SOCIETY OF ACTUARIES

Actuarial Weather Extremes October 2019

Actuarial Weather Extremes: October 2019

A Powerful Typhoon Hits Japan, and Extreme Cold Grips the Great Plains

Overview

This report is the seventh 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 in other regions.

This report highlights two major weather events that occurred during October 2019:

- Typhoon Hagibis – the biggest storm to strike Japan in decades – made landfall on October 12 about 60 miles southwest of Tokyo, bringing high winds, heavy rain and flooding to a large portion of Japan's main island of Honshu.
- A late-October cold spell sent temperatures across the United States (U.S.) and Canadian Great Plains plunging to record lows.

To evaluate the cold spell that affected the Great Plans, Global Historical Climatology Network ("GHCN") data[1] was used to rank observed temperatures against historical late-October temperature data from 1960 through 2018. The appendix provides a detailed description of our approach for ranking these observations.

For Typhoon Habigis, this report focuses on GHCN precipitation data. In addition to heavy rain, Hagibis also produced strong winds and storm surges[2]. However, we have chosen to focus on precipitation because we are still developing an understanding of the available databases for analyzing wind speed and storm surge. The GHCN data – the primary data source we have used thus far in this series of reports – is best suited for temperature and precipitation analyses.

Typhoon Hagibis

Like a hurricane, a typhoon is a cyclone that originates over tropical or subtropical waters. The sole difference is the storm's location: cyclones in the North Atlantic or Northeast Pacific are referred to as hurricanes, while cyclones in the Northwest Pacific are referred to as typhoons.

The precursor of Typhoon Hagibis was an elongated area of low pressure that formed on October 2 near the Marshall Islands, about 2500 miles southeast of Japan. Over the next several days, the system gathered strength while moving to the west, achieving typhoon status on October 6 with sustained wind speeds in excess of 73 miles per hour. After a burst of rapid intensification, the storm became a "super-typhoon" on October 7, with sustained wind speeds in excess of 160 miles per hour. This wind speed equates to a Category 5 hurricane using the Saffir-Simpson Hurricane Wind Scale.

On October 10 and 11, as Hagibis approached the coast of Japan, the storm lost some power. On October 12, just prior to landfall at the Izu Peninsula (about 60 miles Southwest of Tokyo), Hagibis had sustained wind speeds of 100 mph, equivalent to a Category 2 hurricane. Over the subsequent 12 hours, the storm remained over Japan's main island of Honshu, producing record-setting rainfall (Table 1 and Figure 2) across a wide region stretching from the Izu Peninsula in the southwest to Iwaki in the northeast.

Hagibis moved offshore on October 13, pulling away from Japan and heading out into the open ocean.

[1] The GHCN database contains 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.

[2] https://www.nhc.noaa.gov/surge/

Figure 1

Path and Wind Speed of Typhoon Hagibis (source: Weather Underground)

Weather Underground's data for Typhoon Hagibis contains observations spaced at 6-hour intervals. Using this data, we interpolated to arrive at data spaced at 3-hour intervals. Thus, there is a 3-hour time interval between each of the mapped data points.

Color codes for maximum sustained wind-speed measured over a one-minute time interval:

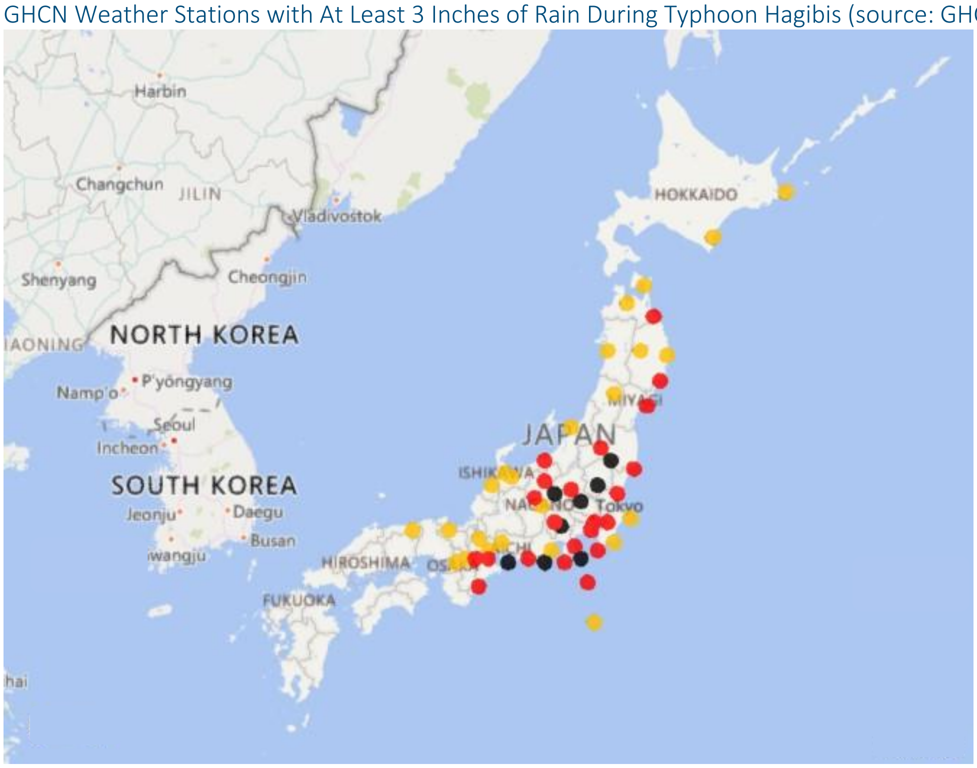
Black = at least 120 mph

Red = 100 to 119 mph

Orange = 75 to 99 mph

Figure 2

GHCN Weather Stations with At Least 3 Inches of Rain During Typhoon Hagibis (source: GHCN data)



Color codes for total rainfall from October 11 through October 13:

Black = 10+ inches

Red = 5 to 10 inches

Orange = 3 to 5 inches

Table 1

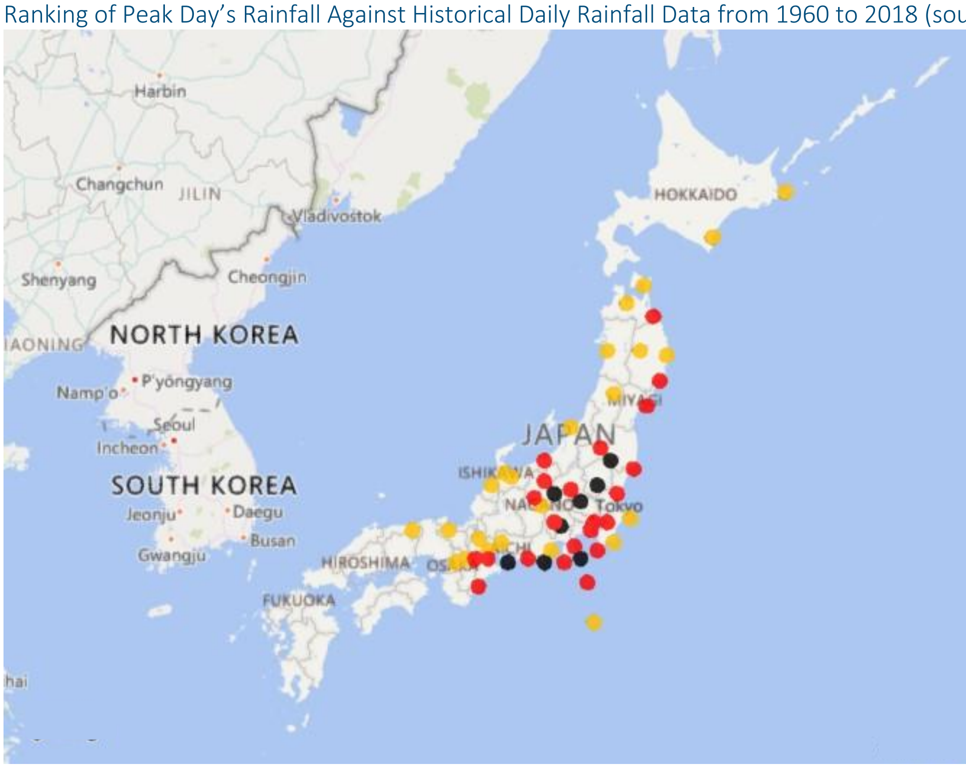
Top Ten Cumulative Rainfall Totals in Japan During Typhoon Hagibis (source: GHCN data)

City or Name of Weather Station	Latitude North	Longitude East	Total Rainfall (Inches)	Rainfall on Peak Day (Inches)	Peak Day	% Ranking of Peak-Day Rainfall
SHIRAKAWA	37.1	140.2	15.0	11.9	Oct 12	100.0%
OSHIMA	34.7	139.3	13.7	11.9	Oct 12	99.9%
KAWAGUCHIKO	35.5	138.7	13.4	11.5	Oct 12	100.0%
KARUIZAWA	36.3	138.5	13.1	12.6	Oct 12	100.0%
UTSUNOMIYA	36.5	139.8	13.0	10.5	Oct 12	100.0%
IRAKO	34.6	137.1	12.0	11.9	Oct 12	100.0%
OMAEZAKI	34.6	138.2	11.5	11.3	Oct 12	100.0%
KUMAGAYA	36.1	139.3	10.2	8.8	Oct 12	100.0%
AJIRO	35.0	139.1	9.8	8.9	Oct 12	100.0%
ISHINOMAKI	38.4	141.3	9.8	6.6	Oct 13	100.0%

The column on the far right shows the percentile ranking of the peak day's rainfall. A ranking of 100% indicates a record relative to historical data from 1960 onwards, using a 10-day radius around the particular calendar day. A value of 99.5% indicates that the rainfall exceeded 99.5% of historical observations. The appendix provides a detailed description of the ranking methodology.

Figure 3

Ranking of Peak Day's Rainfall Against Historical Daily Rainfall Data from 1960 to 2018 (source: GHCN data)



For each GHCN station, the peak daily rainfall between Oct 11 and 13 was ranked against historical data from 1960 to 2018. For example, a rank of 99% indicates that the rainfall exceeded 99% of historical observations falling within a 10-day radius of the particular calendar day. The appendix provides a detailed description of the ranking methodology.

Color codes:

Black = rainfall exceeded prior historical record

Red = 99% to 99.9%

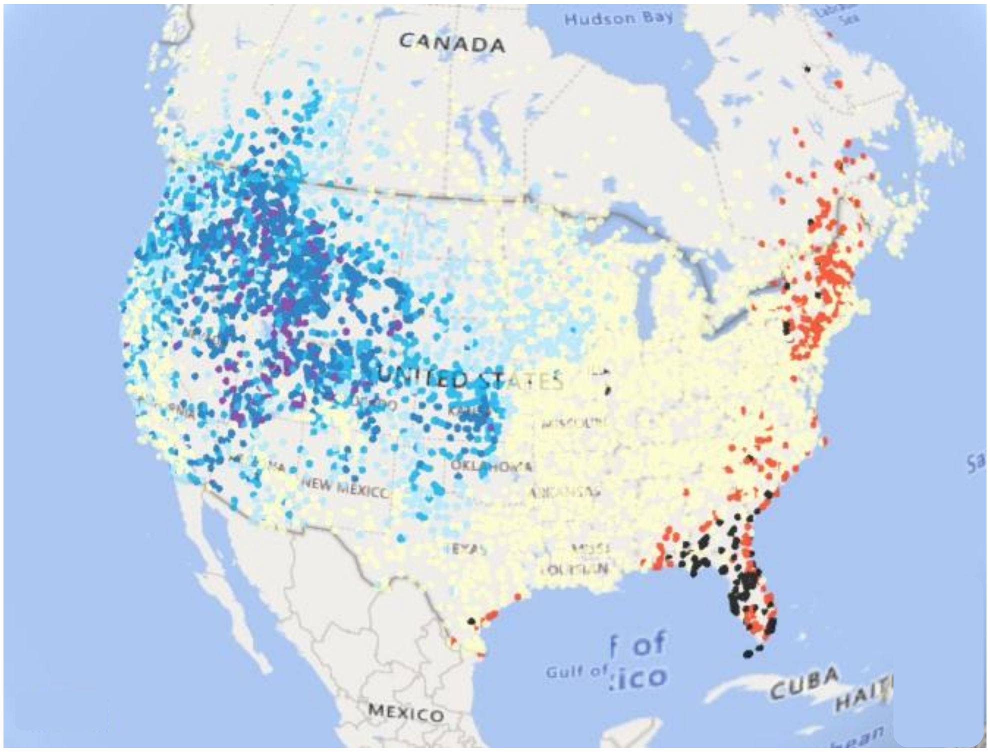
Orange = 97.0% to 98.9%

Record Low Temperatures Across the U.S. and Canadian Great Plains

In North America, the average position of the polar jet stream is just north of the Canadian / U.S. border. The stream acts as boundary between cooler air masses to the north and warmer air masses to the south. Bends or buckles in the stream can send cold arctic air southward into the U.S. or, conversely, can draw warmer air from the south into Canada. On October 27, the polar jet stream began to shift dramatically to the south. By October 28, a trough in the jet stream was positioned close to the U.S. / Mexico border, allowing frigid air to plunge deep into the U.S. Great Plains. From October 28 to 30, record low temperatures were observed across both the U.S. and Canadian Great Plans.

Figure 4

Low Temperatures on October 29 Ranked Against Historical Data from 1960 to 2018 (source: GHCN data)



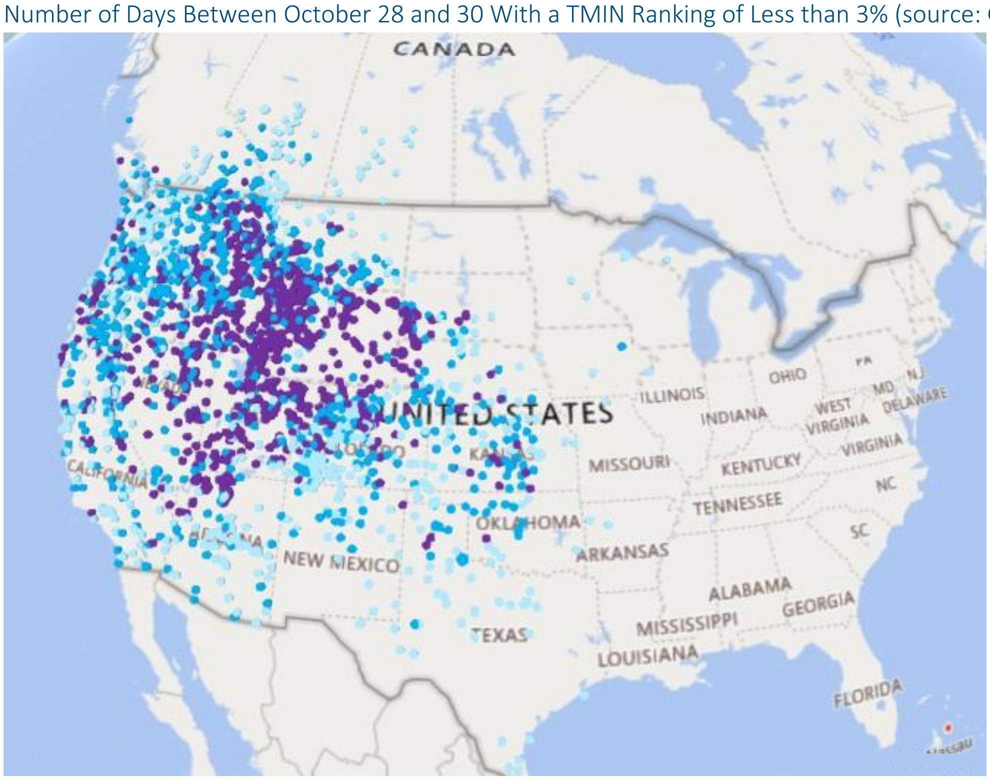
The cold spell was centered around October 29. Daily low temperatures (TMIN) for this day were ranked against historical TMIN data. For example, a ranking of 3% means that, compared to historical data falling with a 10-day radius of October 29, only 3% of observations were less than the TMIN observation from Oct 29, 2019.

Color codes:

Purple = record-low
Blue = Less than 1%
Light Blue = 1% to 3%
Lighter Blue = 3 to 10%
Light Yellow = 10% to 90%
Red = 90% to 97%
Black = 97% to 100%

Figure 5

Number of Days Between October 28 and 30 With a TMIN Ranking of Less than 3% (source: GHCN data)



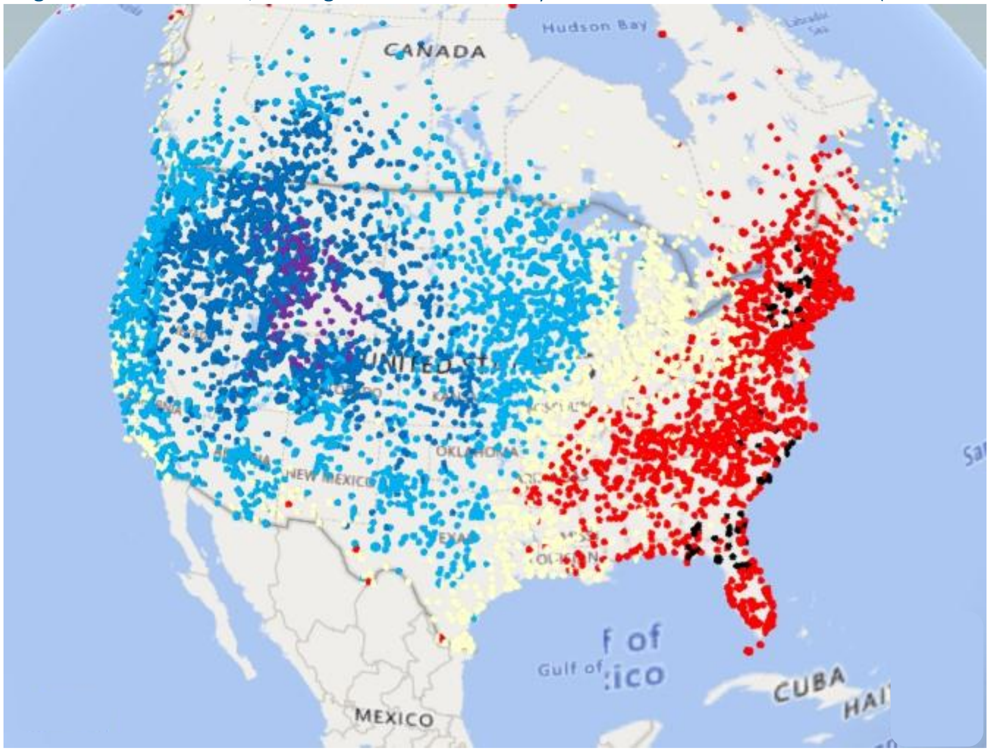
For each of the 3 days from Oct 28 to 30 (2019), the minimum daily temperature (TMIN) was ranked against historical data. A ranking of 3% means that only 3% of historical observations were less than the current TMIN observation. The graph shows the number of days from Oct 28 to 30 (2019) with a TMIN rank of less than 3%.

Color codes:

Purple = 3 days
Blue = 2 days
Light Blue = 1 day

Figure 6

Degrees Below Normal, Averaged Across the 3-Day Period from October 28 to 30 (source: GHCN data)



The minimum daily temperature (TMIN) was averaged across the period from Oct 28 to 30, 2019. This value, in turn, was compared to the "normal" TMIN, which was computed by averaging late-October data across the period from 1960 to 2018.

Color codes:

Purple = 30+ °F below avg
Blue = 15 to 30 °F below avg
Light Blue = 5 to 15 blw avg
Yellow = within 5 °F of avg
Red = 5 to 15 °F above avg
Black = 15+ °F above avg

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:

October: Typhoon Hagibis

According to AIR Worldwide, Typhoon Hagibis may generate between $8 billion and $16 billion in insured losses[3], with more with than half of the losses due to inland flooding. According to "The Mainichi", a Japanese newspaper, at least 83 people died[4] as a result of Typhoon Hagibis.

October: Cold Spell Across the U.S. and Canadian Great Plains

Some farms have reported agriculture losses due to the unexpected cold. For example, "Freight Waves" reports $45 million of estimated damage[5] to the potato crop in North Dakota and Minnesota.

September: Hurricane Dorian

While Dorian had an impact in the U.S. and Canada, losses are heavily concentrated in the Bahamas where the storm was at its greatest strength. According to the Wall Street Journal, as of September 22 the death count stood at 53, with over 1300 people still missing. Total property losses in the Bahamas are estimated at $7 billion[6].

---

[3] https://www.air-worldwide.com/Press-Releases/AIR-Worldwide-Estimates-Insured-Losses-for-Typhoon-Hagibis-Will-be-Between-USD-8-Billion-and-USD-16-Billion/

[4] https://mainichi.jp/english/articles/20191022/p2g/00m/0dm/005000c

[5] https://www.freightwaves.com/news/mother-nature-turns-midwestern-spuds-to-duds

[6] https://www.wsj.com/articles/opening-the-door-to-hell-itself-bahamas-confronts-life-after-hurricane-dorian-11569176306

September: Tropical Storm Imelda
According to the USA Today, the storm has been linked to five deaths[7], and, in its "Global Catastrophe Recap" report for September 2019, AON estimates that economic losses will run over $2 billion.

September: Heat/Dry Spell in the U.S. Southeast
According to the Wall Street Journal[8], the unusual heat and dryness in the U.S. Southeast is having negative effects on agriculture. Potential effects include damage to grass used to feed livestock and damage to the cotton crop. In addition, the dry soil makes it more challenging to harvest peanuts. The Baltimore Sun (a newspaper) indicates that the drought is affecting soybean crops and could even affect next year's wheat crop which must be planted this fall[9].

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[10]. An article in Business Today[11] 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[12].

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[13].

August: Heat Wave in Alaska
During August, large numbers of dead salmon were found in several Alaskan rivers[14]. 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[15].

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[16]; (2) in the United Kingdom, railway service was disrupted because the unusually high temperatures caused train tracks to expand or kink[17]; (3) in the United Kingdom, thousands of chickens died in a farmhouse that lacked a cooling system[18]; and (4) on a farm in the Netherlands, over 2000 pigs suffocated[19] after a ventilation system failed during the heat wave.

---

[7] https://www.usatoday.com/story/news/nation/2019/09/21/texas-flooding-tropical-storm-imelda-death-toll-increases-5/2402290001/

[8] https://www.wsj.com/articles/flash-drought-hits-south-as-record-heat-continues-into-fall-11570058348

[9] https://www.baltimoresun.com/weather/bs-md-drought-report-20190926-yooqxwbbuvcldise7a4oisugtm-story.html

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

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

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

[13] 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

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

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

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

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

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

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

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.

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 rainfall and temperature observation, we used GHCN data from 1960 to 2018 that falls within a 10-day radius of the particular day of interest. In addition, for weather stations that have short data histories, we pooled data from stations within a 10-mile radius, thereby creating a larger historical dataset against which to compare current or recent observations.

For example, consider a precipitation (PRCP) observation of 10.0 inches recorded on September 19, 2019 by a weather station in Vidor, Texas. To rank this observation, a PRCP distribution was compiled from the station's historical data, using observations from dates falling between September 9 and September 29 (a 10-day radius around September 19). Because this particular station has only 3 years of historical data, our ranking algorithm pooled data from nearby stations, resulting in a dataset with a total of 840 days of historical observations. Against this data, the September 19, 2019 measurement of 10.0 inches falls in the 99.8th percentile, which means that only 0.2% of historical observations were in excess of 10 inches.

SOA Research Team for This Report

Patrick Wiese, ASA and Rob Montgomery, ASA, MAAA, FLMI

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.

Society of Actuaries
475 N. Martingale Road, Suite 600
Schaumburg, Illinois 60173
www.SOA.org