CONNECTING THE DOTS TO INNOVATION

Testing Innovative Tools for Inlet Geomorphic Mapping: Overview and Applications

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ENGINEER RESEARCH & DEVELOPMENT CENTER

AGENDA

- Project Team
- Project Background and Motivation
- Summary of Feb. 2024 CIRP TD (Shawler and Sylvester)
- Recent Work
  - Tool Refinement
    - Improving workflows
    - Code improvements/updates
  - Diversifying Inlet Test Sites
- Anticipated Applications and Products

PROJECT TEAM

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Co-PIs:
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Research Team:
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Eli Greenblatt (NAN)
Dag Madara (NAN)
Laurel Reichold (SAJ)
Suzie Rice (NAN)

Coastal Engineering Branch PDT/Advisors:
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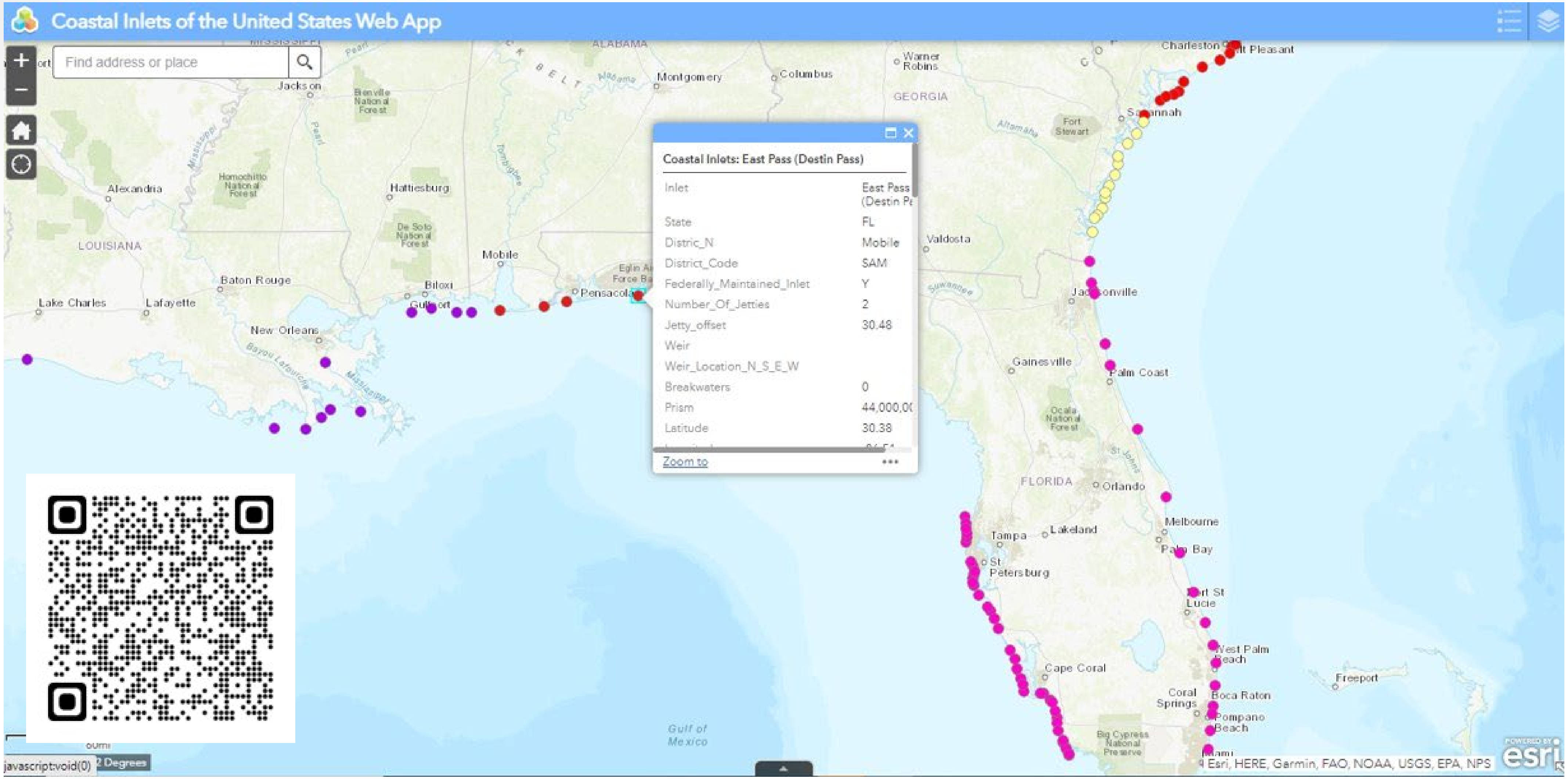
Michael Hartman (ERDC CHL-CEB)

PROJECT BACKGROUND

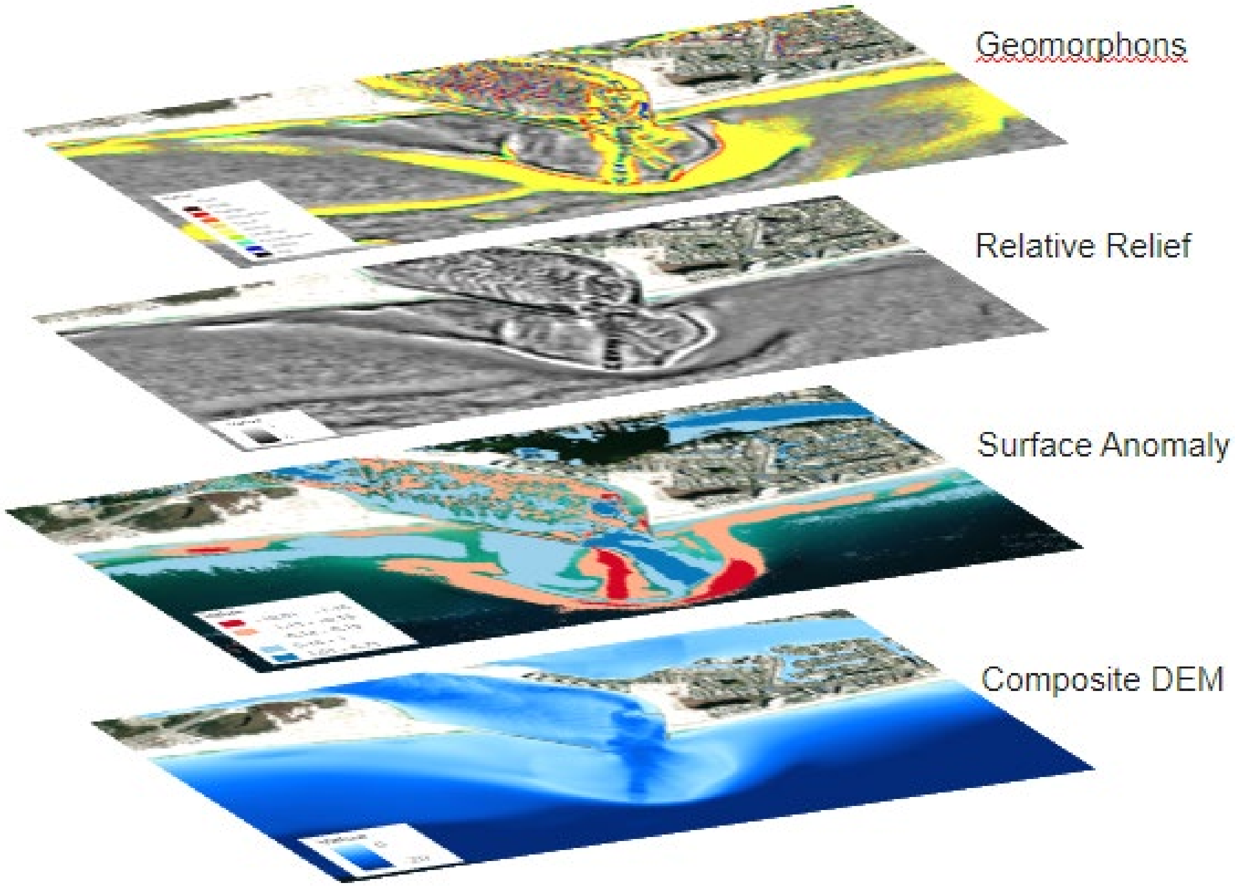
- District Needs
  - Track Inlet Geomorphic Features
    - Optimize dredging and placement
    - Reduce need for or optimize modeling
    - Identify sandy material features
      - Potential borrow sites
        - » Recharge rates?
      - Inputs to sediment budgets
  - Ready-Made Products and User-Friendly Tools

PROJECT BACKGROUND AND MOTIVATION

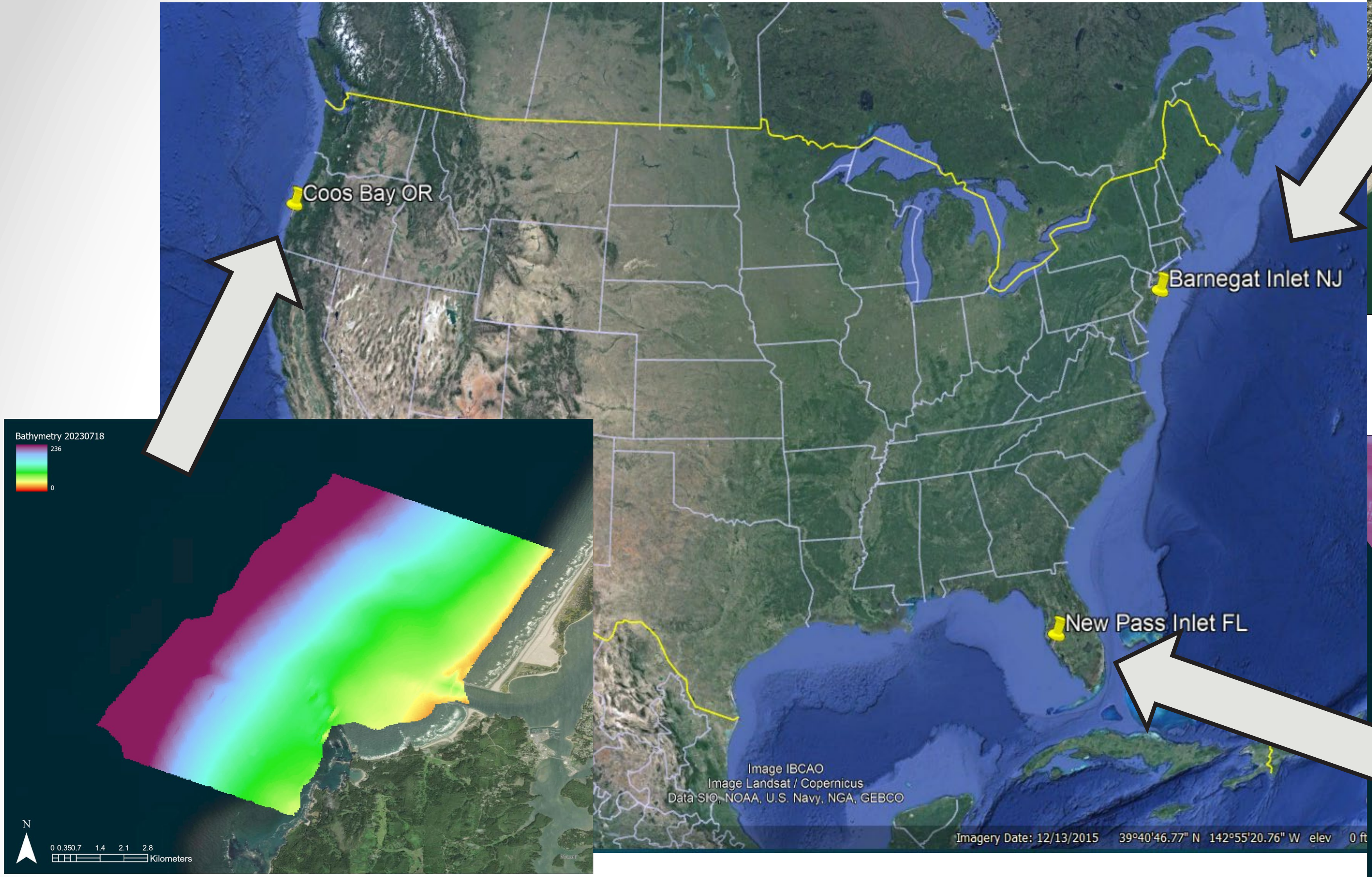


SUMMARY OF CIRP TD (FEB. 2024)

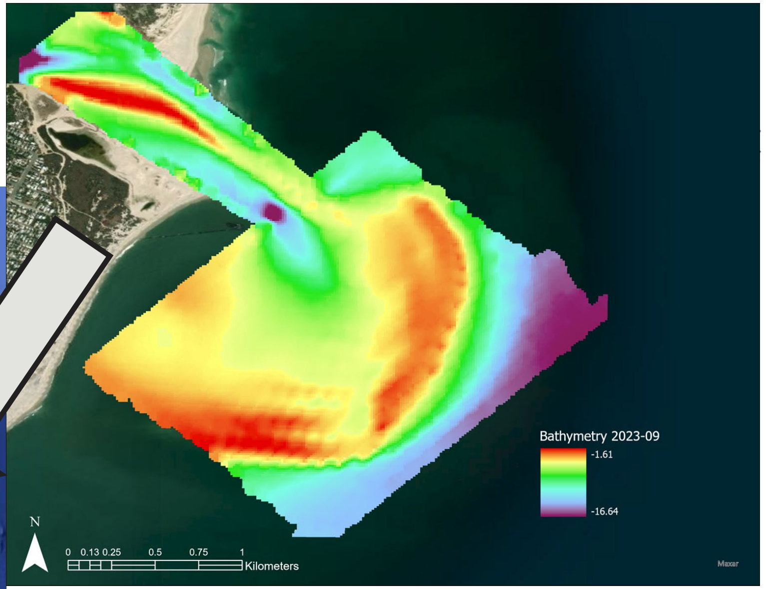
- Initial testing and establishment of workflows for:
  - DEM compilation
  - Relative relief mapping
  - Geomorphons
  - Chronostratigraphy + conformal mapping
- Testing of data rich vs poor inlets



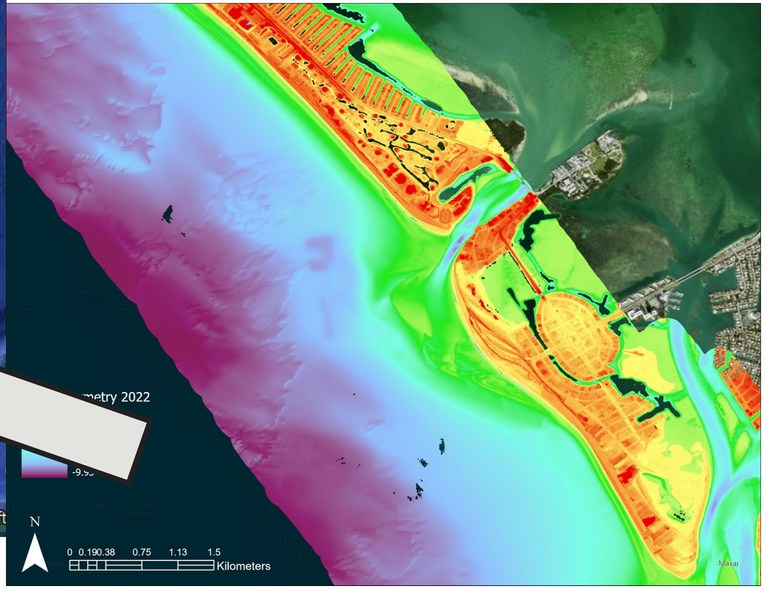
NEW STUDY SITES



Coos Bay, Oregon



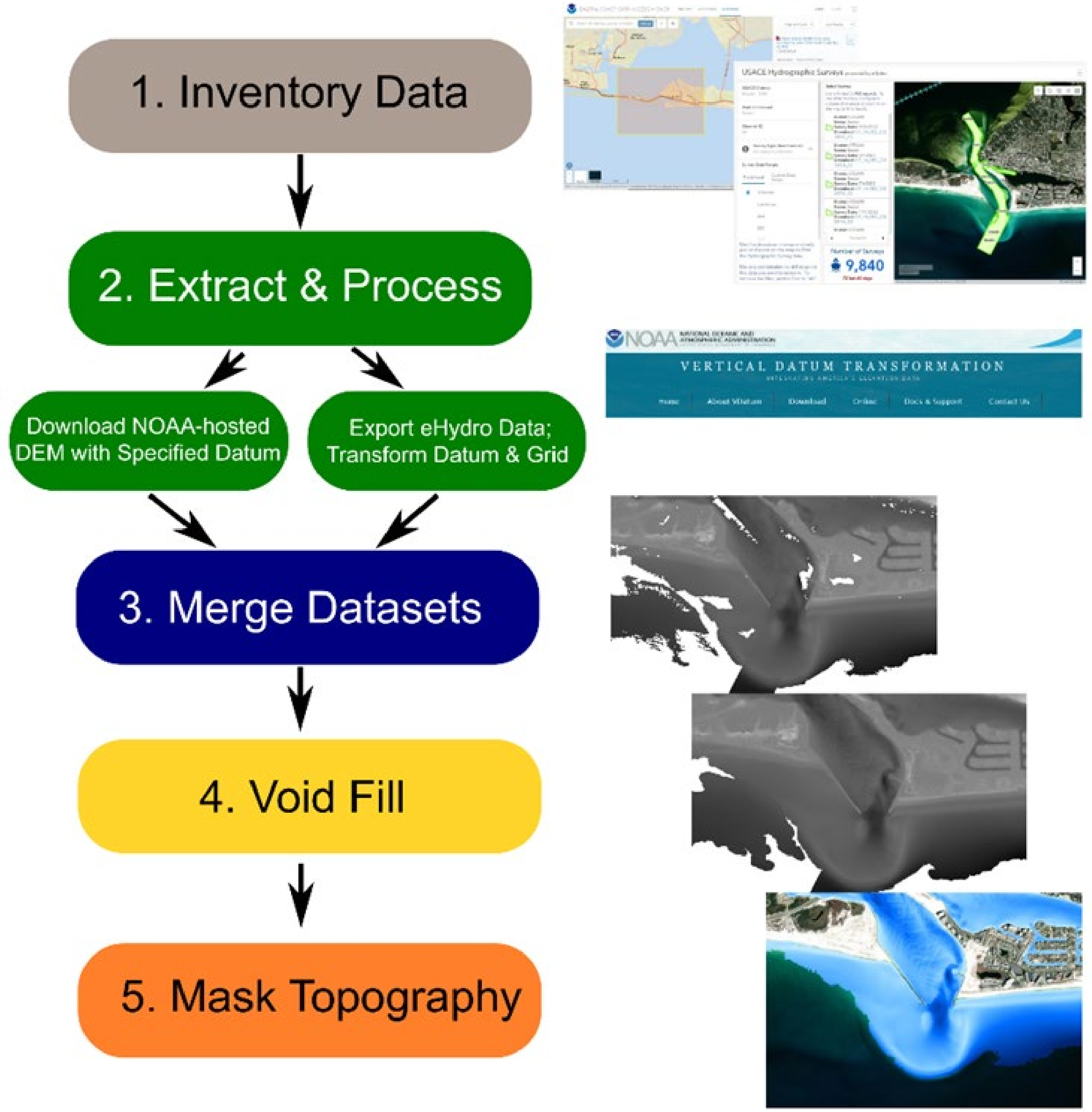
Barnegat Inlet, New Jersey



New Pass Inlet, Florida

BATHYMETRIC DATA COMPILATION WORKFLOW

- NCMP (USACE) topobathymetric lidar data were merged with USACE District-collected bathymetric data (eHydro)
  - Match datums/coordinate systems
  - Mosaic
  - Grid to 3 m
  - Voids filled using IDW interpolation
  - Topographic data masked out



DEM compilation workflow.

RELATIVE RELIEF

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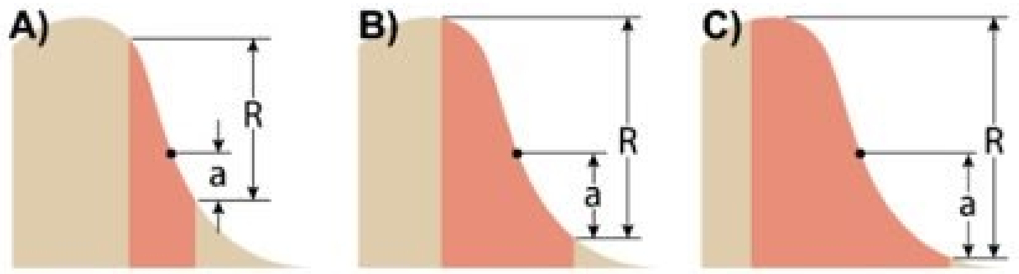
- Relative difference in elevation of each grid cell to neighborhood
  - Ranges from 0 (no relief) to 1 (maximum local relief)
- Repeat analysis with different neighborhood sizes to identify different scales of relief

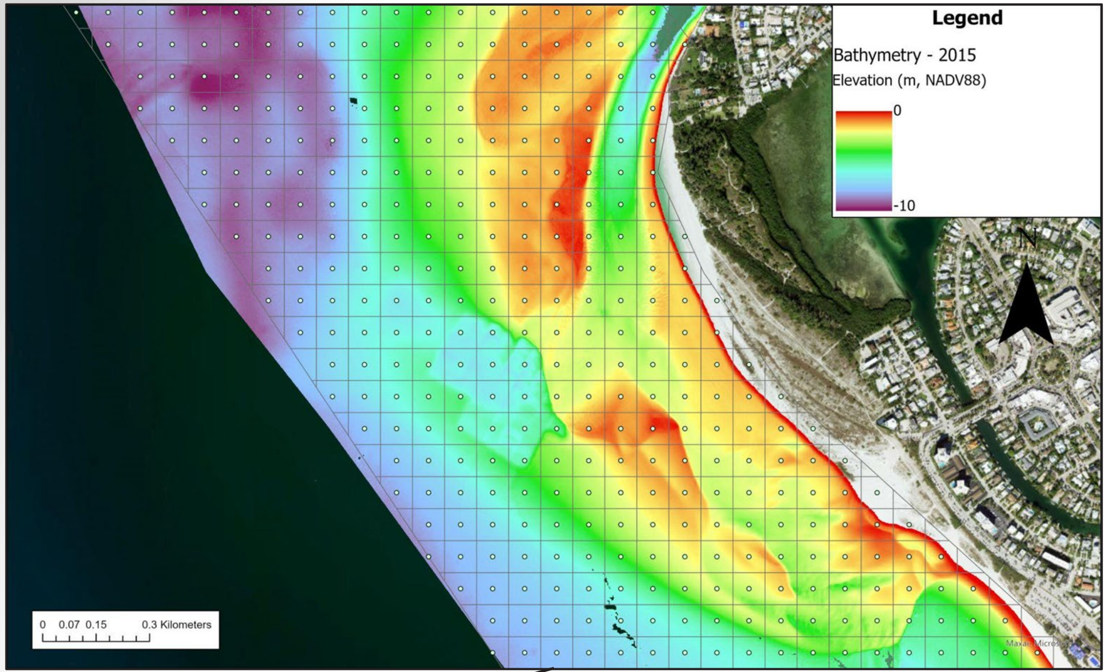
$$RR_c = \frac{(z_c - z_{min})}{(z_{max} - z_{min})}$$

Relative relief at the center location of a window (RRc), calculated using the elevation at the center of the window (Zc) and the minimum (Zmin) and maximum (Zmax) elevations within the window (Wernette et al., 2016).

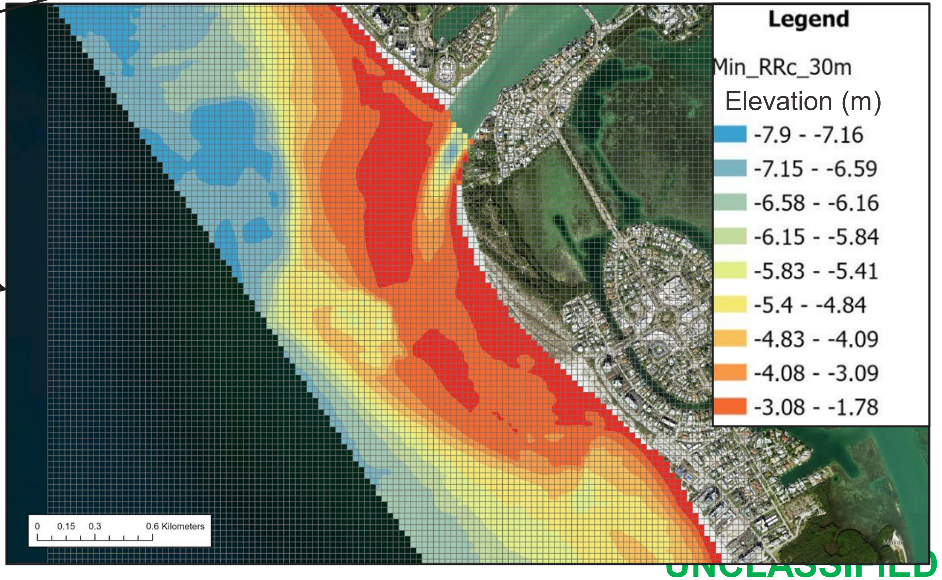


Example of how changing the window size (a) affected the calculated RR for a small (A), moderate (B), and large (C) window size (figure from Wernette et al., 2016).

RELATIVE RELIEF: example



Zonal Statistics:
- Max
- Min
- Range
- Mean
- Median
- Sum
- Std Deviation

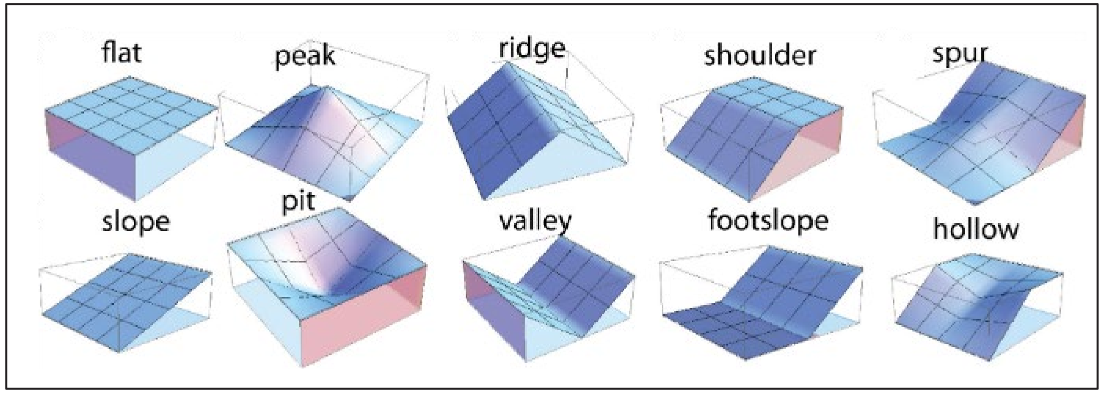


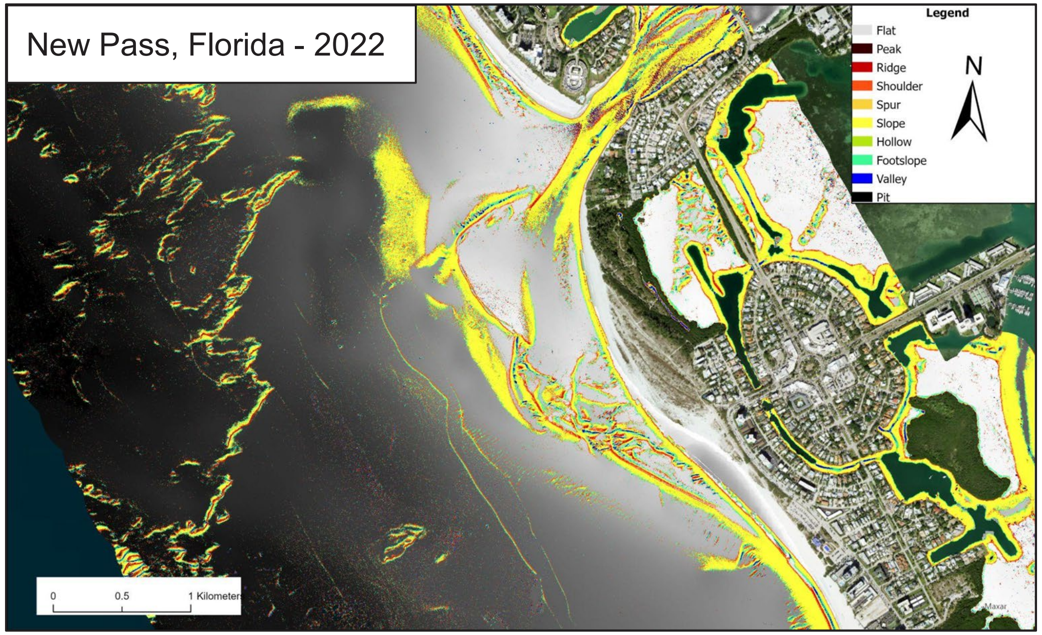
Fine-scale RR: 10m window

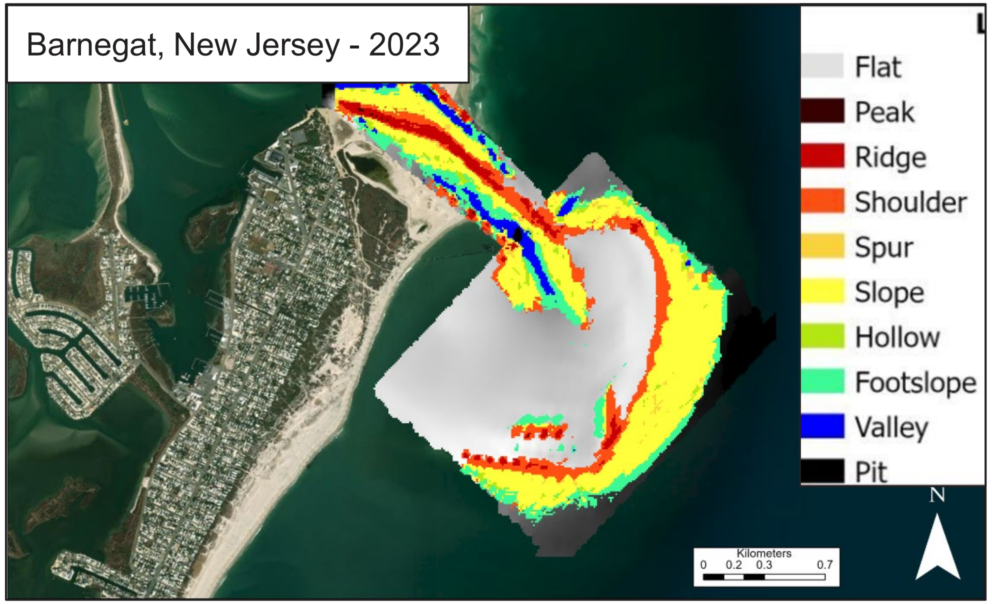
Broad-scale RR: 30m window

GEOMORPHONS

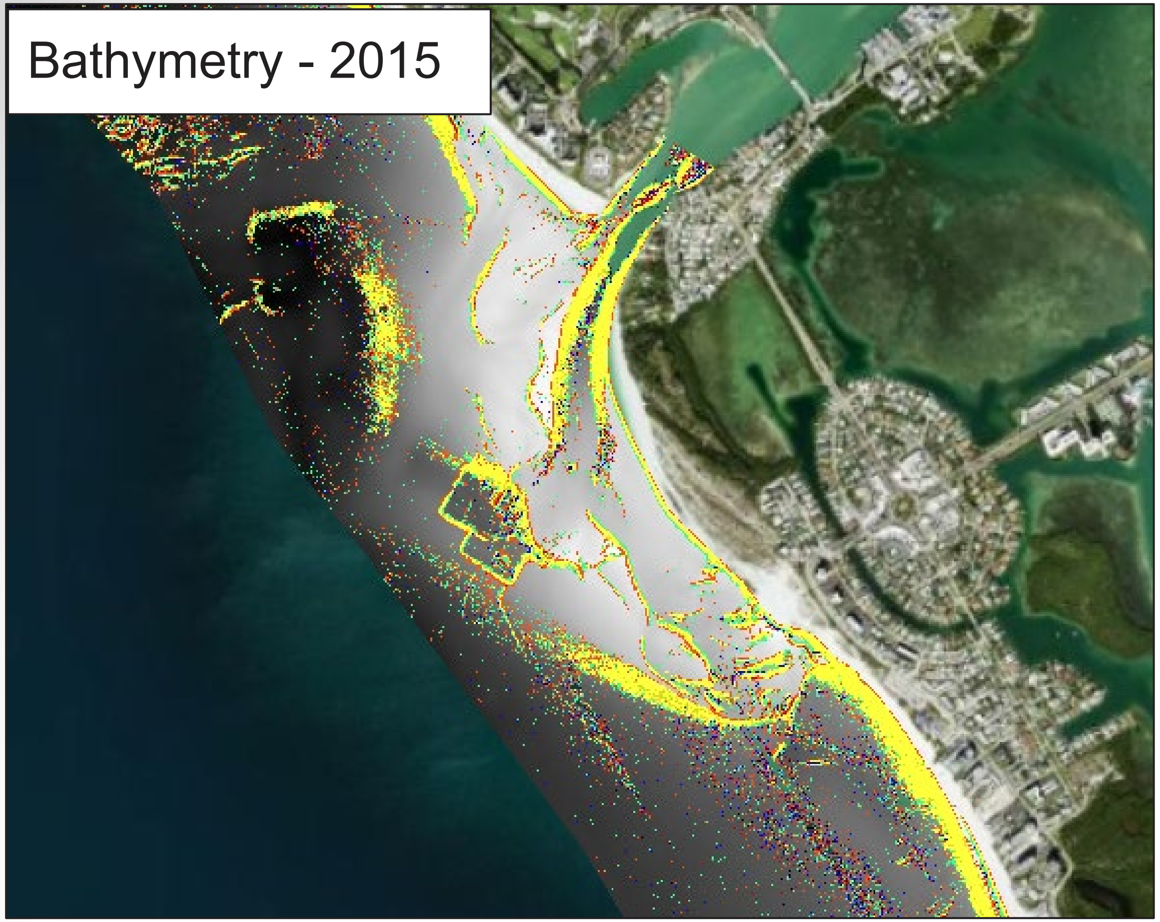
- The Geomorphon Landforms tool is based on algorithm that combines elevation differences and visibility concepts to classify terrain into landform types (Jasiewicz and Stepinksi, 2013).
- The approach uses 10 landform types (i.e., flat, peak, ridge, shoulder, spur, slope, hollow, footslope, valley, and pit) to classify pixel data in a digital elevation model.







GEOMORPHONS: example

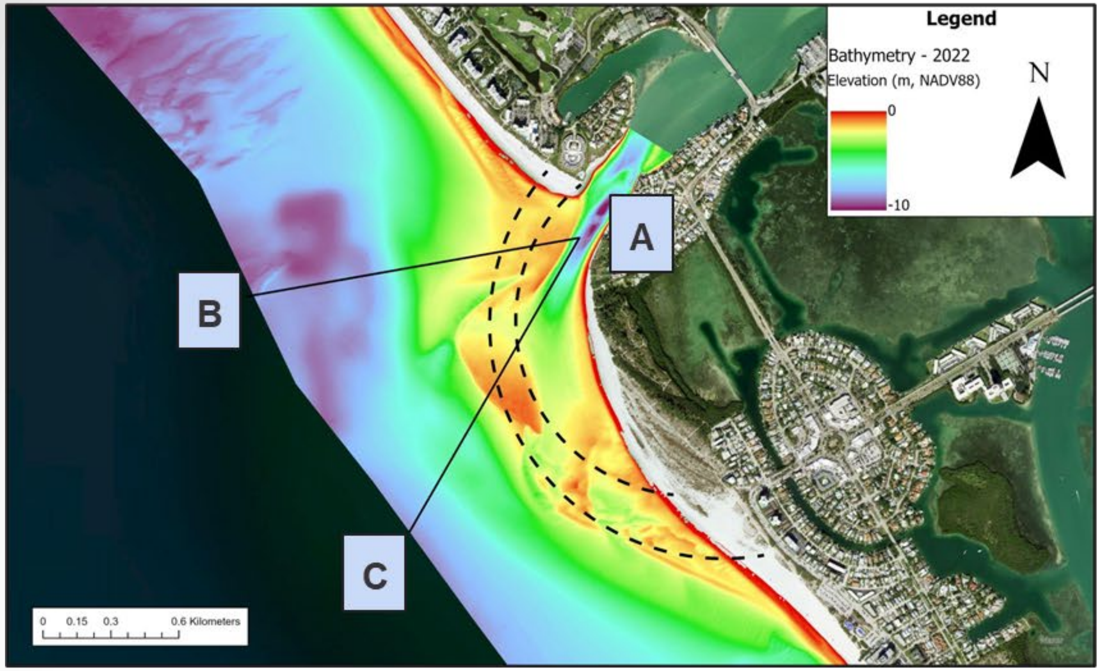


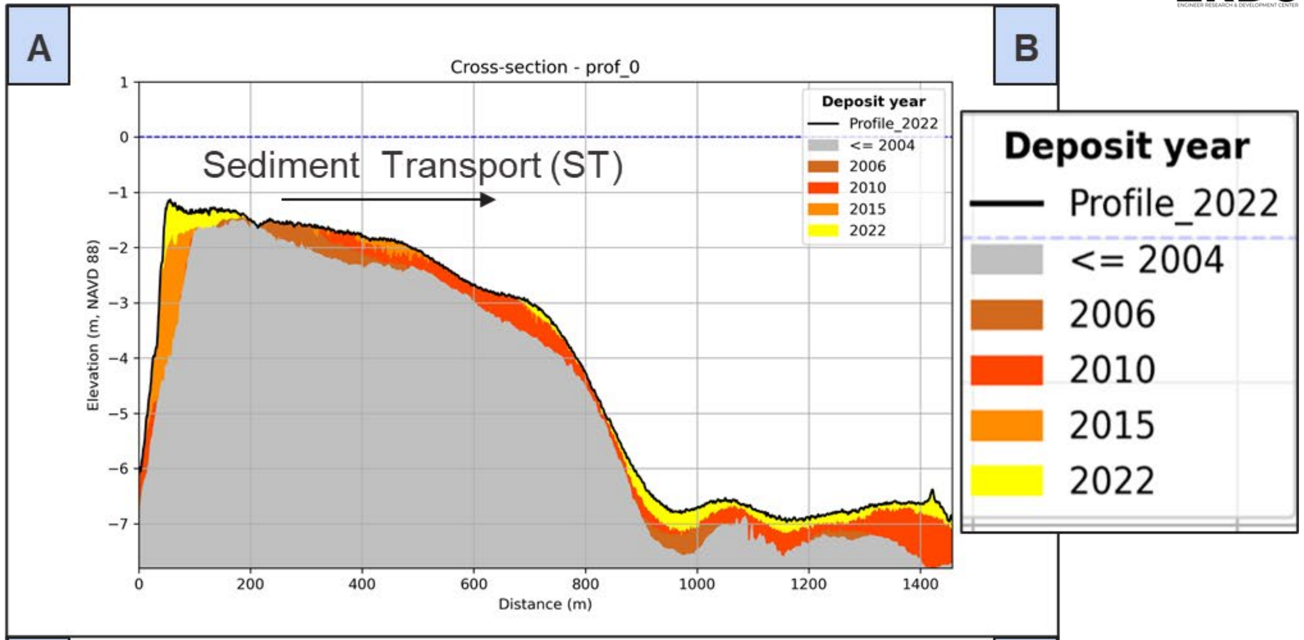
Raster cell size = 1m
Flat terrain angle threshold = 1.5
Search distance = 15 m
Skip distance = 4 m

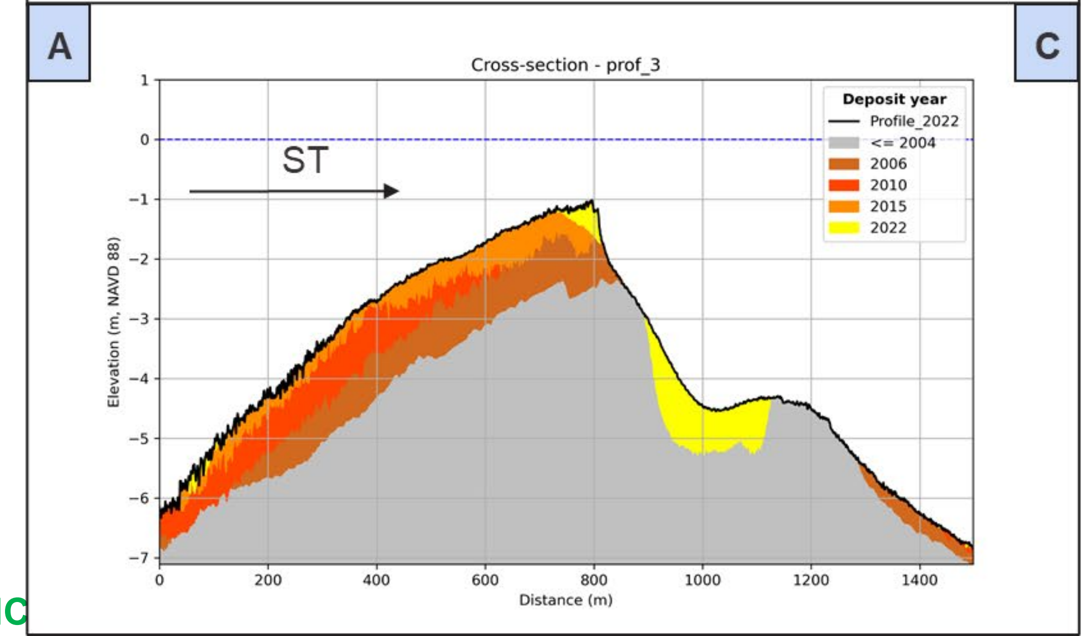
Raster cell size = 10m
Flat terrain angle threshold = 0.17
Search distance = 150 m
Skip distance = 40 m

CHRONOSTRATIGRAPHIC ANALYSIS: example 1

- The chronostratigraphy followed the methodology outlined by Pearson et al. (2022). This stratigraphy illustrates the delta's depositional behavior over space and time.



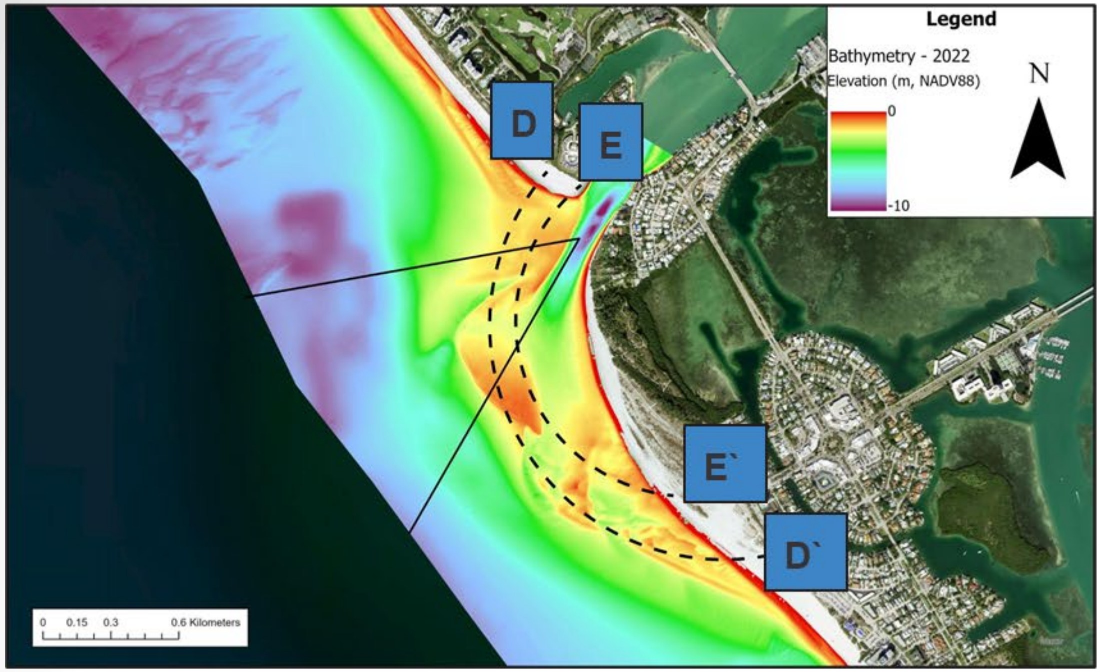


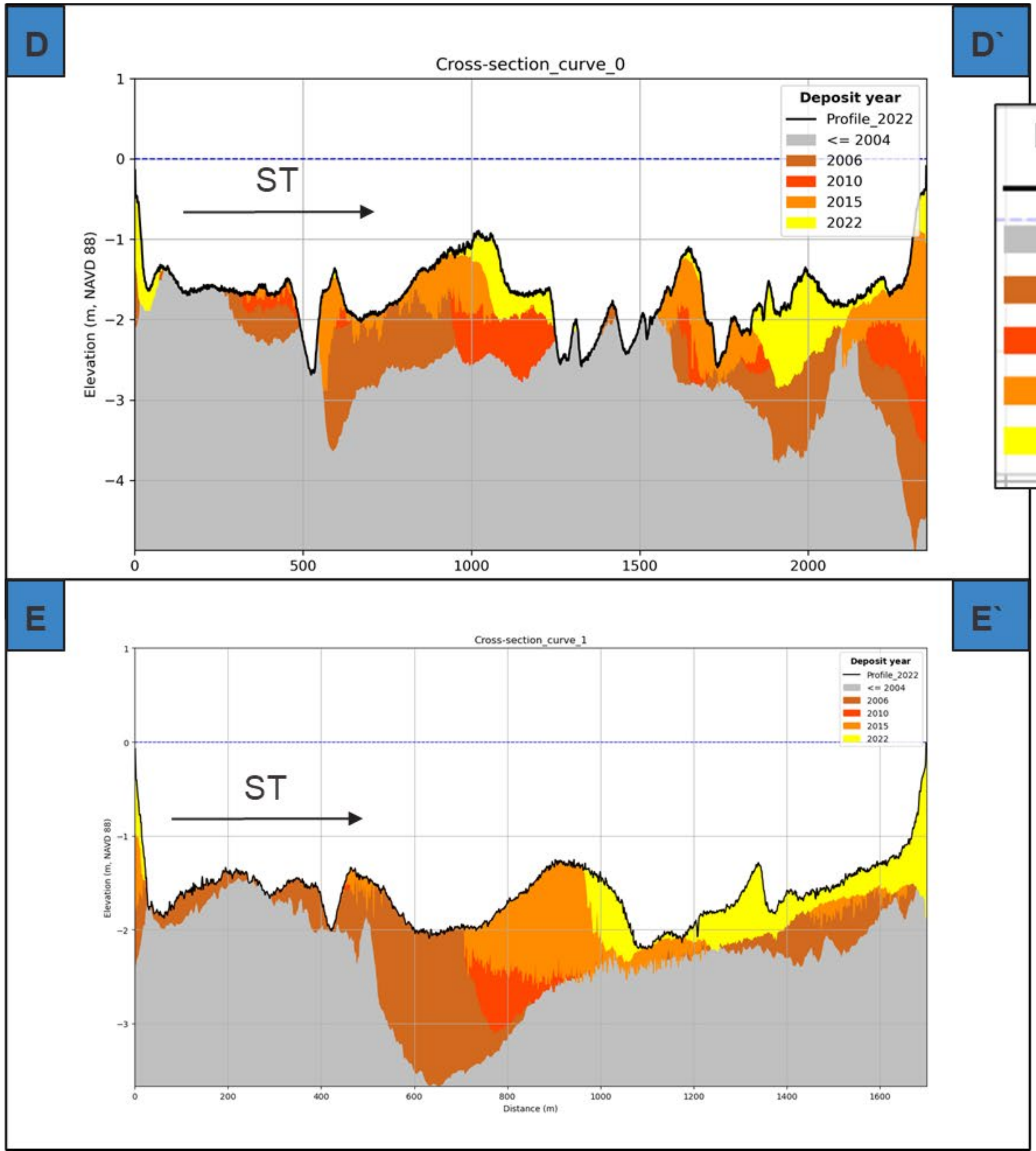


Bathymetric data:

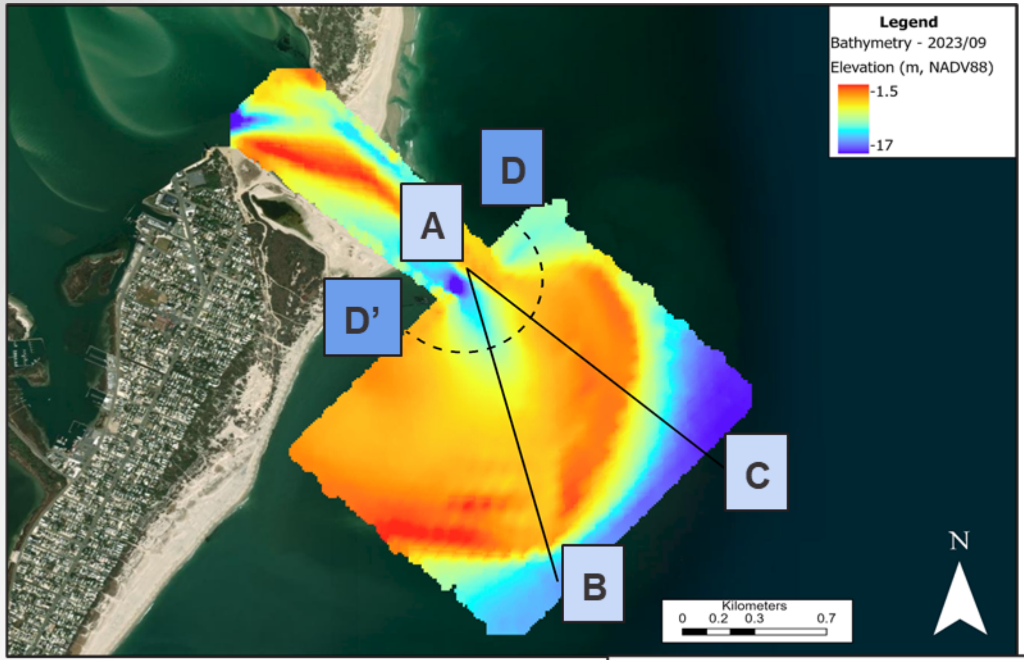
-2004
-2006
-2010
-2015
-2022

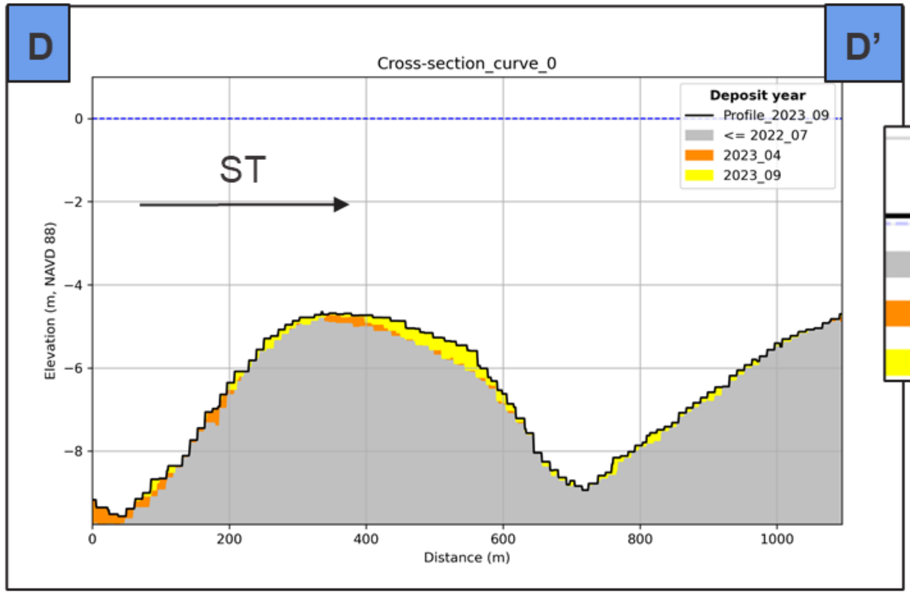
CHRONOSTRATIGRAPHIC ANALYSIS : example 2

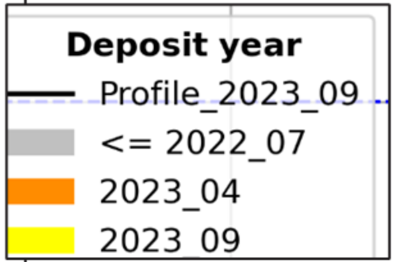




CHRONOSTRATIGRAPHIC ANALYSIS : example 3







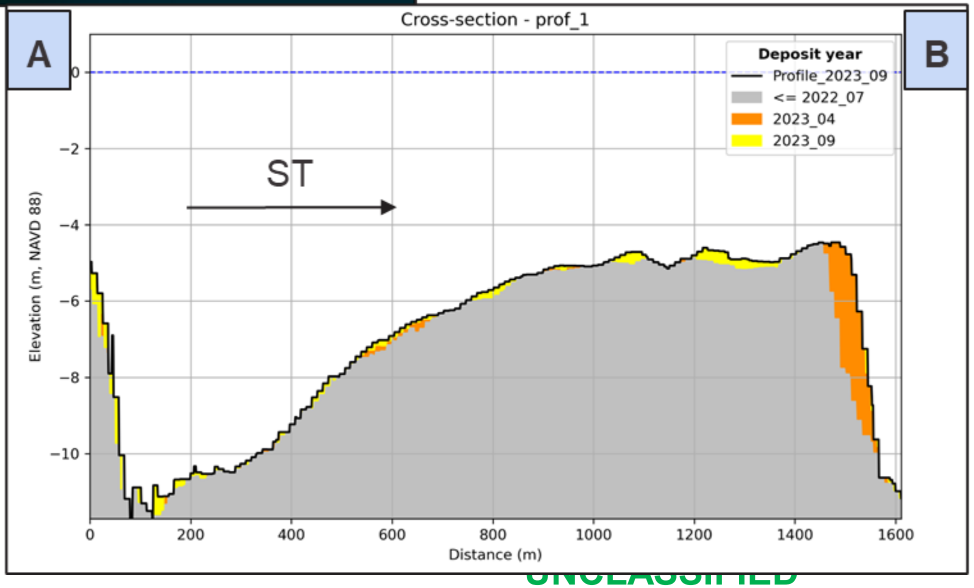
Short-term evolution of the ETD

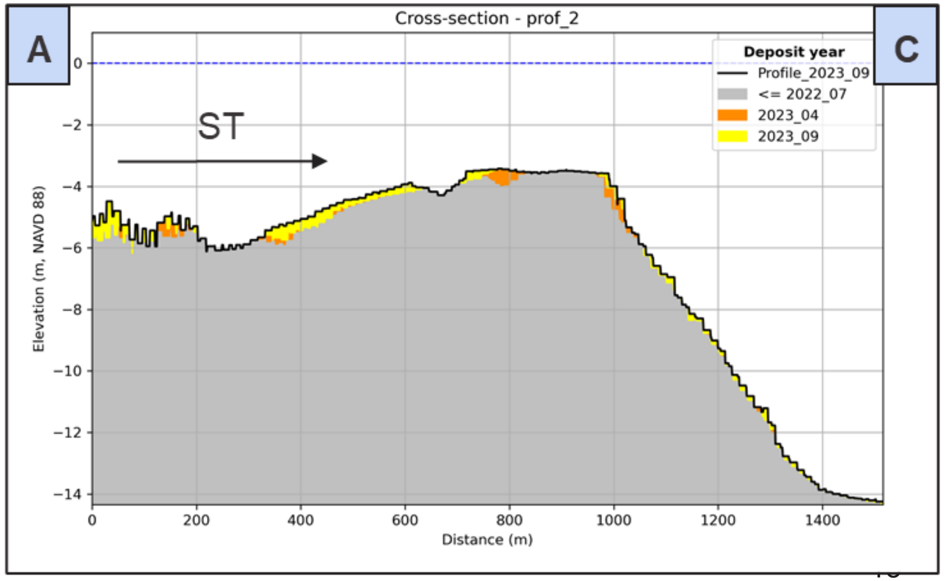
Bathymetric data:

-2022/04

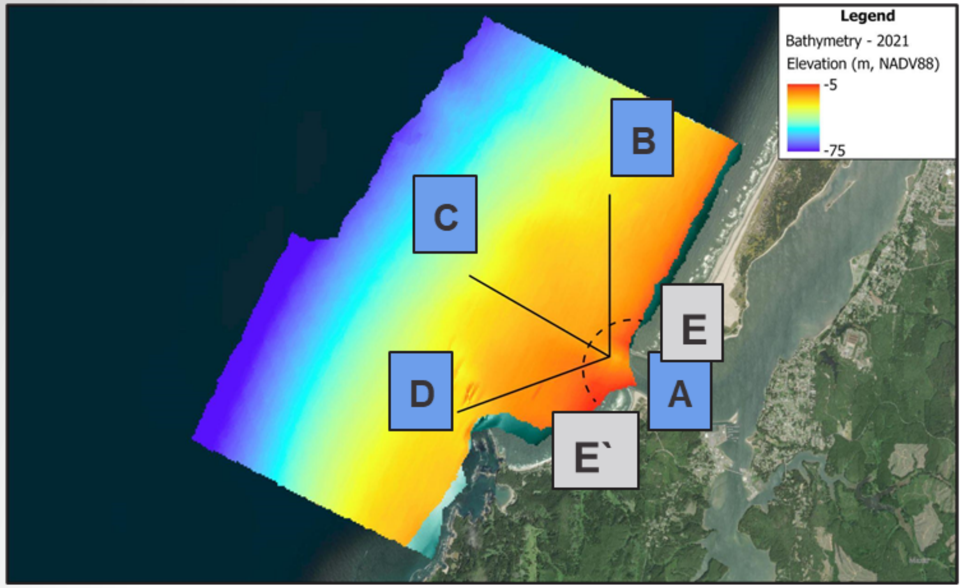
-2023/04

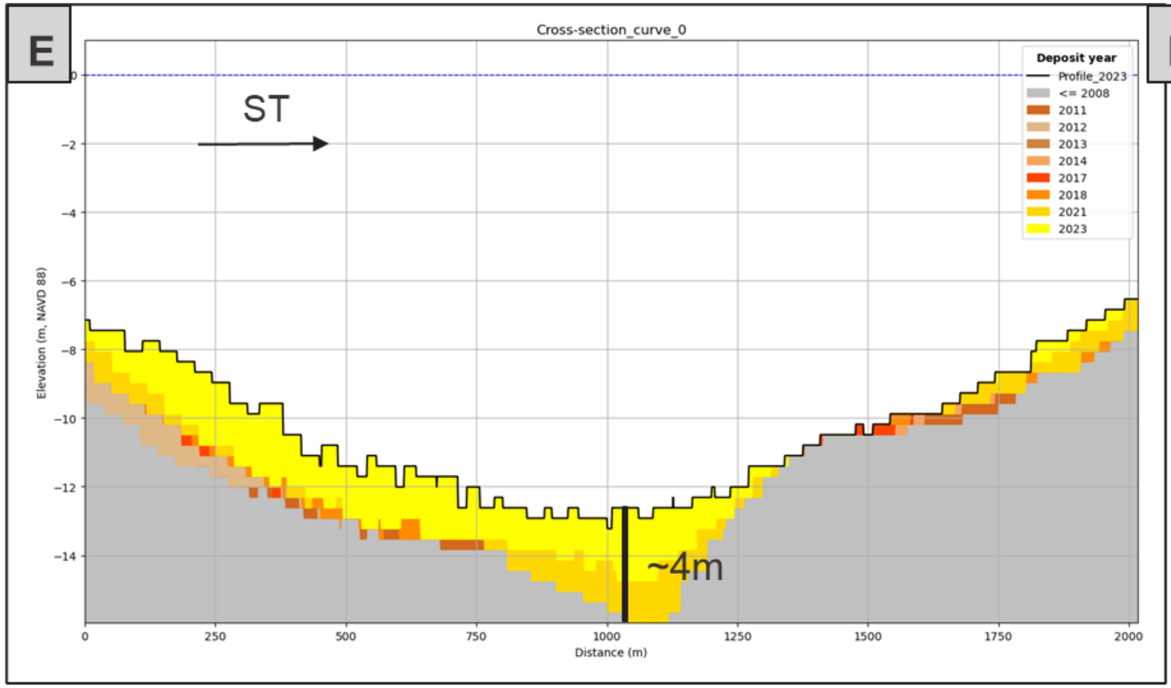
-2023/09

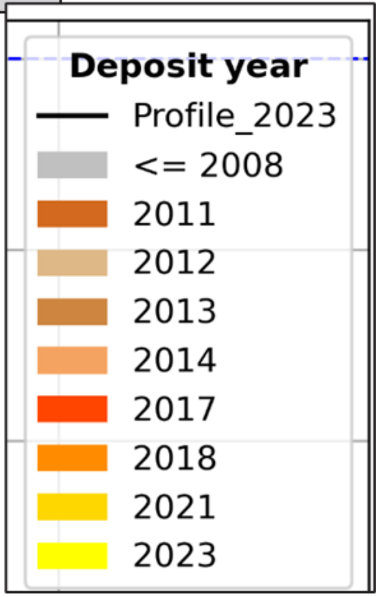


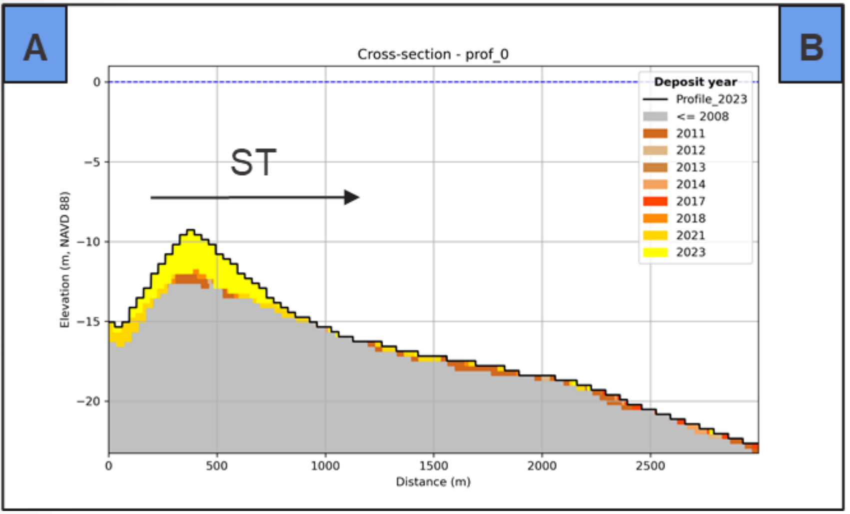


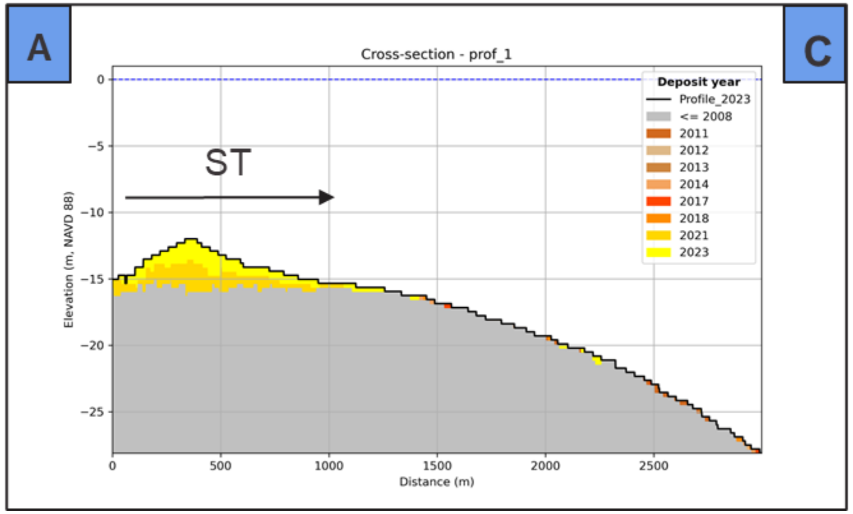
CHRONOSTRATIGRAPHIC ANALYSIS : example 4

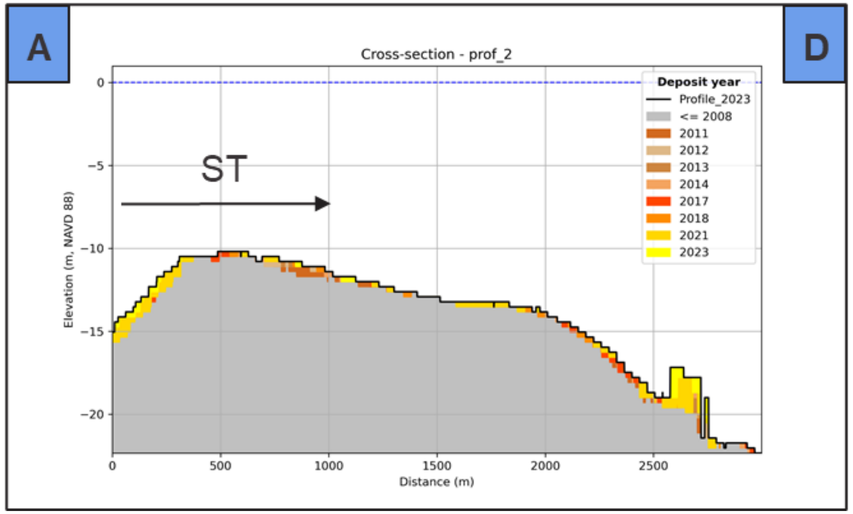












CHRONOSTRATIGRAPHIC ANALYSIS: concluded

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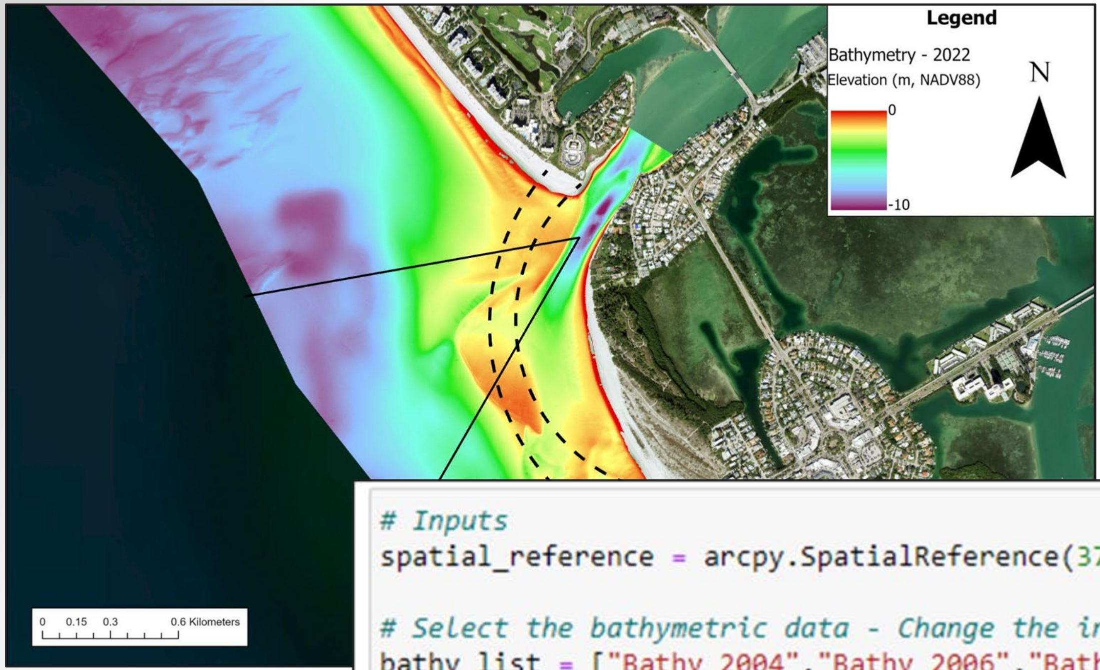
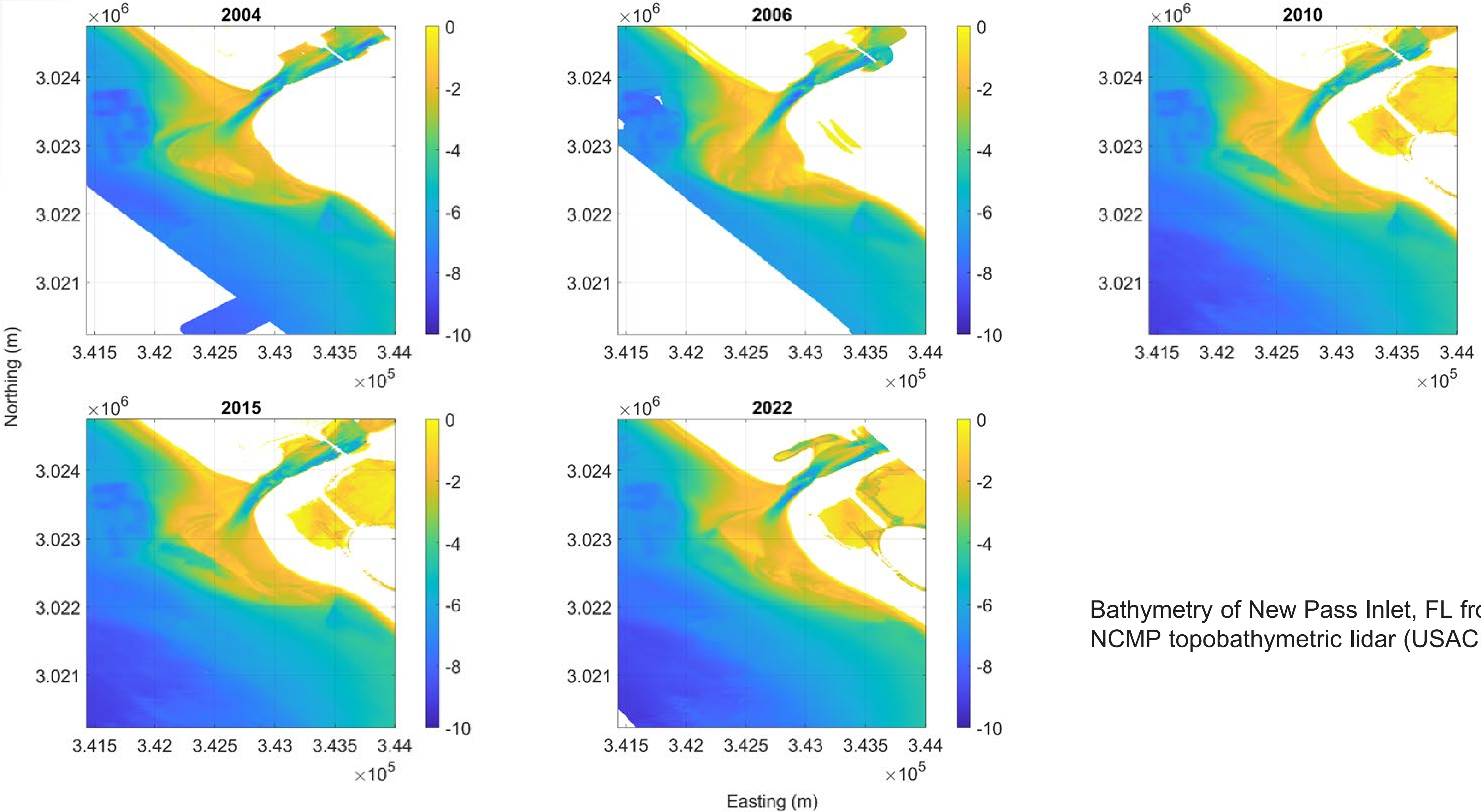



```
# Inputs
spatial_reference = arcpy.SpatialReference(3747)  # NAD 1983 HARN UTM Zone 17N        1

# Select the bathymetric data - Change the information here
bathy_list = ["Bathy_2004","Bathy_2006","Bathy_2010","Bathy_2015","Bathy_2022"]   2
deposit_ages = ["2004","2006","2010","2015","2022"]

# Define the center point coordinates (UTM Zone 17N example)
center_point = arcpy.Point(34778.63, 3023591.11)  # Center Point Coordinates (Easting: 342802.05, Northing: 323598.66)   3

# Define the arc transect shapefile - You have to create the arc transect   4
curve_transect_list = ["curve_transect_0","curve_transect_1"]

# Define angles for the transects (in degrees)
angles = [190, 210, 230, 240]  # for the slide presentation (Report)   5

# Define length of transects
transect_length = 1500  # example length in map units (for the slide presentation)   6

# Add the number of coler acodialy to the number of bathy
color = ["silver","chocolate","orangered","darkorange","yellow"]   7
```

CONFORMAL MAPPING: background

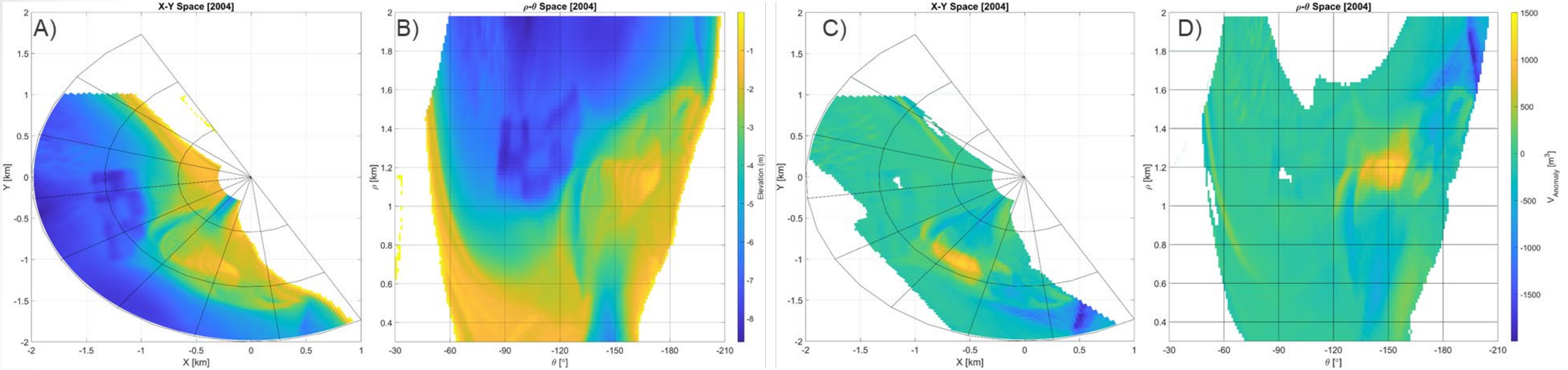
Pearson et al., 2022. “A novel approach to mapping ebb-tidal delta morphodynamics and stratigraphy.” Geomorphology (405).
https://github.com/sgpearson17/bathy2strat



Bathymetry of New Pass Inlet, FL from NCMP topobathymetric lidar (USACE).

CONFORMAL MAPPING, steps 1-3

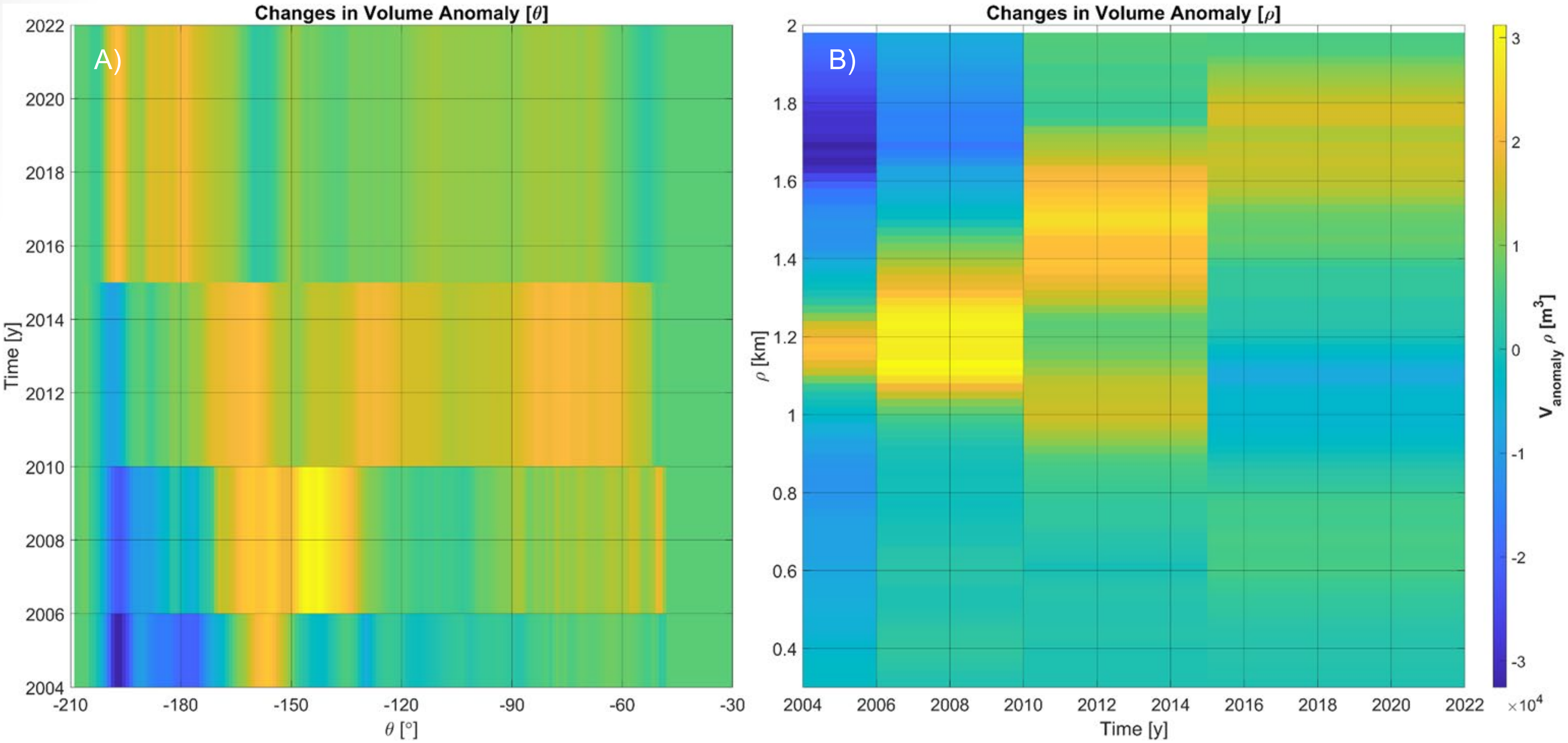
1. Calculate time-weighted mean surface from all surveys
2. Compute volume anomaly for each survey
3. Conformally map to polar space



A) Bathymetry at New Pass Inlet FL in 2004 in XY space B) Bathymetry data from 2004 conformally mapped to polar space C) Volume anomaly (volume above/below mean) for 2004 in XY space D) Volume anomaly for 2004 conformally mapped to polar space

CONFORMAL MAPPING, step 4

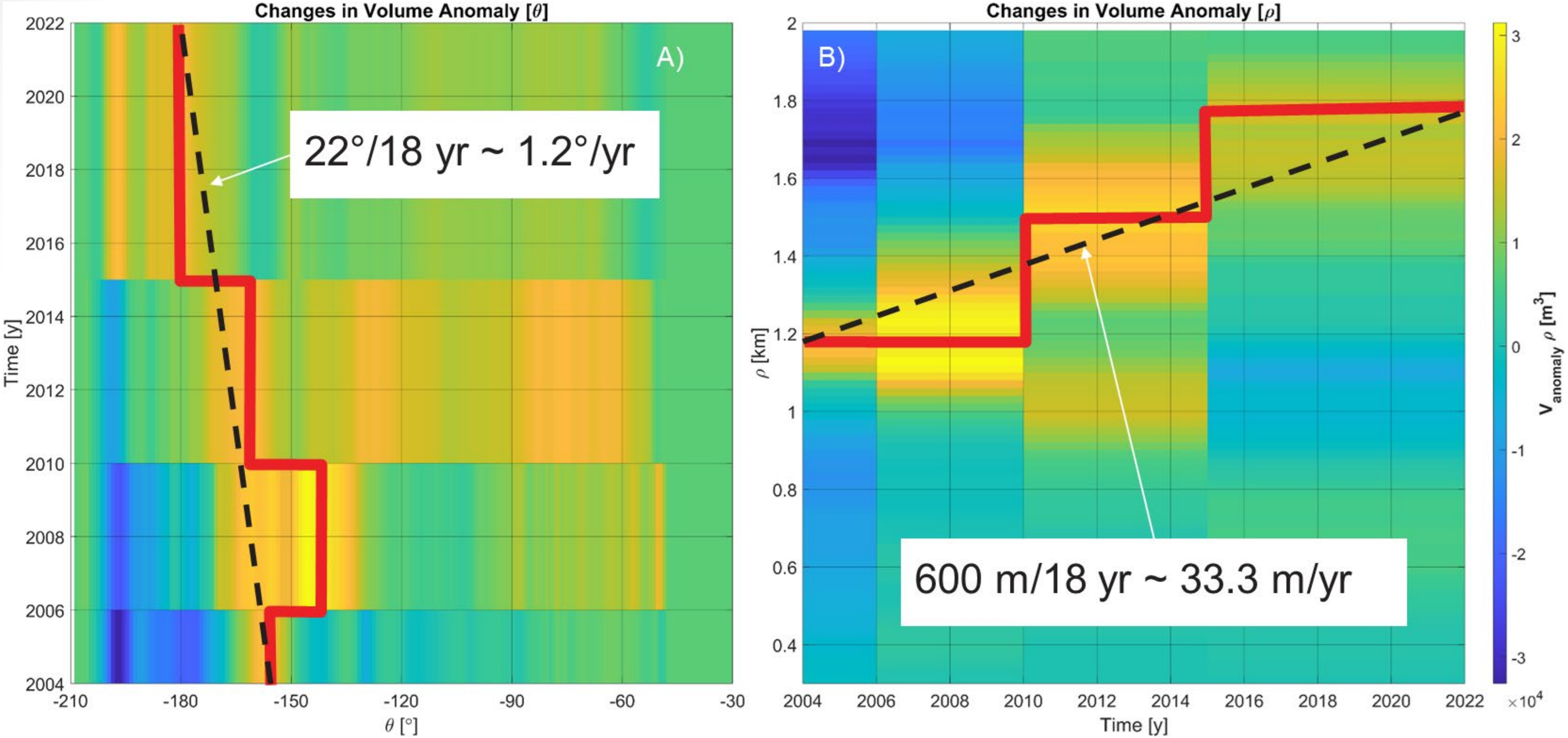
4. Collapse volume anomaly in each dimension (ρ and θ)



A) Timeseries of volume anomaly in θ dimension (rotation about origin) B) Timeseries of volume anomaly in ρ dimension (migration toward/away from origin) for New Pass Inlet, FL

CONFORMAL MAPPING, step 5

5. Next Step: Peak+trough finding analysis to quantify trends

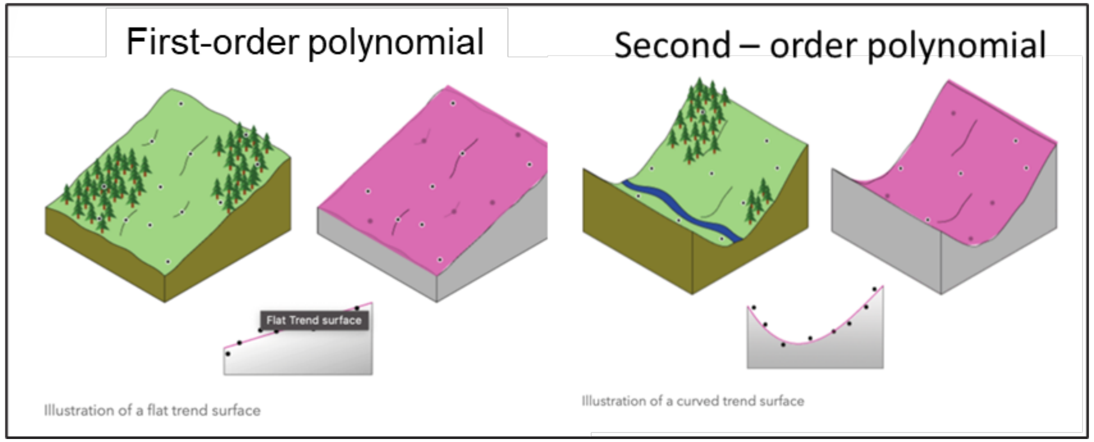


A) Timeseries of volume anomaly in θ dimension (rotation about origin) B) Timeseries of volume anomaly in ρ dimension (migration toward/away from origin) for New Pass Inlet, FL. Example trend lines have been hand-fitted to volume anomaly peaks.

Ebb Tidal Delta Volume Calculation (Prior Work)

Beck and Arnold (ERDC/CHL CHETN, 2019)

- Parallel lines outside area of ebb shoal
  - Extract points, used Trend tool to interpolate a **no-inlet bathymetry surface**
    - Used first, second, third order polynomial only
    - Three unique no-inlet rasters
- Used no-inlet bathy surfaces to estimate volume of inlet ETD shoals
- Applied to 20 inlets on west coast of Florida



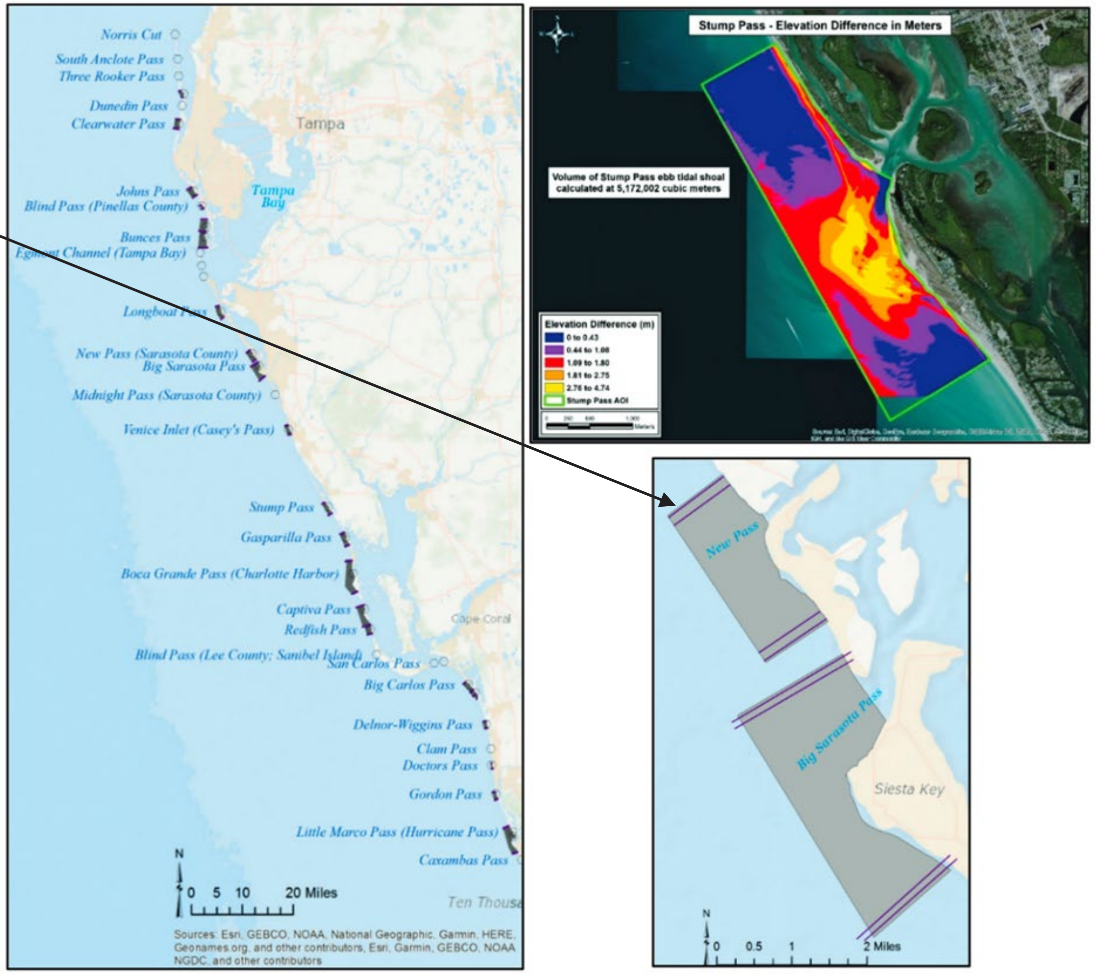


Figure 3. Left: Map of West-central Florida tidal inlets including AOI reaches for the tidal inlets that ebb-tidal delta volumes were computed for. Top right: Example of one tidal inlet ebb-tidal delta volume computation illustrating the elevation difference in meters and the AOI extent. Bottom right: Illustrates the two bounding perpendicular transects along the lateral boundaries of each AOI used in the Trend analysis.

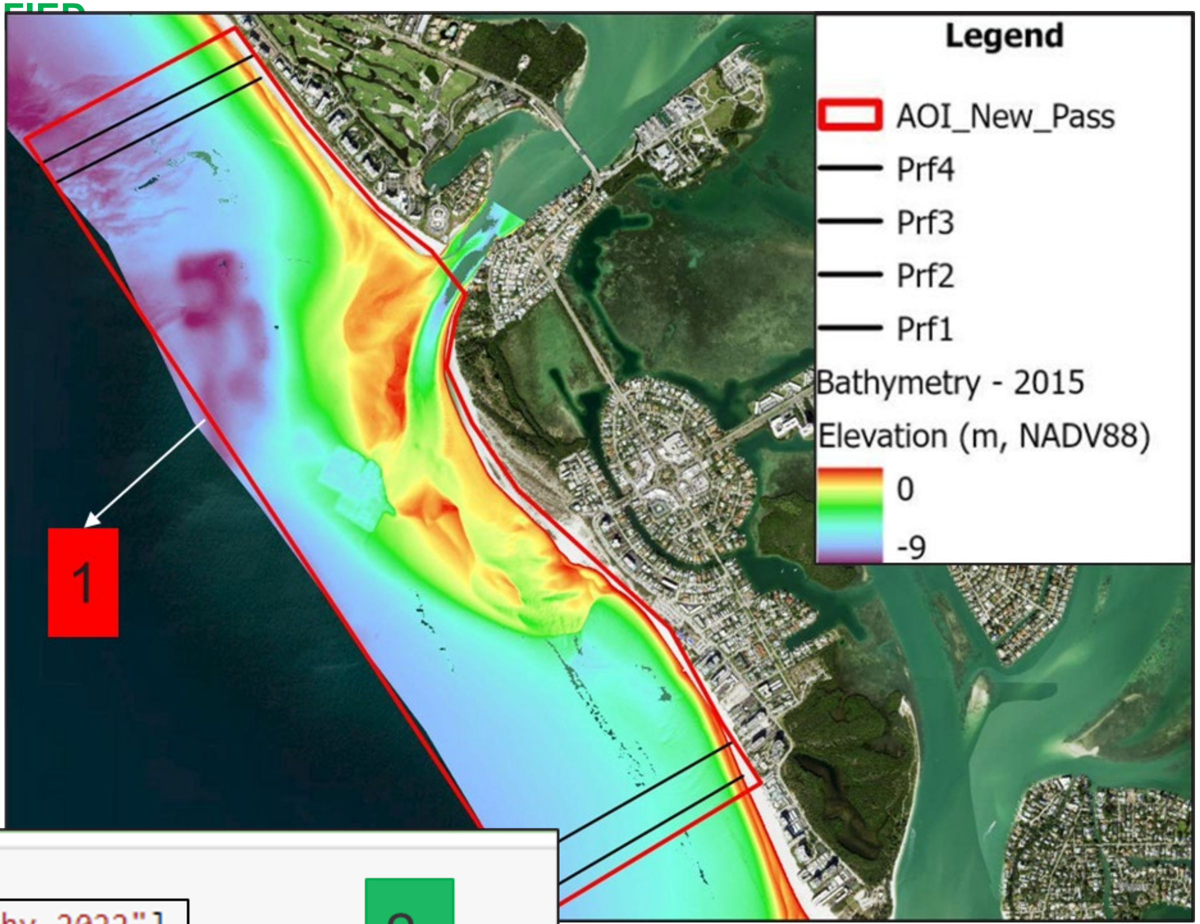
ETD Volume - ArcGIS Pro

Ebb Tidal Delta Volume Calculation Tool

Following the method of **Beck and Arnold (ERDC/CHL CHETN, 2019)**

3 Steps:

1. **Create a polygon that represents your area of interest**
2. **Select the DEMs that represents the bathymetry**
3. **Select the select the location of the transects**



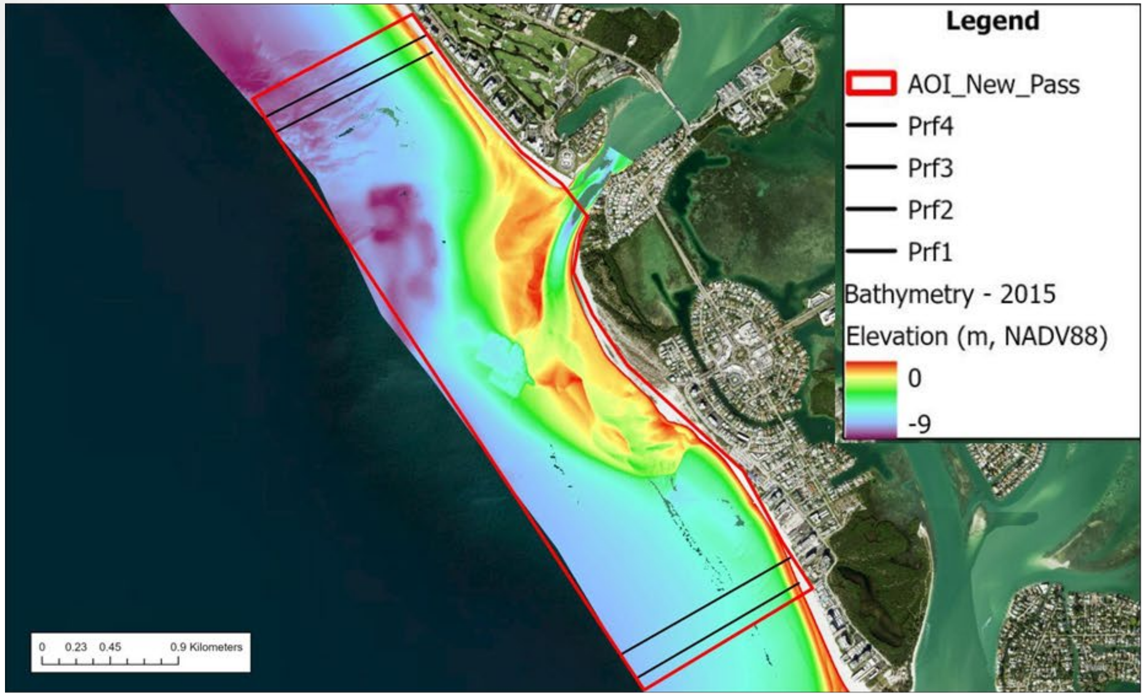

```
# Import the Bathy that will be used to computed the volume
bathy_list = ["Bathy_2004","Bathy_2006","Bathy_2010","Bathy_2015","Bathy_2022"]
spatial_reference = arcpy.SpatialReference(3747)  # NAD 1983 HARN UTM Zone 17N

# Create the transects manualy or use the one from CERI_Transects
process = "M" # "M" is for manualy and "A" automatic (When you have a shapefile with the transects)
```

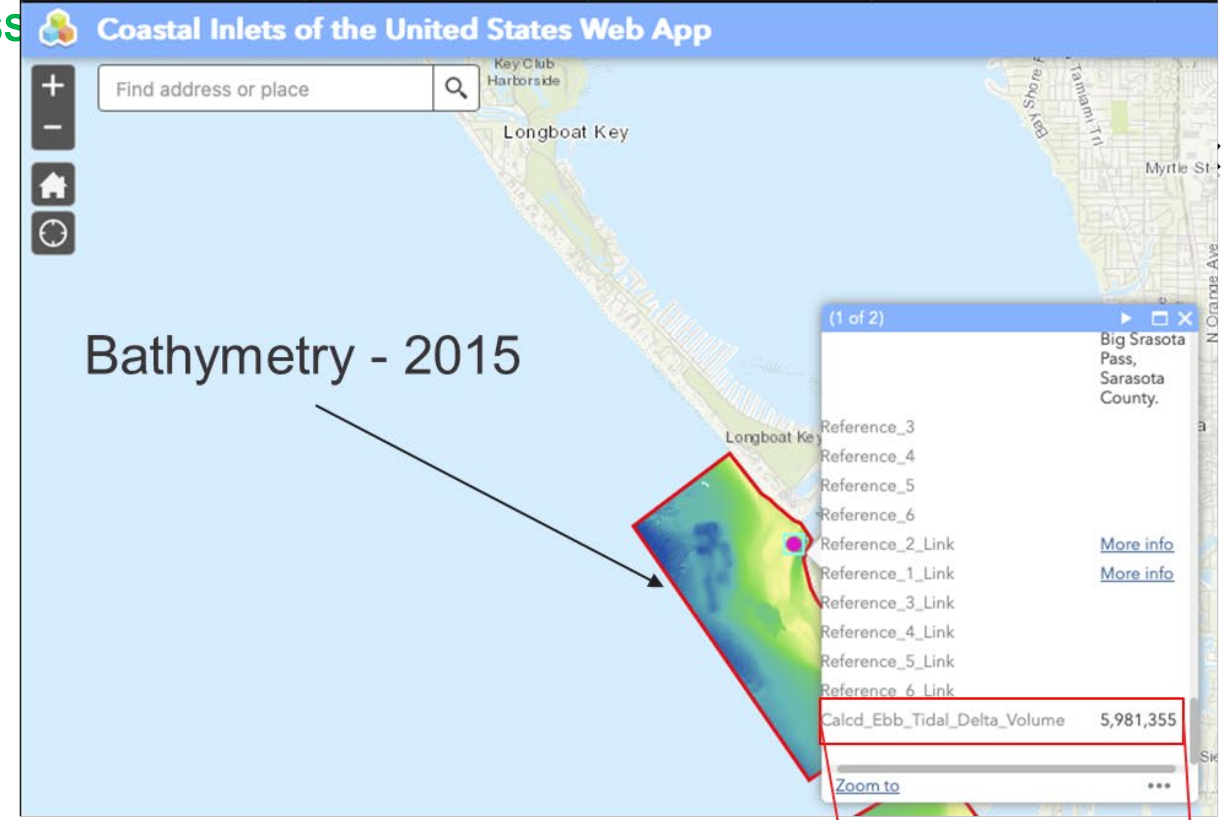
2

3

```
# Create the Points for the Profiles - insert manually the coordinates
prf1 = arcpy.Array([arcpy.Point(341874.45, 3024808.22), arcpy.Point(340789.07, 3024255.54)])
prf2 = arcpy.Array([arcpy.Point(341907.74, 3024691.69), arcpy.Point(340875.63, 3024165.65)])
prf3 = arcpy.Array([arcpy.Point(344283.40, 3021359.70), arcpy.Point(343143.50, 3020708.09)])
prf4 = arcpy.Array([arcpy.Point(344330.28, 3021186.04), arcpy.Point(343243.00, 3020548.80)])
```

ETD Volume - ArcGIS Pro example

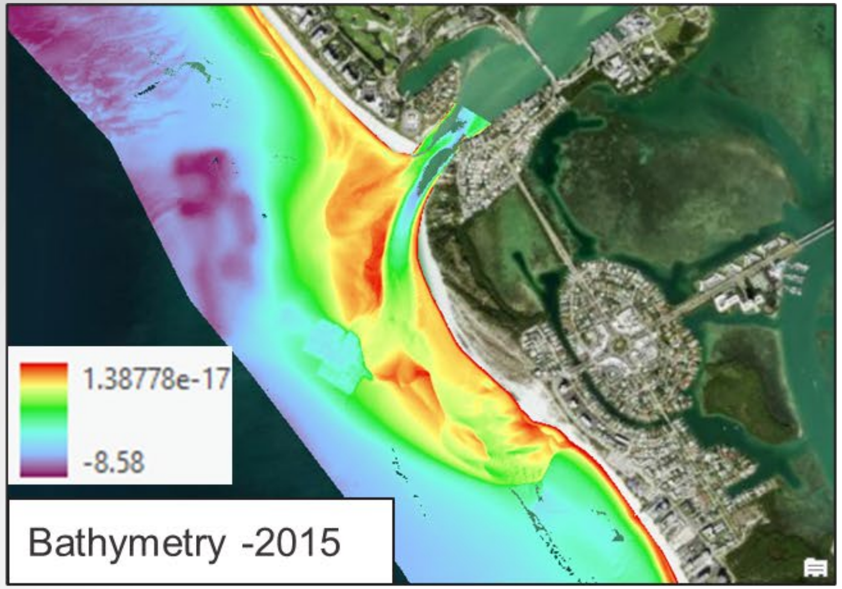




Year	Volume (m³)
2004	6169035.5
2006	6619815.5
2010	4923541.5
2015	**5,814,216.5**
2022	6653568.5

It can potentially become a toolbox to be used in ArcGIS Pro

ETD Volume - ArcGIS Pro example, cont.



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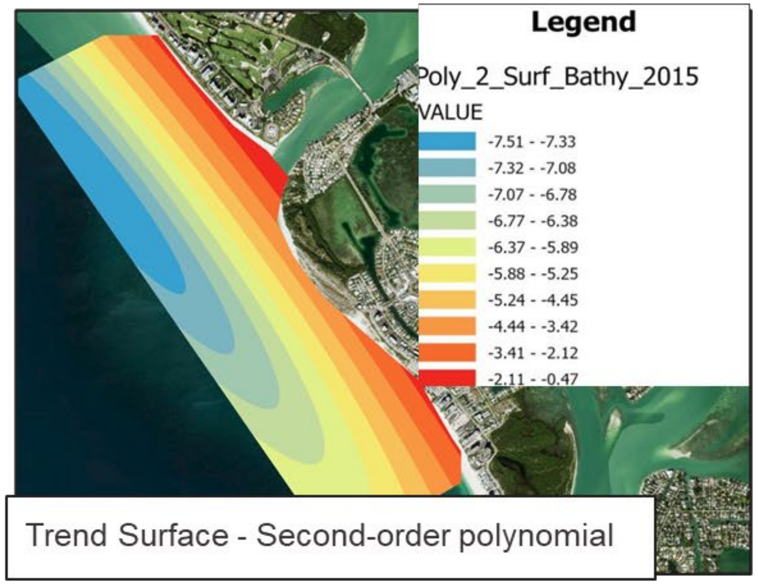

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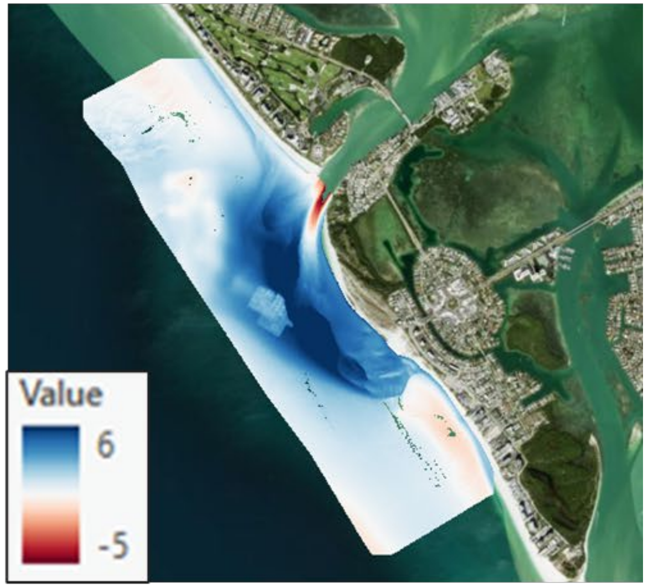
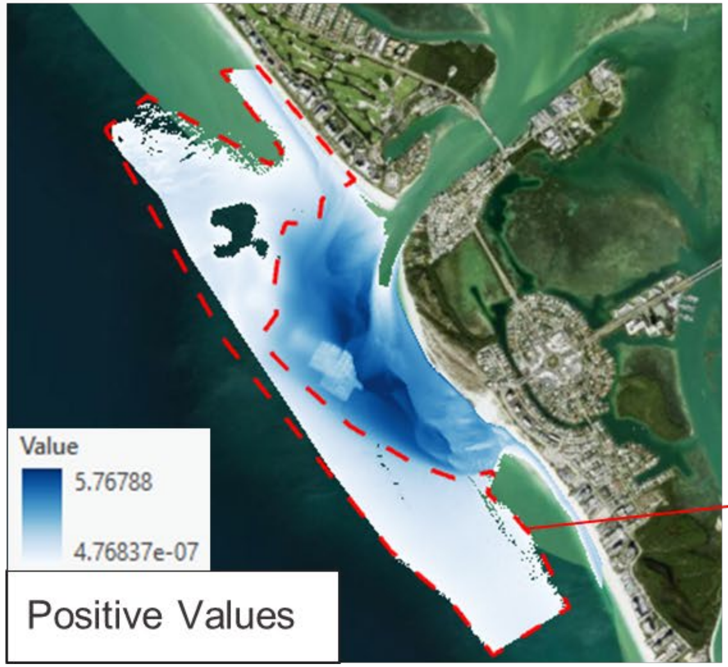


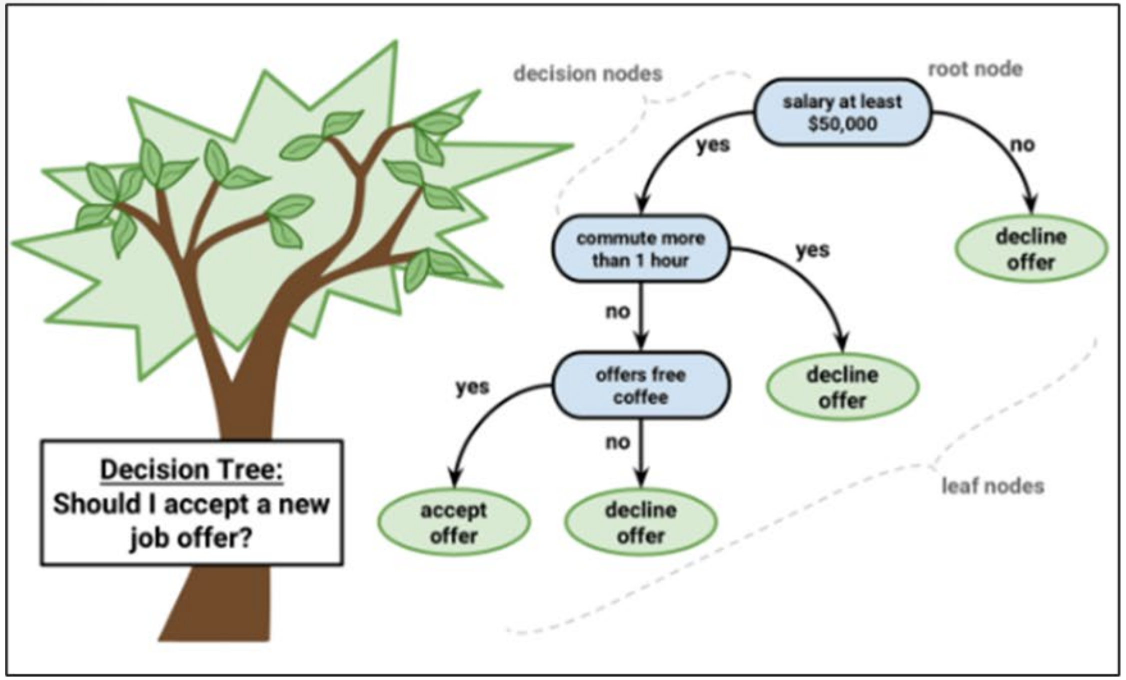


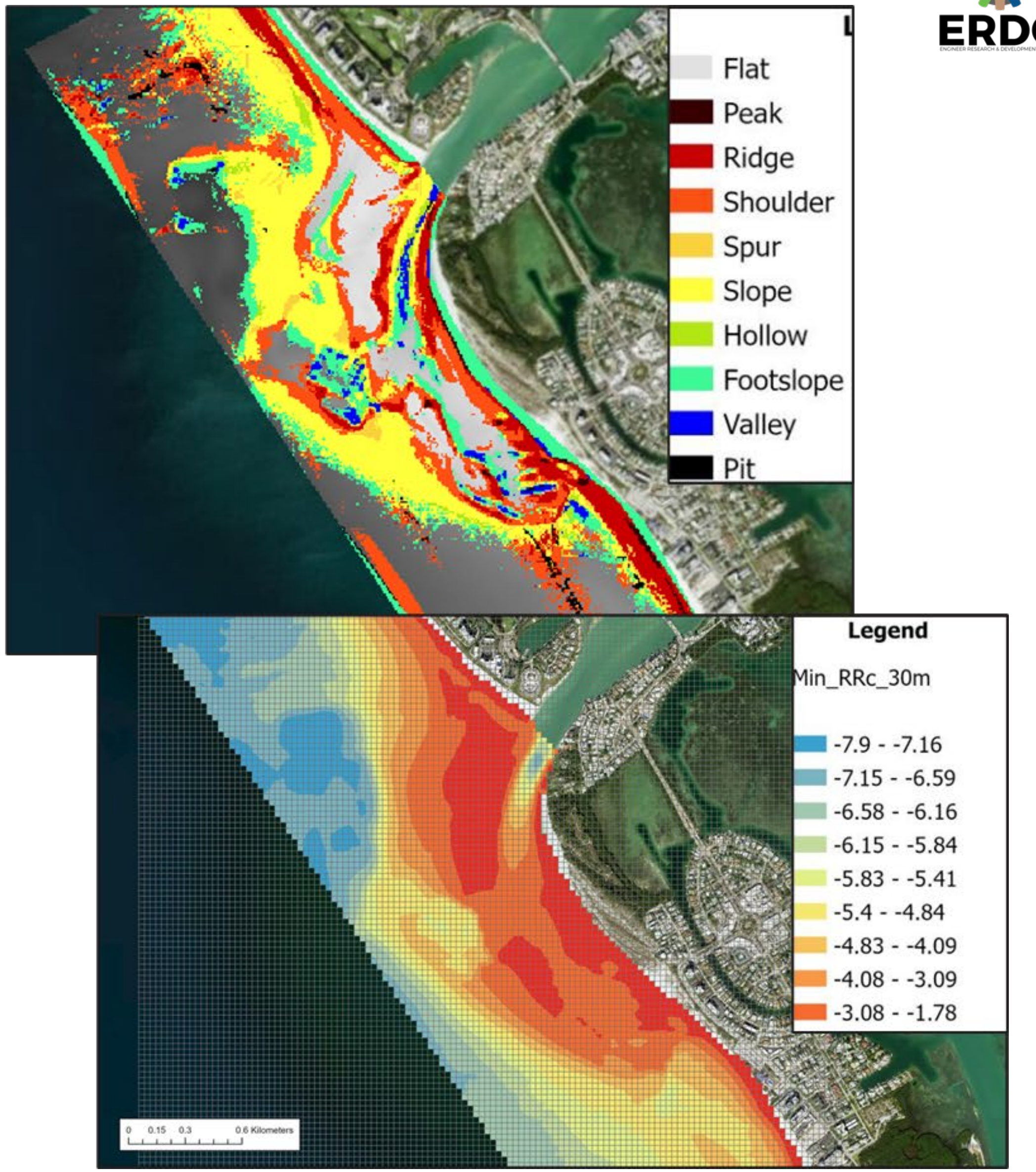
Sum of Positive Values.	
Year	Volume (m³)
2015	**5,814,216.5**

Adding **1,397,832.5 m³** to the ETD volume

Next Steps - Decision Tree

- **Create a decision tree to find the approximate area of the ETD**
- **Definition**: A Supervised Machine Learning algorithm that uses a set of rules to make decisions.
- Use **Geomorphons** and **Relative Relief** to find the approximate area of the ETD





ANTICIPATED PRODUCTS AND APPLICATIONS

ERDC

Short-Term
- Technical Note (in review)
  - Compare methods/approaches at East Pass and Fire Island Inlets
- Poster Presentation
  - ASBPA (Aug. 2024)

Long-Term
- ORISE fellowship – dissertation publications
- Other publications
- Add products/workflows to US Tidal Inlet Atlas
  - ArcGIS tools (toolboxes/workflows)
  - Matlab code -> open source
    - Juptyer notebook

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New tools and methods for mapping tidal inlets: Next Generation Inlets Atlas

by Charlene Sylvester, Justin Shawler, Kaitlyn McPherran, Matheus Bose, and Rekea Williams

References

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