Effect of Climate Change on local sea level rise and its Impact on Coastal Areas: Kolkata Region as a Pilot Study

Broad Area

Habitation and Maintenance

Motivation/Need for the Study

The fourth assessment report of Intergovernmental Panel on Climate Change (IPCC) projected global sea level rise to be between 180 to 590 mm during 1990 to 2090s. Global sea level rise is now of concern because of its significant effect on coastal cities in many regions of the world. Changes in sea level are directly linked to a number of atmospheric and oceanic processes. Physical processes that describe the dynamic global climate systems and the effect of this system behaviour on sea-level change are complex by nature. As per various previous studies, regional sea level rise has a significant impact on global sea level patterns and also on local damages. Hence, the study of regional sea level change is of major interest in the context of climate change for the future of coastal cities.

The proposed research problem evolves from some of the gap areas, as evidenced from literature in the field of coastal hydrodynamics. In global sense, numerous studies in the past were conducted to develop a robust coastal modeling system, wherein the knowledge can be directly translated for practical use by industry, research laboratories, academia etc. It is a challenge to develop a robust modeling system that performs best qualitatively. The coastal hydrodynamics in near shore areas are affected by other physical mechanisms such as tides, currents and surges (which becomes important during extreme events). Changing water level elevation and associated reversing current from tides can affect wave propagation in a coastal environment. The importance of 'doppler shift' is pronounced during such non-linear interaction process that occurs between waves and tidal currents. The second part of the research work utilizes a state-of-art model, named as, ADvanced CIRCulation model (ADCIRC) that is used extensively by the scientific community worldwide. ADCIRC is a hydrodynamic model that can be used to understand water level elevation, storm surge and depth averaged currents in shallow waters using tidal forcing and wind stress as input parameters. ADCIRC is a robust model, and its capability was demonstrated by numerous numerical experiments performed in the Gulf of Mexico during hurricane events. Numerical computations performed using ADCIRC from past cyclone tracks, and subsequent validation of model from in-situ measurements demonstrated that this model

performed very well in most of the cases. Hence the use of ADCIRC for hydrodynamic computations in the Indian seas is justified, undoubtedly the best choice for coastal waters. The motivation behind this proposal is to carry forward the knowledge, with a clear objective to improve quality of coastal forecasts for the Indian seas to the next level, to aid and promote the subject of operational oceanography.

Objective and Scope of Work

Objectives of this study are as follows:

I) To develop a semi empirical statistical framework for regional Sea Level Change (SLC) using relevant climatic inputs.

Towards this, assessment of the regional variation and change in sea level is set as initial objective. An advanced statistical tool will be utilized to develop a framework to model the estimated Sea Level Change (SLC) at the locations of coastal regions.

II) To analyze the region around Kolkata and Sundarban that may/will be impacted by a sea level rise.

Towards this, following work components are considered:

- Selection of past cyclone tracks for case studies – preparation of inventory.
- Detailed case studies of peak storm surge with selected cyclone tracks – followed by a comprehensive validation exercise.
- Investigate the inland intrusion of water due to storm surge for selected coastal destinations using ADCIRC model.
- Study on the impact of environmental hydrodynamics in localized region such as estuaries, and where tidal propagation upstream rivers (for example the Hooghly region etc.) become important.

Methodology

A semi empirical statistical approach will be developed to find out the regional sea level change. The initial rate of sea level rise in response to various climatic variables is to be determined using a semi empirical equation. Curse of dimensionality is expected to be a major hurdle for the analysis. Thus, a suitable statistical approach will be adopted for dimensionality reduction. This will help to combine the relevant climate variables towards the development of a possible combined index. Next, the combined effect of relevant climatic variables on sea level will be estimated. The performance of the developed approach will be assessed with respect to historical observations and will be used to project into the future.

The model ADCIRC since its inception was designed to run in a flexible finite element mesh. The key to obtain a good simulation from ADCIRC solely depends on the quality of the generated mesh. The inland intrusion of water and flooding associated with storm surges is one of the main cause for extensive damages. There has been reports of surge penetrating about 10-15 Km inland particularly when cyclones pass through river deltaic region. Accurate estimation of inland inundation requires a very high-resolution grid, typically having horizontal length scales of about 100 - 200 m at the coast. In addition, high-resolution land topography data from DEM will be required for better understanding the inundation process. The difference of local topography from the maximum water elevation will provide the index to know the vertical extent of water column that results in coastal inundation. The fine tuned ADCIRC model will be subjected to several numerical test cases to arrive at the best possible combination of model physics for operational purpose.

Outcomes/Deliverables

- A statistical framework to assess the sea level change information at the locations of important coastal cities in India.
- A modeling system to assess the extent of coastal inundation/flooding during worst possible scenarios of land-falling cyclones in the head Bay region, east coast of India.
- A document on specific recommendations and maps showing the zone with potential danger
- Web based interactive information for the community.

Team Composition

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