Rapid Visualization and Analysis of ICESat-2 Data using an Intuitive GUI and JupyterHub Notebooks

Siri-Jodha Khalsa¹, Viswanath Nandigam², Adrian Borsa³, Minh Phan⁴, and Luis Lopez⁵

¹University of Colorado at Boulder ²OpenTopography / NCALM ³Scripps Institution of Oceanography ⁴San Diego Supercomputer Center ⁵National Snow and Ice Data Center

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Abstract

NASA's Ice, Cloud, and land Elevation Satellite-2, ICESat-2, carries the Advanced Topographic Laser Altimeter System, ATLAS, which sends 10,000 laser pulses per second towards Earth and records individual photons reflected back to its telescope. The volume of data produced by the instrument, nearly a TB of data every day, presents a challenges for the user wishing to explore and do quick analysis on the data. Although NSIDC, the data center responsible for archiving and distributing ICESat-2 data, provides services such as browse and spatial, temporal and parameter subsetting on the data, these are not necessarily conducive to exploratory work. OpenAltimetry, a collaborative project between NSIDC and the San Diego Supercomputer Center at the University of California, San Diego, has created an online platform that allows users to quickly view photon clouds, or waveform energy profiles in the case of ICESat/GLAS, the predecessor mission to ICESat-2/ATLAS, for any time and location of interest to the user, as well as the surface-specific elevations from the higher level ATLAS products. OpenAltimetry emphasizes ease-of-use and rapid response times. NASA's Ice, Cloud, and land Elevation Satellite-2, ICESat-2, carries the Advanced Topographic Laser Altimeter System, ATLAS, which sends 10,000 laser pulses per second towards Earth and records individual photons reflected back to its telescope. The volume of data produced by the instrument, nearly a TB of data every day, presents a challenges for the user wishing to explore and do quick analysis on the data. Although NSIDC, the data center responsible for archiving and distributing ICESat-2 data, provides services such as browse and spatial, temporal and parameter subsetting on the data, these are not necessarily conducive to exploratory work. OpenAltimetry, a collaborative project between NSIDC, Scripps Institution of Oceanography and the San Diego Supercomputer Center at the University of California San Diego, has created an online platform that allows users to quickly view photon clouds, or waveform energy profiles in the case of ICESat/GLAS, the predecessor mission to ICESat-2/ATLAS, for any time and location of interest to the user, as well as the surface-specific elevations from the higher level ATLAS products. OpenAltimetry emphasizes ease-of-use and rapid response times. A user can do more in depth data analysis on a Jupyter notebook invoked through OpenAltimetry's map-based interface, thus providing a full data analysis stack that lives in the cloud and enables scientists to do their work without investing a lot of time thinking about dependencies and deployments.





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INTRODUCTION

The Ice, Cloud, and land Elevation Satellite-2 (ICESat-2) was launched on 15-09-2018 carrying the Advanced Topographic Laser Altimeter System (ATLAS), which sends 10,000 laser pulses per second towards Earth and records individual photons reflected back to its telescope. Producing nearly a TB of data every day, ICESat-2 presents challenges for both the data center managing the data and the user wishing to explore and access the data.

Here we describe **OpenAltimetry**, an online tool providing altimetry-specific data discovery and access focusing on ease-of-use and quick

response times. It supports NASA's laser altimeter missions: ICESat (2003-2009) and ICESat-2 (13-10-2018 to present) with a web based interactive interface targeting both novice and expert users across different science specializations. The architecture of OpenAltimetry is described in **Section 1**, the basic features of the user interface is described in **Section 2**, and sample displays of the various ATLAS products are shown in **Section 3**. The Jupiter Notebooks and application program interface (API) to



OpenAltimetry is described in Section 4.







NSIDC DAAC Data Server

OpenAltimetry ETL Workflow

Selected ICESat-2 parameters are requested via the NSIDC DAAC API and loaded into a highly optimized PostgreSQL database with tiered storage. The high volume waveform and photon height data are placed in a decoupled object-based storage system using JHDF5, a Java binding for HDF5, to extract data from the HDF5 files on the fly. User requests for downloading data in an area of interest are fulfilled locally (.csv files with accompanying quality parameters) or by initiating a request to NSIDC's API for subsets of the source HDF5 granules.



OpenAltimetry map interface showing reference ground tracks (green) for 17-06-2019, and a sampling of data segments for selected product, ATL06, Land Ice.

AUTHORS: Siri-Jodha S Khalsa¹, Viswanath Nandigam², Adrian A Borsa³, Minh Phan⁴, Luis Alberto Lopez¹

INSTITUTIONS: ¹University of Colorado at Boulder, Cooperative Institute for Research in Environmental Sciences, National Snow and Ice Data Center, Boulder, CO, United States; ²OpenTopography / NCALM, La Jolla, CA, United States; ³Scripps Institution of Oceanography, La Jolla, CA, United States; ⁴San Diego Supercomputer Center, La Jolla, CA

SDSC SAN DIEGO SUPERCOMPUTER CENTER



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OPENALTIMETRY MENU 🗏 **OPENALTIMETRY** MENU \equiv Photon elevations for the strong beam of the central pair. **OPENALTIMETRY** Date: 2018-12-17 | 2019-03-18 | 2019-06-17 ATL07/1 ATL12 ELEVATION PROFILE ATL03 PHOTON HEIGHTS ATL13 Drag zoom on the plots below to view more detail. Date: 2018-12-17 | 2019-03-18 | 2019-06-17 ELEVATION PROFILE ATL03 PHOTON HEIGHTS ATL08: Ground Elevation and Canopy Surface Track 1222 - Sample rate: 100 200 Surface Elevations Select ATLAS beam gt3r (weak) | gt3l (strong) | gt2r (weak) | gt2l (strong) | gt1r (weak) | gt1l (strong) Track ID: 1222 - Beam: gt2l - Sample Rate: 100% Total number of photons: 20,786 - Total segments: 636 - Segment range: [1,952,581 - 1,953,216] Drag zoom on the plot below to view more detail. Return Signal Photor Canopy Heigh Beam: gt3 Latitude: -9.783206939697266 anopy Heights: 55.63984 m

SECTION 3: ATLAS PRODUCTS



Right panel: ground and canopy elevations from segments within a rectangular area selected in the display (left panel).



Photon elevations (right panel) on Greenland ice sheet with melt pond.

OpenAltimet /data/api/openapi.json		
Server /data/api ~		
Public		\checkmark
GET /icesat2/atl03	3	
Parameters		Try it out
Name	Description	
date * required string (query)	Data collection date in the format yyyy-MM-dd	
<pre>miny * required number (query)</pre>	min y coordinate	
<pre>maxy * required number (query)</pre>	max y coordinate	
minx * ^{required} number	min x coordinate	

The OpenAltimetry API supports requests for segment

SECTION 4: API AND NOTEBOOK

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OpenAltimetry IceSat 2 Workflows

Overview

This notebook uses ATL03 data from the IceSat 2 mission via the OpenAltimetry API for subsetting. This API enable users to select a particular region of interest and get pre-processed photon data wihtout the need to deal with big HDF files, the data is downsampled and returns up to ~10,000 cloud points per region of interest.

Instructions

The only thing you need for this notebook to work is a parameter's list that's available on the OpenAltimetry photon chart, paste that string as the OA_REFERENCE_URL and start visualizing your data!

Note that this notebook already has the Python libraries that you might need to do data analysis such as geopandas, plotly, fiona, shapely and more!

]: import numpy as np import pandas as pd import json import geopandas as gpd import matplotlib.pyplot as plt

from shapely.geometry import Point, Polygon

TITE - MATTOMA I' ANTO-ATCHCETCLE - MONALCHAE I' SAVID-ATCHCETCLE - DIEAACTON (W) II fig = go.Figure(data=oa_plots, layout=layout) iplot(fig)



elevation and photon height data by bounding box, beam and trackID, and returns results in .csv or json. To request full subsets of all parameters use the "Download subsetted HDF5 vis NSIDC" link below each elevation plot.

import requests import pyproj import math import plotly.graph_objects as go from plotly.offline import iplot # Paste the OpenAltimetry selection parameters here OA_REFERENCE_URL = 'minx=72.0476&miny=36.6165&maxx=72.0505&maxy=36.6214&date=2019-05-02&trackId # We populate a list with the photon data using the OpenAltimetry API, no HDF! OA_URL = 'https://openaltimetry.org/data/icesat2/getPhotonData?client=jupyter&' + OA_REFERENCE_ OA_PHOTONS = ['Noise', 'Low', 'Medium', 'High'] # OA_PLOTTED_BEAMS = [1,2,3,4,5,6] you can select up to 6 beams for each ground track. # Some beams may not be usable due cloud covering or QC issues. $OA_BEAMS = [3, 4]$ df_beams = [] oa_plots = [] # This function will request the 6 tracks using OpenAltimetry's API def getPhotonData(): series = [] beam_index = 0; for beam in OA BEAMS: beam_index += 1 b url = OA URL + '&beam=' + str(beam) print(b_url) print('Requesting Beam {}'.format(beam_index)) r = requests.get(b_url) data = r.json() series.append(data) print ('Data requests completed you can now plot it on the next cell...' return series

Selecting "Analyze in Jupyter Notebook" below a photon plot opens a notebook in Binder. Users substitutes text string copied to clipboard containing parameters for the data request. Subsequent cells display interactive 3D plot of the photon clouds, plus histograms of their heights

Photons from strong beams for area in Amazon rainforest displayed in Section 3 above. User can select beams and confidence level of photons to be displayed by clicking on the legend.

info@openaltimtery.org

www.openaltimetry.org

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