

Survey of Greenland Glacier area changes

The 45 largest marine terminating glaciers in Greenland are annually surveyed by PROMICE to measure their frontal positions. The results indicate not only a widespread ice area loss, they also reinforce that these glaciers are sensitive indicators of climate change. We find statistical evidence that surface melting is important for glacier area change.

Marine-terminating glaciers

Marine-terminating glaciers are the outlets via which the inland ice sheet discharges to the ocean. When a glacier front is stationary, the iceberg calving (by area) is balanced by the seaward motion of the ice.

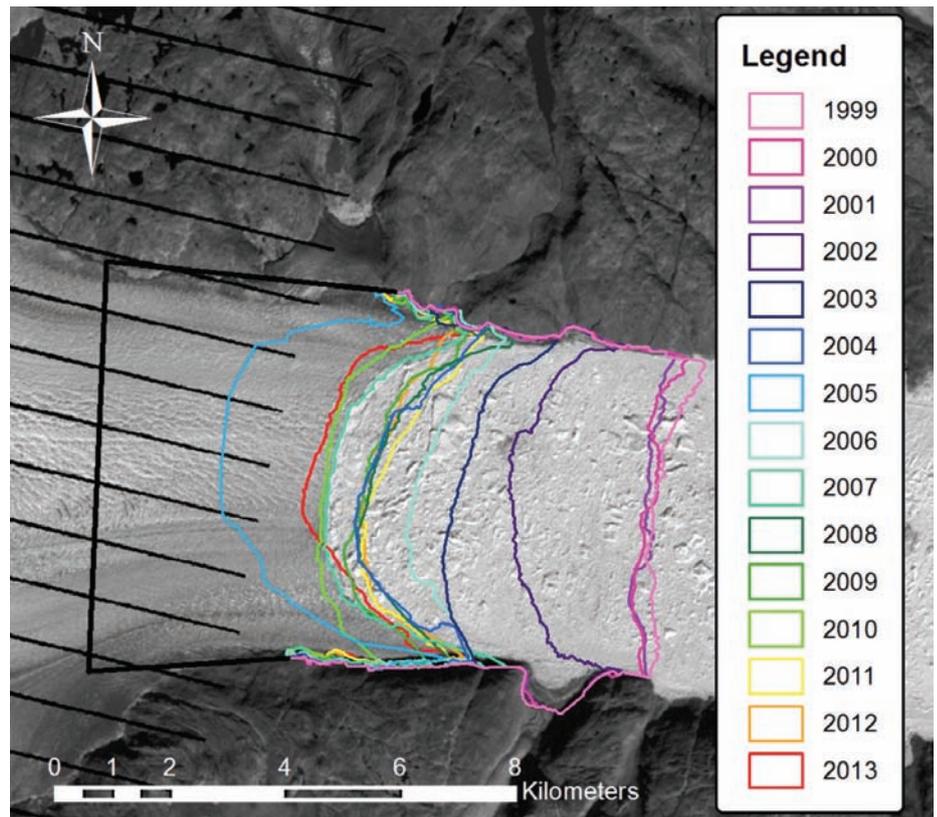
Survey work

PROMICE includes an annual survey of the front position of now 45 of the widest (and fastest) marine-terminating glaciers in Greenland.

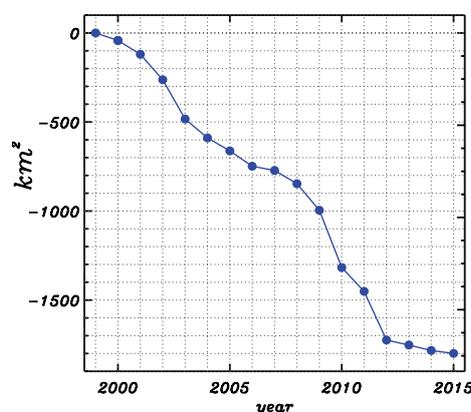
The survey involves manually digitizing the glacier fronts in satellite imagery. We must be diligent searching for cloud free images. The survey began with the launch of Landsat 7 in 1999 and is still running. We update the survey in September each year.

Net ice loss

The surveyed glaciers have collectively lost an area of 1799 km², twenty times the area of Manhattan Island, New York or Copenhagen (88.25 km²) or three times the area of Bornholm (588 km²).



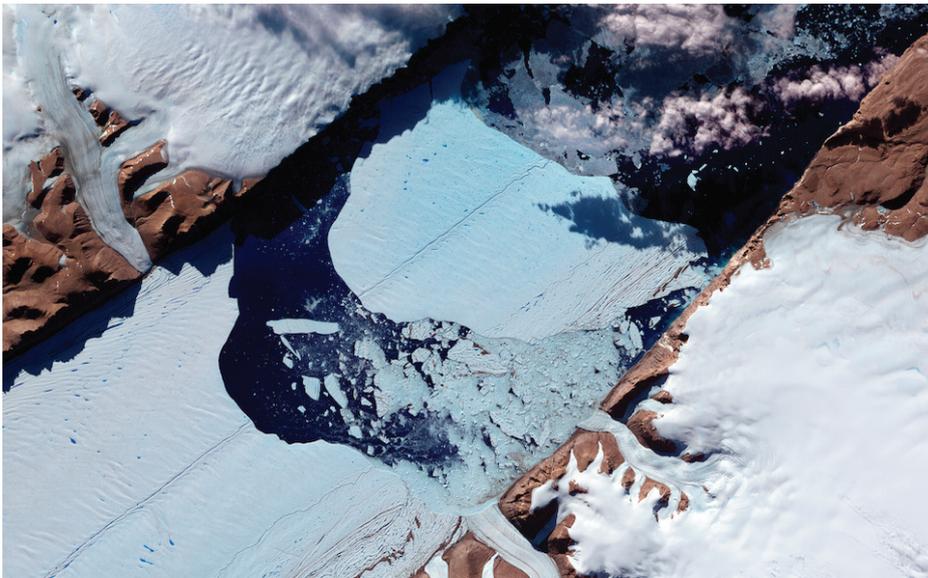
Fifteen frontal positions of Helheimgletscher in the period 1999–2013. The background image is from Landsat 7, 19 August 2007.



Cumulative net area change at the 45 of the widest and fastest marine-terminating glaciers of the Greenland ice sheet (after Jensen et al. (submitted) and Box & Decker 2011).

Climate Sensitivity

Greenland glacier fronts indicate the climate by advancing in the cold season and retreating in the warm season. The winter advance can produce a seasonal floating ice shelf that is lost the following warm season. The springtime retreat is promoted by surface melting producing liquid water draining down into crevasses driving a process called *hydrofracture* that can quickly disintegrate ice shelves.



Confirming that a massive 140 km² calving like this one that occurred at Petermann Gletscher in the record warm summer of 2012, was the result of warm weather is difficult as it would require direct observations of hydrofracture like those conducted at Store Gletscher by GEUS. Photo: NASA.



Installation of (left) crevasse water monitor float and (right) crevasse strain gauge at Store Gletscher.

The PROMICE project measures the glacier front positions each year at the end of summer when they have retreated most to be able to use them as climate indicators.

We find a significant statistical correlation between the date of seasonal minimum glacier front position and glacier latitude indicating that the calving season is shorter in north Greenland, consistent with a shorter melt season.

Further indication that surface melting is part of the ice area change story is that summer air temperatures correlate with the glacier area changes. At all 11 DMI stations we find a correlation consistent with the warmer the summer air temperature, the greater the net ice area loss at the 45 surveyed glaciers. At 4 of the 11 sites, the confidence in that correlation is above 95%. At 7 of the 11 sites, the confidence in that correlation is above 80%.

Work Cited

Box, J.E. & Decker, D.T. 2011: Greenland marine-terminating glacier area changes: 2000-2010. *Ann. Glaciol.* **52**, 91-98, <http://dx.doi.org/10.3189/172756411799096312>
 Jensen, T., Box, J.E. & Hvidberg, C. A sensitivity study of yearly Greenland ice sheet marine terminating outlet glacier changes: 1999-2013, *Journal of Glaciology*, 15|085, submitted 30 Nov., 2015.

Further information
<http://www.promice.dk>

PROMICE

PROMICE is financed by the Ministry of Energy, Utilities and Climate through the climate support programme DANCEA (Danish Cooperation for Environment in the Arctic), which is managed by the Danish Energy Agency.

- The purpose of PROMICE is to monitor the mass loss of the Greenland ice sheet, both the melting on the surface and the volume of icebergs discharged into the sea

- PROMICE is headed in Denmark by GEUS in cooperation with DTU Space and Asiaq in Greenland. Furthermore the programme collaborates with the Danish Meteorological Institute and foreign universities and authorities.
- Read more about PROMICE on promice.org, where you can find photos and videos, get direct access to measuring data from the ice sheet and the PROMICE outreach material. On the website you can also subscribe to our newsletter.
- Information can also be found on portalportal.org a new website where Danish research institutions display the results of their monitoring of the Greenland ice sheet and the sea ice in the Arctic.

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