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

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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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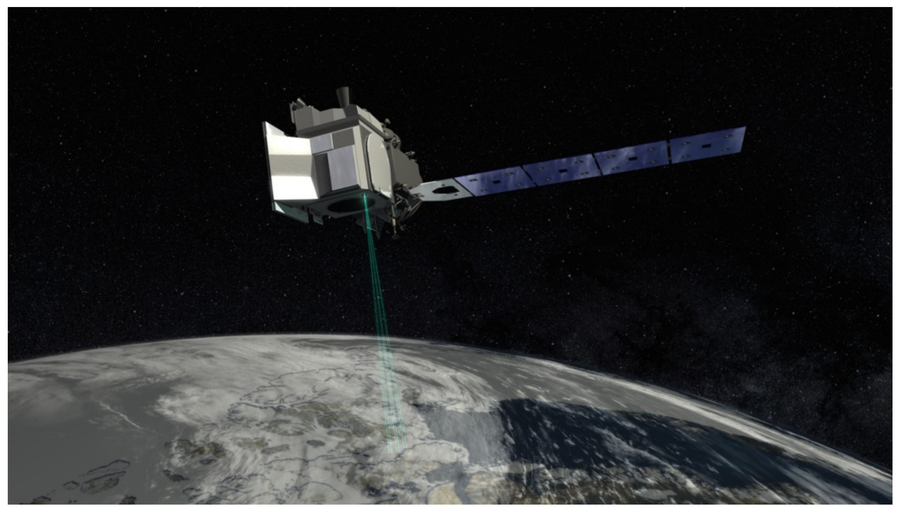
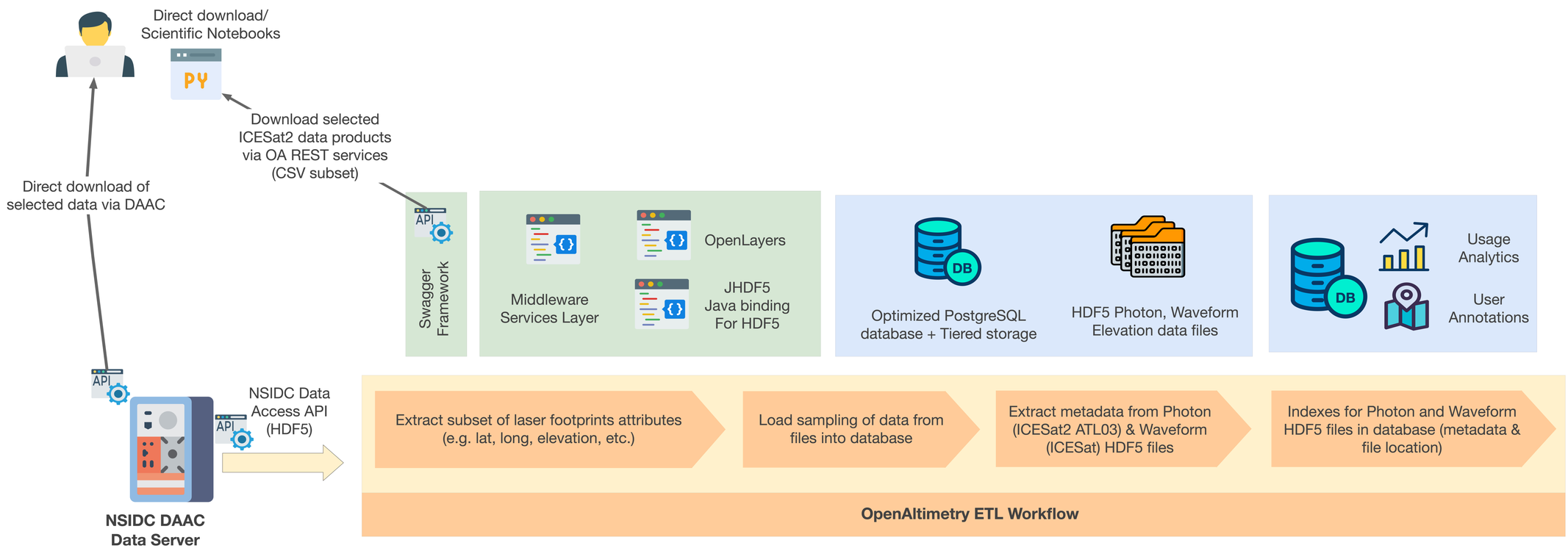
INTRODUCTION

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**.

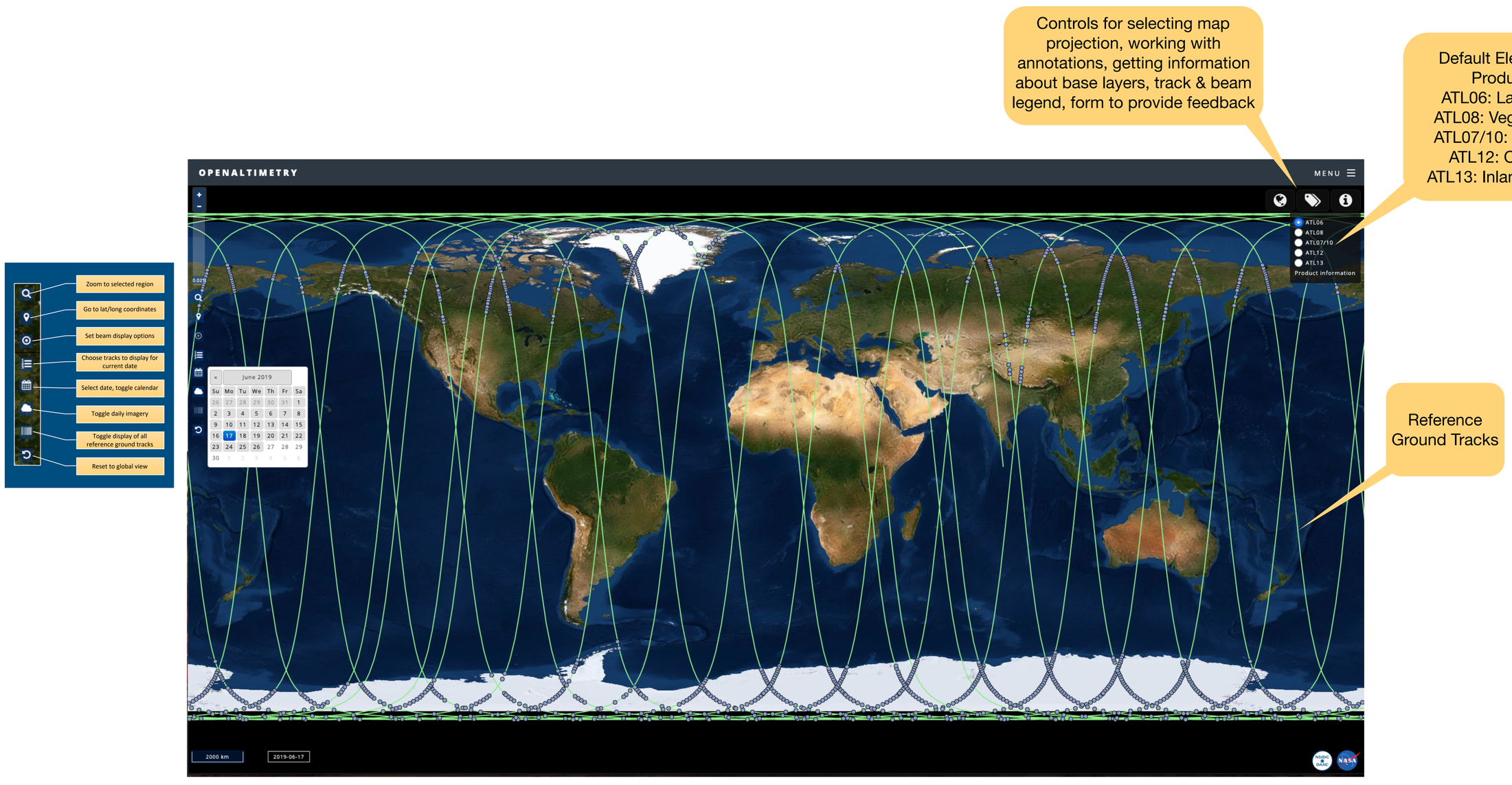


SECTION 1: ARCHITECTURE



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



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

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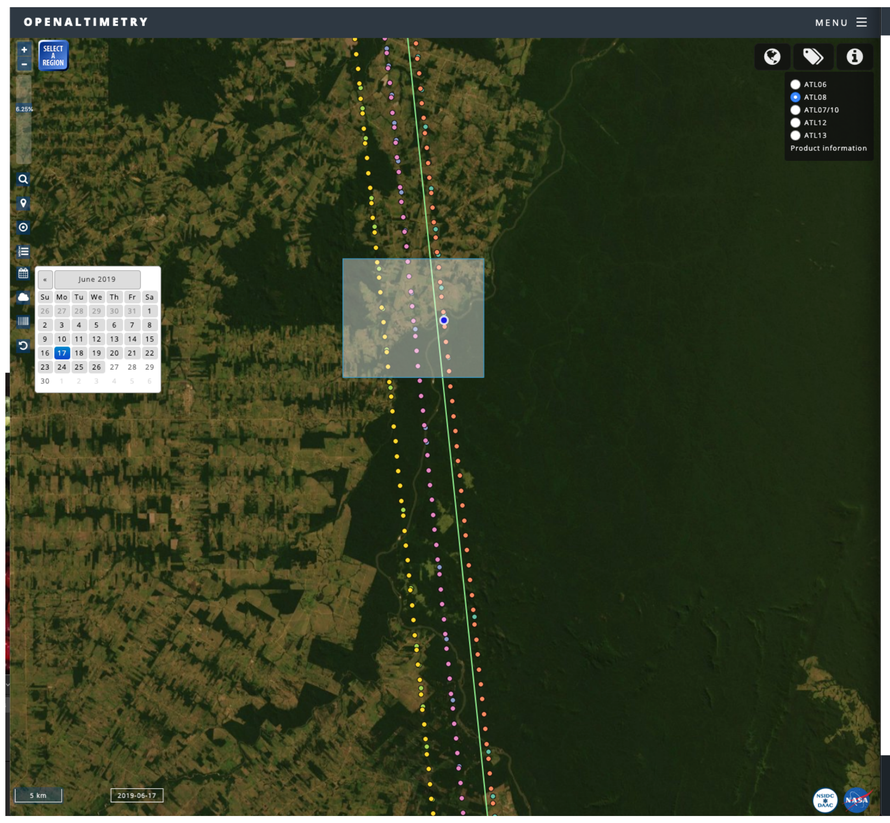
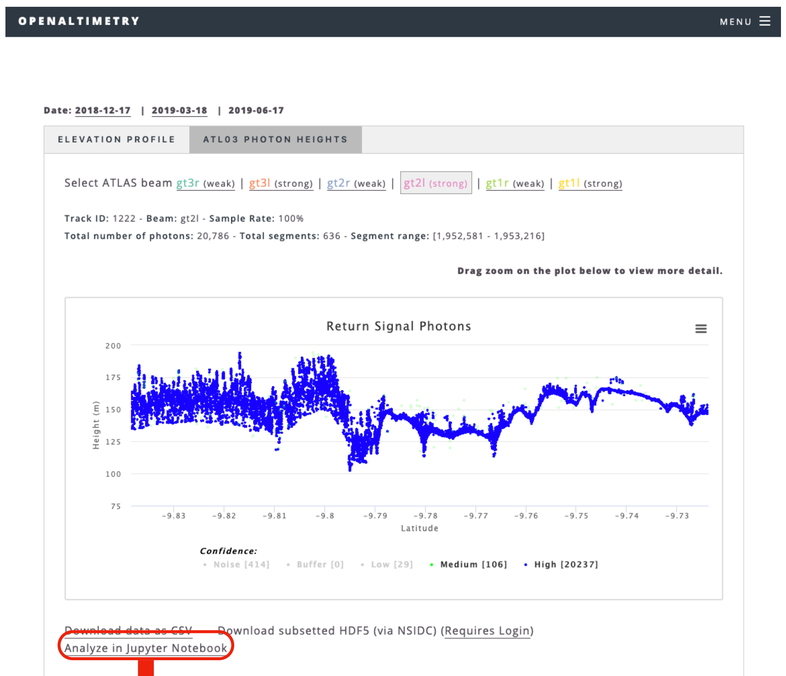
SECTION 3: ATLAS PRODUCTS

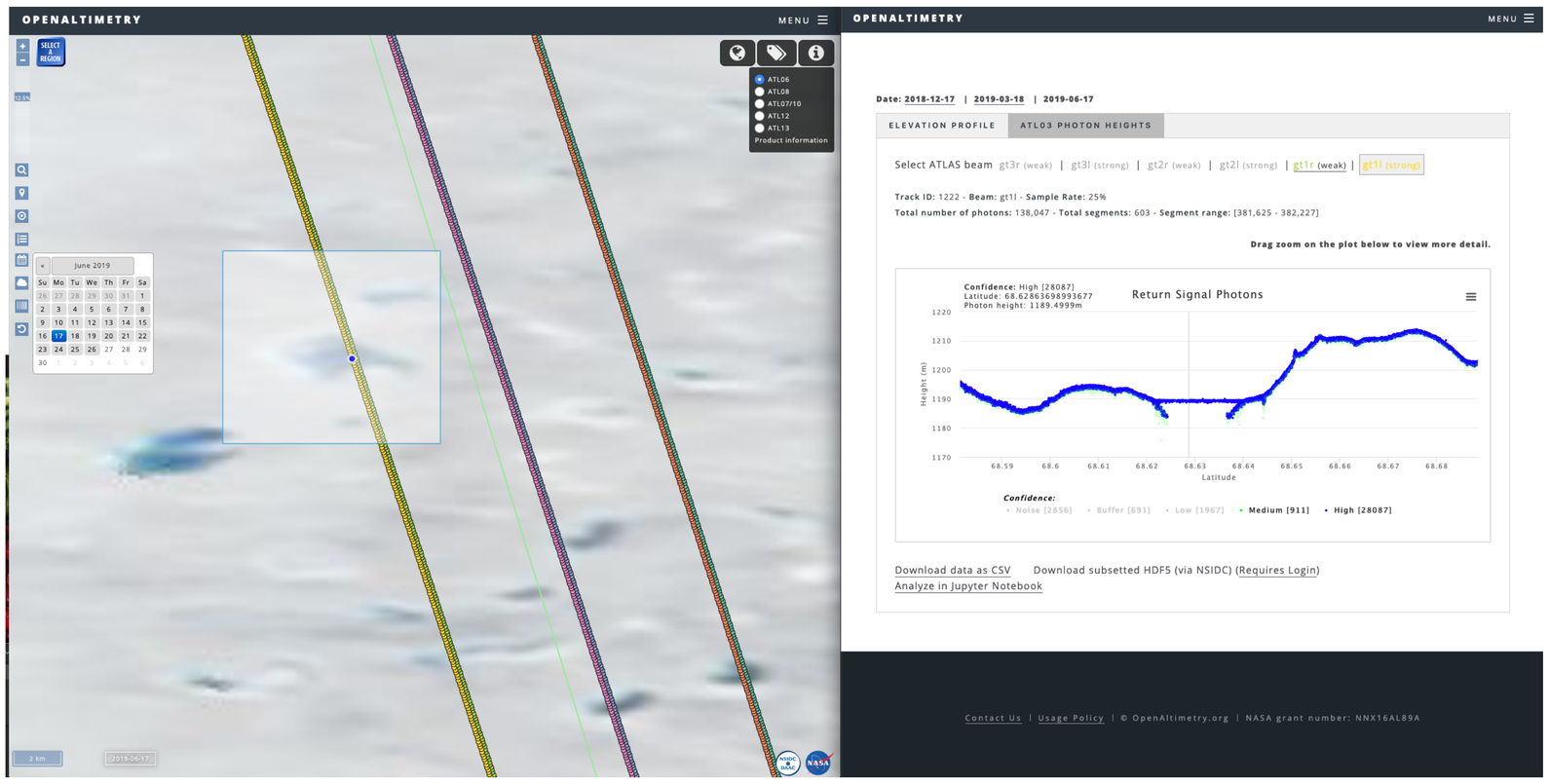


Photon elevations for the strong beam of the central pair.



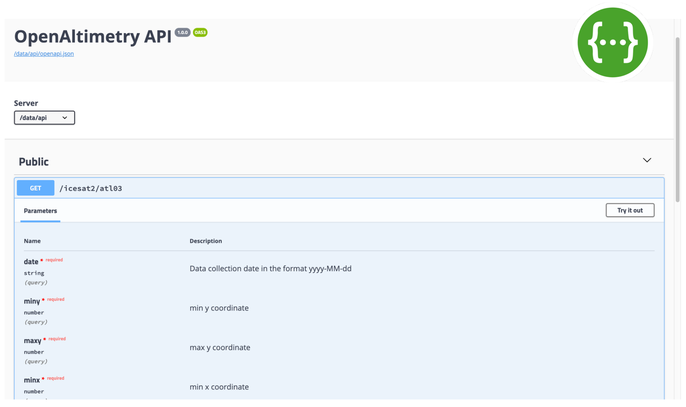
See Section 4

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

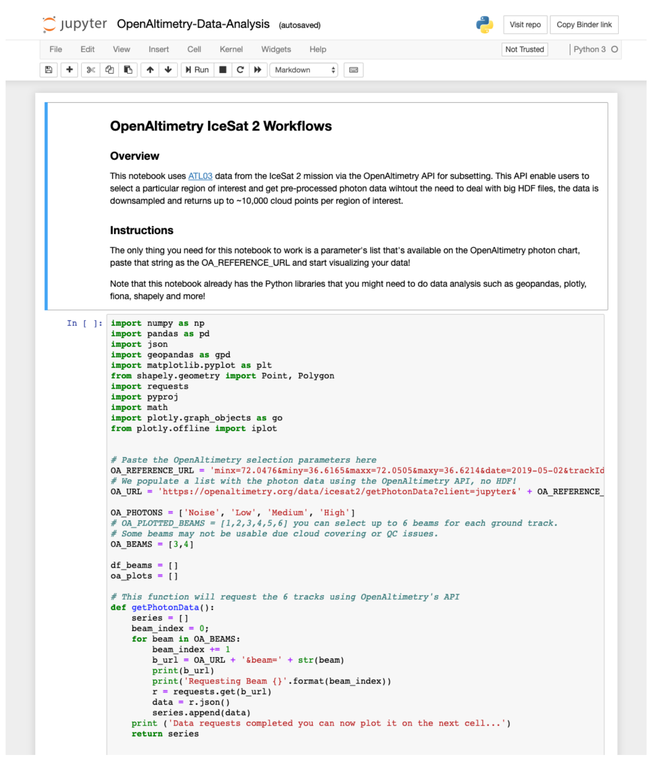


Photon elevations (right panel) on Greenland ice sheet with melt pond.

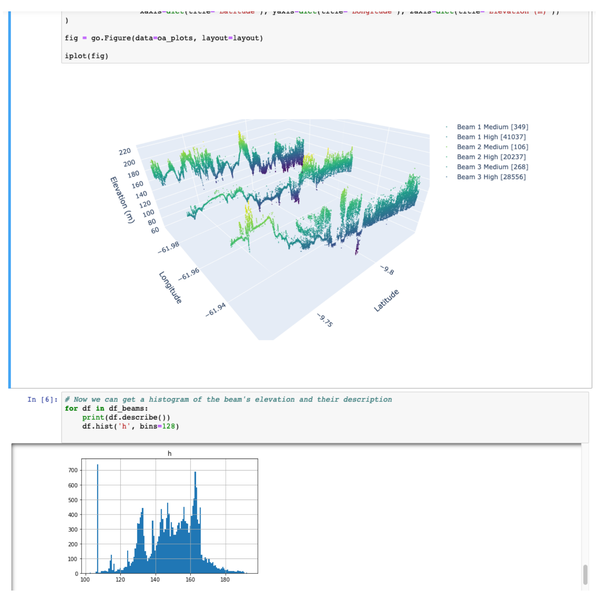
SECTION 4: API AND NOTEBOOK



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.



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.