Measuring Earth with GPS, Unit 3: Glaciers
Activity 3 Student Exercise: Analyze, Interpret, and Apply

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In this activity, you will learn how to analyze and interpret scientific data after describing it. You will conclude by using that data to support a recommendation you make about an issue relevant to society. The questions guide you through the process that scientists use when they work to solve scientific questions. This particular activity uses data from a GPS station near Helheim Glacier in Greenland to better understand long-term trends that can be interpreted by analyzing GPS position of bedrock near the glacier.

Part 1: Writing a hypothesis about GPS data and glacier size

Geologists make hypotheses to explain how one thing affects another and why the relationship exists. They use their hypotheses to make predictions that they can then test by collecting data. In Part 1, you will use your understanding of the relationships between the size of glaciers and the vertical movement of the ground to write hypotheses. You will use those hypotheses to make predictions, and you will test those predictions in Part 2.

If you have not already done so, watch the animation titled, *Glaciers are Retreating: How can we measure the full ice loss? An example from the Greenland Ice Sheet*.

1. The animation explained Earth processes that cause the bedrock vertical position to change. Circle the two processes that cause the position of the GPS station attached to the bedrock to rise.

snowfall snowmelt thinning of glacier thickening of glacier

2. Circle the two processes that cause the position to lower.

snowfall snowmelt thinning of glacier thickening of glacier

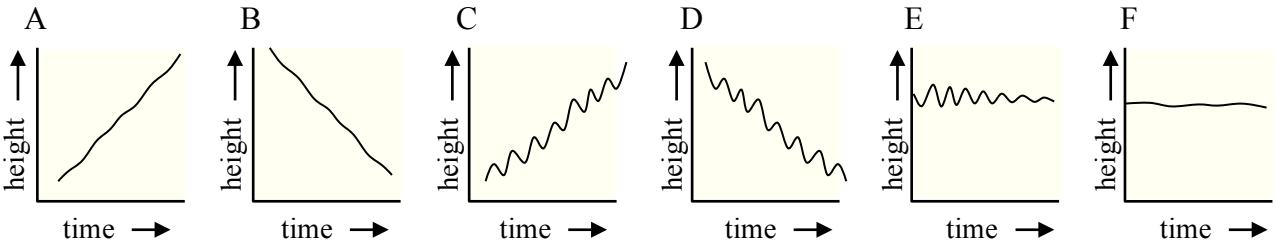
3. A hypothesis includes both how you predict one variable to affect another and why you think that relationship exists. Write a hypothesis about the effect of a glacier's size on the surrounding vertical elevation of bedrock by finishing the sentences:

The bedrock elevation would rise if a glacier becomes _____ (smaller/larger) because… there is less weight pushing down the bedrock

The bedrock elevation would lower if a glacier becomes _____ (smaller/larger) because… there is more weight pushing down the bedrock

4. Circle how confident you are in your hypothesis.

Not confident Somewhat confident Confident



5. Imagine there is a glacier that is shrinking over many years. Use your hypotheses to make a prediction: When the vertical position of the bedrock GPS unit is plotted against time in a time-series diagram, what would the trend look like? Circle the letter that corresponds to the graph above that best fits your prediction.

A B C D E F

6. Imagine there is a glacier that is growing. Use your hypotheses to make a prediction: What would the trend look like over many years? Circle the letter that corresponds to the graph above that best fits your prediction.

A B C D E F

Part 2: Observing and describing GPS data

Below is data from Station KULU near Helheim Glacier in Greenland. In this part of the activity, you will make observations to describe the data. In the next part, you will use those observations to interpret why the GPS unit is moving. A larger version of this figure is included separately.

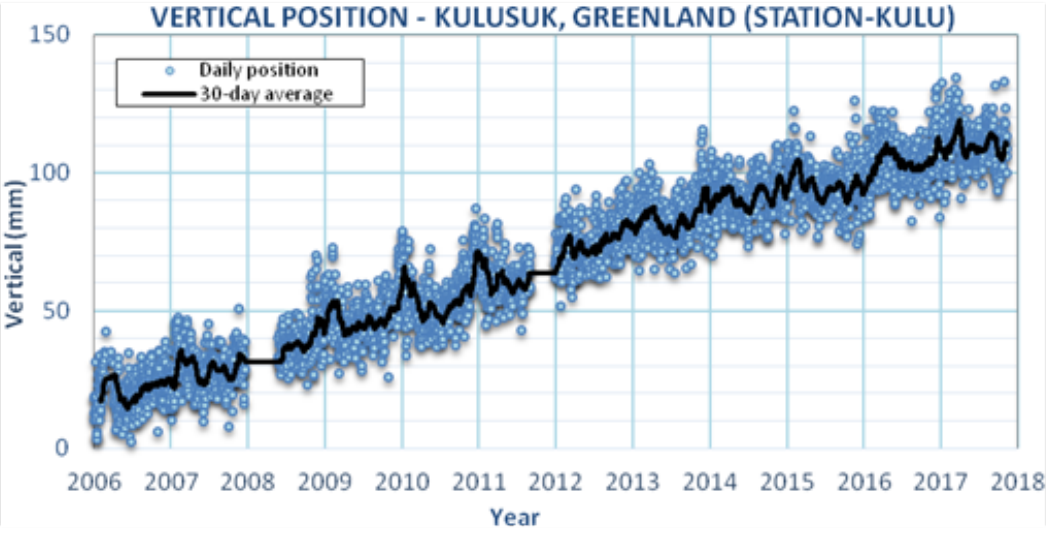


Figure 1. Vertical GPS data from station KULU near Helheim Glacier in Greenland from the beginning of January 2006 to the end of December 2017.

When scientists look at data in graphs, they look for overall trends and describe the data using words and numbers. Answer the following questions to describe your observations of the data as a scientist. You will describe the data at two timescales: 1 year and 5 years.

7. Pick one year of data in Figure 1, and fill in the table to describe the vertical motion of the GPS station. Remember to include units. Year: _____

High point Month: _____	**Low point** Month: _____	**Range of vertical motion** (difference between the high and low point)

8. Write a summary sentence describing the vertical bedrock movement near the glacier that combines (a) the timing (month) of the high point; (b) the timing (month) of the low point; and (c) the range of vertical movement (in millimeters). It may help to review Activity 1.

When describing how something changes position over time, scientists calculate the rate (speed) of change. Notice that the rate is different than the range. For example, you use the range if you describe how far a car drove each day, but you use the rate if you describe a car's speed. If a car is traveling at a rate of 60 miles per hour, it is traveling a distance of 60 miles over the time of 1 hour (60 miles divided by 1 hour equals 60 miles/hour).

9. Pick a five-year interval. Calculate the rate of change for the KULU GPS station near Helheim Glacier during that interval. Be sure to start and end at the same time of year. Remember to include units:

Distance (difference in height from the beginning to the end): _____

Time (number of years from the beginning to the end): _____

Rate (distance divided by time): _____

10. Convert the rate to inches/year. There are 0.039 inches in 1 millimeter. _____
Inches are larger than millimeters, so check that your conversion makes sense.

11. Some people mix up how they use the word "rate" and "position." Which statement below does NOT use the terms correctly when talking about the vertical motion of the GPS station?

The rate of movement is 8 mm/year. The position is rising 8 mm/year.

The rate increased 8 mm/year. It is rising at a rate of 8 mm/year.

12. Which of the following does the rate you calculated measure?

Total amount glacier melts Total amount sea level rises Total amount bedrock moves

Annual amount glacier melts Annual amount sea level rises Annual amount bedrock moves

13. Write a summary sentence describing the long-term vertical movement of bedrock near the glacier that combines the direction of vertical movement and the calculated rate (with units).

Part 3: Interpreting GPS data

After making observations by describing data, scientists interpret the data. Interpretations give meaning to the observations by explaining why they are the way they are.

14. Examine your answers in Part 1 of this activity. Interpret why the bedrock elevation data have an annual pattern of one high and one low.

15. Examine your answers in Part 1 of this activity. Interpret what is happening to the size of Helheim Glacier over many years.

The size of Helheim Glacier is being measured in multiple ways, in addition to GPS. For example, the thickness of the ice has been measured by satellites, and those data show the ice is thinning. The total amount of ice has also been measured by its gravitational pull on satellites, and those data show the amount of ice has been shrinking.

16. Based on this additional evidence, do your hypothesis (Question 3) and interpretation of GPS data (Question 14) make sense?

Yes No If they do not, you will need to fix something!

Part 4: Applying data interpretation to society

Scientists use their interpretations of what is happening in the world around us to learn how society may be affected and help people make informed decisions. In this part, you will apply your interpretations of your observations of the elevation of the GPS station near Helheim Glacier to help a person make an informed decision.

17. Apply your interpretation of the changing size of Helheim Glacier to determine how it affects the level of water in the ocean:

a) How does the changing size of the glacier relate to the ocean?

It adds water to the ocean. It takes water from the ocean

b) Will this cause sea level to rise or fall? rise fall

c) Over how large of an area does sea level change? worldwide only in Greenland

18. Circle the 2 causation relationships that are correct:

Melting glaciers cause bedrock to rise.	Rising bedrock causes glaciers to melt.
Melting glaciers cause sea level to rise.	Rising bedrock causes sea level to rise.
Rising sea level causes melting glaciers.	Rising sea level causes rising bedrock.

Imagine you have a cousin Maria who says, "Who cares if the sizes of glaciers are changing? It won't affect me on the East Coast of the United States. I just won't invest in glacier tourism. Instead, I am going to invest in beachfront property for when I retire."

19. Do you agree or disagree? Formulate an argument to support or refute the statement. Write a letter to your relative with the purpose of encouraging or discouraging her to invest in beachfront property, using GPS data from Alaska and Greenland to support your argument. You will need to explain to your relative how GPS near glaciers can play a role in learning about the future of beachfront property.

Be sure to include the following points in your letter to receive full credit:

• You include a clear statement about whether or not you agree with the relative.

• You use words to describe the data supporting your argument.

• You use numerical rates (numbers plus units) to support your argument. Correctly include what the rate you calculated measures.

• You explain the link between GPS motion and the change in glacier size (your hypothesis).

• You explain the link between the change in glacier size and sea level.

(*Hint: You have already addressed most of these questions by answering questions in Activity 3; it may help to review your previous answers so you can synthesize them to write your letter.*)

Part 5: Reflecting on your results

Scientists reflect on the decisions they make while solving a problem. They also think about how they may change their approach the next time, perhaps because they learned by doing something the hard way or perhaps because they came up with ways to simplify their approach.

20. Assumptions in science are things that you assume to be true but may not be. Scientists have to make assumptions because the world is very complicated and we do not have a limitless amount of instruments, data, or time. Describe two assumptions that you made when you used data from a bedrock station near glaciers in Greenland and Alaska to make an argument of world-wide consequences.

21. If you could have one more piece of information to support your argument, what data would you collect? Explain how you would use this information to support your argument.

Think about how you approached answering the questions in this entire activity.

22. What aspect of working with the GPS data was easiest for you?

23. What aspect of working with the GPS data was hardest for you?

24. You may be asked to describe, analyze, interpret, and apply GPS data again in this class. Make three notes to your future self of skills you developed that you can use or how you would change your approach when presented with GPS data again.