Incorporating the Morphodynamics in ADCIRC Using Time-Varying Bathymetry

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Introduction
Isabel Inlet (2003)
Introduction

Existing Capability with Static Ground Surface
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Existing Capability with Static Ground Surface
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:

  ![Time Step Loop Diagram](image)

- Control over timing during simulation:

  ![Time Varying Bathymetry Diagram](image)
Time-Varying Bathymetry
Implementing the Ground Surface Change Using DEMs

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
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Post-Storm Ground Surface
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Ground Surface Variation Using Observation
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Water Elevation

NC STATE UNIVERSITY

35.22°
35.24°

35.00 m/s

09/17/2003
00:36:59

-75.68°
-75.66°
-75.64°

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Water Elevation

[Graph depicting water elevation at Isabel Inlet with NC State University logo and color scale indicating m/s and m.]
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Water Elevation
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
ADCIRC Mesh
ADCIRC + XBeach
XBeach Mesh
Domain Size:
- 2.2 km × 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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Time-Varying Bathymetry
Implementing the Ground Surface Change Using XBeach

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
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Water level on the sound side

![Water level graph]
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