Section 1

Air Masses

Differences in air pressure are caused by unequal heating of Earth's surface. The region along the equator receives more solar energy than the regions at the poles do. The heated equatorial air rises and creates a low-pressure belt. Conversely, cold air near the poles sinks and creates high-pressure centers. Differences in air pressure at different locations on Earth create wind patterns.

OBJECTIVES

- **Explain** how an air mass forms.
- **List** the four main types of air masses.
- **Describe** how air masses affect the weather of North America.

KEY TERM

air mass

How Air Moves

Air moves from areas of high pressure to areas of low pressure. Therefore, there is a general, worldwide movement of surface air from the poles toward the equator. At high altitudes, the warmed air flows from the equator toward the poles. Temperature and pressure differences on Earth's surface create three wind belts in the Northern Hemisphere and three wind belts in the Southern Hemisphere. The *Coriolis effect,* which occurs when winds are deflected by Earth's rotation, also influences wind patterns. The processes that affect air movement also influence storms, such as the one shown in **Figure 1.**

air mass a large body of air throughout which temperature and moisture content are similar

Formation of Air Masses

When air pressure differences are small, air remains relatively stationary. If the air remains stationary or moves slowly over a uniform region, the air takes on the characteristic temperature and humidity of that region. A large body of air throughout which temperature and moisture are similar is called an **air mass.** Air masses that form over frozen polar regions are very cold and dry. Air masses that form over tropical oceans are warm and moist.

Figure 1 ▶ The motion of Earth's atmosphere can lead to the formation of powerful storms such as Hurricane Florence, which was photographed by astronauts on the shuttle *Atlantis* over the Atlantic Ocean in 1994.

Table 1 ▼

Air Masses		
Source region	**Type of air**	**Symbol**
Continental	dry	c
Maritime	moist	m
Tropical	warm	T
Polar	cold	P

Types of Air Masses

Air masses are classified according to their source regions. The source regions also determine the temperature and the humidity of the air mass. The source regions for cold air masses are polar areas. The source regions for warm air masses are tropical areas. Air masses that form over the ocean are called *maritime*. Air masses that form over land are called *continental*. Maritime air masses are moist, and continental air masses are dry. Air masses and the symbols used to designate them are listed in **Table 1.** The combination of tropical or polar air and continental or maritime air results in air masses that have distinct characteristics.

Continental Air Masses

Continental air masses form over large landmasses, such as northern Canada, northern Asia, or the southwestern United States. Because these air masses form over land, the level of humidity is very low. An air mass may remain over its source region for days or weeks. However, the air mass will eventually move into other regions because of global wind patterns. In general, continental air masses bring dry weather conditions when they move into another region. There are two types of continental air masses: *continental polar* (cP) and *continental tropical* (cT). Continental polar air masses are cold and dry. Continental tropical air masses are warm and dry.

Maritime Air Masses

Maritime air masses form over oceans or other large bodies of water. These air masses take on the characteristics of the water over which they form. The humidity in these air masses tends to be higher than that of the continental air masses. When these very moist masses of air travel to a new location, they commonly bring more precipitation and fog, as shown in **Figure 2.**

The two different maritime air masses are *maritime polar* (mP) and *maritime tropical* (mT). Maritime polar air masses are moist and cold. Maritime tropical air masses are moist and warm.

Figure 2 ▶ A maritime air mass brings fog that rolls in off the coast of California.

North American Air Masses

The four types of air masses that affect the weather of North America come from six regions. These air masses, their source locations, their movements, and the weather they bring are summarized in **Table 2.** The general directions of the air masses' movements are shown in **Figure 3.** An air mass usually brings the weather of its source region, but an air mass may change as it moves away from its source region. For example, cold, dry air may become warmer and more moist as it moves from land to the warm ocean. As the lower layers of air are warmed, the air rises. This warmed air may then create clouds and precipitation.

Table 2 ▼

Air Masses of North America

Air mass	Source location	Movement	Weather
cP	polar regions in Canada	south-southeast	cold and dry
mP	polar Pacific; polar Atlantic	southeast; southwest-south	cold and moist
cT	U.S. southwest	north-northeast	warm and dry
mT	tropical Pacific; tropical Atlantic	northeast; north-northwest	warm and moist

Tropical Air Masses

Continental tropical air masses form over the deserts of the southwestern United States. These air masses bring dry, hot weather in the summer. They do not form in the winter. Maritime tropical air masses form over the warm water of the tropical Atlantic Ocean. They bring mild, often cloudy weather to the eastern United States in the winter. In the summer, they bring hot, humid weather and thunderstorms. Maritime tropical air masses also form over warm areas of the Pacific Ocean. But these air masses do not usually reach the Pacific coast. In the winter, maritime tropical air masses bring moderate precipitation to the coast and the southwestern deserts.

Reading Check **Which air mass brings dry, hot weather in the summer? (See the Appendix for answers to Reading Checks.)**

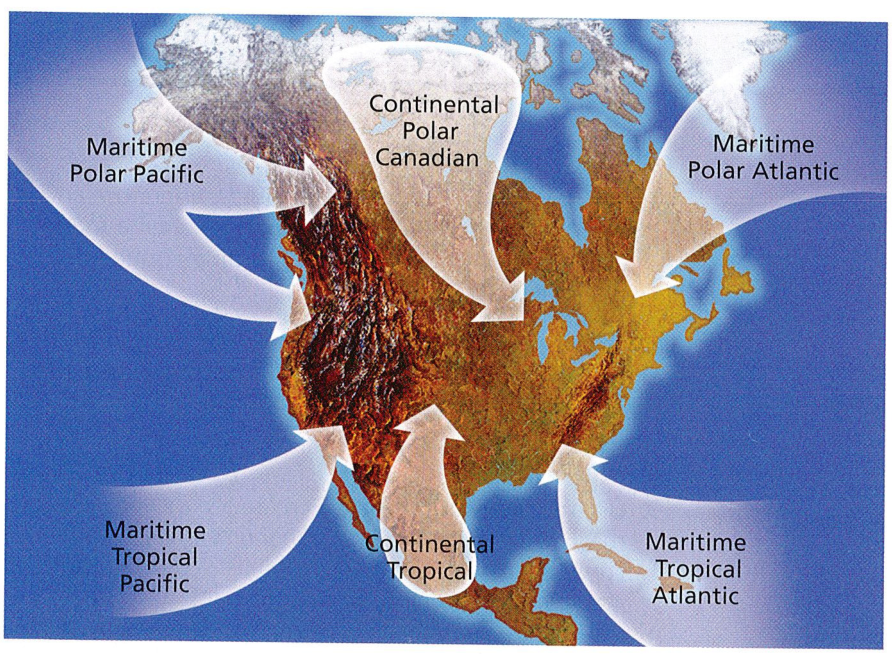


Figure 3 ▶ The four types of air masses that influence the weather in North America come from six regions and are named according to their source regions.

Figure 4 ▶ Maritime polar Atlantic air masses can bring heavy snowfall, such as in this snowstorm that hit New York City in 2003.

Polar Air Masses

Polar air masses from three regions—northern Canada and the northern Pacific and Atlantic Oceans—influence weather in North America. Continental polar air masses form over ice- and snow-covered land. These air masses move into the northern United States and can occasionally reach as far south as the Gulf Coast of the United States. In summer, the air masses usually bring cool, dry weather. In winter, they bring very cold weather to the northern United States.

Maritime polar air masses form over the North Pacific Ocean and are very moist, but they are not as cold as continental polar Canadian air masses. In winter, these maritime polar Pacific air masses bring rain and snow to the Pacific Coast. In summer, they bring cool, often foggy weather. As they move inland and eastward over the Cascades, the Sierra Nevada, and the Rocky Mountains, these cold air masses lose much of their moisture and warm slightly. Thus, they may bring cool and dry weather by the time they reach the central United States.

Maritime polar Atlantic air masses move generally eastward toward Europe. But they sometimes move westward over New England and eastern Canada. In winter, they can bring cold, cloudy weather and snow, as shown in **Figure 4.** In summer, these air masses can produce cool weather, low clouds, and fog.

Section 1 Review

1. **Define** *air mass.*
2. **Explain** how an air mass forms.
3. **Identify** the location where a cold, dry air mass would form.
4. **List** the four main types of air masses.
5. **Describe** how the four main types of air masses affect the weather of North America.
6. **Describe** the air mass that forms over the warm waters of the Atlantic Ocean. What letters designate the source region of this air mass?

CRITICAL THINKING

7. **Making Predictions** How would temperature and humidity at a given location change when a maritime tropical air mass is replaced by a continental polar air mass?
8. **Recognizing Relationships** In which direction would you expect a tropical air mass near the coast of Europe to travel? Explain your answer.

CONCEPT MAPPING

9. Use the following terms to create a concept map: *maritime polar Pacific, maritime polar, continental polar Canadian, air mass, continental polar,* and *maritime polar Atlantic.*

Section 2 Fronts

When two unlike air masses meet, density differences usually keep the air masses separate. A cool air mass is dense and does not mix with the less-dense air of a warm air mass. Thus, a boundary, called a *front,* forms between air masses. A typical front is several hundred kilometers long. However, some fronts may be several thousand kilometers long. Changes in middle-latitude weather usually take place along the various types of fronts. Fronts do not exist in the Tropics because no air masses that have significant temperature differences exist there.

OBJECTIVES

- **Compare** the characteristic weather patterns of cold fronts with those of warm fronts.
- **Describe** how a midlatitude cyclone forms.
- **Describe** the development of hurricanes, thunderstorms, and tornadoes.

KEY TERMS

cold front
warm front
stationary front
occluded front
midlatitude cyclone
thunderstorm
hurricane
tornado

Types of Fronts

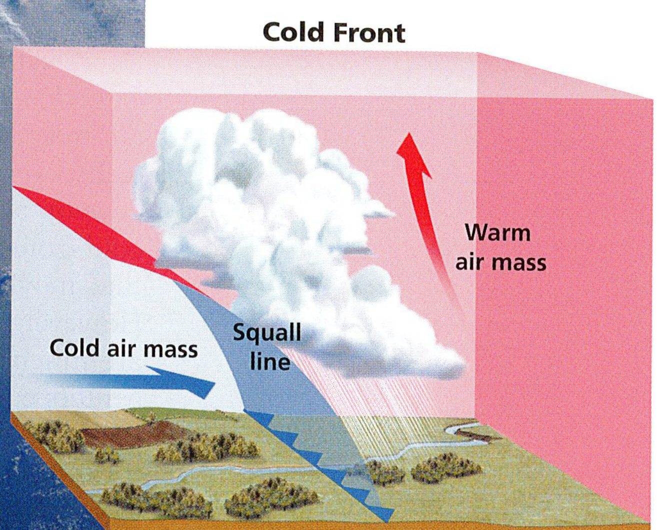
For a front to form, one air mass must collide with another air mass. The kind of front that forms is determined by how the air masses move in relationship to each other.

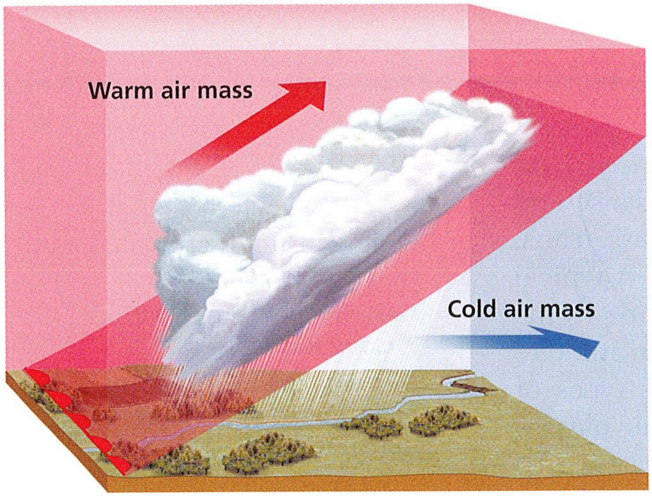
Cold Fronts

When a cold air mass overtakes a warm air mass, a **cold front** forms. The moving cold air lifts the warm air. If the warm air is moist, clouds will form. Large cumulus and cumulonimbus clouds typically form along fast-moving cold fronts. Storms that form along a cold front are usually short-lived and are sometimes violent. A long line of heavy thunderstorms, called a *squall line,* shown in **Figure 1,** may occur in the warm, moist air just ahead of a fast-moving cold front. A slow-moving cold front lifts the warm air ahead of it more slowly than a fast-moving front does. A slow-moving cold front typically produces weaker storms and lighter precipitation than a fast-moving cold front does.

cold front the front edge of a moving mass of cold air that pushes beneath a warmer air mass like a wedge

Figure 1 ▶ As a cold air mass overtakes a warm air mass, a line of thunderstorms called a *squall line* forms. The photo shows a squall line over the North Atlantic Ocean.





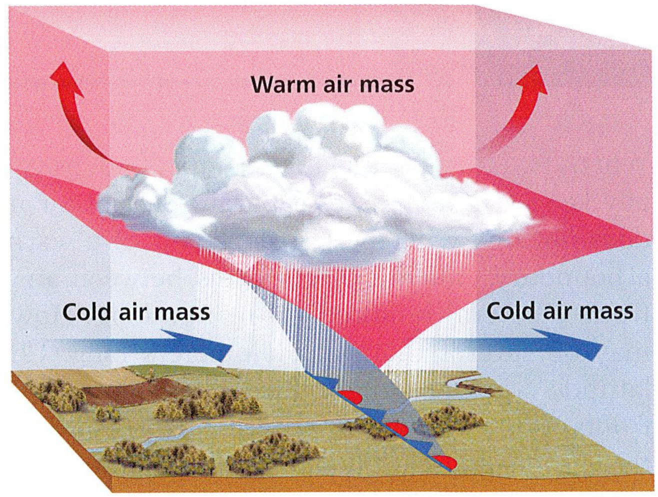


Figure 2 ▶ As a warm air mass rises over a cold air mass (left), a warm front forms at the boundary of the two air masses. An occluded front (right) forms when a cold air mass lifts a warm air mass off the ground.

Warm Fronts

When a cold air mass retreats from an area, a **warm front** forms. The less dense warm air rises over the cooler air. The slope of a warm front is gradual, as shown in **Figure 2.** Because of this gentle slope, clouds may extend far ahead of the surface location, or *base,* of the front. A warm front generally produces precipitation over a large area and may cause violent weather.

Stationary and Occluded Fronts

Sometimes, when two air masses meet, the cold air moves parallel to the front, and neither air mass is displaced. A front at which air masses move either very slowly or not at all is called a **stationary front.** The weather around a stationary front is similar to that produced by a warm front. An **occluded front** usually forms when a fast-moving cold front overtakes a warm front and lifts the warm air off the ground completely, as shown in **Figure 2.**

warm front the front edge of advancing warm air mass that replaces colder air with warmer air

stationary front a front of air masses that moves either very slowly or not at all

occluded front a front that forms when a cold air mass overtakes a warm air mass and lifts the warm air mass off the ground and over another air mass

midlatitude cyclone an area of low pressure that is characterized by rotating wind that moves toward the rising air of the central low-pressure region

Polar Fronts and Midlatitudes Cyclones

Over each of Earth's polar regions is a dome of cold air that may extend as far as 60° latitude. The boundary where this cold polar air meets the tropical air mass of the middle latitudes, especially over the ocean, is called the *polar front.* Waves commonly develop along the polar front. A *wave* is a bend that forms in a cold front or a stationary front. This wave is similar to the waves that moving air produces when it passes over a body of water. However, waves that form in a cold front or stationary front are much larger. They are the beginnings of low-pressure storm centers called midlatitude cyclones or *wave cyclones.* **Midlatitude cyclones** are areas of low pressure that are characterized by rotating wind that moves toward the rising air of the central, low-pressure region. These cyclones strongly influence weather patterns in the middle latitudes.

Stages of a Midlatitude Cyclone

A midlatitude cyclone usually lasts several days. The stages of formation and dissipation of a midlatitude cyclone are shown in **Figure 3.** In North America, midlatitude cyclones generally travel about 45 km/h in an easterly direction as they spin counterclockwise. They follow several storm tracks, or routes, as they move from the Pacific coast to the Atlantic coast. As they pass over the western mountains, they may lose their moisture and energy.

Anticyclones

Unlike the air in a midlatitude cyclone, the air of an *anticyclone* sinks and flows outward from a center of high pressure. Because of the Coriolis effect, the circulation of air around an anticyclone is clockwise in the Northern Hemisphere. Anticyclones bring dry weather, because their sinking air does not promote cloud formation. If an anticyclone stagnates over a region for a few days, the anticyclone may cause air pollution problems. After being stationary for a few weeks, anticyclones may cause droughts.

Reading Check **How is the air of an anticyclone different from that of a midlatitude cyclone? (See the Appendix for answers to Reading Checks.)**

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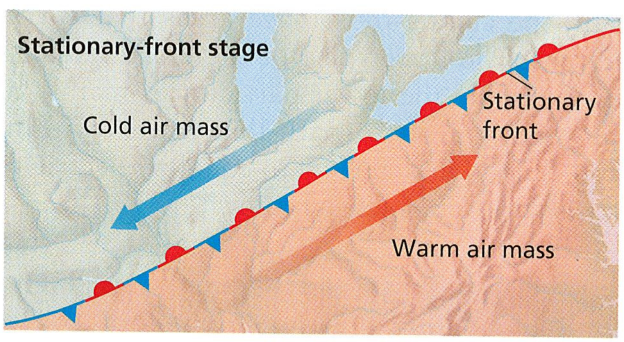
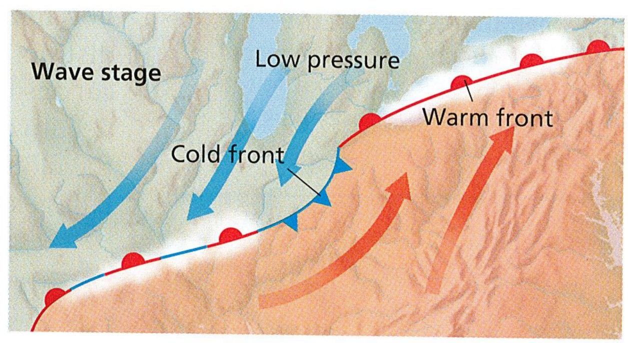
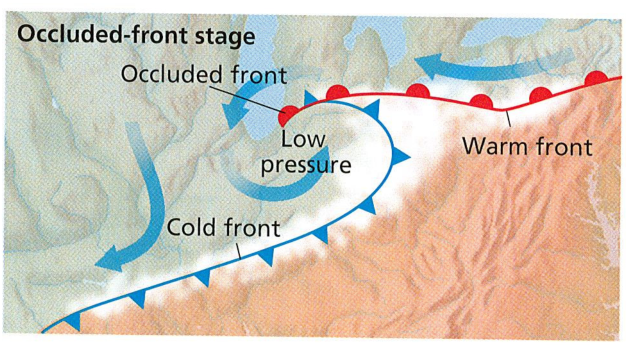
Figure 3 ▶ **Stages of a Midlatitude Cyclone**



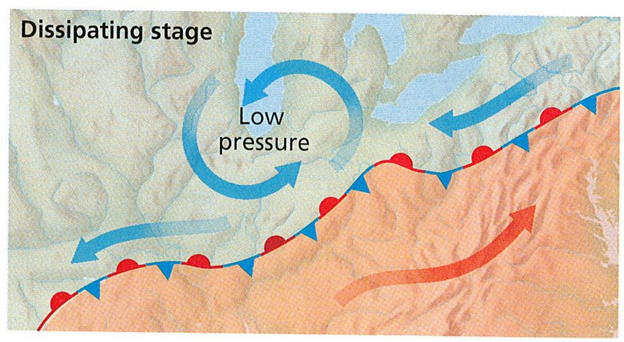
❶ Midlatitude cyclones occur along a cold or a stationary front. Winds move parallel to the front but in opposite directions on each side of the front.



❷ A wave forms when a bulge of cold air develops and advances slightly ahead of the rest of the front.



❸ As the fast-moving part of the cold front overtakes the warm front, an occluded front forms and the storm reaches its highest intensity.



❹ Eventually, the system generally loses all of its energy and the midlatitude cyclone dissipates.