NEXT-GENERATION VOLUME CHANGE PRELIMINARY PRODUCTS

Charlene Sylvester, Scott Spurgeon, Shane Nichols-O'Neill, Brooke Walker, Sam Jackson and Loderay Bracero-Marrero

CIRP Technical Discussion
May 13th, 2025

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BUILDING STRONG

RESEARCH TEAM

Charlene Sylvester

Research Physical Scientist

Project Motivation

Research Roadmap

Scott Spurgeon

Research Civil Engineer

Lit Review

Workflow for STCs

Shane Nichols-O'Neill

ORISE Fellow

Bias Assessments

Brooke Walker

Research Physical Scientist

Volume Calculations

Sam Jackson

Research Forester

Landcover and Dune Vegetation

Loderay Bracero-Marrero

Research Physical Scientist, Taylor-Woolpert

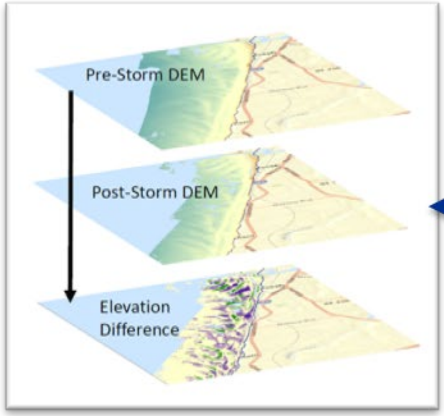
Volume Partitioning

Multi-disciplinary research team members from CHL & EL with ORISE and contract support

PDT members from CHL, SAM, NAP, SAJ, and NAN

BACKGROUND AND MOTIVATION

- SoN 2024-N-1968: New volume-change tools to improve sediment management
  - USACE operations in Navigation, Flood Risk Management, and Environment **require advanced spatio-temporal sediment volume change analysis tools** to capture sediment transport during planning, construction, and monitoring phases of projects.
- SoN 2024-N-1969: Incorporating shoaling rates into sediment budget creation to improve sediment management
  - USACE operations in Navigation, Flood Risk Management, and Environment can **benefit in efficiency gains from volume change analysis tools to capture sediment transport** during planning, construction, and monitoring phases of projects.



Existing Framework:

DEMs of Difference
&
Volume Change Bins

LIMITATIONS OF CURRENT METHODS

- While the existing framework of DEMs of Difference (DoD) and Transect Bins can quantify volumetric change within the fixed in space volume “bins”, there are several limitations to this approach:

1. Following storm events, it is often necessary to modify the cross-shore extent of the transect bins. **The modification of the spatial extent of transect bins limits direct comparison to previous results.**
2. Bathymetric data coverage varies with water clarity and breaking waves at the time of data acquisition. Therefore, **the net volume quantities between time periods are not directly comparable where bathymetric data coverage varies**.
3. While the movement of sediment may be inferred from the DoD, **transport direction of sediment is not currently captured**.

RESEARCH AND DEVELOPMENT GOAL

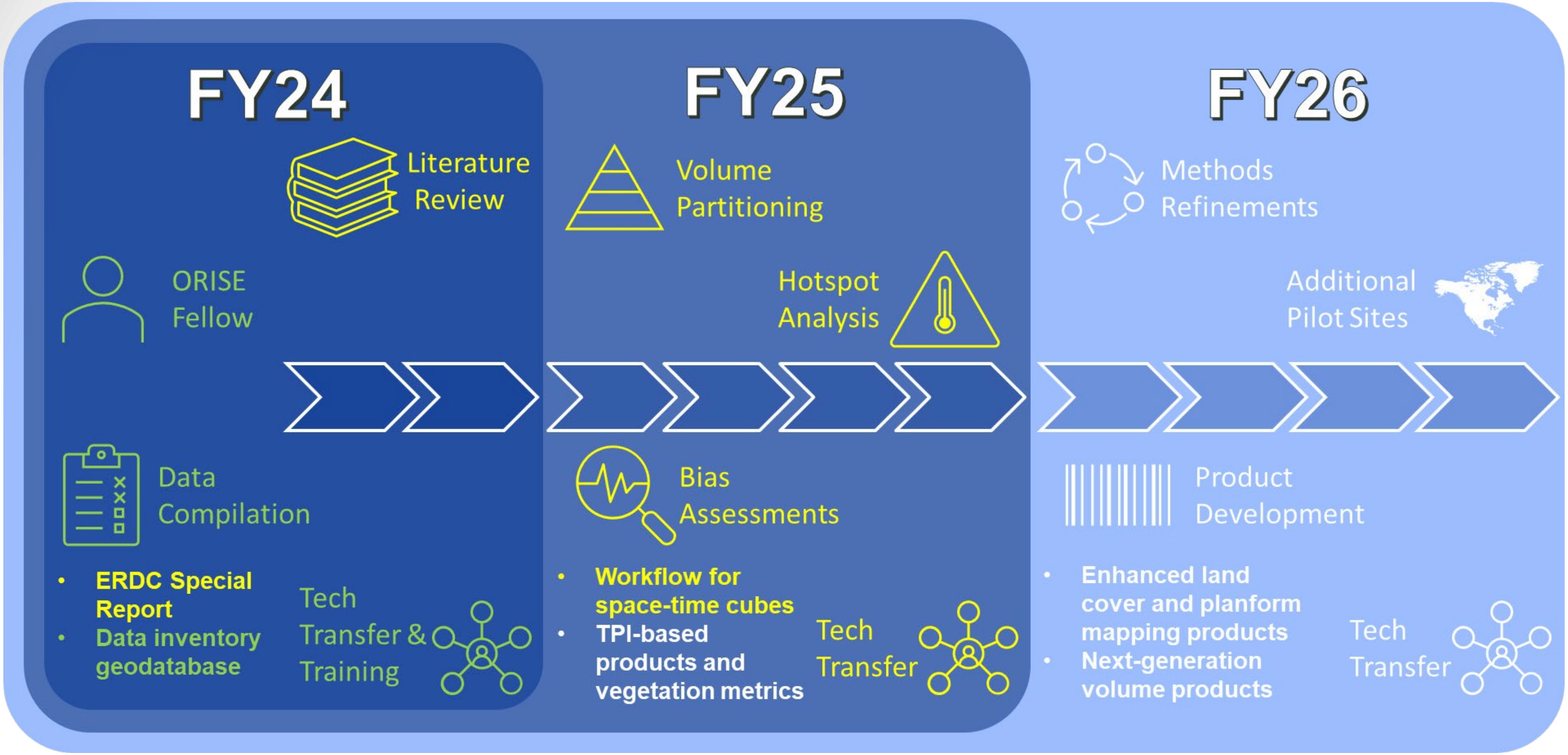
The research team is addressing requirements for **a flexible volume change framework** leveraging current geomorphic feature extraction and classification R&D together with multi-dimensional space-time and conformal mapping approaches **to improve both the characterization and quantification of volumes** for coastal projects in support of sediment budget development, operations and maintenance, and project monitoring.

The project is a three-year effort:

Year 1: Apr – Sep 2024
Year 2: Oct 2025 – Sep 2025
Year 3: Oct 2025 – Sep 2026

UNCLASSIFIED

PROJECT ROADMAP



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LITERATURE REVIEW AND SPACE-TIME CUBE WORKFLOW

Scott Spurgeon
Research Civil Engineer, USACE-CHL

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LITERATURE REVIEW - IN PROGRESS

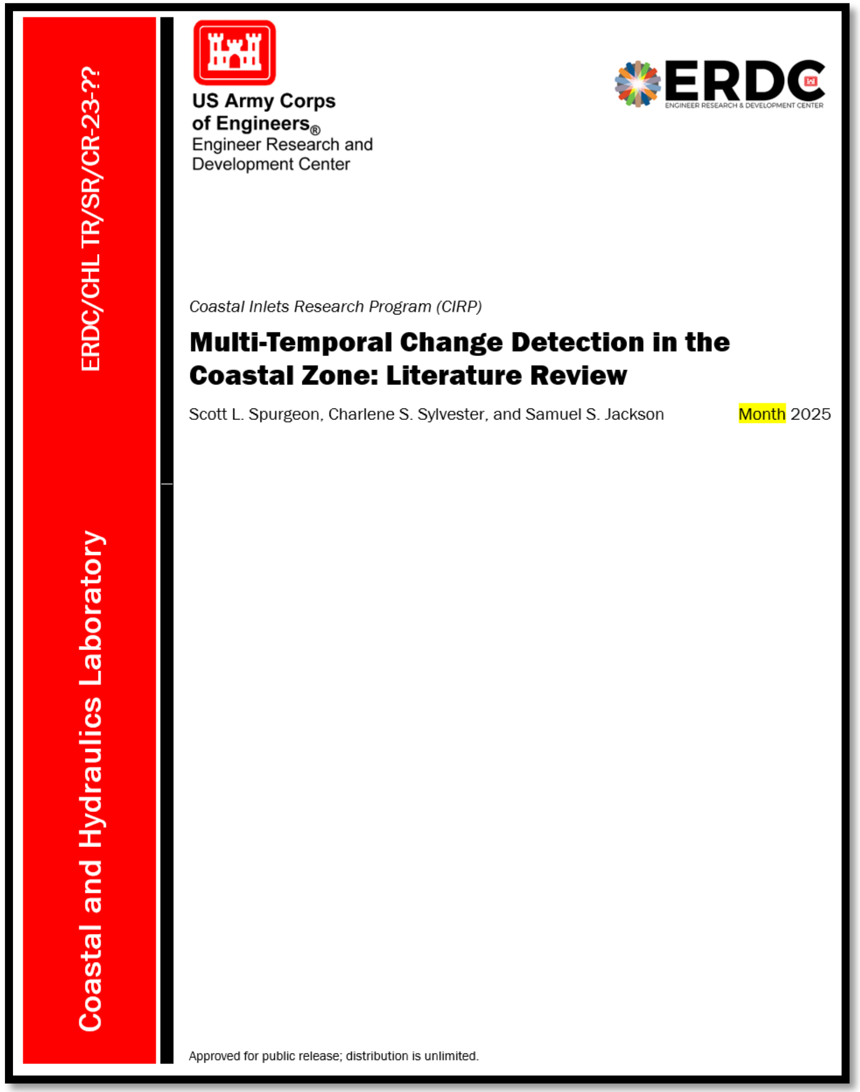
Literature Review Purpose

- BLUF: To determine the current state-of-art related to multi-temporal change detection in the coastal environment, identify temporal data requirements for robust change analysis, and identify existing tools for performing change detection analysis.
- 75+ Refereed Pieces of Literature Sourced from 1976-2024

Topics Include:

- Coastal Volume Change Detection Background
- Shoreline Change Method
- Beach Profile Method
- DEM of Difference Method
- Space-Time Cube Method
- Errors and Uncertainties

IN REVIEW!



ERDC/CHL TR/SR/CR-23-??

Coastal and Hydraulics Laboratory

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Coastal Inlets Research Program (CIRP)

Multi-Temporal Change Detection in the Coastal Zone: Literature Review

Scott L. Spurgeon, Charlene S. Sylvester, and Samuel S. Jackson

Month 2025

Approved for public release; distribution is unlimited.

LITERATURE REVIEW

Literature Review Compilation

Literature of interest was downloaded, and metadata information was sourced into a tracking spreadsheet that can serve as a deliverable. Rows in the tracking spreadsheet were color-coded based on their inclusion in the Special Report.

Tracked fields included:

- Title
- Authors
- Publish Year
- Abstract
- Summary & Key Points
- Keywords
- Quotes with Page Number
- Category
- Current Status

Title	Authors	Year	Abstract	Summary & Key Points	Keywords	Quotes (page number)	Search Category for Result (Keywords)	Current Bin (Dropdown)
2020 hurricane impact assessment for the northern Gulf of Mexico: Hurricane Sally	S. McGill, C. Sylvester, L. Dunkin, E. Eisemann, J. Wozencraft	2021	Regional-scale shoreline and beach volume changes are quantified using the	Rapid delivery of volume change, shoreline change, and beach volume metrics can be	Lidar, imagery, poststorm, beach volume change,	P.3 "Data and products developed under this workflow were delivered incrementally	Difference Raster	Accepted
A Conceptual Model for the Retreat and Volume Loss of the Louisiana Barrier	Campbell, T. and L. Benedet	2005	This is paper is part of an ongoing effort to develop a dynamic	Shoreline change rates converting to volume change rates; Barrier Islands Usage		P. 2171 "Computation of net volumetric change requires four steps: (1) Deveopment	Coastal Volume Change Analysis Techniques	Accepted
A descriptive framework for temporal data visualizations based on generalized	Bach, Benjamin, Pierre Dragicevic, Daniel Archambault, Christophe Hurter, and	2017	We present the generalized space-time cube, a descriptive model for	Space Time Cube Analysis and temporal visualization	STC, 2D visualization of STCs		Space Time Cube Analysis	Accepted
A review of U.S. Army Corps of Engineers airborne coastal mapping in the Great	Molly K. Reif, Jennifer M. Wozencraft, Lauren	2012	The U.S. Army Corps of Engineers (USACE) Joint Airborne Lidar Bathymetry	Reif et al. (2014) provides an overview of the coastal mapping by the National Coastal	NCMP, raster products, imagery, feature extraction		Difference Raster	Accepted
Accounting for uncertainty in DEMs from repeat topographic surveys: improved	Joseph M. Wheaton, James Brasington, Stephen E. Darby and David A. Sear	2009	Repeat topographic surveys are increasingly becoming more affordable,	This is referenced by various other papers, so IS a key publicaiton to reference, perhaps the	DEM of Difference (DoD); fluvial geomorphology;	P. 136 "From the early 1990s (Lane et al., 1994), the morphological method has been	Coastal Volume Change Analysis Uncertainty	Accepted
An analysis of spatiotemporal pattern for COIVD-19 in China based on space-time	Mo, Chunbao, Dechan Tan, Tingyu Mai, Chunhua Bei, Jian Qin, Weiyi Pang, and	2020	This study seeks to examine and analyze the spatial and temporal patterns of	Space-Time Cube Analysis for COVID-19	STC Case Study		Space Time Cube Analysis	Accepted
An Empirical Approach to Beach Nourishment Formulation	Timothy W Kana Haiqing Liu Kaczkowski	2014	This chapter presents an empirical approach to beach nourishment	Coastal planning documentation such Kana et al. (2014) recognize that while movement	Profile-based volume change, guidance document, profile		Coastal Volume Change Analysis Guidance	Accepted
An object-based conceptual framework and computational method for representing	Hongxing Liu, Lei Wang, Douglas Sherman, Yige Gao, Qiusheng Wu	2010	This article presents an object-based conceptual framework and numerical	Lidar used for volume changes, pixel method compared to object-based methodology. The	Erosional and deposition hotspots, raster differencing	P. 26: "This method essentially reduces a large volume of cell-by-cell elevation	Coastal Volume Change Analysis Techniques	Accepted
Application of the AMBUR R package for spatio-temporal analysis of shoreline	Chester W. Jackson Jr.a,b,n , Clark R. Alexander b,c , David M. Bush d	2012	The AMBUR (Analyzing Moving Boundaries Using R) package for the R	The Analyzing Moving Boundaries using R (AMBUR) package (Jackson et al. 2012)	Shoreline change, software, user's guide		Coastal Change Detection	Accepted
ArcGIS Pro Release 3.3	ESRI	2024	Software	Software	Volume Change Tools		Coastal Volume Change Analysis Techniques	Accepted
Articulating Environmental Sustainability Dynamics with Space-Time Cube	Wang, Dezhi, Zhenxiu Cao, Minghui Wu, Bo Wan, Sifeng Wu, and Quanfa Zhang	2024	Conceptually, environmental sustainability involves maintaining crucial	The proposed framework characterizes continuous space-time sequences. The			Space Time Cube Analysis	Accepted
ASPRS Positional Accuracy Standards for Digital Geospatial Data	ASPRS	2014	N/A	Key standards and procedures for computing and reporting accuracy are specified in the	Guidance, accuracy standards		Errors and Uncertainties	Accepted
ASPRS Positional Accuracy Standards for Digital Geospatial Data	ASPRS	2023	N/A	Key standards and procedures for computing and reporting accuracy are specified in the	Guidance, accuracy standards		Errors and Uncertainties	Accepted
Climate Change and Anthropogenic Impact on Coastal Environments	Bini, Monica, and Veronica Rossi	2021	Coastal-transitional areas, including delta plains, strandplains, lagoons,	Discussion of climate change	Climate		Coastal Change Detection	Accepted
Coastal Engineering Manual	U.S. Army Corps of Engineers Engineering Research and Development Center	2002	N/A	See Part 5, Chapter 4-1: Engineering Aspects of Beach Design for discussion on how volume	Guidance, SHOALS, GENESIS, survey usage in volume	"Shoreline positions that are accurately digitized from properly rectified aerial	Coastal Volume Change Analysis Guidance	Accepted
Coastal Wetlands Facing Climate Change and Anthropogenic Activities: A Remote	Wu, Wen-ting, Yun-xuan Zhou, and Bo Tian	2017	Under high-intensity anthropogenic activities and accelerated climate change	Detailed and long-term change detection of coastal wetlands is mapped. Effects of	Coastal wetlands, long-term change, anthropogenic		Coastal Volume Change Analysis	Accepted
Comparison of two open-source tools for diachronic shoreline monitoring: a case	Apostolopoulos, Dionysios N., and Konstantinos G. Nikolakopoulos	2021	Coastal environments are under successive physical and	Apostolopoulos and Nikolakopoulos (2021) compare the shoreline change analysis abilities	DSAS, AMBUR, shoreline extraction, comparison of		Coastal Volume Change Analysis Techniques	Accepted
Control and Topographic Surveying	USACE	2007	Guidance and Documentation	Guidance and Documentation			Coastal Volume Change Analysis Guidance	Accepted
Correlation between nearshore reef structure and shoreline changes in Indian	Harris, L. E., N. Samuelson, and M. Damon.	2003		Harris, Samuelson, and Damon (2003) show alongshore changes in shoreline position occur	Shoreline position change		Coastal Volume Change Analysis	Accepted
Data Cubes for Earth System Research: Challenges Ahead	Montero Loaiza, David, Guido Kraemer, Anca Anghelea, Cesar Aybar Camacho,	2023	Recent advancements in Earth system science have been marked by the	Space-Time Cube Analysis, Earth System Science, Documentation			Space Time Cube Analysis	Accepted
DEMs of Difference	Richard David Williams	2012	A key aspect of geomorphological enquiry is concerned with quantitatively	Introduction of the DEM of Difference method. References that DoD is a 2.5D	DEM of Difference (DoD), Deposition, Erosion, Error,	P. 1 "The focus of the chapter is on producing DoDs in situations that are	Difference Raster	Accepted
Digital Shoreline Analysis System (DSAS) Version 5.1 User Guide	Emily A. Himmelstoss, Rachel E. Henderson, Meredith G. Kratzmann, and	2021	The Digital Shoreline Analysis System version 5 software is an add-in to Esri	The Digital Shoreline Analysis System (DSAS) (Himmelstross et al. 2021) is an add-in to ESRI	Shoreline change, software, user's guide		Coastal Volume Change Analysis Techniques	Accepted
Discussion of: Theuerkauf, EJ and Rodriguez, AB, 2012. Impacts of Transect	Rudolph, Greg L.	2012	Theuerkauf and Rodriguez (2012) utilized terrestrial laser scanning data obtained at	See Theuerkauf and Rodriguez (2012) - this is a discussion of that paper	Rudolph (2012) responded to Theuerkauf and Rodriguez		Coastal Volume Change Analysis Techniques	Accepted
During Nearshore Event Vegetation Gradation (DUNEVEG): Geospatial Tools for	Sam S. Jackson, Christina L. Saltus, and Glenn M. Suir	2023	Monitoring and modeling of coastal vegetation and ecosystems are major	Jackson et al. (2023) introduces the During Nearshore Event Vegetation Gradation	DUNEVEG, vegetation, NCMP, hyperspectral		Coastal Vegetation Extraction and Monitoring	Accepted
Emerging Hot Spot Analysis (Space Time Pattern Mining)—ArcGIS Pro |	ESRI	2024	Documentation	Tool Documentation	STC Tools		Coastal Volume Change Analysis Techniques	Accepted
Erosional hot spots	Dean, R. G., Liotta, R., and Simón, G.	1999	Erosional hotspots, referenced by Kraus and Galgano	Erosional Hotspots	EHS		Space Time Cube Analysis	Accepted
Estimation of Shoreline Position and Change Using Airborne Topographic Lidar	Stockdon, Hilary F., Asbury H. Sallenger Jr., Jeffrey H. List, and Rob A. Holman	2002	A method has been developed for estimating shoreline position from	Estimating shoreline position from lidar, shoreline change	shoreline change, shoreline detection and mapping, lidar		Coastal Volume Change Analysis Techniques	Accepted
Evaluating Proxies for Estimating Subaerial Beach Volume Change Across Increasing	Theuerkauf, Ethan J. and Antonio B. Rodriguez.	2014	Proxies, such as changes in beach profiles and shoreline positions, are commonly	A very similar study by Theuerkauf and Rodriguez (2014) considered the same study	shoreline change, profile change, proxies as volume	P. 603 (11) "Results from this study show that changes in beach profiles and shoreline	Coastal Volume Change Analysis Techniques	Accepted
Evaluation of Airborne Topographic Lidar for Quantifying Beach Changes	Sallenger, A H, W B Krabill, R N Swift, J Brock, J List, Mark Hansen, R A HoLnan	2003	A scanning airborne topographic lidar was evaluated for its ability to quantify	Lidar as a use case for volume change methods	Lidar, DEMs, Volume Change		Coastal Volume Change Analysis	Accepted

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[Literature Review Tracking Link]

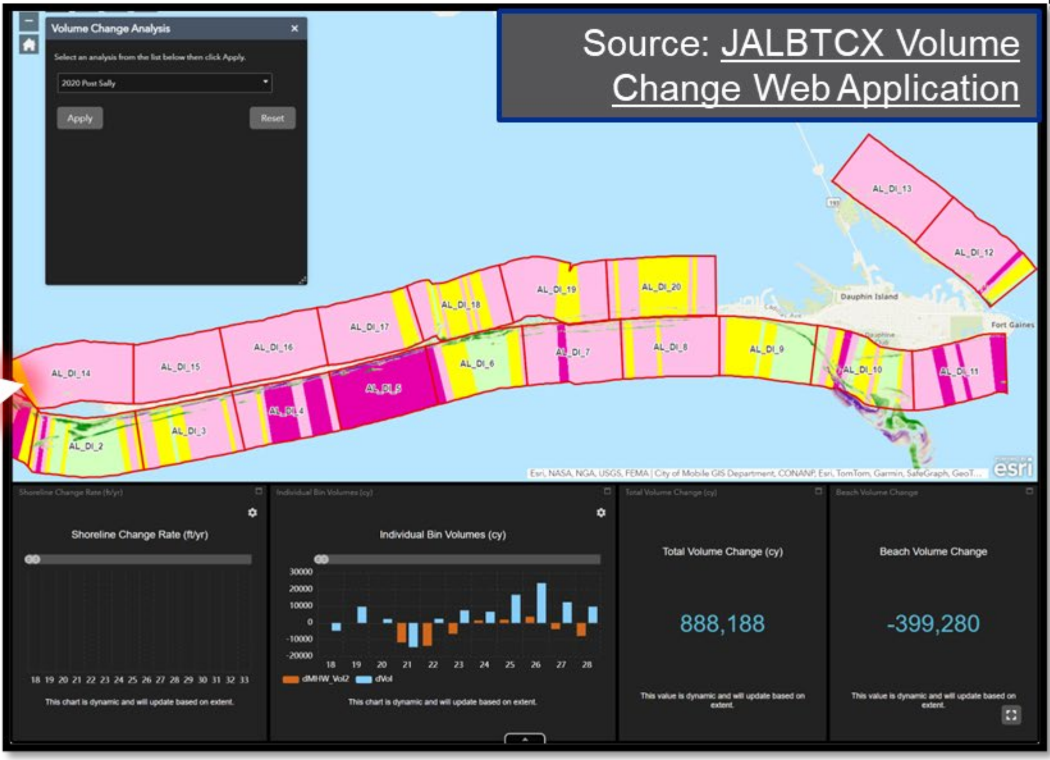
PILOT AREA: MS/AL BARRIER ISLANDS

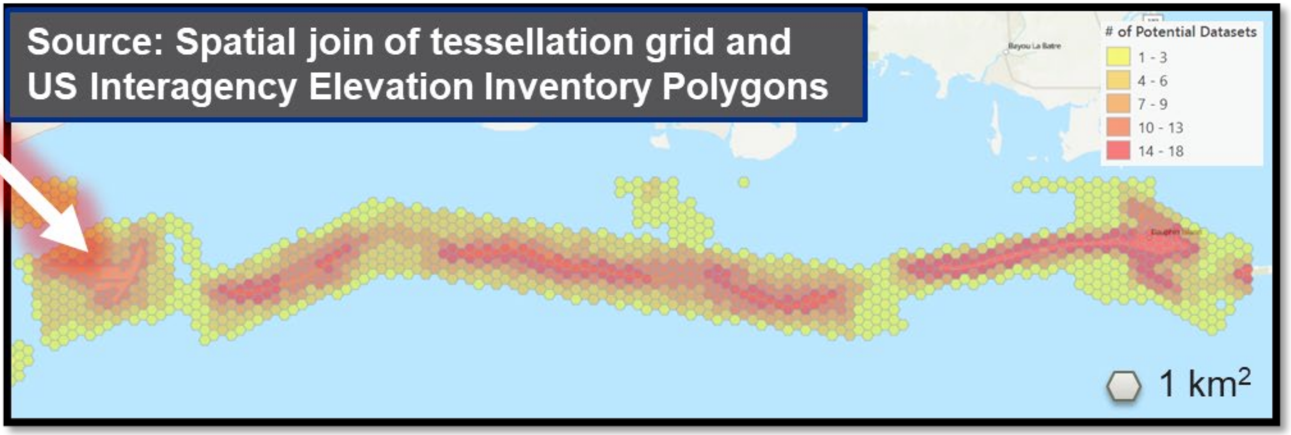
Project Overview

- Part of Mississippi Coastal Improvements Project (MsCIP)
- Aligns with MS Sediment Budget update (SAM reimbursable project)
- Existing volume change products, advanced landcover and vegetation metrics

Data Requirements:

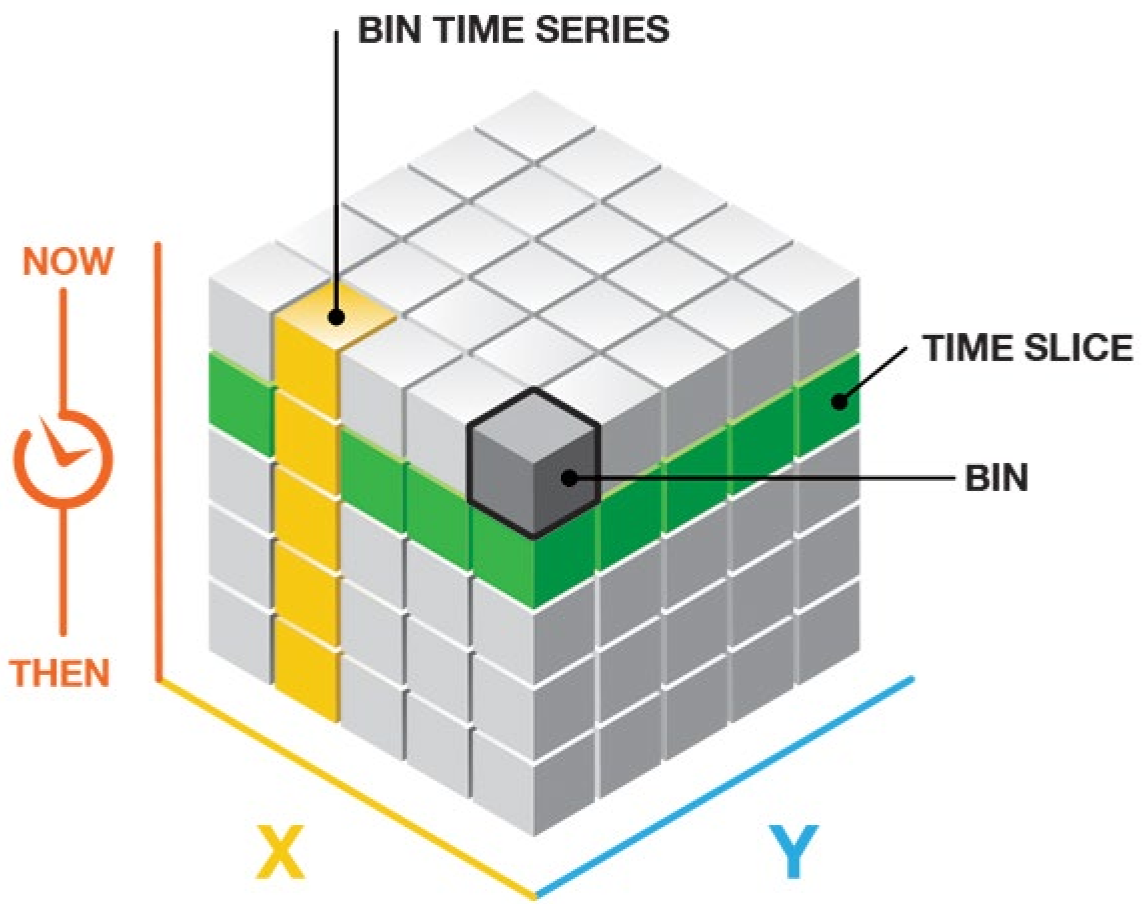
- Spatial resolution supports 3-m DEM (1-m ideal)
- Datasets are available for at least 10 temporally-unique time periods
- Adequate geospatial metadata to support datum transformations





SPACE-TIME CUBES – WHAT ARE THEY?

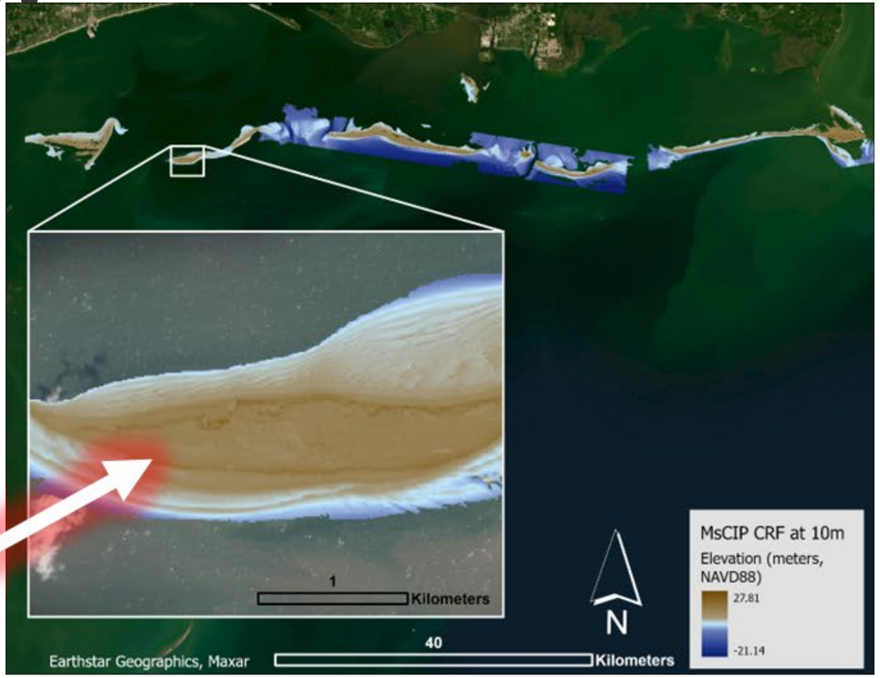
- Space-Time Cubes (STC) are geostatistical tools that allow for analysis in three dimensions.
- The first two dimensions (horizontal plane) are typically x- and y-coordinates, and the third dimension (vertical axis) is typically time.
- Each x, y, and z point is defined as a “bin” within the Space-Time Cube.
- Space-Time cubes provide statistical analyses methods across the entire domain
  - Hotspot Trend Analysis over time
  - Spatial Pattern Identification
  - Time Series Forecasting
- ArcGIS Pro has various geoprocessing tools to create, visualize, and analyze space-time cubes.

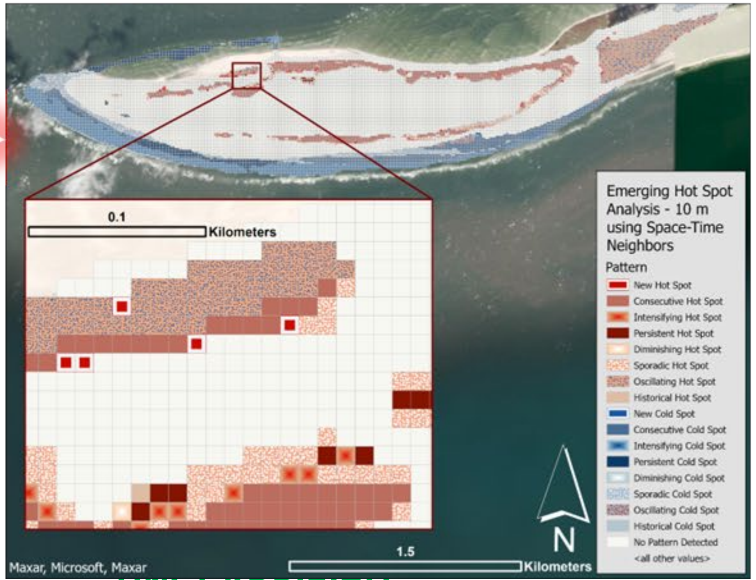


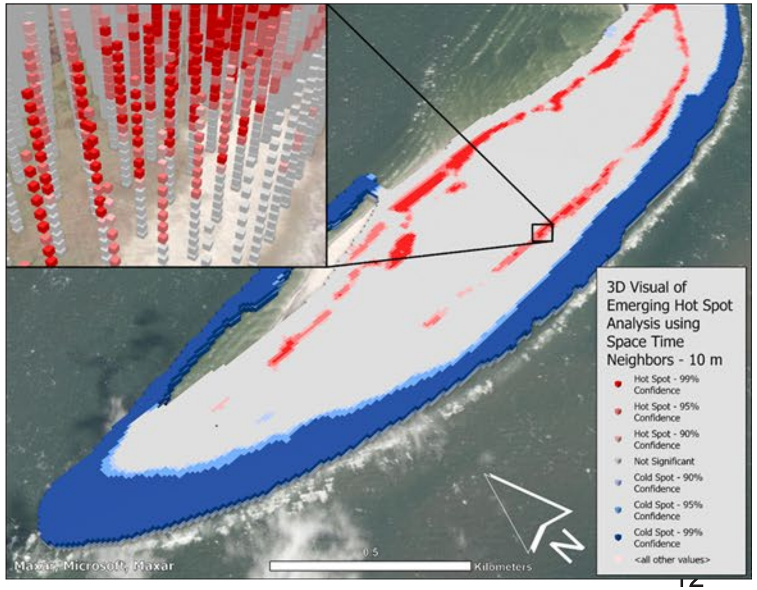
Environmental Systems Research Institute (ESRI). “How Create Space Time Cube Works.” Space Time Pattern Mining Toolbox (blog). Accessed March 14, 2025. https://pro.arcgis.com/en/pro-app/latest/tool-reference/space-time-pattern-mining/learnmorecreatecube.htm.

STC WORKFLOW OVERVIEW

1. Data Sourcing and Preparation
2. Mosaic Dataset (MDS) & Attribute Field Creation
   - Create MDS
   - Add Rasters to MDS
   - Add “Survey Date” and other metadata fields to MDS attribute table
3. Make MDS Multidimensional
4. Create Cloud Raster Format (CRF) File
5. Create STC from CRF
6. Analyze STC
7. Visualize STC







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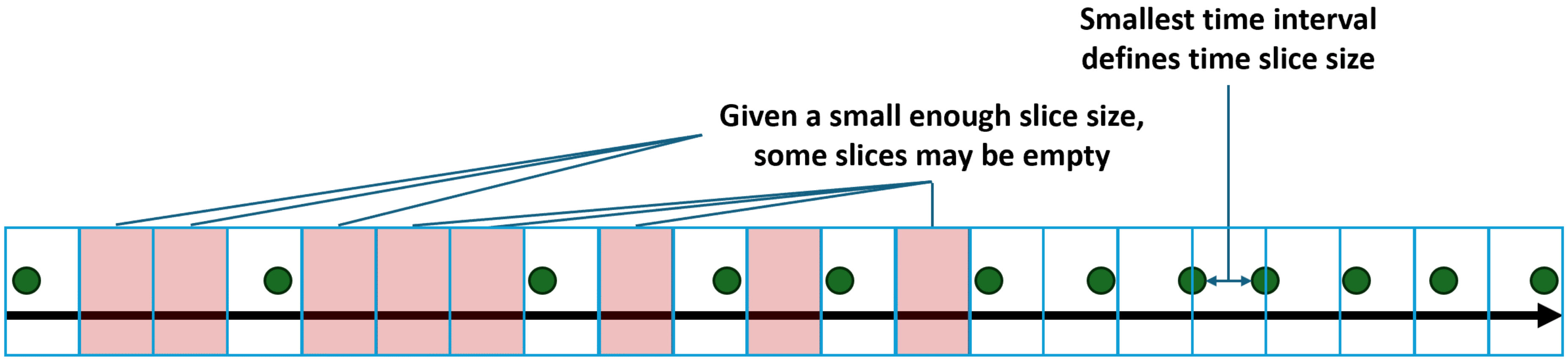
STC BEST PRACTICES

1. The finest possible resolution of the STC should be governed by the smallest cell size represented in the input datasets to avoid interpolation artifacts.
2. Suggested file formats for Mosaic Datasets are GeoTIFF (.tif) or NetCDF (.nc) files.
3. Errors with “Create Space Time Cube from Multidimensional Raster Layer” often arise when creating STCs with lots of bins (either a RastertoNumpyArray Runtime Error or Error 110005). Suggested solution: Increase cell size of input multidimensional raster, reduce extent of AOI, reduce number of input datasets, and/or increase the time step interval to reduce number of time layers.
4. STCs require 10 individual time steps. If the data is not collected at regular intervals, the time step interval for the multidimensional raster and STC will be defined by the smallest time gap between datasets.



$$Bins = \frac{extent\ in\ the\ x-direction\ (meters)}{CRF\ cell\ size\ (meters)} * \frac{extent\ in\ the\ y-direction\ (meters)}{CRF\ cell\ size\ (meters)} * number\ of\ time\ layers$$

NEXT STEPS – SPACE TIME CUBES

- **Technical Note**
- **Best Practices**
  - “Soft Cap” of number of bins vs. absolute cap
- **Products & Analysis**
  - Emerging Hot Spot Analysis
  - Space-Time Pattern Toolbox
  - Time Series Forecasting Toolbox
  - Others?
- **Alternative Testing**
  - Tools outside of ESRI?
  - NetCDF vs. CRF vs. others?

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Establishing a Workflow to Build Space-Time Cubes in ArcGIS Pro with High-Resolution Elevation Data

by Scott Spurgeon, Brooke Walker, Charlene Sylvester

PURPOSE: This Coastal and Hydraulics Engineering Technical Note (CHETN) establishes a workflow to build a space-time cube (STC) using high resolution elevation rasters. The workflow utilizes the mosaic dataset architecture, multidimensional cloud raster format (CRF), and space-time cube geoprocessing tools in ESRI’s ArcGIS Pro (version 3.3+) to consider temporal changes in elevation data across 10+ survey datasets. As ESRI already provides a wealth of documentation for each of their geoprocessing tools, this workflow does not detail every aspect of the tools listed. Instead, it is intended to guide users who may not be familiar with STCs through a step-by-step order of operations, share best practices, and highlight considerations when using elevation data. This CHETN is part of a larger effort to develop the next generation of volume change tools for application in the coastal environment.

INTRODUCTION: Start of paragraph and text here.

BACKGROUND: Start of paragraph and text here.

SPACE-TIME CUBE WORKFLOW: The STC creation workflow presented here is for use with high-resolution raster data, but while the example is specifically focused on elevation data, this workflow is also applicable to imagery data, land cover data, or other rasterized datasets. ESRI provides additional toolsets for use with point data or station data (Create Space Time Cube from Aggregating Points, Create Space Time Cube from Defined Locations) which will not be covered here. The workflow includes data preparation steps, creating a mosaic dataset that references the prepared data, adding additional dimensional information, converting to a cloud raster format, creation of a STC, and how to add raster datasets at a later time.

Data Preparation. Creating a space-time cube requires at least 10 time slices that contain datasets across the temporal record, and additional requirements are included when working with elevation data. First, high-resolution data (e.g., 1-meter cell size) are required to resolve individual features (e.g., dunes), and the largest cell size of any individual dataset will define the smallest cell size of the entire space-time cube. Next, raster formats should be consistent and applicable for use within the mosaic dataset architecture within ArcGIS Pro; GeoTIFF or NetCDF files are preferrable. Finally, all input datasets must have the same horizontal coordinate system, vertical reference datum, and units. The mosaic dataset architecture is capable of projecting raster datasets, applying raster function templates, and visualizing individual datasets on the fly, but individual geoprocessing steps can also be taken before beginning the workflow to prepare data.

EARLY DRAFT

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ASSESSMENT OF BIAS IN DEMS OF DIFFERENCE

Shane Nichols-O'Neill

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ELEVATION BIAS

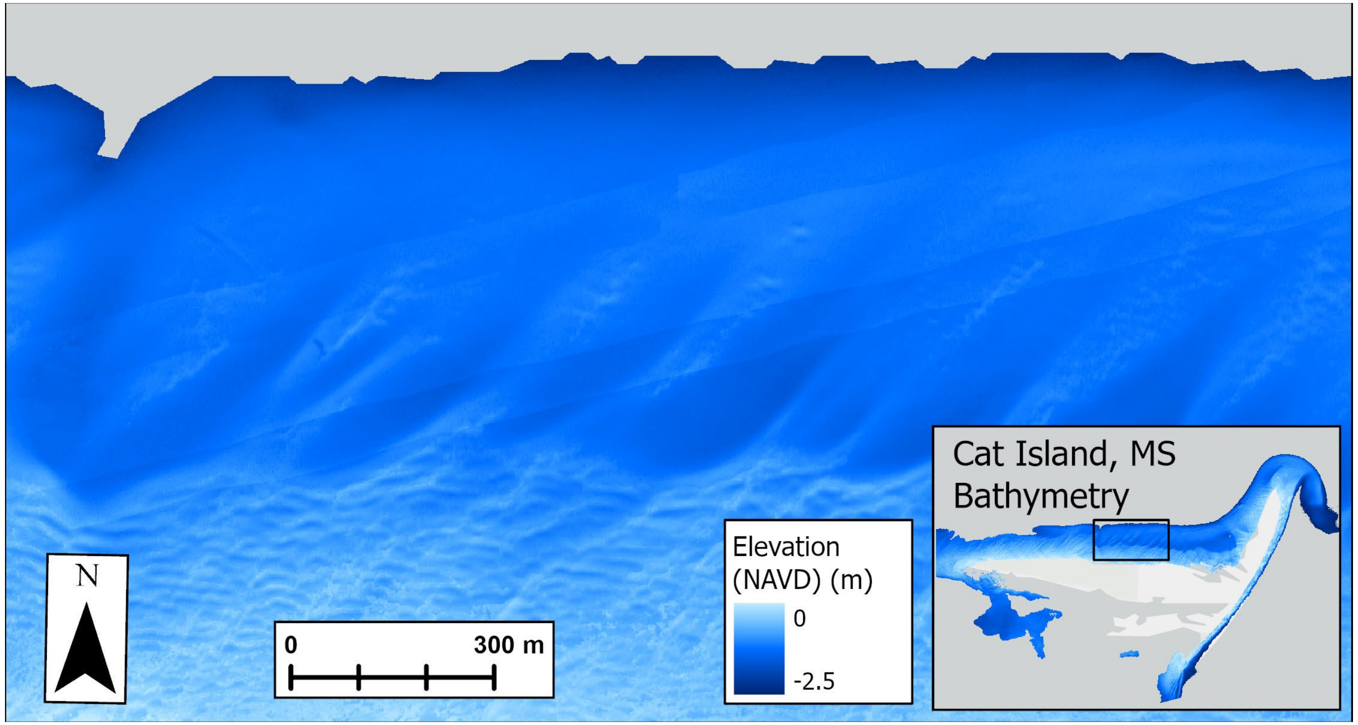
Biases exist in DoD-based change detection products

- Lidar Measurements (Glennie, 2007)
- Effects of Bathymetry (Guenther, 1985)
- DEM creation (Williams, 2012)

Elevation bias may be significant enough to affect elevation-based analysis

- Change detection
- Volume change estimates
- Habitat suitability

Goal: Identify and filter elevation bias in DoD-based change detection products



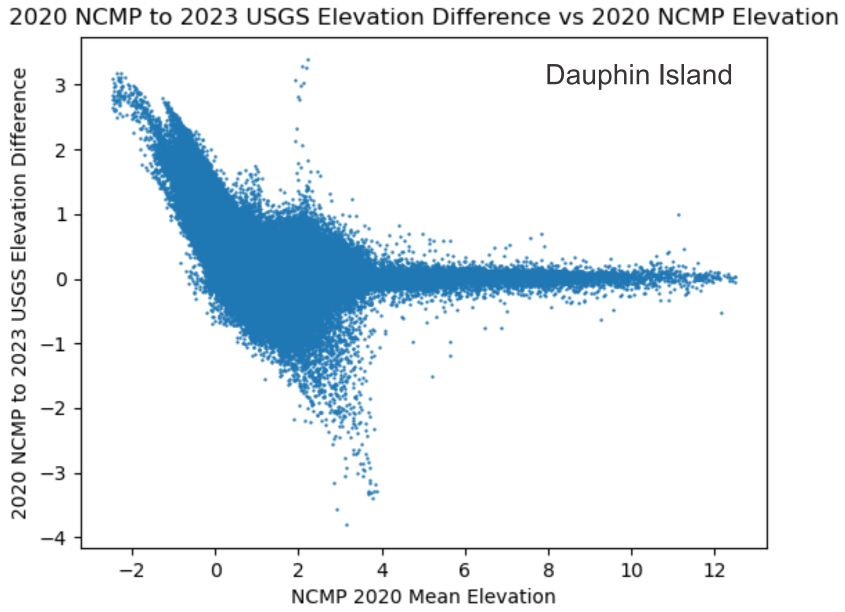
Flightline elevation banding, 2016 NCMP

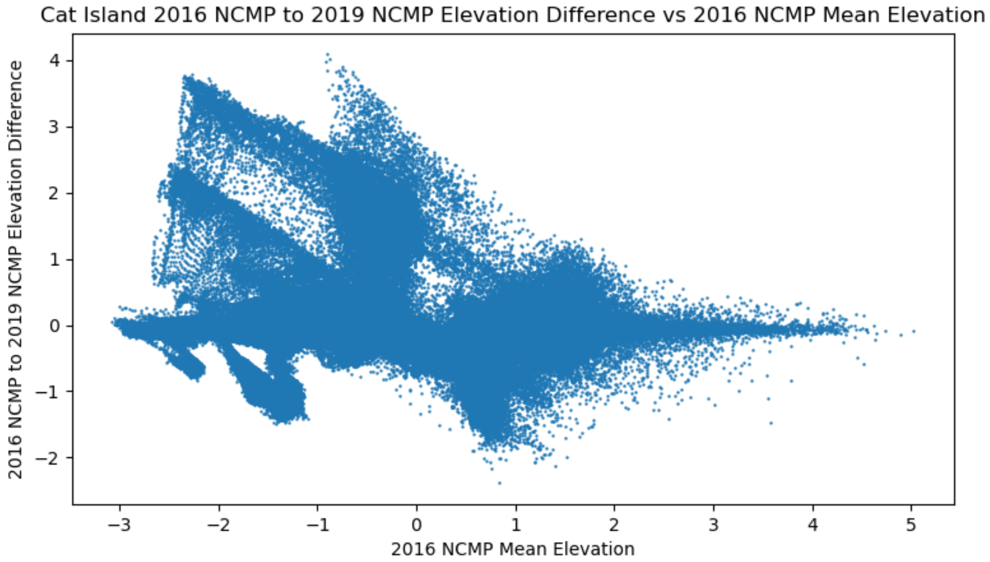
IDENTIFYING ELEVATION BIAS

Elevation change patterns examined based on initial conditions

Plot shape helps to differentiate elevation change results
- physical processes
- human intervention
- measurement/processing error

Potential bias sources
- GPS accuracy
- Water depth-bathymetric lidar calibration



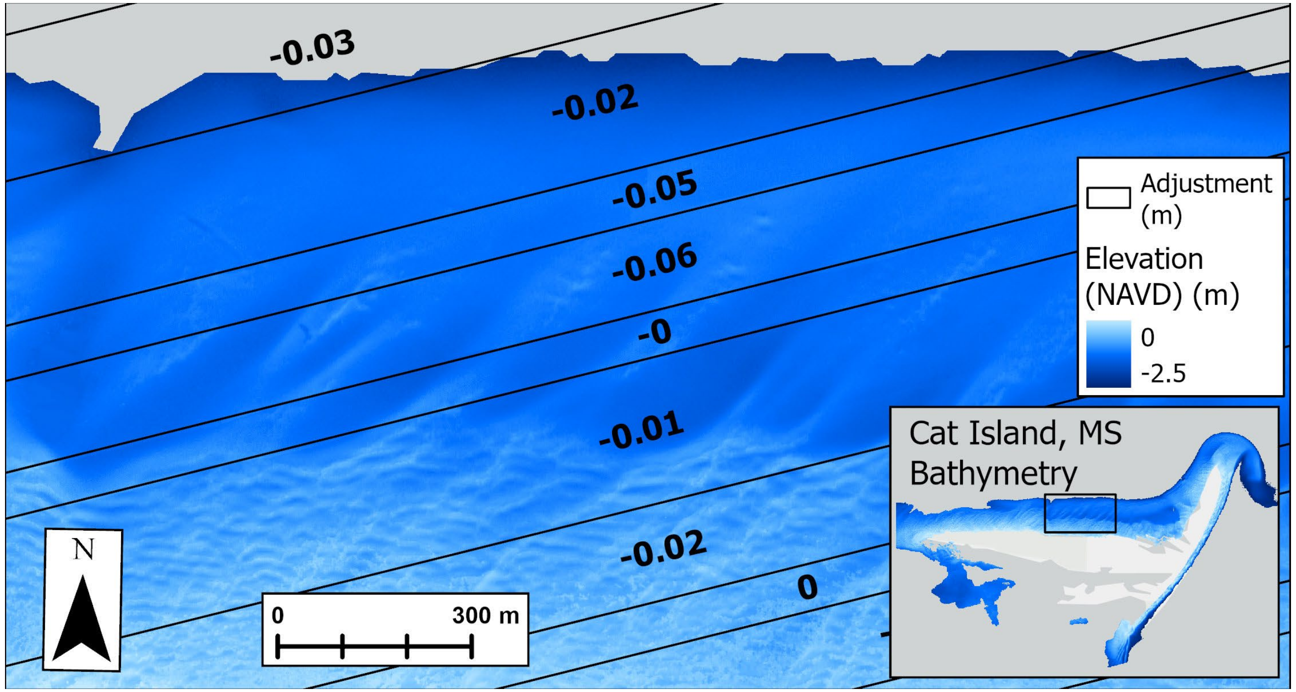


ELEVATION BIAS: CAT ISLAND, MS

Cat Island bathymetric banding related to Lidar flight lines

Solution: provide elevation adjustment for each flight line zone based on an individual mean elevation difference

Moving Forward: identify and apply different techniques to quantify and limit spatially distributed error



Zonal mean elevation difference adjustment

Cat Island, MS Bathymetry Volume Change 2016-2019	
Volume Change, no adjustment	In progress
Volume Change, adjusted	In progress

VOLUME CHANGE: SETTING THE STAGE FOR A FLEXIBLE FRAMEWORK

Brooke Walker

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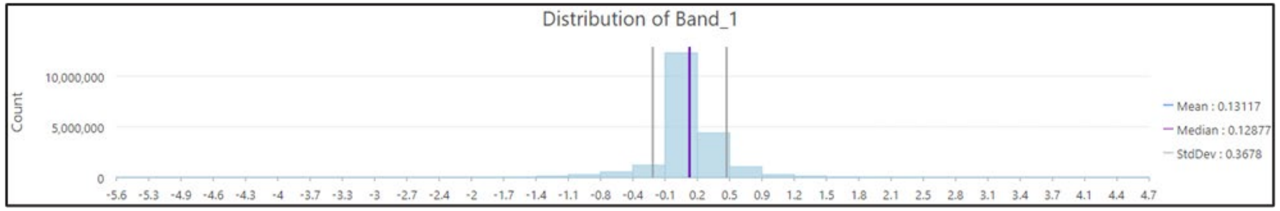
VOLUME CHANGE – 2018-2020

Data Sets:

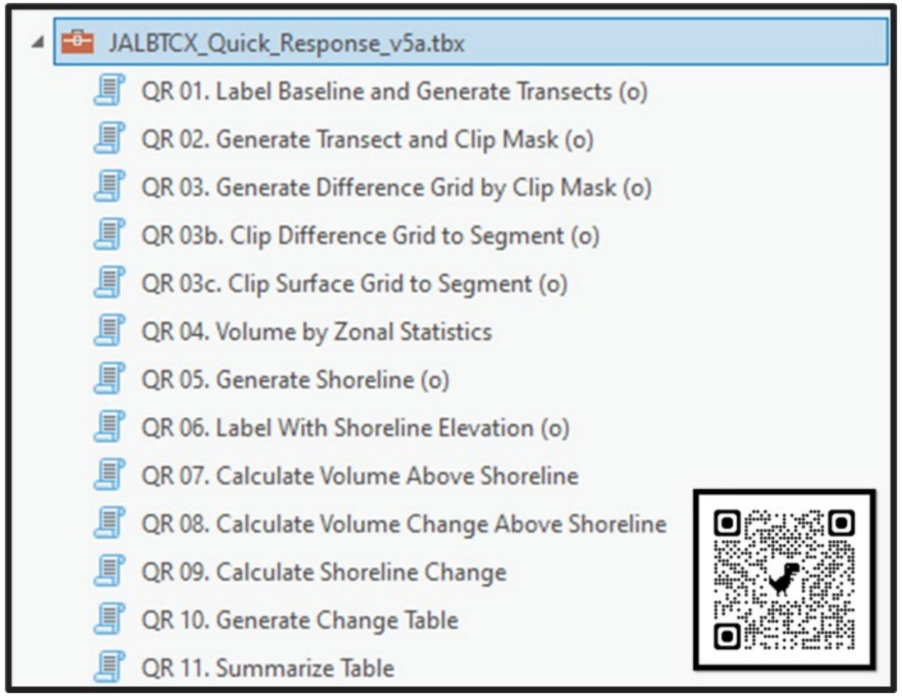
- 2020 USACE NCMP Post Sally Topobathy Lidar DEM: Gulf Coast
    - Collected September-October 2020
    - Mississippi's Ship Island through St. Vincent Island, FL. Also includes shoreline from Biloxi through Pascagoula.
- 2018 USGS Topobathy Lidar: Gulf Coast Islands
    - Collected October-November 2018
    - Dauphin Island and Breton NWR.
- 2016 USACE NCMP Topobathy Lidar DEM: Gulf Coast
    - Collected July-October 2016
    - Covers Barrier Islands from Texas through Destin, FL.
- 2011 USACE NCMP Topobathy Lidar DEM: Gulf Coast
    - Collected May/June 2011
    - Covers the Barrier Islands from Louisiana's Breton NWR to Alabama's Dauphin Island.



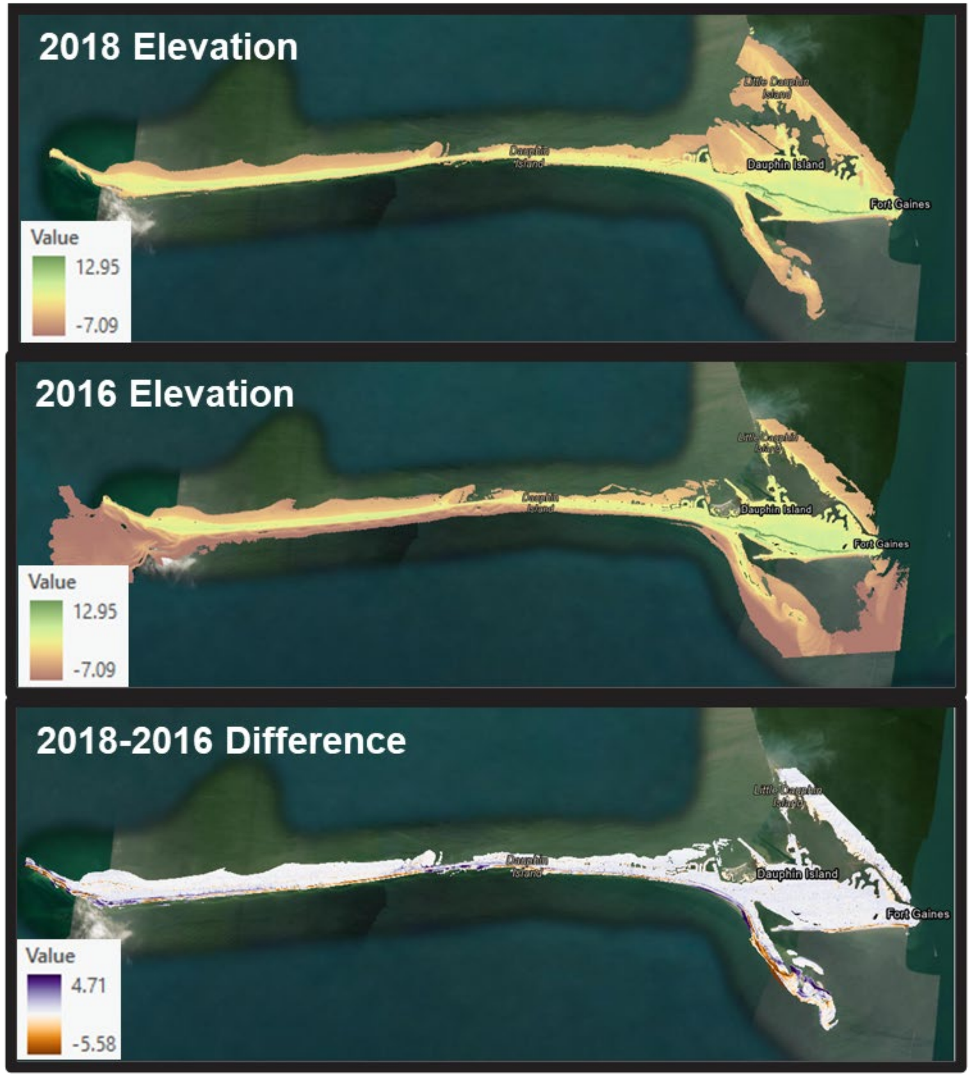
VOLUME CHANGE – 2016-2018

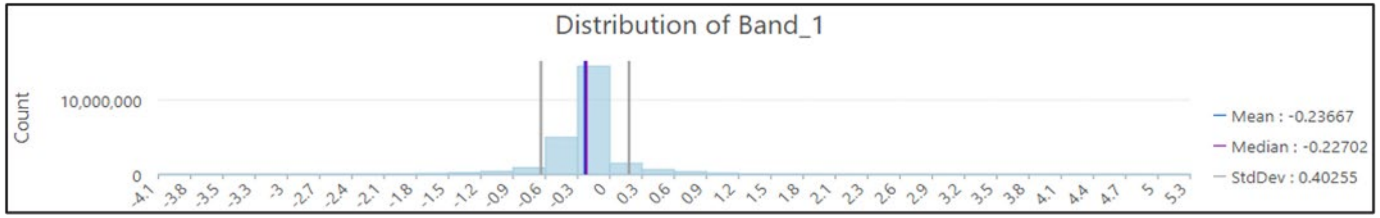
JALBTCX Quick Response Toolbox:

- Leveraged existing 2020 Post-Sally volume change bins to begin workflow at Step QR 04.
- Testing of companion “Multi-Dataset Toolbox”
- Sensitivity testing of bin geometry on volume quantities (Modifiable Areal Unit Problem (Openshaw 1984))



https://cirpwiki.info/wiki/JALBTCX





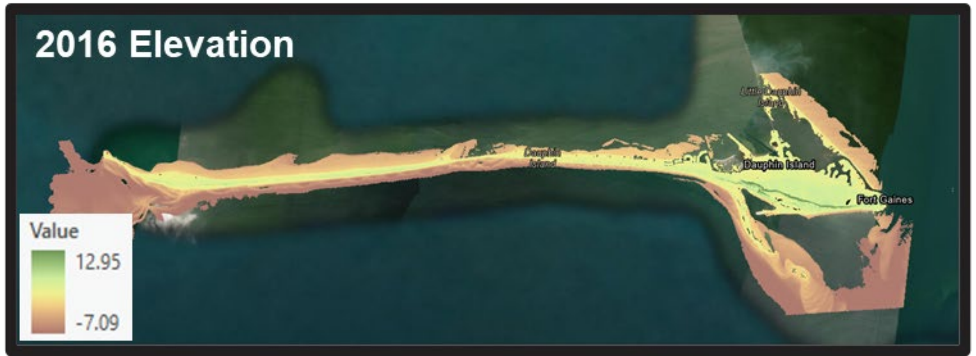
VOLUME CHANGE – 2011-2016

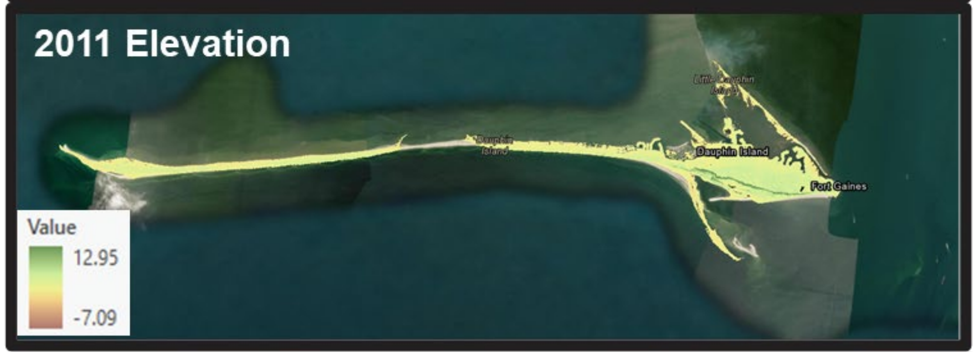
Cell by cell (1-meter by 1-meter) comparison of before and after elevation values using

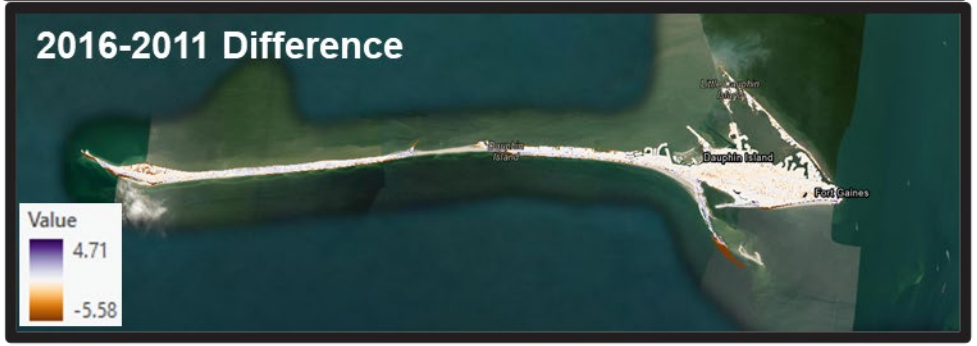
$$Z_{difference} = Z_{after} - Z_{before}$$

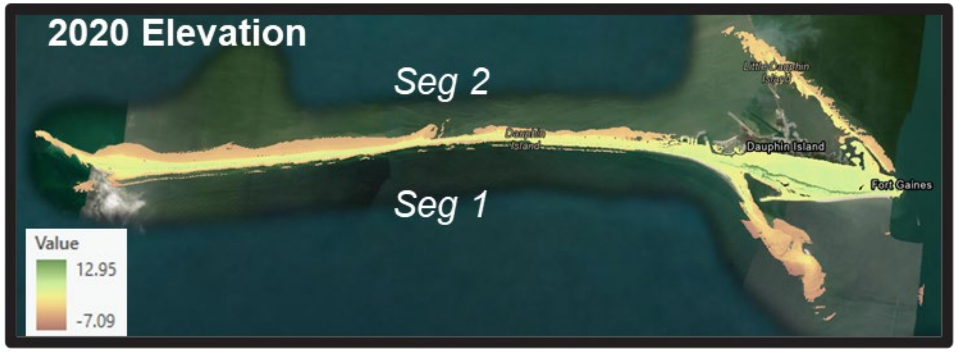
where $Z_{difference}$ is the change in elevation for elevations surveyed later, Z_{after}, and earlier, Z_{before}

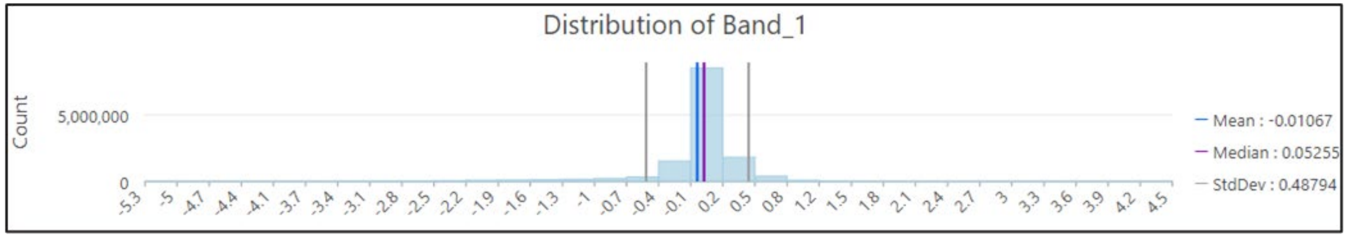
Summation of these cell differences yields volumes (Wheaton et al. 2010; Williams 2012).



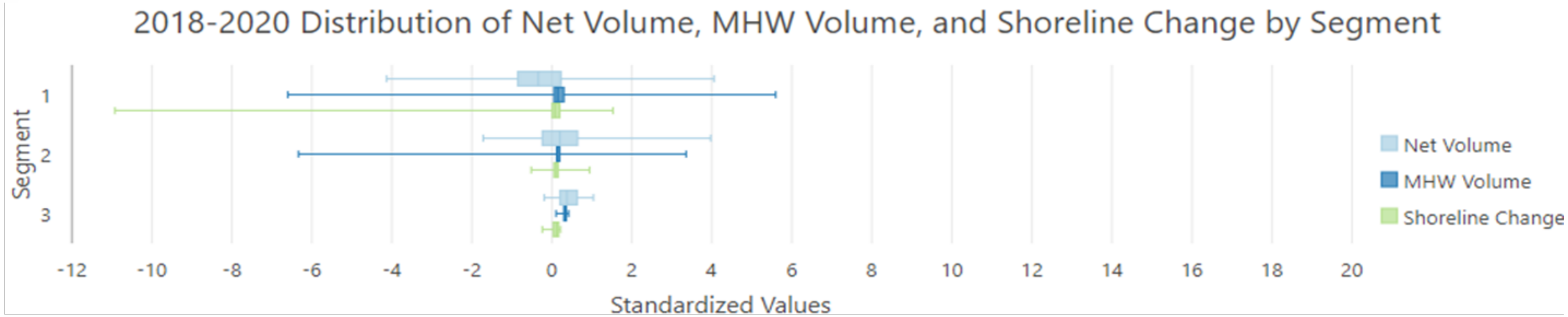


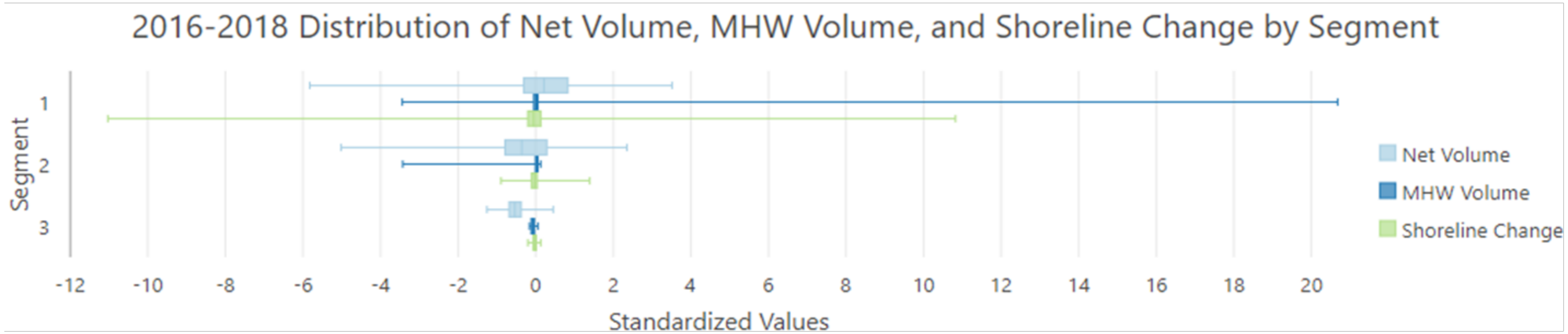


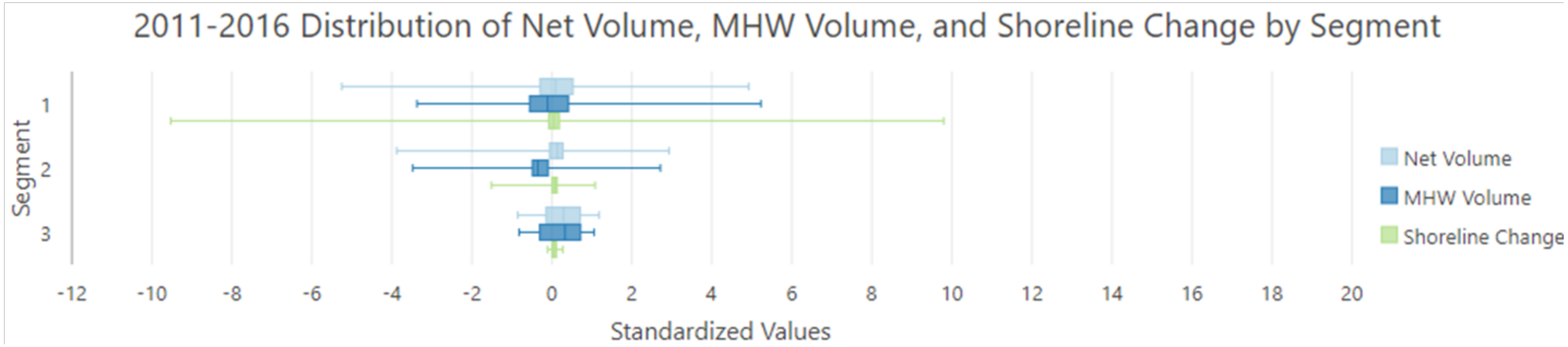




VOLUME CHANGE COMPARISON

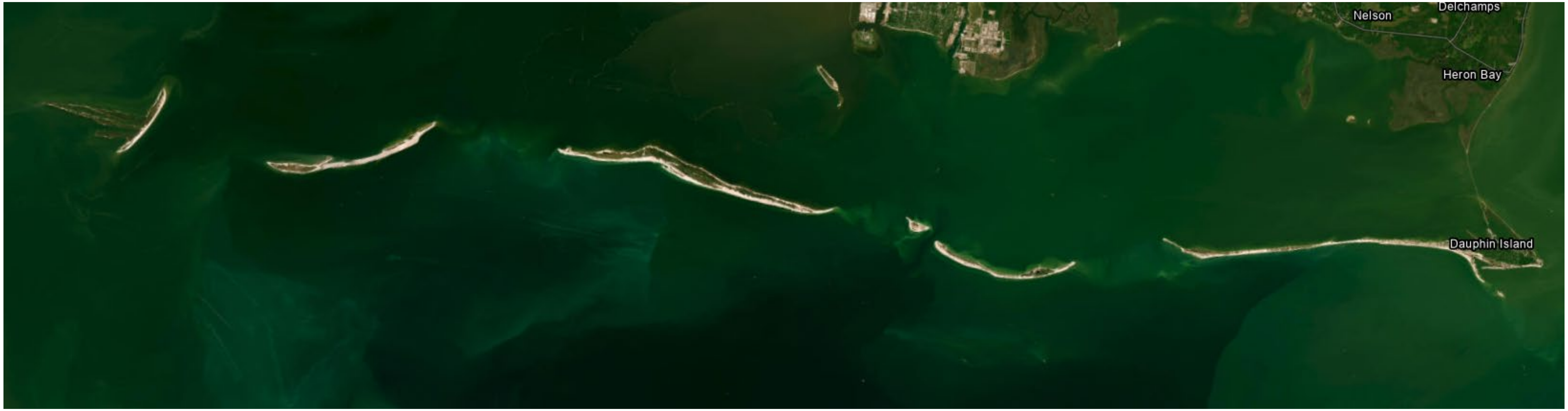






VOLUME CHANGE: NEXT STEPS

- Modify volume bin geometry for full coverage and compare to existing bin volumes.
- Apply bias filtering techniques with Shane.
- Recalculate volumes without bias.
- Analysis will cover from Dauphin Island to Cat Island.



VOLUME PARTITIONING: DEVELOPMENT OF DUNE VEGETATION PRODUCTS

Sam Jackson

U.S. ARMY

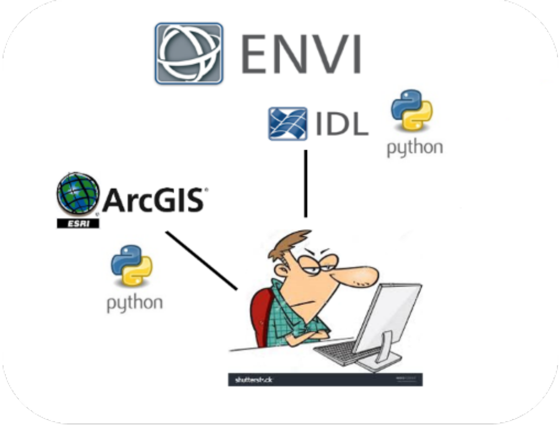
US Army Corps of Engineers®

LANDCOVER AND DUNEVEG PRODUCTS

The Dune Vegetation (DUNEVEG) tool is a Geospatial Toolbox for remote vegetation extraction from NCMP Hyperspectral Imagery and Lidar

Extracted Metrics include the following:

- Normalized Difference Vegetation Index (NDVI)
- Vegetation Cover (Presence/Absence)
- Vegetation Density Estimate (inferred biomass calculated from NDVI threshold)
- Leaf Area Index (LAI)
- Canopy Height Model (CHM)



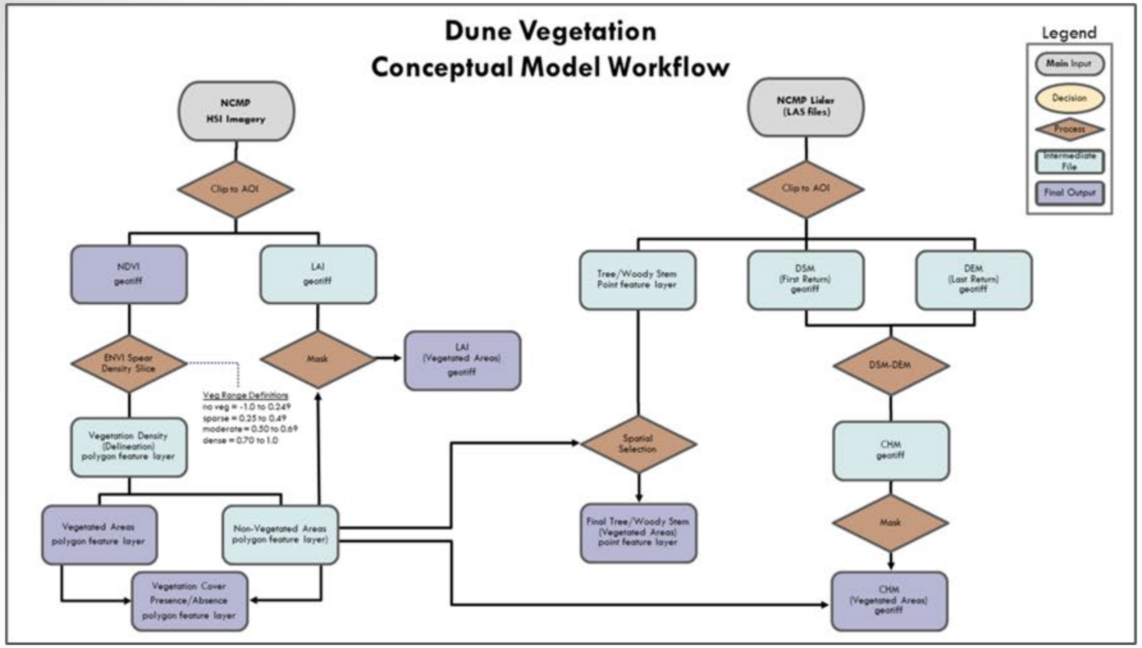
Source:L3Harris Geospatial
https://www.harrisgeospatial.com

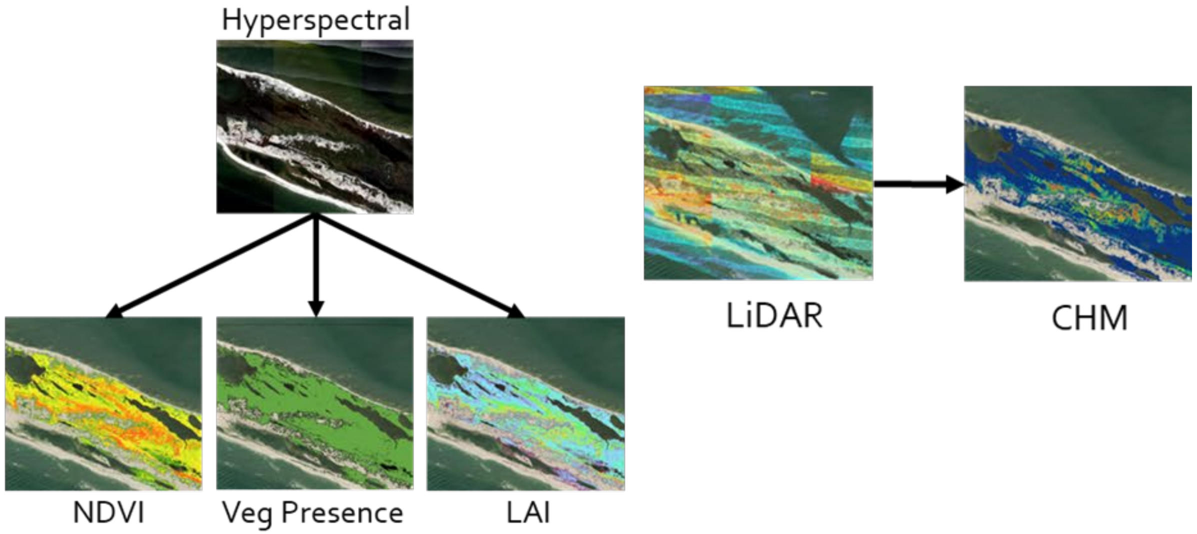
CIRP (next-gen) NCMP datasets analyzed to date:

- 2020 Post-Sally MSCIP (MS Coastal Improvements Program)
- 2019 MS Barrier Islands
- 2016 MS MSCIP

Software requirements: Windows 10, ENVI integration with ArcGIS Pro, Python, ENVIpy ENVI analytics, Band Math Algorithms, ArcGIS Pro Geoprocessing, Spatial Analyst Extension

LANDCOVER AND DUNEVEG PUBLICATIONS

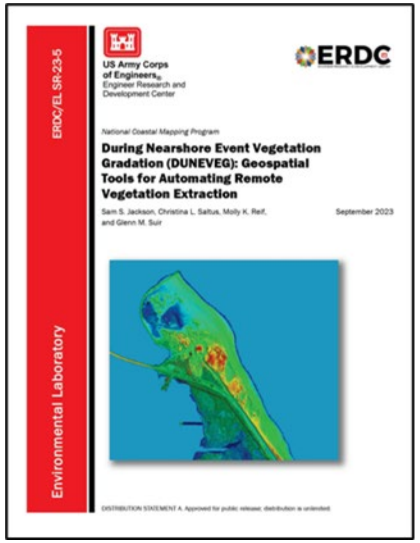


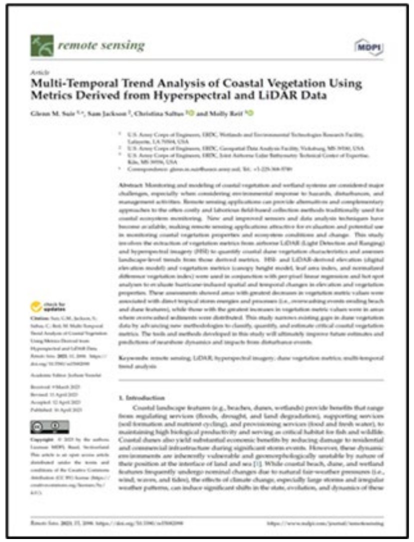


List of Publications:

- Jackson, S.S.; Saltus, C.L.; Reif, M.K., and Suir, G.M. (2023). *During Nearshore Event Vegetation Gradation (DUNEVEG): Geospatial Tools for Automating Remote Vegetation Extraction.* USACE ERDC/EL SR-23-5. Vicksburg, MS: US Army Engineer Research and Development Center.

- Suir, G.M.; Jackson, S.S.; Saltus, C.L., and Reif. M.K. (2023). Multi-Temporal Trend Analysis of Coastal Vegetation Using Metrics Derived from Hyperspectral and LiDAR Data. *Remote Sensing*, 15(8): 2098.





ANTICIPATED MILESTONES AND PRODUCTS

U.S. ARMY

FY25

- Volume Partitioning
  - Relative Relief, Geomorphons, and Vegetation Metrics for Pilot Sites
  - Segmented DEMs and Volumes for Pilot Sites
  - **TN: DEM Segmentation Using Regional Datasets**
- Hot Spot Analysis
  - ArcGIS Pro Workflow and Space-Time Cube Products for Pilot Sites
  - **TN: Workflows for Creating Space Time Cubes from DEM Datasets**
- Investigate Methods to Address Bias
  - Calculation of Bias Metrics and Anomaly Surfaces for Pilot Sites
  - Application of methods reported in the literature

FY26

- Refinement of Volume Partitioning
  - Enhanced Landcover Derivative Products for Pilot Sites
  - Proof-of-Concept Demonstration of Using Enhanced Landcover Derivative Products in SBAS
  - **TN: Use of Segmented Volumes in SBAS: A Case Study**
- Refinement of Hot Spot Analysis
  - **TN/JA: Parameter evaluation for Hot Spot Analysis using ArcGIS Pro**
  - Planform Mapping Products for Pilot Sites
- Refinement of Methods to Address Bias
  - **ERDC Publication or Journal Article on Developing Uncertainty Estimates for Volumes**

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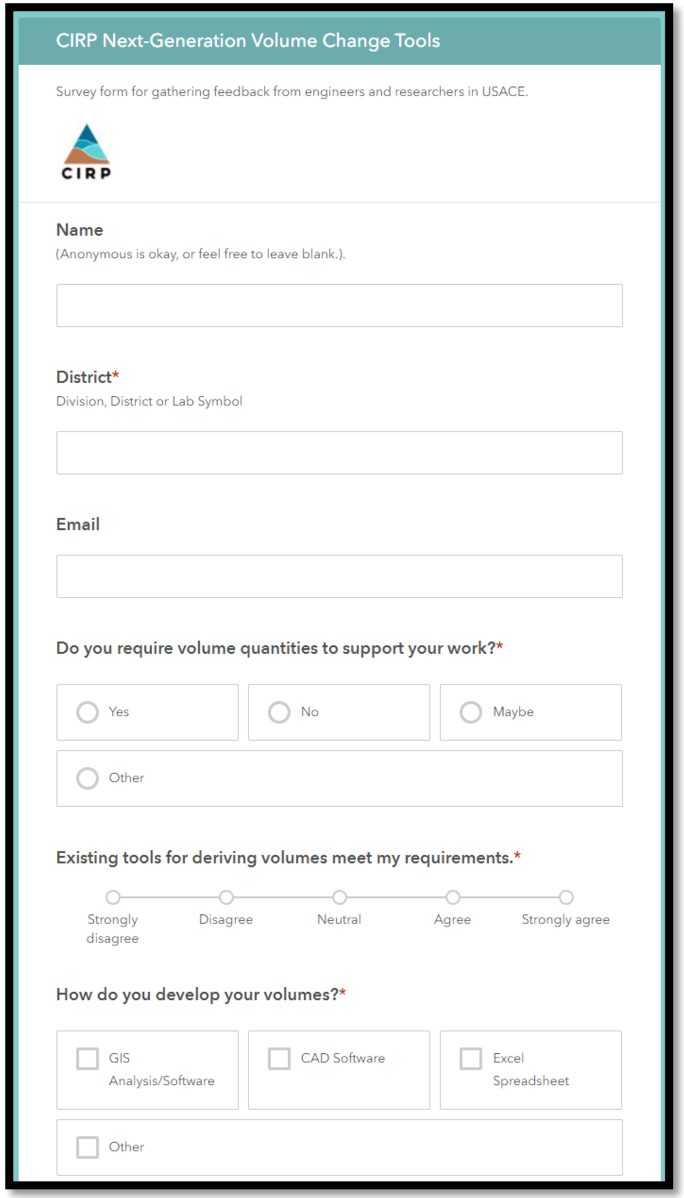
HAVE FEEDBACK?

Have thoughts?
Challenges?
Uses?
Requirements?
Tools?

- Feedback form
- Public data collection
- No login required

https://arcg.is/Tr5v50


CIRP Next-Generation Volume Change Tools

Survey form for gathering feedback from engineers and researchers in USACE.

CIRP

Name
(Anonymous is okay, or feel free to leave blank.).

District*
Division, District or Lab Symbol

Email

Do you require volume quantities to support your work?*
Yes
No
Maybe
Other

Existing tools for deriving volumes meet my requirements.*
Strongly disagree
Disagree
Neutral
Agree
Strongly agree

How do you develop your volumes?*
GIS Analysis/Software
CAD Software
Excel Spreadsheet
Other

*"Volumes play a **critical role** in the navigation and beach nourishment projects from all project phases from feasibility to O&M. **Without volumes, it is impossible to design projects or maintain them.** Volumes are used during design, development of plans and specs, and during emergency post-storm evaluations."*

*"**Ability to compare** baseline conditions as both rates and raw volume changes while also being able to **include storm impacts, management changes and actions**. So, to include them in my analysis but separate them."*

*"**Sediment budget analysis** of tidal inlets and coastal barrier islands. Planning **Beneficial Use** and **DMMPs** for coastal Nav projects."*

*"There is a **variety of tools** being employed in our district and **no consistency**. A set of tools that are easy to use and to replicate the results would be ideal. This was when projects shift, or staff retire new engineers can recreate the old analysis."*

*"For navigation, capacities for **placing channel sediments**; understanding sediment budgets.*
*For CSRM, renourishment quantities and locations; **tracking hot spot** causes and dynamics; sediment budgets*
*For Emergency Management, post-storm calculations that help **inform response for emergency supplemental repairs**."*

CIRP

QUESTIONS?

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