Ice shelf melt: the role of ocean variability

The Filchner-Ronne Ice Shelf is by volume the largest in Antarctica and the physical processes at its ice-ocean interface have a direct effect on the general ocean circulation and ventilation of the deep ocean. But what drives the melt variability and how can it be modelled more accurately?

The Weddell Sea neighbours the Filchner-Ronne Ice Shelf (FRIS) and is a region where large amounts of sea ice are formed. During the process of sea ice formation, high salinity shelf water is produced and it drives circulation under the FRIS, by ice volume the largest ice shelf in Antarctica.

In addition to its potential to significantly modulate sea level, the FRIS plays an important role in the formation of Antarctic bottom water, the densest, coldest and most ubiquitous water mass of the world’s oceans. As a result, the physical processes at the FRIS ice-ocean interface have a direct effect on the general ocean circulation and ventilation of the deep ocean.

So, what drives the variability in melt under the FRIS? This question is vital to the modelling of ice shelf cavities and an ability to predict their likely evolution. The EU’s
DOVuFRIS project analysed data collected over the past several years to detect patterns in melt rate changes and to infer which physical processes would lead to such patterns.

“The patterns we focus on are the duration of different features, how frequently these features occur and whether they repeat periodically or not,” adds Marie Skłodowska-Curie Actions fellow Irena Vaňková, who was the principal investigator.

“From this we can tell, for example, whether the changes are periodic and caused by waves, or aperiodic and caused by eddies. The strength of the events can help clarify what the ocean properties underneath the ice shelf may be.”

**Eddies and their role in ice shelf melt**

Ocean eddies are relatively small-scale features created by instabilities in the ocean and they contribute to mixing of ocean properties, such as temperature. They have their own dynamics and can carry heat far from their source before they dissipate.

A coarse ocean model may not have the grid resolution to represent eddies. It still has a way of mixing different ocean waters, but the result, such as the spatial extent over which mixing occurs, may be different from reality.

“Under an ice shelf it is important to know where exactly mixing occurs, and whether heat is carried, via eddies, all the way to the back of the cavity where the ice is thickest and most sensitive to melting. Having an eddy-resolving model under ice shelf cavities, such as the FRIS cavity, is vital,” says Vaňková, who conducted the project at United Kingdom Research and Innovation jointly with Keith Nicholls.

**Modelling a variable ice shelf base**

The project identified intermittent – aperiodic – freezing at several FRIS locations, which can be linked to water motion under the ice shelf resulting from an instability. This causes water from greater depth to move to shallower depths. As the water rises, its melting point increases, resulting in partial freezing.

Their findings are leading to a much better understanding of what drives this vital process: “Our observations have uncovered how variable the ice shelf base is and we have identified several processes behind this variability. That is definitely good progress. We’ll continue to work with ocean modellers on ways to best integrate these findings and decide which processes are crucial to represent.”

Vaňková’s ultimate aim is to improve the ability to simulate the global effect of the interactions between ice shelves and the ocean.
DOVuFRIS has published two scientific articles, and there are several more submitted or in preparation. The project has also presented its findings at conferences, meetings and seminars, such as the December 2020 American Geophysical Union conference.

“To predict the future of ice shelves, we first need to understand their present state and that is exactly what our project is about. Our new technique allows us to observe and monitor variability in ice shelf cavities at an unprecedented temporal resolution and this will eventually help us understand their sensitivity to change,” explains Vaňková.

Keywords

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