Attenuation of 'short waves' in the mudbank region off Alleppey, Kerala coast, India

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Waves exert pressure on the seabed, and in the case of fluidized mud seafloor, the bed moves, resulting in damping of incoming waves by the fluid mud layer. One of the best examples for such a phenomenon are mudbanks (MB) off Kerala coast. MBs are reservoirs of fine suspended sediments occurring along the coast, which can dampen the waves resulting in clearly demarcated areas of calm water even during the roughest monsoon conditions. MBs off Kerala coast have been considered as unique formations as they occur in a non-estuarine region. Similar formations are reported off the Yellow River delta in the Bohai Sea of China, and near the Amazon River mouth along the northeast coast of Brazil and the Guianas; but these are permanent muddy-bottom, unlike Kerala MBs, which are proved to be dynamic, and shift their positions with time and most importantly occur far away from estuaries (Samiksha *et al.*, 2015). A clear-cut evidence to its formation is yet to be established, as various studies (Samiksha *et al.*, 2015) could not explain all the observed characteristics of the mud- banks and uniqueness of it. Mathew (1992) reported that MBs are typically 2 to 8km in length alongshore, 1 to 3km in the cross-shore direction and mud density in this region generally ranges between 1,080 and 1,300 kg/m^3.

As a part of the Project on Alleppey Mudbank Process Studies (AMPS), we made an attempt to study mudbank-attenuated waves from the measured data. One wave rider buoy was deployed in the expected MB region off Alleppey, Kerala (Fig. 1) at 15m water depth ahead of the onset of the event (21 May - 31 July 2014) (B1), and another one at 7m water depth (26 June - 31 July 2014) (B2) after the formation of the MB. In this presentation, we would like to focus on the behaviour of wave energy spectra after the formation of MB. The highest significant wave height (Hs) observed at location B1 is 3.16m, with maximum wave height (Hmax) of 5.31m for the whole measurement period. But, when we consider the common measurement period (including B2 location), Hs was 2.64m (Hmax = 4.39m) at B1 and Hs was 2.03m and Hmax = 2.12m at B2. Similarly, the mean period at both locations varied from 4 to 10s. Wave direction remained almost the same at both the locations, ranging between 200° and 280° (Fig. 2). H_s were also extracted from the ERA-Interim database (Dee *et al.*, 2011) for the study area in order to use it as reference data for no-MB condition. Comparison of measured Hs with the ERA-Interim H_s clearly indicates the arrival of MB at 15m water depth on 12 June 2014. We analysed the wave height data at both the locations to calculate the percentage of wave height attenuation at B2 location compared to B1 location (Fig. 3), and we found ≈ 50 - 60% attenuation at 7m water depth w.r.t 15m depth. It may kindly be noted that wave height attenuation percentage would be certainly much higher if we compare with H outside the periphery of MB. In our recent study (Samiksha *et al.*, 2015, communicated), we have used the latest version of WAVEWATCH III model with the two mud formulations, viz., Dalrymple and Liu (1978) and Ng (2000) to reproduce wave energy attenuation in the mudbank region, and the model results matched very well with measurements. We also proved the dynamic nature of the MB off Alleppey, which was otherwise only speculated.

In order to analyse wave energy attenuation in the frequency band, typical normalised wave spectra were extracted: (i) before the formation of MB at B1 i.e. on 6 June 2014 and (ii) after the formation of MB i.e. on 24 June and 4 July 2014. The low (long waves) and high (short waves) frequency bands are defined here as $f \leq 0.18$Hz and $f > 0.18$Hz, respectively. We observe downshift of peak frequency as days progressed after the MB formation, with the attenuation of short waves (Fig. 4a). Similar features are observed for the spectra at B2 (Fig. 4b). The energy in the high frequency region of the spectra reduced considerably after the formation of MB at both the locations, but higher at B2. Sheremet *et al.,* (2005) suggested that the observed short-wave dissipation may be due to nonlinear energy transfer within the wave spectrum which further allows the coupling between the short- and long-wave spectral bands, allowing energy to flow toward long waves, where it can be efficiently dissipated via direct wave-bottom interaction. More detailed study is planned in order to study the attenuation of short waves by separating the wind, seas and swells, and also through numerical modelling. In our previous studies the dissipation source term will be analysed in order to account for the attenuation of short and long waves separately, and the results will be discussed during presentation. We acknowledge *ECMWF* for providing the ERA-Interim *wave data.*

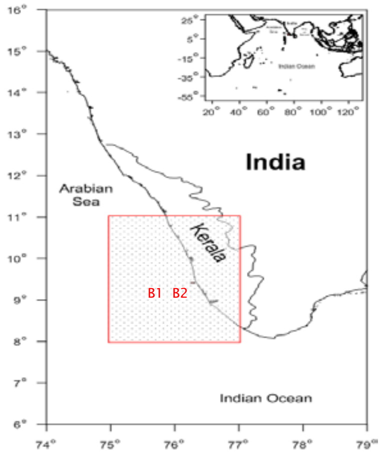

Fig. 1. Area of study and the locations of moored wave rider buoys (B1 and B2) at 15m and 7m water depths off Alleppey, Kerala, India.

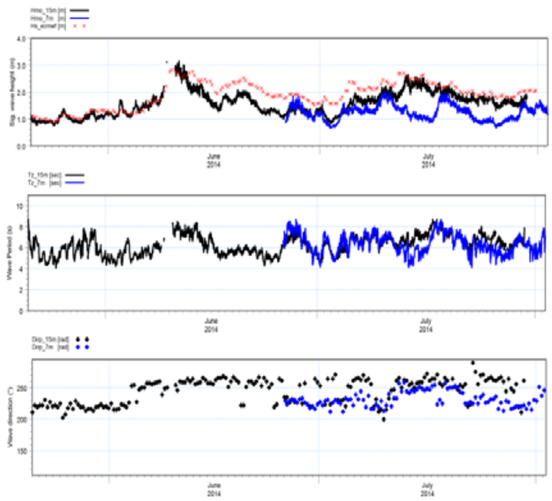

Fig. 2. Comparison of wave parameters (Hs, Tm and Dir) at 15m (B1) and 7m (B2) water depths. Hs obtained from ERA-Interim database is also plotted for reference of no-mud condition (Samiksha *et al.*, 2015).

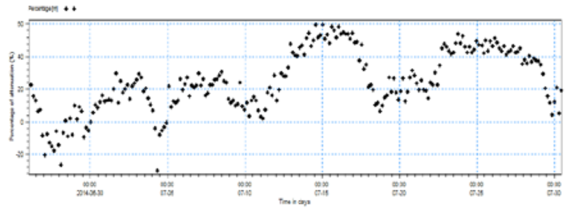

Fig. 3. Percentage of wave height attenuation at 7m water depth compared to 15m water depth.

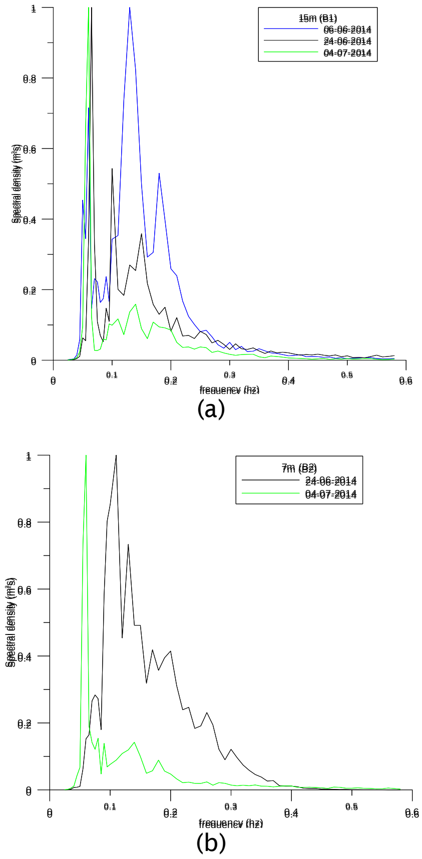

Fig. 4. Normalised wave energy spectra at (a) 15m depth and (b) 7m depth.

References

Dalrymple R.A. and P.L.-F. Liu. 1978. Waves over soft muds: A two layer fluid model. J. Phys. Oceanogr. 8:1121-1131.

Dee D.P. *et al.* 2011. The ERA-Interim reanalysis: configuration and performance of the data assimilation system, ECMWF, Reading, ERA report series 9. 71p.

Mathew J. 1992. Wave-mud interaction in mudbanks. PhD Thesis.

Mathew J. and M. Baba. 1995. Mudbanks of SW coast of India II: wave-mud interaction. Journal of Coastal Research 11:178-187.

Ng C.-N. 2000. Water waves over a muddy bed: a two-layer Stokes boundary layer model. Coastal Eng. 40:221-242.