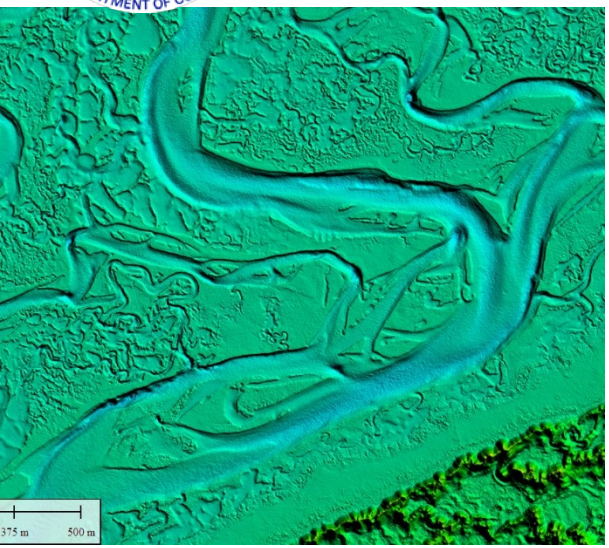
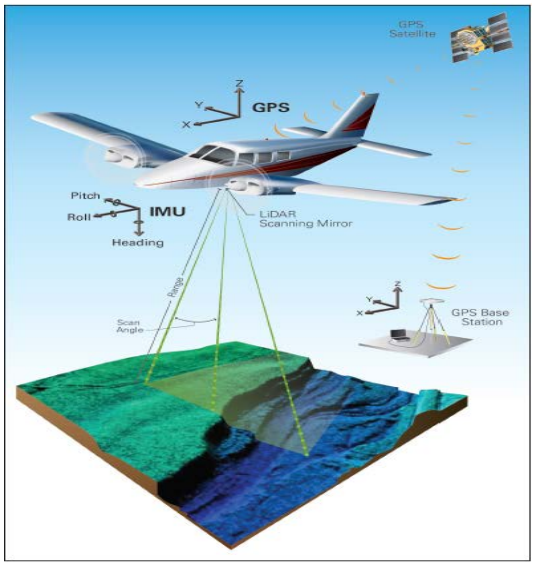
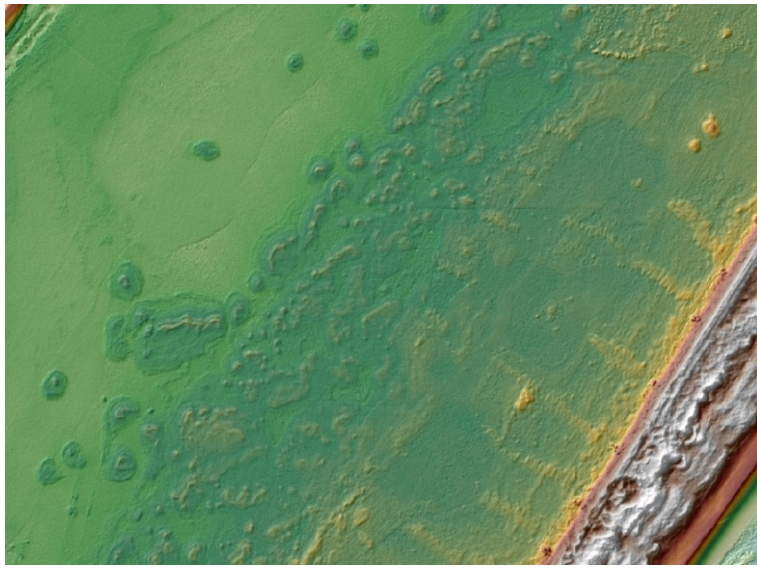




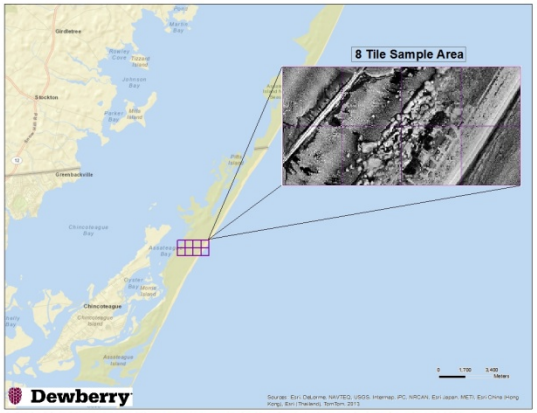


Topobathy Lidar for the Eastern Atlantic Seaboard – the AWARD WINNING NOAA Supplemental Sandy Project

Amar Nayegandhi
Associate Vice President
Director of Remote Sensing
Dewberry

TopoBathy vs. Topo-only

– Benefits of topobathy data



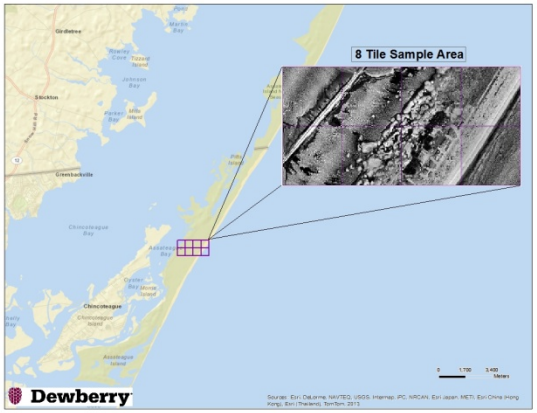
RGB Imagery

Assateague Island, MD

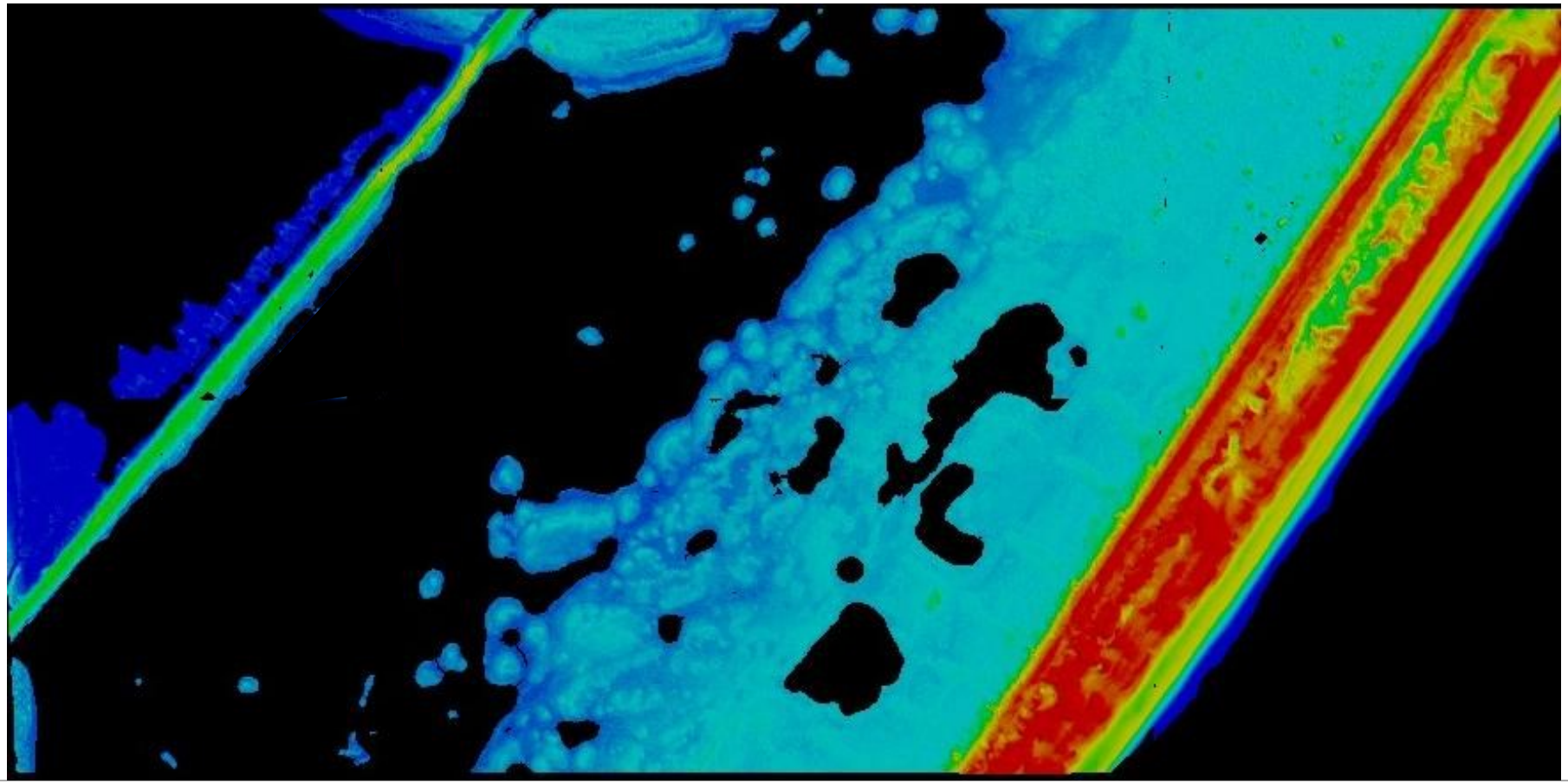
Dewberry

TopoBathy vs. Topo-only

– Benefits of topobathy data



Bare Earth Digital Elevation Model – NIR – Topo-only



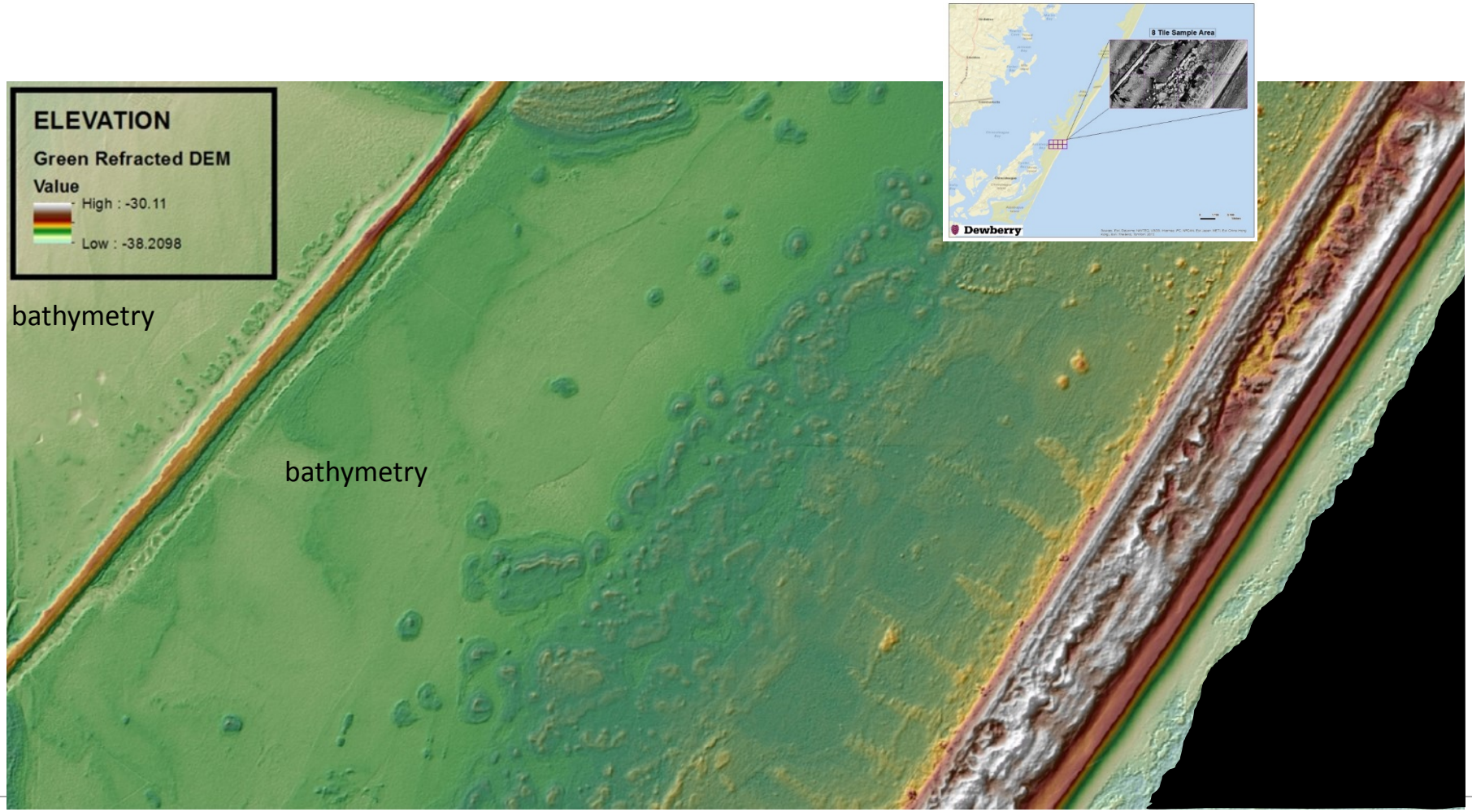
Assateague Island, MD

Dewberry

TopoBathy vs. Topo-only

– Benefits of topobathy data

Seamless topobathy Digital Elevation Model



Assateague Island, MD

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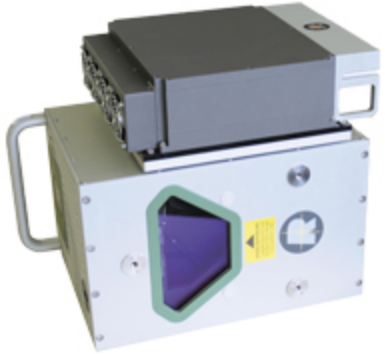
Commercial ALB and topobathy sensors

- Optech CZMIL
- Fugro LADS MkIII
- Leica AHAB Hawkeye III
- Leica AHAB Chiroptera
- RIEGL VQ-820-G / VQ-880-G

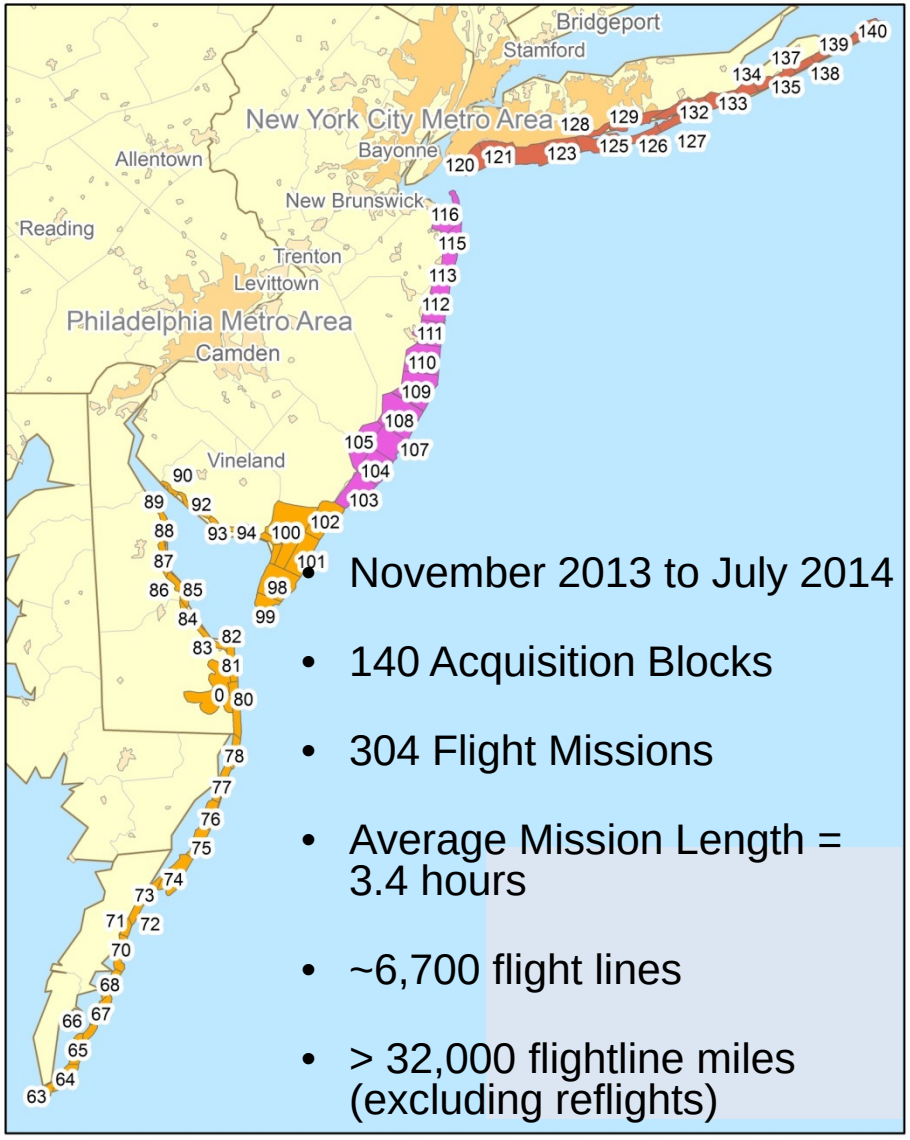


Not intended to be an exhaustive list of all available sensors

Supplemental Sandy Topobathy LiDAR and Imagery Task for the NOAA NGS Shoreline Mapping Program

- Dewberry tasked as prime contractor under the NOAA CGSC II contract
- Subcontractors for acquisition – Quantum Spatial (LiDAR and Imagery), RC&A (Imagery Acquisition)
- 3 aircrafts with topobathy LiDAR deployed and 2 aircrafts with DMC (imagery)
- Imagery production shared between Woolpert and Quantum Spatial. Dewberry did final QC.
- Dewberry and Quantum Spatial processed classified point cloud data. Tuck Mapping and Atlantic Group also helped with processing.
- DEM production and final QC being done by Dewberry.
- Shoreline delineation and attribution being completed by Quantum Spatial and Dewberry

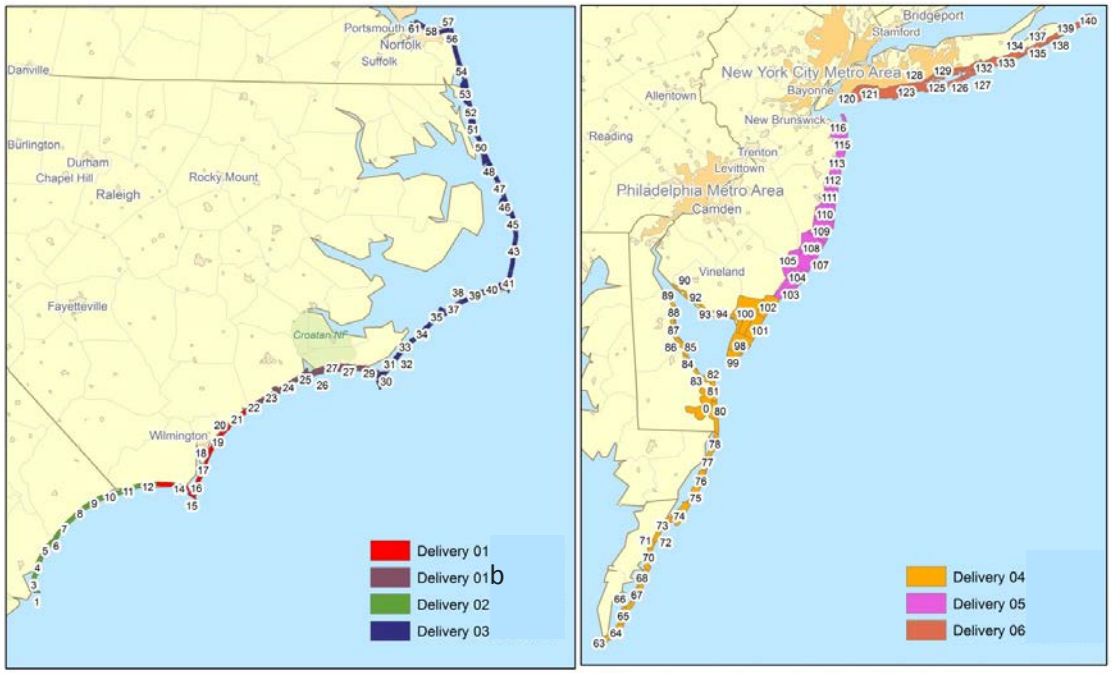
Acquisition Overview



- November 2013 to July 2014
- 140 Acquisition Blocks
- 304 Flight Missions
- Average Mission Length = 3.4 hours
- ~6,700 flight lines
- > 32,000 flightline miles (excluding reflights)

Production Status

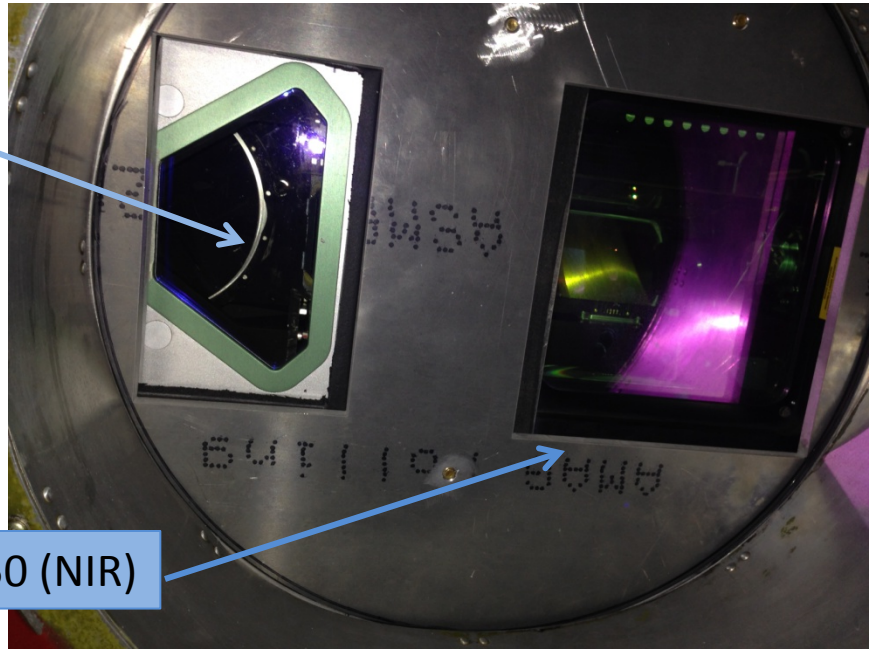
- Six processing delivery blocks defined.



Delivery Status:

- All imagery delivered
- All classified point cloud lidar data delivered
- Derived Products:
  - 65 % of DEMs delivered.
  - Attributed shoreline 50% delivered

Use of Green and IR laser on same aircraft



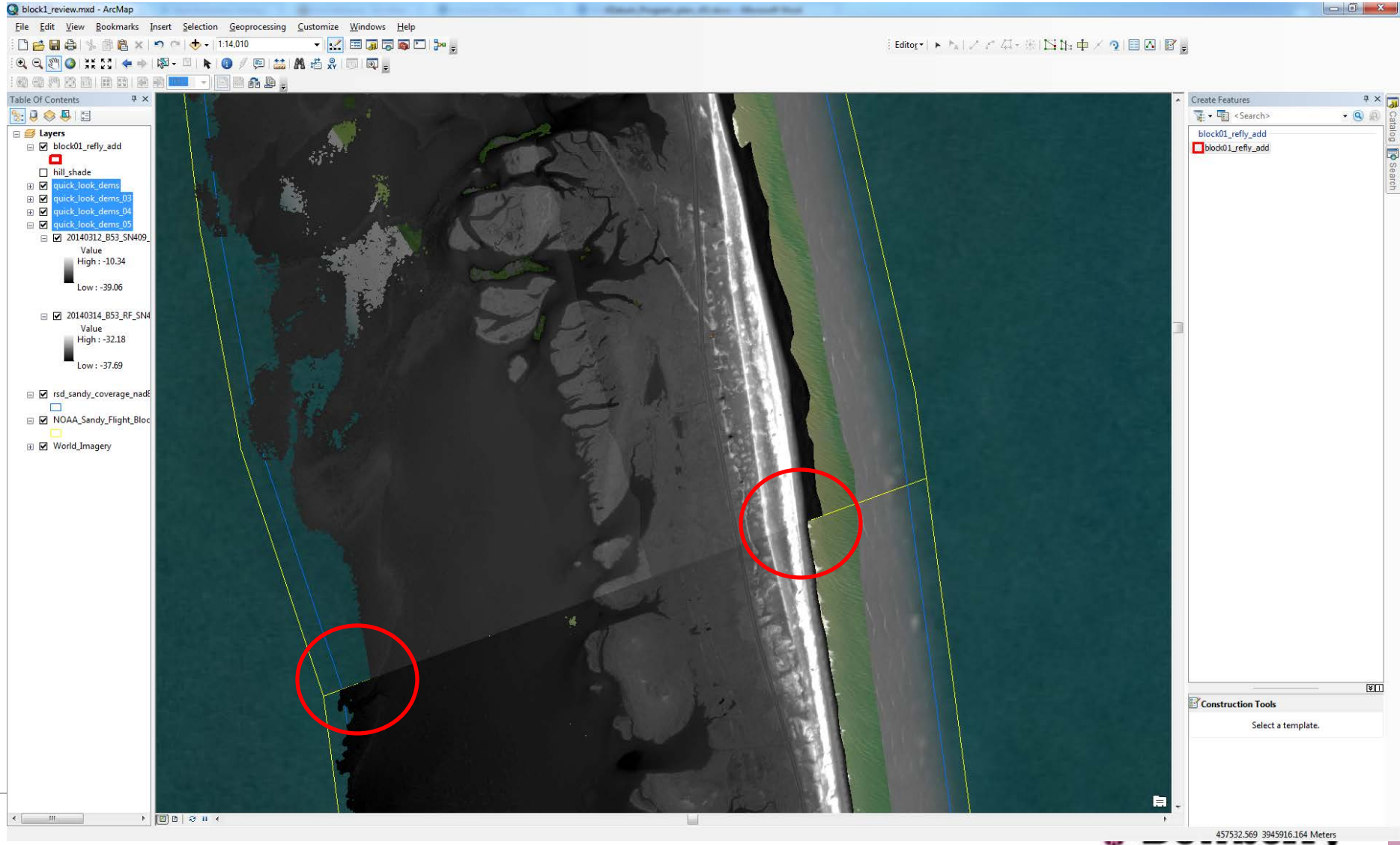
- Riegl VQ-820G has a 20 degree forward look angle
- Leica ALS50 is mounted at nadir
- At 600 m operating altitude, the same "spot" is illuminated by both sensors up to 3.2 seconds apart.

Images courtesy Quantum Spatial

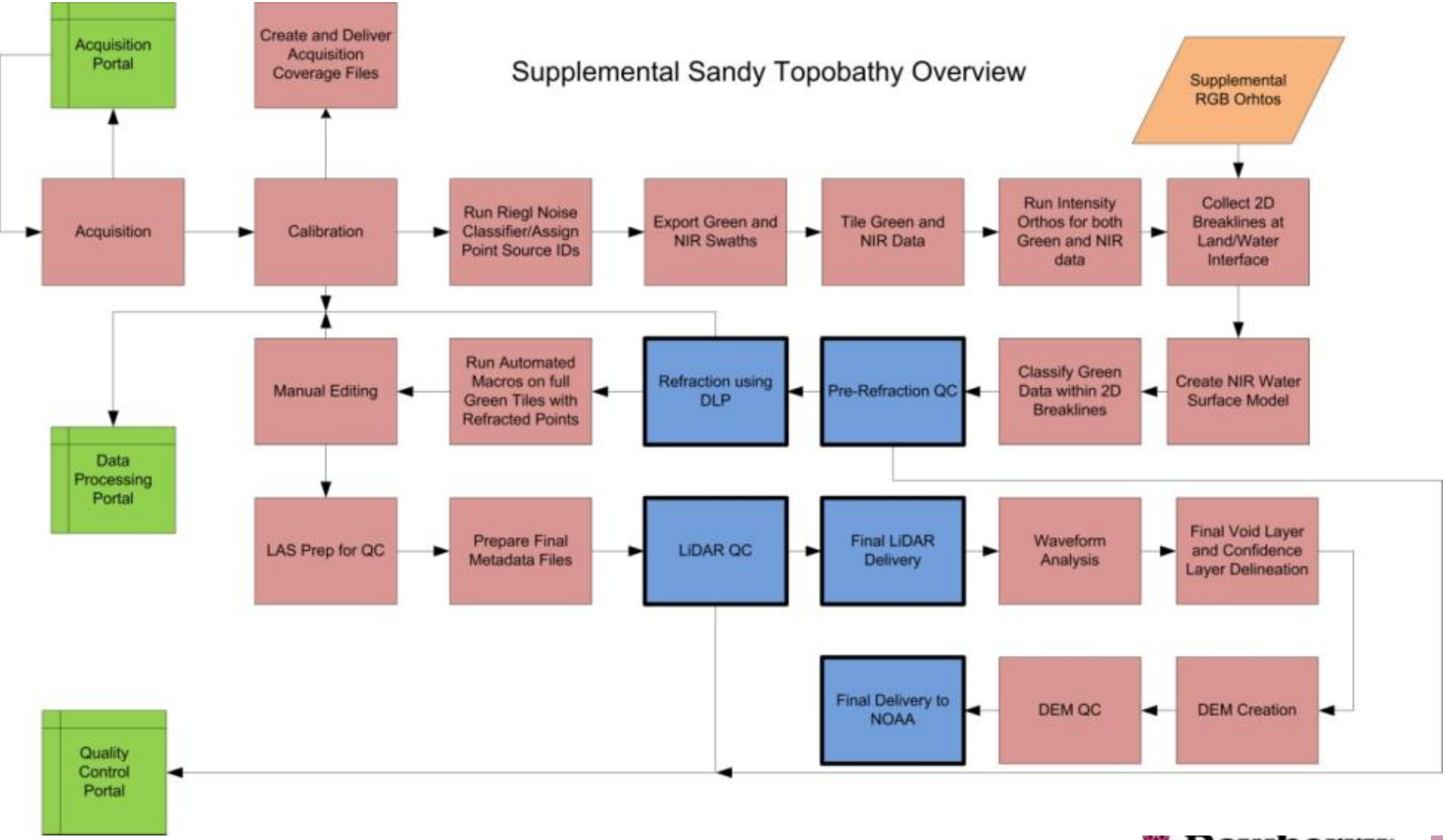
Acquisition Debrief

- Planning for days/times of good water clarity and tide conditions is very challenging
- Important to minimally process data in the field to determine bathy extent
  - Produce and review quicklook maps
- Not easy to rapidly mobilize to different locations in a large project area when water clarity conditions improve quickly
  - NOTAMs need to be in place
  - Base stations need to be set up in advance
- Planning data acquisition in “blocks” had its own challenges and produced some inconsistencies
- Additional flights at 300 m altitude were planned only in open water areas on the ocean side and generally produced better bathymetry than flights at 600 m altitude
- Temporal issues with reflights

Issues with block-by-block acquisition



Topobathy LiDAR Data Production

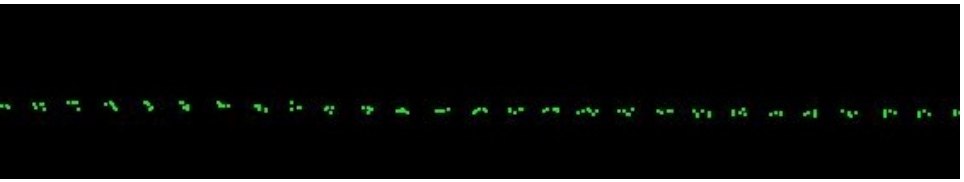


Dewberry

Using NIR LiDAR to determine water surface in shallow backbay areas

Green Intensity

NIR Intensity

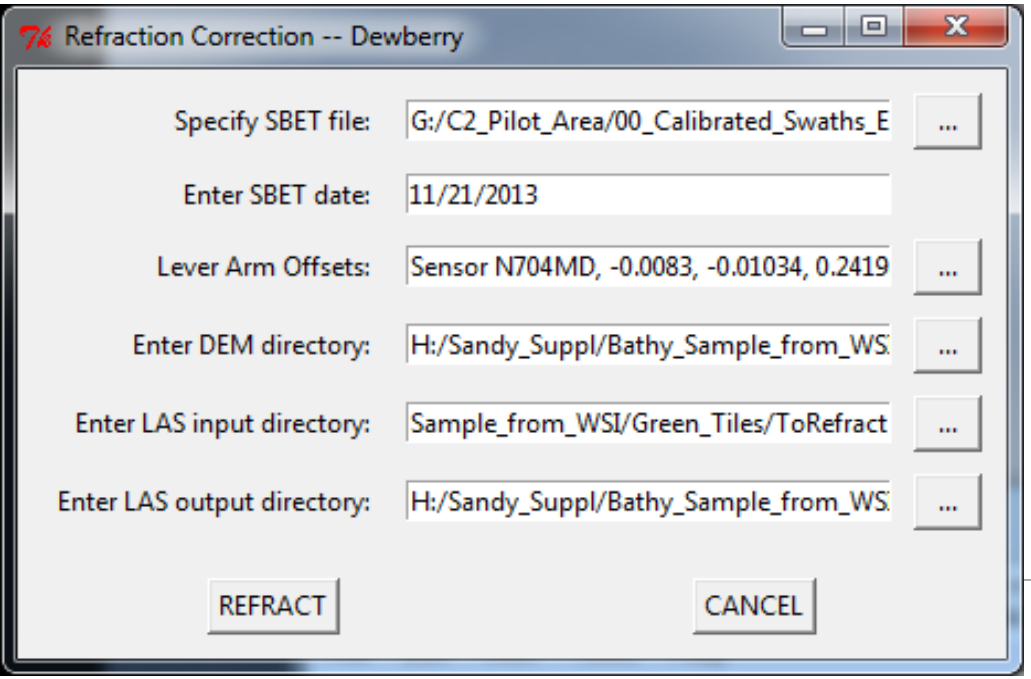


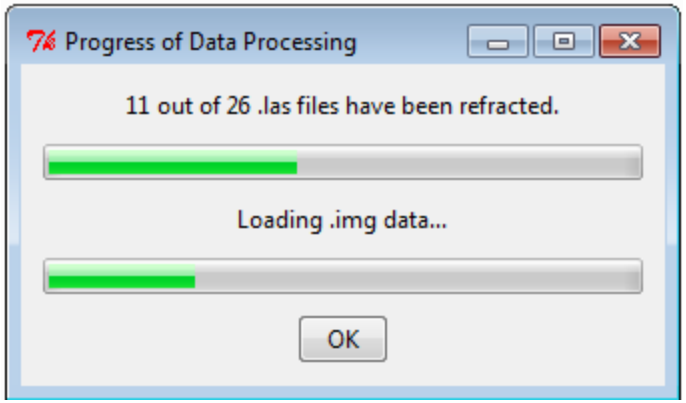
Profile – Green ALL Returns

Profile – NIR (white) + Green Returns

Dewberry's Custom Refraction Correction Tool

- Allows the use of any water surface DEM to perform the refraction
- Creation of clean water surface DEM can be done in any COTS software.
- Python Executable
- Input: SBET (Trajectory), Water surface DEM, Green LAS data
- Output: Refracted Green LAS





LAS Classes used for this project

LiDAR Classification – Production/Editing	
Class	Description
Class 0	Never Classified
Class 1	Unclassified
Class 2	Ground (Topo)
Class 7	Topo Noise (low or high)
Class 15	Unrefracted points due to out of range values compared to sbets
Class 16	Refracted Points above NIR Points
Class 18	Refracted High Water (HW) points landward of the MLLW land/water interface breakline
Class 19	Refracted Points
Class 20	Bathy Points that remain Unrefracted
Class 21	Sensor noise water surface
Class 22	Bathy Noise (Unrefracted green points higher than the NIR water surface)
Class 23	Sensor Noise (all sensor noise-as classified by the sensor software RiProcess-over land, only unrefracted sensor noise points over water)
Class 24	Sensor noise Refracted
Class 25	Water Column (No Bottom Found)
Class 26	Bathy Bottom (Submerged Topography)
Class 27	Water Surface
Class 28	Temporally-changed bottom
Class 30	Submerged object

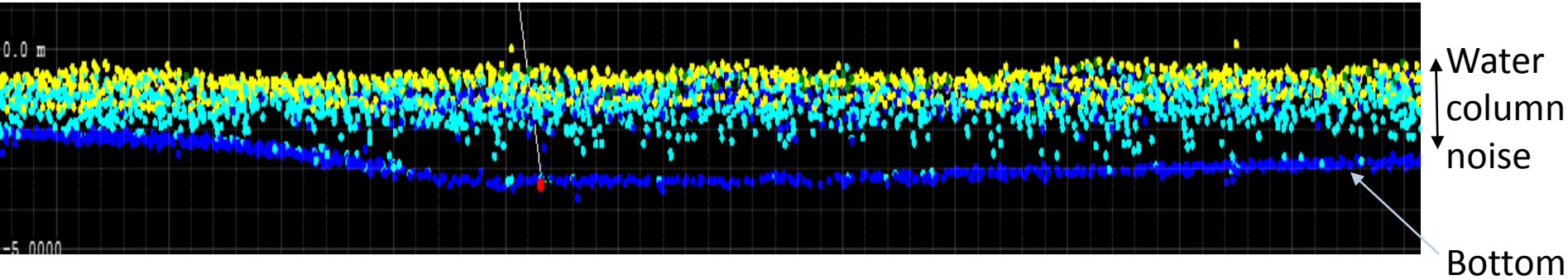
LiDAR Data Production – Sample Data

- Some statistics and a few caveats
- Temporal Issues
- Sample Products
  - Urban setting (Bare earth under vegetation)
    - Density Grid and Confidence Layer
  - Ocean-side performance
  - Bay-side performance
  - Marshy environments
  - Shallow streams
  - Level of detail
  - Submerged Objects
  - Dredged area

Point Density Statistics

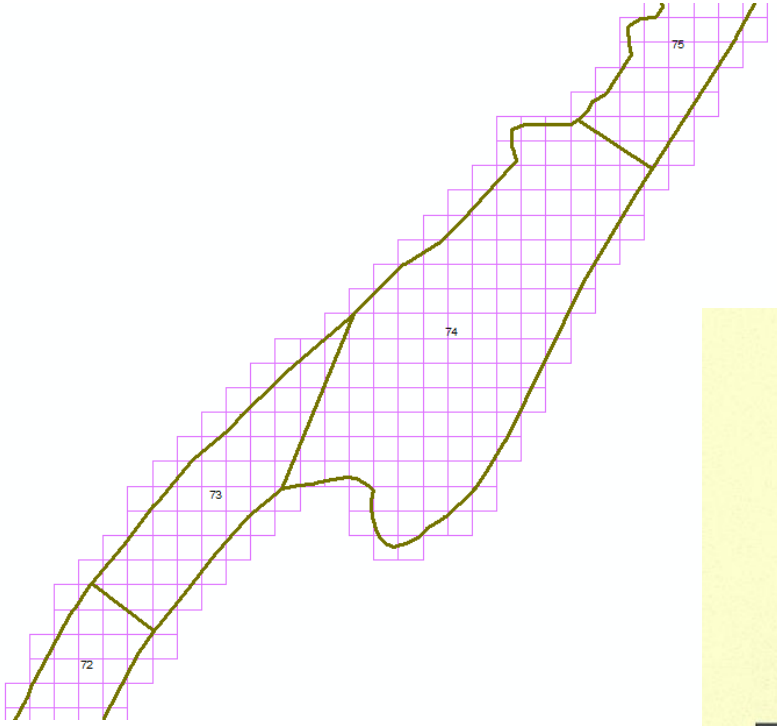
Average* Points per square meter (ppsm)	All returns	Ground and bathy only (classes 2 and 26)
Topo-only	19.1	8.3
Topo-bathy	91.9	5.3
Bathy only	72.0	4.5

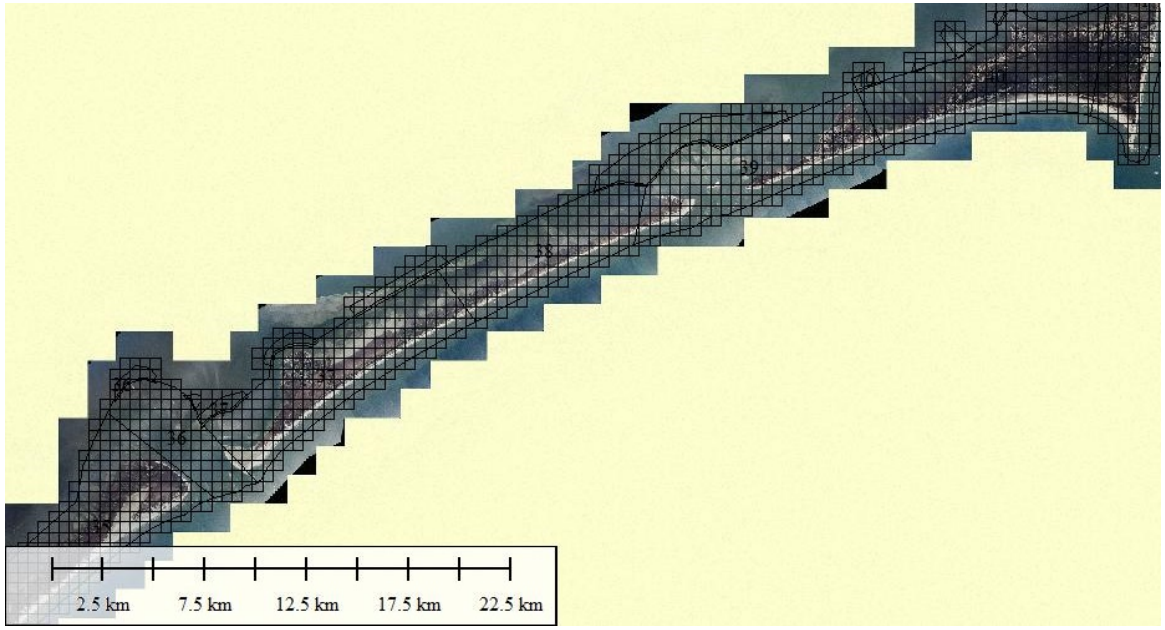
* Determined using representative tiles for each category



Data Production – Tile Grid

Data were processed in 500 m by 500 m tile grids. There are 39,286 tiles in the project area





Final Accuracy Results

$RMSE_z$ in urban / open terrain is 7.8 cm
$RMSE_z$ in submerged topography is 16.5 cm

Land Cover Category	# of Points	$ACCURACY_z$ ($RMSE_z$ x 1.9600) m	CVA – Consolidated Vertical Accuracy (95th Percentile) m	SVA – Supplemental Vertical Accuracy (95th Percentile) m
Consolidated	261		0.226	
Brush Lands and Trees	63			0.240
Tall Weeds/Crops	68			0.227
Urban/Open Terrain	62	0.153		
Forested	68			0.176
Submerged Topography	52	0.323		

Open Terrain must meet 24.5 cm $Accuracy_z$ while Submerged Topography must meet 49 cm $Accuracy_z$. CVA and SVA must meet 36 cm based on the 95th percentile.

Sample Submerged topographic checkpoint

ST 37 located in a Delaware back bay.
Surveyed Z (ellipsoid height)= -35.699 m,
Lidar Z (ellipsoid height) = -35.690 m.
DZ= 0.009 m.

Depth was a little over 2 feet.

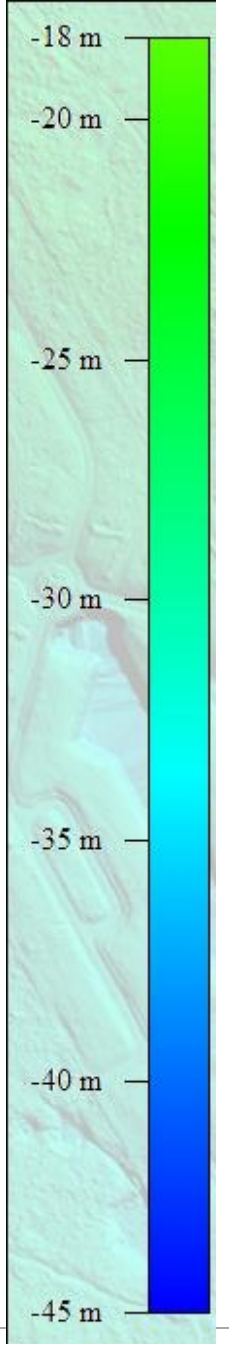
Sample Submerged topographic checkpoint

ST 36 located in a Maryland back bay.
Surveyed Z (ellipsoid height)= -36.254 m,
Lidar Z (ellipsoid height) = -36.230 m.
DZ= 0.024 m.

Depth was approximately 1.5 feet

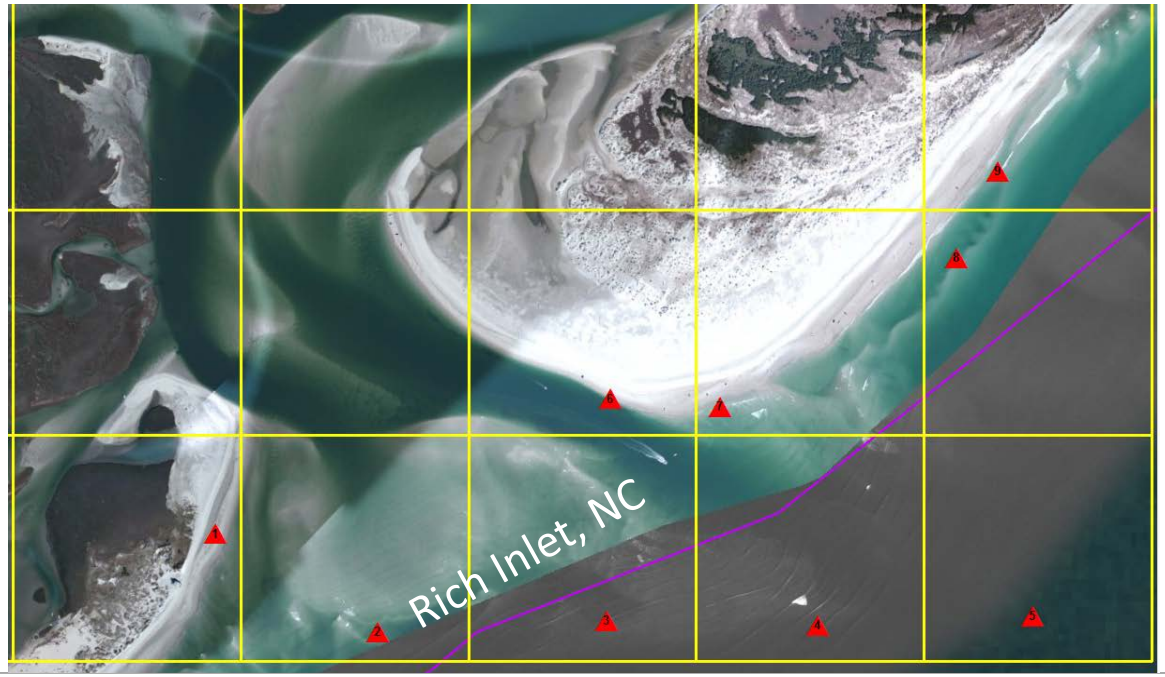
Sample Data – Caveats

- These products are not final – NOAA is still reviewing these data products
- Many DEMs are preliminary and generated from the point cloud data delivered to NOAA. TIN artifacts may exist.
- In several cases, data are referenced to ellipsoid elevations (Color ramp values do not indicate depths)
- Bathymetry data will not always be displayed in the “blue” range of the color ramp

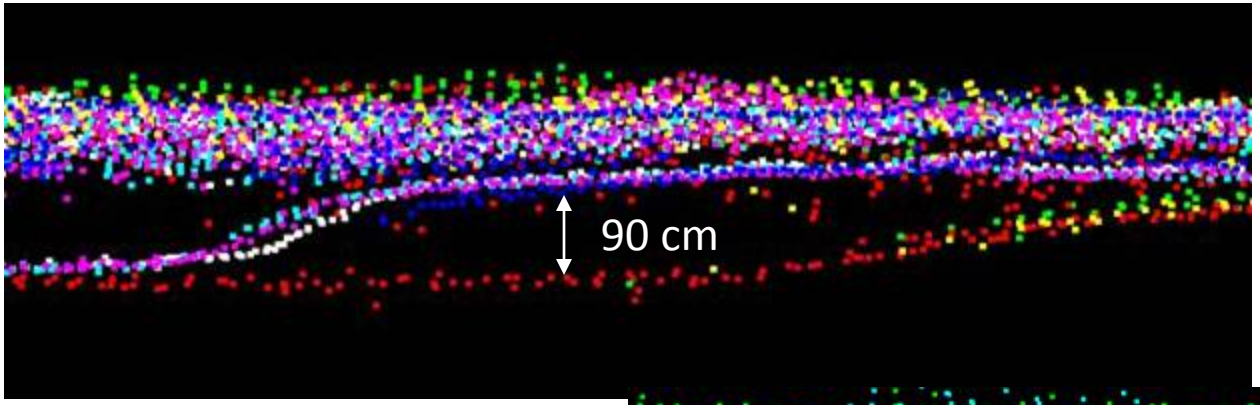


Temporal Discrepancies

- Data acquisition lasted 8 months
- Temporal changes occurred primarily near inlets and island spits due to movement of sediment.

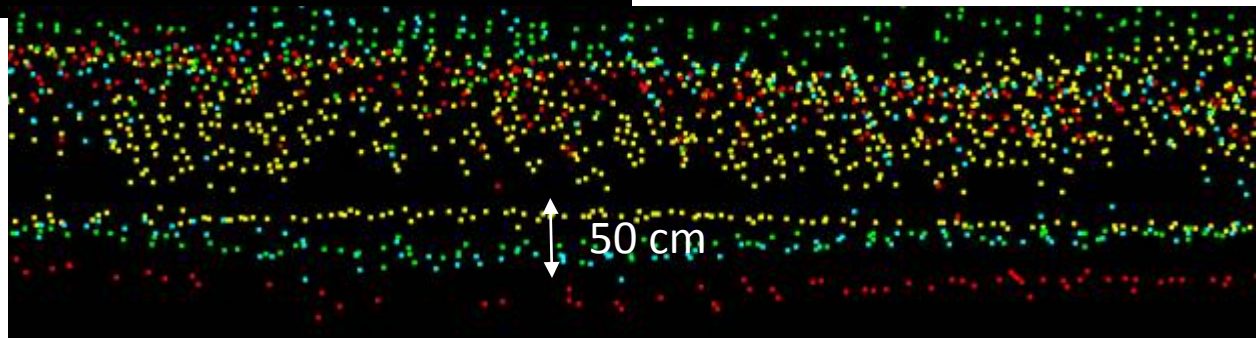


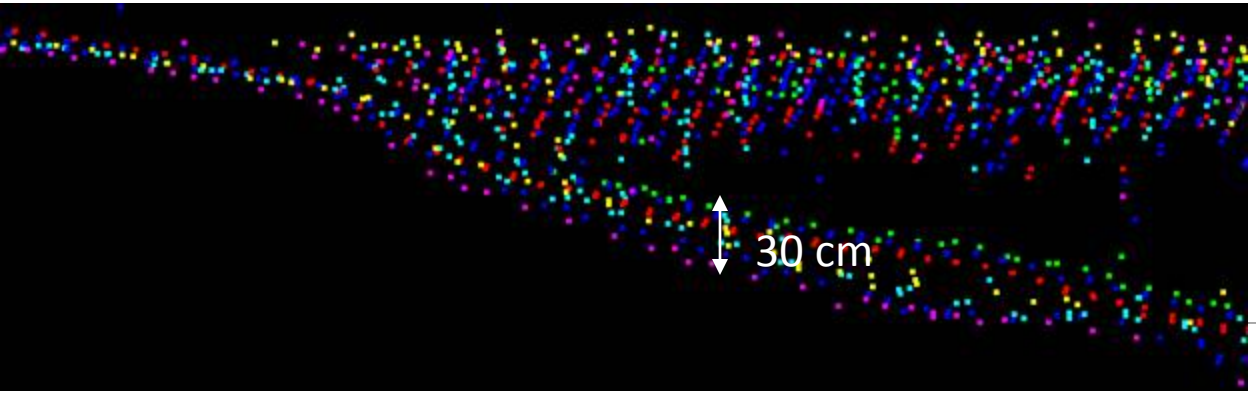
Temporal discrepancies – Sample profiles



Point 3

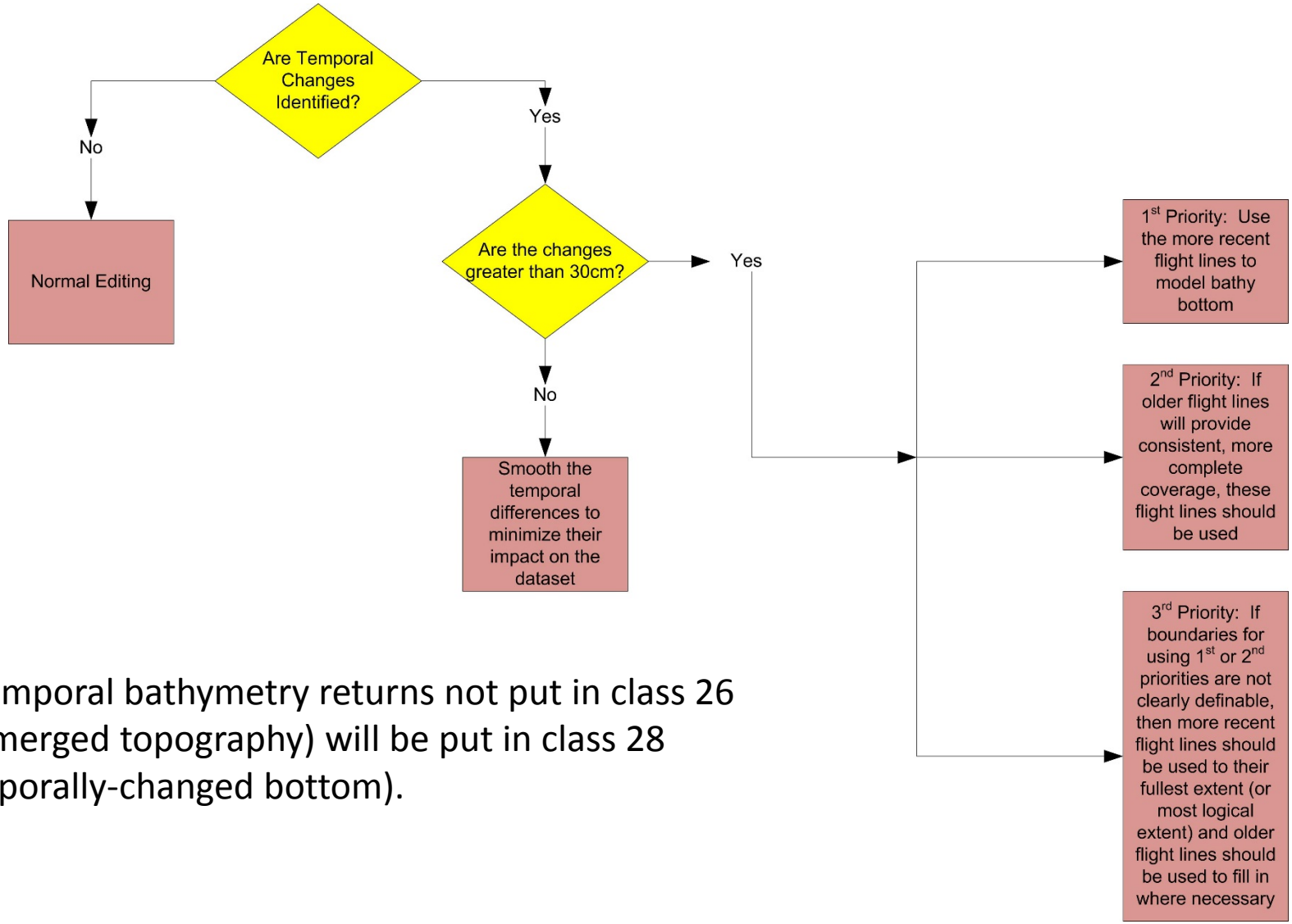
Point 5





Point 6

Temporal Issues – Resolution



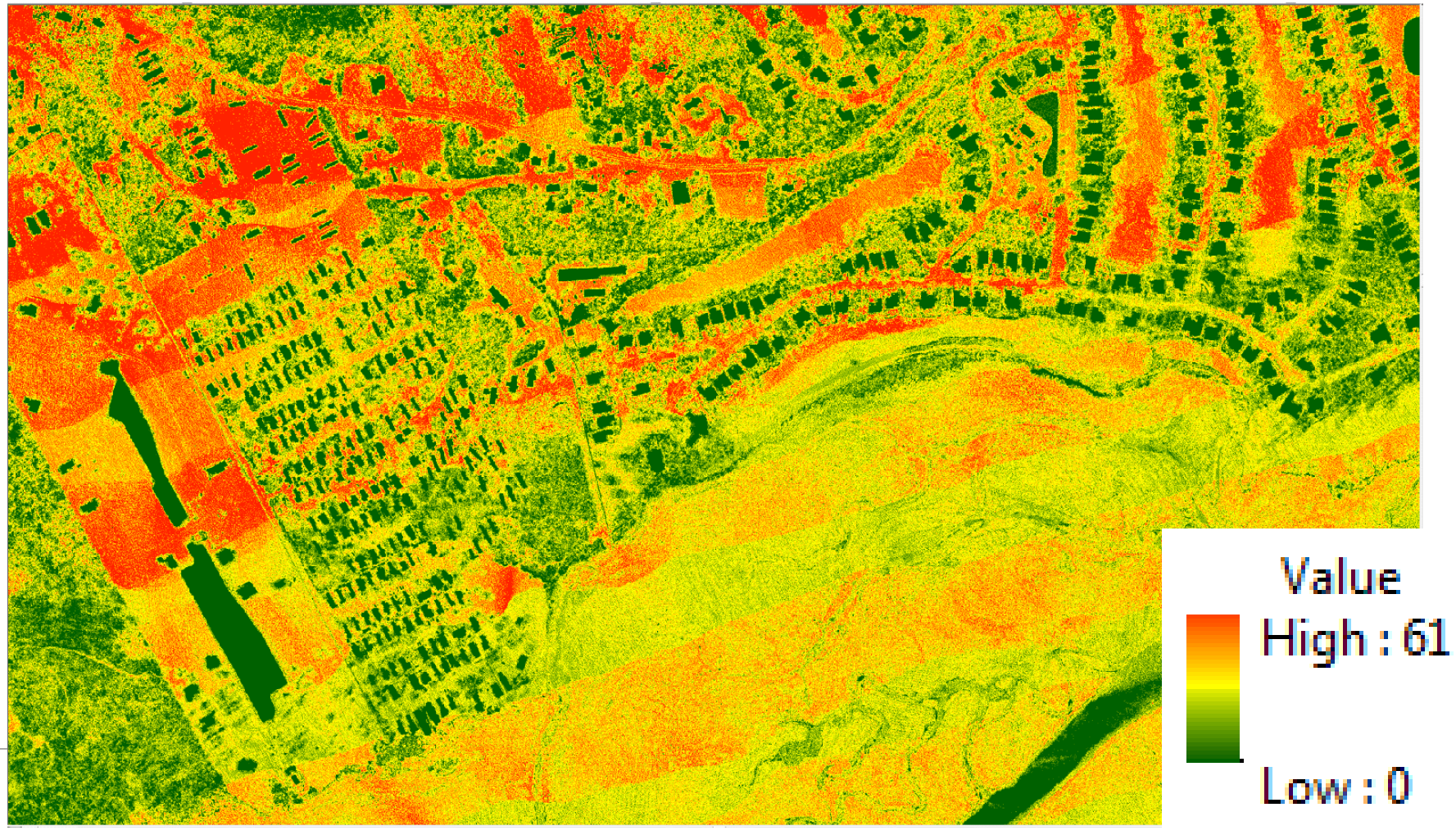
All temporal bathymetry returns not put in class 26 (submerged topography) will be put in class 28 (Temporally-changed bottom).

Sample Data – Urban Area

- Green wavelength topobathy sensors can be used to map in similar conditions as NIR topo sensors.

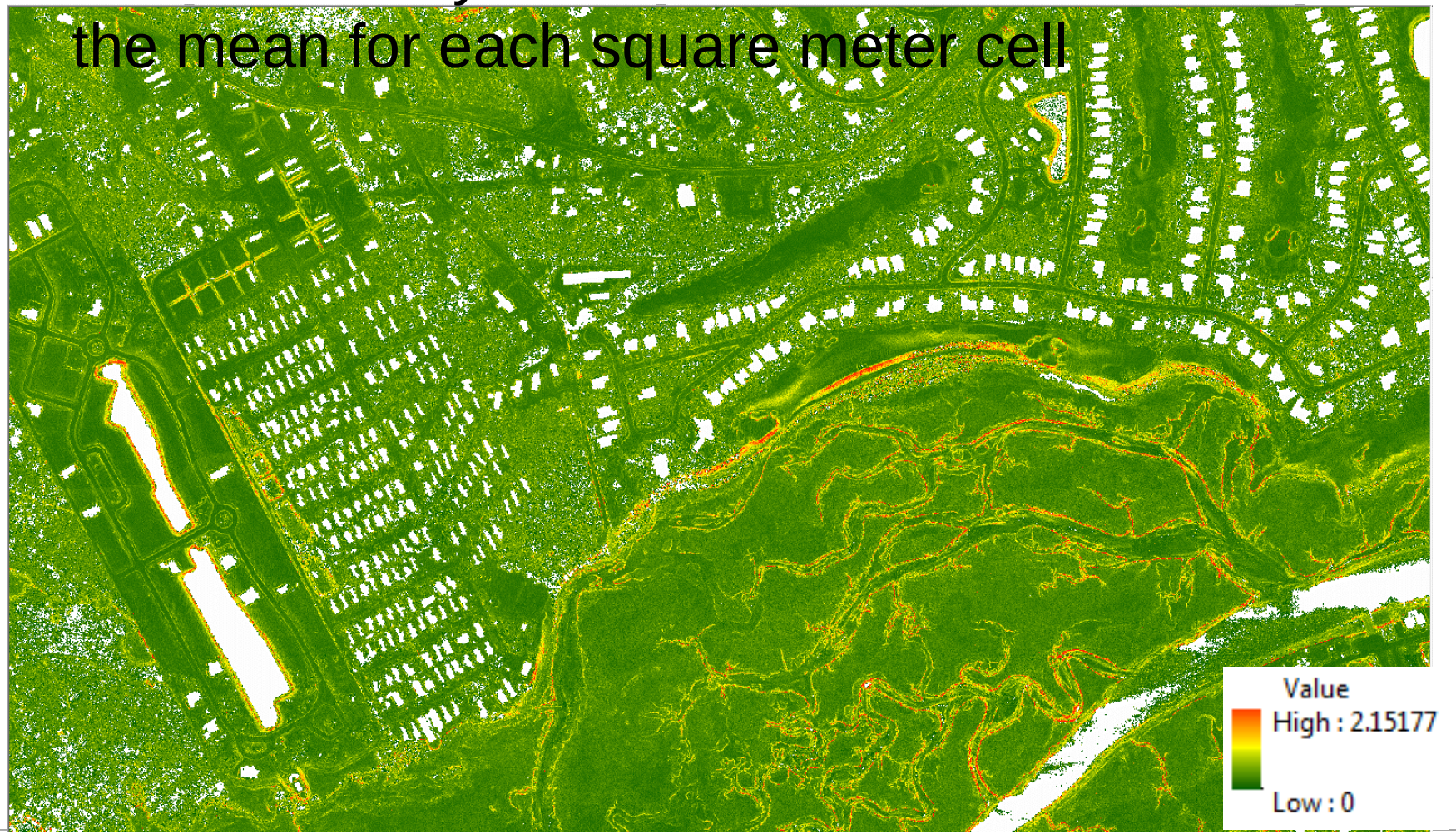
Sample Delivered Product – Density Grid

- Density of classified point cloud data per square meter



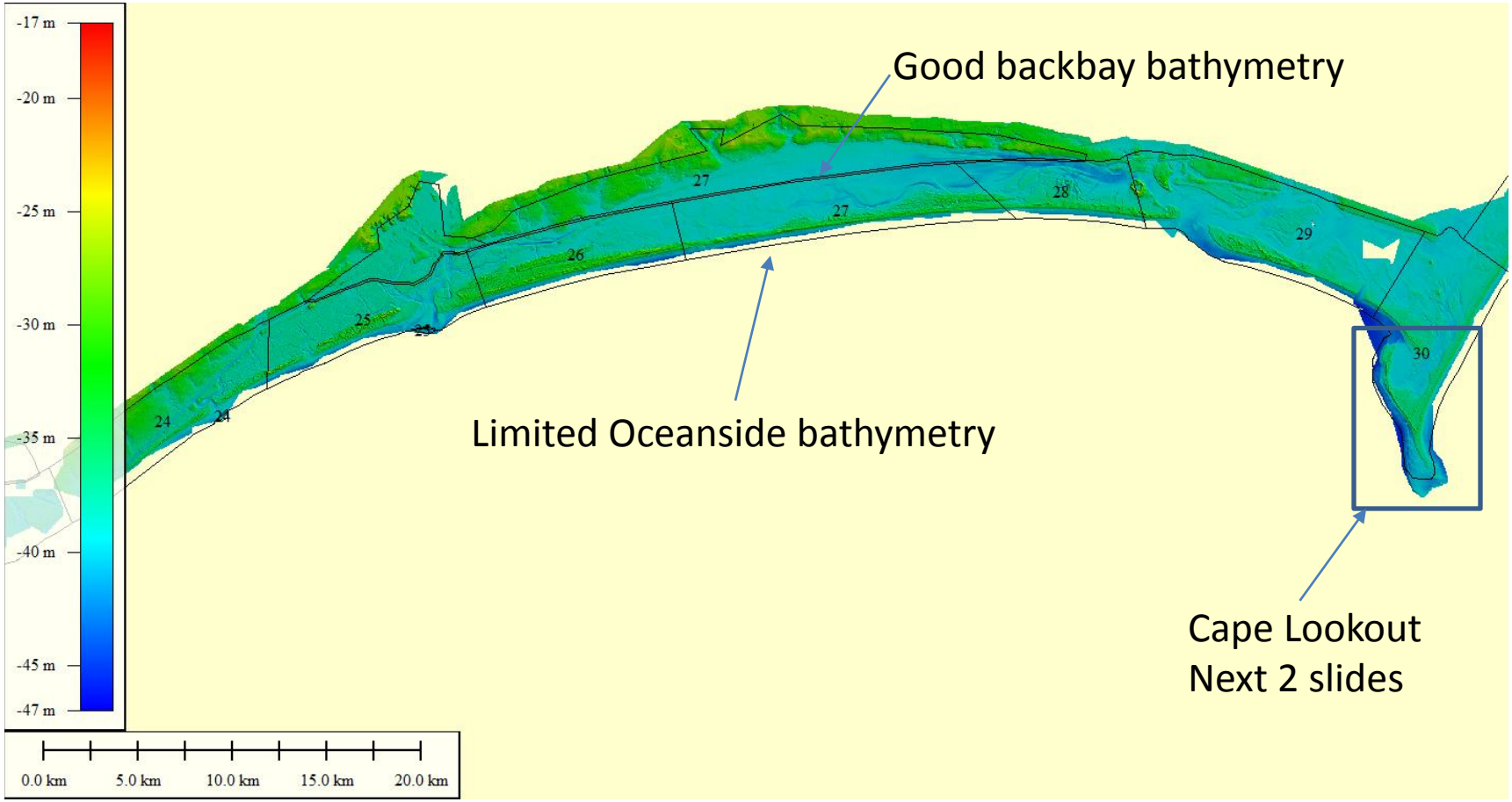
Sample delivered product – Confidence Layer

- Confidence layer is the standard deviation from the mean for each square meter cell



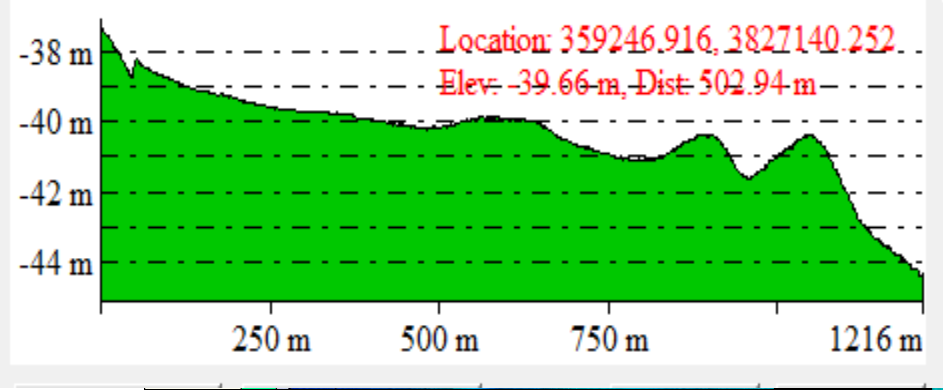
Dewberry

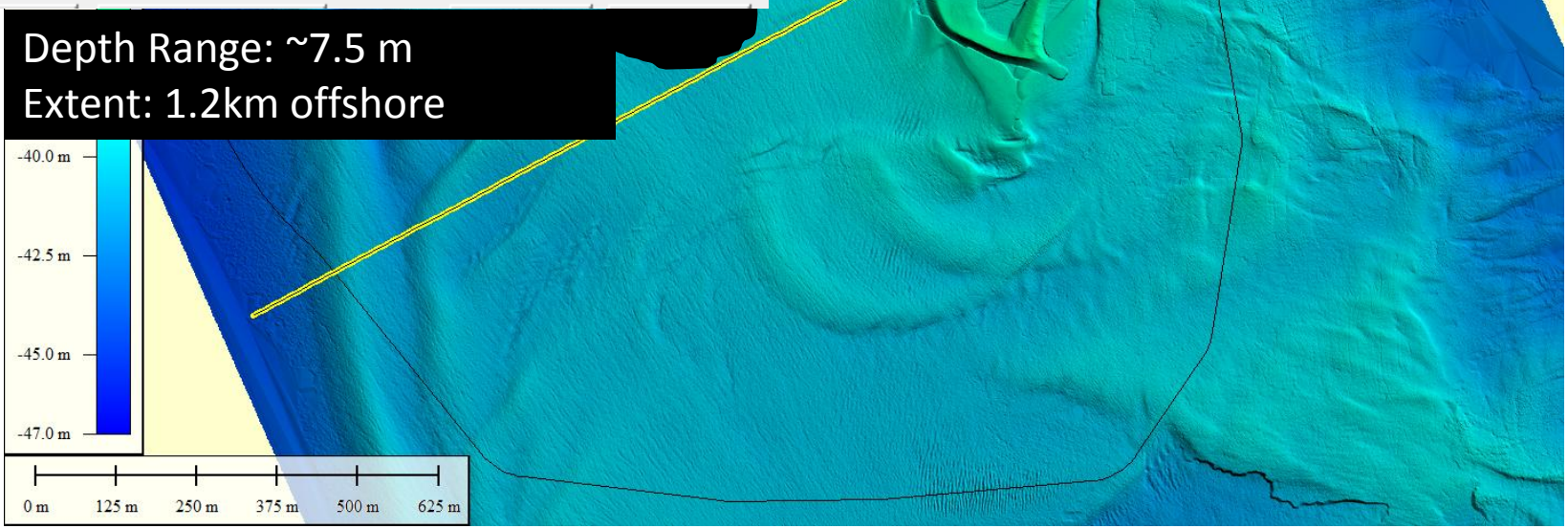
Oceanside and Backbay Performance



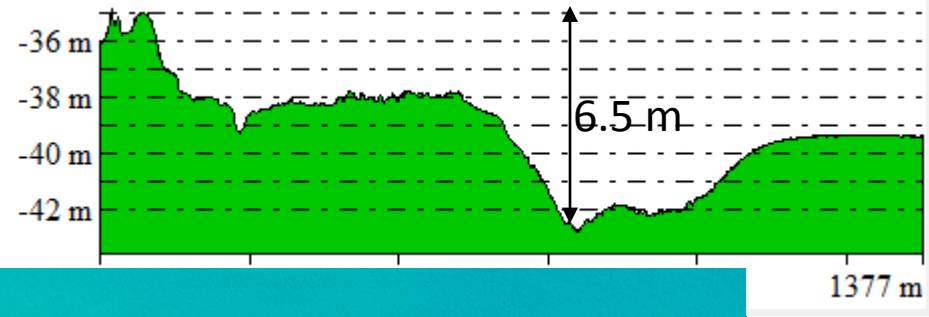
Ocean Side Performance

Cape Lookout (NC)





Backbay Performance



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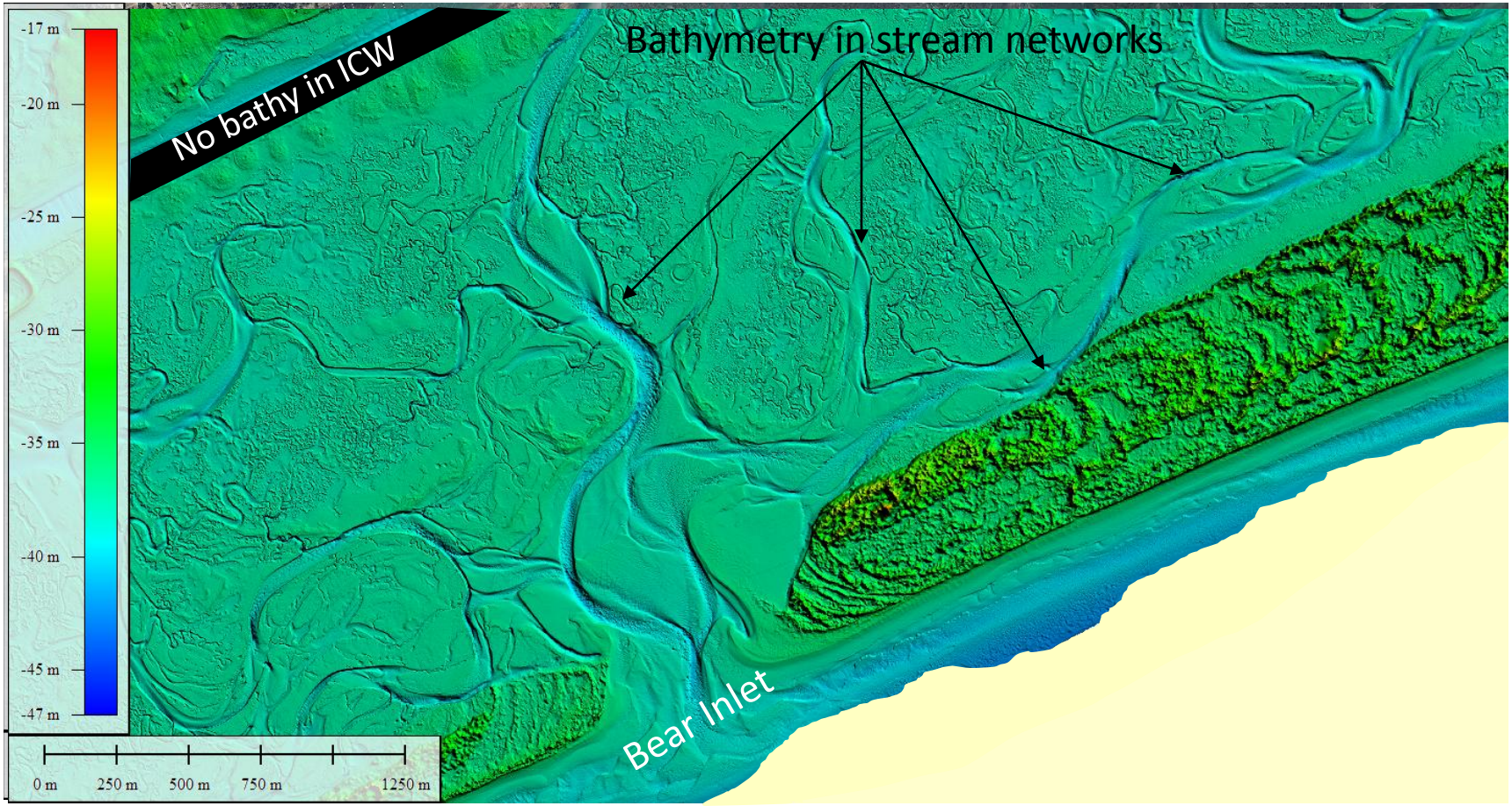
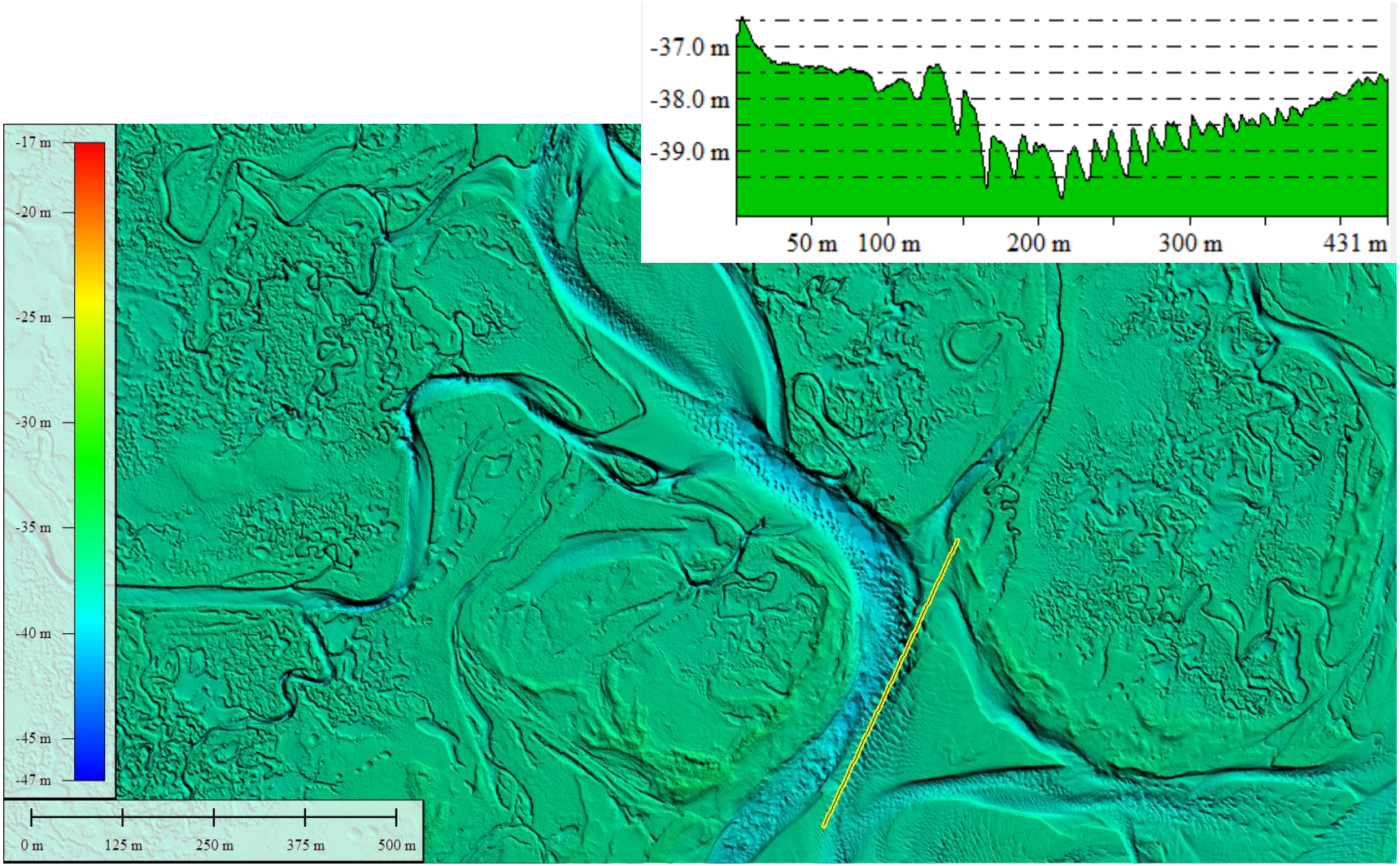
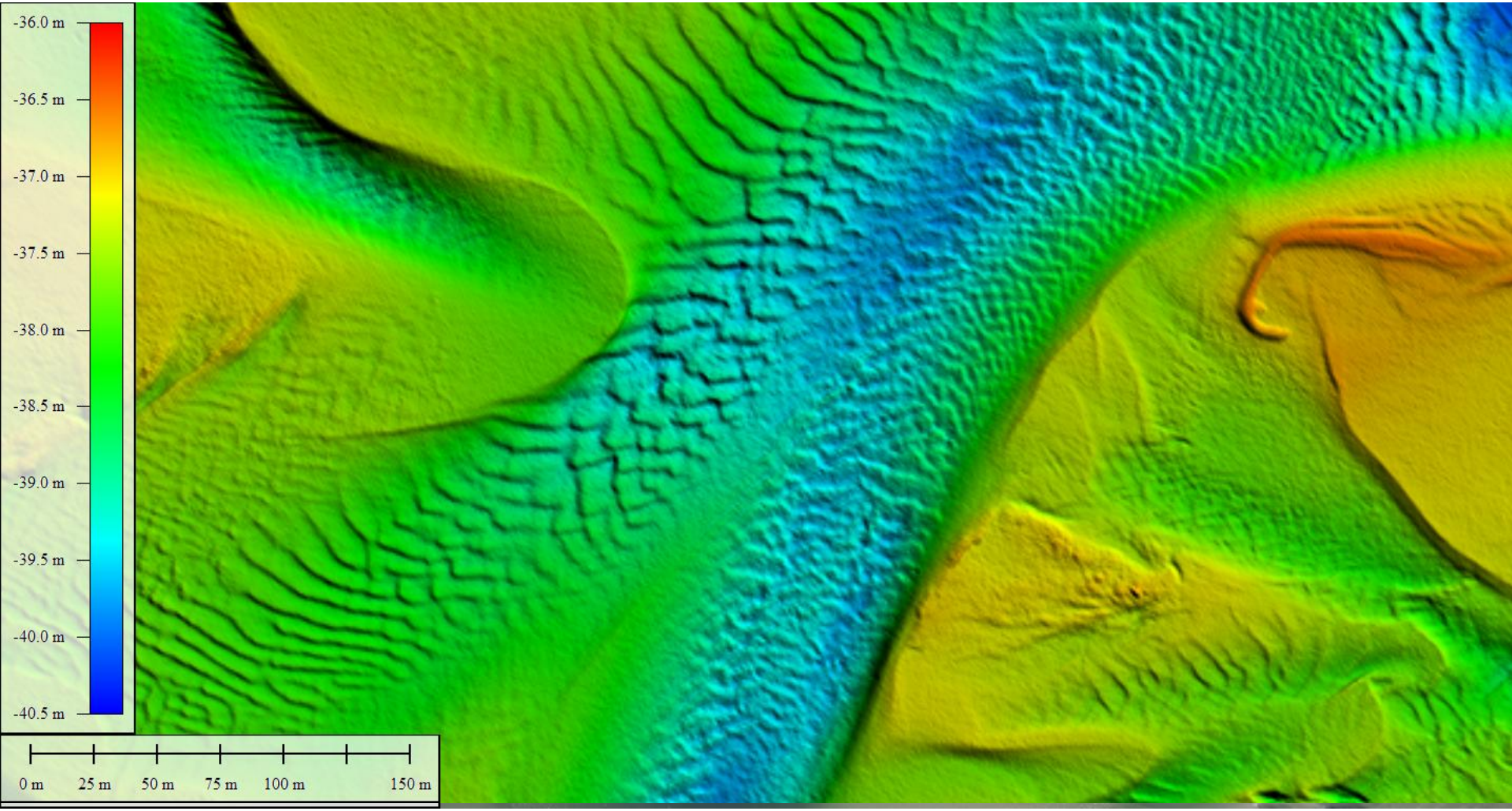
Backbay Marshes



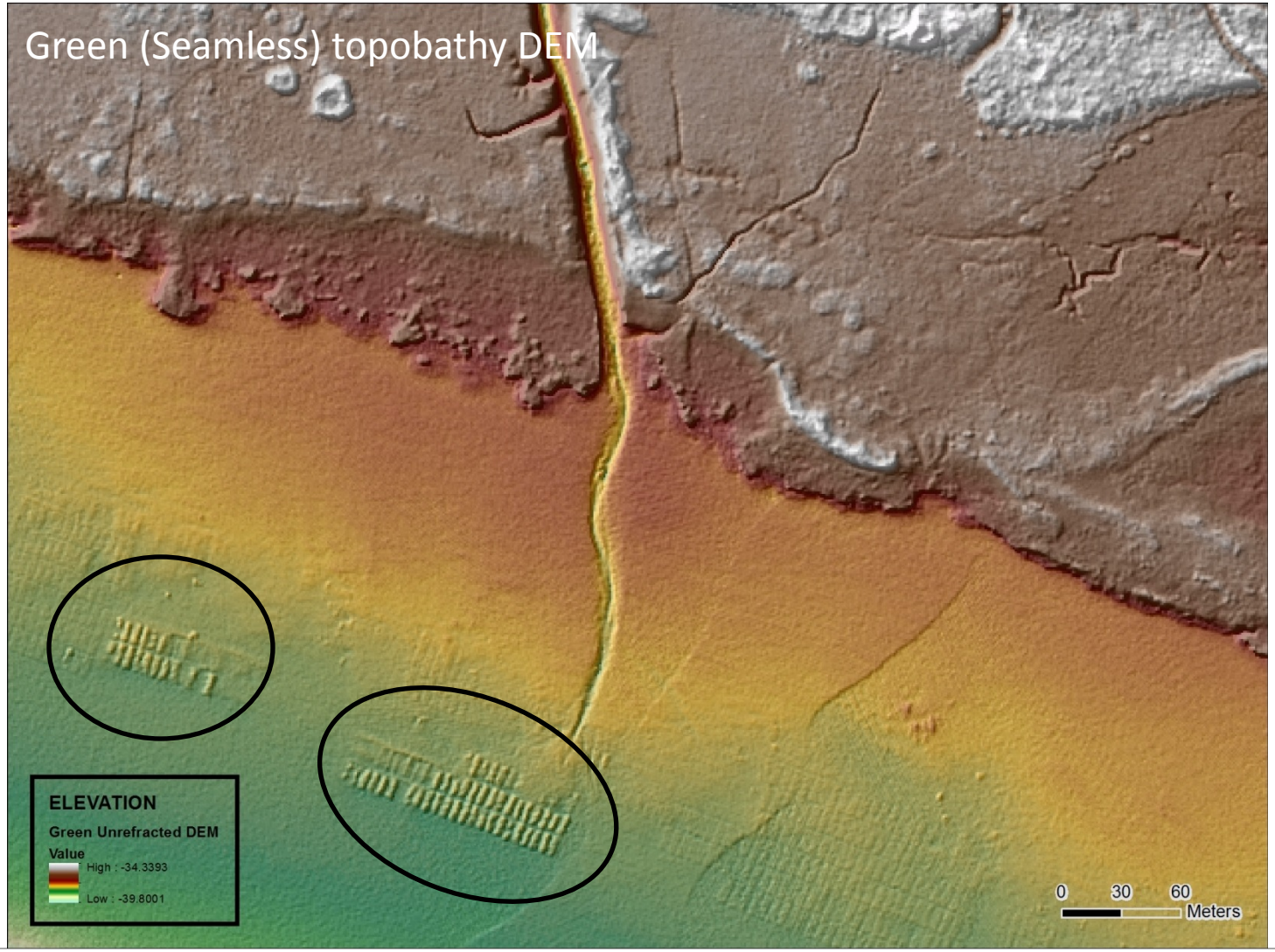
Backbay Marshes



Level of Detail



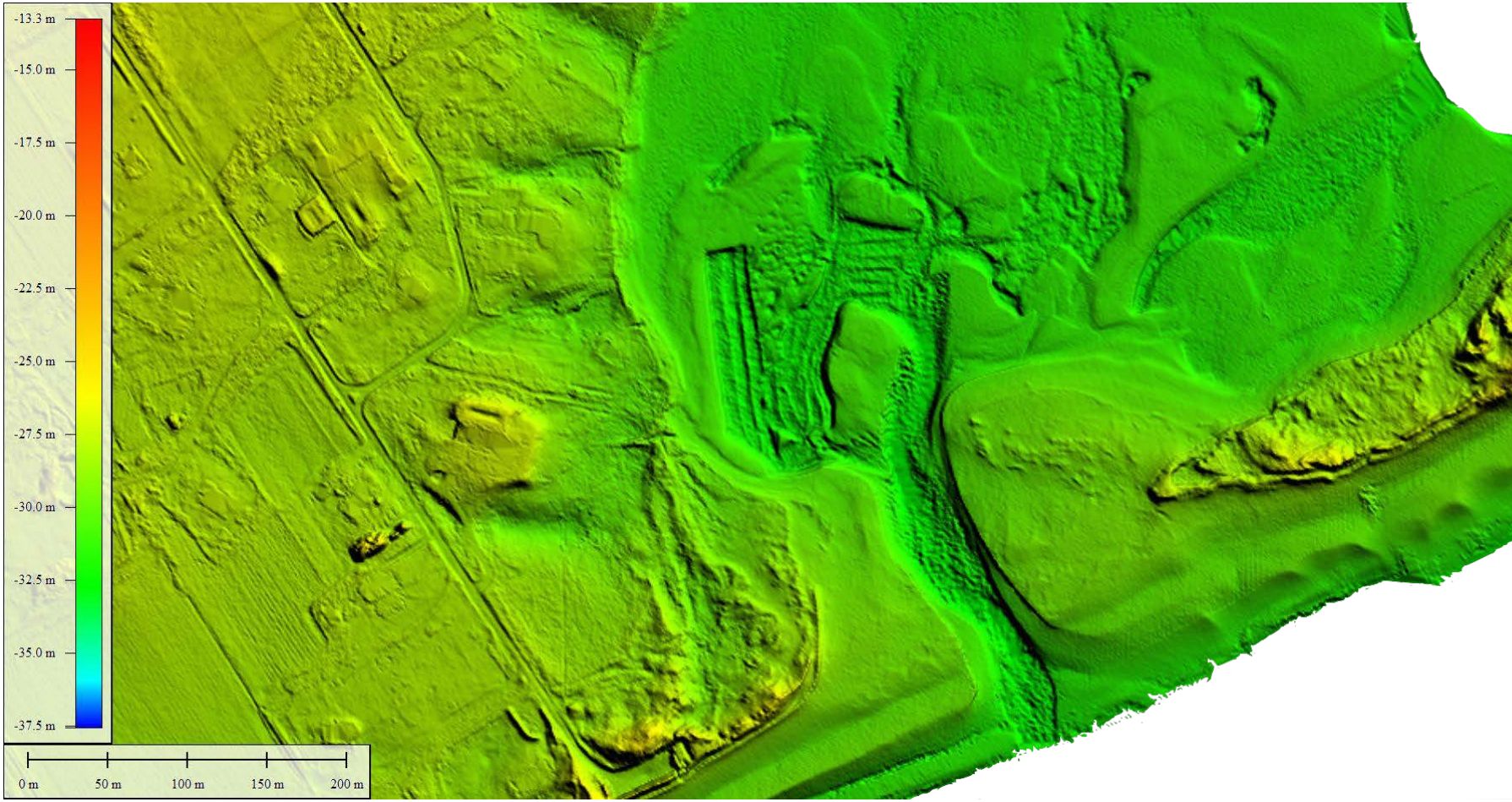
Identifying submerged features in topobathy LiDAR – Oyster beds

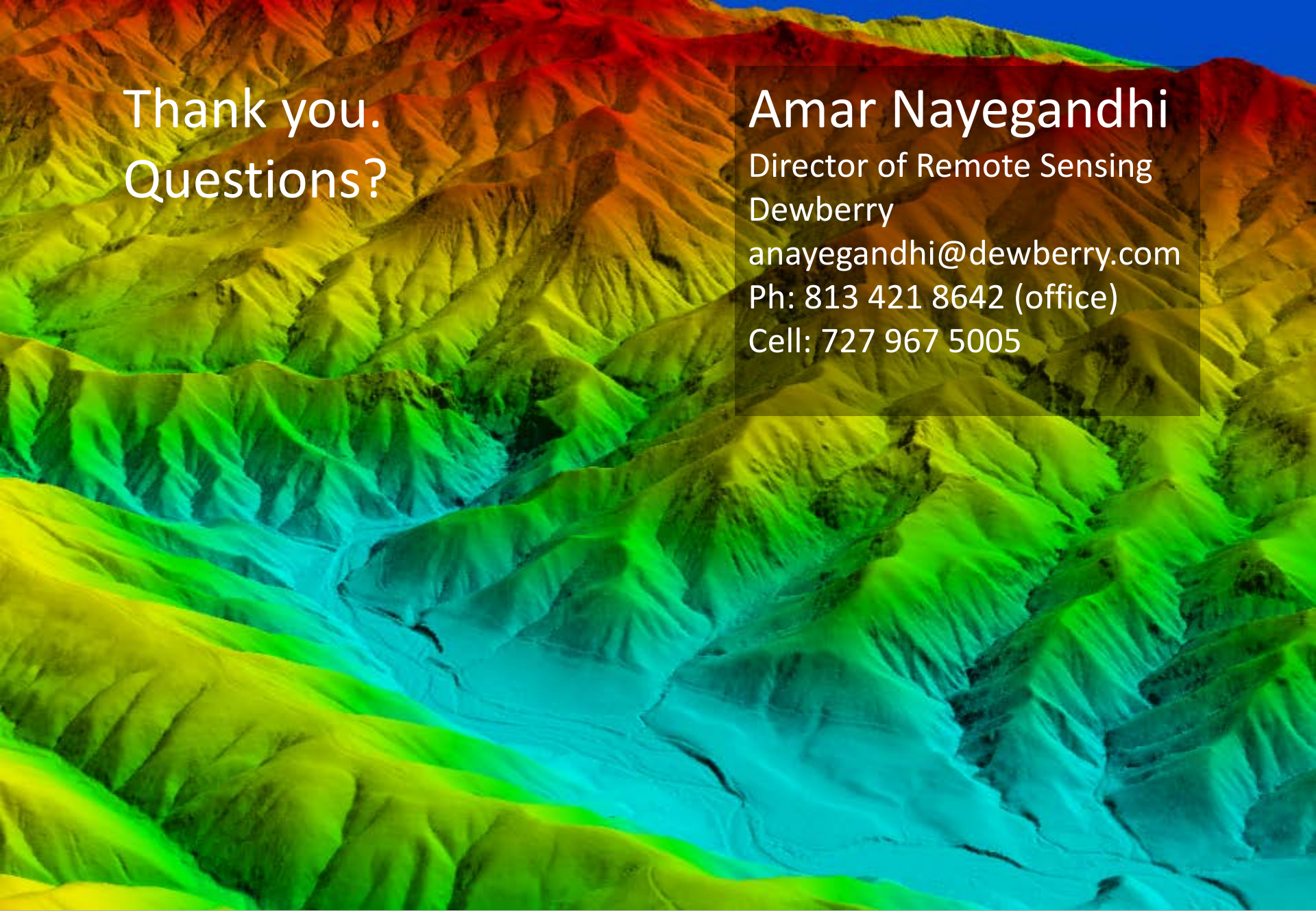


Dredged Area – Fire Island

Dewberry

Dredged Area





Thank you.
Questions?

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Cell: 727 967 5005

Dewberry