STUDY OF STORM SURGES OVER ODISHA COAST (BAY OF BENGAL)-A REVIEW WITH A PROPOSED MATHEMATICAL MODEL

MD. SHAHEER ALI¹, SYED RIZWAN ALI², MD. TASLIM RAZA^{3*} & ARVIND KUMAR SINGH⁴

¹Assistant Professor, Civil Engineering Department, University Polytechnic, Aligarh Muslim University, Aligarh, U.P. India

²Assistant Professor, Civil Engineering Department, Maulana Azad College of Engineering and Technology, Neora,
Patna, Bihar, India,

³Assistant Professor, Mechanical Engineering Department, Maulana Azad College of Engineering and Technology,
Neora, Patna, Bihar, India

⁴Assistant Professor, Computer Science and Engineering Department, Maulana Azad College of Engineering and Technology,
Neora, Patna, Bihar, India

ABSTRACT

Storm surges are oscillations created in water bodies due to cyclones. Moisture evaporated from water bodies when condenses back release heat which strengthens the cyclones. The height of a surge is governed by several factors including cyclone intensity (horizontal pressure gradient, maximum wind speed), the forward speed of the cyclone (longer stay at a location causes a greater amount of transport and surge height) and diameter of winds. The physical characteristics of the coast like bathymetry, the width of the continental shelf, the formation of coastline also affect the height of a surge. Many researchers have worked in this field of mathematical modeling of storm surges. But some sort of effective warning system as is the case with Pacific and Atlantic Oceans is still absent in the Bay of Bengal region. With the present study, we try to create an efficient storm-surge forecasting model inclusive of the coast characteristics as well as precipitation.

KEYWORDS: Storm Surge, Mathematical Modeling & Oscillations

Received: Sep 03, 2019; **Accepted:** Sep 23, 2019; **Published:** Jul 24, 2020; **Paper Id.:** IJCSEIERDAUG20203

1.INTRODUCTION

Storm surges are formed in water bodies as a result of cyclones. Several physical characteristics and meteorological factors of the coast such as head bay, deltas formed by major rivers of Orissa such as Mahanadi, Dhamra, and tides are responsible for storm surge flooding in the region. Thus, the real-time forecasting is of prime importance. One of the important features of the model is that it includes bathymetry calculations for offshore waters. The model has been validated with the data of the Orissa coast cyclones.

The previous models lack the influence of tides on the storm surges. The objective of the present work is to evaluate the tide-surge interaction of the Hudhud cyclone. Numerical storm surge models are built on the shallow water theory based on vertically integrated hydrodynamic equations governing the motion in the ocean. A numerical solution is obtained either through finite-difference or finite-element discretization of the shallow water equations. The effect of non-linear advection on surge computations is studied. The model is influenced by wind stress, Quadratic bottom stress, coastal geometry and bathymetry. Numerical model results are analyzed with two approaches to predict surges. In the nomograms approach, model results are used to generate surge scenarios for

various possible combinations of cyclone parameters. In the second approach, numerical models are used to compute surges for each storm separately.

2.THE OBJECTIVE OF THE STUDY

- Evaluation of the tide-surge interaction by taking into account the different phases of the tidal waves during the 2015 Hudhud cyclone (Odisha) using a nonlinear vertically integrated numerical model.
- Simulation of tides and creation of co-range and co-tidal charts of the semi-diurnal and diurnal components of the Odisha Coast.
- Developing a storm surge model to simulate total water levels and derive surges caused by low-pressure systems identified during the past 41 years (1974-2015).
- Estimation of return levels of extreme sea-level events at major coastal stations along the Odisha Coast of the Bay of Bengal.

3.SCOPE OF THE STUDY

The meteorological and physical parameters of the coast are taken into account Therefore the current study is an attempt to forecast surges, its development with time and determine the extreme sea level. A few attempts have been made to make quantitative estimates of the return periods of the storm surge on the Odisha Coast of India by evaluating several past cyclones. Tidal gauge data is available only at 4-5 stations along the east coast of India and hence, the direct analysis of the observational data is very difficult. Thus it is required to have a numerical model to simulate the storm surges where tidal gauge data is not available.

Our investigation includes exposure indicators for affected territory, population, economic activity (GDP), agricultural lands, wetlands, major cities, and other urban areas. Bathymetry (Fig. 1) in a numerical model also affects the accuracy of the simulated tides. The total water level is a combination of the effects of storm surge, wave set-up, and high tide. However, prediction methods for wave setup are not well recognized yet. Therefore, further studies of the wave setup forecast method are desirable.

- The total coastal land which will be inundated on account of storm surges needs to be estimated for proper evacuation of such areas. This requires a real-time ocean–river finite element model.
- The effect of tides on the storm surges needs to be studied in detail.
- Heavy precipitation alters the sea-water level and thereby affects the height and intensity of storm surges.
- In the present study geographic information system (GIS) software will be used to study the various features like land, population, agriculture, and urban extent, wetlands, GDP, city locations, etc. for:
- A 1-in-100-year storm surge.
- A 10% increase in the intensity over the next 100 years.

CONCLUSIONS

The present study focuses on an efficient storm-surge forecasting model incorporating precise measurement of bathymetry,

bottom friction, open boundary conditions, air-sea interaction, wind field, tide-surge interaction, river discharge, etc. Finite Element Method (FEM) is applied to create a storm surge prediction model for the Odisha Coast of the Bay of Bengal, followed by its validation using the data of previous tropical cyclones occurred in the Odisha Coast of the Bay of Bengal. In the first part of our research, a review of the available models (Table 2) comparing their benefits and drawbacks will be discussed. Thereafter, the boundary conditions for the FEM modeling process would be properly applied. Shallow water equations will be used. The forcing due to barometric changes is ignored. The wind field at the sea surface is derived by using a dynamic storm model. The model domain is reproduced utilizing a staggered finite element grid made up of elements varying in size and shape (Fig. 3) and covers the whole Odisha Coast of the Bay of Bengal.

The model is validated and observed data are compared employing correlation coefficients and RMSE for the three cyclones. The system has to be operated and refined from time to time through several improvements such as spatially variable wind enhancement coefficients and a post-processing procedure. The results of the current forecasting system are compared with the statistical models that are presently used by the Odisha Government as their flooding warning system. This research work would contribute essentially to the operational forecasting system and decision-making schemes for severely affected areas of Odisha.

Figure 1: Finite element model dividing the entire area of study into grids

Table1: Types of Storm Surge Models

SHYFEM	A shallow water numerical model based on the finite element method
Depth averaged hydrodynamic model	A non-linear vertically integrated numerical model based on finite element and finite-difference.

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AUTHORS PROFILE

1. Md. Shaheer Ali is presently working as Assistant Professor since 2016 CES, University Polytechnic, Aligarh Muslim University; Aligarh, India. He has experience of three years. He has done M. Tech (Hydraulic Structures) and B. Tech (Civil Engineering) from AMU, Aligarh, U.P., India. He is a member of ASCE. He has received an award in creative writing (Mind Maze '08) He has following papers in conferences

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2. Syed Rizwan Ali is an Assistant professor in Civil engineering department, Maulana Azad College of Engineering and technology, Neora, Patna, Bihar 801113, India. He has done B.ScEngg (Civil) from Patna University in 1989, M.Tech in Environmental Engg from Patna University in 2002. He is currently pursuing PhD in Environmental Engg (River Bank Filtration) from BRA Bihar University Muzaffarpur. He has 25 years of experience in teaching.

3. Md. Taslim Raza is an assistant professor in the department of Mechanical engineering, Maulana Azad College of Engineering and Technology, Neora, Patna, Bihar 801113, India since Dec 2017. He has a Masters degree in Industrial engineering from King Saud University (KSU), Riyadh in 2013, and has B.Tech in Mechanical Engineering from AMU, Aligarh, U.P. India in 2008. Following are the paper publications by the author:

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4.Dr. Arvind Kumar Singh is an assistant professor, department of computer science and engineering, Maulana Azad College of Engineering and Technology, Neora, Patna, Bihar 801113, India. He has done PhD in computer science in 2016 from BRA Bihar University, Muzaffarpur, Bihar