Robotic glider makes first turbulence measurements beneath an Antarctic ice shelf

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UC Davis doctoral students Cordielyn Goodrich, Andrew Friedrichs and Jasmin McInerney with EPFL's Sebastian Lavanchy and the glider Storm Petrel on the ice beside icebreaker R/V Araon at Jang Bogo Station in Antarcticain January 2019. Credit: Joe Haxel, OSU/NOAA

A small group of scientists and doctoral students from the University of California, Davis, recently returned from Antarctica, where they became the first group to collect turbulence measurements from an underwater glider beneath an ice shelf.

This multinational collaboration being led by the Korea Polar Research Institute, or KOPRI, was only the second time a glider has been successfully deployed underneath an ice shelf.

With this data, scientists will be able to better understand how quickly ice shelves are melting and to make predictions of how these rates will change under future climate scenarios.

The glider, named Storm Petrel, is a type of autonomous underwater vehicle equipped with wings. It was deployed under the Nansen ice shelf on Jan. 7 and resurfaced 20 hours later on Jan. 8. Its sensor package allowed scientists to quantify heat and energy flux using a system that, while relatively common in open water, had never been used this way under an ice shelf.

"It took us three years of development to get to those 20 hours, and we did it," said principal investigator Alexander Forrest, an assistant professor in the UC Davis College of Engineering, who was unable to join this voyage himself but participated with his team remotely from Davis. "I'm quite happy with the success of the vehicle but particularly with the amazing achievement of our UC Davis students leading the operations."

The frozen frontier

Sending an underwater glider beneath the ice shelves of Antarctica is not so unlike sending a scientific instrument into space. After careful planning and calculations, off it goes, into the dark, with black-out communications until it resurfaces. In these environments, it either comes back on its own or it doesn't come back at all.

While under the ice shelf, the glider did not send any signals back to the team for 20 hours. When it did resurface, the researchers aboard the ship were temporarily disconnected from the internet. This left Forrest—alone in Davis and watching for it on his computer screen—to be the only one to see when it came up and shout "Yes!"

Adding to the challenge of operating in this extreme environment, the glider had to be deployed very precisely into a plume of "supercool" water—a tricky task Forrest likens to Luke Skywalker's flight through the narrow trenches of the Death Star—so it could be piloted up, down, in and out without hitting the ocean's surface or bottom.

Fun fact: When water is cooled very slowly it can remain a liquid beyond its freezing point. For this to happen, it has to be so pure that it has no surface on which ice crystals can grow. This is called supercooled water. The scientists were chasing this plume because it indicates the location of meltwater.

"We're trying to understand the dynamics of this system and what this plume is doing," Forrest said. "That plume was much higher in the water column in 2019 compared to 2017, which indicates more meltwater may be happening, which is certainly a cause of concern and should be investigated further."

Ice shelves, glaciers and sea level rise

Sebastien Lavanchy from Ecole Polytechnique Fédérale de Lausanne and Cordielyn Goodrich of UC Davis look over the Cape Wheatstone Cliffs on the Hallett Peninsula from the icebreaker R/V Araon in January 2019. Credit: Jasmin McInerney/UC Davis

Ice shelves have always melted, but in an era of warming polar environments, it's now happening faster. Most melting happens where the ice meets the ocean and largely goes unnoticed—until an ice shelf collapses, an increasingly frequent occurrence over the past decade.

Unlike ice shelves, glaciers are land-based. All across polar landscapes, glaciers are advancing, directly contributing to sea level rise. Ice shelves are already part of the ocean, constantly moving from a solid to a liquid state. Ice shelves do not directly make sea level rise, but they serve to buttress the glacial ice on land. When ice shelves fall away, from the Arctic to the Antarctic, this stabilizing effect is lost, freeing glacial ice to accelerate its journey from the land to the ocean.

"Changes to the ice surface are sometimes easily identifiable, but it is often difficult to fully understand what changes are happening under the ice," said UC Davis doctoral candidate Jasmin McInerney. "This leads to a lot of speculation unless robotics teams like ours are able to physically reach these locations. With so many consequences of ice shelf disappearance, it's important to get rid of as many unknowns as possible to estimate when this may occur."

The Nansen ice shelf is relatively small compared to larger systems such as the Ronne-Filchner, Ross or Thwaites ice shelves. The international team, being led by KOPRI, plans to apply the same techniques developed in this project on the Thwaites ice shelf. Forrest and his team plan to join to continue developing robotic observation tools and techniques.

Provided by UC Davis