

How scientists are using drones to lower the risk of catastrophic flooding from large glacial lakes

June 7 2021, by Rodrigo Narro Pérez



View of Llaca Lake, in Peru, taken from an un-crewed aerial vehicle. Credit: Rodrigo Narro Pérez, Author provided

Early in the morning on Dec. 13, 1941, the citizens of Huaraz, Peru, heard a terrifying rumble echo across the valley. Within minutes, a torrent of water, ice and rocks had poured over the city, [destroying a third of it and killing at least 2,000 people](#).

The natural dam of rocks and loose sediment that had [held back Lake Palcacocha had failed](#). Eighty years later, its collapse [remains one of Peru's most tragic natural disasters](#).

This type of catastrophic event is known as a "glacial [lake](#) outburst flood." Glacial lakes, such as those found throughout the Cordillera Blanca in the Andean mountain range, are often dammed by [glacial moraines that can reach heights of over 100 meters](#). They are impressive, but they are often unstable.

Heavy rainfall and rock, snow or ice avalanches can raise [water levels](#) in moraine-dammed glacial lakes, generating waves that overtop the moraine dam or cause it to collapse, releasing huge amounts of water. These natural disasters are only expected to [become more common in Peru—and around the world as climate warming melts glaciers at historically unprecedented rates](#).

Predicting future floods

This dark history has spurred [international research](#) into the stability of the moraines damming Peru's glacial lakes. The Cordillera Blanca in northern Peru contains the [highest concentration of tropical glaciers](#) in the world. Predicting when these outburst floods will occur—and how destructive they will be—is of enormous concern to the [over 320,000 people who live downstream](#).



The twisted remains of a steel bridge destroyed by a glacial lake outburst flood in Iceland in 1996. Credit: [\(Chris 73/Wikimedia Commons\)](#), [CC BY-SA](#)

[Geological engineering models](#) use variables such as the size and volume of the lake, height, width and slope of the moraine dam, and channel and valley dimensions to estimate the stability of the moraine dam and the risk of flood. Unfortunately, these models don't include much information about the composition of the moraine dam, which can vary significantly depending on its location and mode of formation.

My research, part of a collaboration between McMaster University and [Peru's National Institute for Research on Glaciers and Mountain](#)

[Ecosystems \(INAIGEM\)](#), focuses on establishing the origin of these moraine dams and the physical characteristics of the dams and the lakes they hold back. These features can have [considerable influence on the stability of the dam and its potential for failure](#).

Using UAV to understand the structure of moraine dams

Glaciers create moraines by transporting, depositing and pushing boulders, sands and fine-grained silts and clays along the valley floor and adjacent valley walls, often forming a barrier. But one moraine may be much more stable than another, depending on the materials it contains and how it is formed.

Water may leak through weak points in the moraine's stacked layers, taking sediment with it, or loose rocks may fall after a disturbance such as an earthquake. These weak points make a complete collapse of the moraine dam more likely. Locating these [weak points](#) is an important step in predicting the stability of the lake dams and can allow geoscientists and engineers to design more effective remediation strategies.



Remediation work done at Llaca Lake, Peru, in 1977 included building a dam. Credit: Rodrigo Narro Pérez, Author provided

My colleagues and I are analyzing the architecture of large lateral moraines, which form along the sides of glaciers, in southern Iceland using un-crewed aerial vehicles (UAVs or drones) to collect high-resolution images. We [use these images](#) to [identify and classify areas of coarse- and fine-grained sediment](#) that may form zones of water leakage and sediment removal and cause the dam to fail. We've planned similar high resolution UAV surveys of moraine dams in the Cordillera Blanca for early 2022.

The research will enhance the reliability of predictive models to identify potential glacial lake [flood](#) hazards. It will also identify areas where

remediation work, such as the building of additional outlet channels or armored barriers, is most needed to strengthen the moraine.

This will be particularly important as glaciers melt more quickly, the volume of water held by these natural moraine dams builds, and the destructive power of floods also continues to increase. [A recent study by researchers at the University of Calgary](#) showed that the volume of water in glacial lakes has increased by 50 percent globally since 1990.

Since the beginning of the 19th century, an estimated [165 moraine-dammed glacial lake outburst floods have occurred](#). In addition, approximately [12,000 deaths worldwide can be attributed directly to glacier floods](#).

Our research in Peru will provide new insights into moraine dam stability that can be applied to other regions, such as Bolivia, [the Himalayas](#) and [the Canadian Rockies](#), which are also experiencing an increased risk of glacial lake outburst floods as climate warming continues to melt glaciers.

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Provided by The Conversation

Citation: How scientists are using drones to lower the risk of catastrophic flooding from large glacial lakes (2021, June 7) retrieved 25 April 2024 from <https://phys.org/news/2021-06-scientists-drones-catastrophic-large-glacial.html>

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