

ICESat-2 Applications with *SlideRule*

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*on behalf of the SlideRule Team and ICESat-2 PSO

ICESat-2: Lasers in Space

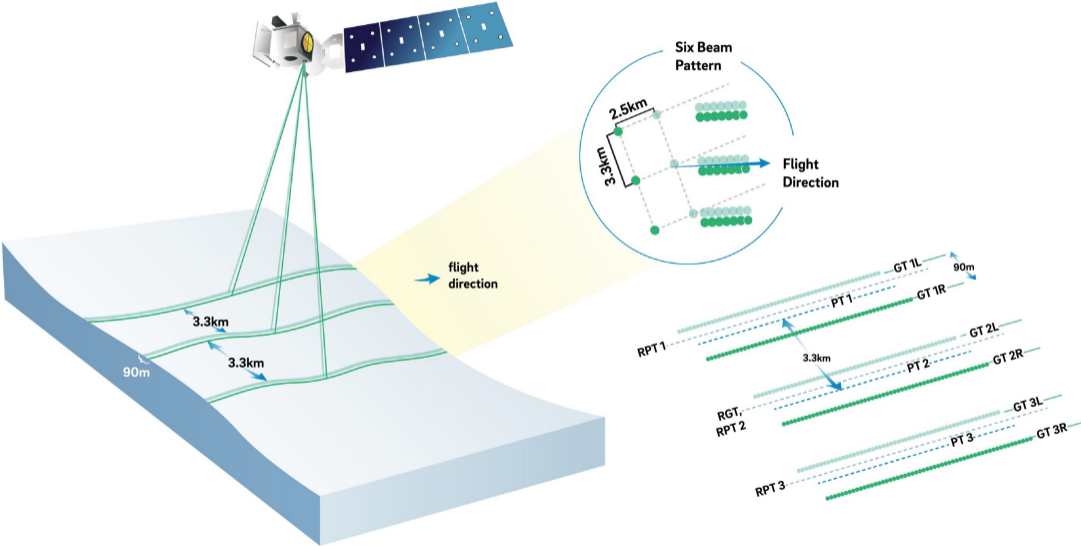
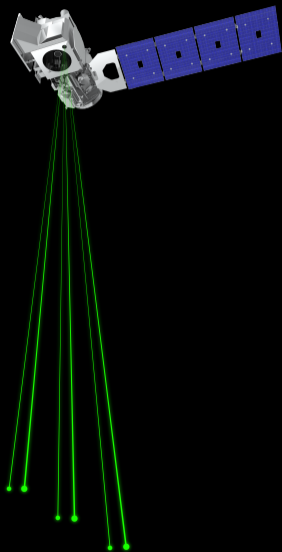


Figure 1 from Smith et al. [2019]

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
 - Assess mechanisms driving recent changes
 - Improve predictive ice sheet models
- 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

ICESat-2 Data Production: *from photons to grids*



ATLAS: Advanced Topographic Laser Altimeter System

ASAS: ATLAS Science Algorithm Software

PGE: Product Generation Executive

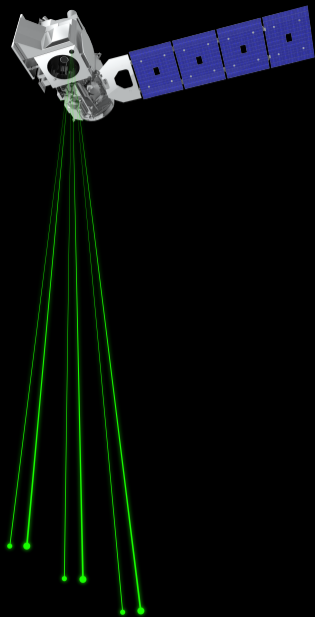
SIPS: Science Investigator-led Processing System

SCF: Science Computing Facility

SlideRule

A new way of generating data products:

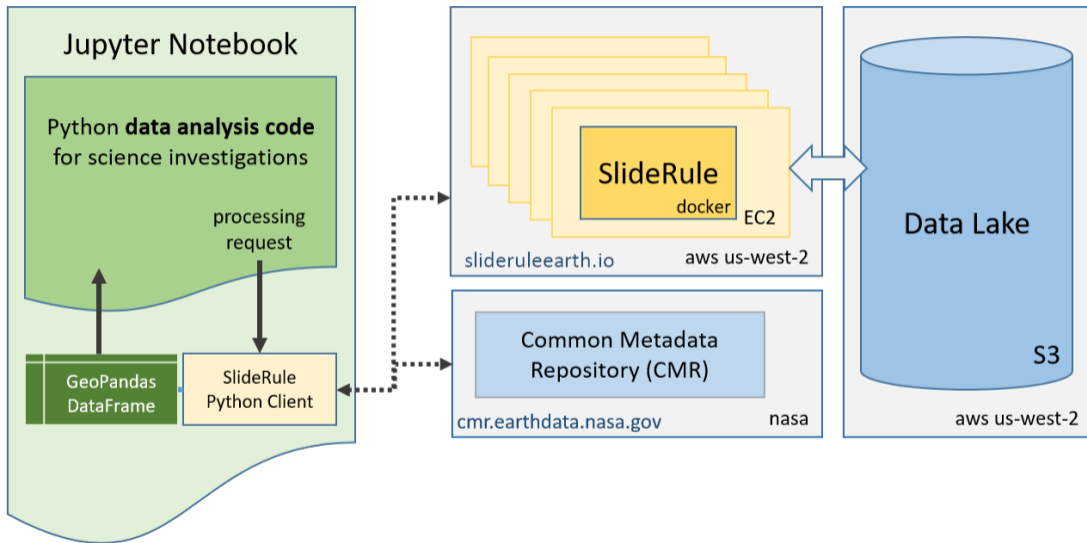
- You know what you want to have
- You decide how to process the data
- We provide a simple, fast way to do it



SlideRule Objectives

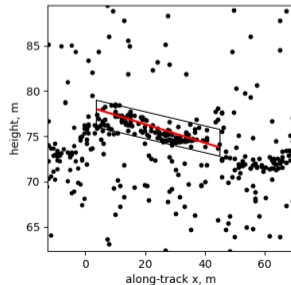
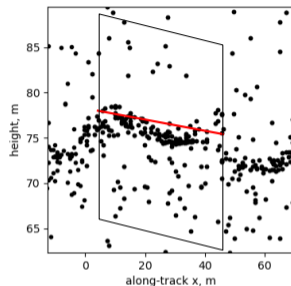
- Develop a publicly-accessible *Science Data Service*
- Make it simple and with on-demand scaling
- Do not require users to download or manage files
- Make it customizable and generalized for broader applicability to multiple science disciplines
- Minimize downtime and continuously deploy new algorithms, improvements, and fixes

How Does SlideRule Work?

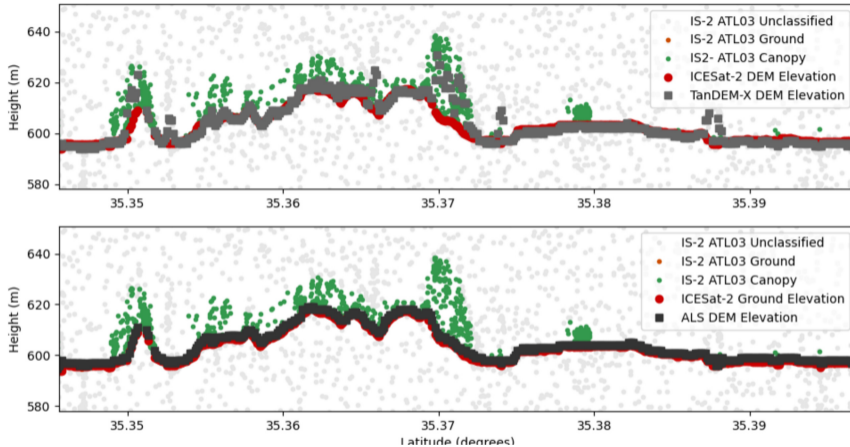


SlideRule ATLO6: *Segment Heights*

- SlideRule concentrates on the early stages of the ATLO6 surface detection algorithm
- *Slimmed down and optimized version of ATLO6:*
 1. Select ATLO3 photons
 2. Fit a sloping segment to the selected photons
 3. Calculate the spread in the residuals to the segment
 4. Select photons within a window of the fit surface
 5. Iterate until solution is stable
- Captures the effects of small-scale surface topography for signal finding
- SlideRule allows custom segment lengths and photon classification schemes for calculating the fit heights

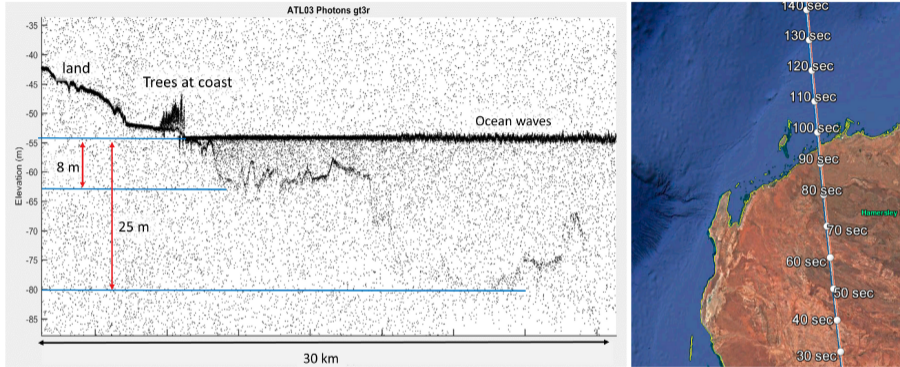


SlideRule ATLO8: *Vegetation Structure*



- SlideRule uses photon classifications from the ICESat-2 Land and Vegetation Height Product (ATLO8) to generate custom vegetation structure products

SlideRule ATL24: *Topobathymetry*



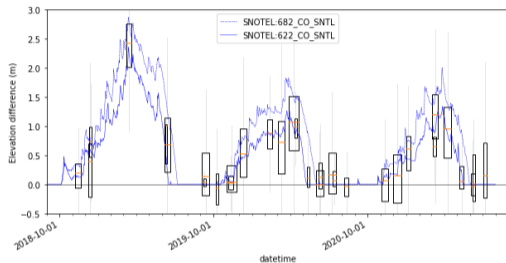
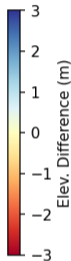
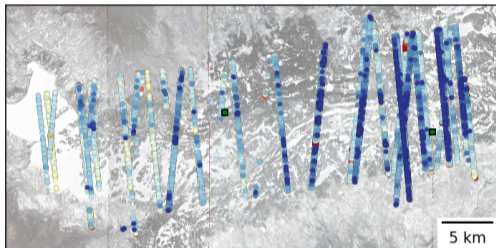
- ATLAS can provide direct bathymetric mapping up to approximately 40 m depth
- SlideRule will generate the official ICESat-2 near-shore coastal bathymetry product
 - “Gold-standard” product will be made available via NSIDC
 - Custom products can be generated using the SlideRule API

Figure 8 from Parrish et al. [2019]

Use Cases: Terrestrial Snow Cover

Hannah Besso (UW), Jessica Lundquist (UW), and David Shean (UW)

ATL06-SR (snow-on) minus ASO Snow-off DTM (2016-09-26)



- Can use ATLO3 photon classification flags in SlideRule from the ATLO8 Land and Vegetation algorithm (DRAGANN) to get the ground or snow-covered surface
- Can combine SlideRule outputs with “snow-off” lidar surveys to estimate snow heights

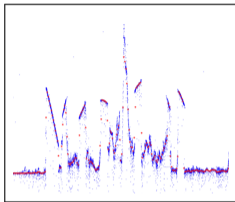
Why SlideRule?

- Shorter segment lengths for rough topography and DEM matching
- Differentiation between vegetated and ground photons

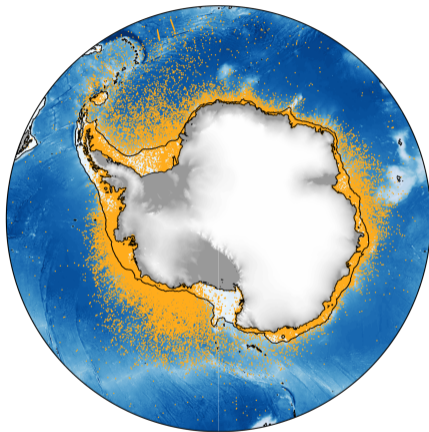
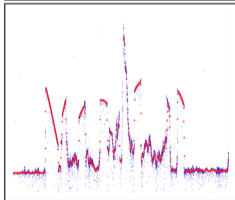
Use Cases: Icebergs

Laurie Padman (ESR) and Susan Howard (ESR)

ICESat-2 ATLO6 product
40-m resolution



SlideRule ATLO6 product
10-m resolution
YAPC classification



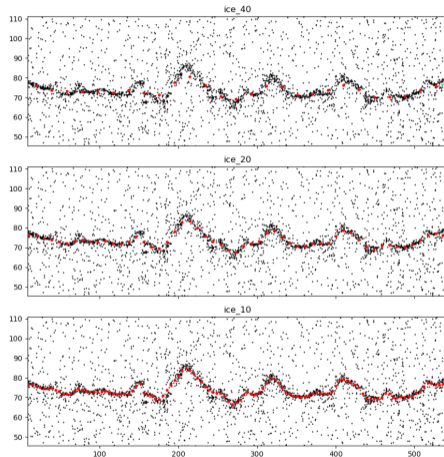
Why SlideRule?

- Shorter segment lengths for capturing iceberg topography and edges
- Freeboard estimates suitable for icebergs
- Detect heights in the open ocean away from standard product masks

Use Cases: Glacier Crevasses and Rough Surfaces

Ben Smith (UW), Tyler Sutterley (UW), and Kristin Poinar (UBuffalo)

- ATLO6 strikes a balance between data volume, accuracy, and resolution, using overlapping 40-m segments
- SlideRule lets us tune the fit algorithm to use shorter segment lengths → can explore variations and advection of crevasses with ICESat-2
- **Example on right:** Photon and estimated segment heights for a weak beam over a rough surface on Byrd Glacier

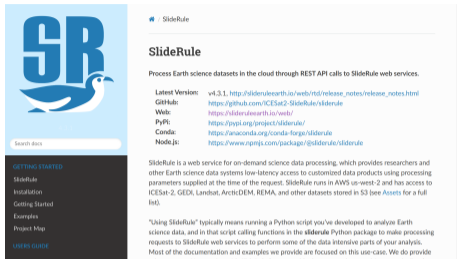


Why SlideRule?

- Shorter segment lengths for capturing rough topography
- Tunable parameters for classifying photon signal probability

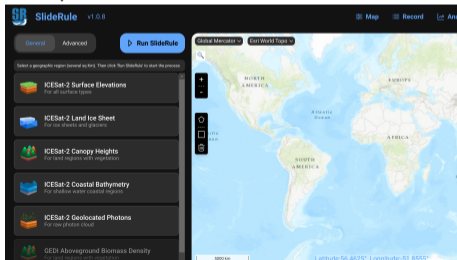
SlideRule Summary

- **Cost Effective:** Near-zero costs incurred when not in use, and ability to scale on-demand
- **Responsive Results:** Results returned quickly so that users don't lose focus (seconds to minutes)
- **Well-documented APIs:** Publicly accessible documentation, examples and web client
- **Continuous Deployment:** Limit downtime and enable new functionality
- **Dataset Integration:** ICESat-2, GEDI, rasters (e.g. ArcticDEM and REMA), and more...
- **Open Access:** Science quality algorithms *for all*



The screenshot shows the GitHub repository for SlideRule. At the top left is the SlideRule logo, which consists of the letters 'SR' in a stylized blue font above a white silhouette of a bird in flight. Below the logo is a search bar. To the right of the logo, the repository name 'SlideRule' is displayed. Underneath, there is a description: 'Process Earth science datasets in the cloud through REST API calls to SlideRule web services.' This is followed by metadata for the latest version (v4.3.1), including links to the GitHub repository, the web interface, and installation instructions for PyPi and Conda. A 'README' section follows, explaining that SlideRule is a web service for on-demand science data processing, providing researchers with low-latency access to customized data products. It lists supported datasets like ICESat-2, GEDI, Landsat, ArcticDEM, and REMA. A final section titled 'Using SlideRule' explains that it typically involves running a Python script that uses the SlideRule Python package to make processing requests to the web services.

<https://slideruleearth.io/web/rtd>



The screenshot shows the SlideRule web interface. At the top, there is a navigation bar with the SlideRule logo, the text 'SlideRule v1.0.8', and buttons for 'Map', 'Record', and 'Add'. Below the navigation bar, there are two tabs: 'General' and 'Advanced'. A prominent blue button labeled 'Run SlideRule' is visible. The main content area is a list of dataset options, each with a small icon and a description: 'ICESat-2 Surface Elevations', 'ICESat-2 Land Ice Sheet', 'ICESat-2 Canopy Heights', 'ICESat-2 Coastal Bathymetry', 'ICESat-2 Geolocated Photons', and 'GEDI Aboveground Biomass Density'. To the right of the dataset list is a map of the world with a 'Global Mercator' projection. The map shows the continents and is currently centered on the Atlantic Ocean. The map interface includes zoom controls and a coordinate display at the bottom right showing 'Latitude: 56.4629°, Longitude: 51.8555°'.

<https://demo.slideruleearth.io>

Thanks for listening!

Website: <https://slideruleearth.io>

GitHub Organization: <https://github.com/SlideRuleEarth>

Documentation: <https://slideruleearth.io/web/rtd/>

Contact Us! Feedback, bug reports, feature requests welcome!

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