

ICESat-2 data access and analysis with icepyx



GitHub: <https://github.com/icesat2py/icepyx>
Documentation: <https://icepyx.readthedocs.io>



Jessica Scheick

University of New Hampshire

Earthdata Webinar
19 November 2025



EARTHDATA

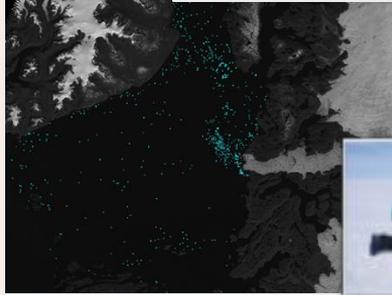


University of
New Hampshire

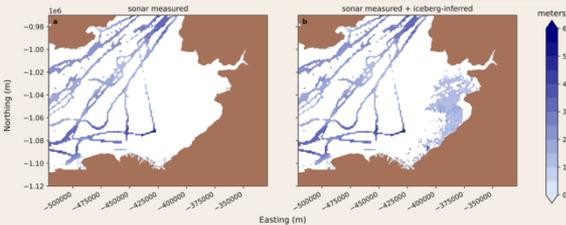


Who am I?

Glaciologist
(icebergs + ice-ocean interactions)



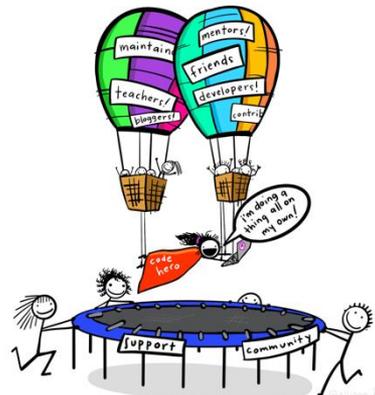
Kane Basin Bathymetry



Open-source
Scientific Software
Developer



Open Science
Advocate +
Educator



Artwork by @alison_horst



icepyx: ICESat-2⁺ data tool

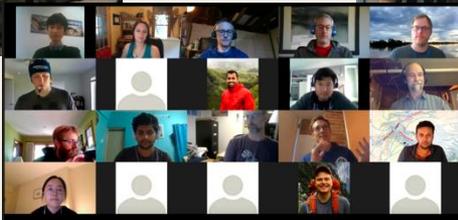
- ❖ *A community* of ICESat-2 data users, developers, data managers, and researchers
- ❖ An open-source Python *software library*

Anaconda.org

2.0.0

pypi package

2.0.0



icepyx Origin Story: 2019 ICESat-2 Hackweek

A hackweek is a welcoming learning environment designed to build an *open and collaborative research community* while introducing participants to new software tools



Tutorials + peer to peer learning + project team-based work

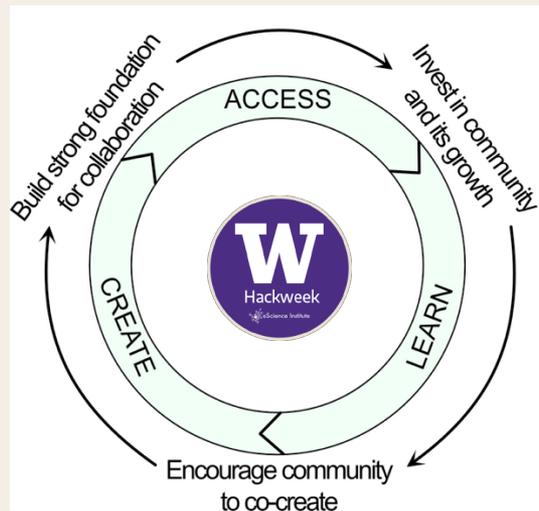


About - People - Using Data Science - Learning Data Science - Software Engineering - Connect with eScience -



What is a hackweek?

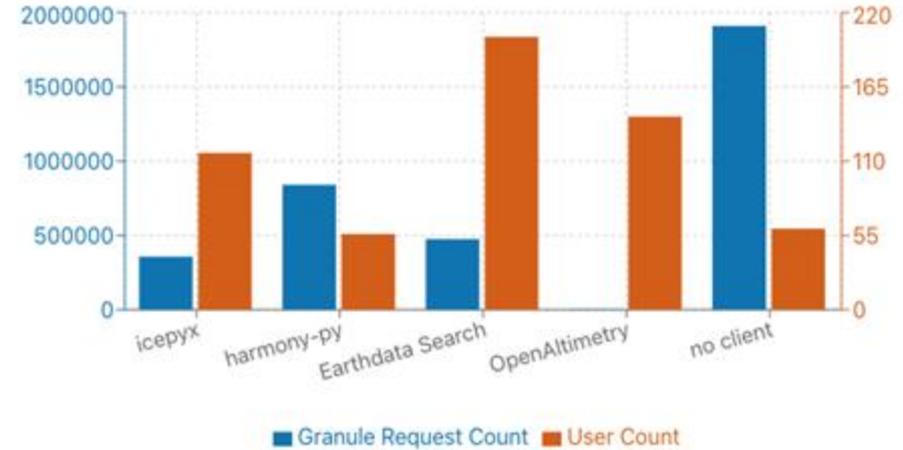
A hackweek is a participant-driven workshop that blends data science education, community building, and project work over a short period of time (one to two weeks). The events are highly immersive and allow participants to work directly with data science professionals to co-shape projects and educational outcomes. Hackweeks often help individuals and teams engage more effectively in open and reproducible science.



A critical community tool

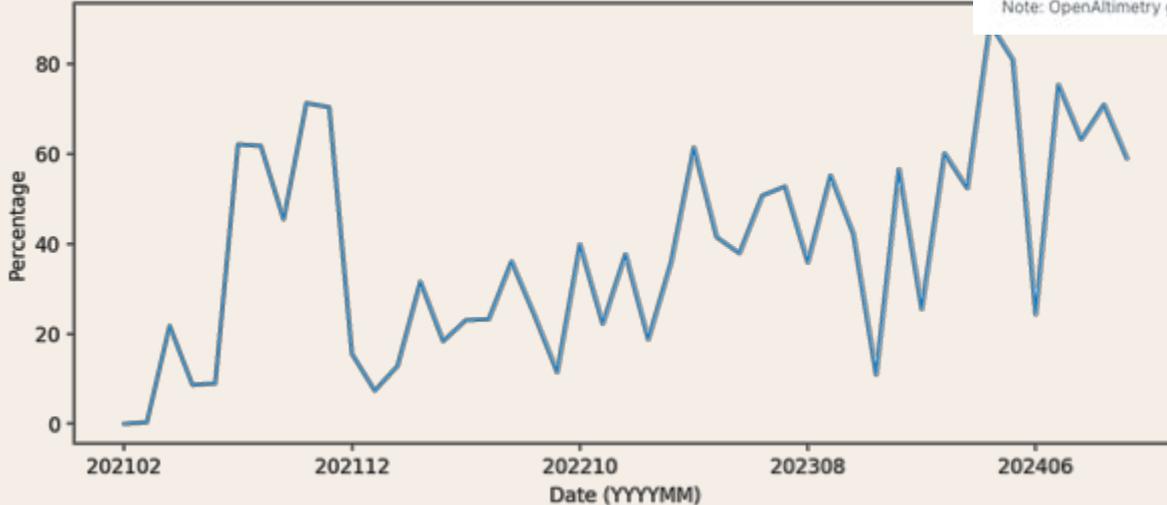


Client Comparison: Granules & Users



Note: OpenAltimetry granule count (2,688) is too small to display relative to other clients.

Percentage of all On-Premises Downloads Using icepyx



Harmony Metrics
1 Oct 2024 – 23 Sept 2025

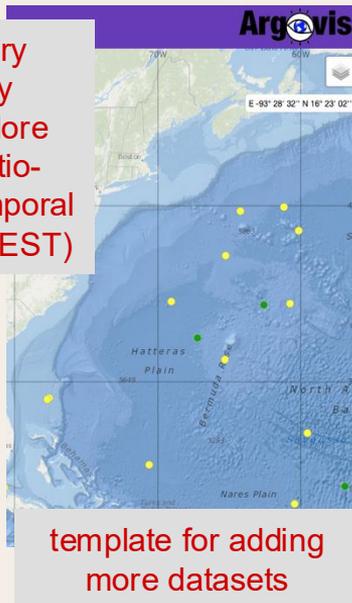
On-premise Metrics
Feb 2021 – Oct 2024

Success Stories

I was able to bring on a master's student to work with ICESat-2 data because they wouldn't need an entire year just to learn how to access the data.

~ professor (cryosphere)

Query
Unify
Explore
Spatio-
Temporal
(QUEST)



icepyx made it possible for me to understand how to work with ICESat-2 datasets. The other information out there was overwhelming.

~ software developer

Over 20 publications and presentations* using or featuring icepyx (*excludes tutorials)

Spatially Continuous Mapping of Forest Canopy Height in Canada by Combining GEDI and ICESat-2 with PALSAR and Sentinel

by [Camille St-Onge](#), [Alvaro Gonzalez](#), [Ricardo B. Lourenço](#), [Werner A. Kurz](#) and [James Seliger](#)

¹ School of Earth, Environment & Society, McMaster University, Hamilton, ON L8S 4L8, Canada

² Canadian Forest Service, Natural Resources Canada, Victoria, BC V8Z 1M6, Canada

³ World Wildlife Fund Canada, Toronto, ON M5V 1S8, Canada

* Author to whom correspondence should be addressed.

Remote Sens. 2022, 14(20), 5156; <https://doi.org/10.3390/rs14205156>

Mapping the Diversity of Agricultural Systems in the Cuellaje Sector, Cotacachi, Ecuador Using ATLO8 for the ICESat-2 Mission and Machine Learning Techniques

[Gardido Fernando](#)

Conference paper | [First Online: 10 September 2021](#)

928 Accesses | 1 Citations

Part of the [Lecture Notes in Computer Science](#) book series (LNCS, volume 12957)

Geophysical Research Letters

Research Letter | [Open Access](#) | [Cite](#) | [Share](#)

How Are Under Ice Phytoplankton Related to Sea Ice in the Southern Ocean?

[K. M. Bisson](#) and [B. B. Cael](#)

First published: 21 October 2021 | <https://doi.org/10.1029/2021GL095051> | Citations: 1

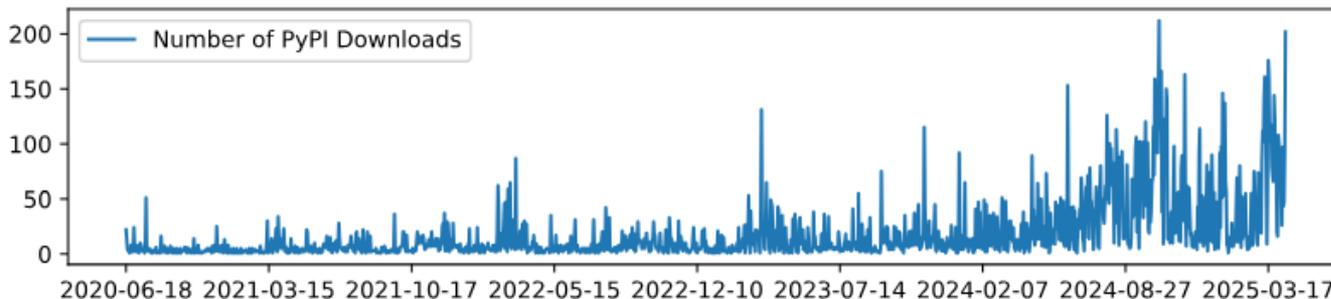
Mapping the grounding zone of Larsen C Ice Shelf, Antarctica, from ICESat-2 laser altimetry

[Tian Li](#), [Geoffrey J. Dawson](#), [Stephen J. Chuter](#), and [Jonathan L. Bamber](#)

Bristol Glaciology Centre, School of Geographical Sciences, University of Bristol, Bristol, BS8 1SS, UK

Correspondence: [Tian Li \(tian.li@bristol.ac.uk\)](mailto:Tian.Li@bristol.ac.uk)

Received: 10 Apr 2020 - Discussion started: 25 May 2020 - Revised: 24 Aug 2020 - Accepted: 25 Sep 2020 - Published: 02 Nov 2020



icepyx: in the community



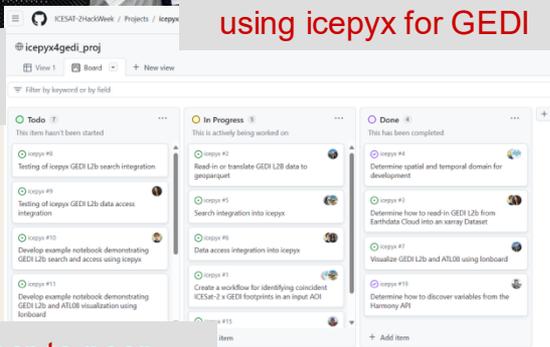
Hackweek Project

Problem solving with DAAC data engineers and managers

Practicing GitHub

Peer-to-peer teaching + learning

using icepyx for GEDI



showing one of the checks failed. In this case, you will need to re-commit your changes until all pre-commit hooks pass (i.e. a failed pre-commit check results in no git commit). Pre-commit will also run on icepyx PRs using the pre-commit CI (continuous integration). As with other automations happening in PRs, you'll want to make sure you pull the changes back to your local version before making new commits.

Considerations with Jupyter Notebook

If you are working in Jupyter Notebook, in addition to manually installing your working version in your Python environment with

```
pip install -e.
```

you will need to dynamically reload icepyx within your notebook by executing

```
%load_ext autoreload
import icepyx as ipx
%autoreload 2
```

in a notebook cell. This allows the Jupyter Notebook to detect and use changes you've made to the underlying code.

Previous

Next

Improved documentation



Tutorials and Cloud Computing

New projects are OPEN

INV51D-01 On a QUEST (Query, Unify, Explore SpatioTemporal) to Accelerate ICESat-2 Applications in Ocean Science via icepyx

add argo functionality to QUEST #427

Merged JessicaS11 merged 140 commits into development from argo on Dec 7, 2023

Conversation 30 Commits 140 Checks 1 Files changed 10 +1,509 -72

GitHub pull request details for 'add argo functionality to QUEST #427' by JessicaS11, including reviewers RomiP, kelseybisson, and zachghiaccio.

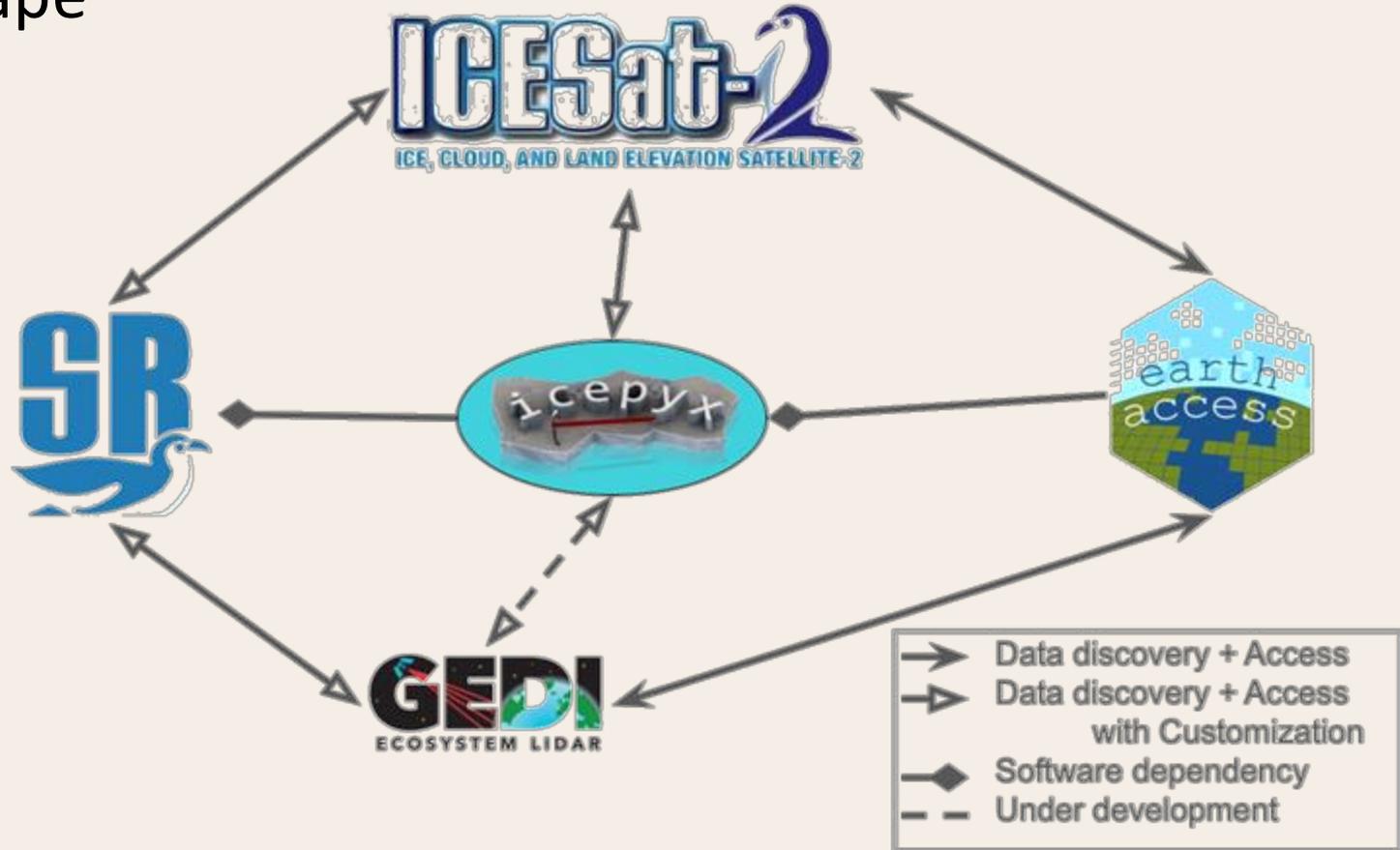
Presentations and publications

Event details for 'Friday, 15 December 2023' from 08:30 to 08:40 at 301-302 - South (Level 3, South, MC).

Abstract

Collaboration and inclusivity will be critical for tackling modern environmental challenges resulting from increased anthropogenic stressors. Even as we celebrate 2023 as the Year of Open Source Science, many scientific disciplines - and thus their technologies, tools and expertise - remain silenced. The ICESat-2 (Ice

icepyx in the ICESat-2 tool ecosystem: a confusing landscape



Extensible communities and tooling

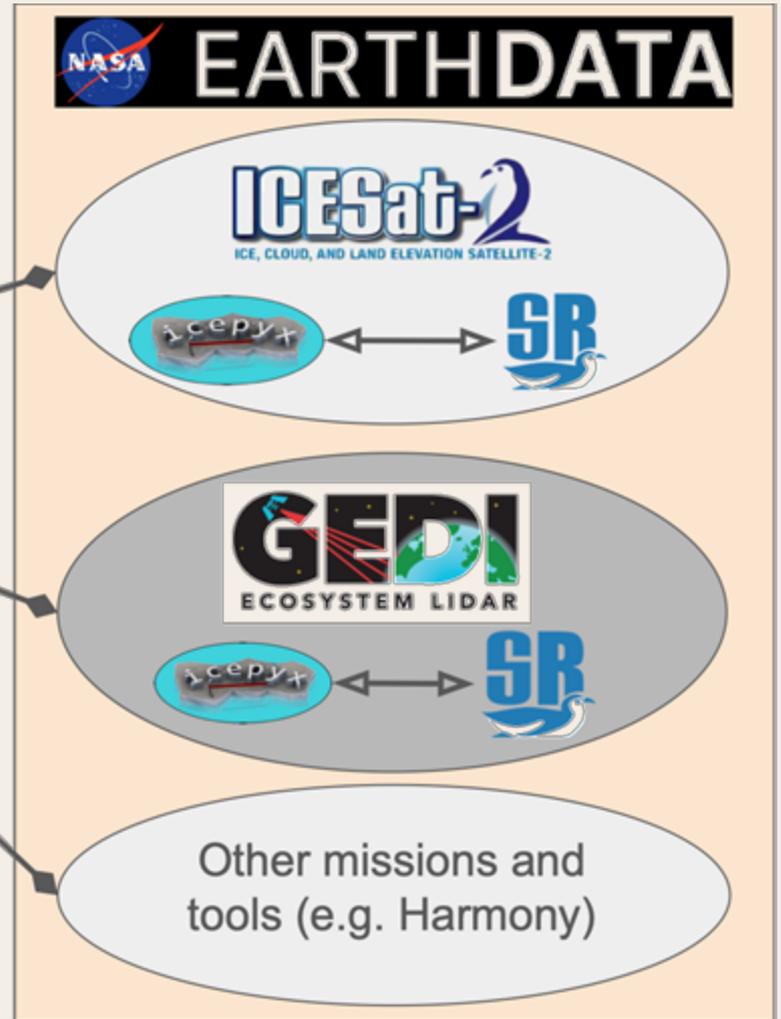
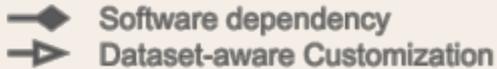


Shared computational infrastructure
(managed cloud hub)



Data search/discovery and
access/authentication

Dataset-aware
customization



icepyx: feature summary (part 1)

Query
Unify
Explore
Spatio-
Temporal
(QUEST)

Adding a new dataset to QUEST

Step 1. Create new branch off development on icepyx

Step 2. Import libraries for analysis

```

from icepyx.quest.dataset_scripts.dataset import Dataset
from icepyx.core.spatial import geodataframe
import requests
import pandas as pd
import os
import numpy as np

```

Step 3. Create class name for the variable of interest

```

class Argo(DataSet):
    """
    Initializes an Argo dataset object
    Used to query physical Argo profiles
    """

```

Step 4. Initialize dataset with bounding box and timeframe

```

def __init__(self, boundingbox, timeframe):
    super().__init__(boundingbox, timeframe)
    assert self._spatial_ext_type == "bounding_box"
    self.profiles = None

```

Step 5. Add code specific to API query for your dataset

```

# builds URL to be submitted
baseUrl = "https://argois-api.colorado.edu/argo"
payload = {
    "startDate": self._temporal_start.strftime("%Y-%m-%dT%H:%M:%S.%fZ"),
    "endDate": self._temporal_end.strftime("%Y-%m-%dT%H:%M:%S.%fZ"),
    "polygon": [self._fmt_coordinates()],
}

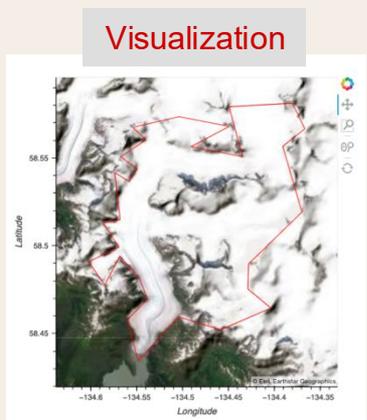
```

Step 6. Add quality control code specific to your dataset

Step 7. Add functionality to format coordinates from the icepyx call to the API for data
(e.g., convert spatial extent into string format needed by API server)

Step 8. Add functionality to parse data into dataframe

Documentation and ICESat-2 Resources



Meet open science and software requirements

template for adding more datasets

latest

Search docs

GETTING STARTED

- Origin and Purpose
- Installation
- Citing icepyx

EXAMPLES

- Accessing ICESat-2 Data
- Subsetting ICESat-2 Data
- ICESat-2's Nested Variables
- Visualizing ICESat-2 Elevations
- Reading ICESat-2 Data in for Analysis
- ICESat-2 AWS cloud data access
- QUEST Example: Finding Argo and ICESat-2 data

USER GUIDE

icepyx

Python tools for obtaining and working with ICESat-2 data

Quick Links: [Installation](#) | [Citation](#) | [Examples](#) | [Source Code](#) | [Contact](#)

icepyx is both a software library and a community composed of ICESat-2 data users, developers, and the scientific community. We are working together to develop a shared library of resources - including existing resources, new code, tutorials, and use-cases/examples - that simplify the process of querying, obtaining, analyzing, and manipulating ICESat-2 datasets to enable scientific discovery. To further enhance data discovery, we have developed the QUEST module to facilitate querying of ICESat-2 data and complimentary Argo oceanographic data, with additional dataset support expected in the future.

Getting Started

User Guide

QUEST

Easy Install

Anaconda.org 2.0.0 pypi package 2.0.0

Download and Cloud data access

Minimal Code

```

import icepyx as ipx
region = ipx.Query(short_name, spatial_extent, date_range)
region.download_granules(path)

```



earthaccess

A Python Library for NASA Earthdata

Easy authentication and token management

icepyx: feature summary (part 2)

Examples

Data read-in

Nested variable management (can be used for ANY hdf5 files)

Peer-reviewed, citable software

JOSS 10.21105/joss.04912

Easily make your workflow reproducible or transition to the cloud

Under-the-hood transition to Harmony services

Support

Community

```
[17]: reader = ipx.Read(path_or_s3url)
reader.vars.append(var_list=['ph_h', 'classed_pc_flag', 'latitude', 'longitude'])
ds_photons = reader.load()
```

[17]: xarray.Dataset

Dimensions: (gran_idx: 1, photon_idx: 25234, spot: 2)

Coordinates:

gran_idx	(gran_idx)	float64	5.54e+04		
photon_idx	(photon_idx)	int64	0 1 2 3 ... 25230 25231 252...		
spot	(spot)	uint8	5 6		
source_file	(gran_idx)	<U74	'./bosque_primavera_ATL08...		
delta_time	(photon_idx)	datetime64[ns]	2019-05-04T12:47:13.5766...		

Data variables:

sc_orient	(gran_idx)	int8	0		
cycle_number	(gran_idx)	int8	3		
rgt	(gran_idx, spot, photon_idx)	float32	554.0 554.0 554.0 ... nan na...		
atlas_sdp_gps_...	(gran_idx)	datetime64[ns]	2018-01-01T00:00:18		
data_start_utc	(gran_idx)	datetime64[ns]	2019-05-04T12:46:31.8763...		
data_end_utc	(gran_idx)	datetime64[ns]	2019-05-04T12:48:54.2008...		
latitude	(spot, gran_idx, photon_idx)	float32	20.59 20.59 20.59 ... nan na...		
longitude	(spot, gran_idx, photon_idx)	float32	-103.7 -103.7 -103.7 ... nan ...		
gt	(gran_idx, spot)	<U4	'gt3l' 'gt3r'		
ph_h	(spot, gran_idx, photon_idx)	float32	nan nan nan ... 0.05103 0.05...		
classed_pc_flag	(spot, gran_idx, photon_idx)	float32	nan nan nan nan ... 1.0 1.0 1...		

Indexes:

gran_idx	PandasIndex	
photon_idx	PandasIndex	
spot	PandasIndex	

Attributes:

data_product : ATL08



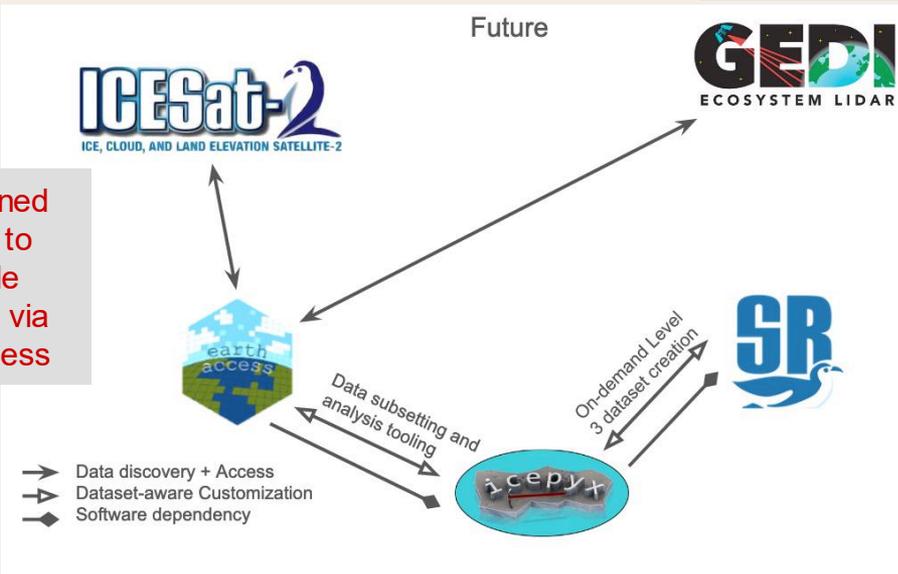
icepyx: ongoing

Subsetting of cloud data

Optimized Cloud data read-in

Streamlined access to multiple datasets via earthaccess

Handling of QuickLook data products



```
xarray.Dataset
> Dimensions:      (gran_idx: 26, spot: 6, photon_idx: 17478)
v Coordinates:
  gran_idx         (gran_idx)          uint64  19705 19713 73801 ... 118012 ...
  spot             (spot)              uint64  1 2 3 4 5 6
  photon_idx      (photon_idx)        int64   1 2 3 4 ... 17475 17476 17477 1...
  source_file     (gran_idx)          object  '/is2-download/processed_ATL...
  delta_time      (photon_idx)        datetime64[ns] 2020-12-07T23:14:42.1079928...
v Data variables:
  sc_orient       (gran_idx)          float64  1.0 0.0 1.0 0.0 ... 0.0 1.0 1.0 0.0
  cycle_number    (gran_idx)          float64  5.0 13.0 1.0 3.0 ... 11.0 12.0 14.0
  rgt             (gran_idx)          float64  197.0 197.0 ... 1.18e+03 1.18e+...
  atlas_sdp_gps... (gran_idx)          datetime64[ns] 2018-01-01T00:00:18 ... 2018-...
  data_start_utc  (gran_idx)          datetime64[ns] 2019-10-09T19:31:32.837255 ...
  data_end_utc    (gran_idx)          datetime64[ns] 2019-10-09T19:32:23.365738 ...
  h_li           (spot, gran_idx, photon_idx) float32  nan nan nan nan ... nan nan na...
  latitude        (spot, gran_idx, photon_idx) float64  nan nan nan nan ... nan nan na...
  longitude       (spot, gran_idx, photon_idx) float64  nan nan nan nan ... nan nan na...
  gt              (gran_idx, spot)    object  nan nan nan ... 'gt1' 'gt1r'
v Attributes:
  data_product :  ATL06
  Description :  The land_ice_height group contains the primary set of derived ATL06 products. This in
                  cludes geolocation, height, and standard error and quality measures for each segmen
                  t. This group is sparse, meaning that parameters are provided only for pairs of segmen
                  ts for which at least one beam has a valid surface-height measurement.
  data_rate :    Data within this group are sparse. Data values are provided only for those ICESat-2 2
                  0m segments where at least one beam has a valid land ice height measurement.
```



Sustainability and governance



Maintained JupyterHub cloud compute environment



More built-in data processing (e.g. strong/weak beams, analysis)

Why should you use icepyx?

- ❖ save time and effort
- ❖ easy to install and use
- ❖ reproducible
- ❖ always get the latest data
- ❖ easily transition to the cloud
- ❖ works on the cloud and locally
- ❖ “knows” about ICESat-2 data
- ❖ be part of an expert community



How do I get involved?

- ❖ Ask questions/post a discussion
- ❖ contribute – it doesn't have to be code!
 - Report bugs
 - Improve documentation
 - Request features
 - Share your example
- ❖ Attend an upcoming coworking session
- ❖ cite your data and software

GitHub:

<https://github.com/icesat2py/icepyx>

Documentation:

<https://icepyx.readthedocs.io>

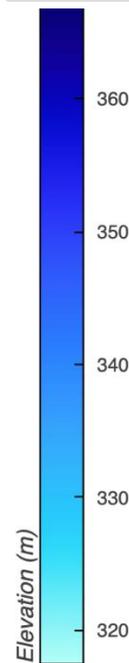
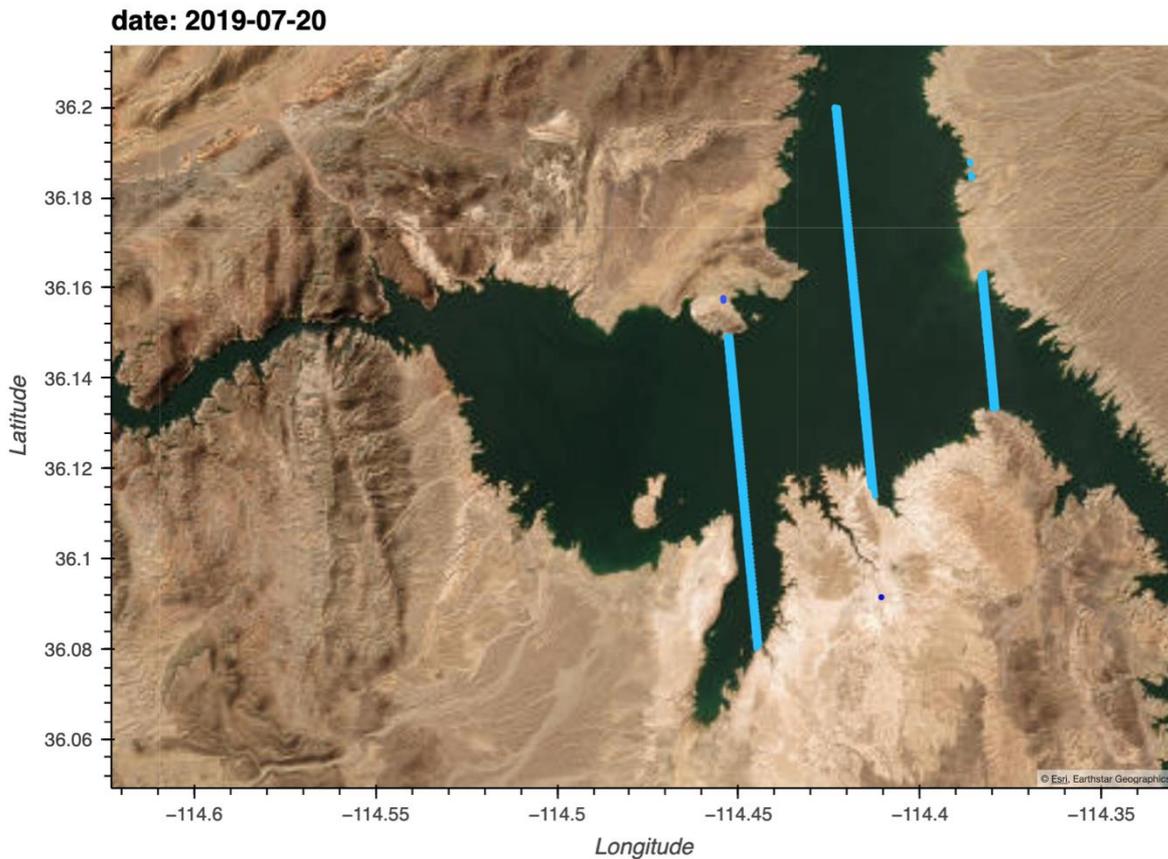


<input type="checkbox"/>	<input checked="" type="radio"/>	Loading data groups <code>ipx.Read.Load</code> can fail on certain files in edge cases	🔔 1	💬 7
		<small>#576 opened 3 weeks ago by jrenrut</small>		
<input type="checkbox"/>	<input checked="" type="radio"/>	Delegate full granule query to earthaccess, keep smart subsetting logic in icepyx		💬 2
		<small>Discussion - feedback solicited enhancement longer_contribution</small>		
		<small>#575 opened 3 weeks ago by weiji14 ↗ v2: use Harmon...</small>		
<input type="checkbox"/>	<input checked="" type="radio"/>	Document project governance	documentation	
		<small>#574 opened 3 weeks ago by mfisher87</small>		
<input type="checkbox"/>	<input checked="" type="radio"/>	Establish python version support/drop policy (SPEC0) in v2	documentation	💬 2
		<small>#569 opened 3 weeks ago by mfisher87 ↗ v2: use Harmon...</small>		
<input type="checkbox"/>	<input checked="" type="radio"/>	Refactor setter for performance and readability		
		<small>#553 opened last month by mfisher87</small>		
<input type="checkbox"/>	<input checked="" type="radio"/>	Move <code>requirements*.txt</code> files into <code>pyproject.toml</code>	enhancement	🔔 1
		<small>#552 opened last month by mfisher87</small>		💬 13
<input type="checkbox"/>	<input checked="" type="radio"/>	Add deprecation warning to icepyx v1	enhancement	🔔 1
		<small>#545 opened on Aug 8 by mfisher87 ↗ v2: use Harmon...</small>		👤
<input type="checkbox"/>	<input checked="" type="radio"/>	[harmony] components of <code>ipx.query</code> likely impacted by transition from EGI		💬 1
		<small>#534 opened on Jul 3 by JessicaS11 📄 5 tasks ↗ v2: use Harmon...</small>		
<input type="checkbox"/>	<input checked="" type="radio"/>	[harmony] [docs] variables and subsetting		
		<small>#533 opened on Jul 3 by JessicaS11 📄 5 tasks ↗ v2: use Harmon...</small>		

Demo: use icepyx to access and plot ATL13

```
spatial_extent = [-114.6, 36.06, -114.36, 36.2]  
dates = ['2019-07-01', '2025-07-30']  
track = ['341']
```

```
mead = ipx.Query('ATL13', spatial_extent, dates, tracks)
```



date

2019-07-20

https://github.com/icesat2pyx/icesat2pyx/blob/hydrology/doc/source/example_notebooks/IS2_atl13_hydrology.ipynb