

Antarctic ice sheet retreat could trigger chain reaction

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Today, Antarctic winds usually blow from the continent out to the sea. Credit: Svein Østerhus

The Antarctic ice sheet was even more unstable in the past than previously thought, and at times possibly came close to collapse, new

research suggests.

The findings raise concerns that, in a [warmer climate](#), exposing the land underneath the [ice sheet](#) as it retreats will increase rainfall on Antarctica, and this could trigger processes that accelerate further ice loss.

The research is based on climate modeling and data comparisons for the Middle Miocene (13-17 million years ago) when atmospheric carbon dioxide and [global temperatures](#) reached levels similar to those expected by the end of this century.

The study was carried out by the Met Office, the universities of Exeter, Bristol, Cardiff and Stockholm, NORCE and the Bjerknes Centre for Climate Research.

"When an ice sheet melts, the newly exposed ground beneath is less reflective, and local temperatures become warmer," said lead author Dr. Catherine Bradshaw, of the Met Office and the Global Systems Institute at the University of Exeter.

"This can dramatically change weather patterns.

"With a big ice sheet on the continent like we have today, Antarctic winds usually blow from the continent out to the sea.

"However, if the continent warms this could be reversed, with the winds blowing from the cooler sea to the warmer land—just as we see with monsoons around the world.

"That would bring extra rainfall to the Antarctic continent, causing more freshwater to run into the sea.

"Freshwater is less dense than saltwater and so it can sit on the sea

surface, rather than sinking and circulating as saltwater does.

"This effectively breaks the connection between the deep ocean and the surface ocean, causing warmer water to accumulate at depth."

The study suggests that the processes triggered by increasing rainfall would reduce the ability of the climate system to maintain a large Antarctic ice sheet.

"Essentially, if more land is exposed in Antarctica, it becomes harder for a large ice sheet to reform, and without favorable orbital positions in the Middle Miocene playing a role, perhaps the ice sheet would have collapsed at that time," Dr. Bradshaw said.

During the warm Middle Miocene period, unusually large swings back and forth in deep-sea temperatures were recorded.

The study shows that fluctuations in the area covered by the ice sheet were a major factor in causing deep-sea temperatures to change so dramatically. Fluctuations in the volume of ice were found to be of much less importance.

Variations in the positioning of the Earth relative to the Sun caused the ice sheet to advance and retreat, and this altered weather patterns—triggering processes that can accelerate ice loss or gain.

Rain falling on the ice sheet can cause fracturing, surface melt and extra freshwater running off the continent, which, in turn, can cause deep-sea temperatures to rise—potentially influencing Antarctic ice from beneath.

The findings of the new study suggest that the Antarctic ice sheet retreated significantly during the Middle Miocene, then stabilized when the warm period ended.

Co-author Associate Professor Agatha De Boer, from the University of Stockholm, said: "When the Middle Miocene climate cooled, the link we have found between the area of the ice sheet and the deep-sea temperatures via the hydrological cycle came to an end.

"Once Antarctica was fully covered by the ice sheet, the winds would always go from the land to the sea and as a result rainfall would have reduced to the low levels falling as snow over the continent we see today."

Dr. Petra Langebroek, a Senior Researcher from NORCE and the Bjerknes Centre for Climate Research, another co-author, added: "These findings imply a shift in ocean sensitivity to ice sheet changes occurs when ice sheet retreat exposes previously ice-covered land."

Professor Carrie Lear, from Cardiff University, who first devised the project, concluded: "This study suggests that during a warm period about 15 million years ago, the Miocene Antarctic ice sheet was capable of major advance and retreat across the continent.

"This is concerning, but further research is needed to determine exactly what this means for the long-term future of the modern Antarctic ice sheet."

Dr. Bradshaw stressed that conditions now are not identical to those in the Middle Miocene, and the model used in the study does not include the impact of feedbacks from the carbon cycle or the ice sheet itself.

The paper, published in the journal *Nature Geoscience*, is entitled: "Hydrological impact of Middle Miocene Antarctic ice-free areas coupled to [deep ocean](#) temperatures."

More information: Hydrological impact of Middle Miocene Antarctic

ice-free areas coupled to deep ocean temperatures, *Nature Geoscience* (2021). [DOI: 10.1038/s41561-021-00745-w](https://doi.org/10.1038/s41561-021-00745-w)

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