Severe Thunderstorm Forecasting and Climatology in Arizona

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THUNDERSTORM FORMATION

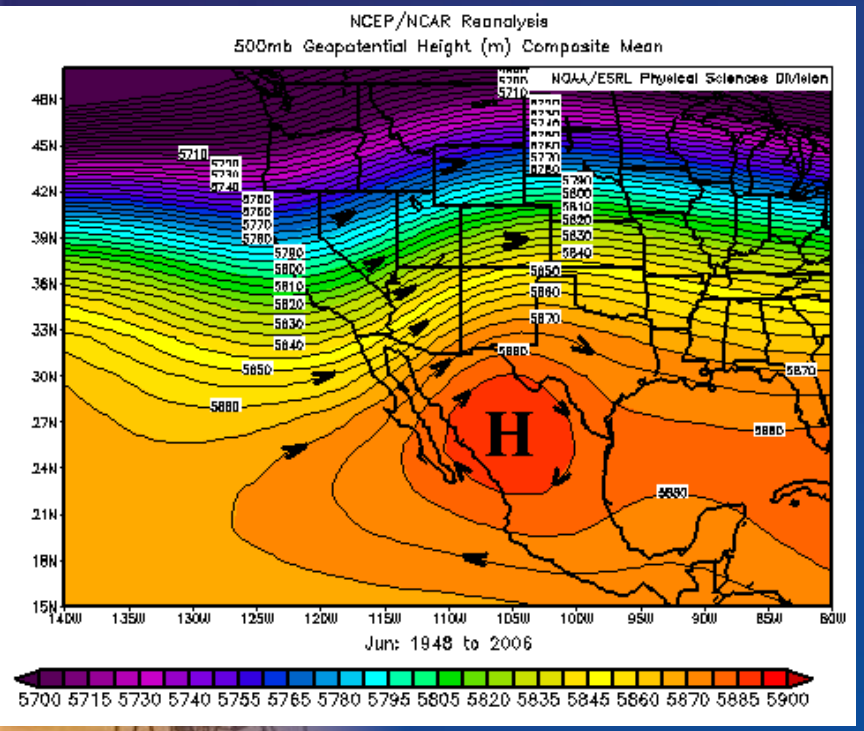
- All thunderstorms result from the same necessary conditions
- What are the necessary conditions?

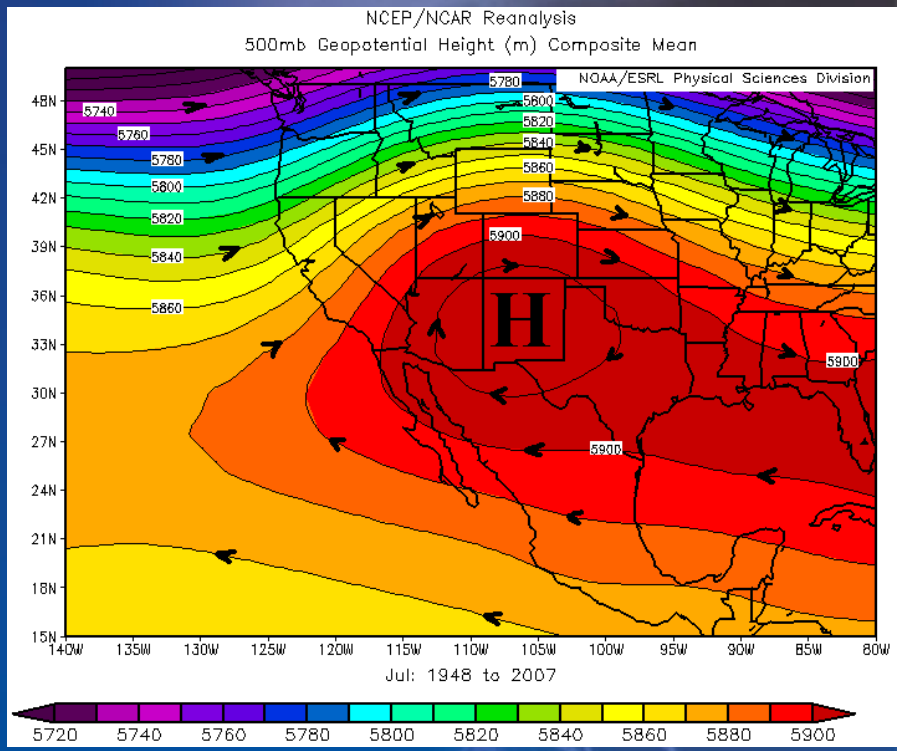
BASIC THUNDERSTORM INGREDIENTS

- Moisture – most notably in the lower levels of the atmosphere
- Instability – ability of air to accelerate up (or down) when given a push
- Lifting Mechanism – The “push” that gets the whole thing started

The North American Monsoon

- 500 mb (~18,000 feet) mean flow

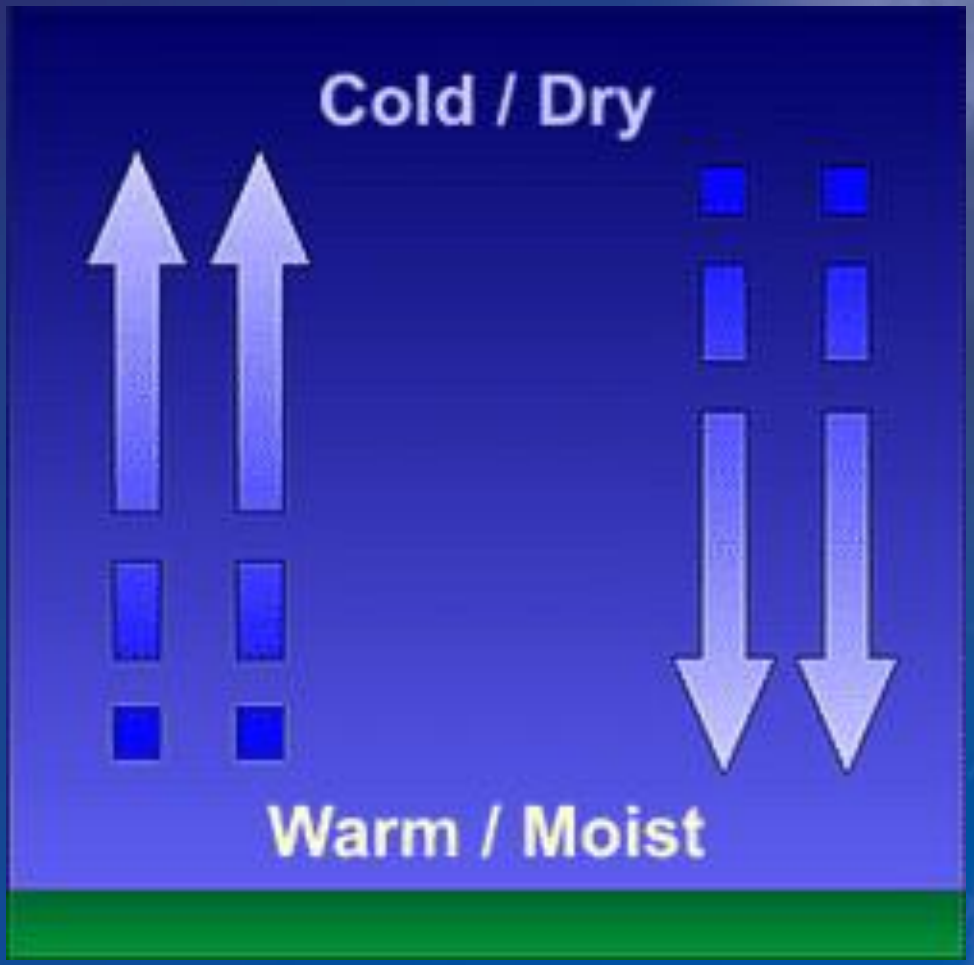




Notice position of the mean upper level high.

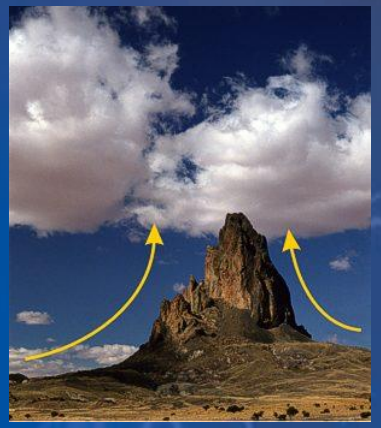
Where does our moisture come from?

Atmospheric Instability

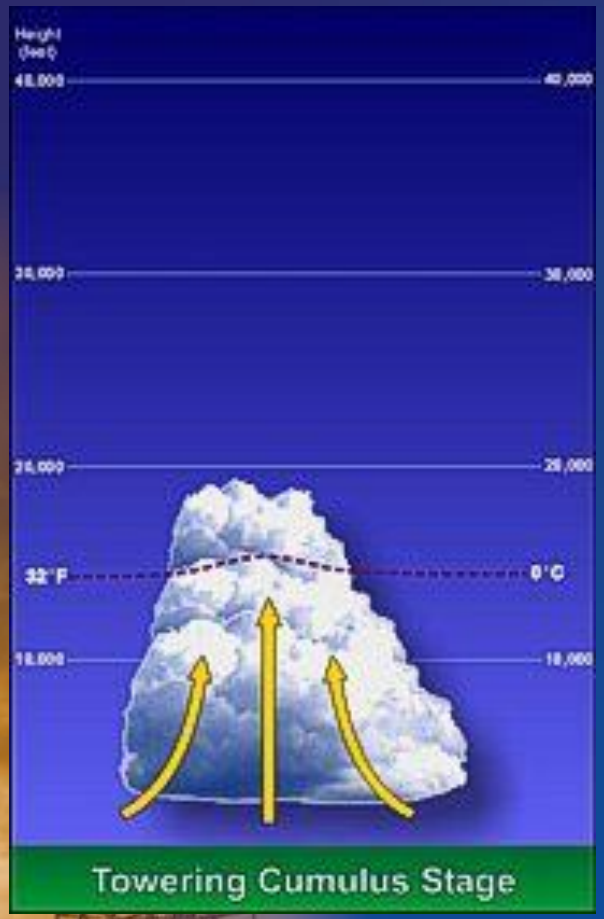


Sources of Lift

- Differential Heating
- Cold Fronts
- Warm Fronts
- Seabreeze Fronts
- Upslope Flow
- Gust Fronts
- Drylines



Towering Cumulus Stage



Hard outline indicates strongest updrafts

Updrafts are the fuel for the thunderstorm.

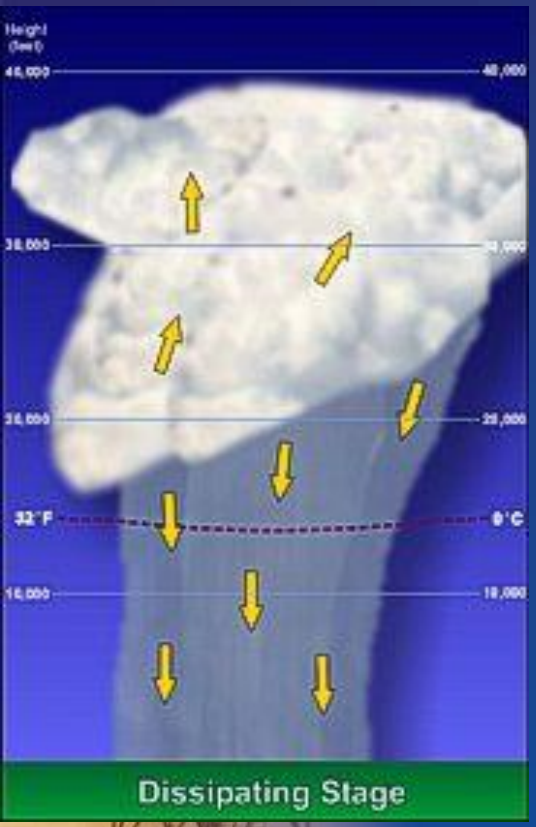
Mature Stage

- Storm now has updraft

  and downdrafts

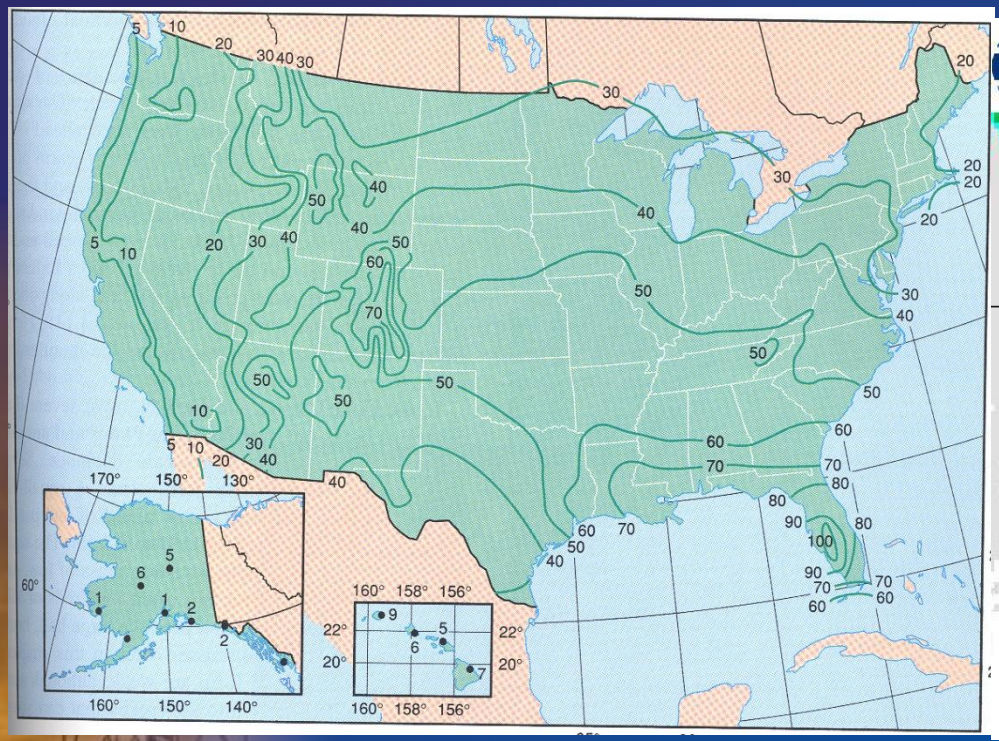
- Downdrafts are recognized as dark fuzzy areas
- Storm is now at its greatest intensity
- Severe weather is most likely at this stage

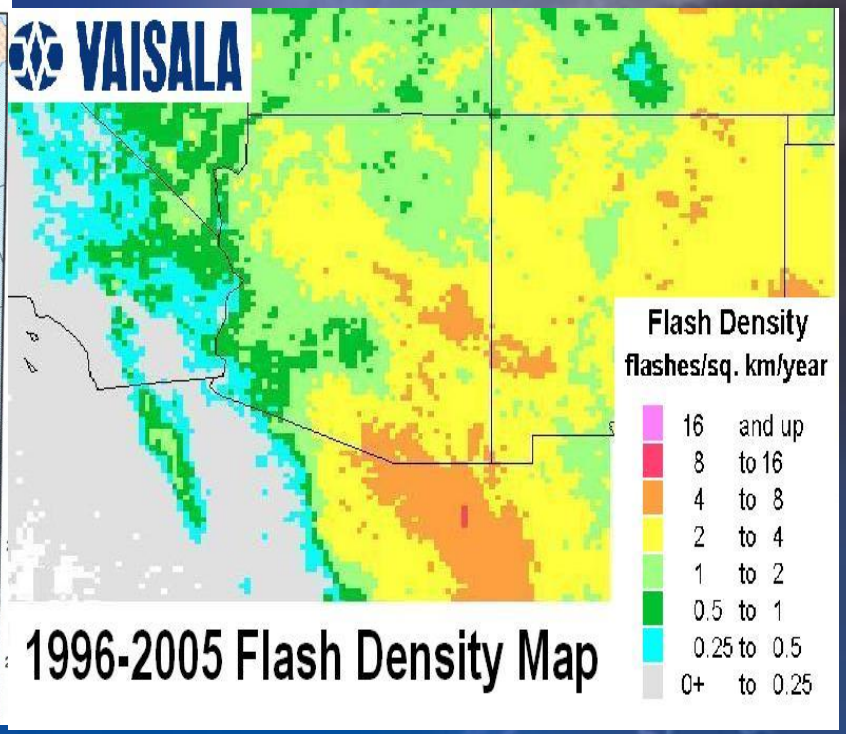
Dissipating Stage



- Storm is predominately downdrafts
- More dark and fuzzy in appearance
- May see an “orphan anvil” (anvil with little or no base below it)
- In some cases microbursts may happen as the storm enters this stage

Thunderstorm Climatology





- Western U.S. lightning generally compressed to just 3 months
- FL is lightning capital of U.S.
- Chihuahua-Sonora border is lightning capital of North America

Lightning Safety

- **When thunder roars, go indoors!**
- **Stay alert and move to indoors ahead of time.**
- **Outdoor locations unsafe (tents, rain shelters, trees, etc.)**
- **Cease hiking, biking, swimming or golfing activities.**
- **Stay in your vehicle! Avoid touching metal.**

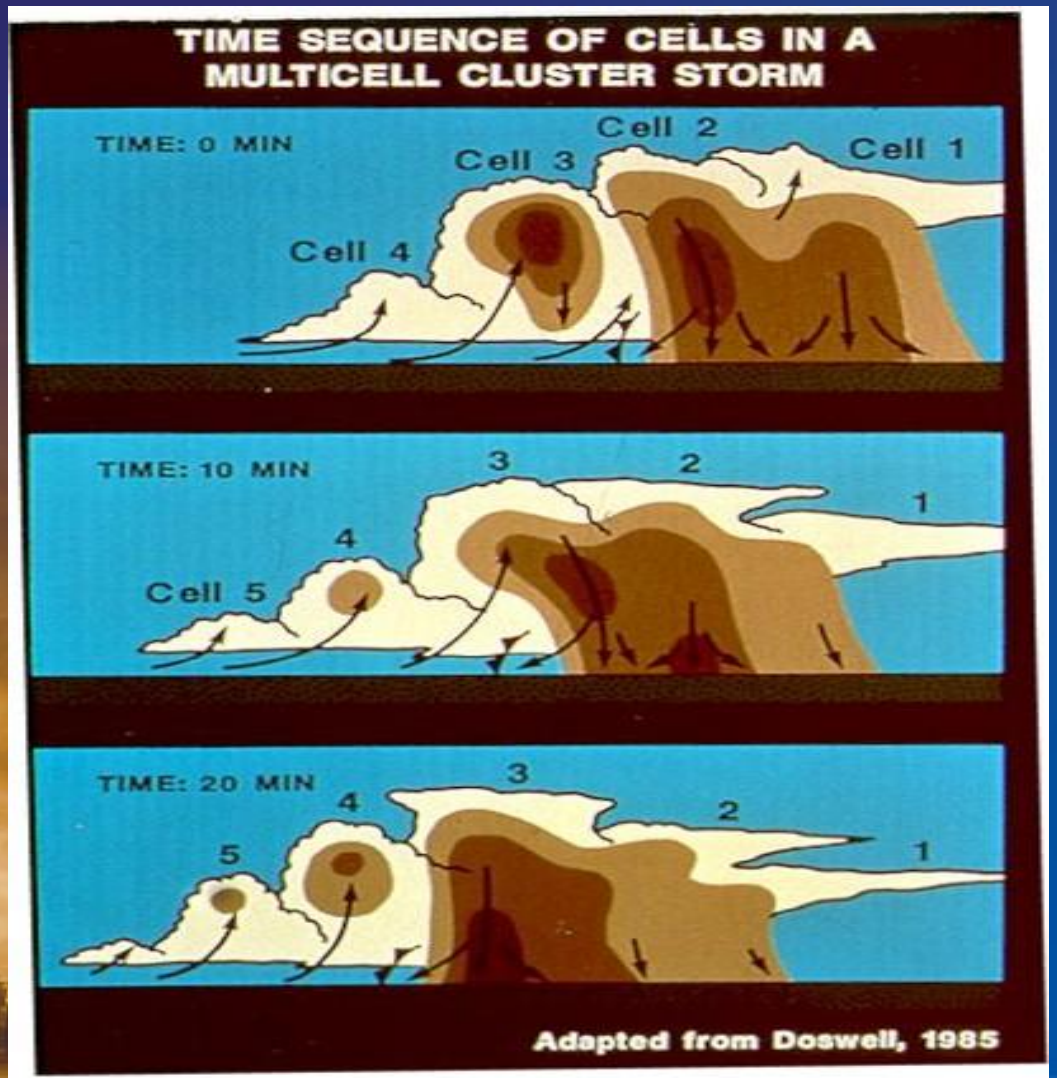
Photo: Vaisala

Thunderstorm Types

- **Pulse/Single Cell Storms**
  - ***Little shear, little organization***
- **Multicell Storms**
  - ***Some shear, organization (lines, clusters)***
- **Supercell Storms**
  - ***Plenty of shear, rotational signatures***

ANY of these storm types can produce "severe" weather

Multicell Thunderstorms



- The clusters are constantly evolving
- As outflow from one cell undercuts another, new development occurs

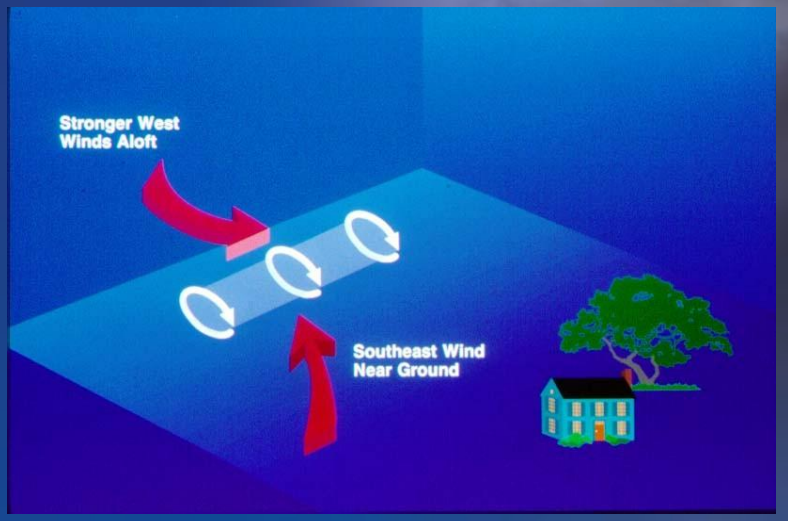
Multicell Thunderstorms

What is a Supercell anyway?

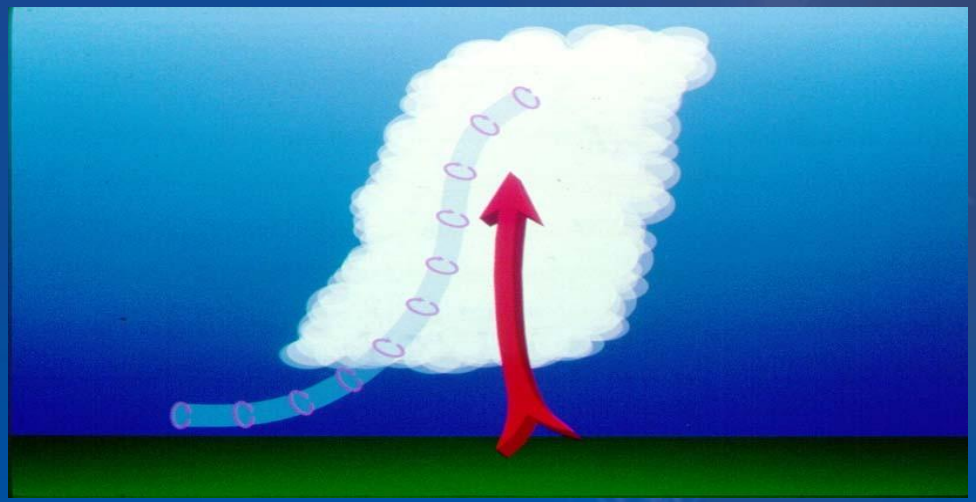
- A Supercell storm is a storm containing a ***mesocyclone.***
  - ***A mesocyclone is a deep, persistent area of rotation several miles in diameter in a thunderstorm.***
  - ***Wind shear is key to its development***

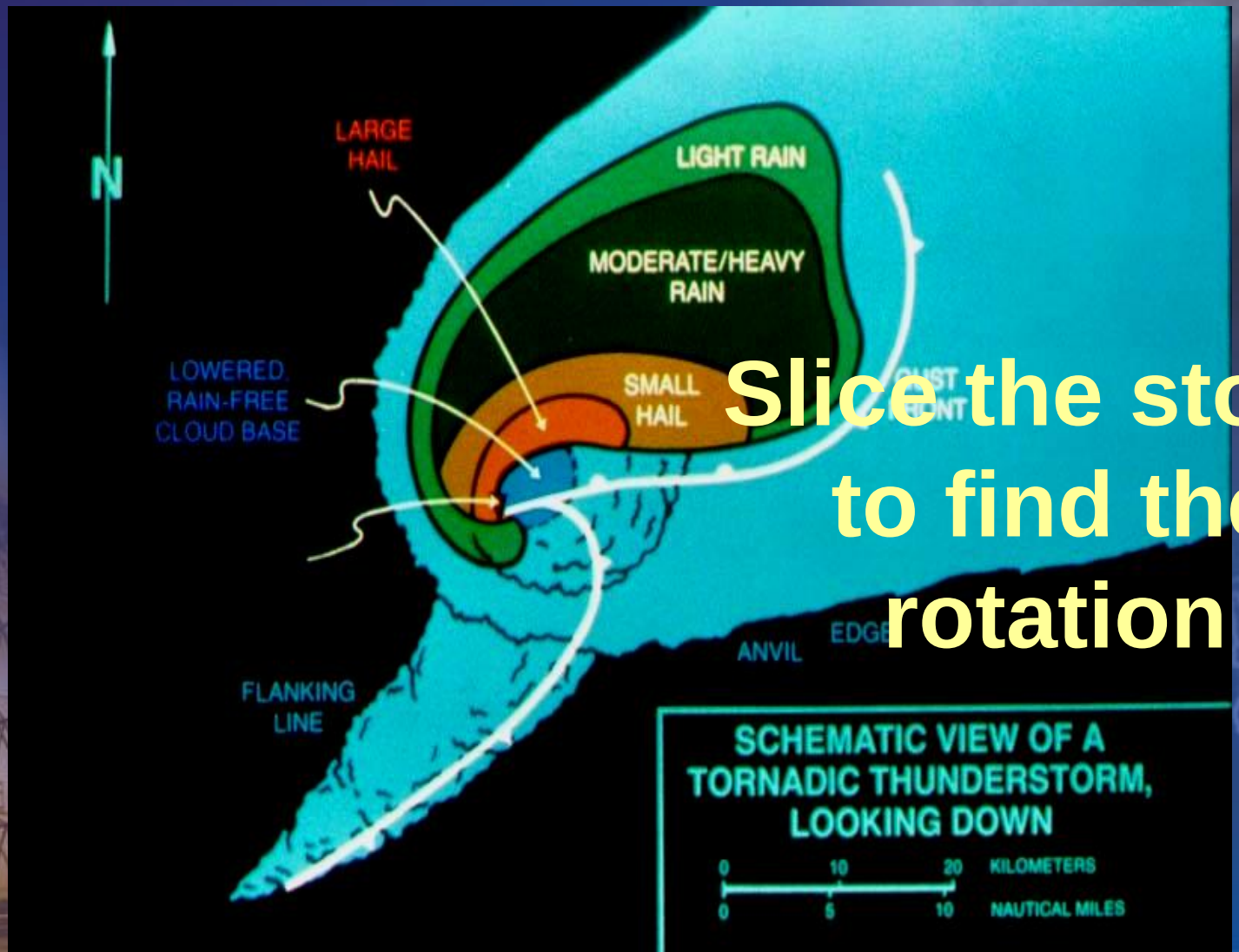
Supercell Development

- Wind shear allows horizontally oriented rolls to develop



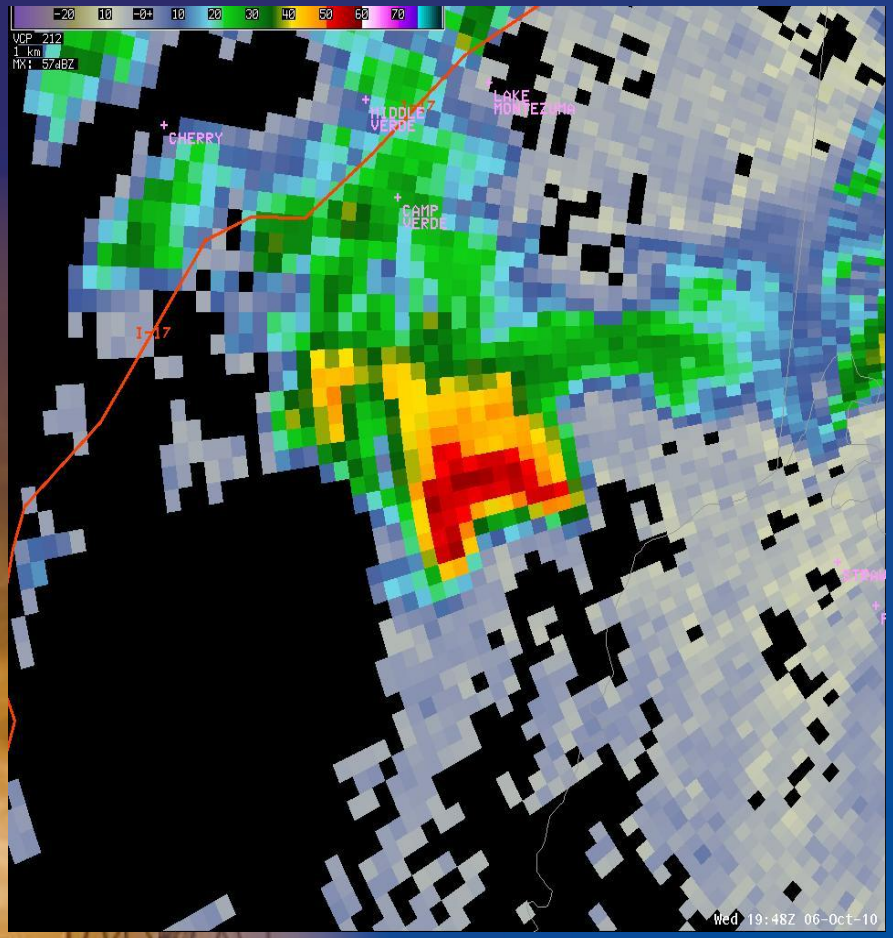
- **As these rolls are tilted into a storm's updraft, the mesocyclone (and supercell) develops.**

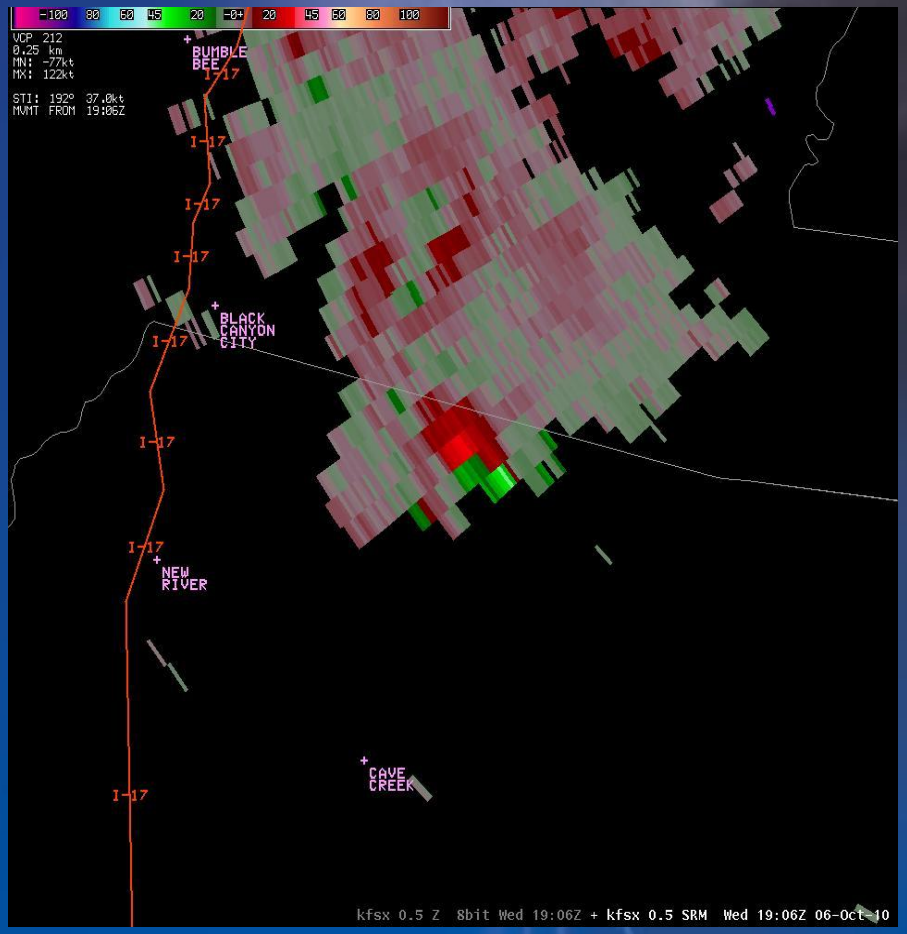




Slice the storm to find the rotation

October 6, 2010

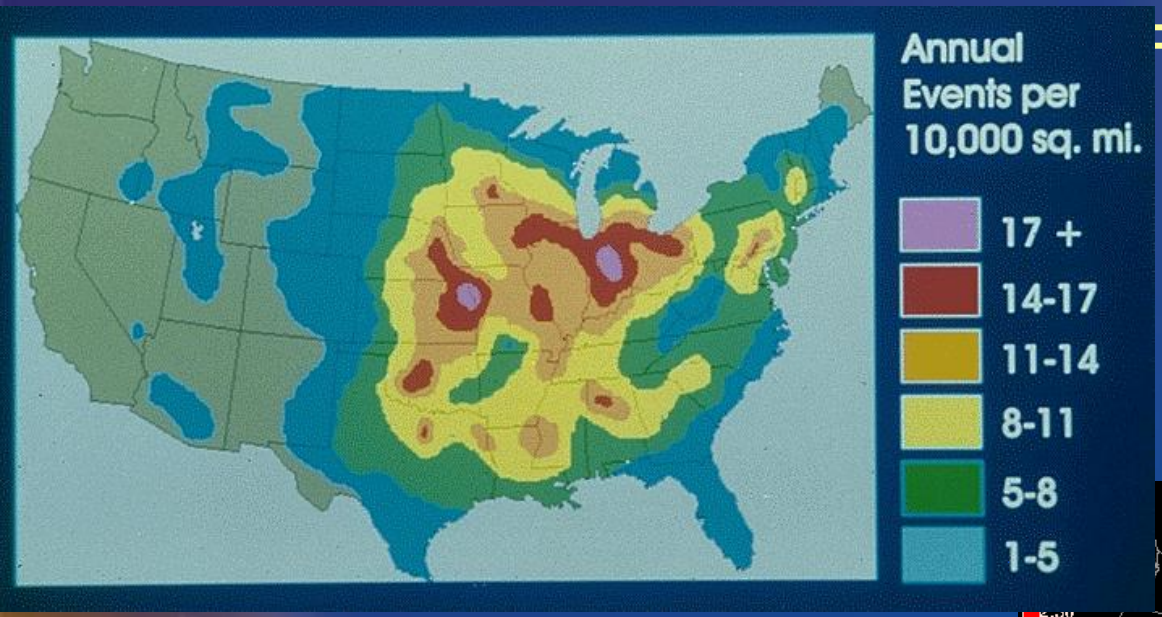


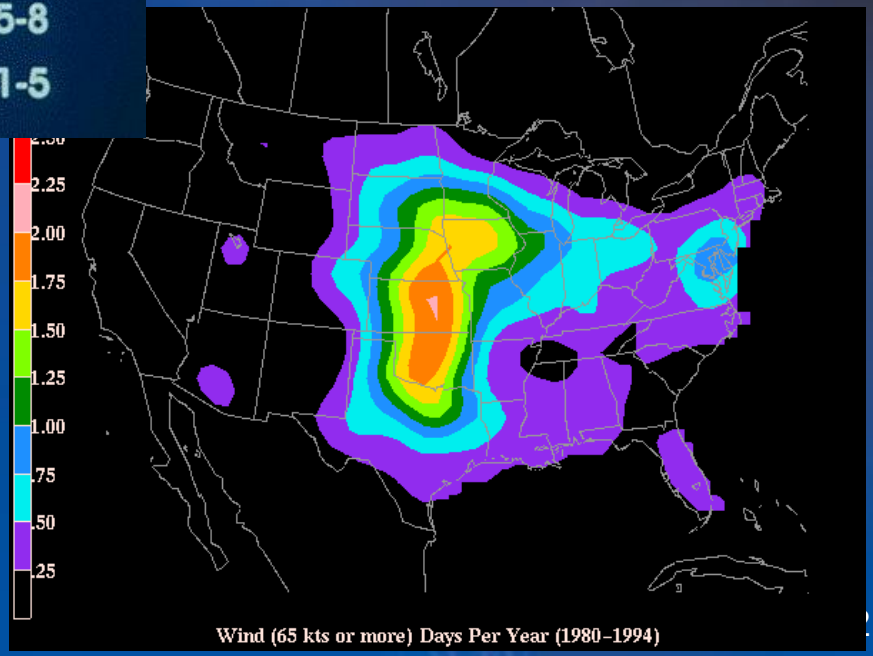


What is a Severe Thunderstorm?

- Wind gusts >=58mph (50kts)
- Hail 1” or larger
- Tornado

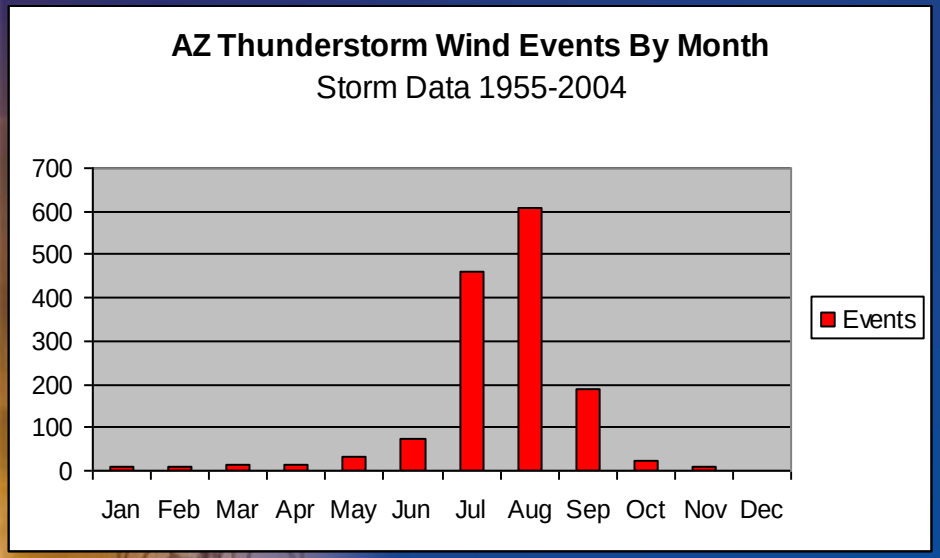
Severe Wind Climatology

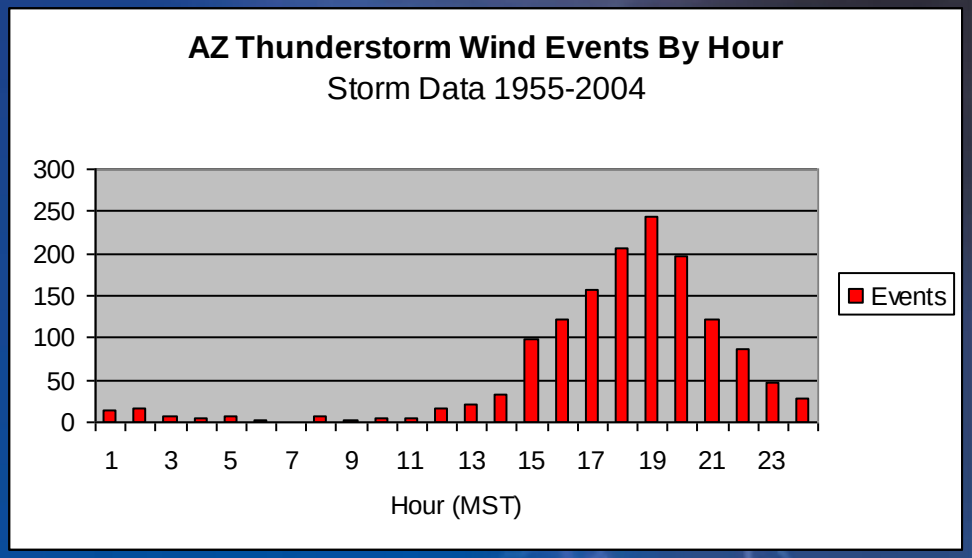




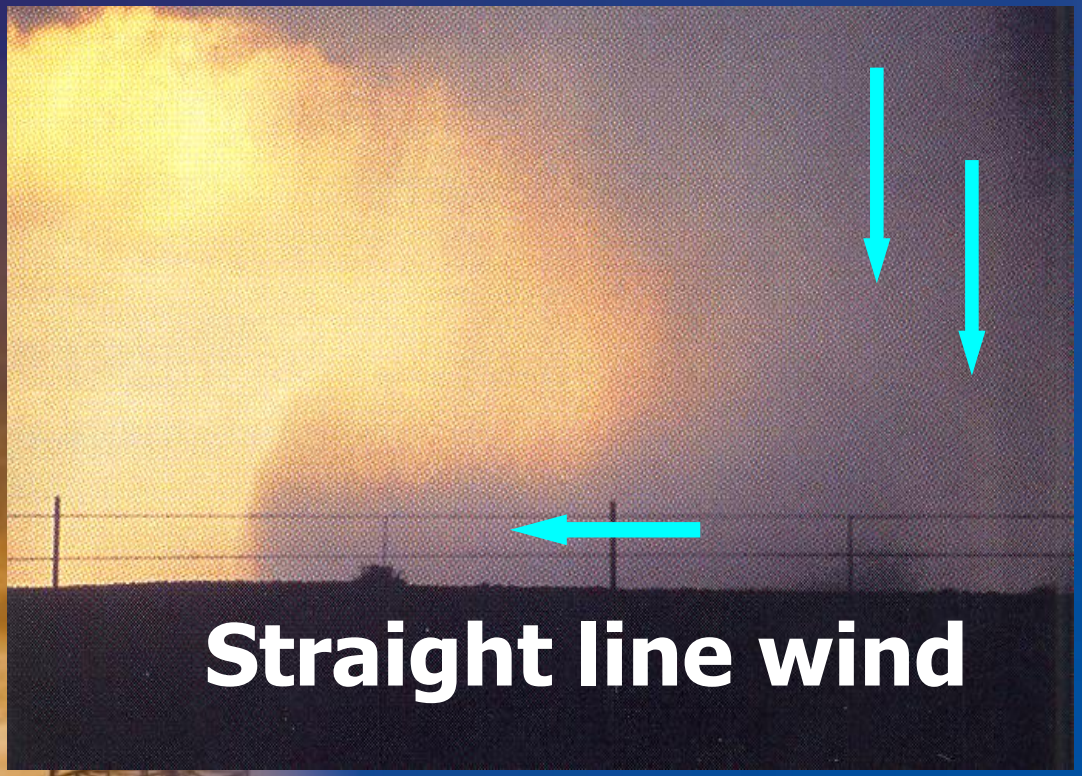
Arizona Severe Thunderstorm Wind

1955-2004



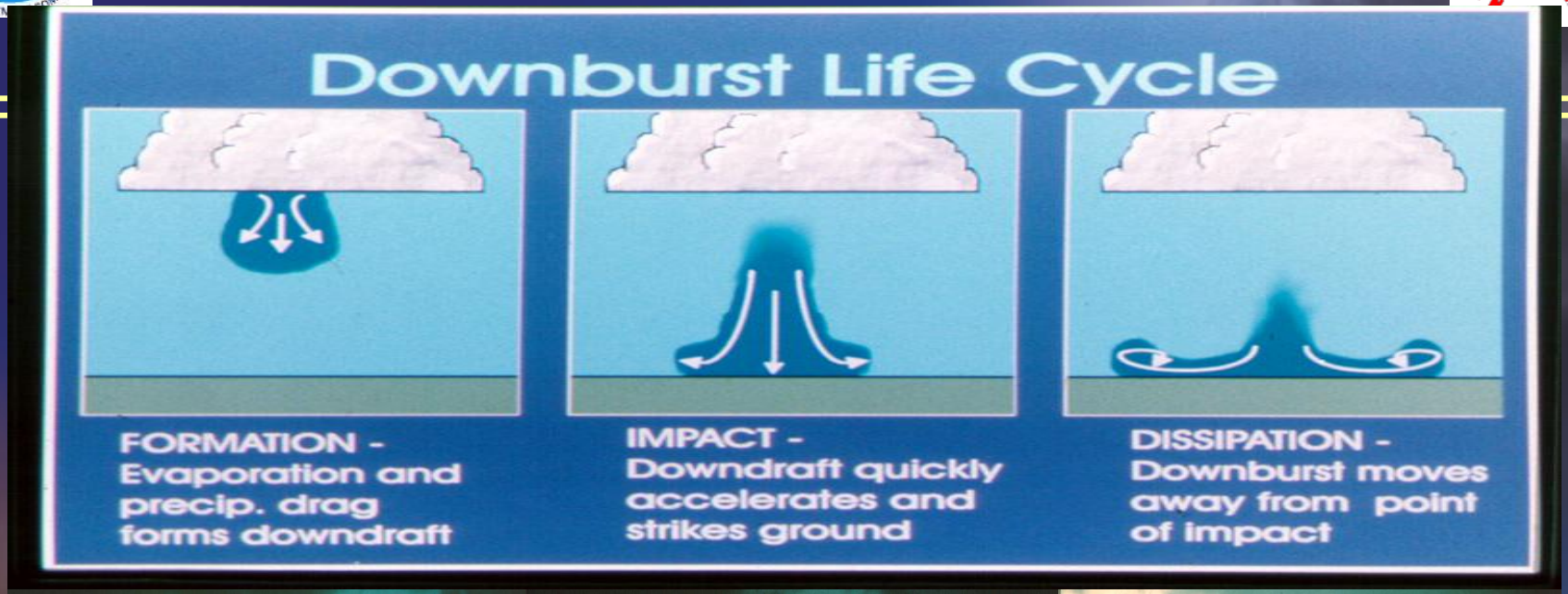


Downburst Wind

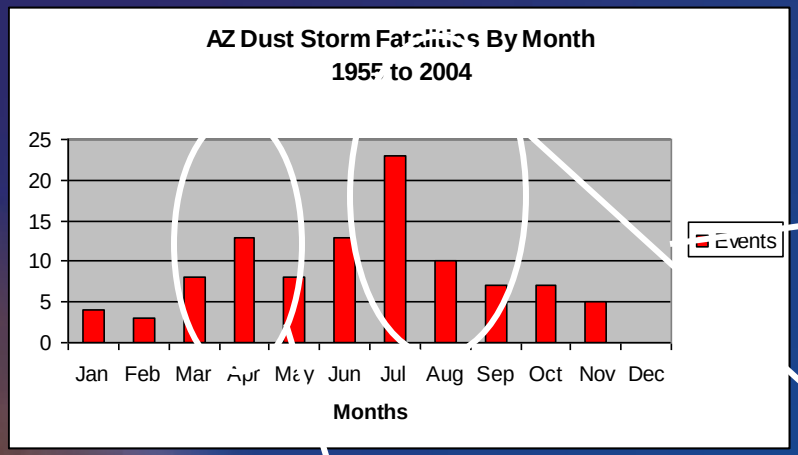


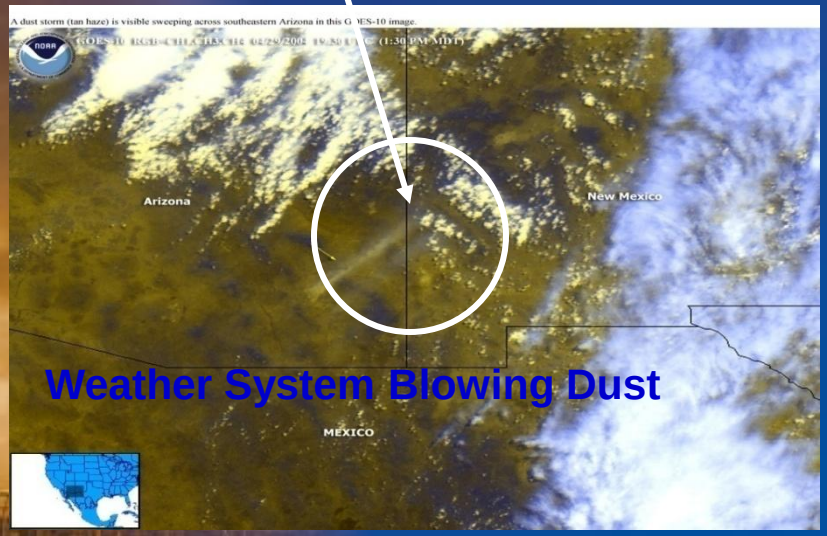
- Downburst hits the ground
- Spreads out horizontally in all directions
- Winds can exceed 100 mph
- Can create dust storms
- Gust front brings cooler air

Downburst Life Cycle



Dust Storms





Weather System Blowing Dust

Thunderstorm outflow Dust Storm

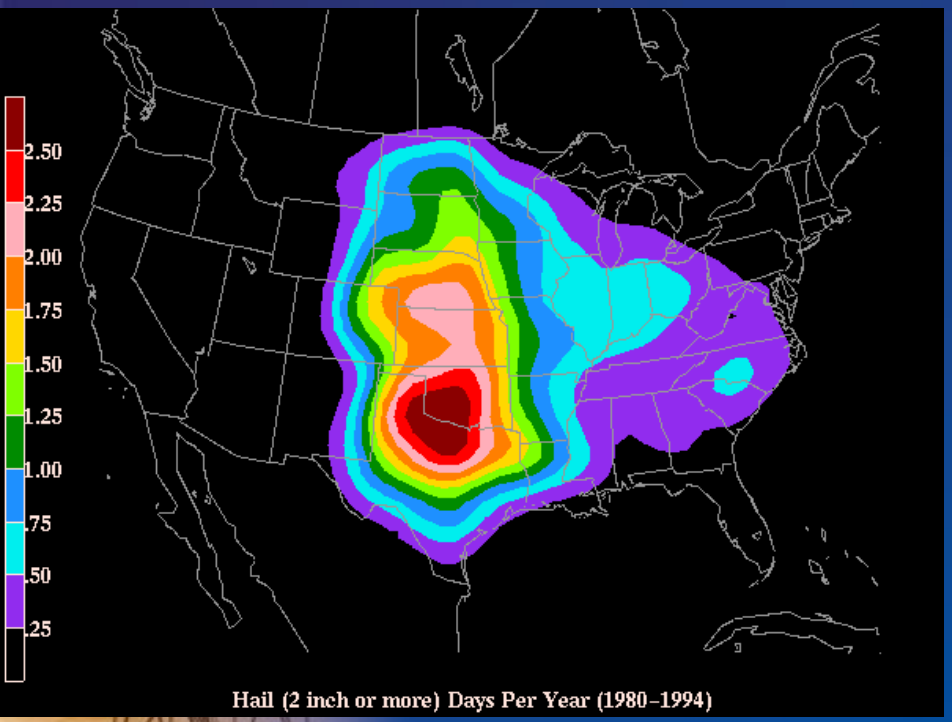
Photo by Stan Celestian, Glendale Community College

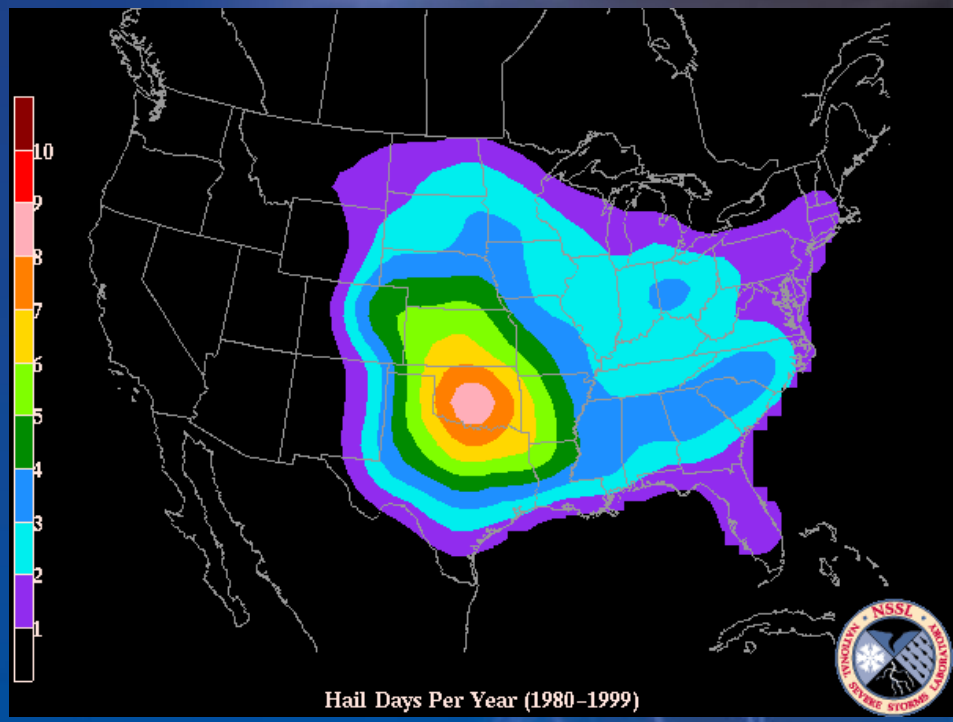
Dust Storm Safety

If you encounter extremely low visibility in a dust storm:

1. Pull **OFF** the road as far as safely possible
2. Turn **OFF** your headlights
3. Place the car in Park or engage the parking brake and take your foot **OFF** the brake pedal

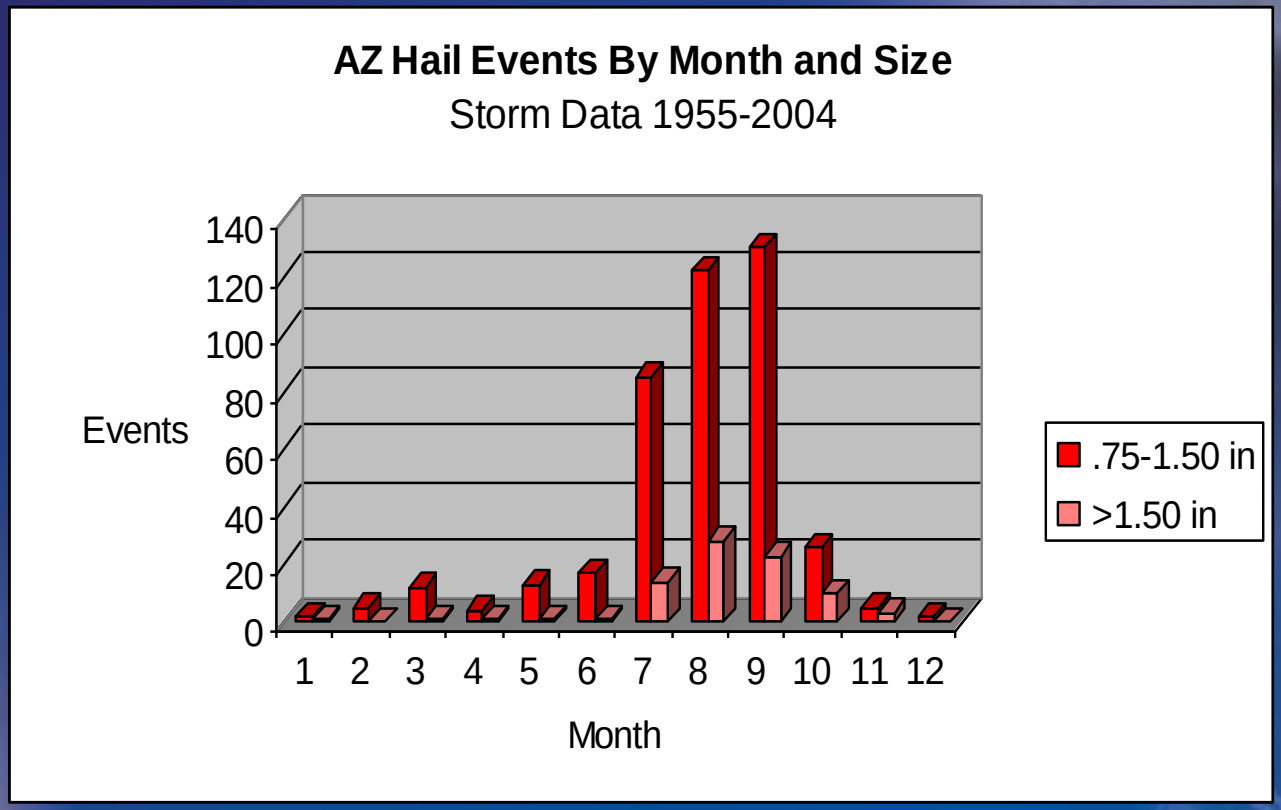
Hail Climatology





Arizona Large Hail

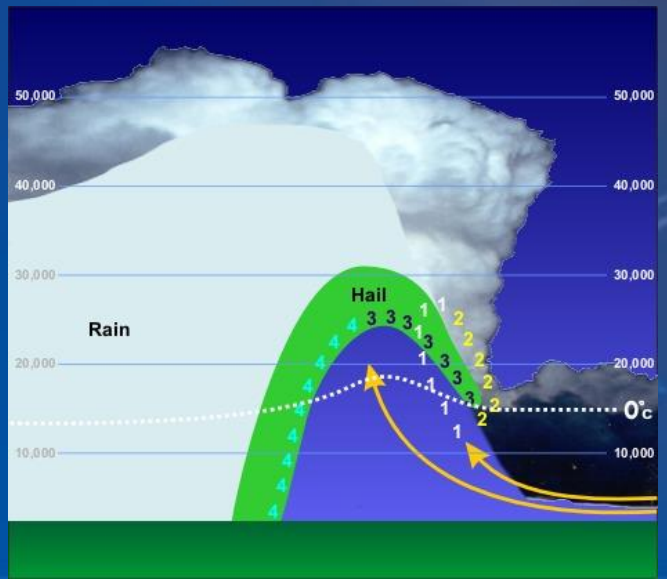
1955-2004



Peak hail Season typically July – September
Largest hail occurs a little later in summer

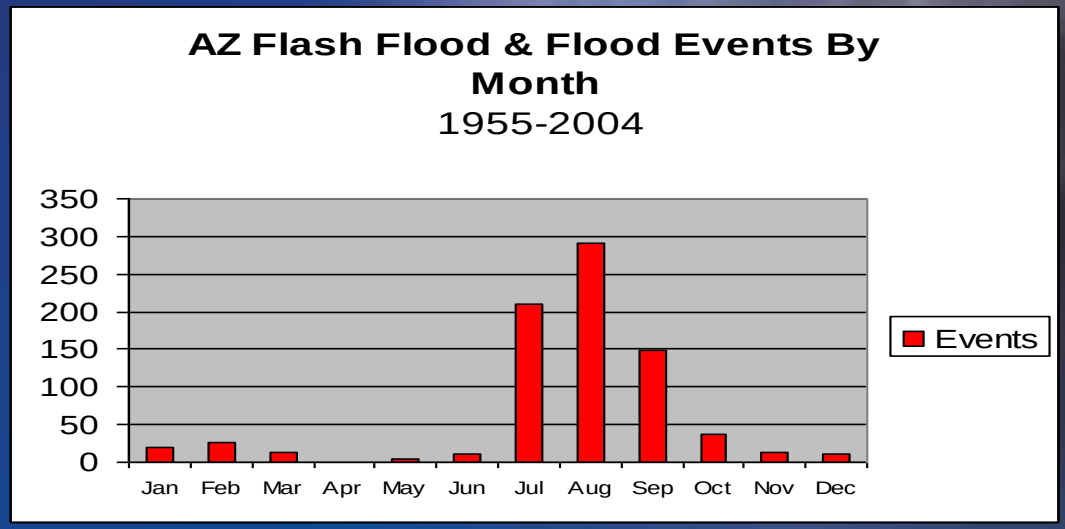
Large Hail

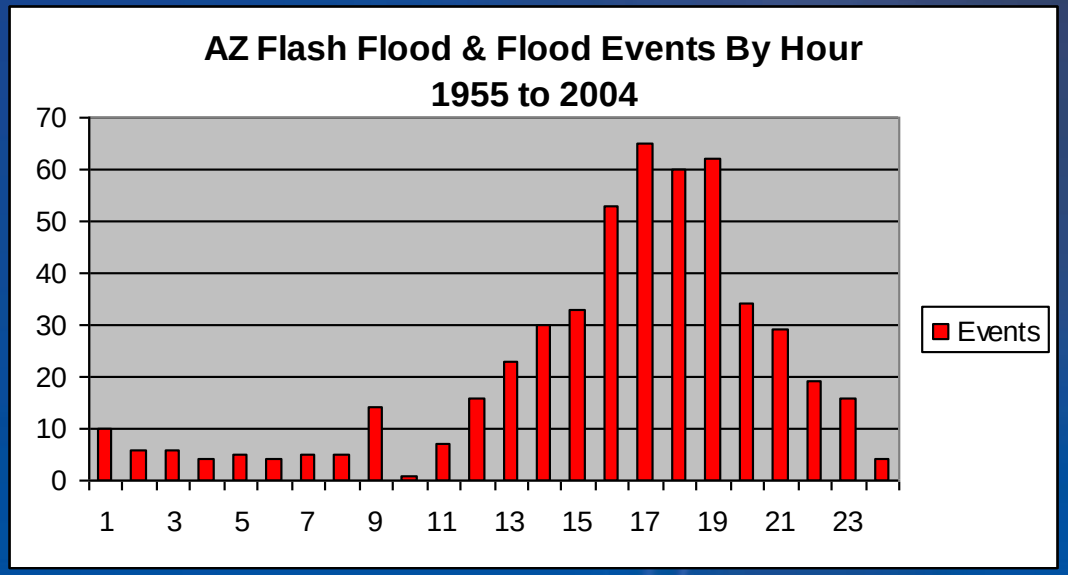
- Strong instability
  - *Need strong vertical motion to hold the hailstone up*
- Need some shear to keep the hail suspended in the thunderstorm
- Relatively cold aloft
- Most thunderstorms actually produce small (<1/4”) hail aloft
  - *Most of it melts before it reaches the ground*
- Where do you think hail is most common in AZ?



Flash Flooding

- Arizona's 2nd deadliest weather hazard behind extreme heat.
- Most deaths occur in vehicles.
- Most frequent during July and August.
- Hundreds of low water crossings and normally dry washes.



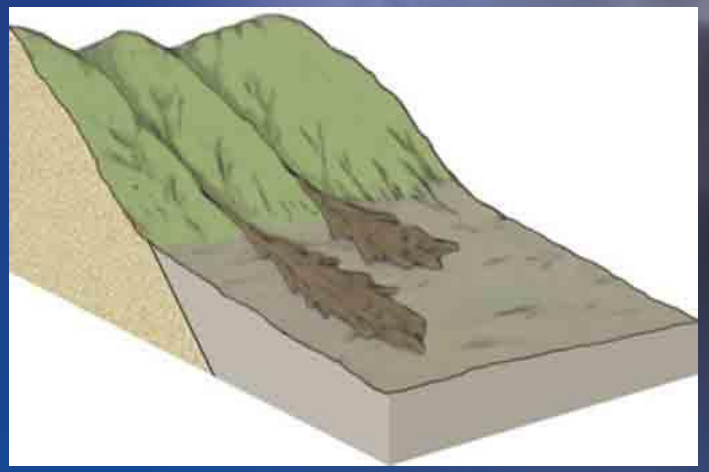


Flash Flood Defined As

- Property damage (including road damage) or loss of life.
- Road, campground or other public access property is closed due to flooding from a thunderstorm.
- Water, greater than 8 inches deep, rapidly moving across any road.
- Wall of water (>= 12 inches) moving down a stream or wash.
- Dam failure or other causative event that makes flooding imminent.

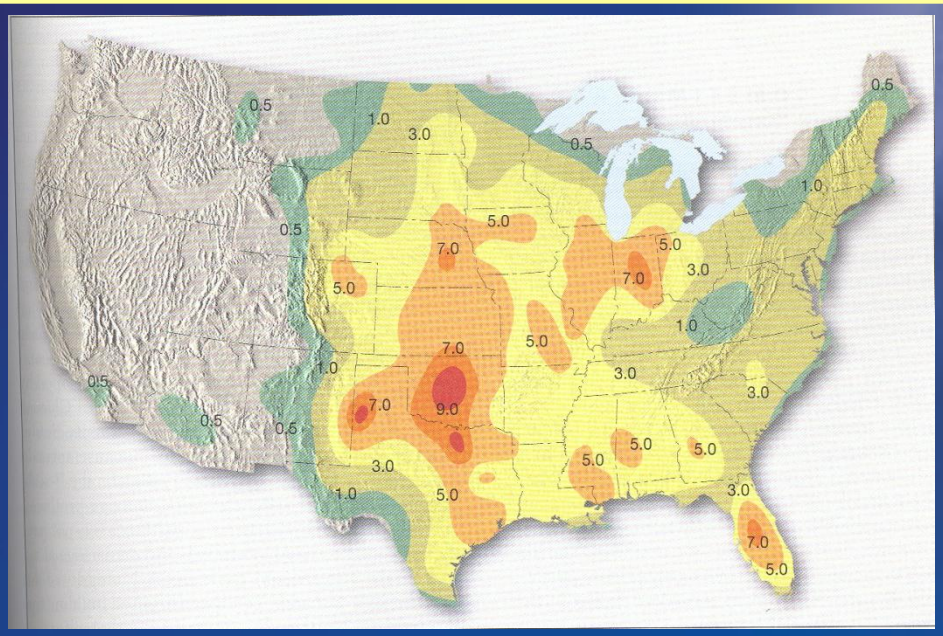
Debris Flows

- Are rapidly moving flows of mixed rock, mud, and water
- Sabino Canyon 2006 was a classic example



El Paso Flash Flood

Tornado Climatology



- Why are tornadoes so infrequent in AZ/W NM?
  - Cloud bases too high
  - If a funnel cloud does develop, it has too far to drop
  - Shear is usually rather weak or incoherent (mountain disruption)
  - Triggering mechanisms are usually aloft
  - Lack of reporting (discussed later)

Tornadoes

Tornado – forms in the mid level of an intense thunderstorm (20K above ground) and descends to make surface contact.

Textbook tornado, not as common in Arizona but do occur.

October 6th, 2010

Landspout Tornado– surface based shear tube that is lifted or stretched upward by a passing updraft to make a connection with cloud base. *An ascending tornado. A typical AZ tornado.*

Favorite Websites

- NWS Tucson: http://www.weather.gov/Tucson
- AZ Hazardous Weather Climatology

  (Davis and Shoemaker)

http://www.wrh.noaa.gov/wrh/techMemos/TM-282.pdf

- NWS "anywhere:" http://www.weather.gov
- Storm Prediction Center: http://www.spc.noaa.gov