Funding provided by NOAA
Sectoral Applications Research Project

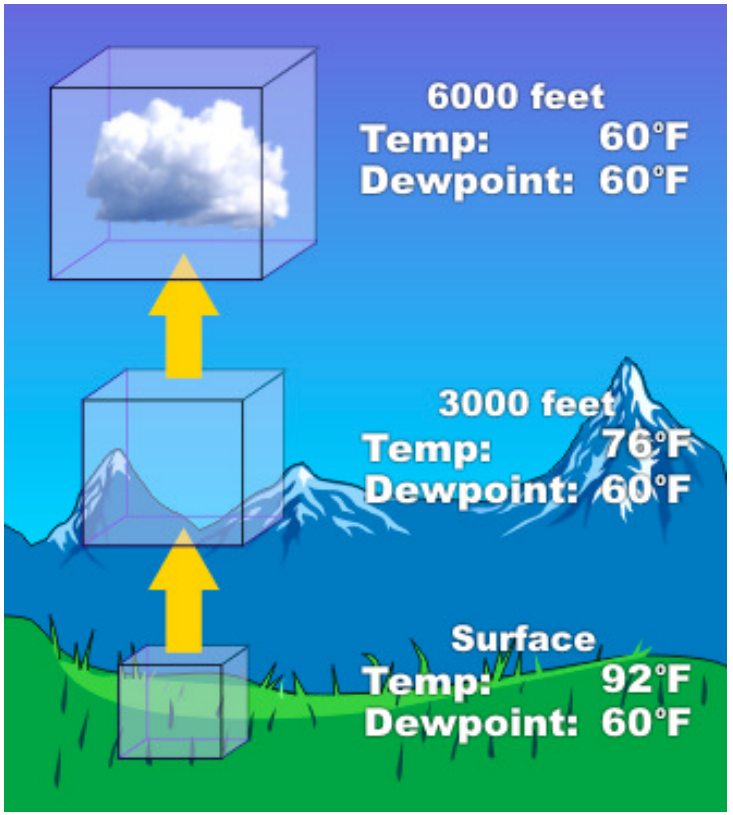
CLOUDS & THUNDERSTORMS

Basic Climatology

Oklahoma Climatological Survey

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 it's 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

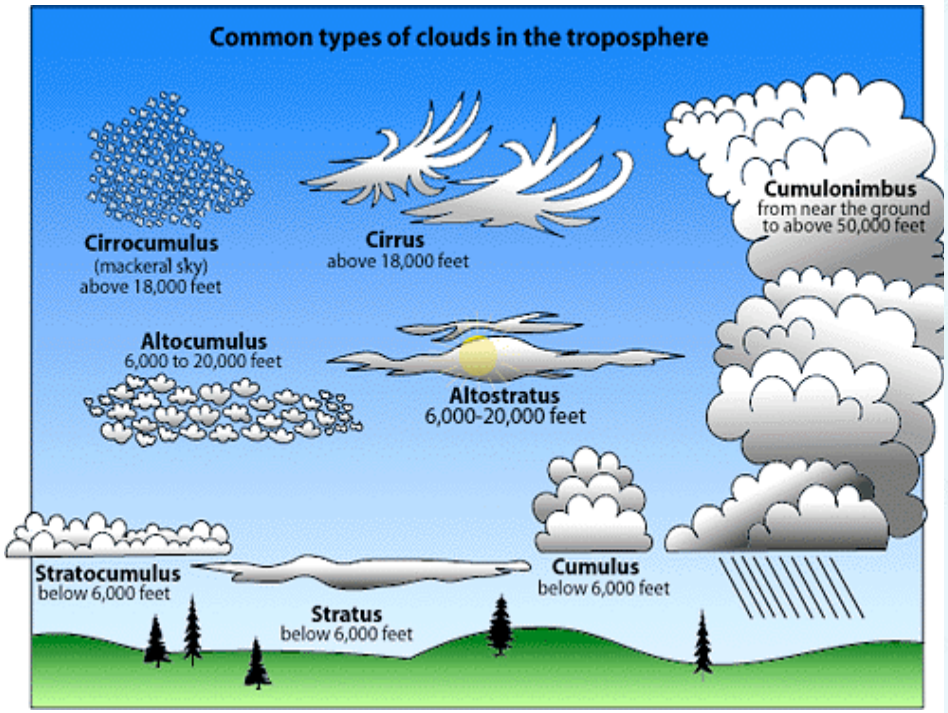


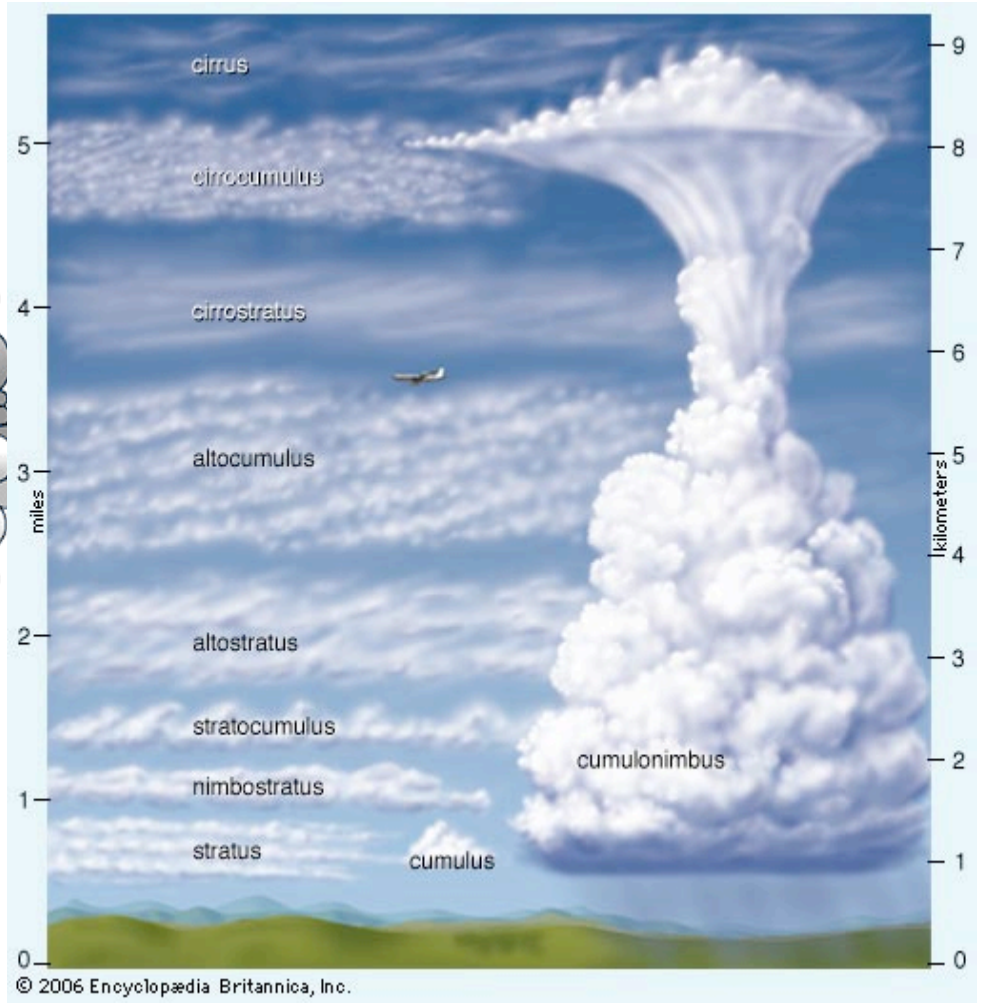

Cloud Types—Stratus, Cumulus, Cirrus

- 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

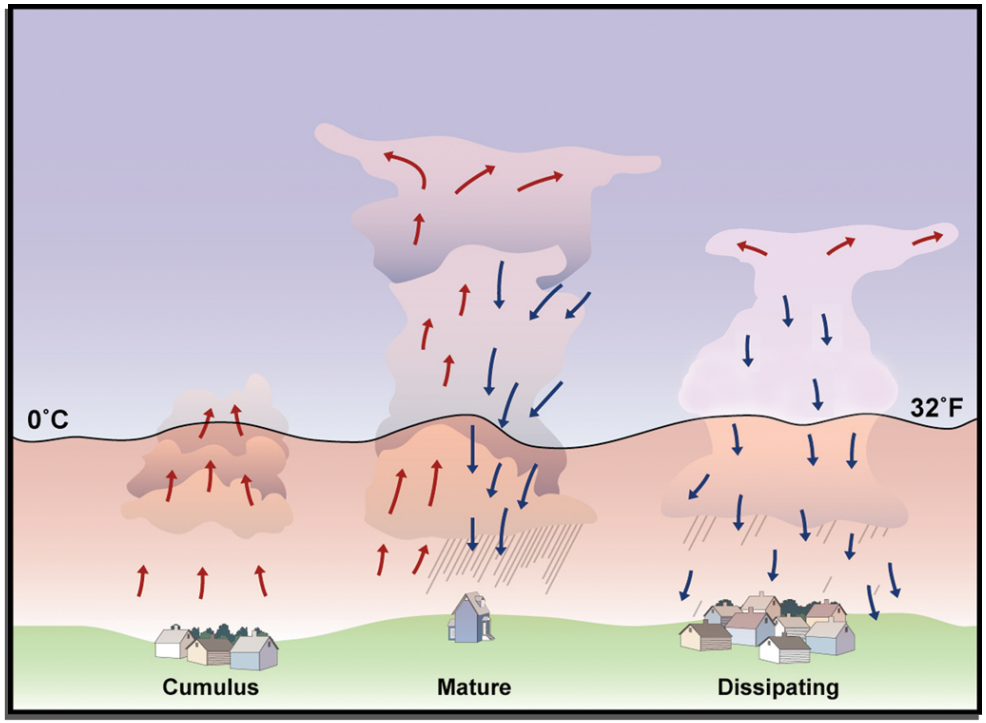




THUNDERSTORMS

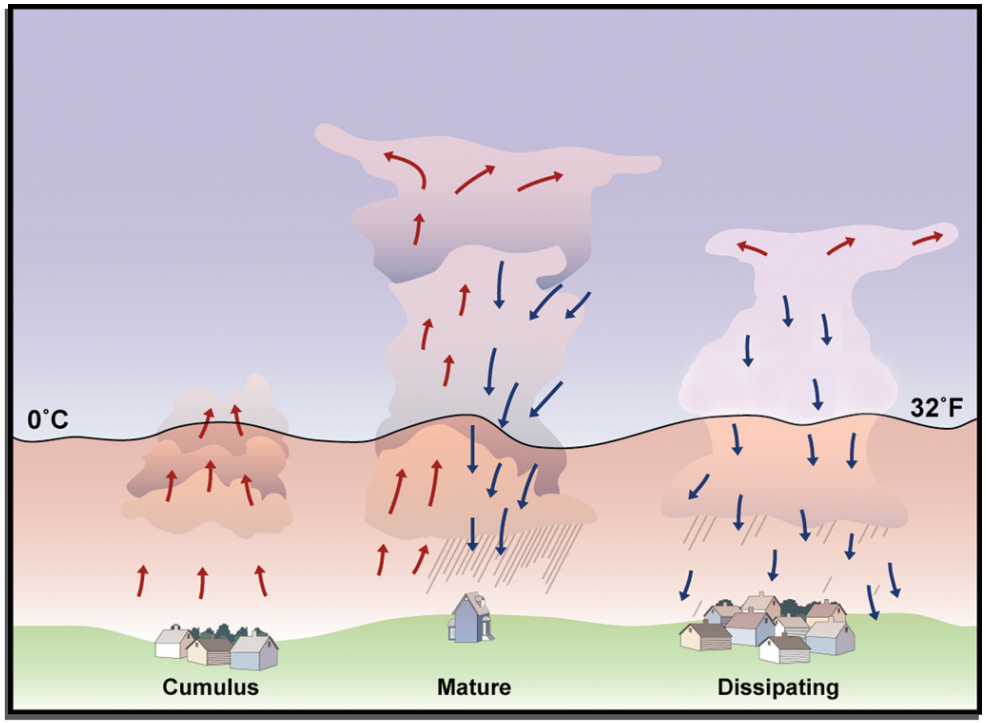
Life Cycle of a Thunderstorm

- 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



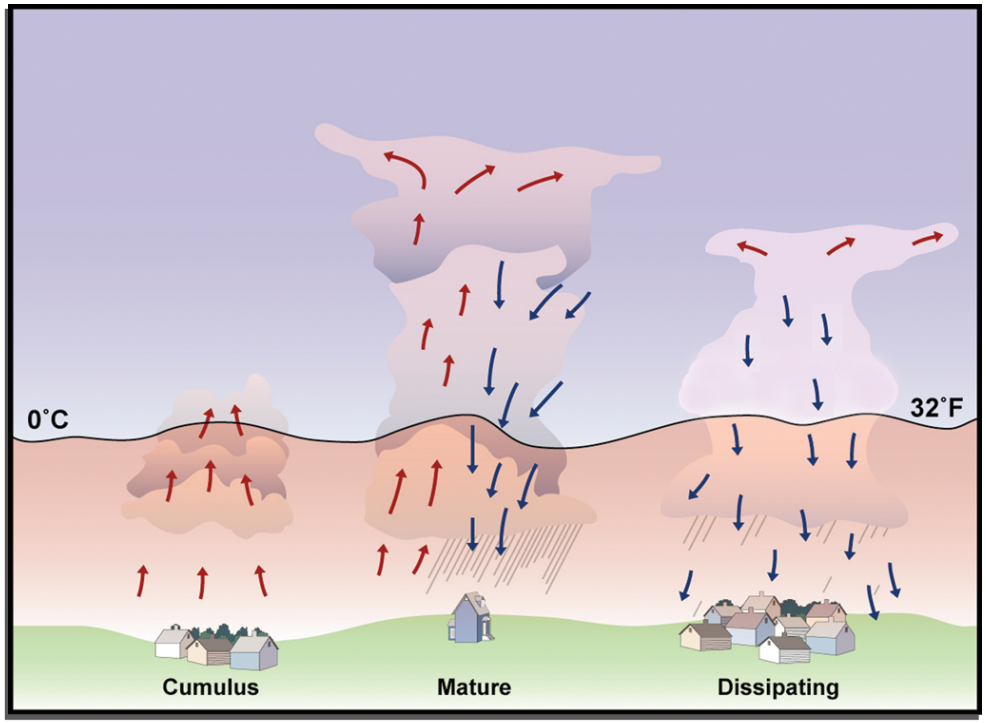
Life Cycle of a Thunderstorm (cont.)

- 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



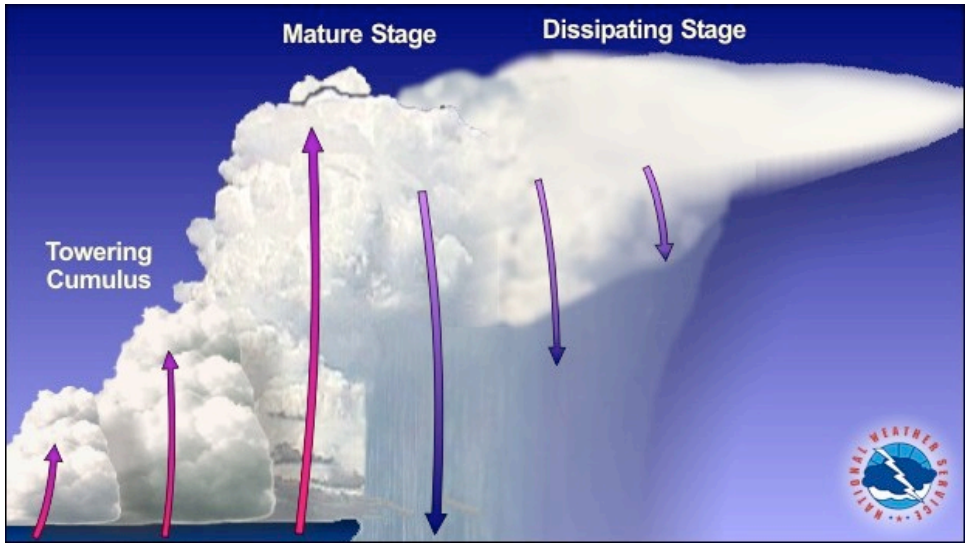
Life Cycle of a Thunderstorm (cont.)

- 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

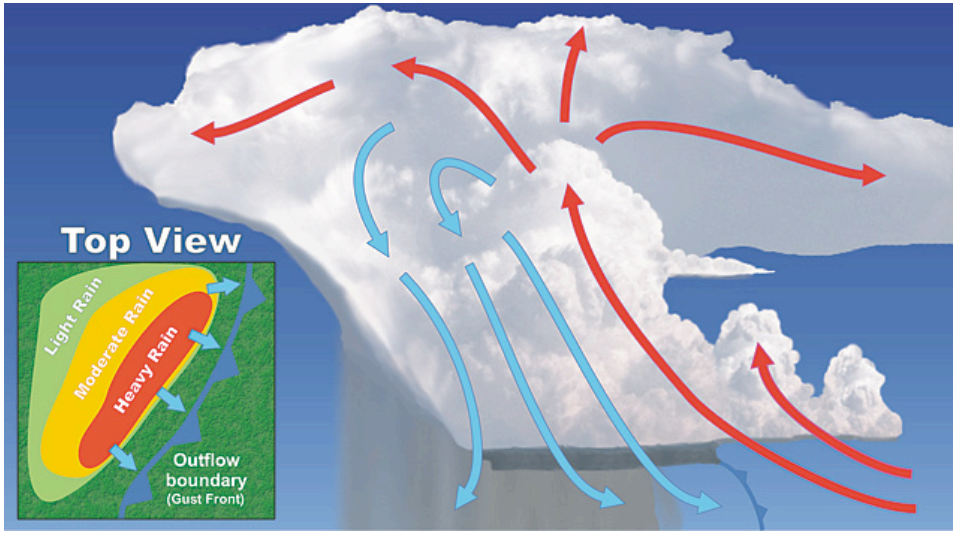
- Main threat: flooding rains
- Cells carried downstream by prevailing winds as they mature
- If speed of development matches speed of movement, may have *"training echoes"* producing heavy rainfall over the same place



Source: NOAA National Weather Service Jetstream

Types of Thunderstorms
Multicell Squall Line

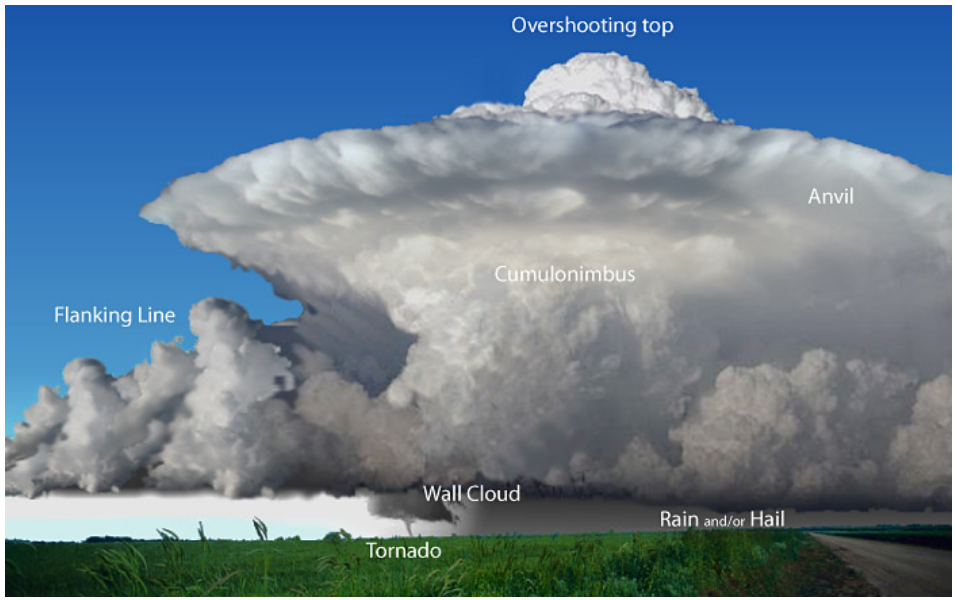
- Main threat: damaging winds and hail
- Cells form along leading edge of a *boundary*, such as a cold front
- *Downdraft* of rain-cooled air reinforces the boundary, creating additional lift
- Line may stretch for 100 miles or longer
- Persists for hours



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

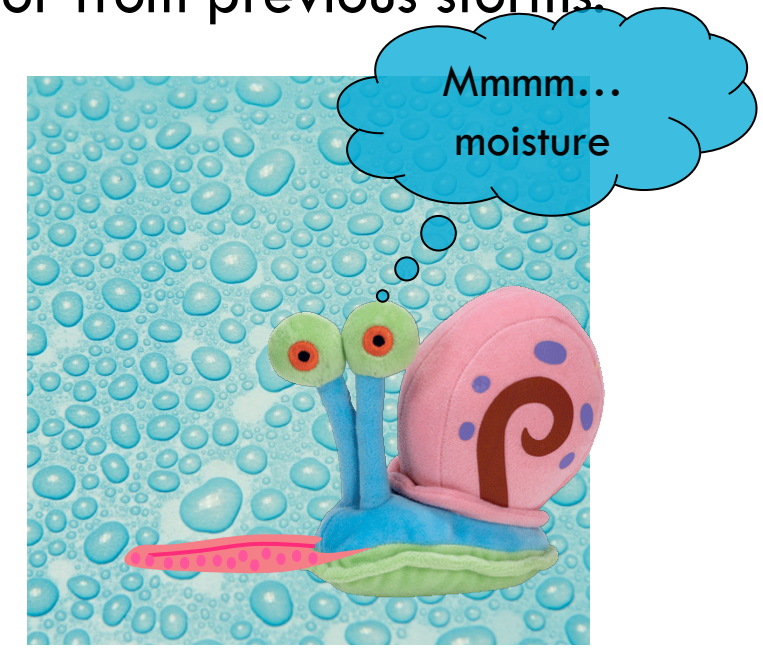
Thunderstorm Ingredients

- Necessary ingredients for convection:
  - **M**oisture
  - **I**nstability
  - **L**ift

- For long-lived, rotating storms (*supercells*), we also need ***S****hear*.

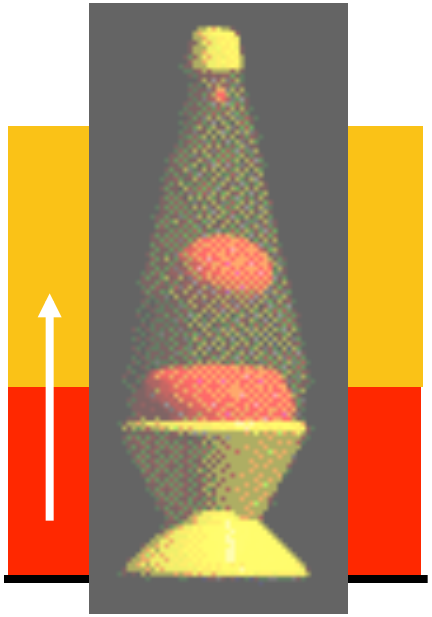
Thunderstorm Ingredients

- Ingredient #1: **M**oisture
  - 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

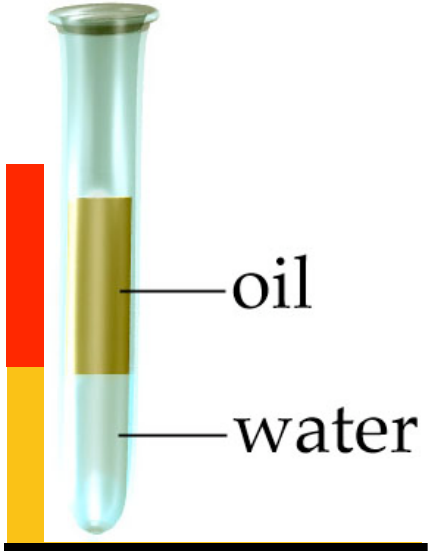


Thunderstorm Ingredients

- 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.



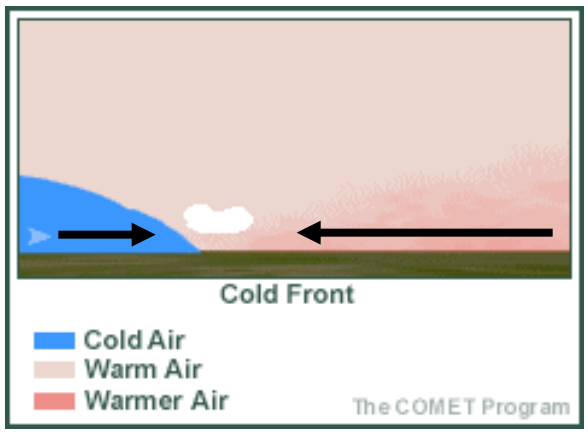
Unstable (Lava lamp)



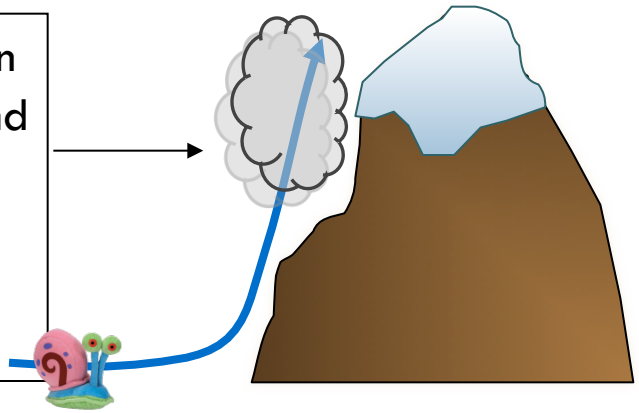
Stable (Oil and water)

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



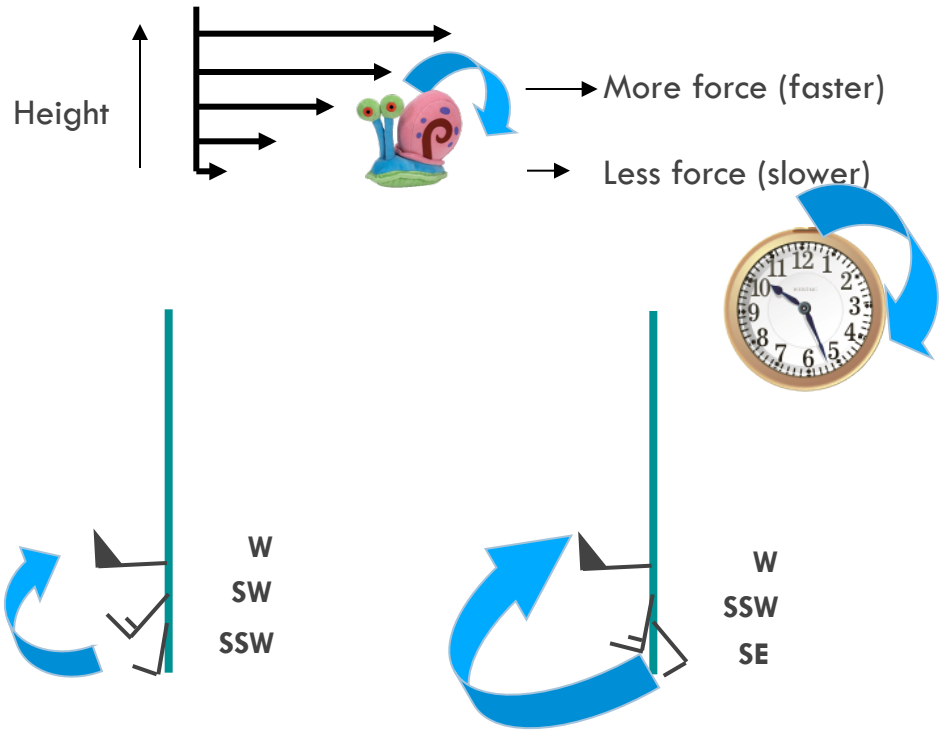
The T cools down to near the T_d and condensation occurs, which creates a cloud



Thunderstorm Ingredients

- Special Ingredient: **S**hear
  - 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.



More directional shear=more "spin"

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.