Polar Ice Sheets connected across oceans

Prof. Natalya Gomez led a study published in *Nature* simulating the Earth's ice sheets and oceans through the last Ice Age and showing that polar ice sheets located on different ends of the Earth can 'talk to each other' through sea level changes. Retreat of one ice sheet causes sea levels to rise at the edge of another ice sheet thousands of kilometers away and drives that ice sheet to retreat too.

Using a new type of numerical model that simultaneously captures the dynamics and flow of ice along with the physics of global sea level changes, we looked at how this effect played out over the last 40,000 years, leading into and out of the last ice age. During the peak of the last ice age 20,000 years ago, sheets of ice several kilometers thick covered much of North America and Northern Europe, and the Antarctic ice sheet on the South pole was larger. A volume of ice equivalent to 130 meters of global sea level rise was locked up in ice sheets at this time, and much of that was in the Northern Hemisphere. (We encourage you to step outside or go to a window, look up, and imagine what 3 kilometers of ice on top of you would look like before reading on.)

Following this period of peak ice cover, ice retreated in the Northern Hemisphere, raising sea levels in Antarctica, which drove the Antarctic ice sheet to retreat sooner, faster and further than when we neglect this sea level teleconnection effect. Including the effect allowed us to explain a range of geological indicators of past changes. For example, they looked at the elevation of past shorelines, the timing of when land beneath the ice was exposed to the sun as the ice sheet retreated, marks left behind by the edge of the ice sheet as it retreated, and one of the key records we focused on – "iceberg-rafted debris". Iceberg rafted debris consists of rocks found in cores taken out of sediment on the ocean floor around Antarctica. These rocks were once locked up in ice on the continent, caught a ride out into the ocean in icebergs (like the one depicted in the picture) , and sunk to form layers on the ocean floor when the icebergs melted. The rocks show us that as the Antarctic ice sheet was retreating after the ice age, there were intermittent bursts of accelerated ice loss when a lot of icebergs were ejected. Their Antarctic ice sheet model simulations were able to capture this behavior when we let the ice sheets in the model 'talk' to each other.

The Earth system is so interconnected with change in one part driving change in another. Drawing on many different types of data and developing a model that connects different parts of the Earth system were key to understanding how and why the Antarctic ice sheet evolved in the past. And this holistic view can in turn shed light on how it may respond in our future warming climate.

Top right: Ice cover during the last ice age; Gomez, N (2020). Bottom right: Iceberg and research vessel Marion Dufresne II in the Scotia Sea during the coring campaign to retrieve sites MD07-3133 and MD07-3134 (taken in 2007).

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Why this is important

This work helps us to better understand the physics and drivers of the polar ice sheets and global sea levels, and to solve the mystery of what caused past changes that we see in geological records. This insight can in turn be used to better understand the future of ice and water on Earth and shed light on the climate of other planets in and outside of our solar system.

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