Status and Results from ICESat-2

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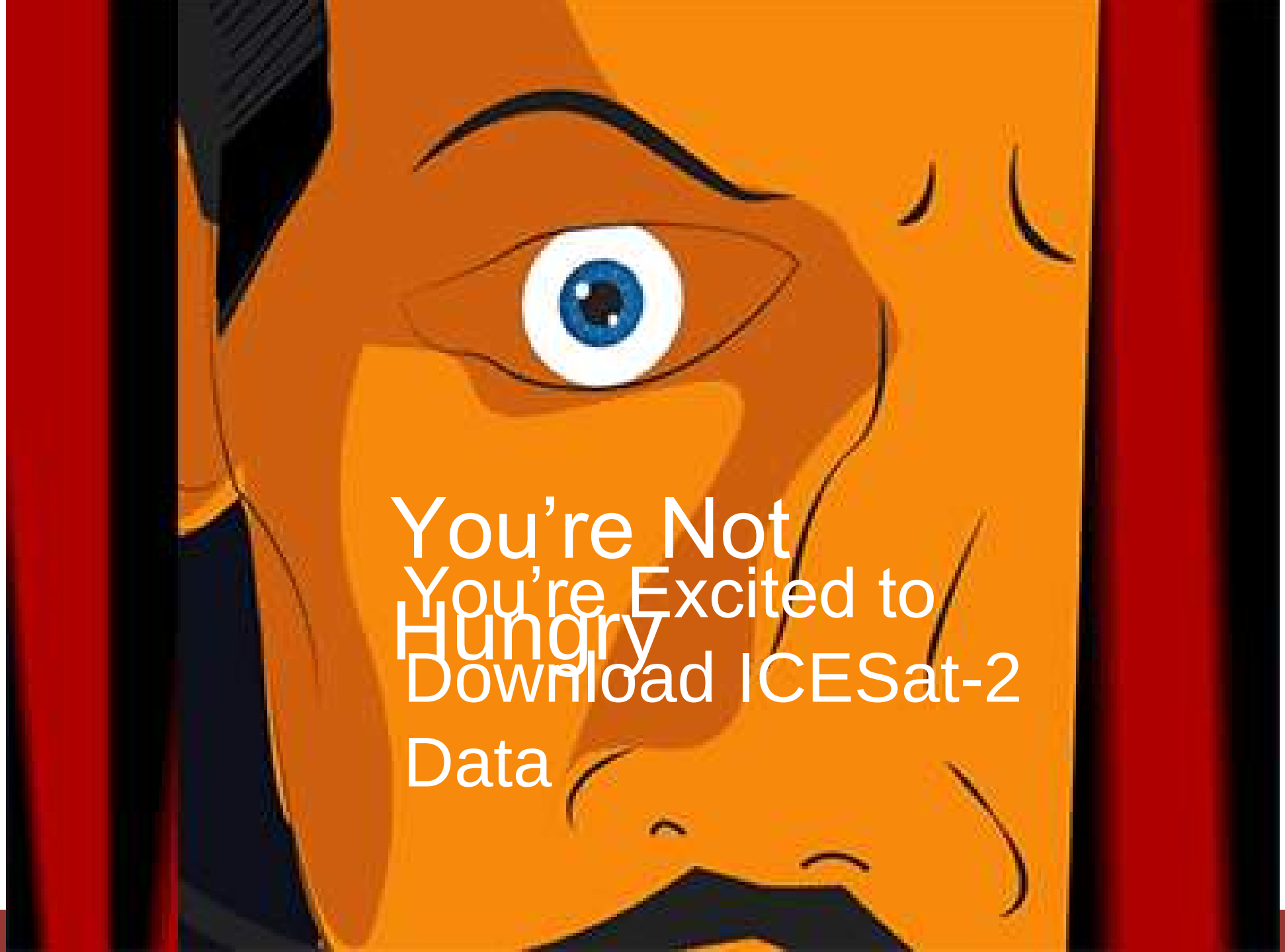
Thanks to Lori Magruder, Eric Guenther, and Mike Alonzo at UT Applied Research Laboratories

NASA Terrestrial Ecology Meeting
September 23, 2019


You’re Not Hungry
You’re Excited to Download ICESat-2 Data

ICESat-2 Successfully Launched on September 15, 2018 from Vandenberg AFB

ICESat-2 has a laser altimeter that collects ranging measurements globally

First release of data was made available May 28th, 2019

ICESat-2 Timeline

SATELLITE

September 15, 2018:	Launch
October 14, 2018:	Began Science Mode Acquisition
June 26 – July 10, 2019:	ICESat-2 in safe-hold due to potentiometer issue on the s/c bus

(No Science Data collected during this time)

July 10 – July 25:	Science mode resumes, but timing bias in pointing solution
July 26, 2019 - Now:	Nominal Science mode acquisitions

DATA PRODUCTS

Release 001: October 14, 2018 – May 3, 2019 currently available on NSIDC

Release 002: October 14, 2018 – June 26, 2019 available on NSIDC ~late-October

Release 002: Post July 26, 2019 – plan to get to nominal processing cadence (~49 day latency)

ICESat-2 Science Objectives

Quantify polar ice-sheet contributions to current and recent sea-level change and the linkages to climate conditions

Quantify regional signatures of ice-sheet changes to assess mechanisms driving those changes and improve predictive ice sheet models; this includes quantifying the regional evolution of ice sheet change, such as how changes at outlet glacier termini propagate inward.

Estimate sea-ice thickness to examine ice/ocean/atmosphere exchanges of energy, mass and moisture;

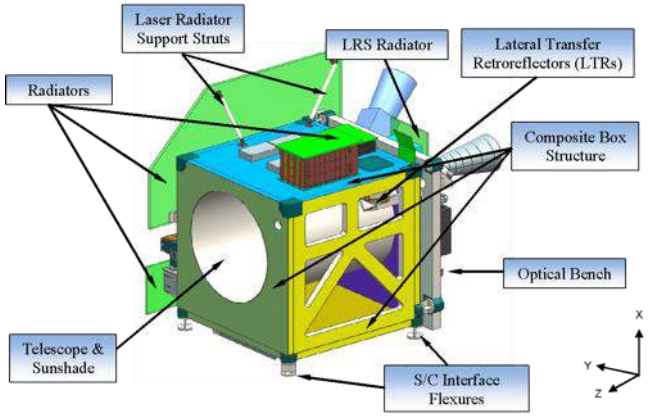
Measure vegetation canopy height as a basis for estimating large-scale biomass and biomass change.

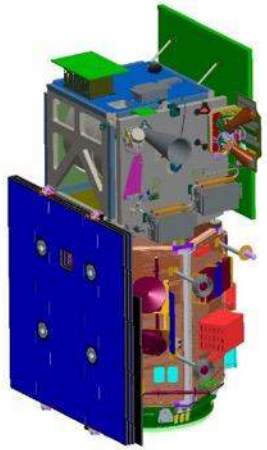
ICESat-2 Mission Overview

Payload

ATLAS – Advanced Topographic Laser Altimeter System developed at GSFC

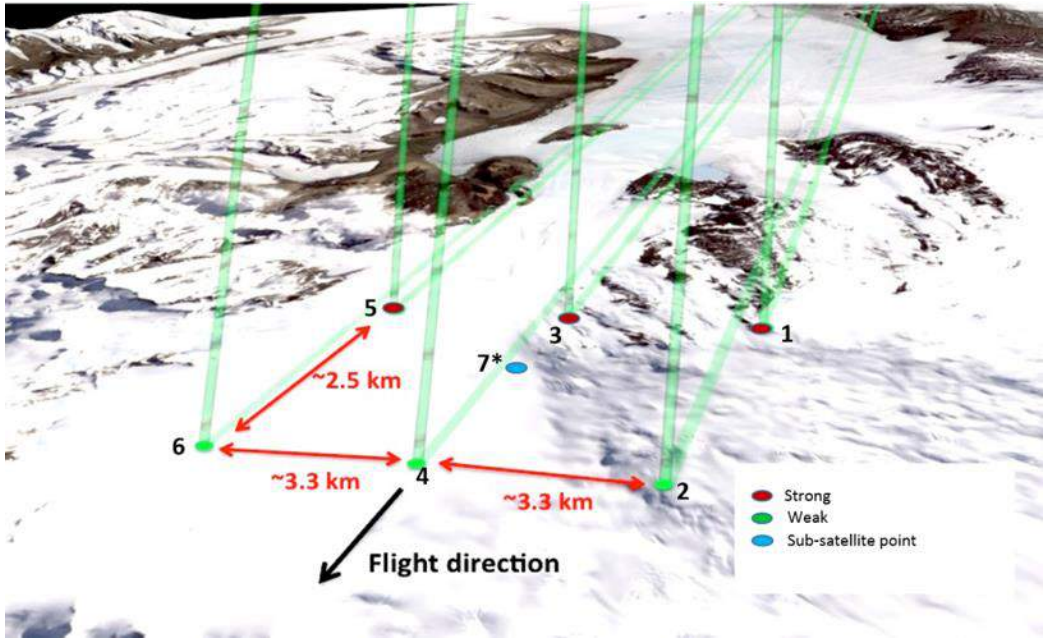
- Measures time of flight of laser pulses
- Measures pointing direction
- Single-photon sensitive detection
- 6 beams, arranged in 3 pairs
- 10 kHz pulse-rep. rate
- 14 m footprint
- spaced 0.7m along-track
- 532nm wavelength





Implementation

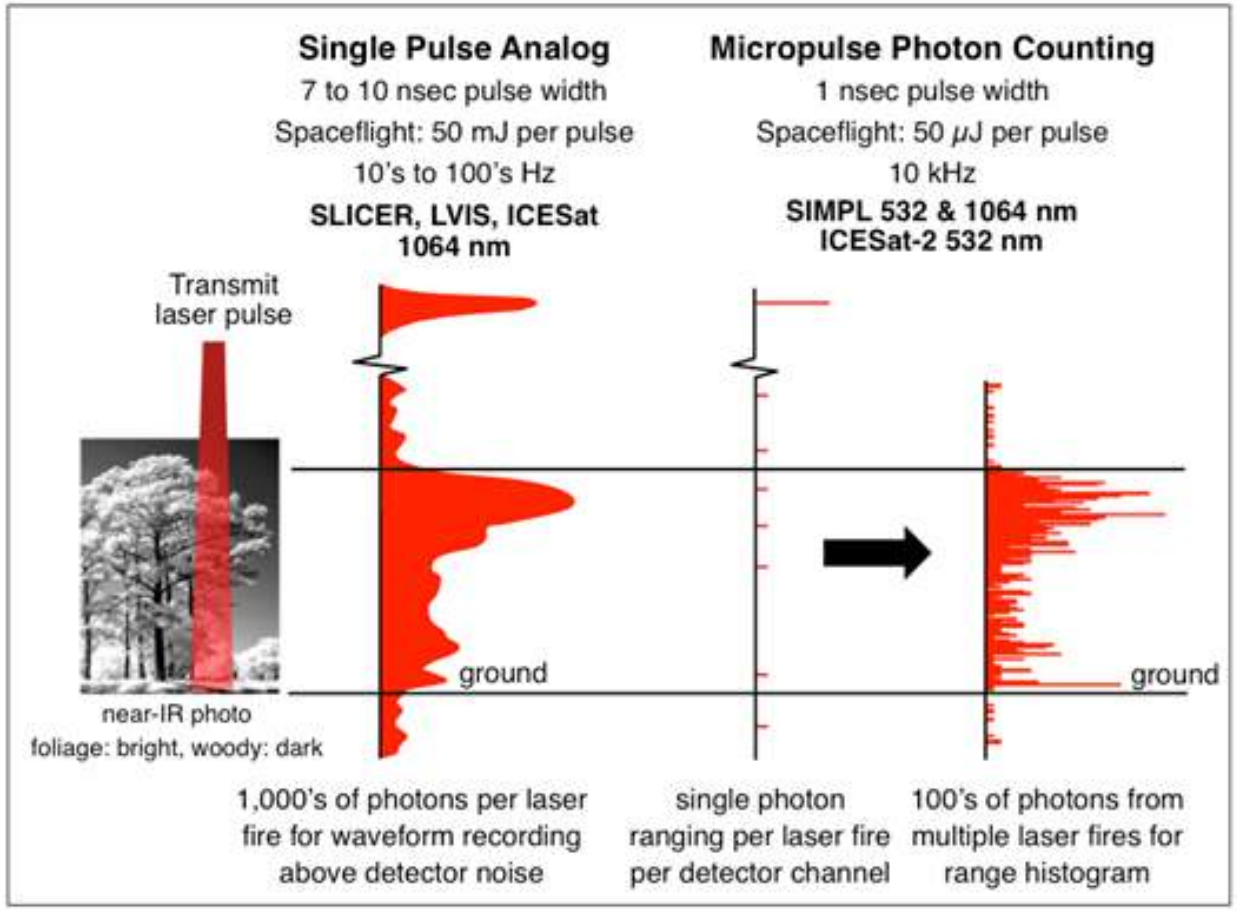
Launch Date: September 15, 2018
Lifetime: 3 years, with consumables for 5+
Orbit: 454 km, non-sun-synch, 92° inclination
Repeat: 91 day exact repeat, ~30 day sub-cycle
Science Data: 1 TB/day
System Pointing: Control = 45 m (14.3 m, CBE)
Knowledge = 6.5 m (4.0 m, CBE)

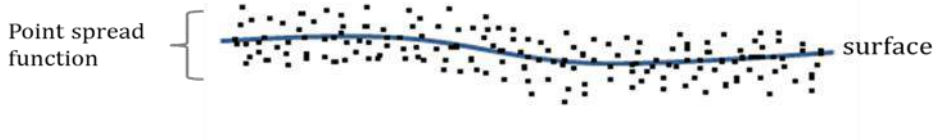


Single laser pulse at 532nm split into 6 beams.
Single-photon sensitive detection.

~3 km spacing between pairs provides spatial coverage
~90 m pair spacing for ***slope determination*** (2° yaw)
high-energy beams (4x) for better performance over low-reflectivity targets.

What is Photon Counting Lidar?





The reflectance of the surface at 532 nm drives the number of returned photons detected by ICESat-2

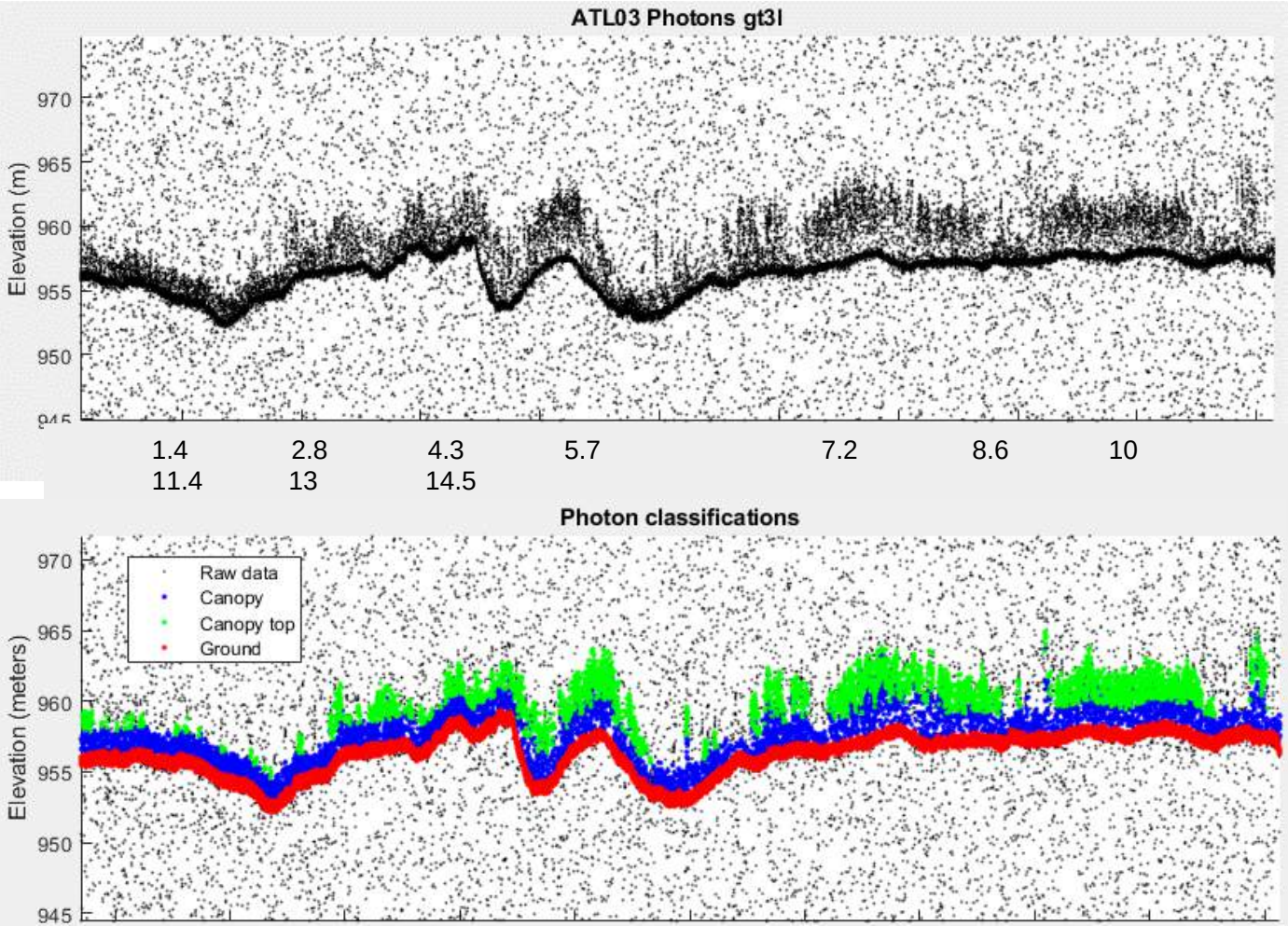
Land ("Vegetation and Ground") are not as bright of reflectors as snow or ice.

We are expecting to get a per shot average of about 1 photon from the ground and 1 photon from vegetation

1 shot every 70 cm in the along-track direction

Semi-arid Woodlands in Botswana

February 3, 2019 day acquisition of ICESat-2 over northern Botswana. Trees with heights < 5m are detected and labeled with ICESat-2.



A mixture of Mopane and Acacia trees dot the landscape in this region of Botswana

Biomass from woodlands are typically estimated empirically from optical data (e.g. Landsat).

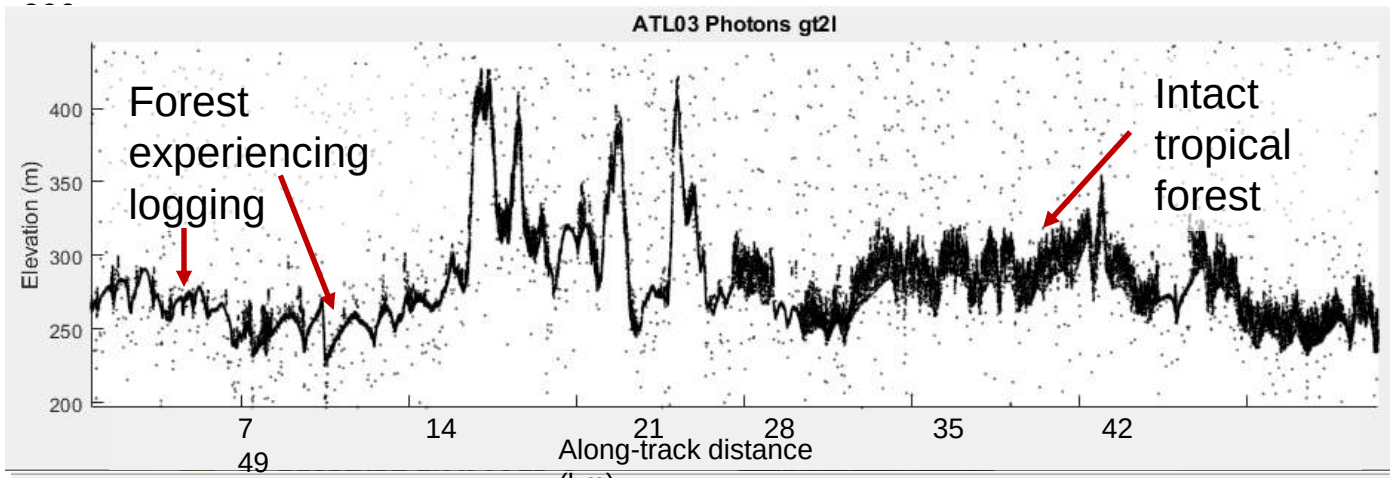
With ICESat-2, we can now calculate canopy heights for these landscapes –thus reducing uncertainty in global biomass estimates

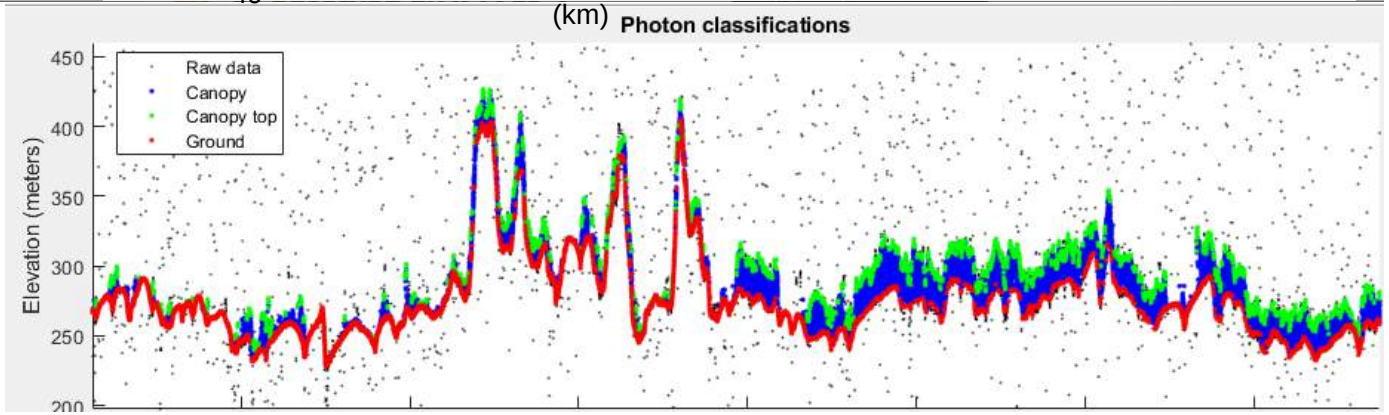
A. Neuenschwander, University of Texas at

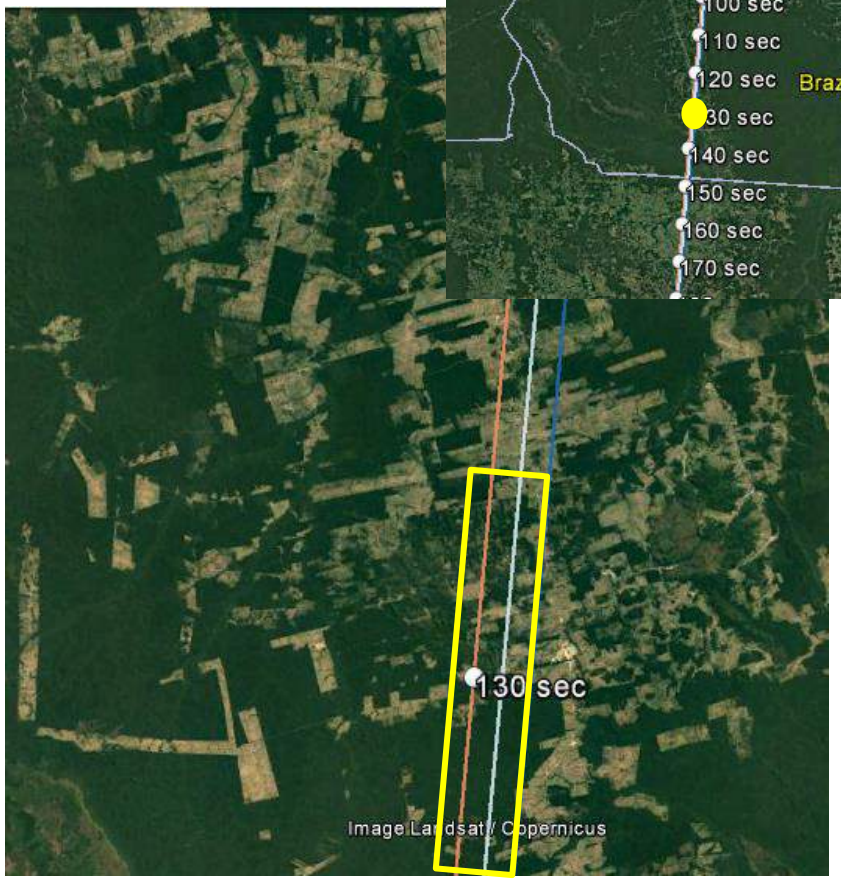
Deforestation from Logging as observed by ICESat-2

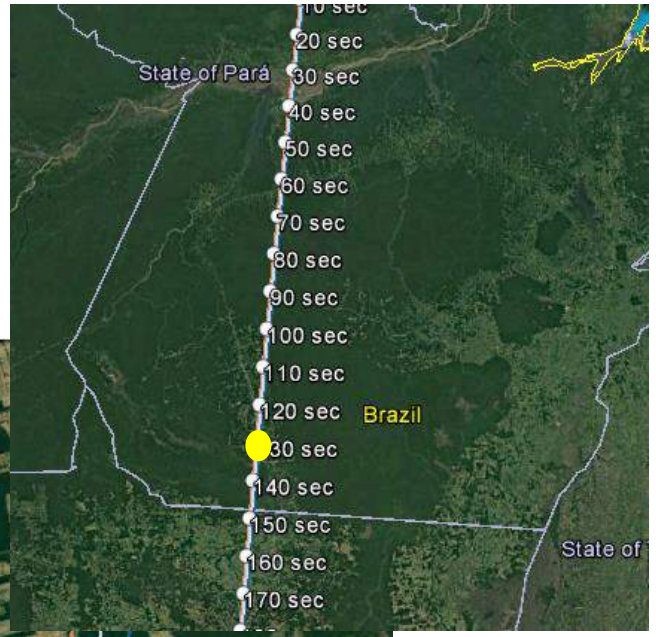
March 19, 2019 night acquisition of ICESat-2 over Brazil's tropical forest

*ATL03_20190319234325_12450208_*









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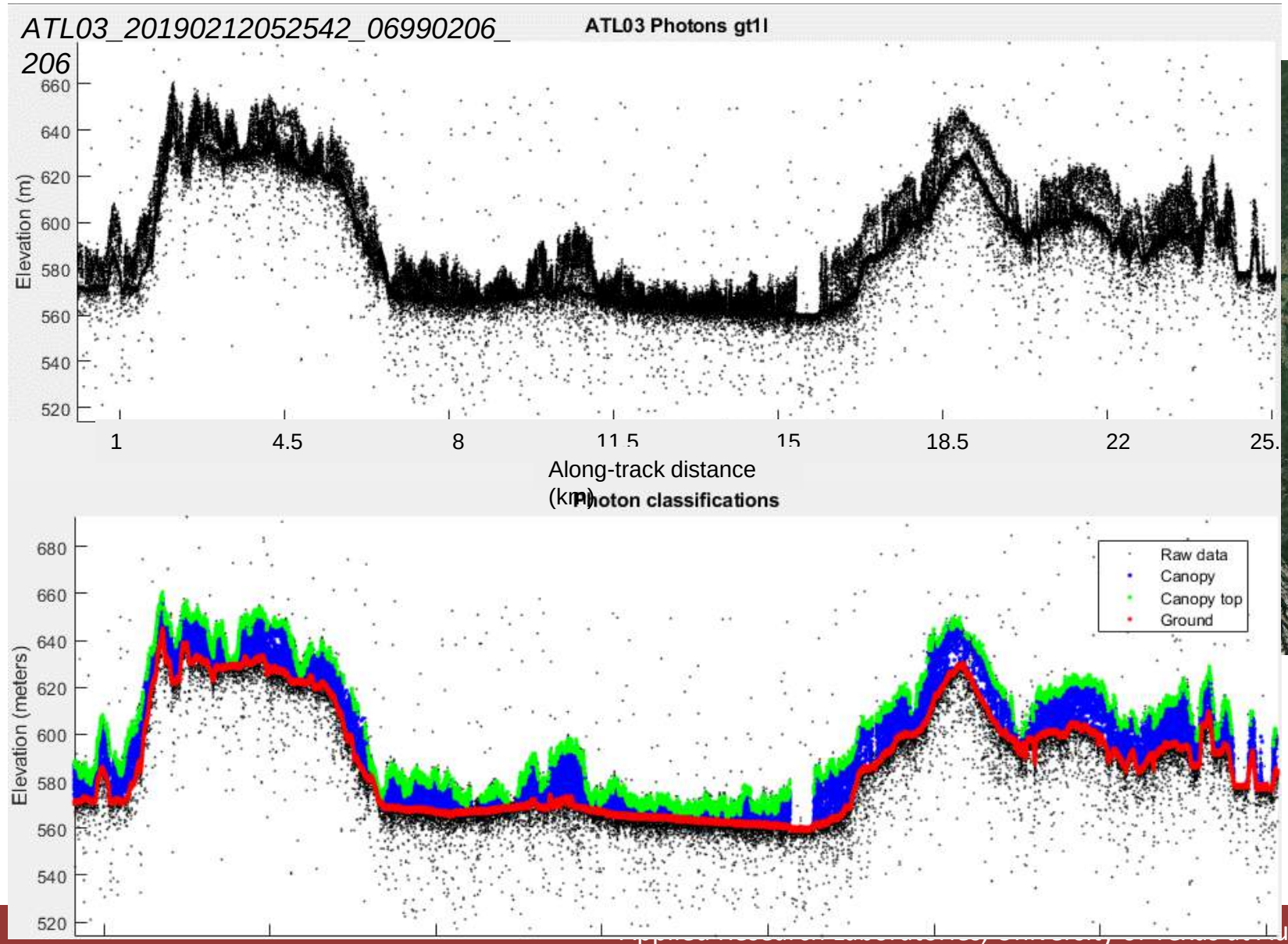
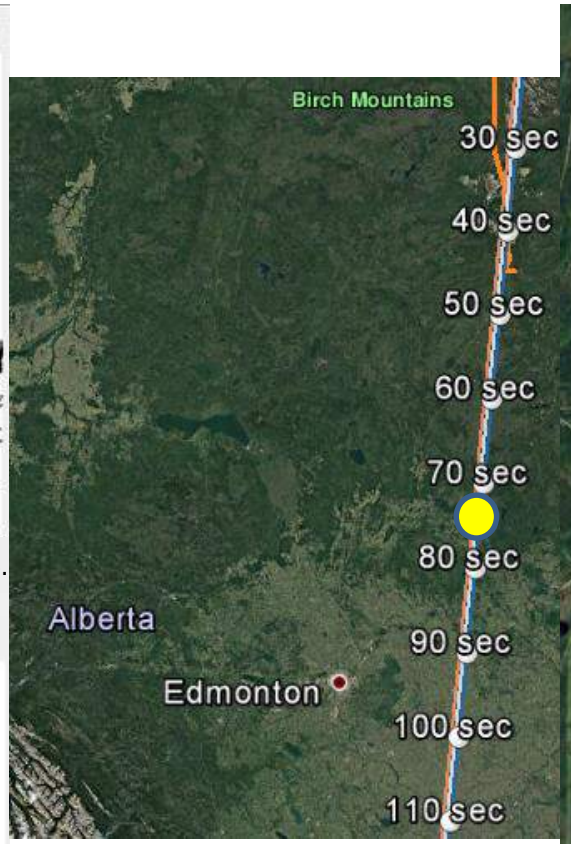
Boreal forest in Alberta Canada as observed by ICESat-2





ICESat-2 Data Products

When are they available? **Release 1 May 28, 2019; Rel 2 ~late October 2019**

Where can you get them? **NSIDC or through Earth Data Search**

What's the latency for final products? **Approximately 49 days from acquisition**

Along-track Products

- ATL03 – Along-track Geolocated Photons ← You might want this product too
- ATL06 – Along-track Land Ice Data Product
- ATL07 – Along-track Sea Ice Data Product
- ATL08 – Along-track Land/Vegetation Data Product ← Definitely get this product
- ATL09 – Along-track Atmospheric Data Product
- ATL12 – Along-track Ocean Data Product
- ATL13 – Along-track Inland Water Data Product

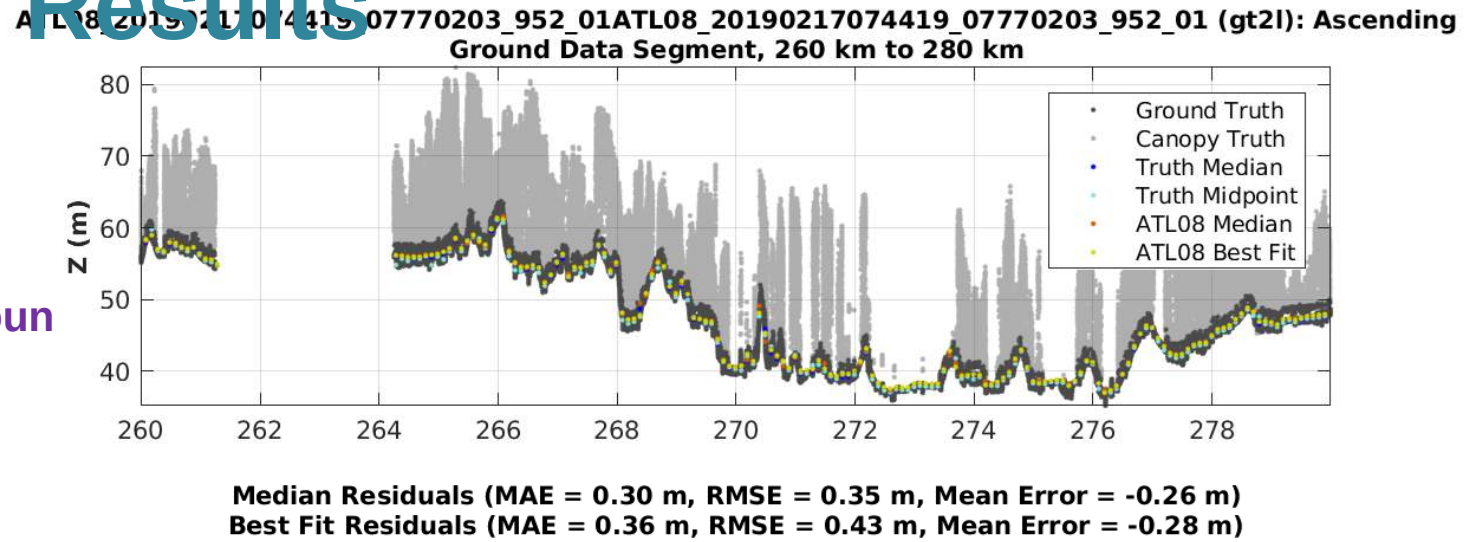
User's Guide for each data product is available from NSIDC

Algorithm Theoretical Basis Document is available for each data product at https://icesat-2.gsfc.nasa.gov

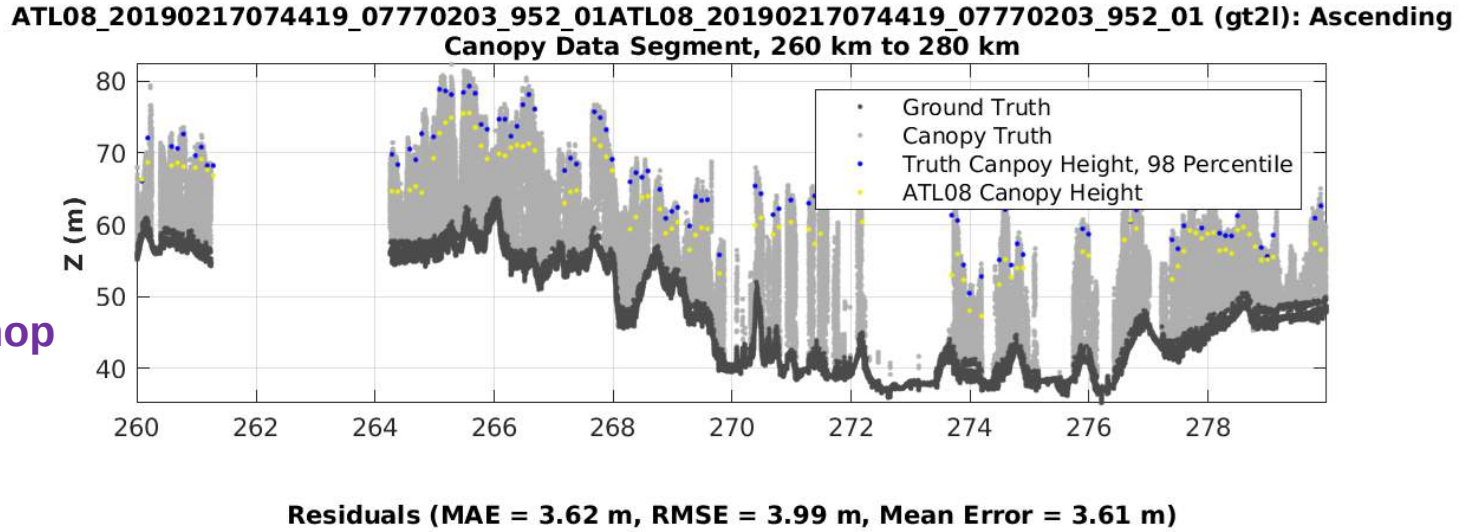
ATL08 Validation: Results

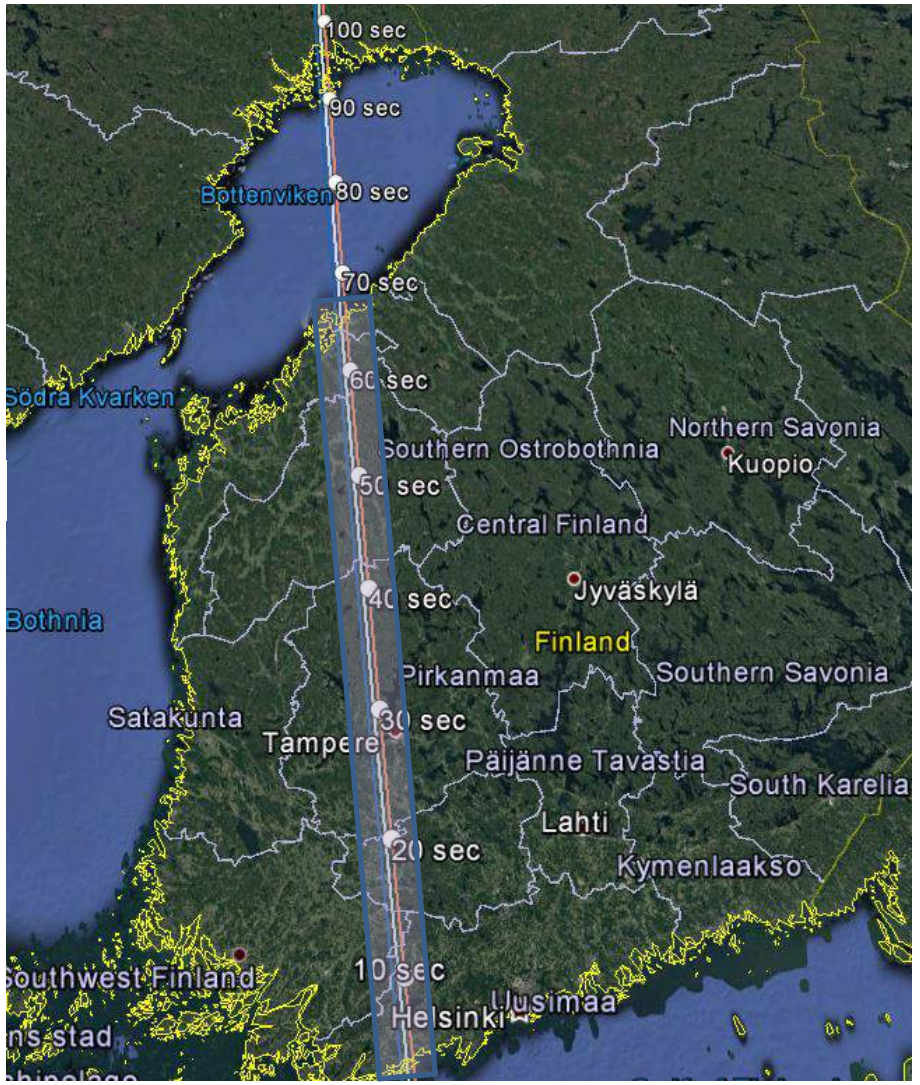
Calculate statistics on 20 km intervals over granule

ground



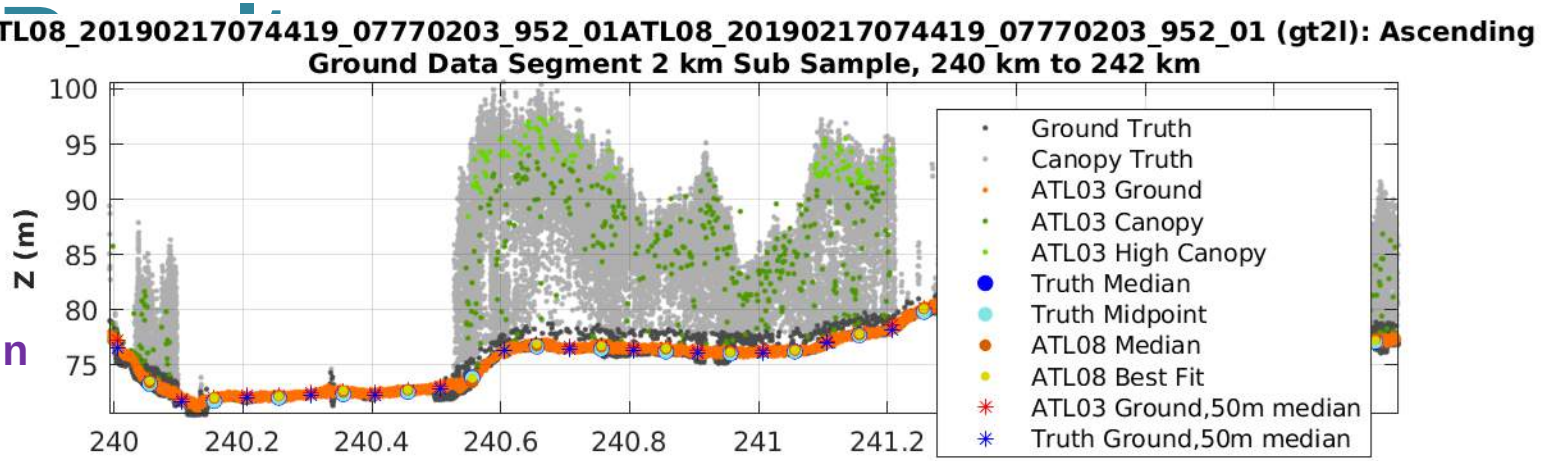
canopy





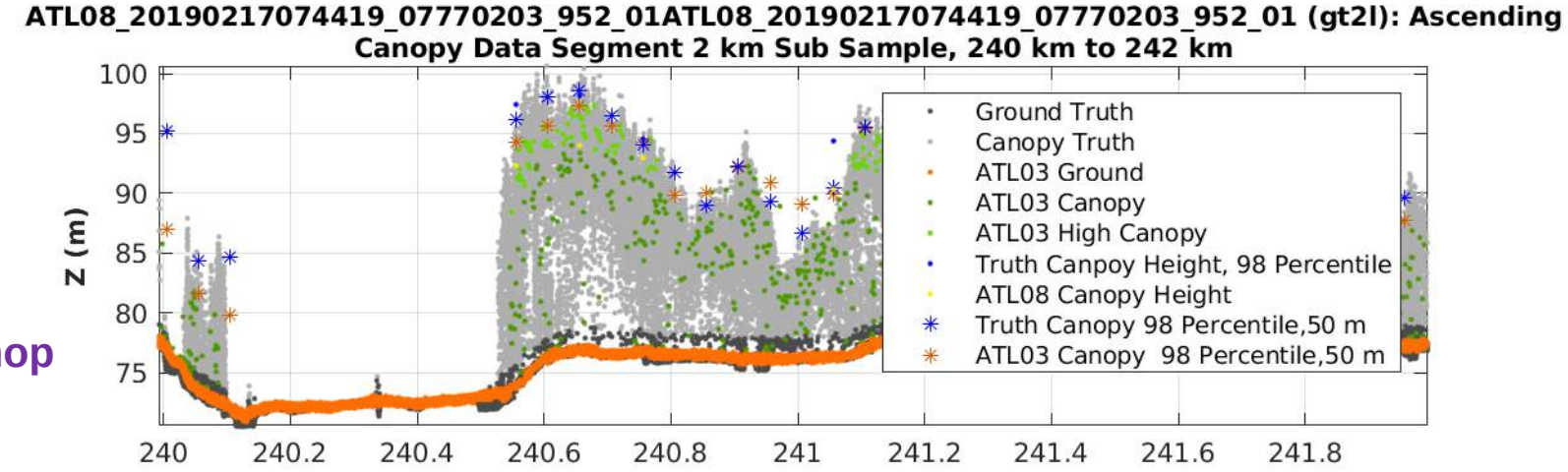
ATL08 Validation:

ground

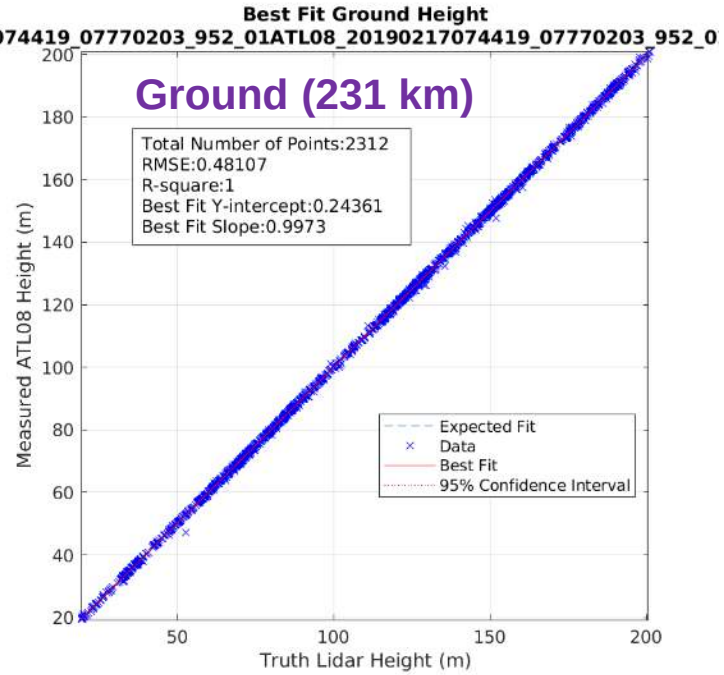


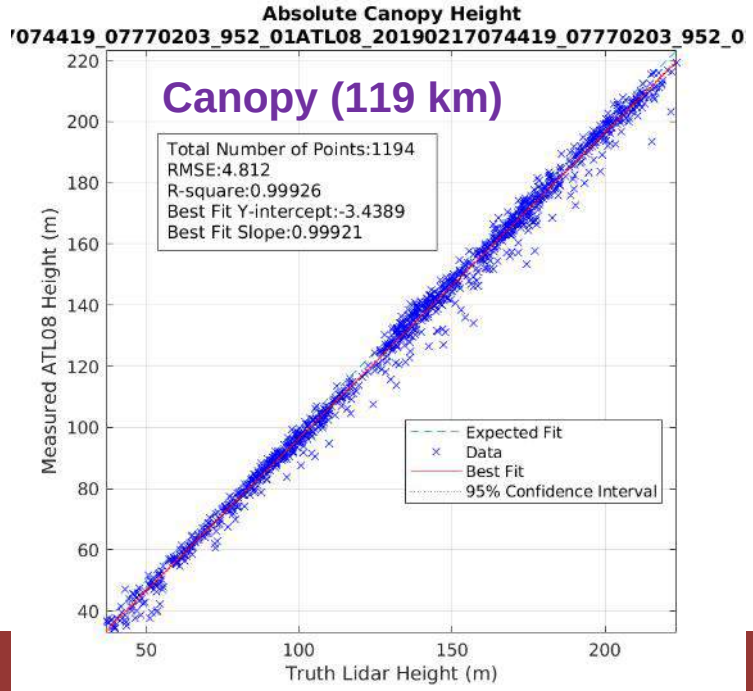
Median Residuals (MAE = 0.19 m, RMSE = 0.21 m, Mean Error = -0.15 m)
Best Fit Residuals (MAE = 0.21 m, RMSE = 0.24 m, Mean Error = -0.17 m)
50 m Binned Residuals (MAE = 0.21 m, RMSE = 0.24 m, Mean Error = -0.20 m)

canopy

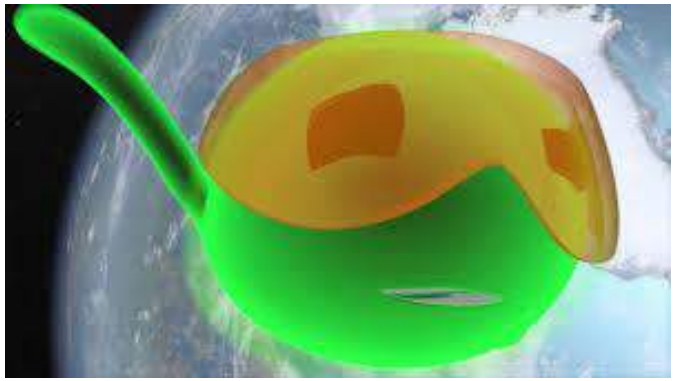


Residuals (MAE = 3.11 m, RMSE = 3.40 m, Mean Error = 3.11 m)
50 m Binned Residuals (MAE = 1.45 m, RMSE = 2.22 m, Mean Error = 0.73 m)



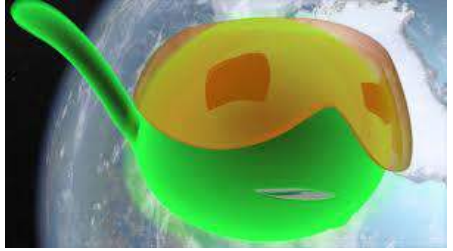


ICESat-2 Python Tools
(PhoREALpy)
Photon Research Exploitation Analysis Library



Pho the Photon

ICESat-2 Python Tools (PhoREAL)



Components:

HDF5 Component Reader

ATL03 Reader

ATL08 Reader

ATL03/ATL08 Photon Class Matching

Geographic/Projected Coordinate Conversion Utilities

Rotate Data

Basic Plotting Functionality

Basic Javascript Plotting Functionality

Output as LAS

Output as ASCII/CSV

Time Convert (UTC to local time)

KML/KMZ generator for each track

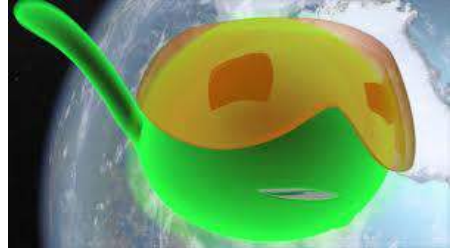
Version 1 of PhoREALpy is posted to GitHUB as of Monday September 23, 2019
github.com/icesat-2UT/phoREAL.py

Jupyter notebook outlining all the modules will also be available on GitHUB

Requirements: python3 (and associated libraries)

Windows/Linux GUI python wrapper to run most of these basic tools

PhoREAL_Toolbox.exe (linux and Windows)



PhoREAL Toolbox v1.0

ATL03 File: Browse

ATL08 File (Optional): Browse

Output Directory: Browse

Ground Track Numbers:

- ☑ GT1R ☐ GT1L
- ☑ GT2R ☐ GT2L
- ☑ GT3R ☐ GT3L

Trim Info Options:

- ☑ None
- ☐ Auto
- ☐ Manual
  - ☐ Latitude Min: Max: Degrees
  - ☐ Time Min: Max: Seconds

☑ Create .las File
☑ Create .kml File
☑ Create .csv File

RUN

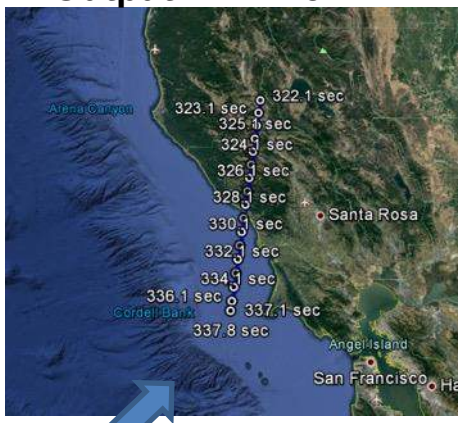
Progress:

Plotting Options:

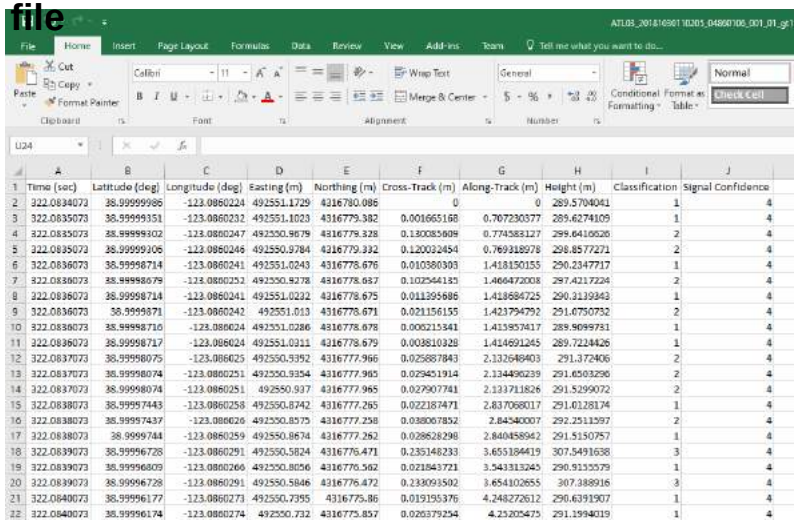
Ground Track:
X Axis: X Label:
Y Axis: Y Label:
Title:
Filter On:

PLOT

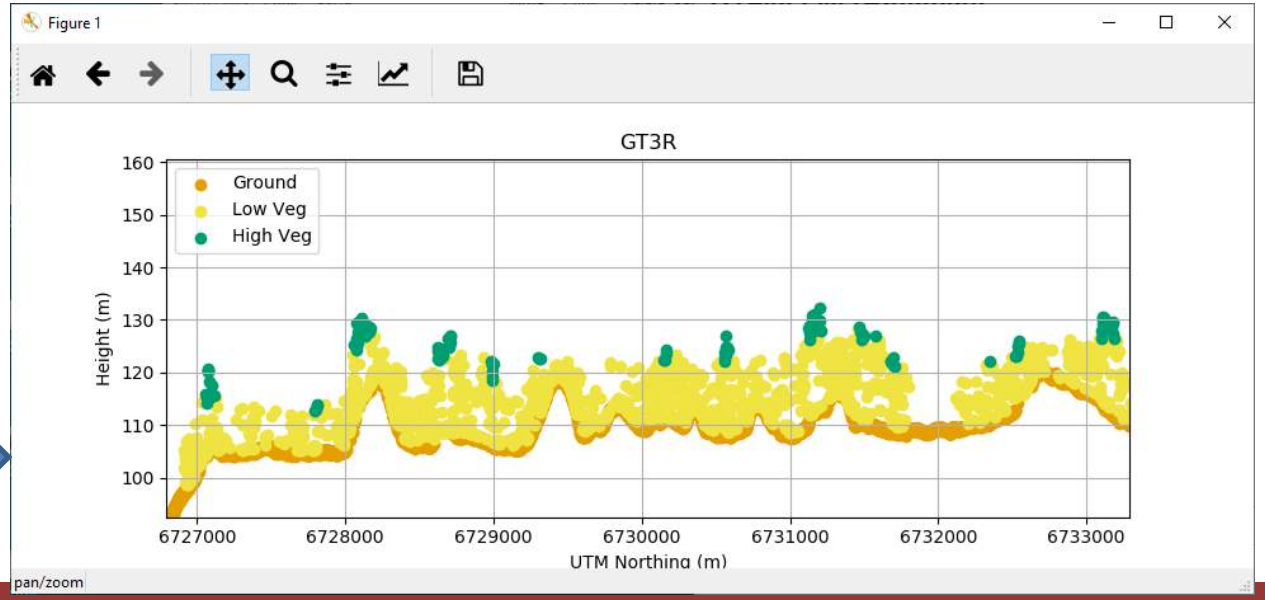
Output .kml file



Output ATL03.csv file

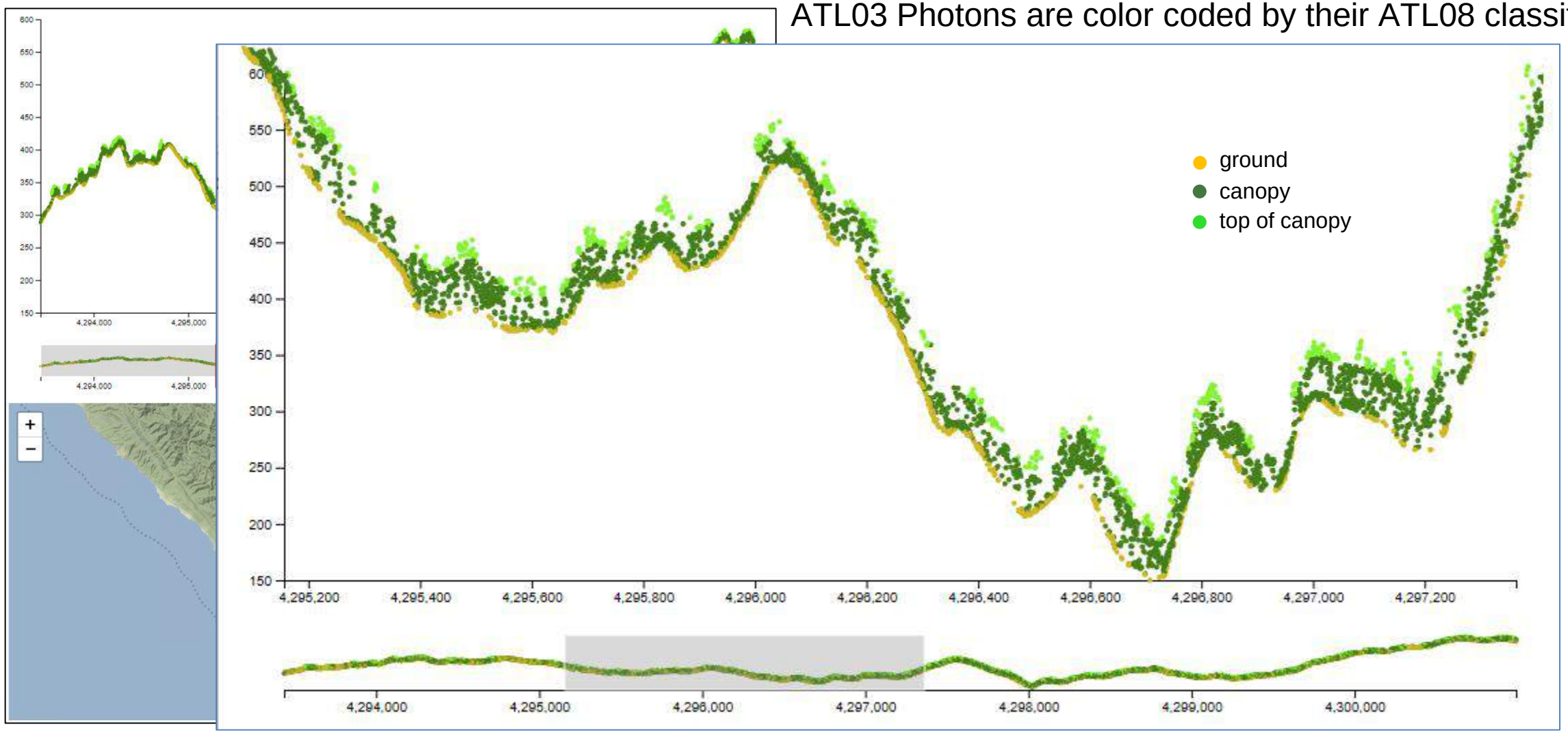


	A	B	C	D	E	F	G	H	I	J
1	Time (sec)	Latitude (deg)	Longitude (deg)	Easting (m)	Northing (m)	Cross-Track (m)	Along-Track (m)	Height (m)	Classification	Signal Confidence
2	322.0834073	38.99999986	-123.0860224	492551.1729	4316780.086	0	0	289.5704041	1	4
3	322.0835073	38.99999351	-123.0860232	492551.1023	4316779.382	0.001665168	0.707230377	289.6274109	1	4
4	322.0835073	38.99999302	-123.0860247	492550.9679	4316779.328	0.130085609	0.774583127	299.6416626	2	4
5	322.0835072	38.99999306	-123.0860246	492550.9784	4316779.332	0.120032454	0.769318978	298.8577271	2	4
6	322.0836073	38.99998714	-123.0860241	492551.0243	4316778.676	0.010380303	1.418150155	290.2347717	1	4
7	322.0836073	38.99998679	-123.0860252	492550.9278	4316778.637	0.102544183	1.466472008	297.4217224	2	4
8	322.0836073	38.99998714	-123.0860241	492551.0232	4316778.675	0.011395686	1.418684725	290.3139343	1	4
9	322.0836073	38.9999871	-123.0860242	492551.013	4316778.671	0.021156155	1.423794792	291.0750732	2	4
10	322.0836073	38.99998716	-123.086024	492551.0286	4316778.678	0.006215341	1.415957417	289.9099781	1	4
11	322.0836073	38.99998717	-123.086024	492551.0311	4316778.679	0.003810328	1.414691245	289.7224426	1	4
12	322.0837073	38.99998075	-123.086025	492550.9392	4316777.966	0.025887843	2.332648403	291.372406	2	4
13	322.0837073	38.99998074	-123.0860251	492550.9354	4316777.965	0.029451914	2.334496239	291.6503296	2	4
14	322.0837073	38.99998074	-123.0860251	492550.937	4316777.965	0.027907741	2.333711826	291.5299072	2	4
15	322.0838073	38.99997443	-123.0860258	492550.8742	4316777.265	0.022187471	2.837068017	291.0128174	1	4
16	322.0838073	38.99997437	-123.086026	492550.8575	4316777.258	0.038067852	2.84540007	292.2511597	2	4
17	322.0838073	38.9999744	-123.0860259	492550.8674	4316777.262	0.028628298	2.840458962	291.5150757	1	4
18	322.0839073	38.99996728	-123.0860291	492550.5824	4316776.471	0.235148233	3.655184419	307.5491638	3	4
19	322.0839073	38.99996809	-123.0860266	492550.8056	4316776.562	0.021843721	3.543313245	290.9155579	1	4
20	322.0839073	38.99996728	-123.0860291	492550.5846	4316776.472	0.233093502	3.654102655	307.388916	3	4
21	322.0840073	38.99996177	-123.0860273	492550.7395	4316775.86	0.019195376	4.248272612	290.6391907	1	4
22	322.0840073	38.99996174	-123.0860274	492550.732	4316775.857	0.026379254	4.25205475	291.1994019	1	4



Web-based Visualizer (PhoSHOW)

ATL03 Photons are color coded by their ATL08 classification



Javascript Plotting Functionality

Key Takeaways

- ICESat-2 is a space-based, profiling lidar mission
  - Does not provide the same resolution as airborne lidar mapping data
  - Does provide global coverage
- Use of strong beams are recommended for vegetation studies
- Night acquisitions are better than day acquisitions
  - Less background noise
- Data quality should improve over time
  - Improved calibrations of the ranging data
  - Improved modeling of orbital variations
  - Improvements to software will continuously be made
  - data will be reprocessed periodically (Release 002 available ~late October 2019)

Thank you

PhoREALpy github.com/icesat-2UT/phoREAL.py

Send comments/praise/love to

amyn@arlut.utexas.edu

Send issues/bugs/complaints to

phoreal@arlut.utexas.edu

LVIS flown during ABoVE summer campaign