Some Aspects Of The Structure Of Extreme Convective Winds And Their Frequency In New South Wales

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1. Introduction

There is increasing recognition among wind engineers that standards derived from synoptic scale wind records may not be appropriate when considering extreme winds initiated by convective processes. It is only relatively recently that the meteorological community has begun to understand the range and complexity of such events. Their impact on aircraft has led to intense investigation, particularly in the United States where Doppler radar, anemometer arrays and instrumented aircraft have been used to study many events in detail.

Systematic surveying of damage tracks led Fujita to identify the so-called downburst phenomenon, a strong downdraft which induces an outburst of damaging winds on or near the ground. Fujita (1978) introduced the concepts of macroburst and microburst to distinguish events on the basis of the dimensional scale of damage paths.

The strength of the downdraft, and the accompanying outflow, may result from a combination of evaporative cooling and precipitation drag, but in some cases the latter is much less important. In the case of the microburst, a further distinction is made between 'wet' and 'dry' events, the latter occurring in the absence of measurable rainfall. In a dry microburst the downdraft may be initiated from weak, high-based precipitation which evaporates as it falls through relatively warm and dry air in the sub-cloud layer. Macrobursts may be more typically associated with the deep convection of thunderstorms. The combination of radial and advective components produces the characteristic fan shape of elements within the damage area. In each case the probability of extreme wind speed increases where there is a substantial contribution from the advective component of the wind.

It is increasingly evident that the problems identified in the United States and in some other parts of the world, notably Argentina, are prevalent in Australia. Structural failure of transmission towers in New South Wales resulting from the severe storms led Pacific Power to commission a report on the nature and frequency of such events in New South Wales. There is strong prima facie evidence suggesting that most, if not all, of the NSW failures occurred with thunderstorms.

In Section 2 of this paper some aspects of the spatial and temporal nature of such events are discussed, including the identification of problems relating to the lack of detailed observational data. In Section 3 the results of a more general analysis of thunderstorm related gusts in New South Wales are outlined.

2. Space and Time Scales of Microbursts

On the basis of a comprehensive survey of downburst activity in the US, Fujita developed a dimensional frequency analysis of downburst damage paths. (See Fig.1). This analysis provides valuable information on the overall scale of downburst events.

However in his analysis Fujita made no distinction between events, either on the basis of the physical processes involved or the gust structure.

A number of downburst events that have occurred in Australia in recent years have also been well documented, Callaghan (1988), ELCOM (1991), Gigliotti and Guymer (1993), Hanstrum and Van Burgel (1992) and others. Such investigations also provide important documentary evidence of storm scale. Two of these storms (Brisbane, 1985 and Mangalore, 1993) passed over anemometer sites allowing direct comparison of damage and recorded wind speed.

Fig. 2 shows an anemograph from the Brisbane event (Brisbane Airport). It shows a microburst, with peak wind speed near 50 m/s, embedded within a macroburst. This interpretation is supported by the damage path assessment which showed smaller areas of severe damage within a broader damage track.

Radar data available for the Brisbane storm showed that the maximum damage occurred in close proximity to the point of maximum reflectivity. Analyses of a Sydney storm which resulted in severe transmission line damage (ELCOM, 1991) and the Mangalore storm also suggest coincidence between the reflectivity centre and most extreme wind. Further investigation is required but the existing evidence suggests that any consideration of the structure of the most

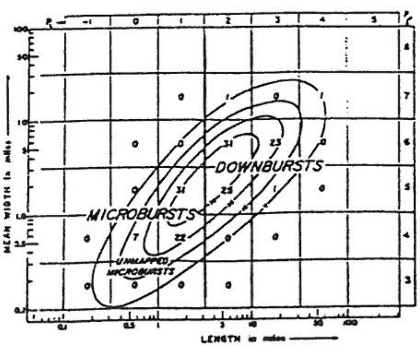

Figure 1. Horizontal dimensions of downbursts in the United states, after Fujita.

severe gusts should be concentrated on the dynamics of the outflow close to the point of downburst touchdown.

In their analysis of wind shear hazard at Sydney airport Spillane and Lourensz (1986) identified four event types and gave characteristic anemograph traces associated with each. They identified separate signatures for microbursts and convective outflows.

Fig. 3 shows such a microburst signature recorded at Mascot in November 1975 which occurred in the absence of thunderstorm activity.

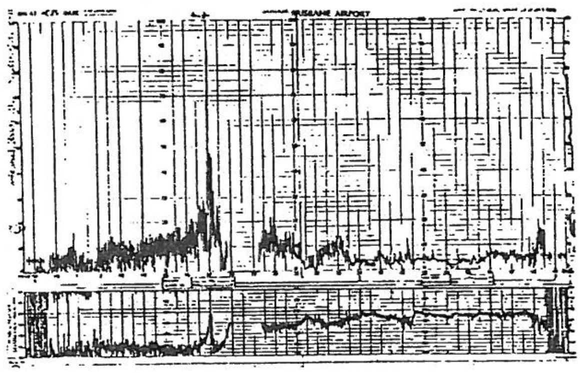

Figure 2. Anemograph recorded at Brisbane Airport in January 1985 showing microburst within a thunderstorm generated macroburst.

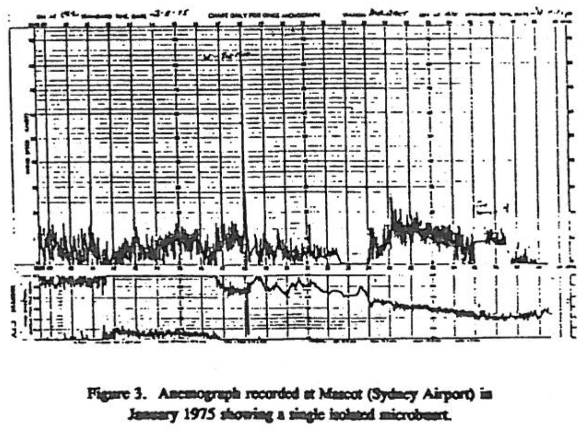

Figure 3. Anemograph recorded at Mascot (Sydney Airport) in January 1975 showing a single isolated microburst.

Although occurring in quite different environments there is at least a general similarity between the structure of the microburst signatures in the two anemographs. However even the duration of the events cannot be adequately quantified due to the limits in temporal resolution of the recording system. The latest generation of Automatic Weather Stations have the capacity to register wind data at one second intervals. Data collected at frequencies of this order would allow for significantly increased definition of the structure of such events.

Following the work of Spillane and Lourensz, work has begun to characterise all severe gusts (in excess of 48 knots) recorded on anemographs in New South Wales. The intention is to determine the relative occurrence frequency of single microbursts, convective outflows and embedded microbursts.

3. Analysis of Existing Records

An analysis of daily maxiumum wind gusts from Bureau of Meteorology sites in New South Wales was made as part of the Pacific Power study.

Given the importance of thunderstorms in the New South Wales failures, return periods were determined both for wind gusts of all types and for gusts apparently attributable to thunderstorms. The second category of events was determined on the basis of a thunderstorm being reported at the synoptic hour on either side of the maximum wind gust. This analysis was undertaken through computer analysis of Bureau wind gust and three hourly synoptic records.

The fitting process used (the method of sextiles, Jenkinson 1969) was improved by grouping data from similar geographic locations; the groupings providing longer data sets. To ensure observations from different sites (and winds from different directions at the one site) were compatible, each gust observation was reduced to an equivalent gust at a height of 10 m approaching over level open terrain (Terrain Category 2).

The return periods determined from the analysis of the grouped data are shown in Table 1. The return periods of the 35 m/s gust were, within the limits of estimated standard errors, consistent with one another, though the return period estimates for all gusts were generally greater than those derived from the Australian Standard AS1170.2. Their consistency tends to support the assumption of a uniform underlying gust population.

The return periods for higher gust speeds were found to be quite variable. They suggest that the probability of severe thunderstorms is greatest in the Sydney area though we can not be certain that this is not the result of sampling variations.

STATIONS	35 m/s	45m/s	55 m/s	65 m/s
Sydney Area				
AG	11	460	7900	116000
TS	32	470	7900	116000
Other Coast				
AG	14	1130	303000	-
TS	16	1430	200000000	
Canberra				
AG	25	1130	30000	620000
TS	43	1130	30000	620000
Cabramurra				
AG	29	1500	93000	5000000
TS	20000000			
Cobar				
AG	117	13000	80000000	-
TS	117	13000	80000000	-
Other Inland				
AG	39	4200	200000000	-
TS	43	4200	200000000	-
AS1170.2				
AG	7	190	5400	152000

Table 1. Estimates of gust return periods for station groups in New South Wales. Results for the 'Sydney area' combine observations from Mascot, Bankstown and Richmond and for 'Other Coast' Nowra, Williamtown and Coffs Harbour. ' Other Inland' include Moree, Tamworth and Wagga. Estimates based on AS1170.2 are included for comparison.

The results show the return periods are dominated by thunderstorm induced gusts at higher return periods and confirm the need to quantify differences between the structure of the thunderstorm gusts and those generated by broad scale synoptic systems.

4. References

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