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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

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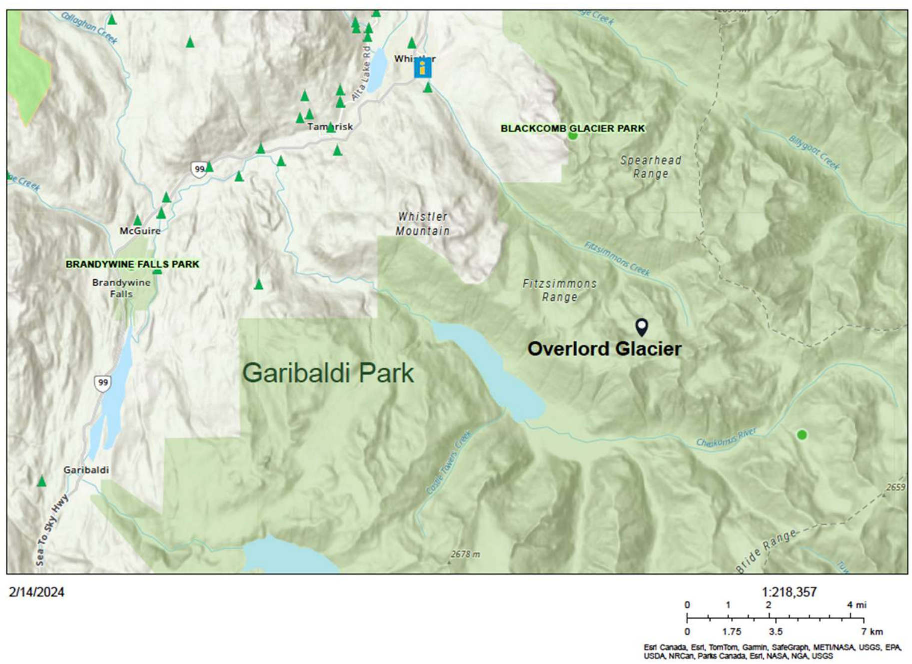

Figure 1. Map of study area (Overlord Glacier) within Garibaldi Provincial Park and the Fitzsimmons Creek drainage, South Coast Region, BC.

Research findings

Funding from the BC Parks Living Lab Program in 2025 allowed us to augment the fundamental baseline data required as part of a five-year research project, launched with BC Living Lab funding in 2024, on Overlord Glacier and its surroundings. Below we report on new datasets that quantify proglacial lake bathymetry and water quality, basin discharge and glacier ice thickness, surface elevation change and surface velocity. The field-based data collection was supported by the Living Lab grant and provides a vital complement to the airborne data, both of which are described below.

Proglacial lake bathymetry

In October 2024 we surveyed lake bathymetry of Investigator Lake at Overlord Glacier using a remotely-control sonar system. We were able to process the lake-depth data in 2025 and found a maximum depth of about 18m within the survey lines. By interpolating these data, we produced a map of lake depth (Figure 2). Using the mapped bathymetry and a high-resolution shoreline DEM from a drone survey, we can estimate the lake volume. The lake-level logger deployed in the lake then, with the bathymetry, allows us to monitor changes in lake water volume. A spatially continuous estimate of lake bathymetry and water volume, along with the growing timeseries of lake level/volume changes, provides important information about the glacier--lake system that will be used in computer modelling of recent and projected glacier change.

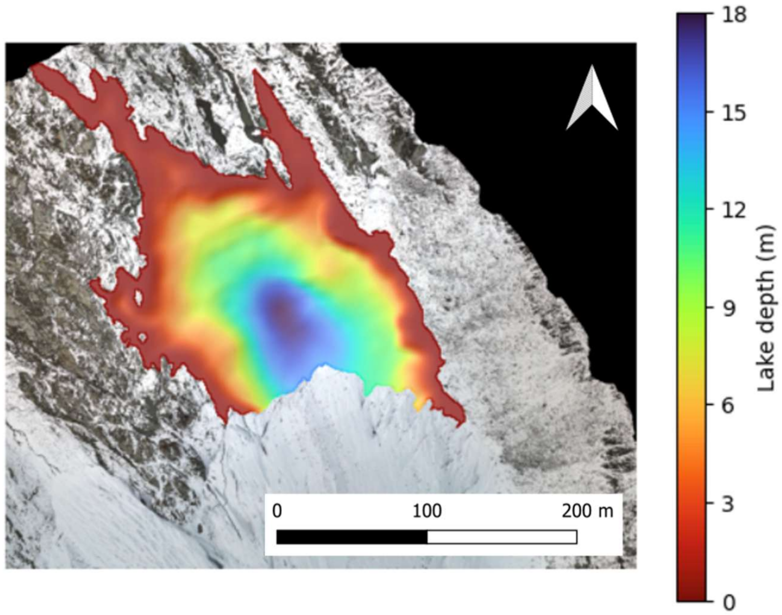

Figure 2. Bathymetry data for Overlord's proglacial lake, showing a maximum depth around 18 metres. The data were obtained from the boat survey carried out in October 2024 and processed in 2025. The gridded lake depth is overlain on airborne imagery of the glacier terminus from October 2024. Orthomosaic credit: Jeffrey Crompton. Bathymetry map credit: Roger MacLeod.

Lake conductivity-temperature-depth data

In September 2025 we serviced the conductivity-temperature-depth (CTD) logger that was installed in the proglacial lake in October 2024. Over nearly one year of data collection, we see dynamic changes in all three variables (Figure 3), where the lake depth varies by decimetres, with an annual low in mid-winter and an annual high in late summer. Water conductivity increases as freeze-up occurs and surface discharge into the lake diminishes, and stays high throughout the frozen period (see stable sub-freezing temperatures below). Conductivity declines abruptly in June as lake level rises, indicating an influx of meltwater into the lake that dilutes the conductive winter water. Conductivity then increases as temperature rise, presumably reflecting the activation of the subglacial drainage and discharge of more enriched water into the lake.

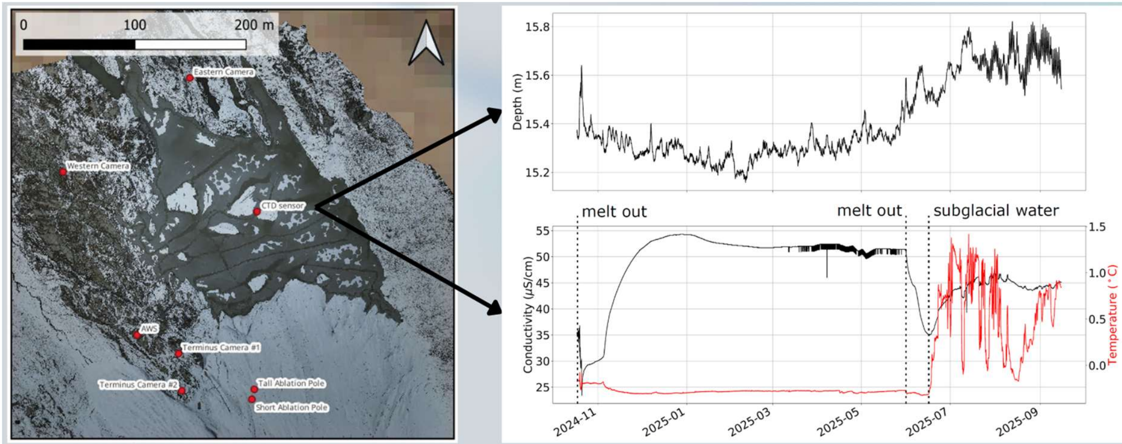

Figure 3. Map of Overlord instrumentation with all four time-lapse cameras, the automatic weather station, the ablation poles and the lake conductivity, temperature and depth (CTD) logger with the 2024/25 data shown on the right. Orthomosaic credit: Jeffrey Crompton.

Discharge gauging

Dilution gauging is a well-established technique to directly measure water discharge. When repeated over multiple values of discharge and water level (typically through the course of a significant daily melt cycle in a glacierized basin), a rating curve can be constructed that allows discharge to be estimated from measurements of lake level alone. This estimation relies on a stable configuration of the channel cross section. Dilution gauging was carried out in September 2025 (Figure 4) to measure discharge from the lake. This single measurement yielded a value of 0.724 m^3/s. A full suite of discharge measurements will be required to effectively relate the lake-level data to discharge.

Figure 4. Jeffrey Crompton from the Geological Survey of Canada/Natural Resources Canada and photographer Corey Green walking back towards Overlord Glacier along the creek where the dilution gauging measurements were made. Image credit: Chloé Monty.

Airborne ice-penetrating data

In May 2025 we had the opportunity to collect airborne ice-penetrating radar (IPR) data to measure ice depth across much of Overlord Glacier that is difficult to access by foot. In the left panel of Figure 5, the pink lines show the ground-based data from 2024, and the gold and blue lines the airborne data collected in 2025, which cover a much greater fraction of the glacier. In the right panel, the interpreted ice thicknesses are shown as a coloured track overlying ice thicknesses estimated by a global model that is independent of ice-thickness observations. The maximum measured ice depth was roughly 160m and was found in the uppermost basin (brightest yellow in Figure 5, right panel). While there is ambiguity in the interpretation of ice thicknesses from radar data, especially in complex terrain, mismatch between measured and modelled ice thicknesses highlight the need for resolving differences between methods. The new ice-thickness data take us one step closer to quantifying the current volume of water locked up in Overlord Glacier, and will help us produce a more reliable model of the present glacier geometry as a pre-requisite to modelling glacier flow and future change.

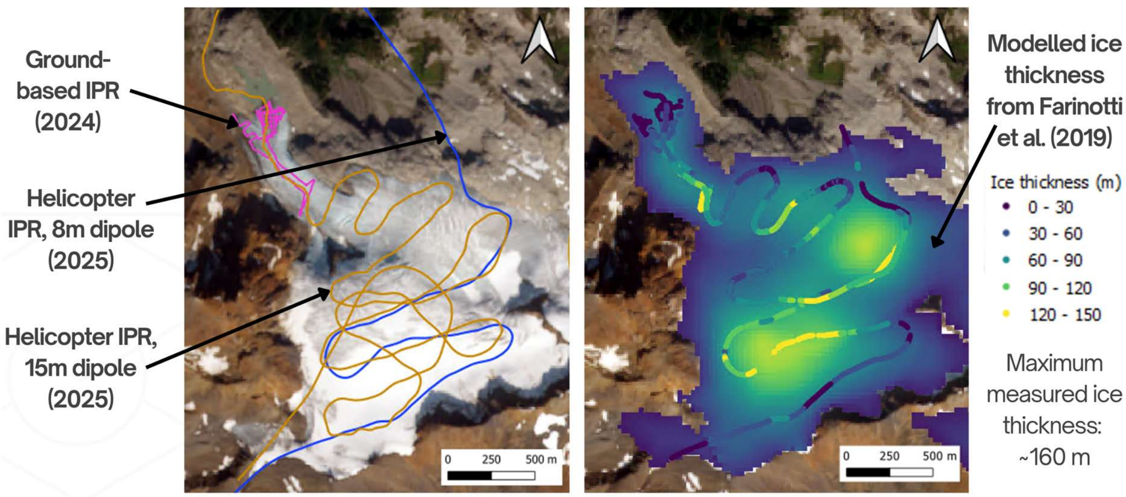

Figure 5. Left: ground-based and airborne ice-penetrating radar survey lines. Right: measured ice thicknesses overlain on a theoretical map of ice thickness from Farinotti et al. (2019). Image credit: ESA, contains modified Copernicus Sentinel data (September, 2024).

LiDAR

Collaborator Brian Menounos (UNBC) has obtained airborne Light Detection and Ranging (LiDAR) data over the region surrounding Overlord Glacier since 2017. Digital elevation models produced with these measurements can be differenced to produce maps of elevation change. Figure 6 shows elevation-change maps over one full year from September 2024 to September 2025 (left) and over the winter accumulation season from September 2024 to May 2025 (right). The average surface-elevation change of Overlord Glacier from September 2024 to September 2025 was –2.08 metres, which when converted to metres water equivalent with an ice density of 910 kg/m^3 yields a net balance of –1.98 m w.e. The average winter elevation change from September 2024 to May 2025 was 4.15 m. Conversion to a meaningful (e.g. water equivalent) measure of winter balance would require reliable estimates of snow density which we are currently lacking.

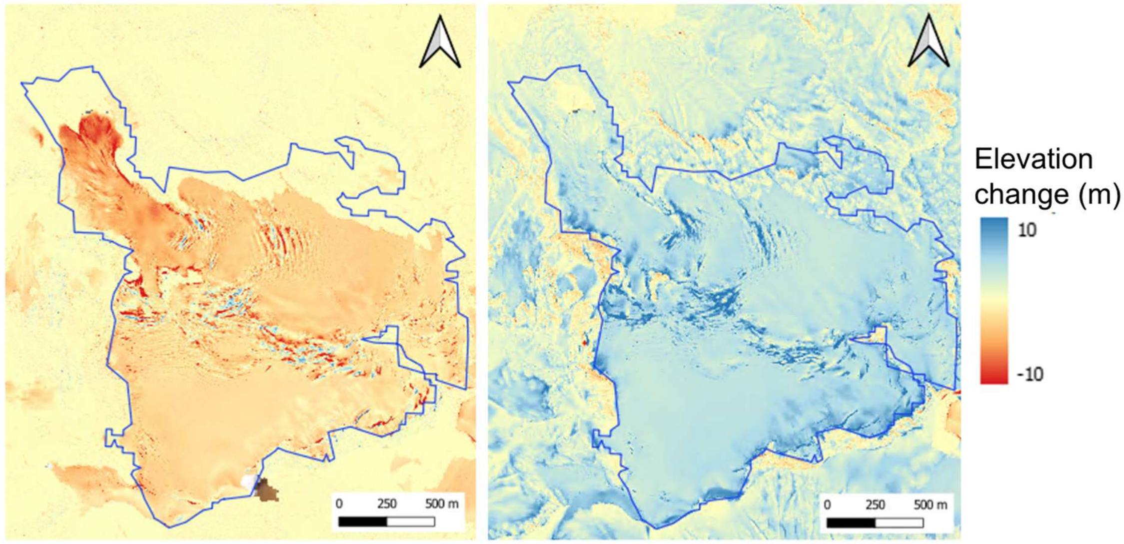

Figure 6. Left: autumn to autumn (September 2024–25) elevation change in metres at Overlord Glacier. Right: winter elevation change in metres at Overlord (September 2024 to May 2025). The glacier outline is from the GLIMS (Global Land Ice Measurements from Space) Randolph Glacier Inventory (RGI) version 7.0 (Raup et al., 2007). LiDAR data courtesy of Brian Menounos.

Using a feature tracking algorithm (autoRIFT: https://www.github.com/nasa-jpl/autoRIFT) applied to the LiDAR data, we can estimate the surface velocity field of Overlord Glacier (Figure 7). The mean velocity from September 2024 to September 2025 is estimated to be 6.8 m/yr, with a maximum of 33.5 m/yr where the glacier is steep and narrow (purple in Figure 7). Velocity estimates are important indicators of glacier dynamics, enable us to better constrain uncertain parameters in ice-flow models and serve as inputs to inverse models of basal topography and friction.

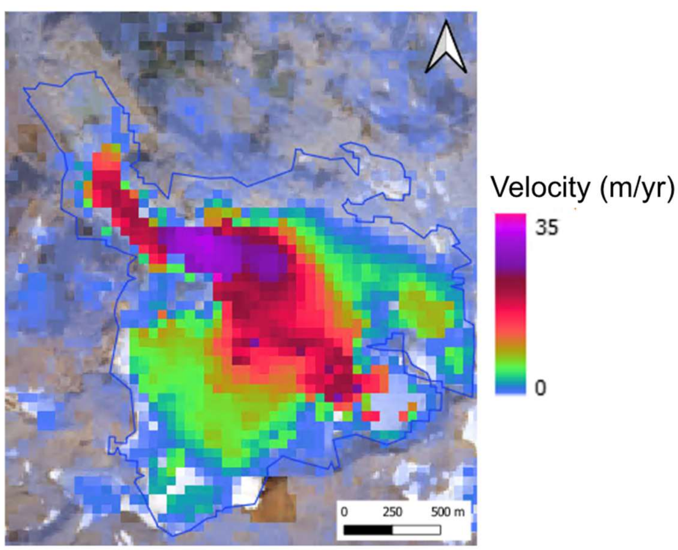

Figure 7. Velocities at Overlord Glacier, calculated over the period from September 2024 to September 2025 in metres/year. The glacier outline is from the GLIMS RGI version 7.0 (Raup et al., 2007). LiDAR data courtesy of Brian Menounos. Image credit: ESA, contains modified Copernicus Sentinel data (September, 2024).

Methods summary

In Year 2 we (1) continued our characterisation of the proglacial lake emerging at Overlord Glacier, (2) collected additional data to quantify glacier geometry and dynamics, and (3) measured the annual glacier-wide mass change.

1. Characterisation of the proglacial lake forming as Overlord Glacier retreats:
    - Servicing of conductivity-temperature-depth (CTD) logger in the lake to monitor in-situ water quality/quantity indicators
    - Processing of bathymetry data collected in 2024
    - Airborne photography of Overlord Glacier and Investigator Lake
2. Characterisation of Overlord Glacier geometry and dynamics:
    - Servicing of time-lapse cameras facing terminus and installation of new cameras perpendicular to terminus
    - Airborne ice-penetrating radar to estimate ice thickness
    - Estimation of glacier-wide velocities from LiDAR data
3. Characterisation of Overlord mass change:
    - Continuation of LiDAR campaign to make repeat measurements of high-precision surface elevation
    - Installation of ablation poles near terminus to measure melt
    - Installation of automatic weather station to measure climate data that will help us determine the energy-balance at Overlord Glacier

Figure 8. Left: Overlord Glacier terminus in proglacial lake. Right: SFU graduate student Chloé Monty and Jeffrey Crompton from the Geological Survey of Canada/Natural Resources Canada installing a tripod for one of the new time-lapse cameras overlooking the glacier terminus. Image credit: Chloé Monty (left) and Corey Green (right).

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 have not yet quantified the runoff fraction derived from non-renewable sources, 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. Overlord Glacier is a popular winter destination for visitors to the ACC Kees and Claire Hut, making it an important system to monitor for public safety.

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

Weather has been a challenge in accessing the site for trips that require mechanized travel to transport heavy equipment. One of our 2025 field campaigns had to be cancelled for this reason. In September 2025, it proved difficult to retrieve the CTD logger from the bottom of Investigator Lake. Too much cable was strung out on the lakebed, and we hypothesise that it might have settled into the mud or sediment accumulated on it. We shortened the cable and tried to put it back in the same location. For the time-lapse cameras that were installed in 2024, the eastern camera successfully took pictures until June, however the western camera died within 10 days of deployment (Figure 9). We changed the batteries of the western camera and removed the eastern camera from the field for maintenance. We had to do some improvising with ablation stakes in September 2025 (Figure 9, centre) but now have a better idea of how to transport and deploy them. Finally, there is a gap in our barometric pressure data, needed to correct the lake-level logger, as this sensor was not deployed until January 2026 (Figure 9, right).

Figure 9. Left: Western timelapse camera setup. Centre: Jeffrey Crompton from the Geological Survey of Canada/Natural Resources Canada securing two sections of an ablation pole together. Right: Barologger installed in January near Overlord Glacier. Image credit: Chloé Monty (left & centre), Iain Sherriff-Scott (right).

Conclusions/next steps

Characterization of the proglacial lake is underway, with preliminary processing of the bathymetry now complete and retrieval of the conductivity-temperature-depth data. The ground-based and airborne ice-penetrating radar data are a major step toward improving our understanding of glacier geometry and quantifying the size of the ice reservoir. We are planning to produce an optimised map of ice thickness to derive maps of bed topography. The continuation of the LiDAR campaign with additional measurements of winter elevation change will help us tune future mass-balance and ice-flow models. With the new time-lapse cameras and ablation poles installed near the terminus we are hoping to assess the influence of the proglacial lake on glacier dynamics and mass loss.

References and links

Coming in the future!