A Physics-Based Classification of Coastal Land-Margins based on Surface Flow

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Introduction

Coastal Land-Margin Definition

A coastal land-margin can be defined by five essential components:

- tidal hydrodynamics
- meteorological events
- ecology
- topography / bathymetry
- freshwater inputs

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Study Area

The Area of Interest (AOI) for this study was the Northern Gulf of Mexico (NGOM), spanning from the TX/Mexico border until the Florida Keys.

Datasets

Two different datasets were used:

1. Digital Elevation Model (DEM): US Coastal Relief Model [8-10]

- 3 arc-second spatial resolution (~ 90 m)
- Topography and bathymetry in a seamless file
- Vertical Datum: Mean Sea Level

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Methods

The proposed technique is based on surface flow hydrodynamics, neglecting subsurface flow, salinity gradients, and mixing freshwater and seawater.

A one-dimensional (1-D) hydrodynamic model (Santiago-Collazo et al., 2021b) was selected for this study's modeling framework.

1-D Hydrodynamic Model

This 1-D model is a finite element model based on the shallow water equations.

Capable of simulating hydrologic and coastal processes, separately or simultaneously, using a fully-coupled technique.

Based on three modules developed using the same governing equations and a common wetting and drying algorithm:

- Coastal Hydraulics Module: simulates the coastal processes at the ocean region based on the Generalized Wave-Continuity Equation (GWCE).
- Watershed Hydraulics Module: computes the rainfall-runoff at the inland region where rainfall is falling using the Kinematic Wave Equations.
- Overland Hydraulics Module: routes the rainfall-runoff over inland regions where the rainfall is not falling using the GWCE.

Due to its 1-D nature, the model has the following benefits over a 2-D model:

- requires less amount of input data (e.g., domain description and environmental forcings)
- capable of performing numerous simulations at a low computational cost

Thus, this 1-D model is suitable to scare-data coastal land-margins that are prone to compound flood (e.g., Bay of Bengal, Philippines, Central

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Results

Typology

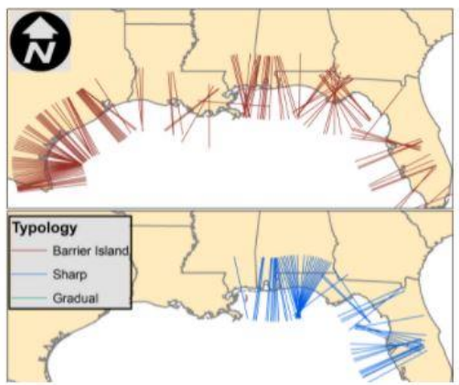
Results show that barrier island transects can be found through the entire AOI.

Sharp transects are mainly clustered within the Florida Panhandle (including Alabama) and the Tampa (FL) region.

Gradual transects are mainly clustered between the Apalachicola Watershed (FL) through the north of Tampa (FL) and east of Galveston Bay (TX) through Louisiana.

The majority of the transects fall within the Gradual (32%) and Barrier Island type (28%), while the second least type was the Sharp transect with 12%.

- Estuary and Inland Waterbody transects had a 23% and 5%, respectively, and were mainly clustered in Louisiana (not shown here).



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Future Work

- Determine rainfall intensities at a daily temporal scale that represents the NGOM climatology.
- Implement machine learning techniques to improve the idealized transect delineation.
- Evaluate the hydrodynamic response of idealized transect with more segments (e.g., 5 to 10 segments).
- Perform a Monte Carlo Simulation using the environmental forcing combinations to produce a simulation forcing set.
- Include a compound flood scenario based on astronomical tides, storm surge, and rainfall-runoff.
- Define the physics-based parameters to classify the coastal land-margins into low-, medium-, and high-gradient.
- Extend the analysis to the US Atlantic Coast

Summary & References

- A transect typology can be established based on similar characteristics to a large spatial extent.
- An automated procedure can be developed to extract data and processes it for creating idealized profiles.
- The transect typology established reesemble the current conditions at the study area.
- A low-computational cost hydrodynamic model is required to simulate thousands of environmental forcings combinations.
- Systematic and automated procedures like the

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