Modernizing a spectral wave model in a coupled modeling framework

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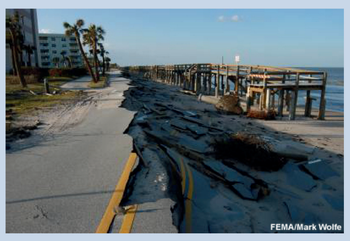
Introduction and Motivation

- Storm surge is a constant threat to coastal communities.
- Accurate and timely predictions of waves and storm surge from coupled circulation and SWMs are imperative to mitigate potential danger and damage to coastal communities and infrastructure.



- Coupling configurations need to account for each models' mesh domain and time scale but run times can be prohibitive.
- Circulation should be simulated over a large domain and time period but waves are more important closer to the coast and when the storm is making landfall.

SWAN+ADCIRC - coupled spectral wave model (SWM) and hydrodynamic circulation model that predicts wave parameters and spectra, water levels, and storm surge.

- SWAN parameterizes source and sink terms in the physics and numeric package.
- Latest release update introduced a new recommended wave physics package.
- New parameterizations of wind input, white capping, bottom friction, swell dissipation, etc.

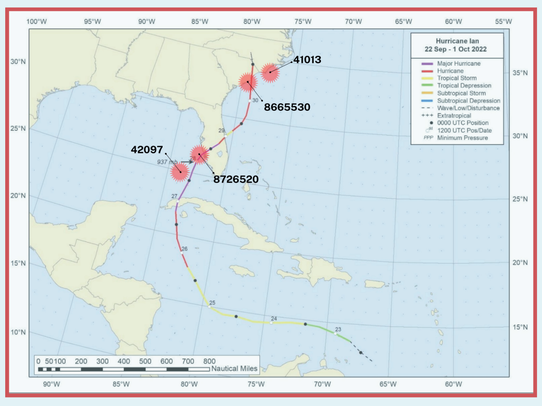
New SWAN Version

Motivation:

- Wave physics are difficult to parameterize.
  - SWAN released version updates with new parametrizations of wave physics.

Research Question

How sensitive are wave and storm surge predictions to the physics packages of SWAN?



Methodology

Implement SWAN version 41.45 into the coupled SWAN+ADCIRC model

- Validate updated version

Storm and Data:

- Hurricane Ian, September 22-30, 2022
  - HSOFS mesh domain
  - Ocean Weather wind inputs
  - Observational data NOAA National Data Buoy Center (NDBC) Buoys and NOAA Tide Gauges

Validation:

Time Series Plots -

- Compare water levels and significant wave heights from Old vs New with observed data from NDBC Buoys and NOAA Tide Gauges

RMS Error -

- At each of the buoy locations

$$RMSE = \sqrt{\sum_{i=1}^{n} \frac{(\hat{y}_i - y_i)^2}{n}}$$

Efficiency Gains

Motivation:

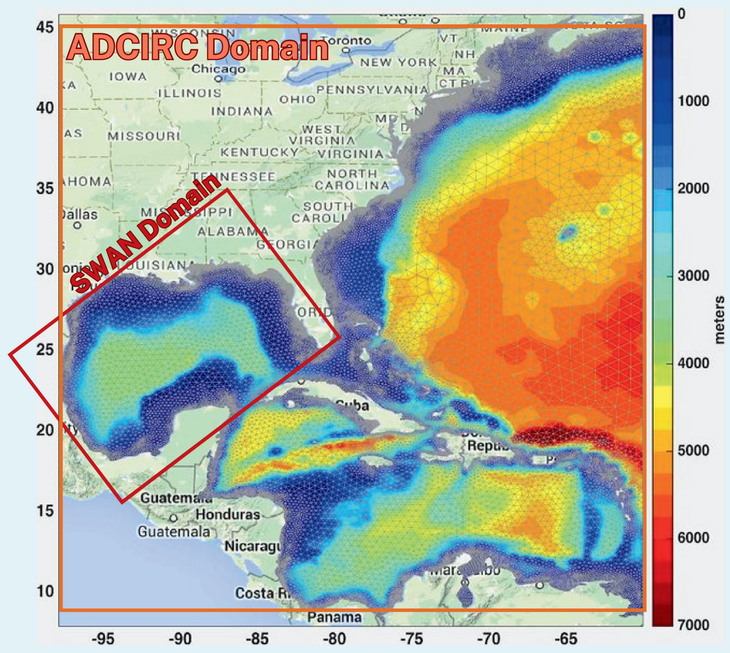
- Wave models coupled with circulation models are computational costly and have long run times.

Research Question

To what spatial and temporal extent does a SWM need to be simulated to optimize efficiency without compromising the accuracy of results?

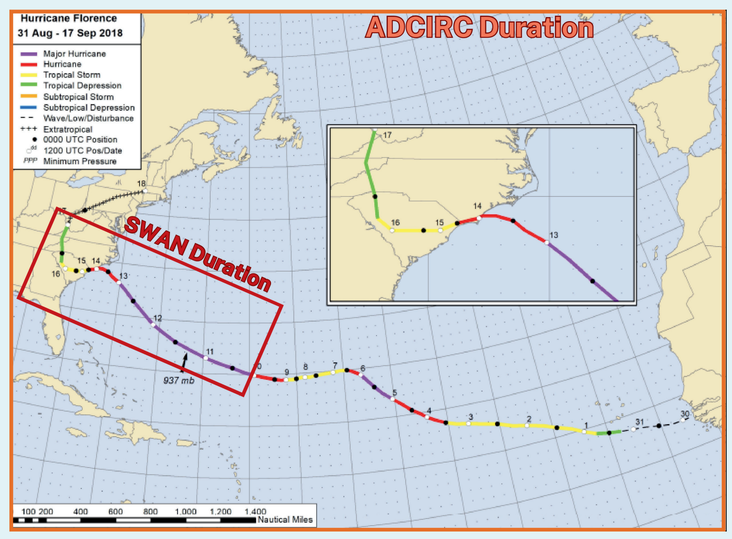
Objective 1: Spatial Domain

- Modernize the boundary conditions in the unstructured mesh, parallel SWAN



Objective 2: Temporal Duration

- Add a light coupler to control when SWAN is activated



- Test varying domains and durations
  - Validate using IMEDS
- Test various storms to determine any additional factors that influence results

Outcomes and Implications:

- Quantify efficiencies gained by using SWAN only when storm is making landfall
- Draw conclusions about a SWMs performance when nested nearshore vs full domain models
- Yield a coupled model with quicker and more efficient runs, leading to more simulations able to run prior to a storm

Results

Old vs New Difference Plots:

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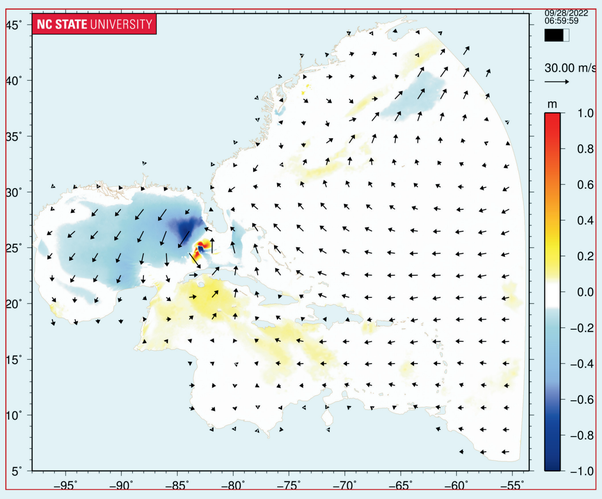

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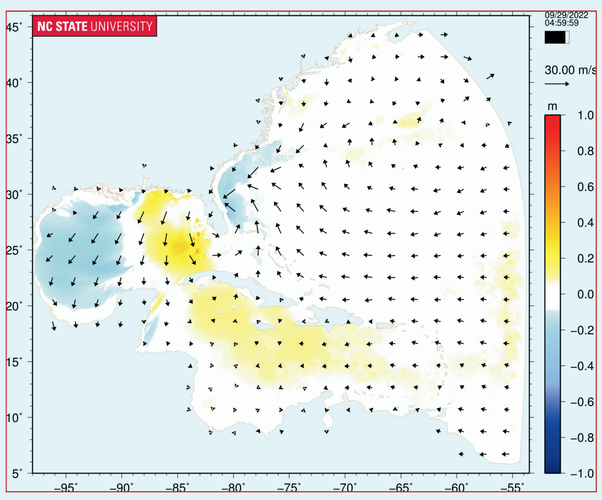

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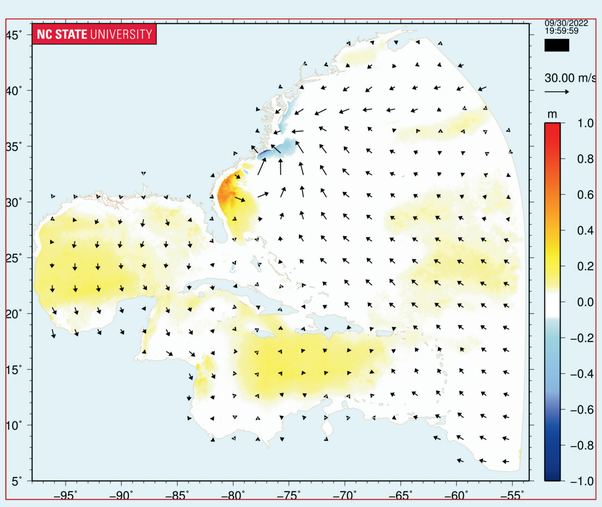
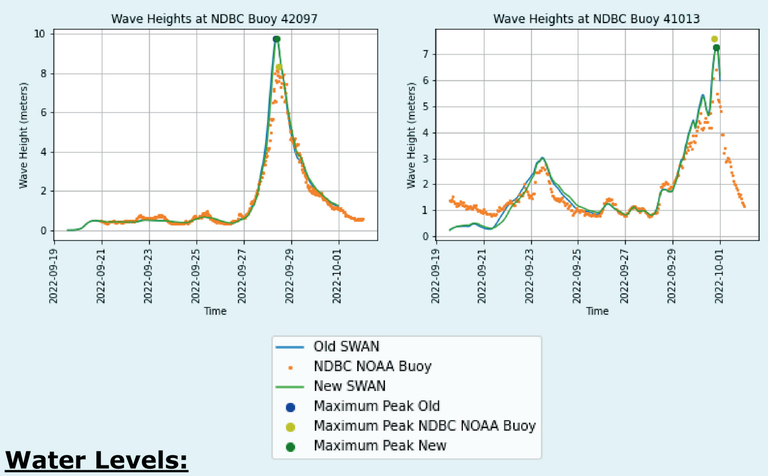
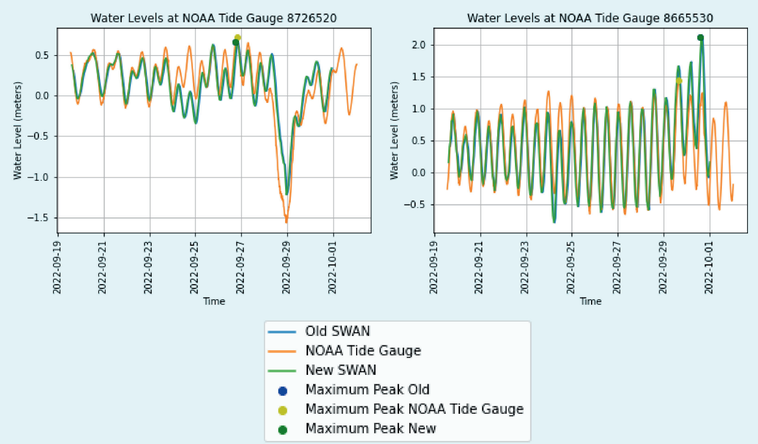


Significant Wave Heights:



Water Levels:



- Results show very minor differences, supporting the implementation of SWAN Version 41.45

Next Steps

- Test new physics package in Version 41.45
  - Including new parameterizations of white capping, bottom friction, sea swell, etc.
- Utilize Interactive Model Evaluation and Diagnostics System (IMEDS, 2014)
  - To give each test configuration a score between 0 - 1.0
- Determine recommendation to the community based on most accurate configuration of input settings

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