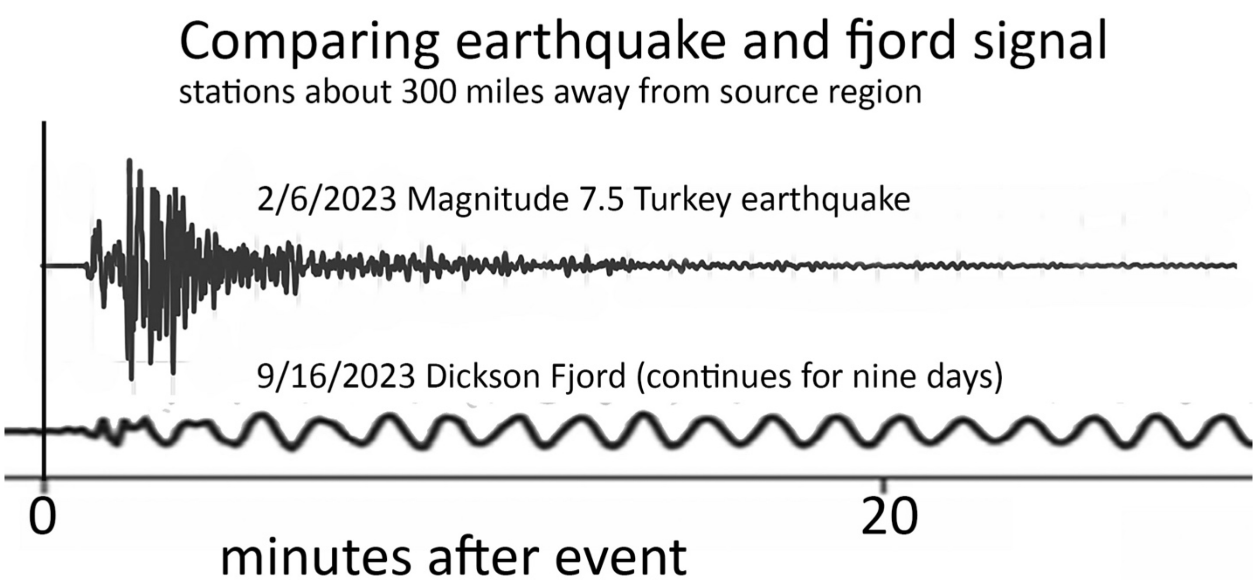
Times Standard

Not My Fault: Strange seismic signals finger a climate change culprit

Lori Dengler for the Times-Standard
Posted September 14, 2024
https://www.times-standard.com/2024/09/14/lori-dengler-strange-seismic-signals-finger-a-climate-change-culprit/



Comparing the seismic signals from a large earthquake and those generated in the Dickson fjord by the landslide-triggered tsunami, both seismic stations are about 300 miles from the source (Turkey seismogram from the USGS, Fjord tsunami from Kristian Svennevig).

A year ago, a series of water surges struck a fjord on the east coast of Greenland. The first indication that something was amiss was on September 16, 2023, when a string of oscillations showed up on a tide gauge on Ella Island, where the Danish Navy maintains instruments and a summer laboratory.

There was no one at Ella's Sirius Dog Sled Patrol station at the time and the anomaly might have gone unnoticed until the next summer if not for signals that showed up at about the same time on seismographs around the world. The signals were not from an earthquake.

Earthquakes produce a characteristic set of waves resulting from the different waves generated by fault rupture. The first signals are sharp and short – in the range of 0.5 to 1 second. That's what gives an earthquake the jolt that you feel. Later parts of the signal are more rolling, caused by the surface waves, generally in the 20 second period range. Humans aren't sensitive to these longer period signals but people outdoors during large quakes may see them ripple across the ground surface as they roll past. Most earthquakes are over in a matter of seconds; the largest earthquakes are felt on the order of minutes. Sensitive seismographs may record traces lasting hours.

The mystery signals were different in all aspects. They were much longer in period, beating up and down about every 90 seconds, and very regular or monochromatic in appearance with almost no variation. The signal progressed around the globe, appearing first on a station in Greenland and arriving an hour later in Antarctica. Most surprising of all, the signals persisted for nine days.

The "unidentified seismic object" quickly became a topic of discussion for seismologists. By using the arrival time of the initial signals on seismic stations around the world, they were able to trace its origin to an area near the coast of eastern Greenland. Seismic experts were baffled, the only source that quickly came to mind was volcanic tremor, but those volcanic signals never persist for so long a time and with such regularity.

Seismologists reached out to geologists working in Greenland who mentioned the Ella Island tide gauge signal. This narrowed down the area of interest to the fjords near the east coast of central Greenland. Grabbing remote sensing data and sending drones to survey the region, researchers finally zeroed in on the source – a colossal landslide into Dickson Fjord about 40 miles as the crow flies from the Ella Island tide gauge.

I first learned about this event five months later when my colleague Brentwood Higman sent me an email. Hig has been studying landslide induced tsunamis for several decades and is particularly tuned in to how climate change is affecting hillslope stability as glaciers retreat. I wasn't the only one unaware of the tsunami. The staff at NOAA's National Center for Environmental Information that maintains a global tsunami database had never heard about it either.

It's no secret any longer. Papers published last month in The Seismological Society of America's Seismic Record Journal and two days ago in Science unveil the sleuthing that went into uncovering the true source and its implications. I love a good mystery and this time the perp was caught nearly red handed.

The satellite and drone data revealed an enormous landslide, over 30 million cubic yards of rock, that had tumbled down the hillslope, over a glacier, and crashed into Dickson Fjord, a twisting 1.75-mile-wide inlet carved by glaciers in the last ice age. When researchers finally accessed the area, they found telltale signs of the tsunami triggered by the landslide, a dark band of debris on the glacier's face at an elevation of 650 feet above the water surface.

The September 16, 2023, Dickson Fjord tsunami now goes into the record books as the fourth highest tsunami recorded in the past two hundred years. An interesting feature of those top four, they all include a landslide as the sole or contributing source. The highest of all, a whopping 1720 feet above the water level, was caused by an earthquake-triggered landslide in 1958 into Lituya Bay, another deep, narrow glacial cut fjord in southeastern Alaska. The second highest was 1980 when the combination of landslide and volcanic blast sent the waters of Spirit Lake on the slopes of Mt. St. Helens over 800 feet high.

Last month's publication in the Seismic Record led by Angela Carrillo Ponce from the German Research Centre for Geosciences identified the landslide source of the Dickson

Fjord tsunami and suggested fjord resonance to explain the long duration of the seismic signals. Glacial fjords offer the ideal geometry to propel waters to extreme heights. Long, deep, and narrow, a landslide tumbling into the fjord can easily displace the waters to surprising heights. And once the water is displaced, it will continue to oscillate for hours or days.

These oscillations are called seiche, standing waves produced in lakes, bays, and other constricted bodies of water when the basin is disturbed. You have likely observed the phenomena when you get out of a bathtub and the water oscillates up and down. Seiche periods are a function of the shape of the basin and volume of water. They can be triggered by anything that displaces water such as landslides, surface waves from very large earthquakes, volcanic disturbances, or large ocean-wide tsunamis disturbing harbors, bays, and inlets.

This week's article in Science led by Stephen Hicks of University College London elaborates on the seismic signals. They assert that the angle of the slide as it entered the fjord, the sharp bend at one end of the fjord and a glacial dam at the other constricted water movement and prevented the seiche energy from dissipating and continued to oscillate with a 90-second period for over a week. What amazes me is that the vibrations were strong enough to be detected by seismic stations more than 5000 miles away for more than a week.

The Dickson Fjord tsunami damaged some of the Sirius Dog Sled Patrol facilities on Ella Island, but no one was there at the time, and the tsunami surges never left the confines of the fjord. But similar landslide triggered tsunamis have not been so benign. In 2017, a slide on the western side of Greenland triggered a tsunami in Karat Fjord, destroying two villages and killing four people. Ten years earlier, a tsunami in southern Chile killed 10 when an earthquake triggered a landslide fell into the fjord of Aysen.

Both the Ponce and Hicks' publications point to these recent landslide-triggered tsunamis as the beginning of a new trend with a clear cause – climate change. As the planet warms and glaciers recede, previously ice-covered hillslopes are exposed. Overlying ice acts as a buttress to slope instability and when the weight is gone, the slopes are more vulnerable to erosion and slides.

We don't know how long the time window for increased slope failures in recently unglaciated areas is, but it is likely to be on the order of hundreds of years as the landscape adjusts to the changes. And it's not just remote Greenland at risk – areas in South America, Alaska, Canada, Europe, and Asia once covered by ice need to be aware of this newly recognized threat.

Note: publications on the Greenland tsunami can be found at https://pubs.geoscienceworld.org/ssa/tsr/article/4/3/172/646242/The-16-September-2023-Greenland-Megatsunami and https://www.science.org/content/article/megatsunami-remote-fjord-rang-earth-bell-9-days

Lori Dengler is an emeritus professor of geology at Humboldt State University, an expert in tsunami and earthquake hazards. The opinions expressed are hers and not the Times--Standard's. All Not My Fault columns are archived online at https://kamome.humboldt.edu/taxonomy/term/5 and may be reused for educational purposes. Leave a message at (707) 826-6019 or email Kamome@humboldt.edu for questions and comments about this column or to request copies of the preparedness magazine "Living on Shaky Ground." Digital copies are at https://rctwg.humboldt.edu/prepare/shaky-ground.