Status and Results from ICESat-2

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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

SATCHELITE

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.
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.
Deforestation from Logging as observed by ICESat-2

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

ATL03_20190319234325_12450208

Forest experiencing logging

Intact tropical forest

Along-track distance (km)
Boreal forest in Alberta Canada as observed by ICESat-2

Along-track distance (km)

Elevation (m)

ATL03_20190212052542_06990206_206

ATL03 Photons gt11

Raw data
Canopy
Canopy top
Ground
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
• ATL06 – Along-track Land Ice Data Product
• ATL07 – Along-track Sea Ice Data Product
• ATL08 – Along-track Land/Vegetation Data 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

Median Residuals (MAE = 0.30 m, RMSE = 0.35 m, Mean Error = -0.26 m)
Best Fit Residuals (MAE = 0.36 m, RMSE = 0.43 m, Mean Error = -0.28 m)

Residuals (MAE = 3.62 m, RMSE = 3.99 m, Mean Error = 3.61 m)
ATL08 Validation:

**Ground (231 km)**

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 (119 km)**

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)

- ATL03 File:
- ATL08 File (Optional):
- Output Directory:
- 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

Output .kml file
Output ATL03.csv file
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
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Send issues/bugs/complaints to
phoreal@arlut.utexas.edu
LVIS flown during ABoVE summer campaign