

Catastrophic outburst floods carved Greenland's 'Grand Canyon'

April 30 2020, by Kea Giles



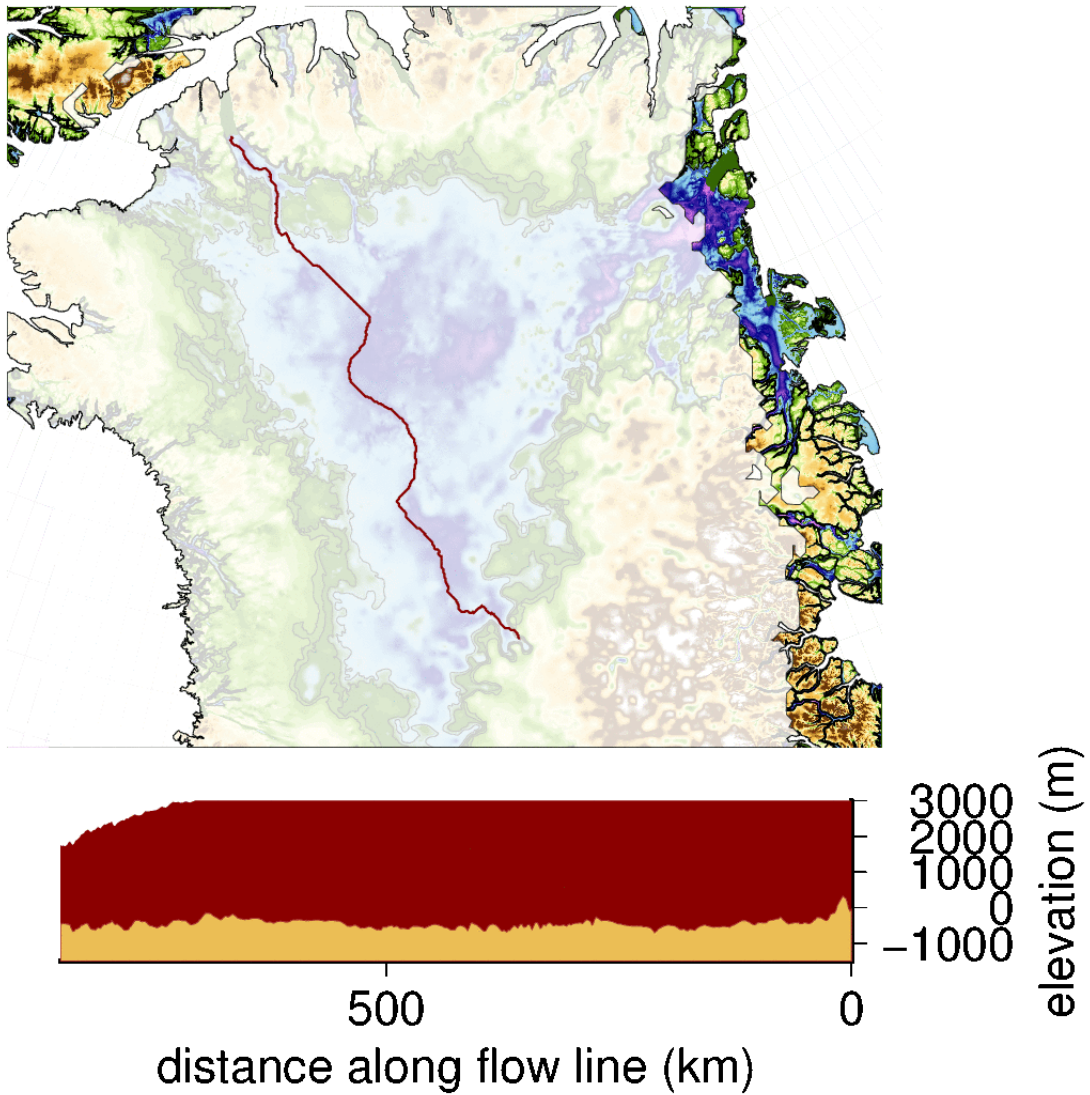
Keisling arriving for fieldwork in Northeast Greenland at the East Greenland Ice Core Project (EGRIP) camp during his GROW Fellowship to the Centre for Ice and Climate. Credit: B Keisling.

Buried a mile beneath Greenland's thick ice sheet is a network of canyons so deep and long that the largest of these has been called Greenland's "Grand Canyon." This megacanyon's shape suggests it was carved by running water prior to widespread glaciation, but exactly when and how the island's grandest canyon formed are topics of intense debate.

Now scientists from the U.S. and Denmark are proposing a surprising new hypothesis for the megacanyon's formation: catastrophic "outburst" floods that suddenly and repeatedly drained large meltwater-filled lakes. The findings, published this week in the journal *Geology*, also suggest that Greenland's subglacial canyon network has influenced the island's ice sheet since its inception.

Although repeated outburst floods have been suggested as the mechanism by which the Columbia River and other North America canyon networks formed, they had not previously been considered as the source of the remarkable landscape hidden beneath the Greenland Ice Sheet, says Benjamin Keisling, the study's lead author and a former graduate student at the University of the Massachusetts, who also collaborated with researchers at Denmark's Centre for Ice and Climate during a National Science Foundation GROW fellowship.

"If the floods we propose occurred, they could have influenced ocean circulation, causing abrupt climate changes with regional and perhaps global significance," says Keisling, now a postdoctoral fellow at Lamont-Doherty Earth Observatory. "The megacanyon beneath northern Greenland also influences how ice and water flow in the subglacial environment today, which affects present-day ice-sheet stability," he says.



Modeled outburst flood during ice-sheet retreat, routed to the outlet of Petermann Glacier. The animation covers 22,000 simulated years, and pauses to highlight a large ice-dammed proglacial lake during the deglaciation. Credit: B Keisling

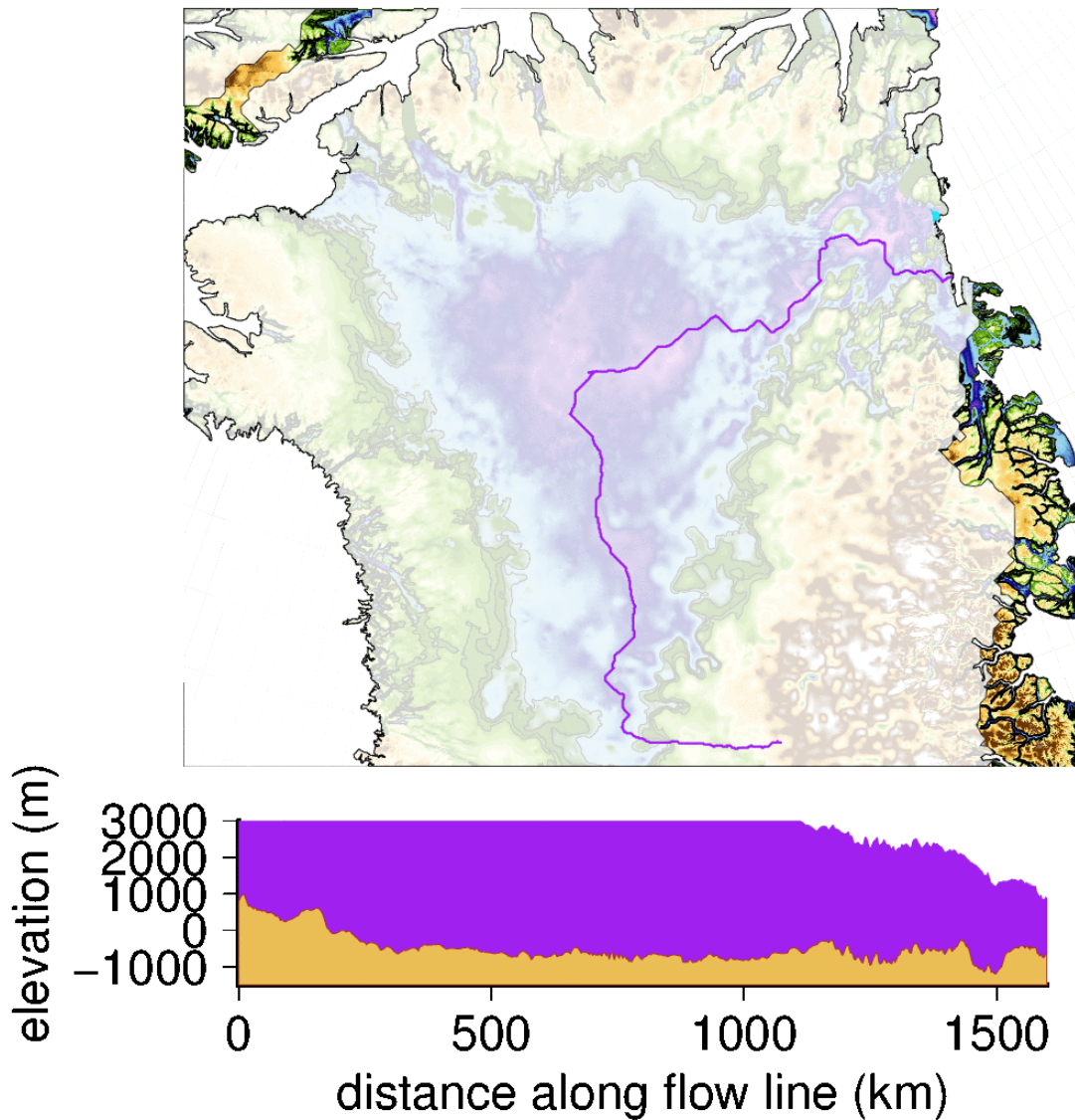
A Different Approach

In most studies of Greenland, researchers use the modern ice sheet as a starting point for understanding how it has changed over time. But for this study, Keisling and his co-authors decided on a different approach: investigating what Greenland looked like prior to widespread glaciation. "We wanted to better understand the dynamics of 'glacial inception'—how, where, and why the ice sheet first grew on an ice-free island," he says.

The team also wanted to gain insights into how the ice sheet grew back after melting. "We know from prior work this has happened multiple times in the past and could again in the future, given enough [global warming](#)," says Keisling.

The researchers used coupled ice-sheet and climate models to simulate the Greenland Ice Sheet's evolution over multiple glacial-interglacial cycles during the global cooling from the Pliocene into the Pleistocene, 2.58 million years ago. They found that following long periods with stable temperatures, an exceptionally warm period could cause the ice sheet to retreat rapidly. This melting led to the development of large, ice-dammed lakes in areas where the bedrock was still depressed due to the former ice sheet's weight.

The simulations eventually show the ice dams give way, leading to large outburst floods. "Over time," says Keisling, "it appears that the filling and draining of these lakes as the ice repeatedly retreated and advanced carved Greenland's megacanyons." Similar floods have been documented at the edge of other retreating ice sheets, he says.



Modelled outburst flood during a deglaciation scenario routed to the outlets of the northeast Greenland ice stream (NEGIS). The animation covers 25,000 simulated years, and pauses to highlight a large ice-dammed proglacial lake during the deglaciation. Credit: B Keisling

Ice-Sheet Stability: Past, Present, and Future

Based on comparisons with modern outburst floods, the researchers estimate that it took tens to hundreds of these events to carve Greenland's largest canyon. According to Keisling, widespread sediment deposition in the water-filled basins may have also impacted the ice sheet's behavior each time it grew back.

Ultimately, Keisling says, the study results point to testable hypotheses that can guide future research to finally settle the ongoing debate about whether the Greenland Ice Sheet's stability has changed over time. "Knowing the history of Greenland's bedrock provides context for understanding the ice sheet's long-term behavior," he says. "This helps paint a picture of what happened during past warm periods when the melting [ice sheet](#) caused global sea levels to rise—a phenomenon we are also seeing today."

More information: Benjamin A. Keisling et al, Pliocene–Pleistocene megafloods as a mechanism for Greenlandic megacanyon formation, *Geology* (2020). [DOI: 10.1130/G47253.1](https://doi.org/10.1130/G47253.1)

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