March 21, 2022

Living Lab Program for Climate Change and Conservation - Final Report

Project title: Kokanee Glacier Forecast Project

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Research findings

- Kokanee Glacier gained 1.91 meters water equivalent (m w.e.) of snow during the 2020-2021 winter. Slightly below average for 2013-2021 period.
- Kokanee Glacier lost 3.83 m w.e. of snow and ice during the 2021 summer
- The 2021 annual balance for Kokanee Glacier was -1.92 m w.e., the worst year on record (2013-2021).
- From 2013 to 2021 the Kokanee Glacier lost 6.5 m of total thickness, equating to a loss of 15% of total ice volume.
    - In 2021, the glacier lost 6% of its volume
- Since 2004, Kokanee Glacier retreated over 500 m, a rate of more than 30 m per year.
    - The glacier retreated 60 m in 2021.
- Using the Open Global Glacier Model, we projected the fate of the Kokanee Glacier over remainder of the 21st century and found that:
    - Kokanee Glacier is projected to disappear between 2050 and 2080.
    - Worst case emissions scenario takes 15 years off expected lifespan.
    - Using an emission scenario in line with the Paris Climate Agreement, the glacier disappears around 2080, then is near the threshold to retain snow (needed to sustain a glacier) over the former glacier area.

Methods summary

- Field mass balance: snow depth is measured using avalanche probes, snow density from snow pits and snow cores, and ablation stakes are used to record ice melt. Mass balance is estimated from these observations following Pelto et al. (2019).
- We collect airborne light detection and ranging (LiDAR) surveys of the glacier each spring and late summer. We post-process these surveys to produce one-meter-resolution digital elevation models (DEM). We the co-register the DEMs and then difference the subsequent DEMs to measure height change, and thus snow depth in winter, and glacier mass change in late summer. These methods are further detailed in Pelto et al. (2019).

- We used the Open Global Glacier Model to project the fate of the Kokanee Glacier with three emissions scenarios low, medium, and high. The model was fed with our ice thickness data.

Key outcomes for BC Parks

- Hazards
    - The record negative mass balance in 2021 caused many crevasse bridges to collapse around the middle of the glacier, making summer travel more dangerous and increases the likelihood of a crevasse fall in winter.
    - The toe, or terminus, of Kokanee Glacier shows signs of stagnation, with low ice velocity, emerging rock outcrops and rapid thinning.
    - Our one-meter-resolution LiDAR DEMs are valuable to assess terrain hazards and are collected each April and September.
- Mass balance record – Our mass-balance record now spans nine years, from 2013-2021. The value of glacier mass balance records increases with temporal length, especially those that exceed a decade. Our record will allow us to quantify the current state of the Kokanee Glacier and will enable us to better forecast the longevity of Kokanee Glacier and the expected date when the glacier will vanish.

Relevance to BC Parks management

- Ongoing monitoring of glacier-related hazards
    - Potentially posting a notice at the Gibson Lake trail head that travel on the glaciers in the park is becoming more hazardous as the glaciers melt and deteriorate and should only be attempted by experienced parties with the proper equipment.
- Public engagement
    - We are happy to provide materials to be hosted at the Kokanee Glacier Cabin relating to Kokanee Glacier. These materials could detail the science and findings and inform the public of the current state and expected fate of the Kokanee Glacier.
    - Our results can be used to educate Park visitors about climate change. There are 2900 glaciers located in BC Provincial Parks, but only the Helm Glacier in Garibaldi Provincial Park is routinely monitored. Our research at Kokanee Glacier provides an outstanding opportunity to communicate and engage with the public concerning changes that are occurring in their local parks.

Project's challenges/opportunities

The spring field trips are logistically and financially challenging, so without continued research funding, we will need to rely LiDAR surveys to estimate winter balance without field visitation. We plan to assess whether we can use the nearby Redfish Creek automatic snow weather station to estimate snow density to convert LiDAR-derived snow depth to snow water equivalent.

Maintaining a continuous mass balance record at Kokanee Glacier is critical, but it requires financial assistance from the Province of British Columbia. The glacier is the only active glaciological mass

balance site in the Columbia Mountains and is thus valuable as a regional benchmark to inform modeling studies.

Conclusions/next steps

We found that Kokanee Glacier lost over two meters of total thickness, equivalent to 6% of the glacier's total volume, a staggering total that is three times the current average rate of mass loss. Years like 2021 pose a threat to the longevity and may act to accelerate the disappearance of the glacier.

We aim to continue studying Kokanee Glacier and extending our annual mass balance record.

References and links

Our mass balance work on Kokanee Glacier was published here in The Cryosphere.

Our ice thickness work on Kokanee Glacier was published here in The Journal of Glaciology.

A summary report on our glacier research is here.

Our presentation during the 2020 Living Labs Research Colloquium is here.

Checklist

- Have you submitted a short blog for BC Parks' website? If not, a blog summarizing your project in no more than 400-600 words is due no later than 30 days after the end of the term of your agreement. We welcome photos or images too to support the blog.
    - Yes, a full version is here. Contact Ben Pelto with any questions.
- Have you added any relevant Living Lab project data or reports to the BC Data warehouse and/or EcoCat? Please contact Jen Grant or Stephen Ban for assistance.
    - No, our mass balance data is available from the World Glacier Monitoring Service
- Invoice submitted? An invoice is required to receive the final instalment of your Living Lab transfer agreement funds. The invoice should include:
    - the university address,
    - the Transfer Payment number (as per your agreement),
    - a one-line description of what the project is about,
    - the amount due (you may need to send this via your financial arm) and indicate that this is the final instalment. The invoice should follow or accompany the completion of this final report template of which both are due on or before March 21st, 2022. **If we do not receive an invoice from you by this date, we will not be able to issue your final payment.**