

Actuarial Weather Extremes

November 2019



Actuarial Weather Extremes: November 2019

Severe Flooding in Venice, and Winter Arrives Early Across the Northern U.S.

Overview

This report is the eighth 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 events that occurred during November 2019:

- In Venice, Italy, a series of near-record high tides in mid-November led to the worst flooding the city has experienced in over 50 years. While the tides themselves are not a weather phenomenon, wind speed and atmospheric pressure are contributing factors to “aqua alta”, the Italian term used to describe an unusually high tide occurring in Venice and the northern Adriatic Sea.
- Across the northern half of the United States (U.S.), a series of winter storms resulted in monthly snow accumulations significantly above historical averages.

The Worst Flooding in Half a Century in Venice, Italy

Flooding is a common occurrence in Venice, a consequence of tidal fluctuations and the city’s low elevation relative to the surrounding Adriatic Sea. More than 25 times a year, on average, a small portion of the city is flooded due to an “aqua alta”, which is defined as a high tide that is more than 90 centimeters above normal¹.

It is uncommon, however, for a large portion of the city to be flooded. A key threshold is 140 centimeters above normal, at which point a high tide will cause more than half of central Venice to be submerged. Historically, such exceptionally high tides have occurred roughly once every three years, the result of a combination of factors such as strong winds blowing from south to north (pushing sea water towards Venice), low atmospheric pressure, and a full or new moon which amplifies tidal fluctuations.

Against this historical data, November 2019 stands out as an outlier, with high tides exceeding the 140-centimeter threshold on November 12, 13, 15 and 17. Thus, the 140-centimeter threshold was breached four times in a single month, compared to a historical average rate of just once every three years.

Table 1

The Twenty Highest Aqua Alta Events on Record for Venice, Italy

Date (YYYY-MM-DD)	High Tide: Centimeters Above Normal	Date (YYYY-MM-DD)	High Tide: Centimeters Above Normal
1966-11-04	194	1936-04-16	147
2019-11-12	187	2002-11-16	147
1979-12-22	166	1960-10-15	145
1986-02-01	158	2009-12-25	145
2008-12-01	156	1968-11-03	144
2018-10-29	156	2000-11-06	144
2019-11-15	154	2009-12-23	144
1951-11-12	151	2010-12-24	144
2019-11-17	150	2019-11-13	144
2012-11-11	149	2013-02-12	143

This data was obtained from Venice’s “Forecasting and Reporting Center for Tides”. The high tides shown in red font are those that occurred in November 2019.

¹ The Tidal Forecasting and Reporting Center of Venice defines “normal” sea level using a tidal gauge near the church of Santa Maria della Salute. The gauge was first established in 1897, at which time a “normal” benchmark – equal to the mean sea level measured across 1897 -- was established. It is relative to the 1897 benchmark that today’s tides are measured.

Table 2
Unusually High Tides in Venice, Italy: Frequency and Impact on Flooding

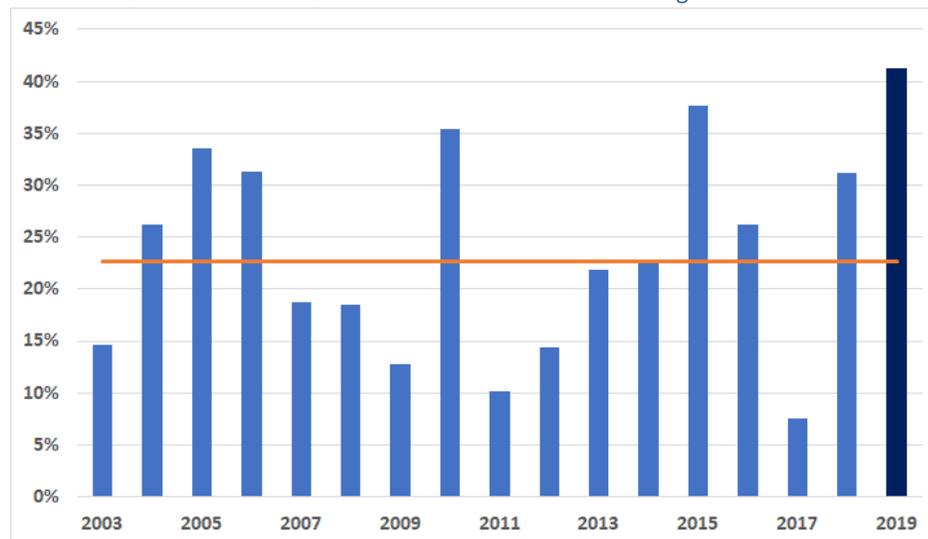
High Tide: Centimeters Above Normal	Frequency (events per year)	% of Central Venice Flooded
90	26.70	2%
100	11.70	5%
110	4.50	12%
120	1.80	28%
130	0.71	46%
140	0.32	59%
150	0.09	70%
160	0.04	77%
170	0.02	82%
180	0.02	85%
190	0.02	88%

This data was obtained from Venice's "Forecasting and Reporting Center for Tides". The frequencies are rounded to two decimal places and reflect data for the period from 1966 to 2015.

A Series of Winter Storms Cover Over 40% of the Contiguous U.S. in Snow

As of November 30, about 41% of the contiguous U.S.² was under a blanket of snow stretching from Washington State to Maine, including most of the Midwest. The 41% coverage rate is a record high for this time of year, according to a National Weather Service snow coverage database that runs from 2003 to the present³. The average snow coverage rate for November 30 is only 22.6%, so the 2019 rate is nearly twice the average, the result of unseasonably cold temperatures and a series of winter storms, including a bomb cyclone⁴ that hit the West Coast just prior to Thanksgiving, and then traveled east across the Northern Plains.

Figure 1
Percent of Land Area of the Lower 48 States with Snow Coverage as of November 30



This data was obtained from the "National Snowfall Analysis" (see footnote 3) which is produced by the National Operational Hydrological Remote Sensing Center, which, in turn, is under the aegis of the National Weather Service.

Based on 2003 to 2018 data, the average snow coverage rate for November 30 is 22.6%, as represented by the horizontal red line.

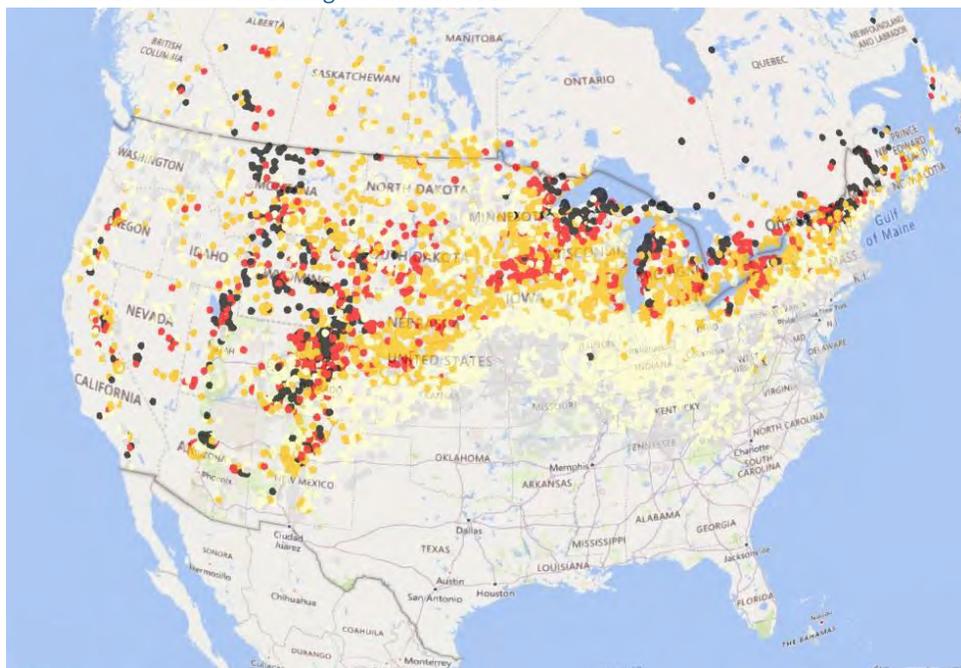
The November 30, 2019 coverage rate is 41.2%, which is 1.83 standard deviations above the historic average.

² The "contiguous U.S." is also known as the "Lower 48", an area that consists of all of the U.S. states except for Alaska and Hawaii.

³ <https://www.noahrc.noaa.gov/nsa/index.html?year=2019&month=11&day=30&units=e®ion=National>

⁴ A bomb cyclone is a powerful, rapidly developing storm that brings with it an abrupt drop in barometric pressure, high winds, and heavy precipitation.

Figure 2
Total Inches of Snowfall During November 2019

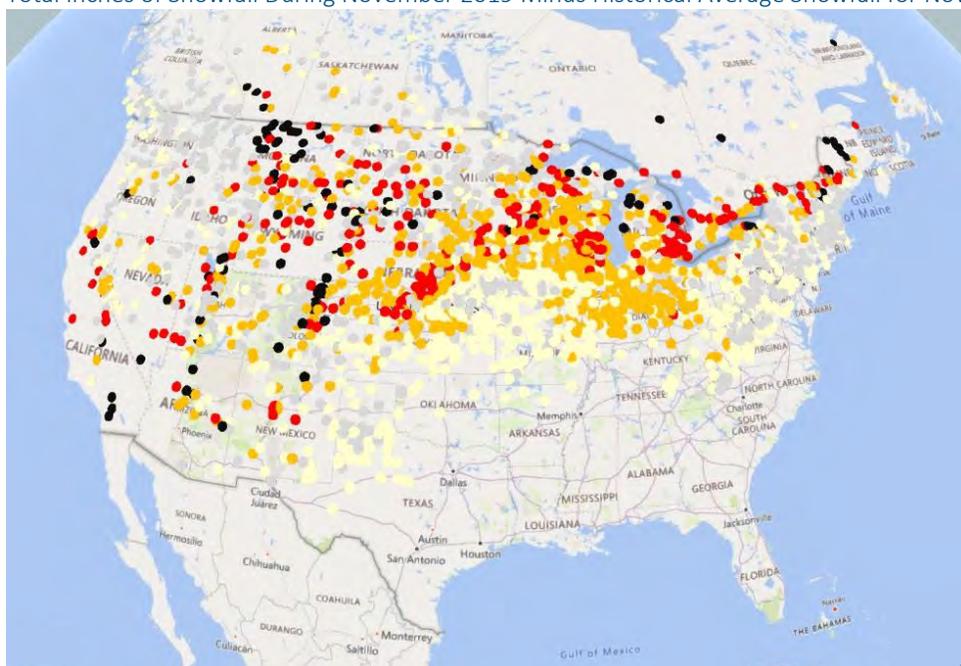


This station-level snowfall data was obtained from NOAA's GHCN⁵ daily database.

Color codes for total snowfall across November 2019:

- Black = 15+ inches
- Red = 10 to 15 inches
- Orange = 5 to 10 in.
- Light Yellow = 1 to 5 in.
- Grey = up to 1 inch

Figure 3
Total Inches of Snowfall During November 2019 Minus Historical Average Snowfall for November



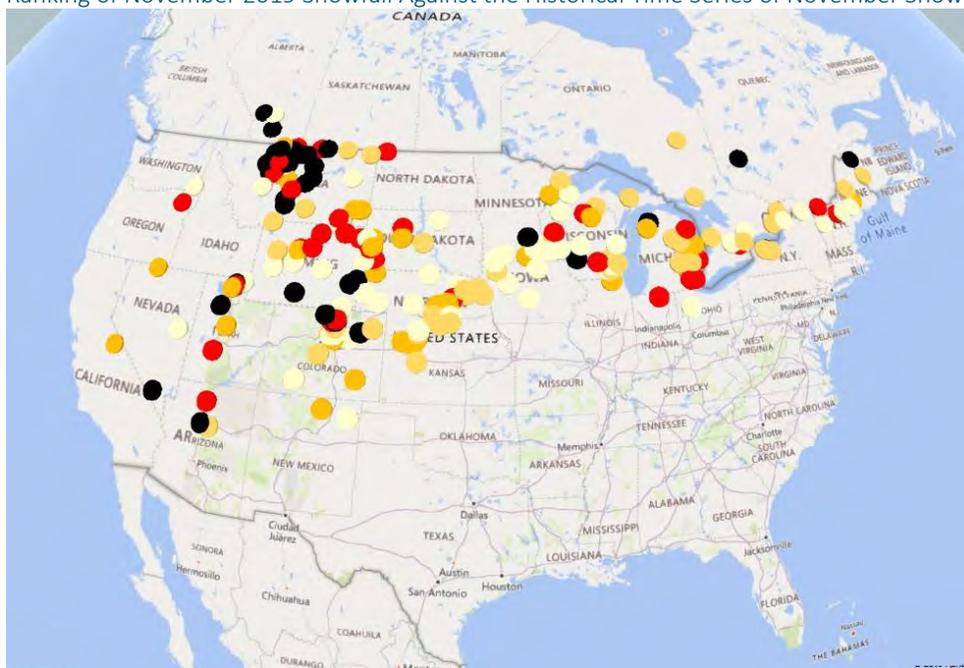
This station-level data was obtained from NOAA's GHCN daily database. Only stations with at least 25 years of historical snowfall data are plotted on this map.

Color codes for total snowfall across November 2019 minus the historical average snowfall for November:

- Black = 10+ inches
- Red = 5 to 10 inches
- Orange = 1 to 5 in.
- Light Yellow = -1 to 1 inch
- Grey = 1 or more inches less than normal

⁵ The Global Historical Climatology Network ("GHCN") weather database 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.

Figure 4
 Ranking of November 2019 Snowfall Against the Historical Time Series of November Snowfalls

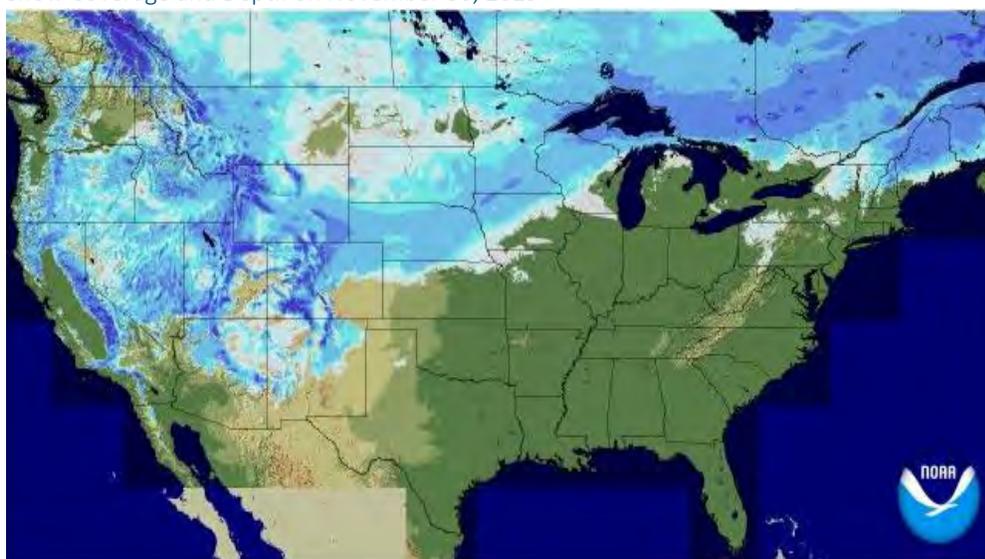


This station-level data was obtained from NOAA's GHCN daily database. Only stations with at least 25 years of historical snowfall data are shown on this map. A ranking of "1" means that the snowfall for November 2019 was greater than any prior November snowfall on record.

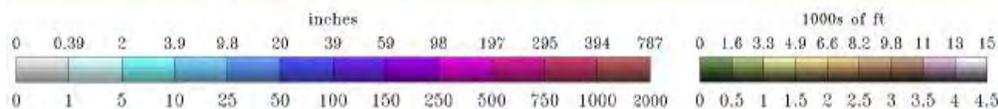
Color codes for ranking:

- Black = 1
- Red = 2
- Orange = 3
- Light Orange = 4
- Light Yellow = 5

Figure 5
 Snow Coverage and Depth on November 30, 2019



This image was downloaded from the "National Snowfall Analysis"⁶ which is produced by the National Operational Hydrological Remote Sensing Center, which, in turn, is under the aegis of the National Weather Service.



⁶ <https://www.nohrsc.noaa.gov/nsa/index.html?year=2019&month=11&day=30&units=e®ion=National>

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:

November: Flooding in Venice, Italy

According to a Wall Street Journal⁷ 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 losses⁸, with more than half of the losses due to inland flooding. According to “The Mainichi”, a Japanese newspaper, at least 83 people died⁹ 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 damage¹⁰ 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 billion¹¹.

September: Tropical Storm Imelda

According to the USA Today, the storm has been linked to five deaths¹², 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 Journal¹³, 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 fall¹⁴.

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 deaths¹⁵. An article in Business Today¹⁶ on

⁷ <https://www.wsj.com/articles/in-venice-a-struggle-to-rescue-damaged-art-and-architecture-11574703868>

⁸ <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/>

⁹ <https://mainichi.jp/english/articles/20191022/p2g/00m/0dm/005000c>

¹⁰ <https://www.freightwaves.com/news/mother-nature-turns-midwestern-spuds-to-duds>

¹¹ <https://www.wsj.com/articles/opening-the-door-to-hell-itself-bahamas-confronts-life-after-hurricane-dorian-11569176306>

¹² <https://www.usatoday.com/story/news/nation/2019/09/21/texas-flooding-tropical-storm-imelda-death-toll-increases-5/2402290001/>

¹³ <https://www.wsj.com/articles/flash-drought-hits-south-as-record-heat-continues-into-fall-11570058348>

¹⁴ <https://www.baltimoresun.com/weather/bs-md-drought-report-20190926-yooqxwbbuvclidise7a4oisugtm-story.html>

¹⁵ <https://www.reuters.com/article/us-southasia-floods/india-floods-kill-more-than-270-displace-one-million-idUSKCN1V413K>

¹⁶ <https://www.businesstoday.in/current/economy-politics/karnataka-floods-landslides-brew-fresh-troubles-coffee-second-year-straight/story/372972.html>

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 reduced¹⁷.

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 1953¹⁸.

August: Heat Wave in Alaska

During August, large numbers of dead salmon were found in several Alaskan rivers¹⁹. 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 rain²⁰.

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 generation²¹; (2) in the United Kingdom, railway service was disrupted because the unusually high temperatures caused train tracks to expand or kink²²; (3) in the United Kingdom, thousands of chickens died in a farmhouse that lacked a cooling system²³; and (4) on a farm in the Netherlands, over 2000 pigs suffocated²⁴ 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.

¹⁷ <https://economictimes.indiatimes.com/news/economy/agriculture/sugarcane-cotton-apple-crops-hit-by-late-rainfall-pan-india/articleshow/70744401.cms>

¹⁸ 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

¹⁹ <https://time.com/5661024/alaska-high-temperatures-salmon-deaths/>

²⁰ <https://observers.france24.com/en/20190821-salmon-die-alaska>

²¹ <https://www.reuters.com/article/us-france-electricity-heatwave/hot-weather-cuts-french-german-nuclear-power-output-idUSKCN1UK0HR>

²² <https://www.telegraph.co.uk/news/2019/07/25/uk-heatwave-britain-bracing-hottest-day-record-temperature-could/>

²³ <https://www.independent.co.uk/news/uk/home-news/chicken-uk-heatwave-farm-deaths-lincolnshire-tesco-sainsbury-a9025516.html>

²⁴ <https://veganuary.com/blog/over-2000-pigs-suffocate-on-factory-farm-as-ventilation-system-fails/>

Data

The snowfall data used in figures 2, 3 and 4 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](#)

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