Cooperative Institute for Research in Environmental Sciences at the University of Colorado Boulder

The Threat from Thwaites: The Retreat of Antarctica's Riskiest Glacier

Ice sheet's demise poses the biggest threat for sea-level rise this century

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Antarctica's Thwaites Glacier is retreating rapidly as a warming ocean slowly erases its ice from below, leading to faster flow, more fracturing, and a threat of collapse, according to an international team of scientists. The glacier is the size of Florida or Britain and currently contributes four percent of annual global sea level rise. If it does collapse, global sea levels would rise by several feet—putting millions of people living in coastal cities in danger zones for extreme flooding.

"Thwaites is the widest glacier in the world," said Ted Scambos, a senior research scientist at the Cooperative Institute for Research in Environmental Sciences (CIRES). "It's doubled its outflow speed within the last 30 years, and the glacier in its entirety holds enough water to

raise sea level by over two feet. And it could lead to even more sea-level rise, up to 10 feet, if it draws the surrounding glaciers with it."

Scambos is the U.S. lead coordinator for the **International Thwaites Glacier Collaboration** (ITGC): a team of nearly 100 scientists funded by the U.S. National Science Foundation and U.K. Natural Environment Research Council dedicated to studying the vulnerable glacier. The five-year collaboration is aimed at collecting instrument data throughout the glacier and the adjacent ocean, and modeling ice flow and the future of the ice sheet. Their work has revealed major changes in the ice, the surrounding water, and the area where it floats off the bedrock below.

THWAITES GLACIER TONGUE. PHOTO: WIKICOMMONS

Thwaites sits in West Antarctica, flowing across a 120km stretch of frozen coastline. A third of the glacier, along its eastern side, flows more slowly than the rest—it's braced by a floating ice shelf, a floating extension of the glacier that is held in place by an underwater mountain. The ice shelf acts like a brace that prevents faster flow of the upstream ice. But the brace of ice slowing Thwaites won't last for long, said Erin Petitt, an associate professor at Oregon State University.

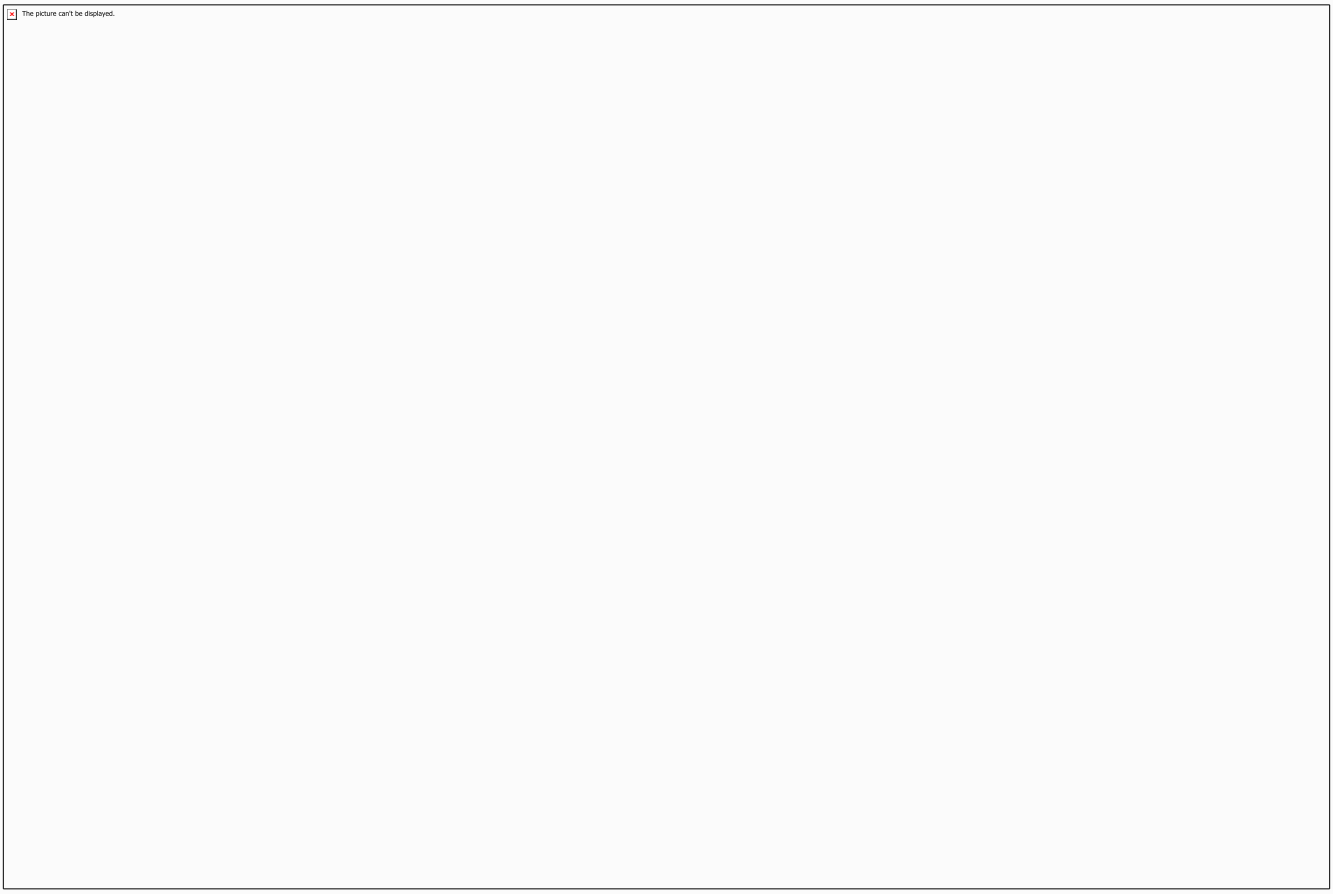
Beneath the surface, warmer ocean water circulating beneath the floating eastern side is attacking this glacier from all angles, her team has found. This water is melting the ice directly from beneath, and as it does so, the glacier loses its grip on the underwater mountain. Massive factures have formed and are growing as well, accelerating its demise, said Pettit. This floating extension of the Thwaites Glacier will likely survive only a few more years.

WATER HEATERS USED BY DAVIS' TEAM TO DRILL A BORE HOLE THROUGH THE ICE SHEET, TO TAKE MEASUREMENTS AND DEPLOY INTRUMENTS. PHOTO: PETER DAVIS/BAS

Warm water is also a threat for the so-called “grounding zone,” the area where the glacier lifts off the seabed, said Peter Davis, a physical oceanographer at the British Antarctic Survey. Davis and his team use hot water to drill access holes from the ice shelf surface to the ocean cavity hundreds of meters below. They have found that the ocean waters in the grounding zone are warm, by polar standards, and salty, and generate prime conditions for melting the ice shelf from beneath.

Peter Washam, a research associate at Cornell University, also studies the grounding zone. His team lowered a remote-controlled underwater robot through the borehole to take measurements of the ocean, ice, and

seafloor in this region. They mapped these properties up to the point where the ice and seafloor came in contact. Washam describes the grounding zone as “chaotic,” with warm water, rugged ice, and a steep, sloping bottom that allows the water to quickly melt the ice sheet from below.



PETER WASHAM'S FIELD TEAM AFTER A SUCCESSFUL DIVE. PHOTO: SCHMIDT/DICHEK

But upstream of this line of floatation, the researchers have found that the water is actually pumped under the ice sheet a short distance by tides. Lizzy Clyne, an adjunct professor at Lewis and Clark College, and their

team study the tidal pumping mechanism that physically forces warm water between the ice and bedrock at Thwaites. The floating portion of the glacier rises and falls with the tides—and that motion acts like a lever, pumping water under the ice sheet. Also, downstream of the grounding zone on the bottom of the floating ice shelf, constant stretching and melting is rapidly creating long channels through the ice where water can flow, impacting the long term stability of the ice shelf, said Clyne.

As Thwaites retreats upstream and into the ice sheet, it may form very tall ice cliffs at the ocean front. Anna Crawford, a postdoctoral researcher at the University of St. Andrews, and her team use computer modelling to study ice cliff failure: a process by which ice can break off the ends of the glacier into the open ocean. The process can take on many forms, but all of them could lead to very rapid retreat of the massive glacier. The bedrock shape of West Antarctica makes the region vulnerable to rapid retreat via ice-cliff failure, as increasingly tall cliffs could be exposed as the ice retreats. This could lead to a chain-reaction of fracturing, resulting in collapse, said Crawford. A challenge for the team is assessing

if, when, and how fast this might occur, but major ice loss is possible within several decades to a few centuries.

“If Thwaites were to collapse, it would drag most of West Antarctica’s ice with it,” said Scambos. “So it’s critical to get a clearer picture of how the glacier will behave over the next 100 years.” ITCG research, including future sea-level projections, will be vital for policy makers in their efforts to mitigate and adapt to the impacts of global sea level rise, the team said.

This work was presented at the AGU Fall Meeting during a **press conference** on December 13. **Recording here**.

CIRES is a partnership of **NOAA** and **CU Boulder**.

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