Greenland in the Red

An overview of ice sheet melt

Measuring the melt

The Greenland ice sheet is one of the largest bodies of ice in the world: at 1,710,000 square kilometers, it is second only to Antarctica in size. It has also been the subject of intense debate regarding the burning of fossil fuels and sea level rise due to melting ice.

As Greenland's ice is "inland ice," rather than the icebergs of popular culture, melting it will have a significant effect on global sea levels. Nearly 80% of Greenland's surface is covered by ice, as shown by the three maps below, which show the difference between Greenland's bedrock (far right), its elevation (left) and the ice in between (center).

Zwally *et al.* observe that, for areas that are covered by ice, measuring change in elevation may approximate change in ice mass. The large map to the right is an extension of those findings.

Their method is tested in a 2011 paper *(1)* in which they analyze the altimetry results of the NASA ICESat/GLAS satellite, which used lasers to measure a variety of variables from 2003 to 2007. Zwally *et al.* used the GLAS data to approximate the change in mass, in gigatons, of ice per year for 50km squares.

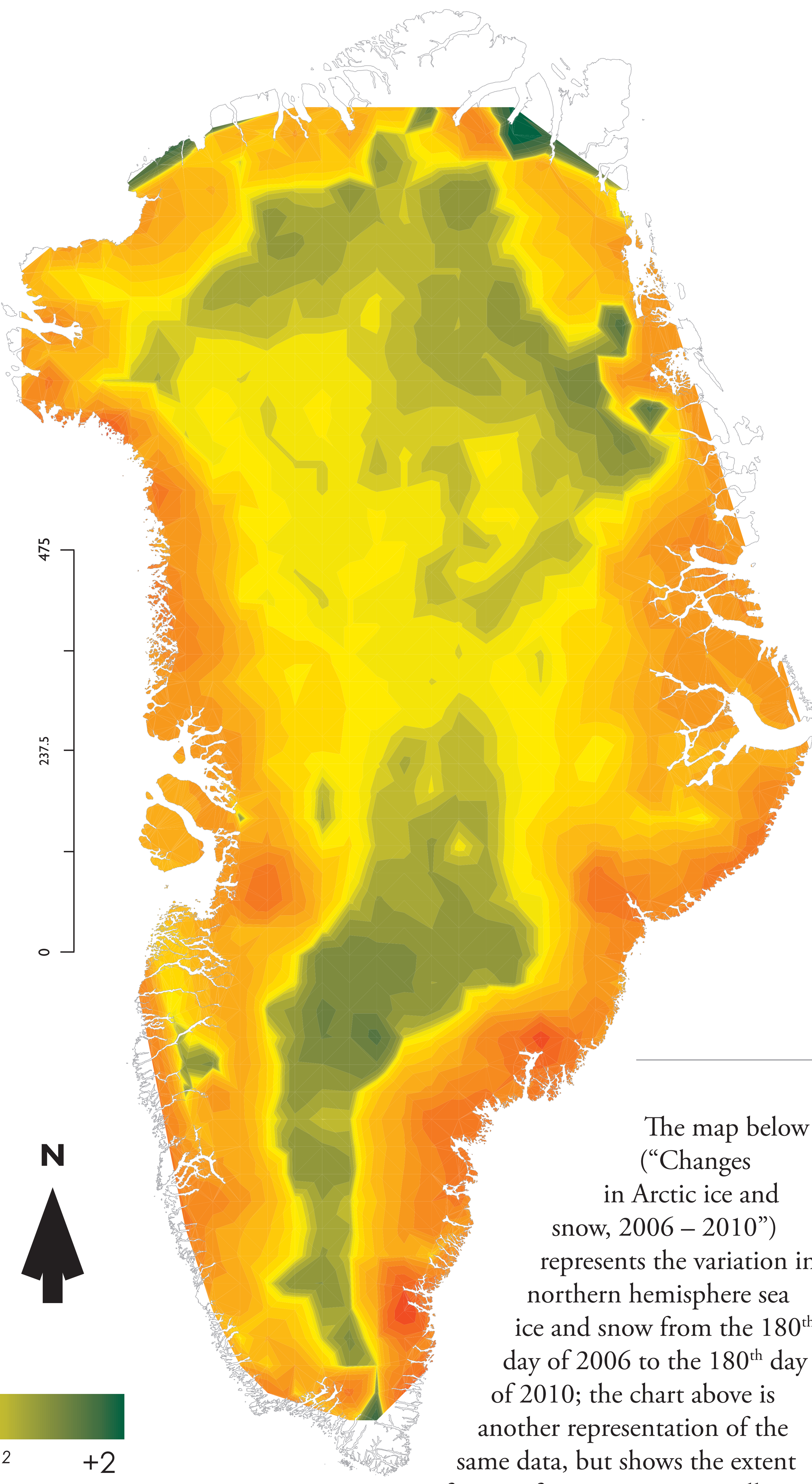
For this analysis, Zwally *et al.*'s point data were reconstructed and projected to a WGS 1984 ellipsoid (the original satellite and derivative data used a TOPEX/Poseidon ellipsoid, which is often used when making exact measurements of altitudes) and then used to create a triangulated irregular network (TIN) with a coastal outline of Greenland as the softline.

This method allowed ArcMap to interpolate between data points without using a complex Kriging algorithm or creating a mask.

Mass loss Gt/year/50km² 2003 - 2007

The TIN effectively illustrates the compaction of Greenland's central glacier *(1)* which is the only area on the island which saw growth during the study period.

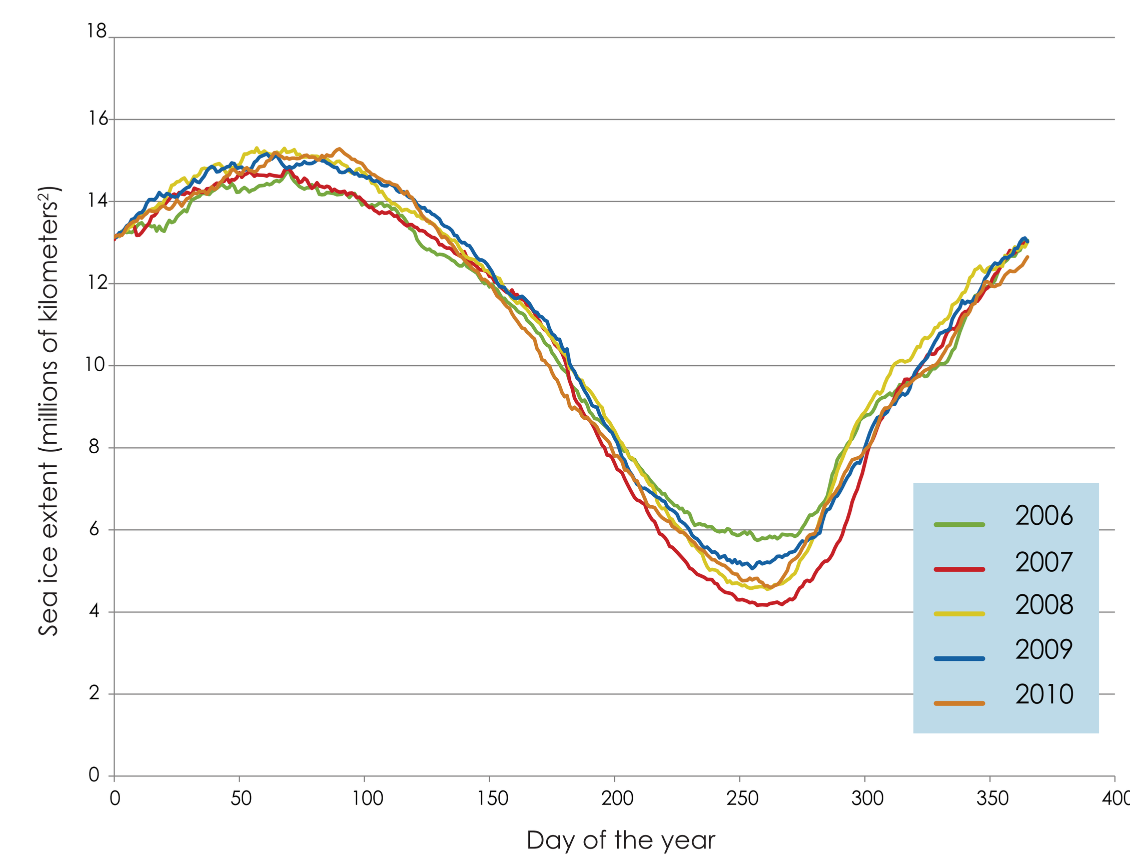
However, this may be due to a trend of ice melting and refreezing further inland: Howat and Eddy reported *(5)* in 2011 that 75% of glacial melt comes from coastal glaciers, which is very troubling because coastal glacial melt leads directly to sea level rise.



Change in mass

-15 Gigatons/year/50km² +2

Sea ice extent, 2006 - 2010



The map below ("Changes in Arctic ice and snow, 2006 – 2010") represents the variation in northern hemisphere sea ice and snow from the 180th day of 2006 to the 180th day of 2010; the chart above is another representation of the same data, but shows the extent of sea ice for every year, in millions of square kilometers.

The sea ice map reinforces the trend seen in the mass loss map to the left: the Arctic is losing ice and snow faster than it can be replaced.

Categories on the sea ice map were not subdivided because the subcategories were not found to be significant across years.

In order to obtain the map of northern hemisphere sea ice, the cut fill tool was used to compare rasters of NOAA Interactive Multisensor System (IMS) ice and snow data using 2006 as a base year *(4)*.

The cut fill tool indicates which areas have increased relative to their 2006 values, and which areas have decreased relative to those values. All other areas experienced no change in ice and snow coverage.

It is important to note that the IMS data differentiates between ice and snow coverage; areas that were iced-over in 2006 but were simply covered by snow in 2010 will be shown as a net-loss because of the nature of the cut-fill raster.

This technique produces similar results to those of Zwally *et al.* and Howat and Eddy, however, so it was deemed appropriate *(1, 5)*.

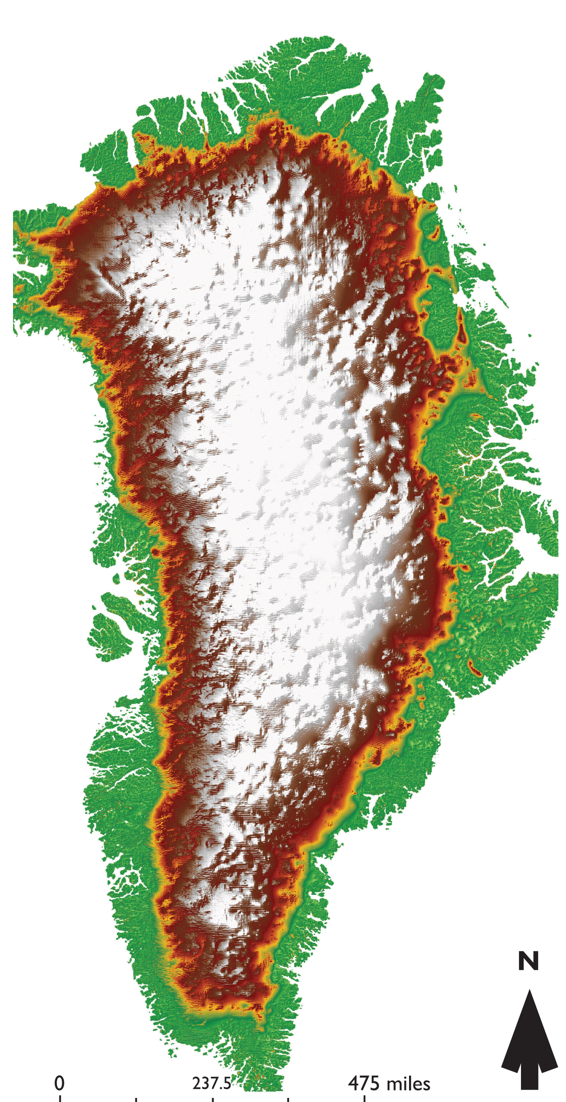
All maps projected in
WGS 1984 NSIDC Sea Ice Polar Strereographic North

Elevation

High: 3368.460m

Low: -112.988m

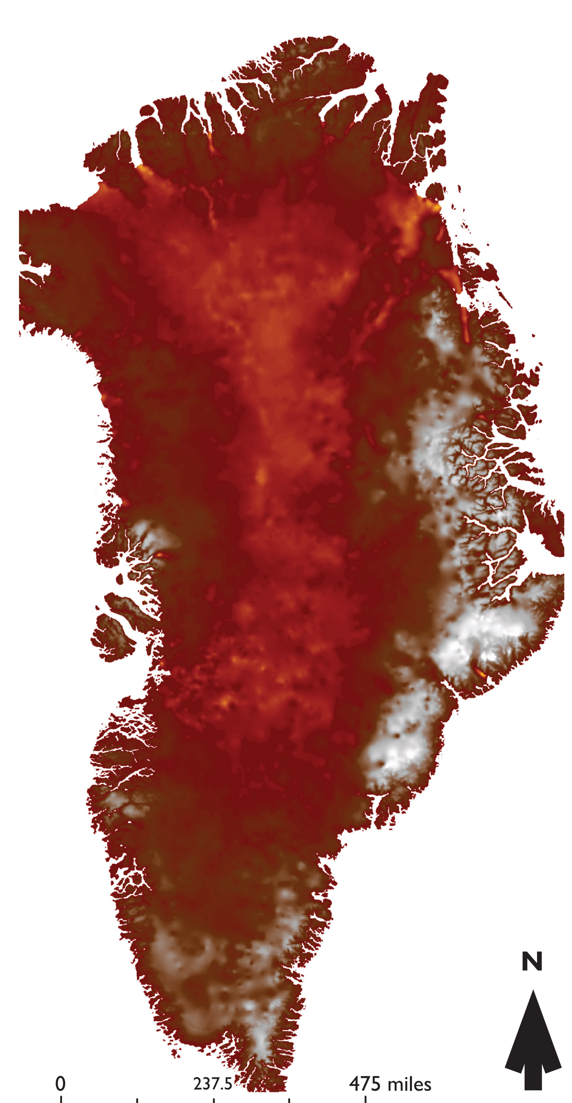
Thickness



High: 4215.2m

Low: -1901.6m

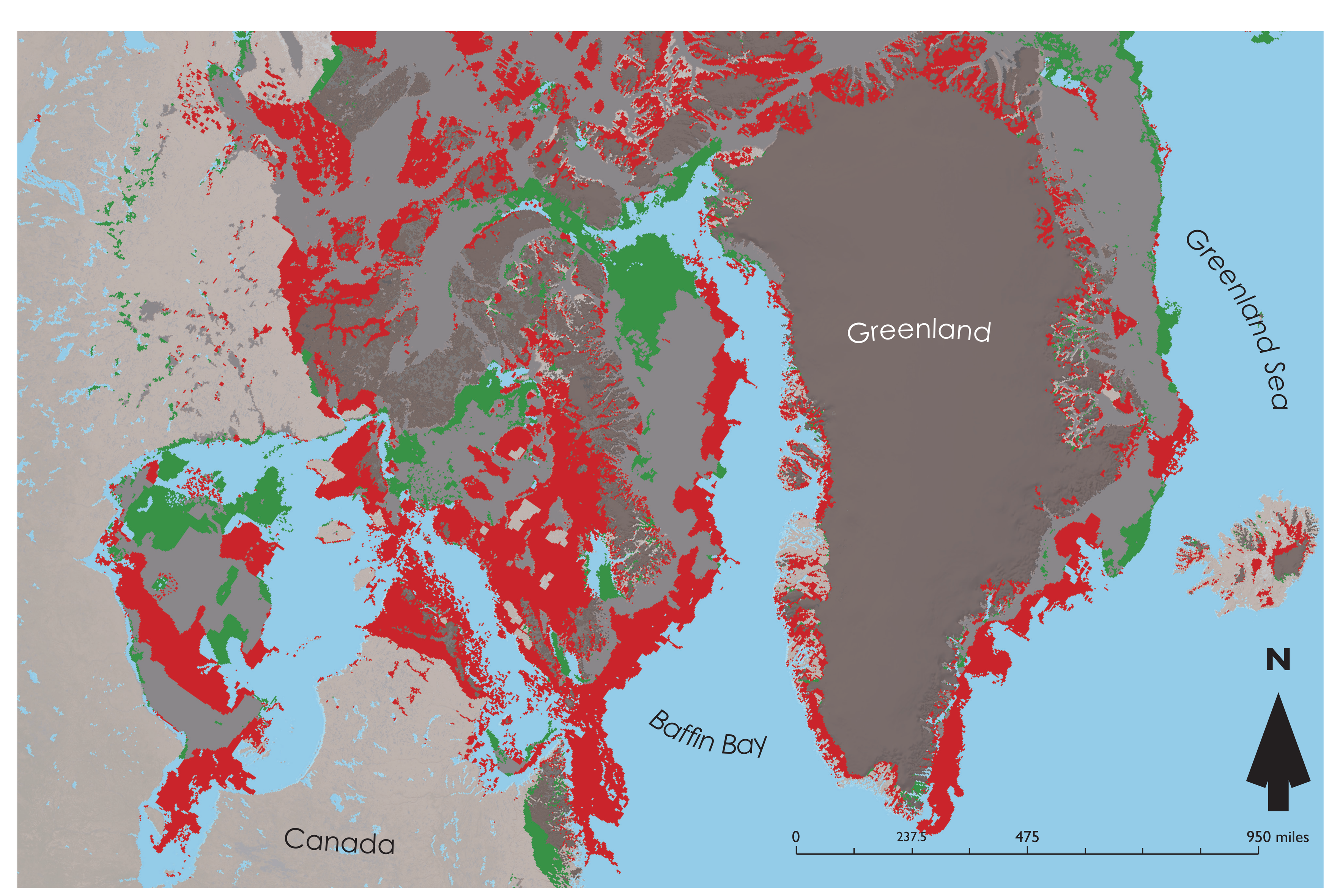
Bedrock



High: 3152.0m

Low: -4215.0m

Changes in arctic ice and snow, 2006-2010



Net gain | Water | Snow

Net loss | Unfrozen land | Ice

Citations

1. Zwally, H. Jay, Jun LI, Anita C. Brenner, Matthew Beckley, Helen G. Cornejo, John DiMarzio, Mario B. Giovinetto, Thomas A. Neumann, John Robbins, Jack L. Saba, Donghui Yi, and Weili Wang, 2011, Greenland ice sheet mass balance data, GSFC Cryospheric Sciences Laboratory. Accessed 2012 12 12 at http://icesat4.gsfc.nasa.gov/cryo_data/grn_mass_balance.php.

2. John P. DiMarzio. 2007. GLAS/ICESat 1 km Laser Altimetry Digital Elevation Model of Greenland. Boulder, Colorado USA: National Snow and Ice Data Center. http://nsidc.org/data/nsidc-0305.html

3. J. Bamber. 2001. Greenland 5 km DEM, Ice Thickness, and Bedrock Elevation Grids. Boulder, Colorado USA: National Snow and Ice Data Center. http://nsidc.org/data/nsidc-0092.html

4. NOAA/NESDIS/OSDPD/SSD. 2004. IMS Daily Northern Hemisphere Snow and Ice Analysis at 4 km and 24 km Resolution. Boulder, Colorado USA: National Snow and Ice Data Center. http://www.natice.noaa.gov/ims/

5. Ian Howat, Alex Eddy, "Multi-decadal retreat of Greenland's marine-terminating glaciers," Journal of Glaciology 57 (2011): 203, accessed December 16, 2012. http://bprc.osu.edu/GDG/howat_inpress.pdf

Terrain data courtesy ESRI.

Evan Moulson
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Tufts University Geographic Information Systems

Tufts