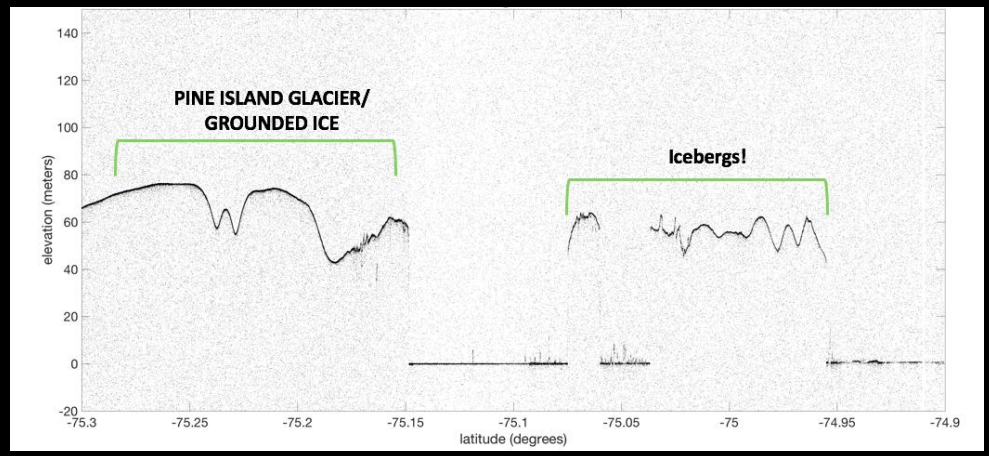
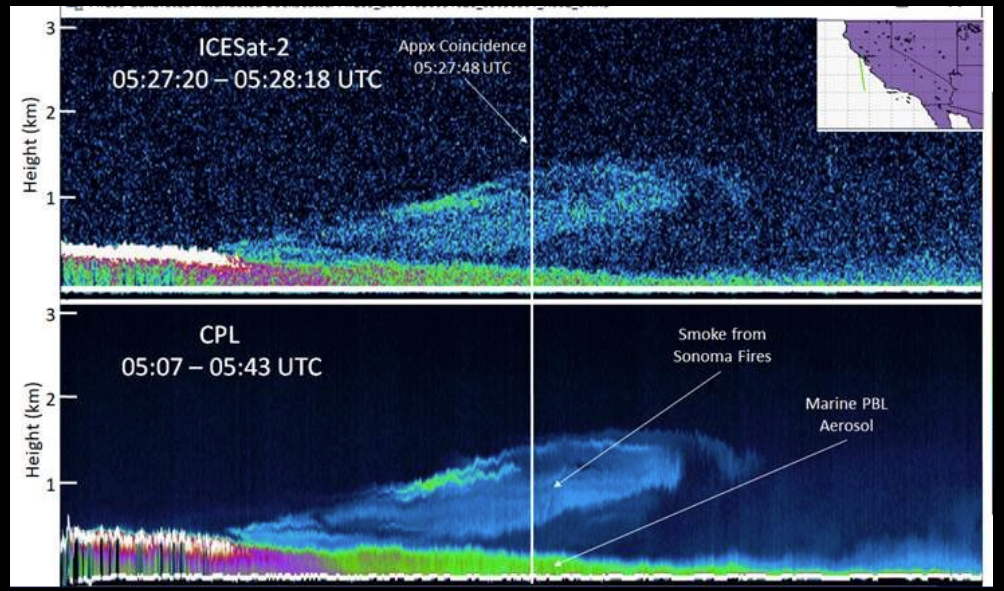
ICESat-2
ICE, CLOUD, AND LAND ELEVATION SATELLITE-2

NASA

ICESat-2 Update and Application to SnowEx

Tom Neumann, Project Scientist
Nathan Kurtz, Deputy Proj. Sci.
Kaitlin Harbeck, Data Product Mgmt.







Mission Status

ICESat-2 Mission

NASA's Earth observing altimetry mission

Successor to ICESat (2003-2009)

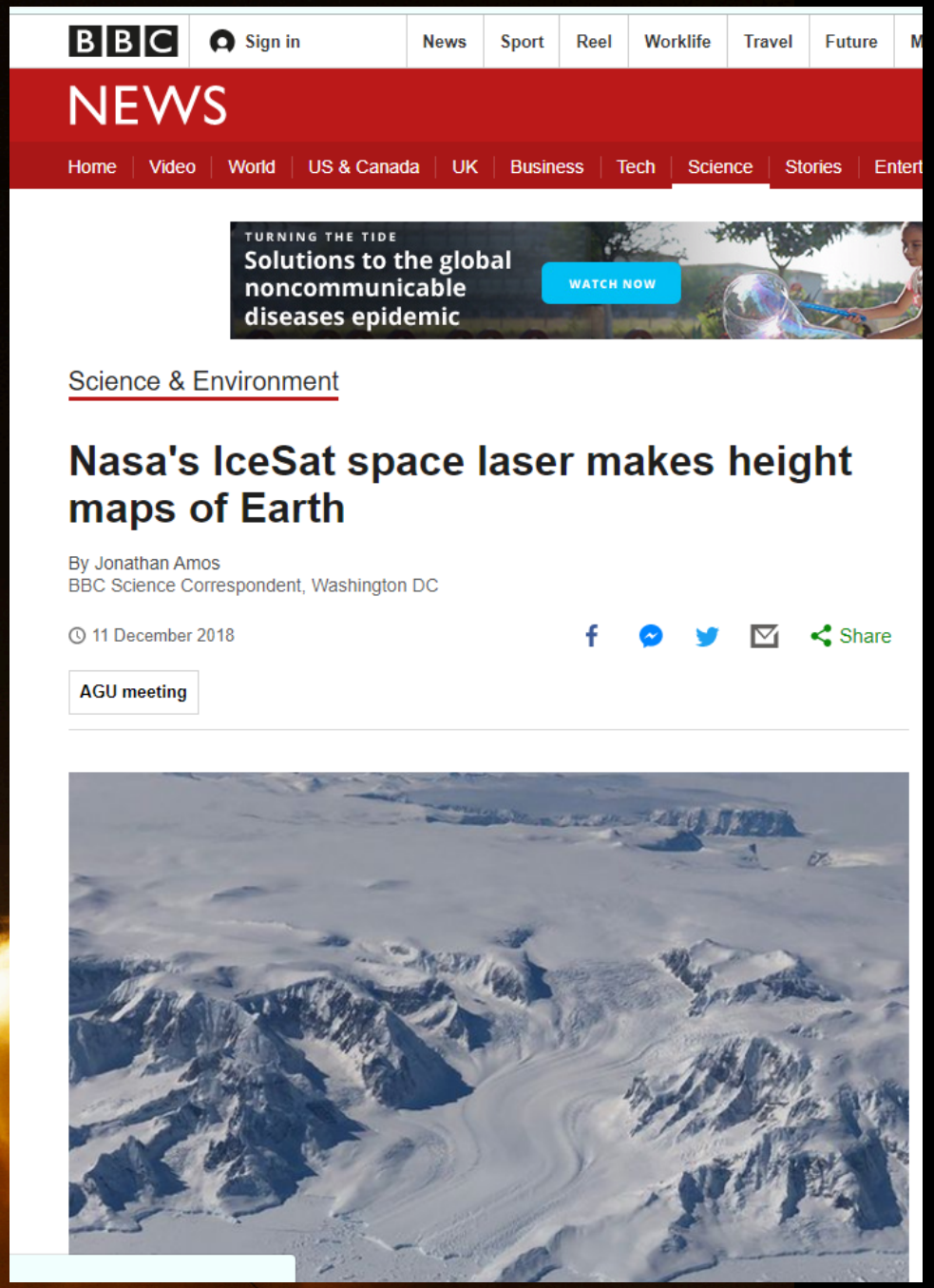
Designated as a top priority in Earth Science Decadal Survey

Launched successfully September 2018

More than a trillion measurements to date

All data available at National Snow and Ice Data Center (nsidc.org)





ICESat-2 Mission Overview

Payload

ATLAS – Advanced Topographic Laser Altimeter System developed at Goddard Space Flight Center, Greenbelt, MD.

Measures time of flight of laser pulses

Measures pointing direction

Single-photon sensitive detection

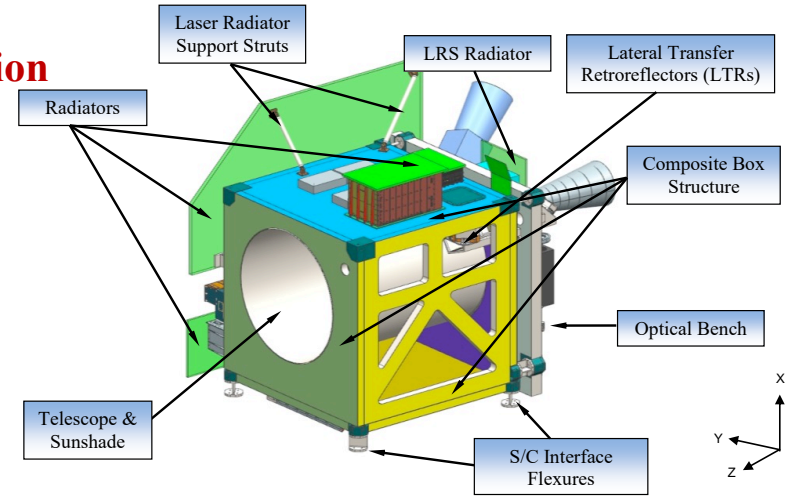
6 beams, arranged in 3 pairs

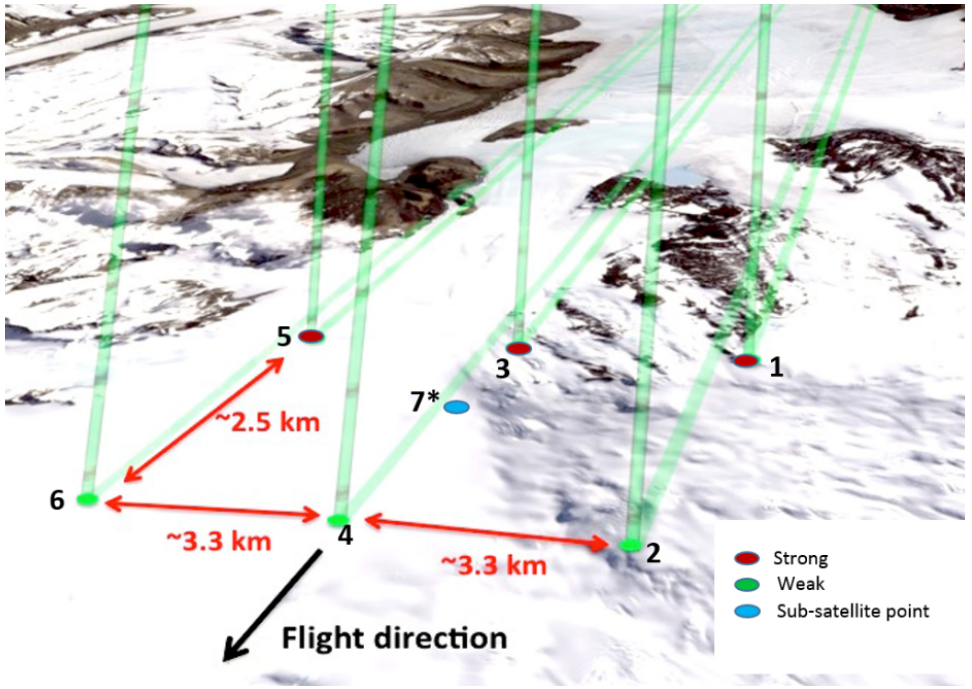
10 kHz pulse-rep. rate

11 m footprint

spaced 0.7m along-track

532nm wavelength





~3 km spacing between pairs provides spatial coverage

~90 m pair spacing for ***slope determination*** (2° yaw)

high-energy beams (4x) for better performance over low-reflectivity targets.

Implementation

Lifetime: 3 years, with consumables for 5+

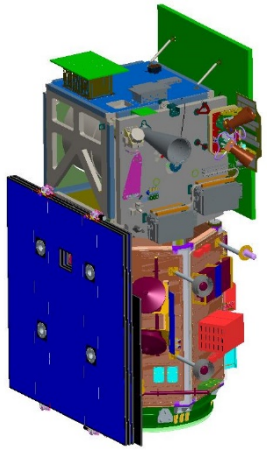
Orbit: 496 km, non-sun-synch, 92° inclination

Repeat: 91 day exact repeat, ~30 day sub-cycle

Science Data: 1 TB/day

System Pointing: Control = 45 m (14.3 m, CBE)

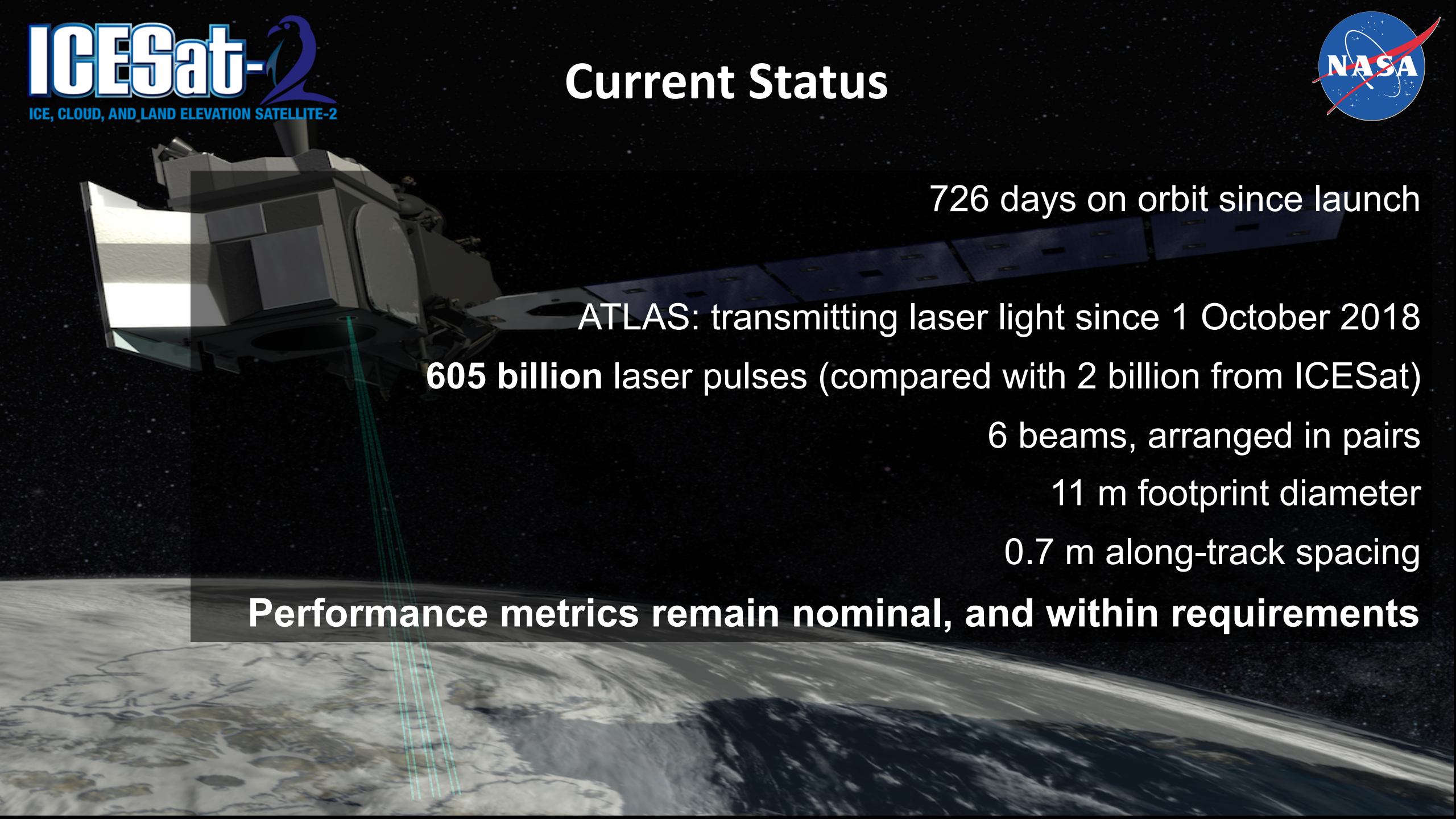
Geolocation Knowledge = 6.5 m (4.0 m, CBE)



Magruder, L.A., Neumann, T. A., Brunt, K., Farrell, S., Fricker, H., Gardner, A., Neuenschwander, A., et. al., (2019) New Earth orbiter provides a sharper look at a changing planet. *EOS,* 100, https://doi.org/10.1029/2019EO133233

ICESat-2
ICE, CLOUD, AND LAND ELEVATION SATELLITE-2

Current Status



726 days on orbit since launch

ATLAS: transmitting laser light since 1 October 2018

605 billion laser pulses (compared with 2 billion from ICESat)

6 beams, arranged in pairs

11 m footprint diameter

0.7 m along-track spacing

Performance metrics remain nominal, and within requirements

ICESat-2
ICE, CLOUD, AND LAND ELEVATION SATELLITE-2

Orbit and Coverage

NASA

500 km altitude

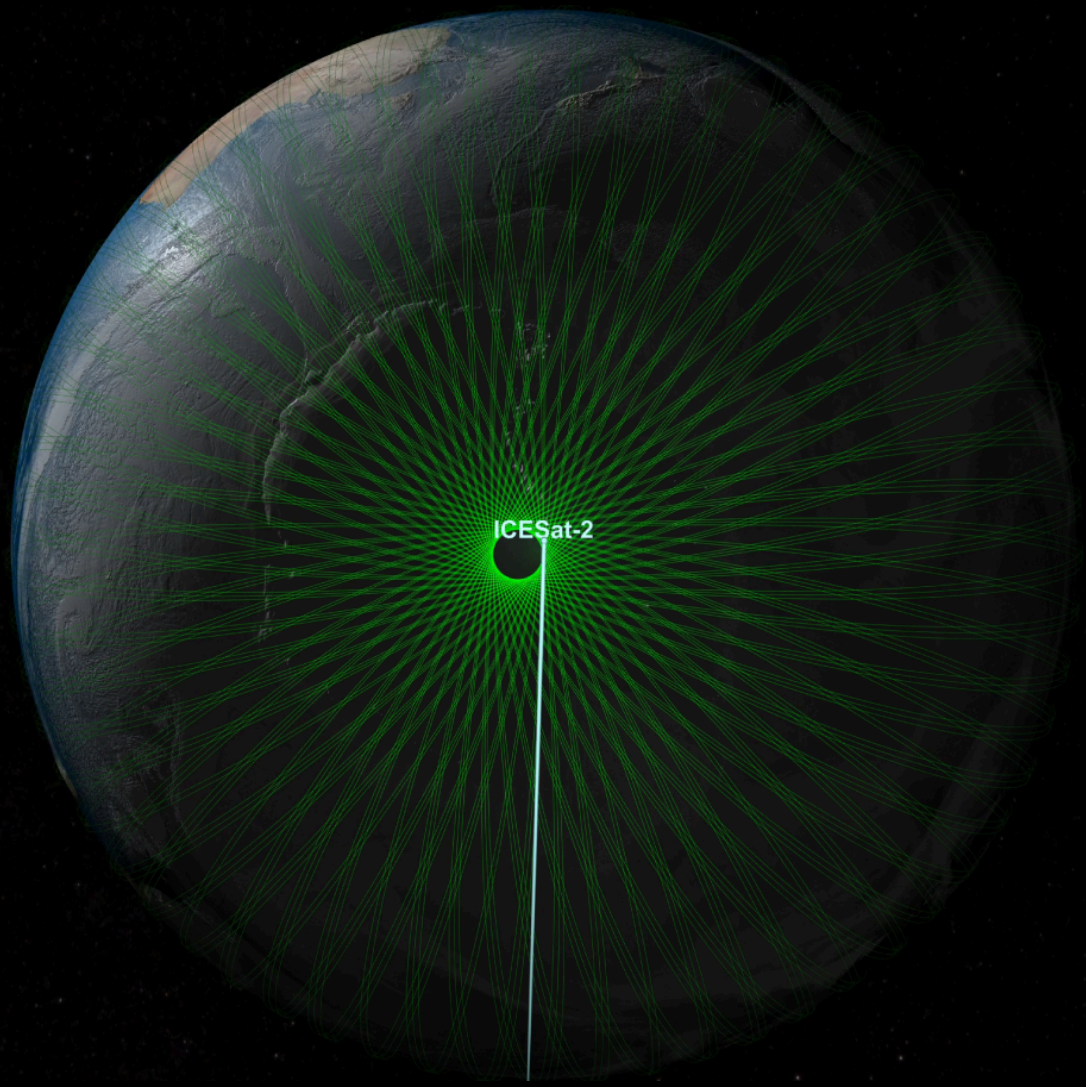
88S to 88N

15 revs/day

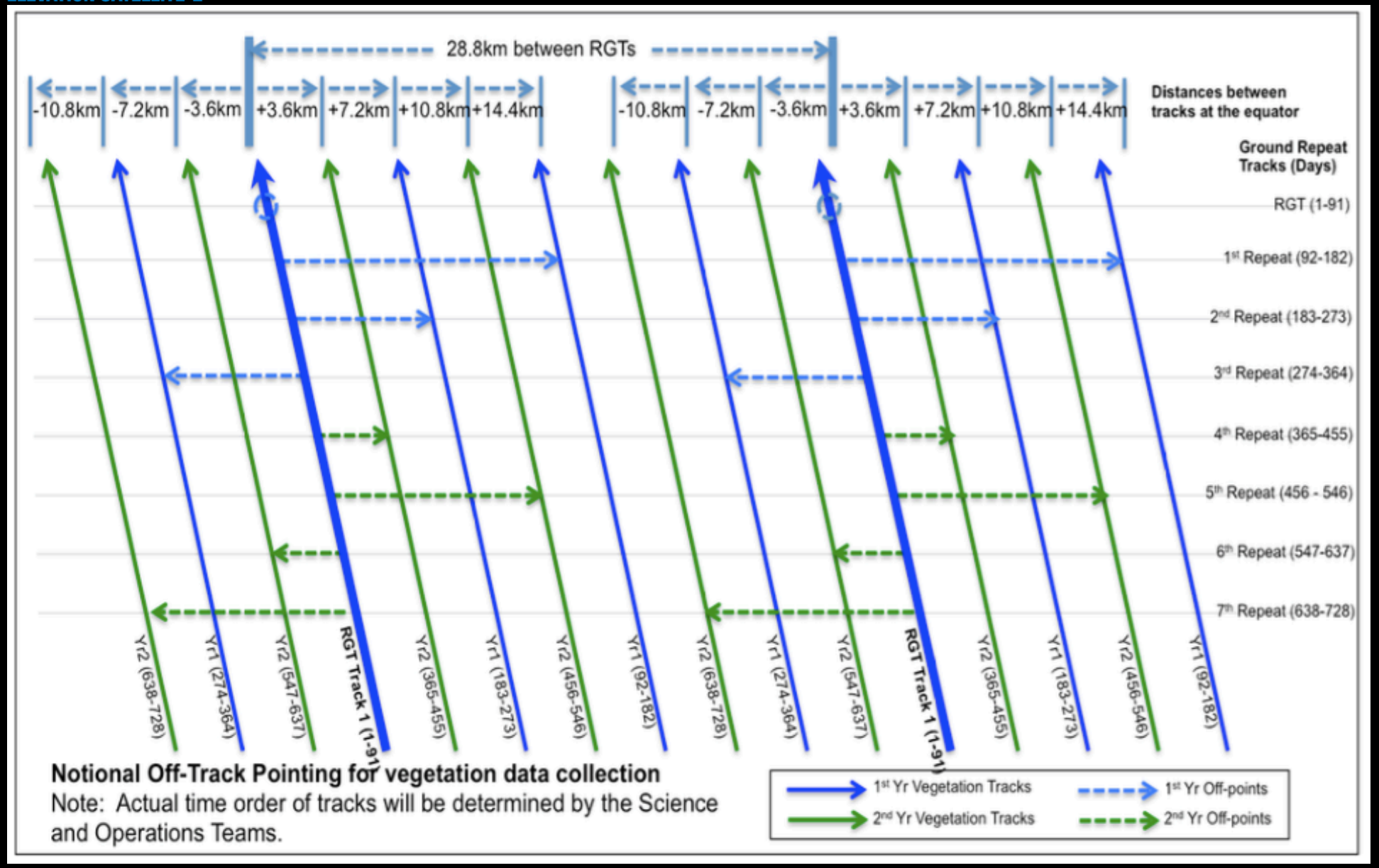
1387 tracks

91-day revisit

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



Off Pointing in Mid-Latitudes

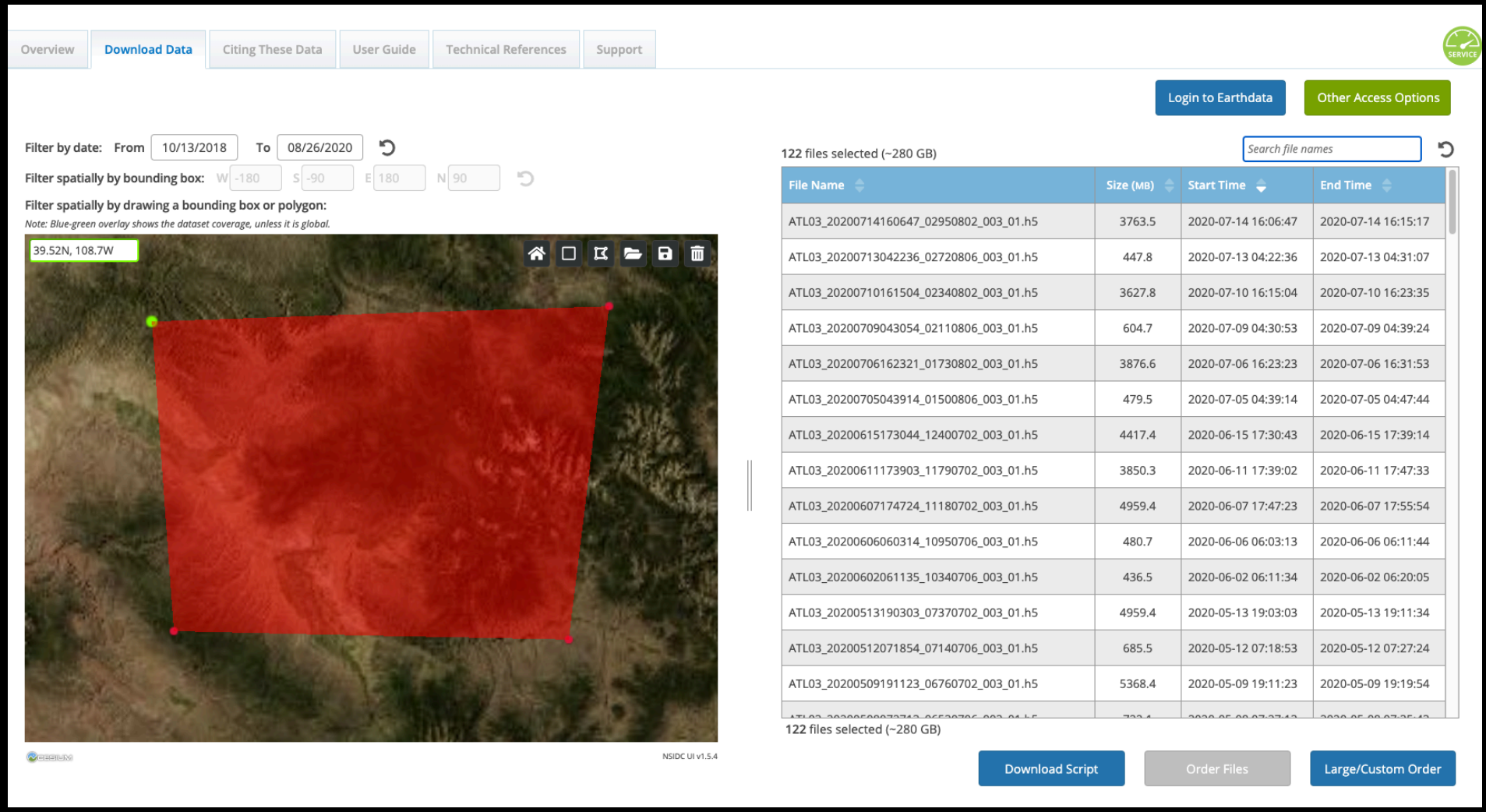


Notional Off-Track Pointing for vegetation data collection

Note: Actual time order of tracks will be determined by the Science and Operations Teams.

Grand Mesa, CO

via NSIDC spatial search tool



Grand Mesa, CO

Reference Ground Tracks
repeat every 91 days

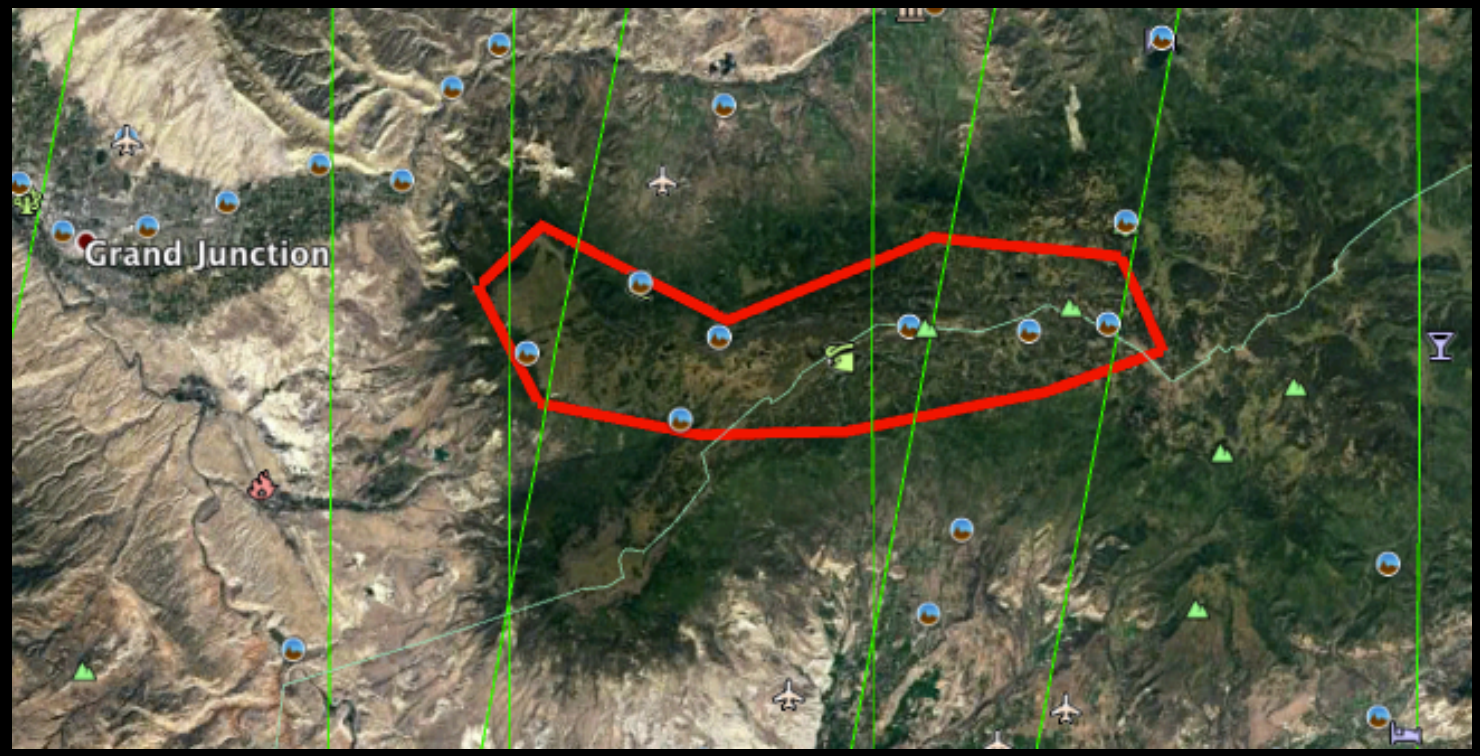
Currently in Cycle 4 (off pointing by ~7 km)

5 RGTs intersect Grand Mesa every 91 days:

211
714
737
1156
1179

Each RGT has 3 strong and 3 weak beams associated with it.

RGT locations (green lines) account for off-pointing plan.



Grand Mesa, CO

Reference Ground Tracks
repeat every 91 days

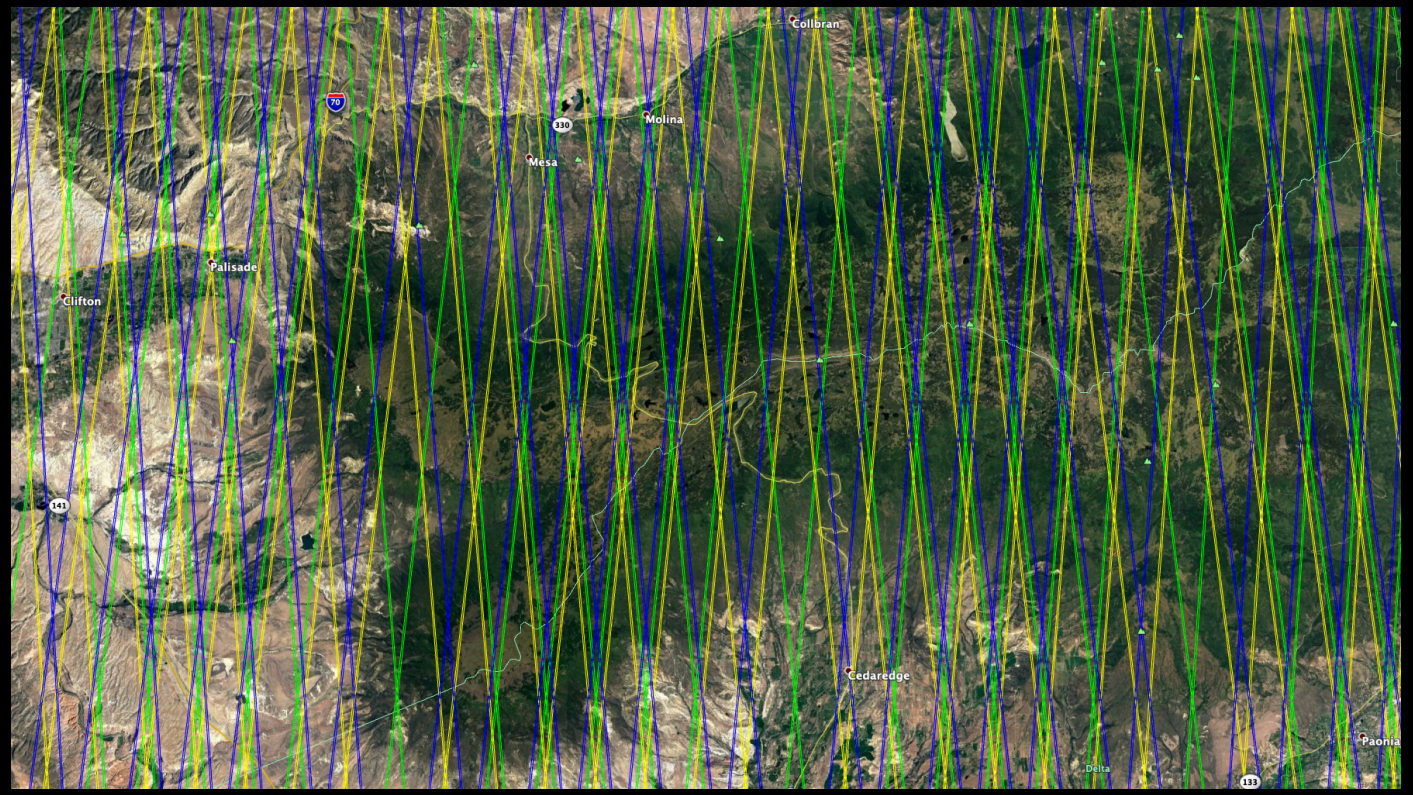
Cycle 9 begins late September 2020

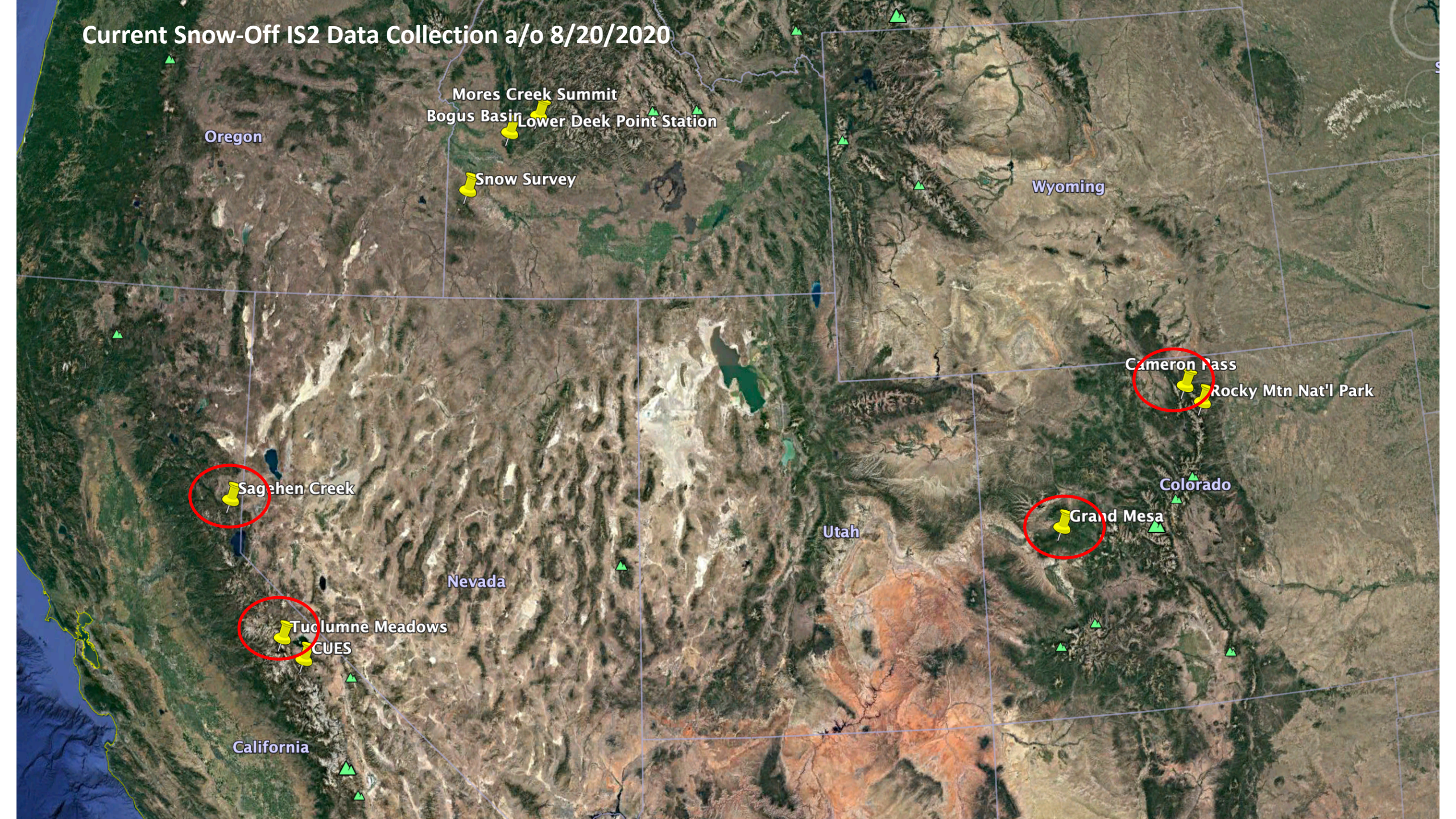
5 RGTs intersect Grand Mesa every 91 days:

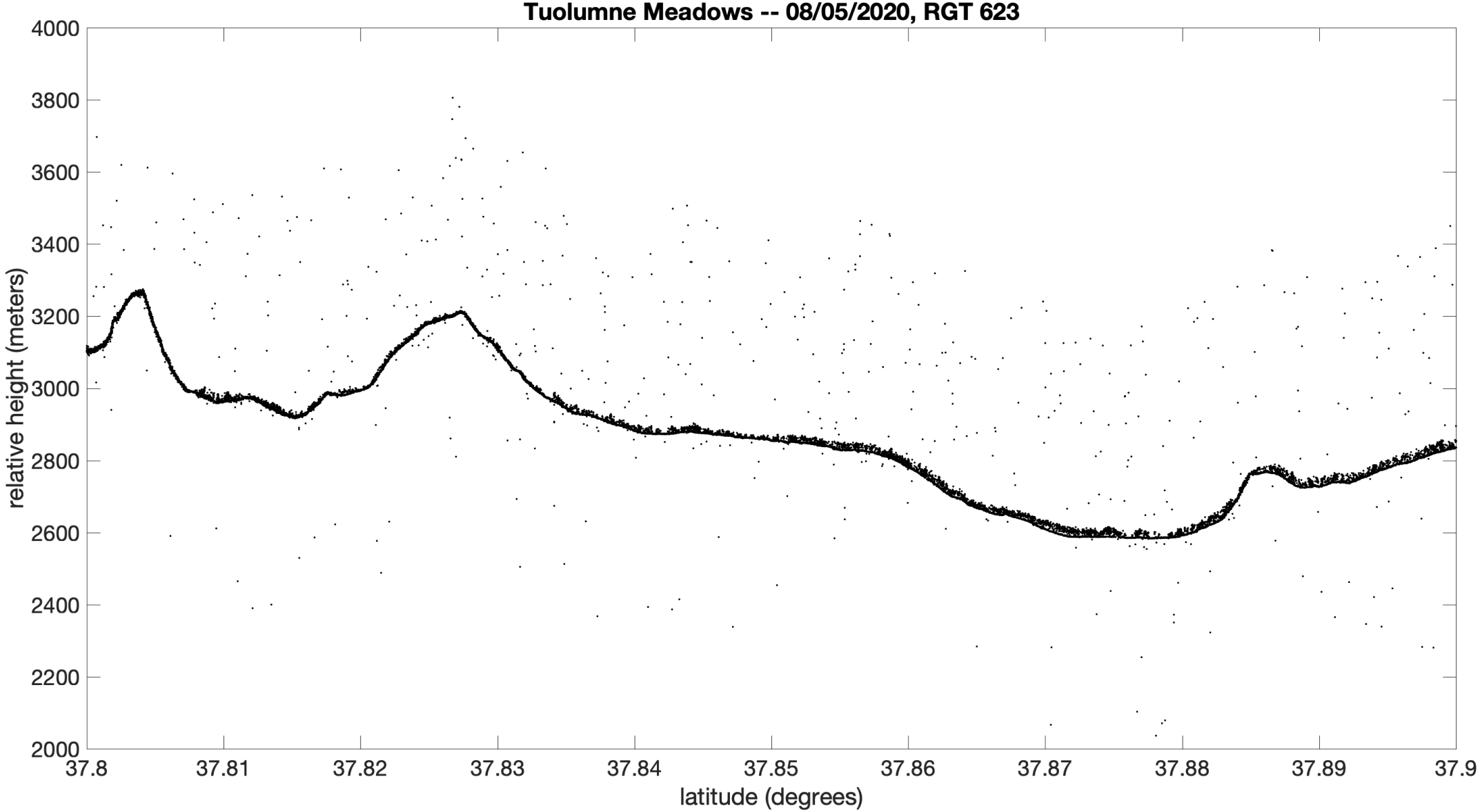
211
714
737
1156
1179

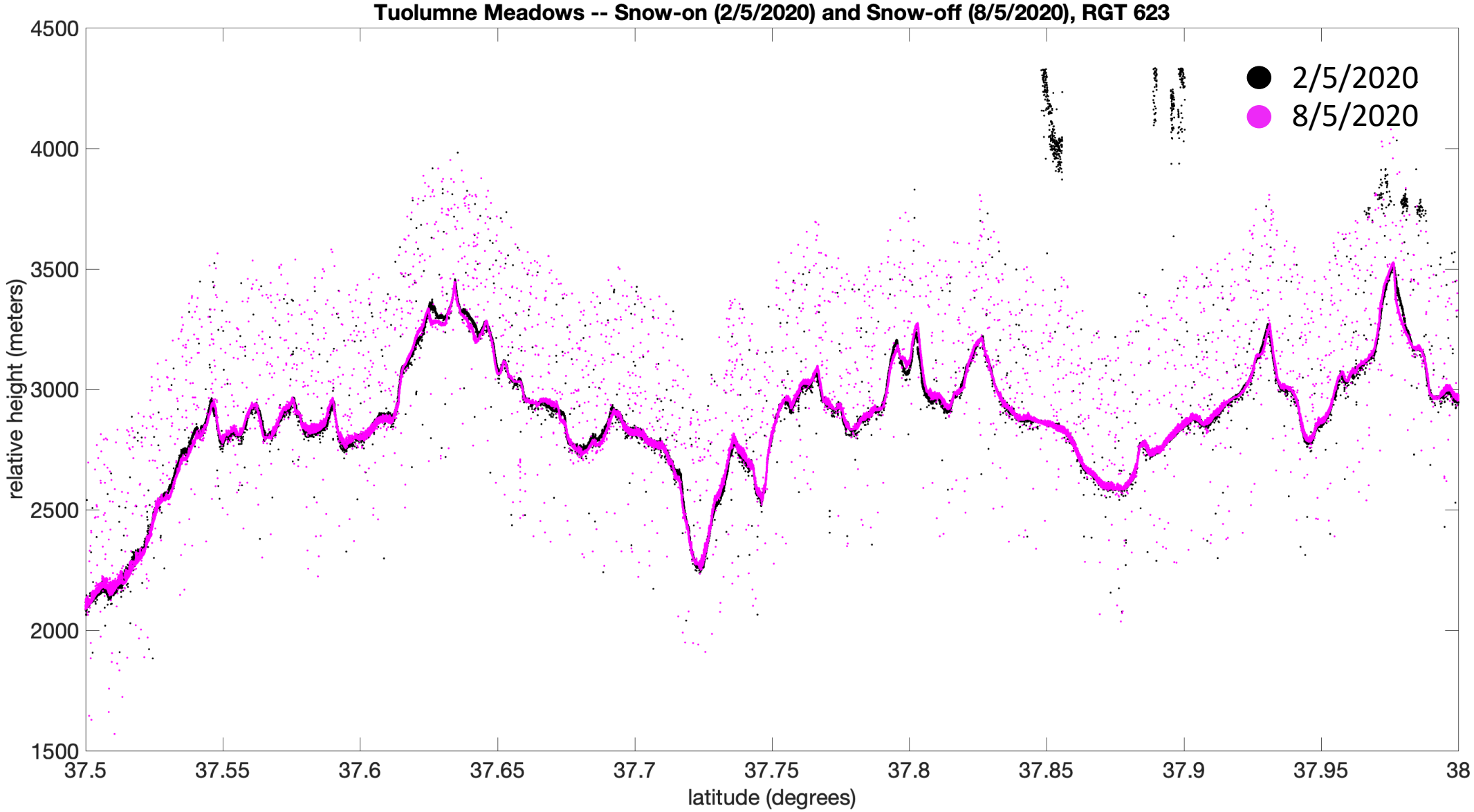
Some are ascending passes, some descending

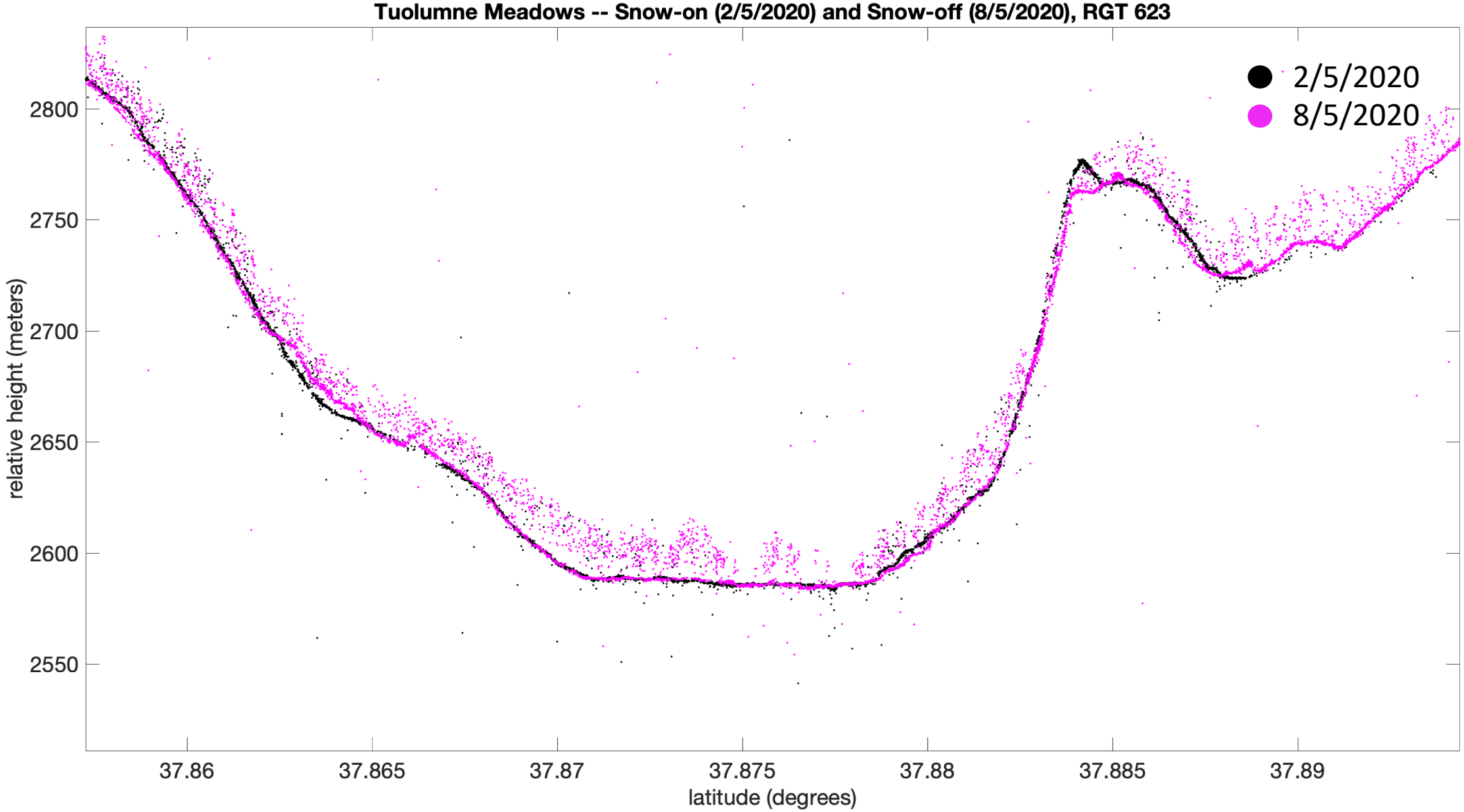
Yellow is right pair
Green is center pair
Blue is left pair
Tracks from Cycle 1 through Cycle 6 are shown




Current Snow-Off IS2 Data Collection a/o 8/20/2020
Mores Creek Summit
Bogus Basin
Lower Deek Point Station
Oregon
Snow Survey
Wyoming
Cameron Pass
Rocky Mtn Nat'l Park
Colorado
Sagehen Creek
Grand Mesa
Utah
Nevada
Tuolumne Meadows
CUES
California


Tuolumne Meadows -- 08/05/2020, RGT 623
relative height (meters)
4000
3800
3600
3400
3200
3000
2800
2600
2400
2200
2000
37.8
37.81
37.82
37.83
37.84
37.85
37.86
37.87
37.88
37.89
37.9
latitude (degrees)


Tuolumne Meadows -- Snow-on (2/5/2020) and Snow-off (8/5/2020), RGT 623
2/5/2020
8/5/2020
relative height (meters)
4500
4000
3500
3000
2500
2000
1500
37.5
37.55
37.6
37.65
37.7
37.75
37.8
37.85
37.9
37.95
38
latitude (degrees)


Tuolumne Meadows -- Snow-on (2/5/2020) and Snow-off (8/5/2020), RGT 623
2/5/2020
8/5/2020
relative height (meters)
2800
2750
2700
2650
2600
2550
37.86
37.865
37.87
37.875
37.88
37.885
37.89
latitude (degrees)

Pointing at SnowEx Sites

Idaho Snow On Status

Name	Date of Orbit	Site group(s)*					TOO STATUS	TO
RGT 341	18 Jan 2020	Banner Summit	Bull Trout Lake	Canyon Creek	Fox Tail Ridge		Performed; cloudy.	
RGT 379	20 Jan 2020	Banner Summit	Bull Trout Lake	Canyon Creek	Fox Tail Ridge		Performed; cloudy.	
RGT 402	22 Jan 2020	Bogus Basin	Lower Deer Point Station				Performed; cloudy.	
RGT 440	24 Jan 2020	Bogus Basin	Lower Deer Point Station				Not performed; exceeded pointing constraints (6.30 d	
RGT 463	26 Jan 2020	Snow Survey	Scan 1	Scan 2	RCEW HQ	cabins at RME	Performed; cloudy.	
RGT 501	28 Jan 2020	Snow Survey	Scan 1	Scan 2	RCEW HQ	cabins at RME	Performed; cloudy.	
RGT 783	15 Feb 2020	Banner Summit	Bull Trout Lake	Canyon Creek	Fox Tail Ridge		Not performed; exceeded pointing constraints (7.08 d	
RGT 821	18 Feb 2020	Banner Summit	Bull Trout Lake	Canyon Creek	Fox Tail Ridge		Not performed; exceeded pointing constraints (7.08 d	
RGT 844	19 Feb 2020	Bogus Basin	Lower Deer Point Station				Fatal; exceeds pointing constraints.	
RGT 882	22 Feb 2020	Bogus Basin	Mores Creek Summit	Mores Creek Summit - SNOTEL			Looks AWESOME in rapid ATL03!	
RGT 905	23 Feb 2020	Snow Survey	Scan 1	Scan 2	RCEW HQ	cabins at RME	Looks AWESOME in rapid ATL03!	
RGT 943	26 Feb 2020	Snow Survey	Scan 1	Scan 2	RCEW HQ	cabins at RME	Looks AWESOME in rapid ATL03!	
RGT 1286	19 Mar 2020	Mores Creek Summit	Mores Creek Summit - SNOTEL				Performed; comically cloudy over your TOO.	
RGT 1324	22 Mar 2020	Mores Creek Summit	Mores Creek Summit - SNOTEL				Looks AWESOME in rapid ATL03!	
RGT 1385	26 Mar 2020	Lower Deer Point Station					Looks AWESOME in rapid ATL03!	

Summer Snow Off Status

Name	Date of Orbit	Site	Latitude	Longitude	TOO Status	TOO ID	
RGT 211	7/9/2020	Grand Mesa MM Tower	39.0395	-107.942	confirmed	1571	clear and good data quality
RGT 272	7/13/2020	Grand Mesa MW Tower	39.0339	-108.214	confirmed	1572	looks like it was cloudy right over your target :(
RGT 295	7/14/2020	Grand Mesa MW Tower	39.0339	-108.214	confirmed	1573	much better!
RGT 531	OFF LIMITS	Cameron Pass	40.5186	-105.8917	OFF LIMITS		
RGT 554	7/31/2020	Cameron Pass	40.5186	-105.8917	confirmed	1623	clear and good data quality
RGT 623	8/5/2020	Tuolumne Meadows	37.875962	-119.363387	confirmed	1627	clear and good data quality
RGT 745	8/13/2020	Sagehen Creek	39.43021	-120.23960	confirmed	1652	clear and good data quality
RGT 768	8/14/2020	Sagehen Creek	39.43021	-120.23960	confirmed	1653	cloudy throughout the region :(
RGT 882	8/22/2020	Bogus Basin	43.932074	-115.665987	confirmed	1673	
RGT 905	8/23/2020	Snow Survey	43.066476	-116.757682	confirmed	1674	
RGT 943	8/26/2020	Snow Survey	43.066476	-116.757682	submitted	1675	
RGT 996	8/29/2020	Rocky Mountain National	40.3129	-105.6483	submitted	1688	
RGT 1065	9/3/2020	CUES	37.643	-119.029	submitted	1698	
RGT 1126	9/7/2020	Tuolumne Meadows	37.875962	-119.363387	submitted	1699	
RGT 1187	9/11/2020	Sagehen Creek	39.43021	-120.23960			
RGT 1324	9/20/2020	Mores Creek Summit	43.932074	-115.665987			
RGT 1385	9/24/2020	Lower Deer Point Station	43.737047	-116.122066			

Colorado Snow On Status

Date	Orbit	Site	Lat	Lon		TOO Status	T
1/30/2020	531	Cameron Pass	40.5186	-105.8917	Crossing of two tracks (531/554)	Looks good in rapid ATL03!	
1/31/2020	554	Cameron Pass	40.5186	-105.8917	Crossing of two tracks (531/554)	Looks *maybe* good in rapid ATL03!	
2/11/2020	714	Grand Mesa SWESARR north intersect	39.032990	-108.180517		Not performed; exceeds offpointing constraints (7.18 deg)	
2/12/2020	737	Grand Mesa SWESARR south intersect	39.016432	-108.161671		Not performed; exceeds offpointing constraints (7.34 deg)	
2/28/2020	973	Rocky Mountain National Park	40.3129	-105.6483	Crossing of two tracks (973/996)	Rejected; request was for off-limit RGT	
2/29/2020	996	Rocky Mountain National Park	40.3129	-105.6483	Crossing of two tracks (973/996)	Looks AWESOME in rapid ATL03!	
4/9/2020	211	Grand Mesa MM Tower	39.0395	-107.942	met tower with snow depth obs	Looks awesome in rapid ATL03!	
4/10/2020	234	Grand Mesa ME Tower	39.1037	-107.884	met tower with snow depth obs	Rejected; request was for off-limit RGT	
4/13/2020	272	Grand Mesa MW Tower	39.0339	-108.214	met tower with snow depth obs	Looks good in rapid ATL03!	
4/14/2020	295	Grand Mesa MW Tower	39.0339	-108.214	met tower with snow depth obs	Looks AWESOME in rapid ATL03!	

California Snow On Status

Name	Date of Orbit	Site	TOO Status	T
RGT 120	3 Jan 2020	CUES		
RGT 181	7 Jan 2020	Tuolumne Meadows		
RGT 204	9 Jan 2020	CUES		
RGT 242	11 Jan 2020	Sagehen Creek		
RGT 265	13 Jan 2020	Tuolumne Meadows		
RGT 326	17 Jan 2020	Sagehen Creek		
RGT 623	5 Feb 2020	Tuolumne Meadows	Looks AWESOME in rapid ATL03!	
RGT 623	5 Feb 2020	CUES	Not performed; exceeded pointing constraints (6.80 d	
RGT 707	11 Feb 2020	Tuolumne Meadows	Fatal; exceeds pointing constraints.	
RGT 707	11 Feb 2020	CUES	Fatal; exceeds pointing constraints.	
RGT 745	13 Feb 2020	Sagehen Creek	Looks AWESOME in rapid ATL03!	
RGT 768	15 Feb 2020	Sagehen Creek	Looks AWESOME in rapid ATL03!	
RGT 1065	5 Mar 2020	CUES	Looks AWESOME in rapid ATL03!	
RGT 1126	9 Mar 2020	Tuolumne Meadows	Looks AWESOME in rapid ATL03!	
RGT 1149	10 Mar 2020	Tuolumne Meadows	Performed; cloudy.	
RGT 1149	10 Mar 2020	CUES	Not performed; too close in proximity to TOO ID 1358	
RGT 1187	13 Mar 2020	Sagehen Creek	Looks AWESOME in rapid ATL03!	
RGT 1210	14 Mar 2020	Sagehen Creek	Performed; cloudy.	

ICESat-2 Data are Publicly Available

National Snow and Ice Data Center (NSIDC DAAC)

Data Products:

- **Geolocated Photons (ATL03)**
- Land Ice Elevation
- Sea Ice Elevation and Freeboard
- **Land Elevation (ATL08)**
- Atmospheric Backscatter
- Ocean Surface Height
- Inland Water Elevation

Rel003 data out 5 May 2020
Data through 15 July 2020
2297 unique data users to date
7,712,619 files served from since May 2019

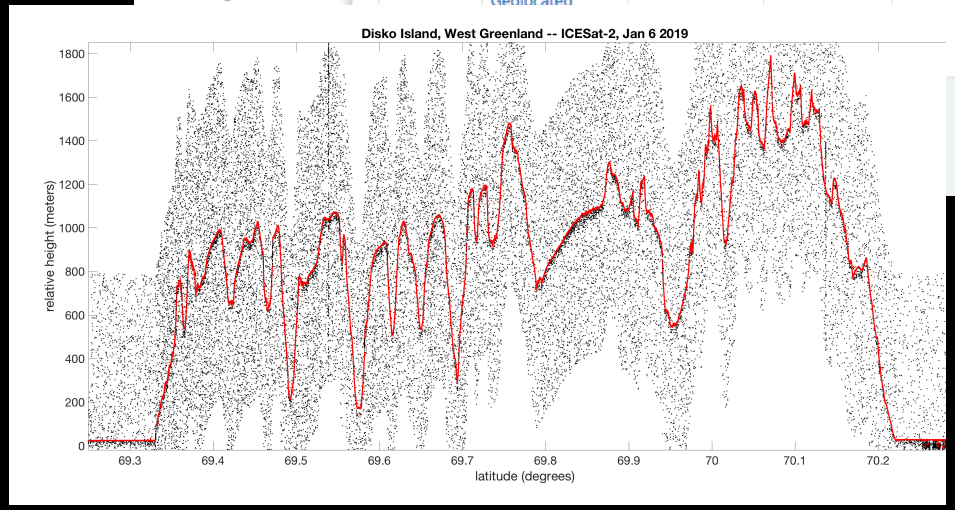


Overview
ICESat-2 Data Sets
Product Descriptions
Level-1
Level-2
Level-3A
Level-3B
Tools
Knowledge Base
ICESat/GLAS Data
IceBridge Data

ICESat-2 Data Sets at NSIDC

The following table lists the ICESat-2 data sets that are currently available at the NASA NSIDC DAAC.

ID	Title	Spatial Coverage	Temporal Coverage	Spatial Resolution	Temporal Resolution	Parameter(s)
ATL02	ATLAS/ICESat-2 L1B Converted Telemetry Data, Version 1	GLOBAL	2018/10/13 to present	Not applicable	Not applicable	Engineering Telemetry Ancillary Data
ATL03	ATLAS/ICESat-2 L2A Global Geolocated	GLOBAL	2018/10/13 to present	70 cm	91 day	TERRAIN ELEVATION
					91 day	Lidar Backscatter



Rugged topography in Greenland

ICESat-2 Measures the Earth

ICESat-2 well on it's way to meeting science requirements:

ice sheet elevation, sea ice freeboard, vegetation canopy height

30+ science papers already in print; many more in review

Initial data quality: < 10 cm vertical, < 10 m horizontal

Spacecraft and instrument remain nominal

