Grounding zone discovery explains accelerated melting under Greenland’s glaciers

UC Irvine researchers suggest we may be underestimating severity of sea level rise.

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Petermann Glacier drains about 4 percent of the Greenland Ice Sheet as it moves inexorably toward the Arctic Ocean. A new observation and modeling study shows that the glacier is more vulnerable than previously thought to the intrusion of warm ocean water on its underside, leading to accelerated melting and boosting the potential severity of future sea level rise.

Picture Credit:

Eric Rignot / UCI

Irvine, Calif., March 13, 2024 – Researchers at the University of California, Irvine and NASA's Jet Propulsion Laboratory have conducted the first large-scale observation and modeling study of northwest Greenland's Petermann Glacier. Their findings reveal the intrusion of warm ocean water beneath the ice as the culprit in the accelerated melting it has experienced since the turn of the century, and their computer predictions indicate that potential sea level rise will be much worse than previously estimated.

For a paper published recently in *Geophysical Research Letters*, the UCI-led team used radar interferometry data from several European satellite missions to map the tidal motion of Petermann Glacier and the Massachusetts Institute of Technology's general calculation model to estimate the impact of climate change in a complex environment involving ice, seawater and land, all of which are under the influence of tides and climate change-driven temperature boosts.

"Satellite data revealed that the glacier shifts by several kilometers – or thousands of feet – as tides change," said lead author Ratnakar Gadi, UCI Ph.D. candidate in Earth system science. "By factoring this migration into the MIT numerical ocean model, we were able to estimate roughly 140 meters [460 feet] of thinning of the ice between 2000 and 2020. On average, the melt rate has increased from about 3 meters per year in the 1990s to 10 meters per year in the 2020s."

Senior co-author Eric Rignot, UCI professor of Earth system science, said that this and other studies conducted by his team in recent years have caused a fundamental shift in polar ice researchers' thinking about ocean and glacier interactions.

"For a long time, we thought of the transition boundary between ice and ocean to be sharp, but it's not, and in fact it diffuses over a very wide zone, the 'grounding zone,' which is several kilometers wide," said Rignot, who is also a senior research scientist at NASA JPL. "Seawater rises and falls with changes in oceanic tides in that zone and melts grounded ice from below vigorously."

Gadi said the model predicted that melt rates will be highest near the mouth of the grounding zone cavity and greater than anywhere else in the ice shelf cavity. Warmer water and greater seawater intrusion beneath the ice explains the observed thinning along Petermann's central flowline.

According to the study, the elongated shape of the grounding zone cavity is a major contributor to accelerated ice melting. In a run of the numerical model taking into account just warmer ocean temperature, the team found thinning of about 40 meters. In a second modeling exercise, an increase in the grounding zone cavity from 2 to 6 kilometers was included, and in that case, ice thinning grew to 140 meters.

"These modeling results conclude that changes in grounding zone lengths increase melt more significantly than warmer ocean temperatures alone," Gadi said.

The researchers noted that grounding zone ice melt reduces the resistance glaciers experience when flowing toward the sea, speeding their retreat. The researchers said this is a key factor used in projecting the severity of future sea level rise.

"The results published in this paper have major implications for ice sheet modeling and projections of sea level rise," Rignot said. "Earlier numerical studies indicated that including melt in the grounding zone would double the projections of glacier mass loss. The modeling work in this study confirms these fears. Glaciers melt much faster in the ocean than assumed previously."

Joining Rignot and Gadi on this project was Dimitris Menemenlis, NASA JPL research scientist. The work was conducted under a grant by NASA's Cryospheric Sciences Program.

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