SOCIETY OF ACTUARIES

Actuarial Weather Extremes
July 2019

Actuarial Weather Extremes: July 2019

A Series of Heat Waves, and the First Hurricane to Make Landfall This Year

Overview

In April 2019, the Society of Actuaries (SOA) released its first monthly report focusing on weather extremes. This report is the fourth in the monthly series, focusing on extreme weather events that occurred in July 2019. While the emphasis of the reports is on weather events in North America, we periodically cover extreme weather events that occur in other locations.

This report highlights four major weather stories that unfolded across the month of July:

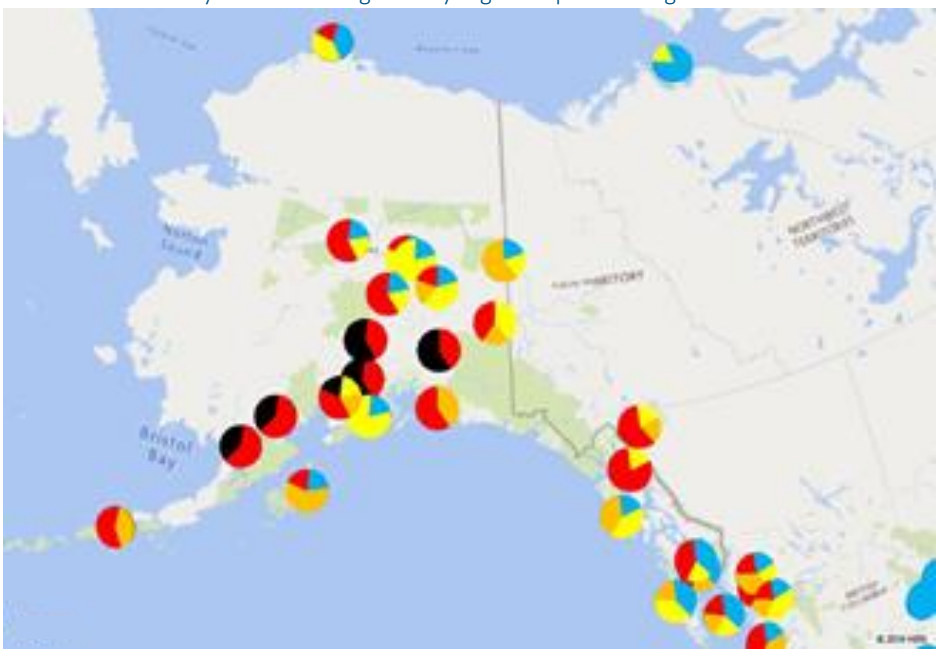
- A heat wave in Alaska, Yukon Territories and British Columbia in early July
- A heat wave in mid-July that stretched from New Mexico to Maine
- A heat wave in late July in Europe
- Hurricane Barry, which struck Louisiana on July 13 and dropped heavy rain on several states

Heat Wave in Early July in the Upper Pacific Northwest

Alaska, Yukon Territories and British Columbia experienced a heat wave from July 4 to July 8, during which time many Global Historical Climatology Network[1] (GHCN) weather stations reported temperatures close to or in excess of previous record highs (Figure 1 and Table 1). While the intense heat subsided after this period, Alaska continued to experience temperatures well above average for much of July. In fact, using data from 1960 to the present, this July ranks as Alaska's hottest on record (Figure 2).

Figure 1

Heat Wave from July 4 to 8: Ranking of Daily High Temperature Against Historical Data from 1960 to the Present



Each pie chart consists of five "slices". Each slice represents a day between July 4 and July 8. For each day, the daily high temperature (TMAX) was ranked against historical observations. A rank of 98%, for example, means that the TMAX observation fell at the 98th percentile of the historical TMAX distribution. The color codes are as follows:

Black = record high TMAX
Red = 95 to 99th percentile
Orange = 90 to 94th percentile
Yellow = 75 to 89th percentile
Blue = below 75th percentile

See the appendix for a detailed description of our TMAX ranking approach.

[1] Data for Figure 1, Table 1 and Figure 2 was obtained from the Global Historical Climatology Network (GHCN) weather database, which is publicly available through the National Oceanic and Atmospheric Administration (NOAA). The appendix provides more information about this dataset, and, in addition, explains our approach for ranking current temperature observations against historical data.

Table 1

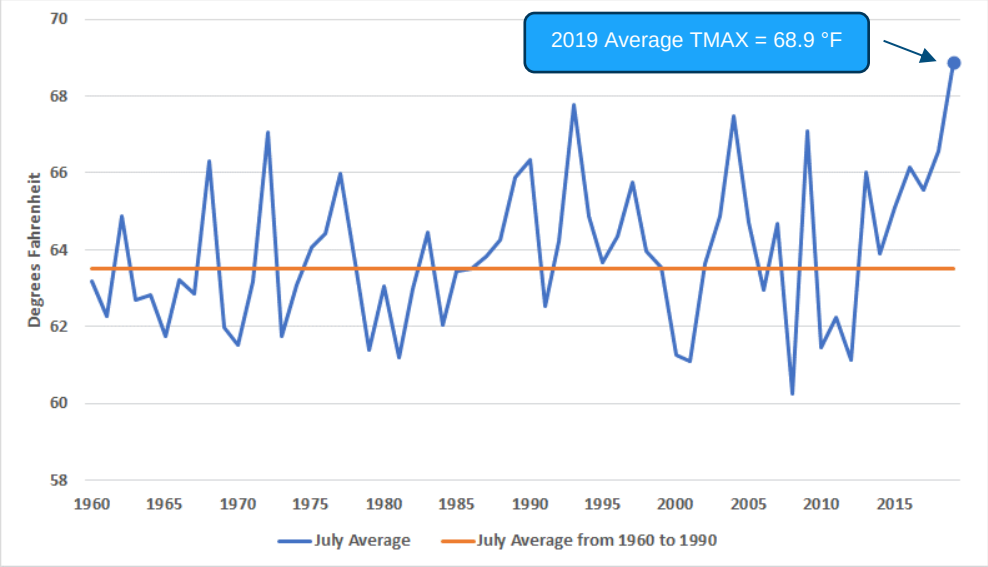
Top Ten Temperature Records July 4 to 8 in Upper Pacific Northwest, Ranked by Degrees Above Prior Record

State	City or Name of Weather Station	Latitude North	Longitude West	Day	Daily High Temperature in Degrees (F)	Degrees (F) Above Average TMAX	Degrees (F) Above Prior Record High TMAX
Alaska	ANCHORAGE INTL AP	61.2	150.0	July 4	90.0	24.8	5.94
Alaska	KING SALMON	58.7	156.6	July 4	89.1	26.1	4.14
Alaska	KENAI MUNI AP	60.6	151.2	July 4	89.1	27.4	4.14
Alaska	TALKEETNA AP	62.3	150.1	July 7	93.0	24.8	3.96
Alaska	KING SALMON	58.7	156.6	July 5	88.0	24.9	3.06
Alaska	TALKEETNA AP	62.3	150.1	July 8	91.0	22.7	1.98
Alaska	ILIAMNA AP	59.7	154.9	July 4	86.0	24.0	1.98
Alaska	ILIAMNA AP	59.7	154.9	July 5	86.0	23.9	1.98
Alaska	GULKANA AP	62.2	145.5	July 7	89.1	20.4	1.08
Alaska	GULKANA AP	62.2	145.5	July 5	90.0	21.5	0.90

"TMAX" is the highest temperature recorded at a weather station across a 24-hour period. Note that by "record high", we mean the highest temperature observed between 1960 and 2018 within a 10-day radius of the particular day-of-interest. Please see the appendix for more information on our ranking methodology.

Figure 2

Average Daily High Temperature in Alaska for the Month of July



Across 20 GHCN weather stations in Alaska with complete (or nearly complete) temperature data since 1960, the average daily TMAX was computed separately for each July from 1960 to 2019. These monthly averages, in turn, were averaged from 1960 to 1990 to produce the graph's horizontal red line which serves as a historical benchmark against which to gauge recent observations.

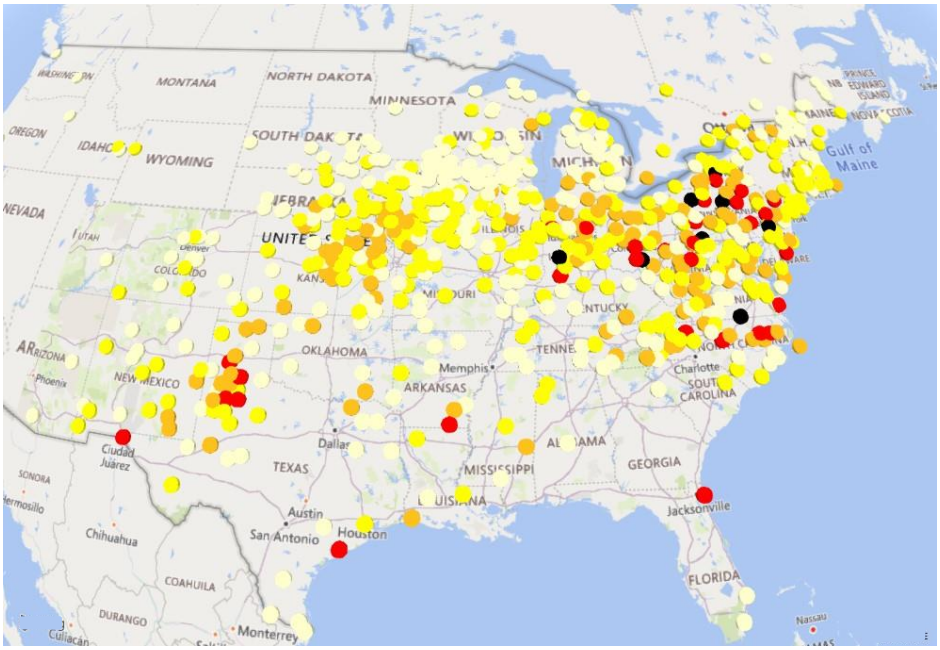
Heat Wave in Mid-July that Stretched from New Mexico to Maine

Between July 18 and July 22, over half of the U.S. experienced a heat wave that was caused, in part, by large high-pressure systems positioned over the central states and over the western Atlantic. While temperature records were broken in various locations, the most striking feature of this weather event was its size, stretching over 2000 miles from New Mexico to Maine (Figure 3).

In relative terms, the heat was more severe at night than during the day. For example, across the subset of weather stations that we analyzed, for the period from July 18 to 22, there were 1576 TMIN observations that exceeded their corresponding historical TMIN 95th percentile, while only 600 TMAX observations exceeded their historical TMAX 95th percentile. TMAX is the highest temperature recorded across a 24-hour period, while TMIN is the lowest temperature (typically occurring at night).

Figure 3

Heat Wave from July 18 to 22: Number of Days Where TMIN Exceeded the 95th Historical TMIN Percentile



Each dot represents a GHCN weather station that recorded at least one daily TMIN observation between July 18 and July 22 that was above the historical 95th TMIN percentile. "TMIN" is the lowest temperature recorded across a 24-hour period, typically occurring at night.

The colors represent the number of days (between July 18 and 22) where the 95th TMIN percentile was exceeded:

Black = 5 days
Red = 4 days
Orange = 3 days
Yellow = 2 days
Light Yellow = 1 day

Table 2

Top Ten TMIN Temperature Records from July 18 to 22, Ranked by Degrees Above Prior TMIN Record

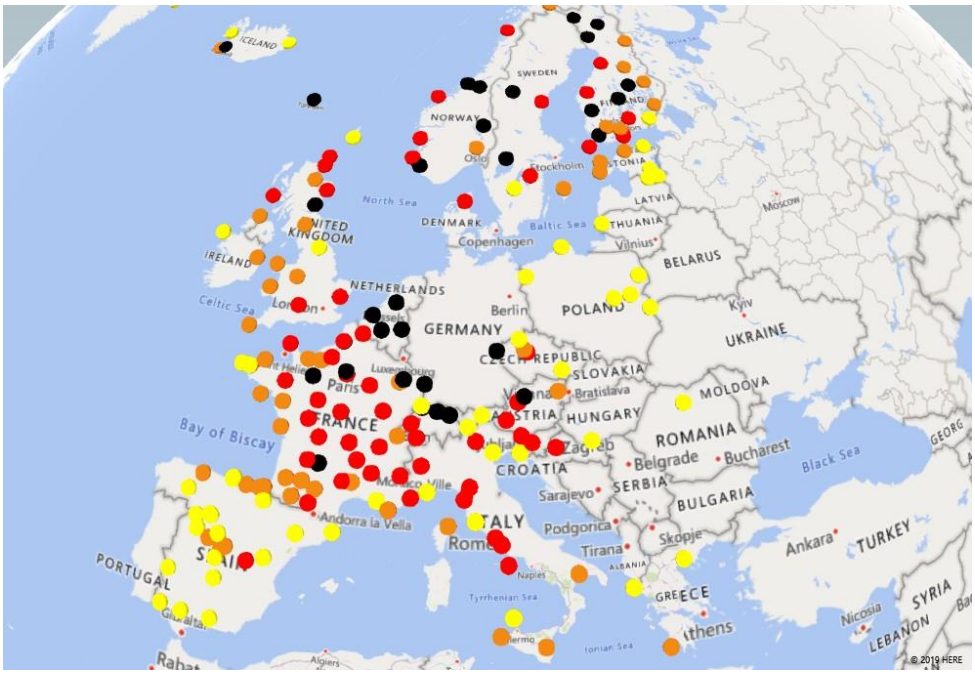
State	City or Name of Weather Station	Latitude North	Longitude West	Day	Daily Low Temperature in Degrees (F)	Degrees (F) Above Average TMIN	Degrees (F) Above Prior Record High TMIN
NM	ANIMAS 3ESE	31.9	108.8	July 21	79.0	14.8	5.0
IL	FULTON L&D #13	41.9	90.2	July 20	82.0	17.2	3.1
IA	MAQUOKETA 4 W	42.0	90.7	July 20	80.1	18.1	3.1
IA	GRINNELL 3 SW	41.7	92.7	July 20	78.1	16.2	2.2
MA	BROCKTON	42.0	71.0	July 21	78.1	16.5	2.2
IL	MT CARROLL	42.1	90.0	July 20	79.0	19.2	2.0
IA	ELKADER 6 SSW	42.8	91.5	July 20	79.0	19.0	2.0
MA	BOSTON LOGAN INTL AP	42.4	71.0	July 21	82.9	16.9	2.0
VT	NEWPORT	44.9	72.2	July 21	73.0	16.3	2.0
OH	AKRON CANTON RGNL AP	40.9	81.4	July 20	77.0	14.6	2.0
"TMIN" is the lowest temperature recorded at a weather station across a 24-hour period							

Heat Wave in Europe in Late July

From July 23 to July 28, much of Western, Central and Northern Europe experienced two or more consecutive days of high heat (Figure 4 and Table 3). In France, several GHCN weather stations recorded four straight days where either TMAX and/or TMIN exceeded their respective 95th historical percentiles. This heat wave comes on the heels of a similar event that enveloped Western Europe just one month ago, in late June.

Figure 4

Heat Wave from July 23 to 28: Number of Days Where TMAX or TMIN Exceeded the 95th Historical Percentile



Each dot represents a GHCN weather station that recorded at least one daily TMIN or TMAX observation between July 23 and July 28 that was above the 95th historical percentile. The colors represent the number of days (from July 23 to 28) where the 95th percentile was exceeded:

Black = 4+ days
Red = 3 days
Orange = 2 days
Yellow = 1 day

For locations with both TMAX and TMIN data, the metric with the greatest number of days above the 95th percentile was selected for mapping.

GHCN data for July for Germany was not available at the time of this report's publication.

Table 3

Top Ten TMAX Temperature Records from July 23 to 28, Ranked by Degrees Above Prior TMAX Record

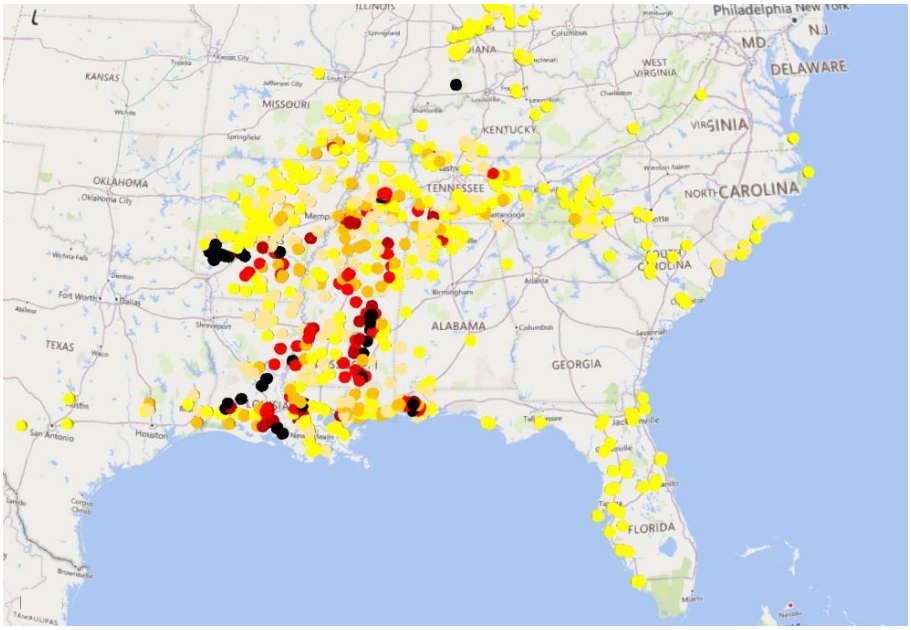
Country	City or Name of Weather Station	Latitude North	Longitude East	Day	Daily High Temperature in Degrees (F)	Degrees (F) Above Average TMAX	Degrees (F) Above Prior Record High TMAX
France	ROUEN - BOOS	49.4	1.2	July 25	106.3	32.8	10.6
France	VALLEE DE SEINE	49.4	1.2	July 25	106.3	31.9	10.6
France	LILLE-LESQUIN	50.6	3.1	July 25	106.7	33.0	9.9
France	LESQUIN	50.6	3.1	July 25	106.7	31.5	9.9
France	ABBEVILLE	50.1	1.8	July 25	106.3	34.6	9.7
France	ABBEVILLE	50.1	1.8	July 25	106.3	33.2	9.7
France	PARIS/LE BOURGET	48.8	2.3	July 25	108.7	31.4	9.4
France	REIMS-PRUNAY	49.2	4.2	July 25	106.0	25.8	7.7
France	REIMS-PRUNAY	49.2	4.2	July 25	106.0	25.7	7.7
France	RENNES-ST JACQUES	48.1	-1.7	July 23	104.2	28.2	6.7
"TMAX" is the highest temperature recorded at a weather station across a 24-hour period							

Hurricane Barry

On July 10, Tropical Storm Barry formed over the Gulf of Mexico, close to the Florida panhandle. It gathered strength over the ensuing 3 days, and, on July 13, briefly achieved the sustained wind speed necessary to be classified as a Category 1 hurricane. After making landfall in Louisiana on July 13, just west of Morgan City, the storm weakened quickly, ceasing to meet the criteria for a hurricane. Nevertheless, it had enough power and moisture remaining to cause significant wind and flood losses, estimated to be over $500 million by industry experts[2].

Figure 5

Total Rainfall from July 13 to July 17



Each dot represents total rainfall across July 13 to July 17, when greater than 2 inches, as recorded in the GHCN daily weather database.

The colors represent the following total rainfalls:

Black = 7+ inches
Dark Red = 6 to 7 inches
Red = 5 to 6 inches
Orange = 4 to 5 inches
Light Orange = 3 to 4 inches
Yellow = 2 to 3 inches

Table 4

Top Ten Cumulative Rainfall Totals (inches) from July 13 to 17

State	City or Name of Weather Station	Latitude North	Longitude West	Total Rainfall (inches)	Day of Peak Rainfall	Total Peak Rainfall (inches)
LA	OBERLIN FIRE TWR	30.6	-92.8	18.2	July 15	15.7
AR	DIERKS	34.1	-94.0	16.2	July 16	16.2
AR	RAGLEY 5.0 SE	30.5	-93.2	15.7	July 15	14.0
AR	MURFREESBORO 1W	34.1	-93.7	14.7	July 16	9.1
AR	LANGLEY	34.3	-93.8	13.9	July 16	12.7
LA	ANTOINE 1 SW	34.0	-93.4	12.9	July 16	8.9
LA	BUNKIE 0.3 WSW	31.0	-92.2	12.7	July 15	8.0
LA	DELIGHT 2.2 WNW	34.0	-93.5	12.4	July 16	11.3
MS	DELIGHT 0.3 NNW	34.0	-93.5	11.9	July 16	10.3
LA	DENHAM SPRINGS 6.8 N	30.6	-91.0	11.7	July 15	9.6

[2] https://www.marketwatch.com/story/hurricane-barry-caused-estimated-losses-of-500-to-900-million-corelogic-2019-07-19

Rough Assessment of the Economic Impact of 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:

May: Severe Weather in U.S. Plains, Midwest and Southeast

Tornadoes, straight-line winds, hail, flooding: at least one billion dollars of insured and economic losses expected.

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 expected to be over $100 million.

April 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 likely to be at least several billion dollars, and perhaps much larger.

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

Wind and flood losses estimated to be over $500 million. Losses occurred primarily in Louisiana.

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[3]; (2) in the United Kingdom, railway service was disrupted because the unusually high temperatures caused train tracks to expand or kink[4]; (3) in the United Kingdom, thousands of chickens died in a farmhouse that lacked a cooling system[5]; and (4) on a farm in the Netherlands, over 2000 pigs suffocated[6] after a ventilation system failed during the heat wave.

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.

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

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

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

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

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. At a minimum, when computing percentile ranks, we require a weather station to 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. Stations with fewer than 600 historical observations are excluded from our calculation of percentile ranks.

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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