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Arctic Ocean freshwater as a trigger for abrupt climate change

The cause of the Younger Dryas cooling remains unresolved despite decades of debate. Current arguments focus on either freshwater from Glacial Lake Agassiz drainage through the St Lawrence or the Mackenzie river systems. High resolution ocean modeling suggests that freshwater delivered to the North Atlantic from the Arctic Ocean through Fram Strait would have had more of an impact on Atlantic Meridional Overturning Circulation (AMOC) than freshwater from the St Lawrence. This has been interpreted as an argument for a Lake Agassiz/Mackenzie River freshwater source. However, although the modeling identifies Fram Strait as the optimum location for delivery of freshwater to disrupt the AMOC, this does not necessarily mean that freshwater came from Lake Agassiz. We hypothesize that another potential source of freshwater was the Arctic Ocean ice cover itself. During the LGM, ice cover would have been extremely thick, due to a stagnant circulation, very low temperatures and continuous accumulation of snow on top of a base of sea-ice, leading to the accumulation of large volumes of freshwater within the Arctic Basin. As sea-level rose and a more modern circulation regime became established in the Arctic, this freshwater would have been released from the Arctic Ocean through Fram Strait, leading to extensive sea-ice formation in the North Atlantic (Greenland Sea) and a major reduction in the AMOC. New model results and a review of paleoceanographic records support this hypothesis. During the Last Glacial Maximum, the Arctic Ocean was covered by sea ice tens-of-meters thick. The episodic break-up and mobilization of this ice during deglaciation released considerable volumes of freshwater directly to the Nordic Seas, where key processes regulating large-scale climate occur. Massive sea-ice export events to the North Atlantic are generated in our model, either by changes in atmospheric circulation, rising sea level submerging the Bering land bridge, or glacial outburst floods draining into the Arctic Ocean from the Mackenzie River. We find that the volumes of freshwater released to the Nordic Seas are similar to, or larger than, those estimated to have come from terrestrial outburst floods, including the discharge at the onset of the Younger Dryas. Our results provide evidence that the storage and release of freshwater via Arctic sea ice played a critical role in driving deglacial climate change.