THE COASTAL WIND FIELD OF THE SOUTHERN CAPE

by

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ABSTRACT

The coastal region of the South Cape is presented as a typical semi-developed coastal zone with a limited environmental dataset. The author places himself in the position of a coastal engineer requiring wind data for design purposes. The various sources of wind measurement are discussed. Time series are presented depicting responses at different sites to the same large-scale synoptic situation. Spatial variations, both across the coastal boundary and in the offshore region are emphasized. These variations are brought to the attention of those engineers who may have to extrapolate wind conditions to their site of interest.

1 INTRODUCTION

The Cape south coast extends from Cape Agulhas to Cape Padrone at the eastern extremity of Algoa Bay (Figure 1). The continental shelf widens considerably in this region to form the Agulhas Bank which has been chosen as the site of a multidisciplinary oceanographic research project. As part of the meteorological program for the project, existing sources of wind data were fully explored. They include:

(i) Long-term wind data from weather offices.
(ii) Synoptic reports from ships of opportunity.
(iii) Wind from offshore drilling platforms.
(iv) Estimated wind data from lighthouses.

An additional source was created in February 1982, when three automatic weather stations were erected at suitable coastal sites. A fourth station was periodically mounted on the *R V Meiring Naudê* and this provided invaluable offshore data. Figure 1 shows the distribution of the various sources of wind data along the coast.

The various types of wind observations are discussed in terms of their accuracy, representativeness and distribution. Justification for such a study, from a coastal engineering point of view, comes from the fact that a significant proportion of the wave energy on this coast is generated by the high-frequency, locally generated component.

2 WIND OBSERVATIONS AT FULLY FLEDGED WEATHER OFFICES

There are two weather offices in the study area, one at H F Verwoerd Airport, Port Elizabeth, and the other at George. Both have been

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National Research Institute for Oceanology, Council for Scientific and Industrial Research, Stellenbosch, Republic of South Africa.

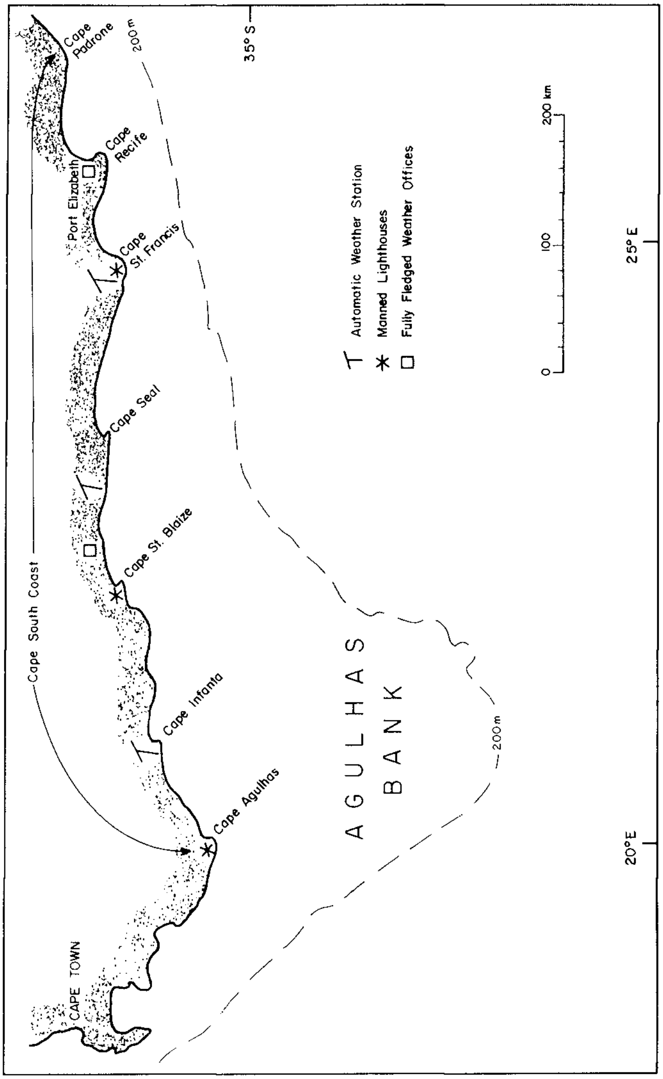


FIGURE 1 : LOCATION OF WIND RECORDING STATIONS

recording hourly wind speed since 1951, using Dines pressure tube anemometers.

H F Verwoerd Airport (see inset Figure 2), is located 3 km from the coast with the anemometer at a height of 60 m a.s.l. The general terrain surrounding the airport is flat with no marked topographical features. Yet it can be shown that data collected here are not representative of coastal conditions.

During the period 1 to 3 September 1978, a series of intense low pressure systems resulted in high seas on the Agulhas Bank. In Figure 2 hourly wind data from H F Verwoerd Airport are compared with those from the oil rig Sedco-K, roughly 40 km to the south (See Section 5 for details of wind reduction to standard height).

It is evident that there was initially no coupling between air movement at the airport and that offshore. However, this situation improved as the boundary layer became more mixed, especially overnight. Nevertheless, if one compares the maximum values measured on the Sedco-K, with the 50-year return value of hourly wind speed for the airport (22,3 m/s), (South African Weather Bureau, 1974), it is obvious that the airport is underestimating offshore conditions. This particular series of storms resulted in a significant wave height of 8,6 m (Shillington and Britten, 1979), at the Sedco-K site while an estimate of up to 15 m was received from a tanker within the Agulhas current further up the coast. The only other source of long-term, accurate wind data is the weather office at George. However, since this station is 221 m a.s.l. and more than 10 km from the coast it was considered to be unsuitable as a source of information on wind conditions.

Hsu (1980) has related <u>mean monthly</u> offshore wind conditions to those at a suitable coastal site. Unfortunately, insufficient data were available for such a study of conditions here. However, it is obvious from Figure 2 that the airport is not suitable for measuring coastal wind conditions.

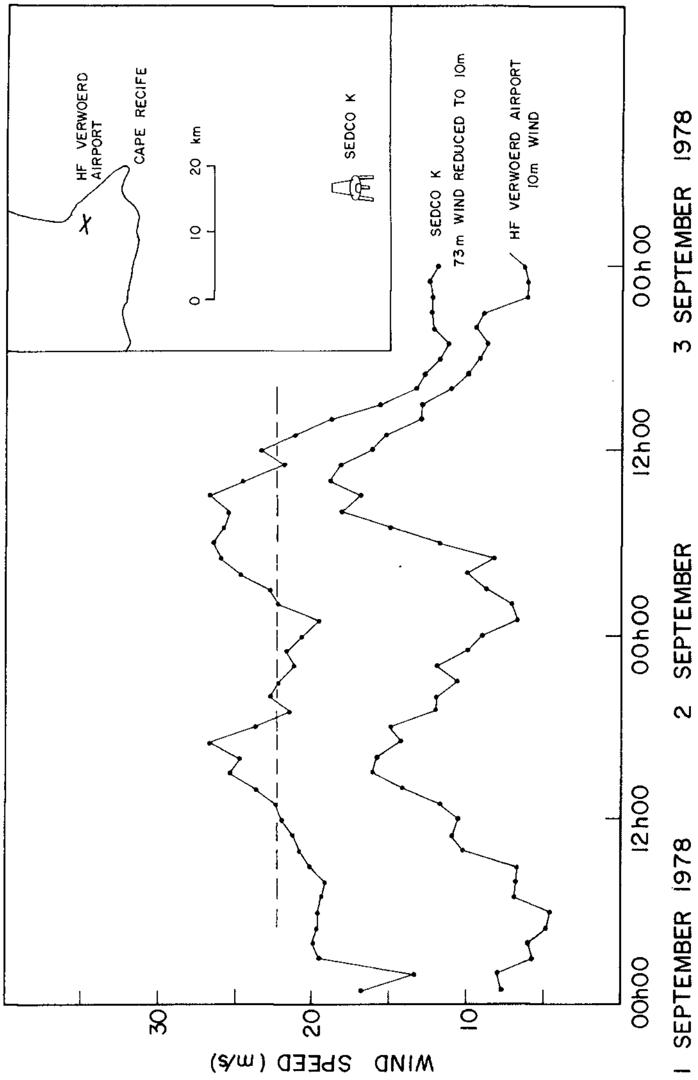
3 WIND FROM OFFSHORE DRILLING PLATFORMS

The search for oil on the Agulhas Bank and the associated demand for environmental data, have provided researchers with invaluable offshore wind measurements. However, even this dataset presents problems:

(i) Although measurements began in 1978, the record is by no means continuous,
(ii) Measurements represent several well sites on the Agulhas Bank,
(iii) The anemometer is 73 m a.s.l. which poses a height reduction problem.

With regard to (ii), another drilling rig, the Sedco-708, was temporarily on the Agulhas Bank, drilling to the south of Sedco-K. While it was in a position roughly 78 km southwest of Sedco-K, wind speeds registered at Sedco-708 were significantly higher for much of the

FIG. 2: VARIATION OF WIND SPEED OFFSHORE - HOURLY AVERAGES



time (Figure 3). However, the latter rig was later moved to a position roughly 74 km WSW of the Sedco-K and the comparison was greatly improved (Figure 4). It was significant that Sedco-708 was closer to the warm Agulhas Current when it was in the first position.

The reduction of wind speed from 73 m to the standard 10 m a.s.l. is a function of boundary layer stability, which may vary considerably in time and space. Whereas the wind power law has previously been applied with the exponent for a neutrally stable atmosphere, i.e.

$$U_{10} = U_{73} \cdot \left(\frac{10}{73}\right)^{,143}$$

subsequent wind measurements showed that this reduction may be too severe, especially under unstable, high-wind conditions. The hourly wind values plotted in Figure 2 were obtained using an exponent of 0,1 which effectively reduced the 73 m wind by 18%. It is felt that this reduction will, if anything, underestimate the 10 m wind, under extreme conditions.

In order to obtain a 50-year return period hourly wind for the Agulhas Bank, the method outlined by Katsiambirtas (South African Weather Bureau 1975), was followed. It should be noted that the chosen dataset of twelve months did not include the September 1978 storm (Figure 2). A value of 25,8 m/s was obtained. This value was exceeded on several occasions prior to the used dataset. This illustrates the folly of applying statistical methods to a relatively short wind record.

4 SHIPS OF OPPORTUNITY

Prior to the advent of offshore drilling operations, synoptic reports from merchant ships ('SHIP' reports) represented the only significant source of offshore wind data on the Agulhas Bank. The coastal engineer planning to utilise these data would have to bear in mind that :

1. Most vessels are 30 km or more from the coast in the region between Cape St Francis and Cape Agulhas (see Figure 5).
2. Reports are usually sent only on the main synoptic hour, i.e. every 6 hours.
3. Vessels will be trying to avoid extreme conditions if possible.
4. Observations are often neglected when the ship is within sight of land.
5. The majority of SHIP reports contain estimated wind speeds.

With regard to this last point, it must be borne in mind that most deck officers use state of sea to estimate wind speed. However, sea state is not purely a function of wind. Boundary layer stability and surface currents play an important role. Also it must be expected that wind estimates will decrease in accuracy as wind speeds increase. There is no simple solution to this problem, since an anemometer would measure relative wind speed and further errors may be introduced in the calculation of true wind speed. A height reduction problem also arises since anemometer height is not provided in the standard message and this will vary greatly from vessel to vessel.

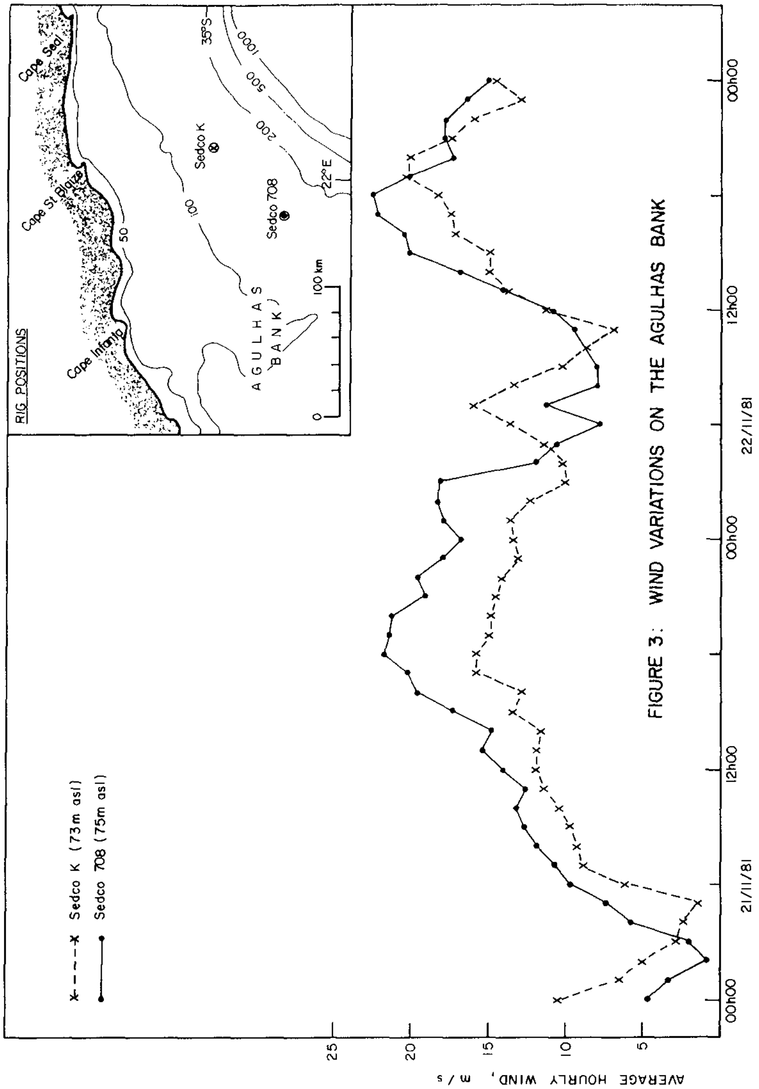


FIGURE 3: WIND VARIATIONS ON THE AGULHAS BANK

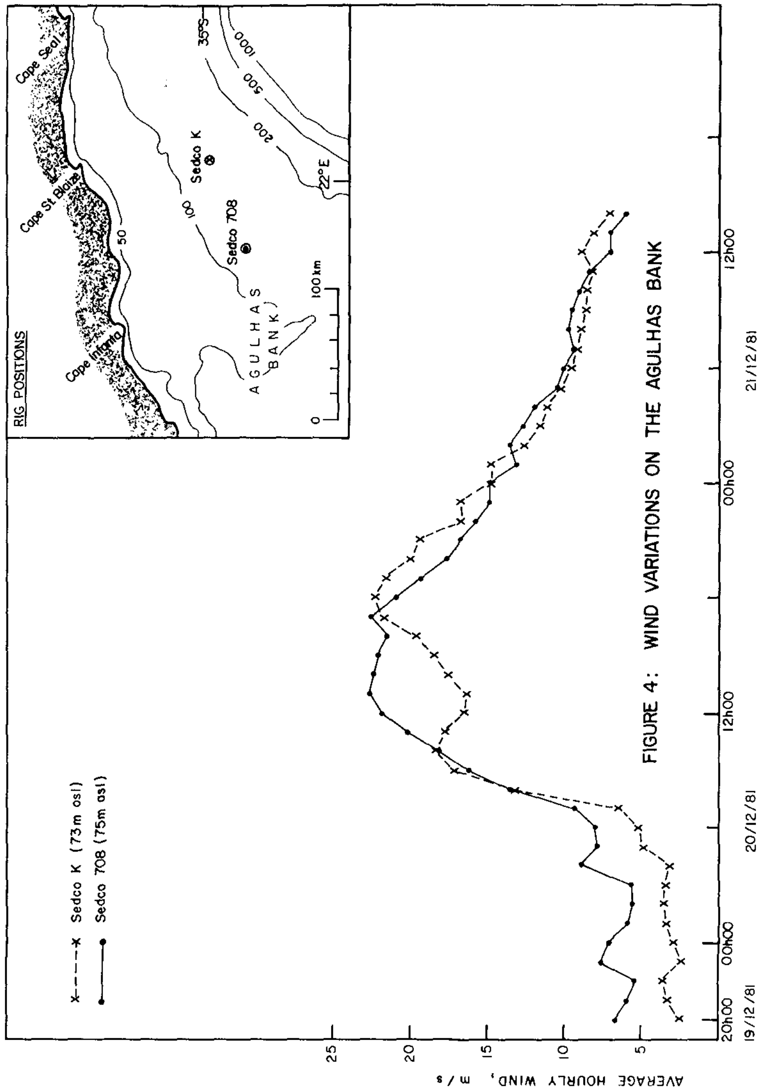


FIGURE 4: WIND VARIATIONS ON THE AGULHAS BANK

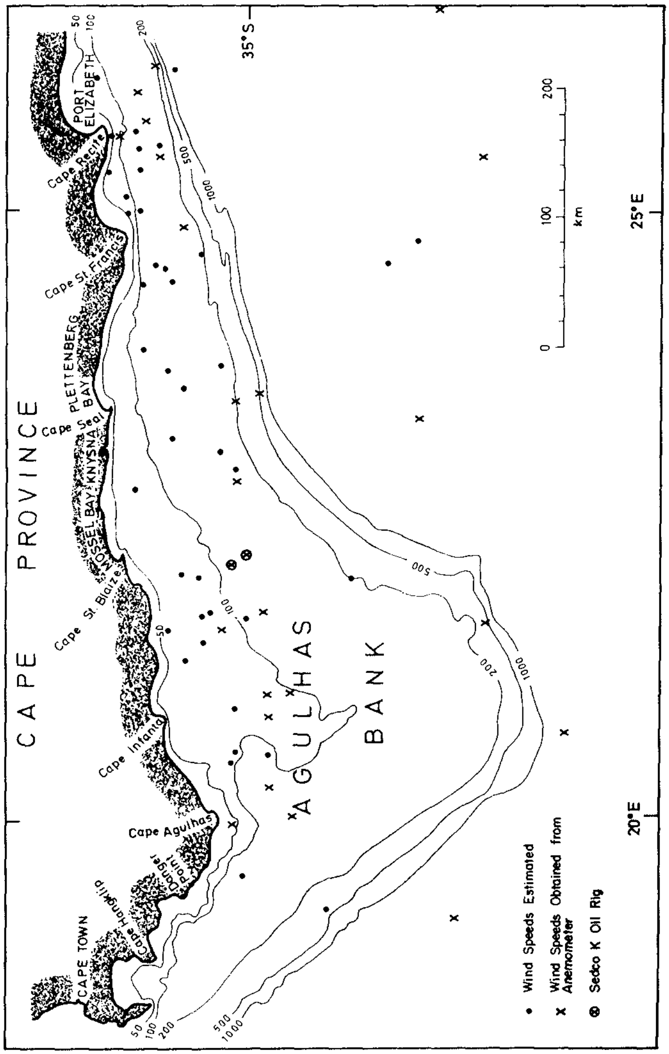


FIGURE 5 : SHIPS' POSITIONS FOR MARCH AND APRIL 1982 AT 06h00 Z

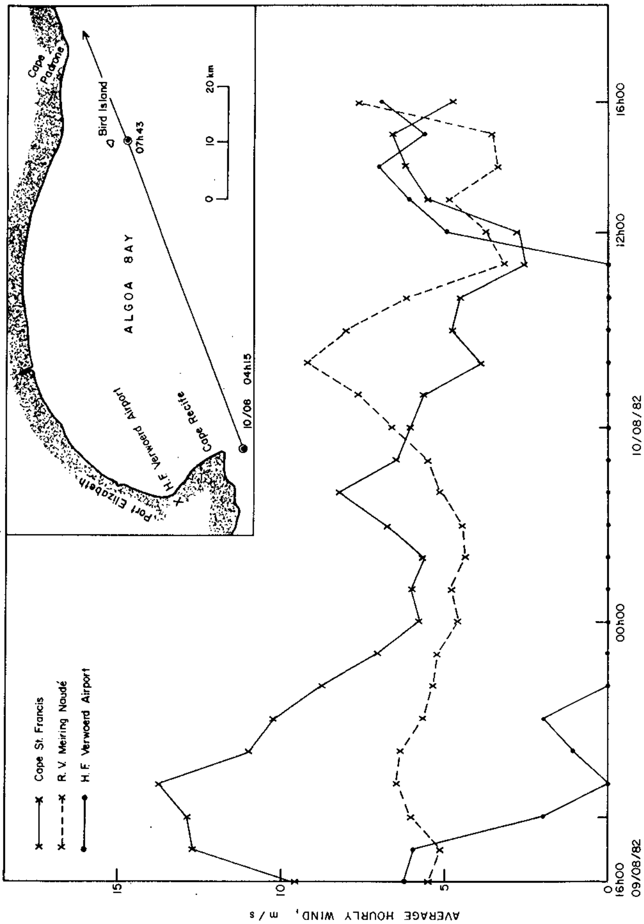


FIGURE 6: SPATIAL VARIATIONS

5 ESTIMATES OF HOURLY WIND FROM LIGHTHOUSES

This represents the only source of long-term, truly coastal observations. There are now only three fully manned lighthouses on the Cape south coast (Figure 1). Of these three -

1 Cape St Francis is fitted with a pressure plate which is of no use under extreme conditions as it is almost horizontal at 15 m/s.
2 Cape St Blaize is badly positioned for wind observations, being sheltered from wind from certain directions.

Bearing in mind the limited accuracy of observations from these lighthouses, it has not been possible to determine their relationship to offshore conditions.

6 AUTOMATIC WEATHER STATIONS

Three permanent automatic weather stations were set up on the Cape south coast in February 1982. At all three sites, the prevailing winds have very limited stretches of coast to cross before reaching the anemometers. The surrounding terrain is also reasonably flat. The anemometers are all placed well above the internal boundary layer (IBL).

A fourth automatic weather station is mounted on the NRIO's research ship, R V *Meiring Naudé*, for those periods which she spends off the south coast. These wind data are invaluable in the study of offshore variation.

Figure 6 illustrates how nocturnal cooling may totally decouple the air flow on shore from that offshore. Early on 9 August, the R V *Meiring Naudé* was crossing Algoa Bay in the direction of Bird Island. A land breeze of about 5 m/s was blowing as the vessel passed within 15 km of H F Verwoerd Airport. At the latter site the establishment of the nocturnal inversion resulted in calm conditions from 22h00 until 11h00 the following day. In the vicinity of Bird Island the land breeze reached a peak of 9,2 m/s at 08h00, finally dying off at 11h00. The third curve in Figure 6 represents conditions at Cape St Francis (see Figure 1). The high wind speeds recorded there on 9 August are due to a frontal wave which was much weaker when passing the R V *Meiring Naudé* (the vessel was at that stage to the west of Cape St Francis). Note that the anemometer at Cape St Francis is above the nocturnal inversion with the land breeze there reaching a peak speed at 04h00.

7 CONCLUSIONS

This study has compared actual hourly wind averages as opposed to the comparison of long-term means. The following conclusions may be drawn:

(1) Although a simple relationship may, at times, exist between wind speed at a coastal site and one a few kilometres inland, the inland record may become completely decoupled due to excessive boundary layer stability.
Should extreme return period winds for such an inland site be applied to the coastal site, a severe underestimate may result.

(2) Extreme return period winds for an offshore site, based on a relatively short dataset (less than 10 years), may also underestimate the true condition.

(3) Offshore conditions may vary over relatively short distances (less than 100 km). This may be attributed, amongst other things, to sea surface temperature distribution and preferred locations for new synoptic developments.

8 ACKNOWLEDGEMENTS

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