Weather Essential Understandings:

What is the difference between weather and climate?

Weather is the state of the atmosphere at a specific place and time.

Climate is the average weather of a specific location over the course of an entire year

What are station models?

Weather station models are used to code weather data into a concise and easily readable form

In a station model, weather data is coded based on where they are located around the central circle.

Station models are used to view the weather in various places at the same time.

What is air pressure?

Air pressure is the force (or weight) of air pushing down on the Earth's surface

Air pressure is measured with a barometer

The more air above you, the higher the pressure.

Therefore, as altitude increases, pressure decreases (less air above you—like a swimming pool)

What factors can change air pressure?

Air pressure also changes due to changes in temperature and moisture

Adding moisture to air lowers its pressure (makes it less dense)

The reason for this is that water vapor is a lighter molecule than oxygen or nitrogen or carbon dioxide.

When a volume of air is humid, the water vapor takes up space normally taken up by heavier oxygen, nitrogen, or carbon dioxide molecules

Therefore drying air increases its pressure (makes it more dense)

Heating air lowers its pressure (and causes it to rise)
Cooling air increases its pressure (and causes it to sink)

How do pressure differences on earth cause wind on earth?

Unequal heating causes convection. Warming air or water lowers its density which causes it to rise. Cooler air is greater in density and sinks in to replace the air or water that left.

Heating air lowers its pressure because it is rising (and exerting less force on the surface.)

Cooling air increases its pressure because it is sinking (and exerting more force on the surface)

Air rushes from regions of high pressure to regions of low pressure

The movement of air from higher to lower pressure is called WIND

How do changes in air pressure result in changes in weather?

When air pressure falls, it indicates cloudy skies and possible precipitation

Rising air pressure means a return to fair weather with clearer skies

What is the Coriolis Effect, and how does it affect wind?

The earth's rotation causes effects to the motion of air and water (fluids.)

The earth rotates counterclockwise as viewed down on the north pole (rotates from west to east.)

The Coriolis Effect is the apparent deflection of moving objects when viewed from a rotating frame of reference (the Earth.)

The Coriolis Effect causes wind and ocean currents to bend to the right in the northern hemisphere and the left in the southern hemisphere.

The faster the wind or ocean current, the stronger the effect.

The Earth is rotating underneath the moving object! (wind, plane, rocket.)

Why are there planetary windbelts on earth?

Just like we can heat a convection box unequally, the earth heats unequally!

The unequal heating of the earth causes zones of different pressure at different latitudes.

Planetary windbelts are due to the unequal heating of the earth.

The equator is an area of low pressure because its intense heating causes air to rise there.

As the air over the equator spreads out, it cools, and sinks around 30^{o} N or S latitude. This creates a high pressure zone at 30^{o}

The air at the poles is cold and sinks due to its high density. This creates a high pressure area at the poles.

As air moves away from the poles it warms and rises around 60^{o} N and S latitude. This creates a low pressure area.

Air rushes from the high to low pressure areas creating prevailing wind belts on the earth.

Planetary windbelts describe the average direction wind flows for a given latitude.

Local winds also result due to local temperature and pressure differences.

What causes land- and sea-breezes?

Land and Sea breezes are due to the unequal heating of land and water.

Sea breezes form during the day and are the result of water temperature being cooler during the day than the land (and higher pressure.) The air under higher pressure over the water moves towards the air under lower pressure over the land as a wind.

Land breezes form at night and are the result of land temperatures being cooler during the night than the land (and higher pressure.) The air under higher pressure over the land moves towards the air under lower pressure over the water as a wind.

How does the location and spacing of isobars indicate wind speed?

Isobars connect points of equal pressure.

Isobars indicate where areas of low and high pressure are. A High is indicated by blue H and a Low is indicated by a red L.

When isobars are spaced closed together, the pressure gradient is high.

When the pressure gradient is high, wind speed is fast.

When isobars are spread out, the pressure gradient is low.

When the gradient is low, wind speed is low.

What are the Processes in the Water Cycle? (Hydrologic Cycle)

A cloud is composed of microscopic water droplets in liquid or ice form that are suspended in air.

Rising air currents keep these light, low density clouds from falling to earth.

For a cloud to form, moisture must first make it into the atmosphere.

Moisture is added to the air when water evaporates from a body of water (primarily the ocean, also lakes, rivers.)

Evaporation is the change of state from liquid to gas.

Evaporation requires a lot of heat energy (2260 Joules per gram!) to occur. Therefore raising the temperature raises the evaporation rate.

Evaporation is a cooling process because it absorbs energy.

The more humid the air, the slower the evaporation rate.

Once the moisture is in the air, it can form a cloud!

Condensation is the reverse of evaporation.

Condensation releases the energy it took to evaporate the water (2260 Joules per gram) Therefore it is a warming process.

Cooling air increases the condensation rate (it slows down molecules of gas and bring them closer together.)

Condensation forms clouds, which then return liquid water to the earth's surface as precipitation.

Since clouds can move, they can transfer moisture (and energy) from one place to another!

Precipitation falls when the water droplets in a cloud become too large for air currents to hold up and gravity pulls them down.

Runoff is the water that falls to the surface but is not absorbed by the ground or plants.

Runoff causes streams to form.
The energy in streams carries away sediments, causing erosion.

Infiltration is the process by which water sinks into the ground (doesn't run off.)

Groundwater is water stored in pore spaces in rock and sediment.

The top of the groundwater is called the water table.

An aquifer is a large mass of underground rock that has pore spaces that hold water.

Climate change can alter the hydrologic cycle by causing polar ice and glacial ice to melt, and increasing evaporation rates.

What are the ingredients for clouds?

1. A source of moisture
2. Evaporation of this moisture source to make the air humid
3. The air reaching the **dewpoint temperature** (the temperature at which condensation occurs)
4. A surface for condensation to occur on (condensation nuclei)

What is needed for air to reach the dew point temperature?

Cooling the air (primary reason)
Adding a lot of moisture to the air

What can cause air to cool?

UPLIFT
- By heating
- By being forced over a mountain (orographic)
- By being forced up by a denser air mass

Why does air cool when it rises?

- The troposphere cools as elevation increases
- Air cools when it expands (adiabatic cooling)

How can we keep track of how likely clouds will form?

Relative humidity measures how close air is to the dew point temperature (saturation)

At the **dew point temperature** the air is saturated with water vapor

Saturation means that the air is "holding" as much water vapor as it can at that temperature.

100% means the air is at the dew point temperature (saturated)
50% means the air is halfway to the dew point temperature (1/2 saturated)
25% means the air is 25% of the way to the dew point temperature (1/4 saturated)

Once air is saturated with water vapor, condensation becomes a dominant process.

Therefore Relative humidity measures how close air is to being saturated with water vapor

The colder the air, the less capacity it has to hold moisture.

Warmer air has a greater capacity for moisture (because of the greater evaporation rate)

This is why cooling air causes clouds to form!

As the air cools, it has less and less capacity to contain the moisture in the air.

As the air cools, the evaporation rate is lowered (evaporation is a cloud-drying process)

How do we measure relative humidity?

A psychrometer is an instrument used to measure relative humidity and dew point temperature.

A psychrometer has two thermometers. One has a moisture-holding cover on it which is saturated (wet-bulb.) The other remains dry (dry-bulb.)

Evaporation from the wet-bulb thermometer lowers the temperature of this thermometer. Therefore, the greater the evaporation rate, the more cooling occurs.

The drier the air, the more evaporation will occur from the wet-bulb and the lower the temperature will be. The dry-bulb is used as a control or comparison (no evaporation, no cooling)

Therefore, the larger the difference between dry- and wet-bulb, the less moisture in the air.

The smaller the difference between the two temperatures, the moister the air (greater R.H. and dew point temperature)

What factors favor cloud formation?

FACTORS THAT FAVOR CONDENSATION….over evaporation

1. Moist (humid) air due to evaporation from a water source
2. A surface for condensation to occur on (condensation nuclei)
3. The air at or near the **dewpoint temperature** (often cooled to this point)
4. Relative humidity at or near 100%

What is the dew point temperature used for?

To determine the amount of moisture in the air (the higher the dew point temperature, the more water vapor in the air)

To determine the temperature at which clouds will form at

To determine the temperature at which air is **saturated (**Air is at 100% capacity for water vapor)

What is needed for air to reach the dew point temperature? (cloud formation temperature)

Factors must favor condensation over evaporation!
LOWERING TEMPERATURE Cooling the air lowers the evaporation rate
RAISING HUMIDITY--Adding a lot of moisture to the air increases the condensation rate (and dew point temperature**)**

- We can either cool air to the dewpoint temperature (air temperature lowers to meet dew point temperature)
- OR we can add moisture to the air to bring up the dew point temperature (dew point temperature rises to meet air temperature)

What can cause air to cool to the dew point temperature?

UPLIFT

By heating (convection)
By being forced over a mountain (orographic)
By being forced up by a denser air mass (at a **front)**

Why does air cool when it rises?

The troposphere cools as elevation increases
Air cools when it expands (adiabatic cooling)

What can cause the dew point temperature to rise to the air temperature?

Moisture added to the air: air moving over a moist surface

What are Adiabatic Temperature Changes?

Adiabatic temperature changes occur when air expands or compresses.

When air expands, it cools. When air compresses, it warms.

When air rises, the pressure on it is less, so it expands and cools
When air sinks, the pressure on it is more, so it compresses and warms

Air that rises and expands can cool to the dew point temperature and cause clouds to form.

Air that sinks and compresses can warm above to the dew point temperature and evaporate clouds.

Therefore, rising air (low pressure) favors cloud formation and storms, while sinking air (high pressure) favors clear skies.

Locations on the windward side of a mountain have a cooler and wetter climate than locations on the leeward side due to adiabatic temperature changes. This is the orographic effect.

What is an air mass?

An air mass is a LARGE body of air (1000 miles or more across, 3-4 miles high!)

An air mass has properties of moisture and temperature similar to the part of the Earth's surface where it developed.

An air mass is able to move to new areas and bring their conditions with them! (weather "souvenirs.")

The location where an air mass forms is called its SOURCE REGION. The source region determines its properties of moisture and temperature.

An air mass is named on its moisture and temperature characteristics.

Maritime means the air mass formed over the ocean and has a lot of moisture.

Continental means the air mass formed over a continent (land) and has low moisture.

Polar means the air mass formed at high latitudes and is cold (Arctic means especially cold and from even higher latitudes.)

Tropical means the air mass formed at lower latitudes and is warmer.

When an air mass overtakes and collides with another air mass a FRONT develops.

What is a Front?

A FRONT is a boundary between two air masses. This is an area of LOW PRESSURE (stormy!)

A WARM FRONT means that warm air invaded a region of colder air.

A COLD FRONT means that cold air invaded a region of warmer air.

Behind a warm front is a warm air mass (such as maritime Tropical) and behind a cold front is a cold air mass (such as continental Polar.)

At a front, the warm air is forced off the ground because it is less dense than the cold air.

The rising warm air creates an area of low pressure along the front.

The rising, warm air expands, cools to the dew point and forms clouds. This is why fronts are stormy.

Cold fronts move faster than warm fronts.

Cold fronts cause warm air to be quickly and forcefully lifted off the ground. This causes thunderstorms, hail, even tornadoes. There is heavy rainfall ahead of the front.

After a cold front passes, there are rapidly decreasing temperatures.

A warm front brings longer, steadier rain.

Warm air rises more gradually in a warm front than a cold front. This creates a long band of clouds ahead of the front. Clouds become less thick and higher the greater the distance from the front.

The slope of warm air rising along a warm front is less than that of a cold front.