WEATHER UNIT STUDY GUIDE

This belongs to:

_____

Block: _____

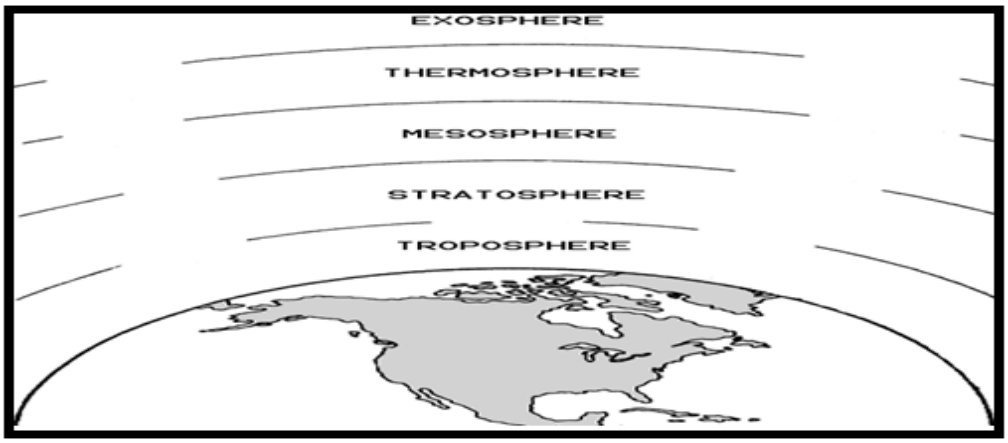
CONCEPTUAL UNDERSTANDING 6.E.2A.

Earth's atmosphere, an envelope of gases that surround the planet, makes conditions on Earth suitable for living things and influences weather. Water is always moving between the atmosphere (troposphere) and the surface of Earth as a result of the force of gravity and energy from the Sun. The Sun is the driving energy source for heating Earth and for the circulation of Earth's atmosphere.

PERFORMANCE INDICATOR 6.E.2A.1

Develop and use models to exemplify the properties of the atmosphere (including gases, temperature and pressure differences, and altitude changes) and the relative scale in relation to the size of Earth.

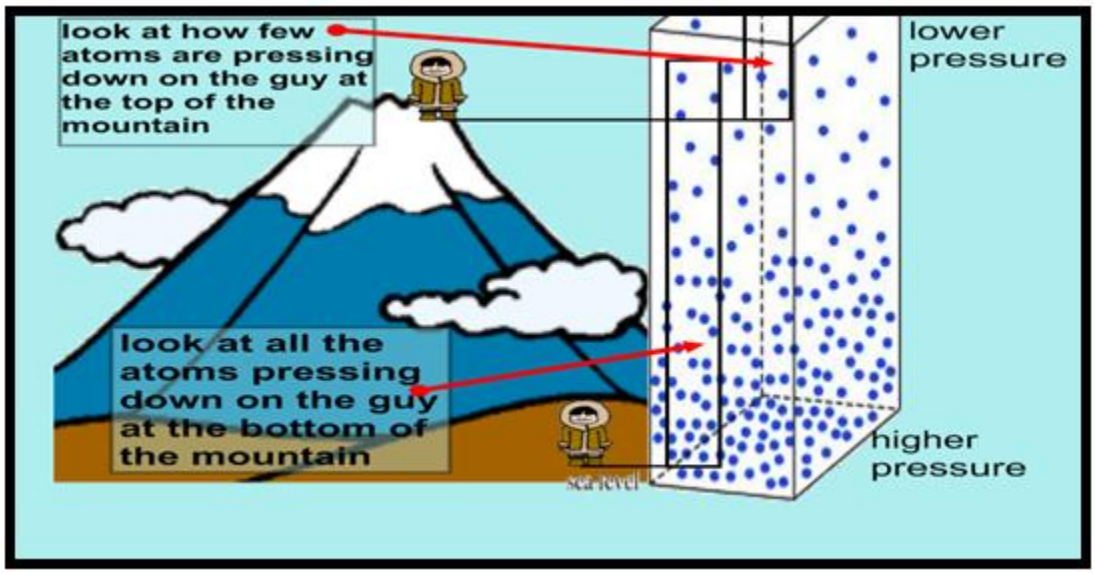
The Earth's atmosphere is divided into several atmospheric layers extending from the Earth's surface outward. The air pressure, the force exerted by the gases pushing on an object, is greatest near the surface of Earth, in the troposphere. As altitude increases, the gravitational pull decreases which results in a decrease in air pressure. The two most abundant (common) gases in all the layers of the atmosphere are nitrogen and oxygen. However, trace gases (such as argon) play an insignificant role in the layers. The atmosphere is dived into layers based on whether the temperature in the layer increases or decreases.



Atmospheric Layers	**Atmospheric Gases** (Note: Nitrogen and oxygen are two of the most common gases found throughout <u>all layers</u> of atmosphere. Trace gases (very small amounts), for example argon – these play an insignificant role.	**Atmospheric Temperatures** Differences in temperatures separate the layers:
Troposphere – where all weather occurs. Clouds are in this layer. This layer is located closest to Earth's surface (6-20 km high)	Water vapor and carbon dioxide – important gases for weather conditions; found in the Troposphere	As altitude increases, temperature decreases in the Troposphere
Stratosphere – where the ozone layer is contained (20 – 50 km)	Ozone – a form of oxygen found in the stratosphere	Stratosphere is cold except in its upper region where ozone is located
Mesosphere (50 – 85 km)		Mesosphere is the coldest layer
Thermosphere (86 – 690 km)	The air is very thin in this layer.	Even though the air is thin in the Thermosphere, it is the warmest of all of the layers
Exosphere This layer is the furthest away from Earth's surface.(691 – 10,000 km)		The cold regions of outer space extend from the Exosphere

ATMOSPHERIC PRESSURE
Air Pressure:

The air pressure, the force exerted by the gases pushing on an object, is greatest near the surface of Earth, in the Troposphere. Air pressure decreases through the layers farther out from the surface, as Earth's pull of gravity decreases.

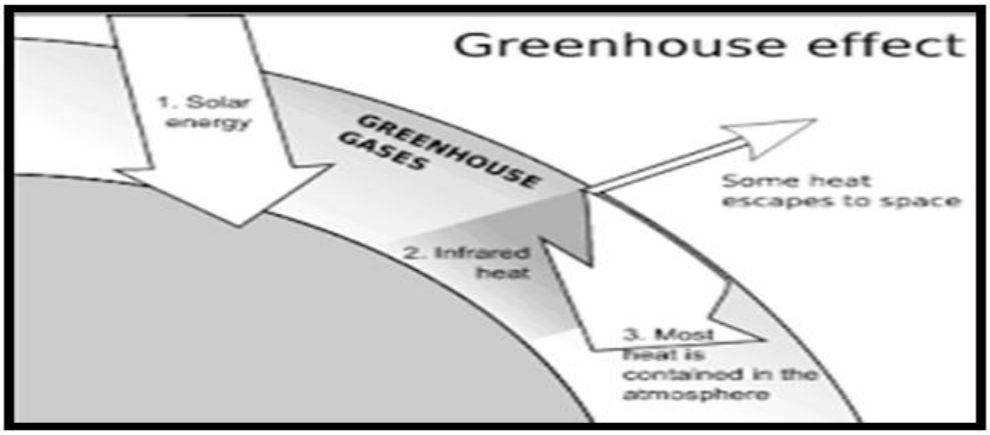


Take a look at this great web site for an easy-to-understand meaning of what air pressure is all about: http://kids.earth.nasa.gov/archive/air_pressure/

PERFORMANCE INDICATOR 6E.2A.2
Critically analyze scientific arguments based on evidence for and against how different phenomena (natural and human induced) may contribute to the composition of Earth's atmosphere.

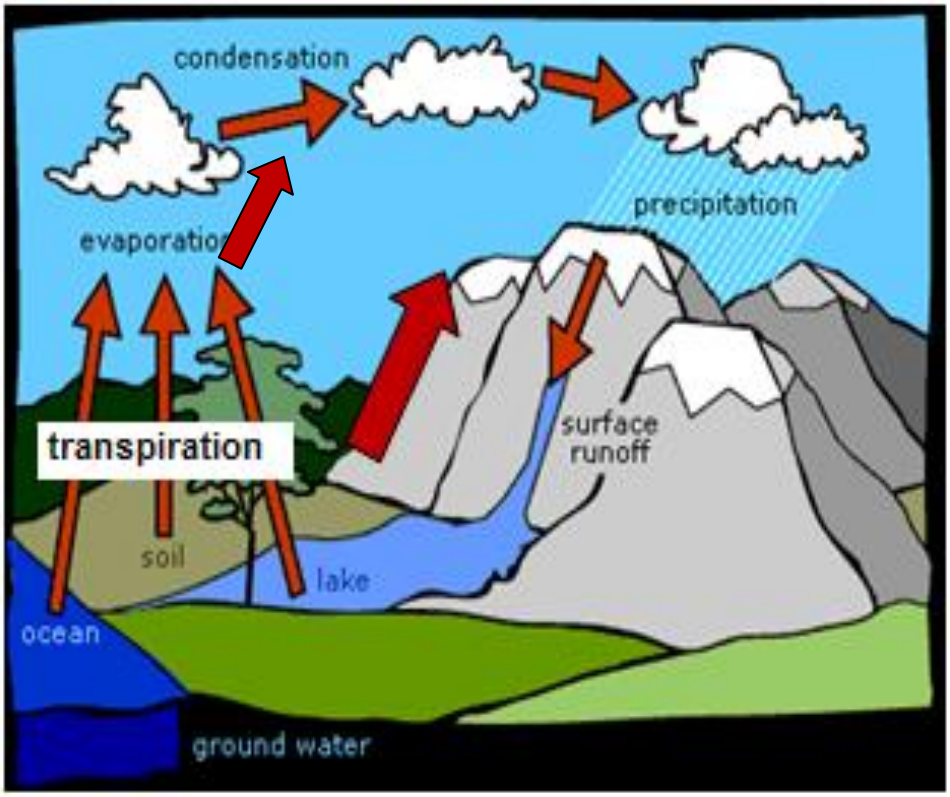
Greenhouse gases in the atmosphere absorb and retain the energy radiated from land and ocean surfaces, thereby regulating Earth's average surface temperature and keeping it habitable. Solar energy that is absorbed by Earth's land and water surfaces is changed to heat that moves/radiates back into the atmosphere (troposphere) where the heat cannot be transmitted through the atmosphere, so it is trapped. This process is known as the greenhouse effect. This can be enhanced by an increase in the gases that trap heat in the atmosphere. Additionally, the composition of Earth's atmosphere has changed over Earth's history, particularly the amount of ozone in the stratosphere. The following evidence can be found to support and refute this phenomenon:

1. Volcanic eruptions affect the atmosphere by releasing ashes, which contain harmful chemicals and large amounts of carbon dioxide (a greenhouse gas).
2. Human activities, such as the release of greenhouse gases from burning fossil fuels and the use of aerosol sprays also contribute to the change in Earth's atmospheric composition.



PERFORMANCE INDICATOR 6.E.2A.3

Construct explanations of the processes involved in the cycling of water through Earth's systems (including transpiration, evaporation, condensation and crystallization, precipitation, and downhill flow of water on land).



Adding or subtracting heat makes the cycle work. If heat is added to ice, it melts. If heat is added to water, it evaporates. Evaporation turns liquid water into a gas called water vapor. As the vapor rises, it cools. As the heat is taken away from water vapor, it condenses to form a cloud. Condensation turns water vapor into a liquid. If heat continues to be taken away, it forms ice crystals (crystallization). **Water continually cycles between the atmosphere (troposphere), land, and ocean via the water cycle. The following processes are propelled by sunlight and gravity:**

Precipitation: After condensation occurs (forming clouds), water droplets fall in various forms of precipitation (rain, snow, freezing rain, sleet, or hail) depending upon weather conditions. Temperature variations/changes within clouds and/or with the region between the cloud and Earth allows for the various forms of precipitation. Gravity is the driving force of precipitation.

Evaporation/Transpiration: Water enters the atmosphere as water vapor through evaporation and transpiration (plants releasing water vapor). Thermal energy from the sun causes water to evaporate and/or transpire.

Condensation/Crystallization: Condensation happens in the atmosphere as water vapor rises in the atmosphere and changes to either water droplets or ice crystals. Clouds form as a result of condensation. In the atmosphere, dust particles (or any other particulates) serve as a surface for water to condense on.

These processes can form on Earth's surface in the following forms:

Dew forms when water vapor condenses directly onto a surface. **Frost** forms when water vapor changes from gas directly to ice crystals on a surface when the temperature at which condensing would take place is at the freezing point or below.

Run-off: If precipitation falls on land surfaces, it **always attempts to move back toward sea level** as *surface-water flow* or *groundwater flow*. The surface that receives the precipitation determines its flow back towards sea level. Examples are: 1) Water will remain on the surface when the surface is not **porous** or the precipitation is falling too fast for the water to sink into the ground. 2) Water will sink into the ground when the surface is **porous,** and there is a lot of space in the soil to hold the water.

Gravity is the driving force for downhill flow of water on land.

CONCEPTUAL UNDERSTANDING 6.E.2B.

The complex patterns of changes and movement of water in the atmosphere determined by winds, landforms, ocean temperatures and currents, and convection are major determinants of local weather patterns and climate. Technology has enhanced our ability to measure and predict weather patterns.

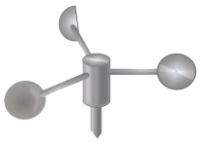
PERFORMANCE INDICATOR 6.E.2B.1

Analyze and interpret date from weather conditions (including wind speed and direction, air temperature, humidity, cloud types, and air pressure), weather maps, satellites, and radar to predict local weather patterns and conditions.

A **meteorologist** can predict the weather by analyzing and interpreting data from observations and tools, such as current weather conditions, weather maps, satellites, and radar images.

What is "weather?"

Weather occurs in the layer of the atmosphere called the "troposphere." It changes day-to-day and moment-to-moment. Weather includes: temperature, air pressure, precipitation, wind speed and direction, and humidity.

Weather conditions are measured using the following instruments	
	**Temperature** is measured in either °C or °F with a **thermometer**. Changes in the air masses result in changes in the temperature.
	**Air pressure** is measured in either inches of mercury or millibars (mb) with a **barometer**. A rise in air pressure indicates fair weather, while a fall in pressure indicates stormy weather conditions advancing. **H**igh pressure brings **h**appy weather (clear weather). **L**ow pressure brings **l**ousy weather (stormy weather.)
	**Precipitation** is measured in either centimeters or inches with a **rain gauge**. Precipitation is the form which water falls from clouds, depending upon air temperature: rain, snow, sleet, freezing rain, hail.
	**Wind direction** is measured with a **wind vane** (also called a **weather vane**). Wind direction is described by the direction <u>from</u> which the wind is blowing. Wind direction indicates the direction of advancing air masses.
	**Wind speed** is measured in miles per hour with an **anemometer**. Wind speed indicates a change in atmospheric flow patterns.
	A **sling psychrometer** or a **hygrometer** is used to measure relative **humidity** (also called a wet-dry bulb). Humidity is the measure of the percentage of water vapor in the air. Increased levels of humidity can be associated with a high probability of precipitation.

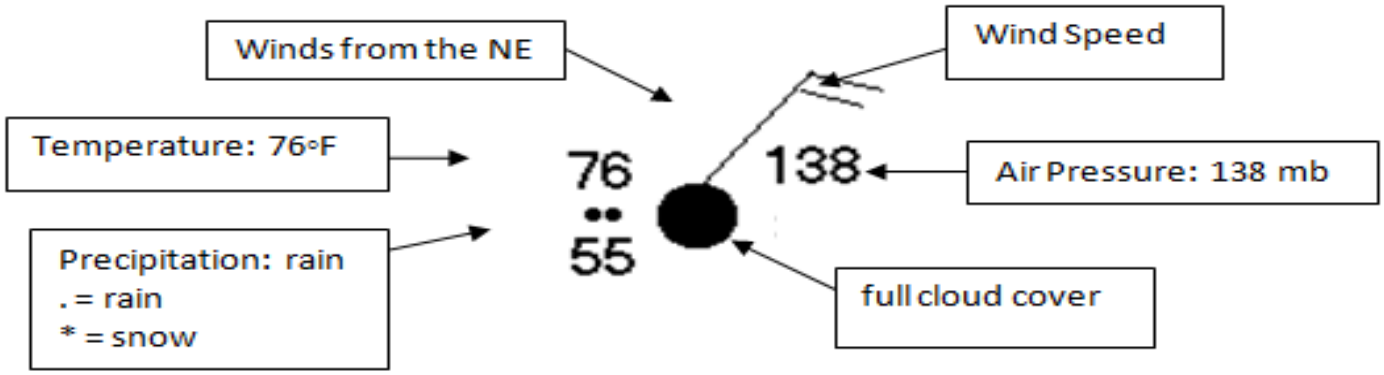
CLOUDS: Clouds form from condensation of water vapor and are classified by a basic shape and associated weather conditions and patterns. Clouds can be classified into three major groups:

Clouds can be classified into three major groups	
	Cumulus • formed at medium or low elevation • puffy with flat bottoms • white cumulus signal fair weather • darker cumulus signal rain or thunderstorms; these are called cumulonimbus clouds (thunderheads).
	Stratus • formed at medium or low elevation • spread out layer upon layer covering a large area • as they thicken, long periods of precipitation can occur over the area where the clouds are located
	Cirrus • formed at high elevations • wispy clouds usually consisting of ice crystals • fair weather or approaching warm front
	Cumulonimbus • also called "thunderhead" • part of thunderstorm conditions that may accompany a cold front

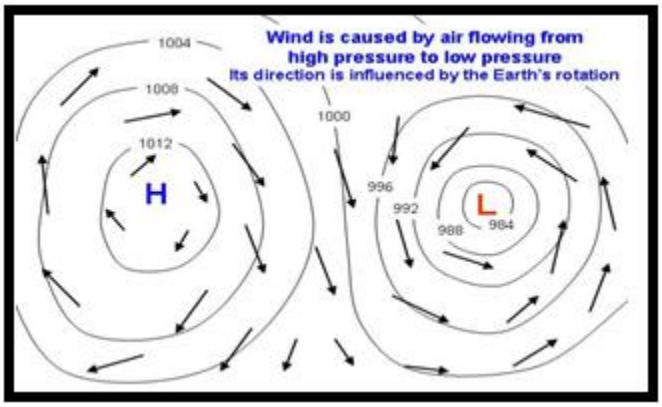
EXTENDED KNOWLEDGE: The names of many clouds are a combination of one of the three basic shapes and a prefix or a suffix. The basic shape name can be combined with the prefix or suffix listed below as clues to the weather conditions that may result. Combinations of those shapes can be used with **nimbus**, which means "rain." For example, **cumulonimbus** or **nimbostratus**. The prefix **alto** may also be used to indicate medium-level clouds formed at about 2-6 kilometers up into the atmosphere. For example, **altocumulus** or **altostratus**.

	**Fog** • Stratus clouds forming when condensation occurs at or near the ground

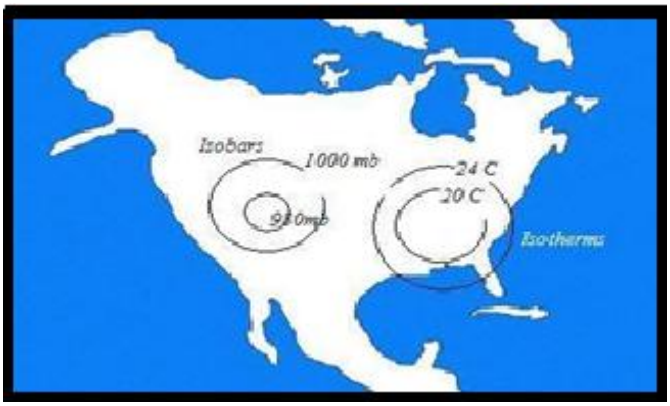
EXTENDED KNOWLEDGE: **Station Models** from specific locations provide information that can also be used to predict weather patterns. Information found on a station model can include cloud cover, temperature, wind direction and speed, precipitation, or barometric pressure. The station model below shows the following information:



WEATHER MAPS: Weather maps can help predict weather patterns by indicating high or low pressure systems (isobars), movement of air masses and fronts, or temperature ranges (isotherms).

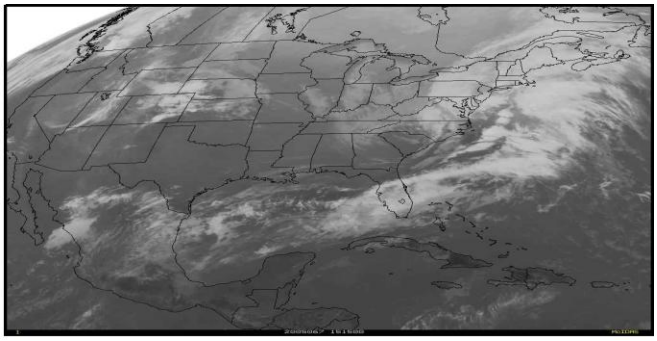


The numbers found inside the rings of high and low pressure systems are called "isobars." They show the barometric pressure (also known as air pressure.)



Numbers inside rings that are shown in degrees Fahrenheit or Celsius are called "isotherms." They indicate the temperature, as measured on a thermometer.

SATELLITES: Satellite images are used for seeing cloud patterns and movements. For example, hurricane clouds and movement can be observed using satellite images.



RADAR: Radar images can be used to detect cloud cover, rainfall, storm location or intensity, and cloud movement, as well as the potential for severe weather (for example, hurricanes or tornadoes).

PERFORMANCE INDICATOR 6.E.2B.2

Develop and use models to explain how relationships between the movement and interactions of air masses, high and low pressure systems, and frontal boundaries result in weather conditions and storms (including thunderstorms, hurricanes, and tornadoes).

The interactions between **air masses**, **fronts**, and **pressure systems** result in various weather conditions.

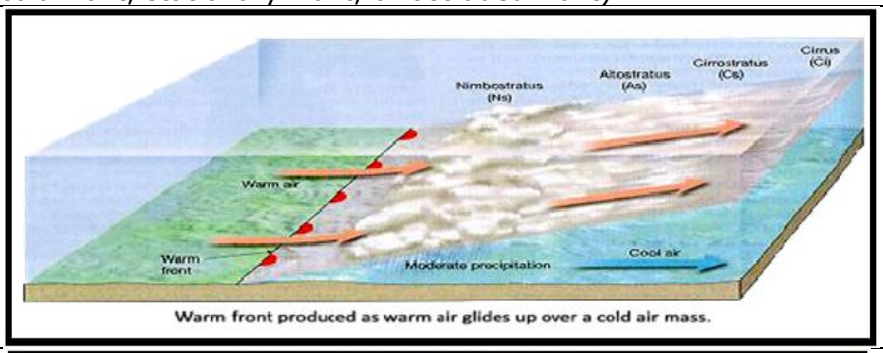
AIR MASS: HUGE bodies of air that form over water or land. They will either form in tropical (warm) regions or polar (cold) regions.

HOW CAN WEATHER BE PREDICTED FROM AN AIR MASS?

Temperature and humidity conditions (for example, warm or cold air, humid or dry air) inside the air masses as they form are important to the weather condition that will happen when the air masses move.

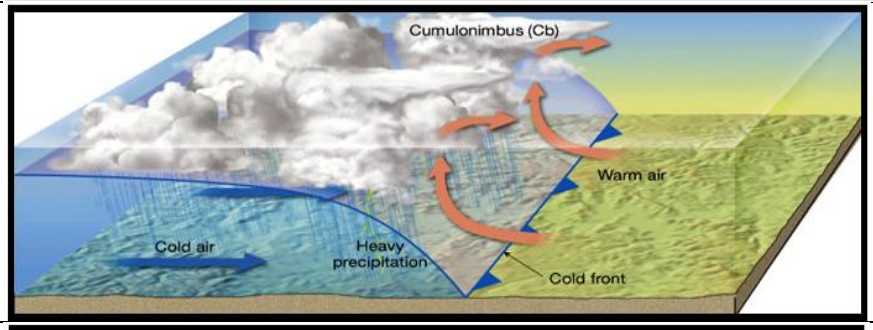
FOUR TYPES OF FRONTS

FRONTS: Fronts are what form at the boundaries (between) air masses when they collide together. Depending upon the temperature of the air masses involved, different types of fronts will happen (warm front, cold front, stationary front, or occluded front).

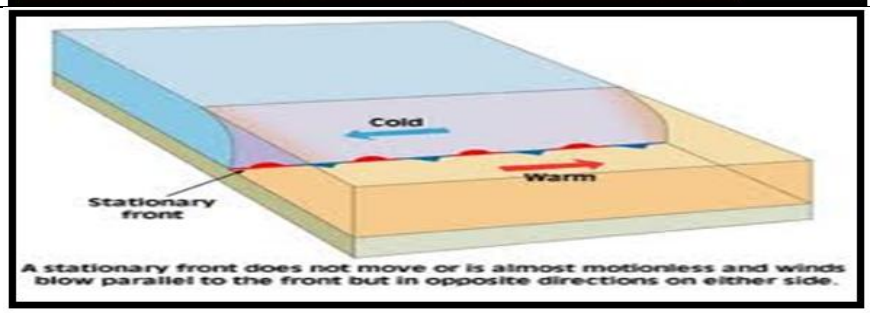


Warm front produced as warm air glides up over a cold air mass.

1. **Warm Front**: This is when a **warm** air mass collides and rides OVER a cold air mass. It may produce long period of precipitation and **warm**er temperatures.

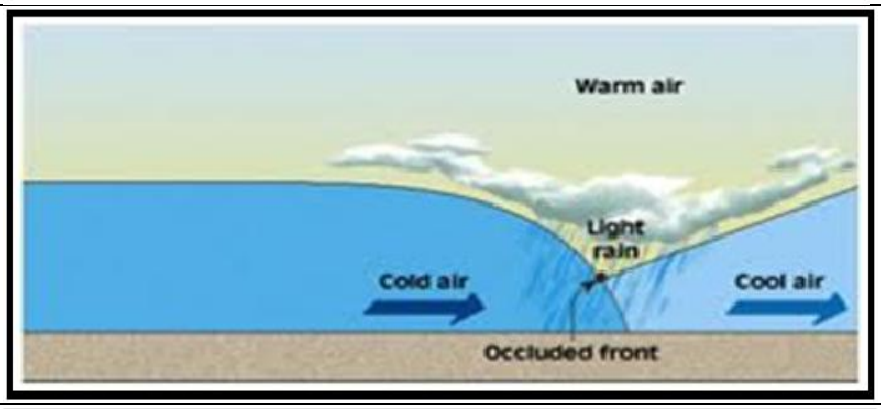


2. **Cold Front**: This happens when a **COLD** air mass collides and slides UNDER a warm air mass. It may produce <u>thunderstorms</u> and sometimes <u>tornadoes</u> and **cool**er temperatures.



A stationary front does not move or is almost motionless and winds blow parallel to the front but in opposite directions on either side.

3. **Stationary Front:** This happens when **NEITHER** a warm nor a cold mass moves at a frontal boundary. It may produce long periods of precipitation.



4. O**cc**luded Front: This happens when a **COLD** air mass pushes INTO a WARM air mass that is BEHIND a **COOL** air mass. The warm air is pushed up above the cooler air masses. It may produce long periods of precipitation.
Note: This front involves <u>two</u> cold air masses.

Table A

Symbols for Surface Fronts and Other Significant Lines Shown on the Surface Analysis Chart

- Warm Front (red)*
- Cold Front (blue)*
- Stationary Front (red/blue)*
- Occluded Front (purple)*

* Note : Fronts may be black and white or color, depending on their source. Also, fronts shown in color code will not necessarily show frontal symbols.

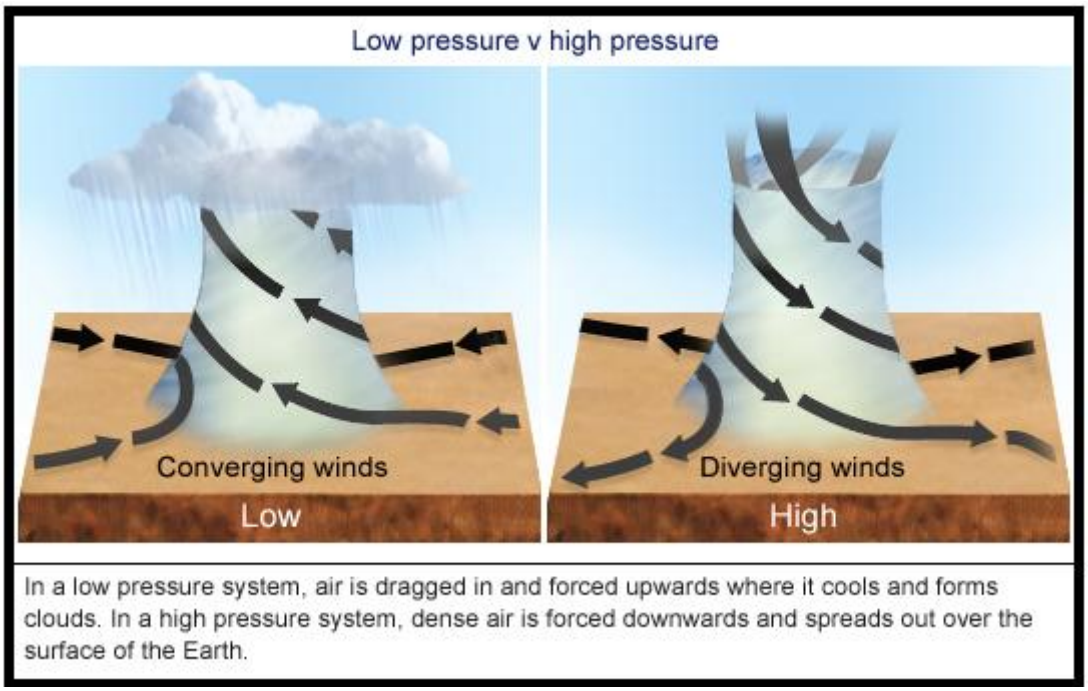
SYMBOLS
(Extended knowledge)

HIGH/LOW PRESSURE SYSTEMS

How do high and low pressure systems form? When warm air rises, or cold air sinks, and it combines with the spinning of Earth, it causes the air to spin. This spinning air forms high and low pressure regions/systems.

High Pressure Systems: These usually signal more fair weather. Their winds circulate around the system in a clockwise direction.

Low Pressure Systems: These usually result in rainy and/or stormy weather conditions. Their winds circulate around the system in a counterclockwise direction.



In a low pressure system, air is dragged in and forced upwards where it cools and forms clouds. In a high pressure system, dense air is forced downwards and spreads out over the surface of the Earth.

STORMS are severe weather conditions. They occur when pressure differences cause rapid air movement. Conditions that bring one kind of storm can also cause other kinds of storms in the same area.

- **Thunderstorms** are storms with thunder, lightning, heavy rains and strong winds. They form within large **cumulonimbus** clouds. They usually form along a **cold front** but can form within an **air mass.**
- **Tornadoes** are rapidly whirling, funnel-shaped clouds that extend down from a storm cloud. The very **low pressure** and strong winds can cause great damage to people and property. They are likely to form within the frontal regions where strong thunderstorms are also present.
- **Hurricanes** are low pressure tropical storms that form over warm ocean water. Winds form a spinning circular pattern around the center (or eye) of the storm. The lower the air pressure at the center, the faster the winds blow toward the center of the storm.

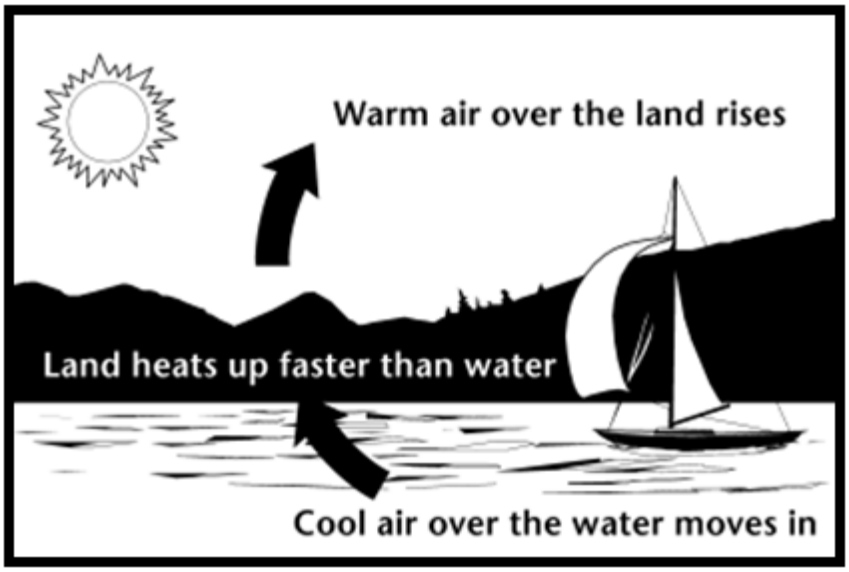
OTHER WEATHER CONDITIONS: Since weather is a condition of Earth's atmosphere at any time, weather conditions may include fair weather, showers or light rain, humid conditions, clear skies with cold conditions, days of clouds and precipitation, or others that do not necessarily involve storms.

PERFORMANCE INDICATOR 6.E.2B.3.:
Develop and use models to represent how solar energy and convection impact Earth's weather patterns and climate conditions (including global winds, the jet stream, and ocean currents).

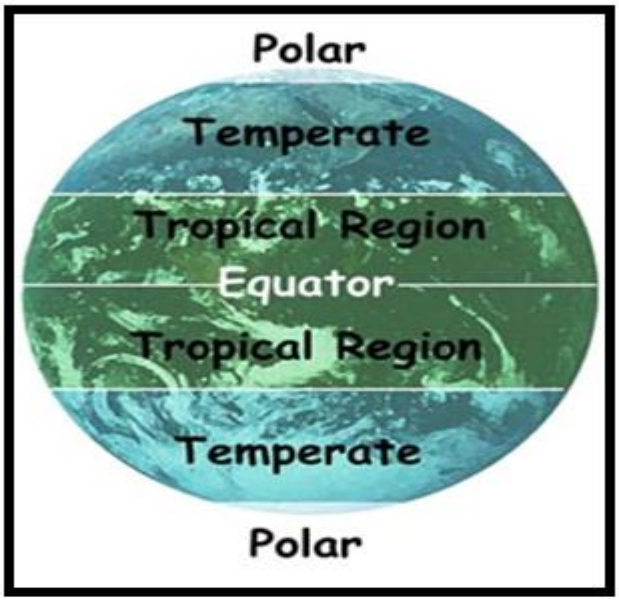
The driving energy source for heating of Earth is solar energy. The rotation of Earth on its axis along with differences in the heating of the Earth impact weather patterns and climate conditions. **(Extended Knowledge:** Because convection cells are in the atmosphere and Earth is spinning on its axis, these global winds appear to curve. This is known as the **Coriolis Effect**.)

Solar Energy Affects Earth's Atmosphere and Surface (land and water)

- The land absorbs heat energy and releases its heat fairly quickly, but water needs to absorb lots of solar energy to warm up. Water warms more slowly but also releases heat energy more slowly. The differences in these heating patterns cause convection currents. **It is the water on Earth that helps to regulate the temperature range of Earth's atmosphere.**



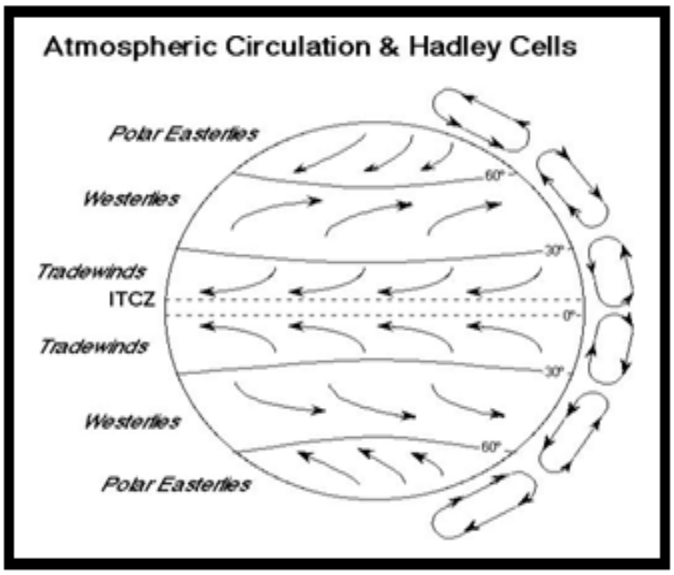
- Global convection currents are set up in the atmosphere because of the unequal heating of Earth's surfaces. There are three atmospheric convection areas that influence the climate regions on Earth.



- **Tropical region** begins at the equator and extends to about 30 degrees north latitude
- **Temperate region** extends from there to about 60 degrees north latitude
- **Polar Region** extends from there to the north pole, 90 degrees north latitude

- Global winds are winds that travel around the globe. Global winds occur in each of the climate regions and effect the direction of weather systems on Earth.

Different types of global winds are described below:



- Trade Winds

Trade winds are found near the equator in the tropical region. They blow east to west and carry warm winds. Tropical weather systems, such a hurricanes, move with the trade winds.

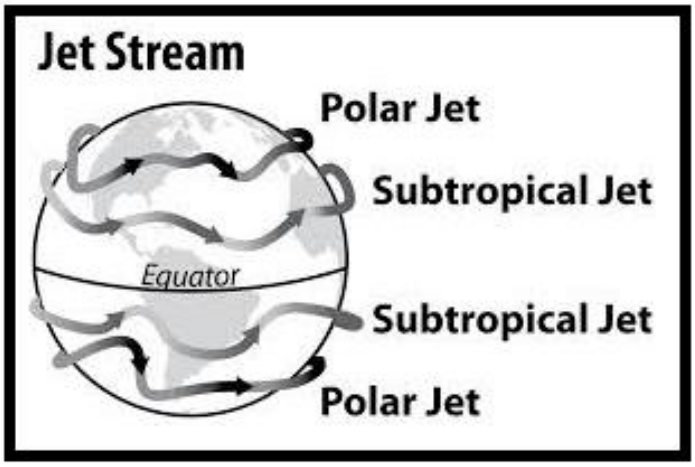
- Westerly Winds

The westerlies blow from west to east in the temperate region. Since the United States is in the westerly wind belt, weather systems move across the country from west to east. These also effect the direction of tropical weather systems (hurricanes).

- Polar Winds (**extended knowledge**)

These winds blow northeast to west in the polar regions moving cold polar air in that climate zone from the poles toward the west.

- Jet Stream



  - The jet streams are fast-moving ribbons of air that moves from west to east in the Northern Hemisphere around the Earth.
  - As these changes occur, air masses and weather systems in its path are moved along by the fast moving air.
  - It dips and bends constantly changes positions.
  - The polar jet stream brings down cold polar conditions from the north; the subtropical jet stream moves warm air.

- Ocean surface currents circulate warm and cold ocean waters in convection patterns and influence the weather and climates of the landmasses nearby.
  - The **warm Gulf Stream** current water influences the eastern Atlantic shoreline of the United States by bringing warm, moist air. The **cold California current** influences its western Pacific shoreline by bringing cold, moist air.

This picture shows the Earth's ocean currents. The arrows show their circular motion. There are warm currents and cold currents. In a colored picture, you would see that the blue arrows represent cold currents and the red arrows represent warm currents.

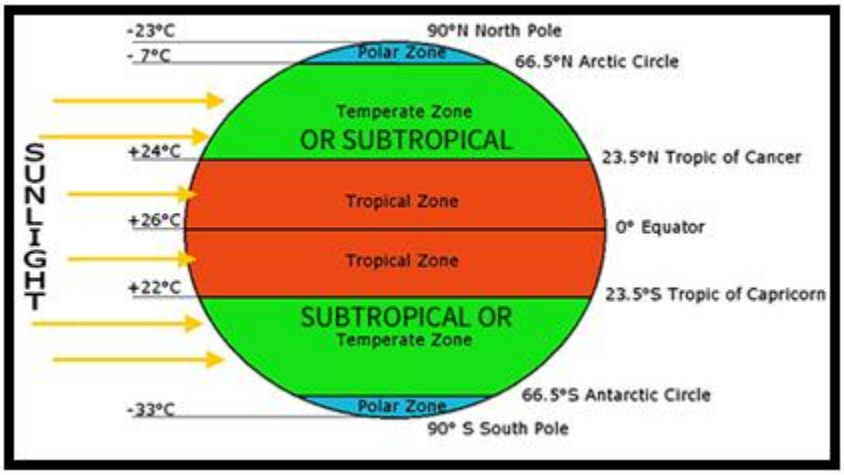
- Global wind belts occur between climate regions because of the characteristics of the convection currents in those regions. The prevailing direction of the global winds in these large regions affects weather conditions. The three major climate zones are a result of these global systems (tropical, temperate, and polar).

PERFORMANCE INDICATOR 6.E.2B.4

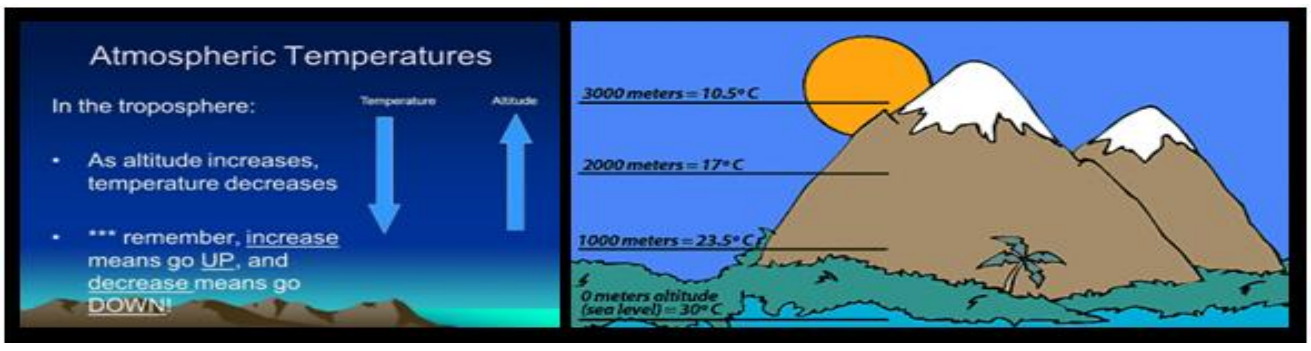
Construct explanations for how climate is determined in an area (including latitude, elevation, shape of the land, distance from water, global winds, and ocean currents.)

All of the following can affect climate in local regions:

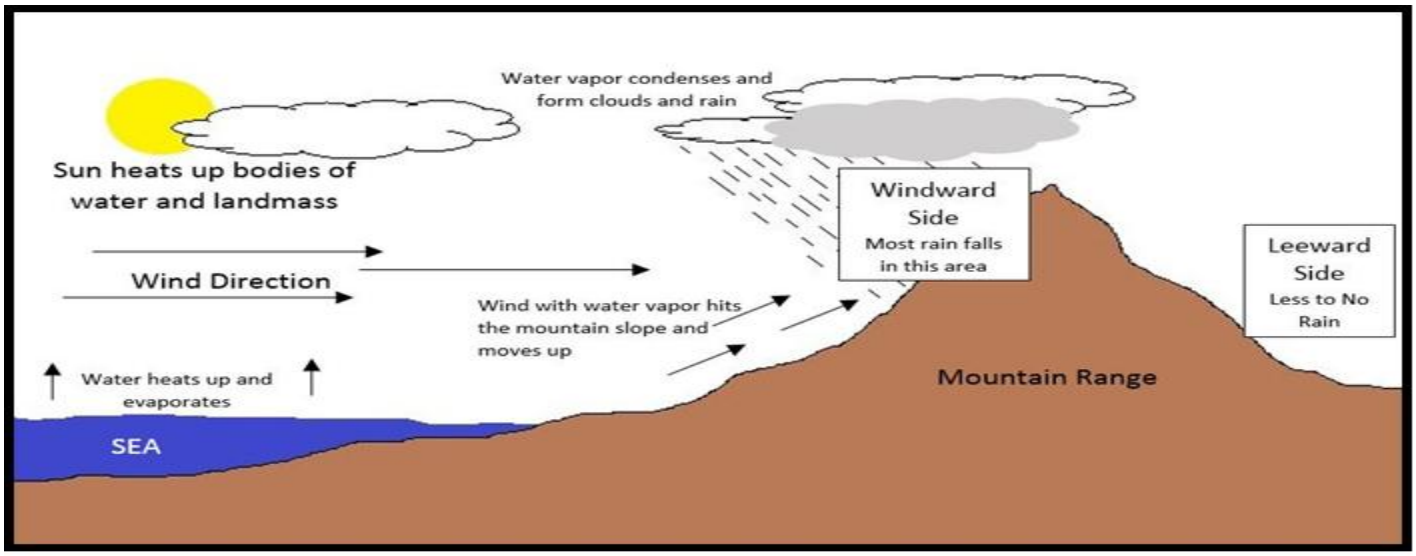
- Latitude:
  - The sun's rays directly strike the equator (latitude 0) and cause the regions near the equator to be warmer.
  - Generally, as latitude increases, the temperature of the area decreases.



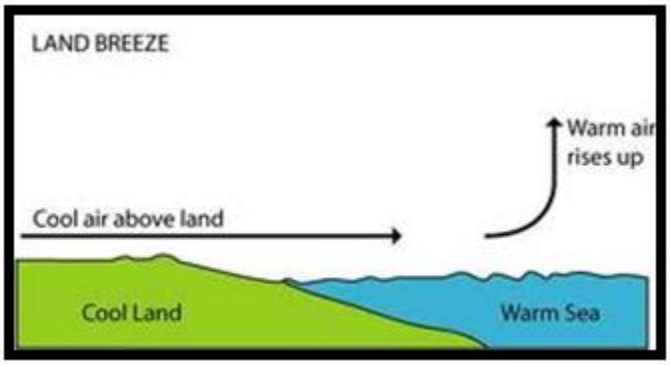
- Elevation:
  - Within the troposphere, as altitude increases, temperature decreases.

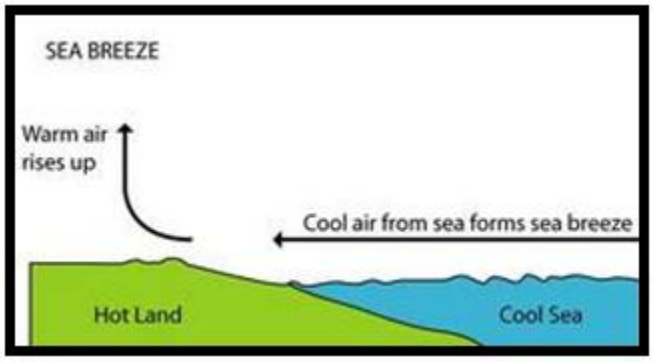


- Shape of the Land (Topography)
    - Certain land formations (mountains and valleys) can affect the movement of air masses, and that will affect the weather conditions a region experiences.

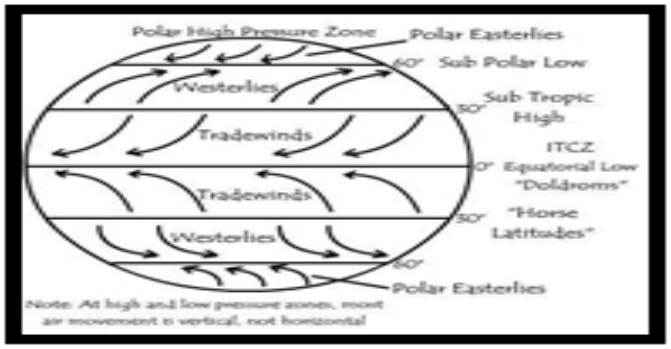


- Distance from Water
    - Land and Sea breezes are local convection currents that occur in areas near water because of the unequal heating of Earth materials.





- Global Winds
    - Global winds provide a predictable pattern for the movement of air in a specific region, and are named after the direction they come from. **(Extended knowledge: there are 3 types of global winds: trade, westerly, and polar.)**



- Ocean Currents
    - Ocean currents circulate heat energy. Air masses that originate over regions of the ocean are moved with currents and affect the climate of coastal regions.