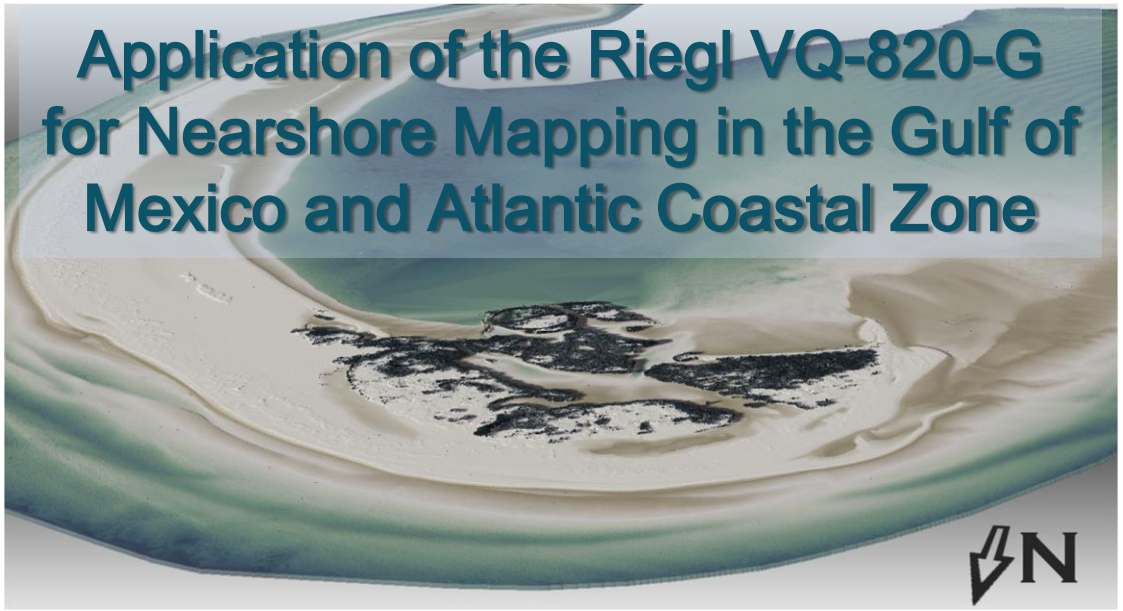
quantum SPATIAL

Application of the Riegl VQ-820-G for Nearshore Mapping in the Gulf of Mexico and Atlantic Coastal Zone



Colin Cooper

June 10th, 2014

JALBTCX

The Power of 3

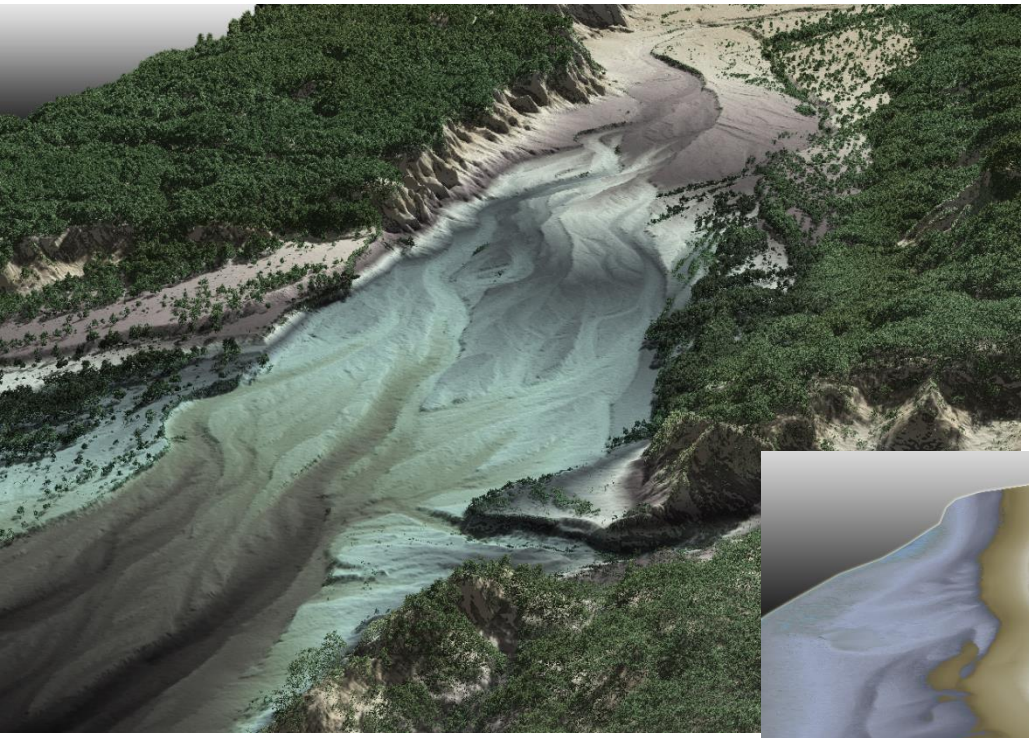
aerometric

PHOTO SCIENCE
Geospatial Solutions

WSI

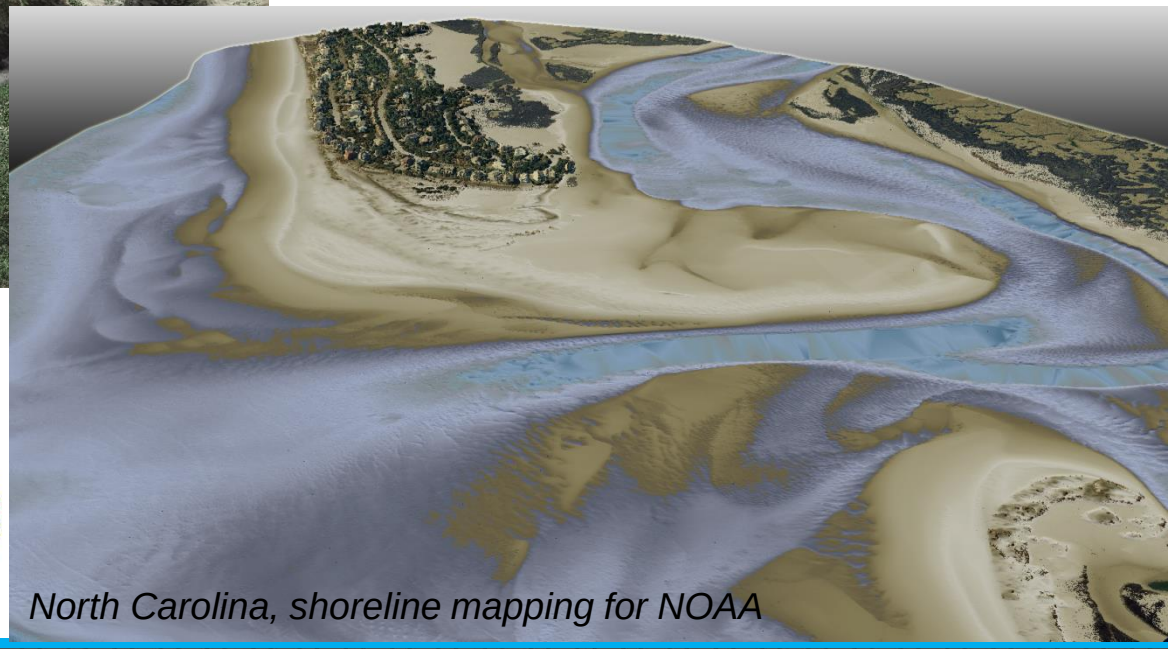
the future is quantum

From Rivers to Coast



Toutle River, WA, flown for USACE

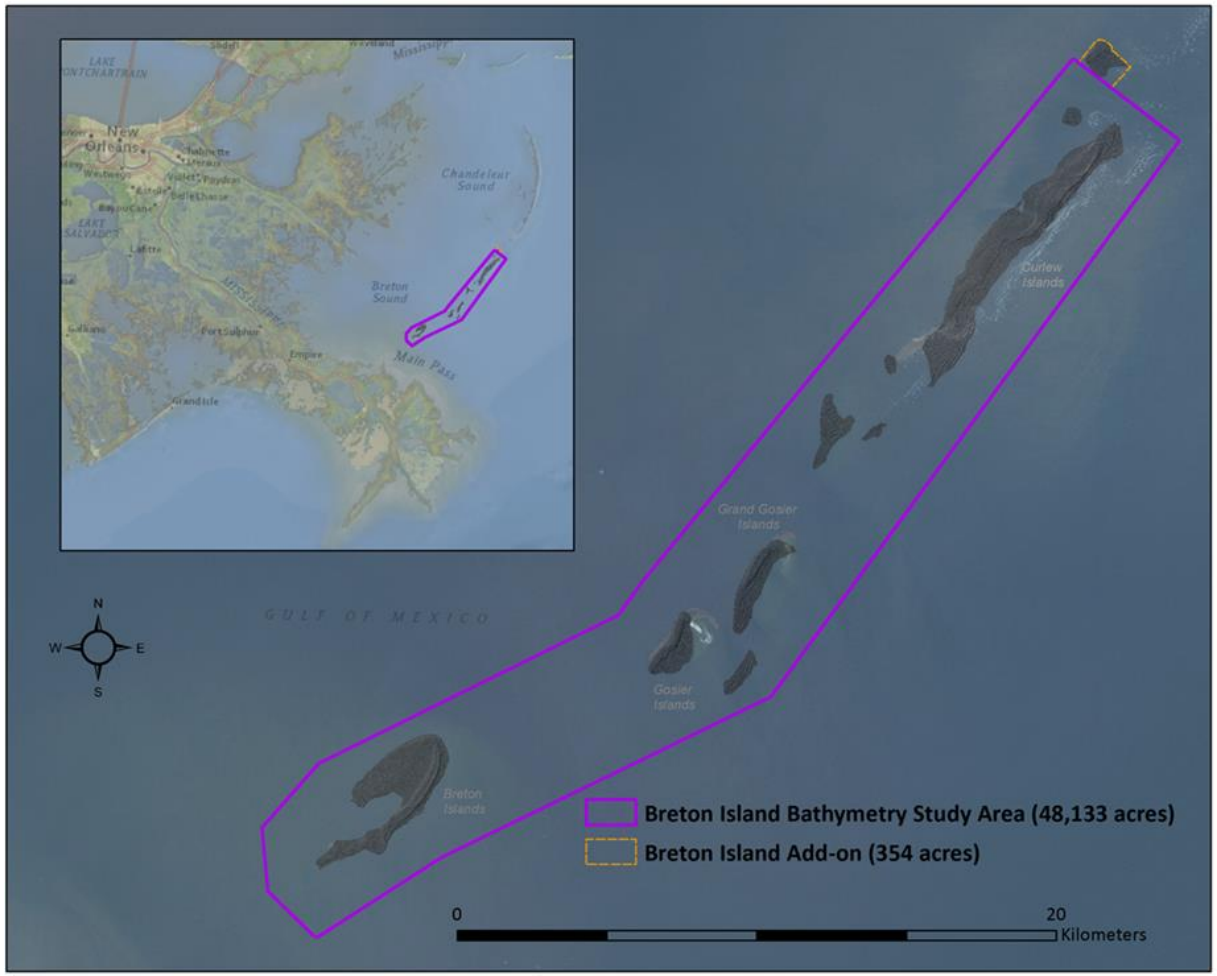
- Acquisition arm for NOAA NGS Shoreline mapping Program (Supplemental Sandy Topobathy LiDAR and Imagery Task)
- Calibration, Processing, QC, Imagery, Shoreline attribution



North Carolina, shoreline mapping for NOAA

Breton National Wildlife Refuge Topobathymetric Survey

- USGS Field Activity # 14LGC02
- 2.0 m NPS
- Landscape analysis and restoration efforts
- Specs based on USGS Spec v. 1.0



Sensor Selection

- Short laser pulse length
- High pulse rate
- High spatial accuracy for both terrestrial and bathymetric returns

LiDAR Survey Settings & Specifications	
Acquisition Dates	01/16/2014 01/18/2014
Aircraft Used	Cessna Caravan
Sensor	**Riegl VQ-820G**
Survey Altitude (AGL)	600 m
Target Pulse Rate	284 kHz
Laser Spot Diameter	60 cm
Field of View	40^0
GPS Baselines	≤13 nm
GPS PDOP	≤3.0
GPS Satellite Constellation	≥6
Maximum Returns	unlimited
Intensity	16-bit
Resolution/Density	≥ 4 pulses/m^2
Accuracy	$RMSE_Z$ ≤ 12.5 cm Land **$RMSE_Z$ ≤ 25 cm Submerged Land**

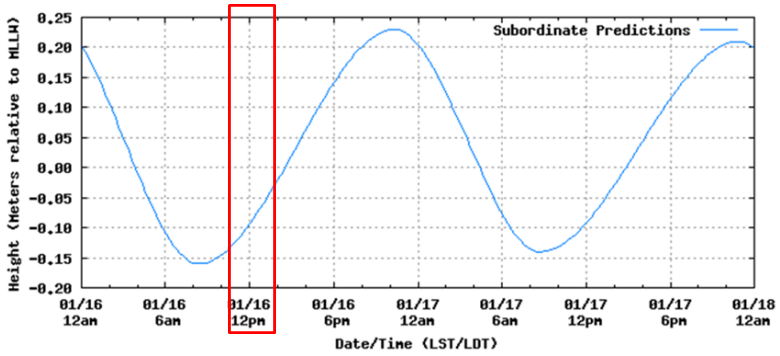
Riegl VQ-820G Bathymetric Sensor

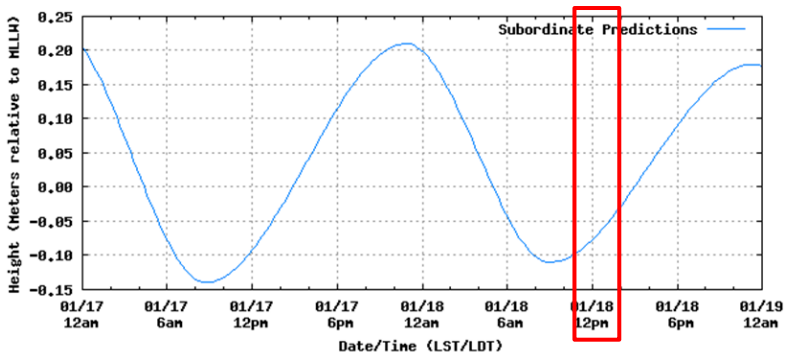
C.1.b.(vii)(c) **Water Clarity:**
(01) If possible, the USGS will monitor water clarity at the AOI. Ideal conditions would be 2.5' secchi disk depth or greater, however it is recognized that this is Louisiana and it rarely gets good water clarity, therefore, it will be flown at optimal water clarity.

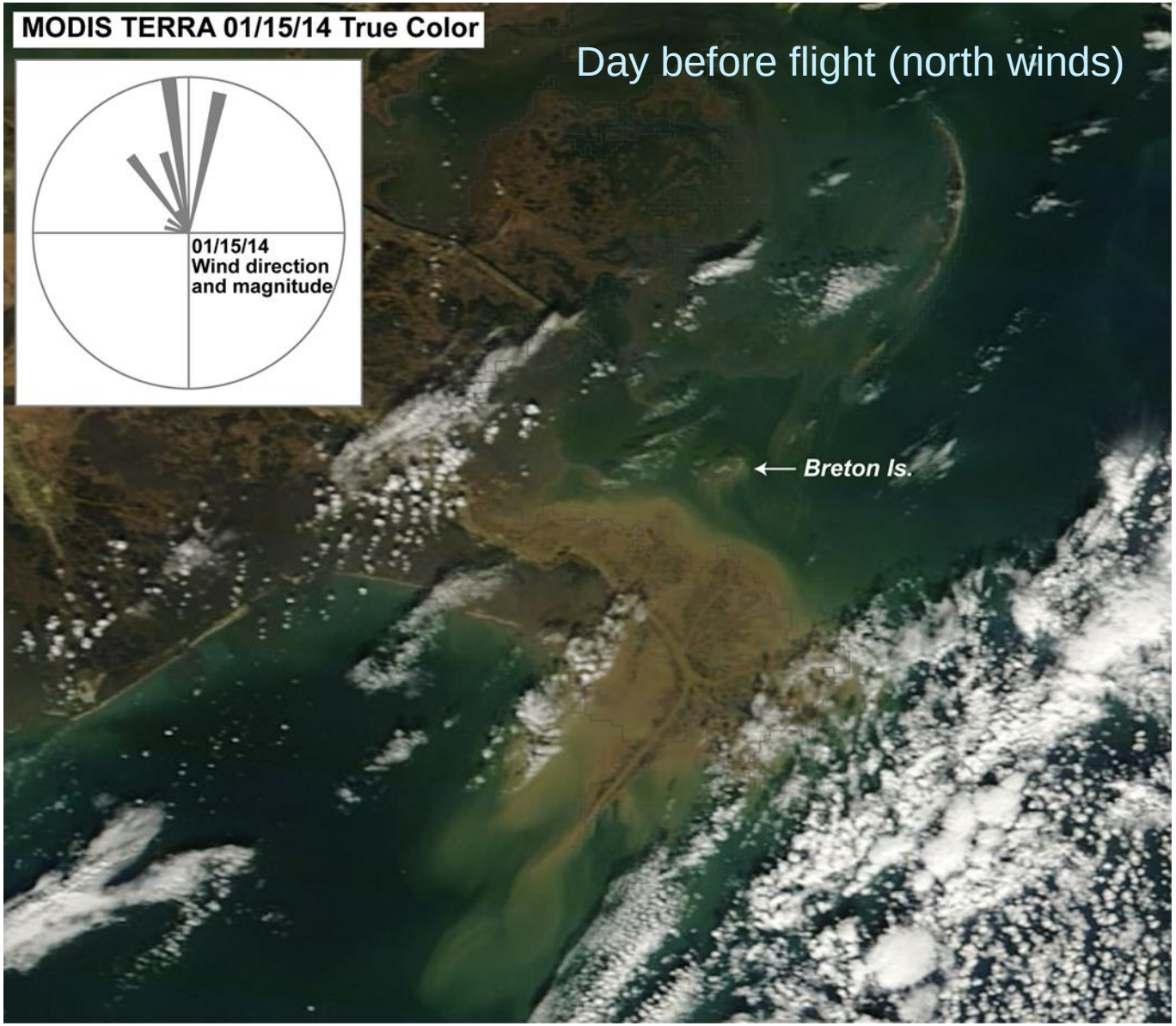
Acquisition

- Ground Control Survey conducted by USGS
  - 2 Monuments established
  - Land Cover check points collected
- Acquisition Window: Jan 6 – Feb 15 during +- 2 hours of MLLW
- Mississippi River mud a real challenge

USGS gauging station no. 8760172 in Chandeleur Light, Louisiana



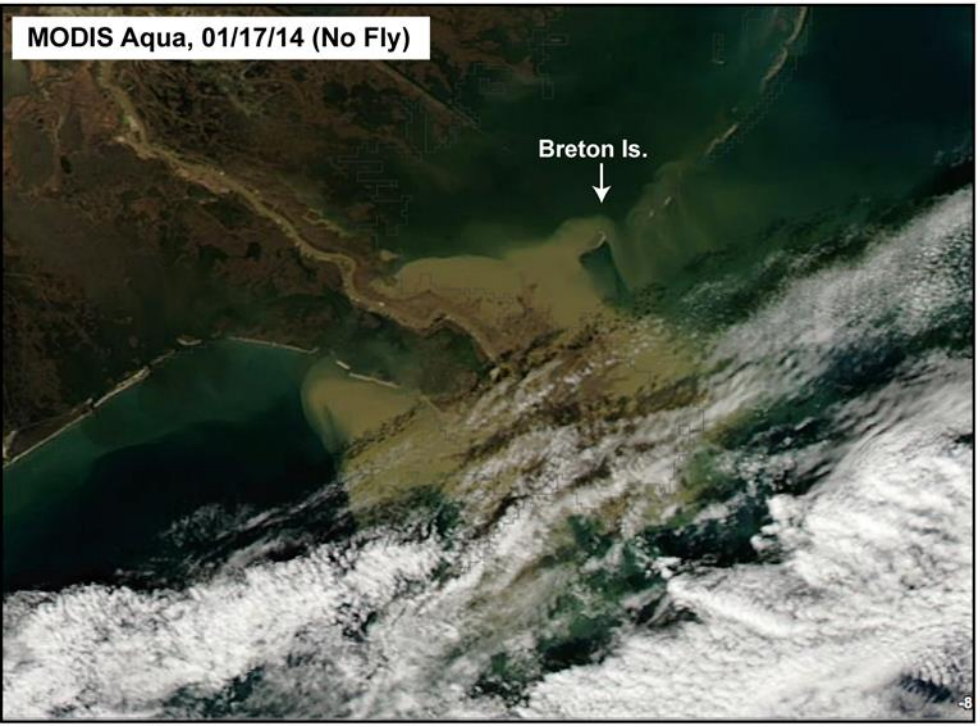




USGS
science for a changing world

USGS
science for a changing world

Day 2 (no fly)



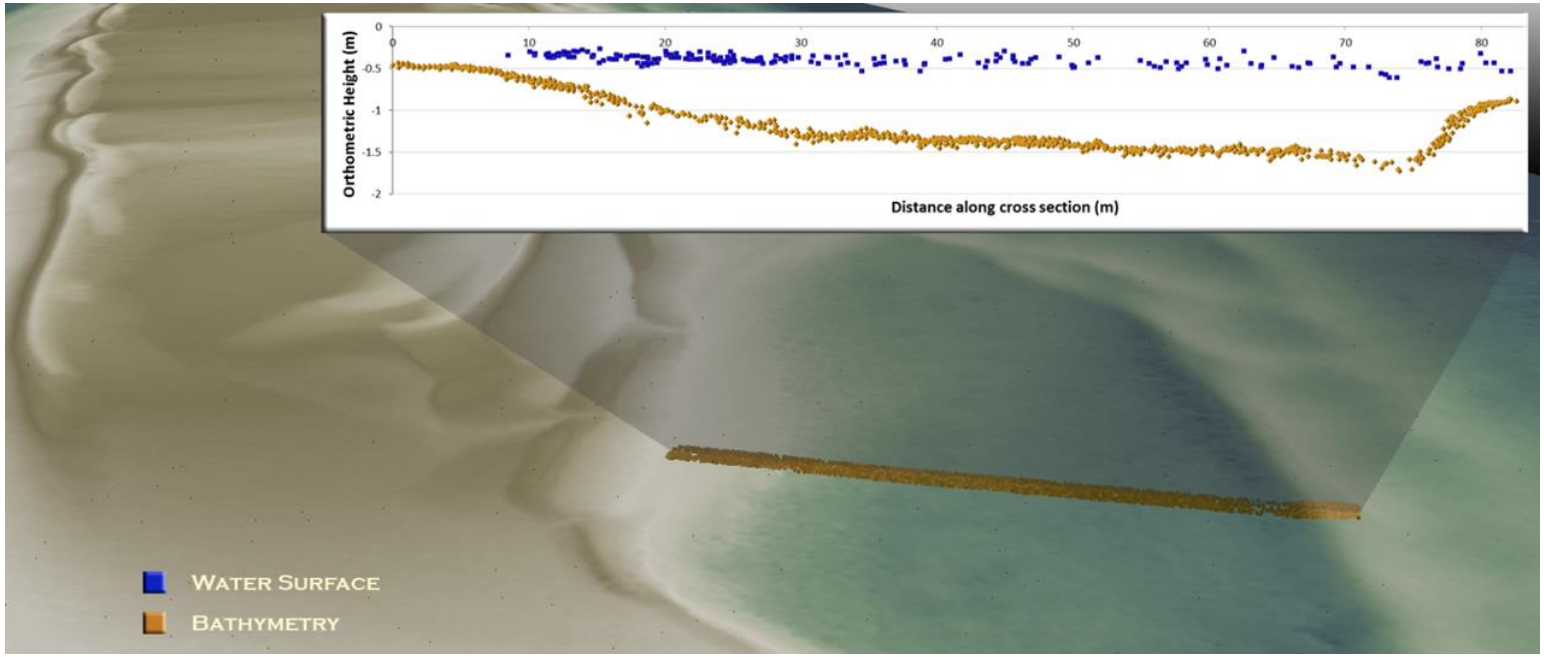
Day 3 (optimal)

USGS science for a changing world

Secchi depths of 1 & 1.4 meters reported by USGS

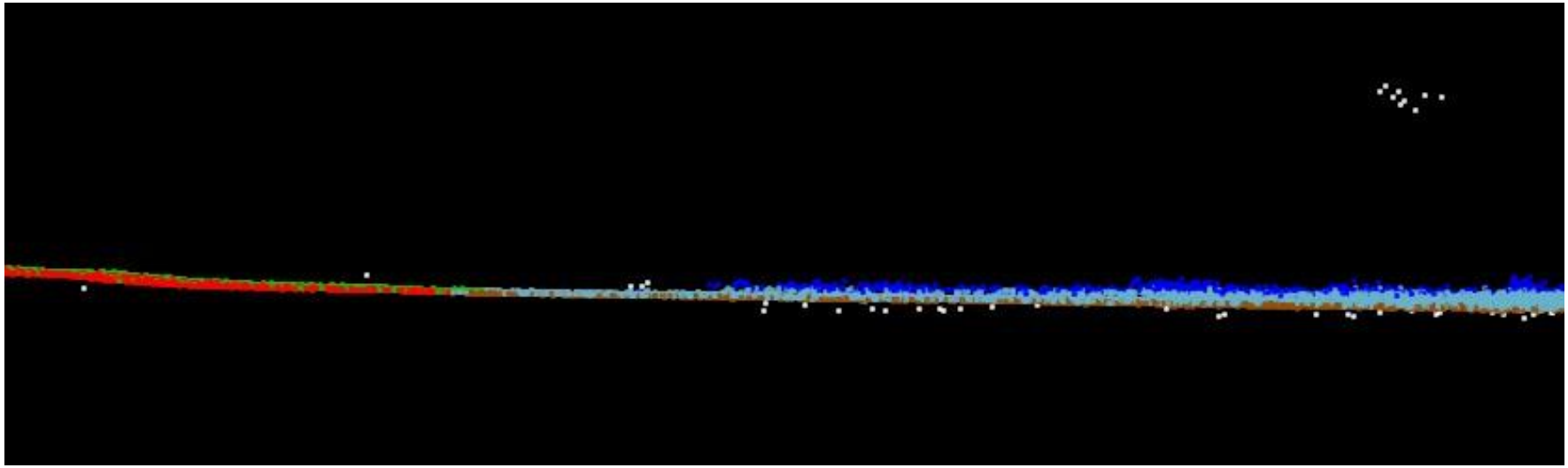
Processing

- Initial Calibration completed in RiProcess 1.5.9
- Refraction Correction processed in RiProcess 1.5.9
- Additional line to line and mission to mission calibration performed in TerraMatch 14

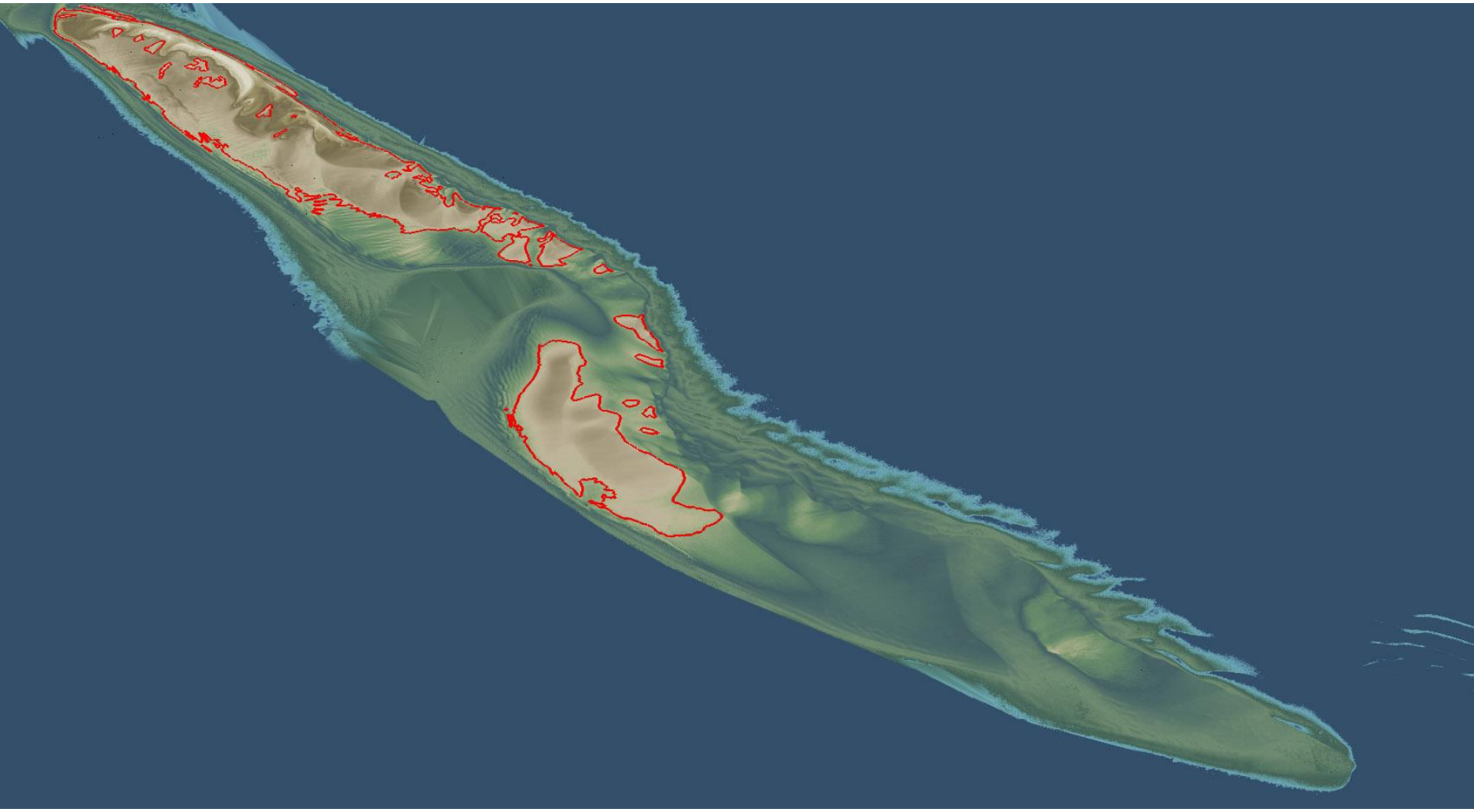


Classification

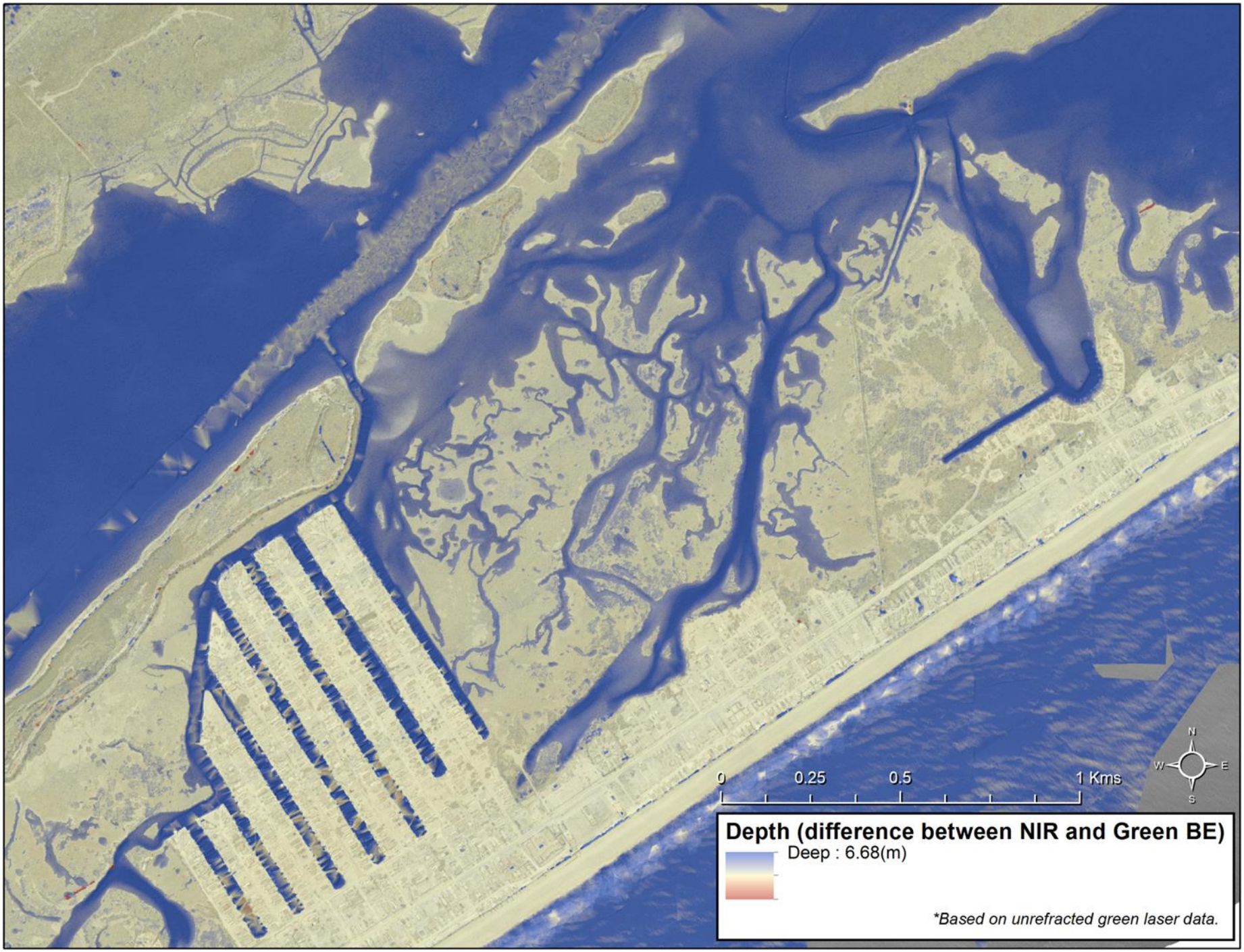
Classification Number	Classification Name	Classification Description
1 (green)	Default	Laser returns that remain unclassified
2 (red)	Ground	Bare earth ground, determined by a number of automated and manual cleaning algorithms
7 (white)	Noise	Laser returns that are often associated with birds, multipath, and atmospherics
25 (light blue)	Water Column	Water column
26 (brown)	Bathymetric Point	Submerged topography
27 (dark blue)	Water Surface	Water surface from bathymetric LiDAR

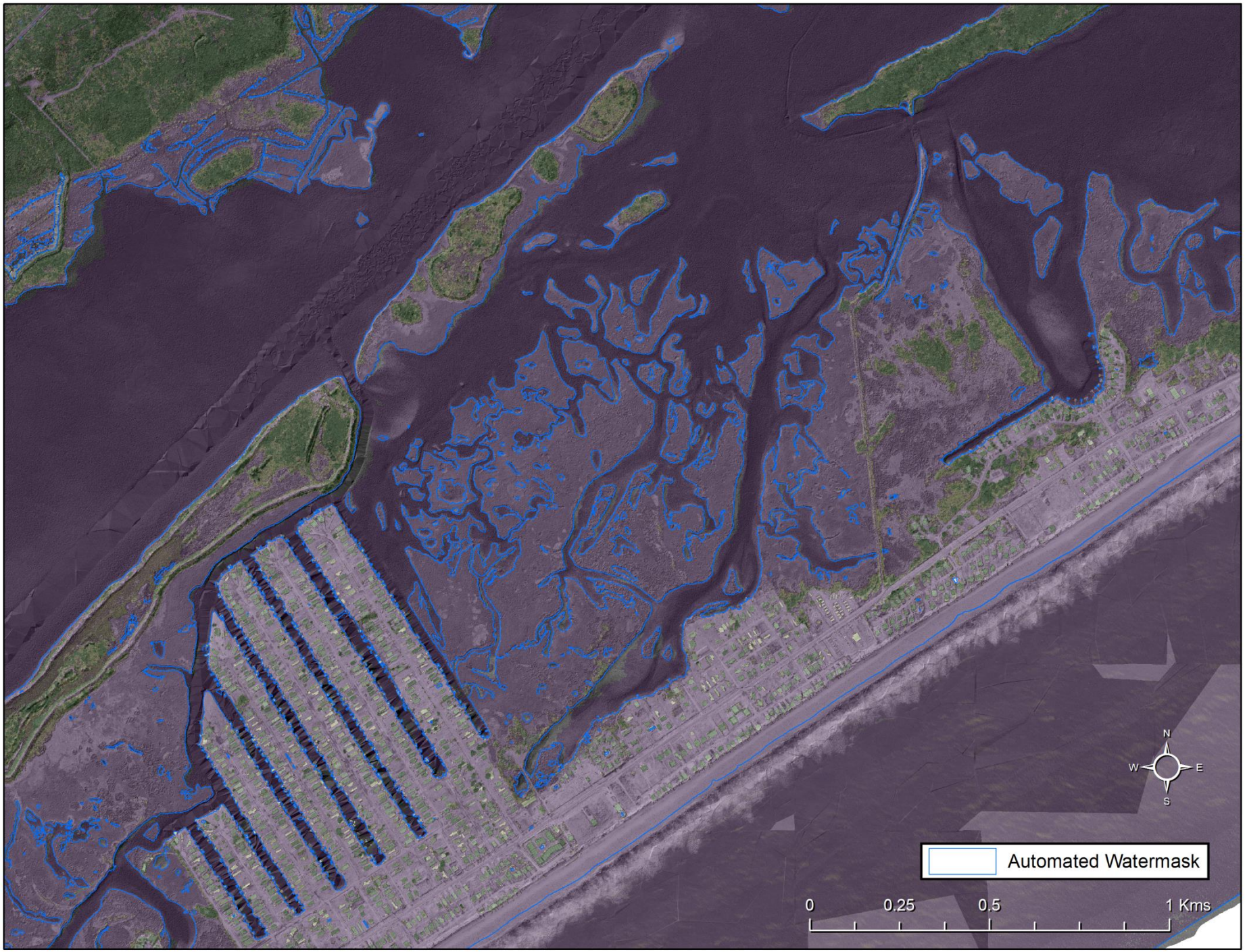


Breaklines

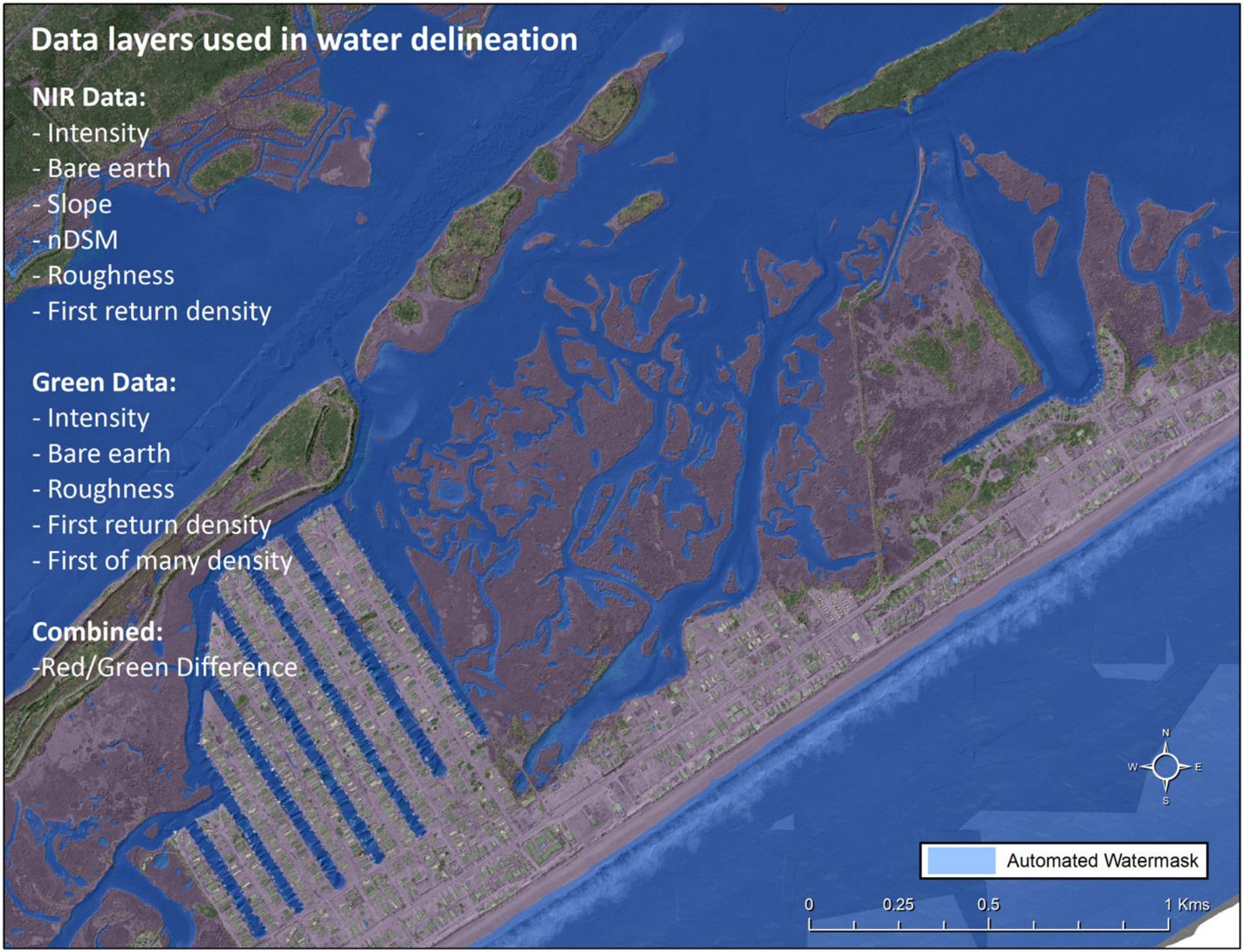



Height from ground (NIR Laser)
High : 5
Low : 0
Intensity (Green Laser)
High : 655.35
Low : 0.32
*Based on unrefracted green laser data.
N
W
E
S
0
0.25
0.5
1 Kms


0
0.25
0.5
1 Kms
N
W
E
S
Depth (difference between NIR and Green BE)
Deep : 6.68(m)
*Based on unrefracted green laser data.


N
W
E
S
Automated Watermask
0
0.25
0.5
1 Kms

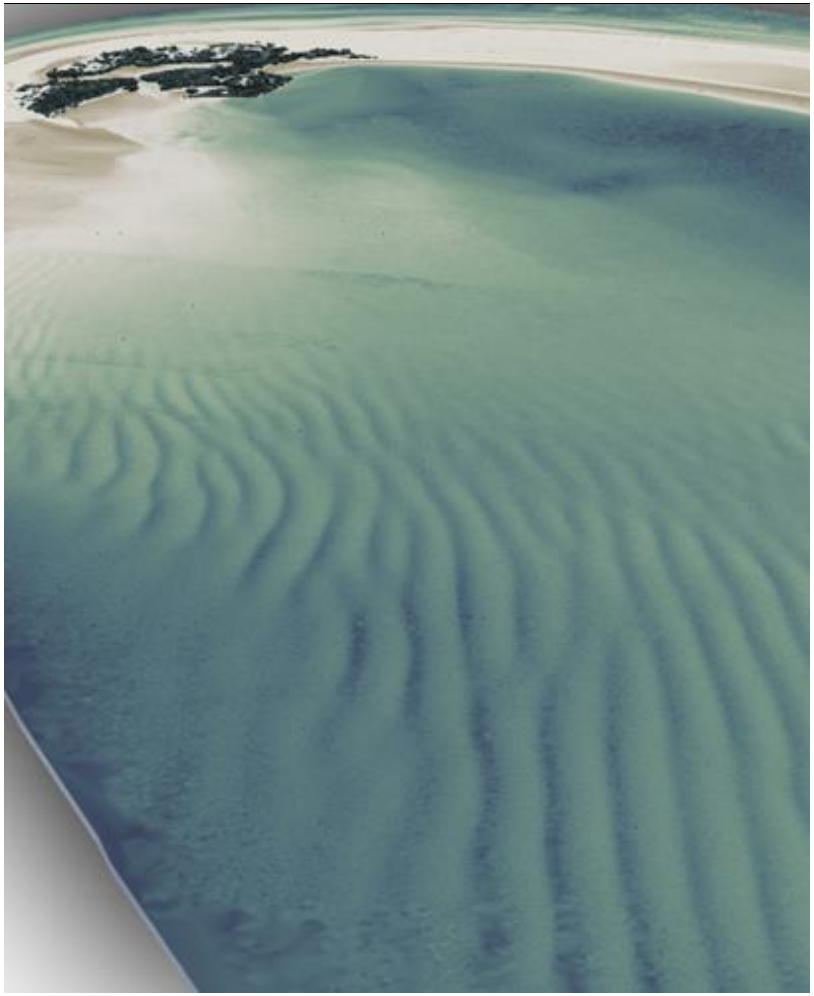

N
W
E
S
Automated Watermask
0
0.25
0.5
1 Kms


Data layers used in water delineation
NIR Data:
- Intensity
- Bare earth
- Slope
- nDSM
- Roughness
- First return density
Green Data:
- Intensity
- Bare earth
- Roughness
- First return density
- First of many density
Combined:
-Red/Green Difference
N
W
E
S
Automated Watermask
0
0.25
0.5
1 Kms

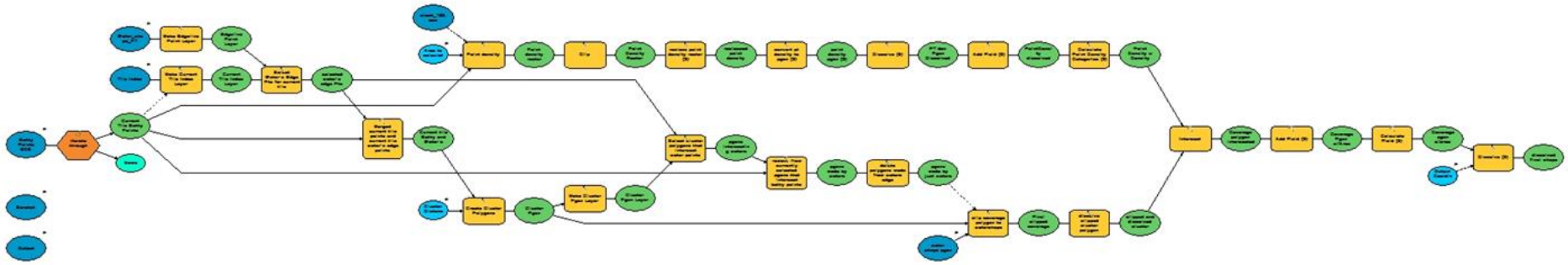
Products

Points	LAS v 1.2 • Classified Point Cloud • Raw Swaths
Rasters	1.0 Meter ERDAS Imagine Files (*.img) and GeoTiffs • Combined Topobathymetric Bare Earth Model (Unclipped) • Combined Topobathymetric Bare Earth Model (Clipped)* • Depth Model* 1.0 Meter GeoTiffs • Intensity Images (All Returns) • Intensity Images (Bathymetry and Terrestrial Returns)*
Vectors	Shapefiles (*.shp) • Site Boundary • LiDAR/DEM Tile Index • Water's Edge Delineation • Submerged Bathymetric Depth/Confidence

**QSI delivered these products in addition to contracted products*



Create Clipped DEM

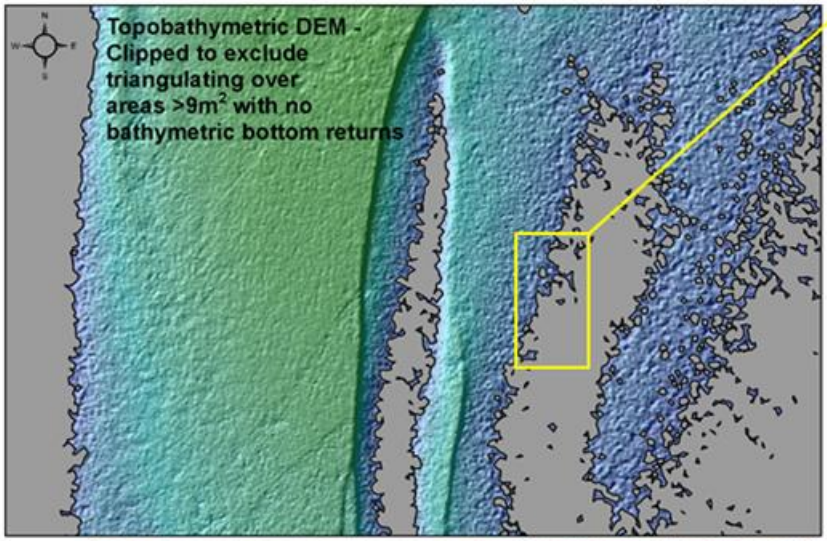


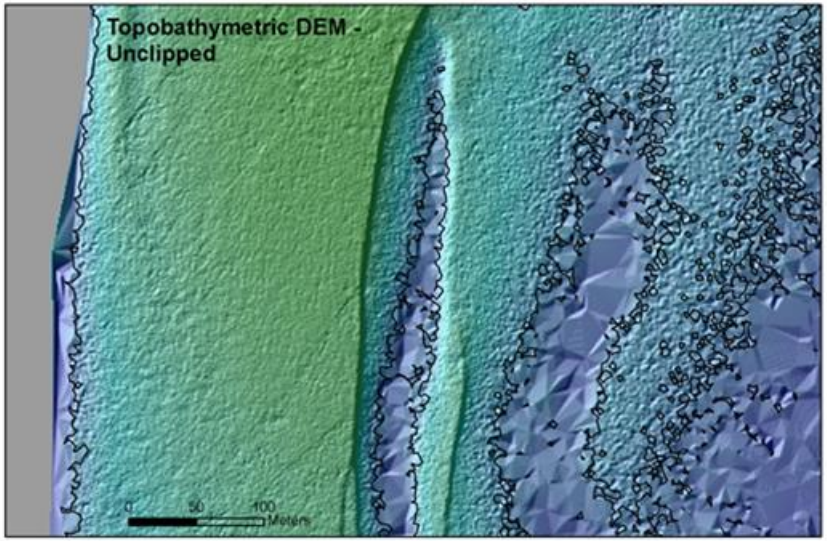
- Create cluster polygons

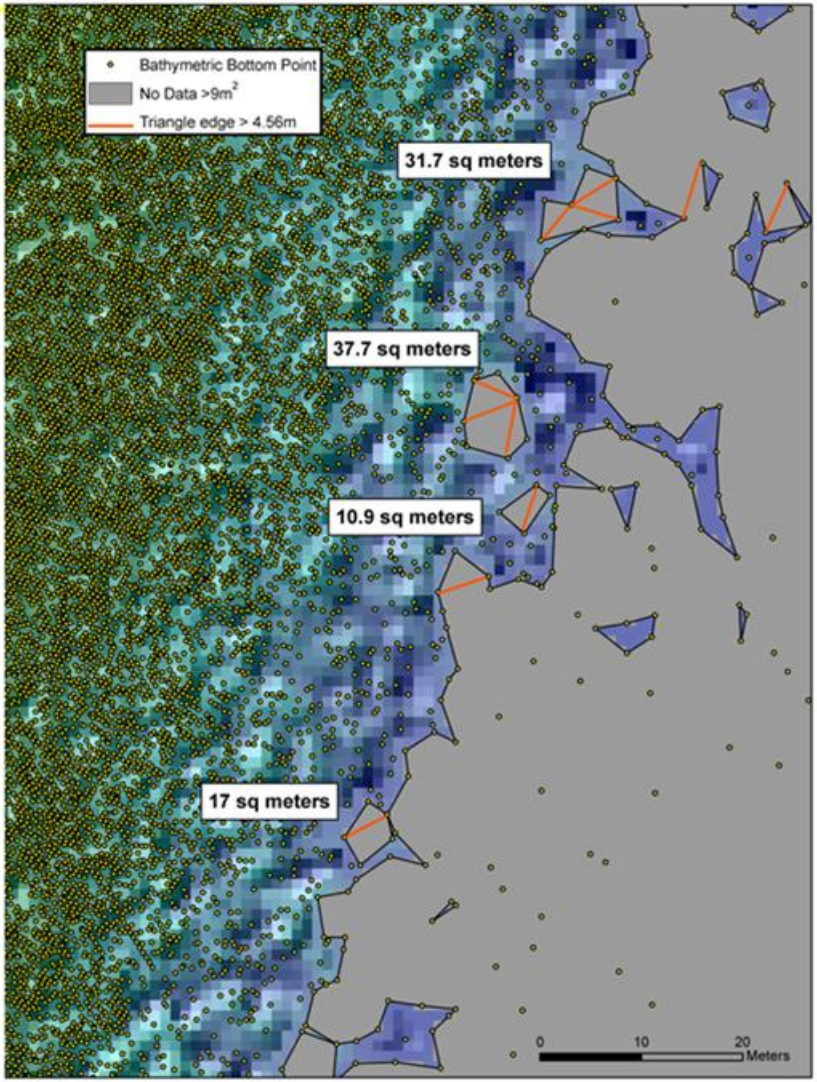
$$CT = \sqrt{(2*\text{void area}/0.866)}$$

CT = max △ edge length, determined by area to be considered void

Inputs		Parameters
Bathymetric Bottom Points		CT
Water's edge polygon		Void area
Tile Index		Output coordinate system
Snap raster		


Topobathymetric DEM - Clipped to exclude triangulating over areas >9m² with no bathymetric bottom returns


Topobathymetric DEM - Unclipped
0
50
100
Meters


Bathymetric Bottom Point
No Data >9m²
Triangle edge > 4.56m
31.7 sq meters
37.7 sq meters
10.9 sq meters
17 sq meters
0
10
20
Meters

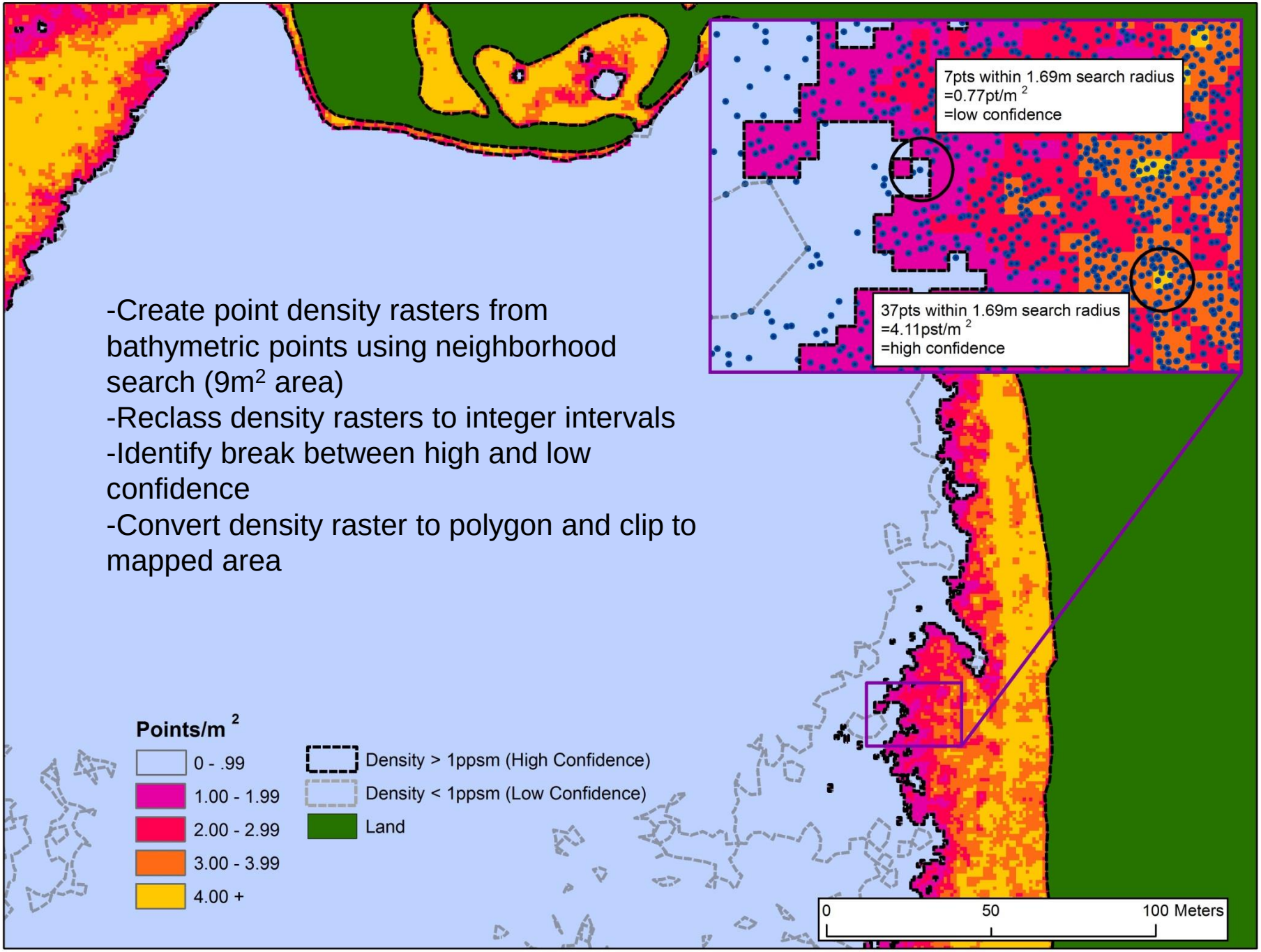
Confidently Dense…

Currently

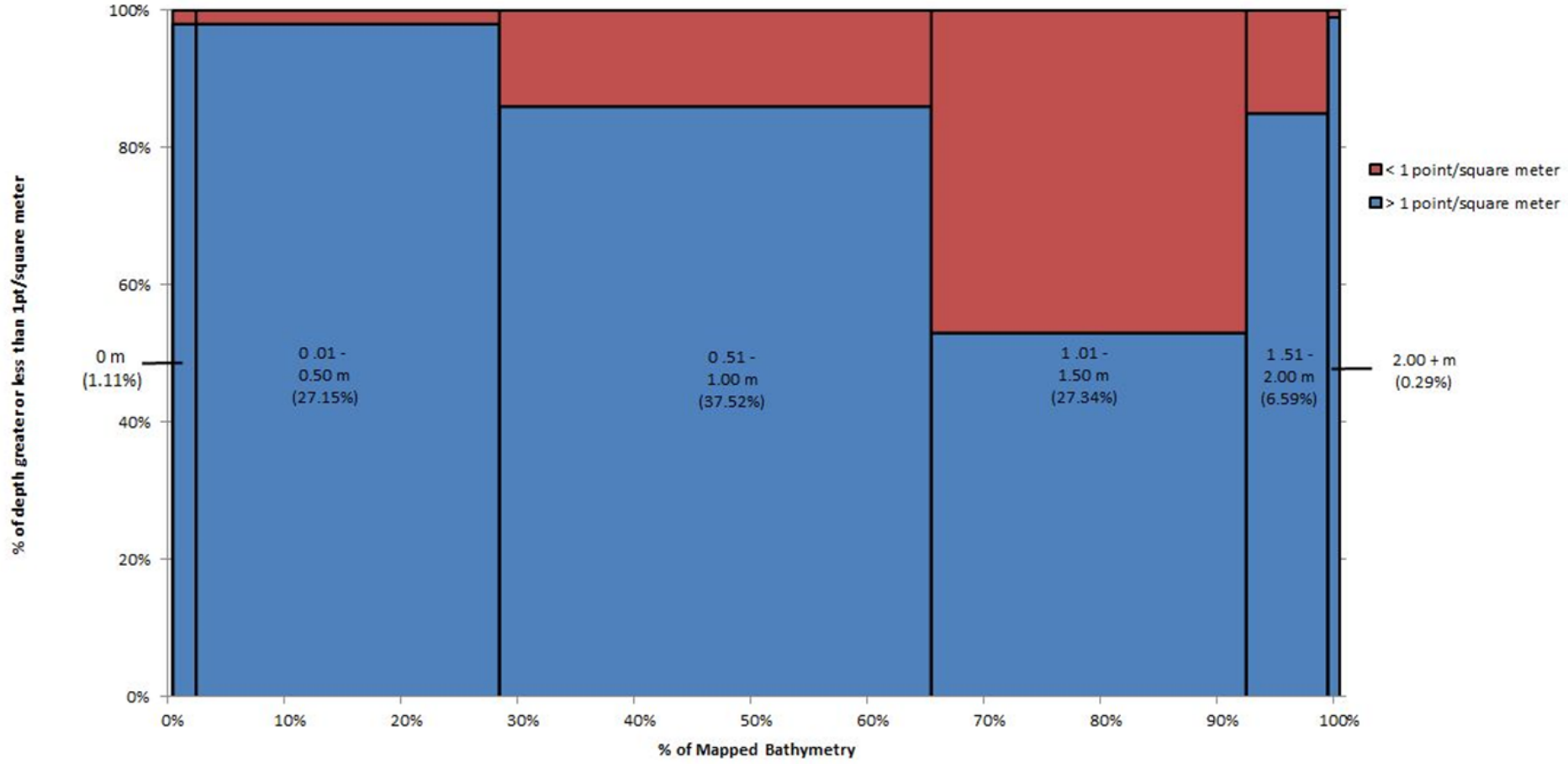
- Create a confidence layer (similar to contour production)
- Repeatability
  - Reliable?
  - Valid?
- Assumes higher density = more confident

Considerations

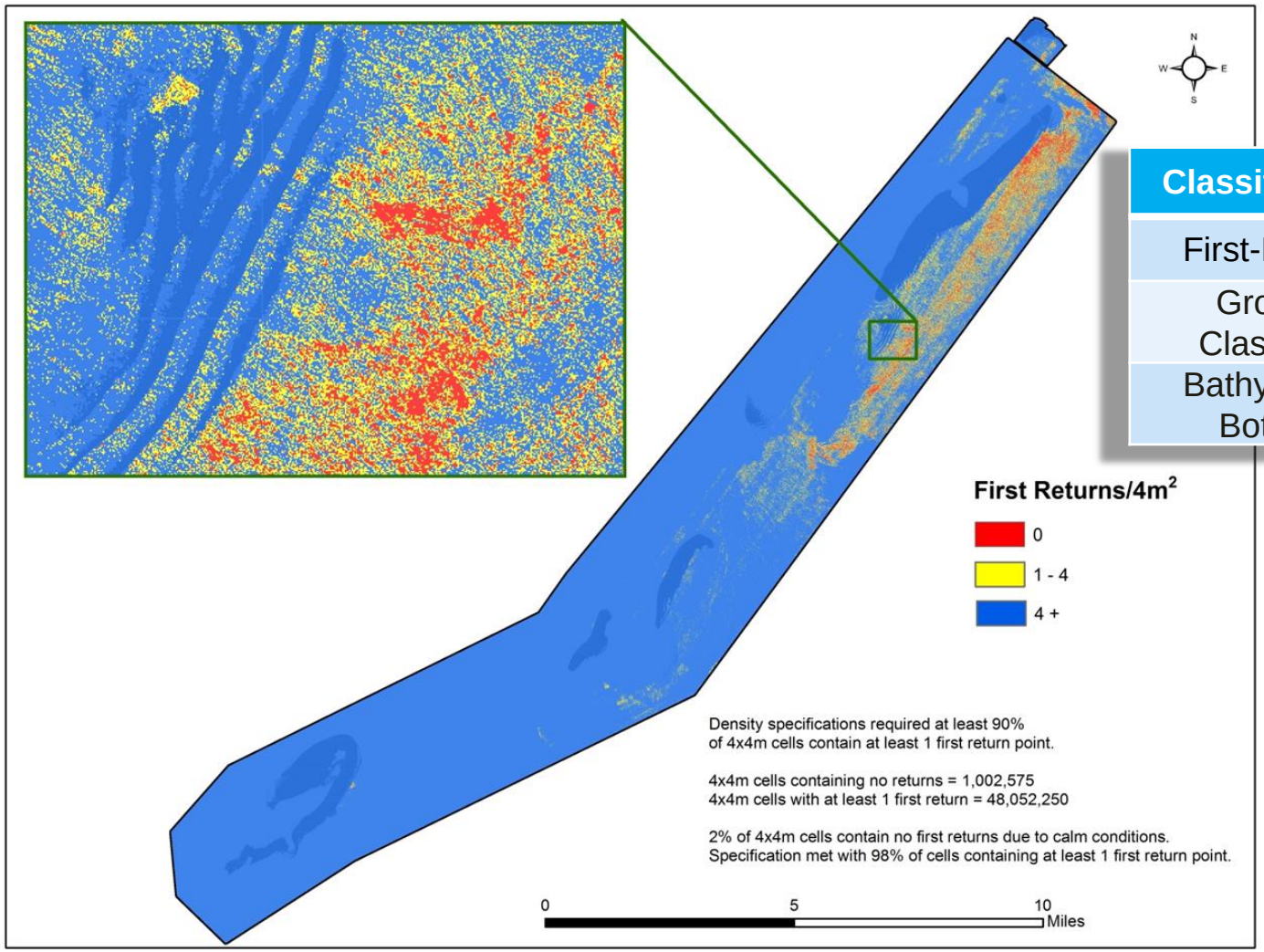
- Uncertainty
- Classification Accuracy
- Model with roughness, standard deviation, FWF attributues
  - See Chris Parrish's talk


7pts within 1.69m search radius
=0.77pt/m 2
=low confidence
37pts within 1.69m search radius
=4.11pst/m 2
=high confidence
-Create point density rasters from bathymetric points using neighborhood search (9m2 area)
-Reclass density rasters to integer intervals
-Identify break between high and low confidence
-Convert density raster to polygon and clip to mapped area
Points/m 2
0 - .99
1.00 - 1.99
2.00 - 2.99
3.00 - 3.99
4.00 +
Density > 1ppsm (High Confidence)
Density < 1ppsm (Low Confidence)
Land
0
50
100 Meters

Results

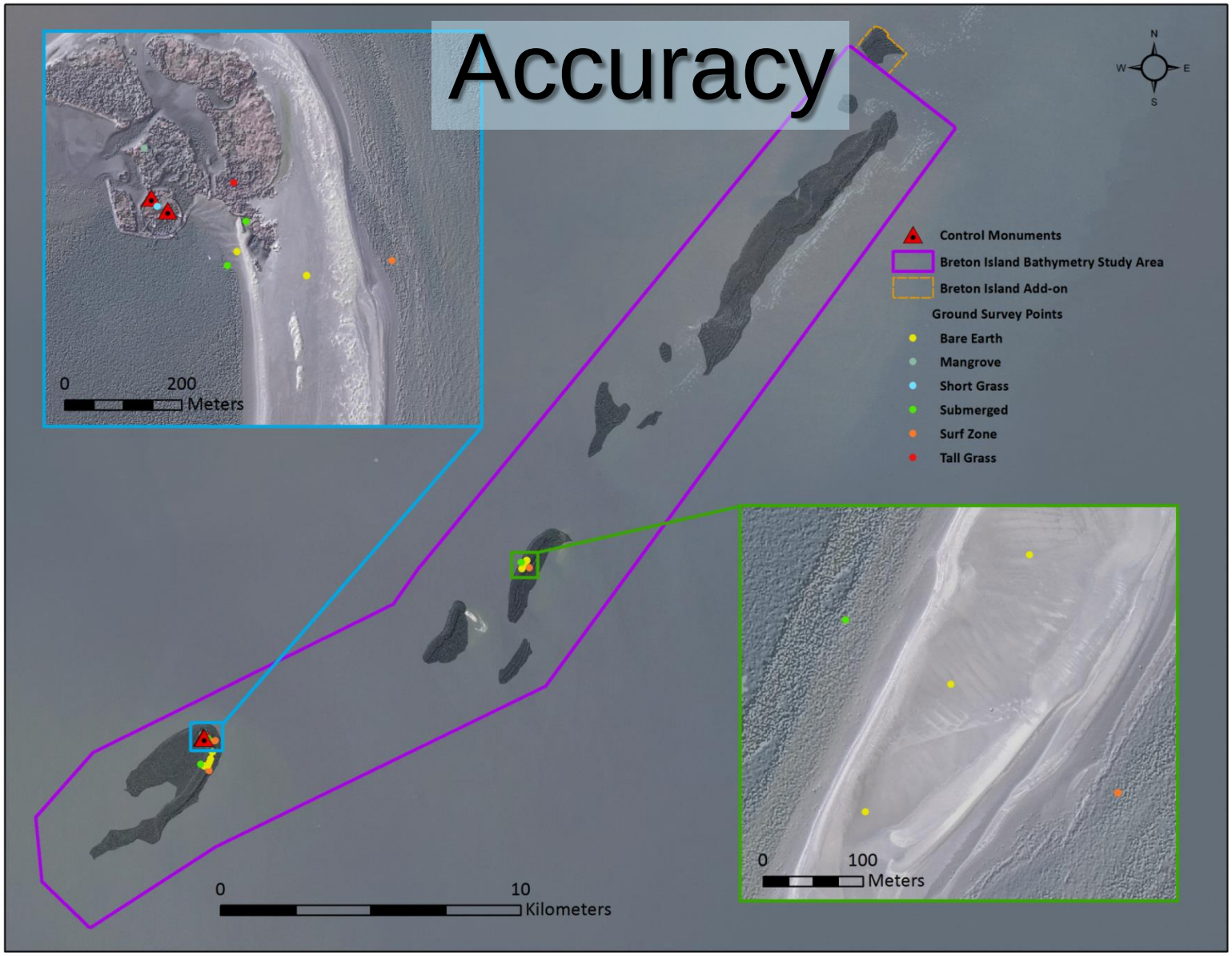

100%
80%
60%
40%
20%
0%
% of depth greater or less than 1pt/square meter
0 m
(1.11%)
0 .01 -
0.50 m
(27.15%)
0 .51 -
1.00 m
(37.52%)
1 .01 -
1.50 m
(27.34%)
1 .51 -
2.00 m
(6.59%)
2.00 + m
(0.29%)
< 1 point/square meter
> 1 point/square meter
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
% of Mapped Bathymetry

Results



Classification	Point Density
First-Return	4 ppsm
Ground Classified	6 ppsm
Bathymetric Bottom	2 ppsm

Accuracy


N
W
E
S
Control Monuments
Breton Island Bathymetry Study Area
Breton Island Add-on
Ground Survey Points
Bare Earth
Mangrove
Short Grass
Submerged
Surf Zone
Tall Grass
0
200
Meters
0
10
Kilometers
0
100
Meters

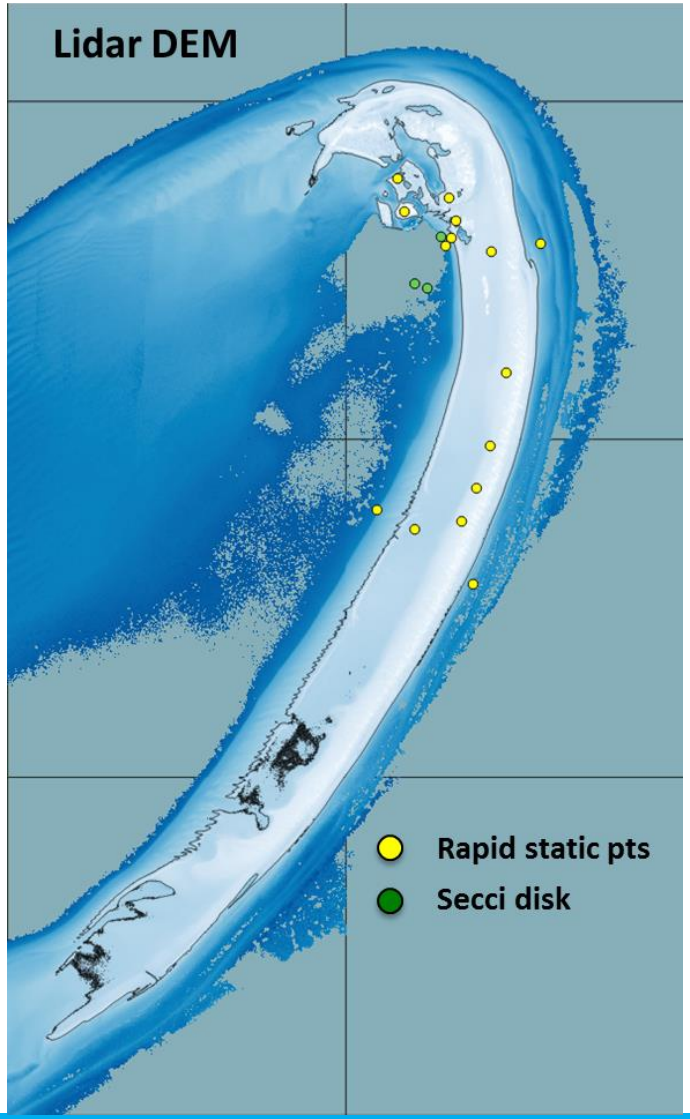
Accuracy

Fundamental Vertical Accuracy	
Sample	10 points
Average	0.012 m
Median	0.021 m
RMSE	0.032 m
Standard Deviation (1σ)	0.031 m
FVA (1.96*RMSE)	0.061 m

Supplemental and Consolidated Vertical Accuracies

	SVA						CVA
Land Cover Class	Bare Earth	Submerged	Surf Zone	Tall Grass	Short Grass	Mangrove	All Land Cover Classes
Sample	10 points	4 points	3 points	1 point	1 point	1 point	20 points
Average Dz	-0.018 m	-0.082 m	-0.017 m	0.075 m	0.148 m	0.01 m	-0.016 m
Median	-0.018 m	-0.066 m	-0.038 m	n/a	n/a	n/a	-0.026 m
RMSE	0.037 m	0.095 m	0.116 m	n/a	n/a	n/a	0.077 m
Standard Deviation (1σ)	0.034 m	0.056 m	0.141 m	n/a	n/a	n/a	0.077 m
95th Percentile	0.068 m	0.148 m	0.145 m	n/a	n/a	n/a	0.149 m

USGS – Comparison with Control Points (preliminary)

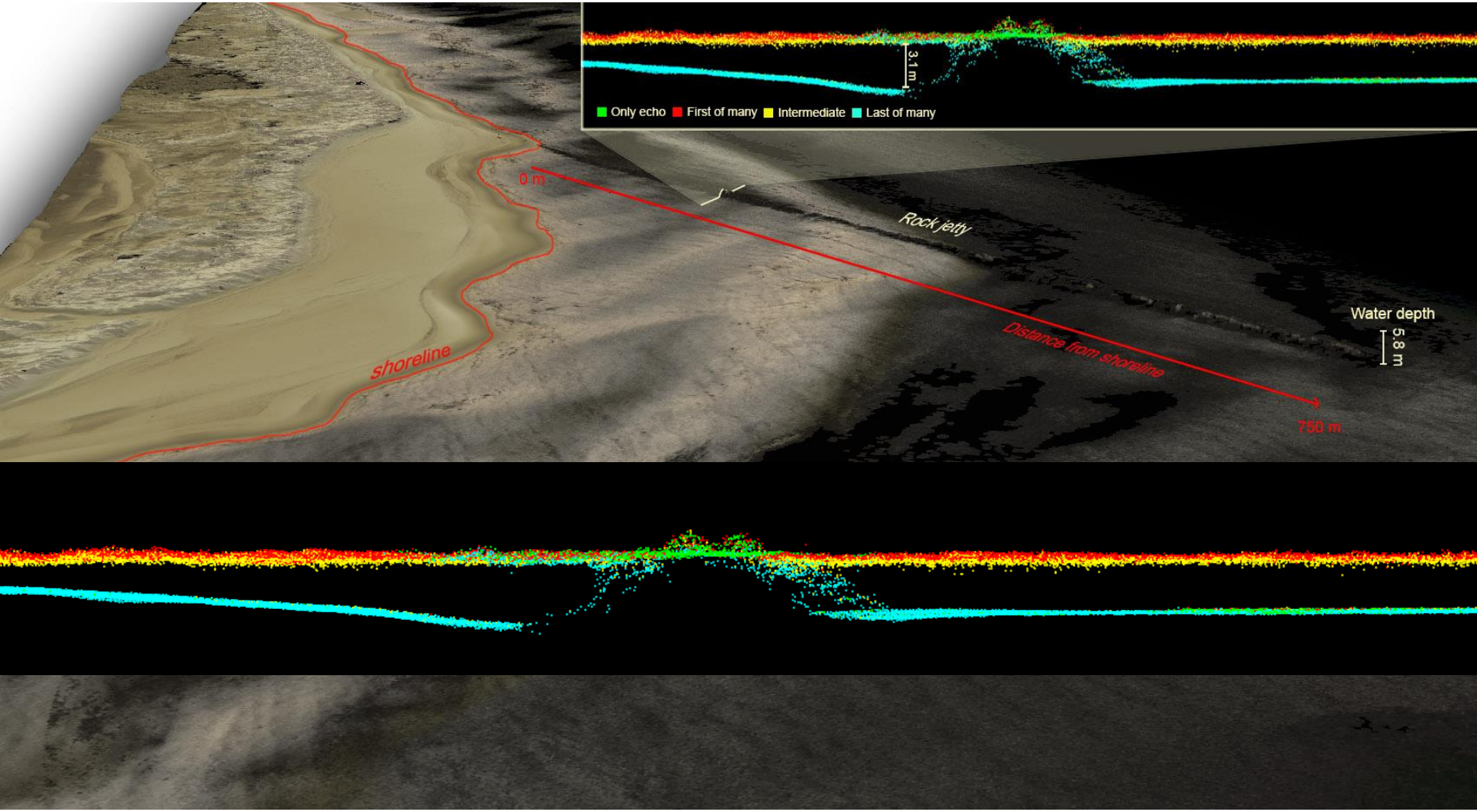


Cover	control	lidar	difference
Bare earth	-0.097	-0.078	0.019
Bare earth	0.438	0.427	0.011
Bare earth	0.255	0.088	0.167
Bare earth	0.622	0.587	0.035
Bare earth	0.681	0.522	0.159
Bare earth	0.534	0.497	0.037
Bare earth	0.573	0.600	0.027
Mangrove	0.425	0.440	0.015
Short grass	1.869	2.009	0.140
Submerged	-1.045	-1.080	0.035
Submerged	-1.037	-1.156	0.119
Submerged	-0.662	-0.653	0.009
Surf	-0.752	-0.823	0.071
Surf	-0.818	-0.699	0.119
Tall	0.272	0.369	0.097
		min	0.009
		max	0.167
		avg	0.071

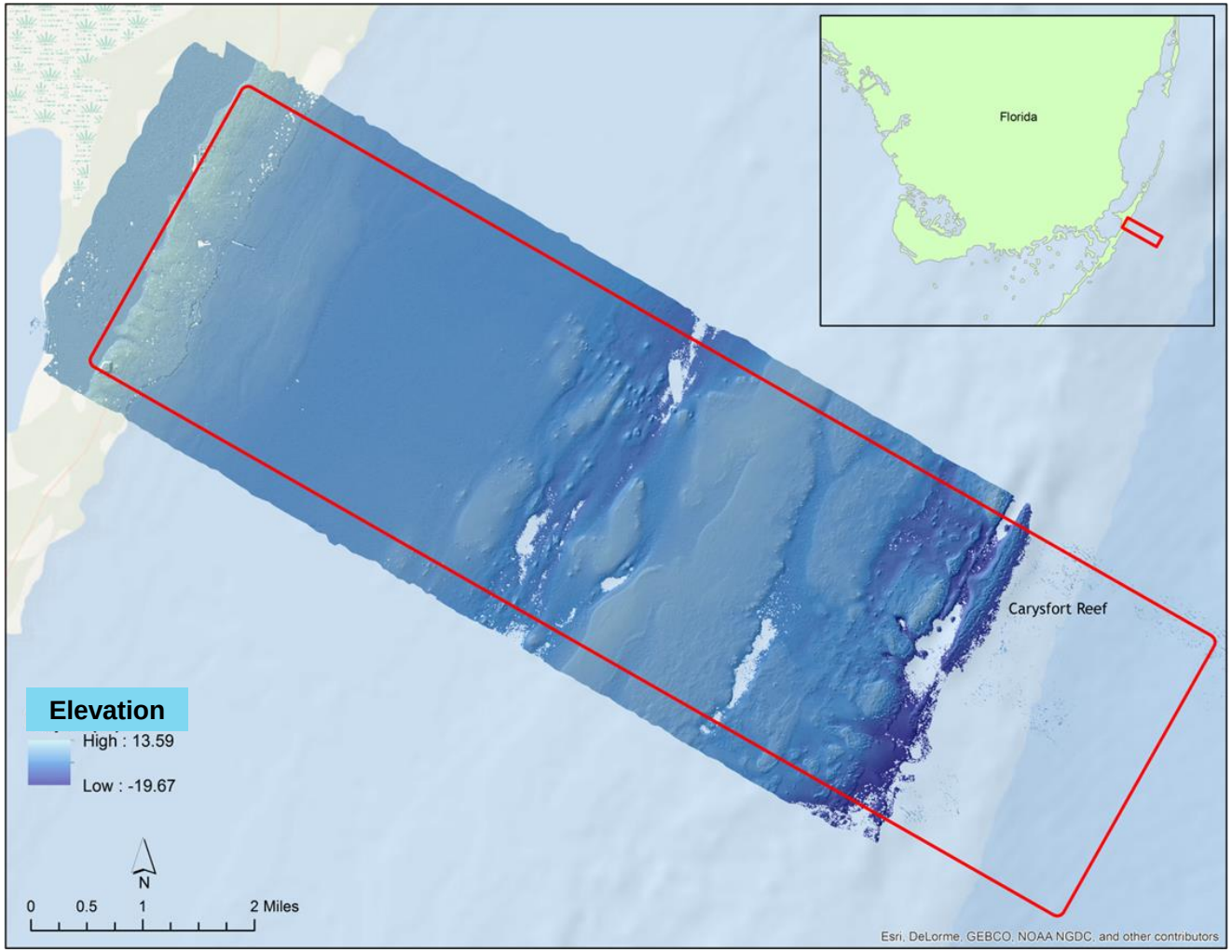
Avg.: 0.054

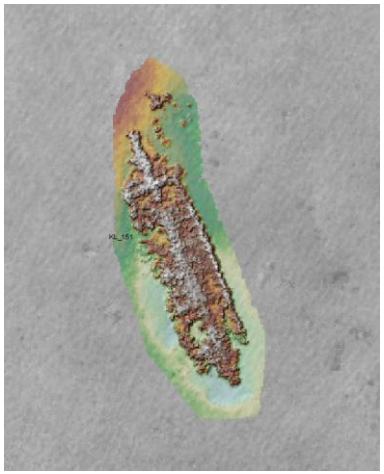
Avg.: 0.095

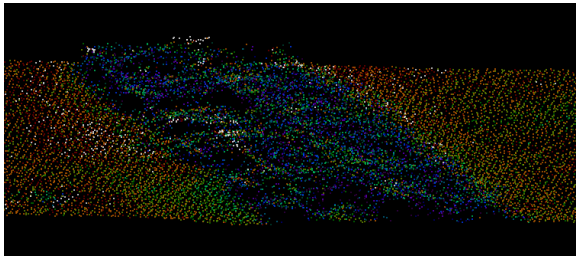
NOAA SANDY

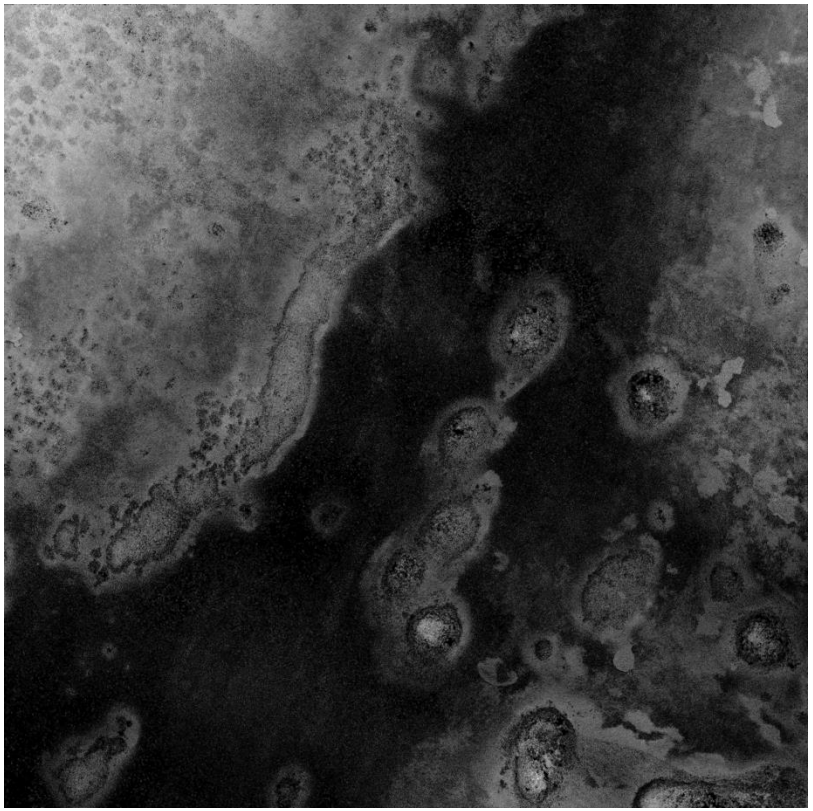

3.1 m
Only echo
First of many
Intermediate
Last of many
0 m
Rock jetty
shoreline
Distance from shoreline
750 m
Water depth
5.8 m

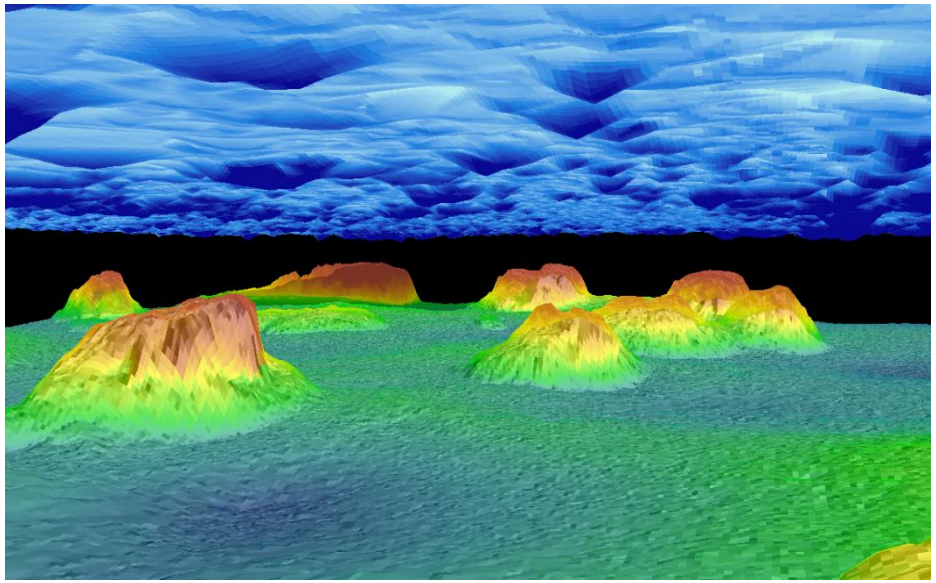
Florida Keys

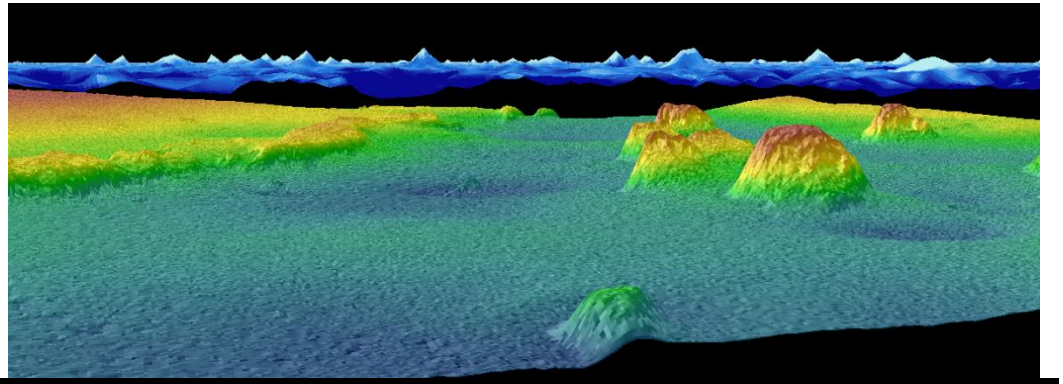


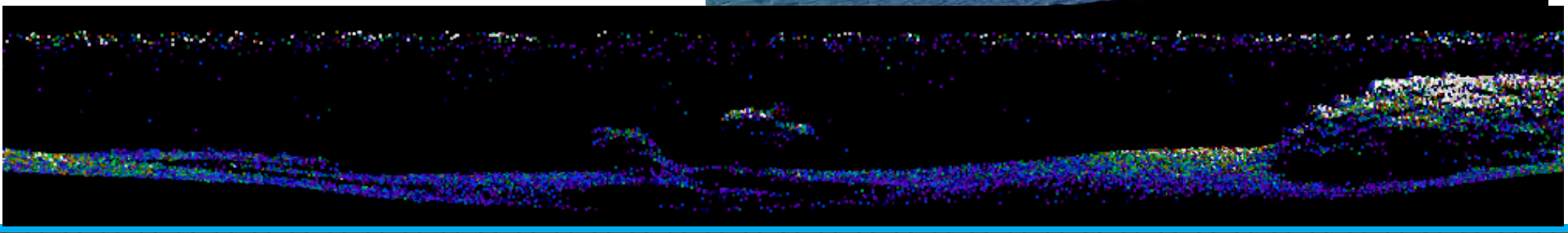


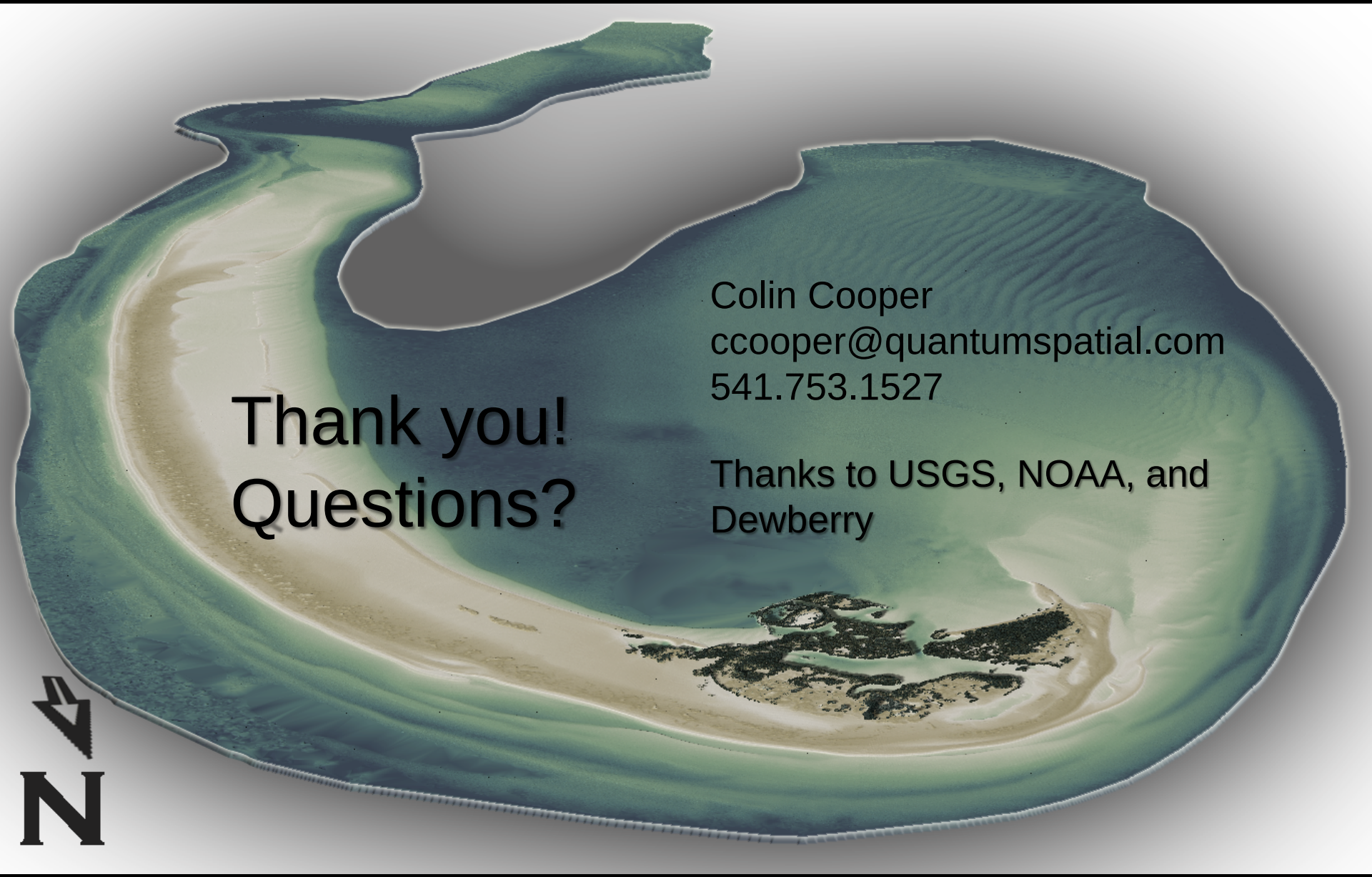




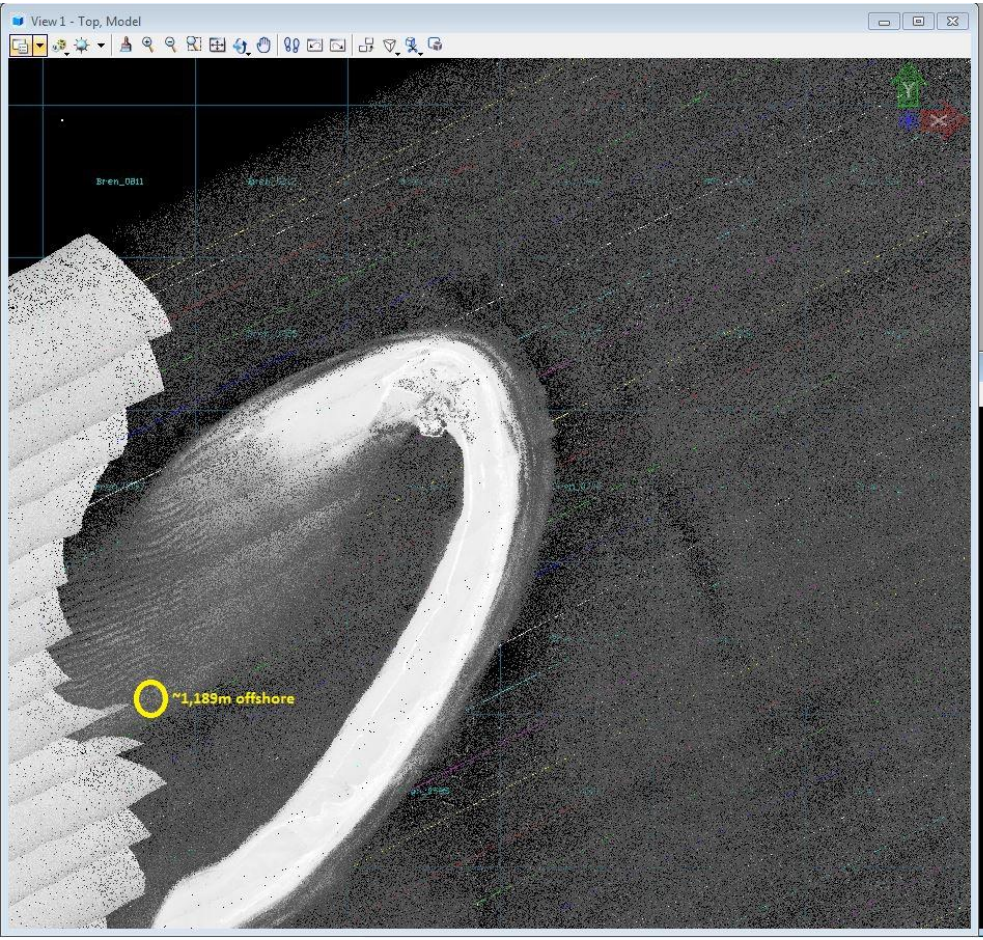


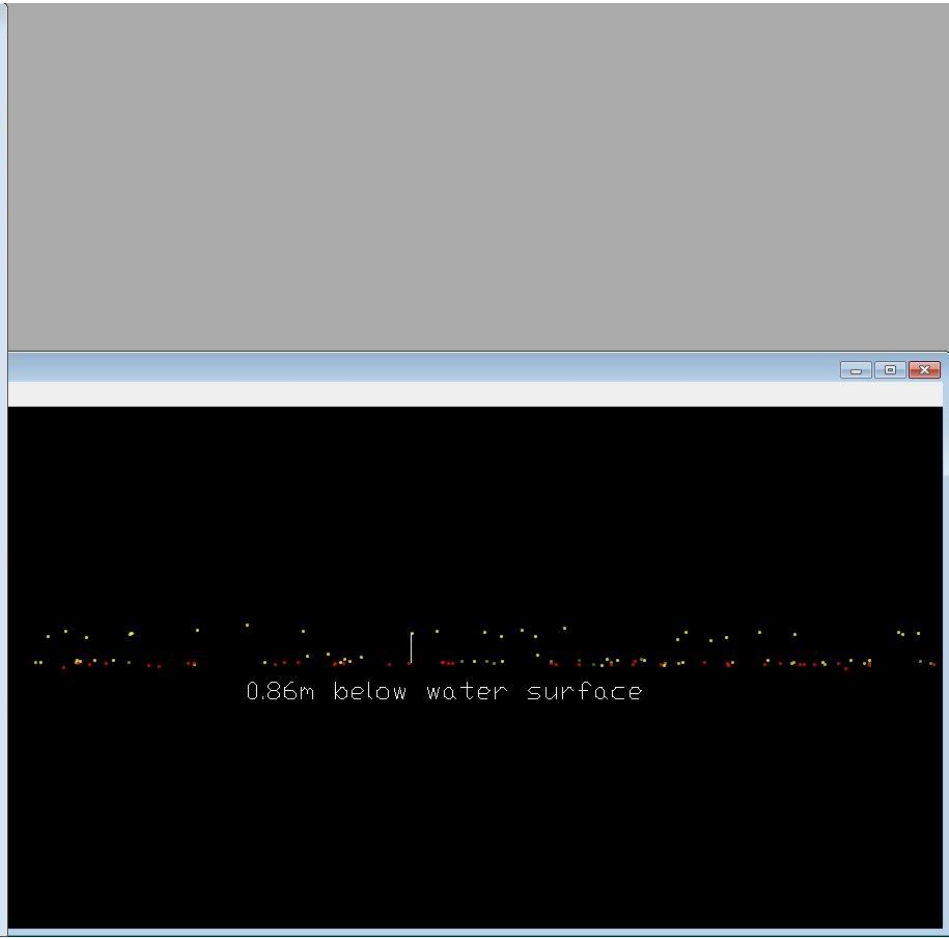


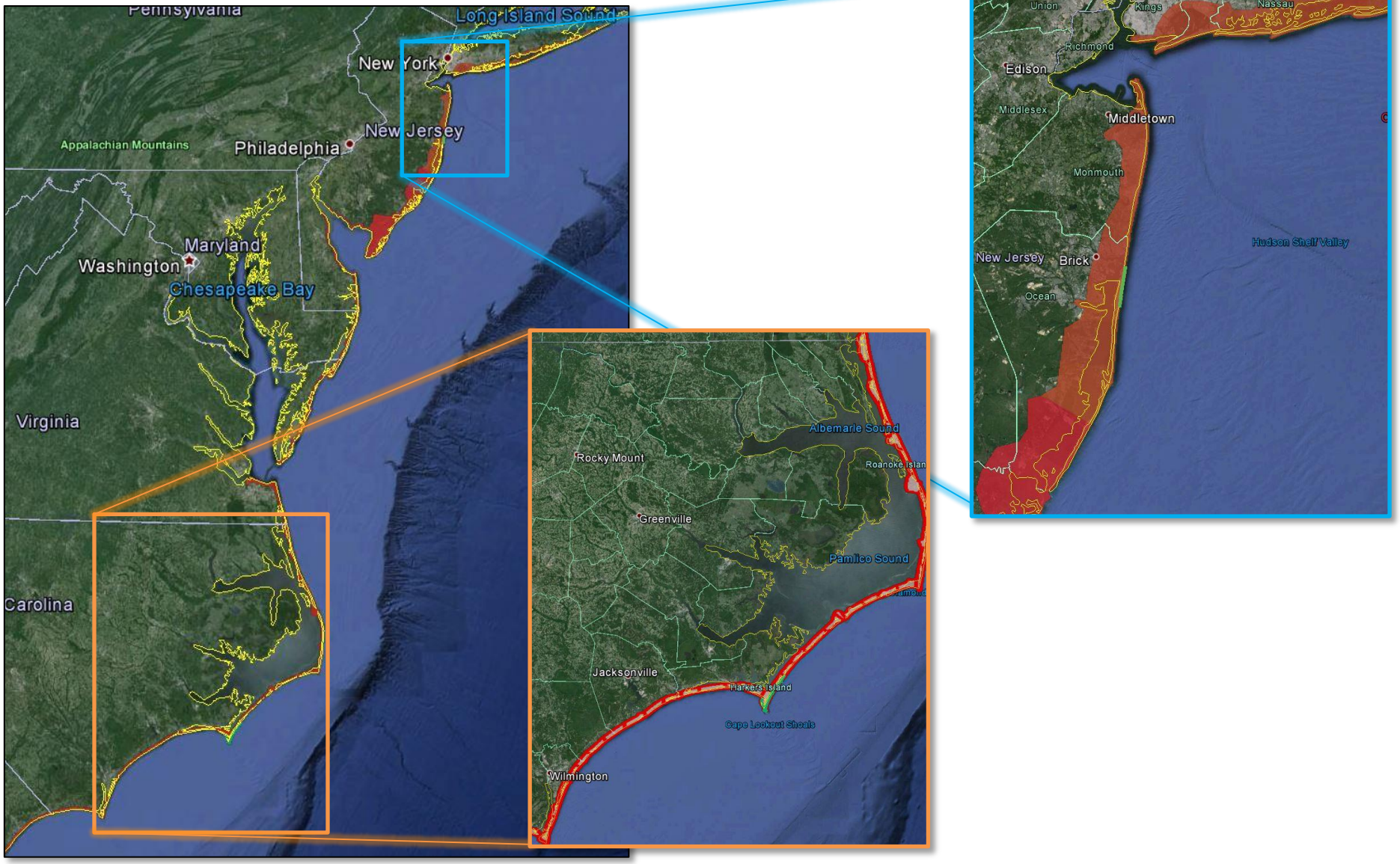


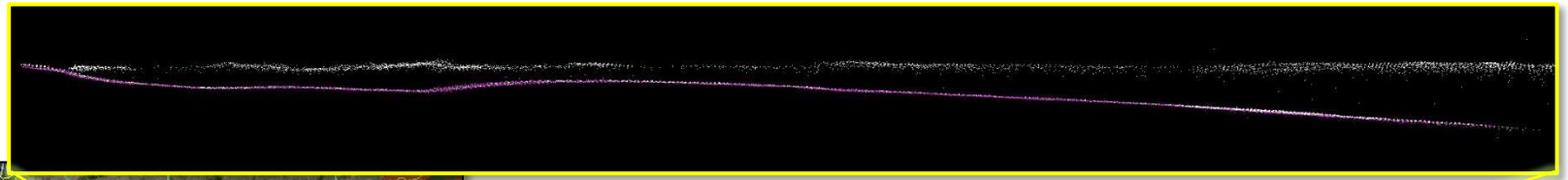

Thank you!
Questions?
Colin Cooper
ccooper@quantumspatial.com
541.753.1527
Thanks to USGS, NOAA, and Dewberry
N

Breton Island – Mississippi Mud

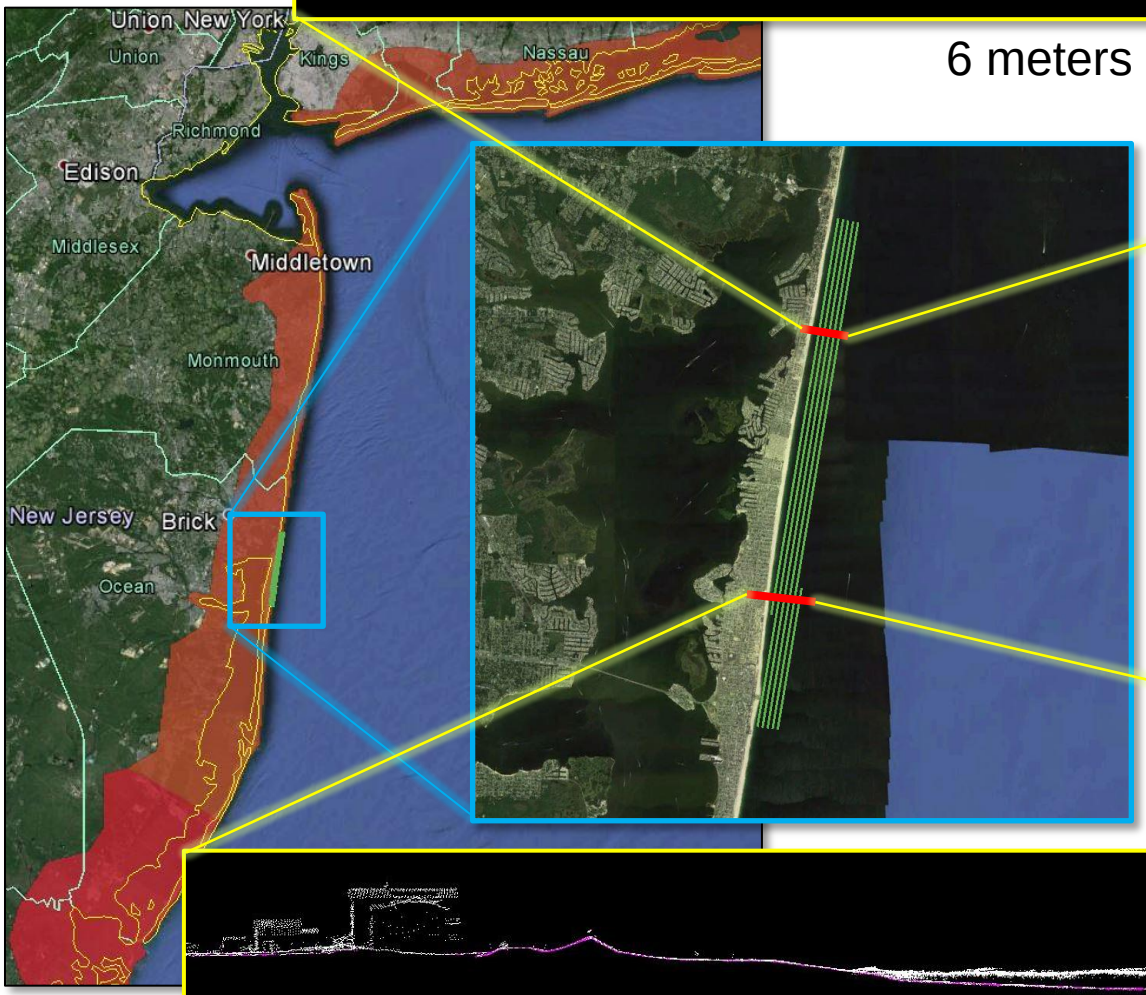




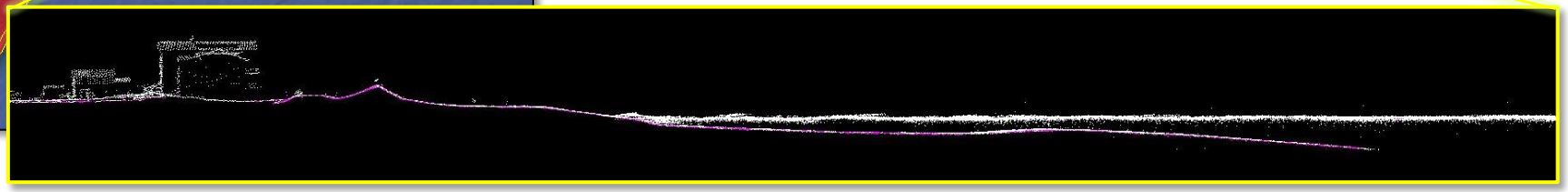

Pennsylvania
Long Island Sound
New York
New Jersey
Appalachian Mountains
Philadelphia
Maryland
Washington
Chesapeake Bay
Virginia
Carolina
Union
New York
Union
Kings
Nassau
Richmond
Edison
Middlesex
Middletown
Monmouth
Hudson Shelf Valley
New Jersey
Brick
Ocean
Albemarle Sound
Rocky Mount
Roanoke Islan
Greenville
Pamlico Sound
Jacksonville
Harkers Island
Cape Lookout Shoals
Wilmington

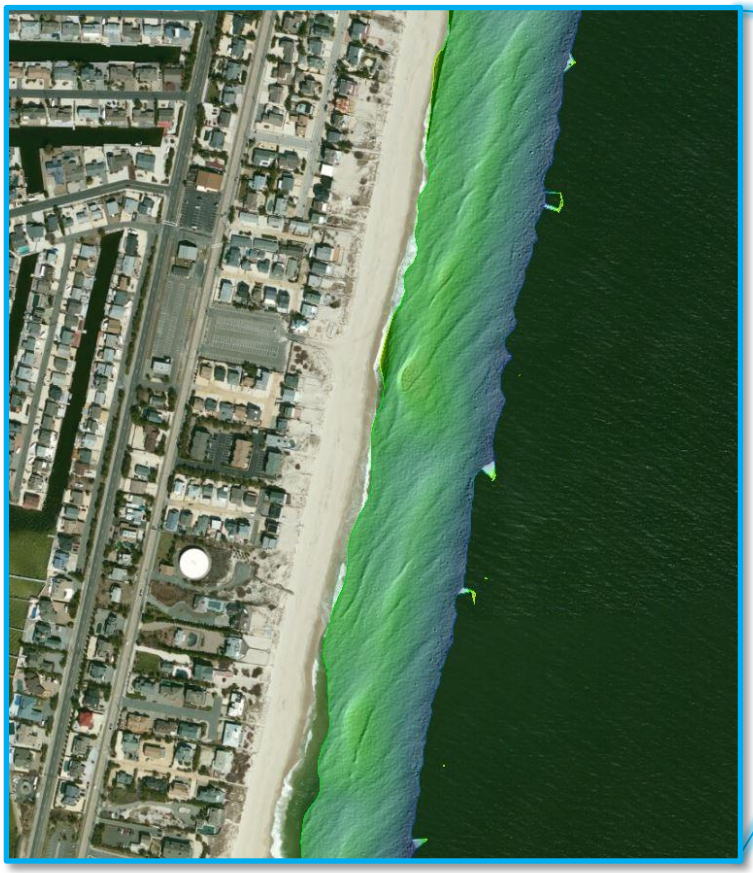


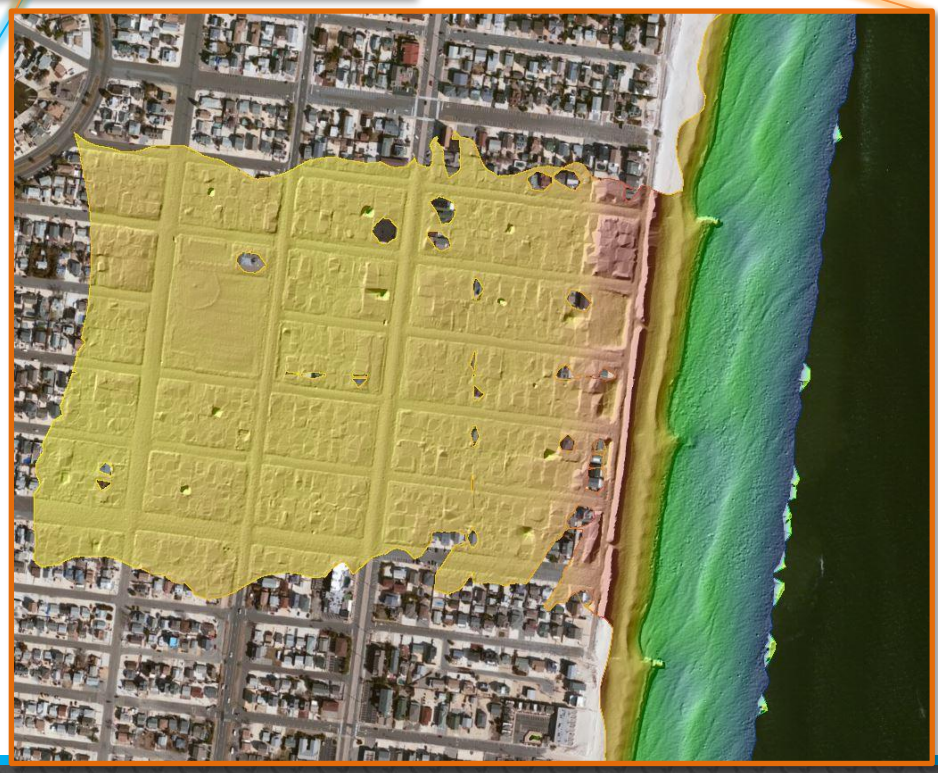
6 meters at deepest extent



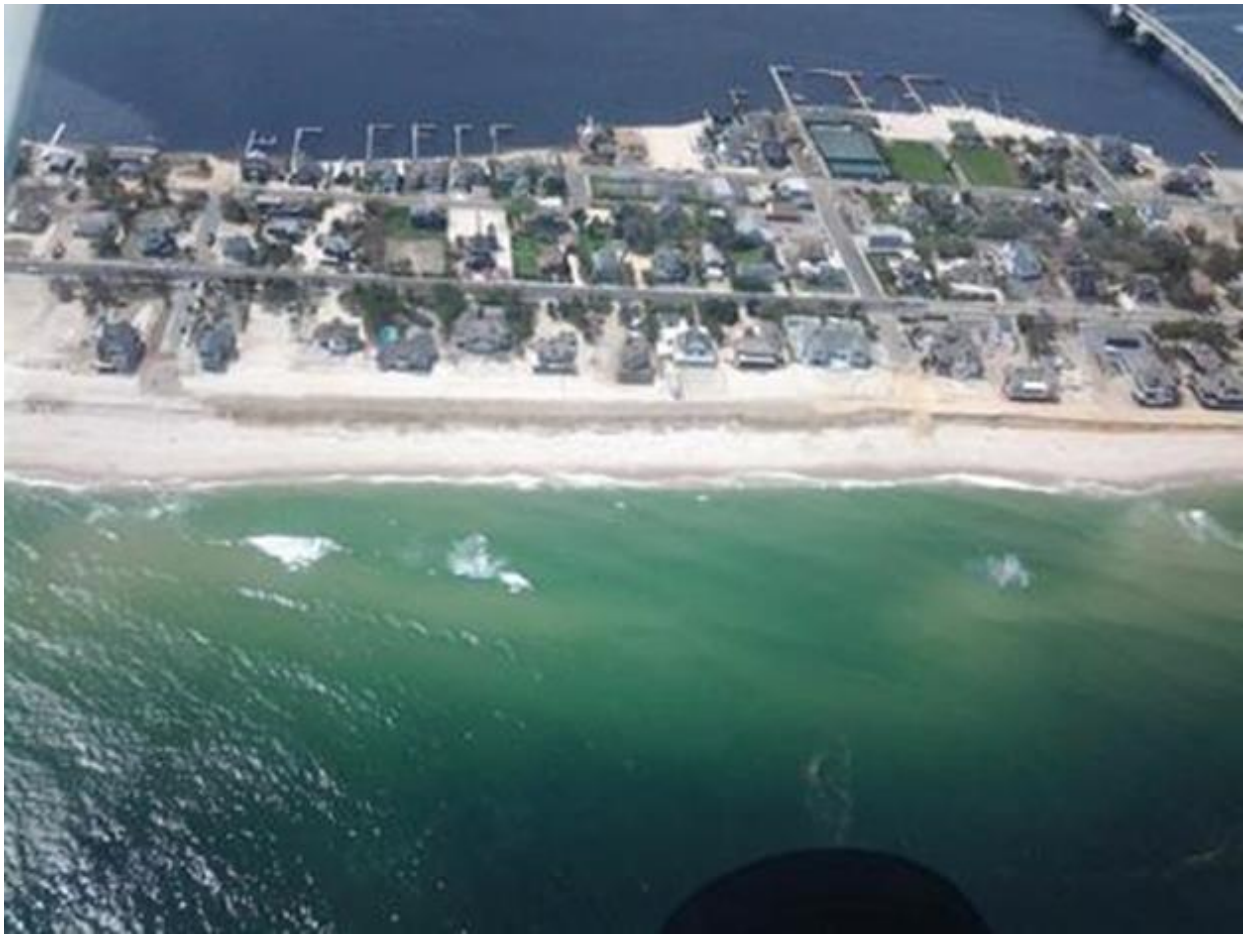
6.5 meters at deepest extent

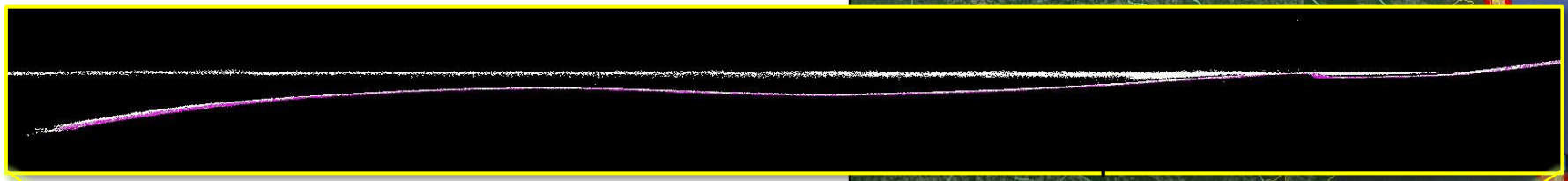






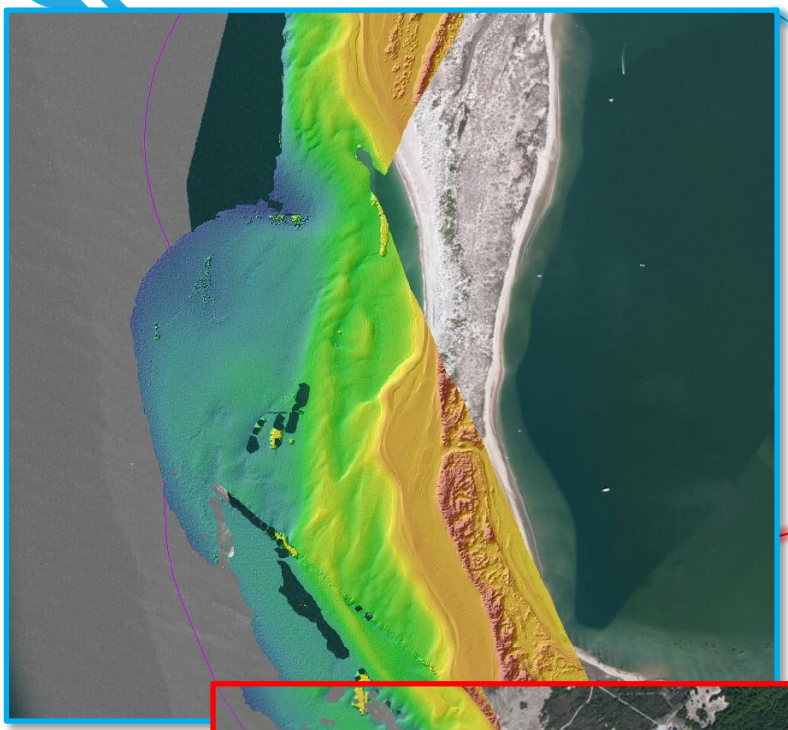
View From Aircraft

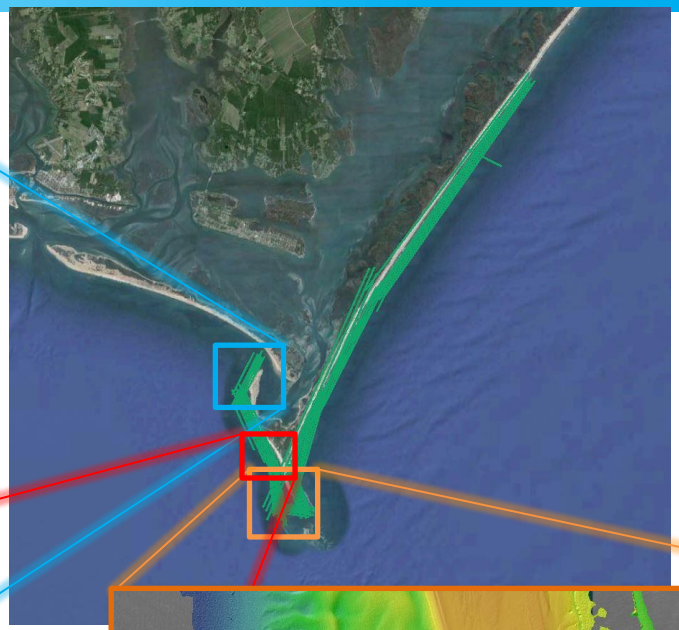


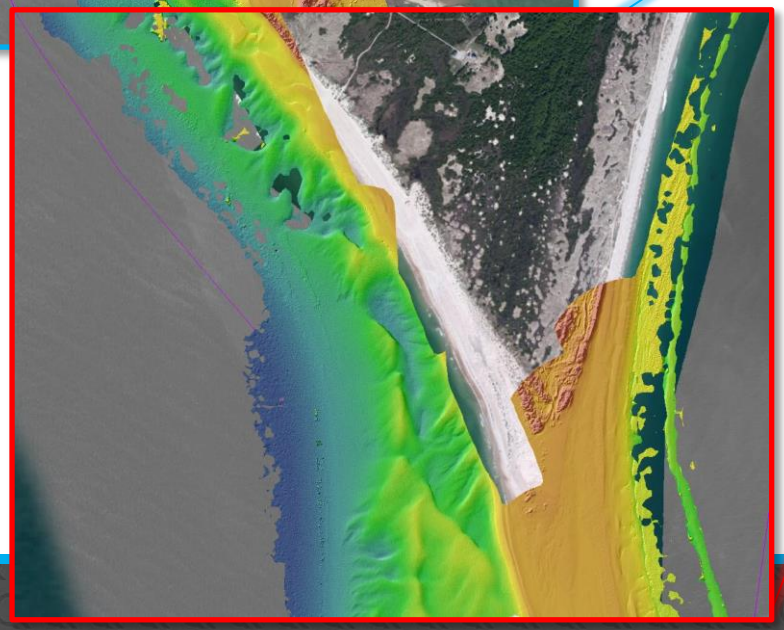


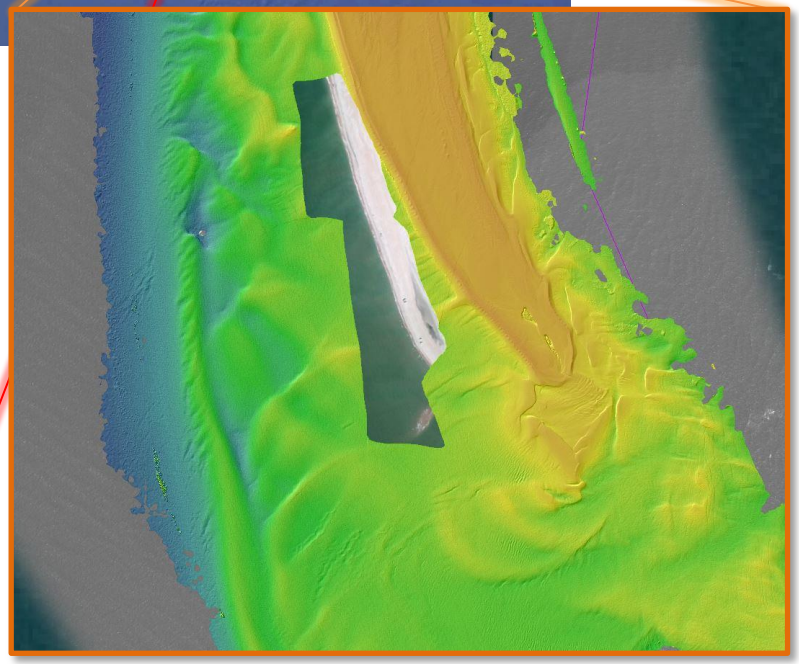
7 meters at deepest extent

11 meters at deepest extent, bathy extending nearly 800 meters offshore









View From Aircraft