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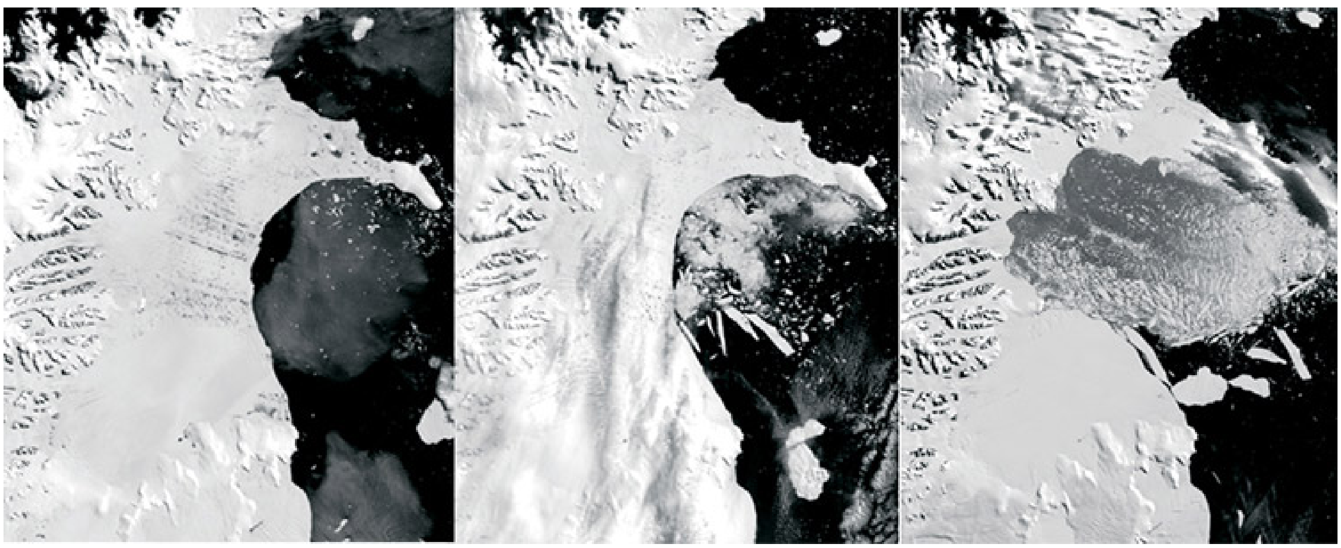
Seismic Network Will Measure the Effects of Ocean Waves on Antarctic Ice Shelves

Researchers to create an innovative way to observe the forces that affect the evolution of ice shelves and possibly trigger their collapse



Larsen B Ice Shelf Collapse, 2002. Credit: National Snow and Ice Data Center

Starting in November, Scripps Institution of Oceanography, UC San Diego, researchers and colleagues will embark on an ambitious and arduous mission funded by the National Science Foundation Office of Polar Programs to install a seismic array on Antarctica’s Ross Ice Shelf.

The data generated by the array is expected to deliver important new information on the dynamics of the stresses that wave impact vibrations place on ice shelves that extend out into the open ocean. With attention on acceleration of sea level rise from increased melting in Greenland and Antarctica of great concern in an era of rapid climate change, the study could help scientists understand what triggers sudden ice shelf collapse.

In the field project, Dynamic Response of the Ross Ice Shelf to Wave-induced Vibrations (DRRIS), a 16-station broadband seismic array will be deployed on the Ross Ice Shelf to measure the response of the ice shelf to impacts from ocean swell and what are known as infragravity (IG) waves. These waves, transformed in shallow water from swell along coasts, could provide the required external forcing needed to extend existing climate-driven fractures.

The team will operate from the temporary Yesterday Camp on the ice near the dateline (180° longitude) from Nov. 10 to Dec. 2, installing nearby stations with snowmobile transits and more distant stations by fixed-wing Twin-Otter flights. Deployment operations and the duration at Yesterday Camp will depend heavily on the weather, which even in summer conditions can be severe with high winds and sub-zero temperatures.

The science team will travel to several widely separated locations on the shelf to install seismic stations in the midst of the Antarctic summer. The array will measure the spatial and seasonal variability of the wave-shelf interaction, including both the generation of elastic stress waves and the flexing of the ice shelf. The deployment will provide the first spatially comprehensive data on the response of ice shelves to infragravity waves.

"This is important because a portion of the large mass of land ice in the West Antarctic Ice Sheet (WAIS) is buttressed by the Ross Ice Shelf," said Scripps research oceanographer Peter Bromirski, the project's lead investigator. "If the ice shelf buttressing is removed, by a collapse or otherwise, WAIS ice will flow much faster to the sea, accelerating sea-level rise. Making baseline measurements is critical to identify the rate at which changes in the ice sheet are occurring, especially the subtle changes that can be recorded by seismometers that may escape detection by satellite altimetry or other means."

The three-year project will involve a 24-month period of field observation that spans two full annual cycles on the Ross Ice Shelf, including the austral winter. Reports from the field will be available through the blog Ice Shelf Vibrations.

Of all the glaciological components comprising the Antarctic Ice Sheet, ice shelves are the most vulnerable to climate change. This is because, as the most seaward extension of a glaciological system, ice shelves are in contact with both the atmosphere above and the underlying ocean. Consequently, ice shelves are in continual adjustment to dynamic forcing from multiple sources: the advancing glacial ice, the bedrock to which they are attached at the continent's edge, the atmosphere, as well as ocean conditions such as temperature, currents and waves. Changes in any of these can alter ice shelf extent, flow velocity, thickness, and other parameters as the shelf responds to new forcing.

Climate change affects ice shelves through warming of the atmosphere causing increased surface melting, and increasing ocean temperatures that melt ice shelves from below. The resulting ice shelf thinning weakens ice shelves, making them more easily fractured. Progressive thinning and associated weakening can result in ice shelf collapse, as observed at the Larsen Ice Shelf in February 2002.

A principal goal of the project is to quantitatively assess how the Ross Ice Shelf responds spatially to the ocean gravity wave spectrum through an annual cycle. Changes in the ocean environment due to a changing climate such as increasing storminess, decreasing sea-ice cover, and warming ocean waters would affect the integrity of Antarctica's largest ice shelves. The response of the ice shelf depends in part on the thickness of the water cavity between the ice shelf and the solid earth below. It also depends on the structural and elastic properties of the ice itself and how those change.

The collapse of ice shelves doesn't affect sea level directly, but it has an important function in buttressing or restraining the flow of glacial ice into the sea, which does increase sea level. (Glaciers are large flowing masses of ice on land. When they move from land into the ocean, that mass adds to the volume of the ocean. The melting of ice that is floating on the ocean — seasonal sea ice, icebergs, or ice shelves – does not cause sea level to rise. This is the same as the water level rising in a glass when ice cubes are added, with no further rise when they melt.) So while melting or collapse of an ice shelf does not increase sea level, the brake on glacial ice flow from land to the sea is removed. As a result, the speed of glacial ice entering the ocean increases, causing an acceleration in sea level rise.

DRRIS project aims to further understand processes that impact ice shelves through the use of a novel diagnostic tool: the year-round deployment of a broad-scale seismometer array on the ice shelf to continuously record vibrations caused by the impact of ocean waves. Analysis of the response — the "pulse" of the ice shelf — will provide information on wave-induced stresses as well as a baseline "state of heath" measurement of ice shelf integrity.

Besides Bromirski, project principal investigators include Ralph Stephen of Woods Hole Oceanographic Institution, Peter Gerstoft of Scripps, and Olga Sergienko from NOAA's Geophysical Fluid Dynamics Laboratory.

MEDIA CONTACT

Robert Monroe, 858-534-3624, scrippsnews@ucsd.edu
Mario Aguilera, 858-822-5148, maguilera@ucsd.edu

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