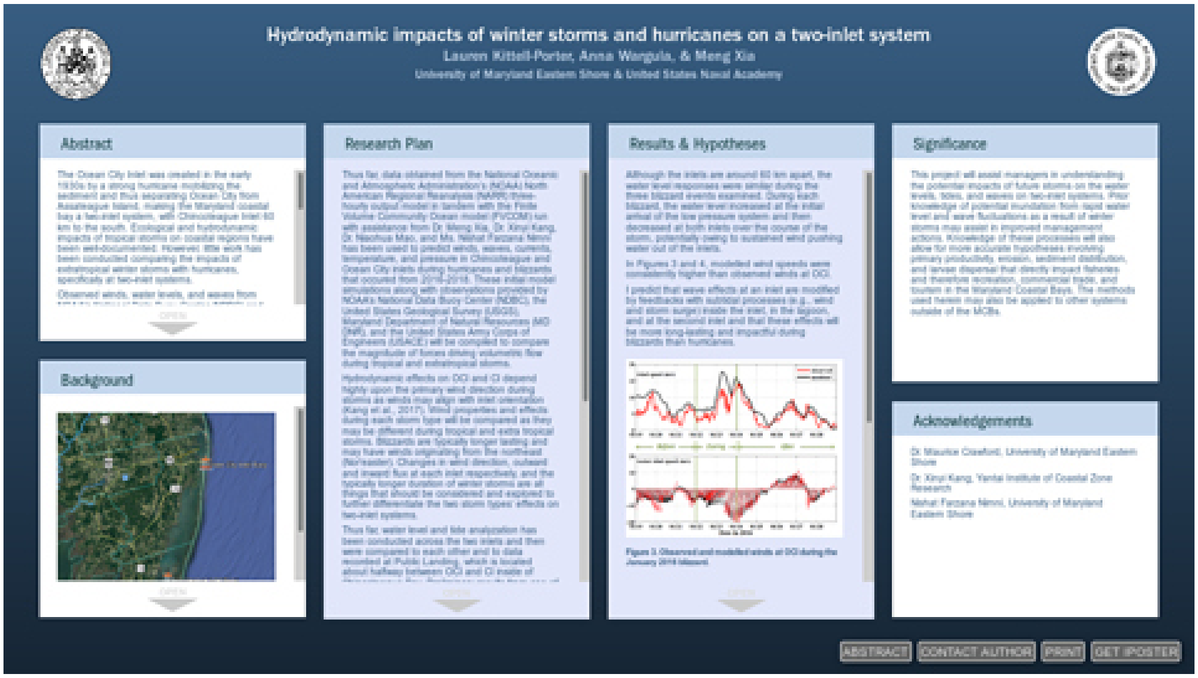
Hydrodynamic impacts of winter storms and hurricanes on a two-inlet system



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ABSTRACT

The Ocean City Inlet was created in the early 1930s by a strong hurricane mobilizing the sediment and thus separating Ocean City from Assateague Island, making the Maryland coastal bay a two-inlet system, with Chincoteague Inlet 60 km to the south. Ecological and hydrodynamic impacts of tropical storms on coastal regions have been well-documented. However, little work has been conducted comparing the impacts of extratropical winter storms with hurricanes, specifically at two-inlet systems.

Observed winds, water levels, and waves from NOAA's National Data Buoy Center (NDBC) and predicted data from the North American Regional Reanalysis (NARR) and Finite Volume Community Ocean Model (FVCOM) models were compiled for 2016 to 2018 to compare the magnitude of forces driving volumetric flow during tropical and extratropical storms. Although the inlets are around 60 km apart, the water level responses were similar during the three blizzard events examined. During each blizzard, the water level increased at the initial arrival of the low-pressure system and then decreased at both inlets over the course of the storm, potentially owing to sustained wind pushing water out of the inlets.

The wind and wave forcing on both inlets will be compared using field data to validate modeled data for one blizzard and hurricane per each year. This study, along with the validated hydrodynamic models that were utilized, will assist in predicting environmental stressors and potential influences on shoreline zones under varying storm intensities in two-inlet systems.

SITE LOCATION & DATA

Observations of water levels were obtained from gauges at Ocean City Inlet (OCI), Chincoteague Inlet (CI), and Public Landing (PL) to evaluate the subtidal dynamics at the inlets and inside the bay due to tropical and extratropical storms.The inlets are separated by a distance of 60 km.

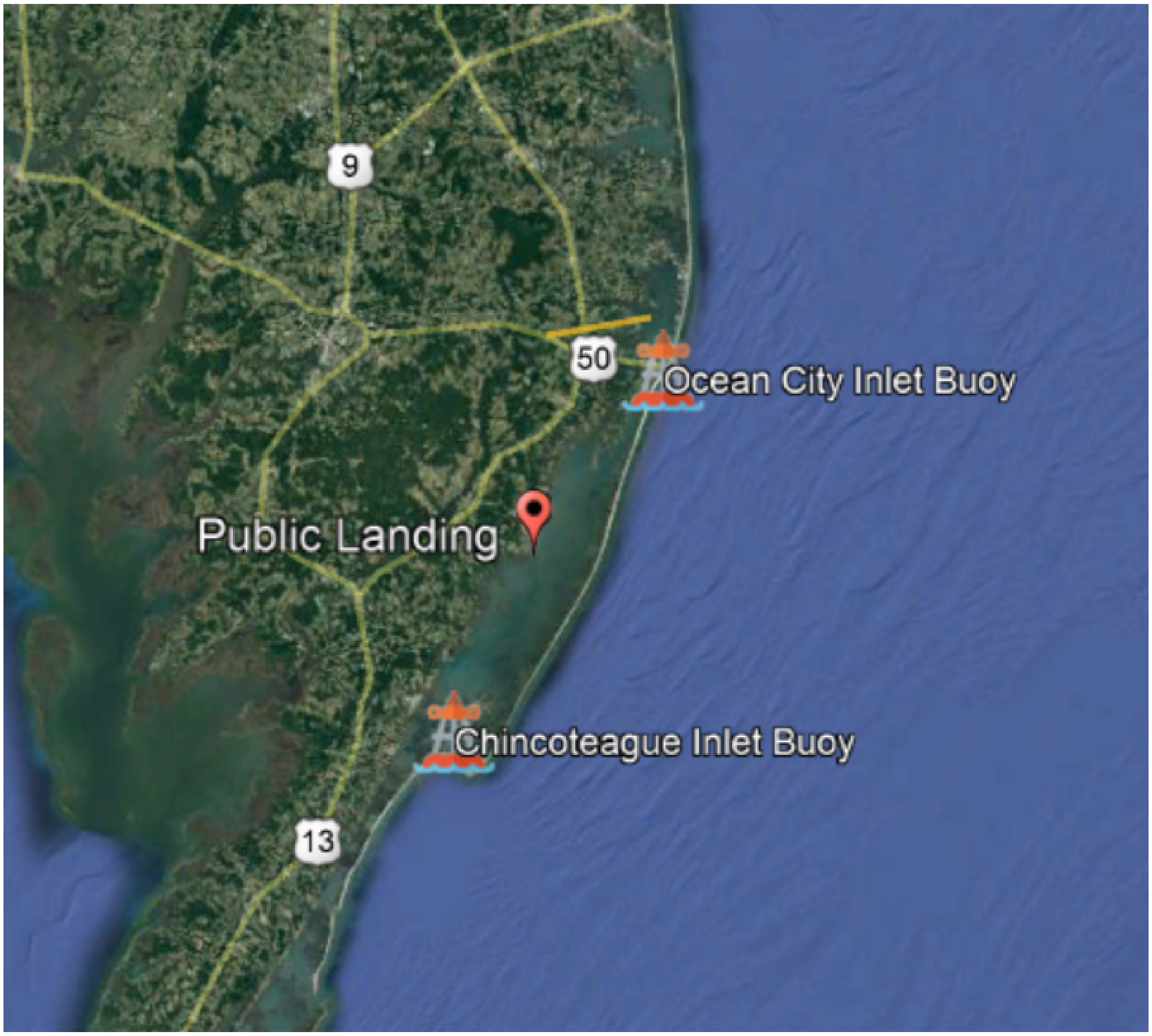

Figure 1. Locations of the Chincoteague Inlet (CI), Public Landing (PL), and Ocean City Inlet (OCI) gauges (Google Earth, 2020).

OBSERVATIONS

Water levels were lowpass filtered to remove signals with periods less than 30 hours. A cross-correlation analysis suggests that PL water levels lag behind CI and OCI by 16-30 hours. Figures 2 and 3 show the water levels during Hurricane Maria in 2017 and a blizzard in 2016, respectively. Although the two inlets differ in scale, their subtidal water level responses are similar. The water levels increased at the initial arrival of the low pressure system and then decreased at both inlets over the course of the storm, potentially owing to sustained wind pushing water out of the inlets.

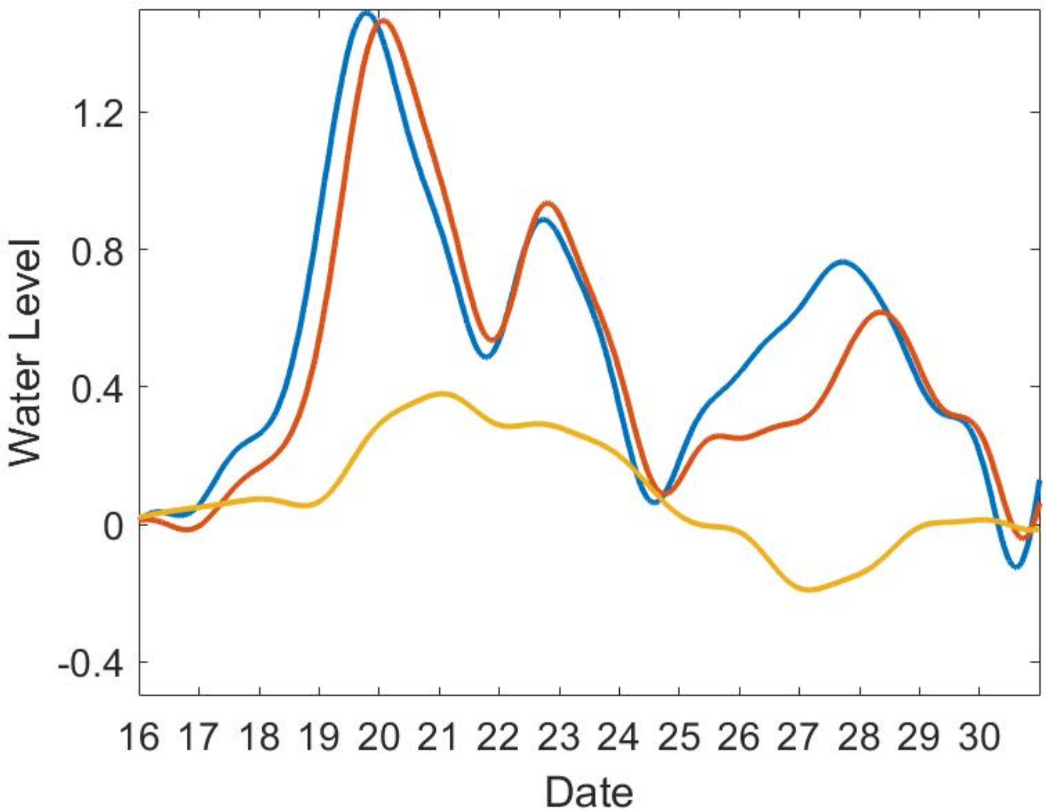

Figure 2. Water levels in meters at Chincoteague Inlet (blue), Ocean City Inlet (red), and Public Landing (yellow) during the passage of Hurricane Maria (September 2017).

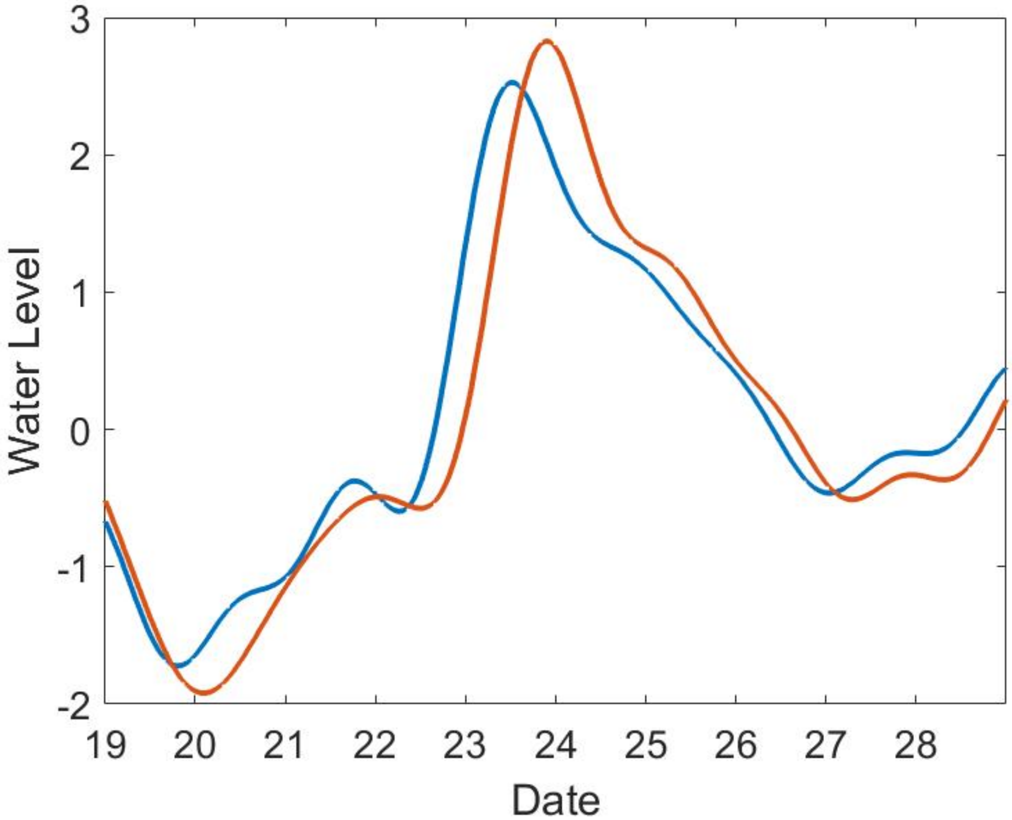

Figure 3. Water levels in meters at Chincoteague Inlet (blue) and Ocean City Inlet (red) during a blizzard in January 2016. Public Landing data was not available.

NUMERICAL MODEL

The Finite Volume Community Ocean Model (FVCOM) was run for two blizzard events that occured in 2016-2018. Figure 4 shows the comparison of modeled and observed wind speed and direction at OCI. The modeled wind was somewhat higher, but reproduced the observed change in magnitude well. Other comparisons of simulations and observations to verify the model are underway.

FVCOM will be used to evaluated the magnitude of forces driving volumetric flow during tropical and extratropical storms, comparing and contrasting the responses of the two inlets. It is expected that the feedbacks between subtidal processes (e.g., wind-driven flows and storm surge) inside the inlets and lagoon will be more long-lasting during blizzards compared to hurricane events previously studied at the site.

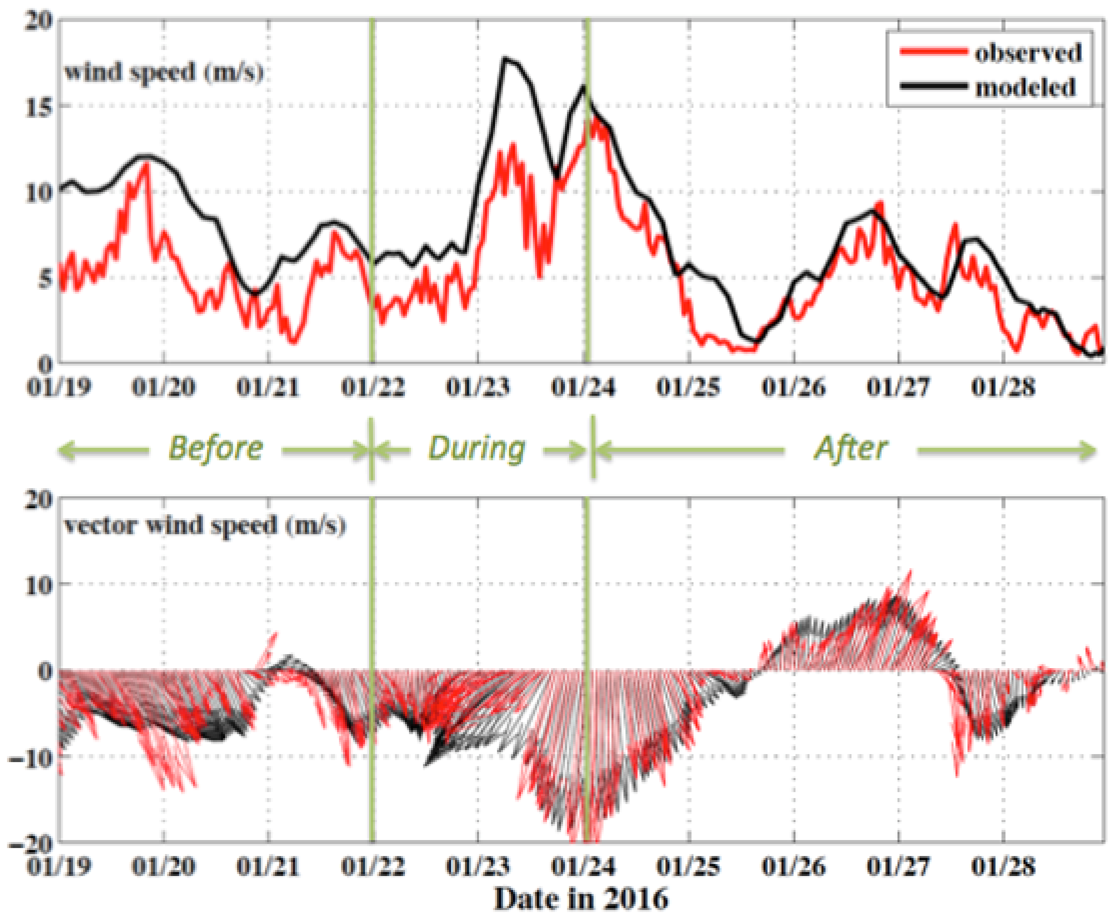

Figure 4. Observed and modeled winds at OCI during the January 2016 blizzard.

SIGNIFICANCE

This project will assist managers in understanding the potential impacts of future storms, including surge, wind, and waves, on the water levels and flooding at a two-inlet system. Better understanding of potential inundation from rapid water level and wave fluctuations as a result of winter storms may assist in improving management actions. Knowledge of these processes will also allow for more accurate hypotheses involving primary productivity, erosion, sediment distribution, and larvae dispersal which directly impact fisheries and therefore recreation, commercial trade, and tourism in the Maryland Coastal Bays (MCBs). The methods used herein may also be applied to other two-inlet systems outside of the MCBs.

ACKNOWLEDGEMENTS

We thank Dr. Xinyi Kang (Yantai Institute of Coastal Zone Research) and Ms. Nishat Farzana Nimni (University of Maryland Eastern Shore) for setting up and running the FVCOM model. We thank Dr. Maurice Crawford (University of Maryland Eastern Shore) for his discussions that improved this work. This work is funded by the National Science Foundation.

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