Exploring the effects of climate change on compound flooding in NC estuarine communities

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DEEPP Dynamics of Extreme Events People and Places

THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL

UNC COLLEGE OF ARTS AND SCIENCES Earth, Marine and Environmental Sciences

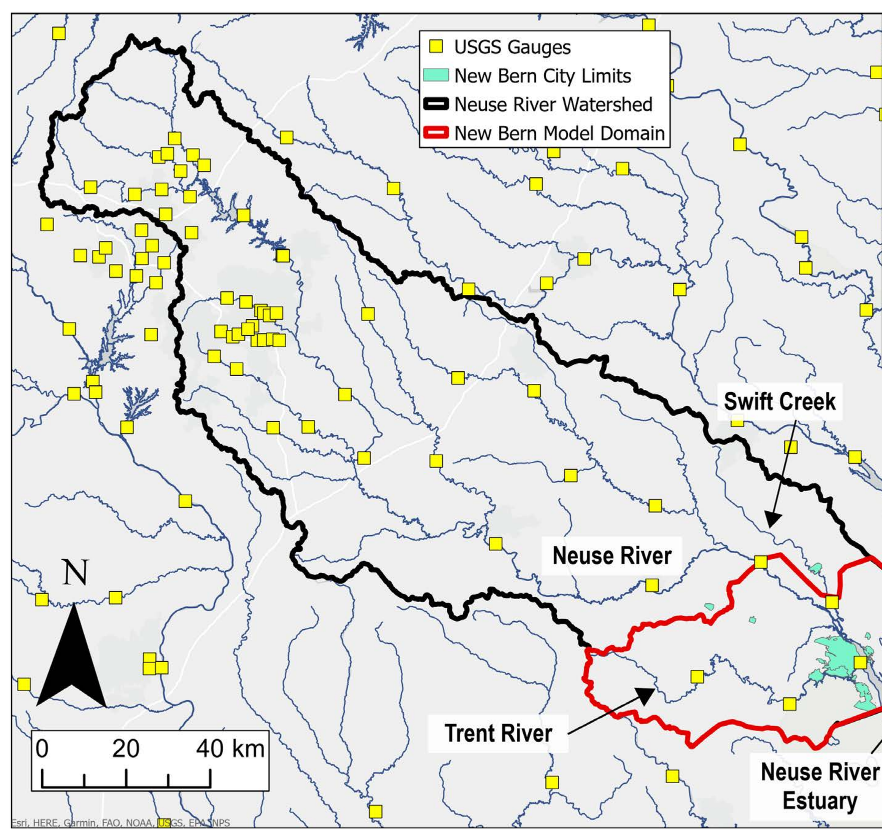
Background

Estuarine communities are increasingly vulnerable to significant flood hazards caused by local rainfall-runoff, riverine overflow, and storm surge. In Eastern North Carolina, climate change threatens to exacerbate flood damages due to increases in peak water levels and duration of inundation during compound flood events. If communities are to make informed decisions regarding their future risk, it is *crucial* they have detailed information on the drivers of flooding and how they are evolving at the local scale.

Conventionally, flood risk is identified based on riverine or coastal threats alone. While coupled modeling approaches have recently been used to simulate the multiple mechanisms of flooding, the relative contributions of hydrologic, oceanographic, and meteorologic processes to the flood hazard profiles and their sensitivity to changes in climate drivers is still poorly understood.

The *objective* of this research is to investigate how water levels and flood extent are impacted by changes in climate drivers in an estuarine environment.

- Validate a hydrodynamic model to observed compound flooding from Hurricane Florence (2018) in New Bern, NC
- Explore the changes on flooding by altering the precipitation and coastal water level inputs to the model



New Bern & Craven County, NC

- At the confluence of the Trent River and the upper portion of the Neuse River Estuary (NRE)
- NRE water levels are micro-tidal; variability primarily caused by variations in the magnitude and direction of wind

Method

MODELS

Super-Fast Inundation of Coasts (SFINCS)

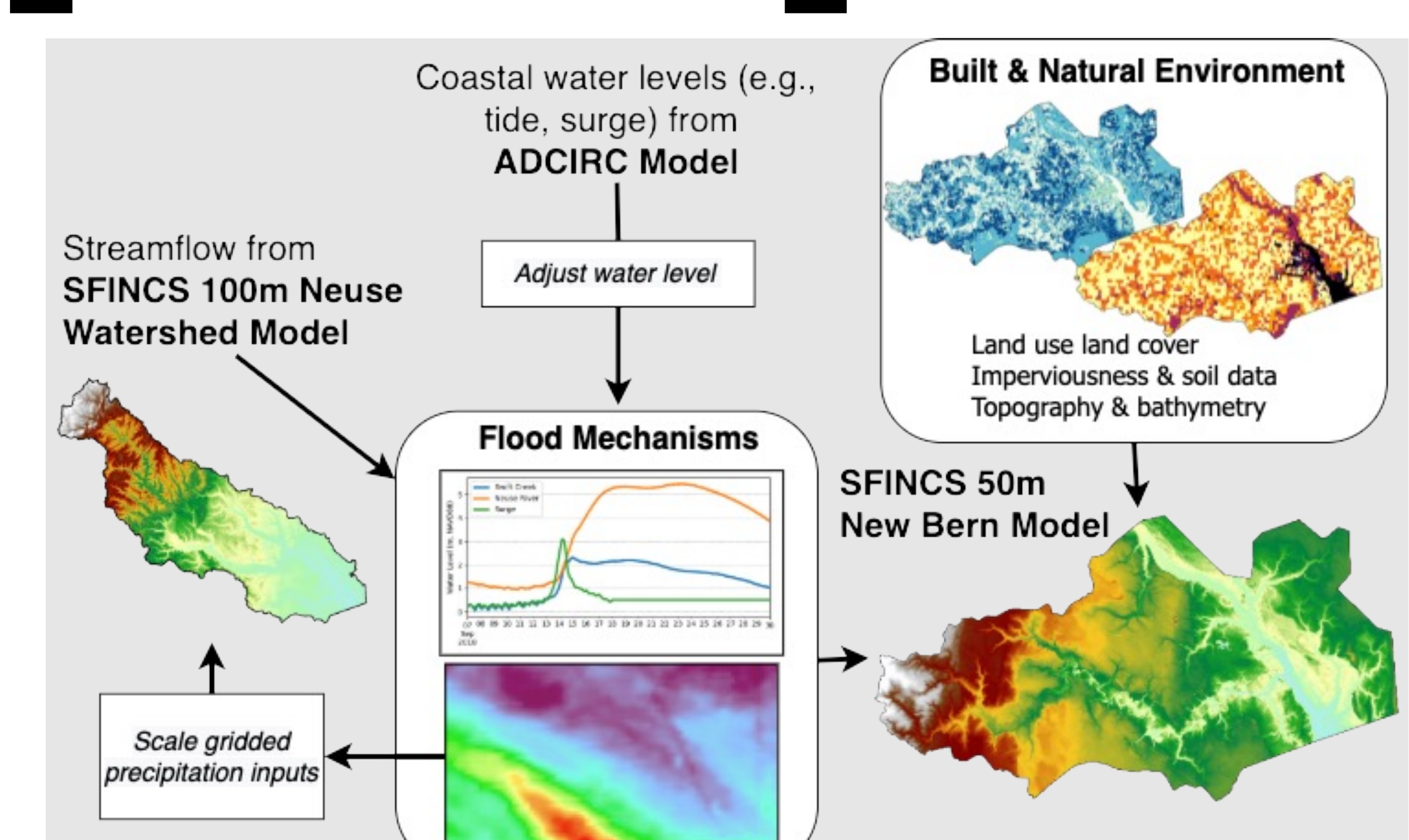
- Two-dimensional, raster-based hydrodynamic model
- Computes overland flow using simplified equations of mass and momentum (Leijnse et al., 2021)
- Inputs include spatially varying precipitation, wind, infiltration, and overland roughness

ADCIRC

- Storm surge hydrodynamic model

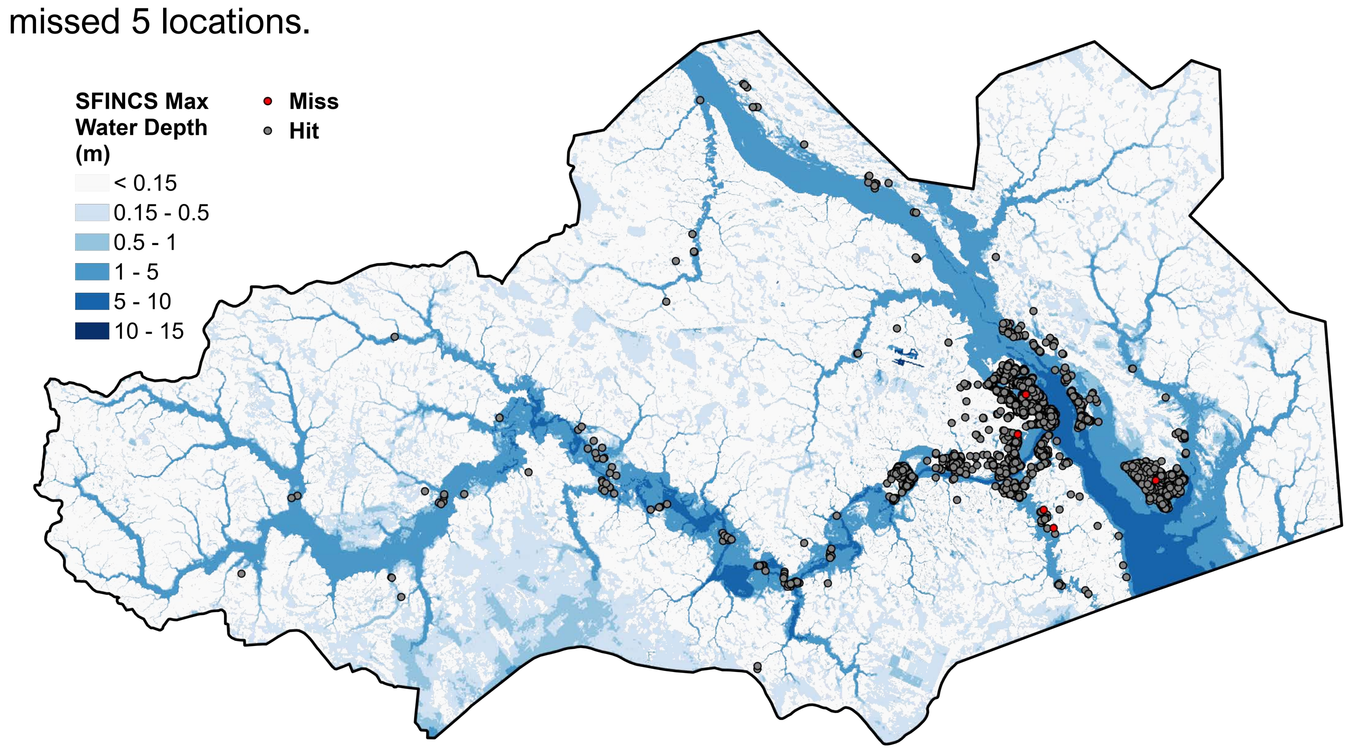
SETUP

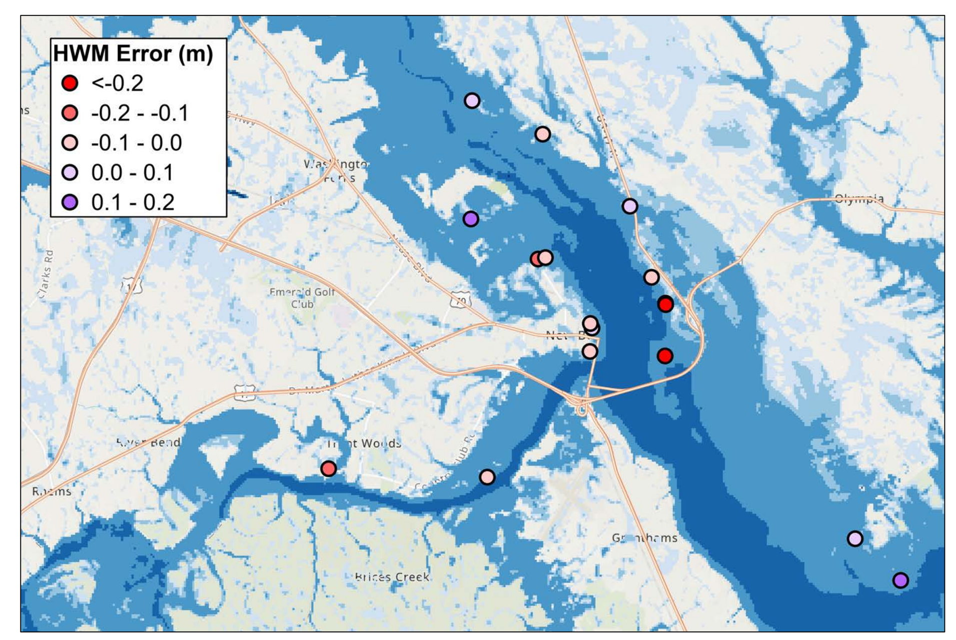
- Hourly Stage IV rain-gauge corrected radar-rainfall is applied directly to the grid
- ADCIRC model output is applied along the downstream coastal boundary
- SFINCS 100m modeled water levels are input at the upstream boundary (Neuse & Swift Creek)
- Curve Number method is used to calculate spatially-varying constant infiltration in SFINCS



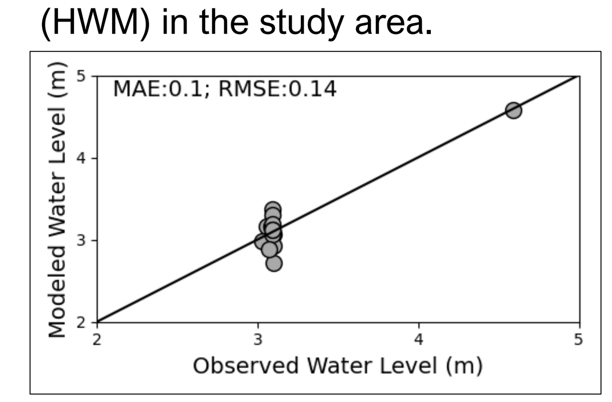
Model Validation

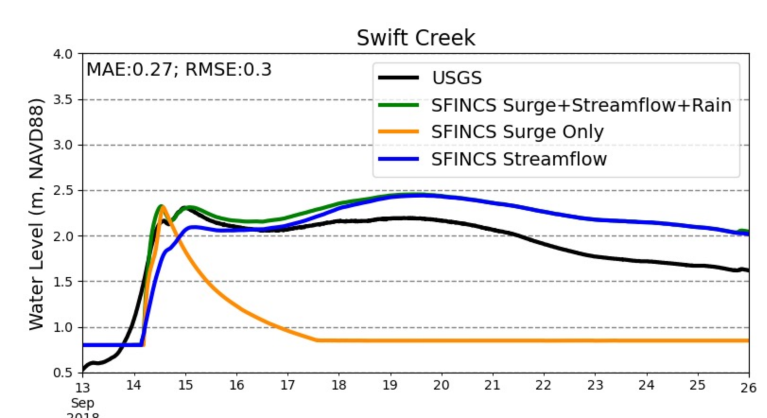
SFINCS was validated against windshield surveys collected by Craven County and NFIP claims data. The model predicted at least 0.05 m (2 inches) of water at 3,594 locations (hit) and missed 5 locations.

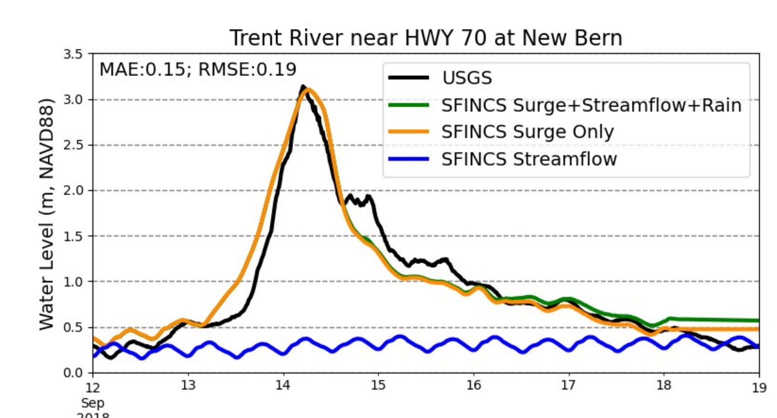




SFINCS predicted water surface elevations within +/- 0.1 meters compared to 19 high water marks (HWM) in the study area.



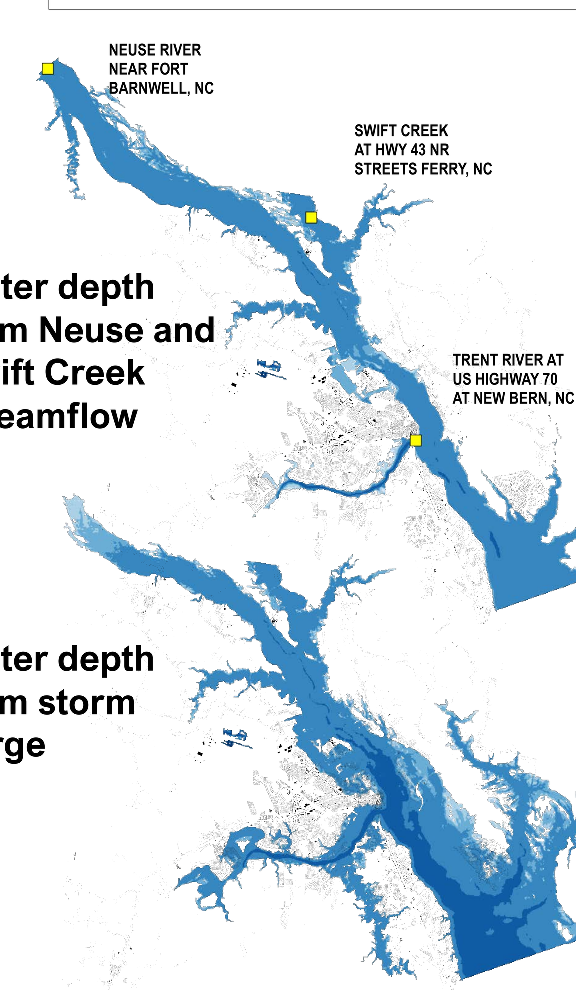




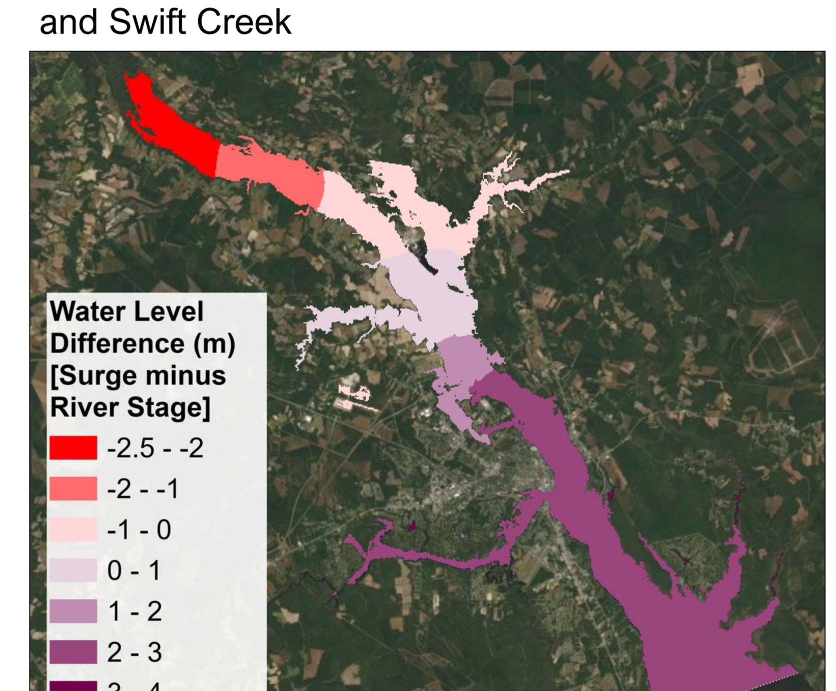
SFINCS Surge+Streamflow+Rain (Baseline model)	Swift Creek (9/14 to 9/24)	Trent River (9/13 to 9/18)
Peak Error (m)	+0.15	-0.04
Mean Absolute Error (m)	0.27	0.15
Root Mean Square Error (m)	0.30	0.19

Water depth from Neuse and Swift Creek streamflow

Water depth from storm surge



Compound flooding from the interactions between storm surge and streamflow occurred just north of New Bern in the lower Neuse River and Swift Creek



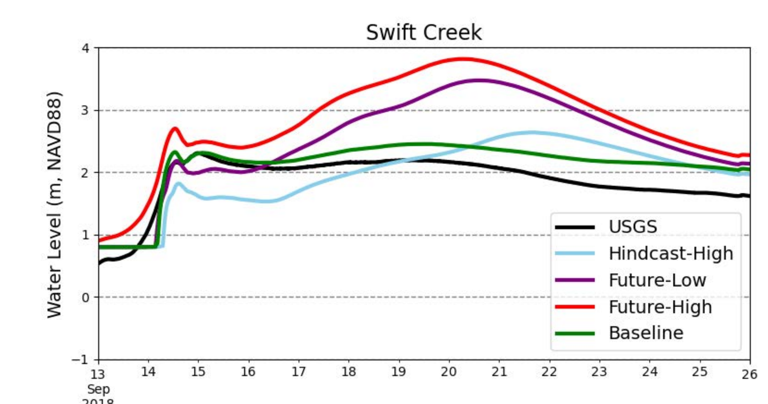
Results

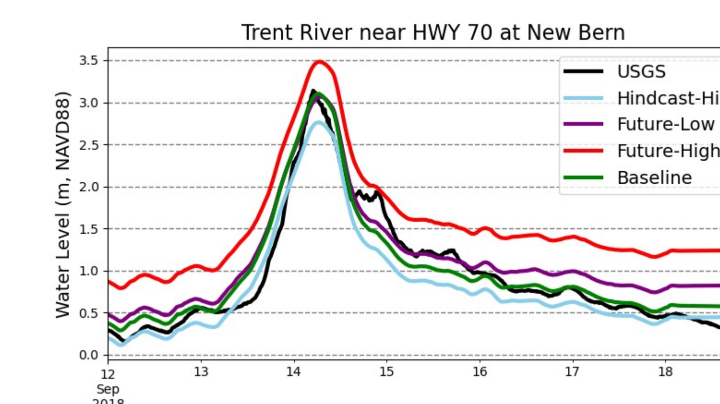
Key Observations

- Water level reanalysis for Hurricane Florence is improved when rainfall, streamflow, and storm surge are included in the model.
- Peak water levels at New Bern are primarily controlled by storm surge. However, the duration of inundation increases with greater river discharge from increased precipitation.
- Increases in pluvial flooding occur because the effectiveness of the local drainage network is impeded by elevated downstream water levels.

Scenario	Sea Level Adjustment to Coastal Water Level Input*	Adjustment to Total Precipitation Input
Hindcast-High	-0.20 meter	15% decrease
Future-Low	+0.10 meter	5% increase
Future-High	+0.50 meter	15% increase

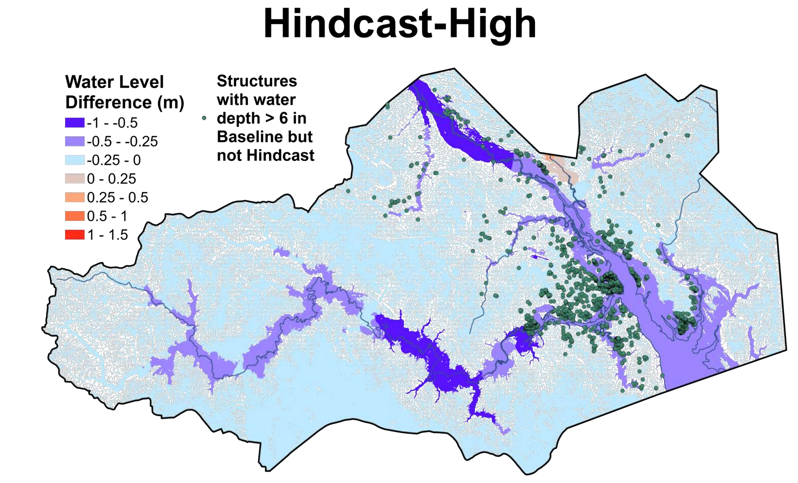
* Sea level rise scenarios are based on low to high regional projections identified by the US Global Change Research Program 2017 (NOAA, 2017).





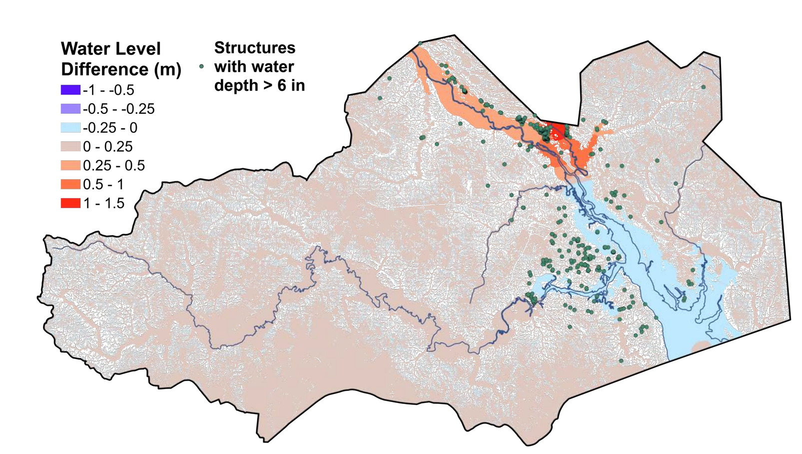
Maps of the difference in the water level for Hurricane Florence flooding between each Scenario and the Baseline

Hindcast-High

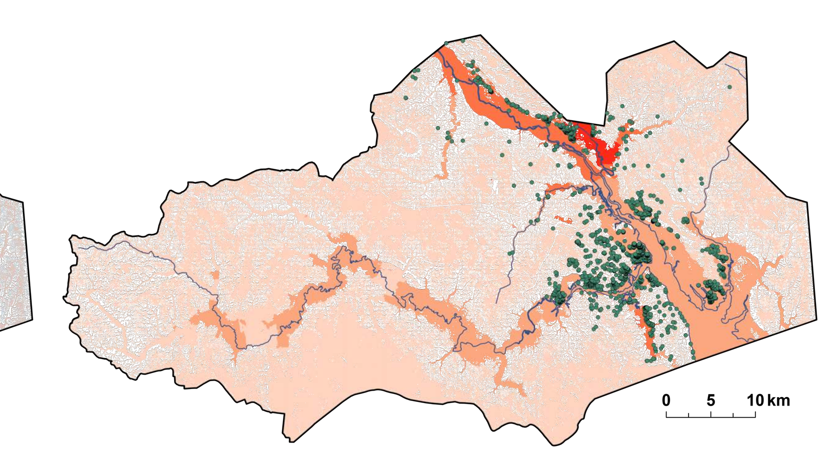


Scenario	No. of structures w/ >6 inches	Change in structures w/ > 6
Hindcast-High	9,725 (17%)	-2,097
Baseline	11,799 (21%)	NA
Future-Low	12,072 (22%)	417
Future-High	14,030 (26%)	2,253

Future-Low



Future-High



Future Work

- Improve model calibration by including wind and decreasing model resolution
- Validate model to additional storms
- Use modeled precipitation and coastal water levels projections instead of scaled boundary conditions
- Estimate building damages using depth-damage curves

Acknowledgements.
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References
Leijnse et. al, (2021). Modeling compound flooding in coastal systems using a computationally efficient reduced-physics solver: Including fluvial, pluvial, tidal, wind- and wave-driven processes. *Coastal Engineering.*

NOAA. (2017). *Global and Regional Sea Level Rise Scenarios for the United States*. Silver Spring, Maryland.