Intertidal Digital Elevation Model (DEM) of Chittagong Using High-Resolution Sentinel-2 Imagery and Tidal Model

Nazmoddoha Ansary, Md. Jamal Uddin Khan, Fabien Durand, A.K.M. Saiful Islam, Stephane Calmant, Marufa Ishaque

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LEGOS

Motivation

- Bathymetry and topography is the key ingredient in Coastal hydrodynamic modeling (Krien et al. 2016)
- Lack of data in the interface of the land and ocean (e.g. Intertidal area)
  - Dynamic erosion and accretion
  - Needs regular monitoring
  - Ship survey is costly and impractical to do regularly
  - Satellite DEM products coverage is minimal
- Bengal delta
  - 300Km shoreline
  - Flat topography
  - Macrotidal region
- Chittagong
  - Second major city and largest port
  - Several cyclones made landfall (notably 1991 Cyclone)
  - Large intertidal flat

DEM From Multi-Band Satellite Images

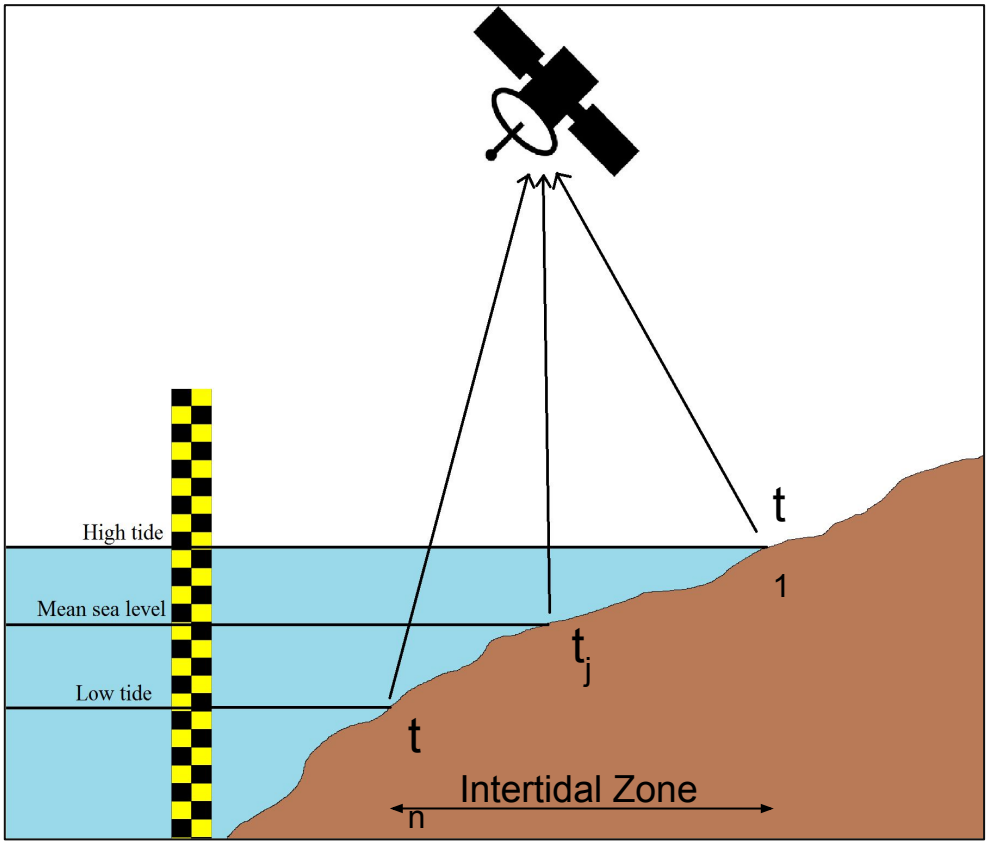


Fig. Schematic of Satellite passing at different tidal water level

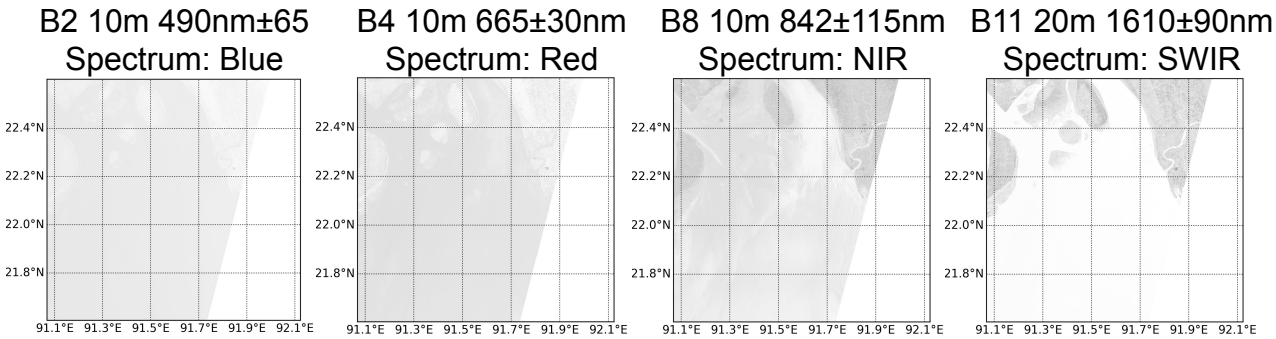
1. Sample multi-band images at different level of water at different time t_1, t_2, . ., t_j, . ., t_n
2. Extract the **instantaneous shoreline** from the images
3. Set vertical height which corresponds to the **instantaneous water levels** between high and low tide for all the pixels

Shoreline ~ Sentinel 2A/B
Waterlevel ~ Hydrodynamic Tidal Model

Sentinel 2 Data-set and Automated Shoreline Detection

Sentinel 2

- Launched by ESA
- Very High-resolution (10m)
- Short revisit (~9 days)
- 13 Bands
- Operational product
- Available from - https://sentinel.esa.int https://theia.cnes.fr



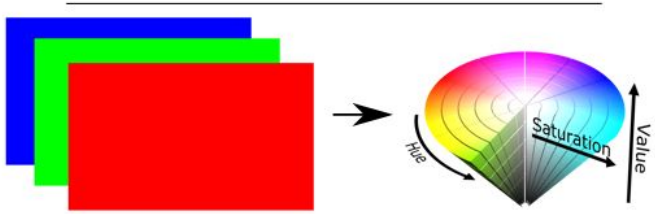
Shoreline Detection

- Based on Pekel et al. 2015 and Bergmann et al. 2018
- Using B2, B4 B8, B11 Bands of Sentinel 2.
- Automated procedure.
- Robust and fault tolerant
- Implemented as a python package for batch processing of large number of images.

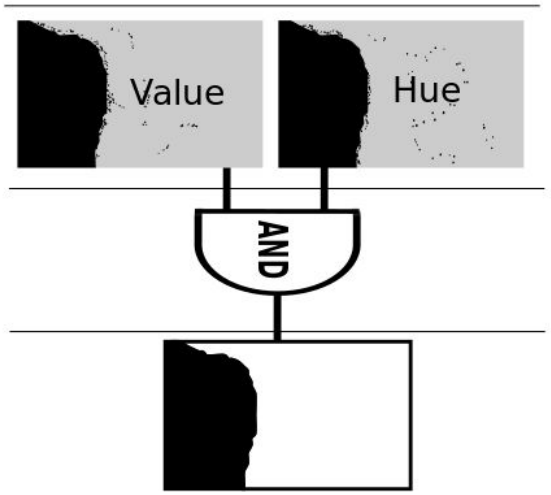
$$red = (1- B11_{unorm})+(B11_{unorm}*B4_{norm})$$

$$green = (1-B11_{unorm})+(B11_{unorm}*B8_{norm})$$

$$blue = (1-B11_{unorm})+(B11_{unorm}*B2_{norm})$$



RGBa to HSV Convertion (Pekel et al. 2015)

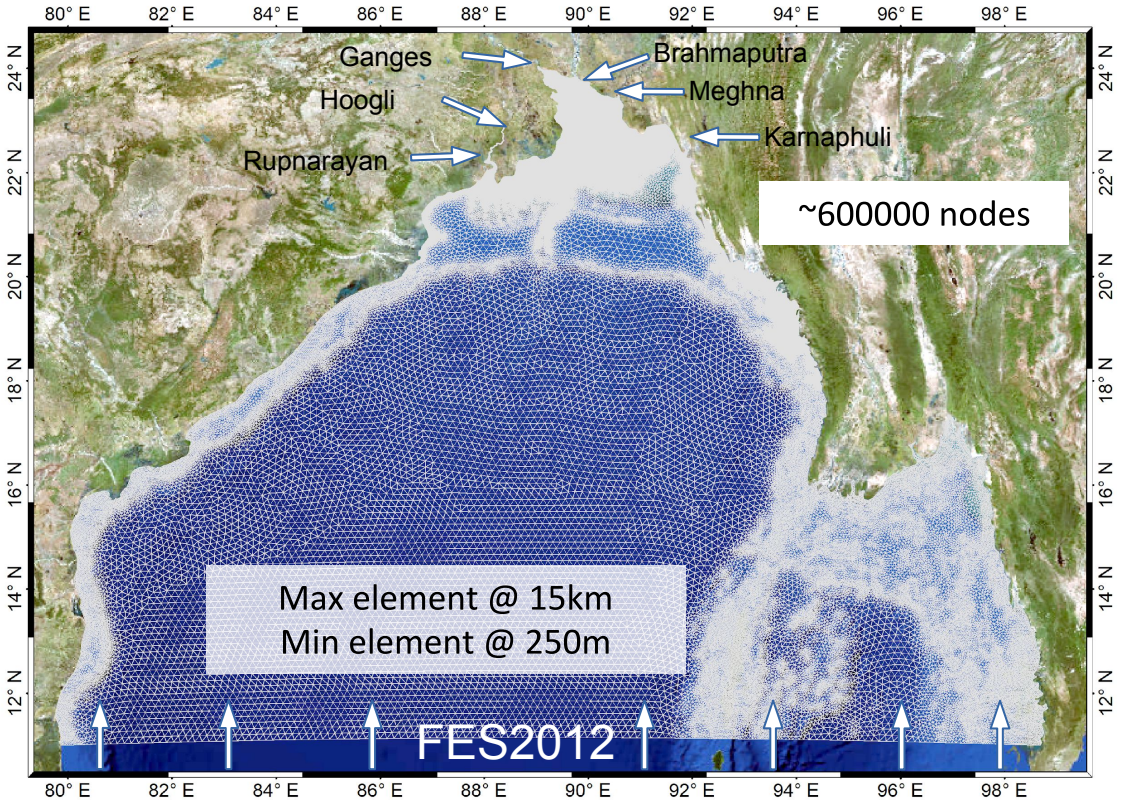


Thresholding the Hue and Value Channel

And connecting Hue And Value

Shoreline detection (Bergmann et al. 2018)

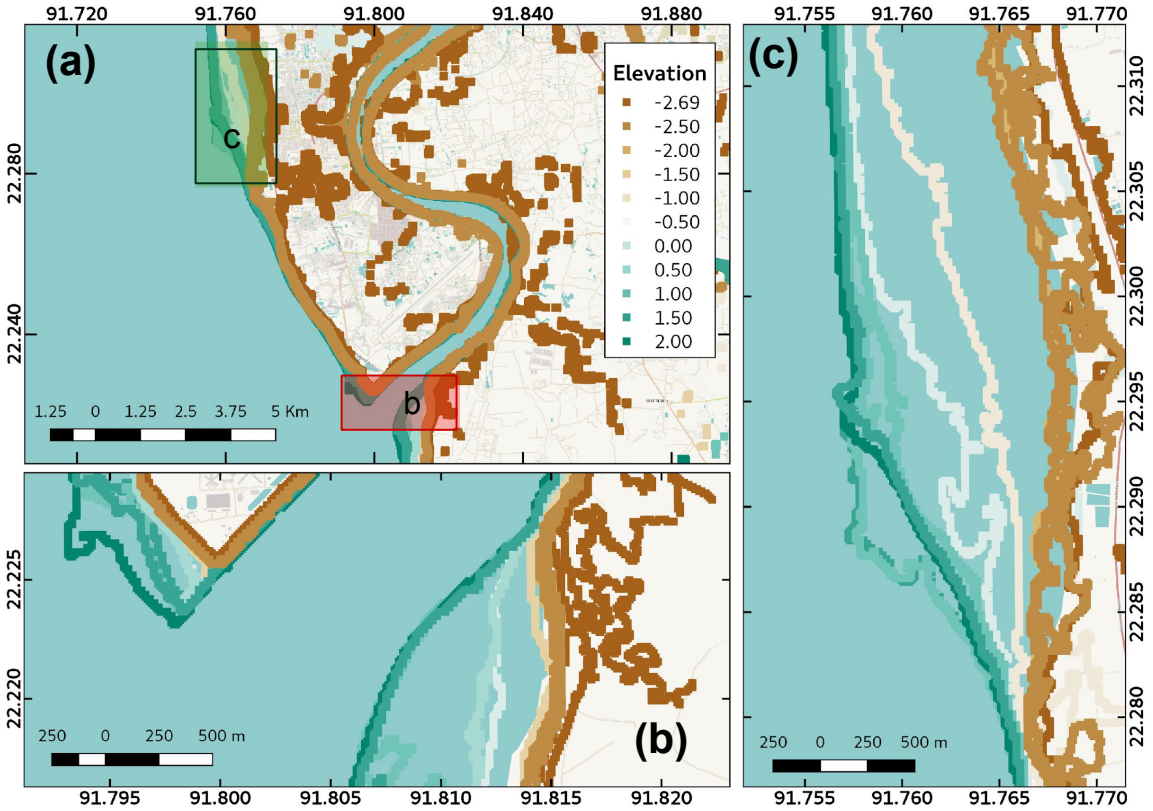
Tidal Model

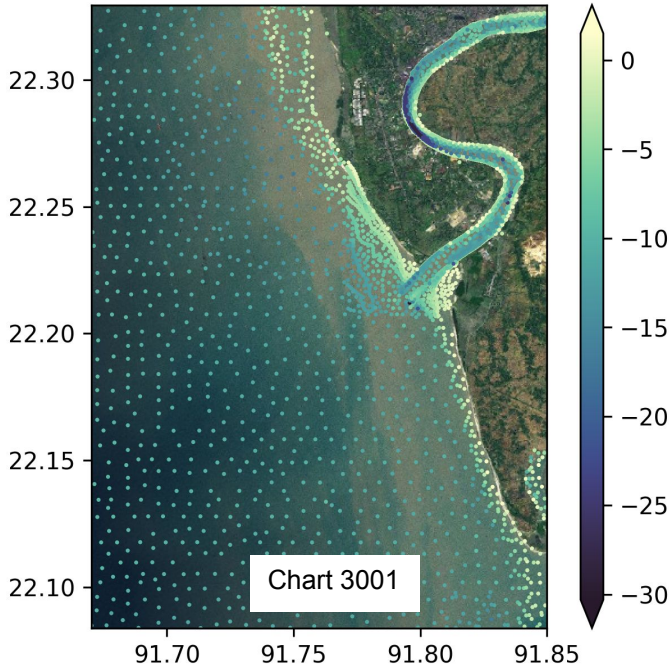


2D – Barotropic – model solving shallow water equation using FEM (SCHISM)

- State of the art modeling framework
- Combines rivers cross-sections, navy charts, high-resolution topographic survey (See Krien et al. 2016)
- 3-10 fold reduction in complex error compared to global tidal atlas
- Typical complex error along Chittagong shoreline is ~10cm (M2, S2, O1, K1)

Estimated DEM and Validation





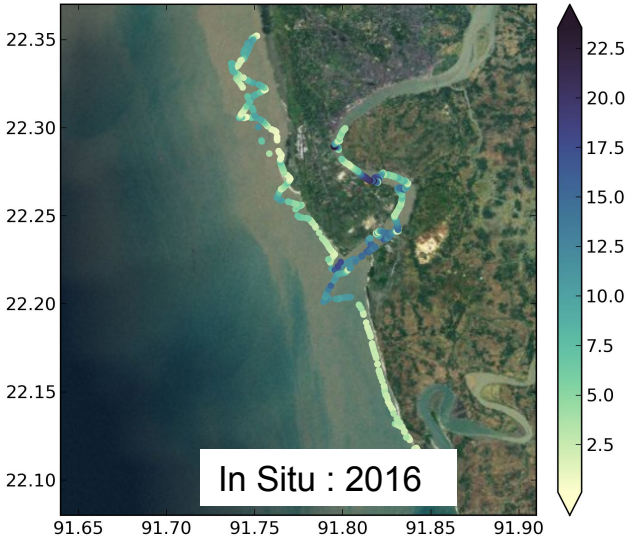


	Chart vs. *In Situ*	Sentinel 2 vs *In Situ*	Sentinel 2 vs Chart
Bias (m)	0.52	2.16	1.06
STD (m)	1.43	2.54	2.13

Take-home Messages

- Knowledge of Near-shore inter-tidal topography is very important for the coastal hydrodynamic modeling but lacks enough data in the delta regions of the worlds, especially Bengal delta.
- Satellite imegeries provides a cheap and reliable means for monitoring coastal land-water interface.
- Combined with hydrodynamic modeling, it is possible to achieve a very high-resolution estimation of topography over the inter-tidal area using freely available Sentinel 2A/B products.
- The accuracy achieved using this methodology is comparable to the error-bar of typical boat based survey.

Thank you!

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