How Do Ice Shelves Affect Sea Level Rise?:
Using Flubber to Model Ice Shelf/Glacier Interactions

Grade Level: 6 - 8
Minutes: 15 - 60 min
Subject: earth science, physical science
Activity type: model, lab, earth dynamics

https://upload.wikimedia.org/wikipedia/commons/1/10/Map-antarctica-ross-ice-shelf-red-x.png

NGSS Connections:
Performance Expectations:
- MS-ESS2- Earth's Systems

Science and Engineering Practices:
- Developing and Using Models

Meet the scientist:

Lynn Kaluzienski is a student research scientist with the Climate Change Institute at the University of Maine. Lynn is a glaciologist and will be conducting field research and gathering data to better understand changes occurring in the Ross Ice Shelf, which happens to be the largest ice shelf in Antarctica. Using the data she collects, Lynn will develop a model to make predictions about the future of the Ross Ice Shelf and its effect on sea level rise. Follow her mission through the 4-H Follow a Researcher™ program (https://extension.umaine.edu/4h/youth/follow-a-researcher/)!

What's an ice shelf?

Ice shelves are thick slabs of ice floating on water, formed by **glaciers** and **ice sheets** that flow from land towards the coastline. Ice shelves are constantly pushed out into the sea by the glaciers behind them, but instead of growing continuously into the ocean as they advance, chunks of ice shelves are broken off to form **icebergs** in a

process called **calving**. Warm ocean water also causes the underside of an ice shelf to melt.

Despite what you might expect, the sea level does not rise when ice shelves melt and break apart since they are already floating on the ocean surface. However, when glaciers flow from land into the ocean they do contribute to sea level rise by contributing water that was trapped on land to the ocean.

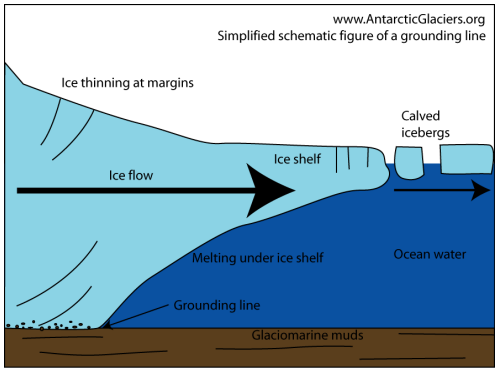


Figure 1http://cdn.antarcticglaciers.org/wp-content/uploads/2012/06/groundingline2da1.png12

So why is Lynn studying the Ross Ice Shelf if it's not going to directly affect sea level? What's the connection?

Big question: How do ice shelves play a role in sea level rise?

To find our answer, we will be using a skill practiced by all scientists to develop scientific knowledge: *Developing and Using* ***Models***.

By Michael Van Woert, NOAA NESDIS, ORA - NOAA Corps Collection (Corp2621), Public Domain, https://commons.wikimedia.org/w/index.php?curid=43819

What's a model?

A model is a simplified representation of a more complex system or phenomenon. In our case, we will be using a material called flubber to represent flowing ice, and a ramp to represent the surface of the earth below a glacier.

It is important to keep in mind that no model is an exact representation of the real thing. After your investigation, you will be asked to consider the strengths and limitations of the model and how you might improve the accuracy of the model.

Investigate!

Your team has been charged with the task of using a model to analyze glacial ice flow before and after the collapse of an ice shelf. In order to compare the flow of ice, you will need to **track a point on the surface of the glacier and measure its movement over time.**

The data that you collect will be used as evidence to construct an explanation of the question asked earlier:

How do ice shelves play a role in sea level rise?

Materials:

- Flubber
  - In a mixing bowl, combine 3/4 cup warm water and 1 cup white glue. Stir until well mixed.
  - In a separate cup, combine 1/2 cup warm water and 1 tsp of Borax powder and stir until the powder is fully dissolved.
  - Pour the cup of Borax solution into the mixture, and stir until a solid lump forms.
  - If the mixture is still too sticky, make another cup of Borax solution, add a very small amount to the mixture and continue stirring. Repeat until flubber is at the desired consistency.
- Ramp
  - Cut a cardboard tube in half lengthwise
  - Line the tube with aluminum foil)
- Aluminum tray
- Ruler
- Markers
- Stopwatch
- Books to prop up ramp
- Tape to hold ramp in place

Part A: Ice shelf intact

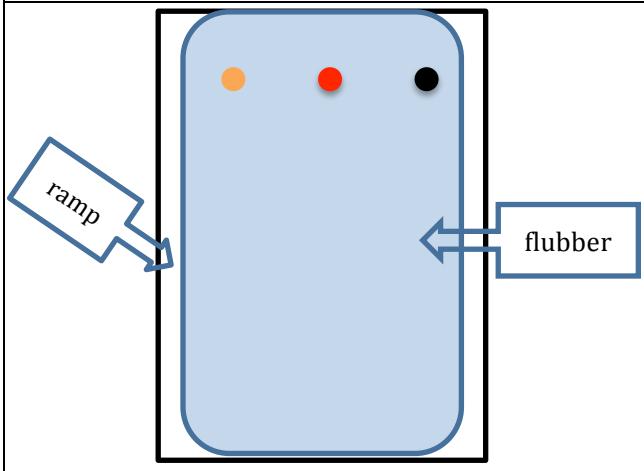
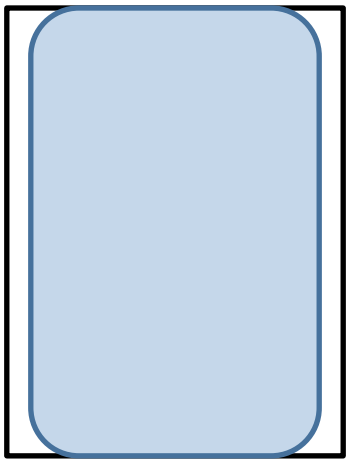
In this part of the investigation, we will simulate the presence of an ice shelf by placing a lump of flubber at the bottom of a ramp. Flubber *on* the ramp will represent a glacier flowing into the ice shelf as seen in the figure below.

NOTE: Wait until you are ready to start recording data before placing the flubber since it will start flowing immediately!

1. **Mark your ramp** - Use a ruler and marker to make marks 5cm apart on the side of your ramp. These will be used to measure the displacement of points on the surface of the glacier as it flows towards the ice shelf.

2. **Organize your data** - You will be tracking three side-by-side marker points on the glacier and measuring the time it takes for each point to move from one ramp mark to the next. Prepare a data table to record the times for each point.

3. **Make a prediction -** Before running your first test, take a minute to record your thoughts about how the marker points on the glacier (as seen on the left) will move over time by making a sketch of the marker points in the space in the column on the right.

Before	After
	
Explain your reasoning:	

4. **Collect your data –** You will be using the marks on your ramp to keep track of the distance traveled by the marker points on the glacier.
    - When you are ready, quickly make three points with a marker arranged like the image in the previous table.
    - Start your stopwatch as soon as the points are made.
    - Record the time elapsed when each point reaches the next mark on your ramp.

5. **Analysis – Using these data, you can determine the average speed (# of centimeters traveled every 1 second) of the points on the glacier.**
    - For example: If the point on the right traveled 5 cm in 35.0 seconds, on average how many cm did the point travel every 1 second?
    - Calculate the flow rate for each point on your glacier and record it in the table below.

Point	**Average Speed** ($\frac{cm}{1 \square ec}$)

6. **Make meaning through reflection –** What did you observe? Answer the questions below to reflect on Part A.

Question	**Response**
1. Did the points move as you expected them to? **2. Based on your observations and measurements, how would you describe the motion of the glacier?**	
3. Do you think the points were speeding up, slowing down, or staying the same speed? **4. What could you do to find out?**	

Part B: Ice shelf collapsed

Now we are going to run the experiment again, but will model the glacier's movement after the ice shelf collapses by not puting any flubber at the end of the ramp, as seen in the figure below.

Organize your data – As in Part A, you will be tracking three side-by-side marker points on the glacier and measuring the time it takes for each point to move from one ramp mark to the next. Prepare your data table to record the times for each.

Make a prediction – Now that we have removed the ice shelf, record your prediction for Part B.

How do you think the flow of the glacier will change without the ice shelf?	
Explain your reasoning.	

Collect your data - You will be using the same marks on your ramp to keep track of the distance traveled by the marker points on the glacier.
When you are ready, quickly make three points with a marker arranged like the image in the previous table.
Start your stopwatch as soon as the points are made.
Record the time elapsed when each point reaches the next mark on your ramp.

Analysis - Calculate the rate for each point on your glacier and record it in the table below.

Point	Average Speed ($\frac{cm}{1\ sec}$)

Make meaning through reflection – What did you observe? Answer the questions below to reflect on Part B.

1. How did your results from Part A compare to Part B?	
2. How do the results of the investigation using the model relate to actual ice shelves and glaciers?	
3. What were some limitations of this model, and how could you make it more accurate?	

4. Back to the big question: **How do ice shelves play a role in sea level rise?**	
5. How did your thinking change after this investigation?	

Adapted with permission from Leigh Stearns at the University of Kansas and Gordon Hamilton at the University of Maine.

Additional Resources:
https://extension.umaine.edu/4h/youth/follow-a-researcher/

http://climatechange.umaine.edu/

http://www.antarcticglaciers.org/glaciers-and-climate/shrinking-ice-shelves/ice-shelves/

Modeling Glacier Dynamics with Flubber (Stearns & Hamilton)
http://nagt.org/nagt/teaching_resources/teachingmaterials/11337.html

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