SOCIETY OF ACTUARIES

# Actuarial Weather Extremes
# May 2019

# Actuarial Weather Extremes: May 2019

## A Triple Dose of Extremes: High Heat, Tornadoes and Floods

## Overview

In April 2019, the Society of Actuaries (SOA) released its first monthly report focusing on weather extremes in North America. This report is the second in the monthly series, focusing on extreme weather events that occurred in May 2019. Each future report will cover weather events that occurred during the most recently completed month.

Our April report relied upon data from the Global Historical Climate Network (GHCN) of weather stations to analyze extreme temperature and precipitation events. This month, we expanded the range of data we analyzed to include not only GHCN data, but also tornado data compiled by the National Oceanic and Atmospheric Administration (NOAA), as well as flood data compiled by the United States Geological Survey (USGS). While floods are not weather events, their causes are typically related to weather. Consequently, we decided that flood events should be covered by this series of papers.

May 2019 was an eventful month with respect to extreme weather in North America. This report highlights three major weather stories that unfolded across the month of May:

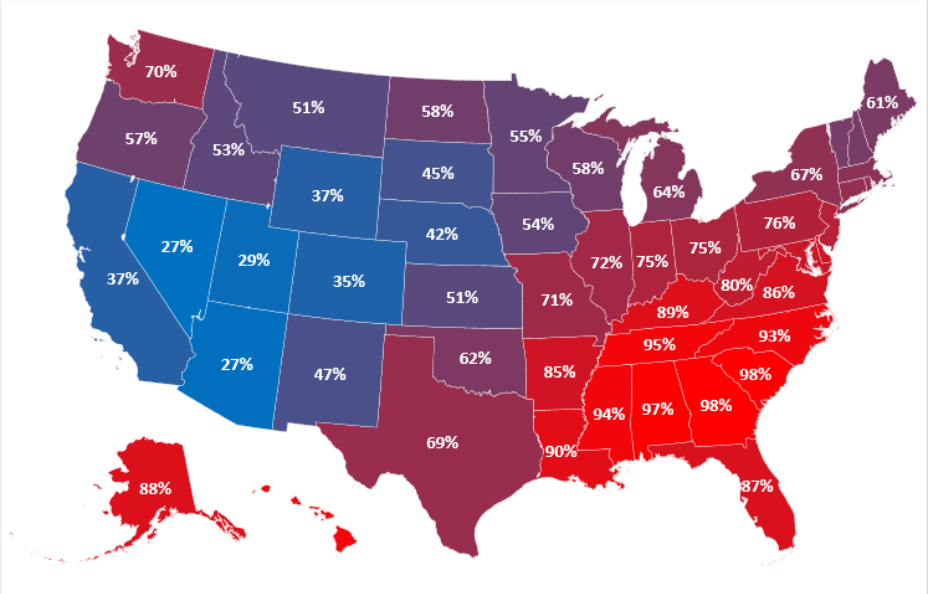
- A heat wave that affected the Southeastern U.S. from May 21 through May 31
- An unusually high number of tornadoes in the Midwestern and Southcentral U.S.
- Widespread flooding throughout the Central and Southcentral U.S.

## Heat Wave in the Southeastern U.S.

Beginning around May 21, and continuing through May 31, much of the Southeastern U.S. experienced a lengthy period of unusually hot weather, as depicted in Figures 1, 2a and 2b.

**Figure 1**

Average Percentile Ranking of Daily High Temperature, from May 21 to May 31

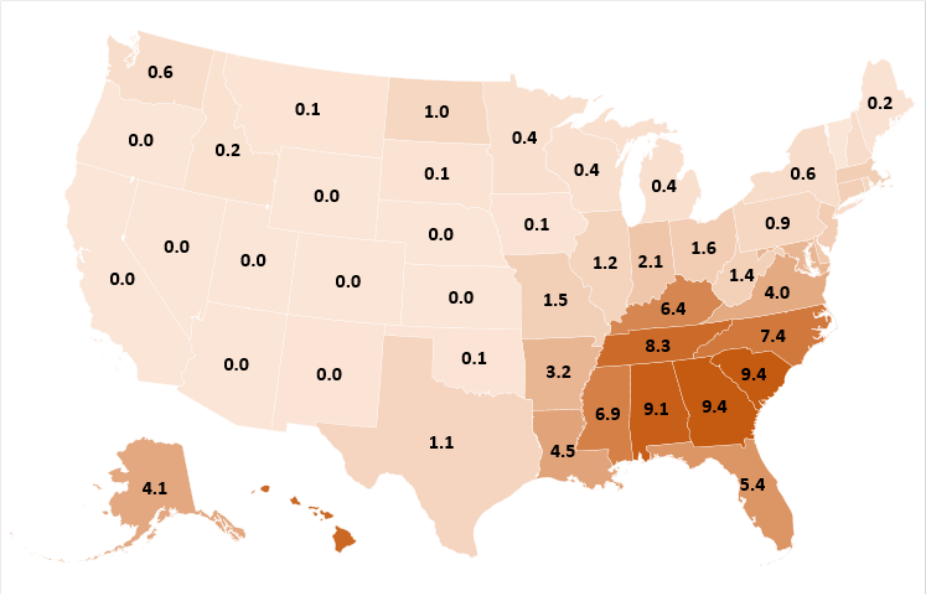



Each GHCN weather station's daily high temperature observation ("TMAX") was compared to its corresponding historical distribution, thereby producing a percentile ranking. For example, an observation with a rank of 98% is greater than 98% of historical observations. These rankings, in turn, were averaged across all stations in each state, and across the period from May 21 to 31, to produce the values in Figure 1.

Please see the "Methods" appendix for a more detailed explanation of the ranking methodology.

**Figure 2a**

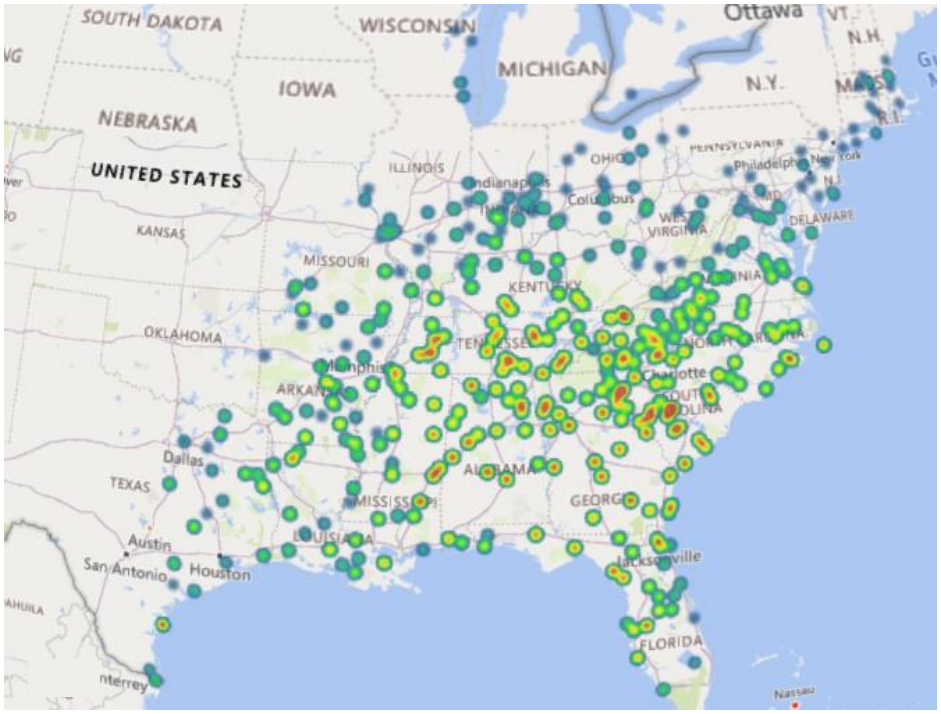
Average Number of Days from May 21 to 31 that Exceeded the 95th Historical TMAX Percentile




Consider the result of "9.4" for South Carolina. This means that, during the 11-day period from May 21 to 31, the average GHCN weather station in South Carolina had 9.4 days of observations where TMAX – the daily high temperature -- exceeded the 95th percentile of the corresponding historical distribution of daily TMAX observations.

**Figure 2b**

Same Information as in Figure 2a, but Shown at the Level of Individual Weather Stations



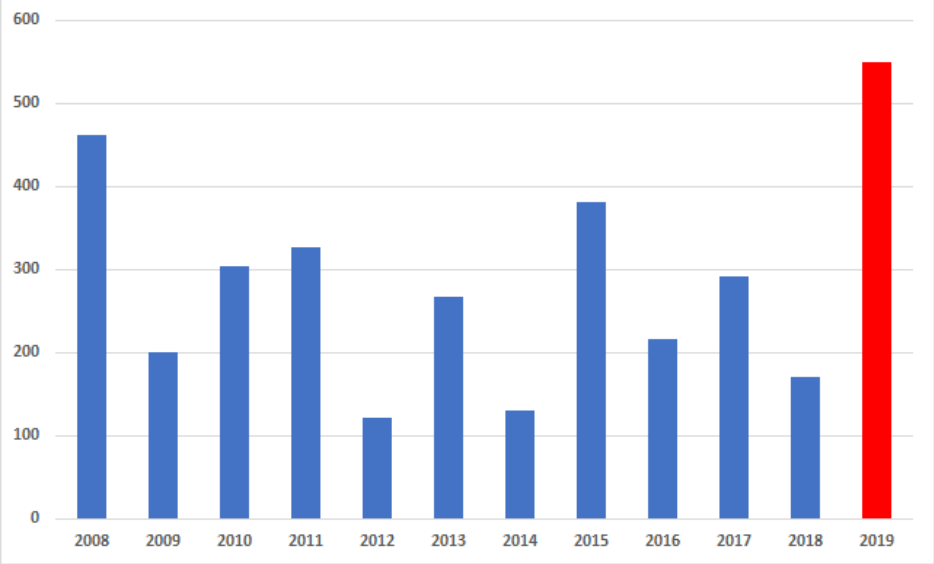

Red indicates a station for which TMAX exceeded the 95th percentile of its historical distribution for the entire 11-day period from May 21 to 31. Dark blue indicates a station which experienced only 1 day above the 95th percentile. The gradient between blue and red represents stations which experienced between 2 and 10 days above the 95th percentile.

## Tornadoes in Midwestern and Southcentral U.S.

According to preliminary data compiled by NOAA, there were 549 tornadoes in the U.S. in May 2019, while the average from 2008 through 2018 for the month of May was only 261. The Midwestern and Southcentral U.S. were hit particularly hard, as depicted in Figures 4 and 5.

**Figure 3**

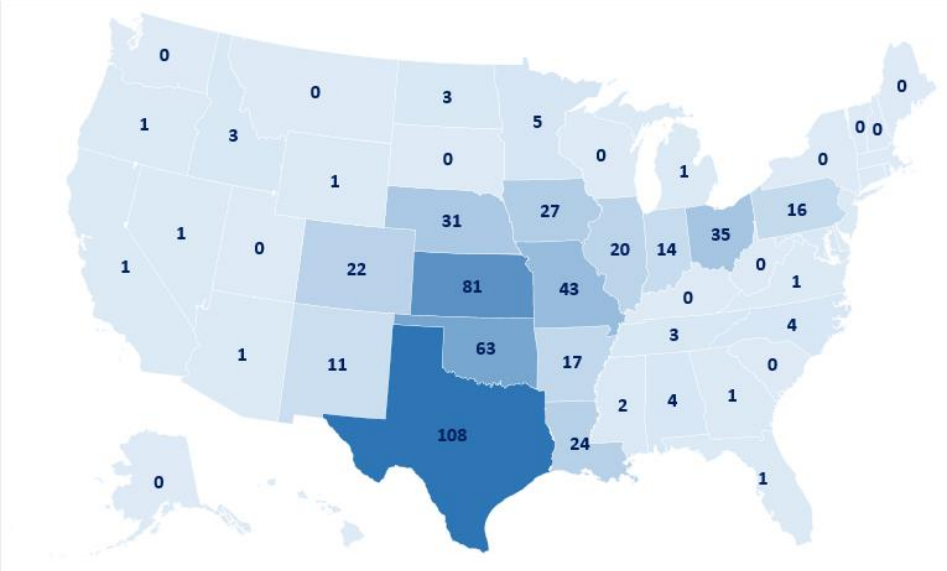
Number of Tornadoes in U.S. During the Month of May




This data was downloaded from NOAA's website. The May 2019 tornado count is preliminary and is therefore subject to future revisions. On average, across the period from 2013 to 2018, the final tornado count was 4% lower than the preliminary count for the month of May, and 7% lower if tabulated across all 12 months. In general, final counts tend to be slightly lower than preliminary counts.

**Figure 4**

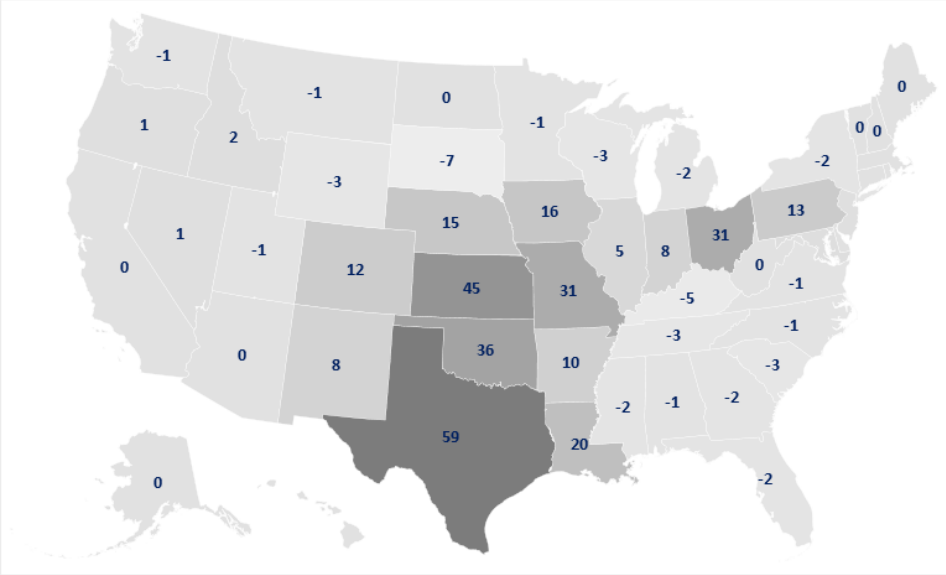
May 2019 Preliminary Tornado Counts, By State




This data was downloaded from NOAA's website. The results are preliminary and, as a consequence, are subject to future revisions.

**Figure 5**

May 2019 Preliminary Tornado Counts Minus Historical Average Actual Counts, by State




Both the May 2019 preliminary counts and the historical averages of actual counts were obtained from NOAA's website. NOAA computed the historical averages across the period from 1989 to 2013.

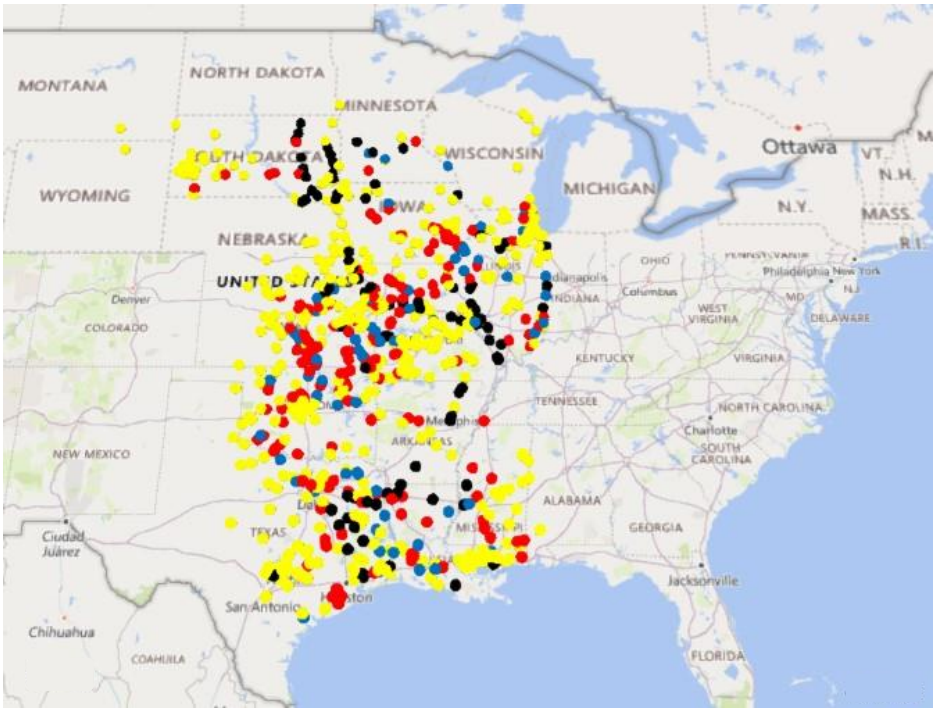
Consider the value of "59" for Texas. This is equal to the preliminary May 2019 tornado count of 108 minus the historical average actual count of 49.

## Flooding in Central and Southcentral U.S.

Significant flooding occurred in the Central and Southcentral U.S. during May, the result of a number of converging weather factors, including the prior month's heavy rain and snow that fell on either frozen or saturated ground. Across the month of May, USGS streamgages reported water levels at or above flood stage at a total of 721 sites (Figure 6), and 122 sites reported major floods (Figure 7).

**Figure 6**

USGS Streamgages that Reported Flooding in May 2019

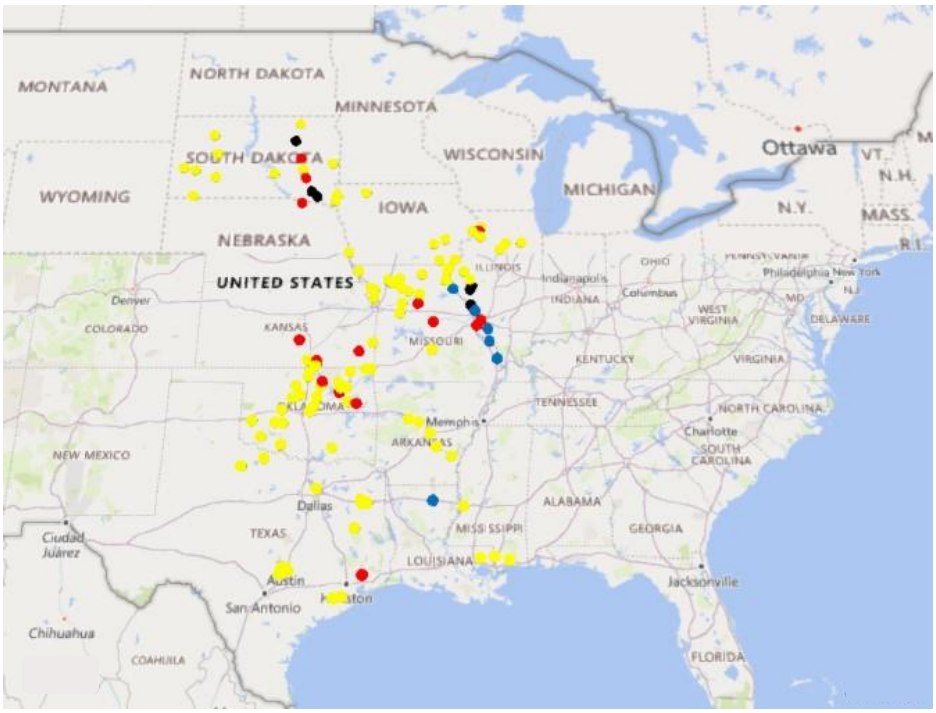



The sites are color-coded to indicate the total number of days of flooding in May 2019, as follows:

Yellow = 1 to 7 days
Red = 8 to 15 days
Blue = 16 to 23 days
Black = 24 to 31 days

**Figure 7**

USGS Streamgages that Reported Major Flooding in May 2019




While Figure 6 shows sites that experienced any level of flooding, Figure 7 shows only those sites that experienced "major" floods.

A major flood is a potentially catastrophic event in which low-lying areas may be completely underwater and large-scale evacuations may be necessary.

The sites are color-coded to indicate the total number of days of major flooding in May 2019, as follows:

Yellow = 1 to 7 days
Red = 8 to 15 days
Blue = 16 to 23 days
Black = 24 to 31 days

## Underlying Causes of May's Extreme Weather

To some extent, the heat wave, tornadoes and floods that occurred in May 2019 are tied together by a common set of causes. A high-pressure system over the Southeastern U.S created a "blocking pattern" which, in addition to locking in the heat in the southeast, acted as a barrier to the free movement of storm systems from west to east. Weather systems coming out of the west were channeled along the border of this barrier, leading to a high level of storm activity in states just to the west and north of the area of high pressure. The blocking pattern, combined with a significantly distorted jet stream which pushed north to Alaska, and then dipped deep into the rocky mountain states before turning north again across the eastern U.S., served to lock-in both the heatwave in the Southeast and the storm pattern in the Southcentral and Midwest. Finally, May events on top of some very cold April weather in areas where ground was frozen contributed to even more flooding when timing of rain coincided with still frozen ground.

## Rough Assessment of the Impact of May's Extreme Weather on Insured Losses

May was a significant month for weather extremes and should prove to be significant in terms of insured losses. Consulting with industry experts, we find that it will be several weeks until initial estimates are available, but May 2019 could become a multi-billion-dollar month for insurance payouts industry-wide. Tornadoes, large hail and straight-line winds should be material contributors to the high-dollar cost. Flood damage, not only in the form of property damage, but also the impact of elevated river levels on agricultural planting and/or yields, will take longer (perhaps months) to quantify, and is expected to be a significant contributor to loss. To put it in a historical context, one expert noted that, subject to review, the past month could become the most active May since 1998 with respect to tornado and hail events. Specific numbers will take a while to materialize, but we will continue to seek the most illustrative loss statistics available to begin to associate economic concepts and insured losses, at a high level, with the analysis of weather extremes.

## Methods

To rank each daily TMAX observations for Figures 1, 2a and 2b, we used GHCN data back to 1960 that falls within a 10-day radius of the particular day of interest. For example, consider a TMAX observation of 93.9°F recorded on May 21, 2019 by a weather station in Charleston, South Carolina. To rank this observation, a TMAX distribution was compiled from the station's 1960 to 2018 historical data, using observations from dates between May 11 and May 31. Against this empirical distribution, the May 2019 observation of 93.9°F falls at the 99.4th percentile, indicating that this was a very hot day by historical standards.

## Data

The data used in this analysis is publicly available and can be downloaded from the internet via the sites listed below.

GHCN daily station data used to produce the heat wave exhibits:

ftp://ftp.ncdc.noaa.gov/pub/data/ghcn/daily/

Filename = ghcnd_all.tar.gz

Preliminary May 2019 tornado counts, by state:

https://www.spc.noaa.gov/climo/online/monthly/1905_summary.html

Historical 25-year average actual tornado counts, by state, for the month of May:

https://www.spc.noaa.gov/wcm/permonth_by_state/May.png

Time series of tornado counts for the U.S. as whole, by year and month:

https://www.spc.noaa.gov/climo/online/monthly/newm.html#2018

USGS streamgage data for May 2019 (or for any user-specified time period):

https://waterwatch.usgs.gov/index.php?id=wwdp2_2

## SOA Research Team for This Report

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## About the Society of Actuaries

With roots dating back to 1889, the Society of Actuaries (SOA) is the world's largest actuarial professional organization with more than 30,000 actuaries as members. Through education and research, the SOA advances actuaries as leaders in measuring and managing risk to improve financial outcomes for individuals, organizations, and the public.

As part of its work, the SOA seeks to inform public policy development and public understanding through research. The SOA aspires to be a trusted source of objective, data-driven research and analysis with an actuarial perspective for its members, industry, policymakers and the public. This distinct perspective comes from the SOA as an association of actuaries, who have a rigorous formal education and direct experience as practitioners as they perform applied research. The SOA also welcomes the opportunity to partner with other organizations in our work where appropriate.

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