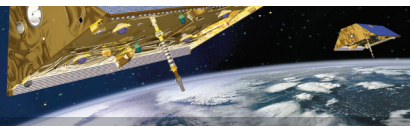




PASSAGE 3

# What Are We Learning?

## Ice sheets are shrinking

Dr. Isabella Velicogna was one of the first researchers to start studying GRACE's early measurements of the ice sheets in Greenland and Antarctica. She was very excited about the data because it was unlike anything that had been previously available. "For the first time scientists can measure the mass of the ice sheets directly," the geophysicist explains. "We're also looking at entire ice sheets, which is great, especially for Antarctica because it's remote and huge." These are two reasons the data collected by GRACE are unique: the mass of the ice sheets is measured directly and the scientists can see the entire ice sheets at one time.

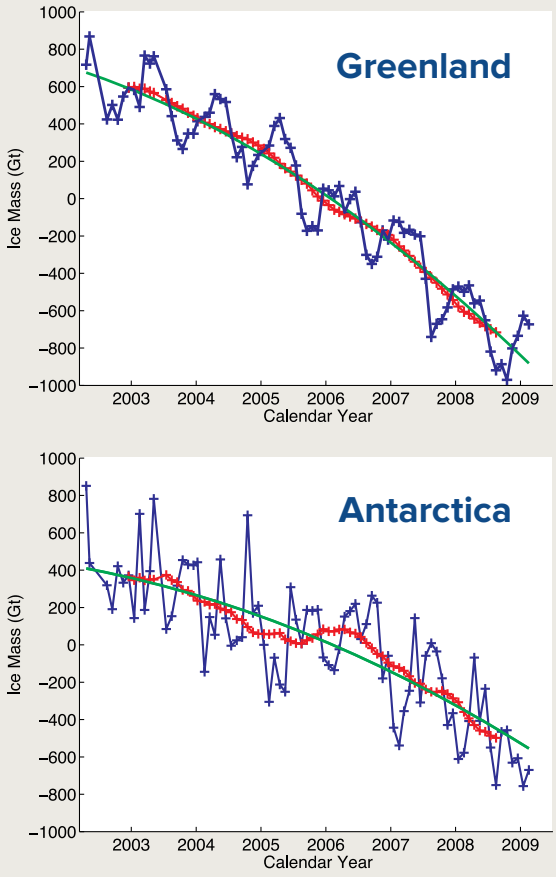
Scientists now have over twelve years of data to work with (from April 2002 to November 2014). There is a clear trend in this data: the ice sheets are getting smaller. Parts of the ice sheets are falling off into the ocean. This process is called discharge and it is in part a normal effect of seasonal changes. In the winter, snowfall adds mass to the ice sheets. In warmer temperatures, some of the snow melts and turns into runoff. But seasonal changes shouldn't have much of an effect on the mass of ice sheets.

## Greenland is losing ice

Greenland is much more sensitive to climate warming than Antarctica. This is because it receives a lot of sun during the summer since it is farther from the poles than Antarctica. This causes its ice sheet to melt substantially during this time. The mass of ice has begun to decrease, and the island's largest glaciers are sliding toward the sea. Most of the melting occurs along Greenland's coast, where ice is rapidly flowing into the ocean. The temperature of the surrounding ocean has a big impact on how fast the ice melts and flows into the ocean.

## Ice Sheets Losing Mass

These graphs of GRACE data show that Greenland and Antarctica are losing ice mass. The blue line is unfiltered data. The red line shows data that is filtered to smooth out variations caused by seasonal changes. The green line is the trend line, which shows the general direction that the data is heading. Trend lines are often straight lines. Notice that in this case the trend line curves downward indicating that, during the time that GRACE has been collecting data, the rate of melting in both Greenland and Antarctic is speeding up.




Graphs Source:
©American Geophysical Union

## Antarctica's ice sheets are increasingly vulnerable

Scientists think that Antarctica is starting to lose ice overall, even though it is not happening as quickly or as extensively as it is in Greenland. But Antarctica's ice mass is far larger, and its geography makes it likely to experience ice melting. The Antarctica Peninsula is a rugged mountain chain that has a summer melting season. Because it extends far enough to the north, it is affected by the relatively warm ocean current that flows around Antarctica. The peninsula's western edge is one of the fastest-warming places on Earth. This is because the West Antarctic Ice Sheet 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. These ice shelves are like dams—they keep Antarctica'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 like a dam collapsing. West Antarctica has a lot of ice shelves—a lot of dams—which means that it's very unstable.

Antarctica's Larsen B Ice Shelf partially collapsed in 2002. It is likely to disintegrate completely before 2020. 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 glacier 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 blue areas show Antarctica's major ice shelves. The Totten Glacier is shown in green. The area in red is the site of the Larsen B ice shelf, which partially collapsed in 2002.**

Image Source: © Dimitri Torterat via Wikimedia Commons

## The rate of melting is accelerating

Scientists know for sure that the ice sheets are melting. However, scientists are also interested in how fast they are melting. Velicogna found that the rate of melting isn't changing the same amount every month. Instead, it's accelerating. The rate at which the

ice is melting is getting faster every month. Prediction is difficult, but based on what the data shows, this trend of acceleration is not likely to change.

The rate is accelerating because the processes that are causing the ice sheets to lose mass have inertia. This means that 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 happening in both Greenland and Antarctica, and the ice has really strong inertia.

## GRACE data show that ice sheet loss has been underestimated

What matters is not only how much ice is being lost, but how quickly. Around the globe, sea levels have risen four to eight inches since the last century. They will continue to rise. This puts 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 computer models predicted. In Greenland, the data show that the ice sheet has lost 240 cubic kilometers (approximately 55 cubic miles) 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 (36 cubic miles) of ice per year. This means there was an acceleration of 250 percent between 2002 and 2006. This rate of acceleration is much higher than the estimates from the Intergovernmental Panel on Climate Change, a group that organizes climate change research. "Nobody expected those changes. Some people still don't believe it," says Velicogna.

PASSAGE 3

# Stop and 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?