

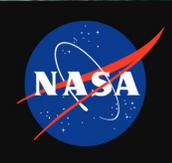
High Latitude Lake and River Dynamics: Capturing Hydraulic Measurements using ICESat-2

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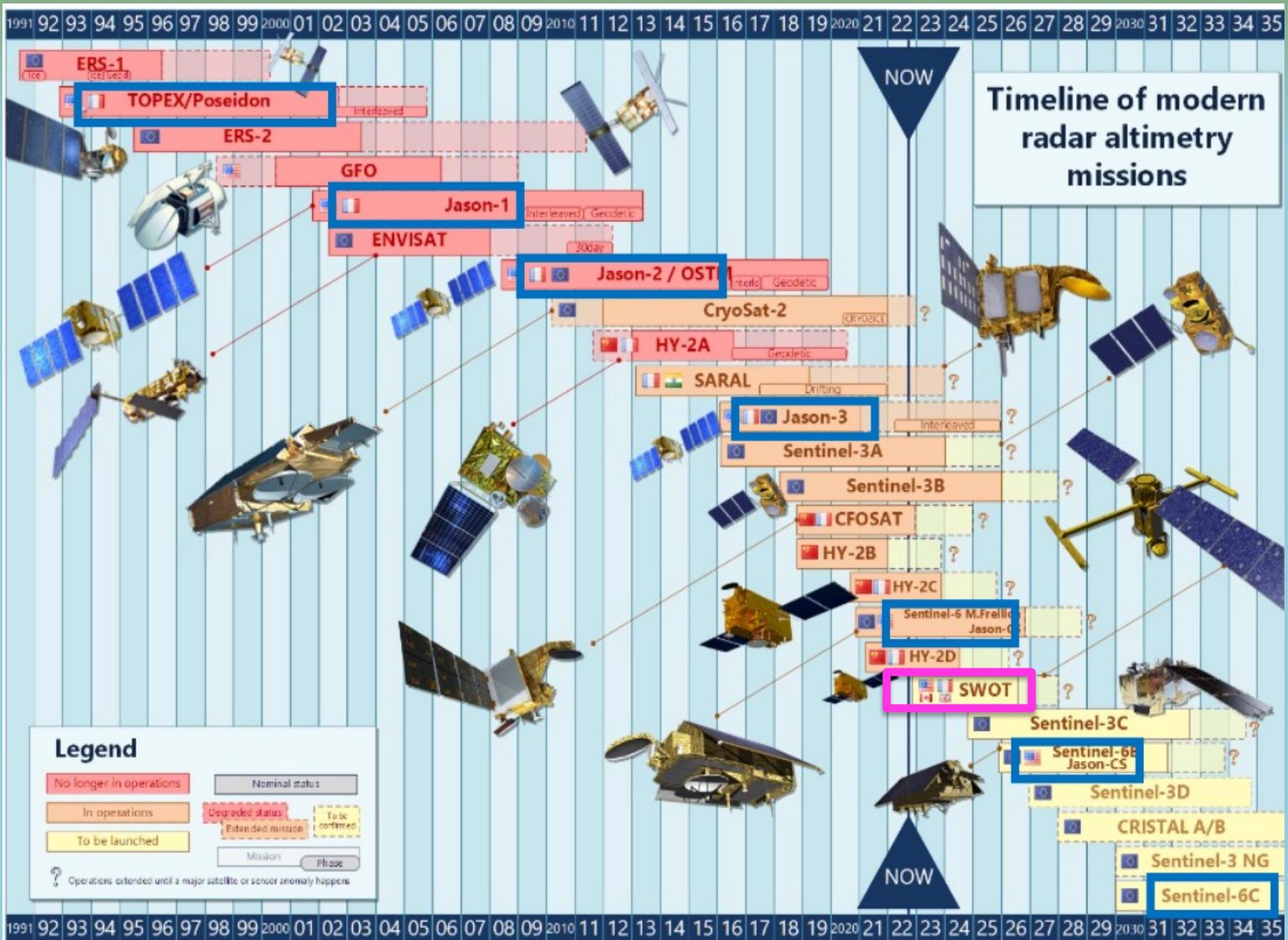
Lake Chakachamna

Glacial lake AK, 75km², proposed HEP construction, concerns wrt fisheries



Multiple applications using Satellite Altimeters (surface elevation and slope)

Must exploit the advantages of each radar and lidar mission, whether part of a continuity suite or a stand alone



Global Water Monitor – portal serving Science and Applied Sciences

Water Monitor Lake... Getting Started Other Bookmarks

90%

Water Storage and Dynamics

Welcome to the Global Water Monitor

An online source for satellite data products relevant to lakes, reservoirs, river channels, wetlands and global mean sea level.
(Main Contact: Charon.M.Birkett@nasa.gov)

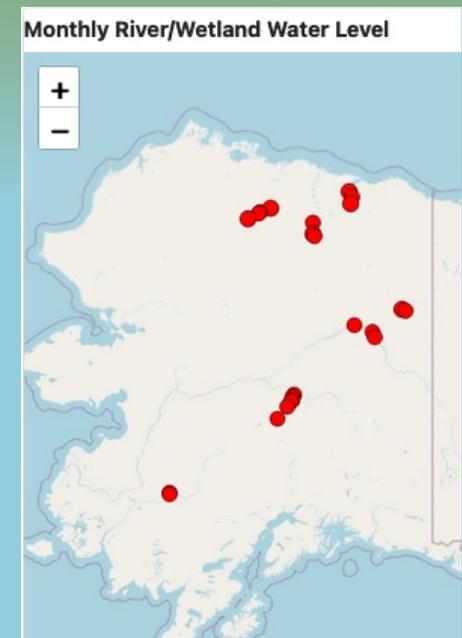
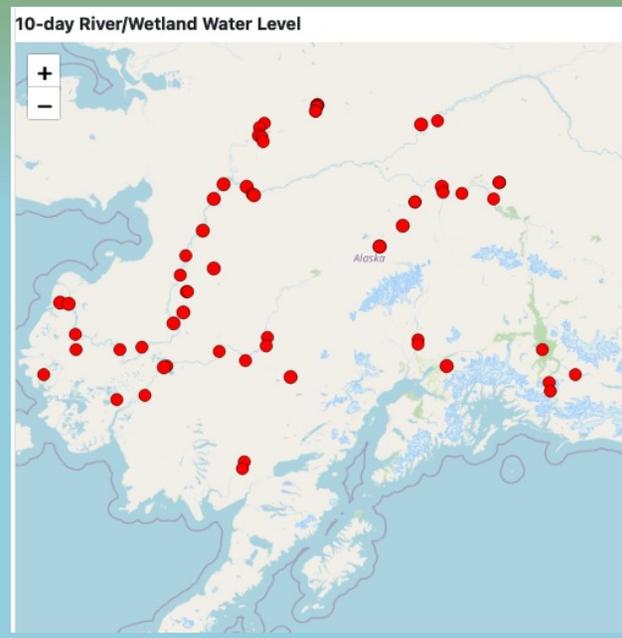
Important Note

Water Monitor - Lakes and Reservoirs

Water Monitor - Rivers and Wetlands

Water Monitor - Global Mean Sea Level

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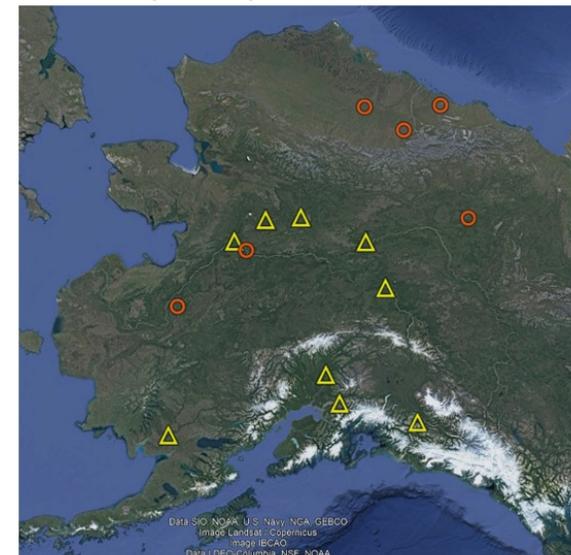


Near-real time altimeter-derived surface elevation data used for operational monitoring.
Archive data used for building baselines (departures from average).

USGS already integrating 10-day and 27-day resolution river reach elevations into the National Water Information System (NWIS) and creating higher-level products such as reach discharge.

Alaska Remote Sensing Streamflow (RSQ) Data in NWIS

- ▲ WSE (ft & m) and Q (cfs):
- [15212000 COPPER R NR CHITINA AK](#)
 - [15281000 KNIK R NR PALMER AK](#)
 - [15292780 SUSITNA R AT SUNSHINE AK](#)
 - [15302500 NUSHAGAK R AT EKWOK AK](#)
 - [15453500 YUKON R NR STEVENS VILLAGE AK](#)
 - [15485500 TANANA R AT FAIRBANKS AK](#)
 - [15564900 KOYUKUK R AT HUGHES AK](#)
 - [645150157475500 YUKON R BL KOYUKUK R NR KOYUKUK AK](#)
 - [654115156231300 KOYUKUK R NR HUSLIA AK](#)
- WSE (ft & m):
- [15389000 PORCUPINE R NR FORT YUKON AK](#)
 - [15564860 YUKON R AT GALENA AK](#)
 - [15565300 INNOKO R AT SHAGELUK AK](#)
 - [15875000 COLVILLE R AT UMIAT AK](#)
 - [15908000 SAGAVANIRKOTOK R NR PUMP STA 3 AK](#)
 - [15955000 CANNING R AB STAINES R NR DEADHORSE AK](#)



Combining Merits of Multi Platform Altimetric Instruments

ADVANTAGES

The contribution of new information where traditional gauge (stage) data is absent.

Determined surface heights are with respect to one common reference frame.

Repeat orbits (to ± 1 km) enable systematic monitoring of all water body types.

Surface water heights are potentially obtainable for any target beneath the satellite overpass.

The ability to monitor seasonal to inter-annual variations during the lifetime of the missions.

RADAR (Ku, Ka)

All-weather operation.

Generally unhindered by vegetation or canopy cover.

Continuity of instruments (30yrs), well validated techniques, good near-real time data lines

*Restricted by profiling-only, along-track spatial resolution,
onboard DEM use in severe terrain, winter ice-on penetration effects*

LIDAR (ICESat-2)

Multiple beams and higher latitudes for enhanced coverage and across-track surface slopes

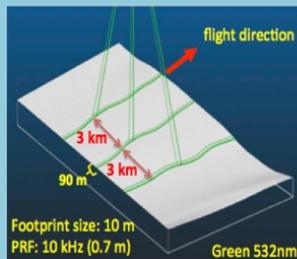
Exceptionally high along-track resolution

Complex topography not a hindrance

Contribution of winter (ice-on) measurements

[Some potential for water depth]

Restricted by cloud coverage and temporal resolution



The ICESat-2 Mission

High-latitude surface dynamics are complex, fast, and driven by snow, ice, permafrost. Modeling efforts that look to understanding mechanisms, and predicting variability due to natural processes and climate change, often lack basic hydraulic measurements, and the frequency of current observations are spatially and temporally poor

*Opportunity for a full investigation into
the CAPTURE and APPLICATION of HYRAULIC MEASUREMENTS
from ICESat-2/ATLAS*

*Focus on High Latitudes: Alaska and Canadian Yukon and British Columbia Provinces
Lake (Storage) and River (Discharge) Dynamics are the overall objectives
Use of ATL.3, ATL.13, ATL.22, and likely via ADAPT platform*

- *Quantity and Quality of elevation/slope/[depth]/ice-status measurements*
 - *Cross-validation using ground- and satellite-based datasets*
 - *Measurement uncertainty, confidence flags, ID of ice-free periods*
 - *Integration into the GWM portal - all results in the public domain*
 - *Future look to integration of lidar measurements in general*

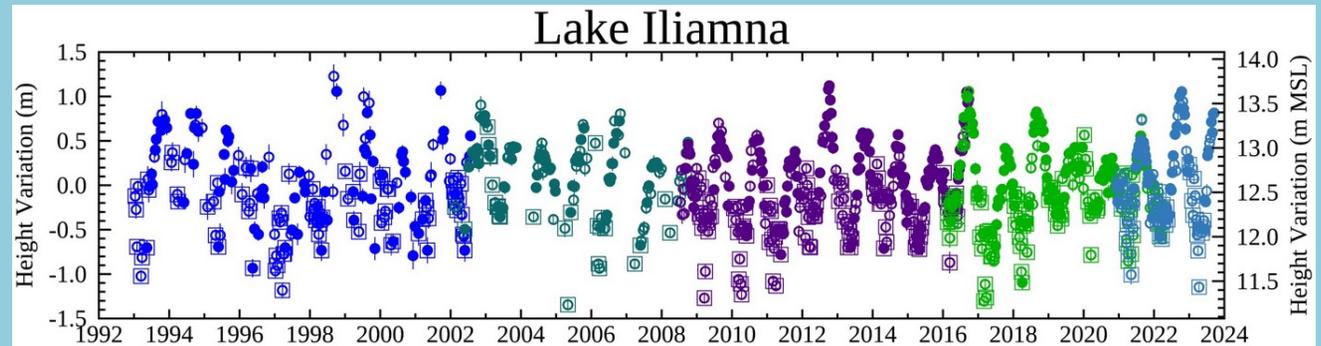
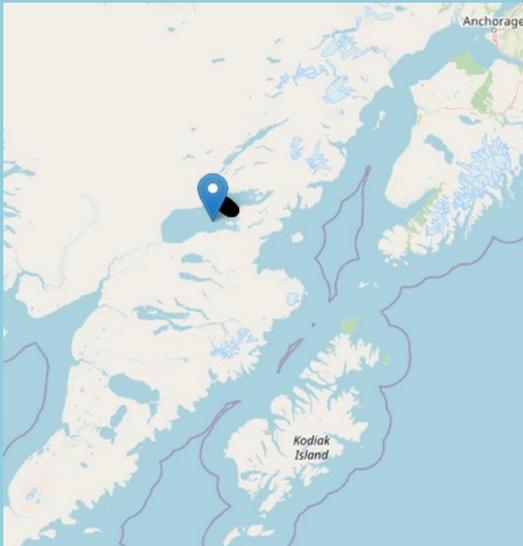
ROSES proposed Tasks are morphing into 6 different projects (so far !)



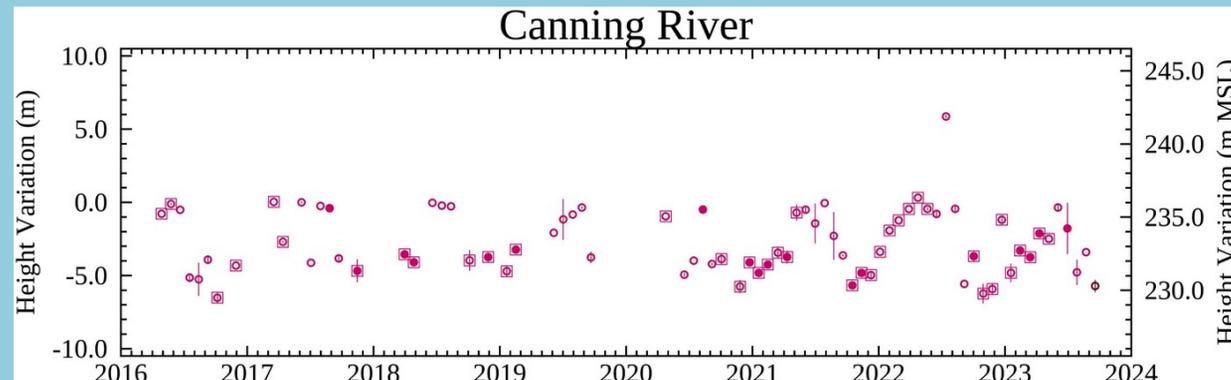
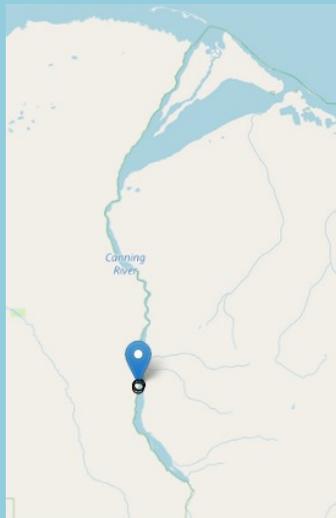
Contributions to General Inland Water Elevation Monitoring

- a) Cross-validation of existing radar altimeter stations (RAS) and enhancing the radar DEM.
- b) Investigation of ICESat-2 data delivery time and repeatability
- c) Integration of ATLAS measurements with traditional gauge and RAS.

Focus on lakes, wetlands, floodplains, and rivers. Collaborators: USGS, NOAA/NWS, FWS, NPS



ICESat-2 surface elevations to be integrated with those from other platforms. Examples shown are from the GWM portal and Sentinel-3,-6 missions e.g., large lakes along the Alaskan/Aleutian Peninsular requested for NPS e.g., gauge-sparse regions on the North Slope requested by USGS Radar altimeters have varying success depending on water body size.



Assisting with cross-validation efforts of new enhanced instruments



Assisting with SWOT KaRIn cross-validation efforts.

Case Study Zone: Alaska and multiple small ponds within the Yukon River Flats region.

Numbers identify ponds being surveyed as part of ongoing SWOT field campaigns.

Capturing Hydraulic Measurements (3)

ICESat-2 survey - multiple small lakes on the Alaskan North Slope.

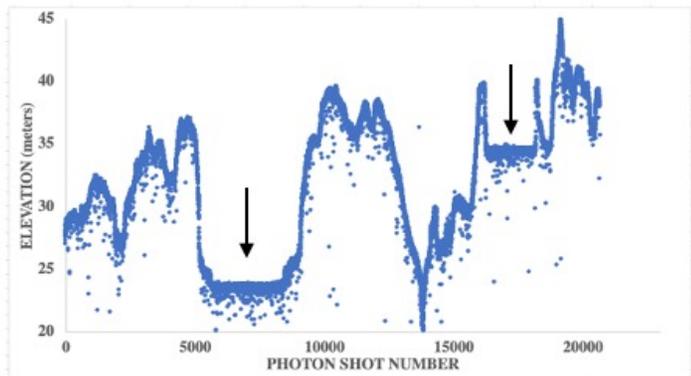
(elevation, slope, [depth], and change in surface status)

Collaborator: AK Fish and Wildlife Service



- a) *Supplementing historical surveys*
- b) *noting current surface status*
- c) *looking to a potential for routine monitoring.*

Arctic National Wildlife Refuge is an important fish and waterfowl habitat. Multiple small, shallow ponds. An ability to record depth during spring melt is of particular interest.



ATLAS can observe very small water bodies. Easily acquired are the frozen surfaces (arrows) of small lakes on the Alaskan North Slope. [Data source: NSIDC/ATL03 11/17/2018 beam 2L].



Capturing Hydraulic Measurements (4)

Glacial (or Ice) Dammed Lakes – Flood hazards

Change in elevation and surface status for pre/post flood analysis

Collaborators: NOAA/NWS, Univ. Calgary

<https://www.weather.gov/aprfc/gdlMain>

NATIONAL WEATHER SERVICE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

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Alaska Glacier Dammed Lakes Main Page

Weather.gov > Alaska-Pacific RFC > Alaska Glacier Dammed Lakes Main Page

Alaska-Pacific RFC
River Forecast Center

River Observations and Forecasts Weather Observations and Forecasts Water Supply Climate and History Seasonal Interest Additional Info

Jökulhlaups / Glacier Dammed Lakes

Jökulhlaups are outburst floods caused by the rapid release of water from a glacier dammed lake. Glacier dammed lakes are formed when a glacier blocks the flow of water out of a tributary valley. Throughout the seasons rainfall, rainfall runoff, snowfall, snow melt and glacier melt all accumulate in the lake. At a semi-regular interval, which differs for each lake, the lake begins a self-dumping process. This process begins when the lake floats the glacier or as a fracture in the blocking glacier begins to release water. As the water flows through the opening it is enlarged by melting due to the heat created by the potential energy of the flowing water. After the water has drained, the opening begins to close off and the lake begins to fill again.

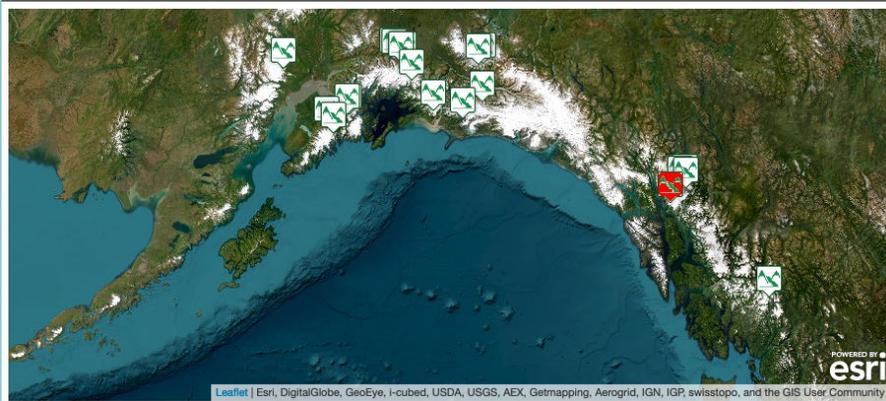
Numerous glacier dammed lakes exist in Alaska. Snow and Skilak Glacier lakes are familiar to those along the Snow and Kenai River due to the flooding or high water levels which can occur after the lake releases. Visit the link below for additional information regarding Alaskan glacial dammed lakes.

To view the information page for a Glacial Dammed Lake, click the map icon to display the link or select it from the dropdown list.

Select a GDL:



Post, A., & Mayo, R. L. (1971). [Glacier dammed lakes and outbursts floods in Alaska. USGS Hydrologic investigations atlas ; HA-455](#)



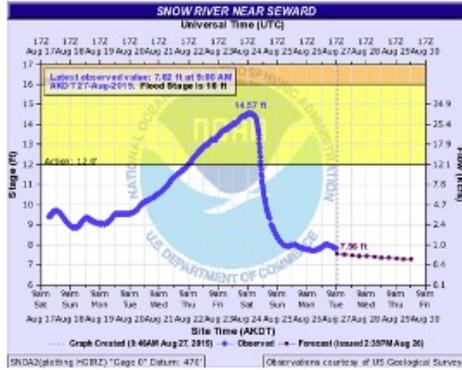
e.g., Strandline Lake, AK, which often experiences rapid changes in elevation with complete drain out. Glacial Dammed Lake inventories (based on multispectral imagery) available. Funding being sought for Canadian fieldwork to support this ICESat-2 study.

NOAA/NWS/AK Glacier Dammed Lakes Monitoring Service



Lake/River Ice dam break up or Excess precipitation – Flood Hazards

Collaborators: USGS



(Top) Much of the population in Alaska resides along rivers. The community of McGrath nestles between a set of meanders and is thus prone to flooding. The May 2022 flood due to ice-dam release raised the Kuskokwim River by ~8feet within 24hrs.

[Center] The Seward Highway is important for the State of Alaska's economy, mobility, and defense. Bridge 605 resides in a glacierized basin and is prone to flooding from outbursts from the base of Kenai Lake. In August 2019, a draining event caused the Snow River to rapidly rise over the course of several days.

[Bottom] variations in flow, elevation, channel width and surface roughness at bridge No.591 on the One Mile Creek before, at peak flood, and at flood demise, during mid-July 2022.

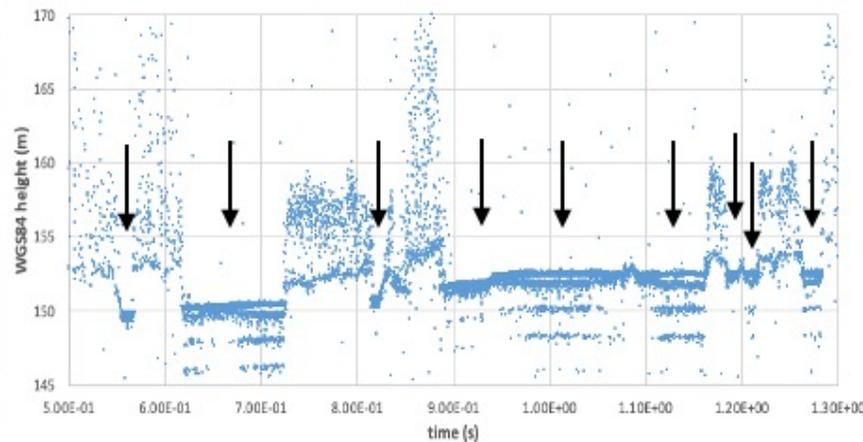


Determining changes in river channel morphology

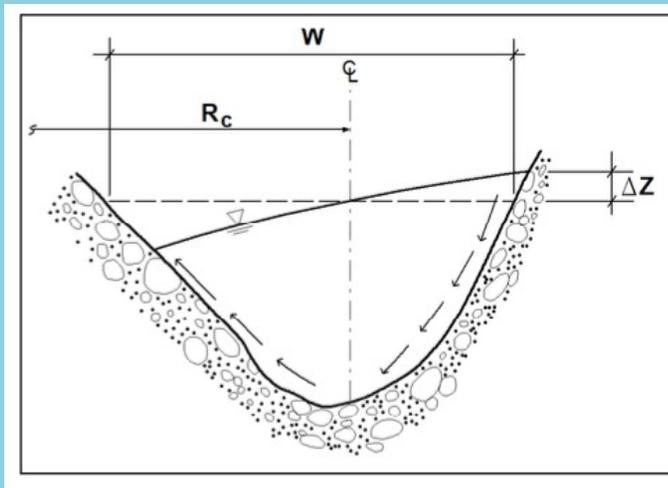
- a) Assessing the complexities within large braided and meandering rivers.
- b) Monitoring the build-up of seasonal ice.
- c) Determining effects of channel erosion and scour (with relevance to flooding and infrastructure damage)

FOCUS ON RIVER REACH SURFACE SLOPE AND “SUPERELEVATION”

Collaborators: USGS



ATLAS surface acquisitions across a braided reach of the Yukon River. The ability to detect each channel in the reach is clearly demonstrated (arrows) but cross-checks are required to investigate the apparent sub-surfaces. [Datasource: NSIDC/ATL03 09/10/2020 beam 1L]



The change in flow direction through a river channel bend results in centrifugal forces that cause the water surface to be higher along the outside of the bend (right) than along the inside (left). The resulting bank-to-bank slope, or superelevation, is an important hydraulic parameter when considering estimations of streamflow and changes due to erosion and scour.

Summary

TO DATE

First steps towards examining ATL product content, access, and delivery speed

Ongoing discussions with respect to,

- Collaborator Requirements

- Study Region Identification

- How best to interface with the Global Water Monitor (GWM)?

- Higher-level ATL product format, e.g., quick looks, 2D regional/basin slope visualizations

NEXT STEPS

ADAPT data access and in depth ATL data exploration

Global Water Monitor – system modification

Note:

This project is running parallel with a SWOT V ICESat-2 study. There will be some overlap in terms of case study targets. The objective here is “What can we learn about ICESat-2 quality/quantity from the new SWOT swath (KaRIn) instrument”?

