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Characteristics of shallow water waves off the central west coast of India before, during and after the onset of the Indian summer monsoon

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ABSTRACT

We studied the wave characteristics before, during and after the onset of the Indian summer monsoon based on data measured using the buoy moored at 3 locations off the central west coast of India. The study reveals the dramatic changes that occur in wave field due to the monsoon. Mean significant wave height before the onset of the monsoon was 0.7–0.9 m and it increased to 2.4–2.6 m during the onset of monsoon at the locations studied. Before the monsoon, due to the sea breeze, the wave height increased and reached its peak at ~1100 UTC. Variation of wave height in one day was up to 2 m with the high values (> 1 m) occurring during the monsoon. In contrast, the range of the peak wave period in one day varied up to 15 s before the monsoon due to the influence of the land breeze-sea breeze system. Also, before the monsoon, the spectral energy was in a wide range of frequencies due to the co-existence of swells and wind-seas, and 26% of the total spectral energy was in frequencies > 0.25 Hz. Conversely, during the monsoon, only 7.1% of the total energy was in frequencies > 0.25 Hz.

1. Introduction

The beaches along the west coast of India undergo seasonal erosion during the Indian summer monsoon (which lasts from June to September and hereafter is called “the monsoon”). The main factor responsible for this erosion is high wind waves generated by monsoon winds (Chandramohan et al., 1994). The average monsoon onset date over the southern part of Indian mainland is 1 June. During 2014, however, the monsoon was delayed and the onset date was 5 June (IMD, 2014). Strong cross-equatorial flow and intense westerlies over the Arabian Sea are the characteristic low-level features in the evolution process of the monsoon over India (Raju et al., 2005). Hence, it is important to know the changes in wave parameters during, before and after the onset of the monsoon. Kumar et al. (2010) studied the wave growth characteristics during a storm for a period of 7 days at a location off the west coast of India at a water depth of 14 m and observed that the maximum wave height increased from 2 to 8 m within 60 h.

Generally, the sea state consists of one or several swells and wind-sea systems (Soares, 1991). Hence, the change in wave characteristics at a location can be either due to a change in the local winds or a change in remote swells. The different wave systems present at a location can be identified by analyzing the wave spectrum (Hanson and Phillips, 2001). Studies conducted in the eastern Arabian Sea indicate that the wave spectrum is bimodal due to the presence of wind-seas and swells (Baba et al., 1989; Kumar et al., 2003; Vethamony et al., 2011). The measurements of waves in the eastern Arabian Sea suggest that the significant wave heights (H_{m0}) hardly exceed 5 m (Kumar et al., 2003, 2010; Vethamony et al., 2011; Sajiv et al., 2012; Glejin et al., 2013; Kumar et al., 2014). The eastern Arabian Sea is relatively calm during the non-monsoon period (Glejin et al., 2013).

The present study examines the changes in the wave characteristics from 1 May to 19 July 2014 at three locations in the eastern Arabian Sea (Fig. 1). 1 May to 6 June 2014 is the period before the monsoon (also referred as pre-monsoon), 7–11 June 2014 is the period at the onset of the monsoon and 12 June to 19 July 2014 is the period after the onset of the monsoon. The paper is organized as follows. Section 2 contains the data and methodology used in the study. Section 3 contains a discussion of the results, and Section 4 summarizes the conclusions.

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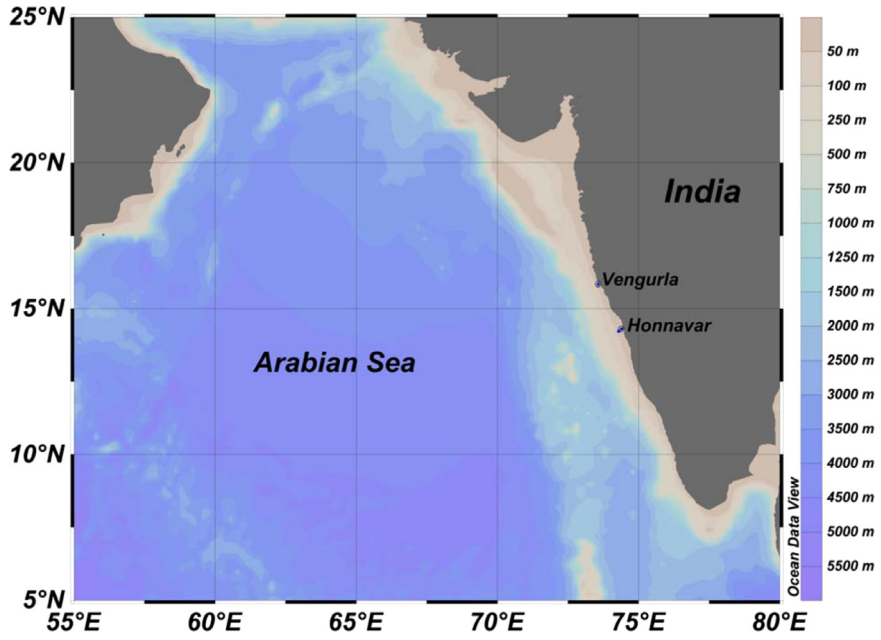

Fig. 1. Map showing the study locations. One location is off Vengurla at 15 m water depth and two locations are off Honnavar at 9 and 30 m water depth. The shadings are the depth in m. Map is plotted using ocean data view.

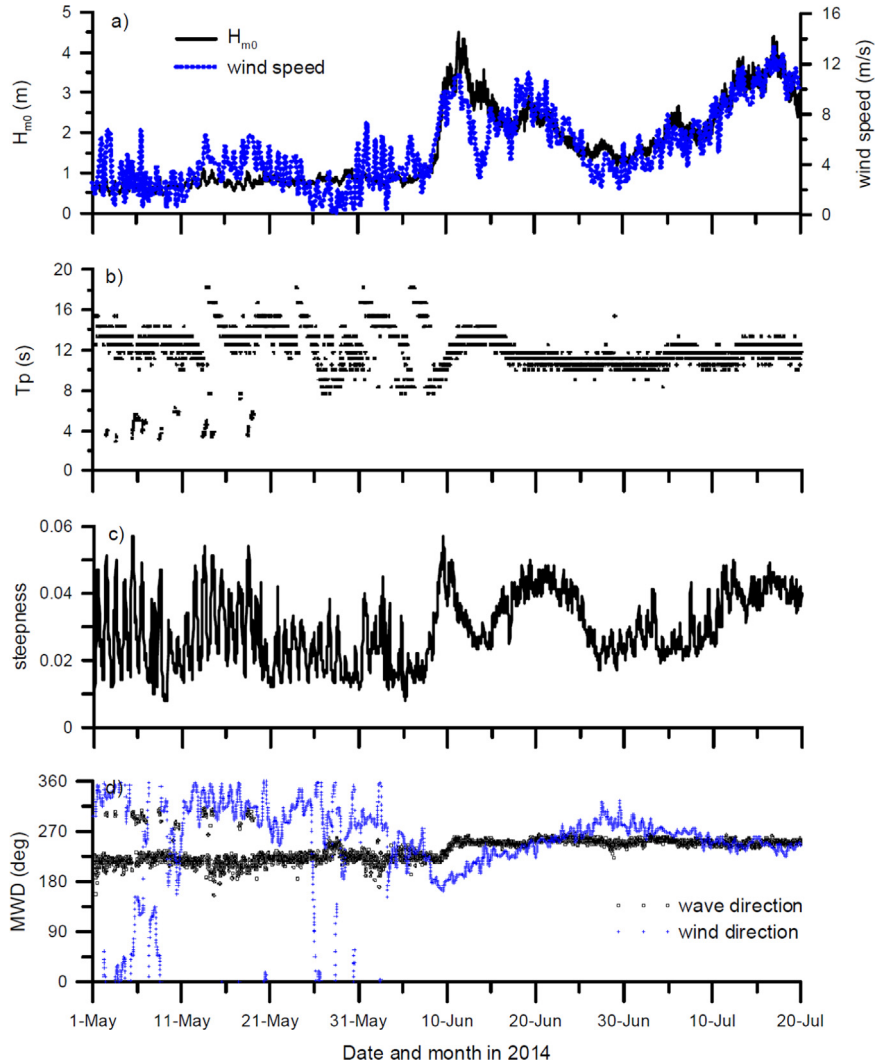

Fig. 2. Time series plot of (a) significant wave height (H_{m0}) and wind speed, (b) peak wave period (T_p), (c) wave steepness and (d) mean wave direction (MWD) and wind direction from 1 May to 19 July 2014 off Vengurla.