SEASONAL MODULATION OF M2 TIDE IN THE BAY OF BENGAL

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Introduction

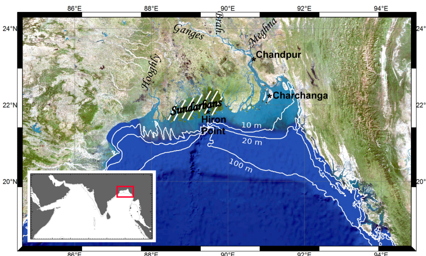

Fig. 1: Geography or the area. The three tide gauge sites used subsequently are indicated.

The northern Bay of Bengal (BoB) is the largest deltaic region of the world ocean. It is also the most densely populated (1200/km^2 on average), and it is highly vulnerable to sea level extremes and associated flooding events (with frequent and deadly storm surges). This is explained by the very low elevation of the whole delta (typically less than 5 meters above MSL). There is thus a need to observe, understand and better represent the variability of sea level in this key-climatic area.

The area is macrotidal, with ranges up to 4-5 m. The tide is dominated by M2 component (lunar semi-diurnal). One of the key parameters of cyclone surges and associated inundation over the area is the tidal water level [Krien et al., 2016a]. The knowledge of the tidal characteristics is limited in the BoB, for several fundamental reasons [Krien et al., 2016b]:

- Poor knowledge of the rapidly changing bathymetry, complex geometry of the delta
- Complex, vigorous rivers outflows that interact with the ocean flow
- Transboundary area, with a scarcity of in situ observations

The oceanographic community of our area puts a lot of hope in the forthcoming altimetric missions devoted to the rivers-estuaries-ocean continuum, such as SWOT. However, a fundamental challenge for these future datasets lies in the necessary de-aliasing of tidal signals. Hence a very good knowledge of the tidal characteristics is a pre-requisite.

This poster deals with one of the least understood facets of BoB tide: its seasonal variability.

Observations of M2 seasonal variation reveal a huge signal in the Bay of Bengal

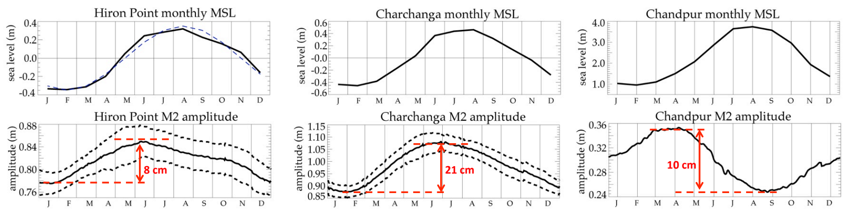

Fig. 2: Seasonal evolution of M2 amplitude (bottom) and monthly mean sea level (top) observed at the three tide gauge sites shown in Fig. 1 (in m).

In situ observations reveal that M2 amplitude in the northern BoB is among the top most variable in the world ocean (it is typically of order 1cm or less in the coastal ocean, worldwide).

A distinct timing of M2 modulation is observed:
- at oceanic locations: M2 amplitude roughly in phase with monthly mean sea level;
- in the estuary: vice-versa.

This constrast suggests two different mechanisms driving seasonal modulation of M2. In particular, it rules ou the linear effect of dilution/concentration of tidal energy, at oceanic locations.

Hydrodynamic modelling of M2 seasonal variation

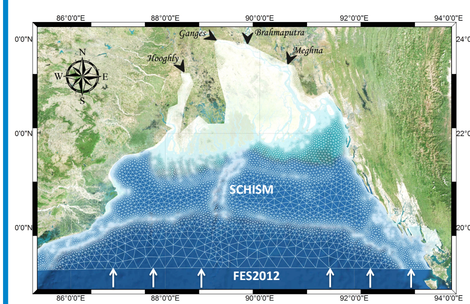

Fig. 3: Domain of our hydrodynamic model SCHISM

We use an unstructured grid (Fig. 3) with varying resolution (from 30 km to 50 m), and the circulation model SCHISM in 2DH mode, forced at the open ocean boundary with FES2012 (26 harmonics). River discharge is imposed for the Ganges, Brahmaputra, Meghna, and Hooghly river (Fig. 5). Seasonal oceanic steric height variability observed at Hiron Point is prescribed at open boundary. Variable Manning coefficient is defined (Fig. 4). The realism of the tide simulated by our model exceeds all solutions previously published (Krien et al, 2016b for full validation). Fig. 6 shows that the model reproduces decently the pattern of seasonal modulation of M2 observed at our three tide gauge stations.

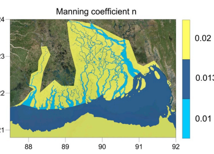

Fig. 4: Map of Manning coefficient of our model

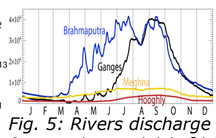

Fig. 5: Rivers discharge forcing the model (m^3/s)

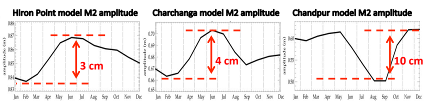

Fig. 6: Amplitude of M2 tide simulated by our model at the three tide gauge sites (in m).

Mechanisms of M2 seasonal variations from the model

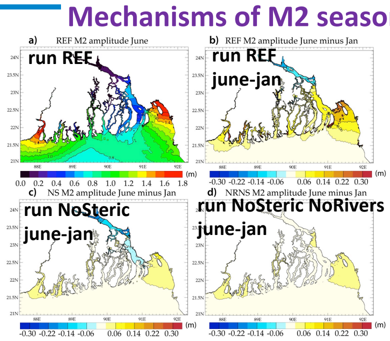

Fig. 7: Maps of M2 amplitude in the model sensitivity experiments (in m)

In order to identify the mechanisms of M2 modulation, we performed a reference run (REF) and 3 sensitivity experiments with the model:

1- Run « NoSteric »: same as REF, but without the seasonal steric height variability imposed at ocean open boundary

2- Run « NoSteric NoRivers »: both steric height variability and rivers runoff are switched off

3- Run « Manningx2 »: same as REF, except that the Manning coefficient (see Fig. 4) is doubled.

Fig. 7 shows that the steric height variability is largely responsible of M2 modulation in the coastal ocean as well as in downstream part of estuaries, while the rivers runoff drive M2 modulation in the upstream part of Meghna estuary.

Fig. 8 suggests that M2 modulation in the coastal ocean and estuaries is driven by seasonal modulation of frictional effects at ocean bottom.

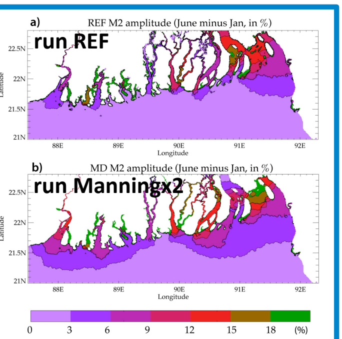

Fig. 8: Maps of model M2 relative amplitude (June minus January), in %

Implications and conclusions

In the northern Bay of Bengal, seasonal variability of the tidal amplitude has a magnitude commensurate – and even superior – to the typical accuracy target of altimetric missions in the coastal ocean and estuaries. As a consequence, our study advocates for a careful handling of the seasonal variability of the tidal range in the altimetric processing systems, over our area. This will be particularly needed when considering the future SWOT swath altimetry mission, dedicated (among others) to the monitoring of water level across the continuum coastal ocean – estuaries – rivers.

REFERENCES

- Krien et al. (2016a), Storm surge dynamics in the head Bay of Bengal: contributions of tide-surge interactions and waves. Cont. Shelf Res., submitted.
- Krien et al. (2016b), Improved Bathymetric Dataset and Tidal Model for the Northern Bay of Bengal. Marine Geodesy, DOI: 10.1080/01490419.2016.1227405 2016.

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