NC STATE

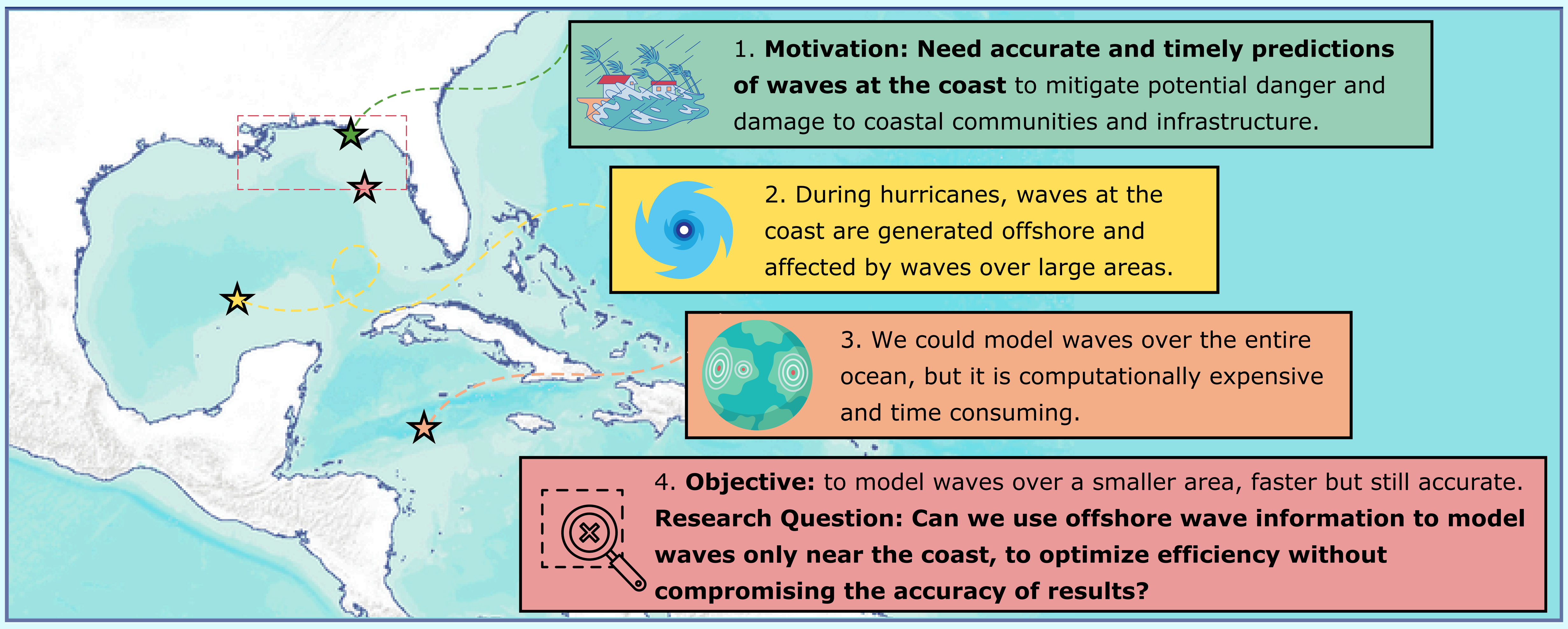
US Army Corps of Engineers®

Spatial controls and efficiency gains within a spectral wave model

Nicole Arrigo, J. C. Dietrich, Chris Massey

nkarrigo@ncsu.edu

Introduction and Motivation



1. **Motivation: Need accurate and timely predictions of waves at the coast** to mitigate potential danger and damage to coastal communities and infrastructure.

2. During hurricanes, waves at the coast are generated offshore and affected by waves over large areas.

3. We could model waves over the entire ocean, but it is computationally expensive and time consuming.

4. **Objective:** to model waves over a smaller area, faster but still accurate. **Research Question: Can we use offshore wave information to model waves only near the coast, to optimize efficiency without compromising the accuracy of results?**

Background:

- Coupled spectral wave (SWM) and hydrodynamic circulation models predict wave parameters and spectra, water levels, and storm surge.
- Water circulation should be simulated over a large domain but is most impacted by waves in shallow water and thus nearshore waves can be modeled over a smaller domain.
  - Most coupled models utilize different domain sizes but this requires heavy spatial interpolation.
- Nearshore wave models require spectral boundary conditions from another source.
  - **Spectral source options:** another model (deep-water or global), wave buoy, earlier simulation of same model.

SWAN+ADCIRC - tightly coupled circulation and SWM

- Utilizes identical spatial mesh domains, eliminating the spatial interpolation, but resulting in the wave model computing for a much larger domain than necessary.

Methodology

Methods:

- Add capability to SWAN+ADCIRC to run SWAN on a smaller portion of the identical ADCIRC mesh.

Need to:

1. **Define smaller domain**
2. **Account for waves from the deep ocean**

User Input
Input mesh domain, nodal attributes file, desired SWAN domain (polygon), internal source locations.

Pre-Processing
Finds nodes in mesh within the desired polygon and sets to active in the nodal attribute file

Finds nodes closest to given sources and creates SWAN input file with commands to apply BCs

SWAN+ADCIRC
ADCIRC identifies nodal attribute. SWAN activates only nodes within polygon

SWAN adds internal sources to boundary data. Applies energy density from inputs and prohibits alternative spectral energy computations here.

Storm and Data:

- Hurricane Michael, October 7-11, 2018
- EC-95 mesh domain
- Two modified SWAN domains using spectral energy inputs from a full domain simulation
- Observational data NOAA National Data Buoy Center (NDBC) Buoys

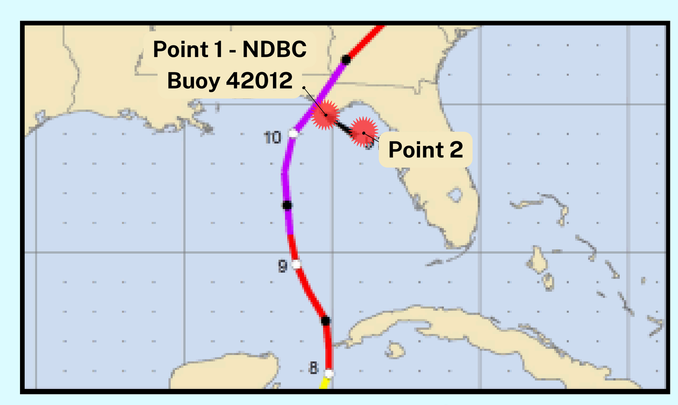
Validation:

Spatial Plots -

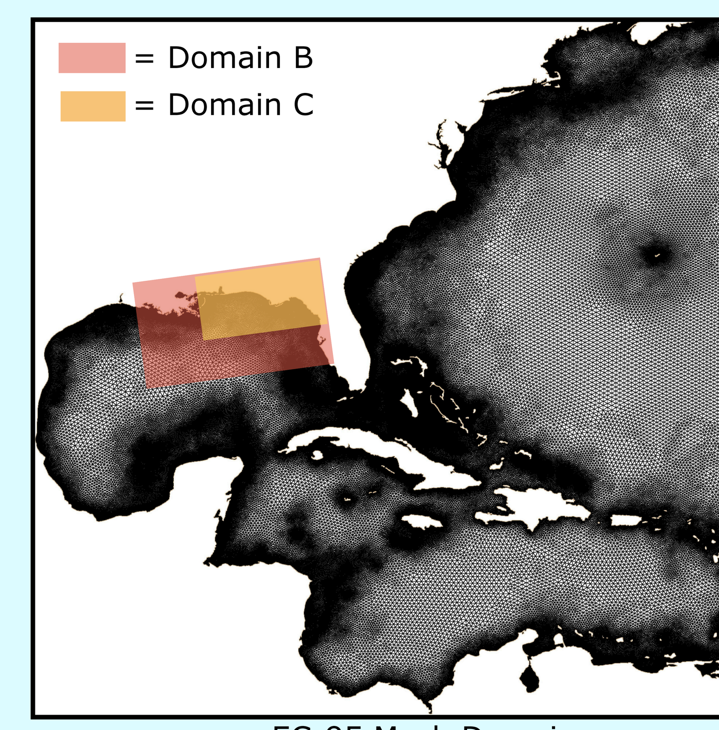
- Depict the wave heights as the storm moves up the Gulf

Time Series Plots -

- Compare significant wave heights from full and partial SWAN domain runs with observed data from NDBC Buoys



Hurricane Michael, 2018



EC-95 Mesh Domain

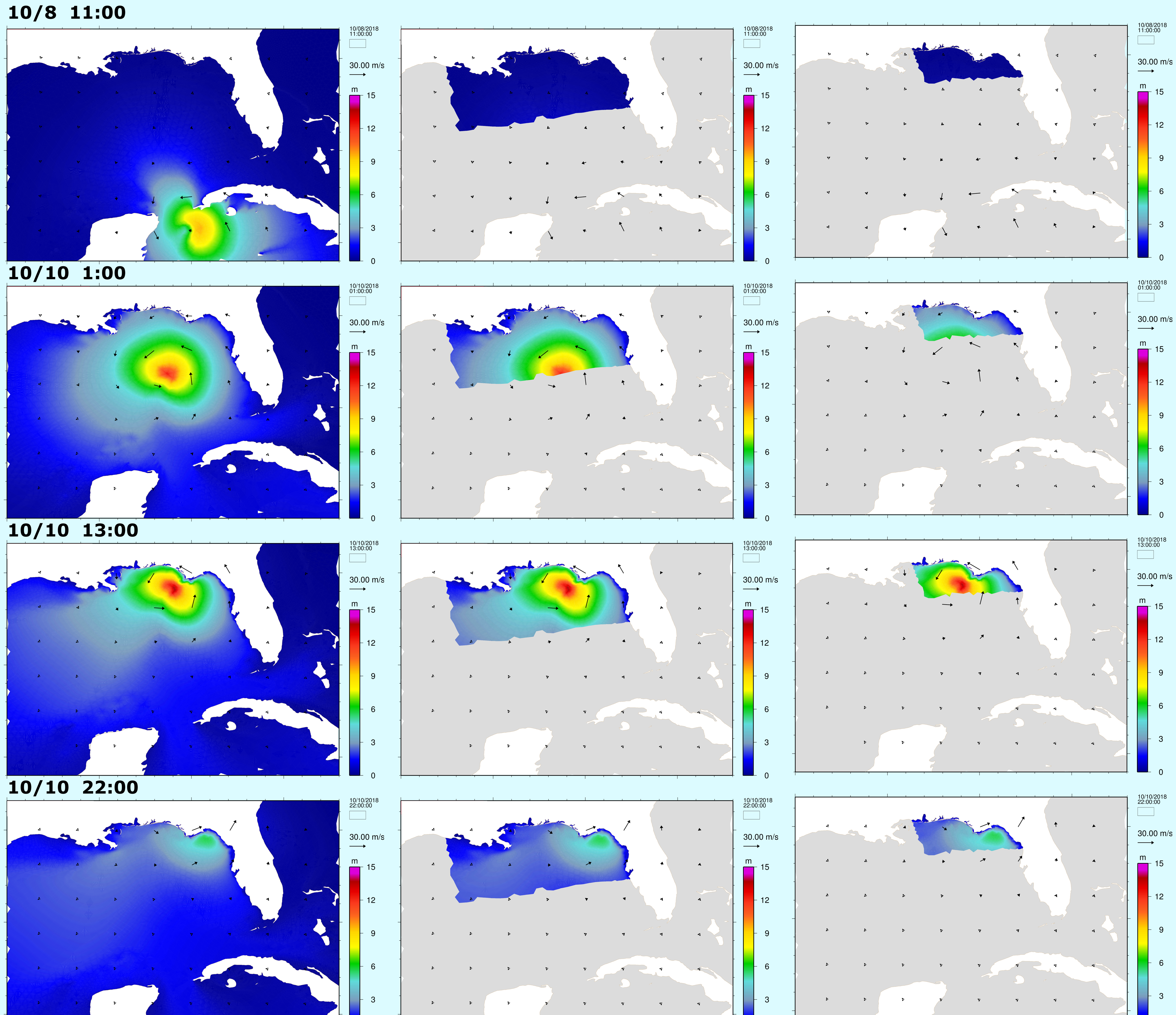
Results

Full vs Partial SWAN Domain Spatial Plots:

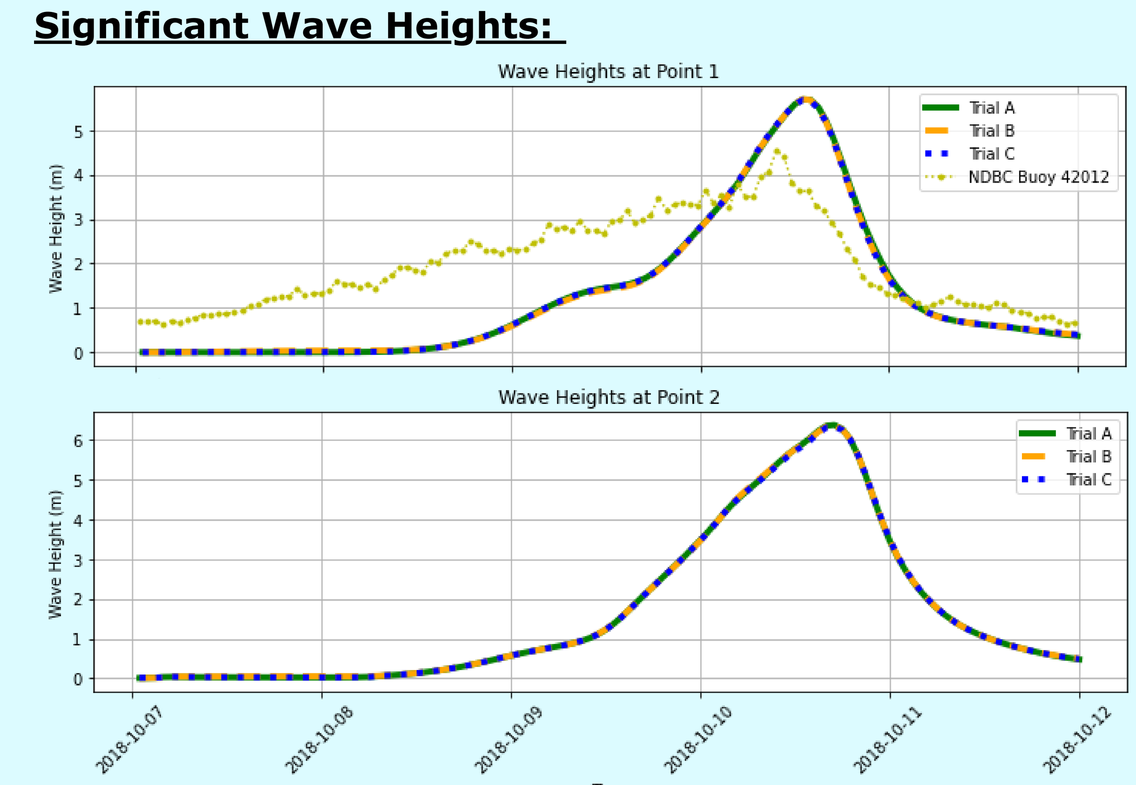
- Significant wave heights at four time steps

Trial A: Full EC-95 Mesh | **Trial B: Partial SWAN Domain** | **Trial C: Partial SWAN Domain**

10/8 11:00 · 10/10 1:00 · 10/10 13:00 · 10/10 22:00



Significant Wave Heights:



- Results show no differences throughout the simulation.

Next Steps

- Parallelize changes to source code to enable decomposition of mesh and additional cores running.
- Test various storms to determine any additional factors that influence results.
- Quantify efficiencies gained.
  - Reduction in simulation time and computational demand.

Conclusion

Conclusion:

- We can use any spatial extent, as long as we have sufficient spectral energy boundary conditions to adequately represent the wave energy generated from offshore.

Outcomes and Implications:

- Increased efficiency by simulating SWAN nearshore, when storm is making landfall.
- Yields a faster, tightly coupled model, leading to more simulations able to run prior to a storm or design.

This research is supported by the United States Army Corps of Engineers. Thank you for making this work possible.