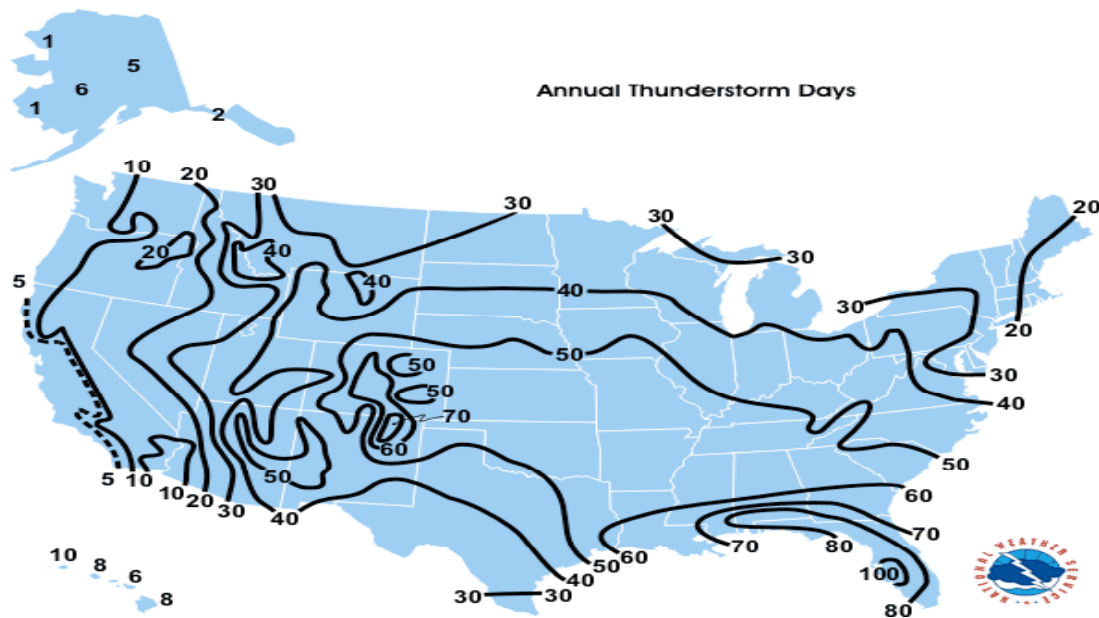


Introduction to Thunderstorms

It is estimated that there are as many as 40,000 thunderstorm occurrences each day world-wide. This translates into an astounding 14.6 million occurrences annually! The United States certainly experiences its share of thunderstorm occurrences.



The figure above shows the average number of thunderstorm days each year throughout the U.S. The most frequency of occurrence is greatest in the southeastern states, with Florida having the highest incidence (80 to 100+ thunderstorm days per year). It is in this part of the country that warm, moist air from the Gulf of Mexico and Atlantic Ocean (which we will see later are necessary ingredients for thunderstorm development) is most readily available to fuel thunderstorm development.

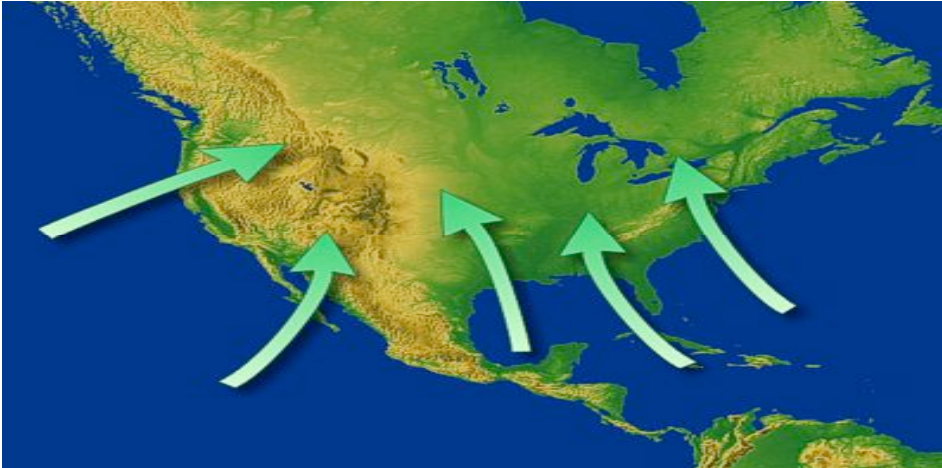
The Necessary Ingredients for Thunderstorms

All thunderstorms require three ingredients for their formation:

- * Moisture,
- * Instability, and
- a lifting mechanism.

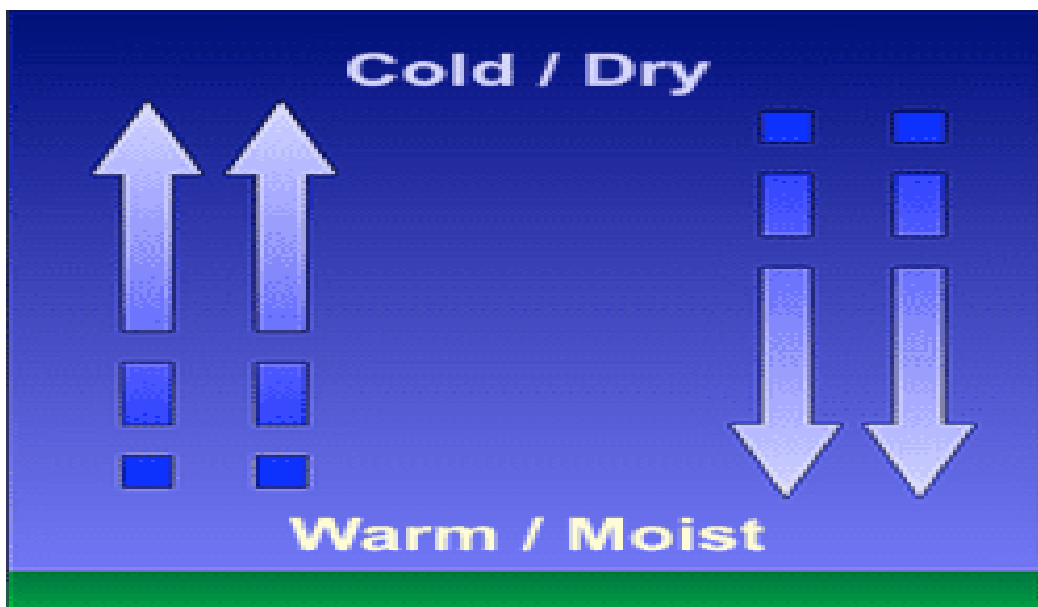
Sources of moisture

Sources of moisture in the continental U.S. Typical sources of moisture are large bodies of water such as the Atlantic and Pacific oceans as well as the Gulf of Mexico. The southeastern U.S. and especially Florida has access to two moisture sources in the Atlantic ocean and the Gulf of Mexico which helps explain why there are so many thunderstorms in that region.



Instability

Instability Air is considered unstable if it continues to rise when given a nudge upward (or continues to sink if given a nudge downward). An unstable air mass is characterized by warm moist air near the surface and cold dry air aloft. In these situations, if a bubble or parcel of air is forced upward it will continue to rise on its own. As it rises it cools and some of the water vapor will condense, forming the familiar tall cumulonimbus cloud that is the thunderstorm.



Characteristics of an unstable air mass with warm moist air near the surface with colder and drier air aloft. Air that is forced upward will continue to rise, and air that is forced downward will continue to sink.

Sources of Lift (upward)

Typically, for a thunderstorm to develop, there needs to be a mechanism which initiates the upward motion, something that will give the air a nudge upward. This is done by several methods.



Differential Heating

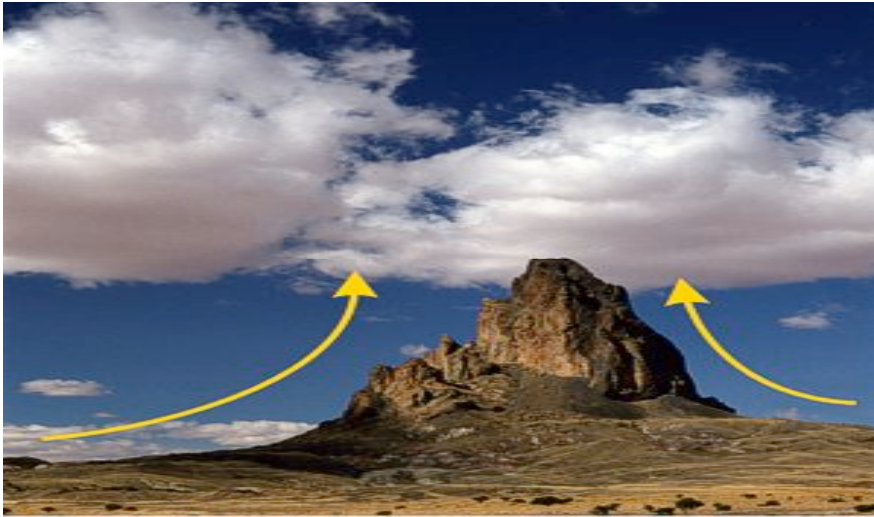
Cumulus building over a wildfire. This heating of the ground and lower atmosphere is not uniform. For example, a grassy field will heat at a slower rate than a paved street. The warmest air, called thermals, tends to rise. In the image (right) a wildfire provided the differential heating for a cumulus cloud to form over the smoke plume.

Fronts, Drylines and Outflow Boundaries

Fronts are the boundary between two air masses of different temperatures. Fronts lift warm moist air. Cold fronts lift air the most abruptly. If the air is moist and unstable thunderstorms will form along the cold front.

Drylines are the boundary between two air masses of different moisture content and separate warm moist air from hot dry air. While the temperature may be different across the dryline, the main difference is the rapid decrease in moisture behind the dryline. It is the lack of moisture which allows the temperatures to occasionally be higher than ahead of the dryline. However, the result is the same as the warm moist air is lifted along the dryline forming thunderstorms. This is common over the plains in the spring and early summer.

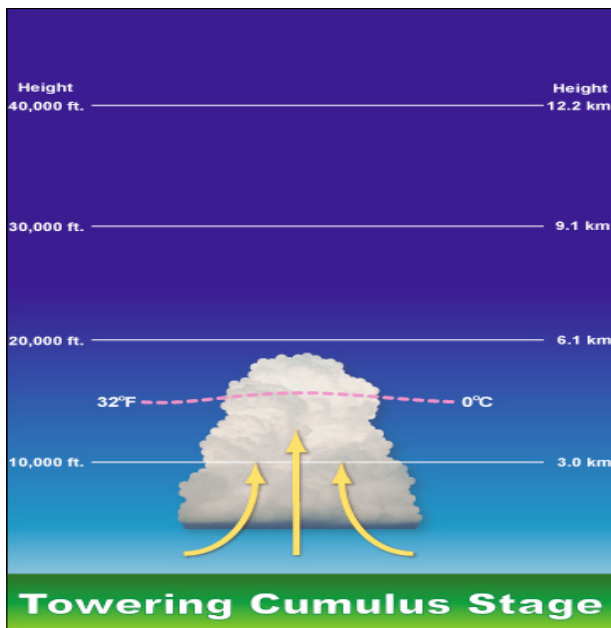
As air encounters a mountain it is forced up the slope of the terrain. Upslope thunderstorms are common in the Rocky Mountain west during the summer.



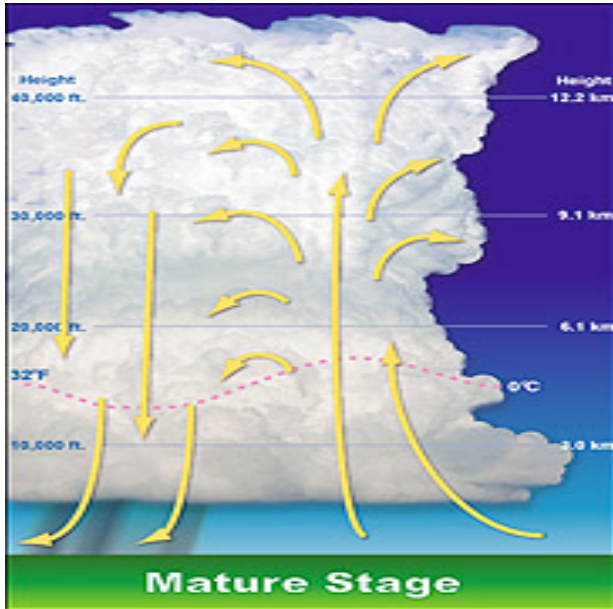
Life Cycle of a Thunderstorm

The building block of all thunderstorms is the thunderstorm cell. The thunderstorm cell has a distinct life-cycle that lasts about 30 minutes.

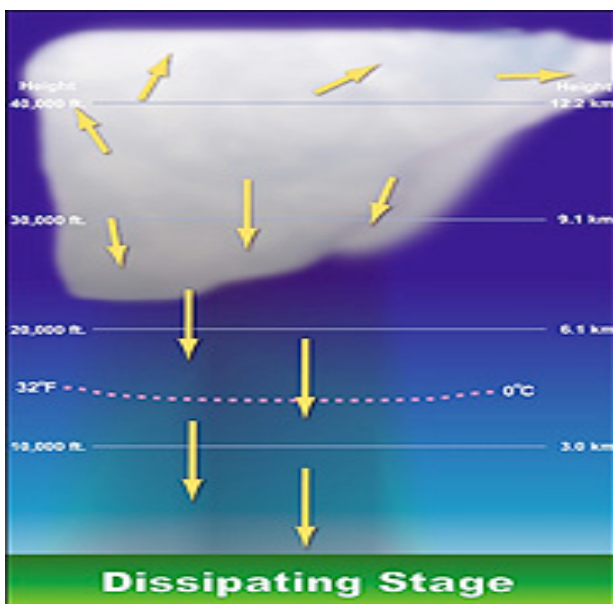
Towering cumulus stage – The first stage is the towering cumulus stage. A cumulus cloud begins to grow vertically, perhaps to a height of 20,000 feet (6 km). Air within the cloud is dominated by updraft with some turbulent eddies around the edges.



Mature stage – The second stage is the mature stage. The storm has considerable depth, often reaching 40,000 to 60,000 feet (12 to 18 km). Strong updrafts and downdrafts coexist. This is the most dangerous stage when large hail, damaging winds, and flash flooding may occur.



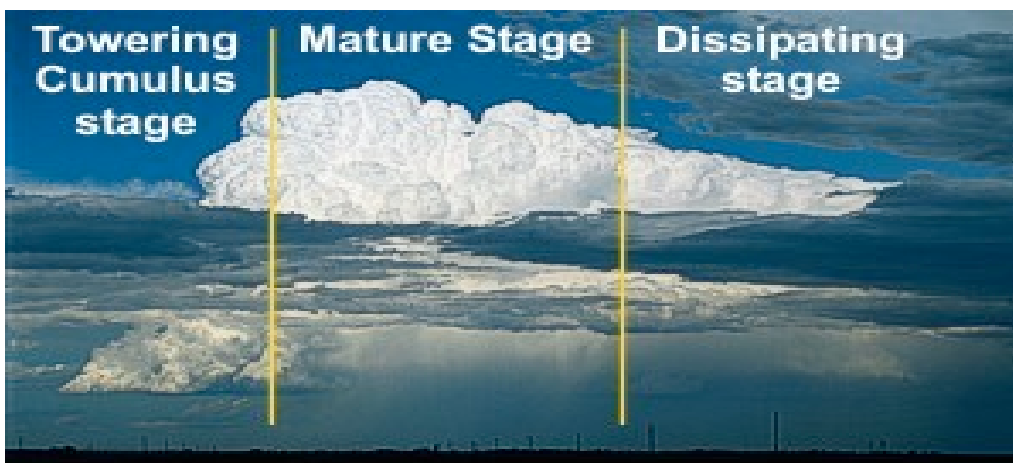
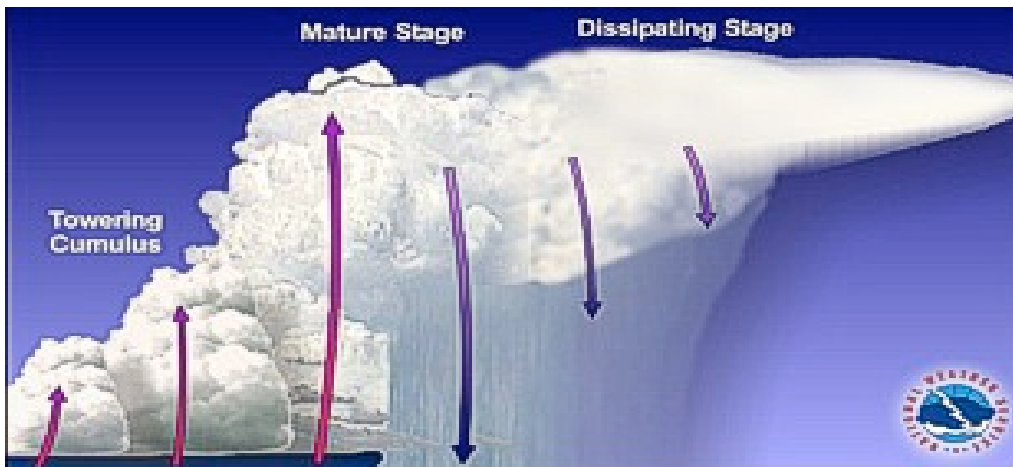
Dissipating stage – The final stage is the dissipating stage. The downdraft cuts off the updraft. The storm no longer has a supply of warm moist air to maintain itself and therefore it dissipates. Light rain and weak outflow winds may remain for a while during this stage, before leaving behind just a remnant anvil top.



Thunderstorm Types:

Multi-cell

Although there are times when a thunderstorm consists of just one ordinary cell that transitions through its life cycle and dissipates without additional new cell formation, thunderstorms often form in clusters with numerous cells in various stages of development merging together. Unlike ordinary single cells, cluster storms can last for several hours producing large hail, damaging winds, flash flooding, and isolated tornadoes.

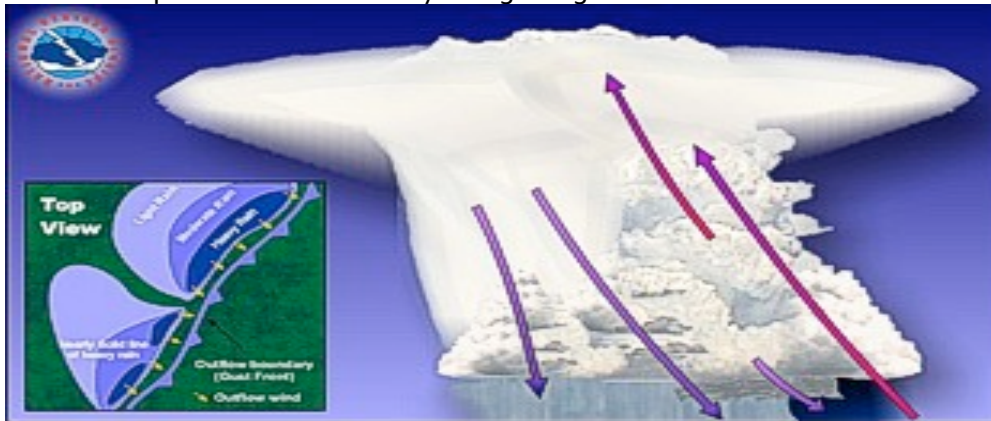


Squall Lines

Sometimes thunderstorms will form in a line which can extend laterally for hundreds of miles. These "squall lines" can persist for many hours and produce damaging winds and hail. The rain cooled air or "gust front" spreading out from underneath the squall line acts as a mini cold front, continually lifting warm moist air to fuel the storms.

Squall line thunderstorm: Leading edge of a squall line Schematic of a squall line and accompanying photograph. Often along the leading edge of the line a low hanging arc

of cloudiness will form called the shelf cloud. Gusty, sometimes damaging outflow winds will spread out horizontally along the ground behind the shelf cloud.



Supercell Thunderstorms

Supercell thunderstorms are a special kind of single cell thunderstorm that can persist for many hours. They are responsible for nearly all of the significant tornadoes produced in the U.S. and for most of the hailstones larger than golf ball size. Supercells are also known to produce extreme winds and flash flooding.

Supercell and spiral updraft View underneath a supercell in picture below.

They are characterized by a rotating updraft (usually cyclonic) which results from a storm growing in an environment of significant vertical wind shear. Wind shear occurs when the winds are changing direction and increasing with height. The most ideal conditions for supercells occurs when the winds are veering or turning clockwise with height. For example, in a veering wind situation the winds may be from the south at the surface and from the west at 15,000 feet (4500 m). Beneath the supercell, the rotation of the storm is often visible as well.

The lowering in the photograph (bottom) represents the wall cloud. The wall cloud is sometimes a precursor to a tornado. If a tornado were to form, it would usually do so within the wall cloud.

