RADAR CHARACTERISTICS OF MICROBURSTS IN THE MID SOUTH*

Ronald E. Rinehart and Mark A. Isaminger

MIT Lincoln Laboratory
Lexington, Mass 02173

1 INTRODUCTION

From March through November 1985, Lincoln Laboratory collected Doppler radar and mesonet data on wind shear events in the area around Memphis, Tennessee, under the sponsorship of the Federal Aviation Administration (FAA). The FAA/Lincoln Laboratory Operational Weather Studies (FLOWS) project focused on the microburst, a low-level divergent wind shear often associated with thunderstorm outflow. Microbursts were identified and defined by Fujita (1981), Fujita and Wakimoto (1981), and McCarthy *et al.* (1982).

Previous projects, i.e., JAWS (Fujita, 1985) which operated near Denver and NIMROD (Fujita, 1985) which operated near Chicago, identified wind shear characteristics in those climatic regions. There was a need to study microburst structure and forcing mechanisms in a wet climate like the southeastern United States. The mid-south region was selected for the following reasons. For one, it has a long thunderstorm season encompassing the spring, summer and fall. This would allow for an interseasonal comparison of downburst variability. Secondly, the location of a major airport within the study area would allow researchers to focus on wind shear and its effect on aviation. Third, the topography was such that blockage and ground clutter contamination were reduced. A clear line of sight between the radar and airport was essential for detecting wind shear.

The following data collection platforms were utilized in the FLOWS project:

1) A 10-cm, 1-MW, 1-deg pencil beam Doppler radar from M.I.T. Lincoln Laboratory (FL2).

2) A 5-cm, 0.25-MW, 1.5-deg pencil beam Doppler radar from the University of North Dakota (UND).

3) A 30-unit mesonet which obtains 1-min averaged wind speed and direction, temperature, relative humidity, pressure and precipitation, as well as the peak wind speed each minute.

4) A 6-station Low-Level Wind Alert System (LLWAS) system near Memphis International Airport (MIA).

5) An instrumented Cessna Citation II jet aircraft from UND.

6) An instrumented Convair 580 turbo prop aircraft from the FAA Technical Center.

7) Additional weather data such as satellite imagery, synoptic charts, radiosondes, and Radar Remote Weather Display System (RRWDS) recordings.

The primary objectives of the FLOWS project were to:

1) Collect and analyse radar and mesonet data pertaining to wind shear in a moist climatic region.

2) Develop and test various NEXRAD algorithms for wind shear detection.

3) Provide a data base for FAA specifications of NEXRAD and terminal weather radar interfaces.

4) Develop and test new techniques for automatically rejecting ground clutter.

This paper will present an overview of microburst statistics tabulated from the FL2 radar logs. Case-study analysis of radar and mesonet data is on-going and will be presented in future research. The Memphis data set will be contrasted with results gathered in a dry climate during JAWS. Additional information on the project is contained in the report by Rinehart *et al.* (1986).

2 DATA COLLECTION

Figure 1 shows the locations of radars, mesonet, and LLWAS stations within the FLOWS study area. Both radars were located within 20 km of MIA, with the mesonet forming a grid between the three sites (UND, FL2, and MIA). The average station spacing of 3 to 5 km is required to resolve the small-scale outflow associated with a microburst. In this study, the mesonet served to determine meteorological characteristics and as ground-truth for Doppler-derived velocities. For data pertaining to mesonet detections of microbursts from the mid-south region see Wolfson *et al.* (1985) and Wolfson *et al.* (1986).

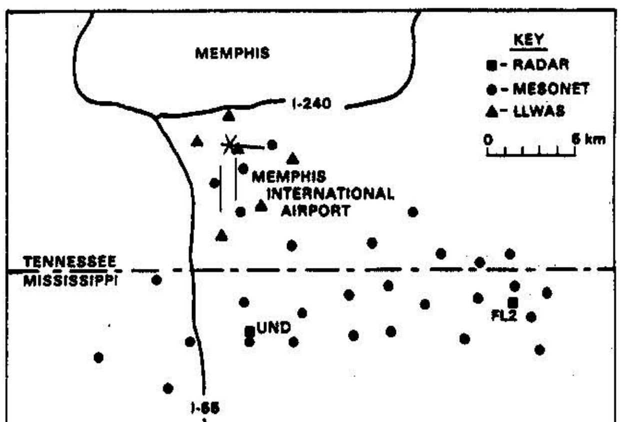

Fig. 1. Map of the FLOWS area showing the locations of the FL2 and UND radars, the mesonet, the LLWAS stations, and the runways at MIA.

* *This work was sponsored by the Federal Aviation Administration of the Department of Transportation. The views expressed are those of the authors and do not reflect the official policy or position of the U.S. Government.*

occurs at 15 m/s and then decreases approximately exponentially as the maximum shear increases. Thus, there are few strong events, but many weaker cases. The largest divergence recorded in the logs was 40 m/s. A comparison with JAWS data reveals essentially the same distribution. At least 24 FLOWS microbursts possessed a shear greater than the 24 m/s velocity differential associated with the crash of Pan Am 759 at New Orleans International Airport as reported by Fujita (1983) and Caracena *et al.* (1983).

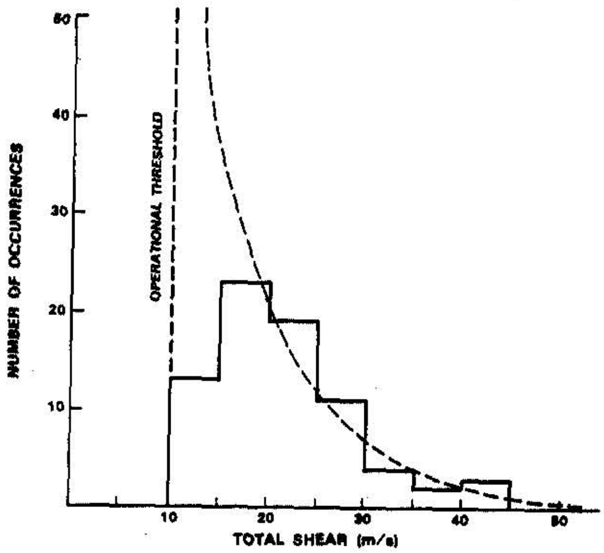

Fig. 5. Distribution of the total shear across microbursts. The dashed line is an exponential fit to the values of 20 m/s and greater.

Figure 6 is a scattergram comparing radar reflectivity and velocity shear for 85 FLOWS microbursts. There is no apparent correlation between these two variables. Strong shears are indicative of the entire range of reflectivity values. The results from Memphis can be contrasted to Fig. 8 in McCarthy *et al.* (1984). Their data indicates more dry events below 30 dBz. The sub-cloud base moisture contents in the southeastern United States reduces evaporative cooling at low-levels. Hence, there is a greater percentage of FLOWS events above 30 dBz. Neither study suggests that one can reliably estimate total shear based on reflectivity.

One of the important issues addressed by the FLOWS project is the question of symmetry. One simple estimate of the degree of asymmetry existent in a microburst is the difference in peak radial velocity toward a radar compared to the peak velocity away from a radar. This difference can suggest the degree of asymmetry of the microburst. Based on this, Fig. 7 shows the number of symmetrical, nearly symmetrical, and unsymmetrical events in the Memphis data-set. The data source for this analysi is the Lincoln Lab radar logs; thus, the shear presented is along only one radial. These results suggest that 85% of the Memphis microbursts were symmetrical or nearly symmetrical. Dual-Doppler analyses will be used to confirm these initial impressions.

Figure 8 is a plot that depicts the relationship between radial shear and the distance across the maximum differential velocities. There is some correlation (r= -0.72), since the shear decreases as the distance increases. The highest velocities were usually associated with the smallest outflows. It is this type of event that is most likely to limit an aircraft's performance upon penetration.

Still another issue investigated was the type of weather systems responsible for microburst formation in the Memphis area. As shown in Table 2, a number of synoptic systems resulted in at least one event of the 102 detected. The most important were air-mass activity (53) and squall-lines (33). As far as forecasting purposes, over one-half of the air-mass and squall-line days resulted in downbursts.

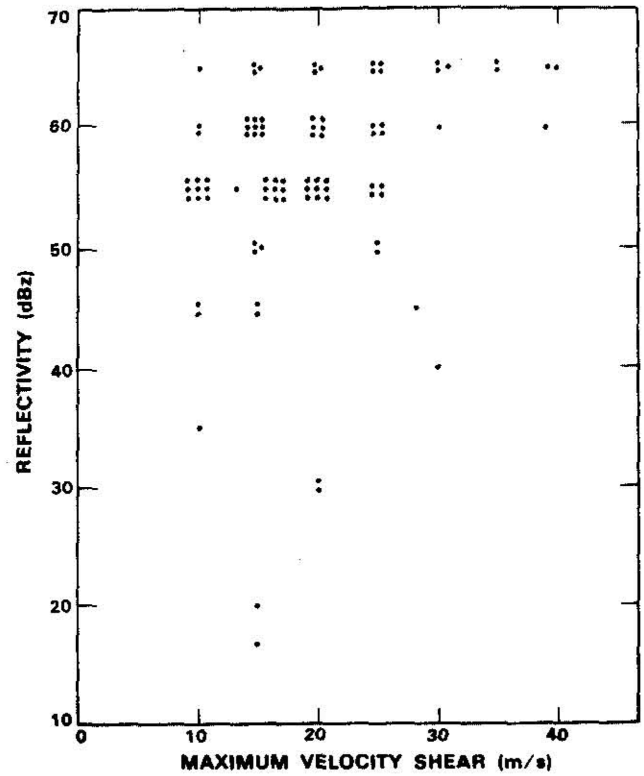

Fig. 6. Scatterdiagram of the maximum radar reflectivity factor associated with each maximum velocity shear value for FLOWS microbursts.

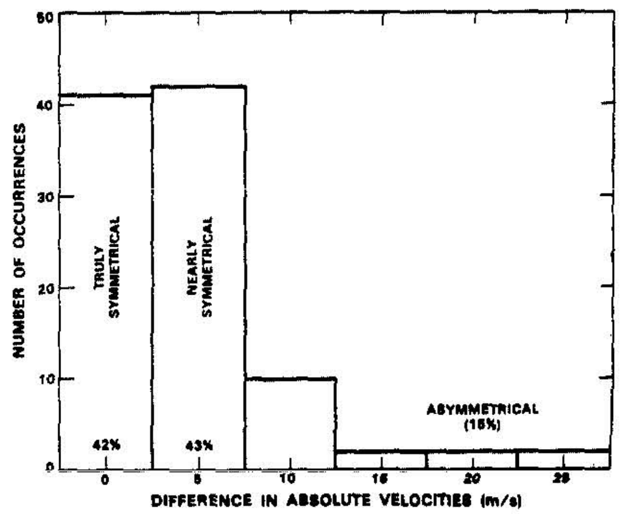

Fig. 7. Distribution of the number of microbursts that might be considered symmetric, nearly symmetric or asymmetric (based on the absolute difference in the maximum approaching and maximum receding velocities recorded in the radar logs).

There were only a few thunderstorm days without any events. Systems such as cold fronts, warm fronts, troughs, and upper-air disturbances were less likely to produce a microburst day.

4 SEASONAL HIGHLIGHTS

This section will summarize several case-studies that are currently under analysis. The "Hickory Ridge Microburst" on June 26th has received the most attention to date. We were able to scan the event