The Challenges of SWOT Tidal De-Aliasing across the Land-Ocean Continuum in Deltaic Environments: A Case Study over the Bay of Bengal

Md Jamal Uddin Khan[1], Fabien Durand[2], Yann Krien[3], Laurent Testut[4], Stéphane Calmant[2], AKM Saiful Islam[5]

[1]LEGOS/CNES, [2]LEGOS/IRD, [3]LARGE, [4]LEGOS/LIENSs, [5]IWFM/BUET

Introduction

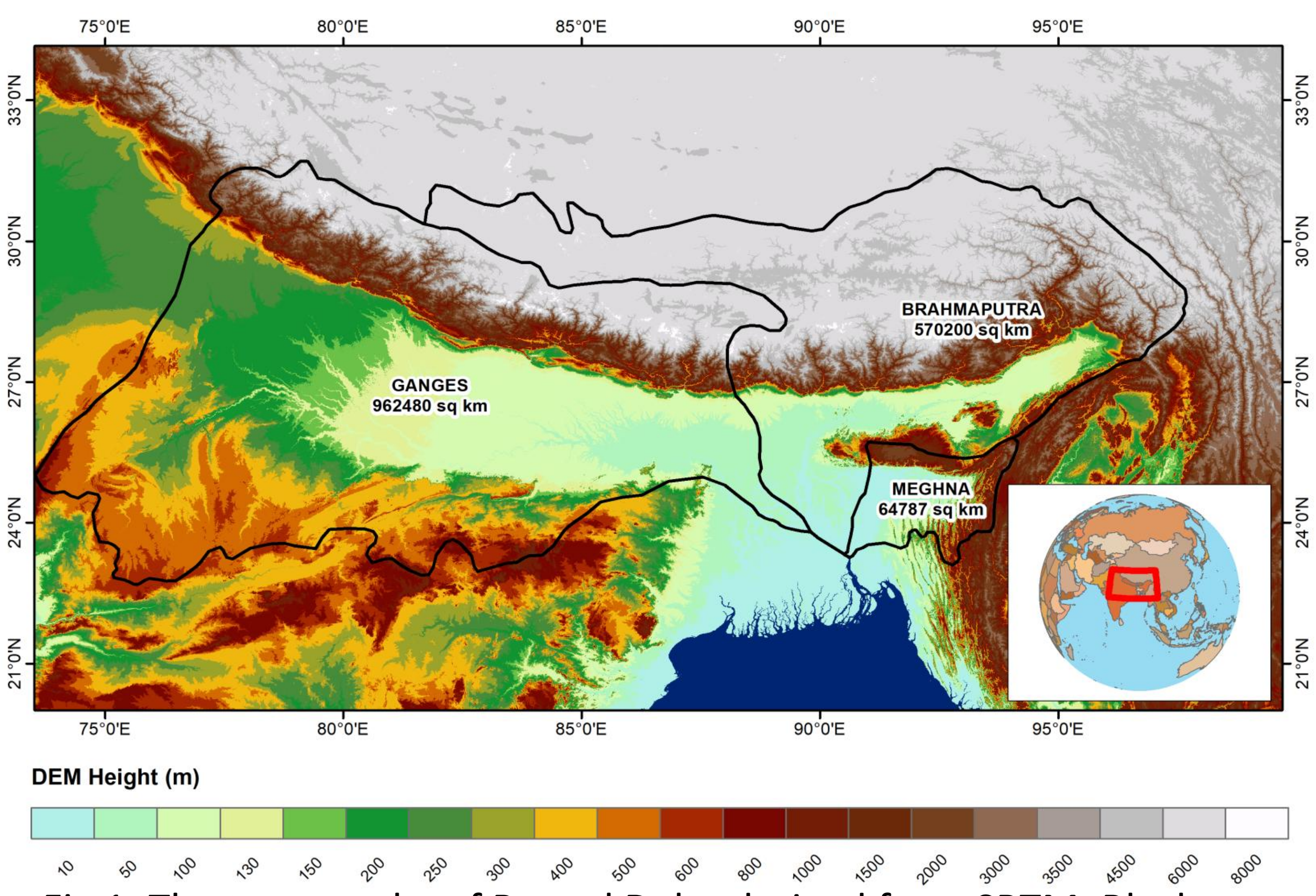

Fig 1: The topography of Bengal Delta derived from SRTM. Black outlines the Ganges-Brahmaputra and Meghna Basin.

In the context of SWOT mission, the signature of tidal variability in water level presents both an opportunity and a challenge. Compared to previous along-track altimeter missions, SWOT will provide an unprecedented coverage of sea-surface height measurement in the near-shore domain, presenting an opportunity to study coastal and shelf tides with unprecedented details. At the same time, the core objective of SWOT mission is to retrieve the non-tidal signals, which will require the de-aliasing of tide from the signal. Compared to open-ocean barotropic tide, which has been mapped quite well with nadir altimetry, coastal and shelf tides in deltaic and estuarine regions will be difficult to retrieve from altimetry and in-situ observations because of their smaller horizontal scale and inherent non-stationarity. The tidal models thus appear unavoidable to assess the spatial and temporal characteristics of the tide, and correcting the future SWOT data.

One such area is Bengal delta (Fig. 1). The northern Bay of Bengal has a characteristic shallow submarine delta with very low topographic gradient (slope of order 10^{-3} or less), macro tidal regime (up to 7m tidal range, Tazkia 2017) and low elevation topography with numerous, interconnected, tidally-influenced rivers.

The state-of-the-art global hydrodynamic tidal models (FES, GOT, TPXO) show typical error in the range of 40cm-80cm over the region (Krien et al., 2016), way beyond what is acceptable for de-aliasing of SWOT data and do not provide enough resolution for the small channels. Moreover the region suffers from the scarcity of in-situ data which makes the problem relatively harder to solve. Here we present an ongoing initiative to collect and in-situ topographic/bathymetric databases, so as to model the tidal water level evolution on northern Bay of Bengal from creek-to-ocean scale. The present model builds on Krien et al. (2016) and uses the same modeling framework (SCHISM) (Zhang and Baptista 2008).

Multisource Bathymetry and Model Mesh

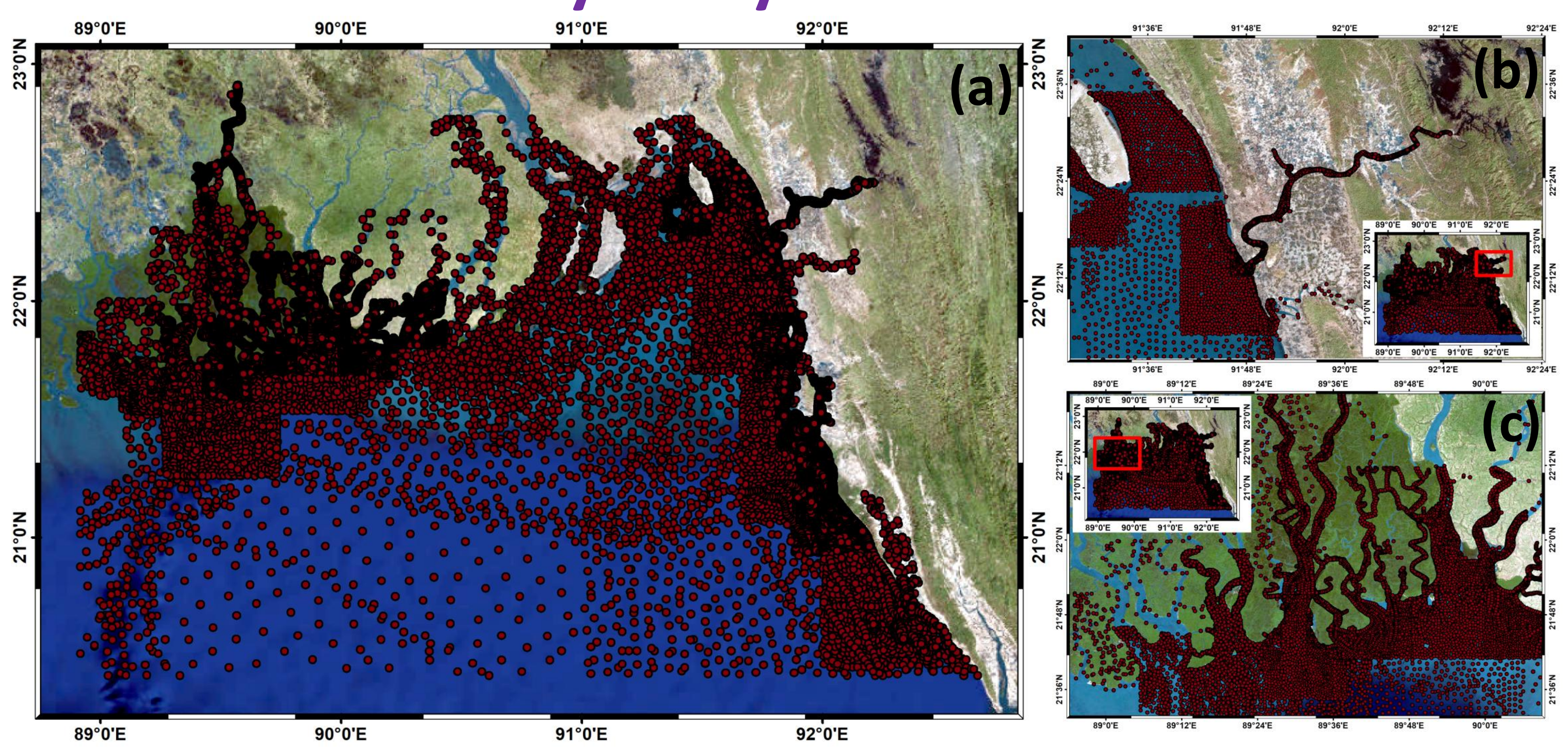

Fig 2: (a) Our bathymetry sounding points primarily digitized for the purpose of the present study. Zoomed view in (b) Chittagong and (c) Sundarban region. We merged these sounding points with the database from Krien et al. (2016).

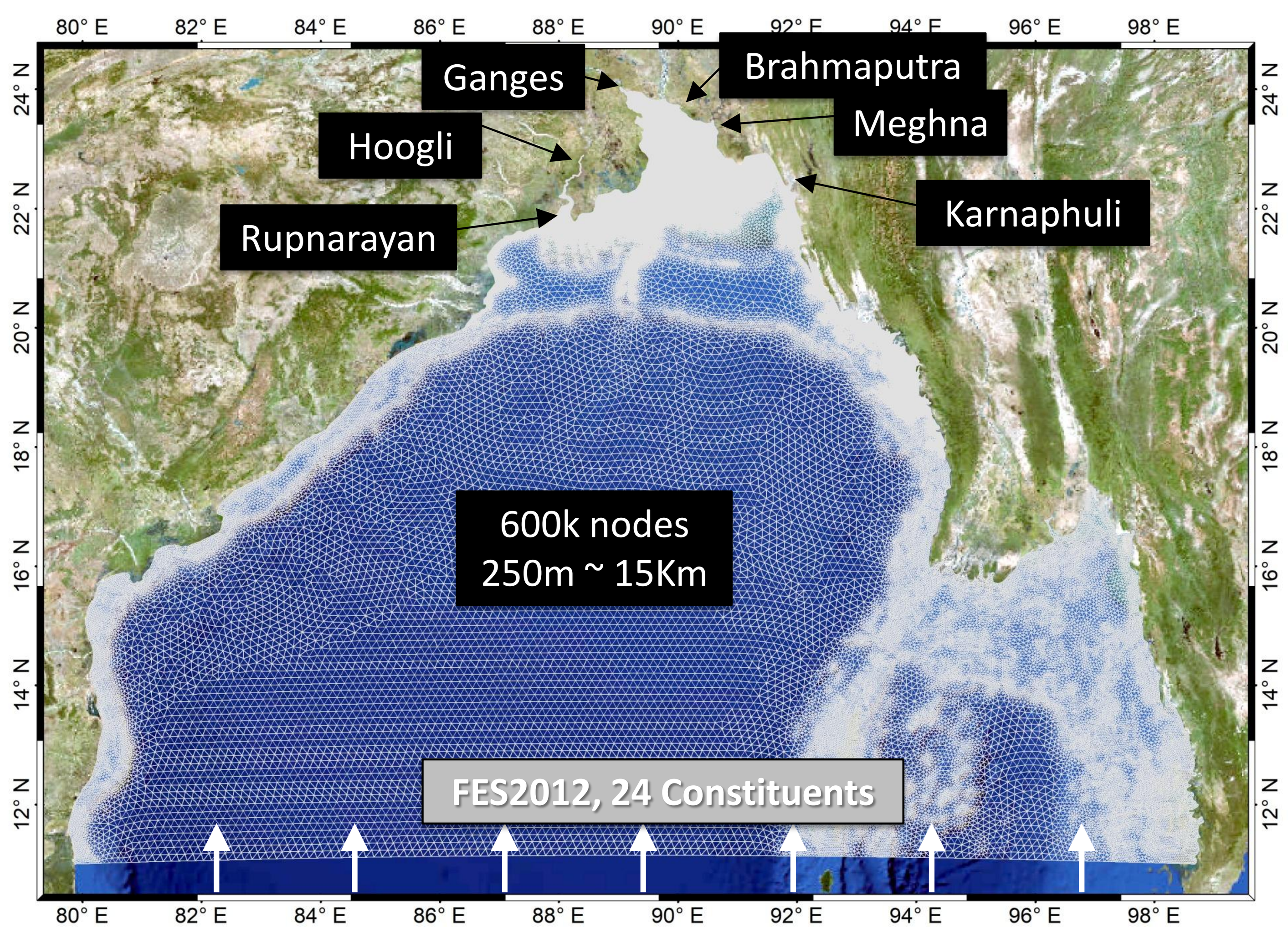

Fig 3: Our hydrodynamic SCHISM model finite-element mesh. We indicate the 6 rivers outflows prescribed at the land boundary.

Model Performance and Results

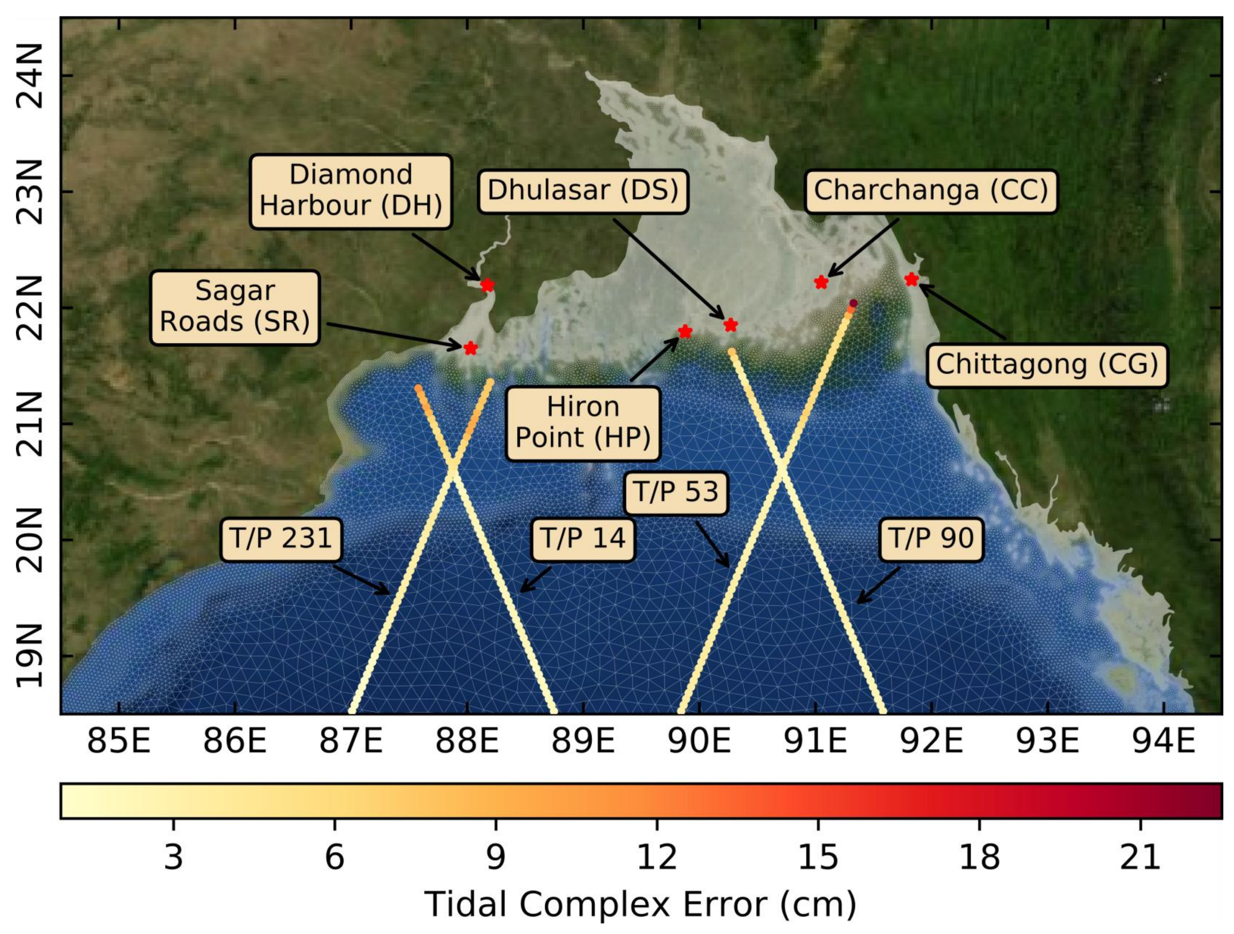

Fig 4: Complex Tidal error along track of T/P class altimeters.

Tab 1. Root-Mean-Squared complex error (cm)

Station	FES2012	Krien 2016	Our model
Charchanga	37	35	21
Chittagong	41	14	18
Dhulasar	44	19	15
Diamond Harbour	NA	15	13
HironPoint	40	13	7
SagarRoad	22	6	5

Complex Error: $|\Delta z| = |A_m e^{i\phi_m} - A_o e^{i\phi_o}|$

RMS Error: $\sigma_s = \sqrt{\frac{1}{2} \sum_{N_{harmonics}} |\Delta z|^2}$

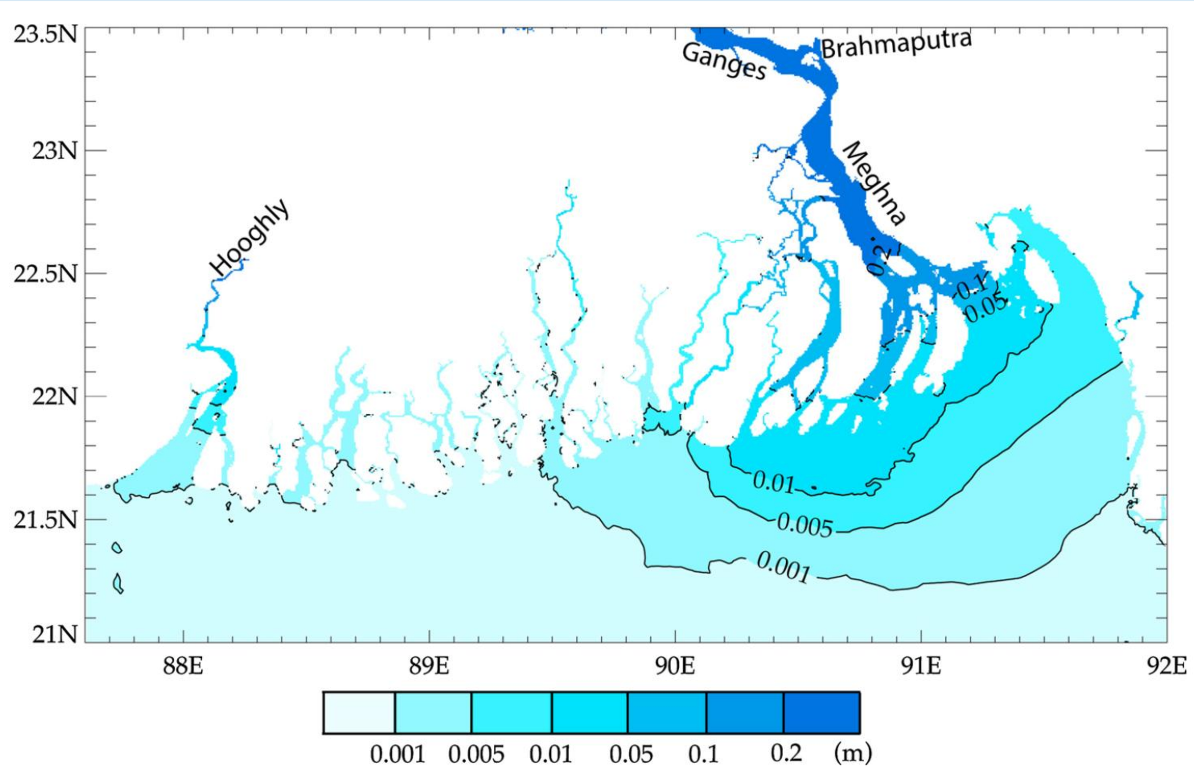

Fig 5: Footprint of freshwater discharge as amplitude of annual harmonics in our model in Barotropic mode (Durand et al. 2019).

Conclusions

- Our cross-scale high-resolution tidal model over Bay of Bengal can provide a high-quality tidal de-aliasing for upcoming SWOT mission.
- Our modeling framework also provides a way to consider non-stationary nature of principal constituents along the coast of Bengal Delta .
- The lack of baroclinic processes in our modeling framework complicates the full description of tidal water level in the near shore regions where SWOT may provide helpful measurements for further model development and Benchmarking.

References

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Contact: Md Jamal Uddin KHAN (jamal.khan@legos.obs-mip.fr)