III Factors That Control Rainfall

Topic 10 Latitude, Prevailing Winds, and Rainfall

OBJECTIVES

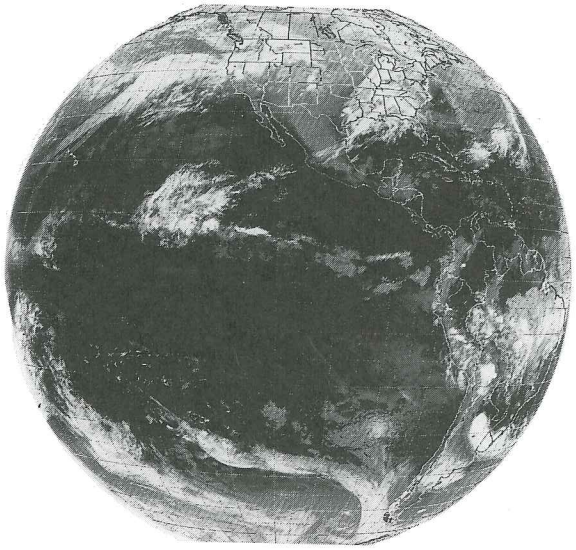
- **A** Correlate the world rainfall patterns with the prevailing wind belts.
- **B** Describe the effects of mountains on rainfall and humidity.
- **C** Explain the effects of nearby oceans on precipitation.
- **D** Discuss the relationship between ocean currents and fogs.

The prevailing wind belts cause precipitation at some latitudes and dryness at other latitudes. Compare the map of the global winds in Figure 28.12 (page 533) to Figures 31.4 and 31.5.

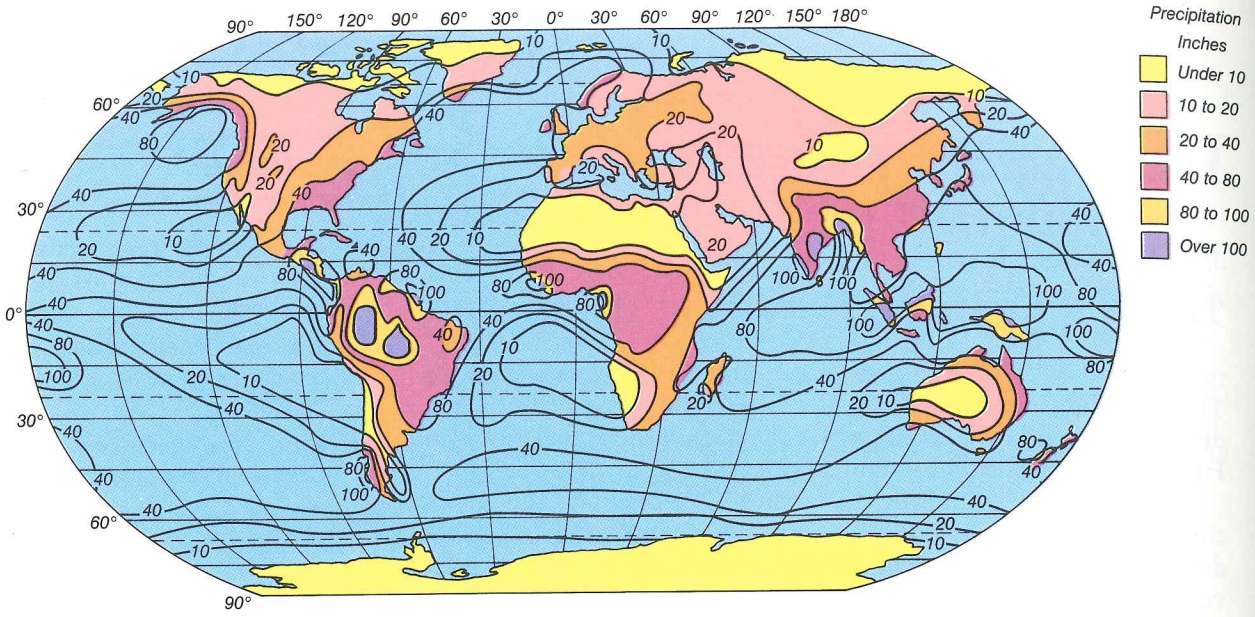
Yearly rainfall is high in the tropics. The precipitation in the tropics follows the pattern of the prevailing winds. The air in the doldrums rises slowly, forced upward by the coming together (convergence) of the northeast and southeast trade winds. This rising air causes almost-daily thunderstorms over the continents. Over the ocean the precipitation is more concentrated in a roughly 300-kilometer-wide band. This band is the most organized part of the intertropical convergence zone (ITCZ), so called because the winds from the two hemispheres mostly converge there (see Chapter 28).

The position of the ITCZ varies with the seasons. The ITCZ reaches its northernmost point around 10° to 20° N in the Northern Hemisphere summer. It moves down to 10°–20° S during the Southern Hemisphere summer. Therefore, in each hemisphere the summer is the rainy season for the area about 10–20 degrees from the equator.

To the north and south of the ITCZ, the rainfall decreases. The air flows outward (diverges) from the horse latitudes. Some of the diverging air flows toward the poles as westerlies; some flows toward the equator as the trade winds. Air sinks to replace the diverging air at the surface. Since clouds and rain cannot form in sinking air, many of the world's great deserts—the desert of Southwest Africa, the desert of the Australian interior, and the Sahara—lie about 20 to 35 degrees from the equator.



31.4 This satellite image of Earth's clouds shows the change of precipitation patterns with latitude. The belt of clouds around the equator is the ITCZ, where much rain falls. At higher latitudes, precipitation falls around traveling low-pressure systems, which look like commas.



31.5 Earth's pattern of annual precipitation

The pattern of precipitation in the middle latitudes, from about 30 to 65 degrees, is strongly related to the passage of low-pressure areas. A second band of convergence lies between the polar easterlies and the westerlies. The convergence brings together warm and cold air masses, forming a zone of strong temperature gradient. Low pressure areas form here. Precipitation falls mainly around the lows and along the lows' fronts. The position of the fronts has an enormous range of latitude. In the Northern Hemisphere winter, cold fronts can reach as far south as 20°N. In summer, warm fronts can reach 65°N. This zone is far less regular than the ITCZ.

The polar easterlies flow from the poles to about 65 degrees. This diverging air is replaced by sinking air from above. The very cold air at the poles can hold little water vapor. Therefore, precipitation in the high latitudes (near the poles) is light in all seasons. It comes almost entirely in low-pressure areas.

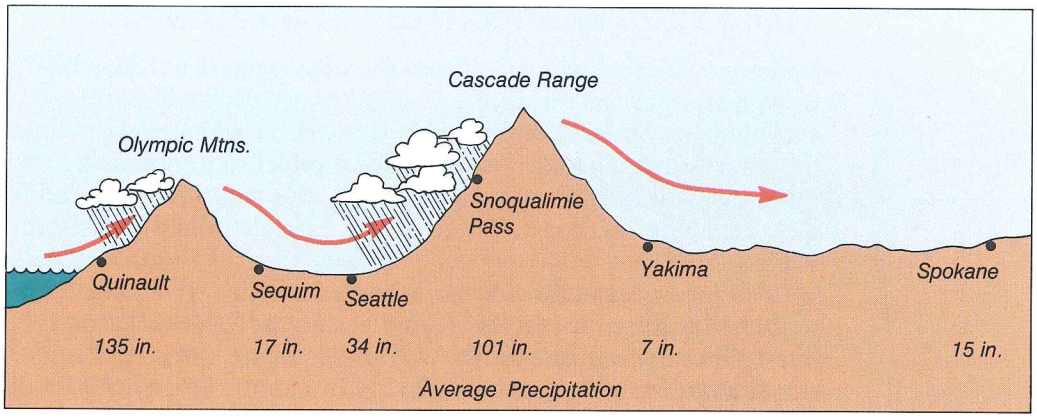
Topic 11 Mountains and Rainfall

The prevailing westerlies and trade winds cause consistent patterns of precipitation along mountain chains. Rising air makes the *windward* side of a mountain—its side toward the wind—rainy. Sinking air makes the side of the mountain away from the wind—its *leeward* side—dry.

The trade winds blow from the northeast in the Northern Hemisphere and from the southeast in the Southern Hemisphere. In the trade-wind belts, the rainy windward sides are:

Northern Hemisphere: northern slopes, eastern slopes
Southern Hemisphere: southern slopes, eastern slopes

For this reason, the east coasts of Africa, South America, and Central America have heavy rains.



31.6 The distribution of the average annual precipitation in the state of Washington is determined by the mountains and the prevailing west wind.

In the prevailing westerlies, relatively strong highs and lows frequently interrupt the prevailing winds. However, on the average, the rainy windward sides of the mountains are these:

Northern Hemisphere: southern slopes, western slopes
Southern Hemisphere: northern slopes, western slopes

The summer *monsoon* dominates the precipitation pattern in the Himalayan Mountains and India. Southwest monsoon winds bring rain to the western slopes of the Western Ghats range. The monsoon winds become southeasterly in the northern Bay of Bengal to the east of India. These winds bring heavy rain to the southern part of the Himalayan Mountains in summer.

Because the water falls out of the air on the windward side of the mountains, the leeward slopes are very dry. They are also warmer than the windward slopes. The leeward slopes are warmer because the raining air traveling up the mountain cools only 0.6°C for each 100 meters it rises. When the dried-out air sinks on the leeward side of the mountains, it warms at a faster rate—1°C for each 100 meters. Warm, dry winds formed in this way often blow down the eastern slopes of the Rocky Mountains and the northern part of the Swiss Alps. These winds are called **chinooks** (shin-OOKS) in the Rockies. In Europe, they are called **foehns** (ferns). The **Santa Anas** are winds that blow shoreward down the Santa Ana Mountains south of Los Angeles. The winds are hot and dry.

When chinooks arrive, they can raise the temperature 20°C in 15 minutes. They melt snow and can cause avalanches. If they blow too long, forests, fields, and buildings dry out. Then a careful watch must be kept against fire. However, chinooks can also make winters milder.

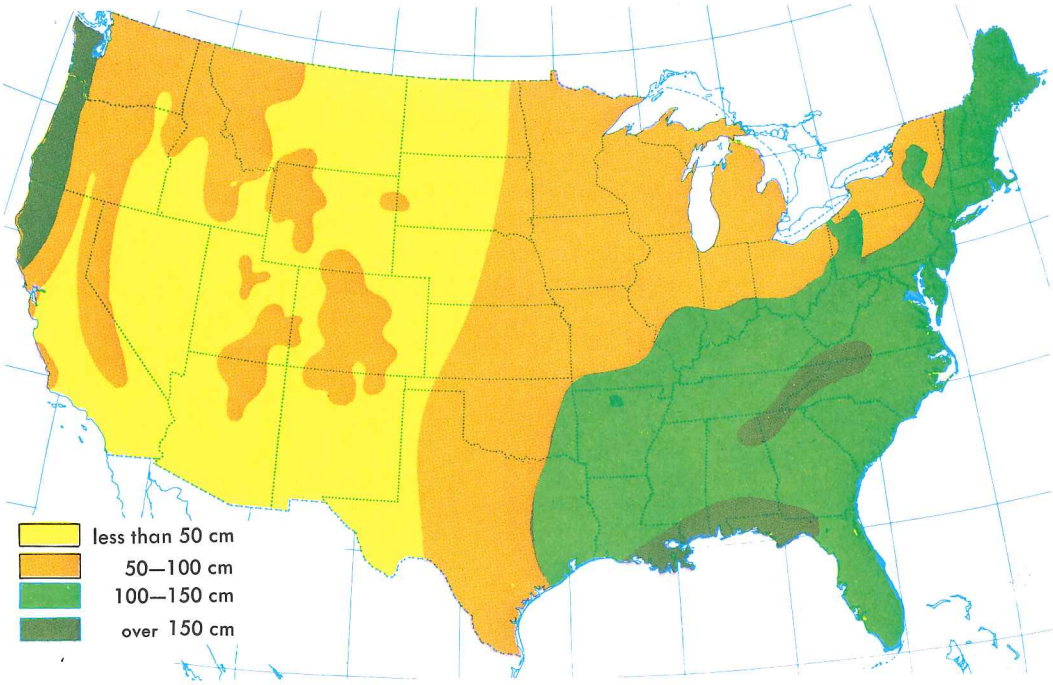
Not all winds blowing down mountains are warm. Some start out so cold that even after heating by compression they remain unpleasantly cold. One such wind is the **mistral** that blows down from the Alps to the Mediterranean Sea. Another is the **bora** that blows down from the mountains of Yugoslavia to the Adriatic Sea. Boras sometimes blow down the eastern slope of the Rockies.

Topic 12 Distance from the Oceans

When prevailing winds blow from the oceans, the rainfall is likely to be heaviest near the shore. Rainfall is usually heavier near the warmer parts of the ocean. Here the air is also warmer and can hold more moisture. The air is also more unstable, so rain clouds form more easily. In the eastern United States, the total yearly rainfall is greatest along the coast. There is less rainfall inland and northward.

Locations near oceans do not always have heavy rainfall. Even though the desert of Peru is located beside the Pacific Ocean, it is one of the driest places in the world. There are three reasons for this. First, the southeast trade winds come from the dry interior of the continent, not from the Pacific Ocean. Second, the desert is on the leeward (western) side of the Andes. Third, the prevailing winds off the coast cause a cold upwelling ocean current. The cold water cools the lowest layer of air. The resulting temperature inversion—warm air from the east over cool air from the nearby ocean—traps the ocean's moisture near the ground and prevents rain clouds from forming.

The eastern interior of North America has more precipitation in the summer than in the winter. The main reason is that in the summer, prevailing winds carry moisture northward from the Gulf of Mexico. A second reason is that thundershowers happen more often in summer because the ground is hotter.



31.7 The map shows average annual rainfall in the continental United States. In the far west, rainfall is controlled mainly by mountain ranges. In the interior and eastern parts of the country, rainfall increases closer to the Atlantic Ocean and the Gulf of Mexico.

Topic 13 Ocean Currents and Fogs

Warm air flowing over cold water makes rainfall unlikely in places like Peru. However, warm moist air over a colder surface often produces fogs. Ocean currents often help set up these conditions. The frequent winter fogs of England and Scotland are an example. These fogs form when warm moist air from the Gulf Stream blows over the cold land.

The summer fogs along the New England coast are another example. They form when warm air moving north is cooled over New England's cold coastal waters. The fogs of Newfoundland form when warm air from the Gulf Stream blows over the icy Labrador Current. The summer fogs of the Pacific coasts of the United States, Peru, and northern Chile are also examples. They form when warm ocean winds blow over cold upwelling coastal waters. In general, fogs form where ocean currents are much warmer or much colder than the adjoining land or water.

TOPIC QUESTIONS

Each topic question refers to the topic of the same number.

10. **(a)** Why do the latitudes near the equator have dry and wet seasons? **(b)** Why are many locations between 20–30° N or S dry all year? **(c)** What factors affect rainfall in the middle latitudes? **(d)** What factors affect rainfall in the polar latitudes?

11. **(a)** Which are the dry and rainy sides of mountain chains? **(b)** Which is the rainy side of the Western Ghats Mountains of India? Why is the rainy side different from other mountain chains of the trade-wind zone? **(c)** Explain why a chinook is warm and dry.

12. **(a)** Describe the relationship between wind and rainfall in coastal areas. **(b)** Why does the eastern interior of North America have more precipitation in summer than in winter?

13. **(a)** What conditions produce fogs? **(b)** How are the fogs over England and Scotland formed? **(c)** How are the fogs over New England and Newfoundland formed?

Map Skills

The following questions refer to the map of Earth's Climates on page 664 of Appendix B.

1. At what latitudes are most of the world's major deserts?
2. **(a)** At around 40° N, where are the marine climates? **(b)** Compare the extent of the marine climate in Europe and North America.
3. At what latitudes are the most humid climates?