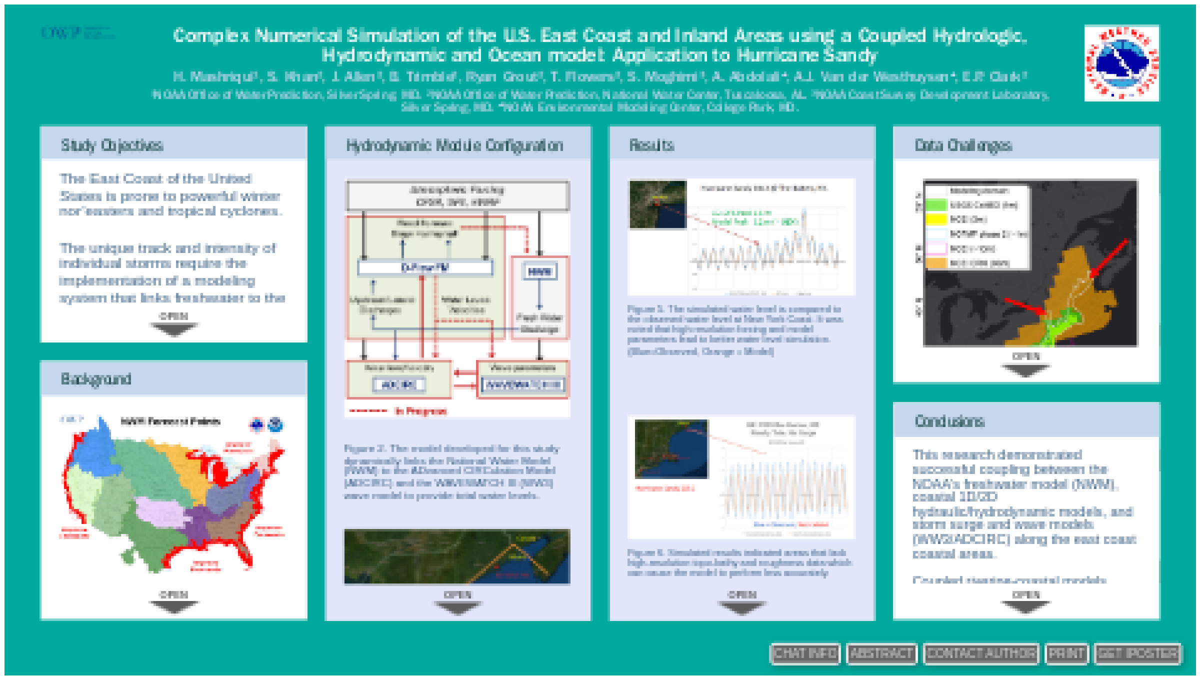
Complex Numerical Simulation of the U.S. East Coast and Inland Areas using a Coupled Hydrologic, Hydrodynamic and Ocean model: Application to Hurricane Sandy

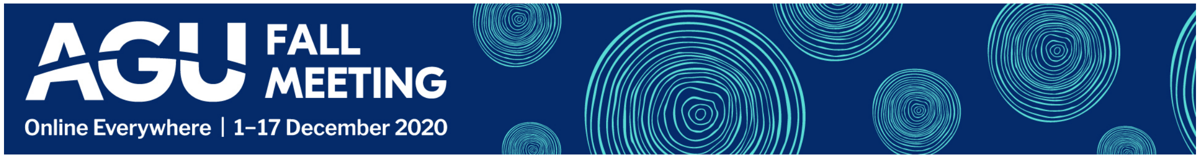


H. Mashriqui[1], S. Khan[2], J. Allen[2], B. Trimble[2], Ryan Grout[2], T. Flowers[2], S. Moghimi[3], A. Abdolali[4], A.J. Van der Westhuysen[4], E.P. Clark[2]

[1]NOAA Office of Water Prediction, Silver Spring, MD. [2]NOAA Office of Water Prediction, National Water Center, Tuscaloosa, AL. [3]NOAA Coast Survey Development Laboratory, Silver Spring, MD. [4]NOAA Environmental Modeling Center, College Park, MD.

NATIONAL WEATHER SERVICE

PRESENTED AT:



STUDY OBJECTIVES

The East Coast of the United States is prone to powerful winter nor'easters and tropical cyclones.

The unique track and intensity of individual storms require the implementation of a modeling system that links freshwater to the saltwater models.

In this study, a coupled inland hydrologic model is linked to an ocean hydrodynamic and wave model to compute total water levels in the coastal zones.

This complex model is evaluated for the 2012 superstorm Sandy which caused massive flooding on the east coast.

BACKGROUND

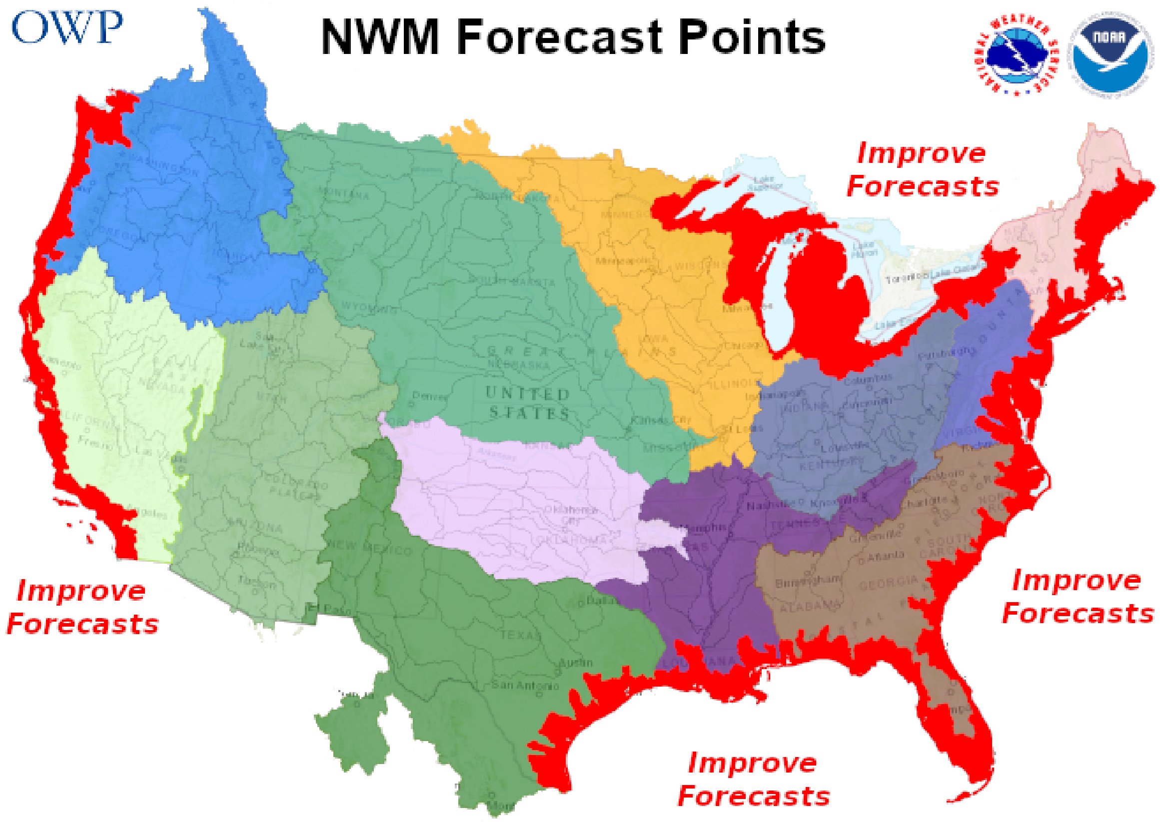


Figure 1. Locations along the US coastlines and the Great Lake areas where a coupled hydrologic-hydrodynamic-wave modeling is required to compute total water levels to provide improved forecasts.

HYDRODYNAMIC MODULE CONFIGURATION

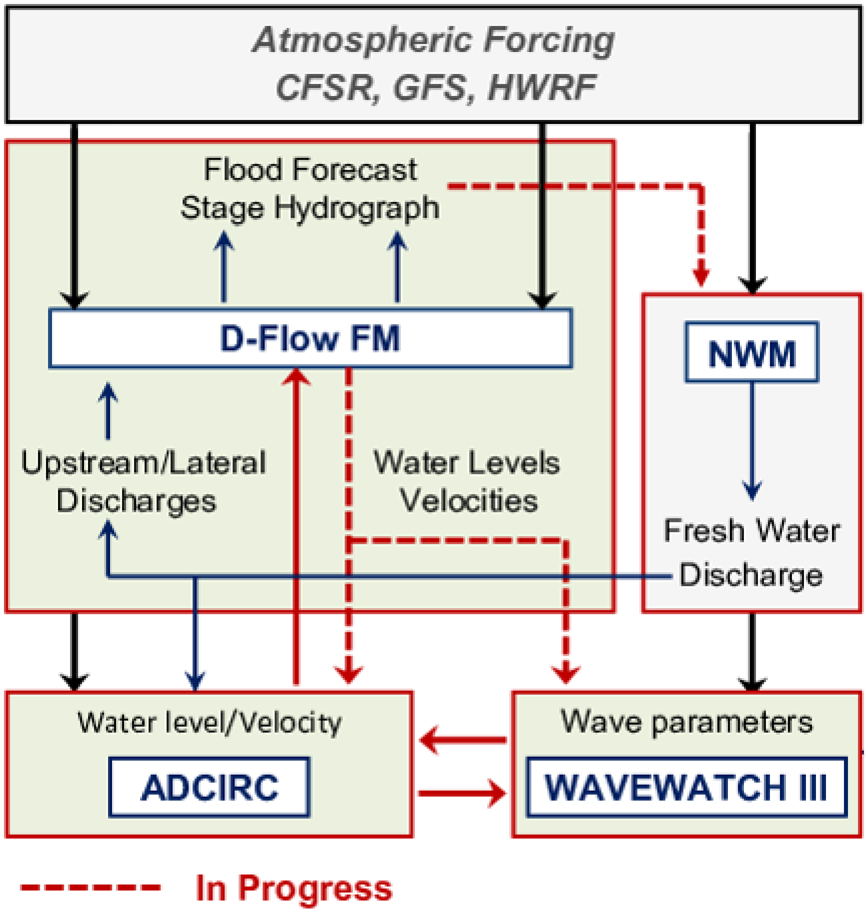


Figure 2. The model developed for this study dynamically links the National Water Model (NWM) to the ADvanced CIRCulation Model (ADCIRC) and the WAVEWATCH III (WW3) wave model to provide total water levels.

Figure 3. The model domain included several states of the US East Coast starting from New Jersey to the St. Croix River at the US-Canada border.

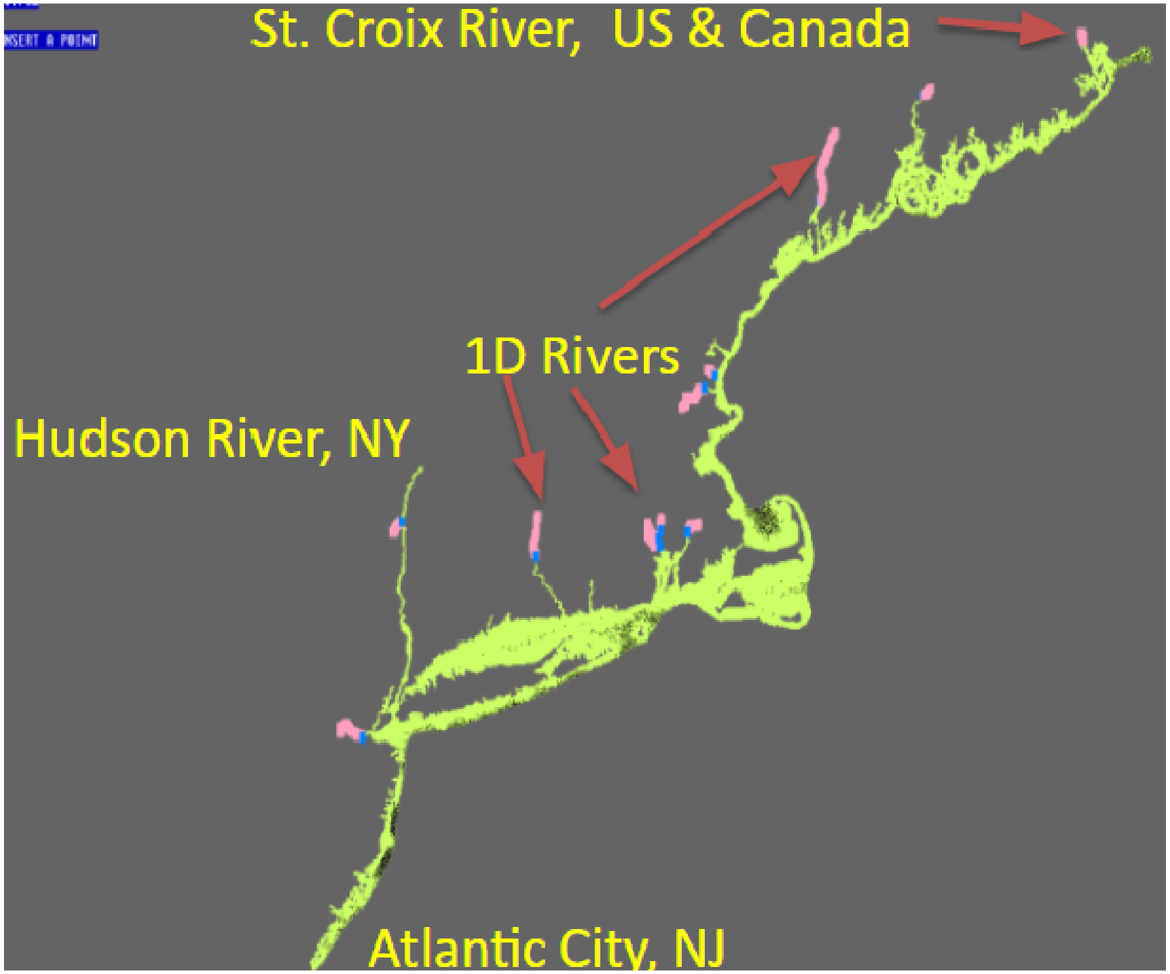


Figure 4. The computational mesh of the hydrodynamic module of the NWM. Detailed one-dimensional cross-sections were provided to capture riverine flooding. The computational mesh was extended to the nearshore areas to link to the saltwater model.

RESULTS

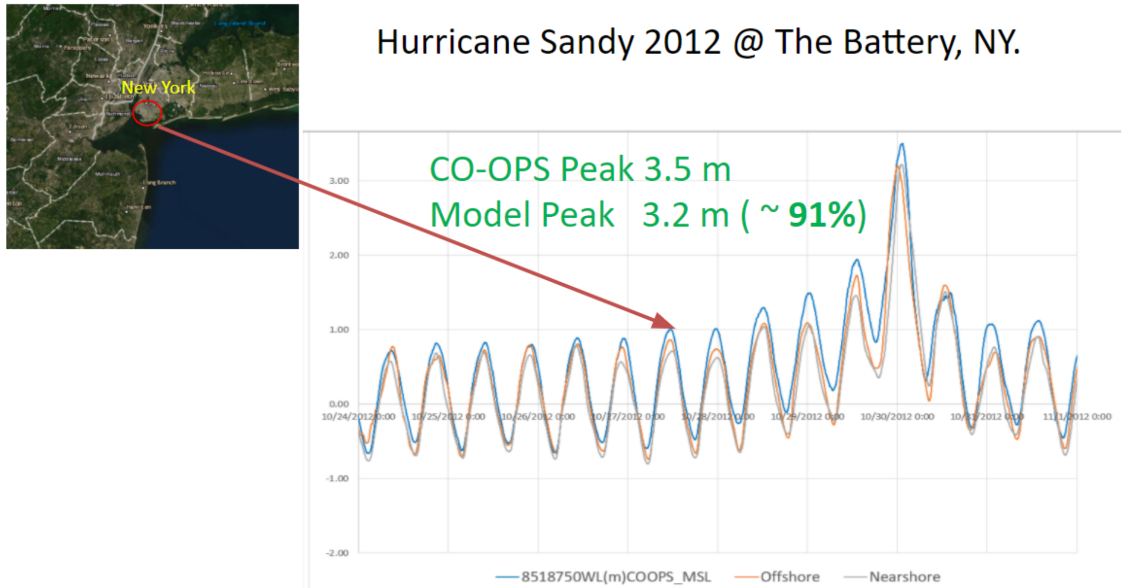


Figure 5. The simulated water level is compared to the observed water level at New York Coast. It was noted that high resolution forcing and model parameters lead to better water level simulation. (Blue=Observed, Orange = Model)

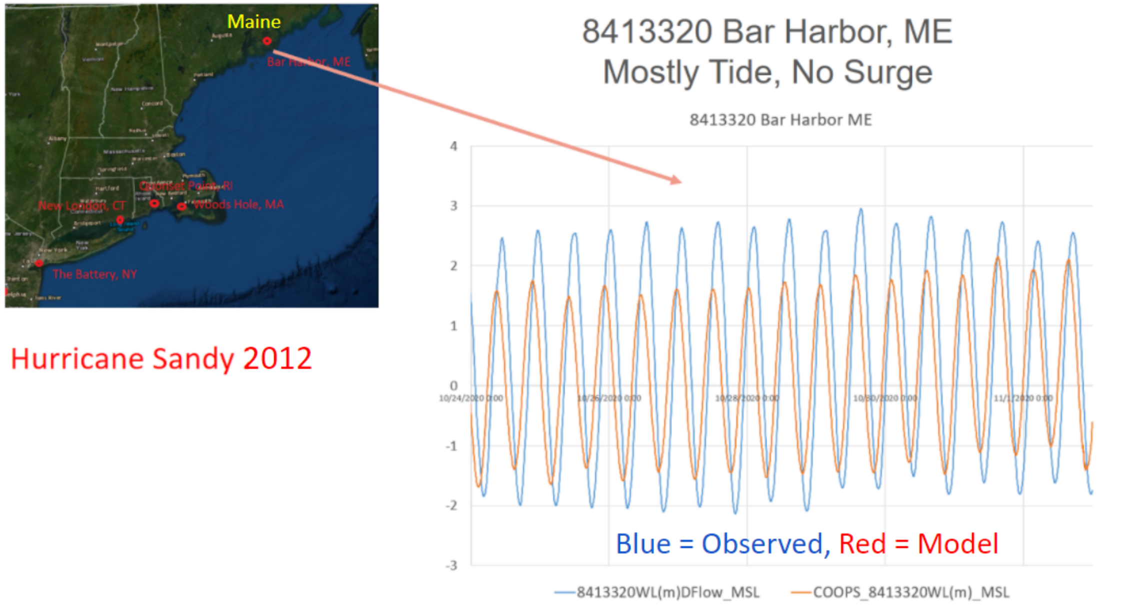


Figure 6. Simulated results indicated areas that lack high-resolution topo-bathy and roughness data which can cause the model to perform less accurately.

DATA CHALLENGES

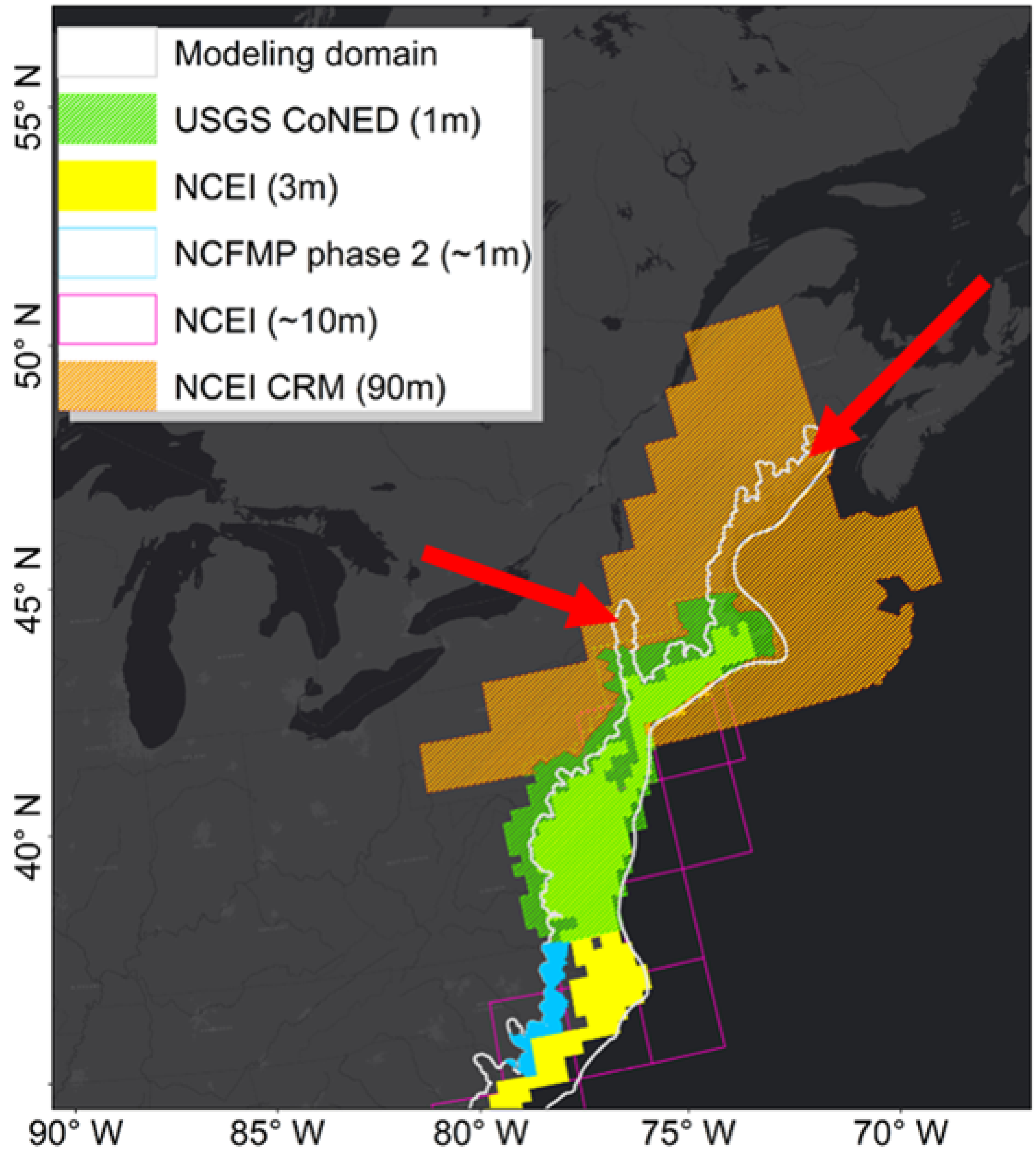


Figure 7. Location of areas that lack high-resolution topo-bathy data along the Maine, New Hampshire coastlines, and upper Hudson river basin.

CONCLUSIONS

This research demonstrated successful coupling between the NOAA's freshwater model (NWM), coastal 1D/2D hydraulic/hydrodynamic models, and storm surge and wave models (WW3/ADCIRC) along the east coast coastal areas.

Coupled riverine-coastal models satisfactorily simulated hydrodynamic characteristics of the east coast during a major storm. Hurricane surge and tide time-series comparisons of water levels at different stations showed a stable model with acceptable results.

Several iterative simulations depicted that water level predictions depend on an accurate representation of the wind conditions, bottom roughness, and topo-bathy data.

Acknowledgments
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ABSTRACT

Fluctuations of the total water level in the U.S. East Coast depends on the complex interactions of freshwater flow, tide, storm surge and wave actions. In order to include all major forcings of water movement in this area, a coupled modeling system consisting of the National Water Model (NWM), the Advanced Circulation Ocean Model (ADCIRC), and the WAVEWATCH III model has been developed. In this system, a coupled inland hydrologic model is linked to an ocean hydrodynamic and wave model to compute total water levels in the coastal zones. In the freshwater component of the hydrodynamic model, 1D river components were included in the model to capture accurate representation of tributaries to the 2D model of the estuary and oceans. The model domain included several states of the US East Coast starting from New Jersey to the St. Croix River at the US-Canada border.

Model simulations were compared with 2012 superstorm Sandy measured tidal water levels and hurricane surge. Initial simulations reproduced satisfactory spatial and temporal variations of water levels due to riverine discharge and storm surge. The model predictions showed that using 1D component allowed better representations of the inland rivers and produced accurate river water levels. Simulations indicated that water level in the inland areas depend on both river discharges and backwater effects of the ocean. These results showed the strengths of the coupled modeling system used in this research to compute total water levels during river flooding that coincides with extreme hurricane surge. Initial results showed that the coupled modeling framework used in this study is capable of total water estimation in the coastal zones and accuracy of the water levels highly depends on the availability of reliable topographic, bathymetric and bottom roughness data.