CART MODEL FOR PREDICTING DUNE EROSION BASED ON STORM INTENSITY AND BEACH MORPHOLOGY

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MOTIVATION

Hurricane Sandy (2012) resulted in historic losses to the beach and dune system in many parts of New Jersey, leaving inland structures susceptible to wave and surge-induced damages. To defend against future threats, the state, in conjunction with the US Army Corps of Engineers, has pursued a statewide system of engineered beaches comprised of a dune paired with a beach nourishment. Currently in the state there is much debate over the degree of protection these projects currently offer, and how this may change in the future due to climate change. Process-based models can be used to try to answer these questions; however, as the number of test cases increase the computational costs may become prohibitive. Here, a data-driven modeling approach is used to assess the variability in the vulnerability of the beach-dune system in New Jersey to a range of storms. Inputs to the model include storm intensity as characterized by the Storm Erosion Index (SEI) (Miller and Livermont 2008) and parameterized pre-storm morphology. The resulting classification tree ensemble has been shown to accurately predict dune volume loss (as a percent) due to historical storms (Lemke and Miller, 2021). Here, the model is applied to further investigate how changes to beach-dune system and sea level rise affect the probability of dune impact.

METHODOLOGY

The classification tree ensemble model used in the analysis was trained using dune erosion data from 30 years of profile data available at 110 locations throughout New Jersey (Stockton University CRC, 2012). These profiles represent a wide range of morphological conditions. Storm intensity is evaluated via the Storm Erosion Index (SEI) and Peak Erosion Intensity (PEI), physically based parameters that consider the three primary drivers of coastal erosion (wave height, water level, and storm duration) (Miller and Livermont 2008). In previous applications SEI has been shown to be more closely correlated with beach erosion, while PEI has been shown to be more closely related to upland damage (Janssen, Lemke, and Miller, 2019).

More recently, SEI and PEI were used to develop a storm erosion climatology for the state of New Jersey (Lemke and Miller, 2020). For each storm in the dataset, SEI, representative of the storm's total erosion potential, and Peak Erosion Intensity (PEI), representative of the erosion intensity at the height of the storm, are tabulated. The developed model is used to compare dune vulnerability to storms of varying intensities under conditions representative of the historical variability within the system. In the case of New Jersey, this variability includes frequent nourishment events.

RESULTS AND FUTURE WORK

Increasing storm intensities were found to increase the severity of dune erosion as expected. Variations in erosion within a particular storm intensity range were found to be related to differences in the in-situ beach configuration, namely the current berm width and dune volumes. Generally, the results highlight the importance of both dune size and berm width in controlling dune erosion. The model was used to highlight the importance of maintaining the minimum USACE design template between renourishments. When beach-dune system was maintained at the design template, major dune damages (>40% volume removal) were limited to the largest storms. However, under typical profiles between nourishments, major damages were predicted at much lower intensities. This work quantifies the attenuation of the nourishment project from initial placement and renourishment. Future work will include consideration of sea level rise and further investigation into the interrelationship between beach width and dune volume.

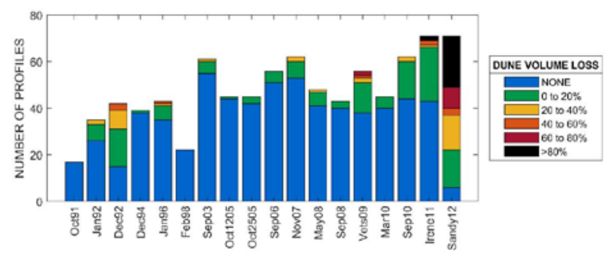

Figure 1 – Dune volume losses in major historical storms

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