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Flash Flooding in Karstic Terrains in South-Central Texas

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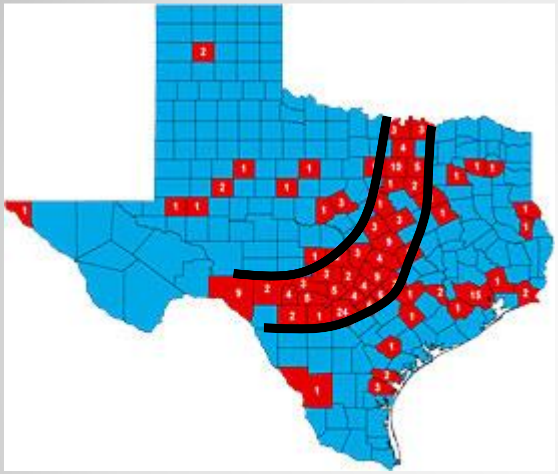
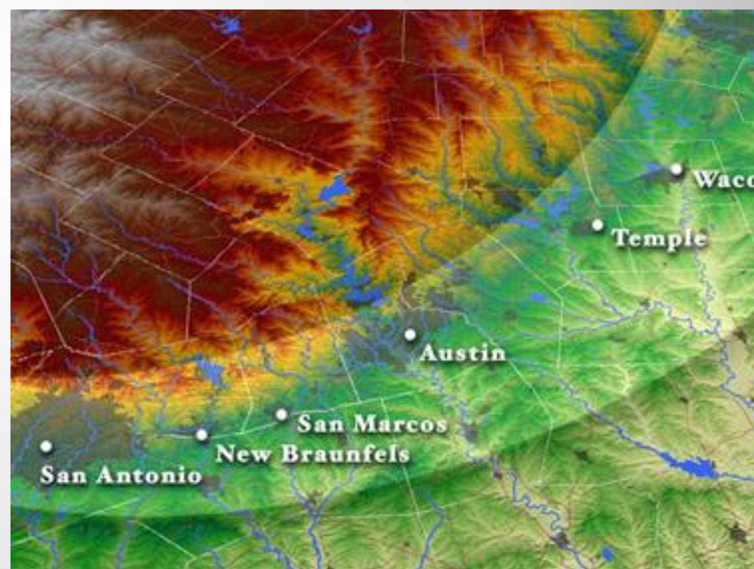
Flash Floods in South-Central Texas



Since 1996, flash floods have claimed 198 lives in Texas.

(National Weather Service)

"Flash-Flood Alley"



Flood.Safety.com

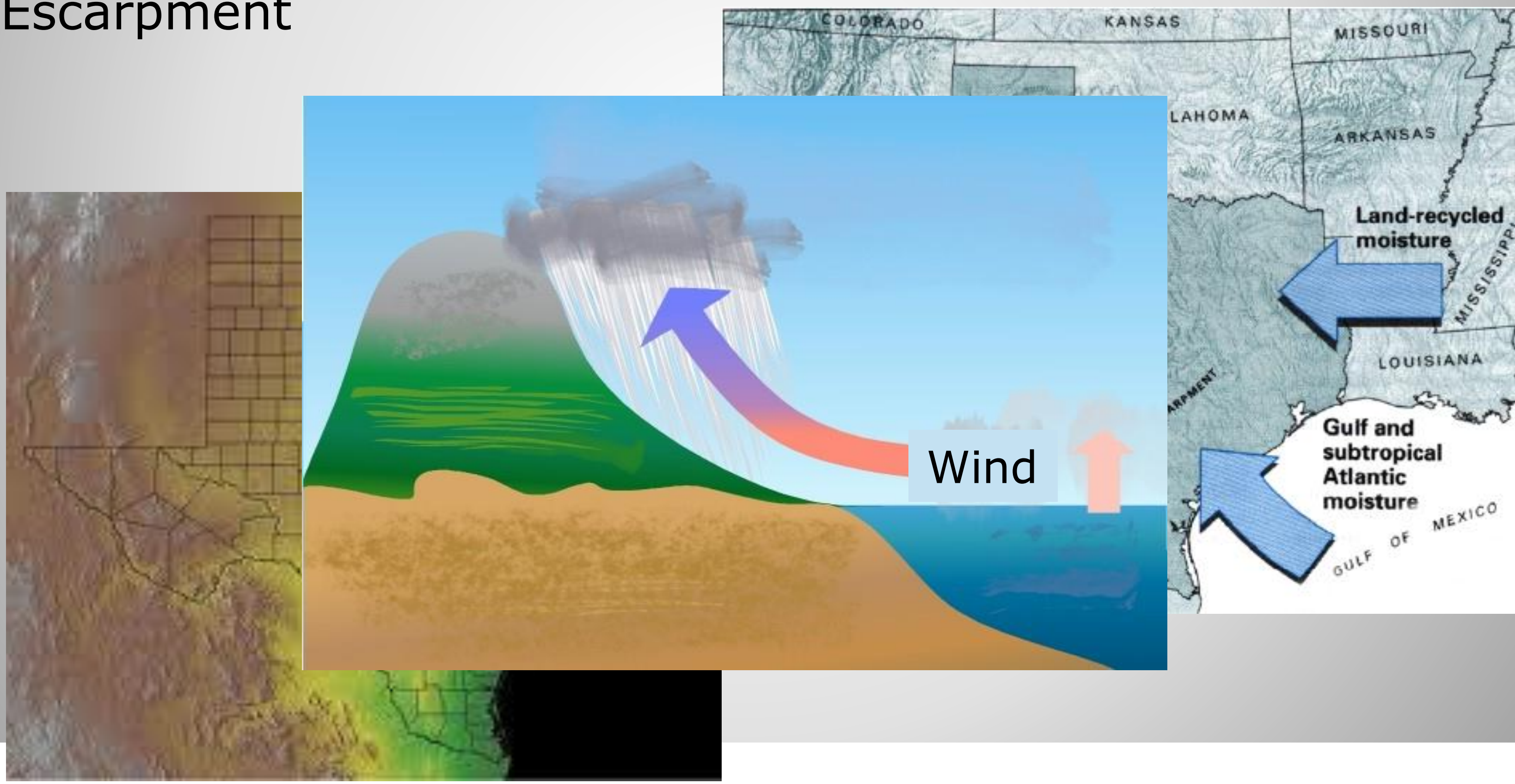
Fatalities by Flooding in the U.S.

Top sixteen flash flood/flood fatality states 1960-1995 Number of fatalities

1. **TEXAS - 612**
2. CALIFORNIA - **255**
3. SOUTH DAKOTA - **248**
4. VIRGINIA - **241**
5. WEST VIRGINIA - **240**
6. PENNSYLVANIA **188**
7. MISSISSIPPI - **181**
8. COLORADO - **168**
9. LOUISIANA - **149**
10. MISSOURI - **122**
11. GEORGIA - **112**
12. NEW YORK - **107**
13. OHIO - **102**
14. ARIZONA - **96**
15. KENTUCKY - **93**
16. TENNESSEE - **91**

Flash Floods

High incidence of flash floods due to <u>intense precipitation</u> juxtaposed with <u>topographic influence</u> of the Balcones Escarpment



Record Precipitation in South-Central Texas

22 inches of rain in 2 hrs, 45 minutes, D'Hanis, Texas, May 31, 1935 (world record for rainfall in that duration of time)

36.4 inches of rain in 18 hours, Thrall, Texas, September 9, 1921, 215 fatalities

48 inches of rain in 3 days, Medina, Texas July 31-August 1, 1978

Texas also possesses many low-water crossings, owing in part to the largely rural nature of its roads

General Characteristics of Flash Floods in Non-Karst Terrains

- Result of high-intensity rain cells that drop large amounts of rain within brief period, typically minutes rather than hours
- Generated on only a small fraction of a drainage basin
- Occurs on steep, relatively impermeable surface (naturally occurring or anthropogenic)
- Excessive antecedent moisture conditions
- Low infiltration capacity
- Rising and recession limbs of hydrographs are sharp and of similar duration
- Total discharge may not be great
- Flash flood waters move at high speeds

General Characteristics of Flash Floods for Classical Karst Terrains (Bonacci, 1995)

- High infiltration rate;
- Rare or non-existence of overland flow and open streams;
- Strong interaction between the circulation of surface water and groundwater in karst areas;
- Small storage capacity of the karst medium;
- Fast groundwater flow through karst conduits;
- High and fast oscillations of groundwater levels in karst areas;
- Interbasin overflow and/or redistribution of the catchment areas caused by groundwater rising;
- Limited discharge capacity of many karst springs;
- Limited capacity of swallow-holes.

How do Karst Flash Floods Differ from Conventional Flash Floods?

Conventional flash floods:

Dominated by surface-water flow

Groundwater contribution to flooding is negligible

Conventional floods are dependent on antecedent moisture conditions

Karst flash floods:

Dominated by GW flow

Antecedent moisture conditions not important

Groundwater surge is important

Groundwater drainage area may differ greatly from surface watershed

Karst porosity ~1%

Groundwater and Surface-Water Flow Dynamics in a Karst Terrain during Flooding

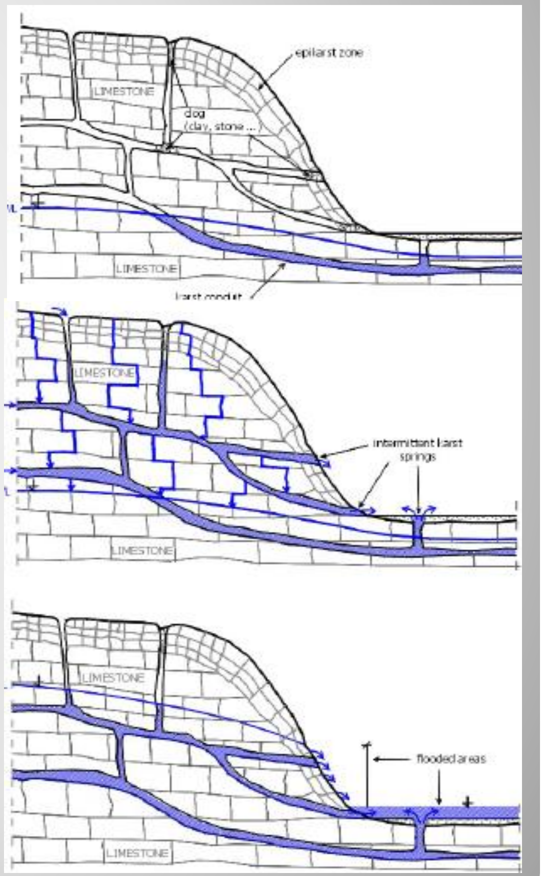
<u>Fossil and inactive</u> karst conduits and springs get <u>activated during a flood</u>

<u>Secondary flow channels become active</u>

<u>Constrictions in conduits</u> can lead to <u>backflooding</u> during flooding and <u>activation of inactive springs</u>

This makes it <u>difficult to monitor and detect</u> flash flooding

Water level in conduits can be greater than water level in adjoining matrix

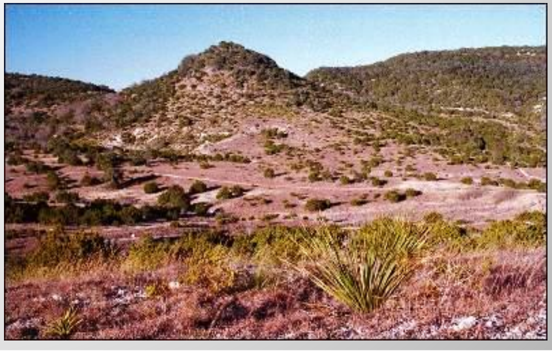


(Bonacci et al., 2006)

How do Texas Karst Flash Floods Differ from Classical Karst Flash Floods?

1. Overland flow and open streams are evident
2. Both GW and surface-water flow are active
3. Infiltration rate is limited

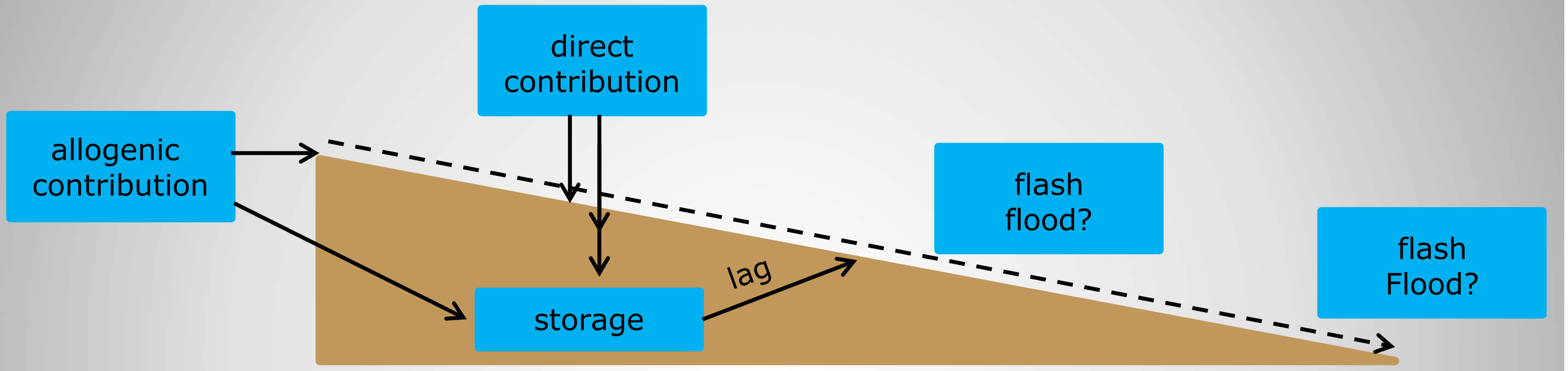
Classical karst terrain



Texas karst terrain

What is needed to formulate a karst flash flood warning system?

Need to Develop a Conceptual Model of Flow Contributions



Critical information needed:

- **Sub-basin delineation**
- **Karst-flow network**
- **Surface-flow regime**
- **Allogenic contribution**

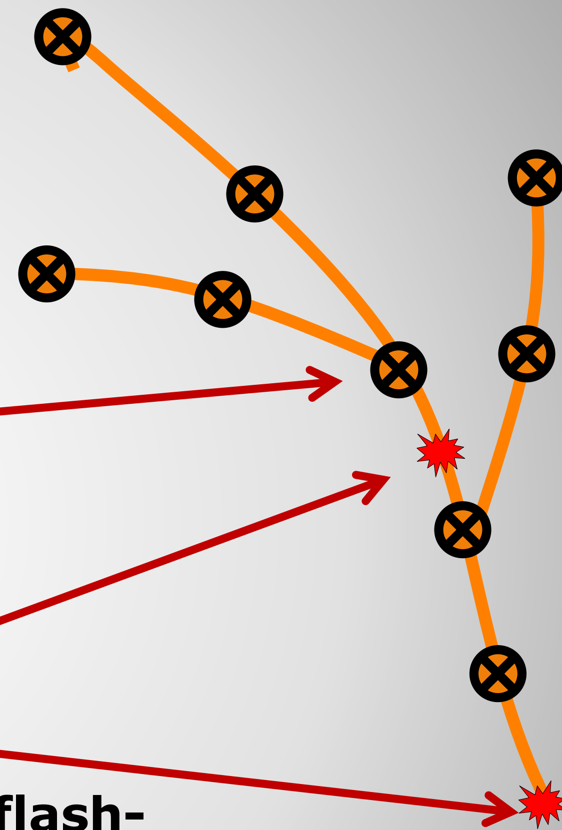
(Karst-flow network, Surface-flow regime, Allogenic contribution →) Lag time, Time-to-peak Retention capacity

- **Groundwater/surface-water interaction**
- **<u>Flooding threshold</u> (excess water?)**

(taken from Bailly-Compte et al. 2012)

Compile:

- Sub-basins,
- NEXRAD precipitation correlated to sub-basins (possibly corrected by gauge),
- Maximum retention potential,
- Sub-basin thresholds,
- Lag times,
- Time-to-peak,
- Downstream focal points (i.e., low-water crossings)



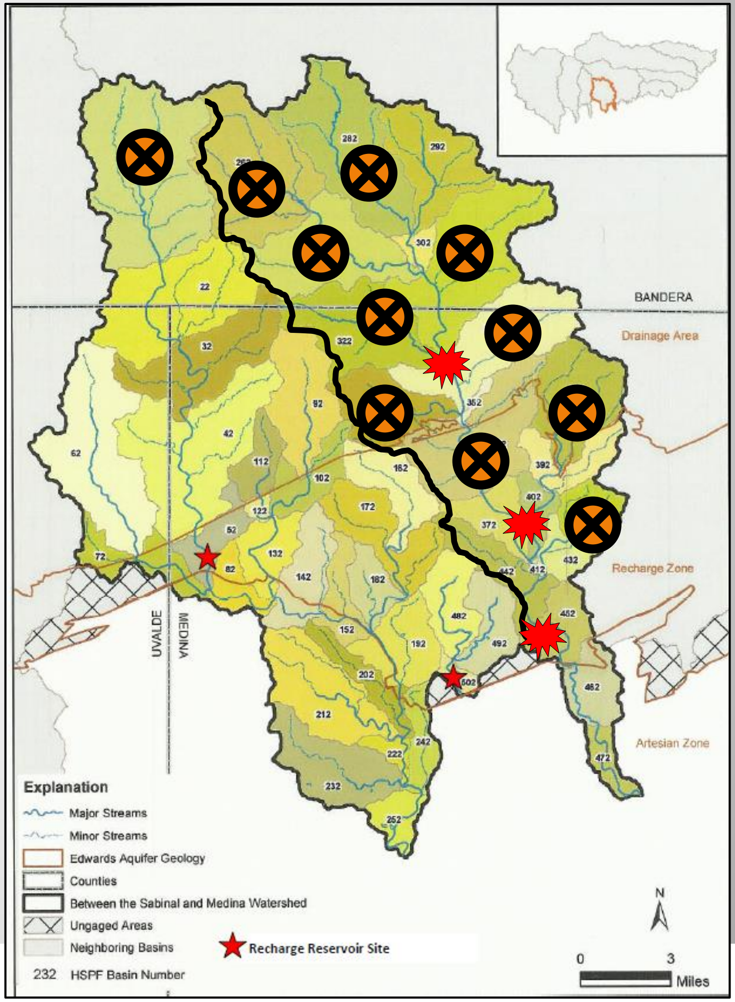
<u>Develop network to integrate data</u> into flash-flood warning system

If correctly implemented, <u>high-speed computing not required</u> for real-time network

Network Development

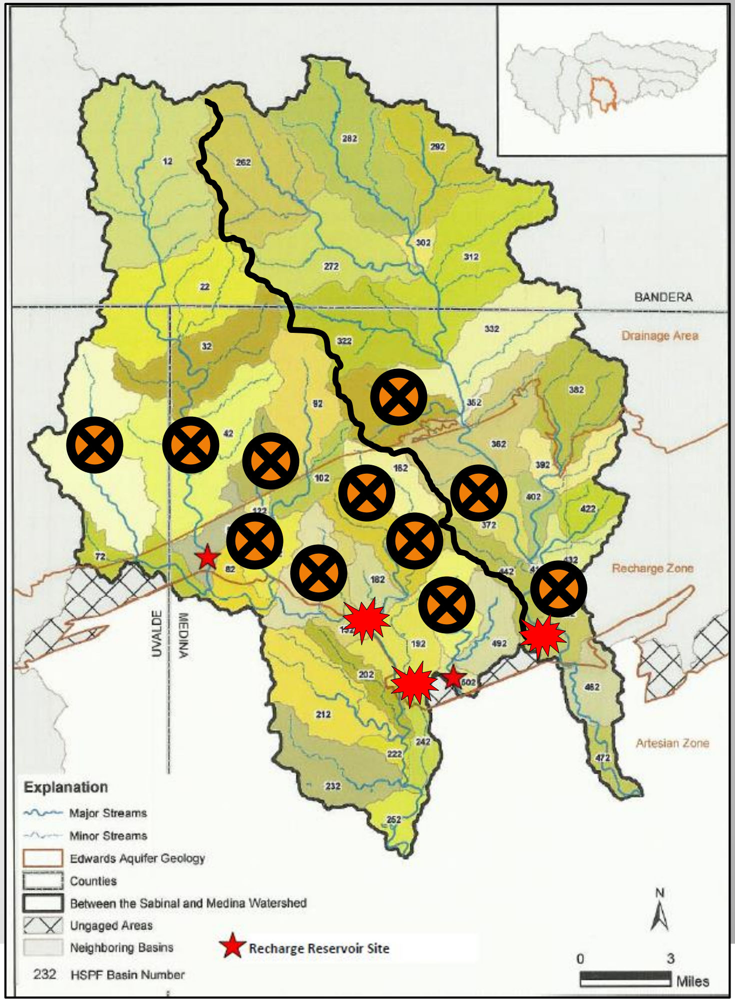
Flash-Flood Warning Network Example 1

- Storm moves NW-SE
- Multiple sub-basin thresholds exceeded
- Downstream danger points triggered only in eastern watershed



Flash-Flood Warning Network Example 2

- **Storm moves W-E**
- **Multiple sub-basin thresholds exceeded**
- **Downstream danger points triggered only in eastern and western watersheds**



Summary

Sufficient data, insight on karst flow, and technology are available to improve flash flood warning in karst terrains

If an improved flash flood warning system is developed:

- **Blanket warnings could be avoided**
- **Critical focal points could be given extra protection**

Flood of July 2002

- Rainfall totals of 30-40 inches
- Damage to 48,000 homes
- 10 Deaths
- 250 high water rescue calls
- $250 Million in losses