Antarctic ice sheets capable of retreating up to 50 meters per day

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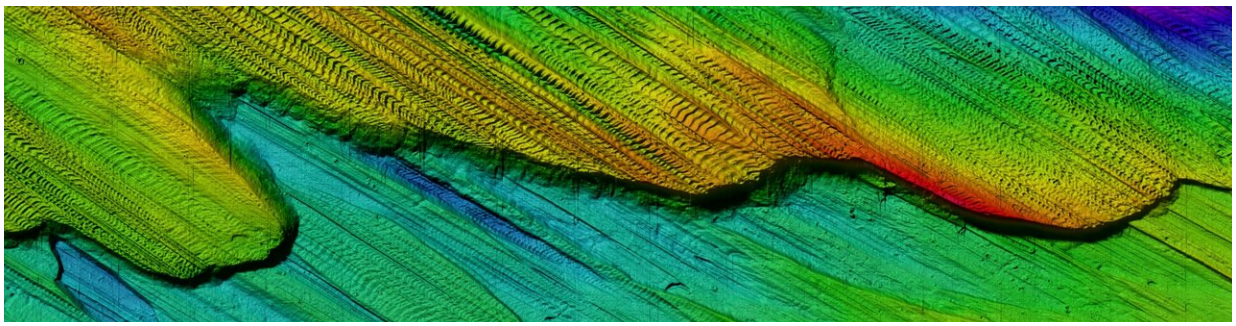


Bathymetric data of the grounding-zone wedge complex, derived from an AUV-deployed multibeam echo sounder. Credit: Julian Dowdeswell

The ice shelves surrounding the Antarctic coastline retreated at speeds of up to 50 metres per day at the end of the last Ice Age, far more rapid than the satellite-derived retreat rates observed today, new research has found.

The study, led by the Scott Polar Research Institute at the University of Cambridge, used patterns of delicate wave-like ridges on the Antarctic seafloor to calculate how quickly the ice retreated roughly 12,000 years ago during regional deglaciation.

The ridges were produced where the ice sheet began to float, and were caused by the ice squeezing the sediment on the seafloor as it moved up and down with the movement of the tides. The images of these landforms are at unprecedented sub-metre resolution and were acquired from an autonomous underwater vehicle (AUV) operating about 60 metres above the seabed. The results are reported in the journal *Science*.

While modern satellites are able to gather detailed information about the retreat and thinning rates of the ice around Antarctica, the data only goes back a few decades. Calculating the maximum speed at which an ice sheet can retreat, using sets of these seafloor ridges, reveals historic retreat rates that are almost ten times faster than the maximum observed rates of retreat today.

"By examining the past footprint of the ice sheet and looking at sets of ridges on the seafloor, we were able to obtain new evidence on maximum past ice retreat rates, which are very much faster than those observed in even the most sensitive parts of Antarctica today," said lead author Professor Julian Dowdeswell, Director of the Scott Polar Research Institute.

View from Agulhas II, the ship from which the AUVs were deployed. Credit: Julian Dowdeswell

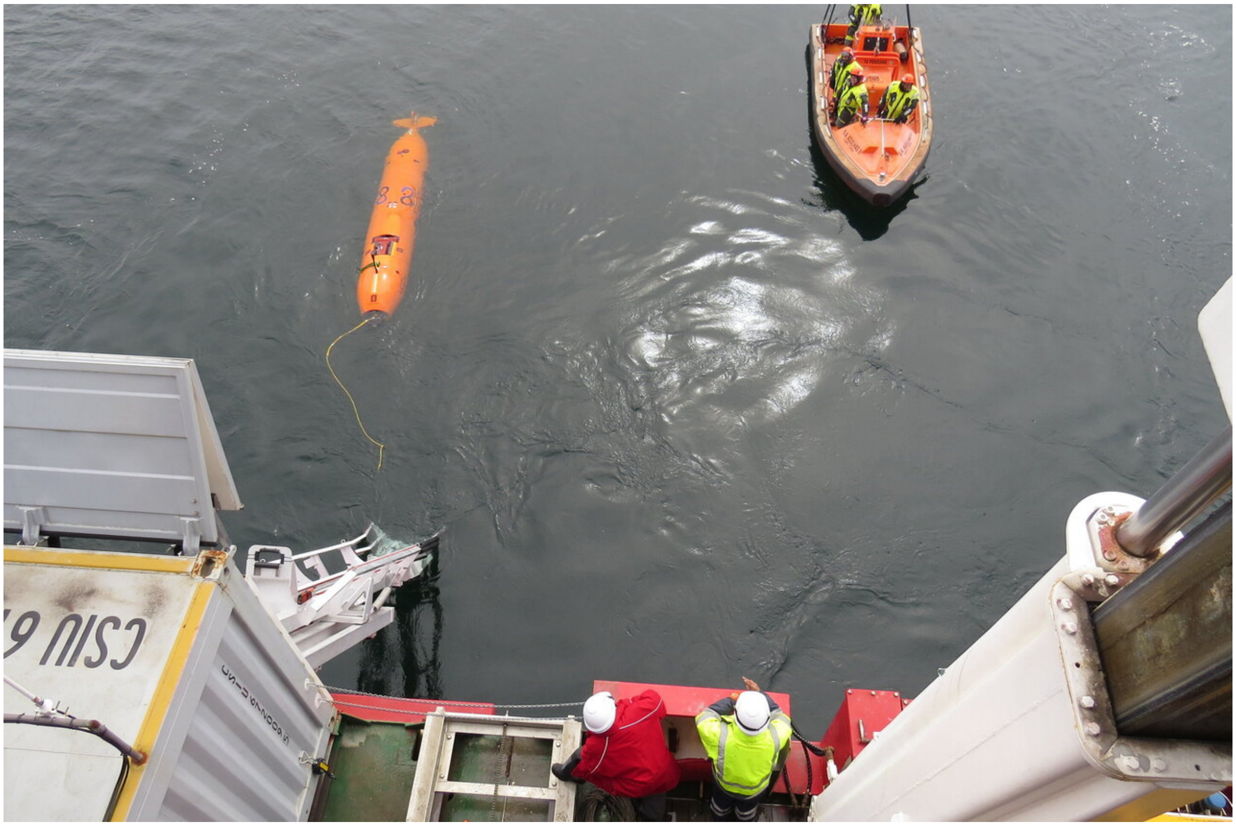
The study was carried out as part of the Weddell Sea Expedition, which set out in early 2019 to undertake a science programme and to find Sir Ernest Shackleton's doomed ship Endurance. Although sea ice conditions at the time prevented the team from acquiring imagery of the legendary wreck, they were able to continue with their scientific work, including mapping of the seafloor close to the Larsen Ice Shelf, east of the Antarctic Peninsula.

Using drones, satellites and AUVs, the researchers were able to study ice conditions in the Weddell Sea in unprecedented detail.

Their goals were to investigate the present and past form and flow of the ice shelves, the massive floating sections of ice that skirt about 75% of the Antarctic coastline, where they act as a buttress against ice flow from inland.

Like much of the rest of the ice in the polar regions, these buttresses are weakening in some parts of Antarctica, as witnessed most dramatically at the Larsen A and B ice shelves, which collapsed rapidly in 1998 and 2002, when roughly 1250 square miles of ice fragmented and collapsed in little over a month.

The ice shelves are thinning because relatively warm water currents are eating away at them from below, but they're also melting from the top as summer air temperatures rise. Both these effects thin and weaken the ice shelves and, as they do, the glaciers they are holding back flow faster to the sea and their margins retreat.



Launch of AUVs from Agulhas II Credit: Julian Dowdeswell

Using AUVs, the team were able to gather data on historic ice shelf fluctuations from the geological record on the Antarctic continental shelf.

"By examining landforms on the seafloor, we were able to make determinations about how the ice behaved in the past," said Dowdeswell, who was chief scientist on the Weddell Sea Expedition. "We knew these features were there, but we've never been able to examine them in such great detail before."

The team identified a series of delicate wave-like ridges on the seafloor, each only about one metre high and spaced 20 to 25 metres apart, dating to the end of the last great deglaciation of the Antarctic continental shelf, roughly 12,000 years ago. The researchers have interpreted these ridges as formed at what was formerly the grounding line—the zone where grounded ice sheet begins to float as an ice shelf.

The researchers inferred that these small ridges were caused by the ice moving up and down with the tides, squeezing the sediment into well-preserved geological patterns, looking a little like the rungs of a ladder, as the ice retreated. Assuming a standard 12-hour cycle between high and low tide, and measuring the distance between the ridges, the researchers were then able to determine how fast the ice was retreating at the end of the last Ice Age.

They calculated that the ice was retreating as much as 40 to 50 metres per day during this period, a rate that equates to more than 10 kilometres per year. In comparison, modern satellite images show that even the fastest-retreating grounding lines in Antarctica today, for example in Pine Island Bay, are much slower than these geological observations, at only about 1.6 kilometres per year.

"The deep marine environment is actually quite quiet offshore of Antarctica, allowing features such as these to be well-preserved through time on the seafloor," said Dowdeswell. "We now know that the ice is capable of retreating at speeds far higher than what we see today. Should climate change continue to weaken the ice shelves in the coming decades, we could see similar rates of retreat, with profound implications for global sea level rise."

More information: J.A. Dowdeswell el al., "Delicate seafloor landforms reveal past Antarctic grounding-line retreat of kilometers per year," *Science* (2020). science.sciencemag.org/cgi/doi … 1126/science.aaz3059

"Tracking the rapid pace of a retreating ice sheet," *Science* (2020). science.sciencemag.org/cgi/doi … 1126/science.abc3583

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