National Weather Service Nashville Presents:

Weather 101

The North American Monsoon

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Poll #1

What is your role or interest in weather?

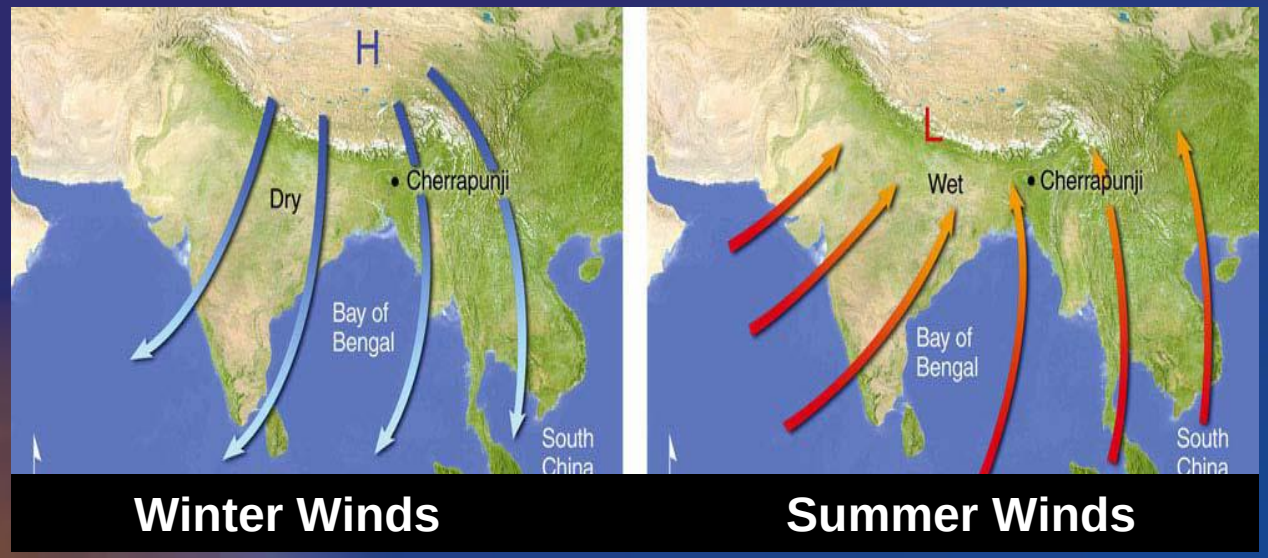
MONSOON METEOROLOGY

North American Monsoon

- Is simply a season, lasting from June 15th until September 30th in the Southwestern US states.
- Used in conversation the same way as the word “Summer” or “Autumn”.
  - “I will be in Canada for the next 6 months, so I will miss the Monsoon.”
- **Does not** refer to an individual thunderstorm or group of thunderstorms.
- Comes from the Arabic word “mawsim” which means, “season”.

What is a “Monsoon”?

- A Seasonal Wind Shift on a Regional Scale



Winter Winds **Summer Winds**

Normal Wind Flow **Monsoonal Wind Flow**

Asian Monsoon

- High pressure over Tibetan Plateau in Winter drives offshore winds
- Low pressure over land in Summer drives onshore winds
- Results in widespread heavy rainfall and flooding

North American Monsoon

- High pressure south over Mexico with westerly flow aloft most of the year
- High pressure moves north over Four Corners and brings moisture into the southwest
- Generally weaker than the Asian Monsoon because the Mexican Plateau is not as high or as large


Southern Plains
Gulf of California
Sierra Madres
(evapotranspiration)
Gulf of Mexico
Eastern Tropical Pacific
North American Monsoon
Low-level Moisture Sources

Monsoon Progression

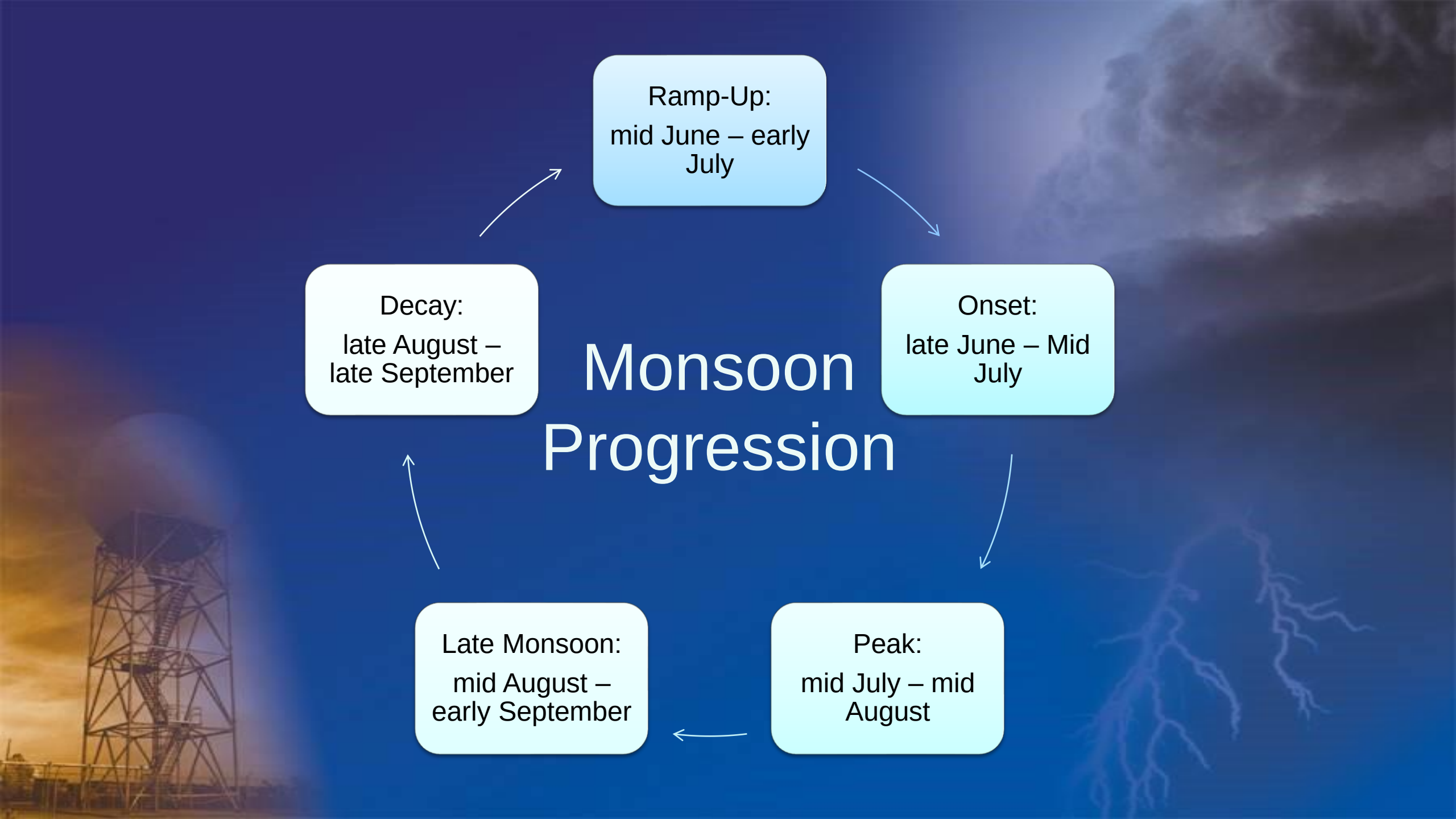
Ramp-Up:
mid June – early July

Onset:
late June – Mid July

Peak:
mid July – mid August

Late Monsoon:
mid August – early September

Decay:
late August – late September



Monsoon Progression

- Ramp Up
  - Tropical moisture starts to infiltrate the Sierra Madres
  - Ridge and wind direction can waver significantly
- Onset
  - Moisture increases over northern Mexico
  - Thunderstorms more organized, numerous and wet
- Peak
  - High pressure strongest and northernmost position
  - Daily storms with threat of flash flooding, wind damage and dust storms.

Monsoon Progression

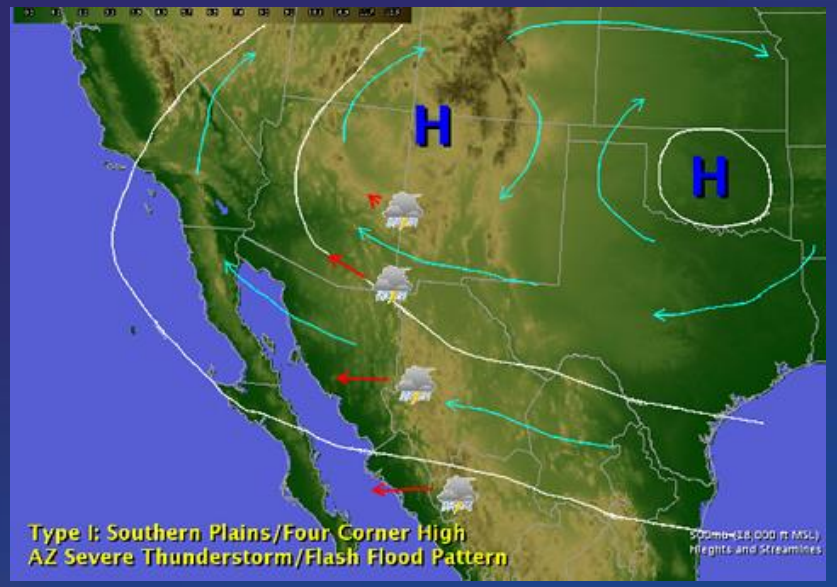
- Late Monsoon
  - Lowering sun angle starts to weaken high pressure
  - Upper level winds more variable
  - Tropical eastern Pacific starts to become a concern
- Decay
  - Ridge has significantly weakened
  - Transition season with cold fronts and the potential for supercells
  - Upper level winds become more westerly over time

Poll #2

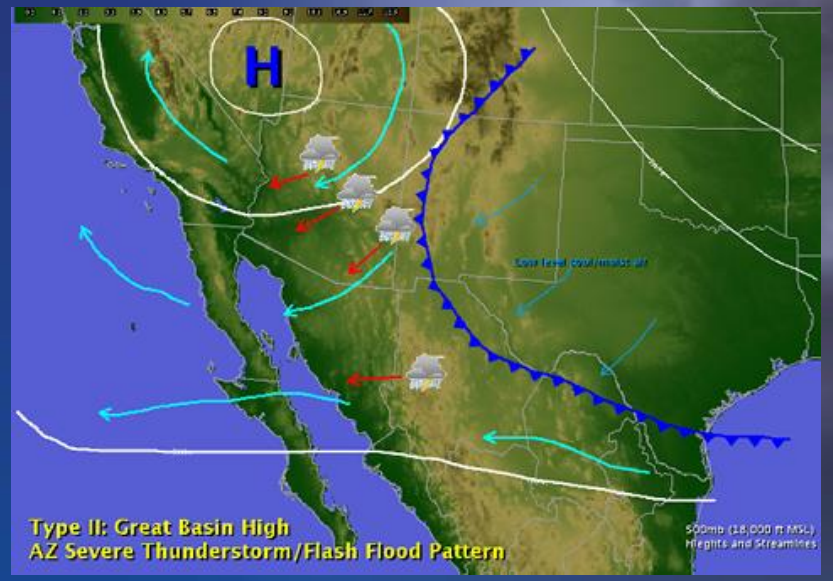
Have you ever experienced the Southwest Monsoon in some way?

North American Monsoon Patterns (4)

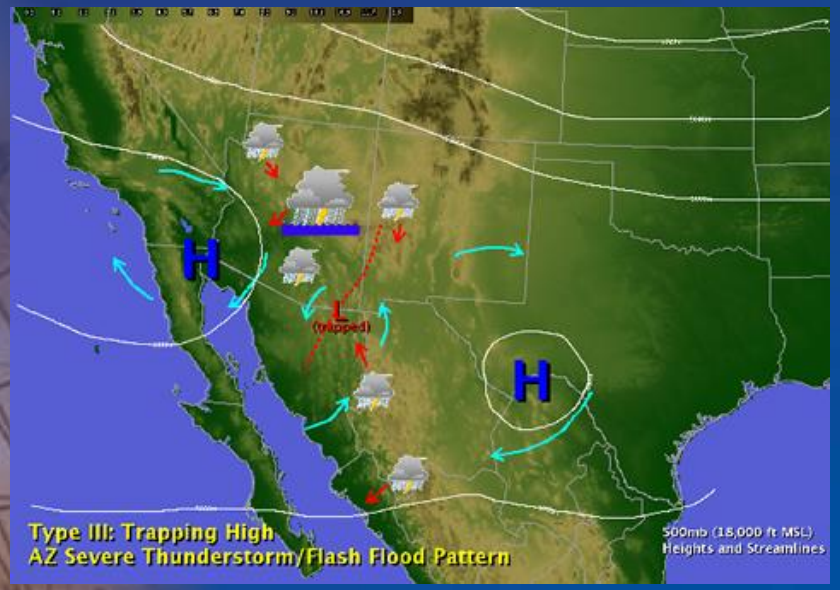
Type I



Type II



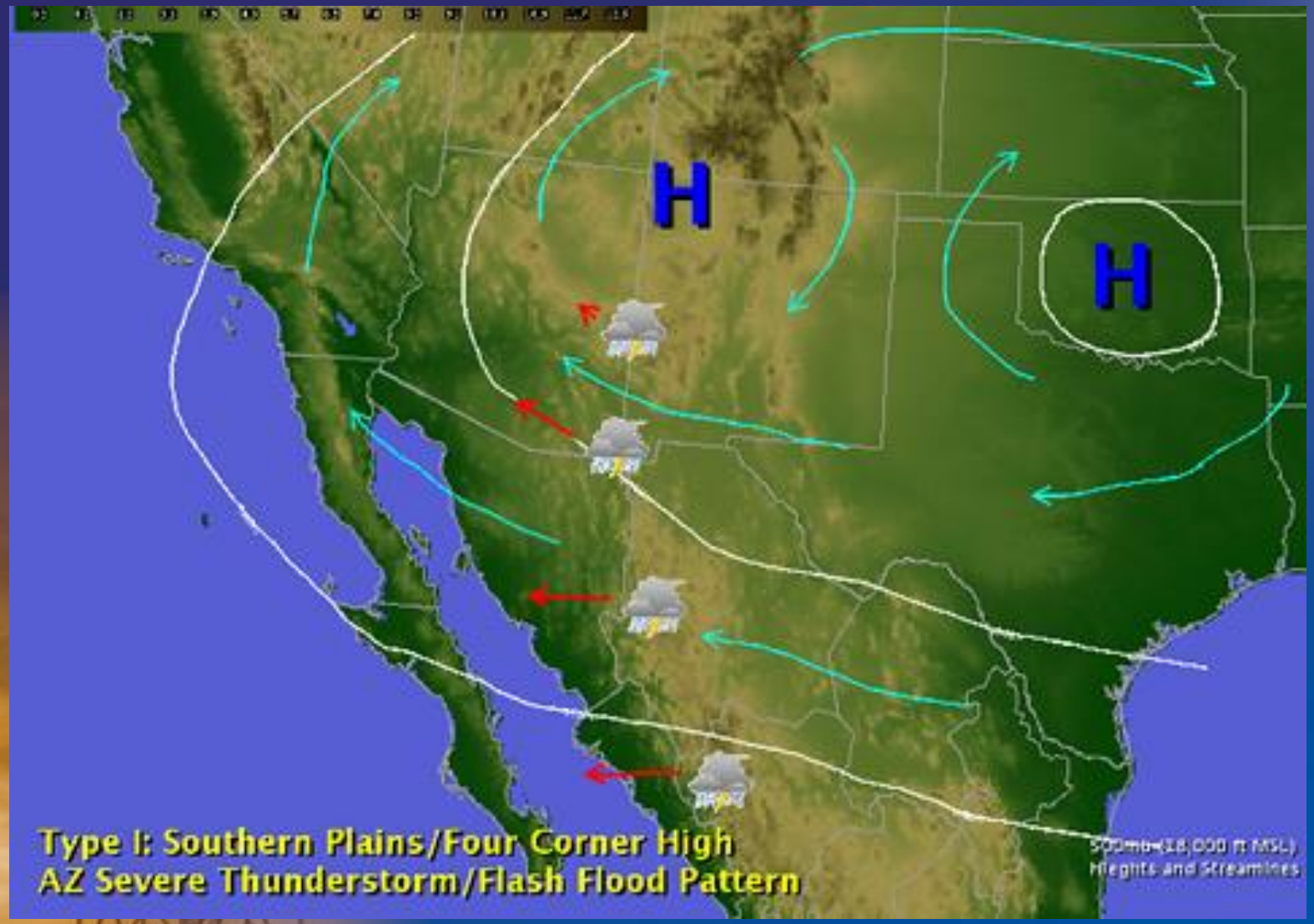
Type III



Type IV

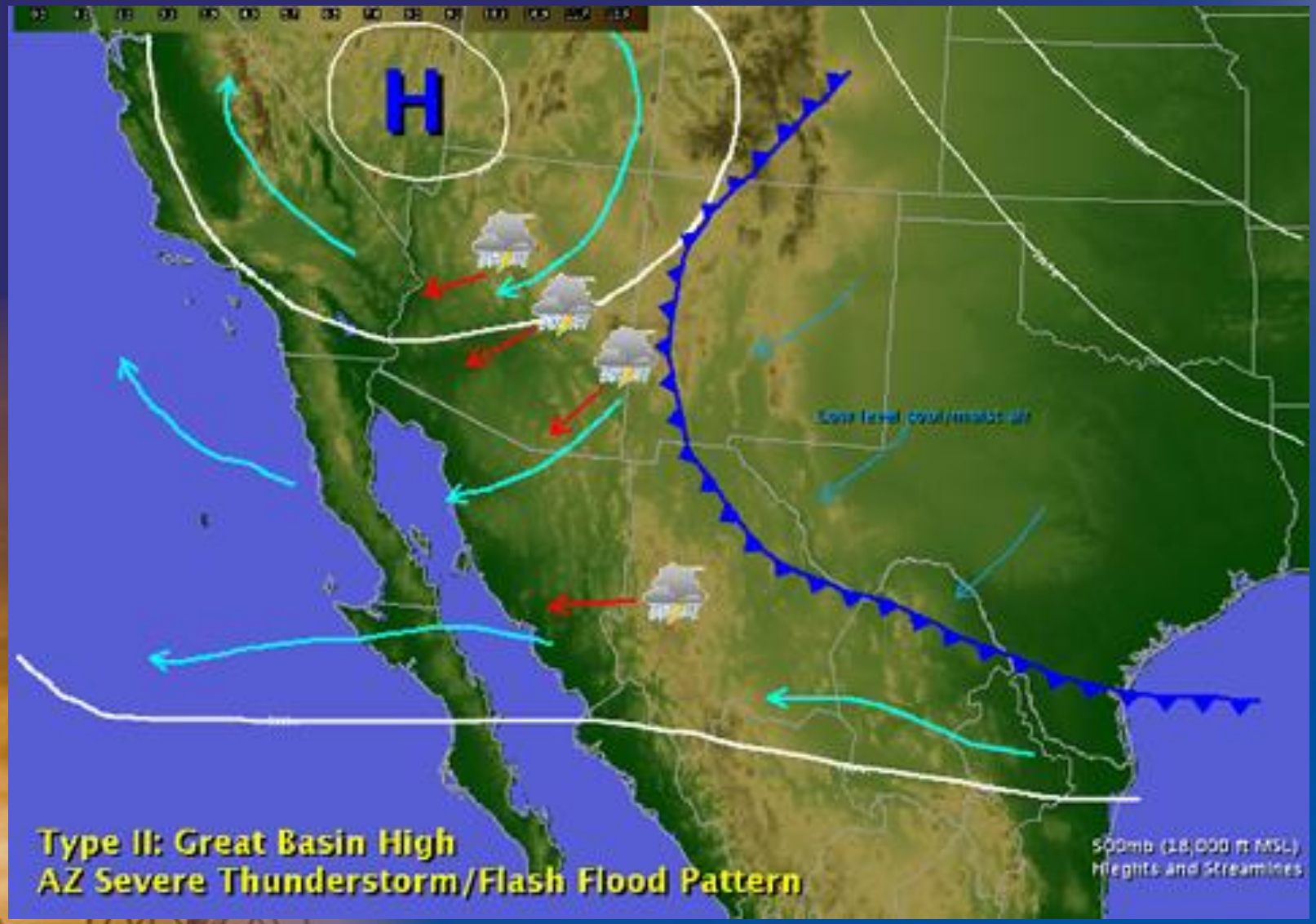
wrh.noaa.gov/twc/monsoon/monsoon_patterns.php

Monsoon Patterns: Type I



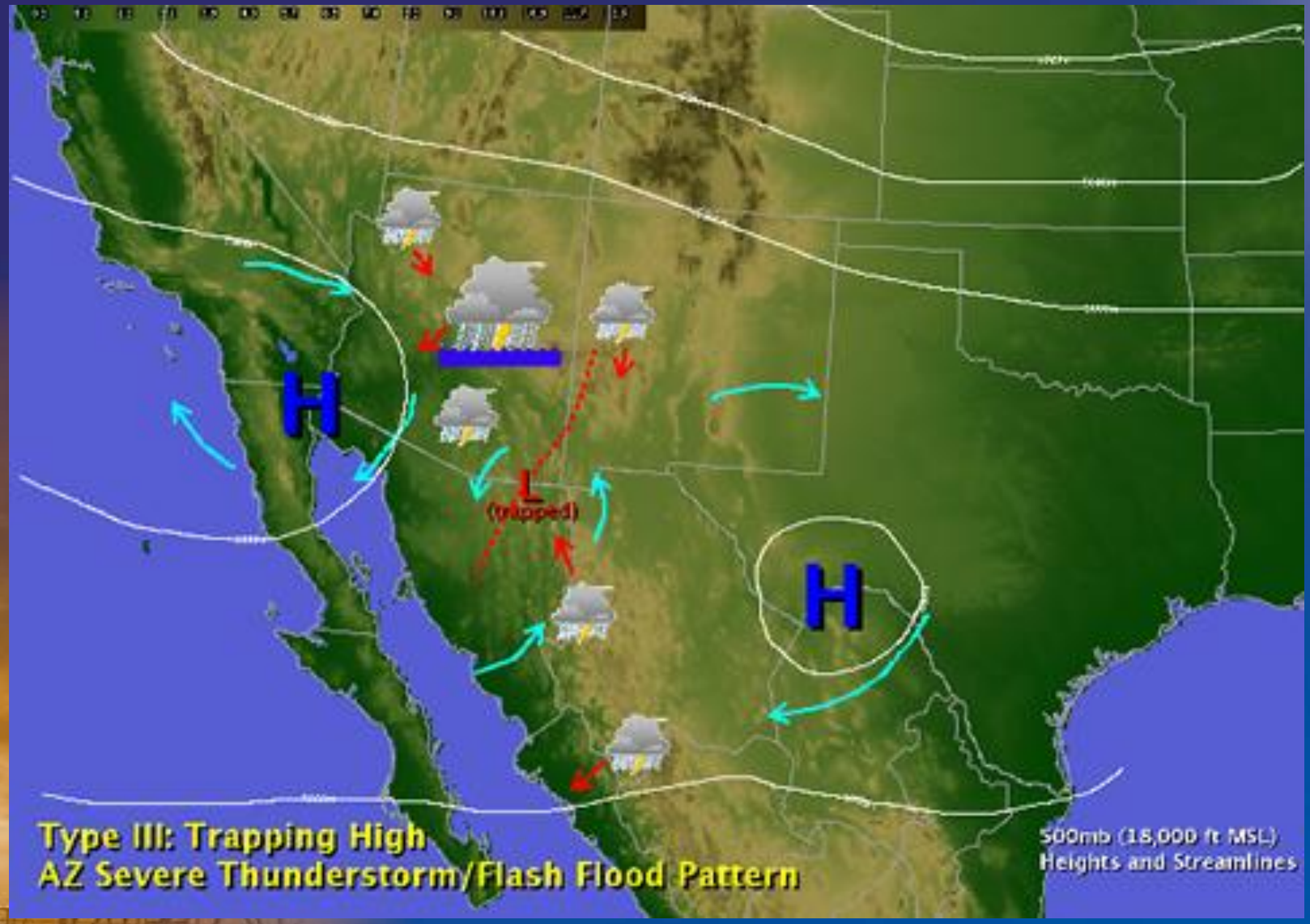
- Most common severe thunderstorm pattern
- Low level moisture increases from the south or east
- Winds between 10k and 20k feet out of the east
- Storms form on the mountains and spread east to west
- When lower levels are dry, damaging winds and dust storms are a major concern

Monsoon Patterns: Type II



- Less common: occurs during height of monsoon
- High pressure over the Great Basin
- “Backdoor cold front”
- Storm move to the southwest off the Mogollon Rim
- Storms tend to last longer w/overnight convection possible

Monsoon Patterns: Type III



- Monsoon ridge weaker and further south, but moisture still present
- Poorly organized thunderstorms
- Light winds aloft often leads to slow storm movement
- Storms may not follow typical diurnal patterns
- Can result in flash flooding and storms lasting through the night

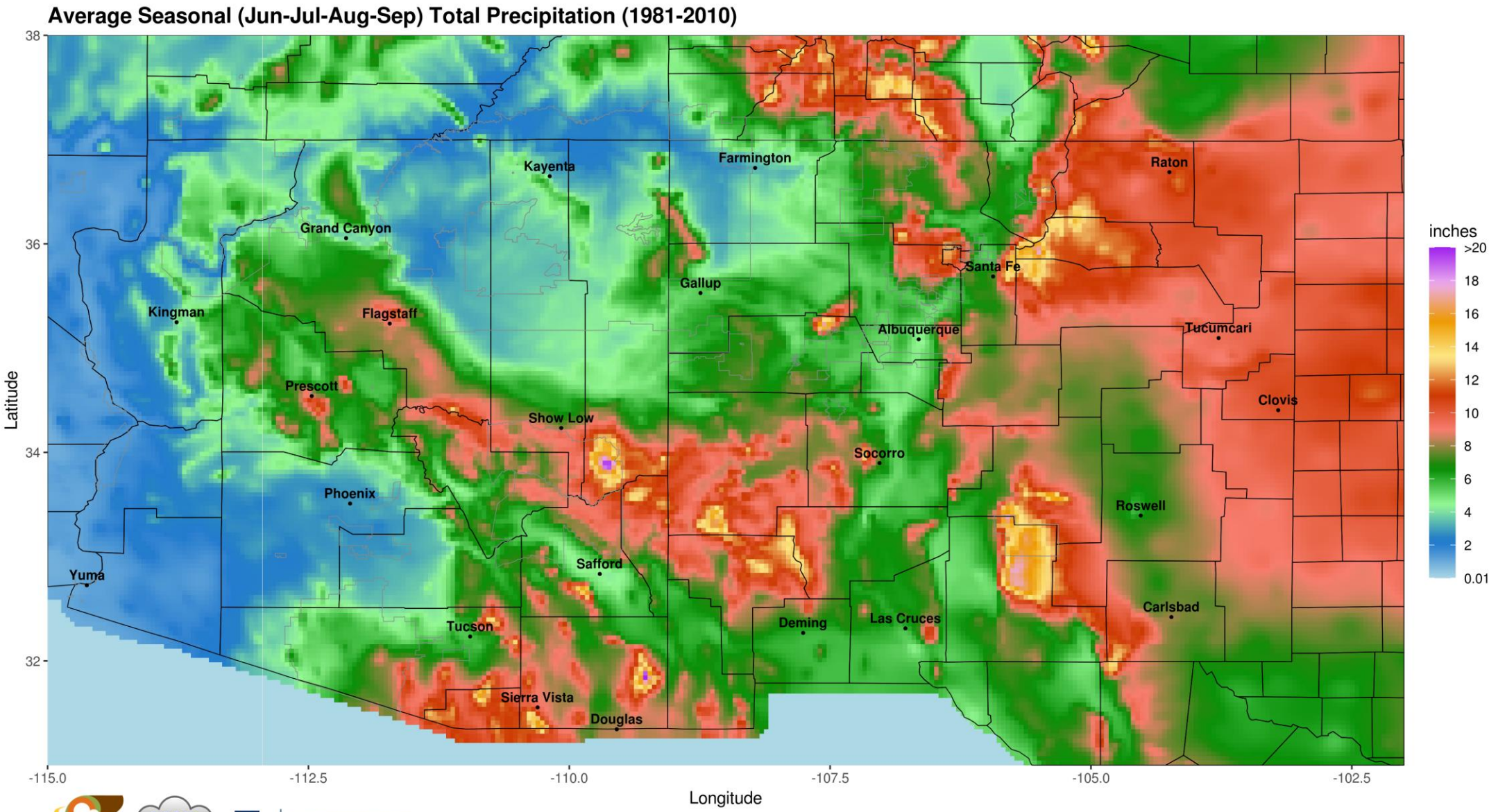
Monsoon Patterns: Type IV

- Does not need monsoonal flow to generate severe weather
- Late August or September
- Winds shifting from the east back to the west
- Storm systems moving in from the west
- More similar to conditions that cause severe weather on the Plains
- Supercells with large hail and tornadoes possible
- Can often signal the end of the monsoon pattern for the year

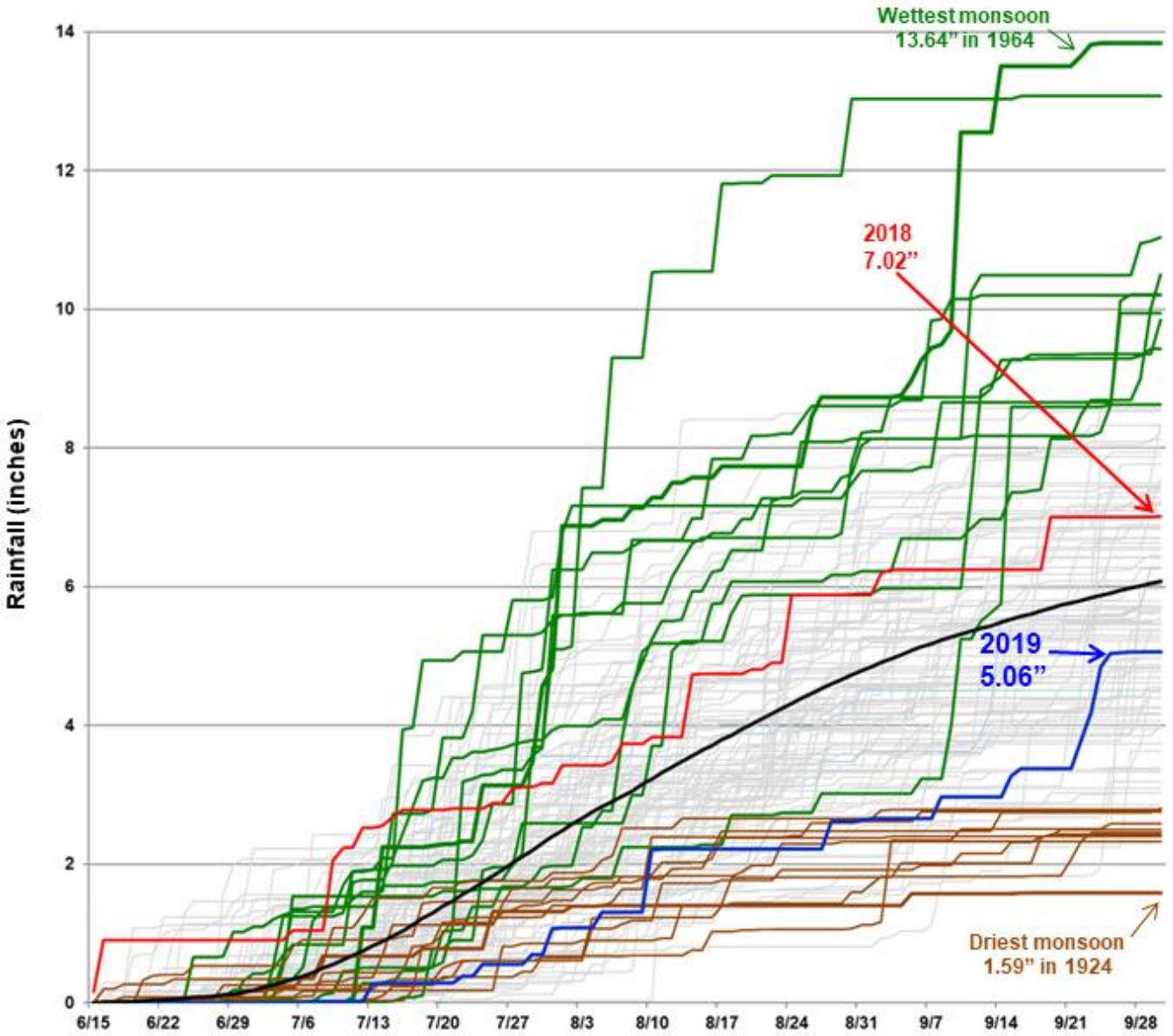
MONSOON RAINFALL & VARIABILITY

Monsoon Rainfall Normals in the Southwest (POR)

Location	June (15-30)	July	August	September	Total
Tucson	0.15”	2.25”	2.39”	1.29”	6.08”
Phoenix	0.02”	1.05”	1.00”	0.64”	2.71”
Yuma	0.01”	0.23”	0.53”	0.52”	1.29”
Albuquerque	0.45”	1.50”	1.58”	1.08”	4.61”
El Paso	0.51”	1.66”	1.61”	1.36”	5.14”
Flagstaff	0.21”	2.61”	3.11”	2.38”	8.31”


Average Seasonal (Jun-Jul-Aug-Sep) Total Precipitation (1981-2010)
Latitude
Longitude
38
36
34
32
-115.0
-112.5
-110.0
-107.5
-105.0
-102.5
Kayenta
Farmington
Raton
Grand Canyon
Gallup
Santa Fe
Kingman
Flagstaff
Albuquerque
Tucumcari
Prescott
Clovis
Show Low
Socorro
Phoenix
Roswell
Safford
Yuma
Carlsbad
Tucson
Deming
Las Cruces
Sierra Vista
Douglas
inches
>20
18
16
14
12
10
8
6
4
2
0.01
CLIMAS
CSAP
http://cals.arizona.edu/climate
THE UNIVERSITY OF ARIZONA
Cooperative Extension
Plot created: 2019-06-06
The University of Arizona
https://cals.arizona.edu/climate/
Data Source: PRISM Climate Group

Monsoon rainfall for Tucson (1895-2019)



The "Haywood plot" on the left shows the accumulated rainfall totals for each monsoon year recorded at the official site in Tucson.

Haywood plots are useful in tracking current season rainfall compared to the seasonal results from the past.

Top 10 wettest Monsoon in Green

Top 10 driest Monsoon in Brown

1981-2010 normal in Black

2019 in Blue
2018 in Red

Remaining years in Gray

2019 total – 5.06"

Monsoon Variability (Tucson)

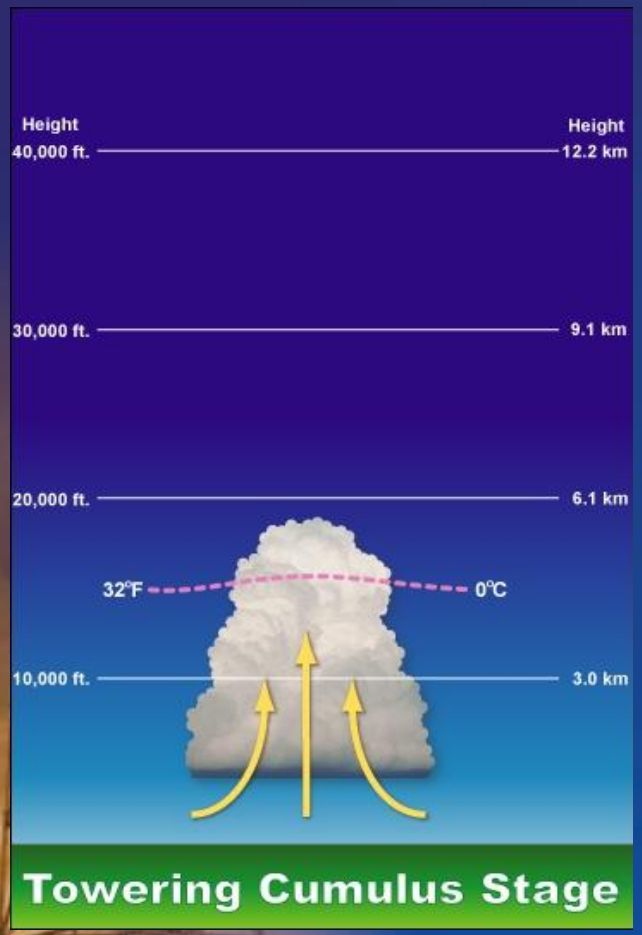
- The driest monsoon season measured 1.59”, and the wettest measured 13.84” in Tucson.
- Therefore, a variation between seasons of 12.25” exists, which is over twice the normal monsoon precipitation at Tucson.
- Understanding the causes for this huge variation is the first step in developing an ability to forecast an upcoming monsoon season.

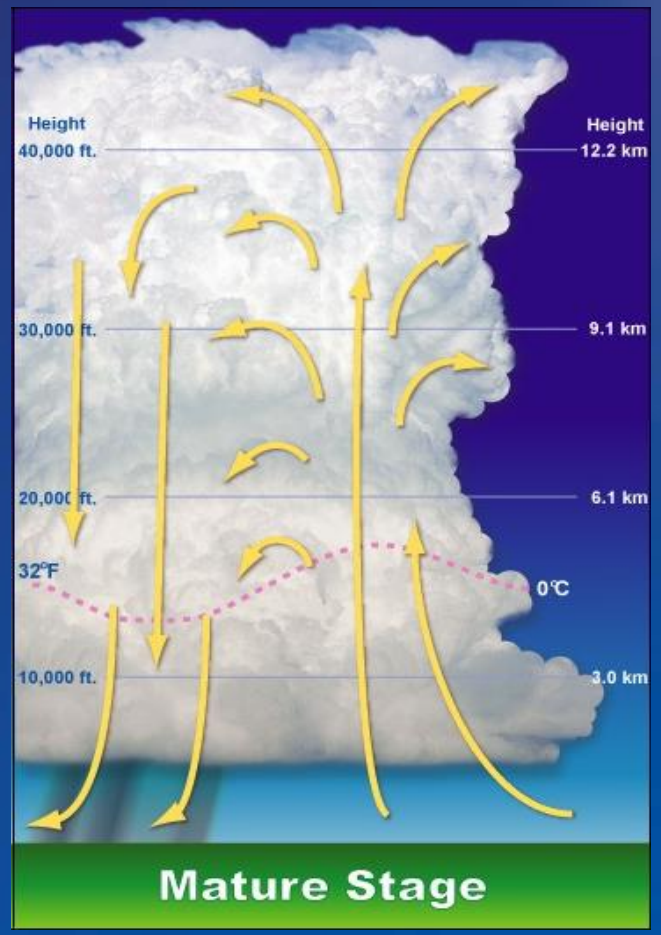
Monsoon Variability (Tucson)

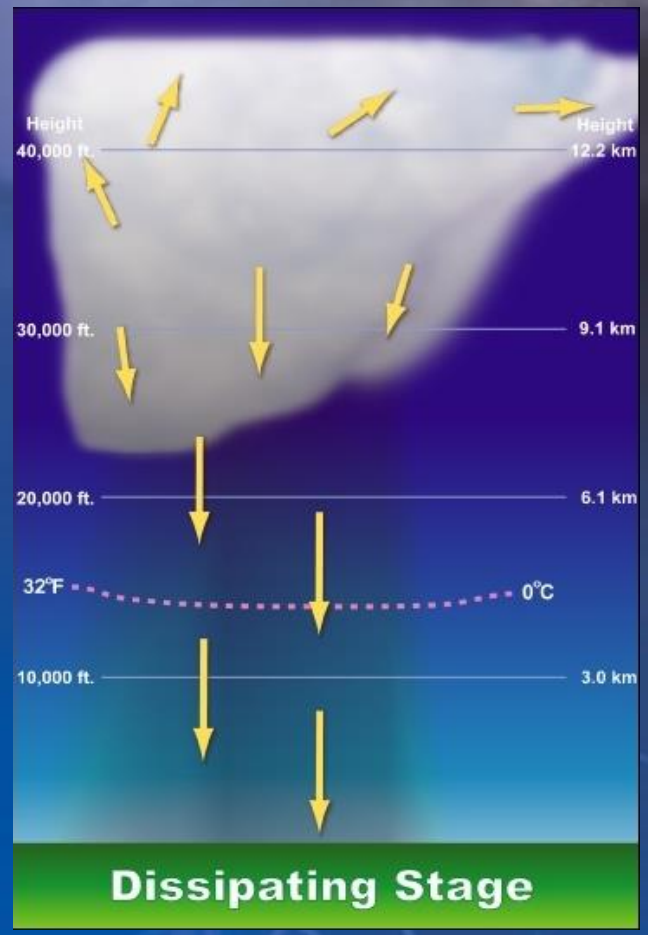
- Research within the past decade or so has investigated the possible causes behind North American Monsoon variability.
  - Sea surface temperatures & anomalies – El Nino and La Nina
  - Large-scale circulation patterns
  - Land surface conditions
  - Tropical convergence zones
  - Moisture transport mechanisms

MONSOON WEATHER HAZARDS

Thunderstorm Life Cycle

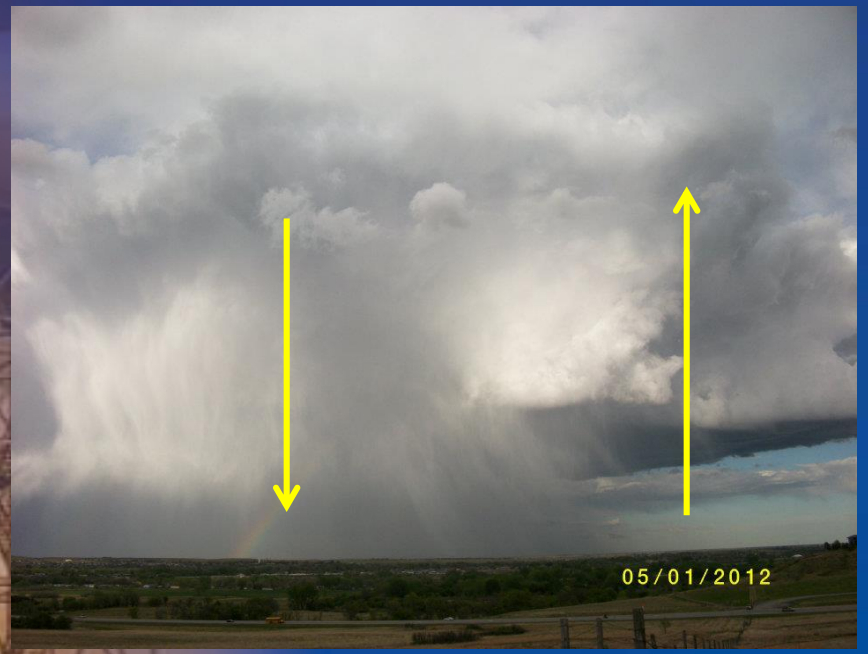


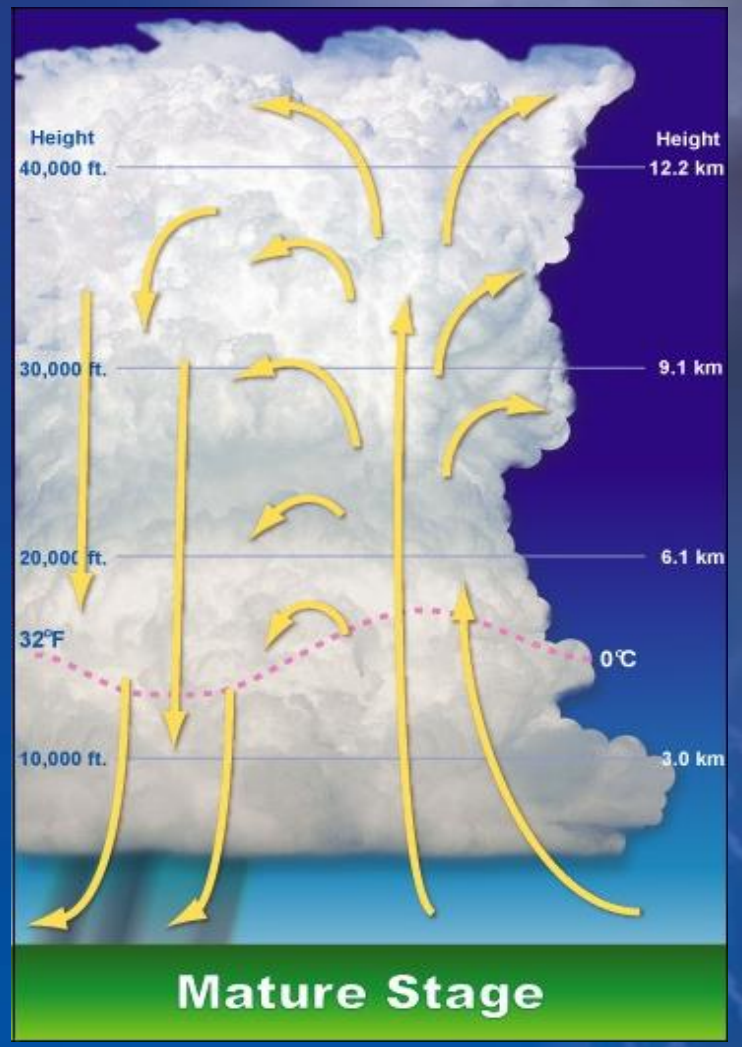




Typical Arizona Thunderstorms "Pulse-Severe"

- Life cycle of typical pulse-severe thunderstorm is only 30-60 minutes





Microbursts

- Downward rush of cool air (and sometimes rain) hits the ground
- Spreads out horizontally in all directions
- Difficult to detect via radar

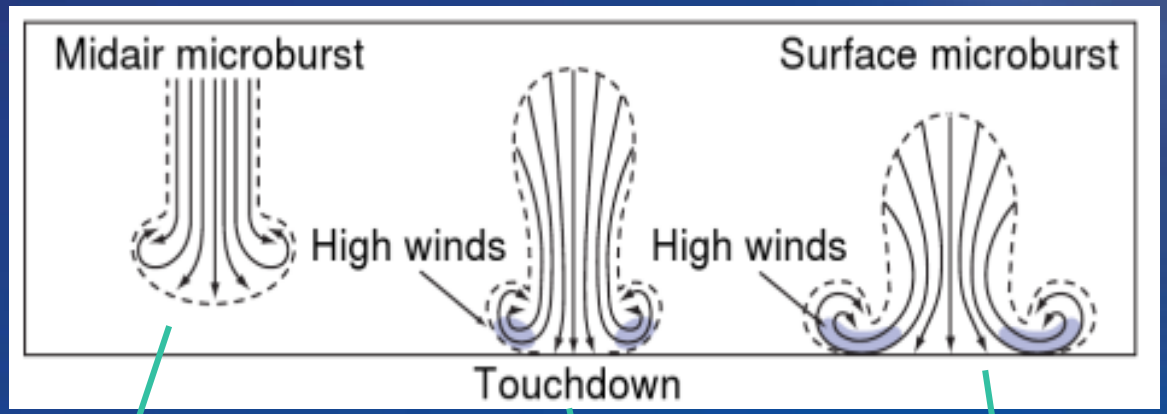
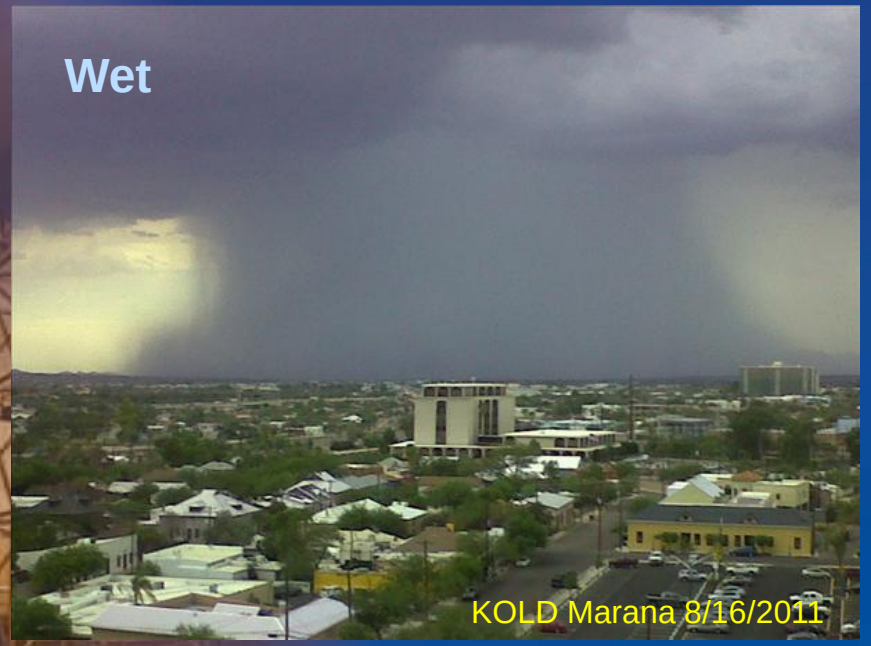


Diagram Credit - Wallace & Hobbs - "Atmospheric Science"

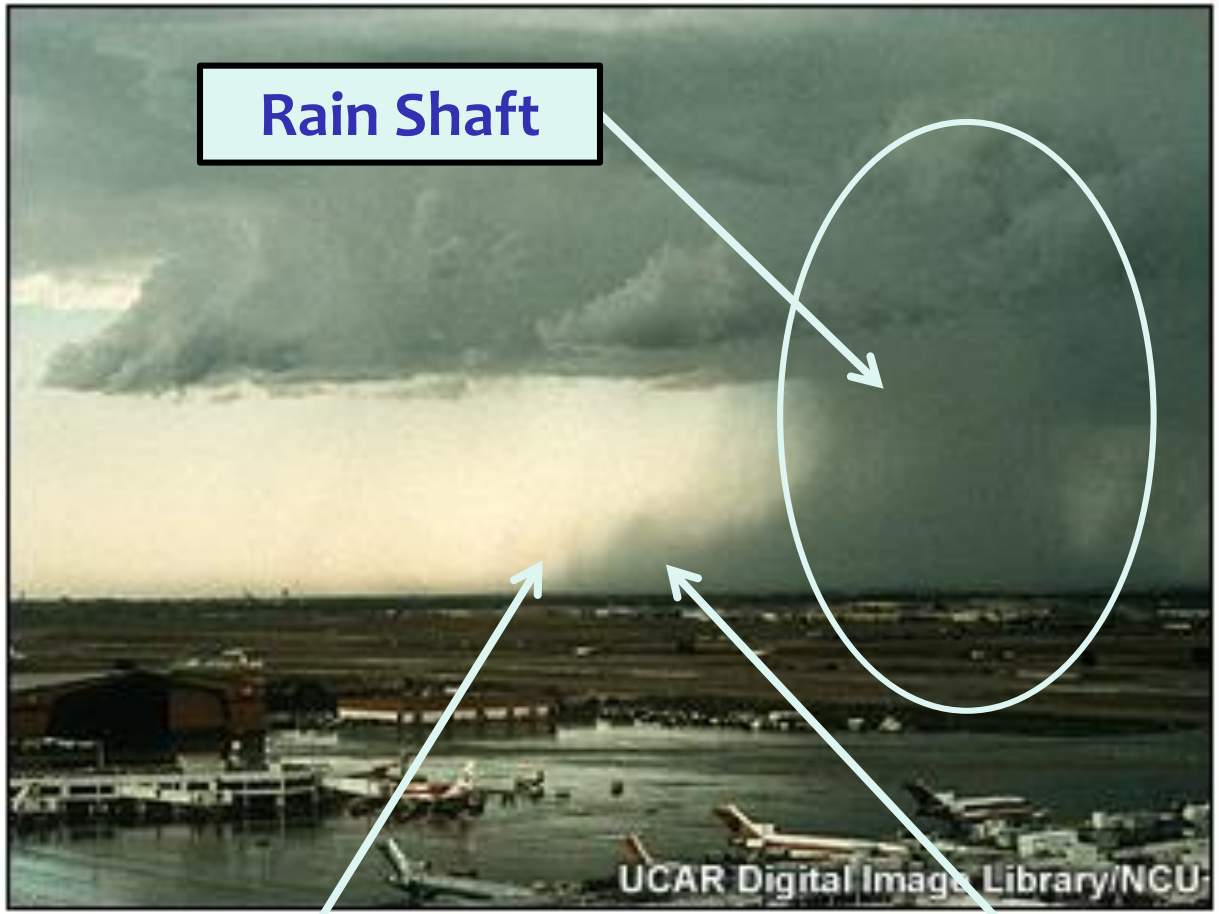
Microbursts

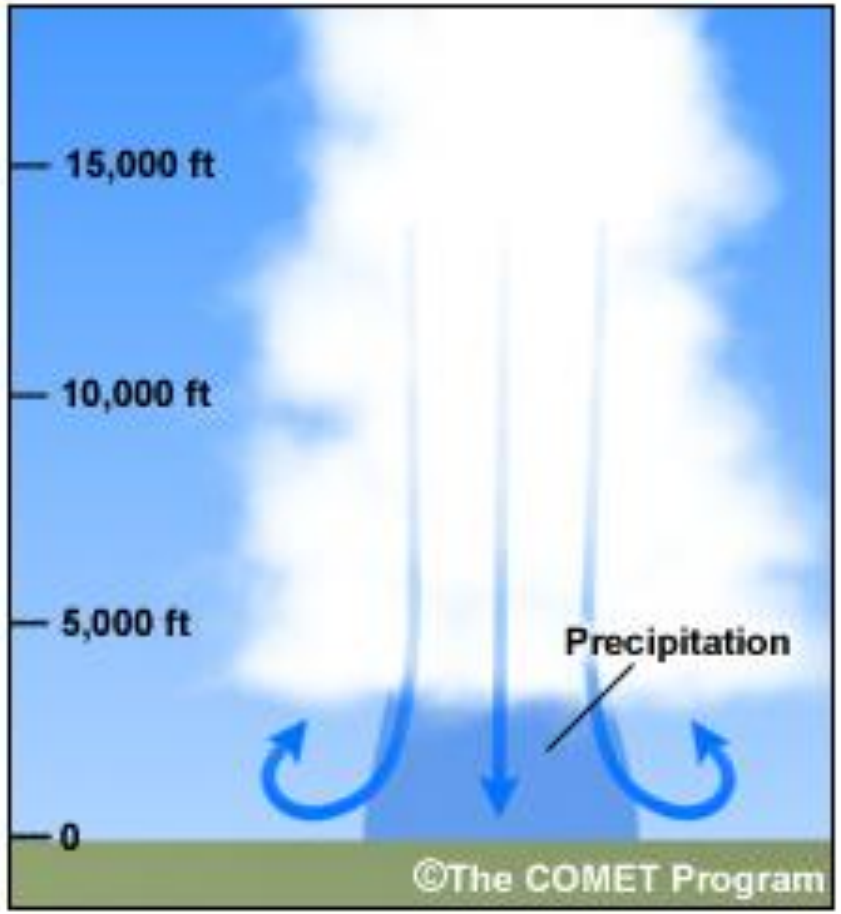
- Microburst or macroburst?
  - Microbursts < 2.5 miles wide
  - Macrobursts > 2.5 miles wide
- Can be “wet” or “dry”
  - Is rain reaching the ground?

- Can trigger blowing dust and haboobs
- Can do extensive damage with winds exceeding 100 mph



What You Might See

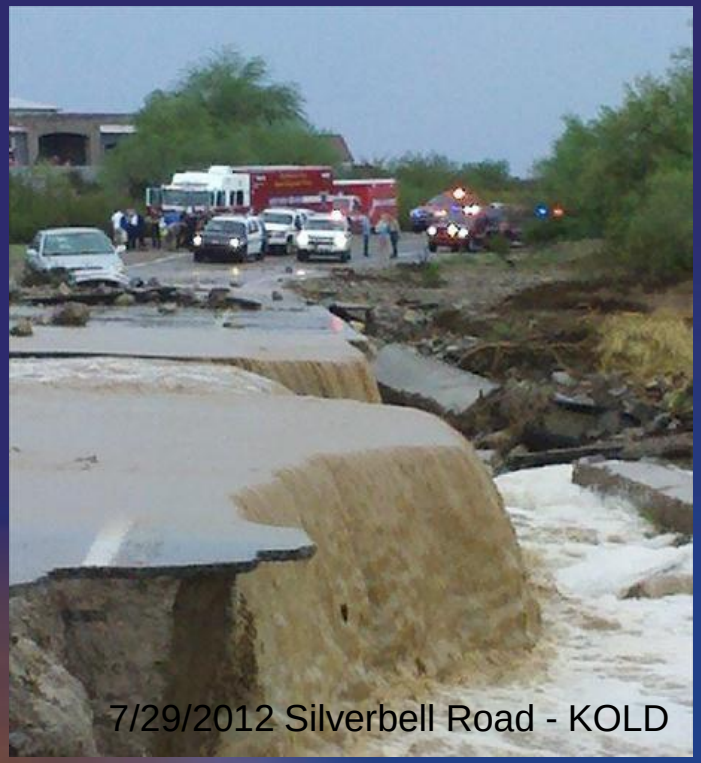




Flash Flooding

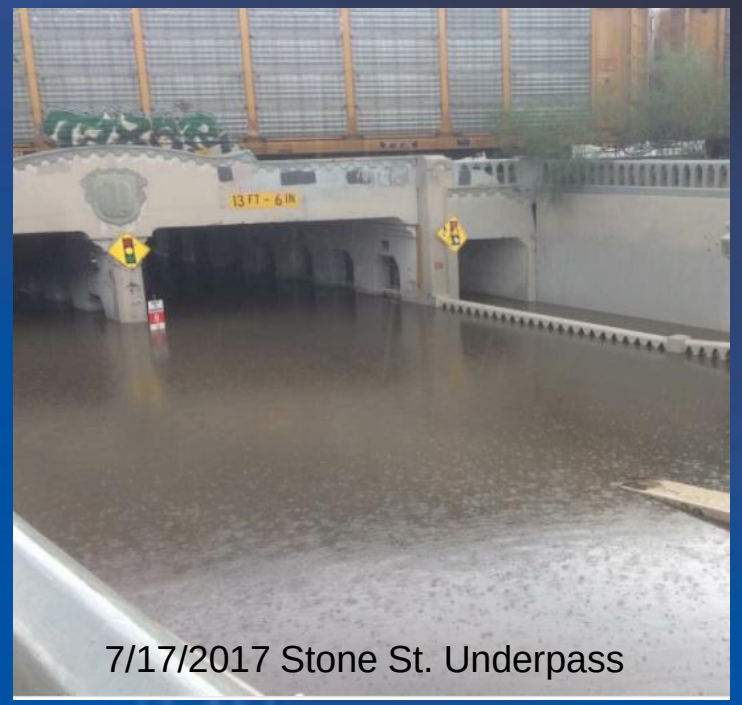
"Water where it shouldn't be!"

- Dangerous flows in normally dry washes, low-lying areas, or roadways
- Arizona's 2nd deadliest weather hazard
- Most deaths occur in vehicles in July & August, and between 3 pm & 9 pm



7/29/2012 Silverbell Road - KOLD

7/10/2018 I-10 & Twin Peaks



7/17/2017 Stone St. Underpass

Dust Storms (Haboobs)

- “Haboobs” are often a result of thunderstorm downbursts.
- Comes from the Arabic *habub*, which means, “blowing furiously”.

Gustnado

- Develops when surface-based gust fronts intersect, or turbulent eddies form on the leading edge of a thunderstorm
- **NOT** a tornado, but can cause wind damage

Hail

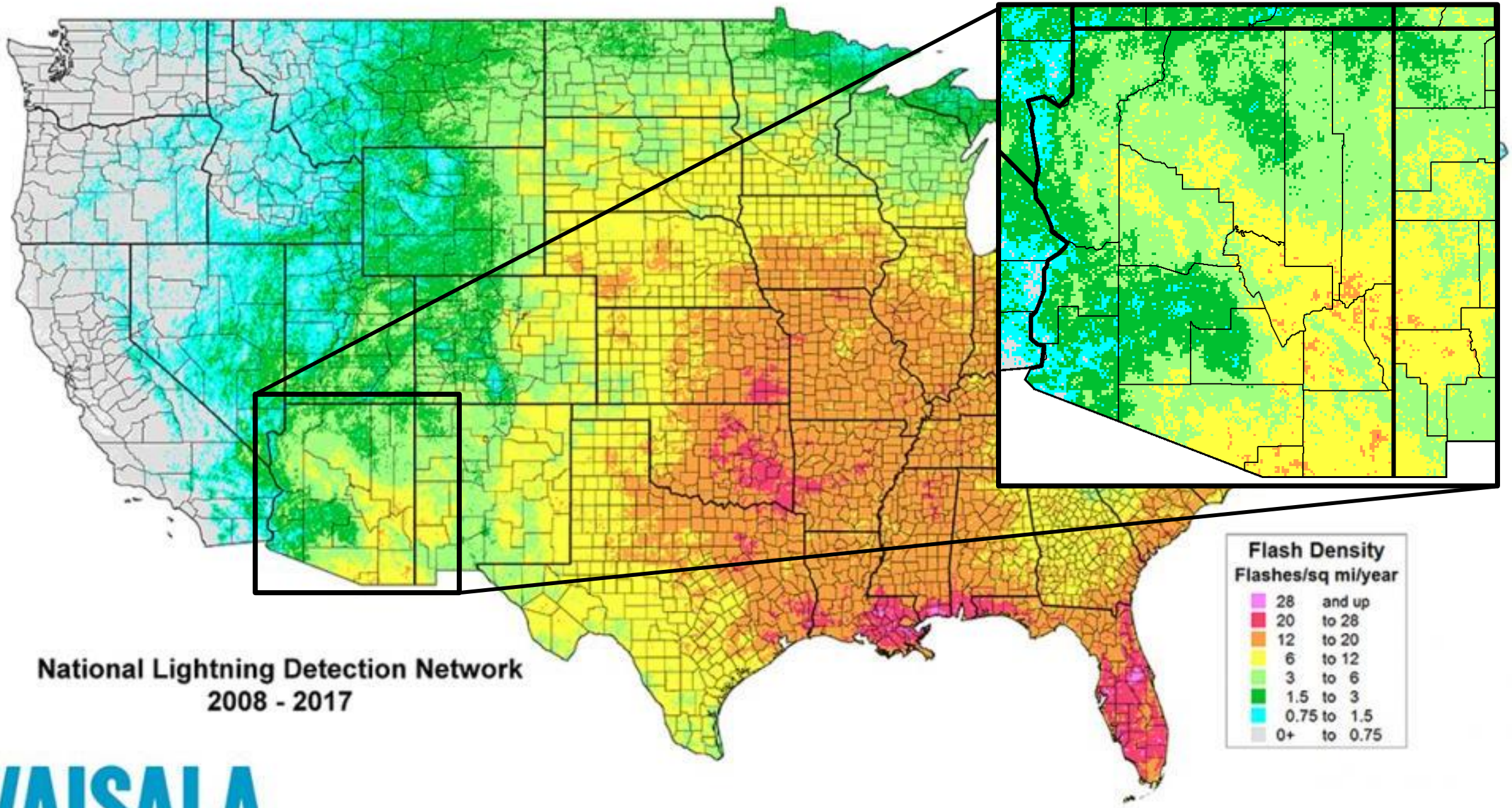
- A typical severe weather hazard, though not extremely common during the Monsoon.
- Rarely larger than golf balls in Southeast AZ.
- Northern AZ and NM do see larger stones

Lightning

"When Thunder Roars, Go Indoors"

- Arizona averages over 600,000 strikes per year, primarily during the monsoon.

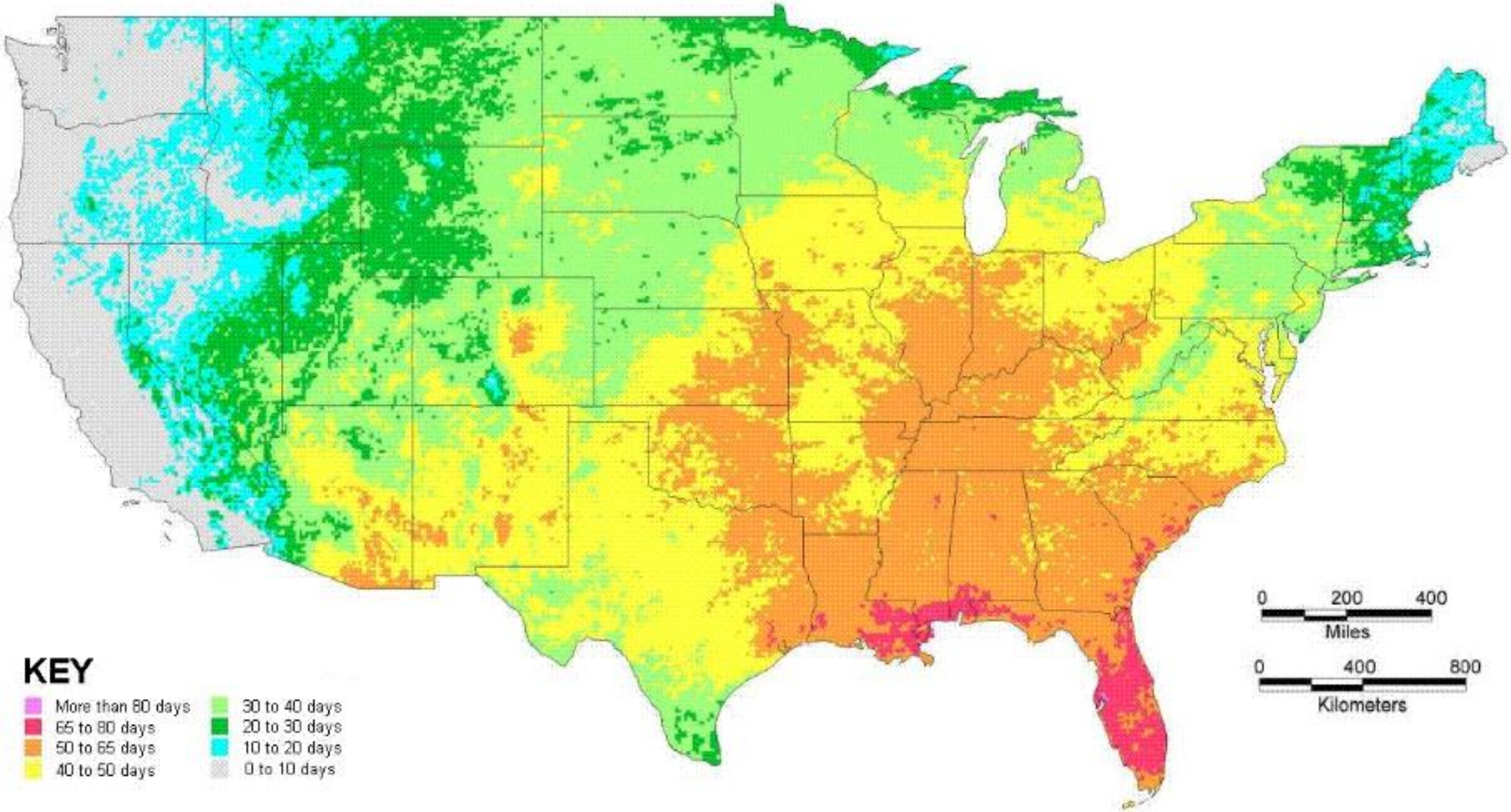
- Most people injured or killed by 1st or 2nd strike.
- One CG lightning strike can reach temperatures over 50,000ºF.
- It is the rapid expansion of this heat that causes thunder.



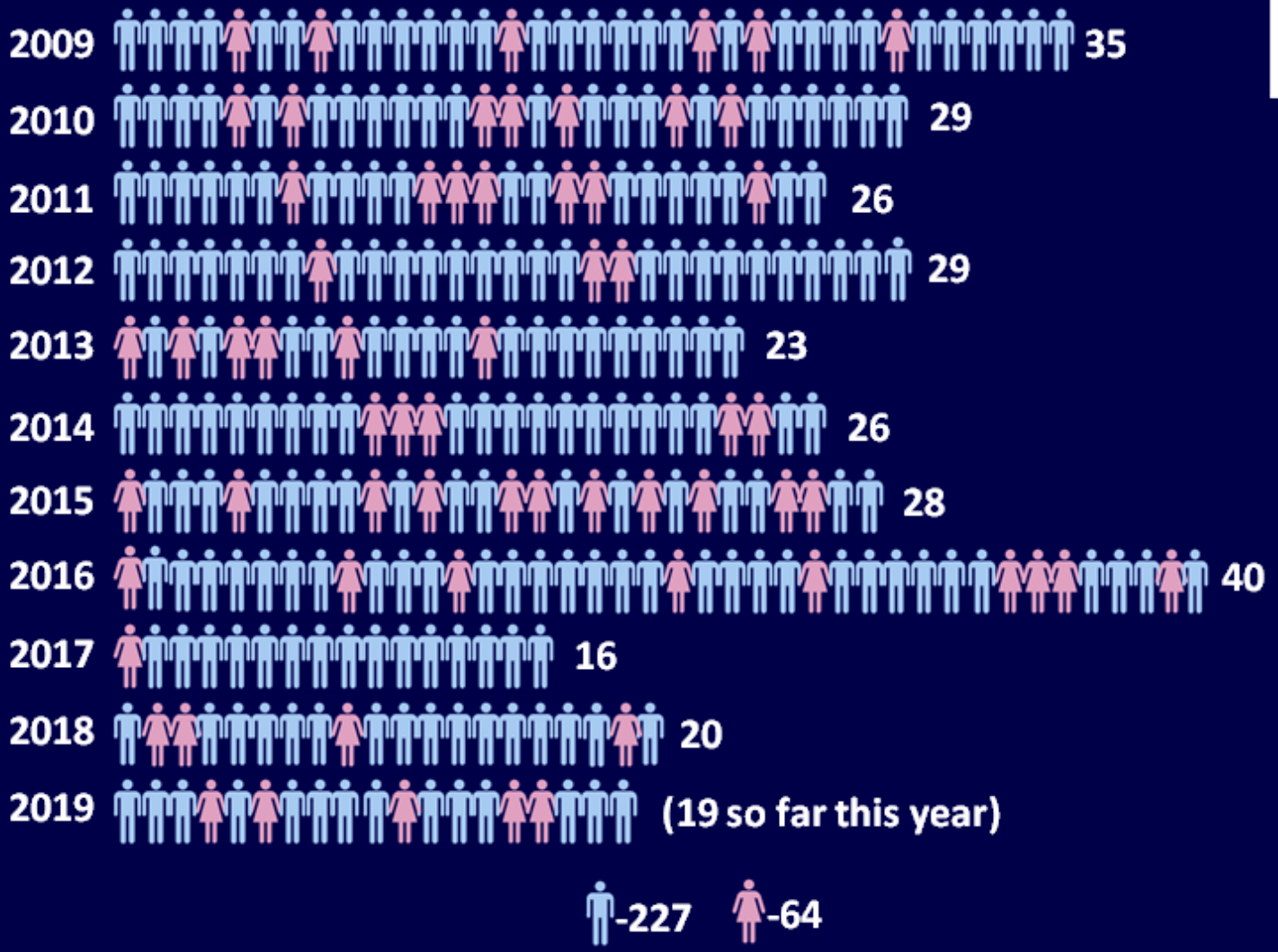
National Lightning Detection Network
2008 - 2017

VAISALA

Average Number of Thunderstorm Days per Year



U.S. Lightning Fatalities
2009-2019



For more information:

https://www.weather.gov/safety/lightning-victims

Poll #3

Did you learn something from this presentation?

Thank you for attending!

Questions?

Contact: Emily Carpenter - Emily.Carpenter@noaa.gov

Or Scott Unger – Scott.Unger@noaa.gov

Next Weather 101: Tues, Nov. 12 @ 7pm CST
Topic: The Radar
Sign up: weather.gov/ohx/weather101
Presentation: weather.gov/ohx/weather101presentations

Other Monsoon resources:

https://www.wrh.noaa.gov/twc/monsoon/monsoon.php

https://www.climas.arizona.edu/sw-climate/monsoon