CHC-NSC 2018
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IIC TECHNOLOGIES

Eastern Canada Bathymetric LiDAR survey

Jeff Lower

Project Overview - Team

CANADIAN HYDROGRAPHIC SERVICE
SERVICE HYDROGRAPHIQUE DU CANADA

IIC TECHNOLOGIES

KASI
KASI AVIATION SERVICES INC.

TELEDYNE OPTECH
Everywhereyoulook™

Project Overview – Total Area

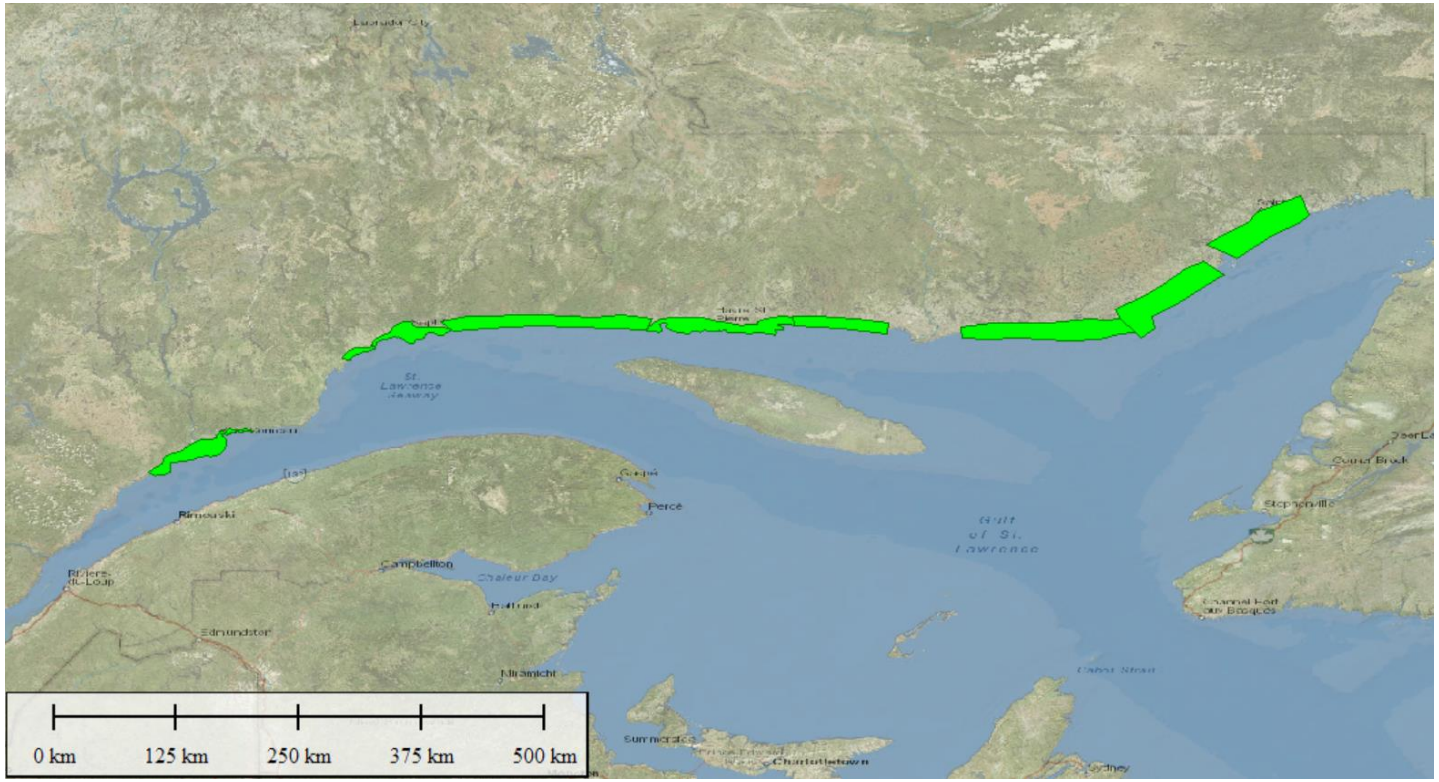
Project	Area (Sq Km)	Notes
Quebec 2016	1,745	
Central 2016	1,381	
Atlantic 2016	2,079	
Quebec 2017	9,107	
Central 2017	2,020	Continuing collection in April/May 2018
Atlantic 2017	6,301	
2016/2017 Total	**22,633**	

Quebec – 2016/2017

Summary

- Two flight blocks
- 1745 sq. km
- 156 flight lines
- 36,571 camera exposures

Quebec – 2017/2018



Summary

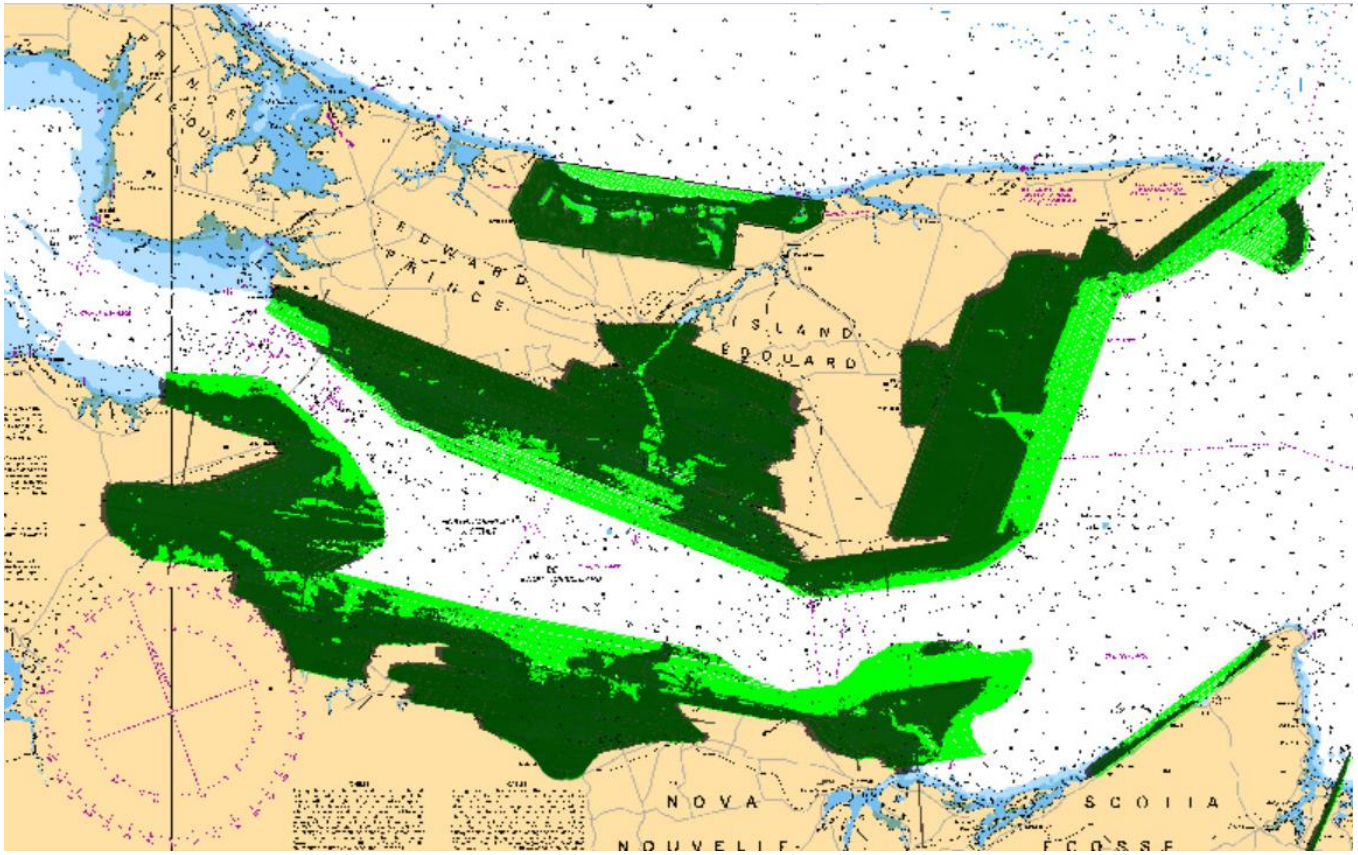
- 10 flight blocks
- 9107 sq. km
- 963 flight lines
- 512,675 camera exposures
- 2 Hyperspectral Only Missions
- Daily concurrent collection of hyperspectral imagery during Lidar flights

Atlantic – 2016/2017

Summary

- 14 flight blocks
- 2079 sq. km
- 279 flight lines
- 43,788 camera exposures

Atlantic, PEI – 2017



Summary

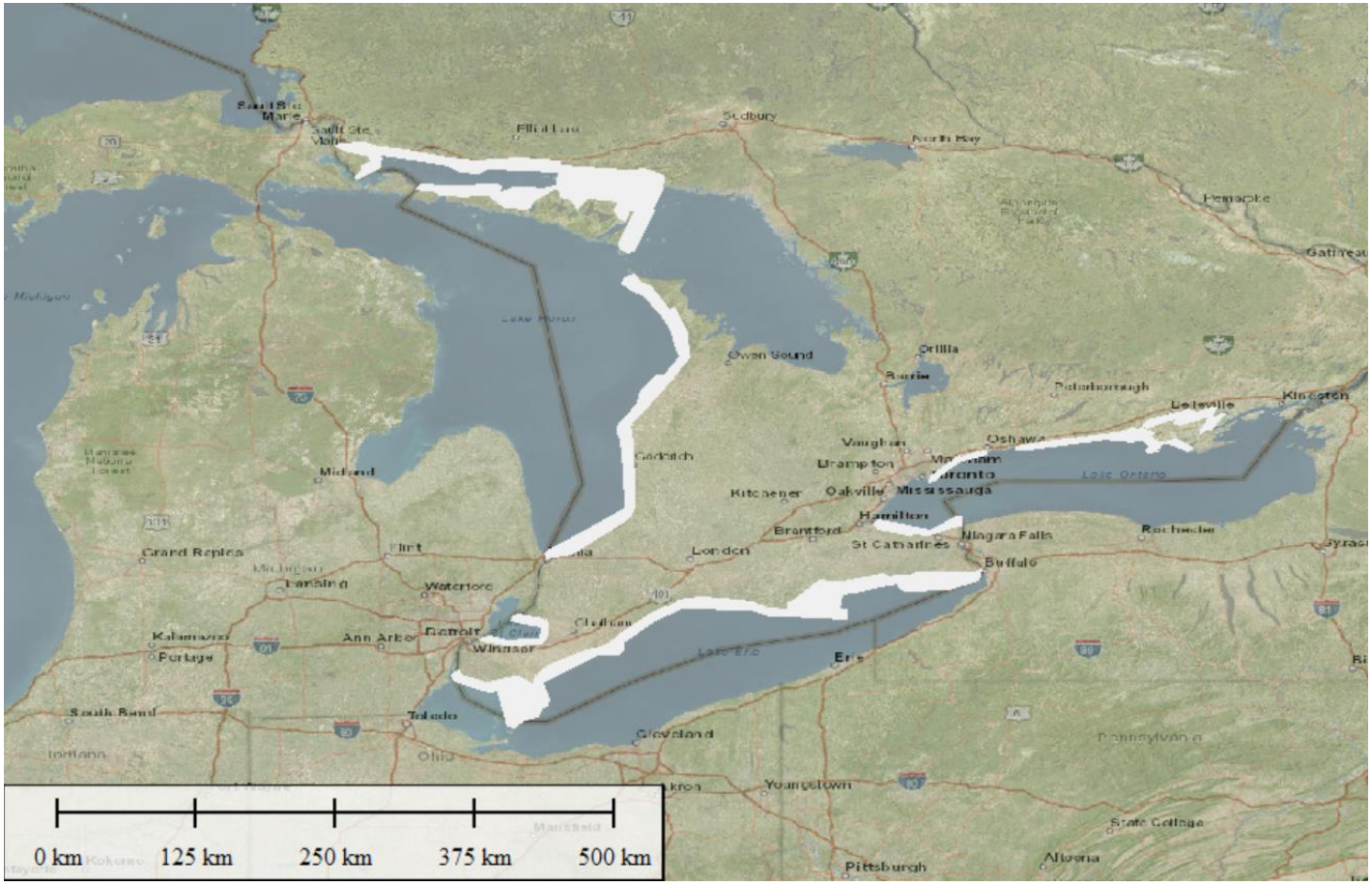
- 8 flight blocks
- 6301 sq. km
- 1254 flight lines
- 436,621 camera exposures
- 2 Hyperspectral only Missions

Central – 2016/2017

Summary

- 7 flight blocks
- 49,521 camera exposures
- 1381 sq. km
- 279 flight lines

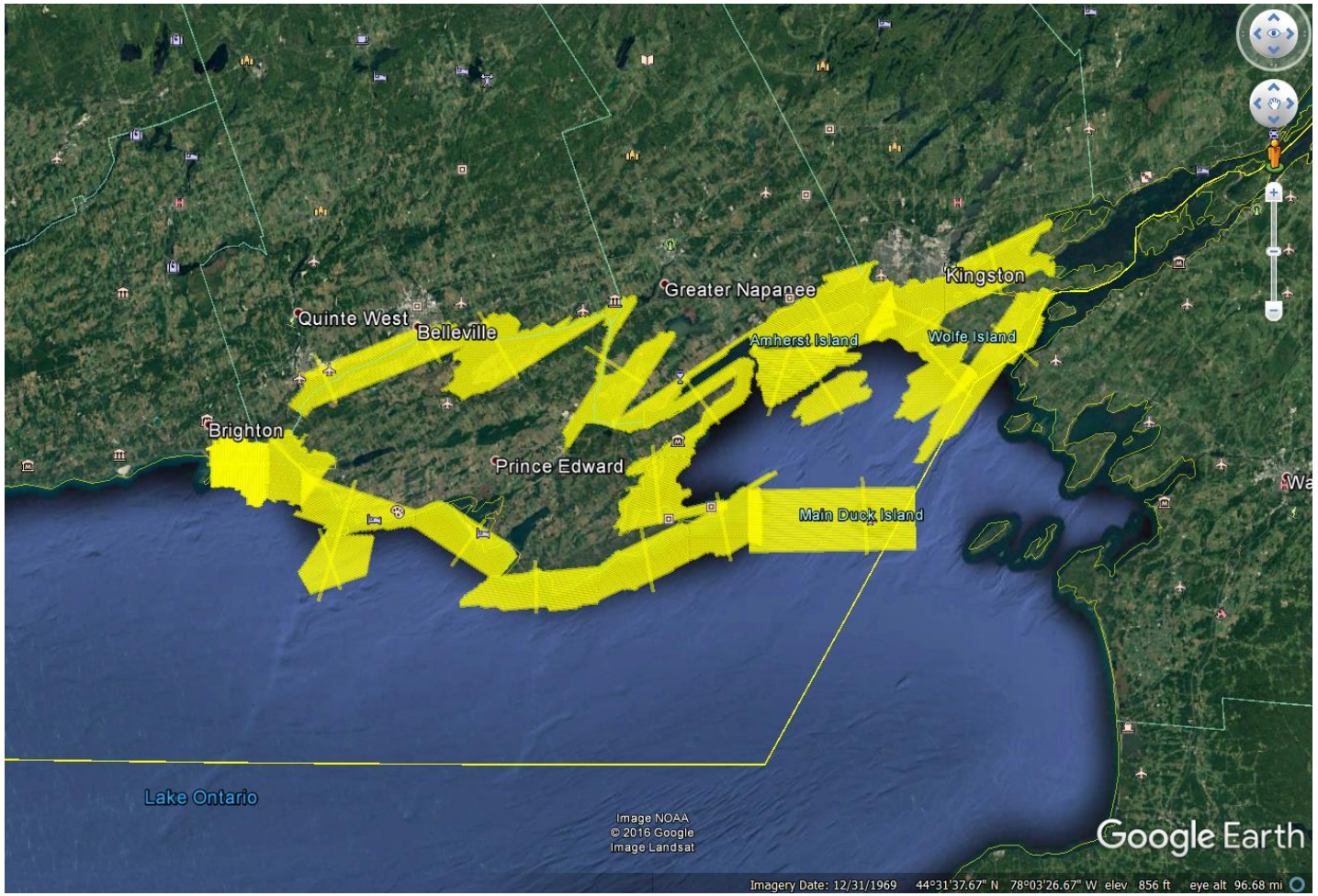
Central – 2017/2018 (to date)



Summary

- 15 flight blocks
- 2020 sq. km
- 476 flight lines
- 146,600 camera exposures

Flight Plan Example



Project Overview - Specifications

- Reflectance data (**bottom reflectivity**)
- Photography (**RGB Imagry/Orthos**)
- LIDAR to meet **IHO Order 1 b**
- Spot data density shall be at least **5m x 5m**
- **Hyperspectral Imagery** (Option)
- **Check lines** across all survey blocks

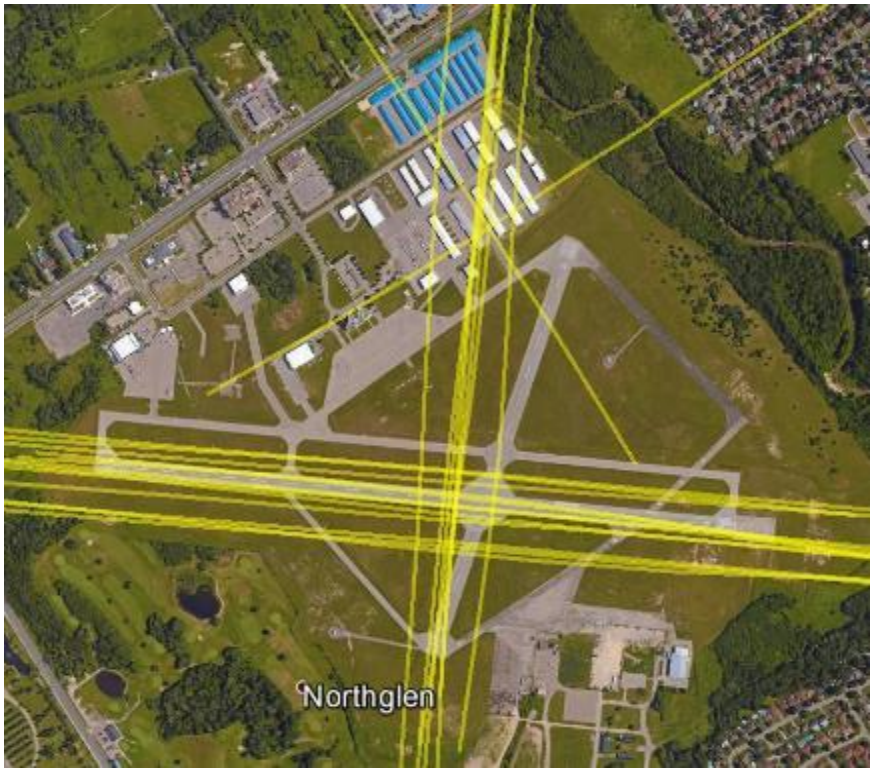
Project Overview - Deliverables

- Raw waveforms
- Processed XYZ point files
- Uncertainty values for all sensors and uncertainty models.
- Radiometrically calibrated reflectance data (bottom reflectivity).
- Integrated Bathy/Topo DEM
- Digital Imagery/ Photos
- Metadata
- GPS/Positioning data
- LAS format
- CARIS format

Equipment

Item	Serial Number / Version
Aircraft	Piper Navajo
LiDAR	CZMIL #06
Digital Camera	CM-4800

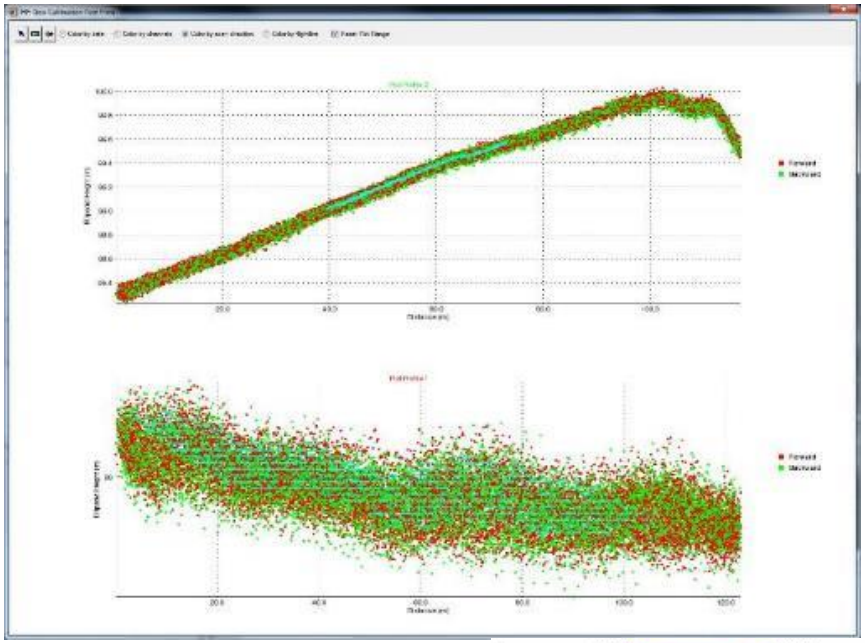
Calibration



CZMIL topographic calibration site over Oshawa Executive Airport in Oshawa, Ontario

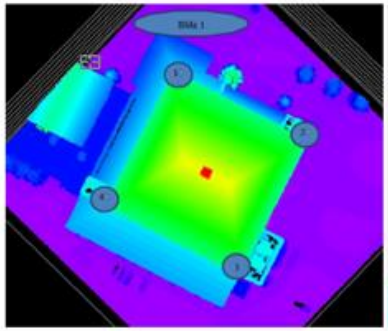
CZMIL bathymetric calibration site over Rouge River, Ontario

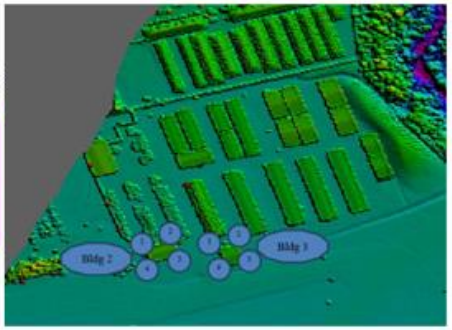
Calibration – Topographic Vertical, Horizontal



Date of Flight	Vertical Accuracy (m)	
20161103 (400m)	Mean (m)	-0.0183022
	Std Dev (m)	0.0179713
20161103 (600m)	Mean (m)	-0.00645261
	Std Dev (m)	0.0284341
20161104 (400m)	Mean (m)	-0.0148007
	Std Dev (m)	0.0211212
20161104 (600m)	Mean (m)	0.0163293
	Std Dev (m)	0.0277608

Topographic Vertical Accuracy Requirement (±15 cm, 2 sigma)





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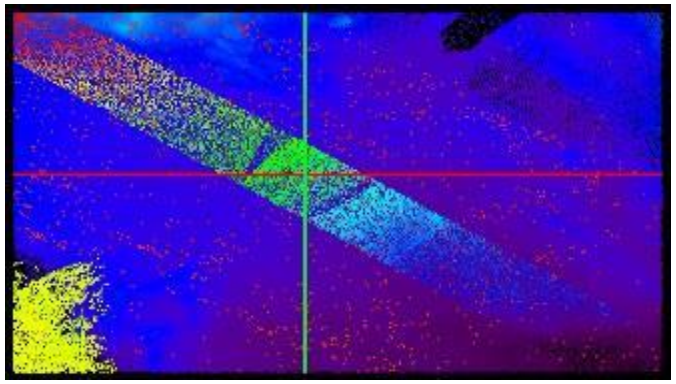
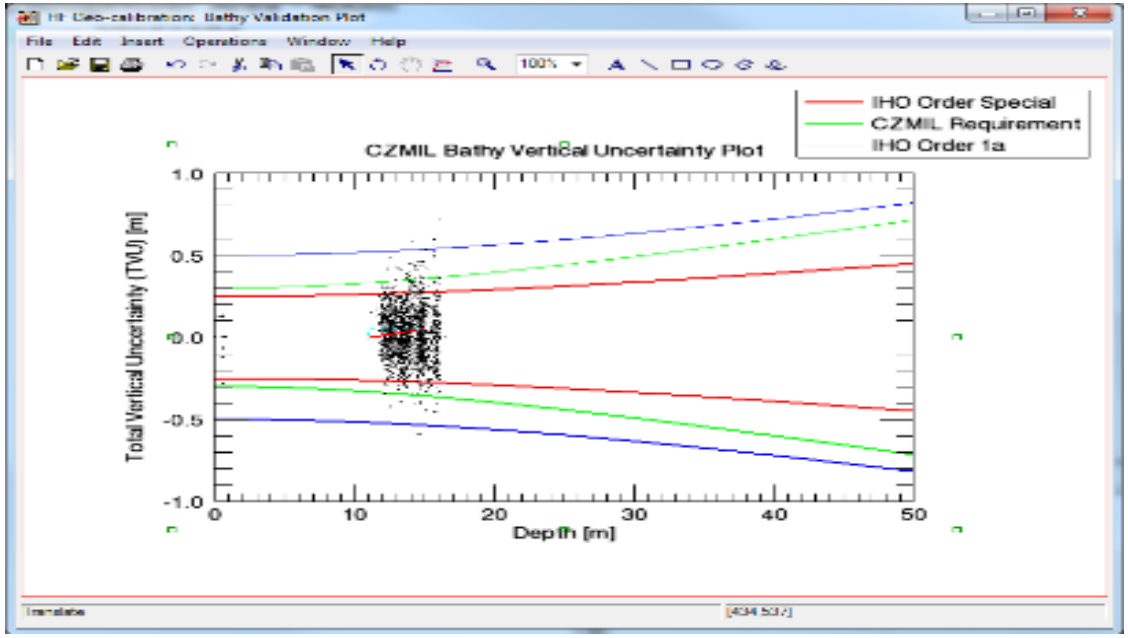




Display | Info

Validation Results

Mean Offset [m]: -0.0683747

STDEV [m]: 0.117678

MSE [m]: 0.00241156

PSNR [dB]: 24.3537

Bathy Accuracy Standard, Vertical [-]: IHO_Order_Special

Total Propagated Uncertainties (TPUs)

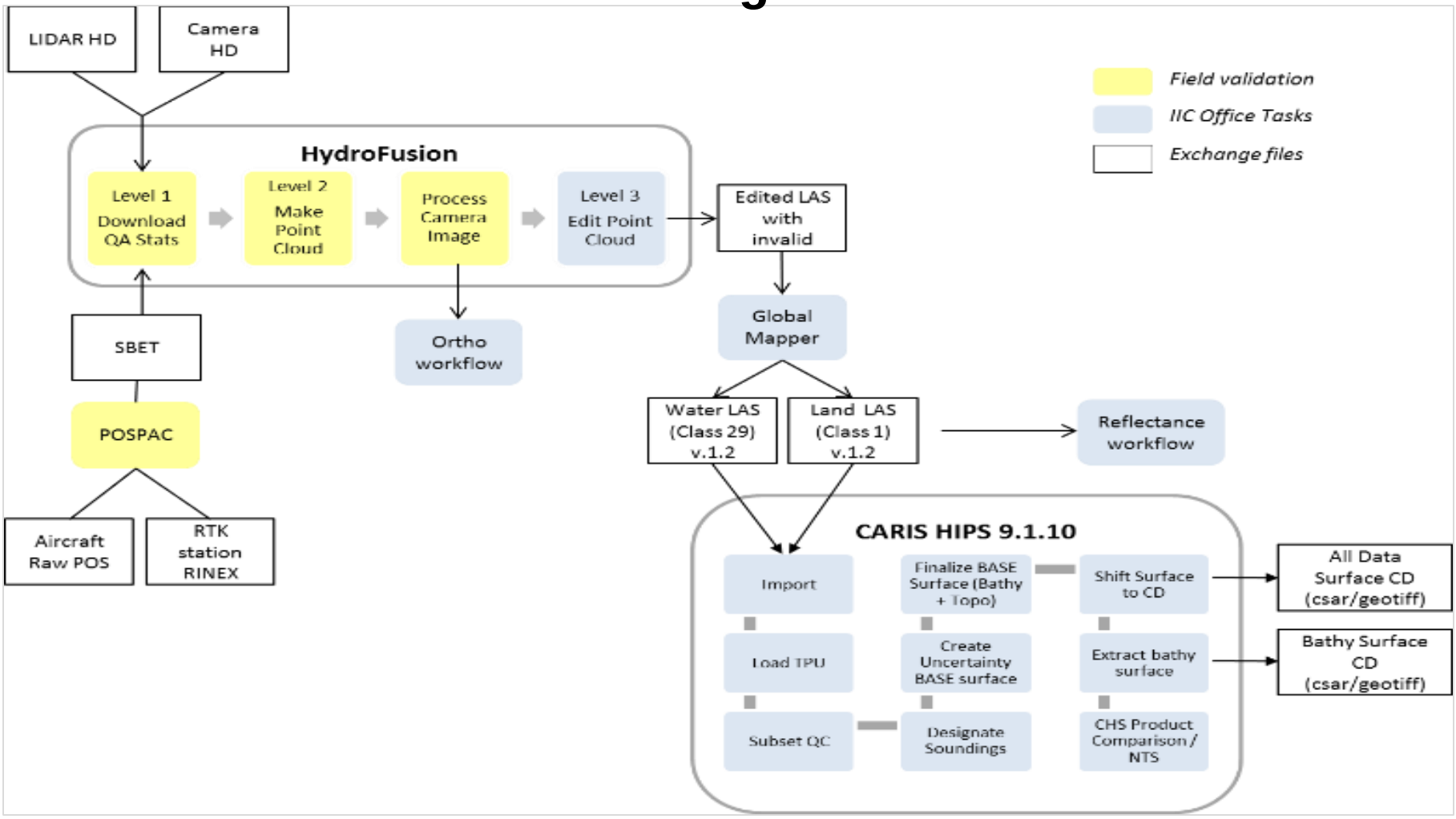
- IIC Technologies determined the total propagated uncertainties using a combination of the CZMIL accuracy model and direct observations of the system compared with ground truth.
- The TPU values required were at 1sigma

The ground truth data in Kingston was utilized to estimate the bathymetric accuracies between 0 and 25m relative to chart datum. Three survey lines were utilized: two lines at 600m altitude and 1 line at 400m altitude

Combined statistics for all lines

Depth Range	Mean Difference (m)	Standard Deviation (m)	Uncertainty (m)
0 to 7.5m	0.237	0.137	0.274
7.5 to 10m	0.211	0.169	0.27
10 to 12.5m	0.025	0.169	0.171
12.5 to 15m	0.043	0.148	0.154
15 to 17.5m	0.175	0.191	0.259
17.5 to 20m	0.101	0.326	0.341
20 to 22.5m	0.224	0.19	0.294

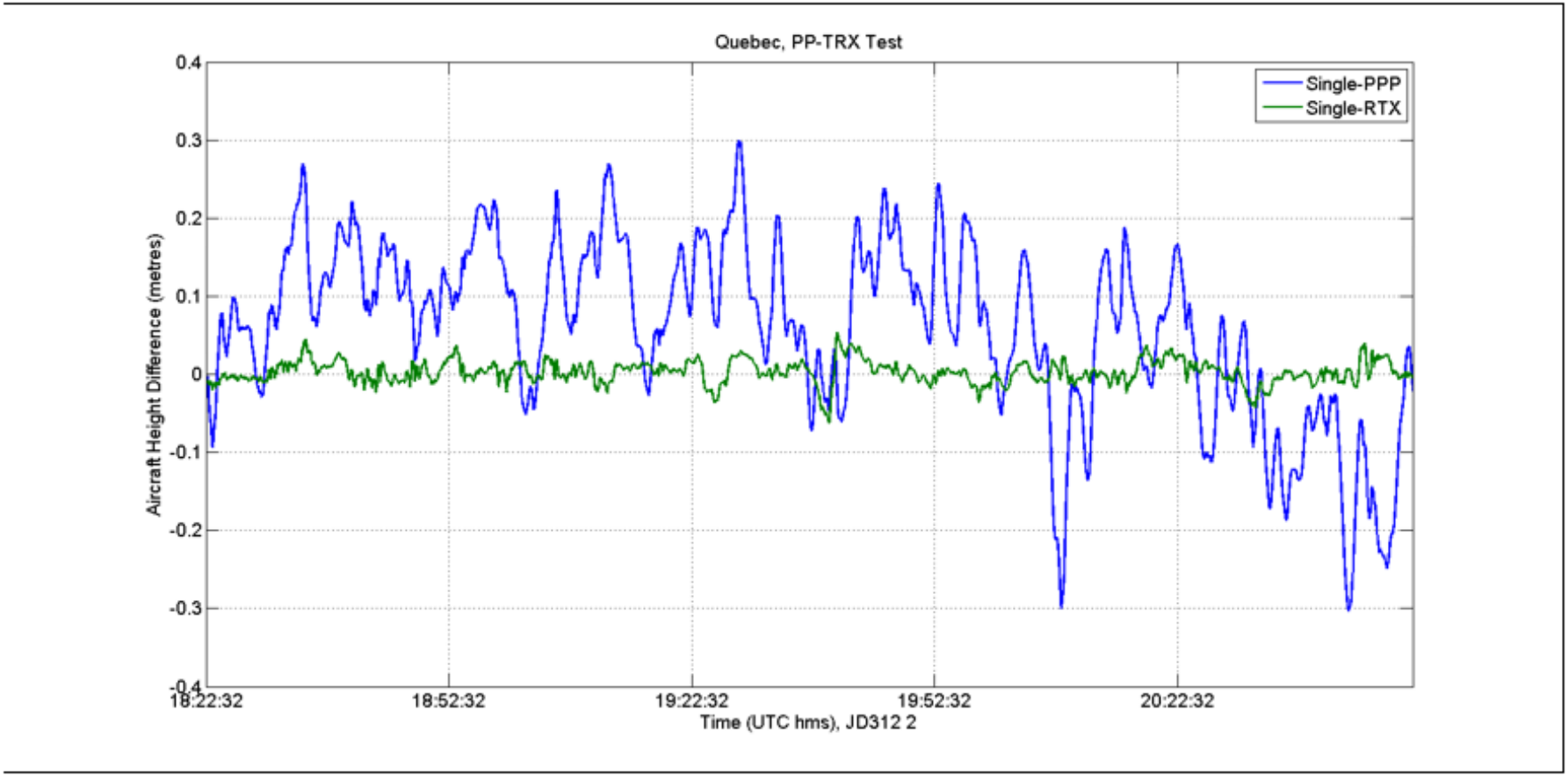
Processing Workflow



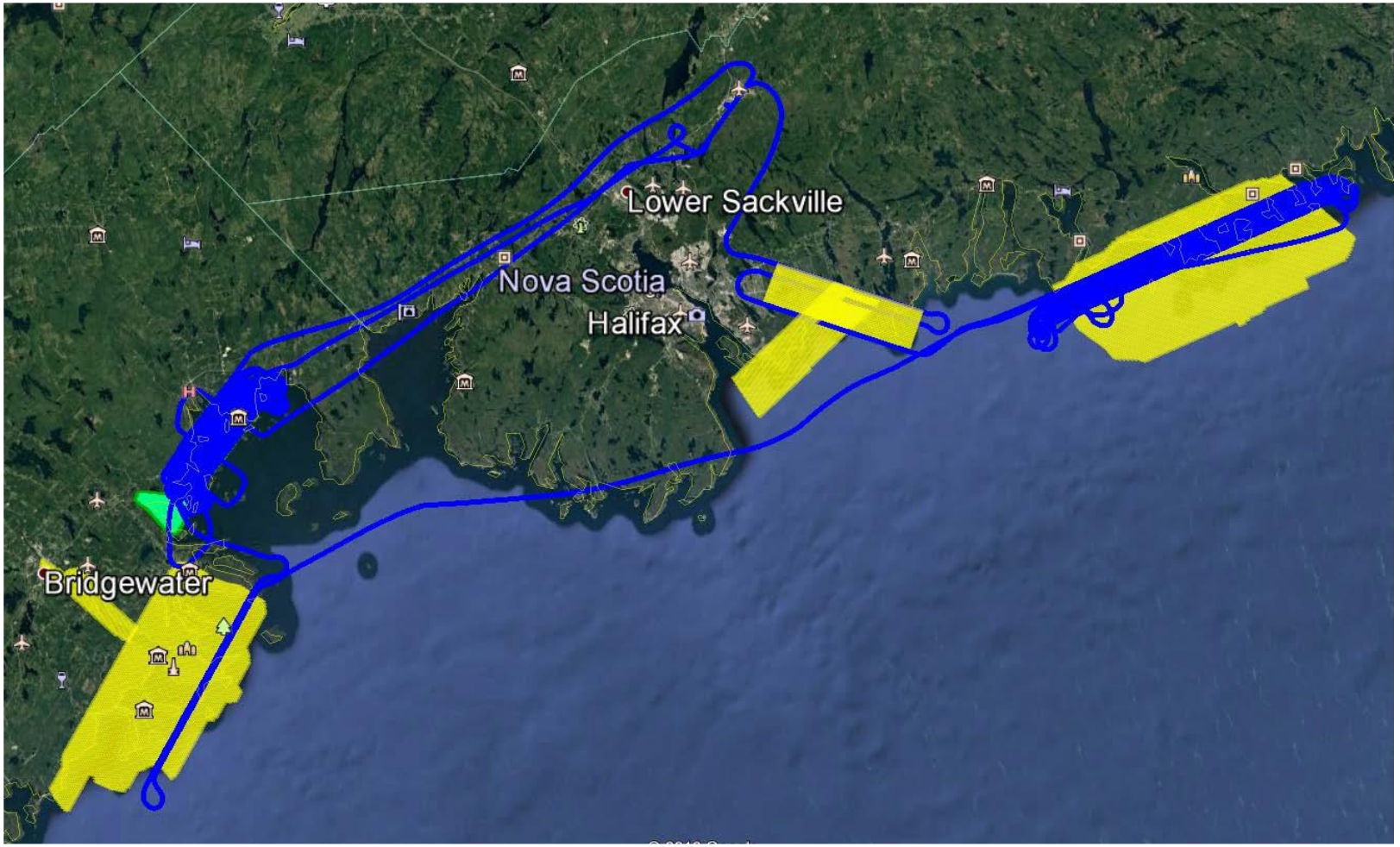
Introduction to PP-RTX

- Officially release in December 2016 with POSPAC 8.0
- PP-RTX creates virtual base stations along the survey track and uses them to refine the solution.
- For all flights, the single base solution and PP-RTX matched very closely within **2 to 3cm** so within the accuracies requirements of the project.
- Applanix technical experts also recommended PP-RTX instead of multi-single base for long flights covering distinct survey areas. This scenario occurred on several days in the Atlantic Region.

PP-RTX vs PPP


Quebec, PP-TRX Test
Single-PPP
Single-RTX
Aircraft Height Difference (metres)
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
18:22:32
18:52:32
19:22:32
19:52:32
20:22:32
Time (UTC hms), JD312 2

Ideal Scenario for PP-RTX



Cost of Base Station Deployment

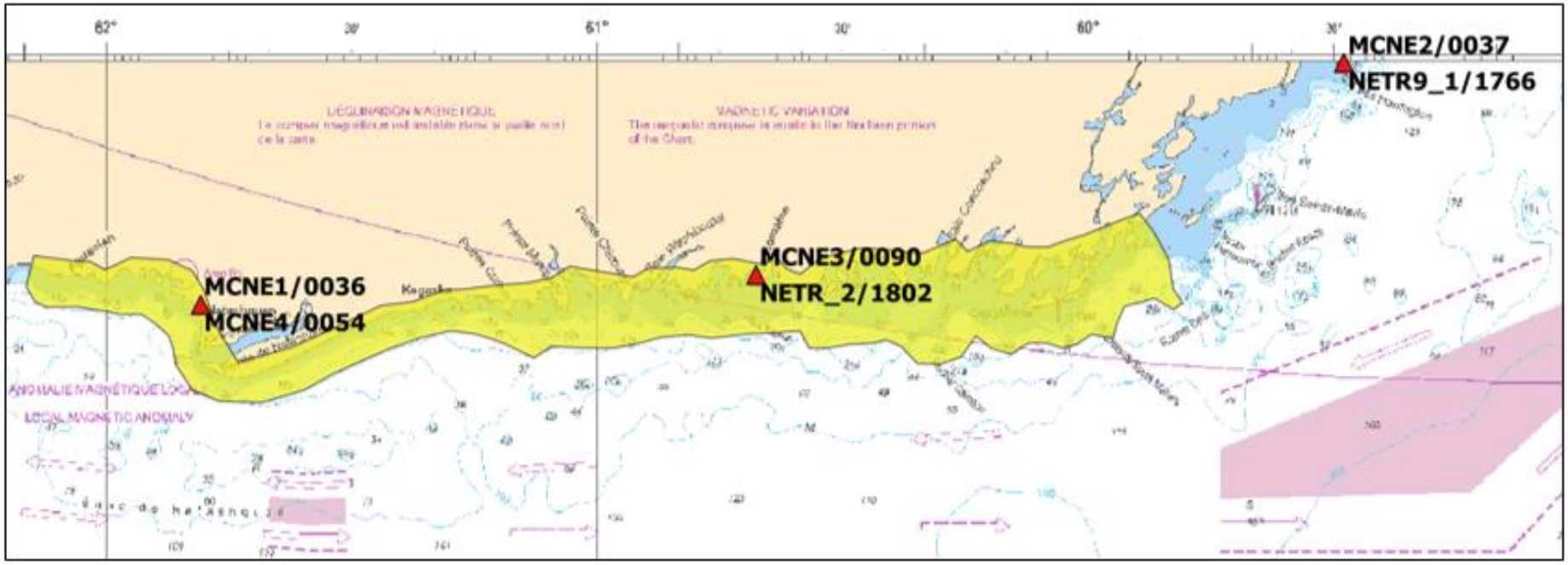


Figure 4: GNSS Base Stations

Project Challenges

- Weather
  - Rain, Snow, Ice, Wind, Fog, Critters

- Highly Variable Water Conditions (Especially Atlantic Region)
  - Sometimes 3+ days for water to settle after storm events or high winds/waves
- Shallow water/tidal mud flats

Weather


GARFIELD
The Chronicle Herald • Saturday, March 4, 2017
JIM DAVIS 3-5
BWINK
SPOING
FUMP
CURSE YOU, MARCH

10 Minute Time Span

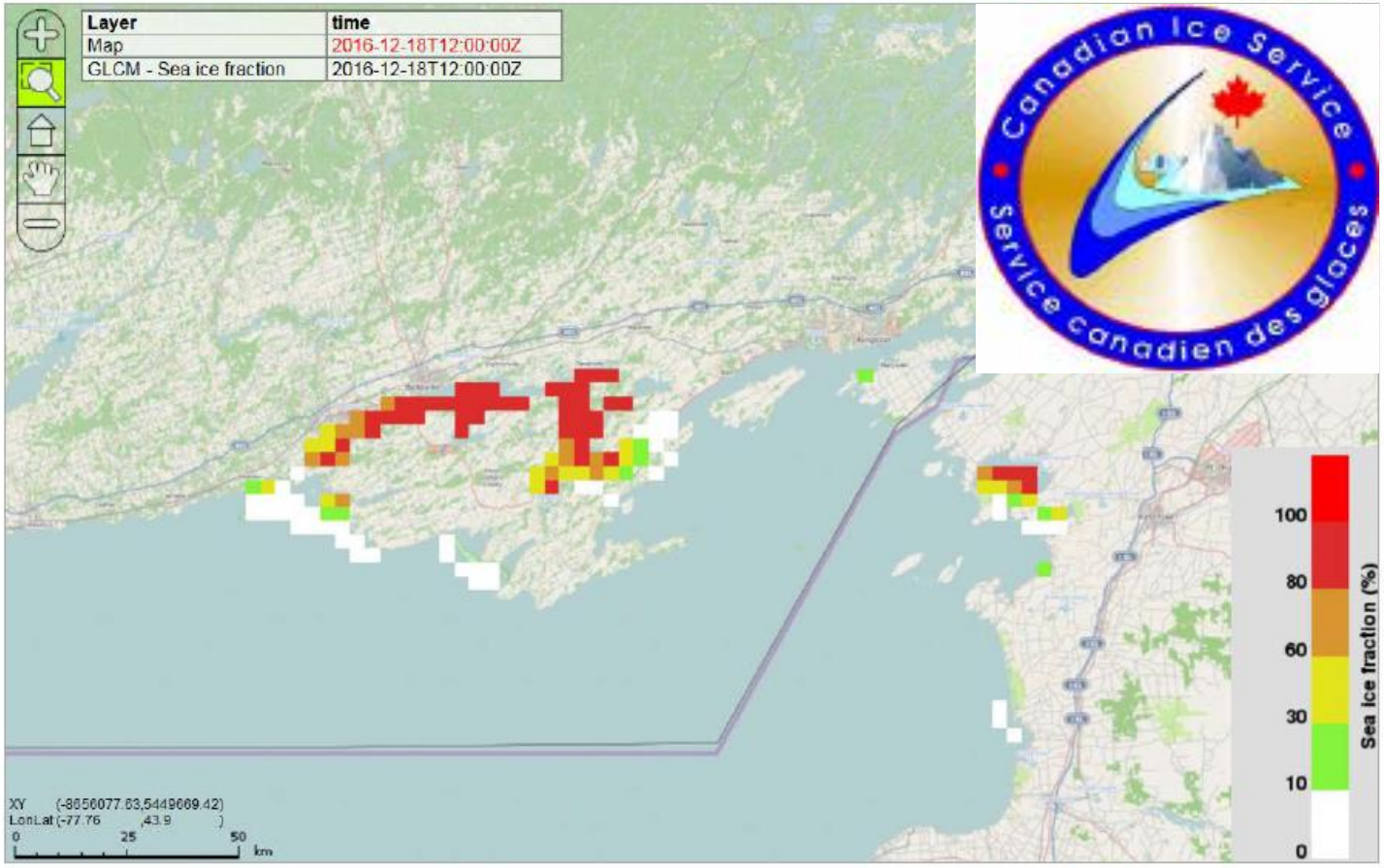
10 Minute Time Span

10 Minute Time Span

Winter Conditions

Winter Conditions

Ice Forecast



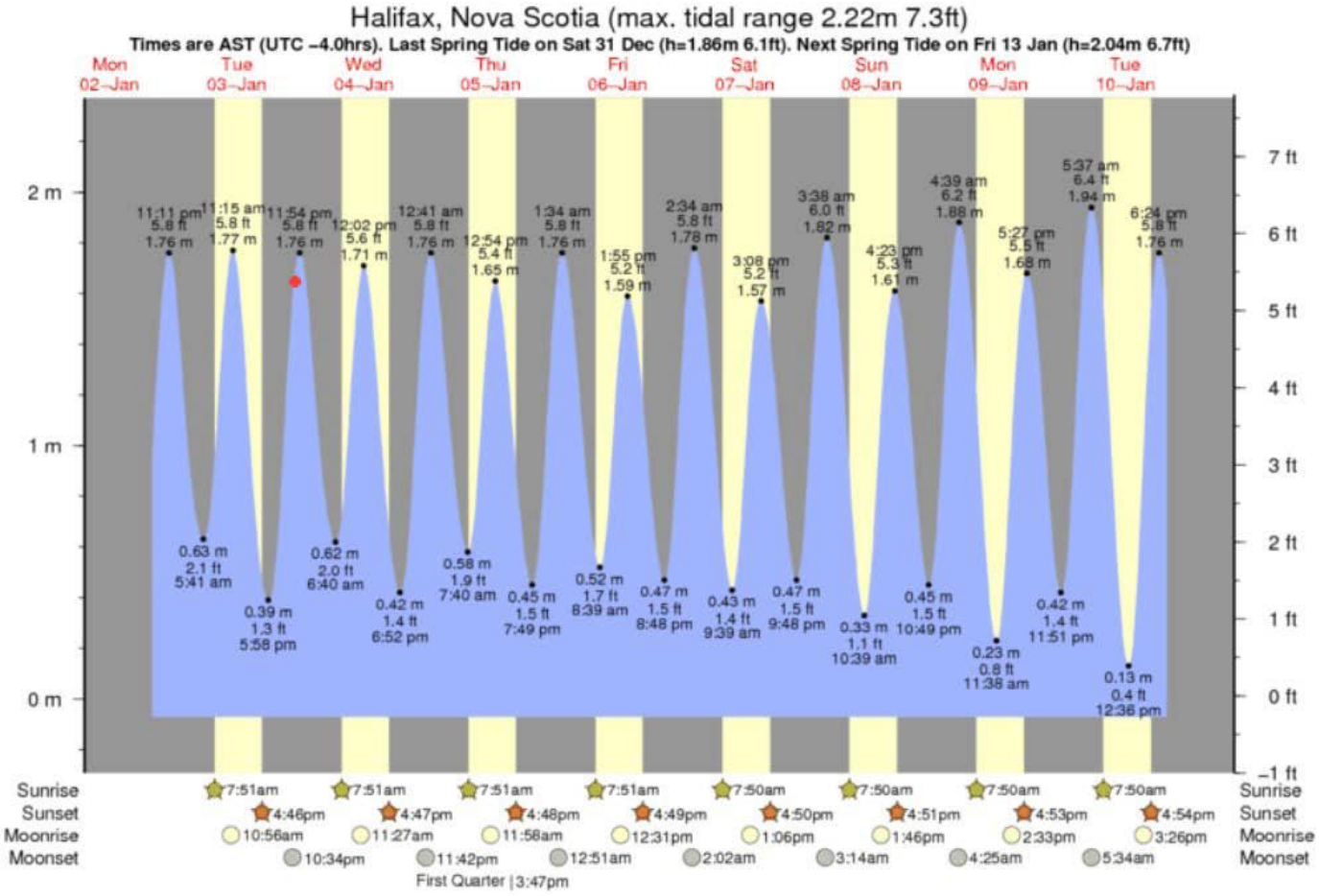
Forecast Lake Ice Fraction at 1200 UTC 18 Dec 2016 (from Experimental Coupled Great Lakes Model)

Ontario Flight Coverage - 2016

Ice

Had to plan inlets before ice formation, or after melting

Tidal Coordination



Halifax Tide Chart. The largest known tidal range at Halifax is 2.22m 7.3 feet

Ortho Mosaic (20 cm) - Ontario

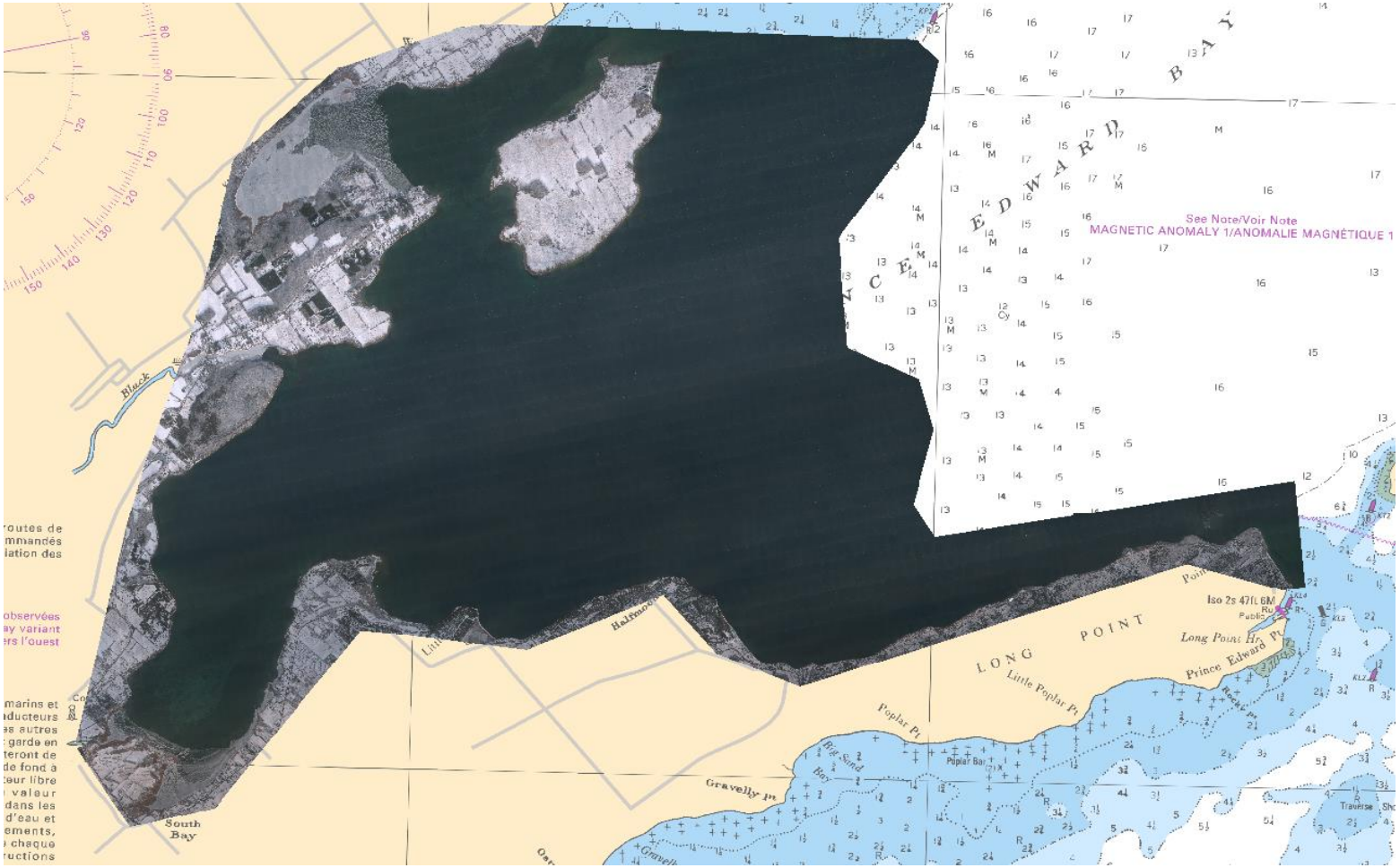
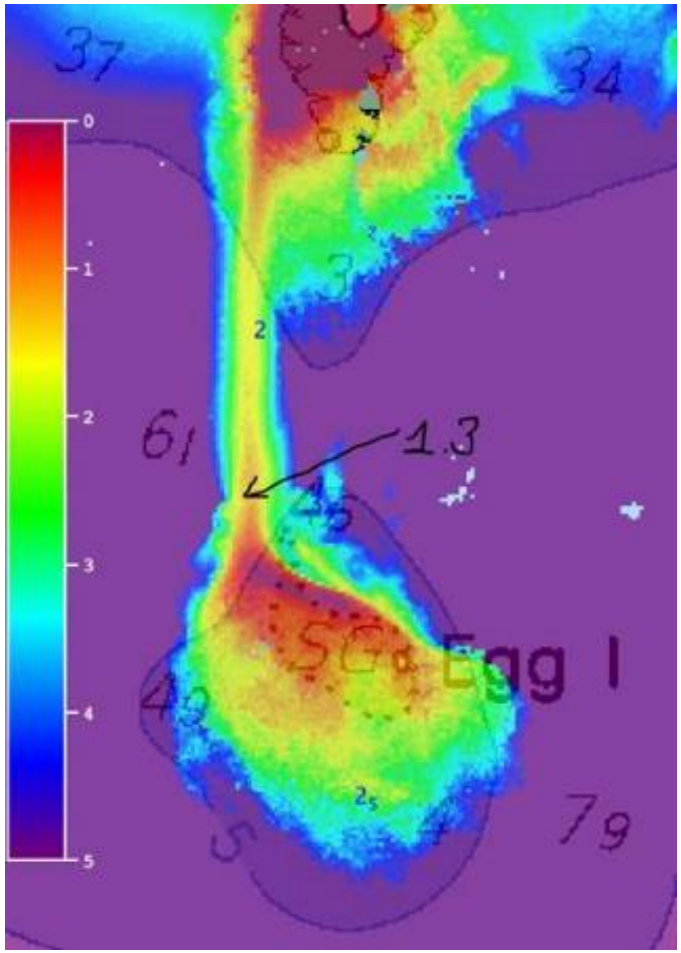
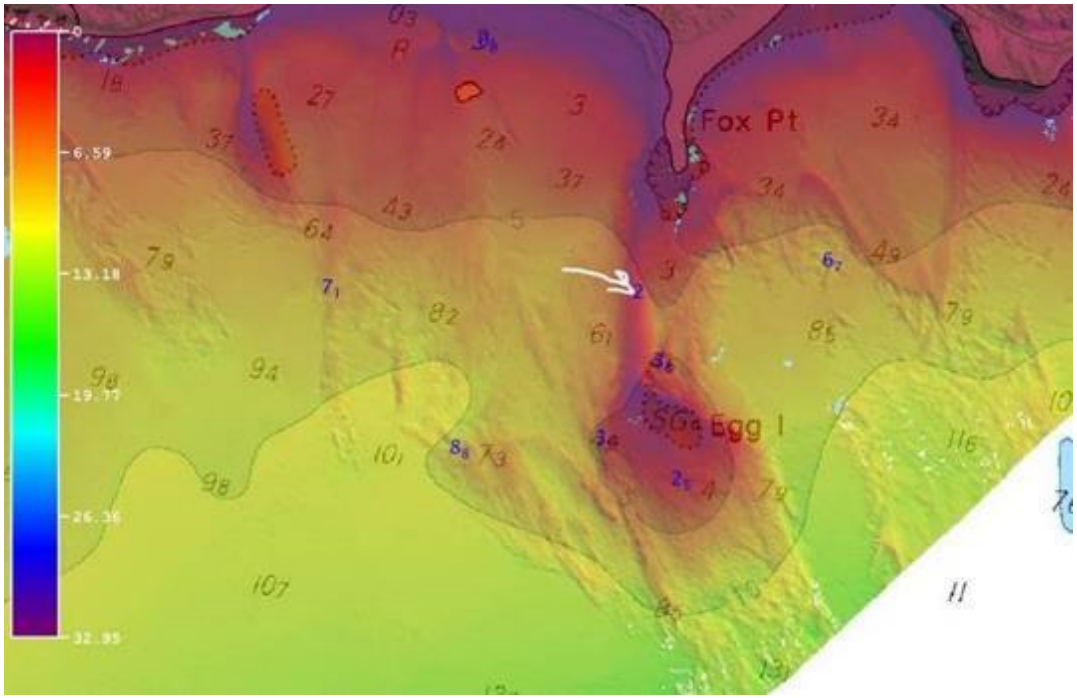


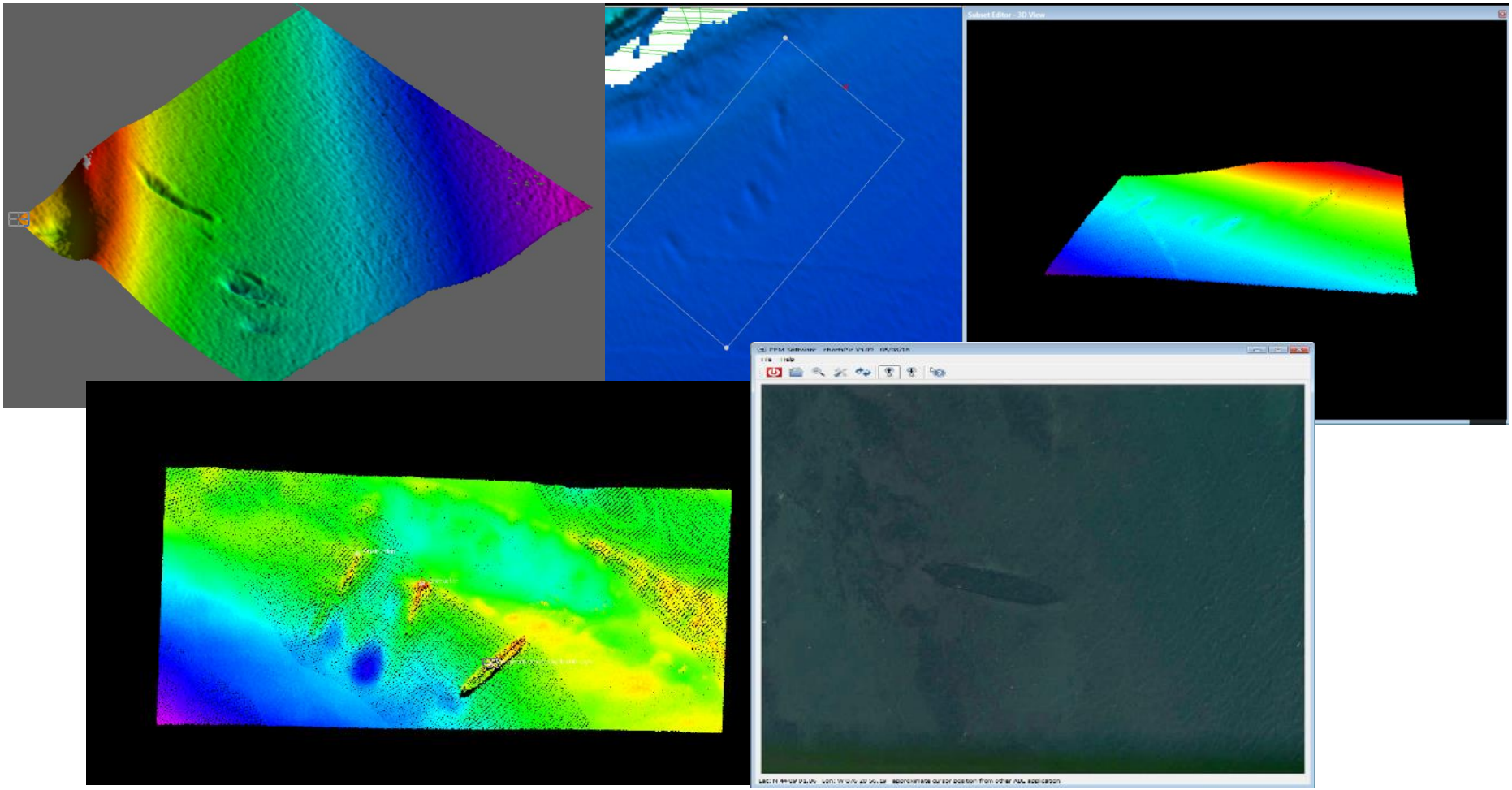
Chart Comparison



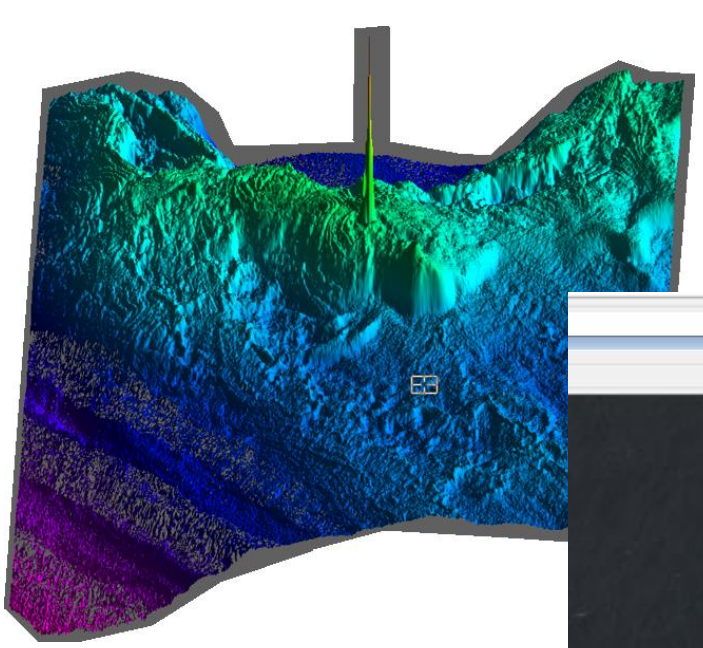


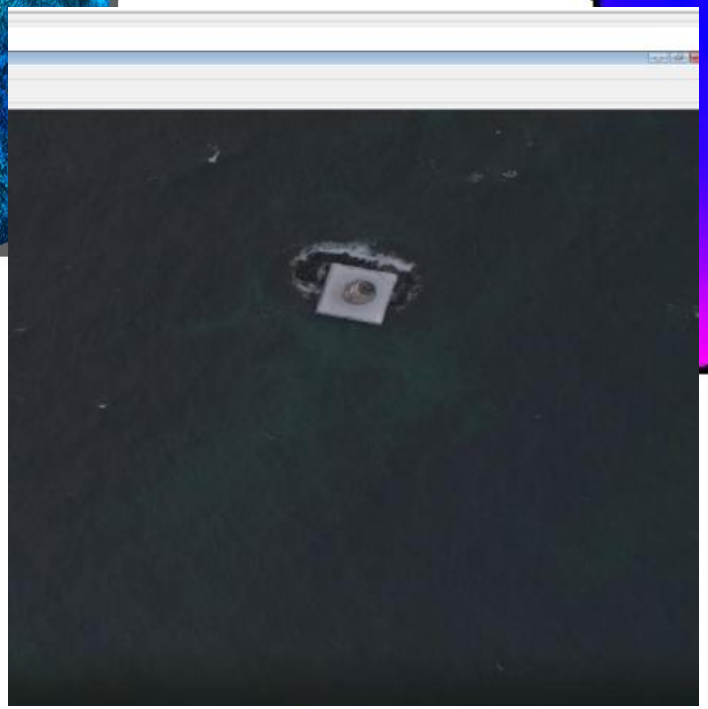
4320 vs. 2016/17 LIDAR: there is a shoal charted at 2 fathoms (3.6m) and measured at 2m

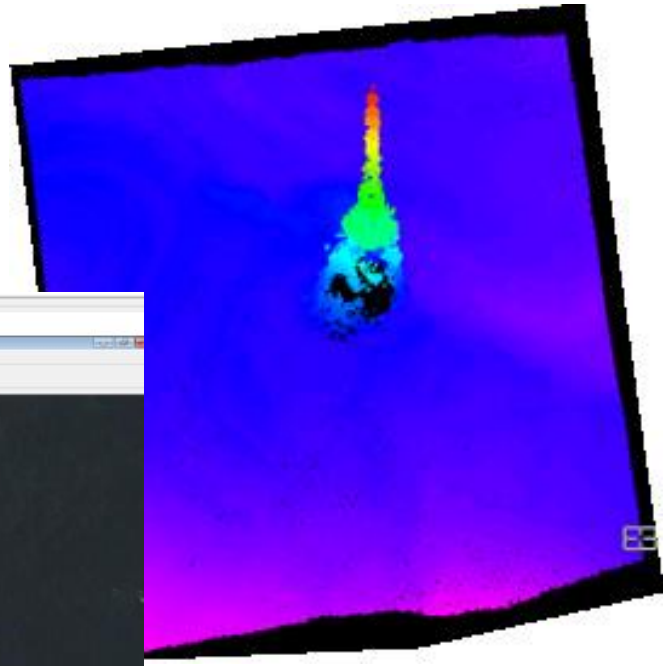
Wrecks and objects observed

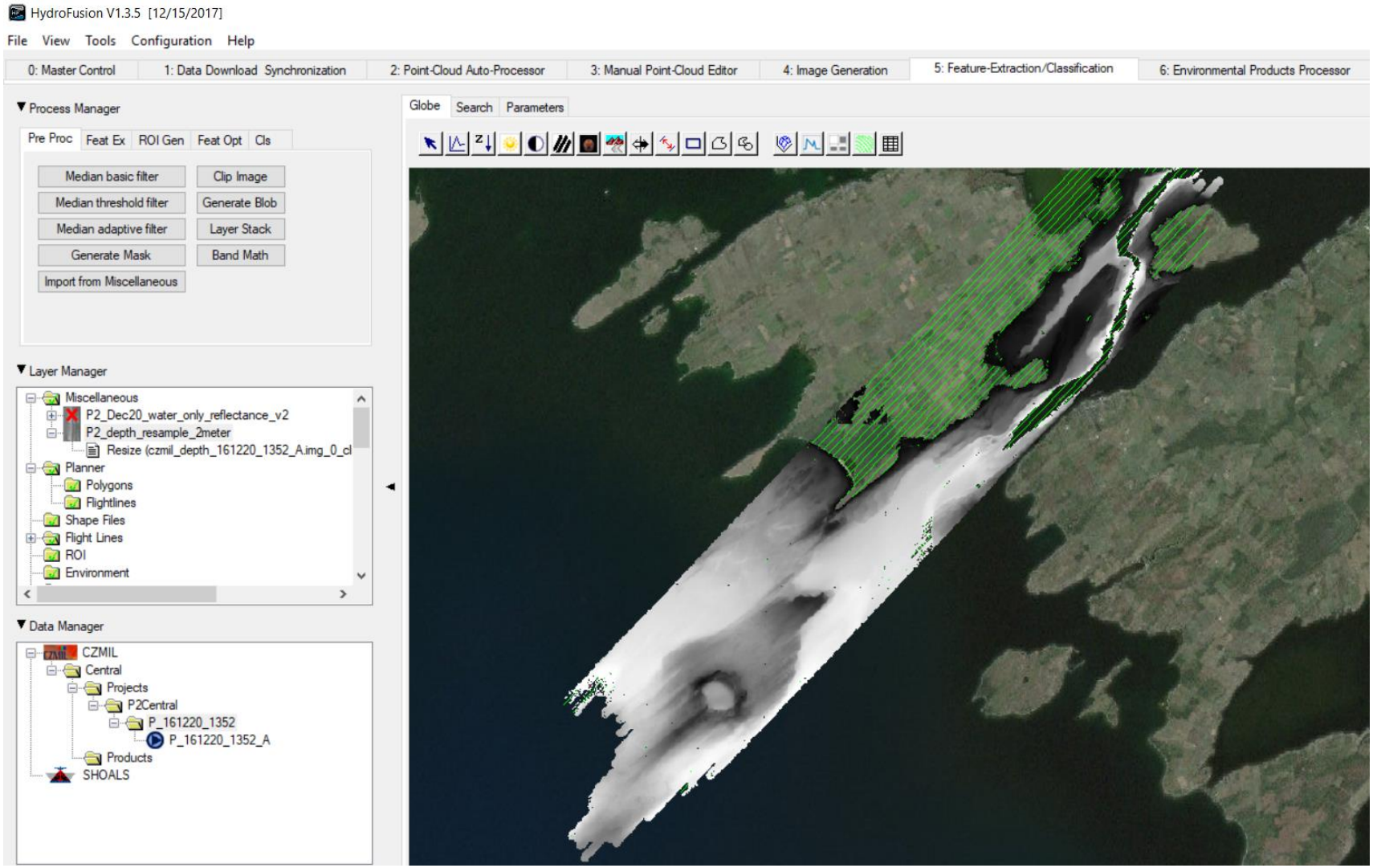


Beacon Observed





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File View Tools Configuration Help
0: Master Control
1: Data Download Synchronization
2: Point-Cloud Auto-Processor
3: Manual Point-Cloud Editor
4: Image Generation
5: Feature-Extraction/Classification
6: Environmental Products Processor
Process Manager
Pre Proc
Feat Ex
ROI Gen
Feat Opt
Cls
Median basic filter
Median threshold filter
Median adaptive filter
Generate Mask
Import from Miscellaneous
Clip Image
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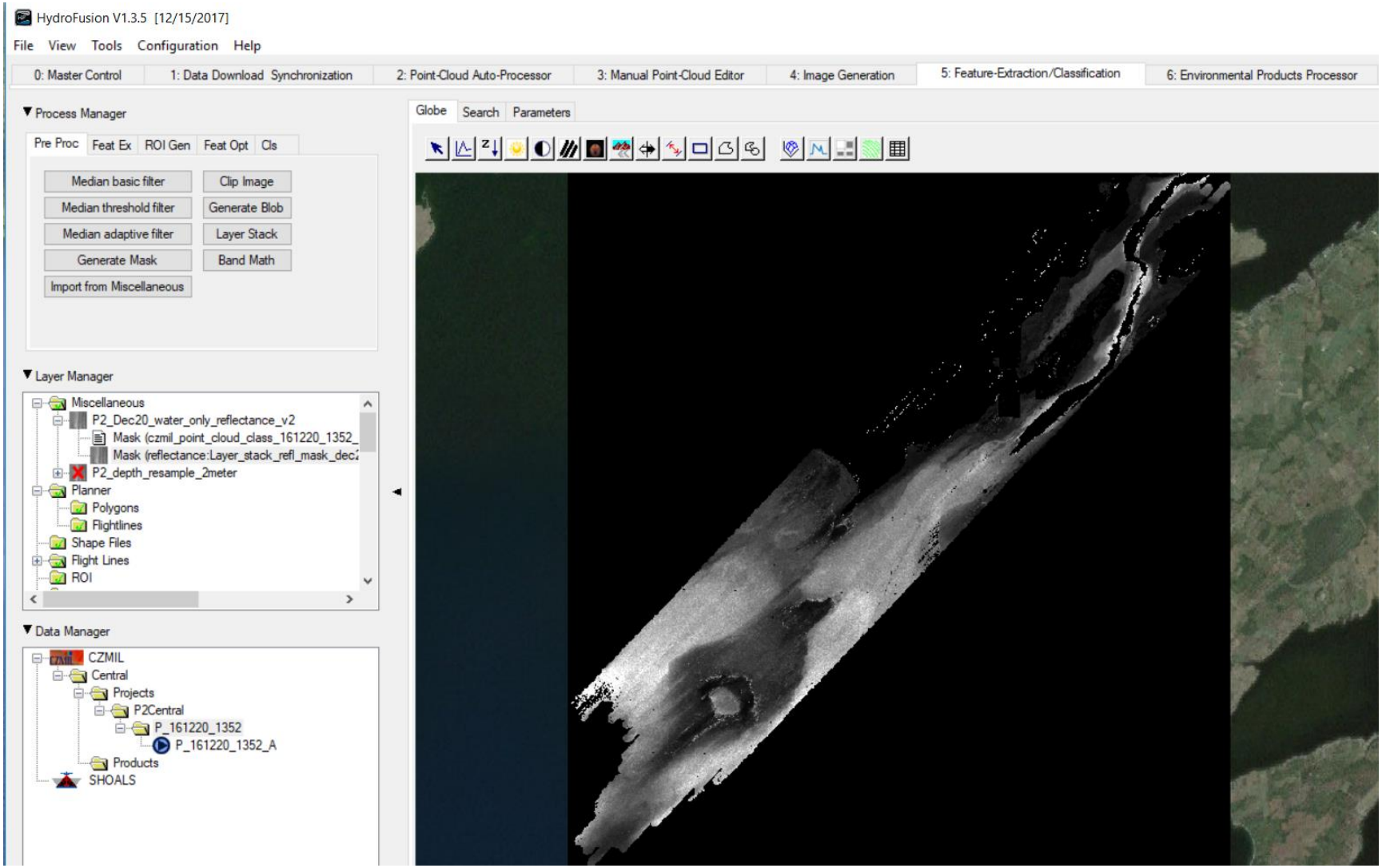
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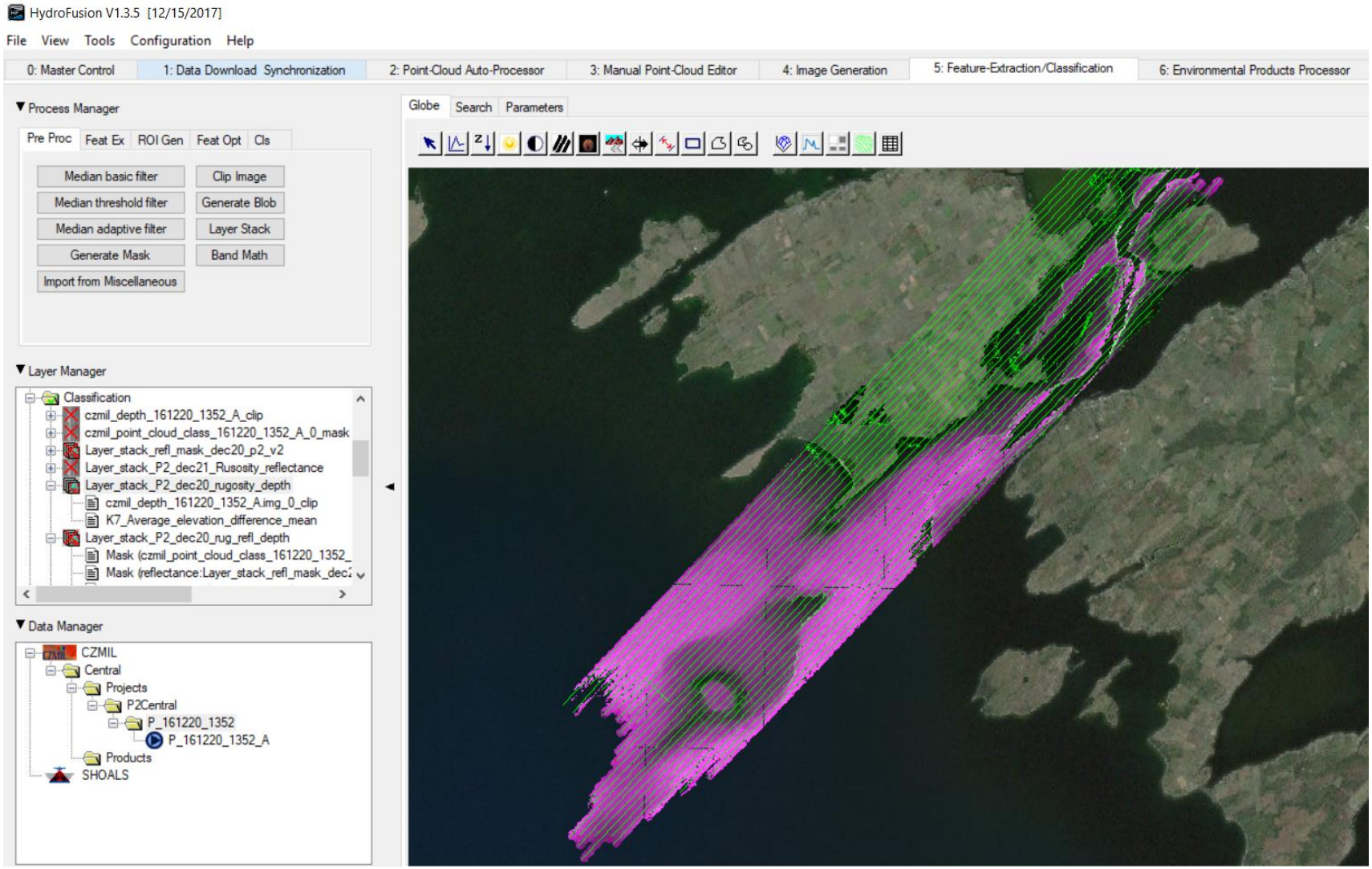
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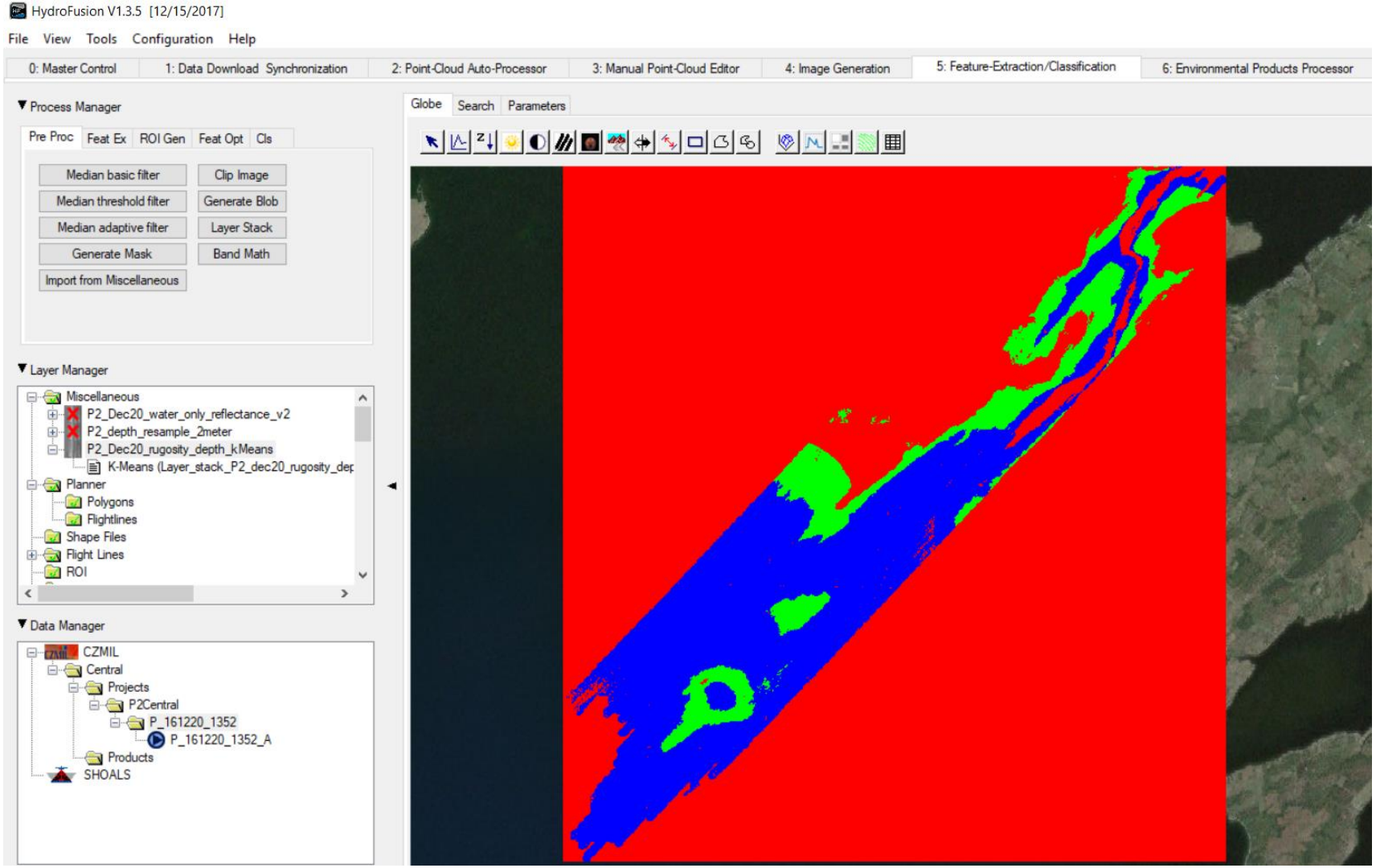
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Search
Parameters

Conclusions

- All survey areas were surveyed and processed according to the contract requirements, achieving order 1b for coverage, uncertainty and object detection.
- Although the water penetration may have been limited in areas, CZMIL demonstrated excellent shoals detection capabilities.
- For future surveys in similar areas in remote locations where access is difficult using PP-RTX is a viable alternative to deploying GNSS base stations. In this project IIC Technologies performed several tests comparing PP-RTX with short base line PPK method and found very close horizontal and vertical uncertainties (within a few centimetres).

Thank You!

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