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Prediction of water levels and extent of coastal inundation due to a cyclonic storm along the Indian coast

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Background

The devastation due to the combined action of storm surge flooding and extreme wind waves generated by the cyclones is a severe apprehension along the coastal regions of India. Numerical ocean models are considered today as an essential tool to predict the sea level rise and associated inland extent of flooding that could be generated by a cyclonic storm crossing any coastal stretch. For this purpose, the advanced two-dimensional depth integrated (ADCIRC-2DDI) circulation model is practical for the simulation of surges and associated water levels off the coasts of India. It is believed that this study would help the coastal authorities to develop a short and long-term disaster management and vulnerability reduction action plan and emergency response in the event of storm surge flooding.

Objectives

The ADCIRC model based on finite-element formulation is ideal for computations of storm surges and associated inundation, as its flexibility allows for large spatial scales to be represented in the domain while permitting higher degree of grid refinement near the landward boundary. The main objective of this study is to configure ADCIRC storm surge inundation model for identifying vulnerable coastal stretches of inundation in the event of any cyclone crossing the coastal regions of India.

Results

In order to properly describe the physics of storm surges, a numerical model must resolve coastal features that can affect storm surge generation and propagation. This means the model domain must necessarily incorporate complex coastal geometries. In this context, a finite-element based model is the best choice as it allows flexibility to represent a larger spatial domain while permitting higher grid resolutions near the landward boundary.

In the present work, the ADCIRC model is configured for maritime states Andhra and Tamil Nadu in the east and Gujarat in the west coast of India. The model is integrated using wind stress forcing resulting from November 1989, 2000, and 1982 cyclones. The model computes water levels using the more accurate on-shore topography associated with extreme surges generated by the cyclonic wind field. Winds in the model are calculated by using a dynamic storm model of Jelesnianski and Taylor (1973). Water levels along the open boundary are obtained from FES95.2 database. The peak water level and associated extent of horizontal inundation are simulated at the time of cyclone landfall are found to be in good agreement with observations of India Meteorological Department.

Conclusions

As the coastline geometry is modeled more accurately, the simulation of extreme water levels and associated inland inundation from ADCIRC looks very realistic. The incorporation of high-resolution off-shore topography, and bathymetry, particularly in the continental shelf may further enhance the capability of the existing ADCIRC model for precise computation of surge amplitude and associated inundation levels. The simulations of water levels along with horizontal extent of inundation are useful to provide early warnings to low-lying areas, guide evacuation of local population, and rescue operations.