

# Retreat of an Unnamed Glacier in Stave River Watershed, Garibaldi Provincial Park, British Columbia



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## Abstract

The retreat of glaciers in southwestern British Columbia is happening at an alarming rate. An unnamed cirque glacier lies on the northeast slope of Galaxy Peak within the Stave River watershed in southeastern Garibaldi Park, British Columbia. A comparison of Google Earth Engine Timelapse imagery reveals that the glacier has been retreating at an average of  $5.5 \pm 7 \text{ m a}^{-1}$  between 1988 and 2020. If the glacier were to continue retreating at this same rate, the glacier would take approximately 232 years to disappear completely. The position of terminal moraines using high-resolution satellite imagery indicates that the approximate length of the glacier during the maximum of the Little Ice Age was 2.2 km. If measured from the end of the Little Ice Age until 2020, the glacier would have retreated at an average rate of  $5.1 \pm 2 \text{ m a}^{-1}$ . Additionally, analysis of sentinel-2 imagery from 2022 indicates the accumulation area ratio (AAR= 0.3) is below the equilibrium accumulation ratio (AAR<sub>0</sub>) required for the survival of glaciers between 1 and 4 km<sup>2</sup>. Other evidence such as rock islands appearing in the accumulation zone and lakes forming on the east margin indicates a low likelihood of survival for this glacier in our current climate.

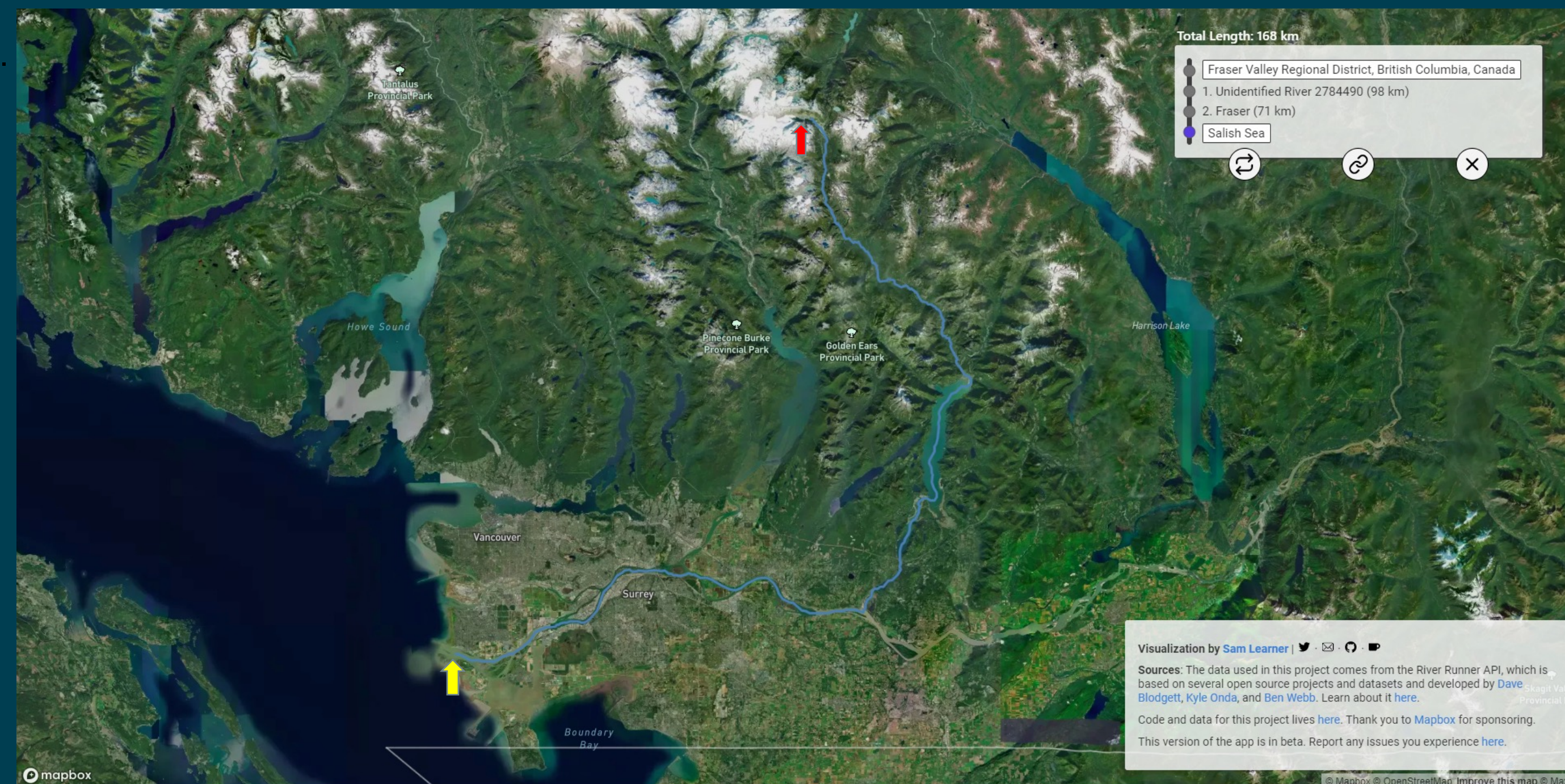


Figure 1. Water drainage from Galaxy Peak Glacier (red arrows indicate Galaxy Peak glacier, yellow arrow indicated ultimate base level of the streams draining the glacier) Source: Sampled from <https://river-runner-global.samlearner.com/> by K. Moore.

## Introduction

Unofficially named "Galaxy Peak Glacier" is located within the unceded territory of the S'ólh Téméxw, In-SHUCK-ch, Státimc Tmicw, Kwantlen and Cayuse, Umatilla and Walla Walla First Nations peoples.<sup>2</sup> This glacier is located 65.2 km northeast of Vancouver, BC and 52 km southeast of Whistler, at (49.740742°N 122.534747°W). The glacial meltwater flows into Stave River for 98km, flows into Stave lake, then into the Fraser River for 71 km, and finally ends up in the Salish Sea. Galaxy Peak Glacier is located within the Pacific Ranges.

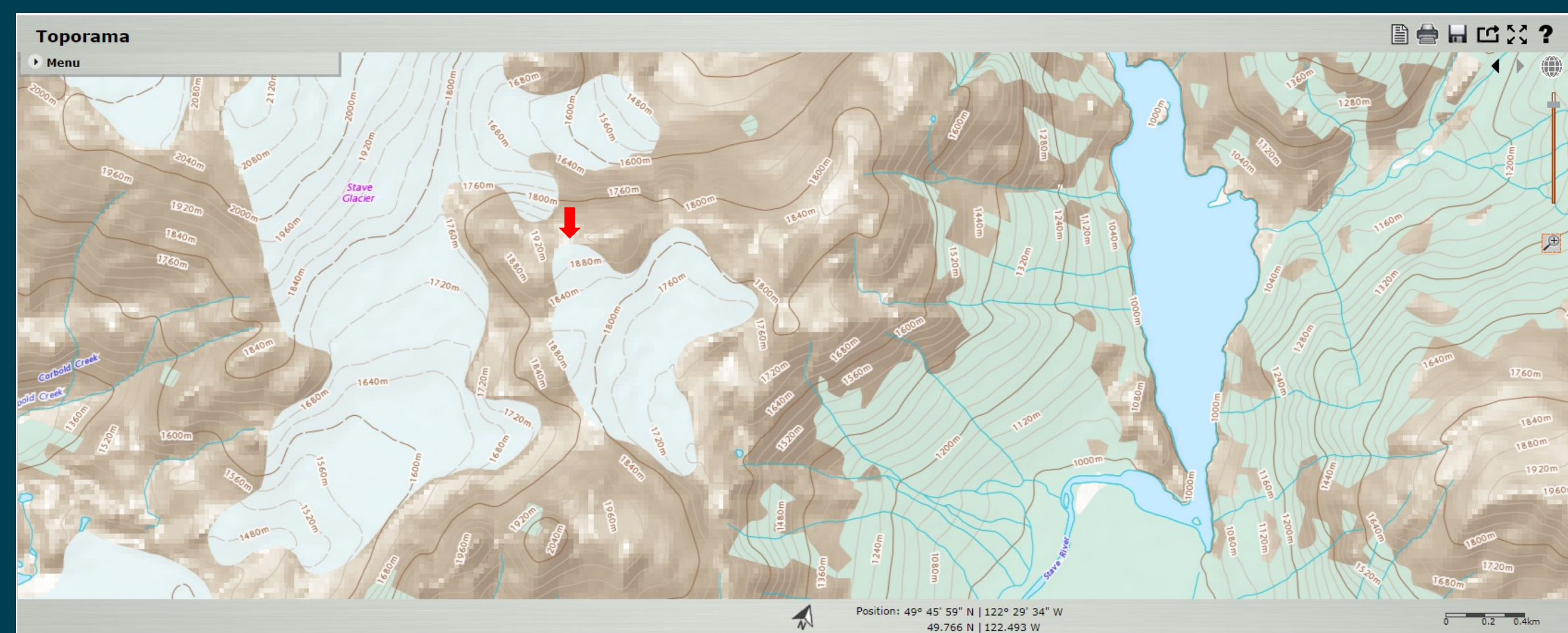


Figure 2. Toporama Map of Galaxy Peak Glacier (red arrow indicates highest elevation) Source: Sampled from [The Atlas of Canada-Toporama](https://www.toporama.com/) by K. Moore. Used in accordance with Government of Canada non-commercial reproduction terms of use.

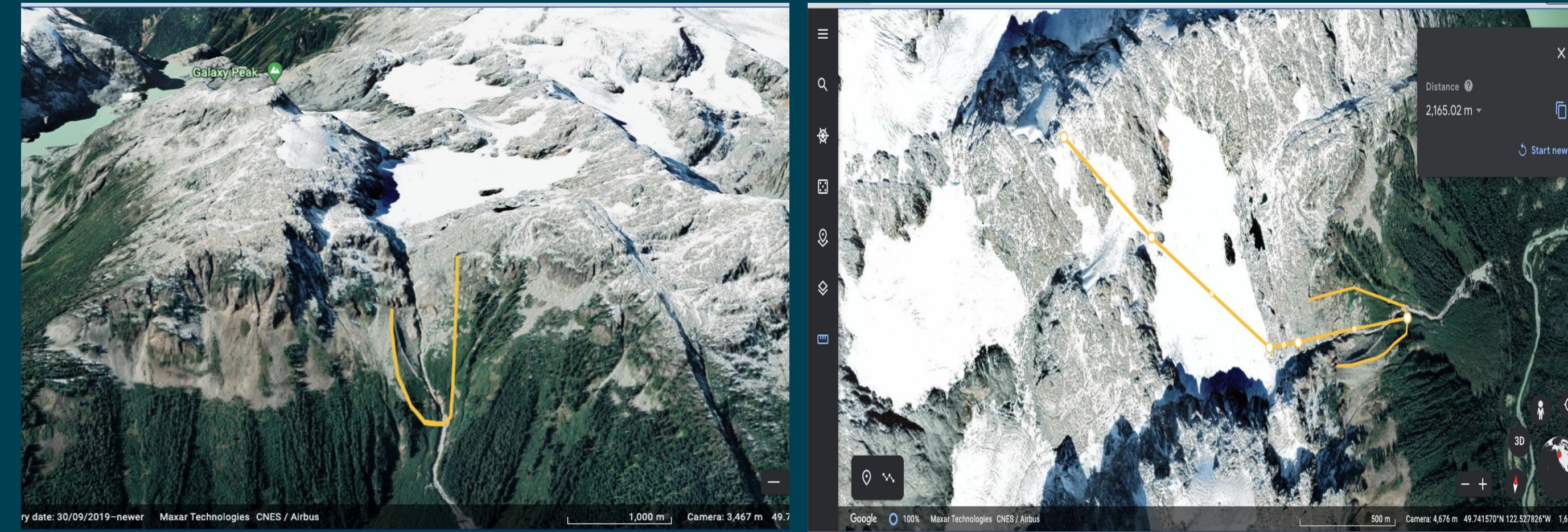


Figure 3. Outlines (yellow) estimated terminal moraines from the Little Ice Age on Galaxy Peak Glacier. Source: Sampled from Google Earth by K. Moore. Used in accordance with Google Earth terms and conditions.



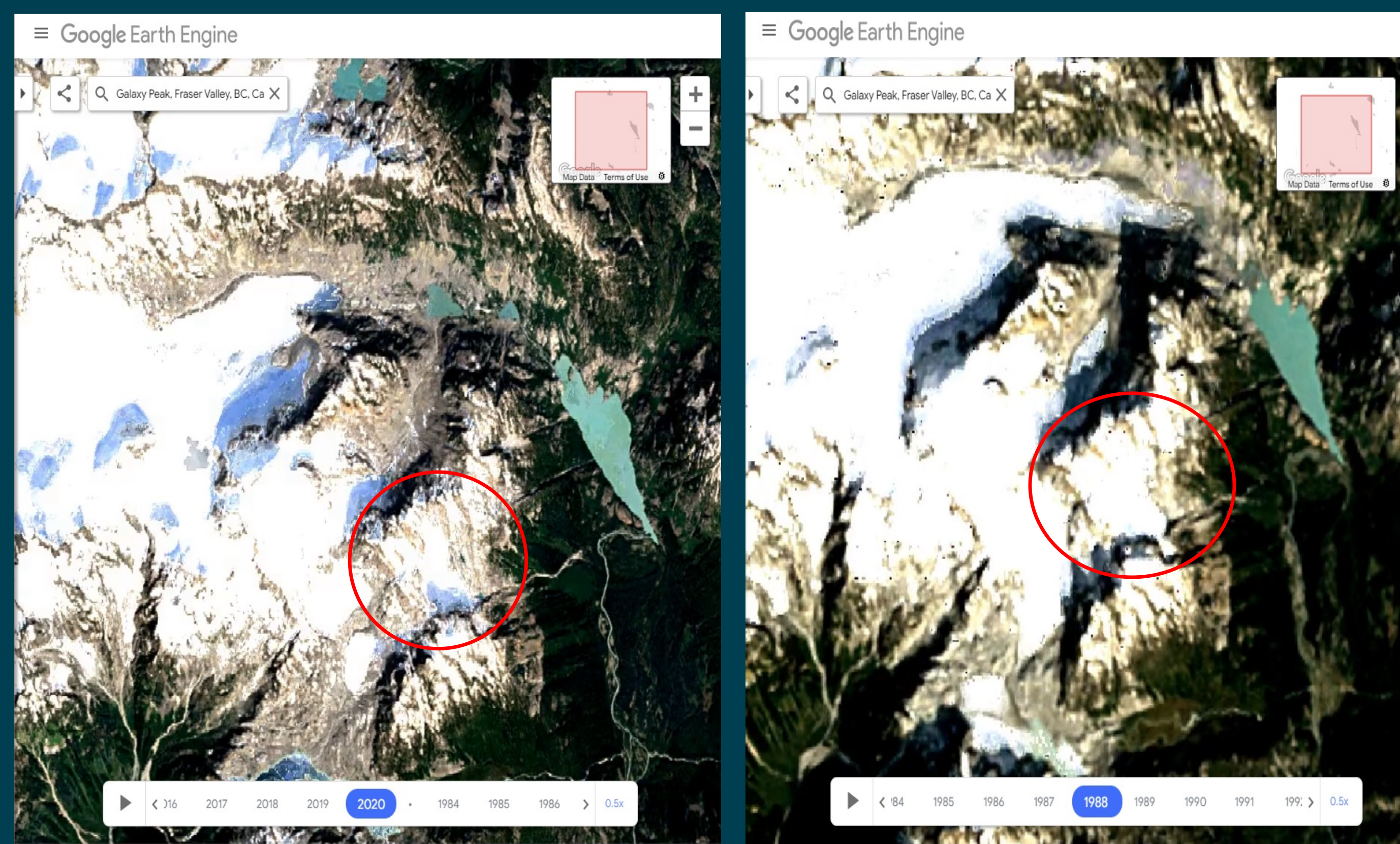
Figure 4. Traces the approximate length (yellow line) of Galaxy Peak glacier at the time of the Little Ice Age. Source: Sampled from Google Earth by K. Moore. Used in accordance with Google Earth terms and conditions.

## Methods

- Retreat since the Little Ice Age was calculated by using the location of terminal moraines from the Little Ice Age identified using Google Earth imagery. The age of maximum extent of the Little Ice Age was assumed to be 1850.
- Retreat from 1988 until approximately 2020 was calculated by comparing the farthest estimated extent of the toe in 1988 identified using Google Earth Timelapse and the most recent image on Google Earth Web.
- Accumulation Area Ratio (AAR) was determined by examining Sentinel hub Playground imagery as well as a paper written by Kern and László (2010) that states glaciers between 1 and 4km<sup>2</sup> should have an AAR of  $0.54 \pm 0.07$ .<sup>1</sup>

## Results

- Retreat from the Little Ice Age until 2020 is about  $5.1 \pm 2 \text{ m a}^{-1}$ .
- Retreat from 1988 until 2020 is about  $5.5 \pm 7 \text{ m a}^{-1}$ .
- The accumulation Area Ratio is approximately 0.5 which is within the bounds of what it should be for a glacier this size.



Figures 5 (left) & Figure 6 (right). Figure 5 depicts the Galaxy Peak glacier in 2020. Figure 6 depicts the Galaxy Peak glacier in 1988. (Red circles indicate where the glacier is) source: Google Earth Engine Timelapse – glacier Sampled from Google Earth by K. Moore and used in accordance with Google Earth terms and conditions.

## Discussion

Inspection of the Sentinel-2 imagery from late in the melt season of 2022 indicates:

- Thinning in the accumulation zone is suggested by the emergence of the rock island towards the top of the glacier. It has grown larger compared to the photo in 1988, and another island is evident to the left of the first one.
- However, 2022 Sentinel imagery indicates a large accumulation area that Kern & László (2010) would suggest would be associated with a positive mass balance for that year. If large annual accumulation like that of the 2021-22 mass balance year were to continue, the glacier could survive the warming climate, although this is unlikely due to the overall recent and longer-term glacier recession.

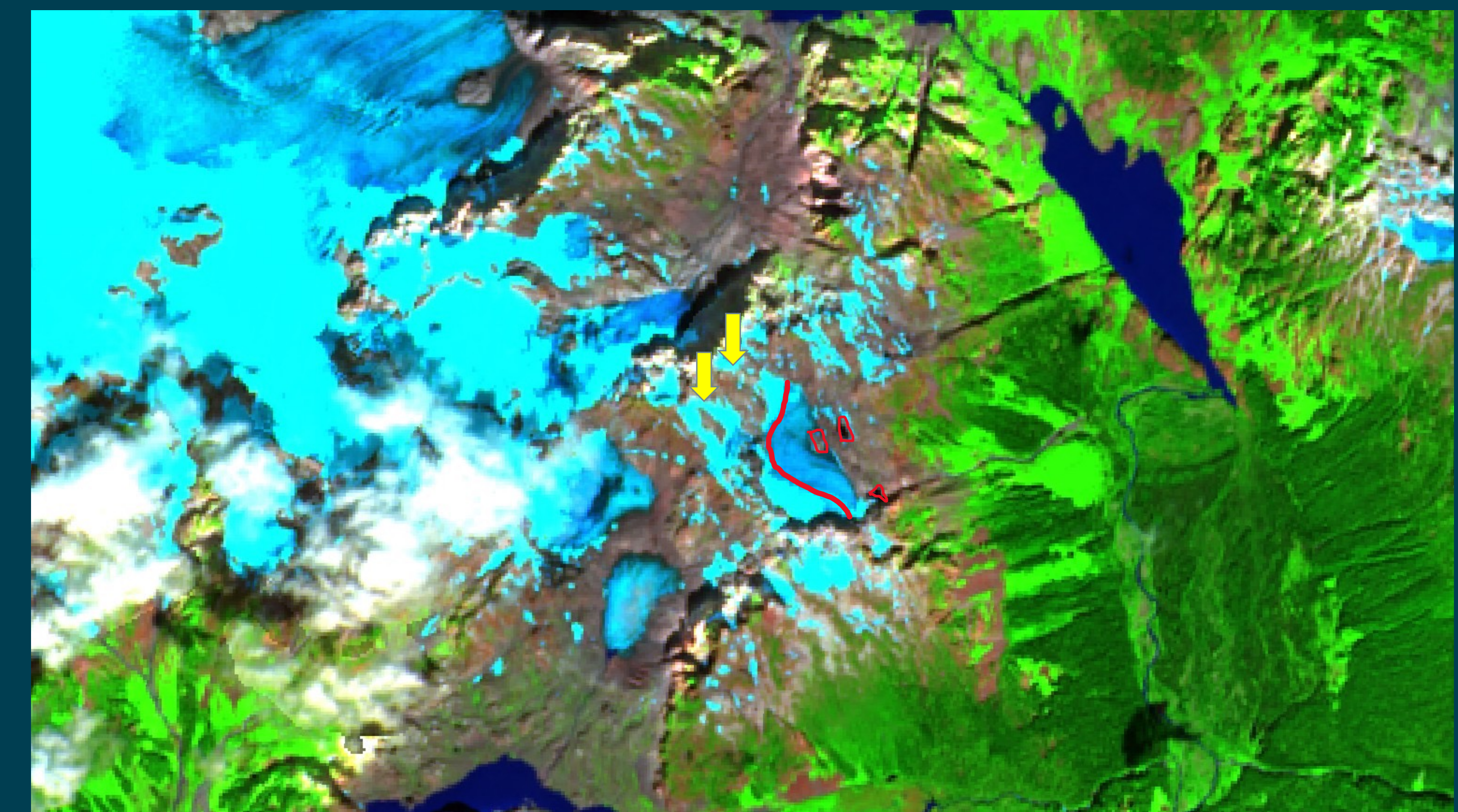


Figure 7. Sentinel 2 imagery taken mid-September 2022 (red line indicates accumulation zone, red shapes indicate lakes and the yellow arrow points to the rock islands) Source: Sampled from Sentinel Hub EO Browser by K. Moore. Materials are shared under CC BY 4.0 license.

## Conclusion

Galaxy Peak Glacier has a low chance of survival in the current warming climate. Comparison from the Little Ice Age and the 1988 toe show the retreat has increased from  $5.1 \pm 2 \text{ m a}^{-1}$  to  $5.5 \pm 7 \text{ m a}^{-1}$ . If the glacier were to continue retreating at  $5.5 \pm 7 \text{ m a}^{-1}$  it would take about 232 years to fully disappear although, I hypothesise the rate of retreat will continue to increase further. Additionally, the mass balance in mid-September 2022 showed to be positive but for the glacier to survive it would need to maintain a positive mass balance for many consecutive years, this is unlikely due to the warming climate. Galaxy Peak Glacier has a low likelihood of survival.

## References

- Kern, Z., & László, P. (2010). Size specific steady-state accumulation-area ratio: an improvement for equilibrium-line estimation of small palaeoglaciators. *Quaternary Science Reviews*, 29(19), 2781–2787. <https://doi.org/10.1016/j.quascirev.2010.06.033>
- Native Land Digital. (2021, October 8). <https://native-land.ca/>