TELEDYNE OPTECH
Everywhereyoulook™

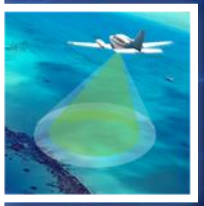
CZMIL Nova – New Teledyne Optech Product

JALBTCX Workshop June 18, 2015

Corvallis, OR

Brian Martin, Vinod Ramnath, Viktor Feygels, Bob Marthouse, Edward Renz, and Kristopher Blackwood

6/18/2015



Accuracy & Productivity Matter

Coastal Zone Mapping and Imaging Lidar CZMIL

- The Teledyne Optech CZMIL is an airborne multi-sensor system designed for highly automated generation of 3D topobathy information for the coastal zones.

- Successfully deployed in more than 6 countries
- Field tested in a wide range of environments
- Designed to comply with DO-160F regulations
  - Electromagnetic Interference (EMI)
  - Shock and Vibration
  - Crash Safety

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Improvements

The improvement constraints to the CZMIL system

- Reduce Size
- Reduce Weight
- Reduce Power Consumption
- Increase Reliability
- Increase Environmental Durability

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CZMIL Nova

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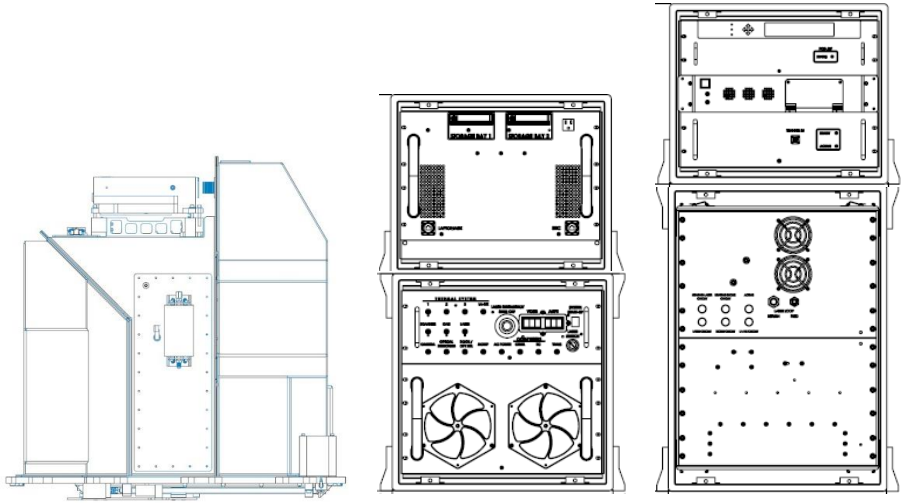
CZMIL Nova

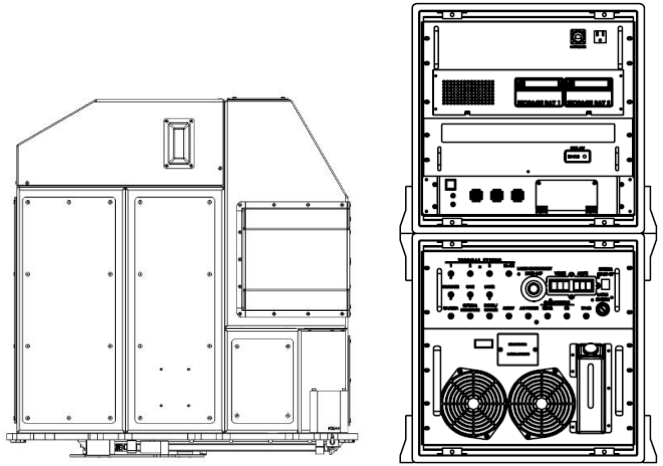
Operator Unit
Control Unit
Thermal Management System
Lidar Sensor Head
CASI-1500 (optional)

CZMIL Evolution

CZMIL 1st Generation



CZMIL Nova



- Reduced Overall System Size by 30%
- Reduced Overall System Weight by 27%
- Decreased the Power Consumption by 25%

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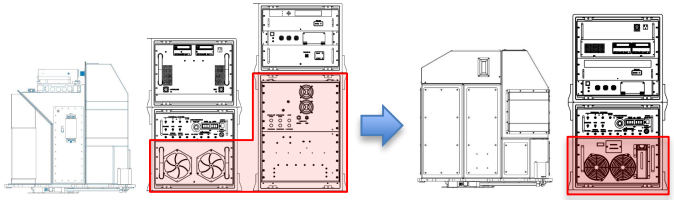
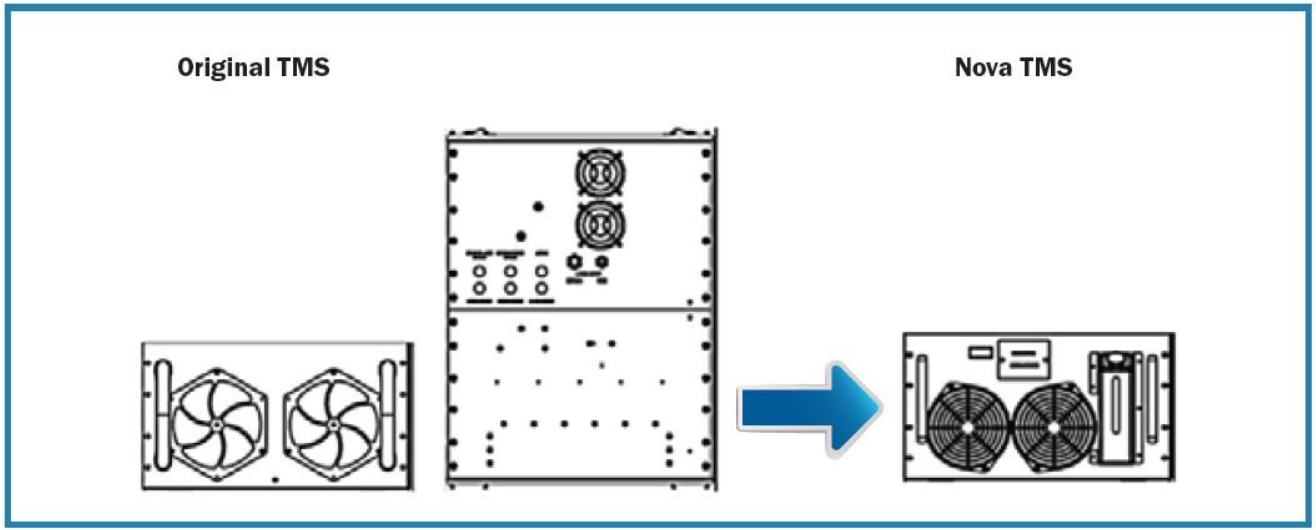
Thermal Management System (TMS) Redesign

The CZMIL TMS is a Peltier element, based hydraulic thermal control system designed to maintain a precise and constant laser diode set point temperature.



- Reduced Size by 70%
- Reduced Weight by 70%
- Reduced Power by 25%
- Improved Thermal Response Time



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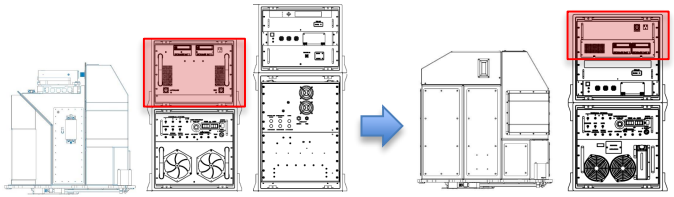
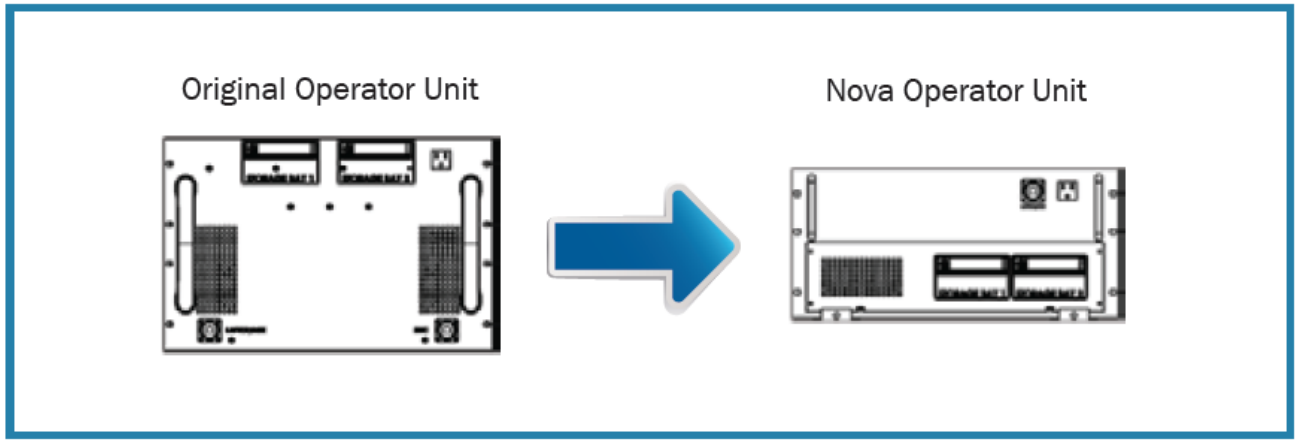
Operator Rack Redesign



The CZMIL Operator Rack houses

- System Level Interface Computer
- Real-time computer
- Data storage computer
- Network switch

- Reduced Size by 28%
- Reduced Weight by 25%
- Improved System Reliability & Field Serviceability



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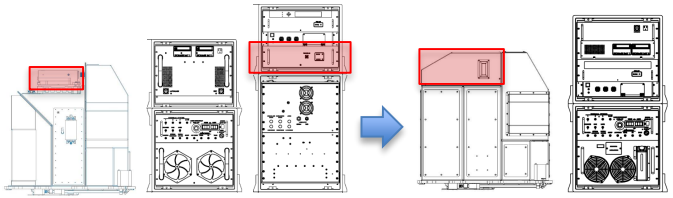
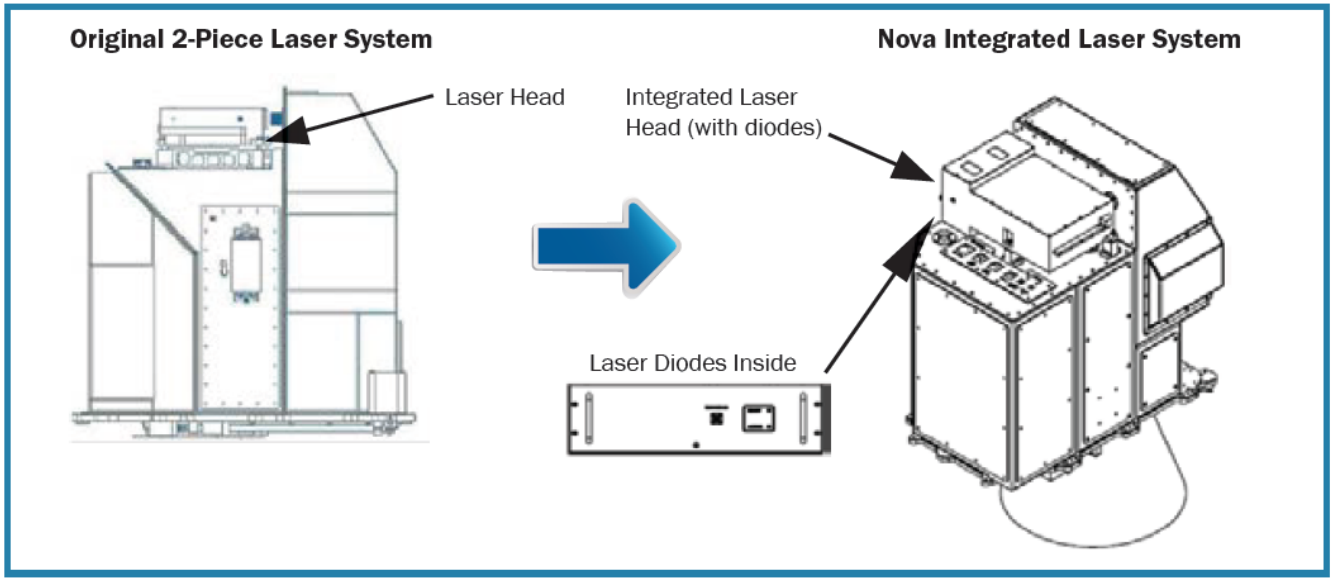
Laser Redesign

The 2-piece CZMIL laser was integrated into a single laser unit.



- Reduced Size by 8%
- Improved Ruggedization



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Piper Navajo Integration

The CZMIL Nova has been integrated into a Piper Navajo

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System Platform Integration

The CZMIL system has been successfully integrated in…

Beechcraft King Air 200

Beechcraft King Air E90

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Conclusion

The CZMIL Nova offers

- Enhanced system reliability
- More versatile platform integration for smaller & more economically efficient aircraft
- Reduced payload = Greater fuel carrying capacity = Longer flights!

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TELEDYNE OPTECH
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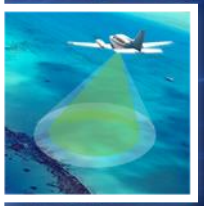
What's new in HydroFusion

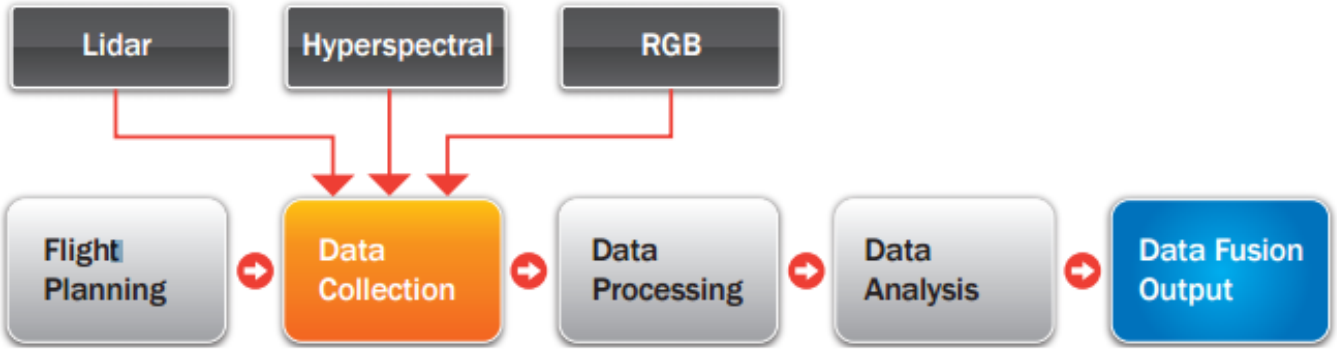
JALBTCX 2015



Vinod Ramnath, Hemanth Kalluri, Viktor Feygels
06/18/2015
Corvallis, OR

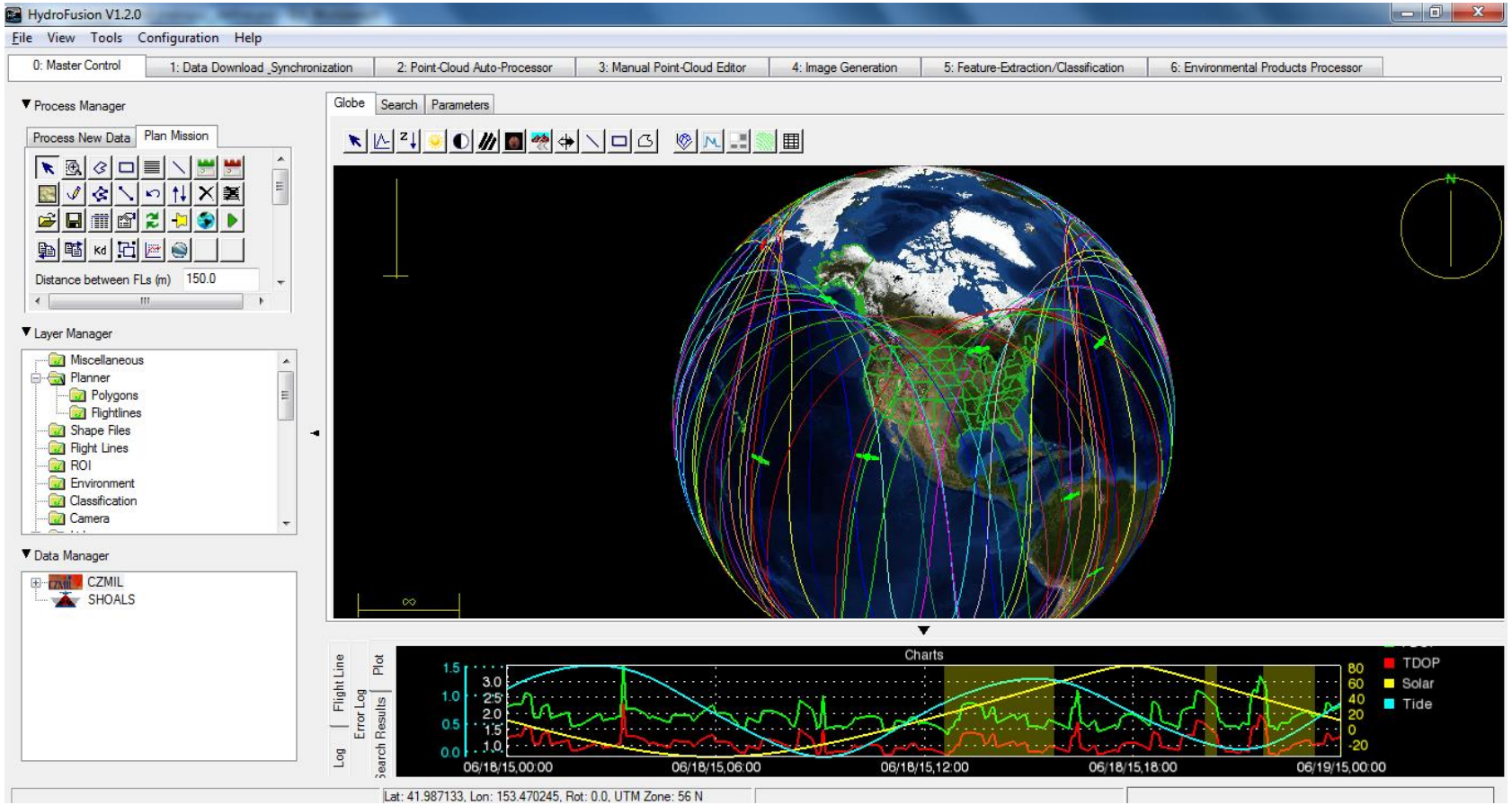
Accuracy & Productivity Matter

HydroFusion



- HydroFusion is a powerful end-to-end software suite for CZMIL Nova
- HydroFusion automatically produces high-resolution 3D data and environmental image products by combining data from three lidar, hyperspectral and digital metric camera—within a data fusion paradigm

HydroFusion



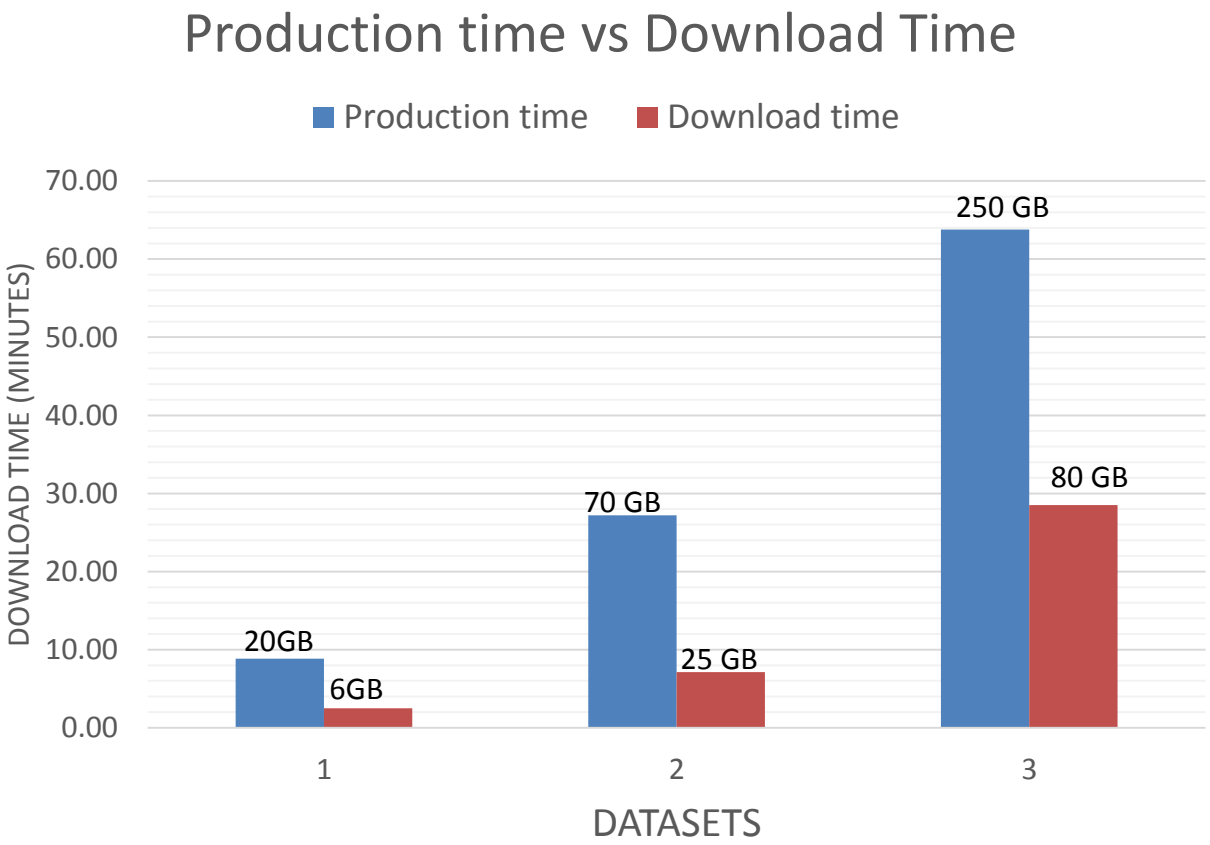
HydroFusion Enhancements

- Lidar download program
- Lidar processing enhancements
- CZMIL Manual Editor
  - QA/QC capability
- Lidar Geo-calibrator program
- Camera color balancing
- Volume Visualizer

Enhance the overall workflow productivity

Lidar Download Program

- CZMIL data rate:
  - 10 kHz Deep bathy
  - 70 kHz Shallow bathy
  - 80 kHz Topo
- CZMIL has 9 channels and waveform storage is standard

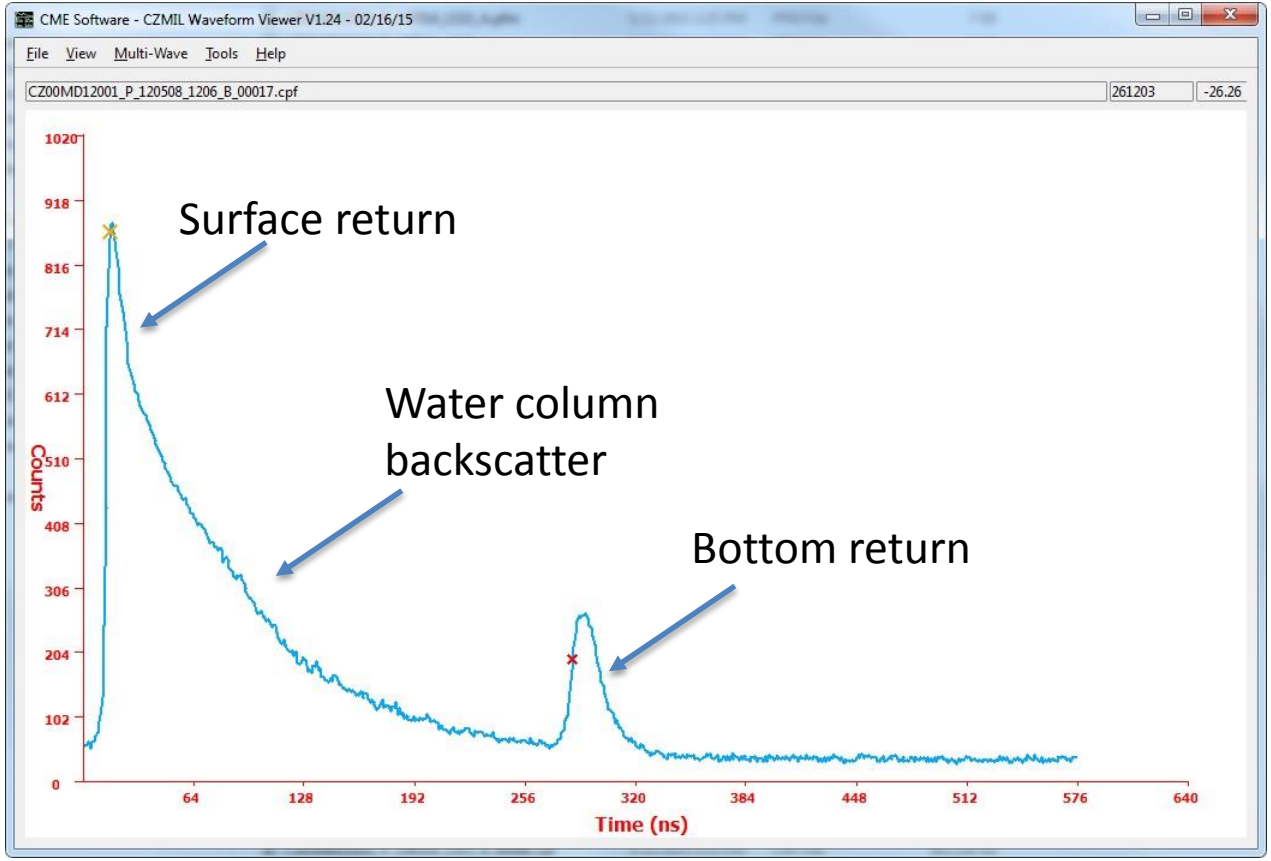


Lidar Download Program

- Download the CZMIL data in **half the time** it takes to collect the data
- The program uses multi-threading architecture
- A data compression ratio of approximately 3:1 is achieved (raw data: downloaded data)

Lidar Processing Enhancements

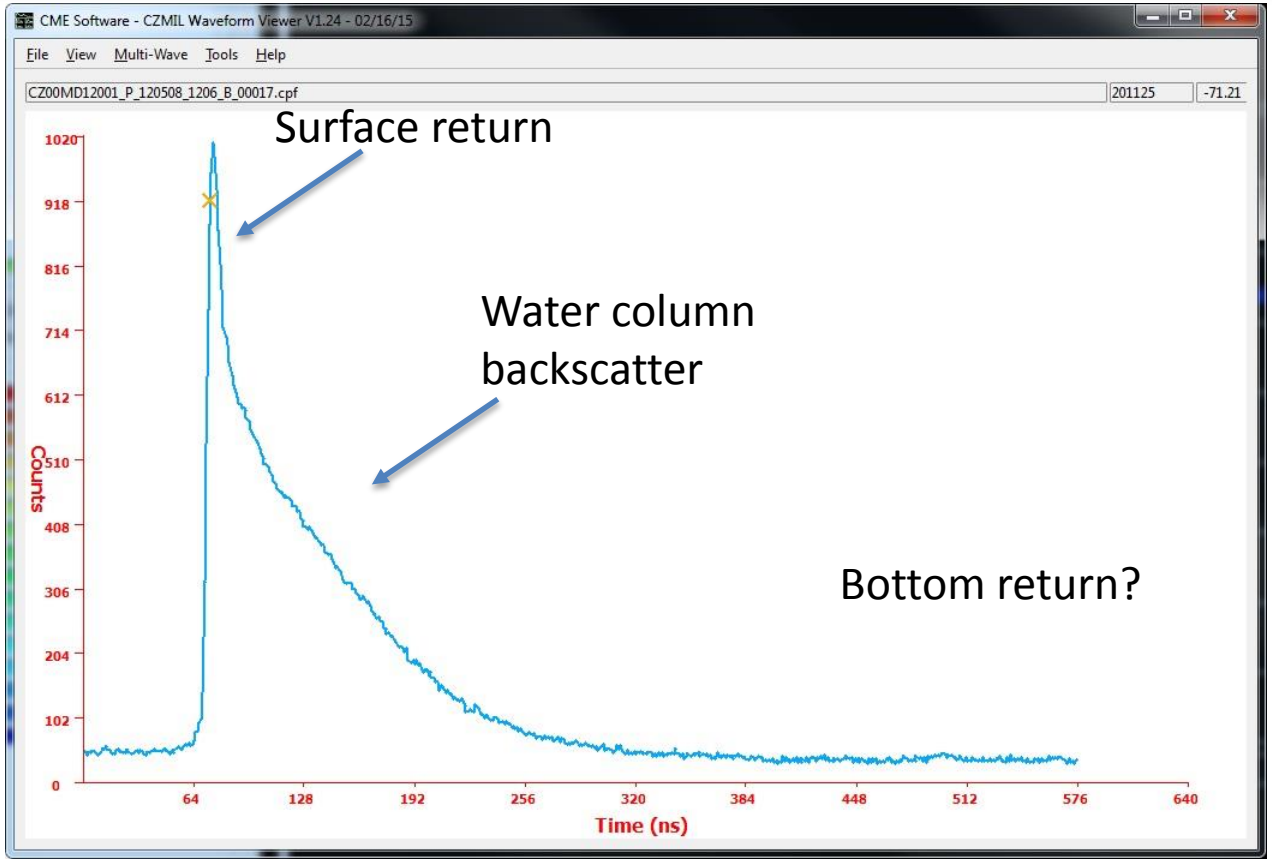
Waveform 1



Typical bathymetric waveform

Lidar Processing Enhancements

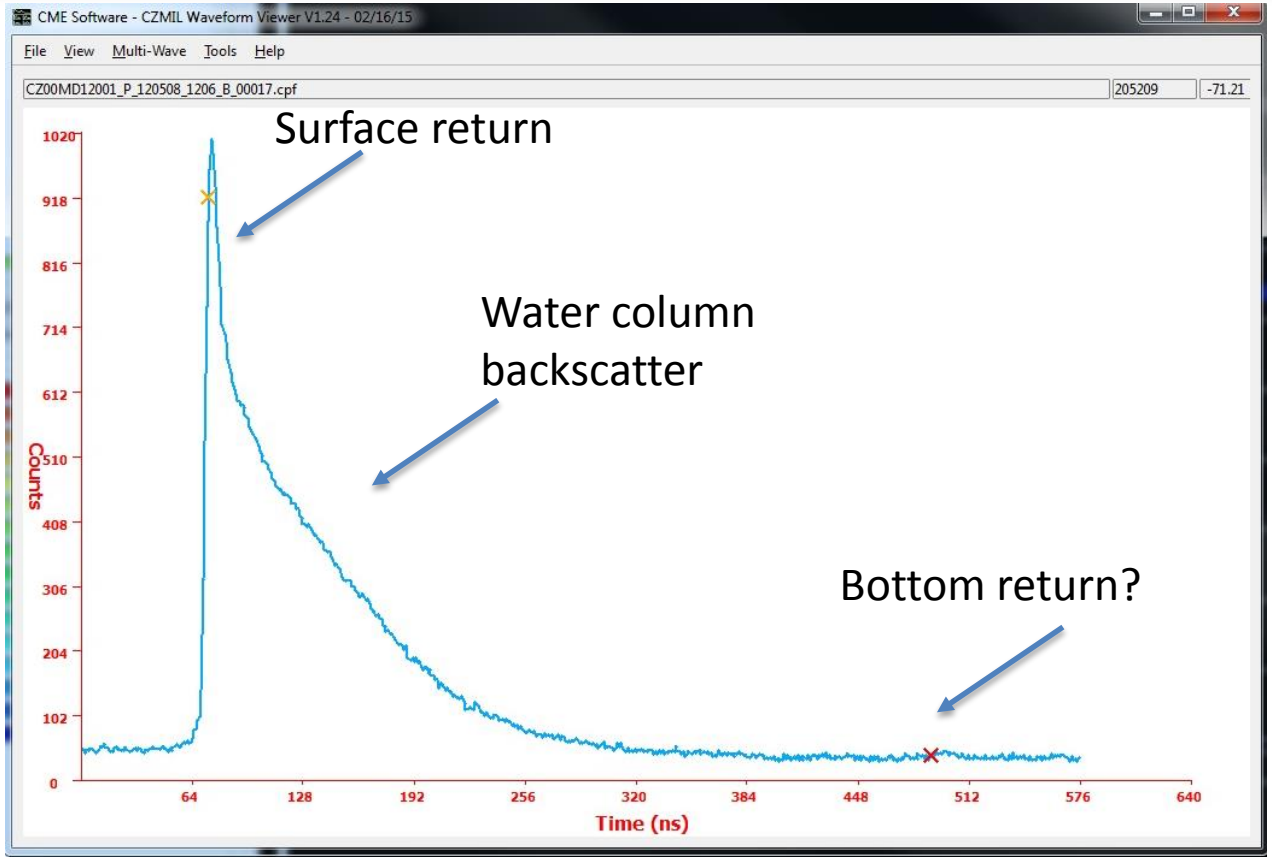
Waveform 2



Typical bathymetric waveform

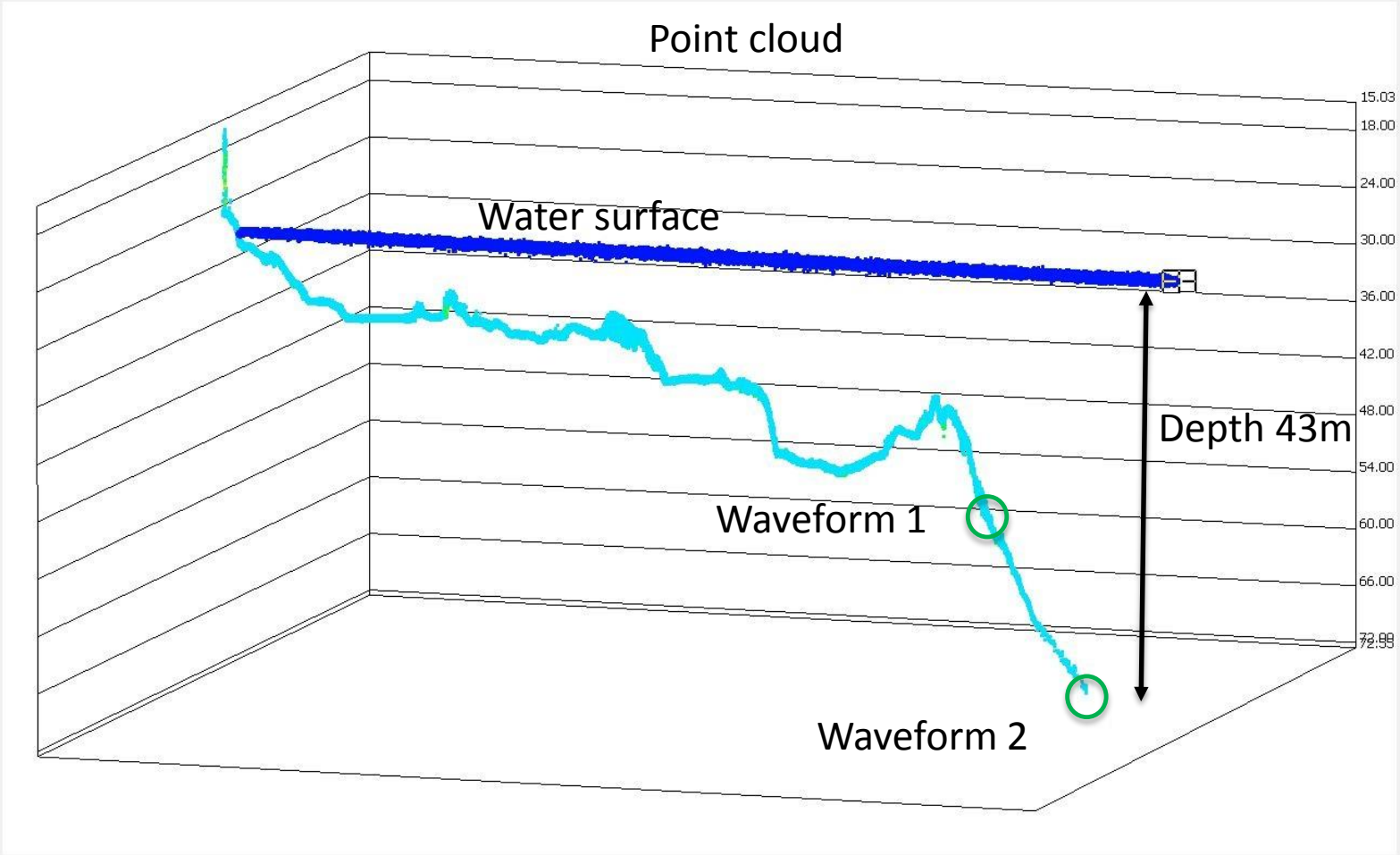
Lidar Processing Enhancements

Waveform 2



Typical bathymetric waveform

Lidar Processing Enhancements

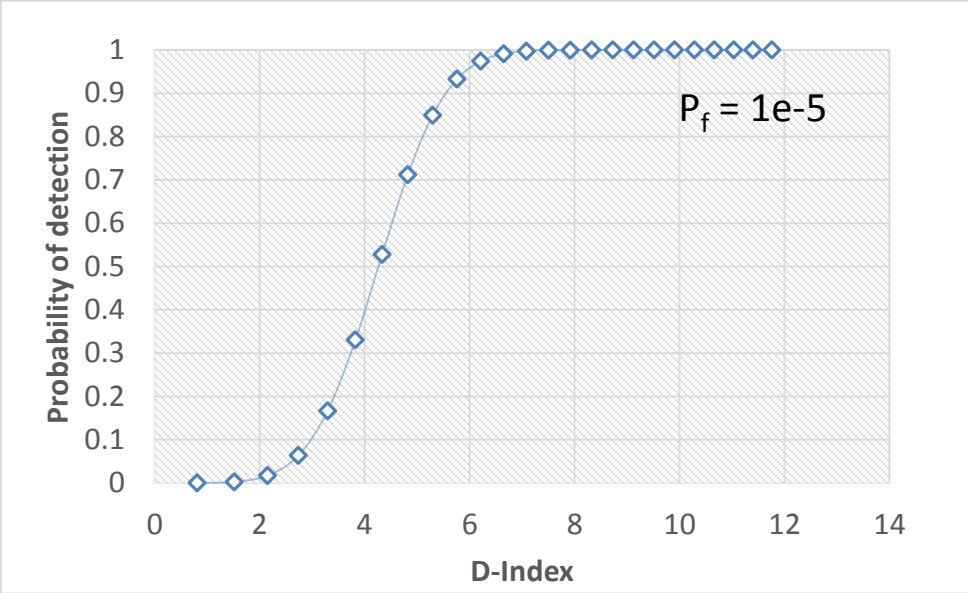


Lidar Processing Enhancements

- We employ "classic" signal detection theory when detecting bottom returns
  - For every detected return probability of detection (P_d) value is reported for a given false alarm probability
- We have adopted a heuristic approach to interest point detection by incorporating spatial information

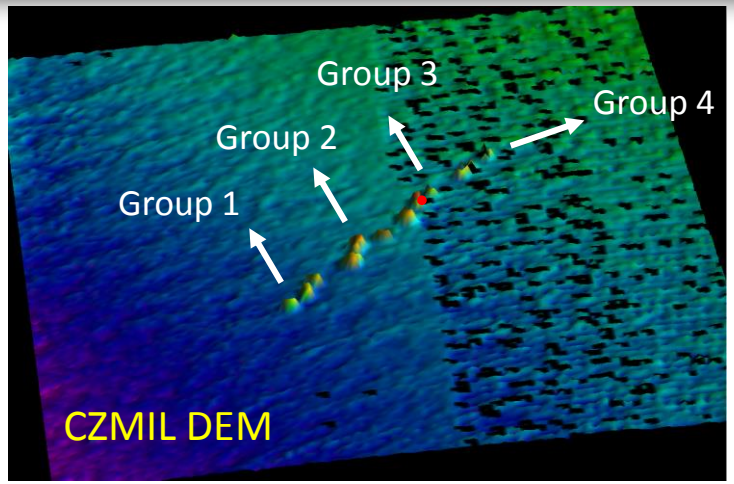
$$P_d = \frac{1}{2} Erfc\left[Erfc^{-1}(2P_f) - D_{index}\right]$$

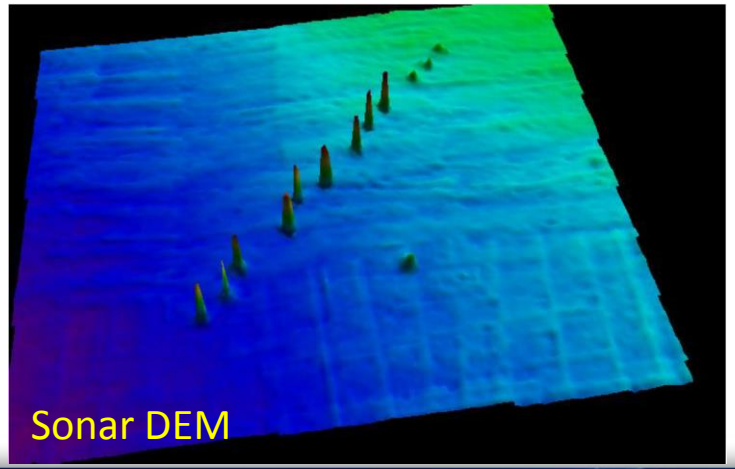
Where P_f is false-alarm probability

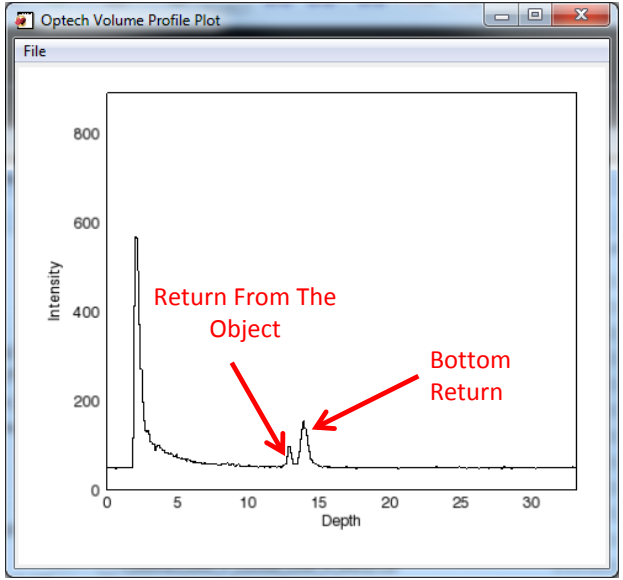


- D_{index} is a better discriminability index metric than Signal to Noise ratio for optical signals
  - The noise distribution is a function of the signal
  - Noise distribution is not normal

Lidar Processing Enhancements





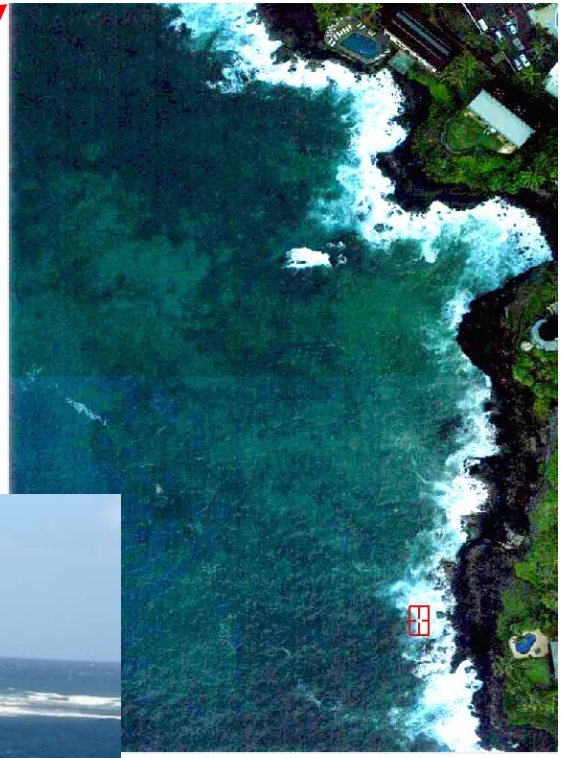


Secondary return from one of the objects clearly visible in the CZMIL waveform

Each individual 1m conical object can be identified

CZMIL data courtesy of JALBTCX

Lidar Processing Enhancements

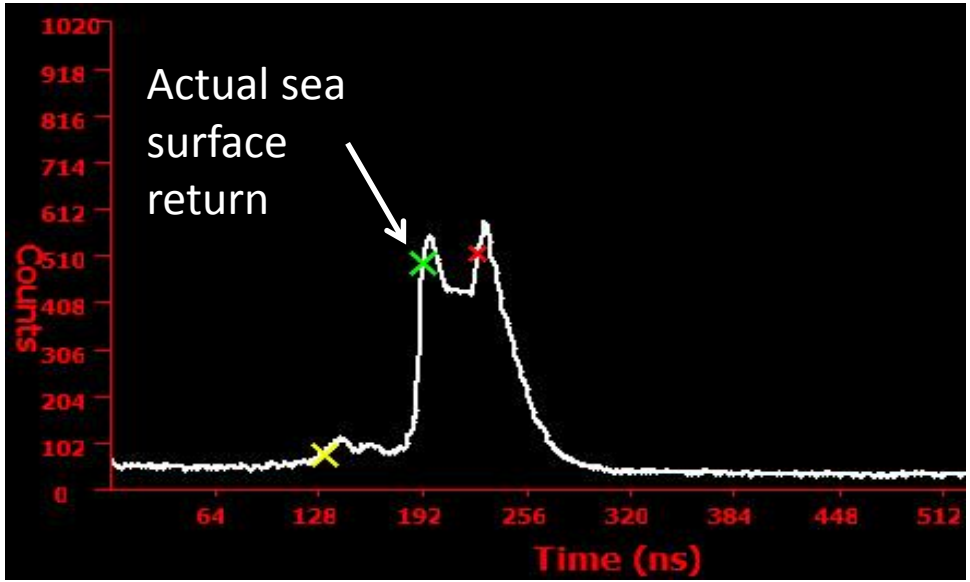


High surf zone illustration: Kauai, Hawaii

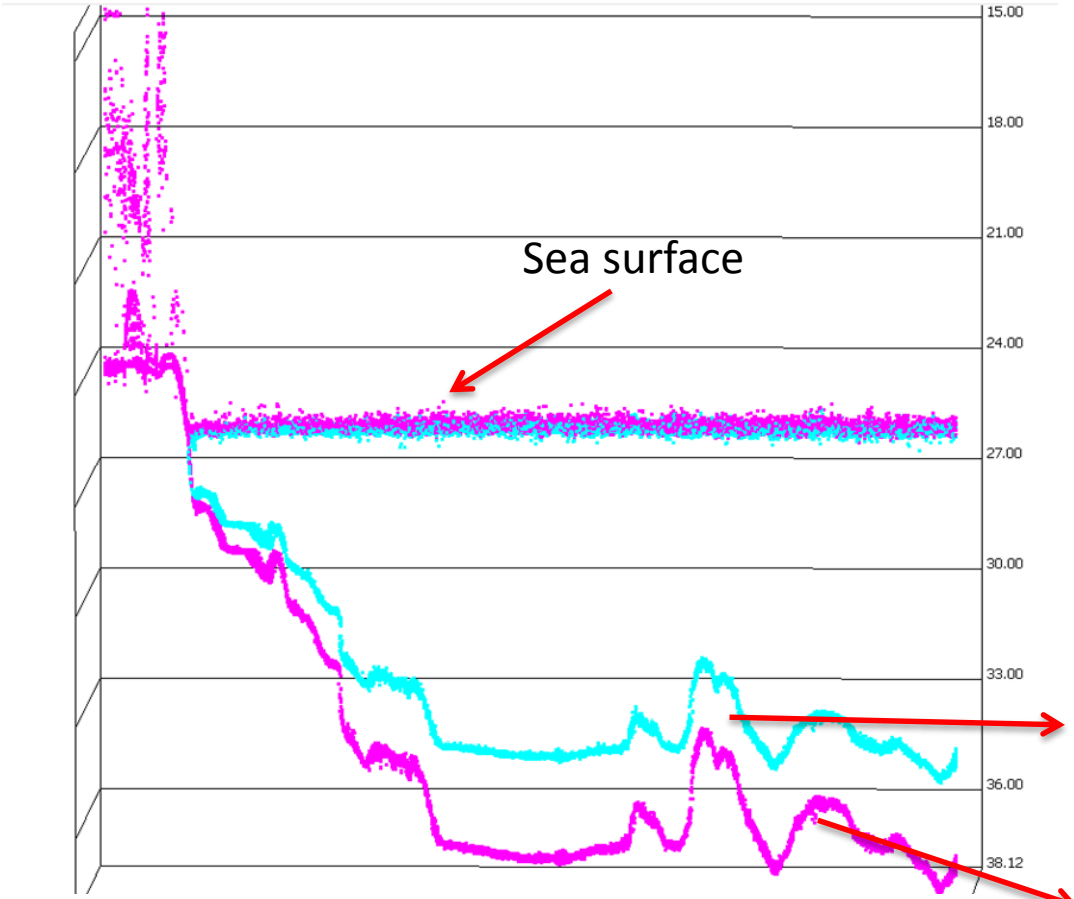
CZMIL data courtesy of JALBTCX

Surface detection

- Areas of breakwater can result in “sea sprays” or “sea smoke” that in turn can result in returns much earlier than the actual sea surface return
  - This leads to inaccurate depth measurement



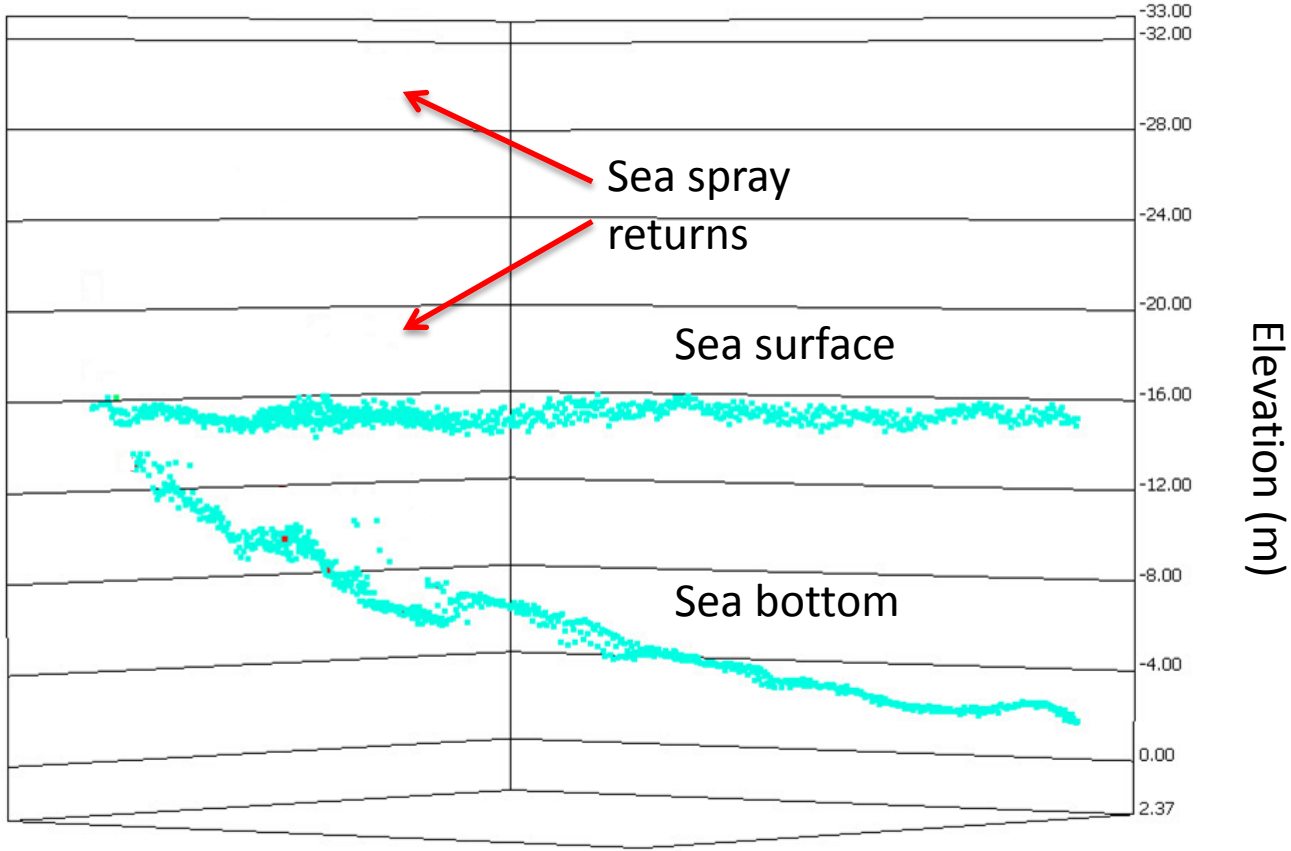
Lidar Processing Enhancements



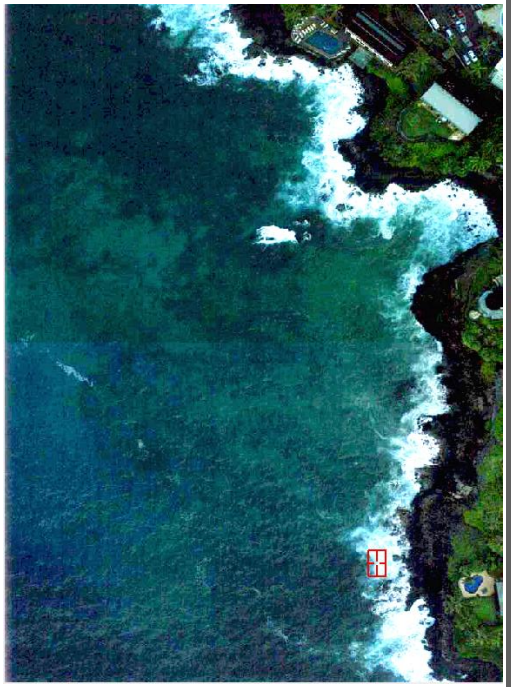
Actual sea bottom

Sea bottom if uncorrected

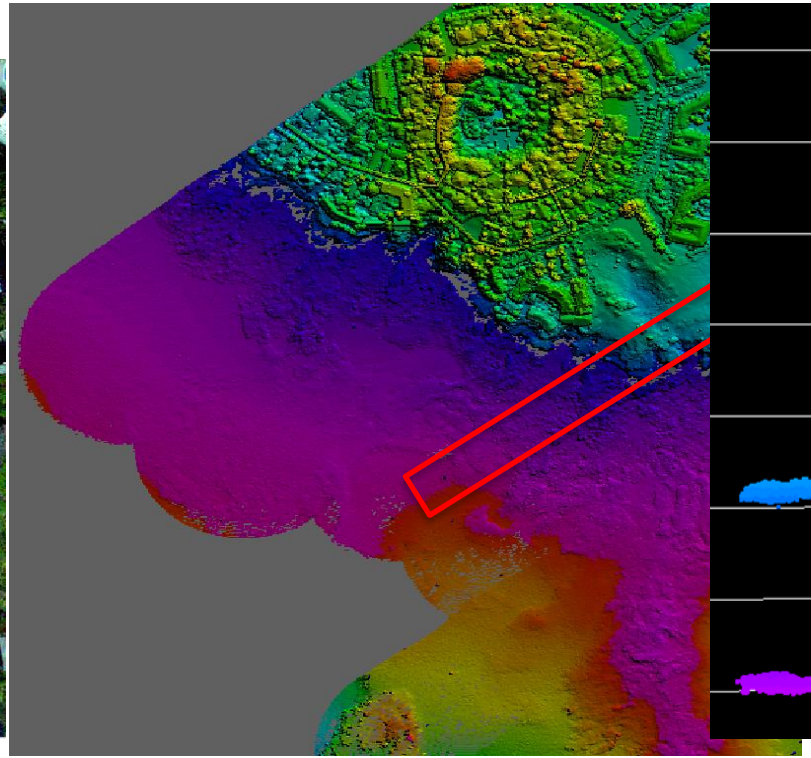
Lidar Processing Enhancements

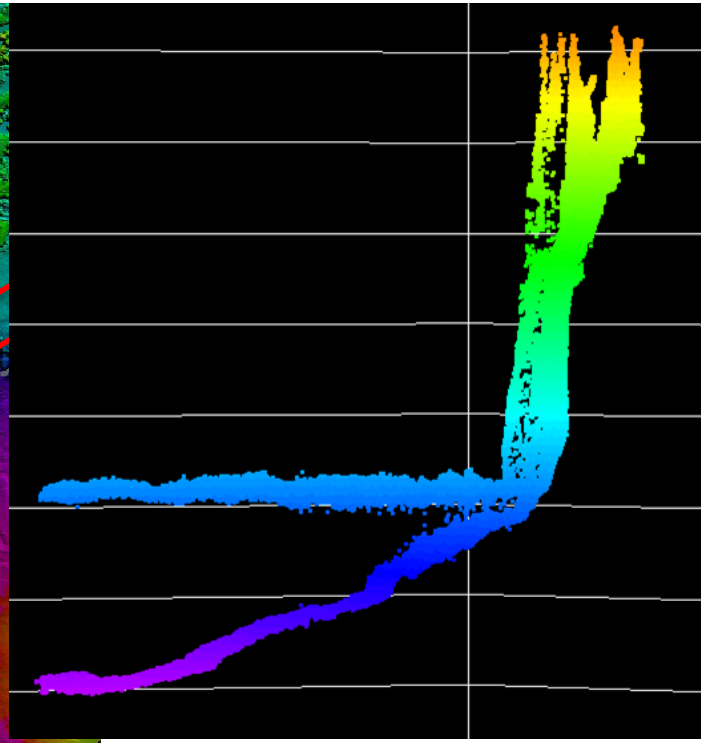


Lidar Processing Enhancements



High surf zone



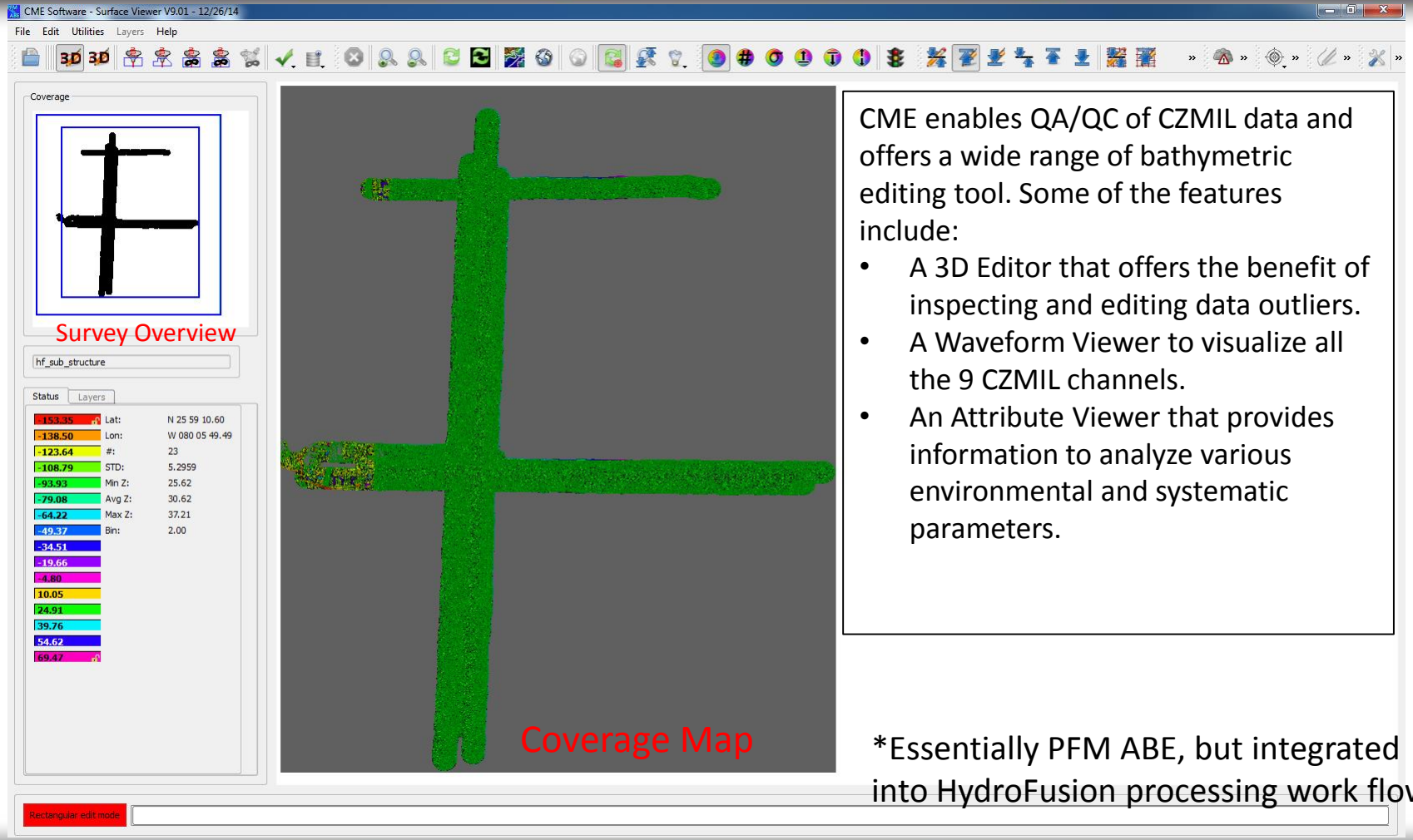


"Before"

"After"

CZMIL data courtesy of JALBTCX

CZMIL Manual Editor (CME)*

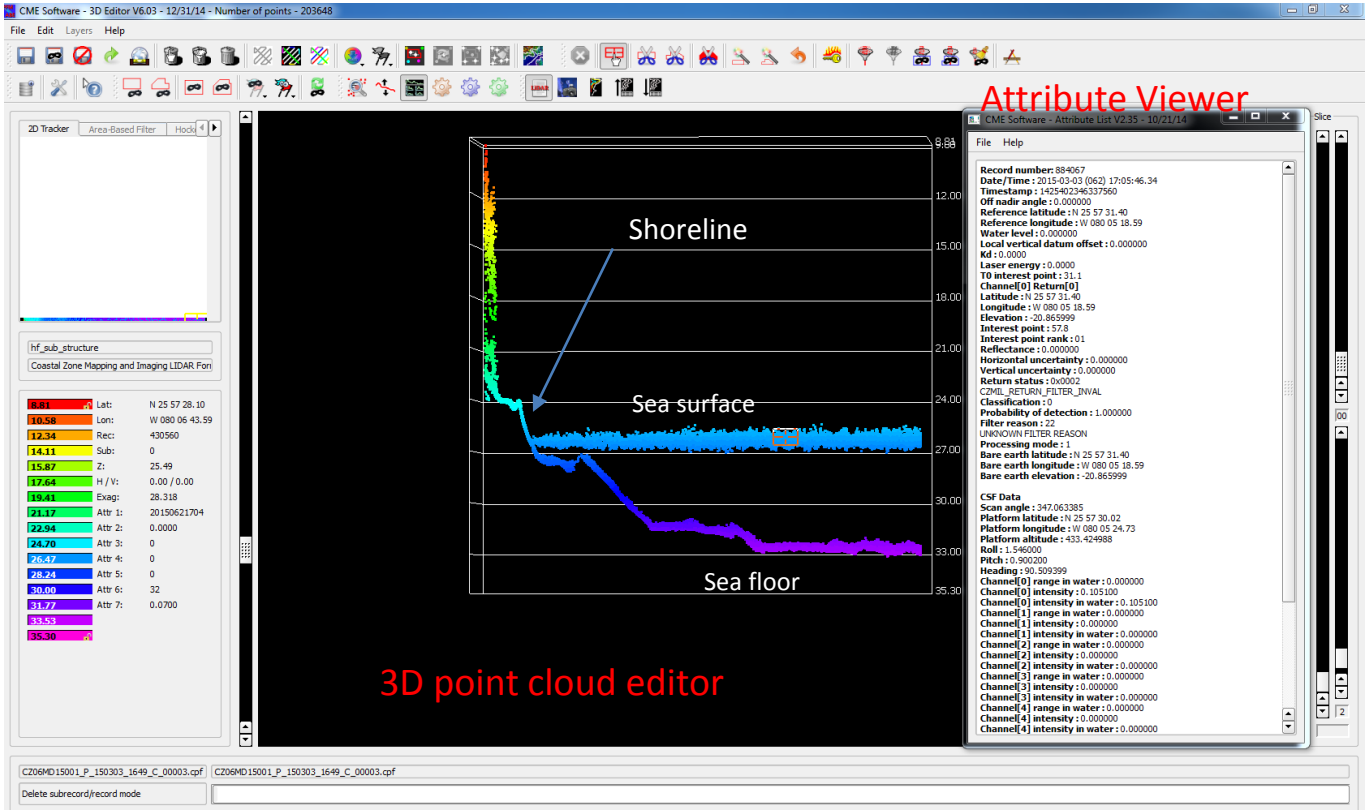


CME enables QA/QC of CZMIL data and offers a wide range of bathymetric editing tool. Some of the features include:

- A 3D Editor that offers the benefit of inspecting and editing data outliers.
- A Waveform Viewer to visualize all the 9 CZMIL channels.
- An Attribute Viewer that provides information to analyze various environmental and systematic parameters.

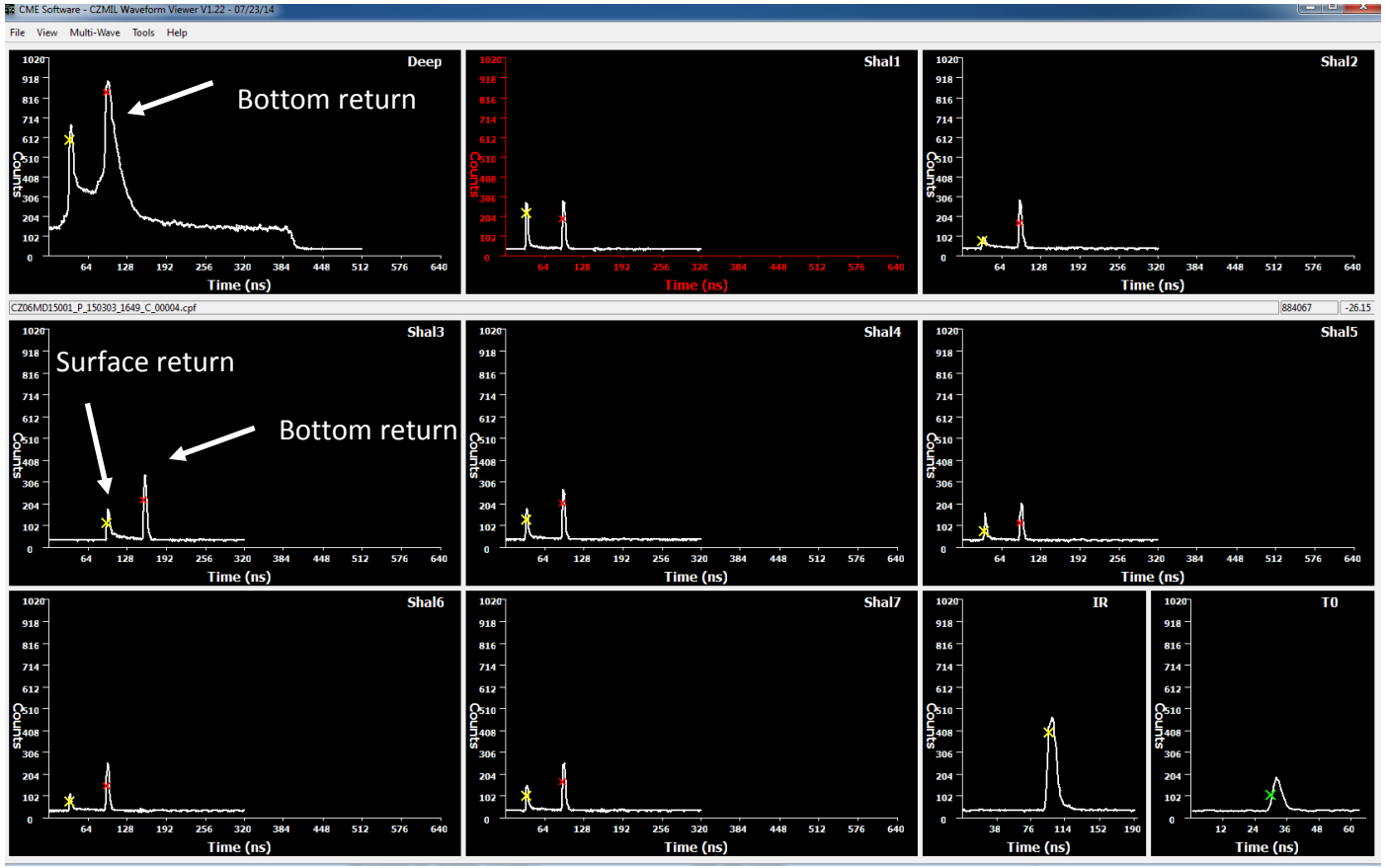
*Essentially PFM ABE, but integrated into HydroFusion processing work flow

CZMIL Manual Editor (CME)



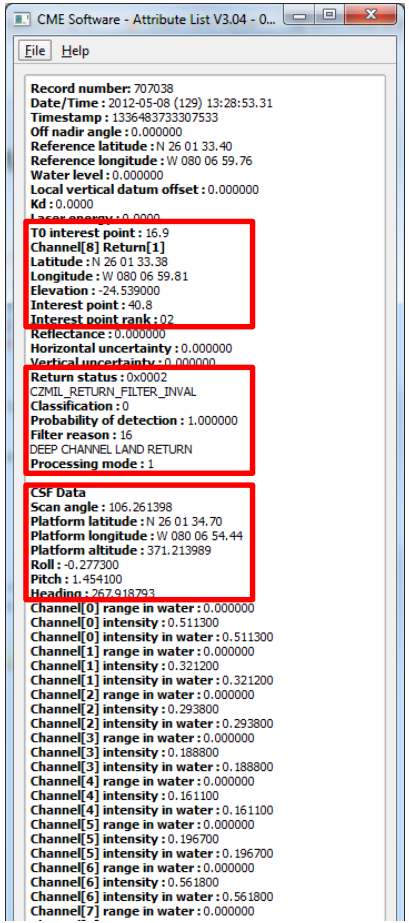
CZMIL Manual Editor (CME)

Waveform Viewer: To visualize all the 9 CZMIL channels



User can inspect corresponding waveforms of a laser shot

CME Attribute Viewer



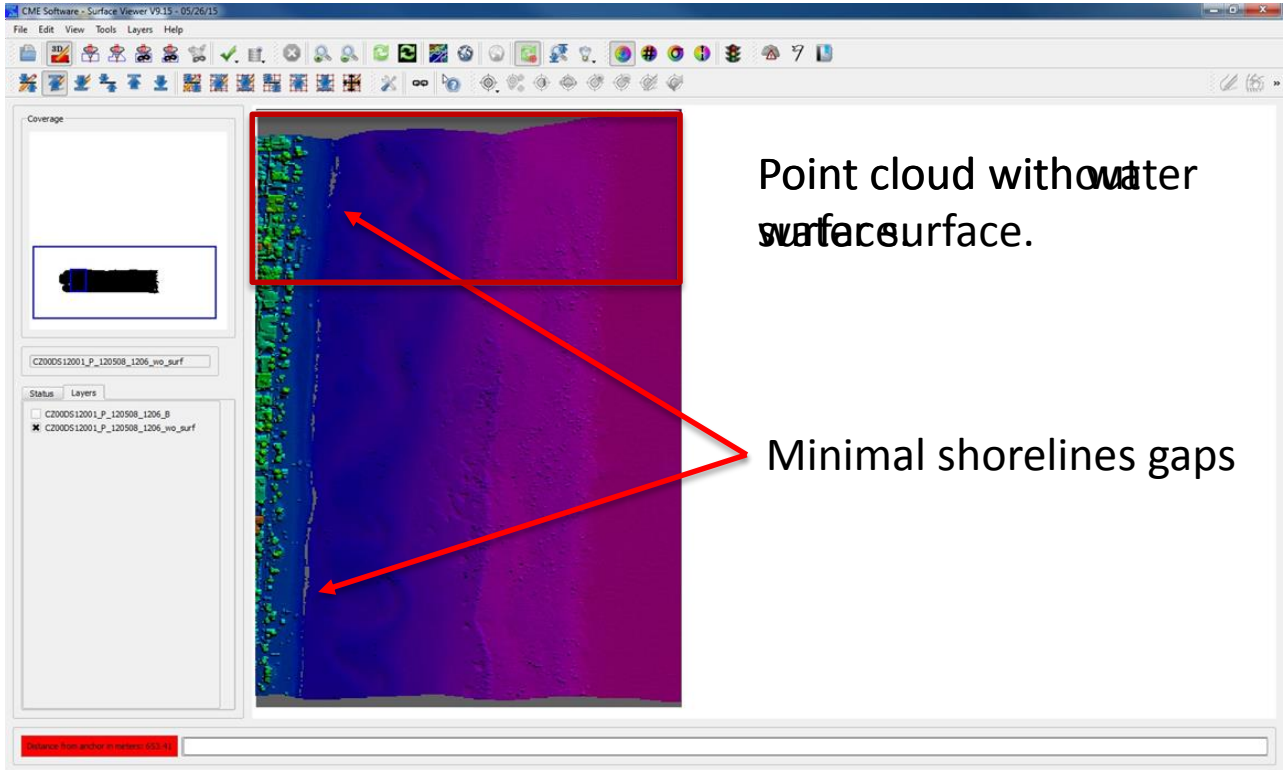
T0 interest point : 16.9
Channel[8] Return[1]
Latitude : N 26 01 33.38
Longitude : W 080 06 59.81
Elevation : -24.539000
Interest point : 40.8
Interest point rank : 02
Classification : 0
Probability of detection : 1.000000
CSF Data
Scan angle : 106.261398
Platform latitude : N 26 01 34.70
Platform longitude : W 080 06 54.44
Platform altitude : 371.213989
Roll : -0.277300
Pitch : 1.454100
Heading : 267.918793

Value	Description
0	Unknown class for the shot
1	Land class
2-31	Reserved for future land sub-classes
32	Water class
33	Shallow water class
34	Average Depth
35	Turbid water class

CZMIL metadata is easily accessed by a user query.

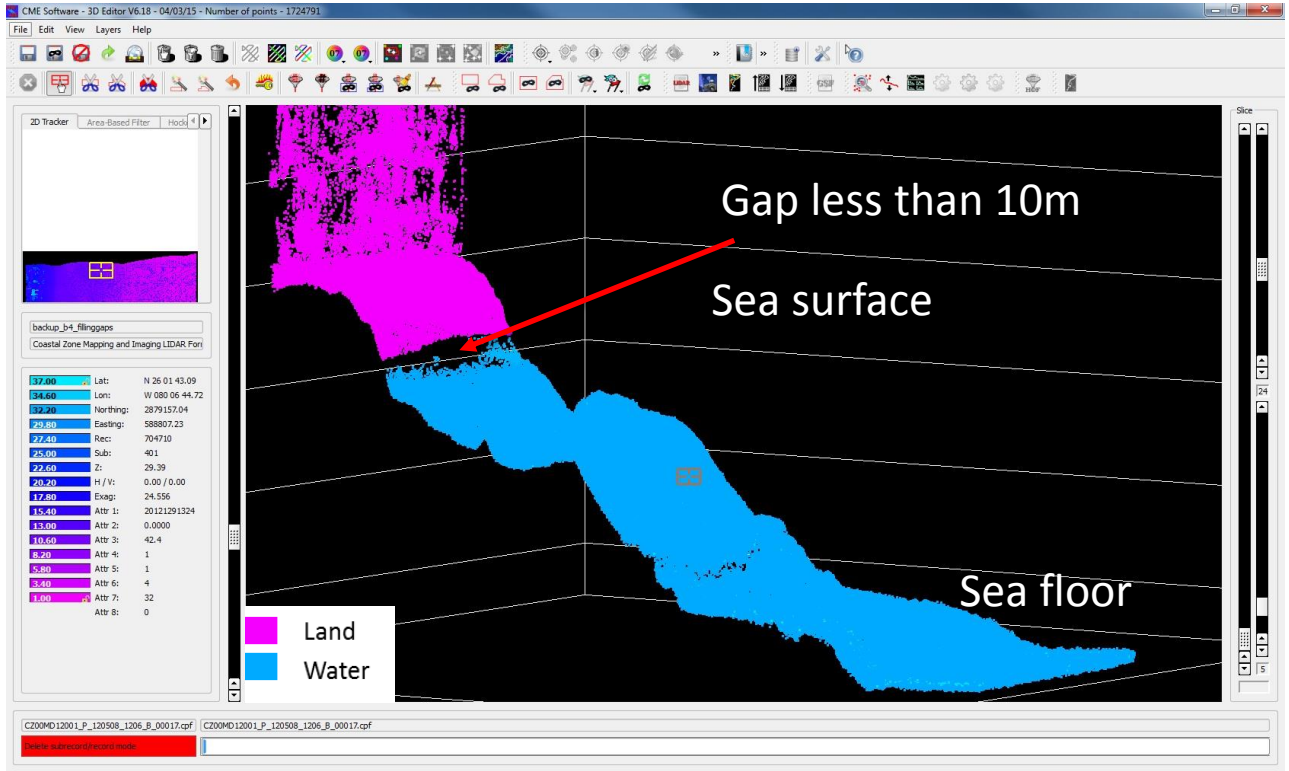
New QA/QC Functionality: Reprocessing tool

Example point cloud shown in CME 2D view



New QA/QC Functionality: Reprocessing tool

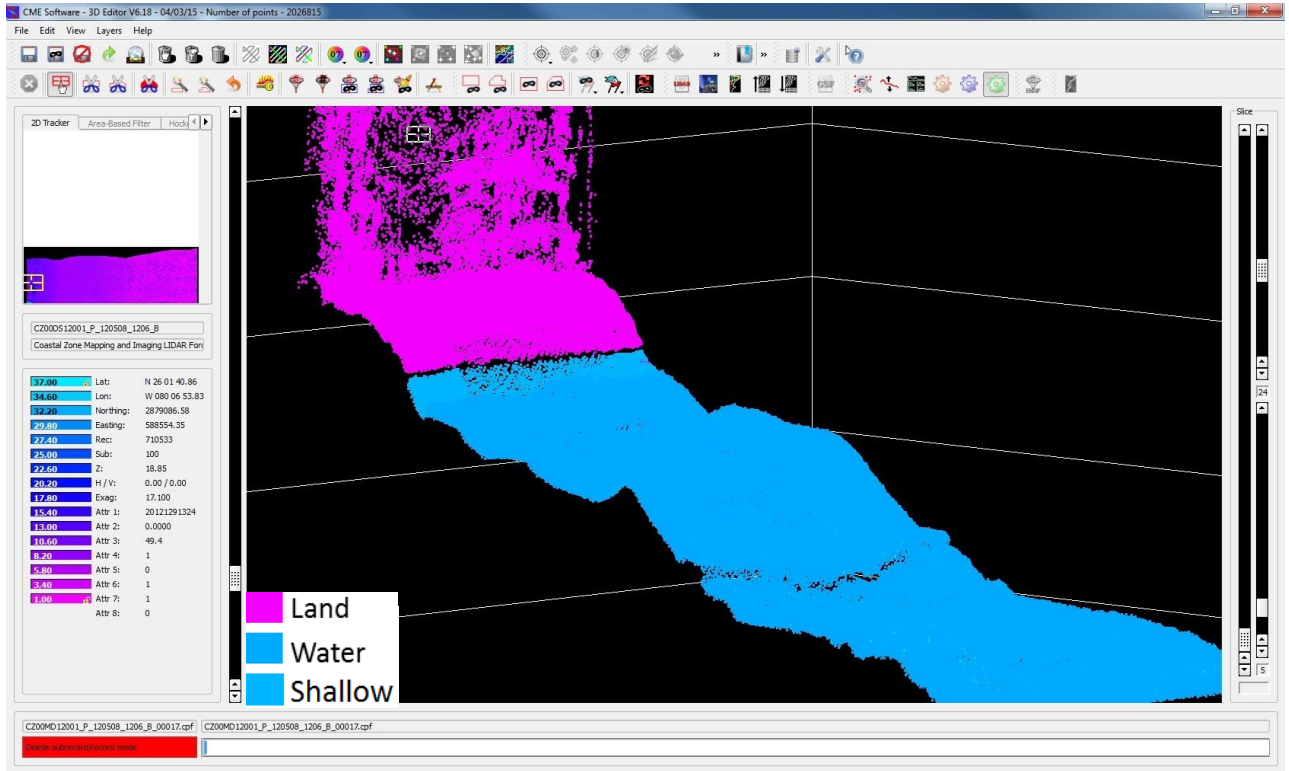
Point cloud in CME-3D editor window. Point cloud is colored based on classification



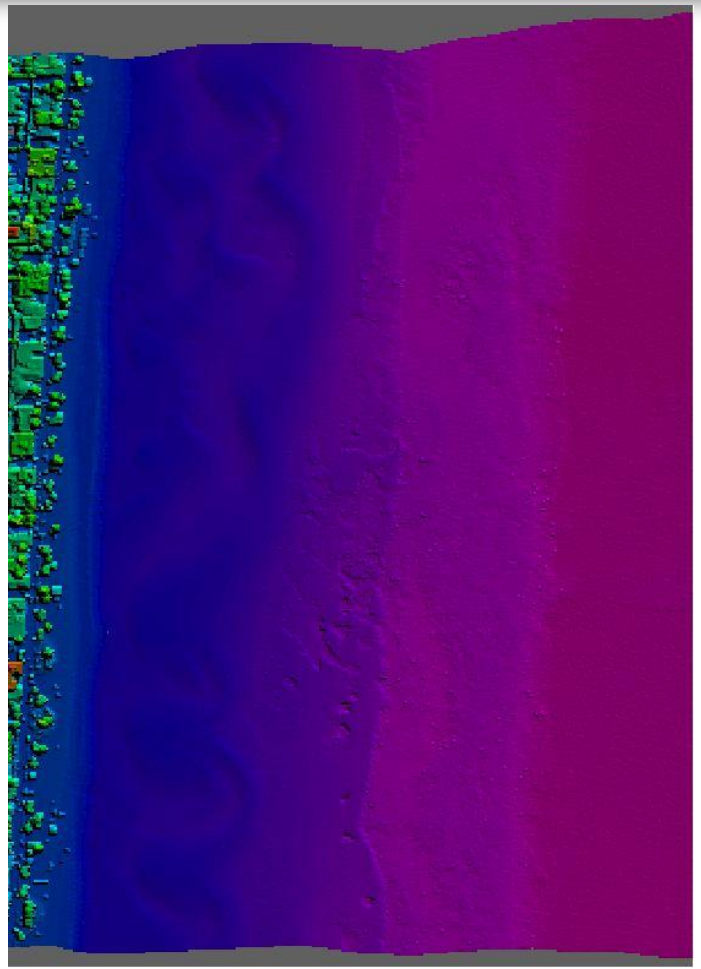
New QA/QC Functionality: Reprocessing tool

3D view of the point cloud after reprocessing

Point cloud is colored based on the classification



New QA/QC Functionality: Reprocessing tool

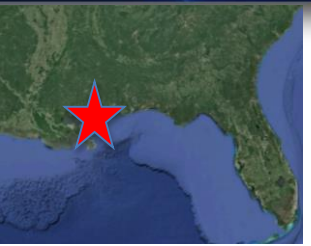


Shots can be re-labeled
and reprocessed on-the-fly!

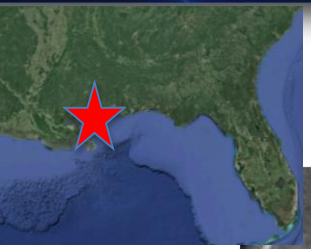
Point cloud in CME-2D view window
before re-processing the data to fill gaps

Point cloud in CME-2D view window after
re-processing the data

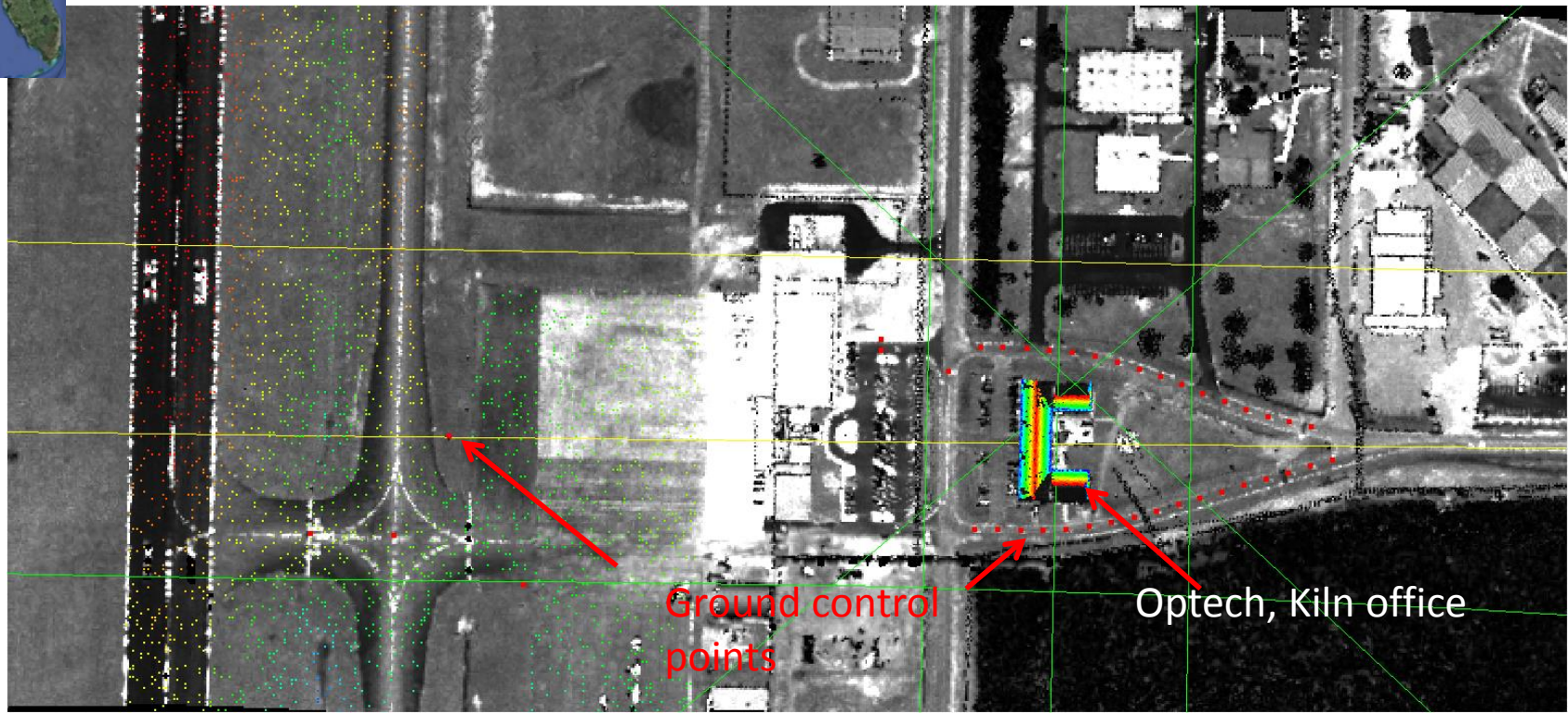
Calibration Site: Stennis Airport



Geo-calibrator Program

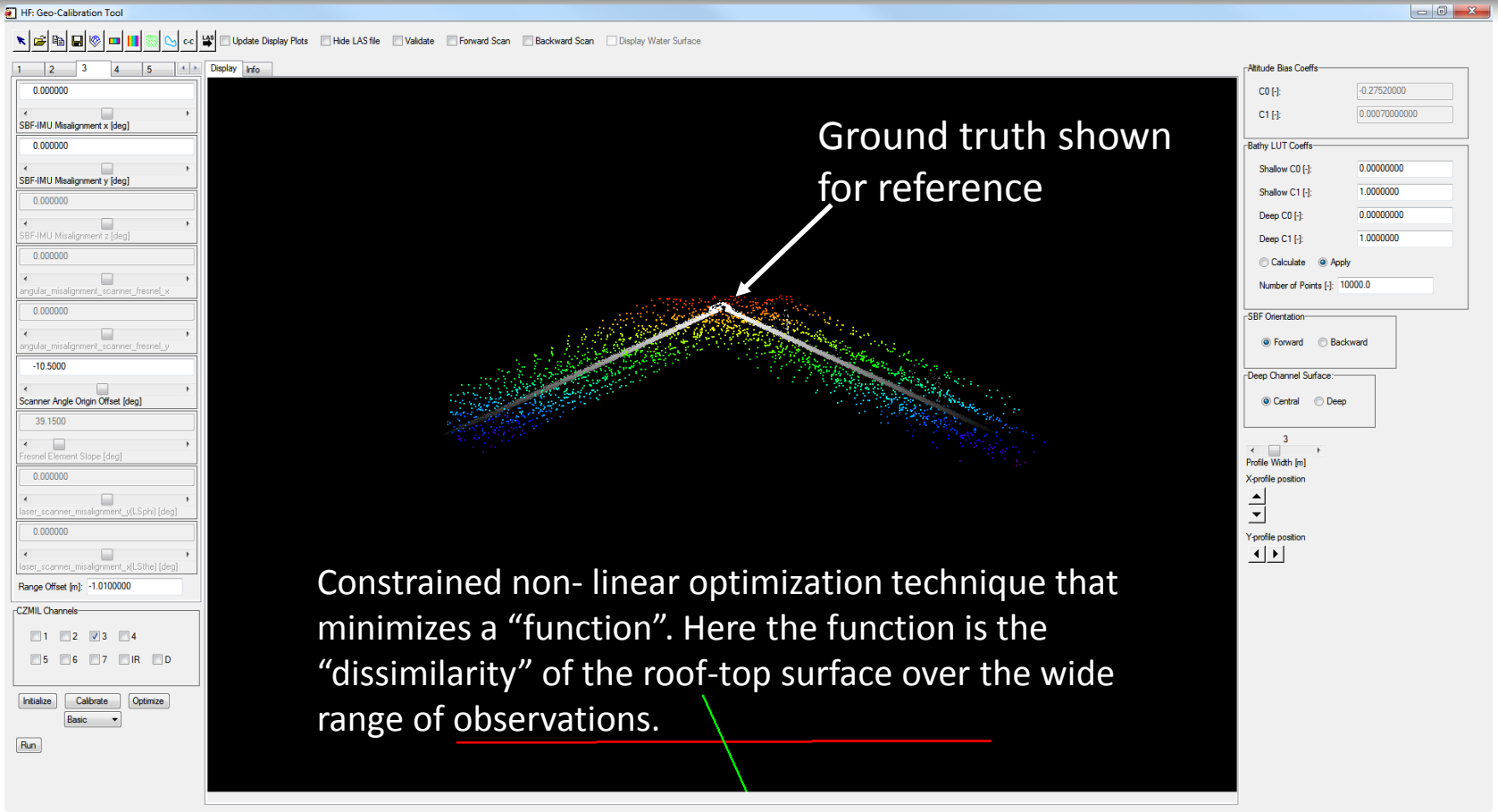


Stennis international airport in Kiln, Mississippi



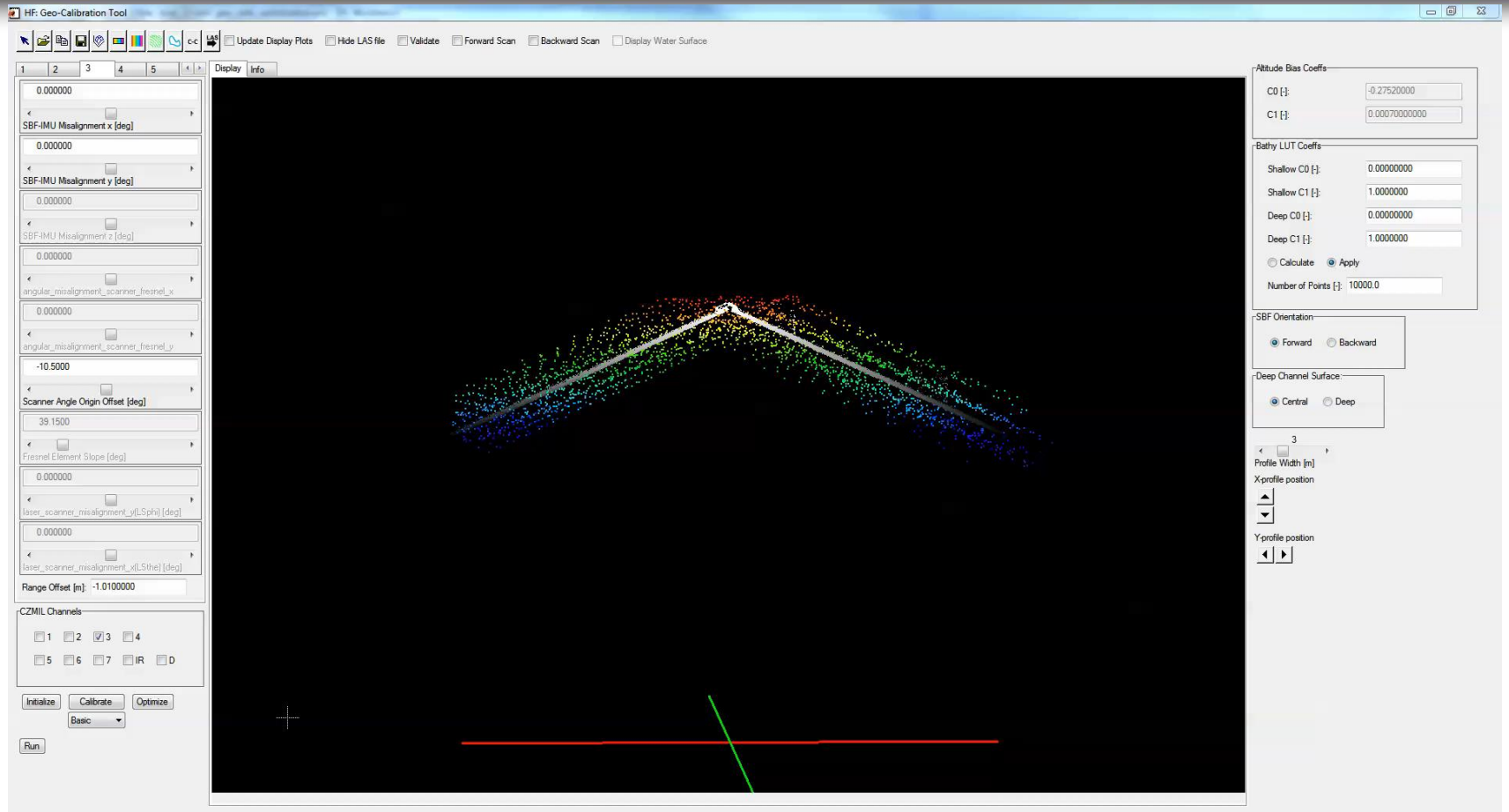
Ground truth data overlaid on CZMIL reflectance image

Geo-calibrator Program



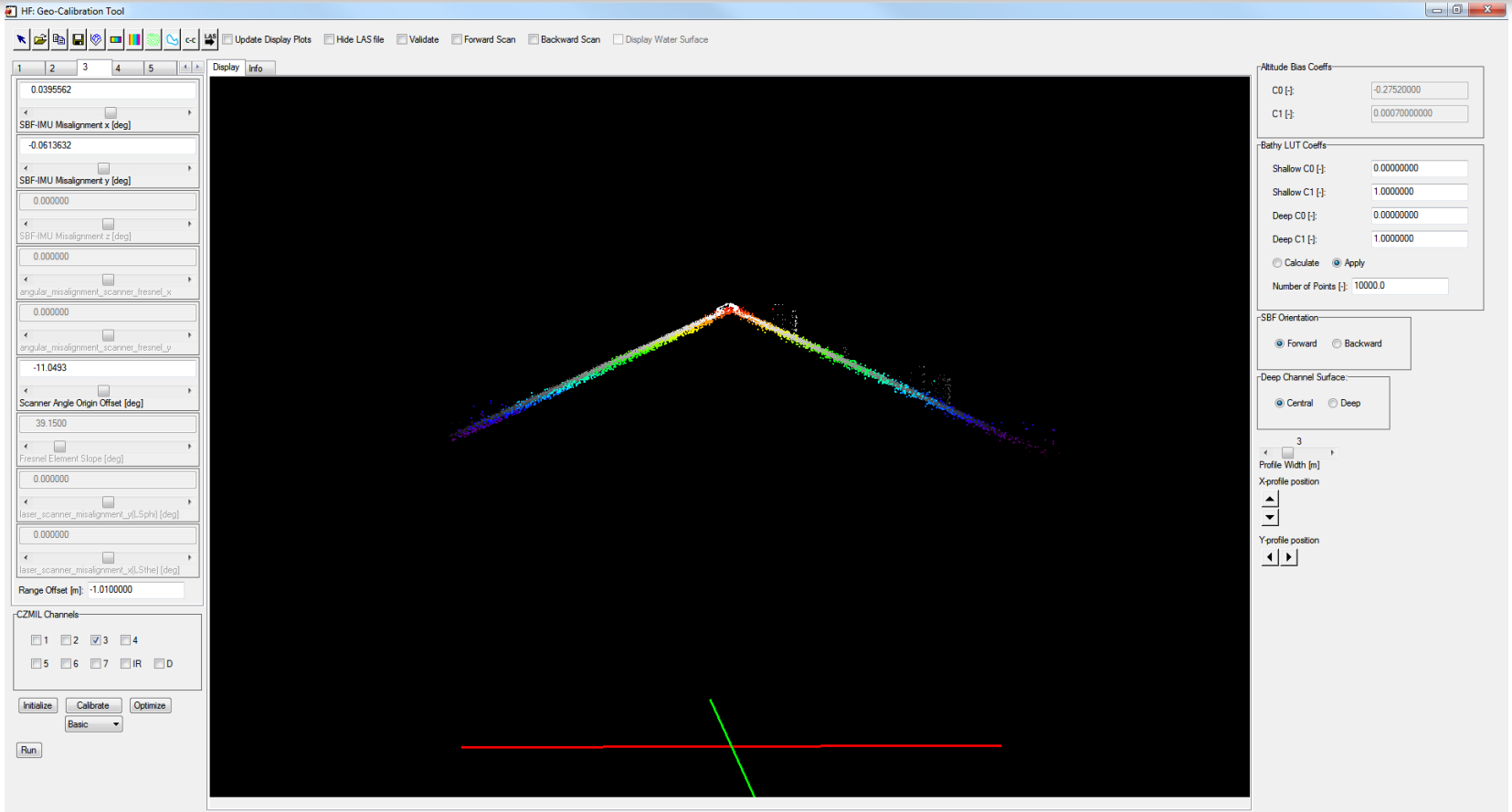
Un-calibrated point cloud over pitched roof before Geo-calibration

Geo-calibrator Program



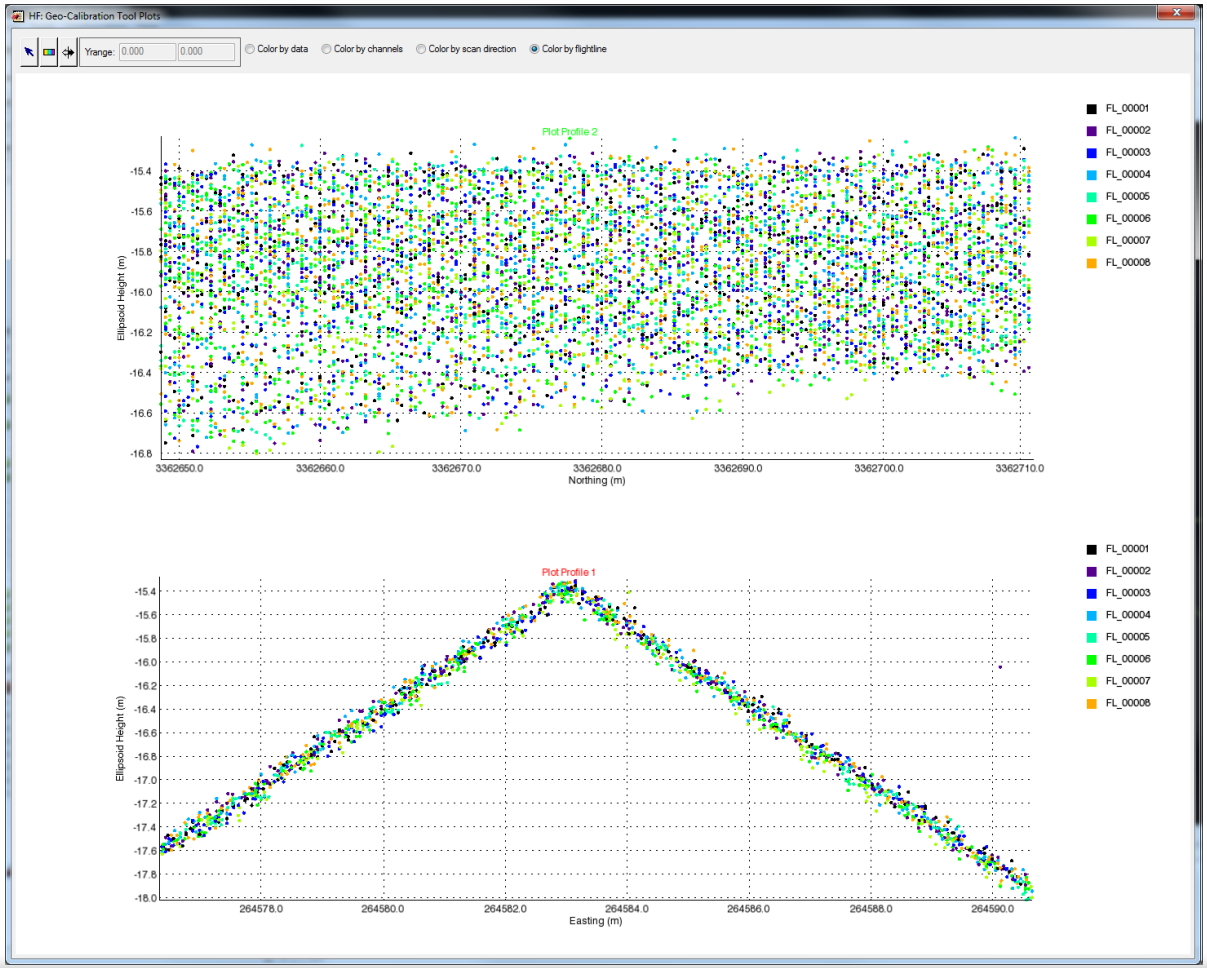
Point cloud Geo-calibration

Geo-calibrator Program



Point cloud over pitched roof after automatic Geo-calibration

Geo-calibrator Program

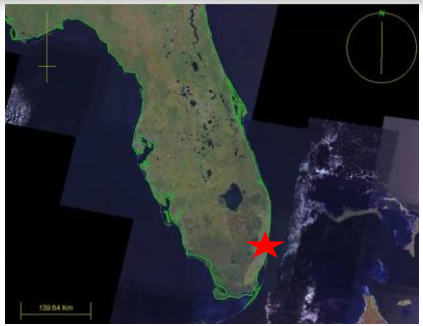


Point data color coded by scan direction

Point data color coded by channel number

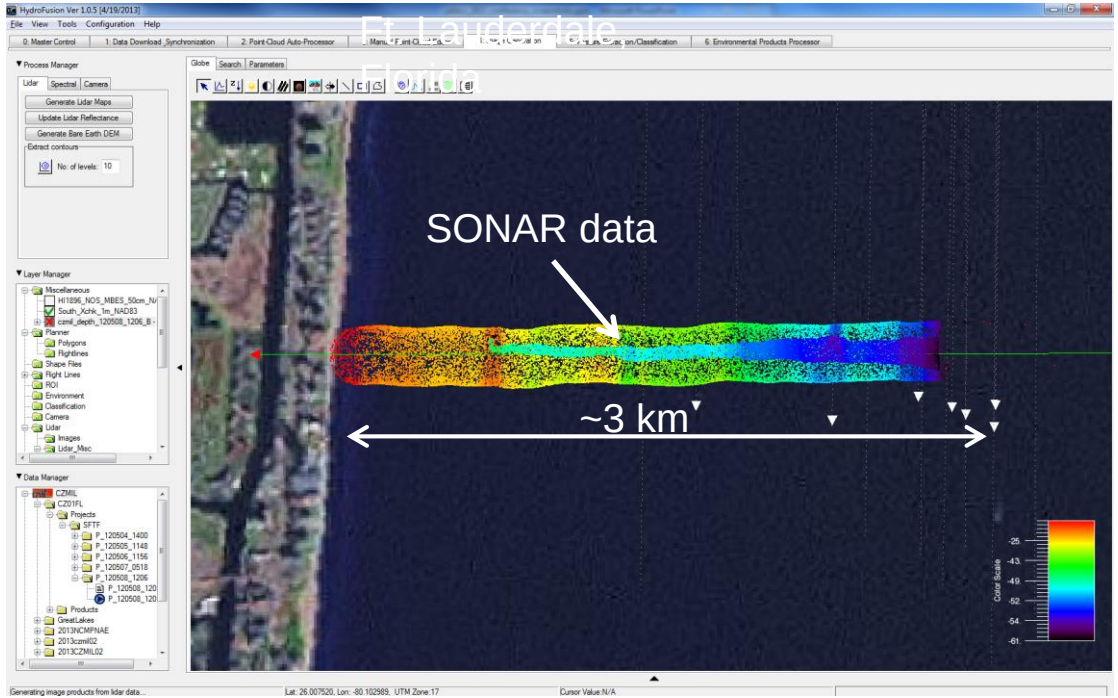
Point data color coded by flightline number

Geo-calibrator Program: Data Validation



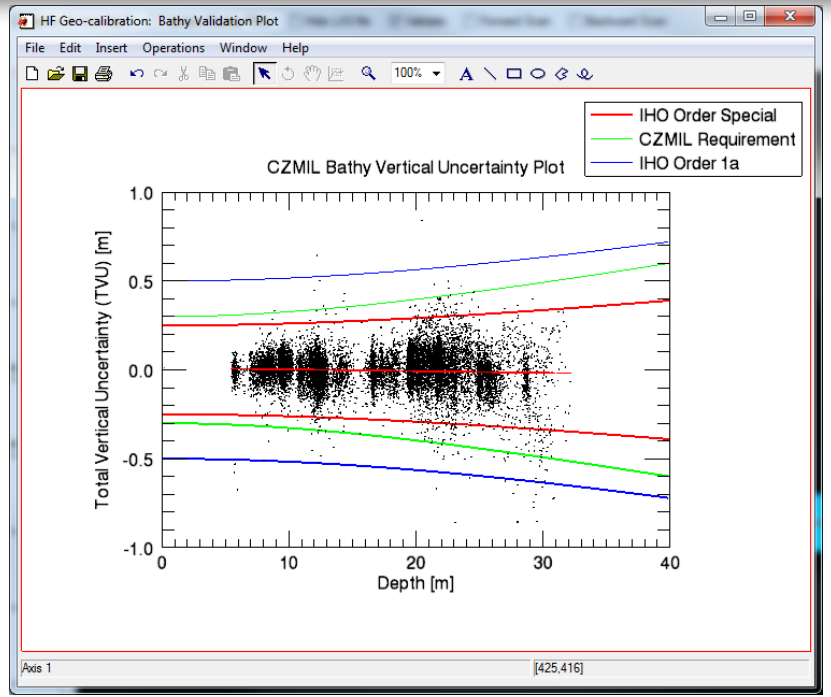
South Florida Test Facility (SFTF),
south of Ft. Lauderdale, Florida

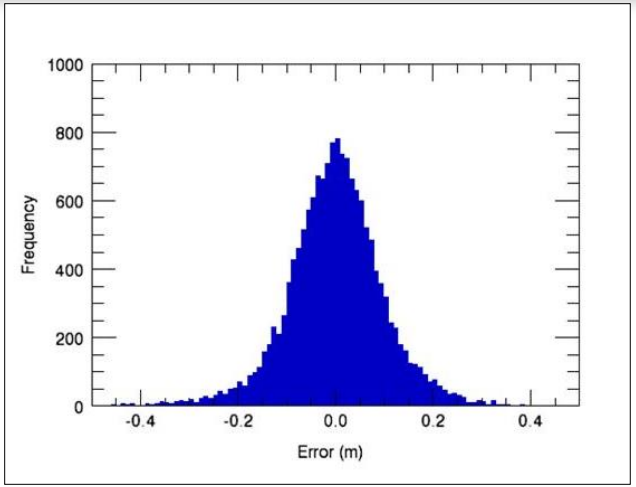
- Ground truth data can be imported in the form of ESRI Shape file or LAS file
- Comparison methodology
  - Surface – Surface
  - Point – Point



CZMIL data collected can be automatically validated against ground truth

Geo-calibrator Program: Data Validation





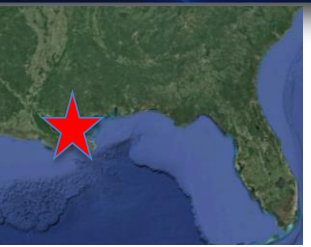
Samples	~ 15000
Mean	0.0019m
Standard Deviation	0.1127m
Absolute Deviation	0.0787m

For the sample space described in the table
~98% of shots are within the red curve

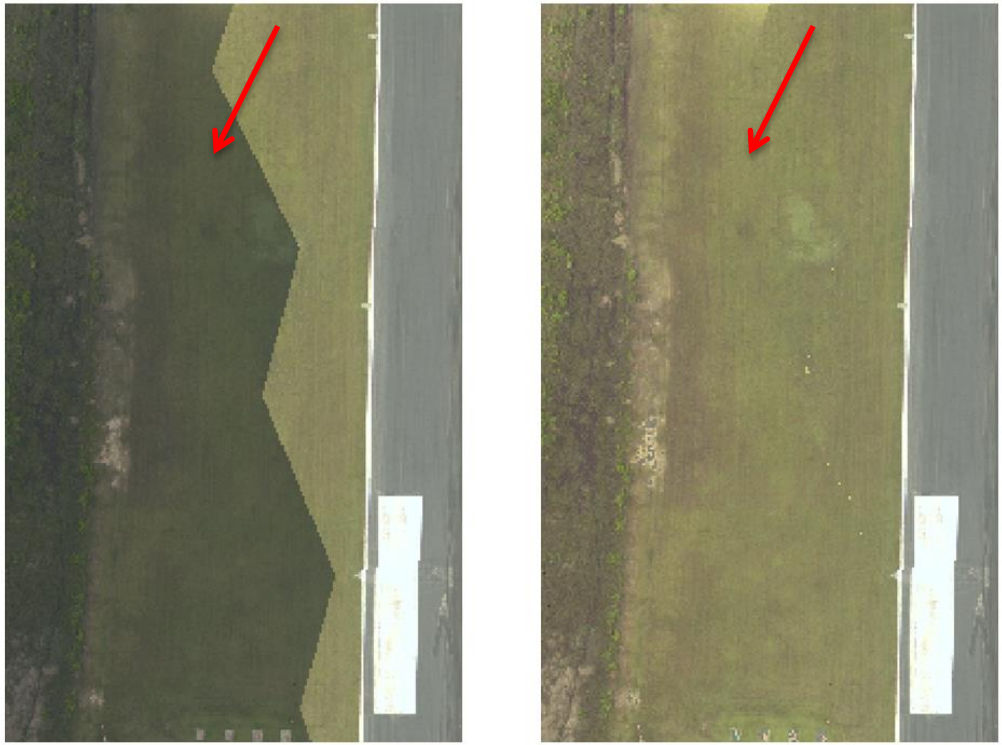
CZMIL data collected can be automatically validated against ground truth and extensively tested by JALBTCX

IHO standards: http://www.iho.int/iho_pubs/standard/S-44_5E.pdf

Camera Color Balancing

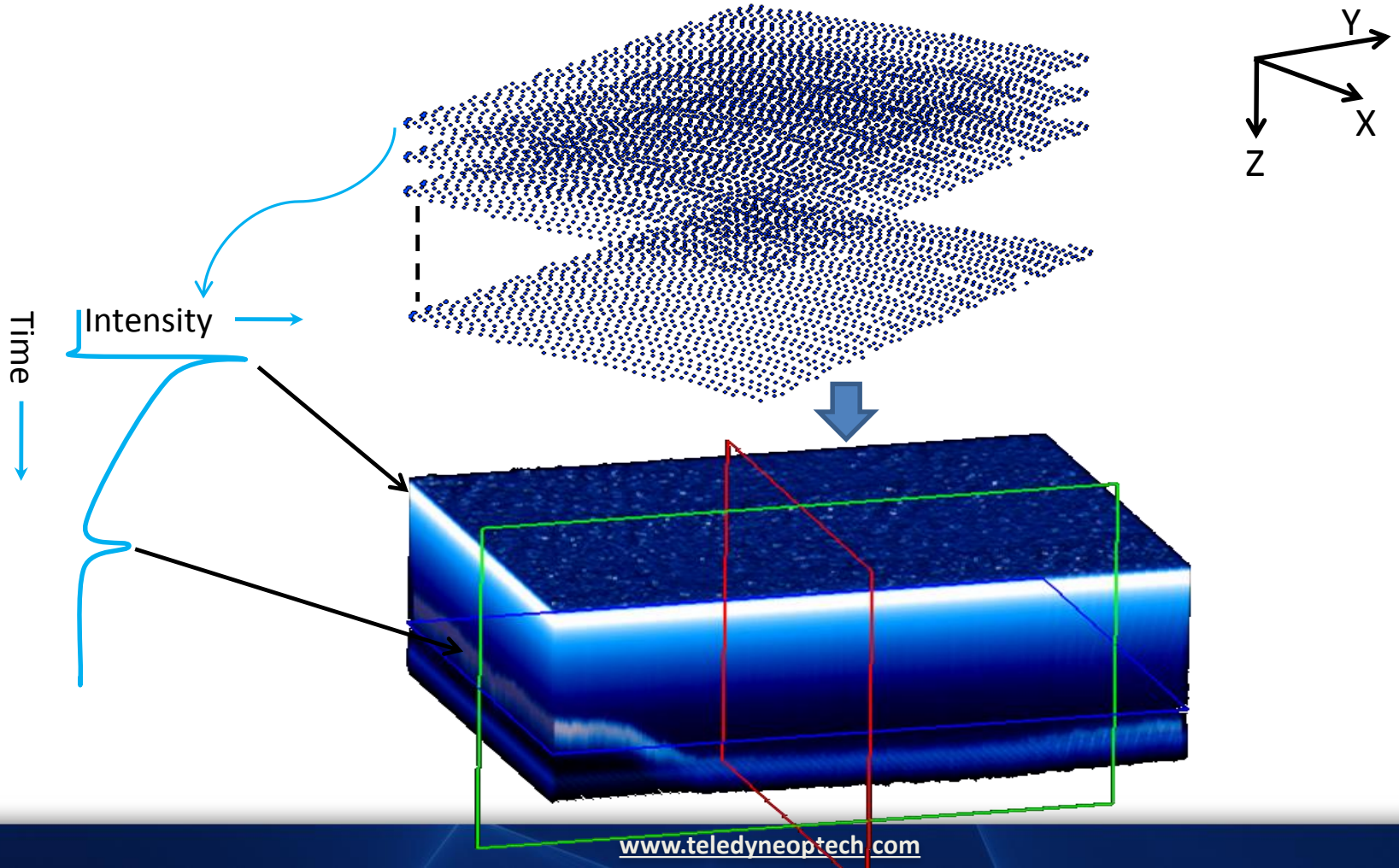


Histogram matching technique is used to remove cloud shadows

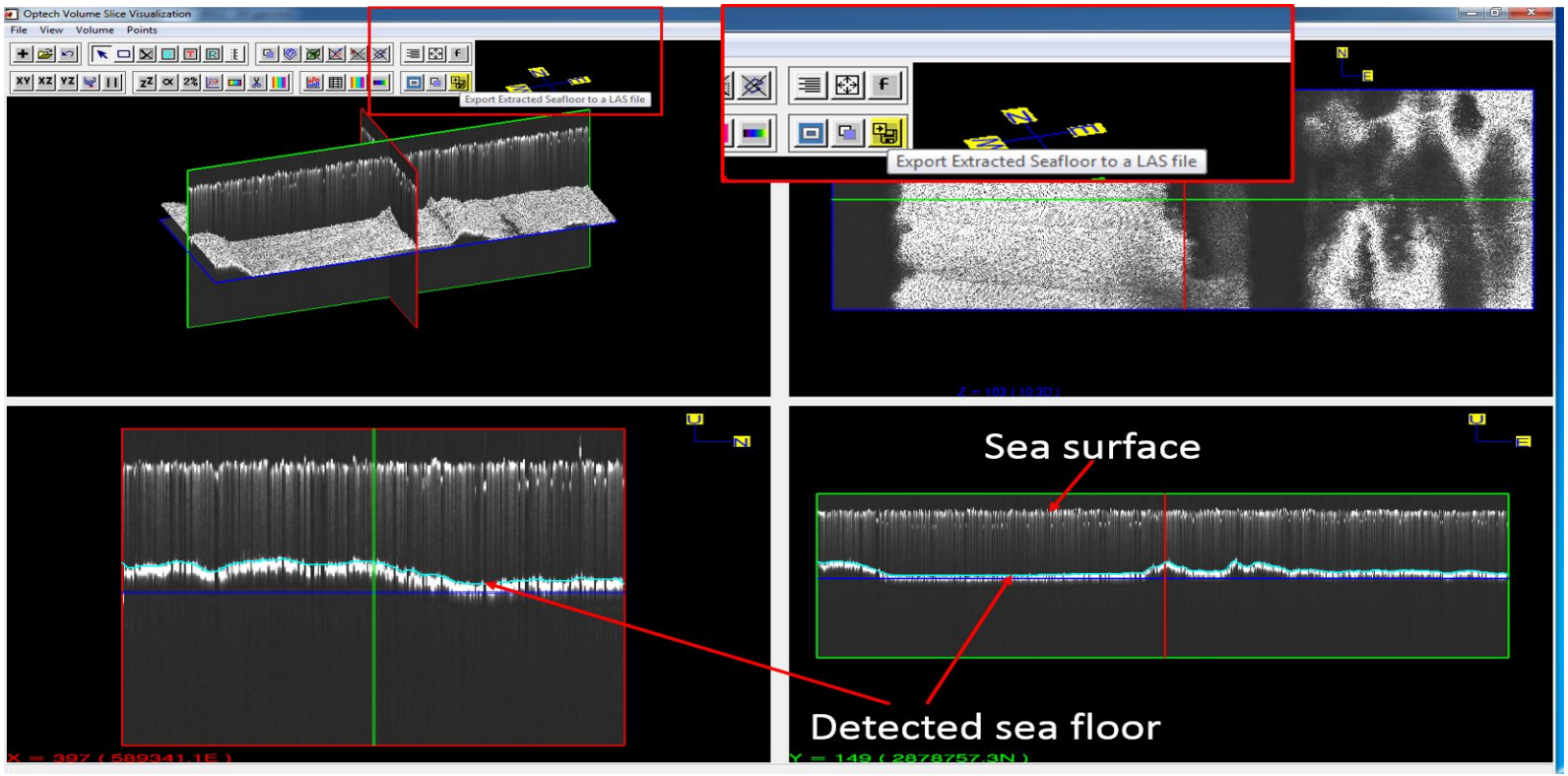


Color balancing of image mosaics in HydroFusion before balancing is applied (left) and after (right)

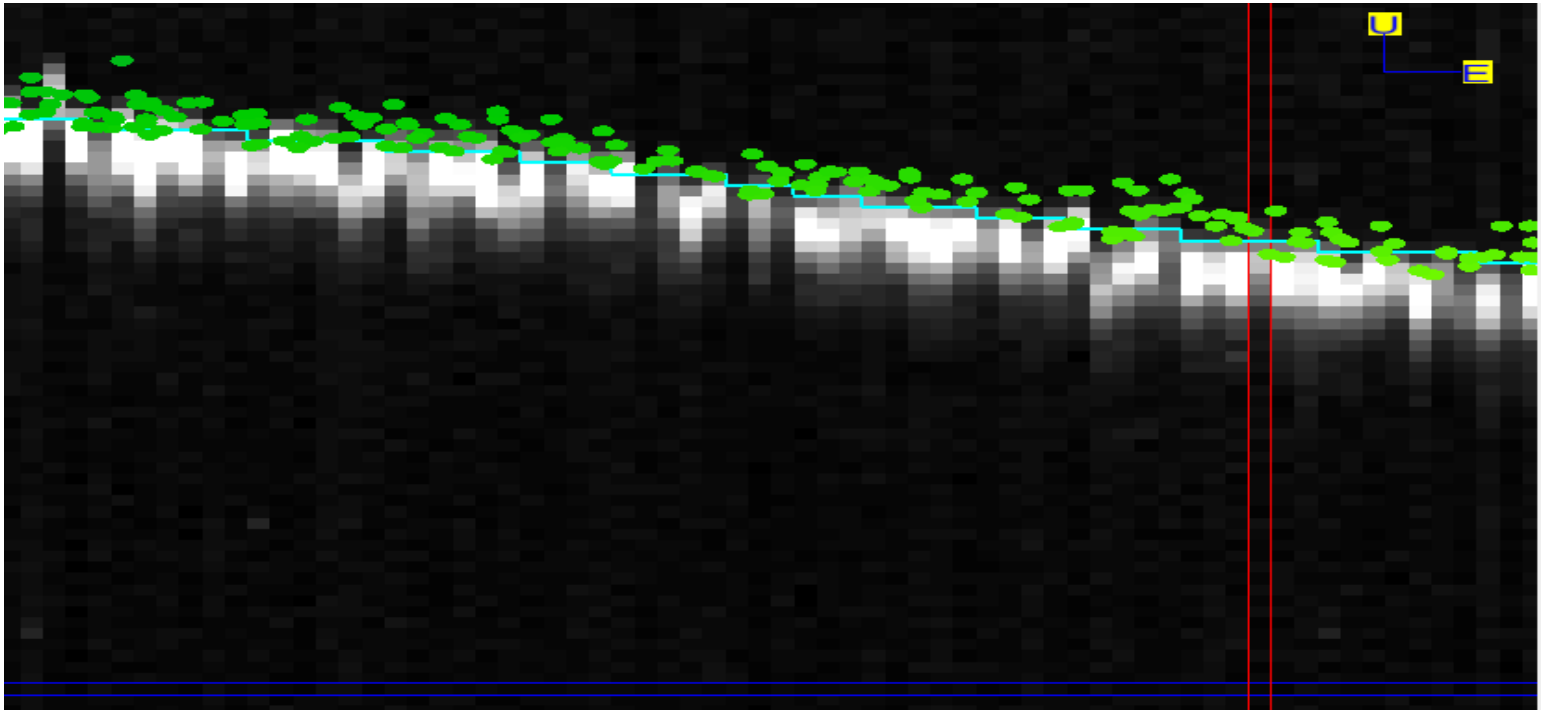
Volume Visualizer



Volume Visualizer



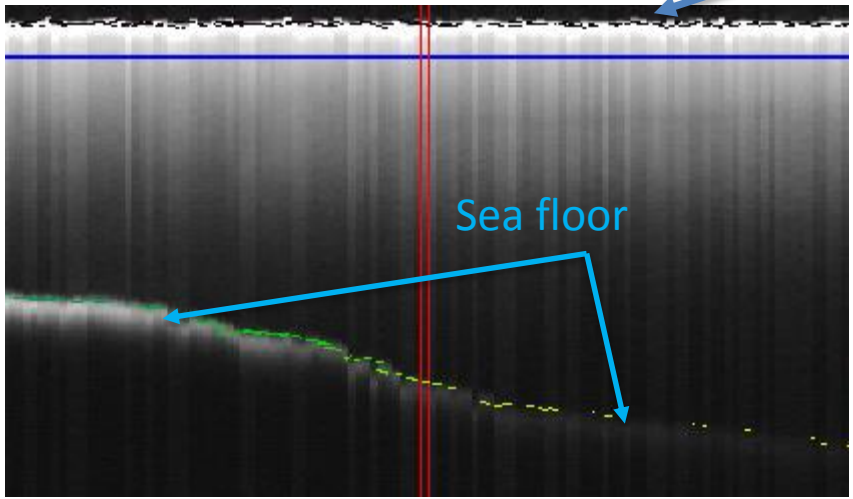
Volume Visualizer



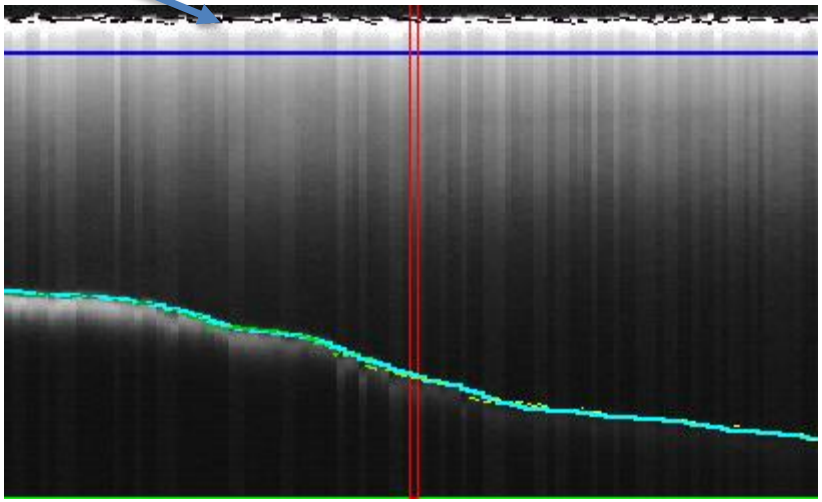
Detected seafloor: Close-up

Volume Visualizer

Sea surface



Waveform-based derived point cloud within Volume Visualizer

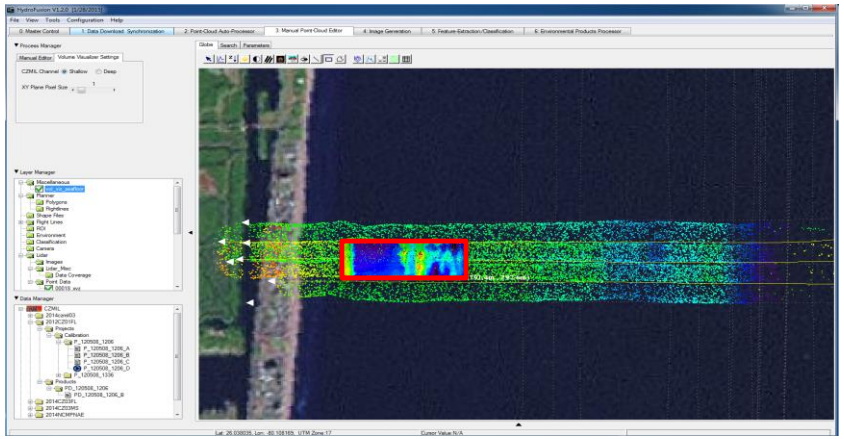


Automatic seafloor detection within Volume Visualizer

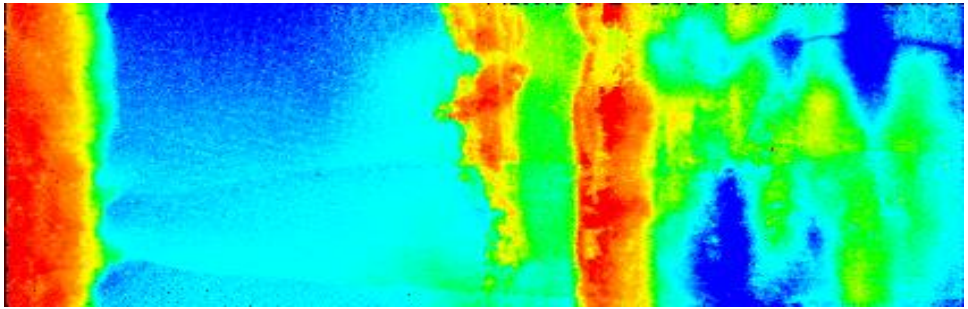
Improve coverage in deeper waters using the image-based “edge detection” technique

Volume Visualizer

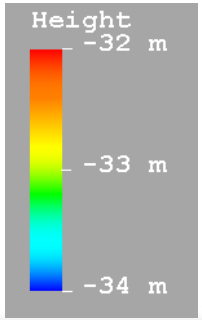
The detected seafloor can be exported out to a LAS file



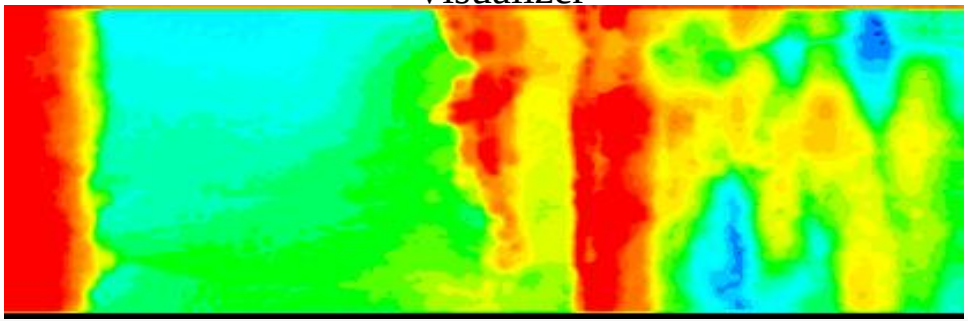
Waveform-based derived point cloud



The next step is to validate the point cloud generated by Volume Visualizer and integrate into the processing workflow

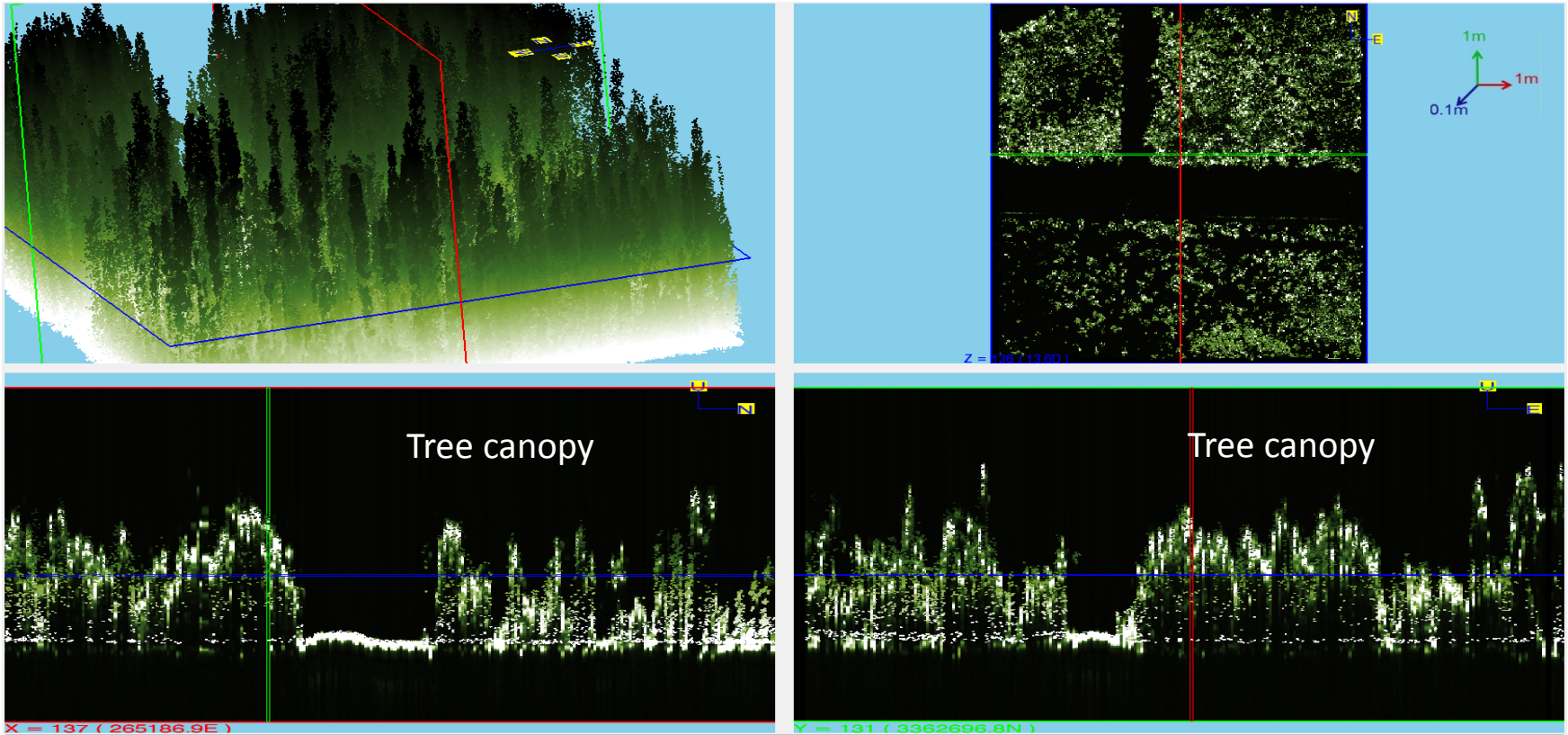


Corresponding point cloud generated by Volume Visualizer



Volume Visualizer

Time-synchronization of waveforms enables “accurate” 3D scene rendering



Acknowledgments

- We would like to thank Joint Airborne Lidar Bathymetry Technical Center of Expertise (JALBTCX) for providing us with CZMIL data and supporting us through the Improvement program

Thank you!