Incorporating the Morphodynamics in ADCIRC Using Time-Varying Bathymetry

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ADCIRC Users Group Meeting, Mar 30-31, 2020

Introduction

Isabel Inlet (2003)

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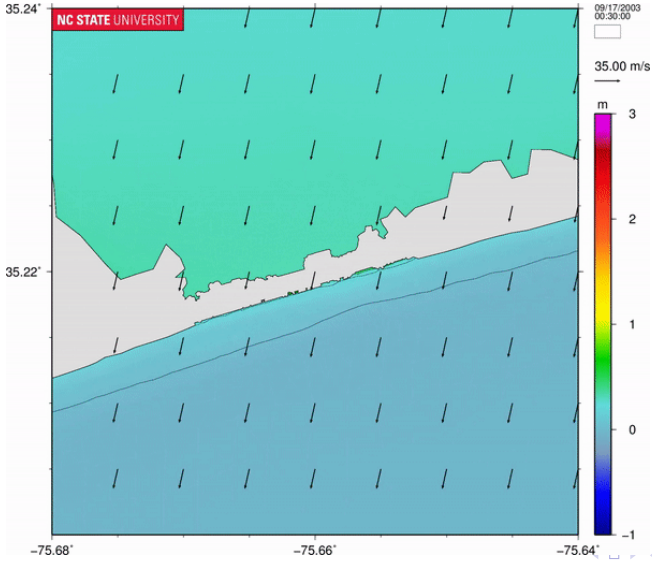
Existing Capability with Static Ground Surface



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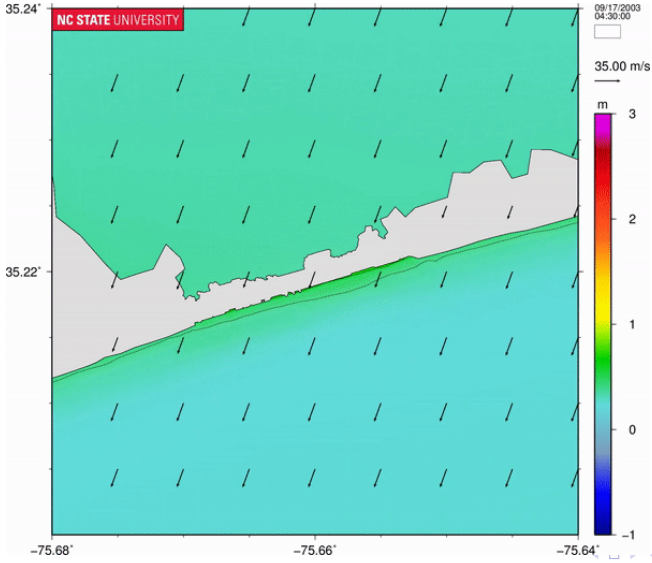

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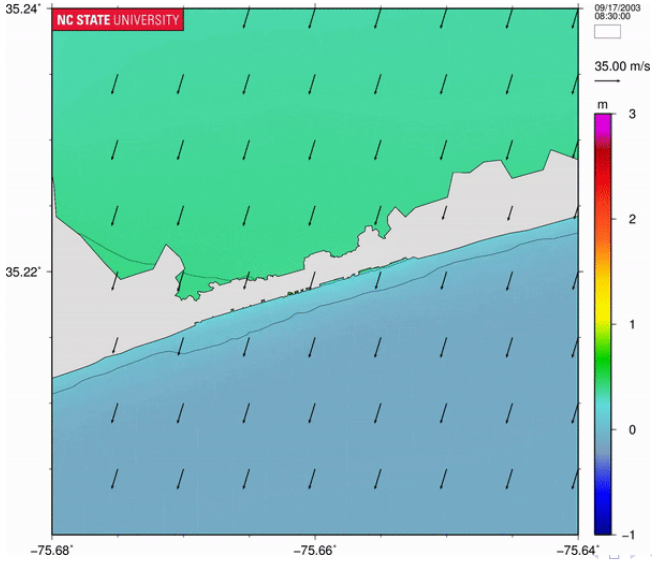

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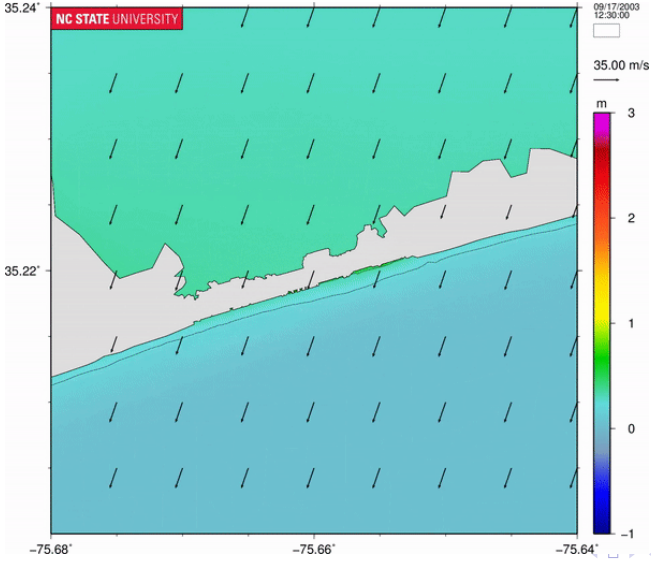

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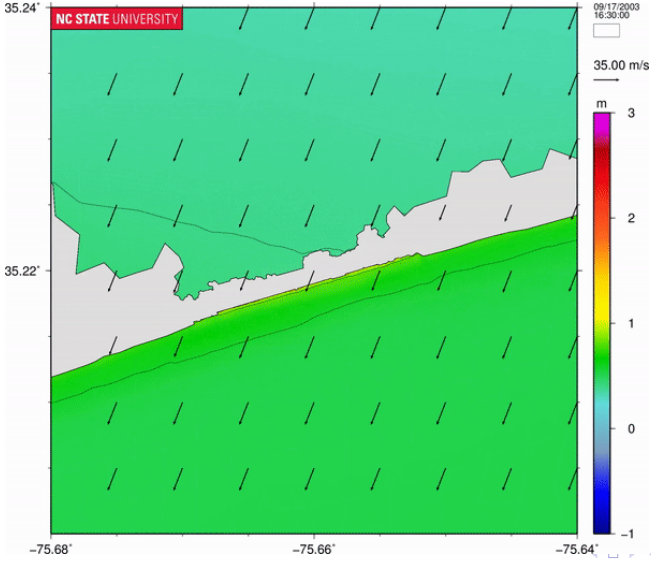

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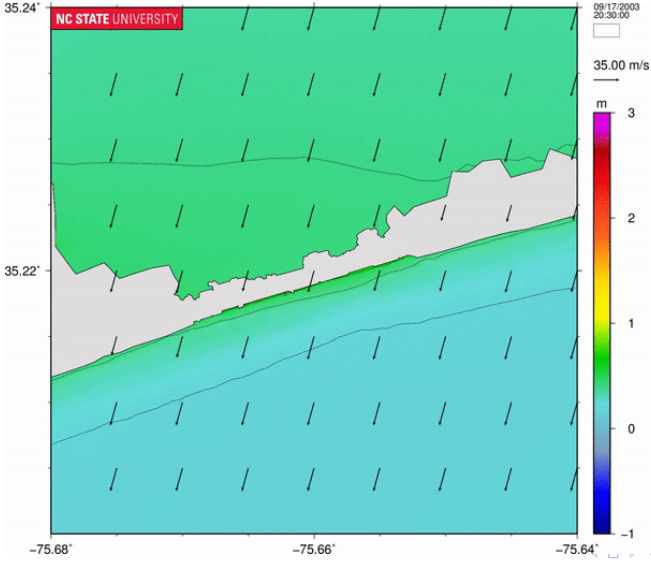

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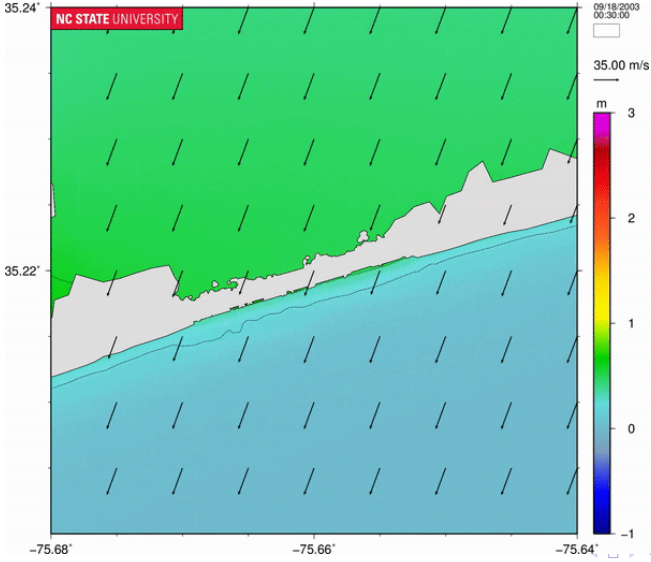

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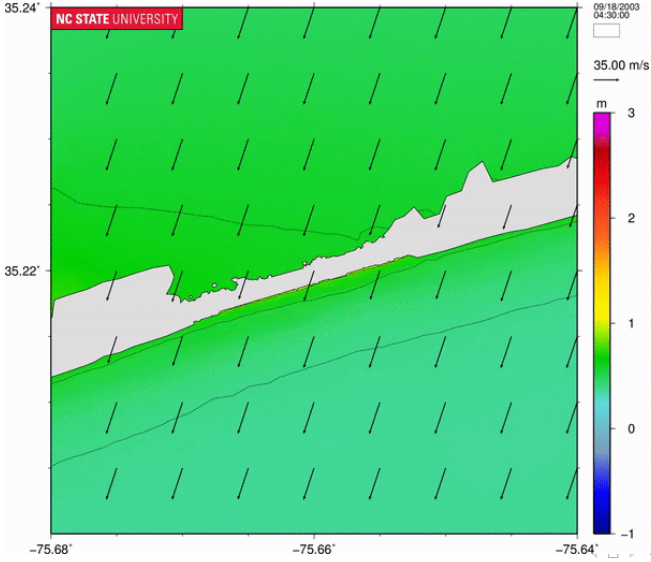

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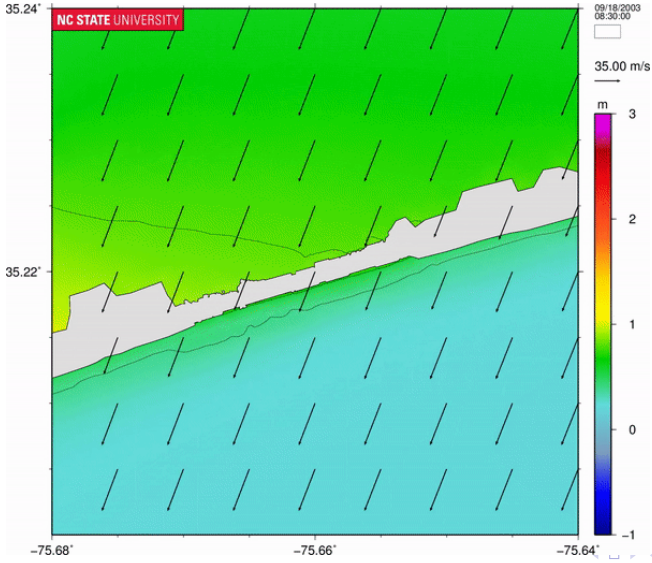

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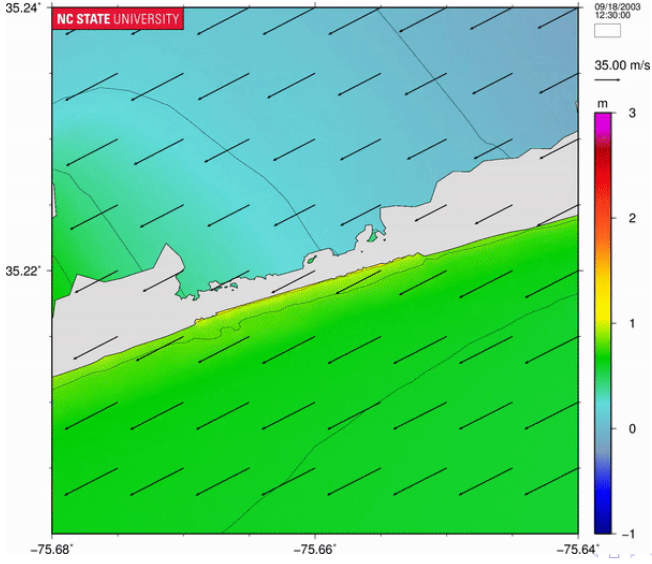

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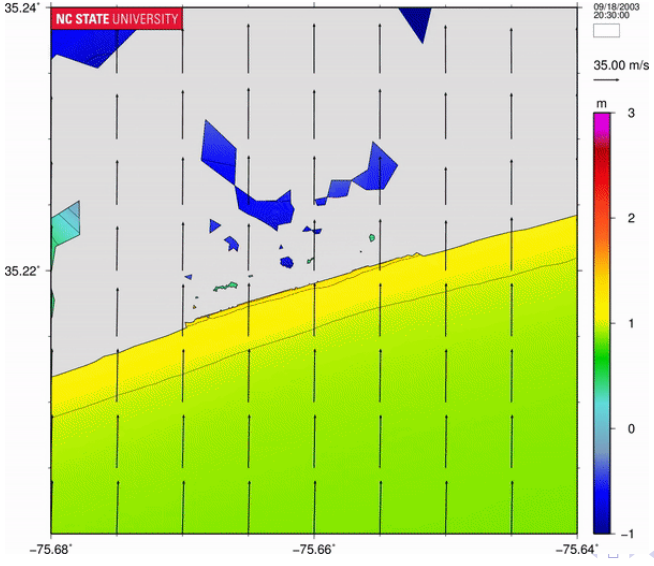

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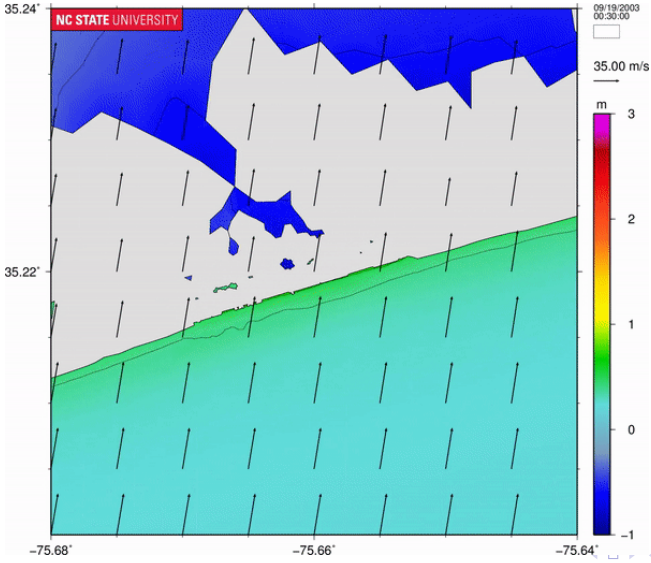

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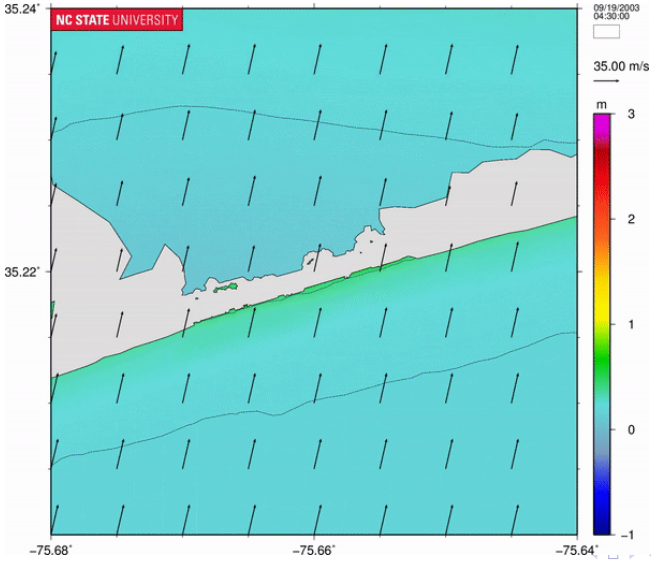

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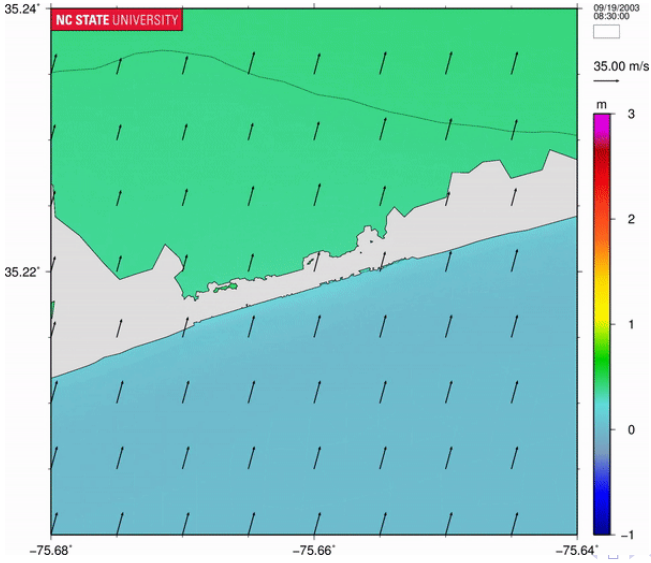

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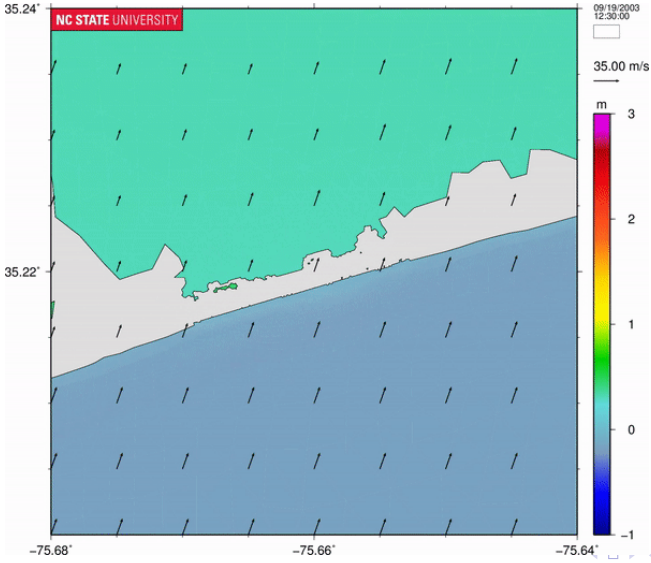

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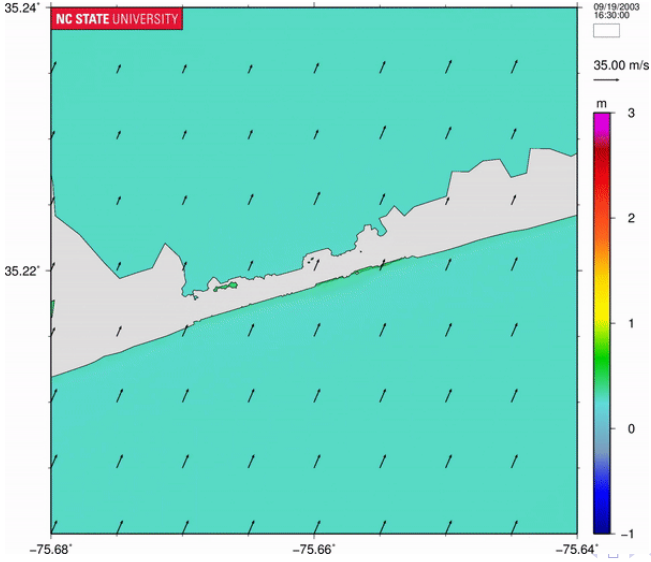

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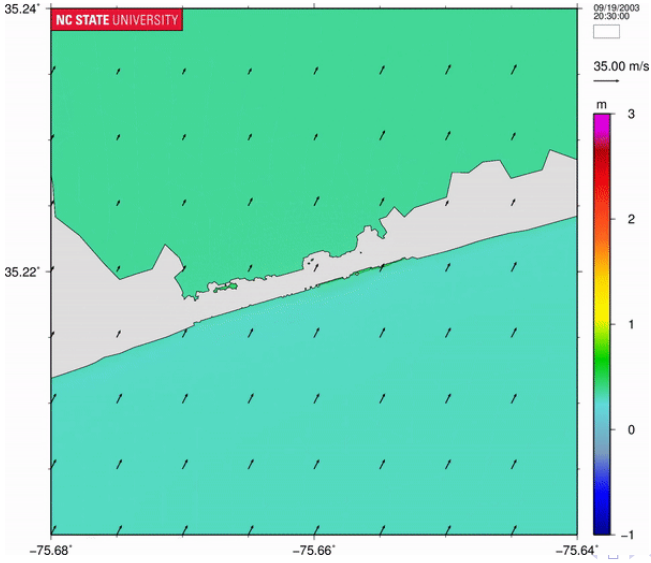

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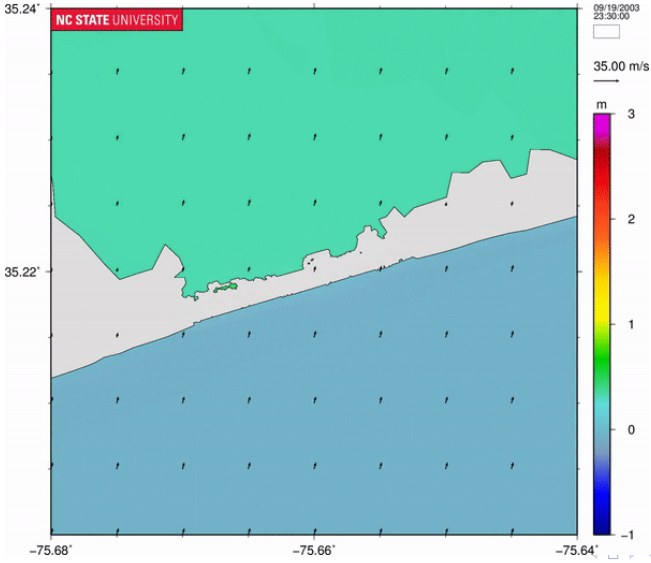


Goals and Objectives

Goals:

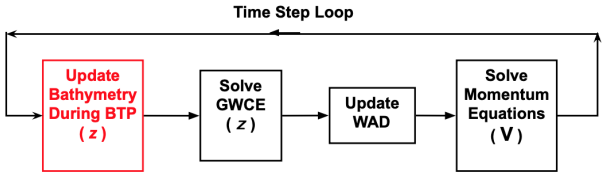
1. Better understand the storm-induced erosion of barrier islands
2. Develop ways to represent that erosion in predictive models on large domains

Objectives:

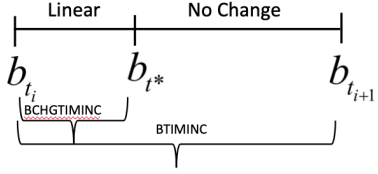
1. Explore the Time-Varying Bathymetry module in ADCIRC
2. Develop a high-resolution hindcast of inlet creation in a barrier island system
3. Implement a two-way coupling of small-scale erosion to larger-scale flooding models

Dr. Chris Massey (USACE) added capability for time-varying bathymetry:

- Occurs at start of time step:



- Control over timing during simulation:



Changes in ground surface, specified at only the vertices near the breach

- Linear transition between Pre- and Post-storm DEMs.
  - Location and magnitude of erosion is coming from the post-storm survey
  - Controlling the erosion over 1 day, during the landfall of the storm
  - Incremental variations:
    - Changes over 1 hour
    - Static over 2 hours

Isabel Inlet
Pre-Storm Ground Surface
6 m
0 m

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Post-Storm Ground Surface

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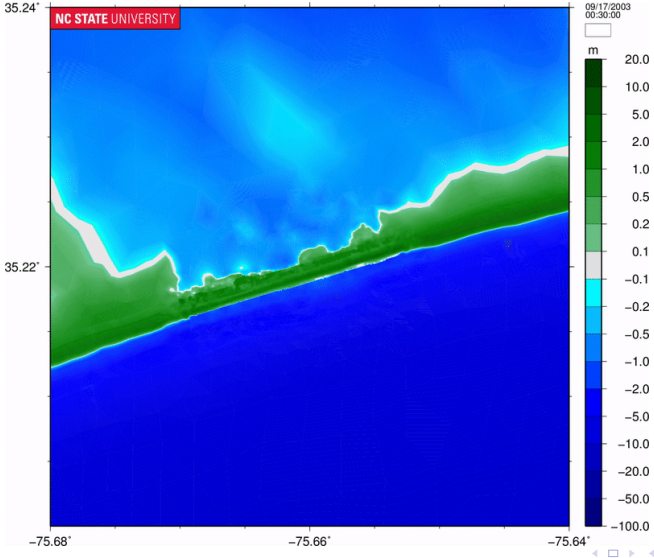
Ground Surface Variation Using Observation



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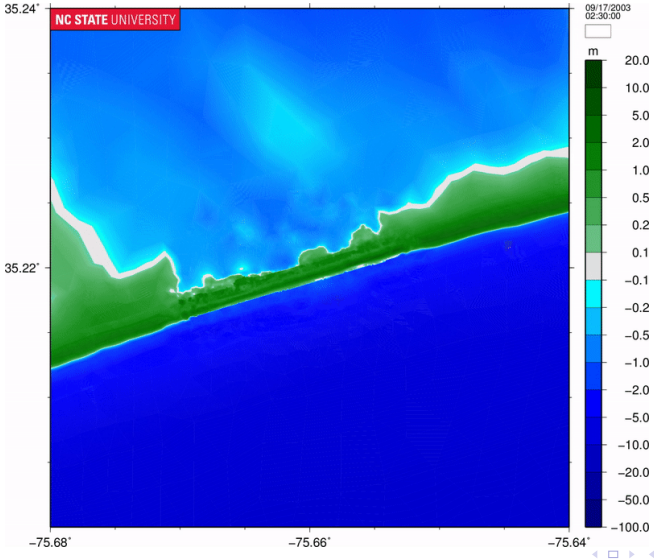

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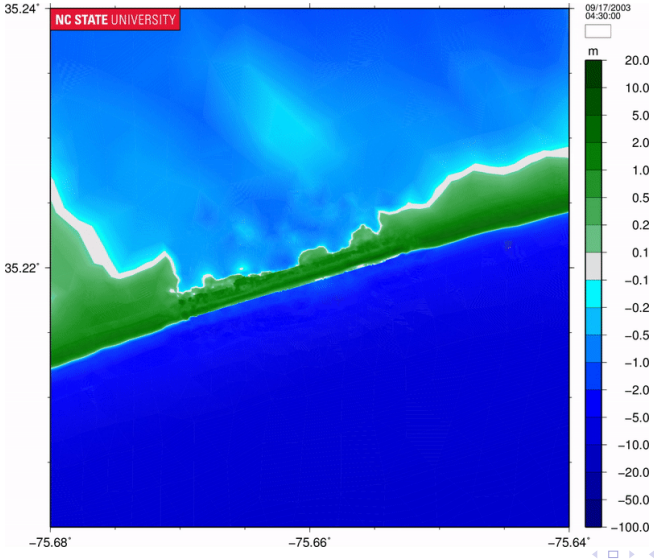

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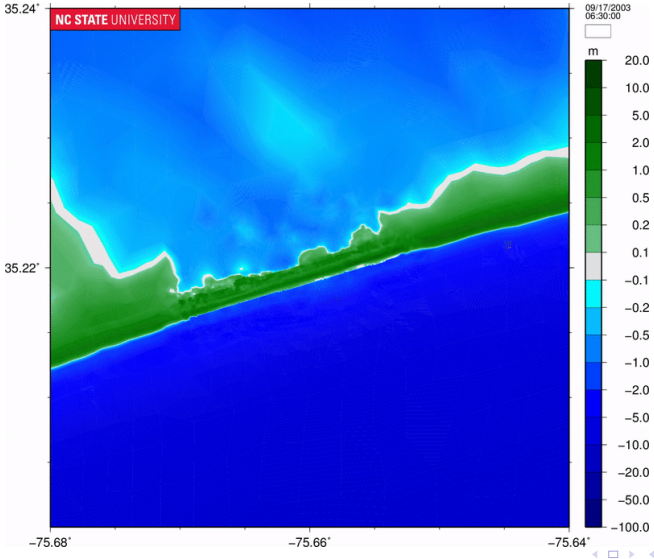

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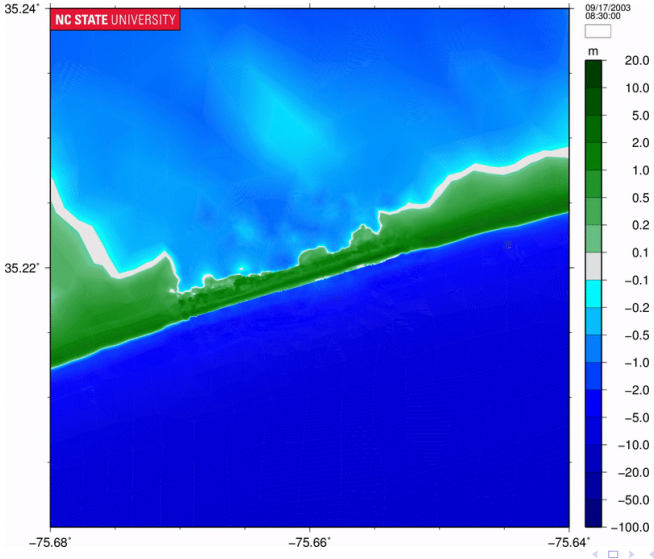

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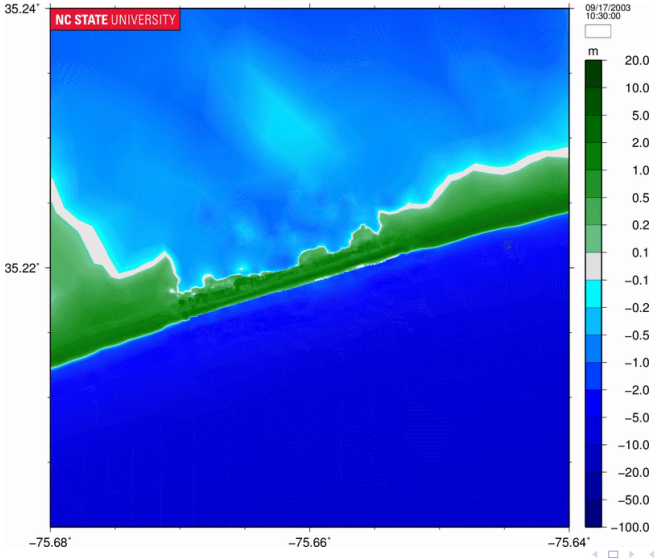

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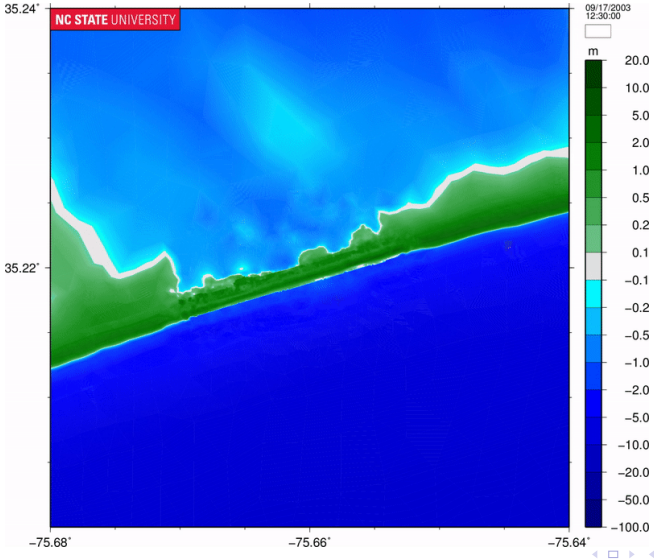

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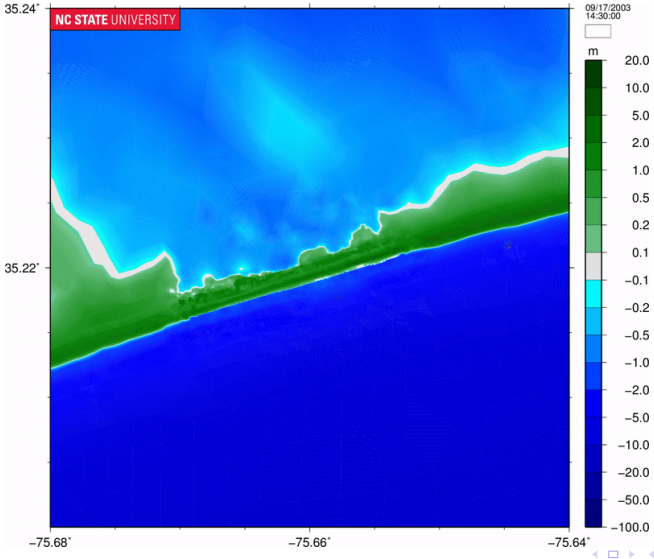

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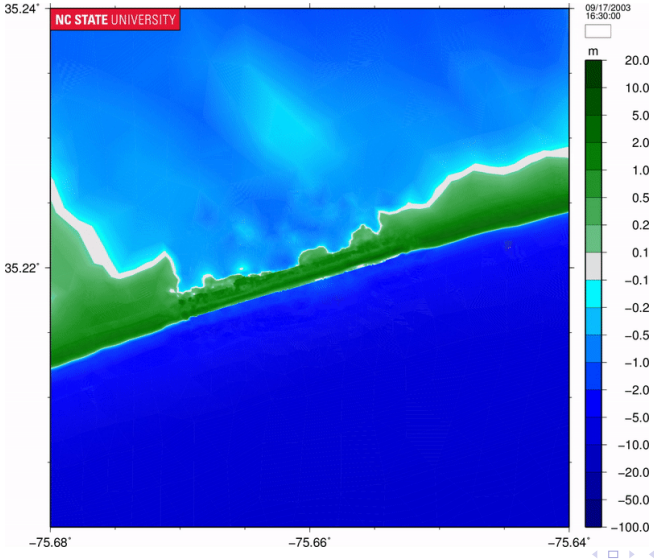

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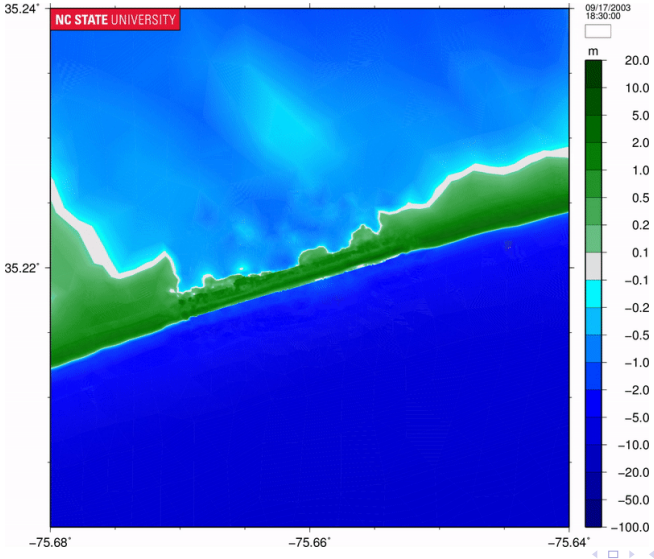

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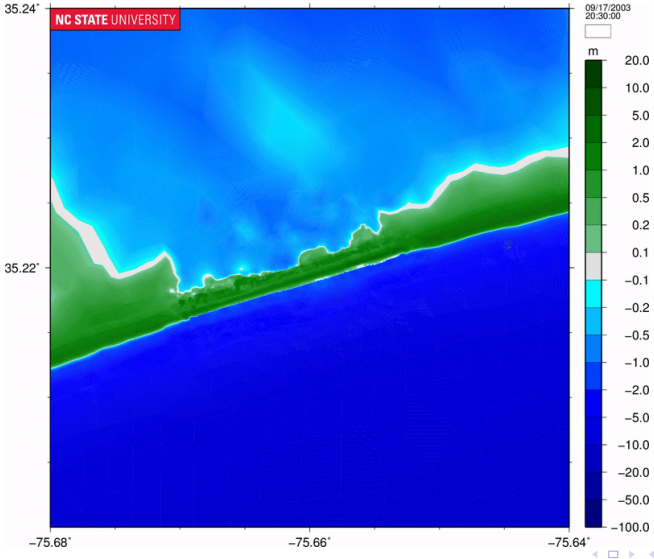

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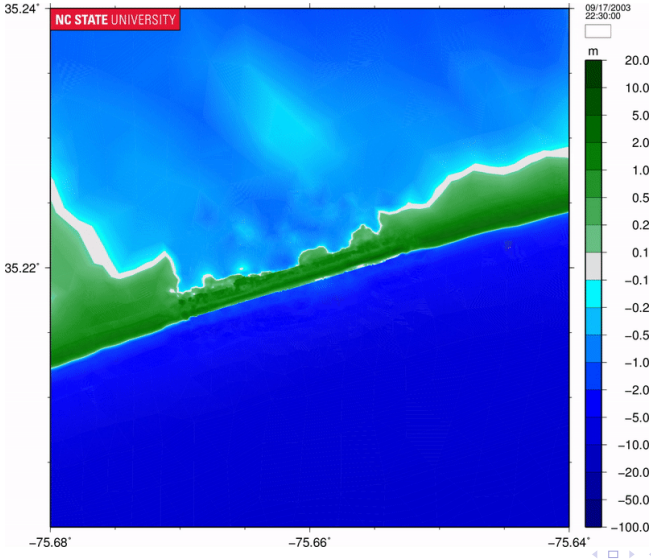

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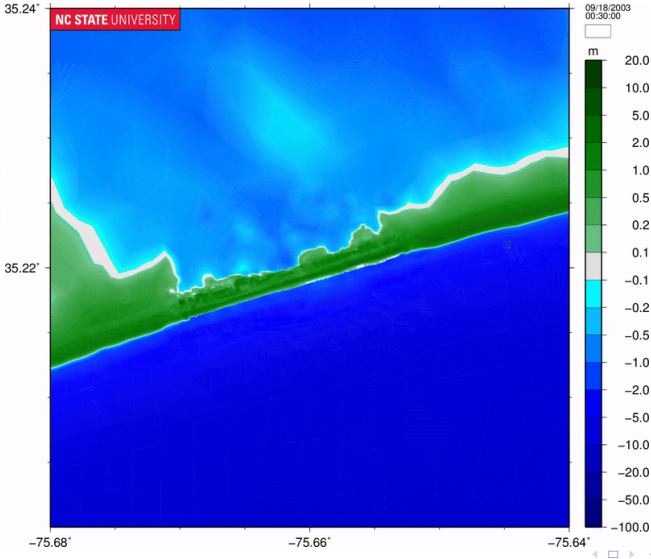

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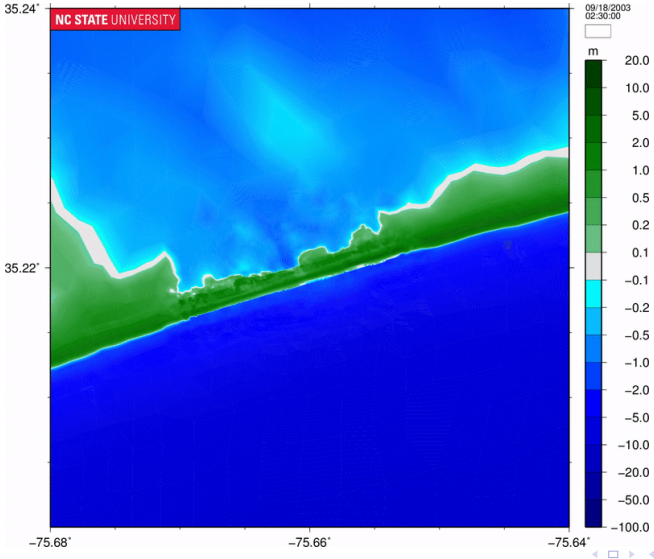

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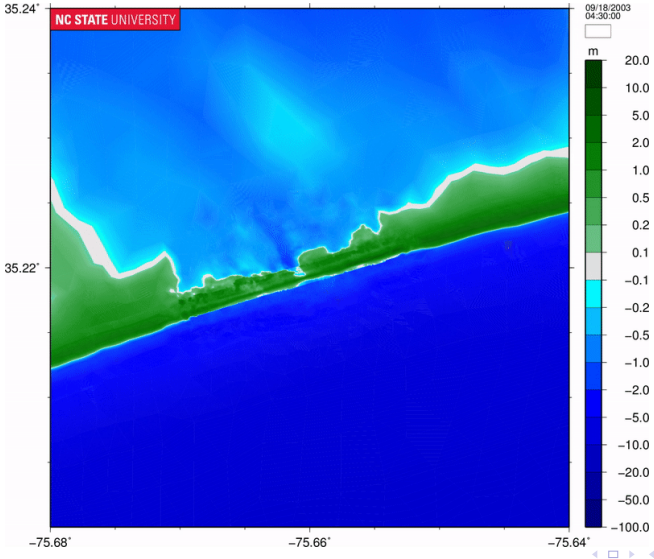

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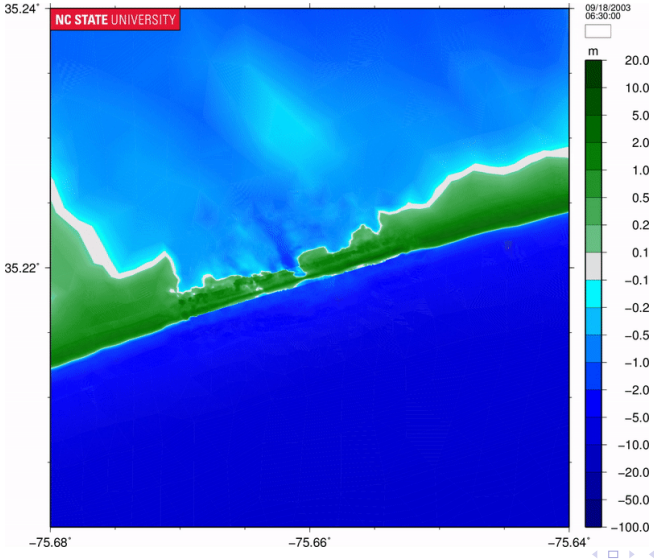

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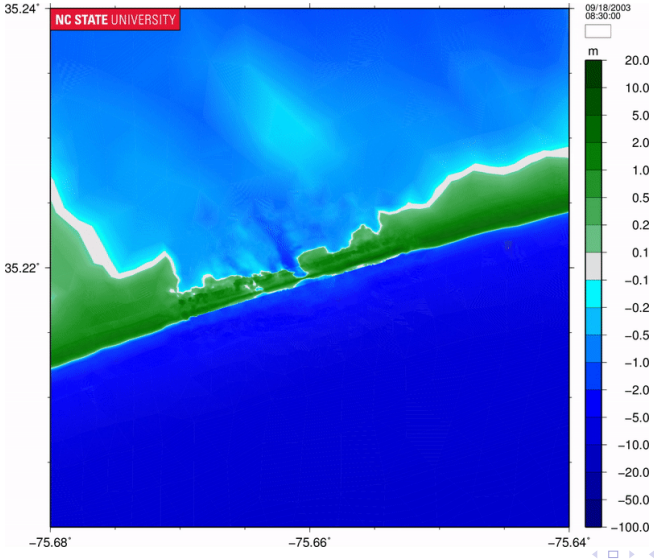

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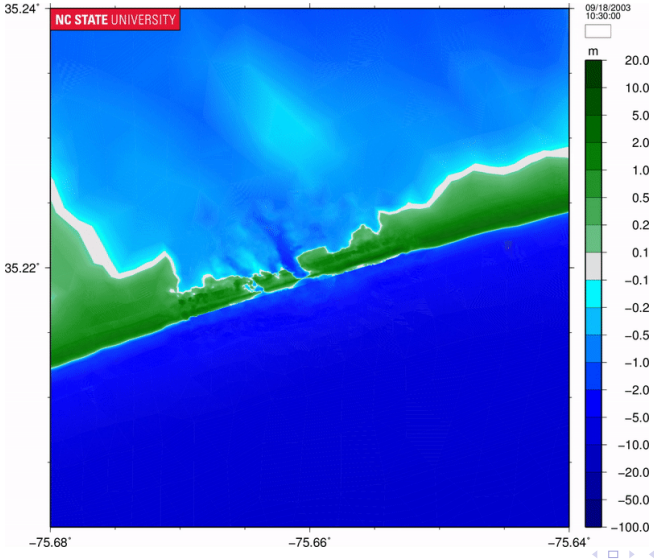

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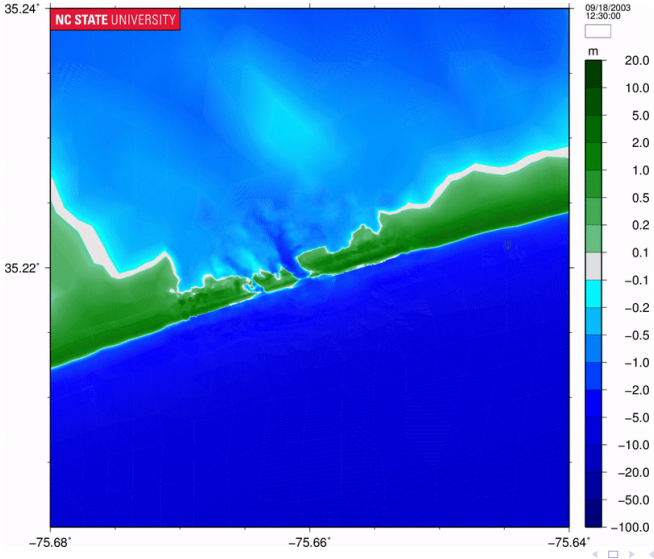

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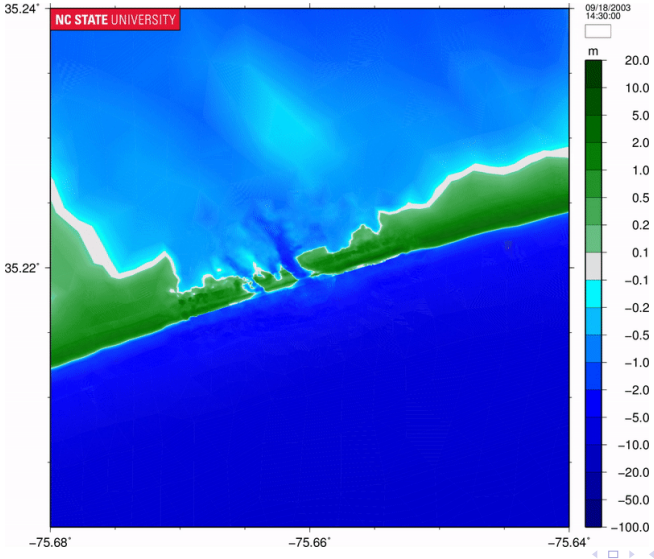

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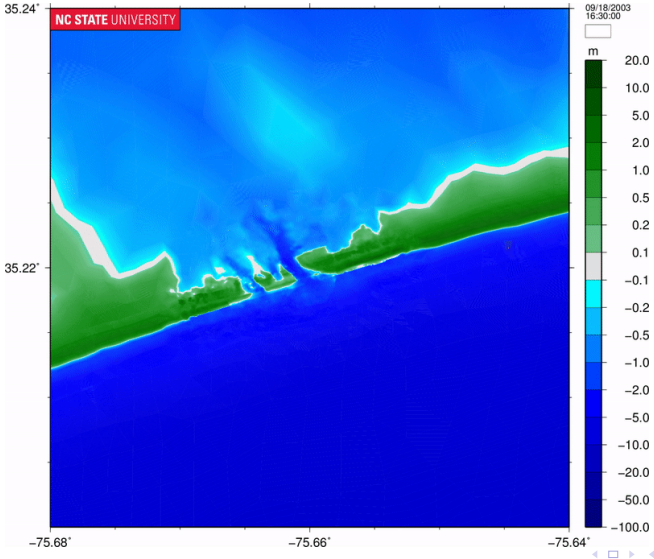

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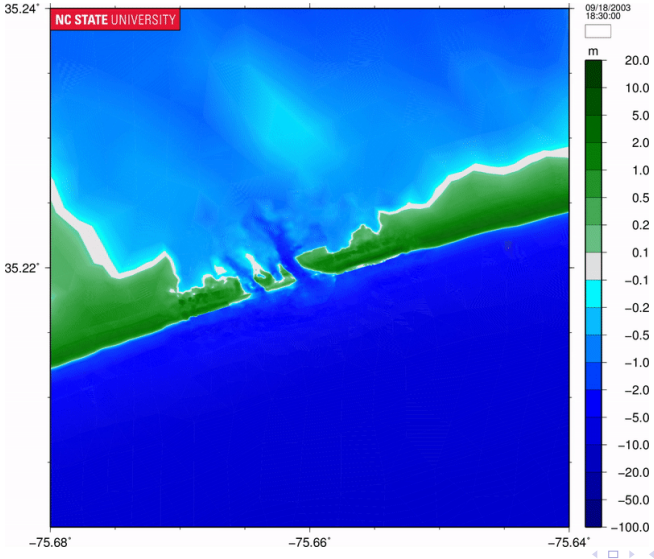

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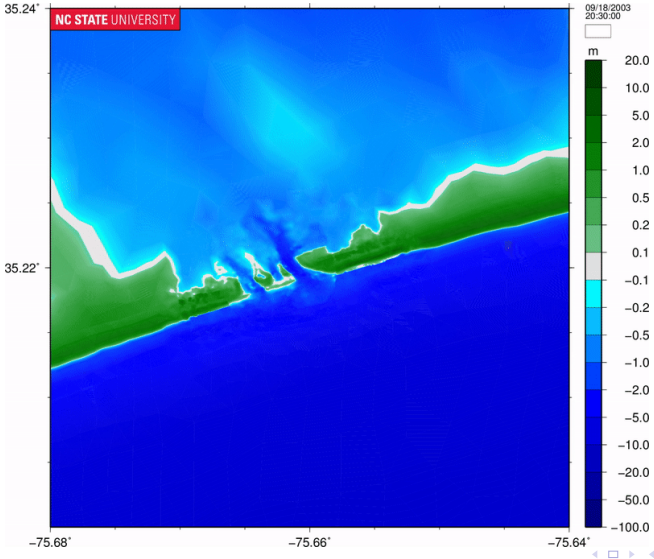

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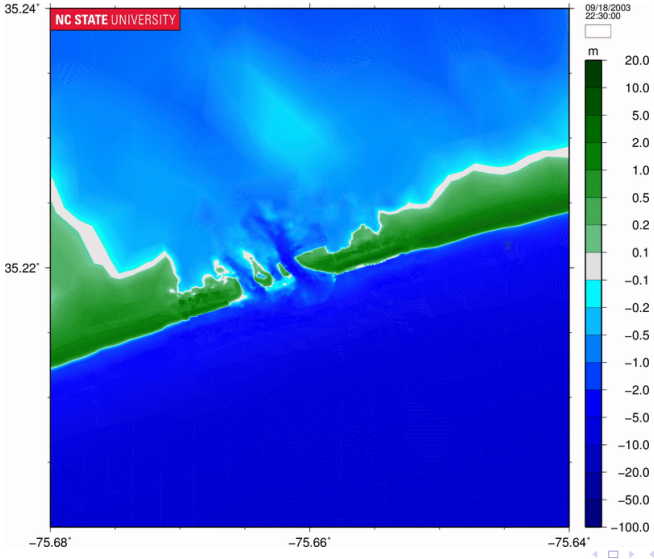

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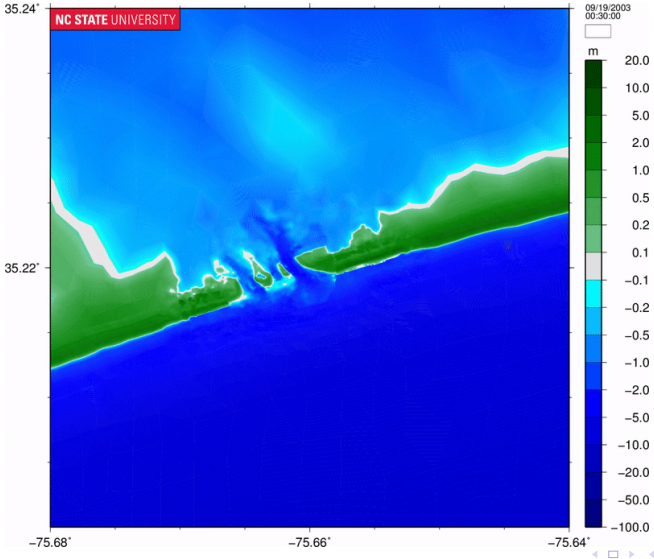

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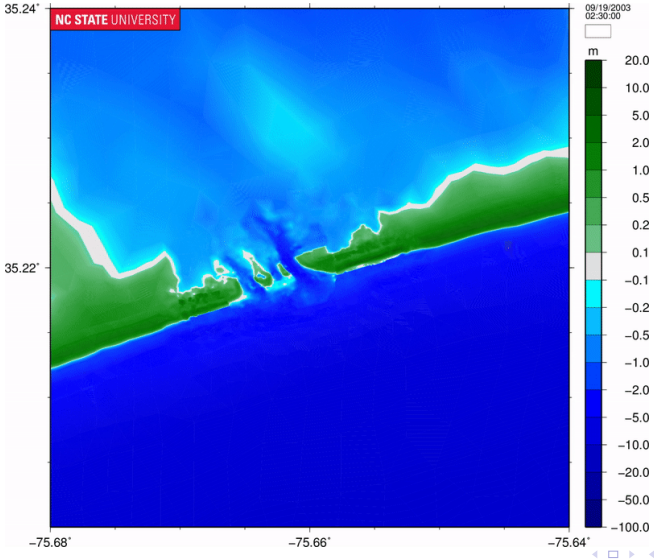

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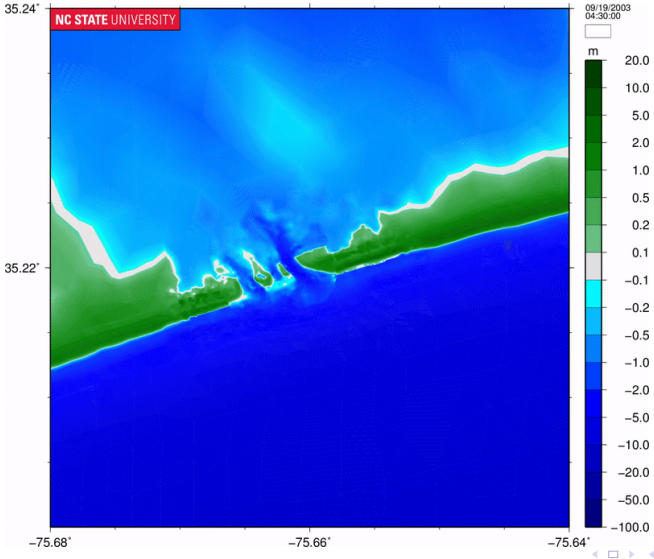

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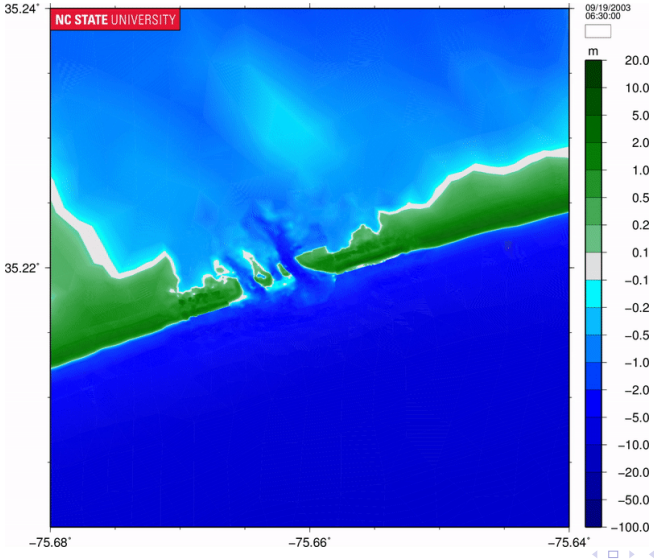

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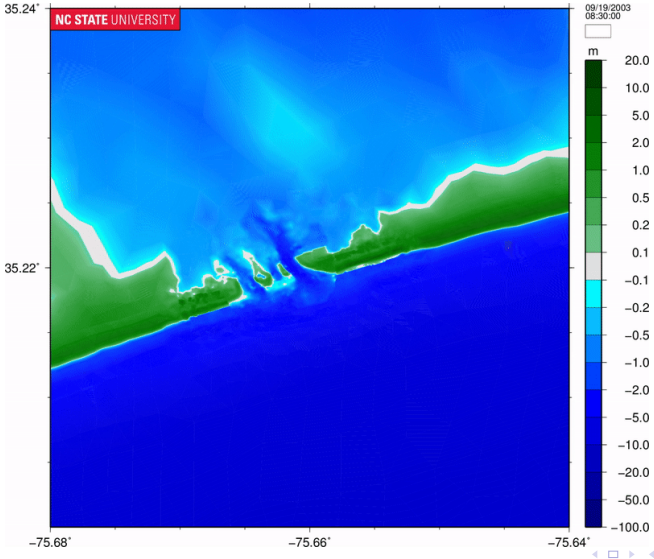

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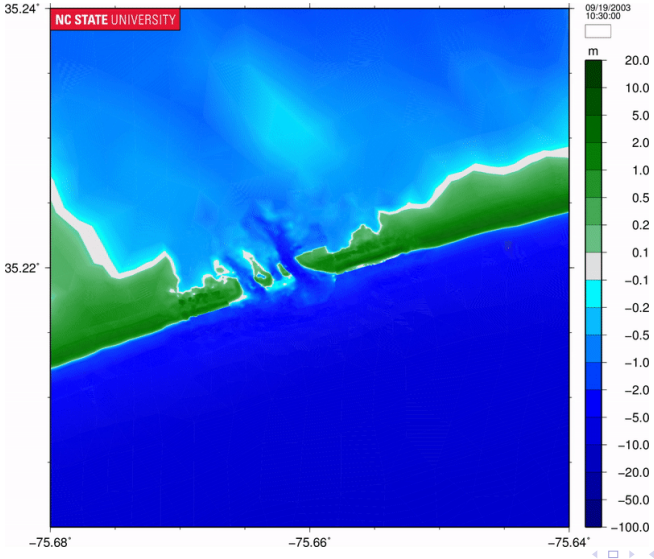

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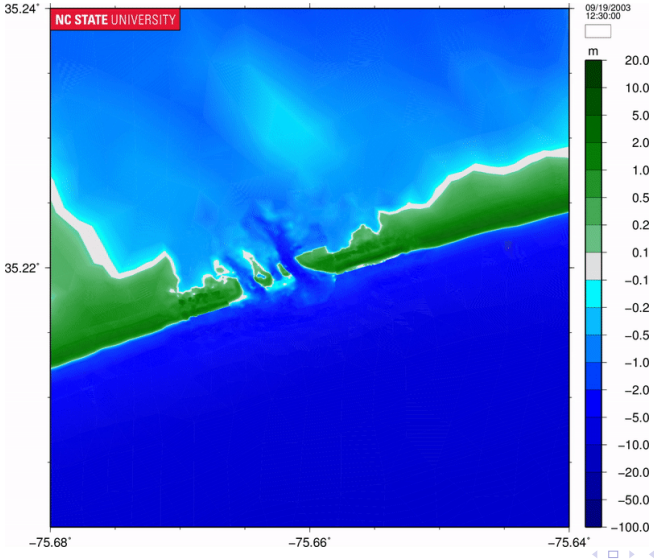

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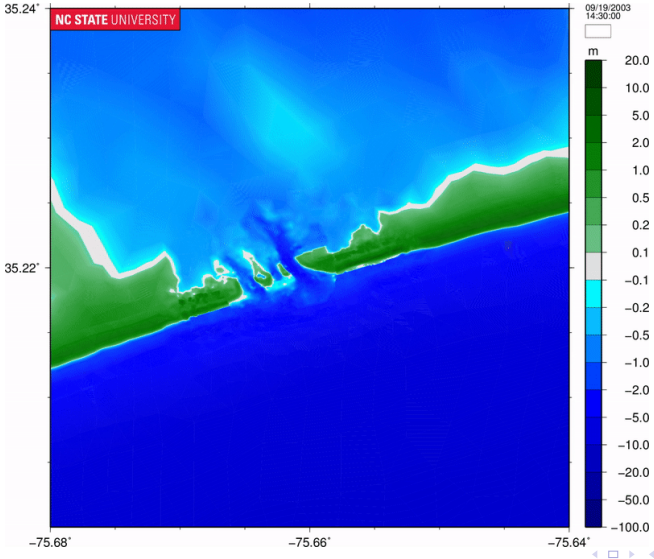

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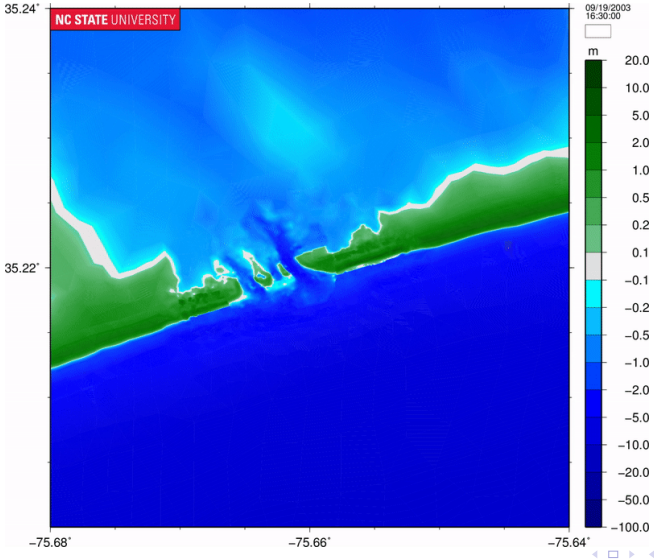

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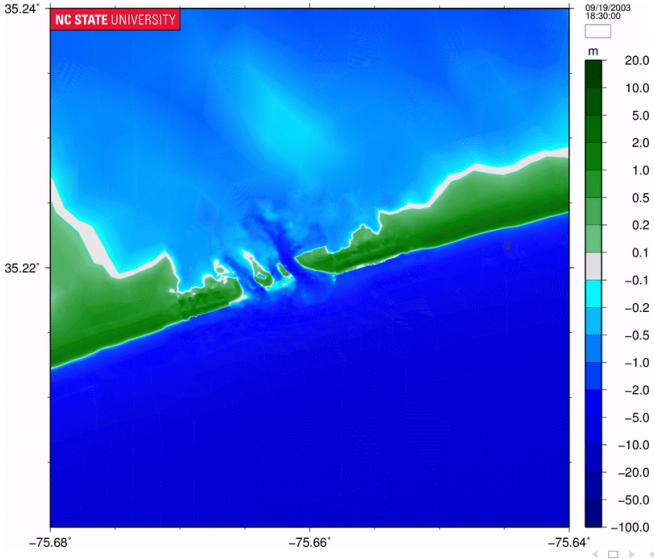

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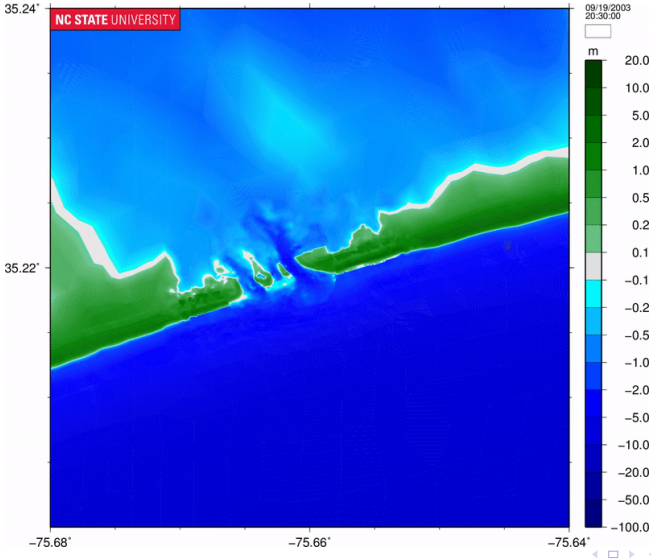

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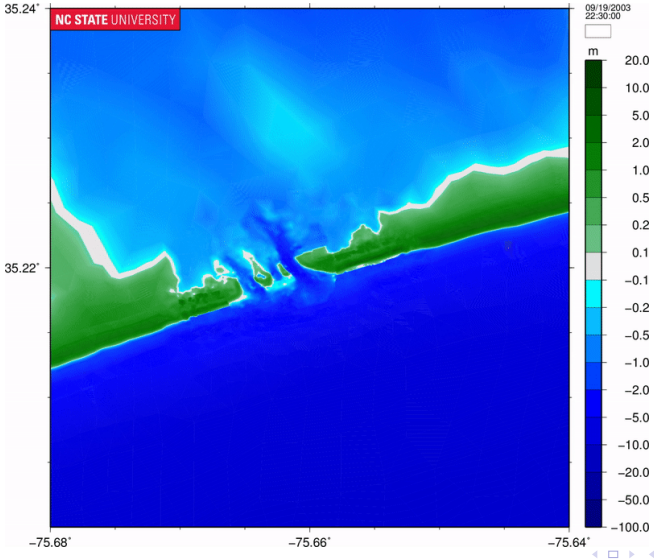

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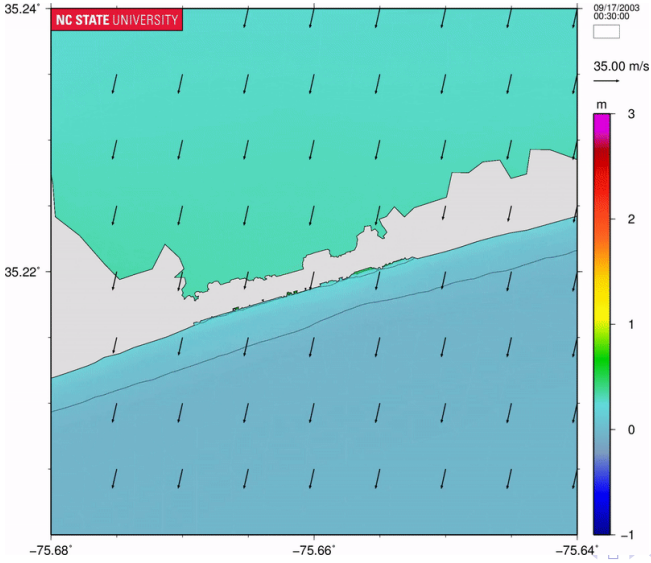

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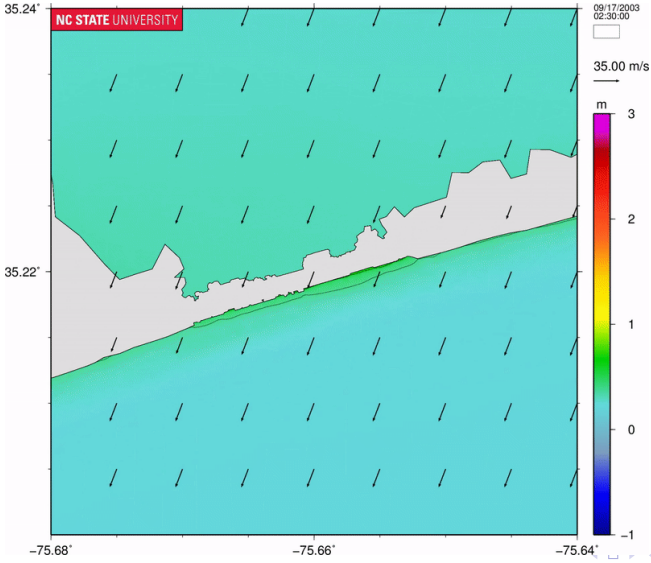

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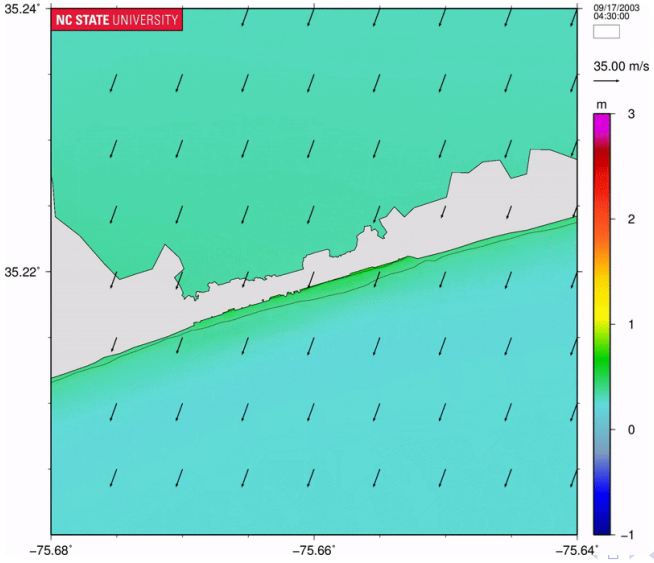

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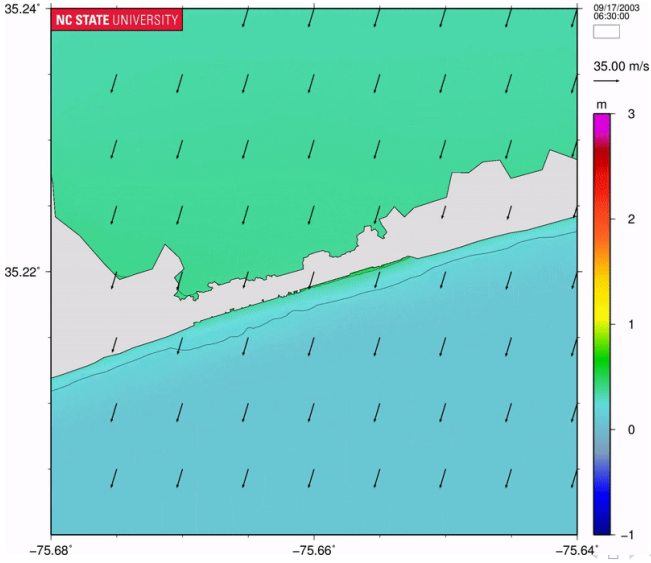

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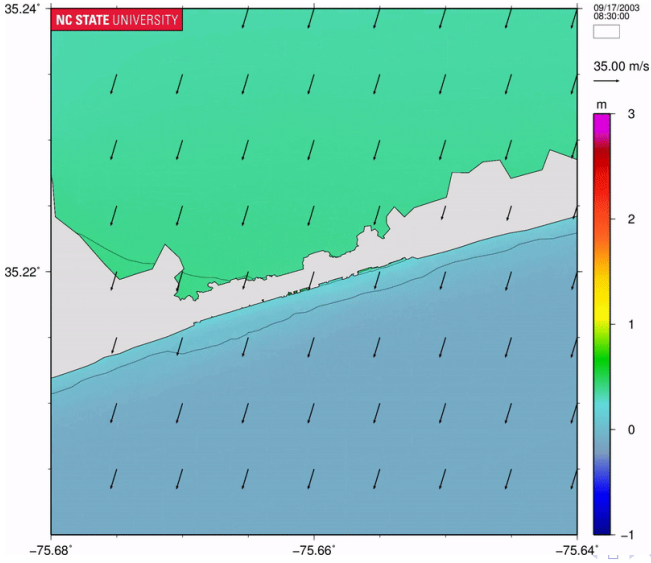

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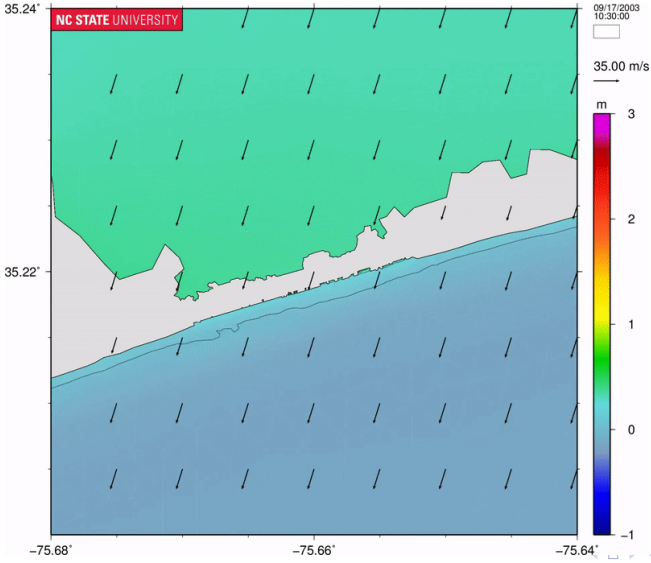

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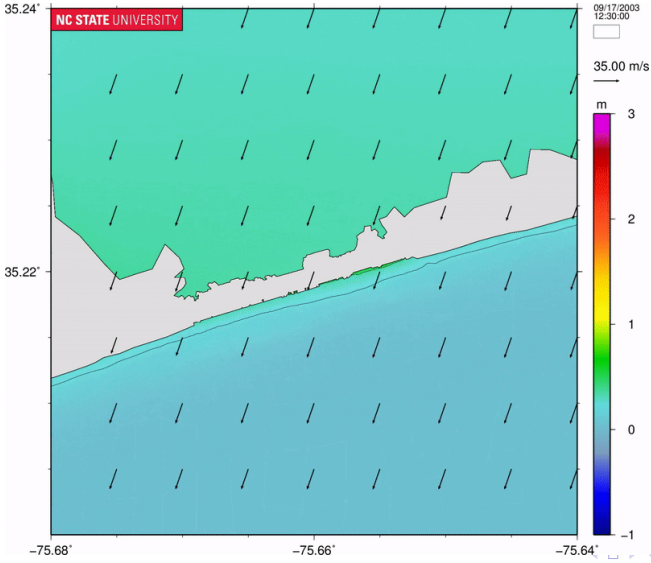

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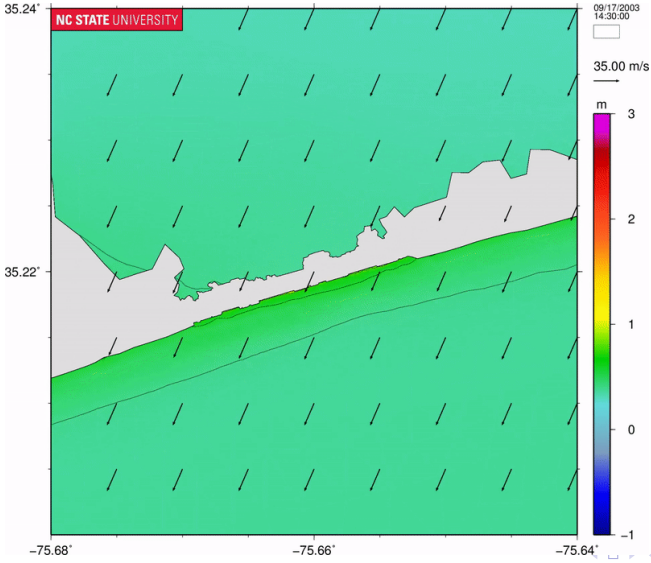

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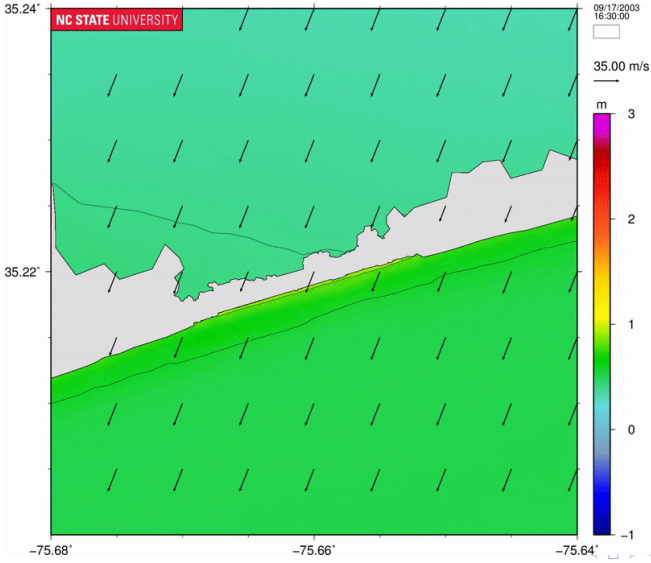

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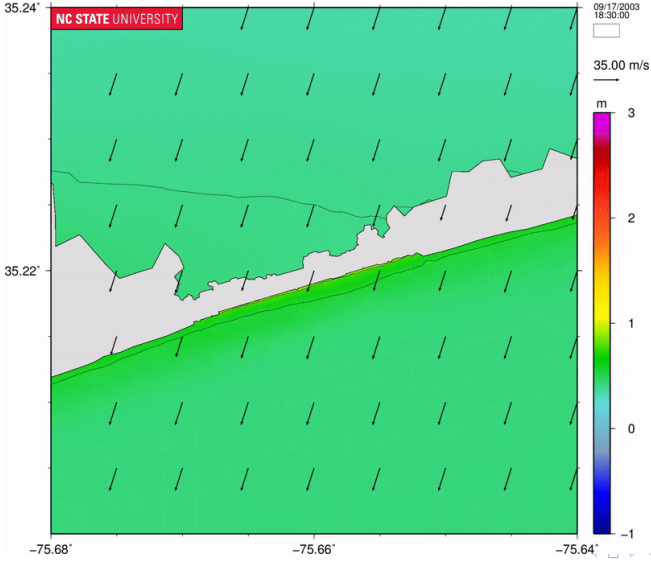

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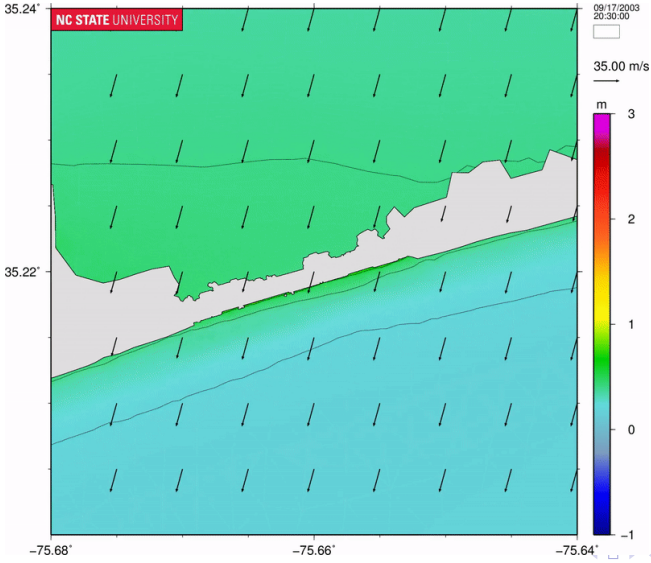

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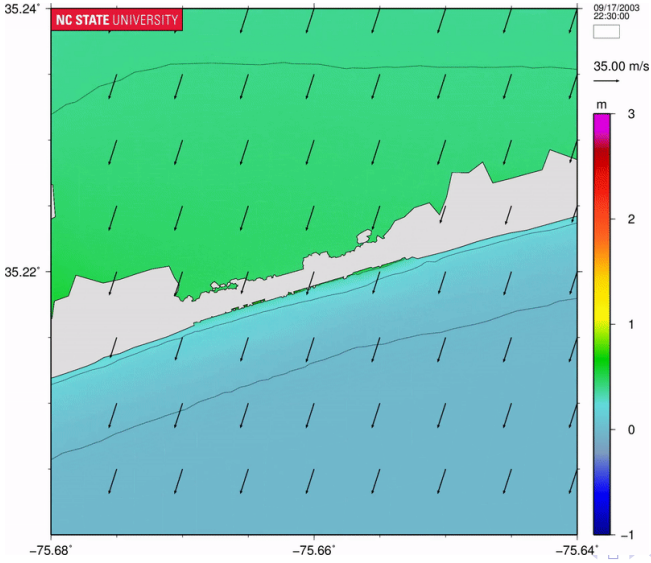

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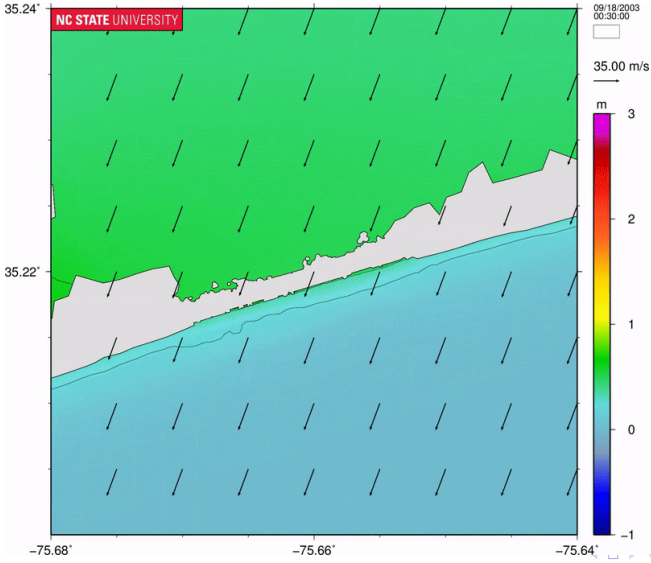

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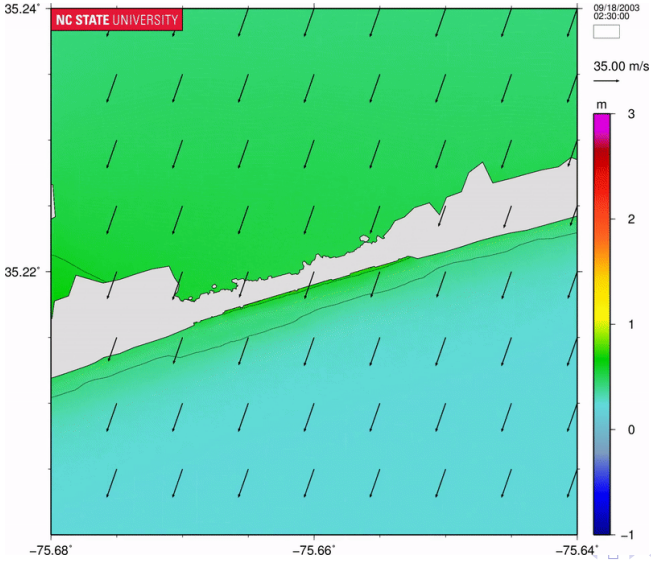

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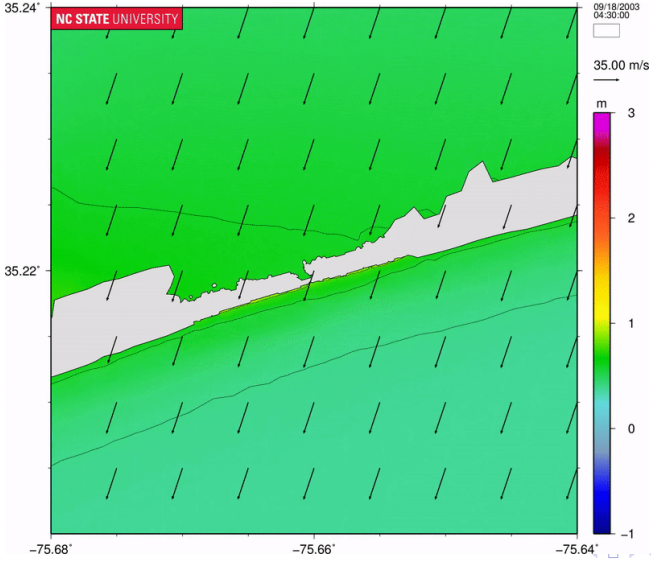

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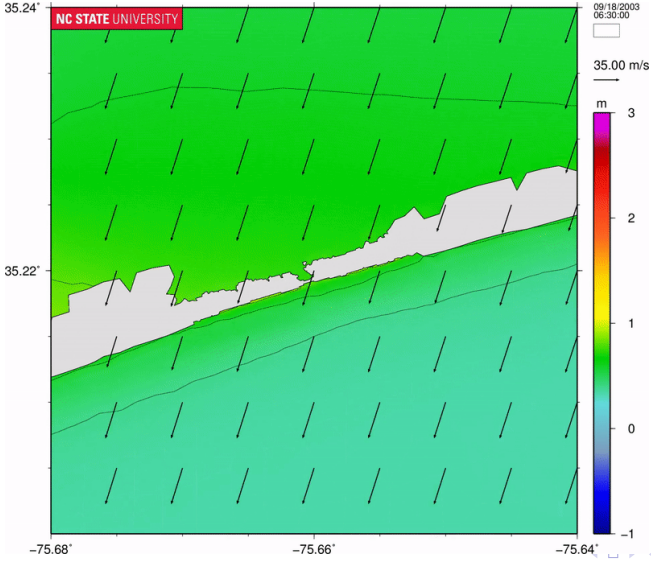

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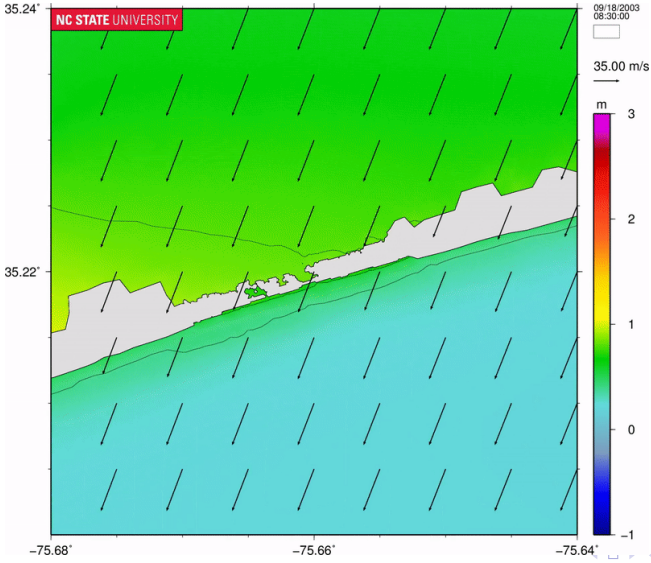

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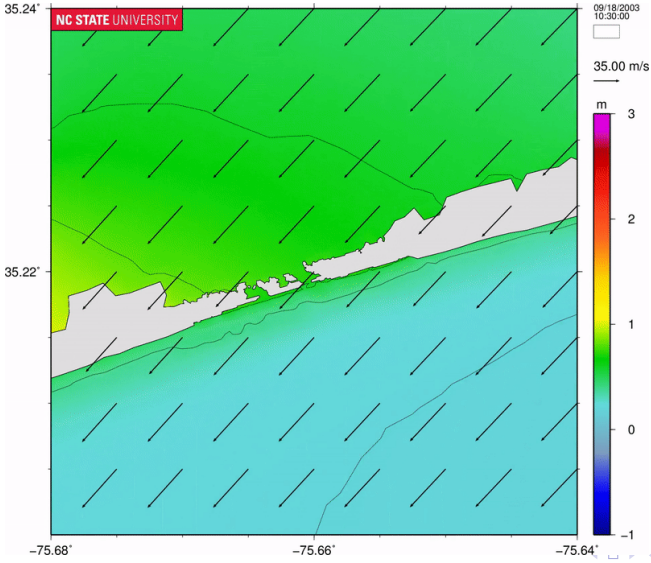

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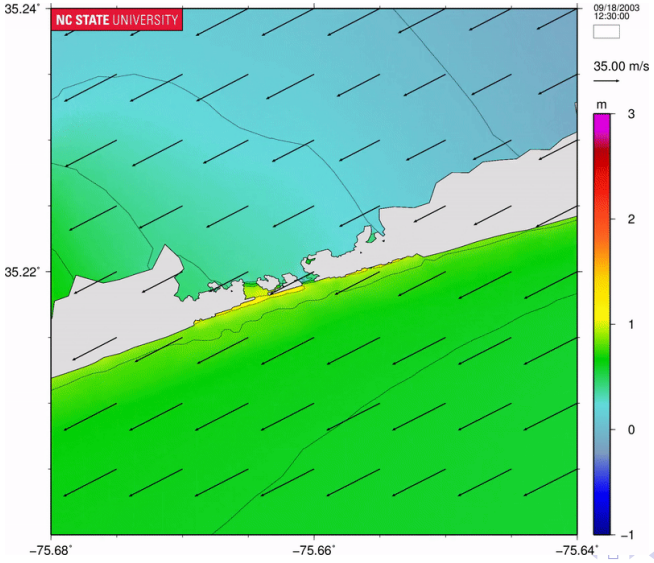

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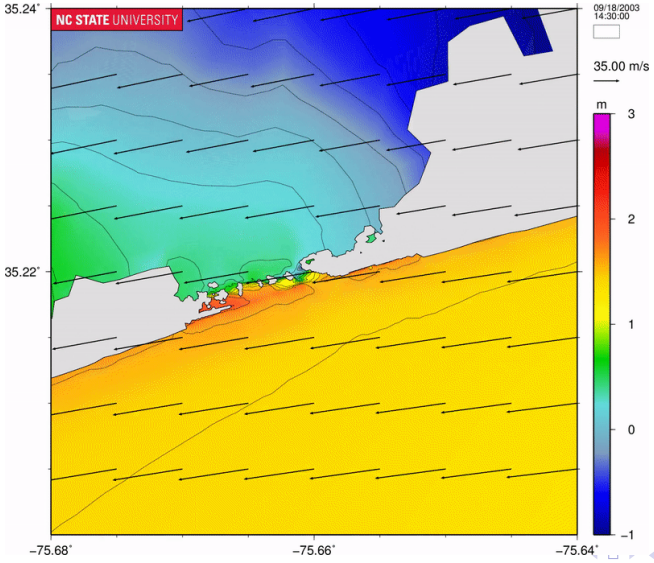

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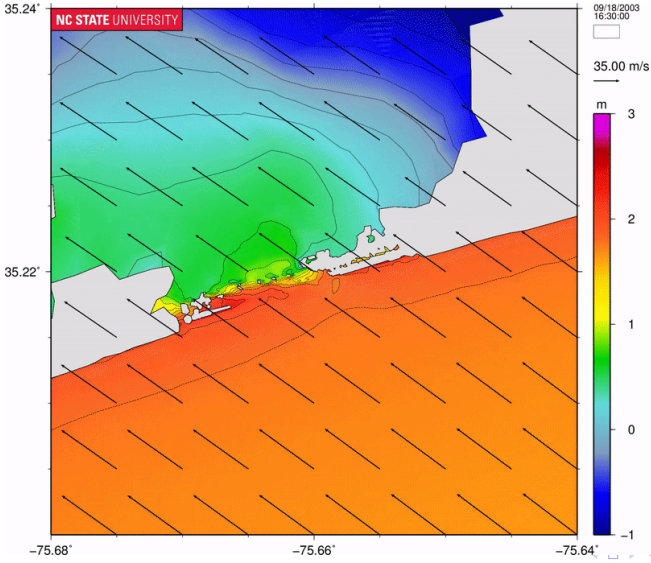

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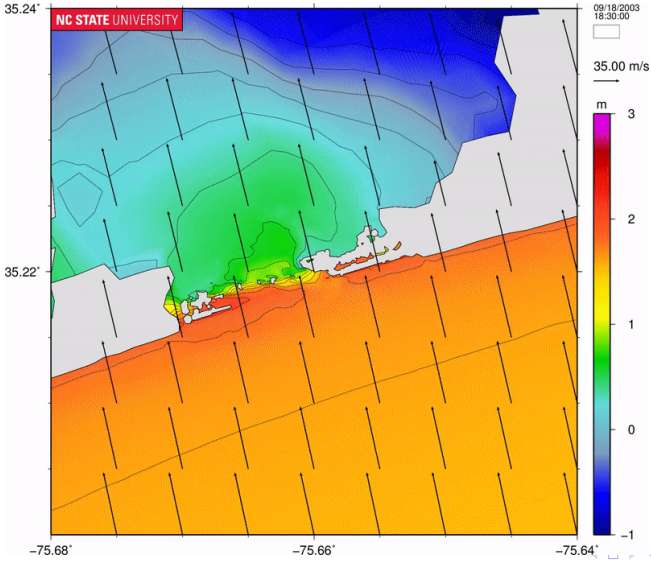

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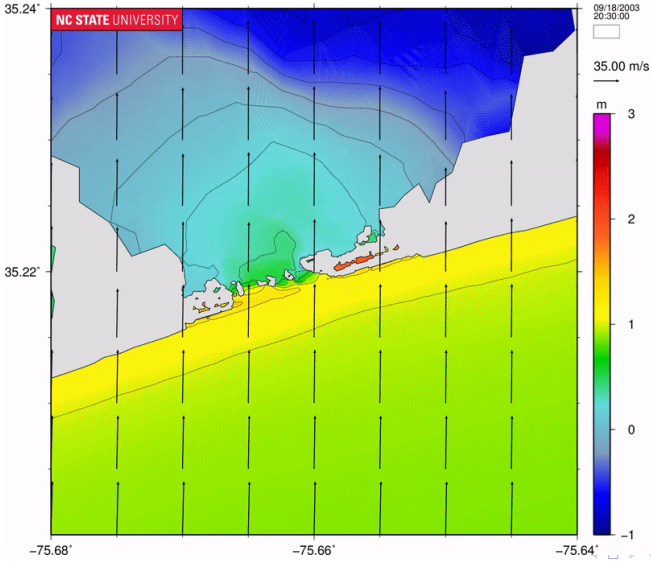

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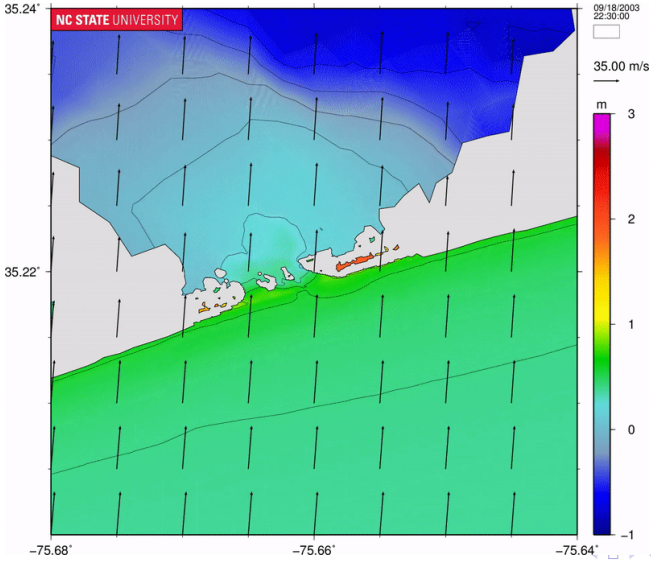

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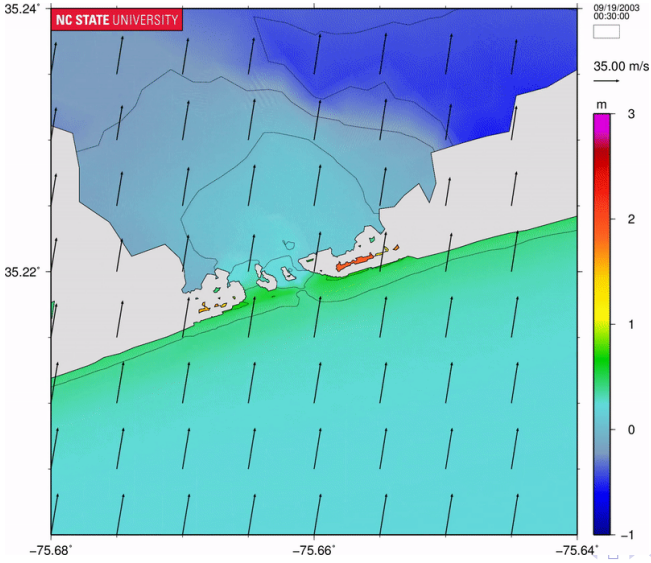

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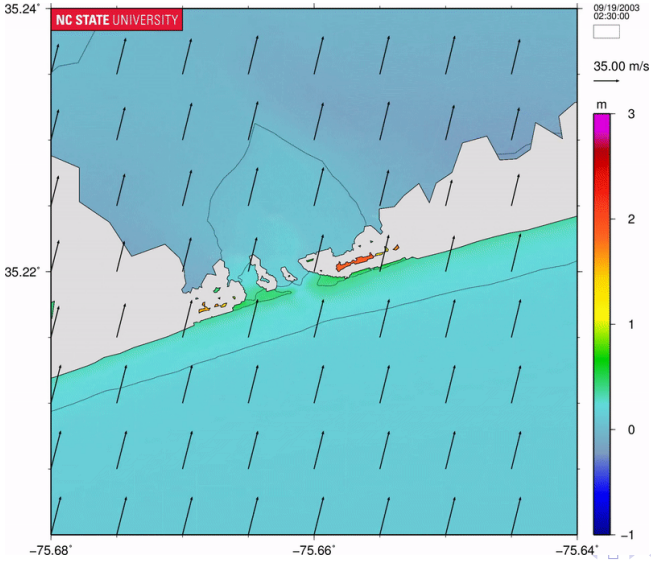

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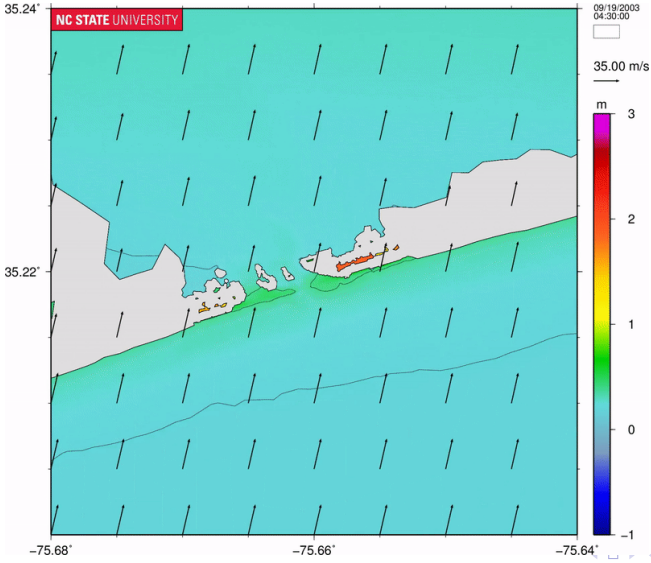

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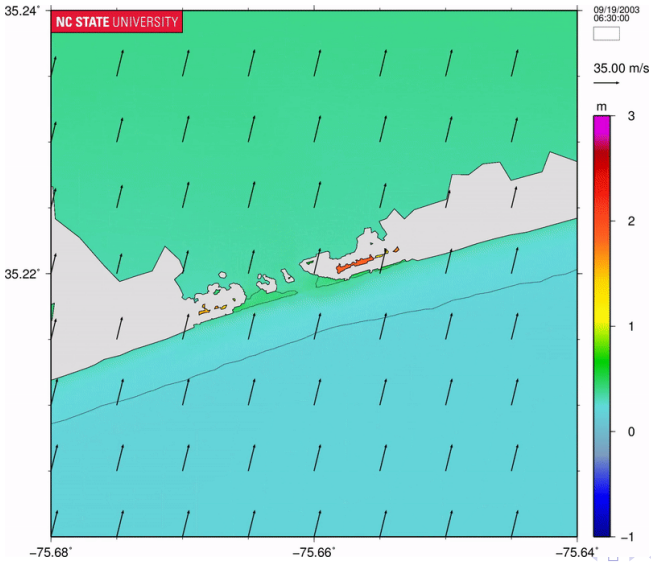

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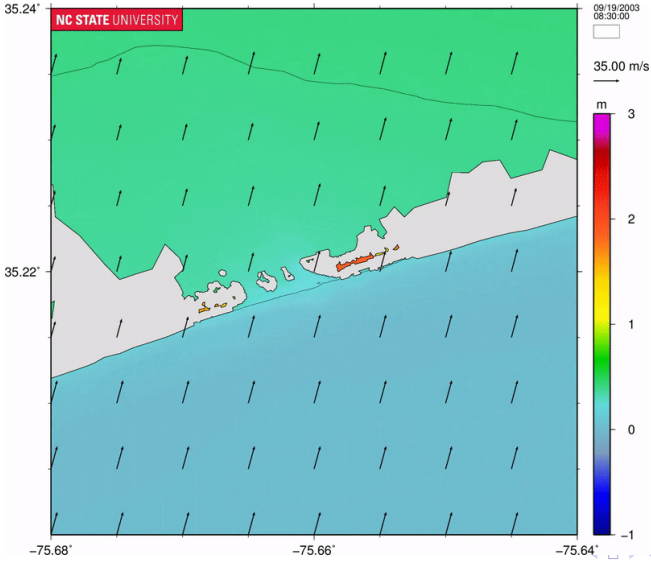

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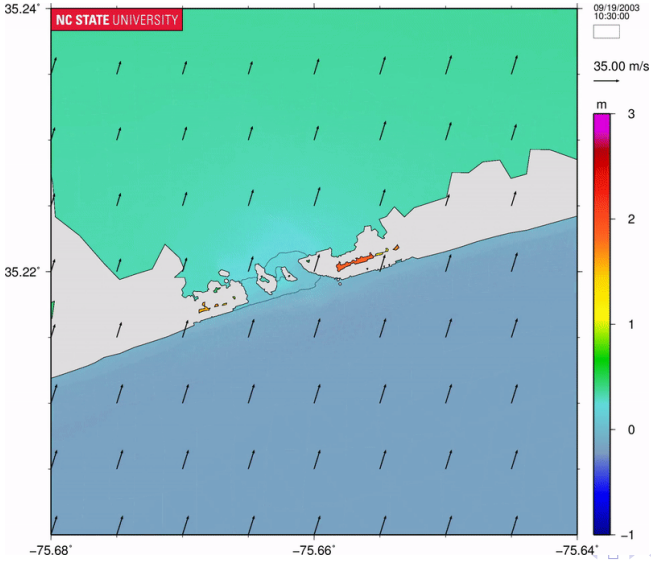

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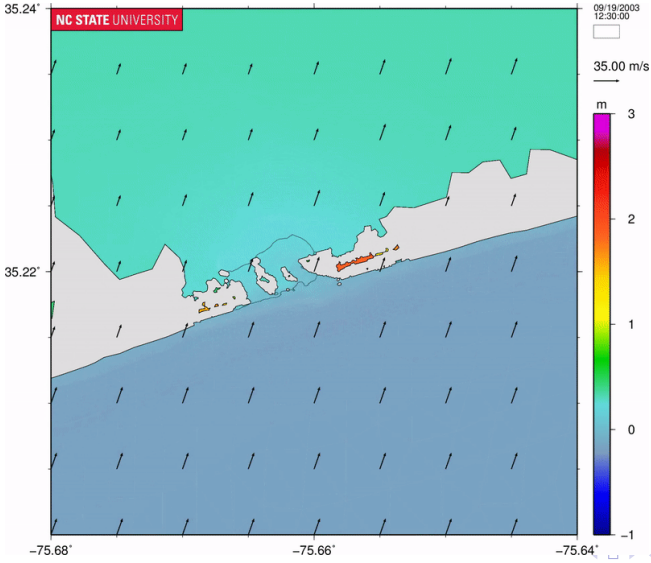

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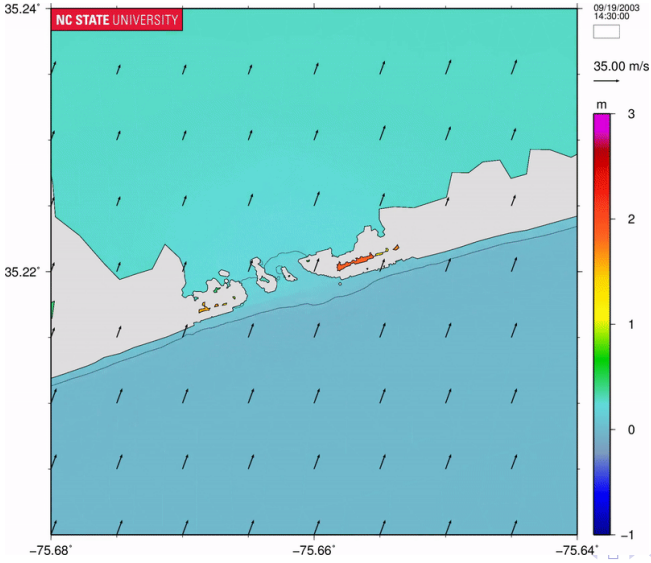

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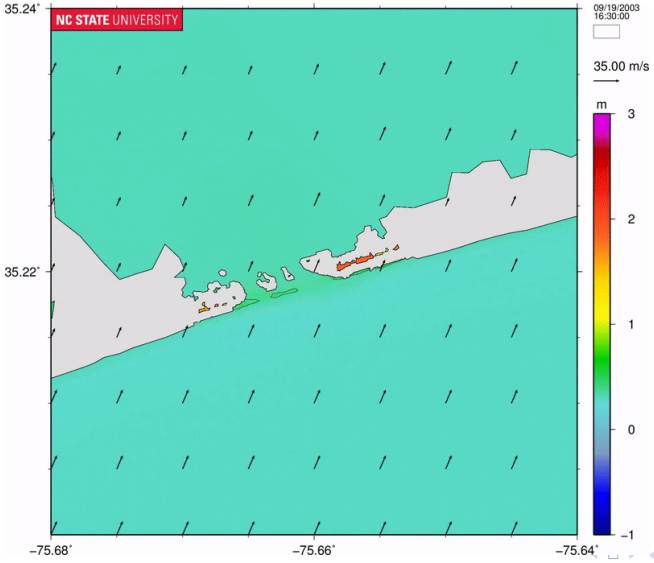

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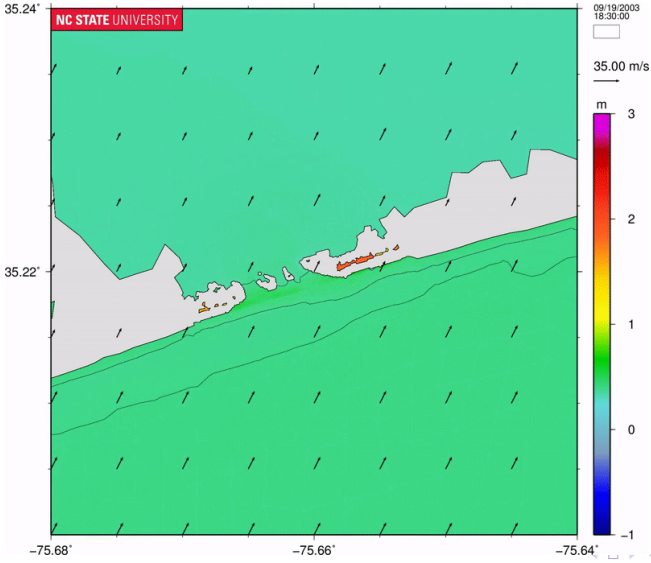

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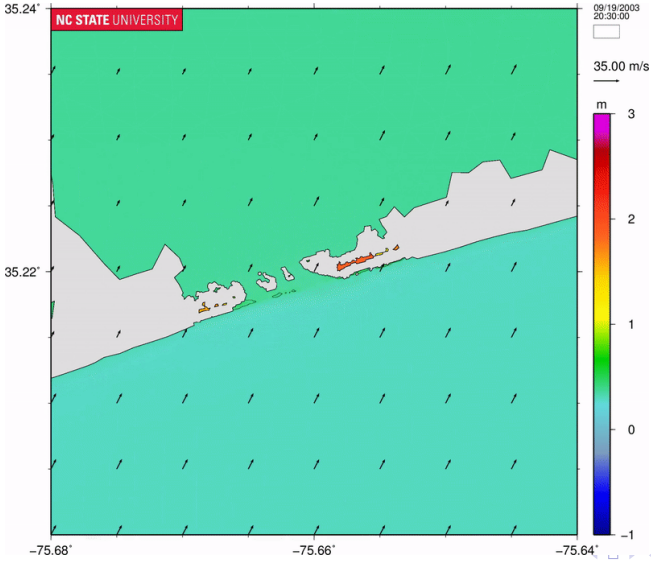

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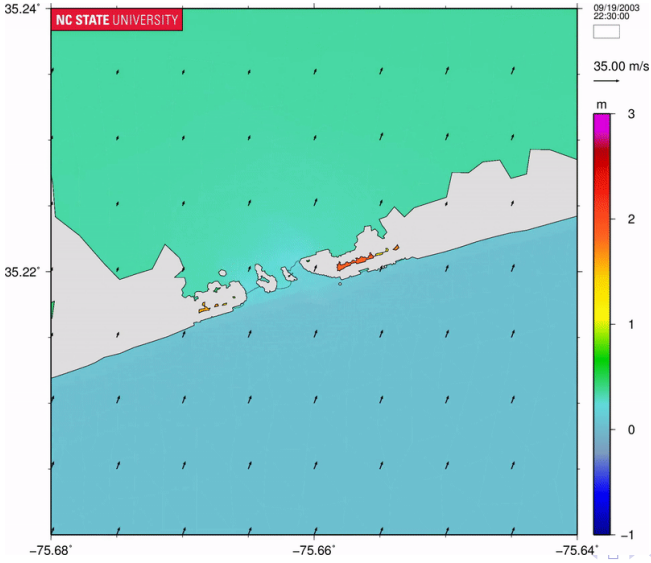

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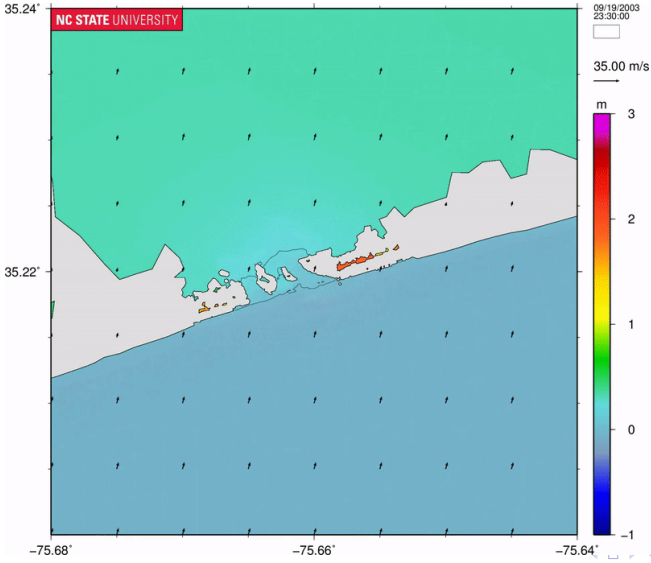


How can we represent the full effects of Isabel Inlet?

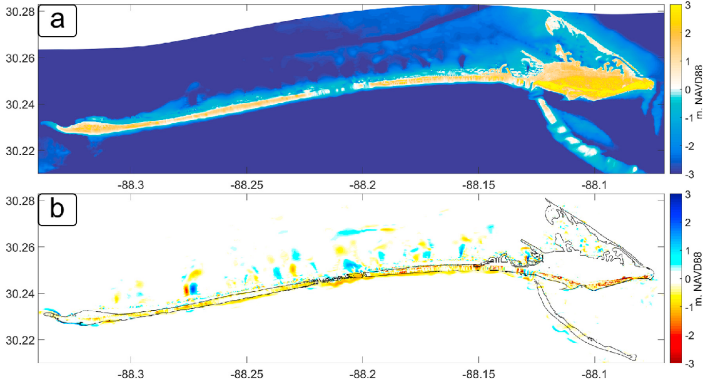
- Need erosion model on smaller domains
  - Typically consider both hydro- and morphodynamics
  - Employed on domains of only a few kilometers
  - We will use XBeach

- Need circulation models on larger domains
  - Bring in winds, waves, storm surge
  - Typically solve the shallow-water equations with a static ground surface
  - We will use ADCIRC

Time-Varying Bathymetry

eXtreme Beach (XBeach)

- Open-source model developed in the Netherlands
- Capable of simulating hydrodynamic and morphodynamic processes
- Applied typically at beach scales (a few kilometers)



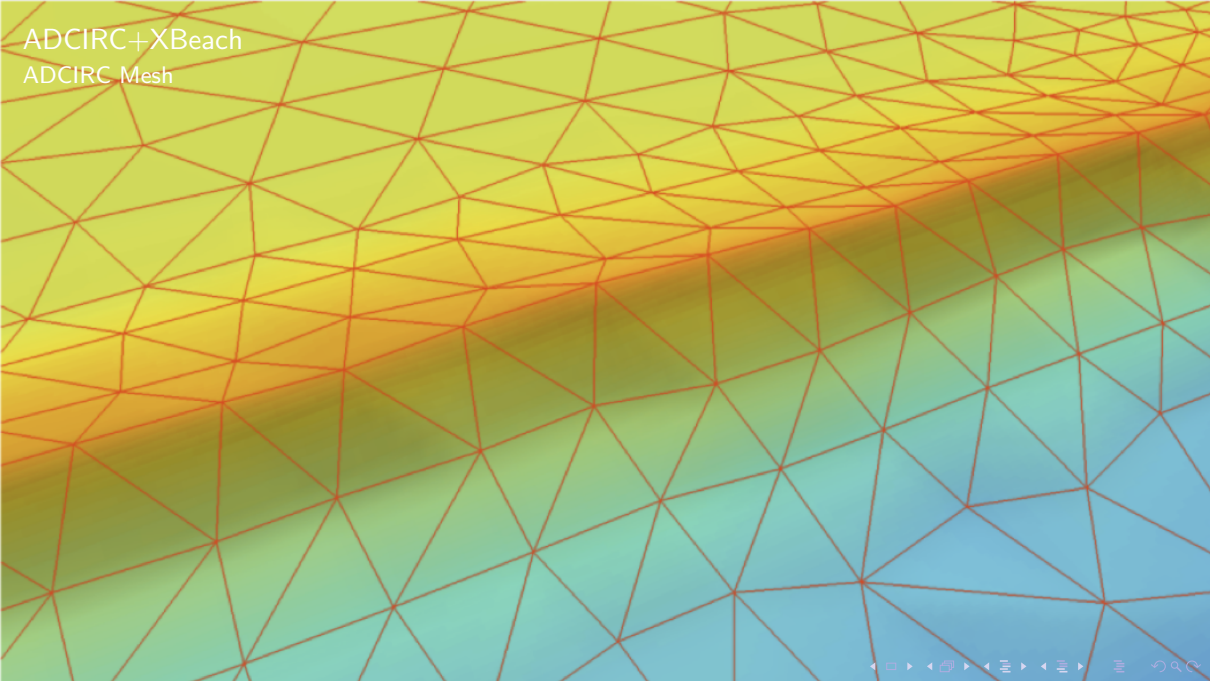
Passeri et al. (2018)

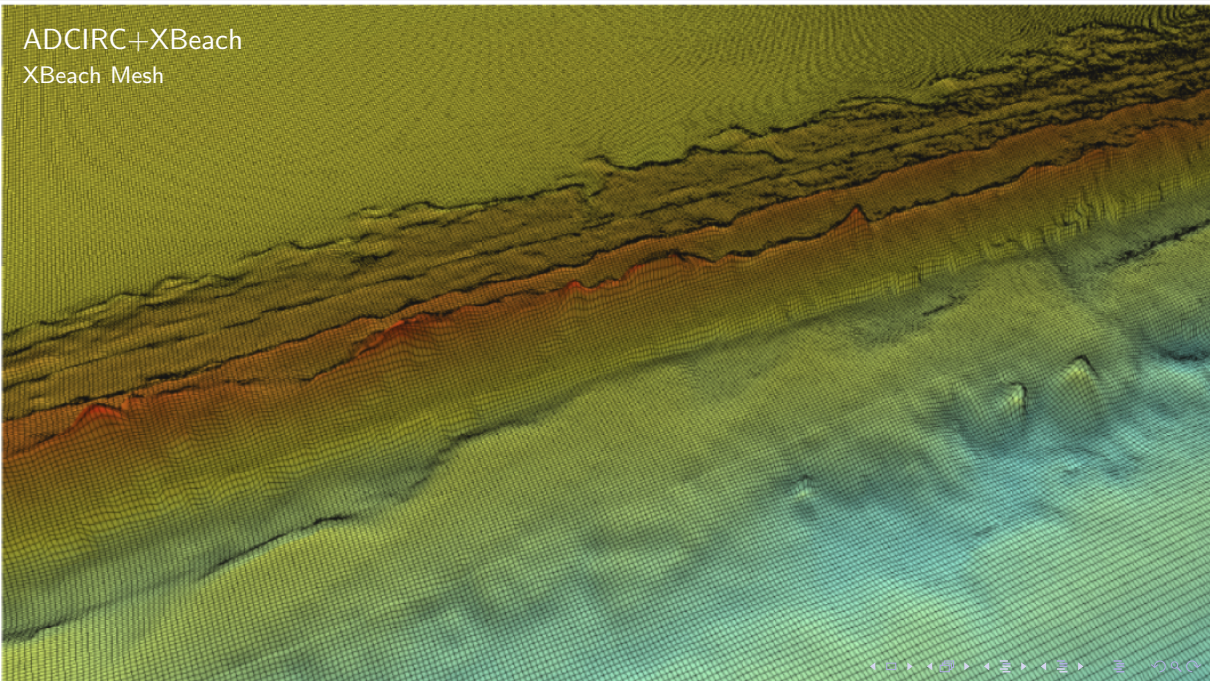
ADCIRC+XBeach

Aerial Photo of Hatteras Island

ADCIRC+XBeach

ADCIRC Mesh




ADCIRC+XBeach
XBeach Mesh

Isabel Inlet

XBeach Grid

Domain Size:

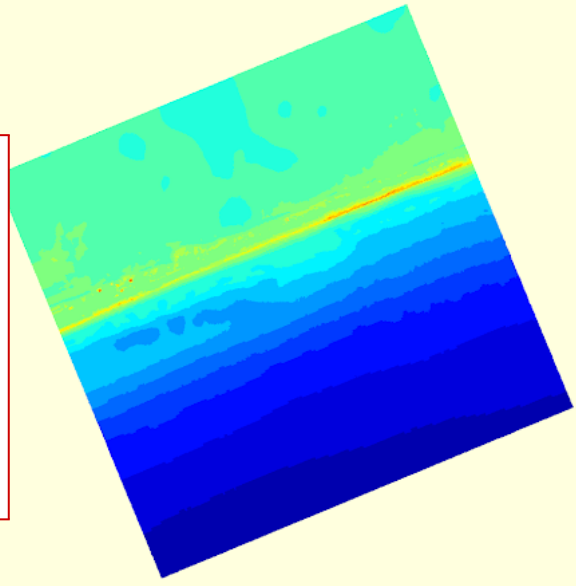
- 2.2 km $\times$ 2.2 km

Resolution:

- Alongshore: 2 to 5 m
- Cross-shore: 2 to 15 m

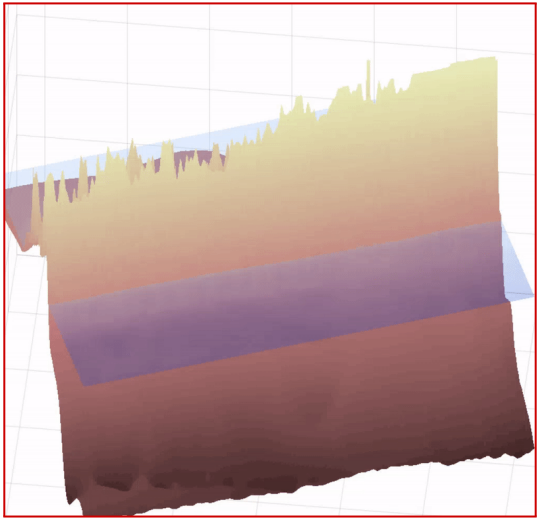
Layers:

- Pre-storm: bathy/topo
- BC: ADCIRC+SWAN



Isabel Inlet

XBeach Hindcast of Inlet Creation



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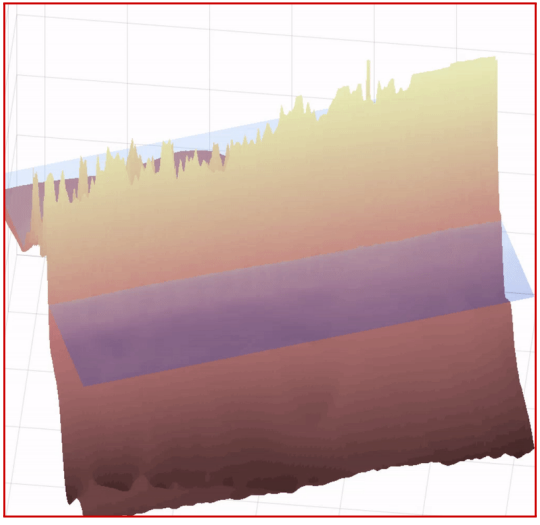

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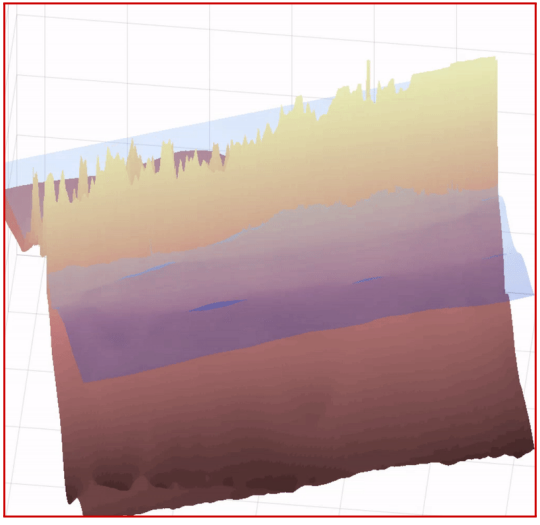

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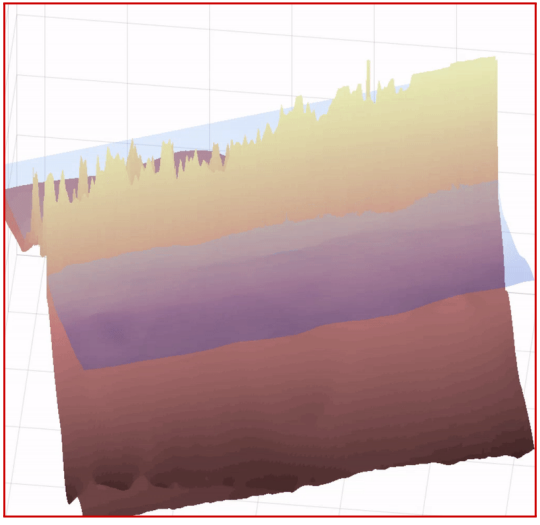

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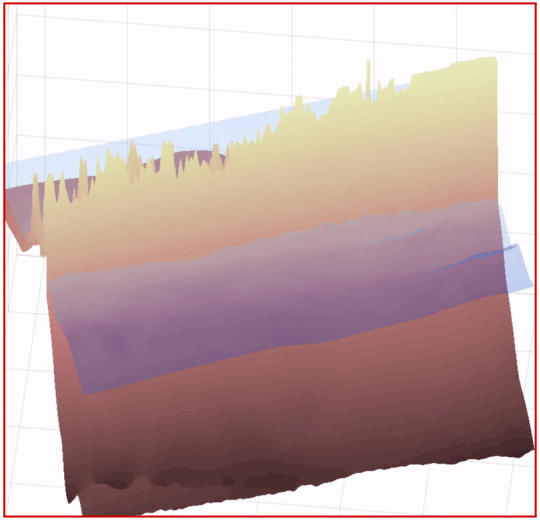

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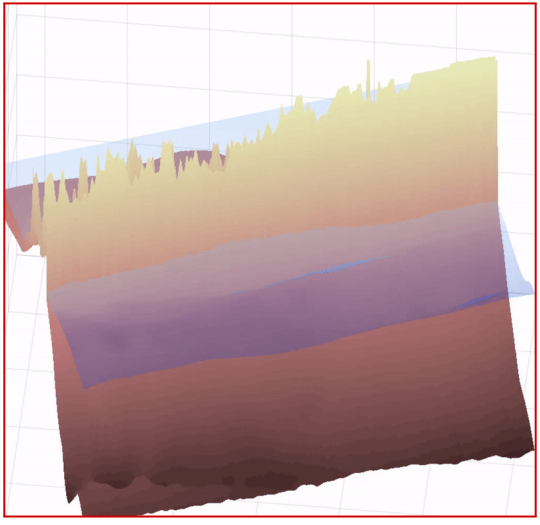
XBeach Hindcast of Inlet Creation



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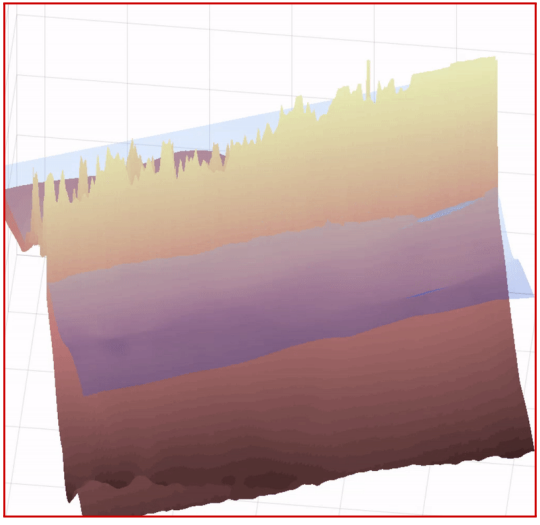

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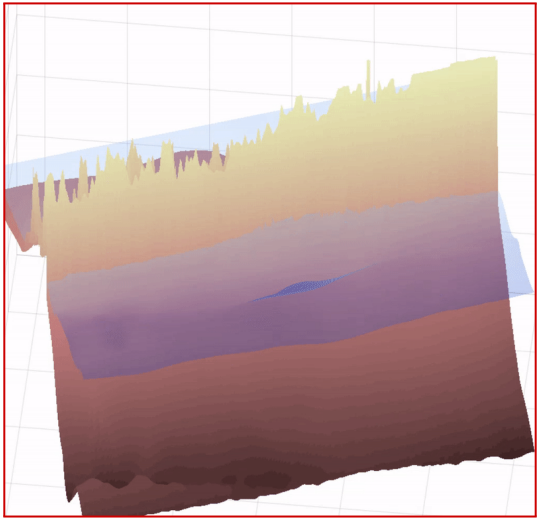

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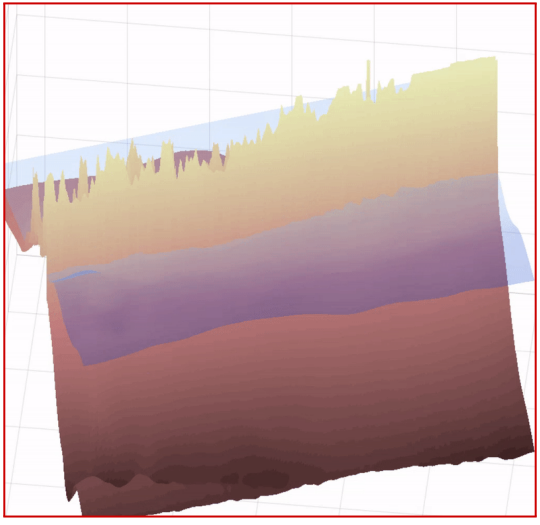

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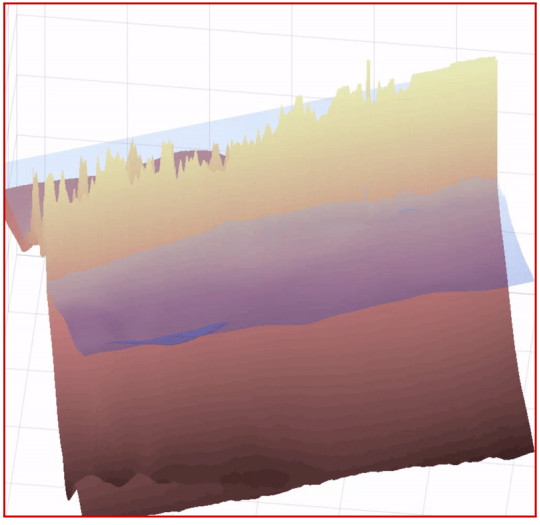

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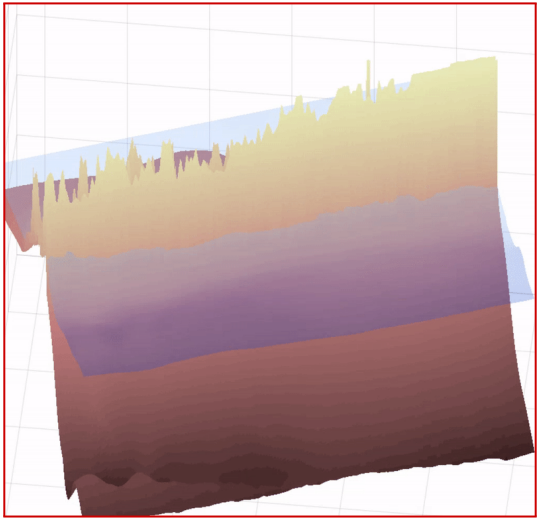

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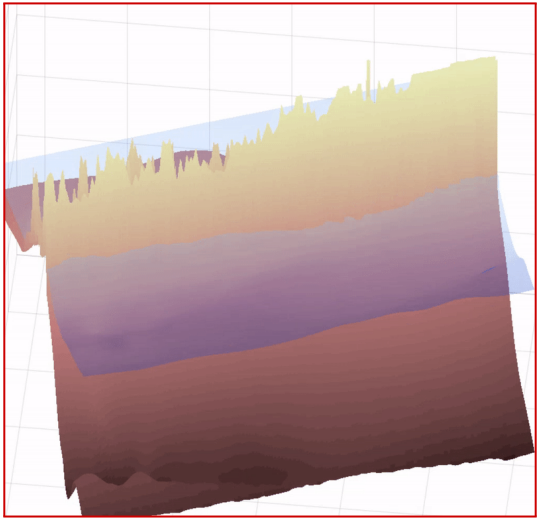

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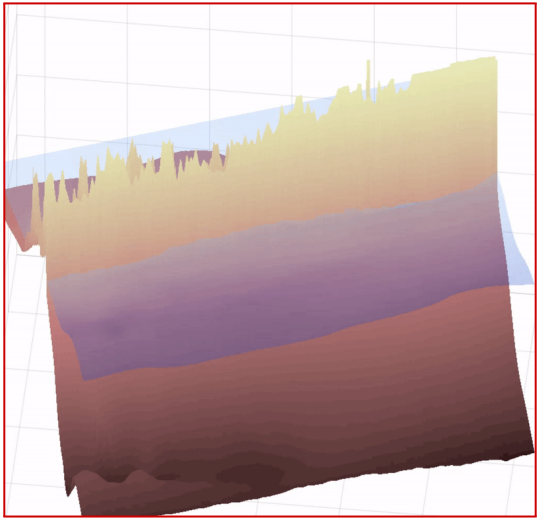

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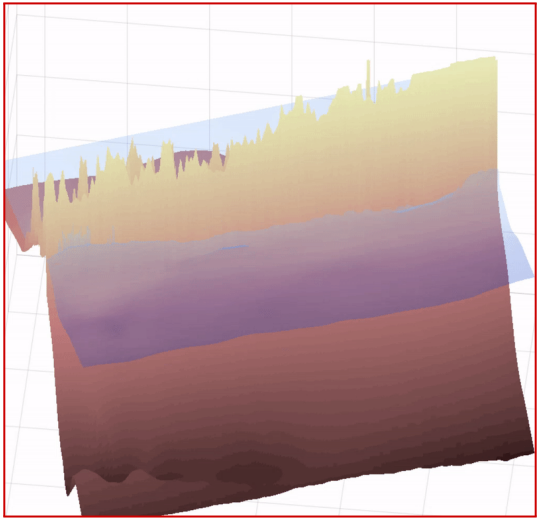

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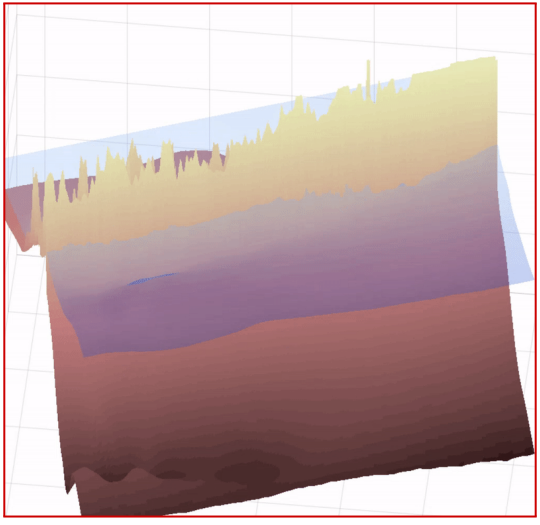

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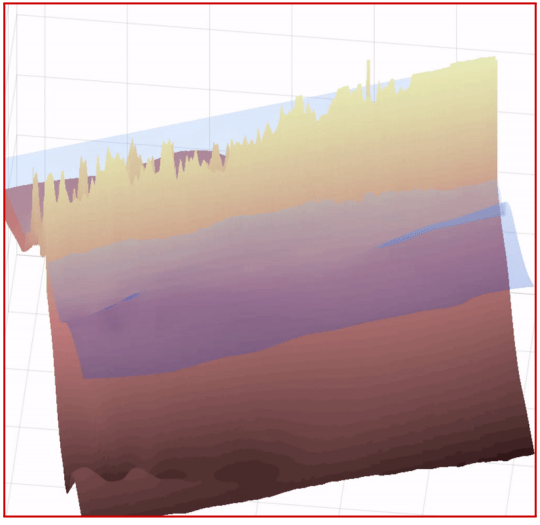

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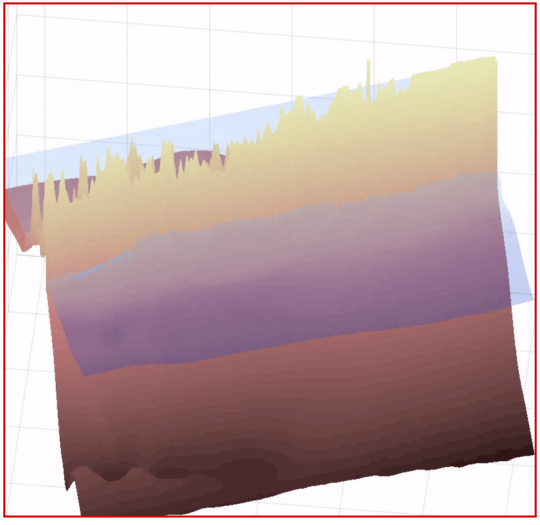

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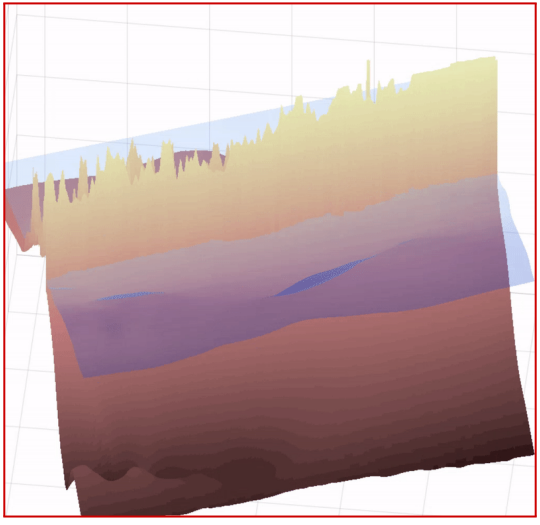

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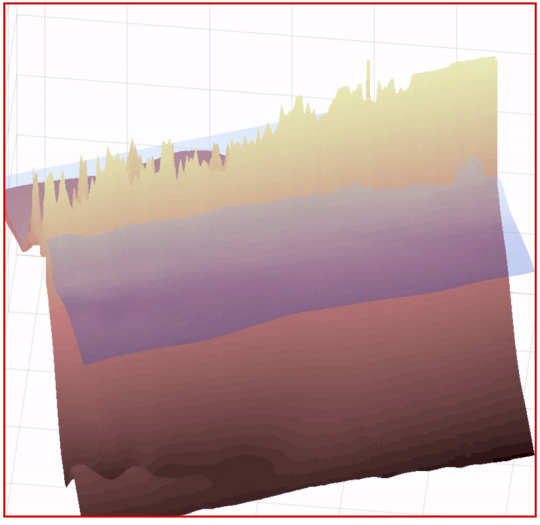

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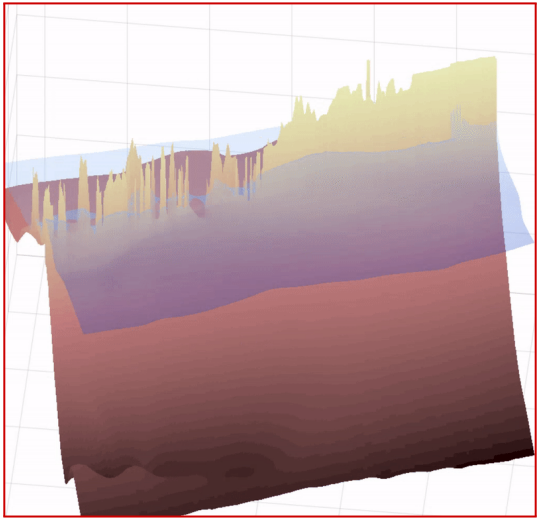

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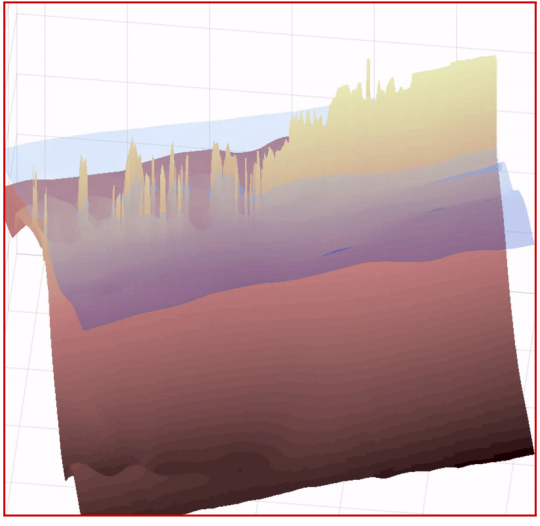

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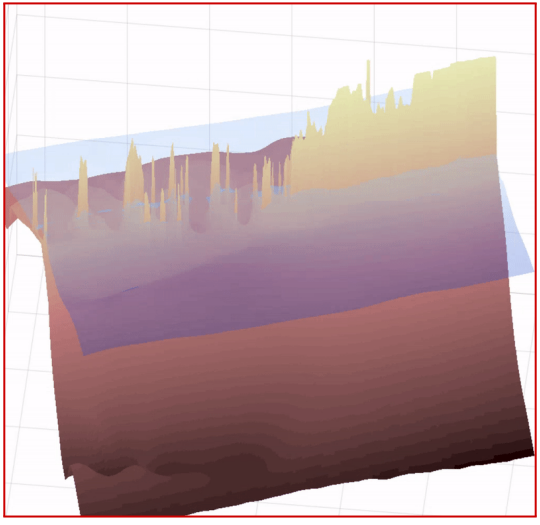

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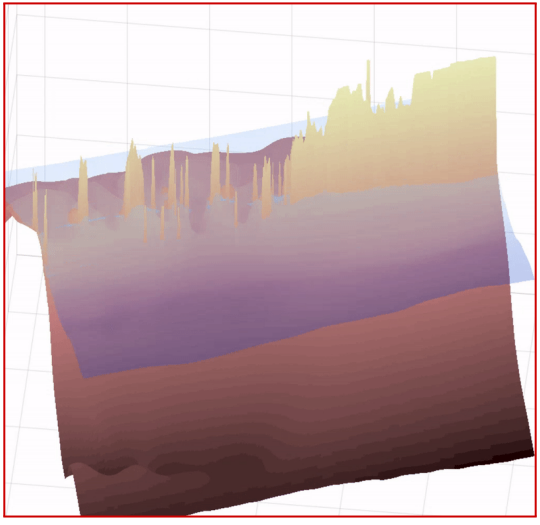

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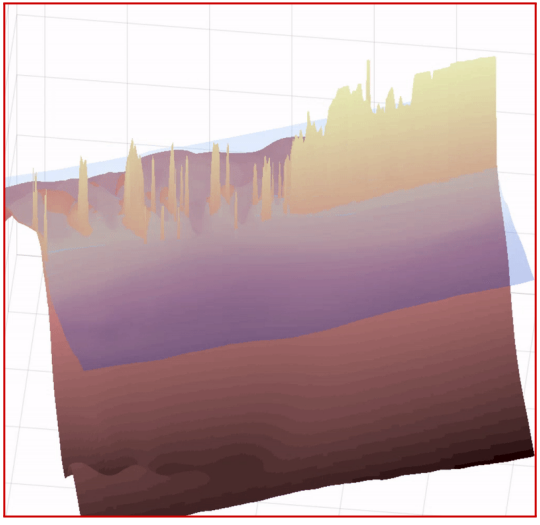

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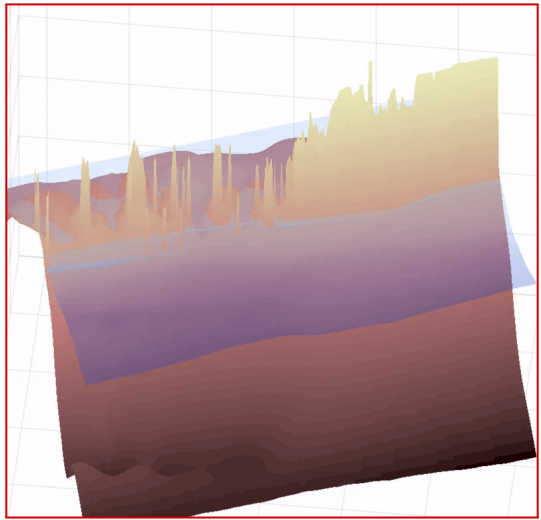

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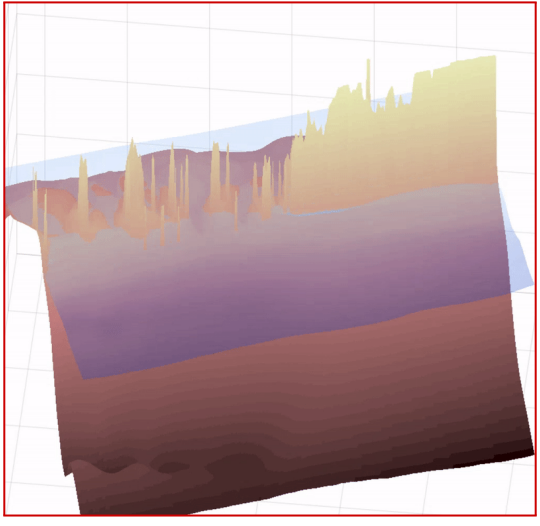

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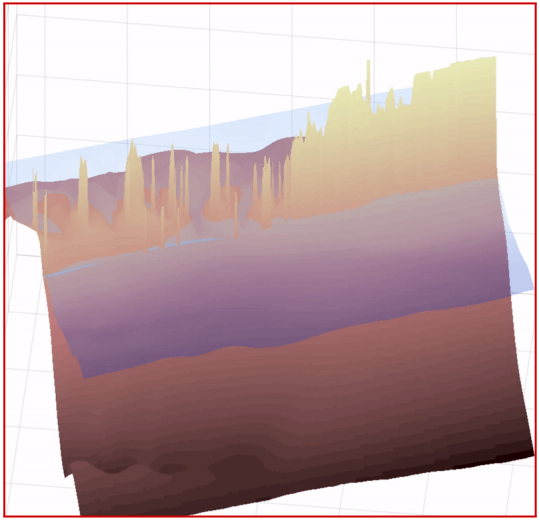

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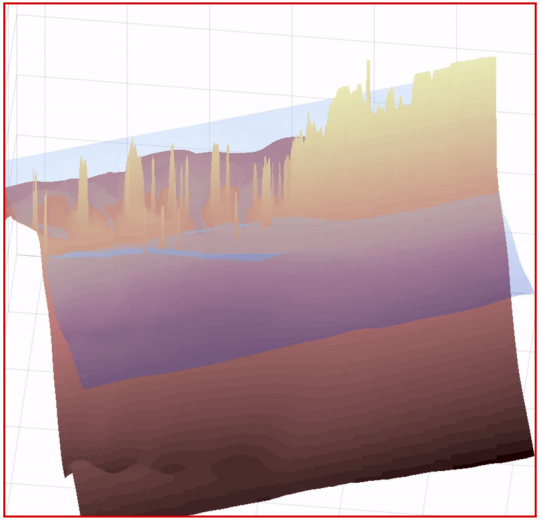

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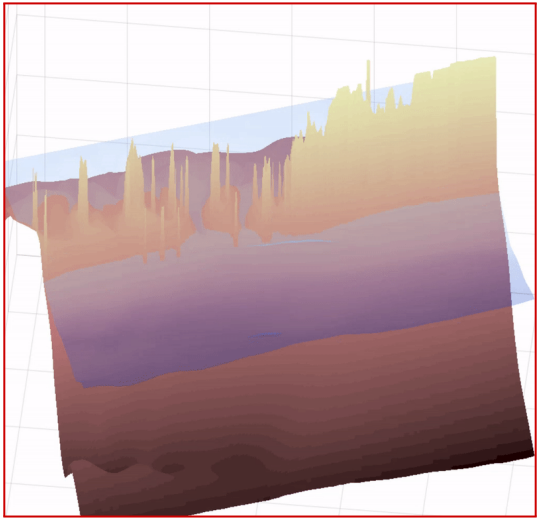

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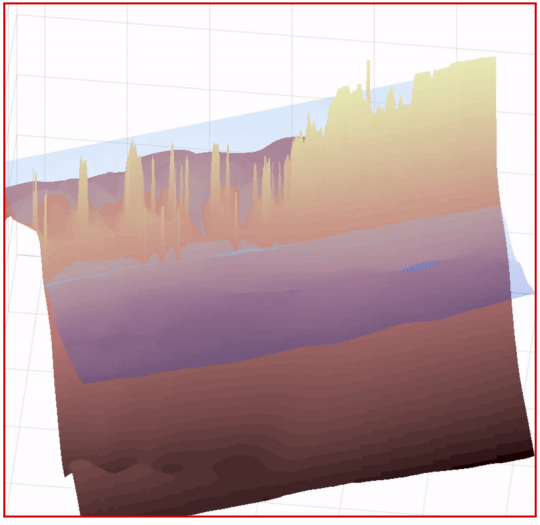

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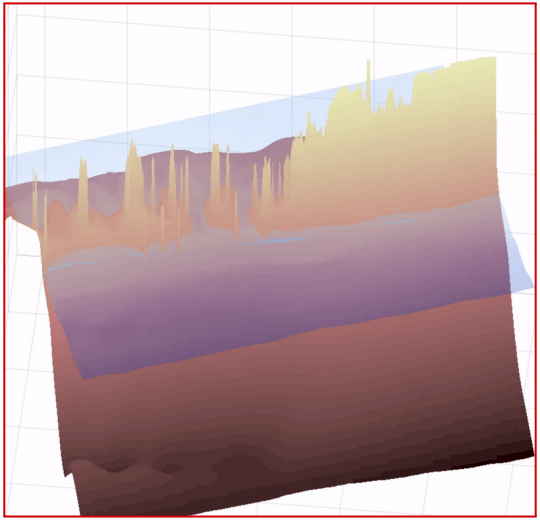

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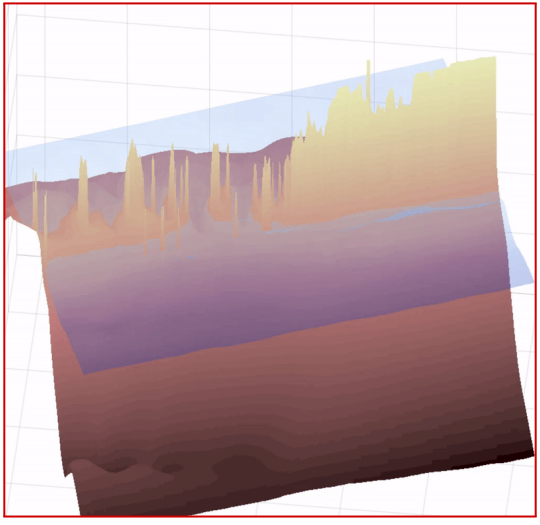

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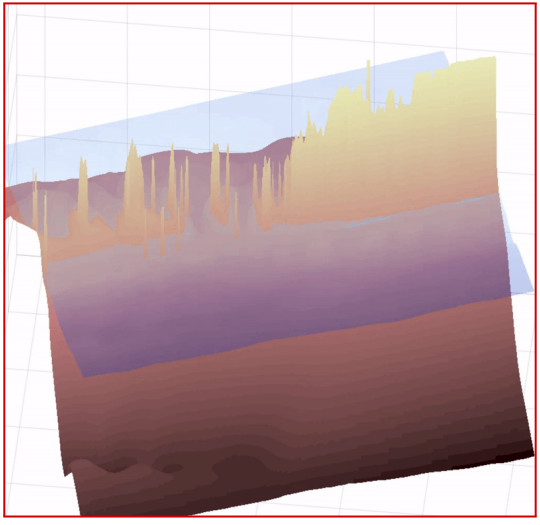

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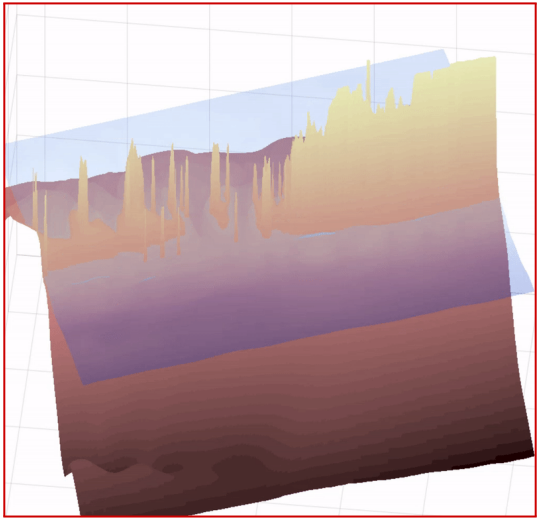

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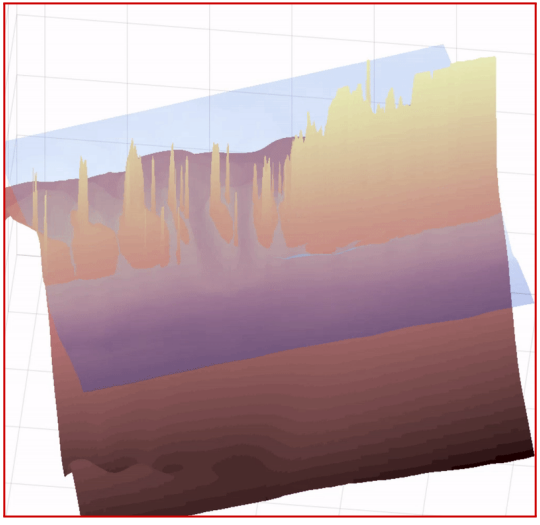

Changes in ground surface, specified at only the vertices near the breach

- Beach erosion and breaching is modeled By XBeach
  - Spatial and temporal evolution of breaching is coming from XBeach prediction.
  - bed update takes place hourly for 3 days

Isabel Inlet

Ground Surface Variation Using XBeach

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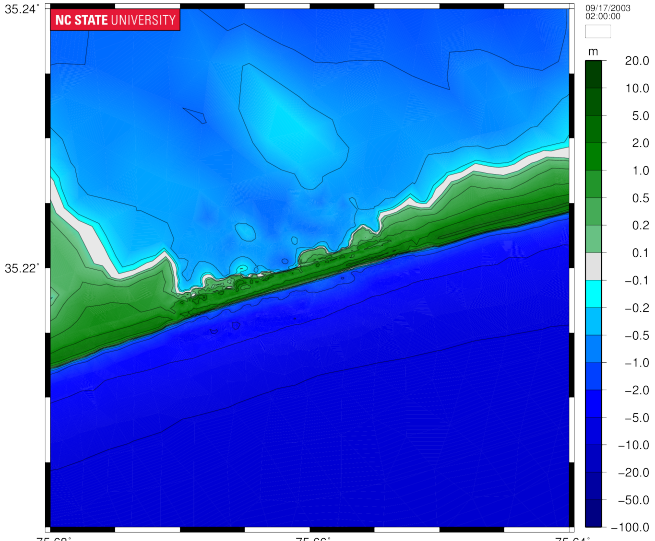

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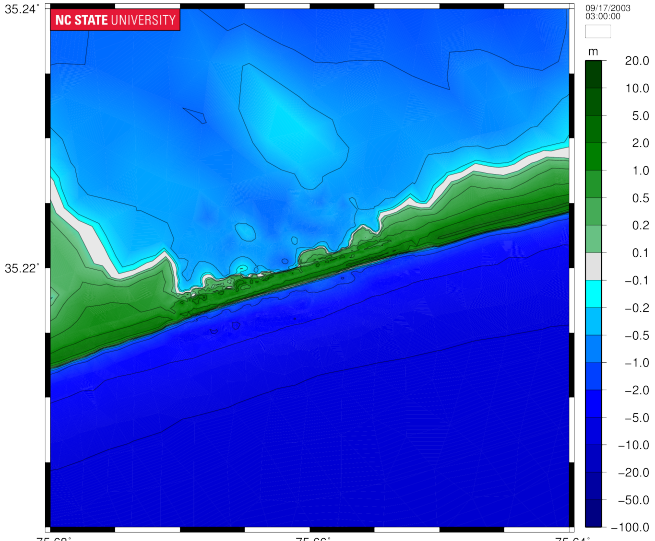

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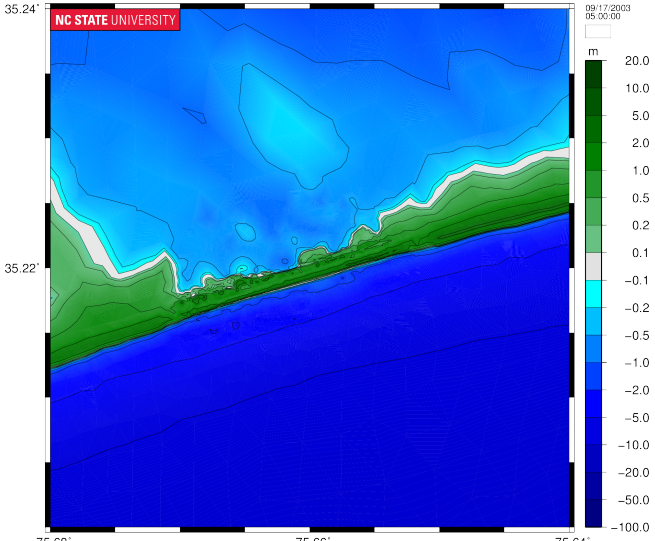

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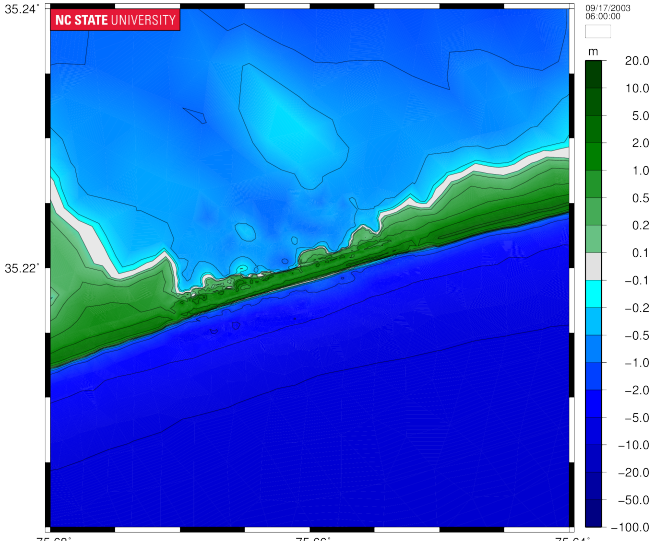

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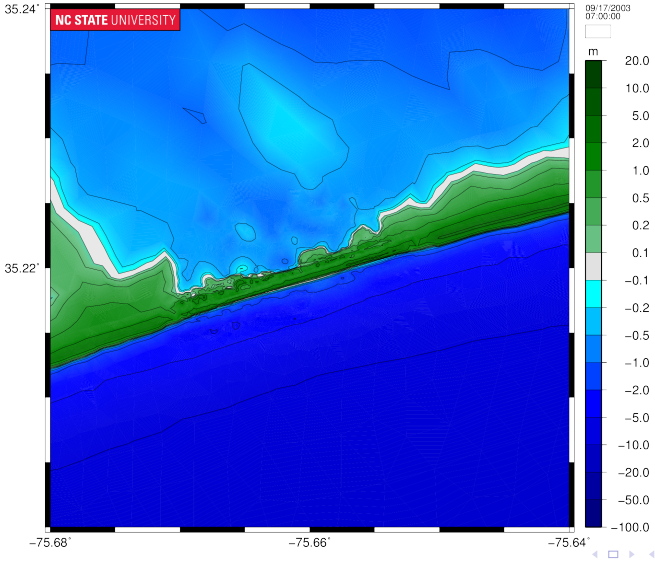

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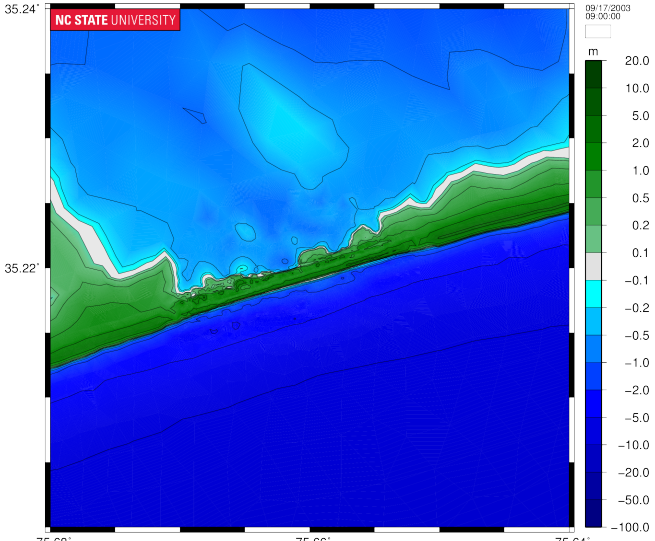

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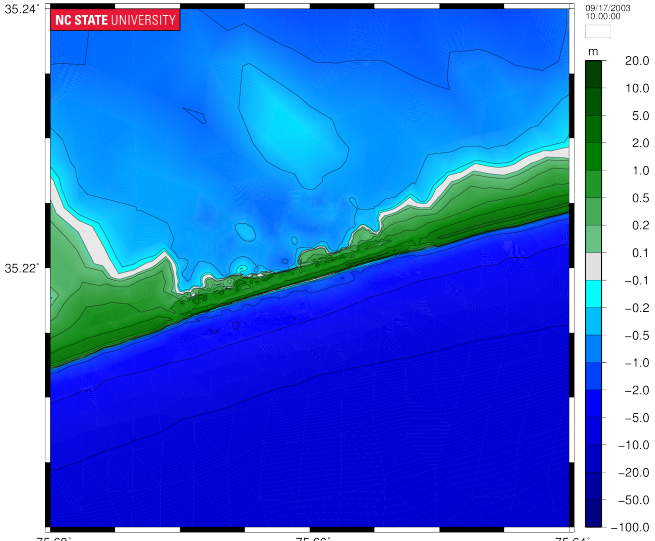

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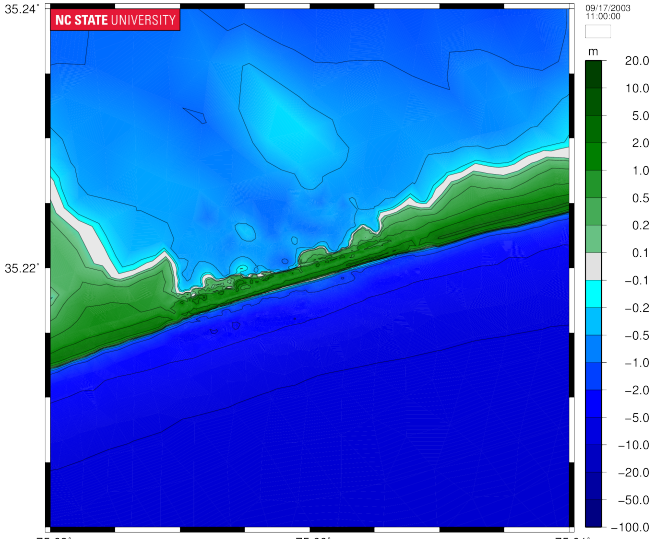

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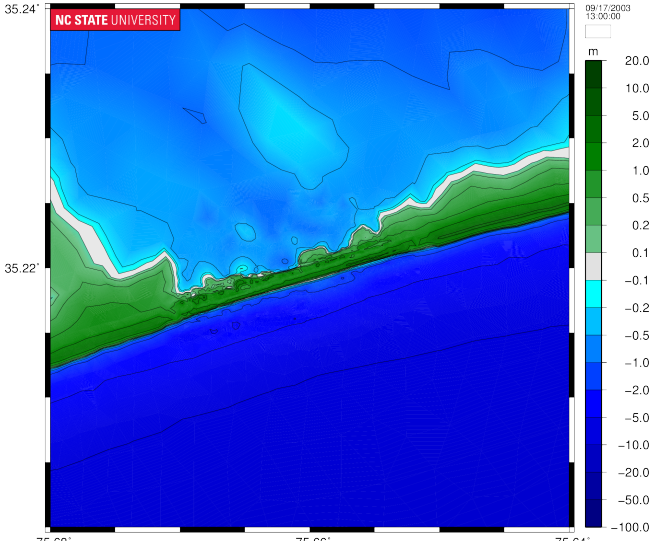

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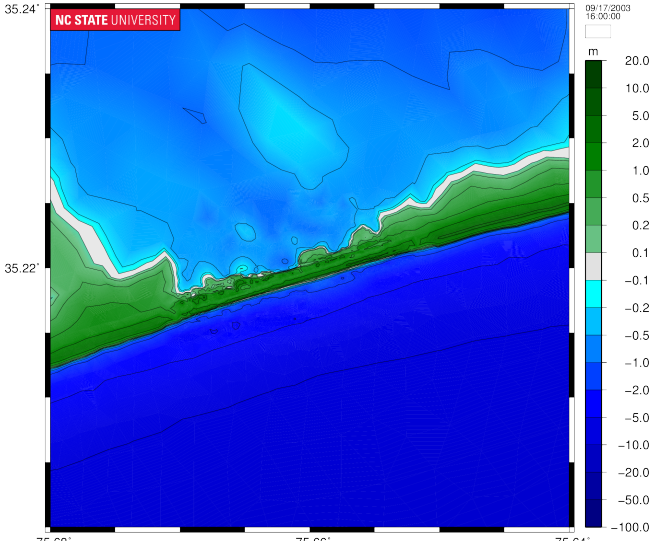

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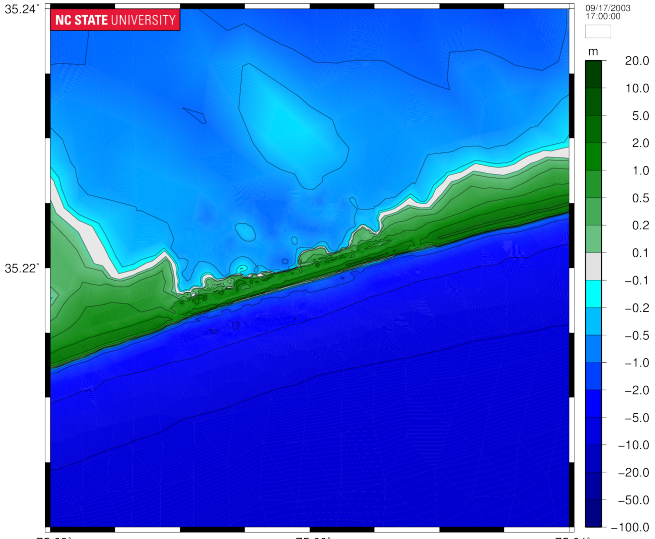

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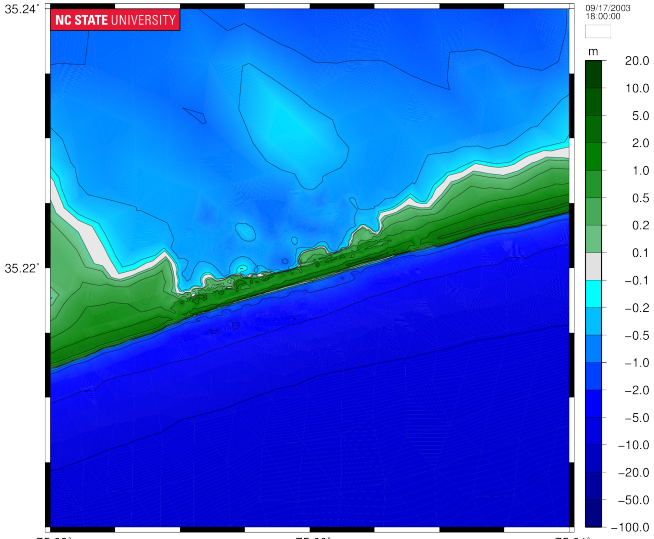

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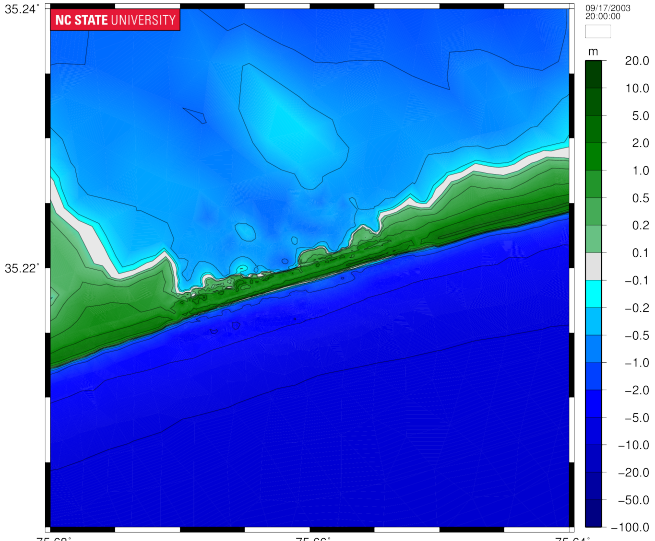

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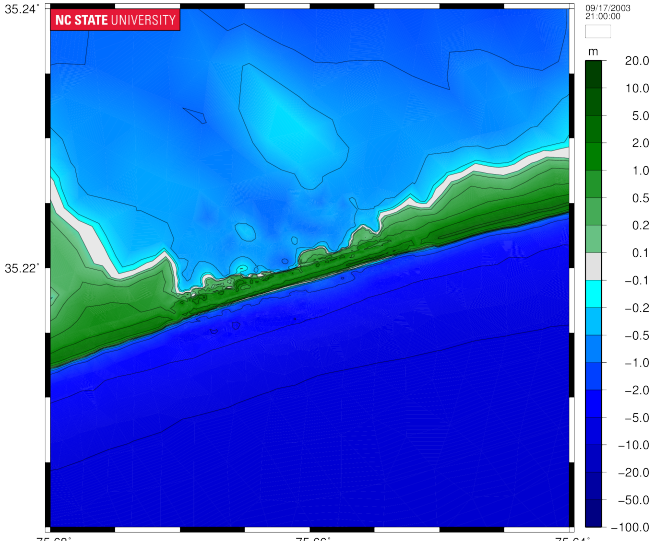

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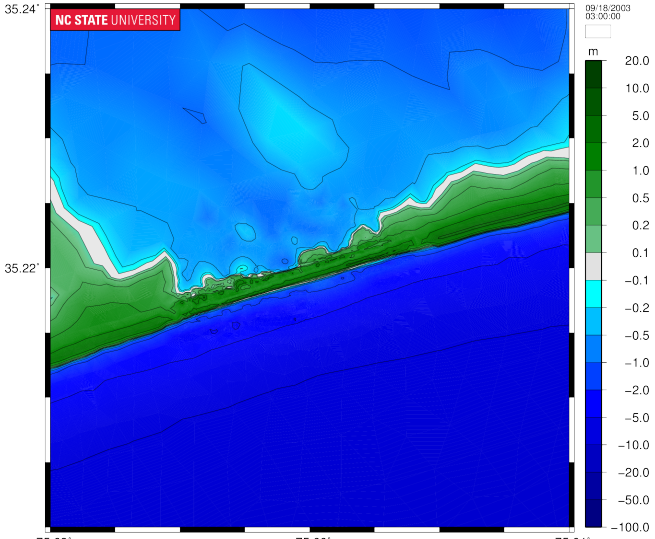

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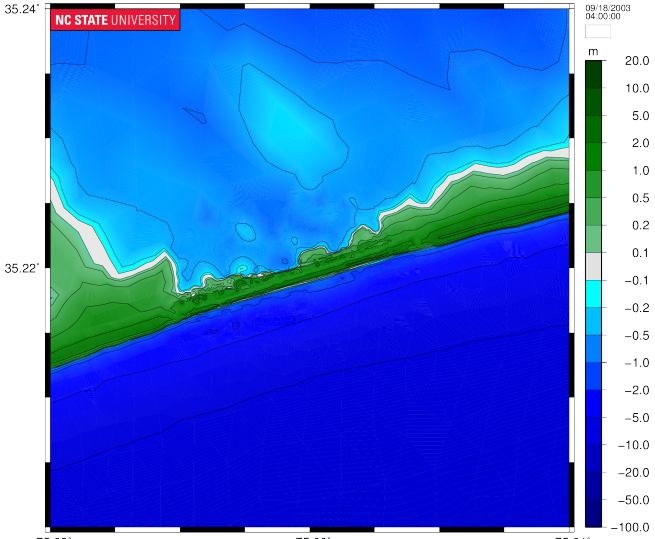

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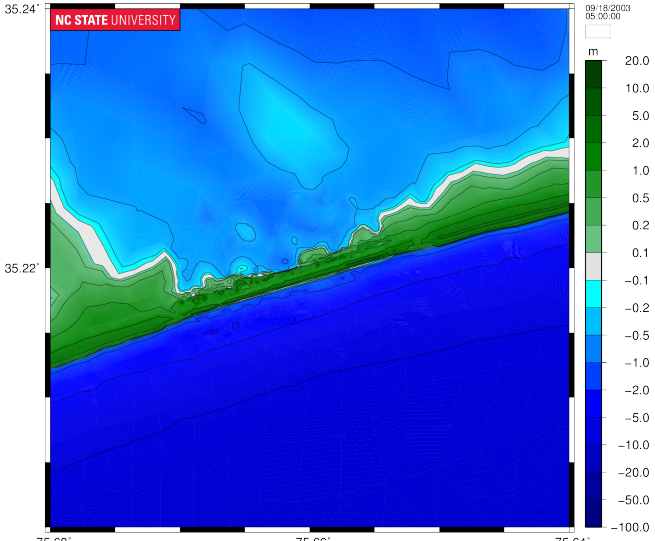

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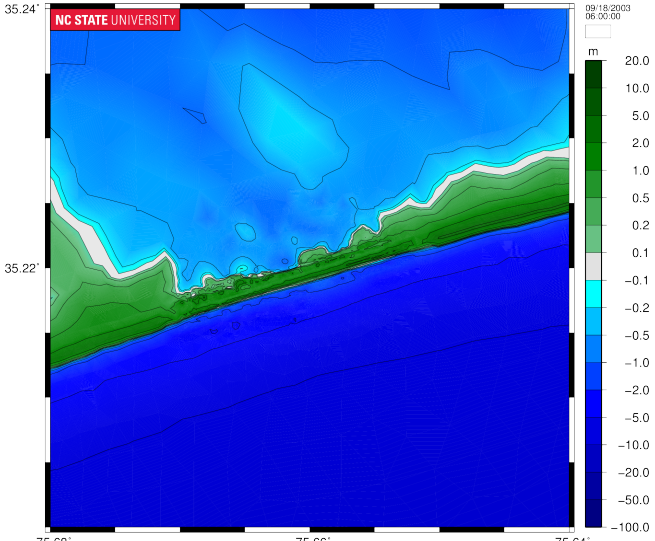

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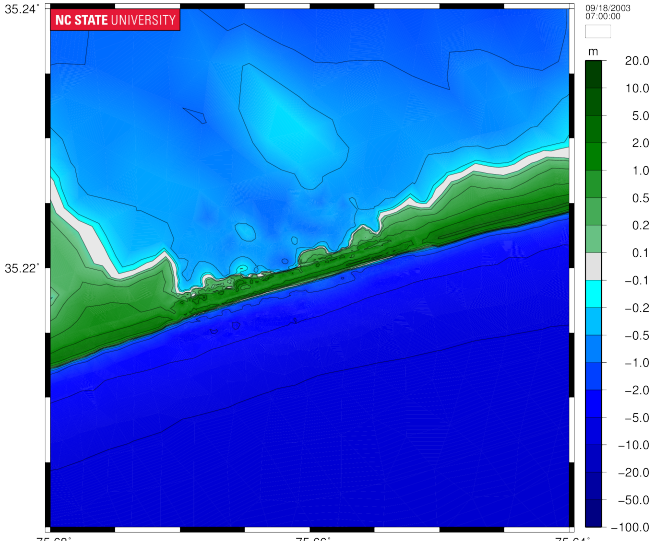

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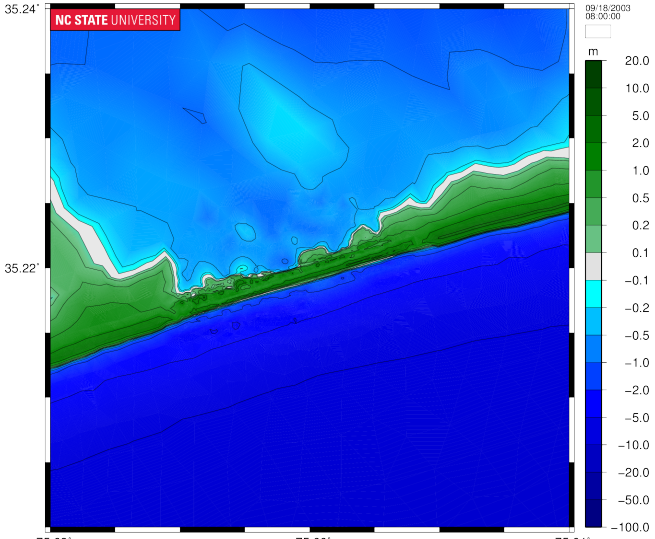

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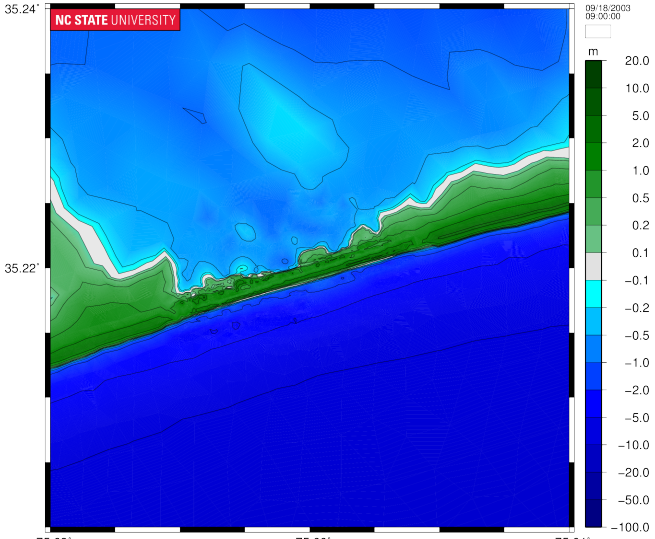

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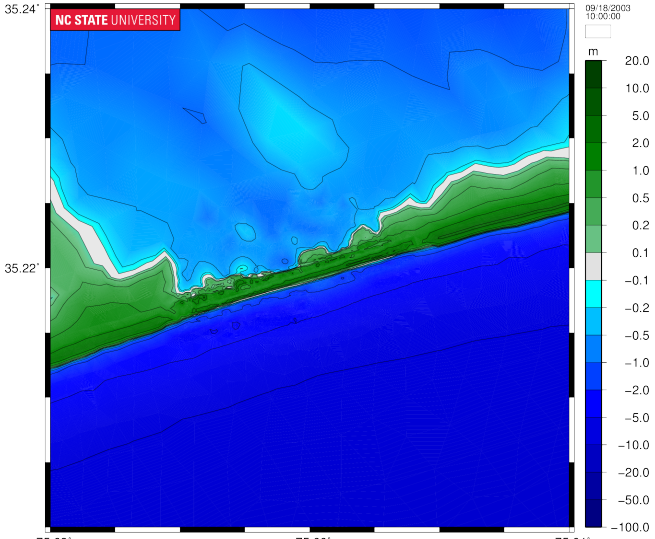

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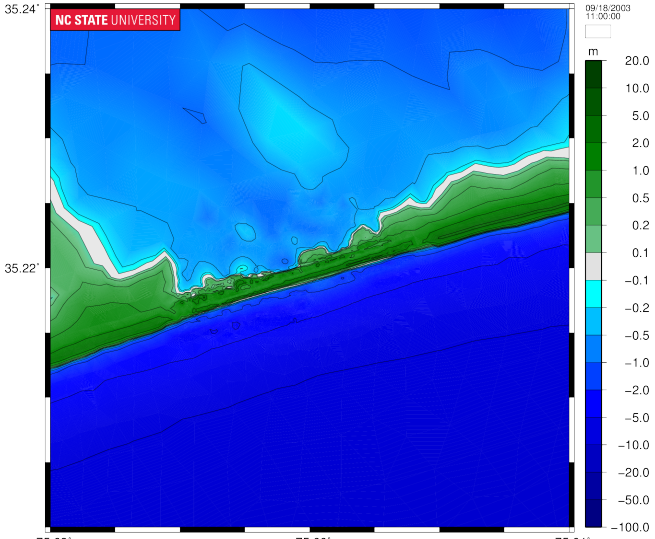

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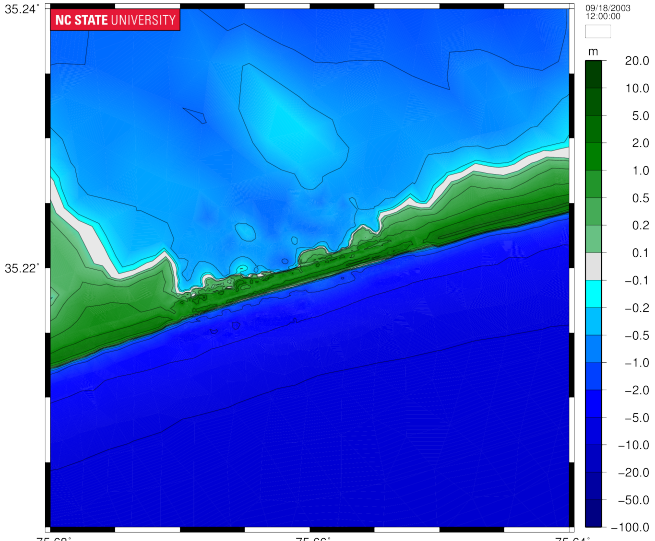

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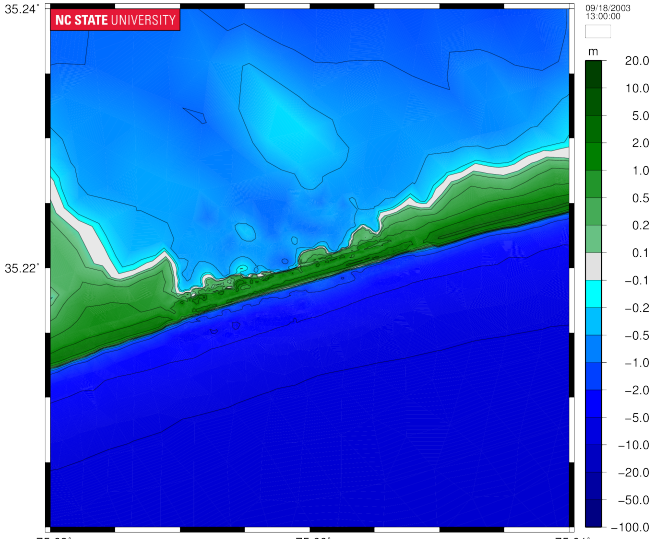

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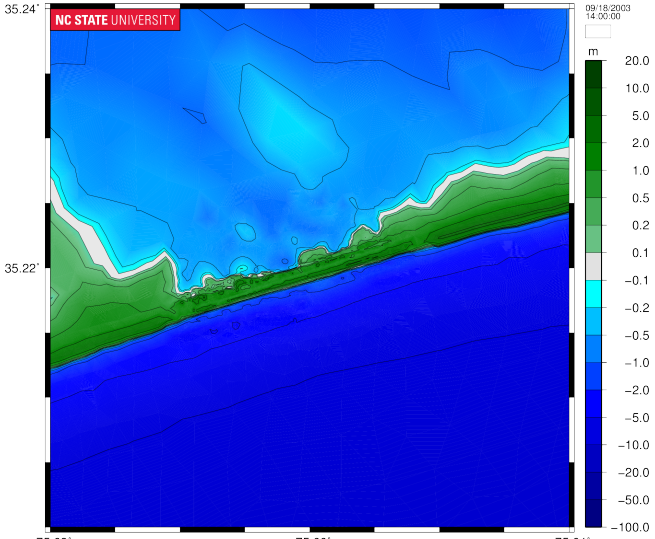

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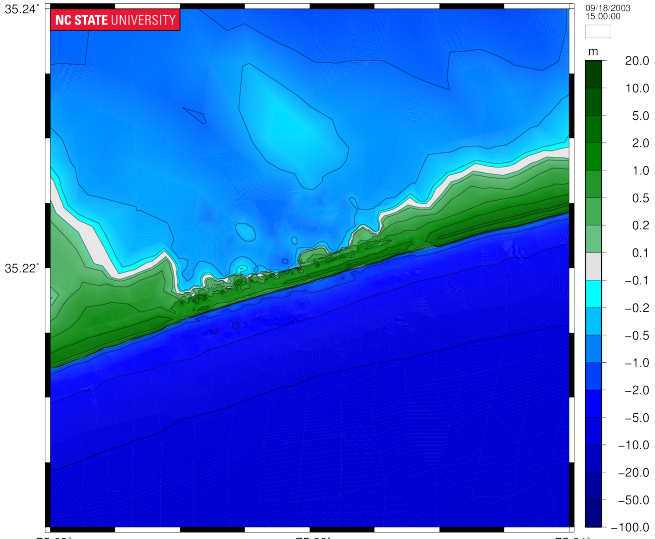

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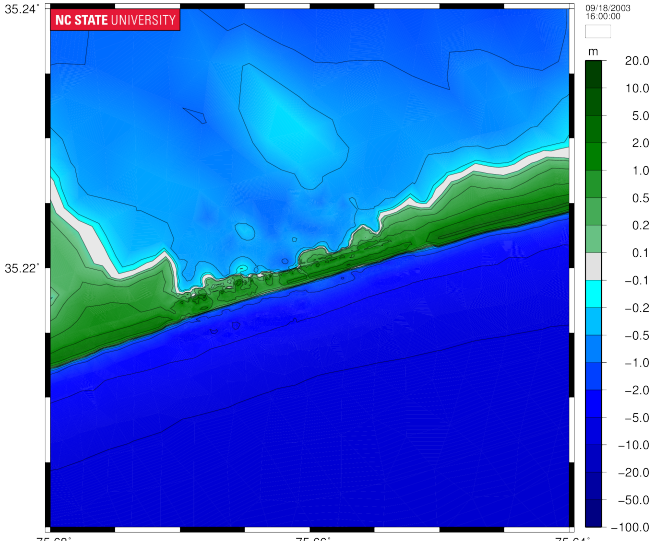

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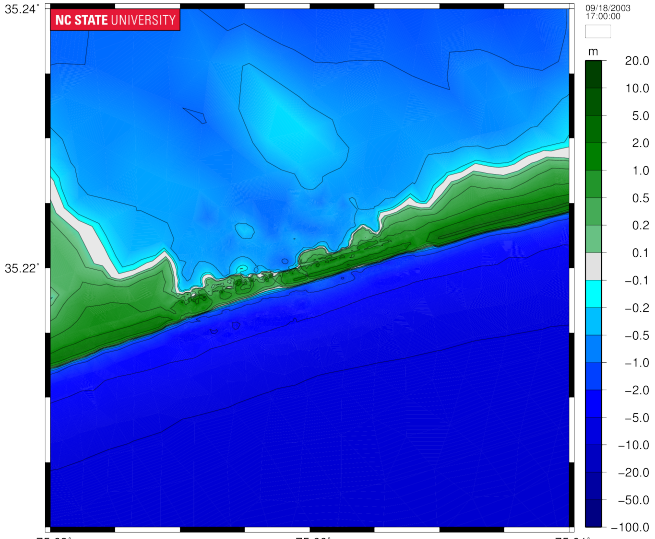

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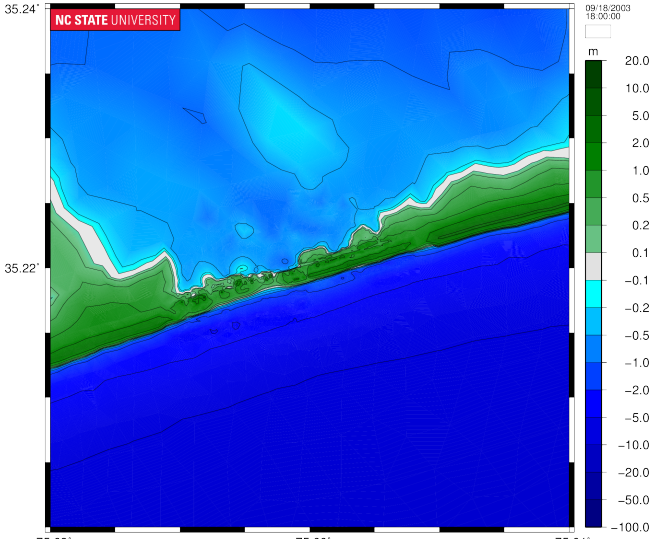

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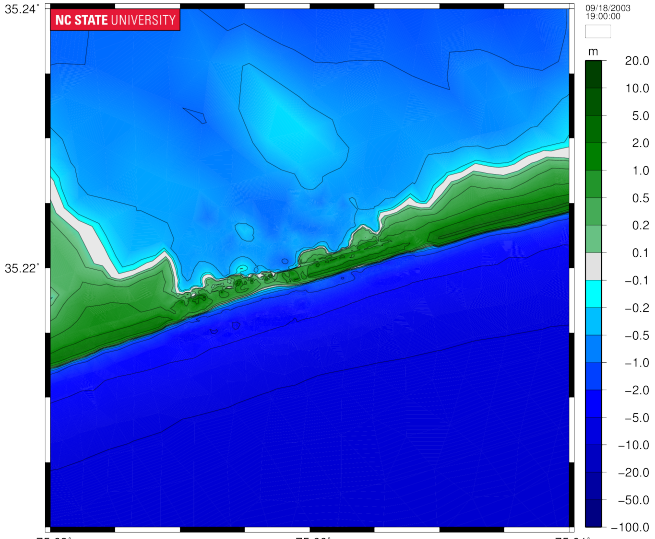

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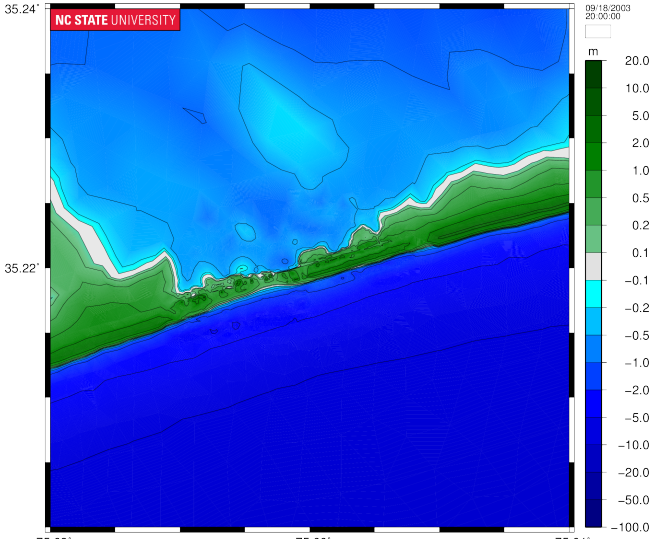

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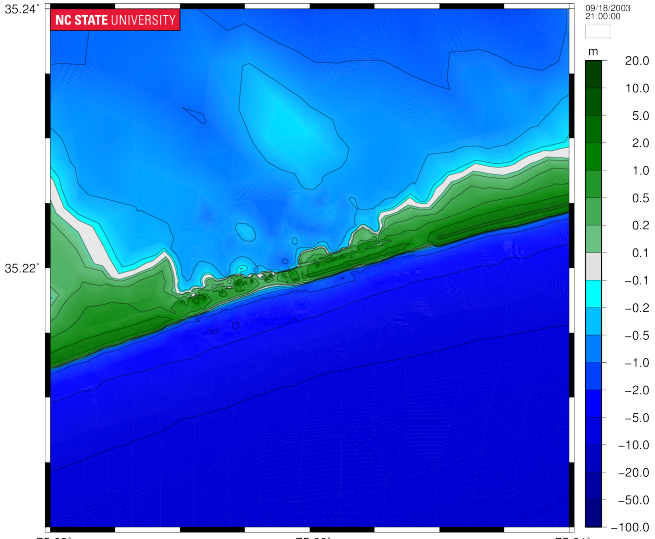

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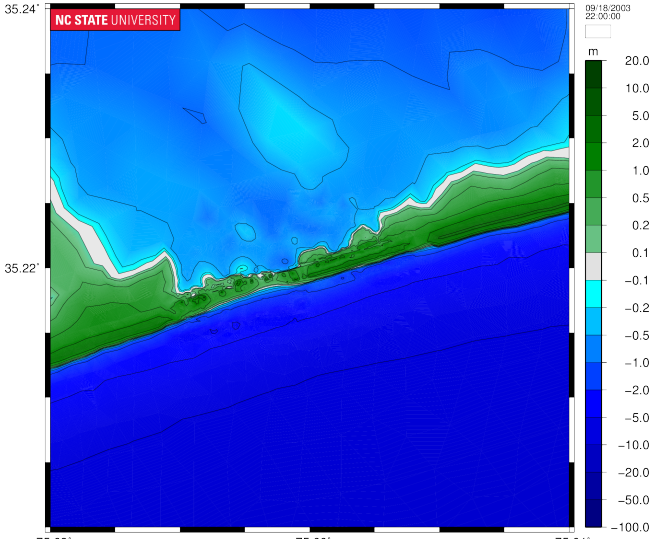

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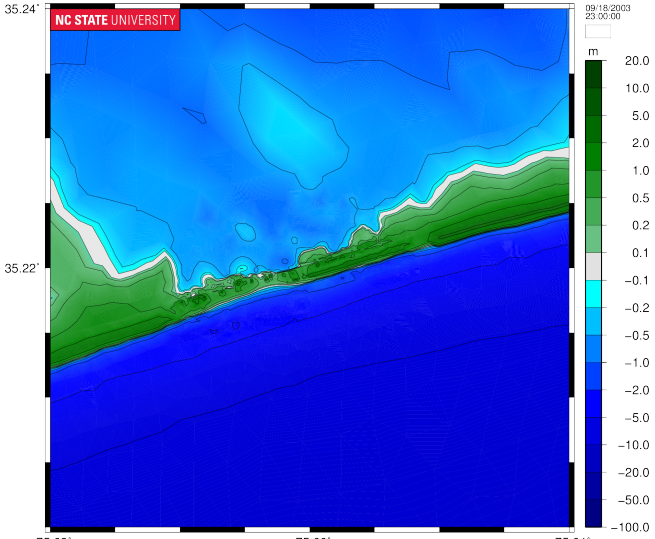

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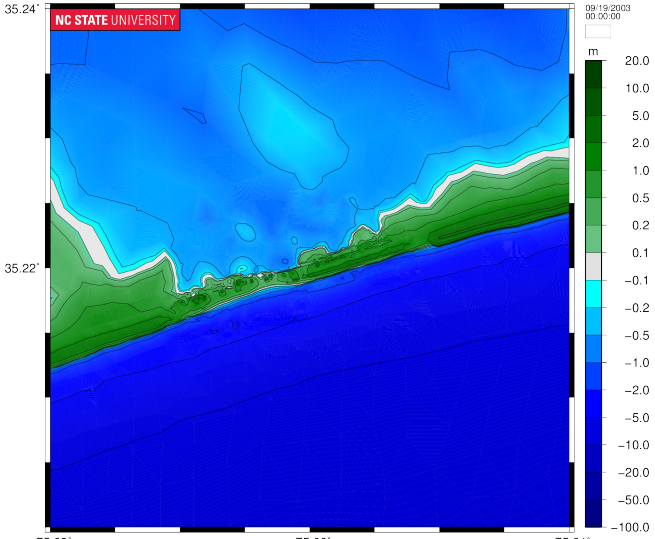

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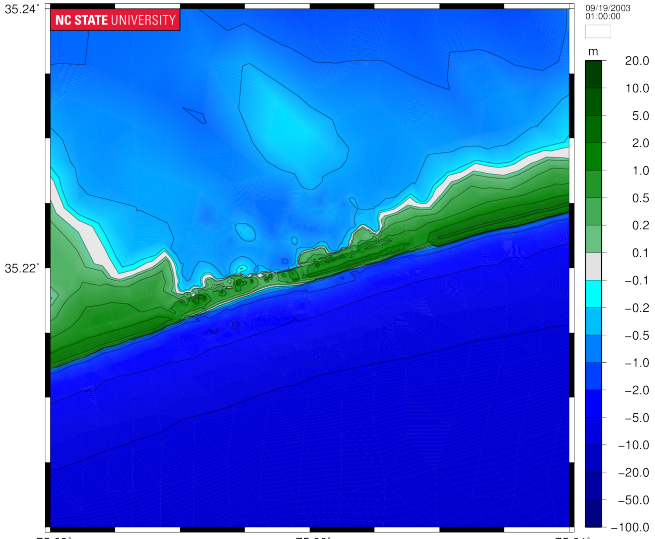

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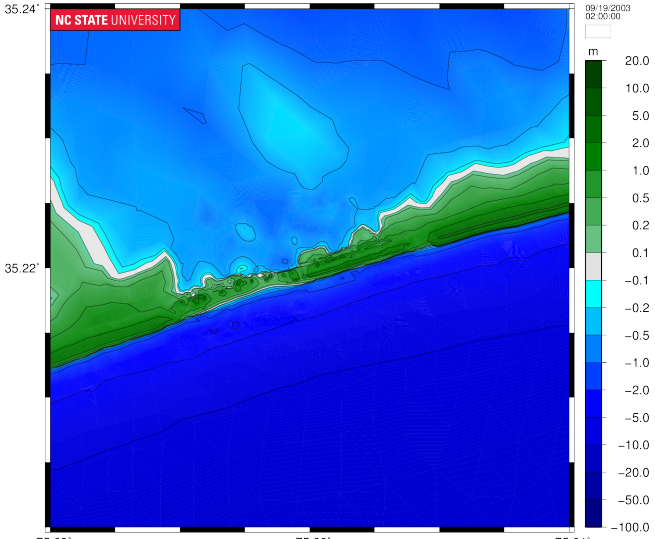

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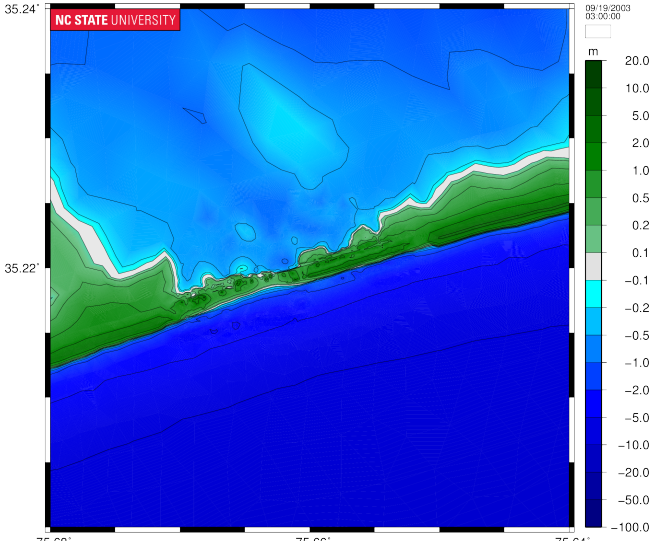

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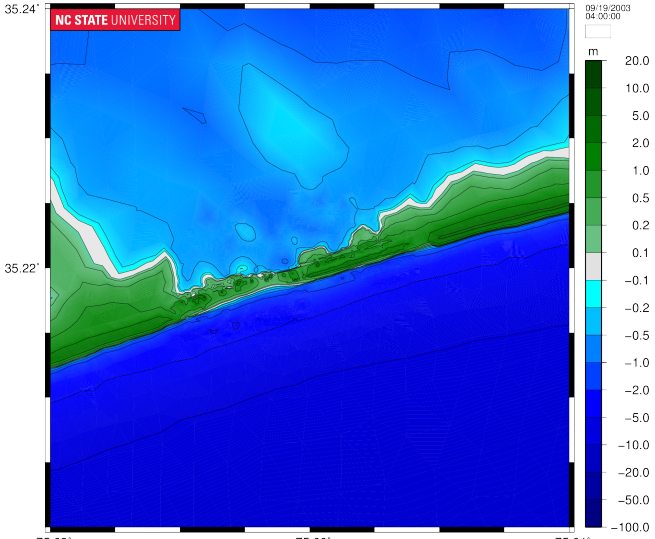

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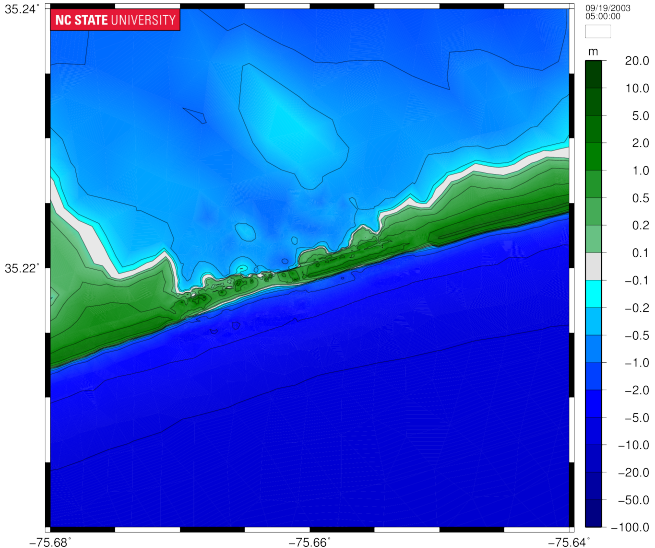

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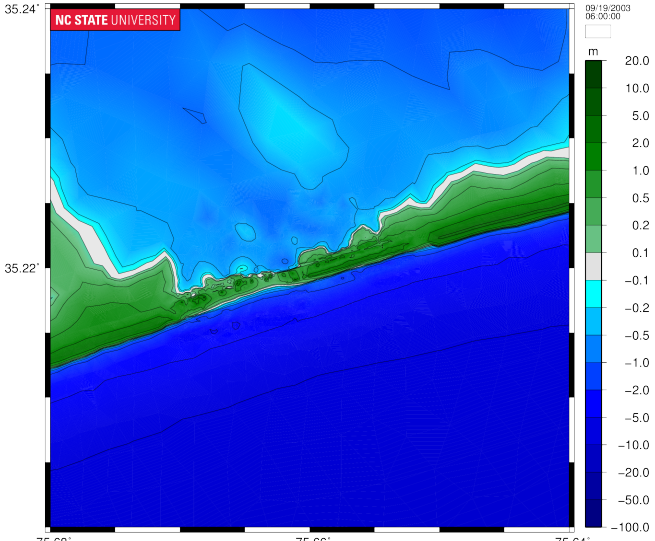

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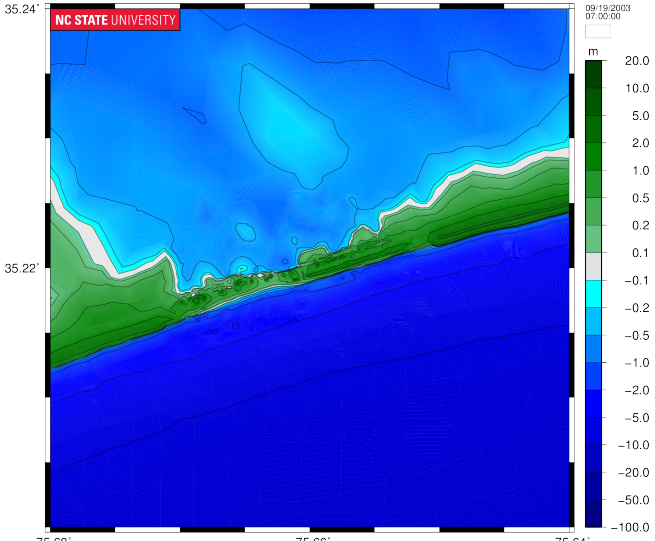

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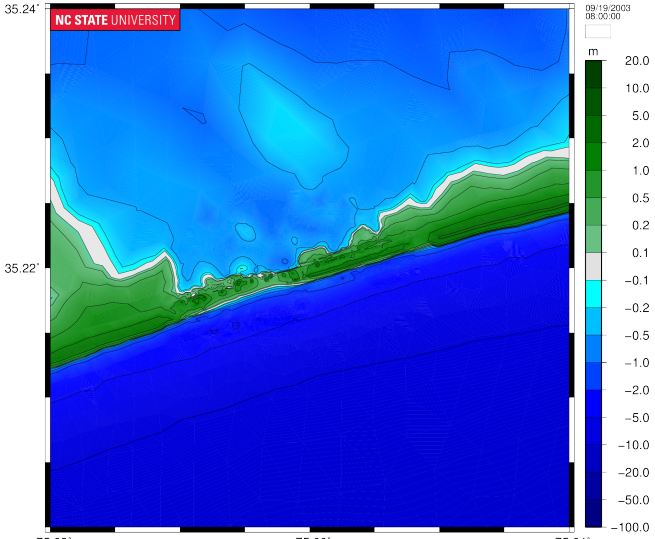

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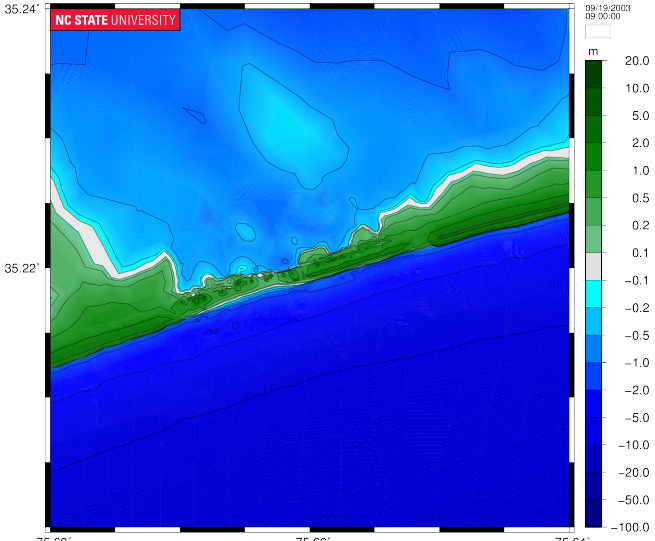

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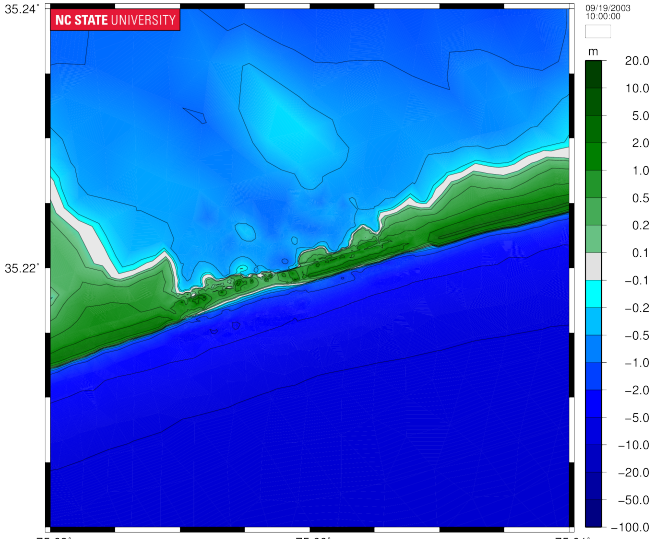

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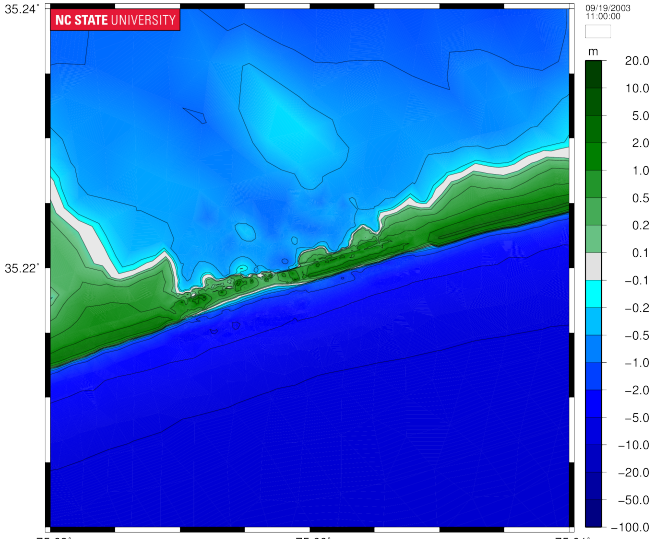

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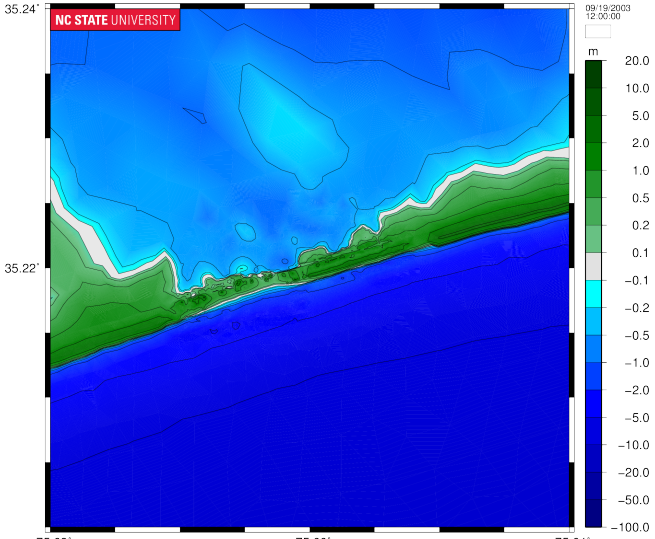

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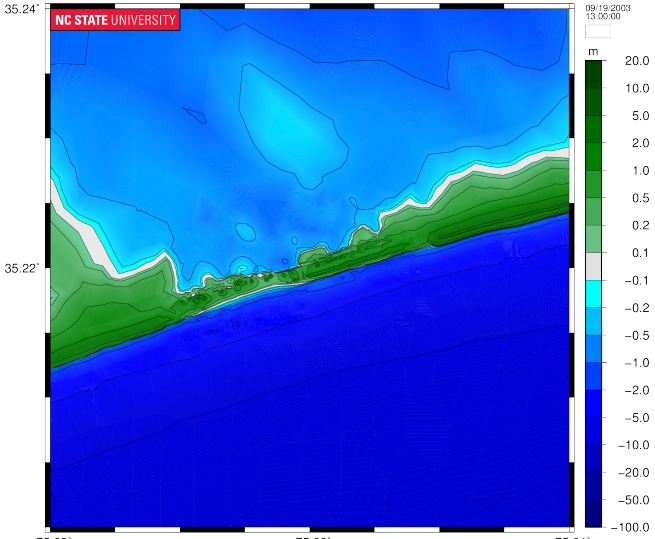

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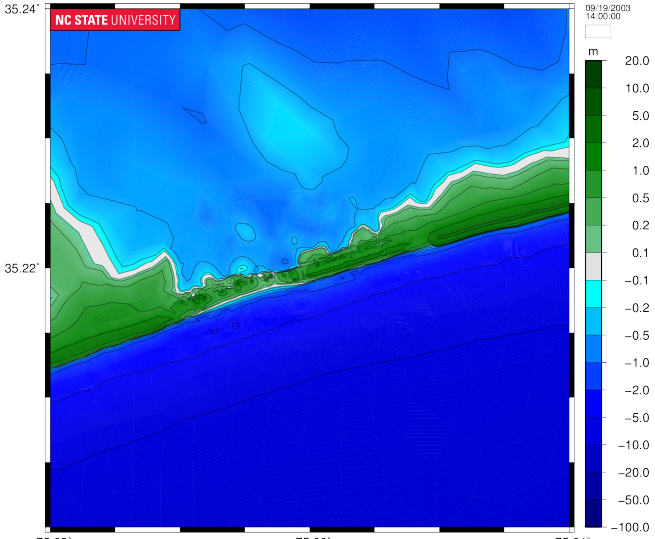

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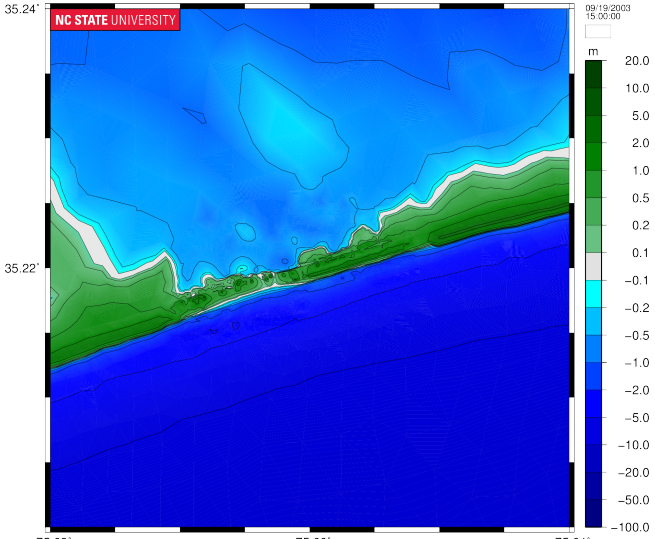

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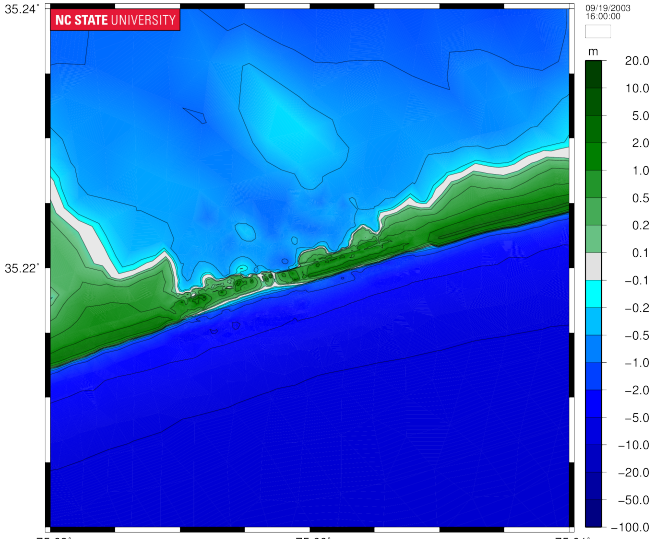

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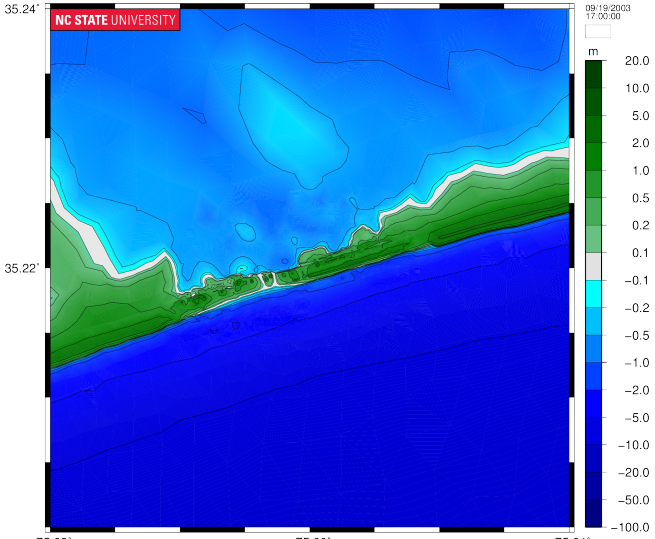

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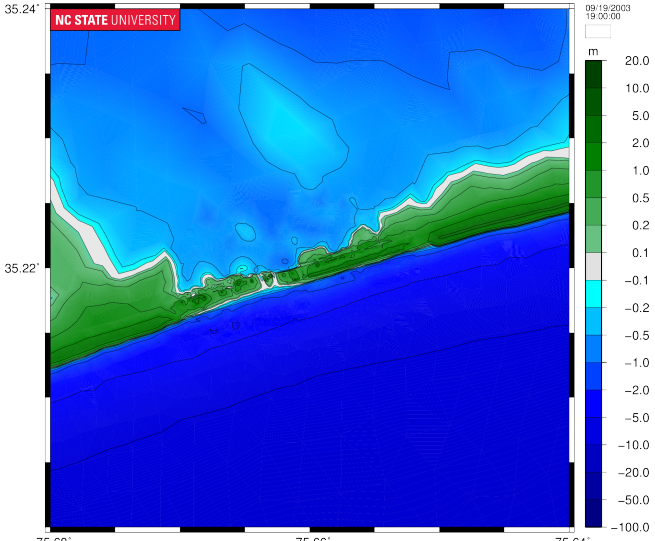

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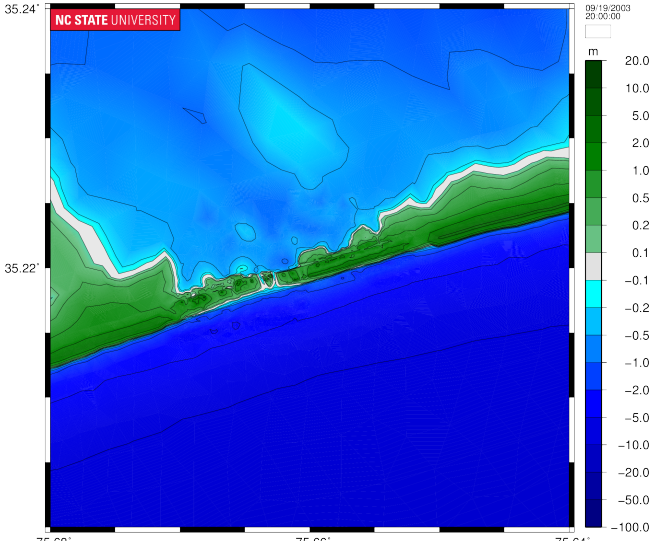

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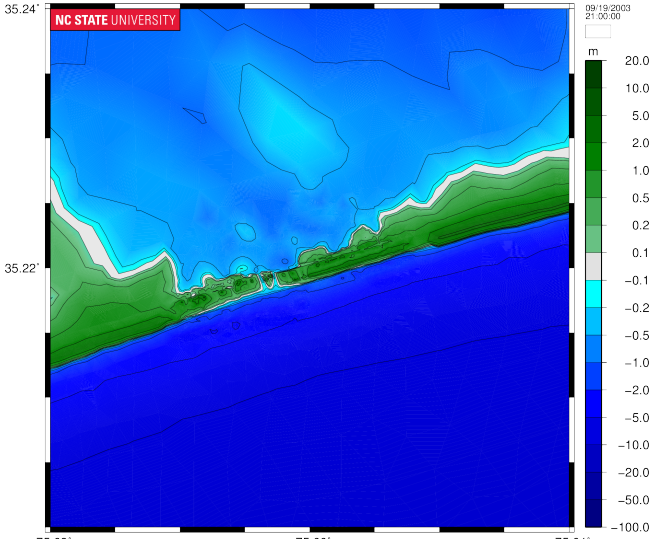

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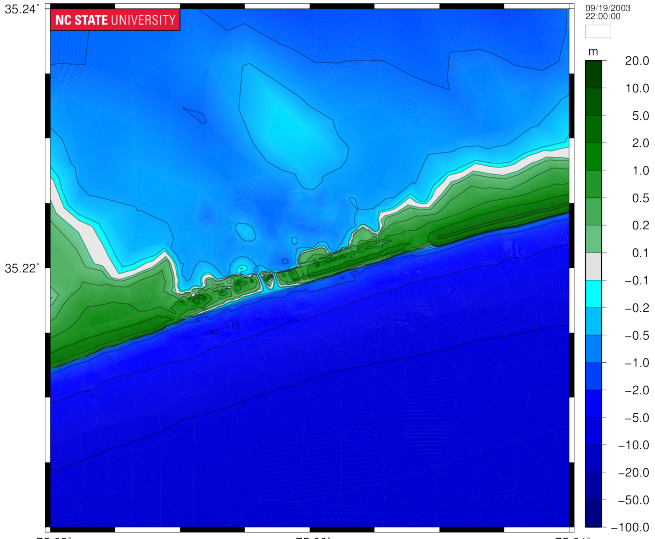

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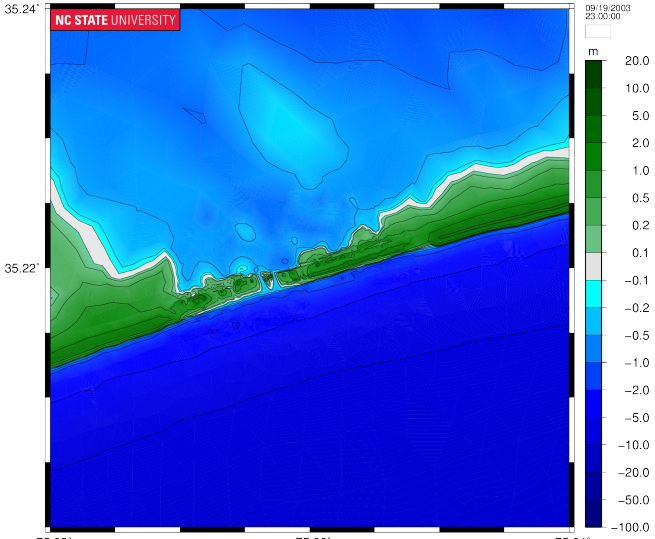

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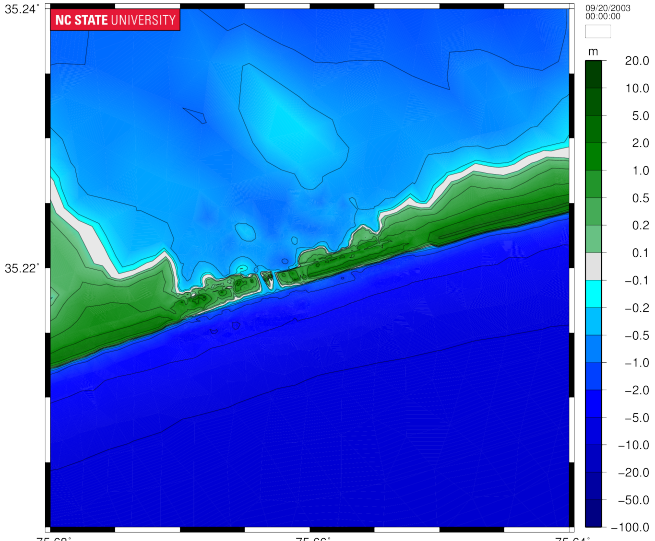

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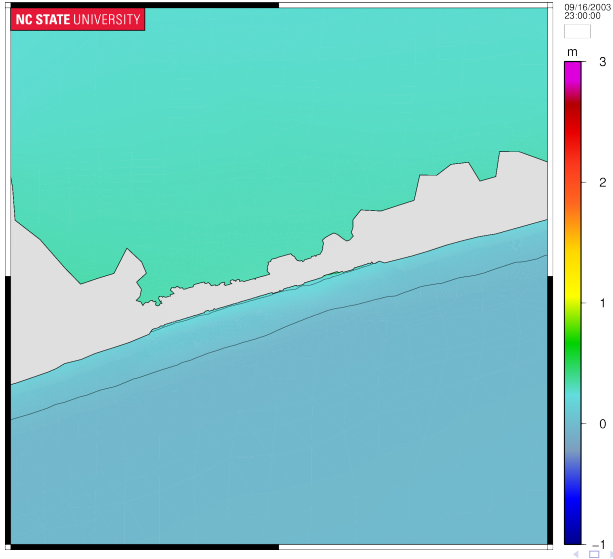
Water Elevation



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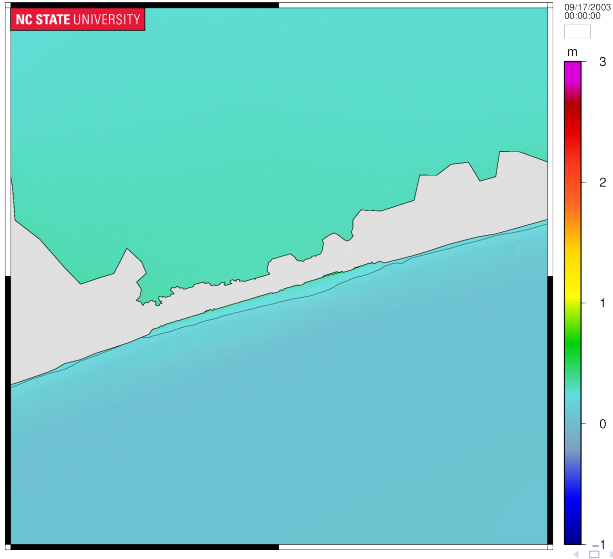

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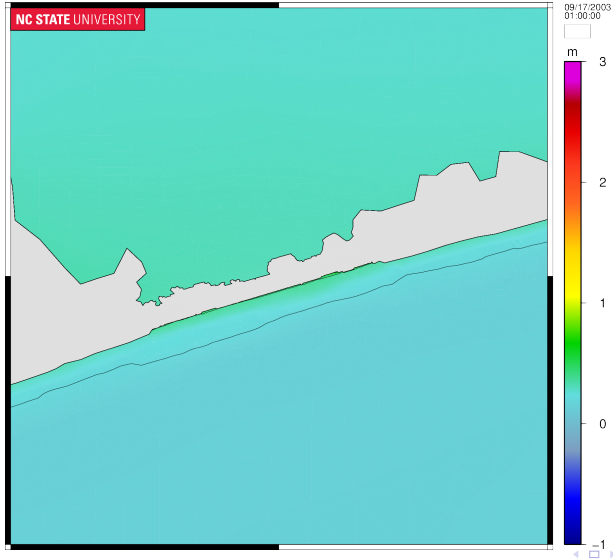

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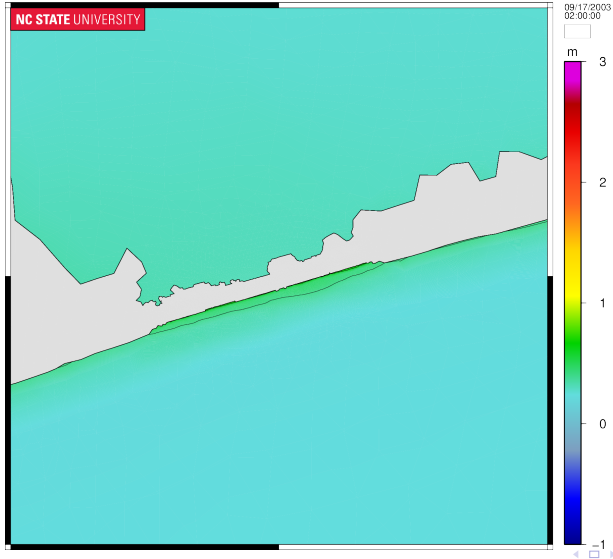

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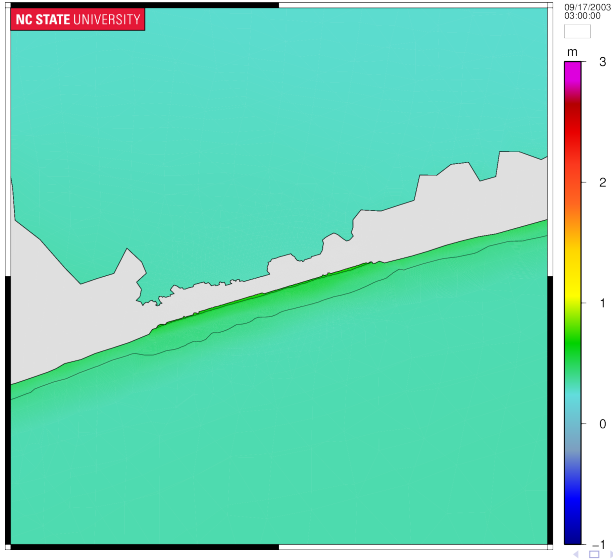

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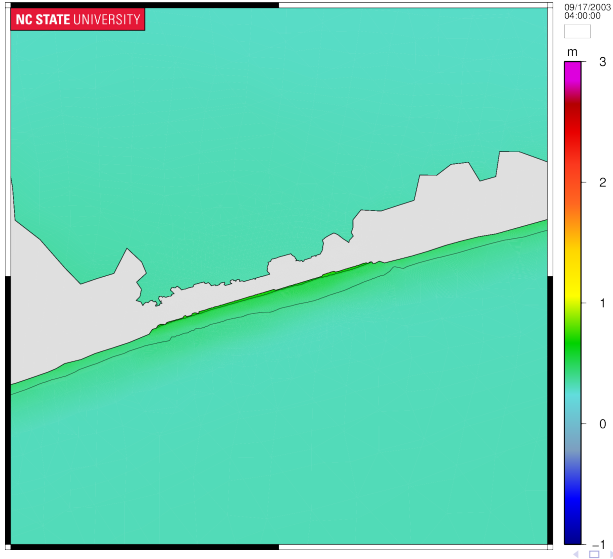

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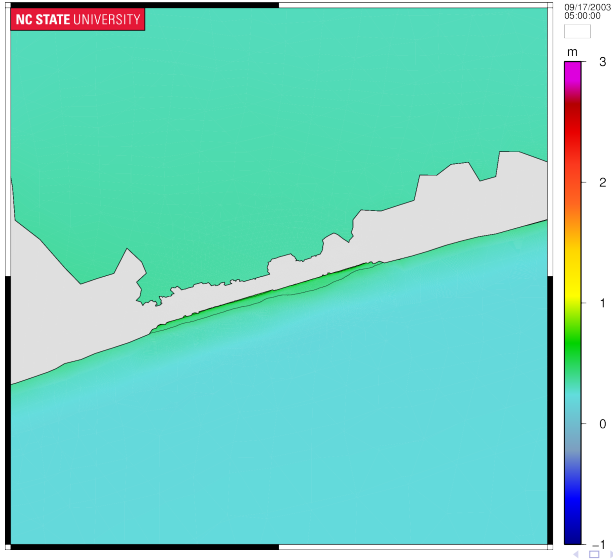

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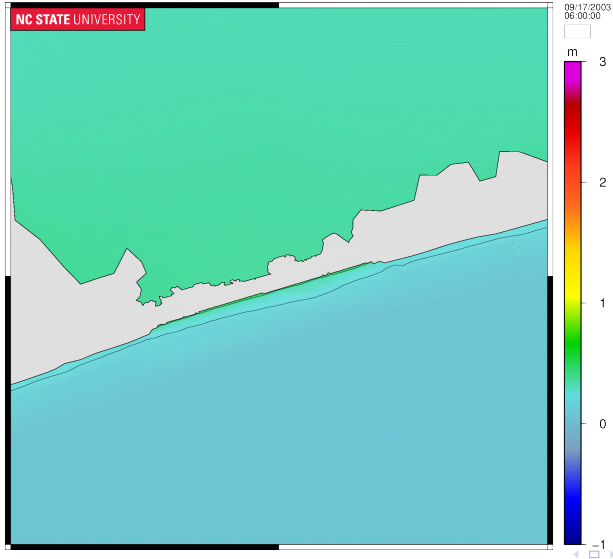

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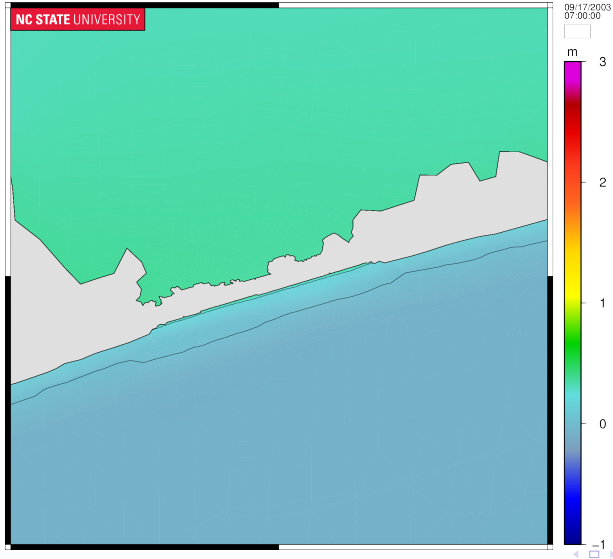

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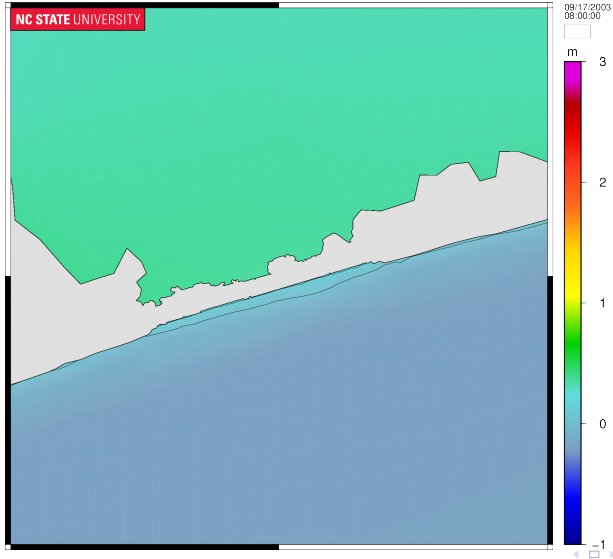

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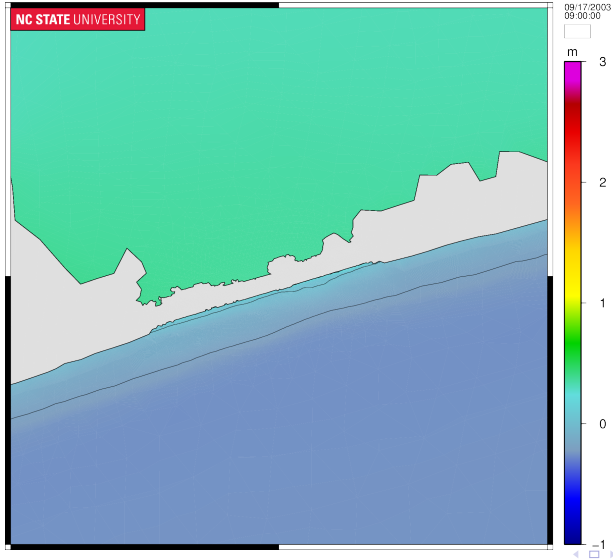

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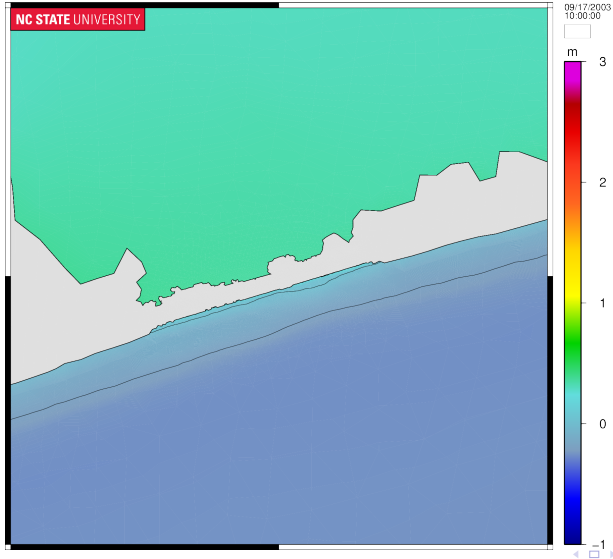

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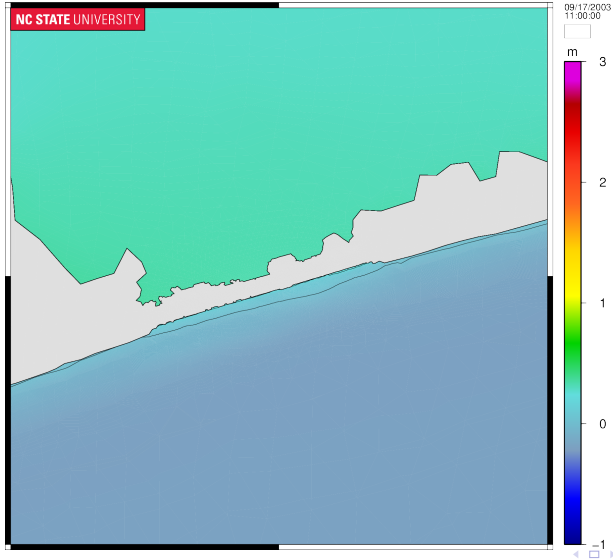

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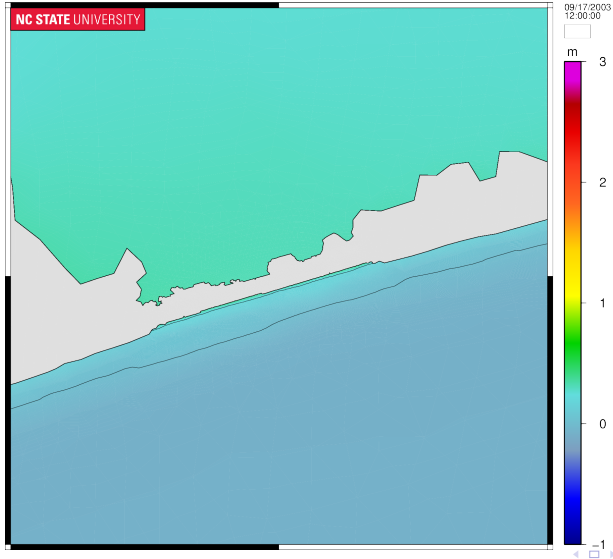

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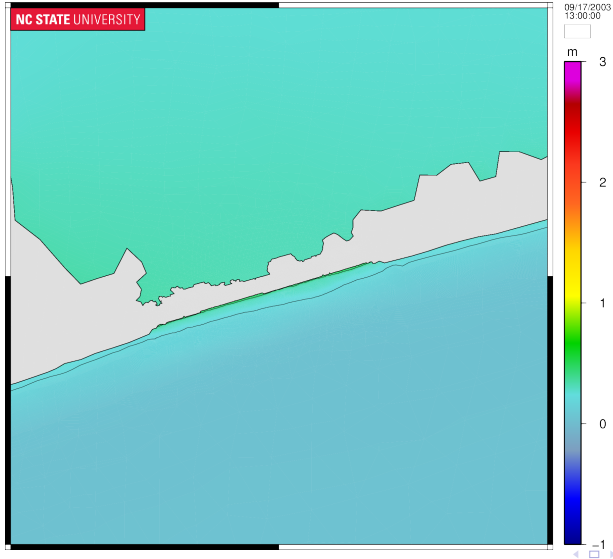

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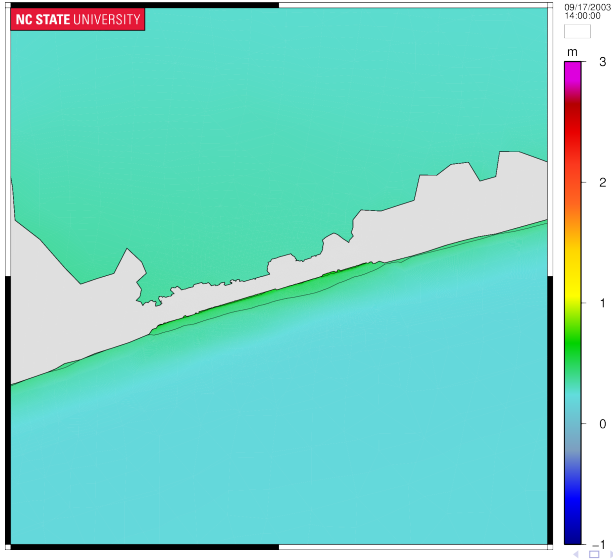

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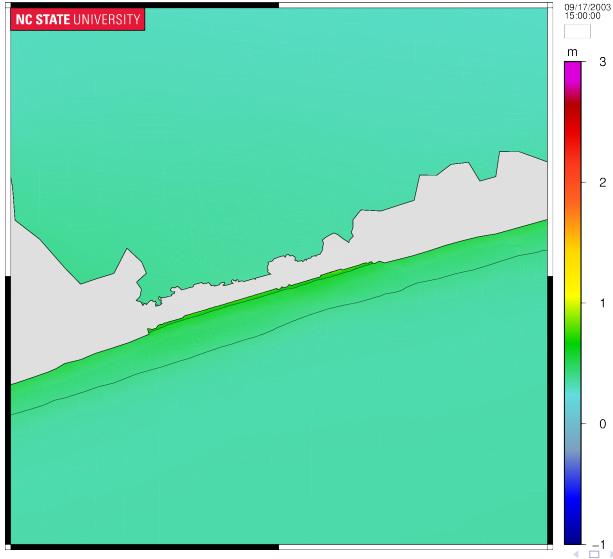

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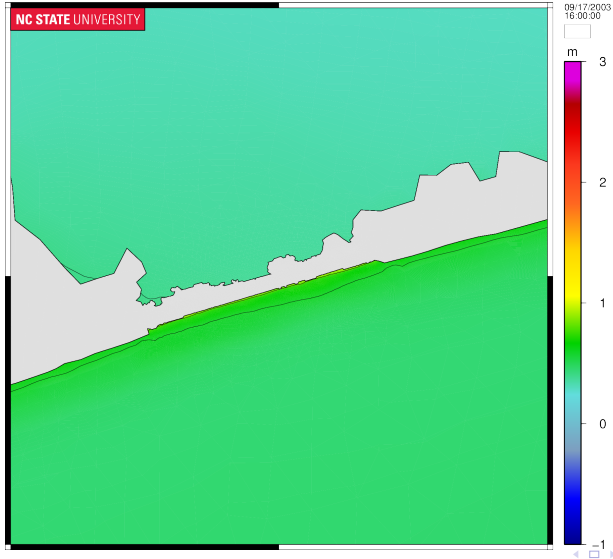

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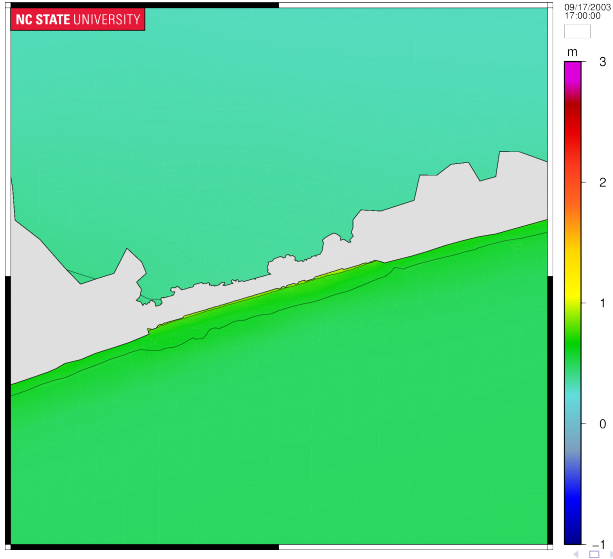

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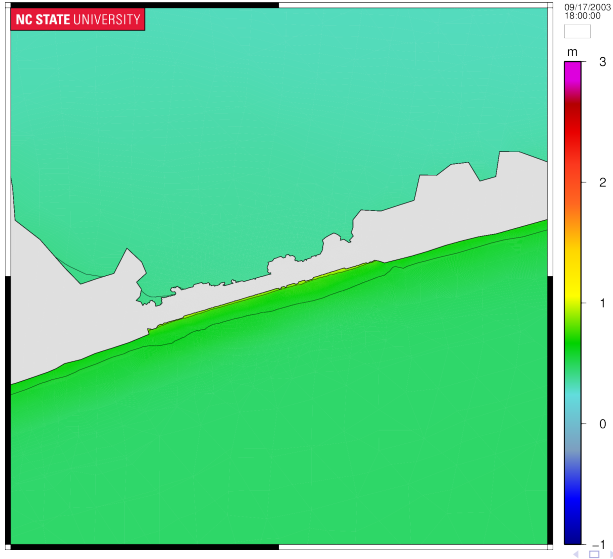

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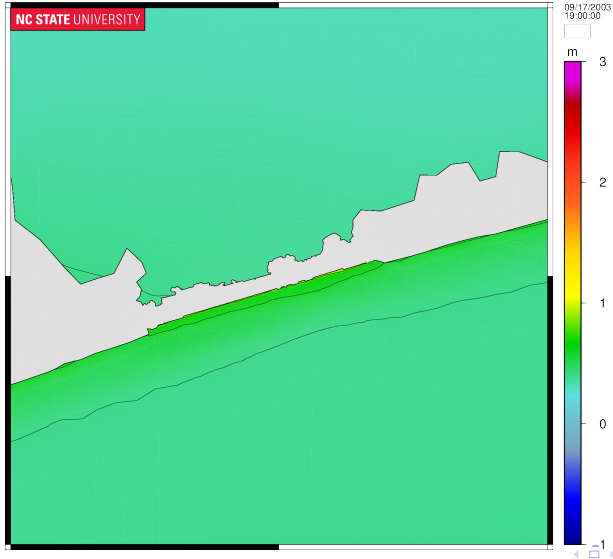

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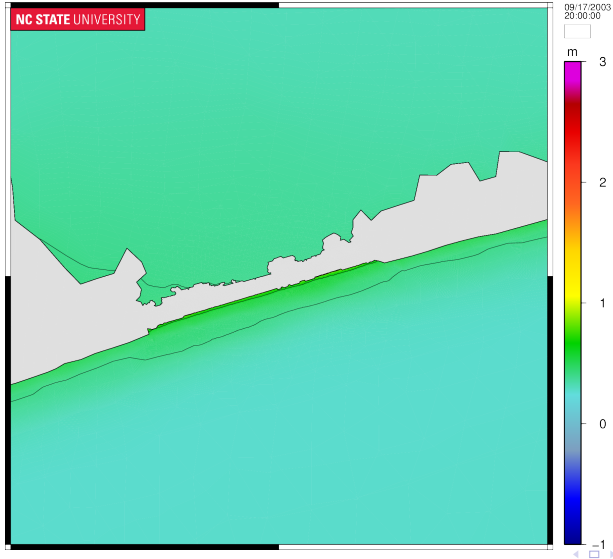

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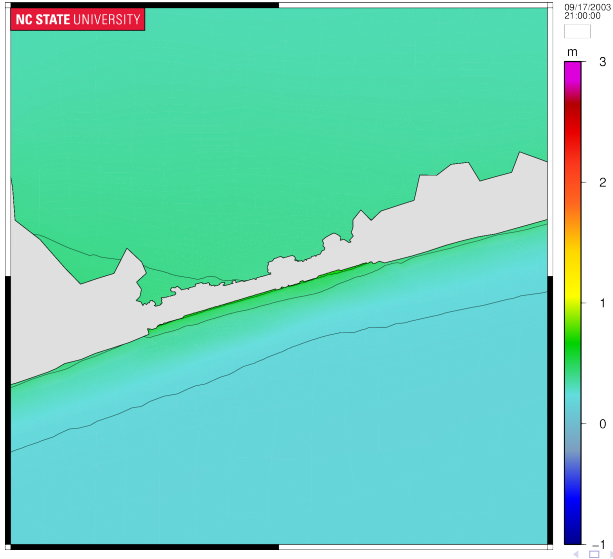

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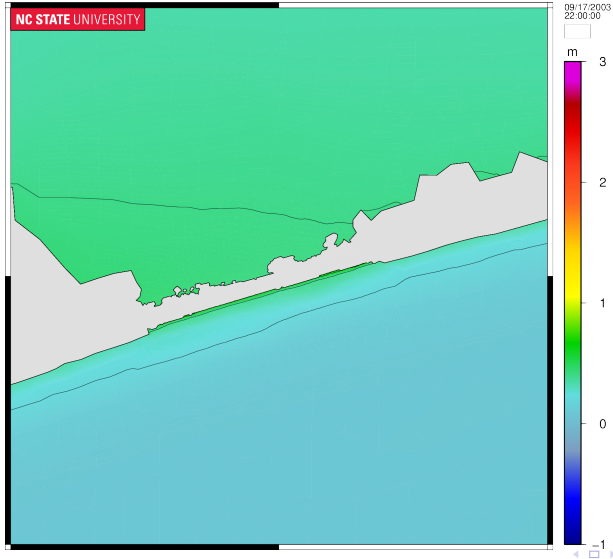

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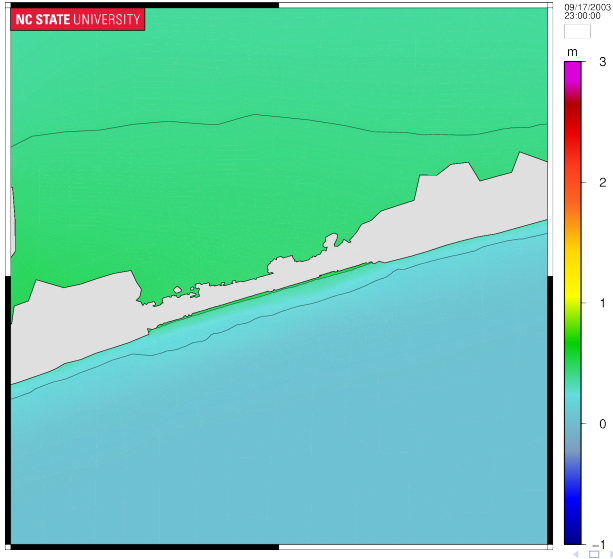

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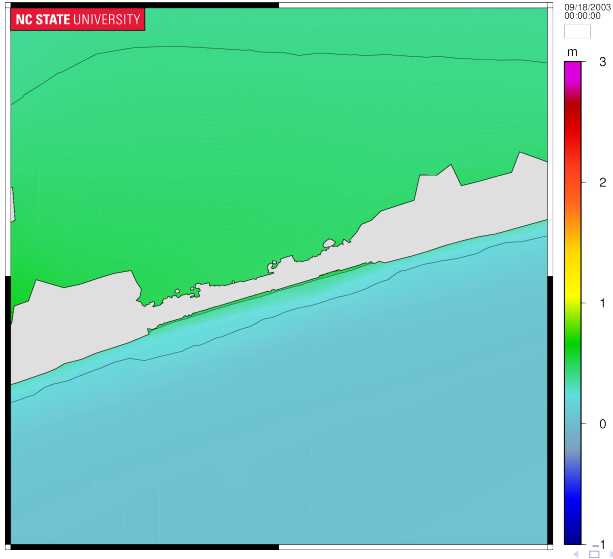

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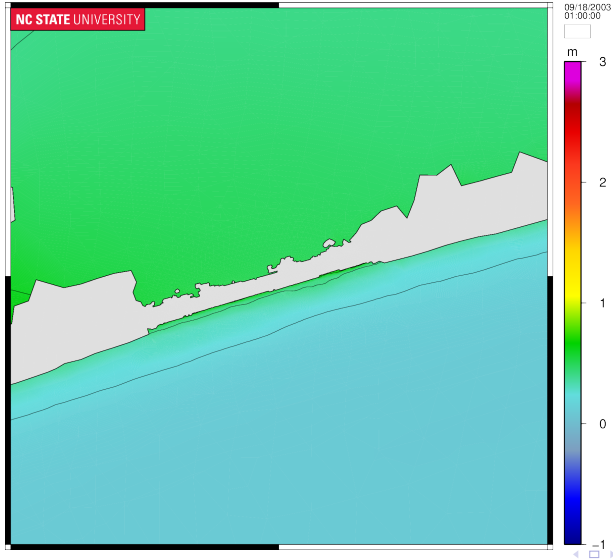

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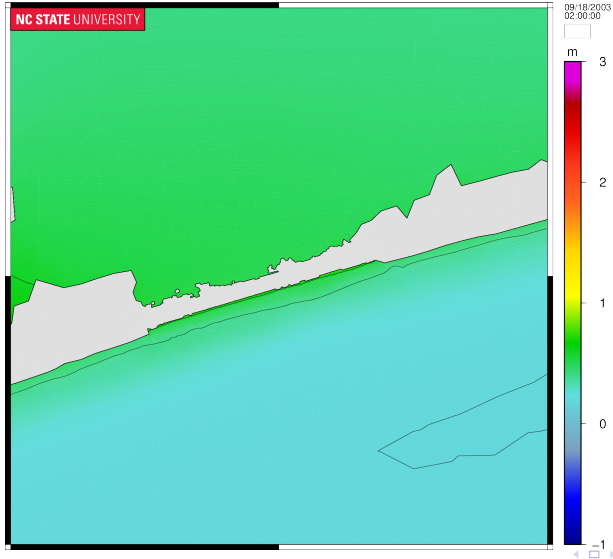

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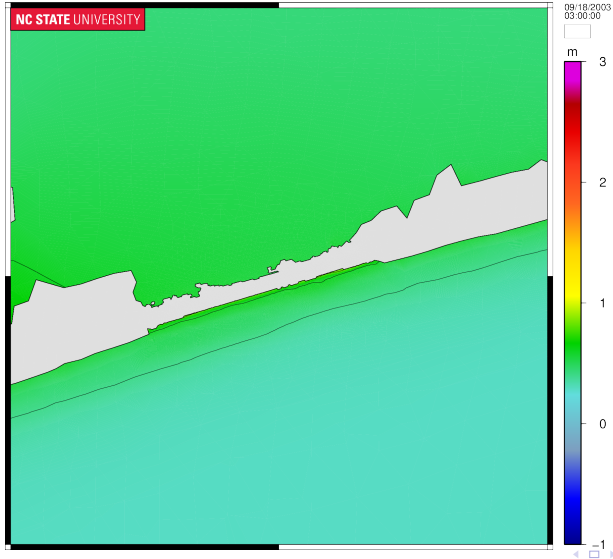

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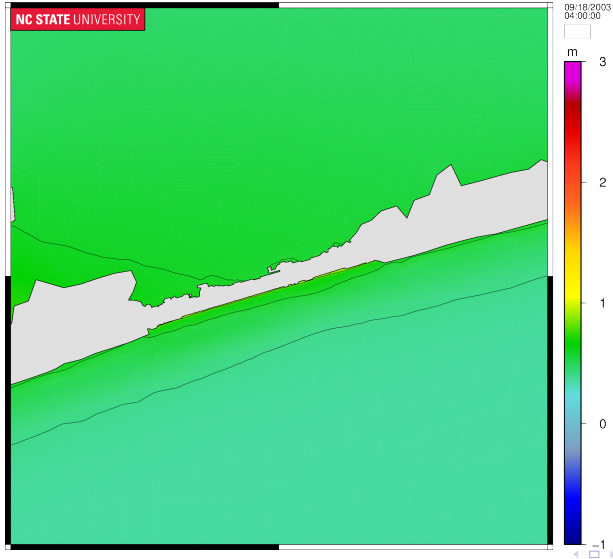

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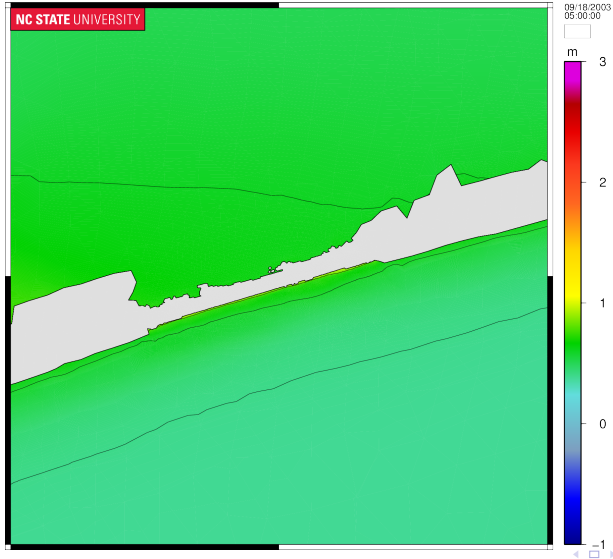

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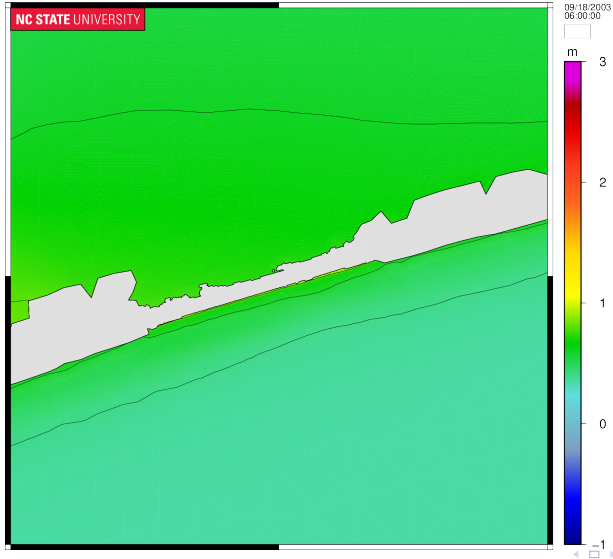

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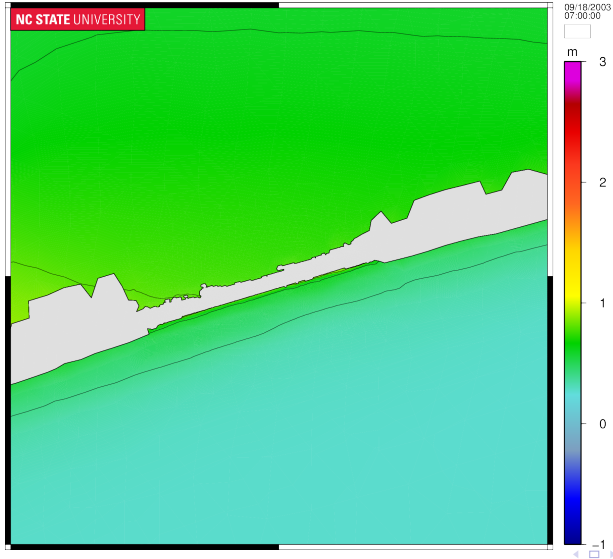

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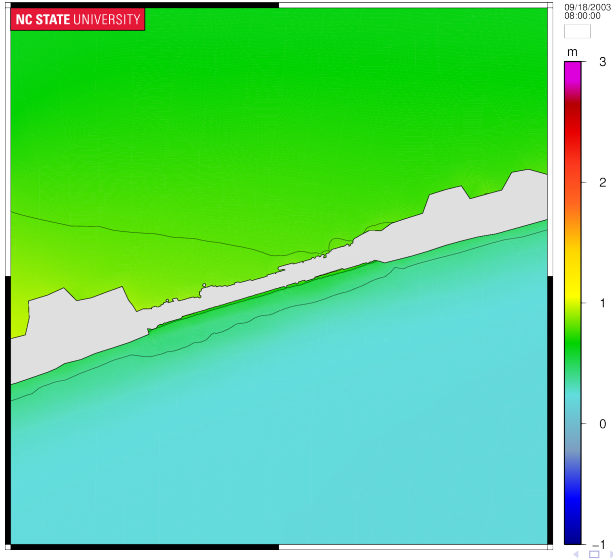

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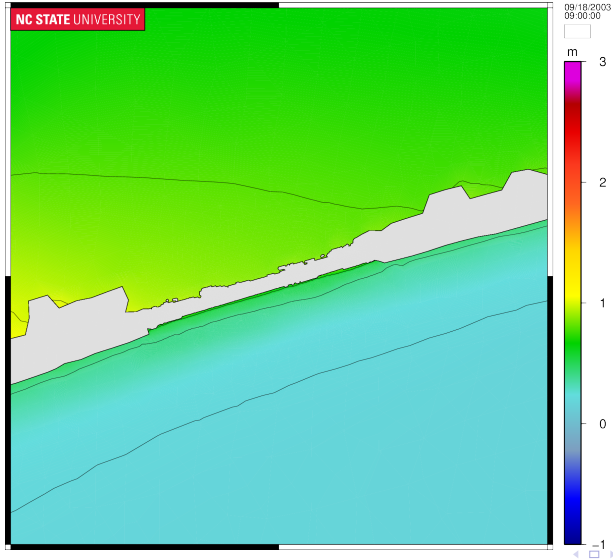

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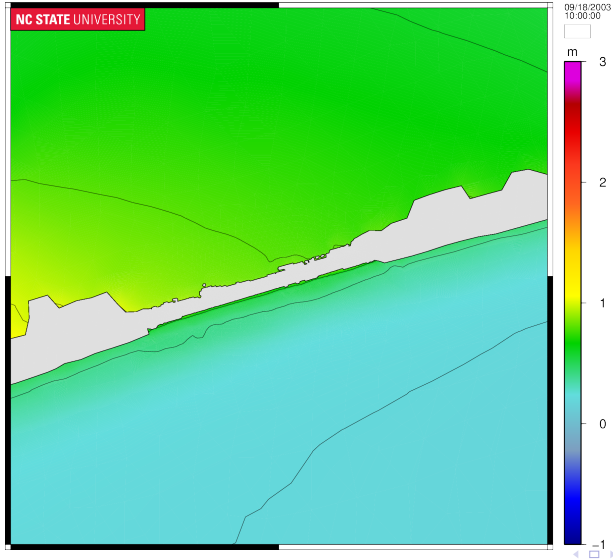

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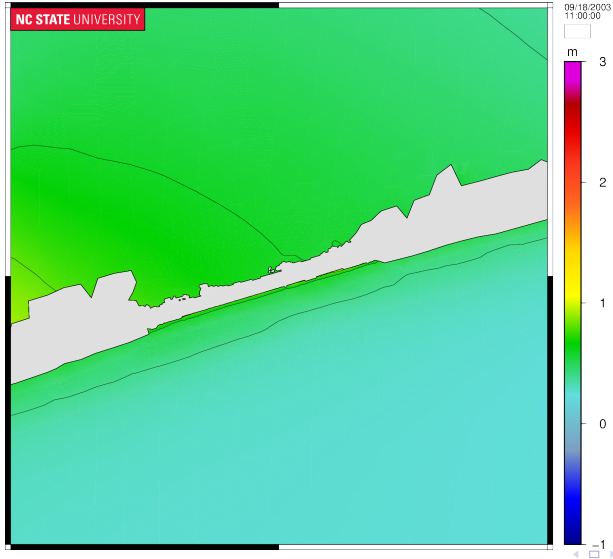

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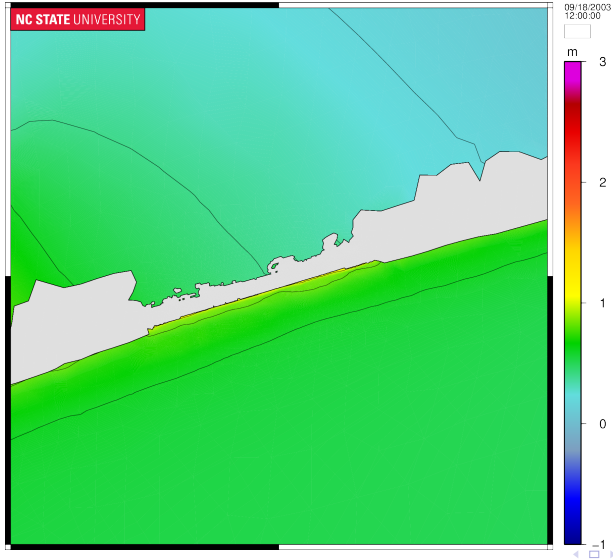

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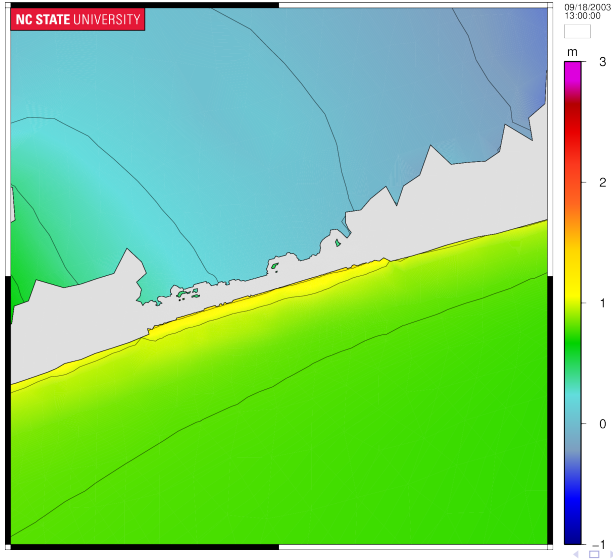

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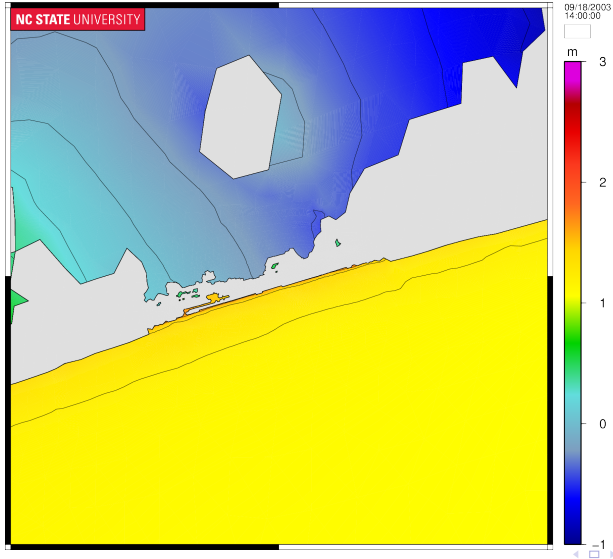

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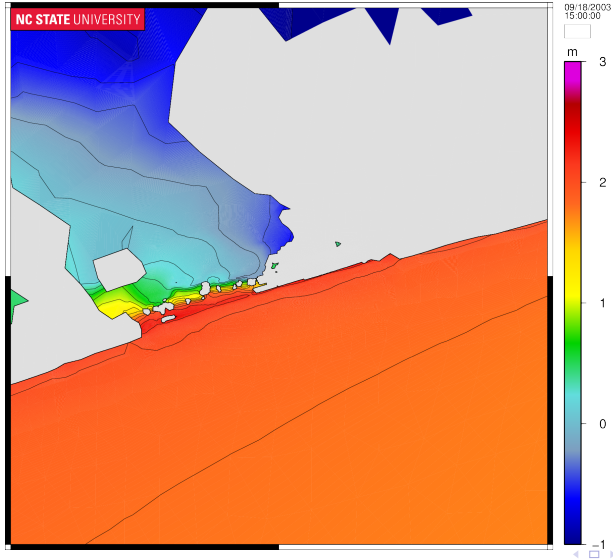

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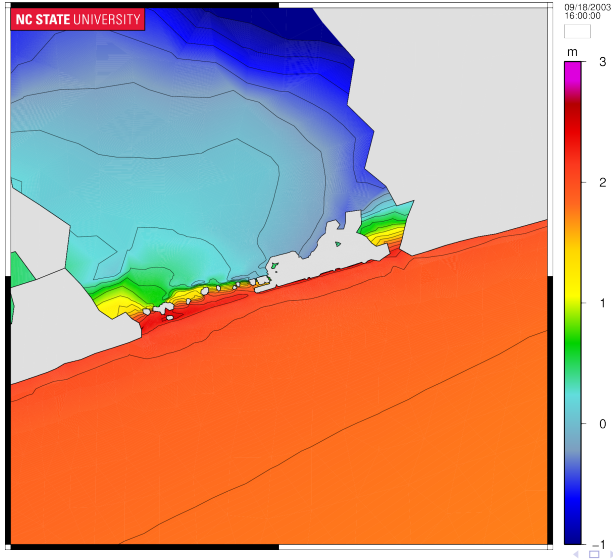

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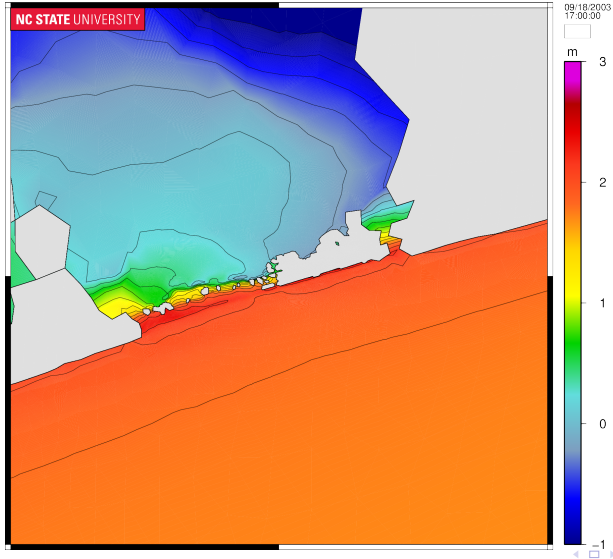

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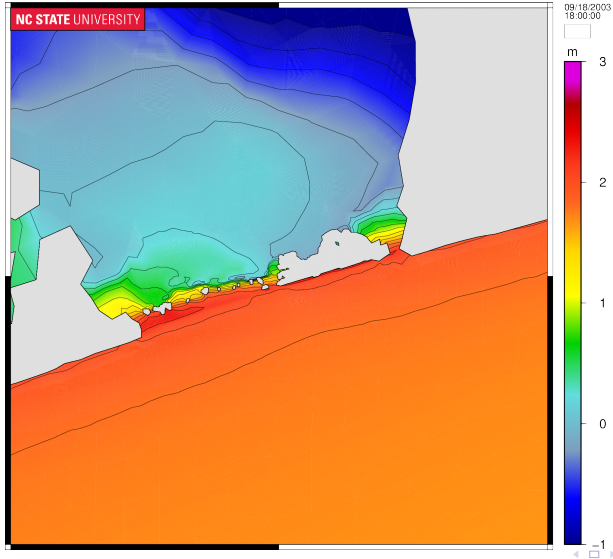

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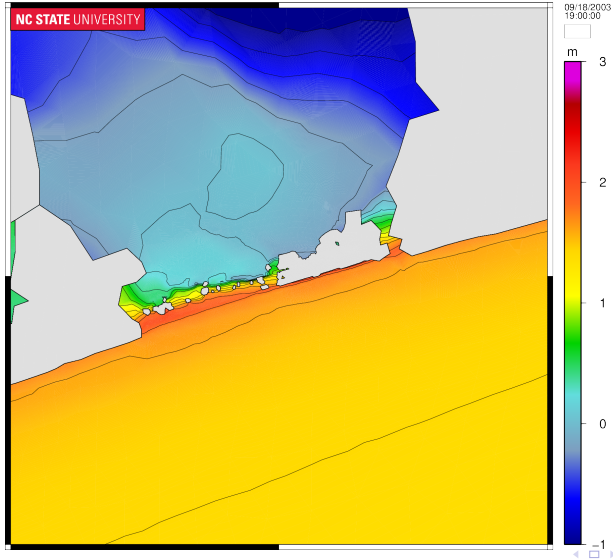

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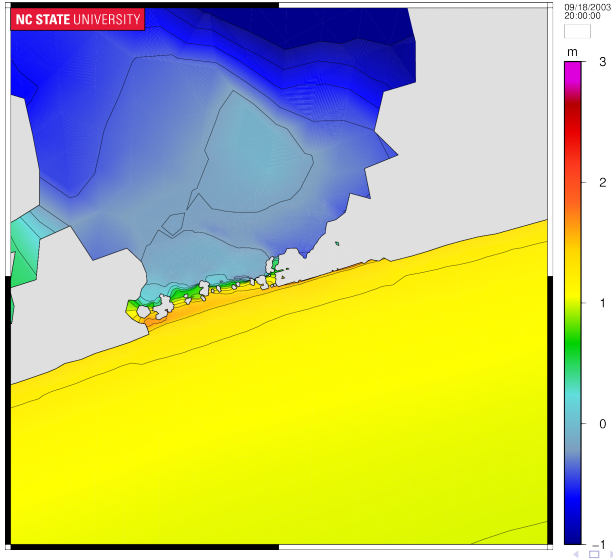

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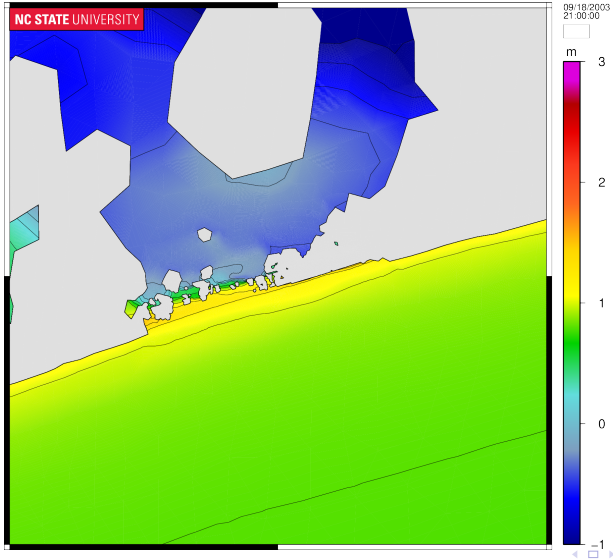

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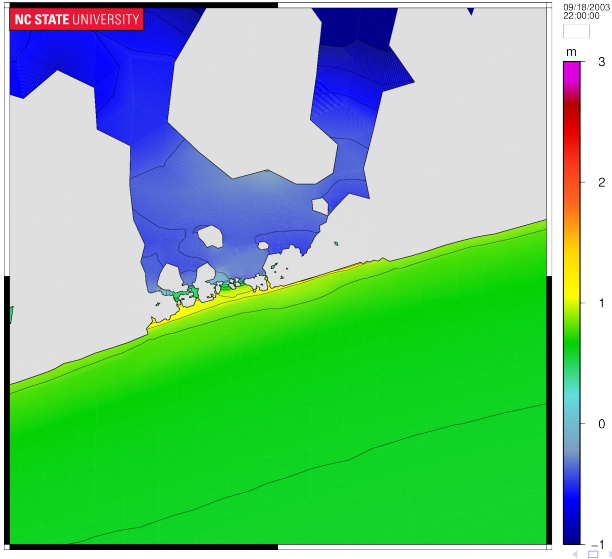

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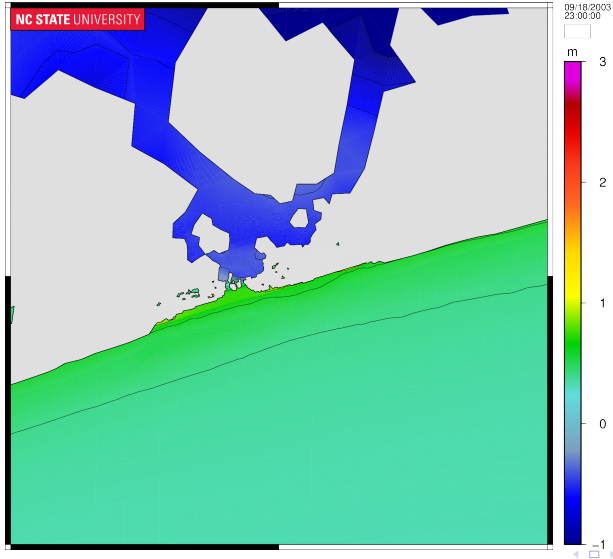

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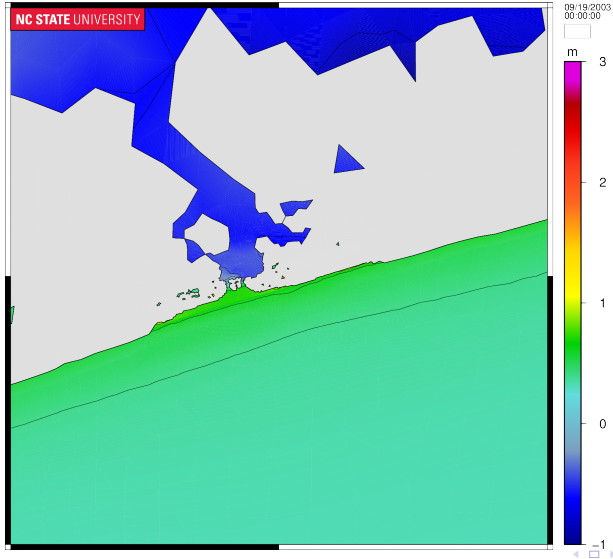

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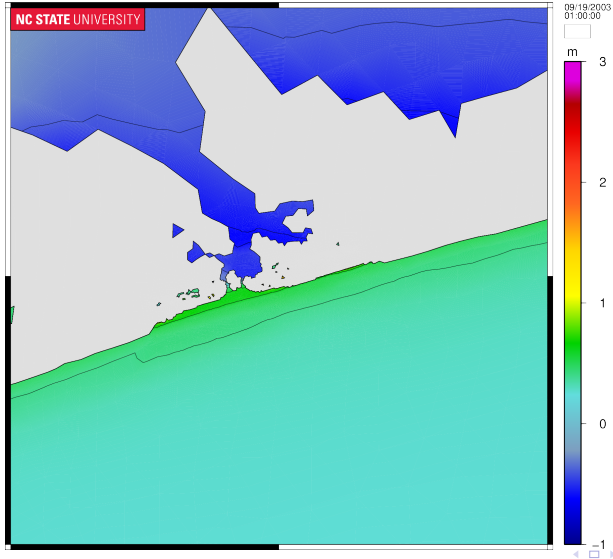

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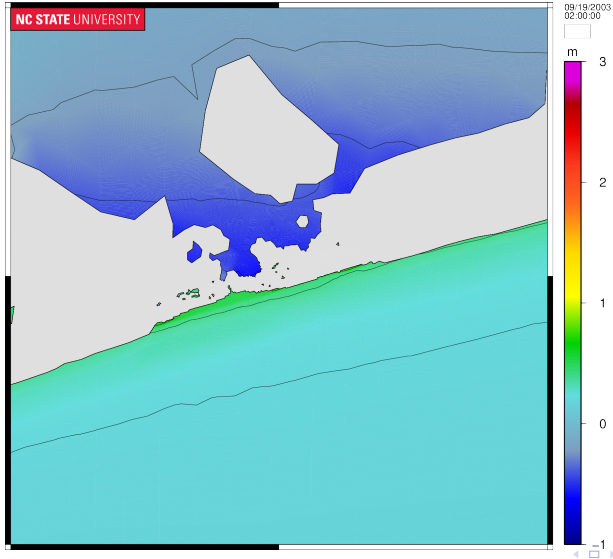

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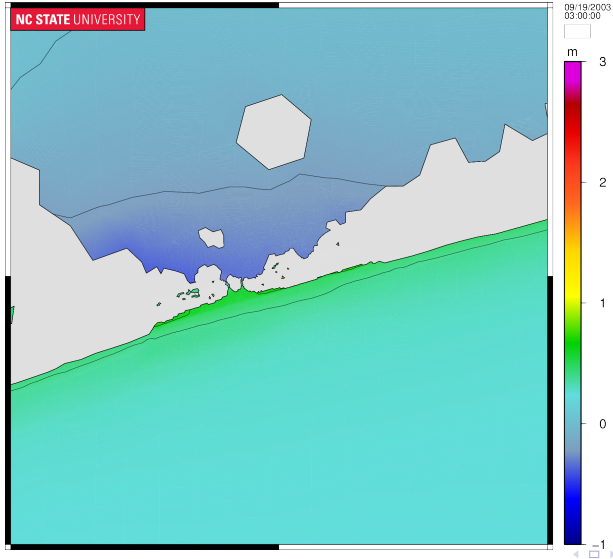

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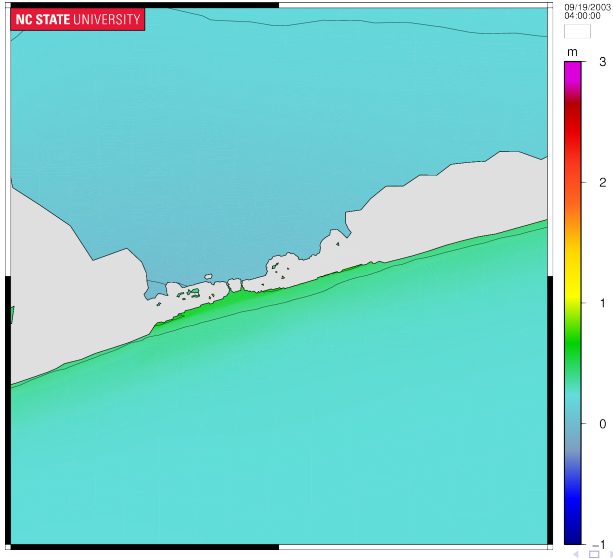

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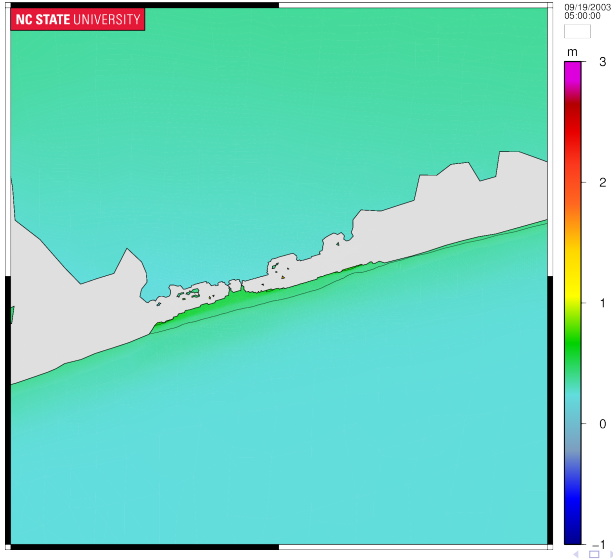

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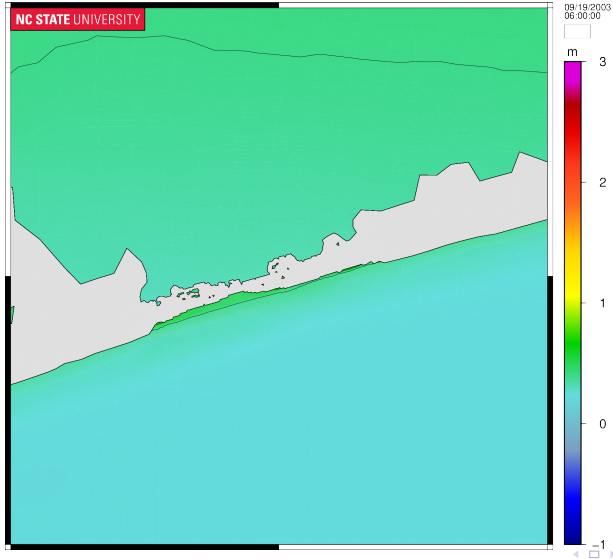

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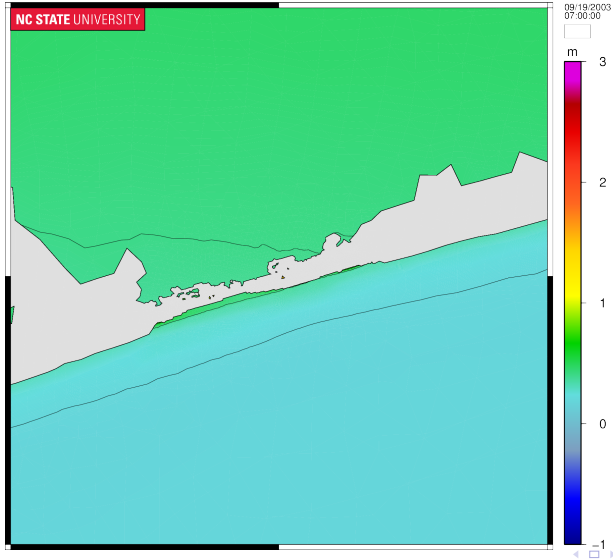

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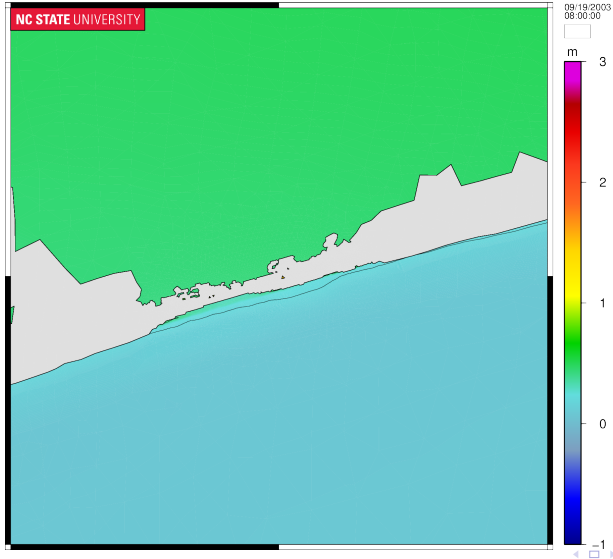

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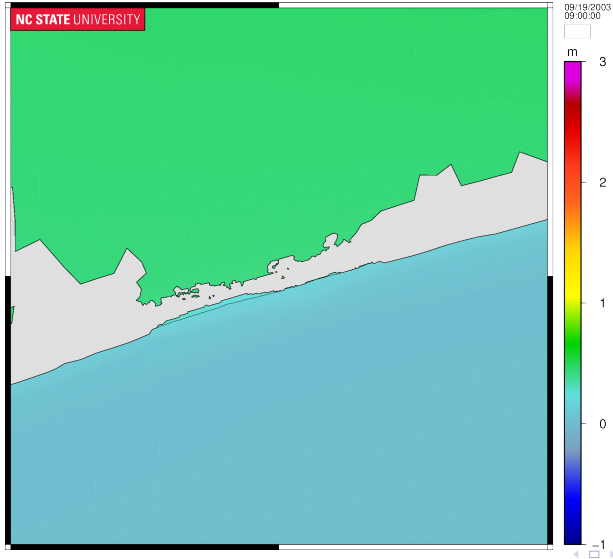

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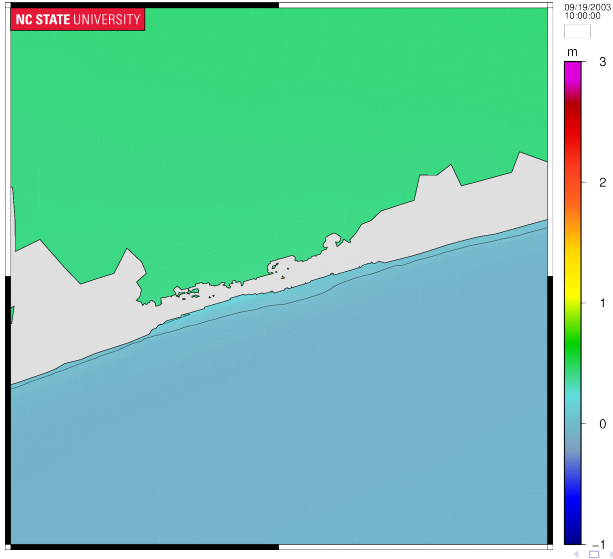

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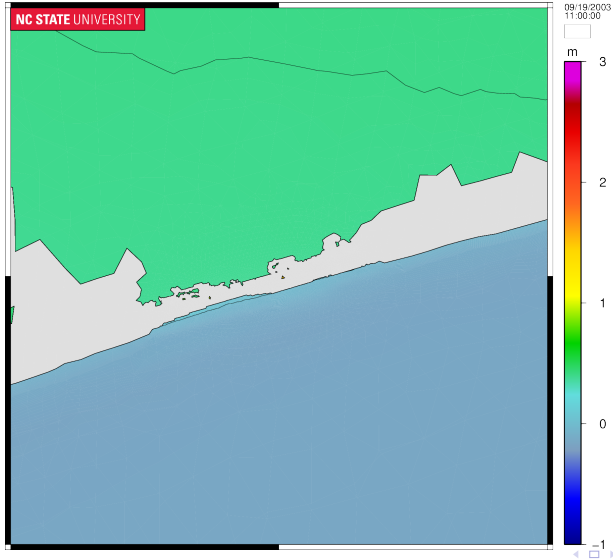

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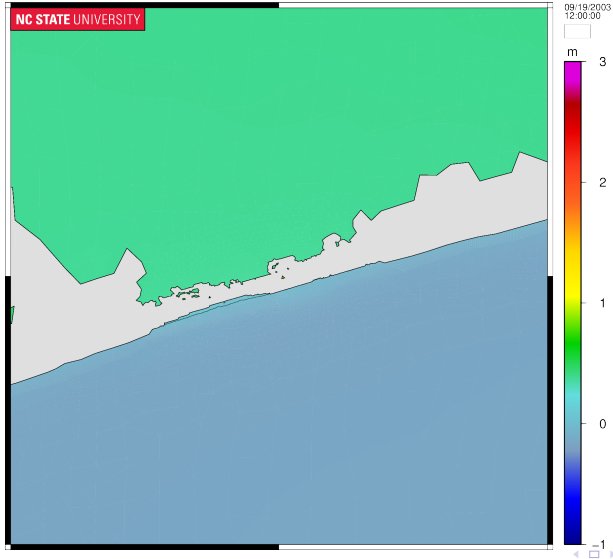

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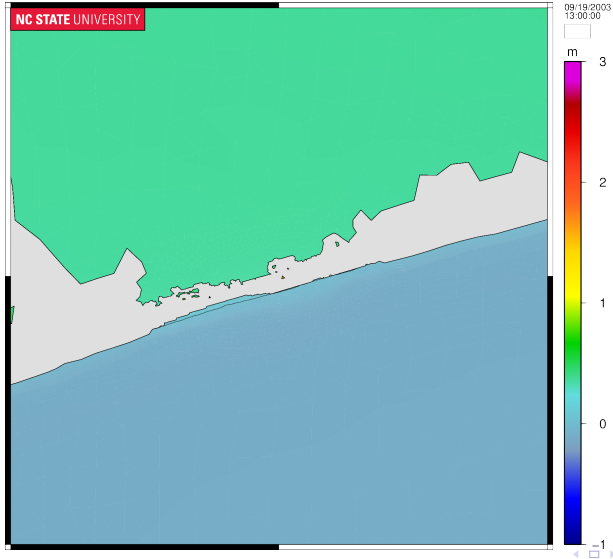

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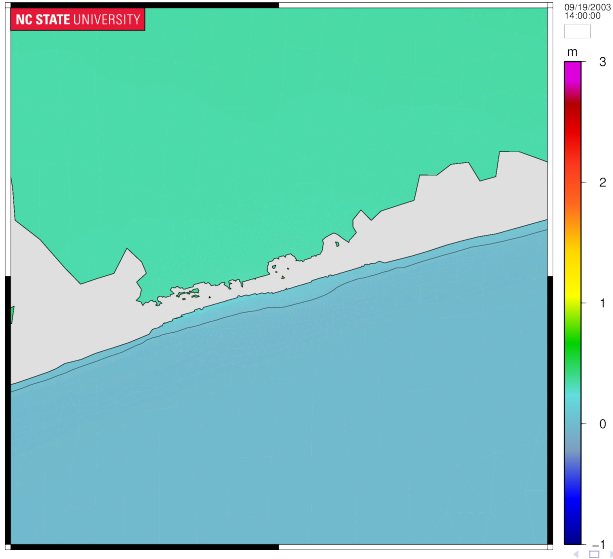

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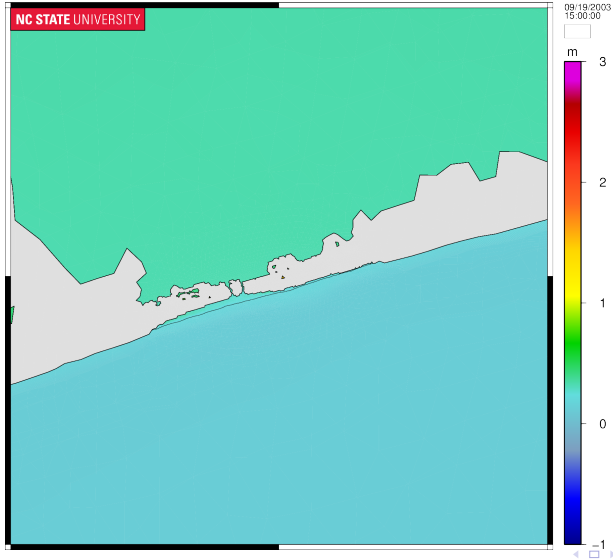

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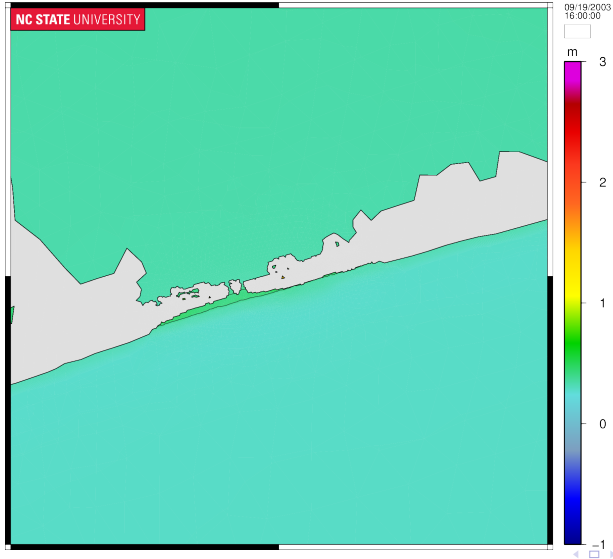

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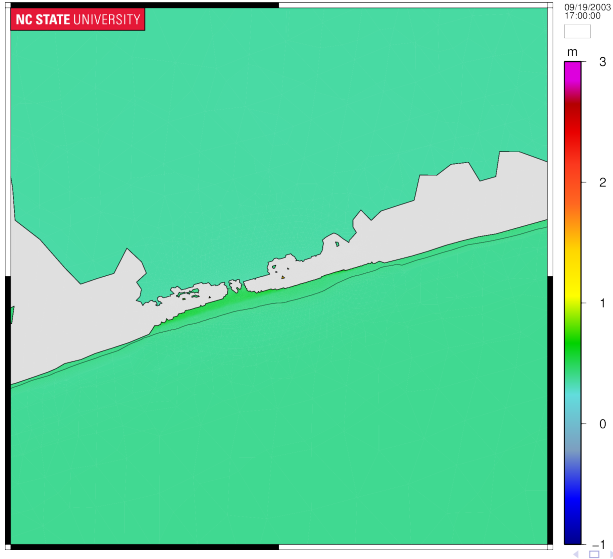
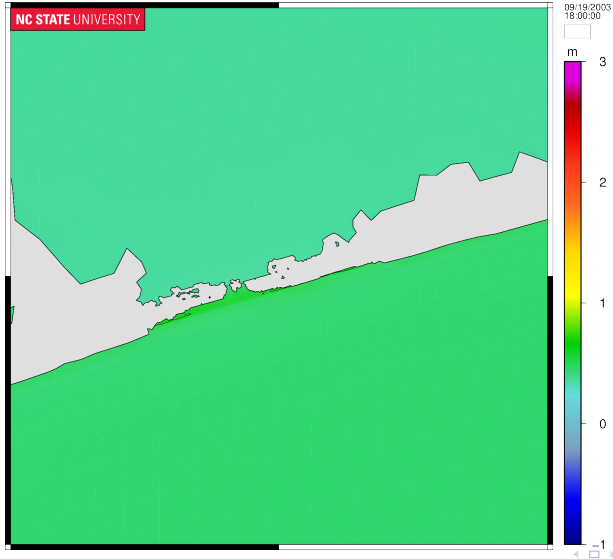


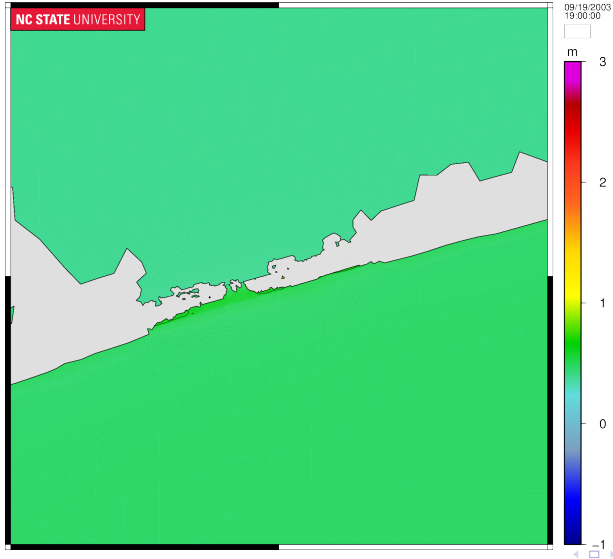
Isabel Inlet

Water Elevation



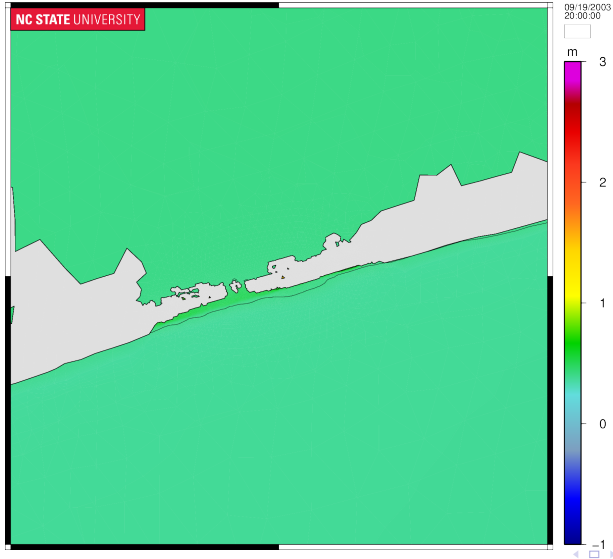
Isabel Inlet

Water Elevation



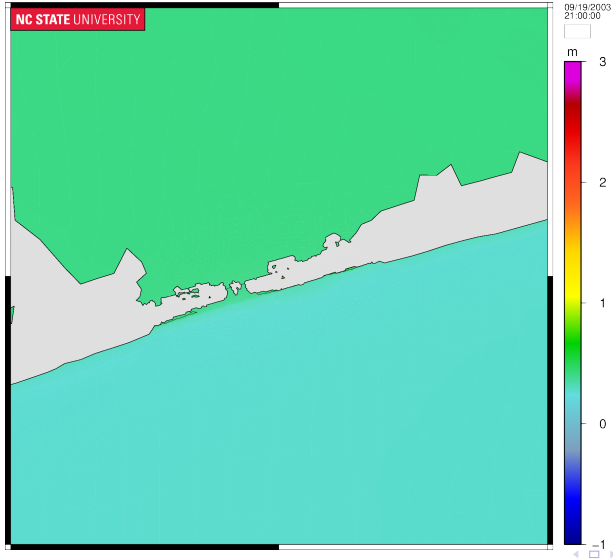
Isabel Inlet

Water Elevation



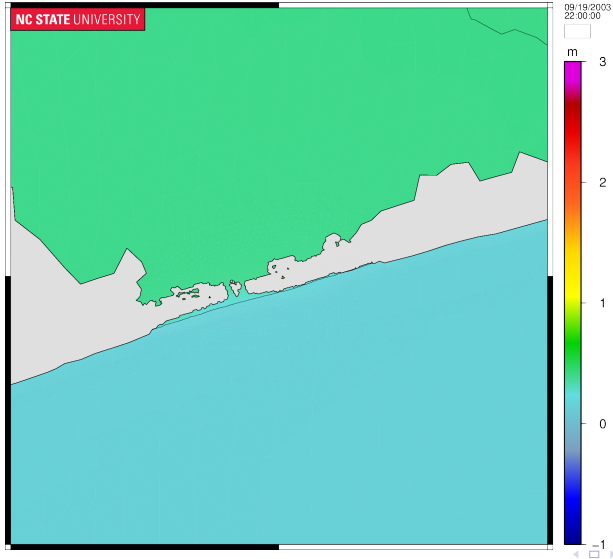
Isabel Inlet

Water Elevation



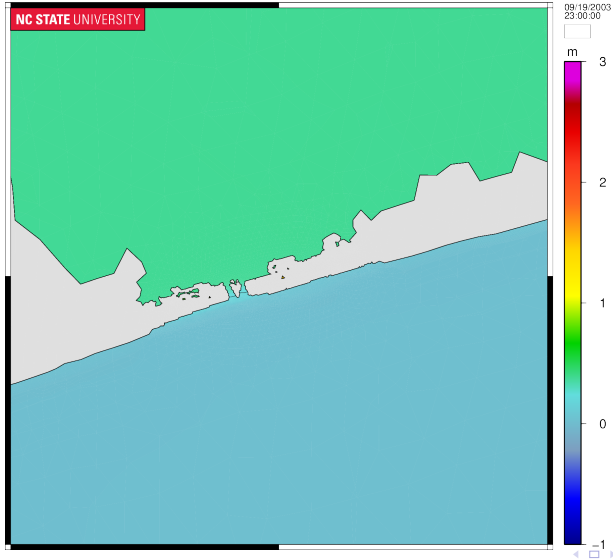
Isabel Inlet

Water Elevation



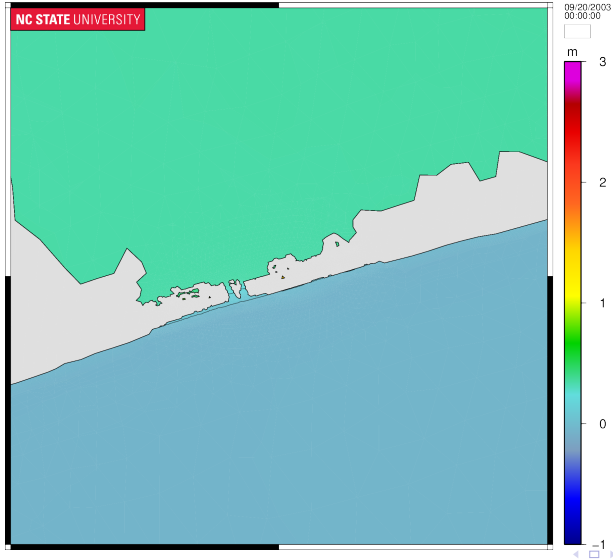
Isabel Inlet

Water Elevation



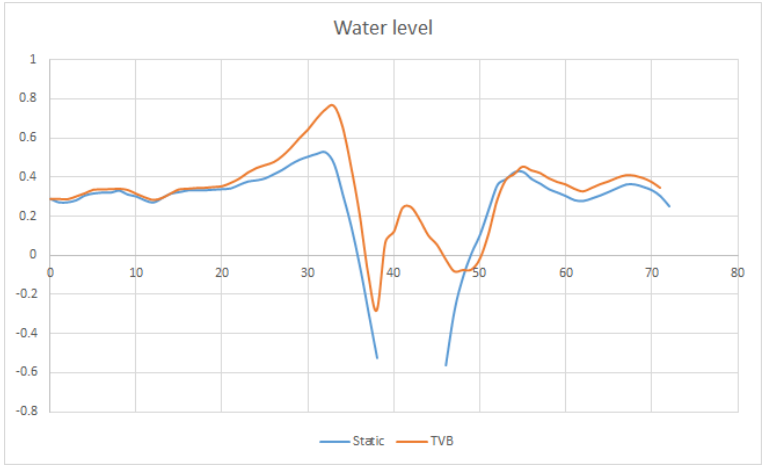
Isabel Inlet

Water Elevation

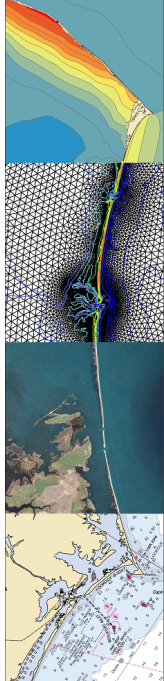


Isabel Inlet

Water level on the sound side



Summary and Future Work

Coupling of Inlet-Scale Erosion and Region-Scale Flooding

1. Static ground surface
   - Does not include erosion
   - Prevents flooding into back-bay
2. Updating the ground surface with pre- and post-storm DEMs
   - Hindcast mode
   - Timing of erosion in not accurate
3. Two-way coupling of small-scale erosion to larger-scale flooding
   - Predictive mode
   - Waves and water levels to XBeach, erosion timing to ADCIRC
   - Significant flows over and through the Isabel Inlet