

Greenland's ancient analogue

New insights into the disappearance of a massive ice sheet that once covered much of North America suggest that Greenland could melt more rapidly than predicted.

Amanda Leigh Haag reports.

The Greenland ice sheet is something of a wild card in predictions of future climate change. If it melted entirely, it could raise global sea levels by an astounding 7 metres, inundating coastal cities. Changes in the ice sheet suggest that Greenland is already responding dramatically to warming, but how quickly it will melt over the coming decades remains uncertain.

Some climate scientists suggest that only a minute fraction of the melting will occur over this century¹. And the most recent report of the Intergovernmental Panel on Climate Change predicts that the melting of ice sheets will contribute only 59 centimetres at most to sea-level rise by 2100.

But with little observational data of ice sheets in retreat, climate models have been unable to account for the dynamic changes taking place in the ice sheets, such as slipping and sliding, subsurface melting, and the formation of ice streams and icebergs. This has led some to conclude that model projections of sea-level rise may fall far short of reality.

Evidence from a prehistoric mass of glacier ice known as the Laurentide ice sheet (LIS) — which existed in climatic conditions much like today's — now supports this case and indicates that Greenland could undergo large changes over centuries, rather than millennia, raising sea levels 1.3 metres by 2100.

“We conclude that we could be grossly underestimating how much the Greenland ice sheet could melt by the end of this century,” says Anders Carlson, a paleoclimatologist at the University of Wisconsin-Madison and the lead author of the study, published online 31 August in *Nature Geoscience*².

SHEET RETREAT

The new study takes an alternative approach to using present-day records of changes in the ice sheet, instead garnering clues from the most recent known ice-sheet disappearance as an analogue for what could happen on Greenland. The



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Greenland's melting ice is projected to raise sea levels 1.3 metres by 2100.

results support other data that point to high rates of sea-level rise during previous interglacial periods³.

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Anders Carlson

By piecing together paleoclimate records from the time of its retreat, the researchers determine that the Laurentide sheet, a vast expanse of ice that extended over most of Canada and the upper reaches of the United States between 7,000 and 20,000 years ago, may have melted rapidly over relatively short periods of 500 and 800 years. This melting would ultimately have contributed 0.7 to 1.3 metres of sea-level rise per century during those periods.

“We think that by about 7,000 years ago this ice sheet had disappeared, so we're talking about an exceptionally rapid disappearance of a very large ice sheet,” says Allegra LeGrande, a postdoctoral

fellow at the NASA Goddard Institute for Space Studies in New York and a co-author on the study.

The scientists used a combination of paleoclimatic techniques to calculate the rate of disappearance of the LIS. By analyzing radiocarbon dates of organic matter and marine shells, cosmogenic dates from the surface of boulders, and the composition of isotopes in marine sediment cores, they were able to decipher the chronology of past temperature changes and variations in the water cycle throughout the early Holocene, around 9,000 years ago, during which the ice sheet is thought to have vanished.

They then plugged these historical data into state-of-the-art climate models to simulate and map the behaviour of the LIS throughout its various stages of retreat, using the isotope data to cross-check their model. These very different approaches led to the same conclusion.

PRESENT PARALLEL

The scientists say that the LIS retreat provides an appropriate comparison to the

Greenland ice sheet, given their similar climatic conditions and latitudes, and their proximity. Temperature increases and subsequent melting can be driven both by intensifying short-wave radiation from the sun and by long-wave radiation such as the heating caused by greenhouse gases in the atmosphere. The solar radiation during Northern Hemisphere summers at the time of the LIS retreat was probably twice as much as the radiation expected from greenhouse gases over Greenland by the end of this century, say the scientists, but the increases in summertime temperatures on the LIS and on Greenland are thought to be comparable nonetheless.

However, although the Greenland ice sheet was present at the time of the LIS retreat, Greenland did not experience similar melting during the Holocene. The difference, says Carlson, is probably that large portions of Greenland were surrounded by ocean, insulating it from warmer summer air temperatures, whereas

much of the LIS terminated on land, allowing it to soak up more heat. But as modern-day Greenland shrinks, he says, "it will become more analogous to the Laurentide ice sheet because there's more land to heat up, causing warmer temperatures that lead to faster retreat."

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Mark Siddall

The researchers hope that their study will improve the ability of climate models to capture fine-scale variations in ice-sheet dynamics. Even then, the behaviour of ice sheets

may be inherently unpredictable, says Mark Siddall, a paleoclimate modeller from the University of Bristol, UK, who was not involved in the study. "We have a lack of understanding, but what understanding we do have is suggesting that ice-sheet responses are very difficult to predict," says Siddall. But the take-home message, he says, is that "ice sheets can respond quickly to warming conditions similar to the ones ... now."

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