CHAPTER 12

Meteorology

BIG Idea **Weather patterns can be observed, analyzed, and predicted.**

12.1 The Causes of Weather
MAIN Idea Air masses have different temperatures and amounts of moisture because of the uneven heating of Earth's surface.

12.2 Weather Systems
MAIN Idea Weather results when air masses with different pressures and temperatures move, change, and collide.

12.3 Gathering Weather Data
MAIN Idea Accurate measurements of atmospheric properties are a critical part of weather analysis and prediction.

12.4 Weather Analysis and Prediction
MAIN Idea Several methods are used to develop short-term and long-term weather forecasts.

GeoFacts

- The coldest temperature ever recorded in the United States was −62.1°C at Prospect Creek, Alaska.
- The sunniest place in the United States is Yuma, Arizona, with an average of 4133 hours of sunshine per year.

LAUNCH Lab

How does a cold air mass form?

An air mass is a large volume of air that has the characteristics of the area over which it formed.

Procedure

1. Read and complete the lab safety form.
2. Place a **full tray of ice cubes** on a table. Place a **pencil** under each end of the tray to raise it off the table.
3. Slide a **liquid-crystal temperature strip** under the ice-cube tray.
4. Place two **pencils** across the top of the tray, and **another temperature strip** across them.
5. Record the temperature of each strip at 1-min intervals for about 5 min.
6. Make a graph of the temperature changes over time for each temperature strip.

Analysis

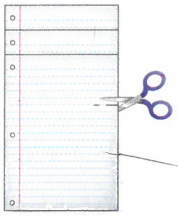
1. **Describe** what happened to the temperatures above and below the tray.
2. **Explain** how this models a mass of cold air.

FOLDABLES™ Study Organizer

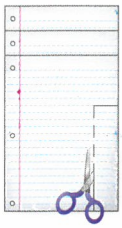
Types of Fronts Make the following Foldable to help identify the four types of fronts.

STEP 1 Layer three sheets of paper so that the top margin or about 5 cm of each sheet can be seen.

STEP 2 Make a 3-cm horizontal cut through all three sheets on about the ~~sixth~~ line of the top sheet.



STEP 3 Make a vertical cut up from the bottom to meet the horizontal cut.



STEP 4 Place the three sheets on top of a fourth sheet and align the tops and sides of all sheets. Label the four tabs *Cold Fronts, Warm Fronts, Stationary Fronts,* and *Occluded Fronts.* The Foldable can be placed in a notebook or stapled along the left edge.

FOLDABLES **Use this Foldable with Section 12.2.** As you read this section, summarize what you learn about the different fronts. Include sketches of air movement and the weather map symbol for each type.

Section 12.1

Objectives

- **Compare and contrast** weather and climate.
- **Analyze** how imbalances in the heating of Earth's surface create weather.
- **Describe** how air masses form.
- **Identify** five types of air masses.

Review Vocabulary

heat: transfer of thermal energy from a warmer material to a cooler material

New Vocabulary

weather
climate
air mass
source region

The Causes of Weather

MAIN Idea **Air masses have different temperatures and amounts of moisture because of the uneven heating of Earth's surface.**

Real-World Reading Link Have you ever walked barefoot on cool grass and then stepped onto hot pavement on a sunny summer day? Around the world, the Sun heats the different surfaces on Earth to different extents. This uneven heating causes weather.

What is meteorology?

What do you enjoy doing on a summer afternoon? Do you like to watch clouds move across the sky, listen to leaves rustling in a breeze, or feel the warmth of sunlight on your skin? Clouds, breezes, and the warmth of sunlight are examples of atmospheric phenomena. Meteorology is the study of atmospheric phenomena. The root word of *meteorology* is the Greek word *meteoros,* which means *high in the air*. Anything that is high in the sky—raindrops, rainbows, dust, snowflakes, fog, and lightning—is an example of a meteor.

Atmospheric phenomena are often classified as types of meteors. Cloud droplets and precipitation—rain, snow, sleet, and hail—are types of hydrometeors (hi droh MEE tee urz). Smoke, haze, dust, and other particles suspended in the atmosphere are lithometeors (lih thuh MEE tee urz). Examples of electrometeors are thunder and lightning—signs of atmospheric electricity that you can hear or see. Meteorologists study these various meteors.

Weather versus climate Short-term variations in atmospheric phenomena that interact and affect the environment and life on Earth are called **weather.** These variations can take place over minutes, hours, days, weeks, months, or years. **Climate** is the long-term average of variations in weather for a particular area. Meteorologists use weather-data averages over 30 years to define an area's climate, such as that of the desert shown in **Figure 12.1.** You will read more about Earth's climates in Chapter 14.

Reading Check **Differentiate** between weather and climate.

Figure 12.1 A desert climate is dry with extreme variations in day and night temperatures. Only organisms adapted to these conditions, such as this ocotillo, can survive there.

Heating Earth's Surface

As you learned in Chapter 11, sunlight, which is a part of solar radiation, is always heating some portion of Earth's surface. Over the course of a year, the amount of thermal energy that Earth receives is the same as the amount that Earth radiates back to space. In meteorology, a crucial question is how solar radiation is distributed around Earth.

Imbalanced heating Why are average January temperatures warmer in Miami, Florida, than in Detroit, Michigan? Part of the explanation is that Earth's axis of rotation is tilted relative to the plane of Earth's orbit. Therefore, the number of hours of daylight and amount of solar radiation is greater in Miami during January than in Detroit.

Another factor is that Earth is a sphere and different places on Earth are at different angles to the Sun, as shown in **Figure 12.2.** For most of the year, the amount of solar radiation that reaches a given area at the equator covers a larger area at latitudes nearer the poles. The greater the area covered, the smaller amount of heat per unit of area. Because Detroit is farther from the equator than Miami is, the same amount of solar radiation that heats Miami will heat Detroit less. Investigate this relationship in the MiniLab on this page.

Thermal energy redistribution Areas around Earth maintain about the same average temperatures over time due to the constant movement of air and water among Earth's surfaces, oceans, and atmosphere. The constant movement of air redistributes thermal energy around the world. Weather—from thunderstorms to large-scale weather systems—is part of the constant redistribution of Earth's thermal energy.

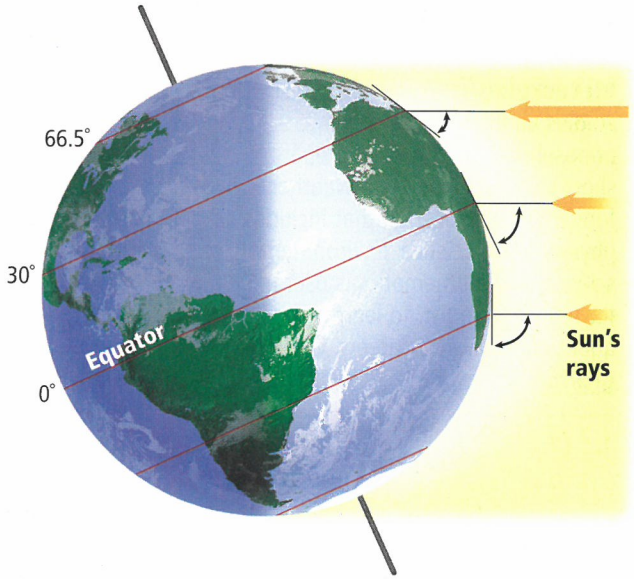


Figure 12.2 Solar radiation is unequal partly due to the changing angle of incidence of the sunlight. In this example it is perpendicular south of the equator, at the equator it is 60°, and north of the equator it is 40°.

Explain *why average temperatures decline from the equator to the poles.*

MiniLab

Compare the Angles of Sunlight to Earth

What is the relationship between the angle of sunlight and amount of heating? The angle at which sunlight reaches Earth's surface varies with latitude. This results in uneven heating of Earth.

Procedure

1. Read and complete the lab safety form.
2. Turn on a **flashlight,** and hold it 20 cm above a piece of **paper.** Point the flashlight straight down.
3. Use a pencil to trace the outer edge of the light on the paper. This models the angle of sunlight to Earth at the equator.
4. Keep the flashlight the same distance above the paper, but rotate it about 30°.
5. Trace the outer edge of the light. This is similar to the angle of sunlight to Earth at latitudes nearer the poles.

Analysis

1. **Describe** how the outline of the light differed between Step 3 and Step 5. Explain why it differed.
2. **Compare** the amount of energy per unit of area received near the equator to the amount at latitudes nearer the poles.

CAREERS IN EARTH SCIENCE

Meteorologist A meteorologist studies air masses and other atmospheric conditions to prepare short-term and long-term weather forecasts. An education that includes physics, Earth science, environmental science, and mathematics is useful for a meteorologist. To learn more about Earth science careers, visit glencoe.com.

Air Masses

In Chapter 11, you learned that air over a warm surface can be heated by conduction. This heated air rises because it is less dense than the surrounding air. On Earth, this process can take place over thousands of square kilometers for days or weeks. The result is the formation of an air mass. An **air mass** is a large volume of air that has the same characteristics, such as humidity and temperature, as its **source region**—the area over which the air mass forms. Most air masses form over tropical regions or polar regions.

Types of air masses The five types of air masses, listed in **Table 12.1,** influence weather in the United States. These air masses are all common in North America because there is a source region nearby.

Tropical air masses The origins of maritime tropical air are tropical bodies of water, listed in **Table 12.1.** In the summer, they bring hot, humid weather to the eastern two-thirds of North America. The southwestern United States and Mexico are a source region of continental tropical air, which is hot and dry, especially in summer.

Polar air masses Maritime polar air masses form over the cold waters of the North Atlantic and North Pacific. The one that forms over the North Pacific primarily affects the West Coast of the United States, occasionally bringing heavy rains in winter. Continental polar air masses form over the interior of Canada and Alaska. In winter, these air masses can carry frigid air southward. In the summer, however, cool, relatively dry, continental polar air masses bring relief from hot, humid weather.

Reading Check **Compare and contrast** tropical and polar air masses.

Table 12.1 Air Mass Characteristics

Concepts In Motion
Interactive Table To explore more about air masses, visit glencoe.com.

Air Mass Type	Weather Map Symbol	Source Region	Characteristics	
			Winter	Summer
Arctic	A	Siberia, Arctic Basin	bitter cold, dry	cold, dry
Continental polar	cP	interiors of Canada and Alaska	very cold, dry	cool, dry
Continental tropical	cT	southwest United States, Mexico	warm, dry	hot, dry
Maritime polar	mP	North Pacific Ocean	mild, humid	mild, humid
		North Atlantic Ocean	cold, humid	cool, humid
Maritime tropical	mT	Gulf of Mexico, Caribbean Sea, tropical and subtropical Atlantic Ocean and Pacific Ocean	warm, humid	hot, humid

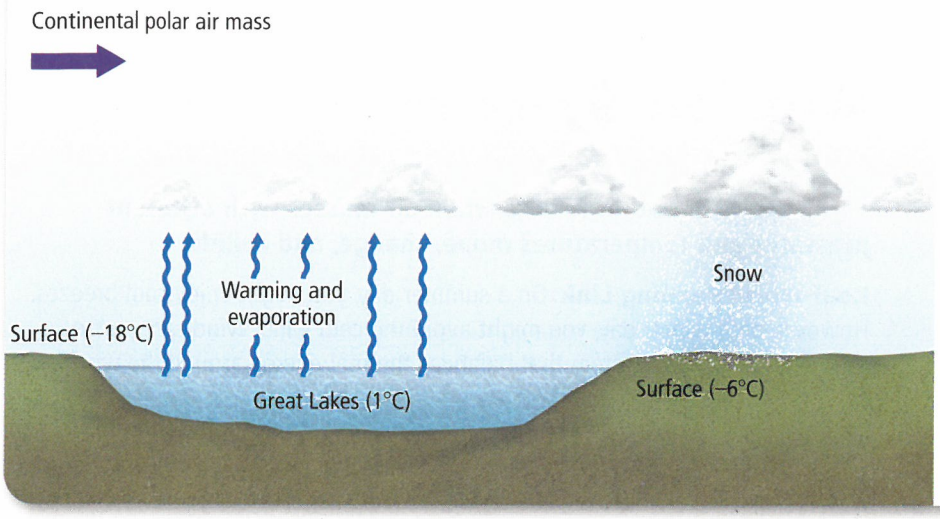


Figure 12.3 As the cold, continental polar air moves over the warmer Great Lakes, the air gains thermal energy and moisture. This modified air cools as it is uplifted because of convection and topographic features, and produces lake-effect snows.

Arctic air masses Earth's ice- and snow-covered surfaces above 60° N latitude in Siberia and the Arctic Basin are the source regions of arctic air masses. During part of the winter, these areas receive almost no solar radiation but continue to radiate thermal energy. As a result, they become extremely cold and can bring the most frigid temperatures during winter.

Air mass modification Air masses do not stay in one place indefinitely. Eventually, they move, transferring thermal energy from one area to another. When an air mass travels over land or water that has characteristics different from those of its source region, the air mass can acquire some of the characteristics of that land or water, as shown in **Figure 12.3.** When this happens, the air mass undergoes modification; it exchanges thermal energy and/or moisture with the surface over which it travels.

Section 12.1 Assessment

Section Summary

- Meteorology is the study of atmospheric phenomena.
- Solar radiation is unequally distributed between Earth's equator and its poles.
- An air mass is a large body of air that takes on the moisture and temperature characteristics of the area over which it forms.
- Each type of air mass is classified by its source region.

Understand Main Ideas

1. MAIN Idea **Summarize** how an air mass forms.
2. **Explain** the process that prevents the poles from steadily cooling off and the tropics from heating up over time.
3. **Distinguish** between the causes of weather and climate.
4. **Differentiate** among the five types of air masses.

Think Critically

5. **Predict** which type of air mass you would expect to become modified more quickly: an arctic air mass moving over the Gulf of Mexico in winter or a maritime tropical air mass moving into the southeastern United States in summer.

WRITING in Earth Science

6. Describe how a maritime polar air mass formed over the North Pacific is modified as it moves west over North America.

Section 12.2

Objectives

- **Compare and contrast** the three major wind systems.
- **Identify** four types of fronts.
- **Distinguish** between high- and low-pressure systems.

Review Vocabulary

convection: the transfer of thermal energy by the flow of a heated substance

New Vocabulary

Coriolis effect
polar easterlies
prevailing westerlies
trade winds
jet stream
front

Weather Systems

MAIN Idea **Weather results when air masses with different pressures and temperatures move, change, and collide.**

Real-World Reading Link On a summer day, you might enjoy cool breezes. However, on a winter day, you might avoid the cold wind. Winds are part of a global air circulation system that balances thermal energy around the world.

Global Wind Systems

If Earth did not rotate on its axis, two large air convection currents would cover Earth, as shown in **Figure 12.4.** The colder and more dense air at the poles would sink to the surface and flow toward the tropics. There, the cold air would force warm, equatorial air to rise. This air would cool as it gained altitude and flowed back toward the poles. However, Earth rotates from west to east, which prevents this situation.

The directions of Earth's winds are influenced by Earth's rotation. This **Coriolis effect** results in fluids and objects moving in an apparent curved path rather than a straight line. Thus, as illustrated in **Figure 12.5,** moving air curves to the right in the northern hemisphere and curves to the left in the southern hemisphere. Together, the Coriolis effect and the heat imbalance on Earth create distinct global wind systems. They transport colder air to warmer areas near the equator and warmer air to colder areas near the poles. Global wind systems help to equalize the thermal energy on Earth.

There are three basic zones, or wind systems, at Earth's surface in each hemisphere. They are polar easterlies, prevailing westerlies, and trade winds.

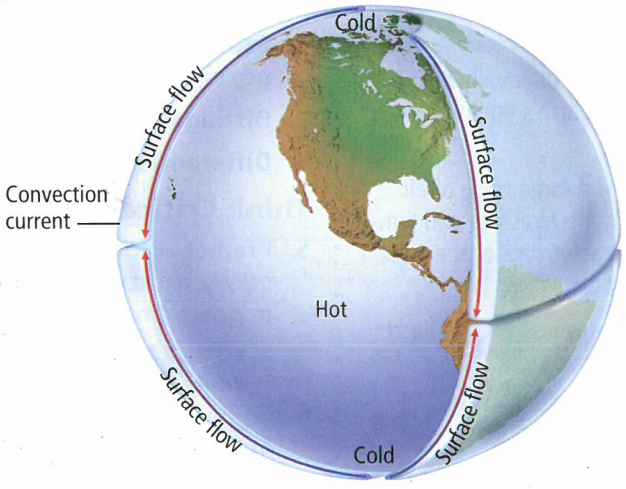


Figure 12.4 If Earth did not rotate, two large convection currents would form as denser polar air moved toward the equator. These currents would warm and rise as they approached the equator, and cool as they moved toward each pole.