# Poster Title: Numerical Modeling to Assess the Changing Coastal Risks from Nor'easters with Sea Level Rise in New England

COASTAL RESILIENCE CENTER

A U.S. Department of Homeland Security Center of Excellence

THE UNIVERSITY OF RHODE ISLAND GRADUATE SCHOOL OF OCEANOGRAPHY

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## Homeland Security Challenge

Coastal storms generate extreme winds, waves and storm surges that threaten the natural and built environment as well as public safety in coastal regions. Sea level rise (SLR) will change these processes, which will in turn change the associated impacts such as coastal flooding. Furthermore, without mitigation or sufficient adaptation, the rising sea levels alone will increase the frequency and severity of coastal flooding from tides. These evolving threats pose challenges to the Department of Homeland Security (DHS) that are twofold, (1) understanding the vulnerability of their own facilities, infrastructure and populations and (2) understanding the broader range of impacts such that FEMA can continue to effectively understand, plan, prepare and respond to these threats.

## Approach / Methodology

The coupled hydrodynamic/wave ADCIRC/SWAN model (Luettich, R. A. and Westerlink, J. J., 2017) is used to simulate a nor'easter for both the present sea level and with 1 m (3.3 ft) of SLR in order to assess the role of SLR on the impacts of storm surge, inundation and wave heights during nor'easters in the New England region. The geographical focus of this assessment is the northeast of Cape Cod, in the towns of Provincetown and Truro (Figure 1). These towns are located on a narrow hook shaped peninsula with unique vulnerabilities due to the storm exposure and the relatively great shoreline to land ratio.

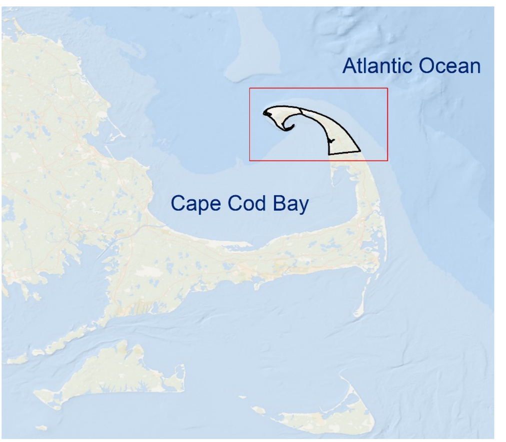


Figure 1: Map showing Cape Cod with study focus region identified.

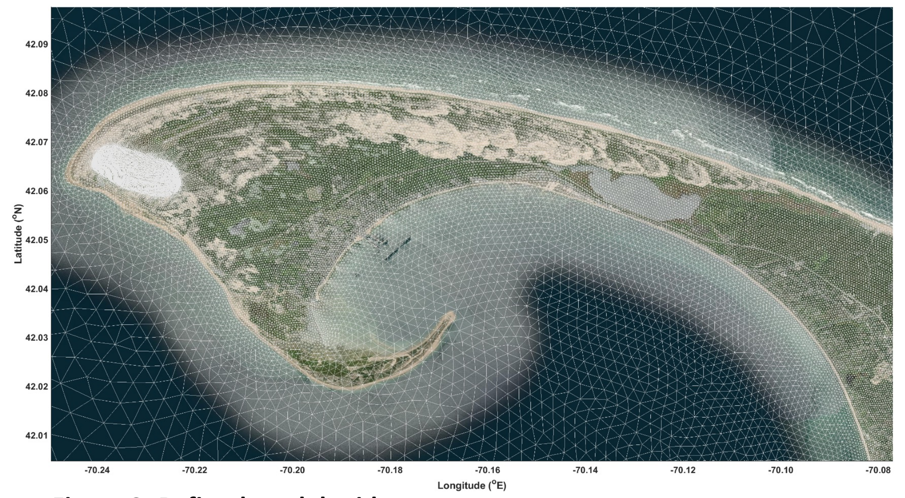

Figure 2: Refined model grid.

The ADCIRC/SWAN modeling leveraged a previously developed model grid of the Atlantic Basin (ESTOFS). For this application, the model grid is refined in the New England region (Figure 2) to better capture the coastal processes and inland flooding. Grid elevations are assigned based on recent high resolution data sets (Danielson et al. 2018). SLR is implemented by assigning an offset to the mean sea level in the nodal attributes definition file.

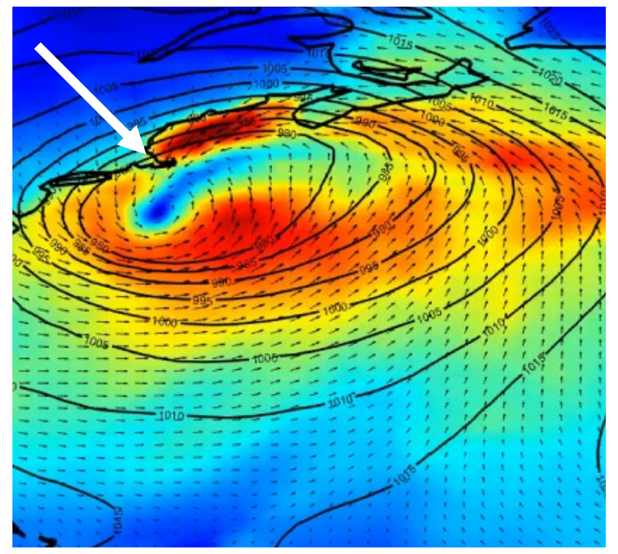

Figure 3: Snapshot of wind speed magnitudes with atmospheric pressure contours. Greater speeds shown in red.

The ADCIRC/SWAN model forcing includes tides at the ocean open boundaries (Egbert and Erofeeva, 2002) and meteorological conditions (Figure 3) from the ECMWF global meteorological reanalysis dataset (Dee et al., 2011).

The January 2[nd]-6[th] 2018 nor'easter caused coastal flooding (Figure 4) and large waves in Provincetown on January 4[th]. This storm is selected for simulations to demonstrate how SLR will change these impacts during a high impact nor'easter.

Figure 4: Photo of inland flooding during the January 2018 nor'easter. Photo credit: Center for Coastal Studies

## Outcomes / Results

The ADCIRC/SWAN model predicts the time and space varying total water level, currents and wave heights. Maps of the maximum inundation depths from the storm are developed for both scenarios as shown in Figure 5. In this figure the inundation is plot only in the areas over land, starting from the shore defined by the approximate present day mean sea level elevation. The inundation depth over land is shown using the color scale on the right with increasing depth from blue to red.

The difference in peak water level due to sea level rise is plot at a set of points in the coastal waters as shown in Figure 6. The time series of total water depth and significant wave height are queried for both scenarios at locations on either side of the peninsula, the locations queried are shown in Figure 6 and the time series are shown in Figure 7. The peak of the storm occurs at the coincidence of high tide and peak wind speeds; this timeframe is highlighted by the black dashed box in Figure 7.

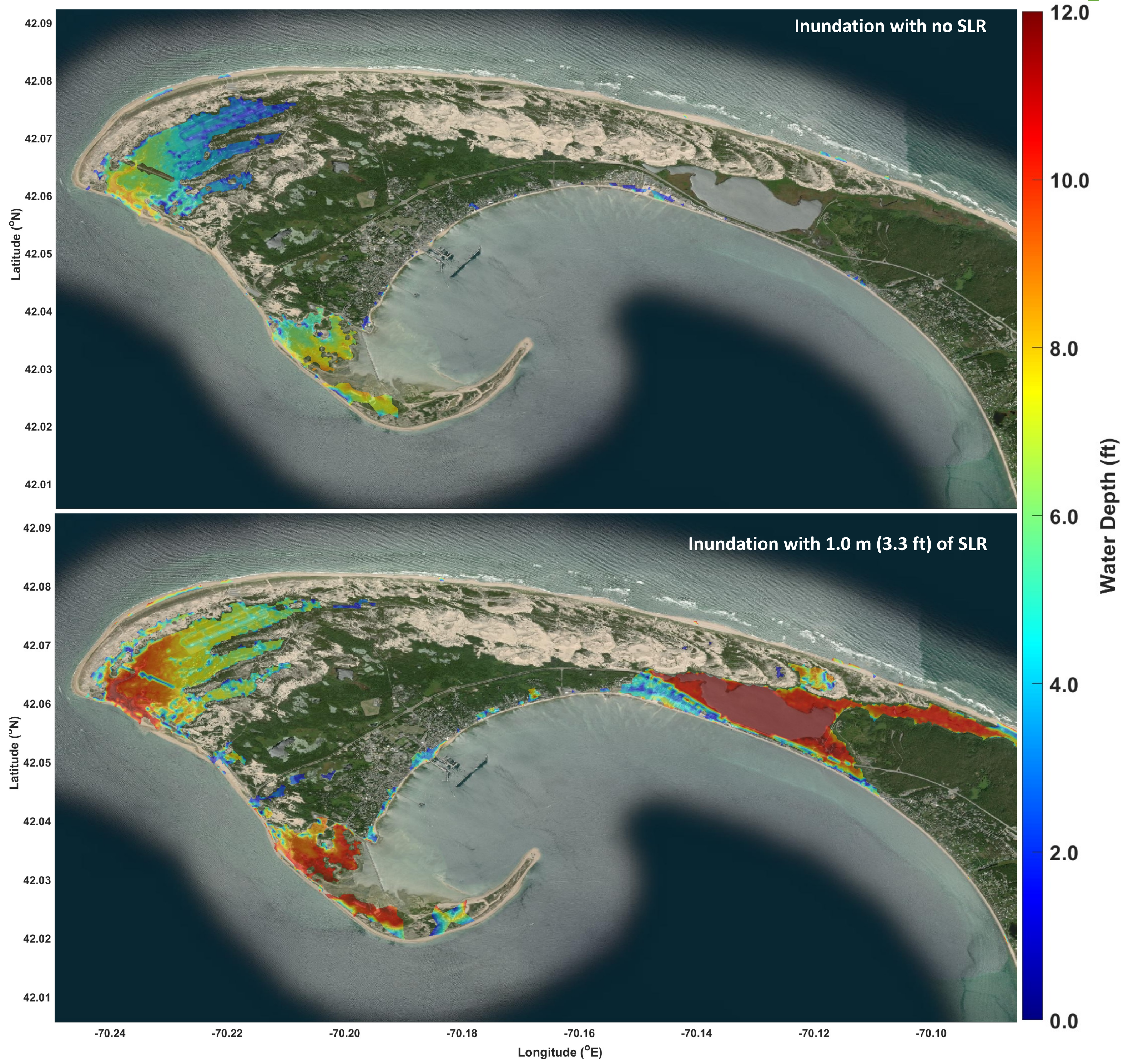


Figure 5: Maps of maximum inundation for scenario without SLR (top) and with 1.0 m of SLR (bottom).

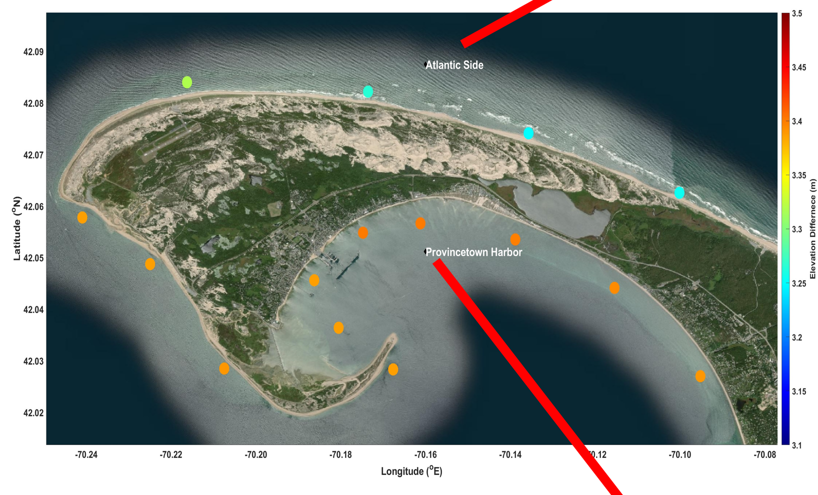


Figure 6 Map with markers showing the difference in peak water level with the addition of 1.0 m (3.3 ft) of SLR. Also shown are locations queried for time series analysis.. The extending arrows pointing to the set of three corresponding plots.

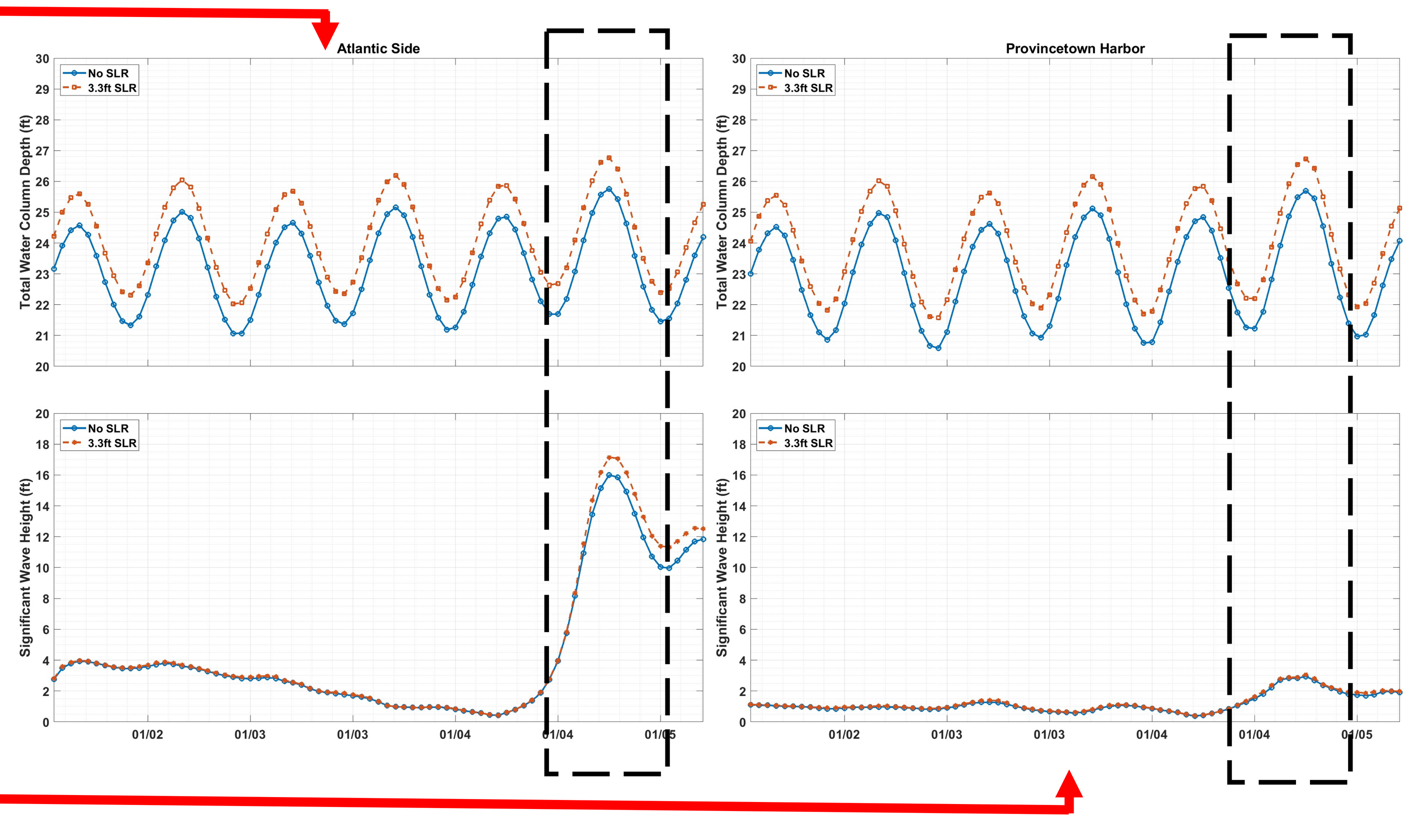


Figure 7: Time series at Atlantic Side (left) and Provincetown Harbor (right) of predicted total water column depth (top) and significant wave height (bottom) .

## Conclusions

The effects of SLR during a historic nor'easter are determined from the results of coupled hydrodynamic and wave model simulations using the ADCIRC/SWAN model. The effect of SLR is isolated by (1) comparing the inundation footprints, (2) comparing the prediction of water level at select coastal sites and (3) evaluating the change in wave heights. The conclusions from the analysis are as follows:

- SLR increases the total water level which increases the footprint inundated during tides and storm surges.
- The increase of the peak water level due to SLR does not exactly equal the assigned increment of 1 m (3.3 ft). Peak water levels mainly vary by +/- 5% along the coast with a differential less than 1 m (3.3 ft) on the Atlantic side and greater than 1 m (3.3 ft) in Provincetown Harbor.
- The inundation during the storm with SLR caused flooding to extend across the peninsula, leaving large portions of Provincetown without the ability to evacuate without having to cross flooded waterways.
- The storm-induced peak significant wave heights on the Atlantic side are much greater than those within Provincetown Harbor. The change in wave heights on the Atlantic side is also greater, with an increase of approximately 1 ft whereas the increase in Provincetown Harbor is negligible.

## References

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