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PREDICTION OF WAVE HEIGHT AND PERIOD INSIDE A CYCLONE FIELD IN THE INDIAN SEAS

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ABSTRACT

Empirical equations to predict wave height and period based on surface wind speed inside a cyclone field over the Indian seas have been derived from a large data set of 162 ship observations corresponding to 32 cyclonic storms. The usefulness of the equations and some of the limitations have been discussed.

Key-words : Wind waves, wave height, wave period, cyclone.

INTRODUCTION

Wind waves in the open sea are generated by wind blowing over sea surface. It is well known that the high surface winds in the tropical oceans are generally associated with cyclonic storms. Further, there is wide variation of wave parameters in the field of a cyclone (Mukherjee and Sivaramakrishnan, 1981). Hence forecasts on wave parameters viz. wave height (WH) and wave period (WP) in a cyclone field are useful and crucial for marine activities of navy, commercial shipping, off-shore oil drilling etc.

General techniques based on theoretical and empirical considerations which could be employed to forecast wave parameters have been described in detail in World Meteorological Organisation publications (Anonymous, 1976 & 1988), Naval Oceanography and Meteorology Memorandum NP 4864 (Anonymous, 1984). Wave height and period at a location are controlled mainly by surface wind speed, duration and the dimension of the fetch area. In a cyclone field, the wind speed and fetch change too rapidly to mark the boundaries of the fetch accurately. Sharma (1980) has attempted forecasting wave parameters inside a cyclone field over Arabian Sea by roughly determining the fetch and employing a wave spectrum model. Mukherjee and Sivaramakrishnan (1981) have established an empirical linear relationship between wind speed and wave height for a cyclone field over Arabian Sea. Their study has been based on nearly 20 observations.

The object of this communication is to extend the above study by involving a large data set and thereby deriving empirical relations for prediction of WH and WP, based only on wind speed inside a cyclone field over Indian seas.

MATERIAL AND METHODS

Thirty two cyclonic storms which prevailed in the Indian seas north of latitude 5°N inside the region bounded by 65°E and 90°E during the period 1961-82 were selected for the study. Out of these 32 storms, 16 belonged to Bay of Bengal, 10 to Arabian Sea and the remaining 6 to both. These gave rise to 118 storm days. For each of the above storm days, 4 weather charts one each for 00, 06, 12 and 18 hrs UTC were prepared. All the available and relevant ship observations stored in the archives of Marine Climatology Section, Meteorological Office, Pune were made use of in the preparation of 468 charts.

Table I. Regression equations based on wind speed (V) for prediction of wave height (WH) and wave period (WP)

Predictand	No.of observations	Correlation coefficient	Percentage variation explained	Regression Coefficiant	Constant Term of the Regressoion Equation	Standard Error
WH	162	0.51*	26.3	0.06	0.60	0.85 metre
WP	162	0.50*	25.3	0.13	1.80	1.81 seconds

* significant at 0.1 % level

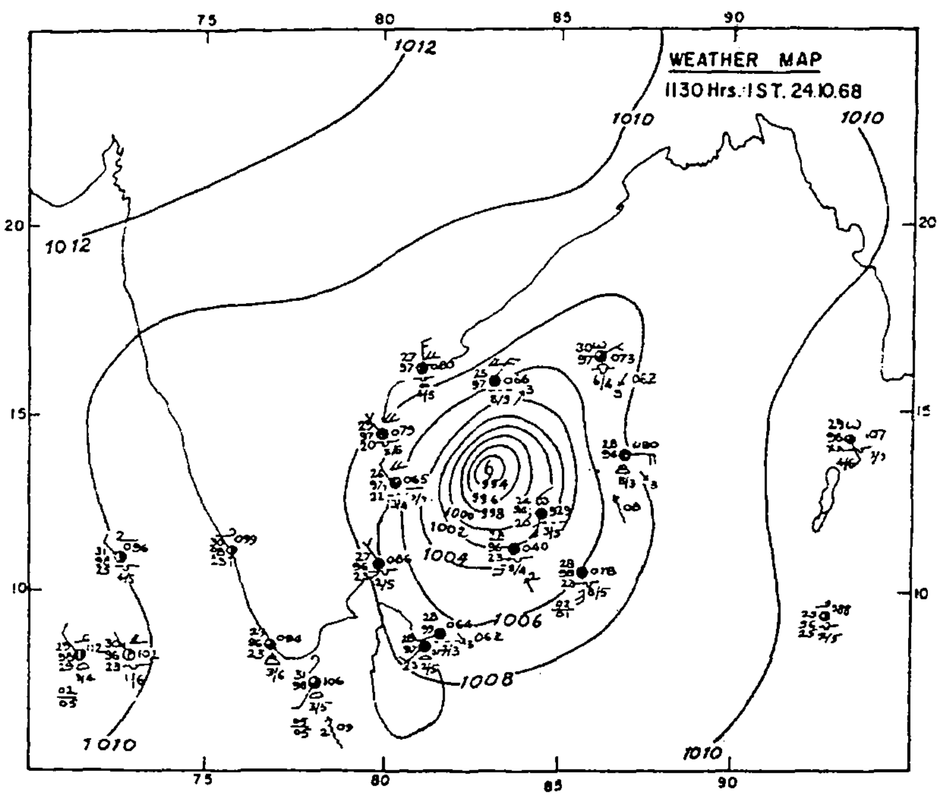

Fig. 1. Weather chart of 24-10-1968 at 1130 hrs IST

The field of a cyclone can be considered as the area covered by the outer isobar. In all 162 ship observations located in a cyclone field of WH, WP and windspeed (V) were available. The values of WH, WP and corresponding V were directly picked up from the above 162 observations (The parameters WH, WP and V reported by a ship are generally based on visual observations only). The reported values of WH and WP are the significant ones. V is reported to an accuracy of 5 knots, WH to 1/2 metre and WP to 1 second. The scatter diagrams of WH & V and WP & V are presented in Fig. 3.

Fig. 1 depicts one of the 468 charts considered in the study. This is the weather chart depicting the surface pressure pattern at 1130 hrs IST of 24.10.1968, when a cyclonic storm was present in the Bay of Bengal. Fig. 2 gives the spatial distribution of the 162 observations in various 5^0 squares. It is seen that the observations are fairly representative of the Indian seas.

RESULTS AND DISCUSSION

A positive correlation between V & WH and V & WP can be always anticipated even in a cyclone field where the fetch changes rapidly. The linear correlation coefficient (CC) between V & WH and V & WP were computed. The CC between V and WH was 0.51 explaining 26.3% of the variation whereas that between V and WP was 0.50 explaining 25.3% of variation. Both these positive CCs are significant at 0.1% level. The regression equations of WH on V and WP on V were also worked out. The details are given in Table I. The regression lines are presented in Fig. 3.

The values of WH and WP given by Fig. 3 for a given wind speed are less than those obtained from the WH-V and WP-V graphs given in NP486A (Anonymous, 1984). This is expected as these graphs supply the fully arisen WH and WP which correspond to a very large fetch and longer duration whereas in a cyclone field the fetch is comparatively small and the duration very short. Incidentally, the values of significant wave height and period obtained from Fig. 3 by taking duration as 3-6 hrs and fetch longer than 50 nautical miles (these values closely approximate the fetch and duration obtained in cyclones) compare very well with the values obtained from graph C-2 (of the same publication) based on surface wind speed, fetch and duration.

As the estimates of the central pressure and the radius of maximum wind of a cyclonic storm based on satellite imageries are nowadays readily available for Indian seas, it is possible to workout the wind speed at any point inside the cyclone field by means of a suitable theoretical pressure/wind profile. It would then be possible from Fig. 3 to obtain estimates of WH and WP at any point inside a cyclone field based on wind speed alone. Further, confidence intervals, at the required significant level based on the standard error given in Table I, in which the spot observations will lie, can be easily constructed. The estimates may not be very accurate for $V<5$ knots and for very large values of V. There were only a few observations with $V>40$ knots in the data set and so the validity of the equations in that range will depend upon the validity of the assumption of linear relation for

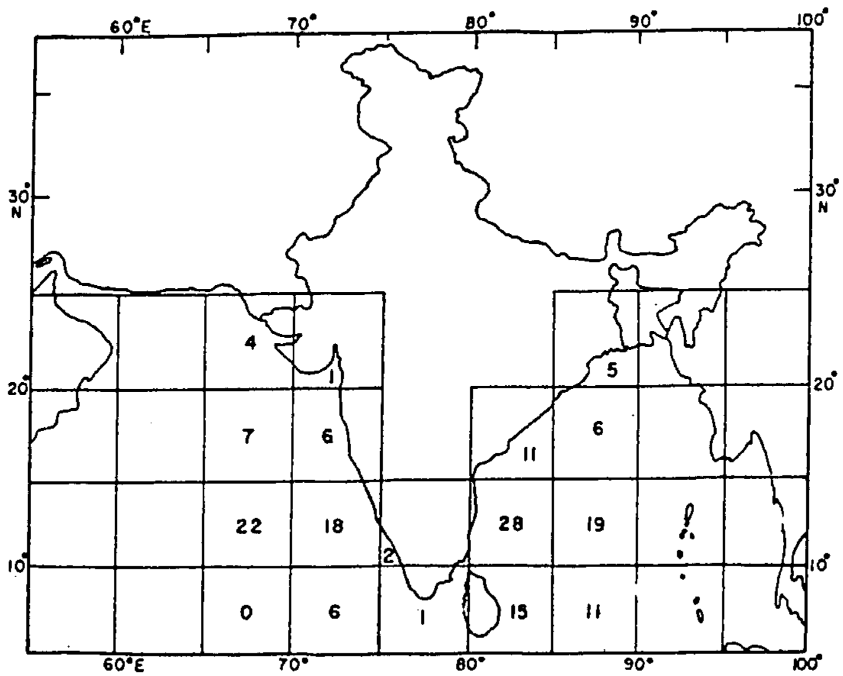

Fig .2. Spatial distribution of the 162 observations considered in the study.

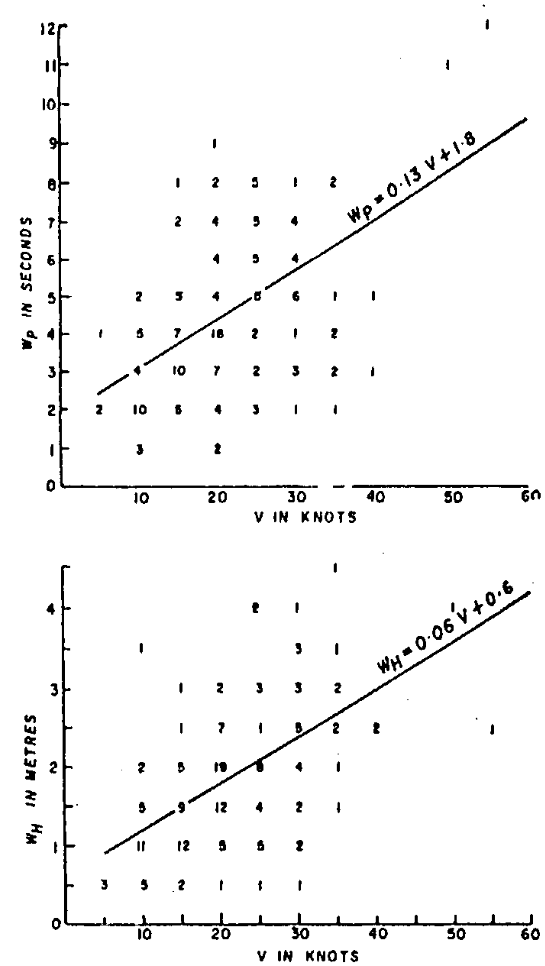

Fig .3. Scatter diagrams and regression lines of WH and WP on V. (The numbers inside the diagram indicate the numbers of observations concentrated at those points).

large values of V. The existence, if any, of non linear relation between WH & V and WP & V was tested by taking various exponents of V as independent predictors. But this exercise did not yield any significant improvement.

Inclusion of fetch and duration as predictors for WH and WP in addition to wind speed may have yielded a slightly higher CC; but then the reliability of such a set of equations would depend upon the highly subjective estimation of fetch and duration. The equations derived, having been based on a fairly large data set of actual observations are statistically stable and must give realistic estimates of wave height and period inside a cyclone field over Indian seas.

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