Ice melt projections may underestimate Antarctic contribution to sea level rise

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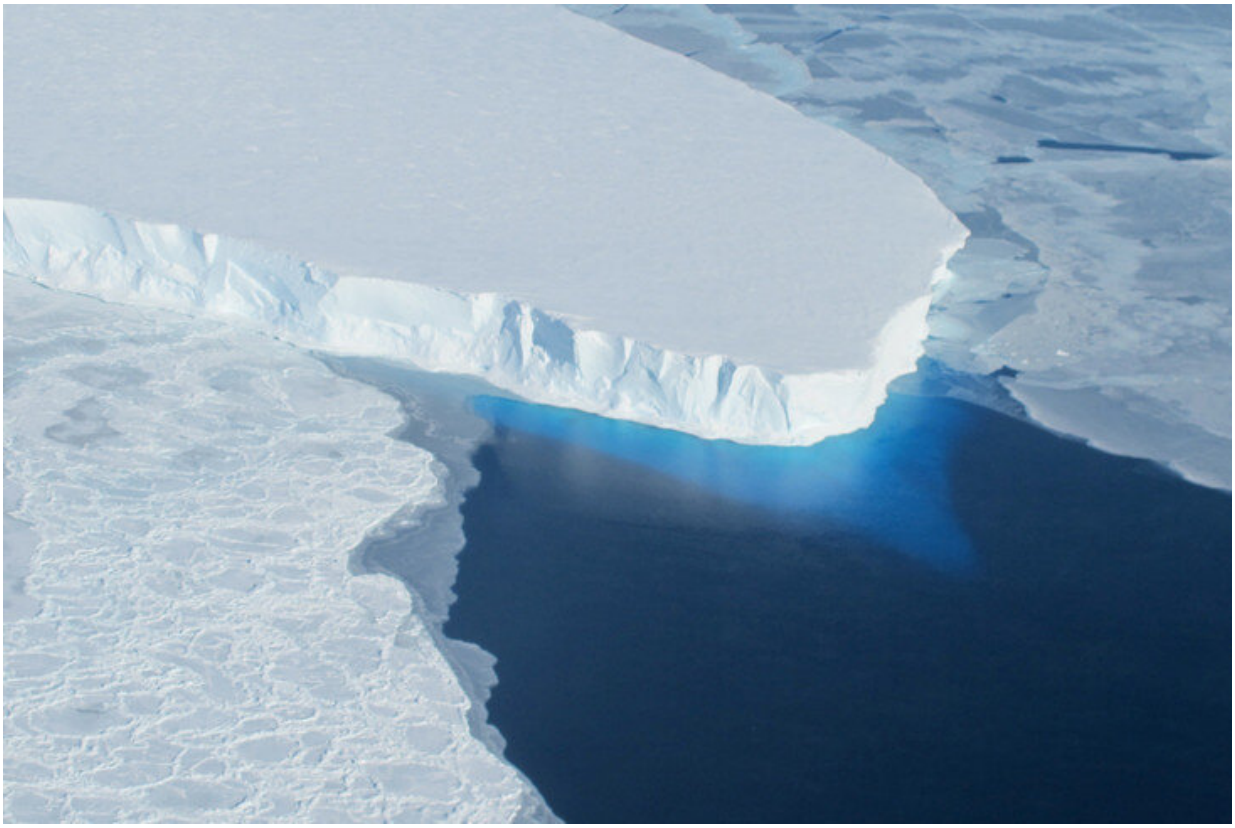

Thwaites Glacier, Antarctica, pictured in 2019. Credit: NASA

Fluctuations in the weather can have a significant impact on melting Antarctic ice, and models that do not include this factor can underestimate the global impact of sea level rise, according to Penn State

scientists.

"We know ice sheets are melting as global temperatures increase, but uncertainties remain about how much and how fast that will happen," said Chris Forest, professor of climate dynamics at Penn State. "Our findings shed new light on one area of uncertainty, suggesting climate variability has a significant impact on melting ice sheets and sea level rise."

While it is understood that continued warming may cause rapid ice loss, models that predict how Antarctica will respond to climate change have not included the potential impacts of internal climate variability, like yearly and decadal fluctuations in the climate, the team of scientists said.

Accounting for climate variability caused models to predict an additional 2.7 to 4.3 inches—7 to 11 centimeters—of sea level rise by 2100, the scientists recently reported in the journal *Climate Dynamics*. The models projected roughly 10.6 to 14.9 inches—27 to 38 centimeters—of sea level rise during that same period without climate variability.

"That increase alone is comparable to the amount of sea level rise we have seen over the last few decades," said Forest, who has appointments in the departments of meteorology and atmospheric science and geosciences. "Every bit adds on to the storm surge, which we expect to see during hurricanes and other severe weather events, and the results can be devastating."

The Antarctic ice sheet is a complex system, and modeling how it will evolve under future climate conditions requires thousands of simulations and large amounts of computing power. Because of this, modelers test how the ice will respond using a mean temperature found by averaging the results of climate models.

However, that process smooths out peaks caused by climate variability and reduces the average number of days above temperature thresholds that can impact the ice sheet melt, creating a bias in the results, the scientists said.

"If we include variability in the simulations, we are going to have more warm days and more sunshine, and therefore when the daily temperature gets above a certain threshold it will melt the ice," Forest said. "If we're just running with average conditions, we're not seeing these extremes happening on yearly or decadal timescales."

To study the effects of internal climate variability, the researchers analyzed two large ensembles of climate simulations. Large ensembles are generated by starting each member with slightly different initial conditions. The chaotic nature of the climate system causes each member to yield slightly different responses, and this represents internally generated variability, the scientists said.

Instead of averaging the results of each ensemble, the scientists fed the atmospheric and oceanic data representing this variability into a three-dimensional Antarctic ice sheet model. They found atmospheric variations had a larger and more immediate impact on the ice sheet, but ocean variability was also a significant factor.

Extensive parts of the ice sheet are in contact with ocean water, and previous studies have suggested that warming oceans could cause large chunks to break away. The process may expose ice cliffs so tall that they collapse under their own weight, inducing a domino effect that further depletes the ice shelf.

The scientists found model simulations that did not include the effects of internal climate variability significantly delayed the retreat of the ice sheet by up to 20 years and underestimated future sea level rise.

"This additional ice melt will impact the hurricane storm surges across the globe. Additionally, for years, the IPCC reports have been looking at sea level rise without considering this additional variability and have been underestimating what the impact may be," Forest said. "It's important to better understand these processes contributing to the additional ice loss because the ice sheets are melting much faster than we expected."

More information: *Climate Dynamics* (2020). dx.doi.org/10.1007/s0038-2-020-0535-8

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