Climate

Climate Cycles

Read to Learn

Long-Term Cycles

Weather and climate have many cycles. Temperatures usually increase during the day and decrease at night. Each year, the air is warmer during summer and colder during winter.

You will experience many climate cycles in your lifetime. But climate also changes in cycles that take much longer than a human lifetime to complete.

Much of our knowledge about past climates comes from natural records of climate. Scientists study ice cores drilled from ice layers in glaciers and ice sheets to gain information about past climate changes. They also study fossilized pollen, ocean sediments, and the growth rings of trees to learn about climate changes. Scientists use the information to compare present-day climates to those that occurred many thousands of years ago.

Ice Ages and Interglacials

Many major atmospheric and climate changes have occurred during Earth's history. **Ice ages** *are cold periods lasting from hundreds to millions of years when glaciers cover much of Earth*. Glaciers and ice sheets advance during cold periods and retreat during interglacials. **Interglacials** *are warm periods that occur during ice ages*.

Major Ice Ages and Warm Periods

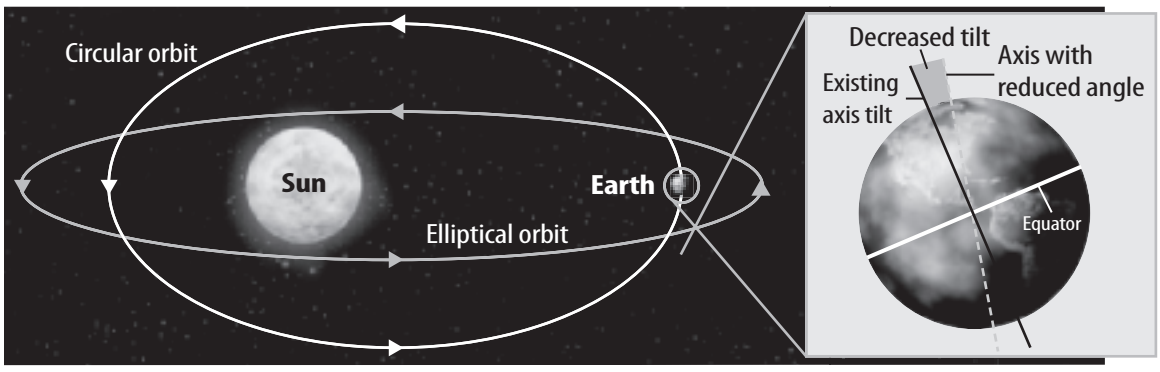
The most recent ice age began about 2 million years ago. Much of Earth was covered with ice about 20,000 years ago. Then the ice sheets started to shrink. About 10,000 years ago, the current interglacial period, called the Holocene Epoch, began.

Temperatures on Earth have varied during the Holocene. For example, the period between 950 and 1100 was one of the warmest in Europe. The Little Ice Age, which lasted from 1250 to about 1850, was bitterly cold.

Causes of Long-Term Climate Cycles

The amount of solar energy reaching Earth changes over time. Earth's climate changes with changes in the amount of solar energy that Earth receives.

The shape of Earth's orbit affects the amount of solar energy that Earth receives. Earth's orbit varies between an elliptical and circular shape over the course of about 100,000 years. The figure below shows the shapes of these two orbits. When Earth's orbit is more circular, Earth averages a greater distance from the Sun. This results in below-average temperatures on Earth.



Another factor that scientists suspect influences climate change is changes in the tilt of Earth's axis. The tilt of Earth's axis changes in 41,000-year cycles. Currently, Earth is tilted at an angle of 23.5°. The tilt angle varies from 22° to 24.5°.

The angle of Earth's tilt affects the range of temperatures throughout the year. For example, a decrease in the tilt angle, as shown in the figure above, could result in a decrease in temperature differences between summer and winter. The slow movement of Earth's continents and changes in ocean circulation also affect Earth's long-term climate cycles.

Short-Term Cycles

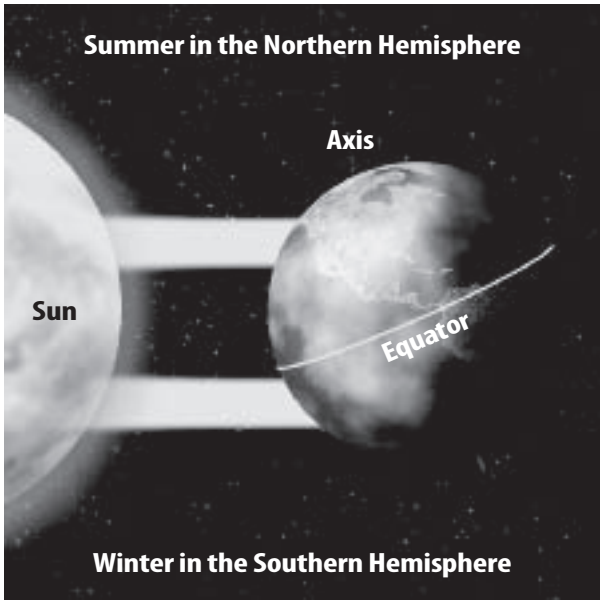
Climate also changes in short-term cycles. Seasonal changes are the most common short-term cycle. Changes that result from the interaction between the ocean and the atmosphere are also short-term climate changes.

Seasons

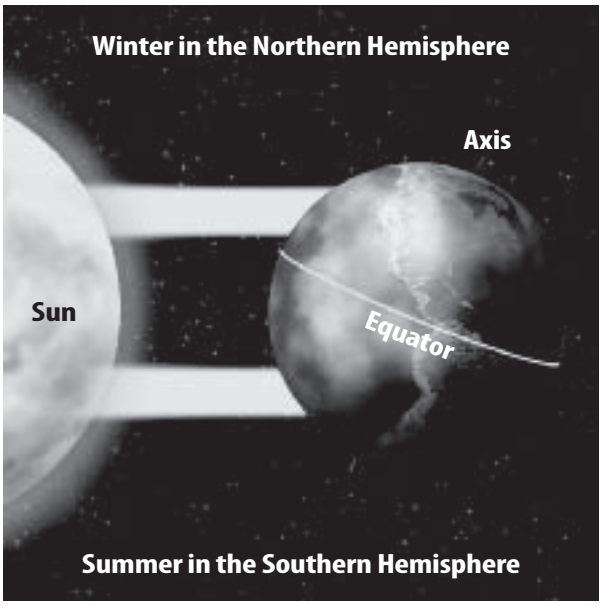
Seasons occur because the amount of solar energy that Earth receives at different latitudes changes during the year. Seasonal changes include regular changes in temperature and the number of hours of daylight.

The amount of solar energy per unit of Earth's surface is related to latitude. Earth's tilt on its axis also affects the amount of solar energy an area receives, as shown below.

When the northern hemisphere is tilted toward the Sun, it receives more direct solar energy. There are more daylight hours than dark hours, and temperatures are warmer. It is summer in the northern hemisphere. During this time, the southern hemisphere receives less overall solar energy. It is winter there.



The opposite occurs in six months when the northern hemisphere is tilted away from the Sun. This is shown in the figure on the top of the next page. There are fewer daylight hours than nighttime hours. Temperatures are colder. The solar energy that reaches the northern hemisphere is indirect and less intense. It is winter in the northern hemisphere. The southern hemisphere receives more direct solar energy, and it is summer there.

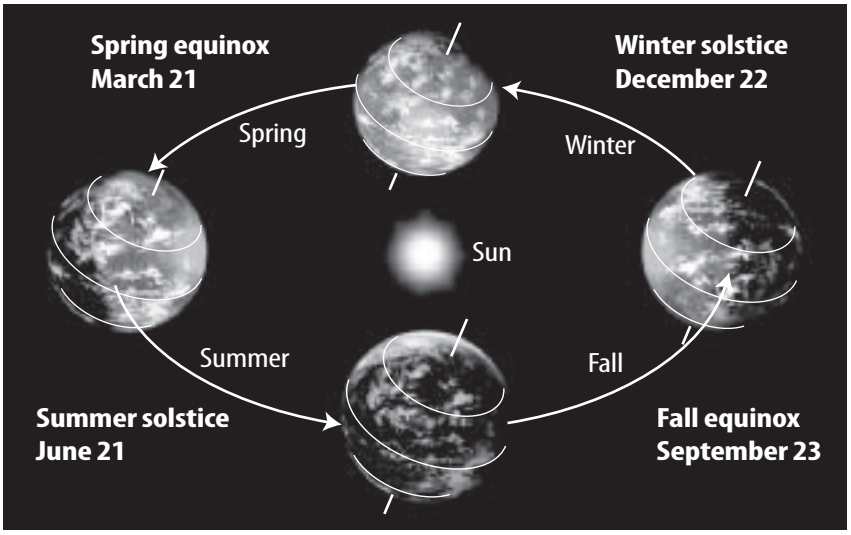


Solstices and Equinoxes

Earth revolves around the Sun once about every 365 days. During Earth's revolution, there are four days that mark the beginning of each of the seasons. These days are a summer solstice, a fall equinox, a winter solstice, and a spring equinox. These days are shown in the figure below.

Solstices The solstices mark the beginnings of summer and winter. In the northern hemisphere, the summer solstice occurs on June 21 or 22. On this day, the northern hemisphere is tilted toward the Sun. In the southern hemisphere, this day marks the beginning of winter.

The winter solstice begins on December 21 or 22 in the northern hemisphere. On this day, the northern hemisphere is titled away from the Sun. Summer begins in the southern hemisphere.



Equinoxes Days when neither the northern hemisphere nor the southern hemisphere tilts toward or away from the Sun are equinoxes. The equinoxes are shown in the figure on the previous page.

The equinoxes are the beginning of spring and fall. The number of daylight hours almost equals the number of nighttime hours everywhere on Earth on equinox days. In the northern hemisphere, the spring equinox occurs on March 21 or 22. Fall begins the same day in the southern hemisphere. On September 22 or 23, fall begins in the northern hemisphere and spring begins in the southern hemisphere.

El Niño and the Southern Oscillation

The trade winds blow from east to west near the equator. These steady winds push warm surface water in the Pacific Ocean away from the western coast of South America. This allows cold water to rush upward from below in a process called upwelling. The air above the cold, upwelling water cools and sinks, creating a high-pressure area. On the other side of the Pacific Ocean, air rises over the warm waters around the equator creating a low-pressure area. This difference in air pressures across the Pacific Ocean helps keep the trade winds blowing.

Sometimes the trade winds weaken. This reverses the normal pattern of high and low pressures across the Pacific Ocean. Warm water surges back toward South America, preventing cold water from upwelling. This phenomenon is called El Niño.

El Niño shows the connection between the atmosphere and the ocean. During El Niño, the normally dry, cool western coast of South America warms, and precipitation increases. Climate changes can be seen around the world. Droughts occur in areas that are normally wet. The number of violent storms in California and the southern United States increases.

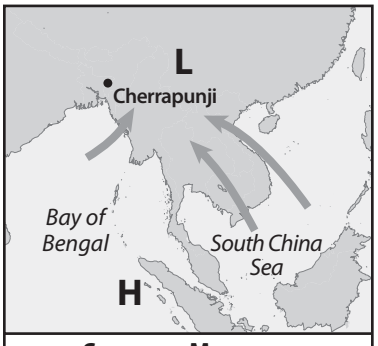
The combined ocean and atmospheric cycle that results in weakened trade winds across the Pacific Ocean is called **El Niño/Southern Oscillation**, or ENSO. A complete ENSO cycle occurs every 3–8 years.

The North Atlantic Oscillation (NAO) is another cycle that can change the climate for long periods. The NAO affects the strength of storms in North America and Europe by changing the position of the jet stream.

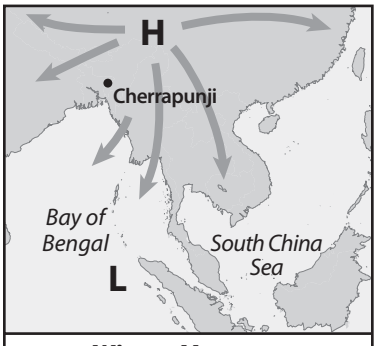
Monsoons

Another climate cycle involving the atmosphere and the ocean is a monsoon. *A* **monsoon** *is a wind circulation pattern that changes direction with the seasons*. Temperature differences between the ocean and the land cause winds. During summer, warm air over land rises and creates low pressure. Cooler, heavier air sinks over the water, creating high pressure. The winds blow from the water toward the land, bringing heavy rains. You can see this in the figure to the left below. During the winter, the pattern reverses. The winds blow from the land toward the water, as shown in the figure on the right.

The world's largest monsoon is in Asia. Cherrapunji, India, is one of the world's wettest locations. It receives an average of 10 m of monsoon rainfall each year. Even more rain falls during El Niño events.



Summer Monsoon



Winter Monsoon

A smaller monsoon occurs in southern Arizona. As a result, weather is dry during spring and early summer. Thunderstorms occur more often from July to September.

Droughts, Heat Waves, and Cold Waves

A **drought** *is a period with below-average precipitation*. Droughts can cause crop damage and water shortages.

Droughts often occur at the same time as heat waves, which are periods of unusually high temperatures. Droughts and heat waves occur when large hot-air masses remain in one place for weeks or months.

Cold waves are long periods of unusually cold temperatures. A cold wave occurs when a large continental polar air mass stays over a region for days or weeks. Severe weather of the types discussed can be the result of climatic changes on Earth or extremes in the average weather of a climate.