ABSTRACT

The head Bay of Bengal located in the north Indian Ocean is a deltaic area with complex geomorphologic setting, and highly vulnerable to threats from sea-level rise and extreme weather events. Wind-wave climate influence the physical processes in this coastal environment and subsequently can intensify the coastal vulnerability. The impact of climate change on wind-wave regime from this region is not known well, and there is a need to perform its long-term assessment for societal benefits. The thesis provides a comprehensive analysis on the temporal variability in domain averaged wind speed, significant wave height (SWH) utilizing satellite altimeter data and mean wave period using ECMWF reanalysis products ERA-Interim and ERA-20C over this region. The SWH derived from WAVEWATCH III (WW3) model and ERA-Interim reanalysis supplements the observed variability in satellite altimeter observations. The analysis shows an increasing trend of annual mean and maximum wind speed derived from altimeter and to a lesser extent for the SWH. Interestingly, the trend is higher for maxima compared to the mean conditions. A separate trend analysis for the wind-seas, swell wave heights and period from ERA-20C deciphers the fact that distant swells governs the local wind–wave climatology over this region, and over time the swell activity have increased. Thereafter, the thesis investigates the spatial variability of trends in wind speed and SWH over the head Bay basin. The study clearly signifies that trends in both wind speed and significant wave height is lower for the western side, unlike that noticed over the eastern side of the basin. The east-west contrast observed in the trends of wind speed and significant wave height is attributed to the variations in sea level pressure (SLP). The SLP in turn is governed by prevailing atmospheric conditions; therefore the study attempts to investigate the inter-annual variability of atmospheric parameters and its role on the observed zonal dipole trend in sea level pressure, surface wind speed and significant wave height. It inspects the linear trend as well as its spatial variability for several atmospheric parameters: air temperature, geopotential height, omega (vertical velocity), and zonal wind, over the head Bay of Bengal, by analyzing National Centers for Environmental Prediction (NCEP) Reanalysis 2 dataset. Significant warming within the troposphere exhibits spatial difference between eastern and western side of the domain. This leads to fall in lower tropospheric geopotential height and its east–west variability, exhibiting a zonal dipole pattern across the Head Bay. Variability in omega also substantiates the observed variations in geopotential height. Further, the study evaluates the influence of this atmospheric variability on the observed dipole in trends of sea level pressure, wind speed and significant wave height. Information on the spectral wave characteristics is an essential pre-requisite for ocean engineering related activities and also to understand the complex wave environment at any given location. There is no comprehensive study available that reports on wave spectra over the head Bay of Bengal region. Thus, the next part of the thesis attempts to describe the characteristics of spectral wave evolution across different locations over this deltaic region based on numerical simulations. Thus, it implements a multi-scale nested modeling method using two state-of-art wave models WAM and SWAN forced with ERA-Interim winds. The inter-seasonal variation in monthly averaged 1D spectra and transformation of spectra along various water depths are discussed along with the associated physical processes. The study indicates that the influence of swells is higher at series of points over the eastern part than those over the western part. The 2D wave spectra exhibits different wave systems approaching from various directions attributed due to reflected swell system from south-southeast all over the year, southwest swells, reversing wind-seas following local winds, and reflected wind-seas from land boundary.