Stability inspection for West Antarctica shows marine ice sheet not destabilized yet, but may be on path to tipping

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Antarctica's vast ice masses seem far away, yet they store enough water to raise global sea levels by several meters. A team of experts from European research institutes has now provided the first systematic stability inspection of the ice sheet's current state. Their diagnosis: While they found no indication of irreversible, self-reinforcing retreat of the ice sheet in West Antarctica yet, global warming to date could already be enough to trigger the slow but certain loss of ice over the next hundreds to thousands of years.

"With more and more ice being lost in Antarctica over the last years, concerns have been raised whether a tipping point has already been crossed and an irreversible, long-term collapse of the West Antarctic Ice Sheet has already been initiated," explains Ronja Reese from the Potsdam Institute for Climate Impact Research (PIK) and the Northumbria University, Newcastle.

"The results of our studies deliver two messages: First, while a number of glaciers in Antarctica are retreating at the moment, we find no indication of irreversible, self-reinforcing retreat yet, which is reassuring. However, our calculations also clearly indicate that an onset of an irreversible retreat of the ice sheet in West Antarctica is possible if the current state of the climate is sustained," Reese continues.

The main driver of ice loss in West Antarctica is relatively warm ocean water that amplifies melting underneath the ice shelves, which are the floating extensions of the grounded ice sheet. Melting of these ice shelves can enhance ice loss as it speeds up the grounded sections of the ice sheet.

That is why the Antarctic margin with its grounding lines—the zone where the grounded and the floating ice are connected—is a key indicator of ice sheet health. An accelerated retreat of the grounding lines could indicate a forthcoming collapse of large marine regions of

West Antarctica's ice sheet—those parts of the ice sheet that are grounded below sea level.

Evolving over 10,000 years, triggered today: Irreversible ice-loss and sea-level rise

Using state-of-the-art ice sheet models, the researchers not only conducted a thorough inspection of signs of irreversible retreat of marine sectors of the Antarctic ice sheet at present, they also ran simulations to investigate how the ice sheet would evolve over the next 10,000 years if current conditions remained unchanged. These hypothetical experiments indicate that even with no additional warming beyond what we have already experienced today, an irreversible collapse of some marine regions of West Antarctica's ice sheet is possible.

Because the ice reacts to changes in temperature very slowly, the authors find that collapse occurs in their simulations at the earliest in 300 to 500 years from now, under current climate forcing. A full collapse would take centuries to millennia.

"The thing with sea-level rise from Antarctica is not that changes would happen overnight as an immediate threat to coastal communities. The process of melting would happen over hundreds or thousands of years. However, the cause could be human actions today, as they have the power to trigger and commit a future of 10,000 years to several meters of global sea-level rise. And stronger warming in the future would even speed up this process," Julius Garbe from PIK stresses.

Changes in ice discharge from Antarctica remain one of the greatest uncertainties in future projections of global sea-level rise.

"The Antarctic ice is our ultimate heritage of the past, millions of years old and often coined 'eternal' ice. But our work shows: While current ice

loss may still be reversible, a destabilization of marine sectors of the ice sheet could initiate a long-term ice loss that is slow but certain. Climate change today could already be enough to tip the scales, that is concerning. Yet, with West Antarctica not destabilized yet, there is still a chance to mitigate at least some of the risk by ambitious climate action," Ricarda Winkelmann from PIK concludes.

More information: Emily A. Hill et al, The stability of present-day Antarctic grounding lines—Part 1: No indication of marine ice sheet instability in the current geometry, *The Cryosphere* (2023). DOI: 10.5194/tc-17-3739-2023

Ronja Reese et al, The stability of present-day Antarctic grounding lines—Part 2: Onset of irreversible retreat of Amundsen Sea glaciers under current climate on centennial timescales cannot be excluded, *The Cryosphere* (2023). DOI: 10.5194/tc-17-3761-2023

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