NEW EXTREME WIND SPEED PREDICTIONS FOR FOUR CITIES

J.D. Holmes (Monash University and JDH Consulting)

Introduction

The design wind speeds in AS1170.2-1989 [1] are based on analyses by Dorman [2] and Melbourne (unpublished) carried out in the early nineteen-eighties. The 1989 edition of the Standard introduced a regional system of all-direction wind speeds for Australia. The largest and most populous region is Region A, with an ultimate limit state (5% exceedence risk in 50 years – approximately 1000-year return period) basic wind speed of 50 m/s, in the current standard. This paper presents a new analysis of extreme wind speeds for Adelaide, Melbourne, Perth and Sydney – the major cities in Region A. The results described here, and for many inland stations, have been used as a basis for specification of new design wind speeds for the draft Australian/New Zealand Standard [3].

Methodology

The methodology for the extreme value analyses differed slightly between the cities, but generally comprised the following steps :

- Daily gust data for days on which the maximum gust exceeded 20 m/s was obtained from the National Climate Centre of the Bureau of Meteorology
- For those days on which thunder was recorded, the original Dines anemometer or AWS charts were inspected to identify the signatures of thunderstorm downdrafts
- Data from multiple stations within a metropolitan area, if available, were composited
- Separate analyses were carried out for downburst gusts and the remainder, the latter being classified as synoptic gusts
- The synoptic data was corrected for exposure for sixteen directions, using correction factors derived at Monash University (unpublished). The downburst data was not corrected.
- The method of 'excesses over thresholds' described by Holmes and Moriarty (AWES5 and [4]), was used to separately analyse the downburst and synoptic winds for each city. (This is essentially a method of fitting the Generalized Extreme Value Distribution to data from all storms)
- If the data indicated positive shape factor (i.e a Type III extreme value distribution), then this value was used for the predictions. When a negative shape factor was indicated (one case only) a shape factor of 0 was used instead. (Negative shape factors produce unlimited wind speeds when the fitted distribution is extrapolated to high return periods [4]).
- A combined probability distribution for winds from either source was calculated for each city

By compositing data from several stations in Adelaide, Melbourne and Sydney, reduction in sampling errors could be obtained. In Perth, for synoptic winds, data from Perth Airport (Guildford) only were used; for the downburst gusts, some data from the Regional Office anemometer was also used. The years of records used for the combined analysis are listed in Table I, as are the maximum recorded values (uncorrected) for each city.

Results

The probability distributions for extreme wind speeds at the standard height of 10 metres, are shown in Figures 1 to 4, for the four cities. In each case, the distributions derived for downburst and synoptic winds are shown, together with the combined wind speed distribution.

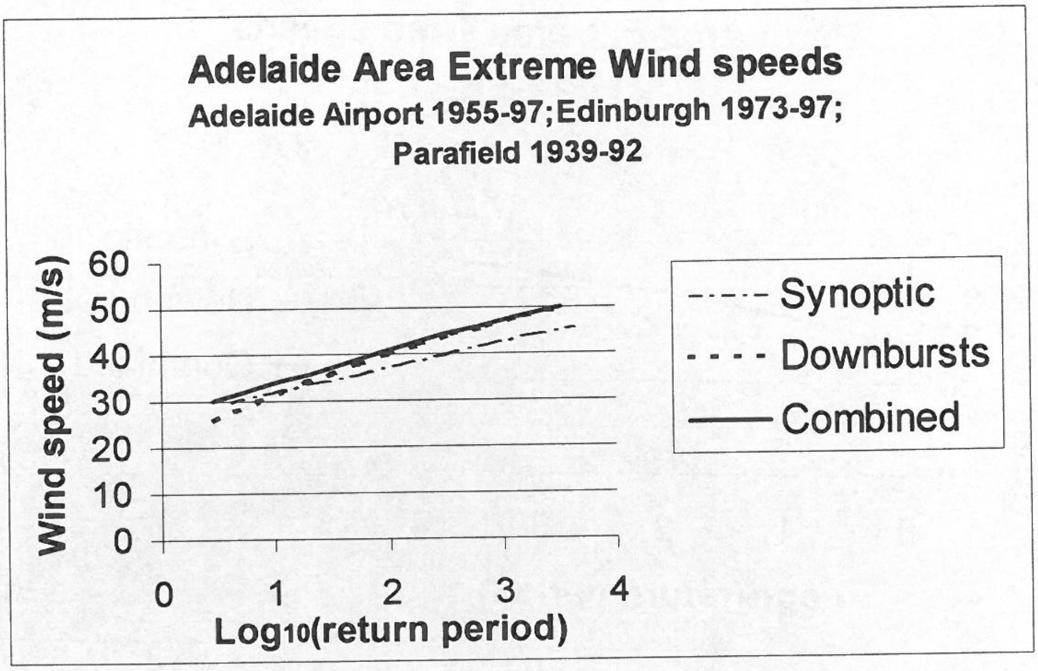

Figure 1. Extreme wind speed predictions for Adelaide

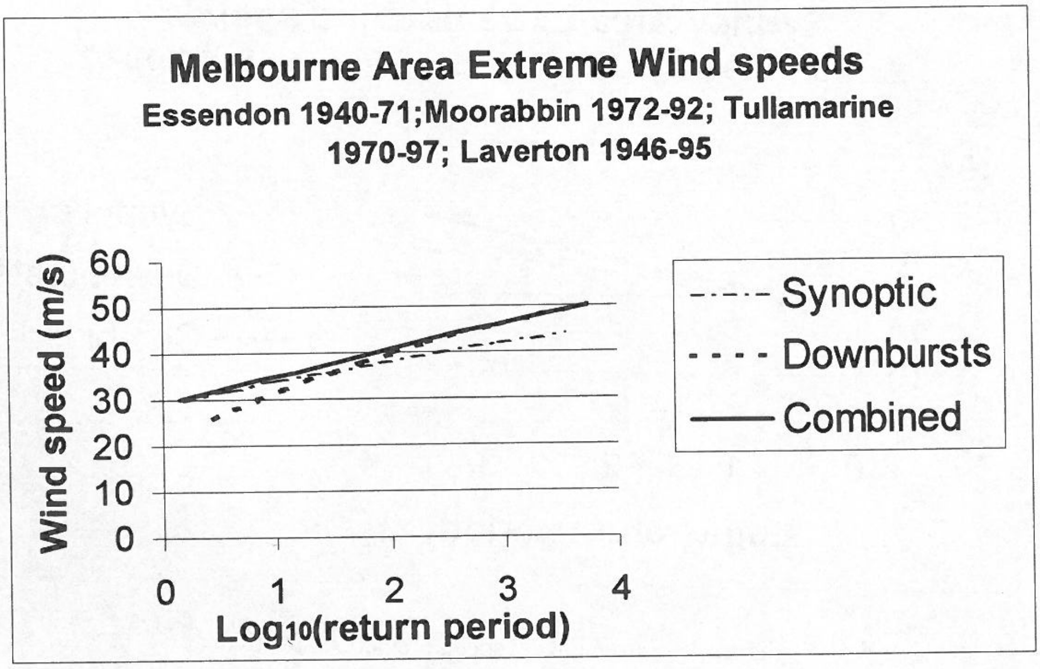

Figure 2. Extreme wind speed predictions for Melbourne

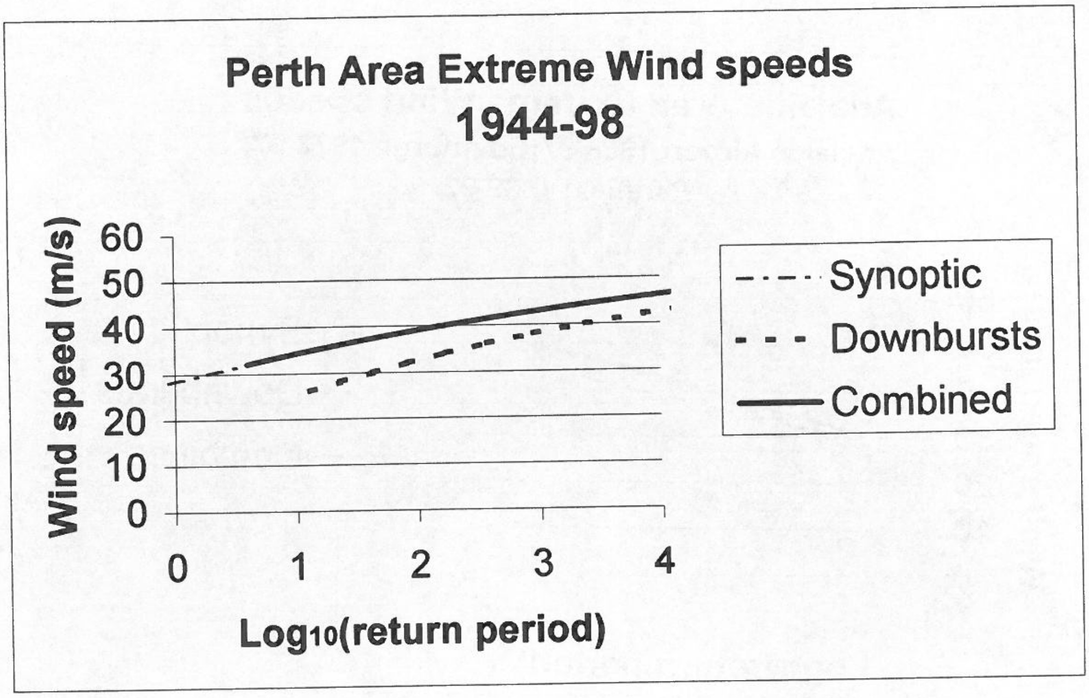

Figure 3. Extreme wind speed predictions for Perth

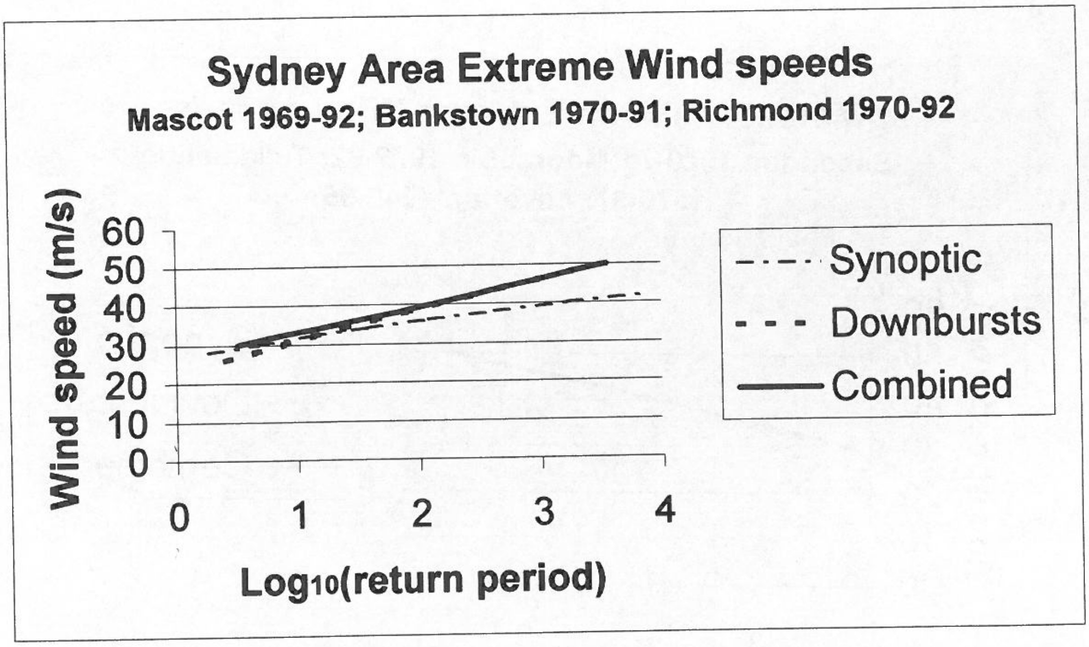

Figure 4. Extreme wind speed predictions for Sydney

The predictions for the three eastern cities (Adelaide, Melbourne and Sydney) are remarkably similar to each other – in all these cases, the dominant wind storm type is the downburst for return periods greater than about 20 years, despite the fact that these storms only generate about 10% of the daily maximum gusts above 20 m/s. Perth, however, is clearly dominated by synoptic winds. Apparently the cold fronts which are associated with most of the downbursts in the other cities, only develop as the weather systems move further east from Perth.

In Table 1 a summary of the predicted extremes from all windstorms is listed in comparison with the values currently proposed in DR99419 [3]. Perth, without a significant contribution from downbursts, has somewhat lower extremes at 500 and 1000 year return periods than the three other cities. The DR99419 values are slightly conservative with respect to the predictions, except for the Adelaide values of V_{500} and V_{1000}.

Table I. Summary of Predictions (m/s)

City	Years of record	Max gust	V_{50}	V_{500}	V_{1000}
Adelaide	91	42.2	38.7	45.3	47.2
Melbourne	126	42.7	38.9	44.7	46.3
Perth	54	34.5	37.7	41.9	43.0
Sydney	69	42.2	37.2	44.0	46.2
DR99419	-	-	**39.3**	**45**	**46.5**

Comments and Conclusions

An analysis of extreme wind speeds for the four major cities in Region A has been carried out making use of new historical data from the last fifteen years, and using new statistical techniques. The results indicate that thunderstorm downbursts are the dominant extreme wind type at 10 metres height for return periods of interest for ultimate limit states, in Adelaide, Melbourne and Sydney. Perth, however, is dominated by synoptic winds. The value of 45 m/s specified as the basic wind speed for a 500-year return period in the draft DR99419 is a reasonable value for these major centres.

Although more research on velocity profiles with height and topographic effects in downburst winds, is required, current knowledge would indicate that downburst winds are probably dominant for structures up to 50 metres in height in the Adelaide, Melbourne and Sydney regions. For structures (such as communication towers) on steep hills or escarpments, or greater than 100 metres in height, synoptic (boundary-layer) winds may be dominant, due to the greater amplification of the wind gusts due to height and topography.

References

1. Standards Australia. SAA Loading Code. Part 2 : Wind loads. AS1170.2-1989

2. Dorman, C.M.L. Extreme wind gusts in Australia, excluding tropical cyclones. *Civil Engineering Transactions, Institution of Engineers, Australia*, Vol. CE25, pp96-106, 1983.

3. Standards Australia/Standards New Zealand. Structural design – general requirements and design actions. Part 2 : Wind actions. DR99419. September 1999.

4. Holmes, J.D. and Moriarty, W.W. Application of the generalized Pareto distribution to extreme value analysis in wind engineering. *Journal of Wind Engineering and Industrial Aerodynamics*, Vol. 83, pp1-10, 1999.