EVENING WIND SURGES IN SOUTH AUSTRALIA

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1. INTRODUCTION

Some effects of diurnal heating over the land mass of south-eastern Australia on the behaviour of summer cool changes have been studied by Berson, Reid and Troup (Manuscript, 1956). Further observational material gathered during the course of that study is presented here, giving evidence of surge-like wind variations which bear some resemblance to the deeply penetrating sea breezes noted by Clarke (1956).

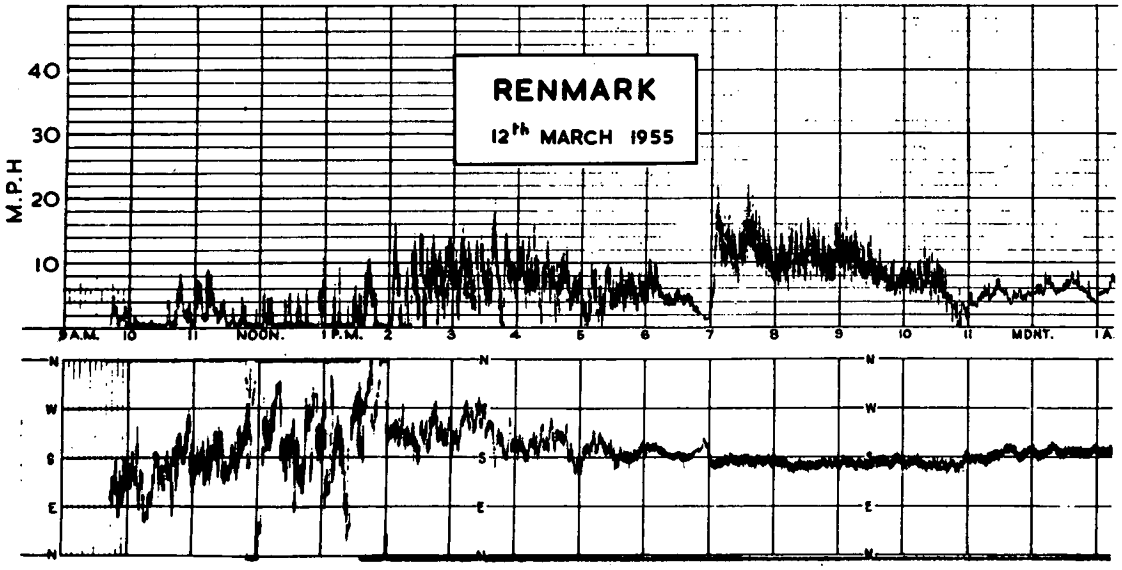


Fig. 1
Renmark anemograph trace showing a typical wind surge

2. EVENING WIND SURGES AT RENMARK

Inspection of the Dines pressure tube anemometer records made at Renmark showed that the expected nocturnal lulling of the wind is often interrupted during the evening by a sudden gust, usually from a southerly direction, and the wind until late in the night may be as strong or stronger than during the day.

Fig. 1 shows the anemograph trace for the 12th March 1955. During the day the large oscillations up to 1400 hours are typical of strong convection in a light wind; when the wind speed increased at 1400 hours the direction trace became noticeably steadier, but the oscillatory trace indicates that convection continued until about 1815 hours. A period of steadier flow then followed until 1845 hours, when the wind commenced to decrease and veer from S to SSW. At 1900 hours the wind increased rapidly to become SSE 15 mph, with a maximum gust of 25 mph. The flow then slowly decreased, the speed falling sharply at 2240 hours, but the renewal of the southerly at 2255 hours probably marks the end of the surge.

The occurrence of several such clearly defined surges led to the recognition of the phenomenon, and a systematic search for all such cases was then made, records for three summers being available. The sudden increase of wind speed was common to nearly all cases, but the change in character of the direction trace from a thin erratic line to a broad steady trace was valuable confirmatory evidence. The speed and direction changes usually occurred simultaneously, but when winds were light the direction trace sometimes showed an earlier onset than was indicated by the speed trace, due to the failure of the instrument to record very light winds. The sharp threshold of this type of instrument accentuates the suddenness of those gusts which follow a period of light wind. The mean winds before and after the gust were averaged over periods of about half an hour for the purposes of the statistical analysis, and the vector change of wind for each occurrence was obtained graphically; the time of onset and the duration of the surge were also noted.

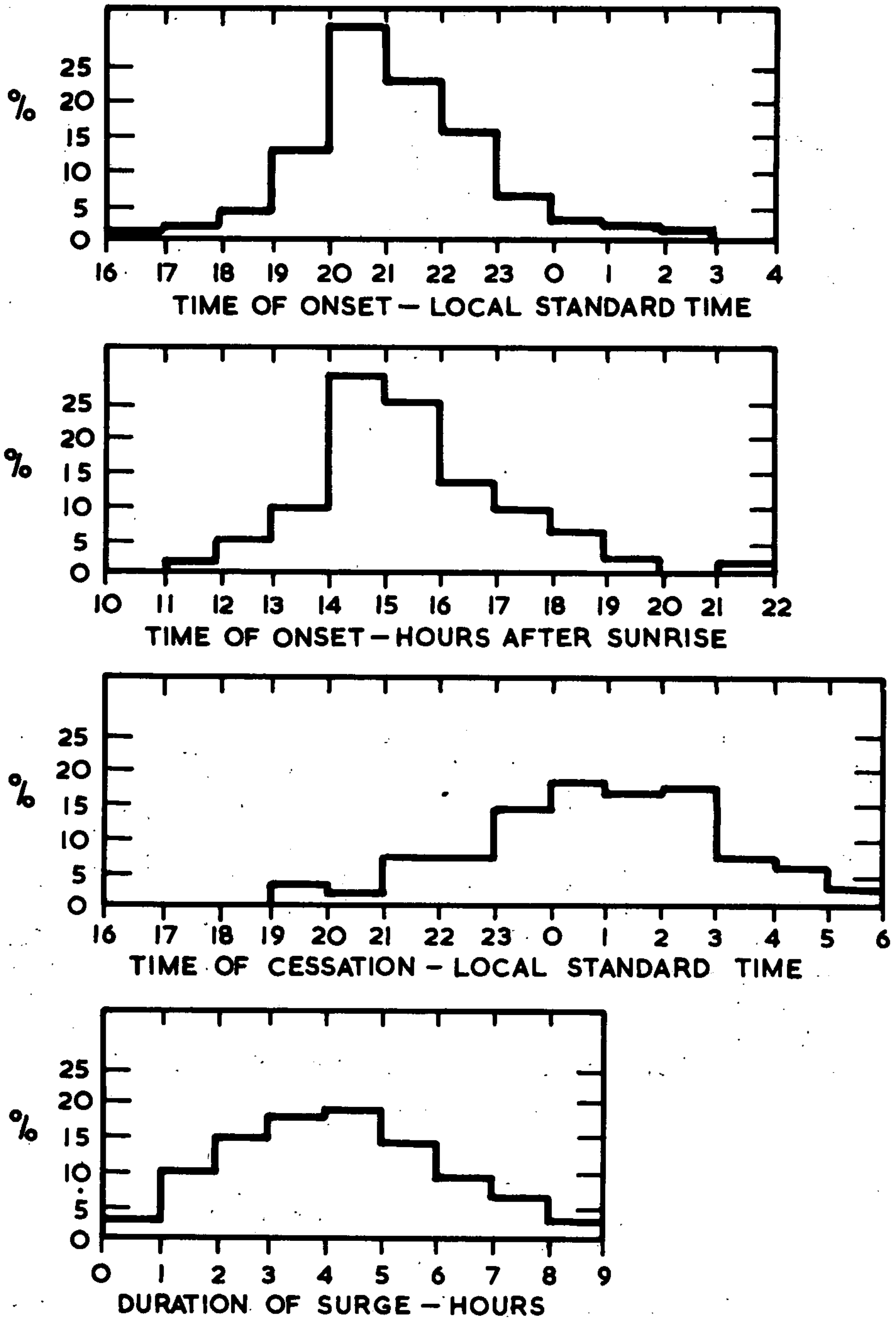
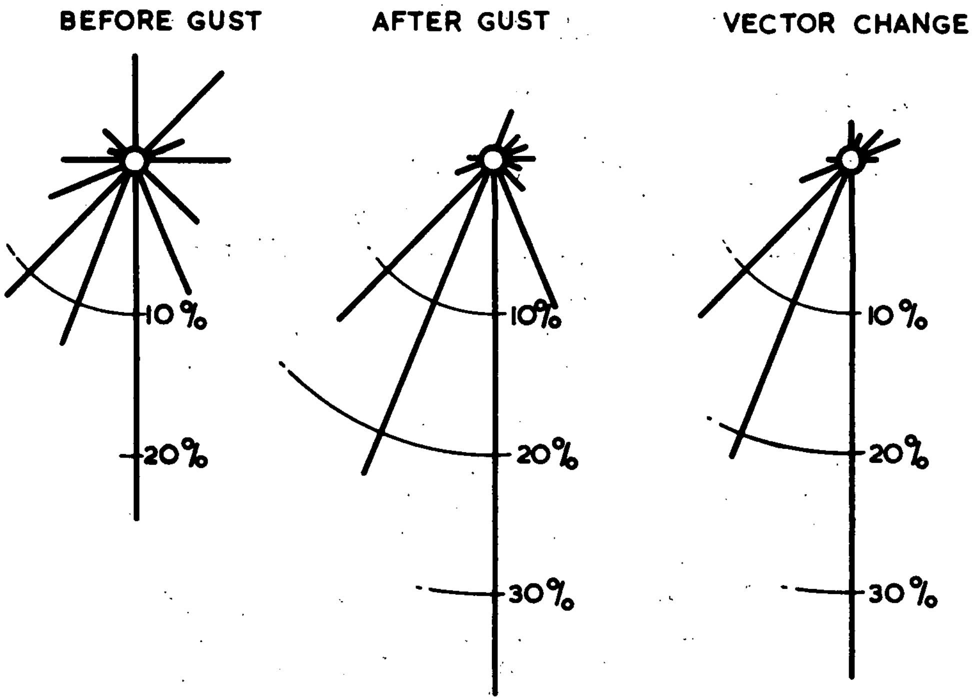
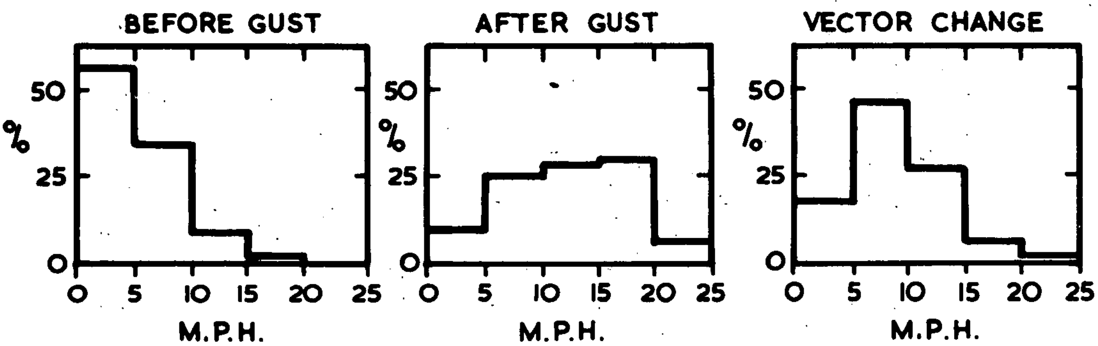


Fig. 2: Percentage frequencies of occurrence of onset and cessation at stated times, and of duration of wind surges at Renmark.



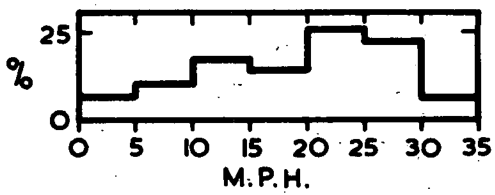
BEFORE GUST AFTER GUST VECTOR CHANGE

PERCENTAGE FREQUENCIES OF WINDS FROM EACH DIRECTION



BEFORE GUST AFTER GUST VECTOR CHANGE

PERCENTAGE FREQUENCIES OF WIND SPEEDS IN 5 M.P.H RANGES



PERCENTAGE FREQUENCIES OF MAXIMUM GUST SPEEDS

Fig. 3: Wind direction roses and speed frequency distributions before and after the onset of Renmark wind surges.

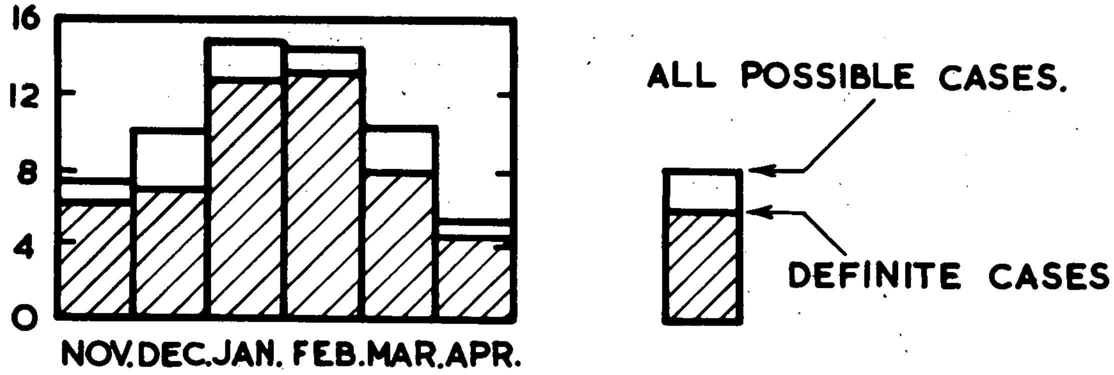


Fig. 4: Average number of surges per month at Renmark.

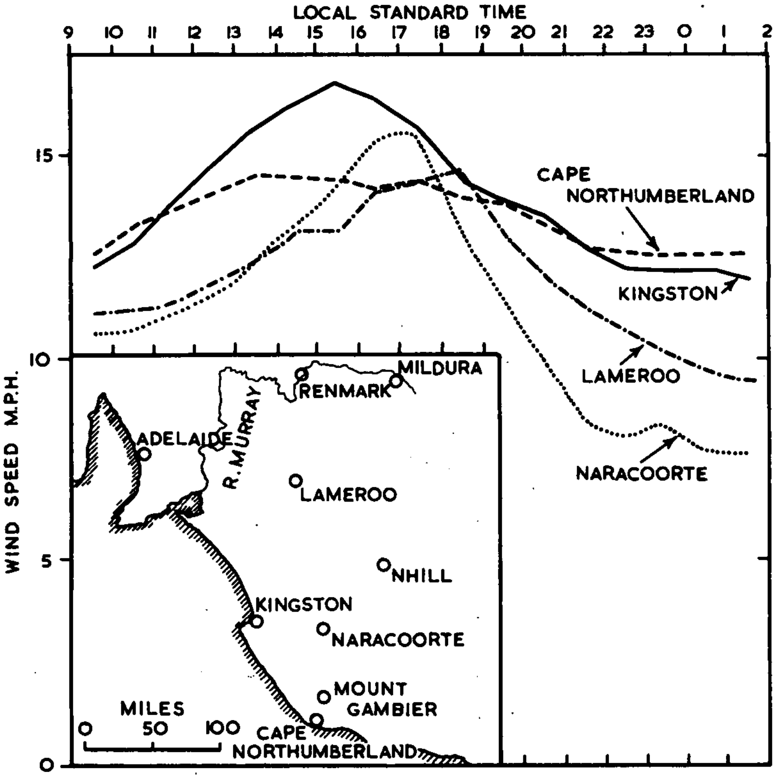


Fig. 5: Mean hourly wind speeds for stations in South Australia, January and February 1956. Inset map shows location of stations.

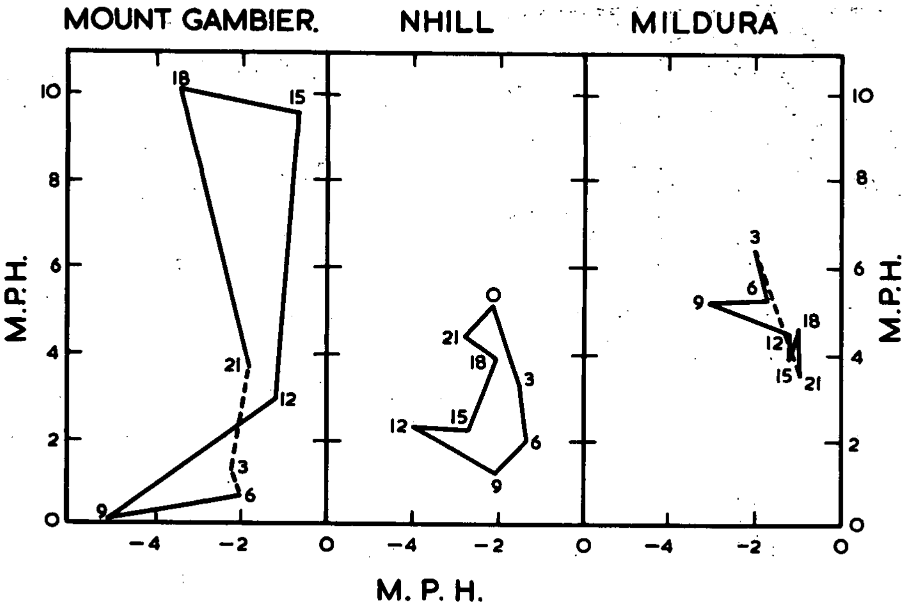


Fig.6: Variation of vector mean wind during the day in fine weather. Winds blow from the origin to the points plotted at different times.

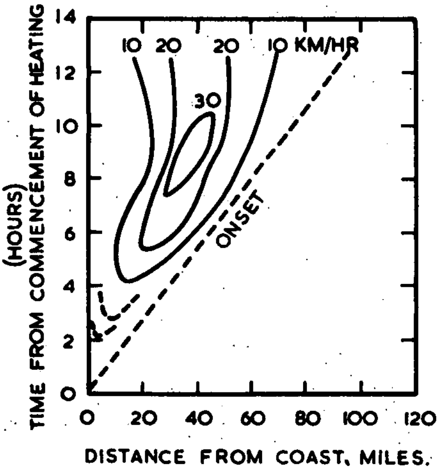


Fig. 7: Magnitude of component of sea breeze blowing parallel to the coast as a function of time and distance inland.

The frequency histogram of the times of onset, Fig. 2, is sharply peaked, over half the gusts occurring between 2000 and 2200 hours. A slight reduction in the spread of the distribution is effected by relating the time of onset to the heating cycle rather than to local time, using the time elapsed from sunrise. The durations of the surges show a much broader peak, having a maximum at 4-5 hours. The duration was sometimes difficult to determine, particularly on those occasions when the surge was superimposed on a moderate southerly flow. The duration bears only a slight relation to the strength of the maximum gust, but does increase with increasing magnitude of the vector change of mean wind. The surges which set in late were not long lasting; those which lasted longest started about 1900-2000 hours. Combination of the time of onset and the duration gives the frequency distribution of the times of cessation, which has a flat peak between 2300 and 0300 hours.

The wind direction both before and after the gust is predominantly from the south, the vector mean winds being 186° 2.8 mph and 190° 9.5 mph respectively, the mean vector change being 192° 6.7 mph. The frequency roses of Fig. 3 show the preponderance of winds with a southerly component, and the histograms show the speed distributions.

The frequency of occurrence per month, corrected for periods of missing record, is shown in Fig. 4. There is a maximum in January and February, when, including some borderline cases which have not been used in the main analysis, a surge is likely to occur once every two days on the average.

3. HOURLY RUN OF WIND MEASUREMENT IN SOUTH AUSTRALIA

Run of wind measurements are available for Lameroo, Naracoorte, Kingston and Cape Northumberland for January and February 1956, and the mean hourly speeds are shown in Fig. 5. Cape Northumberland, in the most maritime position shows little variation during the day, having a broad maximum about 1530 hours. Kingston, on an almost straight coastline, has a more pronounced peak at the same time. At Naracoorte, 50 miles from the coast, the peak occurs about 1700 hours, and at Lameroo, 80 miles from the coast, at 1830 hours.

4. DAILY VARIATION OF WIND IN FINE WEATHER

Fine is used here to mean little or no cloud, hence strong insolation to favour sea breezes. The vector mean winds for about thirty summer days with cloudiness less than 3/8 at any time of the day at Mildura, Nhill and Mt. Gambier are shown in Fig. 6. At Mt. Gambier the southerly component is largest between 1500 and 1800; at Nhill the amplitude of the oscillation is much less, and the maximum occurs between 2100 and 0001 hours; and at Mildura the amplitude is still less, the maximum probably occurring after 0300 hours.

5. CONCLUSION

The evidence from these diverse sources is in agreement with a wind surge lasting for several hours at any place being initiated in coastal regions and being propagated inland, eliminating the possibility of katabatic winds or effects associated with the River Murray at Renmark.

The records from a weekly thermograph at Berri, some 15 miles from Renmark gave an indication of a rapid temperature rise on some occasions, as had been found when the inversion layer is disturbed by the passage of a cool change; the time scale of a weekly chart is too contracted for a detailed analysis of temperature to be made. An inspection of the barograph records from Renmark for a period showed no pressure jumps associated with the gusts; however, the barograph was not of a sensitive type. A negative result was also obtained when like surges were sought in the anemograms from Deniliquin and Broken Hill for some months of record.

In the sea breeze model derived theoretically by Pearce (1955), the wind component parallel to the sea breeze front is small in the early stages of sea breeze development, but is large 8-12 hours after the commencement of heating, and moves inland at about half the speed found here. Fig. 7 shows how this component at the surface changes with time at different distances from the coast, values in km/hr having been read from Fig. 10 of Pearce's paper. In the case of a SW coast, as is approximately the case here, this component would be directed from the SE.

Taking the change of wind with time at any particular distance from the coast up to about 70 km, it can be seen that this component increases to a maximum and then decreases; that the time of maximum is later with increasing distance from the coast; and that it reaches a maximum development 50-70 km inland.

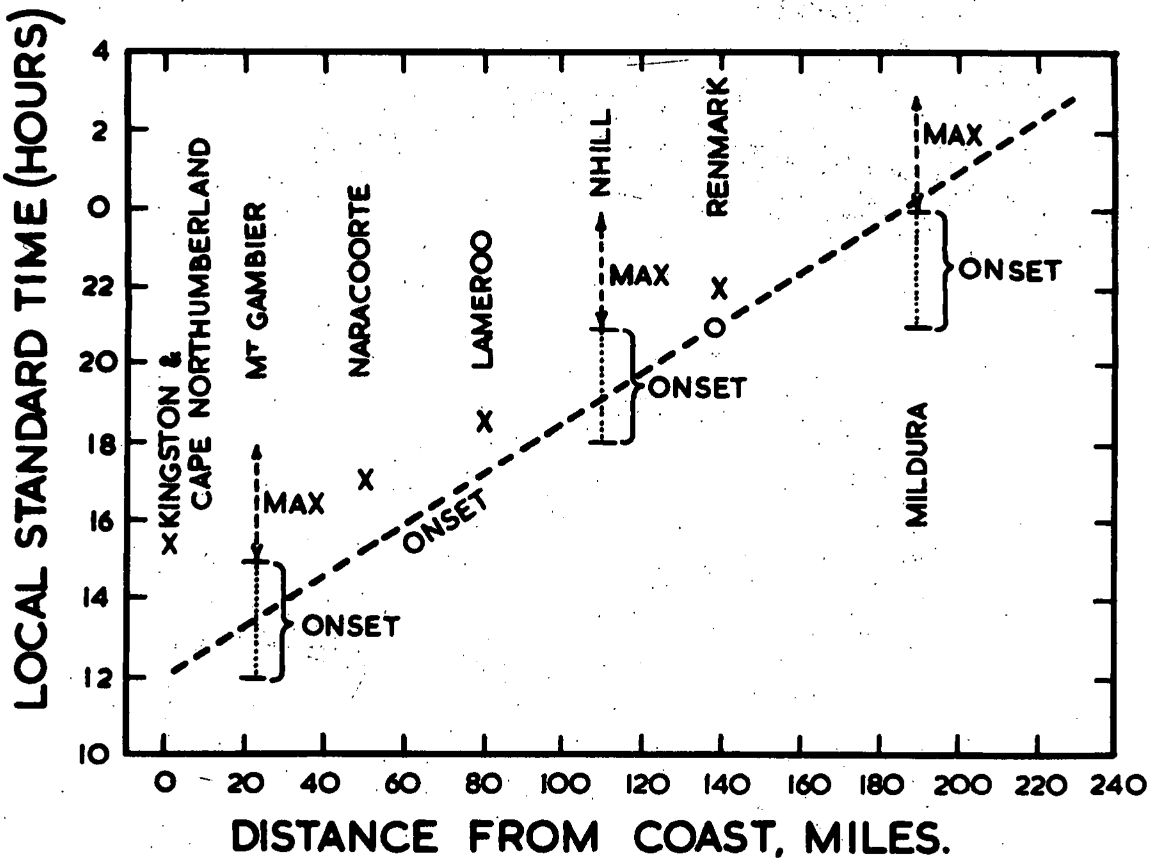


Fig. 8
Wind maxima plotted against distance from coast and time
X - Wind maximum. O - Average time of onset.

Fig. 8 shows on a similar diagram the times of onset and maxima deduced above. The straight lines which have been drawn on these diagrams to give the time of onset give a speed of 16 mph in South Australia compared to 8 mph for the theoretical model. As the latter was computed using typical English values, the speed and depth of penetration would be larger if allowance were made for the lower latitude and stronger insolation applicable to South Australia, and there appears to be reasonable accordance between the model and the observations.

This wind surge may be of only small economic importance, but it is helpful for forecasters to be aware that it can occur with such frequency and intensity. Instances which come to mind are the laying of flare paths for night flying, fire fighting, the siting of industrial plants which produce unpleasant odours and, last but not least, synoptic analysis. The observer in the field is in the best position to establish the climatology of such local effects, in much the same way as did the shepherd of old.

6. ACKNOWLEDGEMENTS

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