

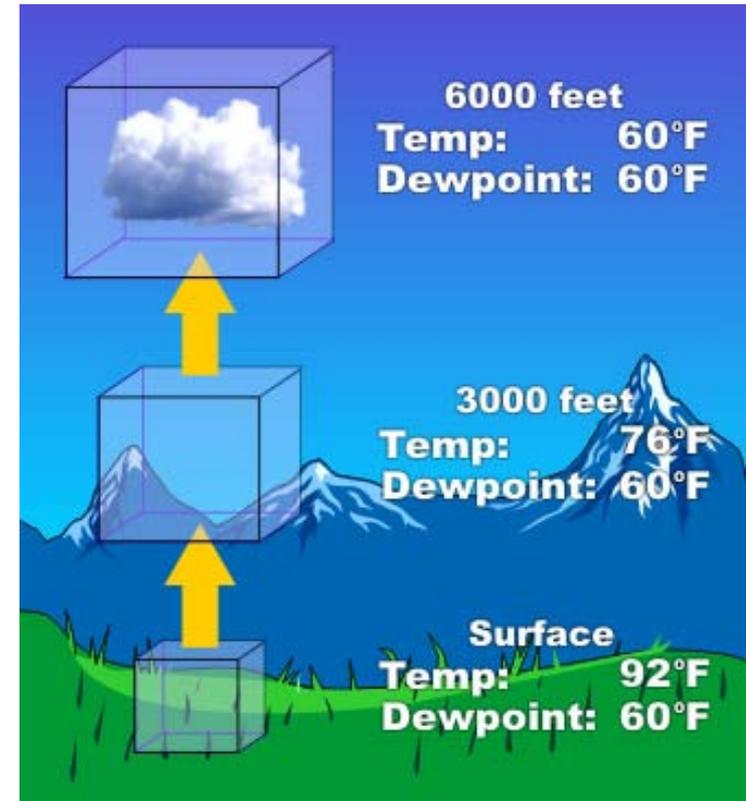
Funding provided by NOAA
Sectoral Applications Research Project

CLOUDS & THUNDERSTORMS

Basic Climatology
Colorado Climate Center

How are clouds made?

- Clouds form when air is cooled to its *dewpoint*
 - Remember *dewpoint*? It's when air becomes saturated
- Often occurs through *lifting*
- As an air parcel rises, it cools, but its moisture remains the same
 - The rate of cooling is called its *lapse rate*, 5.4 ° F per 1000 feet
- When the parcel temperature equals the dewpoint, *condensation* occurs, forming a cloud
 - *Condensation nuclei*, such as salt or dust, provide surfaces onto which water may condense
- Likewise, as air descends it warms
 - Moist air does not heat or cool as quickly as dry air, so air coming out of a thunderstorm may be cooler than its surroundings



Source: NOAA National Weather Service Jetstream

Cloud Types—Stratus, Cumulus, Cirrus

☀ Stratus

- ☀ Low-lying clouds that are wider than they are tall; they often cover a large portion of the sky.
- ☀ Includes:
 - ☀ Fog—A cloud that often forms in low-lying areas overnight
 - ☀ Stratus—A low, uniform cloud, that sometimes has drizzle; the sun is usually not visible through it
 - ☀ Nimbostratus—A dark cloud that often covers the entire sky; steady rain/snow falls from its base
 - ☀ Altostratus—A gray-looking water/ice middle cloud that makes the sun appear “dimly visible”



Cloud Types—Stratus, Cumulus, Cirrus

☀ Cumulus

- ☀ Puffy clouds with relatively flat bases; these clouds can be either wider than they are tall or taller than they are wide
- ☀ Includes:
 - ☀ Cumulus—Small, puffy clouds with relatively flat bases and limited vertical growth
 - ☀ Stratocumulus—A low, lumpy-looking wide-spread cloud with dark and light shading (individual cloud = fist)
 - ☀ Altocumulus—Small puff middle clouds composed of water and ice (individual cloud = thumbnail)
 - ☀ Cumulonimbus—A heavy, dense cloud with great vertical growth—storm cloud



Cloud Types—Stratus, Cumulus, Cirrus

☀ Cirrus

☀ High cloud with a fibrous or feathery appearance

☀ Includes:

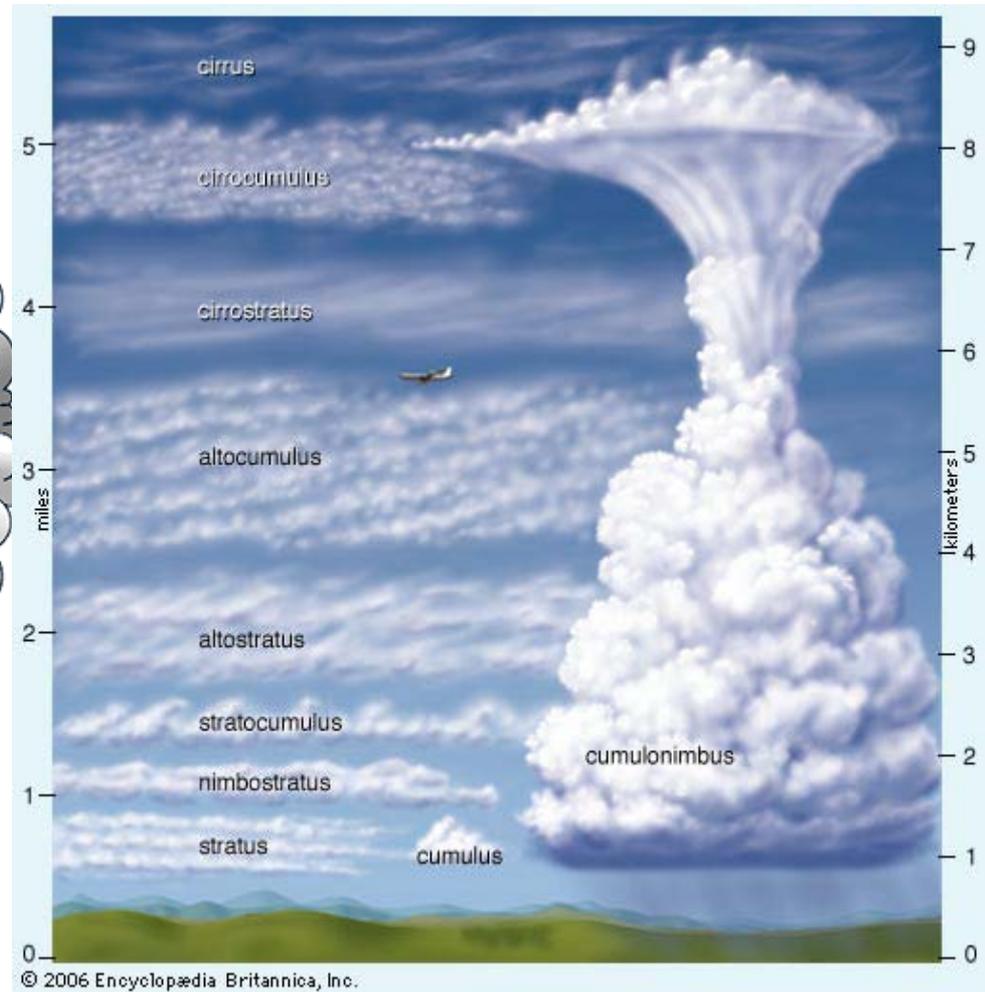
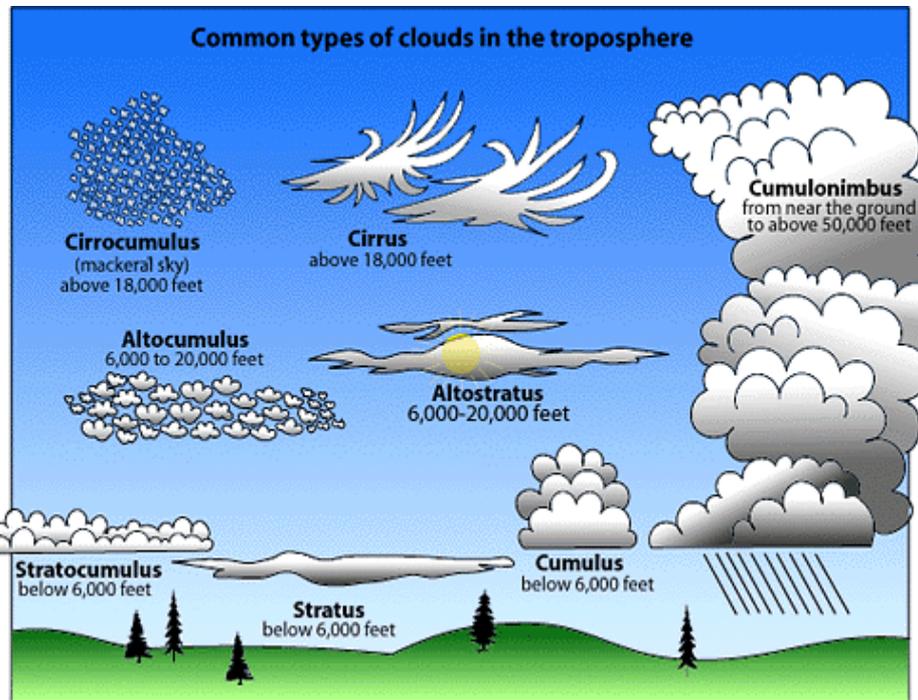
☀ Cirrus

☀ Cirrocumulus—High clouds made of ice; miniature puffs in the form of ripples or grains

☀ Cirrostratus—A white, wide-spread high cloud composed of ice that creates halos around the sun or moon



Cloud Types—Stratus, Cumulus, Cirrus



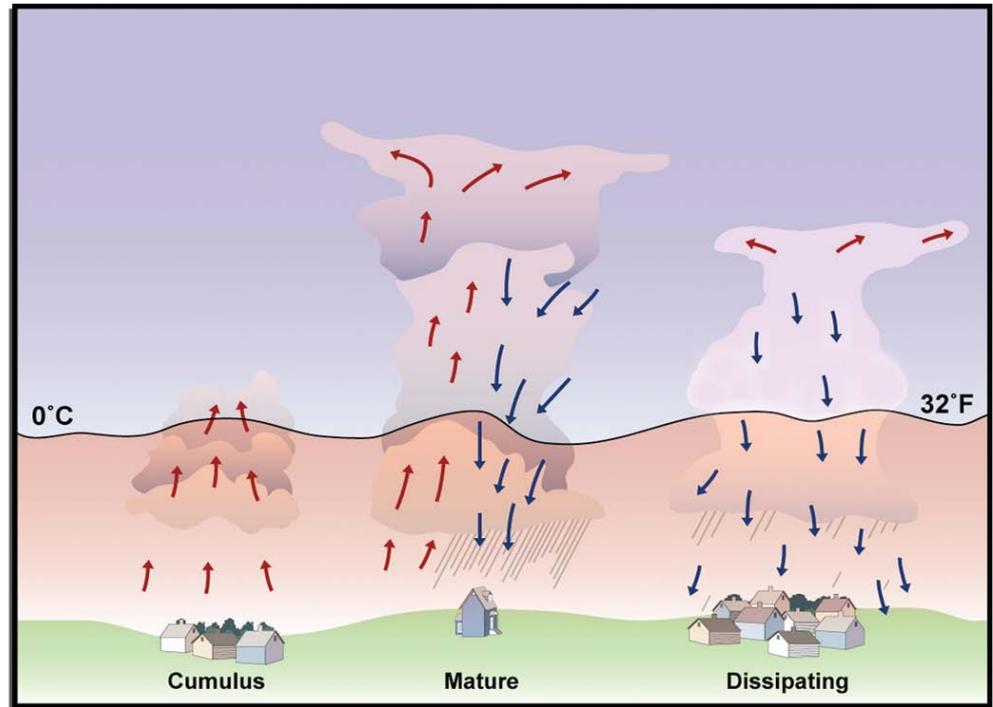


THUNDERSTORMS

Life Cycle of a Thunderstorm

□ Cumulus Stage:

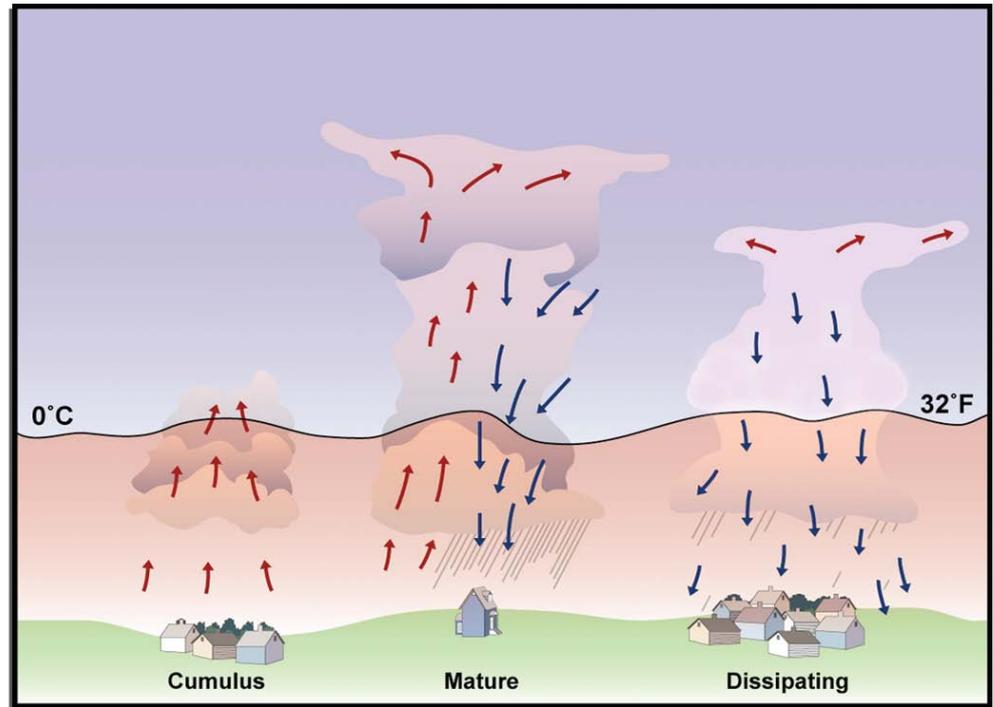
- Towering cumulus cloud indicates rising air
- Usually little if any rain during this stage
- Lasts about 10 minutes
- Occasional lightning during this stage



Life Cycle of a Thunderstorm (cont.)

□ Mature Stage:

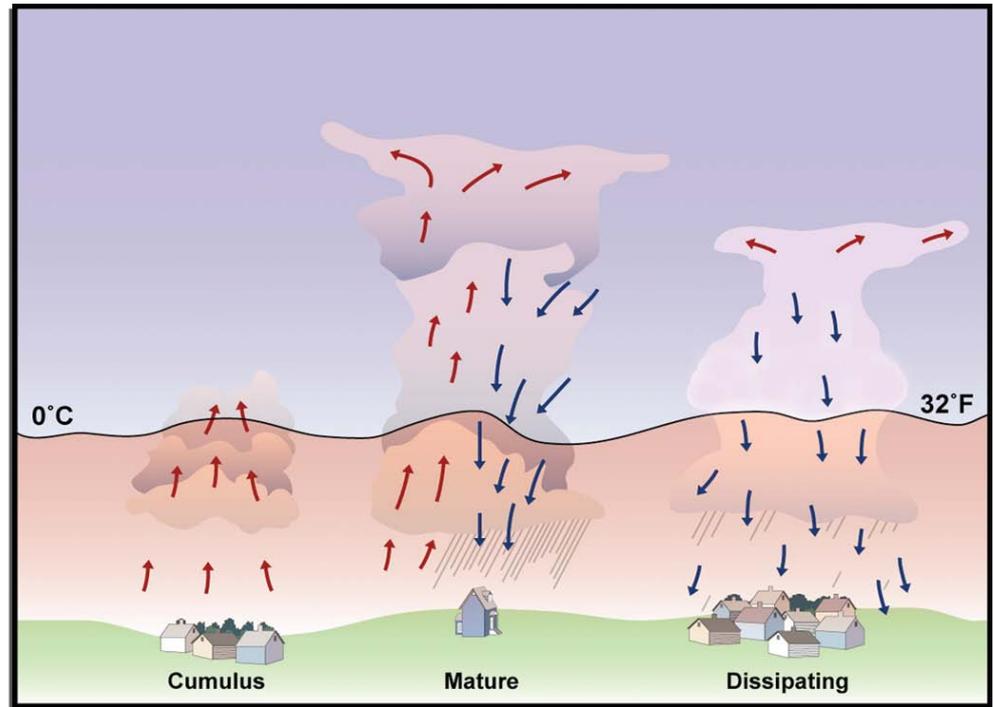
- Most likely time for hail, heavy rain, frequent lightning, strong winds, and tornadoes
- Storm occasionally has a black or dark green appearance
- Lasts an average of 10 to 20 minutes but may last much longer in some storms



Life Cycle of a Thunderstorm (cont.)

□ Dissipating Stage:

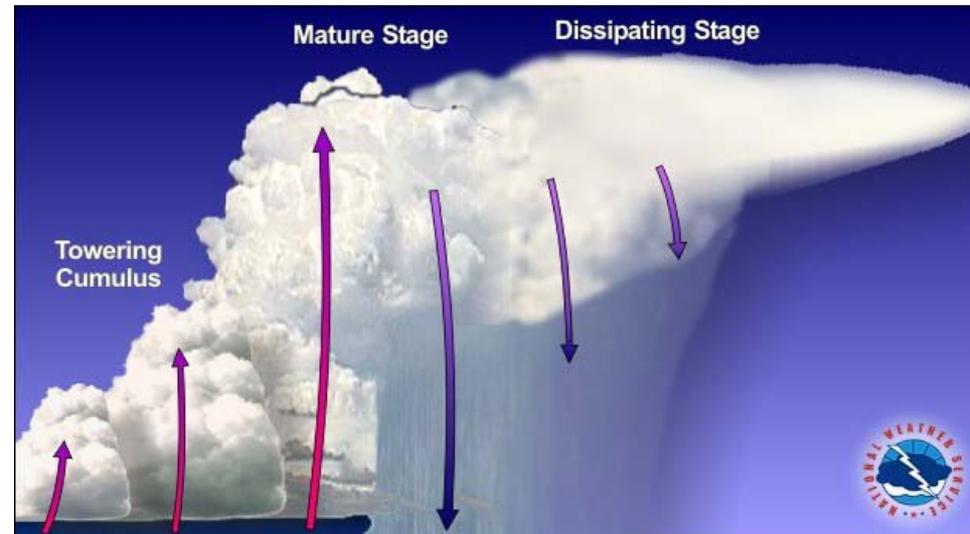
- Rainfall decreases in intensity
- Some thunderstorms produce a burst of strong winds during this stage
- Lightning remains a danger during this stage



Types of Thunderstorms

Multicell Cluster

- Main threat: flooding rains
- Cells carried downstream by prevailing winds as they mature
- If speed of development matches speed of movement, may have “training echoes” producing heavy rainfall over the same place

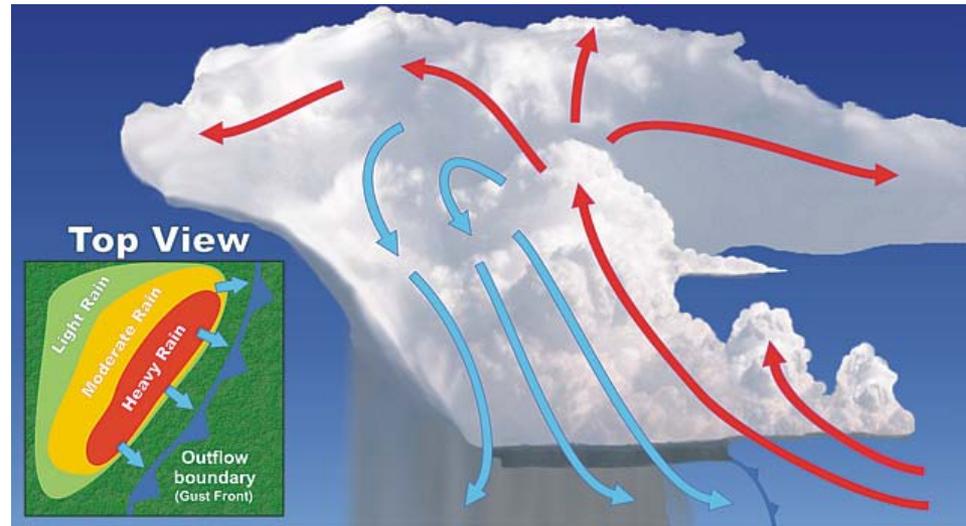


Source: NOAA National Weather Service Jetstream

Types of Thunderstorms

Multicell Squall Line

- ❑ Main threat: damaging winds and hail
- ❑ Cells form along leading edge of a boundary, such as a cold front
- ❑ Downdraft of rain-cooled air reinforces the boundary, creating additional lift
- ❑ Line may stretch for 100 miles or longer
- ❑ Persists for hours
- ❑ **Rare for Colorado**

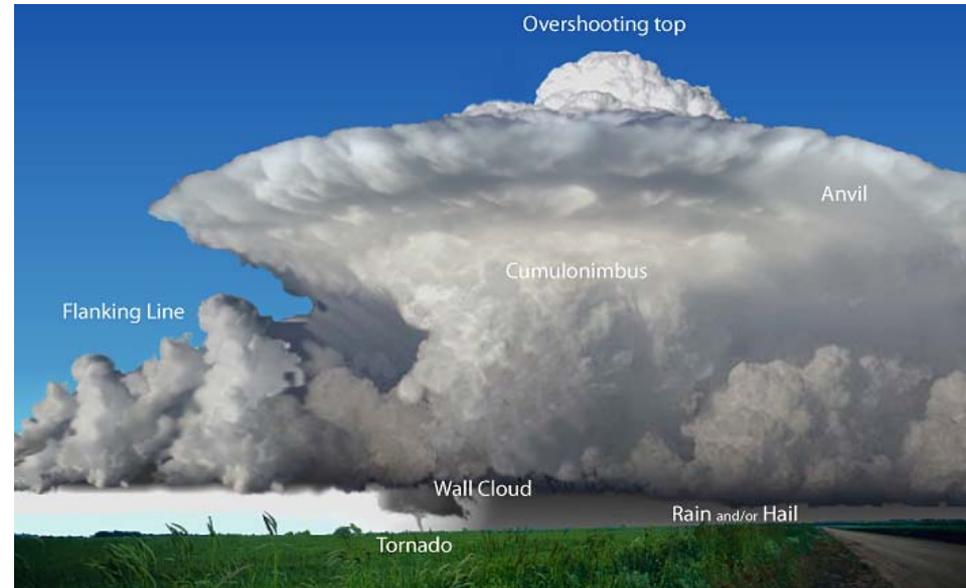


Source: NOAA National Weather Service Jetstream

Types of Thunderstorms

Supercells

- Main threat: tornadoes, large hail, strong winds, flash flooding
- Single-cell thunderstorm, may persist for hours
- Wind shear (change in direction and speed with height) produces rotation within the storm
- Updraft is tilted so that rain (and associated cooler air) is downwind of the storm's energy source



Source: NOAA National Weather Service Jetstream

Thunderstorm Ingredients

☀ Necessary ingredients for convection:

☀ **Moisture**

☀ **Instability**

☀ **Lift**

☀ For long-lived, rotating storms (*supercells*), we also need *Shear*.



Thunderstorm Ingredients

☀ Ingredient #1: **Moisture**

☀ It is the “fuel” for storms.

☀ Typically, we want surface dewpoints above 50-55° F.

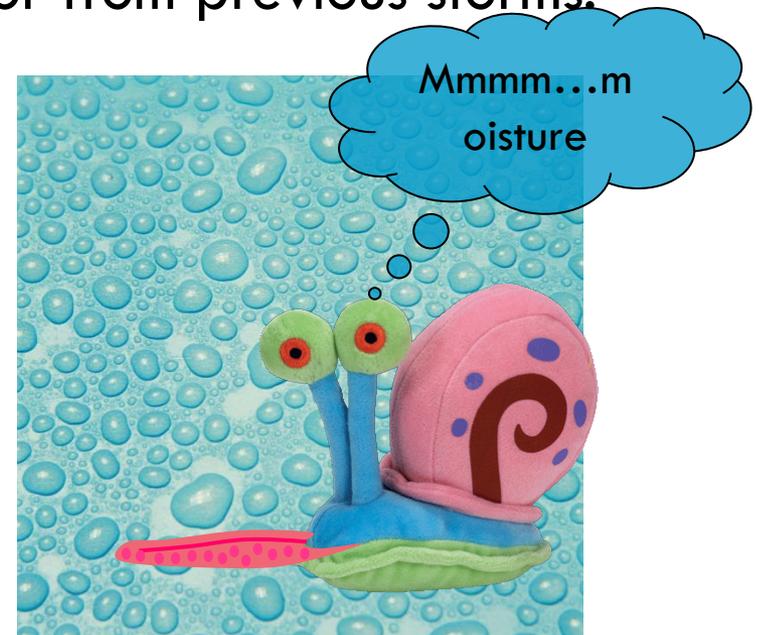
☀ It comes from large bodies of water, large areas of vegetation or irrigated regions, or from previous storms.

☀ Related terms that you might hear on the news:

☀ Tropical Moisture

☀ Dewpoints

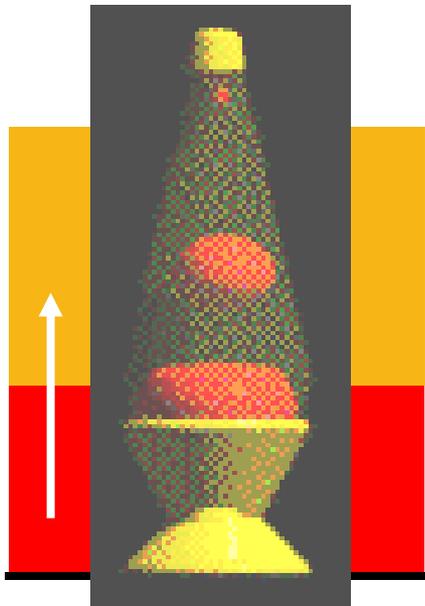
☀ Low-level moisture



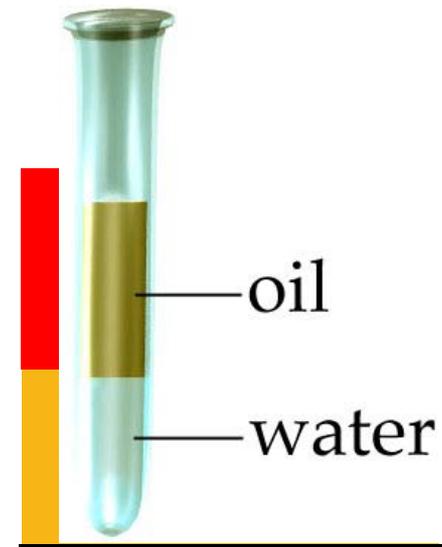
Thunderstorm Ingredients

☀ Ingredient #2: Instability

- ☀ It is the “engine”.
- ☀ Does the atmosphere support rising motion?
 - ☀ Rising motion can occur when the mid to upper atmosphere is cooler (more dense) than the lower atmosphere (less dense).
 - ☀ Large instability can mean stronger updrafts.



Unstable (Lava lamp)



Stable (Oil and water)

Thunderstorm Ingredients

☀ Ingredient #3: Lift

☀ It is the “trigger”—the initiating “push” that is required to start storms

☀ It is caused by:

☀ Boundaries

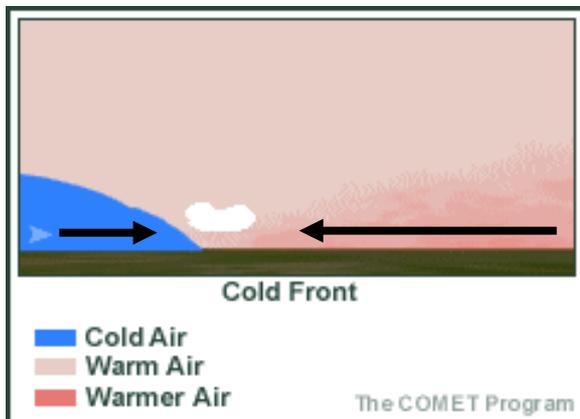
☀ Front

☀ Dryline

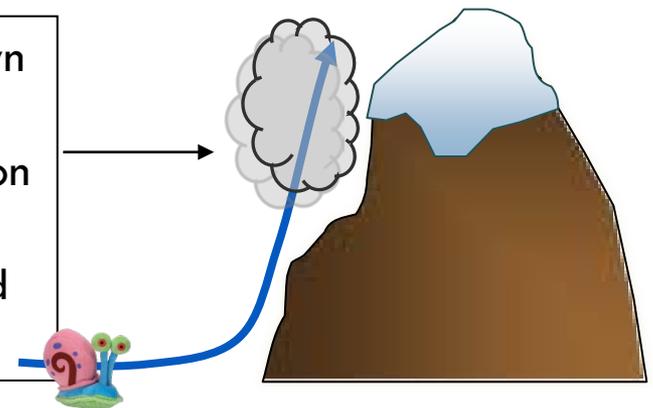
☀ Outflow boundary

☀ Sea breeze

☀ Mountains



The T cools down to near the T_d and condensation occurs, which creates a cloud



Thunderstorm Ingredients

☀ Special Ingredient: Shear

☀ It helps storms to survive longer; it may create rotation.

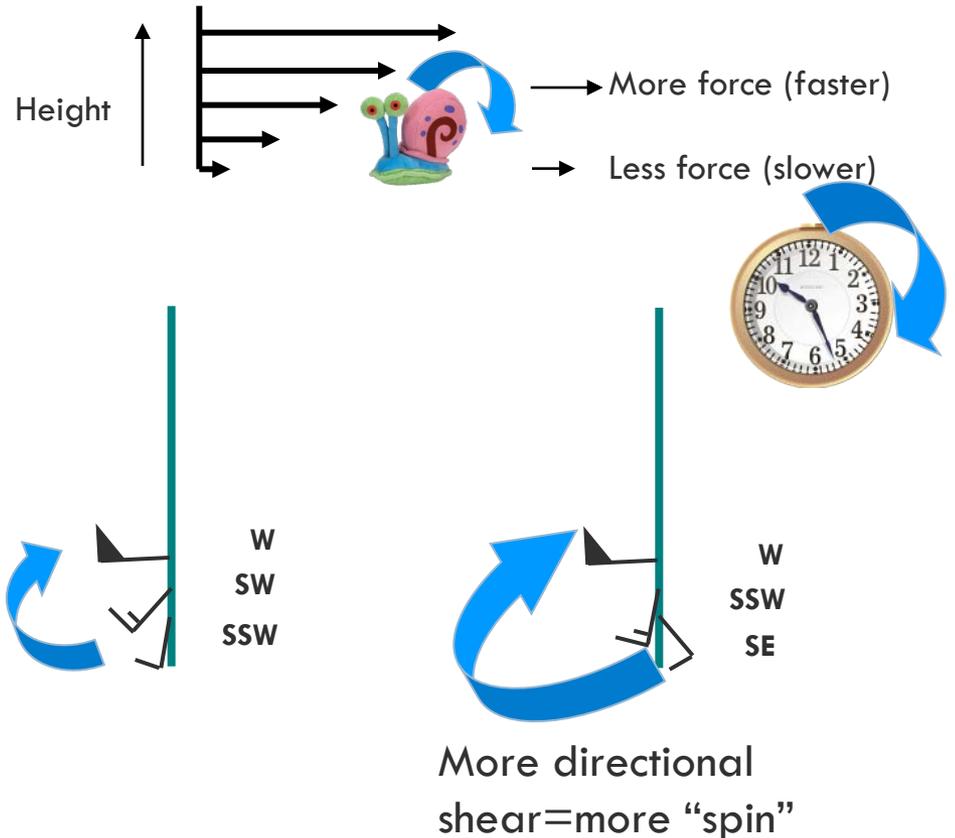
☀ It is defined as the turning and/or increasing of winds with height.

☀ We are mostly concerned with vertical wind shear.

☀ Typically, wind speed increases with height.

☀ The atmosphere can create “spin” (or vorticity) by speed or directional shear.

☀ For severe weather, look for a veering (clockwise) wind profile with height.



Thunderstorm Ingredients

- ☀ If we mix all of the ingredients together, do we get storms?
 - ☀ Not always!
 - ☀ The ingredients are an indicator of **potential** for storms.
 - ☀ A strong cap can stop convection completely, or it can stop it just long enough to create really strong storms later in the day.

