PASSAGE 3

What Are We Learning?

Ice sheets are shrinking

Dr. Isabella Velicogna was one of the first researchers to analyze GRACE's early measurements of the ice sheets in Greenland and Antarctica. She found the data very exciting because GRACE brought something completely different to the table. "For the first time scientists can measure the mass of the ice sheet directly, without having to estimate density or some other variable," the geophysicist explains. "We're also looking at entire ice sheets, which is great, especially for Antarctica because it's remote and it's huge."

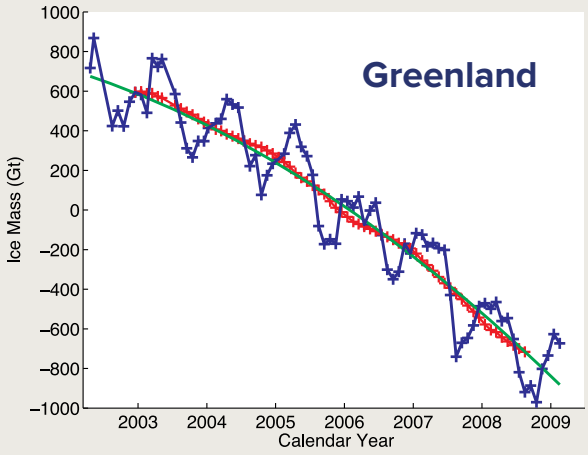
At present, scientists are working with over twelve years of data, from April 2002 to November 2014. A trend has clearly emerged: the ice sheets are getting smaller. Parts of the ice sheets are falling off into the ocean, a process called ice discharge, which turns out to be very important. Discharge is caused in part by natural processes like seasonal changes. Winter snowfall adds mass, and warmer temperatures melt some of the snow, converting it to runoff. But in the big scheme of things, seasonal change doesn't have much effect.

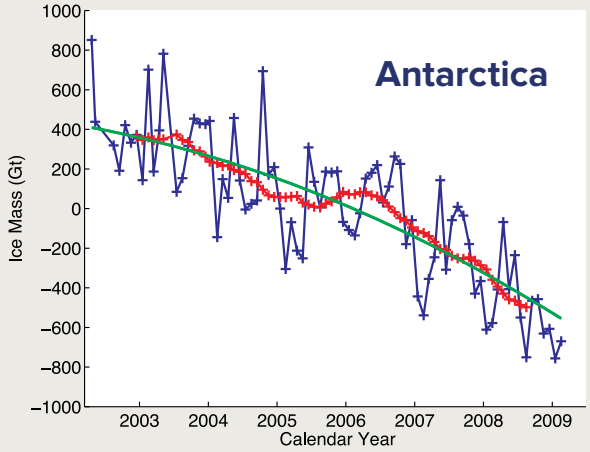
Greenland is losing ice

Greenland is much more sensitive to climate warming than Antarctica because it receives a lot of sun during the summer, when its ice sheet melts substantially. The mass of ice has begun to decline, and the island's largest glaciers are sliding toward the sea. Most of the actual melting occurs along Greenland's coast, where ice is rapidly flowing into the ocean. That flow appears to be particularly sensitive to the temperature of the surrounding ocean. The warm waters presumably melt the bases of the glaciers where they extend out into the sea, so the edges are melting rapidly. More snowfall at higher elevations has offset the loss, but only partially.

Ice Sheets Losing Mass

The declining masses of the Greenland and Antarctic ice sheets as determined by the GRACE satellite mission. Blue lines are the unfiltered data. Red lines are filtered to smooth out seasonal variation. Green lines are the best fitting quadratic trend, which represents the data better than a linear trend (from Velicogna, 2009). The green line shows the accelerating mass loss for both ice sheets.





Graphs Source: ©American Geophysical Union

Antarctica's ice sheets are increasingly vulnerable

Scientists think that Antarctica is starting to lose ice over all, although so far the process has not become as quick or widespread as in Greenland. But Antarctica's ice mass is far larger, and its geography makes it vulnerable. The Antarctic Peninsula is a rugged mountain chain that has a summer melting season, unlike the rest of the continent. It extends far enough to the north to be affected by the relatively warm circumpolar ocean current. The peninsula's western edge is one of the fastest-warming places on Earth. The West Antarctic Ice Sheet appears to be particularly sensitive to the state of the surrounding ocean because much of it sits on land that is below sea level and its edges are in contact with seawater, which is warming.

Small changes in global sea level or a rise in ocean temperatures could cause a breakup of the continent's ice shelves, which operate like dams to keep Antartica's glaciers from flowing toward the ocean. Ice shelves are getting thinner because the ocean is getting warmer and melting the ice shelves from underneath. When the ice eventually disintegrates, it is the equivalent of the dam collapsing. West Antarctica has some very big ice shelves—a lot of dams—which means that it's very unstable.

Antarctica's Larsen B Ice Shelf, which partially collapsed in 2002, is likely to disintegrate completely before the end of the decade. Warmer water underneath East Antarctica's Totten Glacier is causing it to lose ice as well. Without the ice shelves to contain it, the flow from the glaciers speeds up and enters the ocean faster. Since glaciers and ice sheets rest on land, once they flow into the ocean, they contribute to sea level rise.

The rate of melting is accelerating

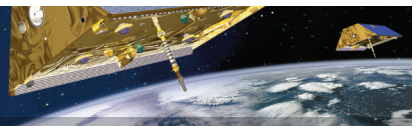
Not only are the ice sheets melting, a second key finding is that "it looks like that this change is not a linear change," Velicogna says. This means that the rate of melting isn't changing the same amount every month. Instead, it's accelerating. Prediction is difficult, but the data indicate that this trend is unlikely to change. The rate is accelerating because the processes that are causing the ice sheets to lose mass have inertia. In other words, once they get going, they keep going. "Imagine a ball rolling down a mountain," Velicogna suggests. "Once it starts, it keeps moving downhill. In the same way, once glaciers start to discharge ice, the process continues until the rest of the glacier eventually makes its way to the ocean." This process is underway in both Greenland and Antarctica, and the ice has really strong inertia.

The blue areas show Antarctica's major ice shelves. The area in red shows the site of the Larsen B ice shelf, which partially collapsed in 2002.

Map source: © Dimitri Torterat via Wikimedia Commons

GRACE data show that ice sheet loss has been underestimated

What matters is not only how much ice is being lost, but how quickly. Globally, sea levels have risen four to eight inches since the last century and will continue to rise, putting coastal communities worldwide at risk. How much more will the ice sheets shrink, and how rapidly? One surprise from the GRACE data was that the ice sheets are disappearing much faster than the models predicted. In Greenland, the data have revealed that the



ice sheet has lost 240 cubic kilometers of ice since 2002. That's 240 times the annual water consumption of metropolitan Los Angeles. In Antarctica, GRACE data show a loss of approximately 150 cubic kilometers of ice per year. These rates—an acceleration of 250 percent between 2002 and 2006—are much higher than the estimates from the Intergovernmental Panel on Climate Change, the main organizing body of climate change research. "Nobody expected those changes. Some people still don't believe it," says Velicogna.

PASSAGE 3

Stop & Think Questions

Based on the Text

1. What conclusions have scientists made based on GRACE data from Greenland and Antarctica?

2. What predictions are scientists making based on GRACE data?

Looking Ahead

3. Based on what you know about how Earth's climate system works, how do you think the melting of Greenland and Antarctic Ice Sheets will affect the climate system?