

## Real time wave measurements and wave hindcasting in deep waters

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Deep water waves off Karwar (lat. 14°45.1'N, long. 73°34.8'E) at 75 m water depth pertaining to peak monsoon period have been measured using a Datawell waverider buoy. Measured wave data show that the significant wave height ( $H_s$ ) predominantly persisted between 2.5 and 3.5 m and the zero-crossing wave period between 6 and 8 sec during the study period. Spectral analysis shows that measured deep water waves generally formed single-peaked spectra conforming to the sea generated by local wind which is predominant in the monsoon period (June, July). The results obtained from the wave hindcast model seem to show a good agreement with those from the measured data with a correlation coefficient of 0.93 between computed and measured  $H_s$  values.

Increasing marine and offshore activities in recent years have created a need for more and improved knowledge of the state of the sea at a given area. This can be obtained by instrument based measurement over a long-term or by forecasting the sea state. Such information would be highly beneficial for various offshore developmental activities, offshore exercises of Navy and also for calibration of hindcast models. Since long-term measurements in deep water are more expensive and historic wind fields are available, forecasting of sea state using numerical models is gaining more and more importance. Appropriate validation of operational wave models is an on-going task carried out at most national centres<sup>1-5</sup>. The objective of the present study is to conduct real time measurements of deep water wave characteristics during monsoon at the study area and to validate the wave model<sup>6</sup> "DOLPHIN" (available at NIO, Goa).

During the 219th cruise of *R V Gaveshani* deep water waves off Karwar (lat. 14°45.1'N, long. 73°34.8'E) along central west coast of India, at 75 m water depth pertaining to peak monsoon period were measured using a Datawell waverider buoy. Wave data was recorded using DIWAR placed on board *R V Gaveshani* stationed in the vicinity of the buoy location. Measurements were carried out from 25 June to 3 July 1989 and the data were analyzed for evaluating various statistical and spectral parameters. Hourly variations of wind speed and direction were also simultaneously measured from the ship's meteorological station during the above period. This information on wind was used as input to the hindcast model DOLPHIN. Measured waves were recorded in PC in the digital form for 20 min duration at sampling rate

of 0.5 sec at every 3 h interval. FFT spectral analysis<sup>7</sup> of wave records was carried out considering 2048 data points. Necessary corrections were made for energy change due to tapering of raw spectral density. Digital data was analyzed using spectral method for various statistical parameters, viz. significant wave height ( $H_s$ ), zero-crossing wave period ( $T_z$ ), wave period corresponding to maximum wave energy ( $T_p$ ), maximum spectral energy ( $E_{max}$ ), spectral width parameter ( $\epsilon$ ), peakedness parameter ( $Q_p$ ) and wave steepness ( $s$ ).

Wave prediction method developed by Sverdrup and Munk<sup>8</sup> is based on significant wave height approach. The widely accepted energy balance equation first introduced by Hasselmann<sup>9</sup> and the theoretical aspects of non-linear wave-wave interactions are included in this model. Based on the JONSWAP experiments Hasselmann *et al.*<sup>10</sup> have concluded about the importance of the non-linear wave-wave interactions. The numerical wave prediction model DOLPHIN is a deep water hybrid point model, a combination of the parametric wind-sea and spectrally treated swells<sup>6</sup>. It is directionally decoupled. The development of this model is based on the study of directionally decoupled energy distribution of wind generated waves<sup>11</sup>. Inputs to the model are wind field (speed and direction at each grid point) and coastal boundary. Model outputs are the significant wave height  $H_s$ , variance density spectra and the directional spectra giving information on the two-dimensional distribution of wave energy.

During the study period, significant wave height varied from 2.1 to 3.9 m, zero-crossing period from 5 to 8 sec, wave period corresponding to maximum

wave energy from 8 to 13 sec, maximum spectral energy from 3.69 to 20.9 m<sup>2</sup>.sec, spectral width parameter from 0.73 to 0.85, peakedness parameter from 1.4 to 3 and wave steepness from 0.02 to 0.07 (Fig. 1). Wave heights were relatively high during the study period. Joint distributions of H<sub>s</sub> and T<sub>z</sub> are shown in Fig. 2. H<sub>s</sub> predominantly persisted between 2.5 and 3.5 m during the study period with the occurrence of 75%, while T<sub>z</sub> predominantly persisted between 6 and 8 sec with the occurrence 75%. Spectral analysis shows that measured deep water waves generally formed single-peaked spectra conforming to the sea generated by local wind which is predominant in the monsoon period (June and July). The wind speed (Fig. 1) varied from 7.2 to 13.9 m.sec<sup>-1</sup> during the period, while wind direction varied from 210°-315°.

Three hourly values of H<sub>s</sub>, T<sub>z</sub>, E<sub>max</sub> and T<sub>p</sub> computed by hindcast model and those based on measured data are shown in Fig. 3. The agreement seems to be

quite good with a correlation coefficient of 0.93 between computed and measured H<sub>s</sub> values.

Figure 4 shows comparison of measured spectra and the computed spectra. The spectra predicted by the model and the measured spectra seem to be reasonably in good agreement.

The results obtained from the model DOLPHIN seem to be encouraging in view of the good agreement found in statistical parameters and the frequency distribution of wave energy obtained from the measured data and the model output. However more such field measurements covering various geographical conditions are essential for assessing the reliability of the model and application of the same with good degree of confidence.

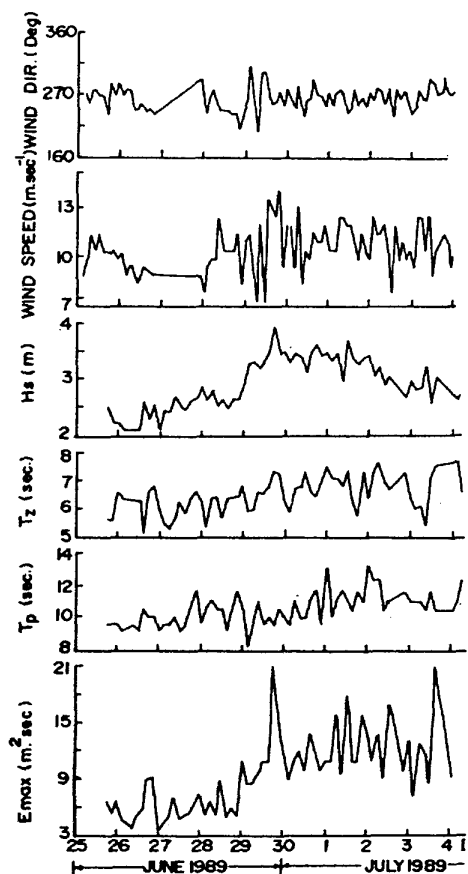


Fig. 1—Daily variation of wave and wind parameters

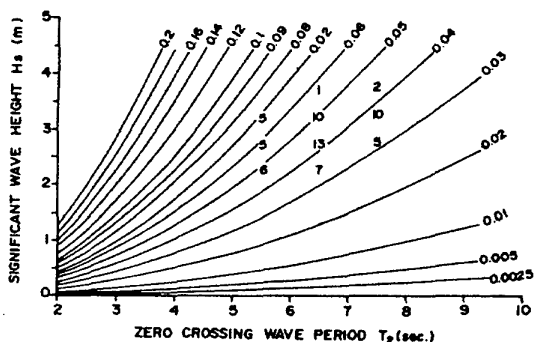


Fig. 2—Joint distribution of H<sub>s</sub> and T<sub>z</sub>

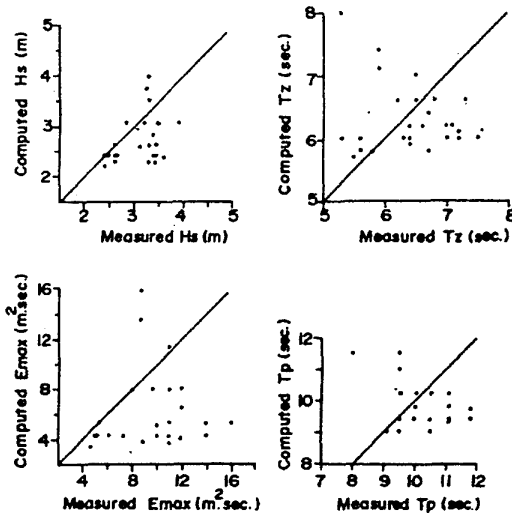


Fig. 3—Comparison of measured and computed values of H<sub>s</sub>, T<sub>z</sub>, E<sub>max</sub> and T<sub>p</sub>

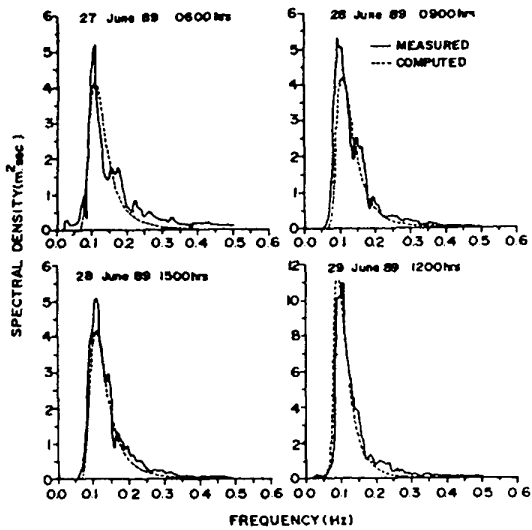


Fig. 4—Comparison of measured spectra with computed spectra

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