Enhancing Efficiency and Flexibility in SWAN+ADCIRC Using Temporal and Spatial Controls

2026 ADCIRC Users Group Meeting

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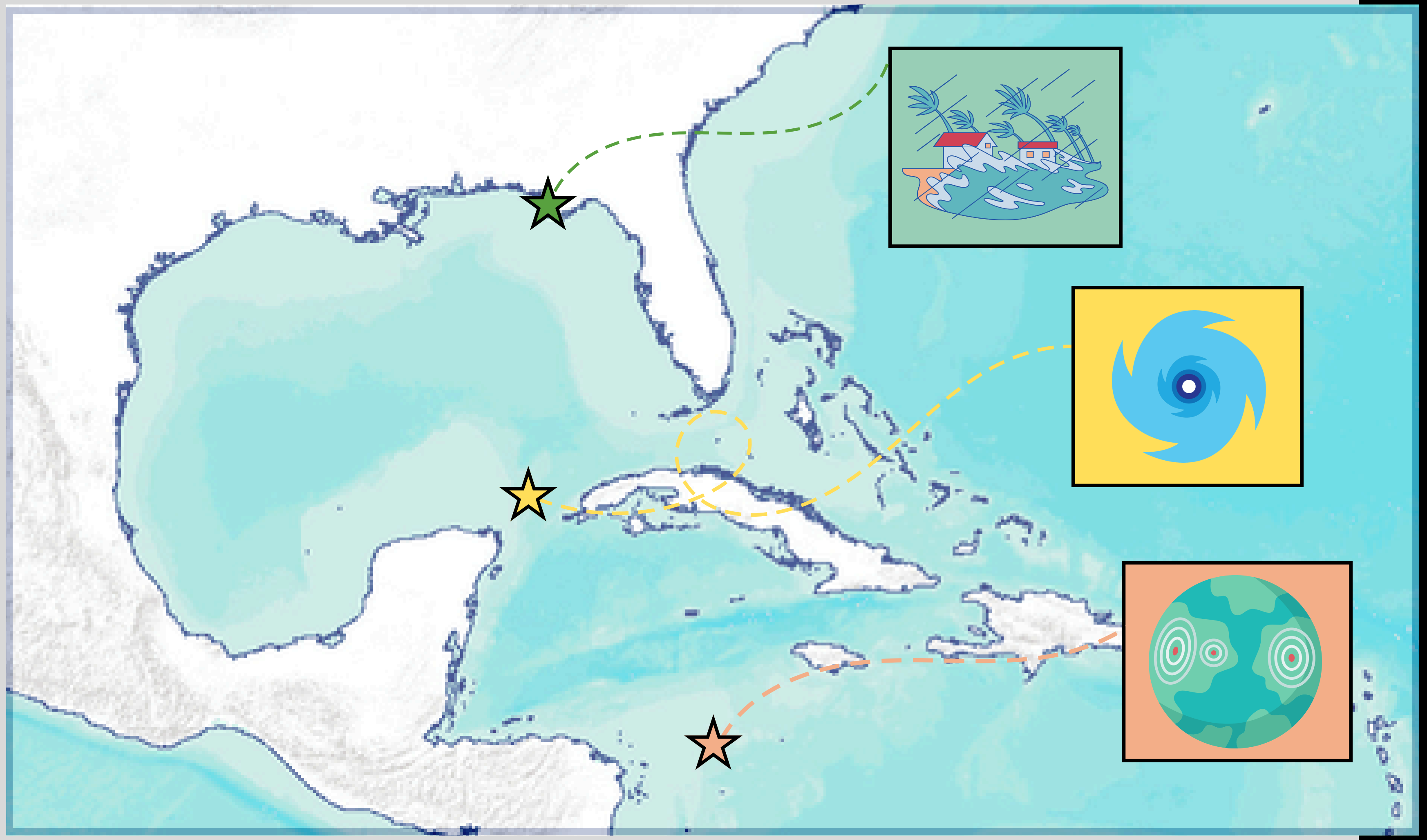
INTRODUCTION

Introduction » Implementation » Test Cases » User Workflow

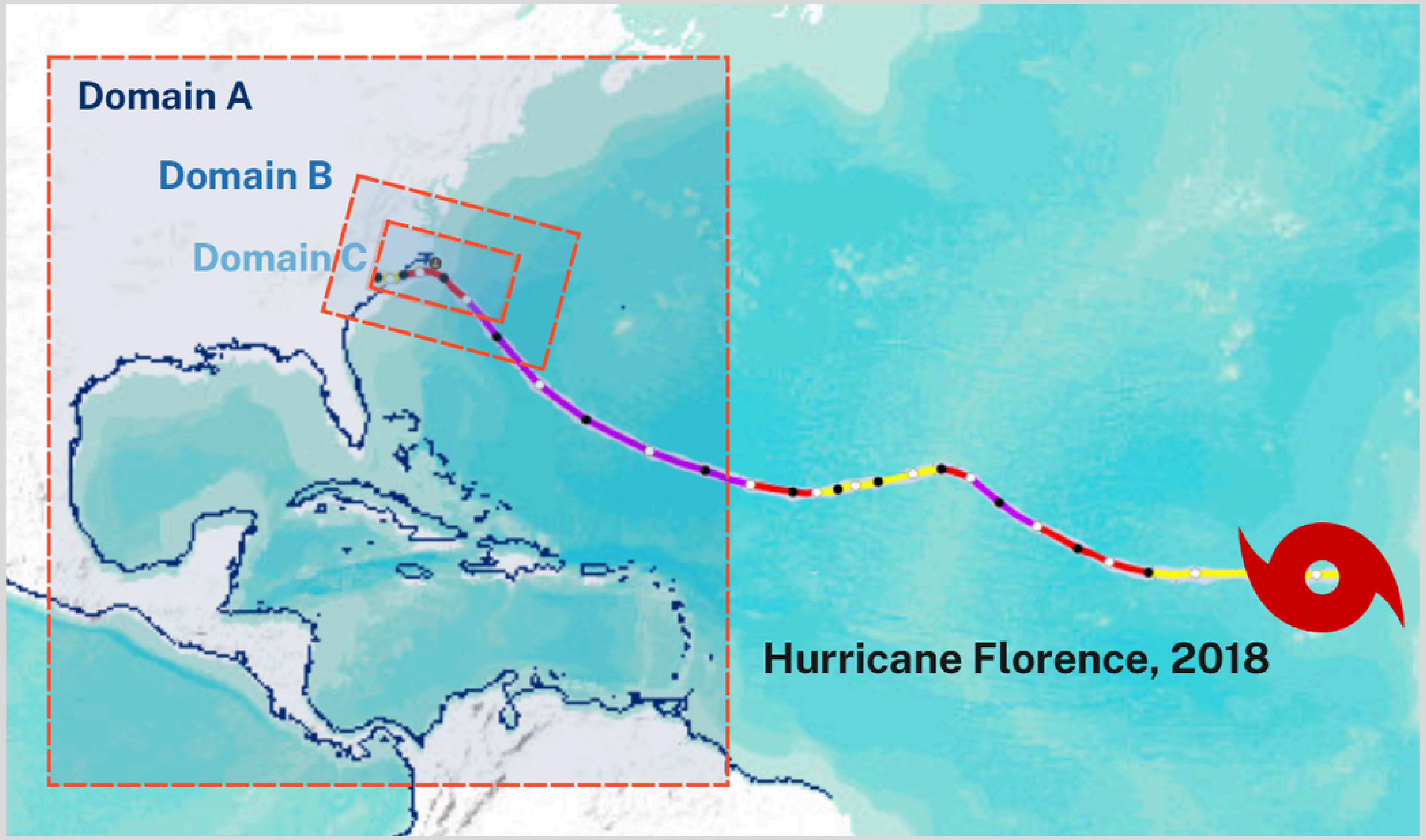
Introduction

Motivation: need for accurate and timely predictions of waves at the coast

- Coupled spectral wave (SWM) and hydrodynamic circulation models predict wave parameters and spectra, water levels, and storm surge
- Circulation simulated over a large domain
- Nearshore waves modeled over a smaller domain
  - Wave modeling – computationally expensive and time consuming



Objective



Objective: to model waves over a smaller area and shorter timeframe, faster while preserving accuracy.

- Alter temporal and spatial controls
- Remain on an identical mesh domain
  - Deactivate SWAN outside of new smaller domain
  - Activate SWAN only for specified time frame

Motivation

Engineering design requires accurate predictions of waves and water levels based on varying design scenario options

- Running large simulations many times with small variations at the coast – costly
- Limiting domain to design variations at the coast – reduce computational cost and time

Storm Surge (nhc.noaa.gov)

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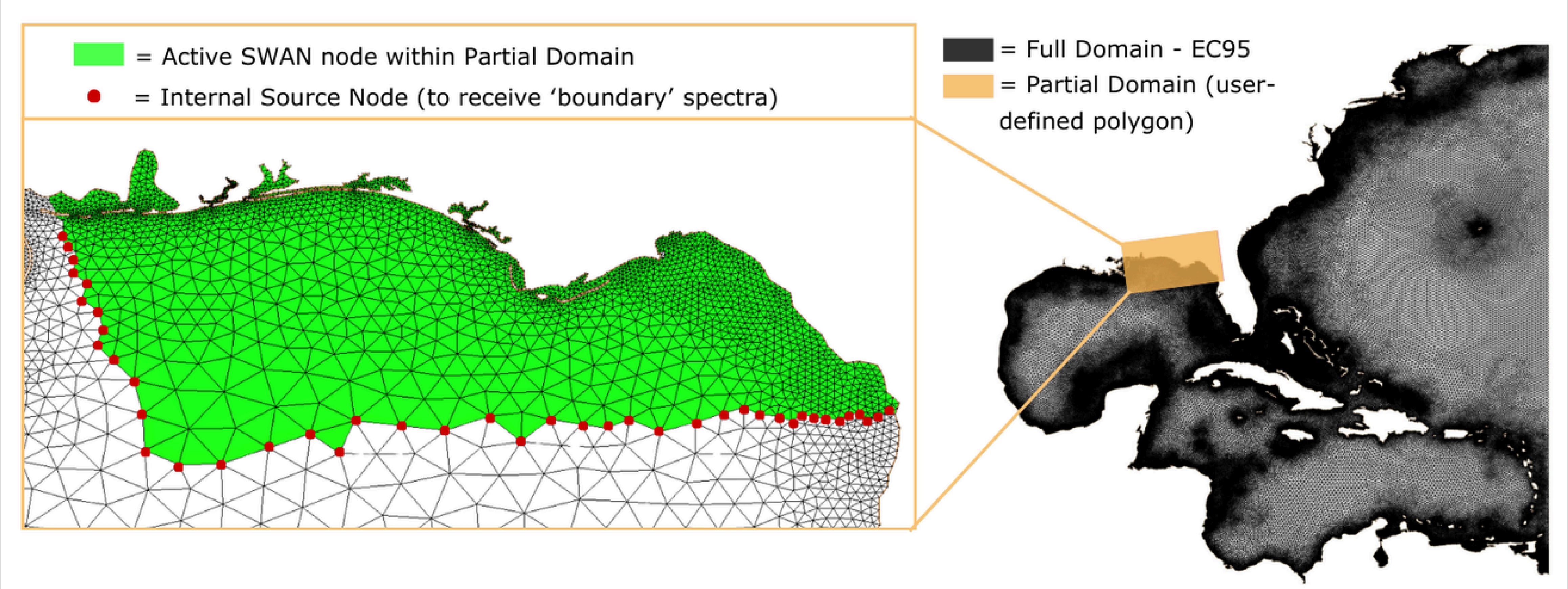
IMPLEMENTATION

Spatio–Temporal Control Development

Added capability to SWAN+ADCIRC to alter SWAN domain spatially and temporally

- To run SWAN over a **selective spatial domain,** on identical ADCIRC mesh
- For **unique time frame**



1. Define spatial domain
2. Account for swell waves from the deep ocean using internal source spectra
3. Define desired time frame

Nodal Attribute

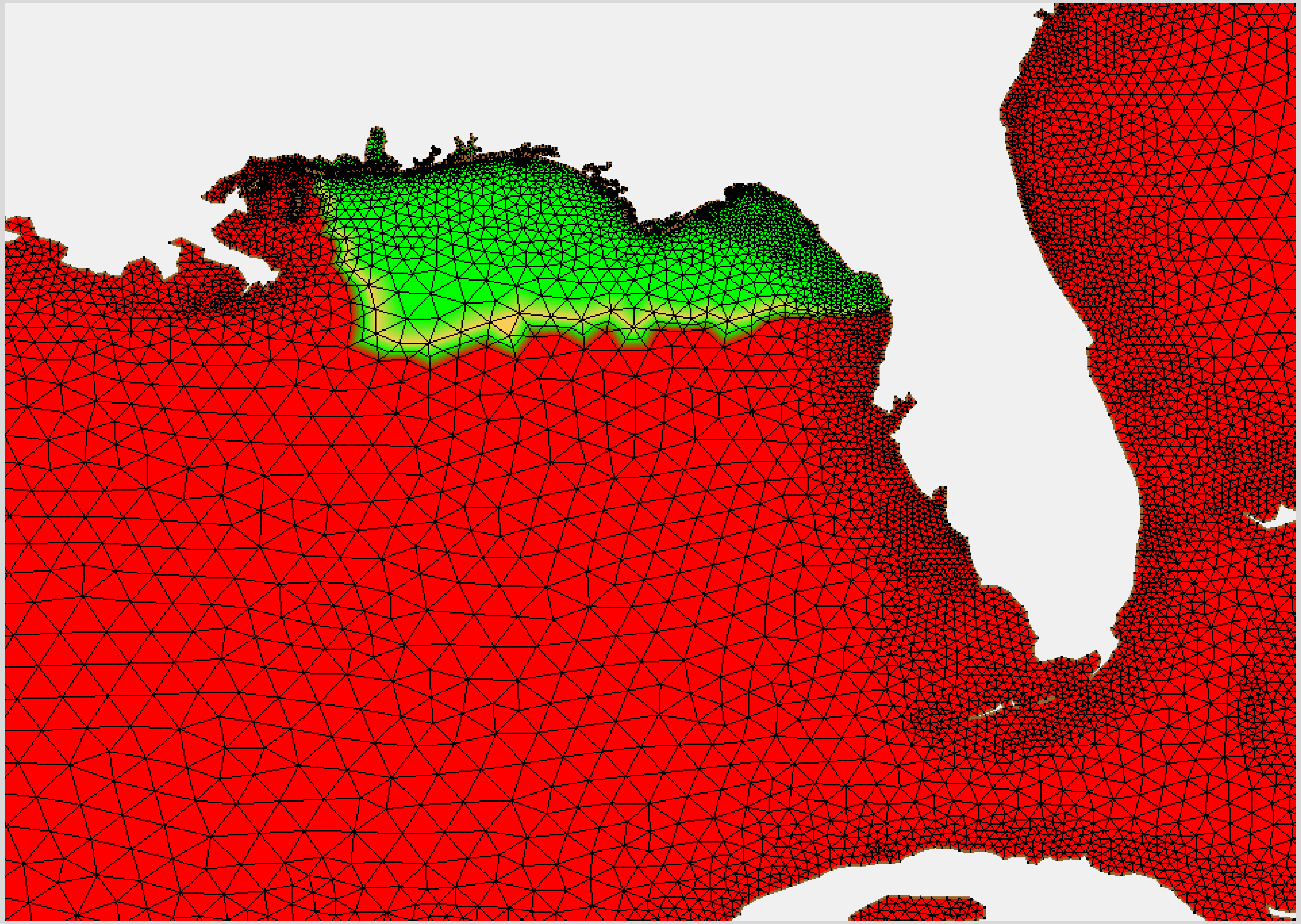
Swan Local Control –

- Two values
  1. Is SWAN active at this node?
     - 1 = on (default value)
     - 0 = off
  2. Is this node an 'internal source'?
     - 0 = not an internal source (default value)
     - Positive integer = internal source

```
Spatial attributes description
swan_local_control
 1                    units
 2                    number of values
 1 0                  default values
```

```
swan_local_control
 28910
 1  0  0        Node #, SWAN on, internal
 2  0  0        source (side number)
 3  0  0
 4  0  0
 5  0  0
 6  0  0
 7  0  0
 8  0  0
 9  0  0
 10  1  101
```

Nodal Attribute



```
Default value 1 0
```

SWAN on Internal source

```
swan_local_control
 28910
 1  0  0
 2  0  0
 3  0  0
 4  0  0
 5  0  0
 6  0  0
 7  0  0
 8  0  0
 9  0  0
 10  1  101
```

Spatial Controls – Implementation

To allow for selective activation of SWAN domain:

- Only activate SWAN for nodes that are set to active (a 1 for SwanLocalControl – 1)
    - Vertices inactive for SWAN computations if set to 0

To allow for internal source handling:

- Count internal sources based on SwanLocalControl−2
    - Treat as boundary nodes
    - Set internal source ‘side’ number based on the index
- In the sweep loop, check to see if vertex is active AND not an internal source before updating at node
    - At internal source nodes, it instead applies the spectral energy input as boundary conditions

Temporal Controls – Implementation

To allow for selective activation of SWAN time frame:

- Added NAMELIST SWANTimeControl
  - with RunStartDateTime as the ADCIRC initial time
- Time control for SWAN begin and end time to fort.26
- Determines how many SWAN time steps to skip before starting calculations
  - Computes and initializes output quantities and radiation stresses if SWAN isn't called

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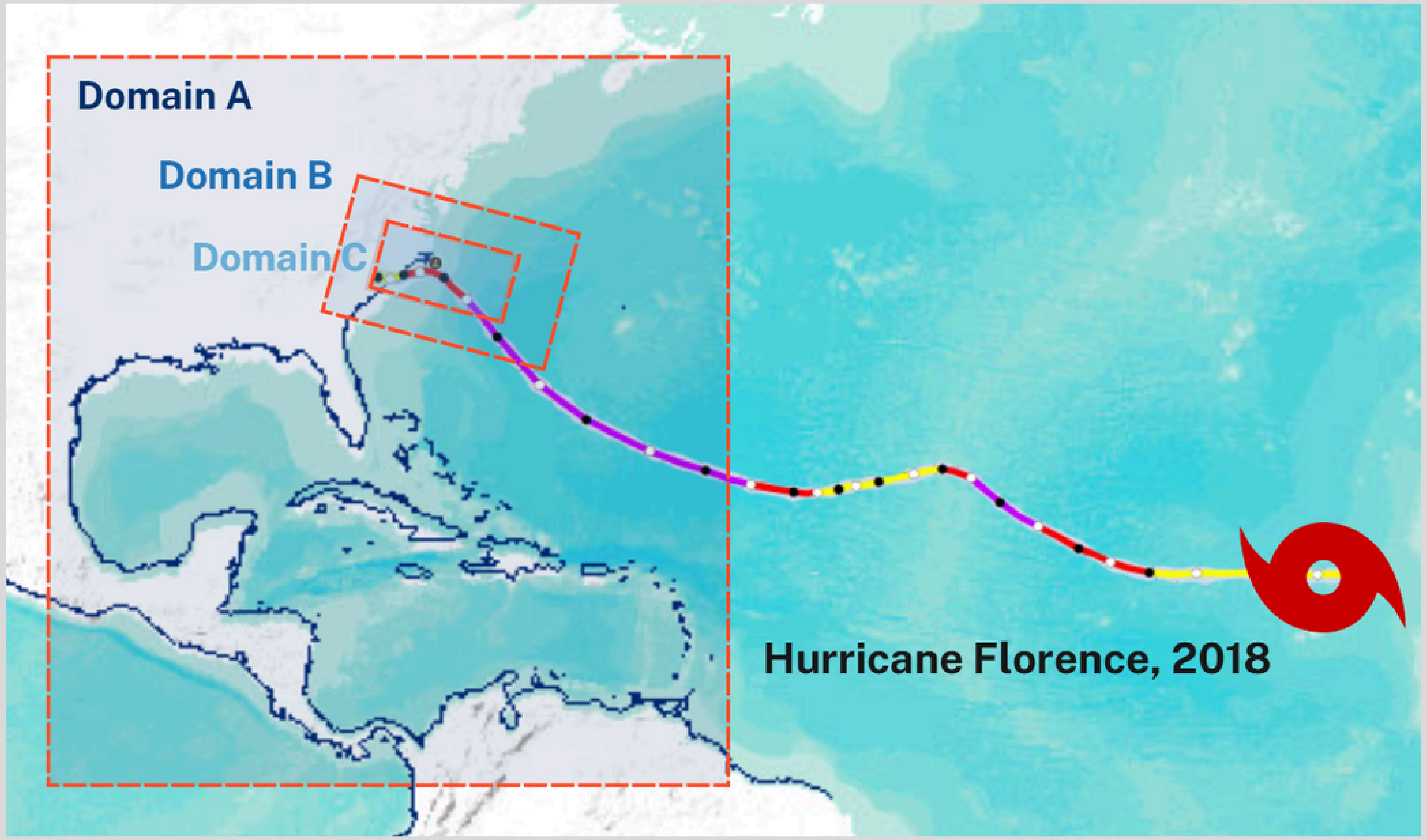
TEST CASES

Validation Tests

Storm and Data:

- Varying SWAN domains
- EC–95 mesh domain

- Hurricane Florence, 2018
- **Spectral Internal Sources –** 2D wave spectra exported from Domain A
  - Input at every node along SWAN Domains B & C



Temporal Domain

9 Days Domain C	9 Days Domain B	9 Days Domain A
4 Days Domain C	4 Days Domain B	4 Days Domain A
2 Days Domain C	2 Days Domain B	2 Days Domain A

Spatial Domain

Validation Tests

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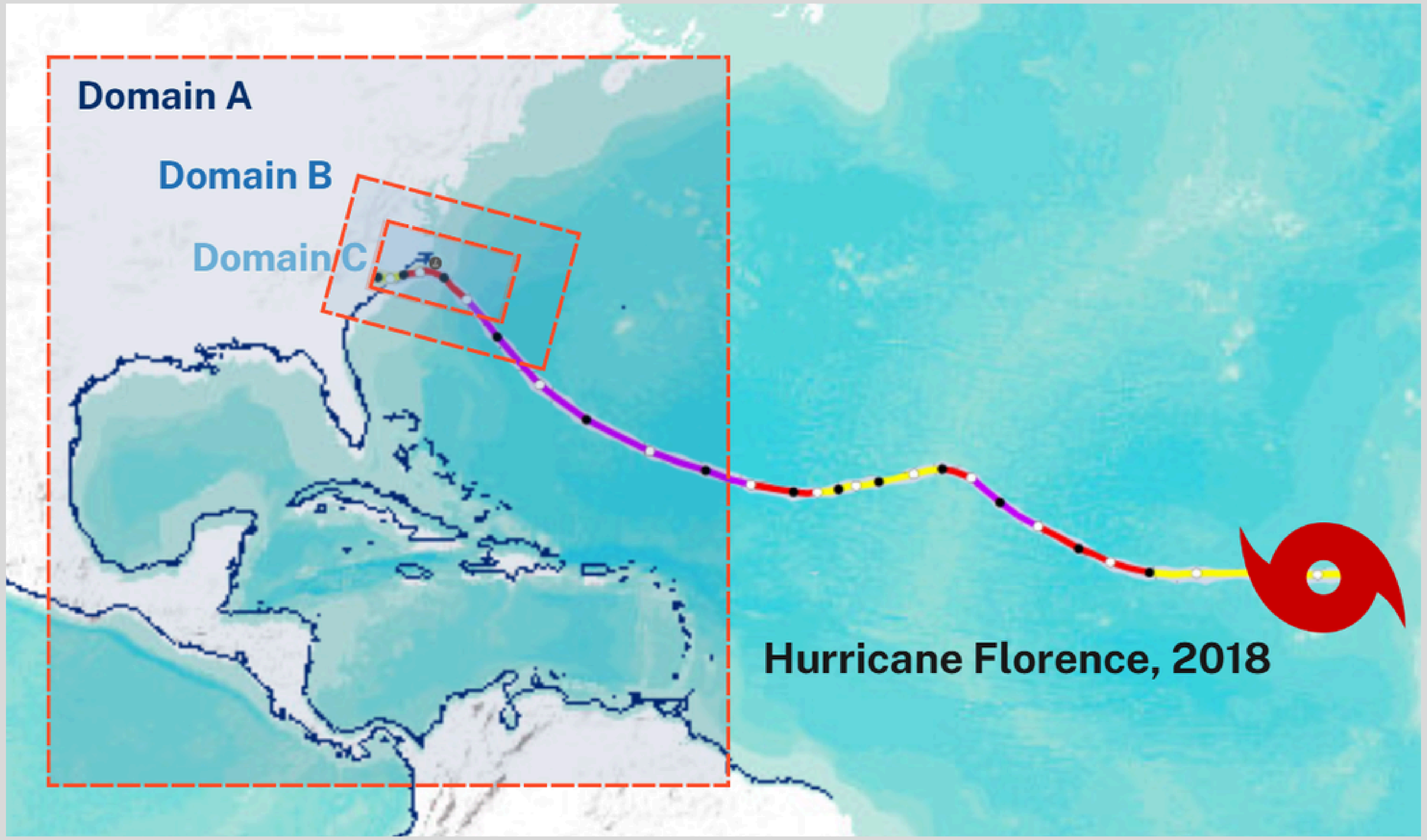
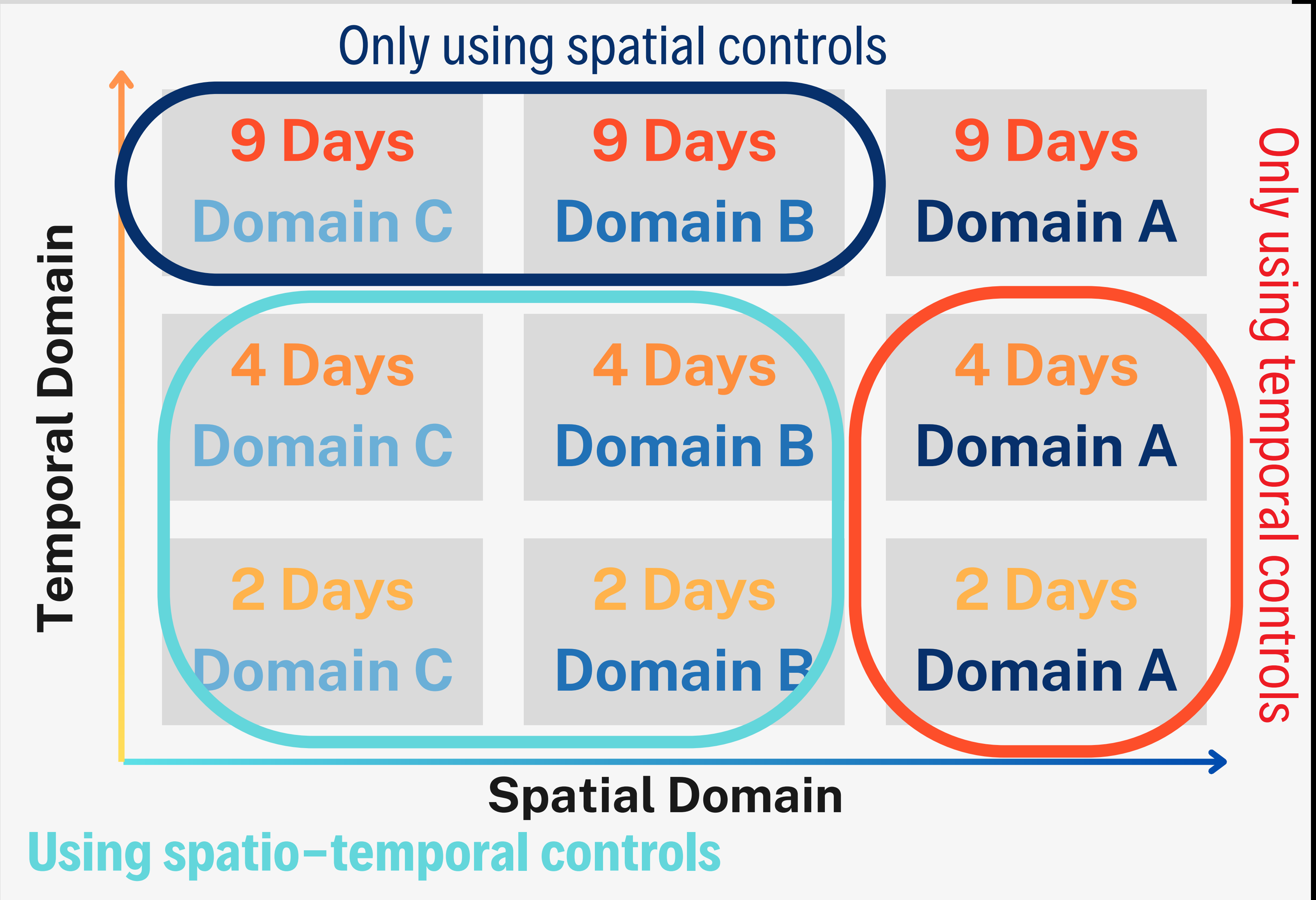
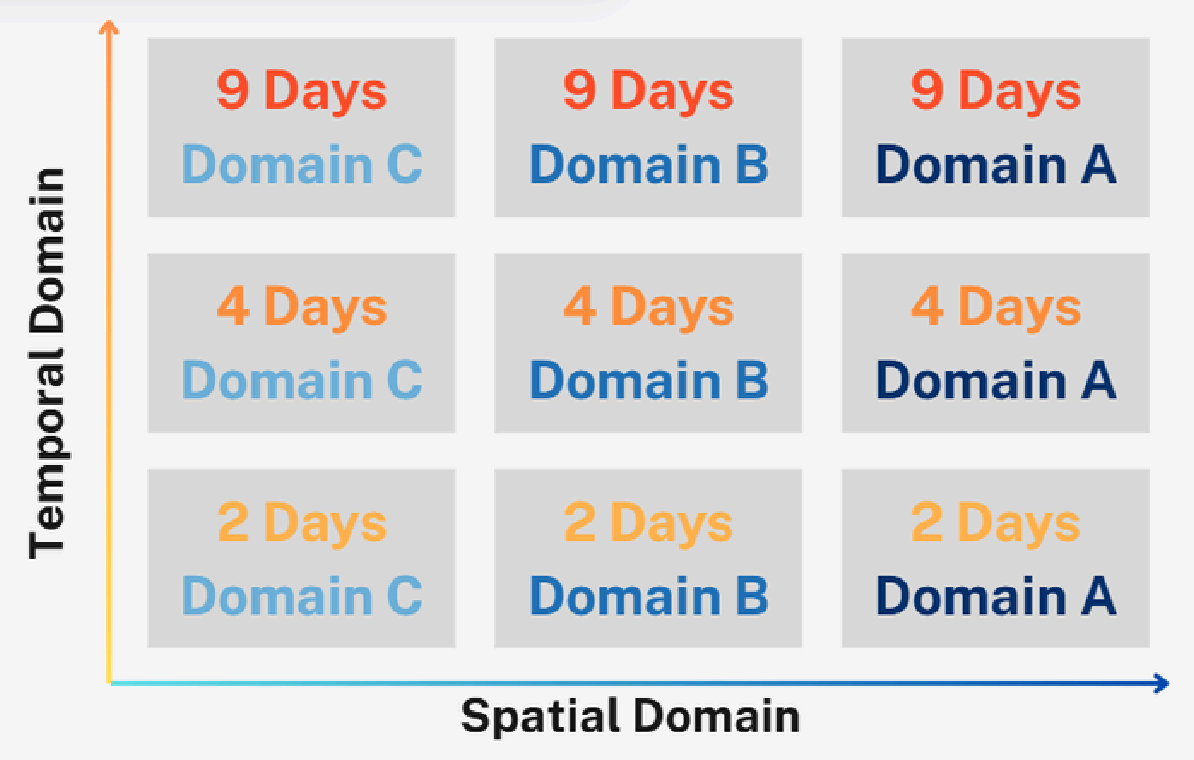
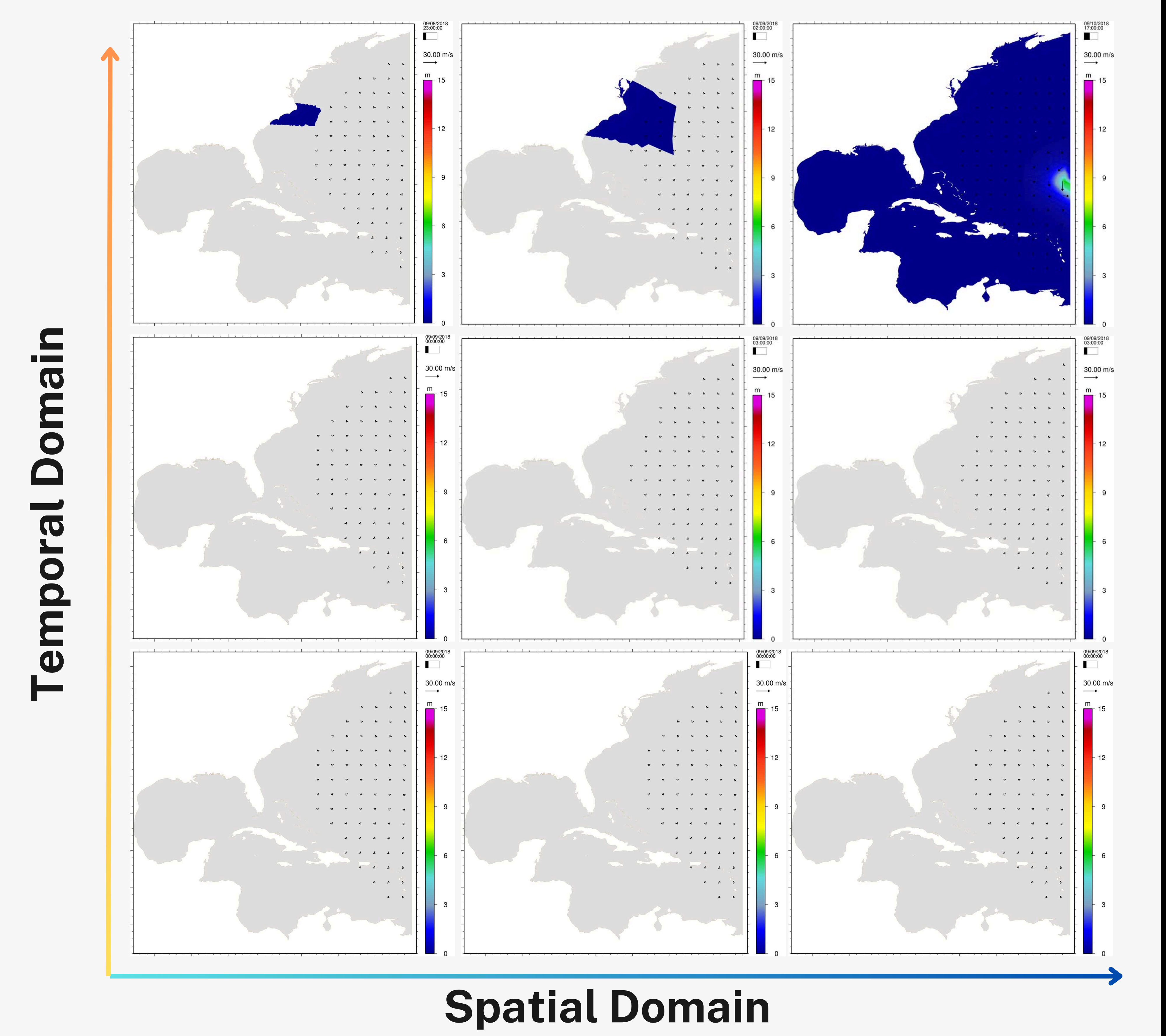




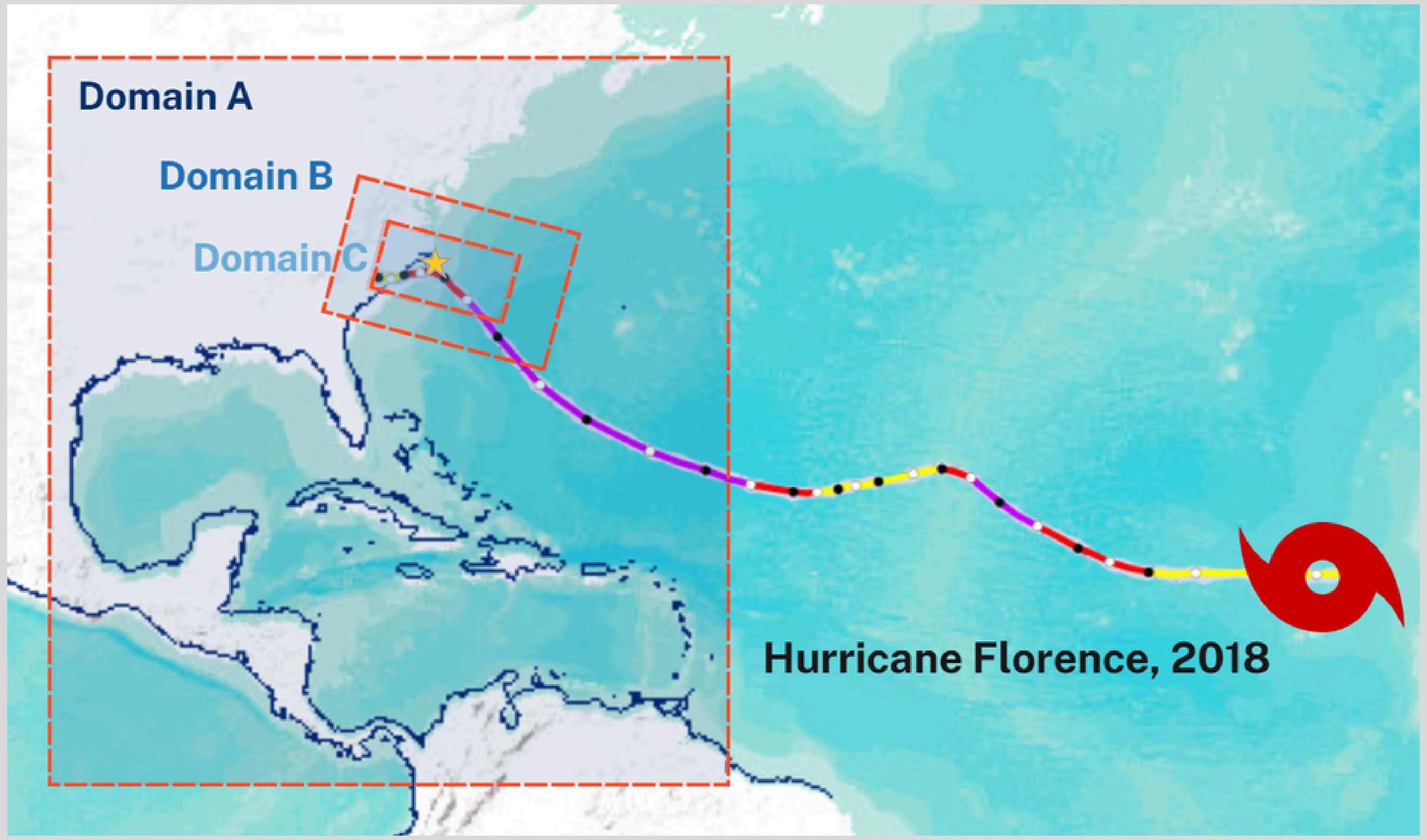
Wave Heights – Florence

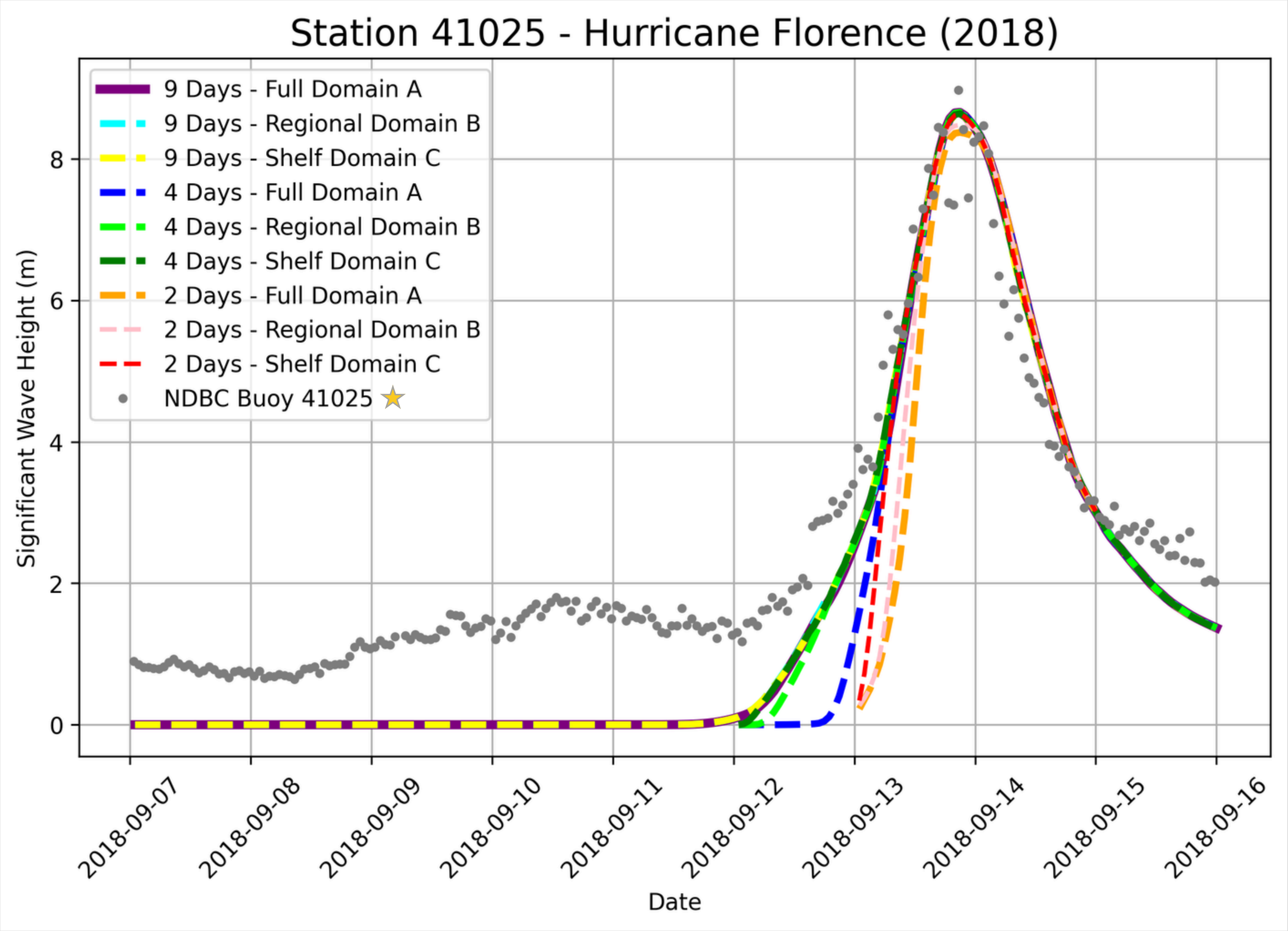


Hurricane Florence (2018) Significant Wave Heights (m) for varying spatial and temporal SWAN domains



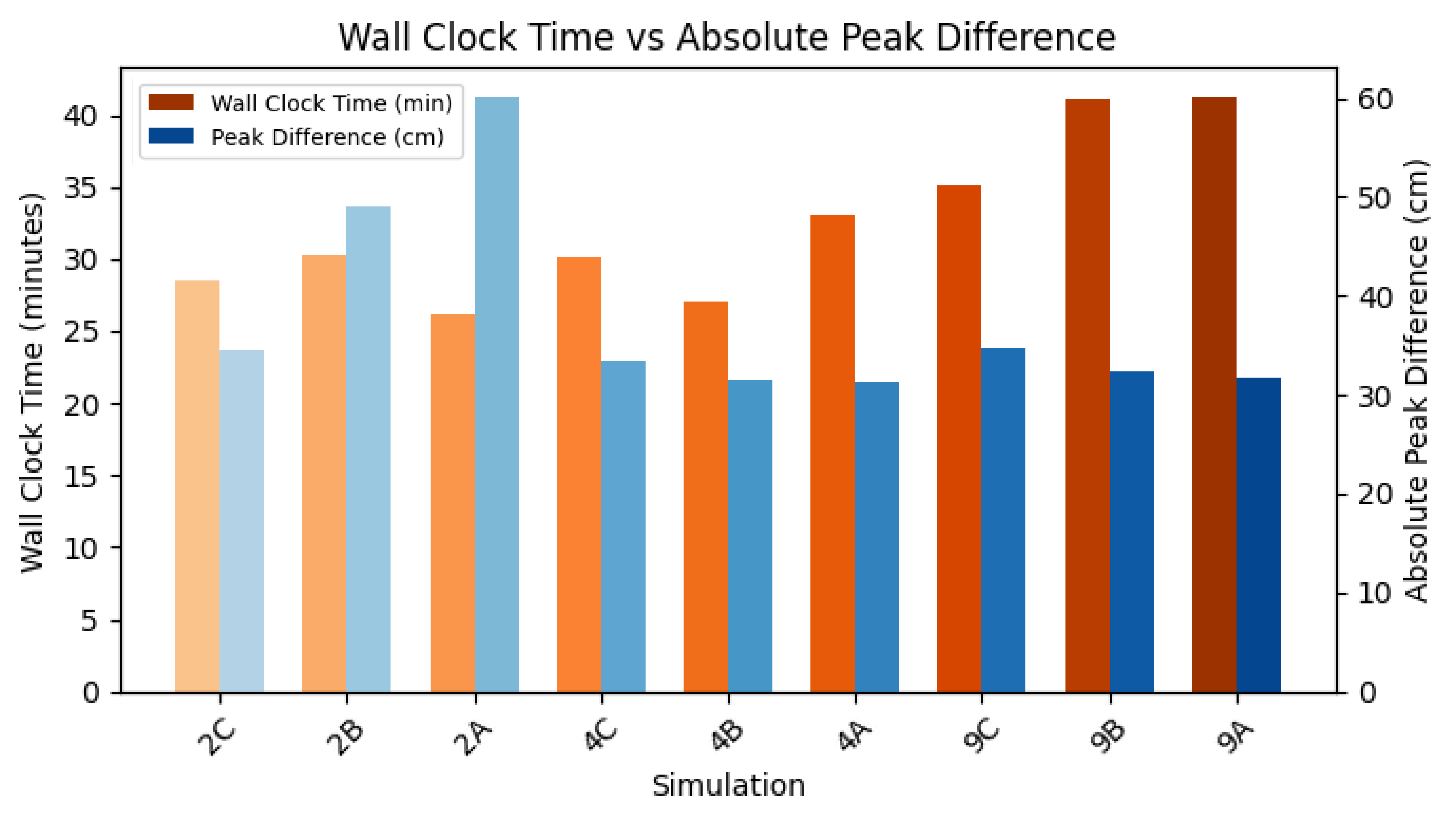
Wave Heights – Florence





Significant Wave Height Time Series

Efficiency vs Accuracy



36.5% Potential Speedup

Temporal Efficiency

South Atlantic Bight (SAB) mesh

- ~1.7 million nodes
- Testing efficiency gains from temporal controls only
- Running SWAN for 2 days vs 9 days:
  - **Nearly twice the speed**

SWAN Duration	Wall Clock Time (Min. of 3 Tests)
9 Days	82:01
4 Days	51:58
2 Days	42:04

48.8% Potential Speedup

Takeaways

- **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
- Tradeoff between computational demand and accuracy when applying spectral inputs
- Balance between optimal domain sizing and simulation duration
    - Likely varies with changing storm characteristics, bathymetry or coastal features, and computational mesh domains

ADDITIONAL USE CASES

Tide Spin Up

Tide spin up using temporal controls

- **14 days of tides only** – then turning on winds and waves without hotstarting

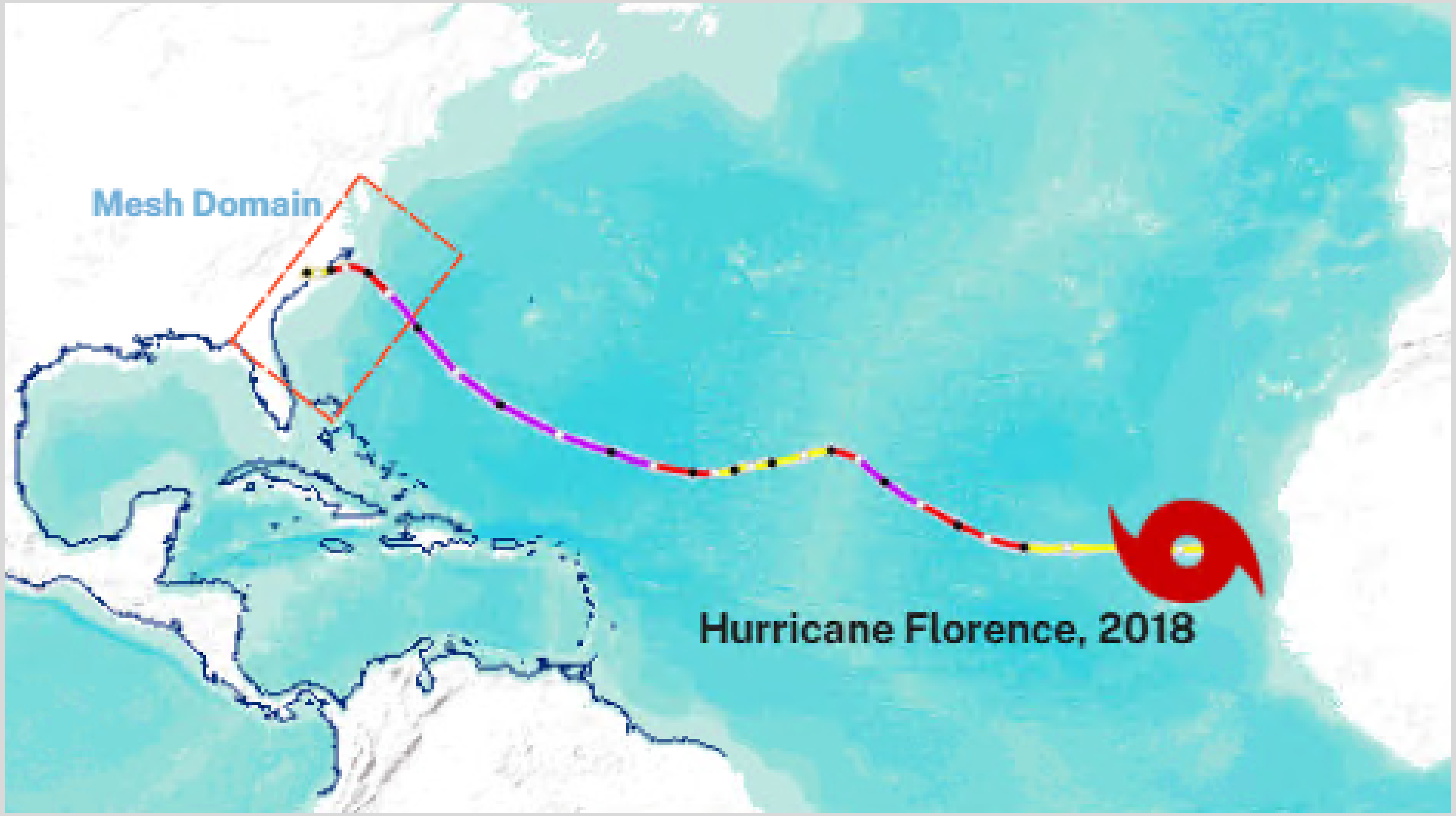
Hurricane Florence, 2018

- Typical SWAN+ADCIRC workflow for hot start:
  - Sim 1: 14 day tide only spin up
  - Sim 2: (+)9 day storm simulation with hot start
- Full Sim with temporal controls:
  - 23 day using temporal controls
    - 14 days tide only with OWI wind blank snaps
    - 9 days waves and winds turn on

Boundary Conditions

Using spatial controls to apply spectral boundary conditions along actual boundary of nearshore mesh domain

- Parallel simulation
- Without limiting spatial domain



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USER WORKFLOW

Temporal Controls – User Workflow

1. **ADCIRC side** – namelist SWANTimeControl used and RunStartDateTime set to start of ADCIRC simulation (ADCIRC model control file –fort.15)

```
&SWANTimeControl RunStartDateTime='20180907.000000' /
```

2. **SWAN side** – COMPUTE time altered to the desired time range (SWAN input file –fort.26)

```
TEST 1,0
COMPUTE 20180912.000000 1200 SEC 20180916.000000
STOP
```

Result: SWAN running for 4 out of the 9 days ADCIRC is running

Spatial Controls – User Workflow

1. **ADCIRC side** –
   a. Increase NWP +1 and include nodal attribute (ADCIRC model control file –fort.15)

```
3                          ! NWP
sea_surface_height_above_geoid
mannings_n_at_sea_floor
swan_local_control
```

   b. Including swan_local_control defaults and non-defaults (fort.13)

```
swan_local_control
 1
 2
 1 0
```

```
swan_local_control
 54
 973 0 0
 977 1 8
 978 0 0
 980 1 9
```

Spatial Controls – User Workflow

2. **SWAN side** –
   a. Input commands to apply spectra at internal sources (SWAN input file –fort.26)

```
BOUnd SHAPespec JONswap 3.3 PEAK DSPR DEGRees
$
BOUndspec SIDE 8 CONstant FILE 'bnd977.spc' 1
BOUndspec SIDE 9 CONstant FILE 'bnd980.spc' 1
BOUndspec SIDE 10 CONstant FILE 'bnd984.spc' 1
```

   b. Spectral files (in main directory)

```
bnd977.spc
bnd980.spc
bnd984.spc
```

Supplementary Scripts

Tools to help create necessary nodal attribute file and SWAN input files

- *make13.py*

```
swan_local_control
 1
 2
 1 0
```

```
swan_local_control
 54
 973 0 0
 977 1 8
 978 0 0
 980 1 9
```

- *update26.py*

```
  bnd977.spc
  bnd980.spc
  bnd984.spc
```

- *source_prep.py*

```
 BOUnd SHAPespec JONswap 3.3 PEAK DSPR DEGRees
 $
 BOUndspec SIDE 8 CONstant FILE 'bnd977.spc' 1
 BOUndspec SIDE 9 CONstant FILE 'bnd980.spc' 1
 BOUndspec SIDE 10 CONstant FILE 'bnd984.spc' 1
```

Spatial Controls – Supplementary Scripts

Specifying a desired spatial domain and internal source spectra locations *(make13.py)*

- Define polygon vertices of the region of interest
- Whether internal sources exist or need to be generated

Expected Results

The following image displays what a modified `fort.13` file would include for `swan_local_control`.

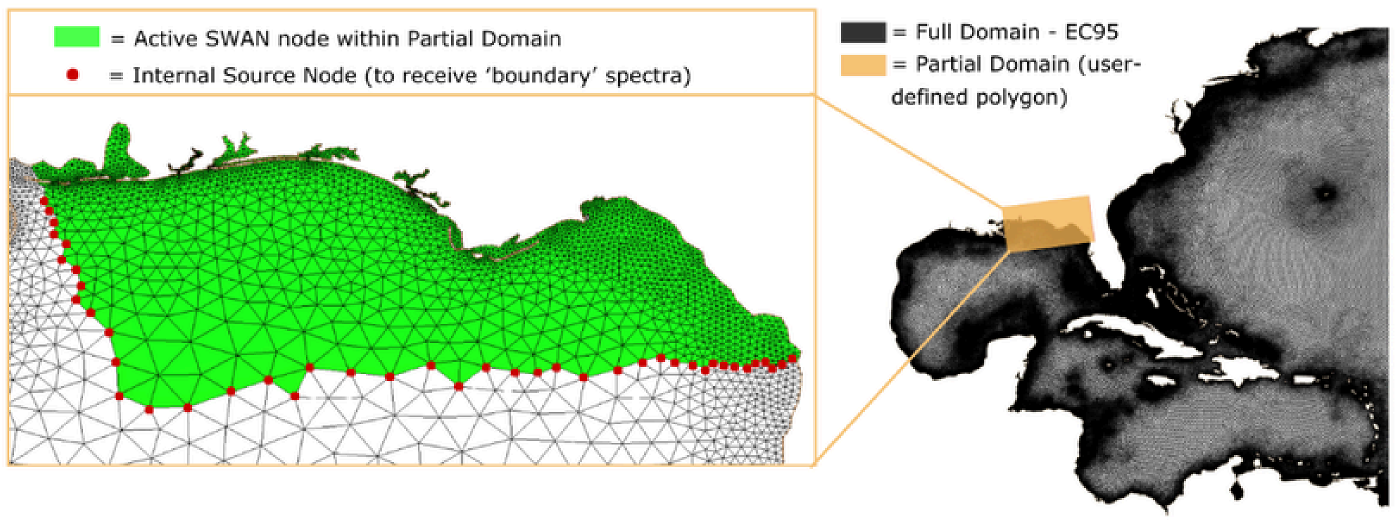


Figure 1. Active SWAN nodes within the EC95 ADCIRC mesh based on user-specified polygon. Green elements correspond to areas of the mesh where SWAN is activated and red dots represent nodes where internal source spectra are applied as 'boundary conditions' for the partial domain.

make13 Python Code

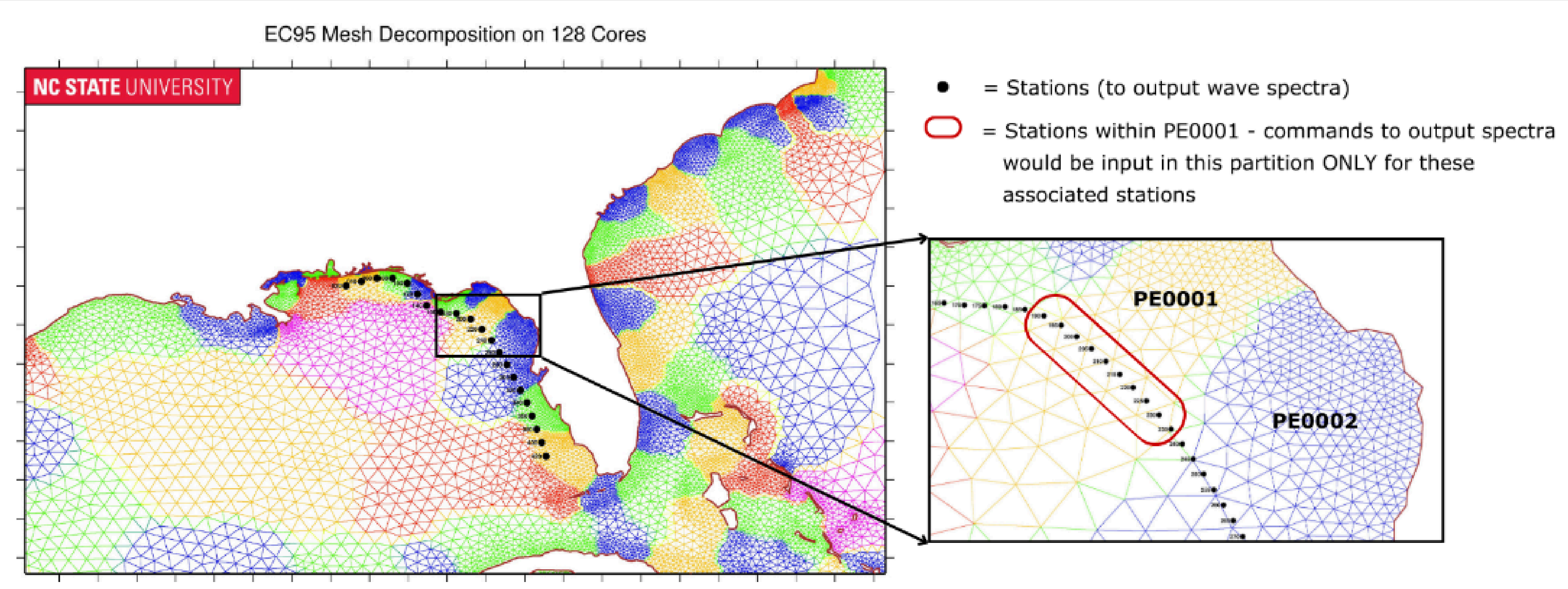
Checks every node in mesh to find nodes within the polygon and sets to active in the nodal attribute file

Finds nodes closest to given sources and sets to a positive integer in nodal attribute file.

Spatial Controls – Supplementary Scripts

Outputting wave spectra (*update26.py*)

- To create a fort.26 to output spectra
- Writes local fort.26 files to output spectra for a given station
  - Puts commands within PE folder containing element that station falls within



Station Location CSV:

```
Station_ID,longitude,latitude
16941,-76.334461,30.757137
...
```

fort.26:

```
POINTS 'bnd16941' -76.334461 30.757137
SPECout 'bnd16941' SPEC2D ABSolute S 'bnd16941.spc' OUTput 20181006.000000 1800 Sec
```

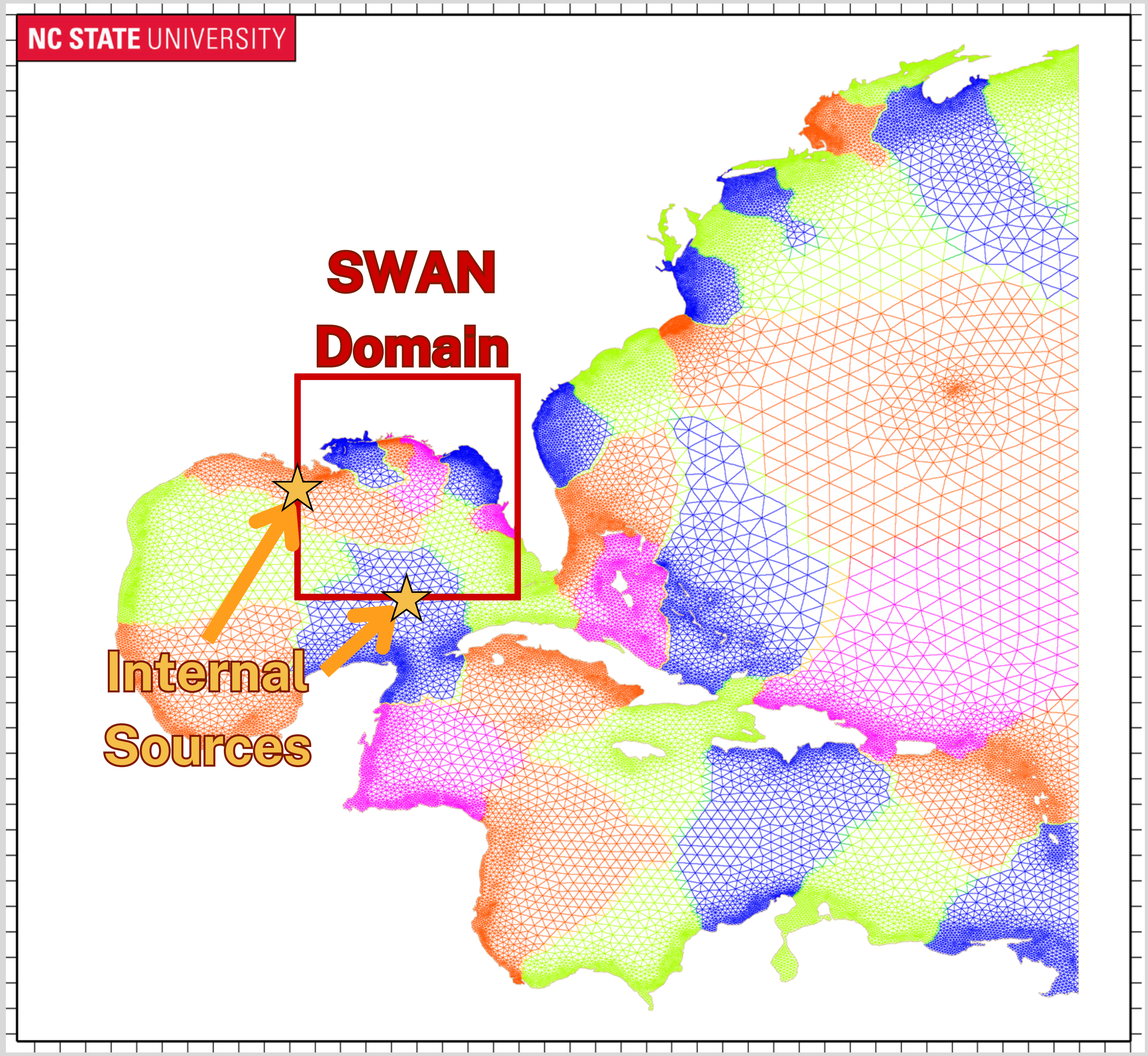
Spatial Controls – Supplementary Scripts

Inputting spectral boundary conditions
(*source_prep.py*)

- Writes local fort.26 files to input spectra based on modified fort.13
  - Identifies which internal source nodes are in which subdomain (PE) folder
  - Adds lines to local SWAN input files (fort.26) to apply spectral BCs

fort.26:

```
BOUnd SHAPespec JONswap 3.3 PEAK DSPR DEGRees
BOUndspec SIDE <side> CONstant FILE 'bnd<node>.spc' 1
```



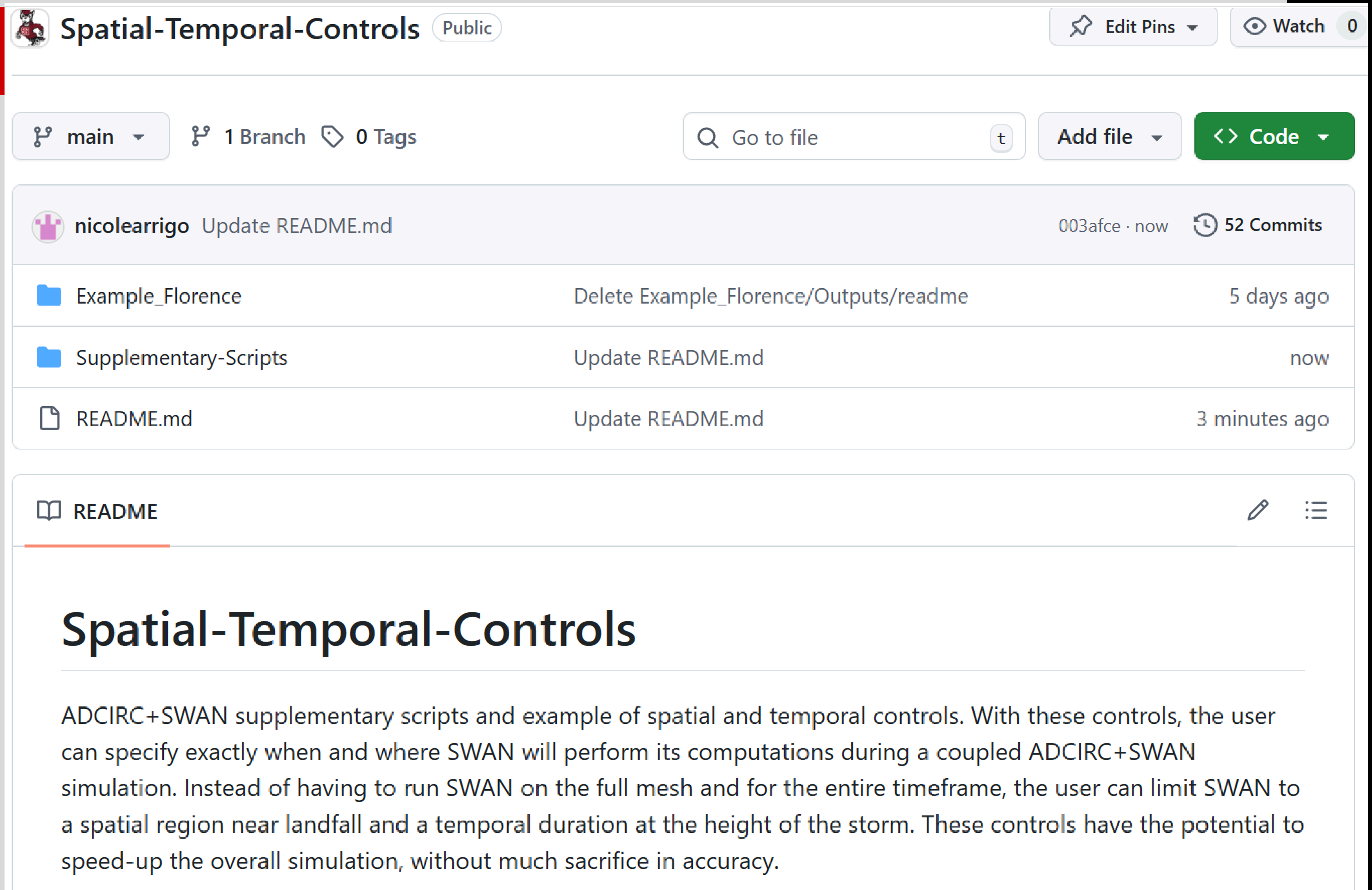
CONCLUSION

CCHT GitHub

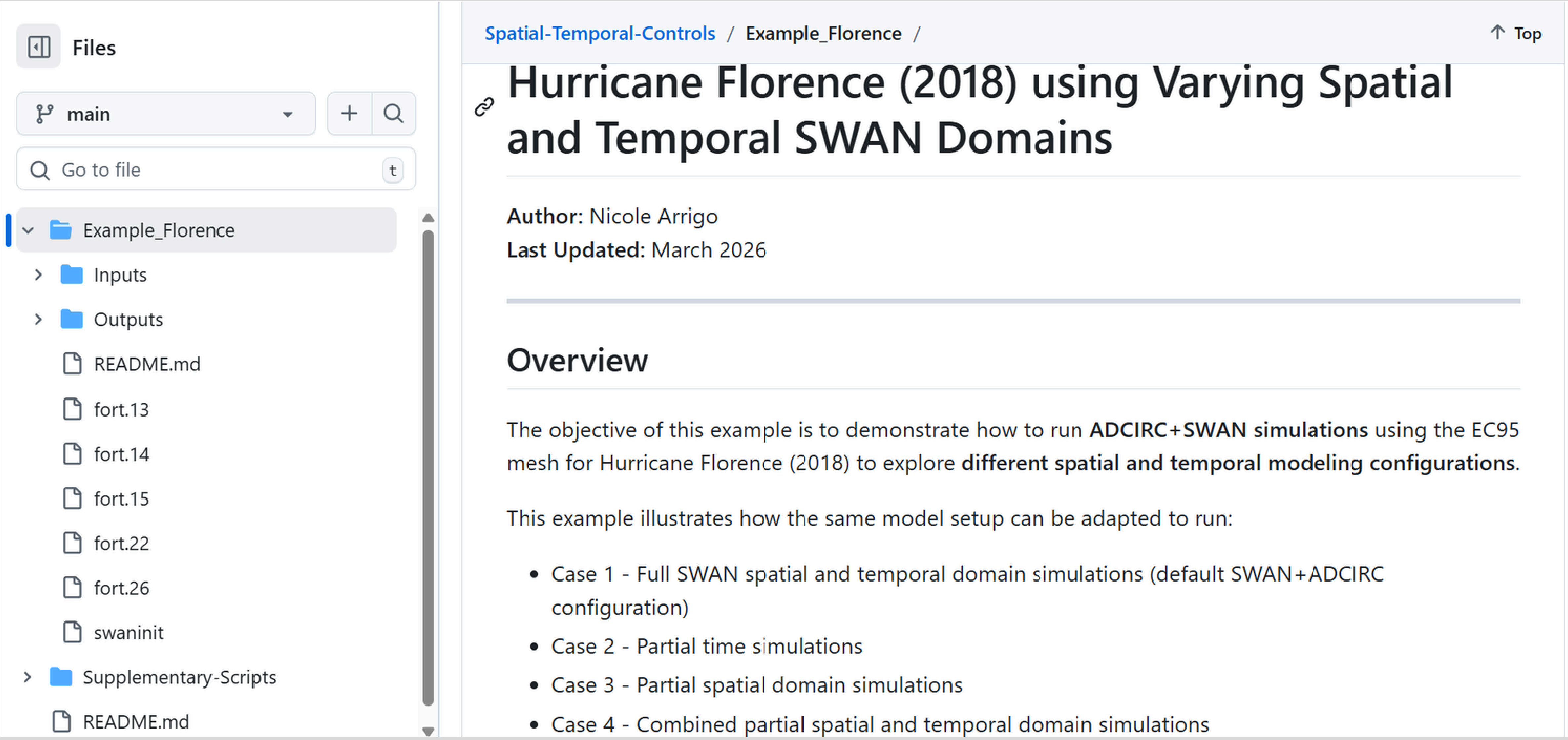
Includes:

- Supplementary Scripts
- Examples using Hurricane Florence (2018)

https://github.com/ccht-ncsu/Spatial-Temporal-Controls/tree/main



CCHT GitHub


Files
main
Go to file
Example_Florence
Inputs
Outputs
README.md
fort.13
fort.14
fort.15
fort.22
fort.26
swaninit
Supplementary-Scripts
README.md

Spatial-Temporal-Controls / Example_Florence /

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Hurricane Florence (2018) using Varying Spatial and Temporal SWAN Domains

Author: Nicole Arrigo
Last Updated: March 2026

Overview

The objective of this example is to demonstrate how to run **ADCIRC+SWAN simulations** using the EC95 mesh for Hurricane Florence (2018) to explore **different spatial and temporal modeling configurations.**

This example illustrates how the same model setup can be adapted to run:

- Case 1 - Full SWAN spatial and temporal domain simulations (default SWAN+ADCIRC configuration)
- Case 2 - Partial time simulations
- Case 3 - Partial spatial domain simulations
- Case 4 - Combined partial spatial and temporal domain simulations

Example Florence

- 4 Cases – Default, partial time, partial space (with another base simulation to export spectra), partial time and space
  - Workflow of each

Conclusions

- Spatial and temporal controls to be implemented in the newest release ADCIRC source code on adcirc GitHub
- CCHT GitHub contains all supplementary scripts, examples, and explanatins
- Next steps – additional use cases and time testing to quantify efficiencies gained

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We appreciate your interest and engagement today

Thank You for Your Attention!

Presented by:
Nicole Arrigo

QUESTIONS?

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Stay Connected! We Value Your Feedback and Questions

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CCHT GitHub

Thank you to our partners at USACE–ERDC for making this work possible.