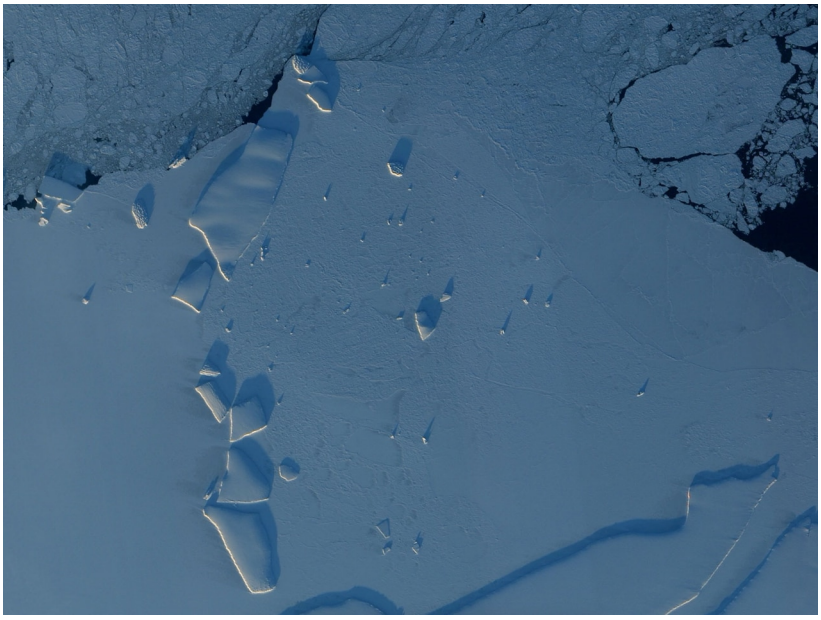

This is the East Antarctic coastline. Icebergs are highlighted by the sunlight, and the open ocean appears black.
PHOTOGRAPH COURTESY NASA

ENVIRONMENT

CONNECTING THE DOTS

We Know West Antarctica Is Melting. Is the East In Danger, Too?

For years, scientists thought that icy, remote East Antarctic glaciers were stable. But that may no longer be the case.

BY **ALEJANDRA BORUNDA**

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Along the coast of West Antarctica, glaciers are retreating at alarming rates, crumbling as warm waters chew at their fragile edges.

But for years, scientists thought that the glaciers of East Antarctica—the hulking ice sheet on the other half of the continent, nearly three miles thick in some parts—were stable. Recently, though, evidence has emerged that shows that some of the East Antarctic glaciers have also started on a slow, inexorable backward march that could eventually lead to the loss of even more ice than exists in all of West Antarctica. [Here's how to define East vs. West at the bottom of the world].

In a study published in July, scientists found that the Totten and Moscow University glaciers of East Antarctica—directly south of Australia—lost about 18 billion tons of ice each year between 2002 and 2016. The glaciers sloughed off enough mass every year to cover New Jersey three feet deep in ice.

That's only about a third of what the West Antarctic glaciers are losing each year. But locked up in the Totten and the smaller neighboring Moscow University glaciers of East Antarctica is enough ice to raise sea levels over 16 feet, if melted fully, more than would be caused by the complete melting of the West Antarctic glaciers. [See what the Antarctic coast looked like 100 years ago]

Thus far, says study lead author Yara Mohajerani, a researcher at the University of California, Irvine,

the Totten and Moscow University glaciers haven't kicked into the kind of high-stakes melting that's unfolding on the other side of the continent. But scientists are concerned that if the glaciers continue their retreat, they could hit a tipping point—after which comes a cycle of runaway melting.

"Totten itself has more sea level rise potential than all of West Antarctica," Mohajerani says. "It's just giant."

ANTARCTICA IS MELTING AT A DANGEROUS PACE—HERE'S WHY

See why the accelerated melting of Antarctica's ice shelves may have disastrous consequences for coastal cities around the world.

The Shape of Collapse

Scientists have long worried about the West Antarctic glaciers. Not only is warm water gnawing at their edges: The bigger issue lies in the very shape of the land upon which they sit. Much of the rock floor underneath the glaciers lies far below sea level. The glaciers above are fat with ice, tucked into the basin like a giant ice cube frozen into a

bowl.

The edges of the ice sheet spill over the edges of the bowl and poke out into the ocean like a mushroom cap, floating on top of the sea that surrounds the continent. That cap provides a key service: it blocks the ocean from reaching the lip of the giant rock bowl in which the ice sheet sits. But if those edges retreat too far, ocean waters could broach the lip of the bowl and start rushing in under the bottom of the ice sheet. And water—even very cold Antarctic water—melts ice. This, scientists think, would trigger essentially unstoppable melting.

Until about a decade ago, scientists weren't particularly concerned about the East Antarctic glaciers. Underneath the hulking, frigid East Antarctic ice sheet, the rock floor was mostly above sea level, and records that looked deep into the past showed that most of the ice sheet had stayed stable for the last eight million years or so, even through a time when CO_2 concentrations in the atmosphere approached today's values. So for years, scientists had considered that the eastern half of the continent—where the ice stretched over three miles thick in some spots—of less immediate concern. The kind of runaway melting that could grip West Antarctica shouldn't be an issue in the East, was the thinking.

By 2008, it became apparent that the West Antarctic glaciers whose roots sat below sea level, like Pine Island and Thwaites glaciers, were in

danger. And that realization prompted scientists to look back to the East, to the Totten and Moscow University glaciers, whose geometry looked disconcertingly familiar to the West Antarctic ones—only bigger.

“Like West Antarctica, part of the basin that [Totten] drains is grounded area below sea level,” explains Karen Alley, a glaciologist at the College of Wooster in Ohio, who was not involved in the study, “which means if you cause that glacier to retreat, it can get into a position that's unstable, and it’s likely to lose a lot of mass very quickly.”

Scientists first discovered that deep basin decades before, when they first started using radar technology to map the ground miles below the ice surface. But only when mapping technologies improved did the hidden topography reveal its true self as so eerily similar to the other side of the continent. The big glacier in East Antarctica, then, was vulnerable in the same way as the West Antarctic ice—but with even larger consequences, up to a breathtaking 16 feet of sea level rise, if fully melted.

CLIMATE 101: GLACIERS

Glaciers appear on almost every continent. However, they are rapidly melting due to the warming climate. Find out how glaciers form and other interesting facts about glaciers.

CSI: Totten Glacier

The task, then, was to figure out how endangered Totten glacier was. Was it retreating toward the lip of the bowl, past which the runaway melting might be triggered? Or was it still fairly stable?

The question has proved remarkably tricky to answer. East Antarctica is, in many respects, a giant cipher at the bottom of the world. “It's like saying we have weather stations in Los Angeles, San Francisco, and New York, and we're going to try to understand the weather in Chicago,” explains Tim Creyts, a research scientist at Columbia University’s Lamont Doherty Earth Observatory. “That's the level of detail we’ve got for most of East Antarctica.”

And we know less about the land buried underneath East Antarctica’s massive ice sheet than we do about the surface of Mars. To even get to the remote, icy Totten Glacier is a challenge. From Australia, it’s a week-long trip via ship through the heaving swells of the Southern Ocean. Or planes with skis attached hopscotch their way thousands of miles across the frozen expanse of ice, often so far that the planes need to stop and refuel from previously stored caches on the ice sheet.

But after 2008, when scientists figured out that the

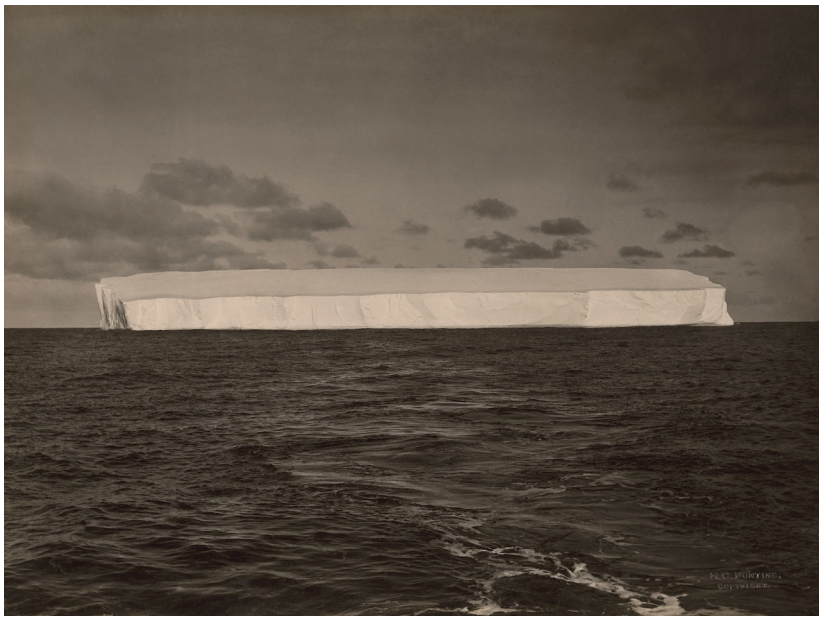
shape of Totten's rock floor rendered it similarly precarious to West Antarctica, they stepped up the number of pilgrimages to the ice and scraped more data from the satellites spinning overhead. Was it thinning? Getting shorter? Getting less dense?

For a while, the answer wasn't clear. Some studies showed that the ice sheet was thinning. But another study showed that, over an 18-year period, the glacier bobbled around in size but didn't appear to thin.

But the longer we look, the more clearly the signal emerges, helped along by vast improvements in the tools scientists use to measure ice from space. Mohajerani and his colleagues, for instance, tracked changes in the glaciers' size with data from NASA's GRACE satellites, which measure subtle changes in Earth's gravitational fields. GRACE satellites register water differently than ice, so the signal changes over time, as melted ice pours into the ocean: The glacier gets lighter and the ocean right next door gets a tiny bit heavier. Overall, Mohajerani and his colleagues saw, the Totten and Moscow University glaciers were losing about 15 percent more ice each year than they were gaining from snow falling on their surfaces. [Learn about other satellites that changed the face of research].

The longer we look, says Bingham, the more clearly we can pick out the changes underway. "We've been waiting for 10 or 15 years for GRACE to start showing ice losses," he says, and now the challenge

is to figure out what caused them.



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Distant shot of a large iceberg, Antarctica.
PHOTOGRAPH BY HERBERT G. PONTING, NAT GEO IMAGE COLLECTION

But Is It In Danger?

The next question, of course, is why Totten and Only by answering "why" can scientists figure out what everyone wants to know: How quickly could this happen? So the work now is in sorting out just what forces are pushing and pulling at the pliable edges of the ice and how, exactly, changing climate conditions are affecting it.

The red-handed culprit of the moment seems to be the ocean lapping at the tongue of the glacier. Warm water can eat away at ice much more quickly than air can—think about a cube of ice popped into a glass of water. And for several years, when oceanographers sent their probes down into the

water around Totten's protruding ice tongue, they found unexpectedly warm water bathing the underside of the ice.

5:26

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"The prevailing wisdom before," says Jamin Greenbaum, an oceanographer at the University of Texas, Austin, "was that there was too much cold salty water on the continental shelf to let the deep warm water to get on the shelf."

Basically, a cold pool of water blocked some of the water percolating offshore from nosing up to the delicate glacier's edge. But something happened to push that warm water in close, and the ice responded accordingly.

"There's a battle going on," explains Greenbaum, between the cold water and the warm, a skirmish at the edge of one faraway glacier at the bottom of the

planet that could resonate throughout.

A study from last year links the intrusion of that warm water to changes in climate. But other scientists aren't quite so sure that we fully understand the connection yet. In a recent study, David Gwyther, a researcher from the Antarctic Gateway Partnership at the University of Tasmania, and his colleagues delve deep into the ocean dynamics that control the change in the water cozying up to the edge of the glacier. The changes, they found, were partly caused by climate, but were heavily influenced by the huge, slow-moving gyrations the coastal Antarctic ocean experiences over years and decades.

This doesn't negate the influence of climate change, he says. But it points to a deeper philosophical question: "When we see change," he asks, "are we actually seeing response to climate change, or just the natural response of the system?"

Understanding what's part of the background noise of the glacier is absolutely key to figuring out what actually matters. There's evidence that Totten scooted up to 200 miles inland in the far-distant past, so scientists know such change is possible. Now, they want to know what the warning signs are.

For Ala Khazendar, a scientist at NASA's Jet Propulsion Laboratory in Pasadena, California, those signs may be here already. "If change starts in East Antarctica—and maybe it is underway

already—there's a good chance it will progress quickly, given what we've seen happen in West Antarctica," he says. "So basically, we'd better be prepared."

The Future

The immediate concern is still West Antarctica, where glacier retreat is well underway; melt from those glaciers, some scientists predict, could raise sea levels globally by more than three feet by the end of the century. Totten in the East, by comparison, seems to be still in the early stages of unraveling.

But there are still many more questions to answer about the East Antarctic glaciers, and they aren't idle. The future existence of low-lying nations depends on knowing how and when these glaciers might change, and billions of dollars of coastal infrastructure—ports, cities, communities—will inevitably be affected. The quiet accumulation of snow on the high plateau, or the barest bit of exposed ice to warm water, could have global effects.

And therefore, tracking the continued change of the glacier is crucial. Each time the GRACE satellites take their stately revolution around Earth, a new point gets added to the dataset, slowly building up a record that shows melted ice slipping from land to sea.

"If it continues this trend," says Mohajerani, "it's

this monster that might wake up."

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