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Huge stores of Arctic sea ice likely contributed to past climate cooling

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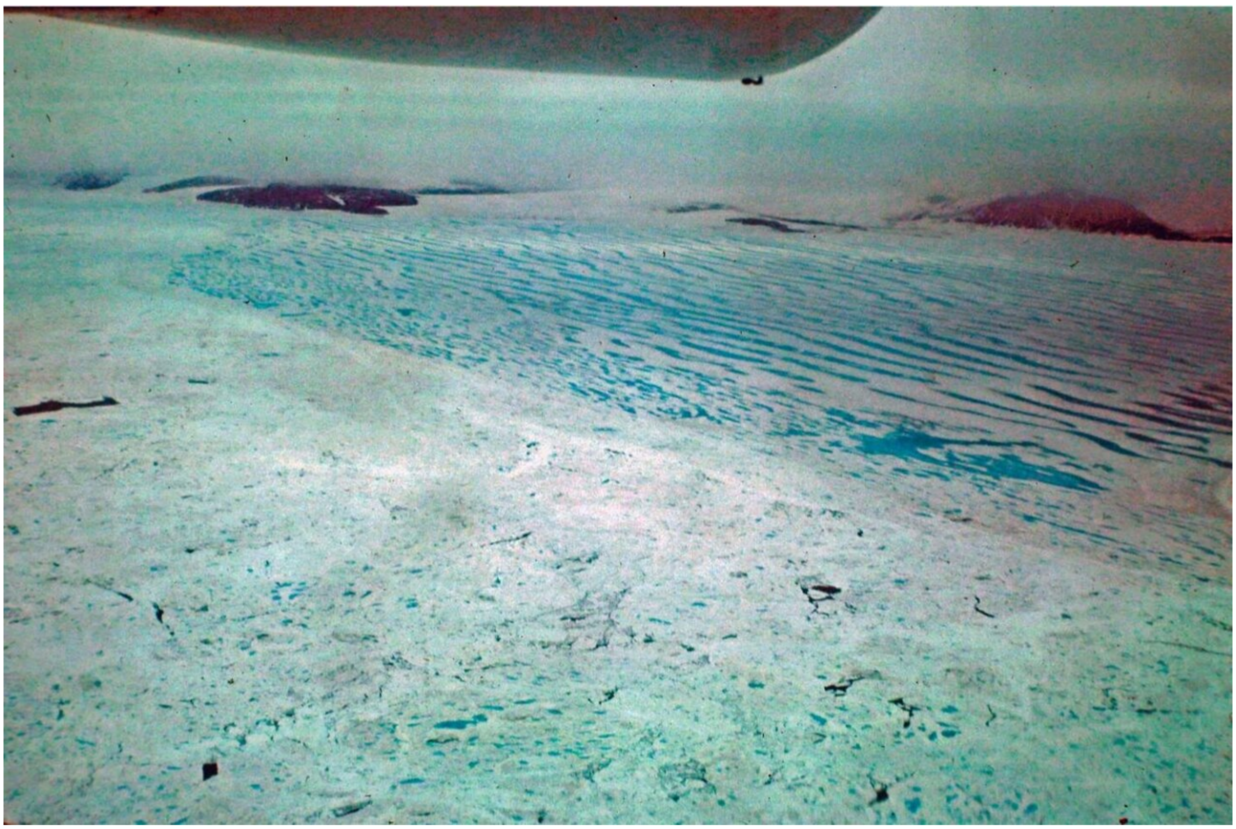

One of the last remains of the formerly extensive ice off the coast of Ellesmere Island, Arctic Canada, pictured in July 2002. At the end of the last Ice Age, ice such as this would have covered large parts of the Arctic Ocean and been up to 164 feet (50 meters) thick in places, creating an enormous reservoir of fresh water independent from land-based lakes and ice sheets, say Raymond Bradley of UMass Amherst and Alan Condron of Woods Hole Oceanographic Institute in a new paper on past climate. Credit: Woods Hole Oceanographic Institution/Alan Condron

In a new paper, climate scientists at the University of Massachusetts Amherst and Woods Hole Oceanographic Institution propose that massive amounts of melting sea ice in the Arctic drained into the North Atlantic and disrupted climate-steering currents, thus playing an important role in causing past abrupt climate change after the last Ice Age, from about 8,000 to 13,000 years ago. Details of how they tested this idea for the first time are online now in *Geology*.

Raymond Bradley, director of UMass Amherst's Climate Systems Research Center, and lead author Alan Condron, research scientist at Woods Hole, explain that geologists have considered many theories about abrupt temperature plunges into "glacier-like" conditions since the last glaciers retreated, notably a very cold period about 12,900 years ago, known as the Younger Dryas. Meteorite impact and volcanic eruptions were proposed to explain these episodes, but evidence has been unconvincing, they add.

Now Condron and Bradley, with Ph.D student Anthony Joyce, say they have new evidence that periodic break-up of thick Arctic sea ice greatly affected climate. Melting of this ice led to freshwater flooding into the seas near Greenland, Norway and Iceland between 13,000 and 8,000 years ago, slowing the strength of the Atlantic Meridional Overturning Circulation (AMOC). They say their experiments show that there was enough cold, fresh water to disrupt ocean salt-temperature circulation patterns and triggr abrupt climate cooling such as the Younger Dryas.

Bradley explains, "Understanding the past helps us understand how the Arctic system works."

Condron says researchers once thought this cold period was triggered by the draining of Lake Agassiz, an enormous glacial lake at the edge of the massive ice sheet that once extended from the Arctic south into modern New York. "But although the lake was big by modern standards, it has been difficult in the climate modeling community to trigger a 1,000-year cold period with the water it contained, because the volume of water is not large enough to weaken the Atlantic circulation over a long period," he notes.

"However, the volumes of water we find stored as sea ice in the Arctic vastly exceed the volume of Lake Agassiz, making sea ice break-up a really good candidate for triggering the Younger Dryas cooling," he adds.

To establish that there was enough ice in the Arctic to disrupt the sea circulation pattern, the researchers used numerical climate model experiments to estimate past Arctic sea ice extent and thickness. They also examined diaries and journals of early 19th and 20th century Arctic expeditions to see if those explorers, whose explorations came at the end of a "Little Ice Age," encountered unusually thick sea ice.

Condron and Bradley cite the impressions of Vice-Admiral Sir George Nares, who led the 1875 British Arctic Expedition to the North Pole. He was so struck by the extensive, thick ice his expedition encountered that he introduced the term "palaeocrystic ice" to describe "floes... of gigantic thickness with a most uneven surface and covered with deep snow."

They note, "It seems from these, and other accounts kept by early Arctic explorers, that the Arctic Ocean was covered by ice considerably thicker than has been observed over the past 30-40 years. While recent climate warming in the Arctic has caused much of this old and thick ice to break up and melt, large pieces of it were also still being reported in the early 20th century." including floes used as scientific research stations by both the U.S. and Russia as late as the Cold War.

They say their numerical ocean/sea-ice model of the volume of freshwater stored as sea ice and changes in ice export at the end of the Ice Age show these were large enough to slow the AMOC and cool climate. Thick ice over the Arctic Ocean created "an enormous reservoir of freshwater, independent of terrestrial sourc¬es." As ice sheets retreated and sea level rose, changes in atmospheric circulation and land-based floods caused this ice to flow to the sea through Fram Strait east of Greenland, where it melted and freshened Nordic Seas enough to weaken Atlantic circulation.

As both the volume of ice stored in the Arctic Basin and the magnitude of these export events far exceed the volume of meltwater discharged from Lake Agassiz, they report, "our results show that ice from the Arctic Ocean itself may have played an important role in causing abrupt climate change in the past." This work was supported by the National Science Foundation and its Extreme Science and Engineering Discovery Environment. Also, numerical simulations were carried out using MITgcm.

More information: Alan Condron et al, Arctic sea ice export as a driver of deglacial climate, *Geology* (2020). DOI: 10.1130/G47016.1

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