July 12, 2025

CliSciPol

Climate Science and Policy for Nonscientists

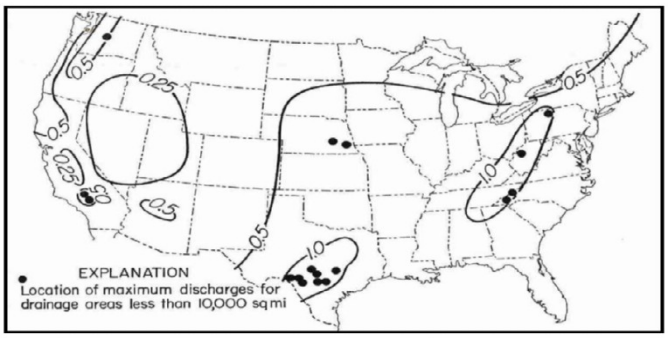
One Picture is Worth a Thousand Words.

The Great China Flood of 1931 killed an estimated 140,000 by drowning, and there followed over 2 million deaths from famine and disease. 31 million people were left homeless. Floods are arguably the most frequent natural disaster and have killed more people in history than any other natural disaster. Recurrent floods on the Yangtze River led to the eventual construction of the massive Three Gorges Dam to prevent flooding down river from the dam.

THE TEXAS FLOOD

Like hurricanes, tornadoes, and wildfires, floods have always been with us. In early 1862 the rain in California lasted 45 days, causing what is known as the Great Flood. All of Sacramento was flooded. The newly-elected governor had to take a row boat to reach the capitol for his swearing in. One-third of the state's taxable properties were destroyed.

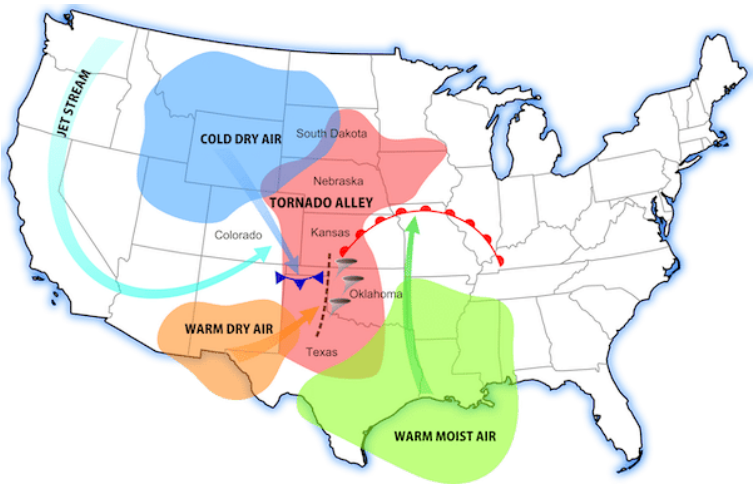
Was the flooding unprecedented or unusual?



Hoyt and Langbein 1940 identified south central Texas as being among the regions of the United States with the greatest risk of flooding.

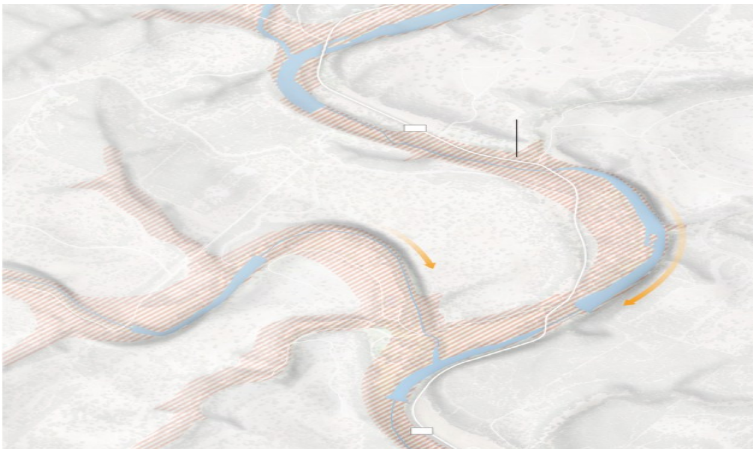
In Texas a flood on July 2, 1932, forced Camp Mystic to close. Its peak flood crest was higher than the present one. Another flood hit the camp in 1935. As early as 1940 the area where the recent Texas flood occurred was identified as having a high risk of flooding. Other notable floods in this region occurred in 1987, when, again, the flood crest was higher than the present flood, and in 2015.

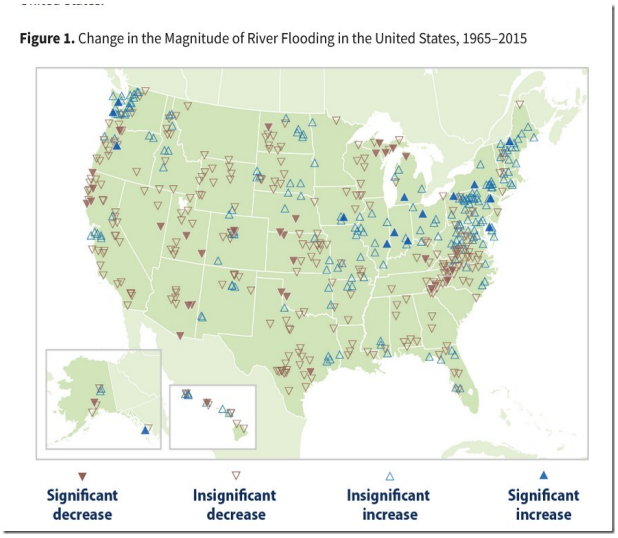
The term “Tornado Alley” is commonly used to identify the areas of the US where tornadoes occur with greatest frequency.



Texans are familiar with the term, “Flash Flood Alley,” or alternatively “The Flash Flood Capital of North America.” This is the path that very moist warm air tends to follow as it sweeps up from the Gulf of America. The “alley” includes the Guadalupe River, North-West of San Antonio, where the recent flash flood occurred.

FEMA has designated most of the banks of the Guadalupe River as a flood zone. This is where the recent flooding occurred, and Camp Mystic is in this designated area.



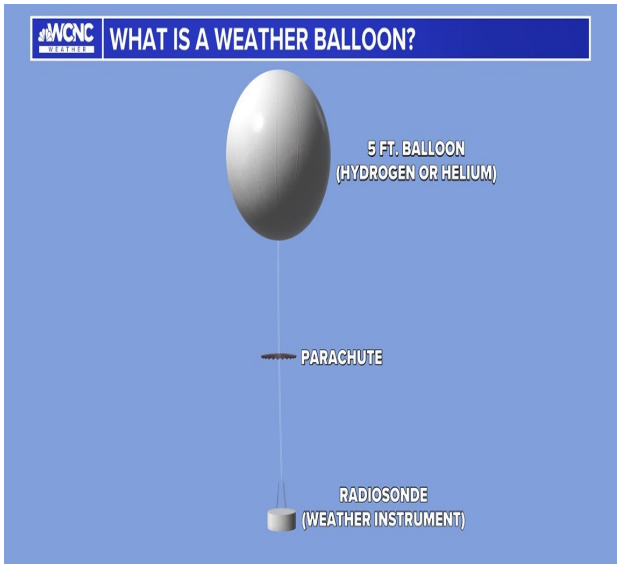


In general, the magnitude of US river flooding has been decreasing. In particular, it has been decreasing in Texas. EPA data shows that the frequency and magnitude of river floods in the Texas Hill Country have been decreasing since 1965. The rainfall of July 3-4, 2025, has been described as “generational but not record-setting.” Rob Fogarty, a meteorologist with the National Weather Service (NWS) for 19 years, says that he had seen “a couple of floods this bad.” Cary Burgess, a local meteorologist says that this flooding “doesn’t happen often” but has occurred at least 4 time in the last 50 years. Roger Pielke, Jr., says, “The flooding was certainly extreme but it should not have been historically unexpected.”

Tropical Storm Barry formed on June 28, 2025. Its track is shown, crossing the Yucatan Peninsula and then hitting the Mexican coast around Vera Cruz. The storm dissipated on June 30. Its highest wind speed was 45 mph, so it barely qualified as a tropical storm (39 mph or more with hurricanes starting at 74 mph). But the remnants, an area of very humid air, moved North towards Texas and, in particular, towards Flash Flood Alley.

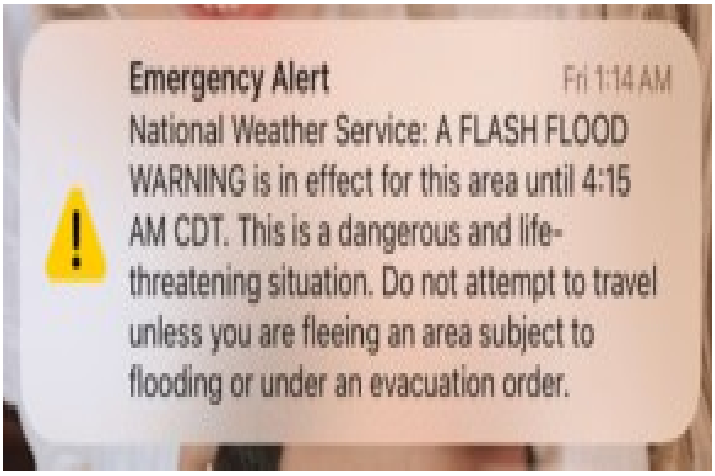
Barry had been followed closely by the National Hurricane Center. The remnants were followed by the National Oceanographic and Atmospheric Administration (NOAA) and the NWS. On Wednesday, July 2, NOAA and NWS arranged for extra staff to follow the developing threat situation. The Texas Division of Emergency Management (TDEM) activated state emergency-response resources, which included prepositioning assets such as swift-water rescue boat squads.

On Wednesday, July 2, the Texas Department of State Health Services confirmed that Camp Mystic had a plan for emergency shelter and evacuation that complied with state law. The bunk houses for campers shown in yellow were only slightly above the level of the Guadalupe River, which, as shown in the map, borders the camp. The houses in white are on a rise, the camp's evacuation location.



On Thursday, July 3, weather balloon data showed record amounts of moisture present in the upper atmosphere above Central Texas. This data played a vital role in forecast messaging that evening. At 1:20 pm a flood watch notice was issued. During the afternoon the NWS identified a "heavy rainfall threat" and augmented staffing. The relevant NWS office (San Antonio) had 3 extra meteorologists on hand for a total of 5. TDEM raised it readiness level to "escalated response." At 6:10 pm a warning issued that flash flooding was likely. At 11:40 pm a flash flood warning was issued to neighboring Bandera County.

On Friday, July 4, at 1:14 am the NWS issued by cell phone emergency flash flood warning alert to Kerr County (where Camp Mystic is located). Unfortunately cell phone service is spotty in the area. At 2:00 am Lorena Guillen, owner of the Blue Oak RV Park checked on the river level and found it normal. "We did have a flash flood warning, but this is very, very normal for the Hill Country." She called the Kerr County Sheriff's Office and asked if there was a need to evacuate. She was told the office had no information although this was around 45 minutes after the 1:14 am emergency alert.

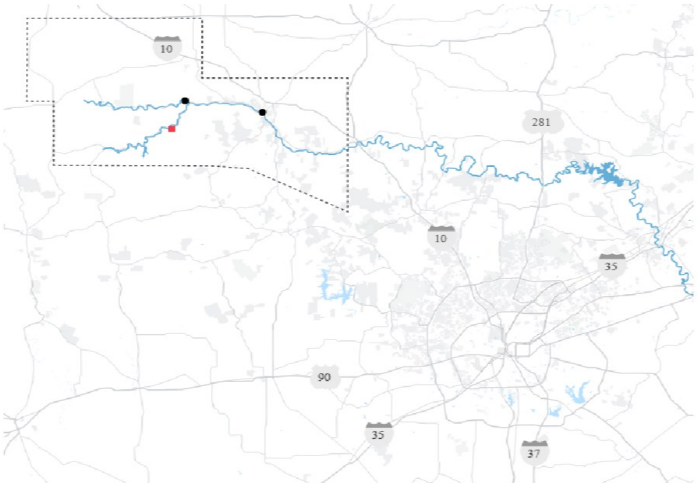


3:00 am Lorena checked the river level again and found that it had risen about 10 feet. All 33 recreation vehicles at her park were swept away within a short period of time. The river rose as much as 26 feet in some places within about 90 minutes.

3:32 am The Kerr County Sheriff's Office posted, "DANGEROUS FLOODING NOW." Sirens had gone off in neighboring counties that had outdoor warning systems. Kerr did not have such sirens but had a CodeRED system that sent alerts by prerecorded telephone calls, text messages, and email.

3:35 am The NWS issued a second emergency alert extending the time period covered.

?:?? am It appears that staff at Camp Mystic did not receive the 1:14 am warning and did not become aware of their danger until significantly later when flood waters started reaching the low-lying campers' bunk houses. Staff and counselors responded, but the details of the response are still uncertain. At the camp there were reportedly at least 386 campers and 64 staff members. At least 27 died including the camp owner/director and at least one counselor. 11 were still missing as of July 11. So over 400 campers and staff members were either successfully evacuated or managed to survive the flood in their bunk houses.

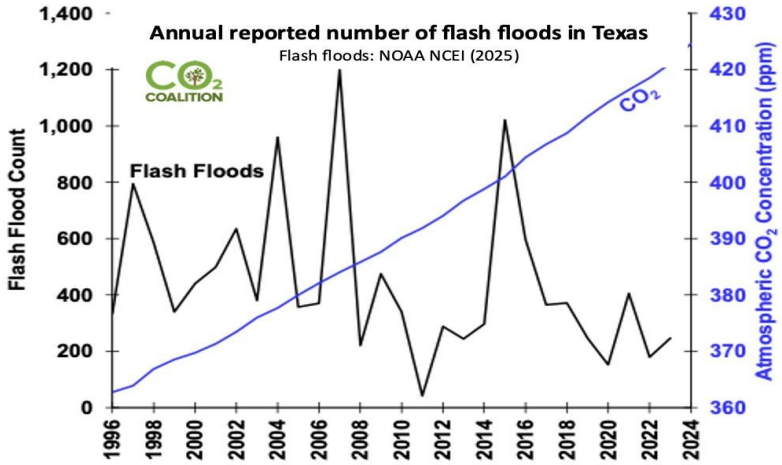


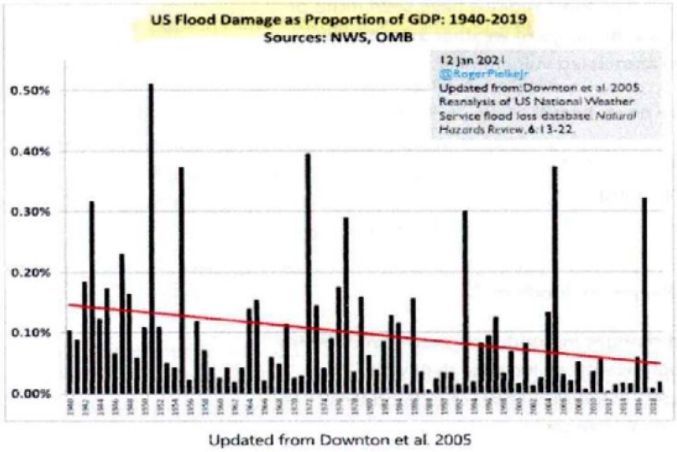
Flood waters poured downstream and ended up in the Canyon Lake Reservoir, which rose from 46% full to 61% full. On the map the Guadalupe River is in blue. Camp Mystic is the red dot. The Canyon Lake Reservoir appears slightly to the South-East of the Route 281 sign. The urban area in the South-East portion of the map is San Antonio. One of the main purposes of reservoirs, such as the Canyon Lake Reservoir and the Three Gorges Dam in China, is to protect areas downstream from

Sunday, July 6 — Democratic strategist David Axelrod suggested that significant staffing shortages at the NWS, resulting from the Trump administration DOGE cuts, may have contributed to the disaster.

Monday, July 7 — Noted writer and environmentalist Bill McKibben suggested that climate change contributed to the disaster. And within days ClimaMeter posted on its web site the claim that the heavy rain was "intensified by human-driven climate change." Climate Central posted on its web site that rainfall intensities in Texas had increased significantly since 1970, ranging from a 6% increase in San Antonio to a 19% rise in Austin.

Anecdotal evidence has been presented above that comparable flash floods had occurred previously along the Guadalupe River. NOAA data shows that the frequency of flash floods in Texas from 1996 to 2024 has been declining with great year-to-year variability. Scientists define "climate change" as a statistically significant change in some climate variable, such as the frequency or the size of flash floods, over a significant period of time, which is usually understood to be 30 years or more.

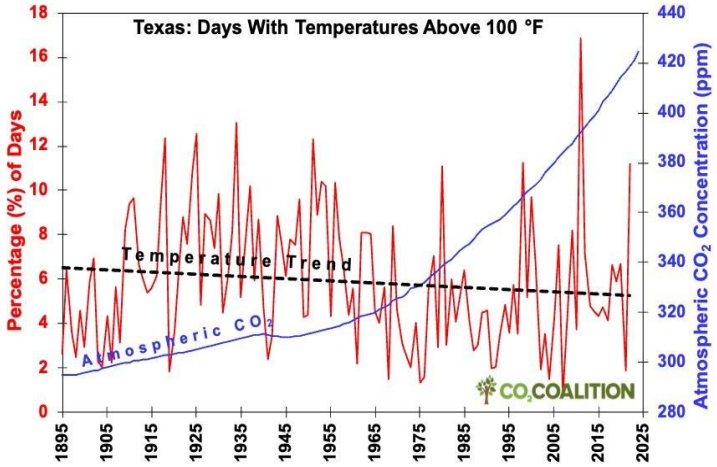


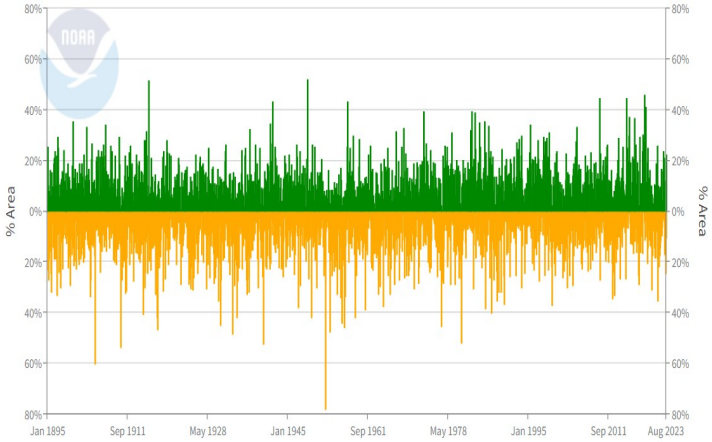


Updated from Downton et al. 2005

Normalized US flood damages from 1940 to 2019 has declined slightly with great year-to-year variability.

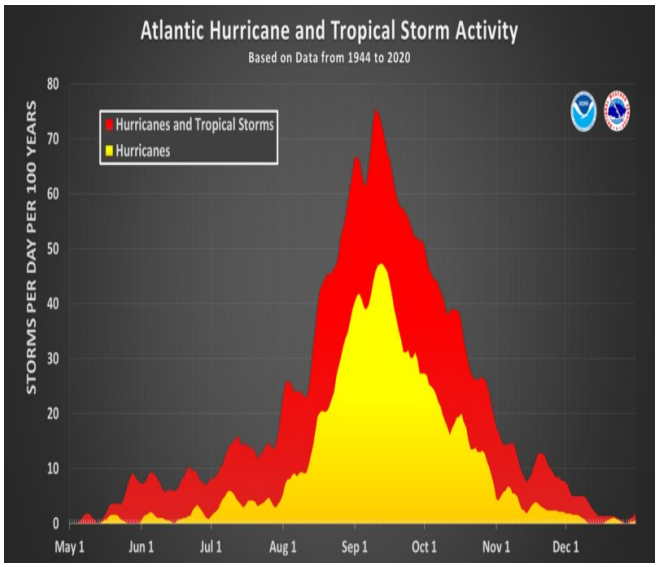
The number of very hot days (over 100 F) in Texas has been declining for over 100 years. Theoretically, rising temperatures may cause increased atmospheric moisture content, which then may cause increased rainfall, which then may cause increased flooding.





NOAA data from 1895 to 2023 shows virtually no change in the percentage area of the US that is categorized as "very wet" (the green bars). The orange bars show the percentage area categorized as "very dry," which appears to be declining slightly since around 1950.

The remnants of Tropical Storm Barry clearly contributed to the flood. The consensus of forecasters is that the present hurricane season will be more active than average. The graph shows average frequency by month of tropical storms, which have a maximum wind speed >39 mph but <74 mph. Hurricanes have a maximum wind speed >74 mph. As of July 12 the Atlantic Basin has been unusually quiet. There have been no hurricanes and only 3 tropical storms (Andrea with max wind speed 40 mph and a duration of 2 days, Barry with a max wind speed 45 mph and a duration 2 days, and Chantal with a max wind speed of 60 mph and a duration of 3 days).



IPCC FINDINGS ON WORLDWIDE FLOODS (AR6 2021)

There is low confidence in how the frequency of flooding will change regionally as it is strongly dependent on catchment characteristics, antecedent conditions, and how atmospheric circulation system respond to climate change. (AR 6 p.1073.

Water regulation and management have, in general, increased resilience to flooding, masking effects of an increase in extreme precipitation on flood probability… There is not always a one-to-one correspondence between an extreme precipitation event and a flood event, because floods are affected by many factors in addition to heavy precipitation. (AR6 p.1567)

Peak flow trends are characterized by high regional variability and lack overall statistical significance of a decrease or an increase over the globe as a whole. … As to floods there is low confidence about peak flow trends over the past decades on the global scale, but there are regions experiencing increases… and regions experiencing decreases. (AR6 p.1568)

There is low confidence in the human influence on the changes in high river flows on the global scale. (AR6 p.1569)

In its most recent Assessment Report, AR6 (2021), the IPCC found limited evidence and low agreement on any observed climate change as to river floods in North America . (AR6 p.1830). Other findings on floods were inconclusive.

It appears from NWS statements to date that it had, in fact, staffed up for the event and had an appropriate number of meteorologists on hand in the San Antonio office to address the situation. It seems clear that at 6:10 pm, Thursday, July 3, it issued a warning that flash flooding was likely. And at 11:40 pm it issued a flash flood warning to neighboring Bandera County. And at 1:14 am Friday, July 4 it issued by cell phone an emergency flash flood warning alert to Kerr County where Camp Mystic is located.

Upmanu Lall, director of the water research centers at Columbia and Arizona State has commented that it is "especially hard to predict" flash floods, and that the warnings "often cover broad areas." Meteorological instruments can follow masses of very humid air, but meteorologists can not accurately predict when the rain will actually start. Since the very humid air is moving, they can not accurately predict where the rain will actually fall.

A problem appears to be that the NWS office in Austin/San Antonio had issued over a dozen warnings in May and June, 2025, and so many people appear to have "tuned out" the warnings. A 2024 RAND report found that nearly 30% of Texas cell phone users opted out of wireless emergency alerts, partially due to exhaustion from the large number of statewide alerts.

The Kerr County Commissioners had been considering at least since 2016 installing a siren warning system in the county. Such systems may be activated either remotely, e.g. from the NWS or from an office of local government, or by river sensors at the immediate location. Such systems existed in nearby Comal and Kendall Counties, which were also on the Guadalupe River. Reportedly, at least once, the voters of Kerr County voted down a proposal to install such a system.

OBSERVATIONS

A major problem for local and state governments is deciding how much money to spend to prepare for extreme events, such as massive flash floods, that are relatively rare.

One might think that, after the 6:10 pm, July 3, warning from the NWS that flash flooding was likely, staff at Camp Mystic, at the Blue Oak RV Park, and at the Kerr County Sheriff's office would have been alertly watching for a following emergency flood warning, such as was actually issued at 1:14 am, July 4. But none of these evidently became aware of the 1:14 am warning in a timely manner.

In considering tragedies, such as this Texas flash flood, it takes considerable time for all relevant data to be assembled and analyzed. This usually involves interviews with a large number of relevant witnesses, a process that is only just beginning. All of the statements contained herein about July events are based on media articles published from July 4 through July 12, the date of this newsletter. So such statements should be considered tentative and subject to revision.

All footnote citations are to the Intergovernmental Panel on Climate Change's publication, Climate Change 2021, The Physical Science Basis, the first part of the Sixth Assessment Report (AR6).