Storm Surge Forecasting along the Bengal Delta Coastline: Challenges and Advancements

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Bengal Delta

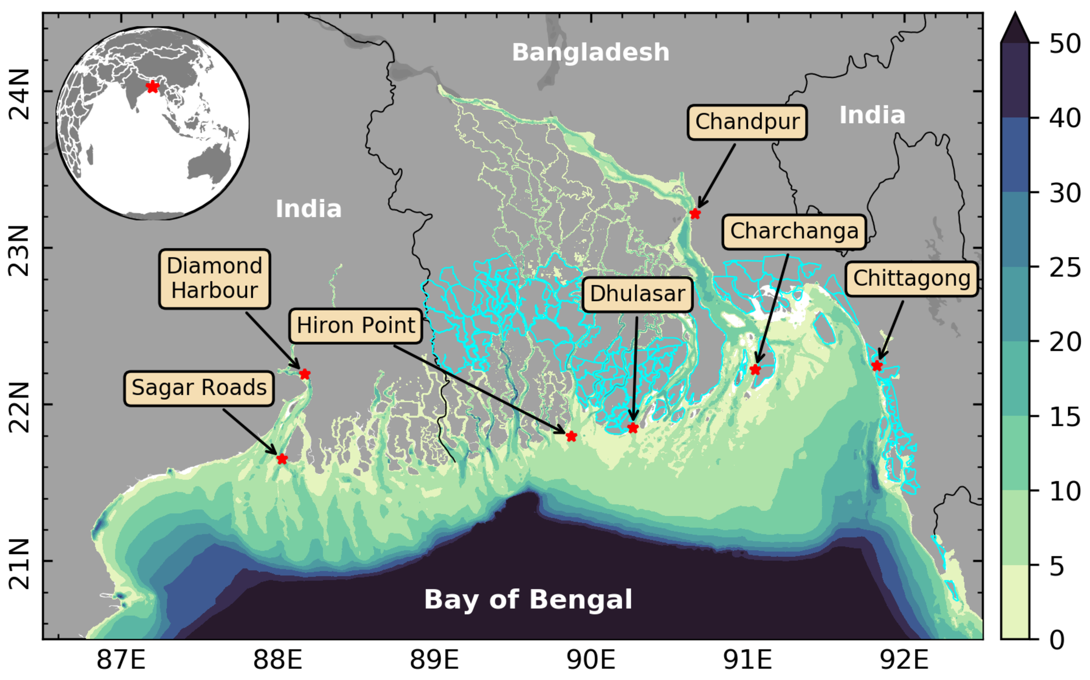

Fig 1: Bengal delta with country borders. The near-shore bathymetry is mapped associated with the color scale. The cyan lines show the limits of the existing polders. Red star shows a few tide gauge location.

- Located in the northern bay of Bengal in the Indian ocean, populated by more than 150M people.
- Flat (O~0.0001m slope) submarine shelf (50-80km width).
- Macrotidal (2.5-5m tidal range)
- Large discharge from Ganges-Brahmaputra-Meghna O~100k m^3/s.
- Strong seasonal steric sea level changes O~35cm.
- Prone to frequent landfalling cyclones, typically 1 strong cyclone every 3 years.

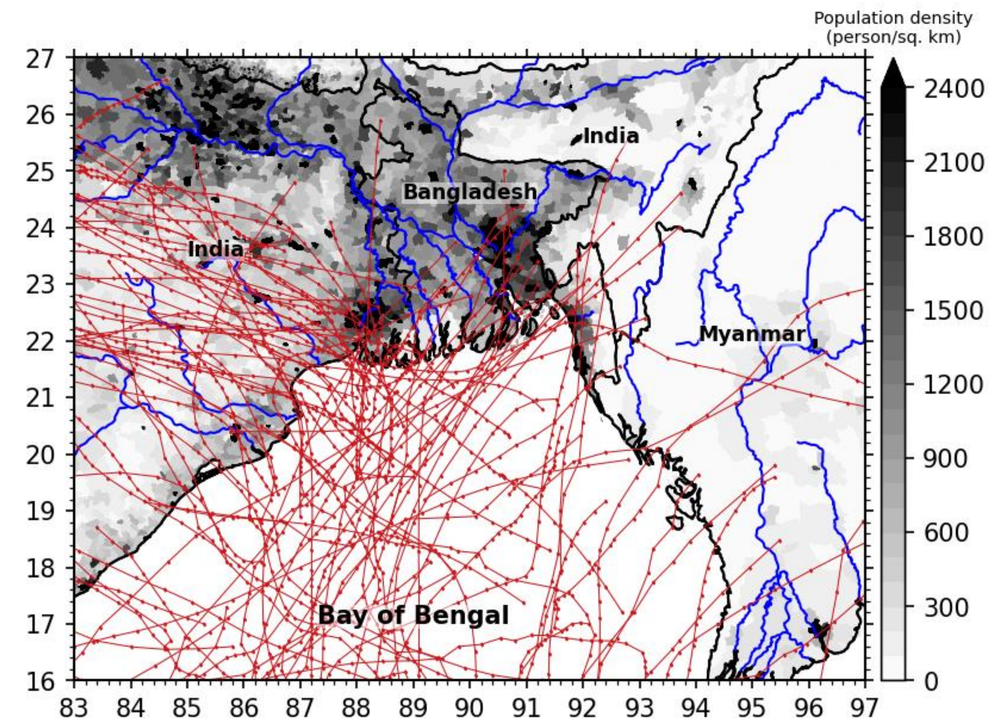

Fig 2: Population density (GPW v4) in gray colorscale and the landfalling storms over the last 50 years (red lines) based on IBTrACS dataset (Knapp et al., 2018)

Mechanisms and Modelling Challenges

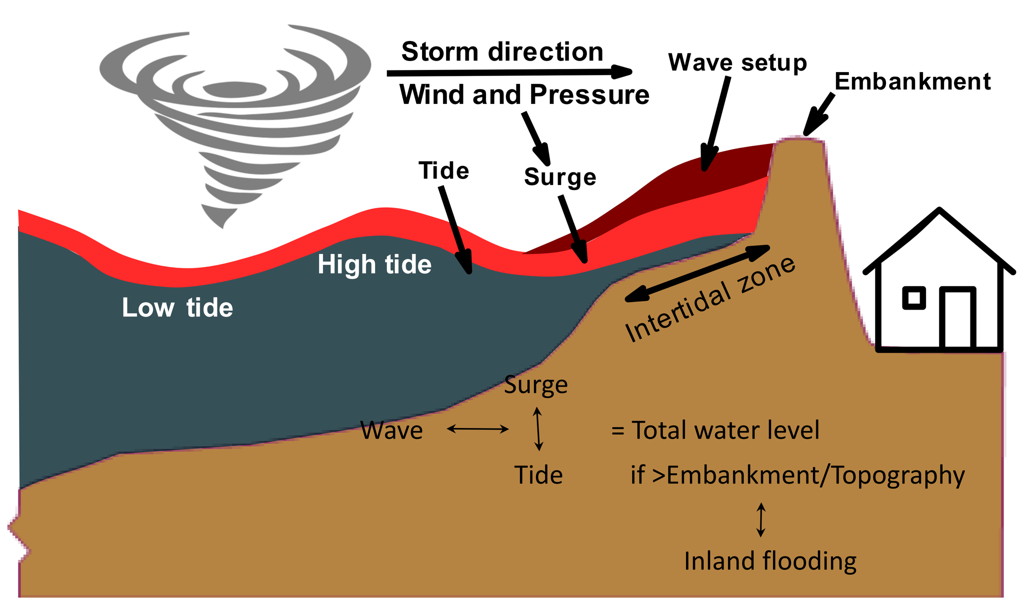

Fig 3: Mechanism of storm surge generation and non-linear interactions between the components of total water level in a macrotidal flat embanked coastline.

- Tide-surge interaction modulates the timing and amplitude of maximum water level during a storm.
- Embankments strongly controls the inland flooding.
- Embankment breaching is often more prominent cause of flooding.

Challenges

1. **A good knowledge of bathymetry, topography, embankments**
2. **An efficient coupled hydrodynamic-wave modelling system.**

Operational agencies of Bangladesh/India lack these requirements -

- No inland flooding, nor embankments in the existing systems.
- No hydrodynamic-wave model coupling.

Fig 4: Community effort to repair a coastal dike before cyclone Amphan landfall.

Bay of Bengal Storm Surge Model

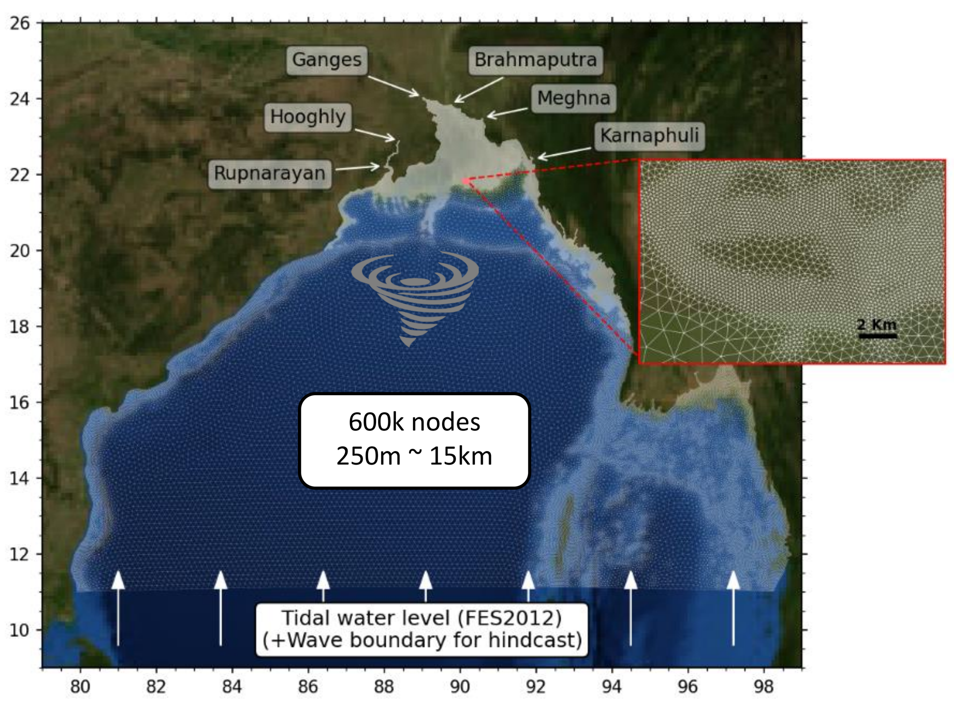

Fig 5: SCHISM-WWM mesh extent and open boundaries.

- Coupled Tide-Surge-Wave model - SCHISM-WWM
- Model mesh is based on a custom bathymetry of Krien et al 2016. and Khan et al. 2019 – including Embankments.
- Best performing published tide model over Bengal. ~2-5 times improvement from Global model (Khan et al. 2020).

Semi-implicit/Implicit schemes ~ allows large timesteps.
300 sec for SCHISM, 1800 sec for WWM-III

BandSOS

BandSOS project (April 2022- April 2024) aims at pre-operationalizing the Bay of Bengal SCHISM-WWM storm surge model at Bangladesh Water Development Board as a coastal flood forecasting system.

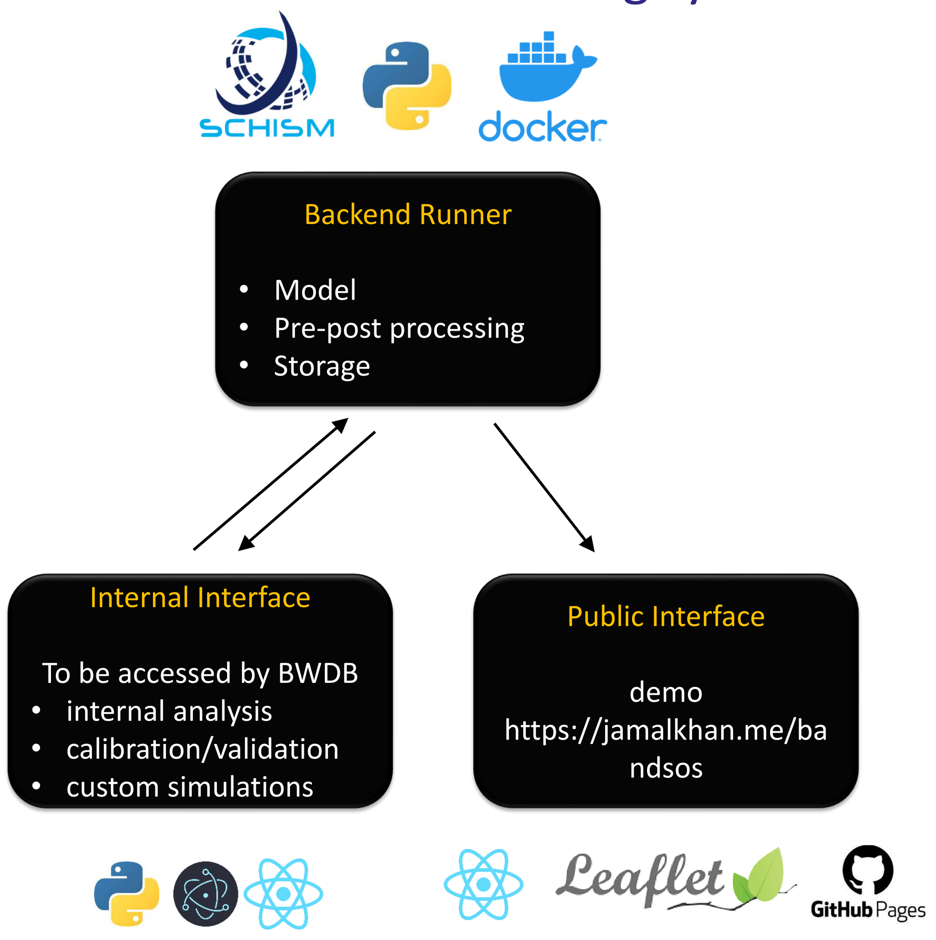

Fig 9: Schematic of the BandSOS forecasting platform based on open-source technologies.

Design priorities for BandSOS Platform

1. Computationally efficient
2. Portable and Reproducible
3. Open-source technologies

Toolboxes (Under development)

pycaz: https://github.com/jamal919/pycaz
bandsos: https://github.com/jamal919/bandsos

Forecasting for Cyclone Amphan (Khan et al. 2021)

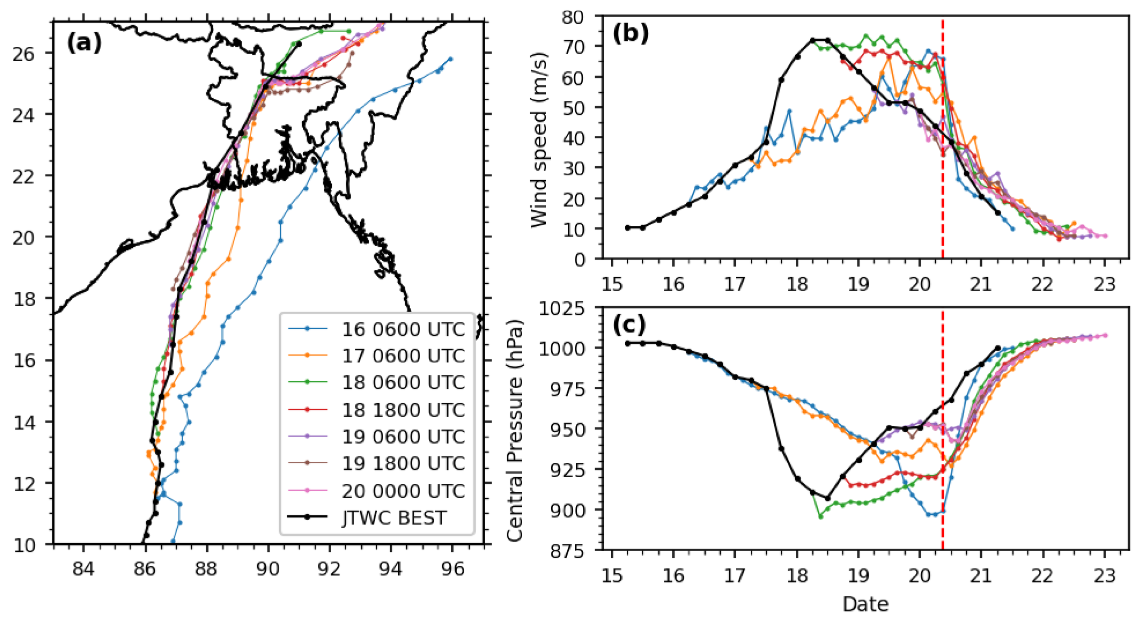

Fig 6: Temporal evolution of the successive HWRF forecasts of Amphan cyclone (a) Forecast track (JTWC best track in black) (b) Wind speed and (c) Pressure. Landfall time in dashed red line.

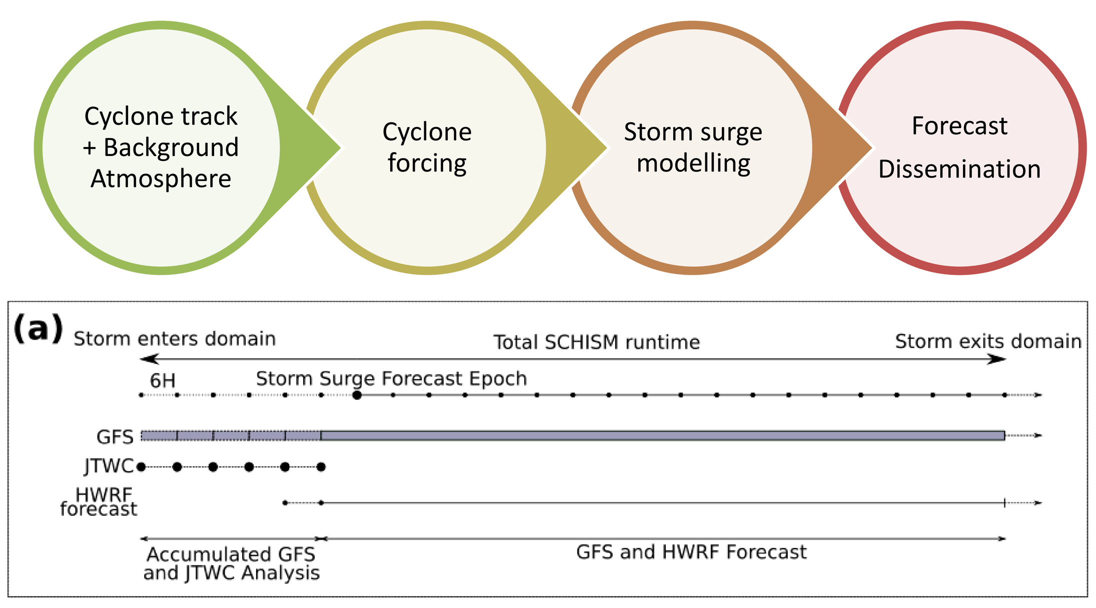

Fig 7: (top) A schematic of a single forecast cycle. (bottom) Temporal combination scheme of the JTWC, GFS, and HWRF forecasts for each 6-hourly storm surge forecast epoch.

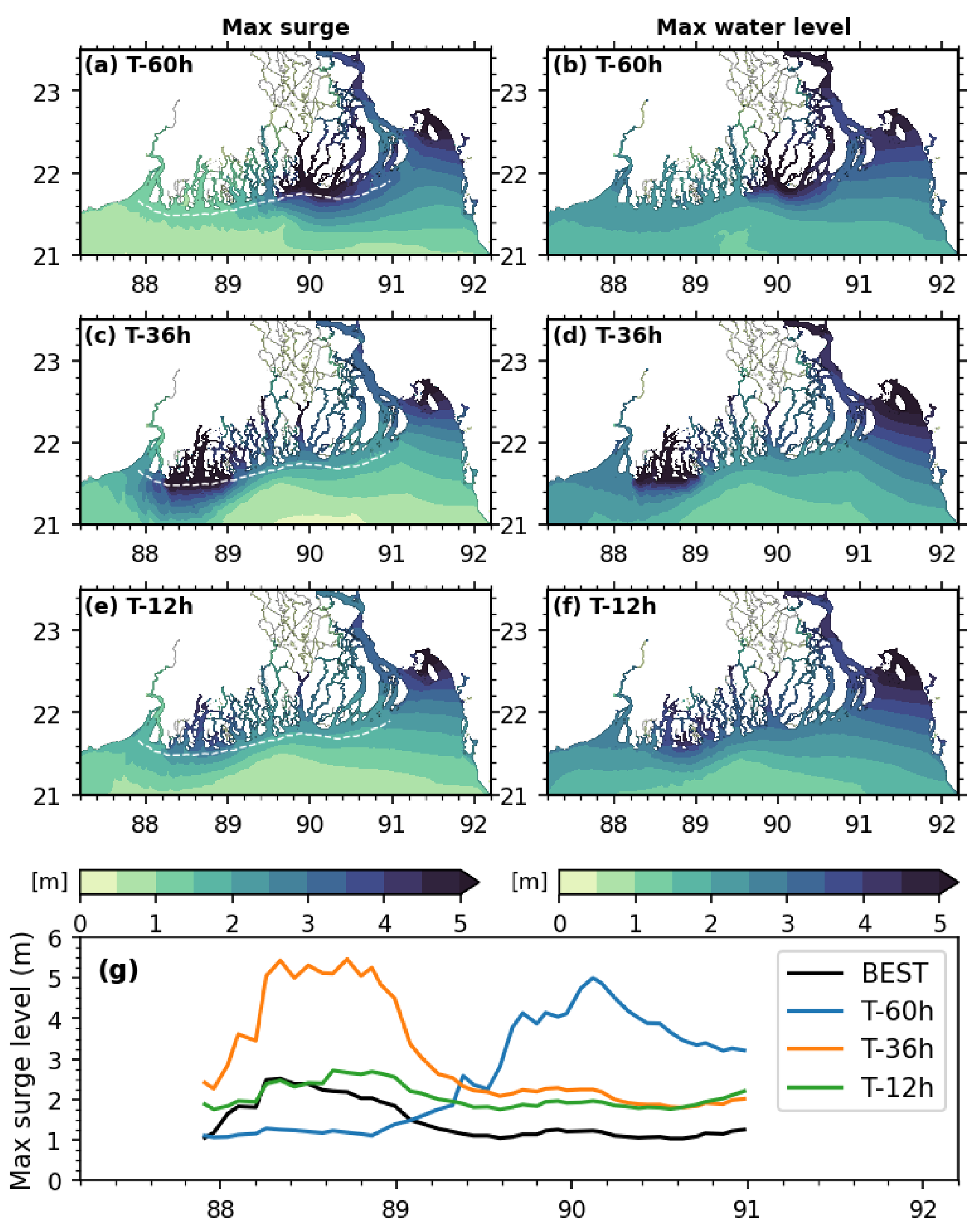

Fig 8: Maximum surge and elevation evolution for forecast initiated at (a–b) T − 60 h (c–d) T − 36 h, and (e–f) T − 12 hours before landfall. (g) Comparison of maximum surge level extracted along the section shown by the white line.

References

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