Scripps Studies Provide New Details About Antarctic Iceberg Detachment

Findings show that ice fracturing occurs in episodes and may be tied to changes evolving over seasons

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A multifaceted research effort by scientists at Scripps Institution of Oceanography at UCSD, and their colleagues has resulted in several important new findings about Antarctica and the changing dynamics of its ice structure.

Scientists have been investigating the mechanisms by which Antarctic icebergs detach from the main continental ice sheet because of the importance of determining the future stability of the entire Antarctic ice mass. Little is known about the processes and forces that lead to iceberg detachments, or "calving."

Furthermore, glaciologists believe areas called ice "shelves," floating slabs of ice that extend from the coasts of the Antarctic Ice Sheet out to sea, may be the first indicators of how climate change is affecting the Antarctic continent because of their direct contact with the ocean and their sensitivity to air temperature warming. Some ice shelves are located in conditions that are close to the melting point of ice, and are therefore more sensitive to changes in atmospheric temperature.

Researchers at Scripps's Cecil H. and Ida M. Green Institute of Geophysics and Planetary Physics used a variety of approaches to uncover details of ice shelf "rifting"-ice fracturing that cuts through the entire thickness of an ice shelf and represents the first stage of the process in which icebergs eventually break away from the main ice mass-on East Antarctica's Amery Ice Shelf. Their findings were recently published in two papers in Geophysical Research Letters.

One paper describes the behavior of the ice shelf rift over a nine year period, while another paper describes changes over time periods as little as seconds. The researchers captured the information through a variety of data sources, including spaceborne readings from NASA's Ice, Cloud, and land Elevation Satellite (ICESat), the Multiangle Imaging SpectroRadiometer (MISR) on NASA's Terra satellite, and synthetic aperture radar. They also coordinated an expedition to Antarctica to deploy global positioning system (GPS) equipment and seismometers directly onto the Antarctic ice, the first time in glaciology that such instruments have been used to study the fracturing of ice shelves.

The first report, led by Helen Amanda Fricker of Scripps, used MISR and other satellite data to monitor the lengths of two "rifts"- on the Amery Ice Shelf from 1996 to 2004. Rifts can lengthen and widen for decades before eventually breaking off.

One area of study focused on a location called the "Loose Tooth," a large rift area fracturing off the ice shelf that resembles a wobbly tooth about to detach. Historical records show that a Loose Tooth-sized fracture preceded the last significant ice break-off event recorded in 1963 to 1964, demonstrating that iceberg calving is a cyclic process.

The scientists discovered that the Loose Tooth and other rifts grow faster in summer (December through March) than in winter. The finding contradicts current assumptions indicating that the forces that cause rifts to propagate are not sensitive to seasonal changes. They also found that the rifts have been widening at a steady annual rate for the past five years.

"There's a lot we don't know about how rifts propagate on ice shelves, but our conclusions give us some hints, including the finding that iceberg calving may be temperature and climate change dependent," said Fricker.

"In order to evaluate realistically the evolution of ice shelves under different climate change scenarios, we need to determine how these scenarios might influence the production rate of icebergs," the authors say in the paper.

The second study used GPS measurements and seismometers, which capture vibrations from ground movement, to investigate an active rift area of the Amery Ice Shelf, similar to the way earthquakes are monitored on the San Andreas Fault.

In this unprecedented field study, the researchers recorded "swarms" of seismic activity that showed that rifts widen in short but powerful bursts of acceleration. They found bursts where the rift lengthened by about 600 feet over four hours. They recorded three of these bursts separated by 10 and 24 days, respectively, with the time in between consistent with the ice sheet's normal, slow widening.

"It was interesting to see this rift just sitting there for a while, and then in short periods of time propagating forward in bursts," said Scripps' Jeremy Bassis, the lead author of the second study and a participant in the Antarctic field experiment.

Also emerging from both studies are new details of the unique mixture of ice fragments, sea ice and wind-blown snow that fills the rift. This "mélange," as it is called, could be instrumental in advancing the size of the rifts by serving as something of a ratchet in the widening process.

"One of the newest measurements we received from ICESat was for determining the thickness of the mélange," said Fricker, who calculated the thickness of the mélange mixture at more than 278 feet in the rift under study.

Since the mélange is a fusion of elements, it adds further complexity in determining how the ice mass fractures are changing seasonally.

"People have understood that rift propagation is an important phenomenon and now we have new data that can really take us places," said Jean-Bernard Minster, a geophysics professor at Scripps and a coauthor of both studies. "These two reports represent a powerful combination. One allowed us to closely look at the rifts over several years with imagery from space, while the other used field instruments right at the tip of the rift to give us one very detailed season of rift propagation.

A third paper related to this research is being prepared for publication later this year. That study is using scientific models to study glaciological stress and rift widening.

In addition to Fricker, Bassis and Minster, contributing coauthors in the international effort included Richard Coleman of the University of Tasmania and the Antarctic Climate and Ecosystems Cooperative Research Centre (ACE-CRC) and Neal Young of the Australian Antarctic Division and the ACE-CRC in Australia.

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