Measuring Earth with GPS, Unit 4: Groundwater
Activity 1 Student Exercise: Observe and Describe

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GPS stations precisely record the position of the solid ground they are on, and they were first installed to measure plate motion. However, geoscientists analyzing GPS data realized that plate motion is not the only geological process that causes the ground to move.

Hi, I'm Kim, a geoscientist who uses GPS data to better understand the effect groundwater has on changes in ground elevation. In this activity, I will guide you to describe scientific data from a GPS station in Puerto Vallarta, Mexico, by making careful observation, and you will use those observations to make a scientific interpretation. I hope to model for you the process that scientists like me use when we work to solve scientific questions.

Part 1: The ground is moving?

When I, as a scientist, look at data, I begin by determining what the graph is showing and then make observations by describing the trends.

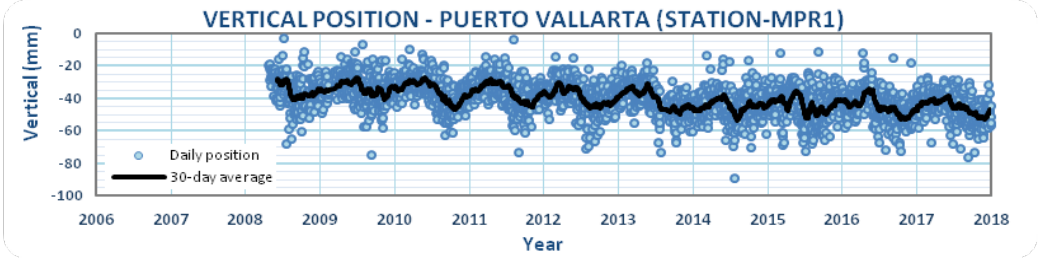


Figure 1. Vertical GPS data from station MRP1 in Puerto Vallarta, Mexico, from the beginning of January 2006 to the end of December 2017.

Let's first examine Figure 1 that shows the GPS data. A larger version of this figure is included separately because it's easier and more accurate to read the numbers off a larger graph. When reading the graph, use the black average line, not the dots.

1. The first thing I do when looking at a graph is to read the title, look at the axes, and make some general observations. What do the axes show, including units?

Horizontal (x-axis): _____ Vertical (y-axis): _____

2. Look at the time scale. The points on the graph rise and fall in a cycle that lasts how long?

One cycle every: day month year decade

3. How do you know the ground is moving?

Part 2: What hypotheses might explain why the ground is moving?

When scientists first noticed that the ground was moving up and down each year, we wanted to know why. Two of the hypotheses we came up with are:

> **Hypothesis A**: The ground elevation lowers because rain water soaks into the ground weighing it down, and the ground elevation rises when the water evaporates.
>
> **Hypothesis B**: The ground elevation lowers because the ground contracts as it dries, and the ground elevation rises when the water from rainfall causes it to expand.

Geoscientists often work with more than one hypothesis (we call them "multiple working hypotheses"), and that is what we'll do here. We will keep both of our hypotheses in mind as we better describe the data to try to determine which one explains the data better.

Based on these hypotheses, let's make some predictions of correlations between the amount of rainfall and the ground elevation. A correlation is a relationship or a comparison between two factors, although it does not necessarily mean that one thing causes the other.

4. Fill in the table below with predictions of correlations based on the hypotheses. We'll later compare our predicted correlations to actual data to figure out which hypothesis is supported by the data.

	When the rainfall is *high*, the ground will be
Hypothesis A	high low
Hypothesis B	high low

There are terms you can use to describe correlations. A positive correlation is when two data sets have highs at the same time. A negative correlation is when one data set has a high at the same time as another data set has a low.

5. Circle what kind of correlation each hypothesis predicts between rainfall and ground elevation:

Hypothesis A	positive correlation	negative correlation
Hypothesis B	positive correlation	negative correlation

Part 3: How much does the ground move and when?

After making overall observations as we did in Part 1, I describe the data using numbers. Using numbers allows us be more precise in our observations and description of vertical movement.

6. I find that it is helpful to use tables to organize data. Fill in the table below using data from two years of your choosing. Include units!

	Year #1	**Year #2**
Year		
High point (maximum height)		
Estimate during which month		
Low point (minimum height)		
Estimate during which month		
Range of vertical movement (difference between high point and low point)		
Convert the range to inches (there are 0.039 inches in 1 millimeter*)		

***I used to have problems with conversions, so I always check that my answer makes sense. An inch is close to 25 times larger than a millimeter, so double-check your answer.*

After I make calculations, I find it's helpful to take a step back to make sure I understand what my calculations mean and put them into context so I can visualize them.

7. Which of the following best matches the range of vertical movement each year?

Thickness of a paperclip Length of a paper clip Height of a table

8. Could you feel the movement? Yes No

Like other scientists, I summarize my findings, so I can feel confident that I understand and can describe what is happening.

9. Write a summary sentence describing the vertical bedrock movement near Puerto Vallarta 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).

Part 4: What observations can explain why the ground is moving?

The GPS data shows us when and how much the ground is moving, but it doesn't show us why. Our hypotheses focused on water in the ground as the cause, so we need to look at data showing the amount of rain to test if our hypotheses explain why the ground is moving.

Examine the graph showing precipitation in Puerto Vallarta, Mexico.

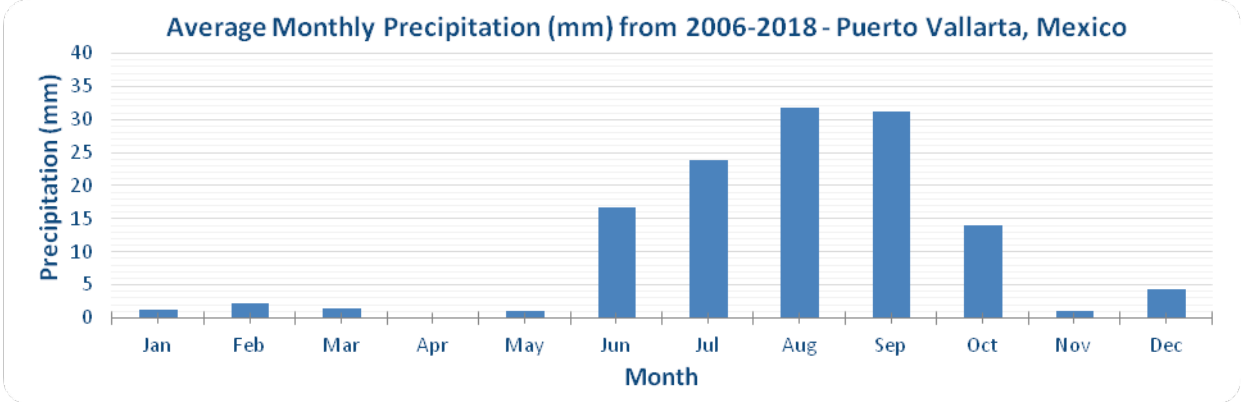


Figure 2. Graph showing precipitation for the area near the GPS station in Puerto Vallarta, Mexico.

10. What do the axes of this graph show, including units?

Horizontal (x-axis): _____ Vertical (y-axis): _____

11. During what months is there significant rain? _____ very little rain? _____

12. How does this precipitation pattern compare to where you live? similar different

I find it helpful to organize my data into a table to help figure out if there is a correlation.

13. Fill in the table below and determine if the precipitation and ground elevation data demonstrate a positive or negative correlation.

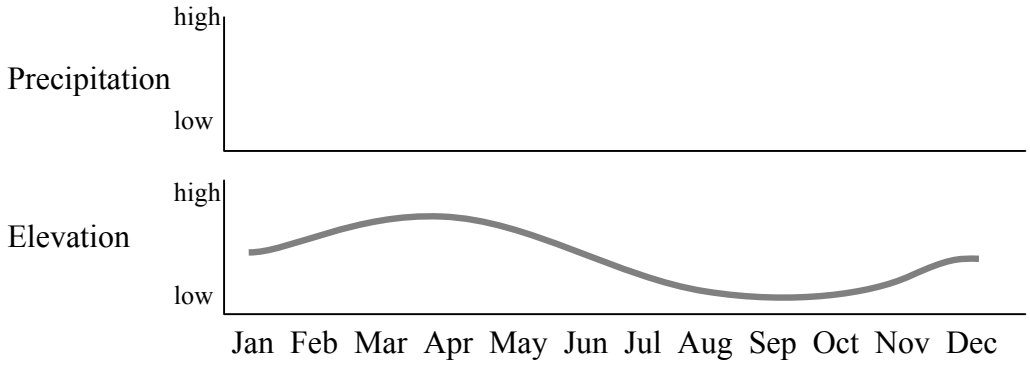
Month	**Elevation of ground**	**Amount of precipitation**
March–May	low high	low high
August–October	low high	low high

14. Based on your table, do the precipitation and the height of the GPS station have a positive or negative correlation?

positive correlation negative correlation

I also find it helpful to sketch simplified graphs to verify and visualize a correlation.

15. I drew in a simple sketch showing the elevation of the ground over one year. In the top graph, sketch in the precipitation data from Figure 2 as a curve.



16. Based on your graph, do the precipitation and the height of the GPS station have a positive or negative correlation?

positive correlation negative correlation

Part 5: Which hypothesis best explains why the ground is moving?

I often make observations that are puzzling. However, I try to make sense of the data and figure out why something is happening. Let's look back at our multiple working hypotheses and see which ones our observations and data support.

17. Look at your predictions of correlation based on the hypotheses, and look at your observations of the correlations. Which hypothesis is best supported by the data?

Hypothesis A Hypothesis B

Summarize in your own words why the ground is moving.

18. Circle how confident you are in your explanation as to why the GPS station is moving.

Not confident Somewhat confident Confident

19. Name one piece of additional data that you would like in order to test your explanation. Explain why you chose that data and how it would test your explanation.