LABORATORY

9 Climate Controls

Introduction

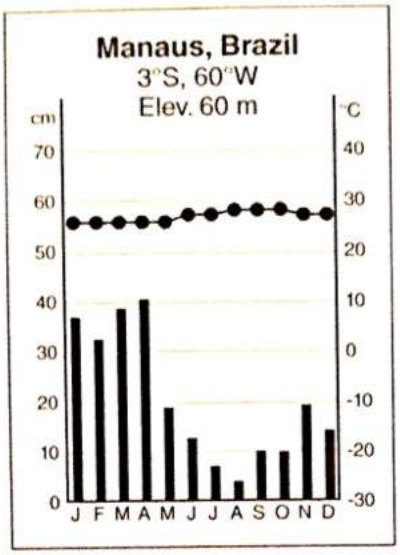
What makes Seattle so rainy and cool and Phoenix so hot and dry? Climate is the statistical weather of a place, and understanding the factors that control climate allows you to anticipate general weather patterns during the year, as well as aid in identifying anomalous weather events. For example, realtors frequently provide climate information to help their clients choose where to live and assimilate to their new environment.

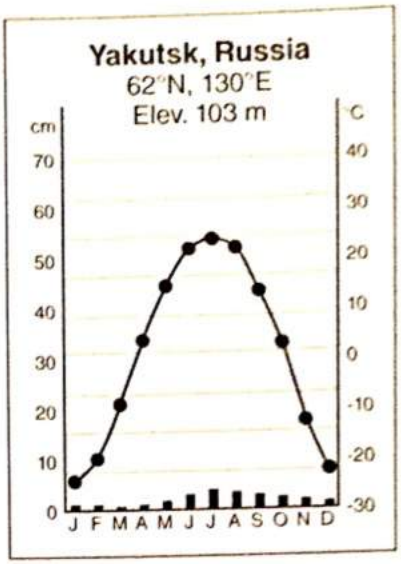
Key Terms

Climograph
Gyre
Orographic Processes
Specific Heat
Continentality
Maritime
Köppen Classification
Rainforest
Monsoon
Mediterranean

Climographs

The average weather of a place is graphically depicted on a **climograph.** A climograph plots the average monthly temperature with the scale on the right as a line graph, and the average monthly precipitation with the scale on the left as a bar graph. Climographs demonstrate more than statistics. Representing climate in this manner reveals seasonal variations in temperature and precipitation and allows estimation of other conditions such as growing seasons.





1. Which location would support a year-round growing season? Which data support your conclusion?

2. Which location's citizens would likely own both heavy winter jackets and bathing suits? Which data support your conclusion?

3. Plot a climograph for Kailua Kona, HI, and a climograph for Hilo, HI. Both cities are located on the island of Hawaii, approximately 65 miles apart. The x-axis is month; one y-axis is used for temperature, and one y-axis is used for precipitation.

Kailua Kona, HI, 19°39′ N, 156°00′ W, 29 feet elevation

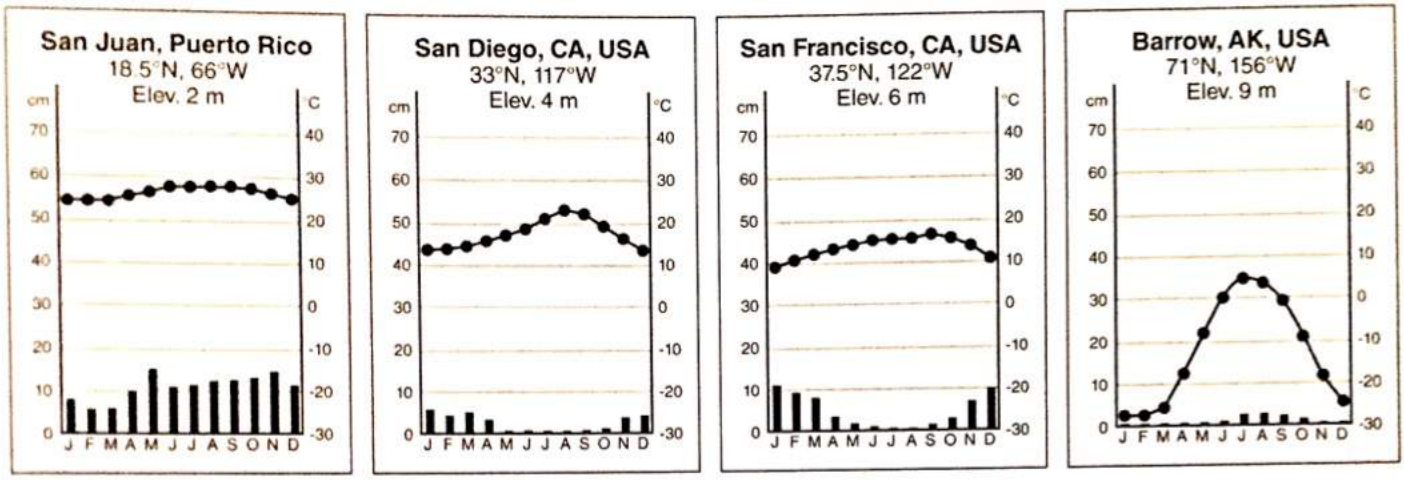
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
°F	72.9	72.9	74.3	75.7	77.4	79.3	80.4	81.3	81.0	79.5	77.2	73.9
Inch	2.7	1.5	2.0	2.1	2.5	1.9	2.5	1.9	2.0	1.8	1.8	1.5

Hilo, HI, 19°42′ N, 155°03′ W, 26 feet elevation

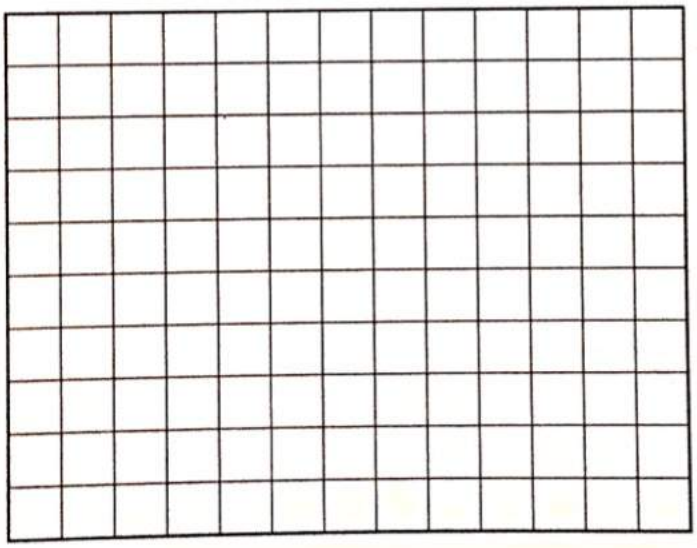
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
°F	71.6	71.6	72.0	72.7	73.8	75.2	75.7	76.3	76.1	75.6	74.1	72.3
Inch	9.0	11.5	14.0	13.8	9.5	6.3	10.0	10.7	7.8	9.7	14.6	11.1

Latitude

Latitude is the fundamental global climate control, controlling the seasonal range in solar intensity. The progression of the solar declination creates a surplus of energy in the tropics, and a deficit of energy near the poles. This imbalance is the driving force behind the Earth's atmospheric and oceanic circulation patterns.



4. Calculate the annual temperature for each of the four locations above (annual temperature = (maximum temperature + minimum temperature) / 2). Create a plot showing the relationship between the average annual temperature and latitude on a scattergram, using appropriate labels, units, and scales.



5. What is the relationship between latitude and annual temperature?

6. Is longitude as important as latitude in controlling climate? Why or why not?

Ocean Currents

Gyres are large circular ocean currents that serve to redistribute heat across the globe (Figure 9.1). These large circulation cells are the result of warm tropical water piling up and moving in the direction of surface winds. Generally, warm tropical currents move along the east coasts of continents, and cold polar currents move along the west coasts of continents. As the ocean exchanges heat with the overlying atmosphere, sea surface temperatures influence air temperatures.

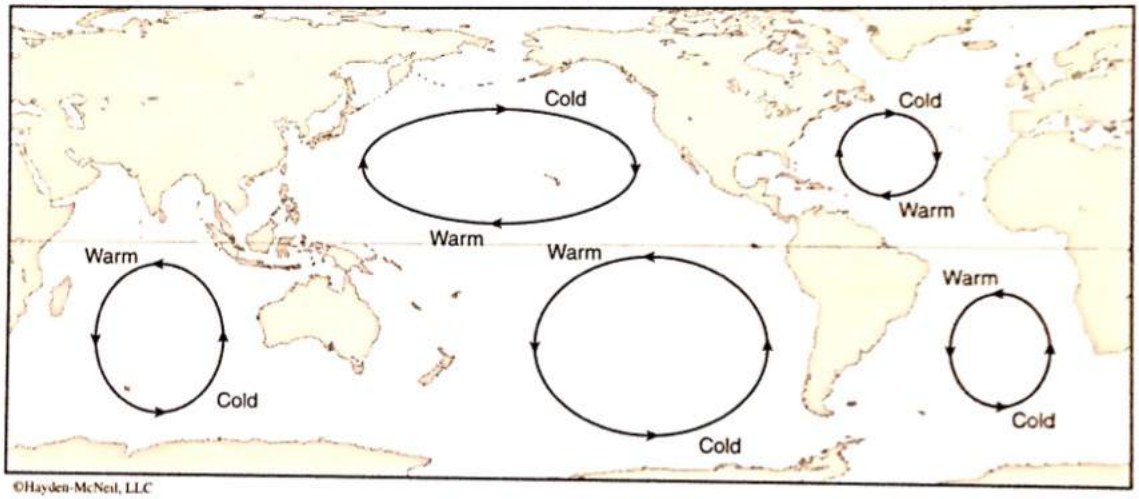
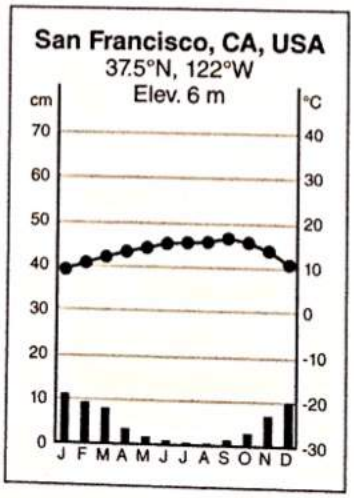
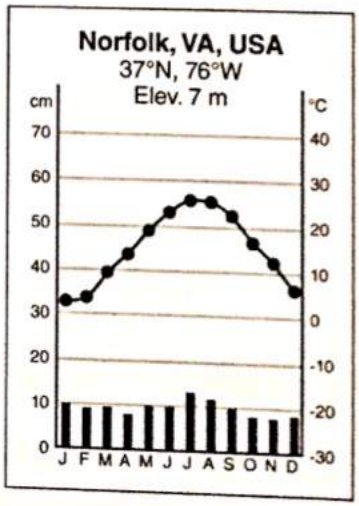


Figure 9.1. Gyres in the Atlantic Ocean. Insolation, wind, gravity, and the Coriolis effect cause clockwise oceanic circulation in the Northern Hemisphere, and counterclockwise oceanic circulation in the Southern Hemisphere.





7. Considering the climographs, which location is impacted by a cold ocean current? What evidence supports your conclusion?

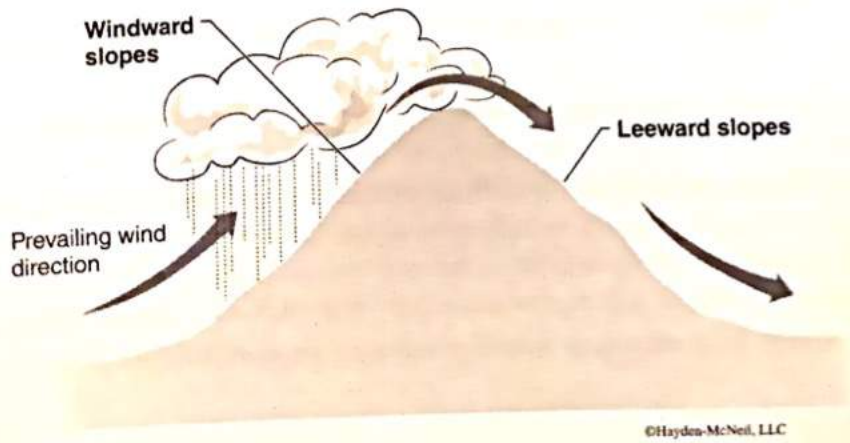
8. Would the currents in these two coastal locations also impact precipitation? Why or why not?

Topography

The presence of large topographic barriers such as mountains plays a tremendous role in determining the climate of certain places. On the windward side of mountains, the air is forced to ascend (rise) and cool adiabatically. **Adiabatic** cooling (or warming) refers to the change in temperature that occurs without the loss or gain of energy. As elevation increases, atmospheric pressure decreases, causing air molecules to expand as they rise, and thus cool; and condense as they sink, and thus warm.

When topographic barriers force air upward, called **orographic lifting**, air can quickly cool to the **dew point temperature** (the temperature at which dew forms, or saturation) and **orographic precipitation** on the windward side of the mountain will occur. The altitude at which the dew point is reached is known as the lifting condensation level (LCL). Because all the precipitation is released on the windward side (think of wringing out a sponge), *as the air moves to the leeward side it is completely dry even though it is below the dew point temperature*. The dry air is then forced to descend (sink) on the leeward side of the mountain, and thus warm, adiabatically.

The resultant climates and vegetation can be particularly distinctive. For example, giant sequoias grow in Yosemite National Park, which is located on the windward side or wet side of the Sierra Nevada range. The Joshua tree yucca grows in the Mojave Desert, located on the leeward side or dry side of the Sierra Nevada range. The term rain shadow refers both to the leeward side of mountains and the extent of dry area beyond.



9. Using either the Dry or Wet adiabatic lapse rate, calculate the adiabatic cooling and warming of the air parcel as it is forced over a mountain. Assume the dew point temperature remains constant. Fill in Figure 9.2 with the corresponding air temperatures.

Dry Adiabatic Lapse Rate = 10°C/1 km (5°C/0.5 km)

Wet Adiabatic Lapse Rate = 6°C/1 km (3°C/0.5 km)

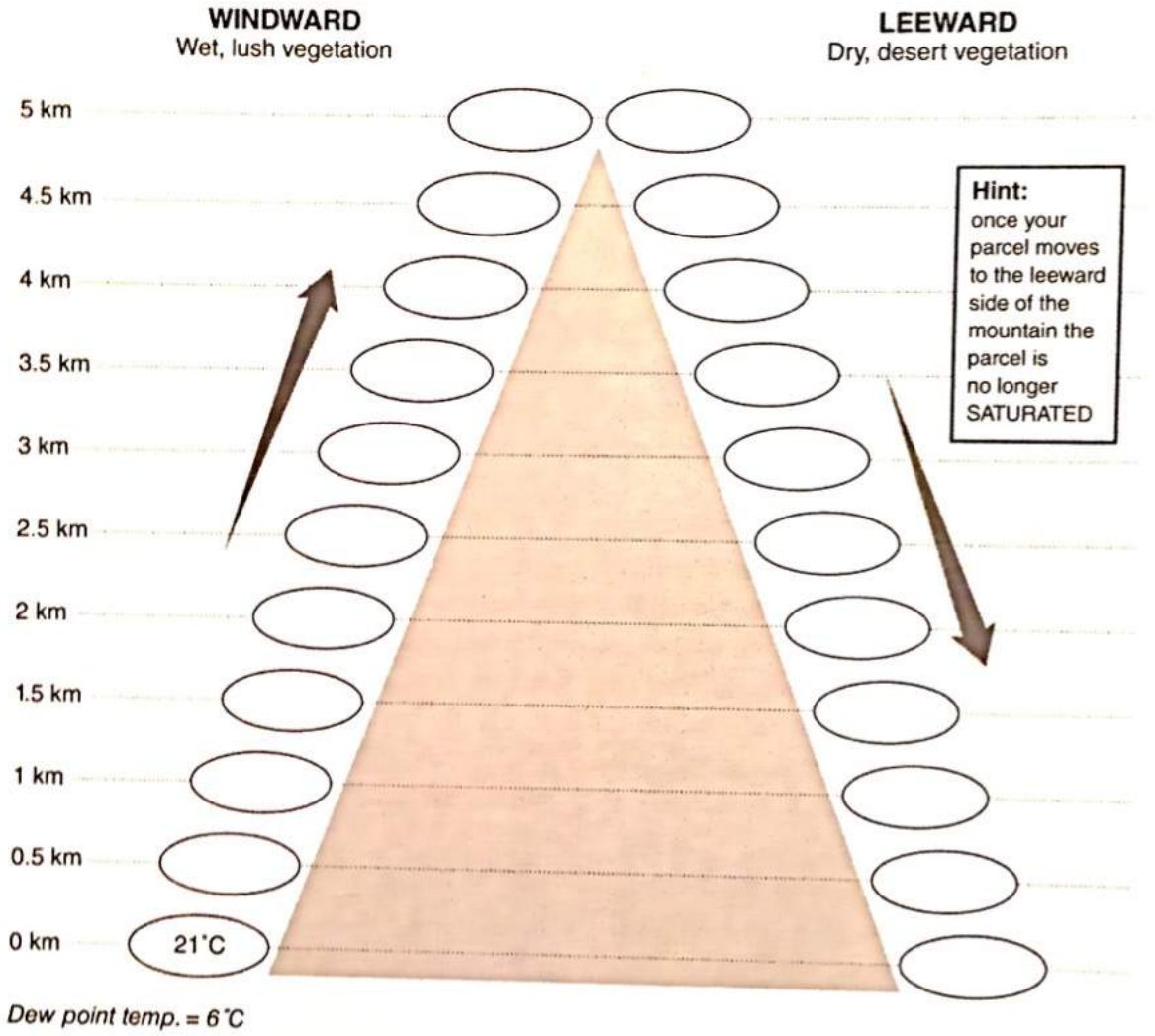


Figure 9.2. *Cooling and warming of an air parcel as it is forced over a mountain.*

Answer the following questions using your answers in Figure 9.2.

10. What is the height of the lifting condensation level (LCL)?

11. Above what elevation would you expect snow to form?

12. Describe the climates on the windward and leeward sides of the mountain in terms of moisture and temperature.

    Windward: _____

    Leeward: _____

13. What representative vegetation would you expect to find in the contrasting climates on each side of the mountain?

    Windward: _____

    Leeward: _____

With your knowledge of topographic barriers and climate, review your climographs of Kailua Kona and Hilo.

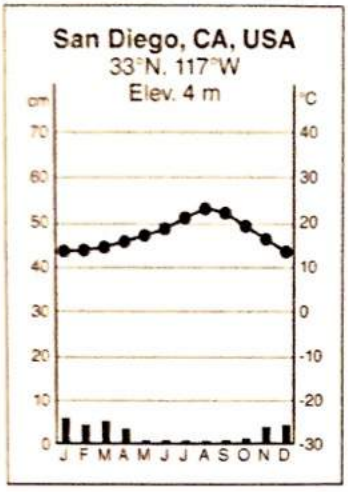
14. Which location is on the windward side of Hawaii? What evidence supports your conclusion?

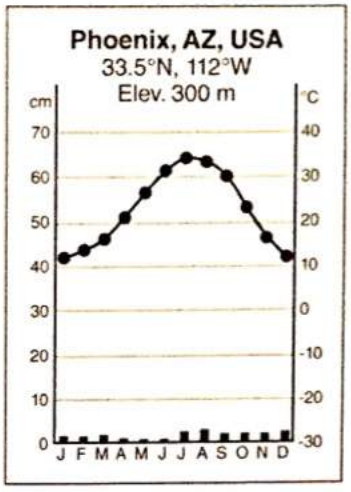
15. What physical feature must be present on the island of Hawaii to cause the difference in precipitation between the two locations?

Distribution of Land and Water

Specific heat is the amount of energy required to raise the temperature of 1 gram of a substance by 1° Celsius. Water has the highest specific heat, an average of five times higher than most land surfaces. This translates to water requiring five times more energy input than land to raise its temperature by 1° Celsius.

Due to the differences in specific heat, land surfaces heat up to five times faster but also cool up to five times faster than water surfaces, which impacts the **continentality** of a location. Continentality occurs at locations far removed from large bodies of water, and is noted by large annual and diurnal temperature ranges, the representation of the dramatic heating and cooling that can happen in arid locations. **Maritime** climates tend to have smaller annual and diurnal temperature ranges due to the moderating impacts of the surrounding water body.





To answer questions 16 and 17 in this section, you must first convert both the maximum and minimum temperatures to degrees Fahrenheit, then subtract the minimum temperature from the maximum temperature to obtain the correct answer.

16. What is the annual temperature range (maximum–minimum), in San Diego? Give your answer in Fahrenheit.

17. What is the annual temperature range (maximum–minimum), in Phoenix? Give your answer in Fahrenheit.

18. Urban lakes, canals, and swimming pools surround Phoenix, so would it still be considered continental? Why or why not?

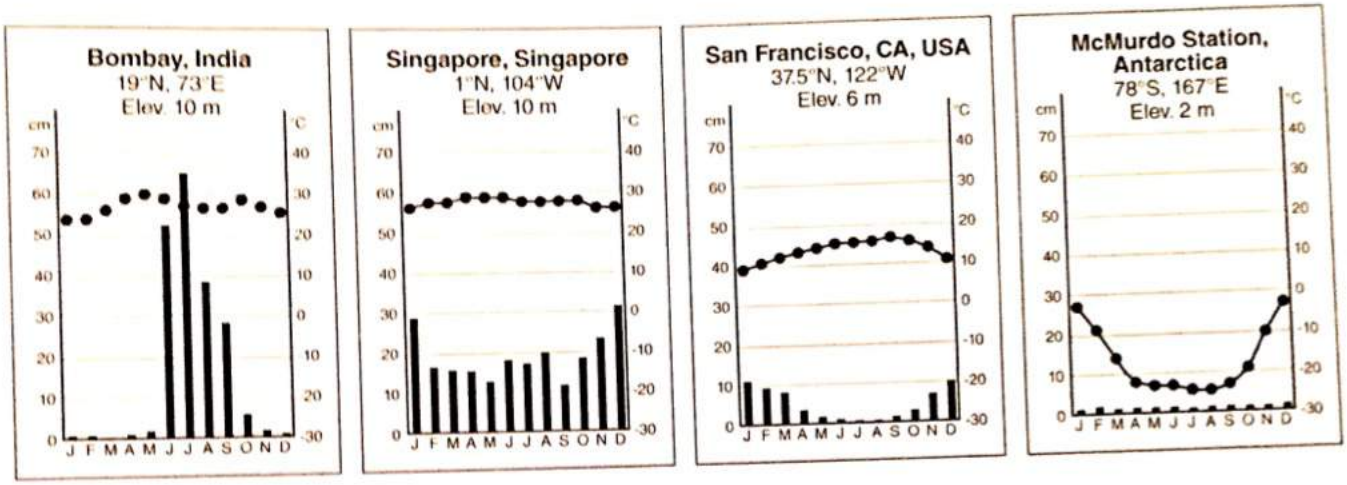
Review your climographs of Kailua Kona and Hilo.

19. Would these locations be considered maritime or continental? In what ways are the climates of these two Hawaiian cities impacted by topography and land–water distribution (maritime or continental)?

20. Does latitude also contribute to the climates of Kailua Kona and Hilo? Explain the evidence that supports your conclusion.

Köppen Climate Classification

The Köppen climate classification system allows ready identification of particular climates through temperature and precipitation patterns. A rainforest (Af) climate experiences precipitation in excess of 6 cm every month of the year. A Mediterranean (Csb) climate is noted by a summer drought. Monsoon (Am) climates result from a seasonal reversal of the winds, and are portrayed by a tremendously wet warm season. Extremely cold temperatures designate a polar (E) climate.



21. Which location has a rainforest climate?

22. Which location has a Mediterranean climate?

23. Which location has a monsoon climate?

24. Which location has a polar climate?