Modeling nearshore dynamics of extreme storms in complex environments of Connecticut

Project Description

Flood hazard planning requires the accurate estimation of total water elevation due to predicted tide, surge, and wave runup to design flood protection structures and improve coastal risk planning for severe storms. The beach topography and nearshore hydrodynamic conditions impact the conclusive flood inundation mapping in complex environments. Conventional approaches to flood modeling are flawed in several different ways. We used a fully nonlinear high-resolution wave model (FUNWAVE-TVD) on the nearshore area to determine total water elevation on the shores of Branford, Norwalk, and New Haven, CT.

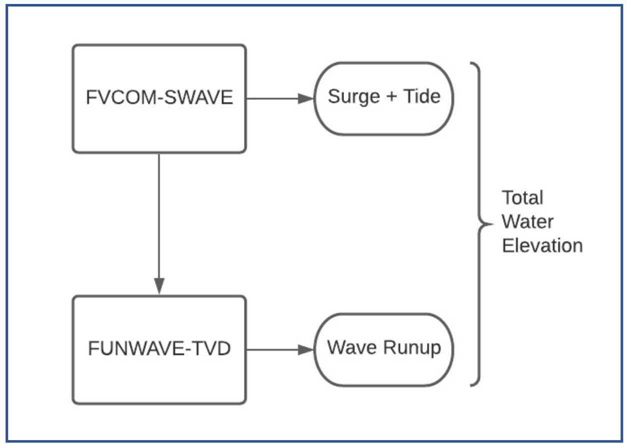

Figure 1: Methodology of the nearshore dynamics modeling

Project Findings

- The FUNWAVE-TVD model is found to model wave processes more accurately in shallow water regions compared to the empirical equation application of FEMA and coupled circulation-phase averaged model application of NACCS and FVCOM-SWAVE.
- We also examined local sea-level rise predictions of storms with 1% (100-year) and 10% (10-year) annual exceedance probability by the year 2050 in Connecticut and found that the flood extent of these two storms showed little to no difference due to the topographic conditions.
- We suggest the planning approaches consider the increase in the frequency of the storms in the predicted inundation zones due to sea-level rise.

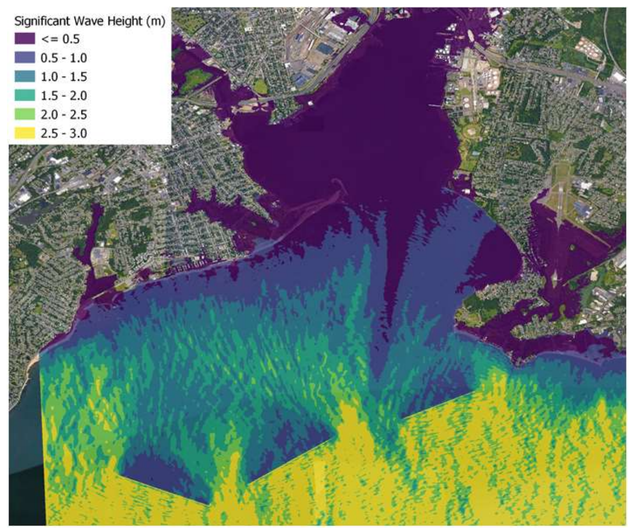

Figure 2: Modeled significant wave height and flood extent in New Haven under the 100-year return period scenario

Research Gaps and Recommendations

- The FUNWAVE model bathy-topography is based on CoNED, which is a bare-earth digital elevation model, thus the effect of on-land coastal structures are not fully considered in this study. Future work would focus on including artificial coastal structures to improve the flood extent estimates.
- The primary disadvantage of FUNWAVE-TVD is being computationally expensive, primarily due to resolving complex governing equations in the adequate spatial resolution of 2 m. An alternative is to use a coupled wave-current model (phase averaging) with empirical equations to estimate wave runup, which may perform better for a natural shoreline with simpler geometry but could be less accurate with the presence of coastal structures.