Abstract

The present thesis uses ADvanced CIRCulation (ADCIRC) model to compute coastal inundation due to combined effect of storm surges and tides along the east coast of India. Simulations are made to compute coastal inundation due to storm tides at every 10 km along the coast by using synthetic cyclonic tracks constructed based on the past cyclone data. The cyclonic winds are computed using the maximum pressure-drop of the cyclone based on 100-year return period. The coast is mapped for the maximum possible extent of inland inundation with water levels at district level. Peak water levels of about 10m are found along the north of Odisha coast. The most vulnerable region in terms of coastal inundation is found in the districts of West Bengal with a maximum extent of about 130km interior. In Andhra Pradesh, the maximum inundated districts are Nellore, Prakasam, Guntur, Krishna and East Godavari. Though the water levels in the Ramanathapuram district in Tamil Nadu reaches more than 8 m, the region is unaffected by the coastal inundation due to high local topography. By examining the inundated area of different water levels, it is seen that more than 75% of the total area is inundated with greater than 2 m water levels in the northern districts of Odisha and Ramanathapuram district in Tamil Nadu.

In recent times, the east coast of India is threatened by cyclones making landfall from different directions. Hence, a detailed investigation is made on the effect of cyclone's approach angle on generation of storm surges and its non-linear interaction with tides and wind waves using a standalone ADCIRC and a coupled ADCIRC+SWAN model. Numerical experiments are executed using 17 idealized straight cyclone tracks of same intensity moving at constant forward speed. The study domain considers an idealized bathymetry with a straight coastline and uniform shelf width. All cyclones make landfall at the same location with angles approaching from 10° to 170° with an increment of 10°. The simulations show that the maximum storm surge is computed

for tracks land falling with 60°-90°. Increase in the peak storm surge is seen about 15% from 10°-60°, while it decreases by about 13% from 90°-170°. Surge-wave interaction modifies the maximum water levels by about 21-26%. The maximum wave contribution is seen for a track with 90° followed by 160° and 20°. During different phases of tide, surge-tide interaction modulates the peak surge, its occurrence and location as cyclone makes landfall at different angles. Extent of affected coastal stretch is maximum on either side of the landfall for the tracks moving close to the coast, while it is minimum for the perpendicular track (90°), confined only to the right of the landfall. The peak surge-tide-wind wave interaction along the coast at both high and low-tide is seen about 2-4h after the landfall. The interaction along the coast depends on approach angles of the cyclone, however the total water elevation (TWE) is mainly modified by both tidal phase and approach angle.

The rise of TWE at the coast is caused primarily by three factors that encompass storm surges, tides and wind waves. The accuracy of TWE forecast depends not only on the cyclonic track and its intensity, but also on the spatial distribution of winds, which include its speed and direction. In the thesis, the cyclonic winds computed using Jelesnianski wind scheme are validated with buoy winds for the recent cyclones formed in the Bay of Bengal since 2010. It is found that the cyclonic winds computed from the scheme show an underestimate in the magnitude and also a mismatch in its direction. Hence, the wind scheme is suitably modified based on the buoy observations available at different locations using a power law, which reduces the exponential decay of winds by about 30%. Moreover, the cyclonic wind direction is also corrected by suitably modifying its inflow angle. The significance of modified exponential factor and inflow angle in the computation of cyclonic winds is highlighted using statistical analysis. The ADCIRC model is used to compute TWE as a response to combined effect of cyclonic winds and astronomical tides.

As contribution of wave setup plays an important role near the coast, a coupled ADCIRC + SWAN is used to perceive the contribution of wind waves on the TWE. The experiments are performed to validate computed surge residuals with available tide gauge data. Comparison of surge residual computed using modified winds in coupled and uncoupled model with observation, reveals that after including wave effects through coupled model simulated residuals are better compared.

The low-lying Mahanadi river deltaic region along the Odisha coast is highly prone to inland flooding during the cyclone period. In particular, upstream river discharge, cyclone induced precipitation and storm tides modify the coastal inundation in the delta region. Experiments are performed using the 1999 Super cyclone and the 2013 Phailin cyclone with a standalone ADCIRC and a coupled hydraulic HEC-RAS and ADCIRC model. The Mahanadi, Brahmani and Baitarani Rivers are included in the computational domain with representative depths. The model simulations infer that coastal inundated area is enhanced by 64% after representing the river delta in the domain while, the river discharge from the upstream contributes additional 14%. The effect of volume of discharge and role of LULC information on computation of coastal inundation during the 1999 Super cyclone is also investigated. The coupled model system is used to quantify the contribution of precipitation on inland flooding during the cyclone period. The results signify that the inundated area becomes almost double after including rainfall data in both the cyclonic cases. Also the model generated inundated area during Phailin cyclone is in good match with the satellite image, demonstrating the coupled system can simulate a reliable inland flooding in the delta region. It concludes that it is essential to resolve the river systems and incorporate hydrological components like river discharge and precipitation for precise computation of inundation.