

Section 4

Changes in Climate

Key Concept Climate changes may be caused by natural factors and by human activities and can affect human and wildlife habitats.

What You Will Learn

- Earth's climates have changed throughout geologic history.
- Climate change may be the result of several factors, including natural events and human activity.

Why It Matters

The choices you make may affect the global climate and the environment where you live.

As you have probably noticed, the weather changes from day to day. But have you ever noticed the climate change? You probably haven't, because climates change slowly. What causes climates to change? Studies show that human activity may cause climate change. However, natural factors can also lead to changes in the climate.

Ice Ages

The geologic record shows that Earth's climate has been both much warmer and much colder than it is today. In fact, much of Earth was covered by sheets of ice during certain periods. An **ice age** is a period during which ice forms in high latitudes and moves toward lower latitudes. Scientists have found evidence of many major ice ages during Earth's geologic history. The most recent ice age began about 2 million years ago.

During an ice age, there are periods of cold and periods of warmth. These periods are called *glacial* and *interglacial periods*. During glacial periods, the large sheets of ice advance. As the ice sheets advance, they get bigger and cover a larger area. Because a large amount of ocean water is frozen during glacial periods, the sea level drops. As shown in **Figure 1**, coastlines of the continents once extended farther than they do today.

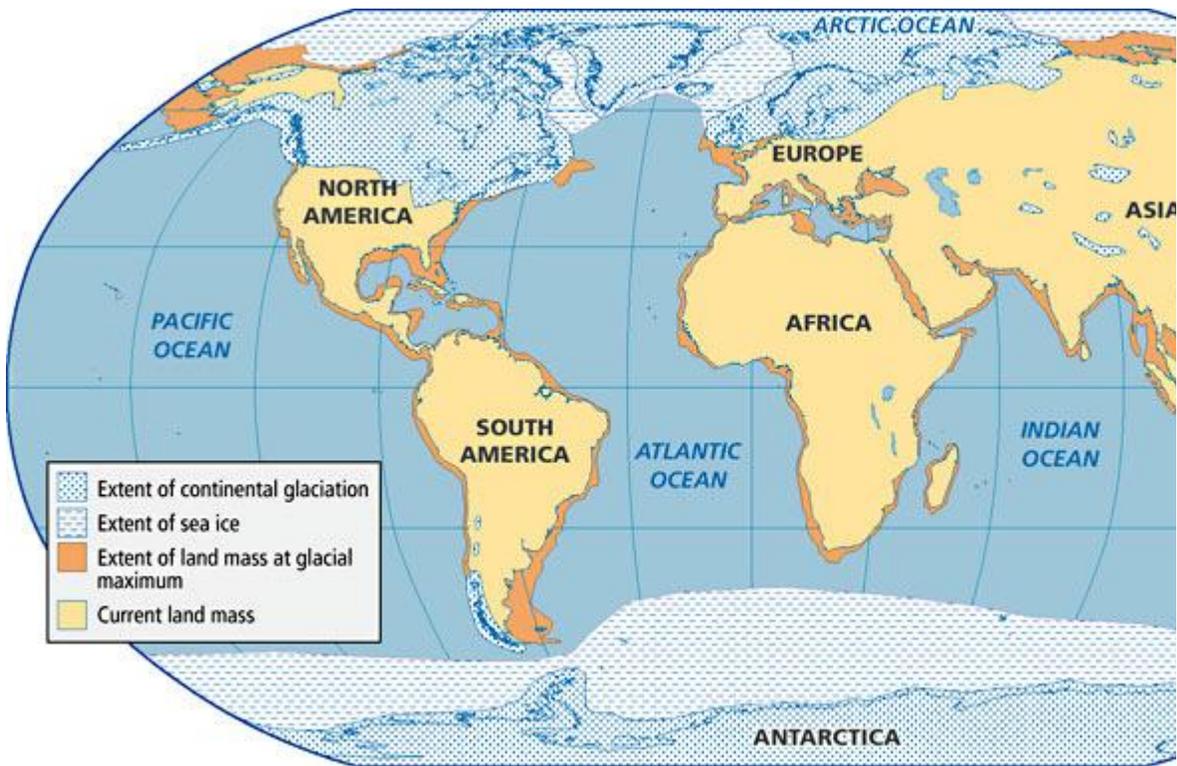


Figure 1 During the last glacial period, about 30% of Earth's surface was covered with ice.

Causes of Climate Change

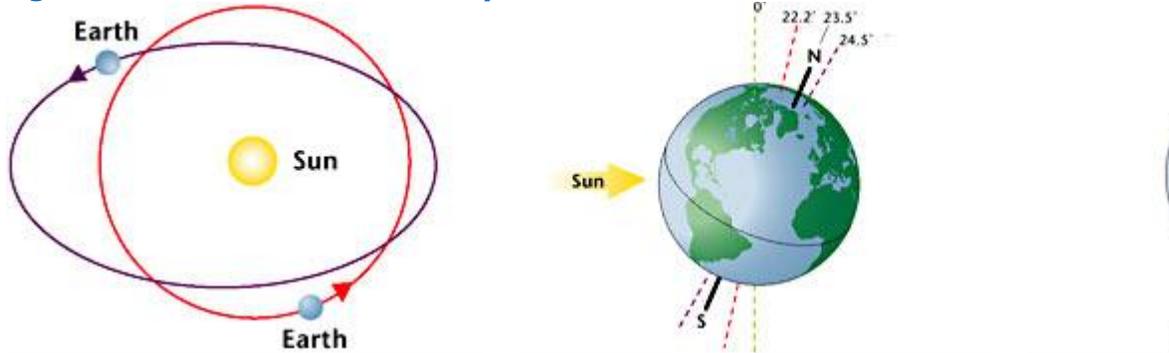
Scientists have formed a number of theories to explain ice ages and other forms of climate change. Factors that might cause climate change are changes in Earth's orbit and tilt of its axis, the movement of tectonic plates, the sun's cycle, asteroid impacts, human activity, and volcanic eruptions.

Changes in Earth's Orbit and Tilt

During an ice age, the temperature alternates between cold and warm. The Milankovitch theory explains why an ice age isn't just one long cold spell. Milutin Milankovitch, a scientist from Yugoslavia, proposed that changes in Earth's orbit and in

the tilt of Earth's axis cause ice ages. The three main parts of his theory are shown in **Figure 2**. These three factors change the amount or intensity of solar radiation received by Earth. As a result, these factors affect climate.

Figure 2 The Milankovitch Theory



Orbit Earth encounters more variation in the energy that it receives from the sun when Earth's orbit is elongated than it does when Earth's orbit is circular.

Tilt Over a period of about 41,000 years, the tilt of Earth's axis varies between 22.2° and 24.5°. The poles receive more solar energy when the tilt angle is greater.

Wobble axis affect radiation 1 parts of E ent times

Standards Check How do changes in Earth's orbit and tilt influence changes in temperature on Earth?

Plate Tectonics

Earth's climate is further influenced by plate tectonics and continental drift. A continent's location relative to the equator and poles determines how much solar radiation the continent receives. The continent's location relative to oceans and other continents is also important. The way continents deflect ocean currents and winds has a strong influence on climate. When continents move, the flow of air and moisture around the globe changes. These changes cause changes in climate.

The Sun's Cycle

Some changes in climate can be linked to changes in the sun. You may think that the sun always stays the same. However, the sun is a variable star. In other words, the amount of energy that the sun emits changes over time, as shown in **Figure 3**. The sun follows a regular cycle during which it releases different amounts of energy at different times. Sometimes, the sun produces a low percentage of high-energy radiation. At other times, the sun produces more high-energy radiation.

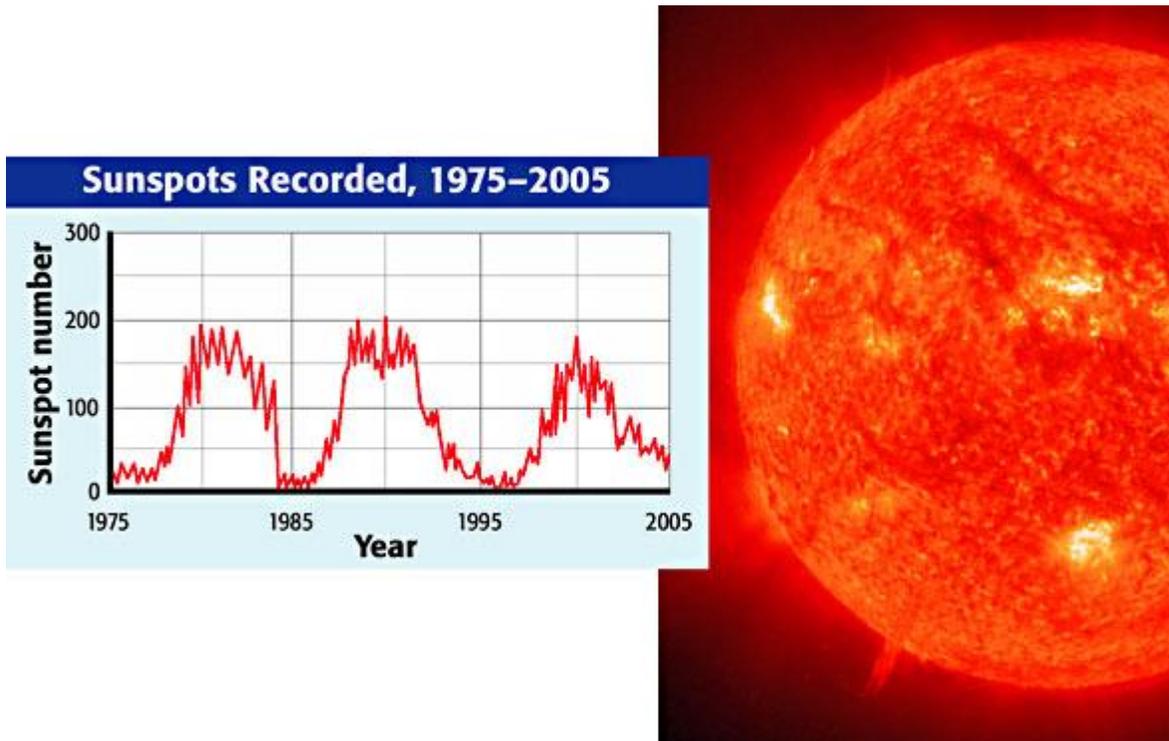


Figure 3 The sun has an 11-year cycle in which it goes from a maximum of activity to a minimum.

Because the sun's energy powers most cycles on Earth, these changes affect the amount of energy in Earth's system. These variations in the amount of energy cause slight changes in Earth's climates.

Standards Check How does the sun's cycle affect climate change on Earth?

Asteroid Impacts

Sometimes, asteroids from outer space crash into Earth. An *asteroid* is a small, rocky object that orbits the sun. Scientists think that if an asteroid 1 km wide were to hit Earth, the climate of the whole world could change.

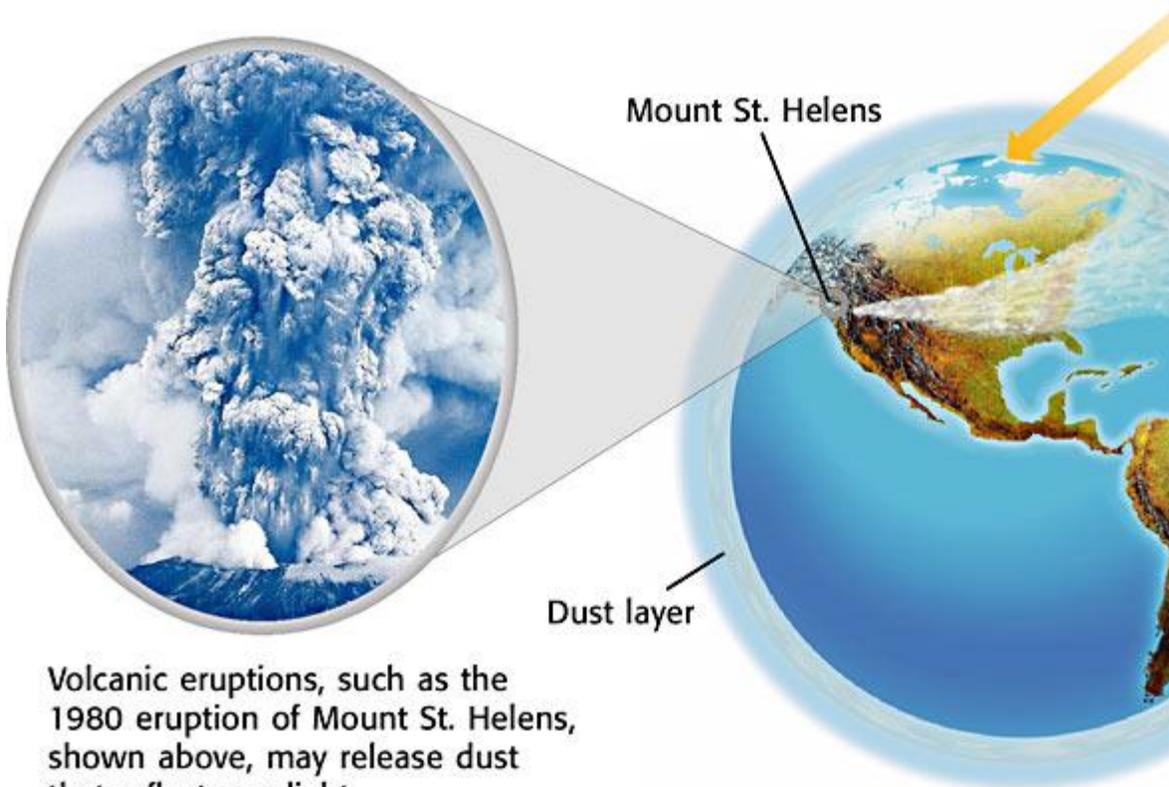
When a large piece of rock slams into Earth, debris from the impact shoots into the atmosphere. *Debris* is dust and smaller rocks. This debris can block some sunlight from reaching Earth's surface. The lack of solar radiation would lower average temperatures, and the decrease in temperature would change the climate. Plants wouldn't get the sunlight they need to grow. Without plants for food, many animals would find it hard to survive. Scientists think that an asteroid that was 10 km in diameter may have struck Earth 65 million years ago. This asteroid impact could have contributed to the extinction of the dinosaurs.



Volcanic Eruptions

Volcanic eruptions can influence climate for a short time. Volcanic eruptions send large amounts of dust, ash, and smoke into the atmosphere. Once in the atmosphere, the dust, smoke, and ash particles act as a shield that blocks some of the sun's rays. When the sun's rays are blocked, solar energy cannot reach Earth's surface. As a result, Earth's surface and atmosphere begin to cool. **Figure 4** shows how dust particles from a volcanic eruption block sunlight.

Figure 4 Volcanic Dust in the Atmosphere



Volcanic eruptions, such as the 1980 eruption of Mount St. Helens, shown above, may release dust that reflects sunlight.

Standards Check How can volcanic eruptions change the climate?

Human Activity

Global temperatures have increased about 1°C during the last 100 years. Researchers are not sure if this increase is a natural change or if it is the result of human activities.

A gradual increase in average global temperatures is called **global warming**. Global warming is caused in part by increases in carbon dioxide, CO₂, concentrations. The burning of fuels for transportation and industry releases CO₂ into the atmosphere. Another factor that increases CO₂ concentrations is the burning of forests to clear land for farming. Burning of the trees gives off more CO₂. Because plants use CO₂ to make food, destroying the trees also takes away a natural way of removing CO₂ from the atmosphere.

Global Warming

Global warming is caused by both natural events and by human activities. Earth's natural heating process, in which gases in the atmosphere absorb thermal energy, is called the **greenhouse effect**. To better understand this concept, think about the inside of a car on a hot, sunny day. The inside of the car gets hot because the sun's rays enter the car through the windows. The seats and other surfaces in the car absorb the sun's energy. Then, the surfaces reradiate that energy as heat. However, the car's windows stop most of the heat from escaping. Therefore, the air inside the car gets really hot.

The Greenhouse Effect on Earth

On Earth, instead of glass stopping the heat from escaping, gases, such as CO₂ absorb the heat. As a result, the heat stays in the atmosphere and keeps Earth warm. However, during the last 100 years, global temperatures have increased. Many scientists think that the rise in global temperatures is due to an increase in CO₂ in the atmosphere.

Consequences of Global Warming

Many scientists think that if the global temperature continues to rise, the icecaps will melt. Evidence that this melting has already started is shown in **Figure 5**. When icecaps melt, water stored in the icecaps raises sea level. The rise in sea level could flood low-lying areas, such as coasts.



Figure 5 This ice sheet in Greenland is melting because of an increase in global temperatures.

If global warming continues, places that receive little rain, such as deserts, might receive even less rain because of increased evaporation. Changes in weather patterns could harm crops in some areas. In other areas, weather conditions for farming could improve.

Standards Check How could global warming affect coastal cities?



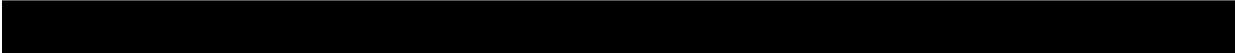
What Humans Can Do

Many countries are working together to reduce the potential effects of global warming. Treaties and laws have been passed to reduce pollution. Industrial practices are being monitored and changed. Even community projects to reforest areas have been developed.

Individuals can also help lower the amount of CO₂ in the atmosphere that is caused by pollution. Pollution is caused mostly by the burning of fossil fuels. Fossil fuels are used for running automobiles and generating electricity. Therefore, humans can reduce pollution rates by using less electricity. For example, people can turn off lights that are not in use and turn down the heat in winter.

Section Summary

- Earth's climate has changed repeatedly throughout geologic time.
- The Milankovitch theory states that Earth's climate changes as Earth's orbit and the tilt of Earth's axis change.
- Climate changes may also be affected by continental drift, volcanic eruptions, asteroid impacts, solar activity, and human activity.
- Excess CO₂ is believed to contribute to global warming.



Chapter Summary

The Big Idea

Differences in pressure, heat, air movement, and humidity result in changes of weather and thus affect climate.

Section 1 Water in the Air

Key Concept The sun's energy drives the water cycle and causes differences in humidity that may lead to precipitation.

- The amount of water vapor in the air is known as humidity.
- Differences in pressure, temperature, and humidity cause clouds and precipitation.



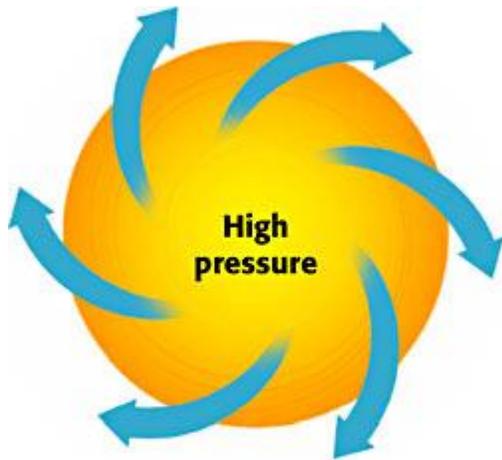
Humidity increases as water vapor enters the air.

Section 2 Fronts and Weather

Key Concept Weather results from the movement of air masses that differ in temperature and humidity.

- Differences in pressure, temperature, air movement, and humidity cause changes in weather, including severe weather.
- Severe weather and floods can cause property

damage and death.



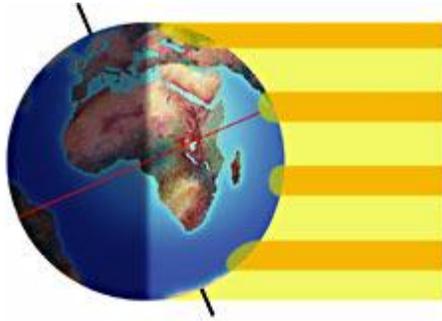
An anticyclone is an area of high pressure.

Section 3

What Is Climate?

Key Concept Earth's climate zones are caused by the distribution of heat around Earth's surface by wind and ocean currents.

- Climate is the average weather condition in an area over a long period of time.
- Climate is affected by latitude, global winds, topography, proximity to large bodies of water, and ocean currents.

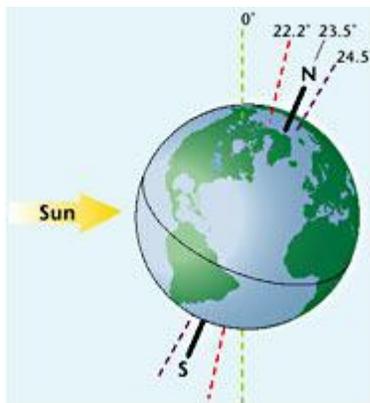


The sun's rays strike Earth at different angles because Earth's surface is curved.

Section 4 Changes in Climate

Key Concept Climate changes may be caused by natural factors and by human activities and can affect human and wildlife habitats.

- Earth's climates have changed throughout geologic history.
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Changes in Earth's tilt over time may cause climate change.



