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Ross Sea Floats Show Why Antarctica's Largest Ice Shelf Melts Rapidly in Summer

Warming of adjacent ocean surface waters main cause of melt in austral summer

A new study in Antarctic waters has found a significant decrease of salinity, or freshening of the seawater surrounding the Ross Ice Shelf, indicating that ice shelf melt is caused by warming surface waters following sea ice disappearance.

Scripps Institution of Oceanography at UC San Diego graduate student Maya Becker (bottom right in foreground) is among members of ROSETTA-ICE preparing to deploy an ALAMO (Air Launched Autonomous Micro-Observer float in the ocean near the Ross Ice Shelf. These floats provide real-time information about the ocean properties in the Ross Sea that affect the ice shelf.

A paper published July 18 by a team of researchers including several from Scripps Institution of Oceanography at the University of California San Diego in the *Journal of Geophysical Research – Oceans* uses results from 13 robotic ocean profilers that sampled the Ross Sea's temperature and salinity for up to three years, including in winter when the sea was frozen over with ice. The data provided new insights into how the Ross Ice Shelf will change in a warming world.

The loss of presently stable large ice shelves like the Ross could add several extra feet of global sea-level rise in coming centuries.

"Many current field programs are focused on parts of Antarctica that are known to be changing, but we must also collect observations in regions that are not changing, to understand how the ice sheet works as a whole," said Scripps Oceanography glaciologist Helen Amanda Fricker, a paper co-author. "This is critical because there remains a large range across predictions of Antarctica's contribution to sea level in future climates."

Ice shelves are the floating parts of the Antarctic Ice Sheet that form around the edges of the continent where it meets the ocean and hold back the flow of the enormous ice sheet. As ice shelves lose mass, their ability to hold back this ice is reduced and more ice enters the ocean, raising sea level.

Sea ice forms in the ocean surrounding Antarctica as the ocean freezes on the surface. Since it is floating, sea ice disappearance does not raise sea level. But sea ice plays a critical role in this icy landscape by reflecting the sunlight from its reflective surface. It also traps heat in the ocean underneath it like a blanket. As the sea ice disappears, it reveals a dark ocean surface which increases the amount of sunlight absorbed, and more heat gets to the ice shelf.

The Ross Ice Shelf is about the size of Spain, and is Antarctica's largest remaining ice shelf. It holds back an amount of ice that would raise sea level 15 meters (40 feet) if it all slid into the ocean. Currently stable, the Ross Ice Shelf has collapsed during past warm periods in history, suggesting that it could happen again. Ice-shelf mass loss depends on temperature in the nearby ocean, but the Ross Sea is vast and covered by sea ice for most of the year, making year-round measurements difficult to obtain.

The new study was part of the larger NSF-funded ROSETTA-Ice project to understand the geological, atmospheric and oceanographic controls on the stability of the ice sheet in the Ross Sea. The ROSETTA-Ice team took a novel approach to gathering ocean data near the ice shelf, deploying six Air Launched Autonomous Micro Observer, or ALAMO, profilers from a New York Air National Guard airplane. Each day, the ALAMOs each made a "dive," profiling from the seabed to the surface, for a total of 231 dives over the Antarctic Summer between December and March. The floats were programmed to avoid collisions with sea ice that could damage their sensors and antennas, and then to park on the seafloor between profiles so that they weren't swept away by ocean currents. Data were sent back to researchers by satellite.

The team found that the largest source of ocean heat causing ice-shelf melting was local summer warming of the upper ocean – down to about the length of a football field – by sunlight after the highly reflective sea ice had disappeared from the region. The team also measured large amounts of fresh water coming into the Ross Sea from rapidly melting ice shelves in the Amundsen Sea to the east. Once this extra fresh water reaches the ice front, it changes how heat mixes down from the surface to the base of the ice shelf where melting occurs, leading the team to conclude that future Ross Ice Shelf stability depends on changing coastal conditions in both the Amundsen Sea and close to the ice shelf front.

“In other places in Antarctica, the ice shelves are being melted by flows of global warm water from the deep ocean to the coast,” said Dave Porter, the Lamont-Doherty Earth Observatory scientist who led the new study. “But changing melt rates for the Ross are caused mainly by a local buildup of heat in the surface layer. The question is: What dictates how much heat we build up in the summer? And the answer is that it’s mostly caused by local weather processes along the ice front.”

The researchers noted that increased ocean heating and ice-shelf melting could occur if the summer season free of sea ice becomes longer, perhaps because of changing local winds pushing the sea ice away from the ice shelf, or if summer cloudiness decreases so that more sunlight reaches the ocean surface.

Scott Springer, of Earth & Space Research in Seattle and a co-author, said that “this approach to collecting data from remote Antarctica’s continental shelves provides a new way to check the reliability of numerical models that we use to understand how the Antarctic Ice Sheet will respond to future changes in the oceans around Antarctica.”

This is critical because there remains a large range across predictions of the volume of ice Antarctica will lose in future climates, researchers said. The loss of presently stable large ice shelves like the Ross could add several extra feet of global sea-level rise in coming centuries. The dependence of ice shelf melting on local conditions near the ice front means that researchers must develop new ways to represent the effects of processes that aren’t presently included in the relatively coarse global models used for climate simulations over century time scales, the authors said.

The ROSETTA-Ice project partners include Lamont-Doherty Earth Observatory of Columbia University, Scripps Institution of Oceanography at the University of California San Diego, Colorado College, Earth and Space Research and GNS Science, New Zealand. Fieldwork was supported by the United States Antarctic Program and the New York Air National Guard, the New Zealand Ministry of Business Innovation and Employment and the New Zealand Antarctic Research Institute. ROSETTA-Ice is funded by the National Science Foundation, The Gordon and Betty Moore Foundation, and the Old York Foundation.

– Adapted from Lamont-Doherty Earth Observatory

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