SOCIETY OF ACTUARIES

Actuarial Weather Extremes
August 2019

Actuarial Weather Extremes: August 2019

Heat Waves in North America and Heavy Monsoon Rains in India

Overview

This report is the fifth in a monthly series that was launched in April 2019. Each report covers extreme weather events that occurred in the month prior to the report's issuance. While the focus is upon weather events in North America, we periodically cover extreme weather events that occur in other locations. This report highlights three major weather events that occurred during August 2019:

- Along Alaska's southern coast, a 12-day period of near-record temperatures
- In southwestern United States and northern Mexico, unusually high heat for most of August
- In southwestern India, monsoon rains several standard deviations above average levels

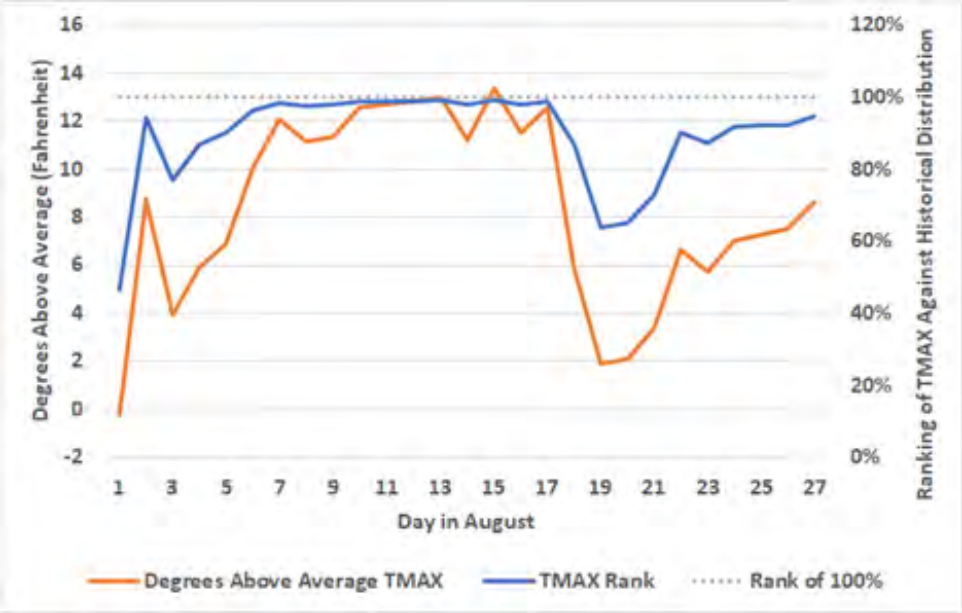
The temperature and precipitation data presented in this report was obtained from the Global Historical Climatology Network ("GHCN") weather database which provides daily weather observations from over 100,000 weather stations worldwide, covering over 180 countries. The GHCN database is hosted by the National Oceanic and Atmospheric Administration (NOAA) and is available for download from NOAA's website.

A Lengthy Period of Near-Record Temperatures Along Alaska's Southern Coast

The southern coast of Alaska experienced unusually high heat for much of August. In Anchorage, for example, on each of the 12 days from August 6 to 17, the maximum daily temperature ("TMAX") was over 10 degrees above normal[1] (Figure 1, orange line, left axis). Each of these daily observations fell between the 96th and 99th percentiles of the corresponding historical TMAX distribution[2] (Figure 1, blue line, right axis). Similar temperature patterns occurred at other weather stations along Alaska's southern coast (Table 1).

Figure 1

Daily High Temperature ("TMAX") Data for Anchorage, Alaska, for August 2019



The orange line shows TMAX on a specific day in August 2019 minus the average historical TMAX for the same day of the year. The blue line indicates how the August 2019 TMAX compares to the corresponding historical TMAX distribution. A value of 97%, for example, indicates that the August 2019 value is greater or equal to 97% of the TMAX data points in the historical distribution. For a detailed description of the TMAX ranking methodology, please refer to the appendix.

[1] "Normal" is defined as the average TMAX for Anchorage computed across the period from 1960 to 2018, using data falling within a 10-day radius of each specific date. For example, to estimate the normal TMAX for August 15, historical data is averaged from August 5 to 25.

[2] For a description of our methodology for ranking temperature observations against historical data, please refer to the appendix.

Table 1

Alaska, Daily High Temperature ("TMAX") Data Across the Period from August 6 to 17

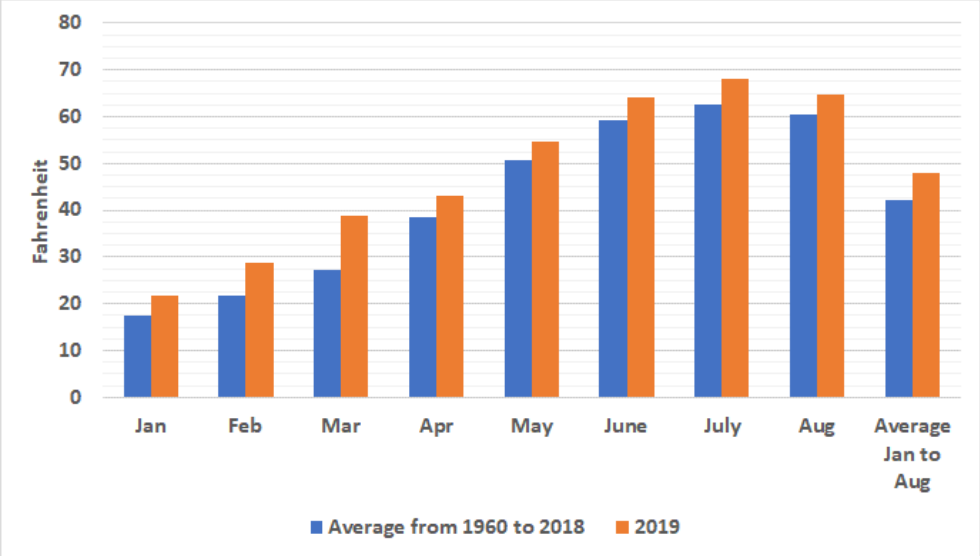
City or Name of Weather Station	Latitude North	Longitude West	TMAX Statistics for the 12-Day Period from August 6 to 17			
			2019 Average TMAX in Degrees (F)	Degrees (F) Above Historical Avg TMAX	Average Daily TMAX Rank in 2019	Days in 2019 Falling Above Historic 90th TMAX Percentile
AK Kodiak AP	57.8	152.5	76.8	15.1	97.3%	11
AK Seward AP	60.1	149.4	75.9	13.8	94.2%	10
AK Iliamna AP	59.8	154.9	73.8	12.1	95.4%	11
AK Anchorage INTL AP	61.2	150.0	76.2	12.0	98.3%	12
AK Kenai Muni AP	60.6	151.2	74.2	11.6	96.1%	12
AK Cordova M K Smith AP	60.5	145.4	72.0	10.2	89.0%	8
AK Juneau INTL AP	58.4	134.6	73.9	10.2	86.2%	5
AK Yakutat State AP	59.5	139.7	69.9	9.4	89.9%	8
AK King Salmon	58.7	156.6	71.6	8.8	87.7%	6
AK Cold Bat AP	55.2	162.7	65.2	8.6	94.4%	10

The first row of this table is interpreted as follows: the average TMAX across August 6 to 17 (2019) was 76.8 °F, which is 15.1 °F above the average TMAX for August 6 to 17 computed using data from 1960 to 2018. The average daily TMAX percentile ranking was 97.3% for August 6 to 17, 2019. Lastly, from August 6 to 17, 2019, there were 11 days where TMAX exceeded its historical 90th percentile. For a 12-day period of normal temperatures, one would expect only 1 to 2 days to exceed the 90th percentile.

The high heat in August comes on the heels of record-setting heat in the month of July. Using data from 1960 to the present, this past July ranks as Alaska's hottest on record[3]. Indeed, across Alaska as a whole, every month this year has been significantly warmer than average:

Figure 2

Average TMAX Computed Across All of the GHCN Weather Stations in Alaska That Have a Lengthy Data History



We identified 19 GHCN weather stations in Alaska with complete or nearly complete TMAX data from 1960 to the present, and used these stations to develop Figure 2. For the first 8 months of 2019, the average TMAX was 47.9 °F, which is 5.7 °F above the 1960 to 2018 average for January through August, and is the second highest Jan-Aug average TMAX since 1960. The highest Jan-Aug average TMAX was 48.5 °F, occurring in 2016.

[3] For more detail, see our July 2019 weather extremes report: https://www.soa.org/resources/research-reports/2019/weather-extremes/

A Month of High Heat in Southwestern U.S. and Northern Mexico

By definition, during an average month of weather as recorded by any particular weather station, TMAX exceeds its 90th historical percentile on 3 days (or 10% of the days of the month). This August, however, in southwestern U.S. and northern Mexico, TMAX routinely exceeded the 90th percentile, indicating a long stretch of unusually warm or hot weather.

Table 2

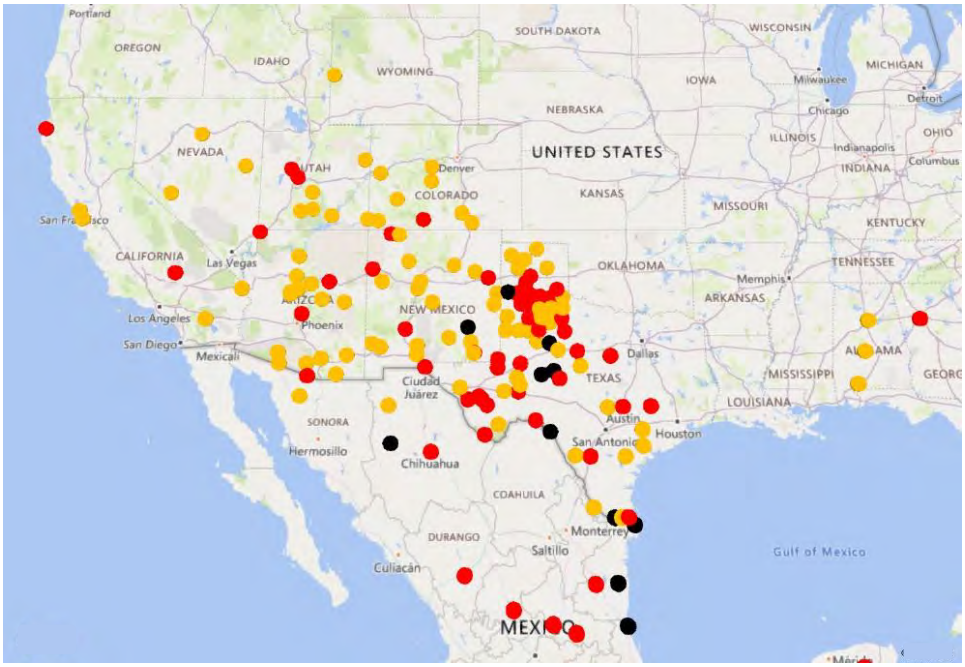
Southwestern U.S. and Northern Mexico: Daily High Temperature Data for this Past August

City or Name of Weather Station	State or Country	Latitude North	Longitude West	TMAX Statistics for the Period from August 1 to 31			
				2019 Average TMAX in Degrees (F)	Degrees (F) Above Historical Avg TMAX	2019 Average Daily Percentile Rank	Days in 2019 Falling Above Historic 90th TMAX Percentile
Tampico Tamps	Mexico	22.2	97.8	100.9	8.88	100.0%	30
TX Snyder	Texas	32.7	100.9	103.5	10.80	93.8%	26
TX Del Rio Intl AO	Texas	29.4	100.9	103.9	7.16	92.6%	23
Soto La Marina (obs)	Mexico	23.8	98.2	106.3	7.72	95.8%	22
TX Water Valley	Texas	31.7	100.7	101.9	7.85	86.4%	22
TX Brownsville	Texas	25.9	97.4	98.2	4.24	85.4%	21
Temosachi (obs)	Mexico	29.0	107.8	97.8	10.55	91.7%	21
TX Cope Rch	Texas	31.5	101.3	102.3	8.34	88.6%	21
TX Friona	Texas	34.6	102.7	97.6	8.93	88.4%	20
NM Roswell Ind Air Pk	New Mx	33.3	104.5	100.6	8.47	86.5%	20

The data to develop this table was downloaded on September 5. As of that date, some of the stations listed above did not yet have complete data for August 2019. On average, for the stations listed above, there were 29.9 days of reported TMAX data for August 2019.

Figure 3

Number of Days in August Where the Daily High Temperature (TMAX) Exceeded the 90th Historical TMAX Percentile



By definition, during an average month of weather as recorded by any particular weather station, TMAX exceeds its 90th historical percentile on 3 days (or 10% of the days of the month). However, in August 2019, TMAX was routinely above this level across the area shown in this figure.

The color codes for the number of days in August 2019 with TMAX above the 90th historical percentile are as follows:

Black = 20+ days above
Red = 15 - 19 days
Orange = 10 to 14 days

Unusually Heavy Monsoon Rains in Southwestern India

India's monsoon season runs from June to September, during which time heavy rain is common throughout much of the country. While the monsoon is critical for replenishing India's reservoirs used for power generation, irrigation and drinking water, unusually heavy rainfall can lead to dangerous flooding. Indeed, heavy rains this past August caused flooding in various regions of India. The states of Karnataka and Kerala in southwestern India were among the hardest hit – particularly during the first half of August -- with total rainfall at or close to record levels.

Table 3

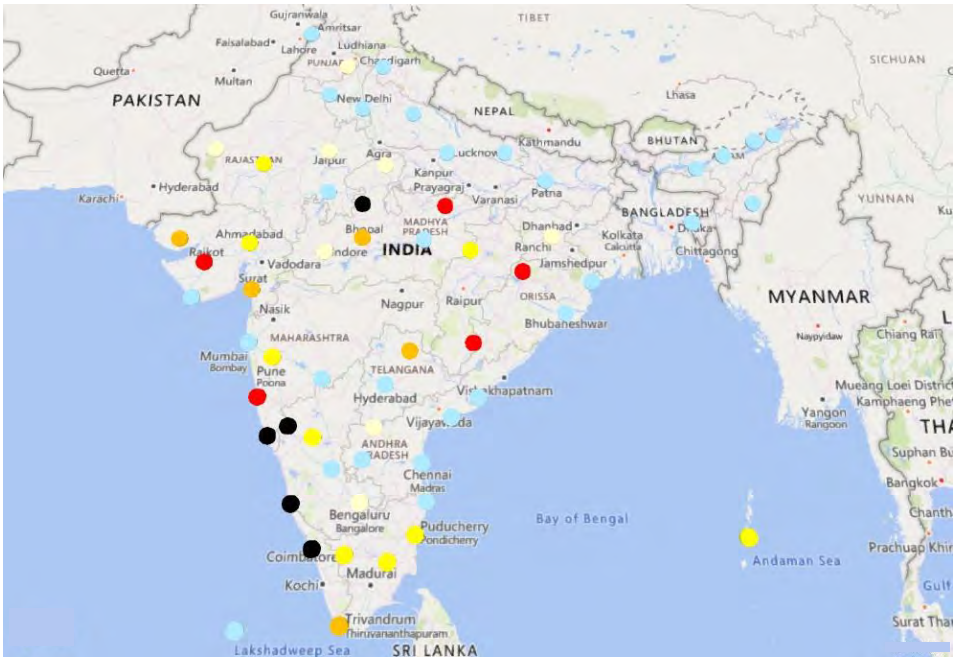
Total Monthly Rainfall in August 2019 for Various Locations in India

City or Name of Weather Station	State	Latitude North	Longitude East	Total Rainfall (inches) In August 2019	August Rainfall (inches) Minus Historical Average	Standard Deviations Above Average	Rainfall Rank Using Data Since 1990
Mangalore/Bajpe	Karnataka	12.9	74.9	60.9	34.9	4.7	1
Kozhikode	Kerala	11.3	75.8	39.8	29.1	3.3	1
Guna	Madhya Pradesh	24.6	77.3	33.4	25.0	4.1	1
Goa/Panjim	Goa	15.5	73.8	40.2	24.5	2.3	1
Belgaum/Sambra	Karnataka	15.9	74.6	26.6	20.4	5.8	1
Jagdalpur	Chhattisgarh	19.1	82.0	26.2	13.7	2.5	2
Satna	Madhya Pradesh	24.6	80.8	19.3	12.9	2.1	2

The final 3 columns on the right were computed using August rainfall totals for each year from 1990 to 2018. The final righthand column is the ranking of total August rainfall in 2019 against the August totals for each year from 1990 to the present. A rank of "1" means that the August 2019 rainfall exceeded the August total for each year from 1990 to 2018. While we prefer to use data back to 1960 to rank observations, in this case, due to data constraints, we used data back to 1990.

Figure 4

Total Rainfall in August 2019 Relative to the 1990-2018 Average for August



Total rainfall in August 2019 minus average August rainfall computed using GHCN data from 1990 to 2018.

The color codes for inches of rainfall in August 2019 relative to the average for August are as follows:

Black = 20+ inches above avg.
Red = 10 - 19 inches above
Orange = 5 – 10 inches above
Yellow = 2 – 5 inches above
Light Yellow = 0 - 2 inches above
Light blue = below average

Rough Assessment of the Losses Caused by Recent Extreme Weather

Economic and insured losses are often difficult to estimate in the immediate aftermath of an extreme weather event. With the passage of time, the extent of the losses gradually becomes clearer. Below, we offer a rough assessment of the cost of some of the weather events covered in our reports over the last few months:

August: Heavy Monsoon Rains in India

According to a Reuters' article published on August 14, heavy rains in the first half of August caused floods and landslides that displaced over one million persons in India and led to 270 deaths[4]. An article in Business Today[5] on August 16 indicates that coffee yields in the states of Karnataka, Kerala and Tamil Nadu are expected to decline by 30% to 40% due to August's rains and floods. Sugarcane, cotton and apple yields are also likely to be reduced[6].

Because India's monsoon season is volatile weather phenomenon with significant rainfall variation from year to year, month to month, and region to region, flood-induced fatalities and economic losses are not unusual in India. According to data from India's Central Water Commission, across the period from 1953 to 2017 an average of 1600 persons died each year due to heavy rains and floods, and across the 5-year period from 2013 to 2017, the average was 1953[7].

August: Heat Wave in Alaska

During August, large numbers of dead salmon were found in several Alaskan rivers[8]. According to observers, the fish died prior to spawning, whereas salmon typically die only after spawning. Some researchers are attributing these premature deaths to unusually high river temperatures caused by a combination of high air temperatures and lack of rain[9].

July: Heat Waves in the U.S. and Europe

Fortunately, few human lives were lost in these heat waves. In regard to economic costs, an assessment is difficult. Some examples of the impact of the heat waves are as follows: (1) in both Germany and France, a number of nuclear power plants had to be taken offline, thus temporarily reducing total power generation[10]; (2) in the United Kingdom, railway service was disrupted because the unusually high temperatures caused train tracks to expand or kink[11]; (3) in the United Kingdom, thousands of chickens died in a farmhouse that lacked a cooling system[12]; and (4) on a farm in the Netherlands, over 2000 pigs suffocated[13] after a ventilation system failed during the heat wave.

July 13-16: Hurricane and Tropical Storm "Barry"

Over $600 million in economic losses and nearly $300 million in insured losses, according to industry experts.

June 21-22: Derecho in Central and Eastern U.S.

An extreme wind event known as a "derecho" caused damage across a 1000-mile path from Nebraska to South Carolina. Thousands of structures affected, with economic losses estimated to be over $100 million by industry experts.

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[4] https://www.reuters.com/article/us-southasia-floods/india-floods-kill-more-than-270-displace-one-million-idUSKCN1V413K

[5] https://www.businesstoday.in/current/economy-politics/karnataka-floods-landslides-brew-fresh-troubles-coffee-second-year-straight/story/372972.html

[6] https://economictimes.indiatimes.com/news/economy/agriculture/sugarcane-cotton-apple-crops-hit-by-late-rainfall-pan-india/articleshow/70744401.cms

[7] https://www.business-standard.com/article/current-affairs/at-107-487-india-accounts-for-1-5th-of-global-deaths-from-floods-in-64-yrs-118071900052_1.html

[8] https://time.com/5661024/alaska-high-temperatures-salmon-deaths/

[9] https://observers.france24.com/en/20190821-salmon-die-alaska

[10] https://www.reuters.com/article/us-france-electricity-heatwave/hot-weather-cuts-french-german-nuclear-power-output-idUSKCN1UK0HR

[11] https://www.telegraph.co.uk/news/2019/07/25/uk-heatwave-britain-bracing-hottest-day-record-temperature-could/

[12] https://www.independent.co.uk/news/uk/home-news/chicken-uk-heatwave-farm-deaths-lincolnshire-tesco-sainsbury-a9025516.html

[13] https://veganuary.com/blog/over-2000-pigs-suffocate-on-factory-farm-as-ventilation-system-fails/

May: Severe Weather in U.S. Plains, Midwest and Southeast
Tornadoes, straight-line winds, hail, flooding: close to $3 billion of economic losses and $2 billion of insured losses, according to industry experts.

May to June: Flooding in U.S. Breadbasket
Flooding has had a significant impact on farmers' ability to plant crops this year. Economic and insured losses are estimated to be in excess of $4 billion by industry experts.

Data

The temperature and precipitation data used in this report was obtained from the Global Historical Climatology Network ("GHCN") weather database, which provides daily weather observations from over 100,000 weather stations worldwide, covering over 180 countries. The database is publicly available through the National Oceanic and Atmospheric Administration (NOAA) via the following FTP site:

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

Filename = ghcnd_all.tar.gz

Methods

To rank each daily TMAX or TMIN observation used in the heat wave exhibits, we used GHCN data back to 1960 that falls within a 10-day radius of a particular day of interest. For example, consider a TMAX observation of 85.5°F recorded on June 18, 2019 by a weather station in Paris, France. To rank this observation, a TMAX distribution was compiled from the station's 1960 to 2018 historical data, using observations from dates falling between June 8 and June 28. Against this empirical distribution, the TMAX observation from June 18th, 2019 falls at the 94th percentile, which means that 6% of historical observations exceeded 85.5°F.

For a station with an unbroken data history back to 1960, our ranking approach involves about 1200 historical daily observations; that is, a current weather observation is ranked against 1200 observations. However, many stations have a shorter history or have a data history with some gaps. In general, we focus on stations that have at least 600 historical observations within a 10-day radius of the day-of-interest. This requirement ensures that the ranking of an observation is meaningful because it is computed against a large set of historical data.

SOA Research Team for This Report

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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.

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