This is the print version of the Skeptical Science article 'Greenland is gaining ice', which can be found at http://sks.to/greenland.

Is Greenland gaining or losing ice?

What The Science Says:
While the Greenland interior is in mass balance, the coastlines are losing ice. Overall Greenland is losing ice mass at an accelerating rate. From 2002 to 2009, the rate of ice mass loss doubled.

Climate Myth: Greenland is gaining ice
"[E]ven if it were true that Greenland's ice had been melting at 'new record' rates, after seven and a half years of global cooling global warming cannot be the cause. The true position in Greenland is to be found in Johannessen et al. (2005), where satellite altimetry established that the mean thickness of the entire Greenland ice sheet had increased at 2 inches per year – a total of almost 2 feet – in the 11 years 1993-2003." (Christopher Monckton)

Global warming affects Greenland in two ways. Warming temperatures cause the ice sheets to thin and lose ice mass around the edges. On the other hand, warmer temperatures also cause more snow to fall in Greenland's interior. Which has the greater effect? Is Greenland losing or gaining ice?

Over the years, a variety of techniques have been employed to measure Greenland's mass balance. Snow pits are dug to measure snowfall. Stations are set up to measure incoming and reflected sunlight. Aircraft use laser altimetry to measure changes in surface elevation. Melt areas are determined by satellites reflecting microwaves off the surface. Satellite radar interferometry measure the horizontal movements of Greenland's glaciers. In 2003, NASA launched the Ice, Cloud, and Land Elevation Satellite (ICESat), using laser altimetry to more accurately measure changes in the Earth's surface elevation.

All this data has been pieced together to form a continuous picture of Greenland's mass balance from 1958 to 2007 (Rignot et al. 2008). There is robust agreement between the various independent measurements and a clear long term trend is apparent. In the 1960s, the ice sheet was losing 100 gigatonnes of ice per year. In the 1970s-1980s, the rate of ice loss slowed to near mass balance. In 1996, the rate of ice mass loss had increased to 97 gigatonnes per year. In 2007, the ice mass loss increased rapidly to 267 gigatonnes per year. To put this into perspective, a gigatonne is one billion metric tonnes, the mass of a cube of water that is 1 kilometre wide, tall, and deep.

So we see a long term trend of accelerating ice mass loss since the 1970s. This is confirmed by the Gravity Recovery and Climate Experiment (GRACE) satellite, measuring shifts in Earth's gravity field. The GRACE data offers a complete picture of the entire ice sheet, allowing comparisons of mass changes in coastal regions (eg - elevations below 2000 metres) with the Greenland interior (above 2000 metres). Over the period 2003 to 2008, the coastal regions were observed to be losing ice mass while the interior was in approximate mass balance. The overall result is that the Greenland ice sheet is losing ice mass (Wouters et al. 2008).

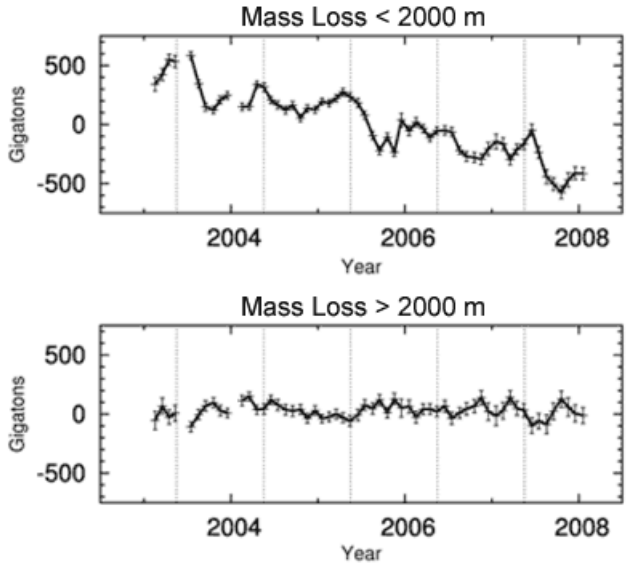

Figure 1. Mass loss from the Greenland ice sheet for coastal regions below 2000 metres (top) and interior regions above 2000 metres (bottom). (Wouters et al. 2008)

The latest GRACE data reveals more about the long term trend. Figure 2 shows the ice mass changes in Greenland from April 2002 to February 2010 (originally published in Velicogna (2009) with more recent data from John Wahr). The black line/crosses show monthly values of ice mass. The orange line is the best fitting quadratic trend. The best fitting trend finds that Greenland ice loss is accelerating at a rate of 30 Gigatonnes/yr^2. Greenland's mass loss doubled over the 8 year period.

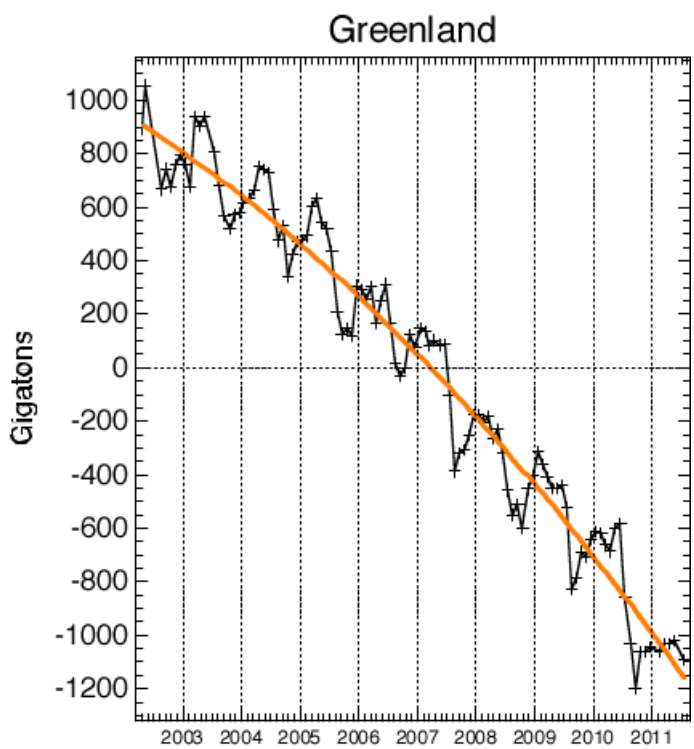

Figure 1: Greenland ice mass anomaly - deviation from the average ice mass over the 2002 to 2010 period. Black line shows monthly values. Orange line shows long-term trend (John Wahr).

The long term trend since the 1970s is accelerating ice mass loss. This is confirmed by gravity satellite measurements over the past 9 years which find that the rate of ice mass loss has doubled over the last 9 years. Just as with Antarctica, Greenland's ice sheet contribution to rising sea levels is continuously and rapidly growing.

Intermediate rebuttal written by John Cook

Update July 2015:

Here is a related lecture-video from Denial101x - Making Sense of Climate Science Denial

[*see video at* ***this link***.]

Additional videos from the MOOC

Expert interview with Jonathan Bamber

Expert interview with Eric Rignot

Expert interview with Isabella Velicogna

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Skeptical Science explains the science of global warming and examines climate misinformation through the lens of peer-reviewed research. The website won the Australian Museum 2011 Eureka Prize for the Advancement of Climate Change Knowledge. Members of the Skeptical Science team have authored peer-reviewed papers, a college textbook on climate change and the book Climate Change Denial: Heads in the Sand. Skeptical Science content has been used in university courses, textbooks, government reports on climate change, television documentaries and numerous books.

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