ICESat-2 data products

Ben Smith

ICESat-2 HackWeek 2020

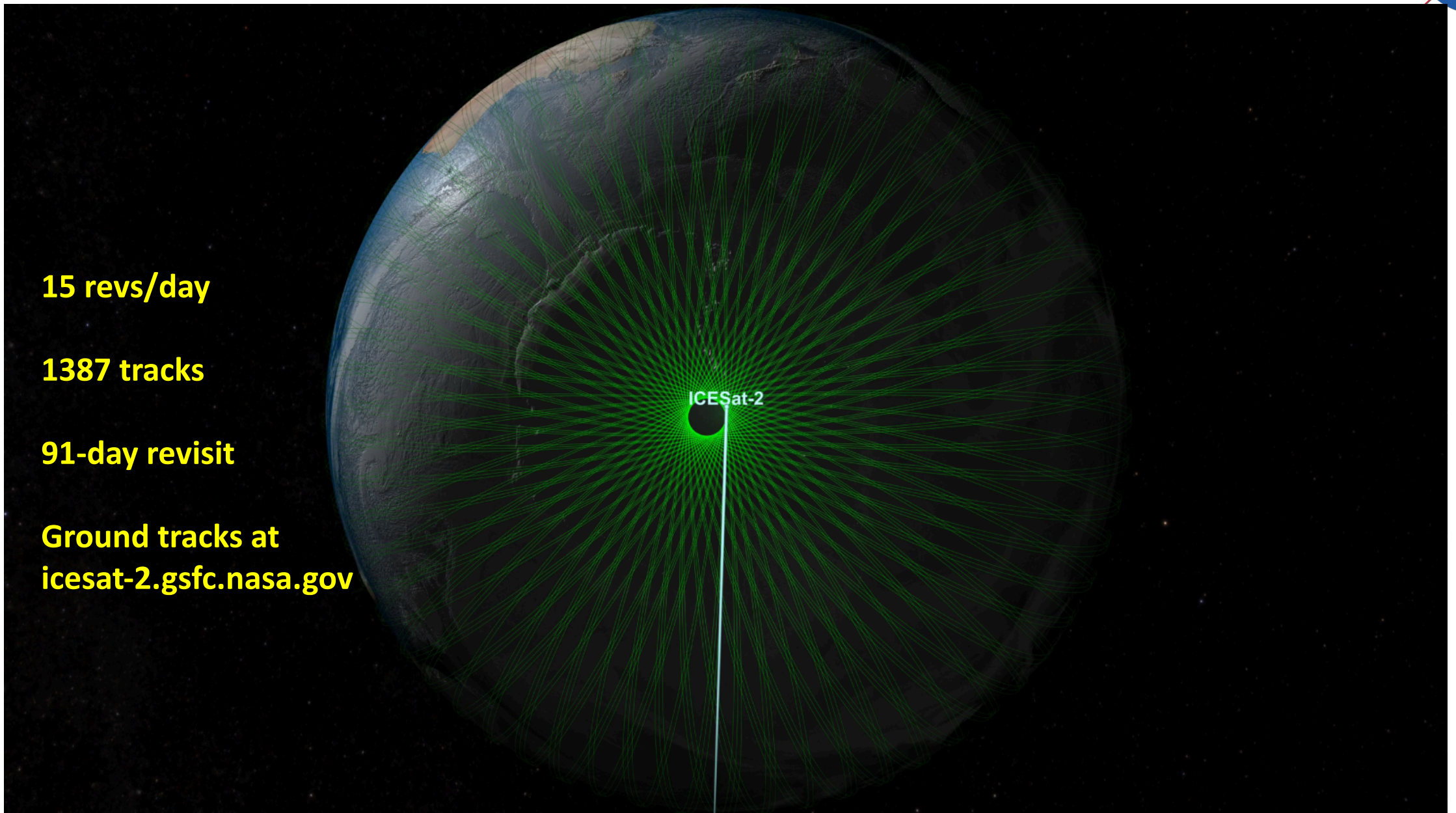
6/8/2020

Outline

- Information common to all data products
  - Timeline of data acquisition
  - ICESat-2 beams and spots
  - Orbital segments and file-naming conventions

- A brief tour of data products
  - Land-ice products
  - Sea-ice products
  - Atmospheric products

Orbit and Coverage



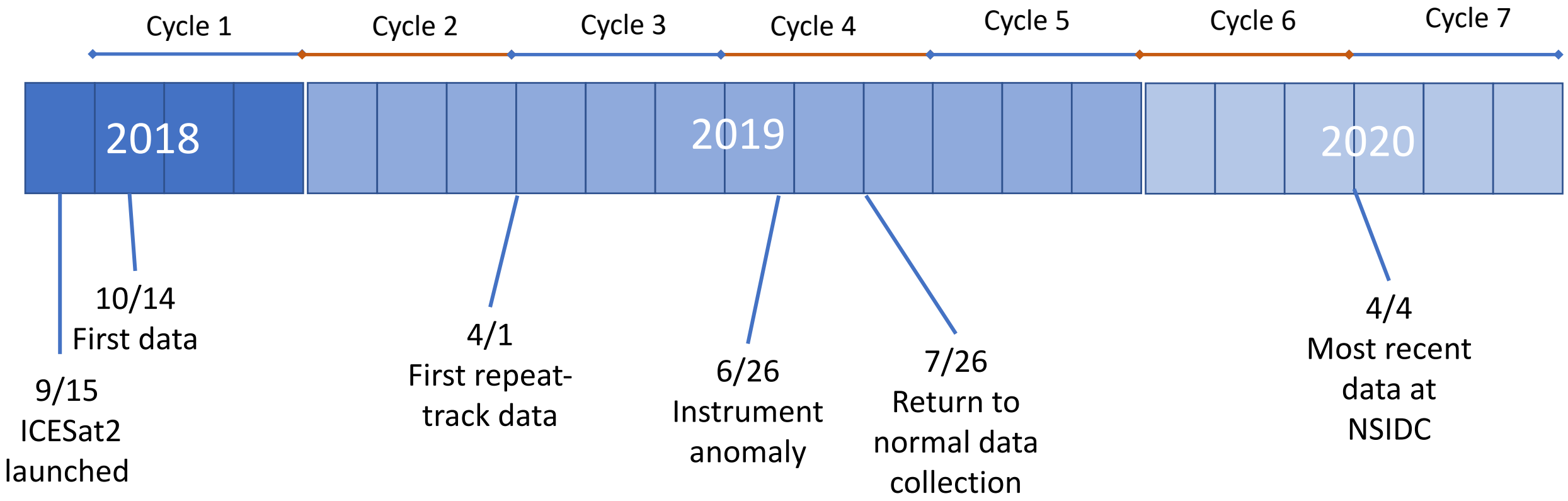
15 revs/day

1387 tracks

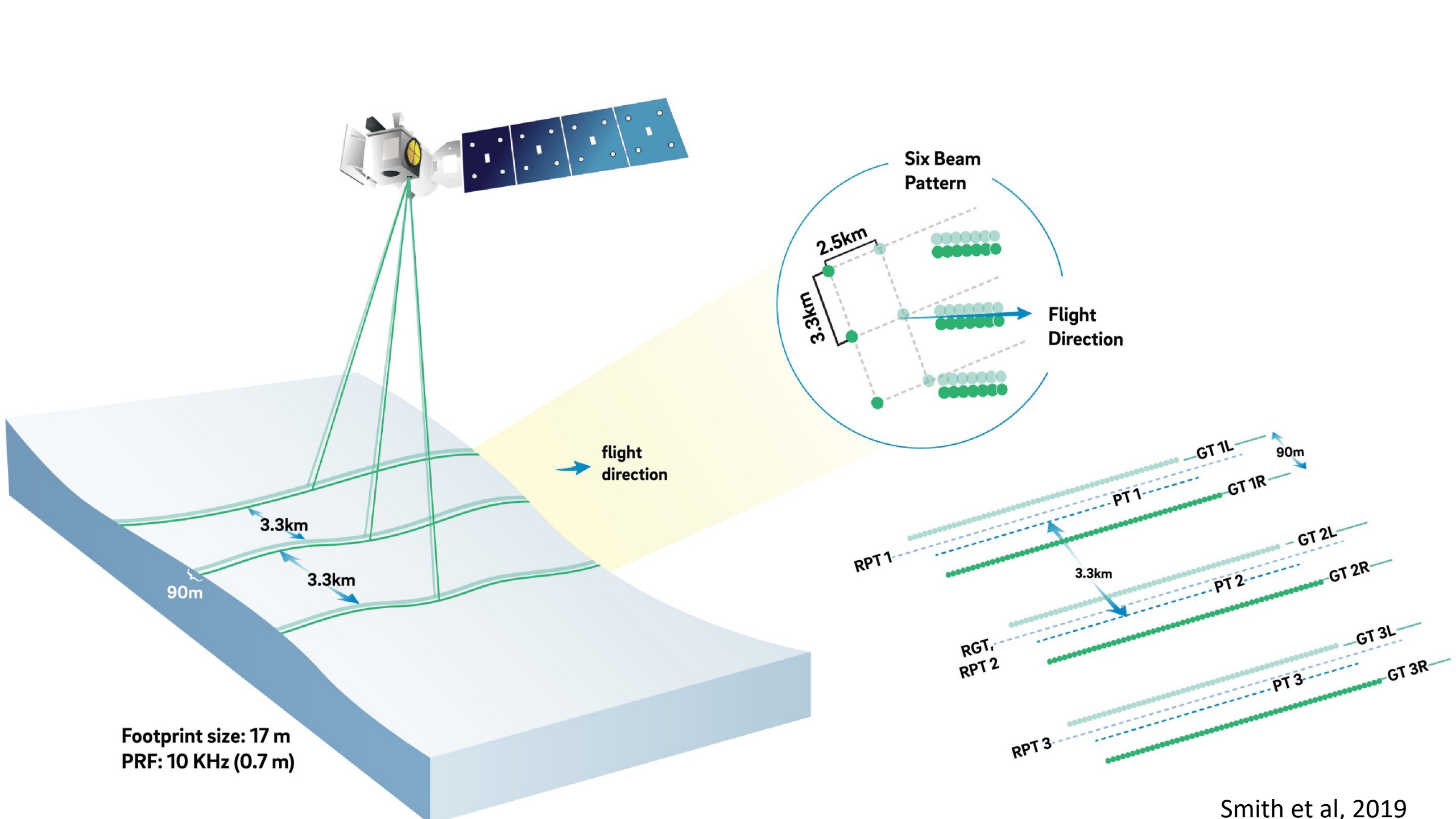
91-day revisit

Ground tracks at
icesat-2.gsfc.nasa.gov

ICESat-2 data timeline



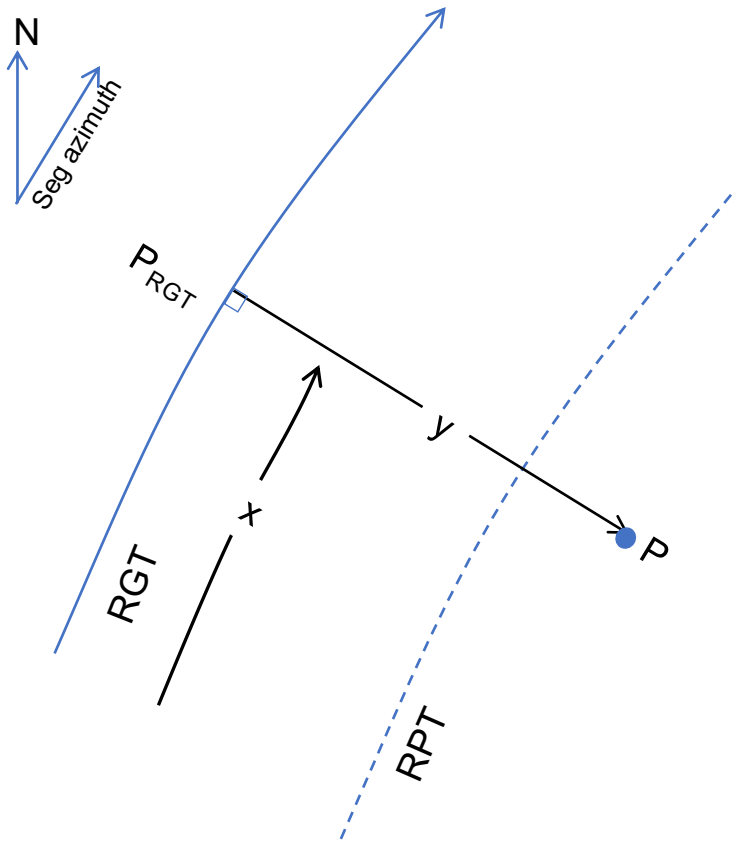
- Non-repeat orbits are available:
  - 10/14/2018 to to 4/1/2019
- Repeat-mode data are available:
  - 3/1/2019 to 6/26/2019
  - 7/26 2019 to present



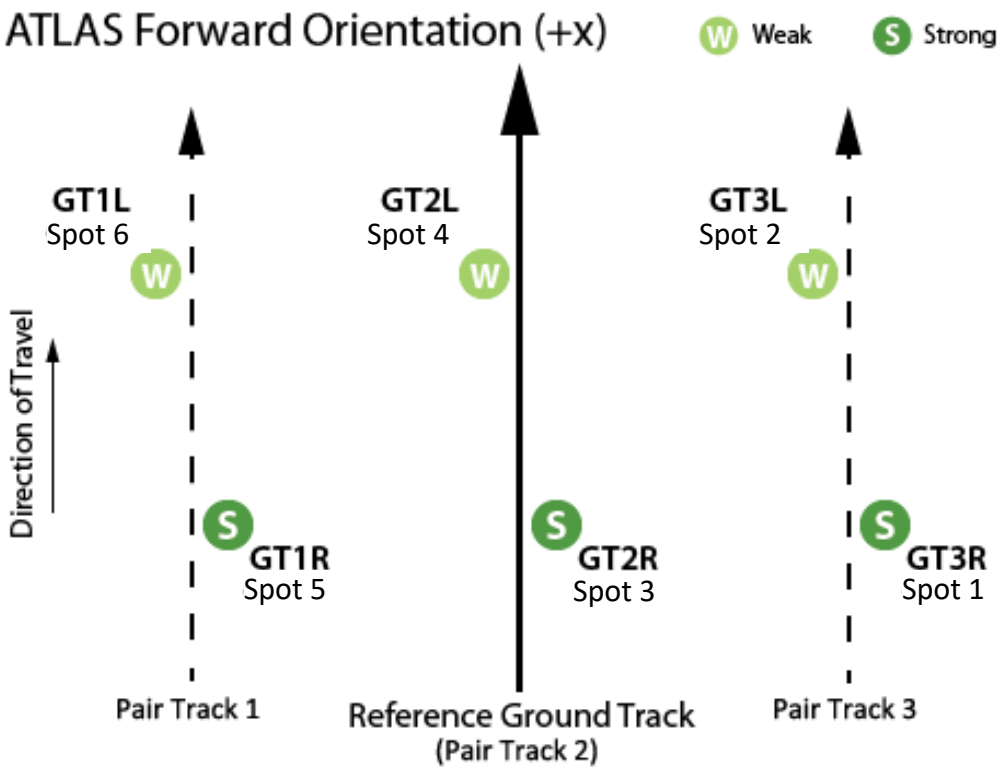
Smith et al, 2019

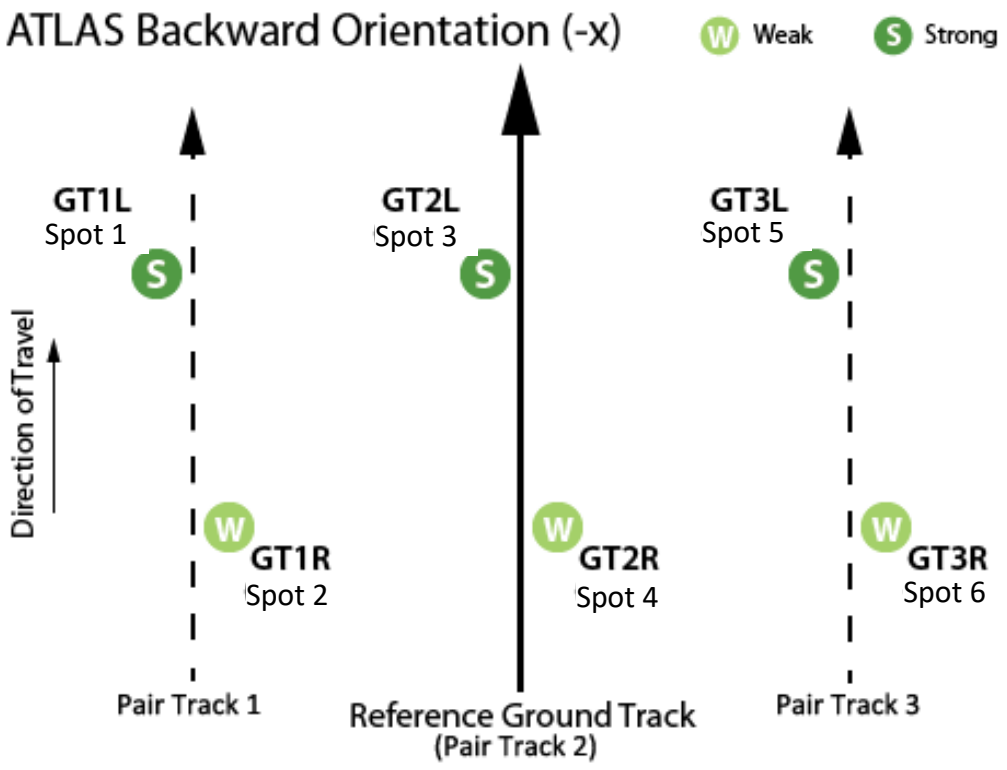
Along and across-track coordinates

- Along-track coordinates (x_rgt) are measured parallel to each reference ground track, starting at the equator, heading North:
  - 0: First equator crossing
  - ~ 6500 km: Southern Greenland, heading north
  - ~10,000 km : Polehole North
  - ~13,000 km : Southern Greenland, heading south
  - ~27,000 km: Northern Antarctica, heading south
  - ~30,000 km : Southern polehole
  - ~33,000 km: Northern Antarctica heading north
- Across-track coordinates (y_rgt) are measured perpendicular to the RGT, to the left:
  - Gt1x: +3200 m
  - Gt2x : ~0 m
  - Gt3x : -3200 m



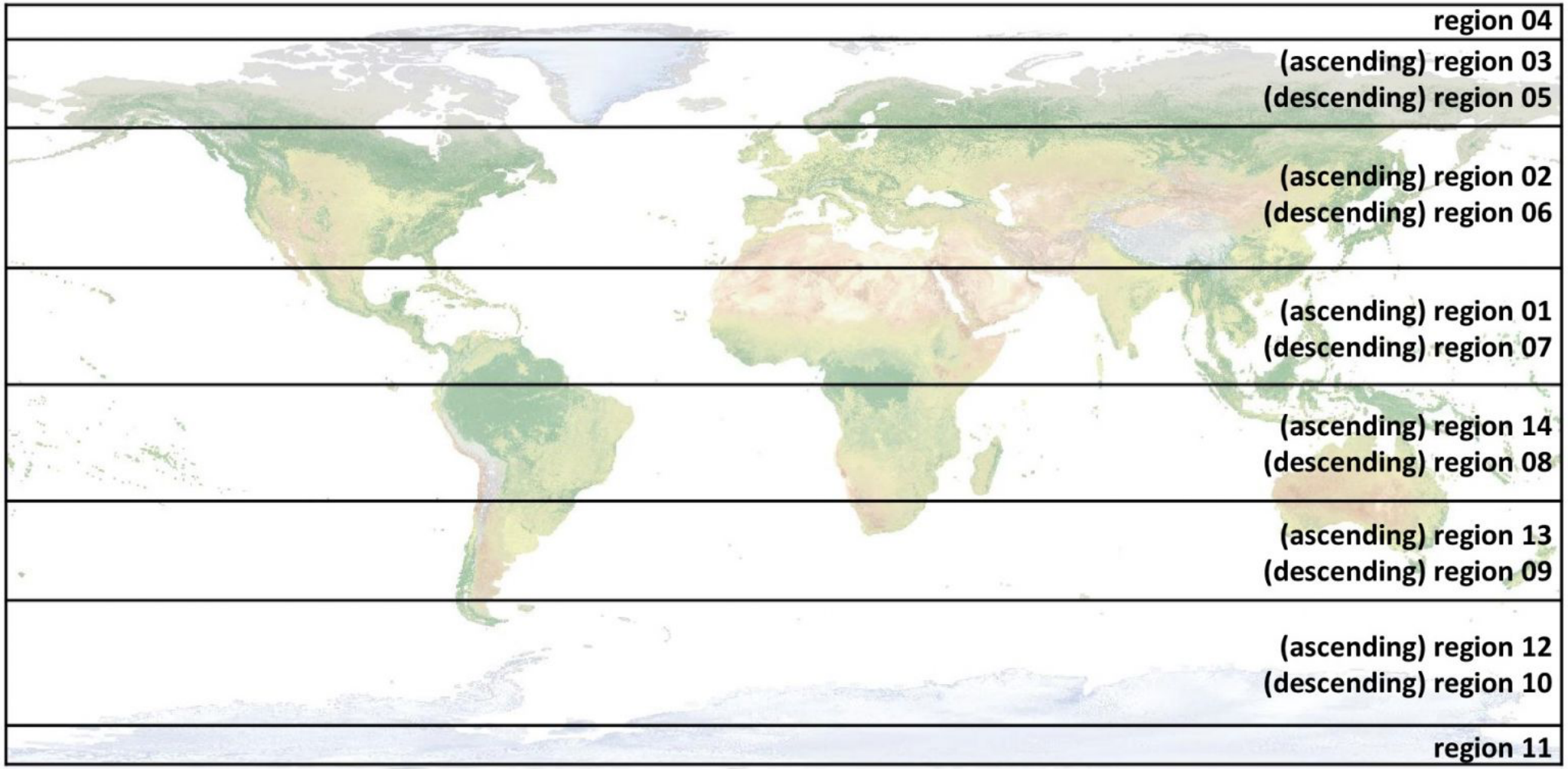
ICESat-2 in its two orientations





Credit: NSIDC

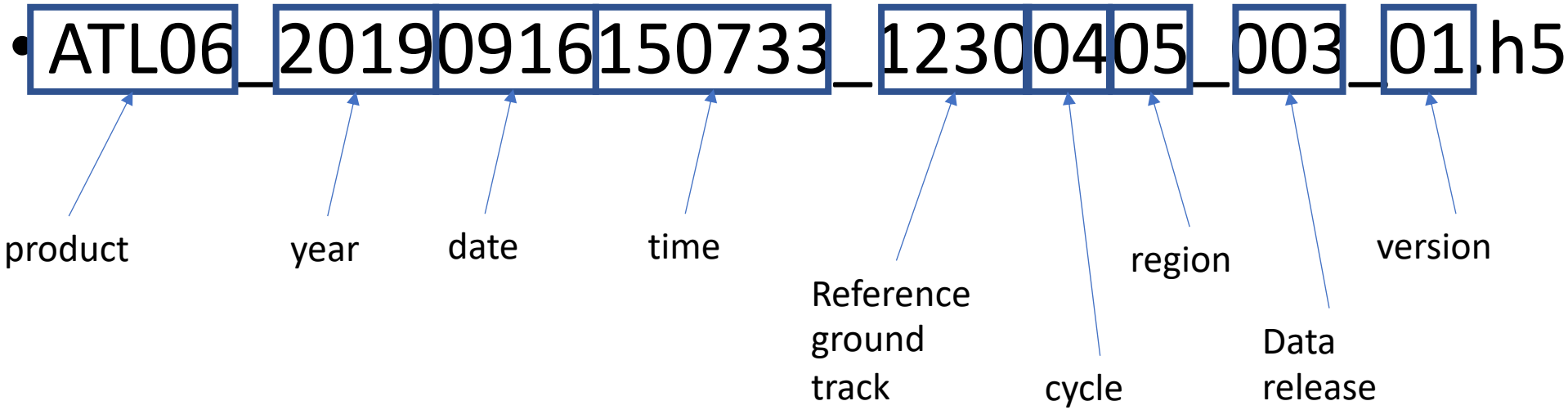
General considerations for along-track products: regions

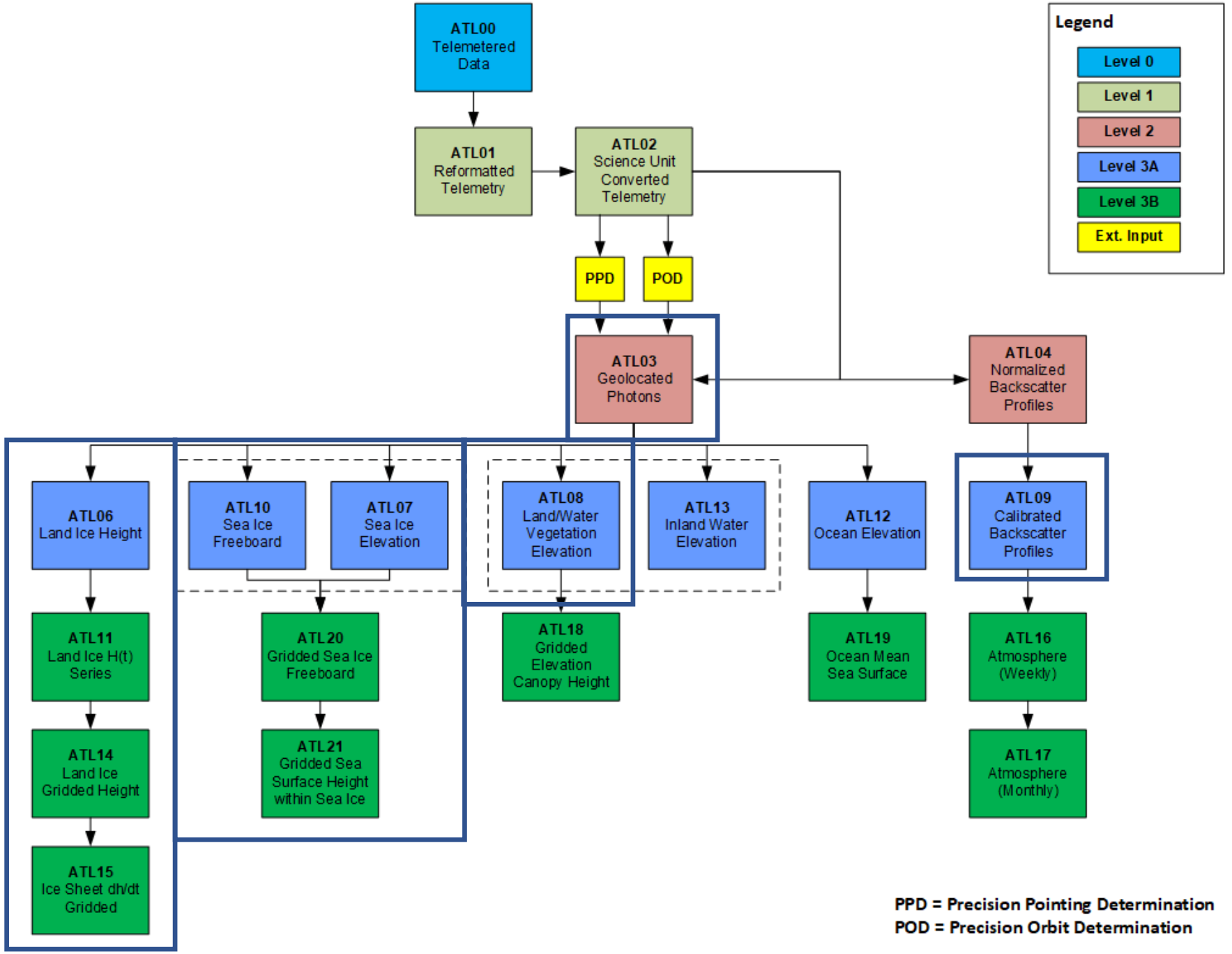


Credit: Kaitlin Harbeck

General considerations for along-track products: File-naming conventions

- File names tell a lot about each product:





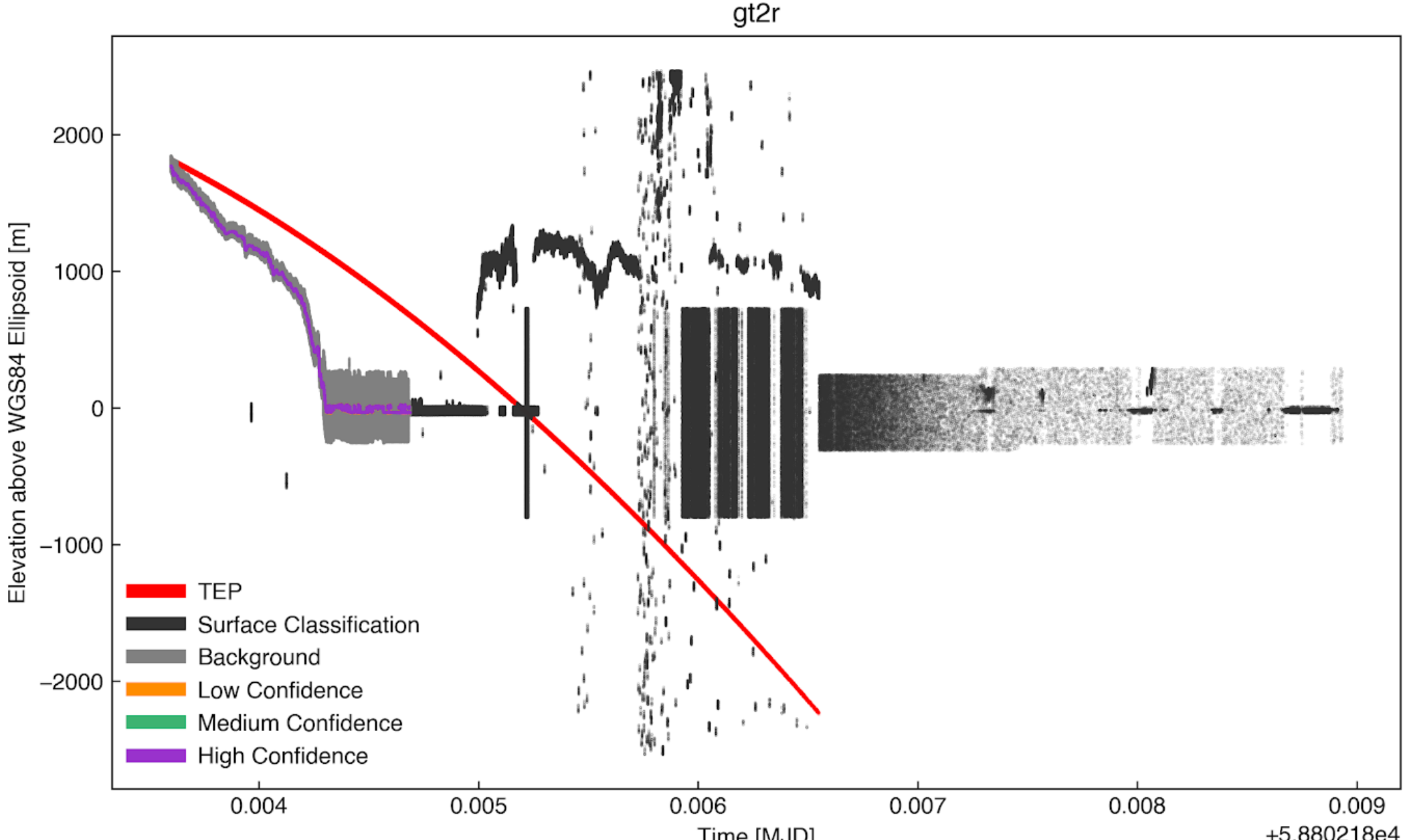
Credit: NSIDC

ATL03- geolocated photons

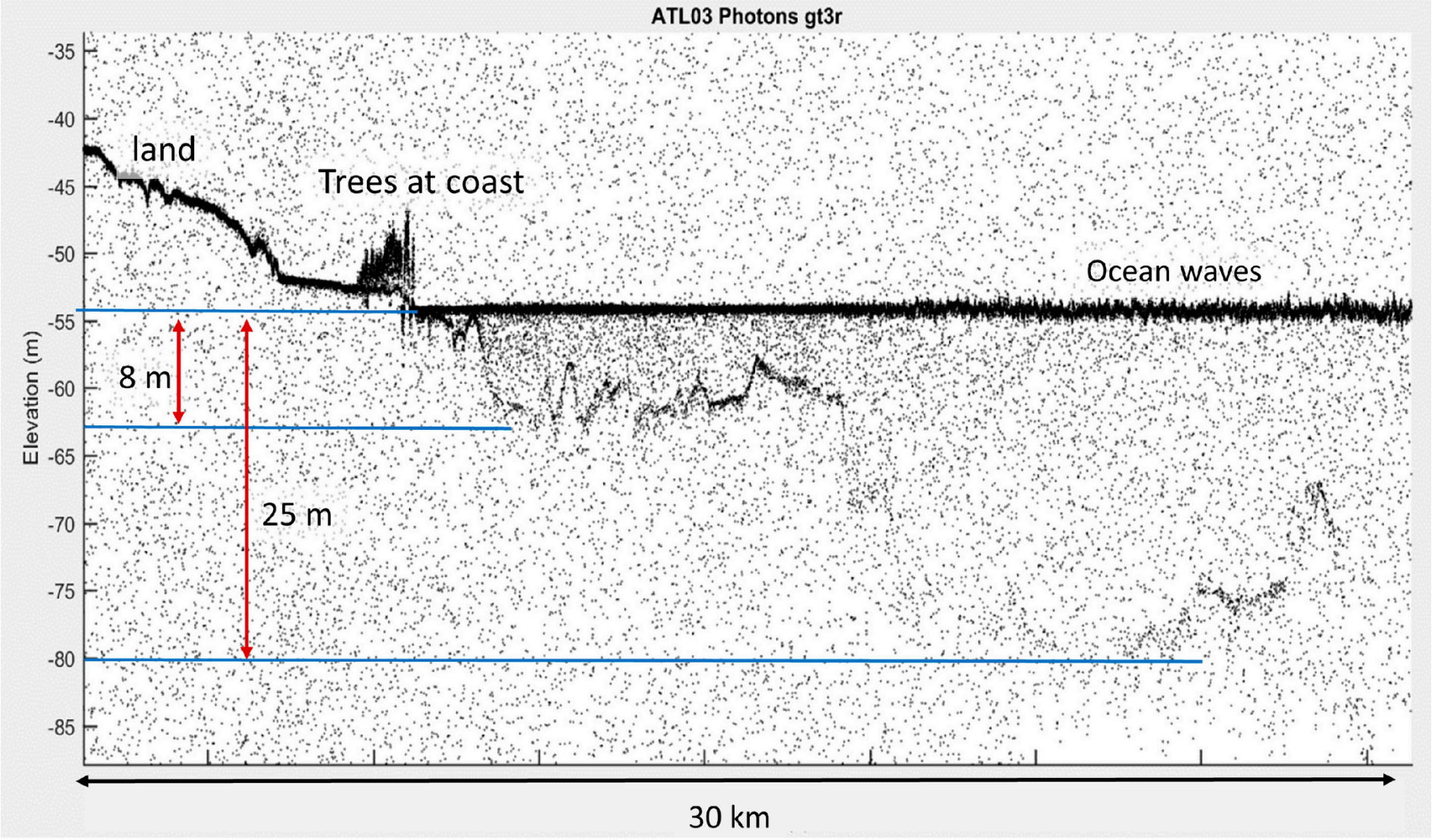
AKA: **The Big One**

- Contains
  - Latitude, longitude, and elevation for photons telemetered form ATLAS
  - Photon classifications for different surface types
  - Tides and atmospheric corrections
  - Instrumental parameters
- Advantages:
  - Every photon is there, and every parameter
- Disadvantages:
  - Same as advantages: This is a large and complex product
- Use it if:
  - You want to understand where other products come from
  - You want to look at surfaces at a scale than that resolved on higher-level products
  - You have lots of storage space and lots of time

ATL03 example: Big, complex data

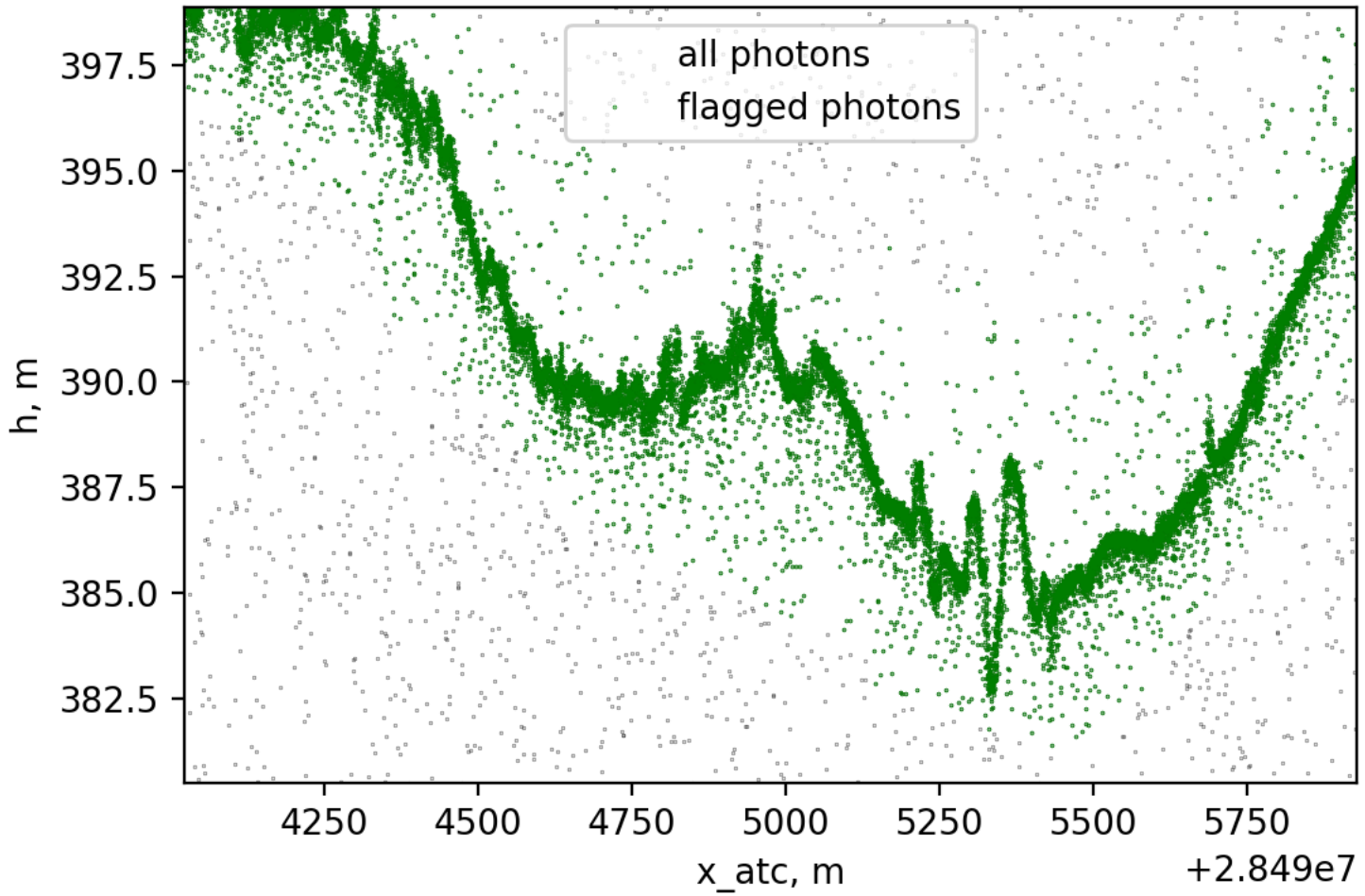


ATL03: Bathymetry



Credit: Parish et al, 2019

ATL03: Complex glacier surfaces

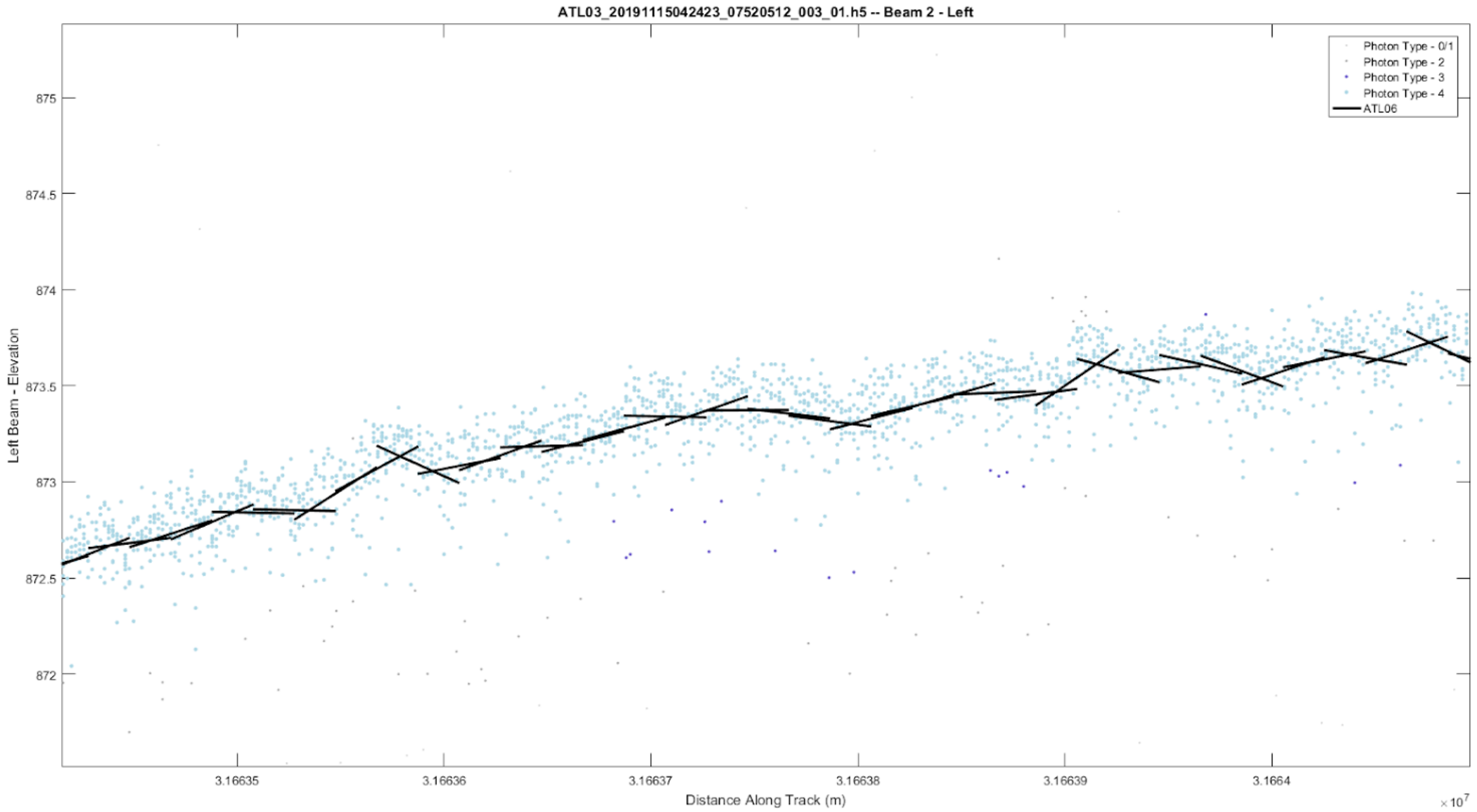


ATL06: Land-ice height

AKA: lots of little lines

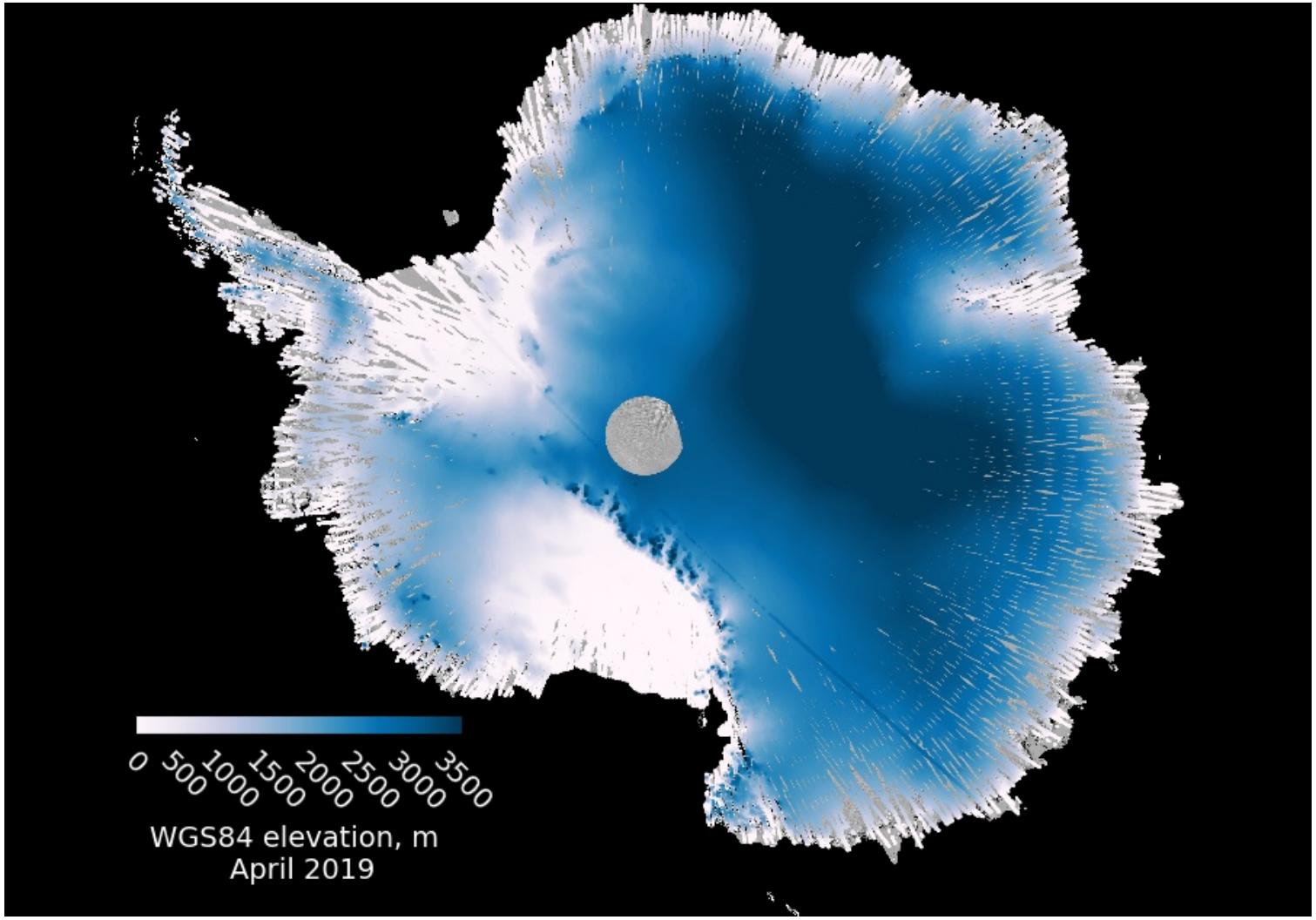
- Contains:
  - 40-meter linear segments fit to land-ice photons (slopes and heights)
  - Error estimates
  - Tides and instrumental corrections
  - Segment quality parameters
- Advantages:
  - Lighter product than ATL03
  - Provides surface heights (not just photon heights)
  - Provides repeatable parameters (can be compared from cycle to cycle)
- Disadvantages:
  - 40-m resolution is too coarse for some applications (crevasses, bare rock)
  - 40-m resolution is too fine for some large-scale studies
- Use it if:
  - You want to make large-scale repeatable measurements of glaciers

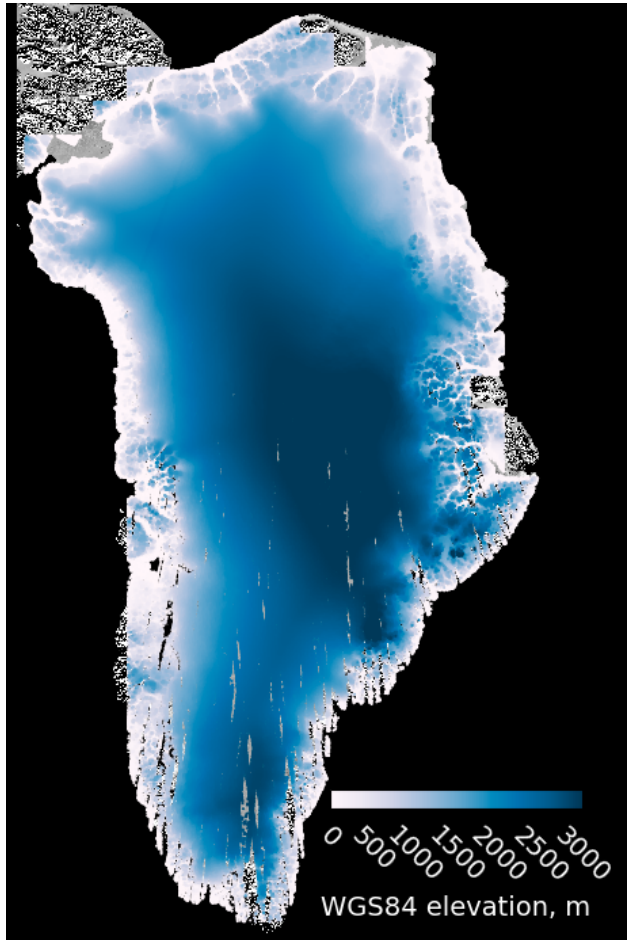
ATL06 example: along-track slopes



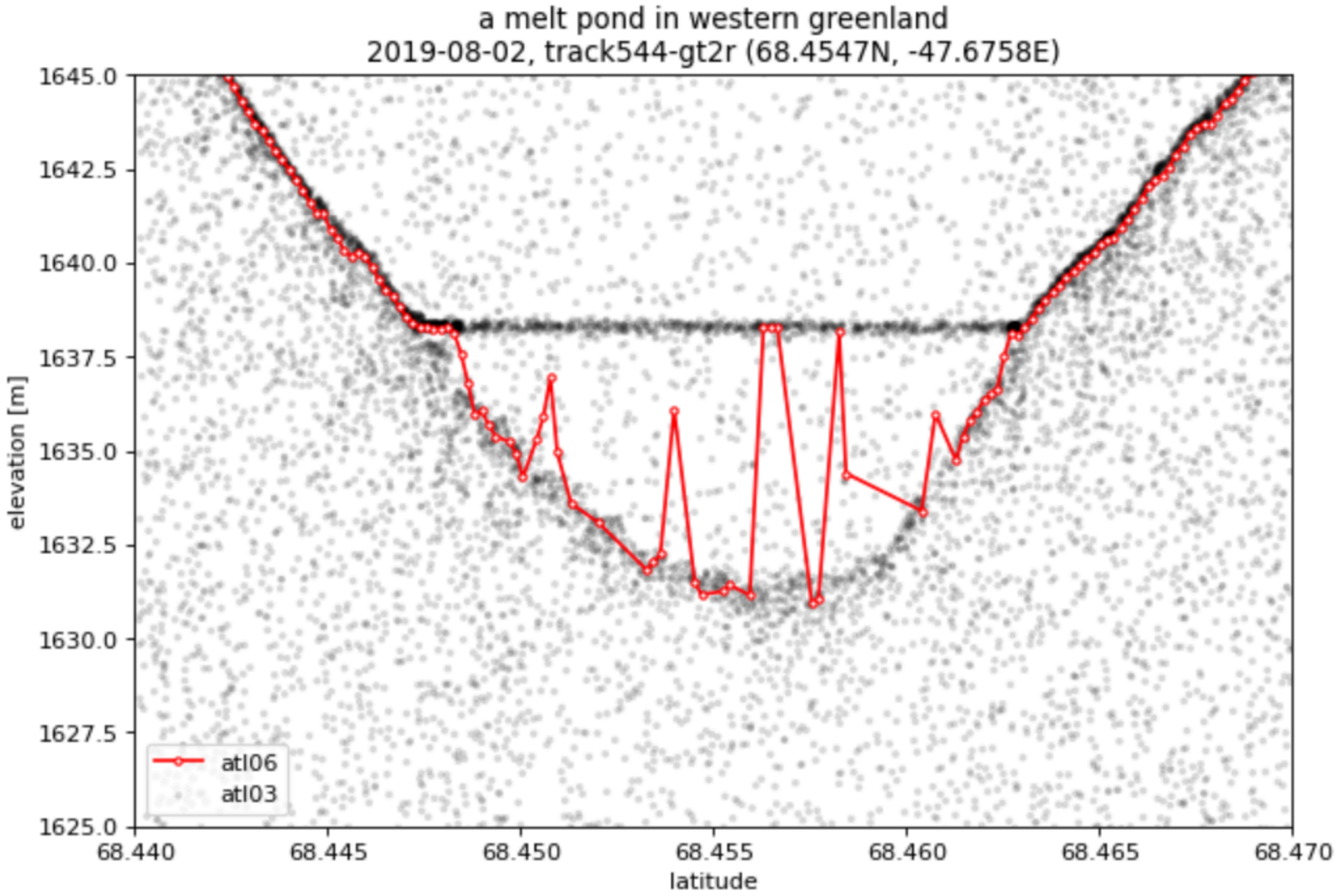
Credit: Holschuh / Sutterley

ATL06: Mapping the ice sheets in a soothing blue haze





ATL06 example: problems with surface water in Greenland



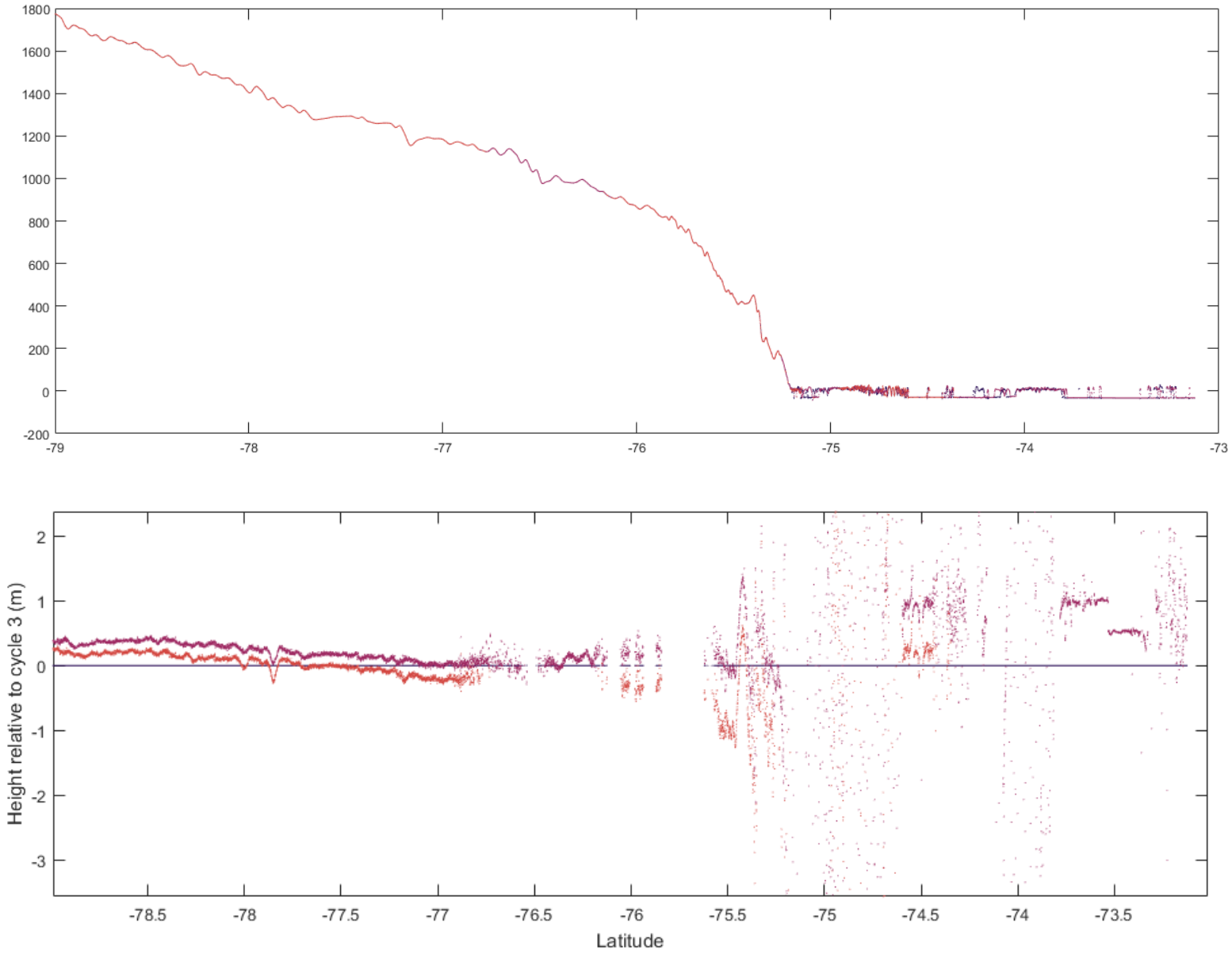
Credit: Philipp Arndt

ATL11: Land-ice H(t) [Future product]

AKA: Like ATL06, but easier

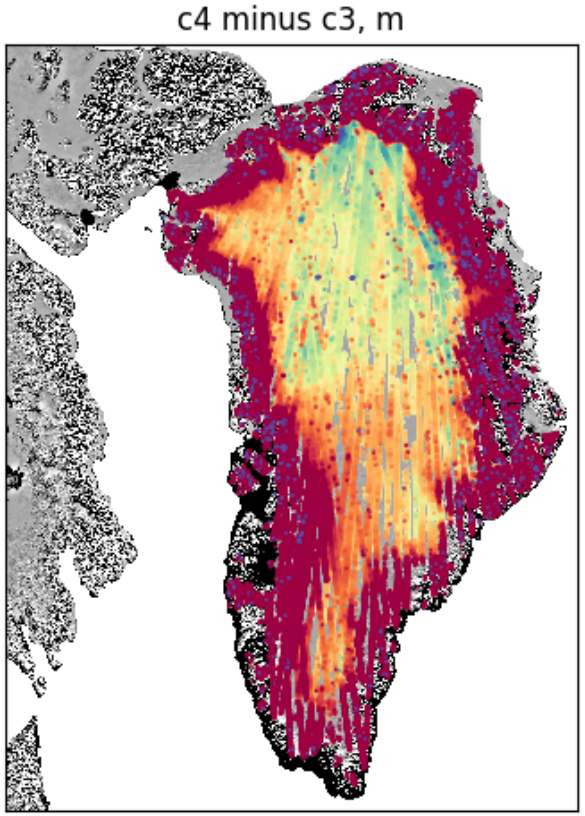
- Provides:
  - Repeat measurements of glacier surfaces, corrected for across-track displacements, accumulated over reference tracks
  - Quality and error assessments
- Advantages:
  - Brings together multiple repeats of ATL06, removes signals that are not related to elevation change
  - Smaller, easier-to-use product than ATL06
- Disadvantages:
  - Loss of detail relative to ATL06 (fewer paramters)
  - May not work well over very complex surfaces
  - Not yet released (should be available through NSIDC later this summer)
- Use it if:
  - You want to measure large-scale glacier change

ATL11 example: Elevation and elevation change

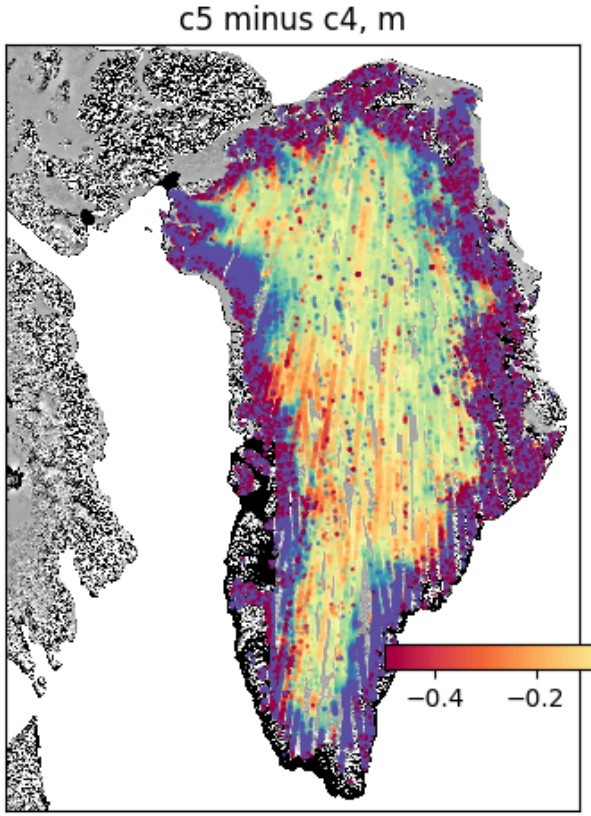


Credit: Holschuh / Sutterley

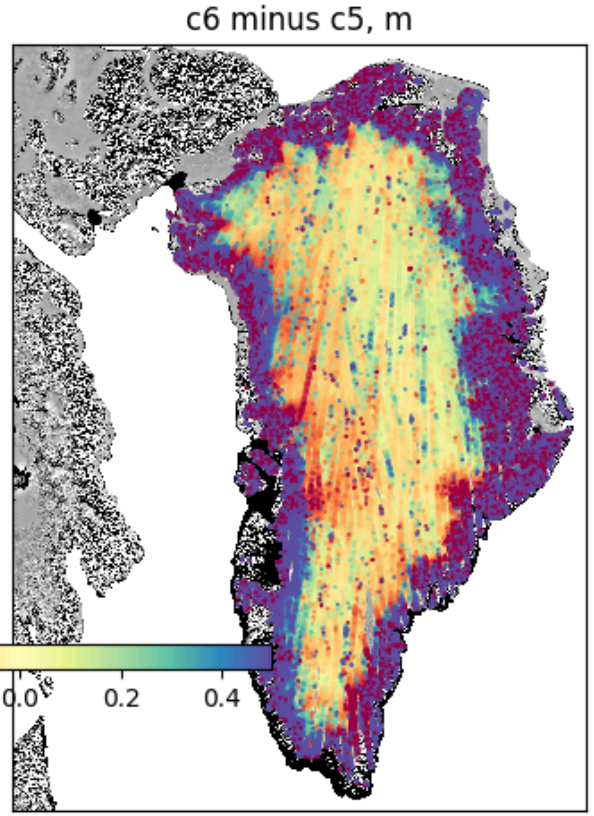
ATL11: Mapping elevation change



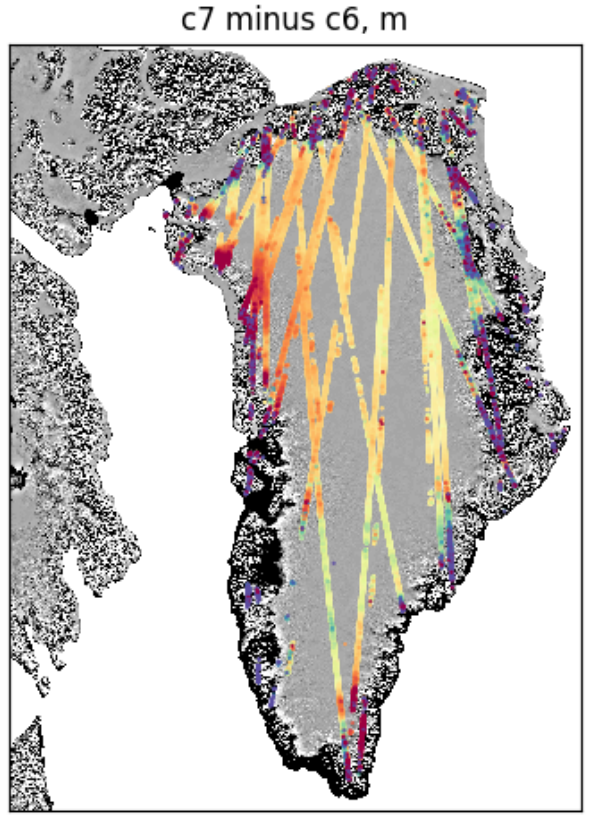
Q2 2019 -> Q3 2019



Q3 2019 -> Q4 2019



Q4 2019 -> Q1 2020



Q1 2020 -> Q2 2020

ATL14/15: land ice DEM and elevation change

AKA: The pretty picture of the ice sheet

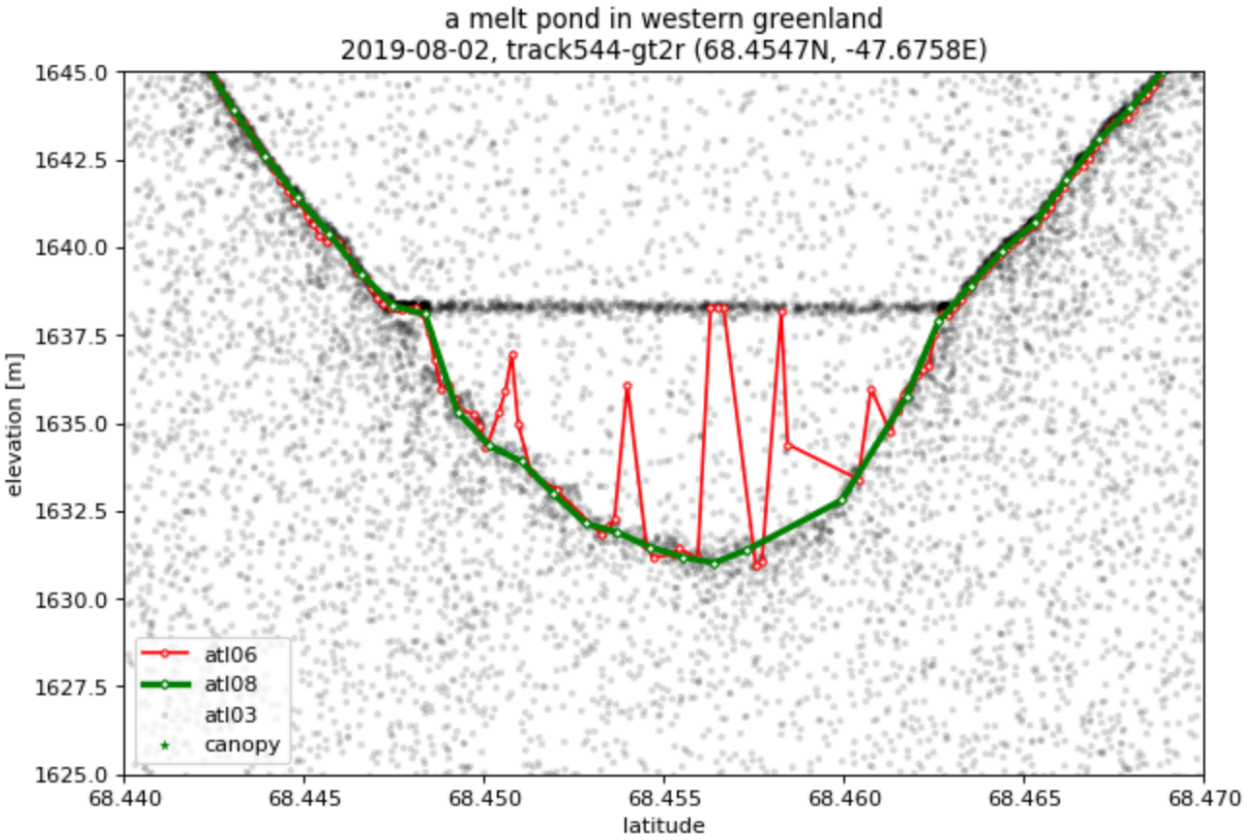
- Provides:
  - Gridded DEM and elevation-change estimates
- Advantages:
  - Brings together repeat measurements from different tracks to map surface-height changes
- Disadvantages:
  - Not released yet
- Use it if:
  - You are living in the future

ATL08: Land/water vegetation elevation

AKA: The salad course

- Provides:
  - Alternate surface-detection methods
- Advantages:
  - Can sometimes detect the surface in complex terrain better than ATL06
  - Does a better job of handling multiple returns (e.g. from lake bottoms)
- Disadvantages:
  - Can produce unpredictable results over sloping surfaces
- Use it if:
  - You need to detect multiple surfaces
  - You want to measure elevations of land around glaciers
  - You are looking at vegetated terrain

ATL08 example



Credit: Philipp Arndt

ATL07: Sea-ice height

AKA: ATL06's cousin

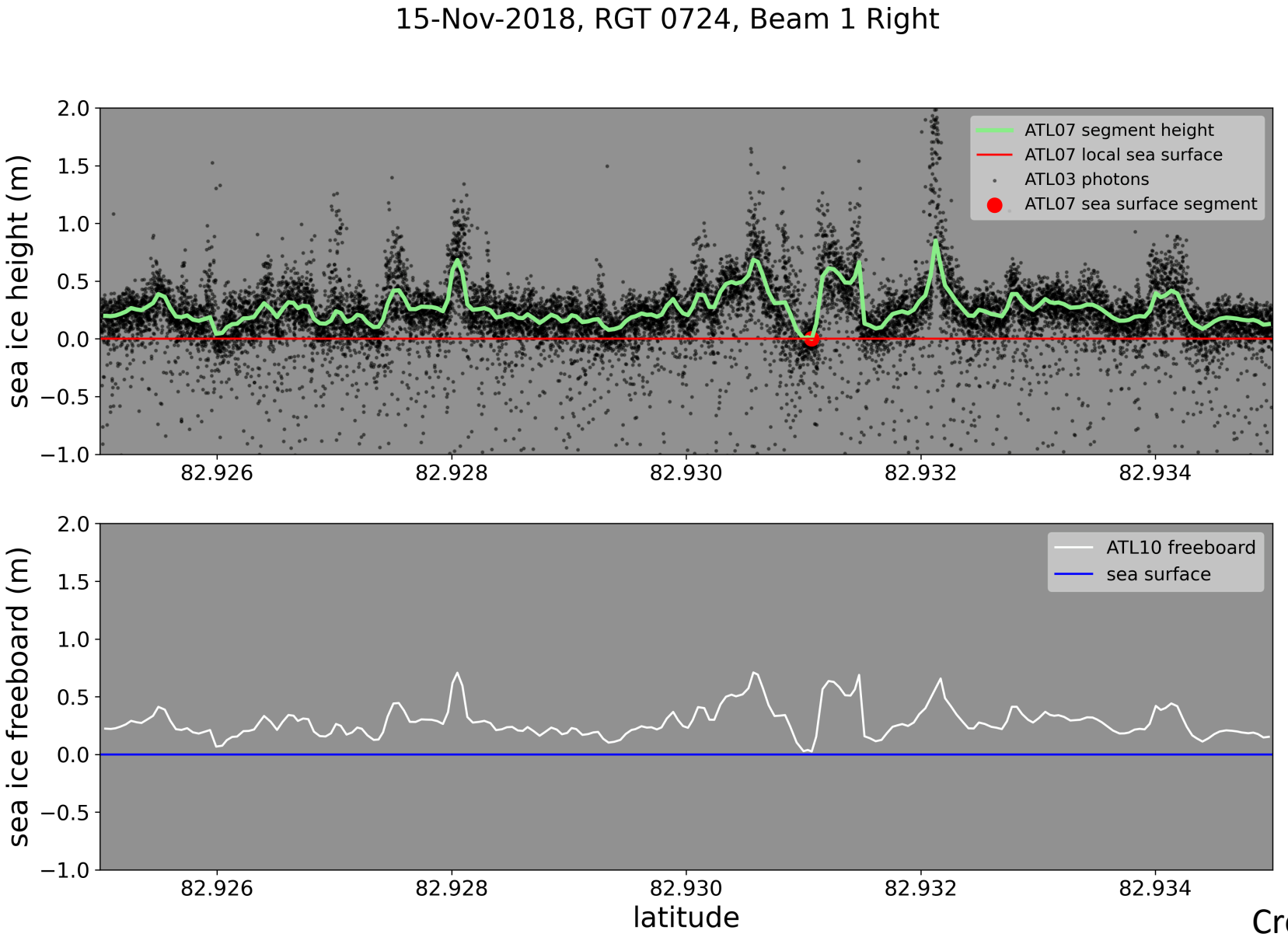
- Provides:
  - Along-track sea surface and sea ice height and type
  - Each segment is an aggregate of 150 photons, segment length varies
- Advantages:
  - Adaptive length scale allows for resolving the sea surface in leads
  - Includes a lot of surface statistics
  - Lighter product than ATL03
- Disadvantages:
  - Only calculated where sea ice concentration is > 15%
  - Loses resolution of small-scale features
  - Height statistics must be weighted by variable segment lengths
  - Surface type classification less accurate in summer on a melting sea ice surface
- Use it if:
  - You are doing any kind of sea ice study!

ATL10: Sea-ice freeboard

AKA: ATL07 plus some math

- Provides:
  - Along-track sea ice freeboard (height of the sea ice above local sea surface)
  - Calculated in 10 km segments if that segment contains a sea surface reference
- Advantages:
  - High spatial resolution and wide coverage
- Disadvantages:
  - Same variable length scale as ATL07
  - Only provided where sea ice concentration > 50% and 50 km from coast
  - Freeboard near ice edge affected by sea state- scattering in troughs of waves result in low sea surface and anomalously high freeboard
- Use it if:
  - You are doing Artic-wide studies or are focused on consolidated ice regions
  - You want to calculate sea ice thickness

ATL07 and ATL10 example:



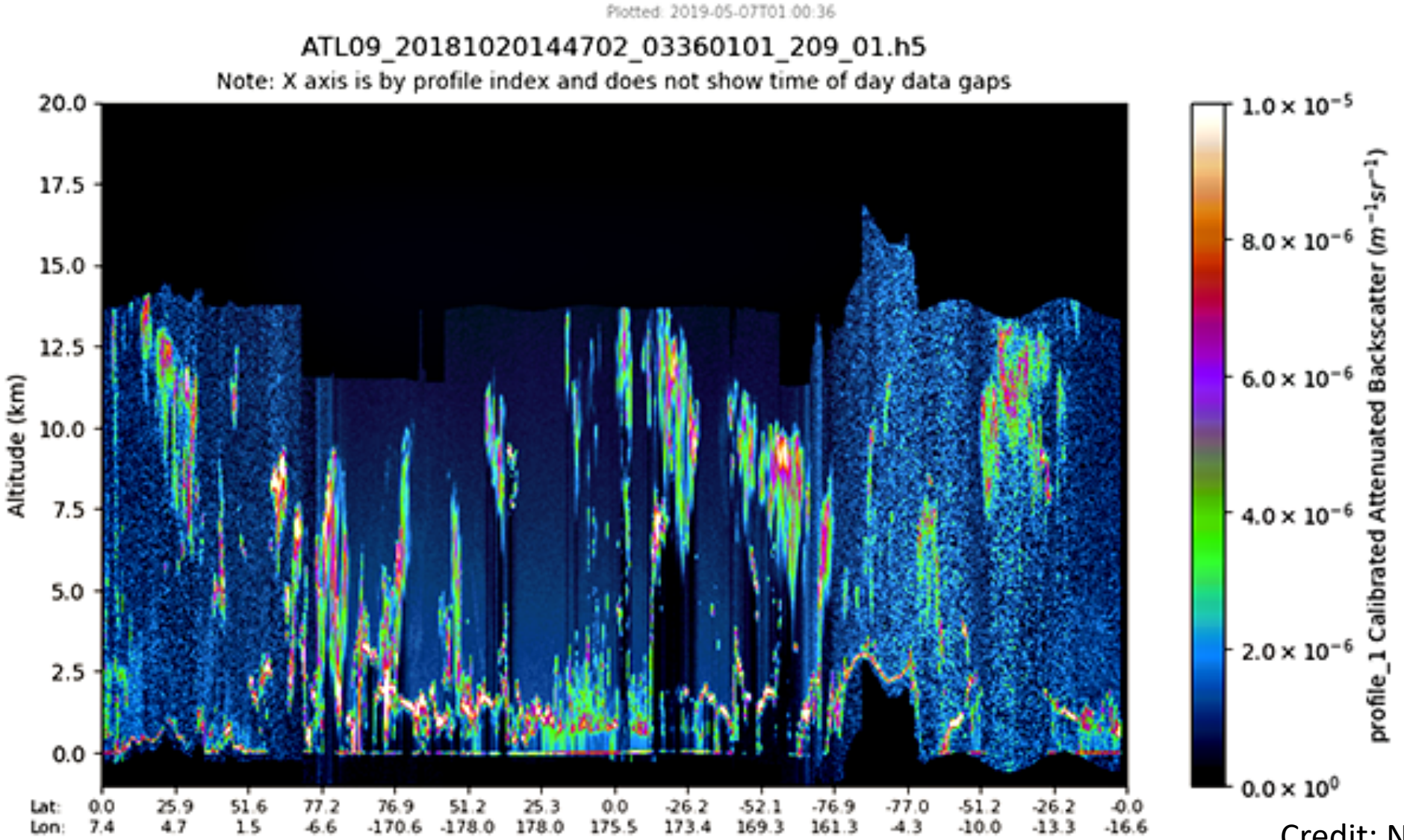
Credit: Ellen Buckley

ATL04/09: Calibrated backscatter / Atmospheric characteristics

AKA: Cloud-o-grams

- Provides:
  - Profiles of atmospheric backscatter
  - Layer heights and optical properties
- Advantages:
  - Shows global cloud properties
- Disadvantages:
  - Complicated product
  - Not presented in the same along-track coordinates as along-track products
- Use it if:
  - You want to know why you can’t see the ground
  - You want to understand atmospheric effects on surface products
  - You’re interested in clouds

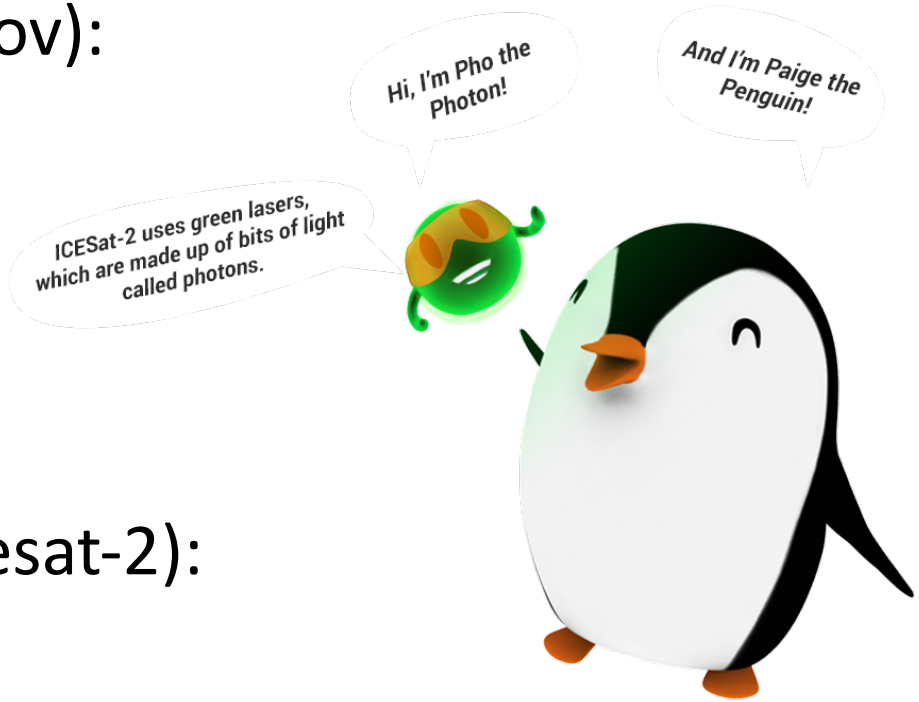
ATL09 example



Credit: NSIDC

Where to learn more:

- The ICESat-2 webpage (https://icesat-2.gsfc.nasa.gov):
  - Links to the Algorithm Theotretical Basis Documents:
  - KMLs of ground-track locations (under Tech Specs)
  - Animations



- The NSIDC landing page (https://nsidc.org/data/icesat-2):
  - Product format descriptions
  - Data file naming conventions
  - News on data releases
  - Known issue descriptions
  - Data(!)