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Actuarial Weather Extremes June 2021

July 2021

Actuarial Weather Extremes: June 2021

Extreme Heat in the Western U.S. and Canada, and Extreme Drought in the Western U.S.

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Overview

This report examines weather extremes for daily maximum temperature (TMAX) and severe drought conditions. The heat extremes were most impactful in the Western U.S. and Canada, and the severe drought conditions are a continuation and worsening of the most extreme condition statuses in the Western U.S.

Extreme Heat Conditions in Western U.S. and Canada: As seen in Figures 1-4 and Table 1, an extreme heatwave occurred in late June 2021 that impacted Oregon and Washington in the U.S. and British Columbia in Canada. Early estimates are that at least 100 deaths are attributable to the heatwave [1], which peaked June 28.

Most Severe Drought Conditions Continue to Expand in the Western U.S.: The severe drought conditions in the Western U.S. have expanded and intensified with all categories of Moderate to Exceptional drought increasing in portion over the month of June 2021. As of the July 8, 2021 report of California and Nevada drought conditions, fully 100% of these two states are in moderate to exceptional drought.[2]

Other June 2021 Extreme Weather Notes:

- The Atlantic basin had three named storms in June 2021. Tropical Storms Bill, Claudette and Danny tied a record for three named storms in the month of June. Combined with Tropical Storm Ana in May, four named storms before July 1 ties the record all of which have occurred in the last 10 years (2012, 2016, 2020, 2021). [3]
- In 2020 there were 30 named storms in the Atlantic basin. This included 11 hurricanes, of which 7 were major hurricanes. [4] For 2021, the National Oceanic and Atmospheric Administration (NOAA) predicts there will be 13-20 named storms in the Atlantic basin, including 6-10 hurricanes, of which 3-5 will be major hurricanes. [5]

[1] The Wall Street Journal. Deadly Heatwave in Pacific Northwest Overwhelmed Healthcare System. July 5, 2021 https://www.wsj.com/articles/deadly-heat-wave-in-pacific-northwest-overwhelmed-healthcare-system-11625493601
[2] Drought Update for California-Nevada. Drought.gov July 8, 2021. Drought Status Update for California-Nevada | Drought.gov
[3] National Centers for Environmental Information – Tropical Cyclones June 2021. Tropical Cyclones - June 2021 | National Centers for Environmental Information (NCEI) (noaa.gov)
[4] NOAA. Updated June 10, 2021. Record-breaking Atlantic hurricane season draws to an end | National Oceanic and Atmospheric Administration (noaa.gov)
[5] NOAA. May 20, 2021. NOAA predicts another active Atlantic hurricane season | National Oceanic and Atmospheric Administration

Heatwave in the Pacific Northwest

A heat wave enveloped the Pacific Northwest in the final week of June, leading to record-high temperatures across much of British Columbia, Oregon, and Washington, and near-record high temperatures in Alberta, Idaho, Montana, California and Nevada. For most locations in the Pacific Northwest, the highest temperatures occurred across the three-day period from June 26 to June 28, with the peak occurring on June 28, and cooler temperatures arriving on June 29. Early estimates suggest that at least one hundred deaths are attributable to the high heat[6].

Using weather station data from the Global Historical Climatology Network[7] (GHCN), Figures 1 through 4 depict the size and the intensity of the heat wave. Each dot in these figures represents daily data from an individual weather station. Figure 1 uses data from all weather stations, while Figures 2 through 4 focus on the subset of stations that have more than 50 years of temperature data. Because most stations don't meet this 50-year threshold, the data from only 995 stations was used to construct Figures 2 through 4, while over 5000 stations were included in the dataset for Figure 1.

For Figures 2 through 4, each station's historical data served as a temperature distribution against which to assess the severity of the June 2021 heat wave. For each day in the heat wave, the observed high temperature was compared against the station's historical temperature distribution. To account for seasonal temperature fluctuations, historical data was restricted to a 7-day radius around each calendar day. For example, to evaluate the temperature observed on June 28, 2021, the historical distribution was constructed using data from June 21 through July 5, drawn from each past year in the station's data records. Thus, a station with 50 years of historical data would have a historical distribution composed of 750 temperature observations (750 = 50 years * 15 days per year).

Figure 1

High Temperatures Exceeding Thresholds of 100 and105 Degrees Fahrenheit on June 28, 2021 (source: GHCN data)

100F or Greater

105F or Greater

[6] https://www.wsj.com/articles/deadly-heat-wave-in-pacific-northwest-overwhelmed-healthcare-system-11625493601

[7] https://www.ncdc.noaa.gov/data-access/land-based-station-data/land-based-datasets/global-historical-climatology-network-ghcn

Figure 2

Percentile Ranking of High Temperature on June 28, 2021 Against Historical Data (source: GHCN)

95th Percentile or Greater

Record-High Temperature (i.e. 100th percentile)

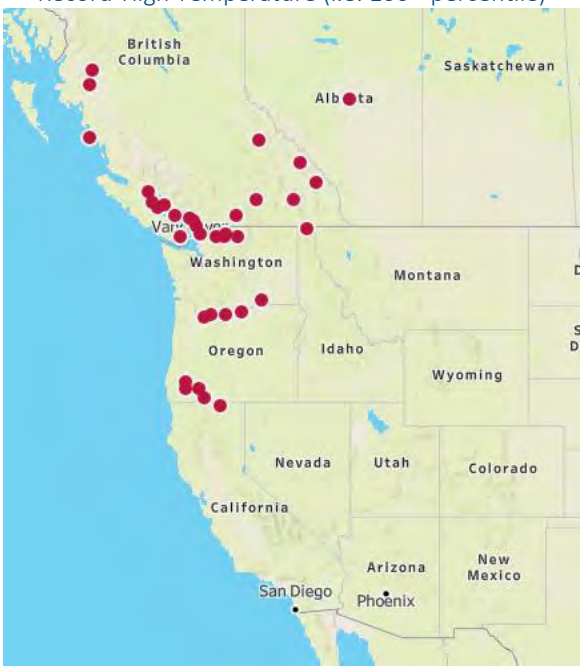


Figure 3

High Temperature on June 28, 2021, Expressed as Standard Deviations Above the Historic Average (source: GHCN)

Greater than 2.0 Standard Deviations Above Avg

Greater than 3.0 Standard Deviations Above Avg

Figure 4

GHCN Station "Shawnigan Lake":
High Temperature on June 28, 2021 Ranked Against Historical Data from 1920 to 2020

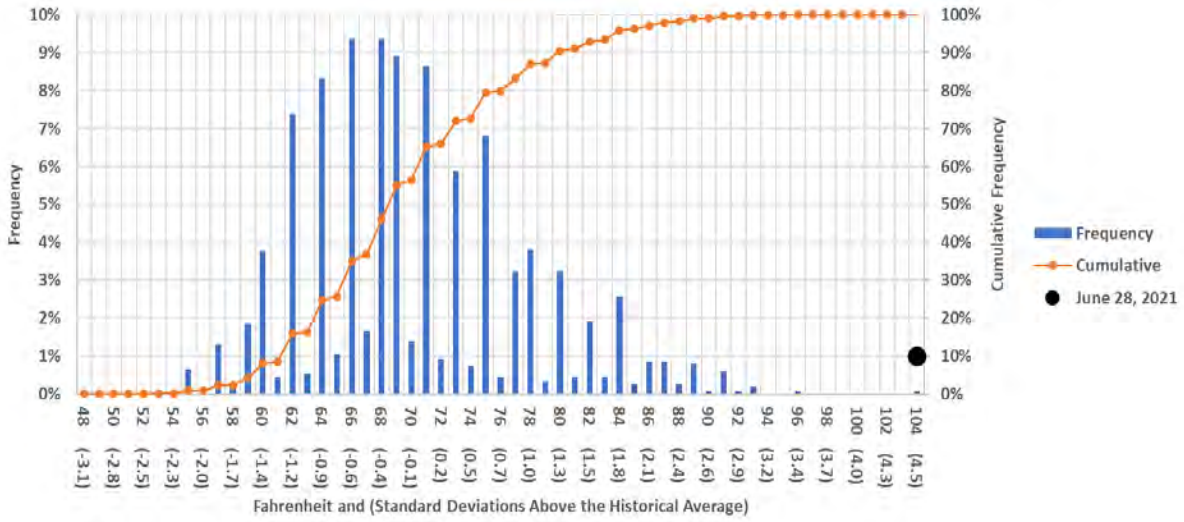


Figure 4 focuses on one station that is illustrative of the severity of the heat wave. This station is located at Shawnigan Lake, which is on Vancouver Island in British Columbia, and is assigned station ID "CA001017230" in the GHCN database. This station has over 100 years of temperature data. The histogram in Figure 4 shows the distribution of the station's daily high temperatures across the period 1920 through 2020, focusing on the period from June 21 through July 5. Over 1500 daily observations are captured in the histogram. The histogram exhibits some "clumping" of observations which, most likely, is due to rounding and precision issues which affect some GHCN stations[8]. However, the clumping doesn't interfere in our ability to conclude that the temperature of 104F recorded on June 28, 2021 was an extreme anomaly. This record-setting temperature is more than 4 standard deviations above the historic average temperature of 70.6F, and more than 8F above the station's previous temperature record of 96F.

Accompanying this report is an Excel file ("June 2021 Heat Wave Graphing Tool.xlsm") that facilitates the construction of graphs such as Figure 4, for any user-specified station and calendar day.

Lastly, Table 1 shows the top 25 temperature records on June 28, 2021, ranked by standard deviations above each station's historical average. Identical to the approach used for constructing Figures 2 through 4, only stations with 50+ years of data history were considered when compiling this table.

Note that for most GHCN weather stations, historical temperatures do not appear to be normally distributed[9]. Therefore, be cautious when interpreting the standard-deviation-above-historic-average statistic. While the statistic is useful for evaluating the severity of a temperature anomaly, it cannot be precisely translated into a probability-of-occurrence (as is possible when analyzing an observation from a normal distribution).

In addition to the heat wave figures presented in this report, two Tableau workbooks[10] are available online, providing a variety of approaches for viewing the temperature data.

[8] For a discussion of the issue of GCHN temperature units, precision and rounding, please refer to "Decoding the Precision of Historical Temperature Observations": https://rmets.onlinelibrary.wiley.com/doi/abs/10.1002/qj.2612.

[9] https://en.wikipedia.org/wiki/Normal_distribution

[10] Two Tableau visualizations of the heat wave data:
(1) https://tableau.soa.org/t/soa-public/views/TMAX_June_20_to_July_9/1_Map
(2) https://tableau.soa.org/t/soa-public/views/TMAX_Rankings/1_Temperature

Table 1

Top 25 Temperature Records on June 28, 2021, Ranked by Standard Deviations Above Historic Average

State or Province	Name of Weather Station	Latitude (North)	Longitude (East)	Daily High Temperature (F) On June 28, 2021	Historical Average High Temperature (F)	Standard Deviations Above Average
BC	MCINNES ISLAND	52.2	-128.7	80.6	60.0	6.1
BC	WHITE ROCK CAMPBELL	49.0	-122.7	101.3	68.8	5.7
BC	CHATHAM POINT	50.3	-125.4	95.0	65.3	4.9
BC	MERRY ISLAND	49.4	-123.9	92.3	67.8	4.8
WA	BELLINGHAM INTL AP	48.7	-122.5	99.0	68.5	4.7
BC	SHAWNIGAN LAKE	48.6	-123.6	104.9	70.6	4.7
BC	COMOX A	49.7	-124.9	98.2	69.1	4.4
BC	BURNABY SIMON FRASER U	49.2	-122.9	103.1	66.8	4.4
BC	POWELL RIVER A	49.8	-124.5	98.6	68.8	4.3
OR	TROUTDALE	45.5	-122.3	116.1	77.1	4.3
WA	UPPER BAKER DAM	48.6	-121.6	109.9	70.0	4.2
BC	CAMPBELL RIVER A	49.9	-125.2	102.2	69.7	4.1
BC	VANCOUVER HARBOUR CS	49.3	-123.1	92.8	69.5	4.0
WA	THE DALLES MUNI AP	45.6	-121.1	118.0	82.6	3.8
OR	BONNEVILLE DAM	45.6	-121.9	106.0	74.7	3.6
WA	DIABLO DAM	48.7	-121.1	109.9	72.9	3.6
WA	NEWHALEM	48.6	-121.2	109.9	72.8	3.5
OR	RIDDLE	42.9	-123.3	111.0	81.0	3.5
AK	SITKA AIRPORT	57.0	-135.3	75.0	59.1	3.4
BC	PRINCETON A	49.4	-120.5	108.5	75.0	3.4
BC	OKANAGAN CENTRE	50.0	-119.4	104.0	77.4	3.4
BC	TERRACE PCC	54.5	-128.6	96.8	69.0	3.2
OR	COQUILLE CITY	43.1	-124.2	87.1	70.1	3.2
BC	NEW DENVER	50.0	-117.3	105.8	75.2	3.2
WA	ODESSA	47.3	-118.6	109.9	83.3	3.1

Most-Severe Drought Areas Continue to Expand in Western U.S. States

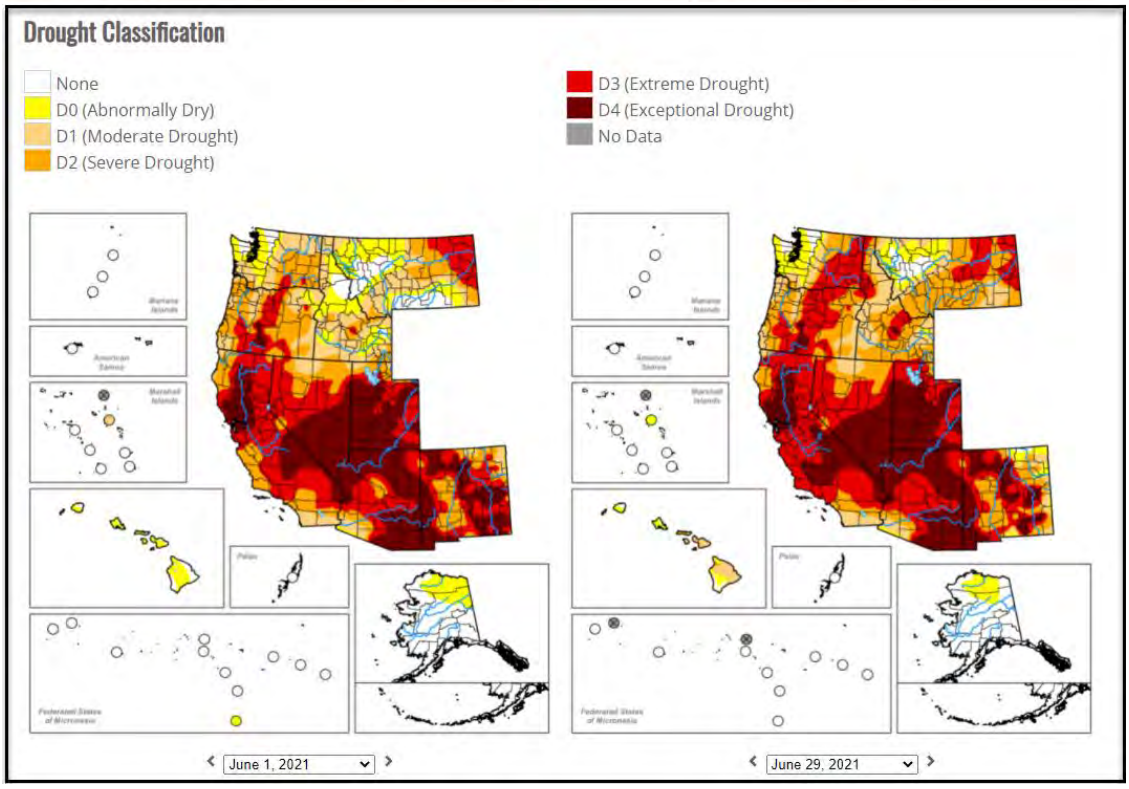
Figure 5 compares early vs late June 2021 drought conditions in the Western U.S. The "Moderate – Exceptional" drought condition areas have increased. Areas of "Abnormally Dry" conditions (yellow) have decreased and areas of "No Drought" have increased; however, this is primarily outside of the Continental U.S. portion of this region. As reported in the July 8 update of California and Nevada conditions, Drought.gov now reports that 100% of California and Nevada are in moderate to exceptional drought. [11]

[11] Drought Update for California-Nevada. Drought.gov July 8, 2021. Drought Status Update for California-Nevada | Drought.gov

Figure 5

COMPARISON OF DROUGHT CONDITIONS IN THE WESTERN U.S. OVER JUNE 2021

Week	None	D0-D4	D1-D4	D2-D4	D3-D4	D4	DSCI
2021-06-01	31.99	68.01	54.61	45.04	33.03	16.38	217
2021-06-29	33.01	66.99	58.52	51.26	37.26	16.60	231
Change	1.02	-1.02	3.91	6.22	4.23	0.22	14



Source: Compare Two Weeks | U.S. Drought Monitor (unl.edu)
Permission | U.S. Drought Monitor (unl.edu)
The U.S. Drought Monitor is jointly produced by the National Drought Mitigation Center at the University of Nebraska-Lincoln, the United States Department of Agriculture, and the National Oceanic and Atmospheric Administration. Map courtesy of NDMC.

Rough Assessment of the Losses Caused by the 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.

Western U.S. and Canada Extreme Heat

Extreme high temperatures across the Pacific Northwest occurred in late June 2021. Early estimates suggest that at least one hundred deaths are attributable to the high heat[12].

Western U.S. Drought

The drought in California and Nevada now covers 100% of the state in moderate to exceptional drought condition. Reservoirs throughout are low. Continued drying increases the risk of wildfires. Record June warm temperatures increase fire potential as well as water temperature impacts on fish. Drought impacts on pasture, water supply and fire potential have expanded and intensified.

Due to the drought conditions, In June 2021, Nevada enacted legislation to permanently ban certain categories of grass. On June 15, the California State Water Resources Control Board issued regulations to stop river diversions and sent notices of water unavailability to over 4,000 rights holders in the Sacramento-San Joaquin Delta watershed.[13]

Feedback

Data

Temperature 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/ghcnd_all.tar.gz
Filename: ghcnd_all.tar.gz

Automated Surface Observing System (ASOS) temperature and precipitation data

The steps below show how to get the hourly temperature and precipitation at the STL Airport, as an example, from the Iowa State University Automated Surface Observing System (ASOS):

Data request web page: https://mesonet.agron.iastate.edu/request/download.phtml

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[12] https://www.wsj.com/articles/deadly-heat-wave-in-pacific-northwest-overwhelmed-healthcare-system-11625493601
[13] Drought Update for California-Nevada. Drought.gov July 8, 2021. Drought Status Update for California-Nevada | Drought.gov

1) Select “Missouri ASOS” as the network and click “Switch to Network”

2) In the list of available stations, select the “[STL] ST. LOUIS” station, and click “Add Selected”

3) In the “Select From Available Data” section, choose the “Air Temperature [F]” and “1 hour Precipitation [inch]” options.

4) Set the date range to 2020-October-1 and 2020-October-31 (or whatever range is desired)

5) Select “Yes” for “Include Latitude + Longitude”

6) Click “Get Data” at the bottom

These steps would give you the results from the URL below.

https://mesonet.agron.iastate.edu/cgi-bin/request/asos.py?station=STL&data=tmpf&data=p01i&year1=2020&month1=10&day1=1&year2=2020&month2=10&day2=31&tz=Etc%2FUTC&format=onlycomma&latlon=yes&elev=no&missing=M&trace=T&direct=no&report_type=1&report_type=2

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