Ice Mass & Sea Level Unit 3: Combined Group Activity (Part 3)

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This combined activity takes place after the individual group worksheets.

Part 1: Summary of Data

Your instructor will divide you into groups. Each group needs at least one person to report on snowmelt, one person to report on ice elevation, and one person to report on ice velocity. Complete this activity as a group.

Snowmelt summary

The group member(s) who worked with Greenland air temperature and snowmelt data should:

- Show the rest of the group the average air temperature maps and explain what the maps reveal;
- Show the rest of the group the snowmelt maps and explain what the maps show;
- Assist the other group members in answering the following questions about the maps:

(1) Overall, have air temperatures in the study sites increased or decreased from 2001 to 2010?

(2) Overall, do temperature changes seem to be more dramatic inland or near the coast?

(3) Overall, do coastal areas or inland areas have a greater number of melting days?

(4) Which study site exhibited the greatest number of melting days in 2012? How many, and in which part(s) of the site?

(5) Did northern or southern Greenland exhibit the most warming from 2001 to 2010?

Ice elevation data summary:

The group member(s) who worked with Greenland ice elevation data should:

- Show the rest of the group the ice elevation map and explain what the map reveals;
- Show the rest of the group time series plots A, B, C, and D and explain what the time series plots reveal;
- Assist the other group members in answering the following questions about the map and time series:

(6) What do the different colors on the map represent about changes in ice elevation from 2003 to 2007?

(7) Regarding ice elevation change in each of the four study areas between 2003 and 2012:

(a) Did any study areas exhibit an increase in ice elevation?

(b) Did any study areas exhibit a decrease in ice elevation?

(c) Which study area showed the least change in ice elevation?

(8) Which study area showed the greatest change in ice elevation?

(9) How can ice elevation data be used to predict whether an area on the ice sheet is thinning or thickening?

Ice velocity data summary:

The group member(s) who worked with Greenland ice velocity data should:

- Show the rest of the group the Greenland-wide ice velocity map and explain what the map shows;
- Show the rest of the ice velocity maps for the individual study sites and explain what the maps show;
- Assist the other group members in answering the following questions about the maps:

(10) Overall, are ice velocities greater in the interior of Greenland or closer to the coast?

(11) Which study area exhibits the greatest overall ice velocity?

(12) Generally, do the glaciers exhibit higher velocities at the tongue or upslope?

(13) Which glacier exhibited the greatest change in ice velocity from 2001 to 2009?

(14) Which glacier's velocity stayed the most consistent from 2001 to 2009?

Part 2: Final Prediction

Your group has worked with ice elevation, ice velocity, and snowmelt data for the Greenland ice sheet. Based on the observations that you have made about each study area (Helheim Glacier, Jakobshavn Isbræ Glacier, Petermann Glacier, and NE Greenland), complete the table on the next page. This table should be a short summary (a few words) of the most important observations that you made for each study area. An observation about air temperatures in the Helheim Glacier study area has been done for you as an example.

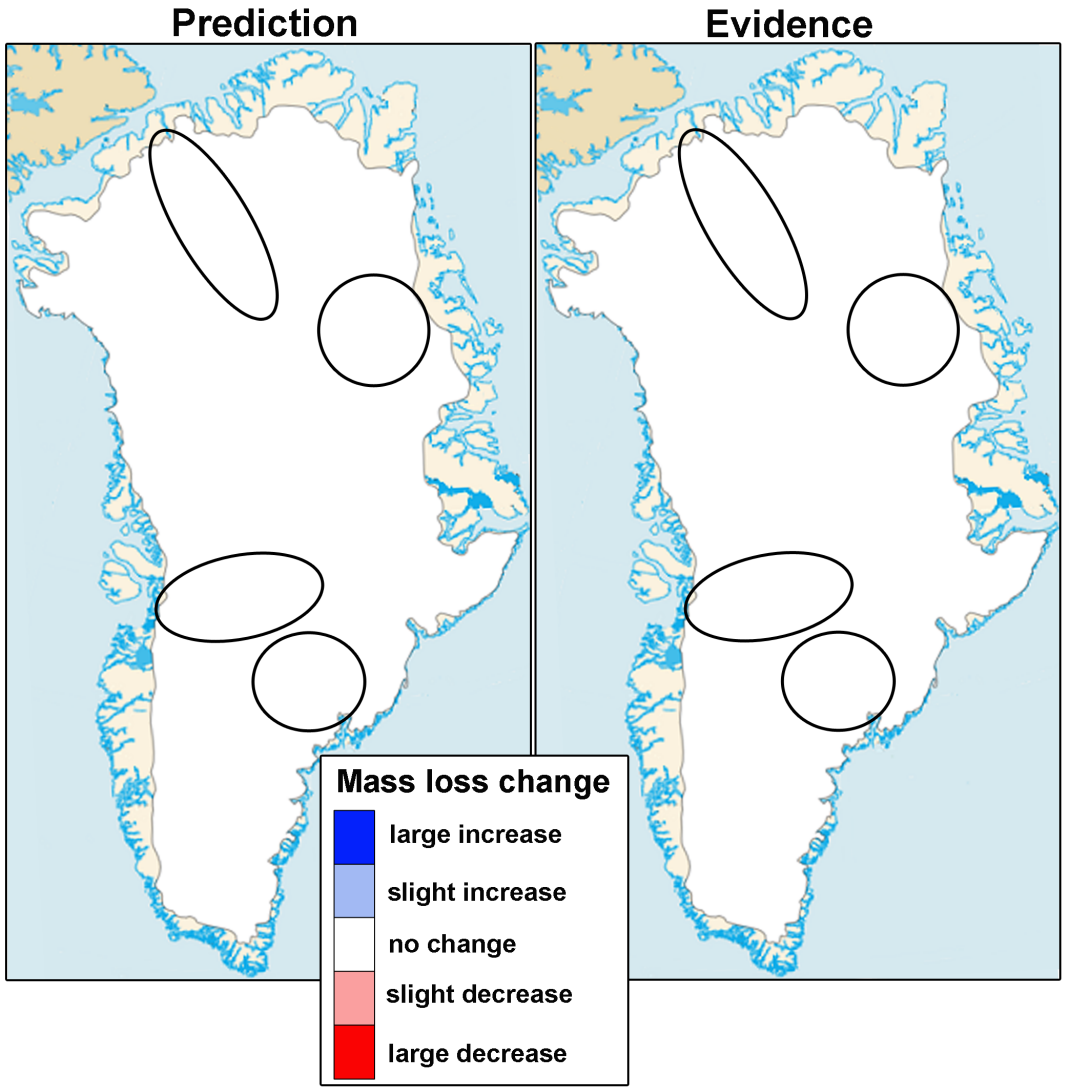
Once you have completed the table, you may find that some of the data contradict each other for a particular study area. If this is the case, circle any contradictory data that you find. (For example, perhaps the snowmelt data contradict the ice elevation data.)

Study area	air temperature changes	number of melting days	ice velocity changes	ice elevation changes
Helheim Glacier (SE Greenland)	*Warming from 2001-2010, most dramatic near the coast.*			
Jakobshavn Isbræ Glacier (SW Greenland)				
Petermann Glacier (NW Greenland)				
NE interior of Greenland				

Using what you have learned about all of these data sets and the summary table that you just created, it is time to make one final prediction as a group about where you would expect the greatest changes in ice mass to occur. Remember: an increase in ice mass indicates that a particular glacier is growing. In contrast, a glacier that exhibits a decrease in ice mass is shrinking.

Follow the same procedure for making this final map that you used at the beginning of the activity. Remember to:

- shade the four study sites circled on the map to reflect your predictions about how much relative ice mass change has occurred in the four study areas from 2003 to 2012.
- on the evidence map, make some written notes in each of the four study sites about how you arrived at your predictions.



After your group has completed your map, please answer the following questions:

(15) Which of the study areas do you predict should exhibit the greatest ice mass loss? Why?

(16) Please explain your strategy for addressing these contradictory data sets. In other words, in the case of contradictory data sets, how did you decide on your prediction for ice mass change? Did one particular data set "win out" over another, or were all data sets considered equally?

(17) How certain are you in your predictions? If you are uncertain, which additional pieces of information would be useful in making your predictions?

(18) What were the biggest challenges in making your predictions for changes in ice mass?

Part 2: What do the GRACE data look like?

You have already completed a homework assignment to learn more about how the Gravity Recovery and Climate Experiment (GRACE) works and what it measures. GRACE measures small changes in Earth's gravity field to help scientists understand changes in different components of the Earth system.

While the air temperature, snowmelt, ice elevation, and ice velocity data with which you have been working give scientists a better understanding about ice sheet dynamics, GRACE allows scientists to "directly" measure changes in the mass of an ice sheet. Below are Greenland GRACE data showing how ice mass has changed since 2003. The map on the left shows ice mass change from 2003 to 2004; the middle map shows ice mass change from 2003 to 2009; and the right map shows ice mass change from 2003 to 2012.

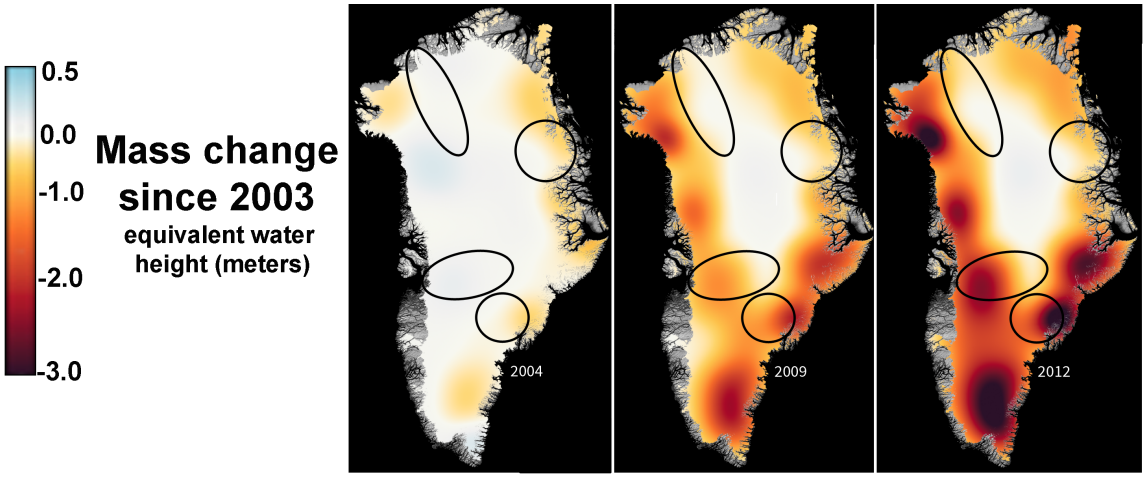


Figure 1: Ice mass change in Greenland from 2003 (http://svs.gsfc.nasa.gov/vis/a030000/a030400/a030478/).

(1) Which color on the maps indicates an increase in ice mass since 2003?

(2) Which color on the maps indicates a decrease in ice mass since 2003?

(3) Which color on the maps indicates no change in ice mass since 2003?

(4) Has ice mass changed more in coastal or inland areas of Greenland? Propose two to three ideas about why this pattern is observed.

(5) According to the GRACE data, has northern or southern Greenland experienced the greatest change in ice mass since 2003?

(6) Please compare your predictive map that you made to the 2012 GRACE map. For each of the study areas, decide whether your prediction for ice mass change corresponds to the actual ice mass change measured by GRACE. If there is a difference between your prediction and the GRACE data, briefly describe how your prediction was different from the GRACE data.

Study area	Difference between prediction and GRACE? (yes or no)	If "yes," how was the prediction different from the GRACE data?
Helheim Glacier (SE Greenland)		
Jakobshavn Isbræ Glacier (SW Greenland)		
Petermann Glacier (NW Greenland)		
NE interior of Greenland		

The time series below shows ice mass change for Greenland as measured from GRACE. The X-axis shows time, beginning in 2002. Please focus on the left Y-axis, which plots gigatons (Gt). 1 Gt is roughly equivalent to 1 km^3 of water. The curve is sawtoothed because of seasonal changes in ice mass (snow accumulation and snow melting each year); you will investigate this pattern more in Unit 4.

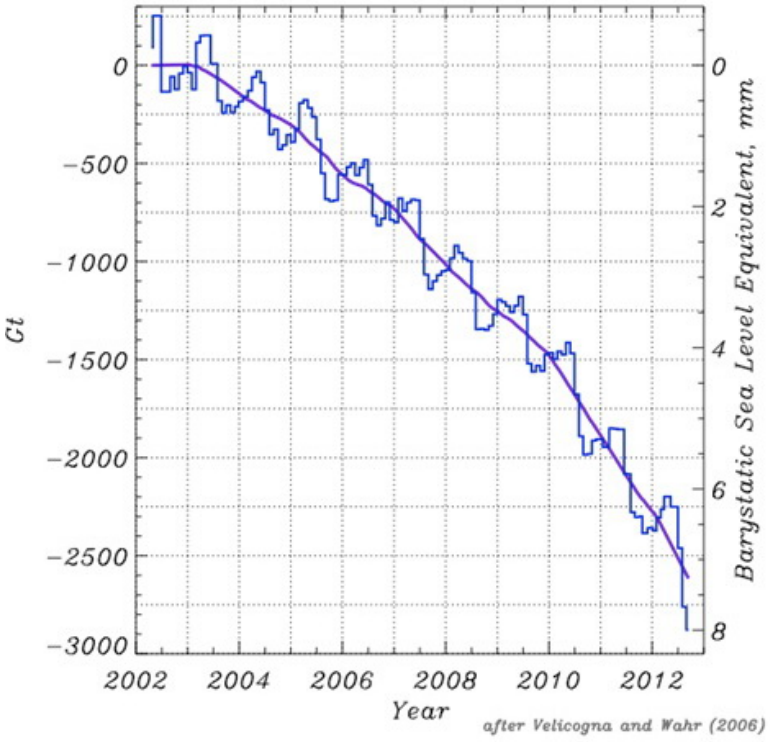


Figure 2: Time series of Greenland ice mass change as measured from GRACE, after Velicogna and Wahr (2006), available at *http://www.arctic.noaa.gov/reportcard/greenland_ice_sheet.html*

(8)

(7) Calculate the average rate of Greenland's ice mass (in Gt/year) change from:

(a) 2003 to 2004:

(b) 2003 to 2009:

(c) 2009 to 2012:

(8) Based on what the GRACE map data revealed, which regions—Helheim, Jakobshavn Isbræ, Petermann, or the NE interior of Greenland—likely contributed *most* to the ice mass changes depicted by the GRACE time series for all of Greenland?