



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

## INTRODUCTION

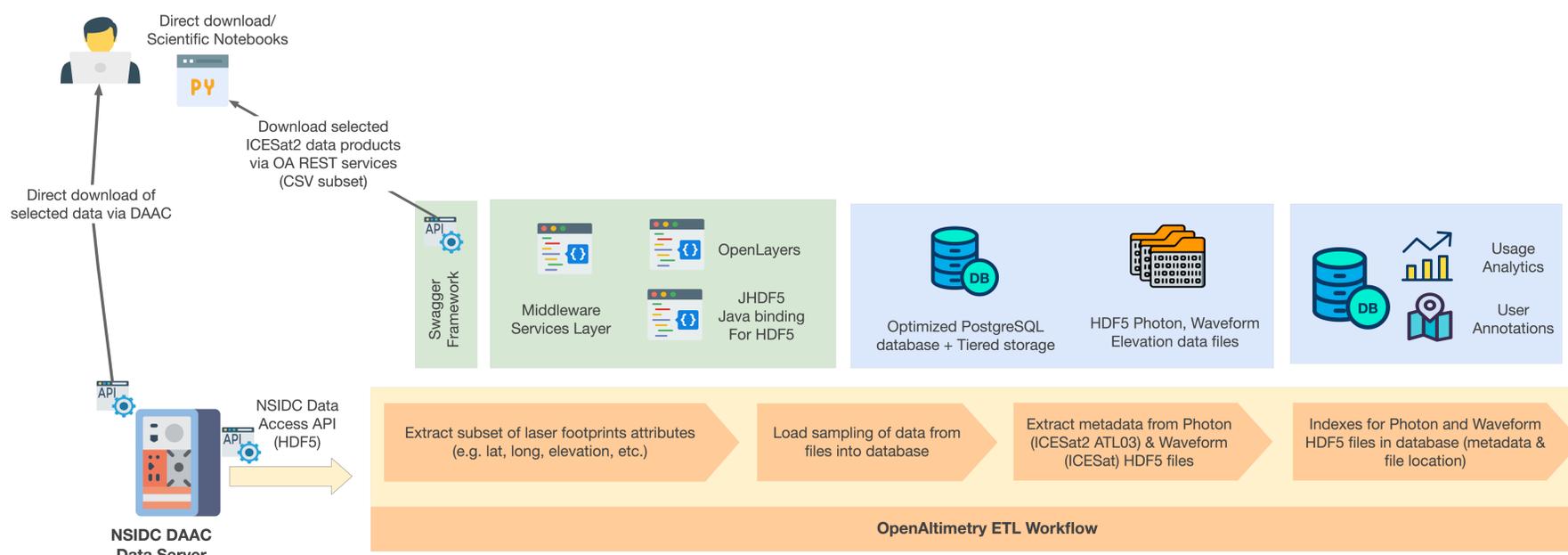
The Ice, Cloud, and land Elevation Satellite-2 (ICESat-2) was launched on 15-09-2018 carrying the Advanced Topographic Laser Altimeter System (ATLAS), which sends 10,000 laser pulses per second towards Earth and records individual photons reflected back to its telescope. Producing nearly a TB of data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



## SECTION 1: ARCHITECTURE



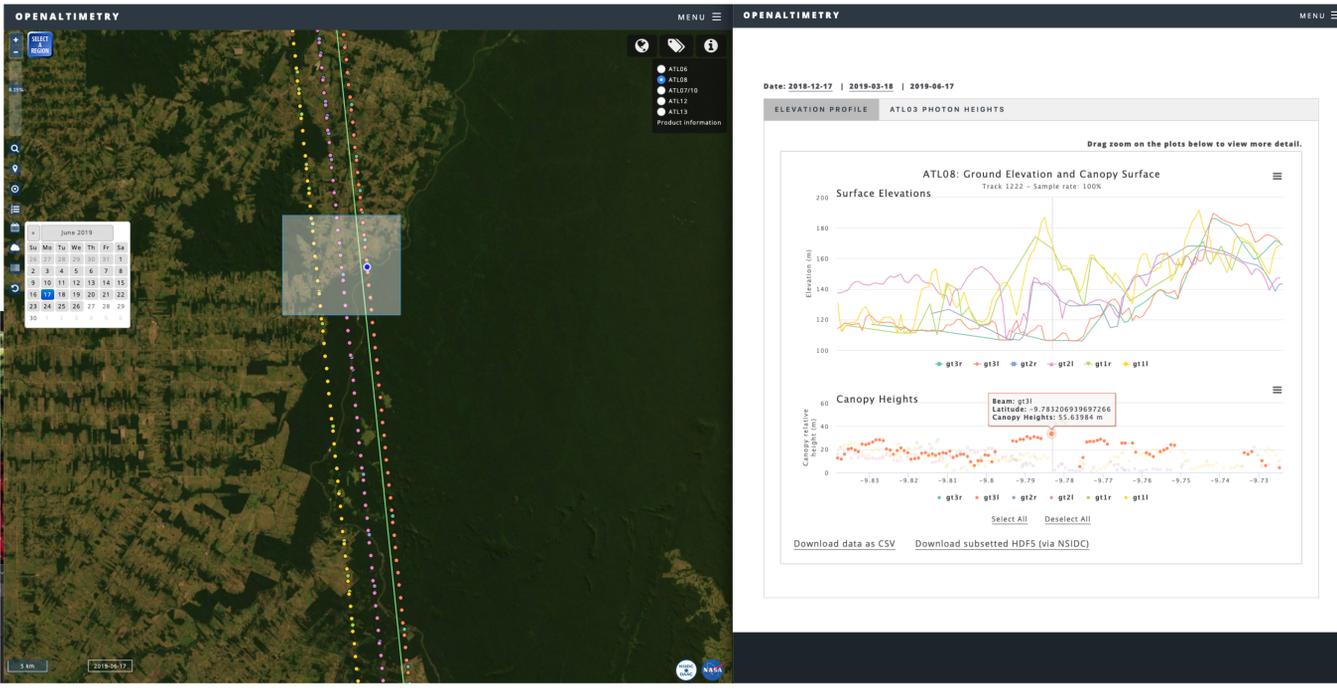
Selected ICESat-2 parameters are requested via the NSIDC DAAC API and loaded into a highly optimized PostgreSQL database with tiered storage. The high volume waveform and photon height data are placed in a decoupled object-based storage system using JHDF5, a Java binding for HDF5, to extract data from 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.

## SECTION 2: USER INTERFACE

The screenshot shows the OpenAltimetry map interface. On the left, a control panel includes: **Zoom to selected region**, **Go to lat/long coordinates**, **Set beam display options**, **Choose tracks to display for current date**, **Select date, toggle calendar**, **Toggle daily imagery**, **Toggle display of all reference ground tracks**, and **Reset to global view**. The main map displays **Reference Ground Tracks** (green lines) and data segments for **ATL06 Land Ice**. A **Default Elevation Product** menu is visible, listing: **ATL06: Land Ice**, **ATL08: Vegetation**, **ATL07/10: Sea Ice**, **ATL12: Ocean**, and **ATL13: Inland Water**. A **Reference Ground Tracks** callout points to the green lines on the map. A **Controls for selecting map projection, working with annotations, getting information about base layers, track & beam legend, form to provide feedback** callout points to the top right of the interface. A calendar for **June 2019** is also visible.

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

**SECTION 3: ATLAS PRODUCTS**

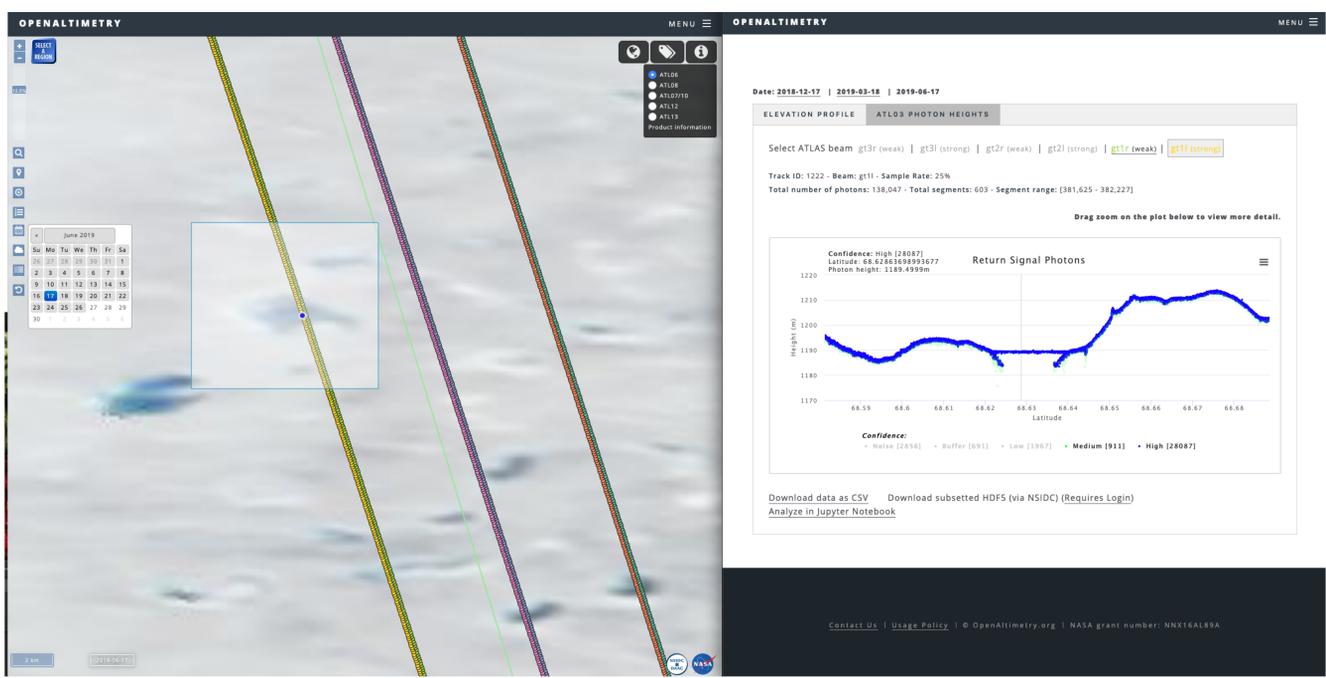


Photon elevations for the strong beam of the central pair.



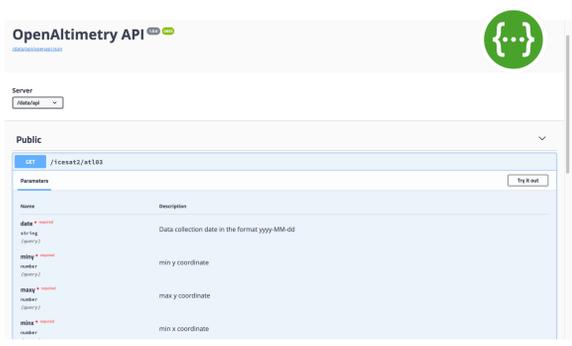
See Section 4

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.

**SECTION 4: API AND NOTEBOOK**



The OpenAltimetry API supports requests for segment 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.

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OpenAltimetry IceSat 2 Workflows

Overview
This notebook uses ATLAS data from the IceSat 2 mission via the OpenAltimetry API for downloading. This API enables users to select a particular region of interest and get pre-processed photon data without the need to deal with big HDF files, the data is downloaded 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!

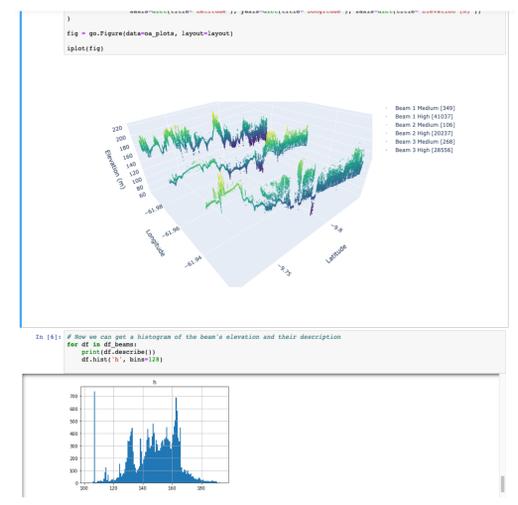
In [ ]:
import numpy as np
import pandas as pd
import json
import geopandas as gpd
import matplotlib.pyplot as plt
from shapely.geometry import Point, Polygon
import requests
import pyproj
import math
import plotly.graph_objects as go
from plotly.offline import plot

# Paste the OpenAltimetry selection parameters here
OA_REFERENCE_URL = "https://icesat2.atlas.org/v2/icesat2/atlas?data=2019-05-02&trackId=1222&min_y=1170&max_y=1220&min_x=-9.83&max_x=-9.73&beam=gt11&confidence=High"
# 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_URL

OA_PHOTOSS = ["Noise", "Low", "Medium", "High"]
# ON PHOTON 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 4 tracks using OpenAltimetry's API
def getPhotonData():
    secno = []
    beam_index = 0
    for beam in OA_BEAMS:
        beam_index += 1
        b_url = OA_URL + "&beam=" + str(beam)
        print(b_url)
        r = requests.get(b_url)
        data = r.json()
        secno.append(data)
    print ("Data requests completed you can now plot it on the next cell...")
    return secno
    
```



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.