CONNECTING THE DOTS TO INNOVATION

NEXT GENERATION U.S. INLETS ATLAS: NEW TOOLS FOR INLET GEOMORPHIC CLASSIFICATION

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U.S. ARMY

US Army Corps of Engineers®

ERDC
ENGINEER RESEARCH & DEVELOPMENT CENTER

AGENDA

- Project team
- Motivation and need from the field
- Current US Inlets Atlas and prior work
- New approaches
  - Workflow development
    - DEM Compilation
    - Relative Relief
    - Geomorphons
    - Conformal Mapping
- Anticipated products
  - Web services, how to use in Pro, how to query/extract from REST

PROJECT TEAM

Co-PIs:
Charlene Sylvester
Justin Shawler

Research Team:
Ashley Elkins (ERDC CHL-CEB)
Aleks Ostojic (ERDC CHL-CEB)
Rekea Williams (ERDC CHL-CEB)
Kaite McPherran (ERDC CHL-CEB)
Matheus Bose (ORISE Fellow)

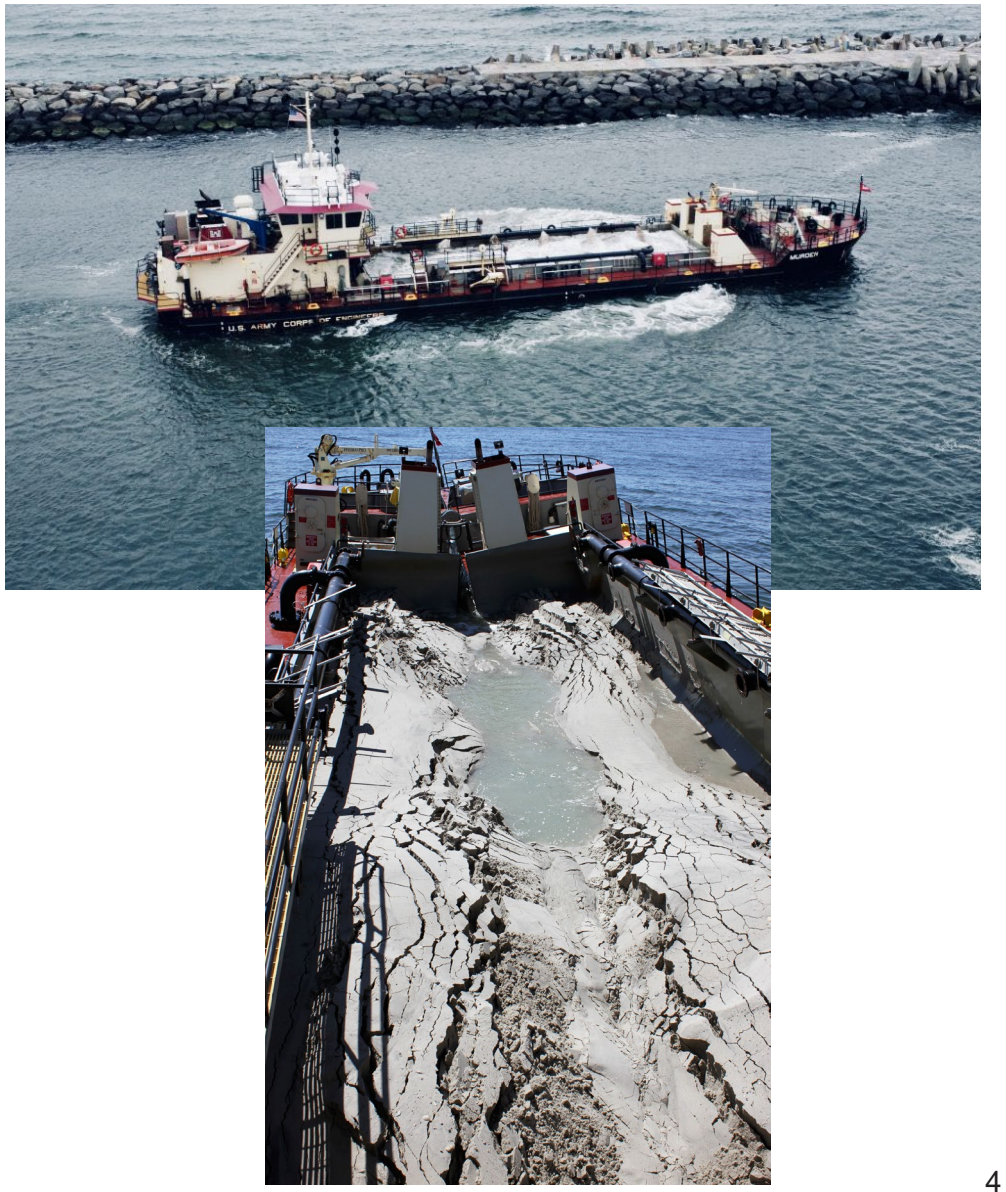
Coastal Inlets Research Program Manager:
Tanya Beck (EDC CHL-CEB)

District PDT/Advisors:
Elizabeth Godsey (SAM)
Eli Greenblatt (NAN)
Dag Madara (NAN)
Laurel Reichold (SAJ)
Suzie Rice (NAN)

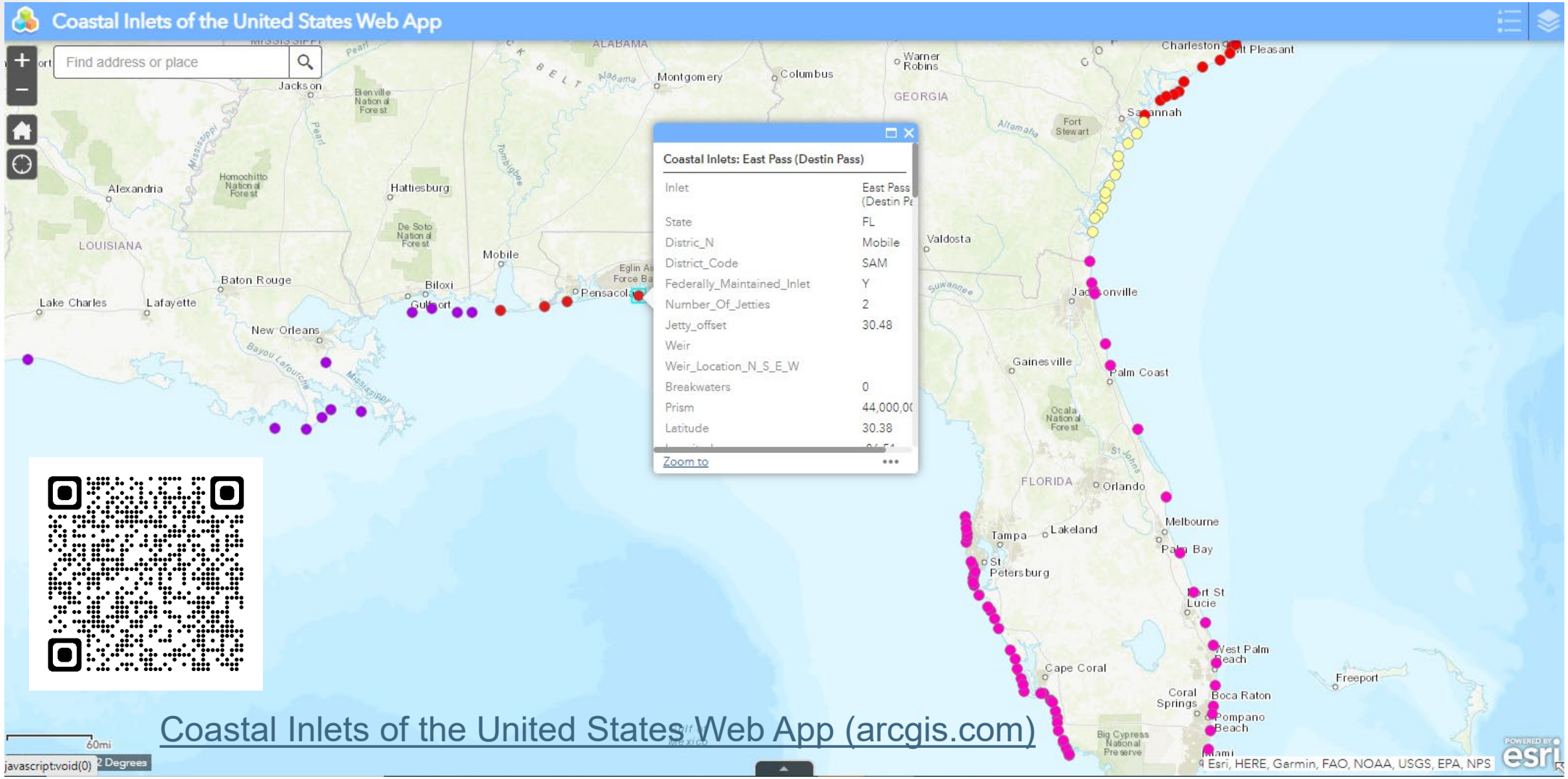
Coastal Engineering Branch PDT/Advisors:
Sean McGill (ERDC CHL-CEB)
Michael Hartman (ERDC CHL-CEB)

NEEDS FROM THE FIELD

- **PDT Kickoff – March 2023**
  - **District Needs**
    - Tracking inlet features → changing dredging practices and placement practices
    - Historical inlet change → inform how engineering interventions may alter sediment transport/morphology
    - Reduce/optimize need for modeling
    - Is sandy material consistently at one spot?
      - » Regulatory
      - » Depth and spatial coverage of where sand is
    - Flood and ebb shoals as borrow area – what is recharge rate?
      - » How much can you take out w/out morphological impacts?
      - » Mining of sand resources
      - » Relates to sediment budget
  - **Preferred Format**
    - Not a static map or report
    - Ready-made, limit additional analyses



CURRENT U.S. INLETS ATLAS



CURRENT U.S. INLETS ATLAS AND 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

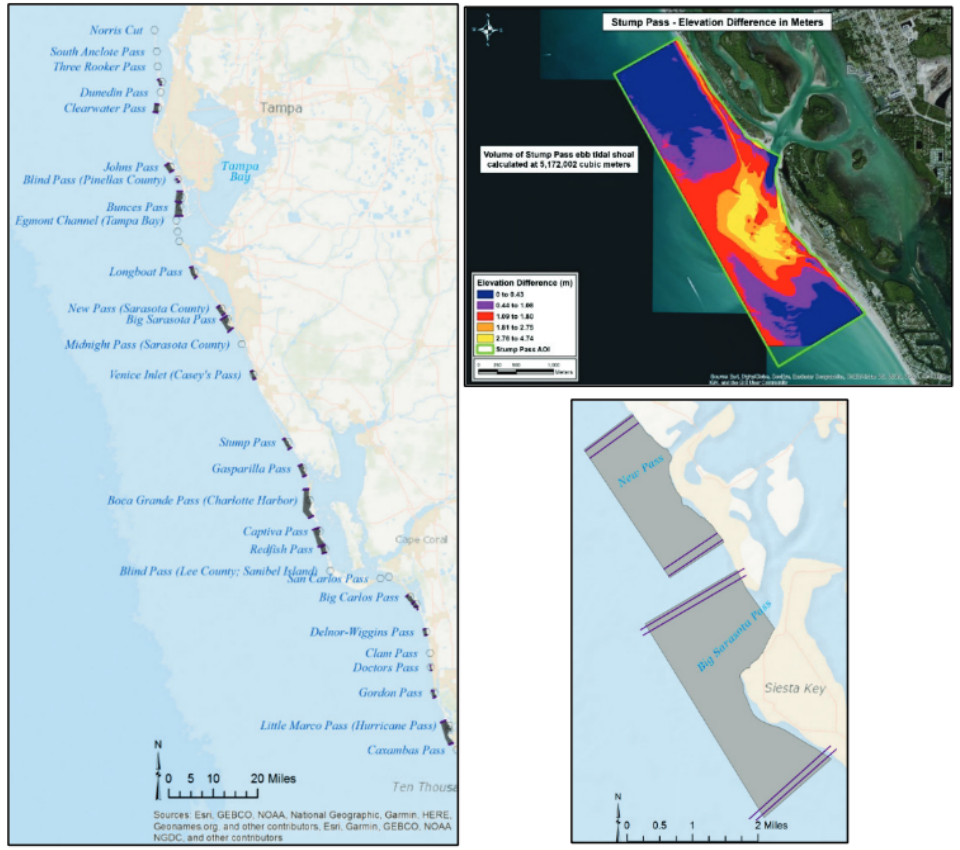


Figure 3. Left: Map of West-central Florida tidal inlets including AOI reaches for the tidal inlets that ebb-tidal delta volumes were computed for. Top right: Example of one tidal inlet ebb-tidal delta volume computation illustrating the elevation difference in meters and the AOI extent. Bottom right: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

PRIOR WORK

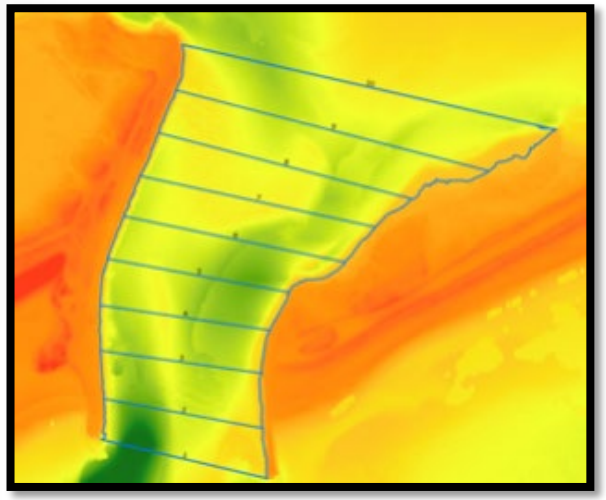
Loderay Bracero Marrero (former ERDC-CHL–CEB)

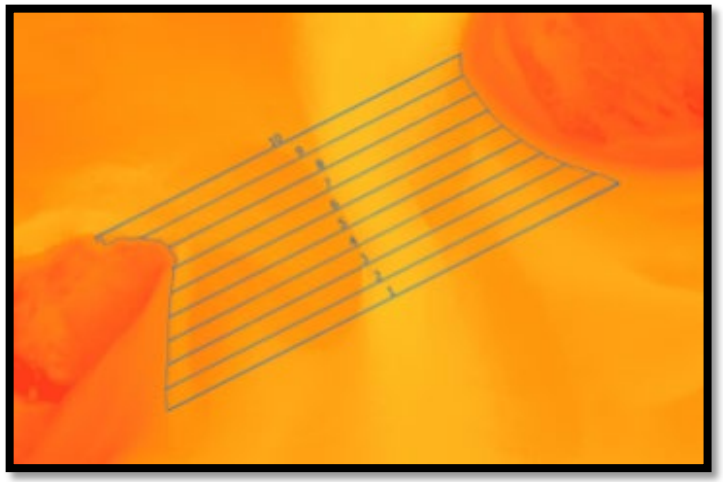
Tidal Basin Hypsometry Pilot Study

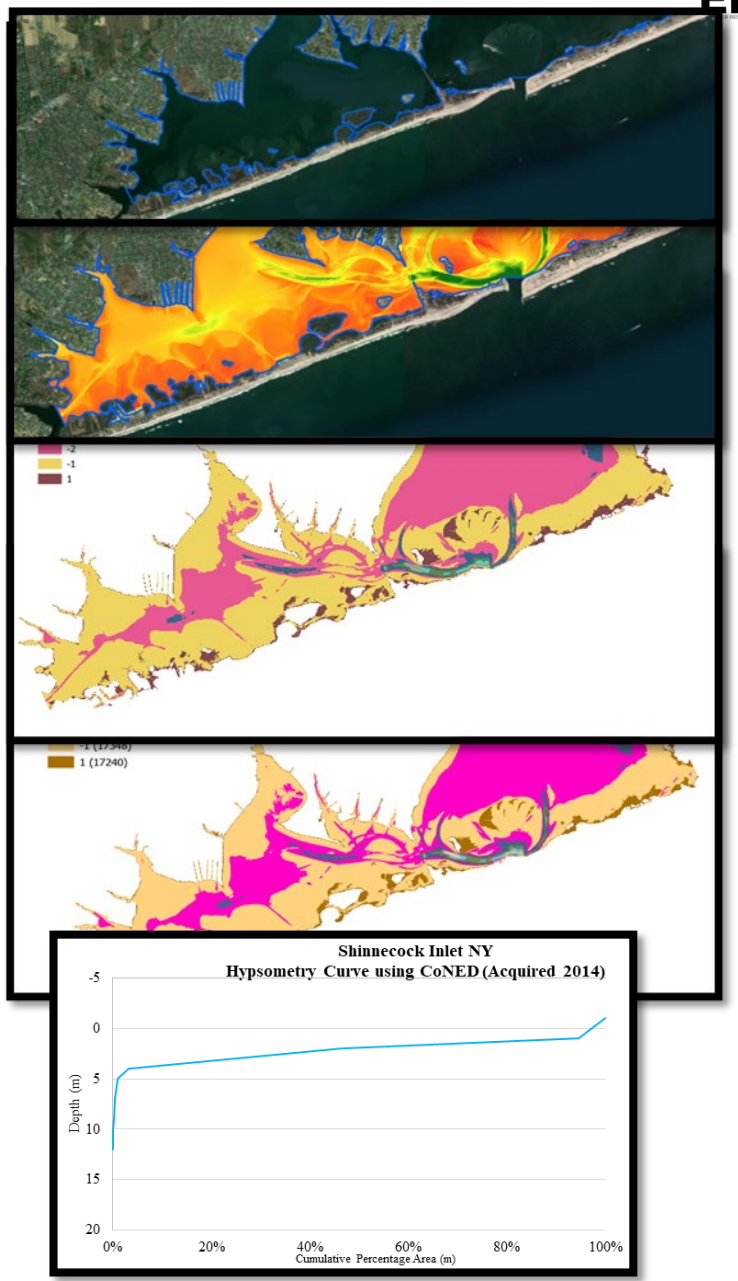
- Hypsometry curve – percentage of area within a particular depth (elevation) range
  - Strahler 1952 – hypsometry of river basins

Cross-Sectional Area

- ArcPro toolbox and Jupyter Notebook







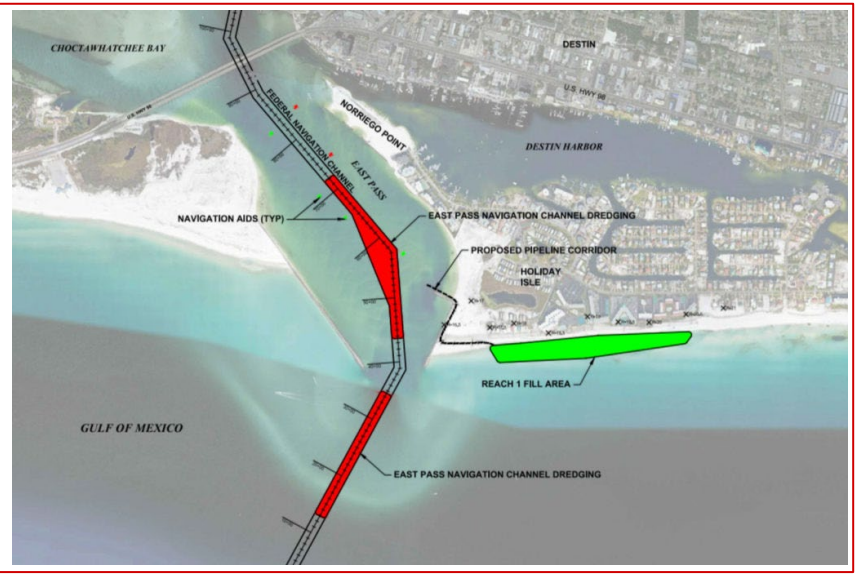
NEXT GENERATION U.S. TIDAL INLETS ATLAS

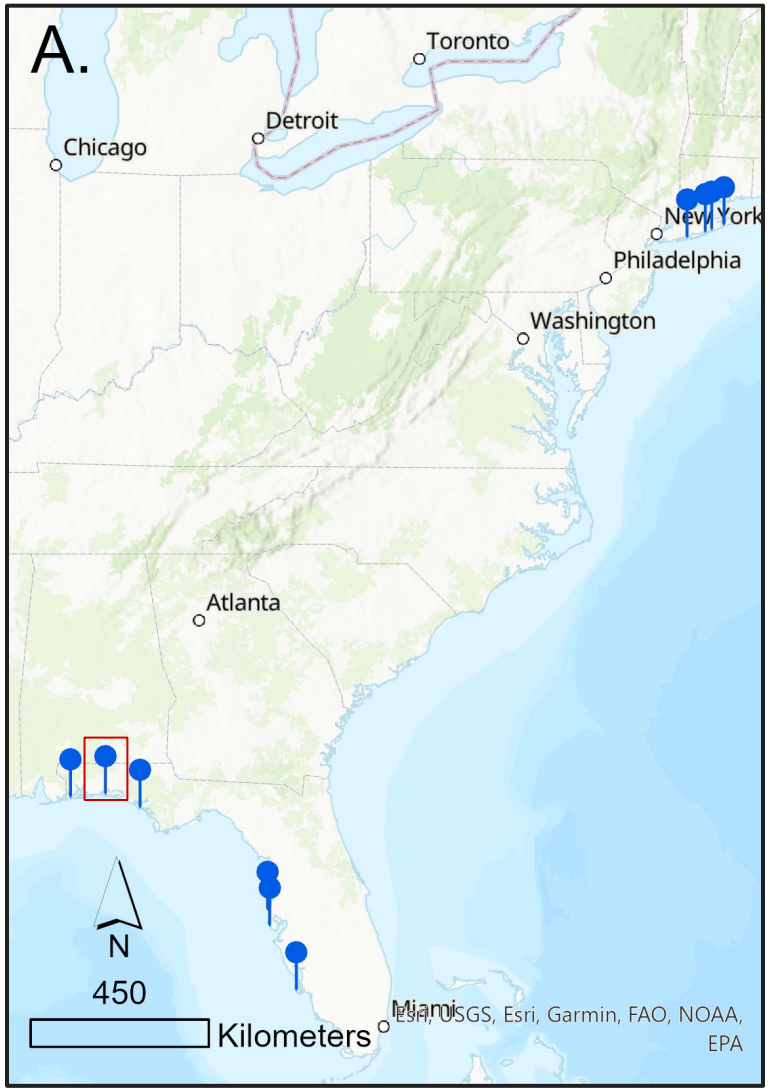
Project Goals

- Automated workflow and standard data products
- Highly detailed and accurate representations of inlet morphology
- Calculations of sediment volumes critical to sediment budget development
- “One stop shop" for trusted and understandable inlet morphology and sediment volumes
- Integrate with ongoing Sediment Budget Analysis System (SBAS) initiative
  - Incorporate the inlet morphology and sediment volumes to support sediment budgets

WORKFLOW DEVELOPMENT

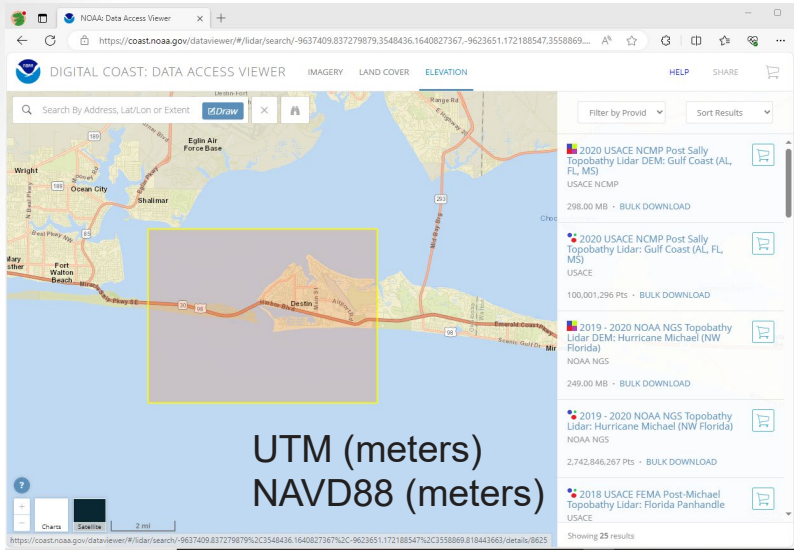
- Project Year 1 (March 2023 – March 2024)
  - Data compilation and DEM development at case study inlets
  - Three primary workflows/approaches tested at East Pass Inlet, Destin, FL
    - Relative Relief
    - Geomorphons
    - Conformal Mapping



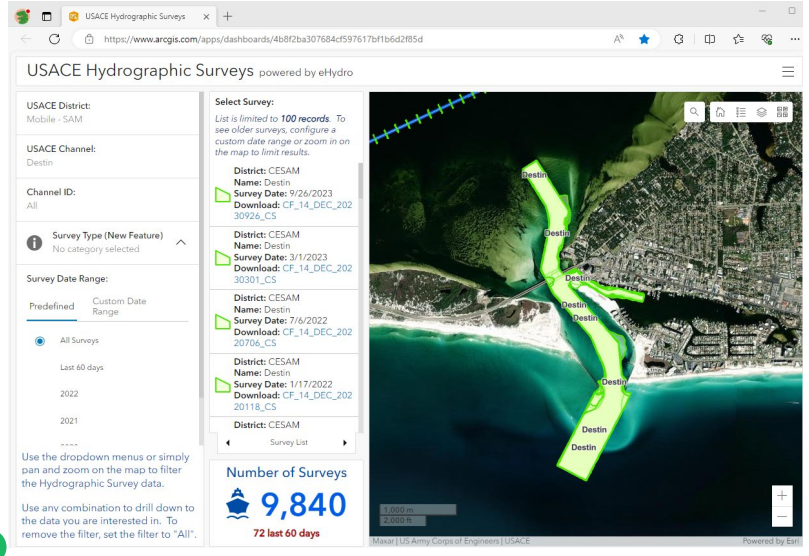


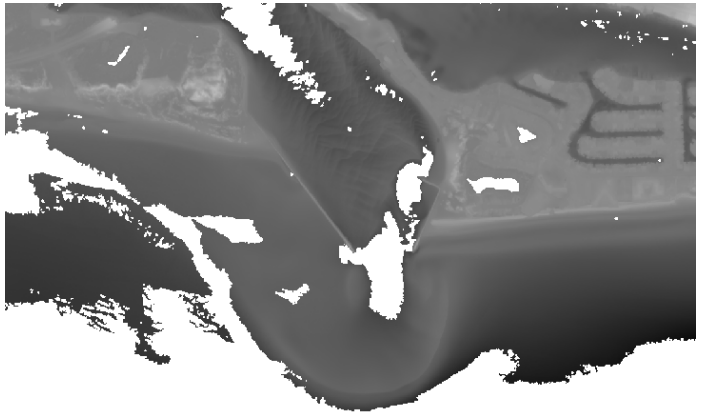
DEM COMPILATION

Inventory | Extract & Process | Merge



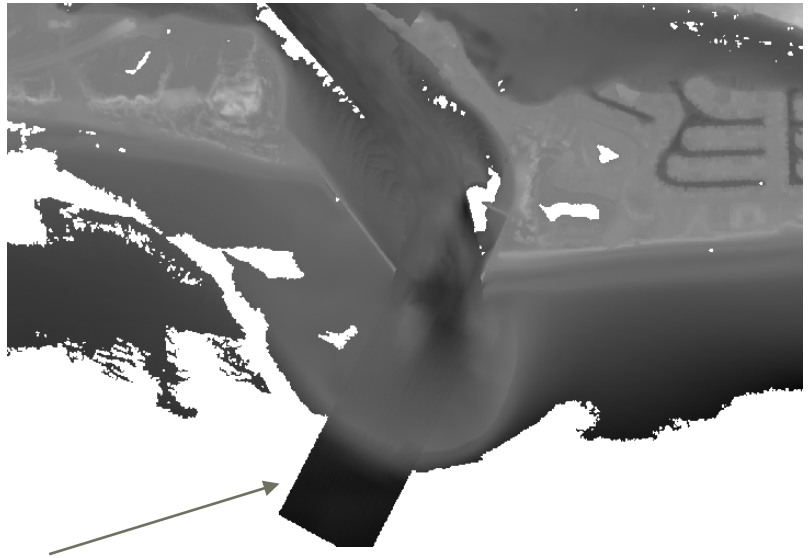
UTM (meters)
NAVD88 (meters)

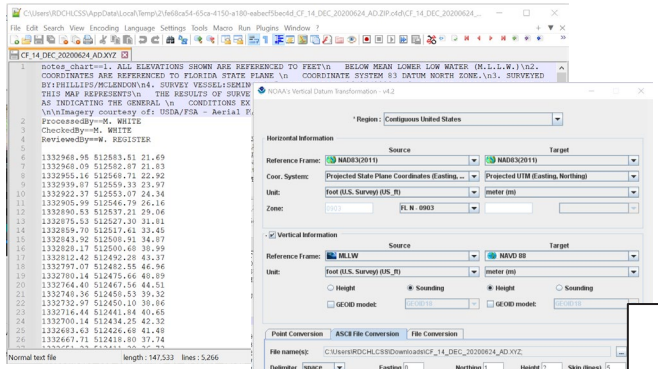




2018 USACE NCMP Post-Michael

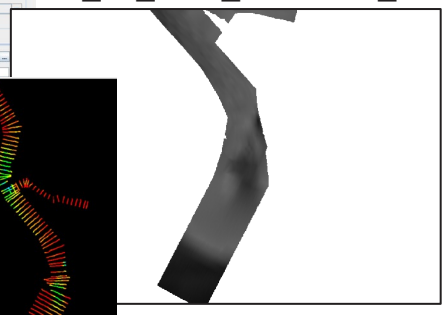
eHydro-filled DEM 3-m resolution





eHydro datum transformation & gridding

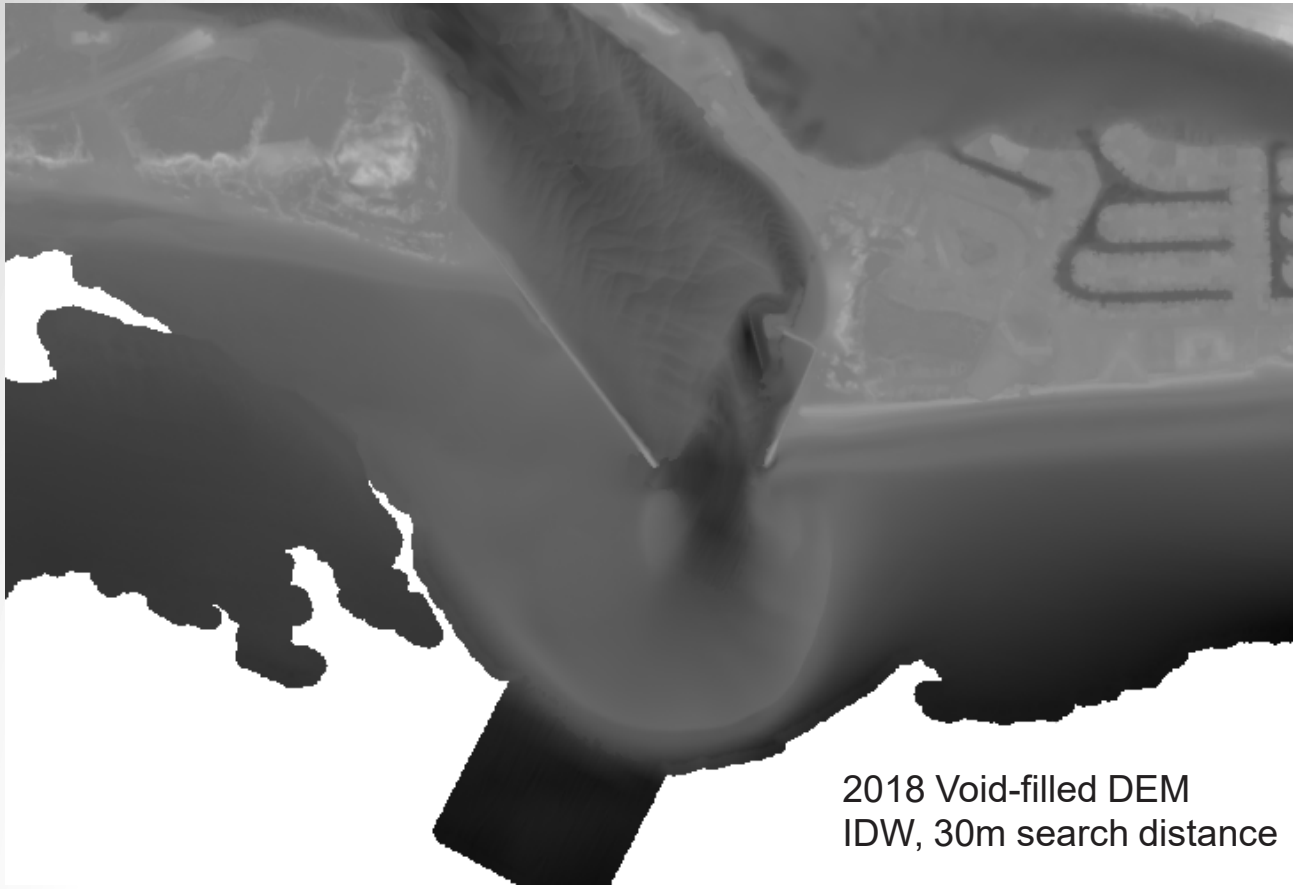
CF_14_DEC_20181109_CS



Workflow support from Rekea Williams

DEM COMPILATION (continued)

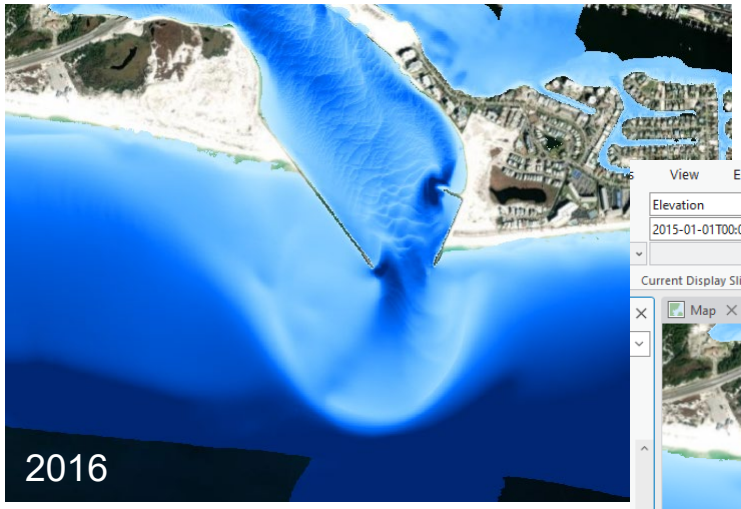
Void Fill → Mask



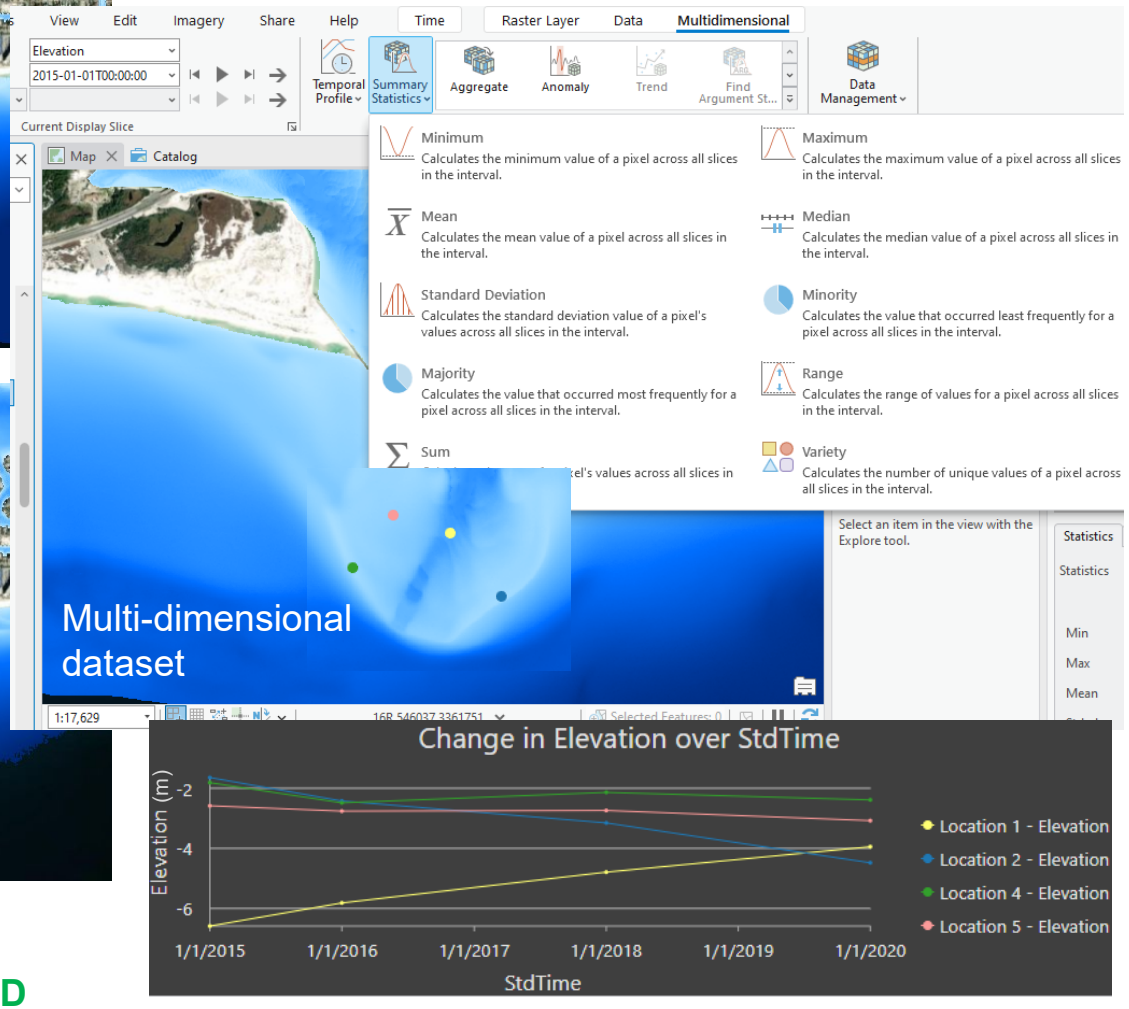
2018 Void-filled DEM
IDW, 30m search distance

2018 Topo- and bathy-masked DEM

MULTIDIMENSIONAL DATASET

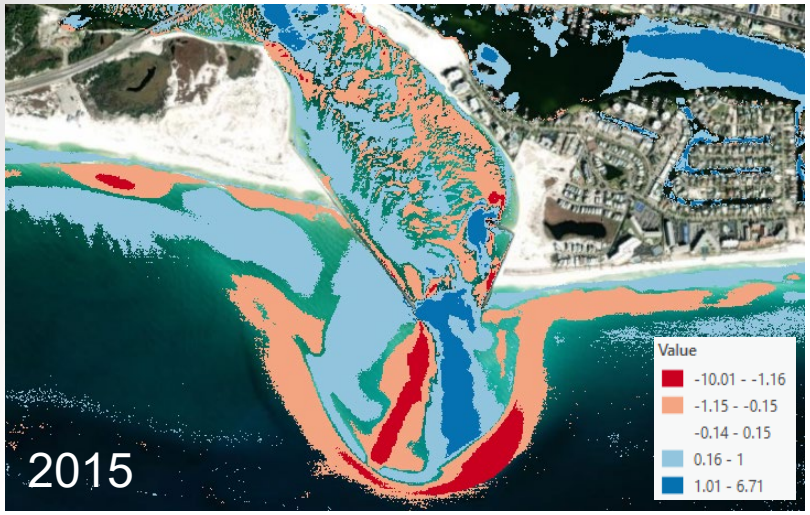


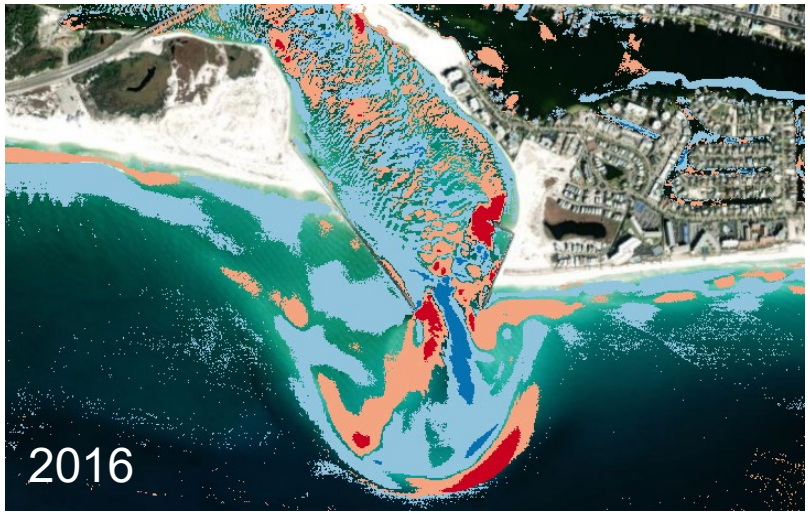
ArcGIS Pro 3.x mosaic dataset to multi-dimensional dataset

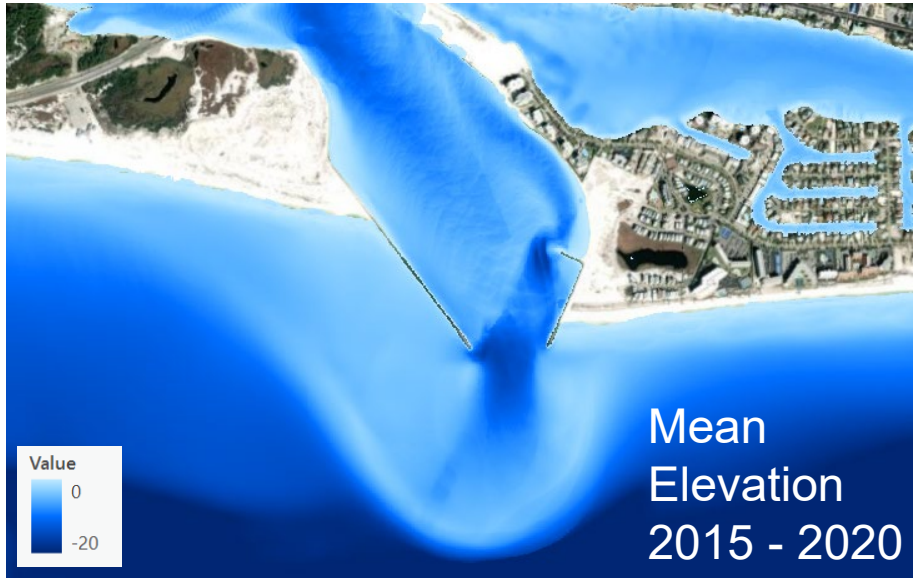


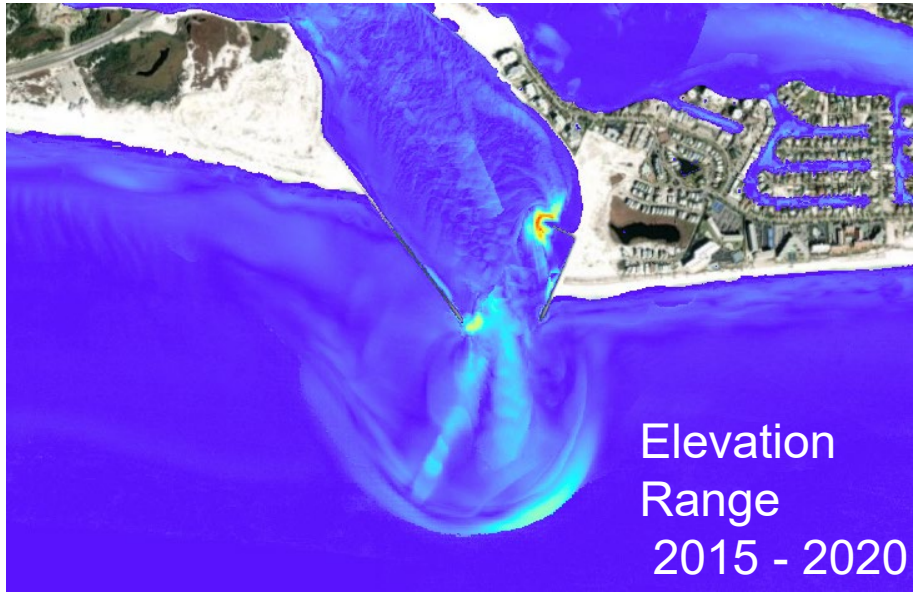
MULTIDIMENSIONAL DATASET PRODUCTS

Surface Anomaly (difference from mean)



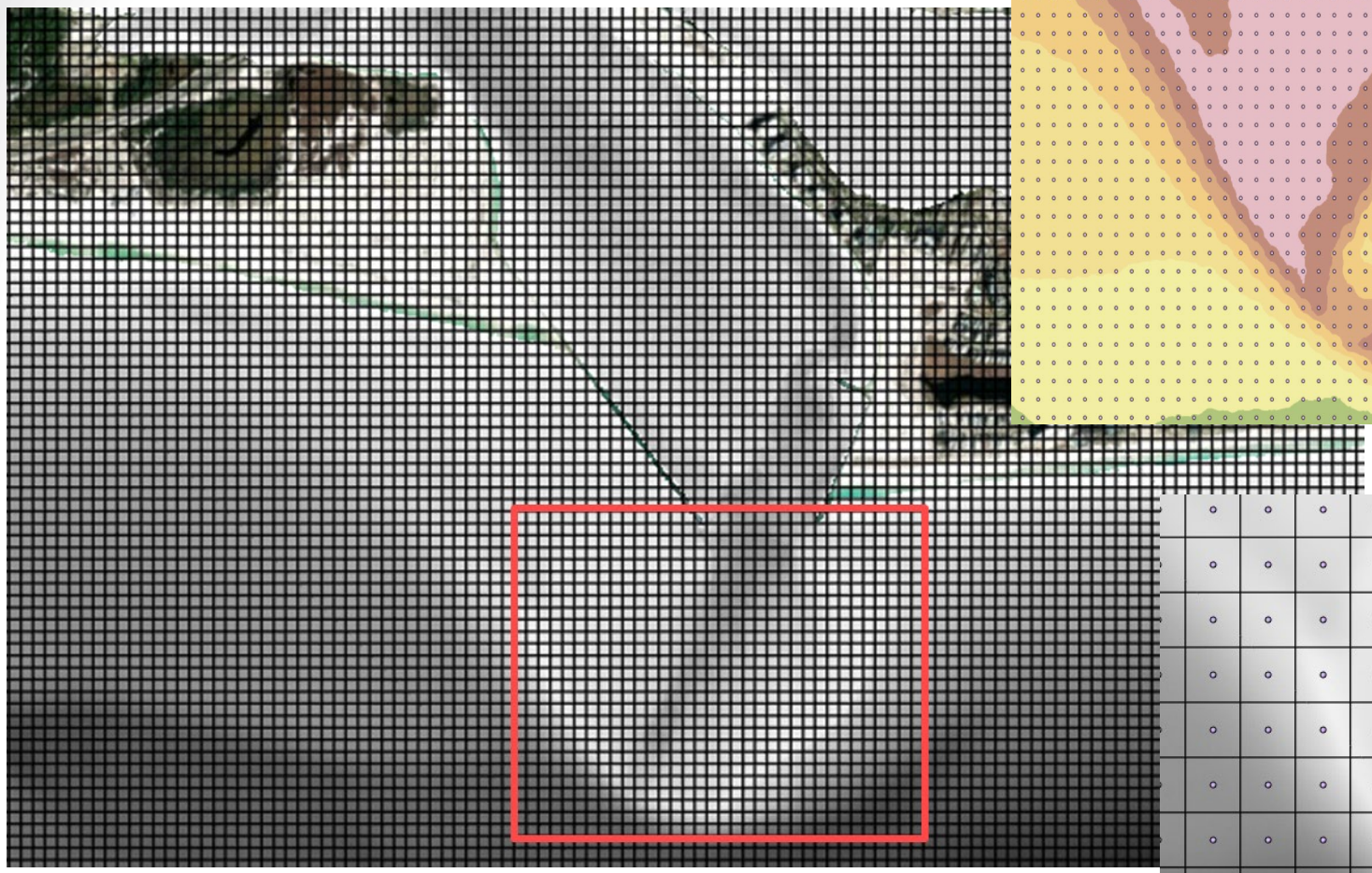




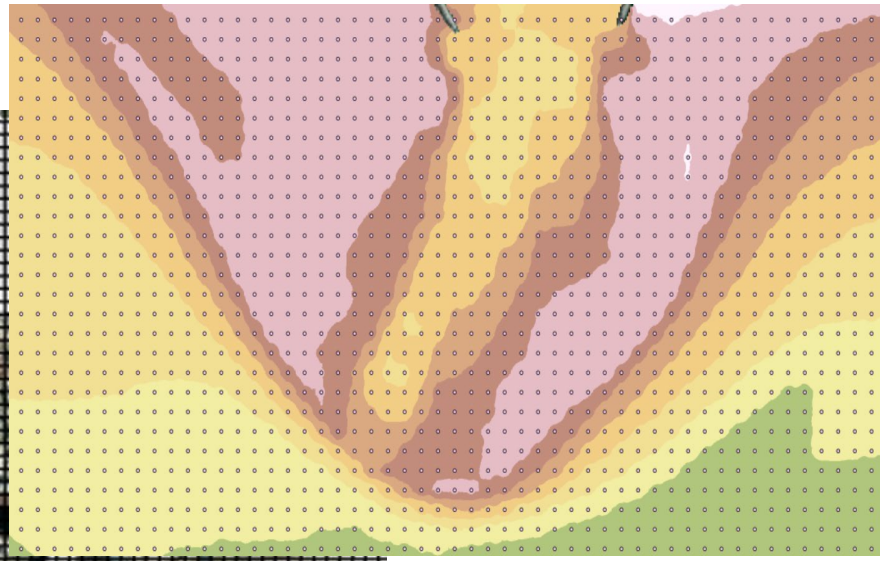


RELATIVE RELIEF

2015 USACE NCMP Topobathy, 3m DEM

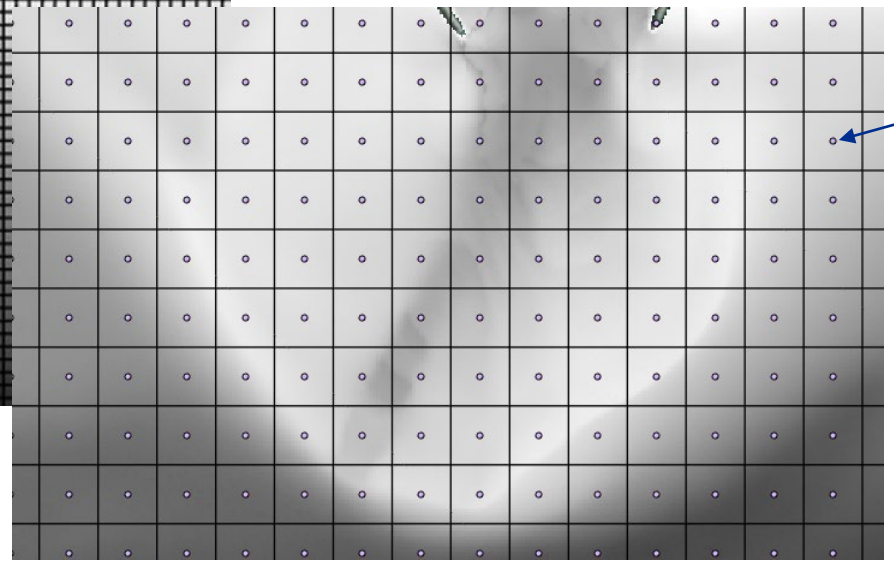


Fine-scale: 30m fishnet



← IDW Min surface

Broad-scale: 90m fishnet

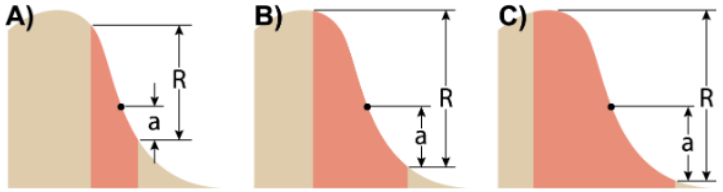


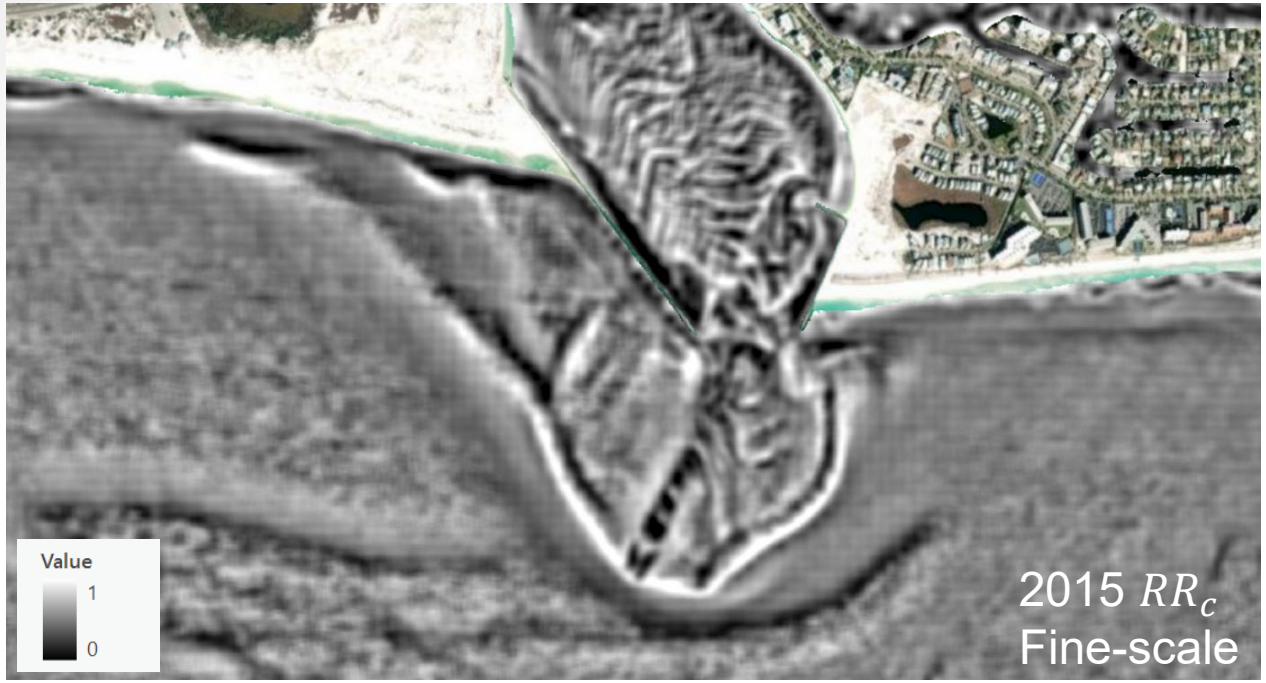
Zonal Statistics:
Max
Min
Range
Mean
Median
Sum
Std Deviation

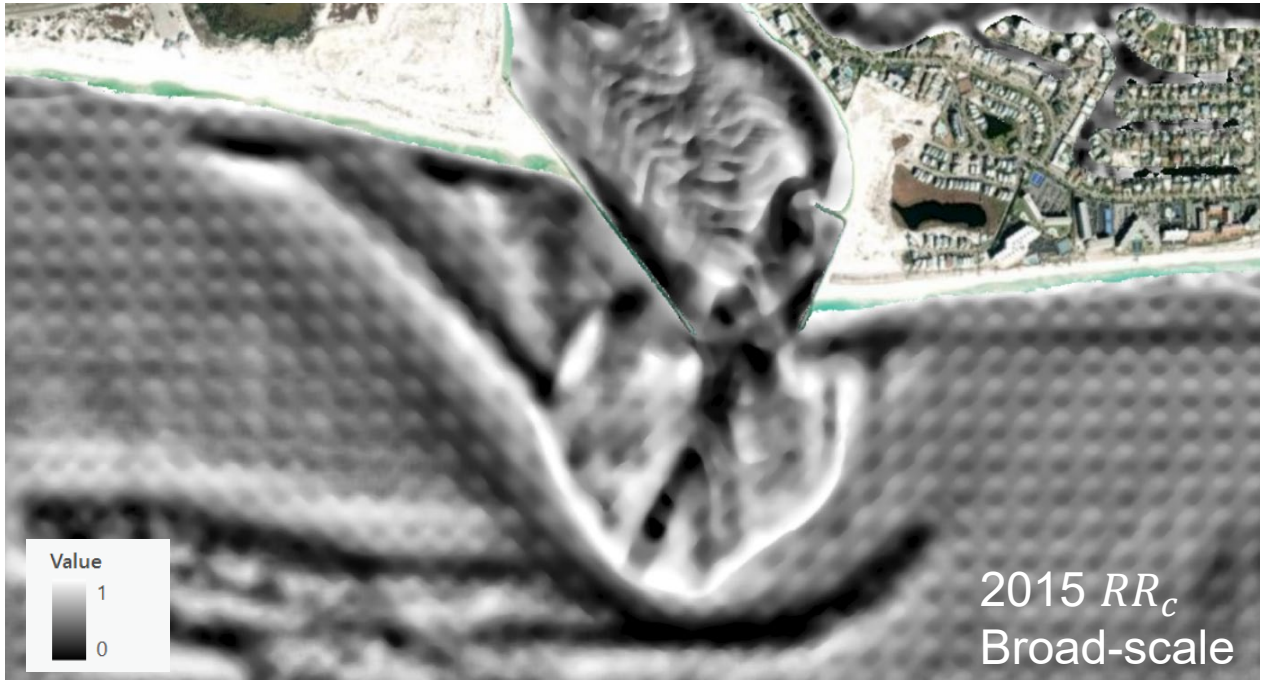
Differentiate geomorphology features based on position relative to surroundings

RELATIVE RELIEF PRODUCTS

Wernette et al., 2016 $$RR_c = \frac{(z_c - z_{min})}{(z_{max} - z_{min})}$$

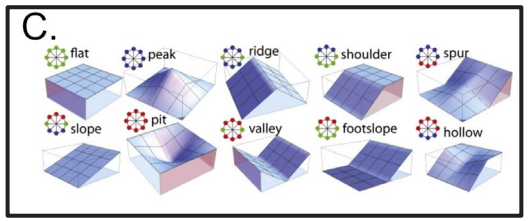






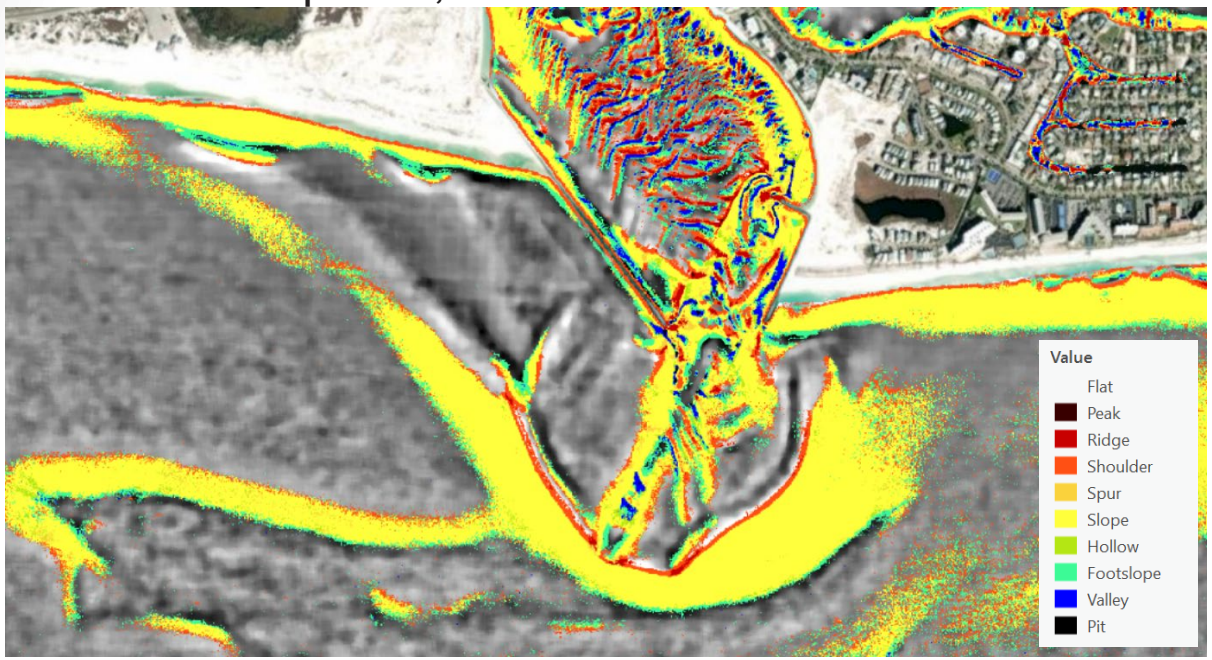
GEOMORPHONS

*Jasiewicz, Jarosław, and Tomasz F. Stepinski. “Geomorphons — a Pattern Recognition Approach to Classification and Mapping of Landforms.” *Geomorphology* 182 (2013): 147–56. https://doi.org/10.1016/j.geomorph.2012.11.005.



Geomorphon Landforms (Spatial Analyst)—ArcGIS Pro | Documentation

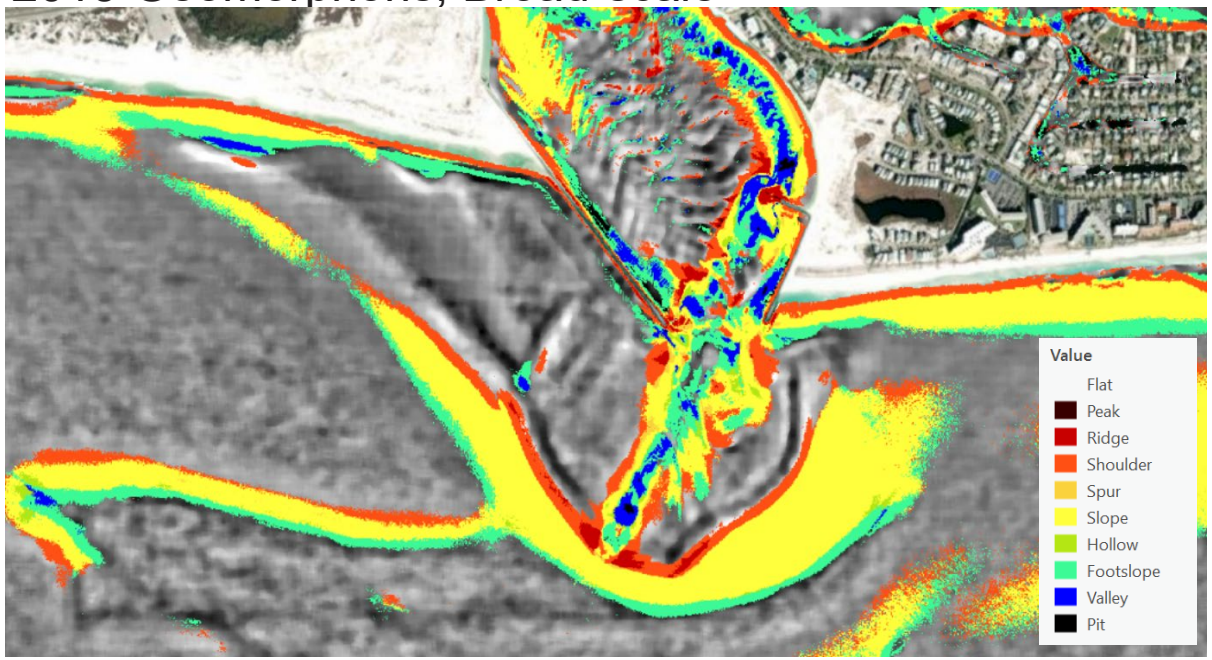
2015 Geomorphons, Fine-scale



Geomorphons overlaid on relative relief

Flat terrain angle threshold = 1.5
Search distance = 30 m
Skip distance = 10 m

2015 Geomorphons, Broad-scale



Geomorphons overlaid on relative relief

Flat terrain angle threshold = 1.5
Search distance = 90 m
Skip distance = 30 m

RELATIVE RELIEF/GEOMORPHONS

Insights at East Pass

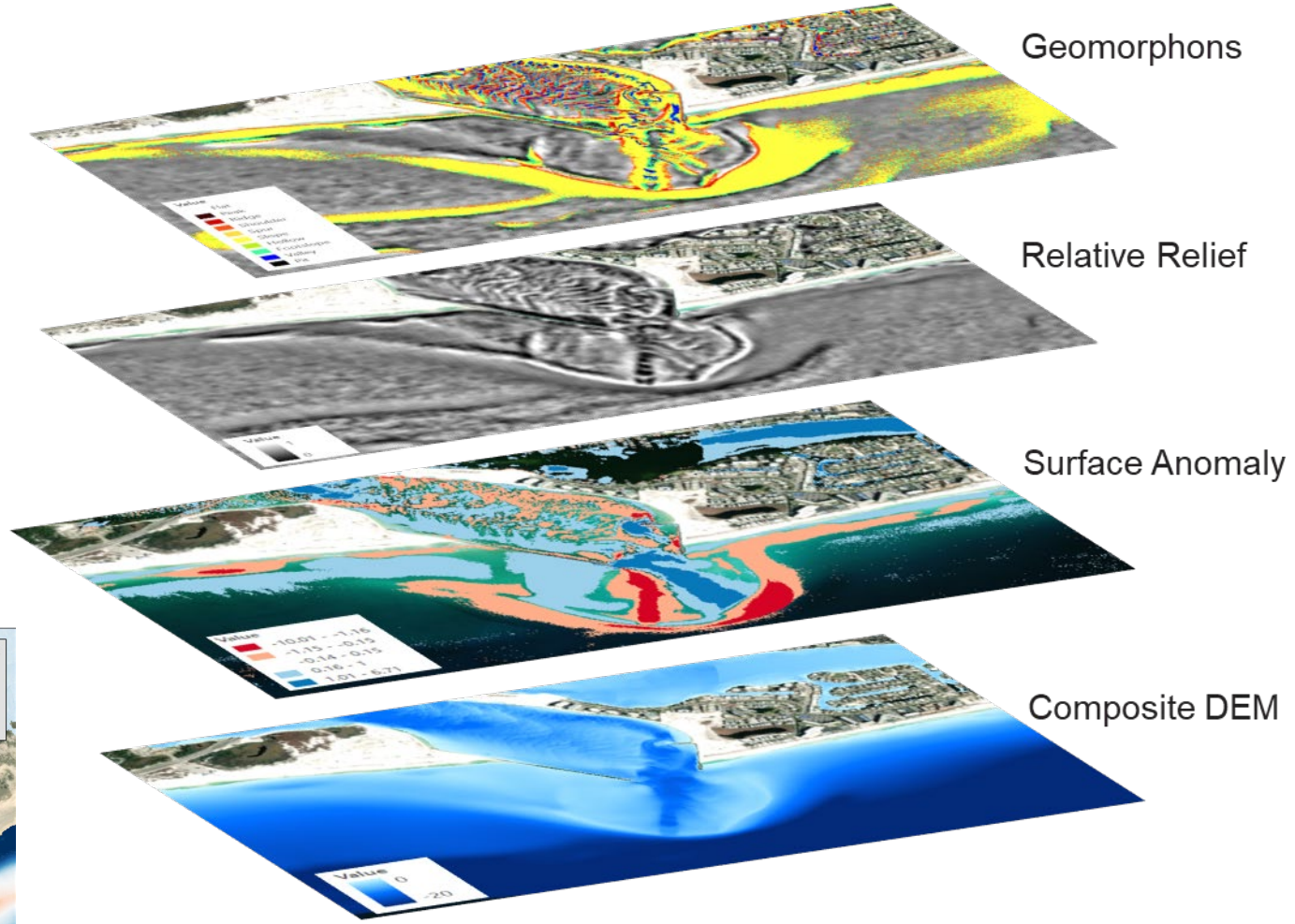
- Spatio-temporally data 'rich' inlet provides opportunities to identify regions of the ebb shoal and navigation channel that are changing

Implications for other inlets:

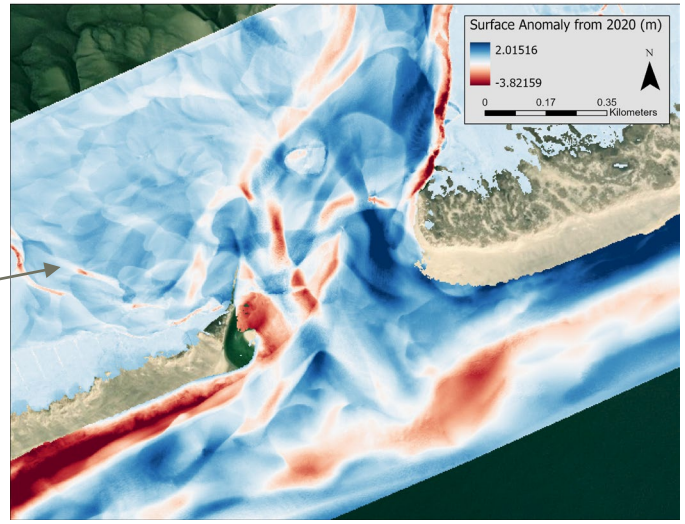
- Data limitations – next case study site is Fire Island Inlet

Next Steps

- In April ORISE Fellow Matheus Bose will implement workflows at additional inlets



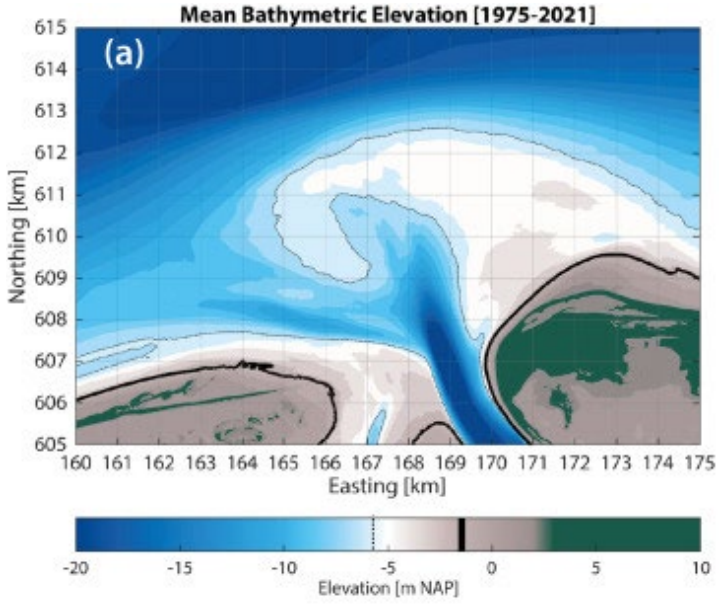
2020 surface anomaly at Wilderness Inlet (closed) Fire Island, NY (product by Matheus Bose)

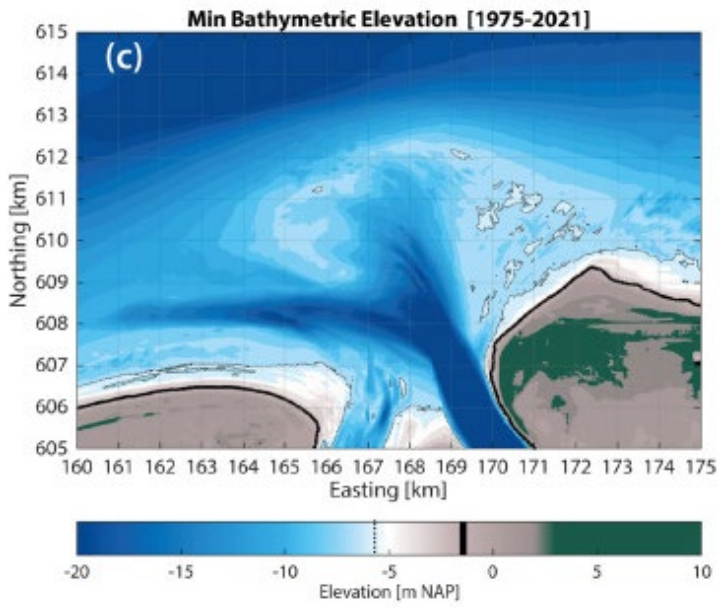


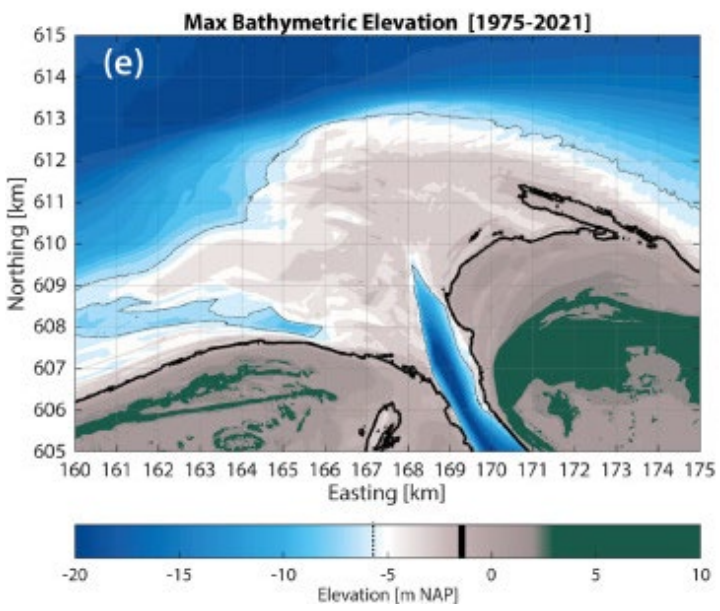
CONFORMAL MAPPING

Pearson et al., 2022, *A novel approach to mapping ebb-tidal delta morphodynamics and stratigraphy*, Geomorphology

- Established workflow and new methods for mapping inlet bathymetric change
- Three parts
  1. **Surfaces in XY coordinates**







CONFORMAL MAPPING: XY COORDINATES

Pearson et al., 2022, *A novel approach to mapping ebb-tidal delta morphodynamics and stratigraphy*, Geomorphology

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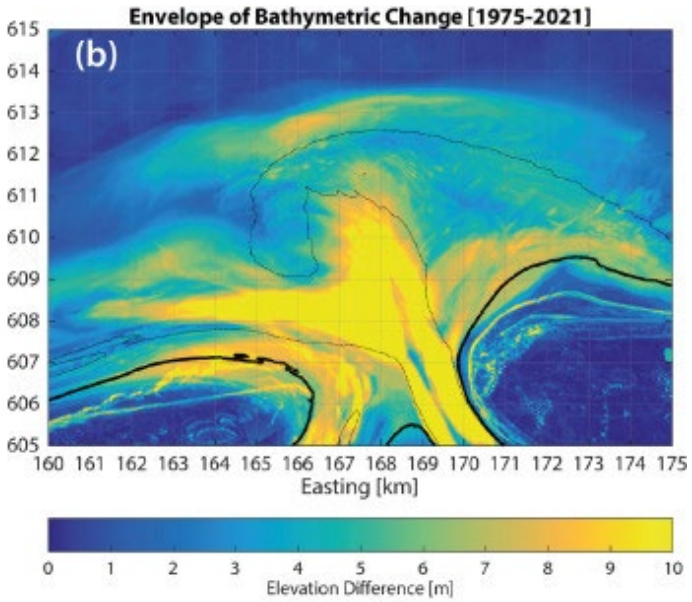
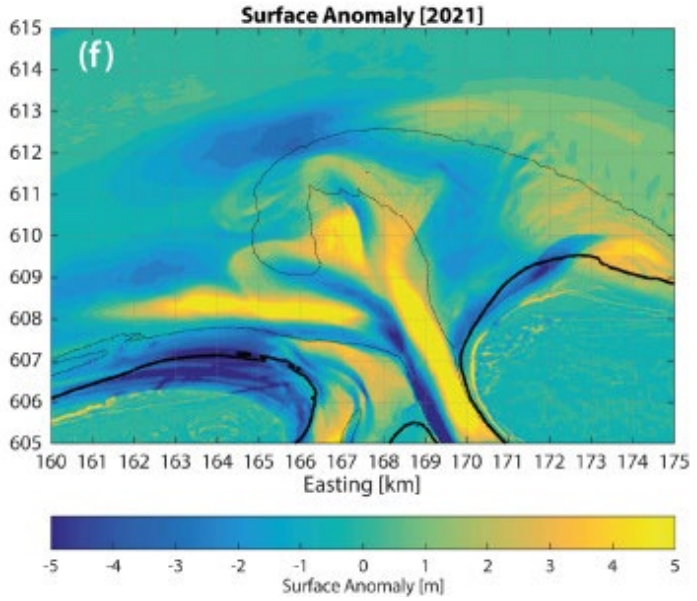
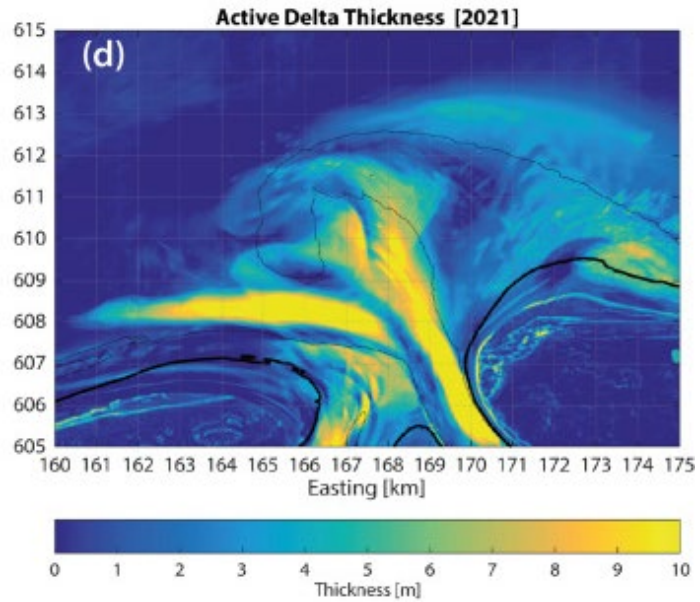
  1. **Surfaces in XY coordinates**



Max - Min



2021 - Mean

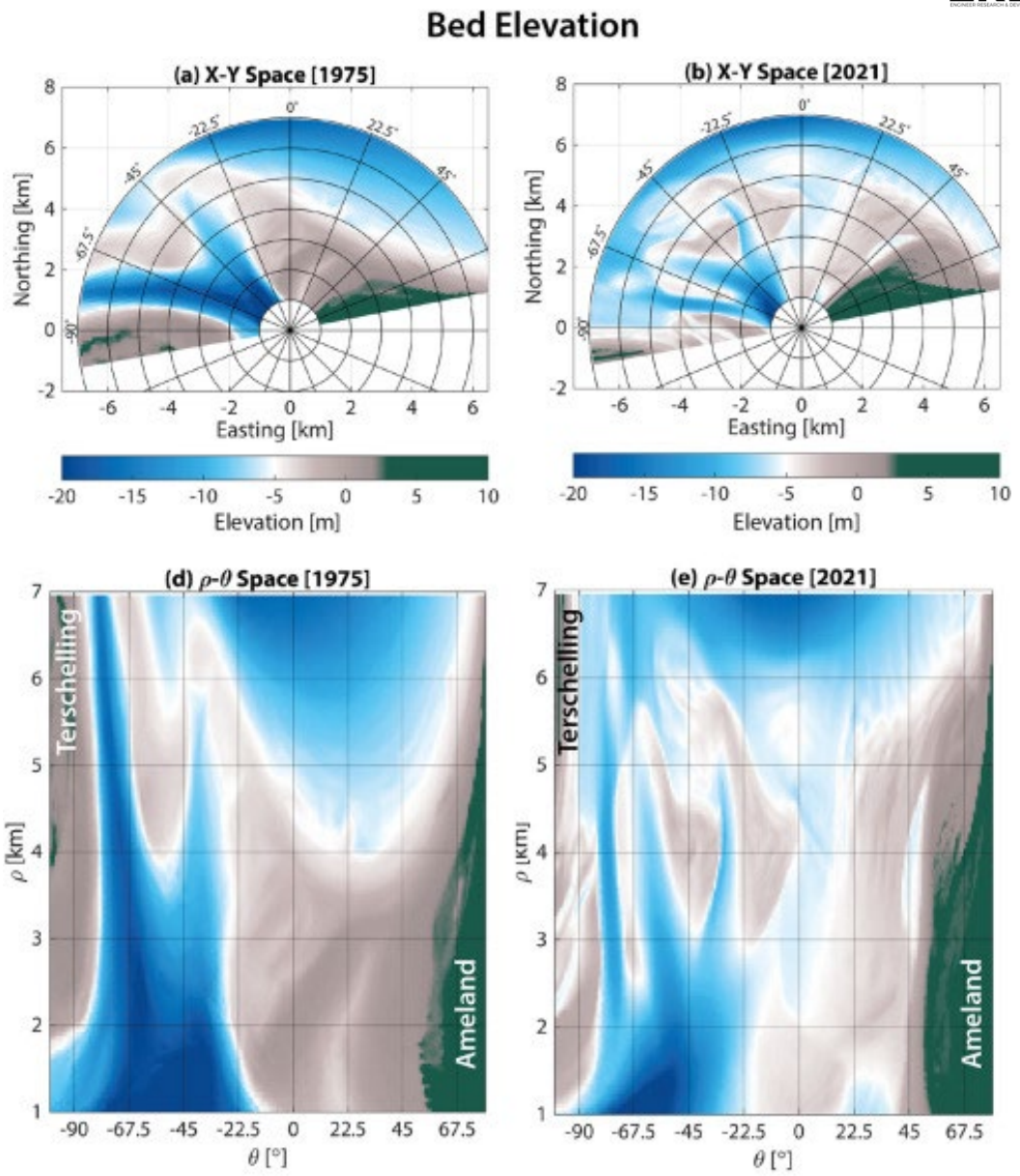


2021 - Min

CONFORMAL MAPPING: POLAR COORDINATES

Pearson et al., 2022, *A novel approach to mapping ebb-tidal delta morphodynamics and stratigraphy*, Geomorphology

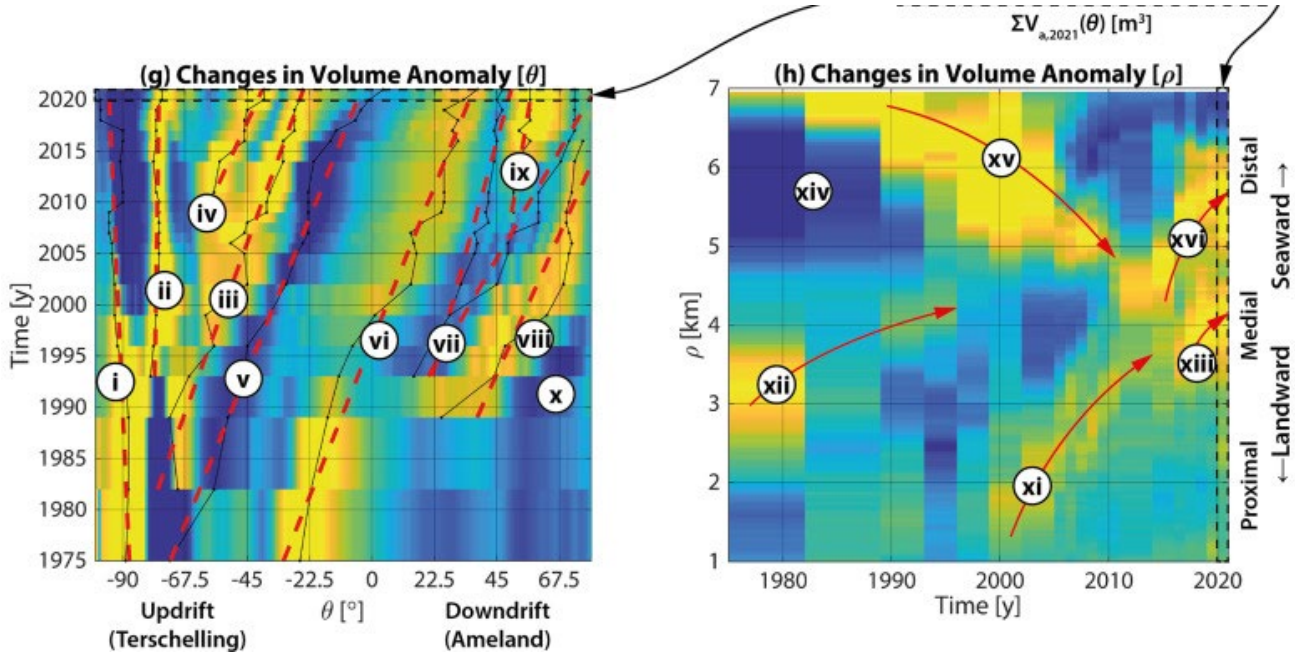
- Established workflow and new methods for mapping inlet bathymetric change
- Three parts
  1. Surfaces in XY coordinates
  2. **Surfaces in polar coordinates**

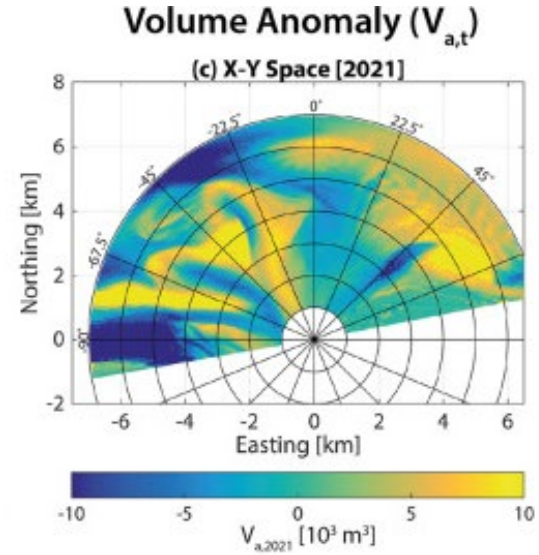


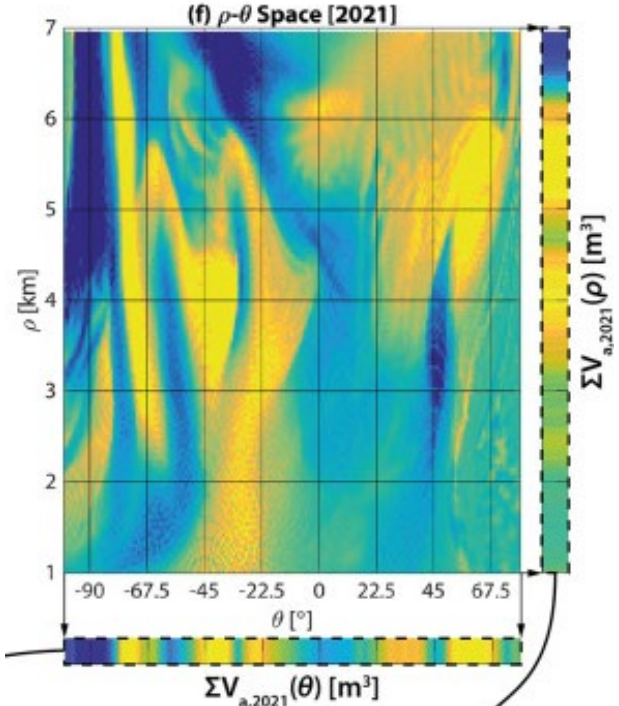
CONFORMAL MAPPING: ANOMALY DETECTION

Pearson et al., 2022, *A novel approach to mapping ebb-tidal delta morphodynamics and stratigraphy*, Geomorphology

- Established workflow and new methods for mapping inlet bathymetric change
- Three parts
  1. Surfaces in XY coordinates
  2. **Surfaces in polar coordinates**





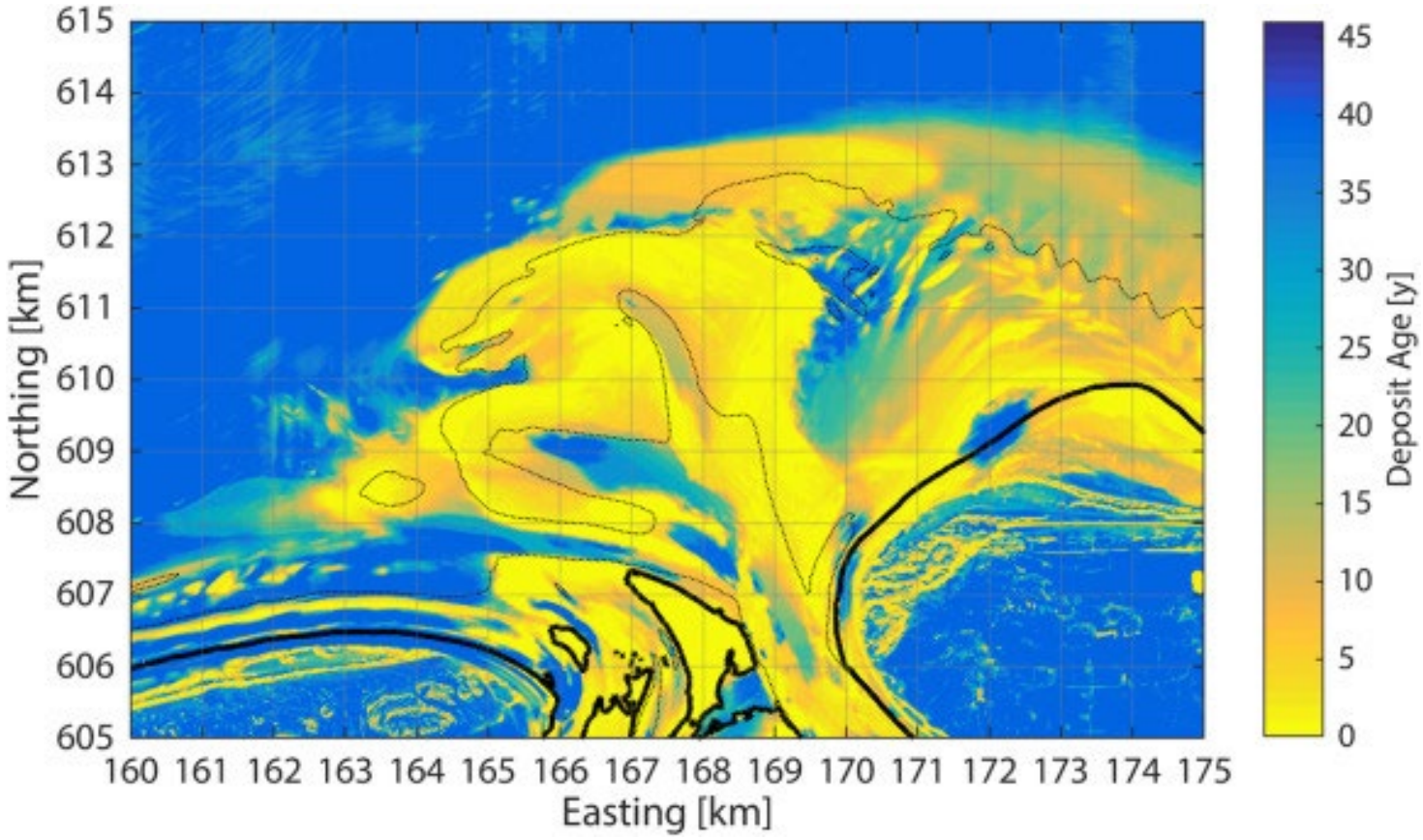


CONFORMAL MAPPING: CHRONOSTRATIGRAPHY

Pearson et al., 2022, *A novel approach to mapping ebb-tidal delta morphodynamics and stratigraphy*, Geomorphology

- Established workflow and new methods for mapping inlet bathymetric change
- Three parts
  1. Surfaces in XY coordinates
  2. Surfaces in polar coordinates
  3. **Chronostratigraphy from bathymetry**

Cell by cell calculation, compare elevation differences at sequential timesteps, repeat for all timesteps



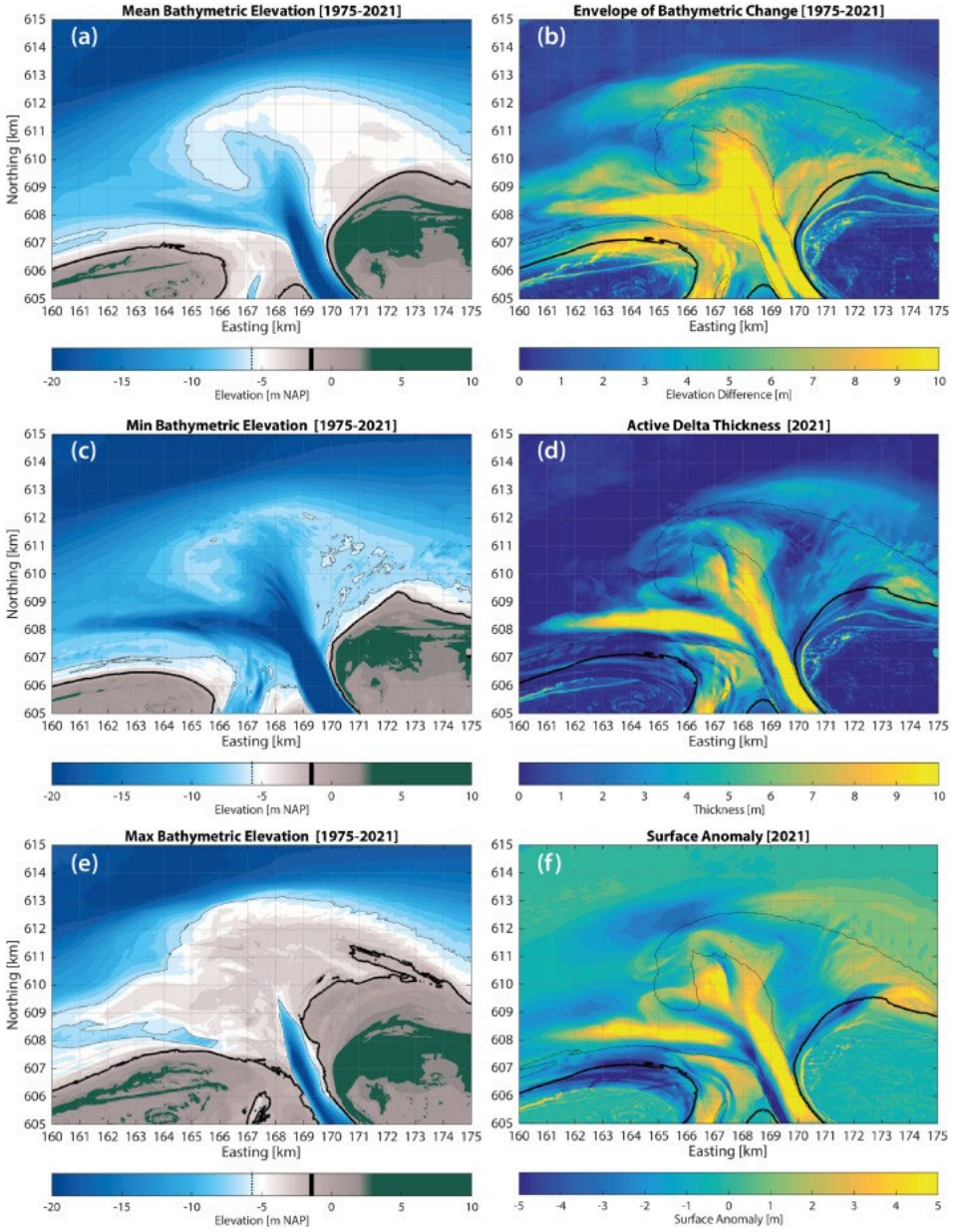
CONFORMAL MAPPING: BENEFITS AND LIMITATIONS

Pearson et al., 2022, *A novel approach to mapping ebb-tidal delta morphodynamics and stratigraphy*, Geomorphology

- **Benefits**
  - Aligns the grid with the principal sediment transport pathways
  - Insight into the most stable regions of the ebb-tidal delta
  - Analysis of deposit thickness, spatial distribution, age, and preservation potential
- **Limitations**
  - Code not accessible
  - Matlab workflow

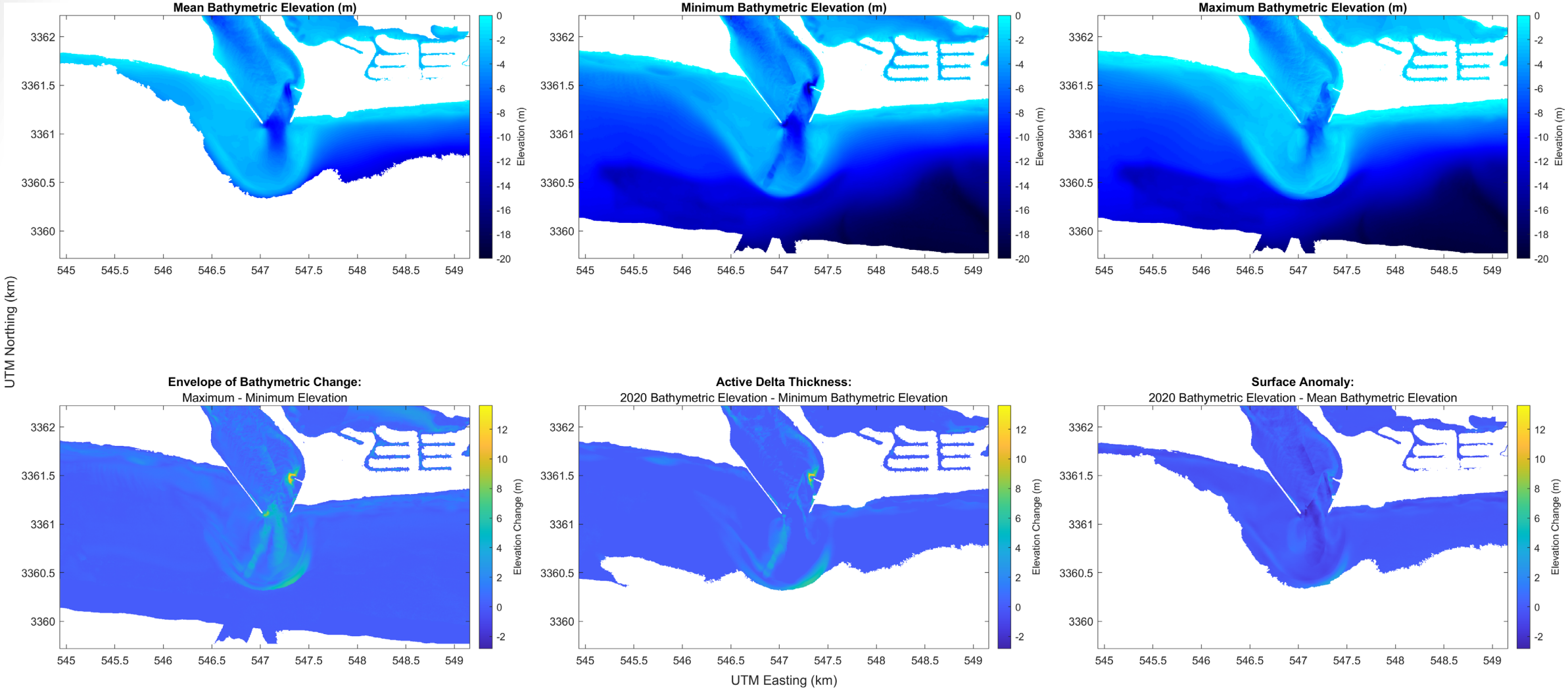
Our Goal

- Year 1: Replicate workflow
- Future: Increase accessibility (Jupyter notebook? Arc tool?)



CONFORMAL MAPPING: RECREATING WORKFLOWS

Kaite McPherran leading effort to re-create and document Pearson's workflow in Matlab

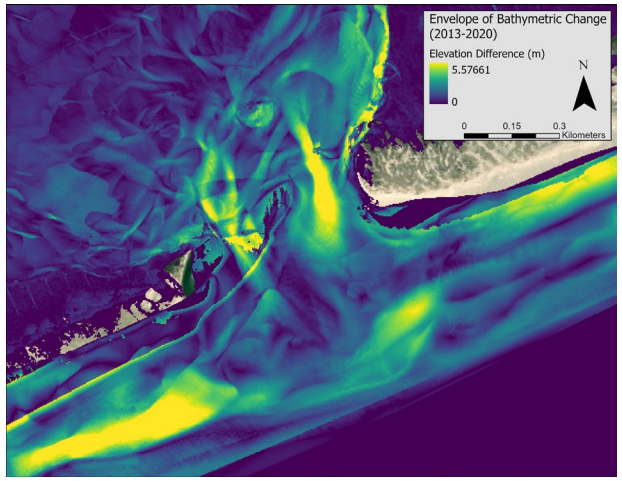


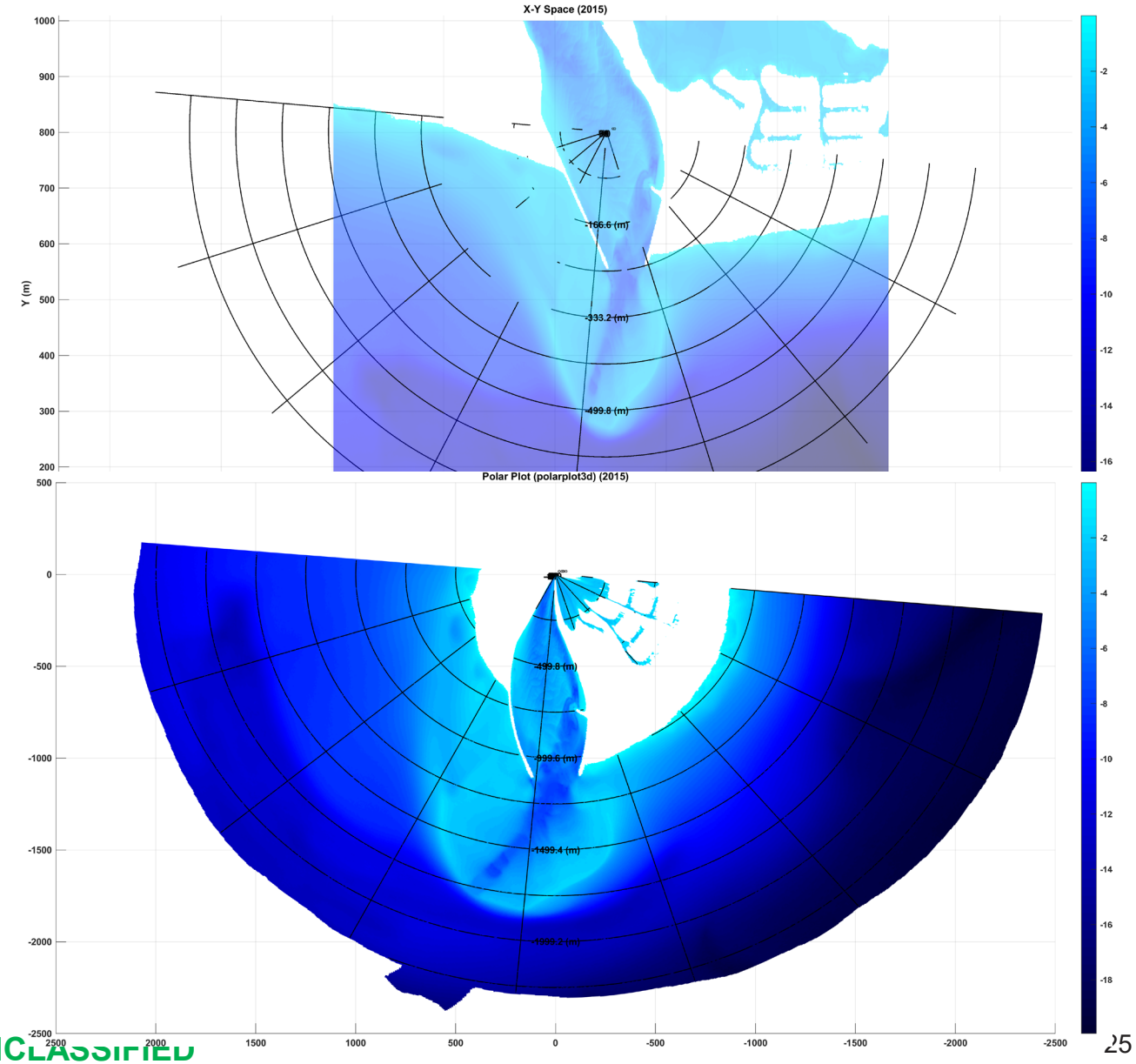
CONFORMAL MAPPING: INSIGHTS AND NEXT STEPS

Insights at East Pass
- Primary sediment transport pathway is outer ebb bar

Implications for other inlets:
- Data limitations – next case study site is Fire Island Inlet
- PDT takeaways
  - Sediment pathways – BU/strategic placement
  - Active delta thickness – targeted ebb shoal mining to speed up natural bypassing
  - Environmental studies – areas of relative quiescence versus natural active deposition
  - Identify shoaling hotspots

Next Steps
- In April ORISE Fellow Matheus Bose will implement workflow at additional inlets
- Envelope of bathy change at Wilderness Inlet (2013 – 2022) ->





NEXT GENERATION: ANTICIPATED PRODUCTS

Short-Term

- Demo image service, how to use in Pro, how to query/extract from REST
- Prototype next-gen geodatabase
- Submit Technical Note summarizing year 1 progress
  - Compare methods/approaches at East Pass and Fire Island Inlets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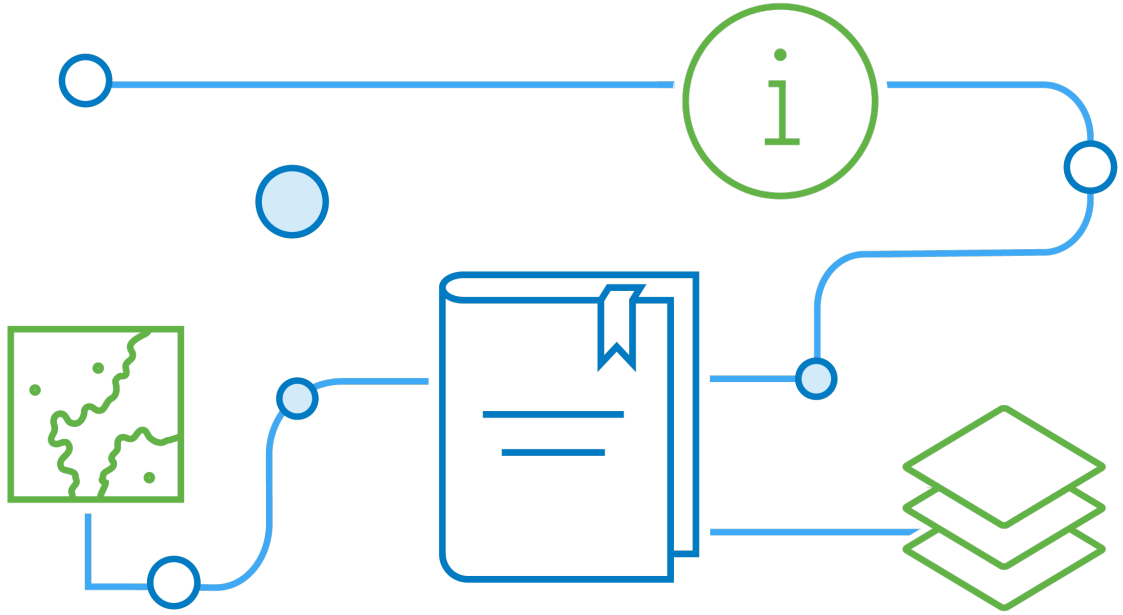
New tools and methods for mapping tidal inlets: Next Generation Inlets Atlas

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

Long-Term

- ASBPA or similar conference presentation
- ORISE fellowship – dissertation publications
- Full web service with data
- ArcGIS tools



Graphic: ESRI