SOCIETY OF ACTUARIES®

Actuarial Weather Extremes
January 2020

Actuarial Weather Extremes: January 2020

Unseasonable Warmth Across Much of the Northern Hemisphere

Overview

This report is the tenth 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.

Relative to historic norms, January 2020 was unseasonably warm across much of the United States, Canada, Greenland, Northern Europe and Russia (Figure 1). As a result of unusually high temperatures throughout much of the northern hemisphere, the global average temperature for the month of January was a record high (Figure 2):

Figure 1

Temperature Anomalies for January 2020, Calculated from NOAA's CPC Global Temperature Database

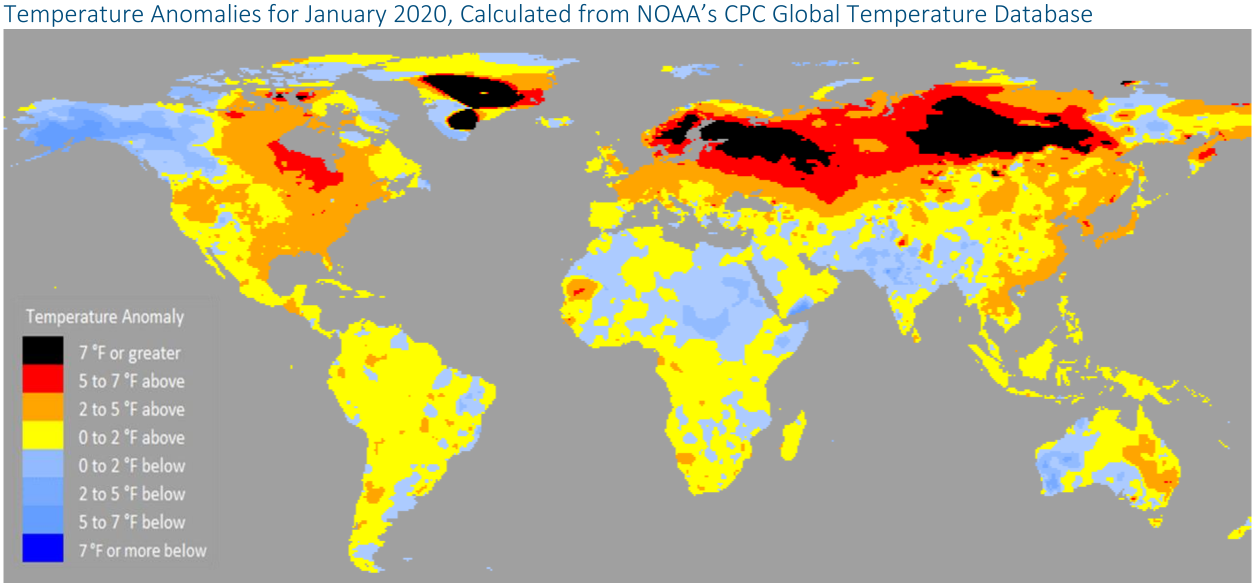
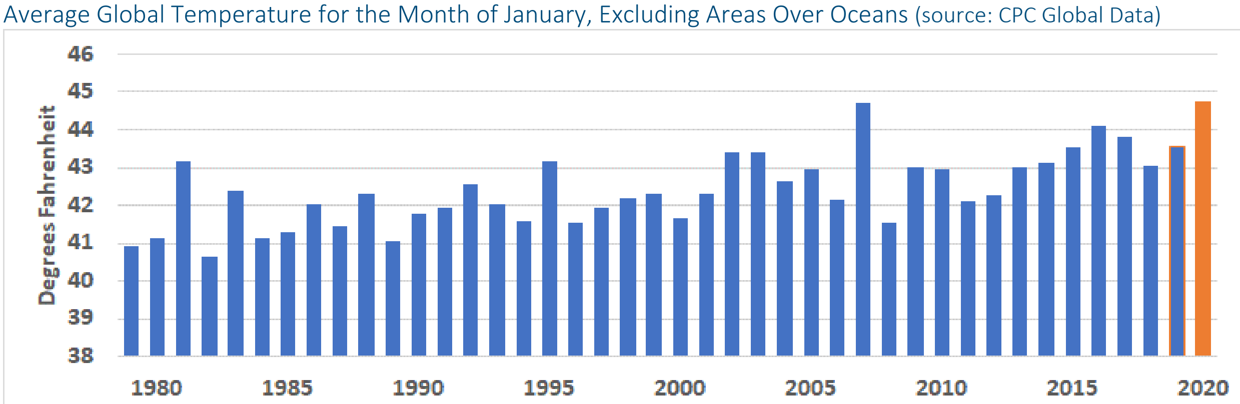


Figure 2

Average Global Temperature for the Month of January, Excluding Areas Over Oceans (source: CPC Global Data)



Using data from the National Oceanic and Atmospheric Administration's (NOAA) CPC Global Temperature database[1], Figure 1 depicts temperature anomalies for January 2020. Separately for each latitude and longitude pair, anomalies

[1] https://www.esrl.noaa.gov/psd/data/gridded/data.cpc.globaltemp.html

were computed by comparing the mean temperature[2] in January 2020 against the mean January temperature computed from 1979 to 2010. A positive anomaly indicates an above-average temperature, while a negative anomaly indicates a below-average temperature.

Figure 2 reveals that the global average temperature in January 2020 reached a record high as measured against CPC data for each January back to 1979. At 44.8 Fahrenheit, the January 2020 global average temperature edged out the previous record of 44.7 Fahrenheit which occurred in 2007. Note that CPC Global Temperature Data provides measurements across the earth's land area, and excludes areas covered by ocean. Correspondingly, the results presented in Figures 1 and 2 exclude areas covered by ocean.

A Closer Look at Temperature Data for January 2020

To provide a better sense of the size of the January temperature anomalies relative to historical data, Figure 3 presents them in standardized form:

Standardized Anomaly = (2020 Jan Average Temp – Historical Average) / Historical Standard Deviation

As in Figure 1, the historical period[3] used to compute the average (and standard deviation) is defined as 1979 to 2010, focusing solely on data for the month of January.

Assuming that temperature follows a normal distribution – which is sometimes referred to as a "bell curve" -- a standardized anomaly can be interpreted as a "standard normal variable". Such a variable has the following probability distribution, which has been color-coded to match Figure 4:

Figure 3
Probability Distribution for a Standard Normal Variable, Color-Coded to Match Figure 4

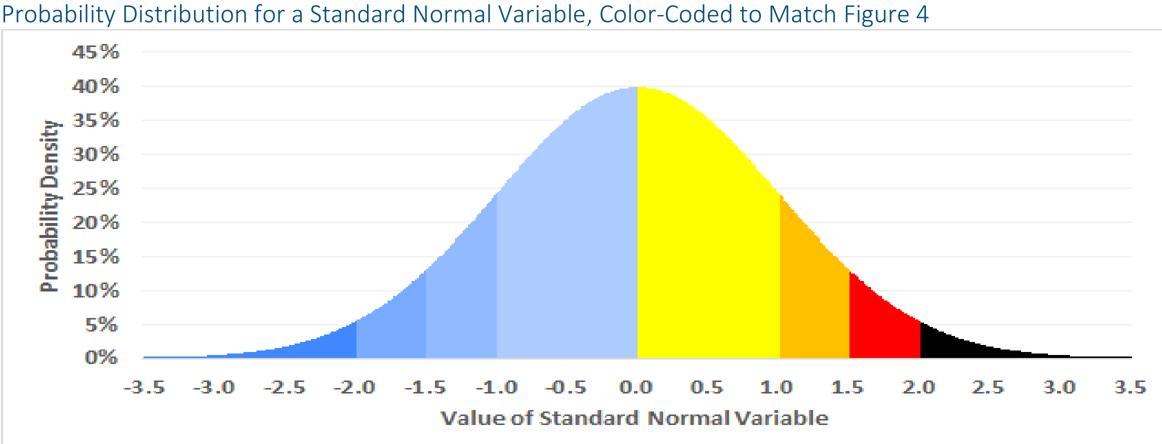


Table 1
Probability Distribution of a Standard Normal Variable

Variable Range	Probability
Greater than 0.00	50.0%
Greater than 1.00	15.9%
Greater than 1.50	6.7%
Greater than 2.00	2.3%
Between 0.00 and 1.00	34.1%
Between 1.00 and 1.50	9.2%
Between 1.50 and 2.00	4.4%

These probabilities focus on the upper half of the distribution which consists of positive values. But because the normal distribution is symmetric, the probabilities are also applicable to the lower half of the distribution. For example, the probability of a value less then negative 2.0 is precisely equal to the probability of a value greater than 2.0. In other words, the distribution is symmetric around its central value of zero.

[2] For each latitude and longitude, the CPC data provides both daily high temperature and daily low temperature. For this analysis, the high and low values were averaged together.

[3] Climate scientists often use periods in the neighborhood of 30 years in length as "reference periods" against which to compare recent observations. The same approach is used in this analysis, with a 32-year reference period -- running from 1979 to 2010 -- used to compute the historic average and standard deviation.

Figure 4

Standardized Temperature Anomalies for January 2020, Calculated from NOAA's CPC Global Temperature Database

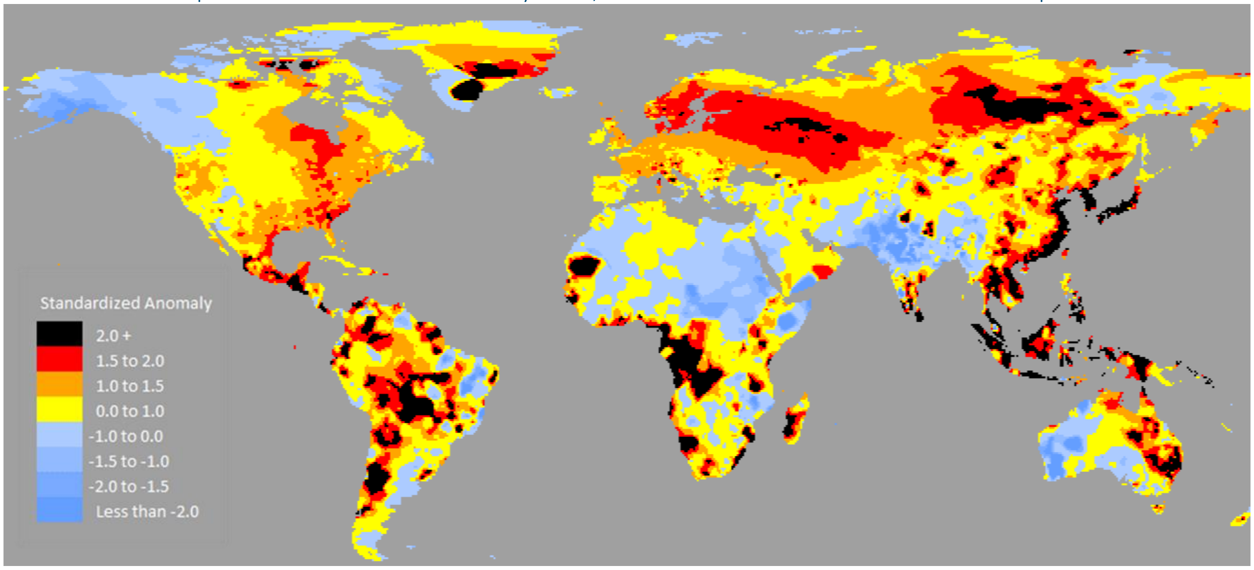
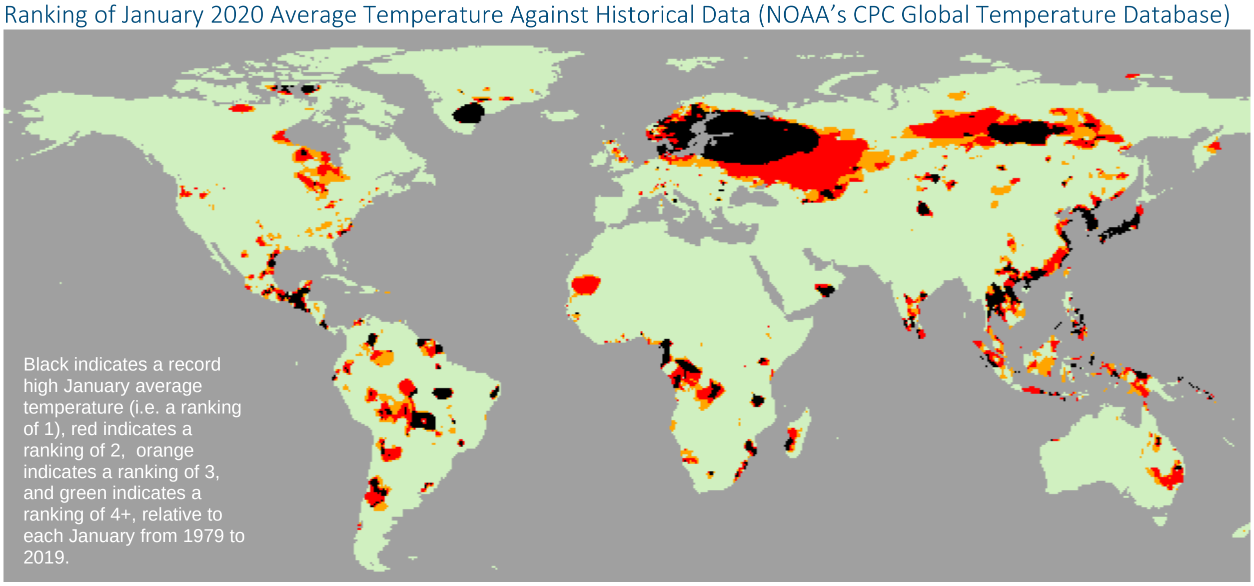


Figure 4 reveals that most of the earth's land surface experienced positive temperature anomalies during January of 2020. Much of the eastern half of North America experienced an anomaly at least one standard deviation above the historic average, and a significant portion of Europe and Russia experienced anomalies in excess of 1.5 standard deviations. South America, Africa and Australia show a mixed temperature pattern, with high positive anomalies in some areas and negative anomalies in other areas. A relatively small portion of earth's total land area is coded black, indicating anomalies in excess of 2.0, but keep in mind that, in a normal distribution, the probability of a value in excess of 2.0 is merely 2.3% (Table 1).

A slightly different picture emerges if, instead of normalizing the anomalies, we simply rank the January 2020 data against history. In Figure 5, black represents a record high January average temperature, red represents a ranking of two, and orange represents a ranking of three, relative to each January from 1979 to 2019.

Figure 5

Ranking of January 2020 Average Temperature Against Historical Data (NOAA's CPC Global Temperature Database)



As indicated in Figure 5, a large portion of Scandinavia and Western Russia experienced record highs in January 2020, along with locations in central Russia, Japan, the Korean Peninsula, and Thailand.

To summarize, January 2020 was characterized by record high temperatures in some locations, as well as an expansive geographic pattern of above-average temperatures spanning most of the earth's land surface. In aggregate, across the entire land surface of the earth, this was the hottest January on record relative to CPC temperature data for 1979 through 2019.

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:

January 2020: Unseasonable Warmth Across Much of the Northern Hemisphere

One of the primary economic effects of the warm weather has been a reduction in the sales and consumption of fuel used for heating. According to an article in "Bloomberg Green", the loss in global oil demand due to warm weather is in the neighborhood of 800,000 barrels a day, which is, according to the article[4], roughly equivalent to the daily oil consumption across Turkey (the country). Ski resorts in France[5] and Japan[6] have had a difficult year due to a lack of snow. In a positive note, the warm weather may have boosted employment growth in the U.S.[7]

September – December 2019: Wildfires in Australia

On January 6, "Business Insider" reported[8] the following damage estimates related to recent and ongoing bushfires: 1600 destroyed homes, 5000 insurance claims totally $375 million, and 1% of GDP growth is estimated to be wiped-out. The article suggests that, after the damages are fully tallied, the cost will run into the billions of dollars. On January 7, "Time" reported that the fires have claimed the lives of at least 24 people[9]. On January 7, the Wall Street Journal reported[10] that, in New South Wales, over 600 head of livestock were killed. Researchers at the University of Sydney estimate that nearly half a billion mammals, birds and reptiles have been killed[11].

November: Flooding in Venice, Italy

According to a Wall Street Journal[12] published on November 25, the mayor of Venice has estimated the damage from the floods to be about $1.1 billion. However, the estimated "cost could rise, as further damage emerge".

November: A Series of Winter Storms Across the Northern U.S.

The most widely reported impacts of the winter storms were school closings, road closings, power outages and flight cancellations. Property damage appears to have been minimal, although it is too soon to offer a reliable cost estimate.

October: Typhoon Hagibis

According to AIR Worldwide, Typhoon Hagibis may generate between $8 billion and $16 billion in insured losses[13], with more with than half of the losses due to inland flooding. According to "The Mainichi", a Japanese newspaper, at least 83 people died[14] as a result of Typhoon Hagibis.

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[4] https://www.bloomberg.com/news/articles/2020-02-09/energy-markets-need-winter-and-climate-change-is-taking-it-away

[5] https://www.independent.co.uk/news/world/europe/france-ski-resort-closed-snow-mourtis-pyrenees-weather-winter-a9331926.html

[6] https://www.scmp.com/news/asia/east-asia/article/3046892/worst-winter-decades-japans-ski-resorts

[7] https://www.reuters.com/article/us-usa-economy/mild-weather-boosts-us-job-growth-jobless-rate-ticks-up-idUSKBN2010G3

[8] https://www.businessinsider.com.au/australian-bushfires-cost-economy-surplus-government-spending-2020-1

[9] https://time.com/5758186/australia-bushfire-size/

[10] https://www.wsj.com/articles/australia-fires-put-farmers-in-double-jeopardy-11578388736?mod=hp_lista_pos1

[11] https://sydney.edu.au/news-opinion/news/2020/01/03/a-statement-about-the-480-million-animals-killed-in-nsw-bushfire.html

[12] https://www.wsj.com/articles/in-venice-a-struggle-to-rescue-damaged-art-and-architecture-11574703868

[13] 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/

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

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[15] 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[16].

September: Tropical Storm Imelda

According to the USA Today, the storm has been linked to five deaths[17], 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[18], 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[19].

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[20]. An article in Business Today[21] 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[22].

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[23].

August: Heat Wave in Alaska

During August, large numbers of dead salmon were found in several Alaskan rivers[24]. 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[25].

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

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

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

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

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

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

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

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

23 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

24 https://time.com/5661024/alaska-high-temperatures-salmon-deaths/

25 https://observers.france24.com/en/20190821-salmon-die-alaska

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[26]; (2) in the United Kingdom, railway service was disrupted because the unusually high temperatures caused train tracks to expand or kink[27]; (3) in the United Kingdom, thousands of chickens died in a farmhouse that lacked a cooling system[28]; and (4) on a farm in the Netherlands, over 2000 pigs suffocated[29] 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.

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 data presented in this report was obtained from the CPC Global Daily Temperature database, which is accessible online via this URL:

https://www.esrl.noaa.gov/psd/data/gridded/data.cpc.globaltemp.html

This database is maintained by the National Oceanic and Atmospheric Administration (NOAA). The data is "gridded" at 0.5 degrees, meaning that it provides data every 0.5 degrees of latitude and longitude. While the data is global, it provides measurements solely for land areas, and excludes areas over oceans.

The data is divided into two parallel components: (1) daily minimum temperature ("tmin") and (2) daily maximum temperature ("tmax"). The analysis in this paper averages tmin and tmax together, thereby creating estimates of the average daily temperature. These daily estimates were averaged across the month of January, separately for each year from 1979 to 2020. The resulting averages for the month of January are the subject of this report.

For Figure 2, the global average temperature was computed as a weighted average across the entire dataset, with the weight of each grid point proportional to the cosine of its latitude. While the data is uniformly gridded with spacing of 0.5 degrees, the length (in miles) of one degree declines as one moves from the equator to the poles. Because grid points are more tightly packed together near the poles than along the equator, an unweighted average would result in the overweighting of areas near the poles. Therefore, to achieve uniform spatial weighting for the calculation of the global average temperature in Figure 2, the weight of each grid point was set in proportion to the cosine of its latitude.

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

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

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

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

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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