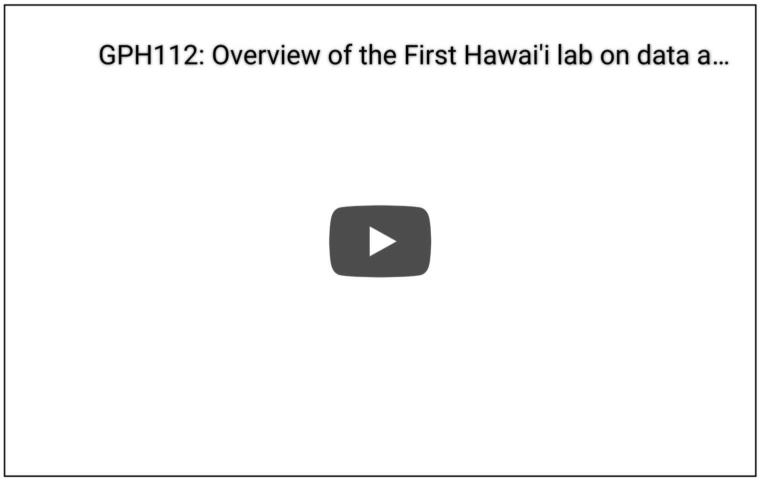
Hawai'i Physical Geography: Helicopter Data Tour

This is a preview of the published version of the quiz

Started: May 18 at 1:53pm

Quiz Instructions

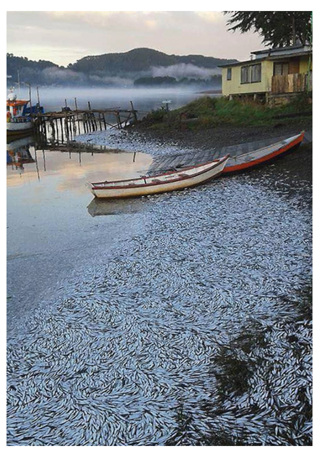
If you are short on time, reading and just doing the lab is faster. But if you are nervous or worried, this video about doing this lab was made for you. (10 minutes in length)



INTRODUCTION: OBJECTIVE OF THIS LAB IS TO BRAINSTORM

Geographers love to pour over and examine maps. Many professional geographers got their start as kids nerding out on books of maps called atlases. Today, future geography stars might spend their hours pouring over collections of all types are widely available online in placed like the **Library of Congress (https://www.loc.gov/maps/collections/)**, university libraries such as the **map and geospatial hub (https://lib.asu.edu/geo)** at ASU, seemless topographic maps (**USA topo link (http://mapper.acme.com/)**), and for K-12 teachers the **Arizona Geographic Alliance maps (http://geoalliance.asu.edu/maps)**.

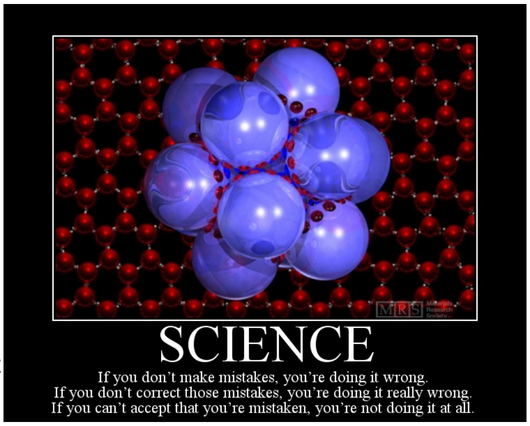
A lot of physical geography research starts with examining maps, looking at patterns, and then coming up with possible physical geography processes to explain those patterns. El Niño is but one example; the fishing industry off the coast of South America has known for centuries (if not millennia) that around the time of Christmas, warm water shows up and fish die offs occur every few years. It wasn't until the 1920s, however, that Gilbert Walker examined maps of pressure and noticed that a "Southern Oscillation" sometimes flip-flops high and low pressure (and rainfall patterns) across the tropical south Pacific. Then, in the 1960s, Jacob Bjerknes connected everything together by studying more maps of pressure, climate, and ocean currents and called the pattern ENSO (El Niño-Southern Oscillation) you learn about in the GPH 111 lecture.



Sardine die-off in Chile (**NASA (https://earthobservatory.nasa.gov/features/ElNino/page3.php)**)

In a synchronous class, whether online or in person, map interpretation often ends up being a brainstorming session. One person might see a pattern, and then another three might offer up explanations of processes to explain that pattern. This can then lead to dreaming up "tests" or ways to disprove one explanation or another. For every pattern that eventually gets figured out, like El Niño, there are often dozens of hypotheses offered up and then disproven by these tests. A review of the science in 1957 listed possible causes of El Niño fish die offs that are now disproven, including: "troublesome and unwholesome" north winds; trade winds extending along the Peruvian coast from the Gulf of Panama; the southward flow of equatorial water; submarine landslides; vertical exchanges of heat and water above the coastal shelf; and changes in the oxygen content of the eastern Pacific waters and more.

This graphic gets at the essence of science -- that we can never "prove" anything doing science. Proofs are for mathematicians. Scientists just try to come up with ways to disprove our explanations for the patterns we see. We publish when we disprove an explanation and we publish we cannot (yet) disprove an explanation. And we try to teach to our students those explanations that are not yet disproven.



But in an asynchronous class like this, we want you to have this experience. Each of the questions you will see in this quiz attempts to provide you a brainstorming experience to think about the patterns you will see.

QUESTIONS IN THIS LAB OVERVIEWED

Each question has you flying a virtual helicopter in the geovisualization with the idea of you kicking back and observing what you are seeing. The questions are designed NOT to be tricky. If they seem easy for you, please don't second guess your answers. Of the questions seem easy, this means you are good at seeing geographical patterns.

- Kohala Volcano: Observing rainfall patterns and how they relate to development of river valleys
- Volcano Types: Flying over two very different giant volcanoes, Mauna Loa and Mauna Kea
- Dew point: This indicator of the amount of moisture is something you can see virtually in the game environment, and you figure out why it changes so much as you go higher and higher
- When a lava flow buries a forest: What comes next?
- Straight(ish) lines are rare in nature, but they can be explained

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Question 1

2 pts

Part 1: Background Information:

Kohala is the oldest of the five large volcanoes (called shield volcanoes). All of Hawai'i's shield volcanoes are composed of the same rock type (basalt). The shield shape of these volcanoes describes that (with some exceptions) they all have gentle slopes.

Most of the Kohala volcano had formed by about a million years ago, even though younger volcanics occur here and there. For the purposes of this question - you can consider the entire Kohala volcano surface to be about a million years old.

Part 2: Exploring the Geovisualization

In the Hawai'i geovisualization - you will use the helicopter mode of fast travel to study the mapped data

- Use Fast Travel to jump to the Honokane Nui Lookout at latitude: 20.1967, longitude: -155.7246
- Again, in the Fast Travel menu, select the other side of Kohala (you can either click on the other side as seen below, or input these coordinates: latitude: 20.0551, longitude: -155.8376) - *this time don't click on the paper airplane icon.* You will be going by helicopter. But I suggest you move the air speed to the fast position and click on scale speed. This will make the helicopter go faster. Just look at the topography and vegetation cover you see in the game.
- Then, do this again, but when you are flying click on the isohyet rainfall layer. You can also go back and forth between Landsat and rainfall.

Also - I recommend that you pull the camera way up high and have the camera point in the direction of the helicopter movement. You might have to experiment with the mouse/mousepad/trackball to figure out camera movement. But this will allow you to see a lot more like this shot of the rainfall layer with the helicopter way below you:

Feel free to make this virtual trip a few times and think about why there are deep stream valleys on one side, and there is only one tiny stream valley on the other side.

Part 3: Select your hypothesis

Here are some explanations that emerged from the 10 students in our focus test group for this assignment:

- there's a lot more rainfall on the east-facing side of Kohala, to get bigger streams and more stream erosion
- the east-facing side had a steeper slope to the volcano helping stream incision
- the rainfall helps vegetation growth that helps decay the volcanic rock so it can erode more easily
- the dating of the volcano surface is wrong, and the east side is older -- giving more time for erosion

Part 4 (Optional): Scientists have found

This 2013 paper on the role of precipitation in river evolution on Kohala supports one of the hypotheses, but the current way of thinking might be wrong. Science can only disprove. You certainly do not have to read this journal article to get the quiz question correct, but we hope that you are curious enough to at least skim it.

QUESTION: What physical geography process is the most likely explanation for the much greater development of river valleys on the eastern side of the Kohala volcano (than the western side of Kohala)? The answer that is keyed as correct is based on the information you saw on the helicopter trip (Landsat image, topography, rainfall).

Keep in mind that we know that some students do like to think "out of the box" - and this is one of the reasons for the appeal process in the syllabus. So if you decide to present your own "out of the box" hypothesis, great, but you must be prepared to send your instructor 2 paragraphs explaining why you think the evidence supports your hypothesis. You do not get to "assert" that you think you are correct. Assertions will not "earn" you the point. You must take screenshots from the geovisualization and explain your thinking clearly with reasoning.

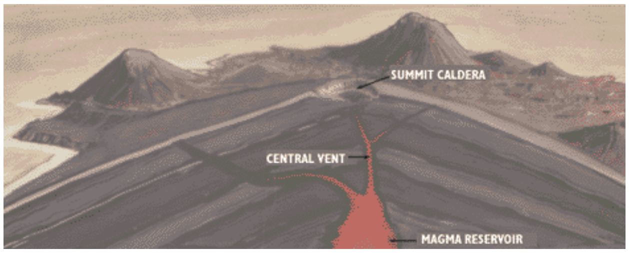
- ◯ There's a lot more rainfall on the west-facing side of Kohala, to get bigger streams and more stream erosion
- ◯ Since the rainfall is pretty even on both sides, there has to be a different explanation than precipitation amounts
- ◯ I have another idea, and my plan is to select this answer ... and send an email appeal to the instructor following the instructions in the syllabus
- ◯ There's a lot more rainfall on the east-facing side of Kohala, to get bigger streams and more stream erosion

Question 2

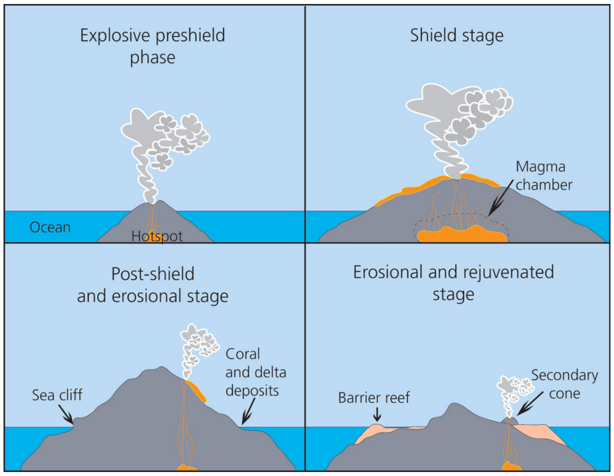
2 pts

Part 1: Background Information

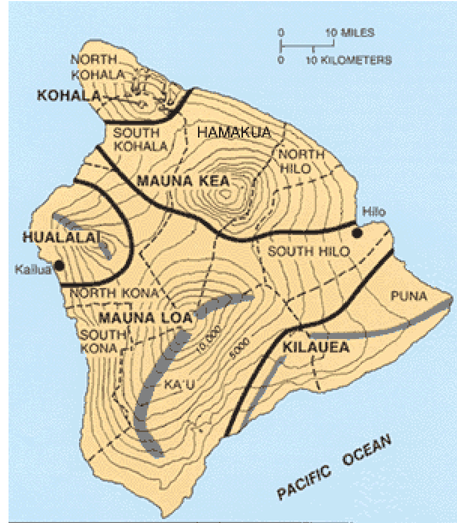
Hawaiian lava is pretty much all the same composition: basalt. This lava comes from melting ocean crust, and so its low in silica and flows easily. Thus, the basic shape of the big Hawaiian volcanoes resembles a shield of the sort that Captain America would carry -- with gentle slopes. However, the ways that this same basic lava type erupts has a lot of variety:



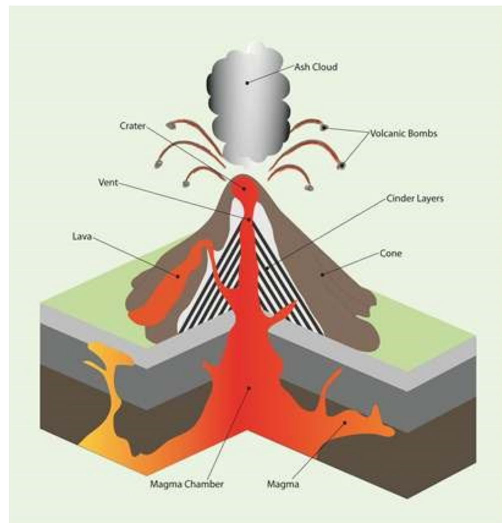
Shield volcanoes go through phases or stages where as a big shield volcano ages, the composition of the lava gets thicker and can support slightly steeper slopes near the summit in the post-shield stage



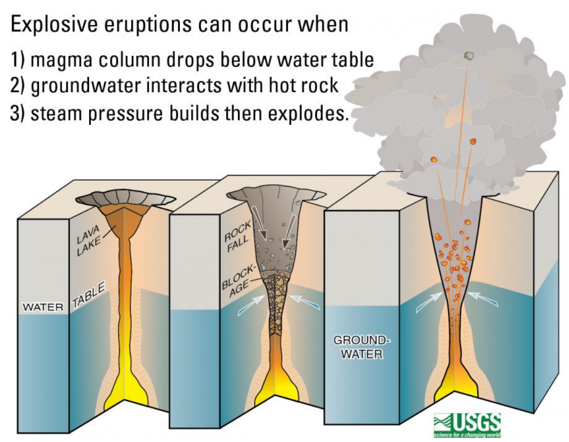
Rift zones during the shield building phase are ridges along the side that are weaknesses whereby lots of lava erupts



Looking like pimples on top of the giant face of a shield volcano, basalt sometimes moves up through groundwater. This breaks apart a lava flow into pieces (called cinder) and contact with the water turns the black color red (through oxidation of the iron minerals, like rusting steel). So reddish colored cinder (and bigger particles called bombs) fly out and drop down creating steeper volcanoes just a few hundred feet high



Sometimes, the magma/lava under the surface does not erupt, but simply turns groundwater into steam. The steam then blows out a hole -- a phreatic eruption. These holes are visible in the game, typically along rift zones.



Part 2: Explore the Geovisualization

In the Hawai'i geovisualization - you will use the helicopter mode of fast travel to study the volcanic eruptions of Mauna Loa and Mauna Kea, -- the two largest volcanoes on the Big Island. You will use the Landsat layer that was processed in a way to "bring out" subtle differences in lava and volcanoes. The DEM (digital elevation model) data provides the 3D effect.

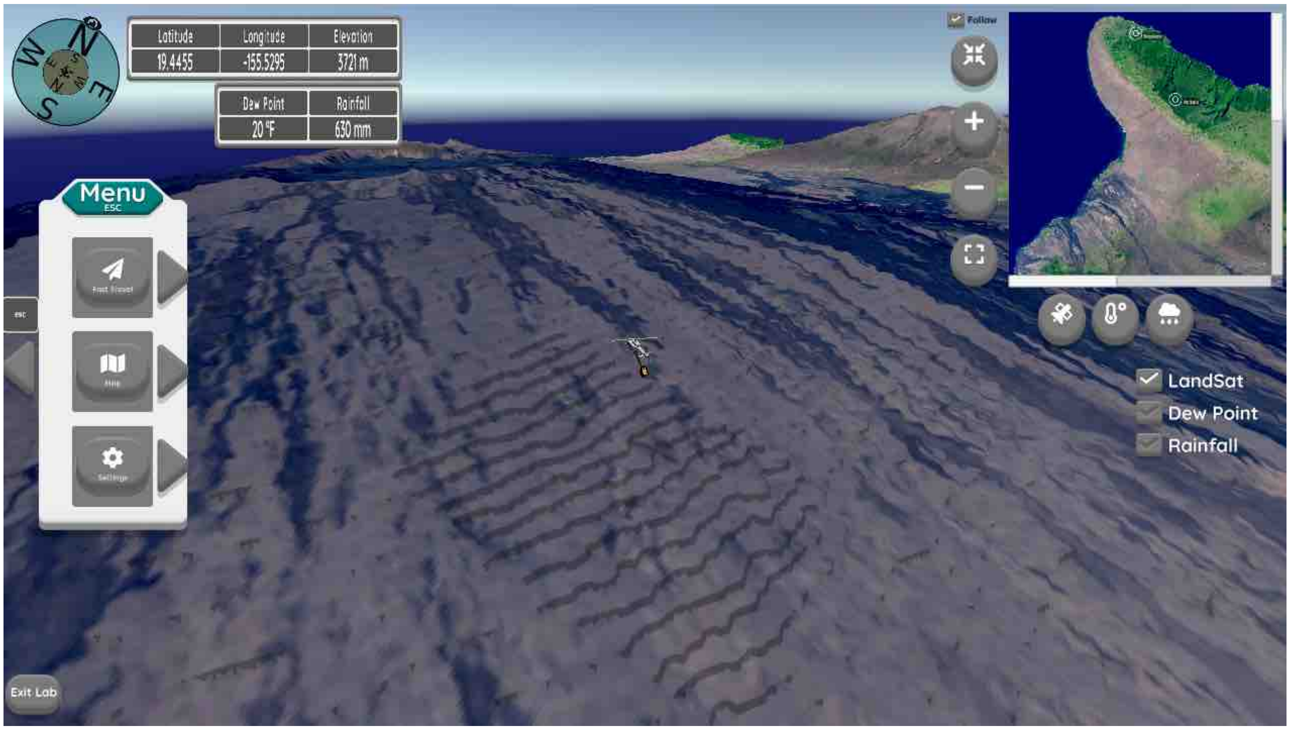
Its best to travel via helicopter to just look at the scenery. I suggest you move the air speed to the fast position on the scale bar and also click on the box "scale speed" -- to make the helicopter go faster.

Also - I recommend that you pull the camera way up high and have the camera point in the direction of the helicopter movement. You might have to experiment with the mouse/mousepad/trackball to figure out camera movement. But this will allow you to see a lot more like this shot:

The idea is for you to just take notes on the volcanic fields you observe on these three helicopter trips and think about the patterns that you are seeing. In particular, focus on the differences you see between the volcanoes.

MAUNA LOA : Fast travel to latitude: 19.3688 longitude: -155.94044 and then in Fast travel, program the end of the flight to 19.5883 and -155.7628 and click the helicopter icon.

MAUNA KEA : Fast travel to latitude: 19.8314 longitude: -155.3544 and then in Fast travel, program the end of the flight to 19.8397 and -155.6003 and click the helicopter icon.



Part 3: Select your Hypothesis:
The students in the focused group were asked the same thing -- to observe differences between the volcanoes and do their best to try to explain why the volcanic features on these volcanoes would look differently. Their hypotheses fell into the following groups:

- The top of Mauna Kea seems steeper than the top of Mauna Loa. The steepness of the slope of volcano depends on the thickness of the lava. Thicker lava makes steeper volcano slopes, suggesting that Mauna Kea might be past the shield stage of very active volcanic activity.
- The top of Mauna Kea seems covered by cinder cones, whereas Mauna Loa has a big depression (a caldera) at its summit. Since cinder cones occur when magma moving up through the subsurface encounters groundwater (breaking up the lava), there must have been groundwater in abundance to produce all those cinder cones. Perhaps, very recent volcanic activity at the summit of Mauna Kea led to all of the groundwater vaporizing away, and the creation of the summit caldera from this recent volcanic activity removed/obliterated the cinder cones that might have once been present. But then again, the abundance of cinder cones might be because Mauna Kea is no longer a super active shield volcano and just has a little bit of magma movement to encounter groundwater and generate only cinder cones.
- The top and also the flanks of Mauna Loa have dark black lava flows, indicating recent eruptions on the side. Mauna Kea does not seem to have very many of these dark black recent lava flows. Thus, it is possible that Mauna Kea is much less active of a volcano, and perhaps might have passed the shield stage of high volcanic activity.
- These volcanoes have a very different appearance, despite being right next to one another. The Kohala volcano also looked different in the previous question. Perhaps each volcano develops a shape "personality". Just as brothers and

sisters can look different, so can the big volcanoes of this Big Island.

Part 4 (Optional): What Scientists Think
This 2014 paper on **how Hawaiian volcanoes are studied** goes into a lot of detail. You certainly do not have to read this journal article to get the quiz question correct, but we hope that you are curious enough to at least skim it.

QUESTION: What physical geography volcanic process is the most likely explanation for the differences you observed in the Mauna Kea vs. Mauna Loa volcanoes?

Keep in mind that you are very free to appeal your choice, in case your selection is scored as incorrect. Thus, please take notes. Write down the reasons why your observations (notes) fit the answer you selected. You do not get to "assert" that you think you are correct. Assertions will not "earn" you the point. You must specify your observations in the appeal to support your choice. Then, email your explanation to your instructor. Science is about observing and using those observations.

- ◯ These volcanoes have a very different appearance, despite being right next to one another. The Kohala volcano also looked different in the previous question. Perhaps each volcano develops a shape "personality". Just as brothers and sisters can look different, so can the big volcanoes of this Big Island.

- ◯ This is one of those circumstances in science where multiple hypotheses are not in conflict. In other words, the hypotheses of several of the piloting students (but not all) are all likely and are mutually consistent.

  1. The top and also the flanks of Mauna Loa have dark black lava flows, indicating recent eruptions on the side. Mauna Kea does not seem to have very many of these dark black recent lava flows. Thus, it is possible that Mauna Kea is much less active of a volcano, and perhaps might have passed the shield stage of high volcanic activity.

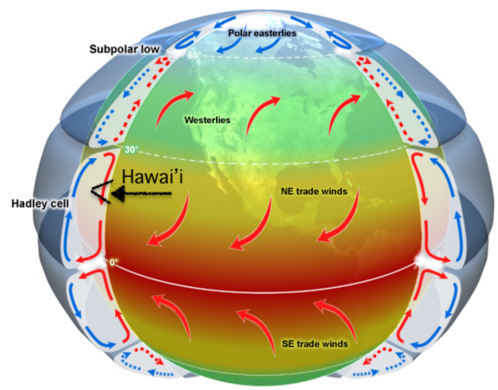
  2. The top of Mauna Kea seems steeper than the top of Mauna Loa. The steepness of the slope of volcano depends on the thickness of the lava. Thicker lava makes steeper volcano slopes, suggesting that Mauna Kea might be past the shield stage of very active volcanic activity.

  3. The top of Mauna Kea seems covered by cinder cones, whereas Mauna Loa has a big depression (a caldera) at its summit. Since cinder cones occur when magma moving up through the subsurface encounters groundwater (breaking up the lava), there must have been groundwater in abundance to produce all those cinder cones. Perhaps, very recent volcanic activity at the summit of Mauna Kea led to all of the groundwater vaporizing away, and the creation of the summit caldera from this recent volcanic activity removed/obliterated the cinder cones that might have once been present. But then again, the abundance of cinder cones might be because Mauna Kea is no longer a super active shield volcano and just has a little bit of magma movement to encounter groundwater and generate only cinder cones.

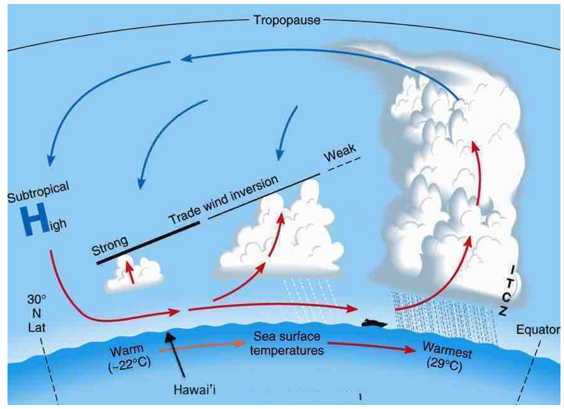
Question 3

2 pts

Part 1: Background Information
Hawai'i is in the belt of the northeast trade winds, part of the Hadley cell. The means that low-level winds are moist and warm and come from the northeast. All of these global circulation diagrams show the descending air of the Hadley Cell reaching the surface at the subtropical high. This is basically true, but reality is more interesting.



At the latitude of Hawaii, the upper air flow that is very dry descends. It does not reach the surface, however. The lowest it goes is called the Trade Wind Inversion (TWI). Below the TWI, the trade winds keep the air very moist with high dew points. Above the TWI, the air is much drier with low dew points. Since the TWI goes up and down throughout the year, this boundary moves up and down. [As you remember from GPH 111, dew point is a measure of how much moisture is in the air. Its the temperature where moisture condenses.]



Part 2: Explore the Geovisualization
In the Hawai'i geovisualization, you will use the helicopter mode of fast travel to examine the mapped data. In the game, start by clicking on the dewpoint layer. You will start by observing how the dew point changes as you fly up and over Mauna Kea.

(1) use Fast Travel to jump to one side of Mauna Kea at 19.8314 and -155.3544.

(2) Again, in the Fast Travel menu, select the other side of Mauna Kea and enter 19.8392 and -155.6003. [I suggest you move the air speed to the fast position and click on scale speed. This will make the helicopter go faster]. Then, click on the helicopter icon.

Feel free to make this virtual trip a few times and switch to the isohyet (rainfall) and Landsat layers to see the changes as you fly up and over Mauna Kea. Observe how the dew point, precipitation, and vegetation (green in Landsat) changes.

Part 3: Select your Hypothesis
Here are some thoughts on what the 10 students in our focus test group observed in looking at the pattern in the geovisualization.

- The trade winds bringing the moisture are not able to reach the top of Mauna Kea, leading to drier air (lower dew points), less rainfall, and less vegetation.
- The colder air up high cannot hold as much moisture, and this leads to lower dewpoints, less rainfall and less vegetation.
- The porous nature of the volcanic material up high on Mauna Kea means that the rainfall just sinks into the ground, and it cannot support as much plant life.
- The Trade Wind Inversion means that the upper elevations of Mauna Kea are dominated by very dry air, producing low dew points and less rain, as well as less vegetation. Also, the descending nature of the air up high means that air does not rise. It sinks. To get rainfall, you need rising air to form clouds. Thus, there are clear skies up high on the volcano and not clouds.

Part 4 (Optional): What Scientists are Thinking
Climatologists write papers that are filled with terminology, and we do not expect you to **read this article about the Hawaiian trade wind inversion**. But even if you skim it, I think you will appreciate the link between the TWI, dry air and the upper elevations of the Hawai'i volcanoes. Certainly this supports one of the hypotheses, but the current way of thinking might be wrong. Science can only disprove. You certainly do not have to read this journal article to get the quiz question correct, but we hope that you are curious enough to at least skim it.

QUESTION: What physical geography process is the most likely explanation for the lower dew points, rainfall and vegetation at the higher elevations of Mauna Kea? The answer that is keyed as correct is based on the information you saw on the helicopter trip (dew points, Landsat image, topography, rainfall).

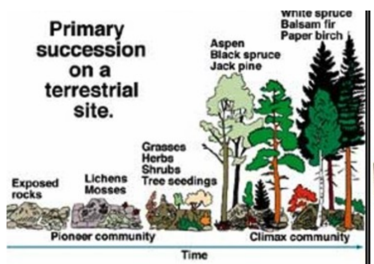
Keep in mind that we know that some students do like to think "out of the box" - and this is one of the reasons for the appeal process in the syllabus. So if you decide to present your own "out of the box" hypothesis, great, but you must be prepared to send your instructor 2 paragraphs explaining why you think the evidence supports your hypothesis. You do not get to "assert" that you think you are correct. Assertions will not "earn" you the point. You must take screenshots from the geovisualization and explain your thinking clearly with reasoning.

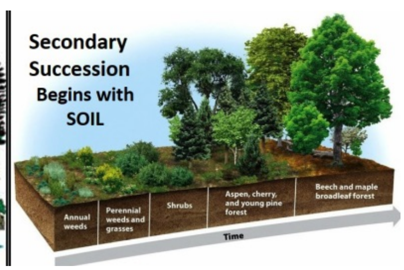
- ◯ The orographic effect means that vegetation and rainfall are more abundant at higher elevations. This is the pattern that is seen throughout the rest of the USA such as the Sierra Nevada mountains in California and the Colorado Mountains.
- ◯ The Trade Wind Inversion means that the upper elevations of Mauna Kea are dominated by very dry air, producing low dew points and less rain, as well as less vegetation.
- ◯ The Trade Wind Inversion means that the lower elevations of Mauna Kea are dominated by very dry air, producing low dew points and less rain, as well as less vegetation down low.
- ◯ Everybody knows that as you go up in elevation, the air is cooler. Cooler air means that it can rain more easily, and this produces the observed patterns.

Question 4

2 pts

Part 1: Background Information
The Big Island of Hawai'i is famous in biogeography and ecology for many reasons, but one of the top reasons involves the topic of plant succession, which is normally divided into primary (e.g. after a lava flow) or secondary (e.g. after a field of crops is abandoned):





Hawai'i with its lava flows of known age is a wonderful laboratory to understand how succession occurs after a new lava flow, because geographers have taken pictures and measurements over time -- like this pair taken 13 years apart.

Fig. 1. The 1955 Kamā`ili `a`ā flow with kipuka in background (photo by D. Mueller-575

Published in 2013
Origin of the Hawaiian rainforest and its transition states in long-term primary succession
D. Mueller-Dombois, Hans Juergen Boehmer

Fig. 2. The same Kamā`ili `a`ā flow fourteen years later with cohort of Metrosideros 580

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with a basic progression being something like this sequence:

Early development

1. A new terrestrial substrate is formed from a volcanic eruption.
2. Lower plant life-forms arrive and develop early from airborne spores (year 1).
3. Arrival of the keystone tree species follows in the form of colonizing cohorts (year 4).
4. Tree individuals are widely spaced; a mat-forming fern spreads underneath (~ 50 yr).
5. The mat-former prevents further influx of the keystone colonizer tree ("sapling gap").

Maturation

1. Tree canopy closure subdues the mat-forming fern and favors tree-fern undergrowth.
2. With the tree ferns an assortment of arborescent shrubs appear (diversity increases).
3. Tree fern trunks serve as sites for establishment of a variety of epiphytes.
4. An epiphytic start facilitates most native sub-canopy trees to become established.
5. On favorable sites the mature cohort forest remains vigorous for at least 400 yr.
6. On marginal sites the vitality of cohort stands begins to decline (~ 200 yr.)

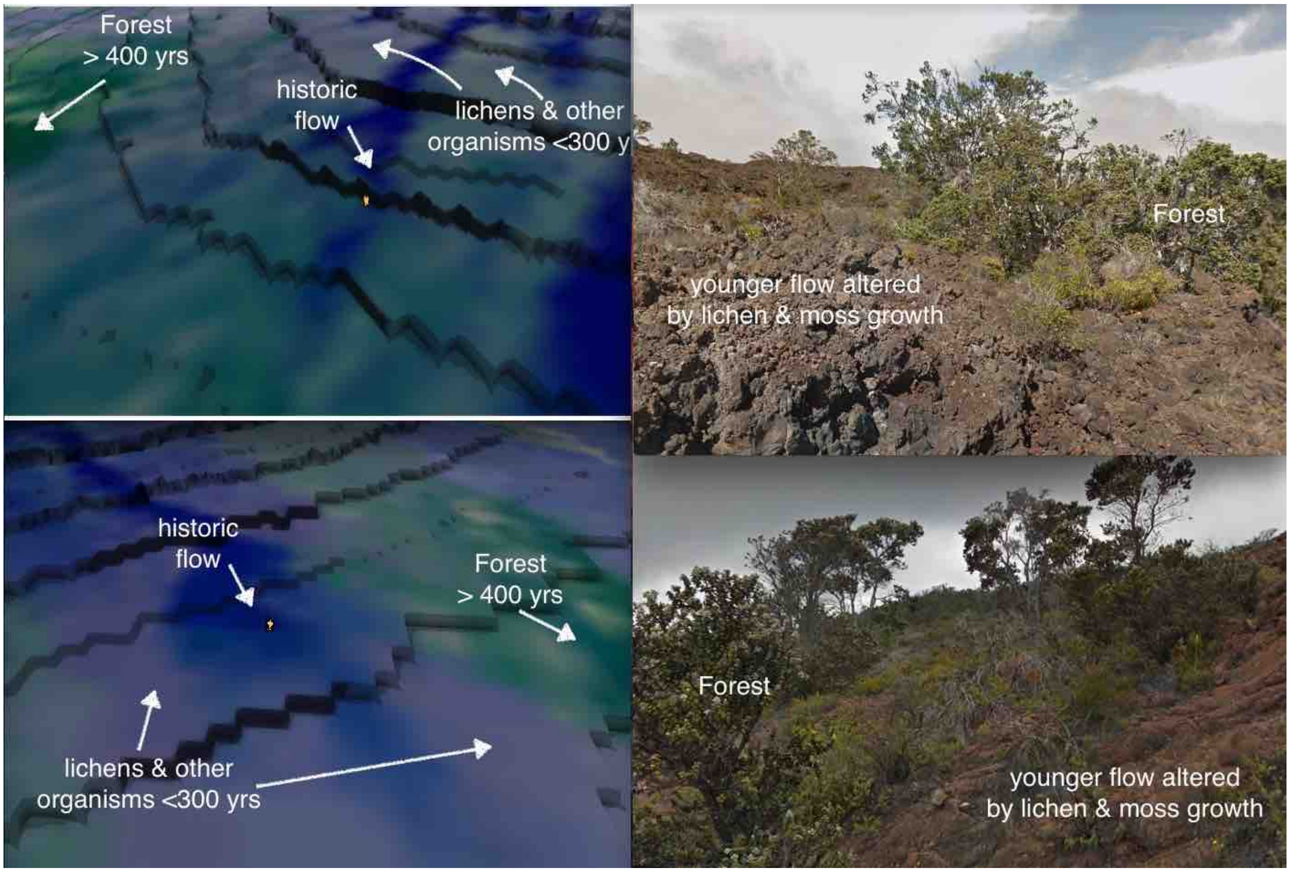
Part 2: Explore the Geovisualization

In the Hawai'i geovisualization, you will use the helicopter mode of fast travel to examine the mapped data (Landsat layer) in a region where lava flows have been active for hundreds of years on the Mauna Loa volcano

(1) use Fast Travel to jump to one side of Mauna Loa at 19.7203 and -155.2044

(2) Again, in the Fast Travel menu, select this location of Mauna Loa 19.5300 and -155.3600 [I suggest you move the air speed to the fast position and click on scale speed. This will make the helicopter go faster]. Then, click on the helicopter icon.

Feel free to make this virtual trip a few times and try to see subtle color differences as a tongue of lava flow gets older and older. The dark black coloration indicates a lava low that is historic, typically younger than 80 years. The dark green indicates a mature rainforest. But the succession changes between are more subtle, and this might help you connect the Landsat image to what would be seen on the ground:



Part 3: Select your Hypothesis

With all of the above background, the 10 students in our focus test group were not exactly sure what else they were seeing -- beside the basic pattern of dark black (recent lava flow) turning into the dark green (of rainforest). Then, after flying back and forth across this "rift zone" of Mauna Loa -- they began to see subtleties in the basic color strips (the strips being lava flows of different ages). The students described these patterns as a "patchwork quilt" of color variations within a lava flow and started speculating (making hypotheses) to explain the patchwork nature of the color shifts between recent lava flow and mature rainforest.

- The basalt lava rocks at the ups and downs (high points and depressions) decay at different rates. Depressions collect more rain, and more water breaks down the lava more quickly into soil. So when there's less bare rock and more soil the trees can colonize faster. This produces a patchwork quilt appearance when the pixel size of the landsat satellite data is 30 m squares.
- There are two types of basalt lava that are found all over Hawai'i: a'a and pahoehoe. Actually these type of textures are found associated with basalt lava flows all over the planet. The a'a lava is rough and craggy, with big blocks of hard rock and then tiny pieces of lava. The pahoehoe lava is smooth and consistently hard. So the hypothesis is that the a'a lava does not break down to produce soil at the same rate. Blocky areas have slow breakdown and slow soil formation. Areas of tiny pieces decay quicker and make soil faster. This produces a patchwork quilt appearance when the pixel size of the landsat satellite data is 30 m squares.
- Lava flow surfaces are uneven by nature, no matter the lava flow texture (a'a or pahoehoe). There are places even on the smoother pahoehoe lava where more water can collect and generate soil faster. Even these small patches of soil can allow tree germination, and then the tree roots can accelerate the process of breaking down the lava into soil. What these students described is a "positive feedback" -- where even a small area of soil can lead to tree establishment, which in turn makes soil production must faster.
- As a lava flows moves through a rainforest, the edges of the flow are not straight lines. The lava flow can leave an "island" of old trees in tact and flow around it. These are called kipuka by Hawaiians, and if there are enough kipuka that are below or even a bit bigger than the 30 meter resolution of the landat pixels, they will alter the color of a few pixels ... making them greener. Bigger areas of kipuka will have a stronger effect on the color. This could produce a patchwork appearance, even as a lava flow ages, by itself and also as an important "seed source" for the surrounding area of a new lava flow.

PICK the best answer

Part 4 (Optional): What Scientists Think
Biogeographers write papers that are filled with terminology, and we do not expect you to **read this article about the Hawaiian succession**.. But even if you skim it, I think you will appreciate the importance of how disturbance (e.g. lava flow) plays a role in plant cover.

QUESTION: What is the best explanation for the patchwork-quilt appearance of the lava flows you see in the helicopter ride? The question focuses on tiny variations in color in the lava flows you see.

Keep in mind that we know that this question has no clearly correct answer. We just want you to think for yourself... take notes ... and if your choice is marked wrong, you should just defend your hypothesis and be prepared send your instructor 2 paragraph sin an email explaining why you think the evidence supports your hypothesis. You do not get to "assert" that you think you are correct. Assertions will not "earn" you the point. Just explain your thinking clearly with reasoning.

- [ ] All of the ideas proposed by the piloting students are reasonable. They are not mutually exclusive. All of the ideas could explain the patchwork-quilt appearance seen in the 30 m resolution pixels.
- [ ] If you would like to propose an alternative hypothesis, and you are picking this keyed wrong answer and purpose, please email your instructor 2 paragraphs (supported by screenshots and reasoning) as to why you think your ideas are better.

Question 5

2 pts

The questions in this quiz have the same basic format -- well -- almost all the same. This one is different. But the idea of observing mapped data (DEM topography, landsat data, precipitation data, dew points) and just thinking about reasons to connect processes to the pattern is still the focus of this question.

This question is matching. You are tasked with going on 4 helicopter rides over natural features that are a straight line. People like to make straight lines: roads; pipelines; canals; and even sometimes straightening natural features like rivers. Physical geography processes rarely generate straight line forms. Rarely is the key word. We have identified four NATURAL (we promise these are not anthropogenic) straight line forms, with the idea of tasking you to match the line with the process.

By now, you've gotten good at fast traveling to the start of the coordinates and then taking a fast helicopter trip to the end.

Name of location listed in canvas question	Starting coordinates	Ending coordinates
Southwest Mauna Loa:	19.3350 -155.6827	19.4399 -155.6019
Hilina pali: **Hint:** pali means cliff	19.2567 -155.3600	19.3108 -155.2557
Mauna Loa southeast side. **Hint:** look at dew point layer and compare it to the line where the green stops	19.37167 -155.4669	19.1258 -155.7419
Hualalai summit ridge	19.7212 -155.9142	19.6589 -155.8110

THESE ARE THE PROCESSES LISTED (here in alphabetical order) IN THE CANVAS QUESTION TO MATCH TO ONE OF THE STRAIGHT LINES LISTED ABOVE. Canvas has big restrictions on the number of characters in a matching question -- and so we provide below longer explanations of the process

Process: a fault one, where the seaward side of the cliff is moving downward. - Pali means cliff in Hawaiian. The seaward side of this cliff is moving downward with each big earthquake moving the down block as much as a meter or more.

Process: forest stops at the upper end due the trade wind inversion - The forest suddenly ends because of the trade wind inversion, above which there is much less moisture (lower dew points) and hence much less rain than below the ending line.

Process: volcanic rift zone dominated by cinder cones- This line is located on a volcano that has characteristics of an active shield volcano (like Kilauea or Mauna Loa) and a volcano that is post shield (like Mauna Kea). Instead of being dominated by lava flows, this rift zone, has cinder cones and phreatic pits that are more characteristics of the post-shield stage.

Process: a volcanic rift zone with basalt flows - The southwestern arm of Mauna Loa is a volcanic rift zone, which is a weakness in the shield volcano allowing magma to emerge in this rifting area. Hence lava flows start at the rift and flow down the flanks on either side.

Southwest Mauna Loa	[Choose]
Hilina Pali	[Choose]
Mauna Loa southeast side	[Choose]
Hualalai summit ridge	[Choose]

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