Hurricane Florence numerical simulations of waves and storm surge using different wind forcing products

COASTAL RESILIENCE CENTER

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

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Homeland Security Challenge

Tropical cyclones can cause intense winds, waves, and storm surge in coastal areas. These extreme weather conditions can put the lives and properties of the people who live in these areas in great danger. Therefore, the Department of Homeland Security needs to be equipped with the best scientific knowledge and forecasting tools for predicting hazards and potential impacts from tropical and extratropical cyclones on critical infrastructure and communities in the U.S. This study aims to improve the ADCIRC Prediction System (APS) modeling capabilities by evaluating the impact of two new hurricane wind products developed by NOAA and URI on storm surge and wave predictions.

Approach / Methodology

Two new wind products are evaluated for their potential use in the ADCIRC-SWAN coupled system. First is NOAA's Hurricane Weather Research and Forecasting (HWRF) model Reanalysis product. Second is the URI Hurricane Boundary Layer (HBL) model (please see poster by Mansur Ali Jisan). Numerical simulations of Hurricane Florence are performed using a coupling between the ADCIRC storm surge model and the SWAN wave model. At the beginning of both simulations, a 12-day (2018-08-31 to 2018-09-12) tidal spin-up of ADCIRC is applied to provide the coupled system with the initial conditions of water elevation and velocity. In the first simulation, the model is forced by the wind from HWRF reanalysis, whereas in the second simulation the HBL wind is applied. In both simulations, the wind was provided every 1 hour to the coupled system, while ADCIRC and SWAN were exchanging parameters every 1 hour. The ADCIRC/SWAN coupled system produces results for the significant wave height (SWH), the total water depth (TWD), and the ocean currents over a large area of the North Atlantic. This study focuses on the SWH and the TWD, close to the area where Florence made landfall (south of Wrightsville Beach, North Carolina, on 2018-09-14).

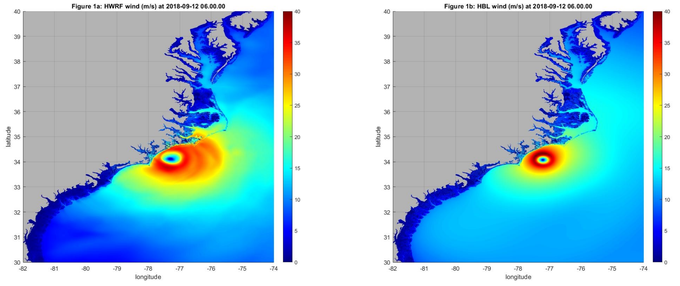


Figure 1: The HWRF wind (left) and the HBL wind (right), 6 hours before landfall, from the output of the ADCIRC model.

Results

Figure 2 shows maps of the SWH and TWD fields for the two different simulations at the time when Florence made landfall. The red line shows the track of Florence, the green dots show the succession of the hurricane center location every 6 hours, the black cross shows the hurricane center location at the time that corresponds to the map shown.

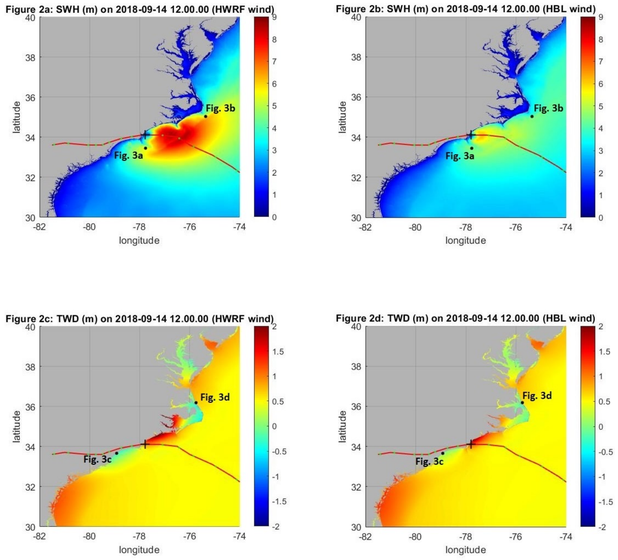
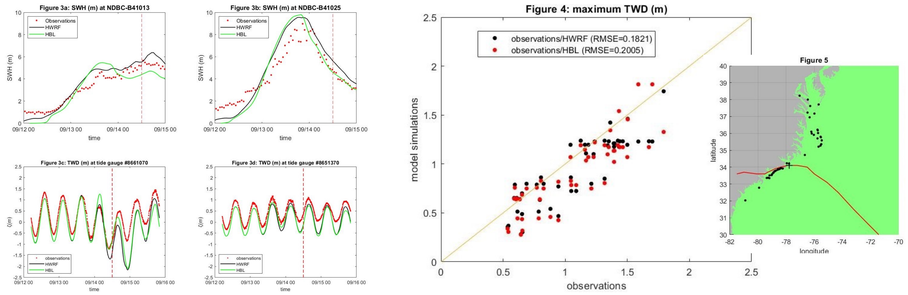


Figure 3 shows the timeseries of SWH and TWD at the left side (3a and 3c respectively) and at the right side of the hurricane (3b and 3d respectively) in the observations and the two simulations. The locations that correspond to these timeseries are shown in Figure 2.The dashed line shows the landfall time. Figure 4 shows the relationship between the maximum observed TWD and the maximum TWD estimated by the model simulations, at the 50 locations shown in Figure 5. The source of the observations are measurements reported by the National Hurricane Center (Stacy and Berg, 2019).



Conclusions

By comparing the results of the two model simulations, we reach to the following conclusions:

- The SWH is significantly affected by the size of the tropical cyclone. The HBL wind has higher maximum wind speeds than the HWRF wind. However, the SWH is higher in the simulation with the HWRF wind because of the hurricane's larger size.
- The TWD is affected by the SWH. In the simulation forced by the HWRF wind, the surge near the coastline is higher in a more extended area at the right side of the hurricane than the simulation with the HBL wind.
- There are approximately the same differences between the SWH observations and simulations, with the observations being closer at times to the results from the model run that was forced by the HBL wind than to the results of the model run that was forced by the HWRF wind.
- In both simulations, the maximum TWD is underpredicted in most of the analyzed locations, which is partially related to the smaller TWD compared to the observation after the ADCIRC spin-up. These results are preliminary and will be evaluated further in more detail in the near future.

References

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