

# Let's Talk About the Monsoon with a Meteorologist



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# Here's the plan...

1. Little about National Weather Service
2. What is the Monsoon
3. Thunderstorm Basics & Risks
4. Predicting Thunderstorms & Communicating Risk

# Why does NWS exist?

Vision: A Weather-Ready Nation: Society is Prepared for and Responds to Weather-Dependent Events

Mission: Provide weather, water, and climate data, forecasts and warnings

- Protect life and property
- Enhance national economy



# What is the NWS?

**FEDERAL GOVERNMENT**

**DEPARTMENT OF COMMERCE**

**NATIONAL OCEANIC  
AND ATMOSPHERIC  
ADMINISTRATION**

**NATIONAL  
WEATHER  
SERVICE**



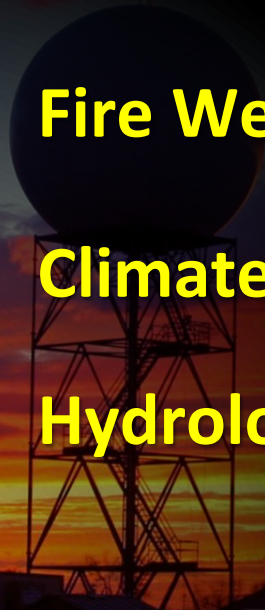


# What is the NWS?



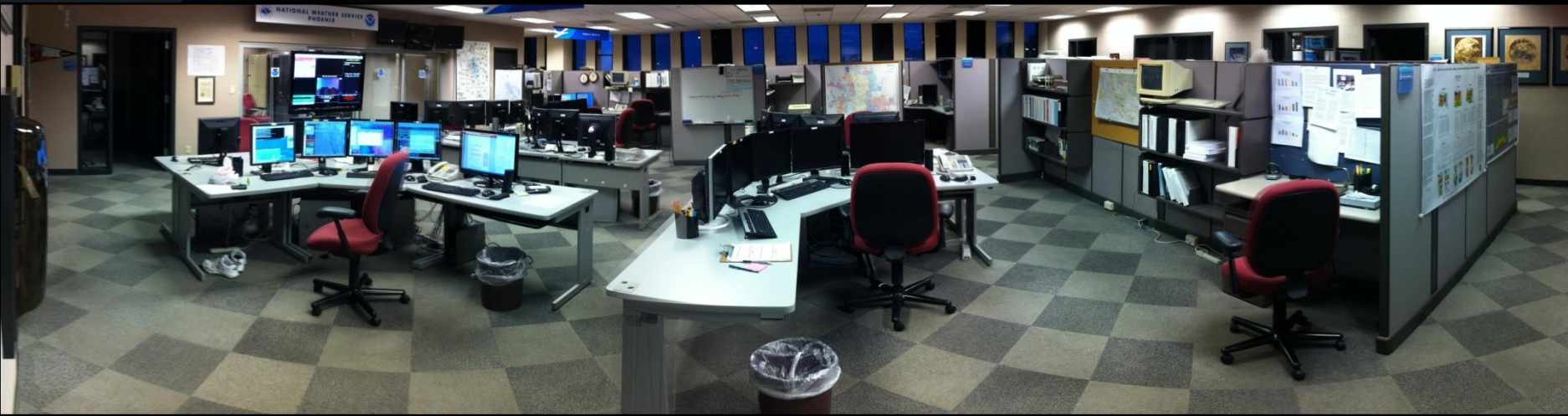
# NWS Services

- **Hazardous Weather:** *Outlooks, Watches, Advisories, Warnings*
- **7 Day Weather Forecasts:** *(text and graphics)*
- **Aviation:** *Specialized forecasts for airlines, traffic controllers, and private pilots*
- **Fire Weather:** *Array of forecasts for land mgmt. agencies*
- **Climate:** *Outlooks from two weeks to a year in advance*
- **Hydrological:** *Water Supply Outlooks, River Stage Forecasts*



# NWS Services

10-15 Meteorologists  
24/7/365 Operations  
2+ Meteorologists

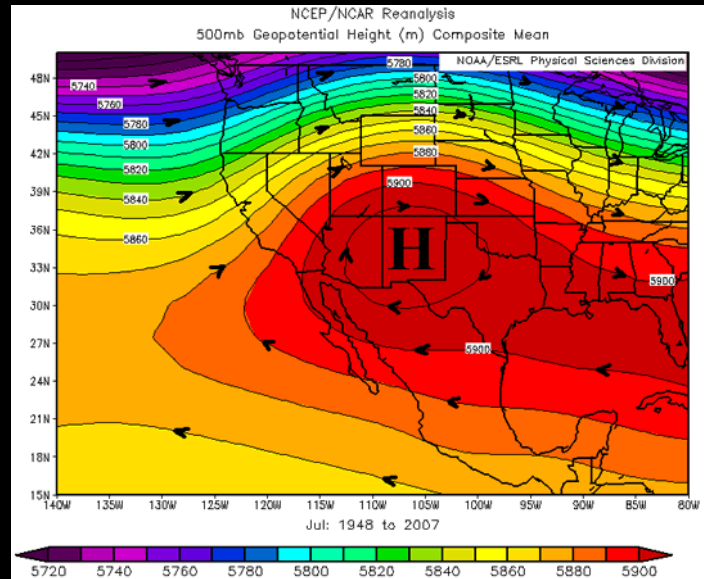
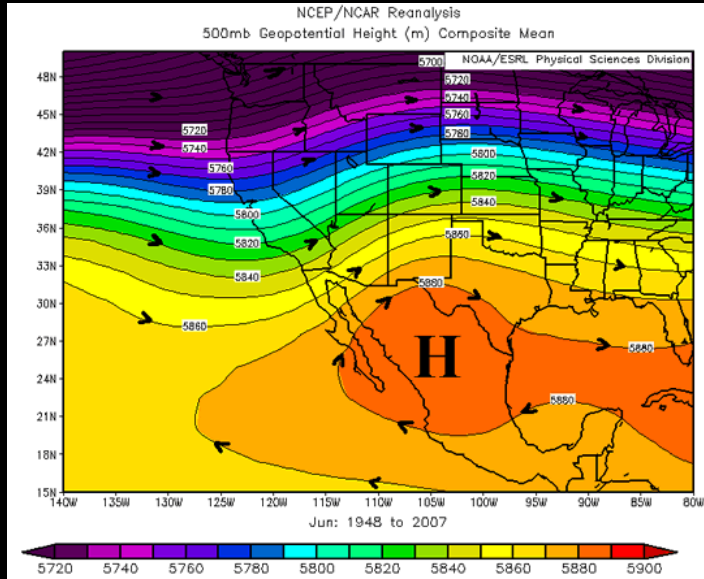




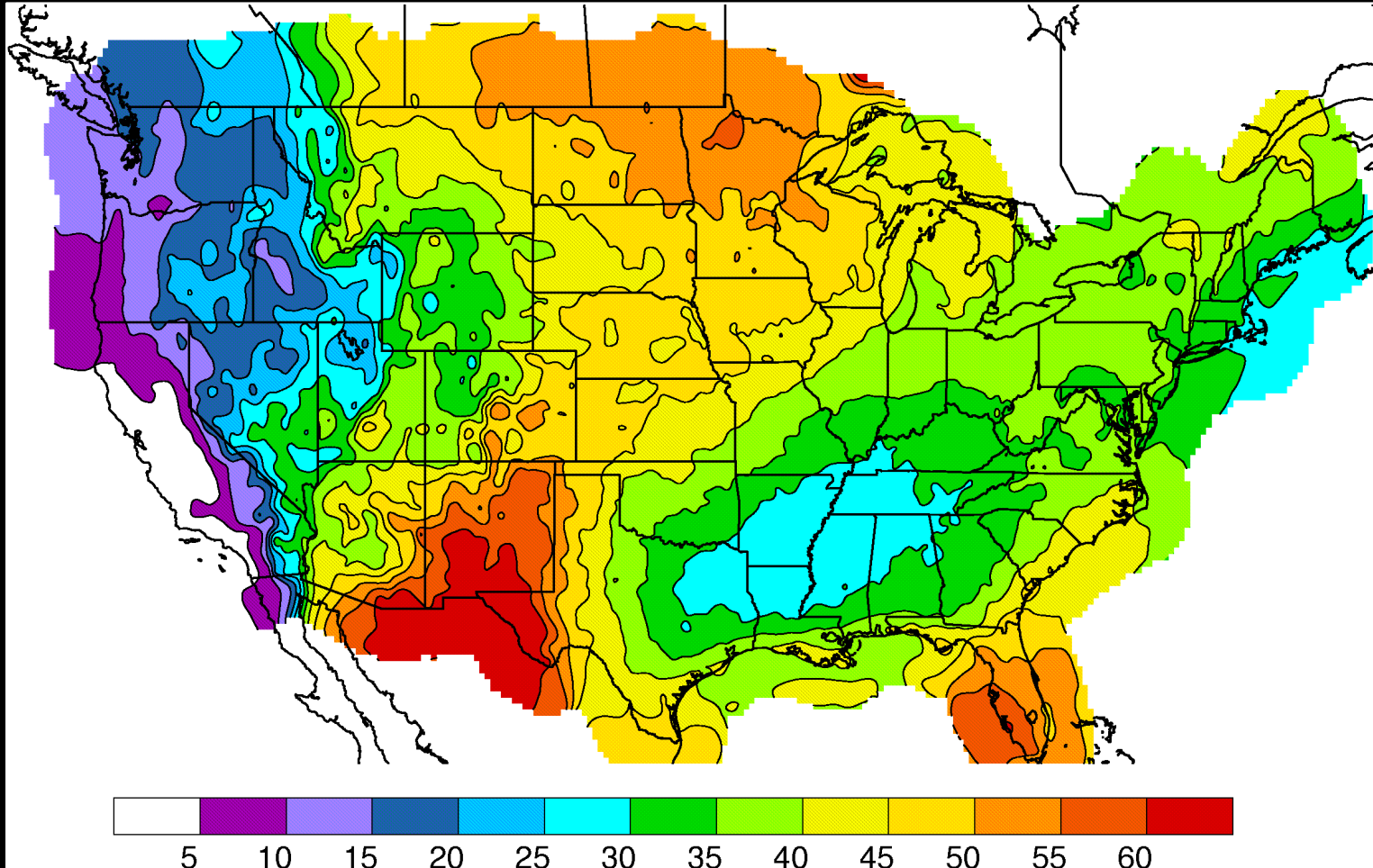
# What is the Monsoon?

- Definition: a seasonal reversal in the prevailing wind flow patterns.
- This tends to occur June 15 – September 30, thus our local calendar based definition.
- A Monsoon is *NOT* a thunderstorm.
- There is no “Arizona Monsoon”, it is the the North American Monsoon.

# What is the Monsoon?



# What is the Monsoon?



**Average (1958-2003) warm season (16 June – 15 October)  
contribution to the yearly precipitation (%)**

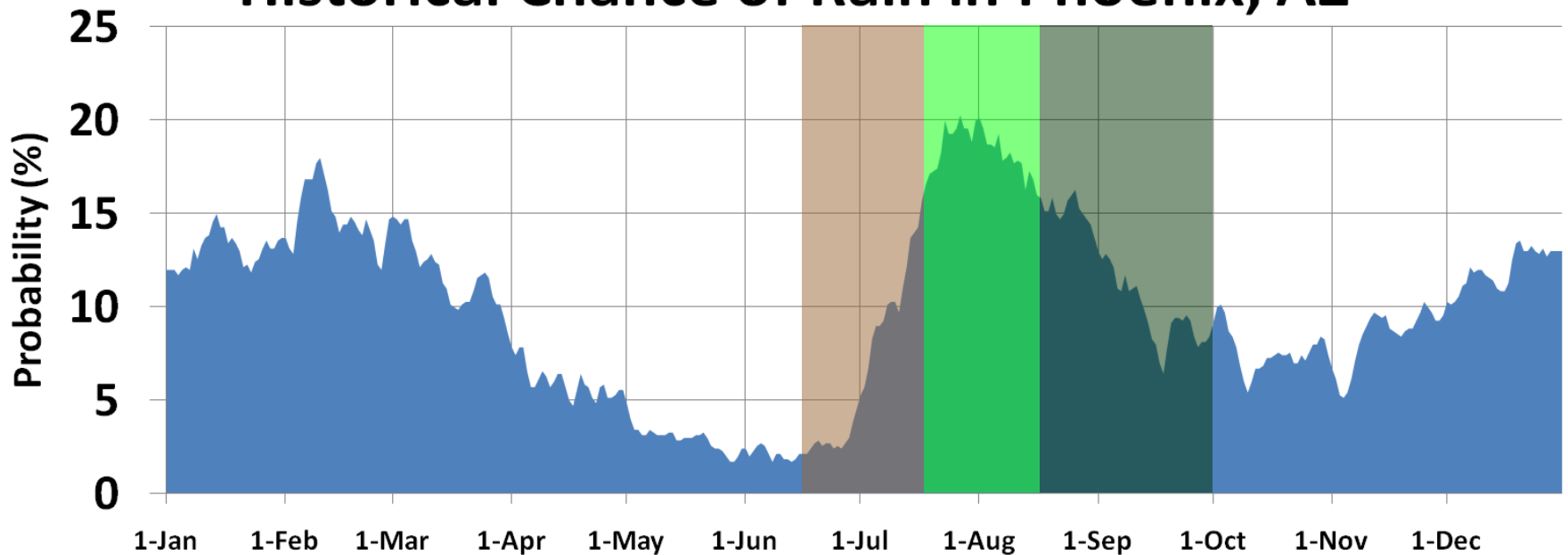
# Monsoon Variability

## Seasonal Patterns

**Early:** lower moisture availability (dry microbursts, dust storms, lightning caused fire starts).

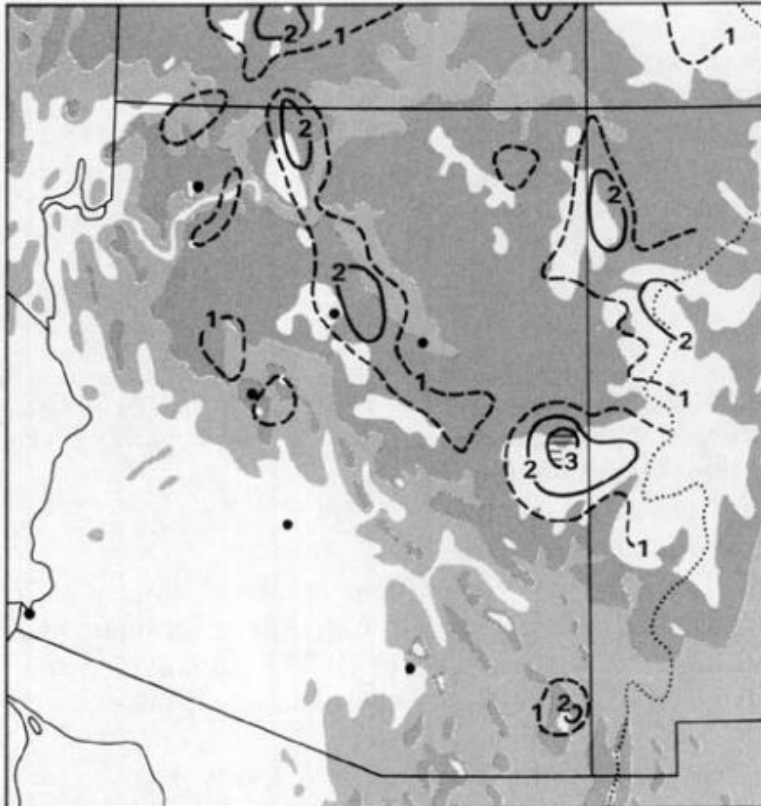
**Middle and Latter:** better moisture (wet microbursts, flash floods).

### Historical Chance of Rain in Phoenix, AZ



# Monsoon Variability

## Daily Patterns



1900 UTC (1200 MST)

FIG. 7. Flash densities (flashes per 100 km<sup>2</sup> per monsoon season) for 1200 MST (1900 UTC) for 1985-90.

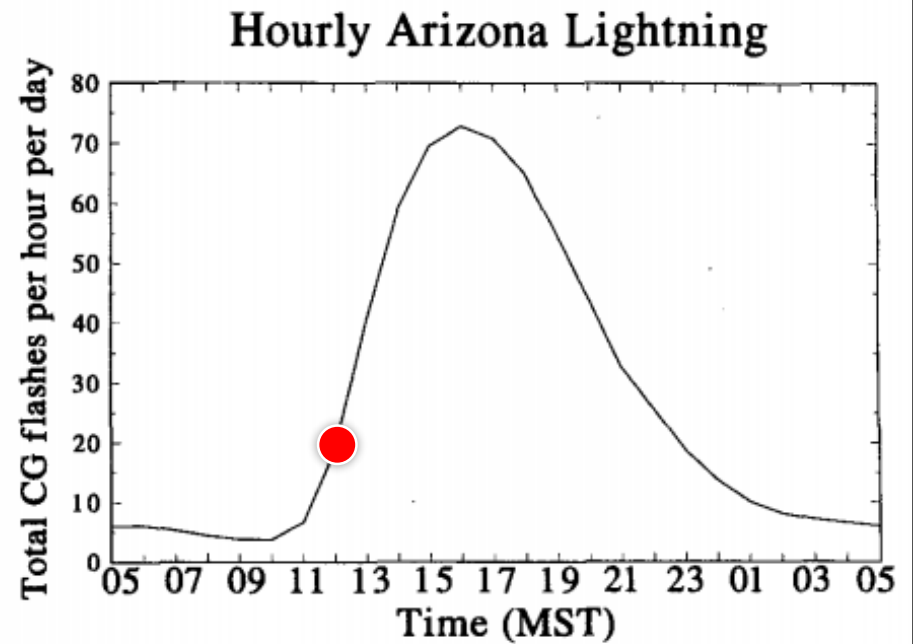
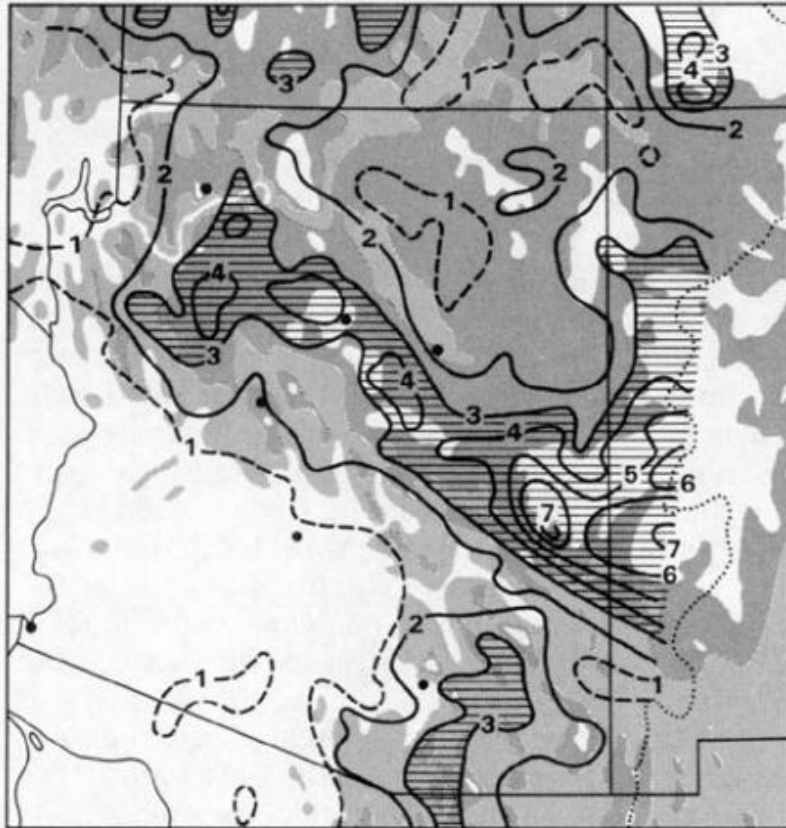


FIG. 6. Average hourly variation of CG flashes across Arizona for 1985-90.

# Monsoon Variability

## Daily Patterns



2200 UTC (1500 MST)

FIG. 8. Same as Fig. 7 except for 1500 MST (2200 UTC).

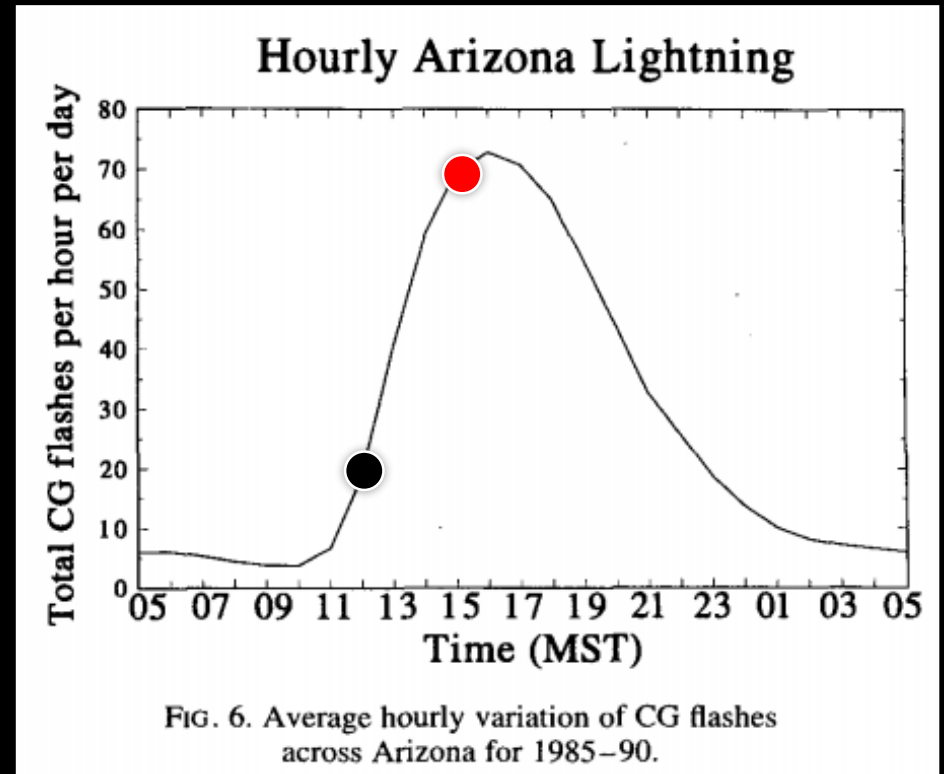
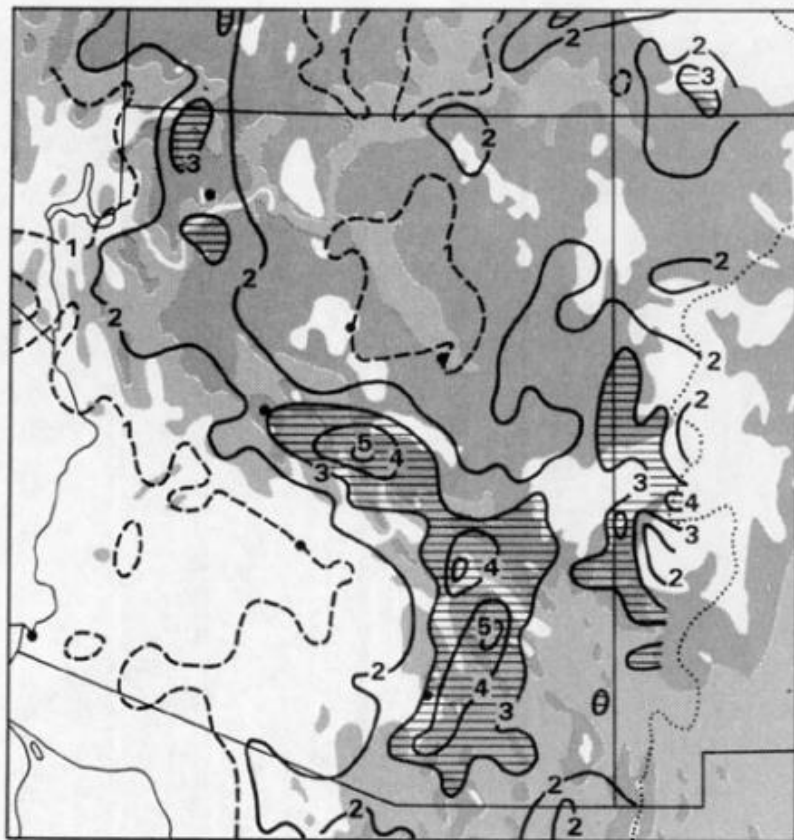


FIG. 6. Average hourly variation of CG flashes across Arizona for 1985-90.

# Monsoon Variability

## Daily Patterns



0100 UTC (1800 MST)

FIG. 9. Same as Fig. 7 except for 1800 MST (0100 UTC).

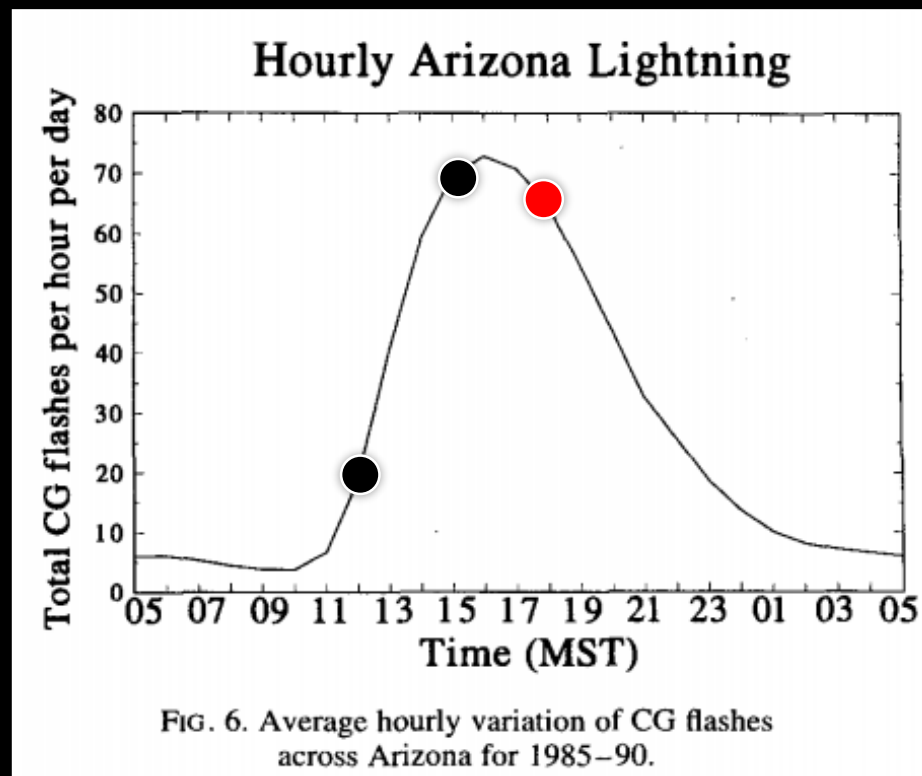
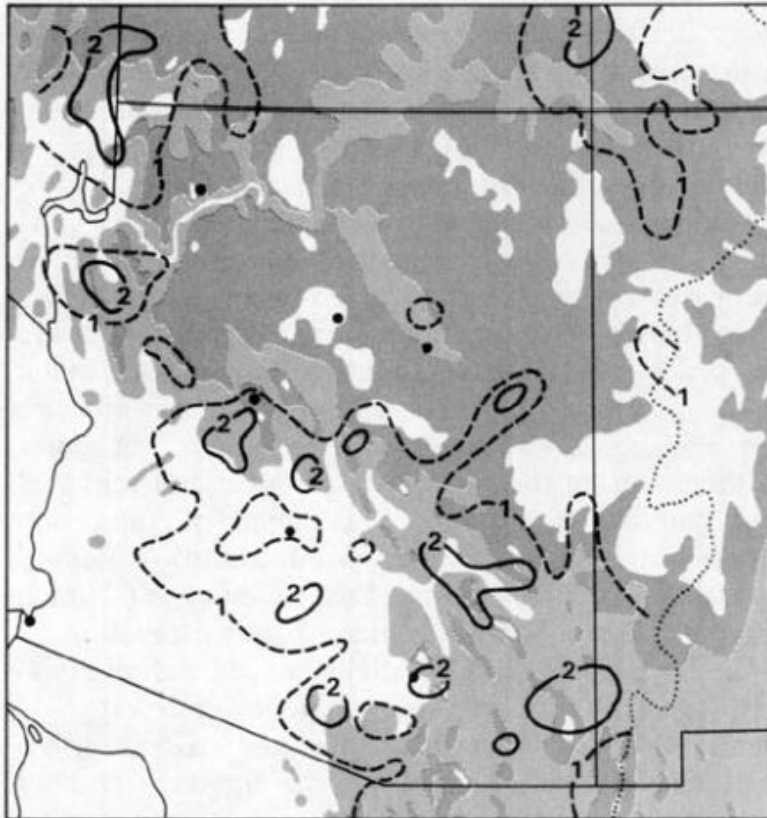


FIG. 6. Average hourly variation of CG flashes across Arizona for 1985-90.

# Monsoon Variability

## Daily Patterns



0400 UTC (2100 MST)

FIG. 10. Same as Fig. 7 except for 2100 MST (0400 UTC).

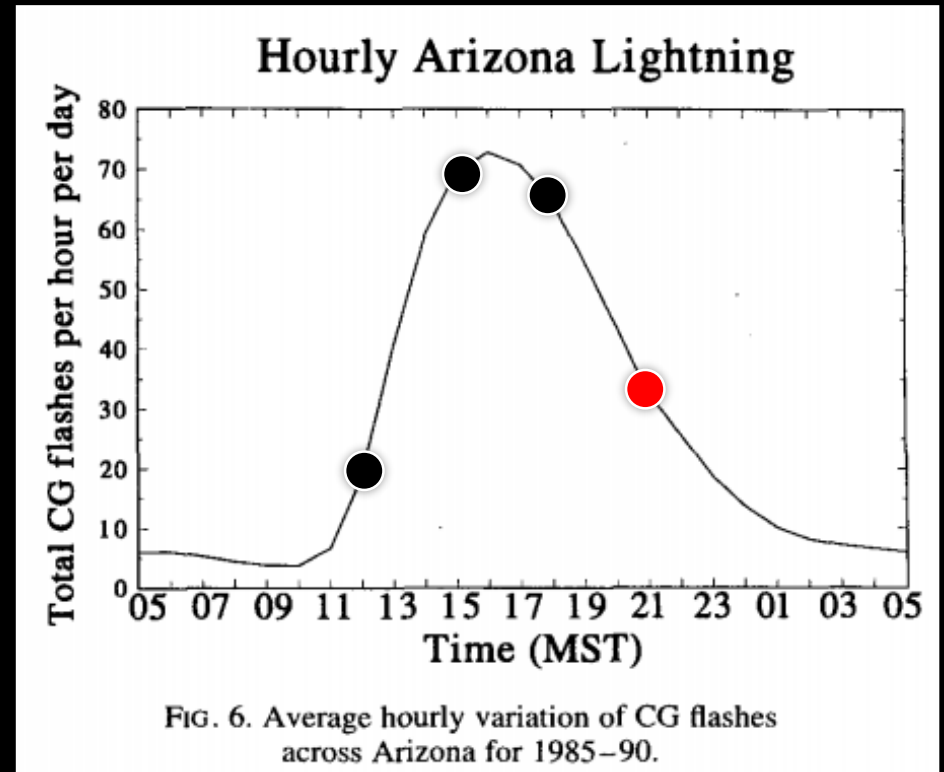
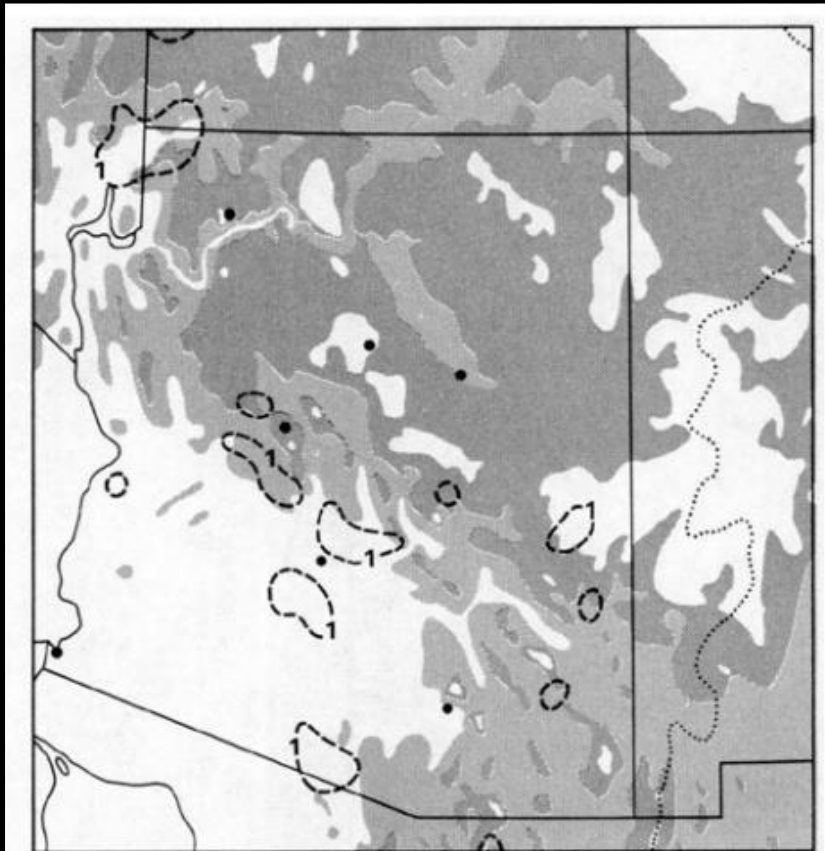


FIG. 6. Average hourly variation of CG flashes across Arizona for 1985-90.



# Monsoon Variability

## Daily Patterns



0700 UTC (0000 MST)

FIG. 11. Same as Fig. 7 except for 0000 MST (0700 UTC).

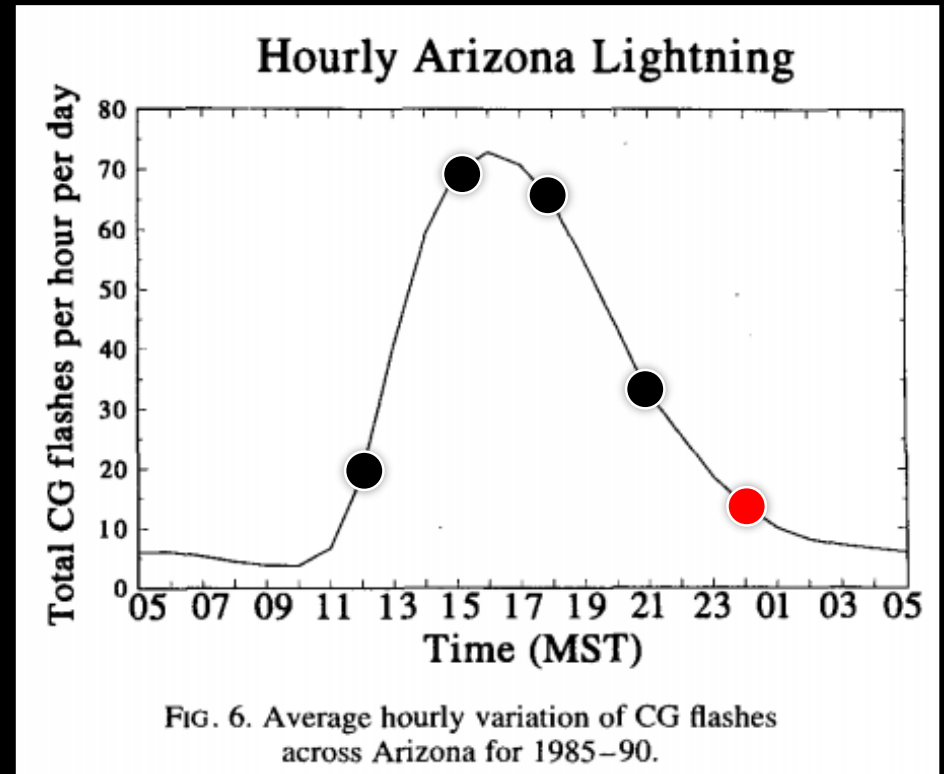


FIG. 6. Average hourly variation of CG flashes across Arizona for 1985-90.

# Biggest Risks During the Monsoon

Decreasing Order of Deadliness

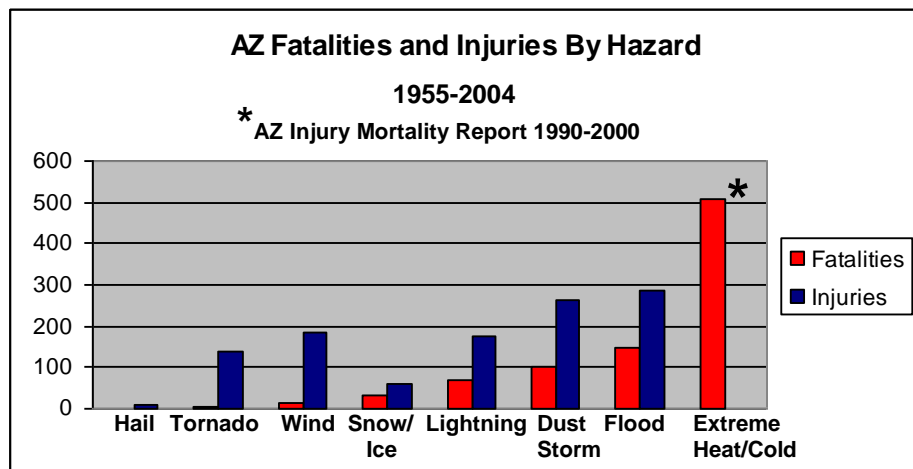
# Biggest Risks During the Monsoon

Decreasing Order of Deadliness - Heat

**#1 Weather-Related Killer** in Arizona. A conservative average of 50+ deaths per year.

- **122 °F** – All-Time Hottest Temperature in Phoenix (26 June 1990).
- **96 °F** – All-Time Hottest *Overnight* Temperature in Phoenix

## Arizona Deaths and Injuries by Hazardous Weather Type



### Data Sources:

- Arizona Climate- *The First Hundred Years* (Sellers, Hill and Sanderson-Rae)
- NCDC Storm Data 1955-2004
- SPC Events Database 1950-2004
- NCDC Storm Events Database: Online- [www4.ncdc.noaa.gov/cgi-win/wwwcgi.dll?wwEvent~Storms](http://www4.ncdc.noaa.gov/cgi-win/wwwcgi.dll?wwEvent~Storms)
- DOT Fatality Analysis Reporting System: Online- [www.fars.nhtsa.dot.gov](http://www.fars.nhtsa.dot.gov)
- University of Arizona Storm Database: Online- [ag2.calsnet.arizona.edu/cgi-bin/storms.cgi](http://ag2.calsnet.arizona.edu/cgi-bin/storms.cgi)
- Injury Mortality Among Arizona Residents, 1990-2000 Report (March 2002)

# Biggest Risks During the Monsoon

Decreasing Order of Deadliness – Flash Floods

- **Copious rainfall** from thunderstorms (2-4+ inches in 1-2 hours, rainfall rates up to 6"/hr).
- **Rocky soil** and widespread **concrete/pavement** in urban areas.
- **Poor drainage.**
- Life-threatening Flash Floods can develop in as **little as 30 minutes.**



# Biggest Risks During the Monsoon

Decreasing Order of Deadliness – Flash Floods

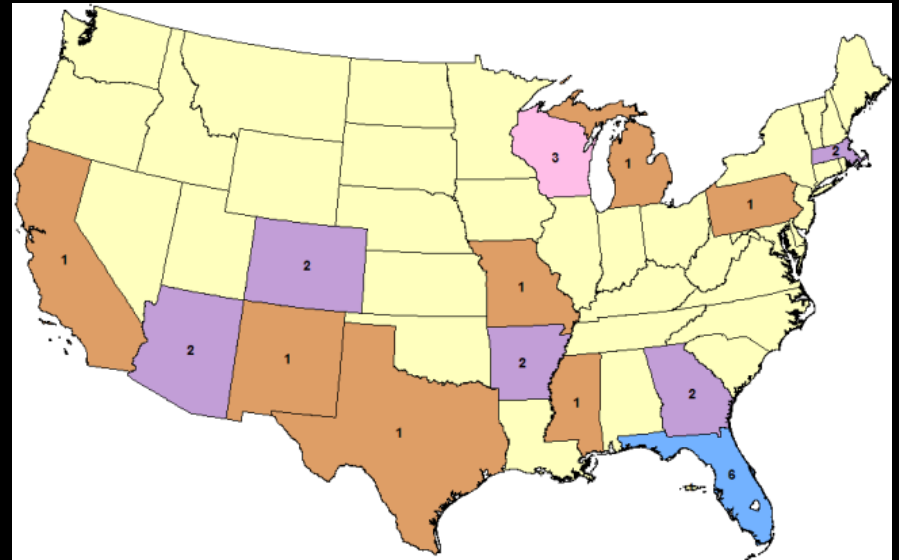
# Biggest Risks During the Monsoon

Decreasing Order of Deadliness - Lightning

Average 1-2 deaths in Arizona (19<sup>th</sup> highest nationally).

Over 600,000 strikes per year!

Eastern Arizona experiences as much lightning as the Central Plains.



# Biggest Risks During the Monsoon

Decreasing Order of Deadliness – Dust Storms



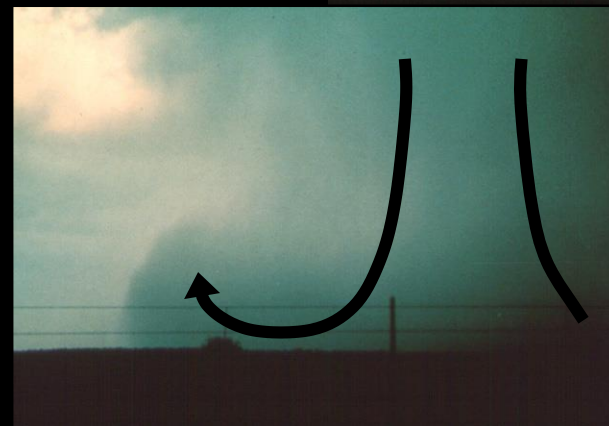
- Caused by large-scale **outflow winds from thunderstorms.**
- Can travel **significant distances.**
- Wind speeds **40+ mph.**
- Visibility to **near zero.**
- Have caused significant **traffic accidents, closed Sky Harbor.**



# Biggest Risks During the Monsoon

Decreasing Order of Deadliness – Downbursts/Winds

- **Definition:** a concentrated strong downdraft that induces an outward burst of damaging winds at the surface.
- A microburst *is* a downburst.
  - *A microburst is < 4 km in diameter, > 4 km is a macroburst.*
- **Key mechanism:** Evaporative Cooling.
- Wind speeds may exceed 100 mph.
- Responsible for most thunderstorm wind damage on the deserts.
- Mistaken for tornado damage.





# Thunderstorm Essentials

- **Moisture**
  - What clouds are made of.
- **Lift**
  - Method of forcing air upward
- **Instability**
  - Ability of air to accelerate upward = buoyancy.
- **Bonus:** Shear (winds change speed/direction with height)

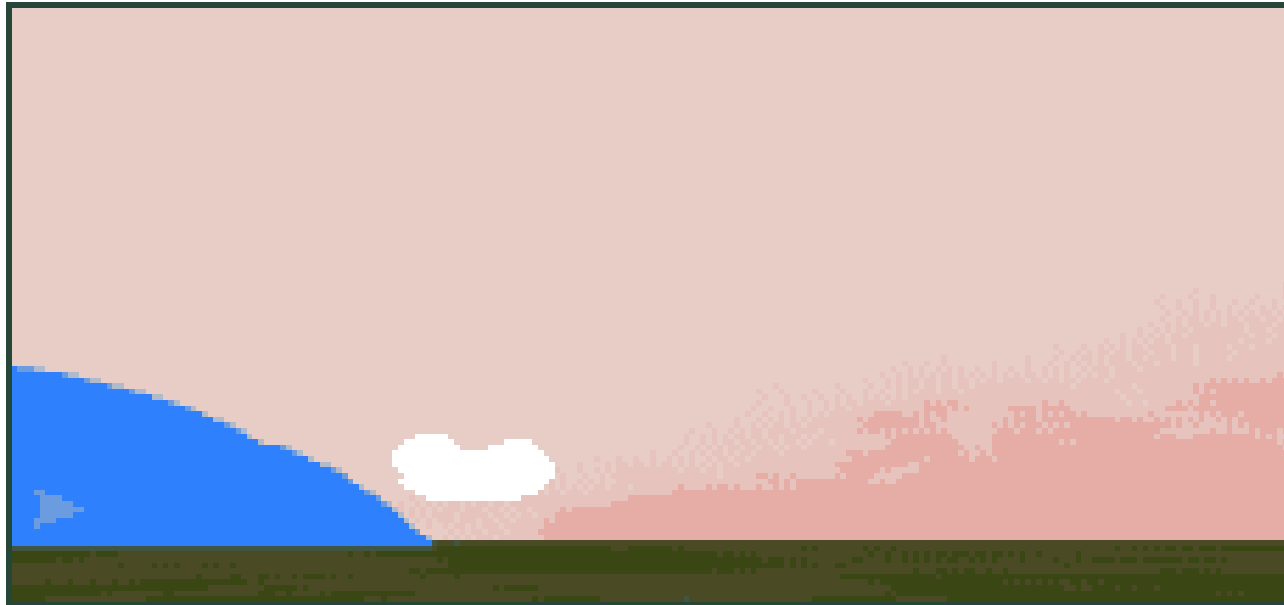
# Moisture



**Q: How many gallons of water are stored in an average thunderstorm cloud?**

A: A thunderstorm cloud contains approximately 275 million gallons of water. With 750,000 gallons of water going over Niagara Falls each second, it would take six minutes for an equal amount of water to go over the Falls. With one gallon of water weighing 8.33 pounds, the weight of the cloud is 2.3 billion pounds, or 1.1 million tons. *Source: USATODAY*

# Lift – Fronts and Boundaries



**Cold Front**

-  Cold Air
-  Warm Air
-  Warmer Air

The COMET Program

# Lift - Elevated Heat Source



Sun heats mountain tops faster than surrounding air

Mountains heat air above them

Air starts to rise

If conditions are favorable, updrafts and thunderstorms can develop

# Instability

If a lifted parcel is warmer (less dense) than environment, it will continue to rise (UNSTABLE)

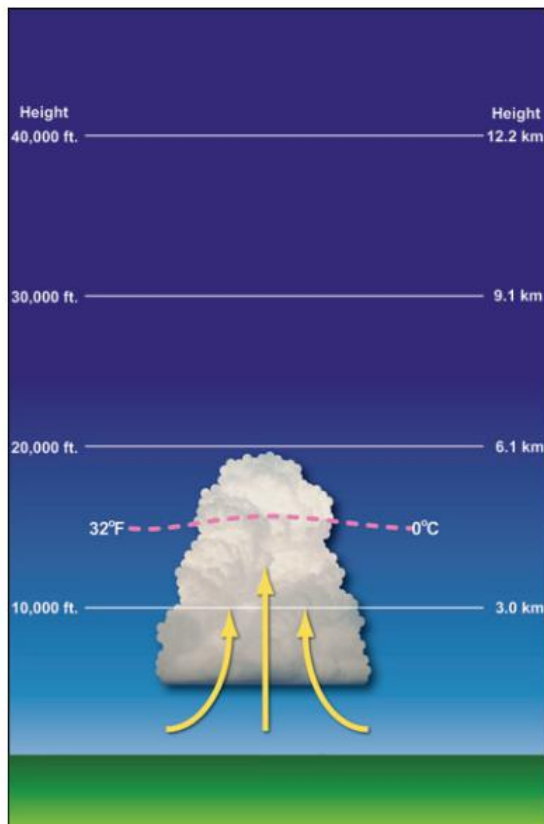
If a lifted parcel is cooler (more dense) than its environment, it will sink (STABLE)



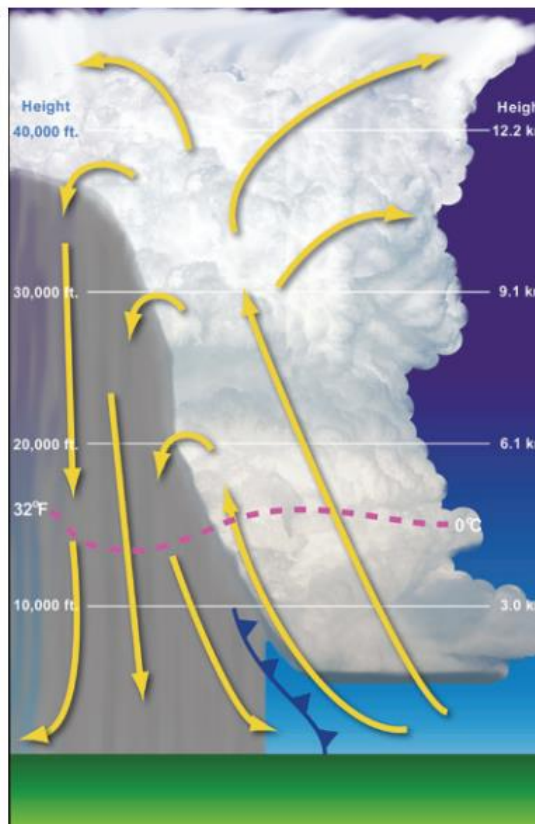
# Mix



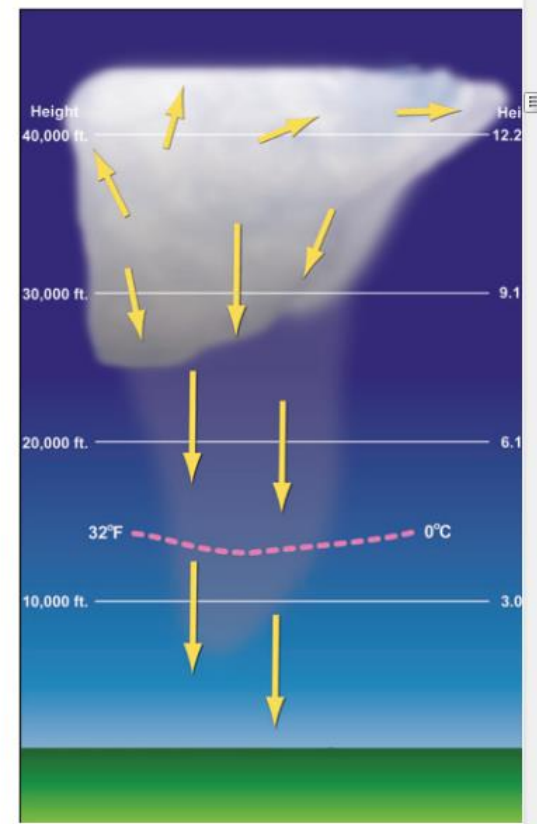
# Thunderstorm Life Cycle



*Towering Cumulus Stage*



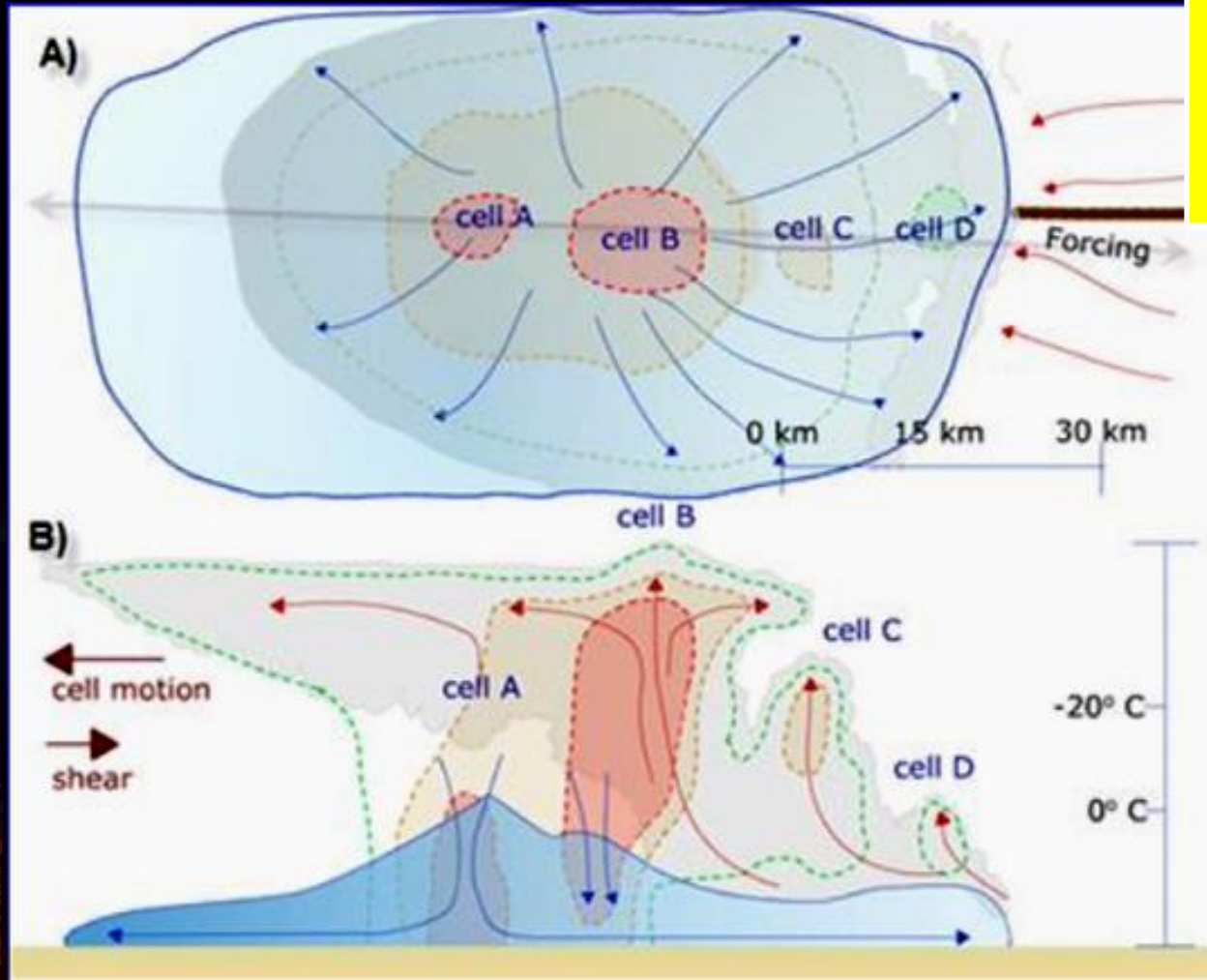
*Mature Stage*



*Dissipating Stage*

# Types of Thunderstorms

## Pulse



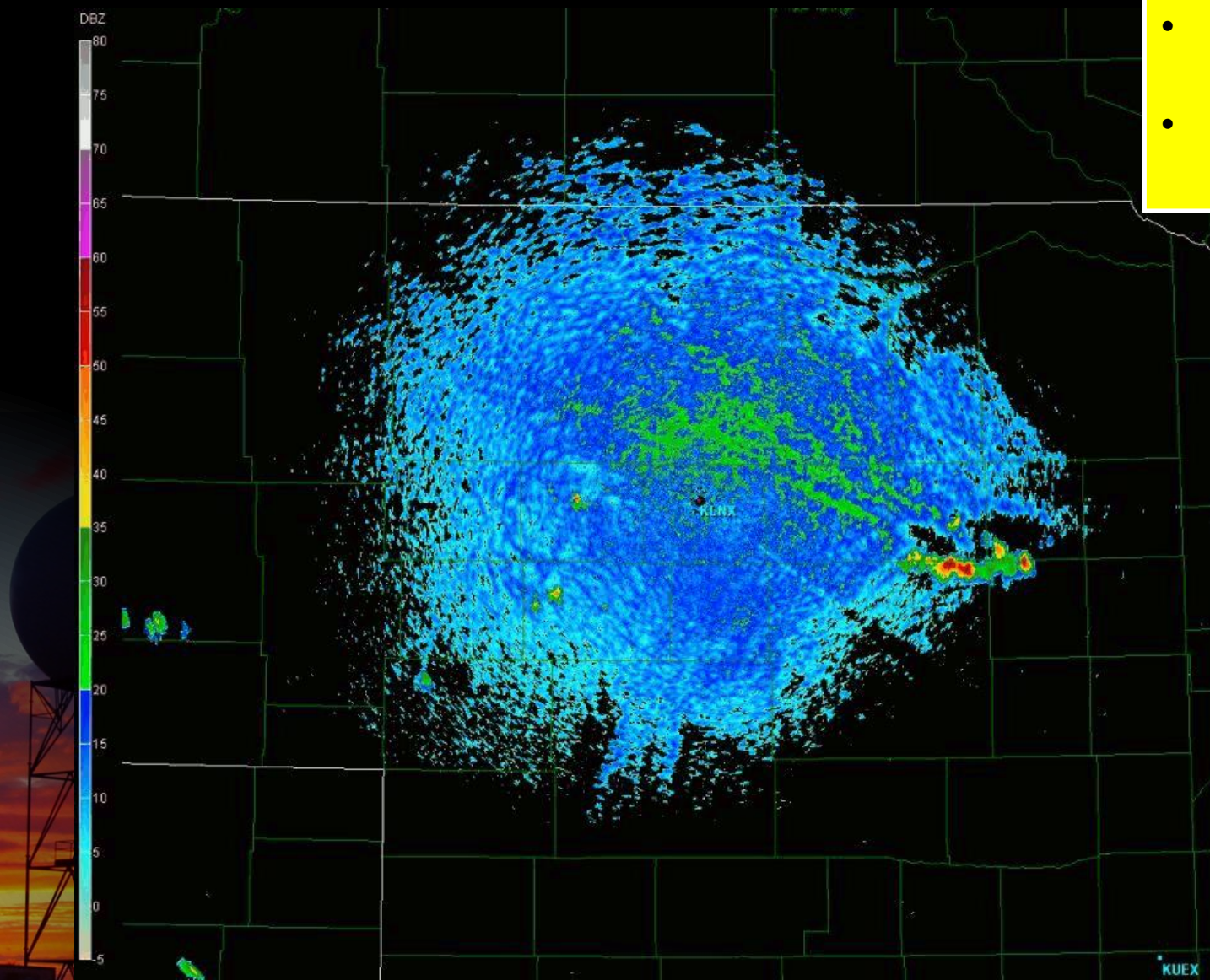
## RISKS

- Damaging Winds
- Flash Flooding



# Types of Thunderstorms

## Pulse



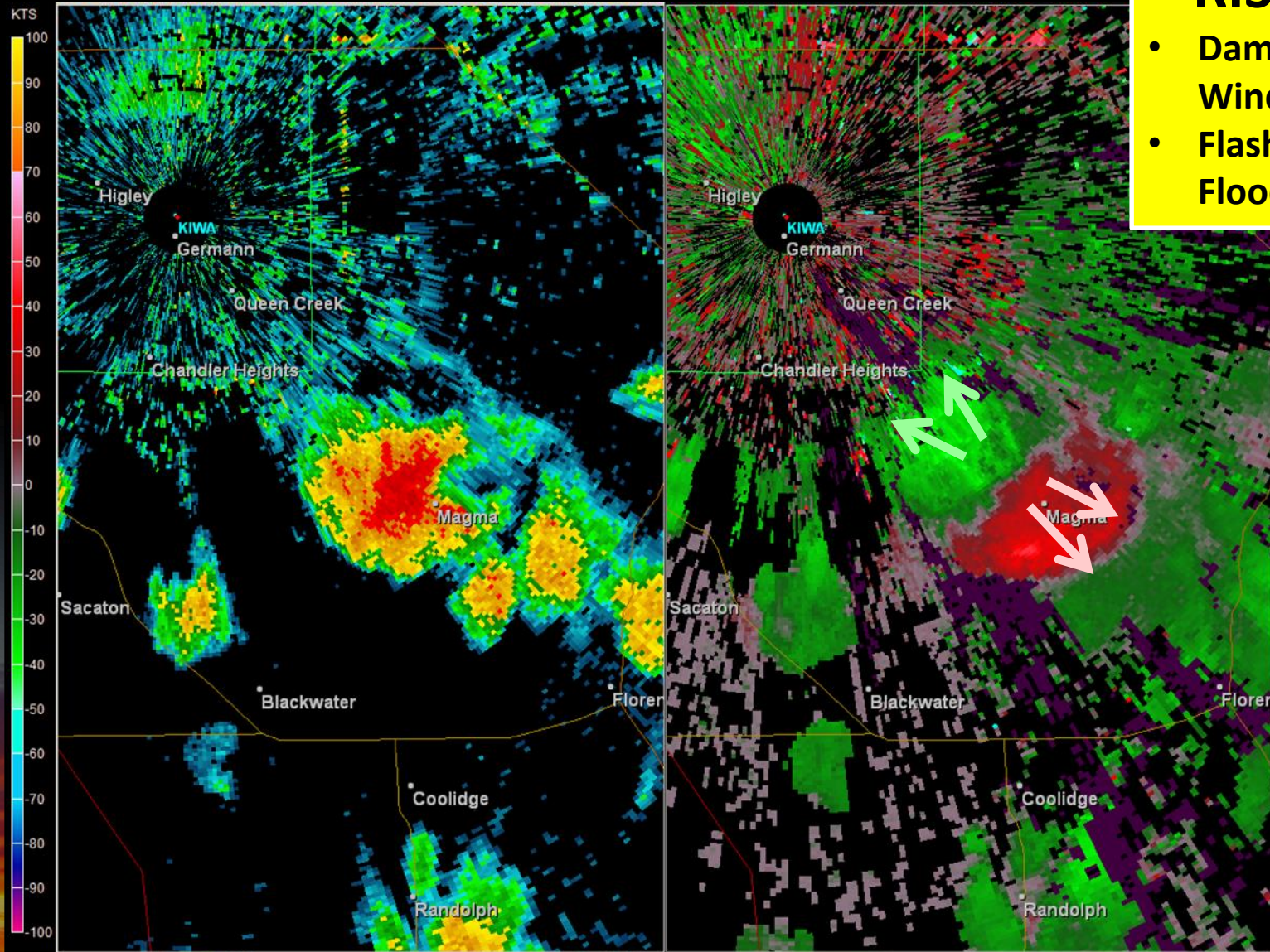
## RISKS

- Damaging Winds
- Flash Flooding

# Downbursts

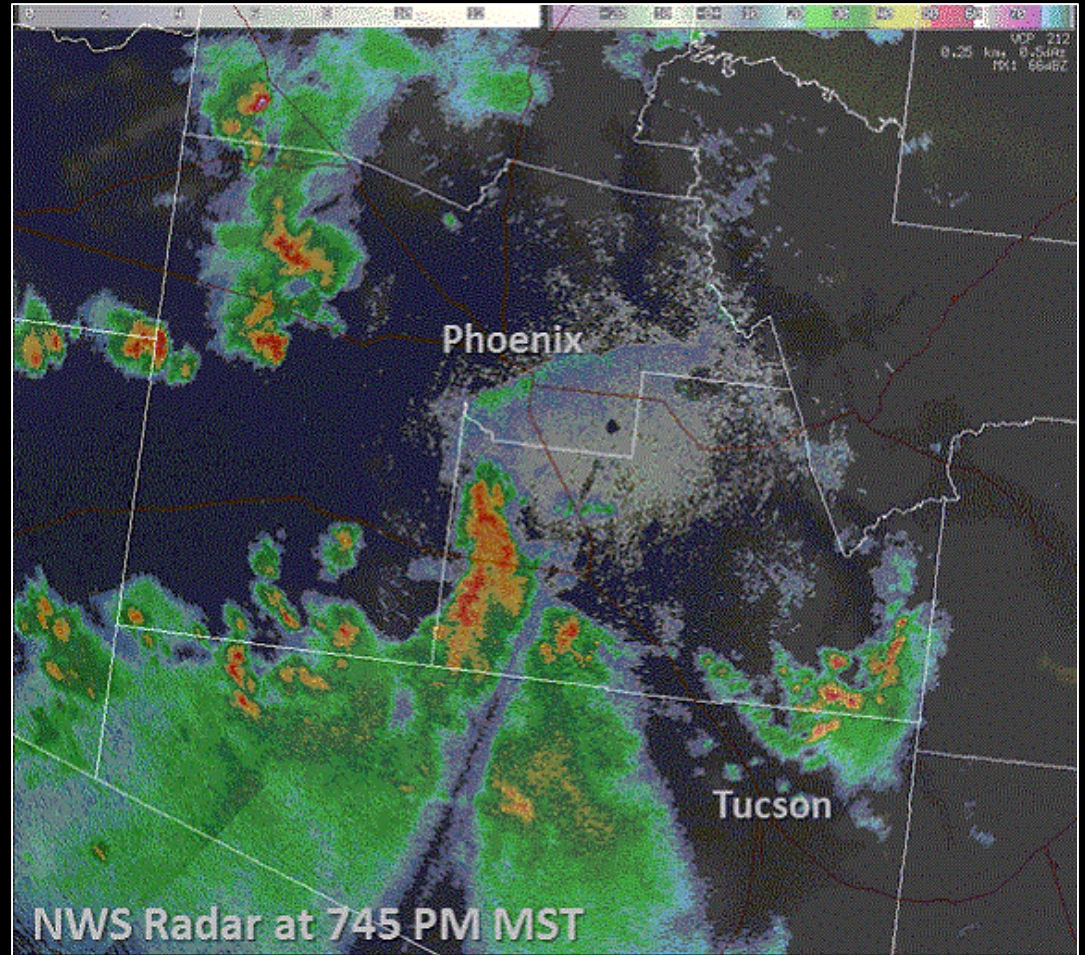
## RISKS

- Damaging Winds
- Flash Flooding



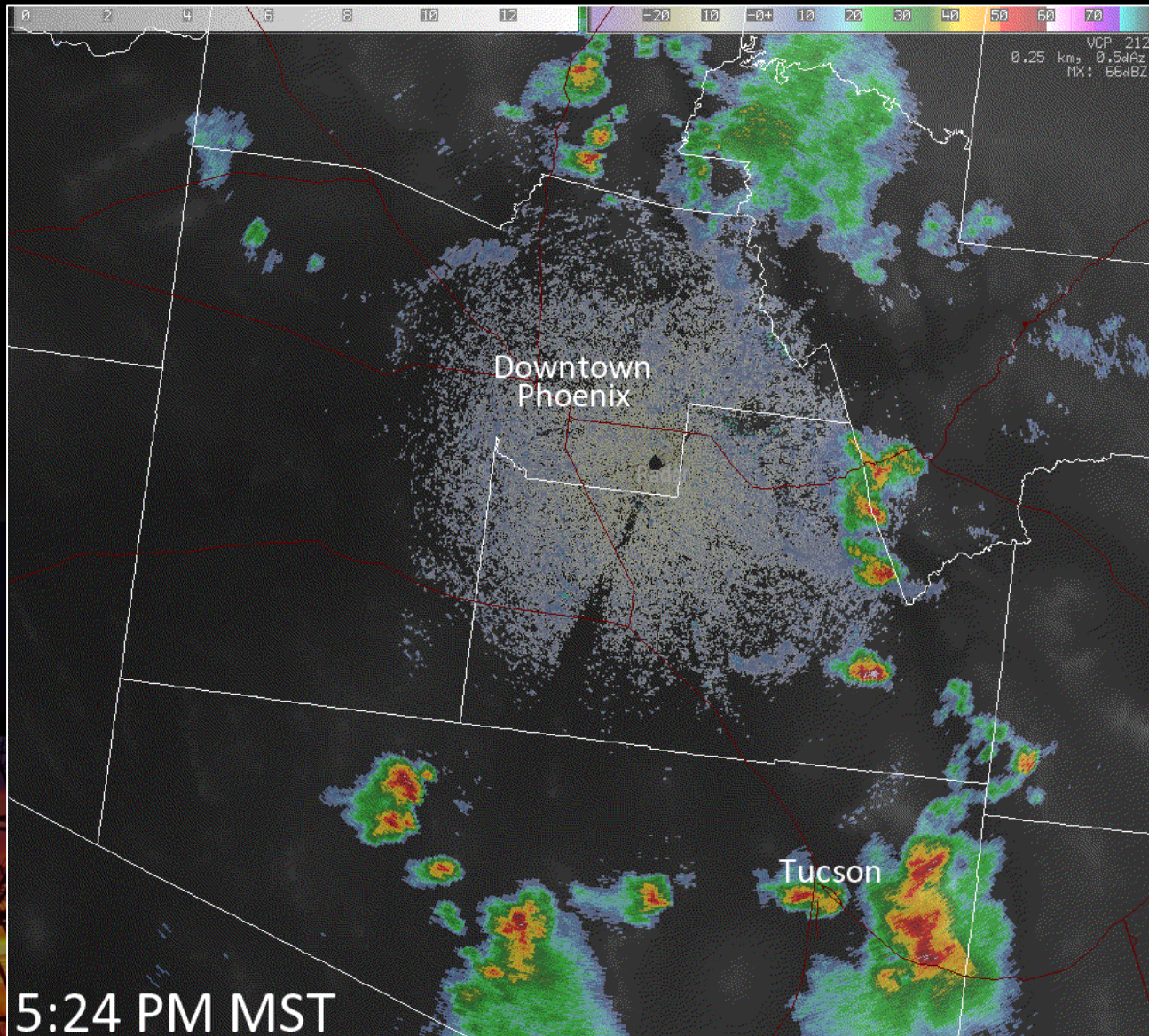
# Dust Storms

5 July 2011



# Dust Storms

5 July 2011



# Bow Echoes

## RISKS

- Damaging Winds

1

Cross Section



2

Cross Section

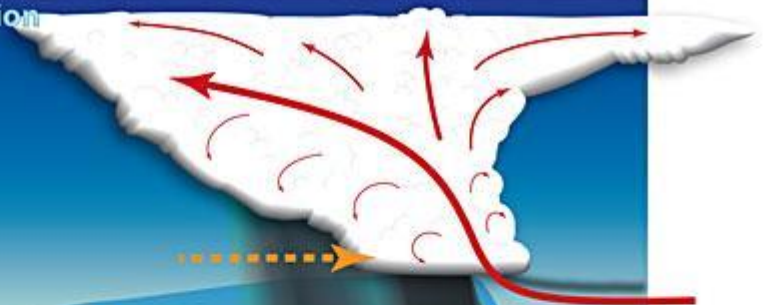


Rain-cooled  
Air

Rain-cooled  
Air

3

Cross Section



Rain-cooled  
Air

Radar  
Depiction



Gust  
Front



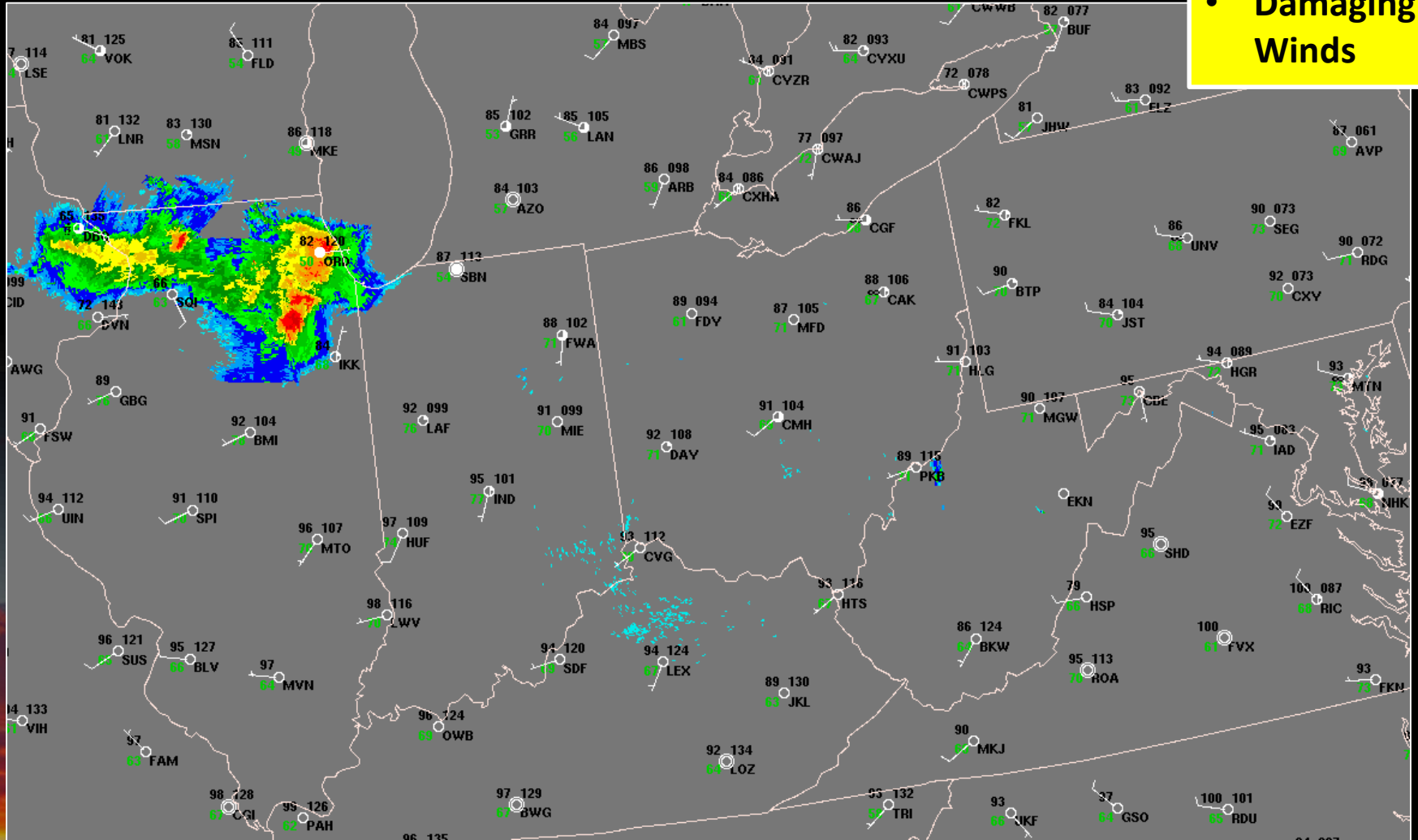
Updraft



# Bow Echoes

## RISKS

- Damaging Winds

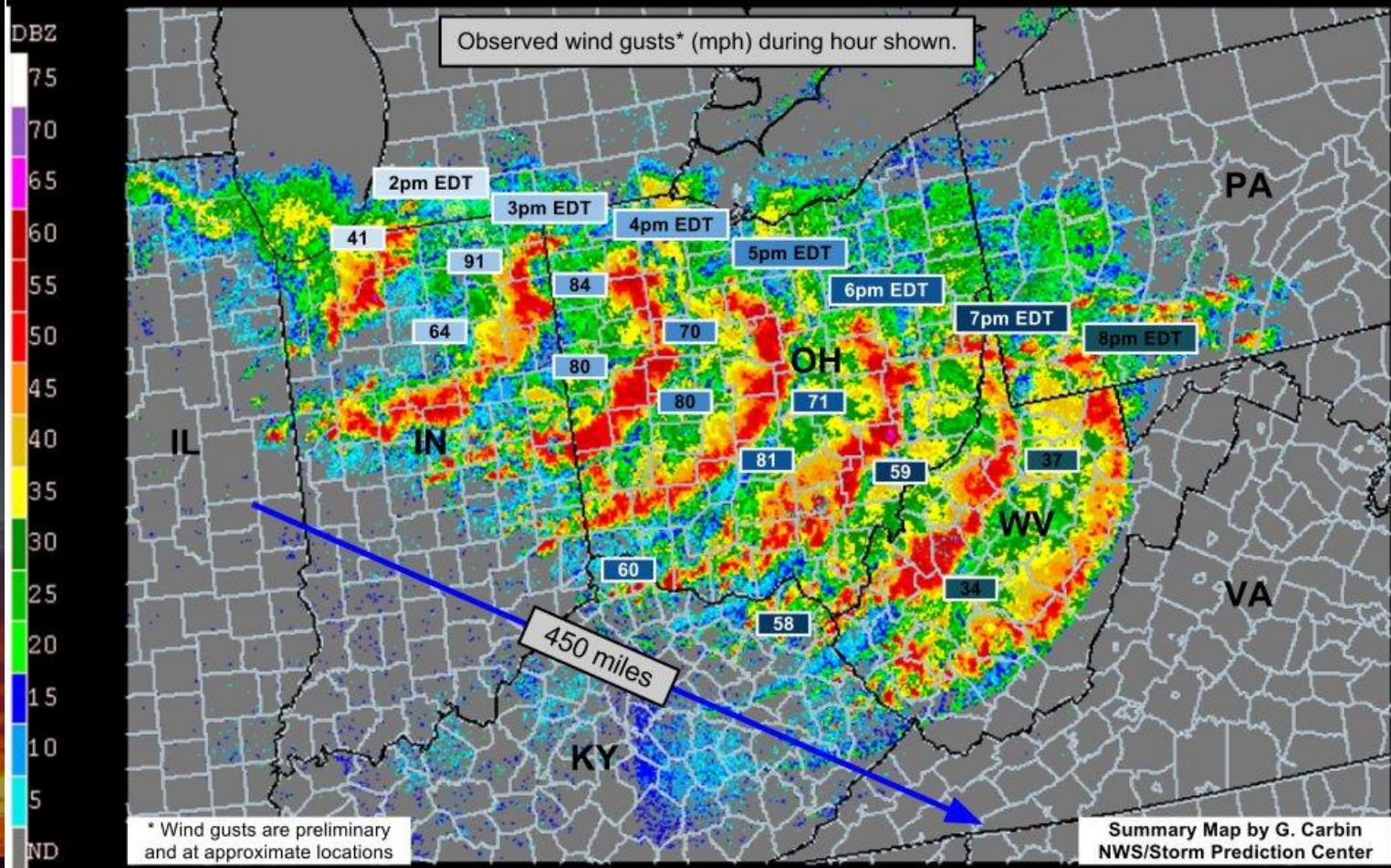


# Bow Echoes

## RISKS

- Damaging Winds

June 29, 2012 Midwest/Ohio Valley Derecho  
Radar Imagery Composite Summary 18-00 UTC  
~450 miles in 6 hours / Average Speed ~75 mph

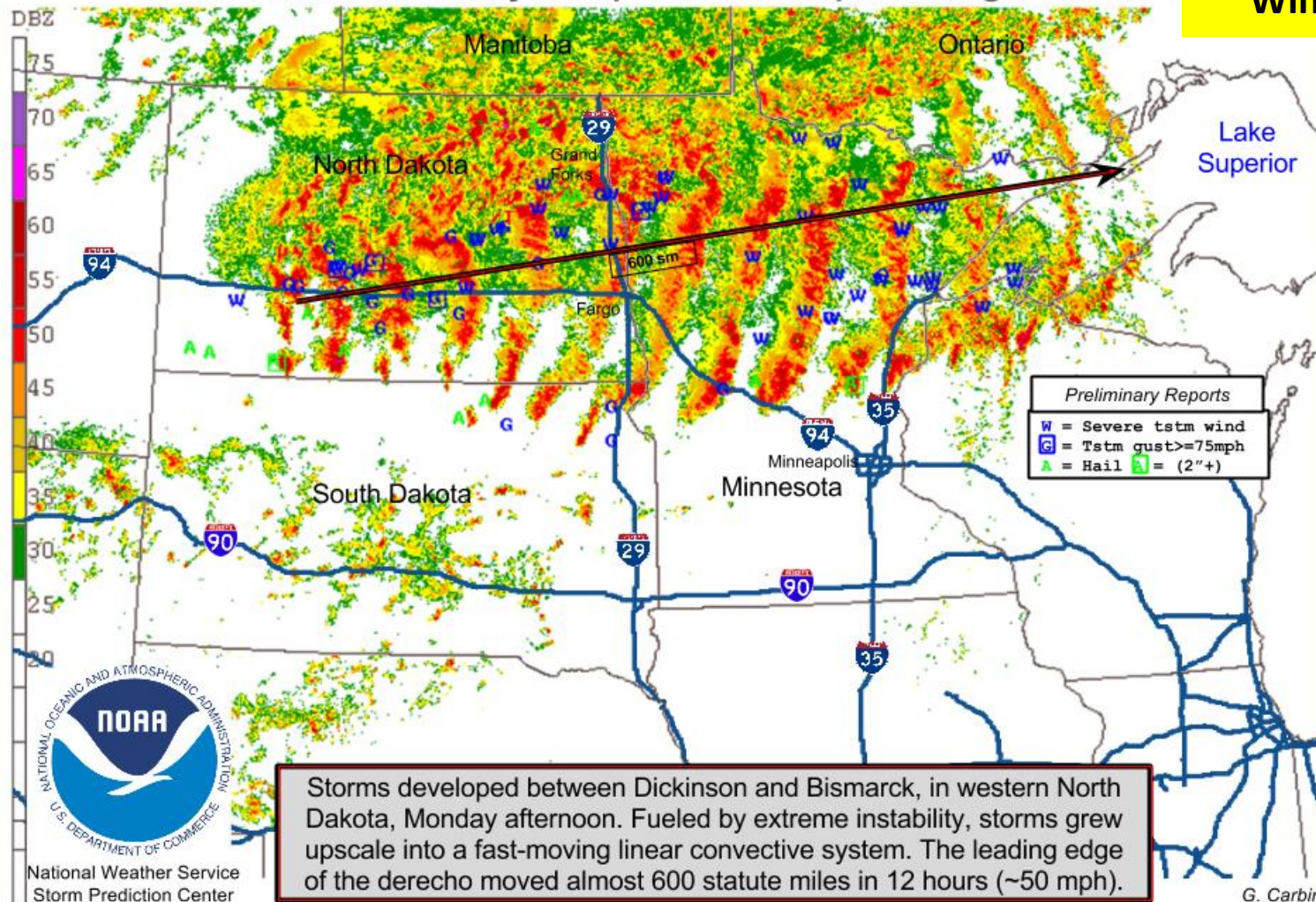


# Bow Echoes

## RISKS

- Damaging Winds

North Dakota/Minnesota Derecho of Monday/Tuesday, July 21-22, 2003  
12 Hour Radar Summary Composite from 4 pm through 4am CDT



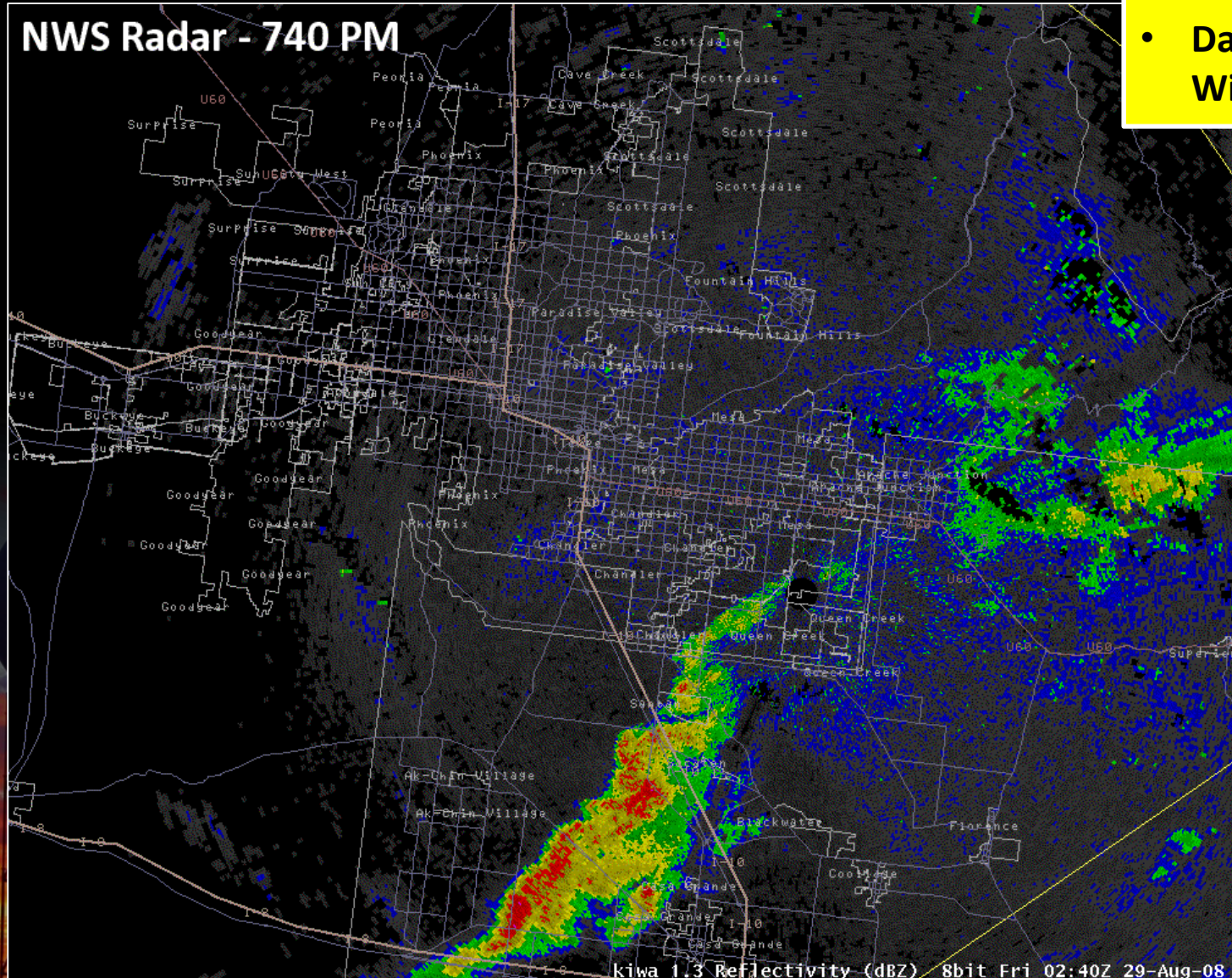


# Bow Echoes

## RISKS

- Damaging Winds

NWS Radar - 740 PM

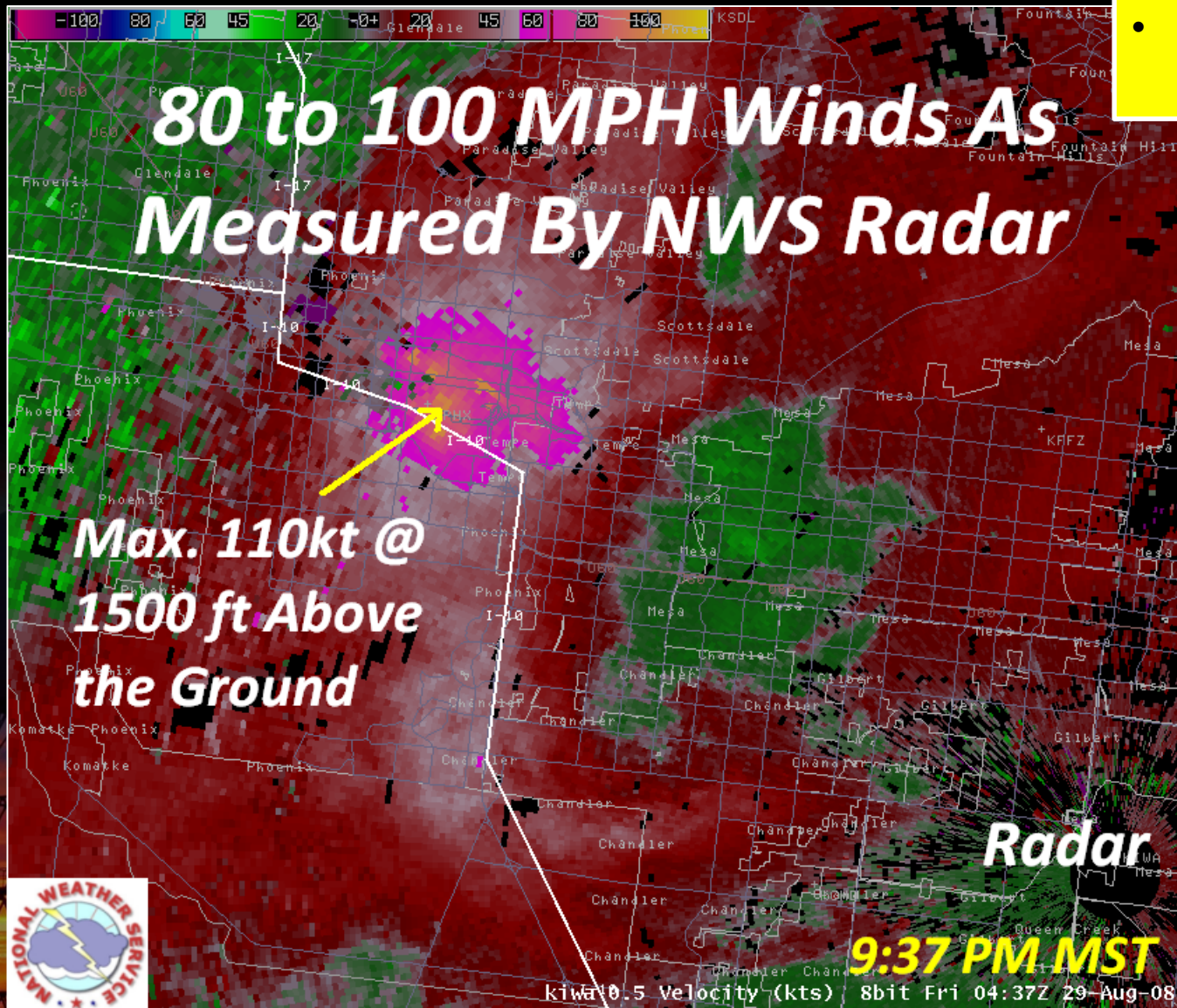


kiwa 1.3 Reflectivity (dBZ) 8bit Fri 02:40Z 29-Aug-08

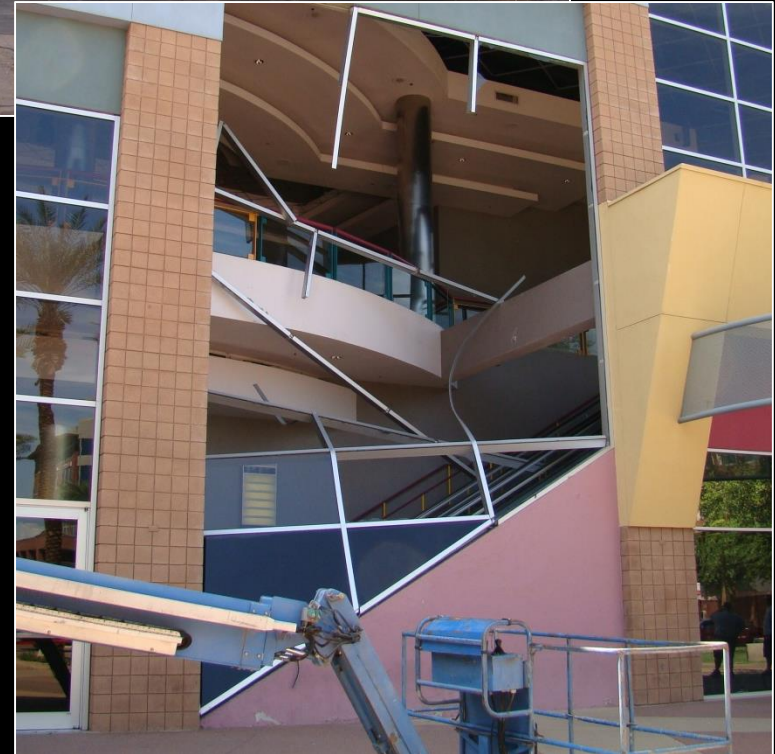
# Bow Echoes

## RISKS

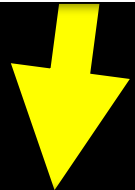
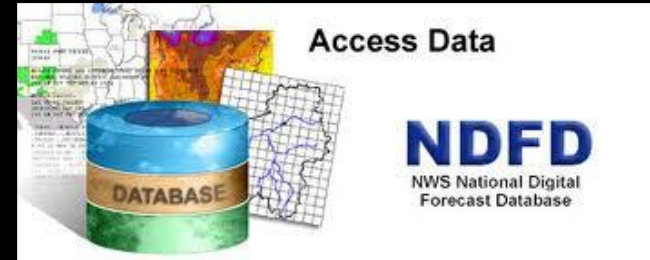
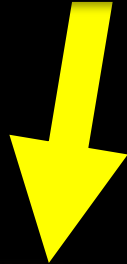
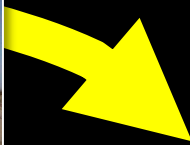
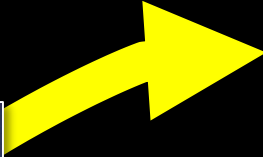
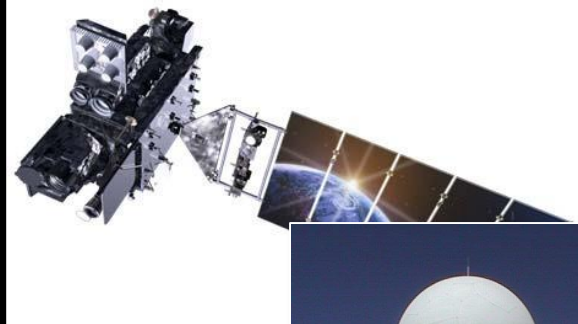
- Damaging Winds



# Bow Echoes



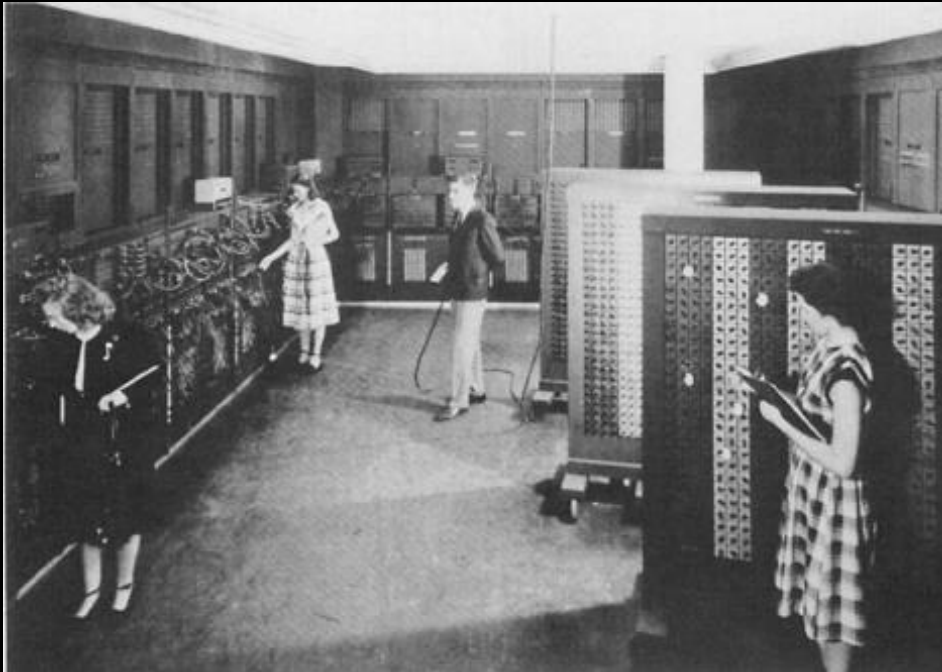
# Predicting Thunderstorms



# Predicting Thunderstorms

## Advances in Computing

	<b>ENIAC</b>	<b>iPhone 6</b>	
<b>Power</b>	140,000 W	10.5 W	13,000x <i>Less Energy</i>
<b>Weight</b>	30 tons	0.0001 tons <i>4.55 ounces</i>	300,000x <i>Lighter</i>
<b>Speed</b>	1 kHz	1.4 GHz x2	2,800,000x <i>Faster</i>

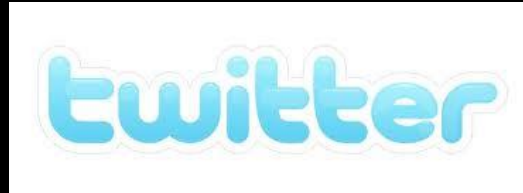


# Predicting Thunderstorms

Model Resolution



# Communicating Risk



**WIRELESS  
EMERGENCY  
ALERTS  
CAPABLE**

