3D seamless cross-scale modelling of tides and their seasonality in the GBM (Ganges-Brahmaputra-Meghna) delta

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Abstract

The Ganges-Brahmaputra-Meghna (GBM) system is the largest delta in the world, located in the Northern Bay of Bengal. It is very densely populated and characterized by low topography (typically less than 3m above mean sea level) (Krien et al. 2016). Numerous processes influence its dynamics, from high-frequency tides to sea level rise, as well as seasonal variations in river flow (wet/dry season) and extreme events (cyclones) (Krien et al., 2017; Elahi et al., 2020). It consistently displays a sharp salinity front, separating the freshwater of riverine origin in the Northern part of the delta, from the Bay of Bengal saline water in the South (Sherin et al., 2020). The position of this front oscillates landward and oceanward over a wide range of timescales, under the influence of the various physical processes mentioned above (Bricheno et al., 2021).

In this study, we use a cross-scale ocean circulation model, SCHISM (Semi-implicit Cross-scale Hydroscience Integrated System Model, Zhang et al., 2016), in a 3D baroclinic high-resolution configuration encompassing the Bay of Bengal and the entire GBM delta. This configuration is an evolution of a previous 2D configuration implemented and used in various studies over the past few years (Krien et al., 2016, 2017; Tazkia et al., 2017; Khan et al., 2020, 2021, 2022). Tide gauge data, extracted in particular from a new dataset (Testut et al., 2024) including tidal harmonics and time series, are used to validate the model.

The aim of this study is to better understand the interactions between salinity and the tidal dynamics. The GBM delta and associated plume are highly stratified (Sinha et al., 1999; Alam et al., 2020) with a large difference in salinity intrusion between the dry and the wet season. Strong stratification tends to stabilize the water column and alter the tidal dissipation within the plume. Through various sensitivity tests, we explore in the model the impact of this stratification on the tidal amplitude along the coast and on its seasonal modulation.