West Antarctic ice comes and goes, rapidly

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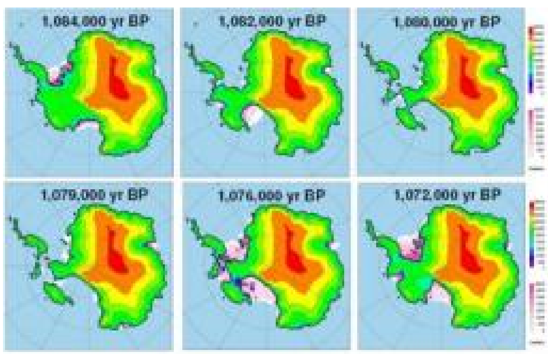

Modeled Antarctic ice sheet at particular times through the warm Marine Isotope Stage 31 event, around 1.07 million years ago. Ice-sheet elevations and floating ice-shelf thicknesses shown by two different color scales, "yr BP" is "years before present." Credit: David Pollard, Penn State

Researchers today worry about the collapse of West Antarctic ice shelves and loss of the West Antarctic ice sheet, but little is known about the past movements of this ice. Now climatologists from Penn State and the University of Massachusetts have modeled the past 5 million years of the West Antarctic ice sheet and found the ice expanse changes rapidly and is most influenced by ocean temperatures near the continent.

"We found that the West Antarctic ice sheet varied a lot, collapsed and regrew multiple times over that period," said David Pollard, senior scientist, Penn State's College of Earth and Mineral Sciences' Earth and Environmental Systems Institute. "The ice sheets in our model changed in ways that agree well with the data collected by the ANDRILL project."

Pollard and Robert M. DeConto, professor of climatology, U. Mass, report their findings in today's (Mar. 19) issue of *Nature*. The results of the first ANDRILL drill core near McMurdo Station, Antarctica, are reported in a companion paper in the same issue. The ANtarctic geological DRILLing project is a multinational collaboration to drill back in time into sediment to recover a history of paleoenvironmental changes.

"We found, as expected, that the East Antarctic ice sheet is stable and did not change," said Pollard.

The East Antarctic ice sheet does not slide into the sea and melt away because most of the bedrock below East Antarctic ice is above sea level. However, on the other side of the continent, to the Pacific side of the Transantarctic Mountain Range, much of the bedrock below the ice lies from several hundred to several thousand feet below sea level, leaving the West Antarctic ice vulnerable to melting.

"We found that the ocean's warming and melting the bottom of the floating ice shelves has been the dominant control on West Antarctic ice variations," said Pollard.

When the floating ice shelves melt sufficiently, they no longer buttress the grounded ice upstream, which then flows faster and rapidly drains the massive interior ice. The grounding line, the junction between the floating ice shelf and upstream ice resting on bedrock, retreats converting more grounded ice to floating ice shelves. Eventually, nearly all of the ice sheet on the Pacific side of Antarctica can disappear as it has in the past.

The researchers' computer model needs past variations of snowfall, snow melt and ocean melting below the floating ice to be specified. These are not obtained from the General Circulation Models often used in climate reconstruction because running those models to create 5 million years of climate history would take years. Instead, the researchers related past variations of these quantities to records of deep sea oxygen isotope ratios that indicate temperature changes in the oceans.

"We assume this is all driven by global-scale climate variations including Northern Hemispheric glacial cycles, so we used the changes in the oxygen 18 record to deduce the Antarctic changes," says Pollard. "Our next step will be to test whether this record really represents sea temperatures around Antarctica."

The researchers compared their model's output with the sediment core record from ANDRILL. In these cores, coarse pebbly glacial till represent the glacial periods, while intervals filled with the shells of tiny ocean-living diatoms represent the nonglacial periods. One way the ANDRILL researchers date the layers is using existing datable volcanic layers within the core.

Pollard and DeConto not only looked at the modeling of the overall West Antarctic ice sheet, they also looked at the nearest grid point in their model to the ANDRILL drilling location. They found that, for the most part, the data trend at that grid point matched the data obtained from the sediment core.

"Our modeling extends the reach of the drilling data to justify that the data represent the entire West Antarctic area and not just the spot where they drilled," said Pollard.

Along with the rapid appearance and disappearance of the ice, the researchers noted that both in the ANDRILL record and the model results, during the early portion of the 5 million years, the periodicity of the glaciation and melting was about 40,000 years which matches the Northern Hemisphere's pattern of glaciation and glacier retreat. The basic driver is very likely the tilt of the Earth's axis which varies with the same period, according to Pollard. However, nearer to the present, the cycle time increased to about 100,000 years as expected, driven by Northern Hemispheric ice age cycles.

During past warm periods, the major collapses in the model take a few thousand years. This is also the expected time scale of future collapse of the West Antarctic ice sheet if ocean temperatures warm sufficiently - longer than a few centuries but shorter than ten thousand years.

The researchers note that when atmospheric carbon dioxide levels in the past were about 400 parts per million, in the early part of the ANDRILL record, West Antarctic ice sheet collapses were much more frequent..

"We are a little below 400 parts per million now and heading higher," says Pollard. "One of the next steps is to determine if human activity will make it warm enough to start the collapse."

Source: Pennsylvania State University (news : web)