Short-term changes in the surface wave characteristics off Kollam coast

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Abstract. Study of wave characteristics off the Kollam coast has been carried out to understand the predominant wave representation during the different seasons of a year. This study becomes important since any developmental activities and coastal issues are confined to the coastal processes of the region. One year continuously measured wave data available with INCOIS is used for the present study. The waves during the monsoon are characterized by higher energy waves and intermediate periods with waves approaching from western directions. The pre-monsoon and post-monsoon seasons are characterized by lower energy waves and shorter periods with the direction being more southwesterly.

1. Introduction
Kollam district (formerly the Quilon), is a coastal town which forms a part of the 590 km Kerala coast and is well known for the occurrence of beach placer heavy mineral deposits. The western side of the coastal district bordered by Arabian Sea is thickly populated, which cites the importance of understanding the coastal processes such as erosion, accretion, shoreline changes, etc., occurring in the stretch which in turn affects the various coastal activities. The fundamental goal of the study is to describe the characteristics of the surface waves in the nearshore waters off Kollam. This is important since waves are the major forcing parameter for the nearshore processes, which in turn predicts the nature of the coast. The dominant portion of the wave spectrum in terms of energy is associated with the surface waves called gravity waves ranging from 1 to 30s [1]. The coastal processes along the south-west coast of India mainly depend on the wave forces, which are the major controlling force, prevailing over the three different seasons; viz. pre-monsoon (February–May), monsoon (June–September) and post monsoon (October–January). Kerala is a monsoon-dominated coast [2]. Even though the waves off the southwest coast of India are well understood, the wave characteristics with regard to the spatial variability in nearshore should be studied at each location [3]. In order to explain the changes in the surface wave characteristics of the actual sea state in statistical terms, the concept of the significant wave is used for the present study [4]. Any attempt to handle the coastal problems requires a thorough understanding of the factors and processes involved in the coastal geomorphological system [5]. A detailed understanding of the wave climate is important to interpret the coastal process and its impact on the shore.
2. Data and methods

One year continuously measured wave data, available with Indian National Centre for Ocean Information Services (INCOIS), is used for the understanding of wave distribution along the coastal stretch of Kollam. The coast along this region is aligned in the SE-NW direction. The wave data measured using the Datawell directional wave rider buoy at 22 m water depth (geographic position 8.9785° N; 76.4445° E) off Kollam from February 2014 to January 2015 is used for the study. The data for every 30 minutes were processed as one record. The gathered data was sorted and analyzed for the three seasons. The ‘International sea and swell scale’ or the ‘Douglas sea scale’ (Table 1) adopted by the World Meteorological Organization (www.nodc.noaa.gov) is used to define the sea state for different seasons.

Table 1. World Meteorological Organization sea state code

| Degree/ Sea state code | Description          | Height (m) |
|------------------------|----------------------|------------|
| 0                      | Calm (Glassy)        | No wave    |
| 1                      | Calm (Rippled)       | 0-0.1      |
| 2                      | Smooth               | 0.1-0.5    |
| 3                      | Slight               | 0.5-1.25   |
| 4                      | Moderate             | 1.25-2.5   |
| 5                      | Rough                | 2.5-4      |
| 6                      | Very rough           | 4-6        |
| 7                      | High                 | 6-9        |
| 8                      | Very high            | 9-14       |
| 9                      | Phenomenal           | Over 14    |

3. Results and discussion

For the purpose of presentation, the wave data are grouped into three seasons; viz. pre-monsoon (February–May), monsoon (June–September) and post-monsoon (October–January). The seasonal average wave characteristics at the 22m water depth off Kollam are given in Table 2.

Table 2. Seasonal average wave characteristics of Kollam

| Parameters                          | Pre-monsoon | Monsoon | Post-monsoon |
|-------------------------------------|-------------|---------|--------------|
|                                     | Range       | Average | SD           | Range       | Average | SD           | Range       | Average | SD           |
| Significant wave height, Hs (m)     | 0.42-14.08  | 0.72    | 0.44         | 0.87-8.23   | 1.79     | 0.44         | 0.28-3.48   | 0.70     | 0.23         |
| Peak period, Tp (s)                 | 2.78-25.00  | 12.94   | 2.9          | 4.76-25.00  | 11.91    | 2.75         | 2.58-20.22  | 12.95    | 2.48         |
| Zero up crossing period, Tz (s)     | 2.94-21.05  | 4.75    | 1.01         | 4.54-16.67  | 6.69     | 0.93         | 2.80-20.22  | 5.37     | 1.42         |
| Peak wave direction, θp (deg)       | 63.30-326.30| 206.34  | 23.82        | 180.00-331.9| 237.14  | 25.12        | 9.84-357.20| 206.78  | 24.26        |

The wave climate along the Kollam coast is quite rough during monsoon season (June to September), with a moderate sea state (wave height range 1.25-2.5 m) and comparatively calm
conditions during the pre-monsoon (February to May) and post-monsoon (October to January) seasons, with a slight sea state (wave height range 0.5-1.25 m).

3.1 Distribution of wave height
The significant wave height (Hs) ranged from 0.28-14.08 m with an average of 1.14 m during the 1 year period of study. It was observed that during monsoon the significant wave height varied from 0.87 to 3.31 m, occasionally with some high waves ranging up to 8.23 m which may be due to storm events. The percentage distribution of significant wave height shows that during monsoon about 83.7% of the wave heights range between 1.25-2.5 m. For the pre-monsoon and post-monsoon seasons, it is observed that majority of the wave heights falls within the range of 0.5-1.25 m, with a percentage occurrence of 92.62% and 80.56% respectively. The wave characteristics are governed by seasons, with high wave activity during the south-west monsoon period (June-September) and comparatively low waves for the rest of the year. The percentage distribution of significant wave heights for pre-monsoon, monsoon and post-monsoon seasons are shown in figure 1 (a), (b), (c).

![figure 1(a)](image-url)

**Figure 1(a).** Percentage distribution of significant wave heights from February 2014 to May 2014

![figure 1(b)](image-url)

**Figure 1(b).** Percentage distribution of significant wave heights from June 2014 to September 2014
Figure 1(c). Percentage distribution of significant wave heights from October 2014 to January 2015

Figure 2 depicts the distribution of mean monthly significant wave height for the study period. This interprets a better representation of monthly changes in the wave characteristics.

Figure 2. Distribution of mean monthly significant wave height during the study period

3.2 Distribution of wave period
According to Bromirski et al. [6], waves were classified into (i) short period waves (T<6 s) dominated by local seas, (ii) long-period waves (T>12 s) results primarily from swell and (iii) intermediate period waves (6s < T< 12s) probably results from a mixture of local and regional wind forcing. The percentage distribution of zero up-crossing period (Tz) and the peak wave period (Tp) for pre-monsoon, monsoon and post-monsoon seasons are shown in figure 3 (a), (b), (c). It was observed that during pre-monsoon and post-monsoon seasons the zero up-crossing period (Tz) falls within the range of 2-9 s contributing to nearly 96.62% and 80.56% of the distribution respectively. The predominant values during pre-monsoon were in the range 4-6 s, contributing to 47.67% of the distribution and that of post-monsoon were in the range 4-6 s, contributing to 49.44% of the distribution. So the majority of the waves belonged to short period waves (4-6 s) during the fair weather seasons.
Figure 3(a). Percentage distribution of wave periods from February 2014 to May 2014

Figure 3(b). Percentage distribution of wave periods from June 2014 to September 2014

Figure 3(c). Percentage distribution of wave periods from October 2014 to January 2015
For the monsoon season it was observed that the zero up-crossing period (Tz) falls within the range of 4-10 s contributing to nearly 83.70% and the predominant values were in the range 6-8 s, contributing to 62.09% of the distribution. Most of the waves during the southwest monsoon were intermediate period waves (6-12 s). The peak wave period (Tp) is the wave period associated with the most energetic waves.

3.3 Mean wave direction

The percentage distribution of wave height and the corresponding directions of the approach of these wave heights for the three seasons viz. pre-monsoon (February-May), monsoon (June-September) and post-monsoon (October-January) are shown in figure 4 (a), (b) and (c).

![Figure 4(a). Wave height and direction distribution from February 2014- May 2014](image)

![Figure 4(b). Wave height and direction distribution from June 2014- September 2014](image)
The waves predominantly approach the coastline from south-south-west (SSW) to south-west (SW) direction during the pre-monsoon and post-monsoon seasons and west (W) and south-west (SW) directions during monsoon season. During the pre-monsoon season majority of waves approaching the coast was with significant wave height ranging from 0.5-1.25m and 52.33% was from SSW direction and 35.53% from SW direction. The major portion of the waves approaching the coast during monsoon was with significant height in the range of 1.25-2.5m and 33.14% was from W direction, 23.39% from SW direction and 16.12% from WSW direction. Post-monsoon season exhibited a similar range of significant wave height as in pre-monsoon but the direction of approach of the waves was different. Waves approaching from SSW direction were 39.17%, that from SW direction was 31.99% and from WSW was about 3.58%.

3.4 Joint distribution of wave height and period
The joint distribution of significant wave height and zero up-crossing wave period was studied for the three seasons. A wave is not specified until it is associated with a reasonable wave period [7]. During pre-monsoon season majority of the waves (71.84%) approaching the coast were with significant wave height between 0.5-1.25m and zero up-crossing periods ranging 4-6 s. For the monsoon season most of the waves (62.08%) approaching the coast is associated with a significant wave height of 1.25-2.5m and zero up-crossing periods of 6-8 s. Whereas during the post-monsoon season most of the waves (66.41%) were with significant wave height ranging from 0.5-1.25m and zero up-crossing period of 4-7 s.

4. Conclusion
The short-term changes in the surface waves off Kollam coast measured at a water depth of 22m have been carried out to understand the predominant wave condition during the different seasons of a year. This study becomes important since any developmental activities and coastal issues are confined to the coastal processes of the region. During the study period, significant wave height and zero up-crossing periods were observed maximum in the monsoon season with predominant waves approaching from W-SW directions. The fair weather seasons exhibits waves with comparatively low heights and short periods. This is due to the variation of wave energy during different seasons and locations. The
information and study on the wave characteristics are extremely important for coastal hydrodynamic studies, carrying capacity studies, coastal zone management, and coastal development activities. The height, period and direction of the wave when approaching the shoreline may vary due to different wave phenomena such as breaking, refraction, diffraction, shoaling, etc., and also may vary with respect to the location. The wave statistics, therefore, indicate the surface wave characteristics of the location which is the basis for the understanding of coastal processes of the location. Further, a long term study of the wave climate is required to thoroughly understand the usual trend and pattern of wave events.

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