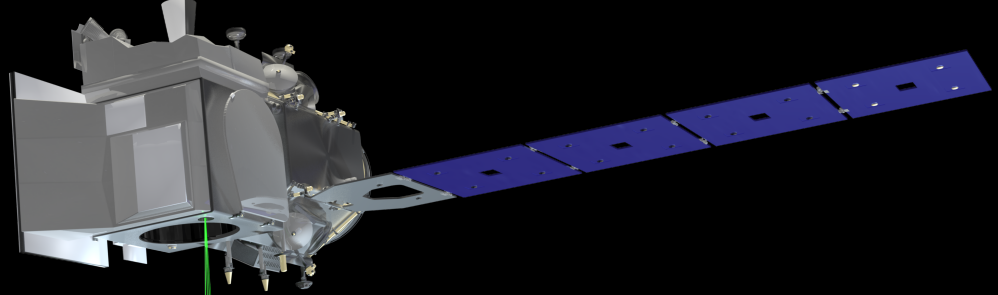


ICESat-2 Applications with *SlideRule*

Tyler Sutterley*
JP Swinski
email: tsutterl@uw.edu

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

ICESat-2: Lasers in Space

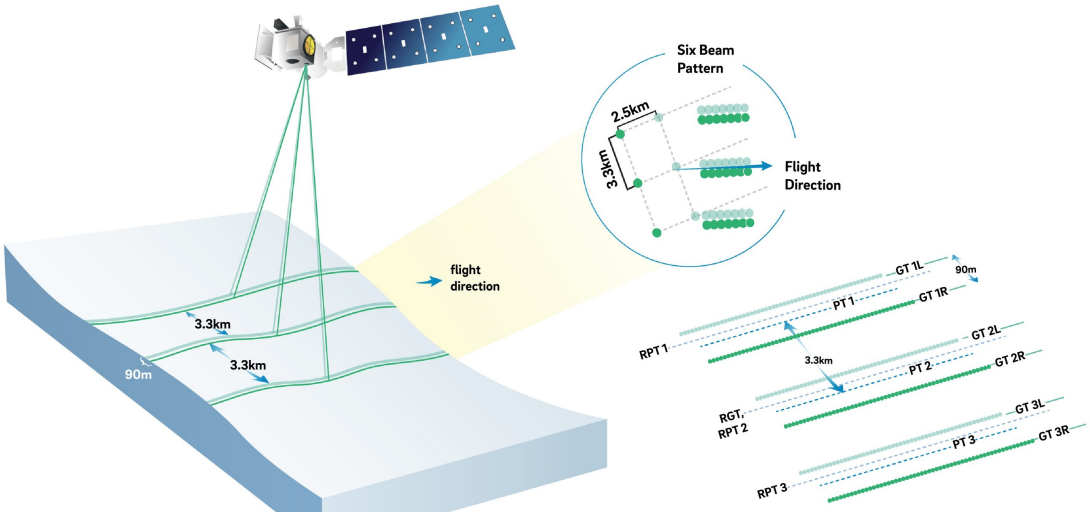
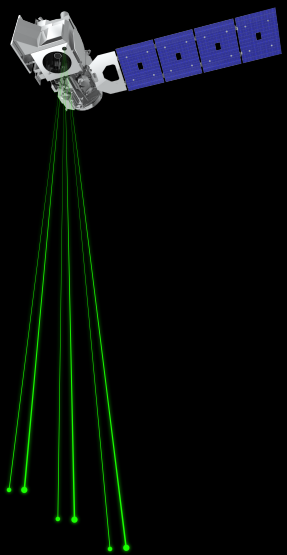


Figure 1 from Smith et al. [2019]

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

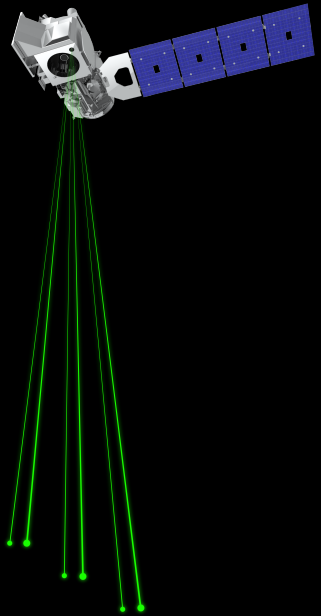
SIPS: Science Investigator-led Processing System

SCF: Science Computing Facility

SlideRule

A new way of generating data products:

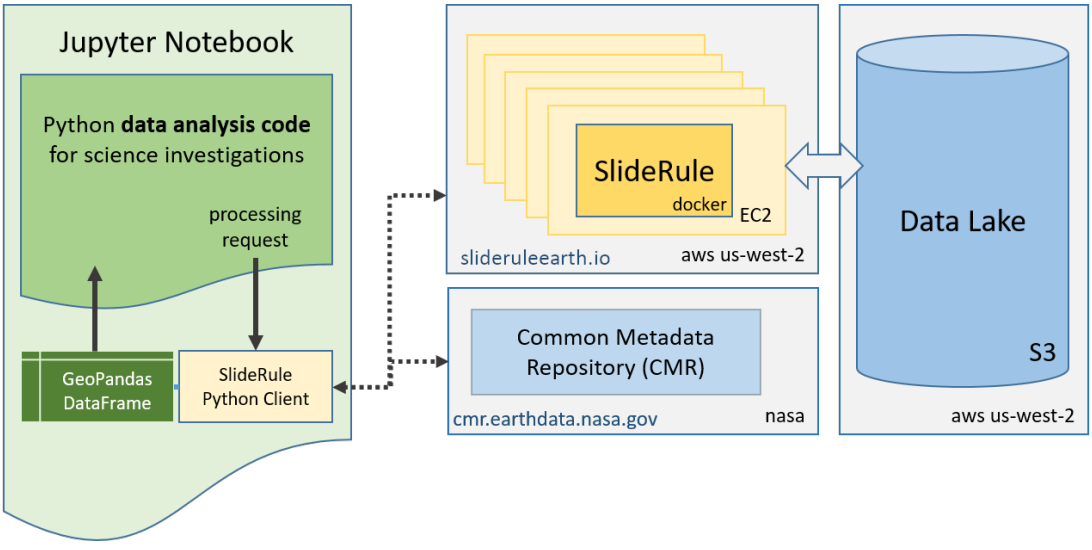
- You know what you want to have
- You decide how to process the data
- We provide a simple, fast way to do it



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

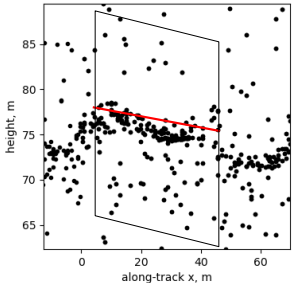
How Does SlideRule Work?

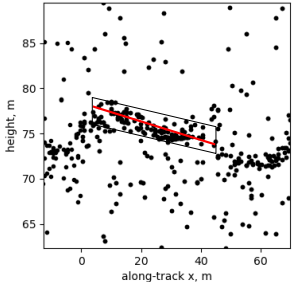


JP Swinski, NASA GSFC

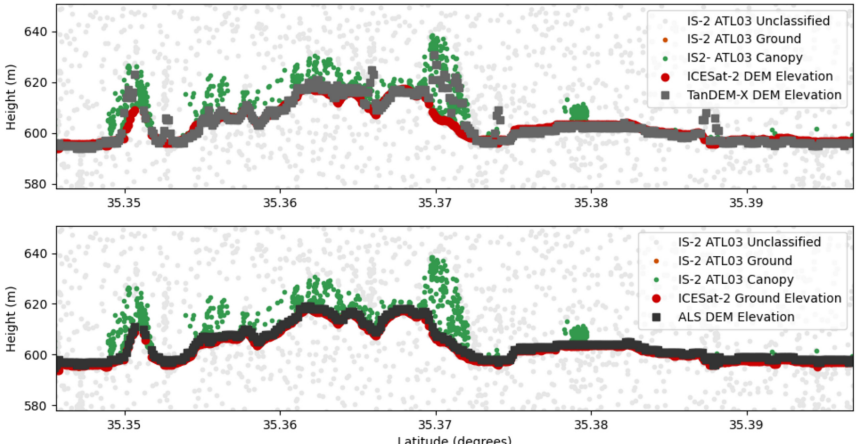
SlideRule ATL06: *Segment Heights*

- SlideRule concentrates on the early stages of the ATL06 surface detection algorithm
- *Slimmed down and optimized* version of ATL06:
  1. Select ATL03 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





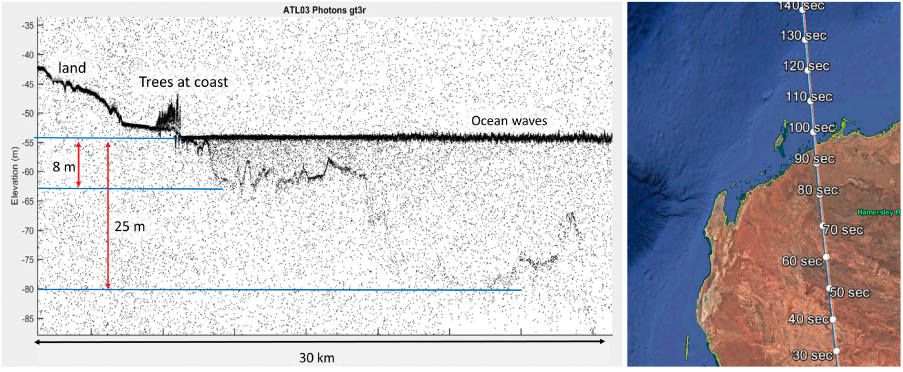
SlideRule ATL08: *Vegetation Structure*



- SlideRule uses photon classifications from the ICESat-2 Land and Vegetation Height Product (ATL08) to generate custom vegetation structure products

Figure 3 from Guenther et al. [2024]

SlideRule ATL24: *Topobathymetry*

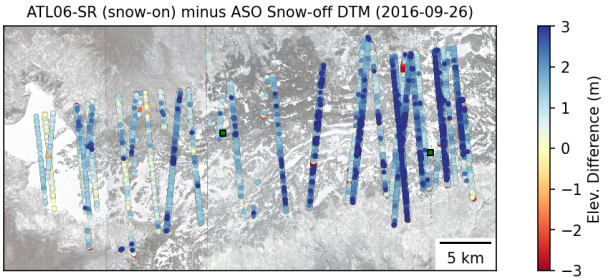


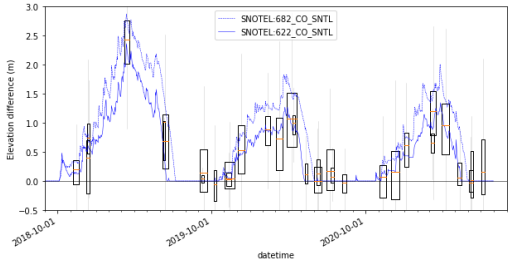
- ATLAS can provide direct bathymetric mapping up to approximately 40 m depth
- SlideRule will generate the official ICESat-2 near-shore coastal bathymetry product
  - "Gold-standard" product will be made available via NSIDC
  - Custom products can be generated using the SlideRule API

Figure 8 from Parrish et al. [2019]

Use Cases: Terrestrial Snow Cover

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





- Can use ATL03 photon classification flags in SlideRule from the ATL08 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

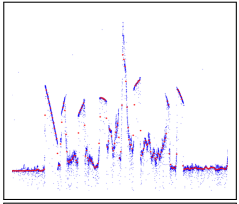
Why SlideRule?

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

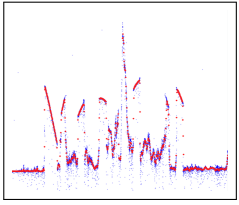
Use Cases: Icebergs

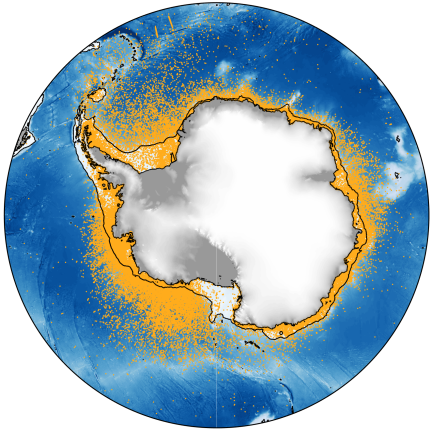
Laurie Padman (ESR) and Susan Howard (ESR)

ICESat-2 ATL06 product
40-m resolution



SlideRule ATL06 product
10-m resolution
YAPC classification





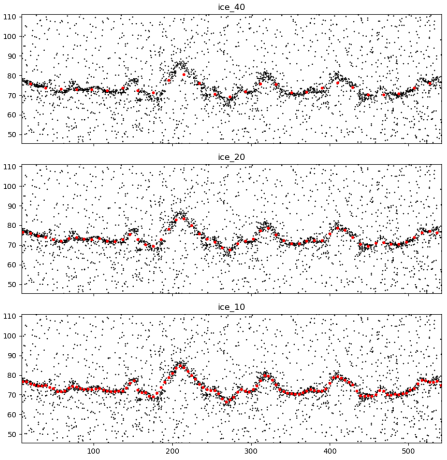
Why SlideRule?

- 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)

- ATL06 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



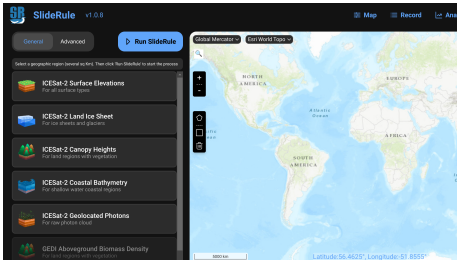
Why SlideRule?

- 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*

https://slideruleearth.io/web/rtd



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!
Private Clusters:	Available for large processing jobs and custom algorithms