POLAR TREC
Learning Resources

Details

- Arctic
- About a week
- Download, share, and remix
- High school and up

How to Measure the Speed of a Glacier

Materials

- Power point presentation that introduces Kronebreen Glacier
- Copies of four student worksheets
- Student computers for viewing video and working with PhET simulation
- planes with edges (PVC pipes split longitudinally work well)
- toothpicks
- school glue
- borax solution (1/4 C borax per 1 quart water)
- small cups
- measuring spoon sets
- craft sticks
- 20 ml graduated cylinders
- sand
- oil
- metric rulers
- timers
- beads

Overview

How glaciers in the polar regions respond to continued climate warming is of great concern. Changes in overall glacier velocities and calving dynamics have immediate impacts on sea level. Accurate predictions of how and when ice loss will occur are crucial to forecasting future environmental change.

This lesson results from experiences working in and around Kronebreen glacier in Svalbard, Norway during High Arctic Change, 2014. Along with viewing pictures and video of the glacier, students will model glacier behavior using physical models and simulations to attempt to answer, "How can we measure the speed of a glacier?" The lesson incorporates time-lapse photography of Kronebreen glacier produced by CRIOS (Calving Rates and Impact on Sea Level), a research collaboration project between the University Centre in Svalbard and the University of Edinburgh, School of GeoSciences.

Students plan and carry out an investigation into the best way to determine the velocity of their model glacier that recognizes the glacier dynamics exhibited by glaciers like Kronebreen.

Objectives/NGSS Performance Expectations

- Students will know that Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-2). **Using simulations, students will learn that a glacier's velocity changes based on environmental factors.**
- Students will develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-ESS2-3),(HS-

ESS2-6). **Students will develop a model glacier to investigate glacier dynamics.**

- Students will plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data. **Students will design ways to accurately measure the flow of their model glacier and compare it to designs used in the field.**
- Students will analyze data using mathematics in order to make valid and reliable scientific claims. (HS-ESS2-2). **Students will calculate the velocity of their model glacier and compare with classmate's measurements for accuracy.**

Lesson Preparation

This lesson asks students to answer the question, "How can we measure the velocity of a glacier?" Prior knowledge of types of glaciers, glacier features and glacier dynamics is necessary before beginning the lesson.
The PhET simulation needs to be downloaded on student computers from the PhET website: https://phet.colorado.edu/en/simulation/glaciers

Procedure

1. Students review background information about glaciers with a power point and are introduced to Kronebreen glacier in Svalbard, Norway, as a basis for investigation.
2. Students make and work with flubber on inclined PVC half pipes to get comfortable with the behavior of materials that exhibit viscous flow. (Directions for making the flubber are on the student worksheet.) Through experimentation with the "model glacier", students recognize that different areas of the flubber/model glacier move at different velocities. Students experiment with making the model glaciers flow at different rates. In groups, students brainstorm ways to measure the differential velocity of the model glacier.
3. Students work with a PhET simulation to explore how changes to climate affect glacier velocity, thickness and length. Working with the simulation will further refine ideas about how to measure the model glacier's velocity. The PhET simulation can be found at https://phet.colorado.edu/en/simulation/glaciers.
4. Students view three YouTube videos of time-lapse photography of Kronebreen glacier. The first video shows how a science team set up seven cameras to capture consecutive images of Kronebreen glacier over five months. The first video can be viewed as a class. The second video is the actual time-lapse photography retrieved from five cameras. Students view the second video using student computers at their own pace as they complete the second worksheet. The third video can also be viewed as a class. It shows recovery of the cameras and the science team's reaction to the successful endeavor. In order, the three videos can be found at:
    - https://www.youtube.com/watch?v=TsskTZ0bepA
    - https://www.youtube.com/watch?v=Llod4k01DCY
    - https://www.youtube.com/watch?v=ZRzQqXUh3h0

5. The class forms teams based on various methods created to measure the velocity of flubber glaciers. The teams use their model glaciers and design methods to measure the velocities at different points. Students conduct their measurements, compare with other teams and present findings in a written report.

Extension

- Depending on student design ideas, the lesson can be extended to incorporate time-lapse photography of the model glaciers or another local phenomenon.
- Students can access satellite or Google Earth imagery as additional ways to visualize Kronebreen glacier.
- Presentations of findings can be expanded to include oral or "science fair type" presentations.
- A 2015 video documents continuing work by CRIOS: https://www.youtube.com/watch?v=-RvSi6l1oTI. Students can continue to follow their scientific research.

Resources

- CRIOS webpage: http://www.geos.ed.ac.uk/glaciology/svalbard_calving
- High Arctic Change 2014: http://www.polartrec.com/expeditions/high-arctic-change-2014

Assessment

Assessment occurs through evaluation of students' written reports. A worksheet outlines the requirements of the report and addresses the student objectives. Alternatively, students may present their findings as a poster display or at a science fair.

Author / Credits

PolarTREC teacher, Peggy McNeal created this lesson based on her experience with High Arctic Change 2014. Peggy may be reached at peggy.mcneal@me.com.

File Attachments

Power Point: Introducing Kronebreen Glacier
Worksheet: MODEL GLACIERS - FLUBBER INVESTIGATIONS
Worksheet: MODEL GLACIERS – PhET SIMULATION
Worksheet: KRONEBREEN GLACIER – IN THE FIELD
Worksheet: Student Instructions- Final Written Report

Next Generation Science Standards Addressed

Disciplinary Core Ideas:

ESS2.C **The Roles of Water in Earth's Surface Processes.** The planet's dynamics are greatly influenced by water's unique chemical and physical properties.

ESS2.D **Weather and Climate.** Global climate models are used to predict future changes, including changes influenced by human behavior and natural factors.

ESS3.D **Global Climate Change.** Global climate models used to predict changes continue to be improved, although discoveries about the global climate system are ongoing and continually needed.

Cross Cutting Concepts:

CCC2. **Cause and effect:** Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.

CCC 4. **Systems and system models.** Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.

CCC 7. **Stability and change.** For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of a system are critical elements of study.

Science and Engineering Practices:

SEP1 **Asking questions and defining problems**
SEP2 **Developing and Using Models**
SEP3 **Planning and carrying out investigations**
SEP5 **Using Mathematical and Computational Thinking**
SEP6 **Constructing Explanations and Designing Solutions**
SEP8 **Obtaining, Evaluating, and Communicating Information**

Name_______________________________
Date______________________

MODEL GLACIERS - FLUBBER INVESTIGATIONS

In your group, each person will make one batch of flubber. The flubber will simulate Kronebreen glacier and viscous flow.

1. In a small cup, mix 1 tbsp. of glue with 15 ml. of water. Stir with the craft stick until it is a smooth consistency.
2. Add 2 tsp. of the Borax solution (skim off the top) to the water-glue mixture. Stir quickly until it holds together than take out of the cup and knead in your hands until firm and dry.
3. Prop one end of the PVC half pipe up 16 mm.
4. Combine the flubber from your entire group to make one big lump. Position your flubber at the top of the PVC pipe and observe with the intent of figuring out a way to measure the velocity of the model glacier.

As you observe, consider the following questions:

- Is the top of the glacier moving at the same velocity as the bottom?
- Are the sides of the glacier moving at the same velocity as the middle?
- Is the glacier thinning?
- What factors are determining the glacier's speed?

Experiment in as many ways as possible to investigate. Ideas:

- Make additional batches of flubber and add food coloring. Combine with your existing flubber, making alternate stripes or other patterns to distinguish areas with different velocities.
- Use toothpicks as "stakes" and observe what happens. In addition to driving the toothpicks in vertically, you can also try inserting them in toward the bottom of the glacier from the sides.
- Place a line of beads across the glacier and observe what happens.
- Create holes in the glacier and observe what happens.
- Use a ruler to measure thickness. Does it change? Does it change consistently across all areas of the glacier?
- Apply water, sand or oil to the PVC pipe and evaluate how this changes the glacier's velocity.

With your group, brainstorm a list of ideas for accurately measuring the velocity of your model glacier in a way that reflects all aspects of the glacier and corresponding velocities. Record this list, with any necessary explanations on the back.

Name______________________________________

Date__________________________

KRONEBREEN GLACIER – IN THE FIELD

Together, you will view a video of how an innovative team of scientists and students worked to take measurements of Kronebreen glacier. Following this video, you will use individual computers to watch a second video found at: https://www.youtube.com/watch?v=Llod4k01DCY. View the second video at your own pace while answering the following questions:

1. Camera 1: From the aerial view, describe the view; in other words, Camera 1 is set up to see:

2. Watch the time lapse from Camera 1 enough times to write a description of all components in the space below. What is happening? Describe everything.

3. How is the view from Camera 2 different? Why do you think they set up both cameras where they did?

4. Describe the view from Camera 3; Camera 3 is set up to see:

5. Describe what you see in the view from Camera 3 and compare it to anything you witnessed with your flubber glacier model or PhET simulation.

6. Describe the view from Camera 5; Camera 5 is set up to see:

7. In the time-lapse from Camera 5, something appears on the surface of the ice not previously seen. What do you think these are?

8. There is a different structure visible from Camera 6. What do you think this is?

Once you have finished viewing the second video, you will come back together to watch “Kronebreen- The Sequel” and experience with the scientists and students the excitement of retrieving their cameras after 5 months!

Name______________________________________
Date_________________________

MODEL GLACIERS – PhET SIMULATION

Open the PhET simulation and spend time investigating the features to familiarize yourself. Specifically, change the aspects of climate (sea-level air temperature and average snowfall) to see the effects on the glacier. You can speed up and slow down the effects by sliding the button at the bottom (years). You can move the bear at the top to navigate along the length of the glacier. Click on the "advanced" tab and check the "ice flow vectors". The relative length of the vectors represents relative velocities. This will provide an indication of what parts of the glacier are moving faster and slower.

1. Adjust the temperature and snowfall to create a large glacier. Click and drag several red tracer flags onto the glacier. Wait a minute or so and add new tracer flags, adding them at positions so that you can compare speeds to one another and to the debris (black dots) within the glacier. Do this with enough flags and for enough time that you can begin to draw some conclusions about the relative velocity of the glacier in different areas and under different climate conditions. Fully describe your findings below.

2. Do the same thing with the borehole drill. Click, drag and click again to drill boreholes in enough locations to draw conclusions and fully describe your findings below.

3. Use the ice thickness tool to measure the glacier at several locations and describe your findings along with any hypotheses/explanations for your findings.

Final Written Report

Your final report will consist of four paragraphs

- In the first paragraph, discuss how a glacier flows. Include how different parts of a glacier (for example, sides, versus middle) move differentially. Discuss how different surfaces (rock versus water, for example) affect the rate of flow. Apply these situations to both your model glacier and what you have learned about real glaciers.

- In the second paragraph, describe how you set up your model glacier. Include its limitations compared to real glaciers. Reference the glacier simulation (PhET) where appropriate.

- In the third paragraph outline your procedure for measuring the flow rate of your model glacier. Describe alternative design ideas, the pros and cons and accuracy of your design. Discuss ways that you controlled your experiment and how you ensured the reliability of results.

- In the final paragraph, provide your results, how you arrived at them (include formulas and calculations) and how they compared with the results of other classmates. Include a data table. Explain any anomalies. Could your procedures be replicated in the field? Explain.