Name: ________________________

Date: ___________

Period: _____

Education and Research: Testing Hypotheses

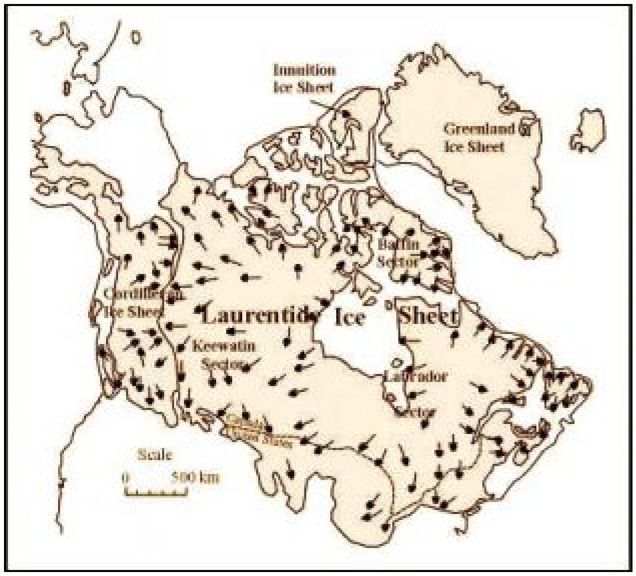
"I'm Melting, I'm Melting!"

PhET Geomorphology Glacier Landscapes Lab

Inspired by Ellyn Enderlin's Geomorphology Glacier Landscapes Lab.

<u>Lab Purpose and Objectives</u>

Although the last glacial maximum (LGM) occurred approximately 20,000 years ago, the modern landscape in North America and many other places around the world contains features left behind from when the glaciers covered a much larger area than at present. Several ice sheets existed in North America during LGM as shown in Figure 1 to the right.

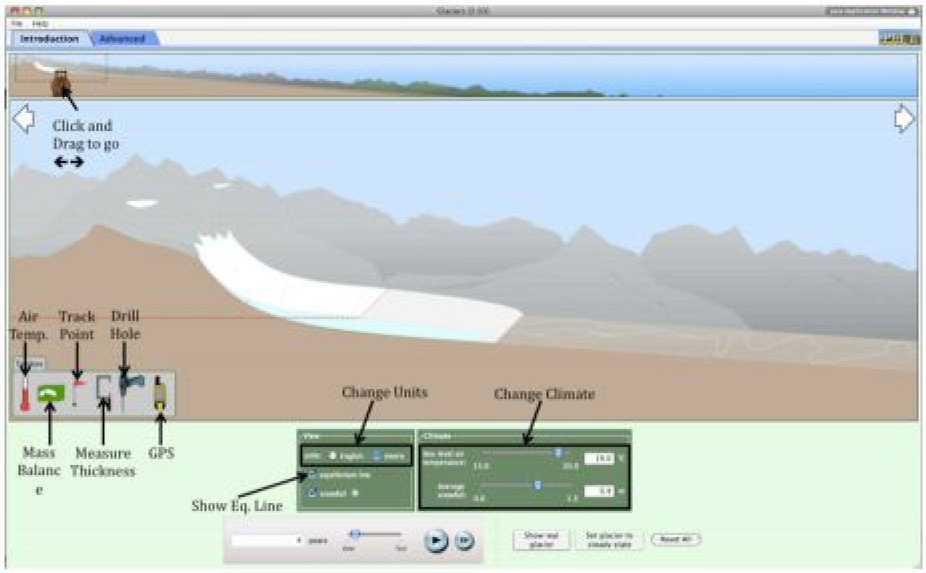


In this lab, we focus on understanding how glaciers shape the landscape and the features that glaciers leave behind after they retreat. We will look at a computer model of glacier flow to examine glacier sensitivity to climate change and depositional features associated with past glaciation.

Part 1: Observing Glacier Flow and Depositional Features

In this section of the lab, you are going to look at a computer model of a glacier that is free to the public through the University of Colorado in order to get a better understanding of glacier flow and depositional features associated with glaciers. The model is simplified, but demonstrates the general behavior of mountain glaciers and allows the user to play with a few tools common to glaciology (the study of glaciers).

1. Go to http://phet.colorado.edu/en/simulation/glaciers . Note- this program requires Java to work and may not be successful on chromebooks.
2. Click the green button that says "Run Now!" to start the model.
3. The model begins with the glacier in a steady state-- the terminus is neither retreating, nor advancing, but the glacier is still flowing. We can tell the ice is flowing if we look at the movement of the little black dots in the ice, which represent rock being carried by the glacier. The ice will flow from the <u>accumulation zone</u> into the <u>ablation zone</u> as time progresses, causing the glacier to deposit <u>till</u> at the terminus.
4. Your teacher will run through how to use all the tools in the model. It is recommended that ***you follow-along during the brief demonstration so that you use the tools properly.*** The tools in the model are labeled in the figure below. *Make sure you switch from *English to metric units and you click on the box to display the equilibrium line!!!*



5. Record the length of the glacier by clicking on the GPS unit icon beneath the glacier and dragging it onto the glacier so that the tip of the arrow touches the glacier terminus. The distance measurement on the GPS is the glacier length. Leave the GPS at that location.

Q1: Initial Glacier Length:

__***distance = 5,370m***________________

6. Decrease the air temperature at sea level by 1°C (from 19°C to 18°C). Click and drag on the bear at the top of the screen to move your glacier window down the valley. Wait until the terminus stops advancing, then measure the length of the glacier using a new GPS symbol.

Q2: How much did the length of the glacier change relative to the initial length? *Show your numbers and units. You may want to use the scroll bar at the bottom of the screen to speed up the advance in order to save time.*

Length change = 30,950m - initial length of 5,370m = 25,580m

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7. Reset your temperature at sea level to 19°C. Slowly increase your average snowfall (by increments of 0.1 m) until the terminus has advanced to just downhill from the terminus location in part (6). You should still have a GPS marker at the terminus position in (6) to remind you where it was located.

Q3: By how much did you need to change the average snowfall in order to make the glacier advance approximately the same distance as in (6)? *You may want to use the scroll bar at the bottom of the screen to speed up the advance in order to save time.*

1.5 m new average snowfall amount - Original average snowfall is .9m = .6 m

Q4: In your opinion, is the glacier more sensitive to temperature OR precipitation change? Use the changes in temperature and precipitation that you used in (6) and (7), respectively, as support for your answer. Explain why you chose your answer.

Temperature had more of an effect compared to precipitation. A 1 degree Celsius decrease in temperature made the glacier larger, faster compared to having more precipitation. While more snowfall made the glacier larger, it took a lot longer to get the glacier to the same size the 1 degree temperature change had.

8. Use the drill tool to put a borehole in the ice, similar to what happens when an ice core is extracted (click on the red button on the drill tool once you pick your drilling location).

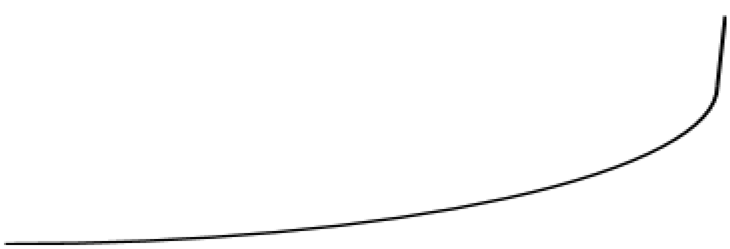
Q5: Watch how the hole deforms with time. Is this what you expected? Use specific examples to explain why.

The glacier hole becomes curved.

Q6: Is friction highest at the glacier surface, at the glacier base, or somewhere in between? Is friction lowest at the glacier surface, at the glacier base, or somewhere in between? How can you* tell where friction (i.e., ice deformation) is the highest and lowest based on the *bore hole you drilled?

The friction on the base of the glacier causes more shear stress so the hole moves slowest at that point. The shear stress on the surface is the least because there is less friction at this point.

Q7: Sketch what the borehole looks like after a short period of time and use it to support your answer to Q5.



9. Increase the air temperature by 0.1°C so that the glacier retreats up the valley.

Q8: You'll notice a well-defined line of black/gray at the most-advanced terminus location. What is this line representing? Be specific.

Terminal moraine - A terminal, or end, moraine consists of a ridge-like accumulation of glacial debris pushed forward by the leading glacial snout and dumped at the outermost edge of any given ice advance. It curves convexly down the valley and may extend up

Q9: Describe the sediment that the glacier left behind. Use glacial vocabulary.

The sediment that is left behind by the glacier is unsorted sediment.

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10. Use the C clamp tool to measure the thickness of the glacier near the center and at the leading edge.

Q10: What is the thickness of each? Be sure to include units.

Center = 372m; leading edge = 38-42m

11. Increase the air temperature by another 0.1°C to cause additional retreat. Use the C clamp tool to measure the thickness of the glacier near the center and at the leading edge.

Q11: What is the thickness of each? Be sure to include units.

Center = 366m; leading edge = 11.491m

Q12: How does the thickness of the glacier change with an increase in temperature? What do you think would happen if the temperature warmed by 1°C? Explain why. Show any computations that you completed.

As the temperature increases, the thickness of the glacier decreases. If the temperature warmed by one degree, then the glacier would experience an even more rapid decrease in thickness. The rate of change would increase exponentially because of the 10x increase in temperature.

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12. Now that you have hypothesized about what would happen to the glacier with a 1°C increase in temperature, test it out.

Q13: Record the actual thicknesses (including units) of the glacier near the middle and at the edge below.

Center = 295m; leading edge = 0.575m

Q14: Where is ablation occurring? Feel free to use the module and the available tools within it. Support your answer with evidence from this exploration.

Ablation is occurring at the surface and at the leading edge of the glacier. This is due to the increased surface area and exposure to the environment of the glacier, leading to an increased temperature of the glacier itself. An increased temperature corresponds to more rapid movement of the water molecules that compose the glacier, therefore transforming them from a solid form (ice) to liquid (water.
