Extreme melting on Greenland ice sheet, team reports

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The Greenland ice sheet can experience extreme melting even when temperatures don't hit record highs, according to a new analysis by Dr. Marco Tedesco, assistant professor in the Department of Earth and Atmospheric Sciences at The City College of New York. His findings suggest that glaciers could undergo a self-amplifying cycle of melting and warming that would be difficult to halt.

"We are finding that even if you don't have record-breaking highs, as long as warm temperatures persist you can get record-breaking melting because of positive feedback mechanisms," said Professor Tedesco, who directs CCNY's Cryospheric Processes Laboratory and also serves on CUNY Graduate Center doctoral faculty.

Professor Tedesco and his team collected data for the analysis this past summer during a four-week expedition to the Jakobshavn Isbræ glacier in western Greenland. Their arrival preceded the onset of the melt season.

Combining data gathered on the ground with microwave satellite recordings and the output from a model of the ice sheet, he and graduate student Patrick Alexander found a near-record loss of snow and ice this year. The extensive melting continued even without last year's record highs.

The team recorded data on air temperatures, wind speed, exposed ice and its movement, the emergence of streams and lakes of melt water on the surface, and the water's eventual draining away beneath the glacier. This lost melt water can accelerate the ice sheet's slide toward the sea where it calves new icebergs. Eventually, melt water reaches the ocean, contributing to the rising sea levels associated with long-term climate change.

The model showed that melting between June and August was well above the average for 1979 to 2010. In fact, melting in 2011 was the third most extensive since 1979, lagging behind only 2010 and 2007. The "mass balance", or amount of snow gained minus the snow and ice that melted away, ended up tying last year's record values.

Temperatures and an albedo feedback mechanism accounted for the record losses, Professor Tedesco explained. "Albedo" describes the amount of solar energy absorbed by the surface (e.g. snow, slush, or patches of exposed ice). A white blanket of snow reflects much of the sun's energy and thus has a high albedo. Bare ice – being darker and absorbing more light and energy – has a lower albedo.

But absorbing more energy from the sun also means that darker patches warm up faster, just like the blacktop of a road in the summer. The more they warm, the faster they melt.

And a year that follows one with record high temperatures can have more dark ice just below the surface, ready to warm and melt as soon as temperatures begin to rise. This also explains why more ice sheet melting can occur even though temperatures did not break records.

Professor Tedesco likens the melting process to a speeding steam locomotive. Higher temperatures act like coal shoveled into the boiler, increasing the pace of melting. In this scenario, "lower albedo is a downhill slope," he says. The darker surfaces collect more heat. In this situation, even without more coal shoveled into the boiler, as a train heads downhill, it gains speed. In other words, melting accelerates.

Only new falling snow puts the brakes on the process, covering the darker ice in a reflective blanket, Professor Tedesco says. The model showed that this year's snowfall couldn't compensate for melting in previous years. "The process never slowed down as much as it had in the past," he explained. "The brakes engaged only every now and again."

The team's observations indicate that the process was not limited to the glacier they visited; it is a large-scale effect. "It's a sign that not only do albedo and other variables play a role in acceleration of melting, but that this acceleration is happening in many places all over Greenland," he cautioned. "We are currently trying to understand if this is a trend or will become one. This will help us to improve models projecting future melting scenarios and predict how they might evolve."

Additional expedition team members included Christine Foreman of Montana State University, and Ian Willis and Alison Banwell of the Scott Polar Research Institute, Cambridge, UK.

Professor Tedesco and his team provide their preliminary results on the Cryospheric Processes Laboratory webpage. They will will be presenting further results at the American Geophysical Union Society (AGU) meeting in San Francisco on December 5 at 9 a.m. and December 6 at 11:35 a.m.

More information: 2011 Melting in Greenland report greenland2011.cryocity.org

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