13 March 2025

Living Lab Program for Climate Change and Conservation - Final Report

BC Parks LIVING LAB

Project title: State and fate of Overlord Glacier and associated downstream consequences

Lead researcher(s): Dr. Gwenn Flowers & PhD student Chloé Monty (Simon Fraser University), Dr. Jeff Crompton (Geological Survey of Canada/Natural Resources Canada), Dr. Brian Menounos (University of Northern British Columbia)

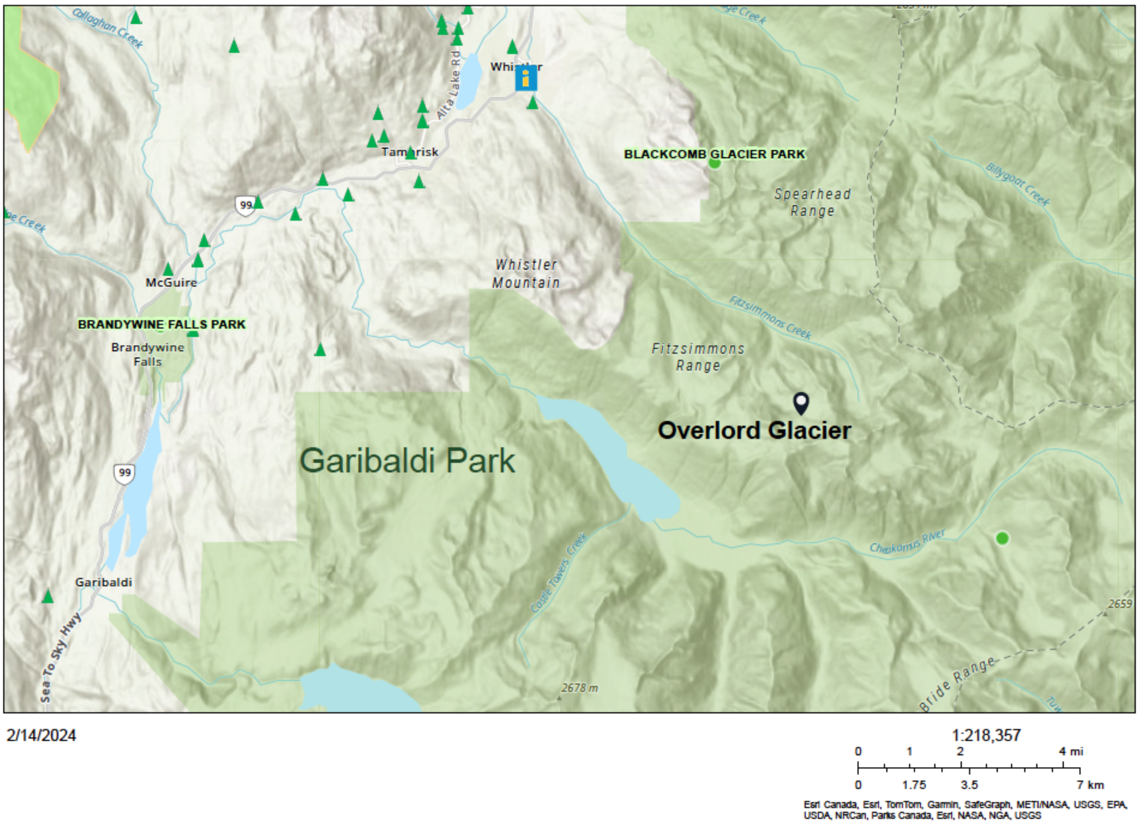

Figure 1. Map of study area (Overlord Glacier) within Garibaldi Provincial Park and the Fitzsimmons Creek drainage, South Coast Region, BC.

Research findings

In total, we collected over 4000 interpretable soundings of ice depth across the terminus of Overlord Glacier. Preliminary data processing indicates an average ice thickness of 40 m and a maximum of 132 m in the surveyed area, with the expectation of deeper ice above the region covered by the survey. Ongoing processing of location data is expected to fill some of the gaps in the current map (Figure 2, left). An example of the data we collected is shown in Figure 2 (right panel) where the lowermost continuous reflector along a ~400 m profile is interpreted as the glacier bed. The glacier bed was easily identifiable in nearly all of the survey lines, in most cases with no processing (e.g., filtering, gain control) applied to the raw data.

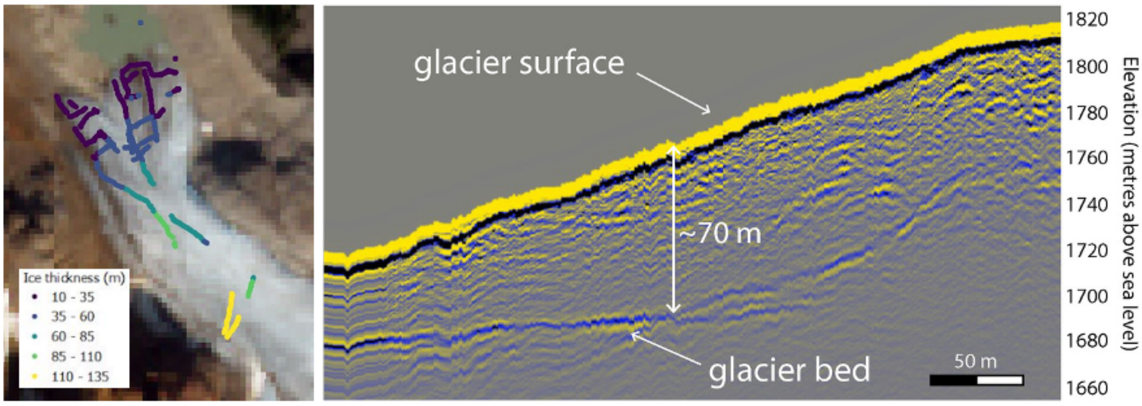

Figure 2. Preliminary results of ice-thickness mapping. Left: Interpreted ice depths along survey lines, Overlord Glacier terminus. Right: 400m-long example radar section showing prominent reflector interpreted as the glacier bed.

A complete map of glacier depth will tell us (1) whether there may be lakes developing beneath the glacier and (2) what the ice-free landscape will look like upon deglaciation. This information is a required input to the computer models that will be used to project future glacier change in the project.

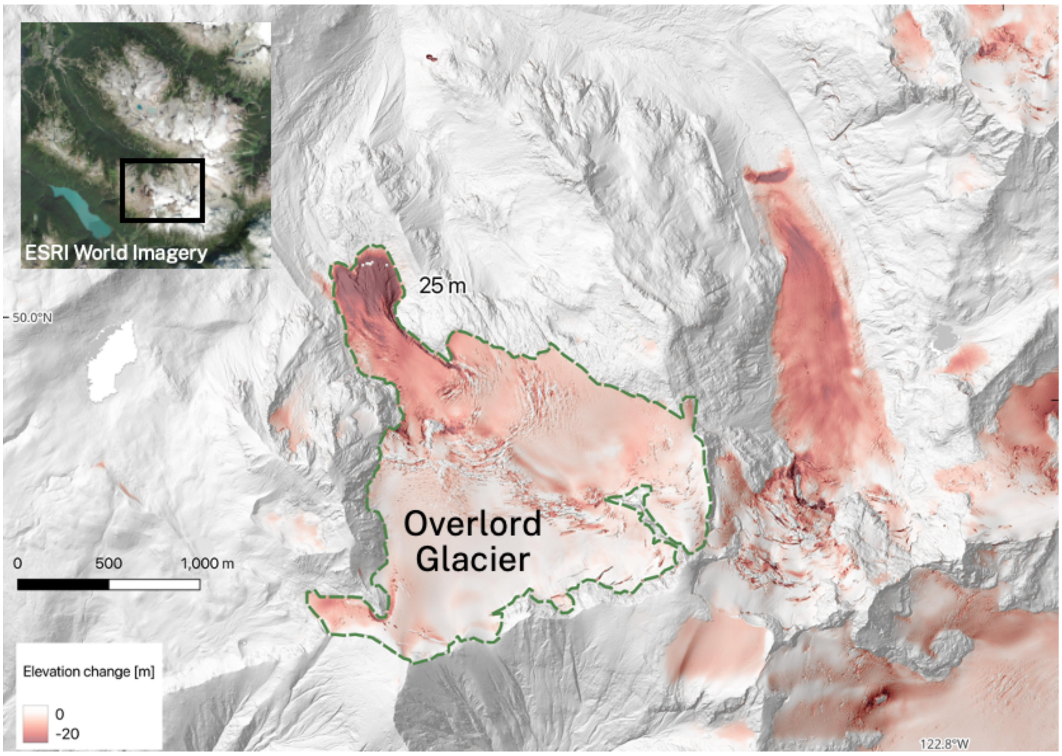

Figure 3. Preliminary results of digital elevation model (DEM) differencing showing pervasive thinning of Overlord Glacier, 2020-2024 (Courtesy of Brian Menounos).

Collaborator Brian Menounos (UNBC) has obtained airborne Light Detection and Ranging (LiDAR) data over the region surrounding Overlord Glacier between 2020 and 2024 (Figure 3). Digital elevation models produced with these measurements can be differenced to produce maps of elevation change over this period, yielding a mean thinning rate of 1.8 m/yr and a total volume loss of 2.55 million cubic metres, roughly equivalent to the volume of 3863 Olympic swimming pools. These data can be converted to estimates of mass loss, which will be used as targets for mass-balance model tuning in a future phase of the project.

Methods summary

In Year 1 of this project on Overlord Glacier, we undertook preliminary characterizations of (1) the proglacial lake emerging with glacier retreat (Figure 4), (2) glacier geometry and dynamics (Figure 2) and (3) glacier mass change (Figure 3).

1. Characterization of the proglacial lake forming as Overlord Glacier retreats:
    - Deployment of a conductivity-temperature-depth (CTD) logger in the lake to monitor in-situ water quality/quantity indicators
    - Remote-control boat survey of lake bathymetry (depth map) and airborne photography of glacier terminus and lake region
2. Characterization of Overlord Glacier geometry and dynamics:
    - Installation of time-lapse cameras imaging the glacier terminus on an hourly basis
    - Ice-thickness survey of Overlord Glacier terminus with a low-frequency radio-echo sounding system
3. Characterization of Overlord Glacier mass change:
    - Continuation of airborne LiDAR campaign on Overlord Glacier to make repeat measurements of high-precision surface elevation

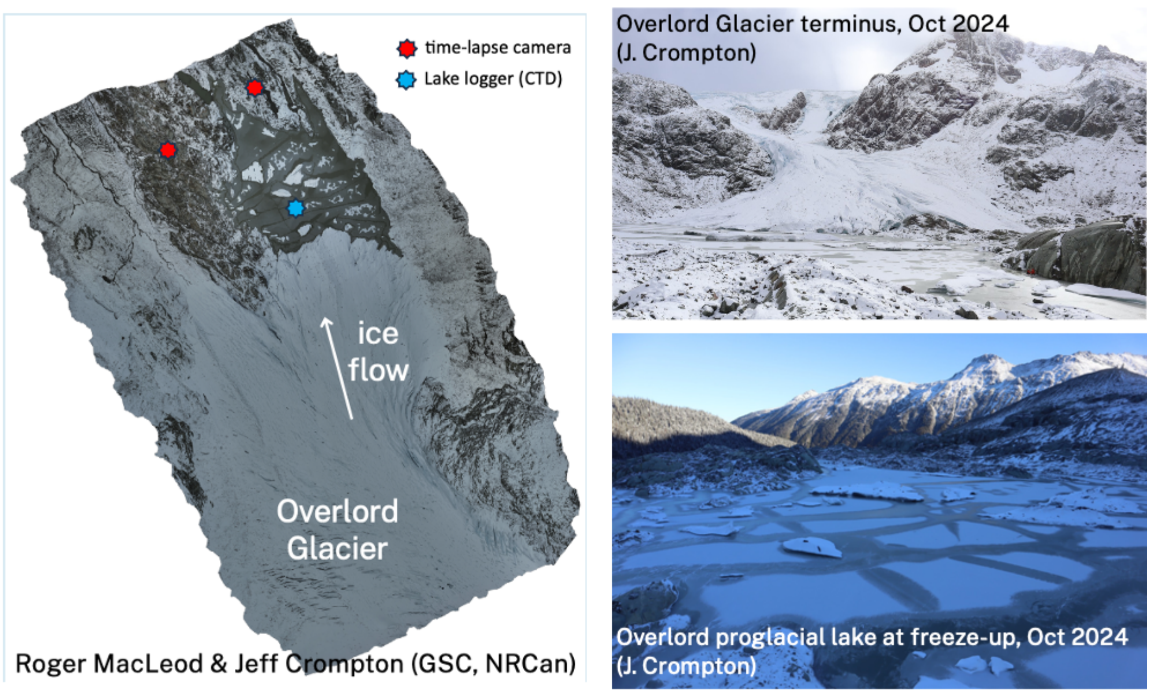

Figure 4. Airborne and ground-based imagery of "Investigator Lake" in front of Overlord Glacier, October 2024. Survey tracks can be seen in the ice forming on the lake. Locations of time-lapse cameras and a conductivity-temperature-depth (CTD) logger is shown in the image at left.

Key outcomes for BC Parks

We are documenting rapid landscape change as deglaciation occurs, including persistent glacier mass loss, meaning some fraction of the runoff in this basin is derived from non-renewable sources. We don't know what fraction that represents yet, nor what its specific downstream consequences will be. As glacier thinning and retreat progress, we expect the proglacial lake to expand, formerly ice-covered steep slopes to be exposed and possible changes in glacier crevasse patterns. Evolving lakes and crevasses may present a hazard even to travelers familiar with the area, especially when coupled with changes in the seasonal snowpack.

Relevance to BC Parks management

At this early stage of the project, we cannot make any concrete management recommendations to BC Parks on the basis of our preliminary results.

Project's challenges/opportunities

Administrative delays in permitting from the Squamish Nation (as this is a new project) resulted in postponement of field work from summer 2024 to fall 2024, making it difficult to schedule the work around fall academic obligations and the weather. The lake survey was particularly difficult to schedule and ended up being completed just as lake freeze-up was occurring (Figure 4). With permits now in place, it should be possible to take advantage of summer conditions for 2025 field work. The radar-based ice-depth mapping in fall 2024 was challenged by the rugged terrain (Figure 5), with steep slopes, debris-covered ice and numerous crevasses that required careful navigation. Augmentation of the maps of ice depth and glacier bed topography will require ground-based work during safe snow-covered conditions and/or airborne radar surveys.

Figure 5. Ice-penetrating radar survey of Overlord Glacier terminus, September 2024. Left: SFU graduate students Tim Hill and Chloé Monty shown with radar system. Right: Challenging survey conditions on lower Overlord Glacier.

Conclusions/next steps

Characterization of the proglacial lake is just getting started, with processing of the bathymetry data underway to make a first map of the lake basin and water depth. Data from the CTD will be retrieved in summer 2025 when the logger is recovered. Work is also underway to create high-resolution digital elevation models (DEMs) of the glacier terminus/lake region using Structure-from-Motion (SfM) photography. Quality control of the ice-depth soundings is underway to produce more complete and reliable estimates of ice thickness in the glacier terminus region. We are in the process of comparing these measurements to existing estimates of glacier thickness and planning future survey campaigns to extend our measurements across the glacier surface. These data will be used to produce DEMs of the ice thickness and glacier bed, which are required inputs to the ice-flow models that will be used to simulate Overlord Glacier form and flow.

References and links

Coming in the future!