CHAPTER

24 Patterns of Climate

WORDS TO KNOW

arid climate	**deforestation**	**temperate climate**
climate	**maritime climate**	**urbanization**
continental climate		

This chapter will help you answer the following questions:

1. What do we mean by climate?
2. What natural and human geographic factors influence the climate?
3. How does the geography of New York State affect its climate?
4. How can we use graphs to compare the climates of different locations?
5. Why is Earth getting warmer?
6. How can humans speed or slow climate change?

ARE CLIMATES CHANGING?

4: 2.2d

A century ago, 150 glaciers covered the mountains of Glacier National Park in Montana. Today, only 27 glaciers remain. Meanwhile, the remaining glaciers are melting back so quickly that scientists estimate all could be gone in 20 years. The shrinkage in glacial ice is a worldwide event. However, a few glaciers are holding their own.

Measuring global climate change is not easy. The nature of global climate change is subtle. Scientists must take into account the natural cycles of temperature change. Nevertheless, analysis of ocean surface temperatures clearly shows a worldwide warming trend. This trend goes back to the beginning of the Industrial Revolution 130 years ago, as you see in Figure 24-1.

Within the ice of Earth's major glaciers is a record of past climates that goes back nearly half a million years. The thickness of annual layers and the crystal structure of the ice tell scientists about conditions of precipitation and temperature in the distant past. Air was trapped in the snow before it was buried within glaciers. Just as rock layers preserve a record of Earth's history, glaciers preserve a record of Earth's atmosphere. Visit the following Web site to view global warming experiments and watch and play games from NASA: ***http://earthobservatory.nasa.gov/Laboratory/PlanetEarthScience/GlobalWarming/GW.html***

Polar glaciers, especially in Antarctica, hold much of Earth's surface water. As a consequence of severe global warming, these glaciers would melt. The coastal regions of Earth would be flooded by

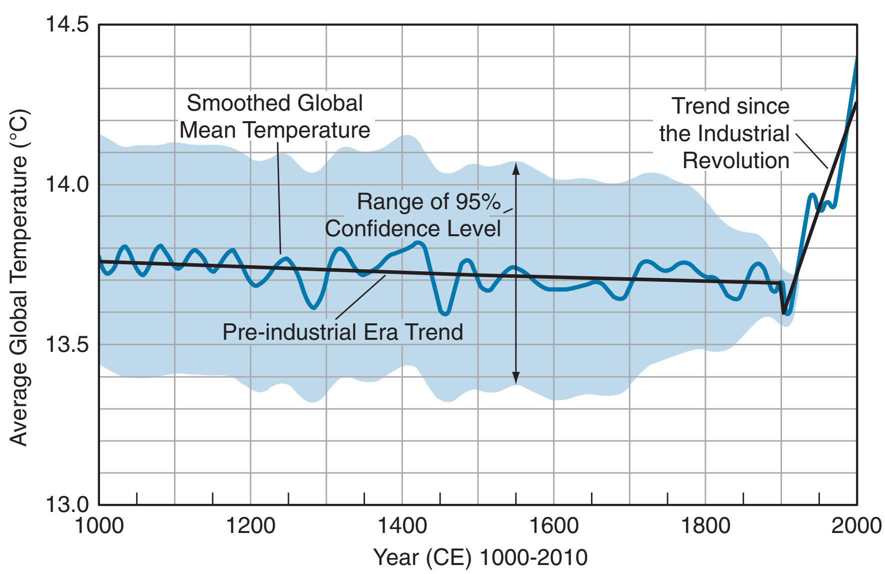


FIGURE 24-1. For most of the past 1000 years, Earth's average temperature has been very slowly decreasing. However, since the Industrial Revolution and our large-scale use of fossil fuels, the pattern has changed dramatically. In the past century we have seen an alarming spike in global temperatures.

rising sea levels. Antarctica holds enough ice to cause sea level to rise about 800 m (240 ft) worldwide. This would flood most of the world's largest cities, including Tokyo, Japan; Jakarta, Indonesia; and New York City. Visit the following Web site to work with interactive flood maps. These maps ask you to input a level of sea surface rise just from 1 to 14 m (3 to 50 ft) to see coastal flooding. *http://flood.firetree.net*

STUDENT ACTIVITY 24-1 —EFFECTS OF RISING SEA LEVELS

1: MATHEMATICAL ANALYSIS 1
6: MAGNITUDE AND SCALE 3

Estimate the total number of people who would need to move due to rising sea levels if the glaciers of Antarctica were to melt. How much do the estimates of different students differ and why are they different?

WHAT IS CLIMATE?

4: 2.1h, 2.1i

Weather describes the atmospheric conditions at a particular place and time, perhaps over a period of hours or days. **Climate** is the average weather based on measurements made over many years. Temperature and precipitation are the main elements of climate. However, humidity, winds, and the frequency of storms are also important. The normal seasonal changes in these factors are a part of climate as well. Scientists base their understanding of the climate of an area primarily on historical records. The more observations and the longer they have been kept, the more accurately scientists can describe the climate.

Scientists classify climates according to temperature. Tropical climates are usually warm. **Temperate climates** include large seasonal changes. Polar climates are usually cold. Scientists combine humidity and precipitation when describing a humid climate or **arid** (dry) **climate**. Visit the following Web site to see extreme records temperatures and ranges in the USA: *http://ggweather.com/climate/extremes_us.htm*

The plants found in an area are an indication of the climate. Rain forests, deserts, grasslands, and tundra are terms that describe both vegetation and climate. As you can see in the two images in

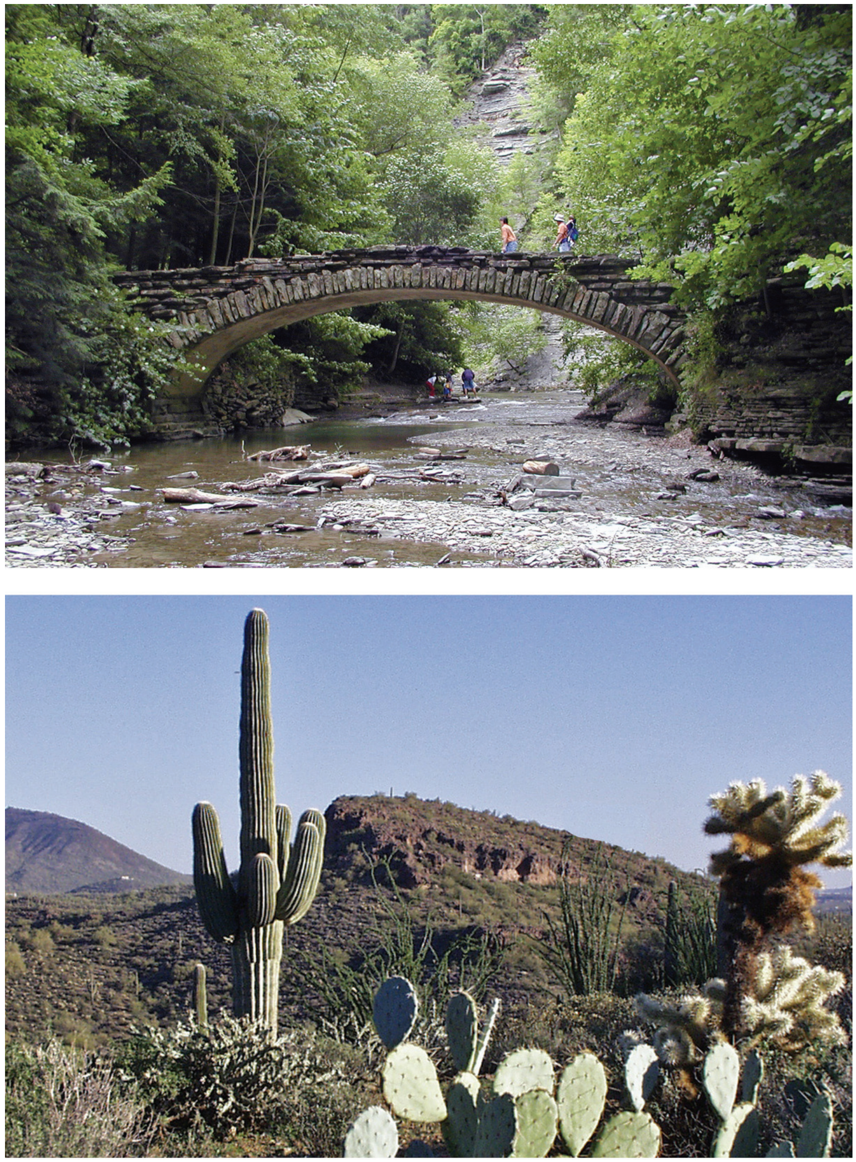


FIGURE 24-2. The kinds of vegetation in these images indicate two very different climates. How is the vegetation in each of these locations adapted to the local climatic conditions?

Figure 24-2, the leafy green trees indicate that this is a temperate climate. The cactus tells you that you are looking at a desert. Places where the natural vegetation changes are probably affected by changes in climate. Figure 24-3, on page 582, is a map of North American climates characterized by temperature, precipitation, and seasonal changes.

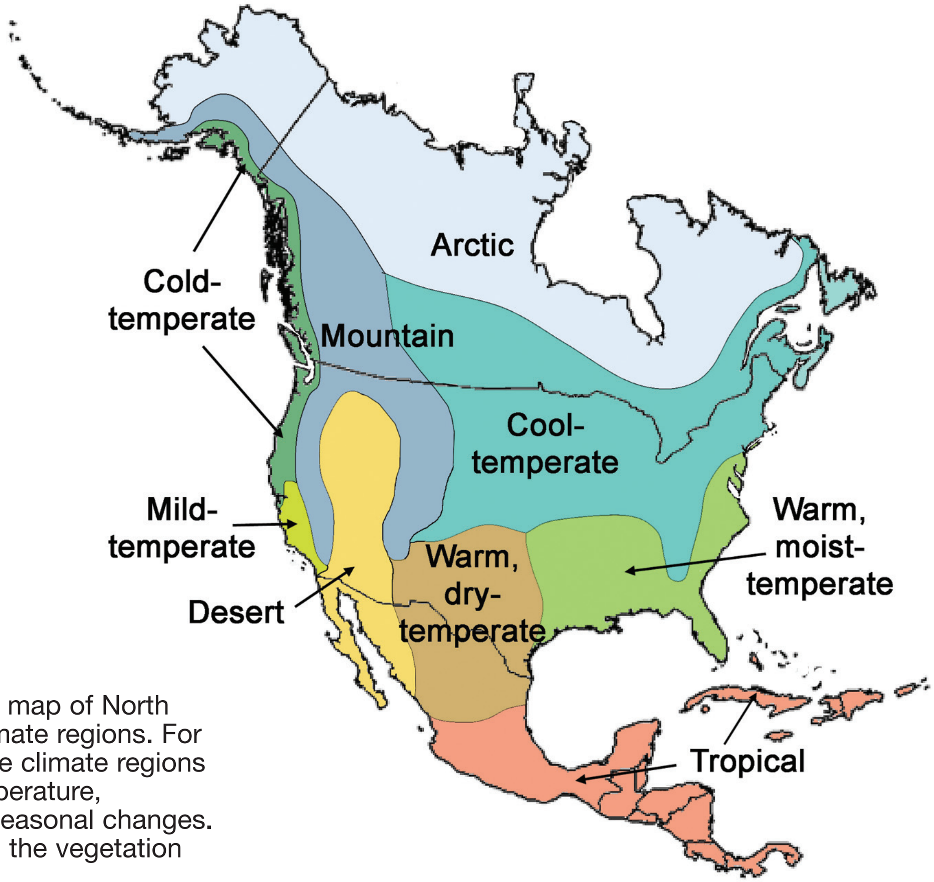


FIGURE 24-3. This map of North America shows climate regions. For the most part, these climate regions are labeled by temperature, precipitation, and seasonal changes. Within each region, the vegetation tends to be similar.

HOW DOES LATITUDE AFFECT CLIMATE?

4: 2.2c

Climate zones circle Earth at specific latitudes. Latitude determines the angle of insolation. The angle of insolation affects the temperature, which influences the climate. Latitude also has a role in precipitation.

Temperature

Variation in the intensity of insolation (sunlight) is the major cause of temperature differences over Earth's surface. In the tropics, where the noon sun is always high in the sky, solar energy is most intense. At the poles, where the sun is never high in the sky, solar energy is least intense.

TROPICS The tropics are sometimes called the latitudes of seasonless climate. Although the noon sun is a little higher in the sky

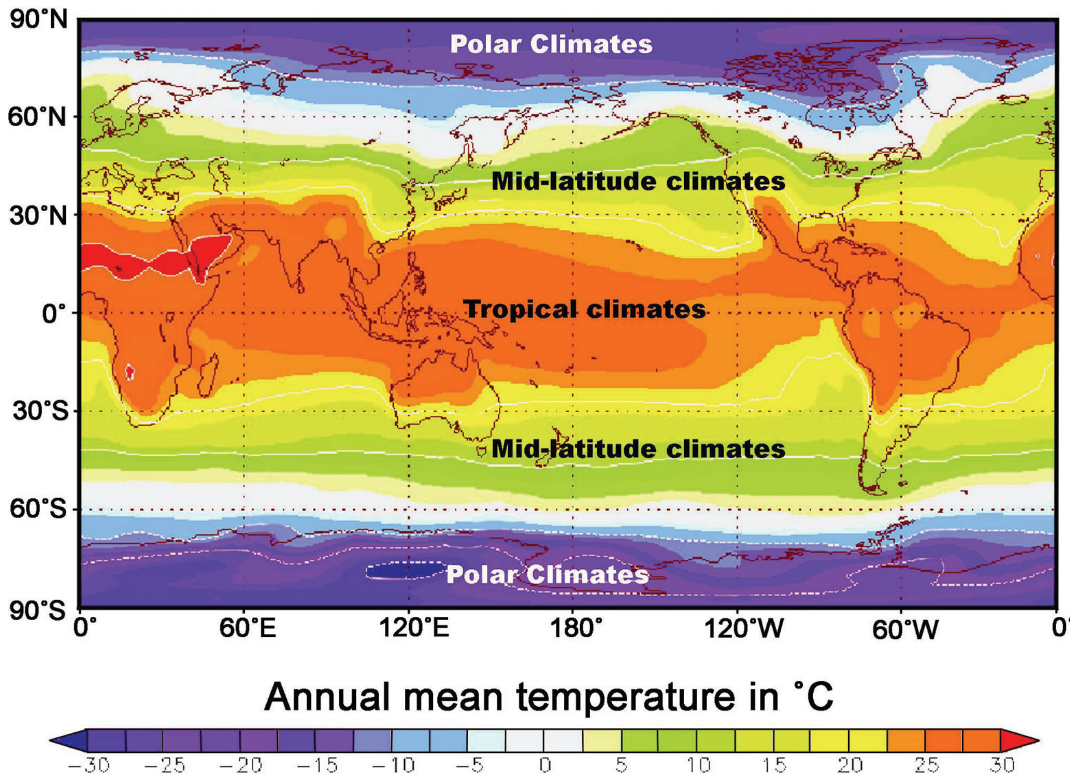


FIGURE 24-4. The temperature zones on planet Earth are mostly a function of latitude. Places near the equator receive the most direct sunlight while the poles receive far less solar energy.

in some parts of the year than in others, the change is small. The seasonal change in the length of daylight is also very small—in fact, hardly noticeable at all. Therefore the intensity of solar energy changes very little throughout the year. Except for high mountain locations, the weather is always warm.

The tropics extend from the Tropic of Cancer 23.5° north of the equator to the Tropic of Capricorn 23.5° south of the equator. (See Figure 24-4.) Here sunlight passes through the minimum thickness of Earth's atmosphere; so relatively little heat energy is lost within the atmosphere.

MID-LATITUDE Locations such as New York State have seasonal climates due to the annual cycle of changes in insolation. These are called temperate climates because the average temperature is neither hot nor cold. The largest seasonal changes actually occur in the mid-latitudes. The seasons in the Northern Hemisphere are the reverse of those in the Southern Hemisphere. When it is summer in the Northern Hemisphere, it is winter in the Southern Hemisphere.

STUDENT ACTIVITY 24-2 —GRAPHING AVERAGE MONTHLY TEMPERATURE

1: MATHEMATICAL ANALYSIS 1, 2, 3

Construct a single graph to show the average monthly temperature at three North American cities for a period of 1 year. Select cities at or near sea level. One location should be in Central America, a second in the main part of the United States, and the third in Canada or Alaska. What does your graph show about latitude and climate?

POLAR REGIONS The polar regions are generally cooler than other regions throughout the year. Nevertheless, they do experience large seasonal changes. In the winter, the days are very short and the sun, if it is visible, is always low in the sky. Insolation is extremely weak and temperatures may stay below freezing for months at a time. Even the summer sun is not very high in the sky, but the number of hours of daylight in the summer is very long. Because there is a large difference in the strength of insolation between winter and summer, most high-latitude locations are much warmer in the summer than they are in the winter. The interior of Alaska has bitter cold winters. However, even in central Alaska, summer temperatures can reach 30°C (about 90°F) at the height of summer. Visit the following Web site to see NOAA Online Weather and Climate Data: ***http://www.weather.gov/climate/***

Precipitation

Rainfall is generally plentiful in the tropics. Most of Earth's desert regions occur roughly 30° north and south of Earth's equator. Another zone of abundant precipitation can be found another 20 degrees or so from the equator. But why do these parallel zones of deserts and plentiful precipitation circle Earth?

These patterns are a result of Earth's rotation acting on terrestrial winds. You learned earlier that instead of one big convection

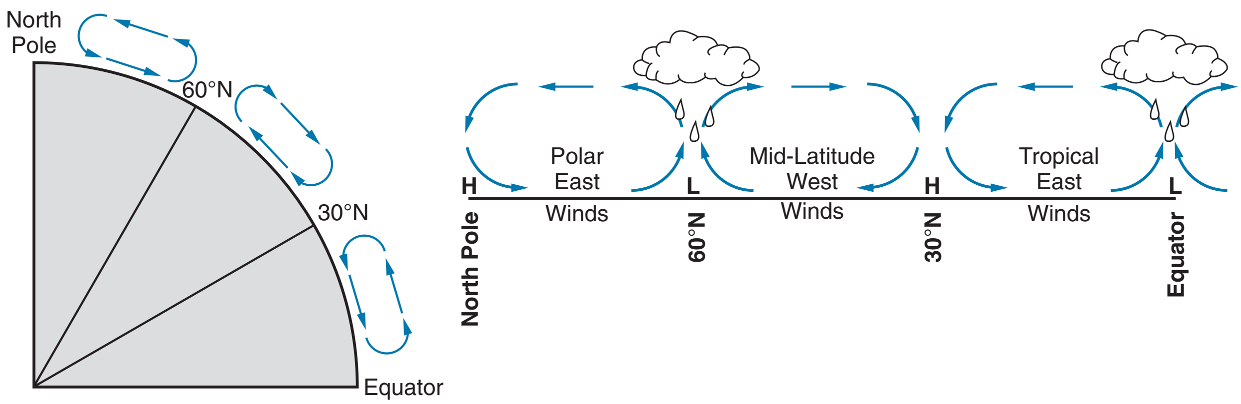


FIGURE 24-5. Places where rising air dominates experience more cloud formation and precipitation. Zones of descending air create high-pressure zones at the surface that have little precipitation.

cell in each hemisphere, the Coriolis effect forms three convection cells in each hemisphere.

The rotation of Earth and the position of the continents break convection in the Northern Hemisphere into three cells. The three convection cells are shown on the Planetary Wind and Moisture Belts diagram in the *Earth Science Reference Tables.* Figure 24-5 is a representation of part of that diagram. The left side of the diagram is a profile of Earth showing convection cells in the Northern Hemisphere. The diagram on the right shows Earth's surface as flat, the way it looks as you stand on it. Along the equator and at about 60° north latitude, air rises, forming low-pressure regions that circle Earth. The rising air causes cloud formation and generous precipitation at these latitudes. However, at latitude 30°N and at the North Pole (90°N) are regions of high pressure where sinking air warms and gets drier as it is compressed by atmospheric pressure. These latitudes have low relative humidity and relatively little precipitation. The 90° segment shown in Figure 24-5 is one of four similar profiles that circle Earth.

These high- and low-pressure belts are not still. Seasonal changes cause them to shift toward the equator in the winter and toward the poles in the summer. Furthermore, the wandering jet streams move these regions of high and low pressure and interrupt them with the passage of storm systems. Other geographic features you will soon read about also influence patterns of precipitation.

WHAT OTHER GEOGRAPHIC FACTORS AFFECT CLIMATE?

4: 2.2c, 2.2d

In addition to latitude other factors, such as elevation, nearness of large bodies of water, winds, and ocean currents, affect climate.

Elevation

The average temperature of a location is related to its elevation. The higher the elevation, the lower the average temperature will be. As rising air expands, it becomes cooler. Perhaps you have noticed that high mountains are often snow covered, even in the summer. Mount Chimborazo, shown in Figure 24-6, and Mount Kilimanjaro in Africa are near the equator. However, these mountains have permanent snow cover near their summits. Nearby locations at lower elevation have a tropical climate where it never snows. Rising dry air cools at a rate of about 1°C/100 m (4°F/1000 ft). Dry air warms at the same rate as it descends.

Mountain Barriers

Mountain ranges affect patterns of precipitation and temperature. Moist winds off the Pacific Ocean blow across California and rise up the western side of the Sierra Nevada Mountains. As the air rises into the mountains, it expands and cools below its dew point. This leads to cloud formation and precipitation. On the western side of the Sierra Nevada Mountains, the climate is cool with abundant precipitation. Seattle and the coast of northern California have a temperate, moist climate.

The air descends on the eastern side of the mountains. The air is compressed by increasing barometric pressure and becomes

FIGURE 24-6. Mount Chimborazo in South America is nearly on the equator. Yet, it is always covered with snow and ice. This occurs because air cools when it expands as it rises up the mountain.

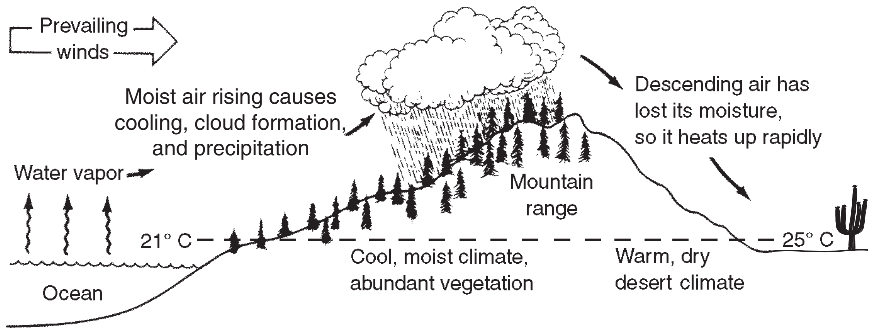


FIGURE 24-7. Cloud formation and precipitation usually occur on the windward side of a mountain range where moist air rises and cools. On the downwind side, descending air is warmed by compression, so the relative humidity quickly drops, generating an arid climate.

warmer. As the descending air warms without picking up moisture, its relative humidity decreases. Inland cities such as Spokane, Las Vegas, and Phoenix are located in the desert climate zone. Climate on the downwind, or leeward, side of mountains is sometimes called a "rain shadow" climate. Figure 24-7 illustrates the difference between climates on the opposite sides of a mountain range.

As moist air rises into the mountains, condensation (cloud formation) releases energy. This slows the rate of cooling. When clouds form, the air cools at a lower rate of about 0.6 C°/100 m (2°F/1000 ft). The descending air cannot pick up moisture. Therefore, the air heats at the greater, dry air rate of 1°C/100 m. Figure 24-8 illustrates this difference.

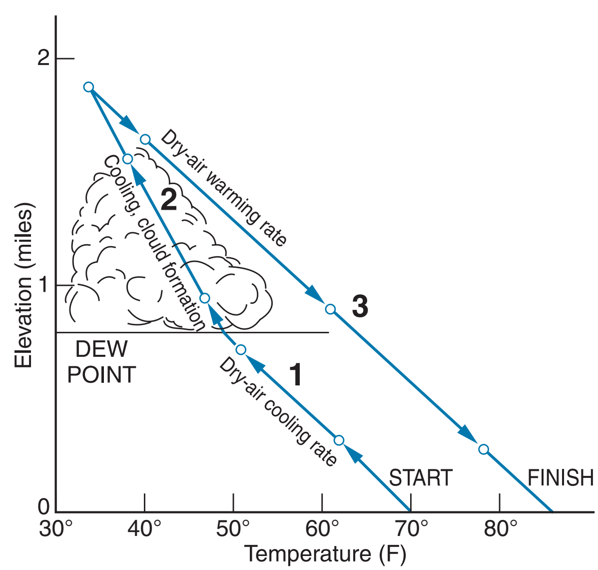


FIGURE 24-8. (1) As air rises, it expands and cools quickly. (2) When clouds form in the rising air, condensation releases the energy stored in water vapor, slowing the rate of cooling. (3) When the air sinks to a lower elevation and becomes warmer, there is no change in state to slow the rapid warming rate.

Large Bodies of Water

The Atlantic Ocean and Long Island Sound moderate the climate of New York's Long Island. Therefore, on Long Island, winters are usually warmer and summers cooler than in other parts of the state. This is especially true for places along the coast when the winds are off the ocean.

The inland regions of New York State experience the highest and lowest temperatures. The lowest temperature ever recorded in New York State was −47°C (−57°F) at Old Forge in the Adirondack Mountains. The record high temperature in New York State was measured in the capitol district: 42°C (108°F) at Troy. Both places are far from the moderating influence of the Atlantic Ocean and the Great Lakes.

STUDENT ACTIVITY 24-3 —MODELING TEMPERATURE CHANGE

6: MODELING 2

You can model the temperature changes over land and water using two containers. Fill one about a third full of sand and the other a third full of water. Place thermometers in both containers just above the sand or water surface. Be sure both thermometers stay completely dry! Position a lamp so it shines equally on both containers. For best results shield the thermometer bulbs from direct light. Compare the temperature changes in both containers.

Why do the oceans have such a great effect on climate? As you learned in Chapter 21, *specific heat* is a measure of the ability of a substance to warm as it absorbs energy or cool as it gives off energy. In general, metals and rock have low specific heats. They heat up and cool down rapidly. However, water has a very high specific heat. It heats and cools slowly.

Winds off the oceans or the Great Lakes, such as Lakes Erie and Ontario, control the temperature of nearby land areas. Even the winds off the Finger Lakes have some moderating affect. All these areas are cooler in summer and warmer in winter than places farther from the water.

There are three other reasons that land areas experience greater changes in temperature than the oceans. First, because water is

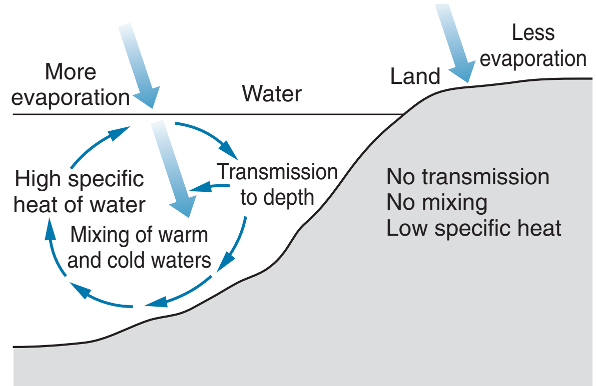


FIGURE 24-9. The ability of the oceans to absorb more heat energy than land absorbs is influenced by three factors: the relatively high specific heat of water, the depth of light penetration, and convective circulation of the water.

relatively transparent, sunlight penetrates deeper into water than it does on land. Rock and soil are opaque, so insolation energy is concentrated at the surface. Second, water is a fluid, so convection currents can distribute energy to the interior. Solids have no ability to mix. Finally, evaporation from the oceans uses some of the solar energy that would otherwise heat the oceans. Although there is some evaporation of water from soil, it is far less than evaporation from the oceans. Figure 24-9 summarizes these factors.

Scientists classify most terrestrial climates as maritime or continental. **Continental climate** is typical of inland areas. It is characterized by large seasonal changes in temperature. Inland areas generally do not experience the moderating influence of large bodies of water. Areas with a continental climate can be arid or moist, depending on the source region of the air masses that move into the area.

Maritime climate is sometimes known as the marine climate. It occurs over the oceans and along coasts, where water moderates the extremes in temperature. Areas that have a maritime climate experience moderate to high humidity.

Prevailing Winds

New York State has greater extremes of climate than many other coastal states. California, for example, is known for its mild climate. While inland areas of California experience greater ranges of temperature than the coastal locations, these extremes are not as great as those in New York State. The reason for this difference is the wind direction. Both states are in the global belt of prevailing west and southwest winds. However, in California those winds come off the Pacific Ocean. In most of New York State, the winds come from inland areas where temperatures are highly changeable. As a result, the nearby Atlantic Ocean has relatively little effect on the climate of most of New York State.

Monsoon climates include an annual cycle of weather patterns caused by shifting wind directions. In winter and spring, the wind comes from high-pressure centers over the continents. Spring weather is warm and dry with large changes in daily temperature. When summer low pressure builds over the continents, the wind shifts direction. It brings moist air from the ocean. Summer monsoon weather is more humid, with cooler days and warmer nights. The summer monsoons also bring clouds and precipitation, which reduce the temperature as well as the daily range of temperature.

Ocean Currents

Many tourists are surprised to see palm trees growing in the some parts of England and Ireland. Palm trees are not native to these countries. However, these imported plants can survive the mild weather conditions found in some parts of the British Isles. The Gulf Stream and the North Atlantic Current transport warm ocean water from the South Atlantic Ocean to the area surrounding Great Britain. These islands experience more moderate temperatures than does New York State. Most of the British Isles have damp and mild winters in which hard frosts are not common. This is true in spite of the fact that Great Britain is roughly 10° farther north than New York State. Along the East Coast of North America at the same latitude as Great Britain is the Labrador province of Canada, where the winters are even colder than in New York State.

Other locations are cooled by nearby cold ocean currents. The California Current keeps the coastal city of San Francisco in "sweater weather" throughout the summer. However, just a few miles inland people often experience desert heat. Even in the summer, local residents who visit the ocean may just wade in the surf. The water is too cold to swim in without a wetsuit. As shown in Figure 24-10, New York City's climate is warmed by the Gulf Stream. The Surface Ocean Currents map on page 58 and in the *Earth Science Reference Tables* provides a useful way to tell where warm and cold ocean currents affect the climate of coastal locations.

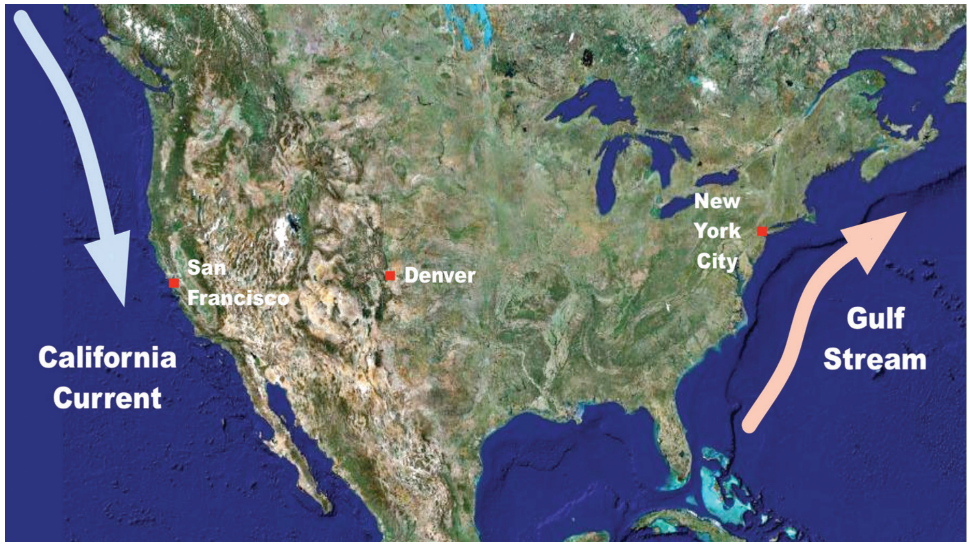


FIGURE 24-10. The California Current keeps San Francisco cool, even in the summer. The Gulf Stream tends to make New York City warmer than it would be otherwise. Denver, far from the moderating influence of the oceans, has large seasonal swings in temperature.

STUDENT ACTIVITY 24-4 —CLIMATES AND OCEAN CURRENTS

6: SYSTEMS THINKING 1

Using a political map of the world and the Surface Ocean Currents map from the *Earth Science Reference Tables,* make a list of countries or regions that are affected by warm ocean currents. Make another list of places affected by cold currents. Alphabetizing your list will help you compare your locations with the lists of other students.

Ocean currents also affect patterns of precipitation. Cold air can evaporate far less water than warm air. In addition, cool air blowing over warmer land surfaces causes the relative humidity to decrease. Decreasing relative humidity makes precipitation unlikely. Therefore, coastal regions affected by cold ocean currents are usually places where rainfall is scarce. The Atacama Desert lies along the west coast of South America. A weather station there has been in place for decades without experiencing any measurable precipitation. On the other hand, the relatively warm Alaska current makes coastal Alaska one of the rainiest places in the United States.

Vegetation

The local climate and soil determine natural vegetation. Therefore, vegetation is a good indicator of the climate. For example, the temperate rain forests along the Pacific coast of the United States and Canada grow only in a cool, moist climate. However, vegetation also contributes to climate. Thick vegetation, such as the trees and plants in a forest, moderate temperature by holding in cool air during the day. At night, the vegetation prevents the rapid escape of warm air. Vegetation slows surface winds. In addition, plants contribute moisture to the air. During precipitation, the plants slow runoff. This gives water at the surface time to soak into the ground. Groundwater is then absorbed by the roots of plants and rises into the leaves, where over an extended period, water is slowly lost by *transpiration.* Transpiration and photosynthesis absorb solar energy, which would otherwise heat the land and air during daylight hours. So forest conditions are generally more moderate and consistently more humid than open land in the same area.

Human activities such as cutting wood, plowing fields, mining, or construction remove native plants. We replace plants with open ground, paved surfaces, or buildings. **Deforestation** is cutting forests to clear land. **Urbanization** is the development of areas with large populations. These activities have replaced natural vegetation with farmlands and cities at an ever-increasing rate. Bare ground and paved surfaces do not allow evaporation of groundwater. These surfaces heat up quickly during the day and cool quickly at night. As a result of urbanization, the local climate becomes drier and warmer with an increased daily range of temperatures.

Urban Heat Islands

Heating and air conditioning release heat to the outdoor environment. In addition, cars, trucks, buses, and other forms of transportation burn fuel and release heat. Businesses and industries, which are concentrated around cities, produce heat. In a city, the high concentration of human activities produces an urban heat island. In general, urban areas, such as New York City, warm more quickly and stay warmer than rural locations.

The effects of urban heat islands are easy to see. Have you ever noticed how much longer winter snow lasts in the country than it does in nearby urban areas? Even undisturbed parks in cities will be clear of snow before similar rural land is snow-free. On summer nights, city dwellers often need air conditioning all night, while in neighboring rural areas, residents can cool off by opening their windows to the cool evening air.

WHAT GEOGRAPHIC FEATURES OF NEW YORK STATE AFFECT THE LOCAL CLIMATE?

4: 2.2c, 2.2d

Throughout New York State differences in climate are relatively small. Many climatologists would classify the whole state as having a humid, continental, temperate climate with large seasonal variations in temperature. However, local geographic features do cause some significant differences in climate at various locations in the state.

As noted earlier, the Atlantic Ocean and Long Island Sound make the climate on Long Island more moderate than inland areas of New York State. Winter precipitation that falls as snow upstate is more likely to be rain on Long Island. Breezes off the ocean keep the humidity higher than in other parts of the state. Long Island is also more vulnerable to hurricanes and coastal storms.

Winter snow lasts longer in higher parts of the Adirondack Mountains and the Catskills for two reasons. First, the mountains, due to their elevation, are a little cooler than other areas of New York State. Second, mountains also influence patterns of precipitation. On the windward side, air rising into these mountain areas expands and cools. This causes increased precipitation throughout the year. Mountains also influence the climate on their downwind side. The land around Lake Champlain and the central Hudson Valley are in the rain shadow of mountains and may have as little as half the annual precipitation of the nearby mountains.

You read earlier that areas of New York State at the eastern end of Lakes Erie and Ontario are subject to “lake-effect” storms. This is especially true in late autumn and early winter, when the lake water is warmer than surrounding land areas. The lakes also moderate temperatures in nearby land areas. The first hard frost of autumn occurs later in these areas. The extended growing season makes land near the lakes valuable for agriculture.

HOW IS CLIMATE SHOWN ON GRAPHS?

4: 2.1g

Climate graphs are a way to illustrate different kinds of climates. On the following graphs, the dark line shows the average monthly temperature. The monthly bar graphs indicate the average monthly precipitation.

Figure 24-11 is a climate graph for Syracuse, New York. Notice the large seasonal changes in temperature and plentiful precipitation throughout the year. Remember that these are average conditions over many years. Therefore, unusual events such as droughts do not appear on these graphs.

Figure 24-12 is a climate graph for a desert location in the southwestern United States. It shows major seasonal changes in

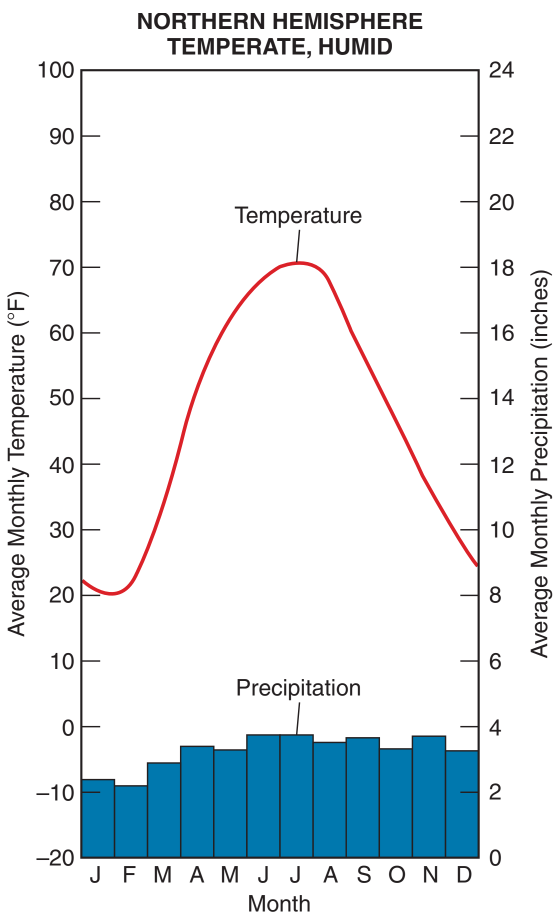


FIGURE 24-11. Temperate humid climate graph for Syracuse, New York.

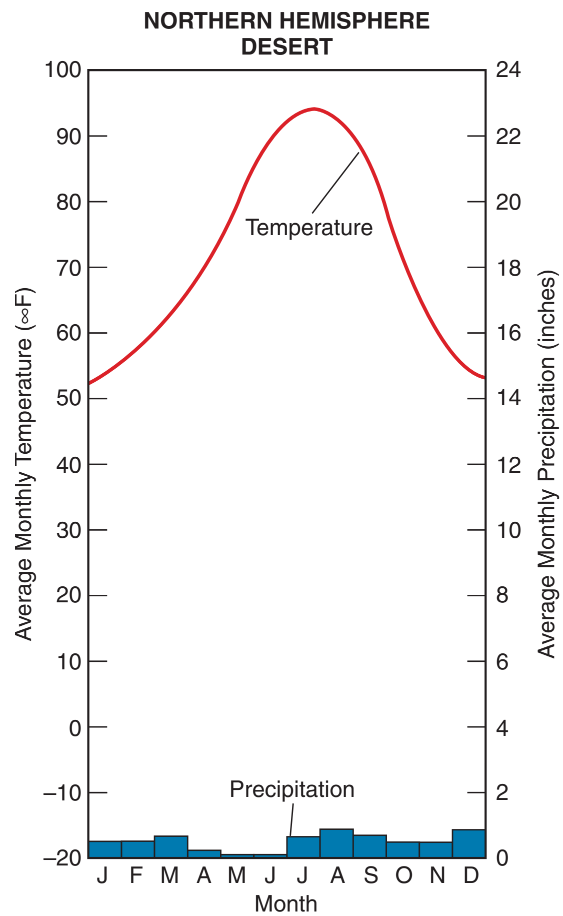


FIGURE 24-12. Desert climate graph for Phoenix, Arizona.

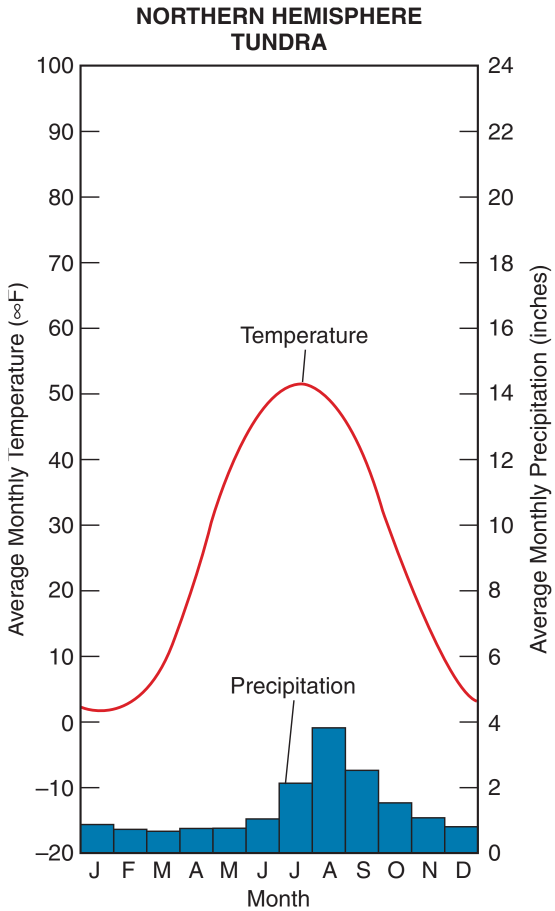


FIGURE 24-13. Arctic climate graph for Nome, Alaska.

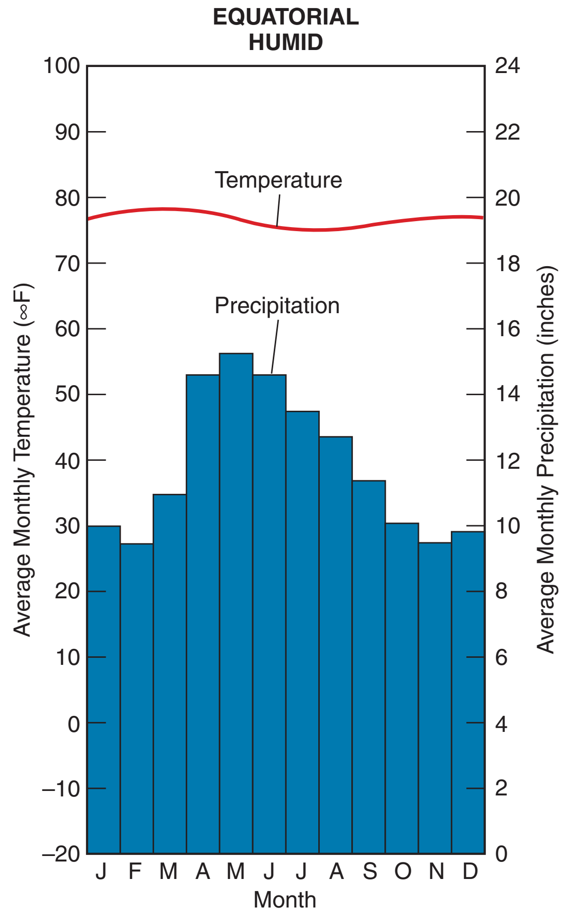


FIGURE 24-14. Tropical climate graph for Fonte Boa, Brazil.

temperature like the Syracuse graph (Figure 24-11). However, this location is warmer in the winter and the summer. The precipitation is limited throughout the year, especially in the spring before the summer monsoon season.

Figure 24-13 illustrates a tundra climate in arctic Alaska. Temperatures are significantly lower than Syracuse, New York, throughout the year. Although precipitation is low, so is evaporation in this cold climate.

The rain forest of tropical Brazil provides the data for Figure 24-14. The average temperature changes very little throughout the year and precipitation is usually plentiful.

Figure 24-15 is the climate graph for Sydney, Australia. Notice that the highest and lowest temperatures are off by 6 months from those of the Northern Hemisphere locations. In the Southern Hemisphere, winter begins in June and summer begins in December. Sydney is a coastal city so the annual temperature range is not as great as it is at the previous temperate locations.

The last climate graph is a monsoon location in India. (See Figure 24-16.) Precipitation is very seasonal. Also notice how the temperatures fall off relatively early when the summer monsoons arrive in July. Compare factors that affect climate by observing climate graphs: ***http://people.cas.sc.edu/carbone/modules/mods4car/cccontrol/index.html***

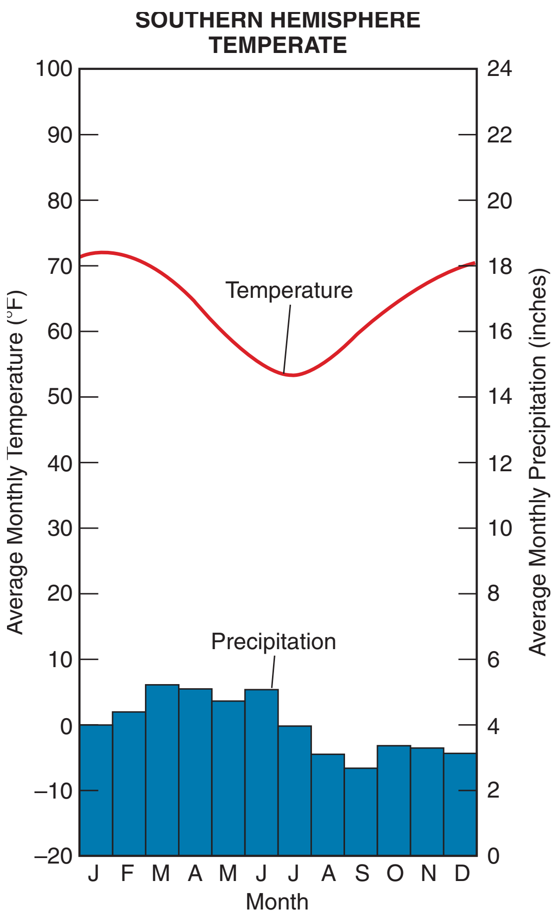


FIGURE 24-15. Southern Hemisphere climate graph for Sydney, Australia.

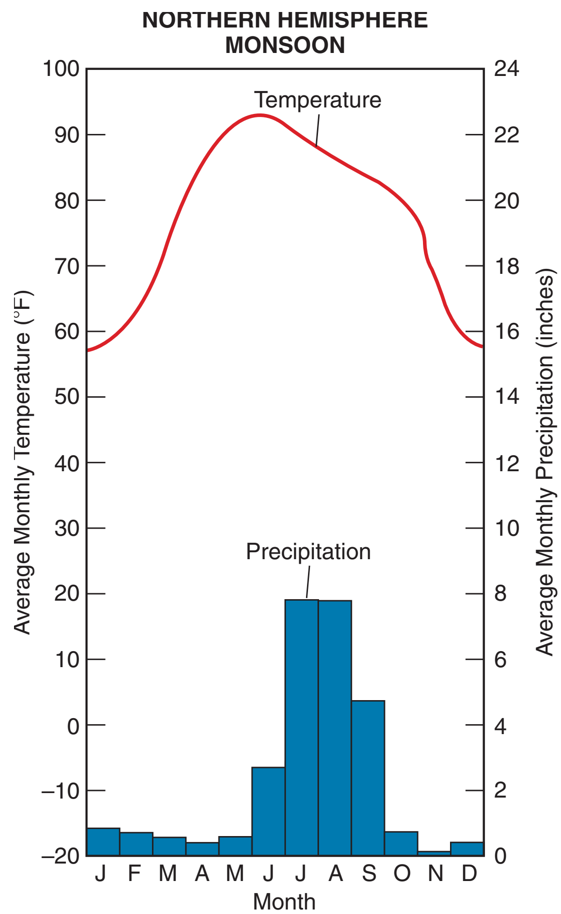
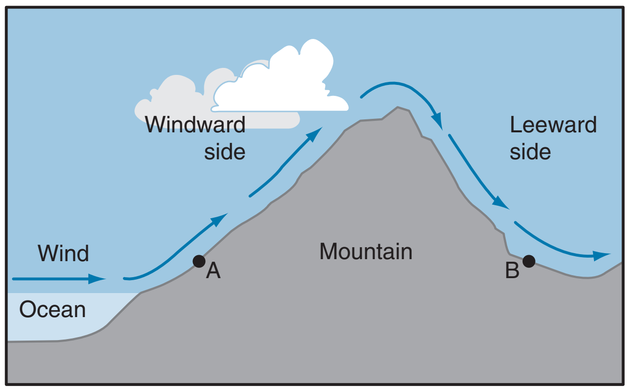


FIGURE 24-16. Monsoonal climate graph for New Delhi, India.

CHAPTER REVIEW QUESTIONS

Part A

Base your answers to questions 1 and 2 on the following diagram, which represents prevailing winds blowing over a high mountain range.



1. Why do clouds often form only on the windward side of the mountains?

(1) Air rises and cools on the windward side.
(2) Air rises and becomes warmer on the windward side.
(3) Air sinks and cools on the windward side.
(4) Air sinks and becomes warmer on the windward side.

2. Points *A* and *B* are at the same latitude and the same elevation above sea level. How does the climate at *A* probably differ from the climate at *B*?

(1) Location *A* has less precipitation.
(2) Location *A* has summer when location *B* has winter.
(3) Location *A* has a greater annual temperature range.
(4) Location *A* is usually cooler in the summer.

3. Why are temperatures in the tropic low-latitudes always higher than temperatures at the South Pole?

(1) The South Pole receives more intense sunlight.
(2) The South Pole receives less solar radiation.
(3) The South Pole has more cloud cover.
(4) The South Pole has more vegetation.

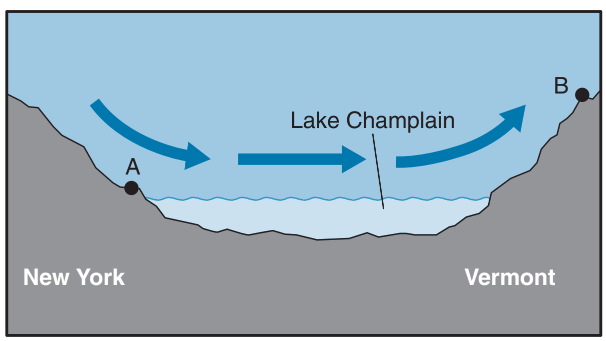
4. Which statement best summarizes the general effects of ocean currents at 20° south latitude on coastal regions of South America?

(1) The east coast and the west coast are both warmed by ocean currents.
(2) The east coast and the west coast are both made cooler by ocean currents.
(3) The east coast is warmed and the west coast is cooled by ocean currents.
(4) The east coast is cooled and the west coast is warmed by ocean currents.

5. Why do oceans moderate the temperatures of coastal areas?

(1) Temperature of ocean water changes slowly due to water's low specific heat.
(2) Temperature of ocean water changes slowly due to water's high specific heat.
(3) Temperature of ocean water changes rapidly due to water's low specific heat.
(4) Temperature of ocean water changes rapidly due to water's high specific heat.

6. The diagram below represents prevailing winds blowing from New York State across Lake Champlain and into Vermont. Compared with the climate at A, the climate at B is



(Not drawn to scale)

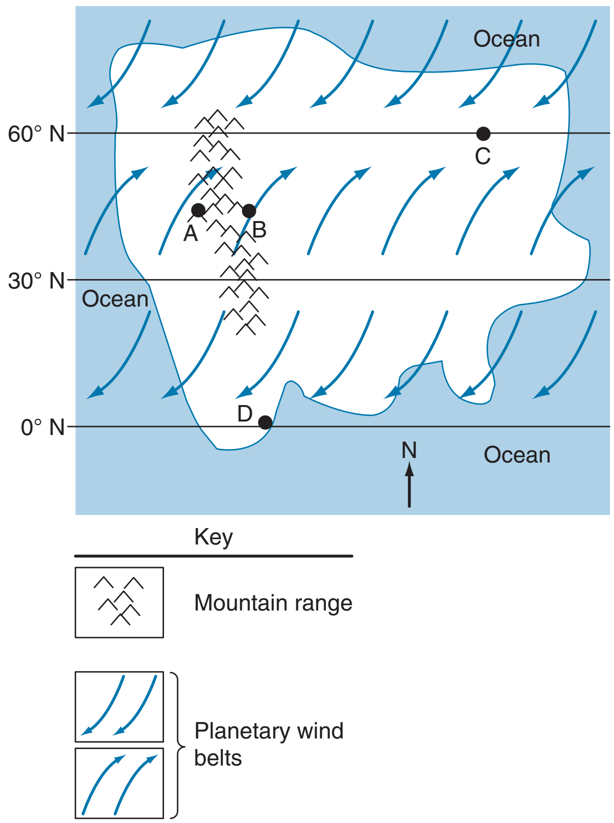
(1) warmer and wetter
(2) warmer and drier
(3) cooler and wetter
(4) cooler and drier

7. London, England is approximately 51°N latitude, 0° longitude. Binghamton, New York, is about 42°N latitude, 76°W longitude. Why does Binghamton have colder winters?

(1) Binghamton is farther from the equator.
(2) Binghamton is closer to sea level.
(3) London is affected by the North Atlantic Drift.
(4) London has a longer duration of insolation in the winter.

Part B

Base your answers to questions 8 through 10 on the map below, which represents an imaginary continent.



8. Locations *A* and *B* are at the same elevation below a mountain range. Compared with the climate at *A*, the climate at *B* is most likely

   (1) warmer and more humid
   (2) warmer and less humid
   (3) cooler and more humid
   (4) cooler and less humid

9. How can we best describe the wind pattern at point *D*?

   (1) converging winds and rising air
   (2) converging winds and falling air
   (3) diverging winds and rising air
   (4) diverging winds and falling air

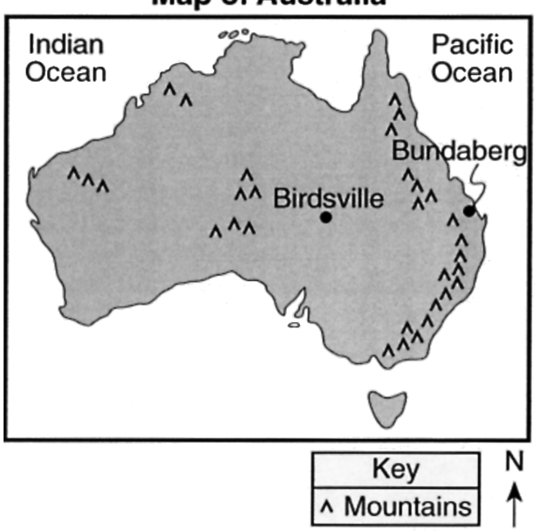
10. Location *C* most likely experiences

(1) low air pressure and little precipitation
(2) low air pressure and abundant precipitation
(3) high air pressure and little precipitation
(4) high air pressure and abundant precipitation

Part C

Base your answers to questions 11 through 13 on the map and data tables below, which show geographic and climate information for two towns in Australia.

Map of Australia



Data Table 1
Average Monthly High Temperatures for Birdsville, Australia

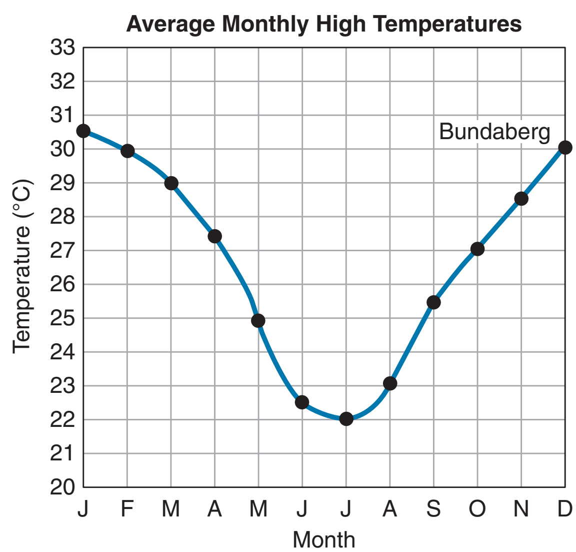
Month	Temperature (°C)
January	39
February	38
March	35
April	30.5
May	25
June	22
July	21
August	23.5
September	28
October	32.5
November	36
December	38

Data Table 2
Information about Two Australian Cities

City	Latitude (° S)	Longitude (° E)	Elevation (m)	Average January Rainfall (mm)
Birdsville	25.9	139.4	47	25
Bundaberg	24.9	152.4	14	105

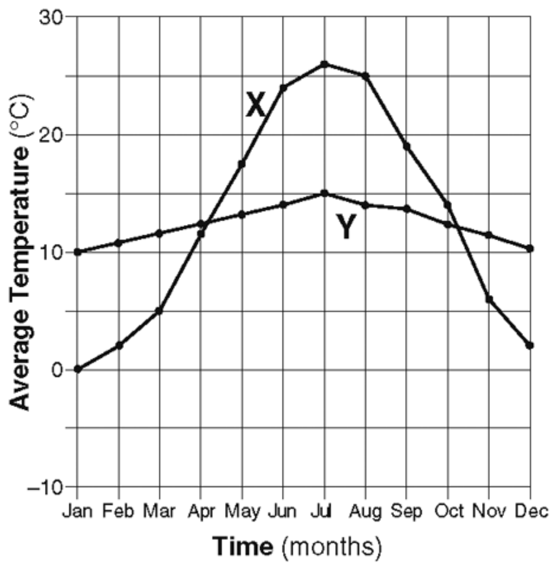
11. Why does Bundaberg have its lowest temperatures at the same time New York State is having its highest temperatures?

12. Make a copy of the graph below, and then plot an **X** to show the average temperature each month in Birdsville. Finally, connect the X's with a line and label the line "Birdsville."



13. State one reason that Birdsville has less rainfall in January than Bundaberg.

Base your answers to questions 14 through 17 on the graph below, which shows the annual cycle of temperature changes at two cities, *X* and *Y*. Both *X* and *Y* are at the same latitude.



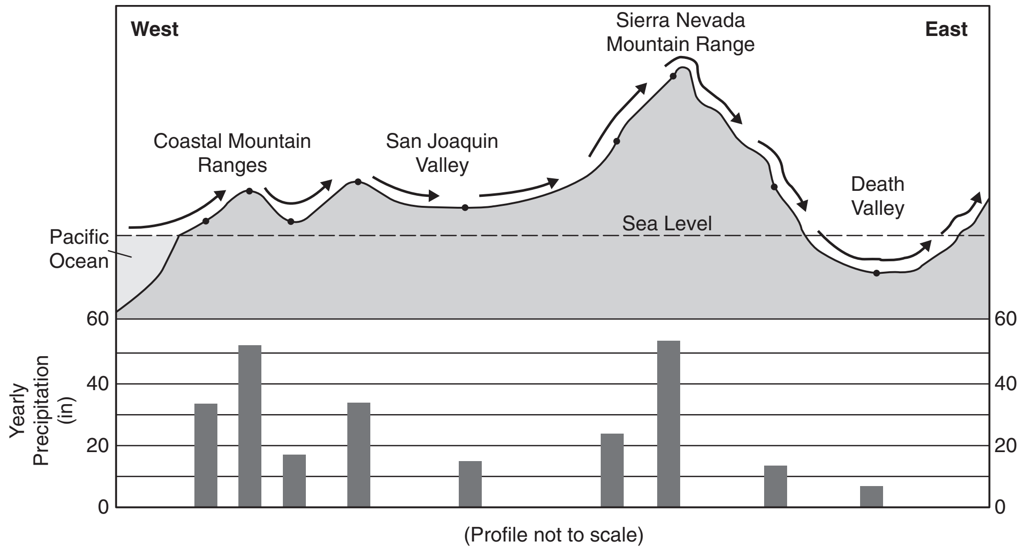
14. What is the range of average monthly temperatures at city *Y*?

15. What geographic factor explains why city *X* most likely has a greater temperature change over the course of a year.

16. What evidence indicates that both city *X* and city *Y* are in the Northern Hemisphere?

17. How would the climate of Britain and Western Europe change if Atlantic Ocean currents stopped moving?

Base your answers to questions 18 through 20 on the topographic profile and bar graph below, which represent rainfall and prevailing winds blowing over the mountains of California.



18. Explain why Death Valley has less rainfall than the top of the Sierra Nevada Mountains.

19. What is the total precipitation combined for the four points in the Coastal Mountain Ranges?

20. Why are temperatures colder in the Sierra Nevada Mountains than in the Coastal Mountain Ranges?