The ICESat-2 Inland Water Products

ICESat-2 Inland Water Team:

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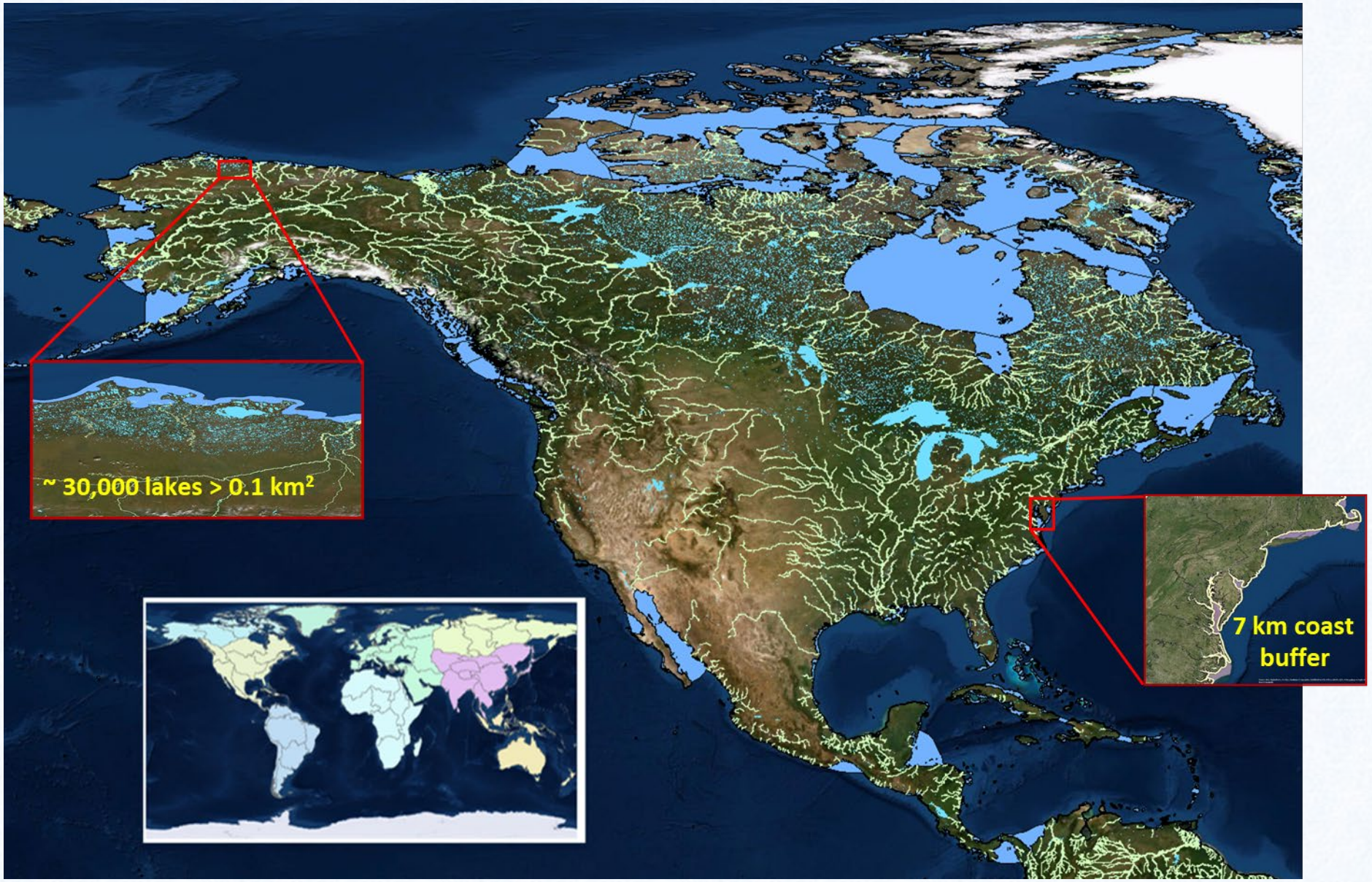
ICESat-2 Launch
Sept. 12, 2018
Vandenberg AFB, CA

Laser Altimetry Applications for a Changing World:
Working with ICESat-2 Inland Surface Water Data
November 19, 2025

ICESat-2 Global Inland Water Domain

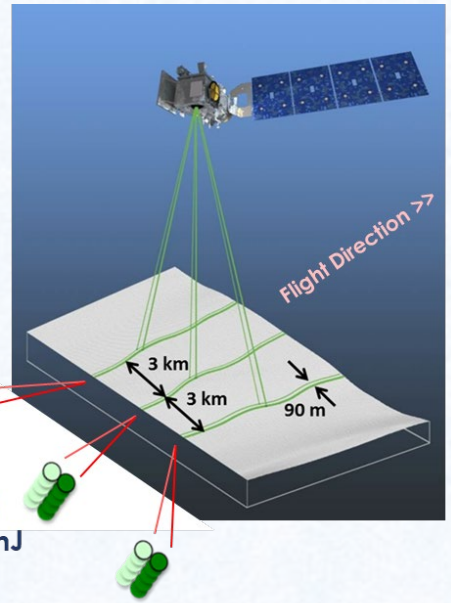


Lakes and Reservoirs (Messager et al 2016)	Count
Area (sq km²) ≥ 10,000	18
10,000 > Area ≥ 1,000	160
1,000 > Area ≥ 100	1,530
100 > Area ≥ 10	14,981
10 > Area ≥ 1	168,492
1 > Area ≥ 0.1	1,242,507
Rivers (Allen & Pavelsky. 2018)	10,253
Coastal Water	11,297
Estuaries and Bays (NMWB, ESRI)	188
Total Water Bodies	1,449,426

ICESat-2 Inland Water Products

Satellite Observations

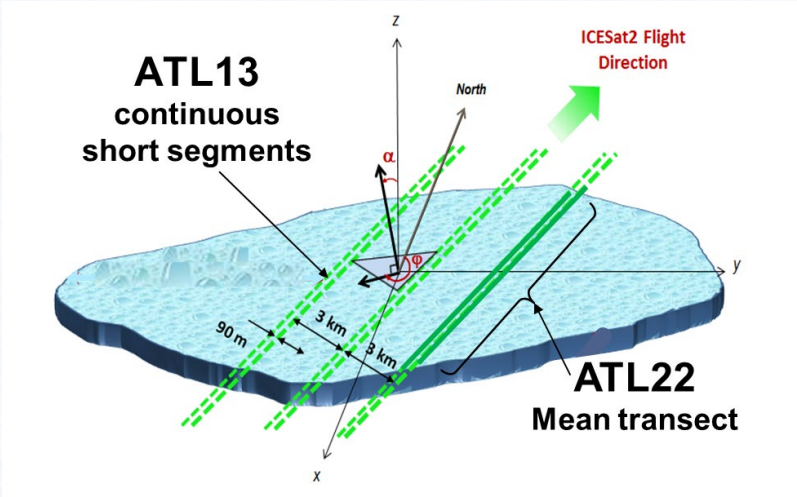
(ATLAS)
Advanced Topographic Laser Altimeter System



0.7m spacing
11m footprint

Weak Beam 25 mJ
Strong Beam 100 mJ

Products Schematic



Principal Hydrology Products

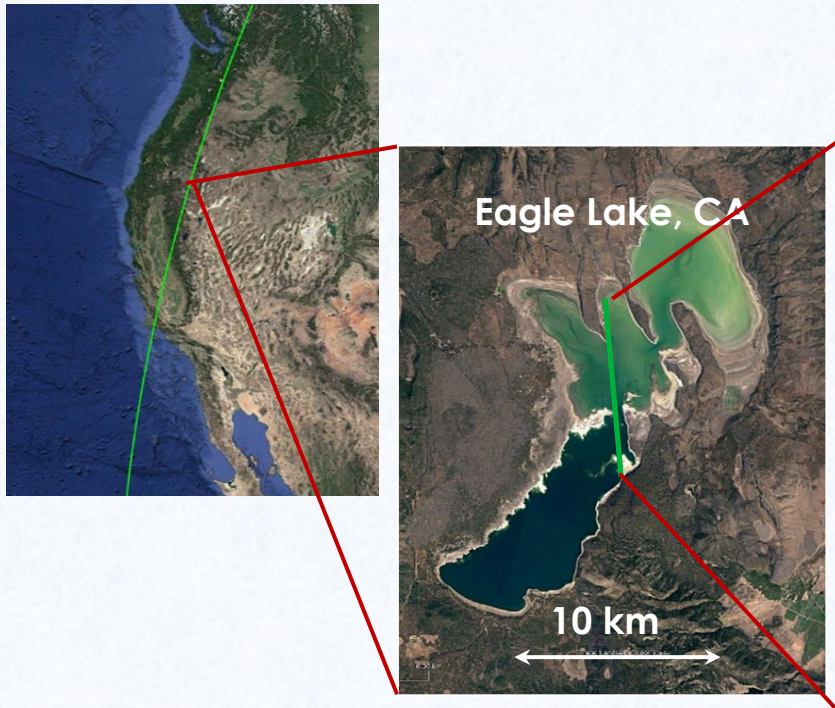
Name	Units
ht_water_surf (WGS84)	m
ht_ortho (EGM2008)	m
subsurface_attenuation	m^{-1}
segment_slope_trk_bdy	-
stdev_water_surf	m
sig_wv_ht	m
water_depth	m
u_derived	m/s

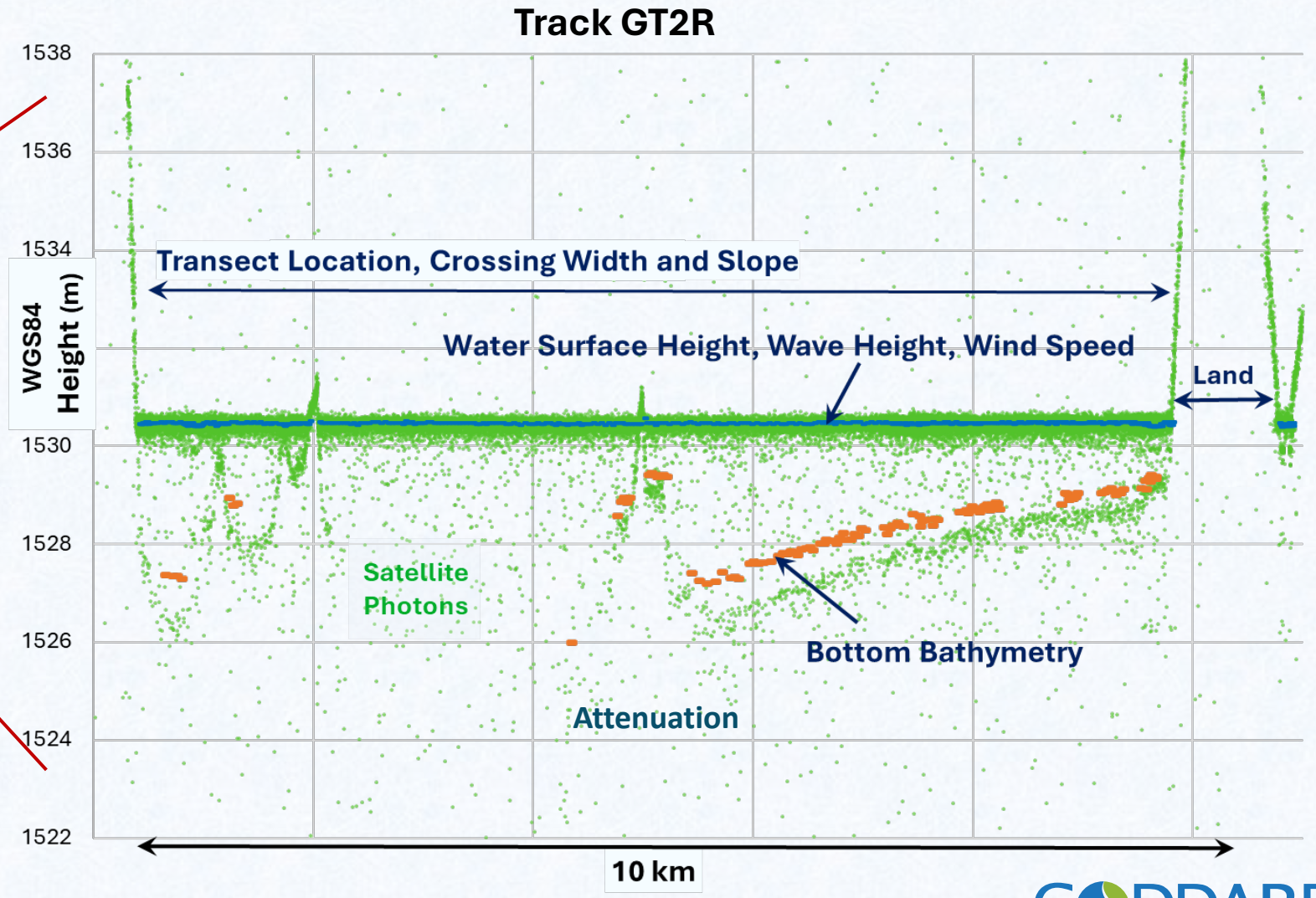
https://nsidc.org/data/ATL13
https://nsidc.org/data/ATL22

Jasinski, Stoll, Hancock, Robbins, Nattala, et al, Algorithm Theoretical Basis Document (ATBD) for Along Track Inland Surface Water Data, ATL13, Release 7, March 2024, NASA GSFC, 186 pp. NSIDC, https://doi.org/10.5067/46BO943W5S2X

Example 1: Eagle Lake CA

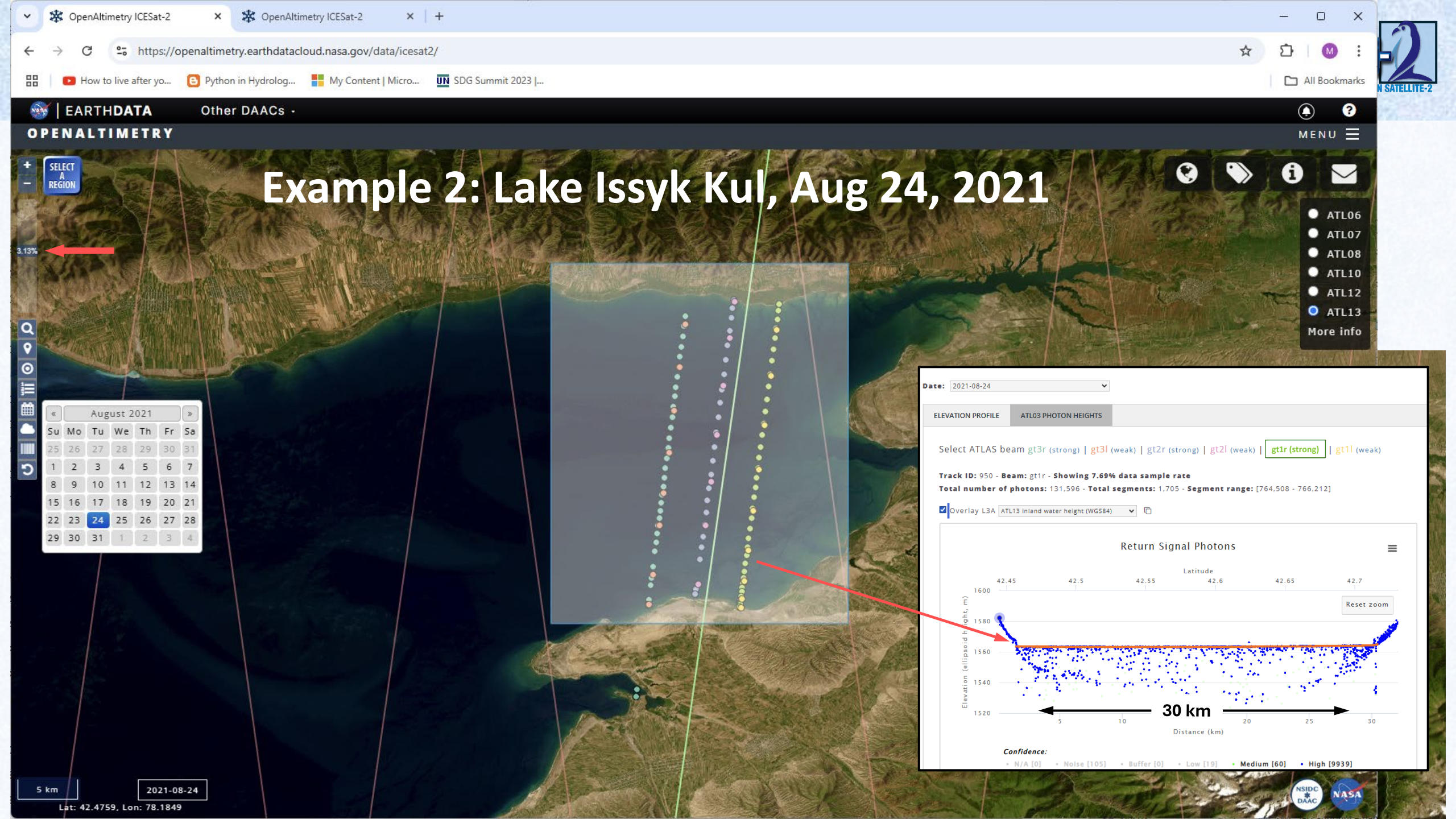
Oct 19, 2018



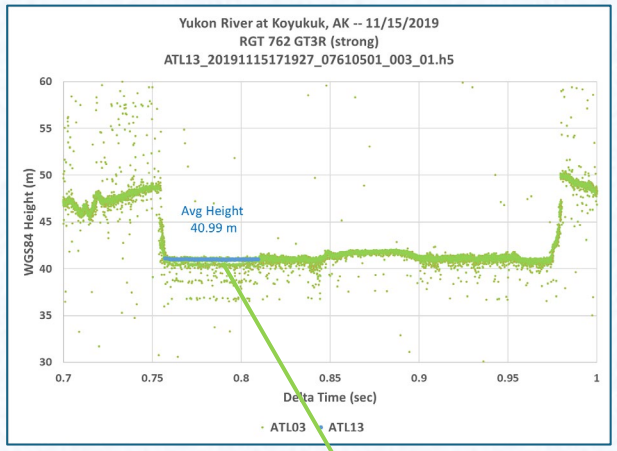


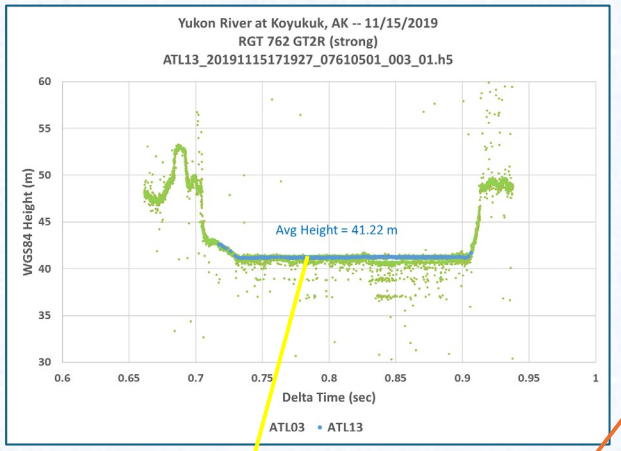
* Water Surface Height RMSE = 0.058m when compared against 2 yrs in situ data

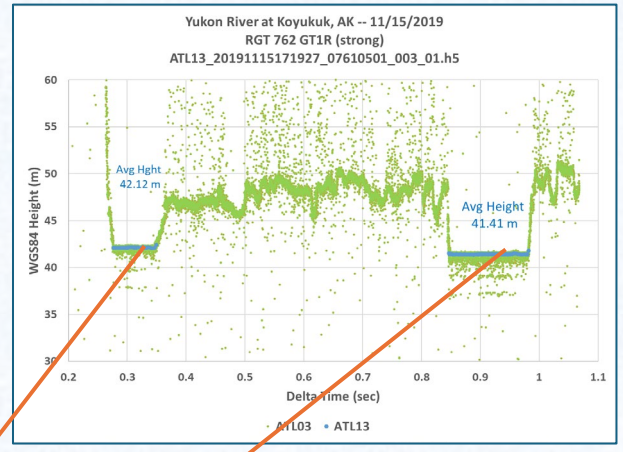
Example 2: Lake Issyk Kul, Aug 24, 2021

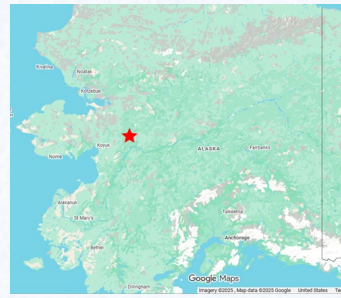


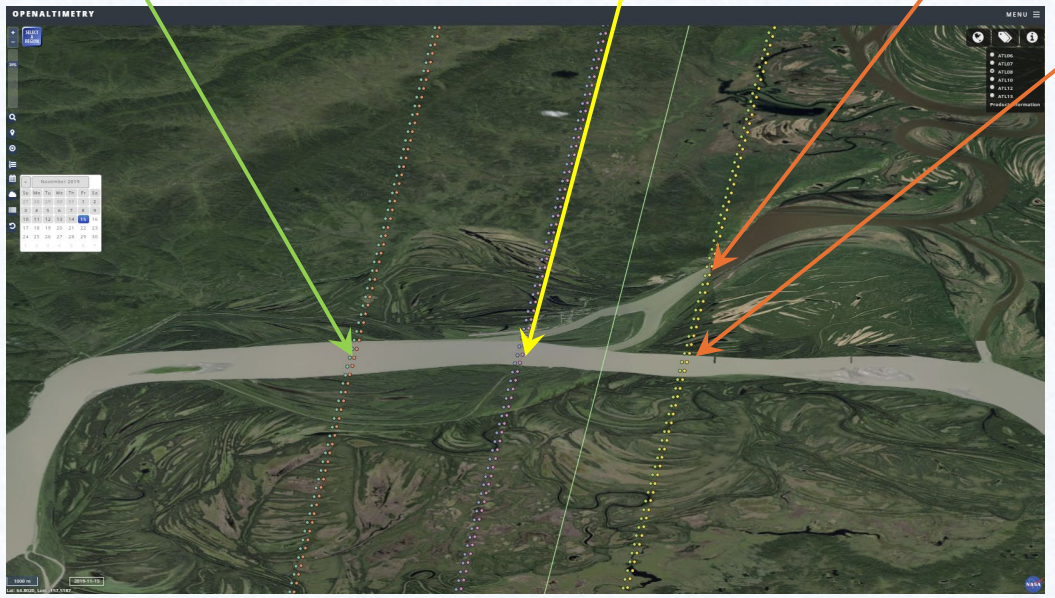
Example 3: Confluence of Yukon and Koyukuk Rivers, AK

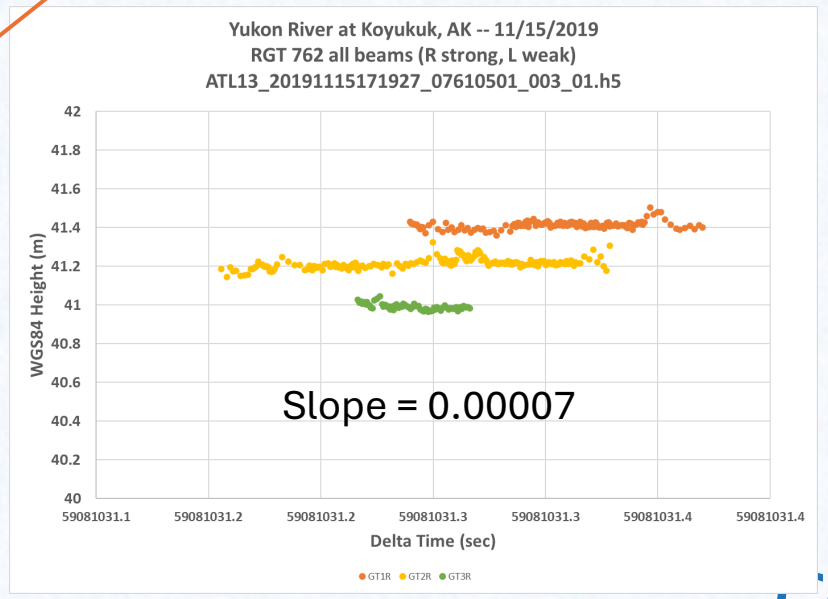




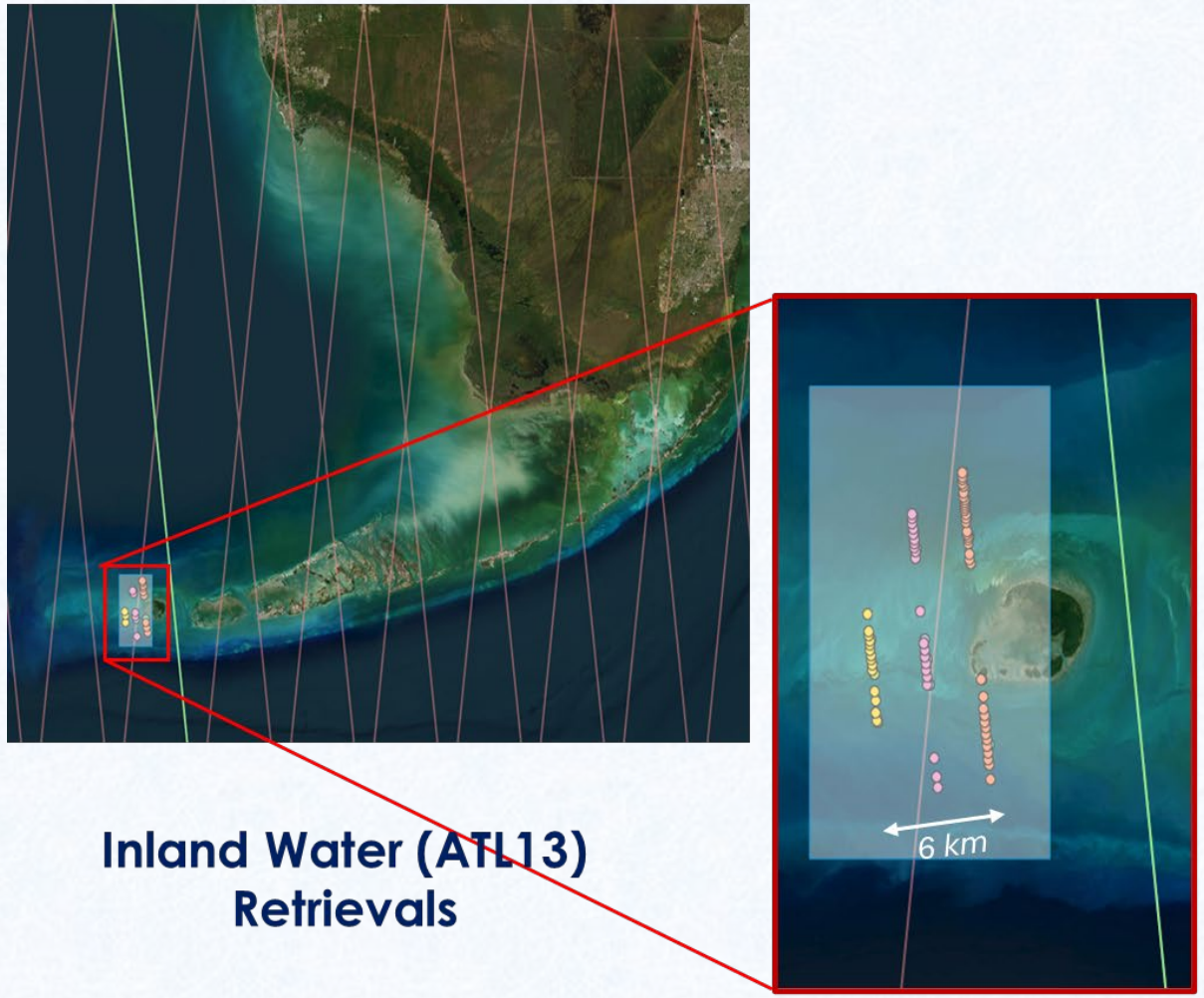








Example 4: Florida Coastal Zone Marquesas Keys 08/11/2019

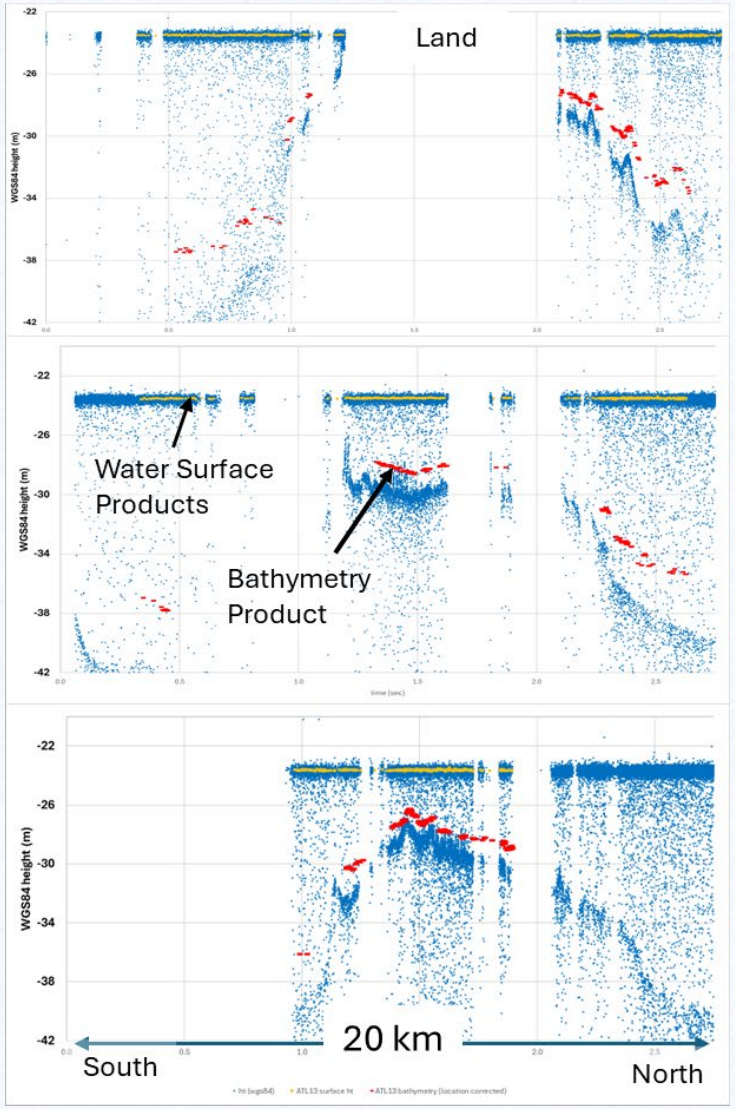


Inland Water (ATL13) Retrievals

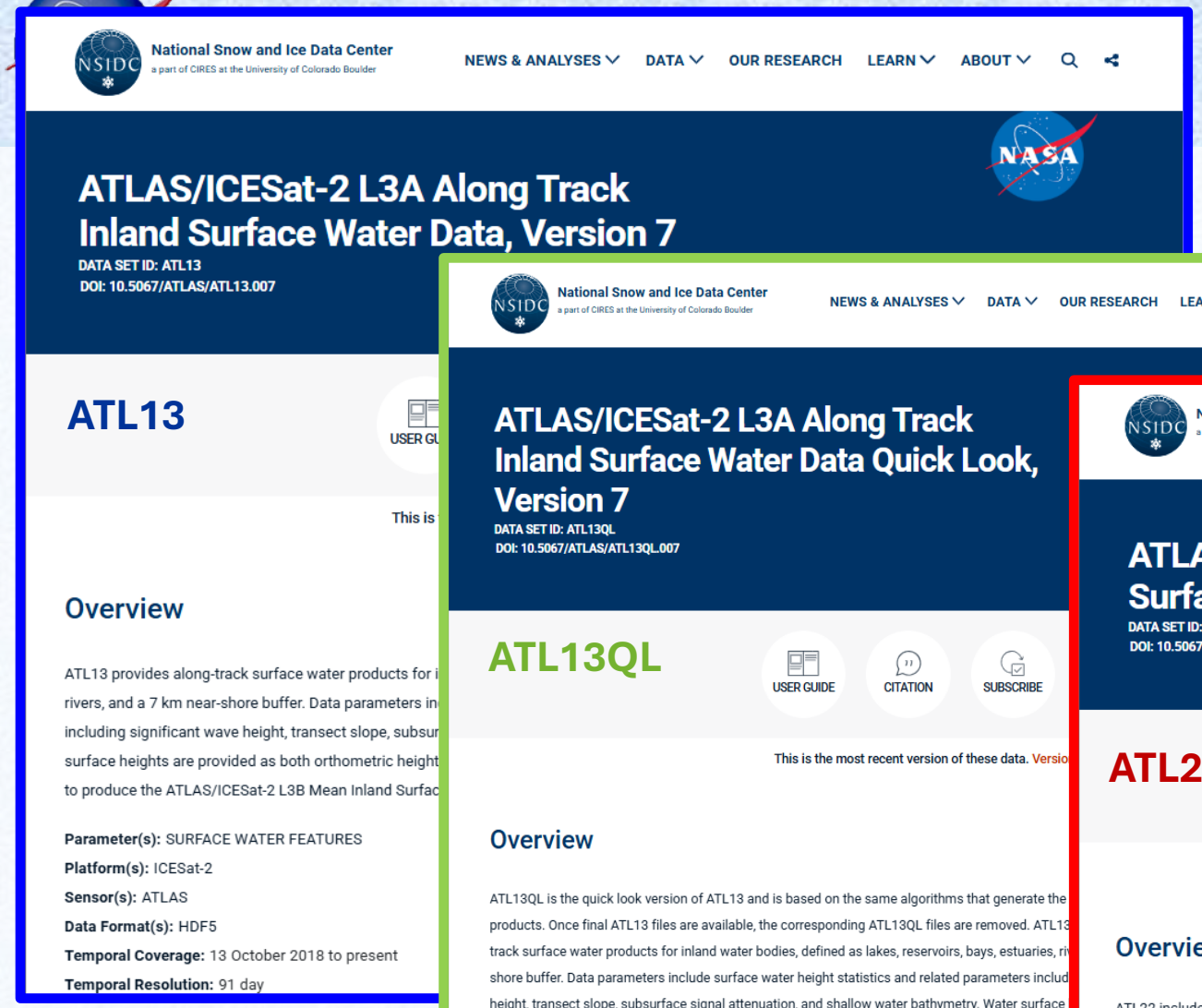
Beam GT3L

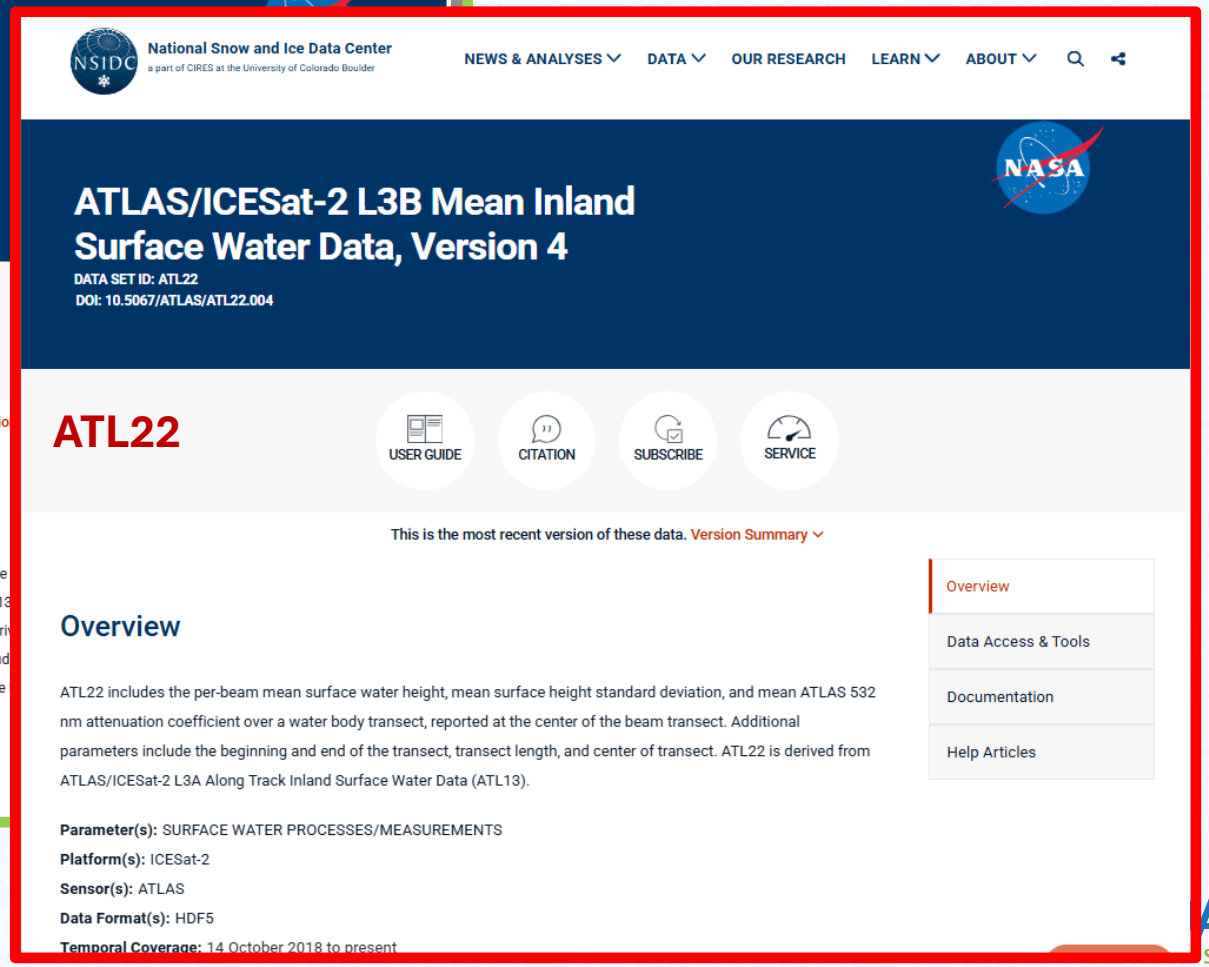
Beam GT2L

Beam GT1L



Recent Inland Water Product Updates Released Aug 2025





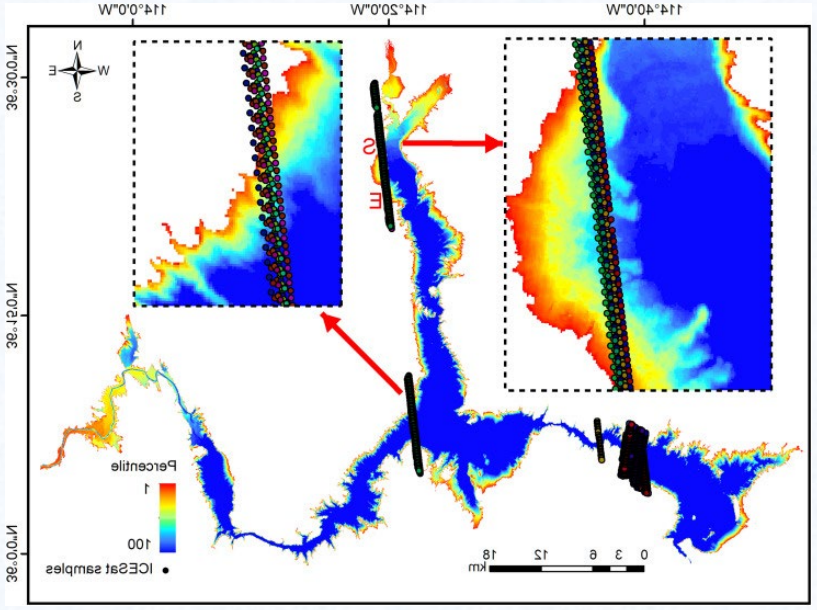
ICESat-2 Metrics
Along Track Products

	Data Product	Users	Files
ATL06	ATL06/L3A Land Ice Height	2218	17,814,578
ATL07	ATL07/L3A Sea Ice Height	696	1,909,495
ATL08	ATL08/L3A Land and Vegetation Height	4615	28,138,763
ATL09	ATL09/L3A Calibrated Backscatter Profiles and Atmospheric Layer Characteristics	386	465,686
ATL10	ATL10/L3A Sea Ice Freeboard	517	2,044,817
ATL11	ATL11/L3B Annual Land Ice Height	302	529,929
ATL12	ATL12/L3A Ocean Surface Height	433	1,196,947
ATL13	**ATL13/L3A Inland Water Surface Height**	**1564**	**1,519,912**
ATL07QL	L3A Sea Ice Height Quick Look	97	8,276
ATL08QL	L3A Land and Vegetation Height Quick Look	365	78,918
ATL09QL	L3A Calibrated Backscatter Profiles & Amospheric Layer Characteristics QL	42	4,562
ATL10QL	L3A Sea Ice Freeboard Quick Look	69	16,018
ATL13QL	**L3A Inland Water Surface Height Quick Look**	**148**	**8,454**

ICESat-2 Metrics
Mean/Gridded Products

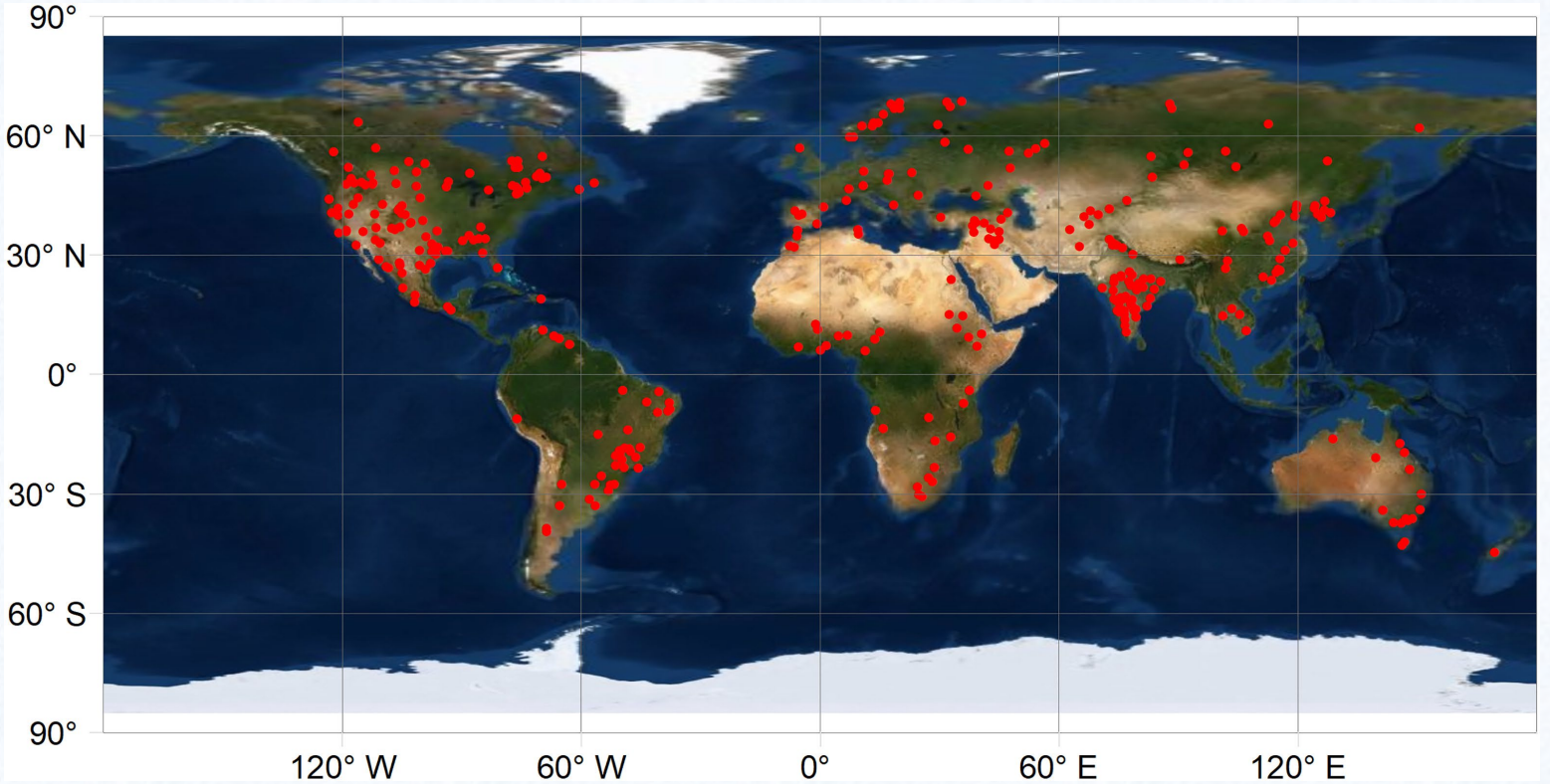
	Data Product	Users	Files
ATL14	L3B Gridded Antarctic and Arctic Land Ice Height	250	1,259
ATL15	L3B Gridded Antarctic and Arctic Land Ice Height Change	284	5,900
ATL16	L3B Weekly Gridded Atmosphere	64	2,928
ATL17	L3B Monthly Gridded Atmosphere	58	1,443
ATL19	L3B Monthly Gridded Dynamic Ocean Topography	88	2,749
ATL20	L3B Daily and Monthly Gridded Sea Ice Freeboard	223	17,910
ATL21	L3B Daily and Monthly Gridded Polar Sea Surface Height Anomaly	90	14,950
ATL22	**L3B Mean Inland Surface Water Data**	**167**	**102,607**
ATL23	L3B Monthly 3-Month Gridded Dynamic Ocean Topography	65	2170
ATL24	L3A Along Track Coastal and Nearshore Bathymetry	134	104,536

Global Reservoir Bathymetry Dataset Using Multi-Source Satellite Imagery and Altimetry (Gao et al, 2020)



ICESat tracks over Lake Mead 2003 - 2009

Texas Data Repository, V1

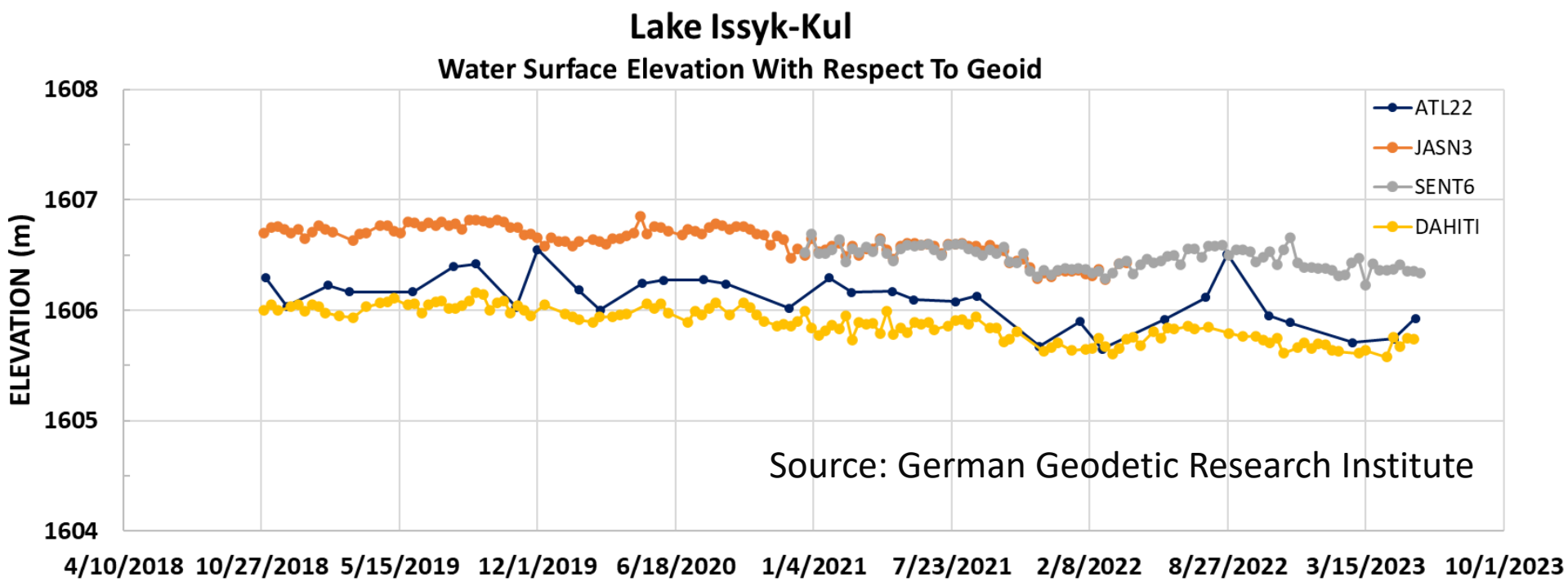


Location map of the 347 reservoirs

Citations:

- Gao, Huilin, 2020, "Global Reservoir Dataset", https://doi.org/10.18738/T8/TO5HJG, Texas Data Repository, V1
- Li, Y., Gao, H., et al.2020. *Remote Sens. Environ.* **244**, https://doi.org/10.1016/j.rse.2020.111831

Assimilation of Satellite Altimetry Lake Time Series Using Data Assimilation



Mission	Altimeter	Spatial Resolution	Repeat Frequency
ICESat-2	ATLAS	11 m	91 days
CryoSat-2	SIRAL	250 m	369 days *(30 day subcycle)*
Sentinel-6	POSEIDON4	300 m	10 days
SWOT	KaRIn	50 m	21 days

Summary

Strengths

- Offers global Data products
  - Orbit inclination Angle = 92 deg
  - Addresses 1.4M water body shapes including lakes, reservoirs, rivers and near shore coasts
- High vertical & spatial accuracy
  - Surface height RMSE reported ~ < 5-10 cm
  - Water bodies > 0.1 km^2 and rivers ~>50 m wide
- Crossing width estimate < 50 m
  - Allows estimates along track elevations interrupted within, e.g. dendritic lake boundaries
- Can yield shallow water along-track bathymetric mapping ~20m in clear water

- ATL13: Well-suited for detailed hydrologic analysis, hydraulic geometry, stream discharge, etc.
- ATL22: Well-suited for water resources applications (water balance, reservoir elev, river slope/discharge)
- ICESat-2 Software such as Open Altimetry and icepyx significantly facilitate analyses

Limitations:

- Low repeat pass frequency limits analysis especially for smaller water bodies
  - (routine off-pointing targets can be requested)
- Limited to partly cloudy or better conditions
- Occasional saturation effects occur limit product development

Thank you!

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NASA Physical Oceanography Program

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