Study proposes an acoustic approach for cheap and effective monitoring of glacier discharge

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A satellite photo (a) and a photo (b) showing the locations of the acoustic sensor (green circle) that recorded glacier sounds, and the water depth sensor (yellow star) that measured changes in water levels in the proglacial stream (adapted from Evgeny A. Podolskiy, Takuro Imazu, and Shin Sugiyama, *Geophysical Research Letters* (2023). Credit: *Geophysical Research Letters* (2023). DOI: 10.1029/2023GL103235

Acoustic signals can be effectively used for monitoring glacial runoff and provide a cheaper and more accessible alternative to existing methods.

Glaciers have been melting and shrinking at an alarming rate, raising the sea-level and causing outburst floods. Scientists are monitoring this change to gauge the meltwater contribution to the ocean and freshwater resources across the globe while also keeping an eye on the risk of glacial flooding. However, glacio-hydrological monitoring is a luxury not every country can afford. The process requires either a substantial effort by observers or sophisticated technology with large volumes of data.

A team of scientists from Hokkaido University led by Evgeny A. Podolskiy, has proposed a safe, affordable, and effective approach for monitoring glacial discharge using sounds generated at the proglacial run-off site. The method, published in the journal *Geophysical Research Letters*, is not only ~100 times cheaper than the most novel methods but is also non-invasive, quick and easily deployable, and can become a tool for long-term glacier monitoring.

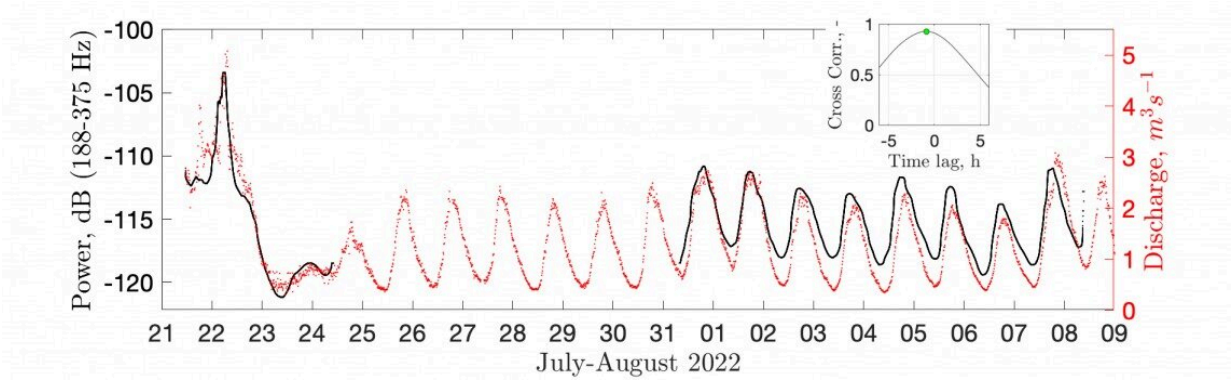
Previous research, including that from the team, linked inaudible (infrasound) signals to glacial runoffs, noting a daily variation in the recordings and a peak during the summer. It was hypothesized that these signals might be generated by the radiation of air-pressure waves from the glacial runoff. Consequently, it was suggested that glacier discharge could be measured by analyzing the audible sounds that are also emitted by melting glaciers.

In the proposed method, an acoustic sensor is deployed in a sheltered location (red circle, bottom right, under the large rock) near the glacier to continuously record sounds; a much easier and simpler process. Credit: Evgeny Podolskiy

The team of researchers conducted the first near-source study at Qaanaaq Glacier, Greenland, that showed acoustic noise levels scale with proglacial discharge, with an easy-to-detect, audible diurnal pattern. "The ambient sound could be described as a continuous hum of roaring water, which would be familiar to anyone who walked near a white water," said Podolskiy.

For recording the ambient soundscape, the team deployed a commercially available bird-song recorder near the terminus of the Qaanaaq Glacier. "We estimated the proglacial discharge by water-depth and flow-speed measurements, which were collected at the intersectional site of the proglacial stream and the road between Qaanaaq and the local airport. The acoustic data was analyzed and the result was then cross-correlated with the discharge in order to single out a frequency band that was the best proxy for the proglacial stream," explains Podolskiy.

The highest correlation was seen in the frequency range of 50–375 Hz. The scientists also found that the noise level clearly mimicked the temporal variation in runoff. Moreover, they observed that the acoustic signal was recorded ~50 minutes before a corresponding change in discharge.



A graph showing the correlation between the acoustic signal (black) and the measured proglacial discharge (red). Credit: *Geophysical Research Letters* (2023). DOI: 10.1029/2023GL103235

The study demonstrated that audible acoustic signals can be used for sensing glacio-hydrological variations remotely and continuously. The method reduces the risk of instrument loss and does not require avant-garde data processing techniques. Although it does not provide the high spatial resolution of fiber-optic tools that are currently used, it breaks new ground in terms of affordability and overall simplicity. This method can be used to set up early-warning systems to timely detect events like glacier lake outbursts and help mitigate glacial flooding events.

The team acknowledges that the sound-discharge relationships in glaciated watersheds may be complex. Future efforts might benefit from a long-term monitoring, clarified relationship between audible and inaudible sounds, as well as assessed interference effects of wind.

More information: E. A. Podolskiy et al, Acoustic Sensing of Glacial Discharge in Greenland, *Geophysical Research Letters* (2023). DOI: 10.1029/2023GL103235

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