Introduction

Earth is enveloped in layers of gases called the **atmosphere**. These layers are responsible for Earth's **weather** and for protecting us from harmful rays of the sun. Weather affects us daily and is a determining factor in many of our decisions. Air pressure, temperature, winds, and humidity change constantly and can produce dangerous conditions like **hurricanes** and **tornadoes**. The day-to-day weather we experience makes up our **climate**. Some areas have a cold, polar climate while others have a hot and humid tropical climate. Climate and weather influence our daily lives. Studying Earth's weather and climate changes will help us to understand how to prepare for or prevent dangerous weather conditions and cope with our ever changing environment.

Atmosphere

Earth is surrounded by a mixture of gases called the *atmosphere.* The atmosphere is divided into four layers, based on differences in temperature and gases present. The layer of the atmosphere closest to Earth is the **troposphere**. This is the layer in which we live, and it contains most of our weather. The troposphere extends upwards from the surface of Earth for about 10 kilometers. The temperature decreases farther up in the troposphere.

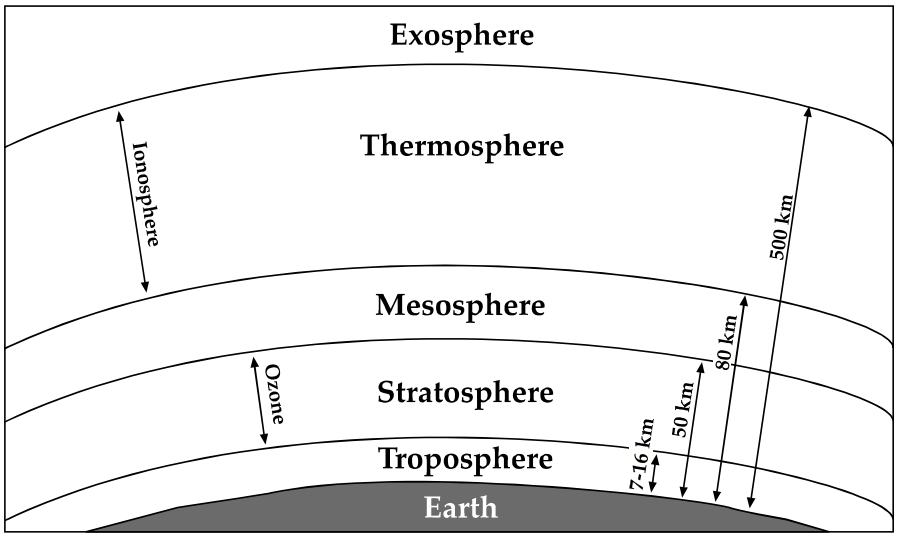
Earth

Just above the troposphere is a narrow layer of strong winds that blow from west to east called the **jet stream**. Planes flying eastward use the jet stream to increase their air speed.

The layer of air above the troposphere is the **stratosphere**. This layer extends to about 50 kilometers above Earth's surface. The air in the lower areas of the stratosphere is very cold, but the air in the upper layers is about the same as it is at sea level.

This warmer temperature is due to the **ozone** present there. Ozone is a gas with three oxygen atoms (O_3), rather than two oxygen atoms (O_2) present in the air we breathe. Ozone absorbs the sun's ultraviolet rays and heats

up the atmosphere. It also shields Earth and keeps ultraviolet rays from reaching Earth's surface. Ultraviolet rays can cause blindness and skin cancer.



For these reasons, it is important that the ozone layer of Earth not be destroyed. Chemicals known as chlorofluorocarbons (CFCs) that are used in aerosol (spray) cans can destroy the ozone layer. Federal laws have been passed which regulate the use of aerosol cans.

Most of the ozone on Earth is in this layer of the stratosphere; however, some of it is found in lower layers. When **lightning** strikes, ozone is formed. You can smell the presence of ozone when lightning strikes. It has a clean, sharp smell.

lightning striking

Above the stratosphere lies the **mesosphere**, where the temperature is colder. It is, in fact, the coldest part of the atmosphere. This layer extends to about 80 kilometers above the Earth.

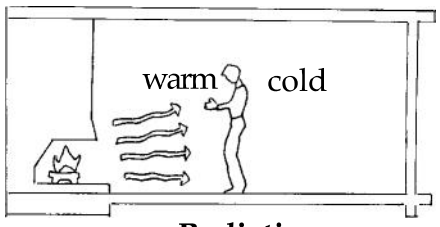
Beyond the mesosphere is the **thermosphere**, which is divided into two parts, the **ionosphere** and the **exosphere**. The ionosphere extends to about 500-700 kilometers. The exosphere is the last layer of the atmosphere and extends for thousands of kilometers upward into interplanetary space.

The thermosphere is very hot because of absorption of the sun's energy. The first part of the thermosphere, the ionosphere, is a layer of electrically charged particles. These particles are bombarded by energy from space. They become electrically-charged particles called *ions* and *free electrons*. These are useful for communication because they reflect radio waves.

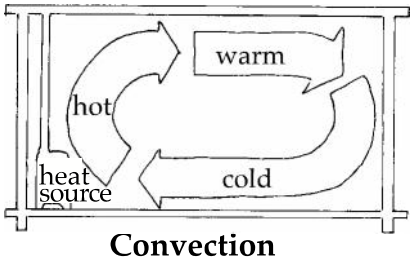
The last layer of the thermosphere and atmosphere is the exosphere. Here, the atmosphere is very thin. In other words, atoms and ions are very far apart. Some gases escape into space.

The Effect of Solar Radiation

Earth receives its heat from the sun. The sun's energy is spread through the atmosphere in three ways—**radiation**, **convection**, and **conduction**. Radiant energy from the sun reaches Earth in the form of waves by a process called *radiation*. These light waves are absorbed by Earth and returned to the atmosphere as heat. As air molecules absorb heat, they begin to move farther and farther apart. Warm air is therefore less dense, or lighter, and rises.



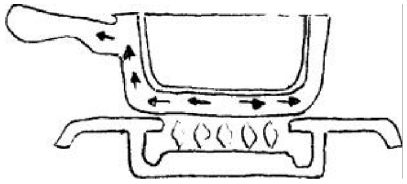
Radiation



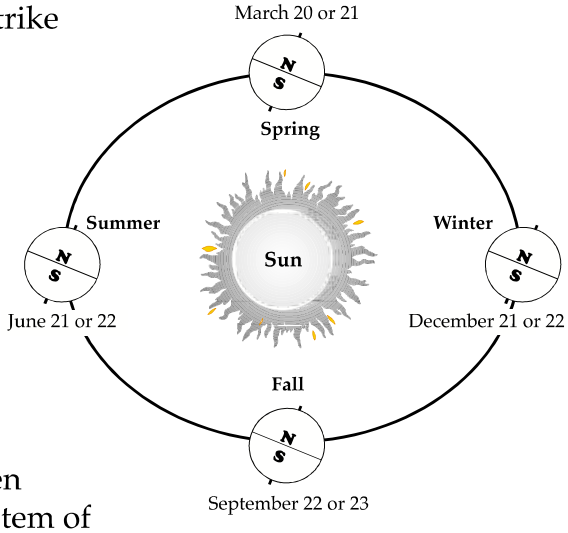
Convection

Convection is the process through which heat is transferred by moving air or water. As the warm air rises, denser, heavier, and colder air moves in to replace it. This movement creates a **convection current**. Convection currents cause a constant exchange of air until the surface is evenly heated. Most of the heat in the atmosphere is transferred by convection currents.

The direct transfer of heat energy through contact is called *conduction*. When cool air above Earth's surface comes into contact with the warm ground, the air is heated. Air temperatures closer to the ground are generally warmer than those higher up. Conduction plays only a minor role in heating the atmosphere because land and water are poor conductors of heat.


Conduction

The angle at which the sun's rays strike Earth varies because Earth is a sphere that rotates on its axis. The sun's rays produce the most heat when they strike Earth at a 90° angle. We call these rays **direct rays**. The area near the equator gets most of the direct rays of the sun. The rays that strike Earth on both sides of the equator hit at an angle that is greater than 90° and are called **indirect rays**. This creates an uneven heating of Earth which causes a system of air currents and winds to be formed. Vertical movements of air are called **currents**, and horizontal movements of air are called **wind**.



High and Low Air Pressure

L
low pressure

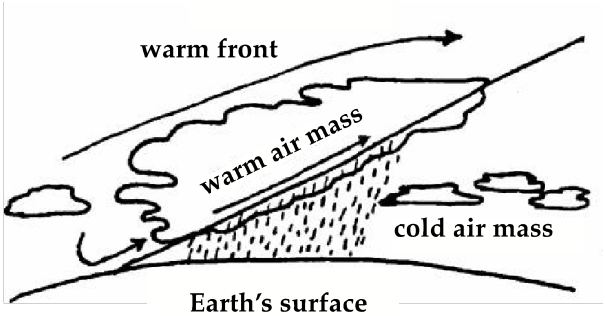
The uneven heating of Earth also causes changes in air pressure. When lighter, warm air rises, it creates an area of low pressure. The winds of a **low-pressure system** move upward, spiraling towards the system's center in a counterclockwise direction in the Northern Hemisphere and clockwise in the Southern Hemisphere. Low-pressure systems generally bring cloudy, rainy weather that is often accompanied by storms.

H
high pressure

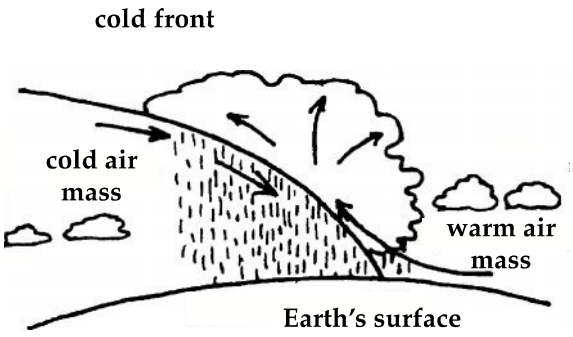
The heavier, cooler air in the upper atmosphere sinks, creating an area of high pressure. The winds of a **high-pressure system** move downward, spiraling outward in a clockwise direction in the Northern Hemisphere and counterclockwise in the Southern Hemisphere. High-pressure systems bring cool, clear skies and dry weather. Differences between air pressure also cause winds. Air will move from an area of high pressure into an area of low pressure. The strength of the wind will depend on the amount of difference in pressure between the two systems. Air pressure systems cause changes in weather and are measured by a **barometer**.

Fronts

Large bodies of air having the same temperature and amount of moisture are called **air masses**. Some air masses form over continents and others form over the oceans. Those forming over the oceans have more moisture in them than the ones forming over land. When two different types of air masses meet, a boundary called a **front** forms. Fronts usually have stormy or unstable weather. There are four types of fronts: warm, cold, stationary, and occluded.



Warm Front. A **warm front** (▬◡◡◡) forms when a mass of warm air meets a mass of cold air. The warm air gradually moves up and over the colder air causing **precipitation** and **clouds** ahead of the warm front. High **cirrus** clouds form and are followed by **stratus** clouds, causing the barometer to fall, and **nimbostratus** clouds producing rain or snow falls for a long period of time. A warm front is indicated by a line with half circles on it.



Cold Front. A **cold front** (▬▼▼▼) forms when a cold air mass pushes a warm air mass in front of it. The cold air wedges under the warm air and lifts it up at a sharp angle, causing the formation of **cumulus** and **cumulonimbus** clouds, which produce thunderstorms and hard rains. Cold fronts generally move through an area quite rapidly, with cool, clear weather following. Cold fronts are indicated by a line with triangles facing the direction the front is moving.

Stationary Front. A **stationary front** (◡▼◡▼) forms when two unlike air masses face each other, but there is very little movement of air. The weather associated with a stationary front is similar to a warm front. Eventually one front or the other moves, forming either a warm or a cold

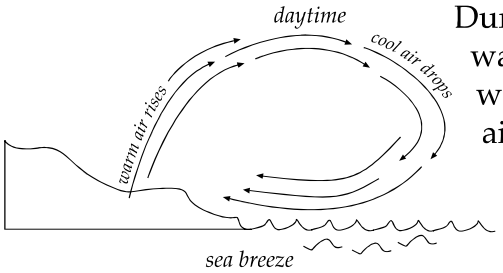
front. The symbol for this front is a line with half circles on one side and triangles on the other.

Occluded Front. An **occluded front** () forms when a cold front overtakes and merges with a warm front. It is characterized by a combination of weather from both fronts. An occluded front is indicated by a line with alternating half circles and triangles on the same side of the line.

Winds

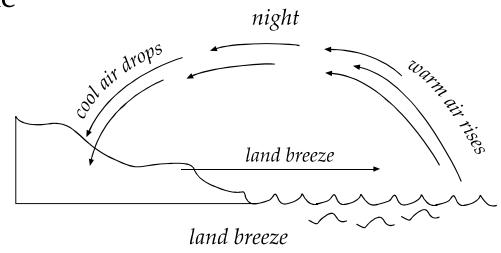
The differences in air pressure caused by the uneven heating of Earth by the sun result in winds. We use a **wind vane** to indicate the direction from which the wind is blowing. An **anemometer** is used to measure wind speed.

There are different types of wind systems. Local wind systems are caused by the specific conditions of a local area. The surface features of a particular area affect the amount of heat absorbed by the sun. Land absorbs the heat of the sun faster than water does, but it also loses heat faster than the water. This causes an uneven heating of the air and results in local winds. Winds are named for the direction from which they come.



During the day, land near a large body of water heats up faster than the water. The warm air above the land rises and the cool air from the body of water moving inland to replace it creates a **sea breeze**.

At night, the land cools faster than nearby bodies of water. Eventually air above the water will become warmer than that above the land and will rise, causing the cooler air from land to move in and replace it. This movement of air from land to sea is called a **land breeze**.



Wind Systems

The unequal heating and rotation of Earth also creates global wind systems, or belts. The air above the equator is warmer than the air above the polar regions. Warmer air rises and travels towards the poles where it cools and becomes heavier. This cool, heavy air then moves back towards the equator where it is again warmed and rises. This warming and cooling process combines with Earth's rotation to form convection currents that create global winds. There are several wind systems on Earth's surface. They are as follows:

Doldrums. The **doldrums** are a windless zone at the equator. The air seems to be motionless, but actually it is constantly being heated and forced straight up. This causes very little wind or no wind at all except during storms. In the days of sailing ships, many ships were caught in the doldrums and lost.

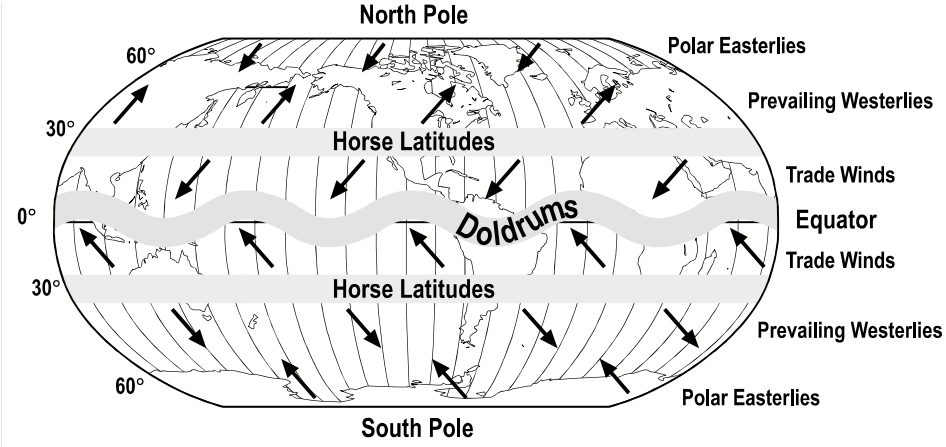
Trade Winds. The wind belt known for the **trade winds** is found just north and south of the equator. In these areas, wind is fairly constant. North of the equator the winds blow from the northeast, and south of the equator they blow from the southeast. Early sailors depended on these winds to get from one continent to another in order to trade, and called them trade winds.

Horse Latitudes. Just north and south of the trade winds at about 30° latitude are two narrow regions known as the **horse latitudes**. This is where the air moving from the equator cools and sinks. It is characterized by clear weather and very little rainfall. There is also very little wind in this area. If ships were caught in this region, they sometimes had to throw horses overboard when they were unable to feed them, giving the area its name.

Prevailing Westerlies. North and south of the horse latitudes are another wide belt of winds known as the **prevailing westerlies**, named for the direction from which they blow. These winds form in areas of Earth where there are large areas of land. The air over the land heats up and rises, then cools and sinks again, creating a wind belt.

Polar Easterlies. The belt known as the **polar easterlies** extends from 65° north and south latitude to the poles. These winds come from the east and blow cold winds away from the polar areas.

Sometimes winds that blow are seasonal. Winds that blow in one direction one season and in an opposite direction in another season are called **monsoons**. During a monsoon, the land becomes hotter than the water, causing winds that blow in from the ocean which bring warm, moist air, producing a rainy season during the summer. In the winter, the land cools more quickly, causing the winds to blow from the land to the oceans, which creates a dry season. A monsoon is actually a very large, long-lasting land and sea breeze.

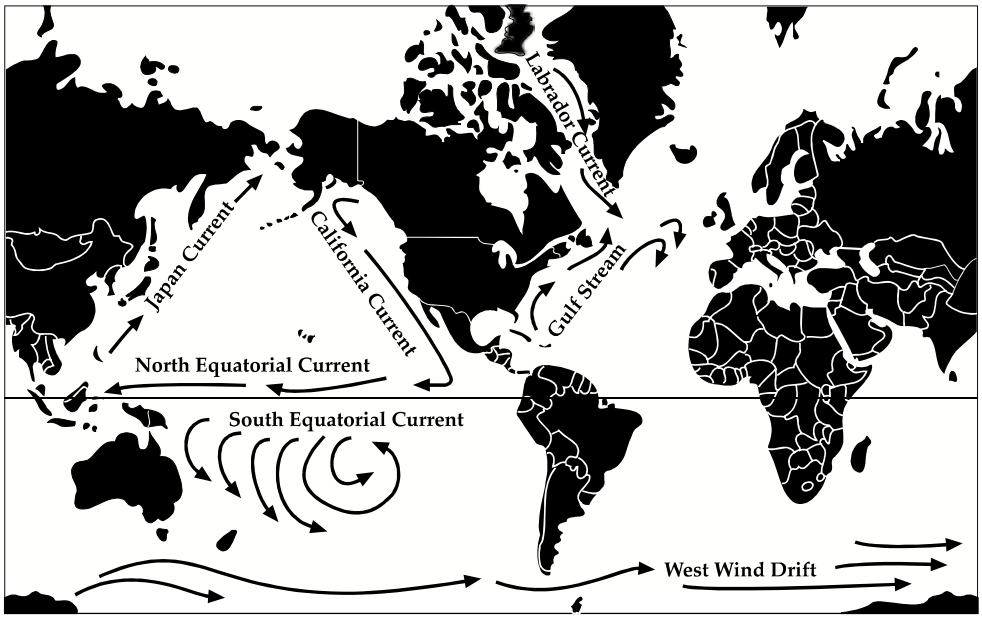


Wind Belts

Currents

A *current* is a moving, streaming, or plowing body of water or air. Ocean currents are sometimes called the *rivers of the ocean*. Like the rivers on the land, ocean currents flow in nearly the same direction.

The ocean has many currents. These currents are caused by the forces of the sun's heat, Earth's rotation, and the blowing winds.



Ocean Currents

Changes in the water temperature cause currents. Differences in water temperature start water movement called convection currents. Because the equator of Earth receives direct sun rays, the waters near the equator are warmer than the waters near the north or south pole. Warm water from the equator is pushed toward the poles by winds and Earth's rotation. This warm current transfers its warmth to the lands it flows by and to the cool waters around the poles. The colder water is heavier, so it sinks and moves back to the equator.

Ocean currents affect the climate of the continents they flow past. Currents that originate near the equator are warm. The warmth of these currents is transferred to the land and to the cool northern waters. The Gulf Stream is a warm current that helps moderate the winters of the British Isles and Norway and keeps them relatively warm for their latitudes. The Gulf

Stream warms our eastern coast of the United States. The Japan Current is also a warm current. It brings a mild climate to parts of British Columbia and Alaska.

Alaskan waters are near the North Pole and nearer to either pole the water cools. Colder, heavier polar waters sink under warm currents and move back toward the equator. The California Current is a colder current that affects the western coast of the United States.

The dense fog of London is an example of the way currents affect the land masses. This heavy fog is caused when the warm, moist air from the Gulf Stream meets the colder air from the Labrador Current.

Storms

There are many different types of storms that occur on the surface of Earth. They range in severity from minor inconvenience to major disaster.

When two fronts collide, rainstorms and thunderstorms form. A *rainstorm* or steady rainfall that lasts for hours forms when a warm front meets a cold front. There is not usually much danger in a rainstorm except for flooding if the storm lasts long enough.

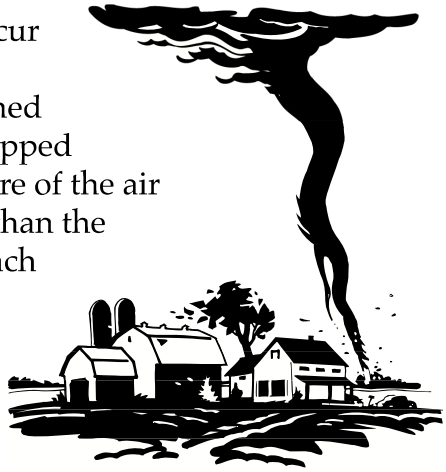
Thunderstorms form when a cold front meets a warm front. As warm air rises, it cools and condenses, forming *cumulonimbus* clouds. These clouds cause heavy rains along with **thunder** and lightning. During thunderstorms, electrical charges build up in the clouds. *Lightning* is the sudden discharge of electricity from the clouds. *Thunder* is the sound made by lightning. It is usually heard a few seconds after the lightning is seen because sound travels slower than light.

Blizzards occur during the winter months. Blizzards combine high winds, below freezing temperatures, and blowing powdery snow. Winds often range from 30 to 45 miles per hour (mph). These severe weather conditions can be dangerous to people and animals.

Low-pressure areas that contain warm air rising in a counterclockwis circular motion are called **cyclones**. The low-pressure areas usually cause rainy, stormy weather. High-pressure areas that have cool, dry air moving downward in a clockwise motion are called **anticyclones**. They bring clear, dry, fair weather. Cyclones and anticyclones move in opposite directions in the Southern Hemisphere. These systems can be either mild or severe.

A *hurricane* is a large, powerful cyclone. Hurricanes start out as low-pressure areas over the ocean in summer or early fall. As the system builds, it forms a spiral motion and contains a large amount of moisture. When wind speed is less than 35 mph, the storm is called a **tropical depression**. If the storm builds to a wind speed of 35 to 74 mph, it is called a **tropical storm**. When sustained winds reach 75 mph or more, a hurricane is born. Hurricane winds can reach over 200 mph; however, most of the damage from hurricanes comes from the flooding caused by the heavy rains associated with the storm.

A *tornado* is a violent, funnel-shaped windstorm that can occur along with thunderstorms or hurricanes. Tornadoes are formed when a mass of warm air is trapped between two masses of cold air. The pressure of the air in the center of the tornado is much lower than the surrounding air, causing winds that can reach 300 mph. The path of a tornado is much smaller than that of a hurricane, but because of its extremely high winds, it can do more damage to the area it strikes. A tornado that forms over the ocean is called a **waterspout**.



Safety Precautions

Storms can cause severe damage. Many safety precautions can be taken to prevent injury and lessen damage.

Rainstorms and thunderstorms rarely cause severe damage, with the exception of flooding. However, if lightning occurs, take the precautions listed on the following page:

Lightning Safety Precautions

1. Stay indoors.
2. Unplug electrical appliances to prevent damage.
3. If outdoors, stay away from tall objects like trees and towers. Also, avoid metal objects like golf clubs and aluminum baseball bats.

Getting struck by lightning can result in burns, loss of hearing, nervous system problems, and death. Lightning is a problem in Florida—especially during the summer and fall.

Hurricanes develop in tropical waters usually between June and November. These storms affect Florida and cause damage from wind and water. Hurricanes cause large-scale destruction and often leave areas without power and telephone service. Therefore, make sure that you have water, nonperishable food, candles, flashlights, a portable radio, batteries, and other items you may need.

A *hurricane watch* means that a hurricane may threaten within 24 hours. *Hurricane warnings* indicate that one is expected to strike within 24 hours. When a warning is issued, take the following precautions:

Hurricane Warning Safety Precautions

1. Leave low-lying areas.
2. Secure boats, outdoor objects, and windows.
3. Fill your car with gas.
4. Leave mobile homes for sturdier shelter.
5. Listen to weather service bulletins.
6. Leave your home for shelter, if advised by authorities.

After the hurricane has completely passed, stay away from heavily damaged areas, flooded areas, and loose wires, and cooperate with emergency officials. Do not mistake the *eye* of the hurricane for the *end*. The eye is a calm area at the center of a hurricane. After it passes, the storm will continue.

Tornadoes can be spawned by hurricanes or occur singly over land or water. Remain indoors or seek shelter in low-lying areas, if outdoors. If

inside, open a window a few inches on the side of the house away from the storm, and take shelter in a small interior area like a hallway, closet, or bathroom.

Blizzards are not a common occurrence in Florida. But if you should be where they occur, it is important to stay indoors, if possible. Frostbite and disorientation are common problems. People in northern areas watch weather bulletins and stay close to home as a precaution.

Danger to human life can be lessened by taking appropriate precautions when warnings are issued. It is important to pay attention to signs of severe weather.

Clouds

Clouds are tiny droplets of water suspended in the air. Clouds form when the air becomes **saturated** (has all of the moisture that it can hold). The droplets of water cling to particles of dust, salt, smoke, or even volcanic ash found in the atmosphere and form clouds.

cirrus clouds

There are three basic types of clouds. They are classified according to their shape and the altitude at which they are formed. There are three basic types:

Cirrus. Cirrus clouds are thin, feathery clouds that form at very high altitudes. They are made of ice crystals and indicate that snow or rain may be coming in the next few hours.

cumulus clouds

Cumulus. Cumulus clouds are puffy with flat bottoms. They look like puffs of cotton in the sky. They form in the middle altitudes and usually indicate fair weather.

Stratus. Stratus clouds are the gray, smooth, layered clouds that lie low in the sky. They block out the sun and usually bring rain or drizzle. Stratus clouds that form close to the ground are called fog.

stratus clouds

Another term used to describe clouds is **nimbus**, which means *rain*. *Nimbostratus* clouds are low, black, layered clouds that cause long periods of rain. *Cumulonimbus* clouds are often called thunderheads because they are the clouds that cause thunderstorms.

Clouds shield against the heat of the sun. Since clouds are made of droplets of water, more light is reflected off them. As a result there are lower temperatures during the day than if there were no clouds. At night, clouds act as blankets that insulate Earth and keep it warmer. Heat waves radiated by the sun that enter the atmosphere are short waves. As they bounce off the surface of Earth, they become longer. These longer waves cannot pass through the cloud layer and therefore bounce back to Earth's surface, maintaining warmer nighttime temperatures than if there were no clouds. Clouds blanket Earth in much the same way a blanket keeps a person warm on a cool night. Cloud cover can keep crops from freezing when the temperatures unexpectedly drop below freezing.

Precipitation

When clouds form, water droplets may grow larger and larger until they are so heavy that they can no longer remain suspended in the air. Water falls to the ground in one or more forms called *precipitation*. There are several types of precipitation. The type of precipitation formed depends on the weather conditions and temperatures.

Rain is the most common type of precipitation. It forms when the temperature of air below the clouds is above freezing and droplets of water fall from the clouds. If the rain falls in very tiny drops, it is called *drizzle* or *mist*.

When the temperature in the clouds is below freezing and the temperature of the air below the clouds is also freezing, crystals of ice called *snowflakes* form. Each snowflake is unique, but all of them have six points.

Sleet forms when raindrops fall through a layer of air that is below freezing, causing the rain to freeze as it falls to Earth. Sleet also forms when snow melts on its way down and then freezes again; sleet will only fall in the winter. Freezing rain forms when conditions on the ground are cold enough to freeze the rain when it lands.

A damaging form of precipitation is *hail*. It can destroy entire crops as well as damage cars and other property. Hail or hailstones are chunks or balls of ice formed in cumulonimbus clouds. A hailstone is formed when a water droplet freezes on a small crystal of ice. Updrafts in the cloud toss the ice balls up in the cloud and then a layer of water freezes on the ice ball. This continues until the hailstone is finally heavy enough to fall to Earth. The average hailstone is about the size of a pea, but sometimes they can get as large as baseballs.

Climates

Weather encompasses the day-to-day changes in the temperature, humidity, wind, and air pressure. *Climate* is the average of conditions that make up an area's weather over a long period of time. Weather changes from day to day, whereas climate remains the same.

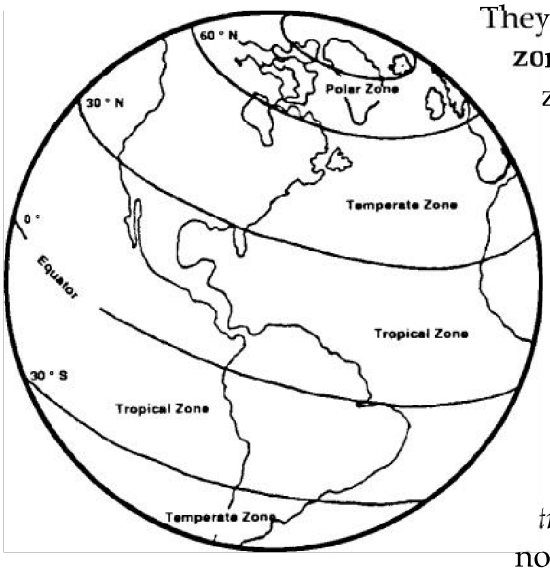
Factors Influencing Climate

An area's climate is influenced by many factors. Some of these include latitude, elevation, and nearness to a major body of water.

The latitude or distance north or south of the equator is a factor in determining the climate of an area. Areas near the equator receive the direct rays of the sun and have warm climates. Likewise, the areas farther from the equator get more indirect rays and are cooler, with the coldest areas being at the poles.

Elevation, or height above sea level, is also a factor in determining the climate of an area. The higher the elevation, the colder the climate. Even high mountains near the equator can have snow-capped peaks. Mountains near coastal regions are also important in forming **deserts**. When the moist winds from the ocean rise and meet the mountain range, they drop their moisture in the form of rain on the side of the mountains nearest the ocean or in the form of snow on the mountains. The air that passes to the other side of the mountains is now dry, and the climate on that side of the mountains will also be dry.

A major body of water near land may have a great influence on the climate. Land near large bodies of water may be humid or moist. Since large bodies of water heat up and cool off much more slowly than land, these areas do not have the extreme temperature changes of large land areas.



climate zones

There are three main climate zones on Earth. They are the **polar zone**, the **temperate zone**, and the **tropical zone**. The *polar* zone begins at each pole and extends to about 60° north or south latitude. Here, the average temperatures remain below freezing and there is little precipitation. Between 60° and 30° latitude on each hemisphere is a region called the *temperate* zone, which has a variance of temperatures and an average amount of precipitation. The *tropical* zone extends from about 30° north latitude to 30° south latitude. It has above-average temperatures and precipitation.

Within these zones there are other climatic types. *Deserts* are areas that receive less than 25 centimeters of rainfall a year. They are usually located along the western border of a large land mass with a range of coastal mountains.

Marine climates are found near large bodies of water. Temperatures in this type of climate do not vary much because the water cools off and heats up much more slowly than the land does. There is also less seasonal change in these areas.

Continental climates are found where there are huge land masses. They are greatly affected by air masses that move in from both polar and tropical regions. They have noticeable seasonal changes and severe temperature changes. Mountain regions located in continental areas also show distinct climatic changes. Higher up in the mountain regions, the climate becomes more like that found in the polar regions.

Summary

Heat and energy are transferred from the sun by Earth's atmosphere through convection, radiation, and conduction. Uneven heating of Earth causes changes in air pressure and air currents. These changes along with the Earth's rotation produce local wind systems and global wind systems.

Blowing winds, the sun's heat, and the Earth's rotation combine to create the oceans' many water currents.

Air masses of different types meet and form warm, cold, stationary, or occluded fronts. Colliding fronts cause many different types of storms. In the event of severe storms such as hurricanes and tornadoes, safety precautions should be used to prevent injury or property damage.

When moist air is cooled, water vapor condenses around tiny specks of dust, smoke, or salt to form droplets. Huge numbers of droplets form clouds. When these water droplets get too heavy, they fall to the ground in some form of precipitation—rain, sleet, hail, or snow. Three basic types of clouds insulate Earth and help shield it from the sun's heat.

Climate is the average weather of an area over a long period of time. Factors such as latitude, elevation, and nearness to water affect climate. Earth's atmosphere has four layers. Each layer has different temperatures and gases present.