Modeling increased impacts of Nor'easters due to sea level rise in coastal New England Parks

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ABSTRACT

In New England, the primary storm impacts are from Nor'easters rather than hurricanes, which are the major concern further south, and are better understood. While research on how climate change is affecting hurricanes is an active area of research, there is limited information on how the impact of Nor'easters may be amplified under a changing climate. In this study, we simulate the storm surge and inundation induced by a 2018 Nor'easter in two New England Parks using the Advanced Circulation Model with winds based on the European Centre for Medium Range Weather Forecasts model. The Model results were validated using a variety of weather stations. The impact of the projected sea level rise on storm predictions were investigated using sea level rise scenarios. This project will help park managers be better prepared to make the park safer for the public and plan for adaptation strategies to protect the park resources.

METHOD AND DESIGN

Figure 1: Nor'easters form from the cold air coming from the Midwest mixing with the warm water and climate coming north from the Gulfstream meeting in the Northeast US. These powerful systems have potential to create slow moving extratropical storms that bring high winds, strong storm surges, and sometimes high precipitation. (Boatus, 2016)

Scenario	Height	Source
Low	22 cm	NPS IPCC RCP 8.5 for 2050 *
Intermediate-low	44 cm	USACE High for 2050 **
Intermediate-high	62 cm	NPS IPCC RCP 8.5 for 2100 *
High	100 cm	Estimate for USACE for 2100 ***

Table 1: The scenarios which were implemented into the ADCIRC model. *Indicates a scenario provided by Caffrey et al (2018). ** Indicates a scenario provided by USACE (2016).

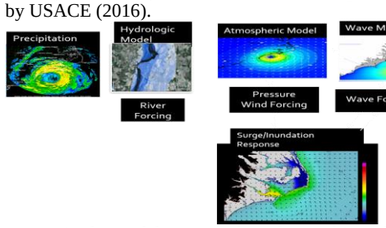

Figure 2: The model in use is the Advanced Circulation (ADCIRC) model. The figure shows the architecture of the modeling system. (Courtesy of Rick Luettich)

PURPOSE

This project will help park managers be better prepared to make the park safer for the public and plan for adaptation strategies to protect the park resources. The outcomes of this project can help the public in the area know what parts of their property are in danger.

VALIDATION

We use the ADCIRC model, which has four components (shown in Figure 2) to model a historic Nor'easter for four different sea level rise scenarios shown in Table 1. We validated the European Centre for Medium Range Weather Forecasts (ECMWF) which provides wind and atmospheric projections by comparing the model data to observed data for the March 2018 storm from 21 different weather stations across coastal southern New England. We then conducted evaluation of the ADCIRC model. This was done by comparing the simulated and observed water level at 16 NDBC and NOAA tide gauges.

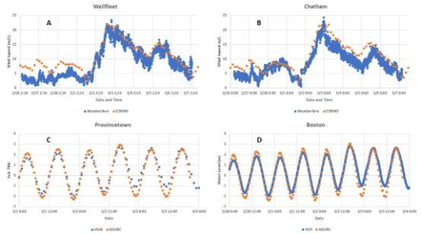

Figure 3: Panels A and B are the time series validations for 2 of the 21 studied stations for the ECMWF wind speed data. Panels C and D are the time series validations for 2 of the 16 stations used to compare against the ADCIRC water level data. The data showed that the ECMWF and ADCIRC accurately projected the wind speeds and water level, respectively.

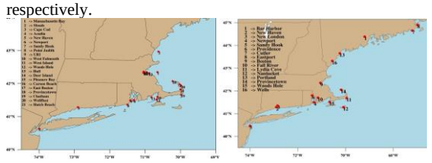

Figure 4: The image on the left shows the 21 stations used to validate the ECMWF wind speed projections. The image on the right shows the 16 NDBC and NOAA tide gauges used to validate the ADCIRC water level projections.

RESULTS

After implementing the sea level rise scenarios into the ADCIRC model, the peak inundation in the northern areas of Cape Cod can be seen in Figure 6. One key feature of the mapped inundation is that as the sea level rises, not only does the water level increase in places such as the airport and lighthouse labeled, but eh land inundated also increases greatly.

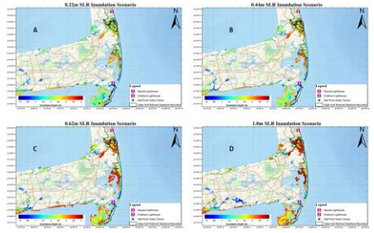

Figure 5: The peak inundation for the three highest sea level rise scenarios for the southern part of Cape Cod. Panels A, B, C, and D show the same area for the 22cm, 44cm, 62cm, and 100cm sea level rise.

It can be seen in Panel D of Figure 5 that the inundation virtually cuts most of Cape Cod from the mainland. This can interfere with their ability to get medical supplies and rescue.

Station Name	22 cm SLR	44cm SLR	62cm SLR	100 cm SL
Hatches Harbor	24	49	71	107
Long Point Marshes	19	47	66	106
Herring Cove Beach	18	45	66	102
East Harbor	20	48	71	106
Nauset Beach	21	43	63	93

Table 2: The maximum difference in water level between the sea level rise scenarios and the control case. It can be seen that in some scenarios, the difference could possibly be as much as +/- 7cm.

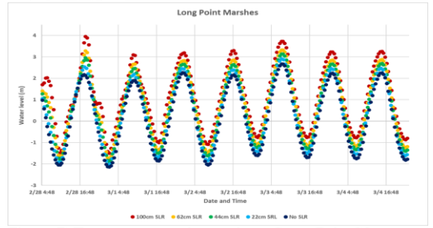

Figure 7: The water level time series at Long Point Marshes, a location in the northern part of Cape Cod, of the four-sea level rise scenario and the control case.

Due to the bathymetry of the land and ocean, the spatial distribution of the inundation and affected areas changes non-uniformly. Park managers would like to know what areas will be affected more than they are now, in the future, so they can prepare such as in Figure 8.

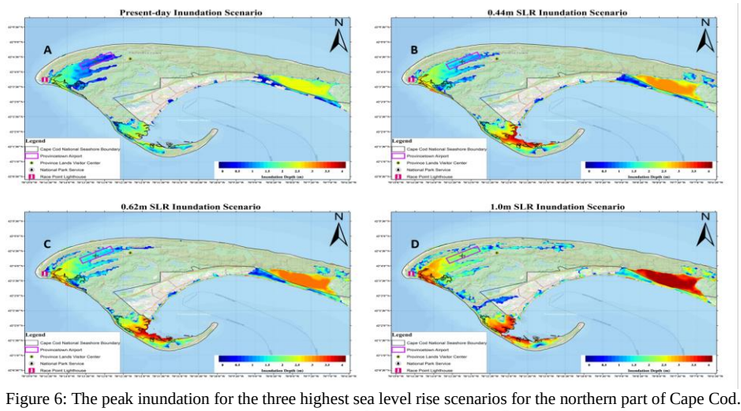

Figure 6: The peak inundation for the three highest sea level rise scenarios for the northern part of Cape Cod. Panel A shows the projections of the inundation during the March 2018 storm. Panels B, C, and D show the same area for the 44cm, 62cm, and 100cm sea level rise.

DISCUSSION

Figure 8: The pavilion above was raised to prevent flooding during storm surges so the water would flow beneath the building. During the process, the affects of sea level rise were not taken into consideration. (Thompson Island Outward Bound 2018)

The ADCIRC model was applied to simulate storm surge and inundation for a historic Nor'easter at four scenarios of sea level rise for Cape Cod National Seashore. The model validation results showed reasonable agreement. As the sea level rises, the impacts that the Commonly used superposition of simply adding the amount of sea level rise to the water level in an area is a simplifying assumption which this modeling improves on shown in Table 2. Figures 5 and 6 show that as the sea level rises, the spatial distribution and height of the water level changes. This is important for park managers to know where the flooding will extend to as the sea rises. In addition, future outreach can share the results with local communities as the residents of Cape Cod know where and how the future flood risk is changing.

REFERENCES AND ACKNOWLEDGEMENTS

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