**Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Chapter 23 - Weather**

**Lesson 1 - Changing Forms of** [**Water**](http://www.youtube.com/watch?v=J8mDGwf-5x0)

Molecules of liquid water are always in motion.

Water is unique because it is the only substance that commonly exist in all three states of matter:

1) Ice (Solid) 2) Water (Liquid) 3) Vapor (Gas)

Water changes from one phase to another when heat energy is absorbed or released.

There are 4 ways to do this: 1) Condensation 2) Evaporation 3) Transpiration 4) Sublimation.

**Condensation**

Condensation is the process by which water vapor (gas) in the air is changed into liquid.

This occurs because vapor present in the warm air is forced to condense into liquid as it is cools.

**Latent Heat**

This process also releases a heat called latent heat because it is energy that is hidden.

Latent heat is the heat released or absorbed by a body during a change of state without change of temperature.

If more molecules gather then heat is released: Ex.= Vapor turns to water.

If less molecules gather then heat is absorbed: Ex. = Water turns to vapor.

If you heat/boil water into a vapor– that energy (heat) is being absorbed by vapor.

Turn that same vapor back into water – the heat absorbed (earlier) is now released (latent).

This will play a huge factor in the formation of a hurricane.

**Evaporation**

90% of the moisture in the atmosphere occurs via evaporation.

The remaining 10% is contributed by plant *transpiration*.

The change from liquid water to water vapor is called evaporation and this process absorbs heat.

So while condensation gives off heat energy evaporation will absorb heat energy.

**The Rate of Evaporation**

The evaporation of liquid water is important to meteorology since the amount of moisture that evaporates into the air leads to changes in the weather.

A combination of warm water and warm air will evaporate the most water.

The five factors that determine the rate of evaporation are:

(1) Water Temperature - The water molecules move faster as water warms. The faster the molecules move the more easily they can escape the water surface. A warm lake or ocean will evaporate a large amount of moisture

(2) Air Temperature- As the air above the water warms it has greater capacity to hold more evaporated moisture. If the air is cold, because is more dense, it is difficult to evaporate a large amount of moisture into the air.

(3) Wind Speed- Higher winds will continue to supply drier air (like a conveyer belt) to the water surface allowing for a greater amount of evaporation to take place.

(4) Dryness of the Air- Dry air will help generate more evaporation especially if the air is warm and dry. There is a higher capacity to evaporate moisture into the air as the air dries. Once the air is saturated then the evaporation rate is minimized.

(5) Direct Sunlight

**Another form of Evaporation is Sublimation**

The process by which water changes from a solid (ice or snow) to a gas, bypassing the liquid phase, is called sublimation.

This can commonly occurs in the mountains or with plants but less than 1% of water vapor enter our atmosphere this way.

**Lesson 2 – Why do Clouds Form**

In order for clouds to form they need three things:

(1) Water Vapor (2) Condensation Nuclei (3) A Mechanism for Cooling the Air

**(1) Water Vapor and Relative Humidity**

Humidity refers how near the air is to its maximum capacity for holding water vapor.

Relative humidity compares the actual amount of water vapor in the air to the maximum amount of water that can be present in the air at the given temperature and pressure.

**Condensation in the Air**

When air cools, its capacity to contain water vapor diminishes.

Which means as night falls the air becomes saturated and if the air continues to cool past the point of saturation, condensation occurs.

**Dew Point**

The water vapor may condense into droplets, forming a cloud.

If the water vapor condenses on the surface, such as grass, it is called dew.

The temperature at which saturation occurs and condensation begins is called the Dew Point.

**2. Condensation Nuclei**

For water vapor to condense and form a cloud, a solid surface must be available.

This surface is referred to as the condensation nucleus.

The troposphere contains millions of suspended particles of ice, salt, dust, and other materials.

Because the particles (especially dust) are so small they remain suspended in the atmosphere for a long time.

**3. The Mechanism for Cooling- Adiabatic Cooling**

Adiabatic cooling is the process by which the temperature of an air mass decreases as the air mass rises and expands.

As a mass of air rises, the surrounding atmospheric pressure decreases.

Thus, fewer collisions between the molecules happen.

The resulting decrease in the amount of energy that transfers between molecules decreases the temperature of the air (cooling air).

As the molecules slow down, some are not able to maintain their vapor form so they cluster (condense) in the air to form tiny liquid droplets.

**How Clouds Form**

While there are several factors that influence and affect the formation of clouds, is the sun that plays the main character.

The Sun creates a thermal which can be thought of as a rising “blob” of warm air due to unequal heating of the earth’s surface.

When the thermal forms at the surface, it is warmer than the surrounding air.

Since the thermal is warmer than the air around it, it rises (convection).

As it rises, it will begin to expand and cool (adiabatic cooling), and will continue to do so until its temperature is the same as the surrounding air temperature.

Key Point: Cool air can't hold as much water vapor as warm air, so the moisture within that thermal condenses and when billions of these droplets come together they become a visible cloud.

**Cloud Size and Height**

Cloud height is often related to the intensity of precipitation generated by a cloud:

Thicker clouds tend to produce more intense rainfall.

Thinner clouds do not generate any precipitation at the surface.

**Condensation Level of a Cloud**

The altitude at which this net condensation begins is called the *condensation level and* is marked by the base of the clouds.

Further condensation allows clouds to rise and expand above the condensation level.

**Lesson 3 - Fog and Cloud Types**

There is no difference between fog and clouds other than altitude.

Fog is defined as a visible moisture that begins at a height lower than 50 feet.

Two common types of fog are called radiation fog and advection fog.

**1. Radiation Fog (Ground Fog)**

Radiation fog is also known as ground fog.

Forms in the evening when heat absorbed by the Earth’s surface during the day is radiated into the air at night.

This heat is transferred from the ground to the air and when it comes into contact with cool moist air, water droplets form.

It usually forms at night and “burn offs” in the morning sun. (Think golf courses and grave yards)

**2. Advection Fog (Sea Fog)**

Advection fog forms when warm, moist air moves across a cold surface.

A very common advection fog is that caused by moist air over a cold body of water (sea fog), which occurs up north in cities like San Francisco.

Advective Fog: Can last for several days; May be advected over large areas and across great distances.

Radiation Fog: Generally short duration (< 24 hrs), often dissipating by afternoon; Typically remains in one place, patchy and localized

**Classification of Cloud Types**

The three basic cloud forms:

(1) Cirrus clouds – highest of clouds about 4 miles – 8 miles above.

(2) Cumulus clouds – middle to high – about 1 to 4 miles above

(3) Stratus clouds – lowest level clouds about 0 – 1 mile above.

Classifications of clouds can also include the prefix nimbo / nimbus = rain

Alto = Latin for high up (ex. also with instruments alto saxophone

**Stratus Clouds**

Stratus cloud a gray cloud that has a flat uniform base and that commonly forms at very low altitudes

Stratus clouds can look like a fog that doesn't reach the ground. *Stratus* means “sheet-like” or “layered.” *(latin)*

Two variations of stratus clouds: Nimbostratus is low level rain clouds. Altostratus thin clouds found at the middle levels and produce very little precipitation.

**Cumulus Cloud**

Cumulus cloud a mid-level, billowy cloud that commonly has a top that resembles cotton balls and can have a dark bottom

*Cumulus* means “piled” or “heaped.” *(latin)*

The flat base that is characteristic of most cumulus clouds represents the condensation level.

Two variations of cumulous clouds: Cumulonimbus clouds are mid-level rain storm clouds. Altocumulus clouds are part of the Middle Cloud group (1 – 4 miles).

**Cumulonimbus Clouds**

Cumulonimbus clouds are high, dark storm clouds also known as, or thunderheads.

They are often accompanied by rain, hail, lightning, and thunder.

**Cirrus Clouds**

Cirrus cloud are thin, wispy clouds blown by high winds into long streamers.

They are considered "high clouds" forming above 4 miles.

*Cirro–* and *cirrus* mean “curly.” *(latin)*

They generally represent fair to pleasant weather.

There are two variations of cirrus clouds worth mentioning: Cirrocumulus & cirrostratus clouds

*Cirrocumulus clouds* are rare, high-altitude, billowy clouds composed entirely of ice crystals.

Cirrocumulus clouds commonly appear just before a snowfall or a rain fall.

**Lenticular Clouds**

Lenticular clouds are unique clouds which typically form around mountains, as a result of the way that the air moves.

Named after the lenses on glasses, these clouds look like flying saucers

**Chapter 24 Lesson 4 - Air Pressure**

Weather can be forecast by monitoring (with a barometer) surface air pressure.

Air pressure is a measure of the weight of the atmosphere above any location; assuming normal air pressure at sea level is 29.92 in.

**Low Pressure Cyclone**

A low pressure area represents a region where there is somewhat less atmosphere overlying it.

While a low pressure center is known for its cloudy conditions, windy weather, rain, snow and unsettled changeable weather often occur, it does not start this way.

A low pressure system develops when relatively warm and moist air rises from the surface of the Earth creating unstable air near the center of the low.

As the warm humid air spirals upwards, it allows cooler air to replace it and also cools the rising air; clouds form and precipitation may occur.

In these low pressure systems the air spirals inwards (counter- clockwise) at the Earth’s surface.

If the pressure is very low, these spiraling winds may reach storm or hurricane force.

**High Pressure Anticyclone**

A high pressure area represents a region where there is more atmosphere overlying it.

High pressure systems tend to: cover a greater area than lows, move more slowly and have a longer atmospheric lifetime.

High pressure starts as cold air, as it sinks, it warms up allowing warmer air to accumulate on top.

The relative humidity decreases as atmospheric pressure increases.

The warm, sinking air makes the atmosphere stable, so warm air at the surface of the Earth cannot rise far before it stops.

High pressure, anticyclones, usually lead to warm, dry weather and cloudless skies in the summer and cold, dry weather in the winter.

These conditions usually lasts for several days or even weeks and may even block the path of a depression.

**Fronts**

A front is defined as the transition zone between two air masses of different density.

A cool air mass is dense and does not mix with the less-dense air of a warm air mass, there are two major fronts: (1) Cold Fronts (2) Warm Fronts.

**Where on Earth Do Front’s Mix**

Middle Latitudes: There is constant competition between the warm air fronts of the tropics and colder air fronts of the Earth’s Poles.

Equatorial or tropics: there are no distinguishable difference between competing air masses.

**Cold Fronts**

A cold front is defined as the leading edge of a cooler mass of air, replacing (at ground level) a warmer mass of air, which lies within a fairly sharp surface trough of low pressure.

Cold fronts will push warmer air mass up into the air because the edge of the cold front is more dense and if the is any moisture in the warm air then clouds will form.

**Speed of the New Front Matters**

A slow-moving cloud front (warm or cold) typically produces weaker storms and lighter precipitation than a fast-moving cold front does.

**Fast Moving Front**

If the cold front is a fast moving front then large cumulus and cumulonimbus clouds typically will form.

Weather may be brief but can become unpredictable and downright violent with wind, rain, hail and thunderstorms and if you live east of the Rockies there is a chance of tornadoes.

Back East where weather can get severe this fast moving cold front is referred to as a squall line.

**Characteristics of a Cold Front**

Dry, gusty winds with a sudden drop in temperature.

Associated with the most violent weather – hail, thunderstorms and tornadoes.

Creating cumulus and cumulonimbus clouds.

**Warm Fronts**

A warm front is defined as the transition zone where a warm air mass is replacing a cold air mass.

The slope of a warm front is gradual because of density differences.

Because of this gentle slope, clouds may extend far ahead of the surface location, or *base*, of the front.

A warm front generally produces precipitation over a large area -It is like throwing a blanket over the car.

**Warm Fronts Characteristics**

Warmer more humid air.

Slower moving front with light to moderate continuous rainfall.

Creates stratus and cirrus clouds and associated with pleasant weather.

**Lesson 5 - Weather Extremes – Nor’easter**

A nor'easter is a storm that mainly affects the northeastern part of the United States - These storms form along the East coast as warm air from over the Atlantic Ocean clashes with arctic cold to the north and west.

Typical in Fall or Winter time - Heavy snow and hurricane-force winds can occur on the northwest side of the nor'easter.

**Difference between Nor’easter and a Hurricane**

The main difference between a hurricane and nor'easter is the size of the wind field.

For example, a hurricane may only have a 30-mile radius of a strong wind field around the center, while a nor'easter may have a 100-mile radius of a strong wind field from the center.

**Rain Shadows**

Rain Shadows are areas that lie in the shadow of mountain ranges and receive little precipitation.

In California, rainfall is heaviest along the western side of the Coastal mountain ranges and the Sierra Nevada’s.

The rain shadow has created semi-arid (Dry) valleys and deserts on the eastern side of the California mountains.

This includes the San Joaquin Valley, Bakersfield, and Death Valley.

**Extreme Weather of California -The Pineapple Express**

The "Pineapple Express" is a weather system that has its origins from the Hawaiian tropics.

It is an atmospheric river of sorts that streams moisture from the Pacific tropics toward the West Coast.

The flow of tropical moisture must be directed into the storm and serve as energy, unleashing unusually extreme amounts of rain over parts of the West.

The high rainfall totals often lead to major flooding, mudslides, road closures and travel delays.

**Temperature Inversions**

Temperature Inversion is the layering of warm air on top of cool air.

Inversion occurs because warm air, which is less dense than cool air, traps cool air beneath it.

**Temperature Inversion Pollution**

Certain weather conditions can make air pollution worse.

In some areas, topography may make air pollution even worse by keeping the polluted inversion layer from dispersing.

Take for example Los Angeles, where warm desert air will trap cooler air against the mountains.

Under these conditions air cannot circulate up and away from an area.

This condition along with the trapping of exhaust from cars, boats and trains can produce *smog,* a general term for air pollution that indicates a combination of smoke and fog.

**Santa Ana Winds**

Santa Ana winds are dry and warm (often hot) winds in the Southern California area that blow in from the desert.

This condition tends to occur during the winter half-year when the high deserts tend to cool more quickly then the Los Angeles (LA) Basin.

**Origins of the Santa Ana Winds**

These winds actually start out as cool desert air.

When high pressure builds over the high desert, air flows clockwise around high pressure systems.

That clockwise flow, along with the attraction for cool air to want to sink pushes air into the L.A. Basin from the northeast (Lancaster) and the east (Hesperia).

**Why are Santa Ana Winds Hot and Dry**

The Great Basin (High Deserts) resides at a higher elevation than the LA Basin, thus, the Santa Ana’s flow downslope.

When air descends, it is compressed, and dries as its temperature rises.

The Santa Ana wind tends to have very low relative humidity (RH), often registering below 10%.

This combination creates a Red Flag Warning (conditions ideal for wild fire).

**Chapter 24 Lesson 6 – Thunder Storms**

Thunderstorms are usually brief, heavy storm that consists of rain, strong winds, lightning, and thunder.

Thunderstorms develop in three distinct stages:

(1) Cumulus stage – In your everyday thunderstorm you have the warm moist air rising because of a swift moving cold front.

(2) Mature stage – Moist air rising causes updrafts within the storm, and colder air descending causing downdrafts.

The wind drafts within the thunderstorm separate because the rain downdraft is cooler than the warm rising air.

(3) Dissipating stage – As the thunderstorm matures the falling rain causes more down drafts, and finally begins to negatively affect the updraft that builds the storm.

This would cause a typical thunderstorm to weaken because less updraft equals less power.

**Lightning**

Lightning is an electrical discharge.

It is produced to balance the differences between positive and negative charges between the cloud and the ground.

**Why do we have Lightning**

It’s not clear how it happens, but charges separate in the cloud and positive charges move up, negative charges move down.

Scientist think it is the water and ice that are moving around inside the cloud; forced up by warm air currents, down by gravity, and compressed in the cloud.

**Stepped Leaders**

At this point since opposites attract, the positive and negative charges are pulled toward each other.

This attraction creates stepped leaders, which are invisible strokes that can only be seen with a camera.

As soon as the negative and positive parts connect there is a conductive path - causing the visible stroke we call lightning.

As the negative charge races down, the air surrounding it heats up.

**Thunder**

The spark is very hot at almost 35,000 °F, and it rapidly heats the air to create a shock wave, called thunder.

What you hear is air pushing against air and these vibrations (sound) bouncing off the ground and the clouds.

**Lightning Rod**

Lightning rods were originally developed by Benjamin Franklin to protect structures.

In the 1700’s building materials, like wood, would easily catch fire creating havoc for towns.

The lighting rod works by providing a low-resistance path for lightning strikes then safely passing their high voltage currents to “ground".

**Lesson 7- Tornadoes**
A tornado is a narrow, violently rotating column of air that extends from the base of a thunderstorm to the ground.

The strength of a tornado is measured by the Enhanced Fujita Scale EF0 – EF5 (5 being strongest).

Observed on every continent except Antarctica.

The North American continent (United States) averages the most recorded tornadoes – about a 1,200 a year.

The peak “tornado season” is during May into early June, but tornadoes can happen at any time of year.

Most tornadoes occur between 4–9 p.m.

**Tornado Alley**

The Midwest (Tornado Alley) is most susceptible to tornadoes because atmospheric conditions are perfect for severe thunderstorms.

Tornado Alley occupies a unique geographic position where warm humid air from the Gulf of Mexico, hot dry air from Arizona and New Mexico, and cool dry air from Canada meet

**Recipe for a Tornado – (1) The Mixing of 3 Distinct and Opposing Air Masses**

Warm humid air from the Gulf of Mexico,

Hot dry air from Arizona and New Mexico

Cool dry air from Canada and Rockies

**Dryline**

The mixing creates a dryline; a type of weather front that often leads to the formation of severe thunderstorms and the potential for tornadoes.

The dryline is a boundary separating dry air to the west from warm, moist air to the east.

When these two converge, the weaker, humid south winds along the dryline, squeeze the moisture boundary into a very narrow area.

**(2) Severe (Supercell) Thunderstorm**

This narrow boundary creates severe thunderstorms, because the dryline acts like a wedge increasing the intensity of the upward draft of moist warm air.

A good deal of a thunderstorm's energy is a result of condensation and latent heat.

More condensation means more heat; more heat means more uplift and stronger winds.

All of this creates a “Supercell” of instability.

**(3) Unstable Air along with Wind Shear**

How the column of air begins to rotate is not completely understood, because not all thunderstorms produce tornadoes.

But one way the rotation appears to occur is through wind shear or when winds at two different altitudes blow at two different speeds.

For example, a wind at 1000 feet above the surface might blow at 5mph and a wind at 5000 feet might blow at 25mph.

This causes a horizontal rotating column of air known as a mesocyclone.

**(4) - Rear Flank Downdraft (RFD)**

While warm moist air rises in the cloud the backside features cool dry sinking air that rushes downward a.k.a the rear flank downdraft (RFD).

The RFD looks like a “clear slot” or “bright slot” just to the rear (southwest) of the wall cloud.

It is often so powerful that people think it is part of the tornado.

The RFD causes gusty surface winds to contain the warm temperatures found in the vortex away from the contrasting cooler temperatures outside of the vortex.

The rear flank downdraft is the motion in the storm that causes the hook echo feature on radar.

**Tornado Dissipates**

Like hurricanes, a tornado’s path is hard to predict because it is haphazard (non-direct).

A tornado ends when the temperature differences disappears and air stabilizes or if moisture dries up.

**Lesson 8 - Hurricanes**

A hurricane also called typhoons (in western Pacific) or cyclones (in Australia and Indian Ocean).

They form over tropical oceans only during the Summer and Fall and rotate counter-clockwise in the northern hemisphere.

A hurricane is a storm system with a low-pressure center and they are fueled by the process of warm water being converted to vapor, which is then converted back to liquid water.

Keep in mind – Most evaporation on Earth occurs along the equatorial regions

Much like tornadoes – hurricanes are given a 1 to 5 rating based on a hurricane’s sustained wind speeds.

The scale used to understand the magnitude of the hurricane’s impact is called the Saffir-Simpson Hurricane Wind Scale.

**Formation of a Hurricane -1.) Starts as a Tropical Depression**

A tropical depression is designated when the first appearance of a lowered pressure and organized circulation in the center of the thunderstorm complex occurs.

Winds near the center are constantly between 20 and 34 knots (25 - 40 mph).

**Formation of a Hurricane -2. Tropical Storm**

Once a tropical depression has intensified to the point where its maximum sustained winds are between 40-75 mph, it becomes a tropical storm.

During this time, the storm itself becomes more organized and begins to become more circular in shape -- resembling a hurricane.

**Low Pressure Forms**

Usually, the heat released in tropical thunderstorms is carried away by wind shear, but if allowed to build up, a low pressure will form.

Low pressure is like a vacuum it has an inward flow of air.

The inward, low pressure causes winds to spiral inward even faster and along with the Coriolis effect causes the winds to spiral in a counter-clockwise direction.

**Formation of a Hurricane- 3. Hurricane**

The system essentially feeds on itself, using warm ocean water as its fuel (latent heat).

And as surface pressures continue to drop, a tropical storm becomes a hurricane when sustained wind speeds reach 75 mph.

**The Eye of a Hurricane**

A pronounced rotation develops around the central core known as an eyewall.

The eyewall is where the strongest winds occur, which encircle the warmest air, in the eye of the hurricane.

**Path of a Hurricane**

Hurricanes and tropical storms have highly erratic movements.

The path is influenced by warm ocean currents and westerly wind paths.

**The End of a Hurricane**

(1) Land will cause a hurricane to dissipate because a hurricane needs moisture and latent heat from warm ocean water to maintain themselves.

(2) Movement North to cooler waters also will end a hurricane.

**What Causes the Destruction**

1) High winds well over 75 mph. 2) Heavy amounts of rain 3) Storm Surge

**Storm Surge**

Occurs when ocean water is blown onshore by the high winds.

The storm surge usually ends up causing major flood damage to the beach communities.

**Difference Between a Tornado and a Hurricane**

A hurricane is a tropical disturbance and gets its energy from latent heat by condensation.

Tornadoes form when two fronts collide, they get their energy from latent heat of condensation and wind shear.