# 2021 Alaska Coastal & Ocean Mapping Summit

Technology Lightning Talks

**December 1st, 2021 | Virtual**

# Orthoimagery & Lidar

Adam McCullough, Quantum Spatial / NV5

**December 1st, 2021 | Virtual**

# Aerial Lidar & Imagery Updates
# 2021 Alaska Coastal Mapping Summit

Adam McCullough – NV5 Geospatial Alaska Program Manager

NV5 GEOSPATIAL
powered by QUANTUM SPATIAL

Photo Credit: NV5 Sensor Operator Benjamin Krause
Kachemak Bay, Alaska 2020

# Geographic Footprint


## NV5 GEOSPATIAL OFFICES

Our production offices stretch from St Petersburg, FL to Anchorage, AK.

Acquisition assets are located in Wisconsin, Kentucky, Oregon, and Alaska. Aircraft and crew are highly mobile and follow weather patterns and project locations.

Acquired Geodynamics LLC. in 2021. Added deep-water hydrographic and geophysical capability.

# Data Acquisition Resources

NV5 GEOSPATIAL
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## PLATFORMS


## REMOTE SENSING EQUIPMENT


| Fixed Wing Aircraft | Number |
|---|---|
| Cessna Conquest II (Two holes) | 1 |
| Piper Navajo | 2 |
| Cessna Caravan (Single hole) | 2 |
| Cessna Grand Caravan (Two holes) | 5 |

| LiDAR Sensors | Number |
|---|---|
| Riegl 1560ii-s LiDAR with Phase One | 2 |
| Riegl 1560ii LiDAR with Phase One | 2 |
| Riegl 880GII Topobathy | 2 |
| Leica Chiroptera Topobathy / Hawkeye | 2 /1 |
| Single Deployment Sensor (CLASS) | 2 |
| Optech Lynx Mobile Mapper | 1 |
| Riegl VMX-2HA Mobile Mapper | 1 |

| Imagery Sensors | Number |
|---|---|
| Vexcel UltraCam Eagle M3 80mm | 1 |
| Vexcel UltraCam Eagle M3 100mm | 1 |
| Leica ADS 100 | 2 |
| Leica Trio Oblique | 1 |
| FLIR SC-6000 Thermal | 1 |
| ITRES CASI-1500H Hyperspectral | 1 |
| Phase One | 8 |

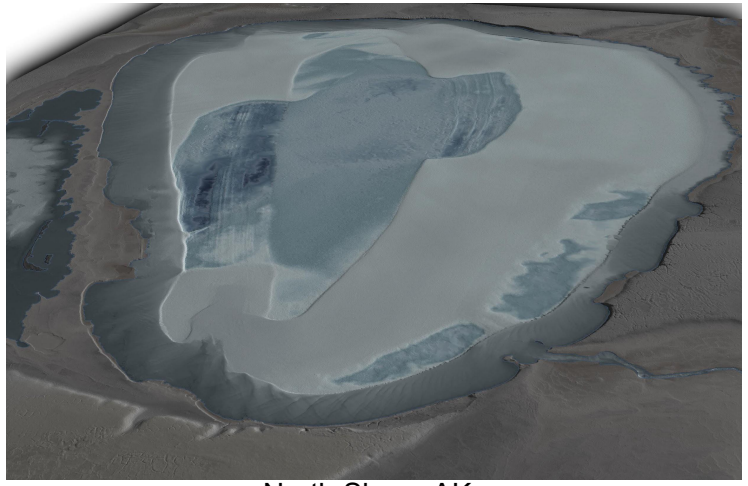
# Lidar Sensor Trends

Topographic Lidar

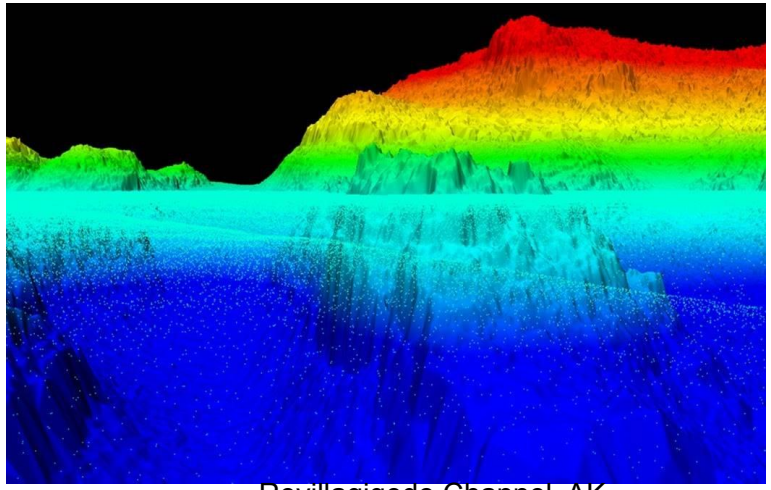

Topobathymetric Lidar
(Shallow water)


Topobathymetric Lidar
(Shallow/Deep water)

Port Lions, AK



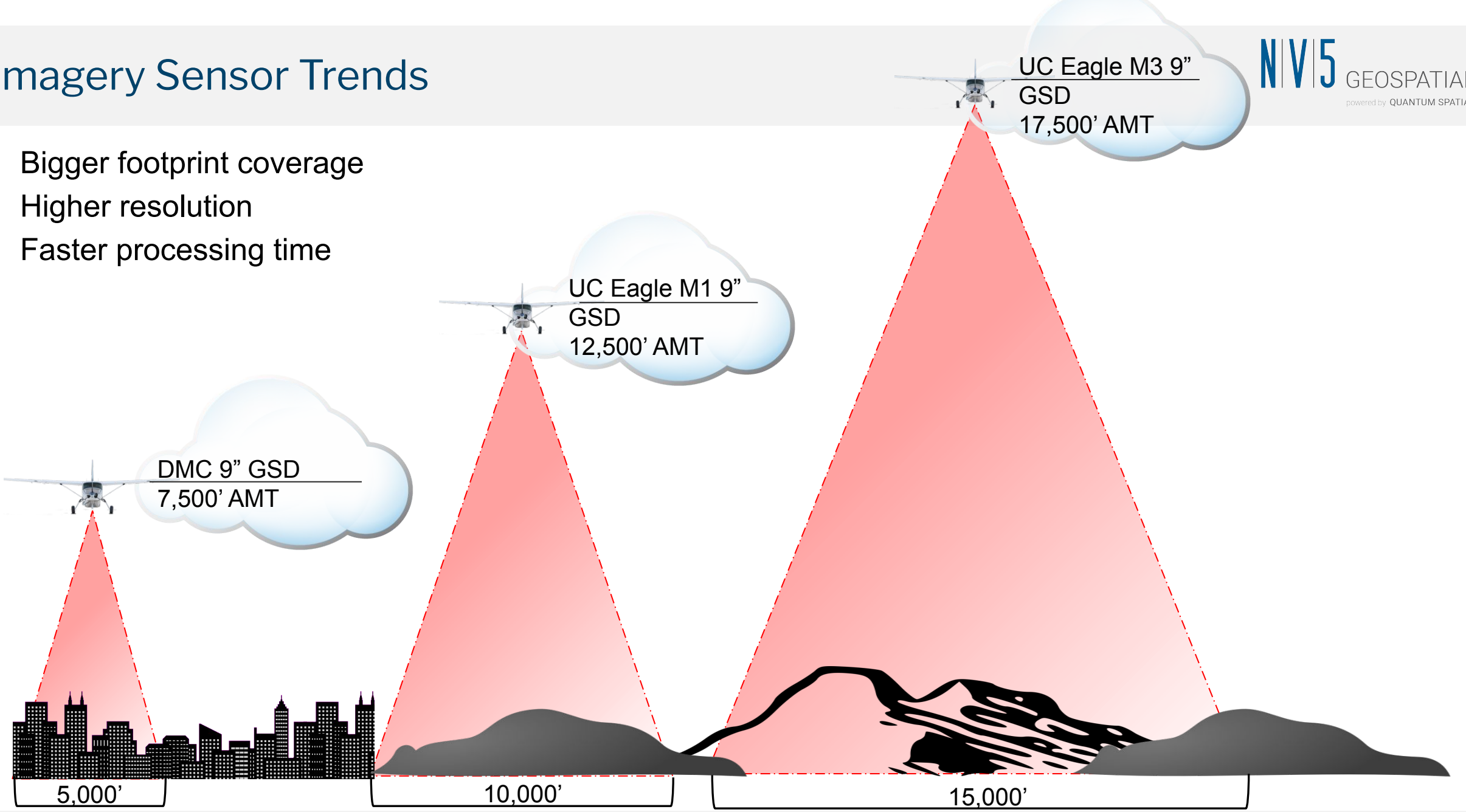
North Slope, AK



Revillagigedo Channel, AK

# Imagery Sensor Trends

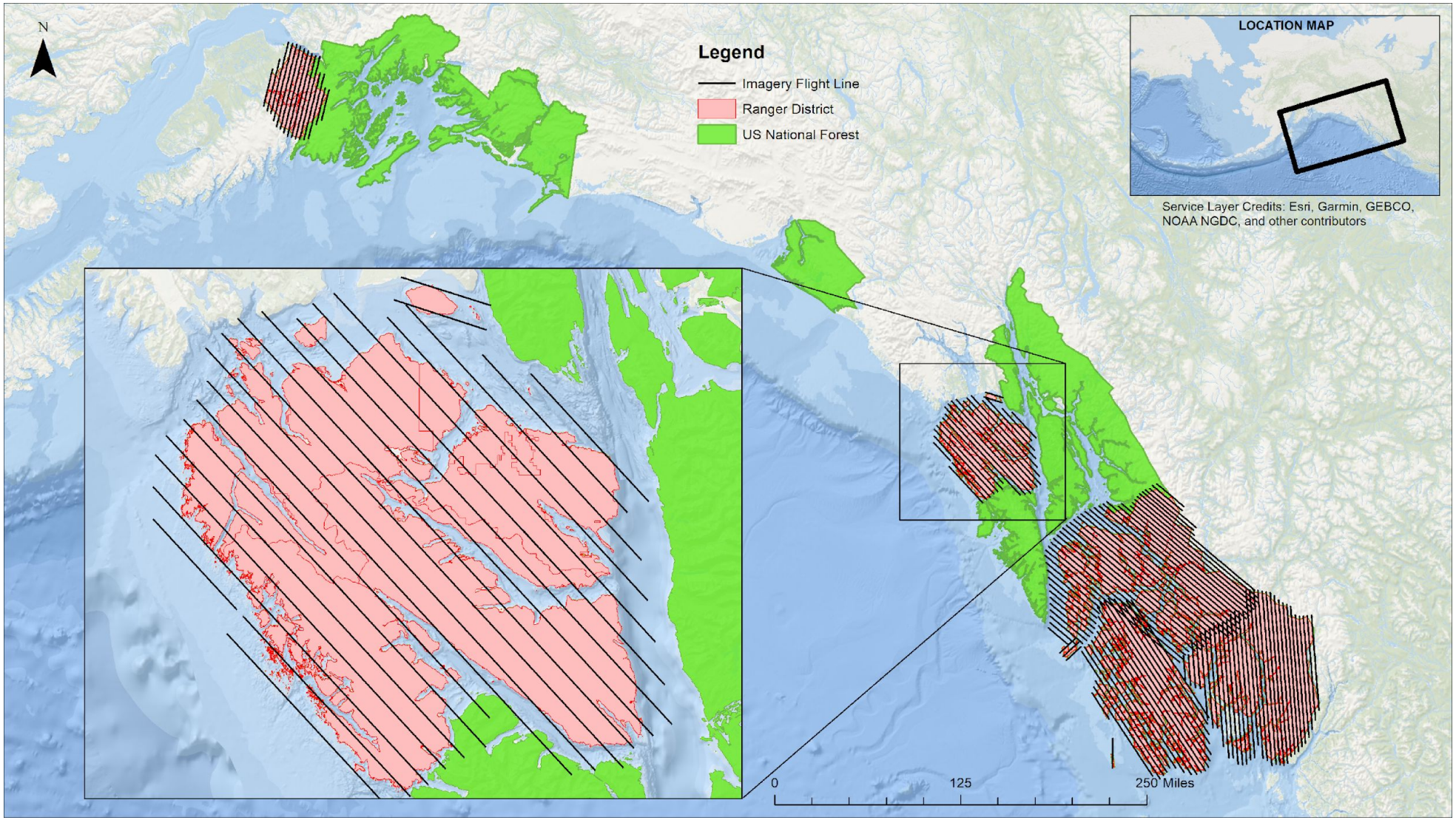
- Bigger footprint coverage
- Higher resolution
- Faster processing time



# Alaska US Forest Service Imagery

Requirements:

- 4-band, 30cm GSD
- 60/30 FL/SL
- 40° Sun Angle
- Leaf On
- Cloud Free/Snow Free



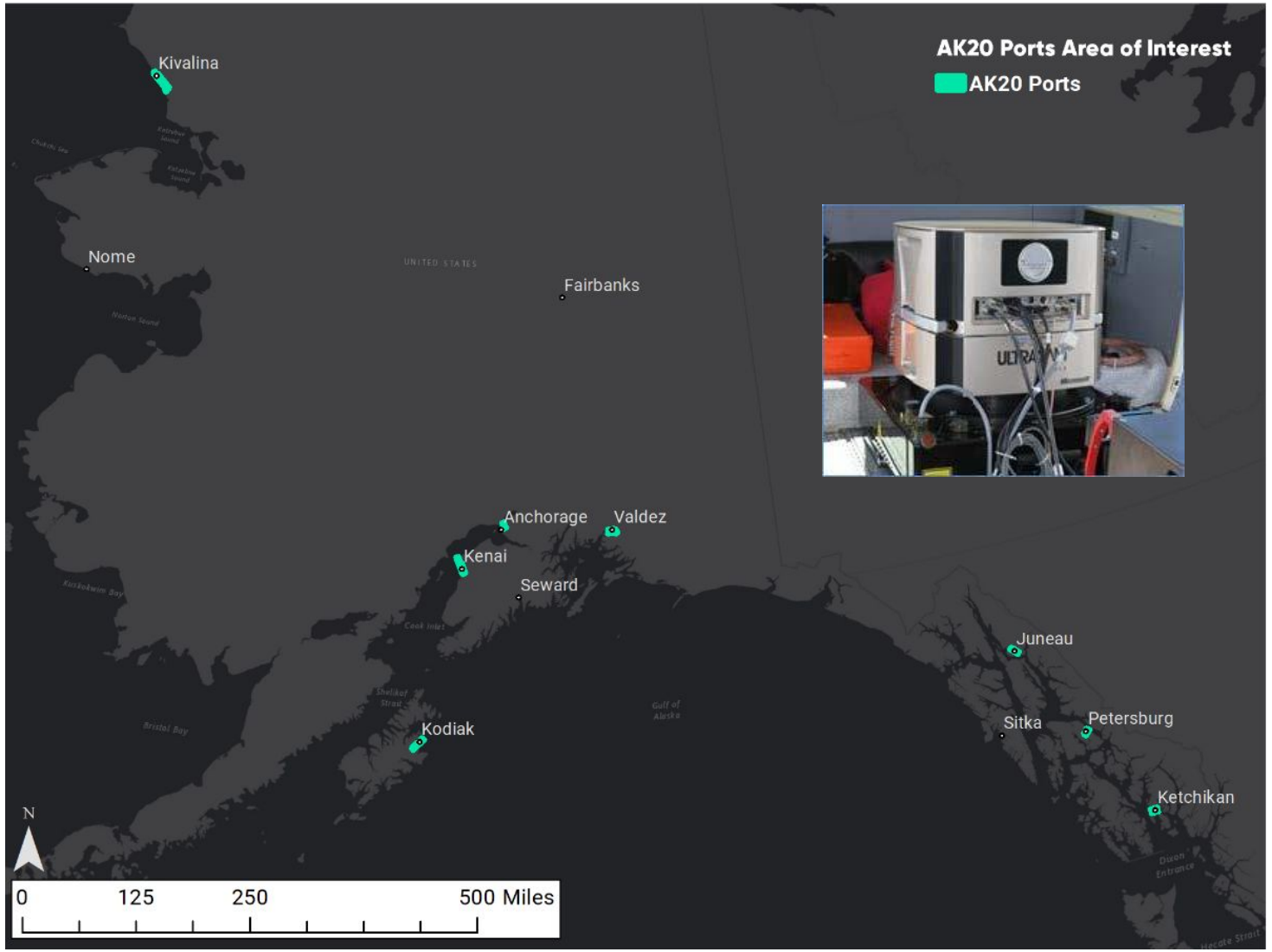
# Alaska Ports

## 8 ports across Alaska

- Kivalina
- Nikiski-Kenai
- Anchorage
- Valdez
- Kodiak
- Juneau
- Petersburg
- Ketchikan

## UltraCam Eagle

- 25-cm GSD
- No snow, ice, smoke, haze
- 25° sun angle



# Port of Alaska (Anchorage)

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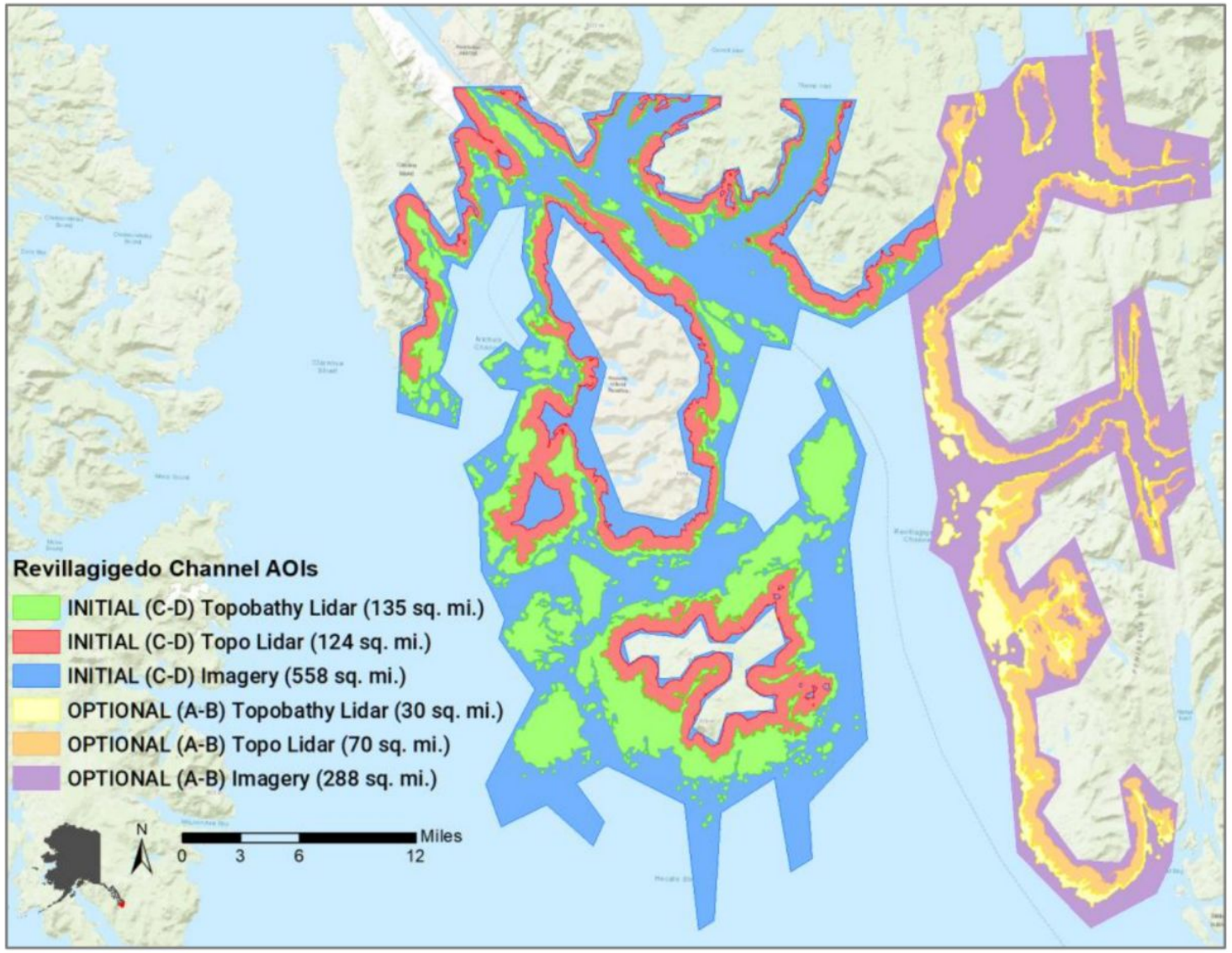
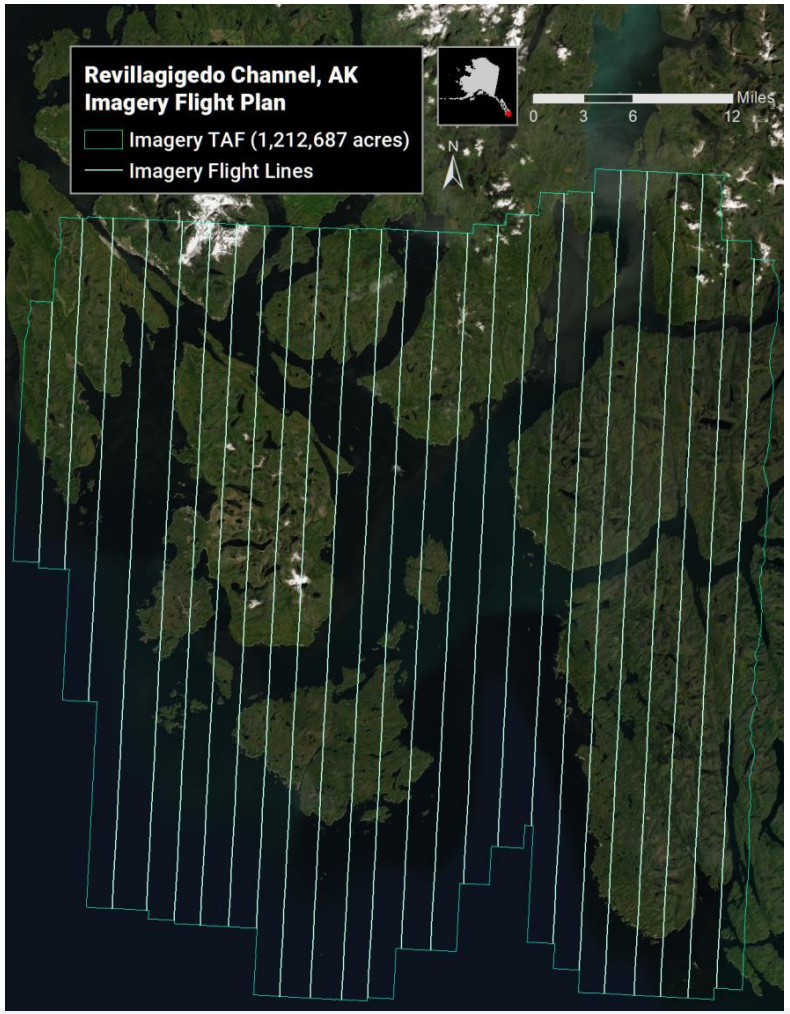
# Revillagigedo Channel, AK

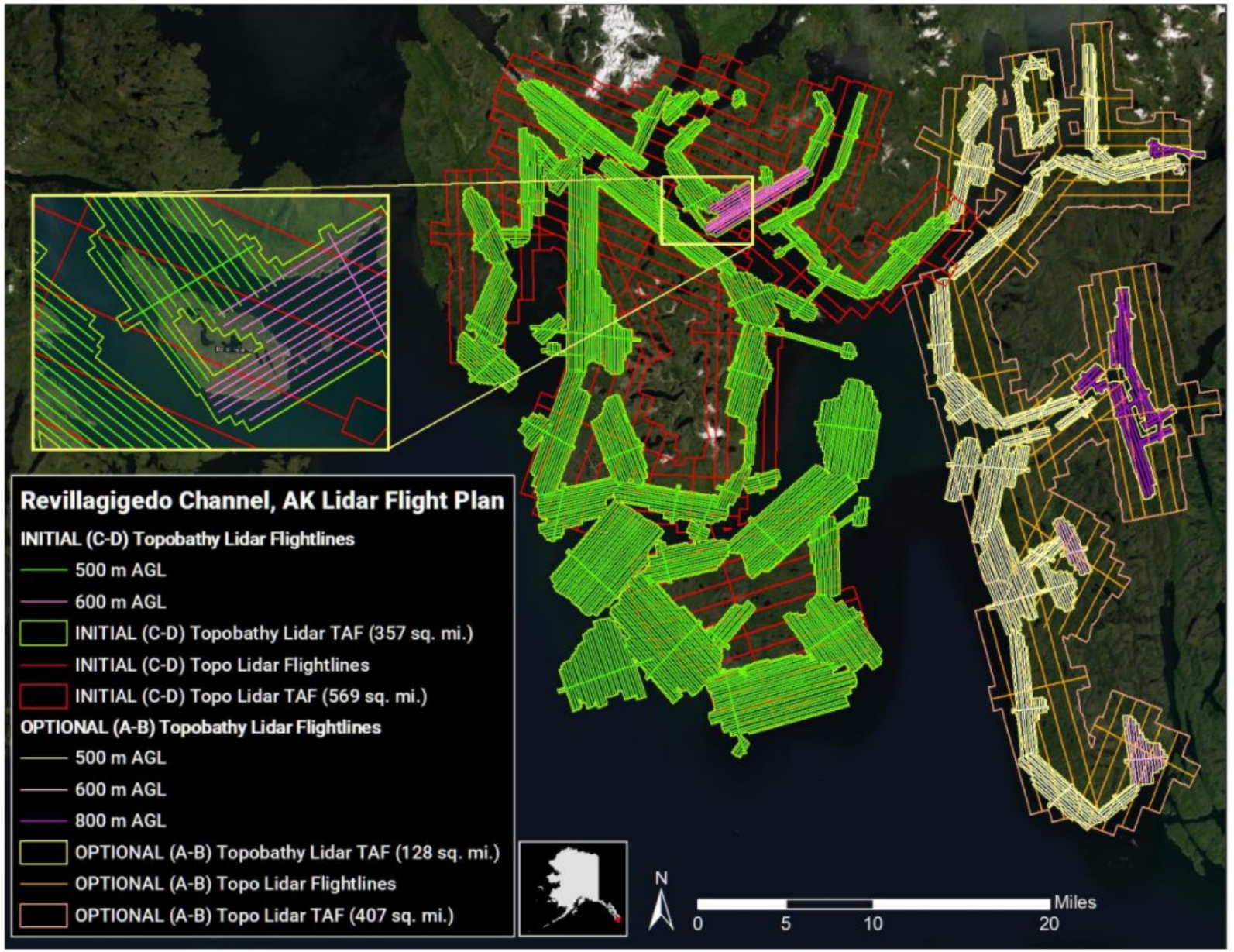
- Three Sensor Technologies
  - Leica Chiroptera 4X/Hawkeye 4X (topobathy lidar)
  - Riegl 1560ii (topographic lidar)
  - UltraCam Eagle (4 band Imagery)
- Acquisition
  - Initial Area – 6/8/21 – 7/3/21
  - Optional Area – 7/30/21 – 8/2/21
  - Imagery in Optional Area is on hold till Spring
- Ground Survey
  - Limited paved/hard ground
  - Access mostly by boat
- Water Clarity Monitoring
  - Satellite imagery (MODIS/Sentinel)
  - Deploy data buoys with Iridium data logger



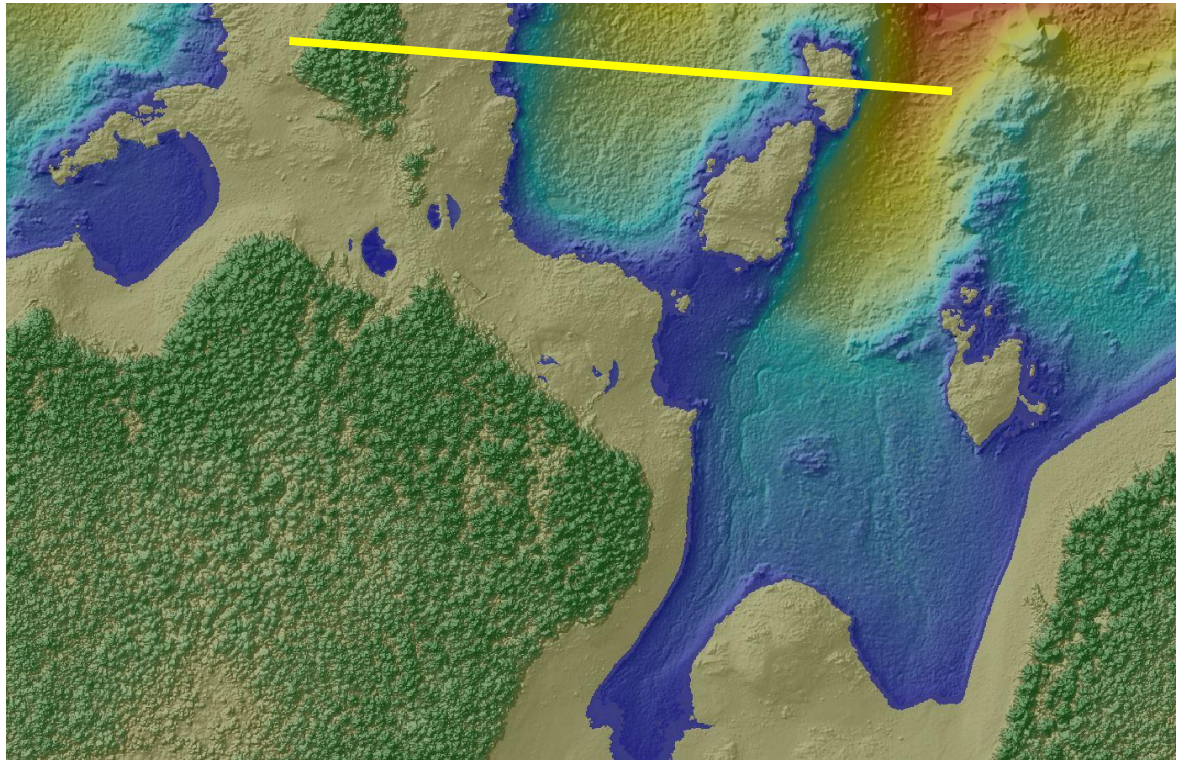
# Revillagigedo Channel, AK

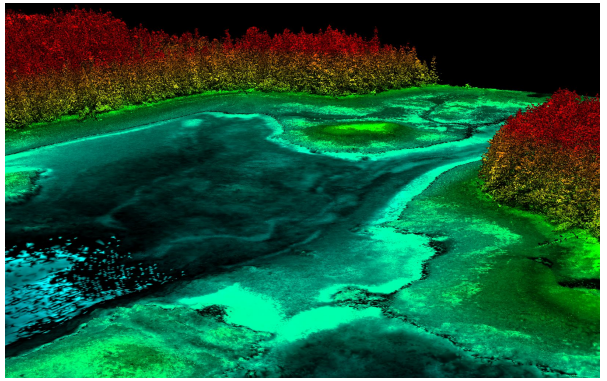
- Flight plans….

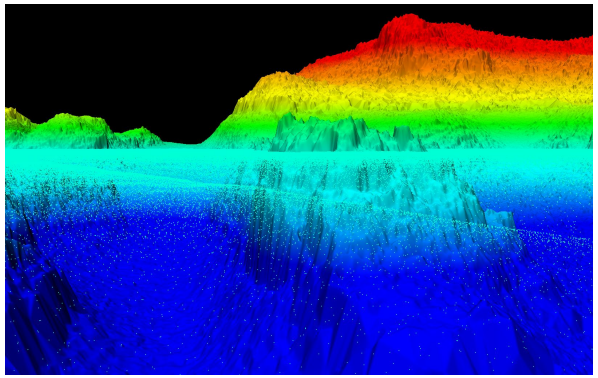


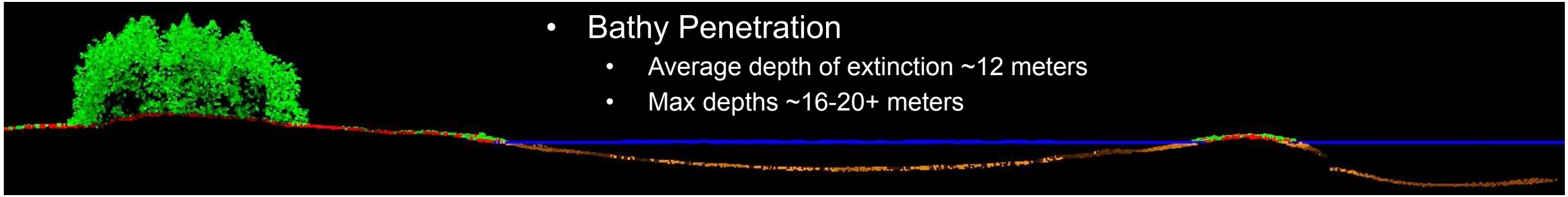



# Revillagigedo Channel, AK









- Bathy Penetration
  - Average depth of extinction ~12 meters
  - Max depths ~16-20+ meters

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# Thank You

**Adam C. McCullough**
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Adam.mccullough@nv5.com

Photo Credit: NV5 Sensor Operator Benjamin Krause
Kachemak Bay, Alaska 2020

# Satellite Imagery

Paulina Zubatov, Planet

**December 1st, 2021 | Virtual**

# PLANET & COASTAL IMAGERY

Paulina Zubatov

Juneau, Alaska - Aug 08, 2019

# The traditional approach is falling short

Limited coverage

Low revisit

Inefficient access

Signal vs noise

# And consequences are profound

Overspending & budget loss

Safety risks

Ineffective policies

Stunted land stewardship

## Planet Dove Satellite

- Always-on, broad-area monitoring
- 3 meter resolution
- RGB and NIR bands

## Planet SkySat Satellite

- Custom, targeted monitoring
- 50 centimeter resolution
- RGB, NIR, and Pan bands

## Planet SkySat Constellation

**SkySats 1-15**
~98° Sun-Synchronous Orbit

**SkySats 16-21**
~53° Inclined Orbit

## Planet Dove Constellation

~98° Sun-Synchronous Orbit

# Coastal Use Cases

- Planning for data collection for Bathymetry maps
- Glacial retreat
- Changes to coastal wetlands and shorelines

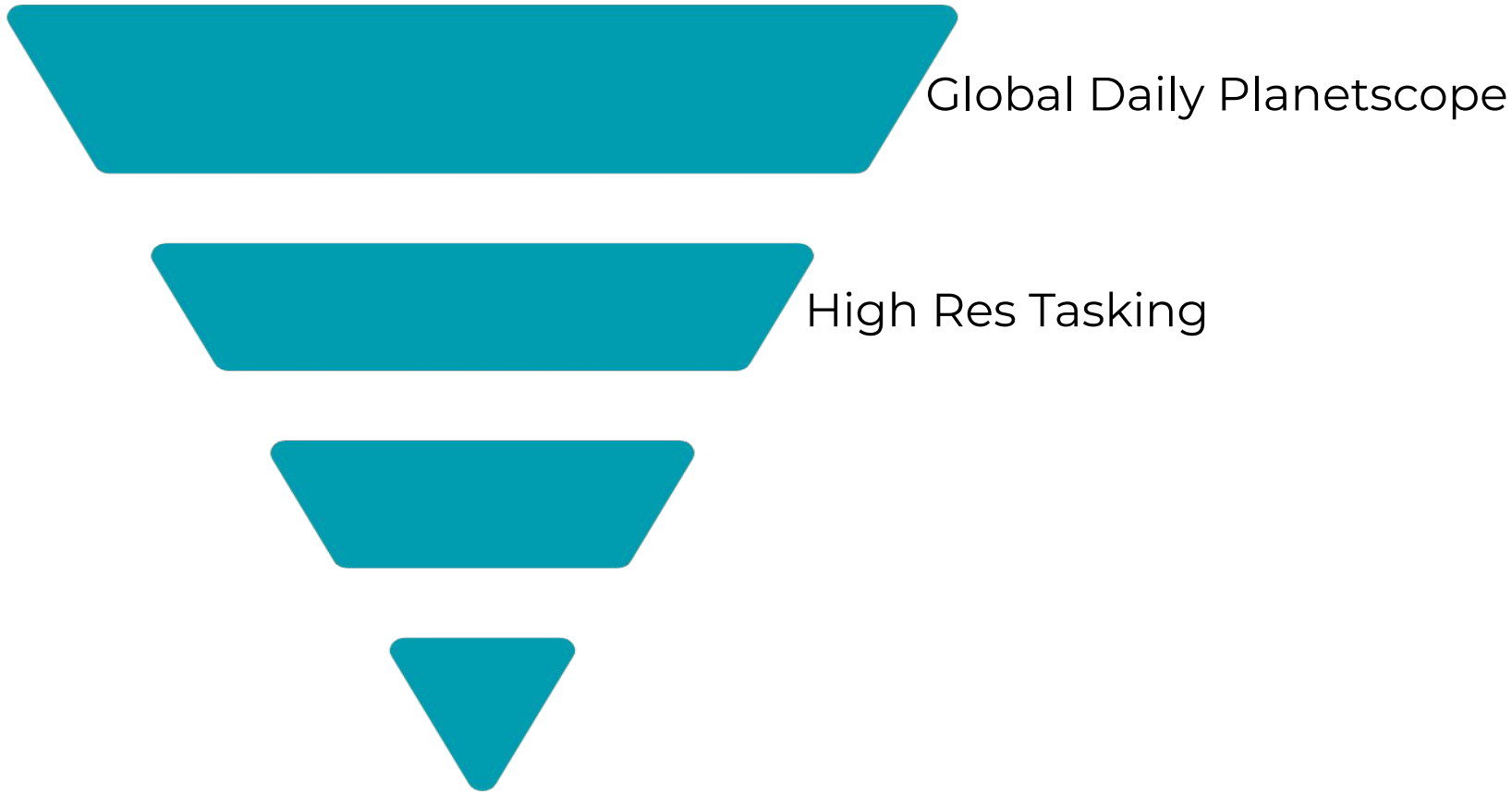
Great Barrier Reef, Australia

# Observation Funnel

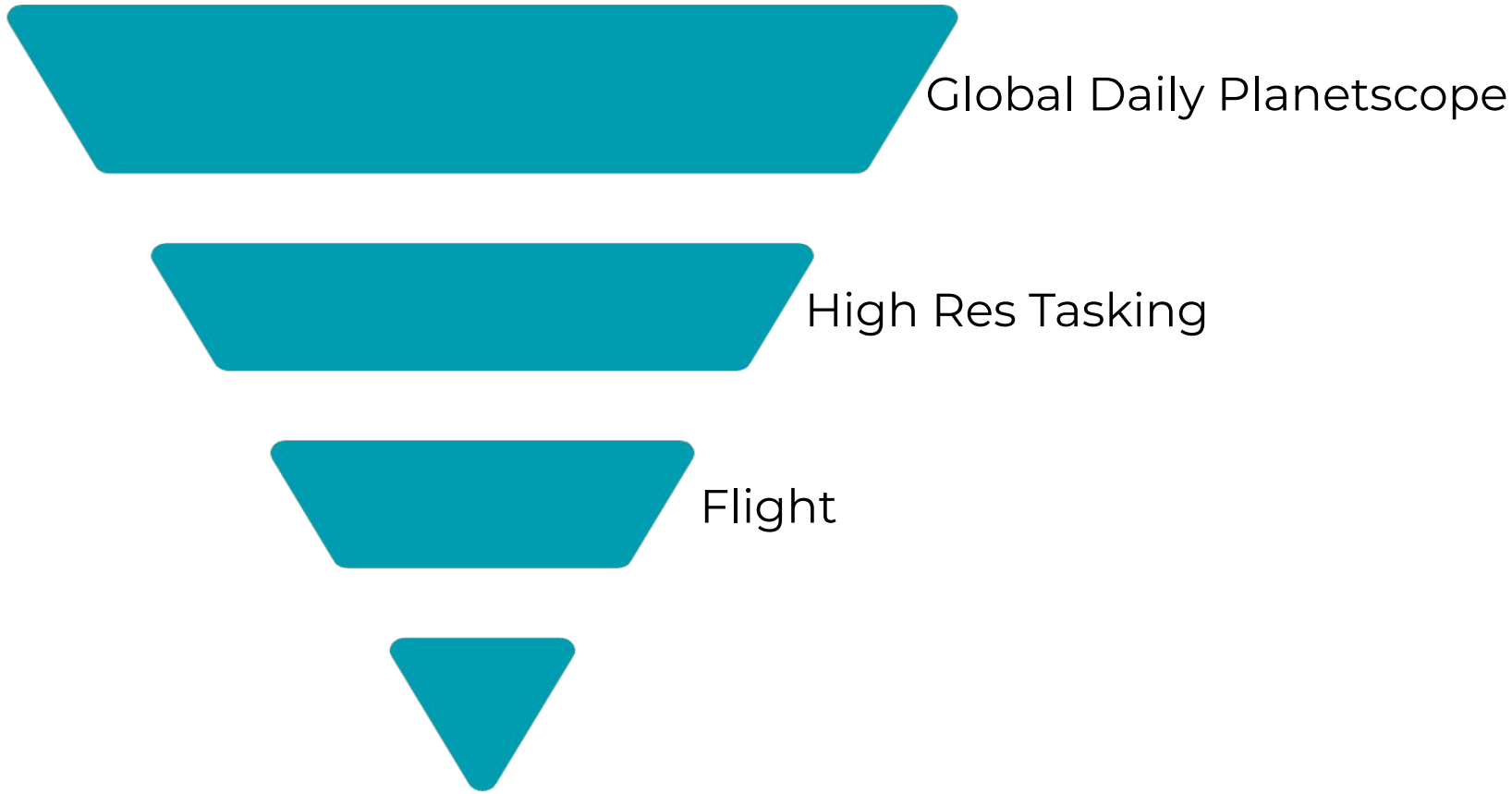
# Observation Funnel

Global Daily Planetscope

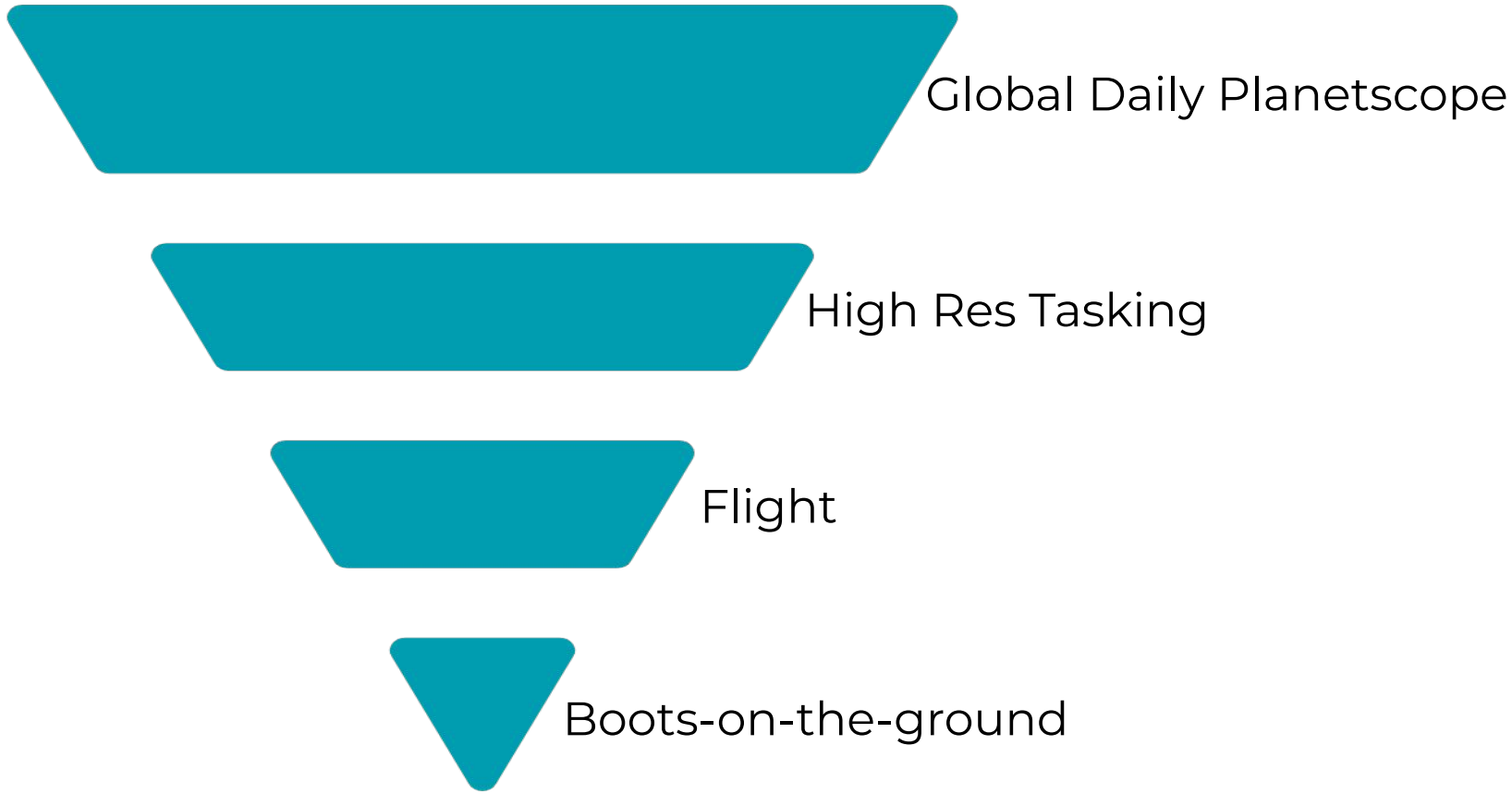
# Observation Funnel



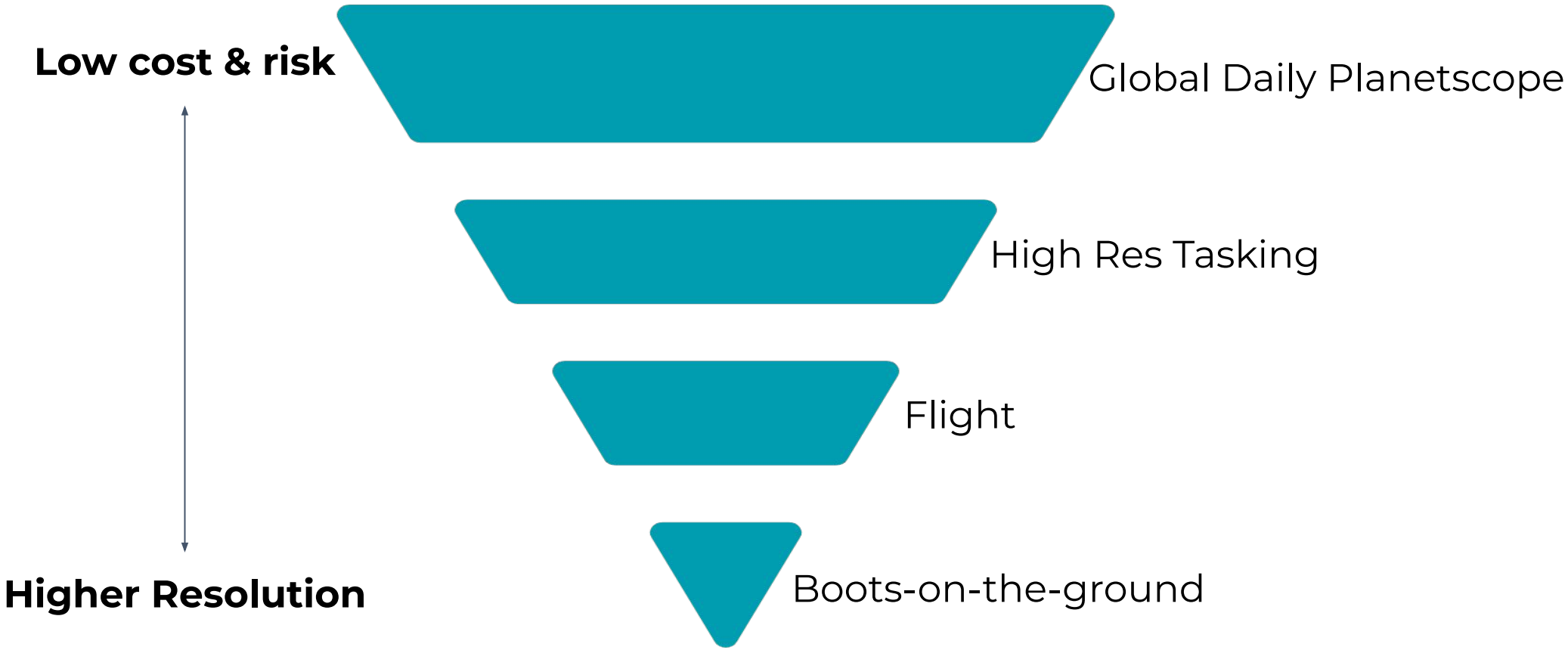
# Observation Funnel



# Observation Funnel



# Observation Funnel



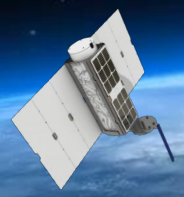
# Coastal Use Cases

- Planning for data collection for Bathymetry maps
- Glacier movement
- Changes to coastal wetlands and shorelines
- **What else?**

Great Barrier Reef, Australia

# Thank you!

**Paulina Zubatov**
**Planet**
**paulina@planet.com**



# Satellite Derived Bathymetry

Dave Flanagan, TCarta

**December 1st, 2021 | Virtual**


TCARTA
Innovative Geospatial Products
www.tcarta.com

# Operational SDB Framework for Mapping Coastal Alaska

## 2021 Alaska Coastal and Ocean Mapping Summit

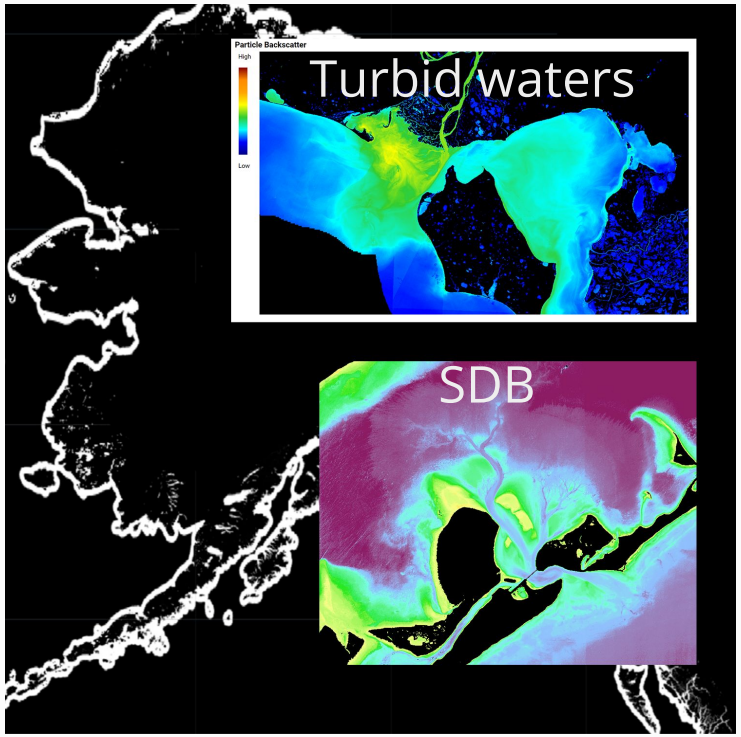
**David Flanagan**
**Remote Sensing Program Manager**
**TCarta Marine LLC**
**df@tcarta.com**

# NOAA SBIR Grant: Multi-Sensor SDB in Alaska and Arctic Waters

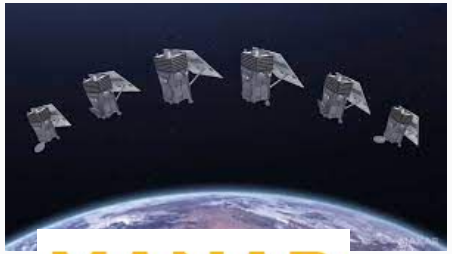
PoP: February 2021 - October 2022

Multi-Platform Integration | Sub-Daily Imaging | Customized Collection for Arctic Conditions | Space, Aerial, Marine Survey Interoperability

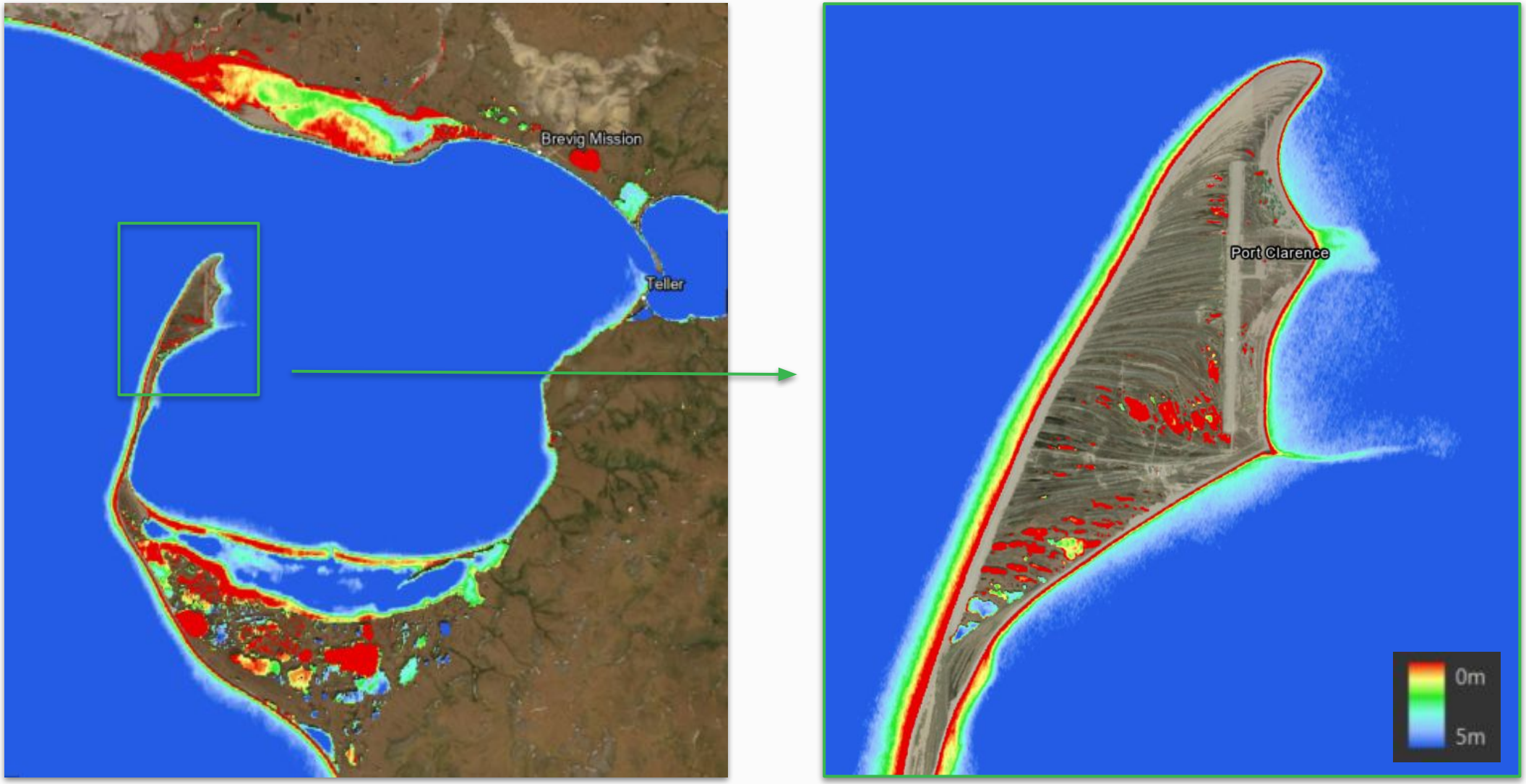
TCarta is underway in Phase 2 of a Small Business Innovation Research (SBIR) grant focused on multisensor integration, custom sensor tasking parameterization for marine imaging, and adaptation of Satellite Derived Bathymetry techniques to Alaskan and Arctic waters.




Multispectral | Hyperspectral | Space-Based LiDAR | Synthetic Aperture Radar (SAR)

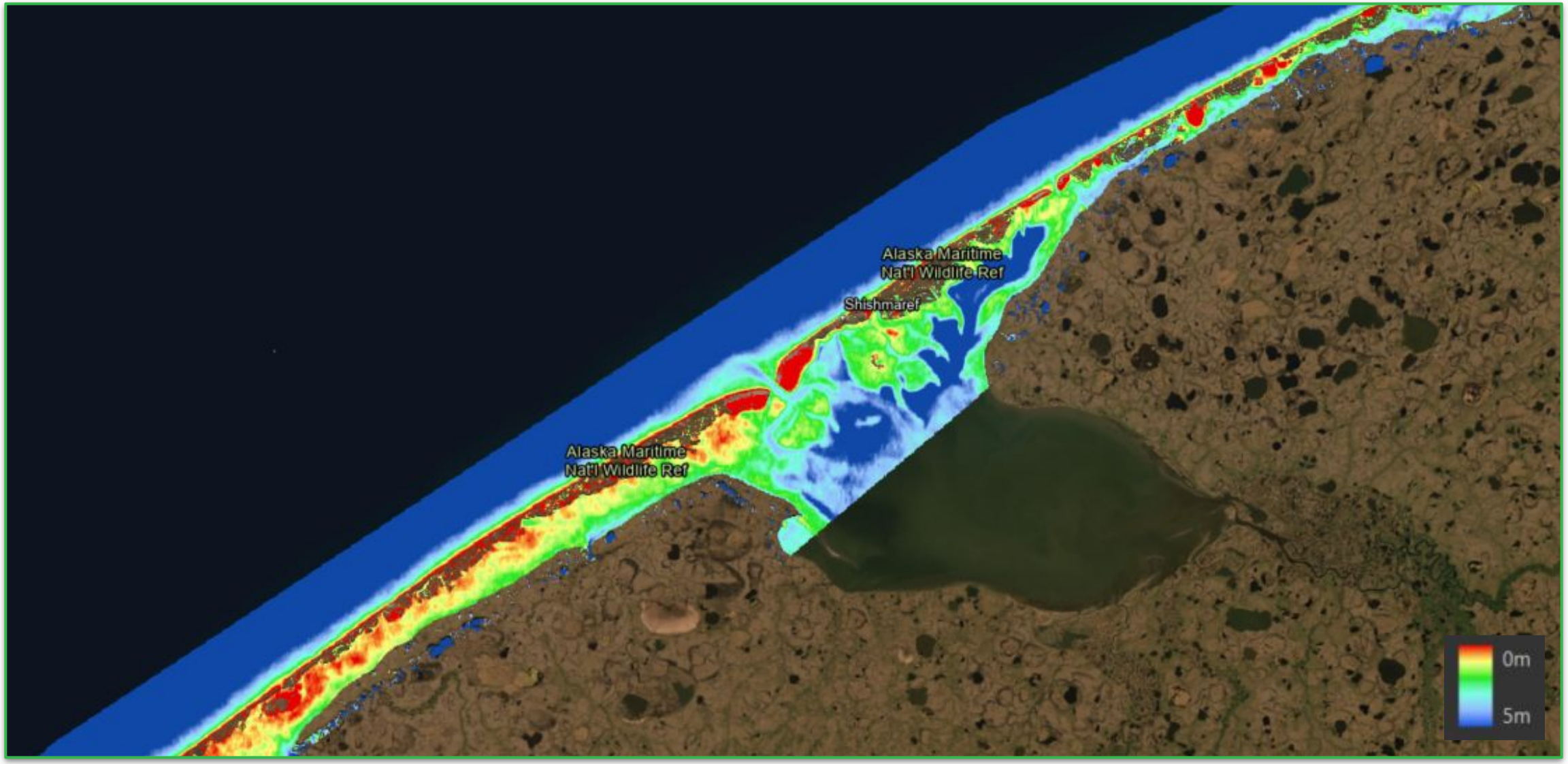


# 10m SDB in Alaska - Port Clarence



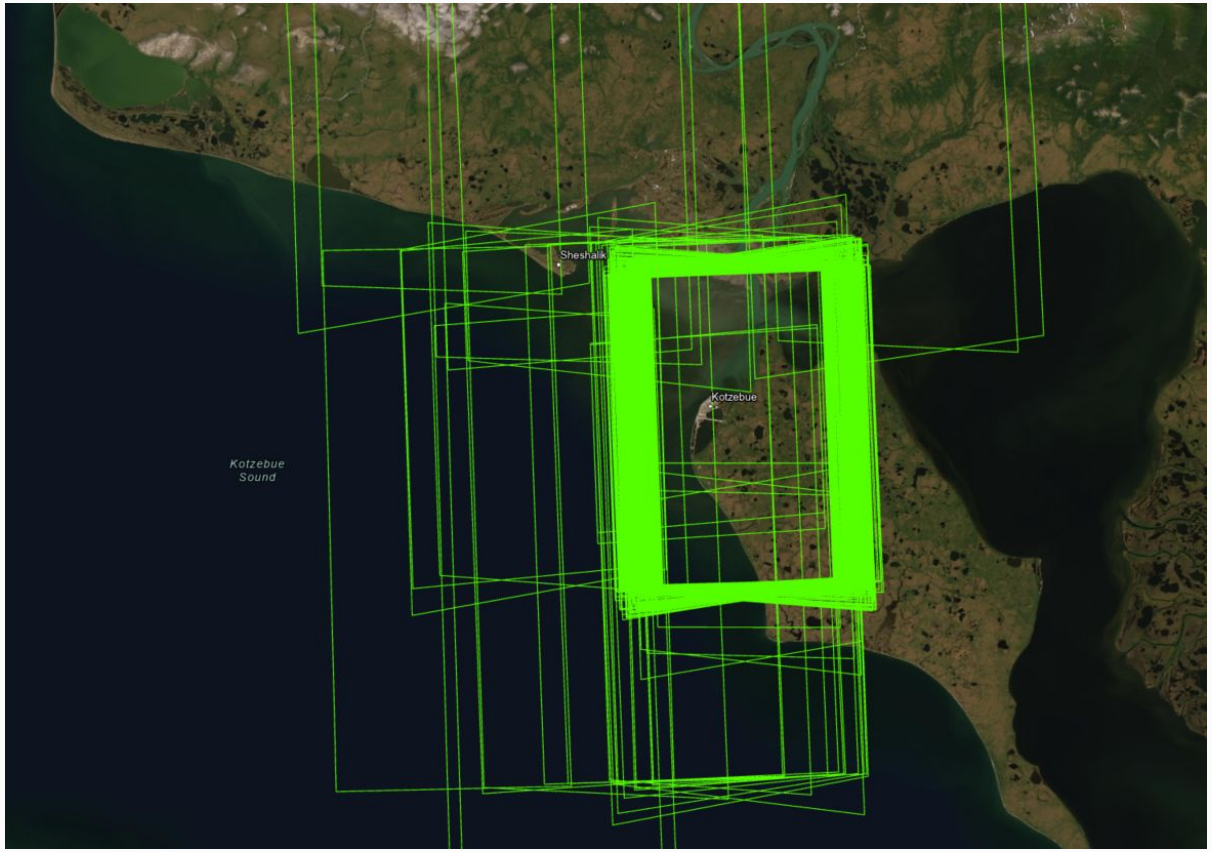
# 10m SDB in Alaska - Percy Islands


# 10m SDB in Alaska - Shishmaref



# Operational 2m SDB

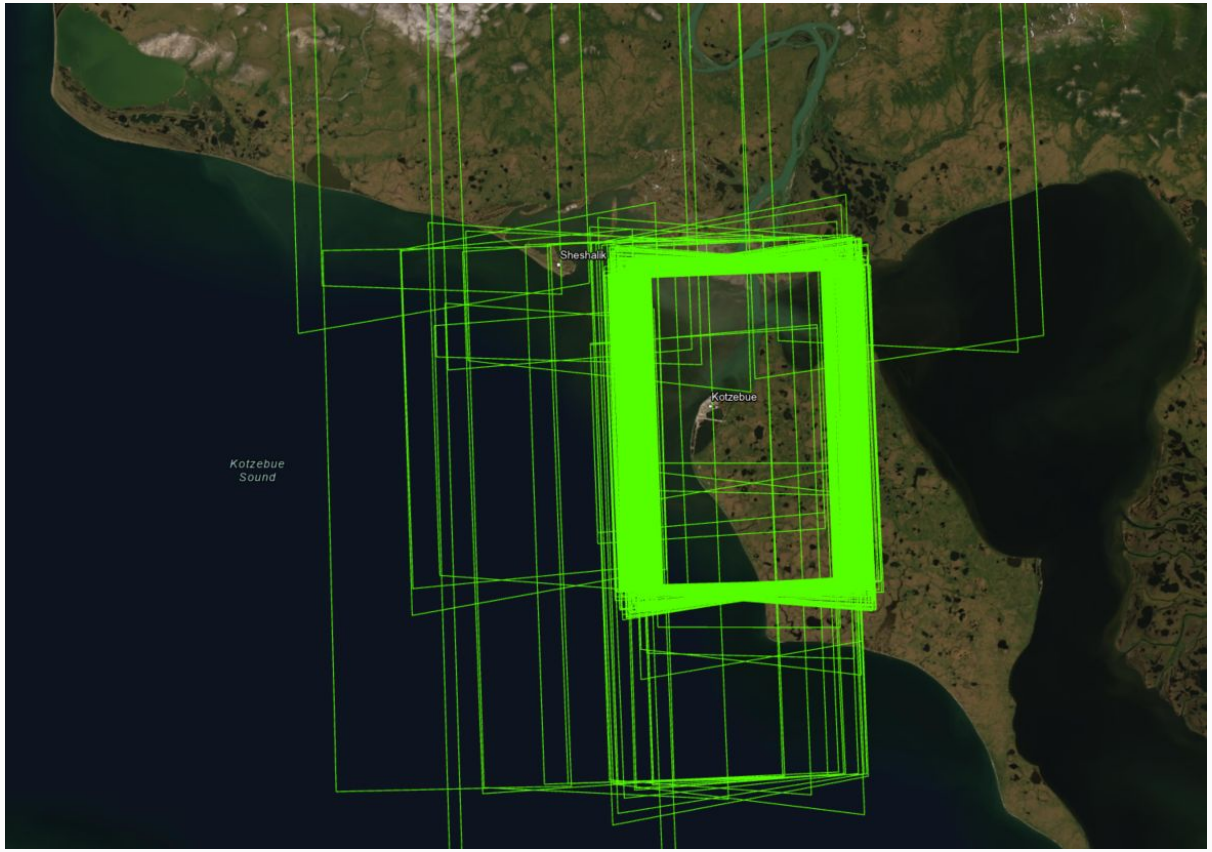
1. Remove images with ice cover.
2. Eliminate images with high cloud cover.
3. Filter for ideal viewing geometries.
4. Identify images with lowest turbidity.




327 total images collected over Kotzebue from April 1 to November 1, 2021.

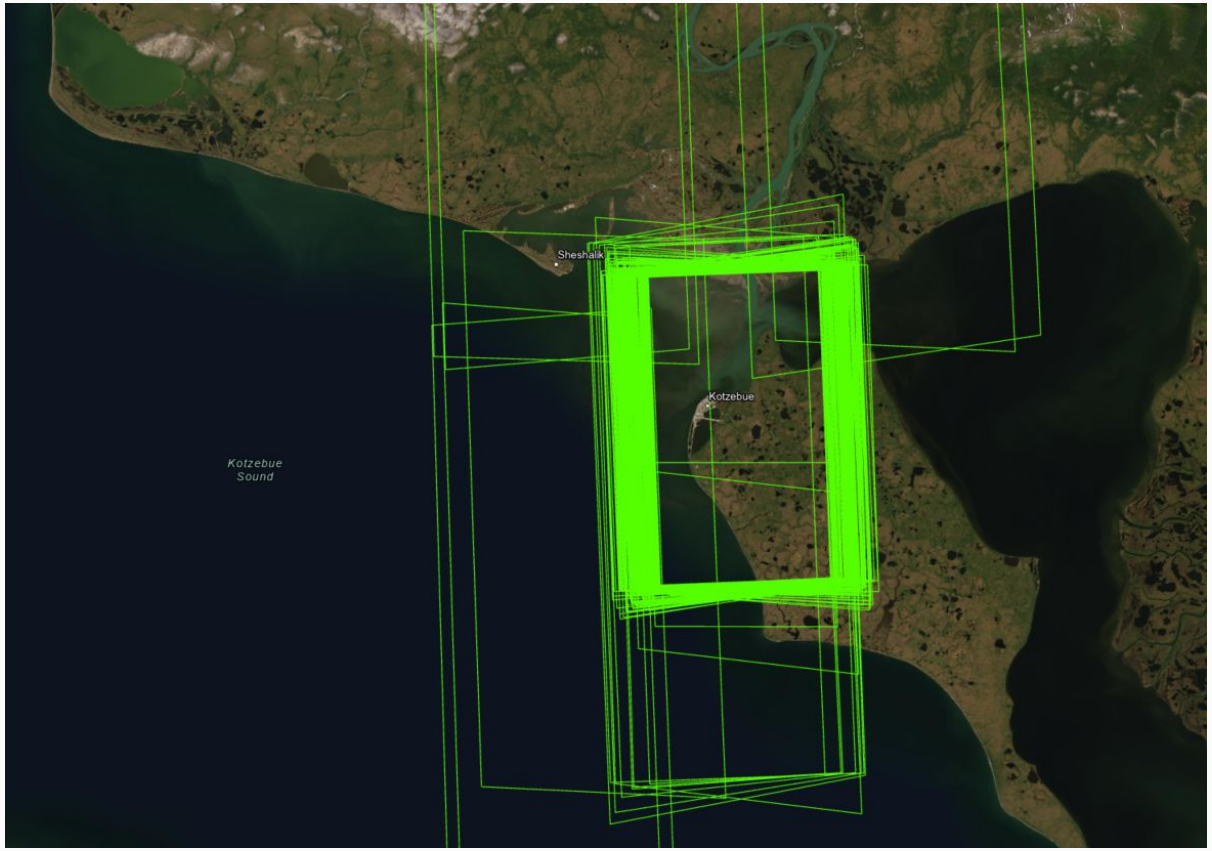
# Operational 2m SDB

| | |
|---|---|
| **Total Images** | **327** |
| **Ice Cover** | |
| **Cloud Cover** | |
| **Viewing Geometries** | |



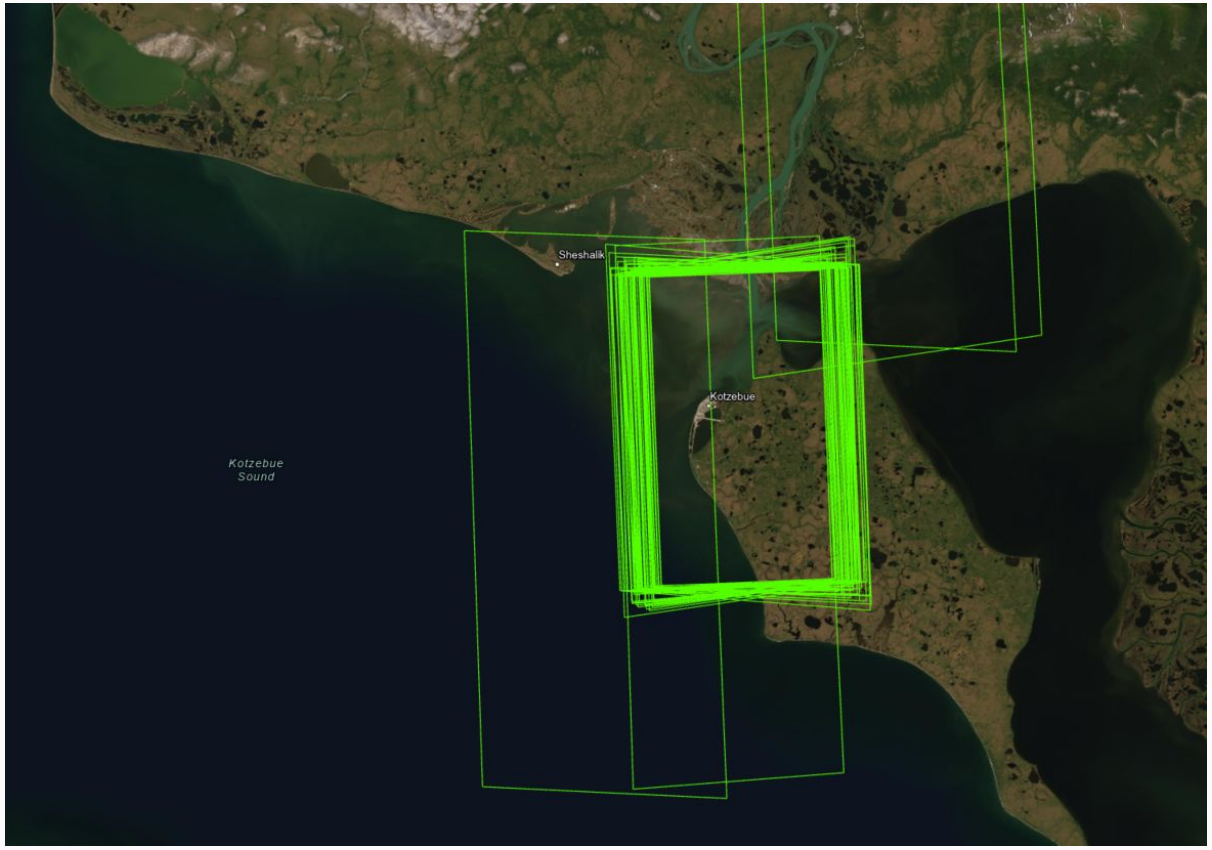
# Operational 2m SDB

| | |
|---|---|
| **Total Images** | **327** |
| **Ice Cover** | **189** |
| **Cloud Cover** | |
| **Viewing Geometries** | |



# Operational 2m SDB

| | |
|---|---|
| **Total Images** | **327** |
| **Ice Cover** | **189** |
| **Cloud Cover** | **60** |
| **Viewing Geometries** | |



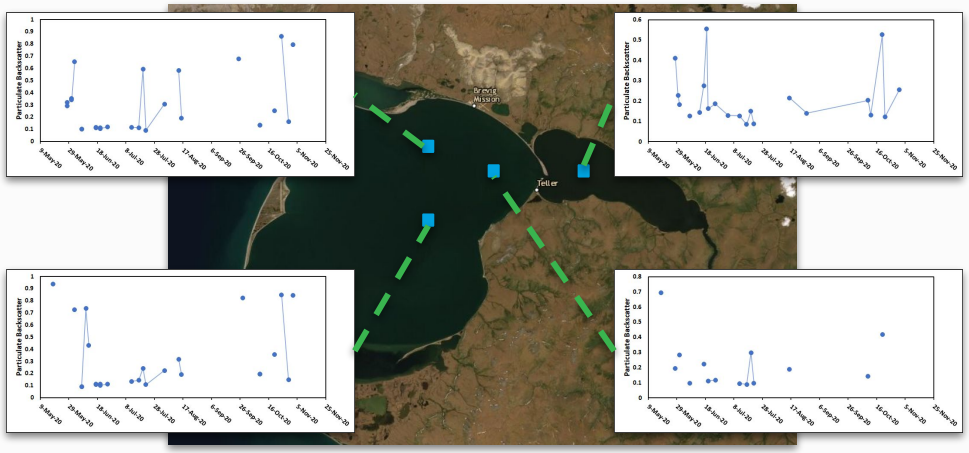
# Operational 2m SDB

| | |
|---|---|
| Total Images | 327 |
| Ice Cover | 189 |
| Cloud Cover | 60 |
| Viewing Geometries | 19 |

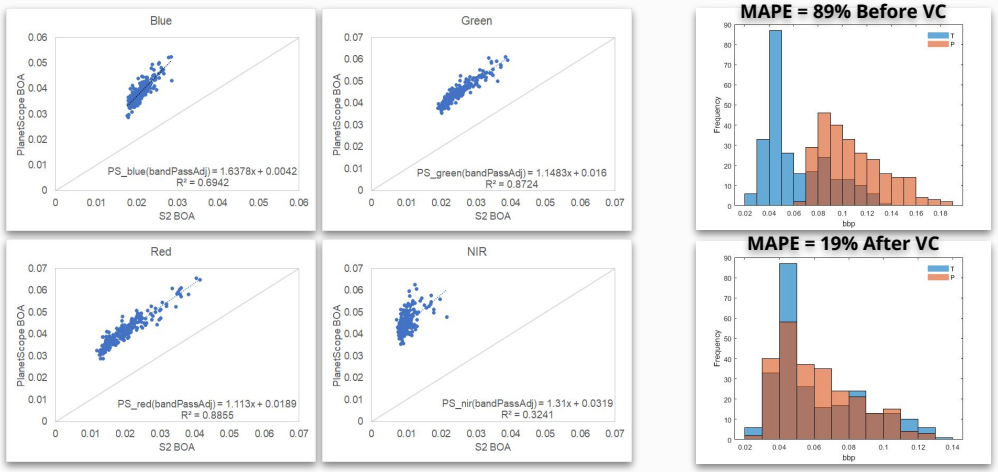
**The next step is to identify the images with the lowest concentration of turbidity.**

# High Resolution Water Clarity

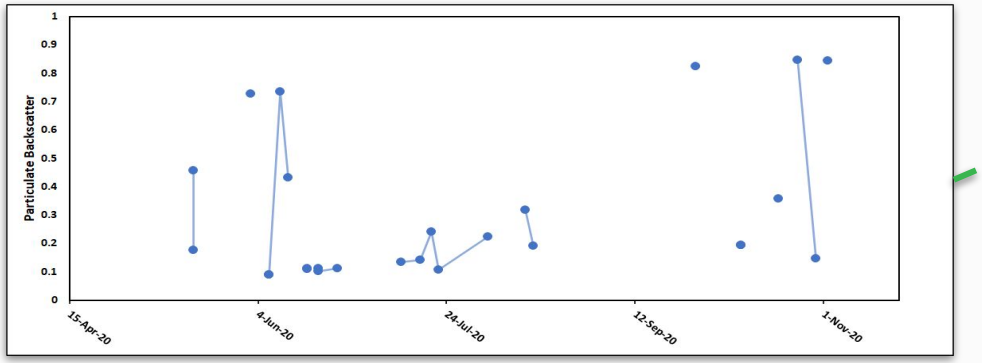
## Water Clarity from Sentinel-2




## Atmospheric Correction for PlanetScope

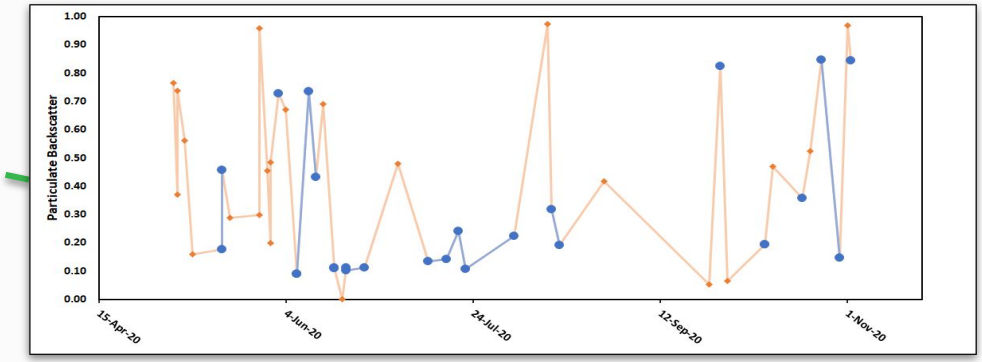



## Sentinel-2 Water Clarity Time Series





## Sentinel-2 + PlanetScope Water Clarity Time Series



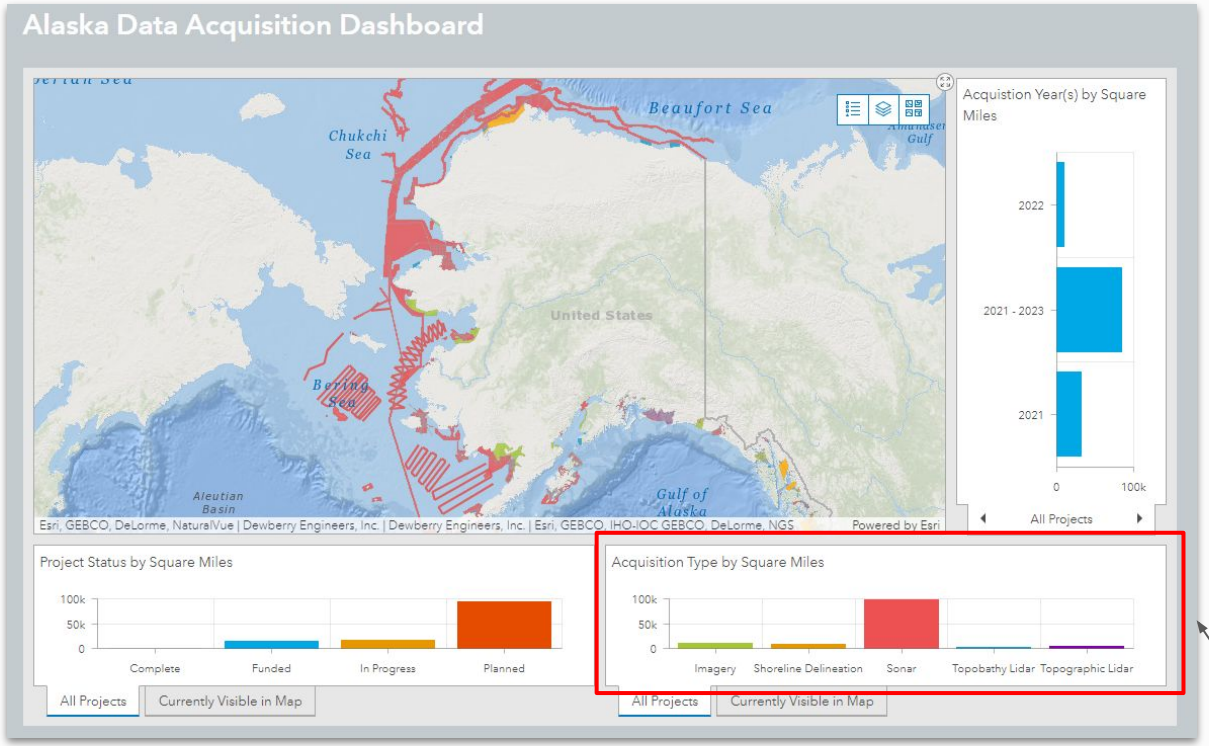
# Limitations of SDB Technology in Alaska

## Technical / Environmental

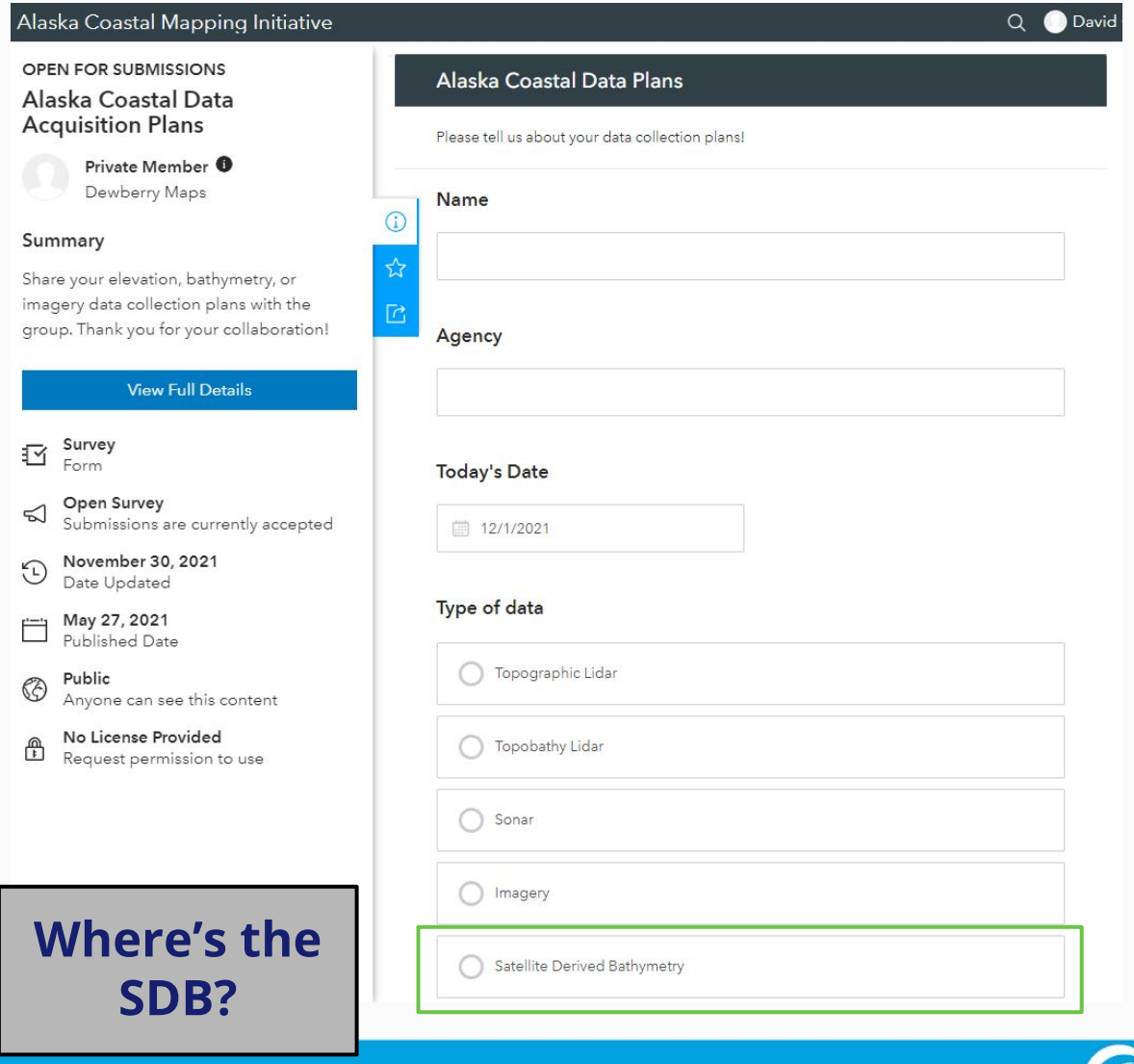
Weather | Turbidity | Imagery

## Business Limitations

LiDAR-first approach | No SDB in acquisition plans




**Where's the SDB?**



# End of Presentation

Thank you!

# Satellite Derived Bathymetry

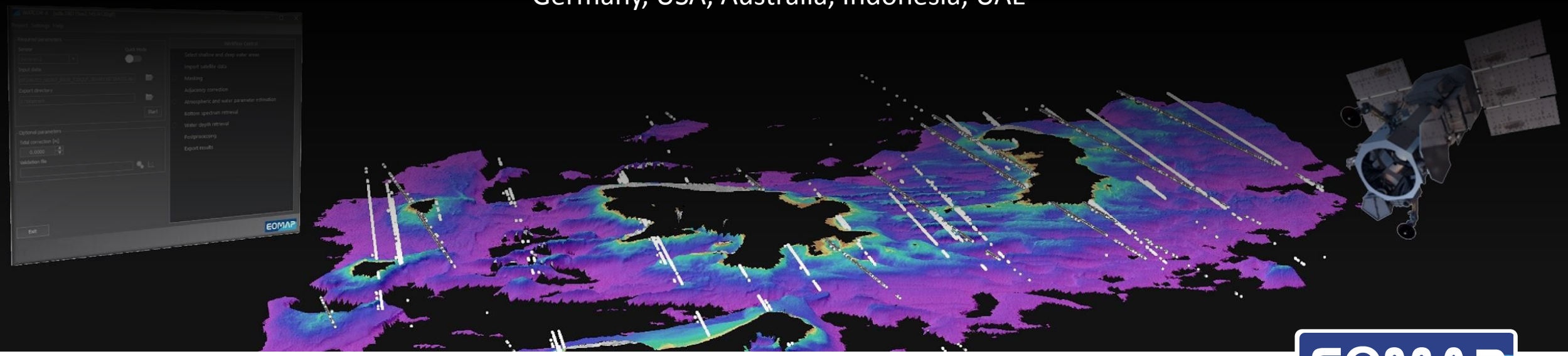
Edward Albada, EOMap

**December 1st, 2021 | Virtual**

# Satellite-Derived data for mapping and monitoring shallow waters in higher latitudes

## Alaska Coastal Mapping Summit 2021
## Dec 1st, 2021

Edward Albada
EOMAP
Germany, USA, Australia, Indonesia, UAE



eomap.com



detect more.

# About EOMAP

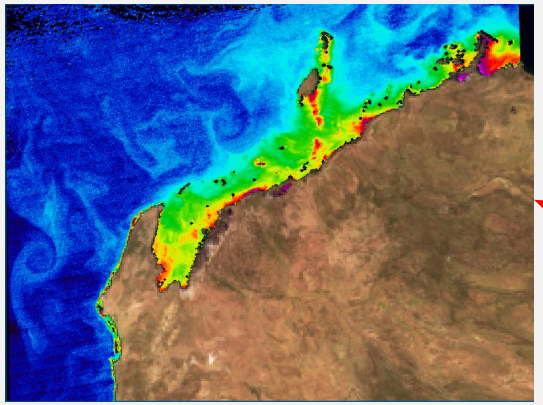
- Experts in **Aquatic Earth Observation** services, established 2006
- Satellite-Derived Bathymetry (SDB) solution provider to global initiatives (EMODnet, Seabed2030, GEBCO), HO‘s for charting update (NZ, UK, AU, others) and industry
- Capability on accessing various satellite sources (active, passive) and analytical methods (physics-based, ML, AI, image interpretation)
- **Seafloor related portfolio**: SDB data, SDB software, Satellite-Lidar databases, seafloor mapping and characterisation, capacity building

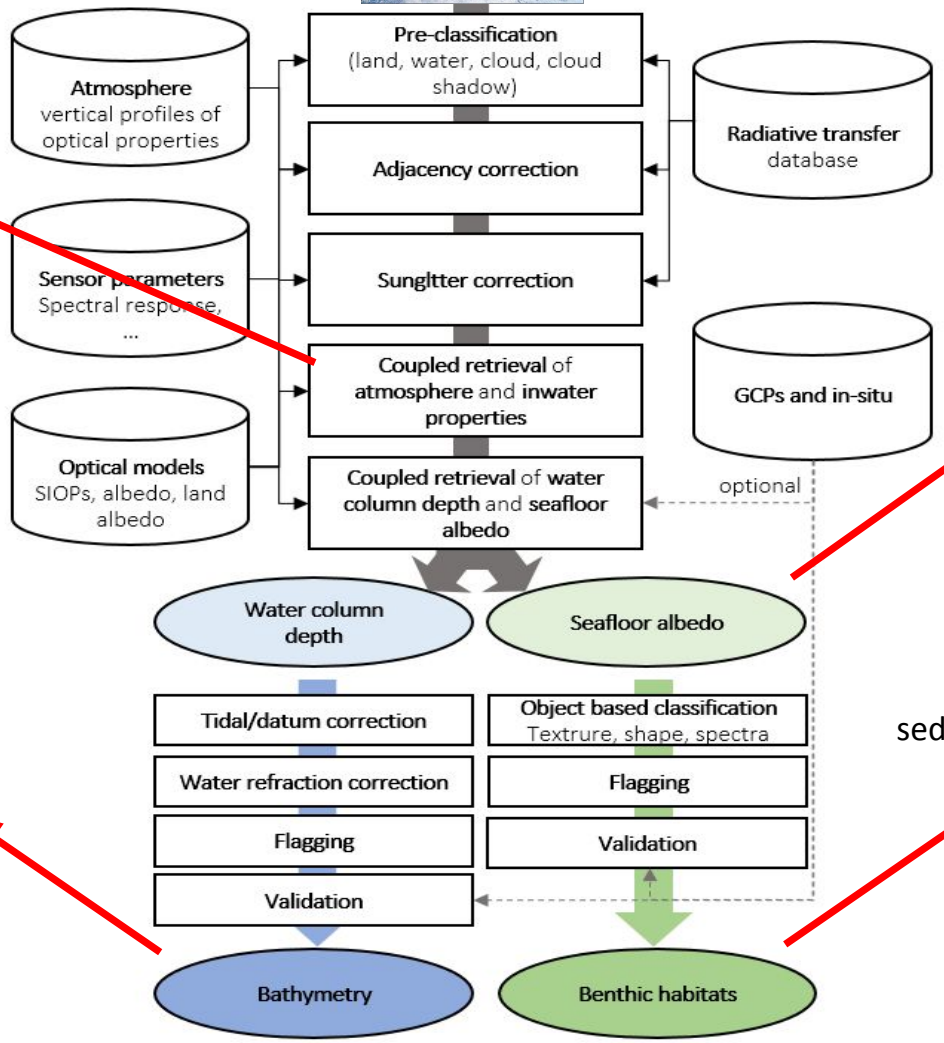


EOMAP
detect more.

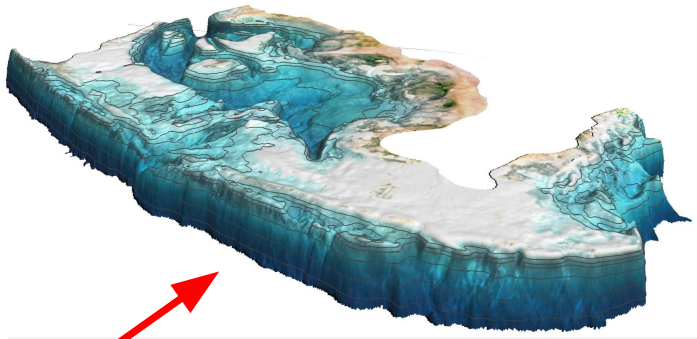
# EOMAP's Physics-based SDB methods

Water quality

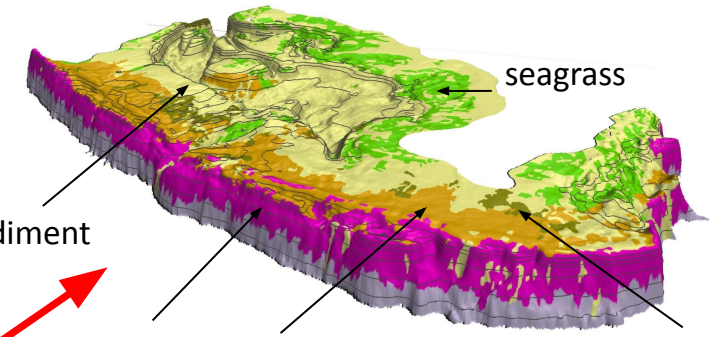


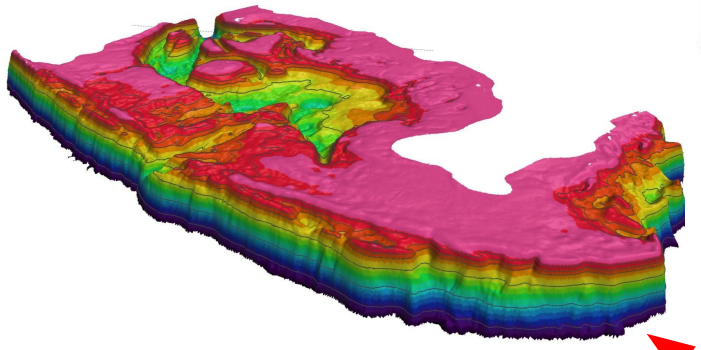



Seafloor reflectance (colour)



Benthic habitats



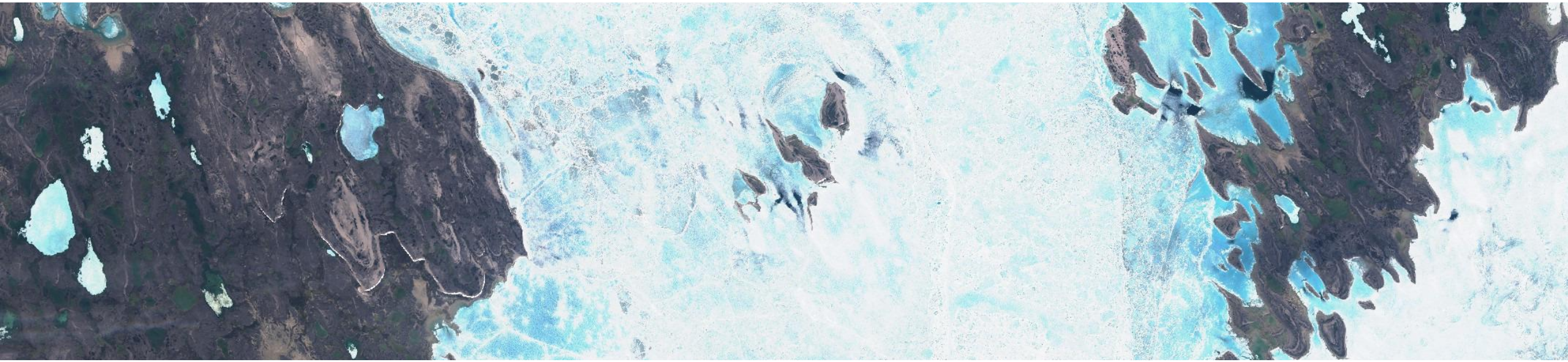
SDB (Satellite-derived bathymetry



EOMAP
detect more.

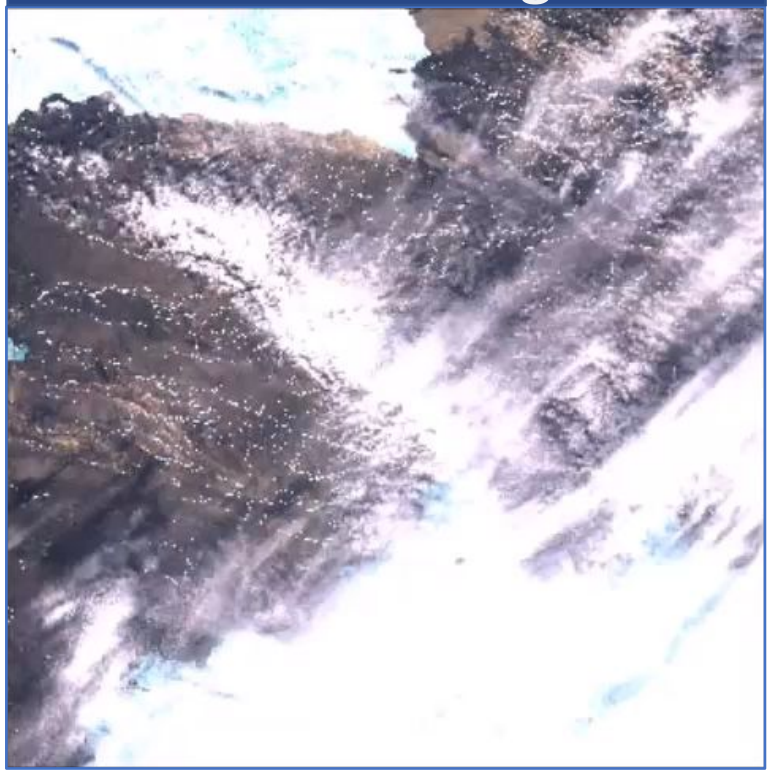
# SDB Challenges in the higher latitudes

- Environmental conditions (ice, cloud, turbidity)
- Seafloor coverage (dense kelp areas)
- Vast areas with no existing survey data

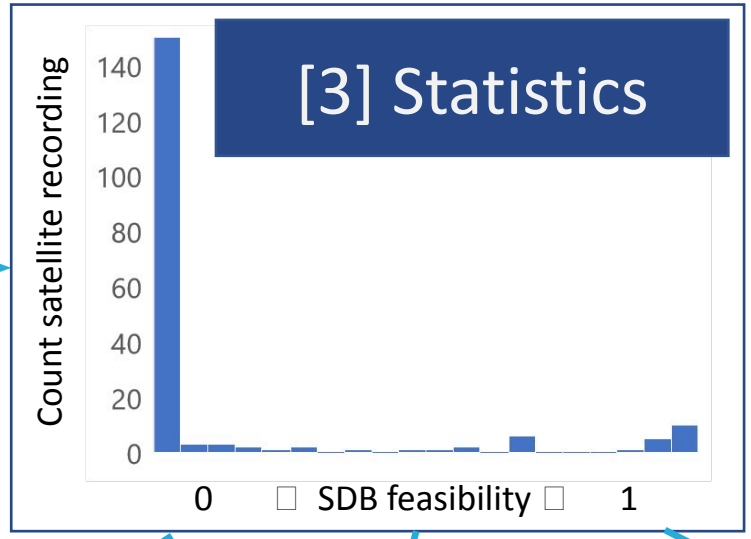


# Site Satellite Image Selection

[1] Accessing all recordings



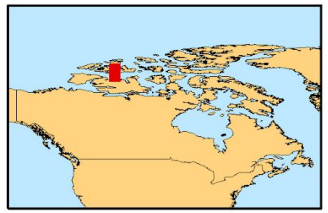
[2] AI SDB feasibility classifier




[4] Selection

# Site Satellite Image Selection

[4] Selection



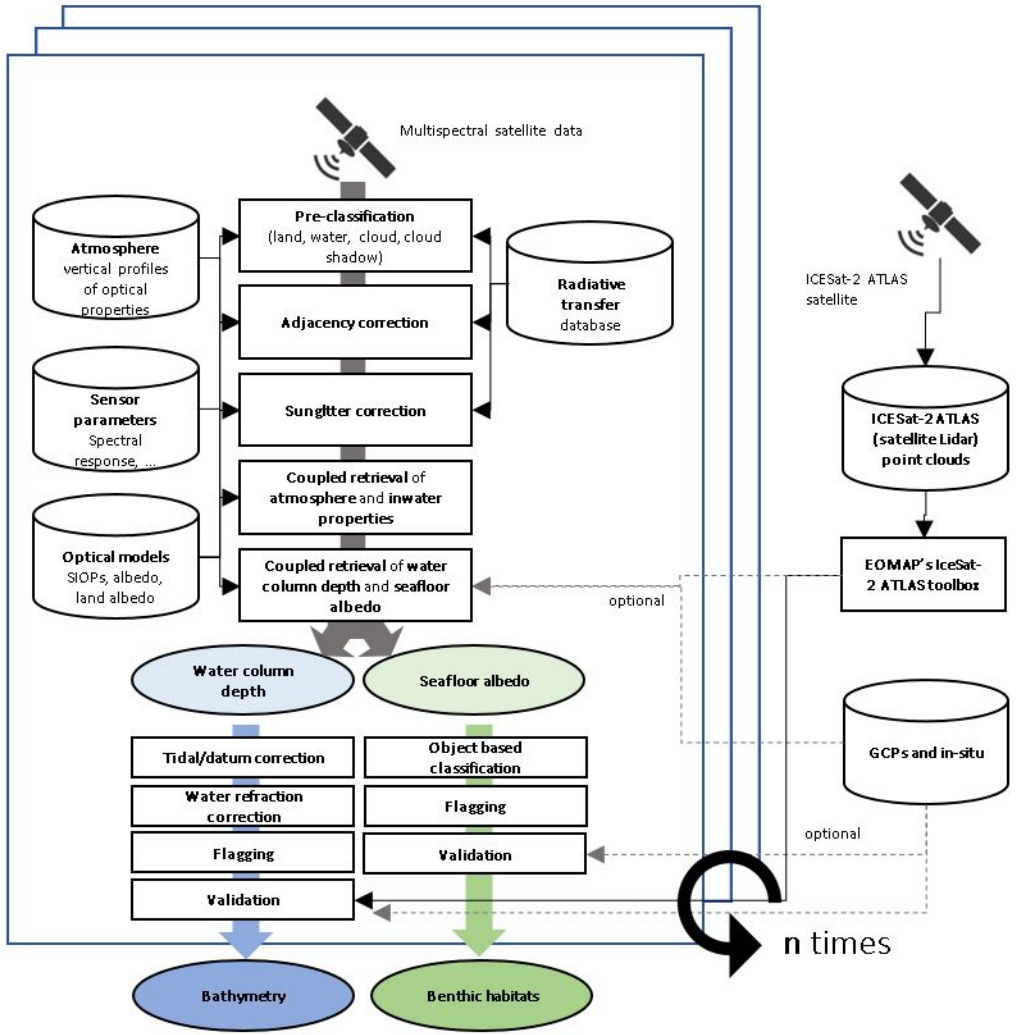
Canada

74°50' Latitude

0 1 km

# Physics-based processing

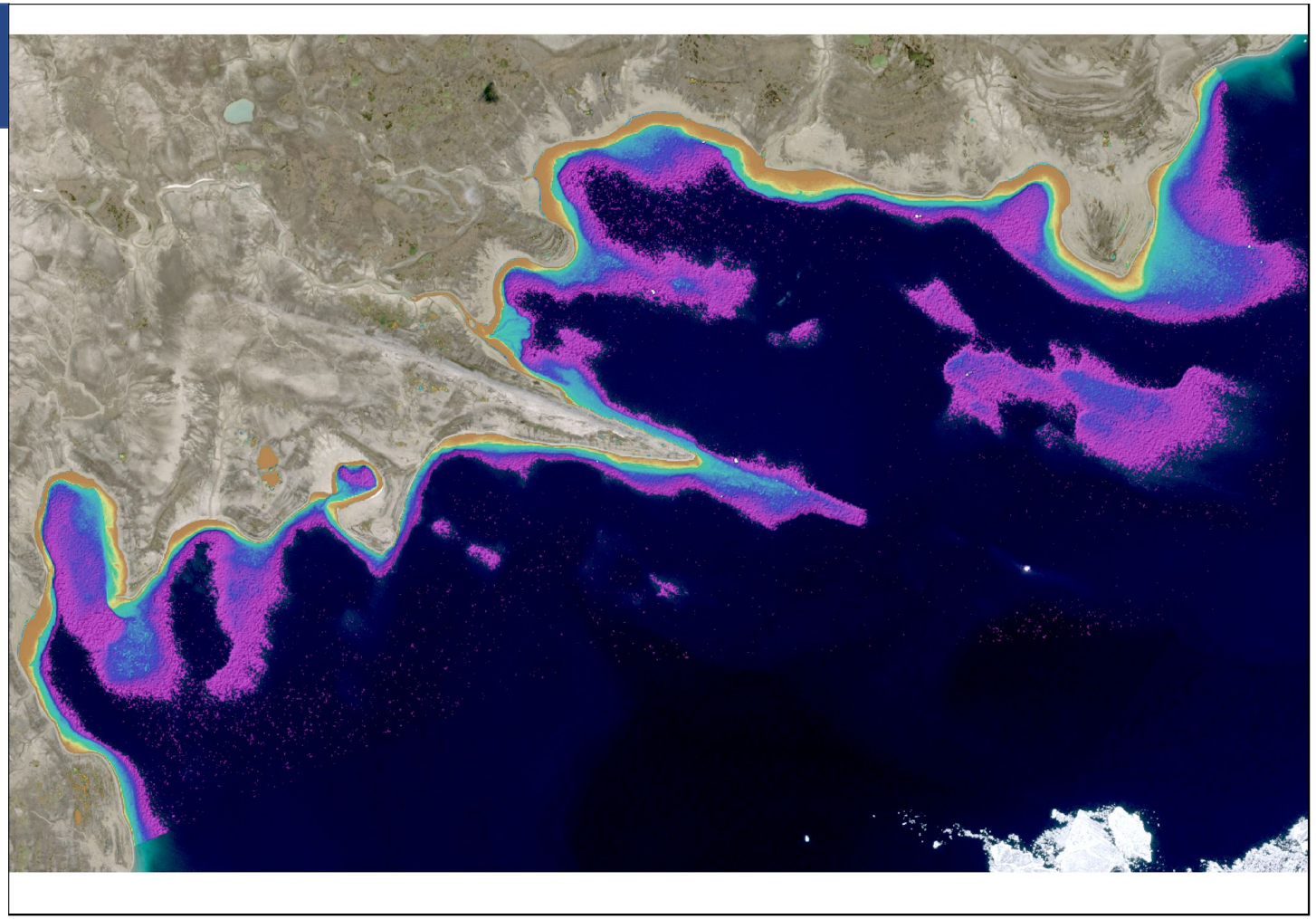
## [5] Processing




- Based on physics based light modelling from sun to seafloor to sensor (some of the algorithms are unique and patented by EOMAP)
- Performs analysis on multiple satellite data to reduce uncertainties and noise
- Integrates recent US Lidar satellite point clouds

# Physics-based processing

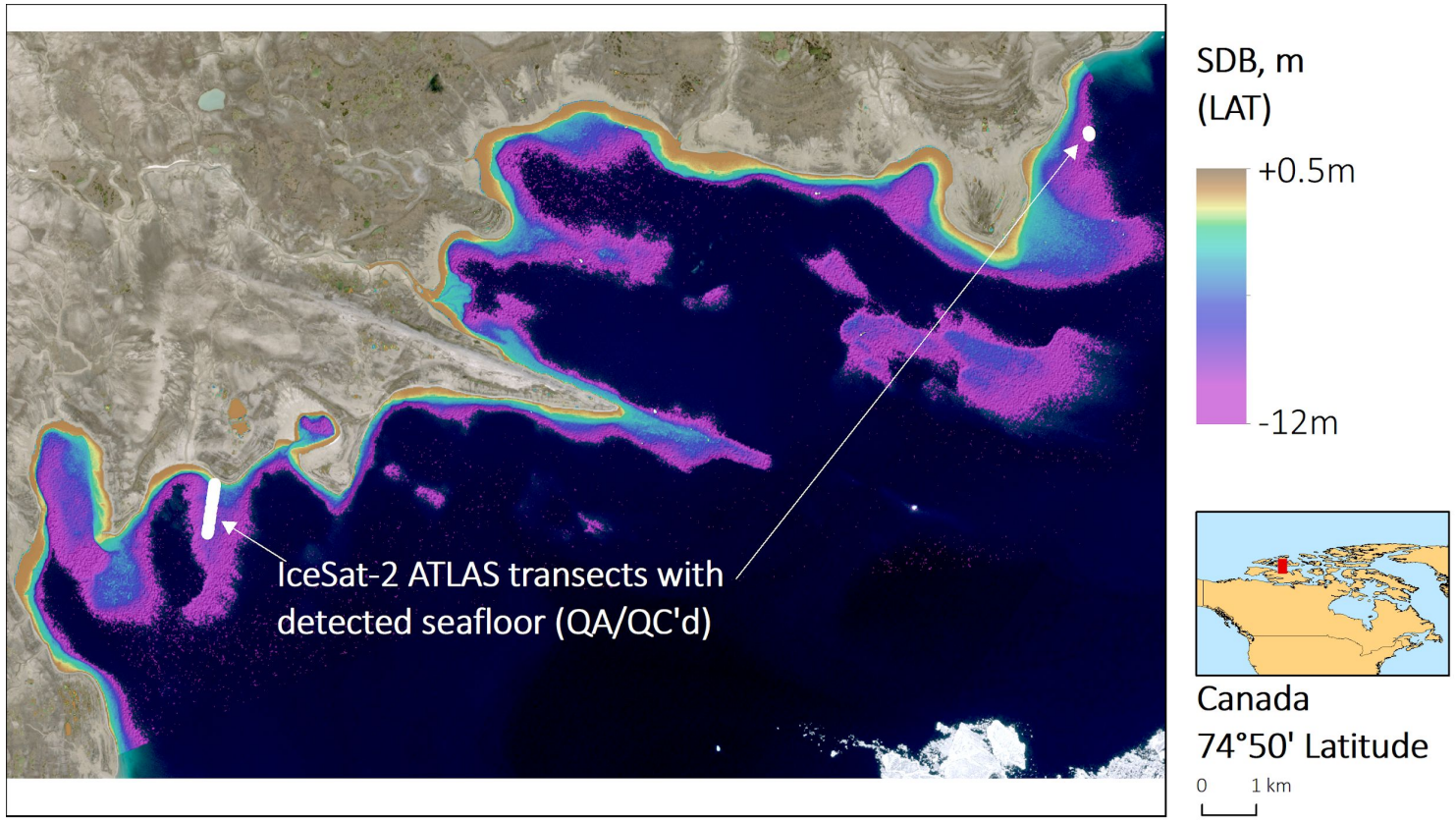
## [5] Processing

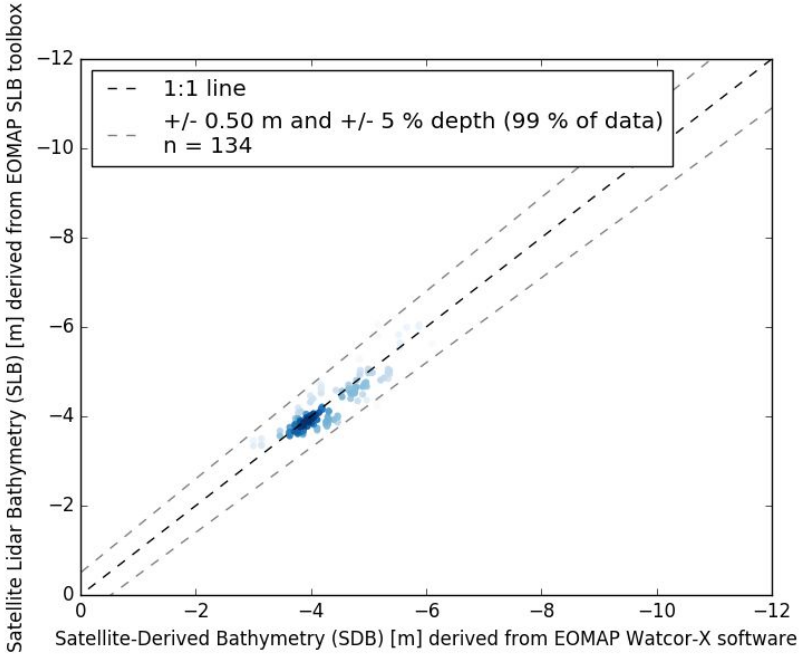



Data derived with EOMAP's physics based Watcor-X Satellite-Derived Bathymetry software.
No calibration, no manual interpretation and no configuration.

# Validation with ICESAT-2 Atlas data

## [6] Validation

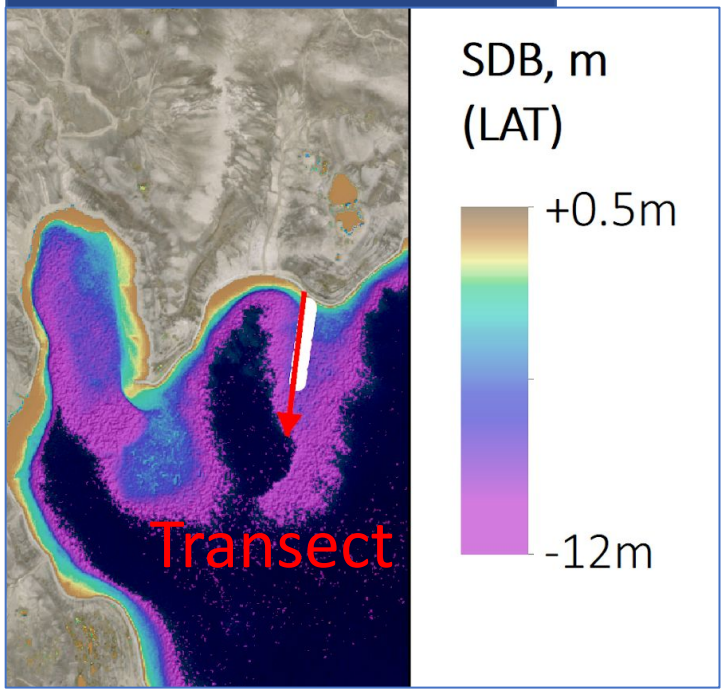


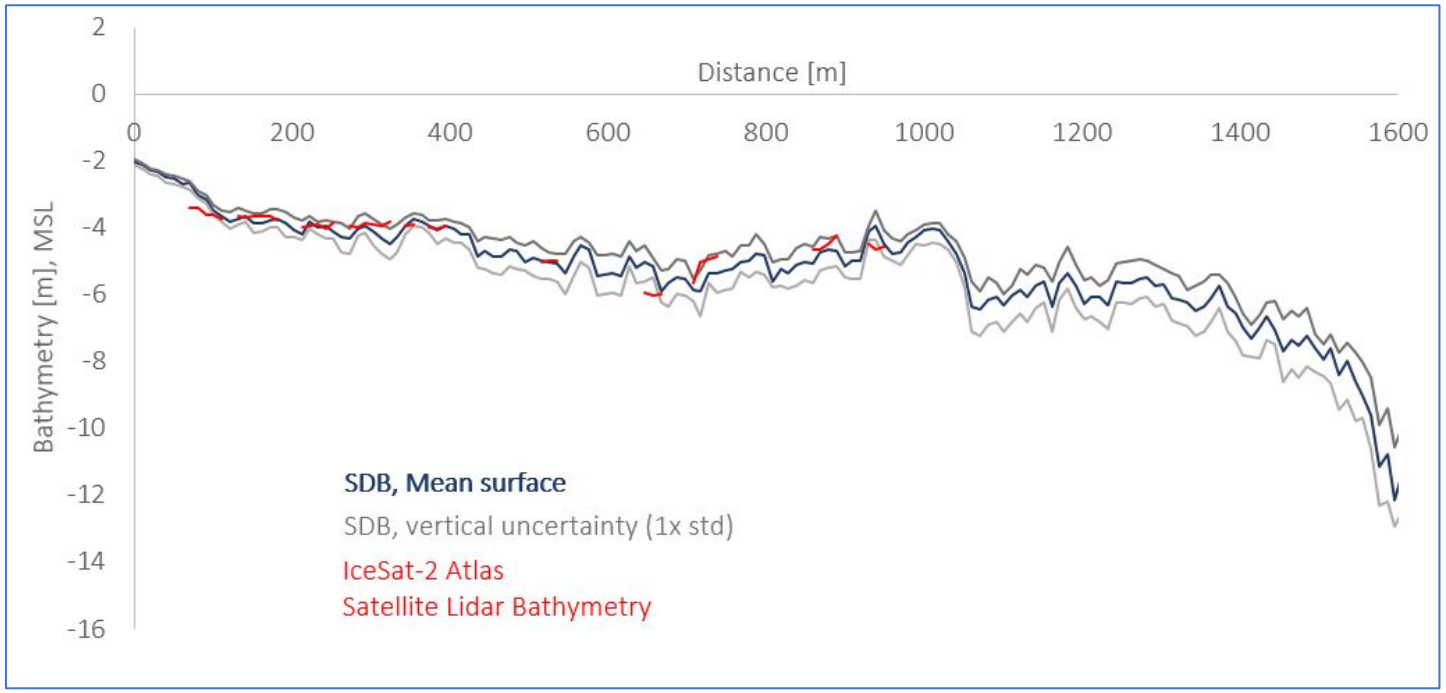




Data derived with EOMAP's physics based Watcor-X Satellite-Derived Bathymetry software.
No calibration, no manual interpretation and no configuration.

# Uncertainty definition

## [7] Uncertainties

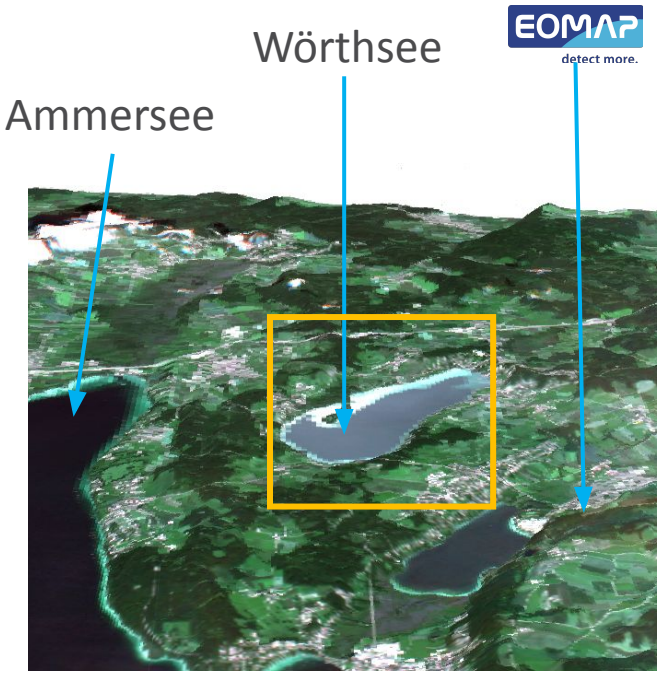


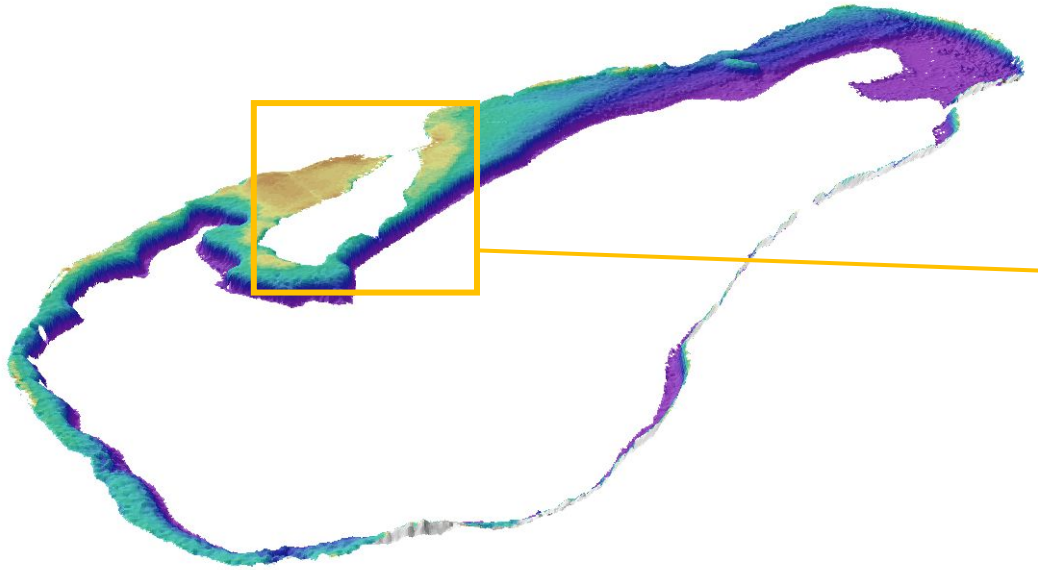



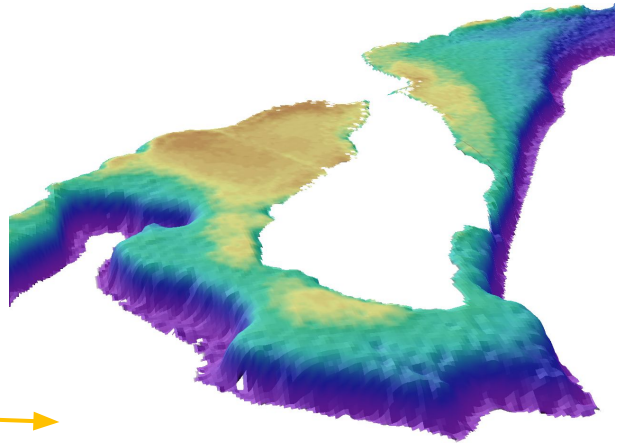

Vertical uncertainties based on sensitivity modelling of the SDB model

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

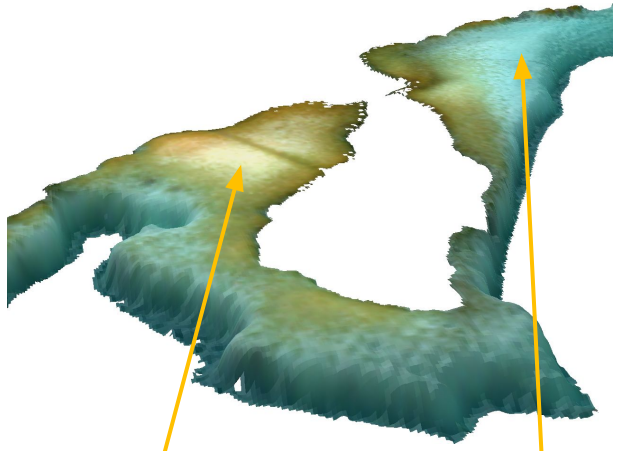
# Satellite-Derived Bathymetry example: Lakes, Bavaria





Satellite Derived Bathy




Reflection (subsurface)

**Planet Doves**

Lake Wörthsee: Depth from 0-7, depth in 3m spatial resolution

# Ongoing and future research for SDB in higher latitudes

- Specific atmospheric correction and coupled retrieval of water and seafloor properties
  - currently addressed by the R&D project *ArcticSense*, co-funded by the German government
- Operational outlier removal and cut-off depth detection
- Continuous improvement on feasibility selection tools, including ancillary data on weather

# Conclusions

- Traceable and standardised processing steps using state-of-the art physics based modelling are key to generate high quality bathymetric data.
- SDB software and service workflow system Watcor-X successfully tested in extreme Northern latitude waters.
- Satellite Lidar (Atlas) can serve (in few but not all locations) as independent and remote source of validation.
- Higher latitude waters have challenging environmental conditions and handling them is topic of ongoing research activities.

# Thank you!

Edward Albada edward.albada@eomap.com

# Satellite Derived Bathymetry

Lauren Decker & Leslie Canavera, PolArctic

**December 1st, 2021 | Virtual**

# PolArctic
# CENA: Coastline Evolution & Nearshore Approximation

Oceanography & Data Science for the Arctic

December 1st, 2021

# PolArctic

**Develops custom Artificial Intelligence and Machine Learning (AI/ML) tools for the Arctic based on the science of Oceanography**

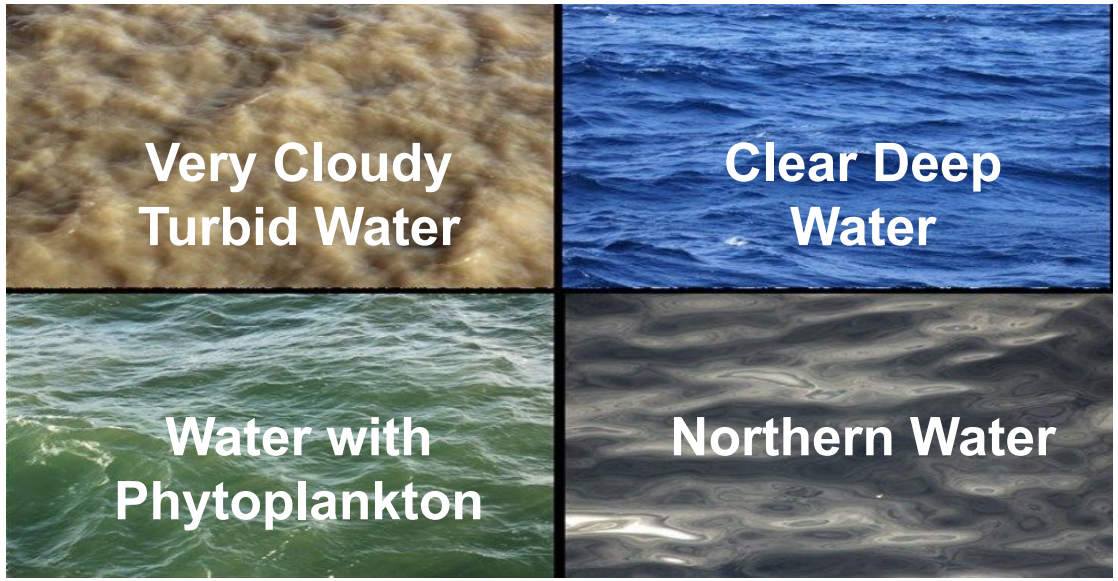
## Focus Areas

**Sea Ice Forecast**

**Coastline Evolution & Nearshore Approximation**

**Aquaculture/Mariculture & Precision Fishing Support**

# Arctic Water




The color of the ocean is determined by:

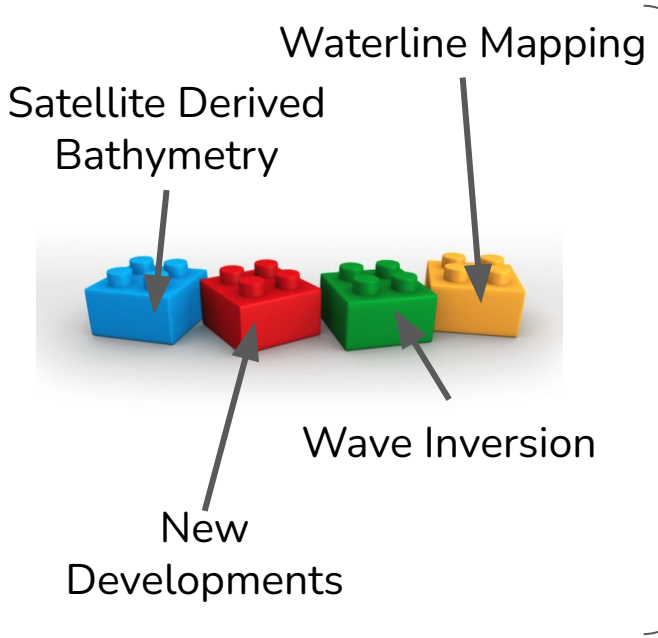
- Depth
- Organic Matter
- Sediment
- Temperature (Ice)

# **CENA**: *Coastline Evolution & Nearshore Approximation*

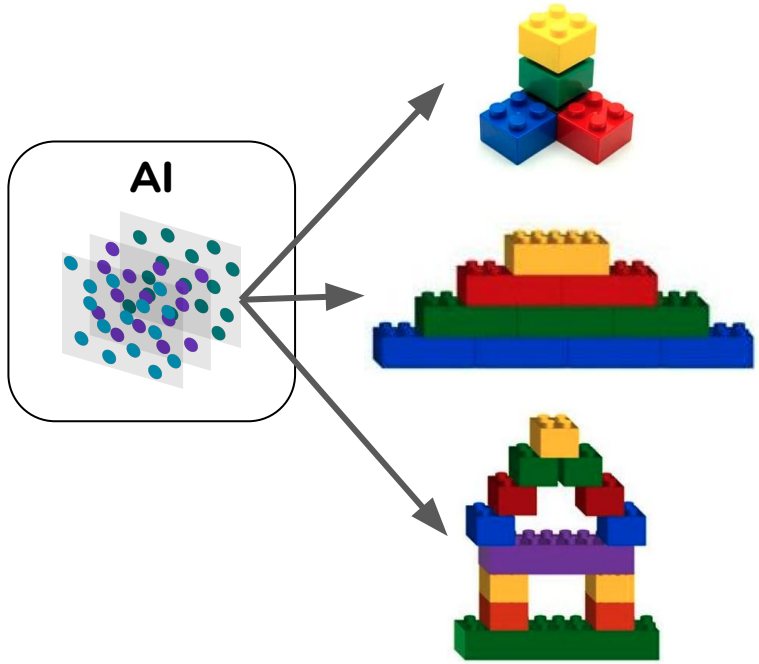
## PolArctic's innovative AI architecture to estimate nearshore bathymetry

Small Business Innovative Research (SBIR) Award

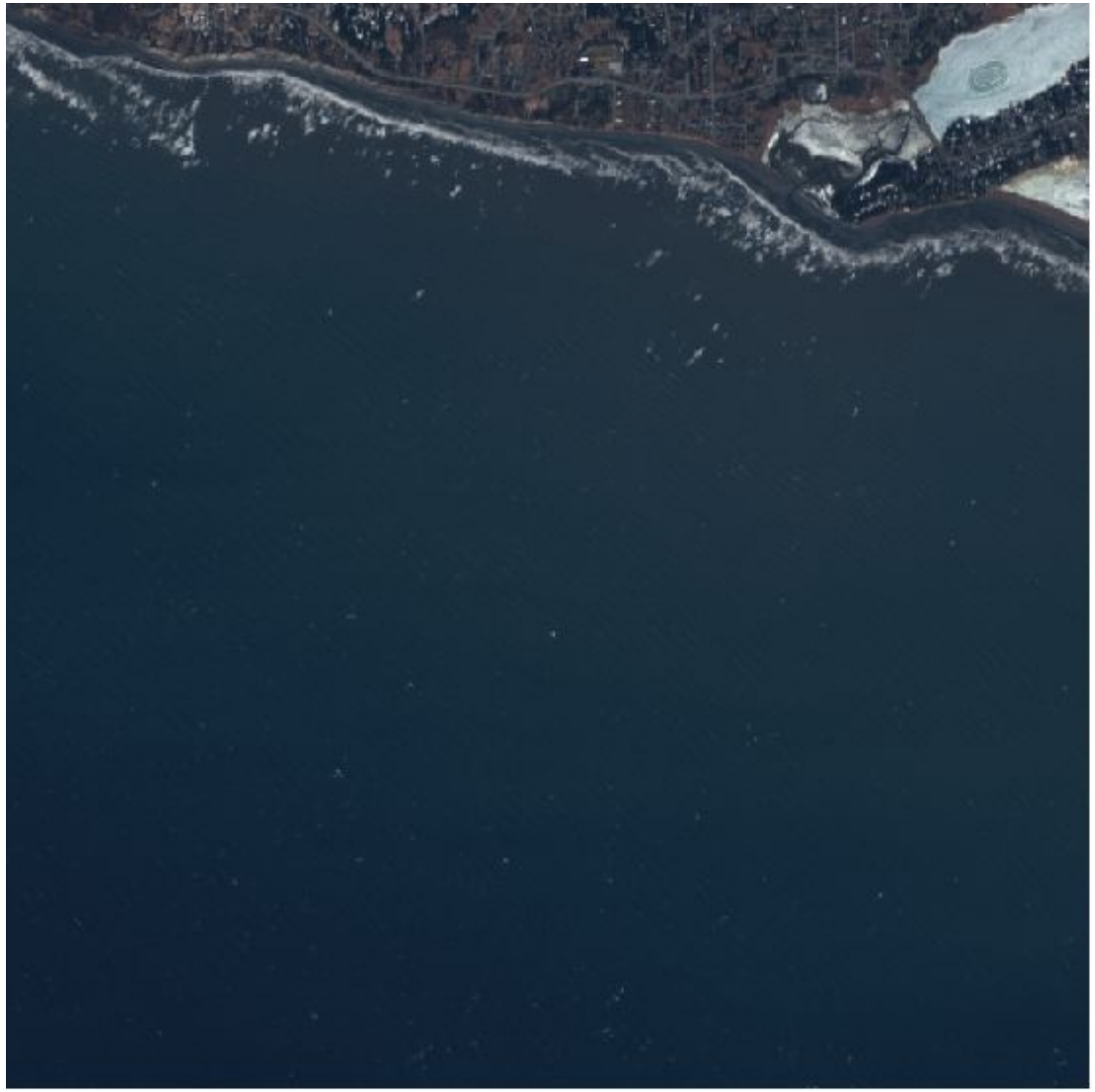
**Building Blocks: Scientific methods**




**Construction: AI ensembling of a new, custom model**



# Test site: Homer, Alaska

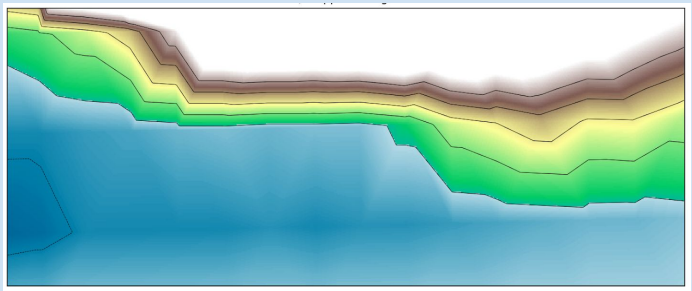


**Sentinel 2 Images**

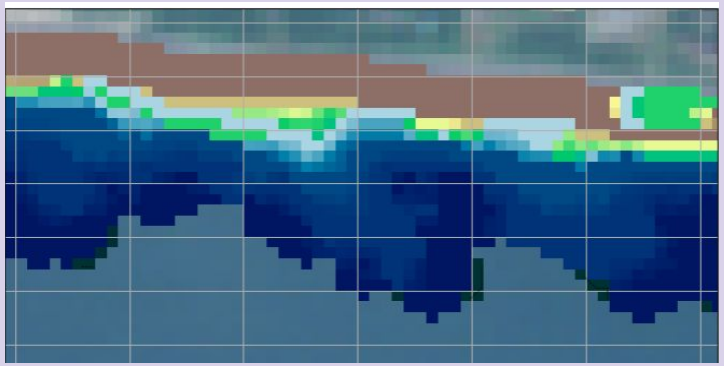
# AI to Map Nearshore Coastline & Beach Classification

## PolArctic's AI Identifies Unique Arctic Coastline at a Regional Scale

### Original NOAA- 750m Resolution



### PolArctic's- 10m Resolution

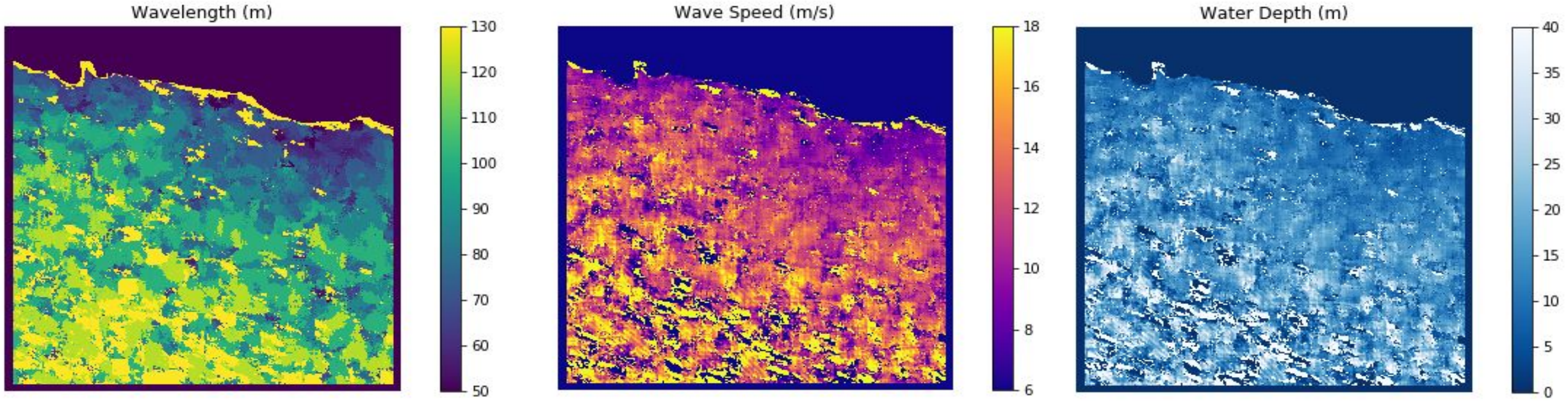


**Mudflats**

**Ocean**

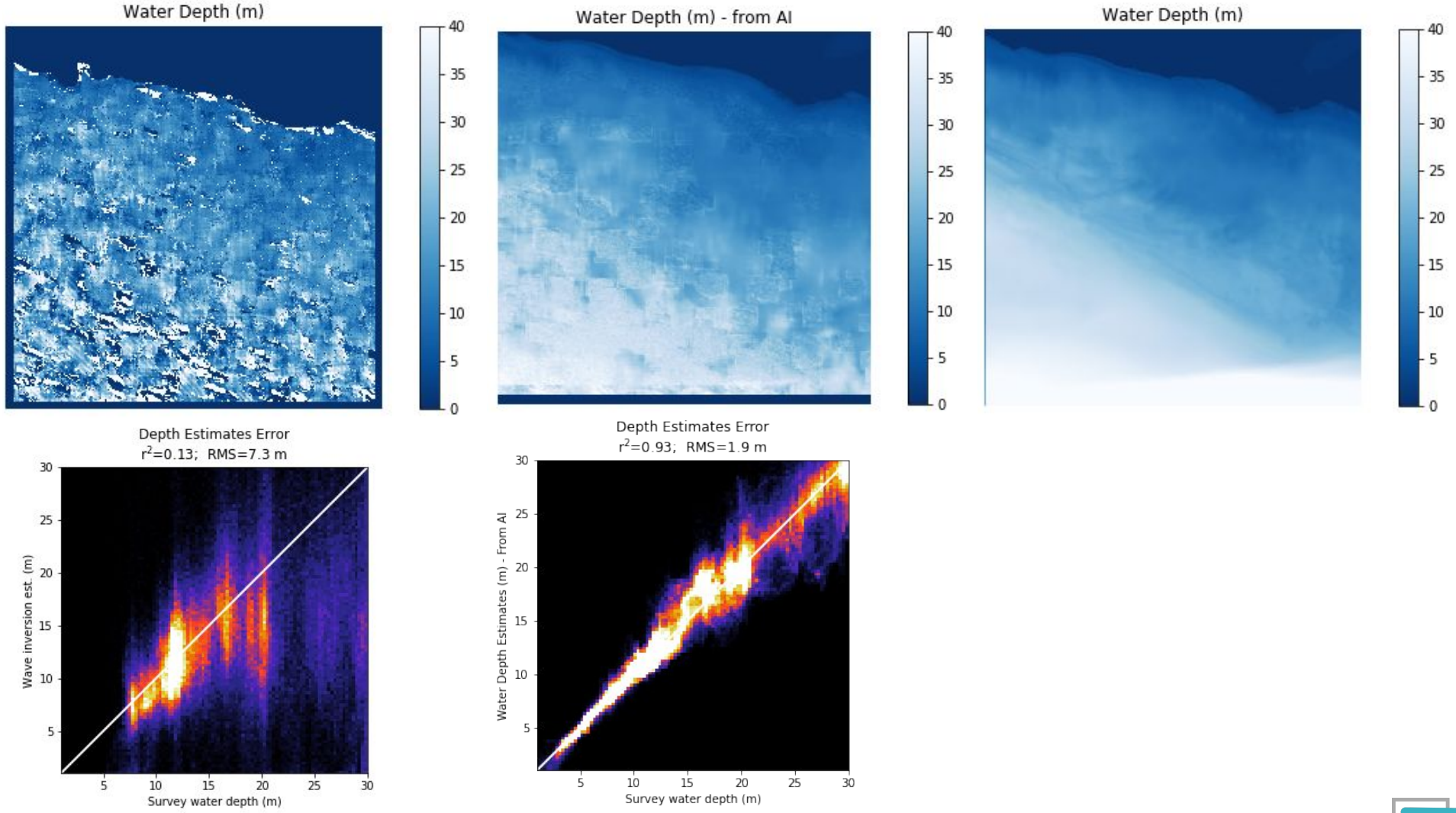
Image: Alaska ShoreZone Imagery (2009)

# Bathymetry from Wave Inversion




- Waves interact with bottom bathymetry at ~½ wavelength of the wave
- This technique is ‘feeling’ the bottom with waves
- Works in high-turbidity environments, like many silty locations in the Arctic

# Bathymetry from Wave Inversion + AI



# Study Site ᖃᐅᔨᓴᖅᑕᐅᔪᖅ

**Belcher Islands near Sanikiluaq, Canada**
ᓴᓐᓀᓗᐃᓕᐅ


ᓇᒃᑐᓪ Johnson Island

ᖃᓄᐃᓕᖅ Wiegand Island

ᐃᑭᕐᓴᖅᑐᓂᖅ
+ South Johnson Polynya

ᑲᒪᓗᖅ
Little Entrance +

ᑲᒡᓗᖅ
+ Big Entrance

ᑕᓯᐅᓴᖅ
Eskimo Bay

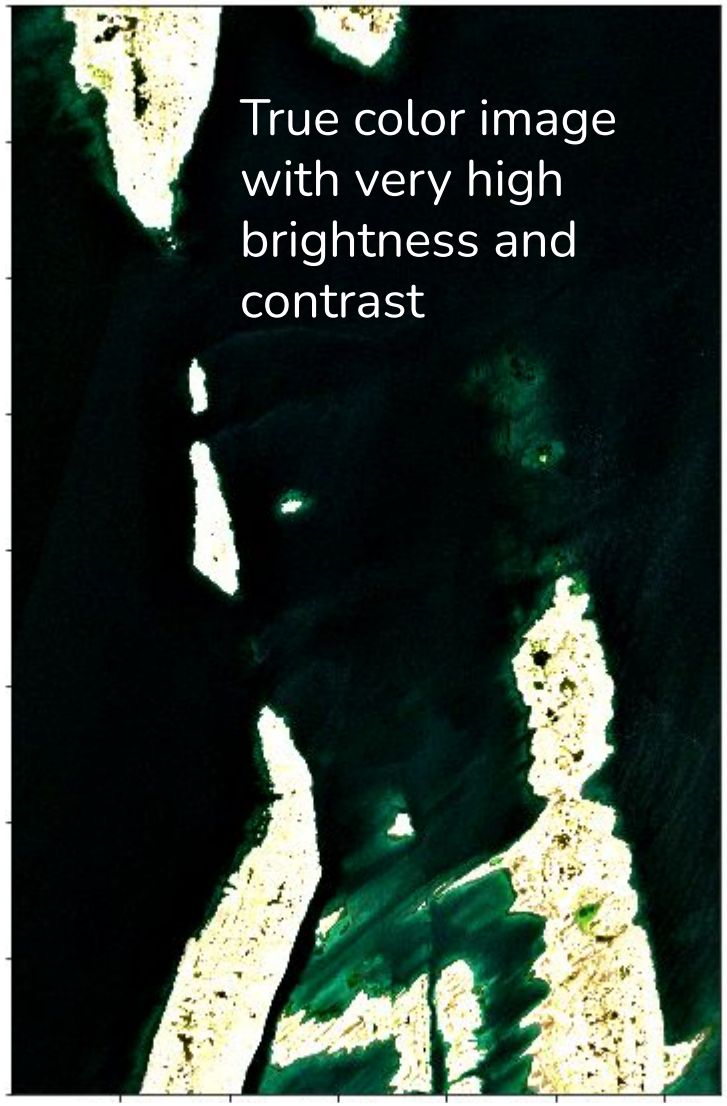
ᓴᓂᑭᓗᒃ
Sanikiluaq

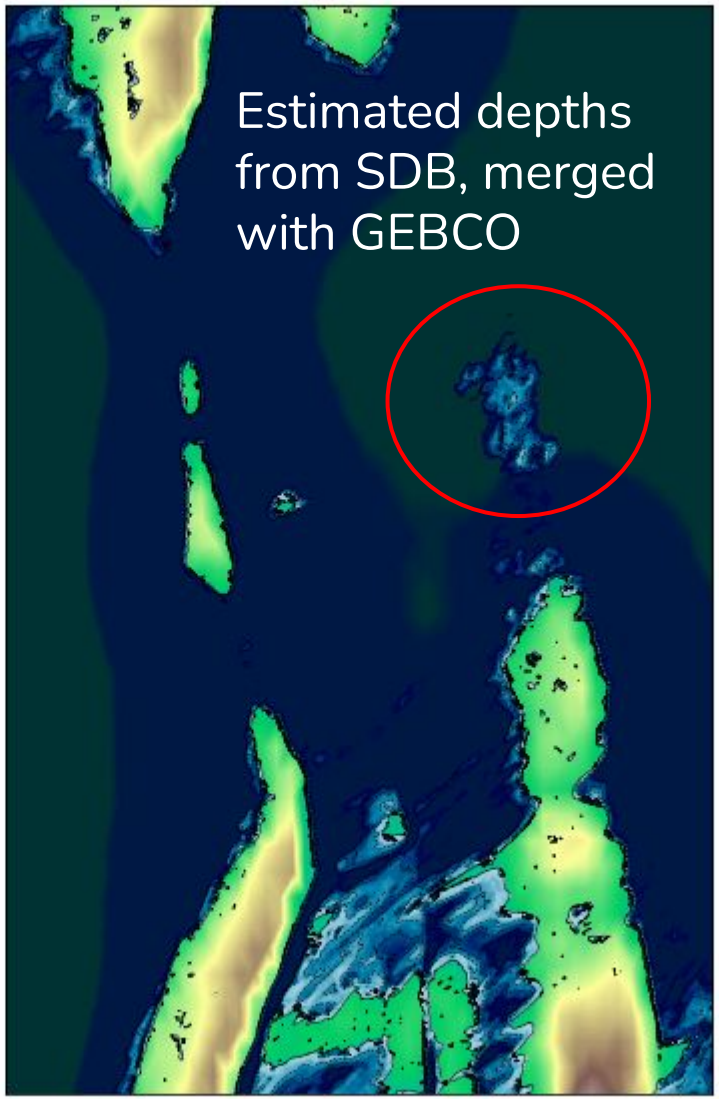
Kugong Island

← Flaherty Island →

ᑐᖅᑲᒃ ᐃᓯᐊ
Tukarak Island

# Bathymetry from Light Attenuation (SDB)





Lighter = Shallow,
Darker = Deeper

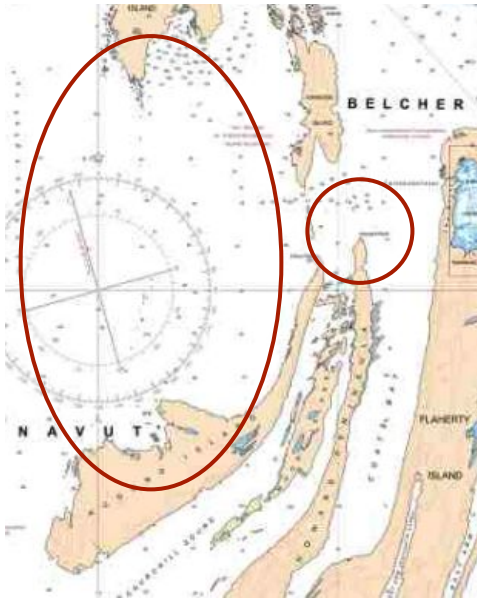
Statistical method to align color changes in green and blue bands with depth

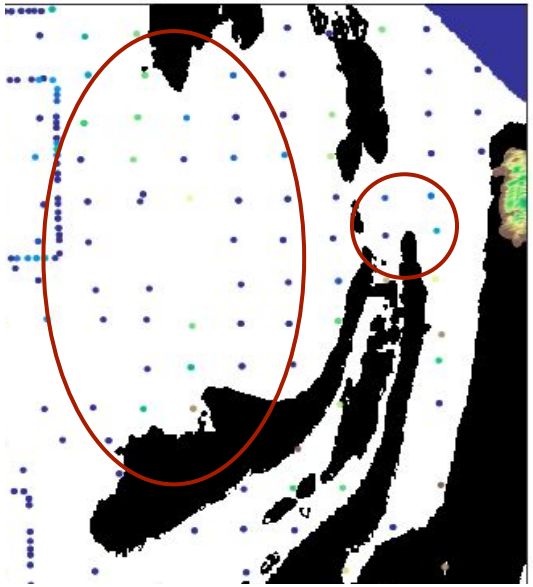
So much of the Arctic is uncharted, this sea mount was not on the map!

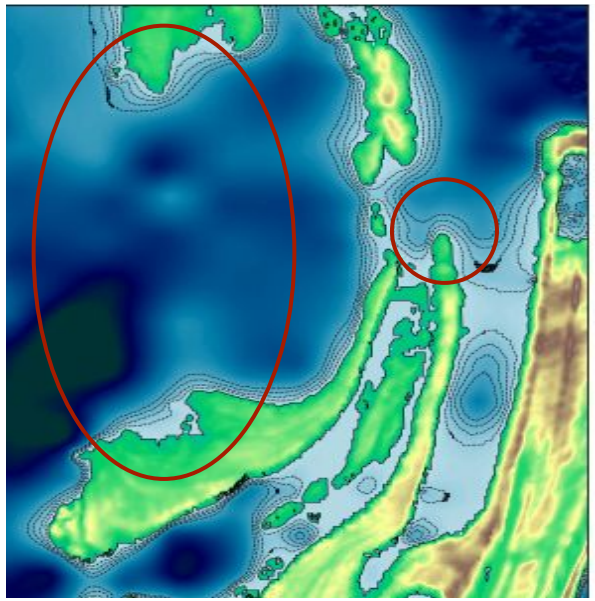
# Using AI to Identified Uncharted Hazards

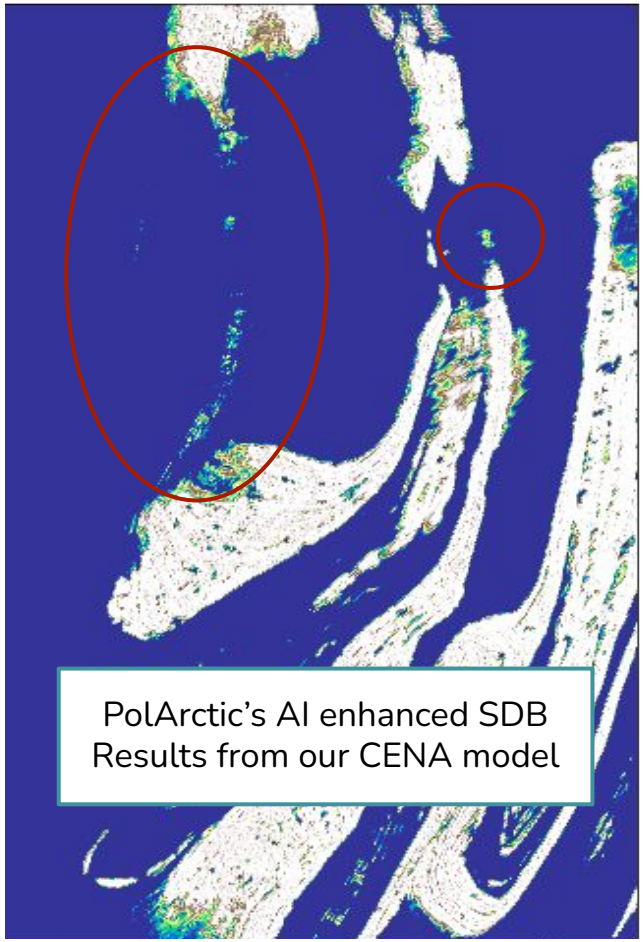
## PolArctic Found an Uncharted Subsurface Sea Mount in Hudson Bay, CA

Nautical Charts, Survey Data, and General Bathymetric Chart of the Oceans (GEBCO) were all missing a subsurface sea mount impacting shipping operations and ocean models for the community.







# Final Thoughts

- CENA is PolArctic's tool for remote sensing nearshore bathymetry
- Remote sensing bathymetry is more than just clear-water SDB or LiDAR
- Tracking change in Alaska's coastline
- Directing hydrographic surveys to poorly mapped regions

Based in the USA, we have an office on the East Coast in the greater Washington DC area, and on the West Coast near Seattle, Washington.

www.PolArcticLLC.com

# Thank you!

# Quyana!

@PolArcticLLC

@arctic_pol

PolArctic

# Leslie Canavera

## Chief Executive Officer
## PolArctic LLC


Leslie Canavera
L.Canavera@polarcticllc.com
PolArcticLLC.com
1-571-494-1992

Leslie is a Yup'ik Alaska Native and a veteran of the US Air Force where she served as an Officer leading multiple overseas tours working with state-of-the-art technology in remote sensing. From the USAF she transitioned to the National Geospatial-Intelligence Agency (NGA) for five years conceptualizing and initializing programs with geospatial, satellites, emerging technology, and analytics. She holds a Bachelor of Science degree from Oregon State University in Sociology, with a minor in Aerospace Studies, completed in 2006. Leslie also completed a Master's in Business Administration (MBA) degree from Northcentral University with a focus on International Business, completed in 2013. Additionally, she is completing a Master of Science degree in Analytics from American University with studies in Artificial Intelligence. PolArctic is a member of the Arctic Economic Council (AEC), and Leslie currently leads the AEC Blue Economy Working Group (BEWG) and sits on the Maritime and Infrastructure and Investment groups. Leslie was listed as a 2021 Forbes Next 1000 entrepreneur.

# Lauren Decker

## Chief Science Officer
## PolArctic LLC

Lauren Decker
L.Decker@polarcticllc.com
PolArcticLLC.com
401-218-0844

Lauren Decker, co-founder and Chief Science Officer at PolArctic LLC, holds a Masters in Science (MS) in Oceanography from the University of Rhode Island. She has provided scientific consulting expertise for over a decade working in research, modeling, and data analysis. At PolArctic, Lauren designed and built the first Machine Learning forecasting tool to predict sea ice extent for the Arctic, and has contributed results to the Sea Ice Prediction Network. She has also worked on the Deepwater Horizons oil spill Natural Resource Damage Assessment (NRDA), the very first wind farm off the coast of Rhode Island, and several environmental monitoring programs. Lauren is the Lead Scientist and responsible for our Project Management Division and oversight of contracts. She is Yup'ik, and grew up in Anchorage, Alaska. Lauren's work in coding and experience in oceanography got PolArctic accepted into the inaugural Blue Tech Accelerator in the US out of over 150 companies that applied. Lauren Decker won The National Center for American Indian Enterprise Development, 2021 Native American 40 Under 40 award.

# Small Business Innovative Research (SBIR) Award

Through the fusion of current knowledge, data, and AI we are building innovative techniques to estimate **nearshore bathymetry for the Arctic**.

Near Shore Bathymetry and Coastline Modeling in the Arctic Through the Integration of Beach Erosion Physics with Augmentation and Curation from an Artificial Intelligence Engine
https://www.nsf.gov/awardsearch/showAward?AWD_ID=1938483

# Why Artificial Intelligence and Machine Learning (AI/ML)?

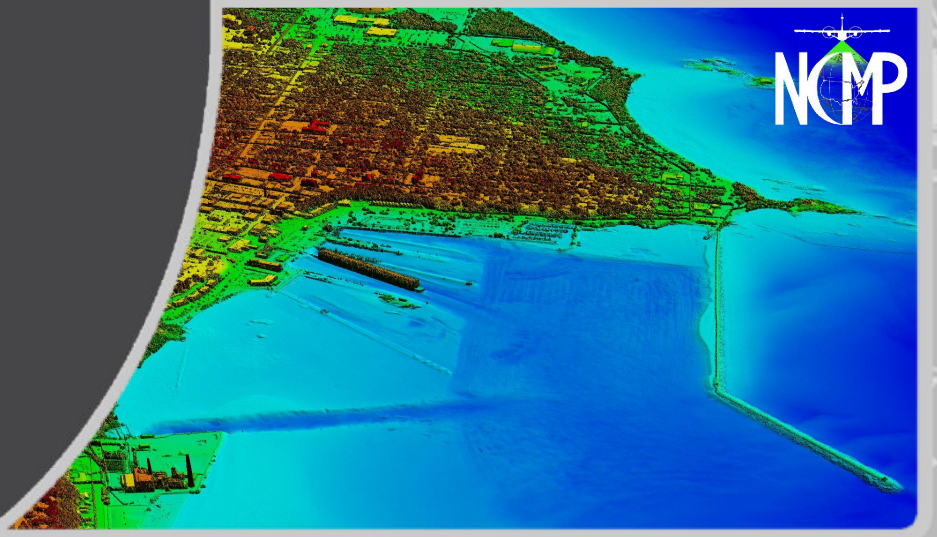
- **Tailored** products, this is NOT a one-size-fits all
- **Fast** model development time
- **Scalable** from local, regional to pan-arctic
- **Results** on demand with fast model runtime
- AI/ML models "**Learn**" the system relationships
  - Excellent at modeling complicated systems where not all variables and relationships are understood
  - Highlights new findings and places for research

# Topobathy Lidar

Jennifer Wozencraft, JALBTCX

**December 1st, 2021 | Virtual**

# Topobathy Lidar
# Joint Airborne Lidar Bathymetry Technical Center of Expertise

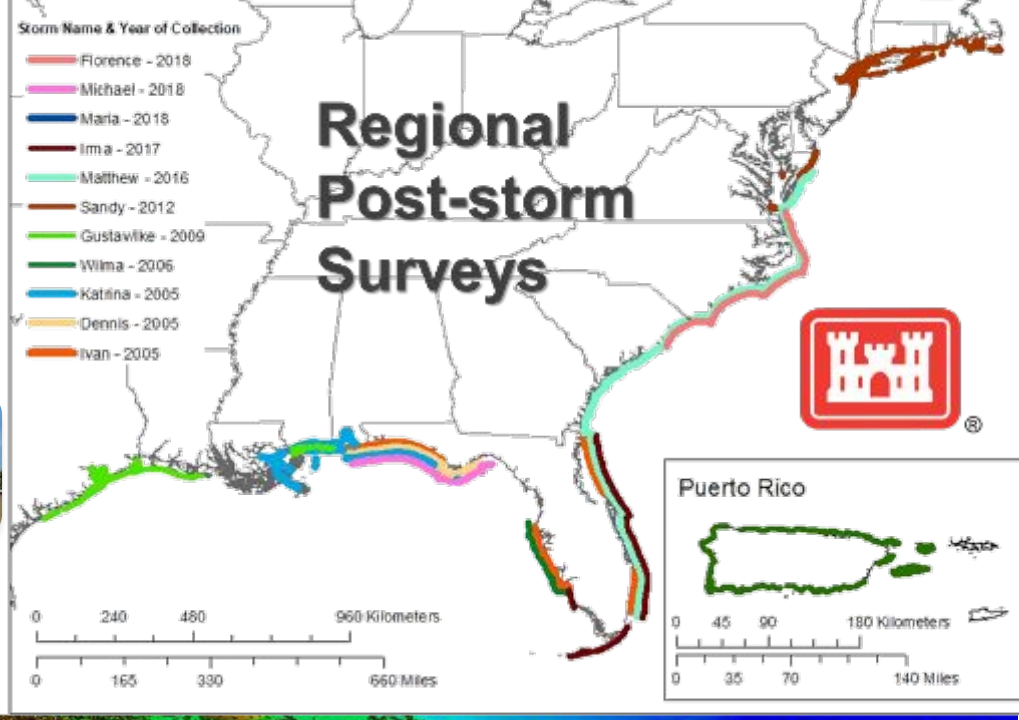

Jennifer M. Wozencraft
- US Army Corps of Engineers National Coastal Mapping Program Manager
- Joint Airborne Lidar Bathymetry Technical Center of Expertise Director
- Coastal and Hydraulics Laboratory, US Army Engineer Research and Development Center

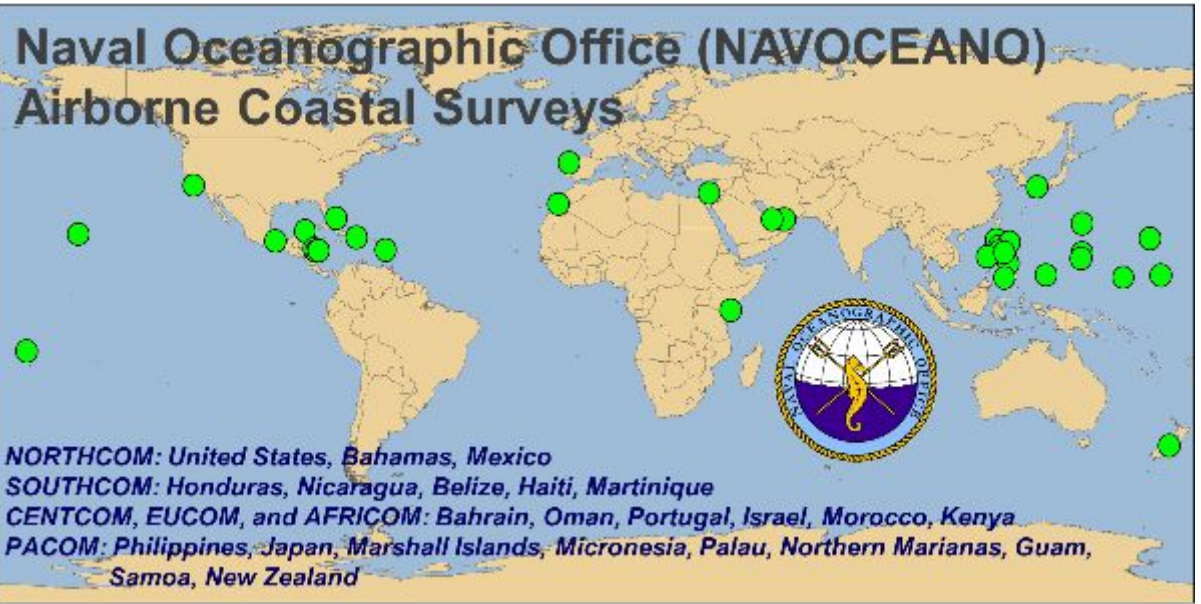
*1 December 2021*

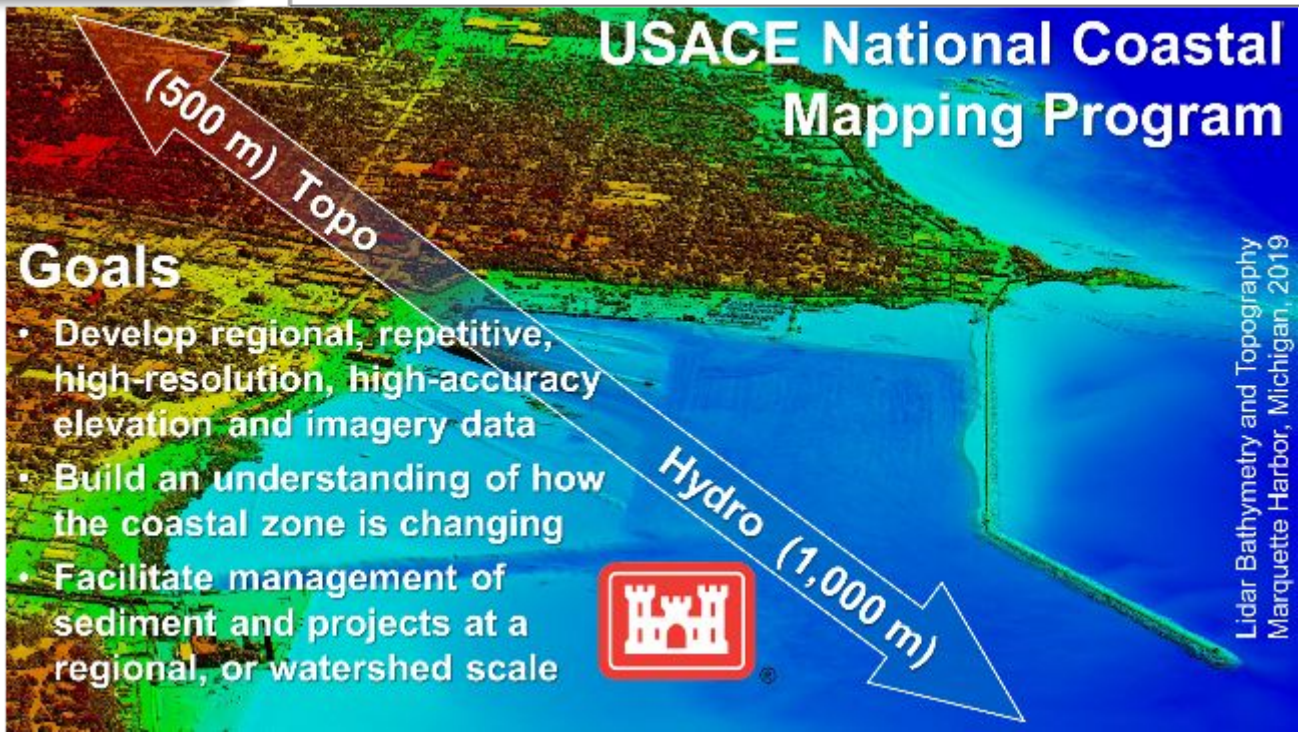
# Joint Airborne Lidar Bathymetry Technical Center of Expertise

**Mission: Operations and R&D in airborne lidar bathymetry and complementary tech for airborne coastal mapping and charting**

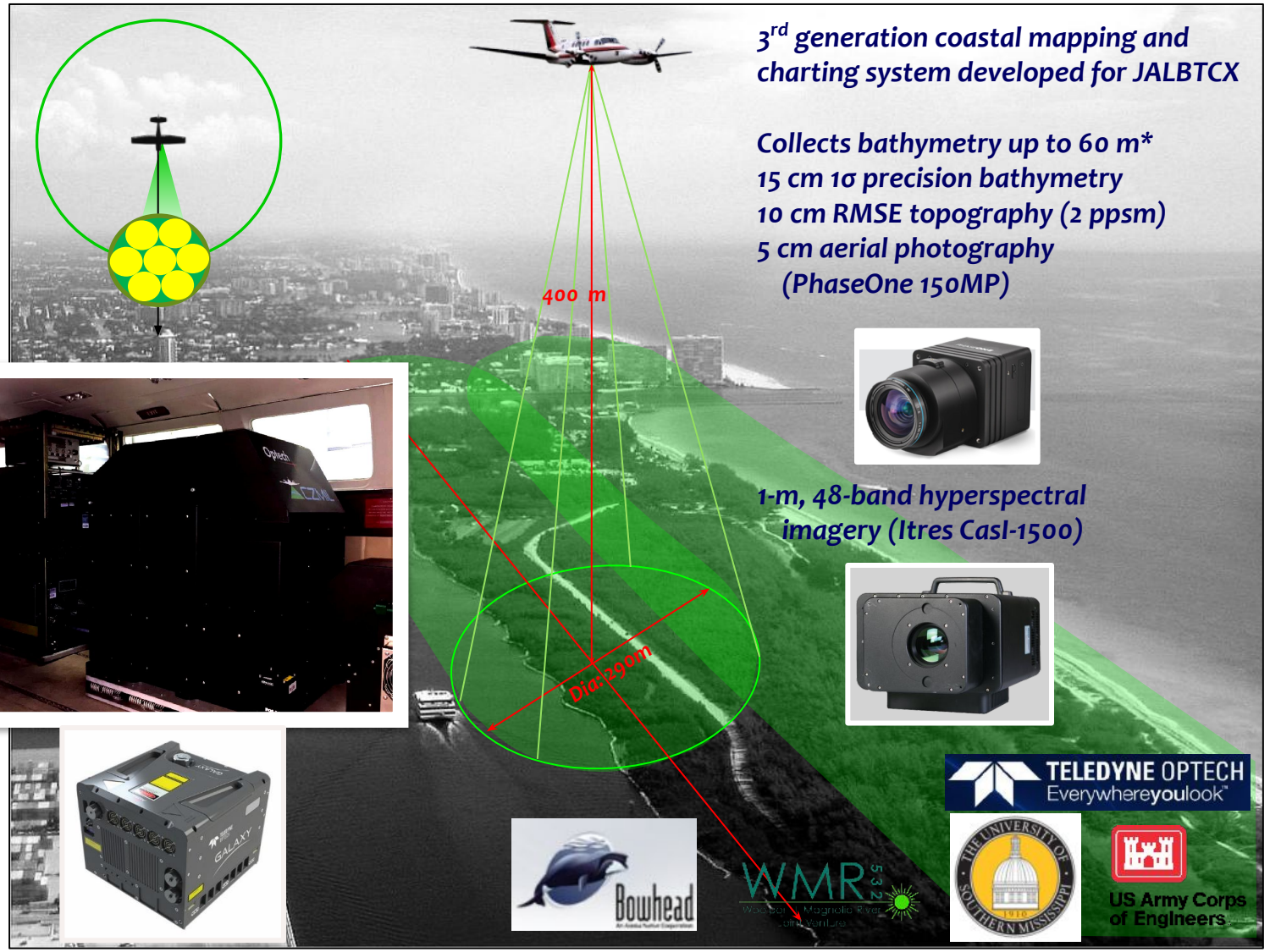
- 22-year collaboration among USACE, Navy, NOAA, & USGS
- Government, industry, and academia partner to advance technology and its application to coastal challenges
- Developed 3 three generations of coastal mapping and charting sensors to meet the needs of the partner agencies
- USACE- and Navy-owned sensors are operated year-round & world-wide



# CZMIL Coastal Zone Mapping and Imaging Lidar




*3rd generation coastal mapping and charting system developed for JALBTCX*

*Collects bathymetry up to 60 m**
*15 cm 1σ precision bathymetry*
*10 cm RMSE topography (2 ppsm)*
*5 cm aerial photography (PhaseOne 150MP)*



*1-m, 48-band hyperspectral imagery (Itres CasI-1500)*







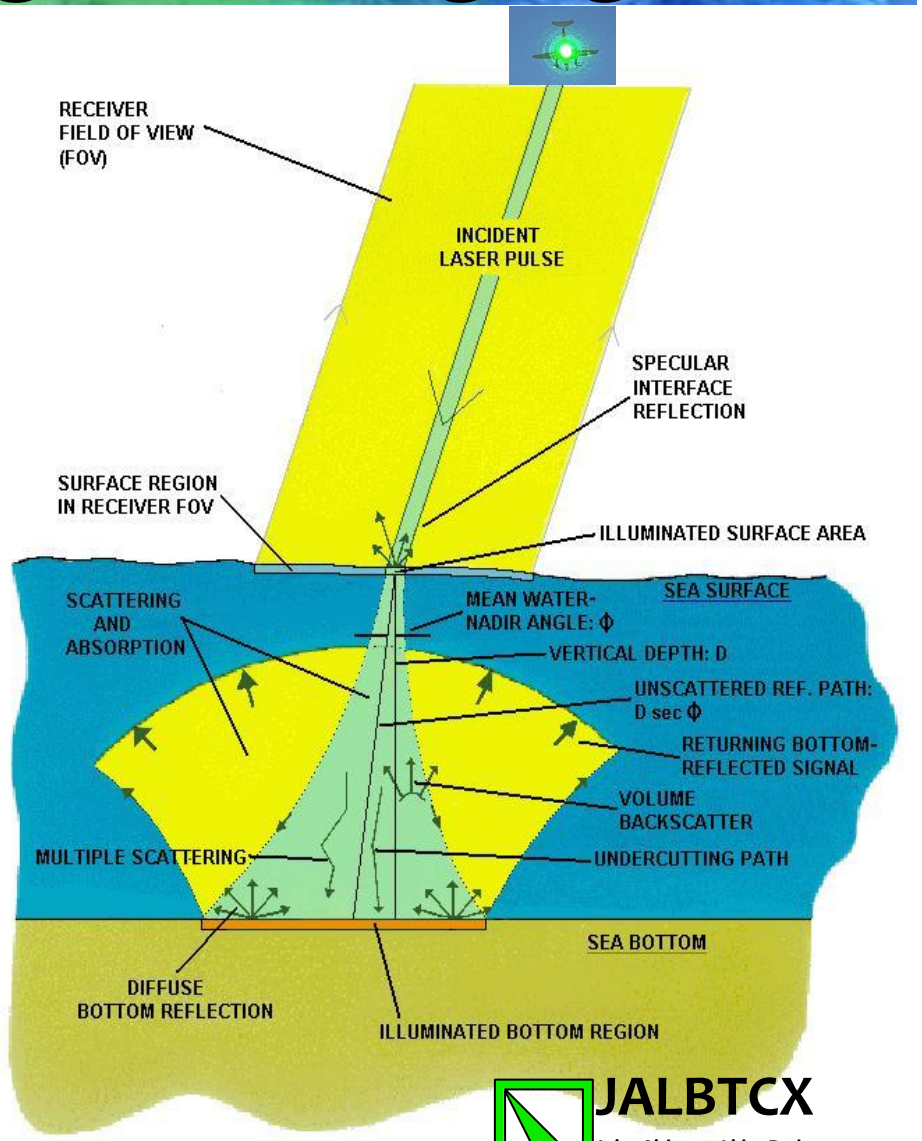
TELEDYNE OPTECH Everywhereyoulook™

Bowhead

WMR 532 Woolpert Magnolia River Joint Venture

THE UNIVERSITY OF SOUTHERN MISSISSIPPI 1910

US Army Corps of Engineers

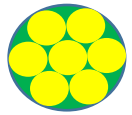



JALBTCX
Joint Airborne Lidar Bathymetry Technical Center of Expertise

# SuperNova Features: Field Programmable

- Best depth penetration
  $K_d \cdot D_{max}$ = 4.4
- 2x Nova point density with SmartSpacing
- **Field programmable sensor modalities**
- 2x Nova waveform sampling rate
- Onboard processing
- CZMIL data processing in CARIS BASE Editor
- Deep Learning algorithms

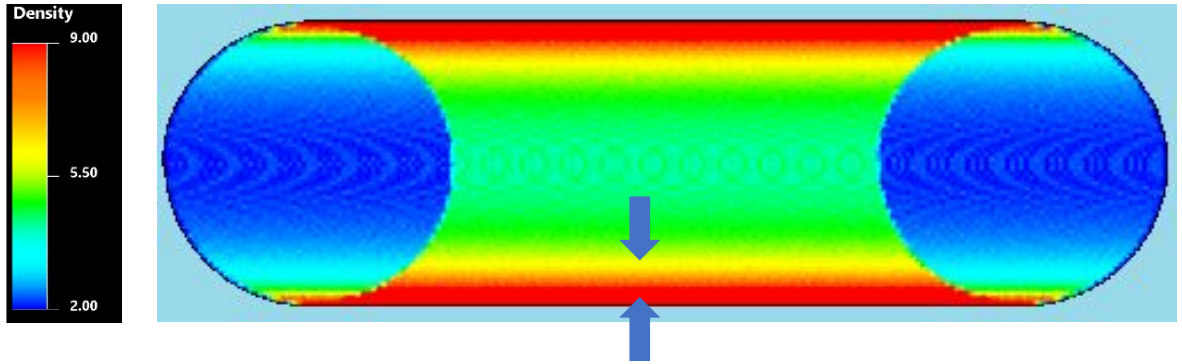
| SUPERNOVA MODE | PURPOSE | PRF (kHz) | Points per meter$^2$ (surface) at 140 knots (8 channels) | Points per meter$^2$ (surface) at 120 knots (8 channels) |
|---|---|---|---|---|
| **Standard_Smart** | Topo / Bathy survey, even point spacing | SmartSpacing | 7.6 | 8.8 |
| **Shallow** | Shallow water, turbid water | 20 | 7.6 | 8.8 |
| **Shallow_Smart** | Shallow water, turbid water, even point spacing | SmartSpacing | 7.6 | 8.8 |
| **Deep** | Maximum depth penetration | 10 | 0.4 | 0.5 |
| **Topo** | Maximum point density, land survey | 30 | 11.4 | 13.3 |



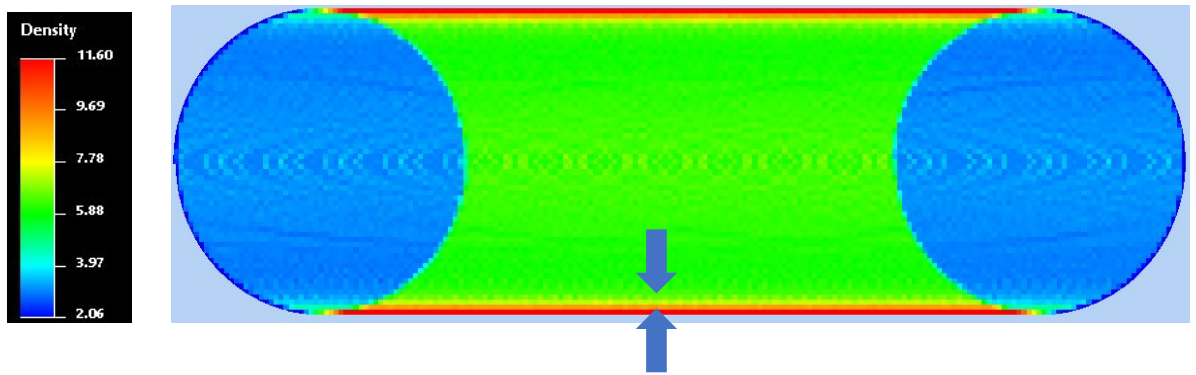
# Supernova Features: SmartSpacing

- Best depth penetration
  $K_d \cdot D_{max}$ = 4.4
- **2x Nova point density with SmartSpacing**
- Field programmable sensor modalities
- 2x Nova waveform sampling rate
- Onboard processing
- CZMIL data processing in CARIS BASE Editor
- Deep Learning algorithms

CZMIL Nova: Standard (non-uniform point spacing)




CZMIL Supernova: SmartSpacing

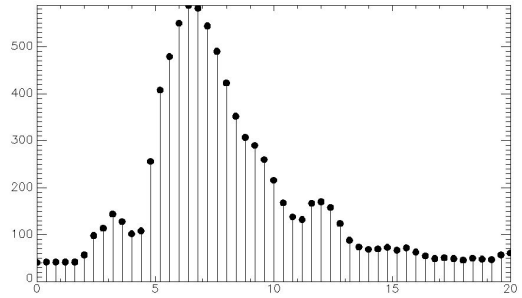



SmartSpacing: More evenly spaced point distribution along the scan for uniform sampling of the survey area

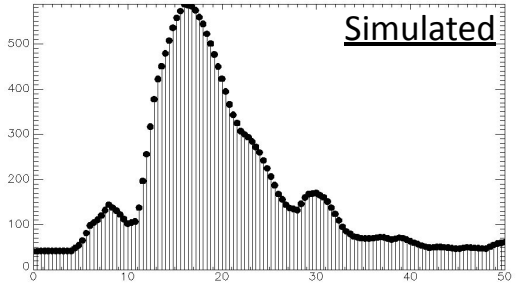
# Supernova Features: Best Depth Penetration

- **Best depth penetration** $K_d \cdot D_{max} = 4.4$
- 2x Nova point density with SmartSpacing
- Field programmable sensor modalities
- 2x Nova waveform sampling rate
- Onboard processing
- CZMIL data processing in CARIS BASE Editor
- Deep Learning algorithms

Nova waveform sample rate

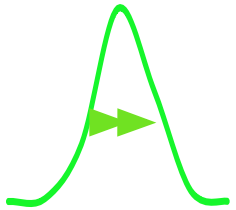



Supernova, > 2x CZMIL Nova




- A Field Programmable Gate Array (FPGA) enabled 16 bit digitizer for digitizing waveforms > 2x CZMIL Nova waveform sampling rate

Shorter pulse width



Programmable PRF

- **10 kHz**
- **20 kHz**
- **30 kHz**

✔ Higher digitizer sampling rate combined with short laser pulse width results in better vertical resolution

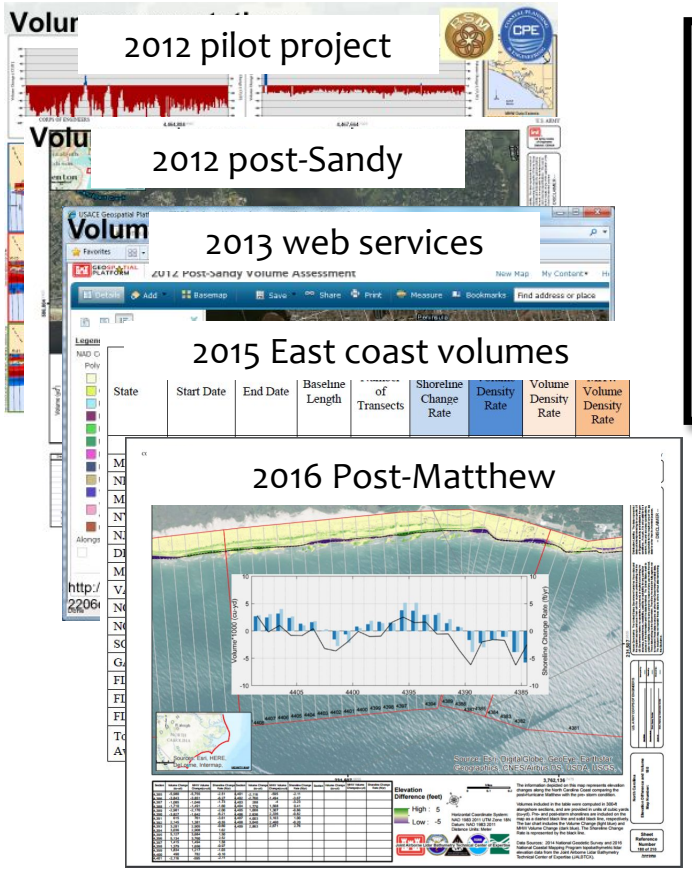
| Parameter* | CZMIL Nova | CZMIL Supernova |
|---|---|---|
| | 2.0 | 2.9 |
| | 4.3 | 4.4 |

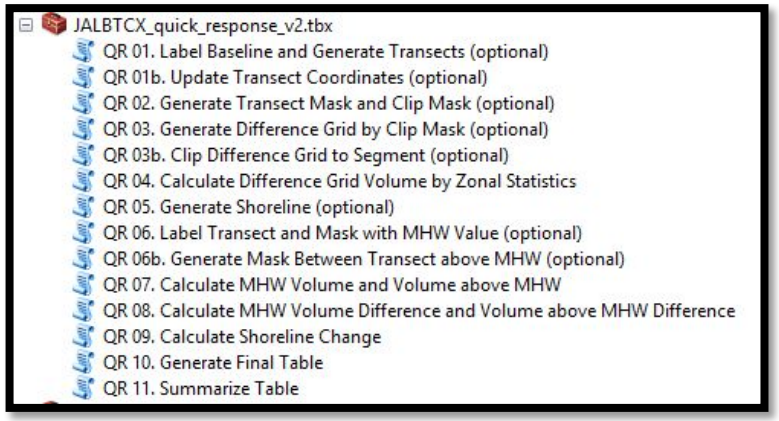
Improved depth performance

**400m AGL, bottom reflectivity > 15%**

# USACE Volume Change Toolbox

A standard procedure to compute elevation, volume, and shoreline change consistently on a regional scale

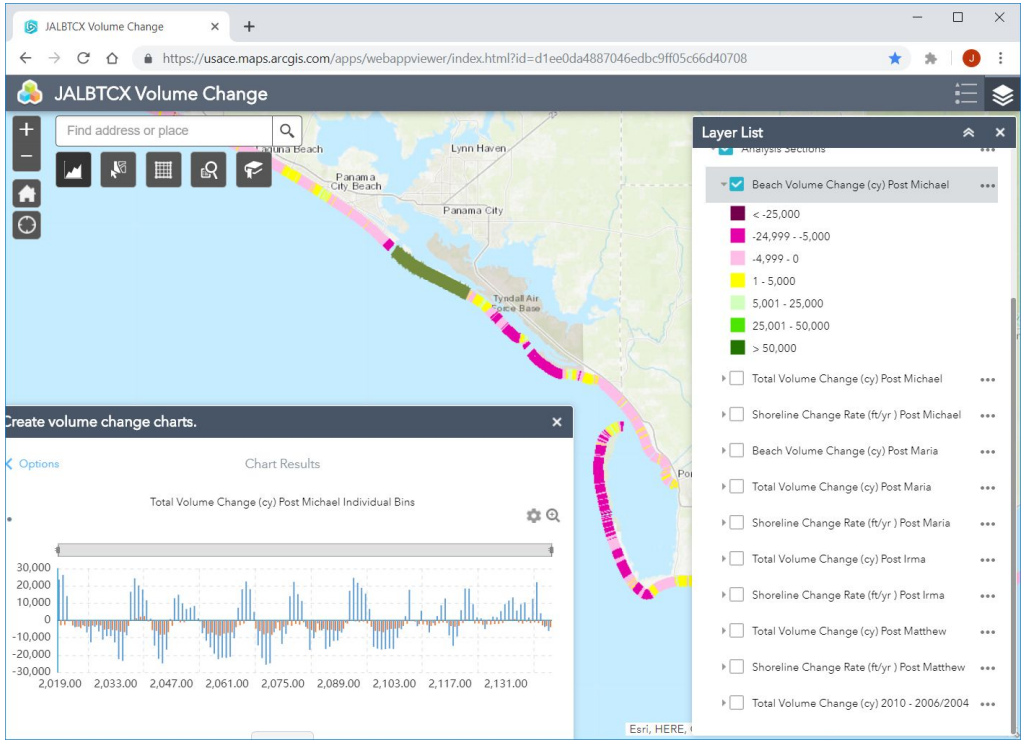



## FY21

- Convert to python 3 for ArcPro
- Improve transect generation
- Automate pdf map making
- Multiple dataset toolbox
- Dune feature detection toolbox (with sandbar features)
- Coastal engineering resilience index toolbox

**Deployed on an operational basis for change analyses after H. Matthew, Irma, Maria, Michael, and Sally. Access to change products through web app.**




https://usace.maps.arcgis.com/apps/webappviewer/index.html?id=d1ee0da4887046edbc9ff05c66d40708

https://www.arcgis.com/apps/webappviewer/index.html?id=1c27ace28b7845deb7f126935f490878

US Army Corps of Engineers

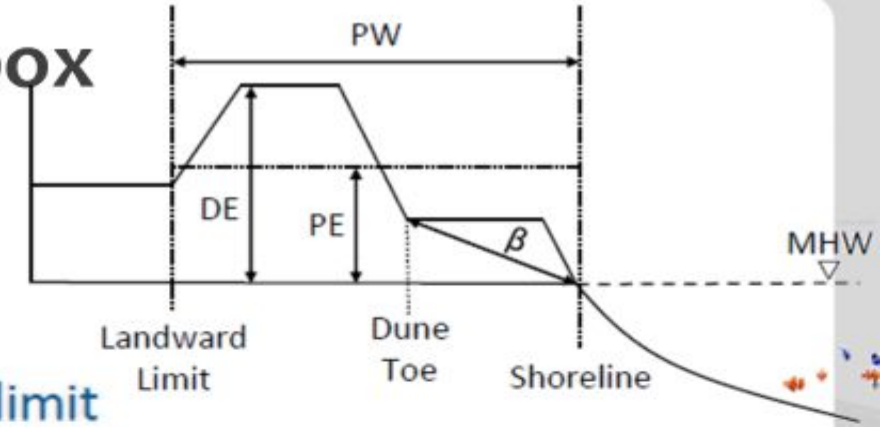
Coastal and Hydraulics Laboratory

Coastal Protection Engineering

JALBTCX
Joint Airborne Lidar Bathymetry Technical Center of Expertise

# USACE Coastal *Engineering* Resilience Toolbox

- Automated – Python in ESRI Arc
- Use existing data – beach profile and LiDAR
- Consistent metrics – shoreline, dune toe, dune crest, landward limit




**Inputs**
- Beach Profile
- LiDAR
- Wave
- Surge
- MHW
- % Fines

**Metrics**
- Shoreline
- Dune Toe
- Dune Crest
- Landward limit

**Outputs**
- Protective Elevation
- Protective Width
- Volume Density
- Wave runup
- Crest Freeboard

Five non-dimensional factors based on beach, storm and wave parameters:

$$a = \frac{PE}{PE_0}; b = \frac{PE * PW * (1-s)}{PE_0 * PW_0}; c = \frac{PW - MR}{PW_0};$$
$$d = \frac{DE - (MS + MHW)}{CF_0}; e = \frac{WR_0}{WR}$$
$$CRI = a + b + c + d + e$$

where :

**WR**: Wave Run-up
**MHW**: Mean High Water
**PE**: Protective Elevation
**PW**: Protective Width
$PE_0$: Protective Elevation; 15 ft
$PW_0$: Protective Width; 500 ft
$CF_0$: Crest Freeboard; 20 ft
$WR_0$: Wave Runup; 2 ft
$s$: percentage of fine sediment
**DE**: Dune Crest Elevation
**MR**: Maximum Shoreline Recession
**MS**: Maximum Storm Surge

*FY21 CERI for three large areas*
- Northern Gulf of Mexico
- Northern Outer Banks
- Long Island, NY

*FY22 CERI areas*
- Cape Cod to Portsmouth, ME
- Lake Ontario
- 200 miles in NWD
- Southern CA

*FY22 CERI advancements*
- Add dune vegetation metric
- Add capability to weight metrics

US Army Corps of Engineers

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Joint Airborne Lidar Bathymetry Technical Center of Expertise

# During Nearshore Event Vegetation Gradation (DUNEVEG): Geospatial Tools for Automating Remote Vegetation Extraction

## PROBLEM

- Coastal systems are increasingly susceptible to climate change and erosion
- Coastal vegetation is critical to ecosystem stability and resilience
- Few studies have correlated vegetation properties with natural and built coastal infrastructure stability

## SOLUTION

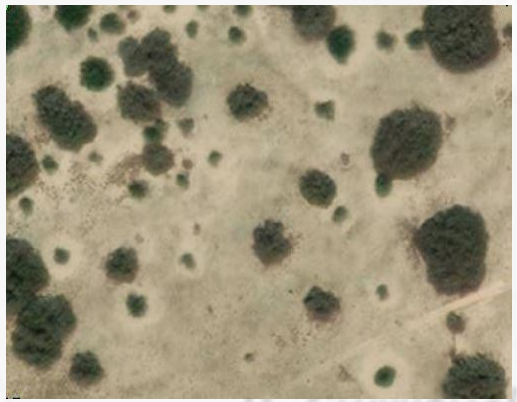
- Utilize high-resolution imagery and lidar to extract coastal dune vegetation metrics: dune vegetation cover (presence/absence), vegetation density estimates, Leaf Area Index (LAI), Normalized Difference Vegetation Index (NDVI), woody stem locations, and canopy height models.
- An ArcGIS Pro geoprocessing toolbox to streamline future data analysis

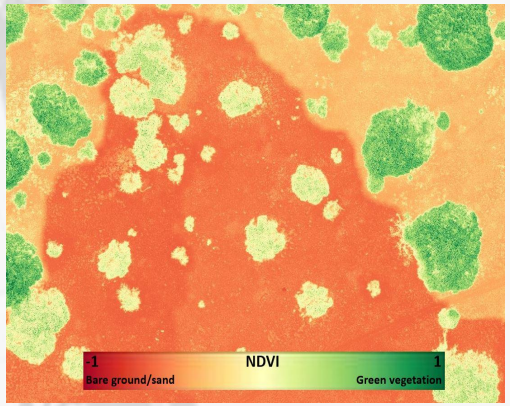
## BENEFITS

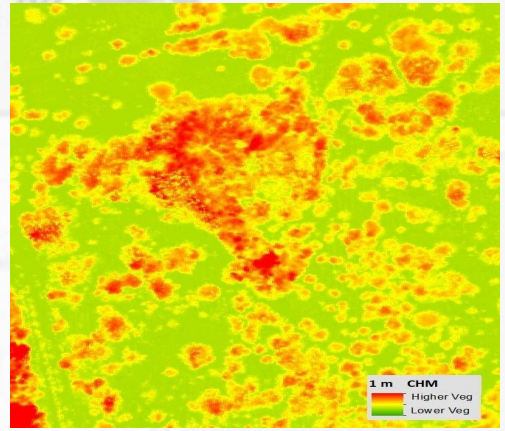
- Method provides streamlined workflow and high priority metrics for assessing coastal vegetation characteristics
- Expands library of vegetation metrics for numerical modeling of coastal storm response to build regional coastal resilience
- Semi-automated tool provided a transparent, uniform approach to quantify vegetation characteristics to save time and cost for coastal studies

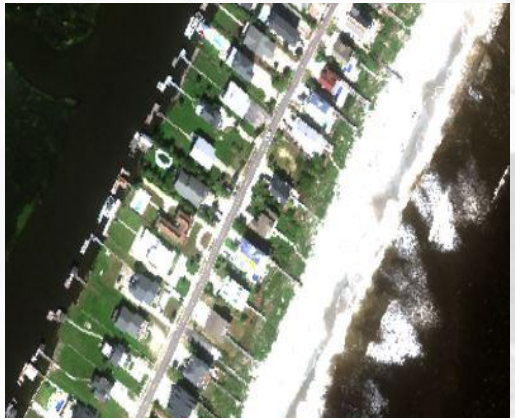
## NEXT STEPS

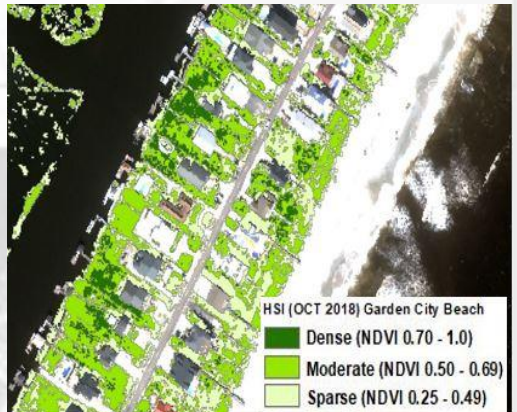
- Evaluate toolbox for different site locations including the Mississippi Barrier Islands to Cape San Blas, FL; Virginia/NC border to Cape Hatteras, NC; Northern NJ to Montauk, NY; and Lake Ontario (NY shoreline)
- Perform multi-temporal (2018-2020) trend analysis of landscape level vegetation change using established metrics







# JALBTCX bathytopo lidar specification

## Contributors

- USACE
  - Jennifer Wozencraft
  - Chris Macon
  - Nick Johnson
  - Charlene Sylvester
- NAVOCEANO
  - Steven Posey
  - Matt Thompson
  - Sheldon Powe
  - Tommy Dye
- NOAA
  - Mike Aslaksen
  - Stephen White
  - Jamie Kum
- USGS
  - Jeff Danielson
  - Jim Kaufmann
  - Josh Nimetz
  - Jason Stoker

## Details

- Started at the request of USGS for an inland lidar bathymetry specification
- Also serves as basis for lidar section, bathymetry chapter, Standard Ocean Mapping Protocol for Interagency Working Group on Ocean and Coastal Mapping
- Started with the USGS 3DEP spec
- Added in elements from the International Hydrographic Organization Standards for Hydrographic Surveys
- Added in standard practice among the agencies
- Removed irrelevant pieces, reorganized a bit
- Agreed on a table of specifications (parameters and values) for lidar bathymetry to accompany existing QL levels for topography
- Agreed on a point cloud classification scheme
- Plan is to circulate for comment next year

| Parameter | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| THU (Constant, m) | 20m | 10m | 5m | 2m | 1m | 0.5m | | | | |
| THU (Variable, m, Depth Dependent) | 0.1 | 0.05 | 0.02 | 0.015 | 0.01 | 0.0 | | | | |
| TVU (Constant, m) *a* in *sqrt(a^2+(b*d)^2))* | 2m | 1m | 0.5m | 0.3m | 0.25 | 0.2m | 0.15 | | | |
| TVU (Variable, m, Depth Dependent) *b* in above (S-44) | 0.023 | 0.02 | 0.013 | 0.01 | 0.00 | .004 | 0.002 | | | |
| Sample Density* (Samples / m^2) (or feature detection requirement)* | 0.02 | 0.05 | 0.1 | | 0 | 1 | 2 | 5 | 10 | 20 |
| System performance (secchi factor or Kd*MaxDepth) (@15%reflectance) | 5 | 4 | | 2.5 | 2 | 1.5 | 1.25 | 1 | 0.75 | 0.5 |
| Grid Resolut | 10 | 5m | 2 | | | | | | | |
| Sample ity (Samples node) | <1 | | 2 | | | | | | | |
| Intensity Processing Level | Level raw | ensity | Le in cc | | | | | | | |

*Table ... bathymetric/topographic light detection and ranging data classification scheme.*

| Code | Description |
|---|---|
| 1* | Processed, but unclassified |
| 2* | Bare earth ground |
| 7 | Low noise (low or high; manually iden d, if necessary) |
| 9 | Water (topographi ensor) |
| 17 | Bridge dec |
| 18 | High noise (high manually identifi necessary) |
| 20 | Ignored groun breakline p mity) |
| 21 | Snow (*if pr nt and ble*) |
| 22 | Temporal exclusion hic senso ically nonfavored data in intertidal zones) |
| 40* | Bathy ic Point, S merged To graphy (e.g., seafloor or riverbed) |
| 41 | Water Surfac ea/river from bathymetric or topographic-bathymetric lidar; distinct Class 9, is used in topographic-only lidar and only designates "water," not "water surface") |
| 42 | surfac nthetic water surface location used in computing refraction at water surface) |
| 43 | Submerged o ct, not otherwise specified (e.g., wreck, rock, submerged piling) |
| 44 | IHO S-57 object, not otherwise specified |
| 45 | No-b om-fo d (bathymetric lidar point for which no detectable bottom return was received) |
| 64 | Submerged Aquatic Vegetation |
| 65 | Denotes bathymetric bottom temporal changes from varying lifts, not utilized in bathymetric point class |

** Minimum requirement, others may be specified*

# Questions?

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Sean McGill
Scott Spurgeon
Ashley Elkins
Cassandra Hankins

Mobile District

Chris Macon
Nick Johnson
Heath Harwood

US Army Corps of Engineers

Time-lapse of a night flight, Long Island, NY, September 2017

NCMP

JALBTCX
Joint Airborne Lidar Bathymetry Technical Center of Expertise

# Topobathy Lidar & Water Clarity

Stephen White, NOAA Remote Sensing Division

**December 1st, 2021 | Virtual**


# NGS Coastal Mapping Program

## Nearshore Bathymetry and Water Clarity

**Stephen White**

**Remote Sensing Division**

**National Geodetic Survey**

National Oceanic and Atmospheric Administration

# The RSD Coastal Mapping Program

- **A congressional mandate to conduct remote sensing surveys of coastal regions of the United States and its possessions for demarcating the nation's legal coastline.**

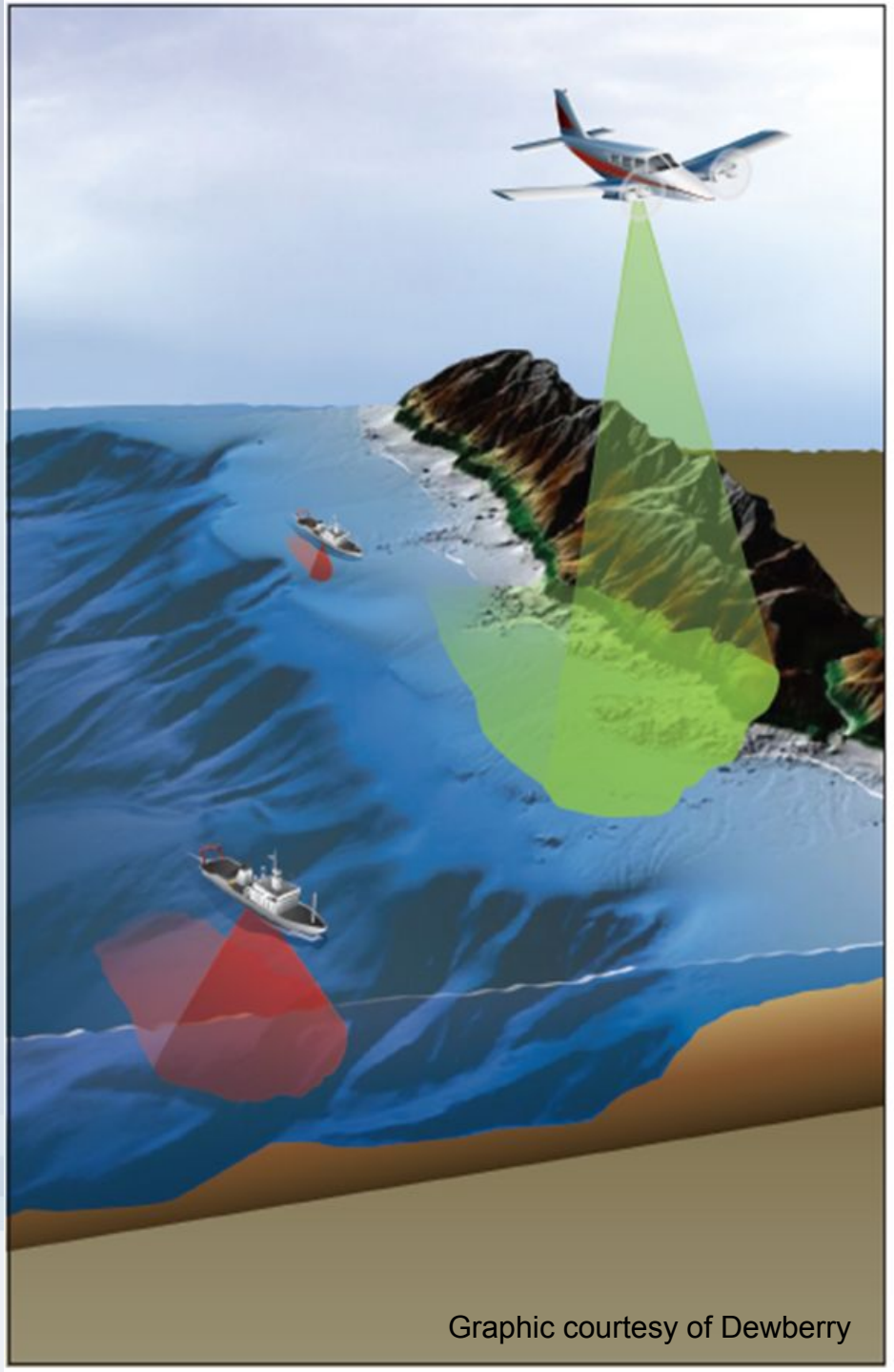
- **Goals:**
  - Provide the Nation With Accurate, Consistent, Up-to-Date National Shoreline
  - Acquire Nearshore Elevation Data

- **Sources:**
  - **Lidar**
  - **Digital Cameras**
  - **High Resolution Satellites**
  - **UAS**

National Oceanic and Atmospheric Administration

# Support of Hydrographic Surveys

- RSD collects nearshore topobathy lidar to the 4m NALL in the year prior to ship ops
- RSD will provide both shoreline and nearshore bathymetry
- Hydro operations will use this data to plan operations and overall situational awareness
- Increases efficiency and safety of launch and ship operations

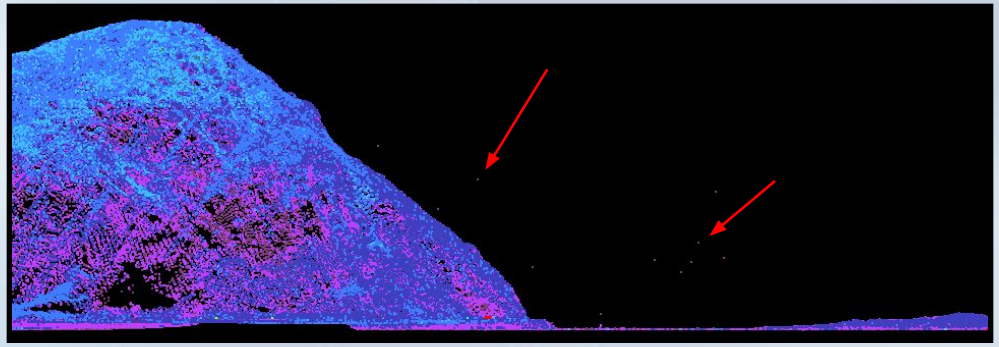


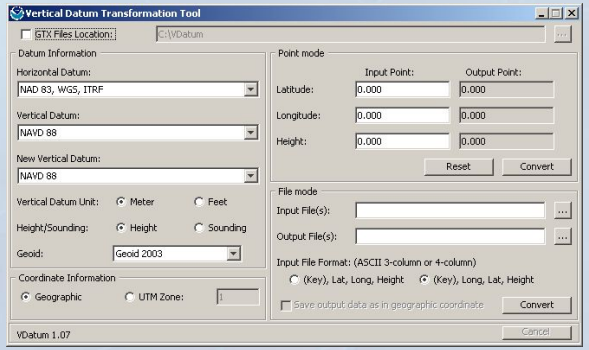
Graphic courtesy of Dewberry

National Oceanic and Atmospheric Administration

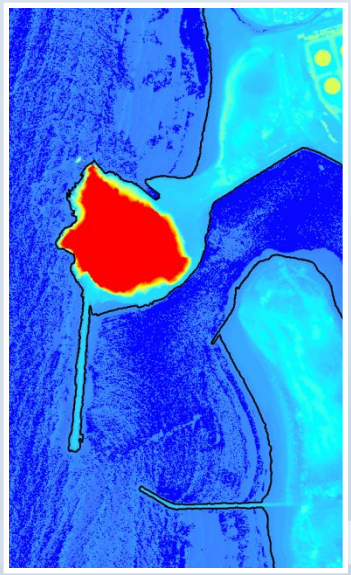
# Lidar Shoreline Extraction

Edit Lidar Point Cloud

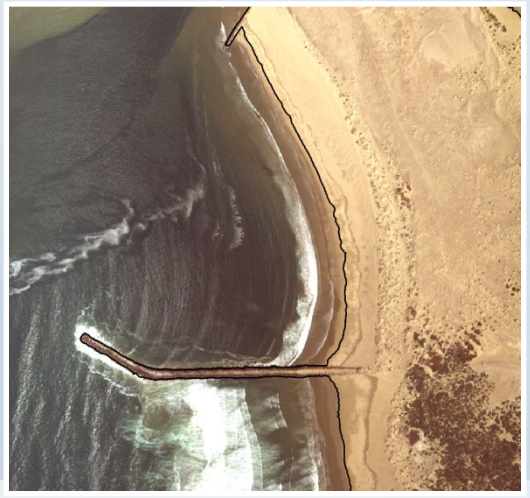





VDatum



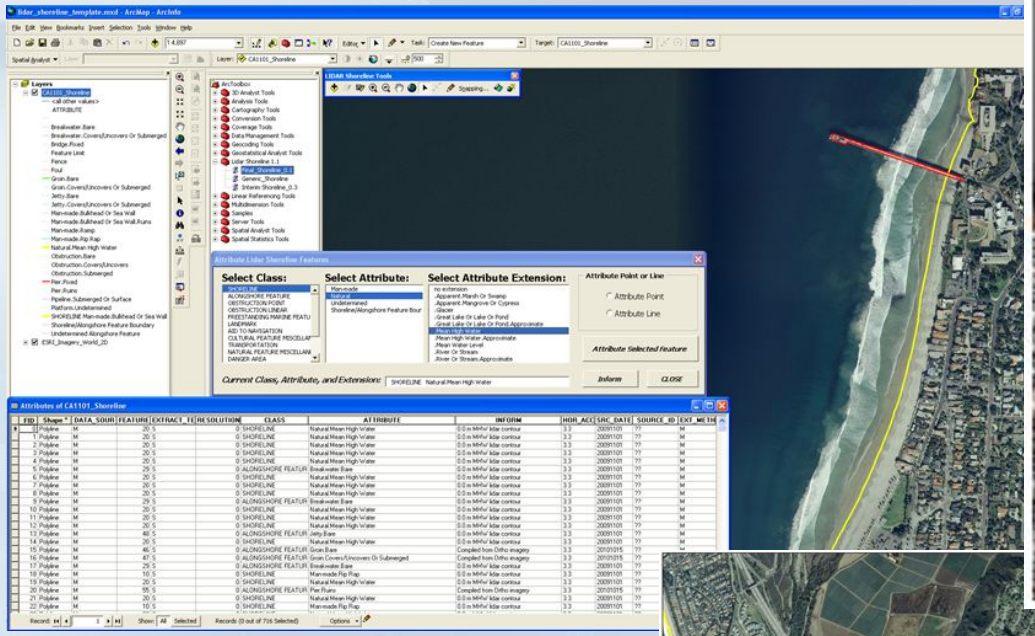
Contour Shoreline from DEM



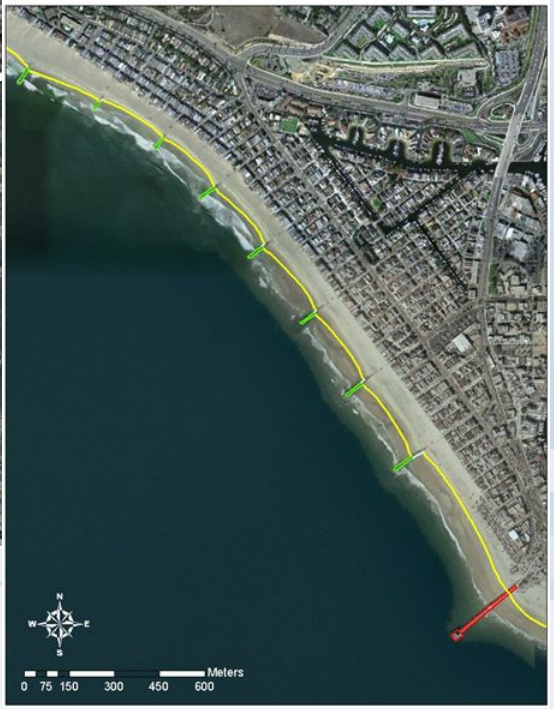
Quality Control &
Feature Attribution

National Oceanic and Atmospheric Administration

# Imagery

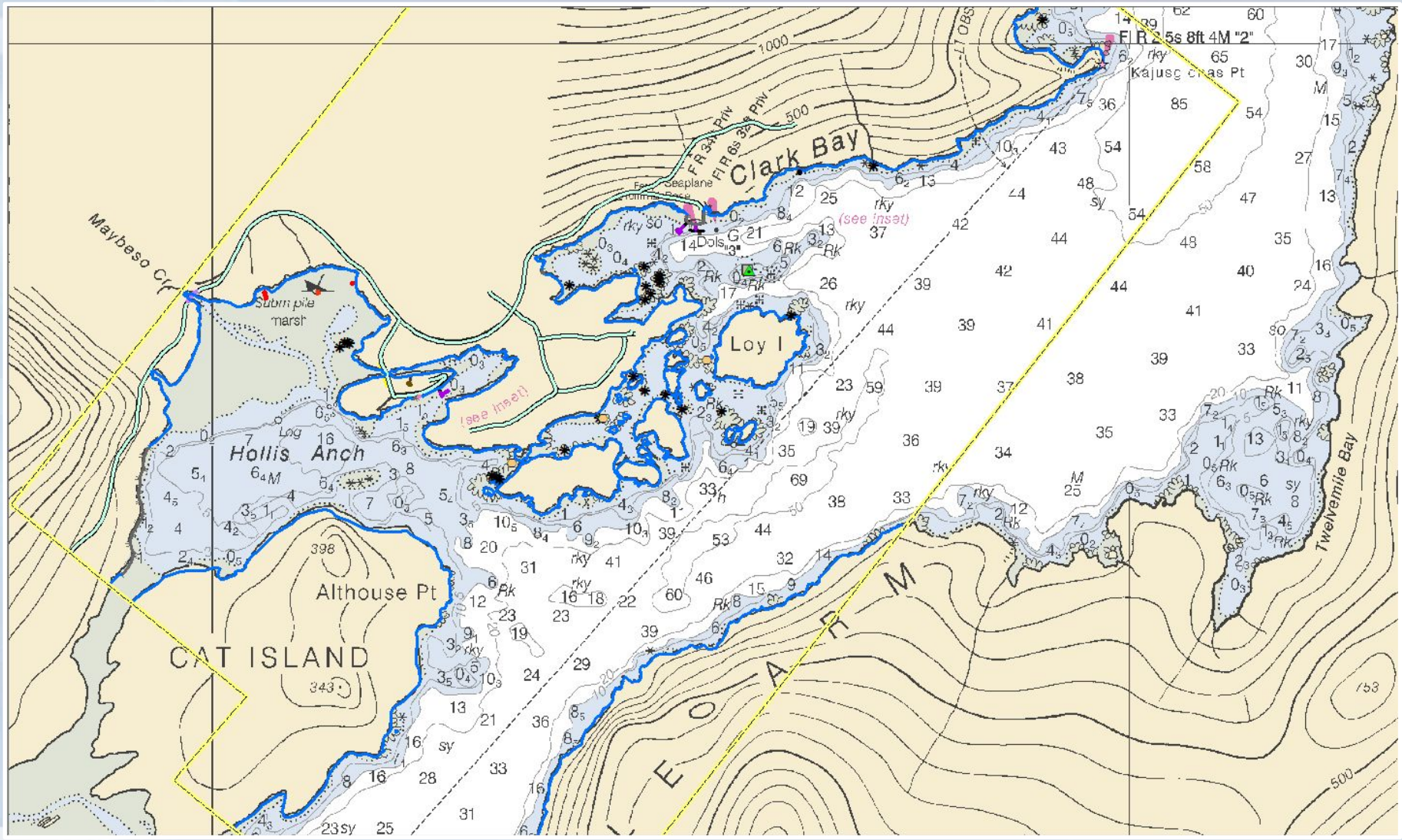







National Oceanic and Atmospheric Administration

# Geographic Cells (Nautical Chart Shoreline)

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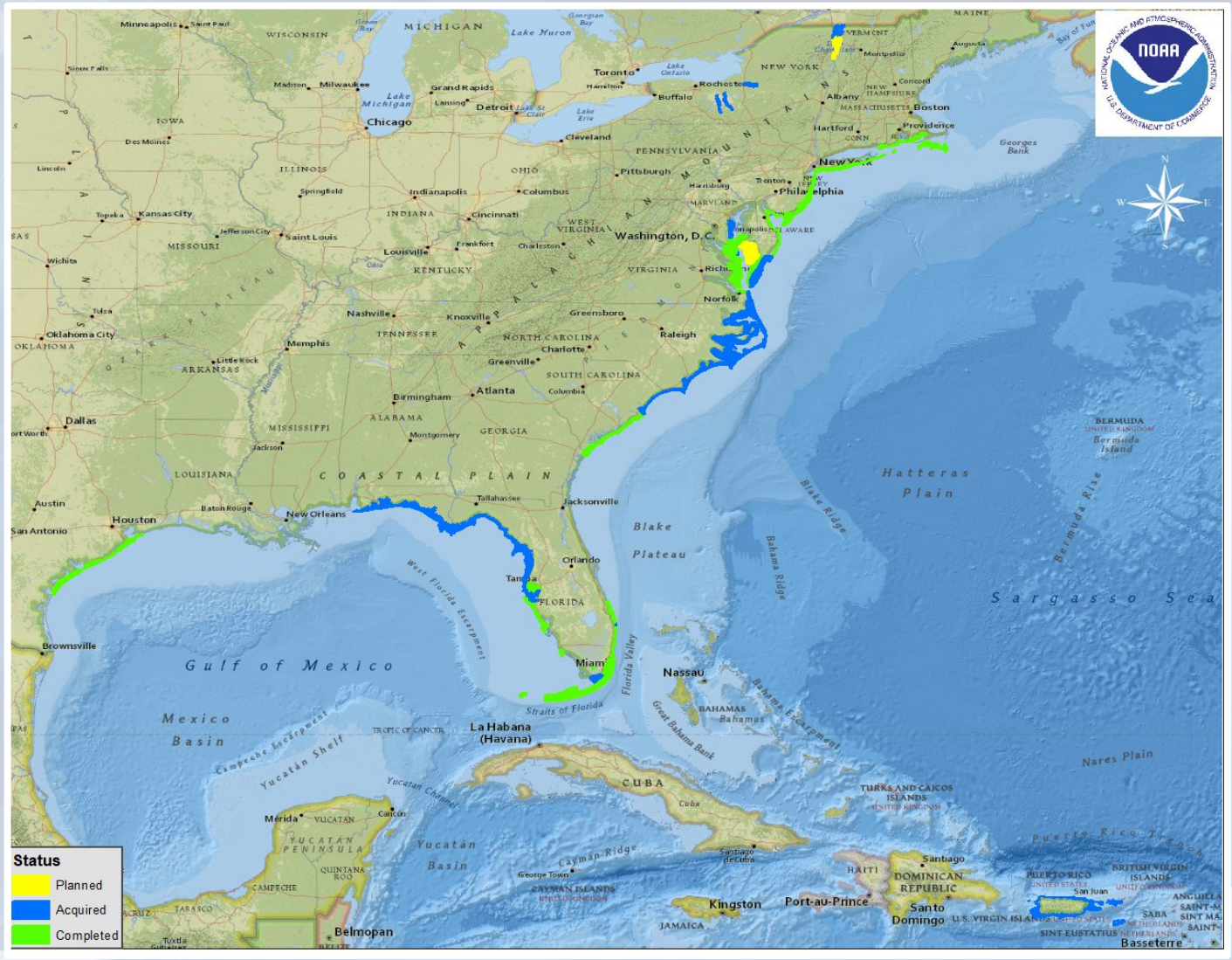
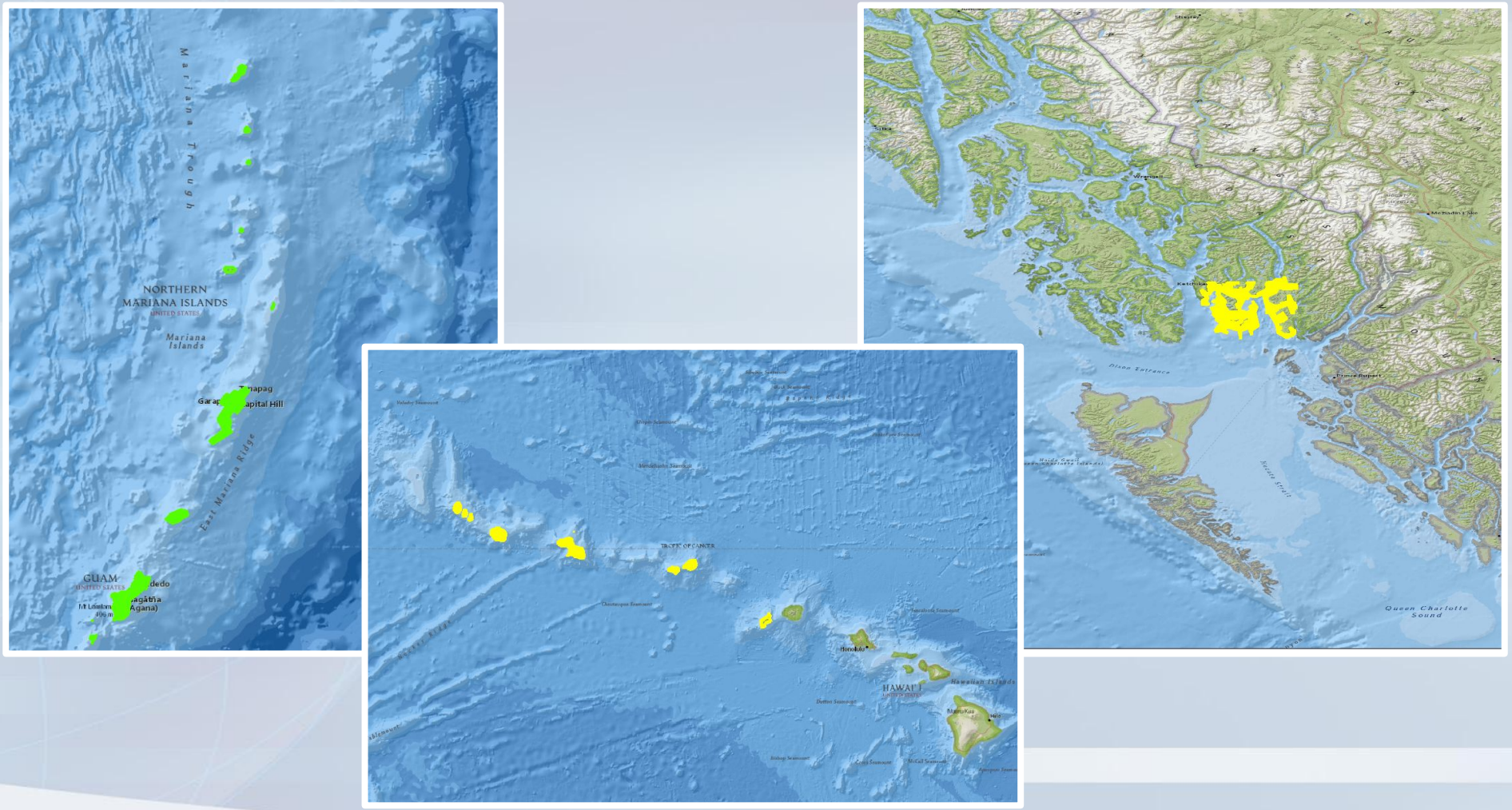
# Topobathy Projects



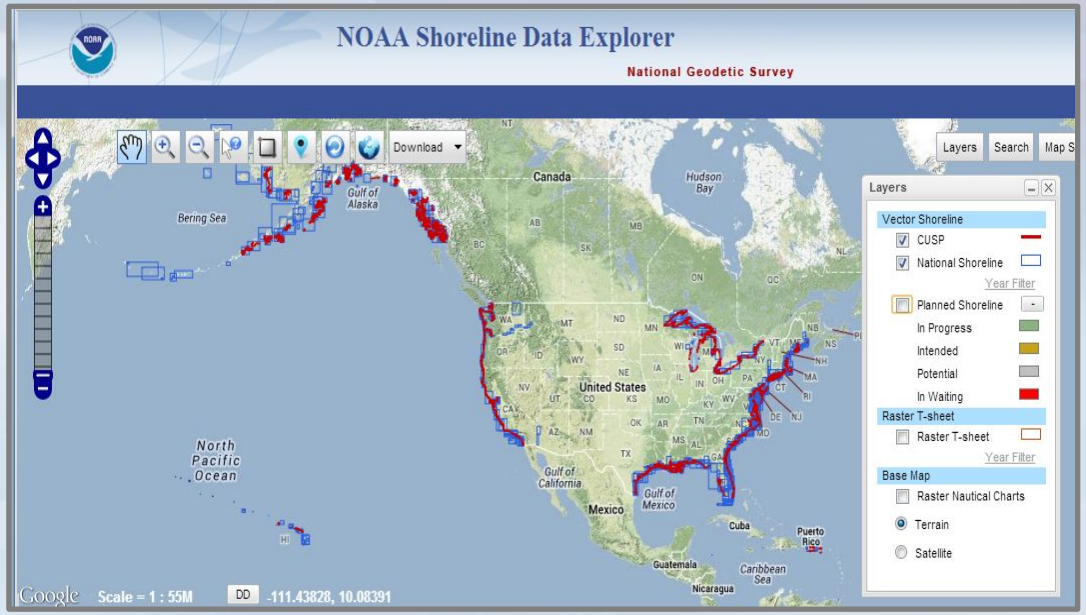

National Oceanic and Atmospheric Administration

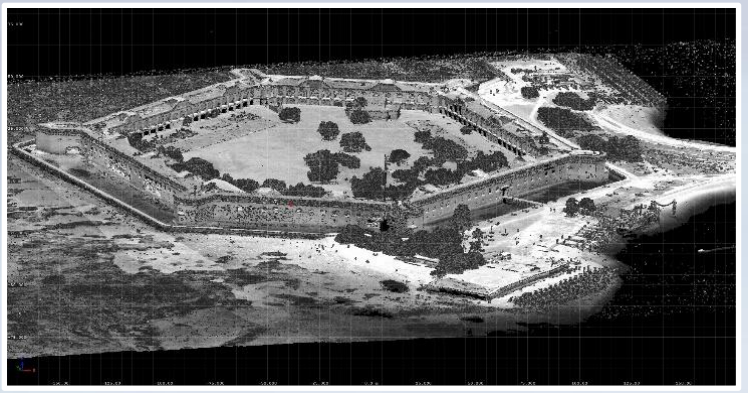
# Topobathy Projects



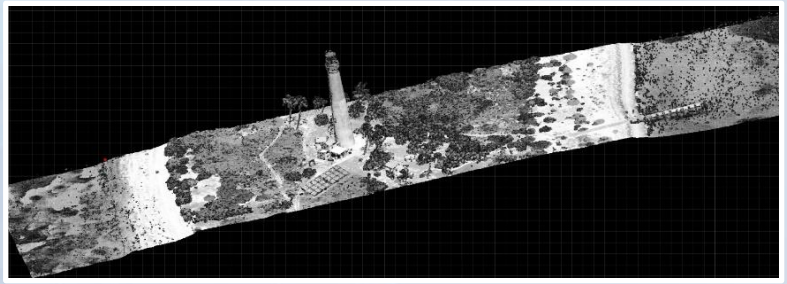

National Oceanic and Atmospheric Administration

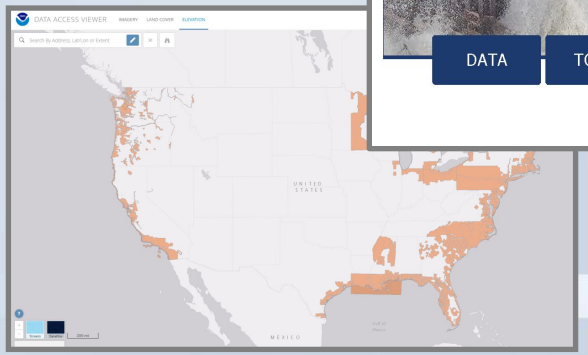
# Distribution of Data

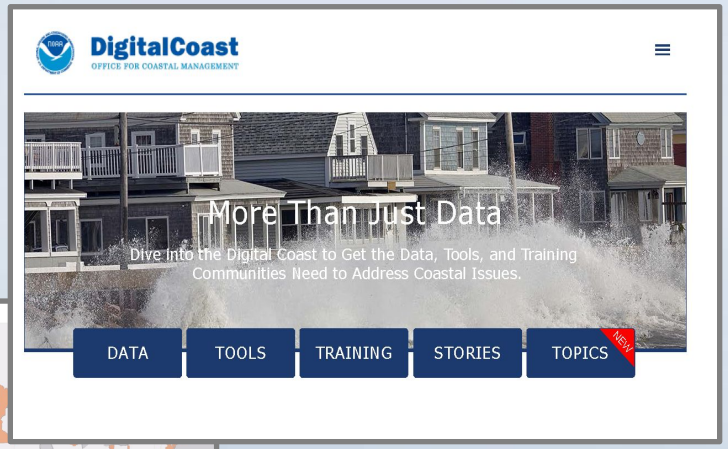


Shoreline (http://www.ngs.noaa.gov/NSDE/)








Lidar and Imagery:

https://coast.noaa.gov/digitalcoast/

National Oceanic and Atmospheric Administration

# RSD Coastal Mapping Program: Products

**Lidar:**

- LAS v1.4 Point Cloud
- 1 Meter DEM (Clipped and Interpolated)
- Total Propagated Uncertainty (TPU)
- Normalized Seabed Intensity

**Imagery:**

- 25cm Tiled Orthomosaic GeoTiffs
- Stereo Imagery

**Shoreline Vectors:**

- Nautical Charting (GC's)
- CUSP

# Products and Sequencing to support Charting

## Pre-Acquisition:
- Boresight and Calibrations Reports
- Planned Imagery flight lines and Footprints
- Lidar flight lines

## Acquisition:
- Lidar and Imagery acquired within 30 days of each other

## Post-Acquisition:
- Acquired Imagery Footprints
- Flight Reports
- Lidar Data Coverage Images

## Pilot:
- Pilot Imagery
- Pilot lidar

## Stereo Imagery and Ground Surveys:
- Stereo Imagery
- EOs
- Ground Survey Shapefiles and Reports (lidar and imagery)
- Airborne Positioning and Orientation Report
- Acquisition Summary

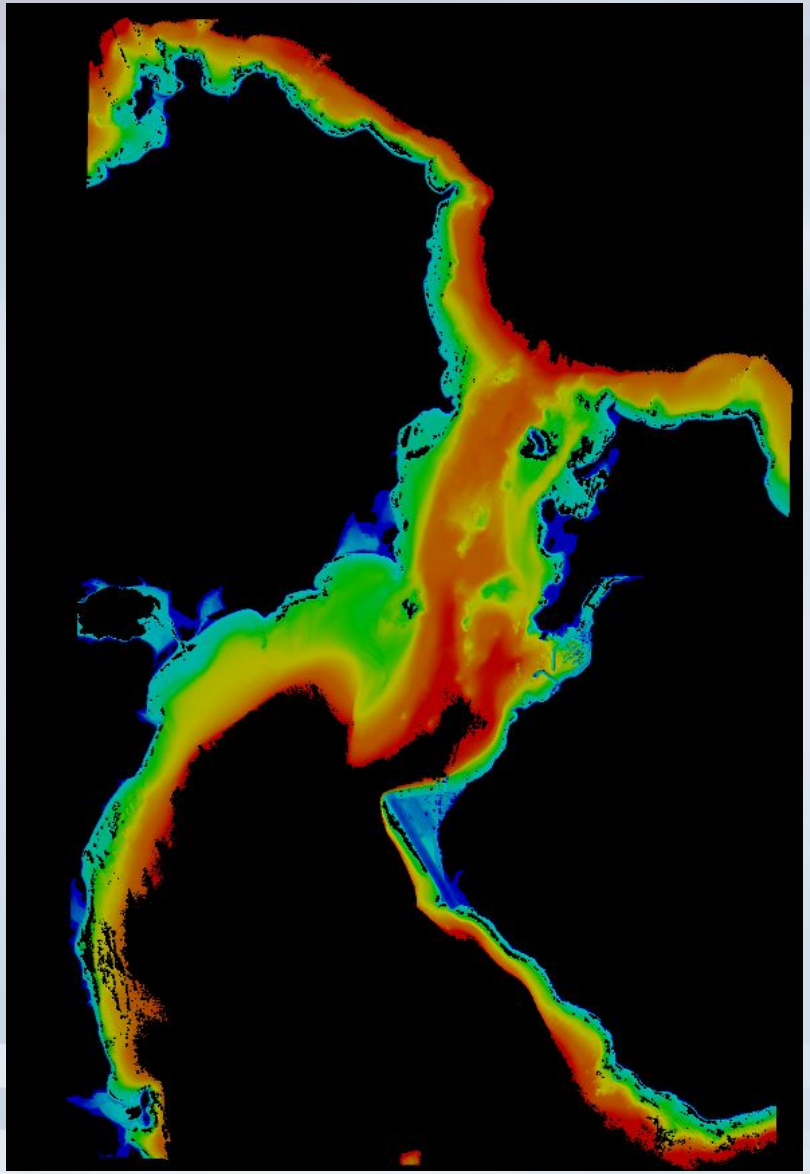
## Imagery Pilot Shoreline:
- EOs (Post-AT)
- AT Report
- Ortho Imagery
- Pilot Shoreline

## Lidar:
- Point Clouds
- DEMs
- Finalized Lidar Trajectory

## Shoreline and Reports:
- Shoreline
- Project Completion Report
- Quality Assurance Report

# Shumagin Island, AK Lidar

Tenix LADS



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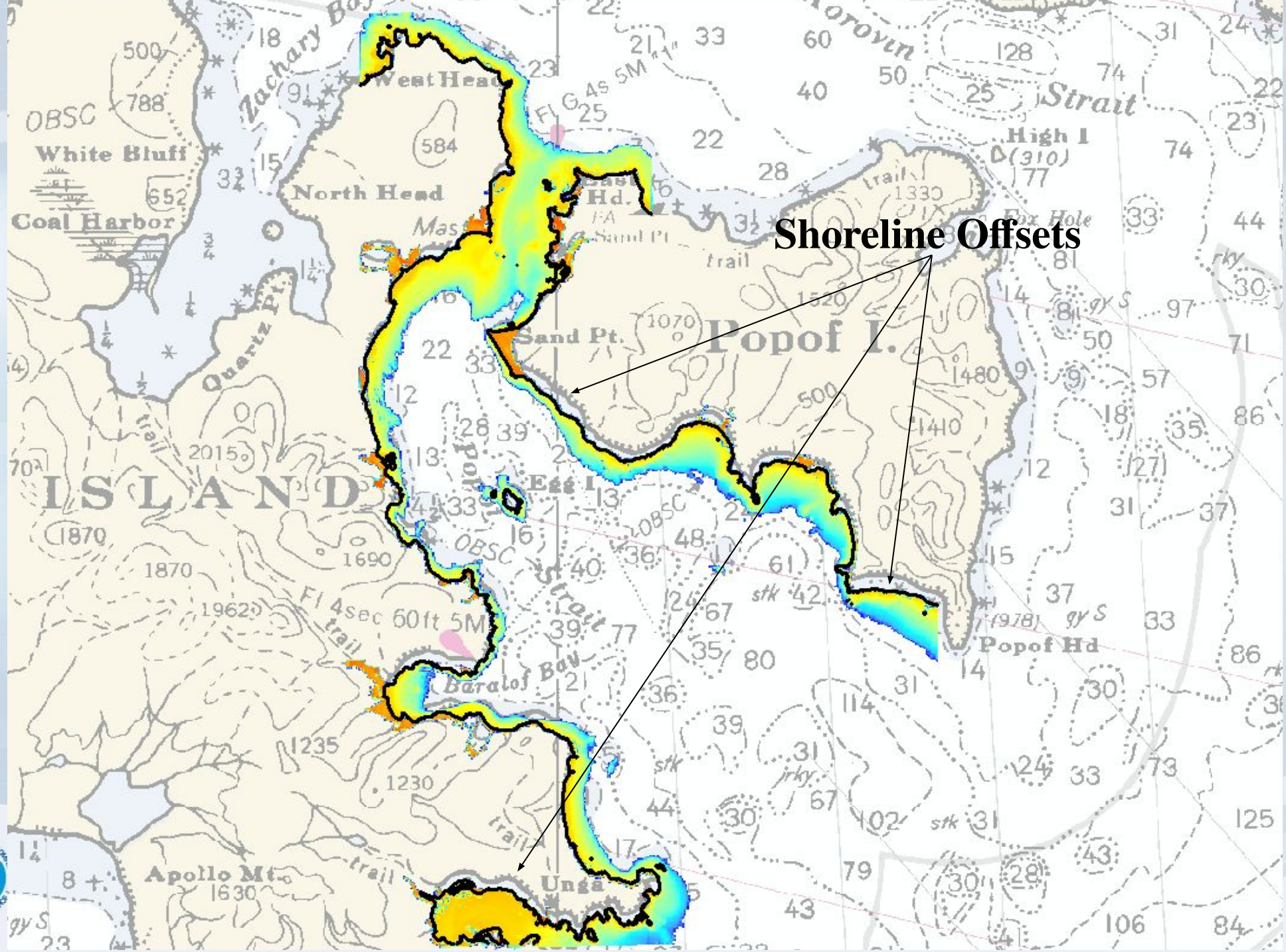
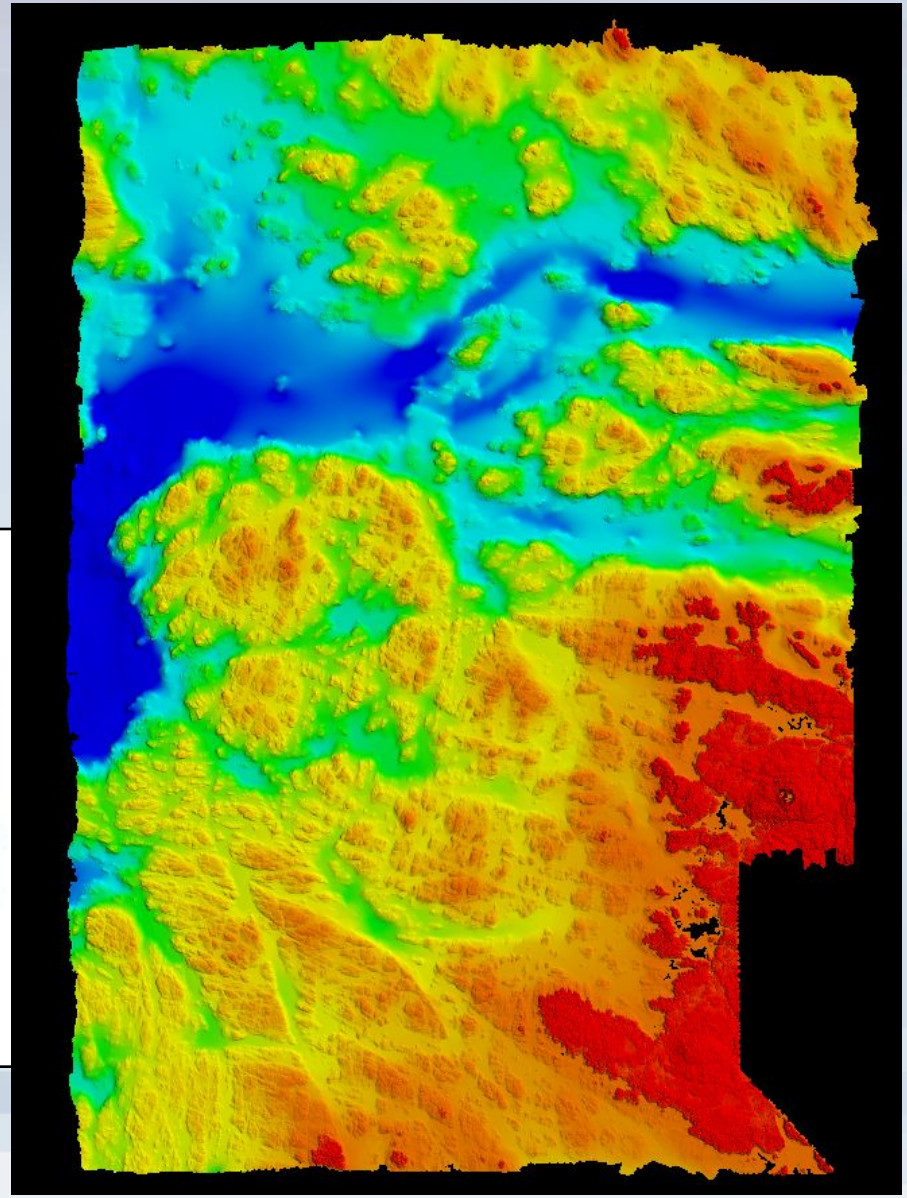

Shoreline Offsets
West Head
North Head
White Bluff
Coal Harbor
Quartz Pt.
Sand Pt.
Popof I.
ISLAND
Egg I
Popof Hd
Strait
High I
Baralof Bay
Apollo Mt
Unga
Fl 4sec 60ft 5M

# Sitka, AK Lidar

Optech

SHOALS



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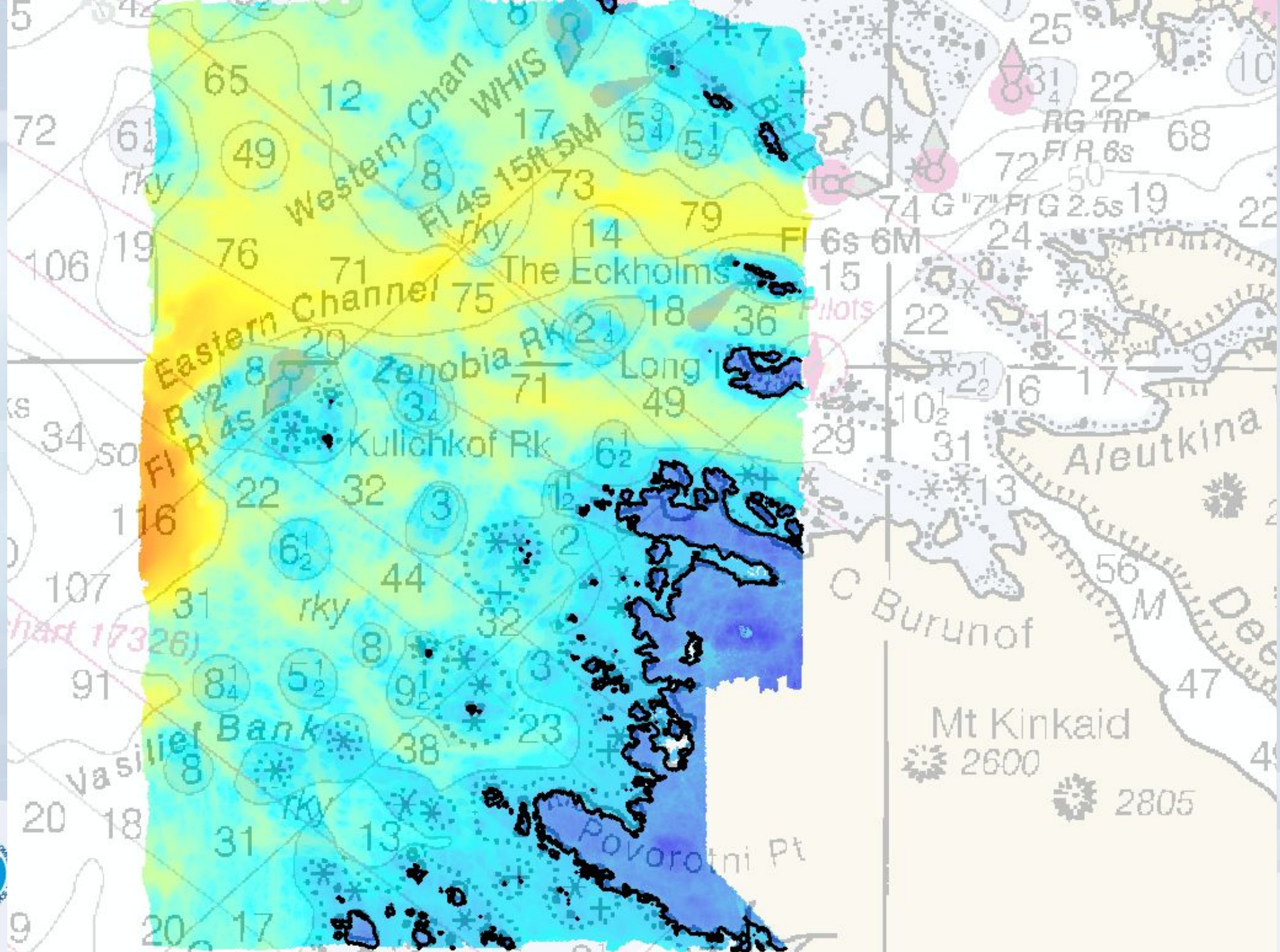
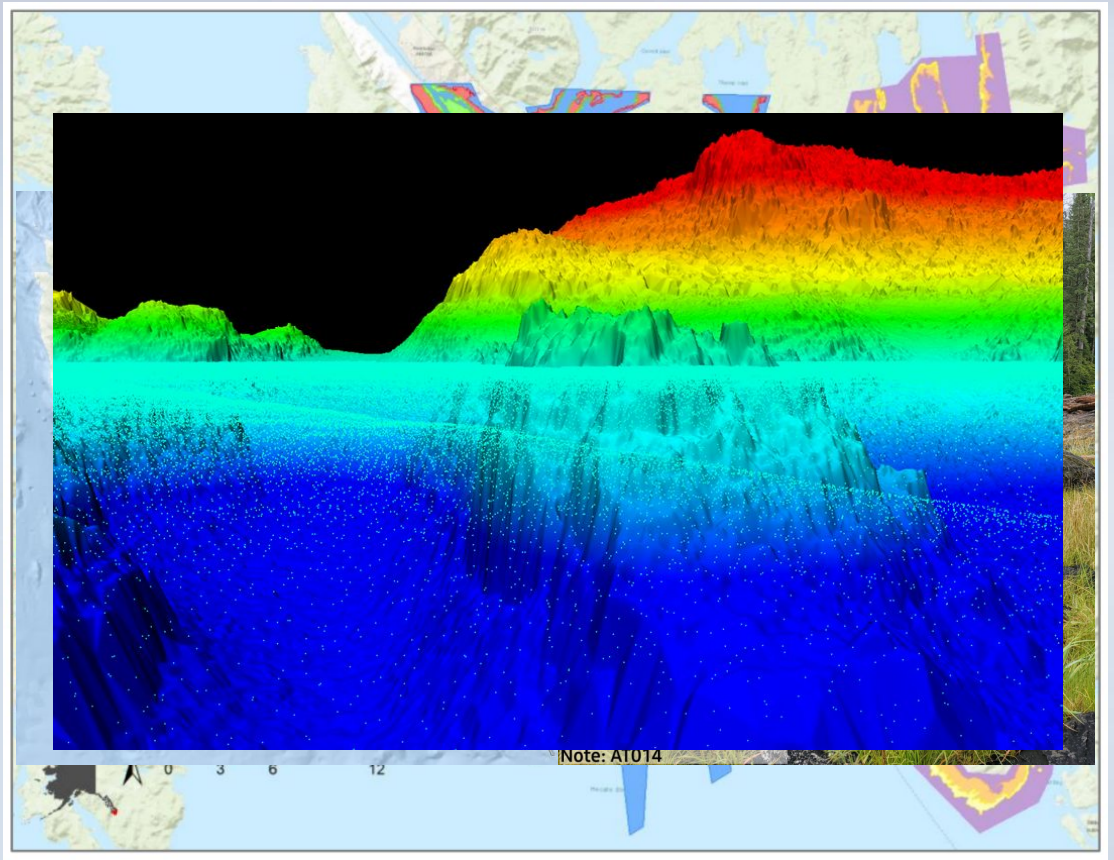
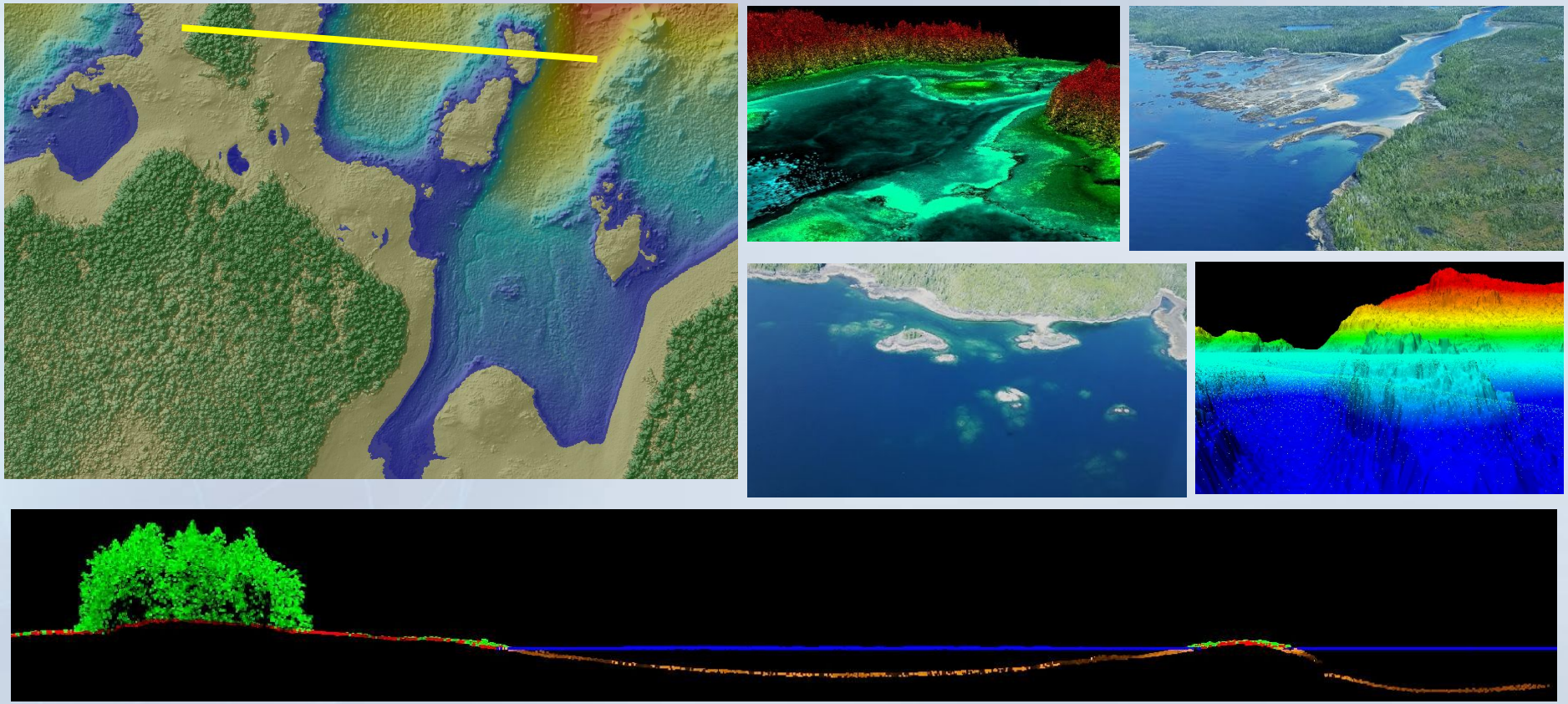

Western Chan
WHIS
Fl 4s 15ft 5M
Eastern Channel
The Eckholms
Fl 6s 6M
Zenobia Rk
Long I
Kulichkof Rk
Fl R 4s
RG "RP"
Fl R 6s
74 G "7" Fl G 2.5s
Aleutkina
C Burunof
Mt Kinkaid
2600
2805
Bank
Povorotni Pt
Pilots

# **Coastal Mapping Program (CMP):** Revillagigedo Channel, AK

- **Sensors**
  - Leica Chiroptera 4X/Hawkeye 4X (topobathy)
  - Riegl 1560ii (NIR)
  - UltraCam Eagle (4 band Imagery)
- **Acquisition**
  - Initial Area – 6/8/21 – 7/3/21
  - Optional Area – 7/30/21 – 8/2/21
  - Imagery in Optional Area is still pending due to weather
- **Ground Survey**
  - Limited paved/hard ground
  - Access mostly by boat
- **Bathy Penetration**
  - Average depth of extinction ~12 meters
  - Max depths ~16-20+ meters



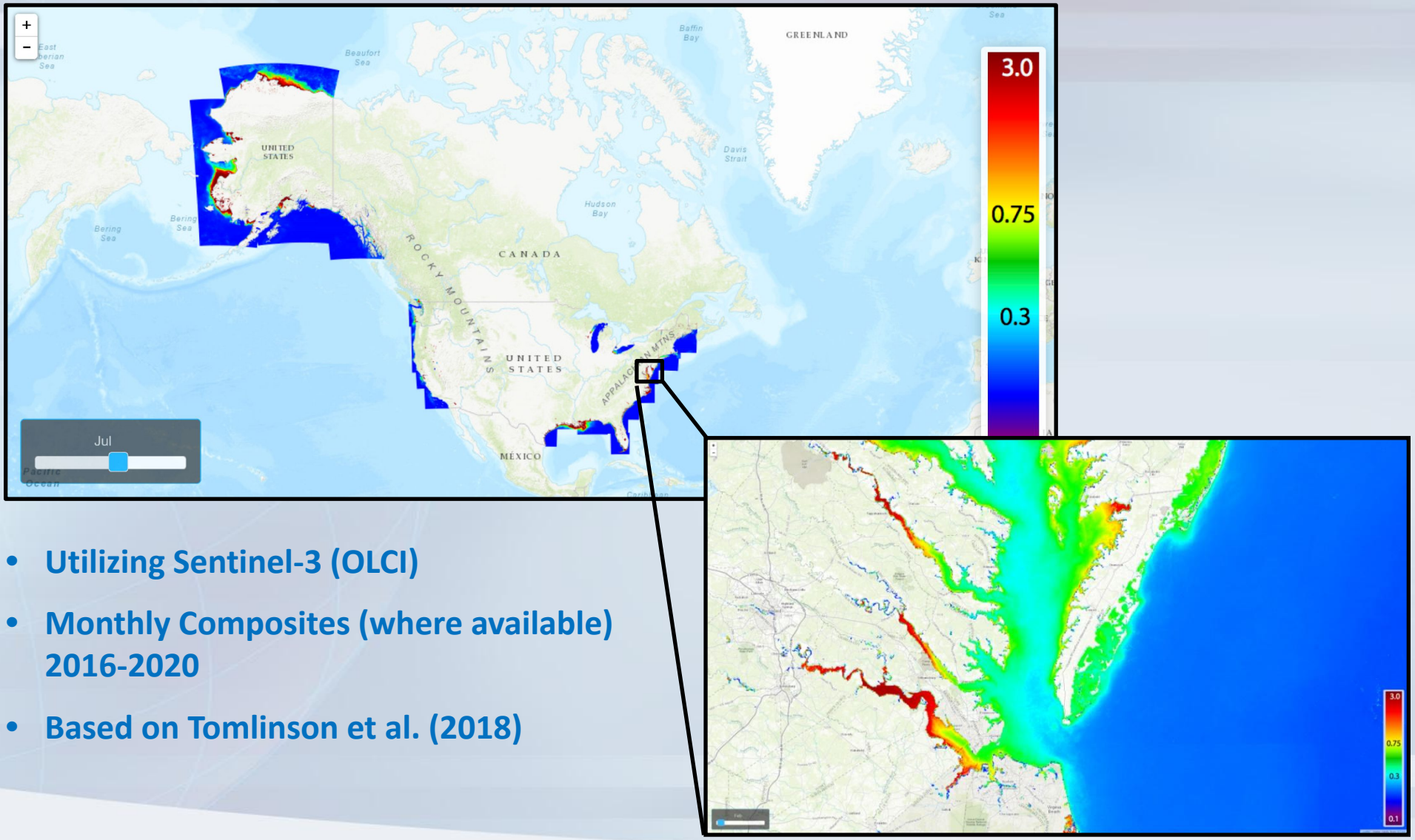
# **Coastal Mapping Program (CMP):** Revillagigedo Channel, AK



National Oceanic and Atmospheric Administration

NV5 GEOSPATIAL
powered by QUANTUM SPATIAL

# NCCOS/NGS: Kd Climatological Maps

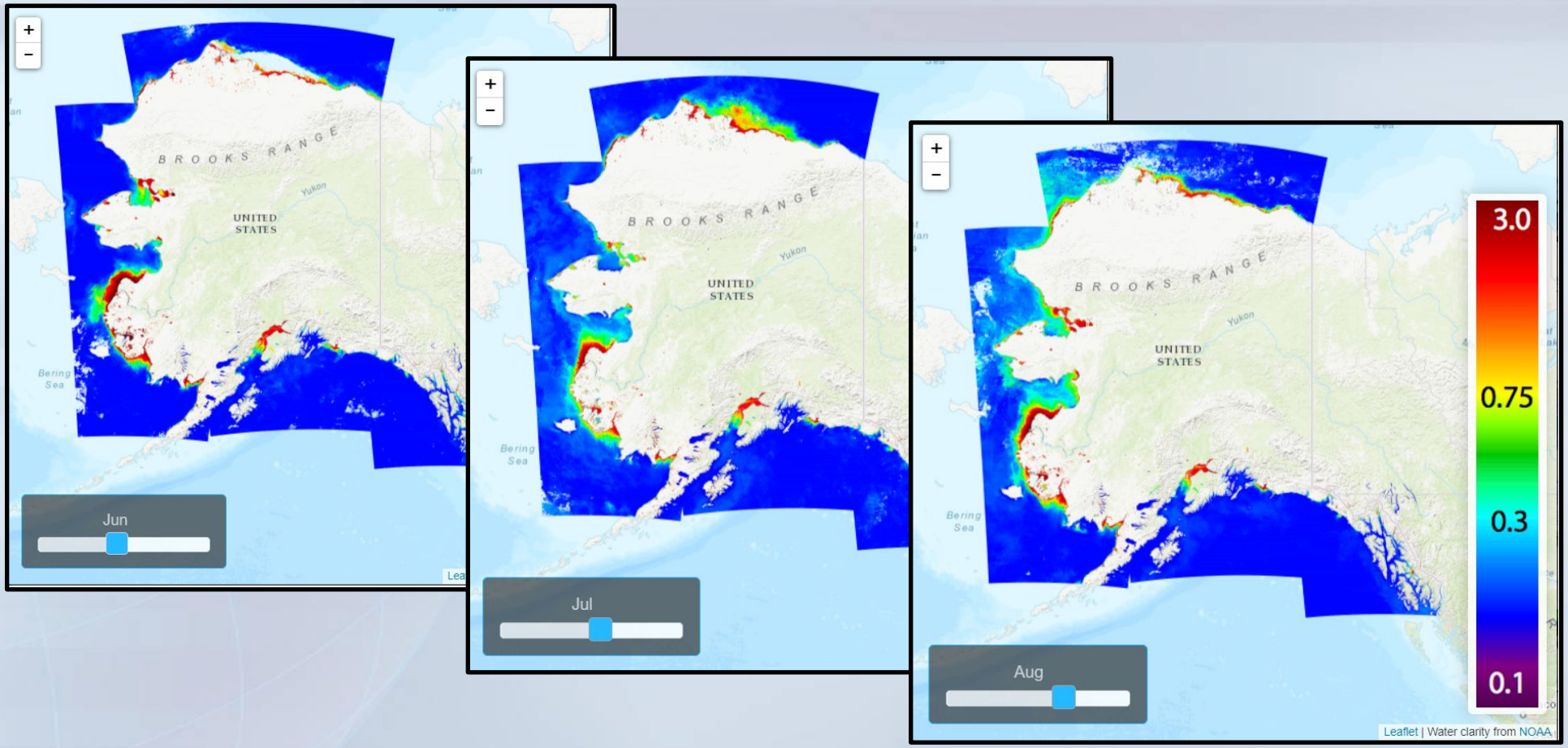



- Utilizing Sentinel-3 (OLCI)
- Monthly Composites (where available) 2016-2020
- Based on Tomlinson et al. (2018)

(Select areas are being reprocessed to remove bottom interference from the shallow water.)

National Oceanic and Atmospheric Administration

# Water Clarity




National Oceanic and Atmospheric Administration

# Revillagigedo, AK Buoy Deployments


National Oceanic and Atmospheric Administration

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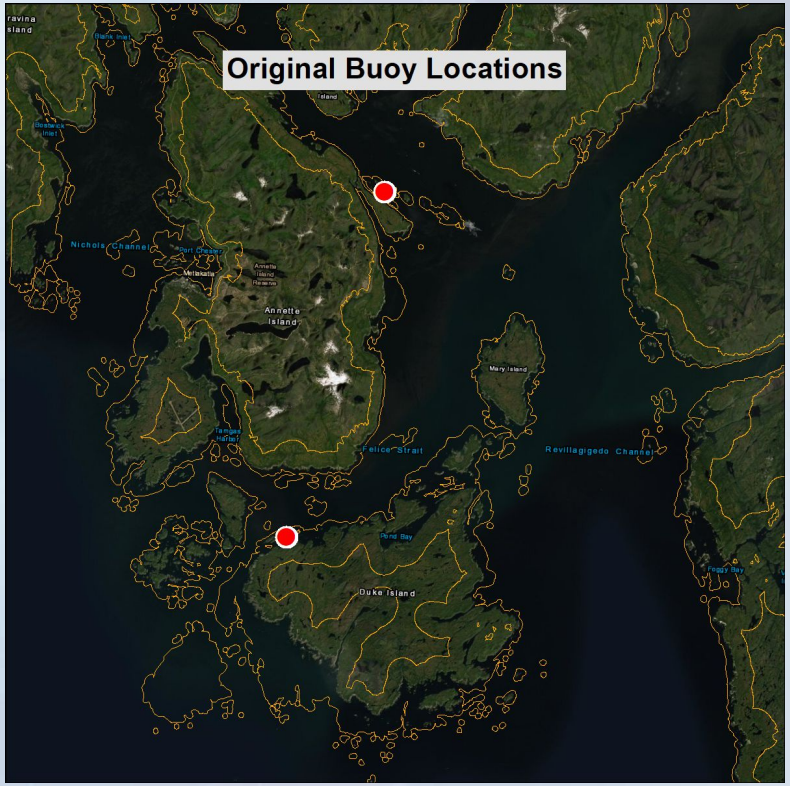
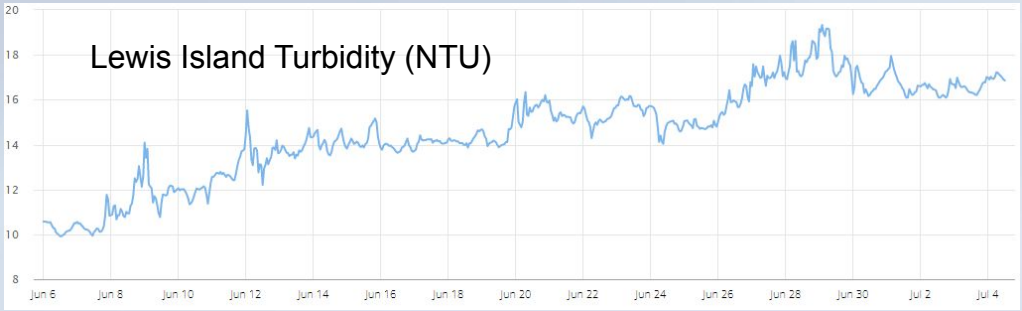
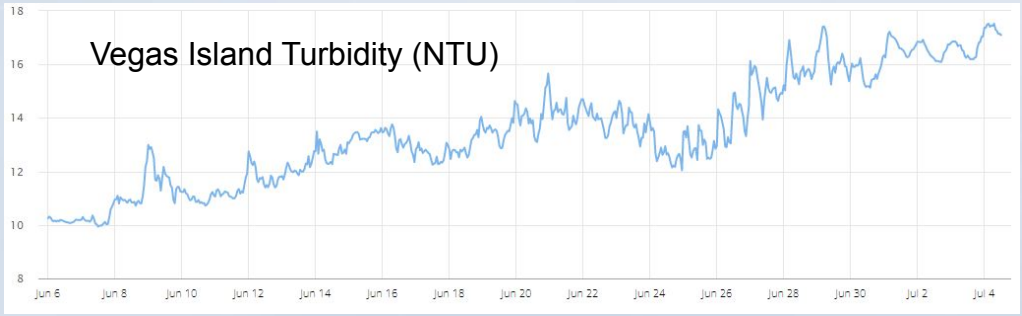
# **Revillagigedo, AK:** Buoy measurements – Original Deployment



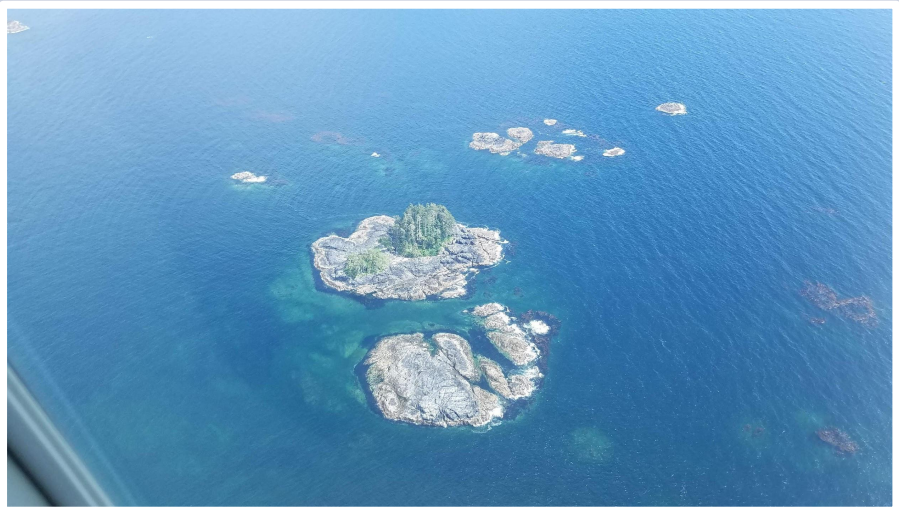



# **Revillagigedo, AK** Operator Photos

June 7th

Low tide 3.68 feet

Wind: 7-9 Knots from SE



July 2nd

Low tide 2.71 feet

Wind: 9-12 Knots from WNW

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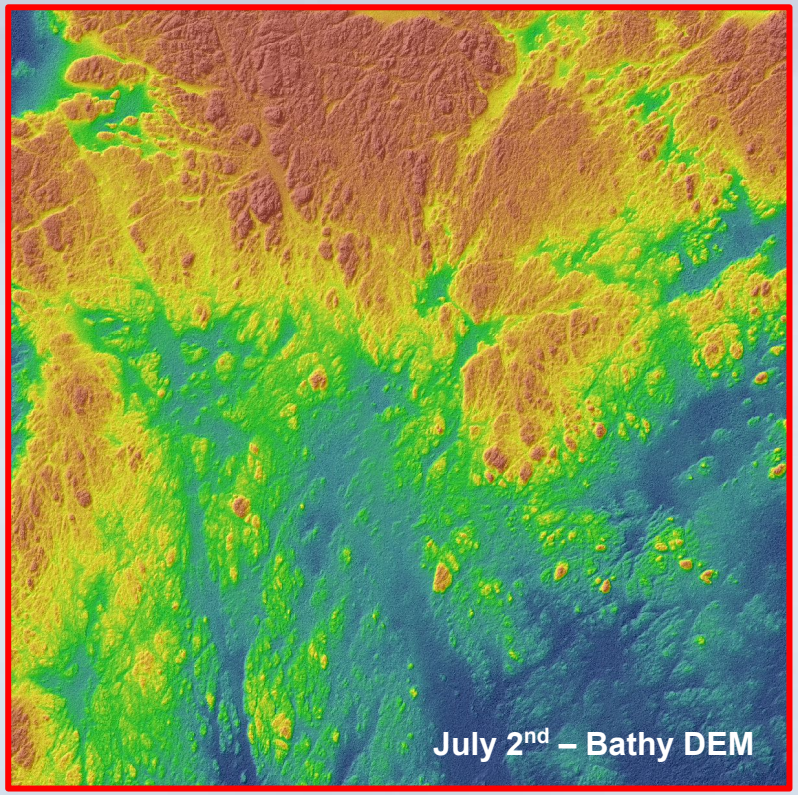
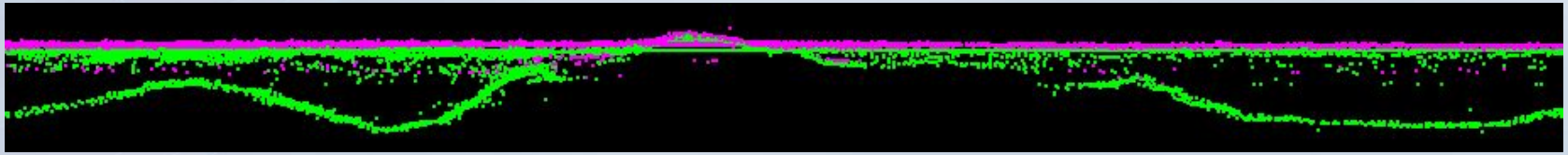
# Revillagigedo, AK Re-flights

Cross Section sample showing June (pink) vs July (green) – max depth in this cross section is about 10 meters.

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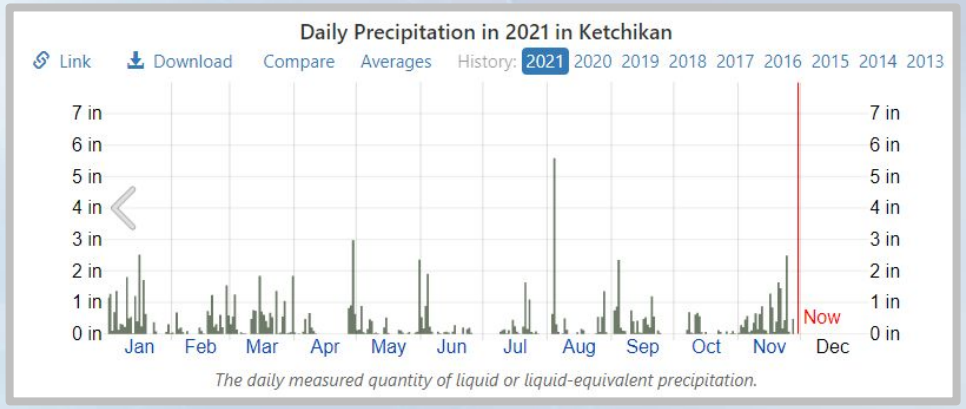
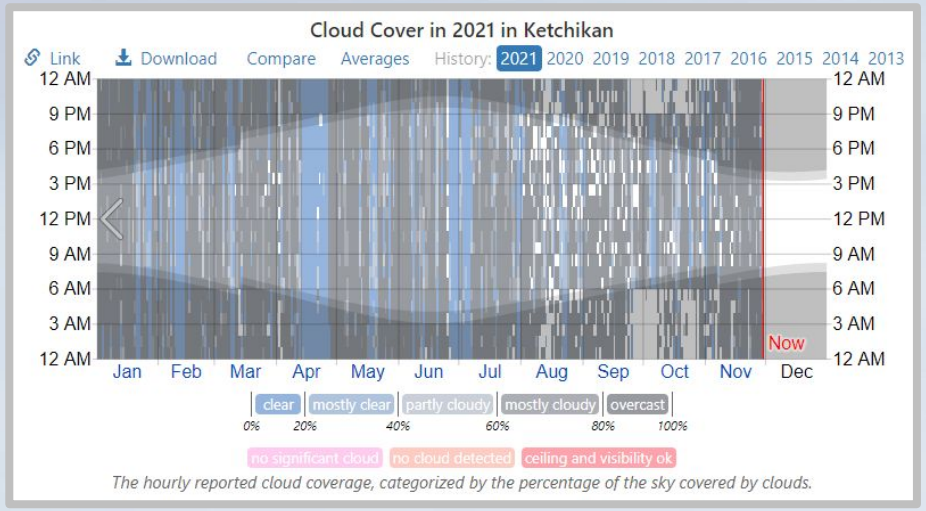
# **Revillagigedo, AK:** Weather a major Factor




*Weather Graphs from weatherspark.com*

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# Water Clarity

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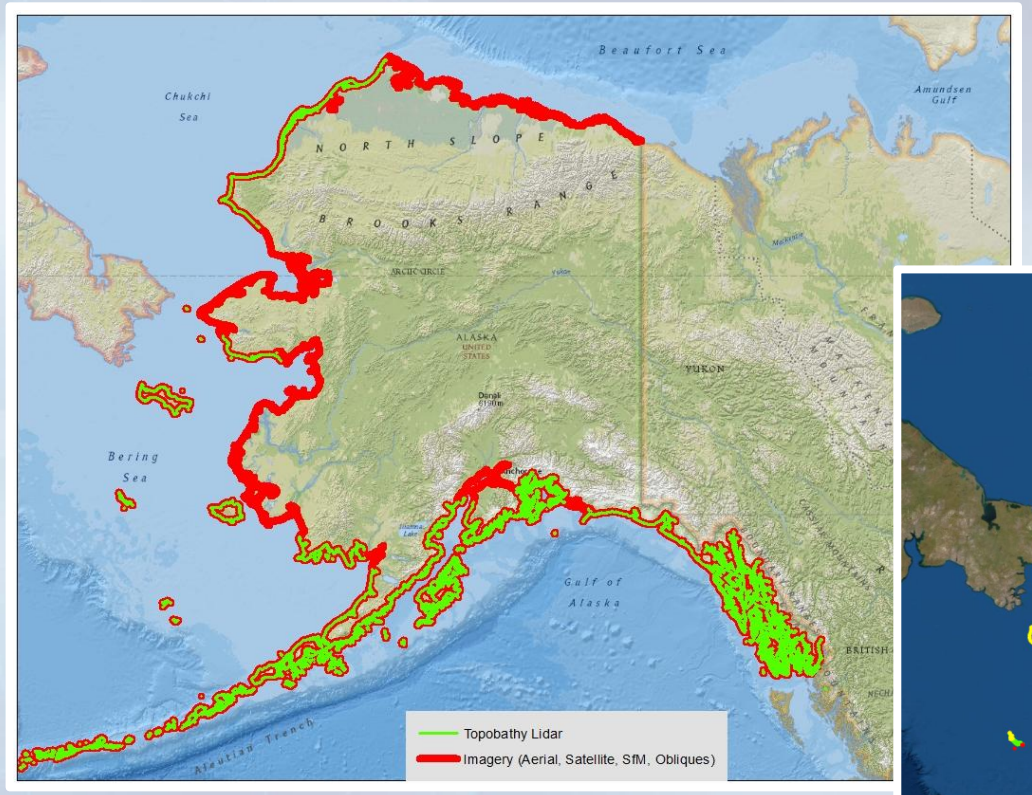
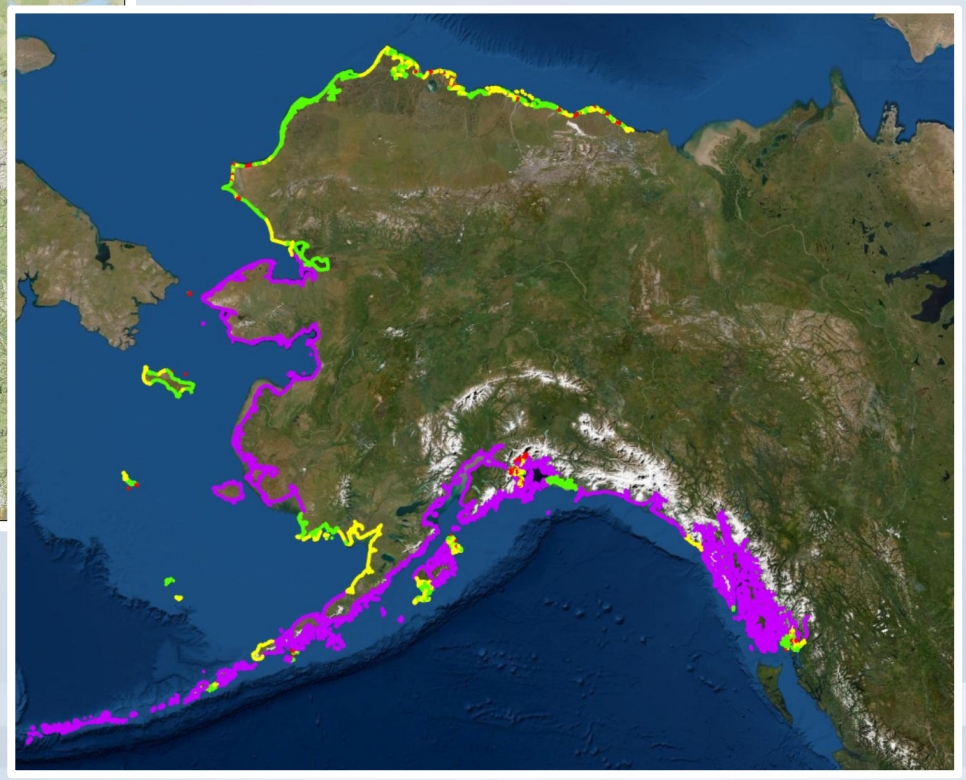
# Draft Strategy for Sensor Utilization is being Revamped



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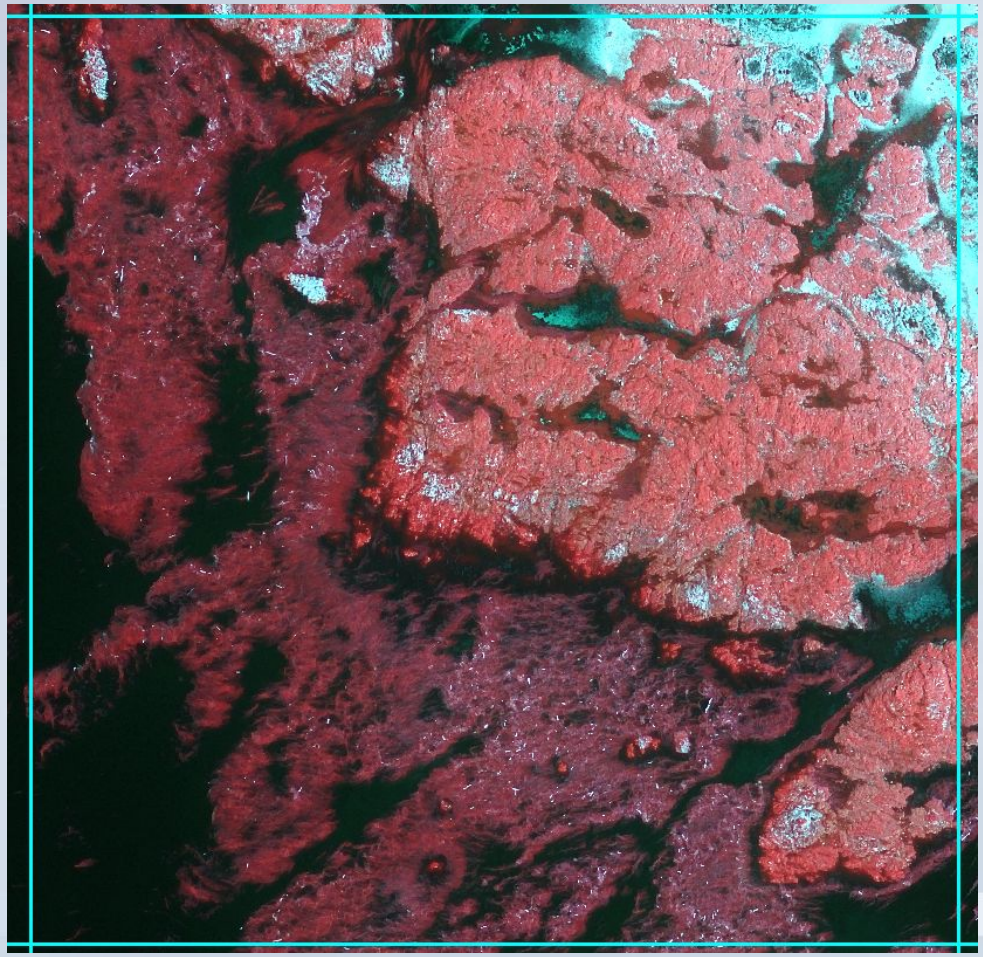
# Environmental Variables

- Weather (rain/fog/mist)
- Clouds
- Ice
- Snow
- Snow/Ice Melt
- Flooding
- Tides
- Kelp
- Funding?



# Questions?

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**NOAA National Geodetic Survey**
**stephen.a.white@noaa.gov**


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# Session Q&A

Ask questions of our presenters by typing them into the question box, found in the menu bar to the right.  Click the triangle next to “Questions” to expand.

Poll Question:

# What technologies are you most excited about?

Aerial & Satellite Imagery

Satellite Derived Bathymetry

Structure from Motion

Topobathy Lidar

# 5 minute break

We will resume shortly