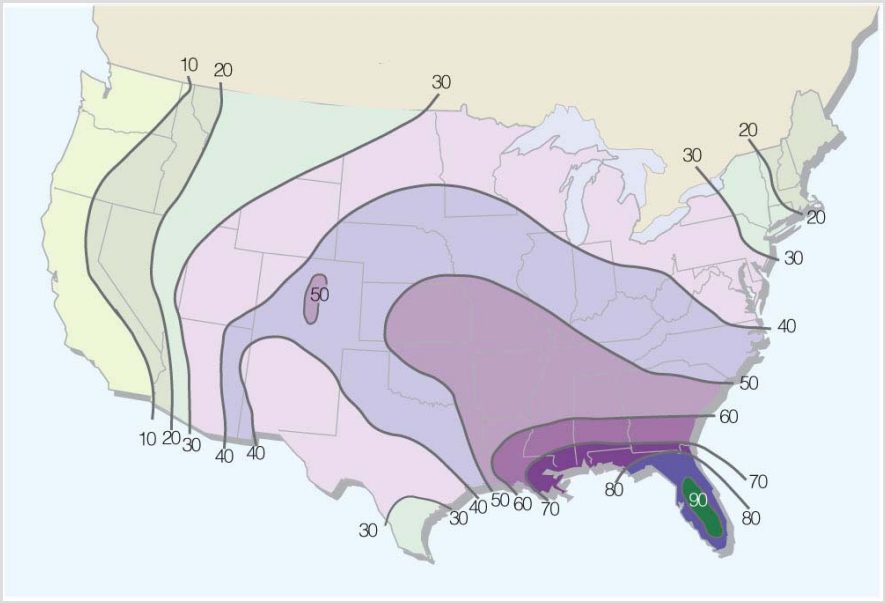
NATS 101
Section 13: Lecture 28

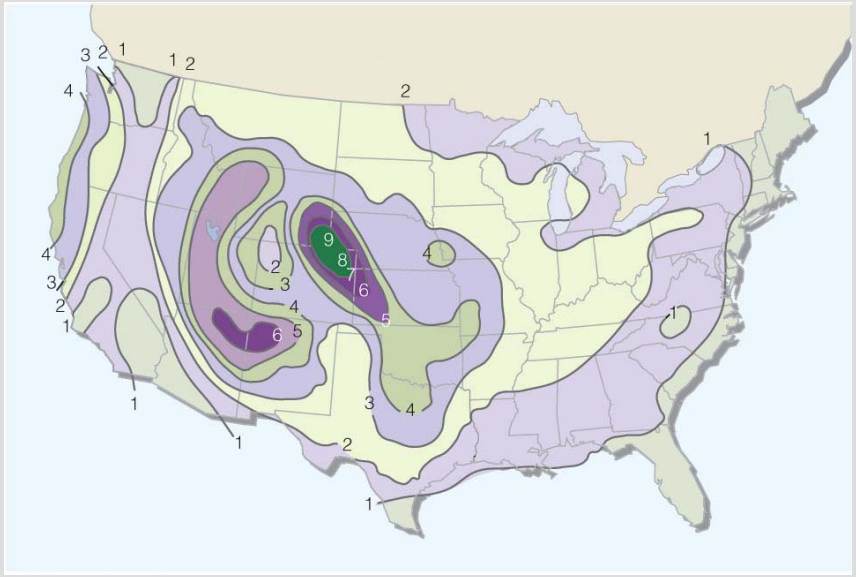
Thunderstorms and Severe Weather

Part III: Western U.S. Hazards and Lightning

Average number of days with thunderstorms



Average number of days with hail



What do you think explains the differences between these two maps?

Why are thunderstorms in the western U.S. different?

The topography is the major factor in generating thunderstorms.
How does this work?

Atmospheric conditions in which thunderstorms form are generally drier with less vertical shear.

- **More hail formation**
- **Dry thunderstorms which only have strong wind and lightning.**
- **Much less likely to develop supercell thunderstorms**

Steep terrain and dry soils enhance (flash) flood potential

Severe weather dangers particular to the Southwest U.S.

Flash flooding

- **Areas of steep topography, such as canyons**
- **Dry arroyos and sheet flood zones**
- **Urban areas with poor drainage**

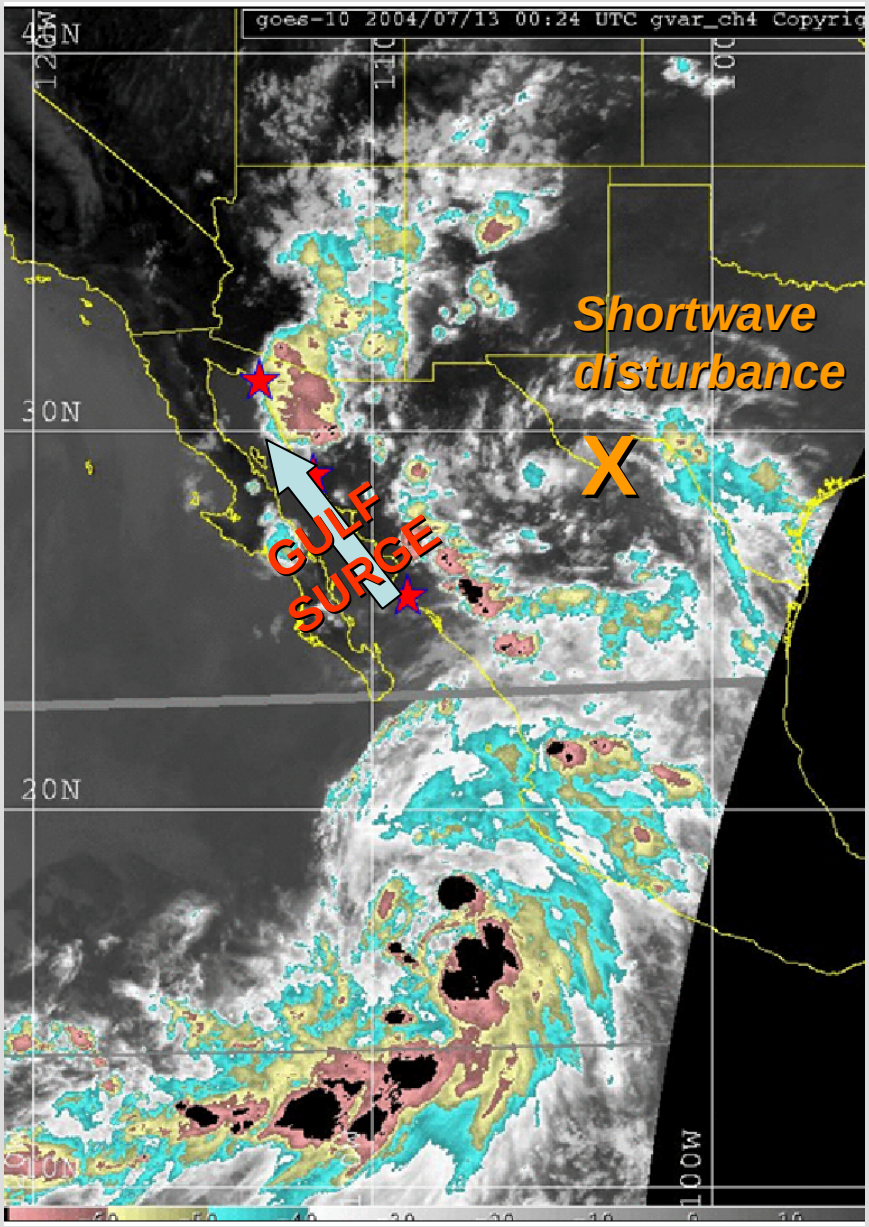
Hail (though it is not too big…)

Dust storms (haboobs)

Microbursts

Lightning and lightning induced wildfire

When are these dangers most prevalent in Arizona?



Conditions for enhanced monsoon thunderstorms

An upper-level disturbance (*X*) traveling around the monsoon ridge.

Low level-moisture surging up the Gulf of California

RESULT

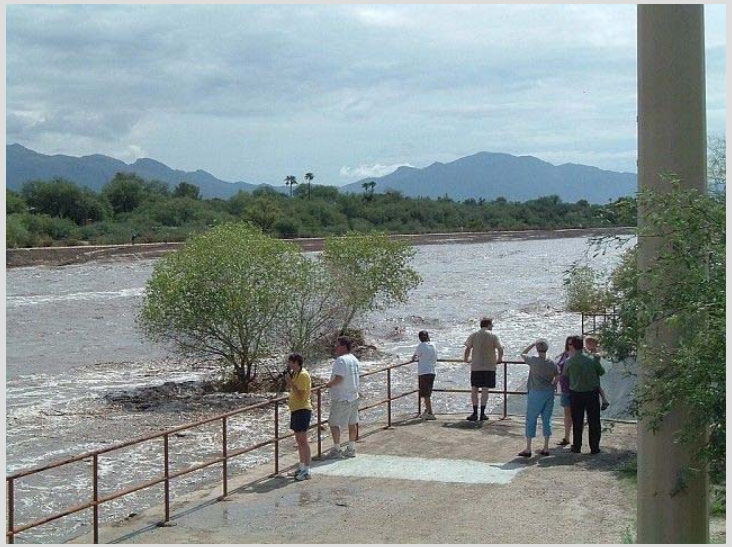
Thunderstorms which originate on the Mogollon Rim intensify and move westward toward low deserts and the Colorado River Valley.

THIS IS WHEN IT RAINS IN YUMA!

Flash Flooding in Arizona

ARROYOS

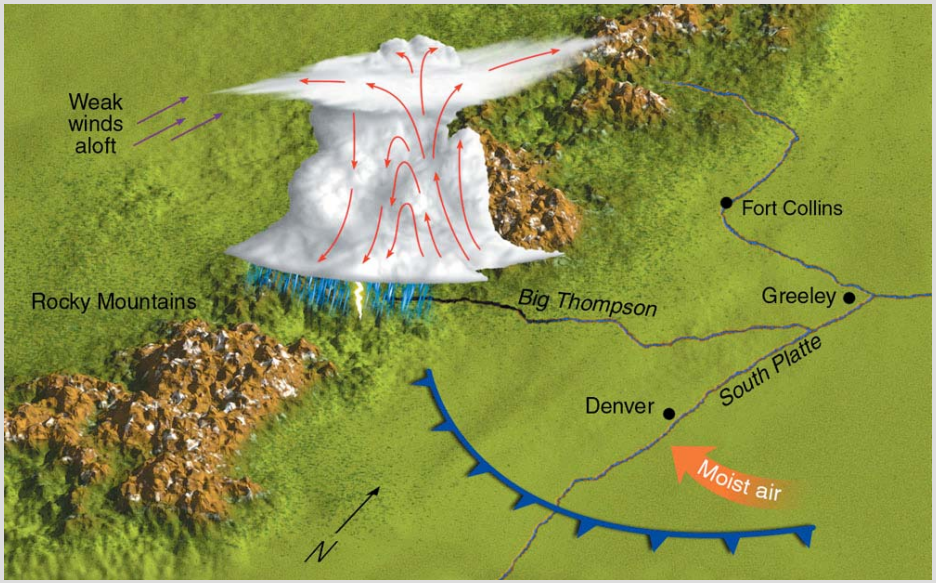
CANYONS AND DRY RIVERBEDS



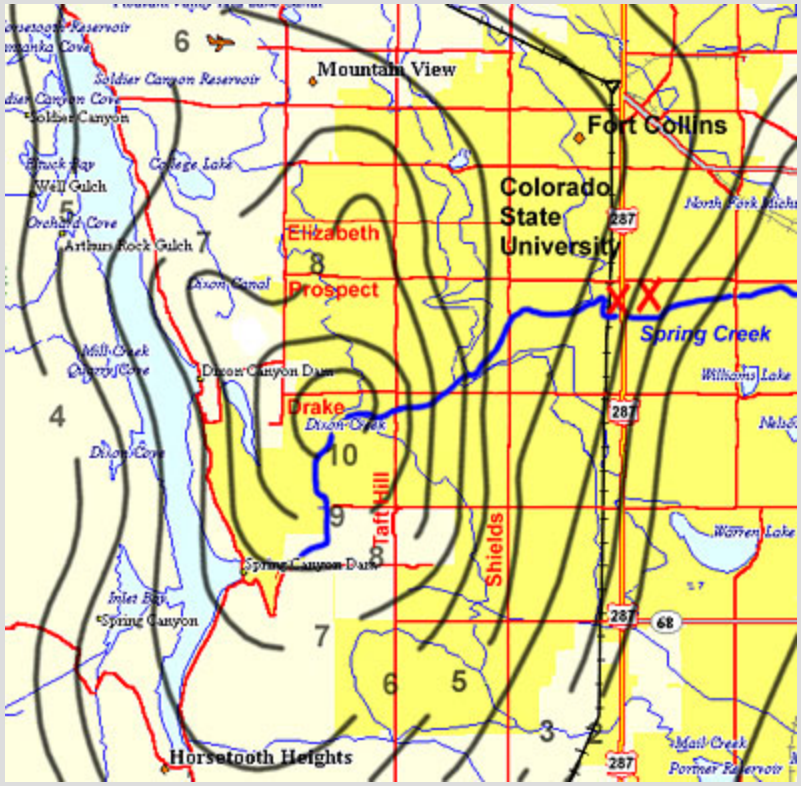
WHEN THE STREETS OR ARROYOS FLOOD, DON'T TRY TO CROSS THEM!!

LAS VEGAS FLOOD, July 1999

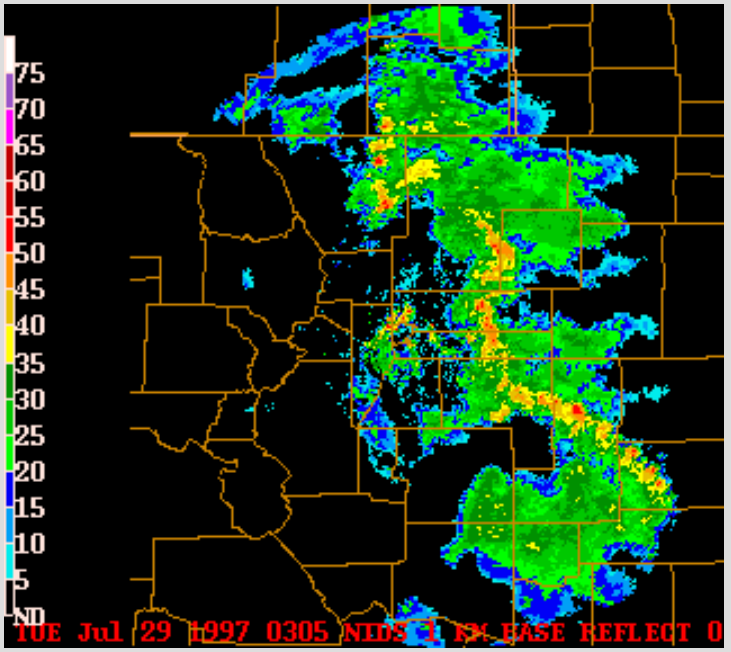
Big Thompson Flood July 31, 1976



Fort Collins Flood
July 29, 1997



Storm rainfall (inches)



Microburst

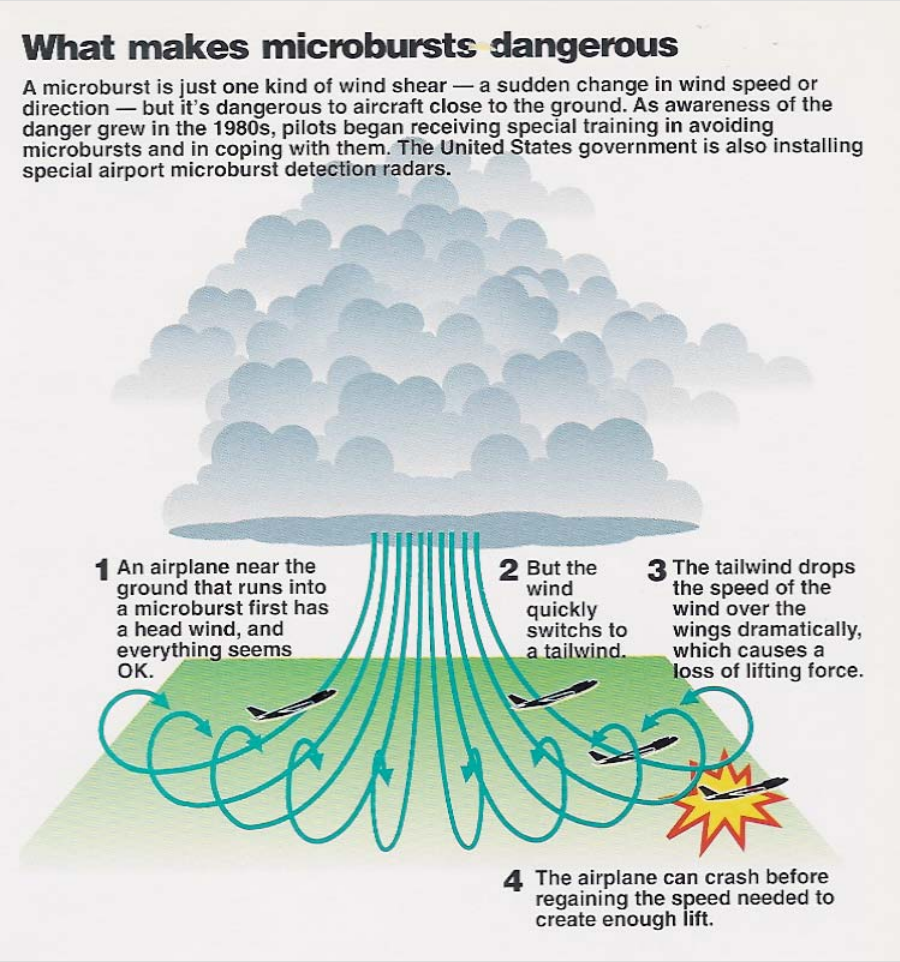
Precipitation in the downdraft part of the thunderstorm evaporates (partially or fully) before it hits the ground.

Cooled air sinks rapidly toward the surface.

Dry microburst near Denver, CO.

Wet microburst on the west side of Tucson, near Ryan Field

Microburst Aviation Hazard



(Williams)

Delta Flight 191
Crashed August 2, 1985
Cause: Microburst related wind shear and pilot error

Haboob: Dust or sand storm

Phoenix, Arizona

Caused by rapid movement of air associated with the gust front of a thunderstorm. Common during the monsoon, particularly just as it starts because the preceding months are dry.

Where is another place these are very common?

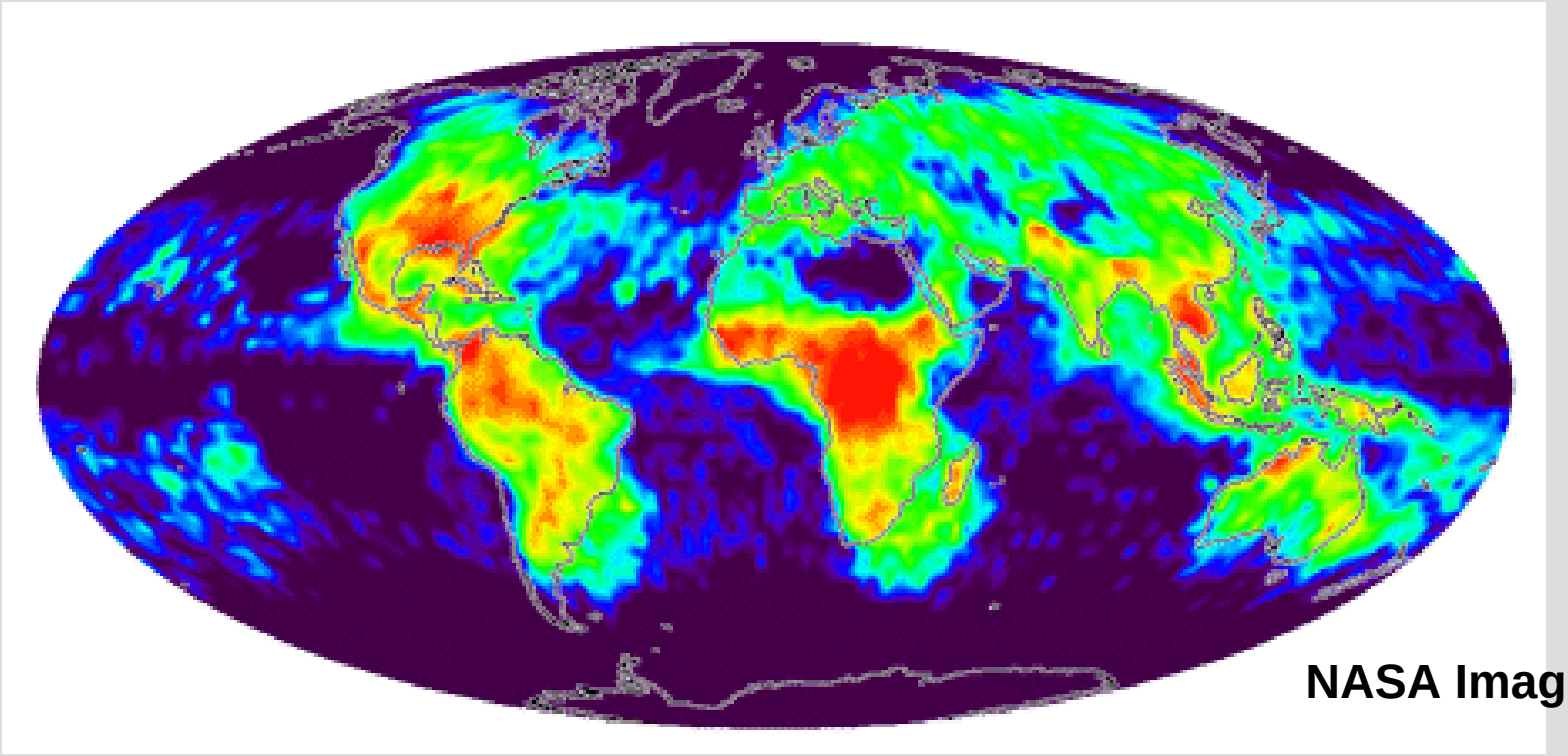
Lightning

Discharge of electricity, or spark that usually occurs in thunderstorms.

Only about 20% actually are cloud-to-ground.

TEMPERATURE WITHIN THE BOLT = 30,000°C
(5X HOTTER THAN SUN)

Global lightning distribution



NASA Imagery

Observation:

Nearly all the thunderstorms which produce lightning occur over land, or close to it.

Very little lightning occurs over the oceans.

Difference in convective clouds
Ocean vs. Land

Maritime Convective Clouds

Few cloud condensation nuclei and virtually no ice condensation nuclei

Mostly warm clouds (no ice) with a relatively few big drops.

Continental Convective Clouds

A lot of cloud AND ice condensation nuclei.

Mostly cold clouds with smaller and more numerous drops and ice particles.

Therefore…

What is necessary for cloud electrification??

Thermoelectric effect in ice

<u>Idea</u>: A separation in charge occurs when there is a temperature difference across ice.

WARMER TEMPERATURE
Higher number of negative ions

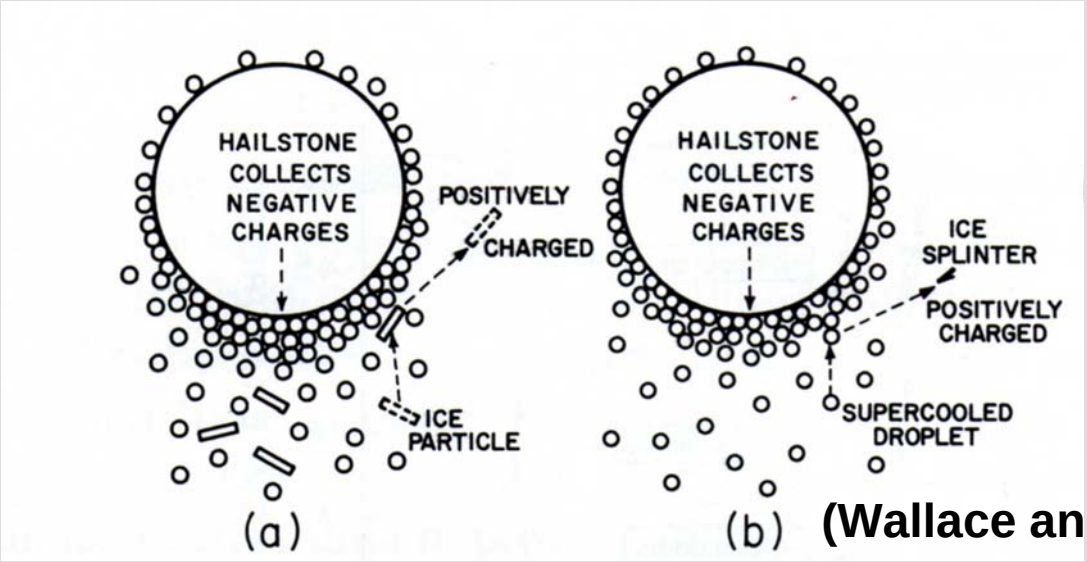
NEGATIVE CHARGE

COLDER TEMPERATURE
Higher number of positive ions

POSITIVE CHARGE

Charging of ice crystals

Consider a hailstone falling in a cloud updraft



(Wallace and Hobbs)

Hailstone collides with a colder ice particle or supercooled cloud drop.

When collision occurs:

The warmer hailstone becomes negatively charged and FALLS.

The colder ice particles become positively charged and RISE.

<u>NET RESULT</u>: TOP PART OF CLOUD IS POSITIVELY CHARGED
BOTTOM PART OF CLOUD IS NEGATIVELY CHARGED

Charge Distribution in Mature Thunderstorm

TOP PART OF CLOUD (BELOW -20°C)
POSITIVE CHARGE

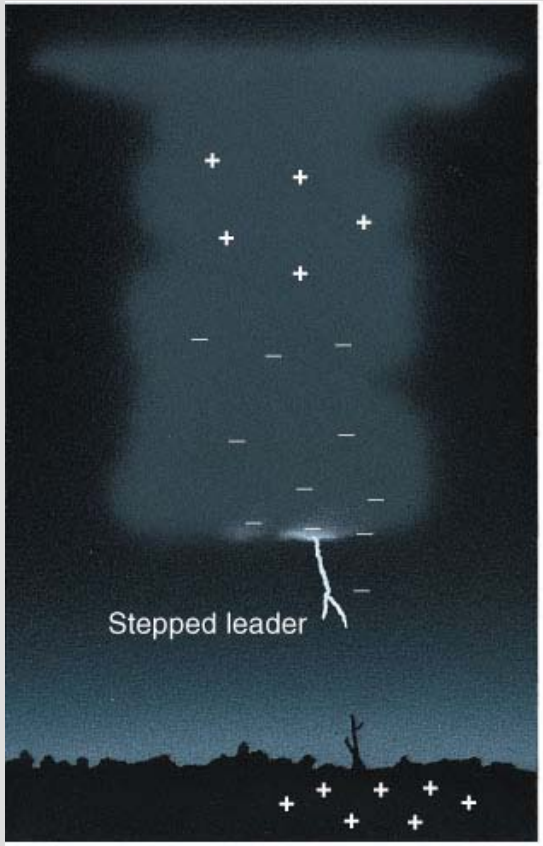
MIDDLE PART OF CLOUD (0°C to -20°C)
NEGATIVE CHARGE

BASE OF THE CLOUD (Around 0°C)
WEAK POSITIVE CHARGE

AT THE GROUND BELOW:
POSITIVE CHARGE COLLECTS ON UPWARD PROTRUDING OBJECTS

Lightning Discharge Sequence

NEGATIVE STEPPED LEADER



Lead streamers of negative charge toward the ground from cloud

POSITIVE STEPPED LEADER

Lead streamers of positive charge from the ground to cloud

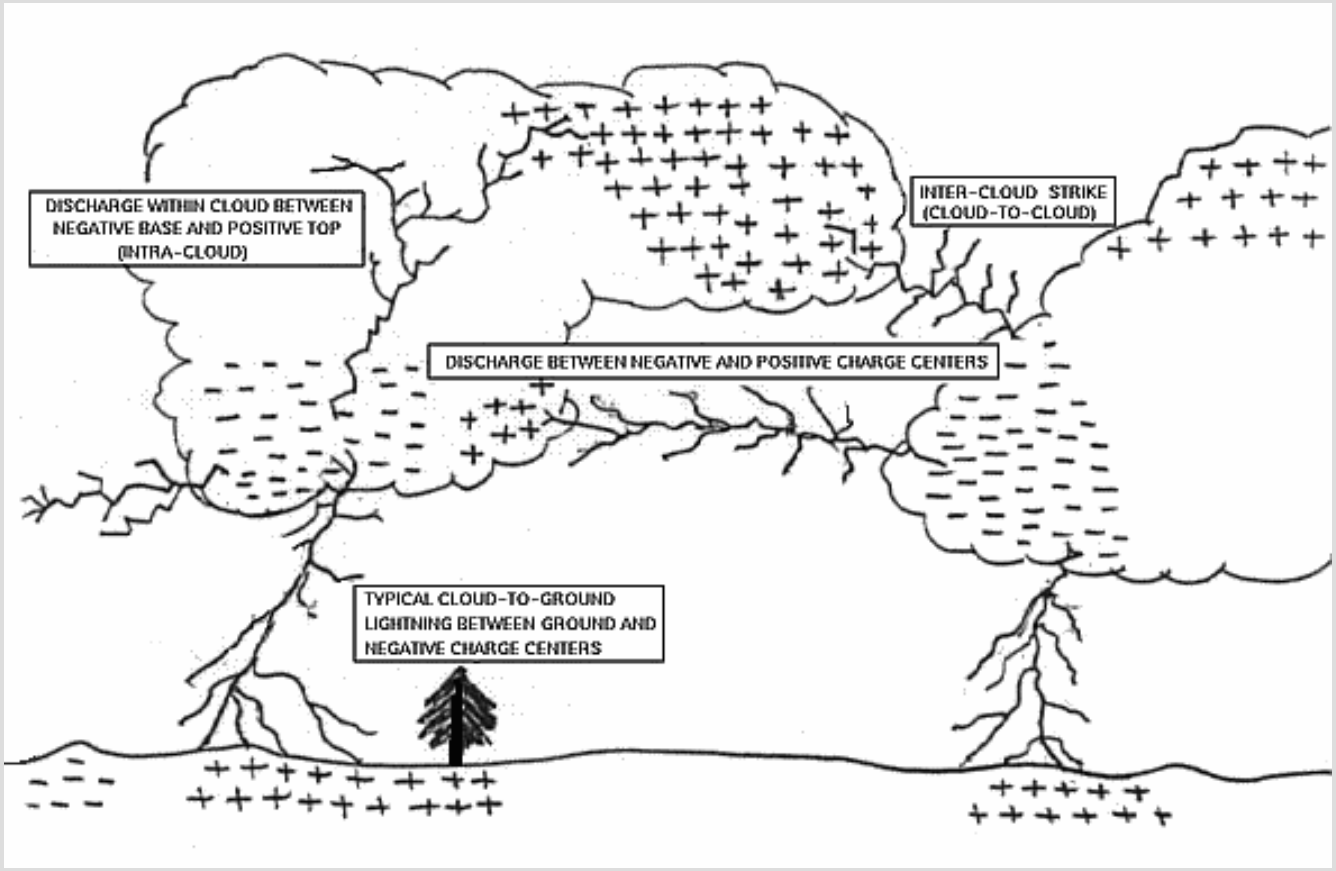
RETURN STROKE (BRIGHT FLASH)

Streams meet, carrying positive charge upward to the cloud.

Types of Lightning Discharges

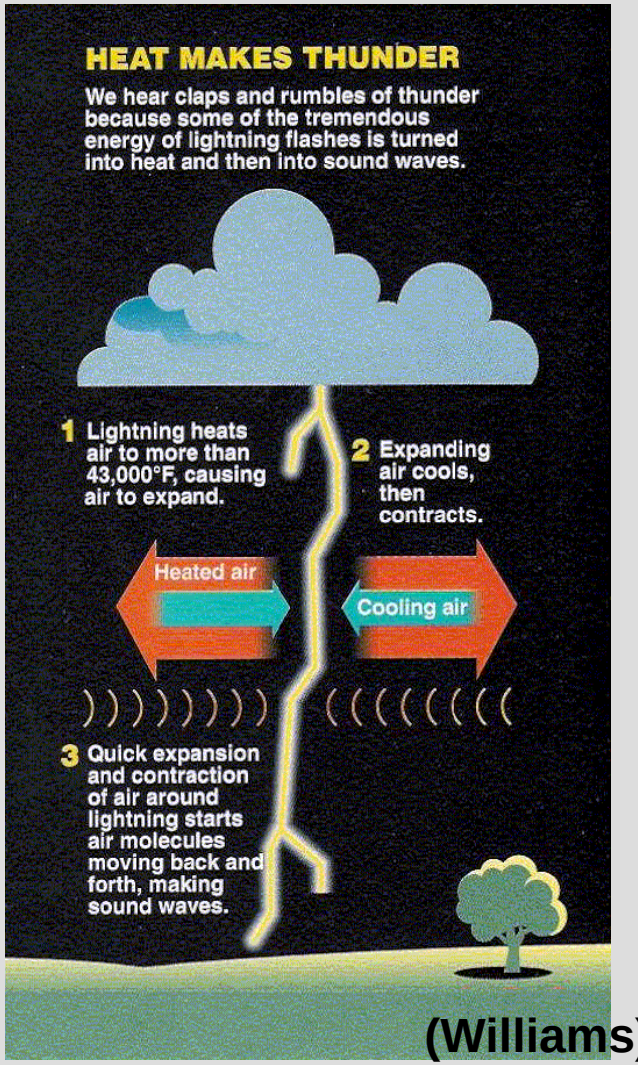
Within Cloud or Cloud-to-Cloud 80%

Cloud-to-ground 20%



One more that IS NOT SHOWN here is POSITIVE cloud-to-ground lightning. Though rare, it is more dangerous because it has a higher current and longer flash duration.

Thunder and the rumble



(Williams)

Heating of the air causes it to expand and contract rapidly.

The expansion and contraction of the air creates a sound wave, which we hear as *thunder*.

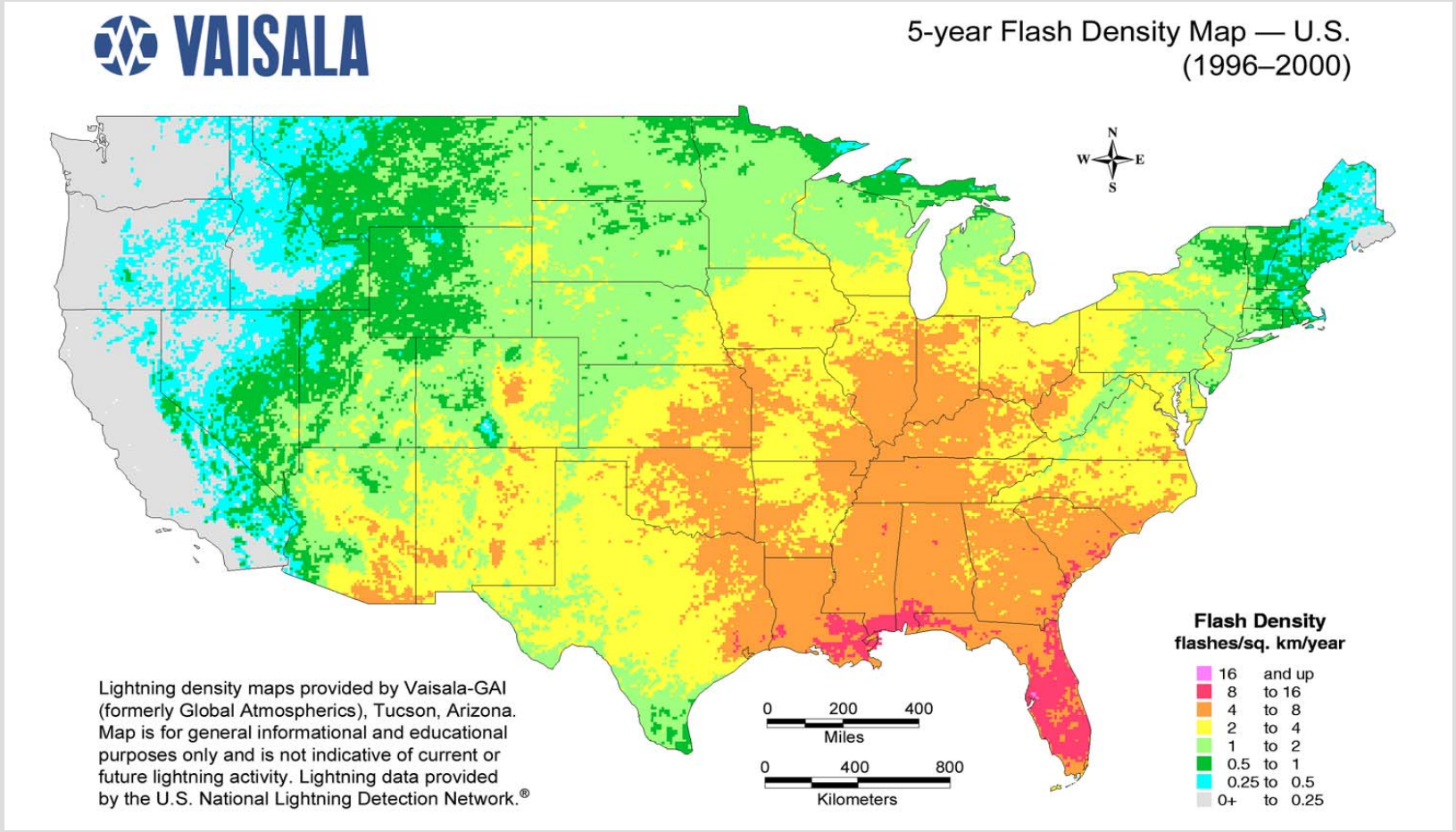
The subsequent rumbling sound may result from

- **Attenuation of the sound wave**
- **Echoes off of obstructions**

RULE OF THUMB TO GAUGE STORM DISTANCE:

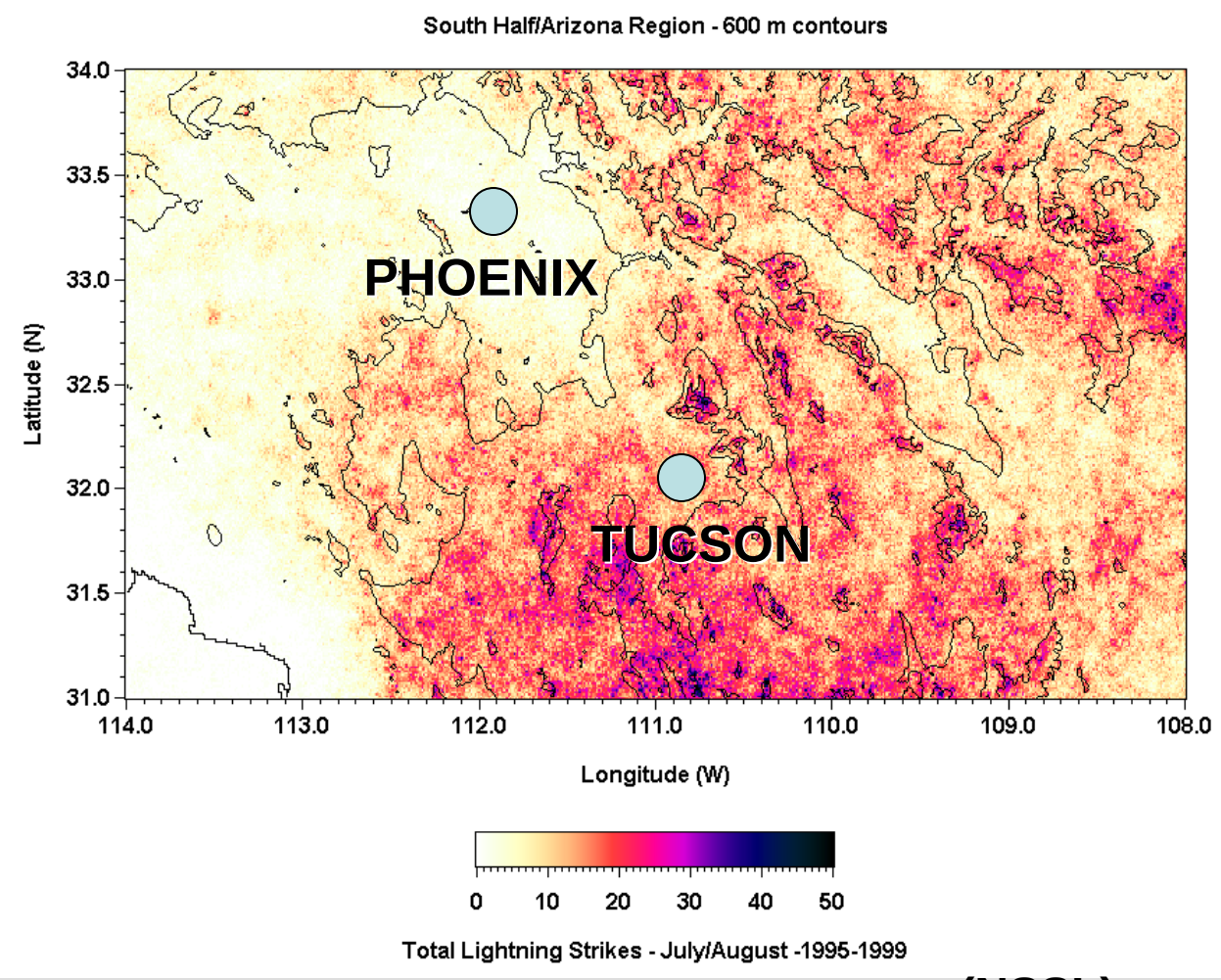
EACH 5s BETWEEN THE FLASH AND THUNDER = _____ DISTANCE.

U.S. Lightning Distribution



(Courtesy Dr. Phil Krider)

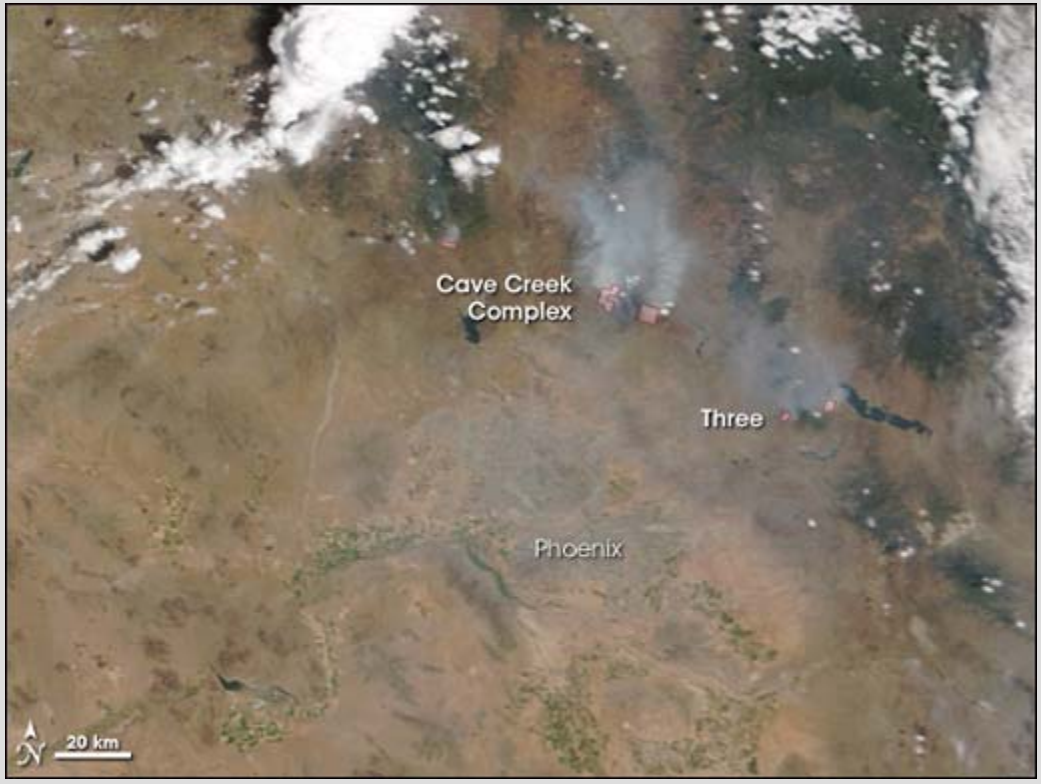
Tucson Lightning Distribution
Southern Arizona



Why is there more lightning in Tucson vs. Phoenix?

(NSSL)

Lightning and Wildfire Danger in Arizona



NASA Image of Cave Creek fire in late June 2005

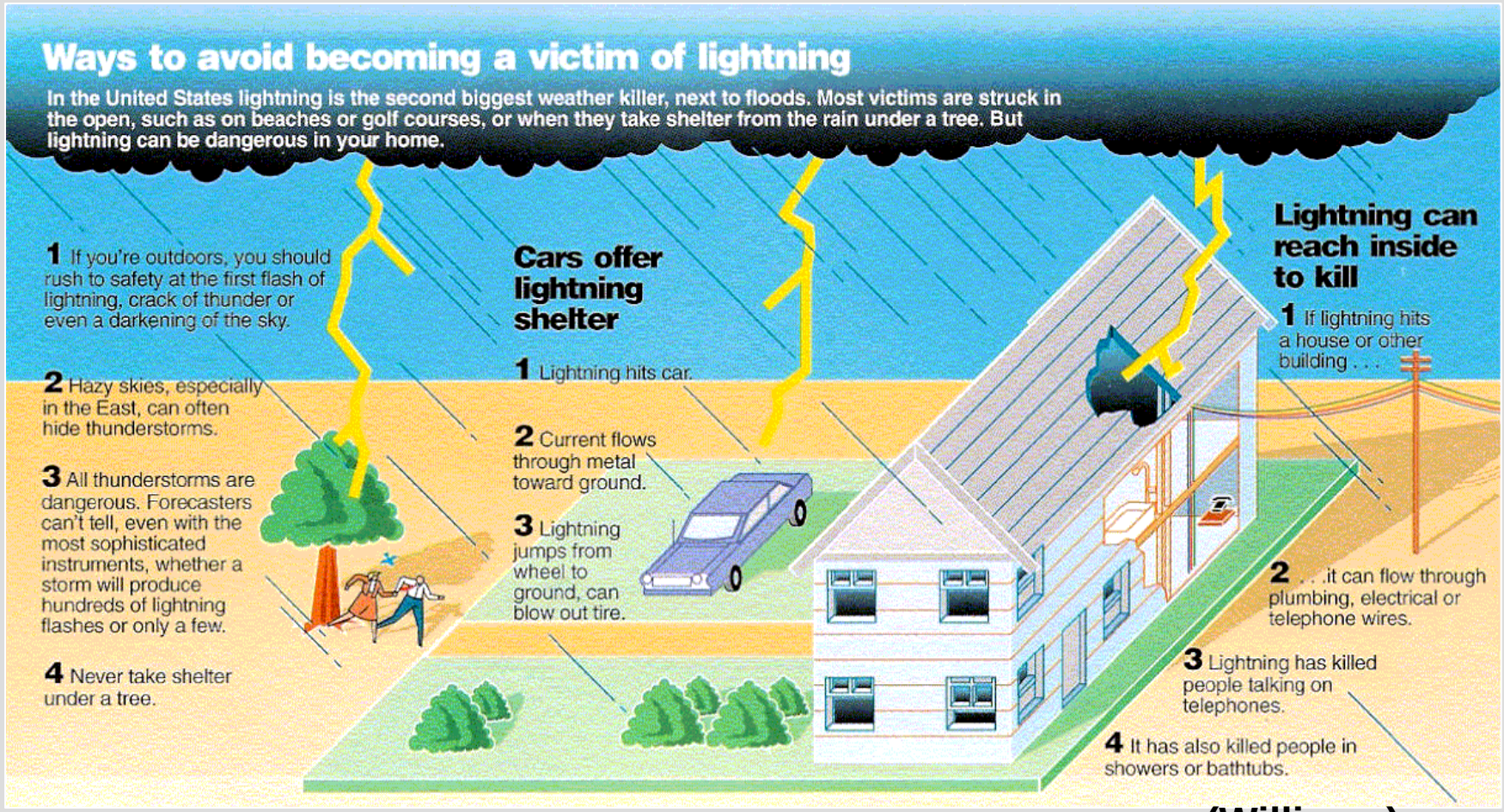
Lightning induced wildfire is a threat in Arizona, which is most acute right before the monsoon.

Factors:

Dry thunderstorms that produce lightning and wind but little or no rainfall.

Late spring and early summer before the monsoon is the driest and hottest part of the year in Arizona.

Weather Safety: Lightning



(Williams)

Summary of Lecture 28

Thunderstorms that occur in the western U.S. are different because of the influence of the topography and the drier and less sheared environment in which they form.

Severe weather dangers before and during the monsoon in Arizona include flash flooding, hail, dust storms, microbursts, and lightning.

The two conditions that enhance monsoon thunderstorms in Arizona are an upper-level disturbance and a low-level moisture surge from the Gulf of California.

Lightning is a discharge of electricity from a thunderstorm

Cloud electrification is due to ice phase processes within the cloud, creating positive charge at the top and negative charge below.

Lightning discharge occurs when lead streamers from cloud and ground meet, then there is a bright return stroke.

Thunder is the sound wave caused by the heating of the air by the lightning.

Reading Assignment and Review Questions

Reading: Chapter 15

<u>Chapter 14 Questions</u>

Review: 10,16,17,18,19,20 (8th ed.)
10,21,22,23,24,25 (9th ed.)

Thought: 6