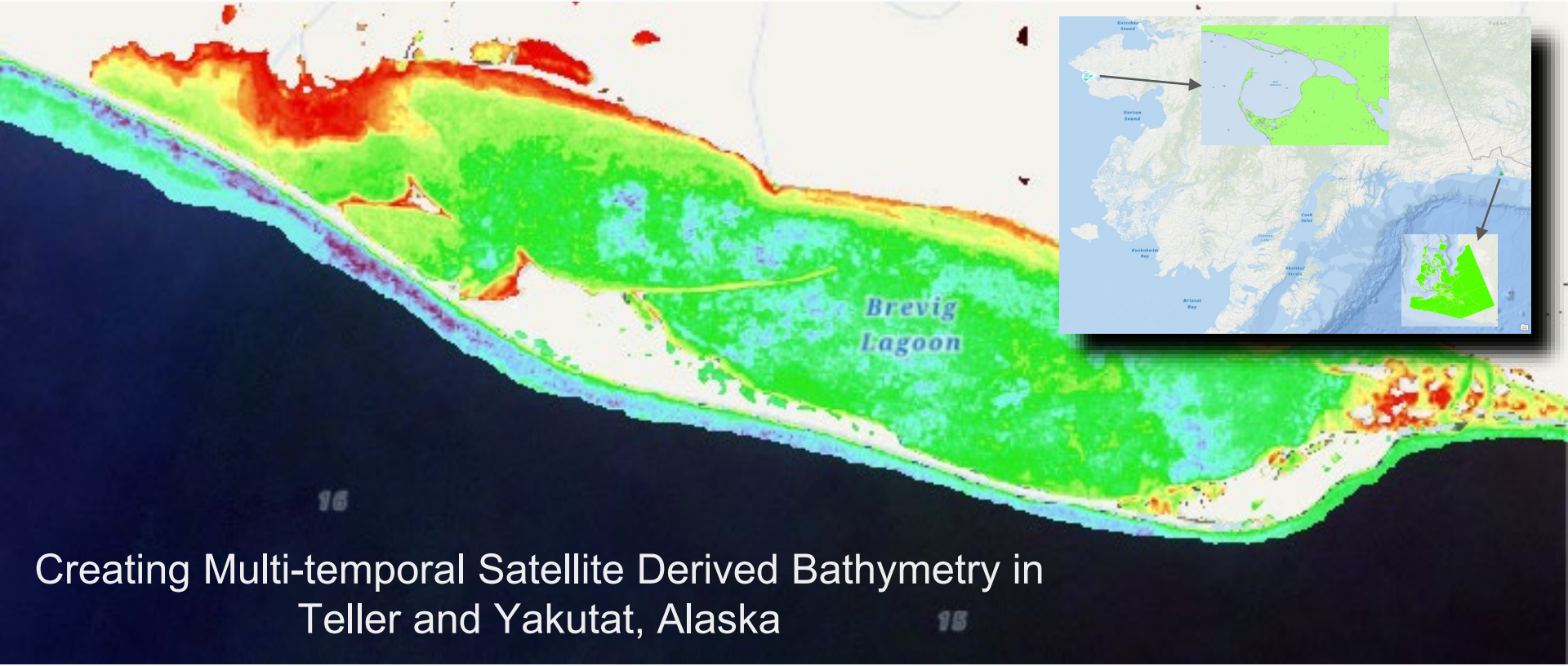
TCARTA

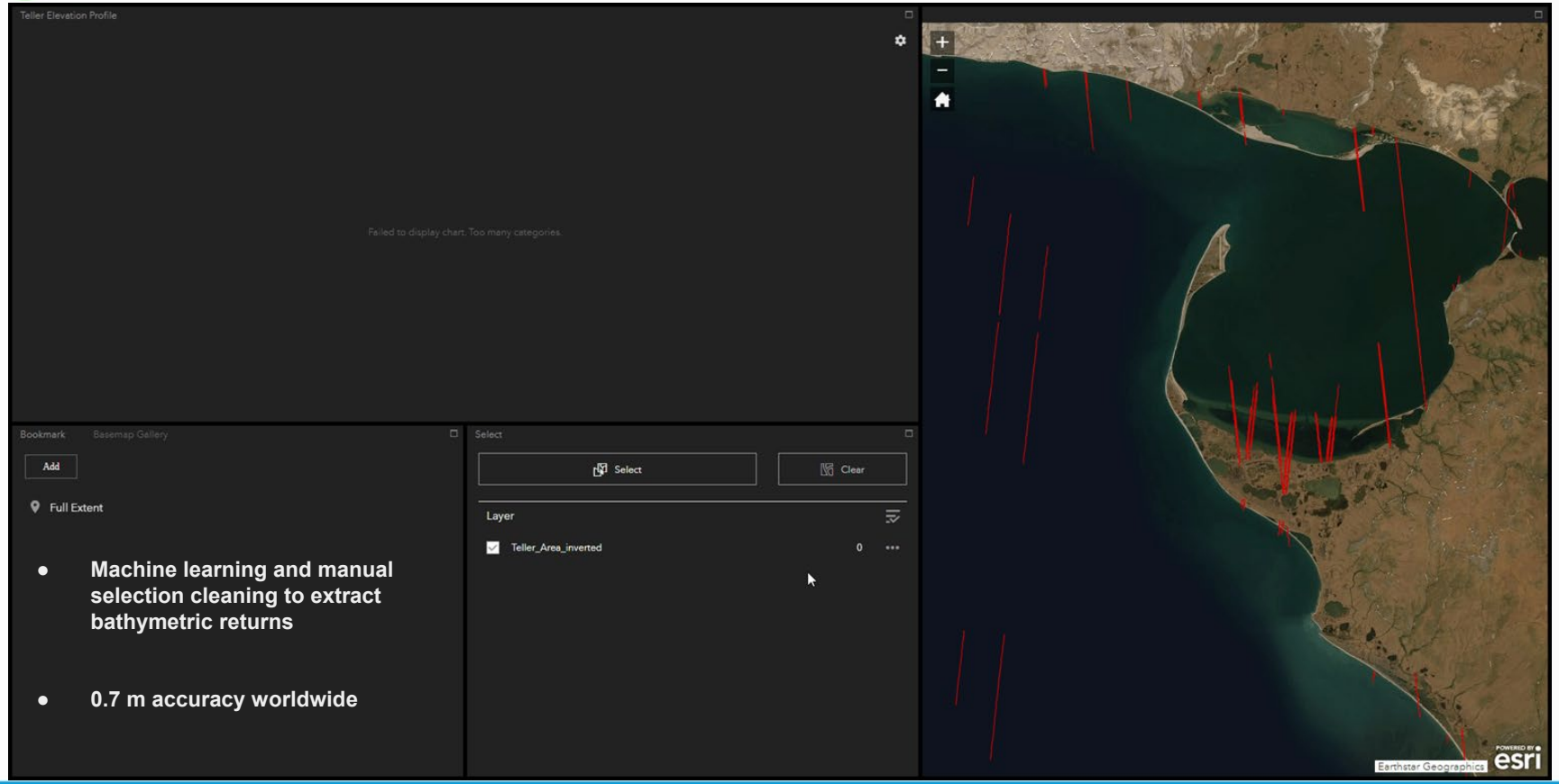
The leading global provider of innovative marine geospatial services & products and satellite based earth observation analysis



Creating Multi-temporal Satellite Derived Bathymetry in Teller and Yakutat, Alaska

Natalie Treadwell, Remote Sensing Analyst

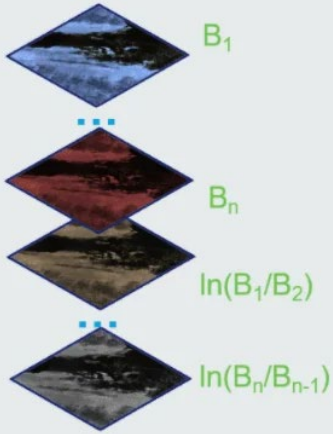
ICESat-2 ATL03 Bathymetric LiDAR Collection



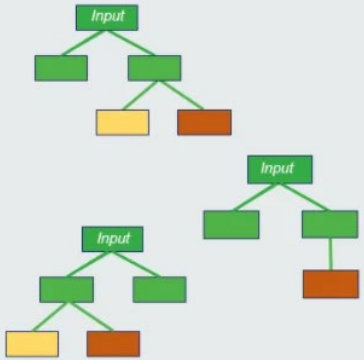
- Machine learning and manual selection cleaning to extract bathymetric returns
- 0.7 m accuracy worldwide

Satellite Derived Bathymetry Methods

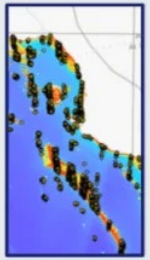
Random Forest Model



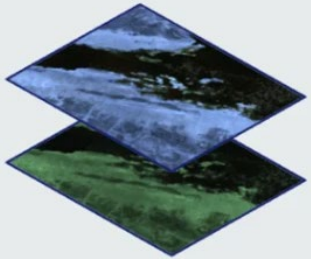
Spectral bands (B) and band ratio permutations (pixel value)



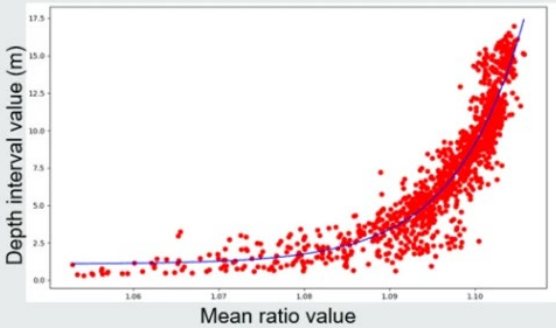
Trained with point data (ICESat-2)



Band Ratio Method



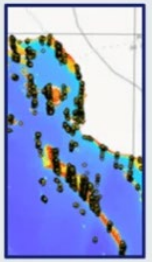
$\ln(B_2/B_3)$



Spectral bands:

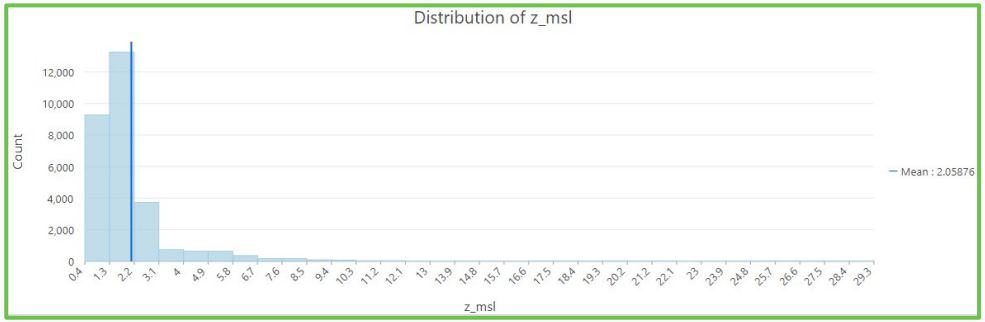
B_2: Blue band
B_3: Green band

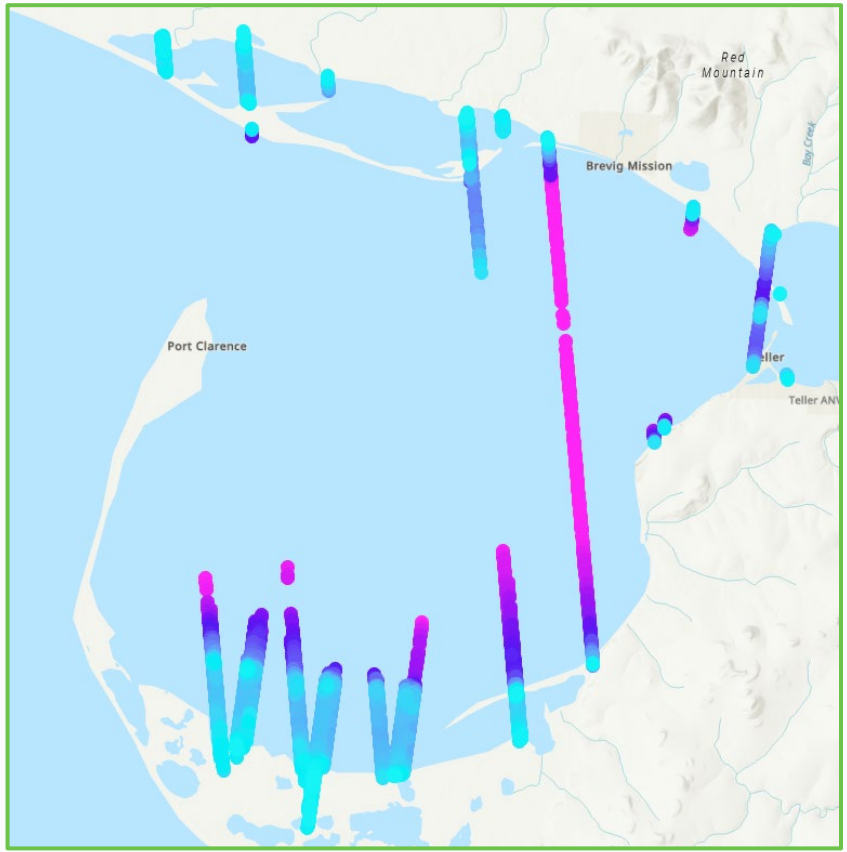
Fit curve between band ratio and depth from calibration data (ICESat-2)



Teller ICESat-2 Collection

Depth Range	0.35m - 29.28m
# Data Points	29,435
DOI	2018-2022
Vertical Datum	EGM2008





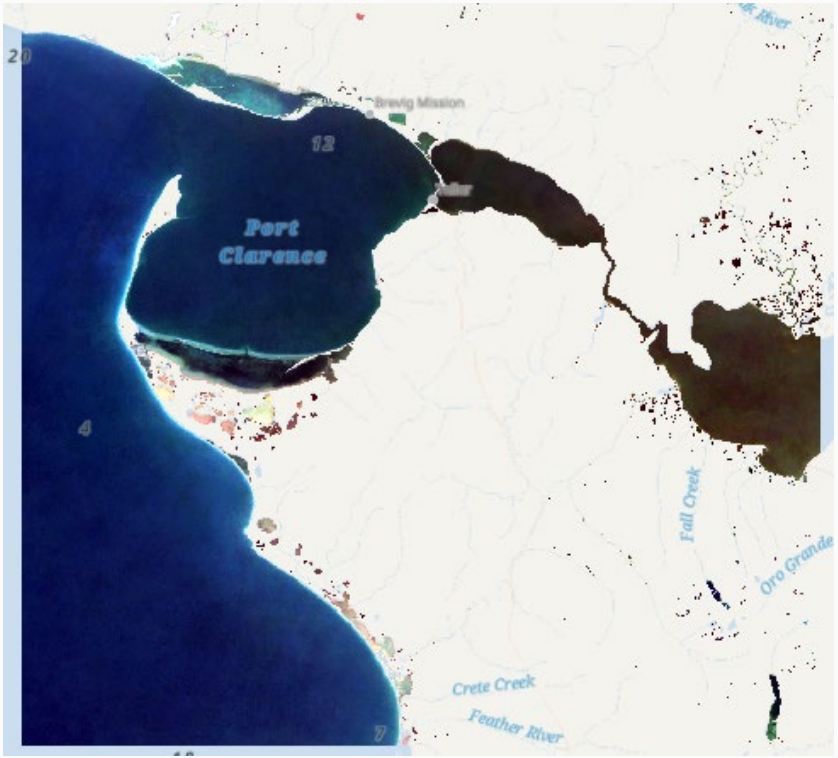
Imagery

(1) Planetscope 3 m

95 images | 43 Mosaics | 1 Composite

(2) Sentinel-2 10 m

621 images | 1 Composite



In-situ Data log

(2) NOAA *(ingested in 2020)*

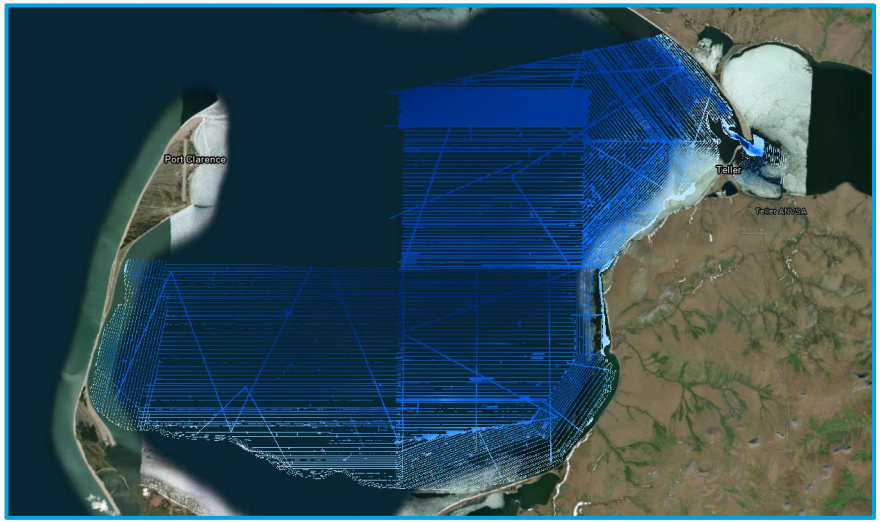
2019 USACE NCMP | Topobathy Lidar Start: 2019-07-09 End: 2019-07-28

(3) NOAA *(ingested in 2017-2018, 3 datasets in ellipsoidal reference)*

NOAA MBES | 474085 H12798 Start: 2017-07-12 End: 2017-08-31

NOAA MBES | 474301 H12800 Start: 2017-07-21 End: 2017-08-23

NOAA MBES | 474299 H12799 Start: 2017-07-21 End: 2017-08-29



Alaska, The Great Frontier

H = Orthometric Surface

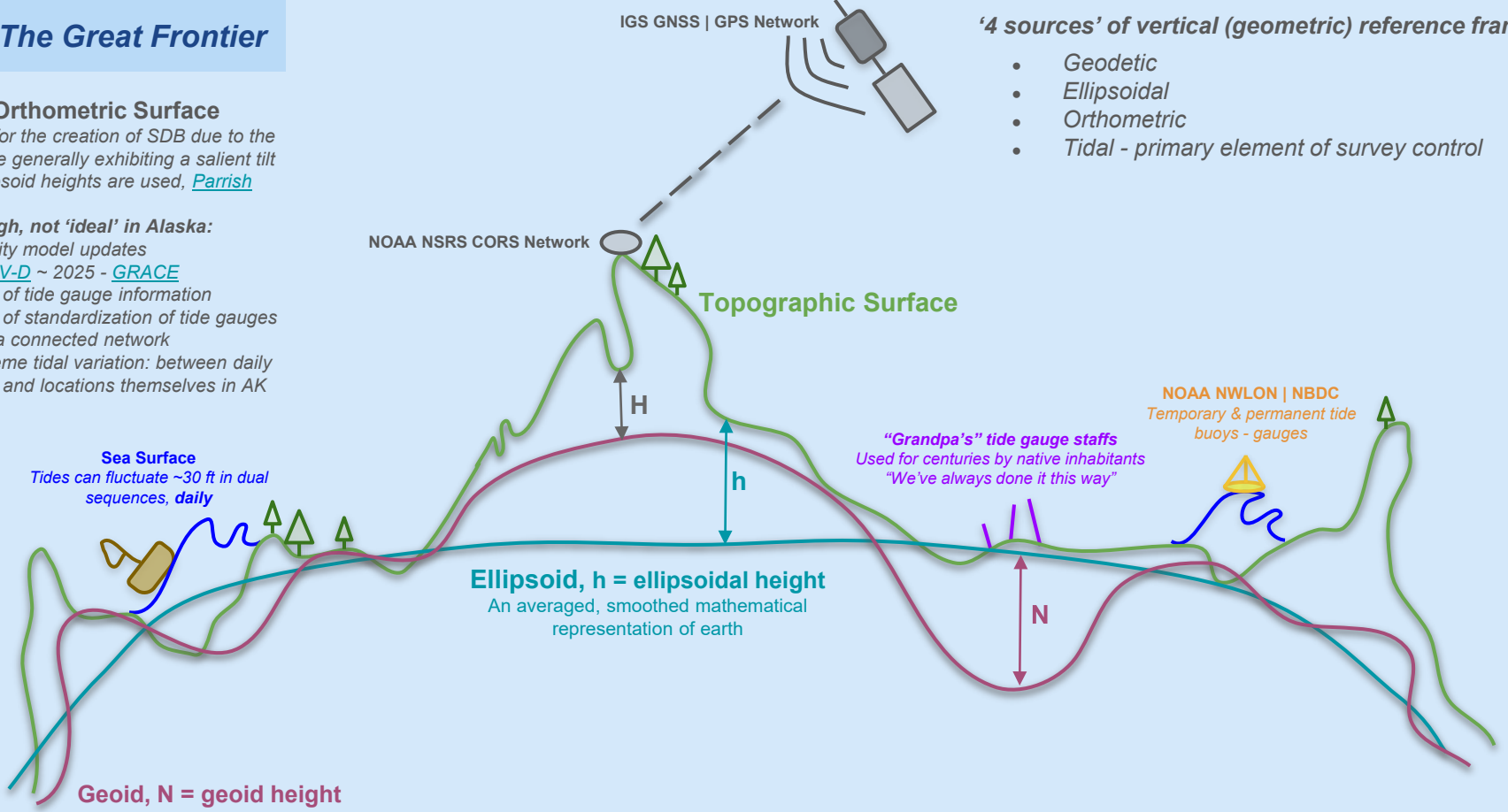
Best to use for the creation of SDB due to the water surface generally exhibiting a salient tilt when ellipsoid heights are used, Parrish

though, not 'ideal' in Alaska:

- *Gravity model updates GRAV-D ~ 2025 - GRACE*
- *Lack of tide gauge information*
- *Lack of standardization of tide gauges and a connected network*
- *Extreme tidal variation: between daily tides and locations themselves in AK*

'4 sources' of vertical (geometric) reference frames

- *Geodetic*
- *Ellipsoidal*
- *Orthometric*
- *Tidal - primary element of survey control*



Geoid, N = geoid height

Gravity model mostly representative of true gravity in all areas of earth - the datum that can be closely tied to what 'MSL is as a datum' analogous to most locations. Although MSL does *not* equal this.

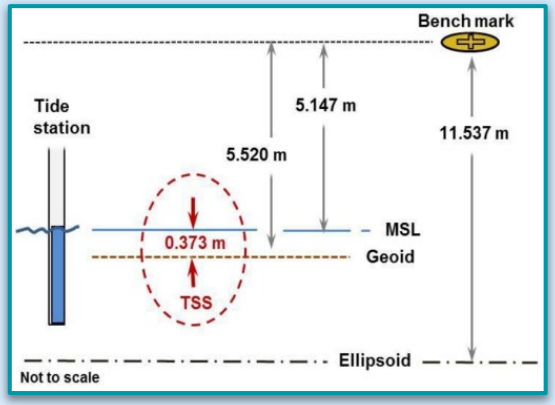
H = h - N

NOAA VDatum

NOAA NGS Toolkit

Citation

Alaska, The Great Frontier



Using Water Levels in Alaska

Resources

1. **NOAA** LT Bart Buesseler
   Using Water Levels in Alaska

Tidal Concurrent Tidal Measurements
TCARI or zoned tide files: reduce data to MLLW based on timestamp: NWLON or NBDC station for tides, NTDE

Ellipsoidal Referenced Separation Models
Separation model (surface) to reduce data to MLLW based on position

VDatum *Does not work in Alaska*
TSS - topography of the sea surface: ortho-tidal offset | NAVD88 - LMSL, MLLW
Transformations between tidal and geodetic datums

Poor Man's VDatum local tidal benchmarks (where the water is) + the geoid (where the water should be ~MSL) = TSS (topography of sea surface) + ellipsoidal heights, ERS = PMVD solution, SEP coverage with minimal curvature interpolation

"Tidal datums are the infrastructure on which the maritime community operates"

1. **Alaska,** DNR
   Alaska Tidal Datum Portal USGG2012 with GRS80 Ellipsoid

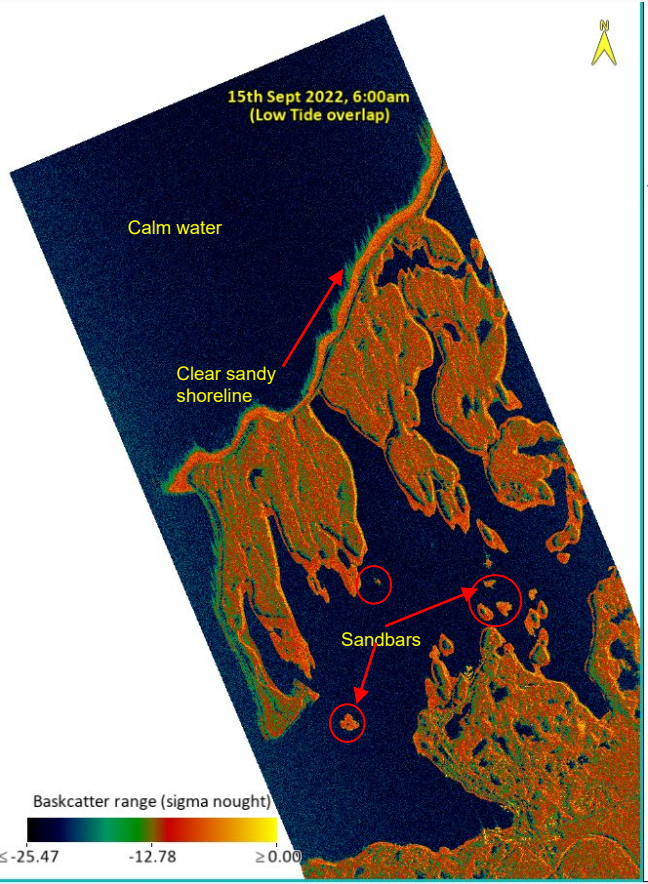
TCarta Workaround

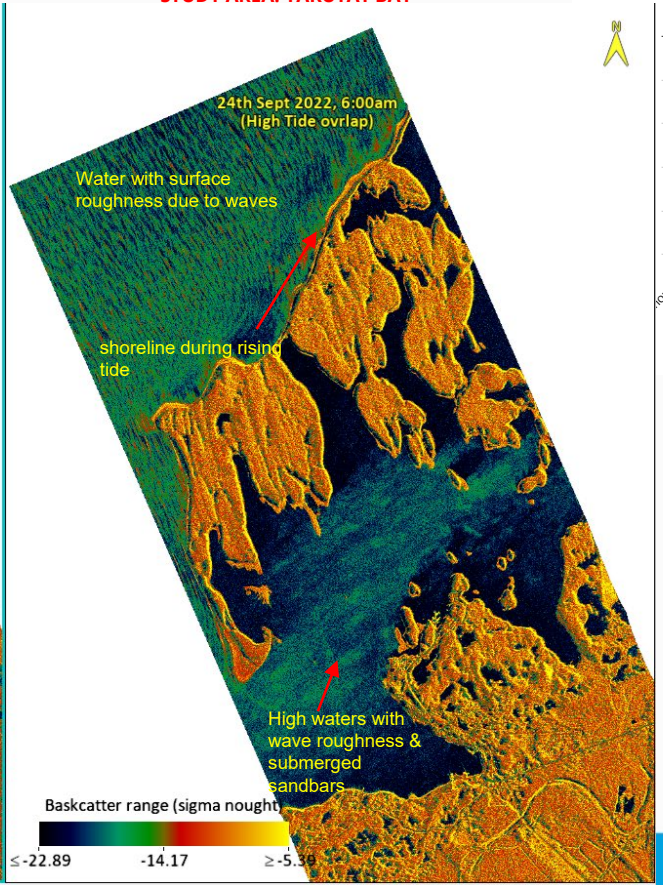
Elliposdal | ICESat-2 & Images → **Orthometric |** SDB Surface Creation → **Ellipsoid-Spheroid |** Calibration and Validation of in-situ data (MBES, SBES, Topobathy lidar) → **Gravimetric Geoid |** Final SDB Surface *approx in reference to local MSL, Alaska*

Synthetic Aperture Radar Shoreline Identification

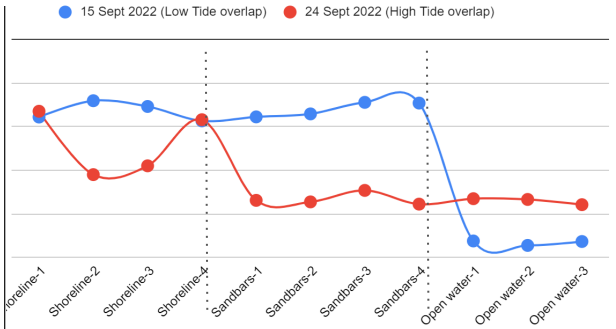
Coastal Feature identification and Temporal changes in backscatter values(feature wise) during HT & LT

STUDY AREA: YAKUTAT BAY

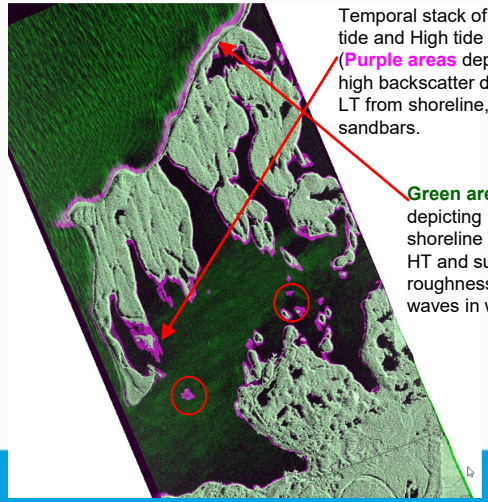




Tidal/Temporal Change in Mean Backscatter (dB) Values of Shoreline, Sandbars and Water pixels (Yakutat bay area)



ROIs of various features exhibiting change during Low tide and High Tide event

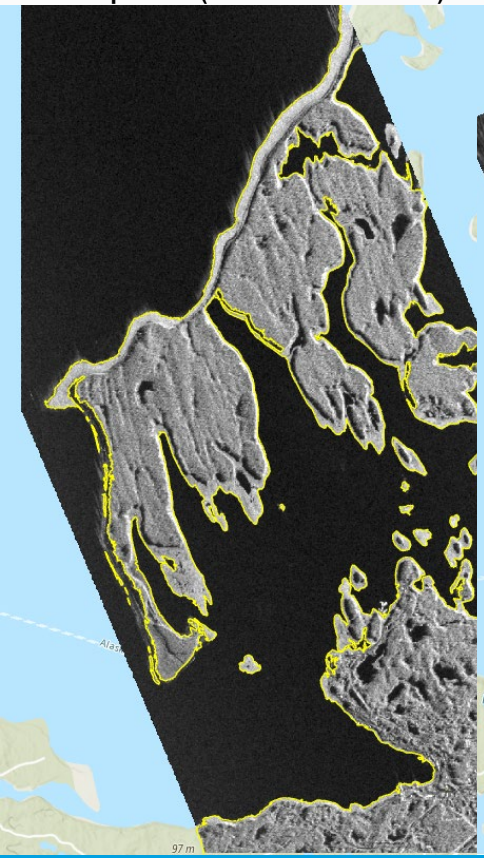


Temporal stack of Low tide and High tide image (**Purple areas** depict high backscatter during LT from shoreline, and sandbars.

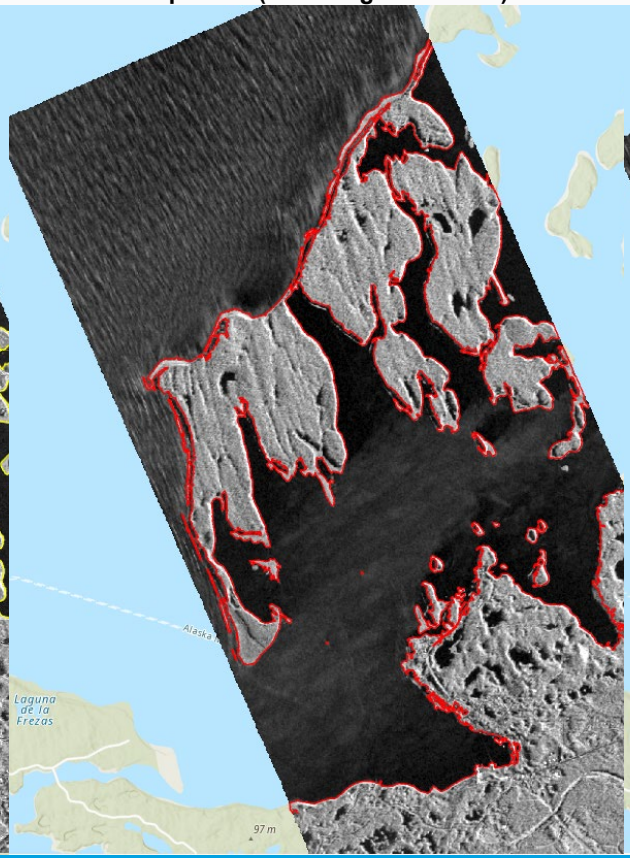
Green areas depicting shoreline during HT and surface roughness due to waves in water)

High and Low Tide for Yakutat, Alaska

15 Sept 2022 (Final Low Tide Line)



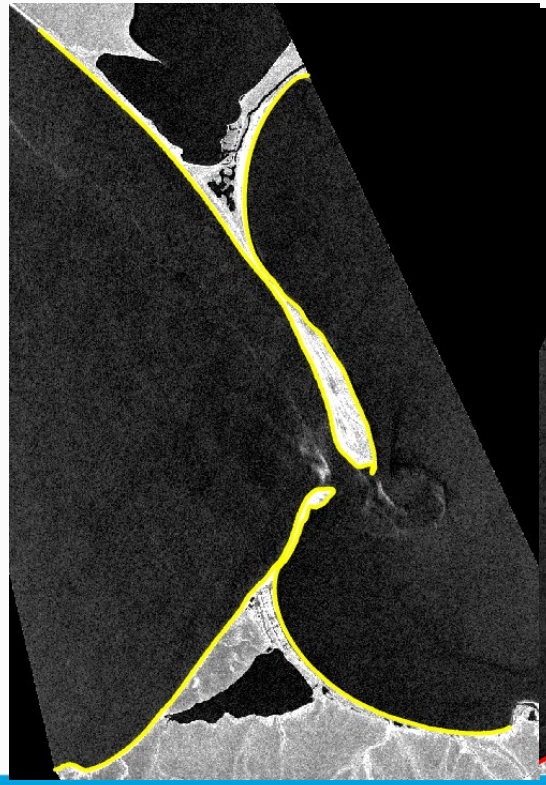
24 Sept 2022 (Final High Tide Line)



LTL & HTL Overlay for Yakutat bay

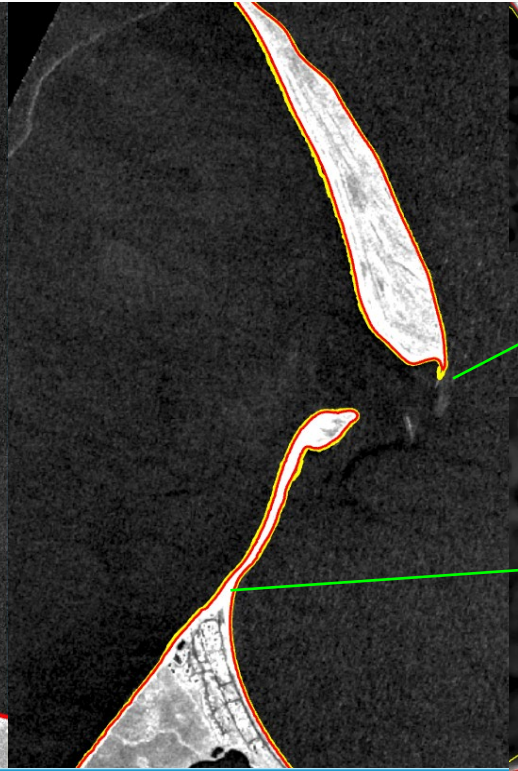
High and Low Tide for Teller, Alaska

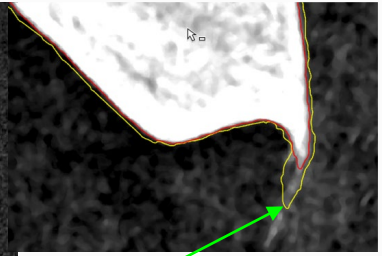
Single Mean Low Tide Line
(computed from 2 LT images)

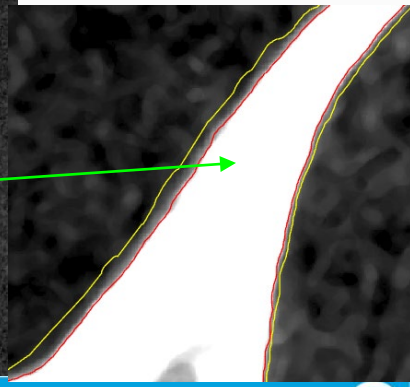


Single Mean High Tide Line
(computed from 4 HT images)

Mean LTL & HTL Overlay





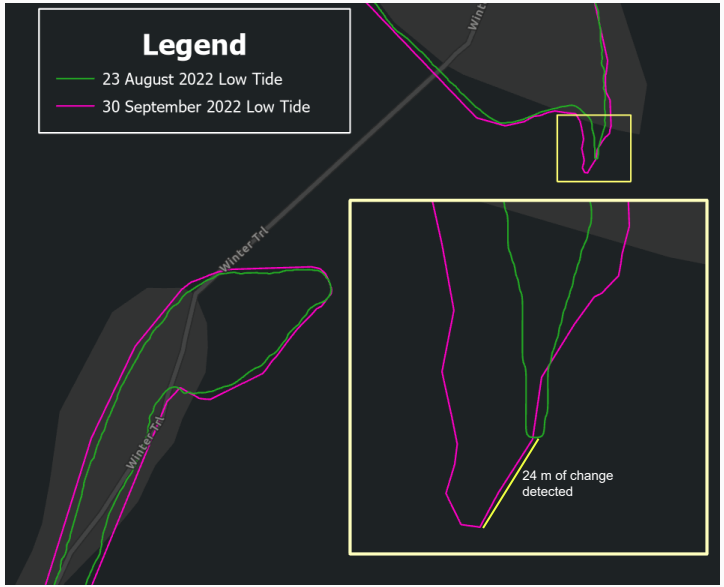


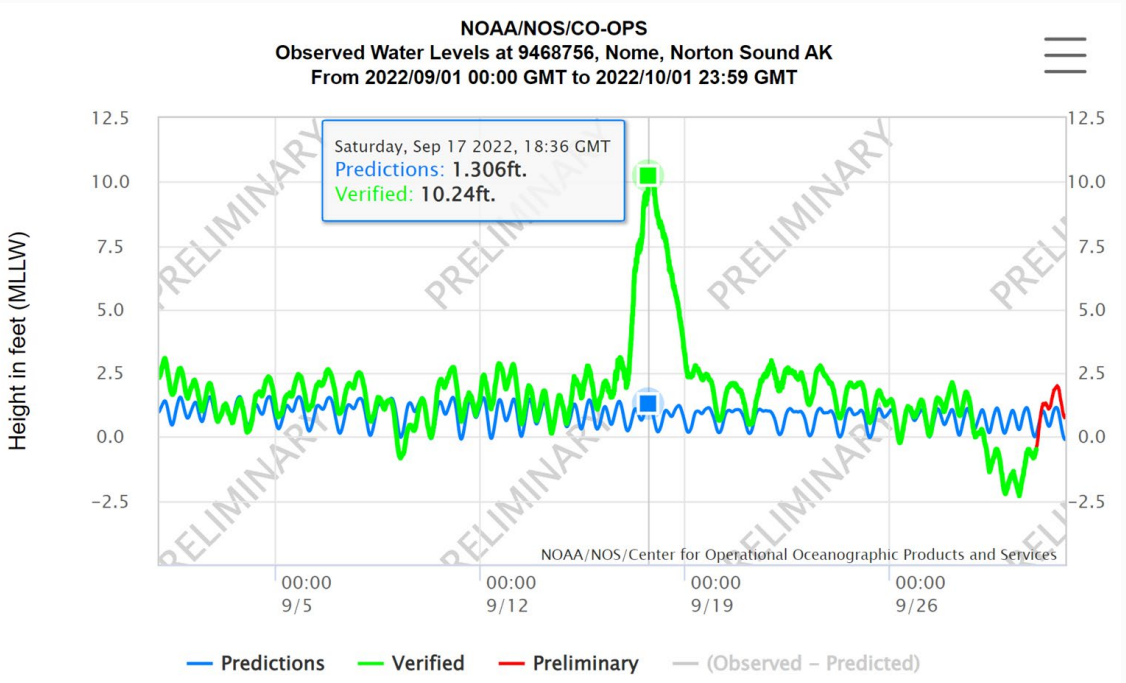
Shoreline change after Typhoon Merbok

Capella SAR

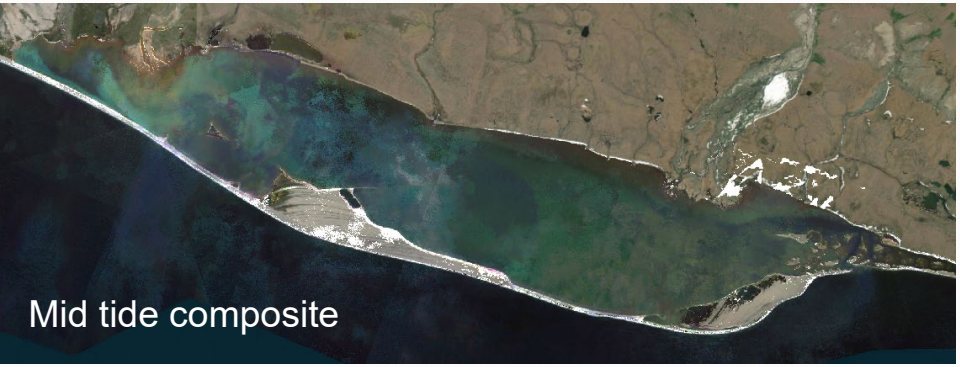
- 1.5 m to 1.6 m resolution
- Accuracy of +/- 5 m

- Shoreline change of 0-25 m across the low tide line





Planet Composites

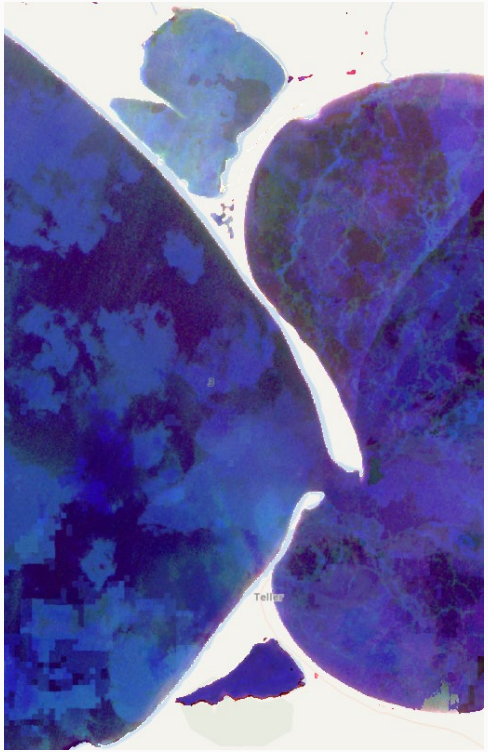


Composites created based on metadata parameters

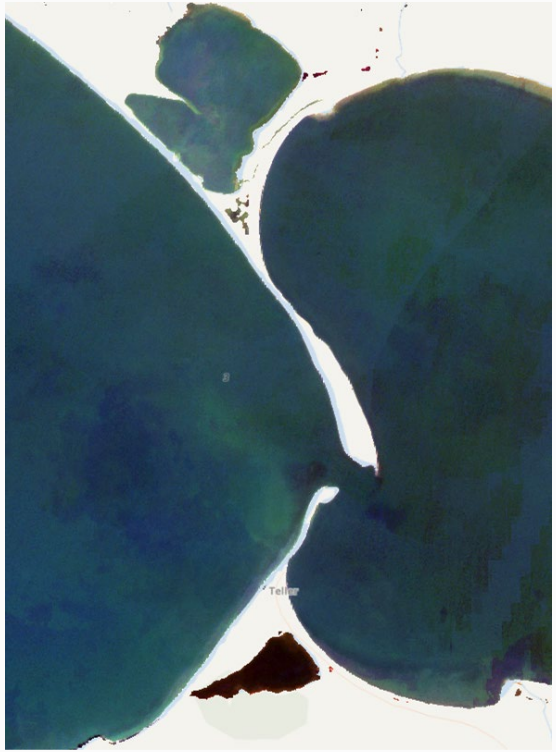
- Tidal range
- Illumination Azimuth
- Turbidity
- Cloud Cover Percentage

Sentinel-2 Percentile 10 Composites

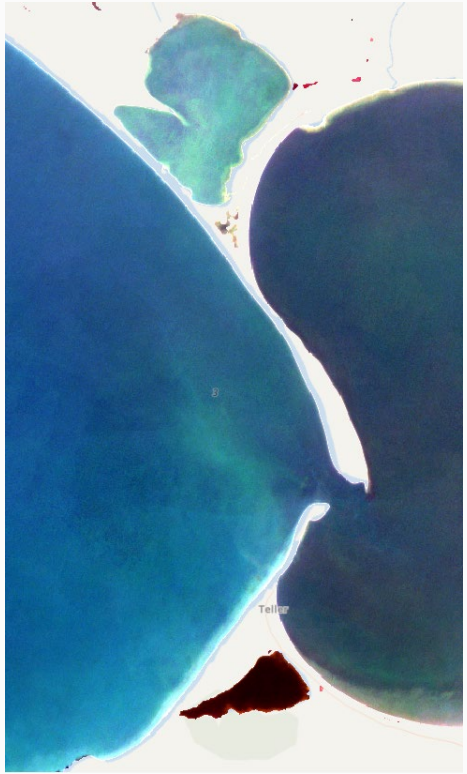
2018- 2019 May - Oct



2017- 2019 June - Sept



2018- 2022 June - Sept



TCARTA Planet Results 3m

Value (m)
5.41
0.48

ICESat-2 70/30 QAQC

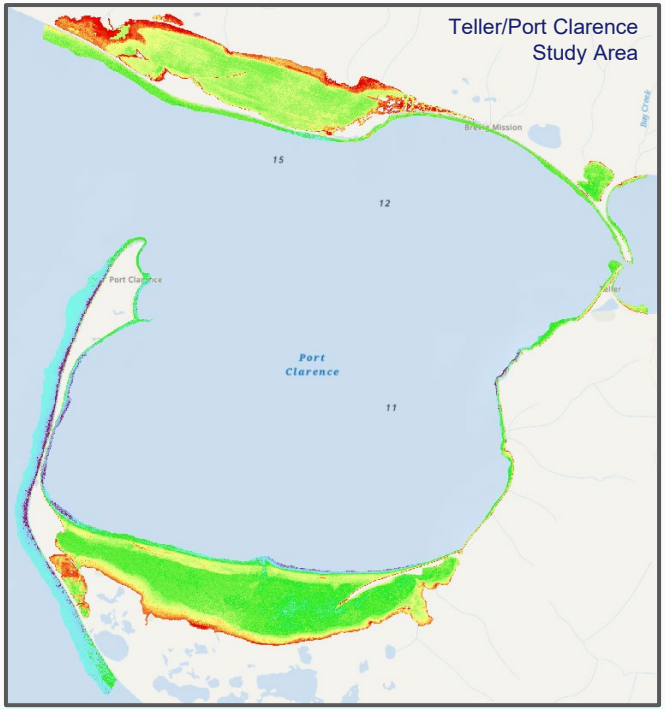
Interval	ME	MAE	MSE	RMSE	MAPE
0.36m - 8.28m	0.01	0.227	0.126	0.355	14.439
0m - 1m	-0.114	0.142	0.057	0.239	15.988
1m - 5m	0.036	0.243	0.12	0.346	13.74
5m - 10m	2.535	2.535	7.691	2.773	93.891

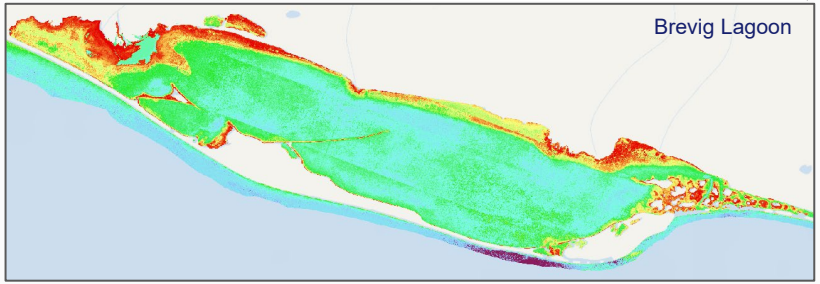
Multibeam Sonar QA QC

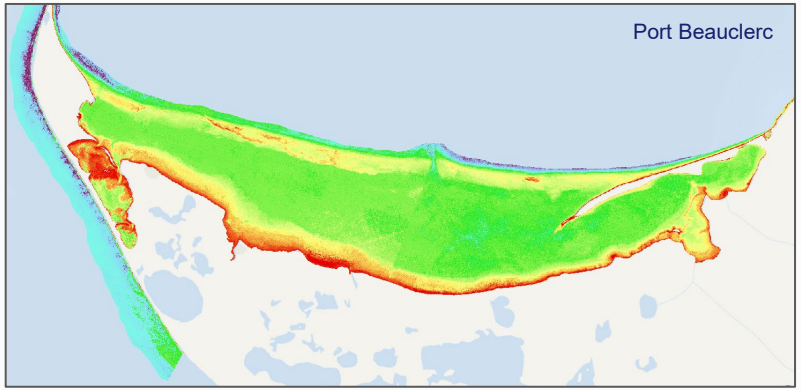
Interval	ME	MAE	MSE	RMSE	MAPE
0m - 3.79m	-2.978	2.981	10.679	3.268	84.68
0m - 1m	-3.115	3.115	11.168	3.342	82.382
1m - 5m	-2.475	2.485	7.667	2.769	61.028

LiDAR QA QC

Interval	ME	MAE	MSE	RMSE	MAPE
0m - 7.0m	1.786	1.933	5.637	2.374	158.629
0m - 1m	-1.273	1.273	1.671	1.293	62.662
1m - 5m	1.56	1.658	3.978	1.994	128.092
5m - 10m	4.533	4.533	21.361	4.622	453.671







Sentinel-2 Results 10m

Value (m)
4.58
0.46

ICESat-2 70/30 QAQC

Interval	ME	MAE	MSE	RMSE	MAPE
0.36m - 8.28m	0.007	0.209	0.109	0.33	13.468
0m - 1m	-0.132	0.155	0.065	0.255	16.507
1m - 5m	0.037	0.215	0.094	0.307	12.402
5m - 10m	2.554	2.554	8.406	2.899	91.671

Multibeam Sonar QA QC

Interval	ME	MAE	MSE	RMSE	MAPE
0m - 3.79m	-2.503	2.506	7.177	2.679	84.15
0m - 1m	-2.434	2.434	6.454	2.54	79.656
1m - 5m	-2.181	2.189	5.218	2.284	60.887

LiDAR QA QC

Interval	ME	MAE	MSE	RMSE	MAPE
0m - 7.0m	1.949	2.053	5.568	2.36	168.231
0m - 1m	-1.202	1.202	1.508	1.228	61.167
1m - 5m	1.834	1.899	4.635	2.153	151.708
5m - 10m	4.376	4.376	19.431	4.408	424.007