



ECO-ACADEMY for Youth and Parent Educators

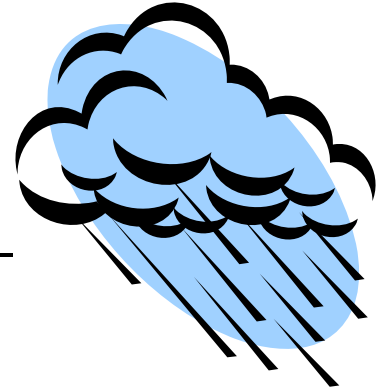
On Earth, common **Weather Phenomena** include wind, cloud, rain, snow, fog and dust storms. Less common events include natural disasters such as tornadoes, hurricanes, typhoons and ice storms. Almost all familiar weather phenomena occur in the troposphere (the lower part of the atmosphere). Weather does occur in the stratosphere and can affect weather lower down in the troposphere, but the exact mechanisms are poorly understood.

Module: Natural Sciences

Weather

Sunshine State Standards:

SC.2.E.7.1, SC.2.E.7.5, SC.5.E.7.3, SC.5.E.7.4, SC.5.E.7.5,
SC.6.E.7.2, SC.6.E.7.3, SC.6.E.7.6, SC.6.E.7.8,
SC.912.E.7.5, SC.912.E.7.6



Objectives

- Understand the concept of weather
- Learn the difference between weather and climate
- Understand different elements that make weather
- Learn about different clouds

Vocabulary

Anemometer- is a device for measuring wind speed, and is a common weather station instrument.

Barometer- is a scientific instrument used to measure atmospheric pressure. It can measure the pressure exerted by the atmosphere by using water, air, or mercury. Pressure tendency can forecast short term changes in the weather. Numerous measurements of air pressure are used within surface weather analysis to help find surface troughs, high pressure systems, and frontal boundaries.

Climate – Climates encompasses the statistics of temperature, humidity, atmospheric pressure, wind, rainfall, atmospheric particle count and other meteorological elements in a given region over long periods of time. Climate can be contrasted to weather, which is

the present condition of these same elements and their variations over periods up to two weeks.

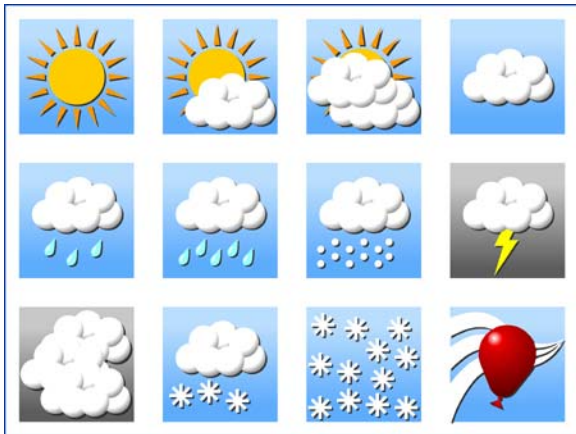
Clouds –is a visible mass of droplets of water or frozen crystals suspended in the atmosphere above the surface of the Earth or other planetary body.

Hygrometers are instruments used for measuring relative humidity.

Thermometer- is a device that measures temperature or temperature gradient using a variety of different principles.

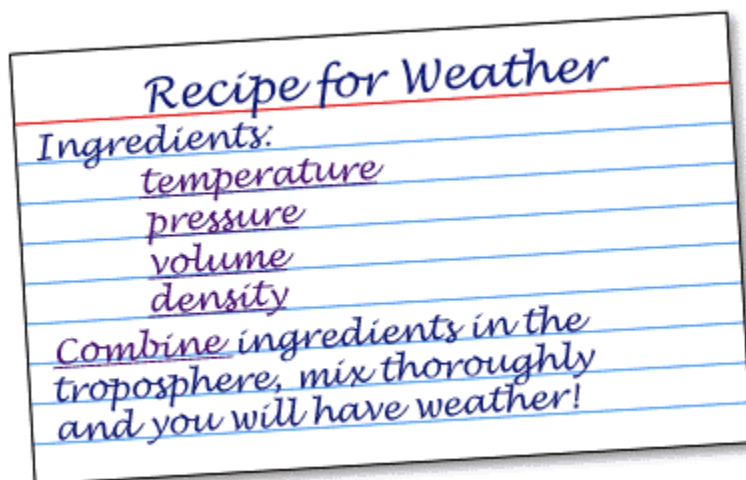
Weather- is the state of the atmosphere as measured on a scale of hot or cold, wet or dry, calm or stormy, clear or cloudy. Most weather phenomena occur in the troposphere, just below the stratosphere.

Background

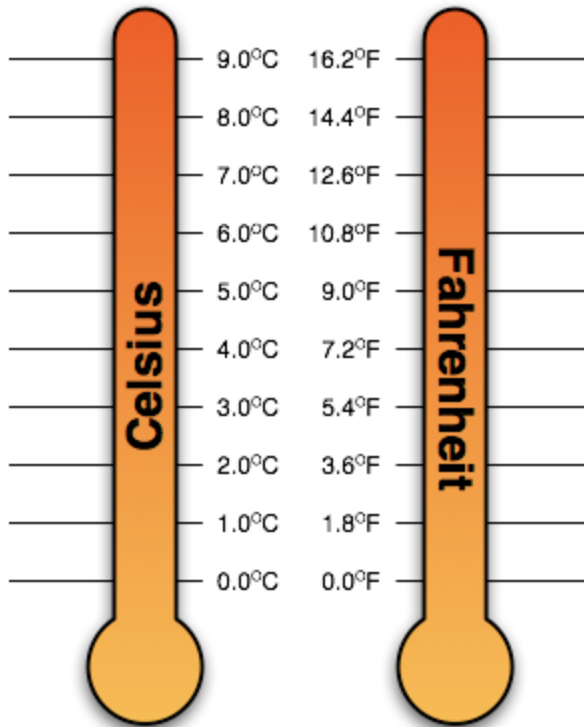


Weather is the state of the atmosphere as measured on a scale of hot or cold, wet or dry, calm or storm, clear or cloudy. Most weather phenomena occur in the troposphere, just below the stratosphere. Weather refers, generally, to day-to-day temperature and precipitation activity, whereas climate is the term for the average atmospheric conditions over longer periods of time. When used without qualification, "weather" is understood to be the weather of Earth.

Weather Ingredients



Temperature



What is temperature?

Temperature is a degree of hotness or coldness that can be measured using a thermometer. It's also a measure of how fast the atoms and molecules of a substance are moving. Temperature is measured in degrees on the Fahrenheit, Celsius, and Kelvin scales.

What is the Wind Chill Index?

The wind chill index is the temperature your body feels when the air temperature is combined with the wind speed. The higher the wind speed, the faster exposed areas of your body lose heat and the cooler you feel.

What is the Heat Index?

The Heat Index is a combination of air temperature and humidity that gives a description of how the temperature feels. This is not the actual air temperature.

Heat Stroke is the most severe form of heat injury and is a life-threatening emergency. It is the result of long, extreme exposure to the sun, in which a person does not sweat enough to lower body temperature. Take a look at the chart below to see what the Heat Index needs to be for you to get heat stroke.

| HEAT INDEX | Affects to the human body |
|---------------|--|
| 130° or above | Heat Stroke <u>highly likely</u> with continued exposure |
| 105° to 130° | Heat Stroke <u>likely</u> with prolonged exposure |
| 90° to 105° | Heat Stroke <u>possible</u> with prolonged exposure |

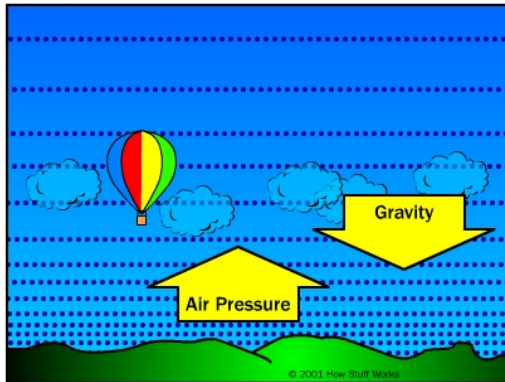
How do you find the temperature for a specific day?

First, go to <http://weather.gov>. Then, click on the map for the place you are looking for. After that, look for a section called Climate. Beneath that title, read what is labeled and click on the one that most suits what you are looking for. This should take you into the National Weather Service's climatic data information for your specific area.

Why can you see your breath when its cold outside?

Your breath is reasonably warm and humid and it has invisible water vapor as a large component of the gas. Warm moist air meeting the cooler air outside the body causes the invisible water vapor to condense the cooler air outside are visible and form the cloud that you see. The relative humidity which depends upon water content and temperature goes to 100%. As the breath gets further from the person's face the water content dilutes and the relative humidity goes down and the droplets go back into vapor form.

Pressure



Pushy Pressure

Pressure is the force of one object pushing on another. In the case of the air around you, it is the force of all the air molecules hitting your body. When you are standing on the ground, the pressure is the weight of all the air above you (all the way to the edge of the atmosphere) pushing down on you. Mind you, it doesn't just push down. All of those molecules are pushing sideways, up, diagonally, and every way imaginable.

Think about the desk your computer is on. If the force of the air were just down, it would probably collapse. Because the air also pushes up, the desk is able to stay in one piece and not collapse under the weight of your books. Think about when you go swimming. There is pressure all around you from the water. That pressure is from the water molecules around you and the air above the surface. The deeper you go, the more pressure, and you have to pop your ears.

A Little About Gases

The key to understanding pressure in the atmosphere is to understand how gases work. You can read about gases and how pressure can increase and decrease when forces change (like temperature and volume). We're also adding on the idea of **density**. Density is the amount of a substance in a specific area. Water has a greater density than ice, which has a greater density than water vapor. When you decrease the volume of a container (and keep the same amount of matter) you will increase the pressure. If you increase the temperature of a container, you will increase the pressure.

Water is a special case where the solid is actually less dense than the liquid form. Ice floats at the top of your soda because it is less dense than the surrounding liquid. The solid version of most compounds is more dense than the liquid version. Liquid states are always more dense than the gas state (under normal conditions).

Real World Explanations

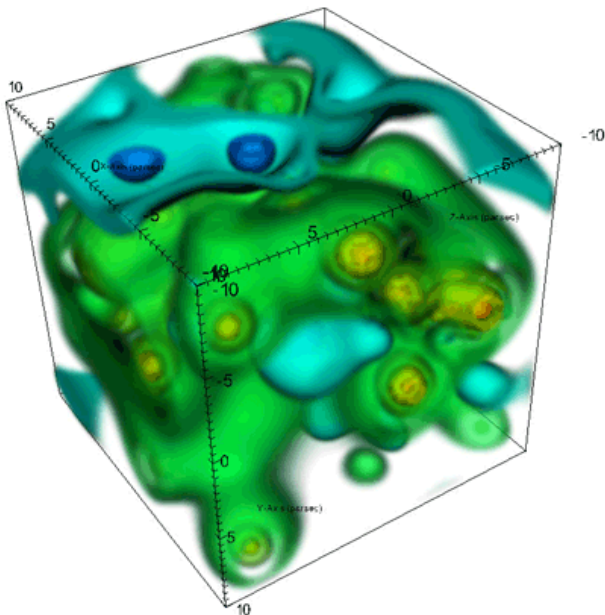
So you have a hot day. Chances are the pressure will rise when it gets hotter. The molecules are getting more excited and have nowhere to go. They wind up pushing on everything with a greater force. Let's say you're up in the sky. There is less pressure because there are fewer molecules above you pushing on you.

That idea explains why the pressure is lower in Colorado than it is on a beach in California. Colorado has a higher **altitude**. When do you get the greatest pressure? On a hot day? No. Really cold days actually have a higher atmospheric pressure. Why? As the temperature drops, the molecules of the air around you begin to **condense** and are less excited. These compressed molecules actually create a greater pressure than the excited and hot ones on a warm day. You will be able to prove this fact if you visit Siberia, Russia. Go figure.

Up Up And Away

Let's talk about the very top of the atmosphere. As you move higher above the ground, the temperature will drop and then begin to rise again. The pressure continually decreases. How? There is a lot more energy hitting the Earth from the Sun as you move closer to the outer edge of the atmosphere. This extra energy causes the molecules to get excited and the temperature goes up. As the temperature increases, there is no pressure pushing on the molecules (like on the surface of the Earth) so they can spread out as much as they want. Only gravity pulls on them. They spread out so much that there is actually less pressure than on a place the same temperature lower in the atmosphere.

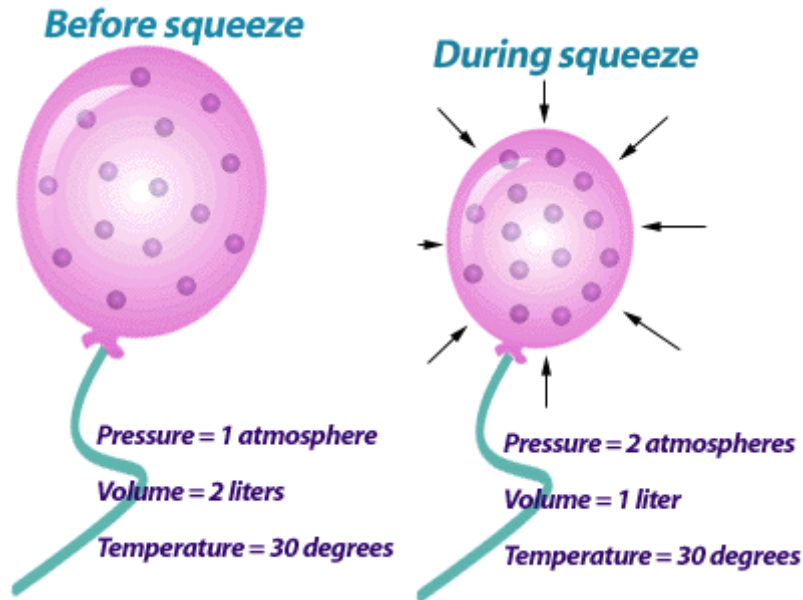
Volume



Volume is how much three-dimensional space a substance (solid, liquid, gas, or plasma) or shape occupies or contains, often quantified numerically using the SI derived unit, the cubic meter. The volume of a container is generally understood to be the capacity of the container, i. e. the amount of fluid (gas or liquid) that the container could hold, rather than the amount of space the container itself displaces


With a fixed amount of gas, when the **temperature** is **increased**, the **volume increases**.

When the **temperature** is **decreased**, the **volume decreases**




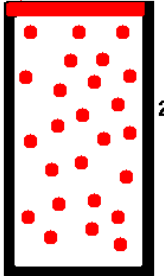
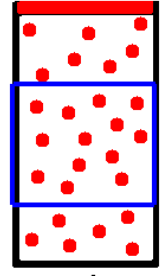
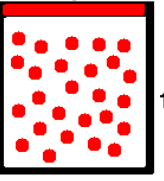
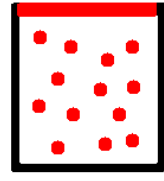
With a fixed amount of gas, when the **pressure** is **increased**, the **volume** is **decreased**. When the pressure is **decreased**, the **volume** is **increased**.

Density



Gas Density



| | | | |
|---|---|---|---|
| <p>Case # 1 Mass = .52 kg Volume = 2 x 1 x 1 = 2 m³ Density = .26 $\frac{\text{kg}}{\text{m}^3}$</p> |  | <p>Case # 2 Mass = .52 kg Volume = 2 x 1 x 1 = 2 m³ Density = .26 $\frac{\text{kg}}{\text{m}^3}$</p> |  |
| <p>Case # 3 Mass = .52 kg Volume = 1 x 1 x 1 = 1 m³ Density = .52 $\frac{\text{kg}}{\text{m}^3}$</p> |  | <p>Case # 4 Mass = .26 kg Volume = 1 x 1 x 1 = 1 m³ Density = .26 $\frac{\text{kg}}{\text{m}^3}$</p> |  |
| $\text{Density} = \frac{\text{Mass}}{\text{Volume}}$ | | <p>● = 20 gm = .02 kg</p> | |

Density is the mass found in a volume of gas, liquid, or solid. Since all atoms and molecules weigh something (have mass), the more of them you pack into a given space, the greater the density.

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

Combining ingredients

If you look closely at the sections on temperature, pressure, volume, and density, you may notice that a relationship exists among these atmospheric variables. Atmospheric scientists express this relationship in one of two ways:

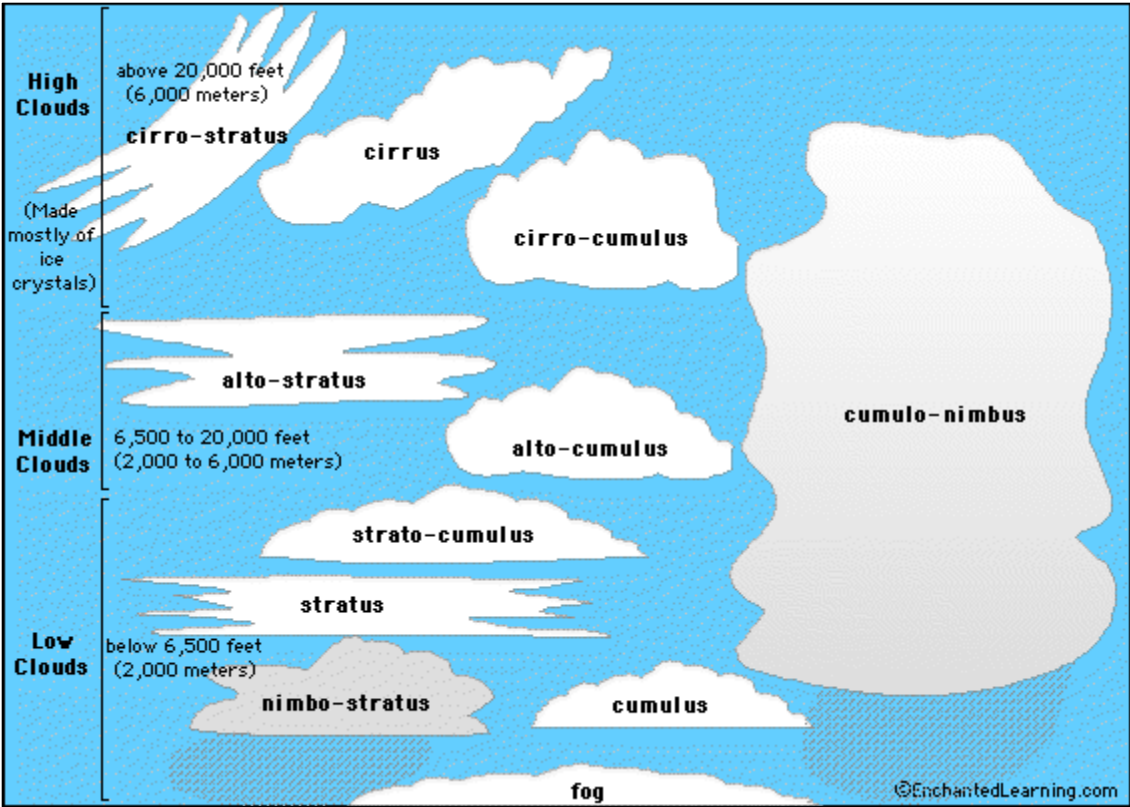
Ideal Gas Law

Pressure = Temperature x Density x Constant

Pressure x Volume = Temperature x Constant

This important relationship is called the "Equation of State" or "Ideal Gas Law" and can be used to help understand the atmosphere.

Clouds



What are clouds?

A cloud is a large collection of very tiny droplets of water or ice crystals. The droplets are so small and light that they can float in the air.

How are clouds formed?

All air contains water, but near the ground it is usually in the form of an invisible gas called water vapor. When warm air rises, it expands and cools. Cool air can't hold as much water vapor as warm air, so some of the vapor condenses onto tiny pieces of dust that are floating in the air and forms a tiny droplet around each dust particle. When billions of these droplets come together they become a visible cloud.

Why are clouds white?

Clouds are white because they reflect the light of the sun. Light is made up of colors of the rainbow and when you add them all together you get white. The sun appears a yellow color because it sends out more yellow light than any other color. Clouds reflect

all the colors the exact same amount so they look white.

Why do clouds turn gray?

Clouds are made up of tiny water droplets or ice crystals, usually a mixture of both. The water and ice scatter all light, making clouds appear white. If the clouds get thick enough or high enough all the light above does not make it through, hence the gray or dark look. Also, if there are lots of other clouds around, their shadow can add to the gray or multicolored gray appearance.

Why do clouds float?

A cloud is made up of liquid water droplets. A cloud forms when air is heated by the sun. As it rises, it slowly cools it reaches the saturation point and water condenses, forming a cloud. As long as the cloud and the air that its made of is warmer than the outside air around it, it floats!

How do clouds move?


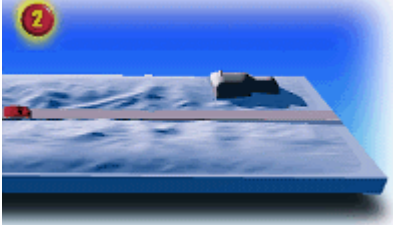
Clouds move with the wind. High cirrus clouds are pushed along by the jet stream, sometimes traveling at more than 100 miles-per-hour. When clouds are part of a thunderstorm they usually travel at 30 to 40 mph.

Why do clouds form at different heights in the atmosphere?

The characteristics of clouds are dictated by the elements available, including the amount of water vapor, the temperatures at that height, the wind, and the interplay of other air masses.

How is fog formed?

There are many different types of fog, but fog is mostly formed when southerly winds bring warm, moist air into a region, possibly ending a cold outbreak. As the warm, moist air flows over much colder soil or snow, dense fog often forms. Warm, moist air is cooled from below as it flows over a colder surface. If the air is near saturation, moisture will condense out of the cooled air and form fog. With light winds, the fog near the ground can become thick and reduce visibilities to zero.

| | |
|--|--|
|  |  |
| <p>1 You need warm air! Southerly winds bring warm, moist air over cold ground or snow.</p> | <p>2 Fog Forms! Moisture condenses into fog as air is cooled from below.</p> |

Cloud Chart

| Cloud Group | Cloud Height | Cloud Types |
|------------------------------------|---------------------------|--|
| High Clouds = Cirrus | Above 18,000 feet | Cirrus Cirrostratus Cirrocumulus |
| Middle Clouds = Alto | 6,500 feet to 18,000 feet | Altostratus Alto cumulus |
| Low Clouds = Stratus | Up to 6,500 feet | Stratus Stratocumulus Nimbostratus |
| Clouds with Vertical Growth | | Cumulus Cumulonimbus |
| Special Clouds | | Mammatus Lenticular Fog Contrails |

Cirrus Clouds

Cirrus clouds are the most common of the high clouds. They are composed of ice and are thin, wispy clouds blown in high winds into long streamers. Cirrus clouds are usually white and predict fair to pleasant weather. By watching the movement of cirrus clouds you can tell from which direction weather is approaching. When you see cirrus clouds, it usually indicates that a change in the weather will occur within 24 hours.

Cirrostratus clouds are thin, sheetlike high clouds that often cover the entire sky. They are so thin that the sun and moon can be seen through them. Cirrostratus clouds usually come 12-24 hours before a rain or snow storm.

Cirrocumulus clouds appear as small, rounded white puffs that appear in long rows. The small ripples in the cirrocumulus clouds sometime resemble the scales of a fish. Cirrocumulus clouds are usually seen in the winter and indicate fair, but cold weather. In tropical regions, they may indicate an approaching hurricane.

"Alto" Clouds

Altostratus clouds are gray or blue-gray mid level clouds composed of ice crystals and water droplets. The clouds usually cover the entire sky. In the thinner areas of the clouds, the sun may be dimly visible as a round disk. Altostratus clouds often form ahead of storms with continuous rain or snow.

Alto cumulus clouds are mid level clouds that are made of water droplets and appear as gray puffy masses. They usually form in groups. If you see alto cumulus clouds on a warm, sticky morning, be prepared to see thunderstorms late in the afternoon.

Stratus Clouds

Stratus clouds are uniform grayish clouds that often cover the entire sky. They

resemble fog that doesn't reach the ground. Light mist or drizzle sometimes falls out of these clouds.

Stratocumulus clouds are low, puffy and gray. Most form in rows with blue sky visible in between them. Rain rarely occurs with stratocumulus clouds, however, they can turn into nimbostratus clouds.

Nimbostratus clouds form a dark gray, wet looking cloudy layer associated with continuously falling rain or snow. They often produce precipitation that is usually light to moderate.

Cumulus Clouds

Cumulus clouds are white, puffy clouds that look like pieces of floating cotton. Cumulus clouds are often called "fair-weather clouds". The base of each cloud is flat and the top of each cloud has rounded towers. When the top of the cumulus clouds resemble the head of a cauliflower, it is called cumulus congestus or towering cumulus. These clouds grow upward and they can develop into giant cumulonimbus clouds, which are thunderstorm clouds.

Cumulonimbus clouds are thunderstorm clouds. High winds can flatten the top of the cloud into an anvil-like shape. Cumulonimbus clouds are associated with heavy rain, snow, hail, lightning and even tornadoes. The anvil usually points in the direction the storm is moving.

Special Clouds

Mammatus clouds are low hanging bulges that droop from cumulonimbus clouds. Mammatus clouds are usually associated with severe weather.

Lenticular clouds are caused by a wave wind pattern created by the mountains. They look like discs or flying saucers that form near mountains.

Fog is a cloud on the ground. It is composed of billions of tiny water droplets floating in the air. Fog exists if the atmospheric visibility near the Earth's surface is reduced to 1 kilometer or less.

Contrails are condensation trails left behind jet aircrafts. Contrails form when hot humid air from jet exhaust mixes with environmental air of low vapor pressure and low temperature. The mixing is a result of turbulence generated by the engine exhaust.

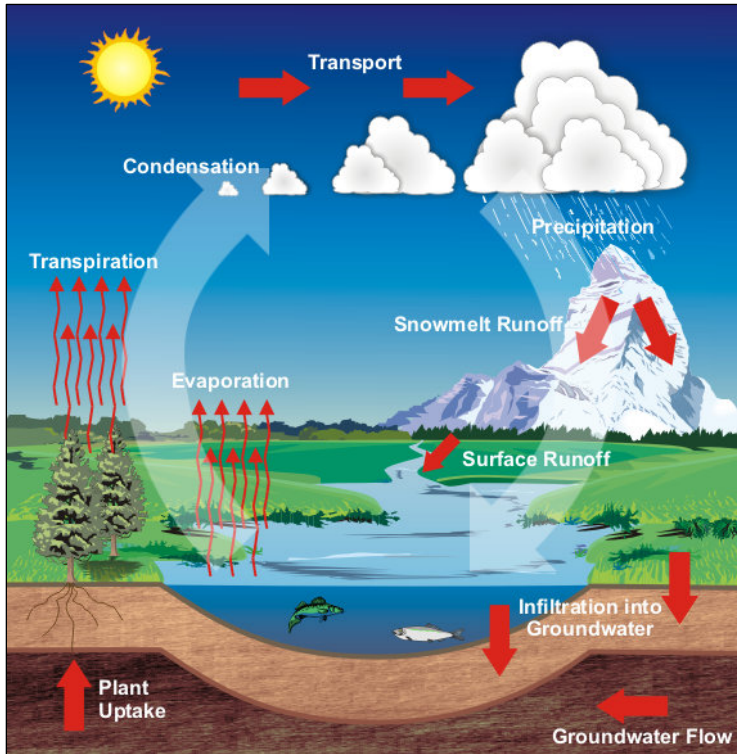
Green Clouds are often associated with severe weather. The green color is not completely understood, but it is thought to have something to do with having a high amount of liquid water drops and hail inside the clouds. In the Great Plains region of the U.S. green clouds are associated with storms likely to produce hail and tornadoes.

Rain & Floods

How does rain form?

Water droplets form from warm air. As the warm air rises in the sky it cools. Water vapor

(invisible water in the air) always exists in our air. Warm air holds quite a bit of water. For example, in the summer it is usually very humid. When enough of these droplets collect together, we see them as clouds. If the clouds are big enough and have enough water droplets, the droplets bang together and form even bigger drops. When the drops get heavy, they fall because of gravity, and you see and feel rain.



What causes rain?

When clouds develop or rain occurs, something is making the air rise. Several things can make this happen. Mountains, low-pressure areas, cold fronts, and even the jet stream.

How big are raindrops?

Raindrops are much smaller than we think! They are actually smaller than a centimeter. Raindrops range from 1/100 inch (.0254 centimeter) to 1/4 inch (.635 centimeter) in diameter.

How fast do raindrops fall?

Not including wind-driven rain, raindrops fall between 7 and 18 miles per hour (3 and 8 meters per second) in still air. The range

in speed depends on the the size of the raindrop. Air friction breaks up raindrops when they exceed 18 miles per hour.



What is a flood?

A flood results from days of heavy rain and/or melting snows, when rivers rise and go over their banks.

What is a flash flood?

A flash flood is sudden flooding that occurs when floodwaters rise rapidly with no warning within several hours of an intense rain. They often occur after intense rainfall from slow moving thunderstorms. In narrow canyons and valleys, floodwaters flow faster than on flatter ground and

can be quite destructive.

Do flash floods hurt people?

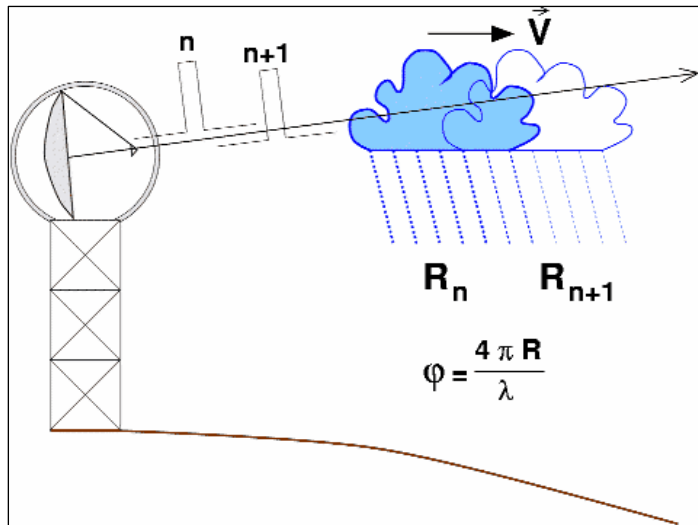
Flash floods are the #1 weather-related killer in the U.S. Nearly 80% of flash flood deaths are auto related. Know beforehand if your area is a flood risk.

How much water is needed for your car to float away?

A mere 2 feet of water can float a large vehicle or even a bus. This is why you should never drive through flooded roads. Just 6 inches of rapidly moving flood water can knock a person down.

What is radar?

Radar is an electronic instrument, which determines the direction and distance of objects that reflect radio energy back to the radar site. It stands for Radio Detection and Ranging. This is what meteorologists use to see rain or snow.



What is Doppler Radar?

Doppler Radar detects precipitation intensity, wind direction and speed, and provides estimates of hail size and rainfall amounts. Doppler Radar gives forecasters the capability of providing early detection of severe thunderstorms that may bring strong damaging winds, large hail, heavy rain, and possibly tornadoes. Combined with satellites, radar gives forecasters the ultimate tools to provide accurate forecasts and advanced severe weather warnings.

How does Doppler Radar work?

Doppler Radar gets its name from the Doppler Effect. Have you ever listened to a train whistle as it was coming toward you? You probably noticed that the pitch of the whistle changed as the train passed you and moved away. This change in the frequency of sound is called the Doppler Effect. Doppler Radar measures the changes in the frequency of the signal it receives to determine the wind.



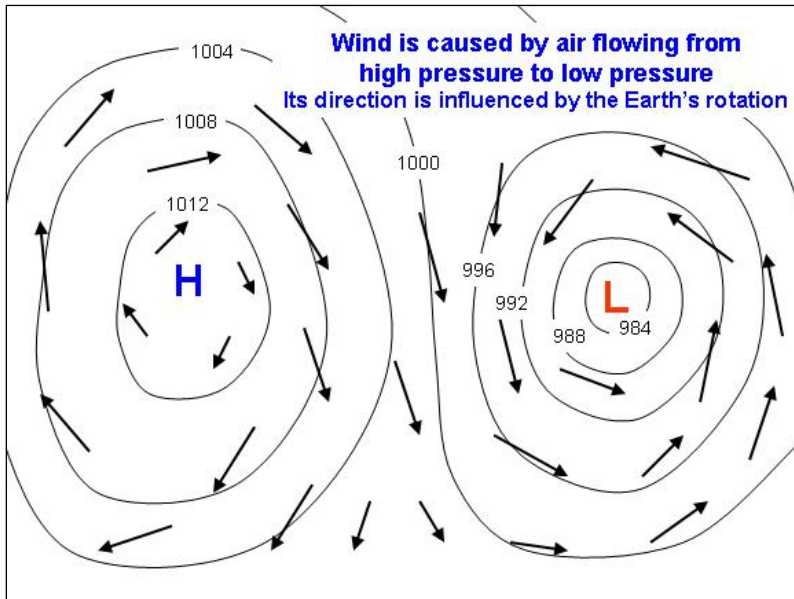
What is NEXRAD Radar?

The National Weather Service has installed a new type of Doppler Radar called NEXRAD Radar. NEXRAD stands for Next Generation Radar. This radar produces many different views of storms and rain that allows meteorologists to determine if a storm could be severe.

Wind

What is wind?

Wind is air in motion. It is produced by the uneven heating of the earth's surface by the sun. Since the earth's surface is made of various land and water formations, it absorbs the sun's radiation unevenly. Two factors are necessary to specify wind: speed and direction.



What causes the wind to blow?

As the sun warms the Earth's surface, the atmosphere warms too. Some parts of the Earth receive direct rays from the sun all year and are always warm. Other places receive indirect rays, so the climate is colder. Warm air, which weighs less than cold air, rises. Then cool air moves in and replaces the rising warm air. This movement of air is what makes the wind blow.

What is a windstorm?

A windstorm is just a storm with high winds or violent gusts but little or no rain.

What is a gust front?

A gust front is the leading edge of cool air rushing down and out from a thunderstorm. There are two main reasons why the air flows out of some thunderstorms so rapidly. The primary reason is the presence of relatively dry air in the lower atmosphere. This dry air causes some of the rain falling through it to evaporate, which cools the air. Since cool air sinks (just as warm air rises), this causes a down-rush of air that spreads out at the ground. The edge of this rapidly spreading cool pool of air is the gust front. The second reason is that the falling precipitation produces a drag on the air, forcing it downward. If the wind following the gust front is intense and damaging, the windstorm is known as a downburst.

What is a downburst?

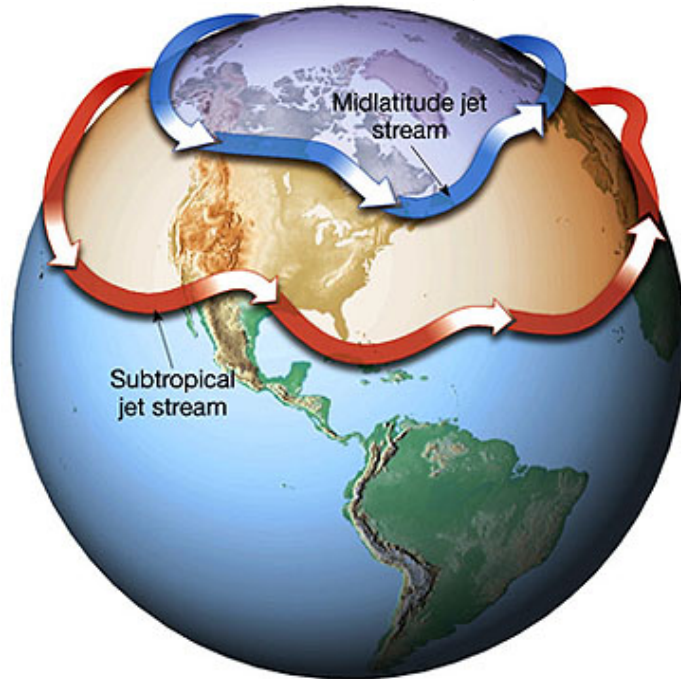
A downburst is created by an area of significantly rain-cooled air that, after hitting ground level, spreads out in all directions producing strong winds. Unlike winds in a tornado, winds in a downburst are directed outwards from the point where it hits land or water. Dry downbursts are associated with thunderstorms with very little rain, while wet downbursts are created by thunderstorms with high amounts of rainfall.



What is a derecho?

A derecho is a widespread and long-lived windstorm that is associated with a fast-moving band of severe thunderstorms. They can produce significant damage to property and pose a serious threat life, primarily by downburst winds. To be classified as a derecho, the path length of the storm has to be at

least 280 miles long. Widths may vary from 50-300 miles. Derechos are usually not associated with a cold front, but a stationary front. They occur mostly in July, but can occur at anytime during the spring and summer.

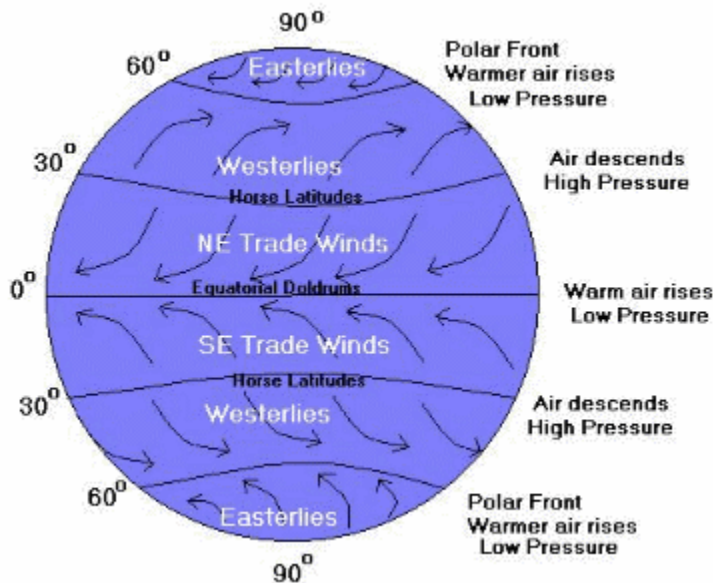


What is the jet stream?

The jet stream is a fast flowing, river of air found in the atmosphere at around 12 km above the surface of the Earth just under the tropopause. They form at the boundaries of adjacent air masses with significant differences in temperature, such as of the polar region and the warmer air to the south. Because of the effect of the Earth's rotation the streams flow west to east, propagating in a serpentine or wave-like manner at lower speeds than that of the actual wind within the flow.

What are the global wind patterns?

The equator receives the Sun's direct rays. Here, air is heated and rises, leaving low pressure areas behind. Moving to about thirty degrees north and south of the equator, the warm air from the equator begins to cool and sink. Between thirty degrees latitude and the equator, most of the cooling sinking air moves back to the equator. The rest of the air flows toward the poles.



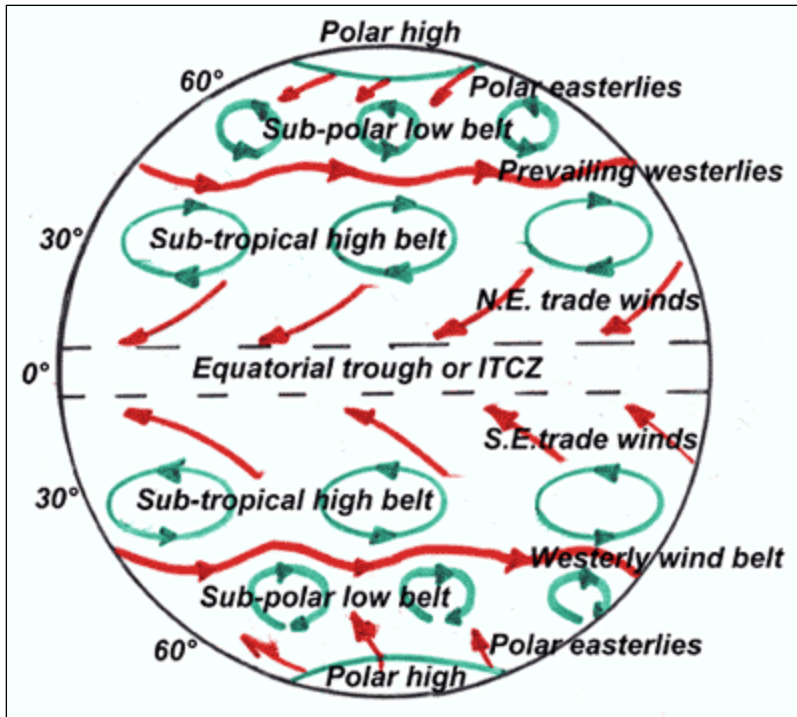
What are the trade winds?

The trade winds are just air movements toward the equator. They are warm, steady breezes that blow almost continuously. The Coriolis Effect makes the trade winds appear to be curving to the west, whether they are traveling to the equator from the south or north.

What are the doldrums?

The doldrums is an area of calm weather. The trade winds coming from the south and the north meet near the equator.

These converging trade winds produce general upward winds as they are heated, so there are no steady surface winds.



What are the prevailing westerlies?

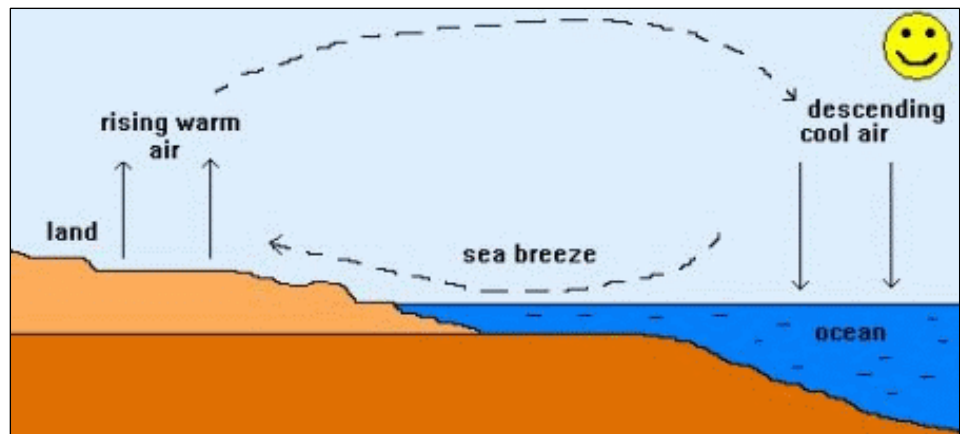
Between thirty and sixty degrees latitude, the winds that move toward the poles appear to curve to the east. Because winds are named from the direction in which they originate, these winds are called prevailing westerlies. Prevailing westerlies in the Northern Hemisphere are responsible for many of the weather movements across the United States and Canada.

What are the polar easterlies?

At about sixty degrees latitude in both hemispheres, the prevailing westerlies join with the polar easterlies to reduce upward motion. The polar easterlies form when the atmosphere over the poles cools. This cool air then sinks and spreads over the surface. As the air flows away from the poles, it is turned to the west by the Coriolis effect. Again, because these winds begin in the east, they are called easterlies.

What is a sea breeze?

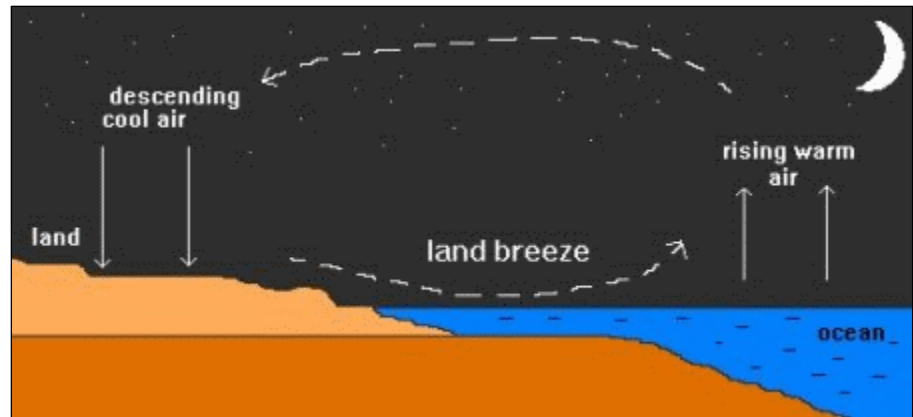
On a warm summer day along the coast, this differential heating of land and sea leads to the development of local winds called sea breezes. As air above the land surface is heated



by radiation from the Sun, it expands and begins to rise, being lighter than the surrounding air. To replace the rising air, cooler air is drawn in from above the surface of the sea. This is the sea breeze, and can offer a pleasant cooling influence on hot summer afternoons.

What is a land breeze?

A land breeze occurs at night when the land cools faster than the sea. In this case, it is air above the warmer surface water that is heated and rises, pulling in air from the cooler land surface.



How is wind helpful to Earth?

Wind is the fastest growing source of electricity in the world. It's often one of the least expensive forms of renewable power available. Some experts say it can sometimes be the cheapest form of any kind of power. Generating power from the wind leaves no dangerous waste products behind. Best of all, its supply is unlimited.

How do windmills work?

Windmills work because they slow down the speed of the wind. The wind flows over the airfoil shaped blades causing lift, like the effect on airplane wings, causing them to turn. The blades are connected to a drive shaft that turns an electric generator to produce electricity.

Hurricanes



What is a hurricane?

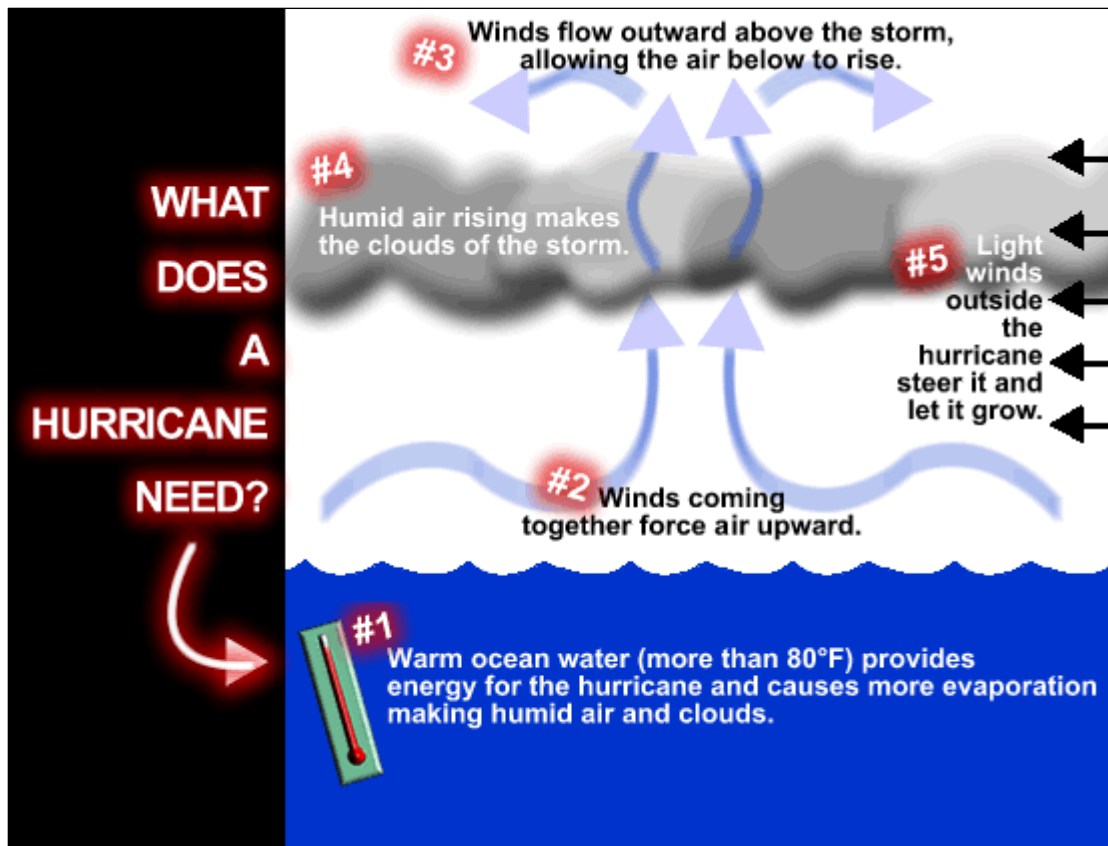
A hurricane is a huge storm! It can be up to 600 miles across and have strong winds spiraling inward and upward at speeds of 75 to 200 mph. Each hurricane usually lasts for over a week, moving 10-20 miles per hour over the open ocean. Hurricanes gather heat and energy through contact with warm ocean waters. Evaporation from the seawater increases their power. Hurricanes rotate in a counter-clockwise direction around an "eye." The center of the storm or "eye" is the calmest part. It

has only light winds and fair weather. When they come onto land, the heavy rain, strong winds and large waves can damage buildings, trees and cars.



How do hurricanes form?

Hurricanes only form over really warm ocean water of 80°F or warmer. The atmosphere (the air) must cool off very quickly the higher you go. Also, the wind must be blowing in the same direction and at the same speed to force air upward from the ocean surface. Winds flow outward above the storm allowing the air below to rise. Hurricanes typically form between 5 to 15 degrees latitude north and south of the equator. The Coriolis Force is needed to create the spin in the hurricane and it becomes too weak near the equator, so hurricanes can never form there.



What is storm surge?

Storm surges are frequently the most devastating element of a hurricane. As a hurricane's winds spiral around and around the storm, they push water into a mound at the storm's center. This mound of water becomes dangerous when the storm reaches land because it causes flooding along the coast. The water piles up, unable to escape anywhere but on land as the storm carries it landward. A hurricane will cause more storm surge in areas where the ocean floor slopes gradually. This causes major flooding.

As you watch the storm-surge animations, notice the effect that the physical geography of each coastline has on storm surge. Also, note the waves on top of the ocean's surface. Wind, waves, and sea-level rise all contribute to storm-surge damage.

Shallow-Water Coastline



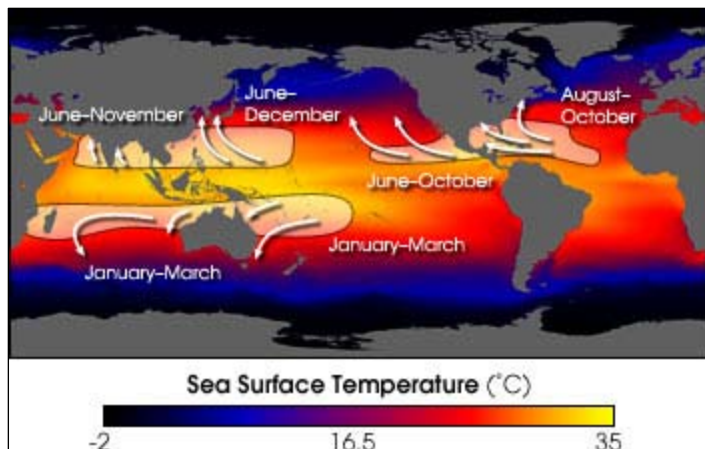
Deep-Water Coastline



With technology the way it is, there are computer models that allow forecasters to predict the amount of storm surge that will affect a coastal area. These are called Slosh Models and take into account a storm's strength, its path, how the ocean shallows, and the shape of the land. Then it calculates how much storm surge a hurricane will probably cause.

When does hurricane season start?

The Atlantic hurricane season is from June 1 to November 30, but most hurricanes occur during the fall months. The Eastern Pacific hurricane season is from May 15 to November 30.



Who names hurricanes?

From 1950 to 1952, tropical cyclones of the North Atlantic Ocean were identified by the phonetic alphabet (Able-Baker-Charlie-etc.), but in 1953 the US Weather Bureau switched to women's names. The rest of the world eventually caught on, and naming rights now go by the World Meteorological Organization, which uses different sets of names depending on the part of the world the storm is in. Around the U.S., only women's names were used until 1979, when it was decided that they should alternate a list that included men's names too. There's 6 different name lists that alternate each year. If a hurricane does significant damage, its name is retired and replaced with another.

What is the difference between a hurricane and a typhoon?

Nothing except geography. Tropical storms occur in several of the world's oceans, and except for their names, they are essentially the same type of storm. In the Atlantic Ocean, Gulf of Mexico, and the Eastern Pacific Ocean, they are called hurricanes. In the Western Pacific Ocean, they are called typhoons. In the Indian Ocean, the Bay of Bengal, and Australia, these types of storms are called cyclones.

Who are the "Hurricane Hunters"?

The brave "hurricane hunters" work for the National Oceanic and Atmospheric Administration (NOAA). Each mission lasts about ten hours, with the crews passing four to six times through the storm. The planes carry radar, sophisticated computers, and weather instruments that determine characteristics such as temperature, air pressure, wind speed, and wind direction inside the hurricane. The crews also release instruments that measure temperature, air pressure, and wind at different levels as the devices drop through the hurricane toward the ocean. By mission's end, NOAA can warn everyone in the hurricane's path. (Below is a satellite image of Hurricane Mitch back in October 1998. The Hurricane Hunters flew into the eye of Mitch just as this Category 5 hurricane with winds of 155 mph smacked right into Central America.)



What is coastal beach erosion?

Coastal beach erosion is the wearing away of land, the removal of beach or dune sediments by wave action, tidal currents, wave currents, or drainage. Waves are generated by storms, wind, or hurricanes and can cause coastal erosion. This may take the form of long-term losses of sediment and rocks, or merely the temporary redistribution of coastal sediments.

Tornadoes

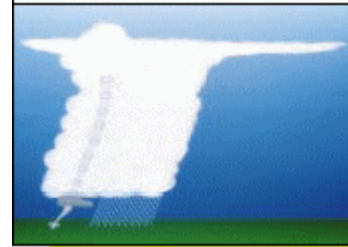
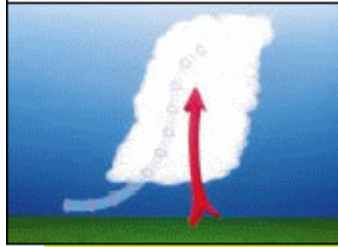
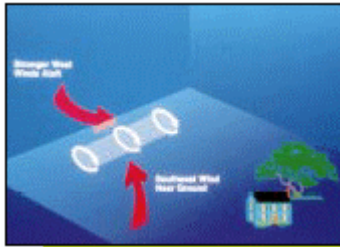
What is a tornado?

A tornado is a violent rotating column of air extending from a thunderstorm to the ground. The most violent tornadoes are capable of tremendous destruction with wind speeds of up to 300 mph. They can destroy large buildings, uproot trees and hurl vehicles hundreds of yards. They can also drive straw into trees. Damage paths can be

in excess of one mile wide to 50 miles long. In an average year, 1000 tornadoes are reported nationwide.

How do tornadoes form?

Most tornadoes form from thunderstorms. You need warm, moist air from the Gulf of Mexico and cool, dry air from Canada. When these two air masses meet, they create instability in the atmosphere. A change in wind direction and an increase in wind speed with increasing height creates an invisible, horizontal spinning effect in the lower atmosphere. Rising air within the updraft tilts the rotating air from horizontal to vertical. An area of rotation, 2-6 miles wide, now extends through much of the storm. Most strong and violent tornadoes form within this area of strong rotation.



A funnel cloud is a rotating cone-shaped column of air extending downward from the base of a thunderstorm, but not touching the ground. When it reaches the ground it is called a tornado.

How do tornadoes stop?

It is not fully understood about how exactly tornadoes form, grow and die. Tornado researchers are still trying to solve the tornado puzzle, but for every piece that seems to fit they often uncover new pieces that need to be studied.

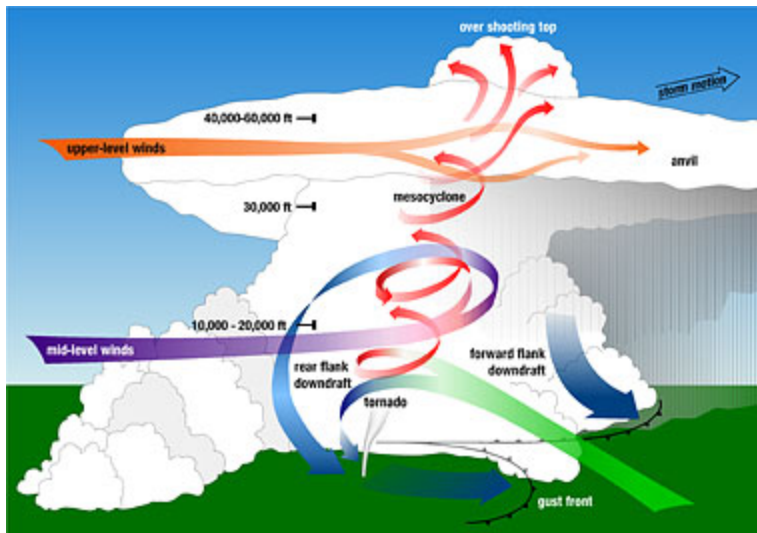
What is a supercell thunderstorm?

A supercell thunderstorm is a long-lived thunderstorm whose updrafts and downdrafts are in near balance. These storms have the greatest tendency to produce tornadoes that stay on the ground for long periods of time. Supercell thunderstorms can produce violent tornadoes with winds exceeding 200 mph.



What is a mesocyclone?

A mesocyclone is a rotating vortex of air within a supercell thunderstorm. Mesocyclones do not always produce tornadoes.



What is a wall cloud?

A wall cloud is an abrupt lowering of a rain-free cumulonimbus base into a low-hanging accessory cloud. A wall cloud is usually situated in the southwest portion of the storm. A rotating wall cloud usually develops before tornadoes or funnel clouds.

What is a waterspout?

A waterspout is just a weak tornado that forms over water. They are most common along the Gulf Coast. Waterspouts can sometimes move inland, becoming tornadoes causing damage and injuries.



What is hail?



Hail is created when small water droplets are caught in the updraft of a thunderstorm. These water droplets are lifted higher and higher into the sky until they freeze into ice. Once they become heavy, they will start to fall. If the smaller hailstones get caught in the updraft again, they will get more water on them and get lifted higher in the sky and get bigger. Once they get lifted again, they freeze and fall. This happens over and over again until the hailstone is too heavy and then falls to the ground.

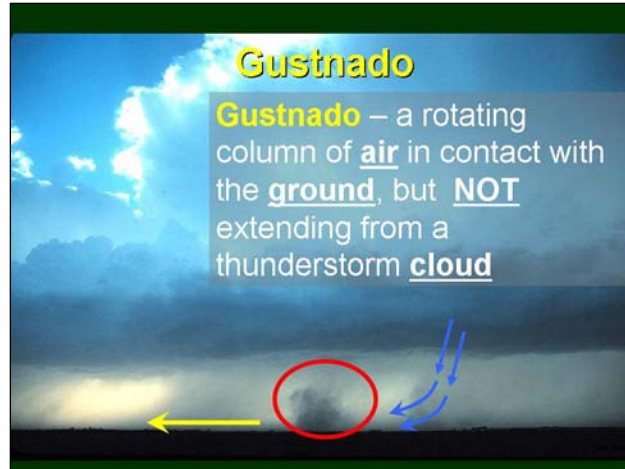
What is the largest hailstone recorded in the United States?

According to the National Weather Service, the largest hailstone is 8 inches in diameter and weights approximately 2 pounds. It fell in Vivian, South Dakota on July 23, 2010.



What is a gustnado?

A gustnado is a short-lived, relatively weak whirlwind that forms along a gust front. A gust front is the surge of very gusty winds at the leading edge of a thunderstorm's outflow of air. Gustnadoes are not tornadoes. They do not connect with any cloud-base rotation. But because gustnadoes often have a spinning dust cloud at ground level, they are sometimes wrongly reported as tornadoes. Gustnadoes can do minor damage.



What is a landspout?

A landspout is a very weak tornado that is not associated with a wall cloud or a mesocyclone. It is the land equivalent of a waterspout.



When are tornadoes most likely to occur?

Tornadoes can happen at any time of the year and at any time of the day. In the southern states, peak tornado season is from March through May. Peak times for tornadoes in the northern states are during the summer. A few southern states have a second peak time for tornado outbreaks in the fall. Tornadoes are

most likely to occur between 3 p.m. and 9 p.m.

Where are tornadoes most likely to occur?

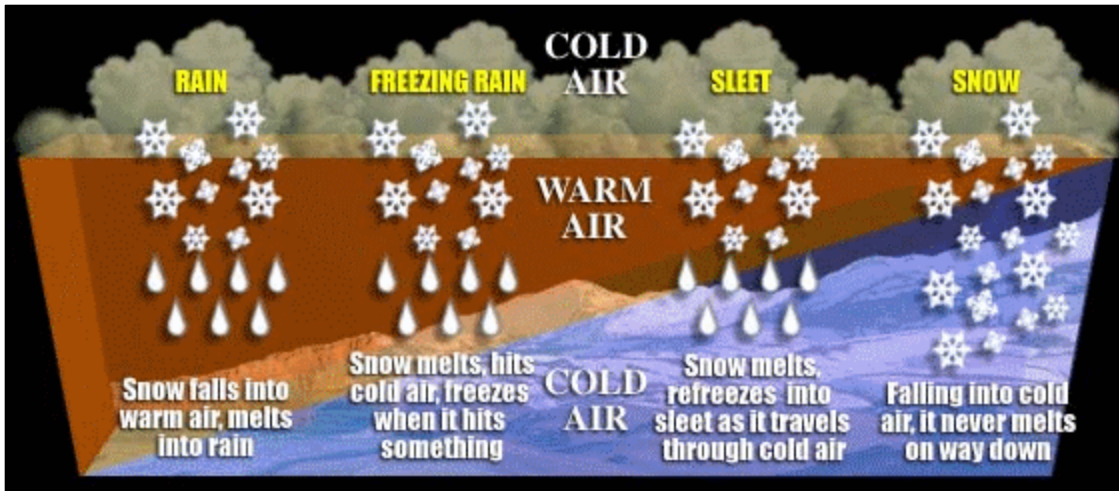
The geography of the central part of the United States, known as the Great Plains, is suited to bring all of the ingredients together to form tornadoes. More than 500 tornadoes typically occur in this area every year and is why it is commonly known as "Tornado Alley".

Winter Storms

How do winter storms form?

Winter storms derive their energy from the clash of two air masses of different

temperatures and moisture levels. Winter storms usually form when an air mass of cold, dry, Canadian air moves south and interacts with a warm, moist air mass moving north from the Gulf of Mexico. The point where these two air masses meet is called a front. If cold air advances and pushes away the warm air, it forms a cold front. When warm air advances, it rides up over the denser, cold air mass to form a warm front. If neither air mass advances, it forms a stationary front.



How is snow formed?

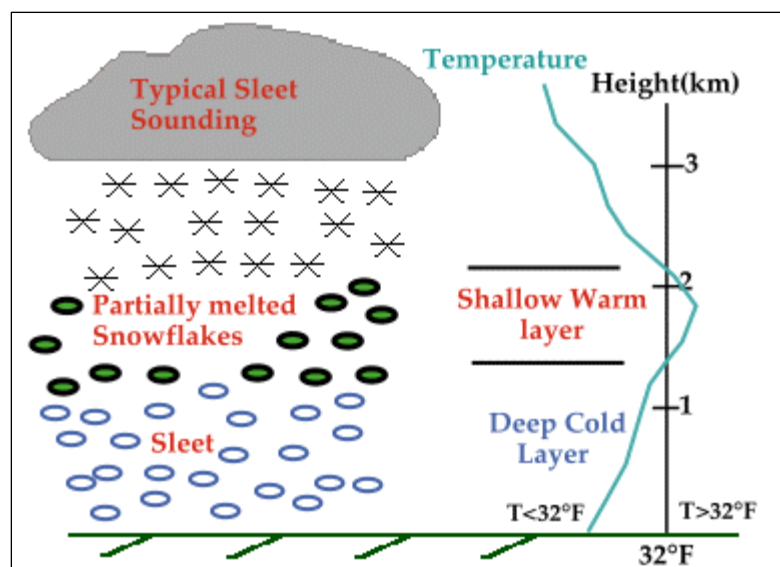
Snow is commonly formed when water vapor undergoes deposition, which is when water vapor changes directly to ice without first becoming a liquid, high in the atmosphere at a temperature of less than 32°F and then falls to the ground.

How do blizzards form?

A blizzard is a long-lasting snowstorm with very strong winds and intense snowfall. You need three things to have a blizzard; cold air at the surface, lots of moisture, and lift. Warm air must rise over cold air.

What are snowflakes?

Snowflakes are made of ice crystals. Each snowflake is six-sided and made of as many as 200 ice crystals. Snowflakes form in clouds where the temperature is below freezing. The ice crystals form around tiny bits of dirt that has been carried up into the atmosphere by the wind. As the snow crystals grow, they become heavier and fall toward the ground.



What is sleet?

Sleet is just rain drops that freeze into ice pellets before reaching the ground. Sleet usually bounces when hitting a

surface and does not stick to objects. However, it can accumulate like snow and cause a hazard to motorists.

What is freezing rain?

Freezing rain is just rain that falls onto a surface with a temperature below freezing. This causes it to freeze to surfaces, such as trees, cars, and roads, forming a coating or glaze of ice. Even small accumulations of ice can cause a significant hazard.

What is an ice storm?

An ice storm is a type of winter storm caused by freezing rain. The U.S. National Weather Service defines an ice storm as a storm which results in the accumulation of at least 0.25-inch of ice on exposed surfaces.

How do ice storms form?

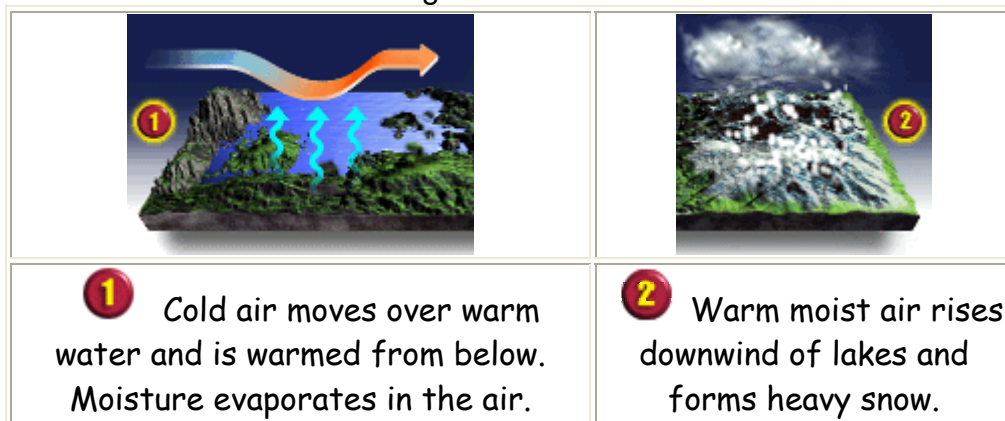
Ice storms form when a layer of warm air is between two layers of cold air. Frozen precipitation melts while falling into the warm air layer, and then proceeds to refreeze in the cold layer above the ground. This creates freezing rain or a glaze of ice.

What is frost?

Frost is white ice crystals that form on a surface, like the ground or leaves of a plant. Frost is created when the air temperature drops below freezing and the water vapor in the air freezes into ice crystals.

How is lake-effect snow formed?

As the cold air flows over the warm lake water, the relatively warm water heats the air's bottom layer as lake moisture evaporates into the cold air. Since warm air is lighter or less dense than cold air, the heated air rises and begins to cool. As the air cools, the moisture that evaporated into it condenses and forms clouds and snow begins falling from the cloud if the air is humid enough.



What is a Nor'easter?

Nor'easters can occur in the eastern United States any time between October and April, when moisture and cold air are plentiful. A Nor'easter is named for the winds that blow in from the northeast and drive the storm up the east coast along the Gulf Stream, a band of warm water that lies off the Atlantic coast. They are known for dumping heavy amounts of rain and snow, producing hurricane-force winds, and creating high surfs that cause severe beach erosion and coastal flooding.

What is an Alberta Clipper?



An Alberta clipper is an area of low pressure that generally forms over Alberta, Canada, east of the Rocky Mountains. They develop east of the Rockies because air flowing eastward over the mountains creates favorable conditions. Once an Alberta Clipper forms it usually moves very rapidly to the southeast across the USA's northern Plains and then to the east off the mid-Atlantic Coast. Clippers usually cause only light precipitation with very few producing major snowstorms. However, if conditions are favorable, some Alberta

clippers can rapidly intensify off the East Coast once the storm taps the relatively warm moist air over the Atlantic Ocean. The storms that rapidly intensify sometimes spread heavy snow over New England and southeastern Canada. Generally, the main weather features associated with Alberta clippers are some light snow and a reinforcement of cold air over the USA.

What is Wind Chill?

The wind chill is the temperature your body feels when the air temperature is combined with the wind speed. The higher the wind speed the faster exposed areas of your body lose heat and the colder you feel.

What is frostbite?

Frostbite is damage to the skin due to prolonged exposure to cold temperatures, usually below 32° F.

What is an avalanche?



An avalanche is a moving mass of snow that may contain ice, soil, rocks, and uprooted trees. The height of a mountain, the steepness of its slope, and the type of snow lying on it all help determine the likelihood of an avalanche. Avalanches begin when an unstable mass of snow breaks away from a mountainside and moves downhill. The growing river of snow picks up speed as it rushes down the mountain. Avalanches have been known to reach speeds of 245 miles an hour (394 kilometers per hour)—about four times as fast as the speediest downhill skier.

Thunderstorms

What is a thunderstorm?

A thunderstorm is a storm with lightning and thunder. Its produced by a cumulonimbus

cloud, usually producing gusty winds, heavy rain and sometimes hail.

What causes a thunderstorm?

The basic ingredients used to make a thunderstorm are moisture, unstable air and lift. You need moisture to form clouds and rain. You need unstable air that is relatively warm and can rise rapidly. Finally, you need lift. This can form from fronts, sea breezes or mountains.



When are thunderstorms most likely to occur?

Thunderstorms can occur year-round and at all hours. But they are most likely to happen in the spring and summer months and during the afternoon and evening hours.

How many thunderstorms are there every day?

It is estimated that there are around 1,800 thunderstorms that occur across our planet every day.

Are thunderstorms dangerous?

Yes, despite their small size, all thunderstorms are dangerous. Every thunderstorm produces lightning, which kills more people each year than tornadoes.

What is lightning?

Lightning is a bright flash of electricity produced by a thunderstorm. All thunderstorms produce lightning and are very dangerous. If you hear the sound of thunder, then you are in danger from lightning. Lightning kills and injures more people each year than hurricanes or tornadoes; between 75 to 100 people.

What causes lightning?

Lightning is an electric current. Within a thundercloud way up in the sky, many small bits of ice (frozen raindrops) bump into each other as they move around in the air. All of those collisions create an electric charge. After a while, the whole cloud fills up with electrical charges. The positive charges or protons form at the top of the cloud and the negative charges or electrons form at the bottom of the cloud. Since opposites attract, that causes a positive charge to build up on the ground beneath the cloud. The ground's electrical charge concentrates around anything that sticks up, such as mountains, people, or single trees. The charge coming up from these points eventually connects with a charge reaching down from the clouds and - zap - lightning strikes! Have you ever rubbed your feet across carpet and then touched a metal door handle? If so, then you know that you can get shocked! Lightning works in the same way.

What causes thunder?

Thunder is caused by lightning. When a lightning bolt travels from the cloud to the ground it actually opens up a little hole in the air, called a channel. Once then light is gone the air collapses back in and creates a sound wave that we hear as thunder. The reason we see lightning before we hear thunder is because light travels faster than sound!

How do you know if lightning is nearby?

If you see dark clouds, then lightning could be present, but the best thing you can do is to listen for thunder. If you hear thunder, then you need to go indoors or get in a car. Don't be outside, where lightning could strike! If your hair stands on end or your skin starts to tingle, lightning maybe about to strike. Get down on your hands and knees and keep your head tucked in. Do not lay flat, because it can give lightning a better chance of strike you.

How far away can you see lightning and hear thunder?

Within those distant thunderstorms, the lightning bolts can be seen as much as 100 miles from us, depending on the height of the bolt, the clarity of the air, and our elevation. Thunder, in comparison, has a much shorter range of detection - usually less than 15 miles in a quiet rural setting and under 5 miles in a noisy city environment.

Can you tell how far away a storm is?

Yes, you can use thunder to tell how far away a storm is. Next time you see a storm, count the number of seconds between when you see the lightning and hear the thunder. Take the number of seconds and divide by 5 and that will tell you how far away the storm is in miles. For example: If you counted 10 seconds between the lightning and the thunder, the lightning is 2 miles away!

$$10 / 5 = 2 \text{ Miles}$$

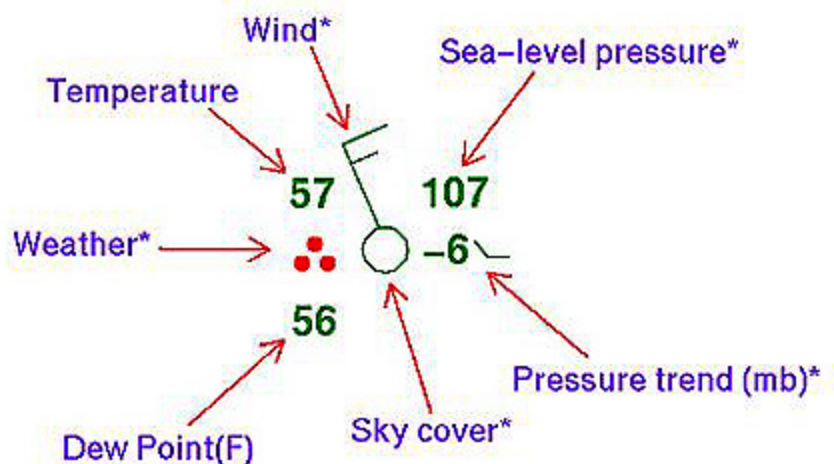
Weather Forecasting

How do meteorologists forecast the weather?

Weather forecasting is a prediction of what the weather will be like in an hour, tomorrow, or next week. Weather forecasting involves a combination of computer models, observations, and a knowledge of trends and patterns. By using these methods, reasonable accurate forecasts can be made up to seven days in advance.

What are weather station symbols?

Weather symbols are used on my weather maps as shorthand for the conditions at weather observing stations.



What is a High Pressure System?

A high pressure system is a whirling mass of cool, dry air that generally brings fair weather and light winds. When viewed from above, winds spiral out of a high-pressure center in a clockwise rotation in the Northern Hemisphere. These bring sunny skies. A high pressure system is represented as a big, blue H.

H

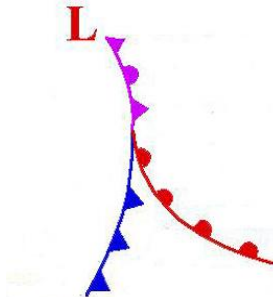
What is a Low Pressure System?

A low pressure system is a whirling mass of warm, moist air that generally brings stormy weather with strong winds. When viewed from above, winds spiral into a low-pressure center in a counterclockwise rotation in the Northern Hemisphere. A low pressure system is represented as a big, red L.

L

What is a front?

A front is a boundary between two different air masses, resulting in stormy weather. A front usually is a line of separation between warm and cold air masses.



What is a cold front?

A cold front is a boundary between two air masses, one cold and the other warm, moving so that the colder air replaces the warmer air. A cold front is represented as a blue line with the teeth pointing toward the direction on movement.



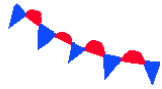
What is a warm front?

A warm front is a boundary between two air masses, one cool and the other warm, moving so that the warmer air replaces the cooler air. A warm front is represented as a red line with half circles pointing toward the direction on movement.



What is a stationary front?

A stationary front is a boundary between two air masses that more or less doesn't move, but some stationary fronts can wobble back and forth for several hundred miles a day. A stationary front is represented as an alternating warm and cold front symbol.



What is a occluded front?

An occluded front is a combination of two fronts that form when a cold front catches up and overtakes a warm front. An occluded front is represented as a purple line with teeth and half circles.



What is a trough?

A trough on a weather map is an elongated area of relatively low pressure. Troughs bring cloudy and rainy weather. A trough is represented by a hash mark line.

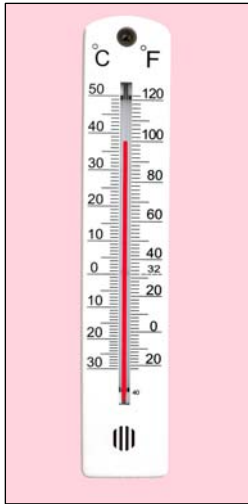


What is a weather satellite?

A weather satellite is a type of satellite that is primarily used to monitor the weather and climate of the Earth. Satellites can be either polar orbiting, seeing the same swath of the Earth every 12 hours, or geostationary, hovering over the same spot on Earth by orbiting over the equator while moving at the speed of the Earth's rotation. These meteorological satellites see more than clouds and cloud systems. City lights, fires, effects of pollution, auroras, sand and dust storms, snow cover, ice mapping, boundaries of ocean currents, energy flows, etc., are other types of environmental information collected using weather satellites.

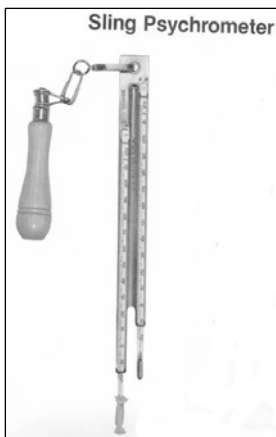
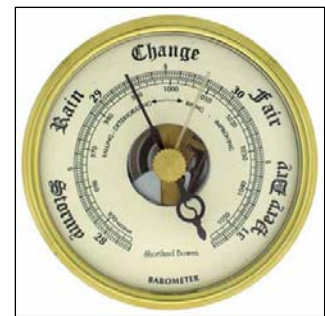


Weather Instruments



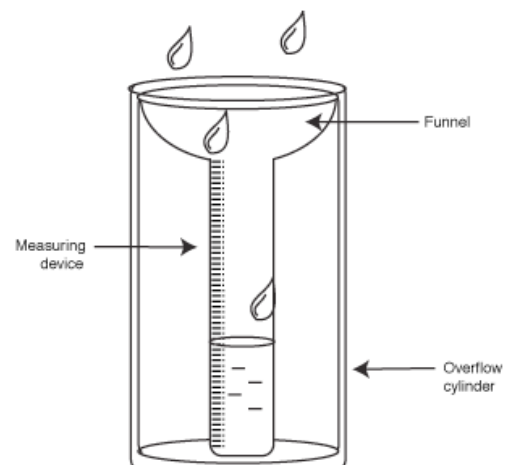
A **THERMOMETER** measures the air temperature. Most thermometers are closed glass tubes containing liquids such as alcohol or mercury. When air around the tube heats the liquid, the liquid expands and moves up the tube. A scale then shows what the actual temperature is.

A **BAROMETER** measures air pressure. It tells you whether or not the pressure is rising or falling. A rising barometer means sunny and dry conditions, while a falling barometer means stormy and wet conditions. An Italian scientist named Torricelli built the first barometer in 1643.

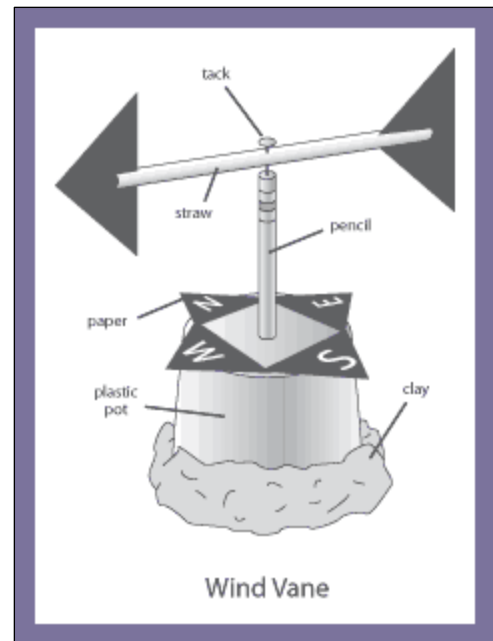


A **SLING PSYCHROMETER** measures relative humidity, using the cooling effect of evaporation. Two thermometers are used in a sling psychrometer. Wet the cloth of one of the thermometers and swing the psychrometer around a few times. Water evaporates from the cloth, causing the temperatures on that thermometer to be lower than the other.

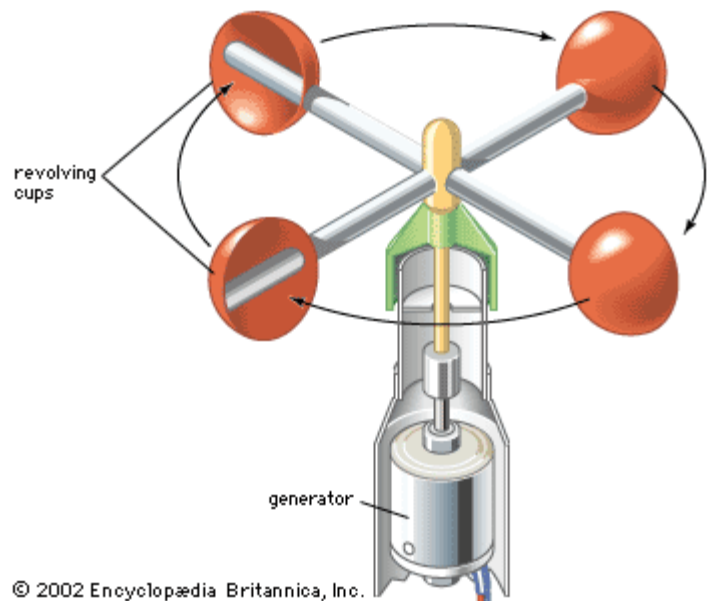
A **RAIN GAUGE** measures the amount of rain that has fallen over a specific time period.



A **WIND VANE** is an instrument that determines the direction from which the wind is blowing.



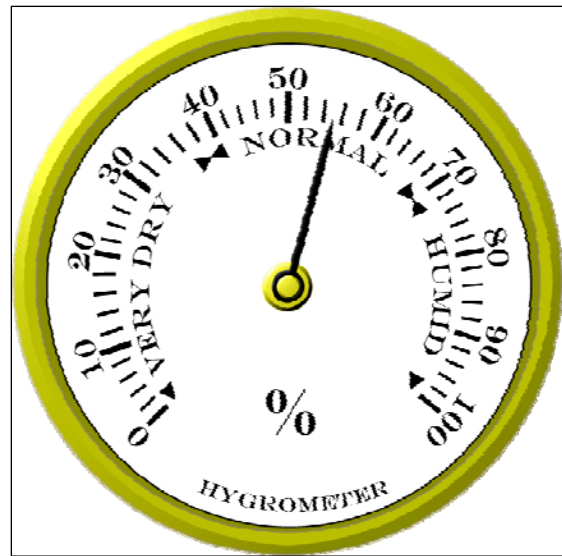
An **ANEMOMETER** measures wind speed. The cups catch the wind, turning a dial attached to the instrument. The dial shows the wind speed.



WEATHER MAPS indicate atmospheric conditions above a large portion of the Earth's surface. Meteorologists use weather maps to forecast the weather.



A **HYGROMETER** measures the water vapor content of air or the humidity.



A **WEATHER BALLOON** measures weather conditions higher up in the atmosphere.



A **COMPASS** is a navigational instrument for finding directions.

WEATHER SATELLITES are used to photograph and track large-scale air movements. Then meteorologists compile and analyze the data with the help of computers.

YOUR EYES are one of the the best ways to help detect the weather. Always keep an eye at the sky and you'll usually be on top of weather conditions.



Activity: Indoor Rainbow

Duration: 45 minutes

Materials:

- glass jar or a large drinking glass
- small mirror
- flashlight
- dark room with white walls

Procedure:

- Fill the jar or glass with water.
- Place the mirror inside the water filled jar or glass.
- Tilt the mirror slightly upward.
- In a very dark room with white walls, shine the flashlight onto the mirror.
- A rainbow will appear! (Note: If no rainbow appears at first, just change the angle of the light from the flashlight or change the angle of the mirror.)

Explanation:

The mirror reflects light that passes back through the water, traveling at an angle. The water bends, or refracts, the light. As the light bends, it separates into the colors of the rainbow...red, orange, yellow, green, blue, indigo and violet.

Activity: Blue Sky Experiment

Duration: 45 minutes

Materials

- flashlight
- 2-liter pop bottle
- milk
- water

Procedure:

- Fill the 2-liter bottle three-fourths full of water and prop up the flashlight, so it will shine through the bottle from the side.

- Add a teaspoon of milk to the water.
- Put the cap on the bottle and shake to mix up the water and milk.
- What do you see? Keep adding milk until you start to see a blue light that is scattered to your eyes from the mixture.
- Once you see the blue light, add more milk to the mixture until you see more of an orange or red light.

Explanation:

Just like in the atmosphere, the mixture scatters more of the blue wavelength than any other color. ' why the sky is blue! At sunrise or at sunset, there is even more scattering taking place due to the angle of the sun. This causes the reds and oranges to scatter into our atmosphere. That's why our sunsets and sunrises are so colorful!

Activity: Cloud in a Bottle

Duration: 45 minutes

Materials:

- 2-liter clear plastic pop bottle
- matches (children will need adult assistance to light matches)
- warm water

Procedure:

- Fill the clear plastic 2-liter bottle one-third full of warm water and place the cap on. As warm water evaporates, it adds water vapor to the air inside the bottle. This is the first ingredient to make a cloud.
- Squeeze and release the bottle and observe what happens. You'll notice that nothing happens. Why? The squeeze represents the warming that occurs in the atmosphere. The release represents the cooling that occurs in the atmosphere. If the inside of the bottle becomes cover with condensation or water droplets, just shake the bottle to get rid of them.
- Take the cap off the bottle. Carefully light a match and hold the match near the opening of the bottle.
- Then drop the match in the bottle and quickly put on the cap, trapping the smoke inside. Dust, smoke or other particles in the air is the second ingredient to make a cloud.
- Once again, slowly squeeze the bottle hard and release. What happens? A cloud appears when you release and disappears when you squeeze. The third ingredient in clouds is a drop in air pressure.

Explanation:

Water vapor, water in its invisible gaseous state, can be made to condense into the form of small cloud droplets. By adding particles such as the smoke enhances the process of water condensation and by squeezing the bottle causes the air pressure to drop. This creates a cloud!

Activity: Suck an egg into a bottle

Duration: 45 minutes

Materials:

- glass bottle with a long, narrow neck (an apple cider jug works well)
- boiled egg
- matches

Procedure:

- Put the empty bottle on a table.
- Peel the boiled egg.
- Light a match and drop it into the bottle. Repeat about three or four times.
- Quickly put the egg over the mouth of the bottle.

Explanation:

What happens? The lit match heats the air inside the bottle. When air is heated it expands and takes up more room. As the heated air expands, some of it escapes out of the bottle. When the matches go out, the air inside the bottle cools and contracts, which takes up less room. This creates a lower pressure inside the bottle than outside the bottle. The greater pressure outside the bottle forces the egg to get sucked into the bottle.

*To get the egg back out of the bottle, tilt the bottle and blow air into it. Make sure you get out of the way, because the egg will shoot out.

Activity: Make a thermometer

Materials:

- clear, plastic bottle (11oz. water bottle works)
- water
- rubbing alcohol

- clear plastic drinking straw
- modeling clay
- food coloring

Procedure:

- Fill about 1/4 of the bottle full with equal parts of water and rubbing alcohol.
- Add a few drops of food coloring.
- Put the straw in the bottle, but don't let it touch the bottom.
- Use the modeling clay to seal the neck of the bottle, so the straw stays in place. (Make sure the straw does not touch the bottom of the bottle.)
- Hold your hands on the bottom of the bottle and watch the mixture move up through the straw.

Explanation:

Why does this happen? Just like any thermometer, the mixture expanded when it was warmed. This made the mixture no longer fit in the bottom of the bottle. As the alcohol expanded the colored mixture moved up through the straw. If the bottle were to get extremely hot, the mixture would have come up through the top of the straw.

Activity: Make it rain

Materials:

- glass mayonnaise or canning jar
- plate
- hot water
- ice cubes
- index cards

Procedure:

- Pour about two inches of very hot water into the glass jar.
- Cover the jar with the plate and wait a few minutes before you start the next step.
- Put the ice cubes on the plate.

Explanation:

- What happens? The cold plate causes the moisture in the warm air, which is inside the jar to condense and form water droplets. This is the same thing that happens in the atmosphere. Warm, moist air rises and meets colder air high in

the atmosphere. The water vapor condenses and forms precipitation that falls to the ground.

Activity: Make your own Hygrometer

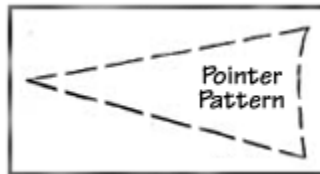


Duration: 1-1.5 hours

Materials:

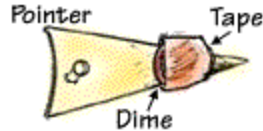
- a scrap piece of wood or flat styrofoam (about 9 inches long and 4 inches wide)
- a flat piece of plastic (about 3 inches long and 3 inches wide) thin enough that you can cut
- 2 small nails
- 3 long strands of human hair (about 8 inches long)
- a dime
- glue
- tape
- hammer
- scissors (strong enough to cut plastic)

Procedure:



1. First, cut the piece of plastic into a triangular shape (refer to pictures).
2. Then, tape the dime onto the plastic, near the point.
3. Poke one of the nails through the plastic pointer, near the base of the triangle.
4. Wiggle the nail until the pointer moves freely and loosely around the nail.

5. On the plastic pointer, between the dime and the nail hole, glue the hair strands to the plastic.



6. Position the pointer on the wood or styrofoam base about three quarters of the way down the side. (Refer to picture.) Attach the nail to the base. The pointer must be able to turn easily around the nail.
7. Attach the other nail to the base about one inch from the top of the base, in line with the pointer.
8. Pull the hair strands straight and tight so that the pointer points parallel to the ground. That is, make sure the point of the pointer is perpendicular to the hair. The hair should hang perfectly vertical and the pointer should point perfectly horizontal.
9. Glue the ends of the hair to the nail. If the hair is too long, trim the ends.

Explanation:

The human hair cells will indicate the level of moisture in the air by expanding and contracting. When their air is moist, the hair will expand and lengthen, making the pointer point down. When the air is dry, the hair will contract and shorten, making the pointer point up. When you make your hygrometer observations each day, you should make a mark to indicate where the pointer points. Over time, you'll be able to see the humidity patterns that will help you forecast the weather.

Activity: How to make a Barometer

Duration: 1-1.5 hours

Materials:

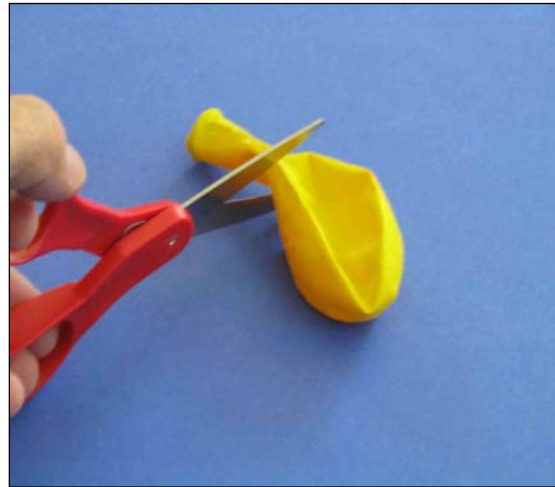
- Large balloon, 11" or larger. Get a good quality balloon; the cheap ones slowly leak.
- Rigid plastic or glass cup. If you select plastic, spend a little extra and get very heavy-grade cups.
- Rubber bands (#30 size seems good, they are about 2" long. They'll need to fit tightly around whatever cup you select.).
- Hardwood dowel (1/8" diameter x 12" long).
- Hot glue gun and glue.
- 8-1/2" x 11" sheet of heavy card stock, such as 90lb Bristol board.

- Paper ruler, divided into millimeters
- 3" x 1/2" x 16" piece of lumber for a base.
- Sharp scissors.
- A piece of #100 grit sandpaper or an emery board for filing a point onto the dowel.

Procedure:

Prepare the Aneroid Chamber

1. Blow up the balloon to stretch it out, and then release the air. Cut off the neck of the balloon so that you can reach into the balloon with your fingers and stretch the balloon out and over the top of the cup. Make sure that the *inside* surface of the balloon ends up on the *outside* so that humidity trapped in the inside of the balloon will not be trapped in the chamber. You may have to practice this several times to do it without ripping the balloon, yet at the same time obtaining a good seal over the top of the cup.



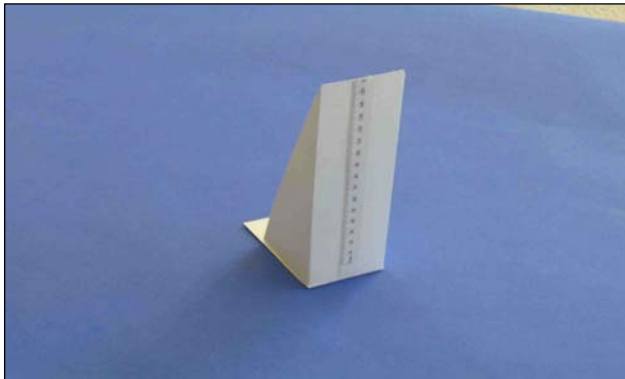
Note: Some like to stretch out the balloon by simply pulling it in their hands. My personal bias is that this does not stretch the balloon uniformly. But blowing up heavy balloons is sometimes difficult for kids.

2. Wrap several rubber bands around the top of the cup and over the balloon to help insure a tight air seal.



Add The Pointer

The long dowel will be glued to the balloon surface so that it extends from the center of the balloon outwards over the edge of the cup. Use two dabs of glue; one at the center of the balloon and one at the rim of the cup.



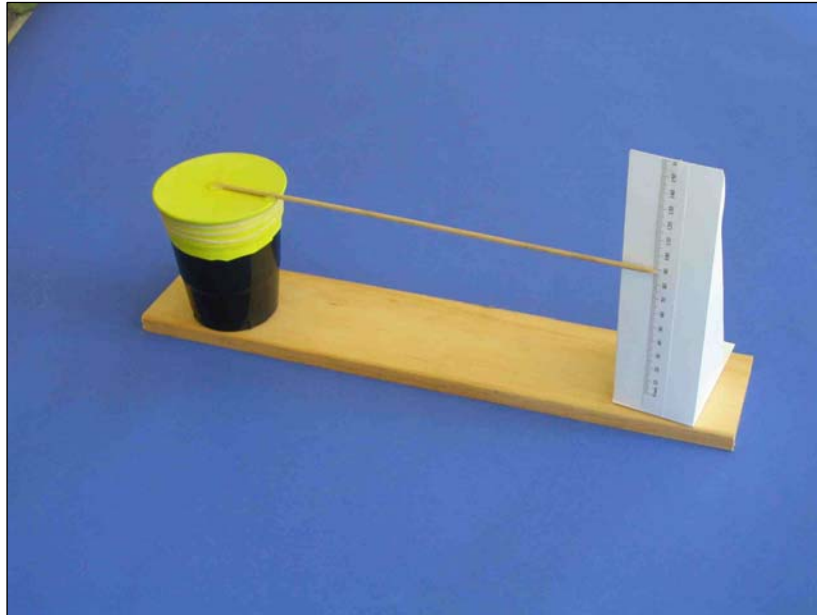
Assemble The Stand and Scale

Cut out and attach this ruler scale to the middle of the stand. Put "zero" toward the base of the stand.

Attach All Parts to the Base.

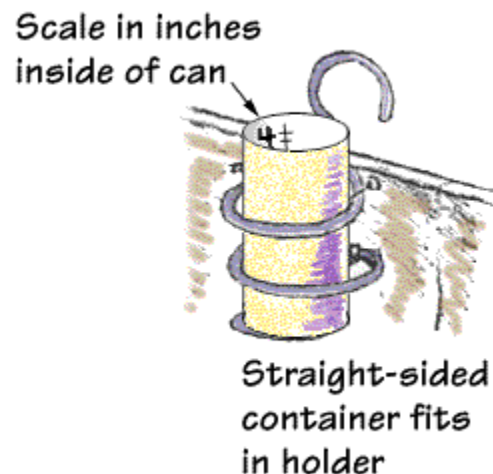
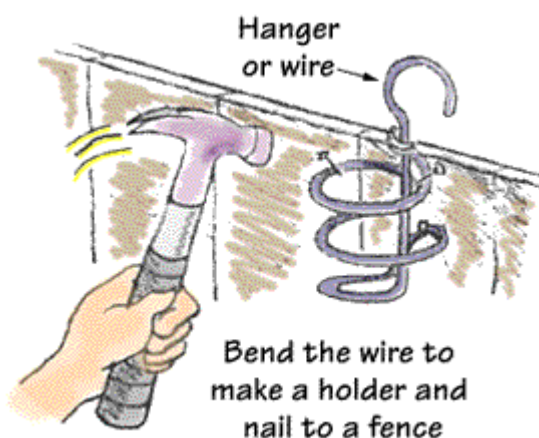
1. Position the cup and scale/stand (without glue) onto the wood base. See the picture below.

2. Use hot glue to attach just the bottom edge of the cup to one end of the base by applying two or three blobs of glue, evenly spaced, around the outside edge of the cup. Position the cup so that the end of the pointer is near the front edge of the base.



3. Use a small sanding board to sharpen the end of the pointer so that its position can be determined precisely. Then attach the scale/stand to the base so that the pointer is nearly touching the scale and is free to move up and down. .

Activity: Make your own Rain Gauge



Duration: 1 hours

Materials:

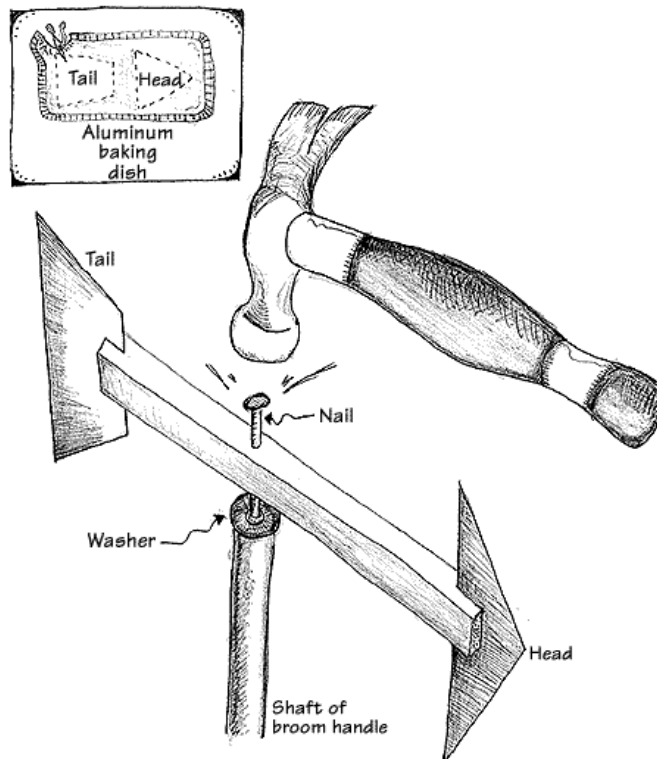
- a glass beaker (or any straight-sided glass that can be marked with a measuring scale)
- a coat hanger or wire (bent to make a holding rack -- see picture)
- hammer and nails (to secure the rack)

Procedure:

1. Basically, any measuring glass left outside can serve as a rain gauge. However, since most rain showers are usually quite windy, you'll want to fasten your rain gauge somewhere so that it doesn't blow over.
2. Locate a good place for your gauge. There should be nothing overhead, like trees, electric wires, or the edge of a roof. These obstructions can direct rainwater into or away from your gauge, creating a false reading.
3. The edge of a fence, away from the building, is often a good place for your gauge.

Once you have found the spot, attach the holding rack (refer to picture). Then, slip your measuring glass into position. Wait for rain, then record your measurement, and empty the glass.

Activity: Make your own Weather Vane



Duration: 1.5 – 2 hours

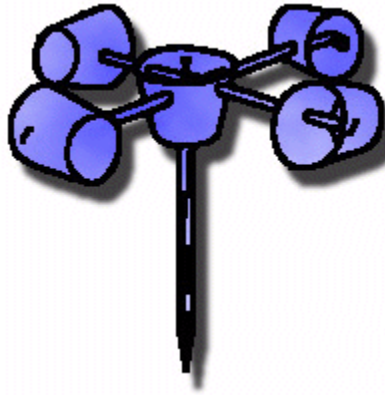
Materials:

- a long wooden dowel (about the size of a broom stick)
- an aluminum pie plate
- a 12 inch long piece of wood (A sturdy ruler would work)
- nails
- a metal washer
- hammer
- glue
- small saw (or serrated knife)
- wire (for mounting)
- scissors (strong enough to cut aluminum)

Procedure:

1. Begin with the 12 inch piece of wood. Use the small saw (or serrated knife) to cut a vertical slit at each end of the stick. The slit should be about one half inch deep. At the midpoint (exactly halfway) of the top of the stick, hammer one nail all the way through the stick. Then turn the wood around the nail several times until the stick turns easily around the nail.
 2. Refer to the pattern picture and cut the head and tail from the aluminum plate. Glue the head into the slot at one end of the wooden stick. Glue the tail into the other end. Allow time for the glue to dry before you take the vane outside.
 3. Attach the weather vane to the long wooden dowel by placing the metal washer on the end of the dowel and then hammering the nail through the wooden stick and into the wooden dowel. (Refer to the picture.) Make sure that the vane moves freely and easily around the nail.
 4. Now you are ready to mount your weather vane outside. If you mounted your rain gauge on a fence, you may want to mount your weather vane near it. Position the wooden dowel beside the fence and secure it with wire. Try to get the vane as high above the fence as you can while still keeping the dowel steady and secure.
 5. The head of the pointer will always point to the direction from which the wind is blowing. For example, if the head points to the NorthEast, then the wind is blowing from the NorthEast. It's as simple as that. (A common mistake is to think that the wind is blowing toward the NorthEast.) Record your wind direction readings in your weather journal.
-

Activity: Make your own anemometer



Duration: 1 hour

Materials:

- five 3 ounce paper Dixie cups
- two straight plastic soda straws
- a pin
- scissors
- paper punch
- small stapler
- sharp pencil with an eraser

Procedure

1. Take four of the Dixie cups. Using the paper punch, punch one hole in each, about a half inch below the rim.
2. Take the fifth cup. Punch four equally spaced holes about a quarter inch below the rim. Then punch a hole in the center of the bottom of the cup.
3. Take one of the four cups and push a soda straw through the hole. Fold the end of the straw, and staple it to the side of the cup across from the hole. Repeat this procedure for another one-hole cup and the second straw.
4. Now slide one cup and straw assembly through two opposite holes in the cup with four holes. Push another one-hole cup onto the end of the straw just pushed through the four-hole cup. Bend the straw and staple it to the one-hole cup, making certain that the cup faces in the opposite direction from the first cup. Repeat this procedure using the other cup and straw assembly and the remaining one-hole cup.
5. Align the four cups so that their open ends face in the same direction (clockwise or counterclockwise) around the center cup. Push the straight pin through the two straws where they

intersect. Push the eraser end of the pencil through the bottom hole in the center cup. Push the pin into the end of the pencil eraser as far as it will go. Your anemometer is ready to use.

6. Your anemometer is useful because it rotates with the wind. To calculate the velocity at which your anemometer spins, determine the number of revolutions per minute (RPM). Next calculate the circumference (in feet) of the circle made by the rotating paper cups. Multiply your RPM value by the circumference of the circle, and you will have an approximation of the velocity of at which your anemometer spins (in feet per minute). (Note: Other forces, including drag and friction, influence the calculation but are being ignored for this elementary illustration. The velocity at which your anemometer spins is not the same as wind speed.)
7. The anemometer is an example of a vertical-axis wind collector. It need not be pointed into the wind to spin. (Note: This paper cup anemometer will produce a reasonable approximation of circumferential velocity, but should not be used for any purpose other than elementary illustration.)

Activity: Make your own Compass

Duration: 1 hour

Materials:

- A flat area where the sun shines directly (no shade)
- A straight stick or dowel, about 18 inches long
- Four heavy rocks (about the size of golf balls)
- A few smaller stones for marking

Procedure:

1. Locate a flat sunny space near your weather station. Begin by digging a hole about six inches deep. Bury the base of the stick. The stick should now be standing up to a height of twelve inches.
2. The first thing you'll need to do is locate "North." Before school in the morning, place a small marking stone at the end of the shadow cast by the stick. After school, later in the afternoon, the shadow should be about the same length as it was in the morning, but in a different direction.
3. Place a marking stone at the end of the afternoon shadow.
4. Position your right foot on the morning stone and your left foot on the afternoon stone. Your body now faces south. Another way to

think of this is that the two shadows meet at the stick to form an "arrow" pointing south.

5. Once you have located "south," place one of the four heavy stones on the ground, about twelve inches in front of the stick. Position a second stone in the "north" position by tracing a straight line opposite away from south. Position "east" and "west" carefully opposite from each other. Be sure that they are equally distant from "north" and "south." You can use your compass to find wind direction and other weather data.

Resources

<http://www.weatherwizkids.com/weather-temperature.htm>

<http://eo.ucar.edu/webweather/basic.html>

<http://en.wikipedia.org/wiki/Climate>

<http://www.fi.edu/weather/todo/todo.html>

<http://www.fi.edu/weather/todo/compass.html>

<http://www.sci-experiments.com/barometer/barometer.html>