Influence of Forcing Conditions on Total Water Level Prediction and Spatiotemporal Patterns in Delaware Bay, USA

D. F. Muñoz[1], D. Yin[2], J. Tian[3], R. Bakhtyar[4], K. Mandli[5], C. Ferreira[6]

[1]University of Alabama, Civil, Construction and Environmental Engineering, Tuscaloosa, AL, U.S. [2]Louisiana State University, Oceanography and Coastal Sciences, Baton Rouge, LA, U.S.
[3]University of Alabama, Computer Science, Tuscaloosa, AL, U.S. [4]U.S. Army Corps of Engineers, Southwestern Division, Galveston, Texas, U.S.
[5]Columbia University, New York, NY, U.S. [6]George Mason University, Fairfax, VA, U.S.
Corresponding author: dfmunoz1@crimson.ua.edu

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ABSTRACT

Accurate forecasts of total water level (i.e., a combination of river flow, tide, surge and wave-induced water level) is imperative for stakeholders that need to rapidly adopt strategies for potential flooding hazards. Based on a systematic set of scenarios, we analyze the influence of relevant forcing conditions on total water level (TWL) prediction in Delaware Bay USA, and quantify the contribution of each forcing toTWL peak for Hurricane Isabel (September, 2003) and Sandy (October, 2012).

RESEARCH OBJECTIVES

1. Investigate relevant forcing conditions in Delaware Bay and quantify their relative contribution to TWL.
2. Evaluate the accuracy of TWL prediction (in space and time) around the TWL peak of Hurricane Isabel and Sandy.

BACKGROUND

This research was developed as part of the National Water Center Innovators Program - SI 2019. Our team studied the complex interactions of forcing conditions in coastal transition zones that affect the NWM's ability to generate accurate TWL forecasts.

Delaware Bay (DB), located at the east coast of the U.S. (Fig. 1), has an approx. length of 210 km starting at Trenton and flows in a southeastern direction towards the Atlantic Ocean. DB is vulnerable to extreme storm surges, rainfall and strong waves (e.g., higher than 1.5 m) as a consequence of the Atlantic Hurricane season, which has affected DB since 1749 with more than 100 tropical cyclones (Salehi, 2018). Tides in the lower bay are semidiurnal and dominated by the principal lunar semidiurnal constituent (M2) with tidal amplitudes about 0.75 m.

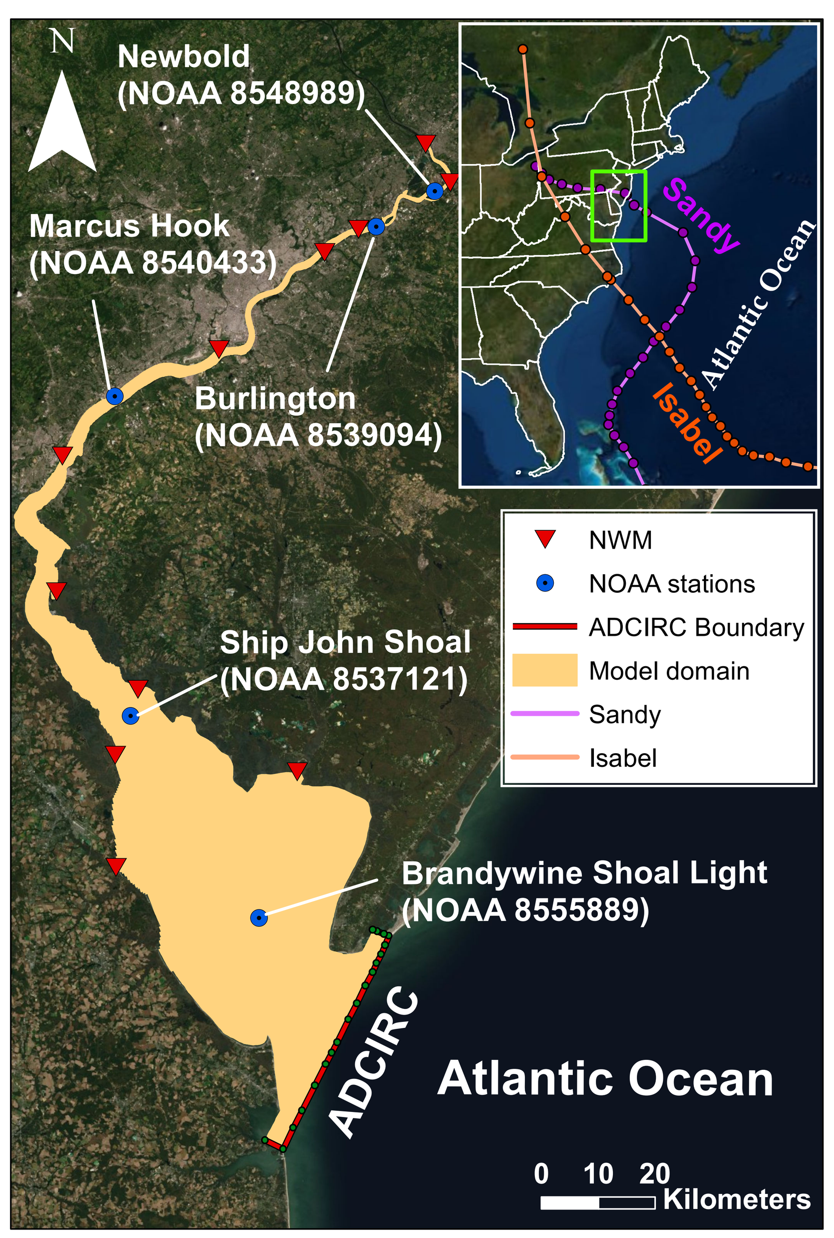

Fig. 1. Map of DB located in the U.S. (green box). Hurricane best tracks of Isabel and Sandy (brown and purple lines, respectively). Model domain (yellow polygon) and NOAA stations (blue circles). NWM-river discharge boundaries (red triangles) and ADCIRC-water level boundary (red line).

MODEL FRAMEWORK

We leverage a previously established model framework that accounts for a calibrated Delft3D-FM model of DB coupled with HWRF, CFSR, NWM, ADCIRC and WW-III models. Figure 2 presents a schematic of the model framework where atmospheric forcing is used to generate wind setup for the NWM and Delft3D-FM models. The NWM in turn generates river discharge input for WW-III, ADCIRC and Delft3D-FM. Likewise, WW-III and ADCIRC interact with each other sharing water level and velocities, and subsequently producing wave-induced water level as ocean /offshore boundary condition for Delft3D-FM.

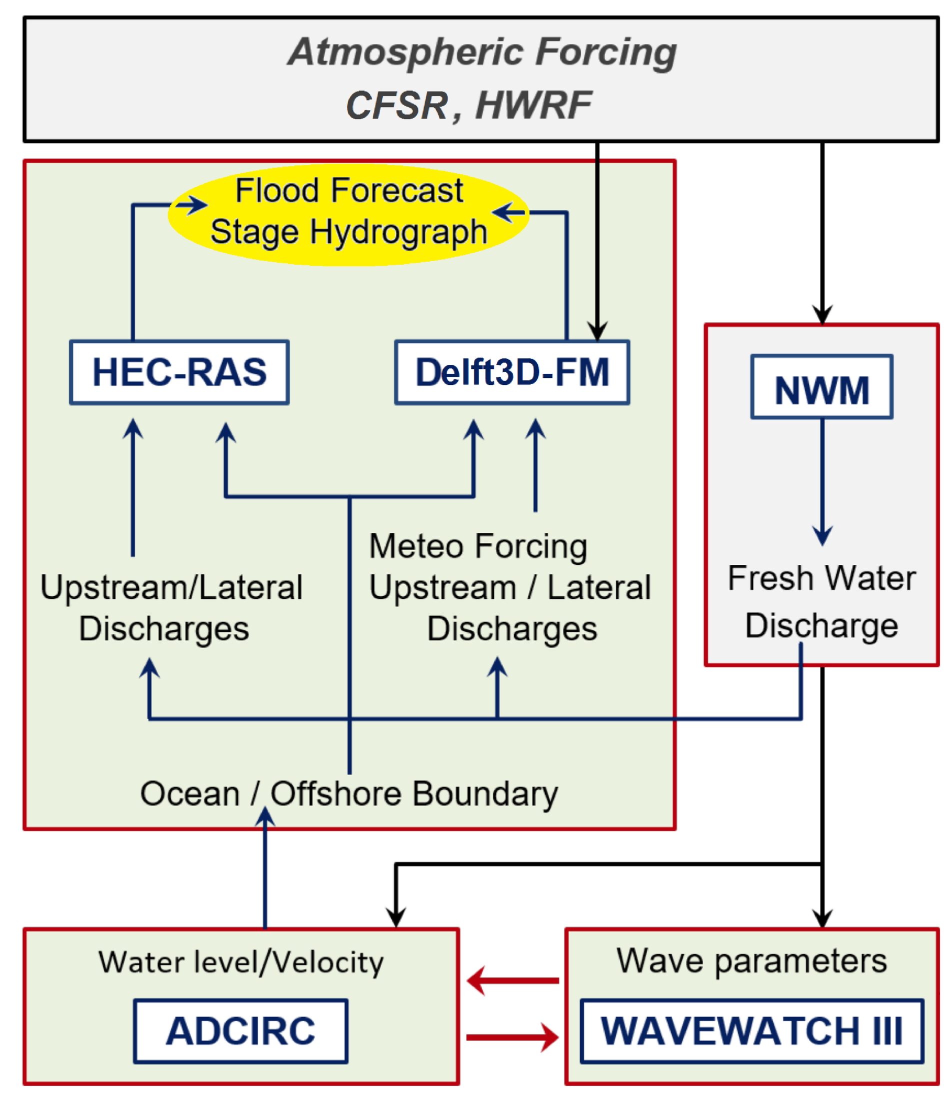

Fig. 2. Model framework adapted from Bakhtyar et al., (2019) and Maitaria et al., (2018). Atmospheric, continental and oceanic models transfer input forcing data to HEC-RAS and Delft3D-FM.

RESULTS

Relative contributions of astronomic tides (AT), river discharge (RD) and storm-surge (SS) to TWL are calculated at five NOAA stations of DB. Distances are measured from Brandywine station (0 km) and continuing in upstream direction (Fig. 3). Influence of forcing conditions on spatiotemporal patterns of RMSE around the TWL peak of both hurricanes (Fig. 4)

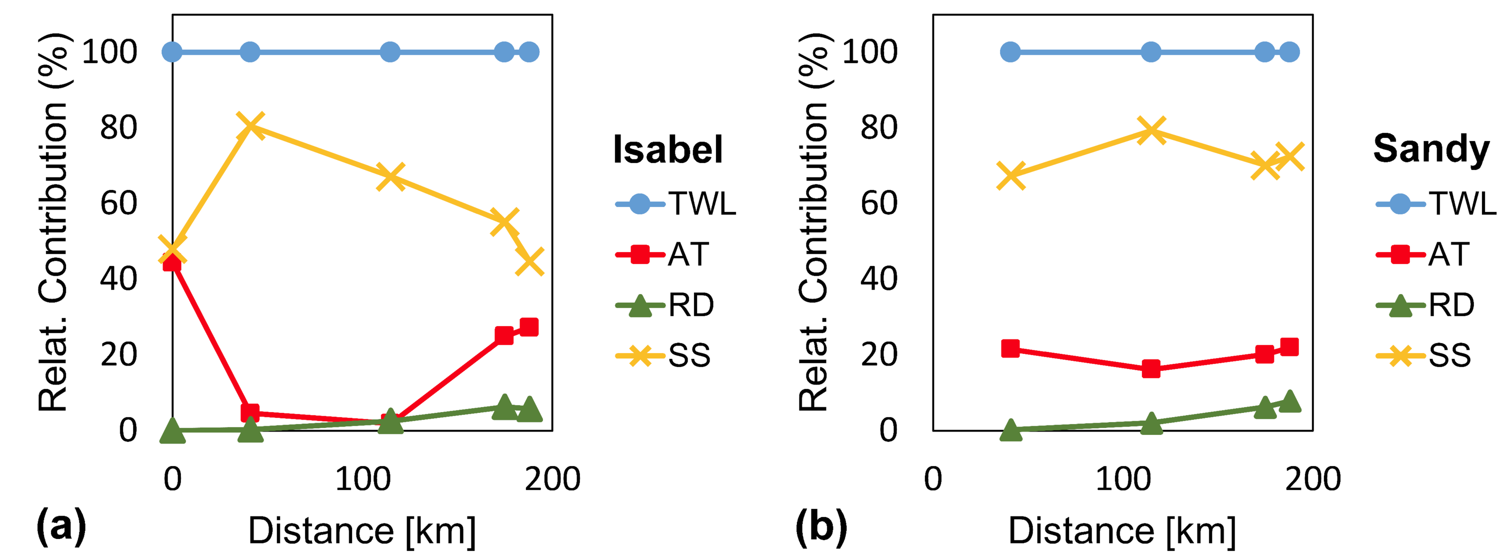

Fig. 3. Relative contribution of forcing conditions (AT, RD and SS) to TWL peak during (a) Hurricane Isabel and (b) Sandy.

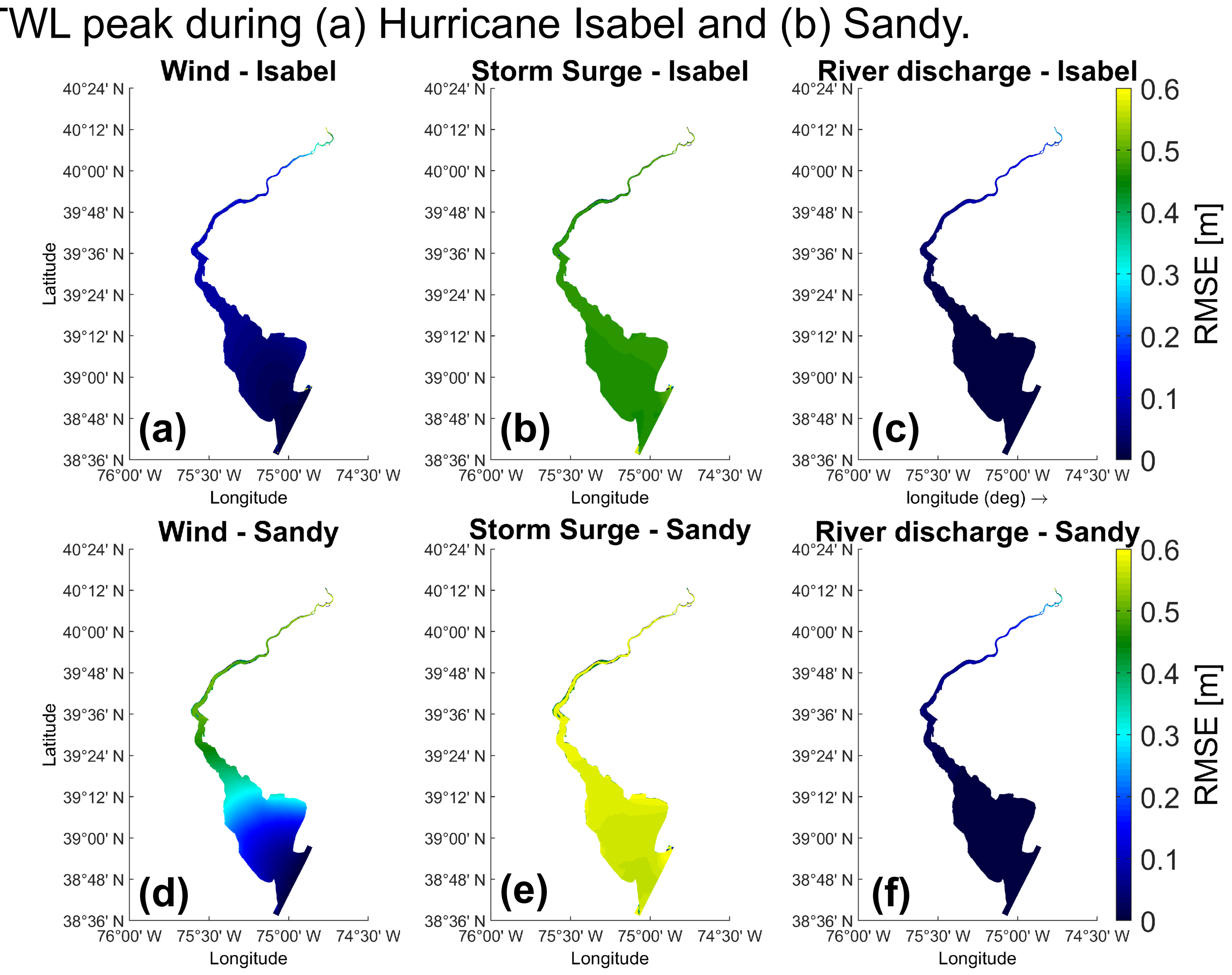

Fig. 4. Spatiotemporal patterns of RMSE around the TWL peak of Hurricane Isabel (top panel) and Sandy (bottom panel). Forcing conditions influence the accuracy of TWL prediction when wind (a, d), storm surge (b, e) and river discharge (c, f) are not simulated.

CONCLUSIONS

It is revealed that in both hurricanes, storm surge-induced water level was the main contributor to TWL. Analyses of spatiotemporal patterns suggest that local wind played a key role to accurately simulate TWL in DB; especially for Sandy due to the hurricane's track proximity to DB.

REFERENCES

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