Hawai'i Physical Geography: Precipitation Patterns

This is a preview of the published version of the quiz

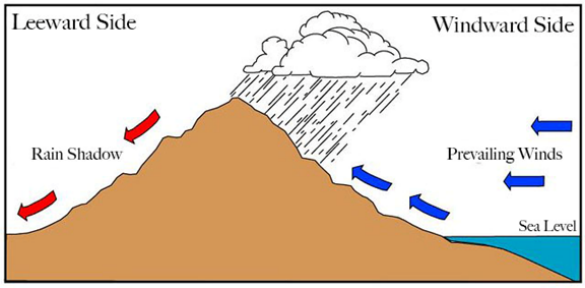
Started: May 18 at 1:56pm

Quiz Instructions

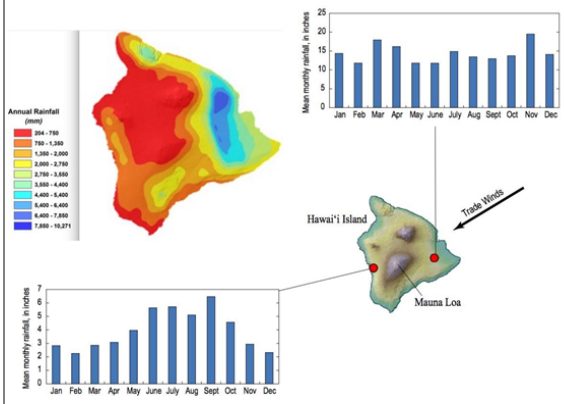
BACKGROUND INFORMATION

Over the ocean near Hawaii, rainfall averages between 25 and 30 inches a year. The islands receive as much as 15 times that amount in some places and less than one third of it in others. This is caused mainly by orographic or mountain rains, which form within the moist trade wind air as it moves from the sea over the steep and high terrain of the islands. Over the lower islands, the average rainfall distribution resembles closely the topographic contours. Amounts are greatest over upper slopes and crests and least in the leeward lowlands. On the higher mountains, the belt of maximum rainfall lies between 2,000 to 3,000 feet and amounts decrease rapidly with further elevation. As a result, the highest slopes are relatively dry.

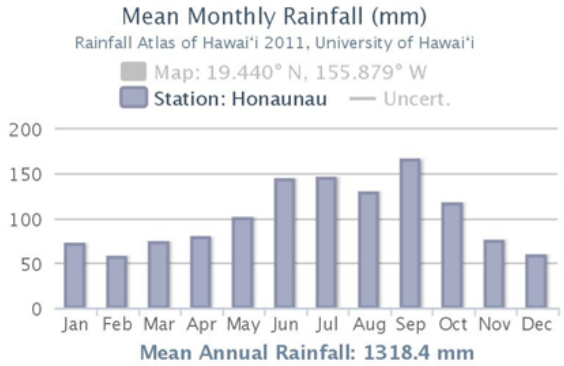
Another source of rainfall is the towering cumulus clouds that build up over the mountains and interiors on sunny calm afternoons. Although such convective showers may be intense, they are usually brief and localized.

Hawaii's mountains significantly influence every aspect of its weather and climate. The endless variety of peaks, valleys, ridges, and broad slopes, gives Hawaii a climate that is different from the surrounding ocean, as well as a climatic variety within the islands. These climatic differences would not exist if the islands were flat and the same size. The mountains obstruct, deflect, and accelerate the flow of air. When warm, moist air rises over windward coasts and slopes, clouds and rainfall are much greater than over the open sea. Leeward areas, where the air descends, tend to be sunny and dry. In places sheltered by terrain, local air movements are significantly different from winds in exposed localities. Since temperature decreases with elevation by about 3 degrees per thousand feet, Hawaii's mountains, which extend from sea level to nearly 14,000 feet, contain a climatic range from the tropic to the sub-Arctic.	 *This is a view looking north, where the eastern side is on the right. The trade winds are forced up and over a topographical barrier. The windward side will be cloudy and wet as air ascends, cools, and reaches the dew point (cloud formation occurs) The lee side will be warmer and drier as the air descends – and this is called the rainshadow.*
	The adjacent image is famous for its portrayal of the dramatic differences in rainfall on the eastern (right) and western (left) sides of Kohala volcano on the Big Island. Moist trade winds encounter Kohala's north-east facing side and are forced to rise. Rising air expands and cools due to adiabatic processes. The cooling results in condensation, cloud formation, and lots of rain. However, when this air starts descending on the southwestern side, it warms. The opposite happens. Warming leads to cloud evaporation and much less rainfall. The effect is clearly dramatic in this image taken from the Space Shuttle.

The figure to the right shows you a mean monthly precipitation at two weather stations on the windward side of Mauna Loa and on the leeward side. Please focus on the vertical scale. The amount of precipitation is a lot lower on the leeward side due to the rainshadow effect. However, in this diagram, the weather station on the leeward side is actually in one of the wetter locations on the western side of the Big island. The conditions that promote this area of more rainfall occur in summer. The summer precipitation maximum on the Kona Coast on the western side of Mauna Loa and Hualalai volcanoes (North and South Kona Districts on the Island of Hawai‘i) have a unique rainfall pattern.

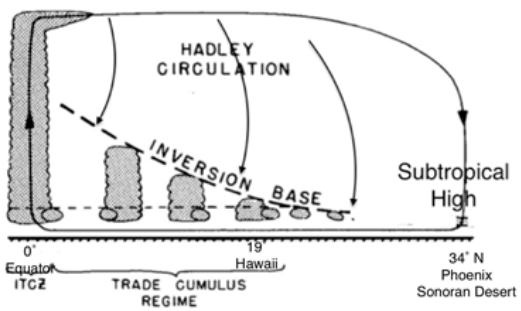


The west-facing slopes of Hualalai and Mauna Loa are sheltered from the trade winds. But, as air flows around the large mountains, it curves back on the leeward side and flows up these slopes, producing a belt of persistent clouds and rain. This area is home to the farms that produce world-famous Kona coffee.



Uplift is enhanced in the afternoons when the sun warms these slopes. Strong trade winds and intense heating during the summer also increase lifting, clouds, and rainfall on the Kona slopes. As a result, this is the only area in Hawai‘i with an afternoon rainfall peak, and with more rain in the summer than other seasons (see mean monthly rainfall at Kona station Honaunau, below and the map of Big Island winds below).

A fourth pattern to the precipitation involves the trade wind inversion.

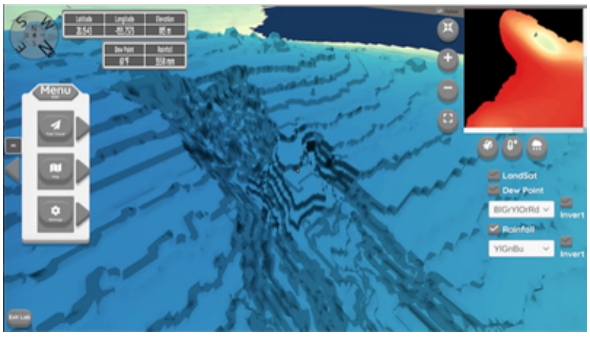
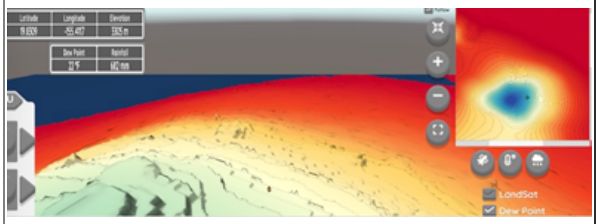
	The orographic effect is capped on the Big Island by the Trade Wind Inversion (TWI). Descending air in the Hadley circulation cell does not reach the ground at the latitude of Hawaii, but it gets close to the surface. The elevation of this TWI varies daily and seasonally, but you can see its average position very clearly in the geovisualization where the rainfall and the dew points drop off dramatically.

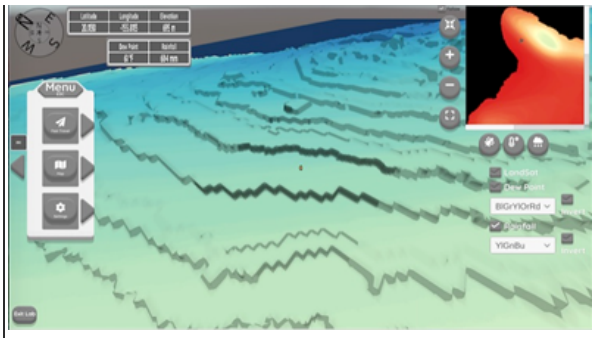
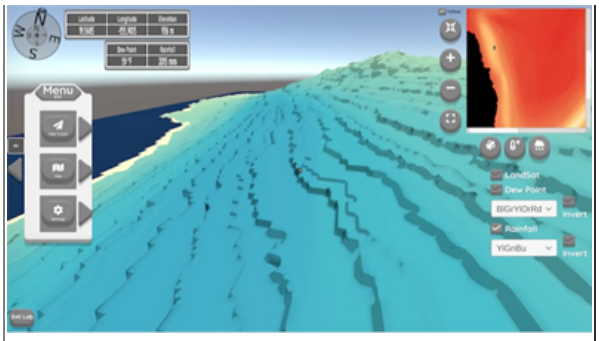
So in total, there are four explanations of the pattern you see in precipitation across the Big Island of Hawai'i. They are:

1. Orographic effects of the northeasterly trade winds
2. Rainshadow effects on the lee sides of the volcanoes
3. Trade wind inversion capping the orographic effect at a certain height
4. Land-sea interaction (afternoon sea breeze) and complex wind patterns (curving of winds around volcanoes) above Kona on the west side of the island.

EXAMPLE QUESTION:

You are given four geographic locations on the Big Island that display a different aspect of precipitation variations. Match the cause of the precipitation pattern that you see in the geovisualization to the location.

20.1543 -155.7373 (precipitation layer)  Explanation: The easterly trade winds are forced to rise when they encounter the Hawaiian volcanoes. This is called an **orographic effect**, where the rising air cools, condenses, forms clouds and enhances rainfall through this orographic (mountain forced) uplift.	19.8309 -155.4117 (dew point data layer)  Explanation: The **Trade Wind Inversion** is a key reason why precipitation amounts are so low above 2300 m on the Big Island. The trade winds and their moist marine air dominate below this altitude. However, above 2300 m, the air is descending as part of the Hadley Cell. The descending air starts at the top of the troposphere and has low amounts of water vapor and hence low precipitation amounts.
20.1130 -155.8113. (precipitation layer)	9.5685. -155.9013 (precipitation layer)

	
Explanation: **Rainshadows** are caused by descending air in the lee of a mountain range (or large volcano). The trade winds reach the top of the Hawaiian volcanoes and descend on their west side. Descending air is compressed, and this compression causes warming at a rate of 10˚C per 1000 meters. This is called adiabatic warning. Warming means that clouds can evaporate and this leads to a reduced amount of precipitation called a rainshadow.	Explanation: During summer, the North and South Kona Districts of the Big Island have **belt of precipitation on the west-facing slopes of Hualalai and Mauna Loa**. This area is sheltered from the trade winds, except as air wraps around these volcanoes, it curves back to the island and flows up slopes. Air flowing up slope cools, condenses and produces a belt of persistent clouds and rain. This uplift is enhanced in the summer afternoon as morning sun heats up the slopes, producing a sea breeze enhancement to the uplift.

Question 1

4 pts

You are given four different geographic locations on the Big Island that display a different aspect of precipitation variations. Please match the cause of the precipitation pattern that you see in the geovisualization to the location:

19.5706 -155.2118

20.0233 -155.7242

19.3522 -155.6577

19.2847 -155.8299

19.5706 -155.2118	[Choose]
20.0233 -155.7242	[Choose]
19.3522 -155.6577	[Choose]
19.2847 -155.8299	[Choose]

Not saved Submit Quiz