Time-lapse of the 'unstable' West Antarctic ice shee

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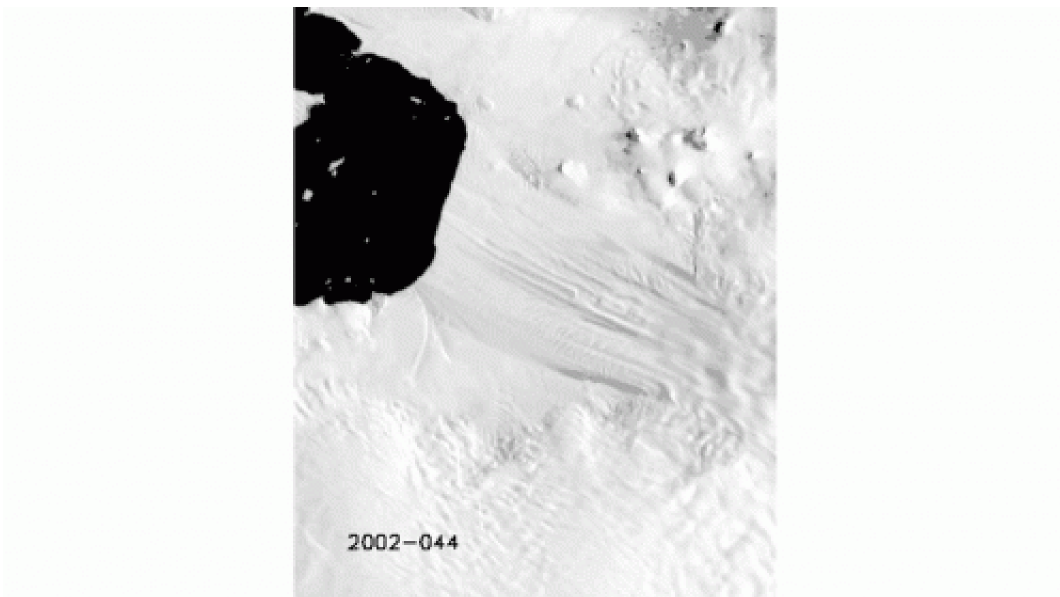

Although the Amundsen Sea region is only a fraction of the whole West Antarctic Ice Sheet, the region contains enough ice to raise global sea levels by 4 feet (1.2 meters). Image credit: NASA/GSFC/SVS

The new finding that the eventual loss of a major section of West Antarctica's ice sheet "appears unstoppable" was not completely unexpected by scientists who study this area. The study, led by glaciologist Eric Rignot at NASA's Jet Propulsion Laboratory, Pasadena, California, and the University of California, Irvine, follows decades of research and theory suggesting the West Antarctic Ice Sheet is inherently vulnerable to change.

Antarctica is so harsh and remote that scientists only began true investigation of its ice sheet in the 1950s. It didn't take long for the verdict on the West Antarctic Ice Sheet to come in. "Unstable," wrote Ohio State University glaciologist John Mercer in 1968. It was identified then and remains today the single largest threat of rapid sea level rise.

Why is West Antarctica's ice sheet considered "unstable"?

The defining characteristic of West Antarctica is that the majority of the ice sheet is "grounded" on a bed that lies below sea level.

In his 1968 paper, Mercer called the West Antarctic Ice Sheet a "uniquely vulnerable and unstable body of ice." Mercer based his statement on geologic evidence that West Antarctica's ice had changed considerably many, many millennia ago at times when the ice sheets of East Antarctica and Greenland had not.

In 1973, University of Maine researcher Terry Hughes asked the question that scientists continue to investigate today. The title of his paper: "Is The West Antarctic Ice Sheet Disintegrating?" In 1981, Hughes published a closer look at the Amundsen Sea region specifically. He called it "the weak underbelly of the West Antarctic ice sheet."

Here's the cause for concern: When the ice sheet is attached to a bed below sea level, ocean currents can deliver warm water to glacier grounding lines, the location where the ice attaches to the bed.

Scientists recognized that this is the first step in a potential chain reaction. Ocean heat eats away at the ice, the grounding line retreats inland and ice shelves lose mass. When ice shelves lose mass, they lose the ability to hold back inland glaciers from their march to the sea, meaning those glaciers can accelerate and thin as a result of the acceleration. This thinning is only conducive to more grounding line retreat, more acceleration and more thinning. In this equation, more ice flows to sea every year and sea level rises.

But that's not all.

Beginning with research flights in the 1960s that made radar measurements over West Antarctica, scientists began to understand that, inland of the ice sheet's edge, the bed slopes downward, precipitously, in some cases.

This downward, inland slope was theorized decades ago, but has been confirmed and mapped in detail in recent years by airborne campaigns such as NASA's Operation IceBridge. In some spots the bed lies more than a mile and a half below sea level. The shape of this slope means that when grounding lines start to retreat, ocean water can infiltrate between the ice and the bed and cause the ice sheet to float off its grounding line.

Why is the Amundsen Sea region more at risk than other parts of West Antarctica?

In addition to the ice sheet being grounded below sea level, there are three main reasons. First, the glaciers here lack very large ice shelves to stem ice flow. Second, they aren't "pinned" by obstructions in their beds except in a few small places, unlike the Ronne and Ross shelves which are pinned down by large islands. Third, as first observed in the 1990s, the area is vulnerable to a regional ocean current, ushered in by the shape of the sea floor and the proximity of the circumpolar deep current. This current delivers warm water to grounding lines and the undersides of ice shelves in the region.

The pace and magnitude of the changes observed in this region match the expectation that Amundsen Sea embayment glaciers should be less stable than others. In some cases, the changes have outstripped expectations.

Pine Island and Thwaites glaciers have experienced significant flow acceleration since the 1970s. Both saw the center of their grounding lines retreat dramatically. From 1992 to 2011, Pine Island's grounding line retreated by 19 miles (31 kilometers) while the center of the Thwaites grounding line retreated by nearly 9 miles (14 kilometers). Annual ice discharge from this region as a whole has increased 77 percent since 1973.

What would a loss of the Amundsen Sea region mean for sea level rise?

Even as Rignot and colleagues suggest that loss of the Amundsen Sea embayment glaciers appears inevitable, it remains extremely difficult to predict exactly how this ice loss will unfold and how long it will take. A conservative estimate is that it could take several centuries.

The region contains enough ice to raise global sea levels by 4 feet (1.2 meters). The most recent U.N. Intergovernmental Panel on Climate Change (IPCC) report estimates that by 2100, sea level will rise somewhere from just less than 1 foot to about 3 feet (26 to 98 centimeters). But the vast majority of these projections do not take into account the possibility of major ice loss in Antarctica. Rignot said this new study suggests sea level rise projections for this century should lean toward the high-end of the IPCC range.

The Amundsen Sea region is only a fraction of the whole West Antarctic Ice Sheet, which if melted completely would raise global sea level by about 16 feet (5 meters).

What are NASA and other science agencies doing to better understand this vulnerable region and its potential impact on global sea level?

To better understand how this section of the ice sheet has changed in recent decades, scientists from NASA and research institutions around the world have made field campaigns to the region and used every airborne and spaceborne tool at their disposal, including NASA satellites and those launched by space agencies in Europe, Japan and Canada.

The National Science Foundation has funded major field campaigns to West Antarctica, including POLENET, which place Global Positioning System (GPS) stations in the area to measure geological changes. A campaign to the Pine Island Glacier ice shelf led by NASA glaciologist Bob Bindschadler measured variables such as water temperature and melting rate at the underside of the ice shelf.

NASA's Operation IceBridge, which began in 2009, continues to fly one extended research campaign over Antarctica each year. IceBridge flights put multiple scientific instruments over key regions of the ice sheet to measure glacier thinning, the shape of the bed and other factors.

In 2017, NASA will launch ICESat-2, the follow-up mission to ICESat, which operated from 2003 to 2009. ICESat-2 will use laser altimetry to make precise measurements of glacier heights. Combined with the ICESat and IceBridge data records, the ICESat-2 measurements will allow for a continuous record of year-over-year change in some of the most remote regions of the world.

Provided by JPL/NASA