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Distribution of wave heights in Bay of Bengal during summer monsoon

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सार — एस० एम० बी० विधि और भारतीय दैनिक मौसम रिपोर्ट 1976-80 की अवधि के पवन आंकड़ों का उपयोग करके ग्रीष्म मानसून में बंगाल की खाड़ी की हिन्दकास्ट तरंग ऊंचाइयों का विवरण दिया गया है । समुद्री तरंग एवं महातरंग की सार्थक तरंग ऊँचाइयों का मासिक औसत .5 से 2.0 मी० तक है । खाड़ी के दक्षिणी और मध्यखण्ड उच्चतर तरंगों से संबद्ध हैं । जून से अगस्त की अवधि में उत्तरी दिशा में महातरंगों का संचरण प्रेक्षित किया गया । रिपोर्ट की गई अधिकतम पवन चालों से संभावित सार्थक उच्चतम तरंग ऊंचाइयों की गणना की गई जो 2.5 से 6.5 मी० के बीच पाई गई ।

ABSTRACT. Hindcast wave heights in Bay of Bengal for summer monsoon are presented using SMB method and wind data reported in *Indian Daily Weather Reports* during 1976-80. Mnnthly average significant wave heights of both sea and swell range between 0.5 and 2.0 m. Southern and central portions of Bay are associated with higher waves. Propagation of swells in northerly direction has been observed during the period June-August. Highest possible significant wave heights computed from maximum wind speeds reported, vary from 2.5 to 6.5 m.

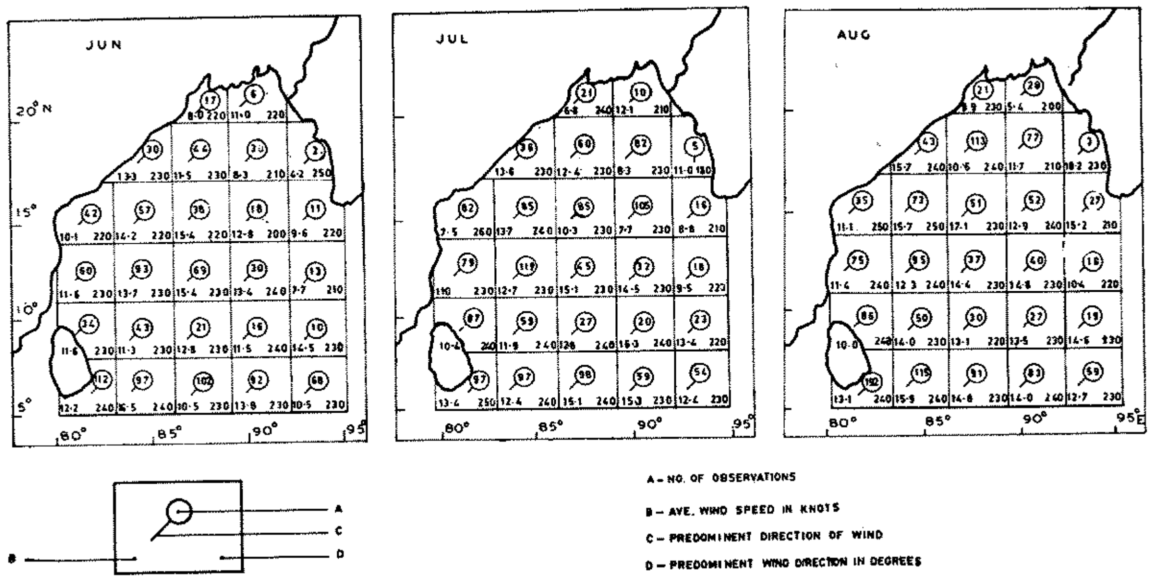
1. Introduction

Wave characteristics in Bay of Bengal have been described in earlier papers based on visual observations reported by opportunity ships (Srivastava *et al*. 1966, Hogben and Lumb 1967, Srivastava *et al*. 1970). There are practically no recorded wave data in this region except for very few such observations with ship borne wave recorder (Sathe *et al*. 1979, Gouveia *et al*. 1981). In the absence of instrumental observations on wave data, there are only two alternatives for obtaining the wave climate over a particular area : either to rely on visual wave data or to compute wave statistics by hindcast procedures based on wind data. Obviously visual wave observations are susceptible to subjective errors and are to be viewed with proper caution. Moreover, a cursory glance of *Indian Daily Weather Reports* (*IDWR*) would reveal that the number of wind data are more compared to wave observations. For hindcasting of waves, it is usual practice to derive input surface wind characteristics from isobars drawn on a weather chart. But it is always desirable to use recorded wind data for wave prediction purposes if considerable amount of data are available in a particular region. Among different wave forecasting methods using wind data, Sverdrup Munk Bretschneider (SMB) method is preferred since significant wave heights predicted through this method agree well with the recorded wave data along the Indian coasts (Dattatri and Renukaradhya 1971, Reddy *et al*. 1980, Prasada Rao and Durga Prasad 1982).

In the light of the above, the authors in the present study have attempted to give the distribution of average sea and swell heights in Bay of Bengal during summer monsoon season by using SMB deep water wave forecasting relationships. Revised formulae given by Bretschneider (1970) are used for this purpose. All computations are carried out with the help of PDP-11/60 computer at NPOL, Cochin.

2. Data and methods

SMB prediction technique is used for hindcasting wave heights in Bay of Bengal during peak monsoon months (June, July and August). Wind data in offshore regions reported in *IDWR* charts are collected for these three monsoon months over a period of 5 years from 1976 to 1980. Total 4196 wind observations are considered in the present study. Entire data for each month are grouped for each 3 deg. square. Predominant wind direction and average component of wind speed in this direction are computed using Wilson's (1955) method. In general predominant wind direction is around 230 deg. Hindcast points are determined based on wind direction and incidentally they happened to be at centre and northeastern corners of each 3 deg. square. Bretschneider's (1970) revised



Figs. 1 (A–C). Monthly average wind speed and predominent wind direction in Bay of Bengal during summer monsoon : (a) June, (b) July and (c) August

deep water wave forecasting relationships (also known as SMB method) are then used for hindcasting significant wave heights at above mentioned points. The average significant 'sea' heights are evaluated considering the fetch is limited to the grid size. In many cases, depending upon wind direction, the diagonal distance of 3 deg. square grid has become actual fetch length and half of this distance is taken for computing wave heights at central points of these grids. Average significant 'swell' heights are computed considering 'effective fetch' (Bretschneider 1970) into account. Apart from these average significant sea and swell heights, the highest significant wave height which could possibly occur in each 3 deg. square is also deducted by using the highest wind speed reported.

3. Results and discussion

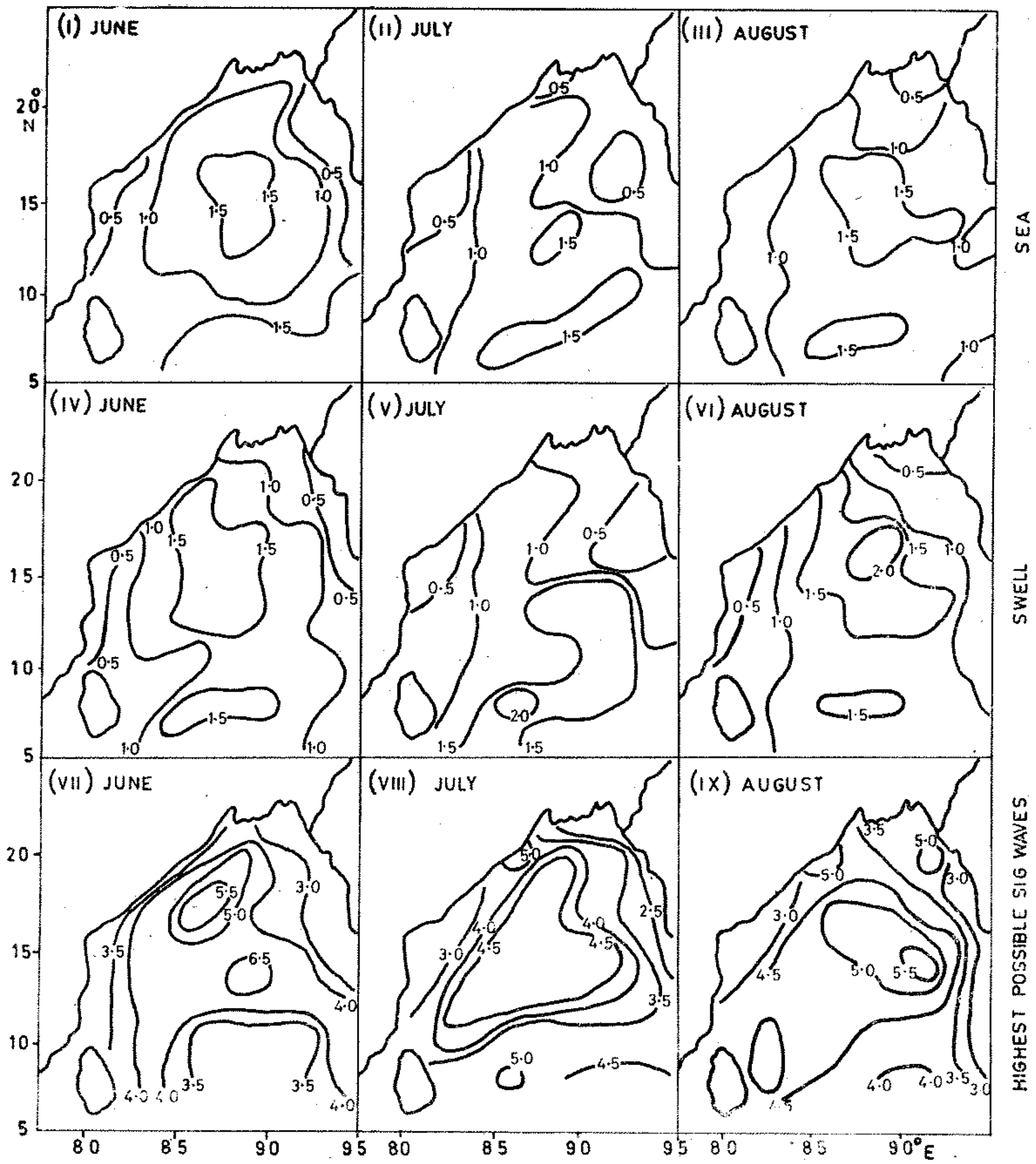
3.1. *Distribution of winds*

Figs. 1 (a-c) give the predominant wind direction and average wind speed for each 3 deg. square in Bay of Bengal for June to August. The predominant winds are steady, blowing from SW and the average wind speed is around 12 kt. It may be seen that low wind speeds occur in the northern part of Bay while high wind speeds are encountered in the southern region. Winds are slightly weaker along eastern and western sides compared to central portion of Bay of Bengal. Thus the winds blowing consistently from SW for considerable duration during summer monsoon (June to August) are responsible for generation of 'seas', its proper growth and propagation of 'swells' into other areas. 'Fetches' are unlimited for waves generated in this region and the maximum fetch lengths available are of the order of 1000 nautical miles.

3.2. *Distribution of wave heights*

Distribution of average significant heights of sea, swell and the highest possible significant wave heights which could occur during monsoon months are shown in Figs. 2 (i-ix). Wave height contours are drawn in 0.5 m intervals. It is interesting to note that the average heights of 'sea' and 'swell' are of same order of magnitude. The presence of both sea as well as swell in the monsoon season would result in wide band wave spectra essentially of bi-model distribution with maximum energy peaks corresponding to dominent frequencies of sea and swell. This may be considered as an important characteristic feature of this region. The average significant wave heights of sea and swell range from 0.5 to 2.0 m during summer monsoon season. Southern and central parts of Bay of Bengal are associated with higher average wave heights and it may be seen a similar situation is observed in case of wind distribution pattern (*see* Fig. 1). In other words, it may be stated that in the areas close to land boundaries wave heights are lower compared to wave heights in far offshore regions. It must be due to variable wind velocities in coastal regions and also due to wave refraction, shoaling and bottom friction in shallow waters. Prasada Rao and Durga Prasad (1982) in their earlier study on waves off Mangalore have discussed the influence of these factors on shallow water wave heights and presented statistical relationships for obtaining shallow water significant wave heights from deep water wave characteristics.

Contours of swell heights also reveal propagation stages of swell from June to August. In June two cells of maximum swell heights (1.5 m) are seen, one at the southern location and the other extends from



Figs. 2 (i-ix). Contours of significant wave heights in 0.5 m interval
(i-iii) : Average sea heights
(iv-vi) : Average swell heights
(vii-ix) : Highest possible significant wave heights

central part to the northern part of Bay of Bengal. In July, the northern cell had disappeared and the southern cell advanced further north. During this month, swells of 2 m height are observed in the southern region. By August the formation of cell structure of maximum swell heights resembles the one which is observed during June which might indicate that it had regained its previous conditions. A small cellular structure of 2 m swell height which is noticed in July at southern location is found to have shifted slightly above the central portion of the Bay by August. This infers propagation of swell in northerly direction in Bay of Bengal during summer monsoon.

Unlike the average significant sea and swell heights, the highest possible significant wave heights which are computed based on maximum wind speeds reported, infer that the highest waves need not necessarily present only at the central and sourthern portions of the

Bay. Contours of highest possible significant wave heights for June show that the wave heights are comparatively lower in southern region than in the central and north western portions of Bay of Bengal. The highest significant wave heights range between 2.5 and 6.5 m in monsoon season. The highest waves are found during June among the three monsoon months for which wave heights are computed. This is in agreement with earlier studies on waves based on visual observations in Bay of Bengal wherein Srivastava *et al.* (1970) reported June is roughest month in this area.

4. Conclusions

Average significant wave heights range between 0.5 & 2.0 m and average heights of sea as well as swell are of same magnitude. Higher waves are observed in southern and central regions of Bay of Bengal. It is envisaged swells propagate from south to north in monsoon season. The highest possible significant wave heights vary from 2.5 to 6.5 m and the maximum wave heights of 6.5 m are noticed in the month of June.

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