mb
Rain gage	Precipitation	0 to 300 mm	0.3 mm

*This is the range for which our pressure sensors were calibrated. Specifications suggest the greatest range of measurement to be between 700 and 1100 mb.

Table 2.4

Average percentage of missing data for each sensor in 1984. Percentages missing of raw and edited data are given separately, and the difference between the two is the percentage of received data rejected in the editing procedure and is an inverse measure of data quality.

Data Type	% Missing Raw	% Missing Edited	Difference
Temperature	2.51	2.53	0.02
Barometric Pressure	0.59	22.09	21.50
Average Wind Speed	0.59	5.55	4.96
Peak Wind Speed	1.07	6.90	5.83
Wind Direction	0.69	5.55	4.86
Relative Humidity	3.37	12.19	8.82
Precipitation	5.50	8.70	3.20
Total Average	2.05	9.07	7.03

During 1985, mesonet data from the 30 PROBE stations were collected for the period beginning in mid-February and continuing through early November. Data from the 6 LLWAS sensors were recorded during January through late November. There was a marked improvement in the performance of these sensors during this data collection period (as compared with 1984). This could be attributed, in part, to better Sensor calibration, a more stable mesonet system, and increased familarity with the individual sites.

2.3.3 Aircraft

The University of North Dakota Cessna Citation aircraft, designated NEXRAD1 during the 1985 flight operations in the Memphis area, was used during two periods: (1) from 21 May through 10 June and (2) from late July through 19 August. Table 2.5 lists the 21 data collection flights made by NEXRAD1 along with a very brief summary of the main focus of each flight. During flight operations, aircraft position was monitored in real time by displaying aircraft location as reported by the Air Traffic Control Radar Beacon System. Beacon reports were brought to the FL2 radar via telephone line from the enroute beacon sensor at Byhalia, Mississippi. The aircraft locations were displayed simultaneously along with the weather information on the radar displays.

The primary purpose for having the aircraft in Memphis was to obtain data characterizing the turbulence environment actually experienced by the aircraft in penetrating various intensity storms and to provide supporting information which can be used in meteorological studies of gust fronts and microbursts. The typical flight profile was developed by directing the aircraft into operationally useful (e.g., reflectivities < 40 dBz) regions where the FL2 radar detected turbulence. Radar turbulence detection is based on real time computations of the rate of dissipation of turbulent kinetic energy, a parameter denoted by $\epsilon^{1/3}$. This parameter is derived from radar Doppler spectrum width measurements. The aircraft data provides a measure of "truth" in assessing the performance of the radar turbulence detection.

On several occasions, the aircraft was vectored into LAWS regions, including penetration of microburst downdrafts and gust fronts. These penetrations provide additional "truth" information for the winds inferred from the Doppler radar measurements. The aircraft meteorological sensors were our principal data source on the thermodynamic structure in the storm mid and upper levels since the NWS sounding was at Little Rock (120 miles to the west).

The UND Citation is instrumented for a wide variety of meteorological measurements as indicated by Table 2.6. However, the turbulence analysis uses only vertical acceleration, pressure, and temperature measurements. Inertial Navigation System (INS) outputs provide aircraft position information used in post-flight radar correlation analysis. Figure 2.8, showing the UND Cessna Citation, exhibits instrumentation clusters at the wingtips and other sensors located in the noseboom.

Table 2.5

Summary of 1985 UND Citation Flights

DATE	TIME (CDT) TAKE OFF	TIME (CDT) LANDING	FLIGHT DURATION (HR:MIN)	NO. TAPES COLLECTED	EVENTS
21 MAY	1620	1806	1:46	9	TEST FLIGHT; TURBULENCE; SOUNDING
28	1604	1920	3:16	8	TURBULENCE
	2051	2158	1:07	3	TURBULENT LAYER (WINDSHEAR)
29	1931	2157	2:26	9	PENETRATED GUST FRONT
4 JUN	1502	1629	1:27	2	"MODERATE" TURBULENCE
5	1550	1940	3:50	8	"WILD RIDE", HAIL STORM; SOUNDING
6	1016	1214	1:58	12	"LIGHT", "MODERATE" TURBULENCE
	1705	1822	1:17	3	GUST FRONT
	1907	2035	1:28	3	TURBULENCE
10	1404	1708	3:04	3	TRAFFIC DELAYS; MULTIPLE APPROACHES
1 AUG	1509	1714	2:05	3	TEST FLIGHT; PROBE CALIBRATION
5	0935	1215	2:40	3	TURBULENCE
	1425	1613	1:48	9	TURBULENCE
6	1625	1740	1:15	2	TV FLIGHT?
9	1604	1744	1:40	2	TURBULENCE
10	1247	1549	3:02	7	MICROBURST & GUST FRONT PENETRATION
11	1543	1756	2:13	3	"MODERATE" TURBULENCE
15	1006	1155	1:49	3	"MODERATE" TURBULENCE
	1537	1816	2:39	6	GUST FRONT & VAULT PENETRATION
16	1006	1217	2:11	12	TURBULENCE
19	1544	1755	2:11	?	"MODERATE" TURBULENCE; COMPUTER PROBLEMS
		TOTALS	48:45	>119	

Table 2.6
UND Citation Instrumentation Specifications

Parameter Measured	Instrument Type	Manufacturer & Model #	Range	Response Time	Accuracy	Resolution
Temperature	Platinum Resistance	Rosemount Engineering Co. 510 B Signal Conditioner & Model 102 Probe	±50°C	1 sec	±0.5°C	0.1°C
Dew Point	Dual Stage Peltier Cooled Mirror	General Eastern Corp. Model 1011	+50 to -75° C	2°C/sec max heating or cooling	±0.2°C 0° to +50°C ±0.4°C -40° to 0°C °1.0°C -75° to -40°C	0.1°C
Altitude	INS and Static Press	Litton LTN-76	0 to 45,000ft	—	undertain due to lack of standard	2 m
Indicated Air Speed	Differential Pressure	Rosemount 858AJ	0 to 5 psid	0.3 msec	.005 psid	.003 psid
Angles of Attack & Slip	Differential Pressure	Rosemount 858AJ	-5 to +5 psid	0.3 msec	.005 psid	.003 psid
Heading	Inertial Nav System	Litton LTN-76 (with dual Speed Resolvers)	0-360°	42 msec update	±2 arc min	.25 arc min
Pitch	"		-90° to +90°	42 msec update	±2 arc min	.25 arc min
Roll	"	"	-90° to +90°	42 msec update	±2 arc min	.25 arc min
Horizontal Accel.	"		+3 to -1 G	42 msec update	±.01G	.001G
Vertical Accel.	"	"	+3 to -1 G	42 msec update	±.01G	.001G
Ground Speed	"	"	0 to 1000kts	42 msec update	dependent upon averaging time	
Position	"	"	——	42 msec update	±1. Naut mi hr^{-1} (without update)	60 ft
	and VOR DME	2 each Collins VIR30A and DME40	0 to 360 deg 0 to 299 naut mi	1 sec	±2 deg ±0.2 naut mi	1 deg 0.1 naut mi

Table 2.6 (Continued).

Parameter Measured	Instrument Type	Manufacturer & Model #	Range	Response Time	Accuracy	Resolution
Time	Quartz Crystal Oscillation	Perkin-Elmer 7/32	24 hours	1 sec	± 1 sec/day	.001 sec
Short Wave Radiation	Hemispheric Pyranometer	Epply	0-2800 watts/m² 0.5-2.8 μm & 0.7-2.8 μm	1 sec	± .5%	Analog
Short Wave Radiation	"Bug-eye" radiometer	Dr. Steve Cox-CSU	.4-.7 μm	10 msec	——	Analog
Infrared Radiation	Hemispheric	Epply	4-50 μm	2 sec	± 1%	Analog
Cloud Photographs	16 mm cameras	L-W International Automax	——	——	——	——
Liquid Water Content	Johnson-Williams Liquid Water Detector	Cloud Technology Inc.	0-9 gm⁻³	1 sec	± 0.1 g/m⁻³	.01 gm⁻³
Cloud Droplet Spectrum	Forward Scattering Spectrometer Probe	Particle Measurement Systems	0.5-47 μm	0.1 sec	± 1 count	± 1 count
Ice crystals & water drops	Optical Array Probe 2D-C	Particle Measurement Systems	25-800 μm	.1 sec	± 1 count	± 1 count
Large Particles	Optical Array Probe 200Y	Particle Measurement Systems	300-4500 μm	.1 sec	± 1 count	± 1 count
Icing Rate	Vibrating Cylinder	Rosemount Model 871FA	0-.02" before recycle	7 sec recycle	± .005"	.001"

Figure 2.8 Photograph of the University of North Dakota Citation aircraft.

2.3.4 Other Weather Information

Finally, we also archived other weather data available for nearby stations such as Little Rock, Arkansas; Nashville, Tennessee; Jackson, Mississippi; Memphis and other locations in the mid-South. We had three sources for these auxillary data. One source was weather maps which were routinely received from the National Weather Service using a DIFAX system; our phone line for this originated at the FAA Central Weather Service Unit at the Memphis Air Traffic Control Center. Another data source originating at the CWSU was for a Laser Fax for obtaining satellite photographs at 30-min intervals. Finally, we frequently logged onto the Weather Services International computerized weather data service to obtain soundings from the stations in the area, NWS radar data reports, and certain forecasting information available from WSI.

During real time operations, RRWDS data from the NWS radars at Millington, TN and Little Rock, AR was used to provide a situation display. These data were occasionally recorded on a 9 track digital tape when the observations might be of use in subsequent analysis. Unfortunately:

(1) the Millington RRWDS data was heavily corrupted in the principal FLOWS measurement region by ground clutter, while

(2) the Little Rock data had relatively poor visibility for storms near Memphis due to radar blockage by intervening terrain,

so that these data were infrequently of use.

3. 1984 MEMPHIS MICROBURST STATISTICS

Presented here are preliminary results on the characteristics of wind shear events in the Memphis area. Microburst statistics for Memphis are contrasted with those computed by Fujita and Wakimoto (1983) for the Denver area during JAWS and the Chicago area during NIMROD. These data were obtained using the mesonet only.

The peak wind speed values were used to initially identify any possible microbursts. A version of the objective technique used by Fujita and Wakimoto (1983) which essentially identifies wind spikes in the data was implemented. For each positive detection, a synoptic map and a 15-min time series for each of the recorded variables were plotted. These plots were then analyzed individually for evidence of an evolving divergent wind pattern, significant changes in temperature, dew point, and pressure, and/or increasing influence of the microburst winds on the surrounding stations with time. Of a total of 3210 algorithm detections, 95.4% were eliminated as cold front passages, high gusty winds, or insignificant wind peaks. It was found that approximately 2.8% were actually gust fronts, and that 58 or 1.8% were true microbursts. In many cases, a gust front signature was evident somewhere in the network at the same time a microburst was occurring.

There are a number of differences between our Memphis mesonet data collection program and those of the JAWS and NIMROD programs. One difference is the length of the program. The NIMROD program lasted 6 weeks, JAWS lasted 3 months, but the FLOWS program lasted 7 mo in 1984 (and 8 mo in 1985).

Another major difference between the Memphis results and the earlier programs is the size and station spacing in the mesonet. The NIMROD program (1978) used 27 mesonet stations spread out over an area approximately 65 km across east-west and 80 km north-south. JAWS also used 27 stations but over an area 20 km east-west by 30 km north-south. The FLOWS program in Memphis had 30 stations over an area 26 km east-west by 13 km north-south.

A final variation between the programs arises out of the way microbursts were identified. The initial identification of microbursts using mesonet data was done using an algorithm of Fujita (which is described later in this chapter). The NIMROD, JAWS and FLOWS mesonet processing was done essentially the same way although the thresholds used for the FLOWS data were adjusted slightly to accommodate the conditions found at Memphis. The large mesonet station spacing mentioned above for NIMROD (and, to a lesser extent, JAWS) meant that many microbursts were only detected at one station ; The factor of 5 or more closer spacing for FLOWS enabled us to only count microbursts which were detected at more than one station. This additional confirming evidence should produce more reliable results for microburst detection than single station analysis. It is our perception that our more stringent criteria results in a fewer number of microburst detection cases than would be the case with the NIMROD JAWS analyses.

As will be seen in the next chapter, the detection of microbursts by radar is in some ways easier than using a mesonet. This is because radar can cover a much larger area than a mesonet and does so with greater spatial resolution, giving it a distinct advantage over a limited number of instruments each of which can only make measurements at a single point.

3.1 Daily Count

The count of 58 microbursts represents the total number of stations impacted by microburst winds during the data collection period. This daily count is compared with similar counts compiled for NIMROD and JAWS in Figure 3.1 (a)-(c). The FLOWS Memphis data shows that, at least in the spring and fall, the microbursts occur in response to the synoptic scale forcing creating the conditions for convective instability on a large scale. During June, July, and early August the percentage of stations experiencing microbursts (<0.25 mm rain) did increase and there was a small clustering of microburst events in mid-July, but never did microbursts occur on a near-daily basis as they did during July 1982 in the Denver area. Of the 58 microburst hits in FLOWS 1984, 15 were dry microbursts, 38 were wet, and 5 were unknown (LLWAS data only were available). Although this total fell between that for NIMROD and JAWS (see Table 3.1), the per day microburst rate was much lower for Memphis. This remains true even when considering only the 42 days common to all 3 experiments.*

Table 3.1
Number of Mesonet Stations Affected by Microbursts
for NIMROD, JAWS, and FLOWS-84

Project	NIMROD	JAWS	FLOWS-84
Dates (days)	19 May-1 July '78 (42)	15 May-9 Aug '82 (86)	2 May-29 Nov '84 (212)
All Events	50	186	58
Dry Events	18	155	15
Daily Average	1.2	2.2	0.27
19 May-1 July Only			
All Events	50	71	14
Daily Average	1.2	1.7	0.33

A preliminary analysis of the data allowed an estimate of the total number of individual microbursts to be made. This number totalled 27 for the Memphis 7-month dataset. For each day the estimate of the number of individual microbursts that occurred is written above the station count bar in Figure 3.1 (c). Only 2 of these, or 7.4%, were determined to be dry microbursts. Of the total number of microbursts, 74% occurred during May, June, and July (see Figure 3.2).

*However, one cannot infer from this statistic that microbursts are more or less frequent in Memphis than Chicago or Denver since 1) the various mesonets differed considerably in areal coverage and sensor spacing and 2) the criteria used to determine a microburst were not identical.

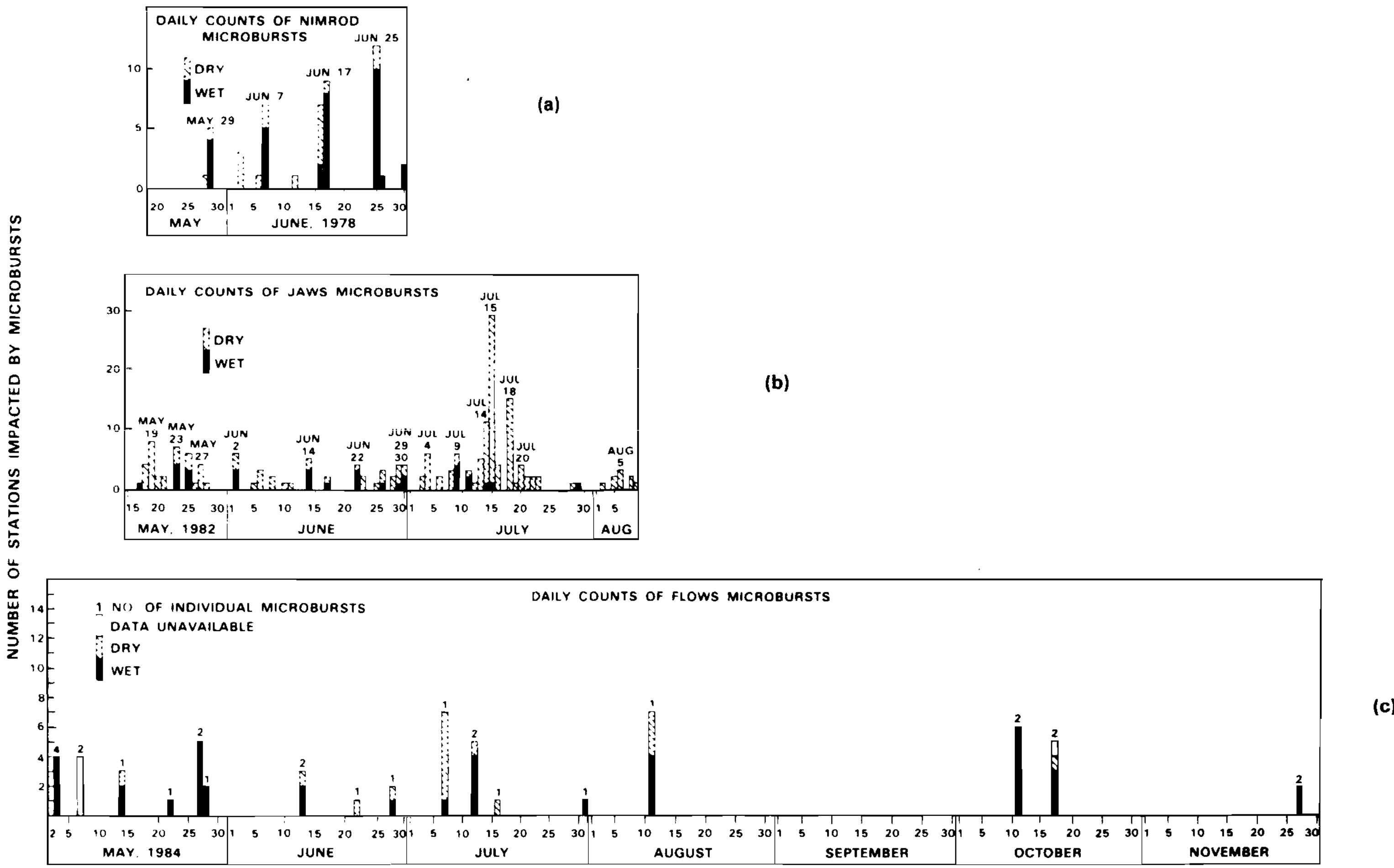


Figure 3.1 Daily counts of microbursts, determined by computer and subjective analysis, for (a) NIMROD (Chicago, 1978), (b) JAWS (Denver, 1982), and (c) FLOWS (Memphis, 1984).

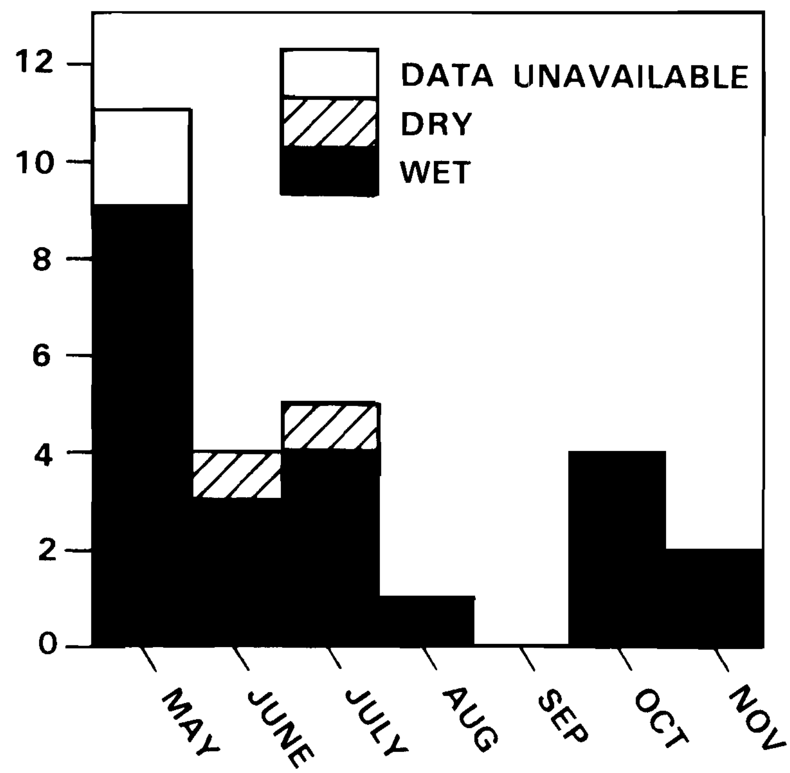


Figure 3.2 Total number of microbursts detected by FLOWS Memphis mesonet during 1984.

3.2 Diurnal Variation

The diurnal variation of the NIMROD, JAWS, and FLOWS microbursts are compared in Figure 3.3 (a)-(c). The peak in the Memphis data occurs between noon and 5 p.m. local time (CDT) with a significant peak between 7 and 10 p.m. Thus the Memphis dataset shows similarities to both the Denver summertime picture, with the solar heating providing much of the forcing for convective instability in the afternoon, and the northern Illinois picture with no strong diurnal dependence and some evidence of nocturnal thunderstorms. The nocturnal thunderstorm phenomena, sometimes related to the occurence of the southerly low level jet, is quite evident in the Memphis area.

3.3 Rainfall Rate

During FLOWS, roughly one tenth of the days on which microbursts occurred had dry microbursts only. This was less than the ratio during NIMROD which was approximately one third, and the JAWS results were just the opposite with rain detected at the surface on only one third of the microburst days (Figure 3.1). Most of the JAWS microburst rainfall rates were below 1 in/hour and all were below 3 in/hour. During NIMROD most microburst rain rates were below 3 in/hour except on one day when 5 microbursts with rates up to 8 in/hour were detected. In contrast, the rainfall rates in FLOWS "wet" microbursts were almost all above 1 in/hour with 14 of 38 or nearly 37% above 3 in/hour (Figure 3.4). Thus the microbursts in the Memphis area (south-central Mississippi valley area) can be typified as very wet with very heavy rain accompanying, and perhaps causing, a significant percentage of them.

In Figure 3.4 the FLOWS microburst rainfall rates are plotted against the peak wind speeds. As with the NIMROD and JAWS microbursts, no clear relationship between the two variables emerges. Except for one case which may have actually been a tornado, all of the microbursts with rainfall rates below 1.5 in/hr had peak wind speeds of 25 m/s or less. However since this category includes all but 6 of the wet microbursts, it is unclear whether a significant correlation exists between wind speed and rain rate in Memphis.

3.4 Wind Characteristics

In characterizing the microburst winds, the distributions of peak wind speed, wind direction, and duration, defined as the period of one-half of the peak windspeed, are of key interest.

3.4.1 Speed

The algorithm used to locate microbursts allowed a minimum of 15 m/s for the central peak wind measurement. Thus there is an abrupt cutoff at the low end in Figure 3.5. Except for a probably insignificant maximum of peaks winds between 22 and 23 m/s, the number of microbursts decreases exponentially as the peak wind speed increases, illustrating the decreasing

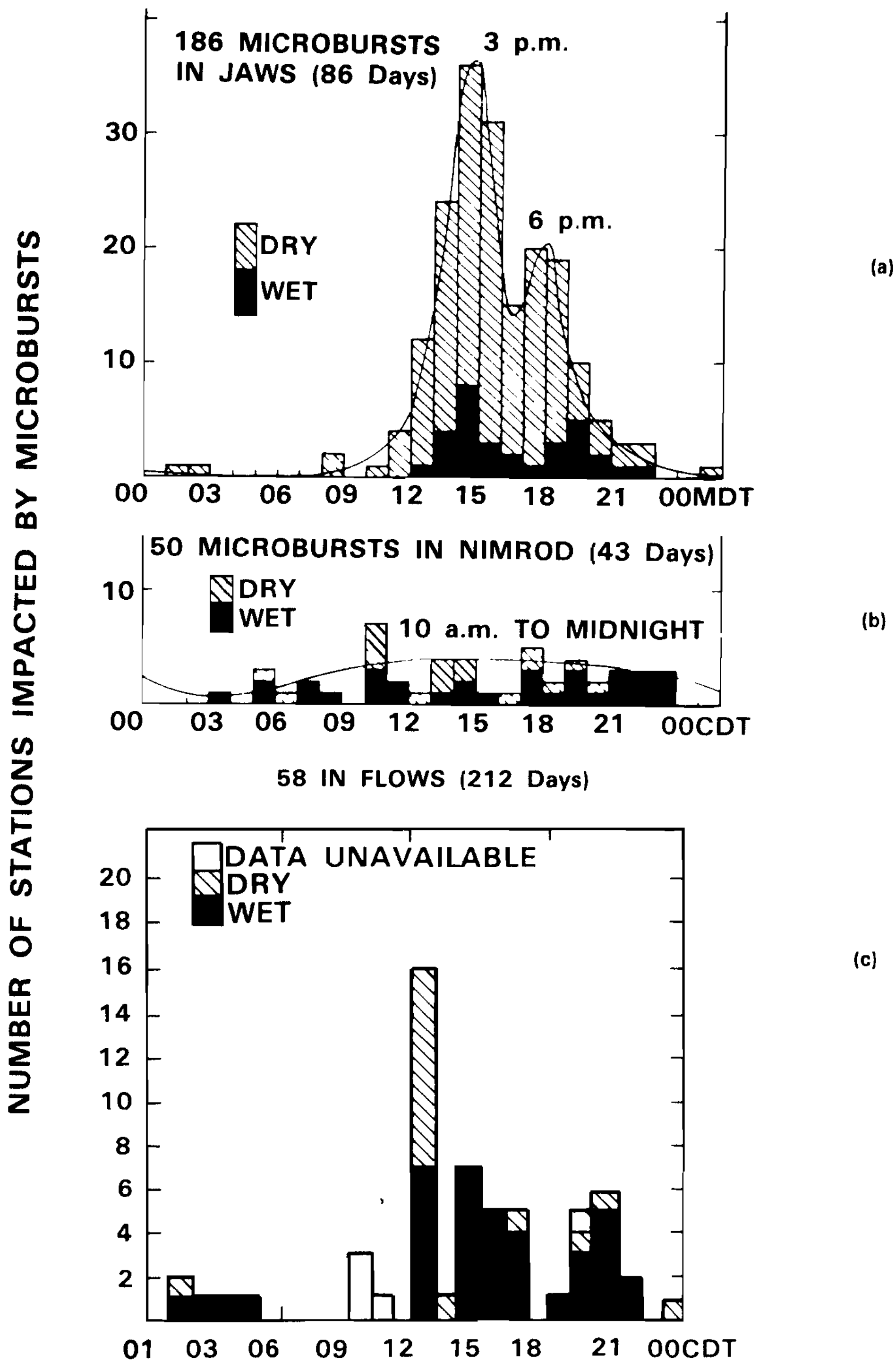


Figure 3.3 Diurnal variation of microbursts in (a) NIMROD, (b) JAWS, and (c) FLOWS. The FLOWS distribution shares some of the features of both the NIMROD and the JAWS distributions.

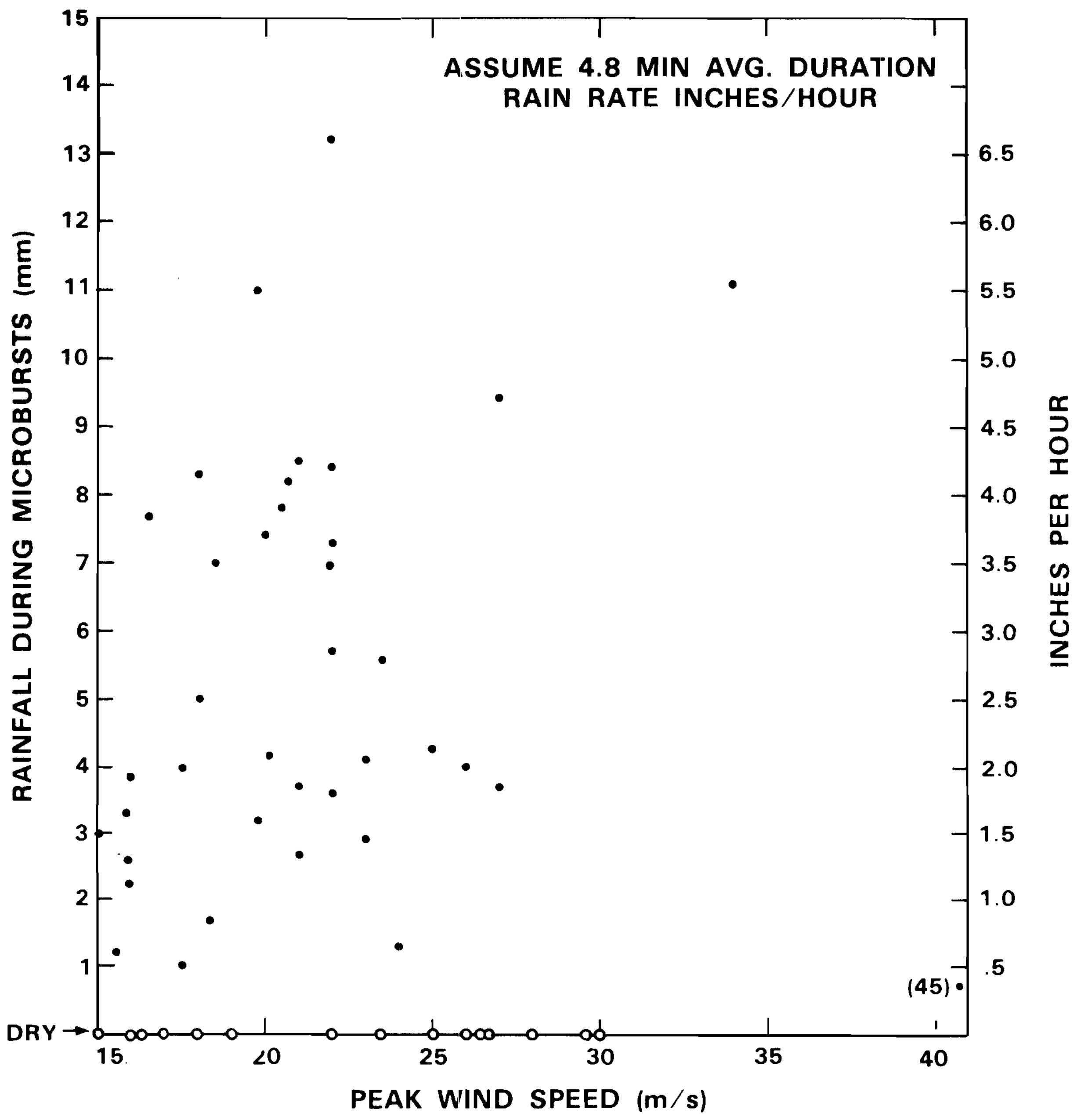


Figure 3.4 Total rainfall (or rainfall rate assuming 4.8-min microburst duration) versus maximum wind speed in 58 wet and dry microbursts during FLOWS 1984.

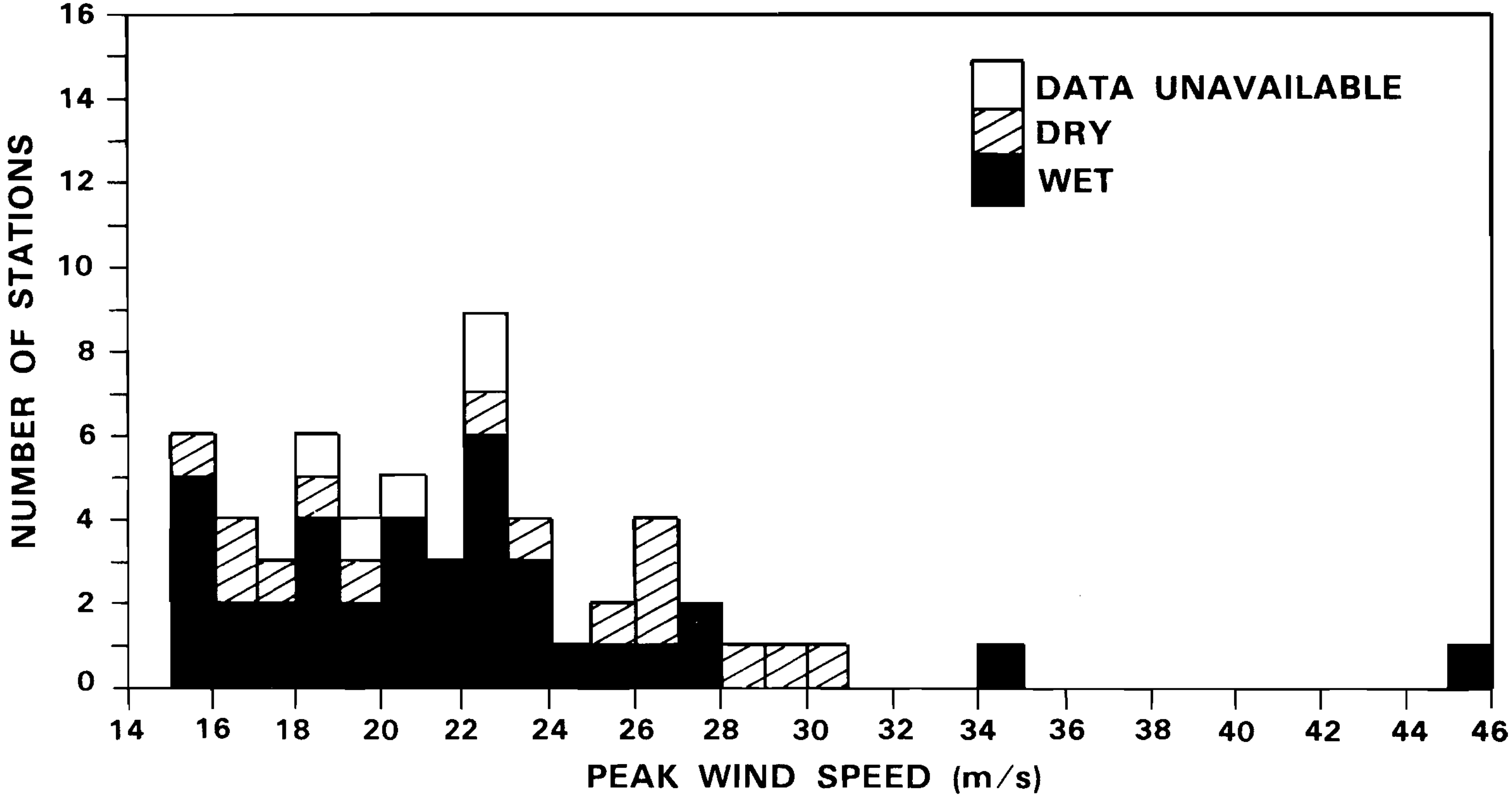


Figure 3.5 Distribution of peak wind speeds in FLOWS 1984 microbursts.

probability of occurrence with increasing wind speed. The NIMROD and JAWS distributions reach a maximum between 13 and 15 m/s while the FLOWS peak wind speed distribution has its maximum around 17 m/s, but the FLOWS data has been corrected for site obstruction effects. The FLOWS distribution is less sharply peaked around the low wind speeds than the JAWS results are, but it is also more sharply peaked and not as uniform as the NIMROD distribution.

3.4.2 Direction

The distribution of the microburst wind direction shown in Figure 3.6 is heavily weighted by winds with a westerly and northwesterly component (250 - 340). Winds appear at most azimuths because of the strong directional shear in the microbursts. The maximum in microburst wind direction coincides with the climatologically-preferred direction of storm approach. This information has great significance for the siting of a Doppler weather radar to be used for airport terminal wind shear detection. The distribution in Figure 3.6 suggests that one should locate a Doppler radar east and slightly south of the region to be protected in the Memphis area in order to detect the maximum radial wind speeds.

3.4.3 Duration

The duration of the peak winds in FLOWS (shown in Figure 3.7) appears to be quite uniformly distributed from 1.5 to 9 minutes with the suggestion of one peak centered about 5.5 min. This distribution differs quite considerably from those for NIMROD and JAWS which are both peaked around 2.5 minutes and decay exponentially at longer durations. There were only 3 microbursts in JAWS and 1 in NIMROD with durations greater than 7 min. In understanding the significance of this, one can relate the duration of the peak wind to the spatial scale of the microbursts. All microbursts confirmed in FLOWS began as divergent wind events less than 4 km in diameter, but most quickly grew to greater diameters. An expanding travelling microburst will produce a wind speed trace that is sharply peaked but has sustained high winds. This was commonly the case in the data analyzed.

3.5 Thermodynamic Characteristics

3.5.1 Temperature

Figure 3.8 shows the distribution of temperature changes in FLOWS microbursts. Only 5.6% of the microbursts were characterized by increases in temperature and close to 38% had temperature decreases greater than 3 . This is in striking contrast to both NIMROD and JAWS results which showed temperature increases in 40% of the cases. The FLOWS Memphis results showing temperature decreases are quite consistent with the creation or enhancement of the microburst downflow by evaporative cooling.

3.5.2 Dew Point

The dew point changes (Figure 3.9 are also consistent with the mechanism of precipitation cooling of the downflow, with 34% of the cases exhibiting an increase in dew point. However, as in the NIMROD and JAWS data

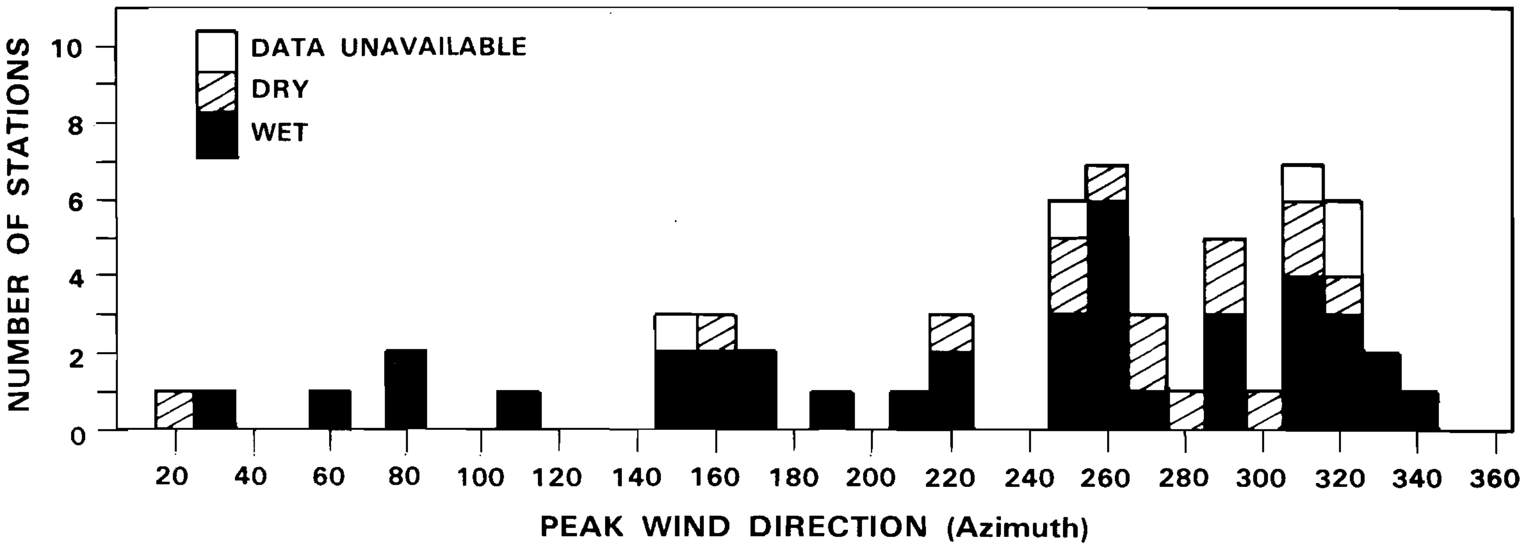


Figure 3.6 Distribution of the direction of peak winds in FLOWS 1984 microbursts.

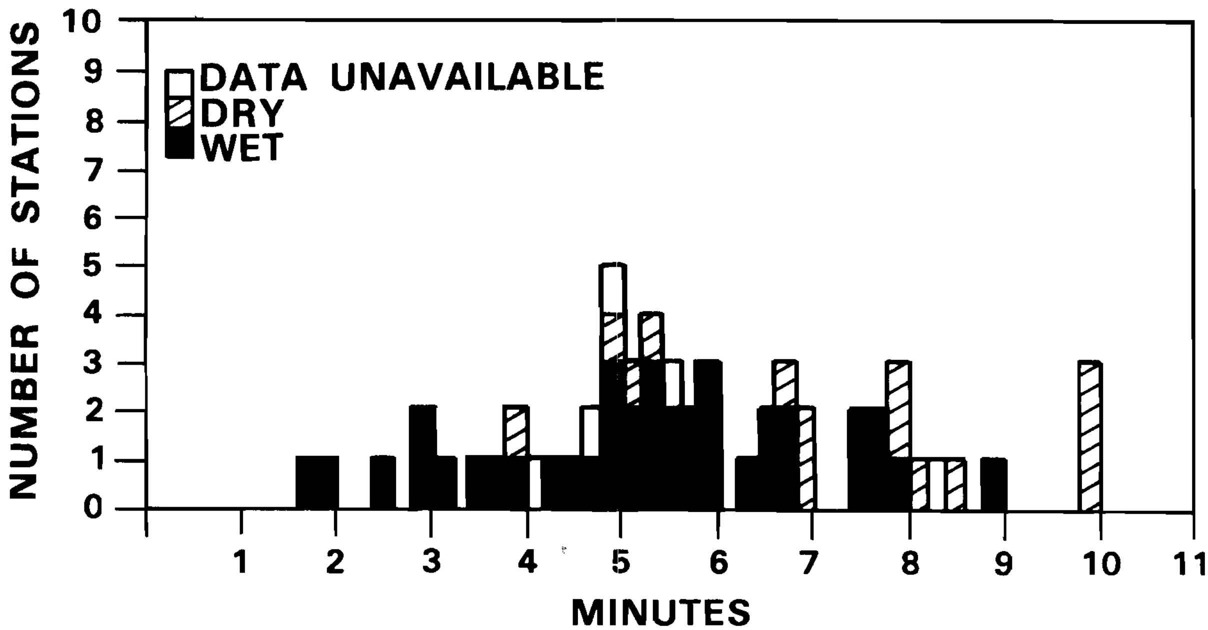


Figure 3.7 Duration of FLOWS 1984 microbursts.

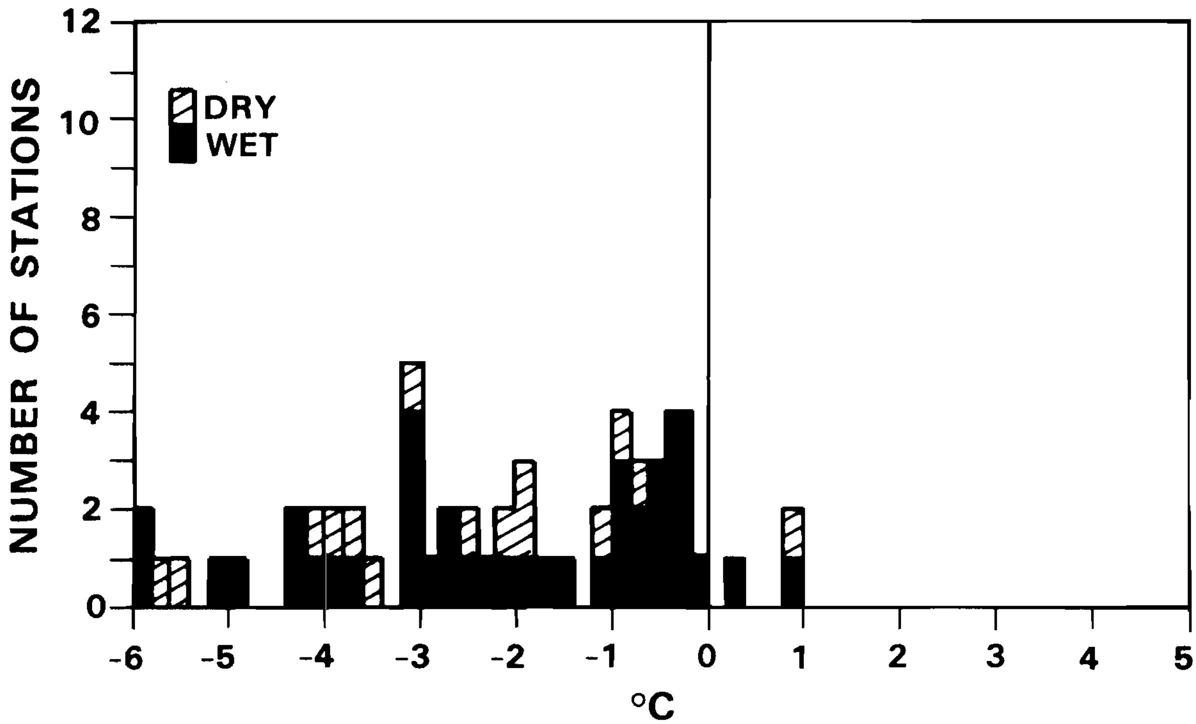


Figure 3.8 Temperature change in FLOWS 1984 microbursts.

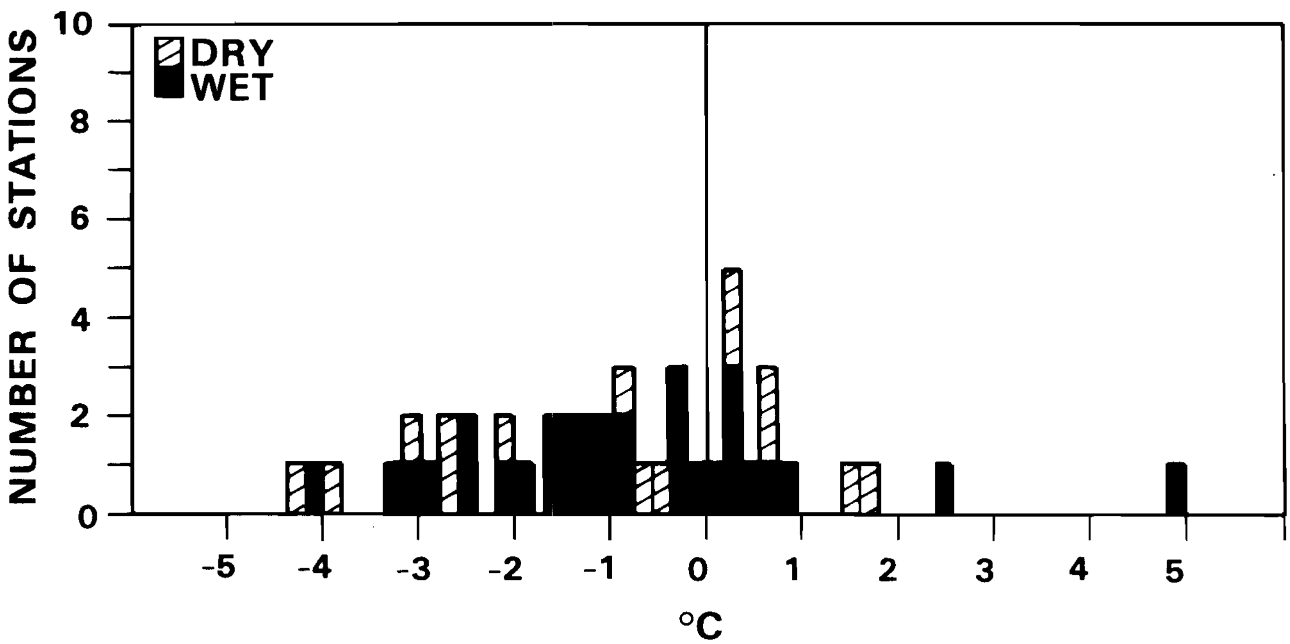


Figure 3.9 Dew point temperature change in FLOWS 1984 microbursts.

sets, the majority of microbursts were accompanied by decreases in the dew point of the air, suggesting entrainment of drier air from some level into the downdraft and/or origination of the downdraft in dry air aloft.

3.5.3 Pressure

The distribution of pressure changes in FLOWS microbursts is shown in Fig. 3.10. Notice that it is basically centered about zero and extends within the ± 2 mb interval. This is completely consistent with the NIMROD and JAWS results and may be explained by the "pressure ring" theory proposed by Fujita (1985).

3.6 Memphis Summary Results

We have presented above preliminary results on the characteristics of low altitude wind shear in the Memphis, TN area based only on the 1984 high resolution meteorological surface data. It was shown that the microburst, a recognized potential wind shear hazard to aviation, does occur with some regularity in this area.

The Memphis microburst characteristics were contrasted with those based on similar mesonet data for Chicago and Denver and found to be quite different. In general, the Memphis microbursts were very "wet", occurring with rain rates mostly 1 to 5 in/hr (only 7.5% of the Memphis microbursts were "dry"). Most microburst expanded rapidly to become "macrobursts" with gust fronts at the outflow edges. There appeared* to be fewer microbursts in Memphis then in other areas previously studied, but their peak wind speeds were higher, their durations were longer, and they were mostly accompanied by cooler air flows.

*Again we emphasize that the various mesonet arrays differed considerably in areal extent and spacing as well as in the criteria used to determine a microburst event.

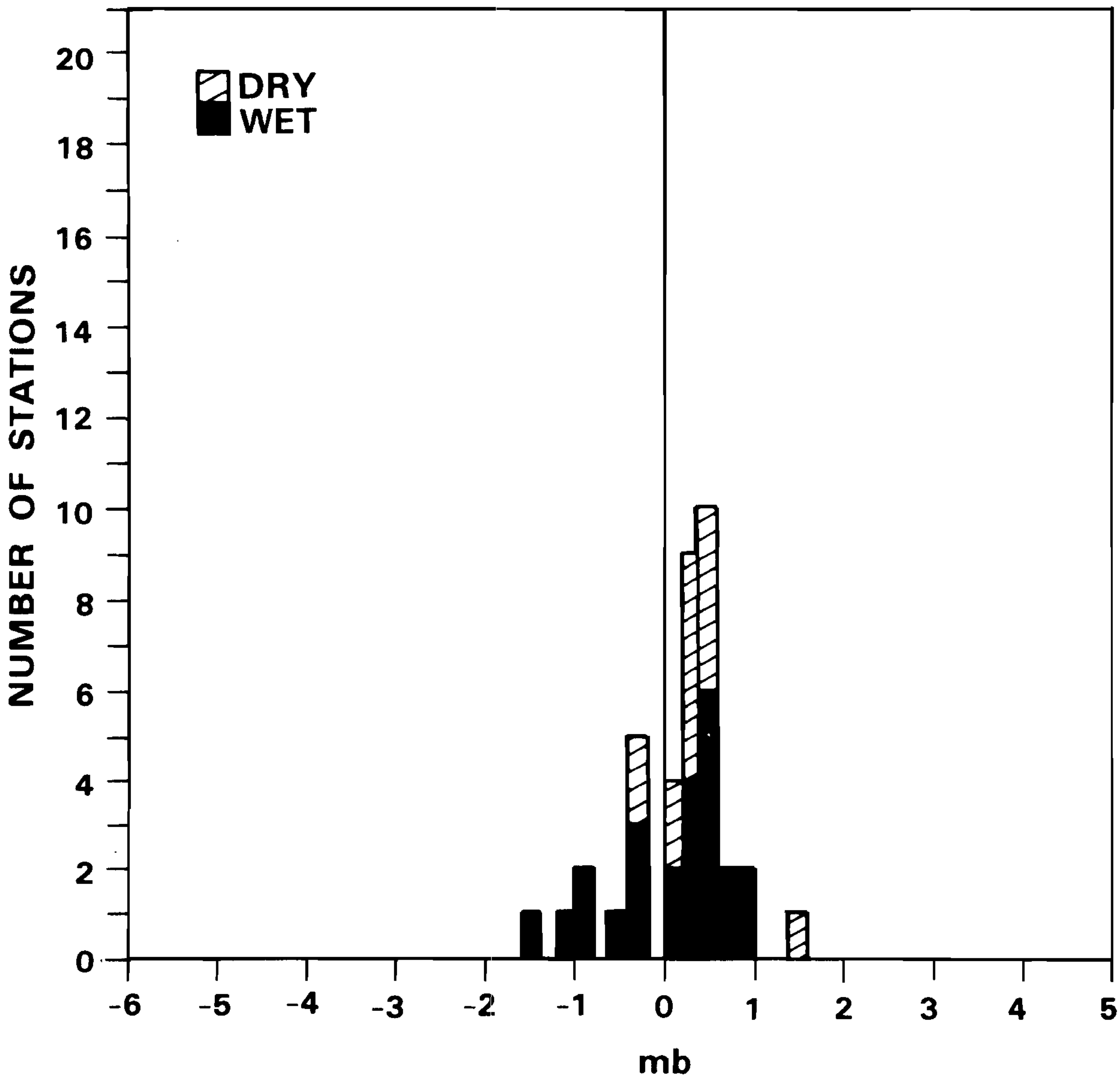


Figure 3.10 Pressure change in FLOWS 1984 microbursts.

4. 1985 DOPPLER WEATHER RADAR WINDSHEAR DETECTION RESULTS

4.1 Statistics

4.1.1 Background and Data Limitations

In this chapter, some of the global statistics from the 1985 field season will be covered, followed by some results obtained by analyzing meteorological information contained in the radar logs and daily summaries (see Appendix A). The global statistics primarily came from the Daily Summary reports which, in turn, were largely based on the more detailed radar logs kept during each operational period. Because of the use of these summaries, there are a number of limitations to the results which will be covered in the following paragraph. At this point it is worth noting that while there are limitations in the data sets used, the information is still quite useful and contains valuable information.

Table 4.1 lists some of the restrictions and caveats that apply to the radar results from 1985. One of the principal limitations is that many of the results came from the daily summary reports. The daily logs were never intended to be a primary source of data for analyses, only a guide to the data, highlighting various events and things to look for in the analysis phase of the program. Some of the results, especially those related to the magnitudes of wind shear events, will be more accurately determined from analysis of the recorded radar data rather than from those few measurements made hastily during the heat of battle. Nevertheless, in spite of the various reasons why some of the results may be biased and/or flawed, the following results still provide a reasonable representation of the true conditions that occurred in and around Memphis during 1985 for LAWS phenomena.

4.1.2 Microburst Definition

Since several of the following results are based on the characteristics of detected microbursts, it is worth describing how microbursts were recognized during real-time operations. In our field operations we had available three color displays of processed radar data --radar reflectivity, radial velocity, and turbulence. The Doppler velocity information is the primary (and mandatory) source of wind information for windshear detection. To detect a microburst on the velocity display, we would look for a couplet of approaching and receding velocities along a given radial from the radar. With the normal display configuration, approaching velocities were greens and blues (with 5 m/s intervals for each color) while receding velocities were browns and yellows (also 5 m/s per color).

Table 4.1

Caveats and Limitations on the Analysis
Based on Radar Logs and Daily Summary Reports

<u>People Factors</u>

Logs and daily summaries were not intended to be a primary data source.

Log entries were made by human beings.

- topics recorded were of interest to operator
- interests vary with time (hourly → seasonal)

Initial detection of events are better recorded than subsequent locations or characteristics

Displays required interpretation

Operators focus on one storm or area (near-sightedness)

<u>Hardware Factors</u>

Data processing limitations both delayed and reduced the number of available displays

During both aircraft operations, focused attention on altitude of aircraft at the expense of other levels

<u>Summary Factor</u>

Daily summaries condense even further the already condensed log entries

<u>Results</u>

Logs are subjective, variable, inconsistent, biased, incomplete

- but useful nevertheless

Microbursts were identified by looking for a couplet of green/blue (approaching) velocities followed by yellow/brown (receding) velocities a couple kilometers further away from the radar but at the same azimuth. The stronger the microburst, the easier it was to detect. This detection procedure required that there be at least 5 m/s velocity toward the radar and 5 m/s away from the radar (i.e., a shear of at least 20 knots). Weaker microbursts or nonsymmetrical microbursts could go undetected by this procedure, but we believe we detected those LAWS events that would have been hazardous to aircraft operations.

The distance between the centers of approaching and receding velocities must be 4 km or less to qualify as a microburst, according to the definition given by Fujita (1985). Most Memphis microbursts fit within this limitation, but we did see some which could have been classified as "macrobursts" because they were larger than 4 km across. Some of these we also labeled "divergent areas" in the radar log, sometimes because we were reluctant to put a microburst or macroburst label on them. In most of the following analyses, microbursts, macrobursts, and divergent areas are all lumped together into a single category and sometimes called windshear "events".

4.1.3 Microburst Statistics

With those definitions in mind, Table 4.2 lists all windshear events detected in real time during the 1985 season by the FL2 operations personnel. As a means to compare data from our two years of operations, Fig. 4.1 gives the number of microbursts detected by the mesonet during 1984 and the number of windshear events detected by the radar during 1985 for each week of the respective field seasons. The number of events per week can be quite variable, both within a year and from one year to the next. The week-to-week variation shown by either data source is caused by nature. The much larger weekly totals seen by the radar, however, are due to the ability of the FL2 radar to detect events over a much greater region than is covered by the mesonet.

Going to an even smaller time scale, Fig. 4.2 shows the number of windshear events per day detected by the radar. As many as 11 microbursts were detected on some days. But most days had none at all. The dashed line on the figure represents an exponential fit to the non-zero event days and suggests what the curve might look like if a larger data sample were available.

4.1.4 Gust Front Statistics

Another wind event observed during the season was the occurrence of gust fronts and thin-line echoes. These are extended radar-detectable low altitude convergent windshears which often arise from the outflows of thunderstorms and other convective storms. Some are quite long lasting while others die out quickly from lack of support from the parent cloud. Table 4.3 lists all gust fronts recorded in the logs along with some initial locations and/or other conditions associated with them. The tabulation is taken from the Daily Summaries and from the radar logs kept during operations.

Table 4.2

Tabulation of microbursts and windshear events detected in real-time by operations personnel during the 1985 field program at Olive Branch, Mississippi. The events tabulated are those recorded in the radar logs and/or the Daily Summary Reports. In the table, Range and Azimuth are to the approximate center of the gust front unless a pair of values is given; in this case the points are to the centers of the approaching and receding velocity centers, respectively; Velocity is the strongest velocity detected in the approaching and receding centers; Delta R is the distance between the microburst couplet velocity centers. Meanings for the "Area" and "DD?" columns are given at the end of the table.

No.	Date (1985)	Time (CDT)	Range (km)	Azimuth (deg)	Velocity (m/s)		Delta R (km)	Remarks	Area	DD ?
1	30 Apr	1700	5.5	200					2	1
2	7 Jun	1629	9	225	-5	10	4		4	1
3	10	1648	14	360	-10	10	3		4	
4		1651	22	12.8	-10	10	2	became line MB		
5		165250			-15	15	2			
6		174040	14.3	322	-15	15	4.4		4	1
7		181040	12	18					4	
8	17	180505	25.9	198	-10	15				
9	22	"afternoon"	"over mesonet"		"winds >=25mph"			became line MB?		
10	24	1340	27	357	-10	10	5			
11		1530	17	313	-5	10	2		3	2
12		1715	70	225				w/rotation		
13	25	1213	11	315				13/14 collided	3	1
14		1213	21	319				" " "	4	
15		1322	"over A/P"		-5	5		scanned w/RHI's	1	2
16		1820	16	"s of AP"	-15	25	9.5		1	1
17	26	1312	11	17	-10	5	1.9		4	
18		1336	7	325	-15	20	4	Hickory Ridge MB	2	1
19		1444	14.6	296	-10	10	3.8		1	1
20	27	1049	30	216				divergent wind		
21		1121	27	192						
22		1515	19	20	-15	15	3.8			
23		1544	11	53						
24		1552	42.2	259	-10	15	1.2			
25	30	1806	21	"WEST"					1	
26	10 Jul	1535	40.1-48.2	345	-10	15				
27		1700	14.7-17.0	66	-15	15				
28		1753	29	313	-10	15				
29		1909	31	31	-15	10				
30		1909	19	56	-5	10				
31		1931	1.7-4.9	140	-10	28			1	2
32	15	1318	17.0-17.8	31	-5	5				
33		1348	6.3	9.4	-5	5			3	2
34		1452	1.1-3.1	26	-10	5		@ 2.5 deg el.	2	2
35		1516	4.5	328	-10	5		@ 2.5 deg el.	2	1
36		2114	27.0-32.2	307	-10	10			4	
37		2130	27.0-29.2	298	-5	5			4	
38		2147	37.1-39.3	345	-10	10				

Table 4.2 (Continued)

No.	Date (1985)	Time (CDT)	Range (km)	Azimuth (deg)	Velocity (m/s)	Delta R (km)	Remarks	Area	DD ?
39	16	1321	15.6-22.0	138	-15"n	10			
40		1401	24.8-32.8	193	-5	25			
41		1452	[22	225	... but, from UND radar position]				
42	23	1303	7.3	320	-10	15	small (fit w/in trackball)	2	1
43		2104	"s of A/P"				macroburst?	1	1
44	1 Aug	1552	21	90	-5	5			
45	5	1017	6	4	-5	10		3	1
46	9	1543	21	301	-5	10		2	2
47	10	1306	^{2}40	^{2}290	-10	5	divergence		
48		1418	18	"due north"	-5	10			
49		1444	17.5	348	-15	25	A/C penetrated	5	
50	15	1542	4	91	-10	5		2	
51		1609	12	260	-5	15		1	
52		1623	7	318	-5	15		2	1
53		1702	36	340	-5	5			
54		1857	29	240	-10	5	divergence		
55	19	1605	91	298	-5	5	divergence		
56		1802	54	285	-10	5			
57		1804	25	321	-15	5			
58		1815	26	326	-10	10	divergence		
59		1816	51	281	-10	5	divergence		
60	23	1417	8	27	shear=20m/s			4	
61	24	0634	32	356	-10	15	macroburst		
62		0649	7	184	-10	10	divergence	4	
63		0914	29	309	-5	5	divergence		
64		0923	25	321	-5	10		5	
65		0925	19	334	-10	10			
66		0951	25	349	-10	10			
67		1032	7	305	-5	10	divergence	1	1
68		1037	13	270	-5	10		1	2
69		1141	27	164	-5	5	divergence		
70		1307	11	140	-10	10	divergence		
71	25	0248	17	355	-10	10		5	
72		0252	6	289	-5	30		1	2
73	7 Sep	1617	23	325	-10	5			
74		1624	9	312	-10	10		2	1
75		1720	9	268	-5	10		1	
76		1809	5	261	-5	10		1	
77		1857	64	312	-5	5	divergence		
78		2033	28	352	-5	20			
79	8	1321	22	277	-5	5		1	
80		1335	12	309	-5	5		3	1
81		1354	8	266	-10	5		1	
82		1358	19	305	-5	5		2	2

Table 4.2 (Continued)

No.	Date (1985)	Time (CDT)	Range (km)	Azimuth (deg)	Velocity (m/s)		Delta R (km)	Remarks	Area	DD ?
83		1422	15	263	-10	5			1	
84		1428	15	22	-10	5			5	
85		1437	11	0	-10	10		divergence	4	2
86		1445	17	123	-10	10				
87		1504	13	90	-10	15				
88		1504	22	77	-10	10				
89		1520	10	115	-10	15		divergence		
90	9	1634	28	312	-5	5				
91		1637	29	318	-10	5		divergence		
92		1716	19	314	-15	15			3	2
93		1800	32	337	-5	5				
94	14 Oct	1656	18	16	-5	15		UND radar gone on 23 Sep 85		
95	11 Nov	1124	22	320	-5	5		mesonet gone		
96	17	1518	11	287	-5	10		lasted >11 min		
97		1548	20	west	-5	5		lasted 20-25 min		
98			29	261	-3	9		detected in playback after-the-fact		
99	19	1846	56	326	-5	5		weak divergence		
100		1918	32	348	shear=15m/s		3.3			
101	27	1218			shear=15m/s		2.1	End of operations!		

DD? -> Dual-Doppler Code
1 - 90 +/- 30 deg
2 - 90 +/- 45 deg
None >45 deg from optimum

Code for Area
1 w/in mesonet
2 w/in 3 km of mesonet
3 w/in 4 km of mesonet
4 >4 km from mesonet but on Fjuita's map
5 off map but still close to mesonet map
None Well beyond map

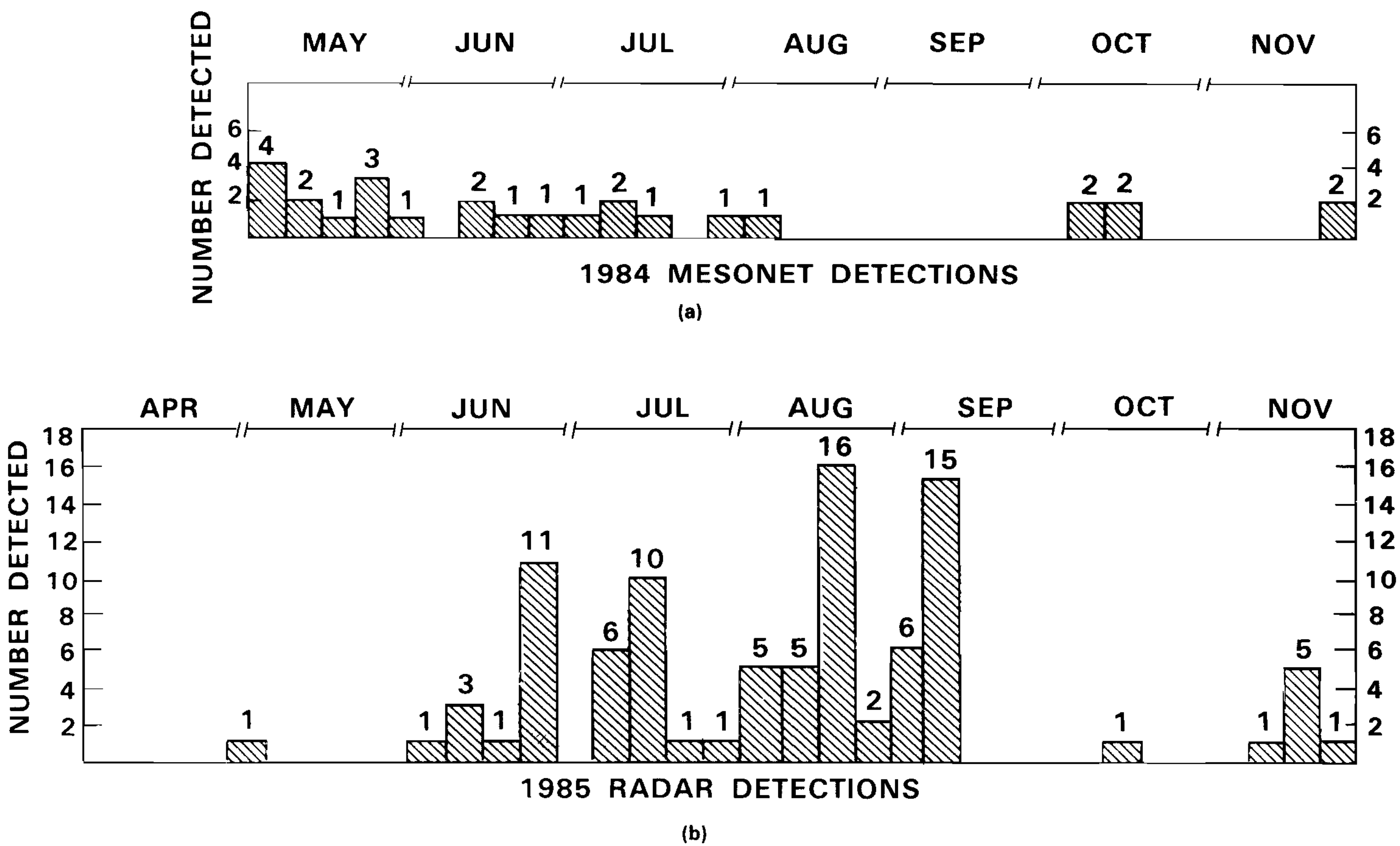


Figure 4.1 Distribution of (a) the number of microbursts detected by the mesonet in 1984 each week of the season, and (b) the number of microbursts detected by the FL2 radar each week during 1985.

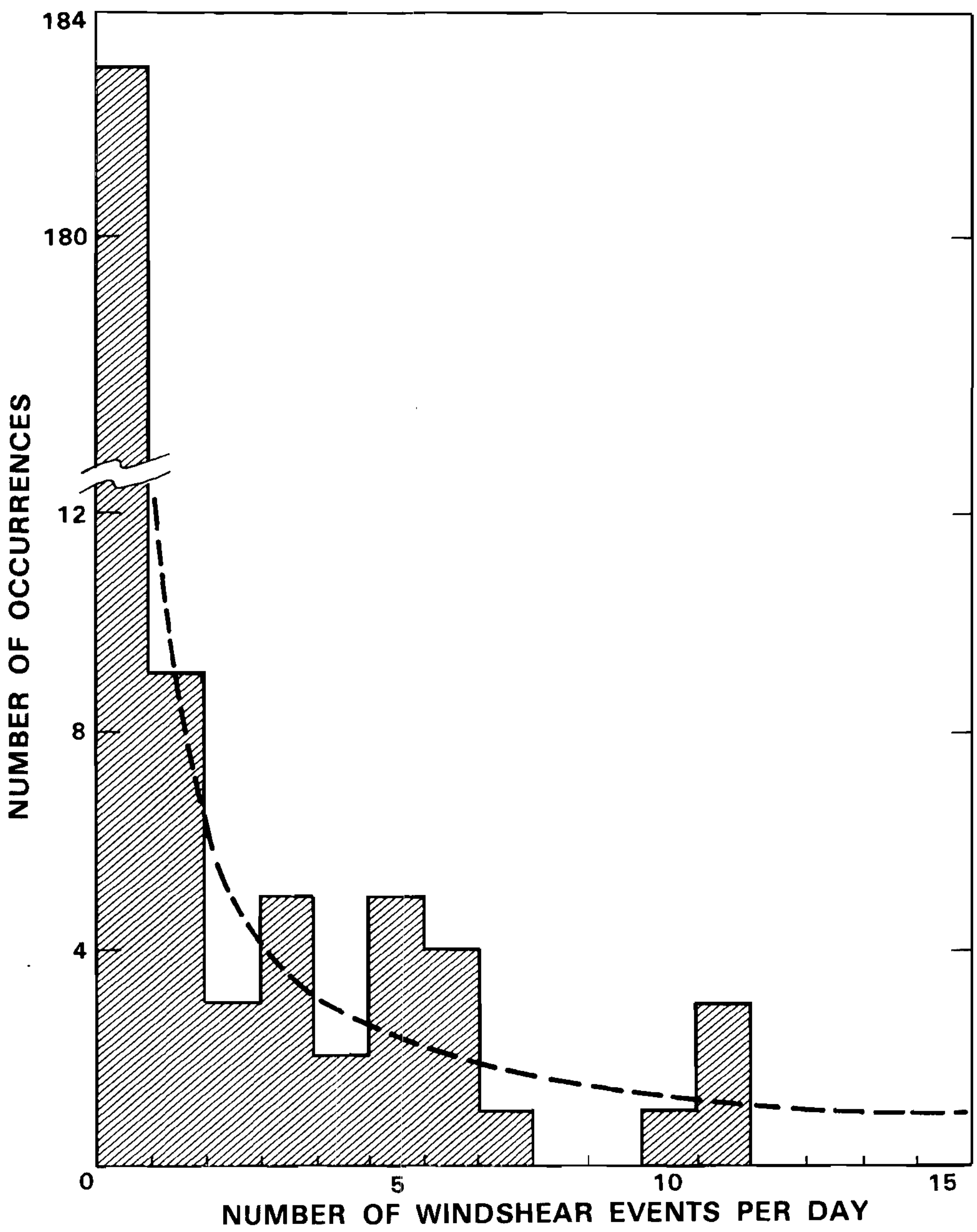


Figure 4.2 Distribution of the number of windshear events per day based on the 1985 radar logs and daily summaries. The dashed line is a power curve fit to the non-zero data points (no. = 2.20 * (no. events per day) -0.844).

Table 4.3

Tabulation of gust fronts detected in real-time by operations personnel during the 1985 field program at Olive Branch, Mississippi. The events tabulated are those recorded in the radar logs and/or the Daily Summary Reports. See text for details and limitations on some of the characteristics listed below. In the table, Del t is the time over which observations of the gust front were made; Range is the distance and Azimuth is the direction to one point along the gust front, but usually the point nearest the radar at the initial time of detection; and z is a representative or typical radar reflectivity factor along the gust front.

No.	Date (1985)	Times Start End	Del t (min)	Range (km)	Azimuth (deg)	Z (dBz)	Remarks
1	15 Apr	1531-1615	-44	28	263		
2	23	1648-1715	>27	36	275		
3	27	1350	>10	31	176		
4	30	1617-1643	26	25	west		
5		1845-1906	21	12	265		
6	1	1352		35	304		
7		1517-1529+	>12	NW of A/P			
8		1619			SSW		
9	28 May	1830-1850+	>20	@UND radar			35 mph @ UND
10	29	2108-2137+	>29	^{2}30	WNW		NEXRAD1 penetrated
11	6 Jun	1723		^{2}25	NW of AP		
12	7	1155		hit AP			Heavy rain, winds
13	10	1608		^{2}15	NW	10	"weak line echo"
14		1701		23	232		
15	11	^{2}1440-1505+	>25	7	320	25	60 mph @ LL radar
16		1816		@ UND radar			15 mph @ UND radar
17		1226-1415	109	30	349	10-15	crossed mesonet (W>E)
18		1906-1929+	>23		south		gusts to 50 mph @ site
19	22	1206-1208+	> 2	13	ENE-WSW		UND detected it first
20	23	1639			NW		Both of these had
21		1639			SE		weak velocities
22		1845		^{2}15	@ AP		Weak velocities

Table 4.3 (Continued)

Tabulation of Gust Fronts

No.	Date (1985)	Times Start End	Del t (min)	Range (km)	Azimuth (deg)	Z (dBz)	Remarks
23	24 Jun	1330		^{2}25	N		GF NW of TRW
24		1330		^{2}25	N		GF S of same TRW
25		1341-1437+	>56	15	356		nice circular outflow
26		1451-1513	22				
27		1544		^{2}16	311		ring gust front
28		1635		43	287		ring gust front
29		1827		32	253		ring gust front
30	25	1216-1241	15	"over city"			Both of these from
31		1216-1241	15	"over city"			MB's over Memphis
32		1307		over AP			Scanned w/RHI's
33		1334					Ring gust front
34		1409-1708	179	40	N		Thin line echo - slow, long lasting
35		1437		30 n.mi	290 from NQA		there is a ring GF
36	26	1321		11	16		Ring GF from MB #1
37		1402-1529	87	21	328		Ring GF from MB #2
38		1555-1655	60	21	136		Moving from SE
39		1555		24	90		Moving from E these merged at 1623
40	27	1456		20	10		Moving from N
41		1548		^{2}5	east		
42	30	1814		west of mesonet			
43	10 Jul	1606-1753	107	22	352	20	Slow, long lasting
44		1827-1850+	>23	31	315		Moved from N
45		1927		9	215		May be same GF as above
46	15	1320		18	31		West of MB #1
47		1521		W to NW to N		>=45	
48		2059-2108+	>9	over UND radar			
49		2223-2304	41	31	273	20	
50	16	1447		Long GF along Miss.R. toward Tenn, then circles toward NE across MEM and then E-ward to the north of us (just over AP)			
51	19	^{2}1430		West of River			Detected by NQA
52		1549					"A few GF's left"
53	21	1520-1727	127	32	259	20	Crossed entire mesonet toward east
54	22	2059-2109+	>10	31	308	20	GF more turbulent than echo
55	1 Aug	1554		7	90	>=30	Shows in Z, V and T
56	5	0902			north		A number of thin-line echoes oriented NE-SW

Table 4.3 (Continued)

Tabulation of Gust Fronts

No.	Date (1985)	Times Start End	Del t (min)	Range (km)	Azimuth (deg)	Z (dBz)	Remarks
57		1333-^{2}1400	>27	14	285		
58	9	1553-1604	>11	26	311	20	Photographed
59	10	1227-1340	>73	40	290		NEXRAD1 penetrated
60		1433		32	31		
61		1528-1618	50	@ UND radar			25 mph at UND
62	12	1649		23	302	15	
63	15	1612-1621+	>9	25	330		NEXRAD1 penetrated
64	19	???? <Log numbers GF 2 and GF3 but I cannot find GF1>					
65		1724-1745	>21	53	270		
66		1809		18	313		
67	18	1544		22	215		
68	25	0304		6	128		
69	3 Sep	1202-1219	>17	17	261		
70	7	1621		19	309		
71		1631		18	299		
72	8	1320-1338+	>18	26	272		Both GF's intersected at AP; new cells built
73		1428		25	25		
74	9	1642-1720	>38	24	313		Intensified cell near AP
75	23	1403-1548	105	60	315		Moved E across mesonet
76	25	1555-1617	>22	22	312		
77		1934		22	161		Fine-line echo
78	29/30	2338-0140	122	18	245		Moved toward East
79	20 Oct	?					Crossed mesonet
80	19 Nov	1845-1910+	>25	42	west		Crossed mesonet, triggered LLWAS alarms
81	27	1121			west		Shelf cloud photographed

It lists characteristics recorded in the log for those gust fronts recognized in real time. Because of the nature of the logs, these tabulations are not entirely consistent nor complete with regards to the actual events. Nevertheless, it provides some useful information of the properties and characteristics of gust fronts in the midsouth region. The times listed are generally minimum lifetimes since not all gust fronts were detected at their inception nor was a gust front always tracked until it had completely died out; further, the start times are probably more reliable than the end times. The range and azimuth to a gust front is usually the first one recorded in the logs; for some gust fronts it may be the only position recorded while for others there may have been several more recorded positions or even speeds of movement.

Comparing results from Tables 4.2 and 4.3 shows that many days with microbursts were also days with gust fronts, and visa versa. Figure 4.3 shows the number of microbursts per day versus the number of gust fronts per day. Only two days with microbursts had no gust fronts, but 18 gust-front days had no microbursts. In general, if a day was a microburst day, there was a very good chance that one or more gust fronts would also be detected; the presence of a gust front was much less reliable indicator that there would be microbursts.

4.1.5 Microburst Wind Shear

One of the important aspects of microbursts and windshear events is the magnitude of the head wind/tail wind difference produced. A measure of this is easily obtained from radar by summing the absolute values of the recorded approaching and receding velocities. Figure 4.4 shows the distribution of the total shear for some 75 events. As mentioned earlier, this sample is biased by some of the operational constraints. Specifically, since we required that an event have at least + and - 5 m/s velocities in the microburst signature, the minimum shear is 10 m/s and is indicated on Fig. 4.4 as the vertical dashed line. Further, those events that just met the criteria were not necessarily always detected. On the other hand, very strong events could hardly go undetected. Thus, the farther to the right we go on Fig. 4.4, the more likely it is that all events of that magnitude were detected. In nature there is probably a distribution of events fron much smaller than our detection criteria to some even larger than we observed. What Richardson said about turbulence (Hess, 1959) could probably be extended to microbursts. He said:

> Big whirls have little whirls
> that feed on their velocity,
> And little whirls have lesser
> whirls, and so on to viscosity.

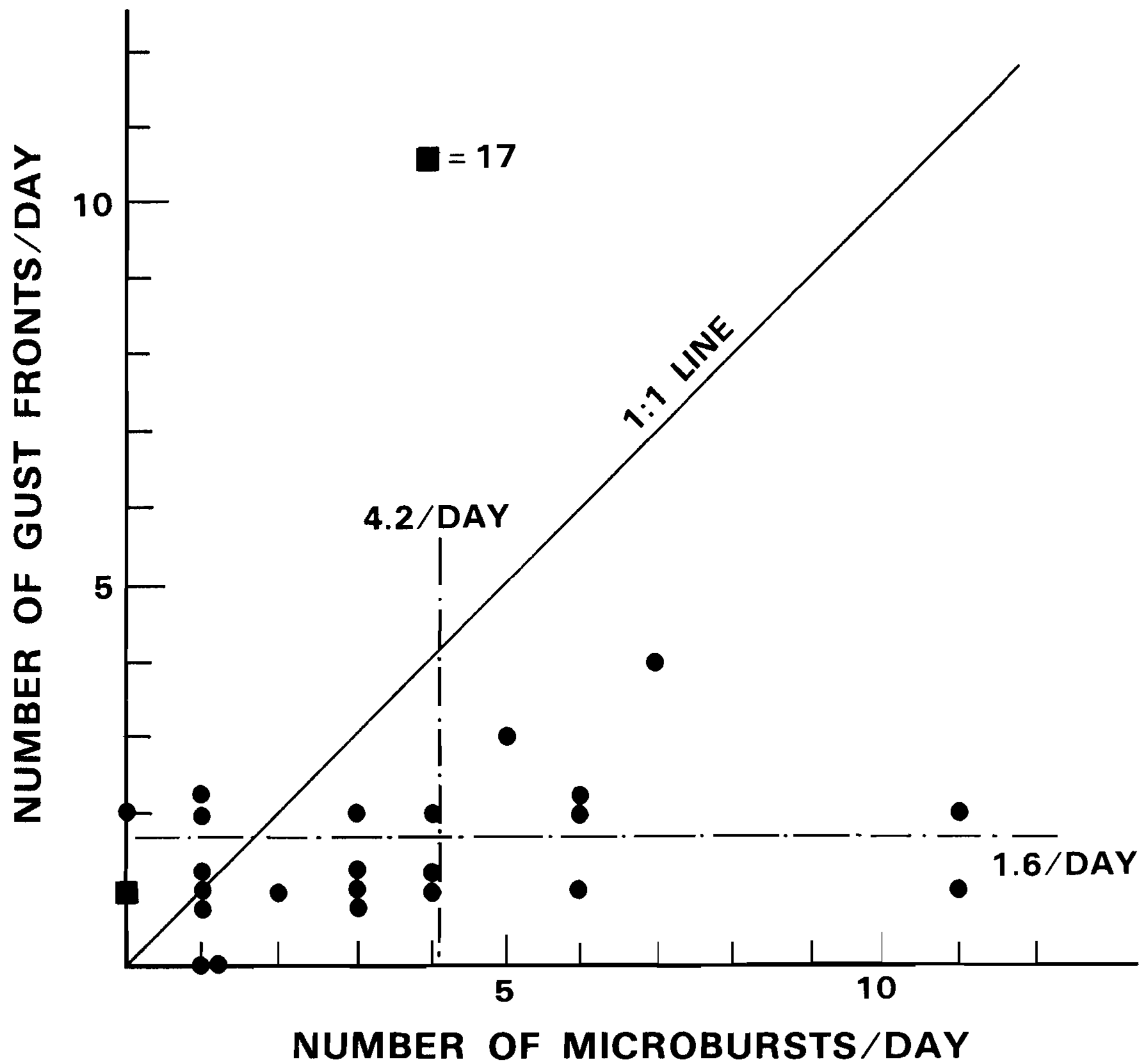


Figure 4.3 Scatter diagram of the number of microbursts per day versus the number of gust fronts per day. The average number of microbursts (4.2/day) and gust fronts (1.6/day) are also given as is the one-to-one line. Note that there were 17 days with one gust front but not microbursts (the square).

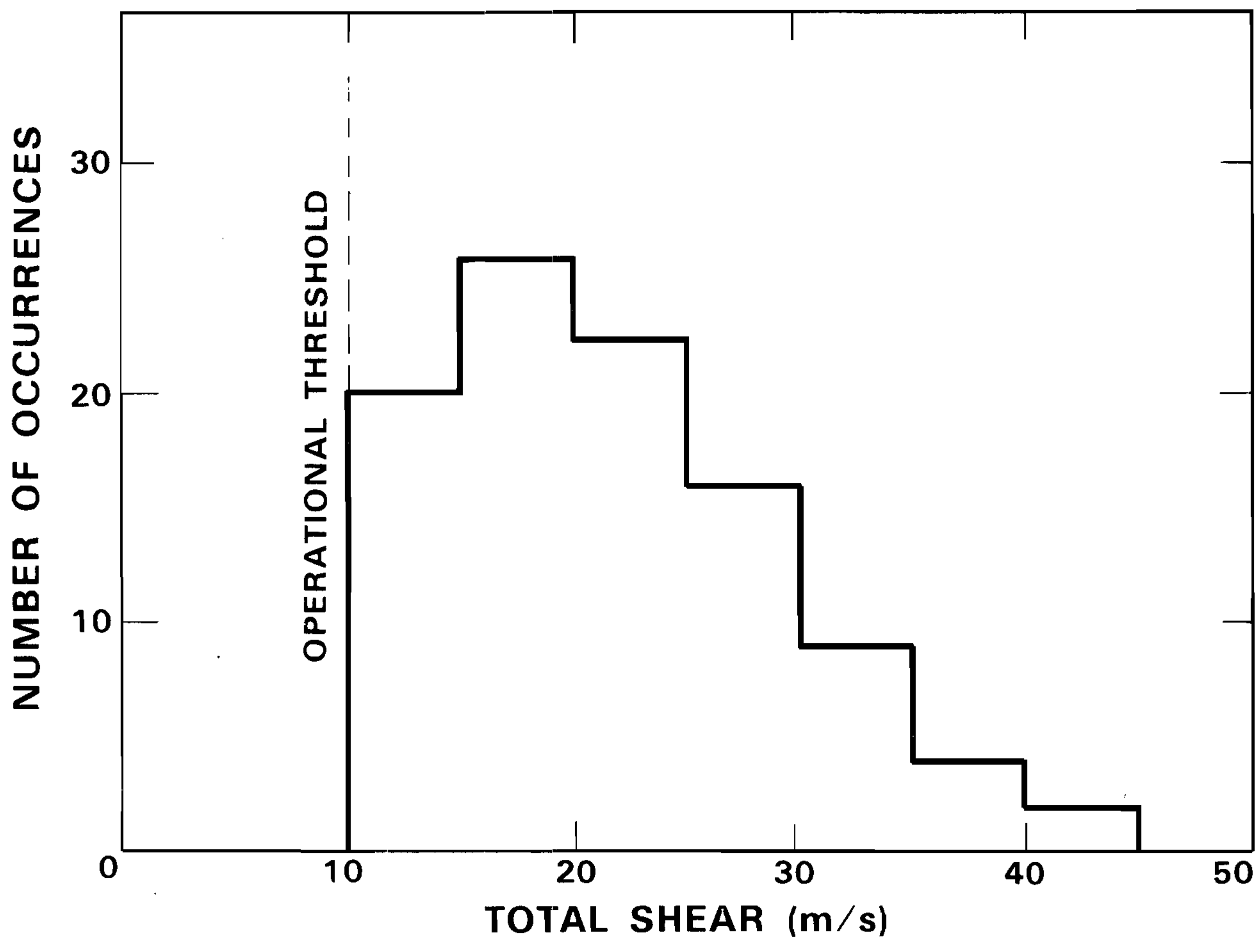


Figure 4.4 Distribution of the number of occurrences of each shear value indicated, where the total shear is the absolute sum of the approaching and receding velocities recorded in the radar log. During operations we did not record events with less than 5 m/s approaching and/or receding velocities. The dashed curve is an exponential fit to those values with 20 m/s total shear or more.

If true for microbursts as well, we might expect many more small features than those detected. The dashed curve is an exponential fit to those events with more than 15 m/s total shear. It suggests that we probably missed detecting as many as 35 events with shears of only 10 m/s (and probably some of those of 15 or even 20 m/s also).

4.1.6 Microburst Locations

Another interesting aspect of microbursts in the mid-South is their locations. Figure 4.5 shows the locations of the windshear events detected between April and November relative to the FL2 radar at Olive Branch. More microbursts were detected north and west of the radar than south and east. Again, an operational bias probably accounts for some of this. Our mesonet was located primarily to the west and northwest of the radar, and we tried to collect data on storms over the mesonet whenever possible. If more than one storm occurred at the same time and we had to choose one over the others, we invariably chose the one nearest the mesonet. In the mid-South most major storm events moved from the west or northwest. Again, the tendency was to concentrate more on storms that have yet to arrive than on those which have already passed over the area.

Looking in more detail at the events that occurred over or near the mesonet, we can examine Fig. 4.6. Of the 43 locations plotted on the map, 14 are within the boundary of the mesonet formed by connecting stations in such a way that no connecting line was longer than 5 km (this is the irregular-shaped polygon). However, events "close" to the mesonet are also likely to be detected. In reality, there is no exact "size" that can be applied to the mesonet. Instead, there is a certain probability of detection that is some function of distance from the mesonet. Even events right over the mesonet could go undetected if they are small enough. The farther from the mesonet, the less likely it is that an event will be detected. In fact, the size of the mesonet is rather fuzzy! Nevertheless, another boundary is drawn on the figure, this one encloses that area which is within 4 km of the mesonet; another 17 events are located in this space. Another dozen events are also shown on the figure outside this boundary. While these are less likely to be identifiable from the mesonet data alone, combining radar and mesonet data for these might yield some useful information.

Figure 4.7 shows the distribution of the number of windshear events as a function of distance from the radar but normalized to give the number per unit area. There is no a priori reason to believe that Olive Branch, Mississippi, is unique meteorologically, that it should somehow influence the weather so as to produce more events than surrounding regions. In reality, the distribution of windshear events is probably fairly uniform over a much larger region. So, why does Fig. 4.7 show many events nearby with virtually none farther away? Again, there are a couple of contributing factors. One, mentioned above, is that we concentrated on nearby events rather than those farther away. This is probably the largest factor in producing this biased distribution. If we had been asked to see how

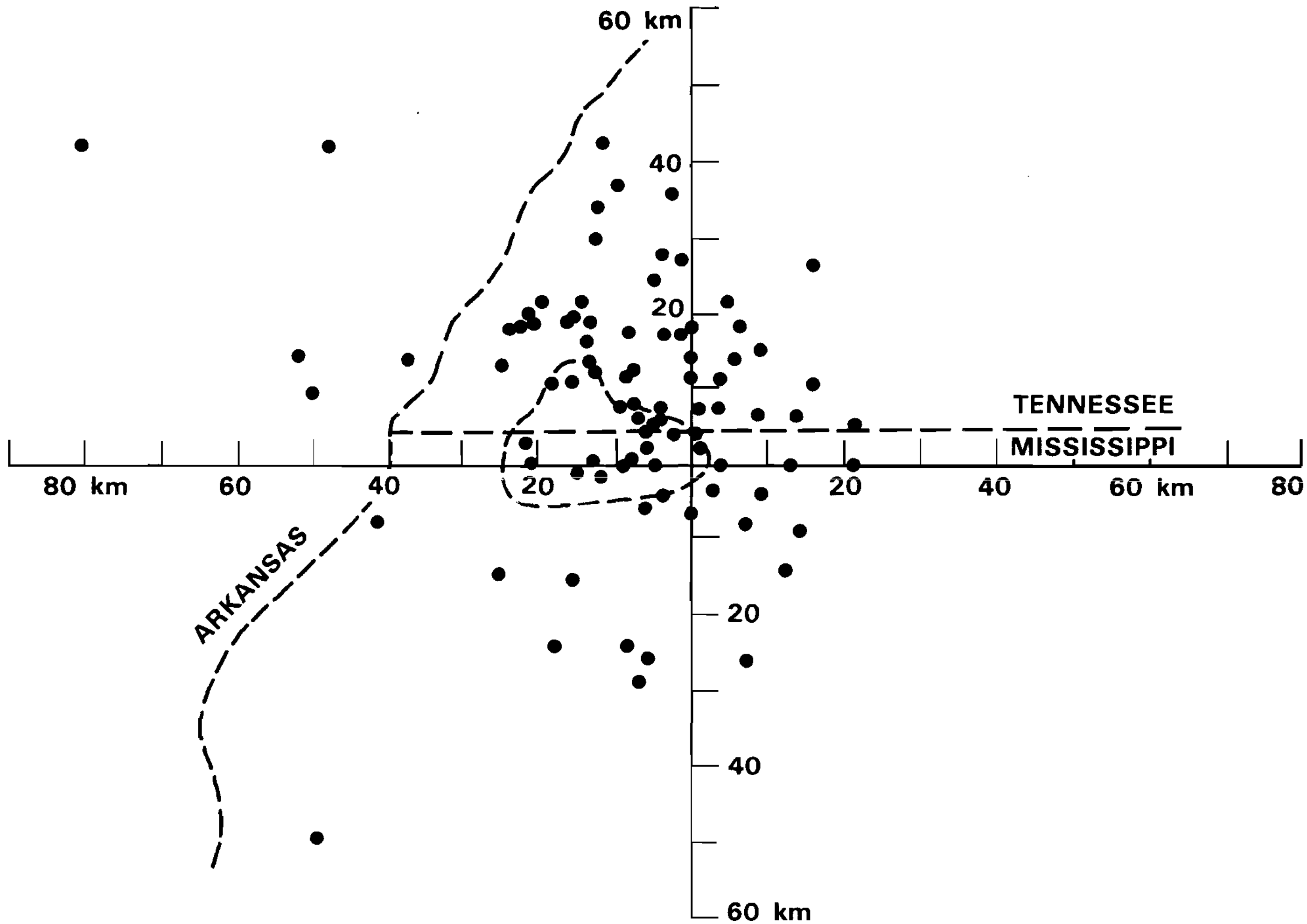


Figure 4.5 Spatial distribution of windshear events in the mid-South. Each point indicates the approximate initial location of a microburst, macroburst or divergence area recorded in the radar log. The dashed area near and just west of the FL2 radar (located at zero range east-west and north-south) is the boundary of the mesonet.

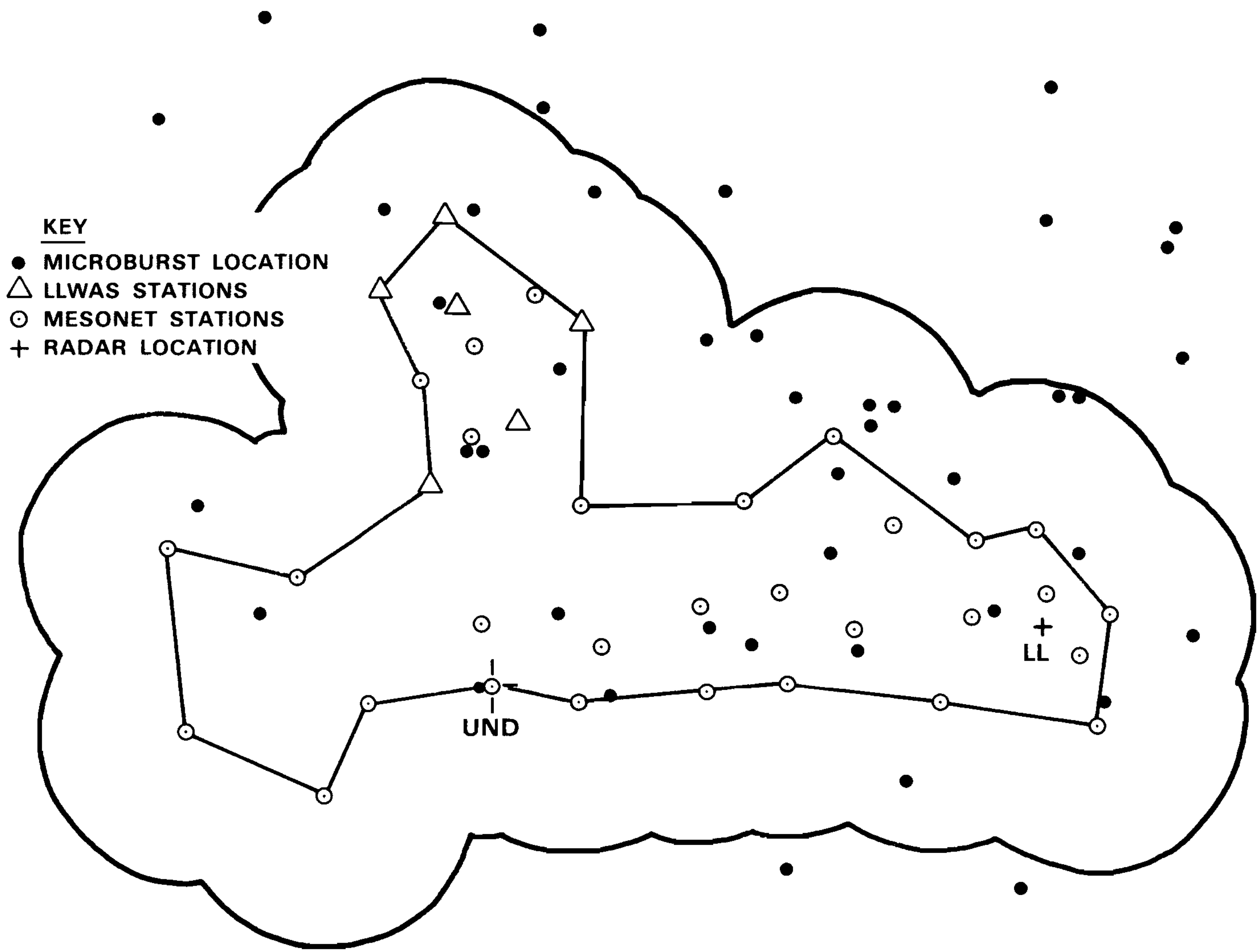


Figure 4.6 Spatial distribution of windshear events near the mesonet. Mesonet stations are indicated by the circled points while wind events are solid circles. The FAA low-level wind-shear alert system (LLWAS) stations are indicated by triangles. The polygon connecting exterior wind stations is one estimate of the size of the mesonet. Another estimate of the size of the mesonet is given by the solid line which is 4 km from the nearest mesonet station.

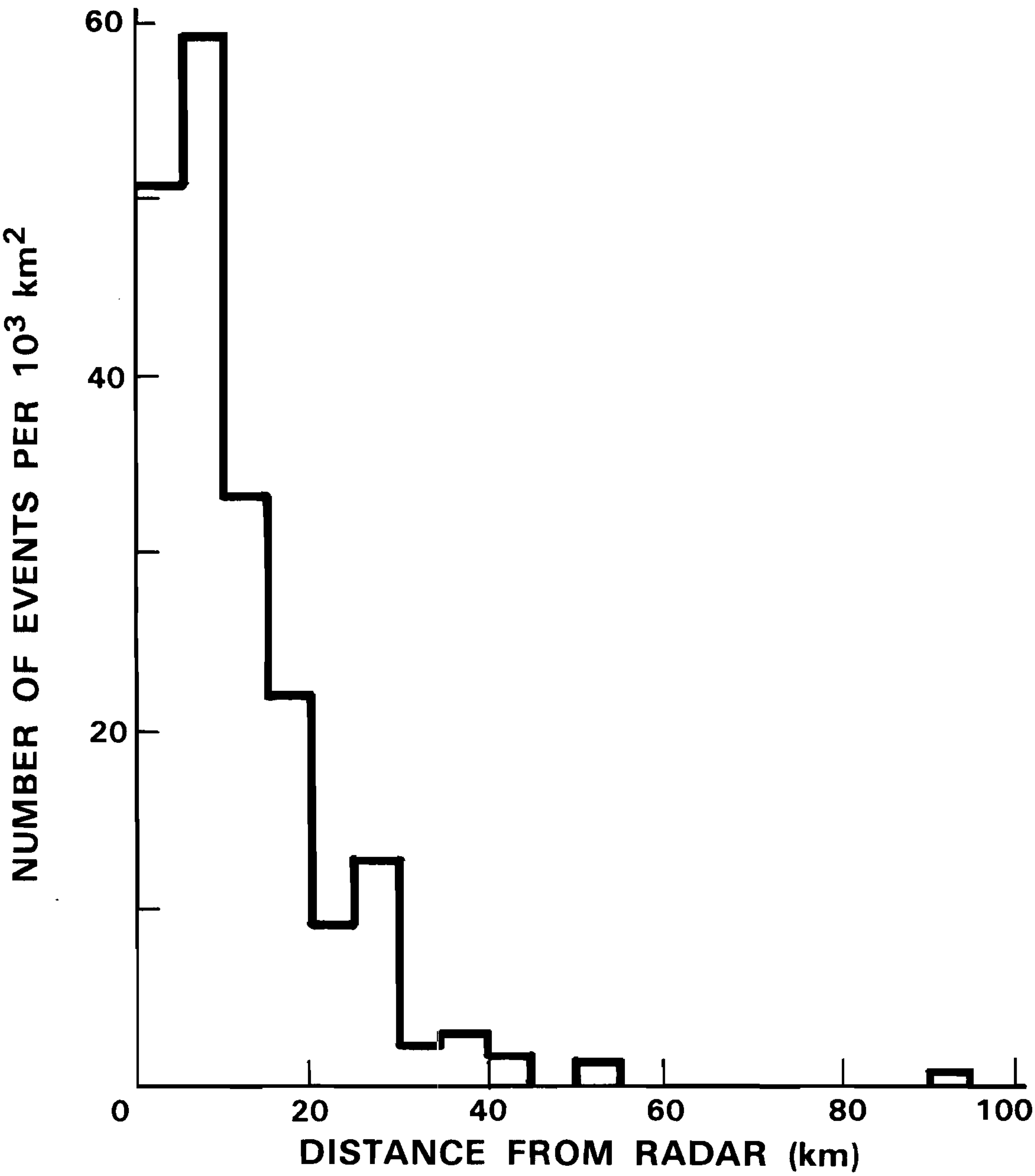


Figure 4.7 Normalized distribution of the number of windshear events per unit area from the radar data for 1985 as a function of distance from the FL2 radar.

many events we could find beyond, say, 40 km, and we concentrated on that and that alone, the distribution would be vastly different. Another reason for this decrease with range, however, is the fact that windshear events are primarily surface phenomena, and the radar beam gets higher and higher above the earth's surface at longer distances from the radar. At some point away from the radar, a windshear event easily detectable at close range becomes undetectable. This distance is a function of both the depth of the outflow produced by the event and the elevation angle being used by the radar. Intervening blockage by nearby trees, buildings, and topography can also reduce the range at which events can be seen in some directions. It is interesting that at least one event was detected at a distance of approximately 90 km from the radar. It is quite likely that a search of the radar data for storms at longer distances would uncover a number of other events at similar or further distances.

4.2 Terminal Doppler Weather Radar (TDWR) Issues

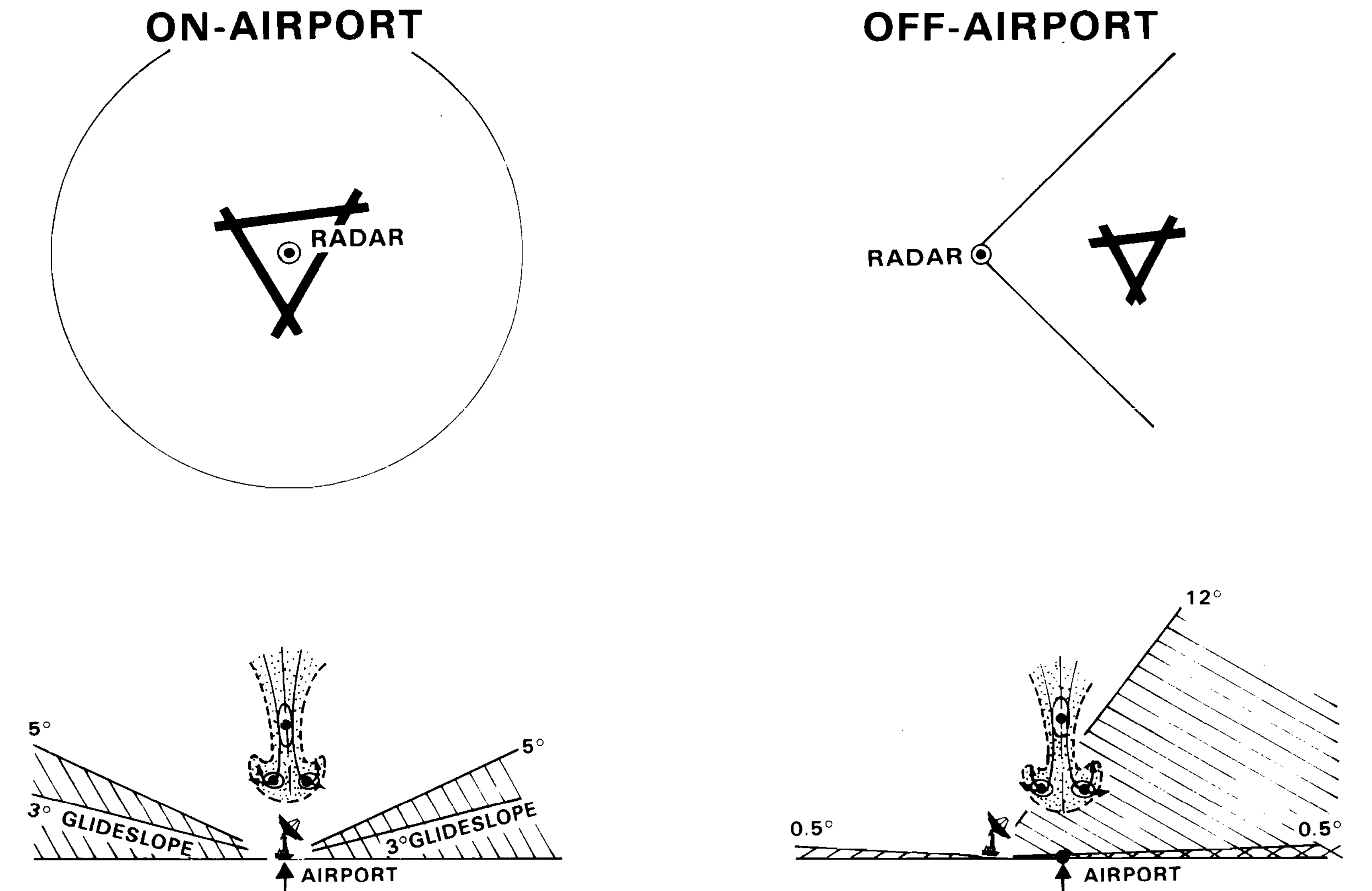
There are a number of issues related to the development of the FAA's Terminal Doppler Weather Radar that can be addressed using the existing data from the 1985 field season at Memphis. Among the concerns are the sensitivity of the system needed to detect critical wind shear regions, required antenna characteristics, and required signal processing capabilities (including clutter suppression, interference rejection and detection, and range/velocity unfolding). Another issue is where to place the radar (on or off the airport). Some of these issues are addressed in the following sections.

4.2.1 Depth of Microbursts

The decision to put a TDWR system on or off an airport hinges in part upon the depth of the wind shear event of concern and whether it is possible or desirable to detect precursor features. Figure 4.8 shows two possible configurations for TDWR use. On the left the radar is located somewhere on the airport while on the right the radar is located at some distance off to one side.

The advantage of the on-airport locations is that the radar is potentially capable of detecting winds along at least some of the runways and is hence better able to determine the actual component of wind an aircraft might encounter. Unfortunately, it becomes necessary to scan full circle or very large azimuths in order to cover activity in all directions. Further, events descending upon an airport could go undetected until the reach the surface, eliminating the possibility of providing any forecasting capability.

In the off-airport case, the radar is potentially capable of scanning high enough to detect precursors and is able to cover the smaller azimuth limits in a faster time but is no longer able to detect the wind component along all runways.



- 360° SCANS
- VULNERABLE TO HAZARDS OVERHEAD
- MEASURE GLIDESLOPE WINDS DIRECTLY

- SECTOR SCANS
- PROTECT ENTIRE TERMINAL AREA
- ESTIMATE GLIDESLOPE WINDS

Figure 4.8 Comparison of on- and off-airport TDWR configurations.

The distance to which a microburst is detectable depends upon at least two factors. One is the reflectivity and spectrum width of the targets producing the return, and the other is the depth of the event. Using data from our 1985 field season we have commenced analysis of the depth features. Fig. 4.9 shows the features identified as being of major concern for radar siting and design. Table 4.4 lists the results on 14 Memphis area microbursts with regard to the velocity, reflectivity, spectrum width, and depth characteristics.

In general, the depth of the outflow is on the order of 300 to 1100 m. A radar beam aimed at 0.5 deg elevation angle would be at 300-m altitude (above ground level) at a distance of approximately 27 km; deeper events would be detectable out to longer distances. Thus, an off-airport radar should be capable of detecting even the shallowest Memphis microbursts out to distances on the order of 25 km or longer. There is probably little advantage to siting a TDWR system any farther away from an airport than this.

Regarding the reflectivity of microbursts, we need to recall that microbursts can be divided into wet and dry categories. The wet microbursts come associated with rain and are usually fairly strong in their return. Dry microbursts, on the other hand, are not associated with nearby rain. Their detectability depends upon the clear-air tracers present in the region affected by the microburst. The reflectivity of dry microbursts can be on the order of 0 to 15 or 20 dBz, possibly even lower for some (Fujita, 1985). Thus, a TDWR radar would need to be sensitive enough to detect these kinds of reflectivities out to distances of at least 25 km or so. This capability should be available on TDWR systems. Note that the reflectivities given in Table 4.4 are all from wet microbursts apparently (core reflectivities exceed 40 dBz in all cases but one, and that has a value of 20-50 dBz).

4.2.2 Microburst Asymmetry

Another issue of concern for operationally useful microburst detection is the shape of the outflow region. A stationary, circularly symmetric microburst would produce an outflow which would be the same in all directions at a particular distance from the outflow center. No matter where a radar were located around this event, it would measure peak approaching and receding velocities that would be identical. For stationary but nonsymmetric microbursts, the radial velocities could be different, depending upon the degree and orientation of the asymmetry relative to the radar. Symmetric but nonstationary microbursts could also give different maximum approaching and receding velocities if the direction of motion of the microburst is toward or away from the radar. And finally, moving nonsymmetric microbursts could also produce different approaching and receding velocity maxima. In Memphis the translational velocity of many of the microbursts was small relative to the velocities produced by the event. Thus, as a rough estimate of microburst asymmetry, we could examine the difference in the approaching and receding velocities.

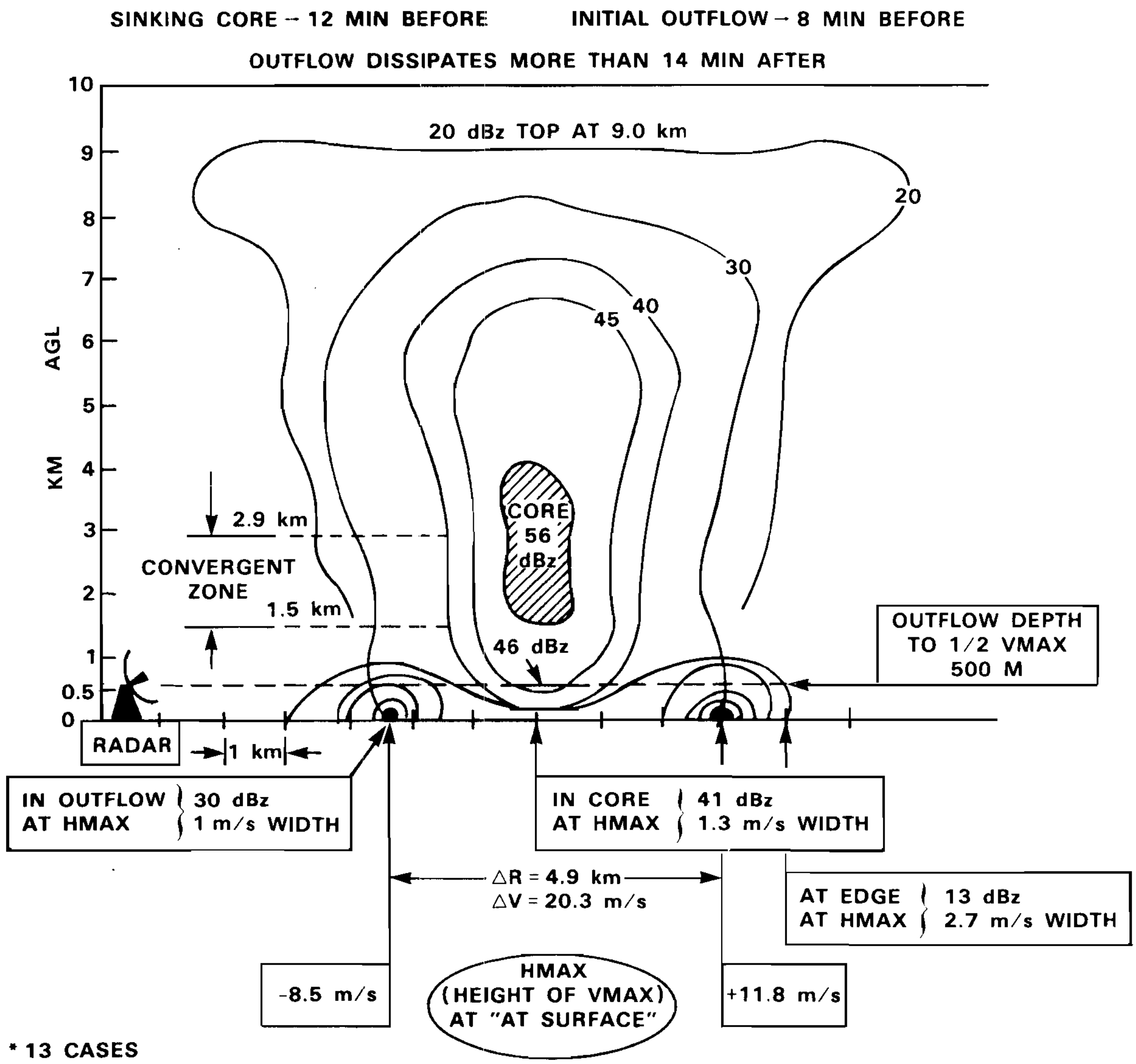


Figure 4.9 Schematic representation of the average outflow conditions measured for 14 Memphis microburst cases.

Table 4.4

1985 FLOWS* MICROBURST DATA

MEMPHIS, TN

SURFACE OUTFLOW CHARACTERISTICS

DATE	TIME (GMT)	HGHT. RES.	Vmax+	Vmax-	ΔR	Height Vmax	Depth (Hu)	Zout	σout
*APR 30	2052	.81	8.0	- 8.0	7.1	0.2-0.5	0.7	20-35	1.5-3.0
*APR 30	2144	.31	23.5	- 4.5	7.2	< 0.1	0.3-0.6	30	0.5
*APR 30	2208	.39	12.6	-10.5	5.0	< 0.1	0.5	25	1.0
JUN 25	1829	.38	6.0	- 4.0	6.5	0.2	0.5	20	0.5
JUN 26	1838	.14	13.5	-13.5	4.5	< 0.1	0.4	50	1.0
JUN 26	1948	.28	10.0	-12.0	4.6	< 0.1	0.4	50	1.0
JUN 30	2305	.47	15.0	- 5.0	7.0	0.2	< 0.8	< 5	1.0-2.0
JUL 15	1957	.09	12.0	-10.0	4.5	< 0.1	0.5	25	1.0
JUL 23	2018	.35	12.0	- 2.0	4.4	0.0-0.2	0.5	20	0.5
AUG 10	2000	.24	6.0	-14.0	5.0	0.1-0.2	0.2-0.8	20-45	0.5
AUG 15	2119	.10	12.0	- 4.0	3.7	< 0.1	0.3	20-45	0.5
AUG 24	2018	.60	12.0	- 6.0	3.0	< 0.5	< 0.6	20	3.0
SEP 7	2219	.16	8.0	- 8.0	3.0	< 0.1	0.4	10-35	0.5
*SEP 8	1855	.26	8.4	-12.6	4.3	< 0.1	0.7	40	0.5-1.0

* = University of North Dakota Enterprise C-band Doppler (1.5 deg)
  = FAA - Lincoln Laboratory (FL-2) S-band Doppler (1.0 deg)

Table 4.4 (Continued)

1985 FLOWS* MICROBURST DATA

MEMPHIS, TN

ADDITIONAL SURFACE REFLECTIVITY AND SPECTRUM WIDTH DATA

DATE	TIME (GMT)	Zcore (.5km)	Zcore (Hmax)	σcore (Hmax)	Zedge	σedge
*APR 30	2052	45	35-40	2.5	15-25	3.0
*APR 30	2144	50	45	1.0-3.0	TH-20	3.0
*APR 30	2208	50	40	1.0	TH-20	2.5-3.0
JUN 25	1829	50	50	0.5	TH-20	3.0-5.0
JUN 26	1838	50	50	0.0-1.0	20-25	3.0-5.0
JUN 26	1948	50	45	0.0-1.0	TH-20	3.0
JUN 30	2305	55	50	3.0	TH-20	2.5-5.0
JUL 15	1957	50	55	1.0	TH-20	1.0-1.5
JUL 23	2018	20-50	20-50	0.0-1.0	TH-25	1.5-3.0
AUG 10	2000	40-45	25-45	0.0-1.0	15-35	1.5-3.5
AUG 15	2119	50	20-45	0.0-1.0	TH-20	2.0-3.0
AUG 24	2018	40	40	3.0	TH	2.0
SEP 7	2219	40-45	20-40	0.0-1.0	TH-30	3.0
*SEP 8	1855	40-45	40-45	1.0	TH-20	1.0-3.0

* = University of North Dakota Enterprise C-band Doppler (1.5 deg)
= FAA - Lincoln Laboratory (FL-2) S-band Doppler (1.0 deg)

Figure 4.10 shows the distribution of the number of microbursts that had the indicated differences in the approaching and receding velocities in our Memphis data. In this analysis, a microburst with -15 m/s approaching and +15 m/s receding velocities would be counted as having zero difference. The velocity measurements were generally limited to a resolution of the nearest 5 m/s because that was the interval available on the color display in real-time during our operations. As can be seen in the figure, most of the events had identical or nearly identical maximum velocities in the microburst couplet centers. Only 15% of all Memphis microbursts had velocity maxima which differed by 10 m/s or more, suggesting that the number of asymmetric microbursts in the midsouth is of similar proportions. Whether or not this is a bothersome number has yet to be determined, but, to the extent that this analysis represents microburst asymmetry, asymmetry does not appear to be a dominant characteristic of microbursts in the midsouth.

The procedure discussed above is really only an estimate of the asymmetry of a microburst. Since a single Doppler radar can only measure the radial component of velocity, it cannot precisely determine whether a microburst asymmetric or not. A better way to do this is to use two Doppler radars and perform dual-Doppler analyses of the combined data sets.

Figure 4.11 is a dual-Doppler analysis by M. Wolfson for the Hickory Ridge microburst that occurred about 7 km north-northwest of the FL2 radar on 26 June 1985. It combines data from the FL2 and UND Doppler radars to produce the horizontal winds within the lowest layer of the storm. The streamlines show that the air was diverging out from the center of the microburst, but not truly uniformily in all directions. The strongest flow from the center was toward the north and the south with less flow toward the west and nearly none toward the northeast. The asymmetry shown in the detailed dual-Doppler analysis would not have been detectable on the real-time FL2 display of this microburst because the radar line of sight was essentially north-south.

4.2.3 Clutter Suppression

Although several Doppler weather radars used for meteorological research (e.g., the CHILL radar operated by the Illinois State Water Survey and the USAF Geophysics Laboratory S-band radar) have had high pass filters for clutter suppression, their clutter filters have by and large not been used for measurement programs due to poor hardware reliability and/or excessive degradation of the weather parameter estimates. Both of the radars used for FLOWS routinely suppressed clutter by the use of high pass linear filters (in the case of FL2) or frequency domain techniques (Passarelli *et al*., 1981). Both radars were successful in reducing their respective clutter environments to an operationally useful level. However, only the FL2 performance is viewed as being germane to NEXRAD/TDWR design and operation since the spectrum residue from the Enterprise magnetron phase locking system seriously compromised the clutter suppression capability of the UND radar signal processor.

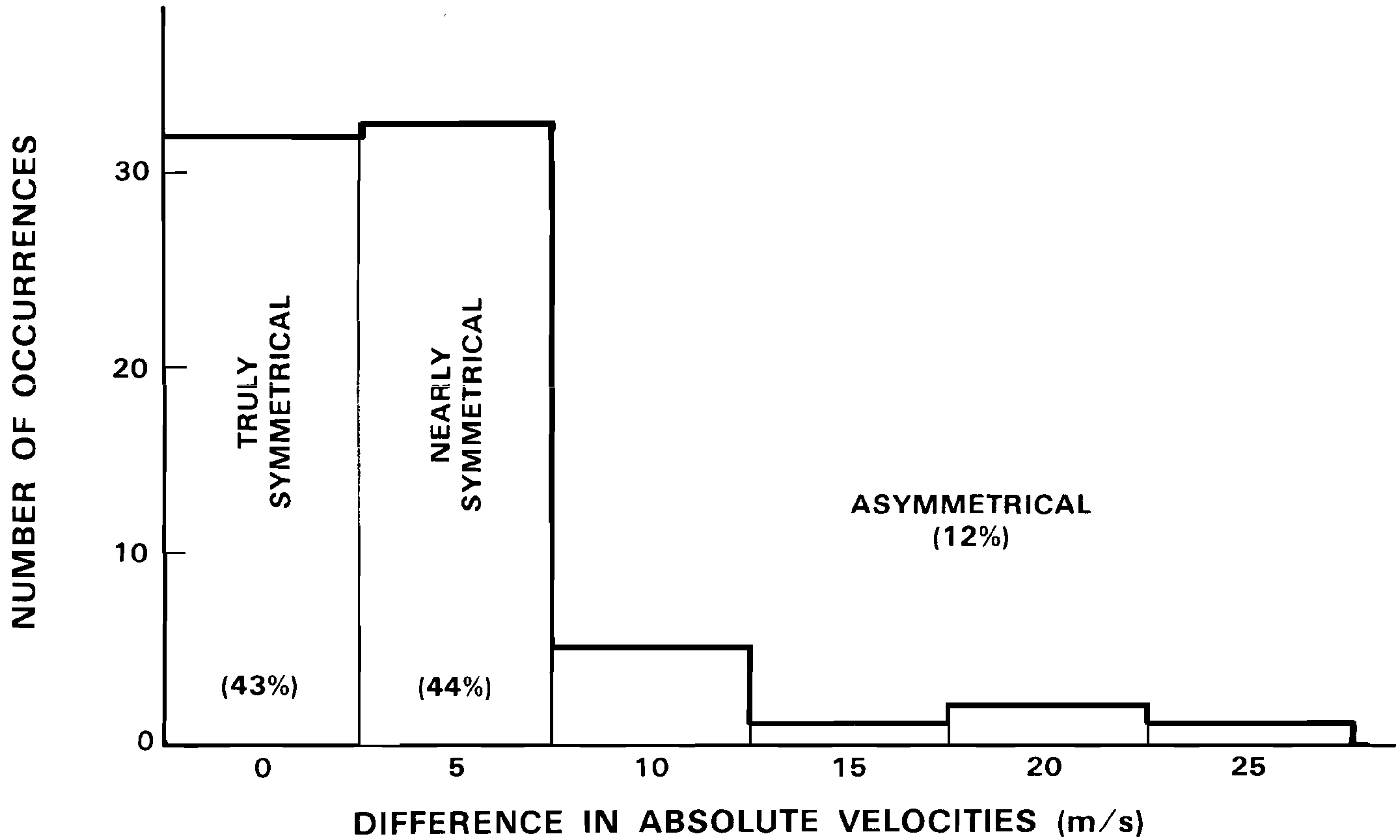


Figure 4.10 Asymmetry in microburst outflows as determined from single radar data.

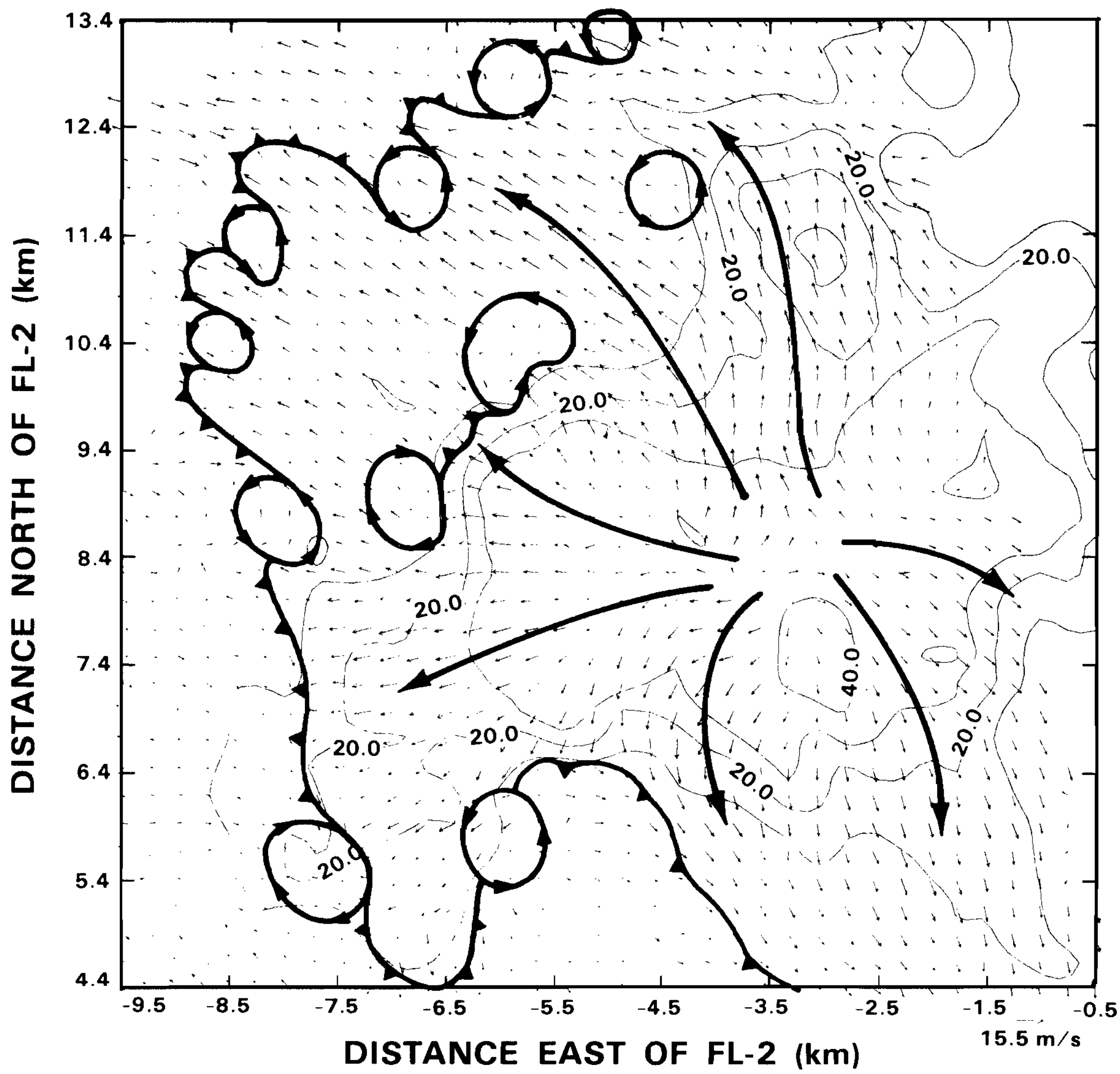


Figure 4.11 Dual-Doppler analysis of the horizontal winds for the Hickory Ridge Microburst of 26 June 1985. The small arrows show the wind at grid points spaced at 0.2 km intervals with a vector 0.2 km long representing a wind of 15.5 m/s. The analyzed frontal boundary shows the position of the leading edge of outflow which has moved out from the center of the microburst. Note the very small circulations shown in this analysis (indicated by the closed contours on the frontal boundary). The light solid contours are radar reflectivity (in dBz, with an interval of 10 dBz between contours).

The 39 point finite impulse response (FIR) clutter filter used in the FL2 radar (including its expected effects on clutter and weather signals) is described in depth by Evans (1983) and hence will not be discussed here. The stop band width of the clutter filters (a key consideration in effects on weather estimates) used in FL2 depend on the PRF and the scan rate. For the bulk of the 1985 testing in Memphis, slow scan rates (< 6 deg/s) and low PRF's (e.g., often 700 Hz) were typically used (due to data throughput restrictions). Consequently, the clutter filter passband edge was often as low as 1.5 m/s which is nearly half of that which might be required for an operational system. This narrow notch width should not have substantially affected the clutter suppression capability, but would produce less effects on the weather parameter estimates than would be the case with a wider stop bandwidth.

Figure 4.12 shows the clutter at 0.5° elevation angle in the vicinity of the FL2 site with and without the clutter filters in operation on a day where anomalous propagation (AP) was present. The peak clutter levels (as expressed in equivalent weather reflectivity level) are seen to drop from over 45 dBz to the clear air return level of +10 dBz. The only clutter levels above +10 dBz with the clutter filters in use were within 1 km of the radar. This very close-in clutter was not of practical concern because LAWS phenomena at such ranges can easily be measured at higher elevation angles where the main beam does not illuminate the clutter sources.

Although the clutter filters were quite successful at suppressing the Olive Branch FL2 site clutter, many important clutter suppression issues could not be adequately addressed at this site since the clear air return typically obscured the clutter residue [See Mann (1986)]. These issues will have to be examined in testing at other sites with FL2.

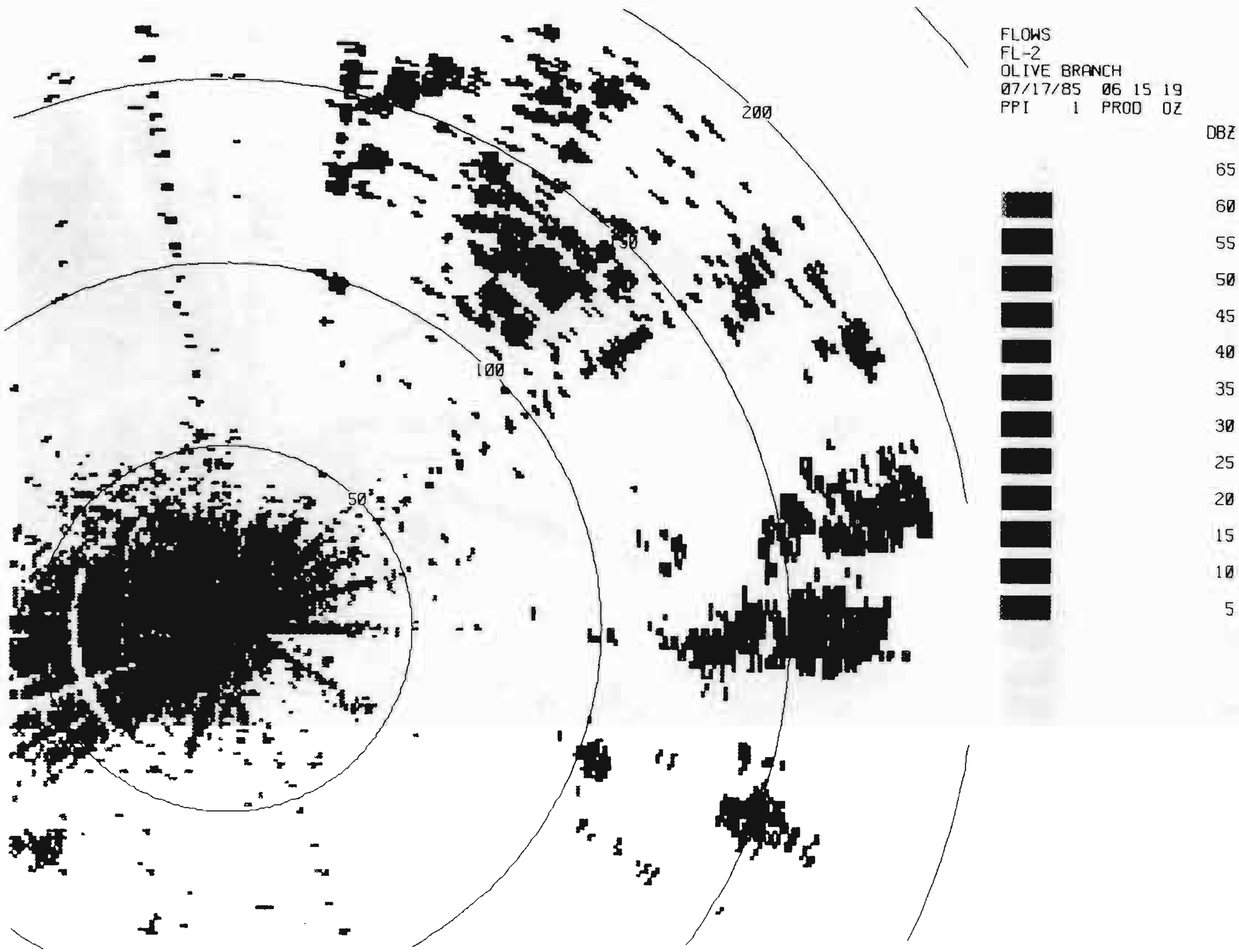


Figure 4.12(a) The effects of using clutter filters during the detection of ground clutter in anomalous propagation northeast and east of the FL2 radar from 100 to 200 km - without clutter filter.

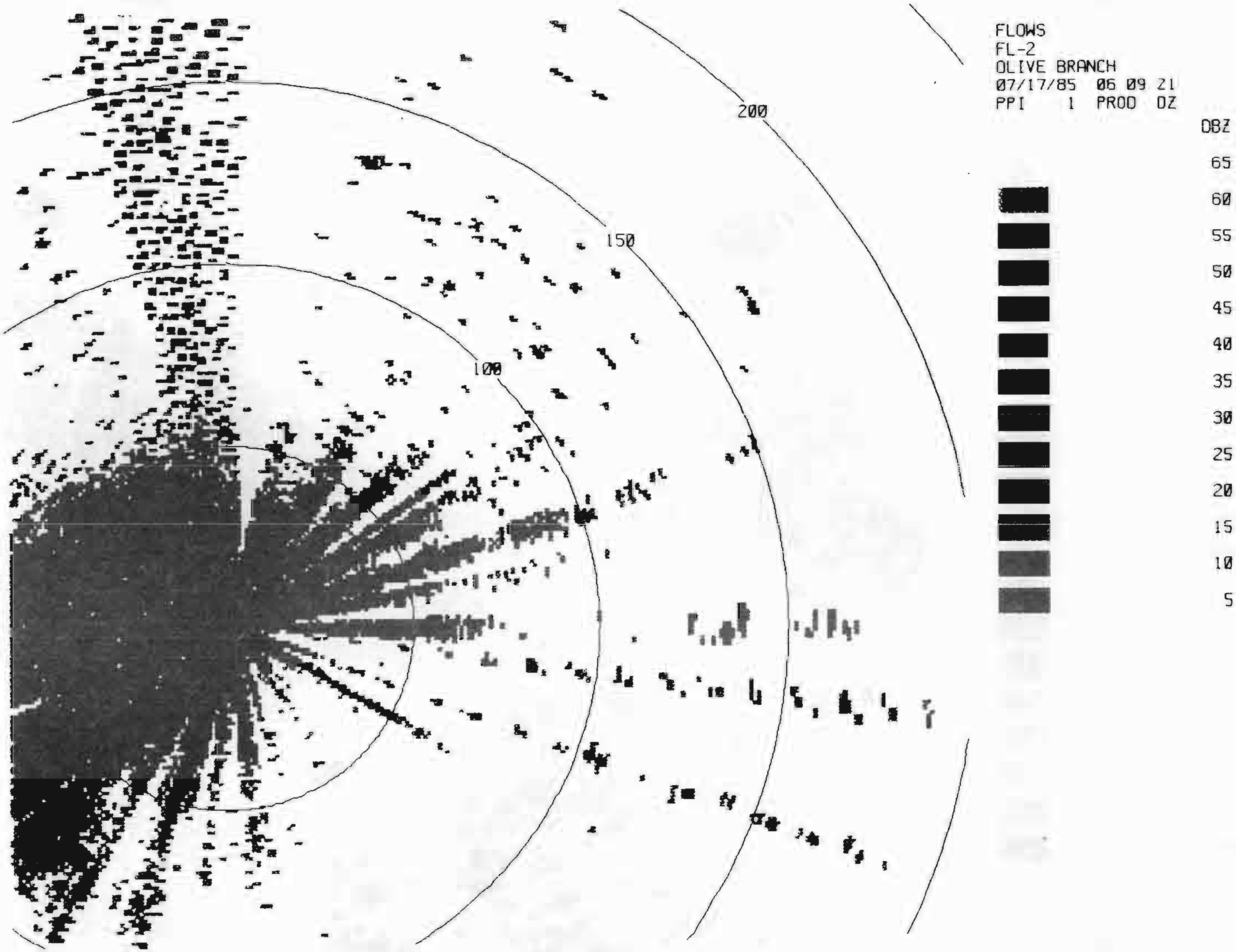


Figure 4.12(b) The effects of using the clutter filter during the detection of ground clutter in anomalous propagation northeast and east of the FL2 radar from 100 to 200 km - with clutter filter.

5. AIRCRAFT TURBULENCE DETECTION RESULTS*

A principal use of the aircraft data is to assess the performance of the NEXRAD Doppler weather radar turbulence detection algorithm. In particular, attention is focussed on the correlation between the computed results for the turbulent kinetic energy dissipation rate, $\epsilon^{1/3}$, based on Doppler radar spectrum width observations and $\epsilon^{1/3}$ computation based on in situ measurements of pressure and vertical acceleration using an instrumented aircraft. In an operational NEXRAD system, the Doppler estimates of $\epsilon^{1/3}$ are to be estimated using the government-supplied turbulence detection algorithm together with the layering algorithm to generate turbulence maps for use by the Central Weather Processor (CWP). Figure 5.1 shows the basic elements in the turbulence data analysis. The various processing steps and algorithms used to estimate turbulence are discussed in the report by Y. Lee (1986). In order to analyze the 1985 Memphis turbulence data, a significant number of enhancements to the software used by Lee are required which have not been fully completed at this time.

Very preliminary inspection of the aircraft data indicates that the Memphis 1985 flights provide observations of a greater variety of storm types and turbulent environments than did the 1983 Boston data analyzed by Y. Lee. As an example, Fig. 5.2 shows the altitude profile of the UND Citation flight on August 10, 1985 where the aircraft penetrated a microburst and gust front as well as measuring the storm mid-level characteristics. Comparing the four "constant" altitude segments, it is clear that the turbulence environment, as indicated by the ability of the aircraft to maintain constant altitude, was significantly different for the different segments. The very different temporal characteristics are evident in the two segments at 12 kft. altitude. Very strong turbulence occurred in the first 12 kft. altitude segment while much lighter turbulence occurred in the second. The corresponding aircraft vertical velocities are shown in Fig. 5.3, and they also indicate the relative levels of turbulence that the aircraft experienced.

The next series of figures focusses on the first turbulent region between 1753 and 1832 UT. Figure 5.4 is a time series showing the estimates of $\epsilon^{1/3}$ based on structure function computations using aircraft vertical accelleration measurements. Figure 5.5 is a similar plot showing $\epsilon^{1/3}$ estimates based on structure function computations using aircraft differential pressure measurements. The figures show reasonable qualitative agreement between these two measures of the actual turbulence experienced by the aircraft along the flight path. Figure 5.6 shows similar time series plots of $\epsilon^{1/3}$ based on radar measurements of Doppler spectrum width. The four parts correspond to different types of spatial averaging associated with layering

*This section was contributed by Dr. A.R. Paradis.

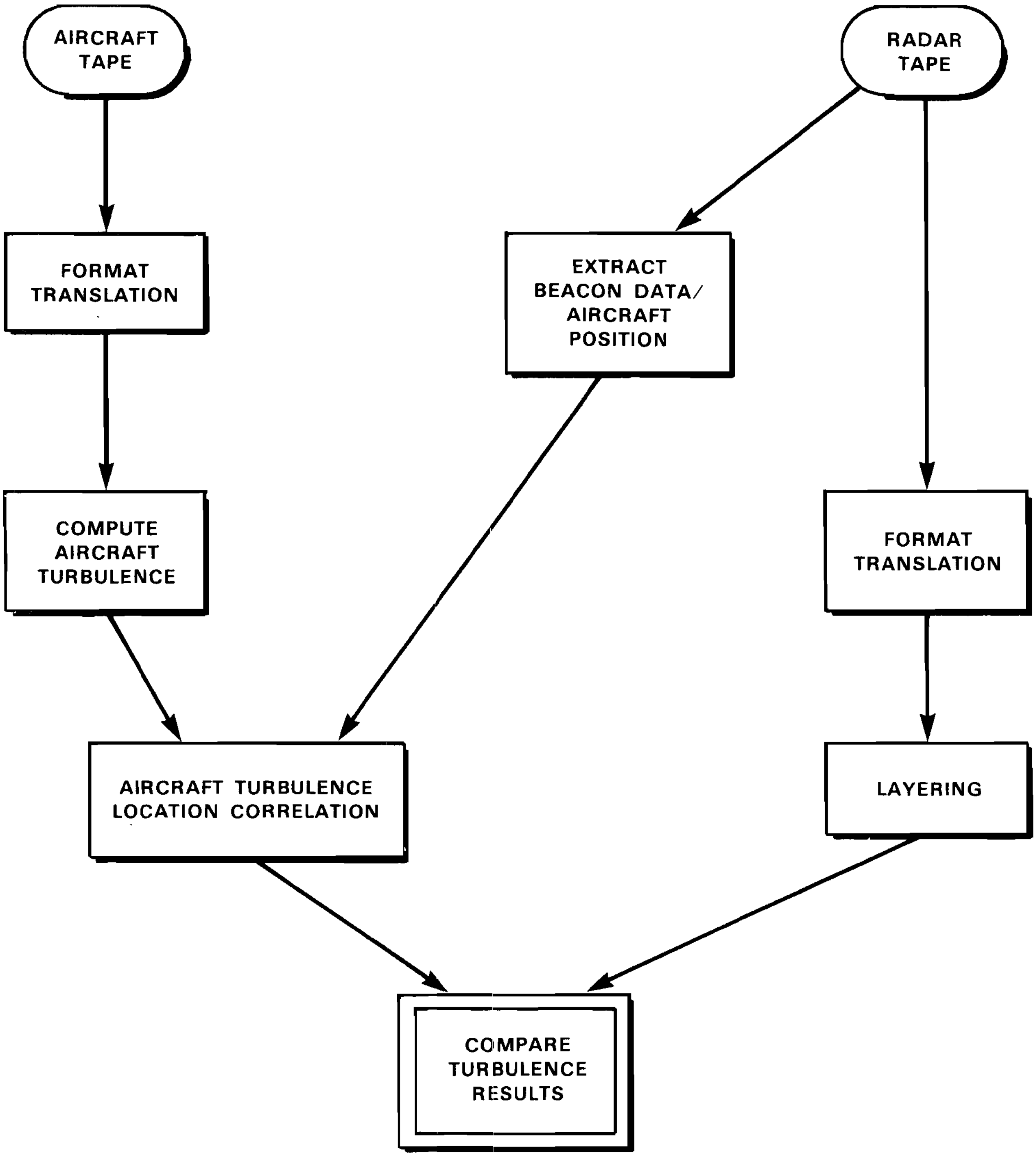


Figure 5.1 Basic elements in the turbulence data analysis.

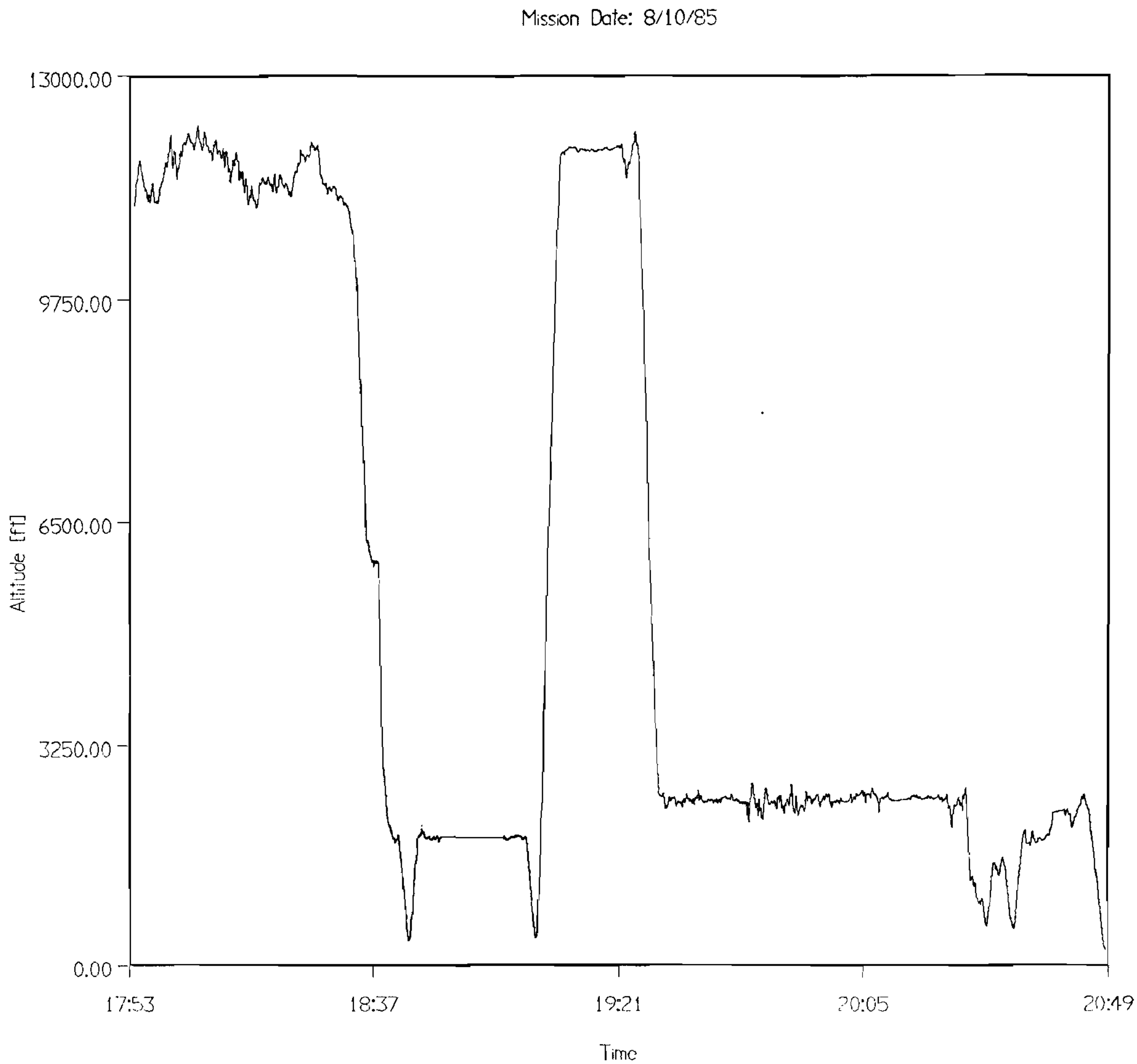


Figure 5.2 Aircraft altitude.

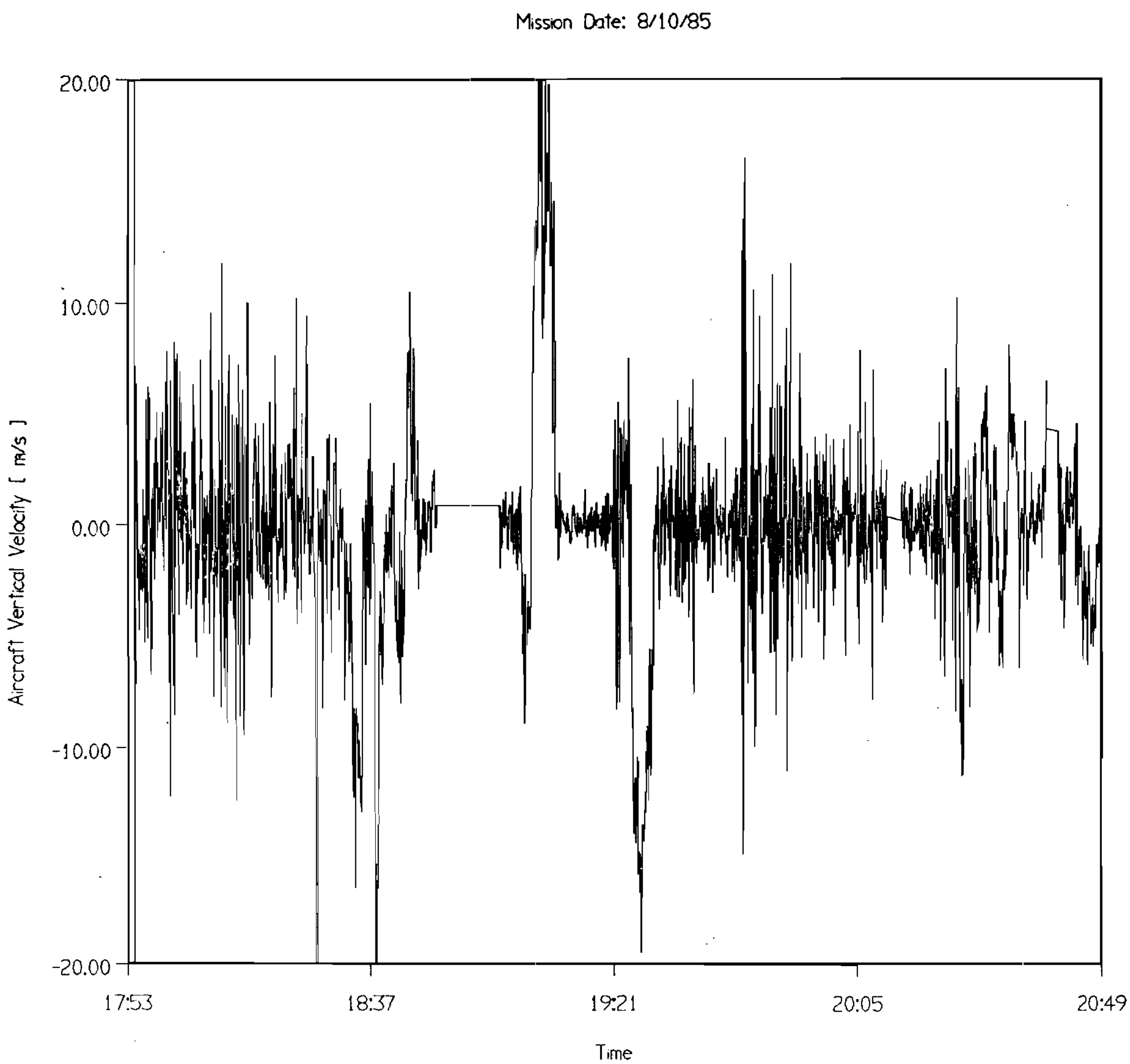


Figure 5.3 Vertical velocity of aircraft.

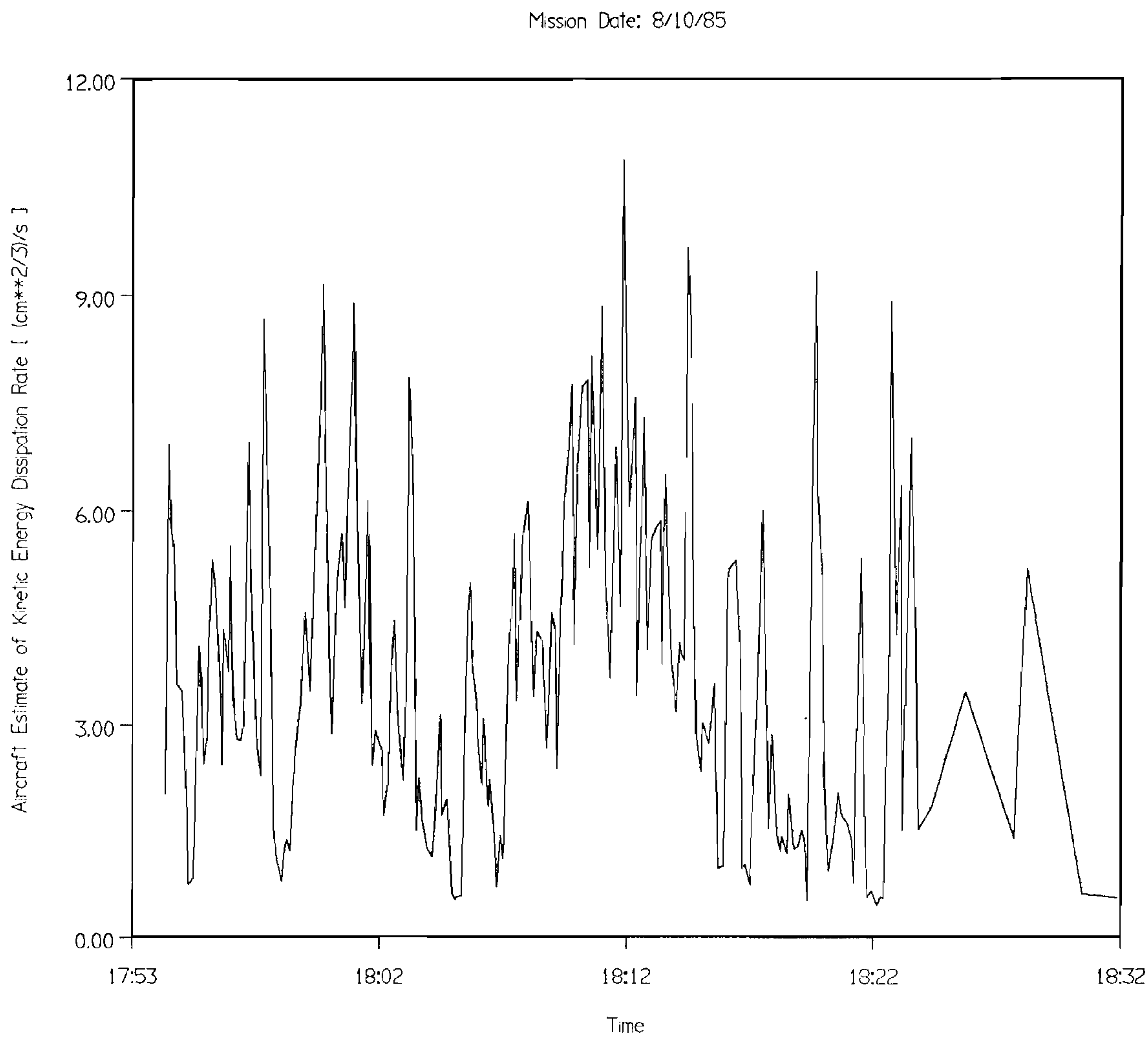


Figure 5.4 Time series of aircraft estimate of kinetic energy dissipation rate computed from peak values (acceleration).

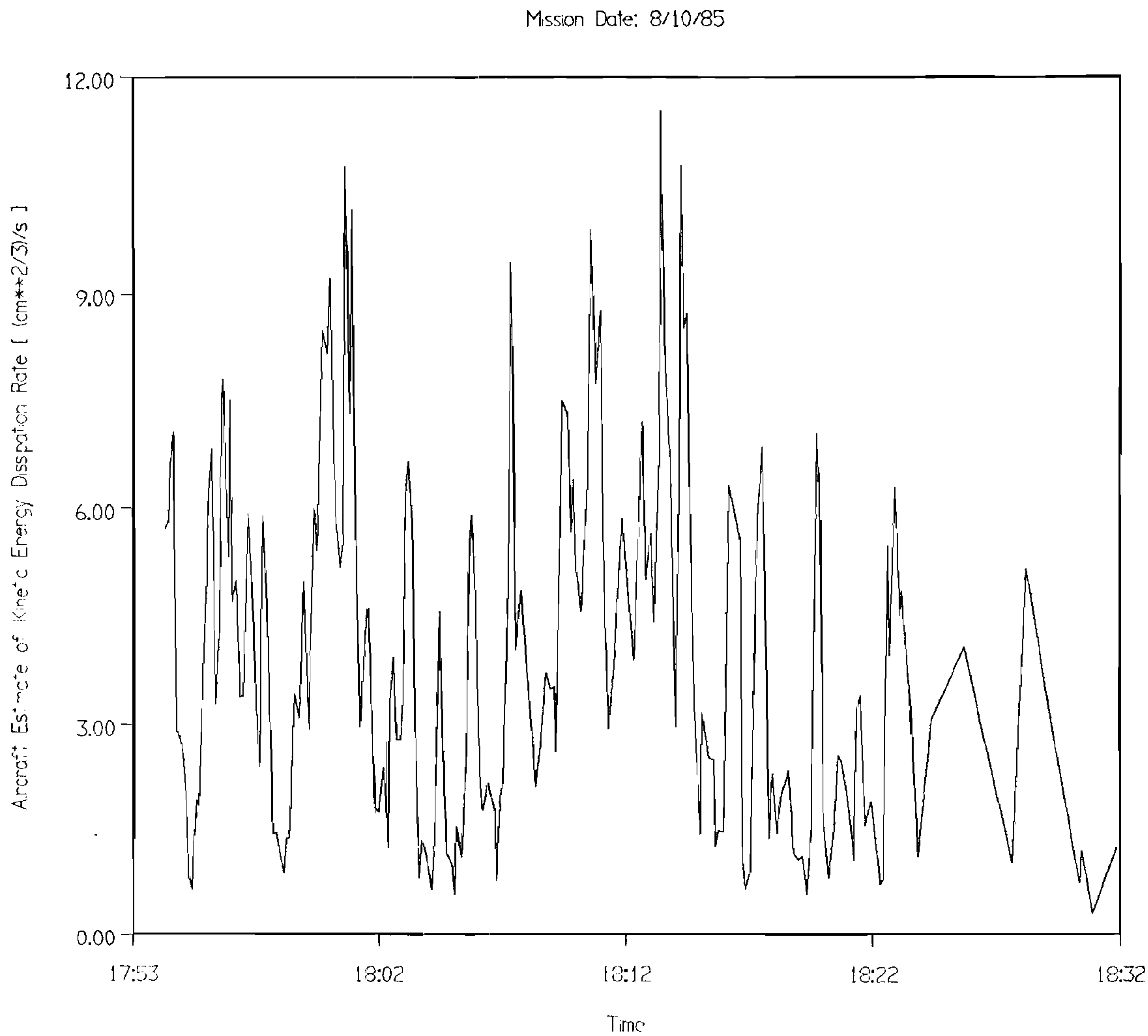


Figure 5.5 Time series of aircraft estimate of kinetic energy dissipation rate computed from peak values (pressure).

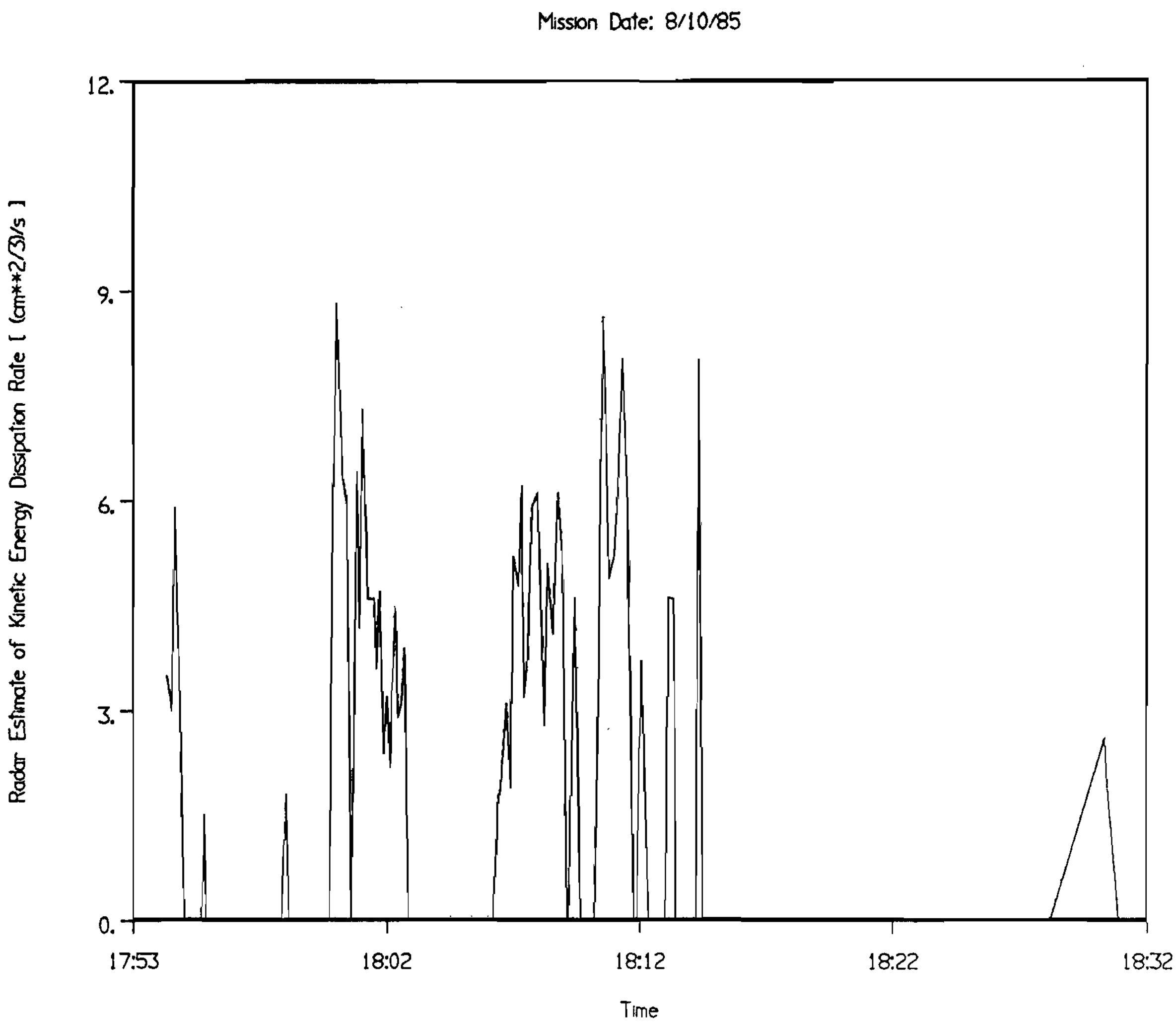


Figure 5.6(a) Time series of radar estimate of kinetic energy dissipation rate along aircraft track. Flight height: 3.5 km, scale size: 1x1x1 km.

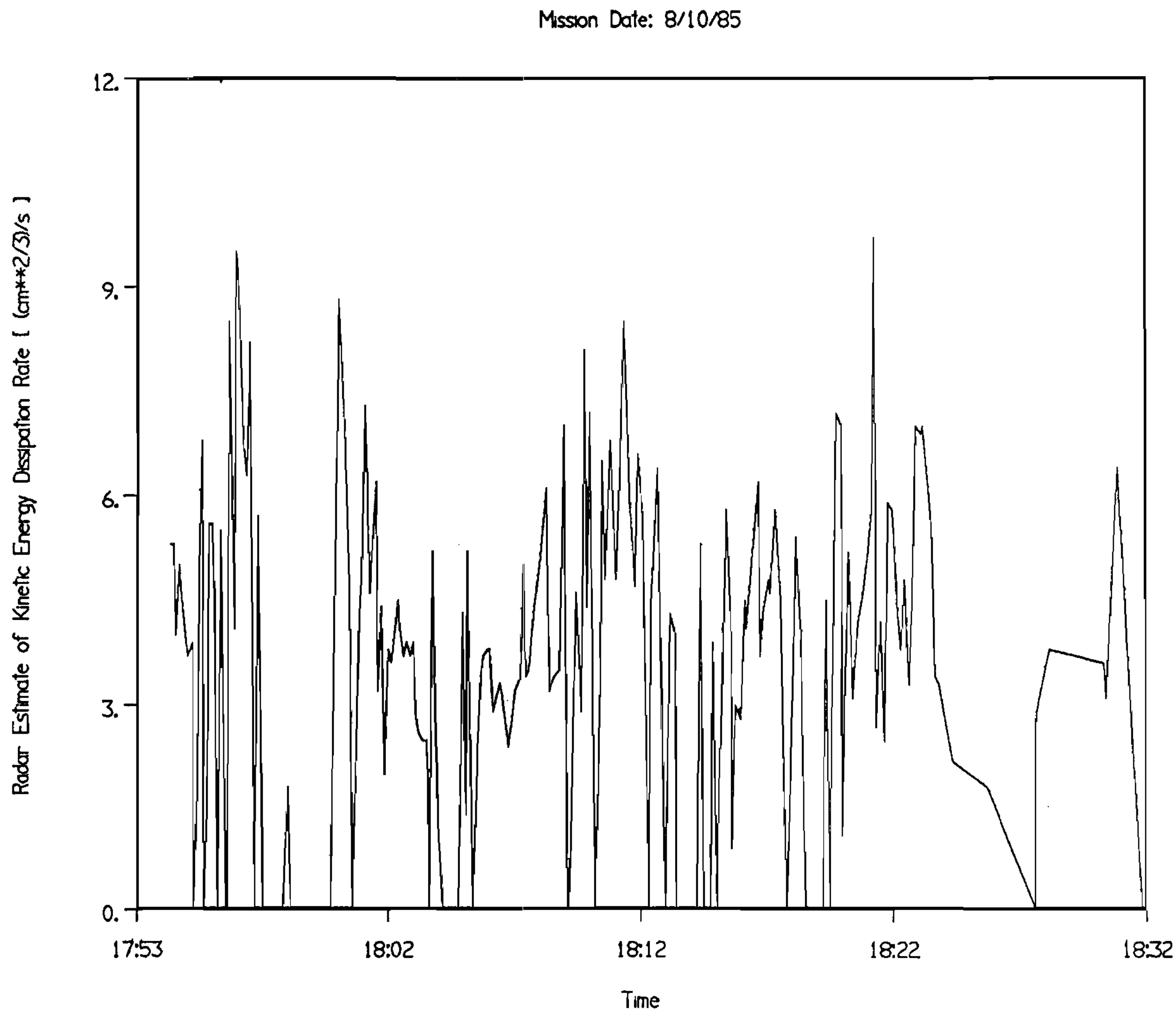


Figure 5.6(b) Time series of radar estimate of kinetic energy dissipation rate along aircraft track. Flight height: 3.5 km, scale size: 1x1x(0.3-7.3) km.

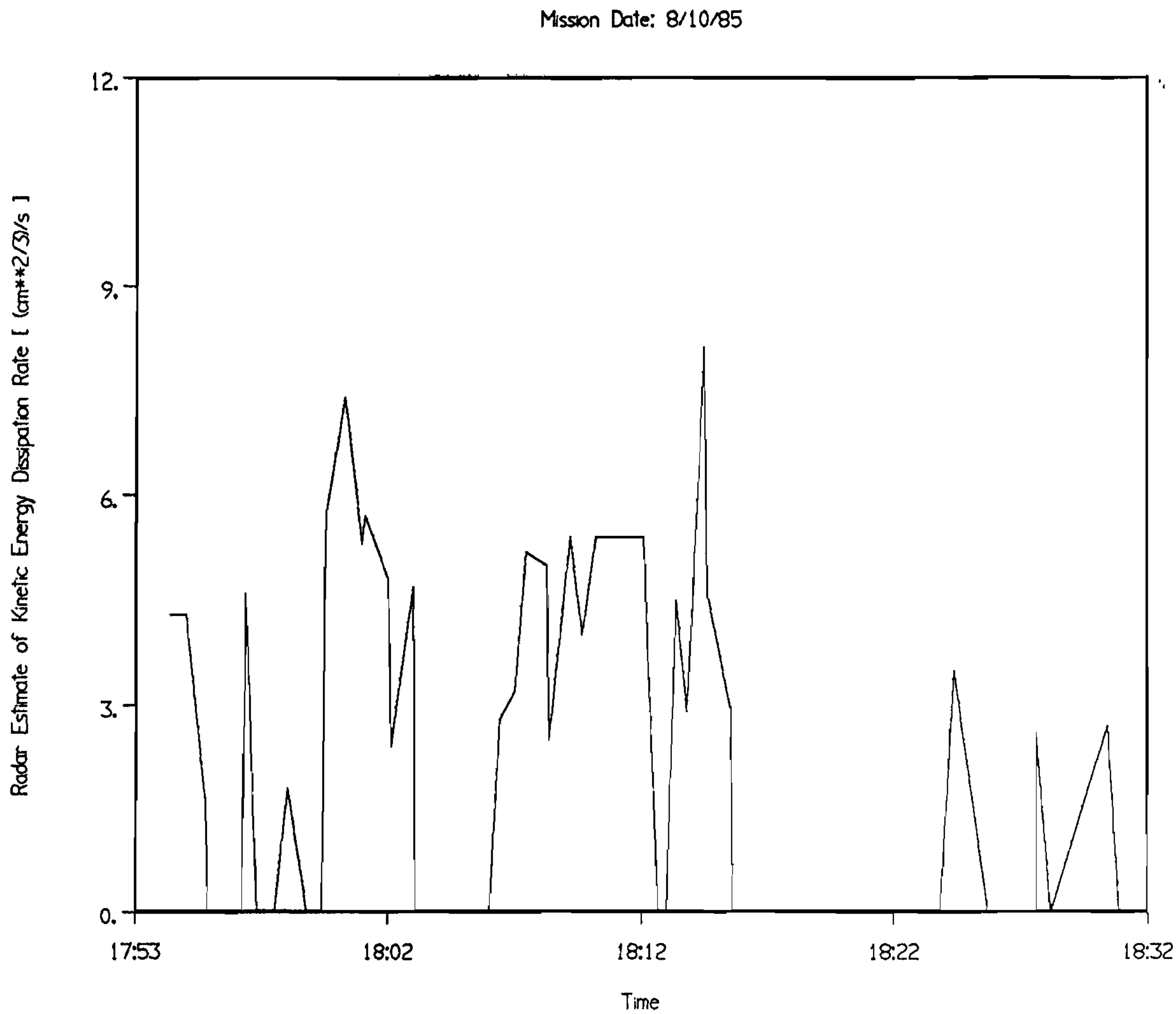


Figure 5.6(c) Time series of radar estimate of kinetic energy dissipation rate along aircraft track. Flight height: 3.5 km, scale size: 4x4x1 km.

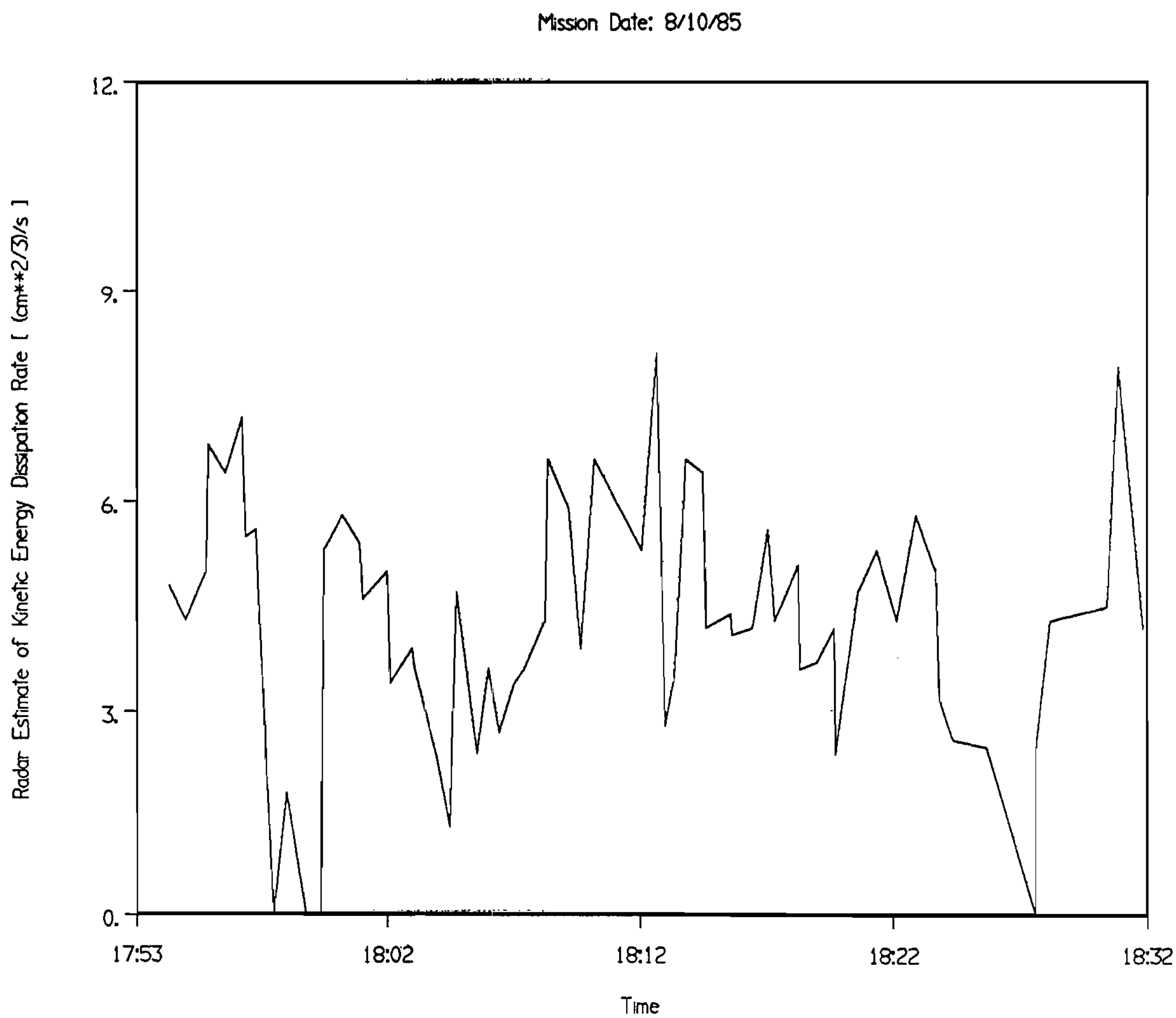


Figure 5.6(d) Time series of radar estimate of kinetic energy dissipation rate along aircraft track. Flight height: 3.5 km, scale size: 4x4x(0.3-7.3) km.

the radar products over different regions of airspace. Figure 5.6a corresponds roughly to "spotlighting" the aircraft with the radar beam. Gaps indicate those times when the aircraft was not located in the appropriate radar resolution volume. Comparing Fig. 5.6a and Figs. 5.4 and 5.5, we see reasonable agreement. In the region near time 1802 UT, where the aircraft measurements indicate lower turbulence, the radar does tend to overestimate the turbulence intensity relative to the aircraft estimates, but this is not a vast overestimation as was the case in the 1983 tests near Boston, MA (Lee, 1986). The remaining figures show the effects of increasing the layering volume vertically and horizontally. Vertical layering, in this example, does not significantly change the turbulence levels from those in Fig. 5.6a. The horizontal layering in Figs. 5.6c and 5.6d tend to smooth the series and extends the indicated regions of higher level turbulence beyond those indicated in Figs. 5.4 and 5.5.

The above result is typical of six other Memphis flights in which the aircraft encountered moderate to strong turbulence (i.e., vertical acceleration > 0.2g). Preliminary results in the case of weak to negligible turbulence indicate that spectrum width estimation becomes unreliable unless there is sufficient signal-to-noise ratio to ensure statistical stability of the estimates. These initial results agree qualitatively with other observations (e.g., Bohne 1985) in that the closest correlation between aircraft and radar based estimates of $\epsilon^{1/3}$ occurred when strong turbulence was encountered by the aircraft.

6. SUMMARY RESULTS

There have been other programs that have studied wind shear events elsewhere in the country. Among these are the NIMROD and JAWS programs run near Chicago and Denver, respectively (Fujita, 1985). In the following sections we compare the results found at Memphis with the earlier studies.

6.1 Comparison of Memphis Results with Earlier Programs

Our 1984 and 1985 field programs have provided a considerable amount of useful data on the frequency and characteristics of microbursts and gust fronts in the southeastern part of the United States; these results likely apply over a much larger part of the country than those of earlier studies near Denver.

6.1.1 Frequency

In earlier sections of this report we showed the number of microbursts detected by the mesonet (Chapter 3) and the radar (Chapter 4). Figure 3.1 compared the numbers of microbursts from NIMROD and JAWS with those of the mesonet in 1984 while Fig. 4.1 compared those from the 1984 mesonet data with those from the radar in 1985.

There are a number of differences between our Memphis data and that from other programs. One is the length of the program. The NIMROD program lasted less than 1 1/2 mo, JAWS lasted somewhat less than 3 mo, but the FLOWS program lasted 7 mo in 1984 and 8 mo in 1985. The frequency of occurrence during JAWS appears to be the highest of the three programs, having as many as 70 microbursts in the peak 7-day period; NIMROD had about 17 in 7 days; Memphis had up to 16 in a week. Thus, the frequency can be much higher in Denver than in Chicago or Memphis.

Another obvious difference among the programs is that JAWS had many dry microbursts while the other two programs had mostly wet microbursts. In fact, Memphis probably has the highest frequency of wet microbursts of the three locations.

6.1.2 Shears and Other Properties

Our Memphis results have shown that microbursts are a frequent visitor to the mid south. While the 1984 mesonet data found only 27 microbursts, we detected 101 in real time during our operations in 1985; further, we detected another 81 gust fronts during the same period.

With one major exception, the characteristics of the Memphis microbursts were similar to those of both JAWS and NIMROD. A detailed comparison of the various characteristics was given in Chapter 3. The exception is the percentage of all microbursts that were associated with rainfall. During NIMROD approximately 1/3 of all microbursts were dry while in JAWS nearly 2/3's were dry. In FLOWS only about 7% of all microbursts were dry.

6.1.3 Gust Front Differences

Gust fronts were also quite frequent in the mid south. During the spring and fall, the gust fronts detected by the radar were typically fairly long and long lasting. During the middle of the year, however, another kind of gust front was frequently observed. These were the ring gust fronts which formed at the leading edge of a microburst and moved out and away from the center of the flow field. Such ring gust fronts also lasted moderately long on occasion but typically were of weaker intensity much of the time. The inherent difference in shape between the traditional, linear gust front and the circular ring gust front, however, may make it difficult to develop a single algorithm which will be equally adept at detecting both kinds. Other studies of gust fronts (Uyeda and Zrnic', 1986) have generally concentrated on the strong, fast moving gust fronts associated with squall-lines and cold fronts, not with the more benign gust fronts emanating from individual showers and thundershowers, although there have been studies of these as well (e.g., Fankhauser *et al*., 1982).

6.2 FLOWS 1985 Data Analysis Procedures and Plans

The results presented above represent a very preliminary analysis of the FLOWS 1984 and 1985 data sets. The much more datailed analysis described below will be necessary to develop reliable automated aviation weather hazard detection algorithms. Below we describe the principal elements of this analysis.

6.2.1 Mesonet Data Processing

The first priority, in the mesonet analysis procedure, is to convert the mesonet data (which are recorded for us by Synergetics, Inc., Boulder, Colorado) into our Common Instrument Data Format (CIDF). The next step is to eliminate any missing or bad data. After this has been accomplished, the obstruction correction factors for the winds are computed and then the wind speeds are corrected. Several derived product variables (dew point temperature, relative humidity, and equivalent potential temperature) are also computed at this time. This process of editing out bad and/or missing data, and calculating derived products takes place during a final translation of the raw CIDF data. The output of this final translation is a CIDF file of data that will be used by various data analysis utilities.

Once the final translation of the data has been completed, a microburst detection algorithm, which was proposed and used by T. Fujita for the Projects NIMROD and JAWS, is then used to identify times for detailed analysis. For the times at which microbursts are detected by the Fujita algorithm,* synoptic plots and time series plots are generated. These

*The Fujita algorithm is effective at detecting microbursts in the sense of a high probability of detection, but it also has a high false alarm rate (P_{FA} > 90%).

plots are utilized for analysis of the events and will ultimately aid in determining the validity of these events. Figure 6.1 shows a synoptic plot for June 30, 1985. A microburst is located in the southwest corner of the plot. Figure 6.2 shows a time series plot for the same day of temperature, dew-point temperature, pressure, peak wind, and net rainfall for a 15-min interval centered about the time a microburst had been detected by the Fujita algorithm. We anticipate analyzing over 300 such plots during the current year to determine the 1985 LAWS characteristics as observed by the mesonet.

The mesonet derived characteristics will then be used for:

(1) Scoring of radar based detection algorithms (as described below)
(2) Studies of the generating mechanisms for LAWS in this region, and
(3) Assessment of the use of the LLWAS system for LAWS detection by itself and in conjunction with radars (NEXRAD,TDWR,ASR9).

6.2.2 Radar Data Processing

We are currently processing the radar data from the 1985 field season in a number of ways. Table 6.1 outlines the major steps in the data analysis procedure along with estimates of the time required for each step. In depth analysis of the data cannot begin until at least the point where images are available, preferably in photograph or hard copy form. While progress on the translations and inventory steps is steady and continuing, resampling and photographing the images has only been done for a handful of days. This work is continuing as rapidly as possible, given the limitations of our computer system and personnel.*

Table 6.2 lists the days designated for processing in a more or less routine manner. The priorities shown in Table 6.2 are based on the position of an event relative to the mesonet or the best dual-Doppler regions, the number of events each day, the number of data tapes collected each day, and the number and duration of gust fronts on each day. This latter criteria was added recently to provide some ground-truth data on gust fronts in the mid south region.

The highest priority for data processing in the near term is the development of a set of:

*The deficiencies of the current Lincoln Laboratory data analysis facility became evident when processing of the 1300 data tapes from the 1985 experiments commenced. Major improvements (a 19 station network of Sun engineering workstations for software development and data analysis and an upgraded Perkin Elmer facility for data processing) will come on-line in May 1986 [Evans (1985)].

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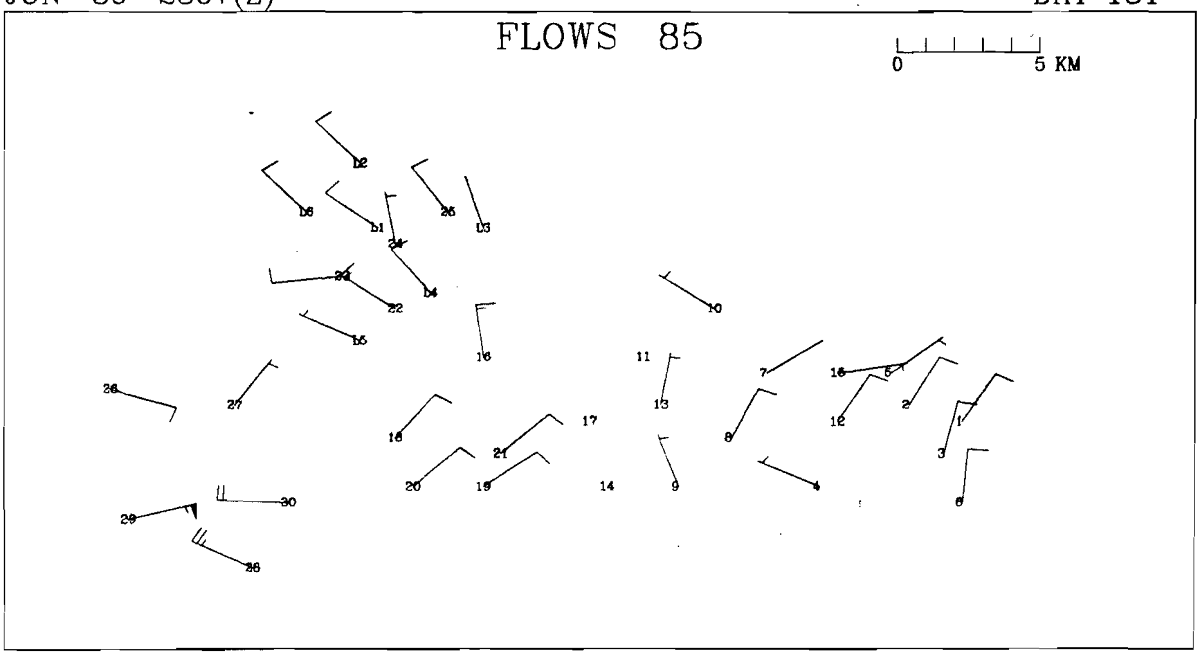

MICROBURST M29

GUST FRONT NONE REPORTED

Figure 6.1 Synoptic plot of winds over entire mesonet.

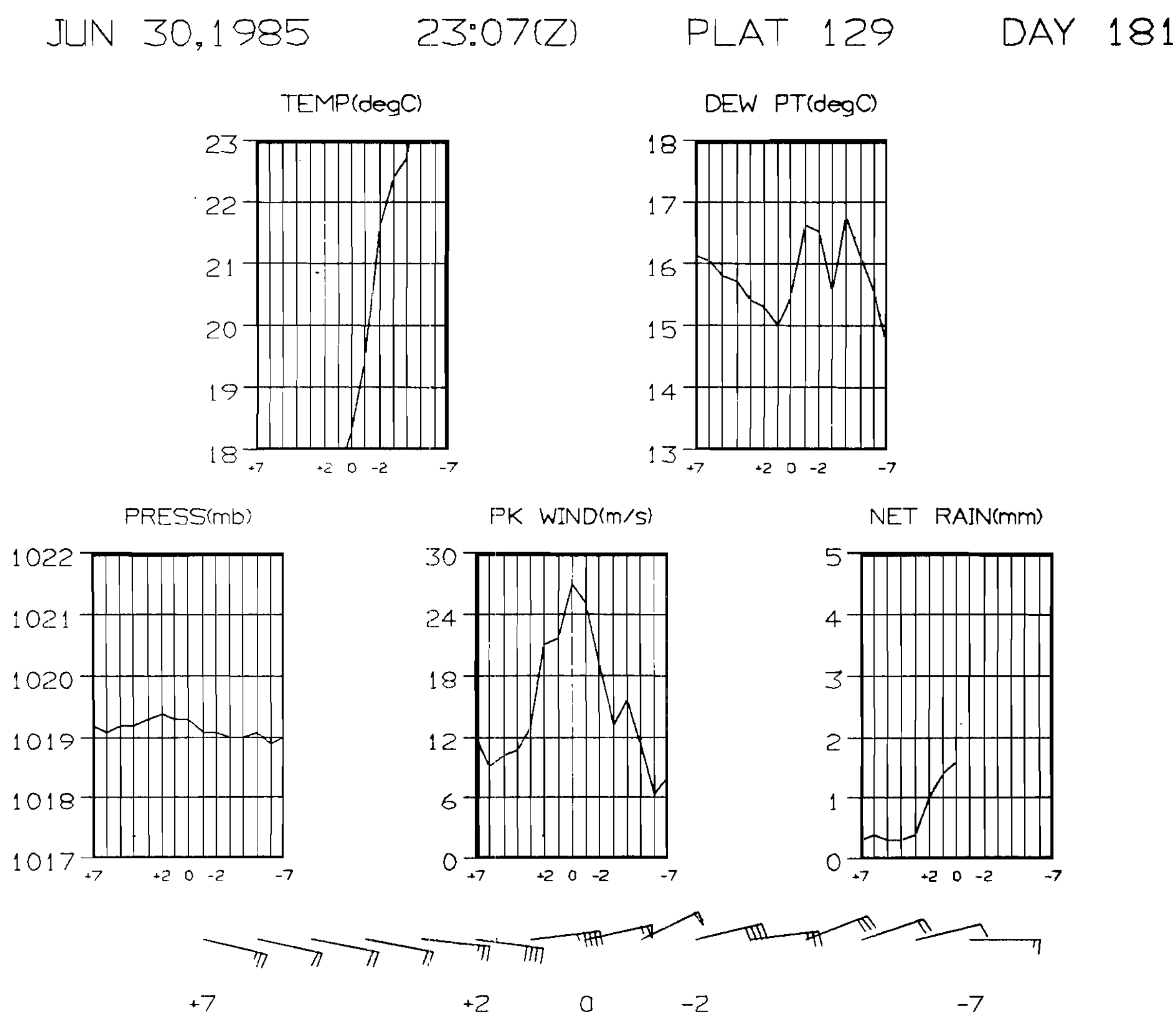

Figure 6.2 15-min time series plot.

Table 6.1

Generalized list of the major activities required for radar data processing along with their status and time requirements.

<u>Radar Data Processing</u>

Activity	Time Required	Status/ Problems	Action
Translate raw → CFT	1 hr/tape	Developmental/ Evolving	Ready
Inventory		Operational	Ready
Resampling to Cartesian	1/2 hr/vol scan	Operational/time Consuming	Ready
Image formation			
Computer files	1 min/frame	Operational/storage Limitations	Ready
Photographs	Few seconds	Works manually/ need color calibration for each film type	Automate-needs software
Terminal Displays	Seconds	Operational/ No Memory	Ready
Hard Copies	Couple minutes	Color Copier On order	Develop software
Divergent Outflow Algorithm	Real time	Developmental	Validate: production runs?
Dual-Doppler Cases	2 hr/vol scan	Developmental/ Evolving	Case studies

Table 6.2

Prioritized list of 1985 FLOWS days for translating raw radar data into common format tapes (CFT). This list was current as of mid-October. Since then several days have been added to the priority list to account for a need to examine gust fronts to test algorithms.

Date (1985)	Mesonet Priority	Dual-Doppler Priority	No. MB's Priority	No. Tapes Priority	Overall Priority	Done
26 Jun	1	1	3/3	2/12	7	Yes
25 Jun	1	1	3/4	4/21	9	Yes
10 Aug	5	5	3/3	2/11	15	Yes
1 Aug	5	5	5/1	1/5	16	Yes
30 Apr	2	4	4/1	5/36	15	Started
7 Sep	1	1	1/6	4/20	7	Started
30 Jun	1	1	4/1	1/5	7	
8 Sep	1	3	1/11	3/13	8	
10 Jul	1	3	2/6	2/12	8	
23 Jul	1	1	4/1	2/12	8	
15 Jul	2	3	1/7	3/15	9	
9 Sep	3	1	3/4	2/9	9	
9 Aug	2	2	4/1	1/7	9	
25 Aug	1	3	4/2	2/10	9	
24 Jun	3	2	3/3	3/14	11	
24 Aug	1	4	1/10	5/28	11	
10 Jun	4	3	2/5	4/20	13	
15 Aug	2	4	2/5	5/33	13	
5 Aug	3	3	4/1	4/24	14	
7 Jun	4	4	4/1	2/10	14	
16 Jun	5	5	3/3	1/3	14	
27 Jun	5	5	2/5	3/16	15	
19 Aug	5	5	2/5	3/15	15	
23 Aug	5	5	5/1	1/7	16	
22 Jun	5	5	5/1	3/13	18	
17 Jun	5	5	5/1	5/31	20	

(1) approximately 30 test cases for microburst outflow detection algorithm testing wherein analysts will determine:

   (a) maximum windshear (at each time)
   (b) areal extent, and
   (c) the location

   of the microburst at each measurement time throughout the microburst lifetime, and

(2) approximately 10 gust front detection/windshift estimation algorithm test cases wherein analysts will determine:

   (a) gust front location and extent
   (b) magnitude of the wind change within the gust front case, and
   (c) net windshift associated with the gust front

   at time intervals approximately 5 minutes apart throughout the gust front observation period.

In both cases, the analysis will be accomplished with knowledge of the current automatic detection algorithm results so that algorithm deficiencies can be identified and remedied as quickly as possible. We anticipate a need for several iterations of the algorithm test/human analysis process before the "truth" is fully established for the test cases.

Certain of these parameters (microburst maximum windshear and areal extent, net windshift associated with a gust front passage) are most effectively determined by dual-Doppler analysis and/or mesonet analysis.

We plan to utilize the expertise at the National Center for Atmospheric Research (NCAR) and the University of Chicago (Professor T. Fujita) to further confirm our analyses of the test cases.

We hope to have an initial set of 6-10 microburst cases and 4-5 gust front cases accomplished by the beginning of June 1986 so that initial real-time algorithm testing at FL2 can commence in July 1986.

While focussing on the reliable detection of microbursts and gust fronts/windshifts near the surface is our top priority, it is also important to obtain a better basic understanding of the physical generating mechanisms for microbursts in a humid subcloud environment. Such analyses will require data from the radars, mesonet and aircraft. The principal near term research in this area is being carried out by M. Wolfson as a part of her Ph.D. thesis studies at MIT. Since Wolfson's work is being largely carried out at Lincoln, we will be able to rapidly utilize salient results as they become available.

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APPENDIX A

SUMMARY OF OPERATIONS

15 April 1985 through 27 November 1985

SUMMARY OF OPERATIONS Date 15 April 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

****

Start time: 0615 CDT
End time: 1718 CDT
Tapes collected: 75-91

Summary of weather situation:

Post frontal airmass showers and thunderstorms (the forecast the day before had not anticipated these!).

Hail reported early (<0720 CST) near SENITOBIA, MS). UND had small hail at 1427 CST.

Scans run:

SECTOR SCANS, 360's, Dual Doppler scans to north, "on-airport" scans.

Comments:

At 1543 CST we detected a weak gust front (gust may be the wrong term for this one - velocities were quite weak, showing both + and -5 m/s and lots of zeros as it approached). It moved toward the mesonet at about 4 m/s but barely made it to stations 26 and 29 before it died from view at about 1615 CST. [Mesonet data for 26 and 29 did not show this went but did show a weak event 1/2 hour or more later.] New development took place at the north end of this gust front (but it moved north of our area and died fairly quickly).

We had thunder at the site.

SUMMARY OF OPERATIONS Date 23 April 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

****

Start time: 0826-0918 CST
End time: 1420-1934 CST
Tapes collected: 22
(No. 104-125)

Summary of weather situation:

The cold front to the west started moving eastward and passed through our area about 03 to 06 CST on 24 April. It produced an early line of TRW's about 7-8 a.m. and other lines from early afternoon till evening.

Scans run:

360's, RHI's, sector scans.

1646 CST-1750 CST: alternated sector scans and RHI's at 20 Az intervals - to use to test cross range and other product generation.

Comments:

This storm and the one of the previous night produced over 4" of rain in the Memphis area.

We had hail at the site from about 1421-1428 CST, pea sized. Winds were strong enough during this time to trigger the high-speed blower ($\geq$55 mi/hr for $\geq$2 sec).

SUMMARY OF OPERATIONS Date 30 April 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

****

Start time: 1330 CDT
End time: 0108 CDT/01 May
Tapes collected: 145-180

Summary of weather situation:

Cold front north and south from a low centered over Oklahoma. A convergent zone over Arkansas will trigger thunderstorms, enhanced by diffluence aloft over this area.

We had a variety of weather from this situation. We had a thunderstorm over the site (part of a line of thunderstorms moving across the area), with lightning very close to the site (if not on the site), strong winds and heavy rain. A gust front oriented NW-SE was observed over the mesonet about 1617 CDT. The airport reported winds of up to 65 mph. A microburst was detected about 1700 CDT at 5.5 km, 220 deg azimuth. Hail fell at the site just about this time also. Another gust front was observed over the mesonet about 1845 CDT. A tornado was reported about 48 km south of the site and funnel clouds were reported over Jonesboro, Arkansas, during the day. Commercial power was off in the Olive Branch area for about an hour during the evening. Rainfall total: 1.23".

Scans run:

Sector scans, full circle PPI's, ONA, OFFA, RHI's, DDS.

Comments:

11 Mesonet sites now have lightning protection added.

The antenna came down very slowly during the second of a set of RHI scans. By calling RHI a second time, the problem seemed to go away.

ROUTER apparently died just about the time we were going to quit anyway.

SUMMARY OF OPERATIONS Date 1 May 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

****

Start time: 1300-1714 CDT
and 1929-2037 CDT
Tapes collected: 181-197

Summary of weather situation:

The cold front which had been approaching for the past couple of days finally arrived, albeit rather anticlimatically. It was preceded again by prefrontal lines of thunderstorms. Interestingly, at one time during the early afternoon, the LIT radar was looking over the top of the low showers along the cold front without seeing them but still seeing the prefrontal showers approaching Alabama.

We again experienced a variety of weather. Gust fronts were detected at 1352, 1517 and 1619 CDT in and around the mesonet. A report of a tornado near West Memphis, Arkansas, during the early evening brought us back for another round of data collection. An interesting aspect to this case was the fact that rotation was clearly detected from the UND site but not from the Lincoln Lab site (even on playback the next day). Apparently the storm motion (which was approximately radially toward the LL radar but tangental to the UND radar), combined wit the moderately slow rotation speed, completed masked any motion away from the LL radar. By subtracting storm motion from this, there should have been relative motion around the center of rotation.

Precipitation: 0.07", 64F/81F.

Scans run:

Sector scans, 360 degree PPIs, OFFA

Comments:

ROUTER died again today, also near the end of operations.

We were instructed not to use MODE 2 by Bill Drury.

An apparent problem with the telephone answering machine at the UND radar site kept us from coordinating any scans on the evening observations of the West Memphis tornado case. As it turns out, however, we were doing roughly the same scans anyway, so some useful dual-Doppler analyses may be possible with these data.

SUMMARY OF OPERATIONS Date 28 May 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

****

Start time: 1549 CDT
End time: 2208 CDT
Tapes collected: 256-276

Summary of weather situation:

The cold front to our north extended across the Ohio valley into southern Missouri and then to Texas. This was expected to stall out in its current location. Another MCC was located over Kansas and moving generally our way. We were expecting isolated weak thunderstorms after 1500 CDT.

By 1520 CDT the MCC had moved closer and was approaching in Arkansas at a speed of 35 knots. NEXRAD 1 was launched and took off at 1604 CDT. They flew through the edges of some cells to the north end of the approaching line of thunderstorms and then flew to the back side of this line of echoes to fly up and down the back of the line in the weaker echo. This flight lasted until about 1830 CDT.

At 2003 CDT we sent NEXRAD 1 on a second flight to penetrate the storm after it had passed through and just to our east. They made a number of passes at different altitudes just above the melting level in the cloud where we saw a layer of enhanced turbulence; this was just above the bright. They did not find any particularly strong turbulence but did find a shallow layer of stronger winds. The displayed turbulence could have been caused by wind speed shear within this narrow layer rather than by turbulence itself. This should be an interesting case to look into in more detail.

Between the two aircraft missions we had a gust front move across the network. It was first detected at our radar at 1829 CDT, just after commencing our on-airport Doppler scans (ONA). This gust front did trigger the alarm on the LLWAS system which we were displaying in the operations room. Peak wind during this event was 21.2 m/s at station 26. Winds generally decreased as it crossed the mesonet. Temperature dropped about 4 degrees Celcius.

Another interesting meteorological event during the time between aircraft flights was the passage of some kind of pressure surge. Just before 2030 CDT the pressure at our site (and at mesonet sites also) dropped about 3 mb in 15 min or so. This was quickly followed by a 4 mb rise. During this time there was no appreciable temperature or humidity change but the winds did generally increase during this time and switched from southerly to northerly during the pressure rise. The gust front of about 2 hrs earlier had much stronger winds but much less pressure change.

28 May 1985 (continued)

We also saw a couple areas of probable rotation in the storms as they approached from the west, well to the west of the River.

Scans run:

360 degree PPI's, sector scans, ONA, RHI's

Comments:

As is usual, we had a number of minor operational problems. One is that the reflectivity display on the three-moment color display occasionally is squashed horizontally (i.e., normal size vertically but perhaps 1/8 normal size horizontally). This is easily eliminated each time by re-ZOOMing the display. This problem has been present throughout our operations for the past 3 or 4 months but has recently become much more frequent. Whereas it might occur a couple times a week before, now it occurs several times an hour. The difference may be related to the changes made last week by Bruce Gillespie to get the aircraft positions displayed. When we do not display the aircraft positions, the problems is not as bad.

Communications to the aircraft were not very good during some parts of the mission. In particular, when they were on the far side of the main area of high reflectivity flying through the extensive echo behind it, they were unable to copy many of our transmissions. We were generally able to copy theirs, but even this was not always true. Some of the problem undoubtably relates to static encountered by them while flying above the freezing level in icing conditions and below the freezing level in precipitation. Some of it was also related to a problem in one of our radios. But some of it is simply due to the lack of power and/or a high enough antenna. We are looking into possible solutions to this and have improved things somewhat already. Nevertheless, communication problems persist.

Aircraft operations behind the main line of echo were limited somewhat because of the extensive amount of lightning they encountered. They requested and were permitted to return to the front of the line because of this later on during the mission. No one had anticipated that this particular storm would be so electrically active.

We noticed a distinctly different appearance in the turbulence display when going from mode 2 to mode 1. While in Mode 2 we were seeing regions of turbulence that did not show up when we went to mode 1. The time we noticed this was 2105 CDT.

SUMMARY OF OPERATIONS Date 29 May 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

****

Start time: 1928 CDT
End time: 2229 CDT
Tapes collected: 277-284

Summary of weather situation:

The stationary front was still north of our location and oriented east-west. Another mesoscale convective complex (MCC) was over eastern Kansas and moving into western Missouri at briefing time. We had good low-level moisture but dryer air was moving from the east into Louisiana and Arkansas. Thunderstorms were expected after 1600 CDT with the possibility of some being severe.

The MCC continued to move in our direction at a fairly steady pace of 25-30 knots. By 1916 CDT we requested NEXRAD1 to take off for the line of approaching echoes. They flew up and down the leading edge of this storm a couple of times and then proceeded to the back side of this line for a couple of passes north and south. Following this we directed them to the front side again.

About this time (2108 CDT) we saw a gust front over the Mississippi River so directed NEXRAD1 back to the Memphis airport to intercept it on a landing approach. This gust front progressed eastward but appeared to weaken as it moved. NEXRAD1 made two approaches over the Memphis airport and succeeded in making measurements in parts of this gust front. Their final approach for landing from the east also passed through the front, albeit, the front was considerably weaker at this time. The LLWAS did give an alert during the passage of this gust front, but winds were generally not very strong during this event. In looking at the mesonet data the next day, we found, contrary to our expectations, that the air behind this gust front was actually warmer and dryer than the air ahead of it. At the time if formed, the MCC was in the process of dying out, and this may have caused the gust front air to be warm and dry. Incidentally, the strong echoes which were approaching our area died out rather abruptly before they crossed the River. Some residual, weak convective activity did cross in to Mississippi south of our area but nothing crossed over into Memphis.

Scans run:

360 degree PPI's, sector scans, OFFA

Comments:

Communications were again marginal at times between our site and the aircraft. However, by giving more way points ahead of time to them, we were not seriously hampered by this most of the time.

The UND ground support computer arrived in the United States this date.

SUMMARY OF OPERATIONS Date: 6 June 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

Data times: 0943-1202 CDT
1612-2036 CDT
Numbers of tapes collected: 298-310

Summary of weather situation:

The stationary front which had been north of our location for the past several days had finally made it over our area. This triggered showers and thundershowers within radar range early in the day.

By 0930 CDT there was a north-south line of strong echoes 60 n.mi west of us, moving toward the northeast. An area of wide-spread echo extended to the north west of this line. We sent NEXRAD 1 to fly on this line of echoes. During this flight, NEXRAD 1 reported both light and moderate turbulence. Another aircraft (54GA, according to NEXRAD 1 who heard the report) reported severe turbulence and icing somewhere near NEXRAD 1's position about 1144 CDT.

At 1621 CDT we requested a second flight for other storms to the west and northwest. AT 1723 CDT we detected a possible gust front and directed NEXRAD 1 to that about 1740 CDT.

At 1812 CDT we directed NEXRAD 1 to land and refuel because another area of storms was approaching at some distance to the southwest. This flight lasted until about 2030 CDT. Turbulence was detected on this flight about 2010 CDT.

Scans run:

Sector scans, RHI's, 360-deg PPI's

Comments:

On the first flight of this day the Memphis VOR/DME went out about 1024 CDT with a forecast of 3 1/2 hours to get it back on the air. This problem was solved in a way which showed the true team effort going into this program. After some initial discussion of alternatives among ourselves and the UND NEXRAD 1 crew, Stan Dajnak got on the phone with Bruce Gillespie who then modified our software used to display VOR/DME coordinates. Stan gave him latitude and longitude coordinates of alternate VOR/DME stations (Walnut Ridge and Holly Springs) and Bruce, while located physically in Lexington, Massachusetts, inserted these into the software on our computers here at Olive Branch, Mississippi. Once the software change was completed, we brought the system down and back up again and were then able to give NEXRAD 1 Wayflight. From the time the Memphis VOR/DME went down to the time we were giving Walnut Ridge coordinates was only 1 hour 28

6 June 1985 (continued)

min. I felt that this was a very good response to the problem and was please it worked so easily. We are now prepared to handle similar problems in a more timely manner. In fact, for the second flight of the day we started out using Holly Springs coordinates but switched to Memphis coordinates once we knew they were back on the air. Note, however, that this process does require taking the data collection system down and bringing it back up again; the ideal solution would allow the choice of VOR/DME coordinates without this loss of data.

We had three flights on this day. The storms covered by the second and third flights could possibly have been handled by a single flight, but we were concerned that the total flying time needed might exceed the remaining endurance of NEXRAD 1; consequently, we had them refuel before the final series of storms approached.

SUMMARY OF OPERATIONS Date: 7 June 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

Data times: 1126-1459 CDT
1623-1705 CDT
Numbers of tapes collected: 311-320

Summary of weather situation:

During the morning there was a low pressure system centered over south-west Illinois with a cold front west of us and a warm front to the east. There was a prefrontal squall line ahead of the cold front and a postfrontal line behind it. This cold front came through our area late in the day.

A short line of thunderstorms developed right over the Memphis area about 1045 CDT and was oriented NNE to SSW with level 2 and 3 echoes on the NWS Millington radar. [Note: At 0900 CDT there was nothing of concern in the area. The UND radar and aircraft people were on their way to our site for an 1100 CDT debriefing on the activities of the previous day before any storms developed. We aborted the debriefing to launch the flight, but it took some time for the UND people to return to their respective bases and get ready for operations (although some of the aircraft people who did not come to the debriefing did some of the preflight activities there).] We attempted to launch a flight ahead of this system but failed to get NEXRAD 1 aloft before the Memphis airport was closed; they were up and flying by 1220 CDT, about 30 min later. At 1151 CDT the LLWAS showed gusts at the airport of 34 kt at centerfield. We collected dual-Doppler data on this storm. NEXRAD 1 did encounter turbulence on this flight (at 1329 CDT they reported being "bounced around").

At 1625 CDT we requested NEXRAD 1 for a second flight for storms close to the Memphis area. These storms produced a microburst near 225 deg azimuth at 9 km range at 1629 CDT. This had -5 m/s to +10 m/s wind shear over about a 4 km distance. About 1625 CDT we detected a gust front about 5 km away. About 1645 CDT we visually observed what appeared to be a funnel cloud from the storm on radar located at 39 km and 96 deg azimuth; this was a short-lived feature which quickly disappeared into cloud base; no strong evidence of rotation had been noted on our real-time displays but it might show in the data after-the-fact.

Scans run:

360-deg PPI's, OFFA, DDS2, DDS1, RHI's.

7 June 1985 (continued)

Comments:

Something happened to the Genesco displays twice during the day. In order to recover from it, we found it necessary to take the system down and reboot. It is not clear what caused these problems, but it may related to a combination of things including a multitude of tasks queued up and tape-writing activities.

NEXRAD 1 had a number of computer crashes between 1257 and 1351 CDT or later. The quantity and/or quality of their data between these times is unknown at present. At 1437 CDT NEXRAD 1 lost one of their sensors (pressure?). We terminated their mission at this time.

SUMMARY OF OPERATIONS Date 10 June 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

****

Start time: 1329 CDT
End time: 1942 CDT
Tapes collected: 321-340

Summary of weather situation:

By mid-morning there was a cold front right over our area which was expected to reverse and move northward as a warm front. The airmass aloft was somewhat unstable with good low-level moisture. Most activity was expected to be farther north, however, primarily in the vicinity of the Ohio River valley and over Missouri. Isolated air mass showers were possible in our area.

By 1330 CDT we had a short line of moderately intense echoes form just across the River from us and to the north. We requested NEXRAD 1 to fly on this at 1328 CDT.

At about this same time we had an interesting layer of clear air return at 10 kft (possibly the top of the boundary layer). Surface winds from the Doppler were from the south-southwest at 5 m/s while the winds in the clear-air return were from the east-northeast at 5 m/s. The source of this return might have been refractive index gradients. This layer of echo last until at least 1450 CDT.

The line of storms moved over our area slowly during the next couple hours or more, producing reflectivities in excess of 60 dBz much of the time, and increasing in aerial coverage during the afternoon. By 1820 CDT there was a wide-spread area of thundershowers and general rain surrounding us from the south through the west and to the north. At longer distances there were also echoes in western Kentucky and northwestern Tennessee with another area of echoes in Mississippi near the Louisiana/Arkansas border.

We detected a number of microbursts from these echoes. Unfortunately, these MB's were all generally north of our mesonet; their winds crossed into the mesonet but their centers were too far away to be well sampled by it. The following are times and locations where these were noted:

Number	Time (CDT)	Range (km)	Azimuth (deg)	Speed shear...over what distance (m/s)	(km)
1	1648	14	360	-10 to +10	3
2	1651	22	12.8	-10 to +10	2
	165250			-15 to +10	2

(Note: At this time MB #2 was becoming a linear MB with a length of several kilometers.)

10 June 1985 (continued)

3	174040	14.3	322	-15 to +15	from 16.7 to 12.3

(Note: The time above is when this was first detected; HOWEVER, the time of the display was 173349 CDT, i.e., we did not get a display of this microburst until 7 min 51 sec after the radar had detected it!)

4	181040	12	18

(Note: This MB was near the azimuth where the tree north of our site blocks or view, so we were not entirely sure that it really was a MB. The UND radar, however, confirmed the divergent outflow from this location later on. Also, the displayed time for this MB was 180319 CDT, 7 min 21 s after its occurrence!)

We also detected a gust front southwest of us at 1701 CDT (23 km at 232 deg azimuth).

Strong winds, heavy rain, and flooding were reported by the public from some of these storms in the newspaper the next day. Dick Meuse and Mo Couture reported marble size hail, very strong winds, heavy rain and street flooding, all about 1700 to 1730 CDT at Poplar Avenue near the Hyatt Hotel.

Scans run:

Sector scans, 360's, RHI's, OFFA.

Comments:

The biggest problem this date was that we launched the aircraft just before the influx/outflux of (Republic) aircraft at the Memphis airport. According to a recent (06 June 1985) newspaper advertisement by Republic, a total of 41 Republic and Delta flights are scheduled to depart Memphis between 1500 and 1600 CDT; presumably, an equal number arrive in the preceeding hour. Because of this traffic and the presence of the storm to the northwest of the airport, NEXRAD 1 was not given clearance to fly any data collection runs until 1602 CDT (they took off about 1404 CDT or earlier). NEXRAD 1 was kept on various headings away from storms during this entire time. After traffic cleared, however, they were able to collect data on approaches to the airport a number of times. Nevertheless, it was frustrating to have gotten them off before the rush only to have them put on hold for so long.

We again had difficulty in communicating with NEXRAD 1 during some of their flight. This was primarily due to the low altitudes and long distances at which they were required to fly during their holding times. Once we were in a data collection mode, communications were generally good. This was the last day for NEXRAD 1 until 29 July 1985.

10 June 1985 (continued)

We lost the data recording system twice during the day. We had to reinitialize the system to resume data collection. The second time this happened it took 17 min to recover. The problem may be related to running the real-time status display on the VT220 and switching from that to something else without cancelling the task. Then when something happens to interrupt things, the uncancelled task prevents a simple reinitialization. (??)

The UND radar was off the air momentarily when commercial power was briefly interrupted; they switched to diesel generator and were back on the air collecting data a few seconds later.

UND has completely caught up on copying all earlier 1984 and 1985 radar data.

Dick Meuse and Mo Couture worked on parts of the radar antenna and waveguide during the morning. When we went into operations, the VSWR on the waveguide was higher than it had been.

SUMMARY OF OPERATIONS Date 11 June 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

****

Data times: 0544-1803 CDT
1310-1858 CDT
Tapes collected: 341-360

Summary of weather situation:

The ever-present front of 1985 which had shifted north to southern Illinois was expected to come through during the evening as a cold front with squall lines ahead of the actual frontal passage.

In reality, the above expectation came at the morning briefing. The real day started earlier. About 0430 CDT, Mr. Martin, the security guard on duty, called Chuck Curtiss because winds were rocking the display trailer and there had been a nearby lightning strike which caused sparks to come from one of the radios in the trailer. I was awakened by thunder about 0515 CDT at home. We assembled the troops and commenced operations at our radar at 0544 CDT and near this time at UND. This operation was on an area of thunderstorms right over Memphis and to the south and southeast within 50 km. Reflectivities were generally less than 55 dBz with occasional touches of 65 dBz. These storms had generally moved off to the east and were dissipating by 0800 CDT when the mission ended. However, during their time in the area they produced a fair amount of lightning and moderately heavy rain (0.28 inches at the site from this storm).

By 1300 CDT a 300 nmi long line of storms had formed from southern Illinois through the boot heel of Missouri through Pine Bluffs, Arkansas. Another line extended from 25 nmi south of Memphis to 200 nmi south-southwest along the Louisiana/Mississippi border. A third pre-frontal squall line extended from near the Alabama/Tennessee/Mississippi border southwestward toward the second line. These echoes moved generally eastward at 18 to 20 knots through the day. One unusual feature of the movement was that even 3 hrs later the long line was still virtually parallel with its original position; most long lines tend to rotate at least some with one part of the line moving faster than other parts; this did not happen during this period.

We had a good gust front come over the site at 1505 CDT, producing 60 mph winds and kicking on the second-stage blower for the third time (second time this year). This gust front was first detected about 1445 CDT. This system moved over us by 1530 CDT, producing another 0.16 inches of rain. Very light rain continued through most of the remaining operations from the extensive anvil and overhanging clouds above us.

11 June 1985 (continued)

By 1718 CDT another short line of small but intense showers and/or thundershowers had formed just west of the River, producing reflectivities of about 55 dBz (minus, of course, the 6 dB correction factor). At this time there was still a bright band over us from the north through east through southeast. This short line of echoes moved into our area and triggered alarms at the LLWAS stations. The UND radar experienced a gust front with winds of 15 mph, but these increased a few minutes later to 32 mph. The day ended with a nice rainbow, including a weak secondary bow, at 1845 CDT.

Scans run:

360's, sector scans, RHI's, DDNH, OFFA

Comments:

It is probably worth reemphasizing here that there was lightning close by with no apparent damage to any of the equipment. Even the radios which reportedly had sparks coming from them seemed to work fine when tested later in the day. Dare I say that the lightning protection seems to be working?

We should have had our third National Weather Service wake-up phone call this morning. It never came. When I called them from the site at 0548 CDT the forecaster on duty was very apologetic, saying it was "...my mistake" and that he had forgotten to make the call because this activity has "...happened so rarely" on the midnight watch.

Three times during the operation when we called for a particular scan sequence, it did not run the first time, requiring a second call to activate it. In each case, however, I think it was for a different reason. Another time we lost the ROUTER program or some other part of the system, but data recording continued.

The antenna had a problem between our morning and afternoon operations and was unavailable (but unneeded) for approximately 2 to 3 hours. The waveguide problem was also solved so that our VSWR returned to a good value.

For some reason we had trouble logging onto the Synergetics computer to get mesonet data. We got the data eventually but at 300 bits/s rather than the preferred 1200.

SUMMARY OF OPERATIONS Date: 17-18 June 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

****

Data times: 1139-1444 CDT
1737-2052 CDT
0218-0454 CDT
Tapes collected: 362-392

Summary of weather situation:

The weather over this time period was predominately prefrontal activity ahead of a cold front extending from a large, deep low pressure area centered over the Great Lakes area. Because the first activity of the day started well before our briefing, we had no forecast (nor need of one) for the day.

A line of showers and thundershowers existed over southern Missouri during the morning which gradually moved our way. This line was part of a decaying mesoscale convective complex (MCC) which had formed the preceeding day and moved over the St. Louis area. The line of echoes moved fairly steadily toward us from the northwest at about 25 knots. The southwestern end of the line which had been coming our way weakened before reaching Memphis. This first line moved through our area about 1300 CDT.

One region of rotation was detected near 50 km, 359 deg azimuth at 2.5 deg elevation at 1219 CDT. Winds on one side were -10 m/s while on the other side they were +15 m/s.

At 1226 CDT a gust front was detected at 29.7 km, 349 deg, showing in both the Doppler and reflectivity data. This gust front crossed the airport about 1257 CDT, triggering the alarm at station 2, passed over the Lincoln Lab radar at 1314 CDT, and hit at the UND radar at 1319 CDT with winds of 30 mph. It was still in existence at 1416 CDT, nearly 2 hrs after first being detected (at 31 km and 233 deg azimuth from us).

This general area of rain continued to move toward the southeast, completely disappearing by 1630 CDT.

Our second mission of the day began at 1737 CDT for a second line of thunderstorms moving toward us from the northwest at 25-30 knots. These had been detected over southern Missouri even before the first mission ended. About 1800 CDT a small line of weak echoes formed 60+ nmi ahead of the line (i.e., about 20-30 nmi past us to the southeast. While the main line moved toward us at a steady pace, the line to the southeast held its position for over 2 hrs, intensifying during this time. Memphis was sandwiched in between these two storm systems in a rather fascinating way. The second storm put out a gust front which came toward us from the southeast while at the same time a shelf cloud from the advancing storm was seen to our northwest. About 1930 CDT or earlier a short line of intense thunderstorms formed perpendicular to both lines and joined them together. This happened essentially over the mesonet west of our radar. These storms produced very heavy rain, frequent lightning, and winds to 50 mph at the site. Rainfall from this second storm system totaled 1.40 in (the 24-hr total was 1.92 in).

This storm also produced a microburst at 180505 CDT at 25.9 km, 198 deg azimuth with -10 to +15 m/s shear (displayed time = 183129 CDT). Rotation was detected at 1747 CDT at 83 km, 338 deg azimuth near a small cell of 55 dBz reflectivity.

A final meteorological observation from this system was that Doppler winds were completely folded once around about 2003 CDT. Since we were using a PRF of 700/s, this was from winds of about 36 m/s (located near 25 km, 170 deg azimuth, 2 deg elevation, and 55 dBz echo).

By 2150 CDT when this mission was terminated, the strongest echoes had moved off to the southeast of us 20-30 miles, leaving behind a large area of widespread level 1 and 2 echo (NWS NQA radar levels). Bright band at 13.6 km generally prevailed northwest of our location and in other directions also (except toward the stronger echo).

The third mission actually occurred early the next morning but was really on the same general storm system. After terminating the previous mission, renewed intensification took place 3 or 4 hrs later near Memphis. We again started recording data on the thundershowers which had formed just south of the Tennessee/Mississippi state line. These storms were only of moderate intensity and did not really encroach upon the mesonet or the Memphis area, but stayed just close enough to require monitoring for awhile. These moved slowly eastward and finally dissipated and moved off enough that the mission ended.

Scans run:

360's, RHI's, sector scans, DDN1, DDS2, ONA

Comments:

Recorded test data using 2nd-trip echo cancellation scheme. These data are on tape 361.

There is a range error on the displayed positions of radar echoes on the three-moment displays. The track ball and the map overlay positions seem to agree with each other and with other maps, but the radar data are too close by 7 to 13 km, depending upon which point on an echo was used to make a comparison. The basis for comparison was the NWS Millington radar (which gives positions in agreement with the NWS Little Rock radar).

17-18 June 1985 (continued)

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Scans run:

360's, RHI's, sector scans, DDN1, DDS2, ONA

Comments:

Recorded test data using 2nd-trip echo cancellation scheme. These data are on tape 361.

There is a range error on the displayed positions of radar echoes on the three-moment displays. The track ball and the map overlay positions seem to agree with each other and with other maps, but the radar data are too close by 7 to 13 km, depending upon which point on an echo was used to make a comparison. The basis for comparison was the NWS Millington radar (which gives positions in agreement with the NWS Little Rock radar).

SUMMARY OF OPERATIONS Date: 22 June 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

****

Data times: 0838-1229 CDT
1455-1707 CDT
Tapes collected: 396-408

Summary of weather situation:

The dominant weather feature over much of the country was a cold front stretching from a low pressure center north of the Great Lakes through Chicago and Kansas City and somewhat beyond there. Ahead of this front were a couple of pre-frontal squall lines. The first of these came through our area during the morning while the second gave us our afternoon weather.

The morning activity consisted of a line of moderately strong thunderstorms oriented generally ENE-WSW which came down from Missouri. Echoes extended from near Clarksville, Tennessee, to beyond Little Rock. As this line approached, it tended to weaken to the north of us. An intense line formed west of us but rotated eastward just north of our position, weakening as it came. This activity generally weakened as it crossed the area. Operations on it ceased just before 1300 CDT.

At 0939 CDT we did record an area of good rotation at 100 km, 335 deg azimuth, 2 deg elevation, near 55 dBz reflectivity with +10 to -10 m/s Doppler velocity change over about 6 km distance.

The afternoon activity was on a small area of echo which contained a very narrow north-south line of 55 dBz echo moving eastward at up to 15 m/s (according to the Doppler velocities). Points in this line reached 65 dBz at times. This line moved over the mesonet during the next hour or so, producing light rain and gusts of 30 mph at the UND site. We had moderate rain with winds of at least 25 mph at our site. No good gust front was detected in this storm; the winds occurred with the rain. There was heavy rain over the city of Memphis during the afternoon. Once this storm cleared the mesonet area, it generally died out. No other activity developed behind it.

Scans run:

360-deg PPI's, ONA

As the morning and afternoon lines of echoes approached from the west, we ran several series of RHI scans at 2-deg and 3-deg intervals (total of 24 cuts each time).

22 June 1985 (continued)

Comments:

During the morning the Genisco displays operated very poorly. We had them go blank a number of times. By turning their power supply off and back on again, they would come up for awhile, but often failed again. We were able to continue collecting data during most of this time but could not see enough weather to make intellignet changes in our scanning strategies. They seemed to work okay during the afternoon.

BPD died at 0857 CDT, causing some loss of data.

We had another lightning strike within 1/4 mile of the site, again causing one of the telephone bells to ring slightly. All equipment continued to operate just fine.

SUMMARY OF OPERATIONS Date: 23 June 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

****

Start time: 1624 CDT
End time: 1912 CDT
Tapes collected: 409-413

Summary of weather situation:

Generally fair weather prevailed over our area. The frontal system extended east-west across northern Kentucky, across Ohio and into a very intense low pressure center well north of the Great Lakes (980 mb central pressure).

Only widely scattered showers and thundershowers existed over the mid-south region. These were to our east and south in Tennessee, Alabama, and Mississippi. A couple of small showers formed just over the Memphis area, however, about 1700 CDT. These produced reflectivities up to 65 dBz at one time, but were mostly only light rain showers. By 1900 CDT they had decreased and drying over the area was evident as these clouds dissipated.

One of the interesting features of the afternoon's activity was the presence of a couple of thin lines of echo across the Memphis area. These showed best in the reflectivity fields, barely at all in the Doppler fields. They did slowly change position, but they were not moving rapidly. Perhaps they were weak lines of convergence. Some of the renewed activity after 1730 CDT seemed to occur just to the north of one of these lines. No strong velocities were noted from them from either our radar or from the UND radar.

Scans run:

360's, sector scans, OFFA

Comments:

BPD paused once and we lost displays.

SUMMARY OF OPERATIONS Date 24 June 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

****

Start time: 1301 CDT
End time: 1842 CDT
Tapes collected: 414-427

Summary of weather situation:

The Bermuda high pressure system off the east coast was expected to increase over the next few days, producing generally clear skies over the area. A convergence line over eastern Oklahoma and western Arkansas might move in later on, bringing move convective activity with it. The air was dry aloft and stable. Cumulus clouds were expected during the afternoon with some isolated thunderstorms possible.

By 1300 CDT there were a number of widely scattered echoes showing on the Millington radar. One shower formed within NQA's ground clutter pattern about 25 km north of us with reflectivities near 65 dBz. This was first detected from the UND radar. As it turned out, several cells formed over the NQA ground clutter region and were not easily detectable on that radar. Widely scattered showers continued through the afternoon, decreasing in both number and intensity by evening time. Some showers seemed to get better organized and more intense in Missouri late in the day, however.

Probably the most interesting feature of the activity of this day was the formation of ring gust fronts from a number of the cells in the area. The characteristic mode of development was for small convective clouds to intensify, grow quickly, and decay. Reflectivities typically reached 55-65 dBz on most of these. A couple put out sufficient wind to be classified as microbursts, but generally the winds from them were quite light. The gust fronts from these cells were fascinating. They formed rings of slowly expanding gust fronts. These gust fronts were usually much more easily detected in the reflectivity fields than in the velocity fields. Reflectivities of the gust fronts were as high as 25 dBz, an unusually strong return for a gust front. Their velocities, on the other hand, were usually weak and hard to distinguish from the surrounding clear air return on the Doppler display. Peak velocities were generally +/- 15 m/s with most in the +/- 5 to 10 region; not particularly fast as gust fronts go. At one time we had as many as three gust front rings on the reflectivity display at the same time (1451 CDT). These gust fronts typically outlived the cells themselves, being detectable after the echoes had completely disappeared.

24 June 1985 (continued)

As an editorial comment, I have the feeling that the gust fronts and microbursts we saw today would have been much stronger had they occurred in the dryer environment of, say, Denver. The moderately high humidity near the surface likely inhibited strong evaporative cooling during the decaying portions of these cells, thus reducing what might have been strong accelerations beneath the clouds. This might be a good case to model numerically with the existing sounding data and again by artificially drying the atmosphere out some and rerunning the model.

Microbursts were detected at approximately the following times and places: 1340 CDT, 27 km, 357 deg azimuth, -10 to +10 m/s over 5 km; 1530 CDT, 17 km, 313 deg, -5 to +10 m/s over 2 km; 1715 CDT, 70 km, 225 deg, distant storm of 65 dBz reflectivity -- it might be a good one to see how far away microbursts can be seen (possibly too large to be a microburst, technically). This latter storm also had rotation it from 1728 CDT and onward (+ 5 to - 10 m/s over 4 km or higher).

Scans run:

Sector scans, 360-deg PPI's, RHI's, and OFFA.

Comments:

Mesonet station 7 went down. Reinitializing the A/D unit brought it back up.

SUMMARY OF OPERATIONS Date 25 June 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

****

Start time: 1209 CDT
End time: 2005 CDT
Tapes collected: 428-448

Summary of weather situation:

The Bermuda high continues to dominate the weather of the southeastern United States, increasing in intensity at all levels. While it was dry aloft, by briefing time we had already exceeded the convective temperature for the day and scattered showers were again expected; thunderstorms already existed in some directions. We had good low-level moisture. Movements were expected to be slow.

Operations commenced shortly after the briefing ended. By 1213 we had two microbursts, one at 11 km 315 deg and the second at 21 km 319 deg. These microbursts collided by 1224 CDT; their ring gust fronts weakened over the next 20 min or so such that they were hard to detect.

By 1304 CDT another cell formed over the airport, putting out a ring echo gust front by 1308 CDT. At 1322 CDT we finally started to see some divergent flow from this (+5 to -5 m/s). The LLWAS gave an alarm at station 5 (21 knots) at 1327 CDT. At 1307 CDT we started a series of 4 RHI volume scans at six azimuth angles through this developing microburst. By 1334 CDT it had a nice ring gust front around it.

During the afternoon we had a number of gust fronts moving in and around the area. UND reported a thin line echo about 40 km to the north and moving southward. This one moved slowly toward us over the next hour and a half, reaching our location about 1627 CDT. By 1708 CDT it had passed south of the mesonet.

Another microburst formed just south of the airport about 1820 CDT. While this one had rather larger shear than others we have seen (-15 to +25 m/s), it was also over a larger distance than most (20.9 to 11.4 km range, i.e., over 9.5 km distance).

At 1847 CDT the radar was showing 15 m/s winds at 0.5 deg elevation angle over the airport but the LLWAS was showing near zero winds at all stations. This could have been caused by a shallow layer of cold stable air near the ground with stronger winds just above it. This might be an interesting case of vertical wind shear that might be of significance to landing/departing aircraft.

25 June 1985 (continued)

This day was characterized by many showers scattered throughout the area (wildly scattered showers). About 1420 CDT clouds were visually growing explosively in the nearby vicinity. These numerous clouds were of fairly small diameter but growing quite tall (relative to their diameters). By 1300 CDT there were visibly fewer clouds outside, but they tended to be larger in size. There appeared to be little organization to the storms in the area through most of the day, but there was a tendency for the storms to form into lines late in the day. One final comment is that the storms on this day generally moved from east to west, contrary to the normal direction of movement.

Scans run:

Sector scans, 360-deg PPI's, OFFA, RHI's (some of the RHI's were through the microburst at 1307 CDT).

Comments:

We lost the Genisco displays again once during the day. A fan on the Genisco power supply was found to be not working.

SUMMARY OF OPERATIONS Date 26 June 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

****

Start time: 1246 CDT
End time: 1742 CDT
Tapes collected: 449-460

Summary of weather situation:

The weather situation continues similar to other days with the Bermuda high pressure off to the southeast. We had increasing moisture over the area. Showers and thundershowers were expected over the area later in the day until sundown.

By 1230 CDT a number of showers had developed within 200 nmi of the Millington radar, including one just to the north of our location. By 1312 CDT this storm produced the first of three microbursts for the day (11 km, 17 deg azimuth, +5 to -10 m/s shear over a distance of 1.9 km). This microburst put out a ring gust front, especially to the west. Parts of this ring gust front were still detectable at 34 km and 320 deg azimuth at 1509 CDT or later.

At 1336 CDT a second microburst formed just south of Winchester Road near Kirby Parkway, later moving over the Hickory Ridge Mall with heavy rain. A few small trees in isolated areas both north and south of the center of this microburst were found blown down and/or damaged by the winds. At its strongest, the shear from this microburst was +20 to -15 m/s over about a 4-km distance (while at 8 km and 330 deg azimuth, approximately). Since a number of the visitors at the site were caught or nearly caught in heavy rain while departing the Mall, this microburst has been called the Hickory Ridge microburst.

By 1444 CDT a third microburst had formed from renewed intensification of this same storm (now located at 14.6 km, 296 deg azimuth, with +10 to -10 m/s shear over 3.8 km distance). This microburst did not seem to last quite as long as the others.

There were also a number of gust fronts (in addition to the ring gust front already mentioned). Two gust fronts approached us at 1555 CDT, one from the east and the other from the southeast. These merged by 1623 CDT and came over us by 1655 CDT, changing our winds from calm to 6 mph.

By 1700 CDT storms were generally decreasing in intensity. Movements throughout the afternoon had been generally toward the west at speeds of only 5 kt or less.

26 June 1985 (continued)

Scans run:

360-deg PPI's, sector scans, RHI's, DDN1, OFFA

Of particular interest was the dual-Doppler scans on the Hickory Ridge microburst to the north. This is probably the best covered microburst with the dual-Doppler low coverage (i.e., 0.0, 0.6, 1.2, and 1.8 deg elevation scans). Scanning in this mode started about a minute after the Hickory Ridge microburst was first detected and continued for another 5 min.

Off-airport dual-Doppler scanning started about 7 min before the third microburst formed near the airport and continue for about 18 min afterwards. This microburst should be well covered with dual-Doppler scans throughout its life history (including before its formation at the ground).

Comments:

At 1030 CDT, Evans, Isaminger, Catching and Rinehart met with Blackwell and Keller at the FAA Control Tower to discuss the air traffic study we are planning to do. Both Blackwell and Keller were very cooperative and should prove very helpful in providing access to the tower and related data sets required to successfully complete this study.

We overwrote one tape during the operations, losing data between 1406 and 1419 CDT (between the 2nd and 3rd microbursts, fortunately).

SUMMARY OF OPERATIONS Date 27 June 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

****

Data times: 0955-1205 CDT
1451-1755 CDT
Tapes collected: 461-476

Summary of weather situation:

Storms developed during the morning, negating the need for a briefing or forecast. These were scattered air-mass showers forming in the moderately moist and unstable air mass ahead of the cold front which was over northwestern Arkansas. This cold front moved into the area during the day, and stalled out nearly overhead; it finally moved through about midnight.

By 1000 CDT we had an area of moderately strong echoes just crossing the River from the west. Other cells in the area were moving at 5 to 6 knots, generally eastward or southeastward. Tops were to 40 kft.

There were also a couple of interesting clear-air layers on the radar, one at 2400 ft and the other from about 10 to 12 kft. These persisted throughout the morning and well into the afternoon.

Operations on the morning storms persisted through noon. There were a couple of microbursts during this time, one at 1149 CDT near 30 km and 216 deg azimuth (I listed this a "divergent wind" in the log, not a "microburst"; reexamining this should decide if it really was a microburst or not). The second microburst occurred at 1121 CDT near 27 km and 192 deg.

During the afternoon the storm activity resumed. Some organization was evident in that a solid line of echo formed between just west of our area and northward into the boot heel of Missouri. We again had microbursts: 1) 1515 CDT, 19 km, 20 deg, +15 to - 15 m/s from 20.9 to 17.1 km; 2) 1544 CDT, 11 km, 53 deg; 3) 1552 CDT, 42.2 km, 259 deg, +15 to -10 m/s from 40.8 to 42 km (near its strongest at 1659 CDT). We also had gust fronts from these microbursts and other nearby storms move across the mesonet. The best of these gust fronts moved from the second microburst listed above and across the mesonet from the northeast. This microburst storm also produced heavy rain and lightning at the radar (0.26 inches of precipitation).

Scans run:

360's, sector scans, DDS2, DDS1, combinations of 360's and sector scans in one sequence.

27 June 1985 (continued)

Comments:

Late in the operations (about 1755 CDT) we completely lost control of the 3250 system. We were unable to cancel some things from the system console and had to reboot the computer completely.

SUMMARY OF OPERATIONS Date 30 June 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

****

Start time: 1644 CDT
End time: 1858 CDT
Tapes collected: 477-481

Summary of weather situation:

The airmass over us was similar to the previous day, generally being cool with northerly winds. A weak, closed low-pressure system was centered over western Kentucky at 500 mb, triggering scattered showers over most of the region from Arkansas to Alabama and Illinois to Mississippi.

We had some small storms develop in the region right around Memphis. About 1635 CDT a small thunderstorm developed just to the north of our site but decreased over the next hour or so without doing very much. At 1806 CDT another storm developed 21 km west of our radar, producing first rotation (at 2.5 deg) and then a microburst. We were scanning this storm using the on-airport scan sequence. It produced a gust front which moved away from the storm toward the west at 10 to 15 m/s. Once this cell cleared the area, no other storms affected the mesonet.

Scans run:

360-deg PPI's, ONA

As mentioned, we collected data on this microburst using the on- airport scanning sequence, i.e., with UND doing 360's and FL2 doing sector scans. This might be a good data set to help decide if on-airport or off-airport radars are best for low-level wind shear detection.

Comments:

BPD paused. We lost a little data recovering from that.

SUMMARY OF OPERATIONS Date 10 July 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

****

Start time: 1518 CDT
End time: 2023 CDT
Tapes collected: 485-496

Summary of weather situation:

The extension of the Bermuda high pressure system over the Gulf of Mexico dominated our morning weather. But the cold front across southern Illinois and neighboring states is starting to move down toward us slowly. There was good low-level moisture in the southeastern US with an unstable atmosphere. Thermal lifting and frontal lifting were expected to give us thundershowers, but the best of these were expected to be along the front later in the evening. Storm speeds were expected to be slow.

By 1510 CDT there was a line of storms from southern Kentucky, through the Missouri boot heel and on toward Little Rock. Another shorter line of thunderstorms was lost in the ground clutter of the Millington radar. These storms moved slowly through our area during the afternoon, producing a total of 6 microbursts (possibly more) and a couple of gust fronts.

Number	Time (CDT)	Range (km)	Azimuth (Deg)	Elevation (Deg)	Speed shear (m/s)	
1	1535	48.2-40.1	345	0.5	+15	-10
2	1700	17.0-14.7	66		+15	-15
3	1753	29	313		+15	-10
4	1909	31	31		+10	-15
5	1909	19	56		+10	-5
6	1931	4.9-1.7	140		+28	-10

During the morning and again during the afternoon there were as many as four layers of clear-air return at heights of approximately 2, 4, 10, and 13 kft. None of these were particularly turbulent but did have low reflectivities.

Scans run:

360-deg PPI's, sector scans, OFFA, ONA, RHI's.

On-airport scans were run from 1826-1900 CDT while watching a gust front come down across the mesonet from the north (near the Millington radar) until it passed over the northern part of the mesonet. This might be another case to look at regarding locating radars on or off an airport.

10 July 1985 (continued)

Comments:

The replacement transmitter tube was installed and adjusted.

Mesonet station 7 was back up.

Early in the data collection period (noted at 1528 CDT but this occurred at other times also) we noticed that we were loosing rays of data without ever getting error messages. We took the system down and reloaded the DAA programs. These data losses may be related to remote users of the computers, but this had not be determined positively yet.

The power supply to the raw video (analog) PPI display went off at 1713 CDT but came back okay thereafter.

The Genisco turbulence display generally worked much of the time during the early operations but was out most of the time later on.

At 1925 CDT we noticed some glitches in the LLWAS data (more than once).

SUMMARY OF OPERATIONS Date 15 July 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

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Data times: 1255-1523 CDT
1718-1746 CDT
2053-2311 CDT
Tapes collected: 498-512

Summary of weather situation:

The weather remained similar to that of the past several days, albeit, somewhat more unstable. A stationary/cold front was northwest of our area with ridging aloft over the Gulf coast. Moisture aloft had also increased. The major area with strong dynamics was along and north of the frontal system. Air mass thunderstorms were expected over our area in greater numbers than recent days, some being locally heavy by late afternoon or evening.

By 1255 CDT a number of air-mass showers had built up over the area, one of these being just to the north of the mesonet (in Millington's ground-clutter region). Shower activity increased during the afternoon, especially to the south over northern Mississippi, Alabama and south-central Tennessee. We had four microbursts form near our area along with their attendant gust fronts. By the end of the first operation of the day, storms in the nearby vicinity had generally decreased. Other storms at somewhat longer ranges persisted.

By 2050 CDT storms had again moved/developed just west of the mesonet. A gust front passed over the UND site at 2059 CDT. Three more microbursts were noted during the evening. An area of rotation was detected at 2201 CDT near 58 km range, 276 deg azimuth. This was in a good north-south line of strong thunderstorms about 55 km west of our radar, showing level 4 and 5 intensities on the NWS radar. This line of storms put out a good gust front which came across the River and into the mesonet late in the evening. As it approached, it generally decreased in intensity and slowed down.

Near the end of our operations (2304 CDT), there was the suggestion of waves in the air behind the gust front. Alternating north-south bands of approaching/receding velocities were detectable in the Doppler velocity data with a wavelength of about 3.5 km and a period of perhaps 9 min (based on the speed of the gust front at this time of 6.5 m/s toward us). There was no evidence of waves in the pressure trace of the microbarograph at the site, but it may have never reached our site.

15 July 1985 (continued)

No.	Time (CDT)	Range (km)	Azimuth (deg)	Elevation (deg)	Speed Shear (m/s)	
1	1318	17.8-17.0	31	0.4	+5	-5
2	1348	6.3	9.4	0.4	+5	-5
3	1452	3.1-1.1	26	2.5	+5	-10
4	1516	4.5	328	2.5	+5	-10
5	2114	32.2-27.0	307	0.5	+10	-10
6	2130	29.2-27	298	0.5	+5	-5
7	2147	39.3-37.1	345		+10	-10

Scans run:

360-deg PPI's, sector scans, DDN2

Comments:

Near the end of the first data collection period we interrupted operations to commence the installation of the new Fujitsu disk on the PE 3250. Because it failed to pass some required tests and because of the limited time available by Stan Dajnak and the PE technician, the system was returned to its former state without completing the installation.

We continued to have missing rays in the displayed data during the operations. Again, this may be related to external users on the 3210 computer.

BPD paused once during the late operation, requiring us to restart the 3250 with RTS.

SUMMARY OF OPERATIONS Date 16 July 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

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Start time: 1312 CDT
End time: 1535 CDT
Tapes collected: 513-520

Summary of weather situation:

The cold front had passed through the previous night and was off to the south. By briefing time there were already air-mass showers to the west, south and east of us. At the surface we had high dew points and there was still good moisture aloft and mild instability. An area of weak vorticity was expected to rotate through our area during the afternoon. Isolated thundershowers were forecast but none severe.

About 1300 CDT a series of isolated cells had formed to the east southeast just south of the Mississippi/Tennessee border with other cells near southern Arkansas, northern Louisiana and central Mississippi. During the early afternoon storms to the south put out a couple of macrobursts. Later on a north-south line of storms developed east of the River in Mississippi, just south of our area. These storms put out a long gust front or thin line echo which extended northward from between the storms and the River toward Memphis and then circled toward the northeast and to the east, crossing over the airport at 1447 CDT. This gust front was detectable for quite awhile. Later during the afternoon the atmosphere seemed to dry out as storms generally decreased and moved farther to the south away from our area.

No.	Time (CDT)	Range (km)	Azimuth (deg)	Elevation (deg)	Speed Shear (m/s)	
1	1321	22-15.6	138	0.5	+10	-15
2	1401	32.8-24.8	193		+25	-5
3	1452	22	225	...from UND radar		

Scans run:

Sector scans, 360-deg PPI's, DDS2

Comments:

We ended the mission while weather was still in the area in order to allow Mark Merritt to use the 3210 computer to test some new DAA software. UND continued lurveilance scanning during this time.

16 July 1985 (continued)

The Genisco display did not operate much at all this day.

At 1300 CDT a power surge on the commercial power line occurred which required recycling various pieces of equipment. It took 13 min to get the 3250 back up and running.

Again we had missing rays of data in our displays while external users were on the 3210 computer from the Lab.

SUMMARY OF OPERATIONS Date 19 July 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

****

Start time: 1417 CDT
End time: 1504 CDT
Tapes collected: 522-523

Summary of weather situation:

Skies were generally clear with stable air over the mid-south region. While there was good low-level moisture, it was dry above 500 mb. The strong ridge over us was expected to divert the front northwest of us and keep it well to our north. Only fair weather cumulus were expected during the day.

At 1226 CDT there was a single storm detected on the RRWDS display. An hour later there was a line of cells from west of the Tennessee/Mississippi state line toward the north into the Missouri boot heel and then northeastward into western Kentucky. Later in the afternoon storms developed just south of the Memphis area in Mississippi along the River. These put out a gust front which moved westward across the Mississippi River. We collected data on these for awhile.

Scans run:

360-deg PPI's

Comments:

We apparently had a power surge about 1315 CDT as the transmitter had a fault light triggered and the PE 3210 had problems coming up. Also, the Genisco displays seemed to have a power supply problem as they had horizontal hold problems near the tops of all three displays simultaneously. Switching to the diesel generator did not solve this problem. As of the end of the day, we still had not determined what might have been the cause of these problems.

We lost displays by zooming to an area outside of the display range (after changing resolution parameters). We had to restart RTS on the 3250 to recover and have displays.

SUMMARY OF OPERATIONS Date 21 July 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

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Start time: 1505 CDT
End time: 1726 CDT
Tapes collected: 524-527

Summary of weather situation:

High pressure continued to be a dominating factor in the local weather, but the cold/stationary front which had extended from the Great Lakes to the Texas panhandle had moved somewhat closer. A trough formed in front of this front and came into our area about mid-afternoon, producing the weather for our operations.

By 1500 CDT there were storms from southern Indiana and Illinois across Missouri and through Arkansas to Louisiana. During the afternoon these generally remained in the same areas with only a few echoes forming east of the Mississippi River in Tennessee and Mississippi.

The only storm to affect our area during the day formed just south of Memphis about 20-30 nmi away. This put out a long gust front which moved eastward across the mesonet. It produced winds of 15 mph or stronger at the UND radar and triggered alarms on the LLWAS with a gust of 32 knots at center field at 1551 CDT. This gust front passed over our site at 1620 CDT and continued moving eastward for the next hour. By 1700 CDT storms were generally decreasing in intensity.

Scans run:

360-deg PPI's

Comments:

One of the fuses on the main power pole to the site blew about 2100 CDT Saturday evening but went unattended until mid-afternoon Sunday; the security guards failed to notify anyone about this. Commercial power was still off as of the time we ended our operations. The back-up generator came on and stayed on during this entire period. To restore power, the power company had to replace one of the transformers on our pole.

SUMMARY OF OPERATIONS Date 22 July 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

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Data times: 0801-0958 CDT
2043-2203 CDT
Tapes collected: 528-535

Summary of weather situation:

Early in the day a cold front extended from eastern Canada across the Great Lakes, thorough Iowa and westward into Wyoming. Ahead of this front was a weak trough extending east-west across Kentucky and Missouri. This system advanced southward during the day and was the cause of our weather. Aloft there was a very weak trough evident in the wind directions (but the height of a constant pressure surface was fairly flat over the southern half of the country). A weak surface low existed over eastern Mississippi and western Alabama.

By 0800 CDT there was a large area of widespread precipitation to the south of our radar with some imbedded convection as strong as 55 dBz. This echo was fairly uniform with regard to both velocities (toward us at 5 to 10 m/s) and turbulence (mostly 3-4 values on the color scale). Off and on during the morning we had light drizzle at the site.

By 2030 CDT new storms had developed in the Memphis area. Before we could get the generators running for this mission, a surge on the commercial power lines knocked the computers off for awhile, delaying the beginning of our data collection. A storm approximately over the River on the west side of Memphis did put out a gust front which moved away from our area. Once this gust front and the storms which formed it moved off to the west-northwest, we ended our operations.

Scans run:

360-deg PPI's, sector scans, DDS2, RHI's

At 0855 CDT we collected a number of volume scans of dual-Doppler data with the UND radar operating in its normal sector scan mode but with the FL2 radar operating in RHI mode. These were collected at the request of Mark Merritt to test the dual-Doppler processing data using this mixed-mode of data collection.

From 2119 CDT until 2127 CDT we collected RHI data at 2-deg intervals on the storms moving off toward the west-northwest.

Comments:

Because of the weather and operations during the morning, there was no briefing.

We collected a set of data in widespread meteorological echo both with and without the clutter filters to see how much (if any) weather echo is cancelled by using these filters. These data were collected between 0942 and 0953 CDT.

SUMMARY OF OPERATIONS Date 23 July 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

****

Start time: 1224 CDT
End time: 2132 CDT
Tapes collected: 536-547

Summary of weather situation:

The stationary front had gradually moved to over Missouri and northern Tennessee by briefing time but was far enough north not to be a major influence on our weather. A small low pressure centered over Louisiana was expected to produce the best weather for the general mid-south region, but that would also be too far away to be a direct problem. We had good low-level moisture and were expected to easily make our convective temperature. Scattered rain showers and thundershowers were forecast for the area, but drying during the evening was expected to decrease any activity.

By 1230 CDT there were a number of small cells on the radar to the west, northwest and north, some just north of the mesonet and airport. During the early afternoon we had only one possible microburst (at 1303 CDT, 7.3 km, 320 deg, +15 to -10 m/s), but it fit entirely within the size of the track ball on the one scan we saw it. At 1328 (27.3 km, 318.8 deg) there was a small region of rotation detected (+15 to -10 m/s). Neither of these features was particularly strong, but they were noted in the log. The first mission continued into the afternoon with the small echoes generally decreasing in intensity near Memphis. By 1600 CDT there were still scattered cells from the northeast to the northwest near Memphis with an area of echoes extending eastward to south of Nashville over central Tennessee. Movement on this day was from the east.

Evening thunderstorms again developed. By 2015 CDT we had several thunderstorms from near the airport and over Memphis to across the River and into Arkansas. These cells also moved toward the west slowly. Doppler velocities in these (and in the afternoon storms) were generally 5-10 m/s at low levels but did reach up to 25 m/s near 20 kft during the evening. Turbulence levels were quite low throughout the day. No significant weather events occurred during the evening's operations.

We had a number of interesting layers of echoes during the day. At one point there were as many as 6 layers of weak echo between the surface and 10 or 12 kft. Some of these might have been thin layers of cloud, but others appeared to be in the clear air.

23 July 1985 (continued)

Scans run:

360-deg PPI's, sector scans, OFFA, ONA

Comments:

We were called by Don Burrows of UND to let us know that there was a problem with one of the engines on the Citation aircraft. It may take 2-3 weeks to repair it or 2-3 days to install a rental replacement. They still hope to be here for operations on Monday, 29 July 1985.

SUMMARY OF OPERATIONS Date 1 August 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

****

Start time: 1529 CDT
End time: 1725 CDT
Tapes collected: 590-594

Summary of weather situation:

The 12Z surface map on Friday depicted a trough to the north of our area. Also, a low-pressure center over the southern Alabama and Mississippi border was bringing a southeasterly flow of moisture to the region. By 18Z the trough had moved very little and was still situated north of Memphis. Temperatures ahead of the line were in the low 90's with dewpoints in the mid 70's.

At low levels (850 and 700 mb) an extension of the Bermuda High in the Gulf was the dominant weather feature for the southeastern United States. The flow pattern at this level was primarily from the southwest at 10 to 15 knots.

The 500-mb chart showed winds from the north northwest in our region around high pressure over northeastern Texas. This same high pressure dome was prevalent at 300 mb with northwesterly winds of 15 to 20 knots in our vicinity.

The morning sounding at Monet, Missouri, was unstable with a Lifted index of -4 and a total totals of 49. The only area of positive vorticity near Memphis was in central Tennessee. So, the additional lifting in that area was expected to trigger severe activity to the east of us.

A radar summary map for 2035Z showed that strong cells up to 55kft had developed along the central Alabama and Tennessee border. Other activity had formed just east of Memphis about 22 km from our radar site. We determined the maximum tops on these storms to be around 43kft. The only other cells of interest today were triggered along the trough to the south of Memphis (30 km). These cells were observed for about 1h, with no noteworthy velocities being detected. For a short period, reflectivities as high as 55 dBz were noticed.

Scans run:

Sect1, Ron1, Ron2

1 August 1985 (continued)

Comments:

The activity today developed quite rapidly and almost went unnoticed. Once taping began, a weak microburst was spotted at 1552 CDT at an azimuth of 90 degrees and 21 km (+5 and -5 m/s of shear). Also a weak gust front developed in the same area around 1554 CDT. The storm responsible for the gust front and microburst formed due east of the site with a strong core of 65 dBz of reflectivity.

The Citation flew a test flight over Arkansas today in order to calibrate their new probe.

Additionally, we switched between Little Rock and Millington on the RRWDS for approximately 1h and sent this tape back to Lincoln Lab for analysis.

SUMMARY OF OPERATIONS   Date 5 August 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

****

Data times: 0752-0828 CDT
0906-1616 CDT
Tapes collected: 595-618

Summary of weather situation:

At 06Z Monday a cold front stretched from north to south across the central Great Plains. Several troughs had formed out ahead of the front, with the closest to our area stretching from Oklahoma into central Arkansas and Missouri. Temperatures in advance of the trough were in the mid to high 70's with dewpoints in the low 70's. The surface flow pattern in the Memphis vicinity was primarily from the southeast. By 12Z on Monday the trough extended from a low in the Texas panhandle through north-central Arkansas, the Missouri Bootheel and southern Illinois. The trough exhibited fairly good convergence with a southeasterly flow in our region and a west or southwest pattern between the front and trough. A meso-high (bubble) had formed over northwest Arkansas due to the cold air outflow from thunderstorms near there. The surface chart at 18Z depicted the trough west of Memphis with a pressure wave over central and southern Arkansas. The flow pattern in and around the mid-south was still southerly. By 03Z the trough had reached Memphis which was experiencing a temperature of 77 F and a dewpoint of 73 F.

The low-level synoptic maps at 12Z showed a short-wave rotating around a low-pressure trough over the Great Lakes. Memphis was experiencing a westerly or southwesterly flow with moderate to high amounts of low-level moisture. The 500-mb chart for 12Z showed winds from the northwest up to 30 knots in the area. Little Rock, Arkansas, was quite dry at this level while Monet, Missouri, was moderately moist. Upper air flow (300 mb) in our vicinity was primarily from the west-northwest at 15 to 20 knots.

The morning upper air sounding at Little Rock was quite unstable with 2.03" of precipitable water, total totals of 48, and a lifted index of -3. Due to weak positive vorticity, ample moisture supply, and afternoon surface heating widespread thunderstorm activity was expected in the Memphis area.

At 1235Z Monday, a line of showers stretched from just south of Memphis all the way up to the Great Lakes. The highest tops (35 kft) were found over the Missouri Bootheel. There was also activity over north-central Arkansas with tops to 41 kft. As the line closest to the city of Memphis passed through it set of a couple of cells northeast of the airport. A mission began at 0752 focussing on the activity nearest the city.

5 August 1985 (continued)

At 0902 CDT, radar indicated a line of echoes orientated northeast to southwest just to the north of the site. Around 1017 CDT a possible small microburst was detected at a range of 6 km and azimuth of 4 degrees. The couplet consisted of -5 and +10 m/s, but was only detected on one volume scan. The maximum tops on this activity was generally about 40 kft. An area of fairly strong rotation in a heavy thunderstorm was detected at 1227 CDT at a range of 32 km and 203 degrees. Over a space of 8 km, a shear of -20 and +5 m/s was observed. At 1339 CDT the airport was closed due to low visibility, high winds, and heavy rain. A gust front was detectable from this line near the airport at 1332 CDT (a range of 14.2 km and azimuth of 285 degrees).

Scans run:

RON1, SECT1, SECT2, RON2, DDS7, DDS2, OFFA, OFFA7

Comments:

Our site was again the center of focus for current information on windshear studies and how they might relate to the Delta 191 crash in Dallas on Friday.

Mark Isaminger went to the Memphis ATC Tower to observe the line of thunderstorms come across the airport. The timing of the storm was about 1 hr too early, so there was not a whole lot of ground traffic for the event. The airport was closed for 20 minutes, but only one plane was forced to wait on the taxiway. If the event had occurred later during Republic's Hub and Spoke operation quite a few planes would have been stacked waiting to takeoff. Since there was not a lot of ground traffic disruptions, no further data was collected besides visual observations.

SUMMARY OF OPERATIONS Date 9 August 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

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Start time: 1450 CDT
End time: 1723 CDT
Tapes collected: 621-626

Summary of weather situation:

Today's weather in the Memphis vicinity was expected to be hot and humid with a slight chance of afternoon thundershowers. The morning upper-air soundings to the west and south were stable with low to moderate moisture supplies. The front to our north was not expected to penetrate into this region due to a "high over low" blocking feature in the southeastern U.S.

The 18Z surface map on Friday depicted a cold front over the western plains which was not expected to influence our weather today. Temperatures in and around Memphis were in the low 90's with dewpoints in the mid 70's. By 21Z on Friday the front had shifted only slightly across the central U.S. and there were no troughs out ahead of it to provide lifting.

At low-levels (700 and 850 mb), the area was primarily under the influence of cyclonic flow around a low-pressure cell over the southeastern U.S. This low, in association with a high over east Texas, was bringing a northerly flow into our region. The 12Z 500-mb chart showed a ridge of high pressure over the Mississippi Valley up into Misssouri. Hence, the only activity today would be isolated air mass thunderstorms in the afternoon once the convective temperature was reached.

By 1435 CDT several cells had developed to our west and northwest at 80 km. The maximum tops at this time were quite low, i.e., 25 kft. Movement on this activity was to the east or towards the radar. The most interesting cell today formed north of the airport due to surface heating and additional moisture over the city. The highest observed reflectivity was 55 dBz at a range of 21 km and 301 degrees. A 0.5 degree tilt at 1542 CDT depicted an area of slight divergence with a maximum shear of 10 m/s. By 1543 CDT the cell north of the airport had expanded to a small microburst (-5 and +10) at a range of 21 km. Several LLWAS sensors at the airport detected the outflow from this thunderstorm and set off alarms. This same cell at 1553 CDT put out a gust front that was evident on all three displays. By 1627 CDT, a new echo had formed along the gust front. By 1735 CDT the storms in our area were dissipating, so taping was stopped.

Scans run:

RON2, OFFA, SECT1

9 August 1985 (continued)

Comments:

Chuck Curtiss, Stan Dajnak, Nat Fischer and Ron Rinehart went to Federal Express at the airport to see their Collins Dopplerized weather radar in operation. The radar we saw was a land-based system similar to those used on aircraft except that it was capable of scanning continuously in azimuth. The Doppler data are used only to indicate the locations of possible turbulence. Turbulent areas are superimposed on the normal three-color intensity display. The system used a combination of a special-purpose processor and an IBM PC with menu-driven operating selections. The color displays had nice overlays of highways, rivers and lakes, political boundaries and such that made it quite easy to locate the positions of echoes relative to ground features. Overall, it seemed like a nice little system.

SUMMARY OF OPERATIONS Date 10 August 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

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Data times: 1227-1626 CDT
1856-1936 CDT
Tapes collected: 627-637

Summary of weather situation:

Due to the hot/humid weather and a southerly flow of Gulf moisture at low levels, today's forecast called for isolated air mass thunderstorms.

Saturday's surface map (12Z) showed a cold front over the east-central plains with a slight bulge into northwest Arkansas and southeast Missouri. Temperature contrasts on either side of the front ranged from 15 to 20 degrees F. By 18Z the front was still positioned in the same area with Memphis located in the warm air sector. Our winds at the surface were southeasterly around a high pressure cell in the Gulf of Mexico. The 00Z surface chart indicated the front had a WSW to ENE alignment across northern Texas, Oklahoma, northern Arkansas and northwest Tennessee.

Low-level (850 and 700 mb) upper-air maps for Saturday depicted a pocket of warmer air through western Arkansas and Missouri. At this layer, Memphis was experiencing an anticyclonic flow around a high in the Gulf, bringing westerly winds to our region. At 500 mb the high pressure dome stretched from the gulf up into the central Mississippi Valley. A closed high persisted at 300 mb over eastern Texas bringing northwest winds of 25 knots into the southeastern U.S.

The radar summary for 1635Z on Saturday indicated a line of thunderstorms from east-central Arkansas into western Kentucky and southern Illinois. Tops on these echoes were around 50 kft. The line was moving southeastward, while individual cells were tracking to the east.

A mission commenced at 1227 CDT with the best activity located at 40 km and 290 degrees from the airport. It had already developed a gust front along its southern edge that was sliding towards the south. At 1306 CDT an area of divergence (+5 and -10 m/s) was observed at a range of 104 km and 30 degrees. This could have been a macroburst or a thunderstorm outflow boundary. A second microburst was detected at 1418 CDT with a maximum differential of -5 to +10 m/s. It was positioned almost due north of the site at a range 18 km. This microburst had formed from a cell that developed over the city as the first pre-frontal line passed through. Today's third microburst was first detectable at 17.5 km and 348 degrees. This cell exhibited a greater wind shear differential than the previous two (+25 and -15 m/s). Since the cell was first observed in its beginning stages, the Citation was able to make at least three passes through the microburst. The crew reported a downdraft of 50 knots while penetrating the cell at 1444 CDT. Both the airplane data and Doppler data should make for an interesting case study at the lab. As this cell progressed southeast of the site it joined with other A cells and formed a line. Mesonet station # 6 on the southern edge of the network recorded 25 mm of precipitation in less than 1 hr. By 1600 CDT most of the activity had either dissipated or moved out of our radar range. Since another area of echoes persisted over northeastern Arkansas, the Citation was called back to refuel in anticipation of a second mission.

At 1855 CDT, a second mission was started with a line of level 3 and 4 echoes about 30 miles west of the city of Memphis. A large area of eastern Arkansas was experiencing at least level 1 activity at this time. Movement on these storms was slowly towards the east and south while earlier cells had tracked southeastward. The area of precipitation began to dissipate just after we started our first tape. So, the airplane crew was contacted and the mission cancelled before they left the hangar. The earlier storms in our area seemed to have modified the atmosphere leading to the rapid decay of the second line. Additionally, the lack of surface heating could have lead to the demise of the evening storms.

Scans run:

RDN2, SECT2, OFFA, SECT1, ONA7

Comments:

The major noteworthy event on this date was the penetration of the microburst by NEXRAD 1. It should prove to be an excellent data set for later analysis. The penetrations of the gust front crossing the airport were also good as was the turbulence encountered early in this flight. Overall, it was the best flight of the season!

SUMMARY OF OPERATIONS Date 12 AUGUST 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

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Oper. times: 0840-0925 CDT
1633-1711 CDT
Tapes collected: 645-646

Summary of weather situation:

The morning surface map showed a stationary front to the north of the Memphis area. The upper-air soundings for our region were moderately stable with a good supply of low-level moisture. However, an inversion and dryness aloft were forecasted to cap any activity later today. Also, a high pressure ridge was prevalent at all layers of the atmosphere over Memphis. With afternoon heating, a few widely scattered air mass thunderstorms were possible, but nothing severe.

At 1638 CDT, a strong cell up to 40 kft developed at a range of 22 km and 302 degrees. This cell put out a weak gust front which was located just northwest of the Memphis airport. Within 30 min the activity had dissipated, so an aircraft mission was cancelled. Only one tape was collected today.

Scans run:

OFFA7, ANP

Comments:

The Genisco color displays went out again over the weekend. Stan feels the intermittent problem is caused by excessive heat buildup when the computer covers are on.

In the morning, we collected data on anamolous propagation using the new 30 dB filter. This event was not captured on the RRWDS, since the recording equipment was pulled out last week. However, photographs of the Millington radar were taken and are available at the site.

SUMMARY OF OPERATIONS Date 15 AUGUST 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

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Oper. times: 0800-1206 CDT
1440-0137 CDT
Tapes collected: 649-681

Summary of weather situation:

The 12Z surface map on Thursday depicted a cold front stretching from northern Texas through Missouri, Illinois, and into the Great Lakes states. A convergence line was found out ahead of the front from northeast Texas to northwest Arkansas. Hurricane Danny was positioned at 29.4N/92.4W or just off the Louisiana coast. Both of the above systems were forecasted to affect our weather today.

Winds in the Memphis vicinity were primarily from the south around the Bermuda High located in the Atlantic Ocean. By 18Z the cold front had shifted slightly towards the southeast and was aligned southwest to northeast across Oklahoma, northern Arkansas, and southern Missouri. Hurricane Danny had made landfall along the Louisiana coast and was positioned at 29.9N/92.5W. The winds in our region were light, being primarily from the southeast.

The upper-air charts for 12Z on Thursday depicted the same scenario as found at the surface. A low pressure cell, associated with Danny was prevalent off the Louisiana coast on both the low and mid-level maps. The flow pattern in our area was southerly or southeasterly at 10 to 25 knots. A fairly strong Bermuda High had entrenched itself at all levels of the atmosphere over the western Atlantic. At upper-levels (300 mb), Memphis was experiencing a 25 to 35 knot wind from the southwest. The strongest jet stream winds were to our north over the Great Lakes. Hurricane Danny was forecasted to follow the low-level flow pattern around the ridge and pass right through the mid-south.

The morning sounding at Little Rock was unstable with 2.00" of precipitable water, total totals of 52, and a lifted index of -6. This was due to the trough (convergence line) that was very close to Little Rock at the time of the sounding. Our first activity of the day built along the trough, which soon intensified into a squall line.

By 0800 CDT, a line of showers was already prevalent in eastern Arkansas with embedded level 4 and 5 echoes. Also, a second line was aligned west to east across west Tennessee with level 3 echoes. Taping on this mission began as soon as the site personnel arrived in the morning.

15 August 1985 (continued)

The most intense line (eastern Arkansas) was at a range of 64 km from the site and was moving east-southeast. At 0846 CDT tops up to 42 kft were detected by our radar. The Citation launched at 1006 CDT focusing on the line of thunderstorms to the northwest of Memphis. There was a band of moderate turbulence in this line, however, most of the best turbulence was in areas of high reflectivity. At 1100 CDT, the line of storms in Arkansas began moving away from our radar to the northwest. The steering mechanism was cyclonic flow around Hurricane Danny located just off the Louisiana coast. By 1130 CDT, the activity had decreased somewhat and moved out of UND's recording range, so the Citation crew was radioed to return to the airport. The first mission ended at 1206 CDT with a line of thunderstorms located in central Mississippi moving towards the north. This line represented the outermost flow band around Hurricane Danny.

During the morning session, the only wind shear detected were two regions of weak to moderate turbulence.

At 1440 CDT, a new mission was commenced to collect data on two different thunderstorm areas within radar range. The first was isolated thundershowers located in west Tennessee and eastern Arkansas which had formed along the outflow boundary of the morning storms. The second was a line of storms in north Mississippi associated with Danny and moving our way. The Citation became airborne at 1509 CDT, focusing on the thundershowers in eastern Arkansas. The afternoon session afforded the opportunity to observe many more wind shear events than in the morning. The following table presents those wind events logged during the afternoon and early evening hours:

EVENT	TIME (CDT)	EL. TILT	SHEAR OR VELOCITY	AZIMUTH/RANGE (km)	
Rotation	1525	0.5	+5 & -5 m/s	238	24
Convergence	1533	3.0	10 m/s	147	7
Microburst # 1	1542	0.5	+5 & -10 m/s	91	4
Microburst # 2	1609	0.5	+15 & -5 m/s	260	12
Gust Front	1612	0.5	10 m/s	330	25
Microburst # 3	1623	0.5	+15 & -5 m/s	318	7
Microburst # 4	1702	0.5	+5 & -5 m/s	340	36
Macroburst	1710	0.5	+10 & -15 m/s	48	15
Echo-free Vault	1745	?	?	North of site	
Divergence	1857	0.5	+5 & -10 m/s	240	29

The afternoon session should provide for a good case study back at the lab. The Citation made several passes through a gust front near the airport and penetrated an echo-free vault. There were quite a few wind events/ microbursts detected that could provide clues to microburst formation and development in a humid climate. In addition, microburst # 2 was situated right over the mesonet, so the radar data can be compared to the mesonet data.

15 August 1985 (continued)

By 2028 CDT, a bright band was observed at 14 kft by our radar. Most of the echoes were weakening with moderate velocities still being displayed. From 2108 CDT to 0131 CDT one volume scan was taped every 15 minutes. During this time, only echoes up to level 2 were detectable on the Millington radar. The second mission ended at 0131 CDT, in order to stand-by for later activity from Tropical Storm Danny.

Scans run:

RON2, RHIT, SECT2, RON3

Comments:

There were no visitors or news media at the site today.

SUMMARY OF OPERATIONS Date 19 AUGUST 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

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Start time: 1423 CDT
End time: 1926 CDT
Tapes collected: 710-724

Summary of weather situation:

The morning weather map depicted a stationary front across the Kentucky-Tennessee and Arkansas-Missouri borders. The 12Z sounding at Monet was moist and unstable with 1.60" of precipitable water, total totals of 54, and a lifted index of -6. Little Rock's sounding was moderately unstable, i.e., a lifted index of -3, total totals of 46, and 1.44" of precipitable water. Their convective temperature had already been surpassed by briefing time (1145 CDT), so air mass thunderstorms were forecasted in and around central Arkansas. The stationary front was expected to begin pushing south later in the afternoon bringing with it a chance for thunderstorm development. However, most of the severe weather should remain north of the city of Memphis. There was a possibility that an outflow boundary could provide additional lifting in our area for thunderstorm enhancement later in the day.

By 12Z the front was still stationary to our north with a trough stretching from north-central Arkansas to northwest Texas. A strong push of colder air was beginning to fill in behind the front. The 00Z surface chart showed the front (cold) had moved through Memphis and was positioned in northern Mississippi. Our temperature had dropped 14 degrees in a 6 hr period. Temperatures and dewpoints in our area were now in the low to mid 70's.

At low-levels, a closed low was situated over eastern Canada with a short-wave rotating around the system to our west. Winds in our vicinity were light and variable at this level. The 500-mb chart depicted the same upper air trough stretching down into Oklahoma. Our wind flow was from the southwest at 10 to 20 knots. Weak high pressure over the Gulf was helping bring mid-level moisture into the Memphis vicinity. By 00Z on Tuesday, the short-wave had rotated through west Tennessee and we were on the backside of the trough.

The mission began at 1423 CDT focusing on the line of thunderstorms in eastern Arkansas along the trough. The maximum tops were 45 kft and movement was to the southeast. The Citation became airborne at 1548 CDT, concentrating their flight on the southern edge of the line.

19 August 1985 (continued)

The airplane data and radar data for today's mission will be beneficial only during the first half of the flight. The crew reported moderate turbulence, negative G's, and hail on a number of occasions. However, they were experiencing computer malfunctions due to a lightning strike nearby and did not record airplane data after 1748 CDT.

Their airborne computer problem was untimely since a microburst signature was detected just north of the airport after they landed. The divergent outflow persisted for about 30 min and the plane could have made several passes through the microburst.

The following wind events were recorded in the log during the afternoon hours:

Event	Time (CDT)	Tilt	Shear or Velocity (m/s)	Azimuth/Range (km)	
Convergence	1510	0.5	+15 & -10	293	119 125
Divergence	1605	0.5	+5 & -5	298	91
Rotation	1646	0.5	+10 & -10	315 320	58
Rotation	1714	0.5	+18 & -5	331 334	62
Gust Front	1724	0.5	+15 m/s	270	53
Gust Front	1738	0.5	+10 m/s	345	35
Microburst	1802	0.5	+5 & -10	285	54
Microburst	1804	0.5	+5 & -15	321	25
Gust Front	1809	0.5	+5 m/s	313	18
Divergence	1815	0.5	+10 & -10	326	26
Divergence	1816	0.5	+5 & -10	281	51

So, at least 2 microbursts and three gust fronts were detected on this day. Also, the area of rotation correlates with a call from the NWS of a funnel cloud reported by an observor over southwest Tipton County. The most interesting radar data tape should be #720 on which several volume scans of alternating RHI's/PPI's were obtained through a microburst. The RHI's appeared quite impressive on the displays during the operation.

Scans run:

RON2, SECT2, RHIN, RHI, OFFA7, RON1, SECT1

SUMMARY OF OPERATIONS Date 23 AUGUST 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

****

Start time: 1320 CDT
End time: 1604 CDT
Tapes collected: 726-732

Summary of weather situation:

Today's surface map depicted a warm front to our west aligned northwest to southeast across southwest Missouri and eastern Arkansas. There was slight positive vorticity in our area that could provide lifting for thunderstorm development this afternoon. The sounding from Little Rock was somewhat unstable with a lifted index of -2, a total totals of 45, and 1.70" of precipitable water. However, most of the moisture was below 500 mb, since the sounding was dry at this level. Nashville and Jackson's soundings were both moist at mid-levels, so a dry line was located between the three stations. The warm front was forecasted to slide off to the northeast bringing a warm/moist southwest wind and a chance for afternoon thunderstorms in our vicinity. If the warmer air mass collided with the dry line in our area, there was a distinct possibility of severe weather this afternoon.

By 18Z, the warm front had passed through Memphis bringing a southwest wind of 5 to 10 mph to the region. A low-pressure center had formed over southwest Missouri and trailed a stationary front to a second low over the Texas/Oklahoma panhandle. The dominant weather system today was an occluded low over the northeastern Great Plains with a cold front stretching from northeast to southwest into New Mexico and Arizona. Temperature contrasts on either side of the front ranged from 20 to 30 degrees. The 21Z chart depicted the warm front at its 18Z position, riding up the cold front in west Tennessee and central Missouri. The cold front had pushed into western Missouri and central Oklahoma and a weak trough had formed over northeastern Arkansas. By 00Z on Saturday the warm and cold fronts had become stationary and the trough had dissipated. The cold front now stretched from an occluded low near the Great Lakes southward into northwest Arkansas and then into the Texas panhandle.

Today's episode commenced at 1320 CDT with a line of showers east of Memphis and a few isolated thundershowers over west Tennessee and north Mississippi. By 1450 CDT, the activity had merged into a line from 40 miles west to 40 miles east of the site. None of the strongest cells approached the mesonet and only 0.05" of rainfall fell at the field site.

23 August 1985 (continued)

A possible dry(?) microburst was detected at 1417 CDT with 20 m/s of wind shear (8 km and 27 degrees). The maximum tops were observed to be 40 kft on this activity with movement to the northeast. By 1604 CDT, the storms were dissipating and the last tape was collected.

NOTE: The showers today formed due to 1) afternoon heating and 2)the warm front as it passed through our area. Most of the activity was stratiform (layered) with a few embedded convective cells.

Scans Run:

RON1, ONA7, RHI, OFFA

Comments:

Chuck changed the temperature/humidity sensor at station #4 and the temperature readings are back to normal.

Brad Assilen will be leaving for North Dakota over the weekend, so Al Borho will carry out all responsibilities at the UND site.

SUMMARY OF OPERATIONS Date 24 AUGUST 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

****

Start time: 0626 CDT
End time: 1625 CDT
Tapes collected: 733-760

Summary of weather situation:

The weekend forecast called for thunderstorms to develop along a cold front that should pass through Memphis on Saturday evening. By the end of the work day on Friday the cold front was aligned north to south across the Great Plains.

At 12Z, the cold front was positioned northeast to southwest across the Missouri Boothill and central Arkansas. A squall-line had formed in between the warm and cold fronts stretching from Memphis to western Kentucky. Temperatures and dewpoints in our vicinity were in the low to mid 70's. By 18Z the cold front had become stationary along its southern reaches, while the central portion had drifted into northwest Tennessee and eastern Arkansas. Memphis was still located in the wedge between the two fronts. The surface chart for 00Z on Sunday depicted the cold front in extreme eastern Arkansas showing little or no movement. The warm front had pushed northeastward out of our vicinity and was weakening.

The morning sounding at Little Rock was quite unstable, i.e., a lifted index of -6, total totals of 50, and 1.76" of precipitable water. The upper-air charts for Saturday (12Z) depicted a deep trough over the western Great Lakes extending up to the 300 mb level. The flow pattern around the trough was advecting colder air into our vicinity from the northwest. There were fairly moderate winds of 15 to 35 knots from 5000' to 32,000' above the surface.

This morning's taping session begin around 0630 CDT with the first pre-frontal squall already over the city of Memphis. There were numerous strong cells evident north of the site upwards to 50 kft. Movement on these cells was to the east and southeast at 25 to 35 mph. By the time we had collected our last tape on Saturday afternoon a total of three squall-lines had passed over the city. Numerous wind events, high reflectivities, and strong turbulence were noted with the passage of each line. The following significant wind events were logged during the morning and afternoon hours:

24 August 1985 (continued)

Event	Time (CDT)	Tilt	Shear or Velocity (m/s)	Azimuth/Range (km)	
Macroburst	0634	0.5	+15 & -10	356	32
Divergence	0649	0.5	+10 & -10	184	7
Rotation	0848	0.5	+10 & -5	349	40
Divergence	0914	0.5	+5 & -5	309	29
Microburst	0923	0.5	+10 & -5	321	25
Microburst	0925	0.5	+10 & -10	334	19
Microburst	0951	0.5	+10 & -10	349	25
Divergence	1032	0.5	+10 & -5	305	7
Microburst	1037	0.5	+10 & -5	270	13
Divergence	1141	0.5	+5 & -5	164	27
Rotation	1304	0.5	+15 & -5	211	34
Divergence	1307	0.5	+10 & -10	140	11
Rotation	1314	0.5	+20 & -10	197	21
Rotation	1404	0.5	+10 & -15	188	93
Gust Front	1544	0.5	+15 m/s	215	22

So, there were at least 5 microbursts/macrobursts recorded during this episode. Also, the areas of divergence could be further analyzed at the lab to ascertain if any more microbursts occurred on this day. It appears that most of the microbursts we noted today were initiated by strong convective cells within the squall-lines.

By the early evening hours on Saturday the cold front still had not passed through Memphis since our winds were still southerly.

NOTE: Around 1042 CDT lightning struck very close to the site causing the antenna to stop momentarily and the displays to blink. Also, several VT-220 computer terminals were knocked out at this time. All of the above occurred even though we were on generator. There was a minor delay restarting the system, so we lost 6 min of radar data from 1042 to 1048 CDT. Fortunately UND was not affected by this event and continued recording without incident. Their data could be used to fill in the gap caused by the delay we encountered. This episode was the first good test for the lightning protection system at the site. It probably served as a ground for the lightning bolt, thus protecting the radome and the trailers. Once the system was back up we continued to scan the displays in order to follow this storm as it moved off to our southeast.

At 1105 CDT, the NWS called and reported wind damage from a tornadoe or gust front in the Olive Branch area. We played back the data tape for this episode, but did not spot any TVS or Microburst signature. Al and Chuck surveyed the damage and reported that all of trees were blown down to the east or southeast. The strongest winds we were displaying were 28 m/s away at 104150 CDT. UND's tape for this time period might be able to shed some light on the event.

24 August 1985 (continued)

A dump of the mesonet data for this day showed a peak wind gust of 28.1 m/s at station #6 at 1041 CDT. Since, the event was partially within the mesonet the ground-based anemometers can be used to determine if a microburst or gust front was responsible for the damage.

Scans run:

RON2, RHI, SECT2, SECT1, DDN2, RON1, OFFA, DDS7H, ONA

Comments:

We did not receive a wake-up call from the NWS on the storms that arrived early Saturday morning. Joe Walker (MIC) will be contacted next week to determine why the procedure established by Ron was not carried out.

SUMMARY OF OPERATIONS Date 25 AUGUST 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

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Start time: 0236 CDT
End time: 0631 CDT
Tapes collected: 761-770

Summary of weather situation:

By 03Z on Sunday the front had become quasi-stationary just east of the Memphis vicinity. There was a strong push of colder air in behind the front as evidenced by the temperature and pressure waves. The 09Z chart showed the front had passed through Memphis and was about 50 miles to our east. Our wind flow shifted from the south to the northwest and eventually to the north.

The upper-air charts depicted the low-pressure trough over the southern Great Lakes at all levels. There were strong winds of 60 knots from the northwest prevalent at 32,000'. This strong jet was responsible for the activity moving off so rapidly once it formed. The mesonet stations recorded rainfall amounts of 0.50" to 0.75" within a 15 min time span.

After the frontal passage early Sunday morning, Memphis experienced a pleasant day with clear skies and a cool/dry north wind.

The following wind events were logged during the early morning session on Sunday:

Event	Time (CDT)	Tilt	Shear or Velocity (m/s)	Azimuth/Range (km)	
Microburst	0248	0.5	+10 & -10	355	17
Microburst	0252	0.5	-5 & +30	289	6
Gust Front	0304	0.5	-5 m/s	128	6
Velocities	0355	1.0	-23 m/s	149	32
Velocities	0417	0.5	-33 m/s	137	49

This morning's data collection lasted about 4 hr in order to track the entire life history of the strong cells that formed along the front. At least 2 more microbursts were logged bringing the total to 7 for the weekend. The second microburst was inside the mesonet, so the radar data can be analyzed along with the mesonet data.

25 August 1985 (continued)

Scans run:

RON2, SECT, RON1, RHI

Comments:

Once again we received no warning call from the NWS. At the present time there is no explanation for the deviation from the standard procedure.

SUMMARY OF OPERATIONS Date 3 SEPTEMBER 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

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Start time: 1052 & 1507 CDT
End time: 1333 & 1535 CDT
Tapes collected: 771-777

Summary of weather situation:

At 12Z, a surface low associated with the remnants of Hurricane Elena was located east of Texarkana. The upper-air winds in our region were from the south-southwest at 35 to 40 knots. A moderate PVA lobe was situated over the surface low and was moving to the north-northeast. There was a narrow convective line running from south of Memphis to just east of Jackson, Mississippi. Due to the possibility of lifting later in the day when the lobe moved through, there was a slight chance for thunderstorms within recording range. However, most of the severe activity was forecasted to remain south of the city of Memphis.

By 21Z, the surface low associated with Elena had dissipated and only an upper-air low pressure system remained.

The 12Z upper-air charts for Tuesday depicted a closed low over the tri-state area of Texas, Louisiana, and Arkansas. This was the upper air support for Hurricane Elena as the storm tracked through the southern Mississippi Valley.

Our operation today commenced at 1052 CDT focussing on a line of echoes orientated north-northwest to south-southeast from west of Memphis to Greenwood, Mississippi. The line of storms was moving to the northeast with some embedded level 3 and 4 cells on the leading edge.

At 1202 CDT, a gust front was detected at an azimuth of 261 degrees and 17 km. This event portrayed 15 to 20 m/s on the Doppler display and a gust of 32 mph when it hit LLWAS #6 at the airport. This fine-line echo was tracked for about 45 minutes across the mesonet. The only other wind event of significance was a cell that exhibited 20 m/s of rotational shear over 2 km. This area was detected at a range of 54 km and 73 degrees which was far from the mesonet. There was no thunder heard or lightning observed as the showers passed over the UND and Lincoln Lab sites. Total rainfall at our site today was 0.17".

Scans run:

SECT2, SECT1, RON2

Comments:

Most of the heavy activity from this storm system was far to our south and west. Several locations in north-central Arkansas received up to 8" of rain in a two-day period starting on Tuesday. By the time the activity arrived in our area the precipitation was generally stratiform with only a few embedded convective cells.

SUMMARY OF OPERATIONS Date 7 SEPTEMBER 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

****

Start time: 1544 CDT
End time: 2121 CDT
Tapes collected: 784-803

Summary of weather situation:

The 12Z surface chart depicted the Bermuda High well entrenched over the southeastern United States. The high pressure dome extended throughout the stack and was situated over the western Atlantic Ocean. Our entire region was experiencing a southwest influx of warm and moist air. Little Rock and Jackson both had unstable morning soundings, i.e., total totals of 48, lifted indices of -4, and 1.66 to 1.87" of precipitable water. The convective temperature would be excedded by mid-day, so there was a good chance for air-mass thundershowers this afternoon.

The major synoptic feature on the charts this morning was a cold front which stretched from a low over western South Dakota eastward to the Great Lakes states. A stationary front extended from the low northwestward up into Washington state. Temperature contrasts of 20 to 30 degrees were noted on either side of the front. This system was expected to push into the ridge and arrive in our vicinity in 3 to 4 days. Due to an abundant supply of low-level moisture, low convective temperature, and an unstable atmosphere; today's forecast called for air-mass thunderstorms in the Memphis area.

The 18Z surface chart depicted a stationary front stretching from the Great Lakes states through the central Great Plains and into the Pacific Northwest. Strong ridging aloft over the extreme southeastern United States was slowing down all fronts moving our way. Temperatures in the mid-south were in the low 90's with dewpoints in the mid 70's. The winds were light and southeasterly at this time. By 21Z, the front was still far to our north showing little movement over the past 3 h. Our region was experiencing good surface convergence with southwest winds in eastern Arkansas and southeast winds evident in west Tennessee and north Mississippi. Undoubtedly this helped to trigger thunderstorm development during the early evening hours.

The operation commenced in the afternoon with numerous air-mass thundershowers located in west Tennessee, north Mississippi, and eastern Arkansas. The maximum echo tops were 52 kft with a slow drift towards the northeast. By 1730 CDT, several strong cells had formed over the city with movement to the northwest. At 1830 CDT, a line of thunderstorms observable in eastern Arkansas was beginning to push across the river. The cells over the city merged with those in eastern Arkansas and intensified as they tracked across Memphis. New cells developed in the wake of previous ones each exhibiting frequent ligtning which caused numerous power outages in Shelby County. These thunderstorms began dissipating around 2100 CDT after dumping 1 to 2" of rain over the city of Memphis. By 2120 CDT, the tops had decreased to 22 kft and taping stopped soon after this time.

7 September 1985 (continued)

The following significant wind events were logged during today's mission:

EVENT	TIME (CDT)	EL. TILT	WIND SHEAR OR VELOCITY (m/s)	AZIMUTH/RANGE (km)	
Microburst	1617	0.4	+5 & -10	325	23
Gust Front	1621	0.4	+5 m/s	309	19
Microburst	1624	0.4	+10 & -10	312	9
Gust Front	1631	0.5	+5 m/s	299	18
Microburst	1720	0.5	+10 & -5	268	9
Rotation	1754	4.9	+10 & -10	335	83
Microburst	1809	0.5	+10 & -5	261	5
Gust Front	1837	0.4	?	230	10
Divergence	1857	0.5	+5 & -5	312	64
Microburst	2033	0.5	+20 & -5	352	28

There were at least 5 microbursts and possibly another logged on Saturday in association with numerous air-mass thunderstorms. Once again we were able to obtain alternating PPI and RHI scans through cells exhibiting divergence or forecasted as such. The radar tapes containing volume scans with this strategy are 785, 786, 788, and 790.

Scans run:

RON1, SECT2, RHI, OFFA7, ONA, SECT1, RON2

Comments: None

SUMMARY OF OPERATIONS Date 8 SEPTEMBER 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

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Start time: 1308 CDT
End time: 1631 CDT
Tapes collected: 804-816

Summary of weather situation:

This mornings upper-air soundings were moist and unstable. Our area was still being dominated by the western arm of the Bermuda High. We were under the influence of a southerly flow pattern bringing an ample supply of moisture into the region. The convective temperature would easily be reached by the afternoon hours, so the forecast called for air-mass thunderstorms later in the day. Additionally, the outflow from the previous days storms was expected to provide extra fuel for thunderstorm development.

At low-levels (850 and 700 mb) the Bermuda High off the east coast was allowing for an anticyclonic flow from the southwest into our vicinity. This high pressure ridge extended throughout the atmosphere up to 500 mb's. At this level we were experiencing a cyclonic flow or easterly wind around a low-pressure cell over southern Alabama.

The 17Z map surface map showed the southeastern United States still being influenced by the western extension of the Bermuda High. Temperatures in the mid-south were around 90 with dewpoints in the high 70's. By 21Z, a small meso-high had formed over Memphis due to the cold air outflow from previous thunderstorms. The temperature in Memphis was 10 to 15 degrees cooler than surrounding locations.

The following wind events were observed during the operation this afternoon:

EVENT	TIME (CDT)	EL. TILT	WIND SHEAR OR VELOCITY (m/s)	AZIMUTH/RANGE	(km)
Gust Front	1320	0.5	?	272	26
Microburst	1321	0.5	+5 & -5	277	22
Microburst	1335	0.5	+5 & -5	309	12
Microburst	1354	0.5	+5 & -10	266	8
Microburst	1358	0.5	+5 & -5	305	19
Microburst	1422	0.5	+5 & -10	263	15
Microburst	1428	0.5	+5 & -10	22	15
Gust Front	1428	0.5	?	220	29
Divergence	1437	3.0	+10 & -10	0	11
Microburst	1445	0.5	+10 & -10	123	17
Microburst	1504	1.0	+15 & -10	90	13
Microburst	1504	1.0	+10 & -10	77	22
Divergence	1520	0.5	+15 & -10	115	10

8 September 1985 (continued)

So, this afternoons air-mass activity allowed for quite a number of microbursts to occur. Over the weekend a total of 14 to 16 divergent signatures at low elevation tilts were logged. This is the most microbursts detected by the FL-2 radar in a two-day period this year.

We were able to obtain one additional RHI/PPI scan sequence through a microburst this afternoon. The radar tapes containing these alternating volume scans are 808 and 809. Since, several of the microbursts were detected over the mesonet a data set comparison between the radar and ground stations is possible.

Scans run:

RON2, SECT1, RON1, OFFA7, RHI

Comments:

NOTE: On both Saturday and Sunday the importance of a lifting mechanism such as a gust front to thunderstorm enhancement and intensification was noticeable. Many echoes would build-up rapidly upon colliding with a gust front only to soon dissipate and put out a divergent signature. A entire data set could be initiated to evaluate thunderstorm enhancement and microburst formation along with gust fronts.

SUMMARY OF OPERATIONS   Date 9 SEPTEMBER 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

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Start time: 1615 CDT
End time: 1928 CDT
Tapes collected: 817-825

Summary of weather situation:

This morning's weather map depicted a cold front in southwest Missouri, northwest Arkansas, and central Oklahoma. The Bermuda High was still dominating the southeastern United States bringing a southerly flow into the region. Our atmosphere was unstable with lifted indices of -4, total totals in the low 50's, and 1.75" of precipitable water.

Today's forecast called for pre-frontal and air-mass thunderstorms, during the late afternoon and early evening hours. Warm air advection out ahead of the front was expected to slow down this system. Additionally, the Bermuda High should stall the front to the northwest of the city of Memphis.

By 1200 CDT, a line of heavy thunderstorms was aligned northeast to southwest across central Arkansas. Movement of these storms was eastward with the outflow expected in our vicinity by the early afternoon. Around 1600 CDT, the activity had drifted within recording range, so taping commenced. While sector scanning this line (80 km), several convective cells were noted near the airport. At 1621 CDT, a new scan (OFFA) was called in order to collect data on the echoes closer to the site. In a 1 h and 30 min period, there were at least 4 microbursts, 1 gust front, and several convergent signatures detected. Most of the above events were over the city of Memphis with the 1716 CDT case occurring just outside the mesonet. The tops were up to 46 kft and the cells were drifting northward.

From this afternoons activity, we were able to obtain one additional RHI through a divergent signature at 1711 CDT. Around 1720 CDT, a number of LLWAS sensors at the airport picked up a wind event and set off alarms. This information was quickly relayed from the controllers to incoming and departing traffic. By 1820 CDT, the cells over the city had dissipated, so we opened our scan to cover the line of storms now in extreme eastern Arkansas. This was a pre-frontal line that had propagated well out ahead of the cold front. No substantial wind events were recorded on these echoes, even though they topped out at 50 kft. By 1928 CDT, most of the activity had dissipated, so our last data tape was collected.

9 September 1985 (continued)

The following significant wind events were logged during Monday's episode:

EVENT	TIME (CDT)	EL. TILT	WIND SHEAR or VELOCITY (m/s)	AZIMUTH/RANGE	(km)
Microburst	1634	0.5	+5 & -5	312	28
Divergence	1637	0.5	+5 & -10	318	29
Gust Front	1642	0.5	15 m/s	313	24
Microburst	1716	0.5	+15 & -15	314	19
Microburst	1723	0.5	?	North of A/P	
Microburst	1800	0.5	+5 & -5	337	32
Rotation	1858	2.0	+10 & -5	234	76

Scans run:

SECT2, RHI, OFFA7, DDN7L, SECT1, ONA, RON2

Comments:

The radar tape containing the RHI scan through a microburst is #819. For the third straight day, air-mass thunderstorms formed over or near the city of Memphis causing locally heavy rainfall, numerous microbursts, and scattered power outages.

SUMMARY OF OPERATIONS Date 23 SEPTEMBER 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

****

Start time: 1314 CDT
End time: 1615 CDT
Tapes collected: 831-838

Summary of weather situation:

The 12Z surface chart depicted a low over northeast Iowa trailing a cold front southward into northwest Arkansas and then southwestward to southern New Mexico. A squall line had formed ahead of the front stretching from St. Louis through central Arkansas and then to near Texarkana. A high pressure cell over the Tennessee/North Carolina region was bringing a southeast flow into our area. Temperatures and dewpoints around the mid-south were in the low 70's.

The upper-air maps for 12Z showed a deep low-pressure trough extending down the Great Plains states. This trough predominated throughout the atmosphere and was negatively tilted at the 700 to 300-mb level. Our upper air winds were westerly and southwesterly at 20 to 50 knots. Little Rock had a 500 mb dewpoint depression greater than 30 degrees, indicating a dry layer at mid-levels. Strong cold air advection was influencing the western-most reaches of Arkansas and Missouri. Additionally, an upper-air low (tropical disturbance) over the Mississippi Gulf Coast was advecting a warm and moist air mass into the southeastern United States. There was moderate positive vorticity for thunderstorm development with this system.

By the early morning hours, a line of thunderstorms up to 46 kft stretched across central Arkansas. However, this activity dissipated before tracking into radar range. At the same time, lighter showers in association with the low were prevalent over north Mississippi and west Tennessee. This area of rain was moving to the northeast, so no data tapes were collected during the morning. A rainshower passed over the site at 0830 CDT with moderate reflectivities and no significant velocities aside from storm motion. The rain only lasted about 5 to 10 minutes, so a mission was not started at this time.

Today's forecast called for showers and thundershowers as the front passed through later in the day. Afternoon heating should provide additional lifting for convective developement. Most of the stronger dynamics with the system should be to our south and east out of recording range.

By 1200 CDT, a few showers had formed along the front in northeast Arkansas. At 1309 CDT, a line of echoes up to level 4 was evident from the Missouri Boothill to west of Memphis. A few pre-frontal thundershowers (50 dBz) were developing along the Tennessee/Arkansas border at this time. The mission commenced at 1309 CDT, focusing on the line to our west which was 75 km long and 6 km wide. Soon after data collection started, a second line of showers had formed along the Mississippi River. These cells exhibited tops to 30 kft and reflectivities as high as 55 dBz.

23 September 1985 (continued)

At 1403 CDT, a weak gust front was detected at 315 degrees and 60 km. This was the only significant wind event noted on this day. By 1500 CDT, the gust front arrived at the Memphis airport producing a directional shift of 90 degrees, but no appreciable velocity change. The Doppler display portrayed velocities on this event up to 10 m/s, which correlates with peak gusts of 18 and 22 mph at the Lincoln and UND sites respectively. Total rainfall at the site on Monday was 0.07". No thunder or lightning was logged by either Doppler site with the passage of this system. The line dissipated somewhat as it crossed the river with the main activity passing north and south of the mesonet.

The weakness of today's activity can be attributed to the lack of moisture on the Little Rock sounding above 580 mb's. Most of the moisture was at low-levels providing for showers as the front passed through. However, dryness aloft prevented any significant convective developement in our region. The sounding for Jackson was not indicative of our air mass, since at 12Z the station was reporting a thundershower nearby.

Scans run:

SECT2, RON1, RHI, SECT1

Comments:

After today there will be no more opportunity for Dual Doppler scans, since it is UND's last operational day in Memphis for 1985. All of their radar tapes have been copied and sent to the Lab.

Chuck Curtiss left for Huntsville last night in order to obtain signed land owner agreements for the 1986 mesonet sites.

SUMMARY OF OPERATIONS Date 25 SEPTEMBER 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

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Start time: 1328 & 1826 CDT
End time: 1619 & 2037 CDT
Tapes collected: 839-853

Summary of weather situation:

This morning's surface chart showed a low over northeast Texas which trailed a cold front through central Texas and into New Mexico. A warm front extended from the low to the Louisiana Gulf Coast. The winds at Memphis were light and easterly. The upper air maps indicated a deep trough at all levels across the central United States. Jackson's sounding was slightly moist and unstable (Lifted Index/-3, K-Index/35, and Precipitable Water/1.35"), while Little Rock was drier and stable (Lifted Index/+8, Total Totals/18, and Precipitable Water/0.95"). There was a moderate PVA lobe with this system as it rotated to the east.

By mid-morning, our winds would shift to a southerly direction and allow a warmer/moister air mass to encroach into the mid-south. Therefore, the atmosphere out ahead of the front would become more unstable throughout the day. Most of the severe weather should be in southern Arkansas and northern Louisiana where more of the dynamics were found.

By noontime, a strong southerly flow up to 30 mph was noted at the field site. The cold front at this time stretched southwestward into southwest Texas. Temperatures ahead of the front were in the 70 and 80's, while readings in the 50's were common in the western Plains. The temperature at Memphis was 78 degrees with a dewpoint of 67. A 20 degree increase in the dewpoint temperature had occurred since 12Z. The 21Z chart depicted a low over central Iowa which trailed a trough down into west Tennessee. The cold front extended from southwest Tennessee through central Arkansas, Texas, and south-central New Mexico.

The mission commenced at 1328 CDT, focusing on a line of echoes (Level 1-5) aligned northeast to southwest across eastern and central Arkansas. Warmer air was overriding the cooler air along the front and the cells were propagating to the northeast. The maximum tops were up to 46 kft with the entire area drifting to the east. At 1555 CDT, a fine-line echo was detected at 314 degrees and 25.5 km's. This was the only significant log entry during the afternoon session. By 1630 CDT, this activity was to our east and a second line of thundershowers (post-frontal) had formed in eastern Arkansas.

These storms began moving to the east very rapidly, so a second mission was initiated at 1821 CDT. Thunder and lightning were observed to our west as the storms crossed the Mississippi River. At 1934 CDT, a second fine-line which turned out to mark the frontal position was noted to the northwest of the mesonet. The other wind events displayed this evening were strong velocities associated with storm motion and moderate anticyclonic rotation (35 m/s of shear). Higher reflectivities were also noted along with the thundershowers during the later mission. Radar summaries depicted the strongest storms 150 miles to our southwest in southern Arkansas and northern Louisiana. The air mass there was moister and more unstable than in our vicinity.

Scans run:

SECT2, RON2

Comments: None

SUMMARY OF OPERATIONS Date 29 SEPTEMBER 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

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Start time: 2331 CDT
End time: 0143 CDT
Tapes collected: 854-861

Summary of weather situation:

This morning's surface chart displayed a low over Lake Michigan which trailed a cold front southwestward through central Oklahoma and into southwest Texas. From there it turned northwestward up into extreme northwest New Mexico. A pool of colder air (20 and 30 degrees) was filling across the Plains states behind the front. Also, a squall line had formed ahead of the front in central Texas. High pressure over the east coast was allowing for a southeast flow into the mid-south. The cold front was expected to begin pushing into the ridge and arrive in Memphis late Sunday or early Monday.

The upper-air charts depicted a deep trough prevalent at all levels across the Great Plains. The trough was positively tilted at 500 mb's, stretching into southern California. The front side of the trough portrayed southwest or west winds of 15 to 50 knots. At 12Z, the soundings in our area were generally dry and stable. The only moist and slightly unstable sounding was Monet, Missouri, located nearest to the front.

A strong southerly flow was noted in the Memphis vicinity by mid-morning. Hence, a warmer/moister air mass would prevail later in the day when the front arrived. So, the forecast was for a good chance of showers and thundershowers on Sunday night or early Monday morning. However, most of the strong activity would be along the squall line in eastern Texas and western Louisiana.

By 21Z on Sunday, the front had virtually stalled and extended from a low over Monet through western Arkansas and into eastern Texas. The squall line was evident several hundred miles ahead of the front in Louisiana and southern Arkansas. Temperatures around the mid-south were in the low 80's with dewpoints in the high 50's and low 60's. The 1900 CDT soundings depicted the moist and unstable air mass that was encroaching into the southeast. Little Rock had a lifted index of +1, K-index of 33, and 1.61" of precipitable water, while Jackson's readings were as follows (Lifted Index/-3, K-Index/27, and Precipitable Water/1.72"). There was a good chance for convective developement along the front in our area.

During the late afternoon and early evening hours numerous showers were noted on the Millington radar over central Arkansas. This activity was sliding to the northeast and would not directly affect the mid-south. However, the outflow from these showers could provide additional moisture and lifting for thunderstorm enhancement later as the front progressed east. By 2200 CDT, the front had moved into central Arkansas with a line of showers and thundershowers prevalent in eastern Arkansas. The strongest echoes were level 3, so site personnel were called for a mission. BY 2310 CDT, a solid line (170 miles long and 20 miles wide) of level 3 and 4 echoes extended from Blythville, Arkansas, to Monroe, Louisiana. The 3210 computer had to be rebooted and the DAA reloaded, so taping did not commence until 2331 CDT.

Once again the activity tonight was similar to other episodes this week. Moderate reflectivities and strong velocities associated with storm motion were the primary focus of attention. Brief thunder and lightning were noted with the storm passage over the Lincoln Lab site. The only significant event was a weak gust front detected at 2338 CDT. This fine-line propagated across the mesonet producing a slight wind shift at the Memphis airport. However, the LLWAS sensors showed little velocity change during its passage. This echo was displayed on the reflectivity and turbulence monitors, but not velocity. There was no significant winds noted at the field site with its passage. The strongest cell tonight came across the site about 2420 CDT. The total rainfall during the operation was 0.70". An additional 1" fell with light rainfall throughout the night. A bright band was observed by 0100 CDT and taping stopped soon afterwards.

We were able to obtain several RHI scans through the gust front as it approached the mesonet. Once again this fine-line was only detectable on the reflectivity and turbulence displays. This scanning strategy will be preformed on stronger gust fronts later in the season.

Scans run:

SECT1, RON1, RHI, RON2

SUMMARY OF OPERATIONS Date 30 SEPTEMBER 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

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Start time: N/A
End time: N/A
Tapes collected: NONE

Summary of weather situation:

By 0700 CDT, the cold front was just passing through the city of Memphis. A narrow convective line along the leading edge was out of recording range to our east. Memphis was experiencing a cool northwest breeze at this time. The upper-air flow in our area was southwesterly around a low-pressure trough. Due to frontal overrunning light rainshowers were possible throughout the day. Our atmosphere was stable with a drying trend forecasted over the next few days. However, at present a moist air-mass still persisted across the mid-south.

So, today's forecast called for light rain continuing all day long, but no chance for convection. Radar summaries for Monday depicted generally layered rainfall across the region with tops less than 24 kft. Since, no significant velocities were displayed with this system, no additional data tapes were collected. The convective line ahead of the front had passed through last night and tapes were gathered at that time.

The total rainfall at the site from 0000 CDT to 1900 CDT was 2.28". Most of this fell as light rain during the morning and afternoon. Rainfall amounts across the mid-south varied from 0.75" to over 3 1/2" in Greenwood, Mississippi.

Scans run: None

Comments:

Doug Piercey, Art Dockery, and John Maccini arrived at the site today in order to rewire, install, and test both old and new elements of the DAA/Signal Processor. They also planned modifications on the 3210 interface board to the Signal Processor.

SUMMARY OF OPERATIONS Date 14 OCTOBER 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

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Oper. Times: 0934-1051 CDT
1224-1328 CDT
1440-2005 CDT
Tapes collected: 866-888

Summary of weather situation:

The 12Z surface map depicted a stationary front extending from a low off the Atlantic coastal states through the central Ohio Valley and then southwestward to southeast Kansas. A cold front trailed from central Oklahoma to central Texas. Temperature contrasts of 15 to 25 degrees were noted across the frontal boundary. An elongated low-pressure trough had formed south of the stationary front across western Kentucky, southeast Missouri, northwest Arkansas, and eastern Oklahoma. A meso-high was evident over southwest Missouri/northwest Arkansas due to the cold air outflow from previous thunderstorms. Weak high pressure centered in the Carolinas was advecting a warm/moist air mass into the mid-south.

Upper-air charts for today displayed a trough extending down the Great Plains. The winds in our vicinity were southwesterly and westerly at 20 to 60 knots. A short-wave (700 & 500 mb) was rotating through the larger-scale pattern over the eastern Plains. The 12Z baroclinic analysis portrayed moderate positive vorticity in the Memphis area. The morning soundings showed a moist and unstable atmosphere across the region, i.e., 1.75" of precipitable water, lifted indices of -2 to -4, and total totals in the low 50's.

The cold front was forecasted to push toward the mid-south later in the day. This would allow for air-mass and pre-frontal (squall) thundershowers within recording range.

By 0938 CDT, a line of showers up to 36 kft had developed from Memphis to Greenwood, Mississippi. We obtained sector scans and RHI's on this activity with no wind events observed. As the line progressed eastward, data collection ceased until the thunderstorms across southern Missouri and central Arkansas drifted within range.

The 15Z map depicted the frontal boundary stretching from the Ohio Valley to the southern Plains and Desert Southwest. A trough extended across the Missouri Boothill, southern Illinois, and west Kentucky. The trough changed into a squall-line in southern Missouri, northwest Arkansas, and southeast Oklahoma.

14 October 1985 (continued)

The line of thunderstorms to our west and northwest propogated within recording range shortly after noon. A strong cell over the Missouri Boothill exhibited a rotational shear of +15 to -10 m/s across 2 km. The maximum tops at this time ranged from 38 to 43 kft. There were no other wind events noted with these echoes as they tracked northeastward.

By 18Z, the squall-line was evident in eastern and central Arkansas. A meso-high had formed at the surface in northwest Arkansas due to the thunderstorm outflow. The final mission on Monday was initiated at 1440 CDT, focusing on a line (squall) of thunderstorms across eastern Arkansas. These cells exhibited stronger velocities and higher reflectivities than those earlier in the day. The following wind events were logged during the afternoon and early evening:

EVENT	TIME (CDT)	EL.TILT	VELOCITY OR SHEAR (M/S)	AZIMUTH/RANGE (KM)	
GUST FRONT	1558	0.5	20	275	42
GUST FRONT	1607	0.5	5	344	49
MICROBURST	1656	0.5	+15 & -5	16	18
GUST FRONT	1753	0.5	15	300	10

The most significant event was the first gust front which tracked across the A/P and mesonet. Station 25 (near the A/P) recorded a peak gust of 21.72 m/s at 1630 CDT. We were able to obtain several volume scans of RHI's through the gust front as it approached. The data tapes containing these scans are 874, 875, and 876.

By 00Z, the squall-line was just to the east of Memphis. The cold front remained to our west situated in northwest Arkansas and southeast Oklahoma. Only stratiform precipitation persisted in the immediate vicinity after 2005 CDT. Since, no significant velocities were displayed, data collection ceased soon thereafter.

Scans run:

SECT2, RHI, RON2, FAST2L

Comments:

There is a possibility that range gates 301-400 contained bad data during the mission. The data from these gates appeared to be misplaced, always at a range of 86.4 km on the displays. Nat and Chuck tested several boards in the DAA/Signal Processor before determining the bad element.

SUMMARY OF OPERATIONS Date 20 OCTOBER 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

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Start time: 1320 CDT
End time: 1523 CDT
Tapes collected: 903-906

Summary of weather situation:

The 18Z map portrayed a stationary front stretching from northeast Kentucky through west Tennessee and into eastern Louisiana. Temperatures ahead of the front ranged from 70 to 80, while 60 and 70 degree readings were common in the cool air sector. Our air-mass was moist and unstable, i.e., lifted indices of 0 to -5 and 1.50 to 2.00" of precipitable water. Today's forecast called for showers and a few thundershowers out ahead of the front.

By 1320 CDT, a line of showers up to 17 kft had developed from Memphis to the west Tennessee/west Kentucky border. An occasional, scattered thundershower was embedded within the weaker activity. Several tapes were collected with only one wind event listed in the log. This was a weak gust front (5 m/s) which tracked across the Mesonet. The fine-line was not detectable in any of the RHI tilts displayed during real-time. We collected the last tape at 1509 CDT, with only one cell noted above 20 kft.

Scans run:

RON2, SECT2, RHI

SUMMARY OF OPERATIONS Date 11 NOVEMBER 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

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Oper. times: 0315-0344 CST
0519-0753 CST
1101-1203 CST
Tapes collected: 918-926

Summary of weather situation:

By the early morning hours, the stationary front had drifted slowly southward into northwest Tennessee and northeast Arkansas. A number of cells had developed along and just south of the boundary within recording range. The tops were around 30 kft, so we decided to scan this activity in case a wind-shear event was displayed. For the first 2 hrs, reflectivities to 55 dBz and velocities of 10 m/s were detected on the low-elevation tilts. The closest cell during this time was 60 km to the west of the radar.

By 0300 CST, the activity had intensified somewhat with lightning observed to the north of Memphis. There were also several new cells that formed over or near the Memphis Airport. Taping commenced at 0315 CST, focusing on a weak thundershower at 316 degrees and 27 km. For the next hour, numerous showers and thundershowers developed over or near the city with movements to the northeast. We collected several data tapes with no wind-shear events detected. The mission ended until redevelopments later in the morning.

Around 0500 CST, several echoes were displayed just north of the Memphis Airport. Once again we gathered radar tapes with only moderate reflectivities (50-55 dBz) and benign velocities portrayed.

NOTE: The data on tape 923 was collected with the XRTS/Version 20 RTS. This change was employed in order to compare weather data between the two systems. The experimental version allowed the displays to be updated at a faster rate, i.e., 30 sec to 1 min. However, several problems with the newer system were still evident. For one, the reflectivities between the two systems was 10 to 12 dB different. Also, there were radials of missing weather information displayed on all three monitors. This problem should be addressed further before the system becomes operational in Huntsville.

The last mission today commenced at 1101 CST due to new cells that had formed to the southwest and northwest of the airport. At 1124 CST, an area of divergence (+5 and -5 m/s) was detected at 320 degrees/22 km. This event persisted for at least two volume scans and could have been a weak case of wind-shear. Taping ceased at 1203 CST, since no other significant velocities were indicated.

11 November 1985 (Continued)

NOTE: Today's weather activity was rainshowers and thundershowers with tops less than 30 kft. The main reason for collecting data tapes was the close proximity of the echoes to the Memphis Airport.

The forecast for the rest of the day called for showers to continue in northwest Tennessee and eastern/central Arkansas. The area of rainfall would drift northward with the front later in the day. Most of the mid-south would remain in the warm-air sector and experience a southeast wind. No further convective activity was anticipated within recording range.

Radar summaries for Monday afternoon and evening indicated mainly Level 1 and 2 showers to the west and northwest of Memphis (100-150 miles). There were no radar tapes collected on this weak, stratiform-type precipitation.

Scans run:

SECT2, RHI, RON1, SECT1, ONA

SUMMARY OF OPERATIONS Date 17 NOVEMBER 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

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Start time: 1419 CST
End time: 1710 CST
Tapes collected: 932-940

Summary of weather situation:

This morning's surface map depicted a stationary front over central Georgia, southern Alabama, southern Mississippi, central Louisiana, and eastern Texas. High pressure off the eastern U.S. coast and low pressure in the southwest were advecting moist air into our area at mid and upper-levels. Warm air overrunning would lead to the possibilty of condensation and rainfall across the mid-south. However, no convective activity was forecasted within recording range.

The Little Rock sounding portrayed a moist but stable atmosphere from the surface to the 500-mb level. A precipitable water amount of 1.20" (175% normal) was indicated on the sounding. Since our atmosphere was stable with no significant lifting mechanism, only stratiform rainfall was anticipated today.

By 1400 CST, light to moderate rainshowers were prevalent in southwest Tennessee, north Mississippi, and east Arkansas. We decided to collect data on this event using a scan sequence containing 1 degree steps. Tops of 25 kft and reflectivities to 55 dBz were noted with several echoes. As the cells tracked northeastward, an embedded cell to 26 kft was observed just southeast of the Memphis Airport. At this time, the only velocities of interest were 10 m/s of convergence.

At 1518 CST, an area of divergence (+10 and -5 m/s) was detected at 287 degrees/11 km. This wind-shear event persisted for several volume scans covering approximately 11 min. A second divergent signature (+5 and -5 m/s) was displayed 30 min later at a range of 20 km to our west. We were able to obtain two volume scans of RHI's through this cell. The shear persisted for 20-25 min, intensifying to a differential of 20 m/s over 2.5 km. Unfortunately there were no ground-based sensors to substantiate this event. The wind at the site gusted to 9 m/s out of the west for a 4-5 min time span after 1614 CST. The pre-event wind was either calm or a weak (1-2 m/s) east-southeast flow. So, the site experienced approximately the same wind speeds and wind direction depicted by the Doppler display.

Today's divergent signatures were noteworthy since no apparent signs of convection were noted with this activity. Also, no pre-cursors were logged during real-time operations. Radar tapes 935-938 might prove to be an interesting data-set when analyzed at the Lab.

17 November 1985 (continued)

By 1630 CST, the rainfall was dissipating with tops ranging from 16 to 20 kft. No other velocity shears were detected as the echoes tracked across southwest Tennessee. The last tape was collected at 1710 CST. By this time, the warm front was positioned in northern Mississippi. As the boundary moves through during the night, most of the rainfall would push northward out of recording range.

NOTE: While playing back tape 935 using 3 m/s color bars, a third divergent signature (+9 and -3 m/s) was noted. This event was detected at an azimuth of 261 and a range of 29 km. This couplet was not logged during real-time, since 5 m/s velocity steps are utilyzed.

Scans run:

RON1, SECT1, RHI, RON2

Comments: None

SUMMARY OF OPERATIONS Date 19 NOVEMBER 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

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Start time: 1720 CST
End time: 2002 CST
Tapes collected: 941-947

Summary of weather situation:

The 12Z chart depicted a low-pressure cell over central Oklahoma trailing a cold front through central Texas. An occluded low in the western Great Lakes was accompanied by a moderate cold front which stretched from eastern Wisconsin southwestward to Oklahoma. Temperature contrasts of 20 to 25 degrees were noted across the frontal boundary in the southern Plains. The temperature in Memphis was 70 with a dewpoint of 66. Our winds were gusting to 18 mph out of the southeast.

At 850-mb, a closed low was positioned over the northern and central Plains states. A negatively tilted trough axis was prevalent at all levels over the mid-section of the United States. Most of the dynamics and vorticity with this system would remain to the north of the mid-south. High pressure ridging throughout the stack was still dominating the east and southeast. This anticyclonic flow regime would continue to advect a warm, moist, and unstable air-mass into our area.

The upper-air soundings nearby depicted a slightly moist and unstable atmosphere with precipitable water amounts ranging from 0.90-1.44" and lifted indices of 0 to -1. The winds on the Little Rock sounding veered from the south at low-levels to west-southwest up high. The jet max (130 knots) with this system was located over the southern Plains.

NOTE: As the squall-line moved across western Arkansas/southwestern Missouri last night there was localized flooding, heavy rain (4 to 7"), remained in effect until 1100 CST for northern Arkansas, southern Missouri, and eastern Oklahoma. The NWS Severe Weather Outlook indicated a slight risk for severe thunderstorms in our region. As of the morning, a convective line was developing in eastern Texas and Oklahoma ahead of the cold front.

Today's forecast called for pre-frontal showers and thunderstorms by this afternoon or evening. Our maximum temperature should reach the high 70's and break the record high for this date. A strong southerly breeze would continue to advect moist and unstable air into the southeast. The cold front was expected to push into the ridge and arrive in Memphis early in the morning on Wednesday.

19 November 1985 (continued)

The other major weather feature on the charts was Hurricane Kate, located at 22.7N/80.5W or just along the northern Cuba coast. The storm contained sustained winds of 110 mph and was tracking to the west at 20 mph. The system was expected to skirt the northern Cuba coast and weaken before tracking into the Gulf and regaining its strength. The hurricane would not affect the U S. mainland for at least 2 or 3 days.

By 1720 CST, a line of showers and thundershowers stretched from Cape Giradeau, Missouri, to Pine Bluff, Arkansas. The strongest storm south of Jonesboro contained a Level 5 echo with tops to 43 kft. The mission commenced as soon as the line moved to within 120 km of the site. For the first half of the operation, we noted good low-level convergence, high reflectivities (55 to 65 dBz), and mid-level rotation. The entire area was moving eastward with individual cells racing to the northeast. As the line tracked into eastern Arkansas, a sudden drop in echo tops and storm reflectivities was noticed.

At 1846 CST, a weak divergent signature (+5 and -5 m/s) was detected at 326/56. We also observed a long, thin gust front 42 km to our west at approximately the same time. This fine-line was evident on all three displays with maximum velocities between 15 and 20 m/s. Several volume scans of RHI's were obtained through the gust front as it approached. By 1910 CST, this wind event had arrived at the A/P initiating numerous LLWAS alarms. The western boundary sensors shifted to the west-northwest at 30 to 35 mph.

The final wind-shear event was a microburst logged at 1918 CST. This case presented a divergence of 15 m/s over a range of 3.3 km (348/32). During the last hour, only weak to moderate reflectivities and moderate velocities associated with storm motion were noted. Within 1 1/4 h the maximum echo tops had dropped from 43 to 16 kft. Since, no additional wind events were likely, the last data tape was collected at 2002 CST.

By the time the activity reached the site only light rainfall was recorded (0.14"). There was no lightning/thunder reported with this line as it tracked across west Tennessee and north Mississippi. Once again, the strongest activity occurred outside of recording range in central Arkansas.

Scans run:

SECT2, SECT1, RON1, RHI

Comments: None

SUMMARY OF OPERATIONS   Date 27 NOVEMBER 1985

MIT Lincoln Laboratory Field Site
Olive Branch, Mississippi

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Start time: 1121 CST
End time: 1344 CST
Tapes collected: 962-963

Summary of weather situation:

This morning's charts showed the cold front stalled over extreme southwest Tennessee. Showers and occasional thundershowers would build along the front within recording range. We would operate only if strong cells form near the A/P or the field site. Most of the day will be allocated for report-writing and packaging of site materials.

Today's mission commenced at 1121 CST focusing on a line of showers and a few thundershowers that formed in extreme eastern Arkansas. At this time, a level 5 echo was being displayed just southwest of Memphis. The storms were tracking rapidly eastward so we decided to collect a data tape as the event crossed the A/P. The first tilt displayed reflectivities of 60 dBz and a gust front already present ahead of the main line. The tops on this activity ranged from 30 to 37 kft. The fine-line was detectable on several RHI scans. As the shelf cloud approached the site, a series of photographs were taken. The winds at the field site gusted to 35 mph out of the west.

Throughout the early afternoon, both strong convergence and moderate mid-level rotation were noted. Brief thunder was heard with a cell to our north. The final wind-shear event was a microburst logged at 1218 CST. This couplet portrayed 15 m/s of divergence over 2.1 km. There were no other strong velocities with this system aside from storm motion. The total rainfall at the site during the mission was 0.45". The NWS did not receive any severe weather reports as the line tracked across the area.

Scans run:

RON2, RON1, SECT, RHI

Comments:

The newest version (XRTS/20) of the RTS was utilyzed on today's episode.

Today was the final operational day for weather collecting purposes at Memphis.