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Antarctic ice-sheet retreat and sea-level rise during the last deglaciation

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Reconstruction of the last global sea level rise faces uncertainties because only a few robust results are available for Antarctic ice sheets. Modeling studies reconstruct a late ice-sheet retreat starting around 12 ka BP and ending around 7 ka BP with a large impact of an unstable West Antarctic Ice Sheet (WAIS) and a small impact of a stable East Antarctic Ice Sheet (EAIS). However, two regions in the Atlantic sector of the Southern Ocean provide evidence that Antarctica responded much earlier and provided a significant contribution to the last sea-level rise.
On the continental slope of the southeastern Weddell Sea, seven POLARSTERN cores preserved varved sediment during the Last Glacial Maximum (LGM) on contourite ridges, indicative for intense, seasonally variable bottom-water production, presumably caused by brine injection in polynias and shelf-ice plowing in front of the ice shelf, which had advanced toward the shelf edge. The following postglacial bioturbated mud favors at least partially open surface water and occasionally intensified iceberg calving. The termination of varvation marked the retreat of the EAIS from the shelf edge around 19 ka BP. The timing coincides with Meltwater Pulse 19 ka from the Northern Hemisphere (NH) and with the initiation of the temperature increase in the Southern Ocean and over East Antarctica. After a short ice re-advance, a second retreat occurred around 16 ka – also a time of enhanced global sea-level rise and a period when glaciers rapidly retreated in Patagonia.
Sediments from the central Scotia Sea are located in the prolongation of the “iceberg alley”, where icebergs exit the Weddell Sea to the north. Accordingly, this is an excellent location to trace ice-sheet dynamics. Sites MD07-3134 and MD07-3133 document four phases of enhanced iceberg activity as indicated by the amount of small ice-rafted debris (IRD) at 19.5, 16.5,14.5, and 12 ka. The first two are most likely related to the two ice-sheet retreat signals documented by the Weddell Sea sites. The third phase relates to Meltwater Pulse 1A; the fourth phase falls roughly into period of the Younger Dryas.
Since all four phases manifested at times when atmospheric temperature rise over East Antarctica accelerated, we interpret all phases as ice-sheet retreat signals. Since models can only produce a part of the required global meltwater from NH ice sheets, and most phases relate to prominent global meltwater pulses, there is also indication that Antarctica contributed meltwater to the global sea-level rise during the four phases, with the EAIS as a major contributor during the first three phases, and the WAIS contributing mainly to the last phase when the Antarctic Cold Reversal had ended. In any case, our study shows that the oceanic record in the Weddell and Scotia Seas, the atmospheric temperature development over East Antarctica, and global sea-level rise are closely related, with possibly severe impacts on future climate and ice-sheet modeling studies.