# WEATHER

## Teacher Guide

including

Lesson Plans, Student Readers, and More Information

**Lesson 1** - Fact or Folklore?

**Lesson 2** - Interaction of Ocean and Atmosphere

**Lesson 3** - Charting Weather Patterns (Lab)

**Lesson 4** - Causes of Precipitation

**Lesson 5** - Severe Weather

*designed to be used as an Electronic Textbook*
*in class or at home*

**materials can be obtained from the Math/Science Nucleus**

# EARTH SCIENCES - WEATHER

## Lesson 1 - Fact or Folklore

**MATERIALS:**

reader

**Objective:** Students will learn how data can prove or disprove weather folklore.

**Teacher note**

Students are familiar with the weather because they personally deal with it every day. They decide what to wear and how their hair should be combed by looking at the weather outside. It is natural for people to devise a system where they try to predict the weather. However, in today's media rich environment, most students in affluent nations just turn on the television. However, there are many weather lores (not laws) that can help us predict and appreciate the weather, which are used in many developing countries.

The following websites have more of these lores. You may want students to ask their relatives or friends if they know of any other "fun" lores and discuss them in class.

http://www.shoal.net.au/~seabreeze/weather.html

No matter what the scientific reason is for the weather, all organisms have to cope with it. Most organisms have adapted and evolved to different weather conditions. Palm trees can bend and sway in high tropical winds without breaking. Polar bears have thick fat layers and white fur to help cope with the Arctic cold. Ducks have special oil reserved to coat their feathers to protect them from the rain.

Polar bears

Palm tree in a hurricane

Not only do organisms have protection against weather, they have developed strategies to coincide with changing climatic seasons. For example, many vertebrates have their offsprings to coincide with "spring" to insure good weather for their young. In many places the reproduction of amphibians coincides with the rainy season.

Theophrastus

There have been many historical writings on weather. Hesiod, a Greek poet around 800 BC advised sailors it was safe to go to sea, when the first leaves of the fig tree were the size of a crow's footprint. Aristotle (384-322 B.C.) wrote 150 philosophical treatises including one called *Meteorology*. Based on his observations he tried to describe and explain weather such as rain, cloud, mist, dew, snow, hail, wind, thunder, lightning, hurricanes, haloes, and rainbows. Theophrastus (372-287 BC) a Greek philosopher, compiled a book on weather signs that would help farmers and sailors predict the weather.

Celsius

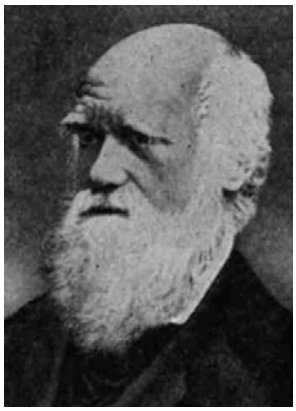
**Meteorology** or the science of weather was mainly based on observation. Many weather instruments were not invented until the start of the 1600's. Even the **thermometer** was not invented until 1714 when Gabriel Fahrenheit of Poland used the freezing of salt water as "zero" degrees. Fresh water would freeze at 32 degrees and boils at 212 degrees. In 1742 Anders Celsius, a Swedish astronomer devised a metric system, by using the freezing of water as zero degrees and boiling at 100 degrees.

Scientific data collection of weather did not really begin until the mid 1800's. Few people collected information associated with maps, time, and date. The Smithsonian Institute in Washington, D.C. in the 1840's began a systematic retrieval of data by providing scientific instruments (i.e., thermometers) to people throughout the United States. The program grew and the data was collected for almost 20 years. When the Civil War broke out in the United States, the program was dismantled and the Signal Corp of the U.S. took up weather monitoring, especially since weather was important in war. However, the military did not collect scientific data, so the United States Weather Bureau of the Department of Agriculture was born in 1891. They trained people to read instruments and collect data throughout the country.

Today there are many government, research, and private groups collecting data. The instrumentation is more sophisticated and can continuously record weather conditions and send data continuously using satellites. The internet can provide people data from around the world on many web sites.


Ants moving eggs

People always talked about the weather, especially in letters. Sailors, fisherman, farmers, and shepards learned to look at weather signs to try and predict the weather. Some stories were good and others were myths. One of the earliest weather folklore was in the 4th century BC, when Theophrastus wrote *"If ants on the side of a hollow carry their eggs from the nest to the high ground, it indicates rain."*

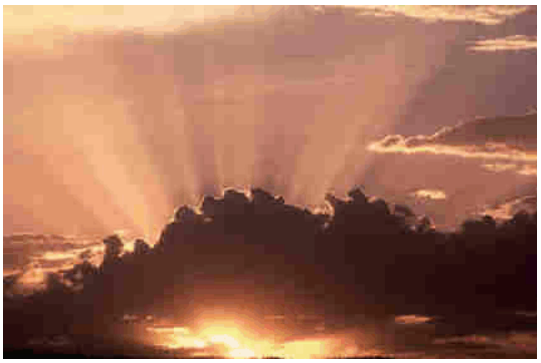

Charles Darwin

Even Charles Darwin would collect these signs and create weather verses:

*The hollow winds begin to blow*
*The clouds look black, the glass is low,*
*The soot falls down, the spaniels sleep*
*And spiders from their cobwebs peep*

Below are some weather lore that are based on truth. After the rhyme the scientific reasoning for it follows.

***When the dew is on the grass, Rain will never come to pass.***
***When grass is dry at morning light, look for rain before the night.***


Rain or fair weather

High pressure (fair weather) usually allows for cooling at night resulting in the formation of dew early in the morning. Low pressure (rainy weather) is associated with rising air which inhibits the development of morning dew.

***The gnats bite and I scratch in vain,***
***Because they know it is going to rain.***

Flying insects fly closer to the ground before the rain plus the drop in density of the air before the rains irritate the little fellows causing them to swarm more and to bite more diligently.


Ring around the Moon

***Ring around the moon,***
***Rain will fall soon.***

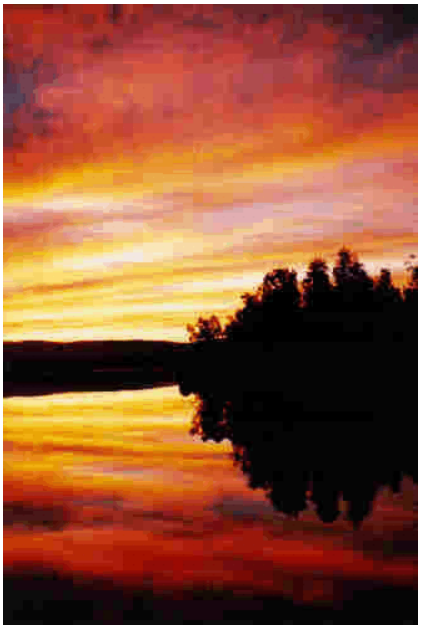
The ring is produced by moonlight passing through high thin cirrus clouds. Approaching cirrus clouds along with a falling barometer (low pressure), are usually associated with weather fronts, which produce rain.

***Sound traveling far and wide,***
***A stormy day will betide.***

Rain develops as the density of the air drops. This density change causes sound waves to travel differently, usually farther than normal. This allows for a better mixing of the air which carries the fragrance of the flowers, or the putrid smell of the marsh or ditch to the nose. Animals, having a much better sense of smell can detect far sooner than humans changes in the air and many times become restless with the coming of rain.

***Red sky in morning, sailor's warning.***
***Red sky at night, sailors' delight.***

Red skies in the morning mean storms are coming, and red skies at night means calm seas. This is usually true along coastal areas.



Red sky at night

Red sky in morning

The changing of weather has always been a celebration in many societies. It was an important event to know when to prepare for bad weather or when to plant crops. Many of the holidays that are celebrated throughout the world have something to do with a change of weather.

In the United States there is a tradition of Groundhog day on February 2. It is when the groundhog comes out of his hole after a long winter sleep to look for his shadow. If he sees his shadow, there are six more weeks of bad weather and he will go back to sleep. If he does not see his shadow, spring weather is here and he will stay above ground.

Groundhog Phil being interviewed


This tradition comes from the Europeans who used a hedgehog. Since the early colonists to America did not find a hedgehog, they substituted a groundhog. In Punxsutawney, Pennsylvania, an entire event has developed to create a media event around Phil the Groundhog.

# EARTH SCIENCES - WEATHER

## Lesson 2 - Interaction of Oceans and Atmosphere

**MATERIALS:**

reader

**Objective:** Students compare the air and oceans contribution to the weather.

**Teacher note**

A discussion on El Nino can focus on how the oceans control weather patterns. The warming of an ocean and land has to do with heat transfer. Water is slow to warm up but slow to cool down. Water rarely changes more than a few degrees over short periods of time. Land on the other hand can change its temperature very quickly depending on whether the Sun is out or not, sometimes changing as much as 10°C (50°F) within 12 hours. Large water masses like the oceans tend to maintain heat longer than land.

Wind, unlike water, can change its pattern quicker because it is a gas, which is lighter than water. Wind relies on the transfer of solar heating from large masses of water for some of its energy, which causes a change in the direction of the wind. So when El Nino changes the temperature of the water, this in turn changes wind direction. Wind tends to move from an area of high atmospheric pressure to low atmospheric pressure (almost a downhill motion). The surface of warm water tends to be less dense and slightly higher than cold water which is more dense.

Currents within the ocean help transfer the heat from one place to another. For example, southern England is noted for its foggy but mild weather, which is unusual considering the latitude of England. The Gulf Stream current, as it is called, travels from the Gulf of Mexico, along the eastern United States and then crosses over the Atlantic to England because of the Coriolis effect. Although this is a long journey, the water is still warm and transfers some of the heat to surrounding land masses.

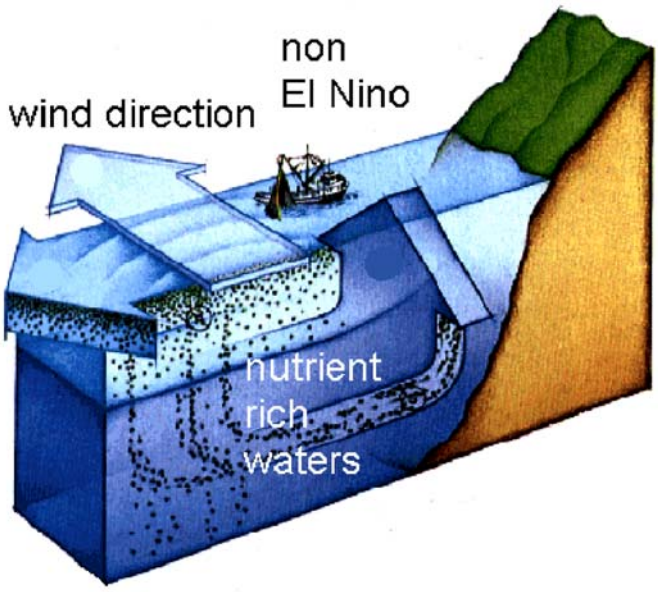
The interaction of the ocean and atmosphere causes the weather. Whether the ocean or atmosphere is the more controlling factor, is difficult to ascertain. As students read information on El Nino, they can see that it took a long time before the pattern of change could be understood. El Nino helped the scientific community to understand the global causes of weather.

For more information consult:
http://www.cpc.ncep.noaa.gov/index.html

Coast off Peru, Aquas Calentes

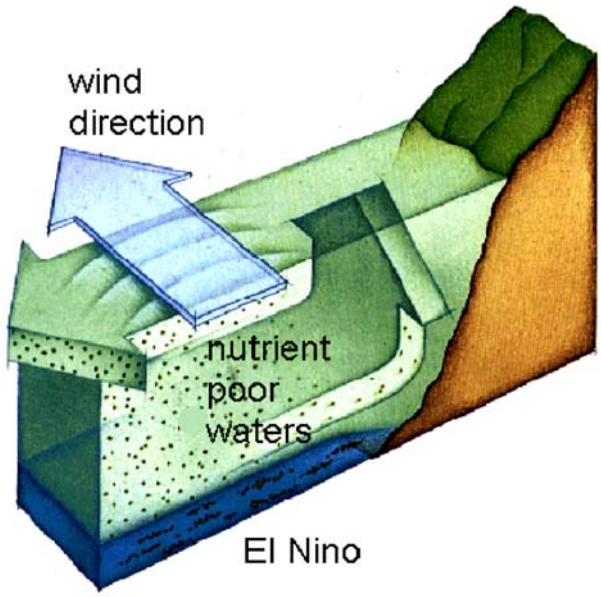
Peruvian fishermen used the term "Corriente del Nino" or the "Current of Christ Child" in reference to a warming of the Pacific Ocean's surface temperature close to Christmas time. **El Nino**, as it was called by Cambial Carillo in 1892, would sometimes kill fish and bird life, but would also bring different kinds of tropical fish into the Pacific Ocean off of Peru. Although this change in the oceans was observed as a recurring event for over a century, the name El Nino is still widely used as a symbol of this phenomenon.

Until recently, El Nino was considered to effect only the west-central seaboard of South and North America, with little or no changes in world wide weather patterns. Now, meteorologists think that understanding El Nino will help explain droughts and floods that occur in other parts of the world during an El Nino, and might also be able to help predict these weather changes.



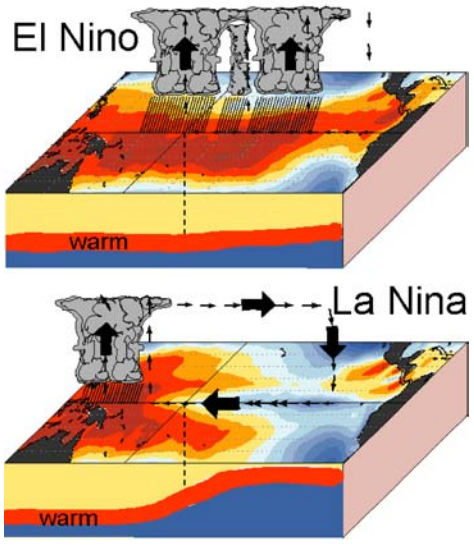

Although details of El Nino events can be traced in the written literature back to 1726 using different ship captains' logs, it probably was in existence before that time. The latest and one of the strongest and longest El Nino on record, began in early 1982 and continued until late summer of 1983, and caused disastrous results throughout the world. Scientists blamed droughts in Australia, Indonesia, Peru, and Hawaii. Storms and flooding in California, south Pacific, Gulf States, Cuba, and Ecuador as well as destruction of Pacific coral reefs and changes in the fish population off of Peru to California were blamed on El Nino.

When El Nino is not active, nutrients are brought upwards from the ocean currents. This provides the nourishment for plankton and serve as the basis of the food chain which drives the Peruvian fishery. As the trade winds relax during an El Niño, fewer nutrients are brought from depth and the productivity of the region is diminished. During the most severe El Niños, the productivity may be so low that the fishery collapses. Beaches along the effected area have dead sea lions, bivalves, shrimp-like creatures, and a variety of birds like cormorants and boobies. The tide pools are also effected because many invertebrate faunas that lived among the rocks disappeared. But how could a warming of a current cause such an effect?



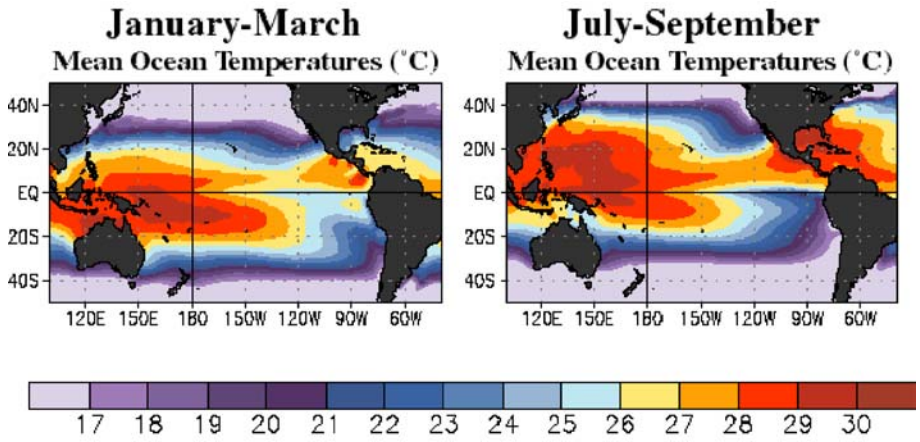

The biological community that lives in the eastern Pacific Ocean likes cold water, which come from the bottom waters and surfaces (called **upwelling**) along South America and the North American west-central coast. Water upwells because the wind blows seaward, causing the water to move westward. This leaves a water "gap" which must be replenished. Cold water that circulates on the bottom, moves upward bringing cold water. This cold water brings nutrients such as oxygen, nitrates, phosphates, and silicates that are essential to the growth of little organisms called plankton, which is food for bigger animals.

These little organisms, many no larger than the diameter of your eyelash, begin what is called the food chain. Little plants (mainly diatoms) are eaten by larger critters (foraminifera, radiolarians, and other one celled protozoa) which in turn are eaten by larger organisms (copepods, krill) which is the main staple of fish which in turn serve as food for the very large fish, marine mammals, and marine birds. When the little plants cannot convert sunlight to useable energy, the other organisms in the food chain have little available food. The links in the chain are broken, only to cause starvation and death affecting even the largest organism in the food chain.




Traditionally El Nino refers to an increase of ocean surface temperatures over a large area of the South Pacific. The increase is only a matter of 2° to 7°C, but this is enough to upset the delicate balance that living organisms have with their environment. Scientifically, El Nino no longer refers just to this warming. Scientists have learned that these ocean changes are coupled with an atmospheric change which starts in the Indonesian area. This change is called the Southern Oscillation and refers to a reversal of the western Pacific **trade winds** which blow east to west during an El Nino. Normal Pacific trade winds in southern hemisphere blow west to east.

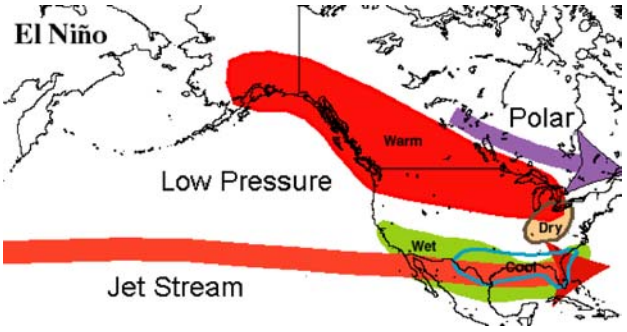
This ocean/atmosphere condition is called the El Nino/Southern Oscillation (**ENSO** for short) events. The winds of the ENSO event bring warm water to the eastern Pacific Ocean which creates a living environment that the organisms are not able to cope with. Increases of temperature, no matter how slight, can cause drastic results to little organisms that live in the sea. These events usually recur every 2 to 10 years, with an average of four years and individual events can last up to 2 years.




Although the ENSO event caused many organisms to die, some species love the warm water. Nineteen different types of marine animals liked the water and increased in number along the coast of west South America in the 1982-83 event. This included the dolphin fish, skipjack, bonita, tuna, scallop and shrimp. On land, coastal deserts in South America bloomed with flowers and other plants. Even in the United States, the corn yield always seems to increase during an El Nino.

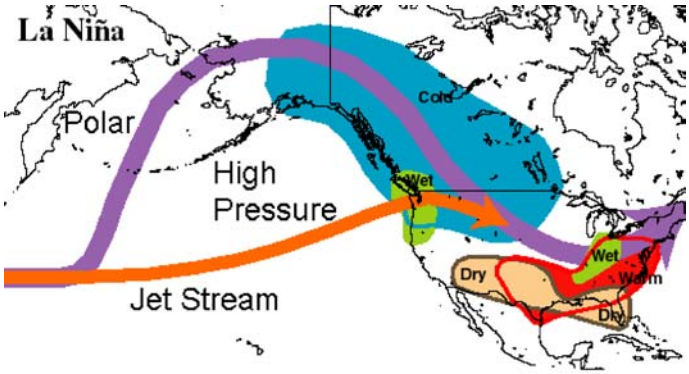
Understanding the importance of an El Nino/Southern Oscillation event involves many scientific concepts. More importantly, an ENSO event illustrates the "chicken before the egg problem" or the cause/effect relationship in true scientific terms.

Does the atmosphere change first in an ENSO event and then change water temperature (ocean-air hypothesis) or does the water circulation change, causing the temperature to change thereby creating changing weather patterns (ocean-ocean hypothesis)? Unfortunately, physical oceanographers and meteorologists are still debating this. These two models try to explain why El Nino causes increased water temperatures off North America.




El Nino conditions

All scientists agree that El Nino does cause drastic changes in the biological community, but some scientists blame more disasters on El Nino than others. To resolve this debate scientists are still analyzing data. Understanding this cycle might give us warnings so we can expect an El Nino before it arrives. This can prepare countries to expect abnormal weather patterns. Already they have determined that stronger than average **easterlies** in the west equator at least 18 months, signals an approaching El Nino. Also sea level (the height of water is not all one level) is unusually higher in the west than in the east Pacific and a larger layer of warm water in the west Pacific warns oceanographers that an ENSO event is coming.




La Nina conditions

# EARTH SCIENCES - WEATHER

## **Lesson 3** - Charting Weather Patterns

**MATERIALS:**

reader

**Objective:** Students use the internet to compare different weather.

**Teacher note**

Observations of current temperature, humidity, wind, pressure, and highest and lowest temperatures are usually transmitted by commercial radio and television, telephone, recording systems, and NOAA (National Oceanographic and Atmospheric Agency) Weather Radio for the localities they serve.

Data such as the previous day's highest and lowest temperature and precipitation amounts are generally carried in newspapers for both the local area and other cities. Many papers carry foreign reports. Television and radio weather programs sometimes carry selected data, primarily for U.S. cities.

Records of past weather, which also are compiled and analyzed to describe climates on a local, regional, or worldwide basis, are maintained by NOAA's Environmental Data and Information Service.

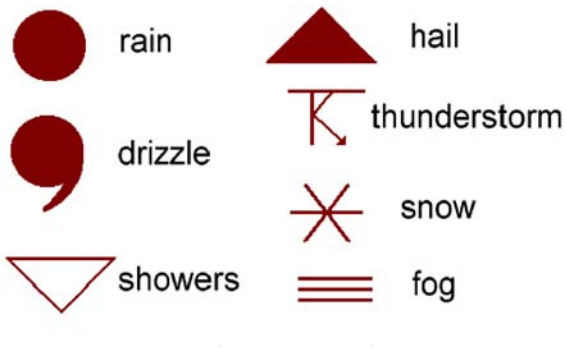
In this activity students will use the internet or printed copy to find two regions of the world to compare. Students choose the region and then record the information on the worksheet. They have to look at the reasons for different weather conditions. They may have to search the internet for more information on each of the areas to get a better idea of the reasons for the weather.

We recommend the following websites, but there are many other weather type sites on the web.

University of Michigan, world wide information
http://cirrus.sprl.umich.edu/wxnet/

National Weather Service, World Wide
http://weather.noaa.gov/weather/ccworld.html

National Weather Service, United States
http://weather.noaa.gov/weather/ccus.html




Weather symbols of precipitation

Weather is a very personal phenomenon. We want to know if it is rainy or sunny to help us decide what to wear. A farmer or fisherman needs to know if a storm will influence their decision to harvest or fish. Before a plane goes into the air, the pilot must check to see if the weather conditions could prevent his flight from continuing. Problems in communication, especially wireless transmission, can also be caused by weather patterns.

Do not confuse weather with the **climate**. Climates can be considered the average weather conditions over a long period of time. The climate is influenced by latitude, land and water distribution, altitude, land barrier, air movement, ocean currents, permanent storm areas, temperature, humidity, precipitation, cloud cover, high and low pressure centers, and other weather phenomena. Climate defines the seasons for each geographic region. For example, spring in the mid latitudes brings mild climate, but in the low latitudes spring brings little change in the weather.

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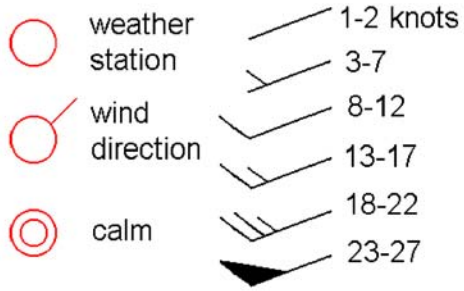
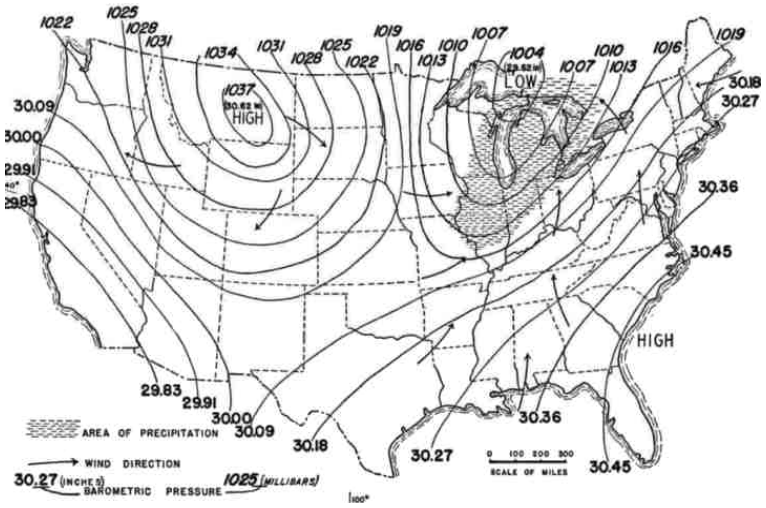
Learning how to chart weather conditions and interpreting them is important. In this exercise you are asked to look at several internet sites to interpret the weather. First, we need to define the different weather elements. The elements that make up the weather include the type of clouds in the sky, the temperature of the air, the amount of moisture or **humidity** in the air, and the speed and direction that the wind is blowing.




Wind speed and direction



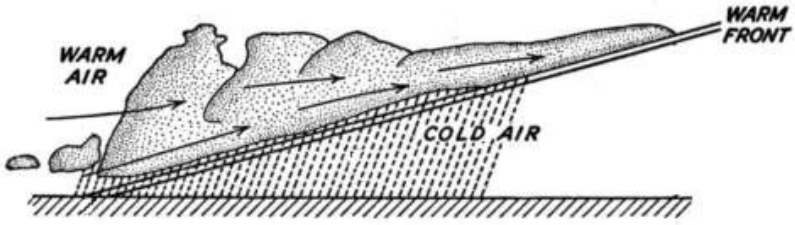

Weather map of pressure typical of winter

Symbols on weather charts help the meteorologist chart and predict the weather easily. If you make a chart of the pressure measured in millibars of mercury, you can get a sense of the direction of weather. Pressure is influenced by humidity and temperature.

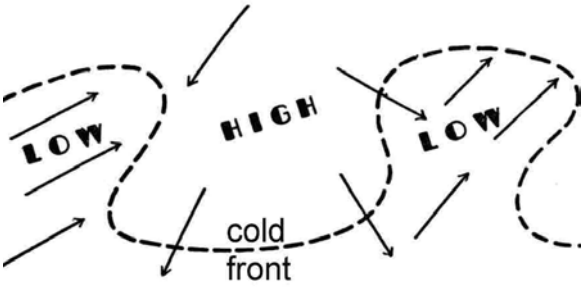
Charting pressure helps to predict where the weather pattern is going. Atmospheric pressure moves weather systems. Cold air is more dense than warm air causing what is called **high pressure**.

In the area of higher pressure the air molecules are closer together than in areas of lower pressure. Warm air, which is lighter, cause **low pressure**. Air that is warmed exerts less pressure on the ground creating a low pressure region. Cold air when it is over the oceans will actually depress the sea level in that area. Warm air will elevate the sea level.

Cold air is denser and heavier and pushes the warmer, lighter air upward. Depending on how the warmer air is pushed will depend upon how big the "fight" will be. Where these two air masses meet is called a "**front**." How these different fronts meet cause weather patterns to change. Remember there are many temperature variations of "cold" air and "warm" air, resulting in many weather types.



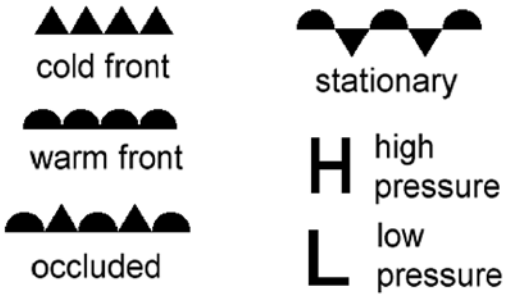

Warm front



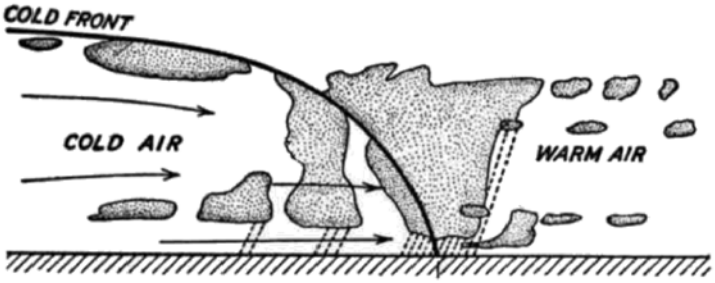

Moving from low to high pressure causes movement

Fronts form when air masses collide because air masses do not mix unless they are similar in temperature and moisture content. When warm air displaces cold air at the ground, the front is referred to as a warm front. When cold air replaces warm air at the ground the front is referred to as a **cold front**.

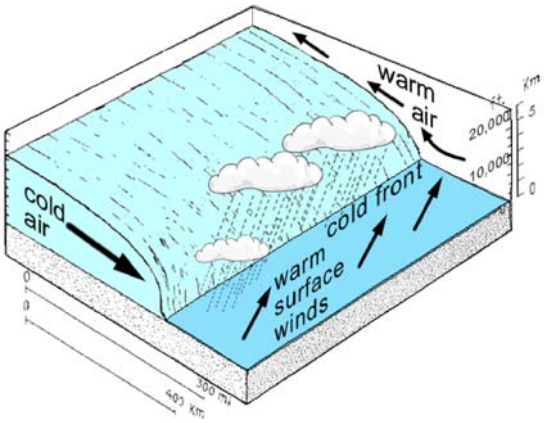
If the boundary between warm and cold air does not move, it is called a stationary front. When a cold front meets a warm front, and goes under it, the fronts are **occluding**.




Weather map symbols for fronts



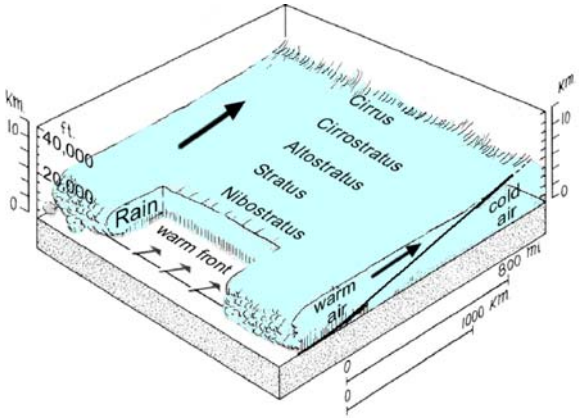

Cold front



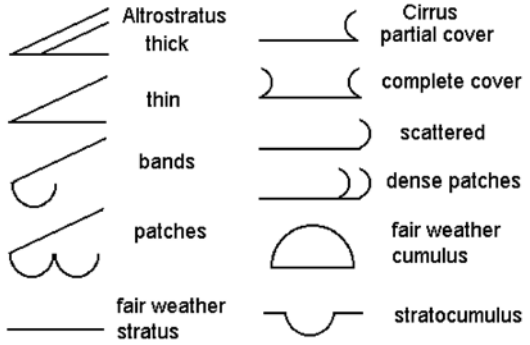
Cold front

Thickening **cumulus** clouds warn of the coming cold front. Cold polar air cuts in sharply beneath the warm, moist tropical air. The cold air mass goes under the warm air mass at a steep angle. Strong winds between the lower and upper air masses can cause violent storms. Huge cumulonimbus many build up all along the front, bring heavy rains and sometimes **thunderstorms** as it passes over.

A **warm front** is when warm, moist air from the tropics, slides over a wedge of cold polar air. As the warm air moves over the cold air, wispy cirrus clouds form and a milky veil of cirrostratus clouds can be seen. Above the base of the front, clouds thicken first with altostratus above great, gray nimbostratus clouds. A rain storm falls in the cold sector beneath the front.



Warm front

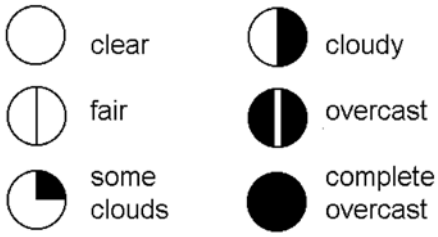


Types of clouds

The Earth is made up of both land and water. The interaction of land and water influences the weather dramatically. The weather is local, and to understand your weather you have to look at the local conditions to understand the different weather patterns that occur.

In this exercise you will look at the internet and compare two regions on the same day. You must choose two areas that are on the same latitude but one is near the water and the other is on land with little influence of the water.

Use the worksheet and fill in the appropriate answers. Then try to determine why the weather is different or the same, and what influences the weather in both these regions.



Cloud cover

**EARTH SCIENCES - WEATHER**

**PROBLEM:** How do regions on the same latitude compare with each other?
**HYPOTHESIS:**
**MATERIALS**: Internet

**PROCEDURE:**
Use the table below to find out information in the two regions you have chosen.

Describe region 1 (include longitude and latitude):

Describe region 2 (include longitude and latitude):

| | Region 1 | Region 2 |
|---|---|---|
| precipitation | | |
| temperature | | |
| pressure | | |
| cloud cover | | |
| types of clouds | | |
| wind direction | | |
| wind speed | | |

**CONCLUSION:** What is the difference between these two regions and can you determine why?

# EARTH SCIENCES - WEATHER

## **Lesson 4** - Causes of Precipitation

**MATERIALS:**

reader

**Objective:** Students compare different forms of precipitation.

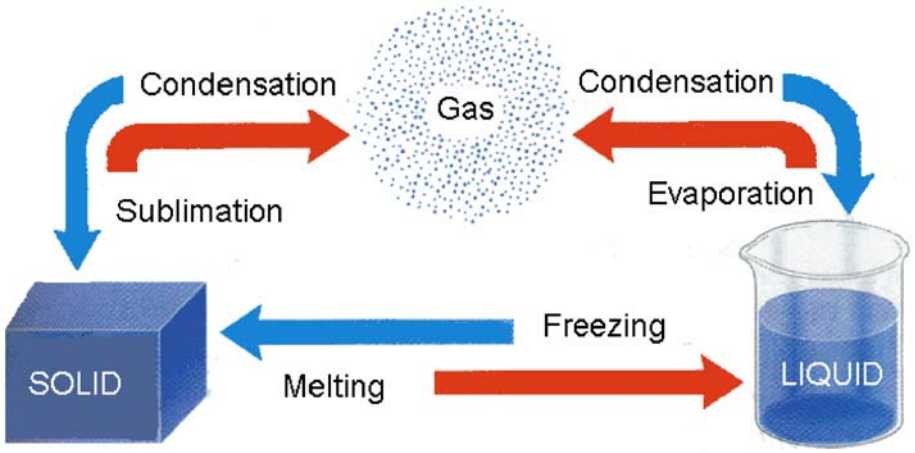
**Teacher note**

Most students are familiar with the different types of precipitation from their own experience. Rain is wet, snow is cool, and hail is ice. Most are unfamiliar with the causes of the different forms of precipitation.

Review with students the different types of clouds including cirrus, cumulus, and stratus. Nimbus clouds refer to dark clouds, so cumulonimbus are fluffy, dark clouds that usually mean rain is about to fall. "Alto" means high, so altocumulus mean high fluffy white clouds.

Discuss how precipitation is formed. Most students will read the material but will still understand the information especially how rain is formed. The notion that rain forms around a particle, gets heavy and falls is not quite the truth. Make sure they understand that there are two theories. The collision-coalescence process that is caused when large cloud droplets fall more rapidly than smaller droplets and the small drops stick to the drops until rain forms. The other process which is sometimes called the Bergeron process refers to ice crystals that grow at the expense of cloud droplets in cold area. They become larger and heavier and fall, before they reach surface of the Earth they turn back into rain.

This reader goes through the major forms of precipitation. There are some more specialized forms especially in different parts of the world, that are not discussed in this section.




The amount of moisture, wind speed, topography, and temperature are important for the immediate weather. Pressure, wind direction, and movement of air masses are important to predict the weather. Water in the atmosphere moves around and causes all kinds of weather. The physical properties of water allow this compound to move easily from one state of matter to another. Rain is the liquid form. Snow, sleet, and hail are the solid form. Water vapor is the gaseous form.

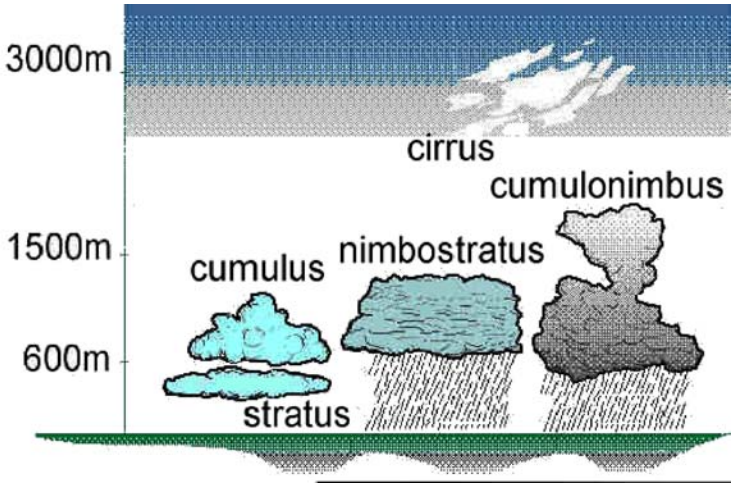
When a liquid is converted to gas, it is termed **evaporation**. **Condensation** is when vapor turns back to a liquid. Melting occurs when a solid is changed to a liquid, and freezing is the revere process. When a solid goes directly to a gas and vice versa, this is called **sublimation**. **Frost** is an example of sublimation in nature.

The frizzies

Humidity describes the amount of water vapor in the air. Warm air can hold more water vapor than cold water. Tropical areas are noted for their high relative humidity. On a humid day, people with naturally curly hair experience the "frizzies" caused by a stretching of the hair.

Clouds, **fog**, and **dew** are formed when condensation occurs. The air must be saturated with water vapor and tiny bits of particulate matter known as condensation nuclei must be present. These nuclei serve as surfaces for the condensation of water vapor.

In cloud formation the process is rapid and results in the formation of billions of tiny water droplet. They are so fine that they remain suspended in air. Difference in heat within clouds can cause convection which allows the small droplets to move within the cloud. This is when it gets interesting. The droplets can freeze as it gets colder and then in warmer areas, they melt. All these different conditions cause different types of weather.

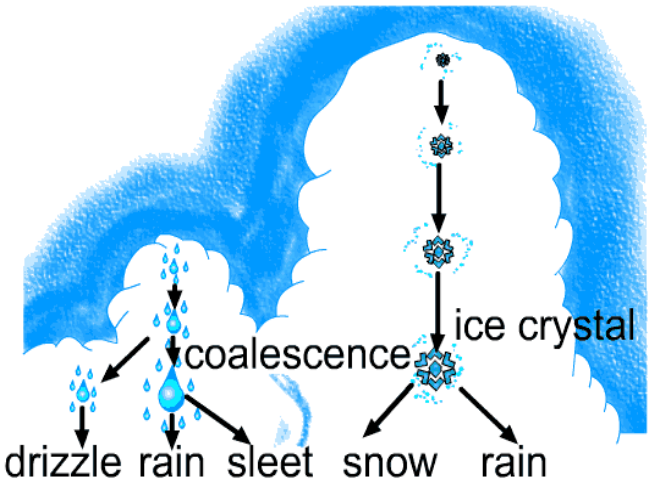



There are four major groupings of clouds based on their position. High-level clouds form above 20,000 feet (6,000 meters) and since the temperatures are so cold at such high elevations, these clouds are primarily composed of ice crystals. High-level clouds are typically thin, wispy, and white in appearance. Cloud types include **cirrus** and **cirrostratus**.

Mid level clouds typically appear between 6,500 to 20,000 feet (2,000 to 6,000 meters). Because of their lower altitudes, they are composed primarily of water droplets, however, they can also be composed of ice crystals when temperatures are cold enough. Cloud types include **altocumulus** and **altostratus**.

Low clouds are composed of water droplets since their bases generally lie below 6,500 feet (2,000 meters). However, when temperatures are cold enough, these clouds may also contain ice particles and snow. Cloud types include **nimbostratus** and **stratocumulus**.

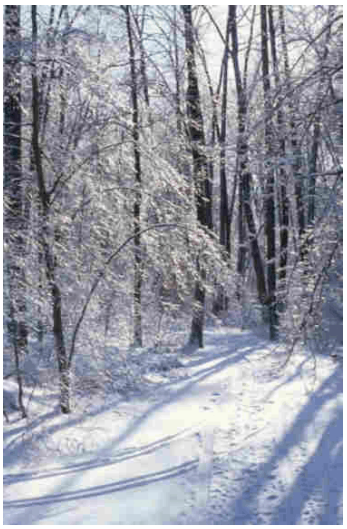
Vertically Developed Clouds are created commonly through either thermal convection or frontal lifting. These clouds can grow to heights in excess of 39,000 feet (12,000 meters). Cloud types include fair weather **cumulus** and **cumulonimbus**.

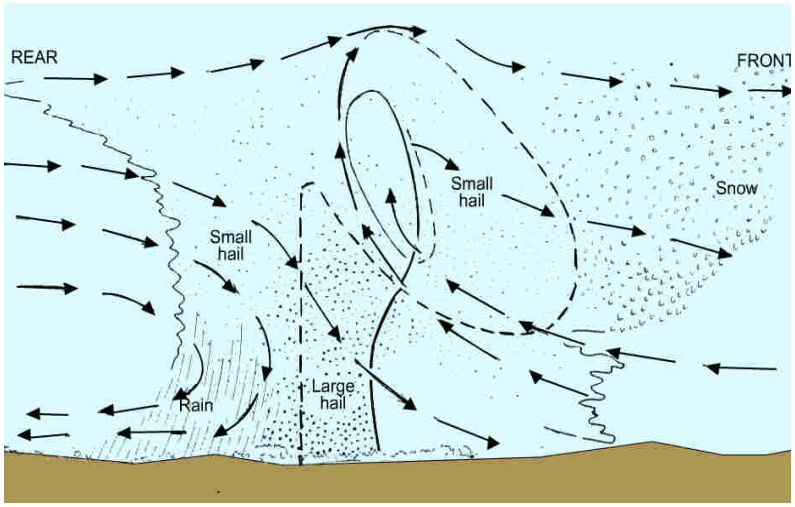


Precipitation models

Raindrops are formed when tiny droplets are enlarged, first by moisture from the surrounding air condensing on them and then by coalescing with other droplets during their descent. Raindrops vary in size from about 0.02 in. (0.5 mm) to as much as 0.33 in. (8 mm) in thunderstorms.

There are two main processes to form precipitation in clouds. **Coalescence** is a warm rain process, cloud droplets collide with each other and then coalesce (stick together) to form larger droplets. Eventually the droplets grow large enough that they become precipitation droplets. In the ice crystal process, ice particles exist in a cloud along with supercooled water and the ice crystals grow rapidly due to the differences between water and ice saturation vapor pressures.


Snow is a form of precipitation



Hail formation

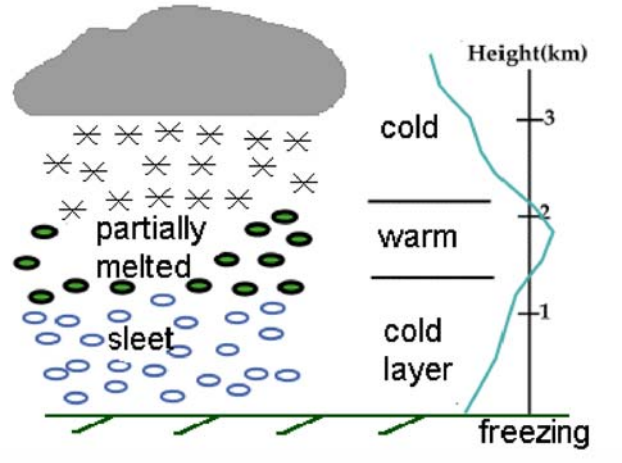
**Hail** is a large frozen raindrop produced by intense thunderstorms, where snow and rain can coexist in the central updraft. As the snowflakes fall, liquid water freezes, forming ice balls that will continue to grow as more and more droplets are accumulated. Upon reaching the bottom of the cloud, some of the ice balls are carried by the updraft back up to the top of the storm.

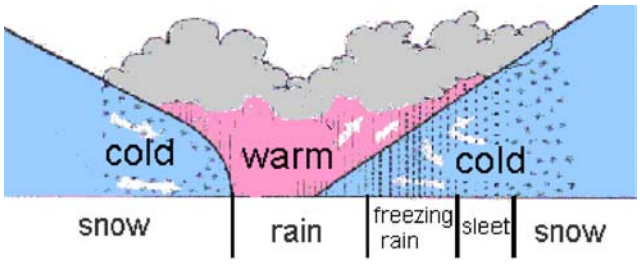
As the ice balls once again fall through the cloud, another layer of ice is added and the hail stone grows even larger. Typically the stronger the updraft, the more times a hail stone repeats this cycle and consequently, the larger it grows. Once the hail stone becomes too heavy to be supported by the updraft, it falls out of the cloud toward the surface. The hail stone reaches the ground as ice since it is not in the warm air below the thunderstorm.


Baseball size hail

Sleet is less prevalent than freezing rain and is defined as frozen raindrops that bounce on impact with the ground or other objects. The diagram shows a typical temperature profile for sleet indicating the atmosphere's temperature at any given altitude. The vertical line in the center of the diagram is the freezing line. Temperatures to the left of this line are below freezing, while temperatures to the right are above freezing.

Snowflakes are simply aggregates of ice crystals that collect to each other as they fall toward the surface.



# EARTH SCIENCES - WEATHER

## **Lesson 5** - Severe Weather

**MATERIALS:**

reader

**Objective:** Students compare different types of severe weather.

**Teacher note**

Humans and most other organisms survive well in areas where the weather is not extreme. We all require water, but we can tolerate a large range in temperature.

Humans are the best adapted to living in all weather and climates because we have the technological knowledge to create a liveable environment. No human without technology could survive in a desert or the polar caps. However, some organisms have evolved to live in extreme weather conditions.

What are these severe and extreme types of weather? A regular sunny day or rainy day is not extreme, but the thundering and lightning of a thunderstorm is. Snow or rain is within a normal range, but a blizzard or flash flood is not. Severe weather conditions include hurricanes, monsoons, and tornadoes.

This reader goes through wild forms of precipitation, wind, and temperature. There are many websites that can help make this unit very informative, as most young adults love disasters. There are also many hobbyist who are called "storm chasers." These people follow weather conditions that suggest an impending storm. They will travel to the storm center, especially tornadoes, to see nature at its extreme.

The following websites can help students learn more about the power of severe weather.

http://australiasevereweather.com
http://www.chaseday.com
http://www.strikingimages.com/buffs.htm
http://www.stormchaser.com
http://stormchasing.com
http://stormchase.com

There are many extreme and severe types of weather throughout the Earth. Some areas like the Arctic and Antarctic are extremely cold throughout the year, and others like the tropical rainforest in Brazil are hot and steamy.

A forming thunderstorm

Severe weather can occur just about everywhere. There are some areas where some types of severe weather are common. For example, most children in coastal California rarely see snow or lightning, while children in Florida are unfamiliar with hot, dry weather. People in the mid-west United States are familiar with **tornadoes**, while monsoons are a way of life for people of India.

There are many different forms of severe weather. We will look at thunderstorms, tornadoes, **hurricanes**, and **monsoons** in this section.

Lightning during a thunderstorm

Thunderstorms are generated by temperature imbalances in the atmosphere and a violent example of **convection**. Instability causes convective overturning of the layers of air, with heavier, denser layers sinking to the bottom and the lighter, warmer air rising rapidly.

Lightning is a build up of electrons concentrating and discharging static electricity during a thunderstorm. As the thunderstorm develops, interactions of charged particles produce an intense electrical field within the cloud. A large positive charge is usually concentrated in the frozen upper layers of the cloud, and a large negative change, along with a smaller positive area, is found in the lower portions.

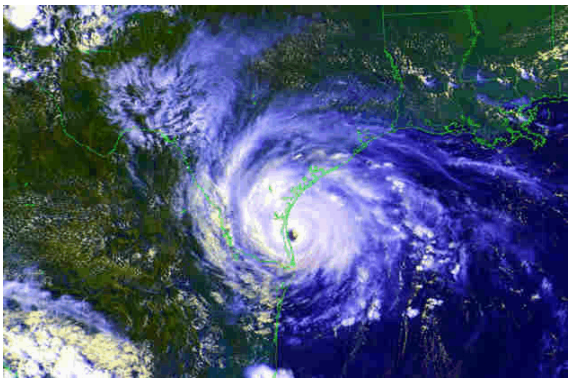
Thunder is the sound produced by explosive expansion of air super heated by a lightning stroke. When lightning is close by, the thunder sounds like a sharp crack. More distant strokes produce growling and rumbling noises. Because the speed of light is about a million times that of sound, a **lightning bolt** is seen before the sound of the thunder.

A severe thunderstorm may spawn a tornado, a violently rotating column of air which descends from a thunderstorm cloud system. The winds of a tornado are the most violent winds that occur on the Earth, reaching speeds of up to 300 mph. It extends down from a mass of dark clouds as a whirling funnel and moves over land in a narrow path. On the average, tornadoes move about 30 miles an hour, however, some move very slowly while other speed along at 60 miles an hour or more. Tornadoes generally rotate counterclockwise in the northern hemisphere, and clockwise in the southern hemisphere.

Tornadoes usually last less than an hour, traveling distances of about 20 miles. Tornadoes occur throughout the world, but mostly in the central United States in what is called “Tornado Alley” during the spring and summer.



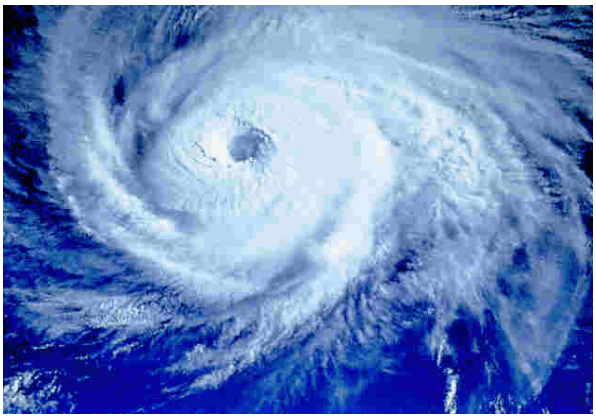

Hurricanes are a type of storm that forms over the tropical regions of the world’s oceans. By definition, a hurricane is a storm that has a wind speed greater than 118 kilometers per hour (74 miles per hour). The Sun beats down on the ocean waters day after day and the air above this water gets hot. Cold air moving in from many directions, pushes this hot air straight up until the hot air reaches a cool layer of air. The water vapor condenses very suddenly and becomes a driving rain. Cooler air from the outside moves in, in a whirling motion, like water going down a drain. The center or "eye" of the hurricane is calm, but all around it the winds and rain are swirling



Hurricane in the Atlantic

Approaching hurricane

The term hurricane is only used in North and Central America. It comes from the word *Huracan*, the Caribbean name for the god of evil. Hurricanes have different names in other part of the world. In Asia, they are called **typhoons**. In the Southern Hemisphere, they are called tropical **cyclones**.

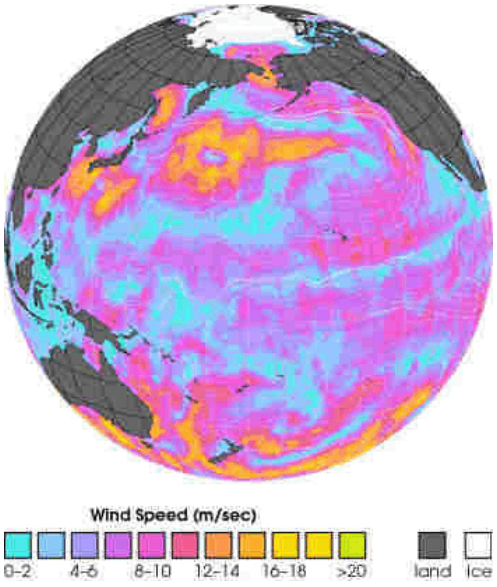


Typhoon in the Pacific

Hurricanes, typhoons, and tropical cyclones do not happen all the time. These storms all have "seasons," or times of year when conditions are right for storm formation. For example, the hurricane season in the Atlantic Ocean extends from May through October of each year.

Before the invention of weather satellites, meteorologists had no more than a few days warning before the arrival of a hurricane. They had to depend on changes in air pressure or ocean waves, or reports from ships to tell if a storm was coming. Today, however, meteorologists watch the breeding grounds of hurricanes closely through satellites. They monitor the growth of storms, and examine their direction of movement. This allows them to warn ships at sea, and give advance warning to coastal areas that the hurricane might hit. When hurricanes get close to North America, they are often visited by the "hurricane hunters." These are Air Force planes whose crews bravely fly through hurricanes to gather detailed information about their characteristics. The planes carry advanced radars, and also drop parachuted weather probes.

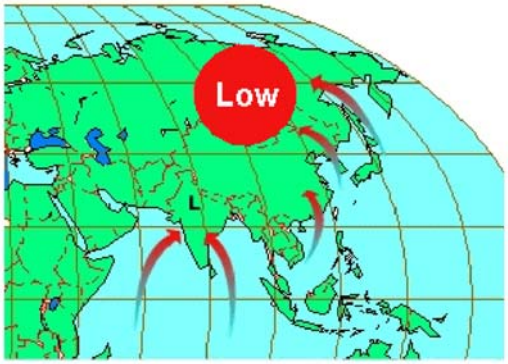
Regardless of what they are called, these storms have several features in common. They are large, up to 960 kilometers (600 miles) in diameter. They have strong winds, blowing at speeds up to 320 kilometers (200 miles) per hour. These winds blow in what is called a cyclonic circulation pattern. This means that the wind blows along a curved path that spirals inward toward the center of the storm. The pattern of winds defines the cloudy arms of a hurricane, which are easily visible on satellite photographs. The winds blow inward because the center of the hurricane is a zone of low pressure called the eye. In contrast to the raging winds and heavy rain around it, the eye is an area of clear skies and fairly calm winds.




Typhoon in the North Pacific

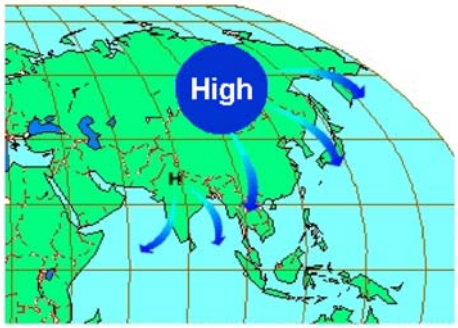
Hurricanes are dangerous for several reasons in coastal areas. The high storm winds pile up a mound of water in front of the hurricane, called the **storm surge**. This mound may be tens of miles in width, and thirty or forty feet in height. When the hurricane reaches a coastline, the storm surge is pushed on the land. This can cause massive flooding of low lying areas. Storm surges are made worse by the high winds of a hurricane, which create large ocean waves, further increasing flooding.

Meteorologists divide hurricanes into five types, based on their wind speed, air pressure, and storm surge. Category 1 hurricanes are the weakest, while Category 5 hurricanes are the worst. Similar scales are used in Asia and Australia to classify typhoons and tropical cyclones.




Monsoon circulation occurs in the Indian Ocean and southern Asia area. This area is different from the Atlantic and Pacific because the northern hemisphere is land and the southern hemisphere is ocean. This creates a heating difference that creates severe weather patterns. Monsoons cause flooding of key agricultural land in the southern Asian countries. It causes thousands of deaths every year because of the fury of monsoons.

Air pressure is one of the primary factors for monsoons. In the summer, a high pressure area lies over the Indian Ocean while a low exists over the Asian continent. The air masses move from the high pressure over the ocean to the low over the continent, bringing moisture-laden air to south Asia.




During winter, the process is reversed and a low sits over the Indian Ocean while a high pressure area lies over the Tibetan plateau so air flows down the Himalaya and south to the ocean. The migration of trade winds and **westerlies** also contributes to the monsoons.

**Flooding** is also caused by the heavy rains that accompany hurricanes and monsoons as it reaches land. Flooding and storm surges combine to make drowning the leading cause of death. Winds are also dangerous in these storms. Flying debris often kills or injures people, or damages buildings.

Not all floods are associated with hurricanes. Just too much water in an area that drains slowly could cause this problem. Floods are a natural and inevitable part of life along the rivers of our country. Some floods occur seasonally. Winter or spring rains, coupled with melting snows or **torrential rains** associated with tropical storms, can fill river basins with too much water quickly and cause flooding. Other floods are sudden, resulting from heavy localized rainfall. These **flash floods** are raging torrents which rip through river beds, urban streets, coastal sections and mountain canyons after heavy rains, and sweep everything before them.

Flooding causes damages in urban areas

**Earth Science- Weather - Unit Test**

Part 1. Definitions Match the number of the term or concept in Column 1 with the letter of the correct definition in Column 2.

| Column 1 | Column 2 |
|---|---|
| 1. monsoon | a. measure of moisture in the air |
| 2. ice crystal process | b. solid state of matter to gaseous state of matter |
| 3. cirrus clouds | c. layered balls of ice |
| 4. humidity | d. whirlwind that mainly occurs in the United States |
| 5. sublimation | e. process of rain formation |
| 6. hail | f. static electricity discharged from clouds |
| 7. tornado | g. large, white clouds |
| 8. front | h. wispy, thin, veil-like, and high |
| 9. lightning | i. high winds and flooding, occurring in Indian Ocean |
| 10. cumulus | j. two air masses that meet |

**Part 2.** Multiple Choice Choose the best answer to complete each statement.

1. Weather is not influenced by
    a. air movement
    b. rotation of ocean currents
    c. type of organisms
    d. high and low pressure centers

2. Wind moves away from
    a. a high pressure area
    b. a low pressure
    c. other clouds
    d. A cold area

3 Weather folk lore
    a. is never true
    b. is always right
    c. are based on experience
    d. are silly stories

4. Which of the following severe storms do not have high winds
    a. hurricane
    b. typhoon
    c. monsoons
    d. thunderstorms

5. Which of the following measures air pressure
    a. Thermometer
    b. Barometer
    c. Weather balloon
    d. Anemometer

6. El Nino is traditionally
    a. a warming in the equatorial Pacific Ocean
    b. a cooling in the equatorial Pacific Ocean
    c. a warming in the Atlantic Ocean
    d. a cooling in the south Pacific

7. Rain can be formed by
    a. nuclei formation
    b. heat
    c. ice crystal process
    d. centripetal force

8. Storm surges are caused by
    a. tides
    b. hurricanes
    c. tornadoes
    d. rain

9. A cold front
    a. warm air displaces cold air
    b. cold air goes under a warm front
    c. cold air replaces warm air
    d. warm air displaces hot air

10. A weather map usually do not record
    a. temperature
    b. precipitation
    c. wind direction
    d. type of clouds

**ANSWERS:**

**Part 1.**

1. I
2. E
3. H
4. A
5. B
6. C
7. D
8. J
9. F
10. G

**Part 2.**

1. C
2. A
3. C
4. D
5. B
6. A
7. C
8. B
9. C
10. D