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Numerical Modelling of the Influence of Meteorological Forcing on Water-Level in the Head Bay of Bengal

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Abstract : Water-level information along the coast is very important for disaster management, navigation, planning shoreline management, coastal engineering and protection works, port and harbour activities, and for a better understanding of near-shore ocean dynamics. The water-level variation along a coast attributes from various factors like astronomical tides, meteorological and hydrological forcing. The study area is the Head Bay of Bengal which is highly vulnerable to flooding events caused by monsoons, cyclones and sea-level rise. The study aims to explore the extent to which wind and surface pressure can influence water-level elevation, in view of the low-lying topography of the coastal zones in the region. The ADCIRC hydrodynamic model has been customized for the Head Bay of Bengal, discretized using flexible finite elements and validated against tide gauge observations. Monthly mean climatological wind and mean sea level pressure fields of ERA Interim reanalysis data was used as input forcing to simulate water-level variation in the Head Bay of Bengal, in addition to tidal forcing. The output water-level was compared against that produced using tidal forcing alone, so as to quantify the contribution of meteorological forcing to water-level. The average contribution of meteorological fields to water-level in January is 5.5% at a deep-water location and 13.3% at a coastal location. During the month of July, when the monsoon winds are strongest in this region, this increases to 10.7% and 43.1% respectively at the deep-water and coastal locations. The model output was tested by varying the input conditions of the meteorological fields in an attempt to quantify the relative significance of wind speed and wind direction on water-level. Under uniform wind conditions, the results showed a higher contribution of meteorological fields for south-west winds than north-east winds, when the wind speed was higher. A comparison of the spectral characteristics of output water-level with that generated due to tidal forcing alone showed additional modes with seasonal and annual signatures. Moreover, non-linear monthly mode was found to be weaker than during tidal simulation, all of which point out that meteorological fields do not cause much effect on the water-level at periods less than a day and that it induces non-linear interactions between existing modes of oscillations. The study signifies the role of meteorological forcing under fair weather conditions and points out that a combination of multiple forcing fields including tides, wind, atmospheric pressure, waves, precipitation and river discharge is essential for efficient and effective forecast modelling, especially during extreme weather events.

Keywords : ADCIRC, head Bay of Bengal, mean sea level pressure, meteorological forcing, water-level, wind
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