Glaciers in Canada found to be thicker than previously suggested

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Panoramic view of the Canadian Rockies, which are the headwaters of the Columbia River. Credit: Ben Pelto

Among snowy, ice-capped peaks in the northernmost section of western Canada's Columbia River Basin, a research team, led by University of British Columbia Ph.D. student Ben Pelto, collected measurements of glacier thickness. Their findings, published by the *Journal of Glaciology* in September, suggest that the glaciers in the basin are on average 38% thicker than previously believed.

Quantifying ice thickness has long been a challenge to glaciologists because it often requires ground measurements, unlike ice-covered area, which is an easy metric to quantify from aerial or satellite imagery. Measuring ice depth matters because it is a metric important to assessing

future glacier flow and glacier contribution to stream flow in the region. The total number of observations of glacier thickness in the Columbia River basin was low, hampering research efforts reliant on such data. To help fill this major gap, Pelto's team measured ice thickness on five glaciers, and then combined their data with previous surveys and used a model to estimate the region's total ice volume.

Daniel Farinotti, a glaciologist at ETH Zürich, told GlacierHub that ice thickness data is required for many important studies such as those seeking to model crucial interactions of glaciers with their rocky base material, or for assessing glacier potential to support hydropower, an important renewable energy. A global glacier thickness database—GlaThiDa—compiles data for these types of studies. However, to date, the observations that feed into it remain sparse and tend to only be for a few local regions.

Pelto said that his team's primary motivation for collecting new data was to be able to model the flow of the glaciers. Thicker glaciers tend to flow at faster rates and to transport larger volumes of ice. "Glacier ice thickness is critical for anticipating the rate and timing of glacier retreat as well as the subsequent effects on local water cycles," Pelto told GlacierHub.

Ben Pelto’s team of glaciologists during their fieldwork expedition to collect glacier thickness data. They are seen towing the pair of ice-penetrating radar devices on skis. Credit: Jill Pelto

The study site, the Columbia River Basin, covers 670,000 square kilometers in British Columbia and seven states in the United States. Pelto's team only collected measurements in the upper Canadian portion of the basin, which represents 15% of the basin's area, but provides 30-40% of its total water runoff through glacier-fed water cycles. The basin provides more hydroelectric power in the United States than any other river system in North America, marking it an area of strategic societal importance.

The scientists went on fieldwork expeditions to collect ice thickness data

each spring between 2015 and 2018, Pelto told GlacierHub. They acquired their measurements using an ice-penetrating radar device. It works by transmitting radio waves down into the ice. The radio waves then bounce off the bedrock and return to the device. The time in between sending and receiving the signals indicates how thick the ice is.

Wearing skis, the researchers towed the radar equipment across the ice on two sleds. The rear sled held the transmitter and the front sled the receiver and computer. One team member held a leash attached to each sled to ensure the units traveled across the glacier in a straight line. "We must travel straight up and straight down the glacier slopes to collect accurate data, which is challenging," Pelto told GlacierHub. The slow, arduous nature of this work helps explain why glacier thickness has been difficult to quantify.

Previous studies have deployed ice-penetrating radar from airplanes and helicopters, which overcomes the challenges of groundwork, but such equipment is rare and costly, and often the spatial resolution of airborne surveys is so coarse that it is not useful in mountain glaciers. The most accurate method to estimate ice thickness is to drill through the glacier ice to the bedrock, but again this is slow, cumbersome, and expensive.

Another image taken during the team's expedition to the study site. Credit: Jill Pelto

Pelto's team found that the average ice thickness of the glaciers was 92.5 meters (303 feet). This finding suggests that previous results underestimated the thickness by 28-49%, but Pelto explained that two small glaciers contributed to the higher values in this range. Looking at the results from the five larger glaciers, the average was a 23% underestimate. The improved ice volume estimates, calculated from the thickness observations, are 17-29% greater than previously thought. This finding indicates that earlier research did miss up to one-third of the ice in the Canadian portion of Columbia Basin, the most heavily glaciated section.

As glacial environments warm and glaciers shrink, the melt and runoff from these regions typically declines. A greater ice volume would suggest a delay in this trend, because it suggests that there is a larger reservoir from which the runoff is derived. However, Pelto told GlacierHub that although the data may imply a slightly slower decline in runoff, it postpones this shift only by a matter of years. "More importantly, my results suggest the importance of improving regional estimates and the work offers a framework for doing so," he added.

This new study offers an advance in the understanding of glaciology and provides greater confidence in the measurement of ice volume. The type of data obtained in the study is important to a variety of further research efforts that seek to understand the processes occurring beneath glaciers or how glaciers contribute to streamflow and freshwater supplies. This knowledge is crucial given our changing climate: understanding how glaciers may respond to future warming is essential for policymakers and communities as they lay plans to prepare for the downstream impacts that melting mountain glaciers will have on many lives.

More information: Ben M. Pelto et al. Bias-corrected estimates of glacier thickness in the Columbia River Basin, Canada, *Journal of Glaciology* (2020). DOI: 10.1017/jog.2020.75