The Temporal and Spatial Distribution of Severe Wind in South Australia

INTRODUCTION

The main purpose of this study was to assess the temporal and spatial distribution of severe winds in South Australia (SA). This enabled an objective assessment of the frequency of occurrence of damaging wind within specific regions and at point locations. Also of interest was the peak intensity of each event, which was specified by the maximum associated wind speed.

DEFINITION of SEVERE WIND

In line with internationally accepted standards of wind intensity, the Bureau of Meteorology in Australia defines severe wind as either :

- A measured wind gust (10 metres above ground level for a duration of less than 1 minute) equal to or greater than *90 kilometres per hour (49 knots).*
- A measured average wind speed (10 metres above ground level for a duration of ten minutes or more) of equal to or greater than *65 kilometres per hour (34 knots).*
- Wind which causes significant damage to structures or vegetation.

The measured wind thresholds are widely accepted as closely defining the lower bound for damage production, whether it be to vegetation or man made structures. Experience in South Australia has verified that very little damage occurs at wind speed below these thresholds, but as wind speed increases above the thresholds, damage severity increases exponentially.

DATABASE

Since the establishment in 1987 of a Severe Weather group at the South Australian Regional Office of the Bureau of Meteorology, a comprehensive database of severe wind events has been maintained. Sporadic data from events prior to 1987 has been archived but it is not a complete record. For this reason, only data from 1987 onward has been utilised for this study.

Events were included in the database if they complied with the definition of severe wind (as above). All measured events were by Bureau operated weather stations. These were unequivocal. Events where measurement was not recorded were included in the database only after damage had been verified either by inspection (by one or more Bureau officers) or by a source known to be reliable. If there was some doubt, then the event was not included.

DATA ANALYSIS

The data was divided into two types of severe wind event :

- Convective Severe Wind (CSW)
- Non-Convective Severe Wind (NCSW)

This was done because the meteorological environments which lead to the two types are quite different. A CSW event occurs almost exclusively in association with one or more convective clouds (cumulus or cumulonimbus) in the form of a "downburst" or "tornado". Because CSW events are on the scale of clouds, the majority affect a very small area, usually of the order of a hundred square kilometres or less. This is particularly the case with tornadoes. Occasionally a large cluster of convective clouds can lead to a wide area being affected by a large scale downburst, but this is not common. Because individual convective clouds have a maximum life span of only a few hours, CSW typically occur over a short time interval, often only a few minutes at any one point.

A NCSW event is usually associated with an intense low pressure system which is of much larger scale than that of convective clouds - often of the order of thousands of square kilometres. In some cases NCSW can occur over wide areas, but in other cases severe wind is very localised. By definition, convective clouds are not associated with these events. Often however, clouds of the non-convective (stratiform) variety accompany the event, and occasionally NCSW events occur with clear skies.

Temporal Distribution - Annual

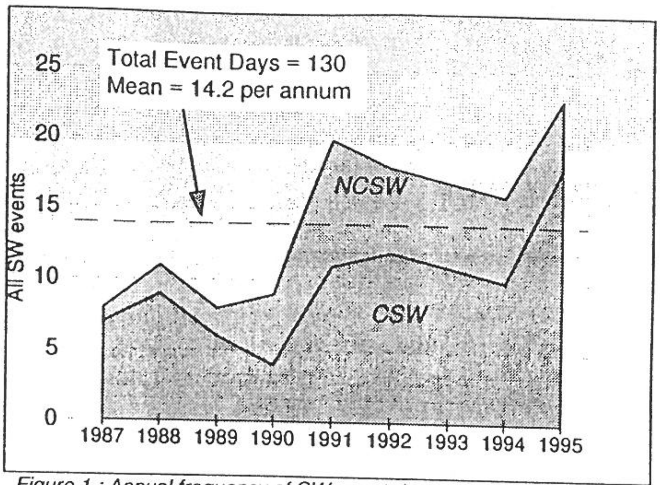

Figure 1 : Annual frequency of SW event days. An event day occurs when one or more SW events is recorded.

Figure 1 shows the state-wide annual frequency distribution of Severe Wind (SW) event days in South Australia since 1987. Event days were analysed rather than discrete events because it provided a better indication of the relative temporal frequency of the two types.

There were approximately twice as many CSW event days (88) compared to NCSW (42). A total of 130 event days over 9 years were recorded at an average of about 14 per year, or slightly more than one a month. The apparent increase in annual frequency since 1990 may in part be explained by an increase in the density of the Bureau's automatic weather station network during the period, and the establishment of a network of volunteer severe weather observers.

Temporal Distribution - Monthly

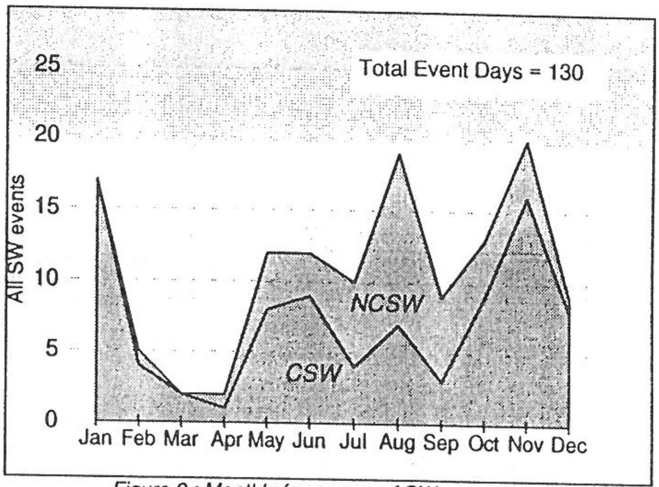

Figure 2 : Monthly frequency of SW event days.

The relative monthly frequency of SW event days is shown in Figure 2. Clearly there was a preference for CSW during the period from October to January, with a marked reduction in occurrence from February to April. In contrast, NCSW event days were most frequent from July to September. When combined, this led to two main peaks, one in the late spring to mid summer, and the other in late winter. The late summer to early autumn period was clearly the period when SW was least likely.

Spatial Distribution

The state-wide spatial distribution of CSW and NCSW can be compared in Figures 3a and 3b. Most CSW event days (Figure 3a) occurred within the Adelaide and Mount Lofty Ranges forecast district (23). The lowest frequency was on Kangaroo Island (1) and in the Upper Southeast (2). A significant proportion of CSW events occurred in northern parts of the state.

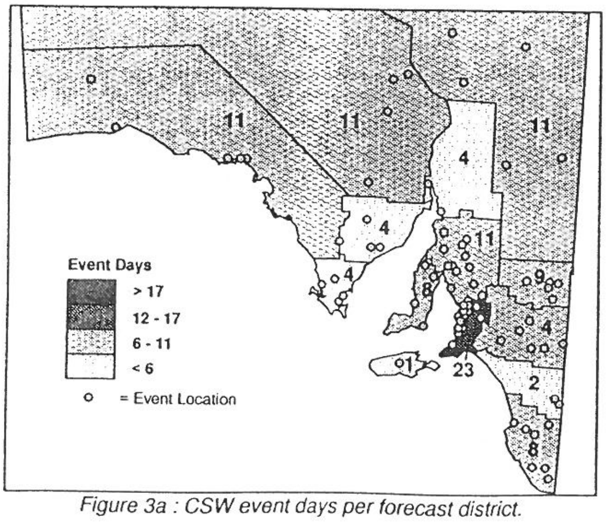

Figure 3a : CSW event days per forecast district.

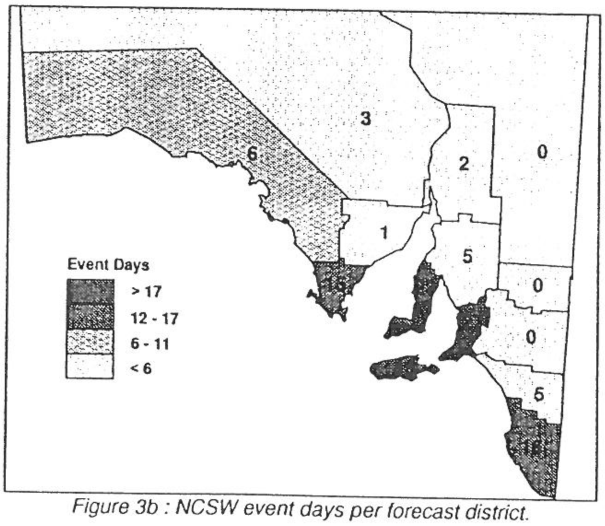

Figure 3b : NCSW event days per forecast district.

In contrast, NCSW events (Figure 3b) clearly favour southern coastal areas of SA. Again most recorded event days (27) were within the Adelaide and Mount Lofty Ranges district. However, spatial frequency was also high on Yorke Peninsula (23), on Kangaroo Island (18), in the Lower Southeast and on Lower Eyre Peninsula.

The SW types are combined in Figure 3c, showing that the Adelaide and Mount Lofty Ranges district was the most regularly affected (50), followed by Yorke Peninsula (31) and the Lower Southeast (24). The districts least often affected by SW events were Eastern Eyre Peninsula (5) and the Murraylands (4).

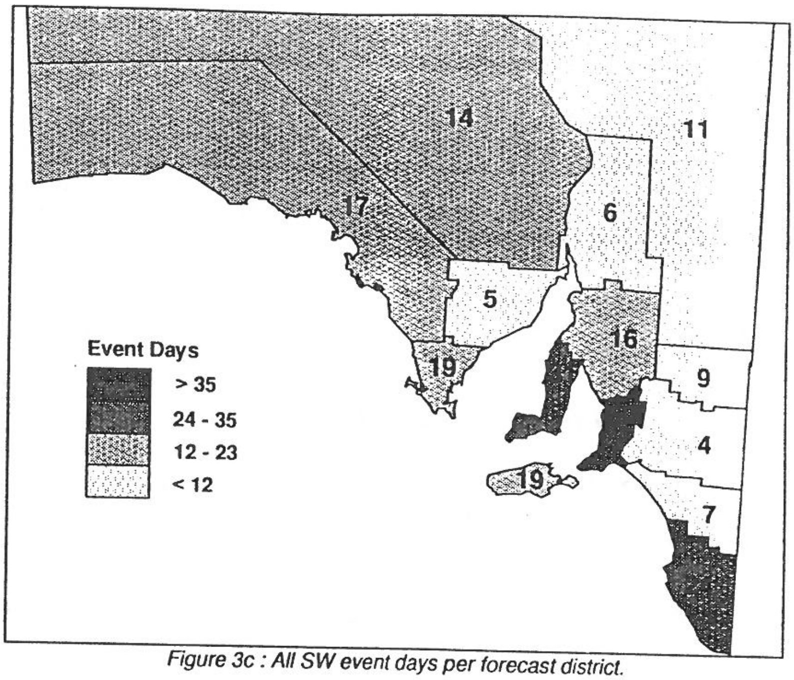

Figure 3c : All SW event days per forecast district.

It is important to bear in mind here the effect of observational density within the respective districts. The Adelaide and Mount Lofty Ranges district has the densest network of Bureau observations, with 7 automatic weather stations. It is also the most populated area in the state. This means that there is a relatively low probability of a SW event occurring without it being detected. Conversely, in districts like Eastern Eyre Peninsula, the Murraylands and the Upper Southeast which are sparsely populated and have a low density observational networks (there are *no* automatic weather stations in the Murraylands and Upper Southeast, and only one on Eastern Eyre Peninsula), the probability of an event not being detected is relatively high, particularly if it is of small scale.

The results presented here are therefore not necessarily a representation of the true spatial distribution. To more accurately gauge the real spatial distribution, the data needs to be normalised to an observational density which is the same for each district. Such analysis is beyond the scope of this study but it is intended to use this procedure in the future.

Frequency at Point Locations

To assess the frequency with which SW events affect individual localities, SW data for the four SA meteorological offices were analysed. Continuous observations are maintained at these offices, so that every SW event which affects the office location is recorded.

Unfortunately, data relevant to the location of NCSW events at individual offices was available for only the latter five years of the database (from 1991). Nine year data (from 1987) was available for CSW events. All events within a 10 kilometres radius of the meteorological office were included. All the data were normalised to a 10 year frequency. Figure 4 and Table 1 show the results for each station, with the table providing a break-

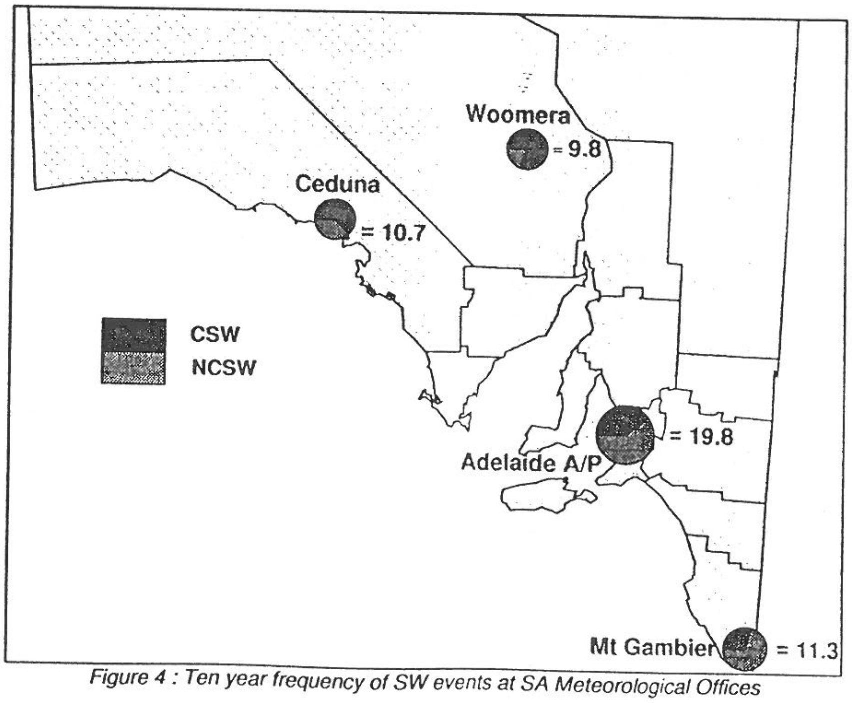

Figure 4 : Ten year frequency of SW events at SA Meteorological Offices

	CSW	NCSW	All SW
Ceduna	6.7	4.0	10.7
Woomera	7.8	2.0	9.8
Adelaide	7.8	12.0	19.8
Mt Gambier	3.3	8.0	11.3

Table 1 : Ten year frequency of SW events at SA Meteorological Offices

down of the events into the two categories.

The dominance of CSW at Woomera is not surprising, given the analysis of district events (Figure 3). There was also a preference, though not as marked, for CSW at Ceduna. The reverse was the case at Mount Gambier where NCSW were more common. In Adelaide NCSW were more frequent than CSW but to a lesser degree than at Mount Gambier.

The analysis indicates that at Woomera, Ceduna and Mount Gambier, the temporal frequency all SW events was very close to one per year. In contrast, for Adelaide the frequency was almost double that for the other offices, at nearly two events every year.

Distribution of Maximum Wind Speed

For each SW event, the maximum wind (gust) speed was either measured or estimated. Of the total of 160 events, 81 were measured by Bureau recording equipment. For the remainder, maximum wind speed was estimated using a scale based on damage severity (Fujita, 1981). Table 2 summarises the Fujita scale.

Scale	Wind Speed (km/h)	Expected Damage
F0	90-117	Light Damage
F1	118-180	Moderate Damage
F2	181-253	Considerable Damage
F3	254-332	Severe Damage
F4	333-418	Devastating Damage
F5	419-512	Incredible Damage

Table 2 : Fujita scale for damaging wind

The frequency distribution of measured wind speeds within given ranges is shown in Figure 5a. The profiles of both CSW and NCSW are very similar. Almost 60% of events had a maximum wind speed of less than 100 kilometres per hour, and only about 3% of events exceeded 120 kilometres per hour. The strongest measured wind gust in the database was a CSW of 159 kilometres per hour at Ceduna.

Figure 5b shows the frequency distribution of all SW events in the database, including the 79 events where the maximum wind speed was estimated. An exponential fit was applied to give a more realistic representation. Since every NCSW event was measured, the distribution for NCSW events is the same as in Figure 5a,. In comparison to the distribution of measured CSW events the distribution for estimated CSW is weighted more heavily toward higher wind speeds. This was caused by the contribution of tornadoes to the data. Tornadoes affect only very small areas, but often produce damage of much greater severity than that produced by downbursts. There were 31 (27%) tornadic events in the CSW database but not one direct measurement of tornadic wind speed. All measured CSW events were downbursts.

There was no event rated as F3 intensity or greater. There were however, several (13) events of F2 intensity, all of which were believed to be tornadic, with wind speeds in excess of 181 kilometres per hour.

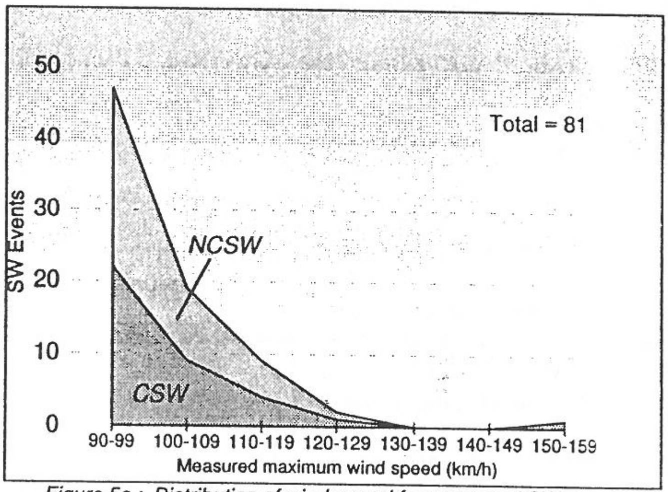

Figure 5a :. Distribution of wind speed for measured SW events

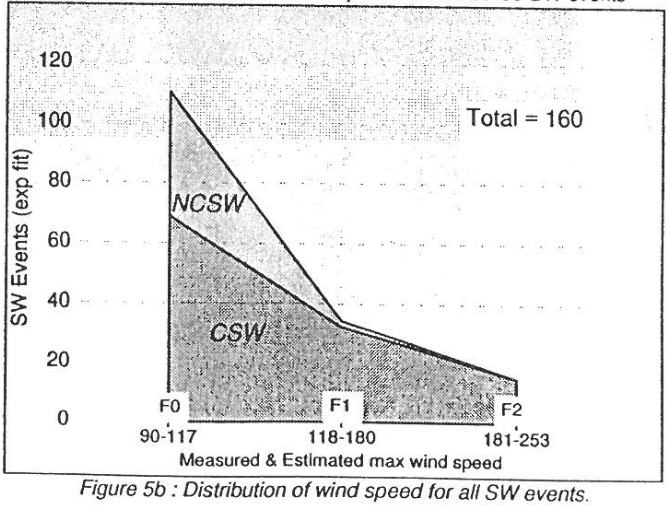

Figure 5b : Distribution of wind speed for all SW events.

Reference

Fujita, T., 1981: Tornadoes and downbursts in the context of generalised planetary scales. *J. Atmos. Sci., 38, 1511-1534.*