SATELLITE-BASED COASTAL MONITORING: TOOLS FOR EFFICIENT PRE- TO POST-STORM ASSESSMENTS

Edward Albada, PE

EOMAP USA Inc.

EOMAP

a Fugro company

WHO IS EOMAP?

- Private high-tech company
  Acquired by Fugro 2025
- Focus on satellite data analytics, IT solutions, webapps and API
- Specialise in aquatic environments
- International team of 50+ employees
- Serving HOs, engineering, academia, costal zone managers…

HQ in Germany with affiliates in USA, Australia, Indonesia, Dubai

PROBLEM STATEMENT & OBJECTIVES

Need Statement

- Rapid assessments of beach volume losses immediately after a storm event

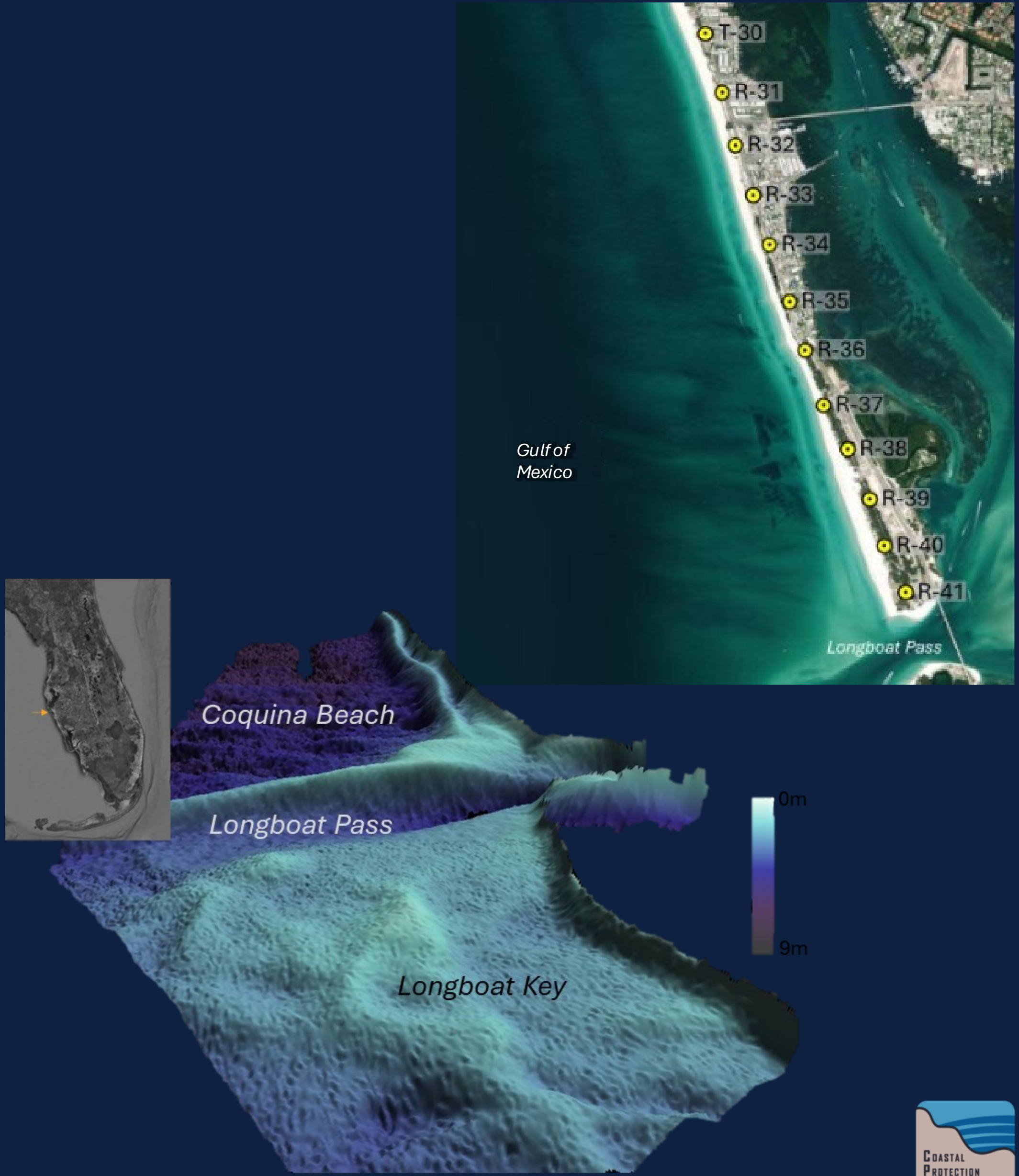
Problem Statement

- Beach profiles = incomplete coverage
- Time delay in collection
- Expensive

Proof of concept

- SDB as an alternate data capture tool.
- Evaluate the usefulness and effectiveness of using SDB in estimating volume losses after a storm event.
- Comparative analysis of SDB and hydrographic surveys conducted at Coquina Beach, Manatee County, Florida following Hurricane Idalia.

Coquina Beach, Manatee County, FL



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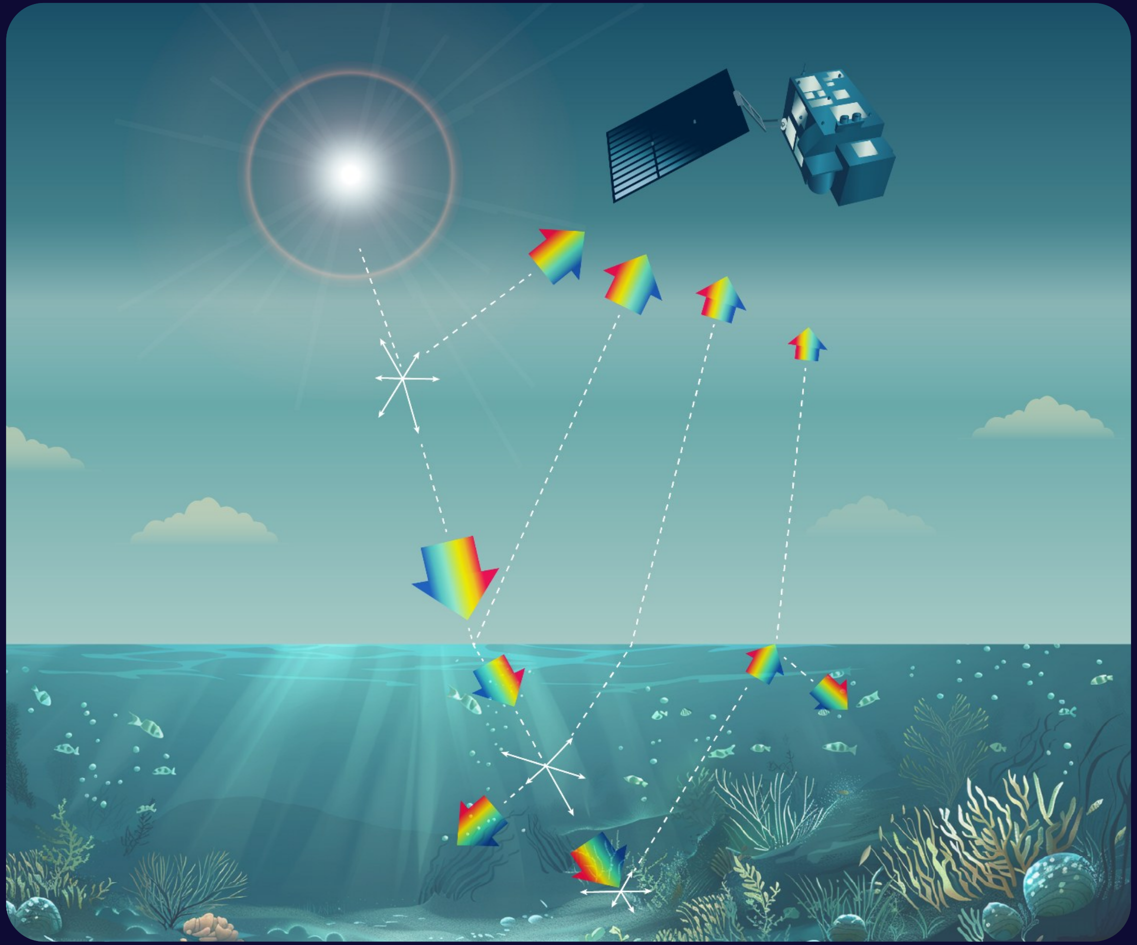
METHODOLOGY WQ RETRIEVAL



- Physics-based **Modular Inversion Processor MIP**
- Addressing of
  - ↗ geometric conditions
  - ↗ all dependencies of scattering and absorption
  - ↗ bidirectional reflection/ transmission at the water surface

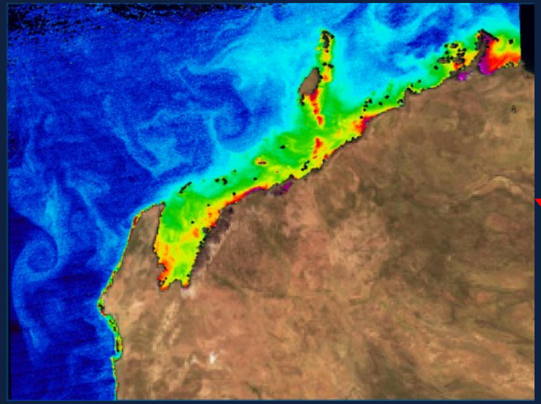
Output:

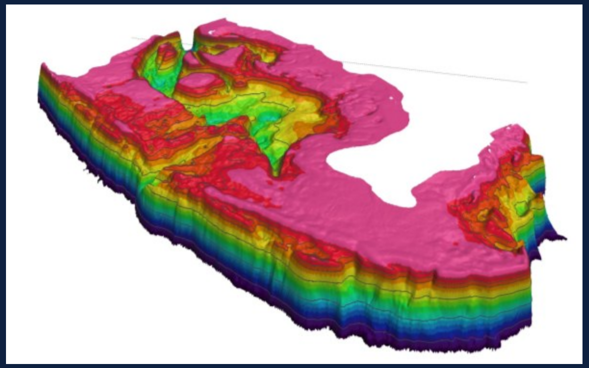
Seabed characteristics such as **SDB, benthic mapping**

Quantitative **water quality** parameters such as **Chlorophyll, Turbidity, or Secchi Disc Depth, harmful algal bloom indicator**

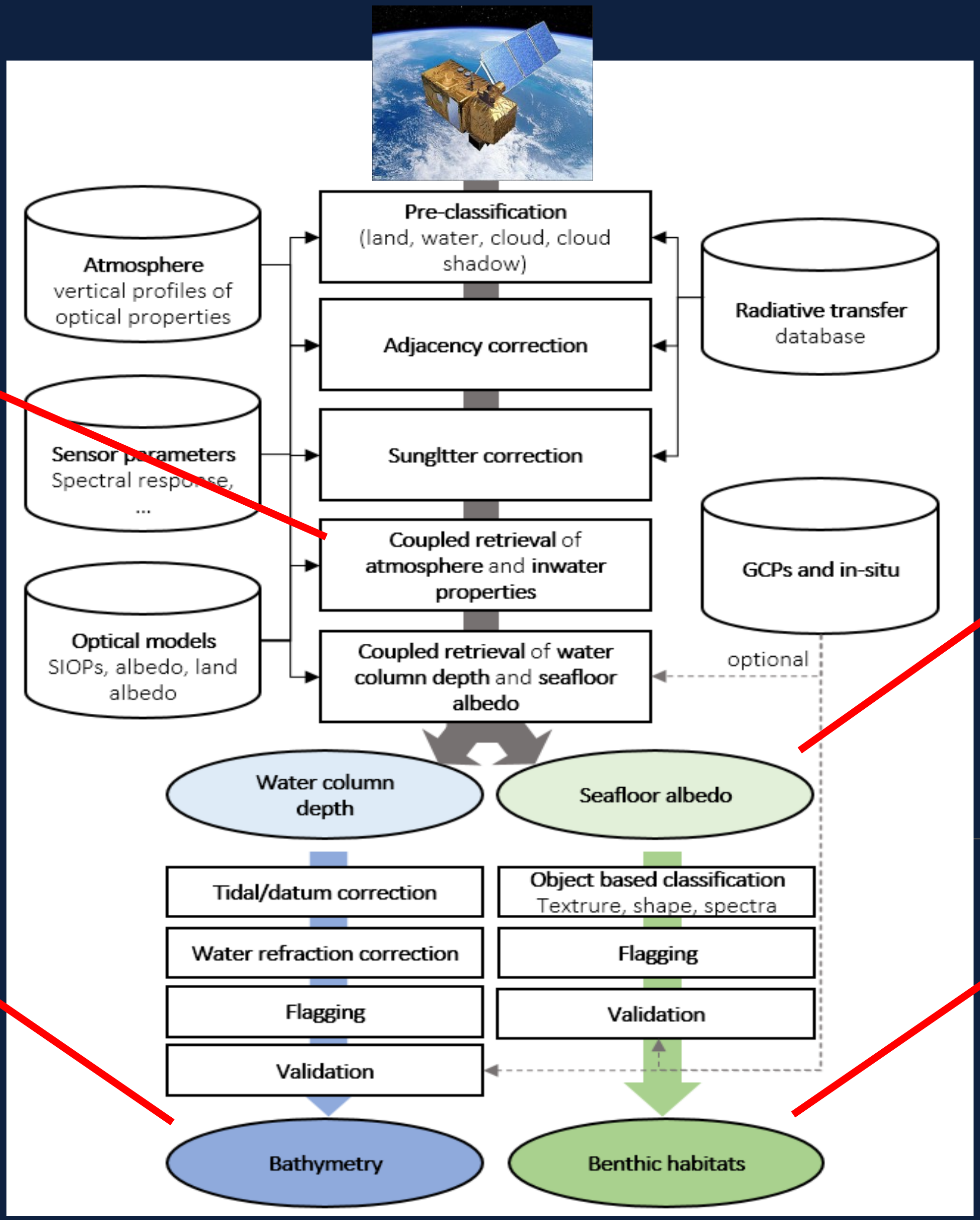
MODULAR INVERSION PROGRAM

Water quality

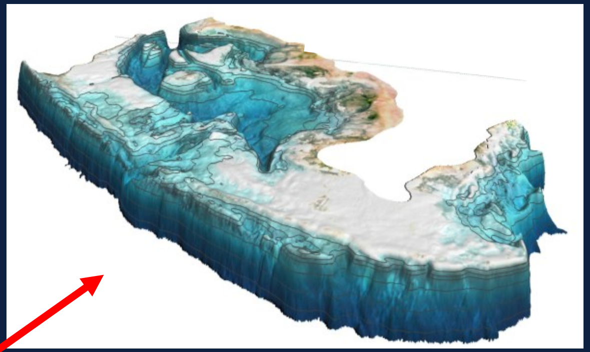




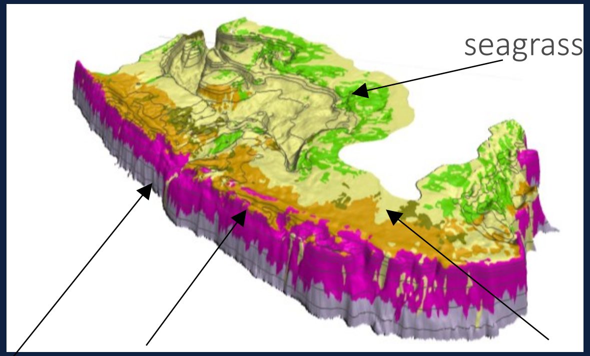
SDB (Satellite-derived bathymetry



Seafloor reflectance (colour)



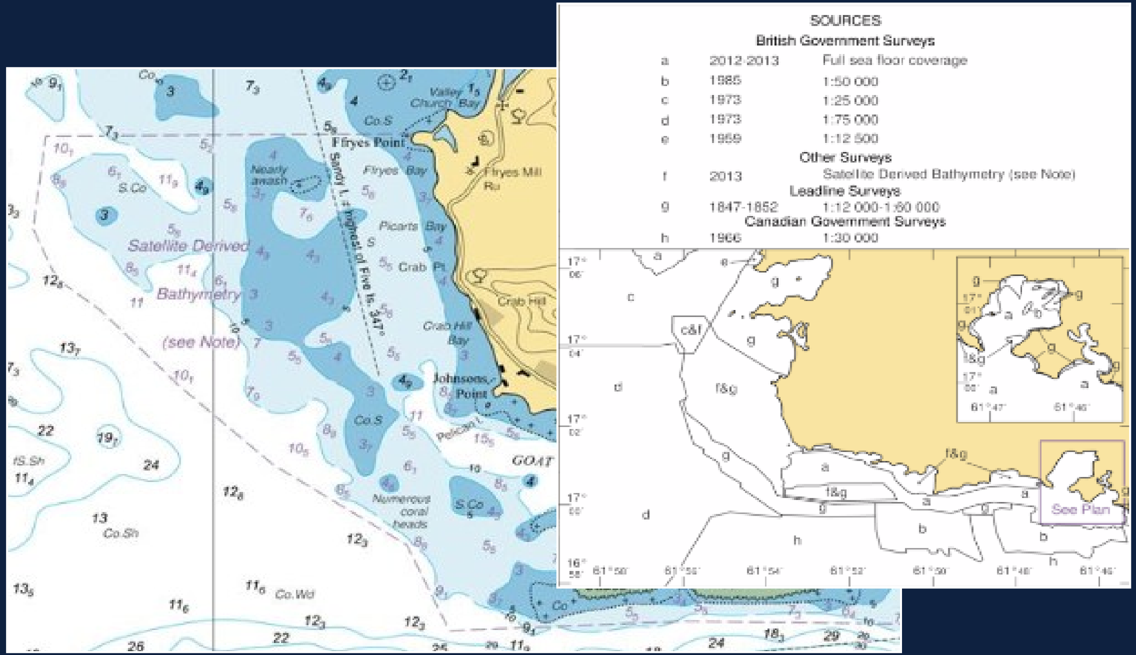
Benthic habitats



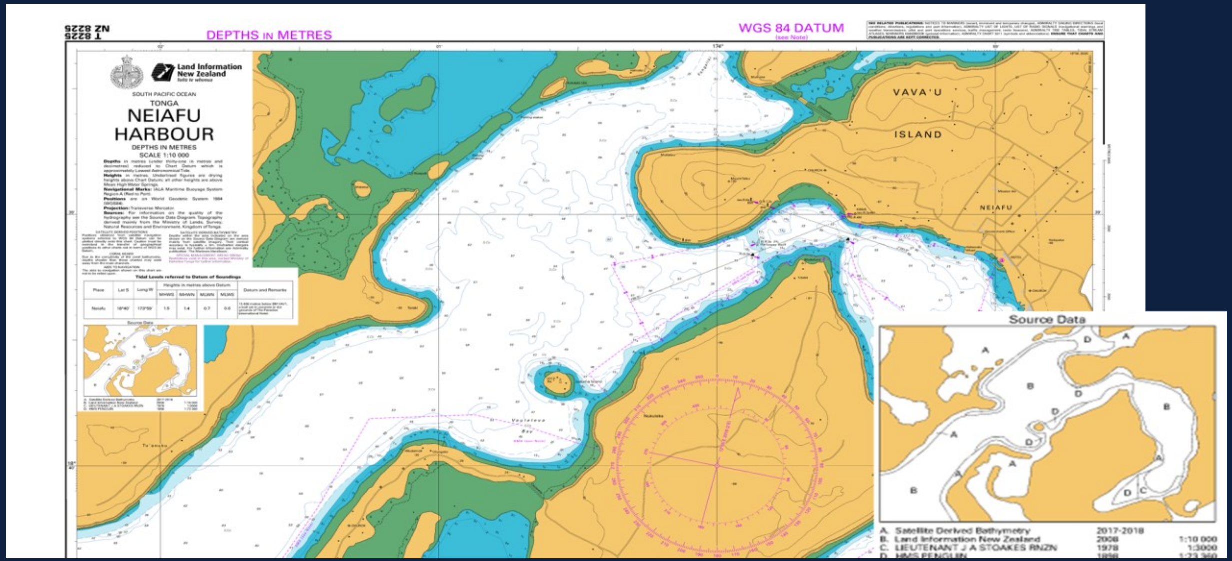
SDB BENEFITS

- Very high (0.5-2 meters) to high (10- meters) spatial resolution
- No on-site mobilization is needed
- Fast turnaround (hours to a day post-capture)
- Accessibility and cost-effective vs. traditional methods
- Map the gaps (rocky, reefs, shallows)
- Access to historical and real-time data in challenging waters
- Accepted/Suitable for nautical charting, hydrodynamic modeling, and coastal zone management

British Admiralty Chart BA 2066 Southern Antigua



New Zealand LINZ NZ8225 Neifu Harbour, Tonga



NEARSHORE CHANGE DETECTION

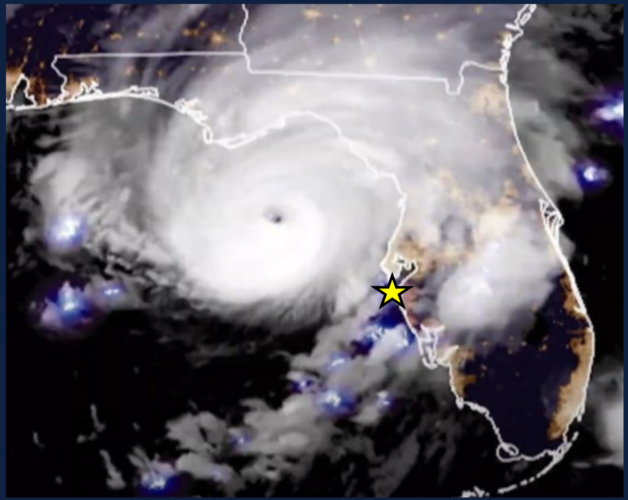
Monitoring bathymetry over time allows to understand dynamics and future trends

Satellite-Derived Bathymetry allows a unique access to past (almost 30 years) and ongoing seabed changes.

HURRICANE IDALIA

- Hurricane Idalia, August 30, 2023
- Intense surge, waves on west coast of Florida:
    - NOAA St. 42099 (St. Petersburg) Hs = 33.8 ft
    - Storm surge Tampa 4.5 ft
- Coquina Beach impacted by the storm from a combination of extreme surges and waves
- Beach Erosion approximately 75,000 cubic yards
- Demonstration conducted with consulting firm CPE

Hurricane Idalia (2023)



Coquina Beach post-Hurricane Idalia (2023)

COQUINA BEACH SURVEYS

Topo-bathy survey

- APTIM: December 2022 (pre-Idalia) and October 2023 (post-Idalia) at each FDEP R-Monument.

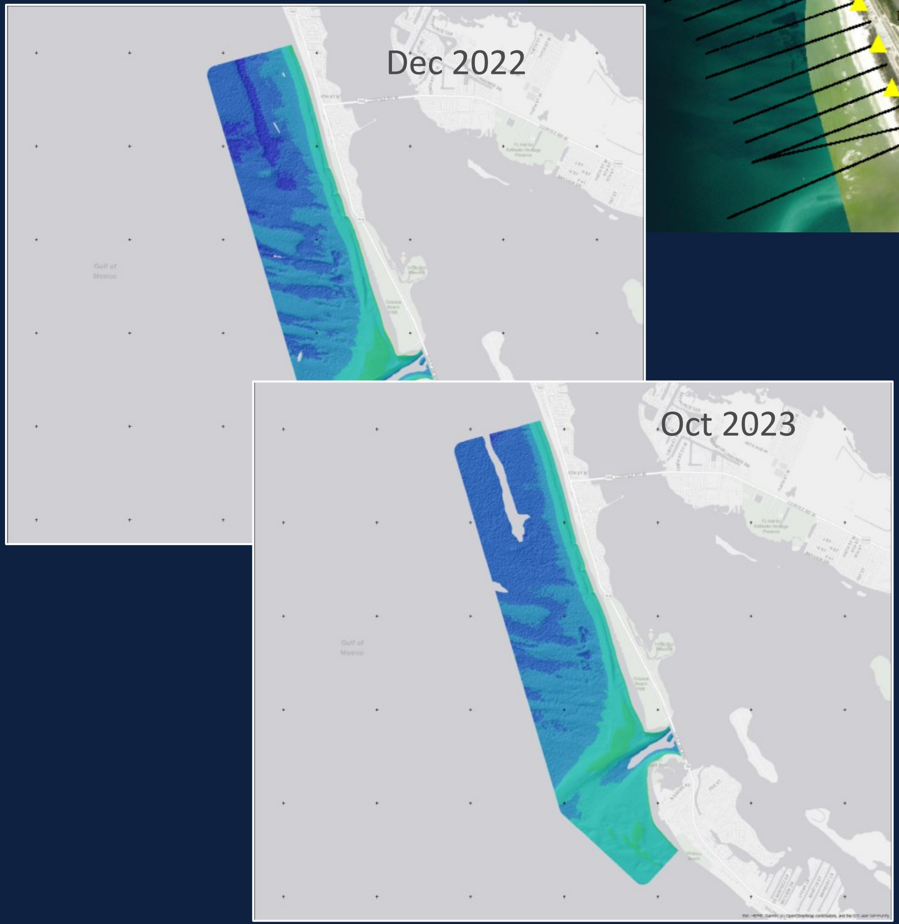
Satellite-Derived Bathymetry

- December 2022 (pre-Idalia) and October 2023 (post-Idalia) from **Planet's Super-Dove satellites** with approximately 10 ft spatial resolution.
- SDB calculated with EOMAP's **physics–based algorithms**.
- <u>No local survey or training data were used in this process!</u>

Volume changes compared using approach from FEMA Storm Damage Report from the landward survey limit to the depth of closure (-18 ft NAVD), or to the nearshore hardbottom and artificial reefs, in some location.

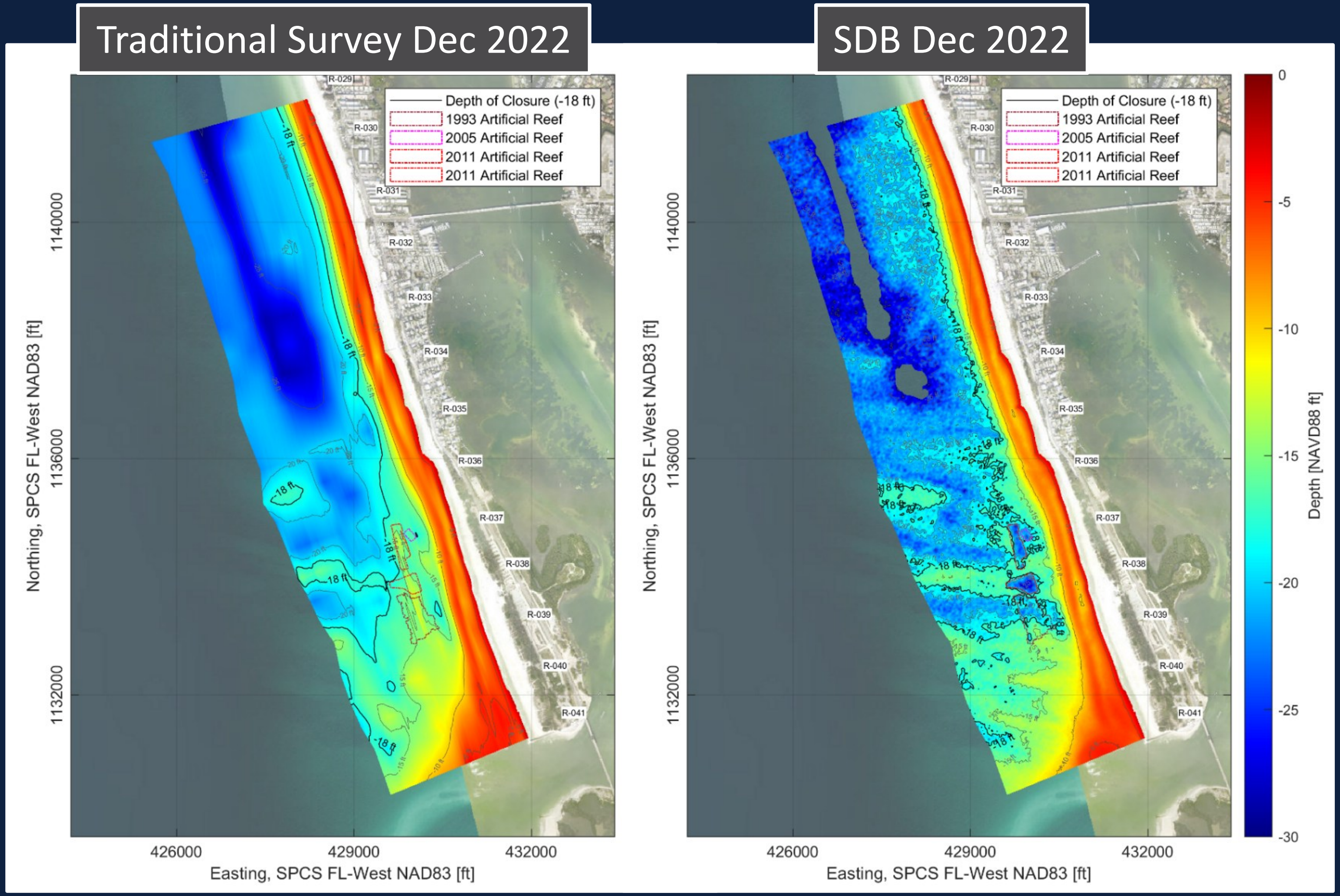
Topo-bathy survey

SDB



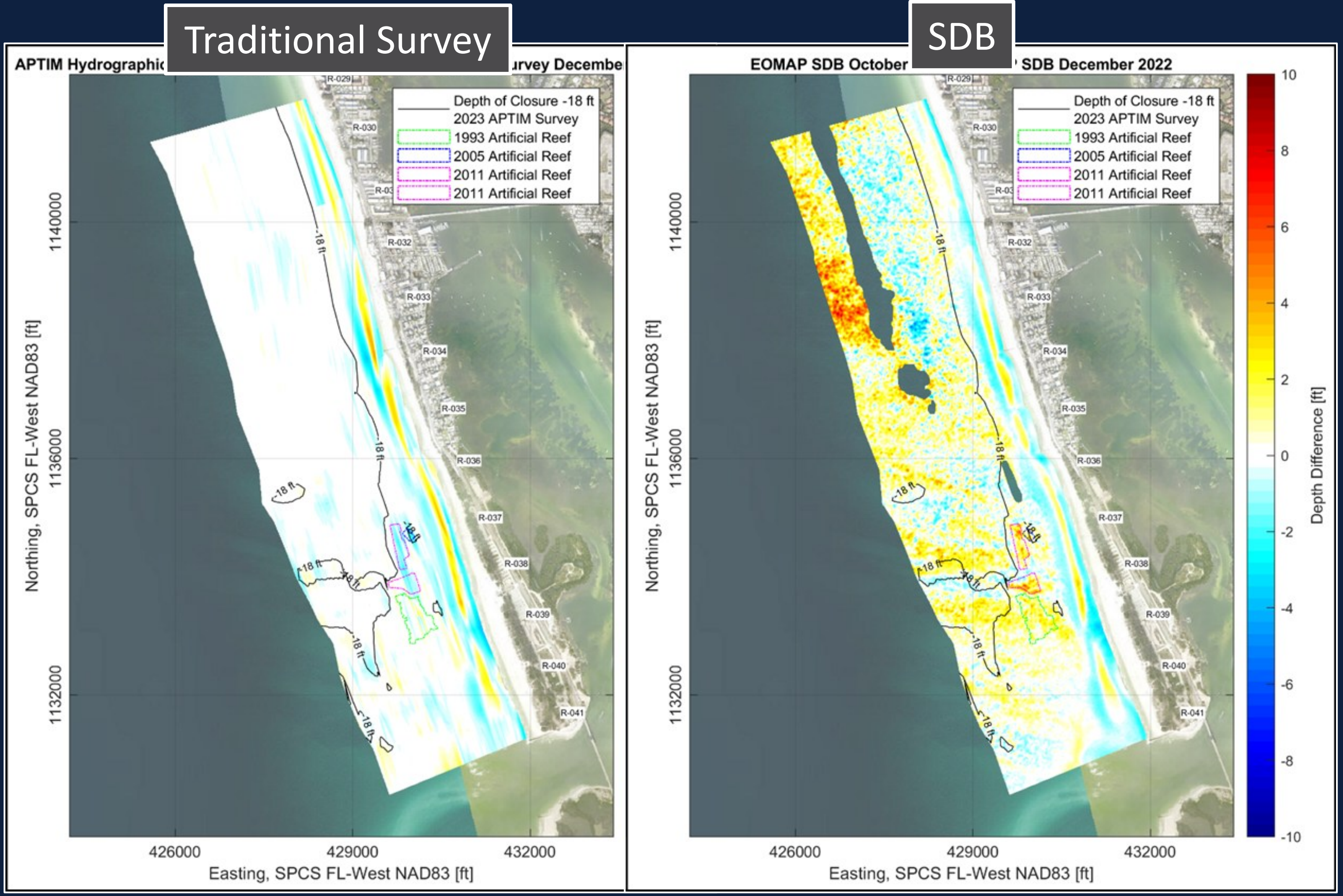
COMPARISON ANALYSIS – SURFACE PLOTS

- **SDB creates dense bathymetry grids from the shoreline** and captures spatial changes with higher resolution, providing a **detailed depiction** of bottom morphology
- Hydrographic survey shows smoother bed morphology (line interpolation)
- Notable differences at the artificial reef locations where SDB shows deeper water elevations
- SDB accuracy can further be improved by identifying project specific critical areas before data processing



COMPARISON ANALYSIS – SURFACE DIFFERENCE PLOTS

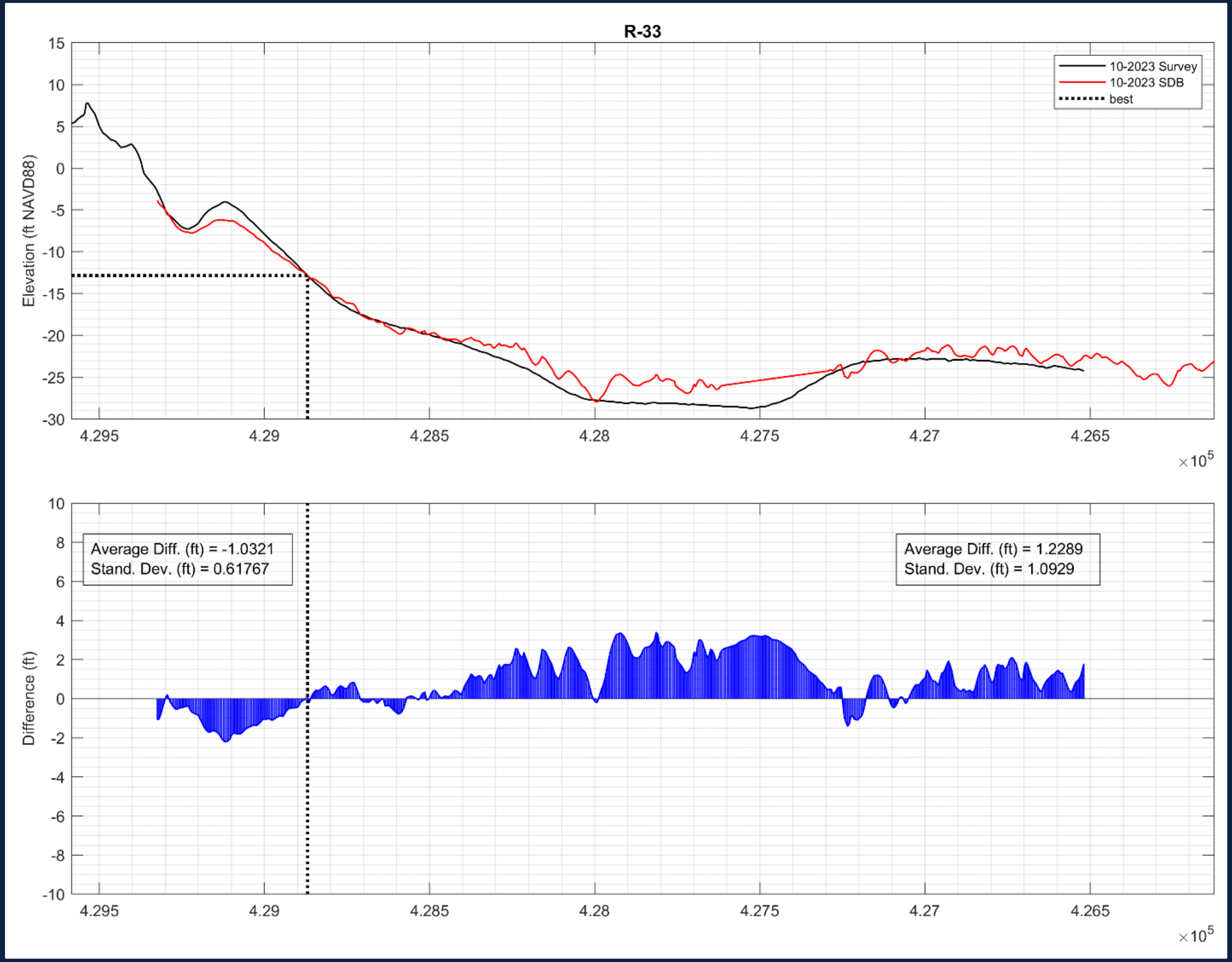
- Similar trends in areas shallower than the Depth of Closure (-18 ft NAVD)
- Similar Pattern of shoreline erosion and accretion at the nearshore bar
- Deeper than the Depth of Closure, a greater difference is observed between the datasets



COASTAL PROTECTION ENGINEERING

COMPARISON ANALYSIS – PROFILES

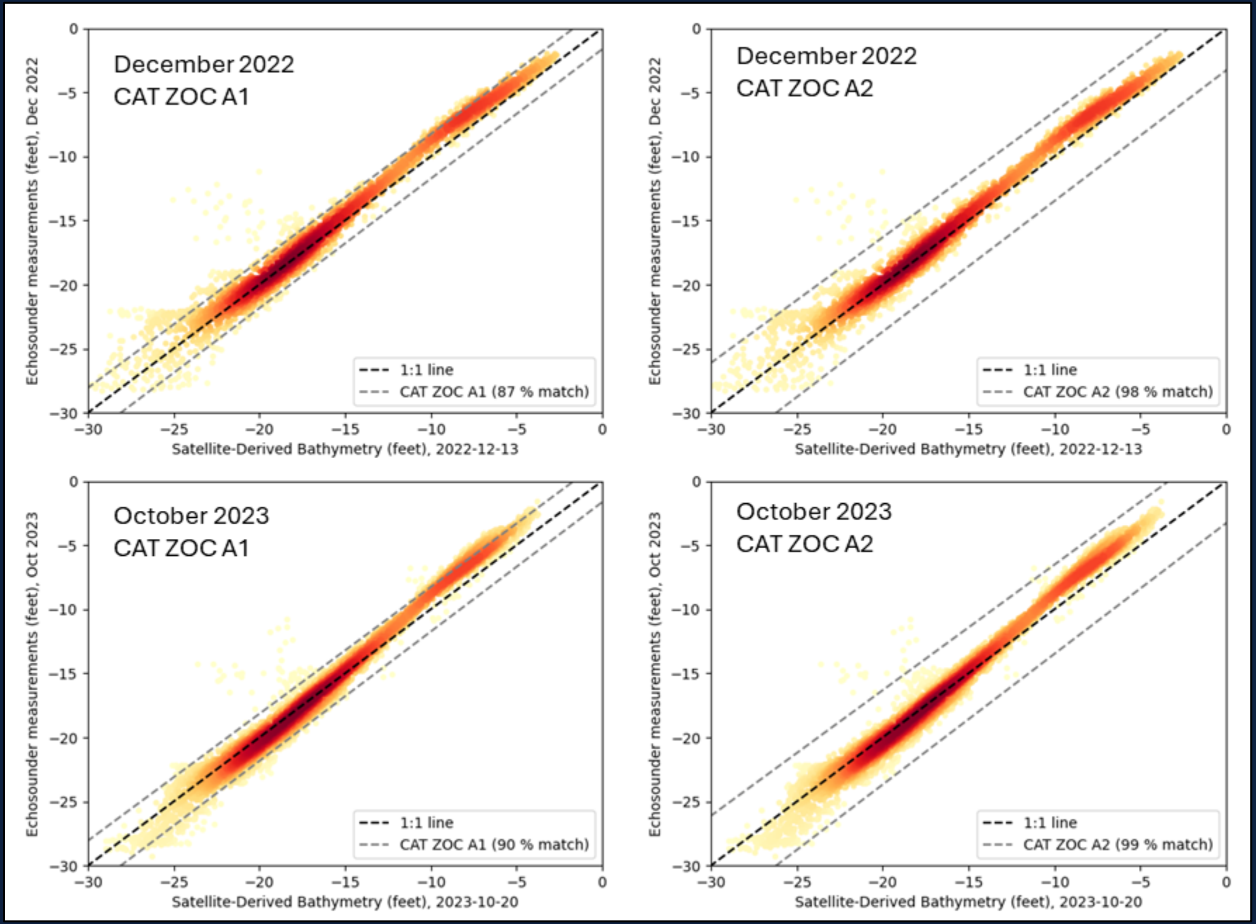
- SDB data extracted along FDEP monuments
- **SDB captures the overall profile shape accurately**, with few exceptions
- **Average difference approximately 1 foot** compared to hydrographic survey
- Shallower elevations: lower standard deviation
- Deeper elevation (>-20ft): greater variability in difference between the hydrographic survey and SDB data



COMPARISON ANALYSIS – STATISTICAL

- CATZOC (Category Zone of Vertical Confidence) used to evaluate vertical accuracies, which is a common measure for specifying uncertainties in charts
- *Nearly* achieved CATZOC A1
  - → >95% of all data have 0.5m absolute and 1% relative uncertainties
- Achieved CATZOC A2
  - → >95% of all data have 1m absolute and 1% relative uncertainties

Note: **SDB was processed without the use of training data;** further improvements in vertical accuracies can be achieved with post-processed calibration-validation routine from a few existing survey profiles



COMPARISON ANALYSIS – VOLUME

- **Traditional survey** → Volume loss of **77,700 cy** (7.2 cy/ft)
- **SDB survey** → Volume loss of **71,200 cy** (6.6 cy/ft)
- Difference between datasets → 6,500 cy (0.6 cy/ft)

Notes:

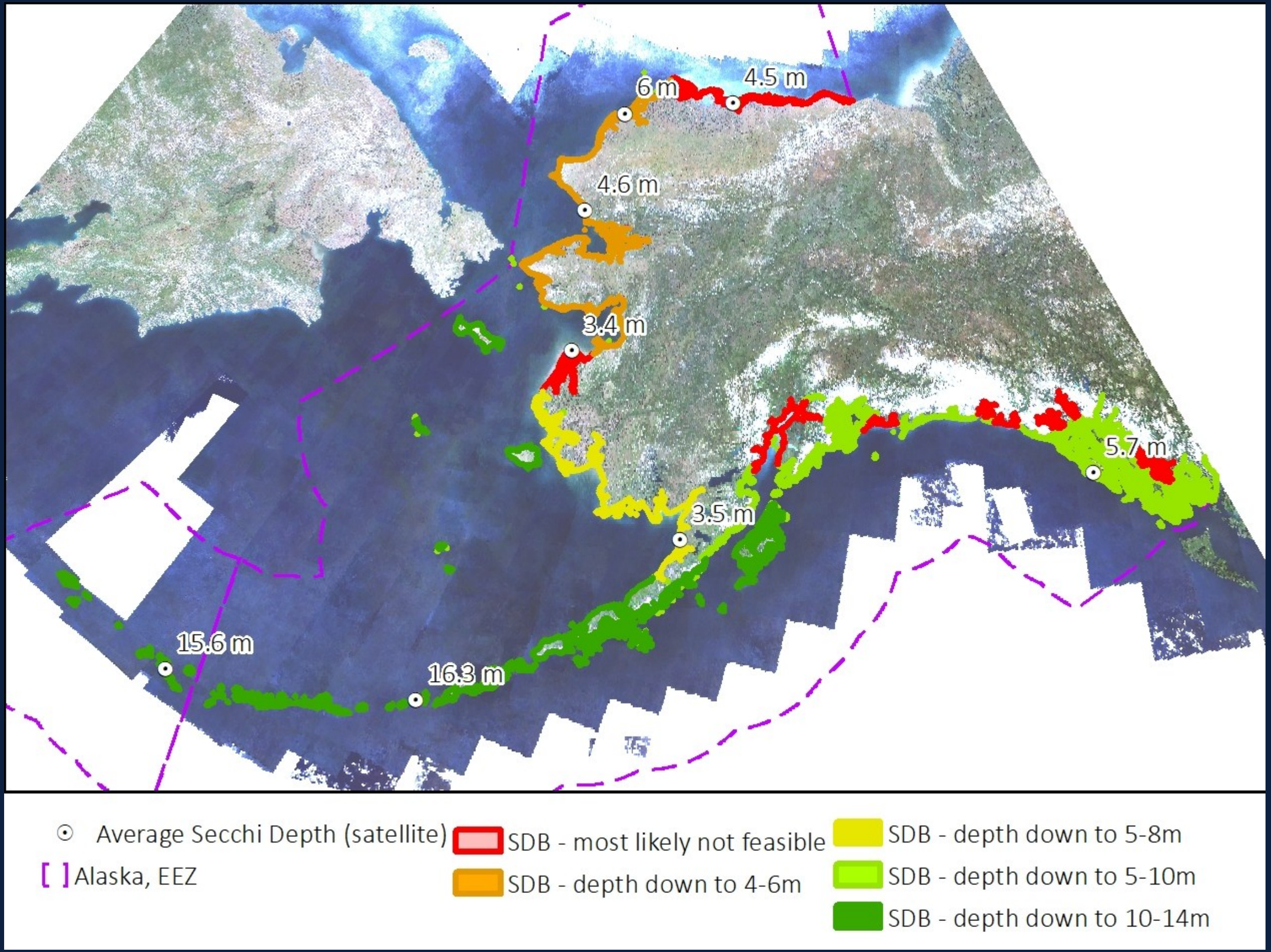
- comparison of volume change varied profile by profile
- SDB resolution captures intricate spatial changes, particularly around the inlet, which may account for the difference in volume losses.

Profiles	Distance (ft)	Pre-Idalia (Dec 2022) to Post-Idalia (October 2023)					
		SDB		Hydrographic Surveys		Difference	
		Density (cy/ft)	Volume (cy)	Density (cy/ft)	Volume (cy)	Density (cy/ft)	Volume (cy)
T-30		-2.3		-5.0		2.7	
	1126		-1,900		-2,000		100
R-31		-1.1		1.4		2.5	
	900		-4,500		-900		3,600
R-32		-8.9		-3.3		5.6	
	966		-10,400		-1,900		8,500
R-33		-12.5		-0.5		12.0	
	951		-15,200		-8,600		6,600
R-34		-19.5		-17.5		2.0	
	1019		-7,600		-8,300		700
R-35		4.6		1.2		3.4	
	922		700		-900		1,600
R-36		-3.2		-3.1		0.1	
	521		-4,200		-2,000		2,200
R-36.5		-12.9		-4.6		8.3	
	506		-4,000		-2,700		1,300
R-37		-2.8		-6.1		3.3	
	440		-2,800		-3,300		500
R-37.5		-9.9		-8.7		1.2	
	440		-1,900		-4,200		2,300
R-38		1.4		-10.5		11.9	
	464		-2,100		-4,000		1,900
R-38.5		-10.4		-6.7		3.7	
	465		-3,400		-7,800		4,400
R-39		-4.3		-27.0		22.7	
	453		400		-6,800		7,200
R-39.5		6.2		-3.1		9.3	
	453		3,700		-6,000		9,700
R-40		10.3		-23.3		33.6	
	429		-800		-7,200		6,400
R-40.5		-14.1		-10.3		3.8	
	425		-8,000		-7,100		900
R-41		-23.5		-23.0		0.5	
	291		-9,200		-4,000		5,200
R-41+305		-39.9		-4.4		35.5	
Study Area (R-30 to R-41+305)	**10,774**	**-6.6**	**-71,200**	**-7.2**	**-77,700**	**0.6**	**6,500**

ALASKA SDB FEASIBILITY

Challenges

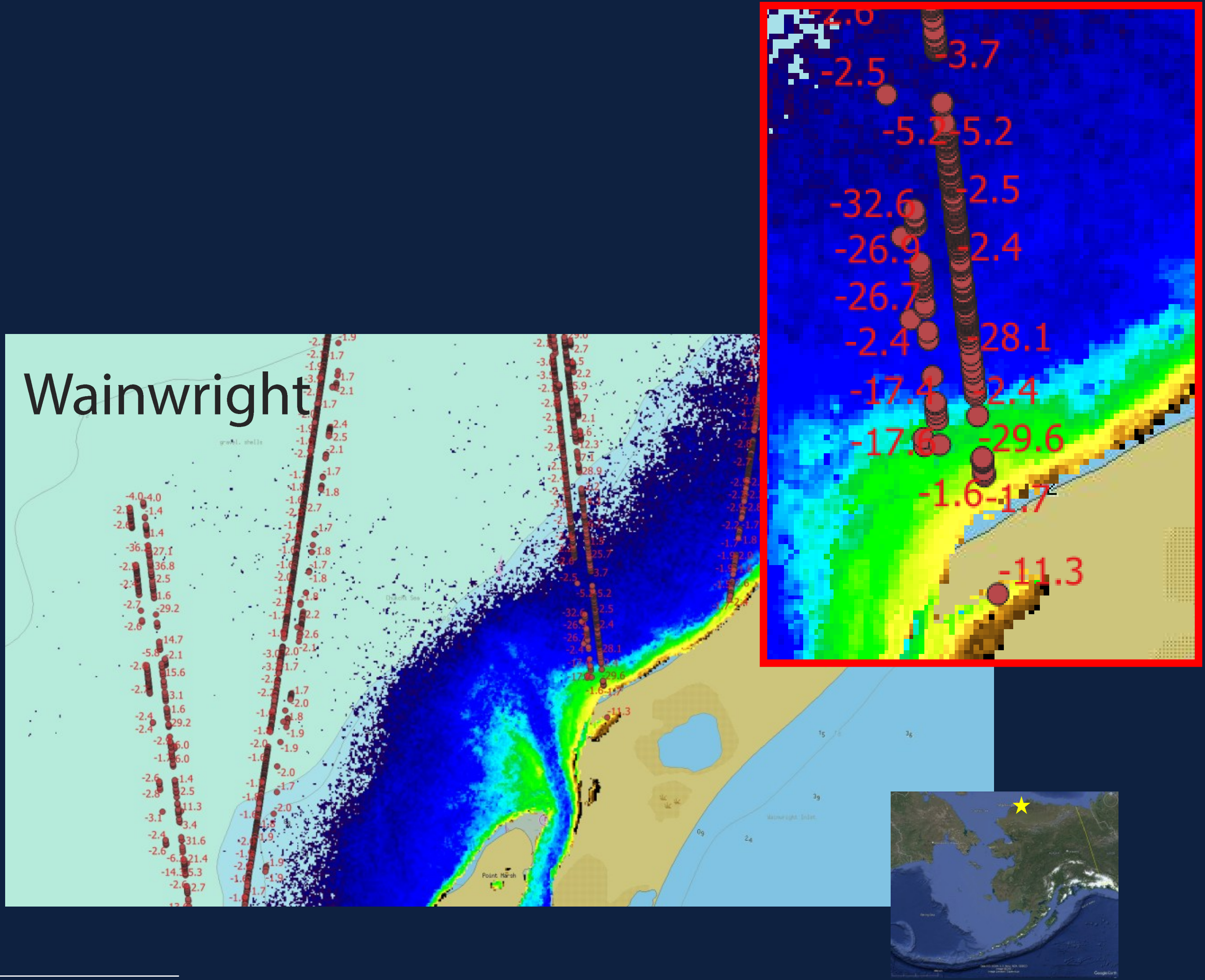
- Low light intensity at the seafloor
- Dynamic turbidity
- High cloud coverage
- Ice coverage
- Dense kelp forests

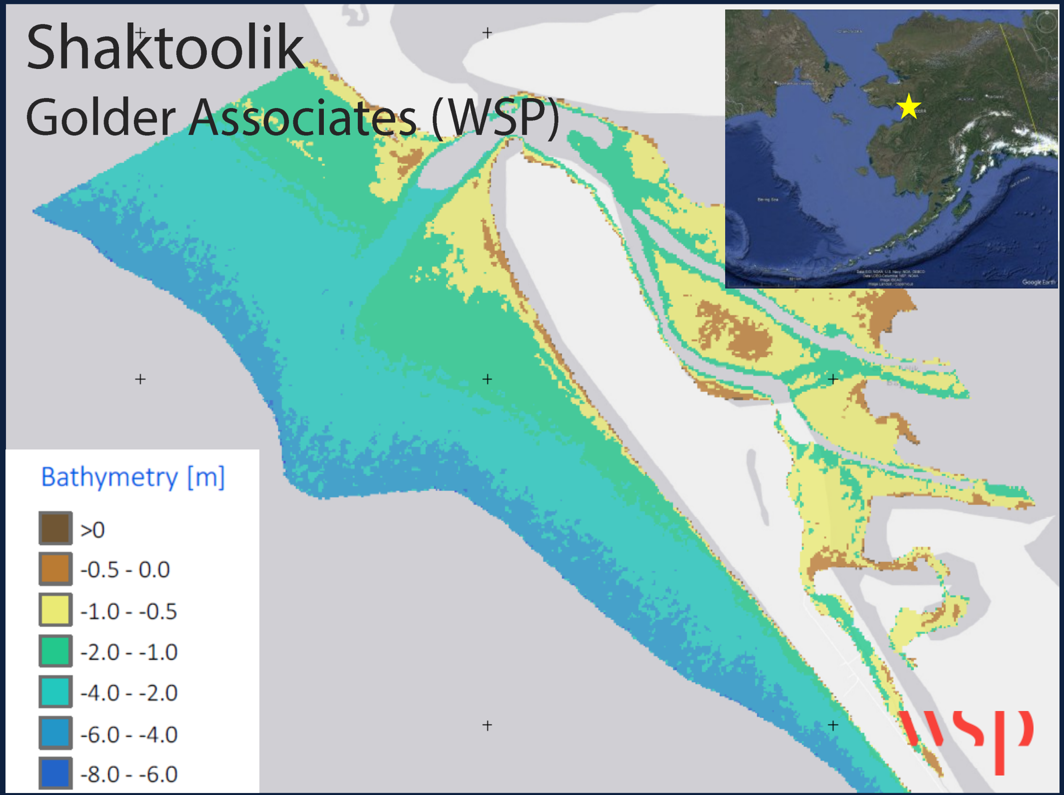


Norton Sound

- SDB feasibility areas (red)
- Yukon River turbid, intertidal mapping only

ALASKA SDB FEASIBILITY

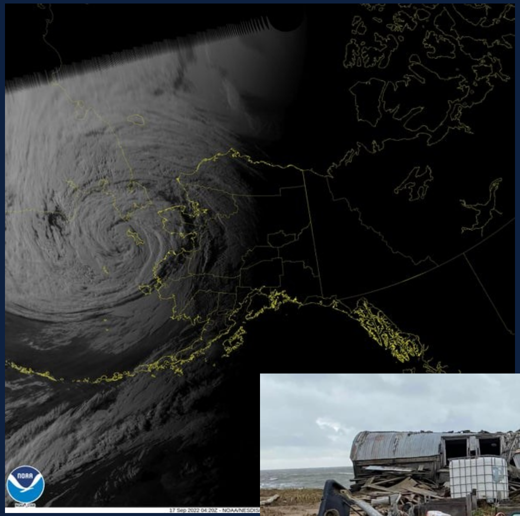




MERBOK ASSESSMENT - NOME

Merbok: Sept. 17, 2022.

NOAA St. 46265 (Nome) Hs = 18.5 ft
Storm surge +10.5 feet above low-tide
50-year high (since November 1974)



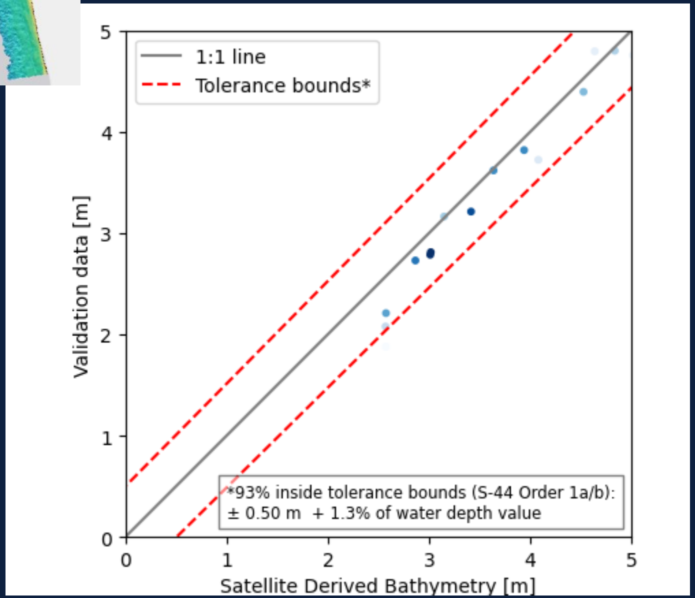
MERBOK ASSESSMENT - NOME

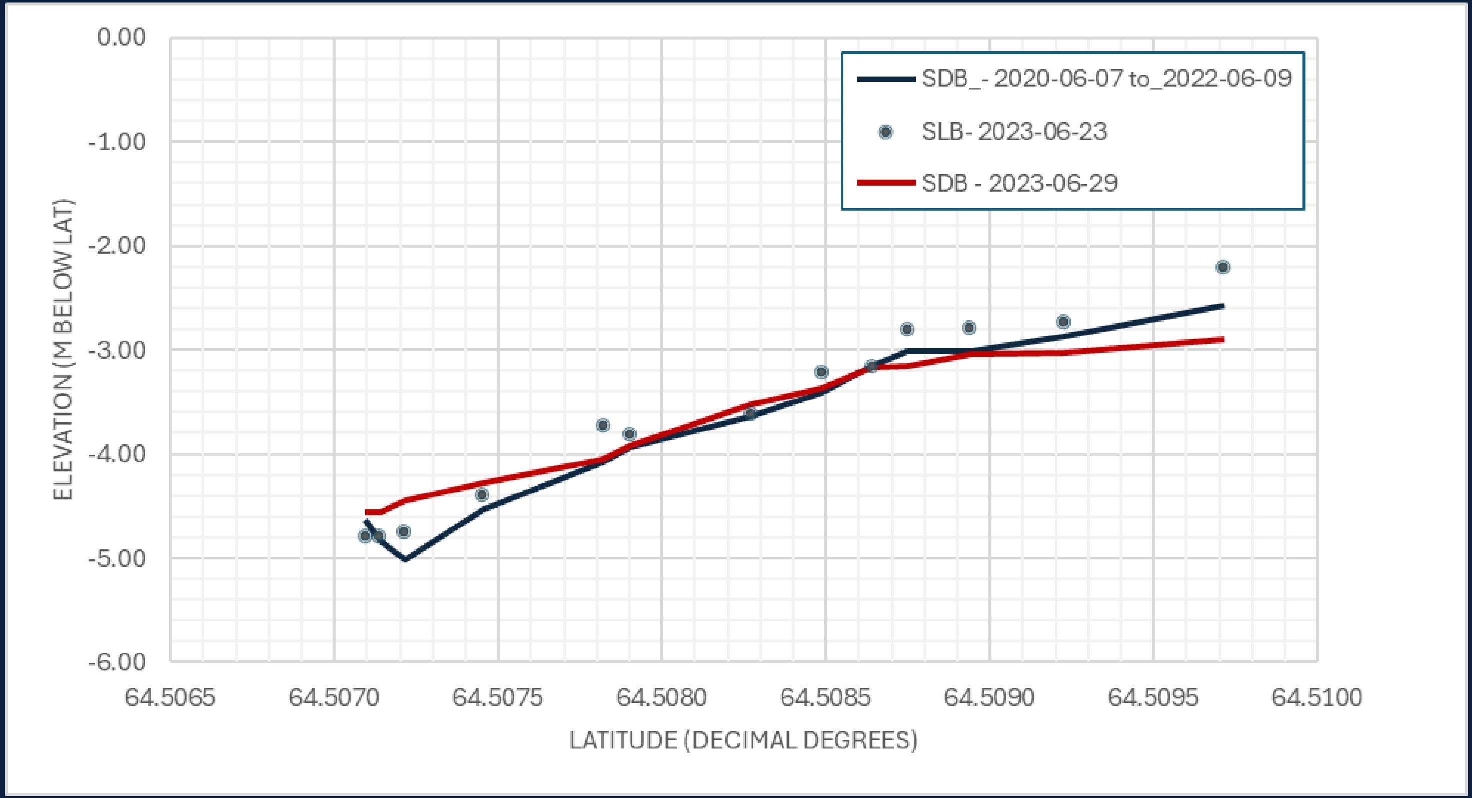
SLB with Post-storm SDB

- 15 points available for comparison
- good agreement with an RMSE = 0.29

Pre- to Post–Storm Comparison

- Erosion in shallow water (<3m deep)
- Deposition in offshore bar (>4 m deep)





SUMMARY

SDB has the potential to be a **valuable tool** in rapid post-storm disaster assessments:

- **Rapid** post-storm disaster assessment tool
- **Cost-effective and accessible**
- Ability to **go back in time**: baseline bathymetric surface pre-storm and rapid assessment post-storm from archives
- Detect subtle **spatial changes in high resolution**
- **Nearshore morphology** analysis for numerical modelling calibration
- **Global Repeatability**: Using Planet data (daily records), we can process SDB almost anywhere needed

SDB Bathymetric Change
Sept 21st – Aug 8th

Albada, E. Hartmann, K., Signorin, M., Benedet, L., Ryan, C. Bodinger, C., (2025) "Satellite derived bathymetry as a tool for rapid assessment of storm-induced impacts to beach fill", Shore & Beach, Vol. 93, No. 1, Winter 2025, available at : https://doi.org/10.34237/1009311.

EOMAP

Thank you!

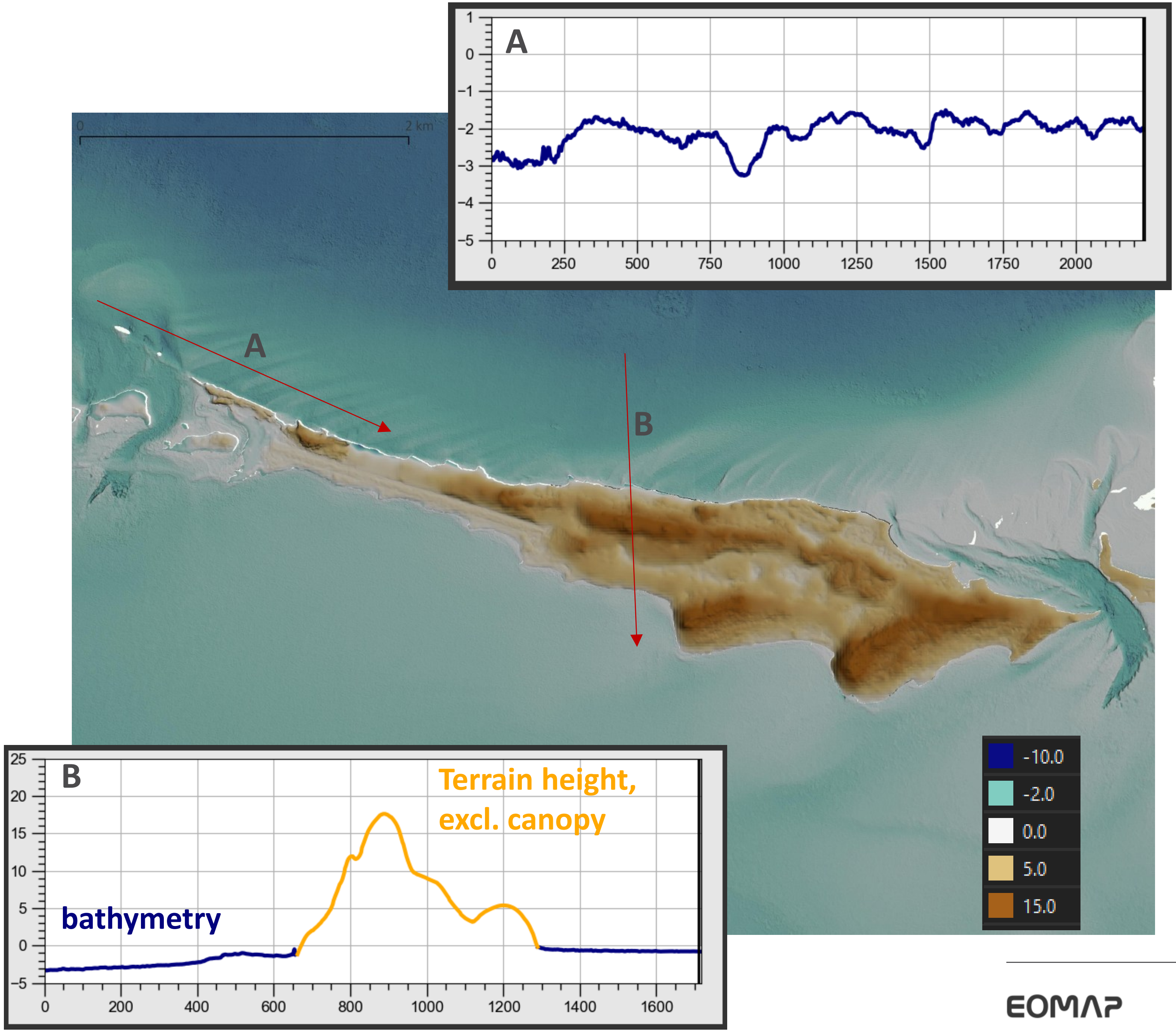
EOMAP
a Fugro company

Mail: we-care@eomap.com
Internet: eomap.com

Germany (HQ)
USA
Indonesia
UAE
Australia

SEAMLESS, INTEGRATED SURVEYING

2m resolution Digital Surface Model combined with Satellite-Derived Bathymetry, Bahamas, Hog Cay



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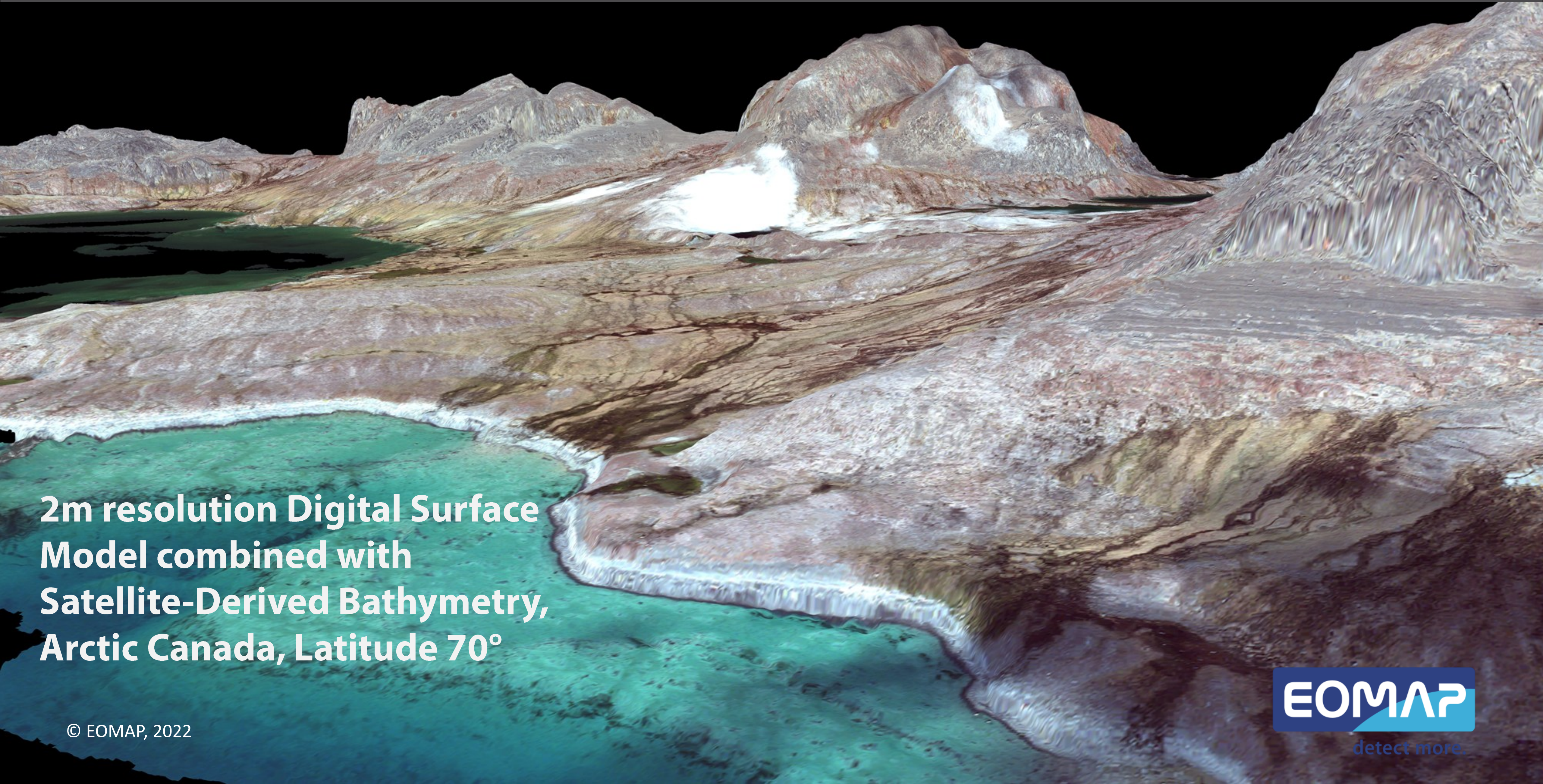
Multisource bathymetry and Digital Elevation Models

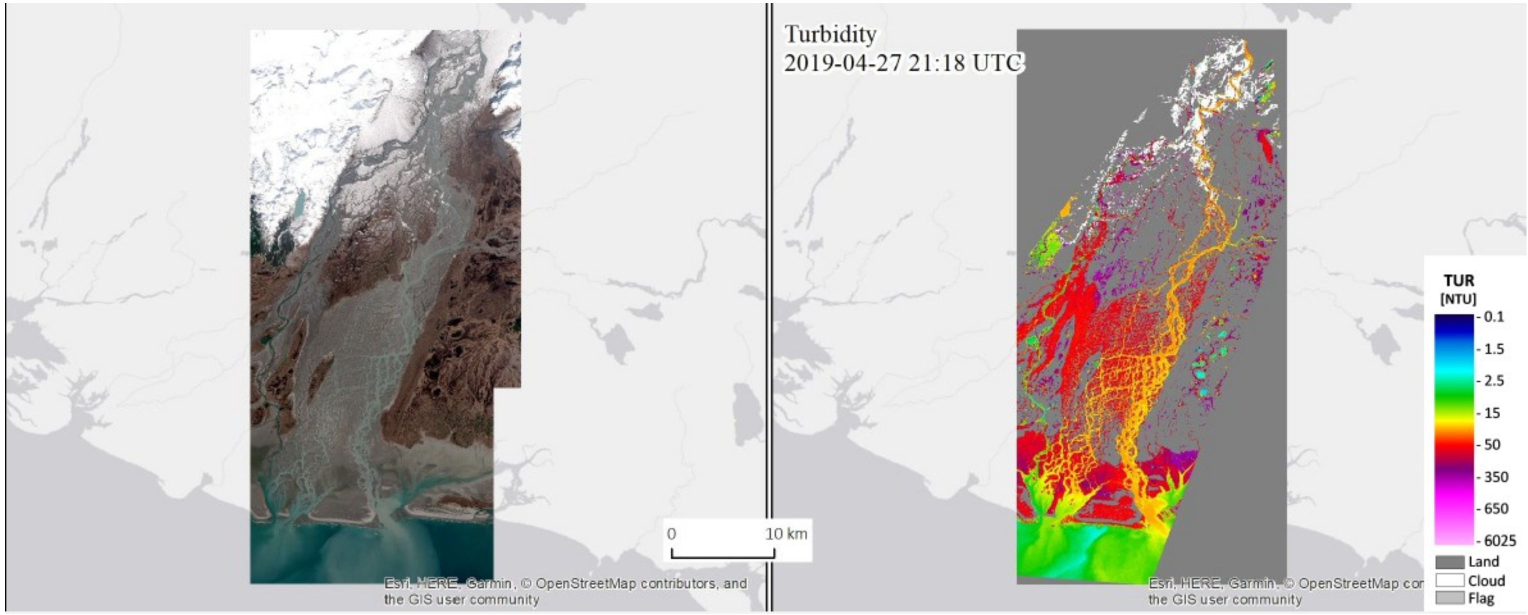


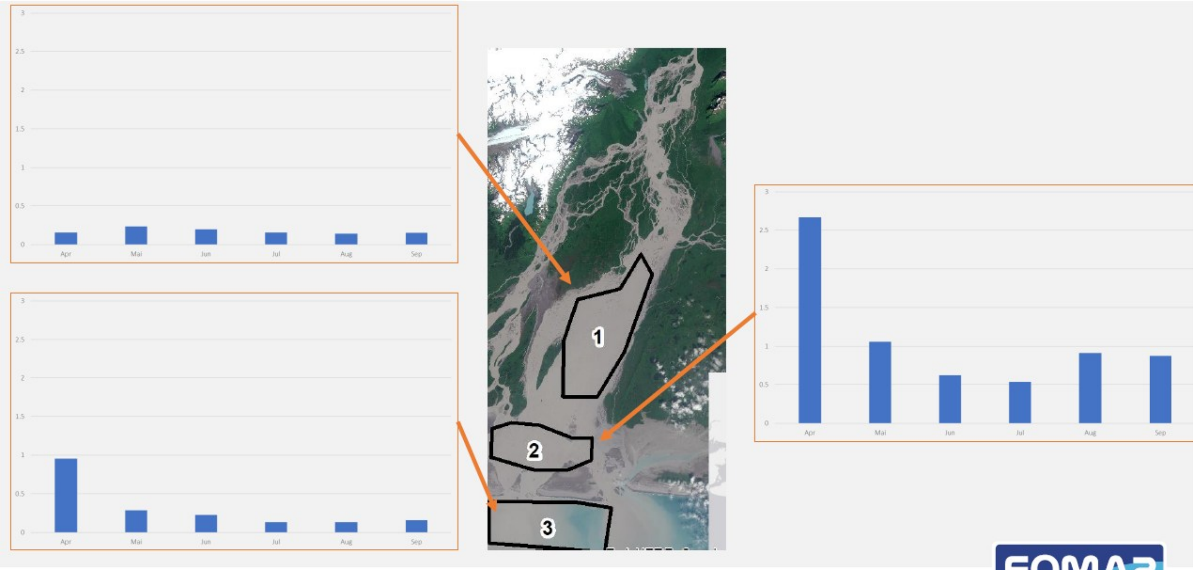
2m resolution Digital Surface Model combined with Satellite-Derived Bathymetry, Arctic Canada, Latitude 70°

WATER QUALITY FOR SURVEY CAMPAIGNS

Copper River

- 2018 – 2020
- 59 cloud free images
- Statistical analysis produced for 3 polygons between April to September for:
    - Turbidity
    - KD90
    - Z90
    - Secchi Disk Depth





EOMAP detect more.