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A relationship between wind speed and wave height in cyclone and depression field in Arabian Sea

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ABSTRACT. Based on accurate wave data obtained from the observations in Arabian Sea cyclone of June 1976 by the rigs of ONGC in Bombay High area and also with additional data of wave observations by ships in the depression field of May 1975 over the same sea a linear relationship between wave height and wind speed is obtained empirically. A simple model for this has been proposed. The relationship has been tested for the depression of September 1974 and cyclonic storm of 1978. The agreement between observed and predicted wave height is found to be reasonably good.

1. Introduction

Oscillatory wind waves are formed in the open sea by transference of mechanical energy blowing over the sea surface. With increased economic activities over the high seas and along the coast it has become necessary to understand more about the waves. In tropical seas the most dangerous weather systems are the tropical cyclones. For mariners both winds and waves associated with these cyclones are equally dangerous. Now a days forecasting wave parameters not only for military and merchant navy but also for off-shore mining has become a routine activity in many forecasting offices. For meteorologists this is a new challenge to be met. Normally the variation of wave heights remain within a small and tolerable range in most of times; there is always a very large variation associated with the tropical cyclones and depressions. It is, for these reasons, necessary for a meteorologist to find out relationship between wind speed and wave height in association wit cyclones and depressions.

Starting from the classical theories on wave by Airy and Stokes' attempts have been mad to understand the mechanism of generation c wave by Jeffreys (1925), Sverdrup and Mun (1947), Bretschneider (1952), Phillips (1957) Darbyshire (1955) and many others. Howeve none of the theories is applicable universally King (1959) observed that in many areas loca conditions may have to be taken into account.

Mukherjee and Sivaramakrishnan (1977) hav given a model of distribution of wind and wav in a hurricane field.

In the present study an attempt has been mad to establish empirically the relationship betwee wind speed and wave height in cyclone an depression fields over Arabian Sea.

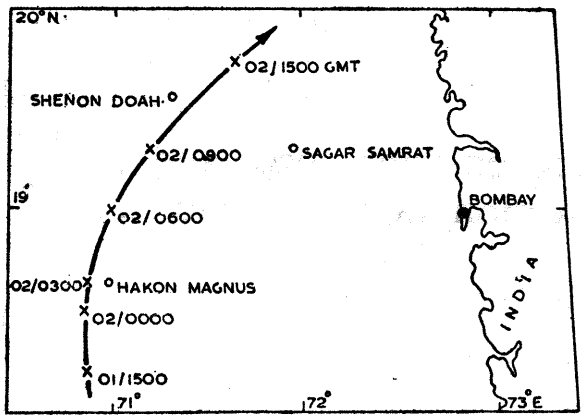

Fig. 1. Track of severe cyclone, 1 and 2 June 1976

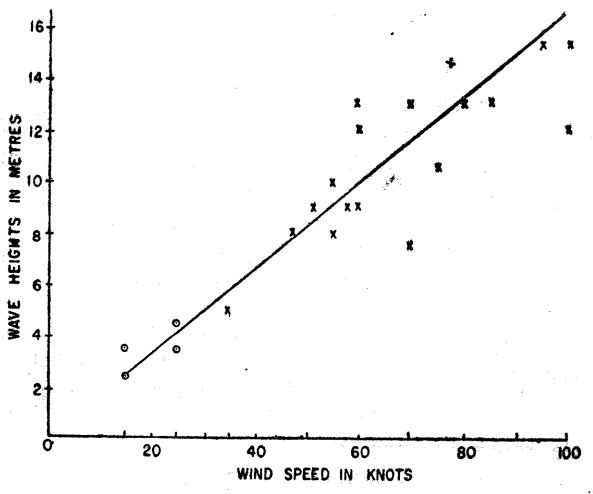

Fig 2. Wind speed and wave height relationship

TABLE 1

Predicted maximum wave heights by different methods

Methods	Predicted wave ht (ft)
Scripp's Institution (1944)	26
Suthon (1945)	22
Darbyshire (1952)	58
WMO Tech. Note No. 446 (1976)	60

Maximum wave height recorded was 53 ft

TABLE 2

Comparison of predicted and observed wave heights

Wind speed (kt)	Wave heights (m)	
	Predicted	Observed
25	4.3	4.5
25	4.3	3.5
30	4.8	4.0
35	5.7	5.0
35	5.7	4.0

2. Data

In June 1976, a severe cyclonic storm over the Arabian Sea passed over the Bombay High area where three rigs belonging to the Oil and Natural Gas Commission (ONGC) of Government of India were jacked up. The wind observations were taken from the instruments mounted on these rigs. The wave heights were observed with respect to markings on the legs of the rigs. These markings are in feet and hence the accuracy of observation is within half a foot. The main observations for this study are from these rigs. Some observations from ships in the field of depressions in May 1975 were also used.

After developing the relationship between wind speed and wave height in these situations, it was verified for two years, 1974 and 1978. Here also only ships observations have been utilised.

3. Results and discussions

The track of the severe cyclonic storm on 2 June 1976 is shown in Fig. 1. It will be seen that the cyclone passed over an area where three oil rigs, *Sagar Samrat, Hakon Magnus* and *Shenan Doah* fell in the field. The available observations of wind speed and wave height are plotted in Fig. 2. Values of wind and waves from 1 to 3 May 1975 and also of 30 and 31 May 1975 are plotted in the same figure to indicate that they also fit excellently.

It may be observed that the best fit curve is a straight line. The wind speeds are in knots and wave heights are in metres. A simple theory is proposed to explain this relationship.

Almost all theories try to relate the maximum height of wave to some power (greater than unity) of the wind speed. An initial verification of these models for the observations in 1976 show either a higher or a lower estimate of wave heights. These are shown in Table 1. Hence an *ab initio* model without bias is tried here. It is assumed in our approach that the effects of viscosity and surface tension are negligible. The waves are generated *in situ* by transfer of mechanical energy of wind to the surface of the sea to build up waves in the fields of the disturbance.

The kinetic energy of unit mass of air is equal to $V^2/2$ where V is the wind speed.

Again the energy of waves for unit wave crest per wave length is equal to $\rho g H^2/16$, where ρ is the density of sea water, g is the acceleration due to the gravity and H is the height of the wave.

Since waves are assumed to be created by transfer of energy *in situ* let us assume that the wave energy be proportional to the kinetic energy of the air above it.

Thus

$$\frac{\rho g H^2}{16} \propto \frac{V^2}{2}$$

From which we get

$$H \propto V$$

Thus a plot of H against V should be a straight line passing through the origin. This is what has been brought out in Fig. 2.

In 1974 a depression formed over Arabian Sea. A few observations were available from the field of depression. Again a severe cyclonic storm passed over Arabian Sea in November 1978 and it crossed coast near Nalia. Here also some ships observations were available from the storm field. The wave heights predicted from Fig. 2 are compared with observed wave height

and are shown in Table 2. The agreement between the observed values and the predicted ones is reasonably good considering the accuracy of observations by the methods followed by the ships.

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