Part of the Greenland ice sheet may be close to a tipping point

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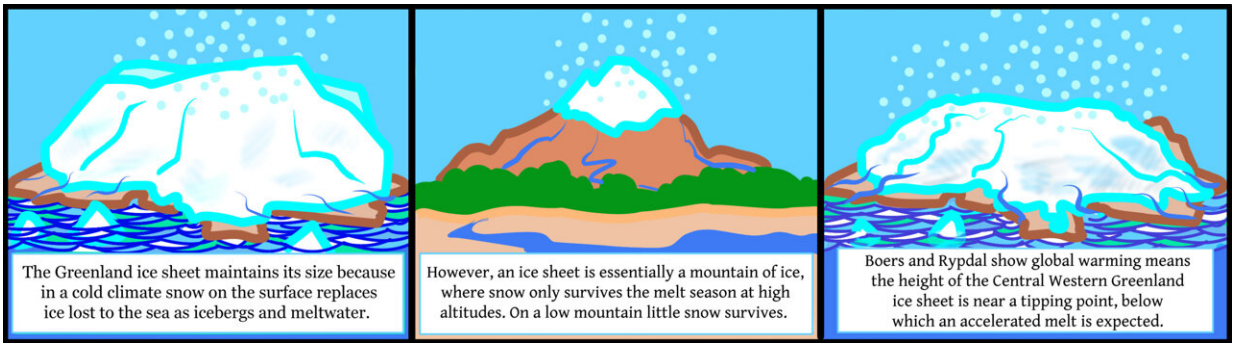

Accelerated melt. Credit: TiPES/HP

Data from the Jakobshavn drainage basin of the Central-Western Greenland ice sheet reveals that the distinct mark of this part of the ice sheet has reached a tipping point. That is the conclusion by Niklas Boers from Potsdam Institute for Climate Impact Research, Germany and Martin Rypdal from the Arctic University of Norway, after careful studies of the development in melt rates and ice-sheet height changes during the last 140 years. The two authors propose close monitoring of the Greenland ice sheet to assess the situation. The work, published in *PNAS* today, is part of the TiPES project, coordinated and led by the University of Copenhagen, Denmark, and the Potsdam Institute for Climate Impact Research, Germany.

In the article, Rypdal and Boers have analyzed reconstructions of the height changes of the Central-Western Greenland ice sheet since 1880, and have compared them to corresponding model simulations. From the analysis, they conclude that this part of the Greenland ice sheet is losing stability, consistent with the idea that it is very close to tipping into a state of accelerated melting, regardless of whether the Arctic warming trend is halted in the coming decades.

"We might be seeing the beginning of a large-scale destabilization, but at the moment, we cannot tell, unfortunately. So far, the signals we see are only regional, but that might simply be due to the scarcity of accurate and long-term data for other parts of the ice sheet," says Dr. Niklas Boers.

An ice sheet can only maintain its size if the loss of mass from melting and calving glaciers is replaced by snow falling onto its surface. The warming of the Arctic disturbs this mass balance because the snow at the surface often melts away in the warmer summers.

Melting will mostly increase at the lower altitudes, but overall, the ice sheet will shrink from a mass imbalance. Therefore, a positive feedback mechanism kicks in: as the ice sheet surface lowers, its surface is exposed to higher average temperatures, leading to more melting, further height reductions, and correspondingly accelerated mass loss. Beyond a critical threshold, this process cannot be reversed, because with reduced height, a much colder climate would be needed for the ice sheet to regain its original size.

The instability that Boers and Rypdal have found in melt and reconstructed ice-sheet height data from the Central-Western Greenland ice sheet indicates that the critical threshold has at least regionally been reached due to the last 100 years of accelerated melting.

The increase in surface melt will possibly be compensated at least partly by increases in snowfall as precipitation patterns over the ice sheet will change due to the changing ice-sheet height.

However, if the Greenland ice sheet as a whole transits into accelerated melting there will be severe consequences for the entire planet. The Greenland ice sheet contains the mass equivalent to raising global sea level by 7 meters. A loss of the Greenland ice sheet is also expected to add to global warming due to decreasing albedo as well as disrupt major ocean currents, monsoon belts, rainforests, wind systems and precipitation patterns.

"We need to monitor also the other parts of the Greenland ice sheet more closely, and we urgently need to better understand how different positive and negative feedbacks might balance each other, to get a better idea of the future evolution of the ice sheet," says Niklas Boers, who together with Martin Rypdal expects to see accelerated melting in the near future.

More information: Niklas Boers el al., "Critical slowing down suggests that the western Greenland Ice Sheet is close to a tipping point," *PNAS* (2021). www.pnas.org/cgi/doi/10.1073/pnas.2024192118

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