Office of the Washington State Climatologist

July 2021 Report and Outlook

July 8, 2021

http://www.climate.washington.edu/

June Event Summary

Average June temperatures were much above normal statewide, with larger warm anomalies east of the Cascade Mountains. Precipitation was mixed. Eastern WA, the northern Puget Sound, and the northwest Olympic Peninsula had much below normal precipitation. The remainder of western WA, on the other hand, had normal to above normal precipitation, in large part because of one heavy precipitation event mid-month.

A ridge of high pressure over WA brought us our first heat wave of the summer, and the month began on a warm note. Record high daily temperatures were recorded on the 2nd and 3rd in eastern WA (for example, a daily maximum temperature record of 100°F was recorded at Omak on the 3rd), with temperatures in the upper 90s to low 100s for portions of the area. Little did we know at the time that this would pale in comparison to the major heat wave coming at the end of month.

But before we get to that, it is also worth noting the extremely cool day on June 6, which kicked off the only week of the month with measurable precipitation around the state. High temperatures were only in the mid-50s; Figure 1 shows the

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below normal high and low temperatures during that stretch at Spokane International Airport. At SeaTac Airport, there hasn't been a June high temperature that low (55°F) since 2012 (6/5). An

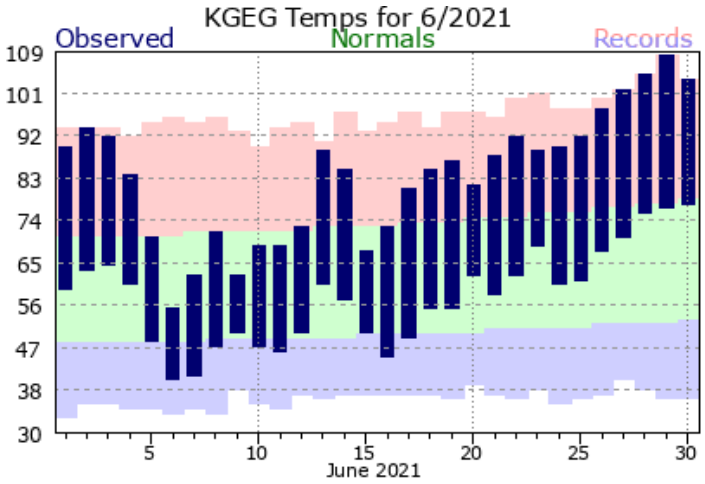


Figure 1: June 2021 maximum and minimum temperatures for Spokane International AP compared to the 1991-2020 normal (green envelope) and records (blue and red). NWS

unusually strong jet stream and low pressure system was responsible for a wet period from the 11th through the 15th. Within that relatively rainy period, daily maximum rainfall records were set at Olympia (0.95") and SeaTac (0.81") on the the 13th.

We now turn our attention to the remarkable, record-breaking heat wave that occurred at the end of the month. Temperatures soared across the state from the 25th through the 30th as an extremely strong ridge of high pressure set up over our region. This ridge is a classic and notable feature of our PNW heat waves, but the strength of the ridge (at least as measured by the upper air sounding at Quillayute) was unprecedented in the record. Figure 3 shows the 500 hPa geopotential height anomalies on June 27 compared to the average anomaly during the historical heat waves defined in Bumbaco et al. 2013. The higher anomalies are situated in virtually the same place as our typical heat waves, but are much larger (300 m vs. 120 m) for the recent event. It is also worth noting that a majority of the heat waves defined in the referenced paper occurred from mid-July to mid-August, making this late-June heat wave unusual in how early in the warm season it occurred.

Record daily maximum and minimum temperatures were broken throughout the event statewide, with triple digits highs and lows in the 70s both west and east of the Cascades. All-time high temperature records were also set at several stations (Table 1) and the warmest temperature ever recorded in WA (118°F at Ice Harbor Dam on 8/5/1961 and at Wahluke on 7/24/1928) may have been broken (pending a committee review). There were also all-time record high ***minimum*** temperature records set during this event; for example, both SeaTac (73°F) and Spokane (78°F)

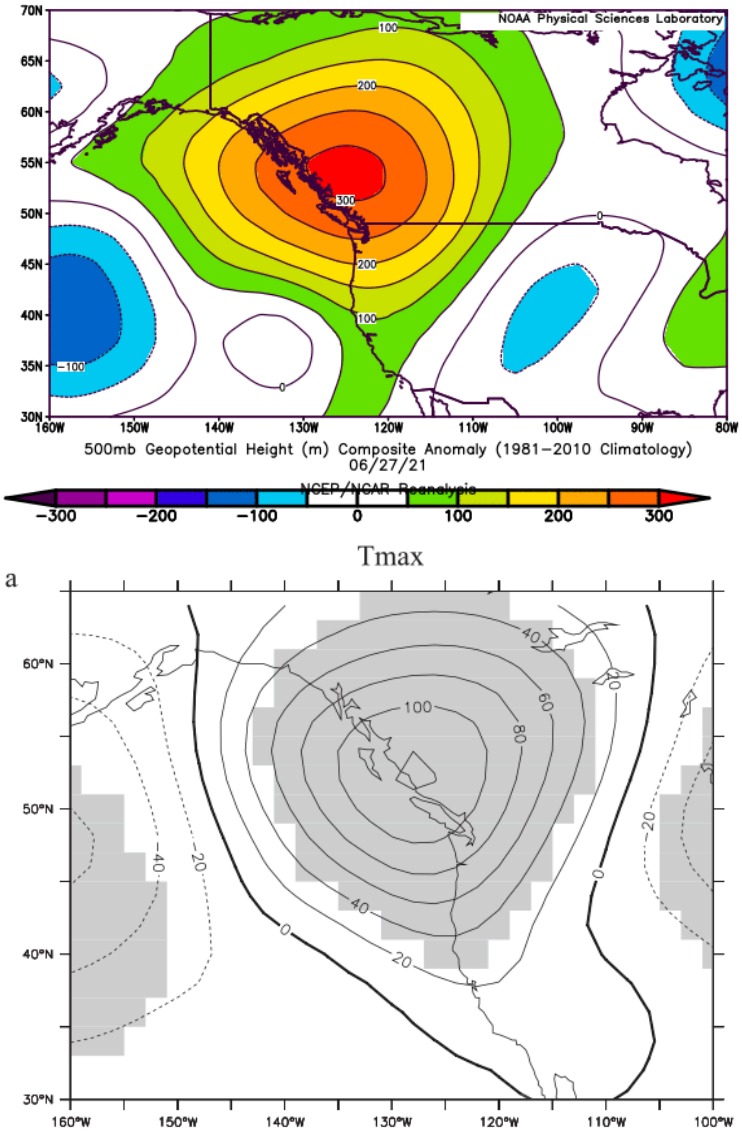


Figure 2: (top) 500 hPa geopotential height anomalies on June 27, 2021 and (bottom) the composite 500 hPa anomalies for all of the daytime heat events in Bumbaco et al. (2013) using the NCEP/NCAR Reanalysis and 20th Century Reanalysis.

set those records on the 27th and 30th, respectively. In recent days, devastating impacts to human health, agriculture, and wildlife are being reported on; more information on the impacts of this event will become clear in the coming weeks and months.

Finally, we close with a few statements regarding the linkage of this recent event to global climate

change caused by increased greenhouse gases. Previous work by OWSC defining a heat wave as 3 consecutive days above the 99th percentile, found that there is actually **not** a statistically significant trend in daytime heat events in western WA and western OR using that measure. As an aside, a significant increasing trend in frequency of nighttime heat events was found for the same region. There are a few caveats here: there's about a decade of more observations that need to be added to the analysis, including the warm summers of 2015 and 2018. OWSC plans to update this research. But even though a signal did not emerge in daytime events using that definition, we do expect to see more extreme heat events like what we just experienced in a changing climate. Furthermore, increased greenhouse gases are very likely to have played some role in the event, though the exact contribution of the human component remains to be seen. There is already some preliminary modeling research that shows that climate change contributed 3 to 4°F to the warmest daytime temperatures associated with this event. It is likely to motivate many more studies. Stay tuned as this unprecedented event will be studied from multiple angles in the next few years.

Station	All-time high temperature record (°F)	Date	Previous Record; Year
Omak	117	6/28	114; 1928
Walla Walla AP	116	6/29	114; 1975 & 1961
Pasco Tri Cities AP	115	6/27	112; 2006
Odessa	115	6/28	112; 1961
Prosser	114	6/30	111; 2002
Yakima AP	113	6/29	110; 1971
Wenatchee	113	6/28	110; 1941
Mazama	112	6/28	103; 2020
Chelan	111	6/28	110; 2015
Olympia AP	110	6/28	104; 2009
Quillayute	110	6/28	99; 1981
Republic	109	6/28	108; 1924
Spokane AP	109	6/29	108; 1961 & 1928
Plain	109	6/28	104; 1939
SeaTac AP	108	6/28	103; 2009
Davenport	107	6/28	105; 1928
Hoquiam	103	6/27	95; 2016
Bellingham AP	99	6/28	96; 2009

Table 1: All-time high temperatures records set during the 2021 heat wave at selected WA stations.

Reference

Bumbaco, K.A., K.D. Dello, and N.A. Bond, 2013: History of Pacific Northwest Heat Waves: Synoptic Pattern and Trends. JAMC, 52, 1618-1631.

Snowpack and Drought Summary

At this point in the year, the seasonal snowpack in the mountains is typically melted out. The heat wave at the end of June caused quick melting of the snowpack that remained in the mountains. Some sites, such as Alpine Meadows (3,500'), had above normal snow water equivalent (SWE) in May and June, but ended up melting out at the typical time of year, specifically losing about 16" of SWE during the last week of June alone. Average June streamflow (Figure 3) was normal to above normal for most of the state, though there were some below normal (10-24th percentile) and much below normal (less than 10th percentile) streamflows in the southern Puget Sound and parts of eastern WA. We will continue to watch streamflow closely as snowmelt will no longer be a factor in the coming summer months.

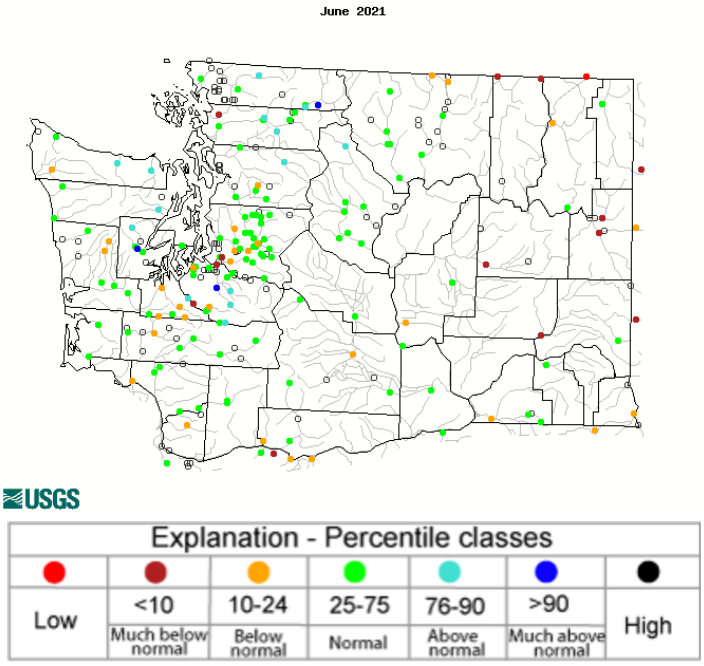


Figure 3: June average streamflow for WA (from USGS).

The extremely dry conditions in eastern WA in June worsened the depiction of drought on the U.S. Drought Monitor (Figure 4). Currently, extreme drought ("D3") extends through a majority of eastern WA and the area of severe drought ("D2") has been expanded since our last newsletter. WA State issued a "Drought Advisory" on May 24 for a majority of the state. More information can be found here.

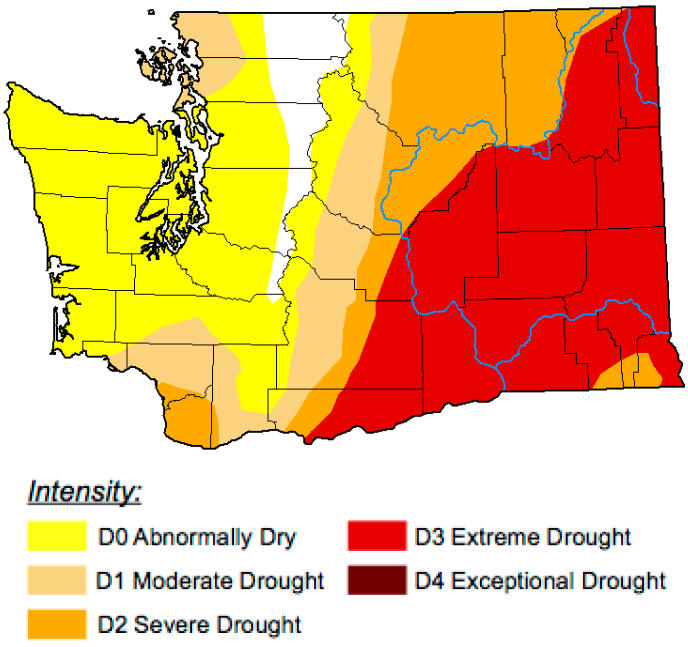


Figure 4: The July 8, 2021 edition of the U.S. Drought Monitor.

Report Your Drought Impacts

Are you experiencing a drought impact? Your on-the-ground observations are critical in helping us understand the broad picture of drought in the state. The National Drought Mitigation Center and partners have developed Condition Monitoring Observer Reports on Drought (CMOR-drought), a short survey that allows the public to enter their observations regarding crops, water supply, fire, etc.

Climatology of WA's Puget Sound Lowlands Climate Division (#3)

Written by: Haley Staudmyer

This is the third installment of the "Climate Divisions of WA" series, in which we discuss Climate Division 3 – the Puget Sound Lowlands Climate Division. For analyses of Climate Divisions 1 and 2, see the August 2018 and August 2019 editions of our newsletter. As seen in Figure 5, the division encompasses most areas coastal to the Puget Sound, including the major cities of Olympia, Tacoma, Seattle, and Bellingham and encompassing most of the population of WA State. Most of the division is nestled between the Olympics and the Cascades. True to its name, elevation rarely breaches 1000' in the Puget Sound Lowlands, but the borders of the division that include the northeast side of the Olympic Mountains see higher elevations up to between 4,000 and 5,000 ft.

Figure 6 illustrates the monthly total precipitation, as well as the maximum and minimum temperatures averaged over the division for 1991-2020. Though many perceive Seattle to be one of the rainiest cities in the country, average annual precipitation for this climate division totals at 45", which is less than half of that of Climate Division 1. That being said, cities within Climate Division 3 regularly see more than 150 days with precipitation each year, most of which occur between October and April when the lowlands are subject to more of a pervasive gloom rather than intense deluges. During the long rainy season, the westerlies and the jet stream provide a frequent source of moist air and low-pressure systems that flow around and over the surrounding topographical features, often producing large sheets of stratiform clouds and small-droplet

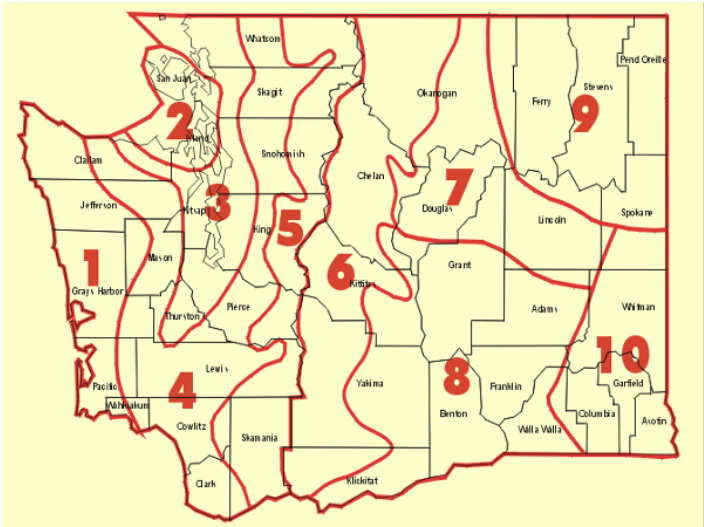


Figure 5: Map of all the WA State Climate Division from the Climate Prediction Center.

precipitation. One may notice February is drier than March on average during this time period; there is no particular climatological explanation for this other than the fact that this division has happened to experience some rather dry February months and rather wet March months over the past twenty years. The central portion of Climate Division 3 can sometimes be rainshadowed by the Olympic Mountains if the flow from an incoming storm is westerly. This feature results in Seattle actually receiving considerably less annual precipitation (39.34") than many southern locations within the division (such as Olympia: 50.62"), where the Olympic Mountains tend to have less of an impact.

Keeping in line with the rest of the state, temperatures in this division are, on average, warmest in August and lowest in December. Proximity to water keeps temperatures fairly moderate throughout the year. The average

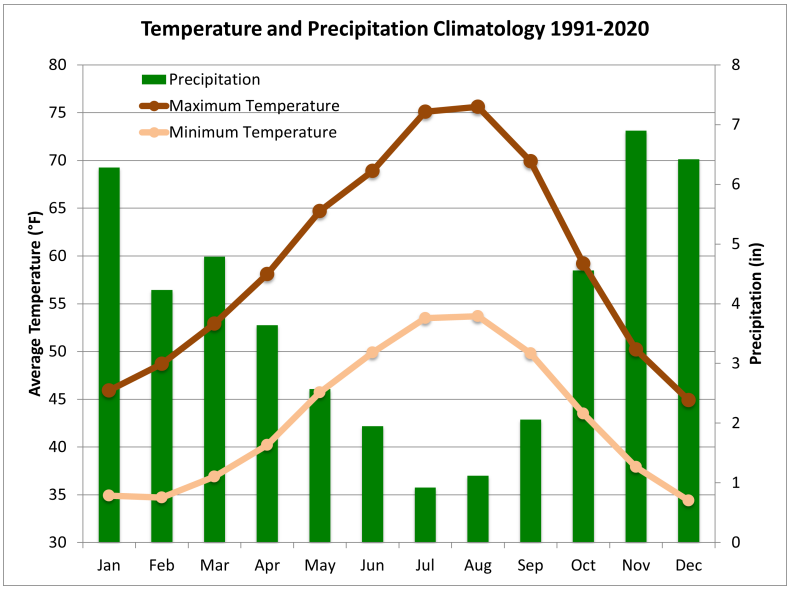


Figure 6: Monthly maximum temperature (°F), minimum temperature (°F), and total precipitation (inches) for the 1991-2020 period for Climate Division 3.

Monthly Record	Value (Anomaly)	Month
Warmest	68.4°F (+4.1°F)	July 1958
Coldest	24.1°F (-16.3°F)	January 1950
Wettest	17.21" (+10.79")	December 1933
Driest	0.00" (-0.92")	July 1922

Table 2: The warmest, coldest, wettest, and driest month for Climate Division 3 using the period of record (1895-2021). The anomaly is relative to the 1991-2020 normal.

minimum temperature in December remains above freezing at 34.4°F, while the average maximum temperature in August tops out at a comfortable 75.6°F. At least most natives of the region will tell you the gloom of the long winter is worth it for the beautiful, temperate summer. Readers of this newsletter will recall that the Goldilocks Climate Index of last month's issue found that the three cities with the "best" climatology in the state reside in Climate Division 3. The typically moderate summer temperatures are also why the majority of homes and apartments in the area are without air conditioning – which is all well and good unless a heat wave passes through.

Table 2 shows the warmest, coldest, wettest, and driest months in Climate Division 3 since the record began in 1895. The results look familiar – the records for the warmest, coldest, and driest months go to July 1958, January 1950, and July 1922, respectively, and are the same among all three climate divisions the OWSC has reported on thus far. The wettest month on record for Climate Division 3, December 1933, is also one of the two instances that tied for the wettest month on record in Climate Division 1 (though Division 1 saw twice as big of an anomaly). Regional weather patterns capable of producing monthly extremes are usually on a much larger spatial scale than that of a single climate division.

Figure 7 shows seasonal wind rose charts for Seattle Tacoma International Airport as an example of the wind climatology for the climate division. This single location is not representative of the wind climatology of all parts of the climate division, but it is a useful example. Compared to Climate Divisions 1 and 2, the Puget Sound Lowlands experience much less seasonal variations in wind strength and direction. Winds are southerly or southwesterly, more often than not, but northerly winds are also frequent, especially during the summer. The regional terrain generally channels the winds, with winds out of the west being particularly uncommon. Strong winds are

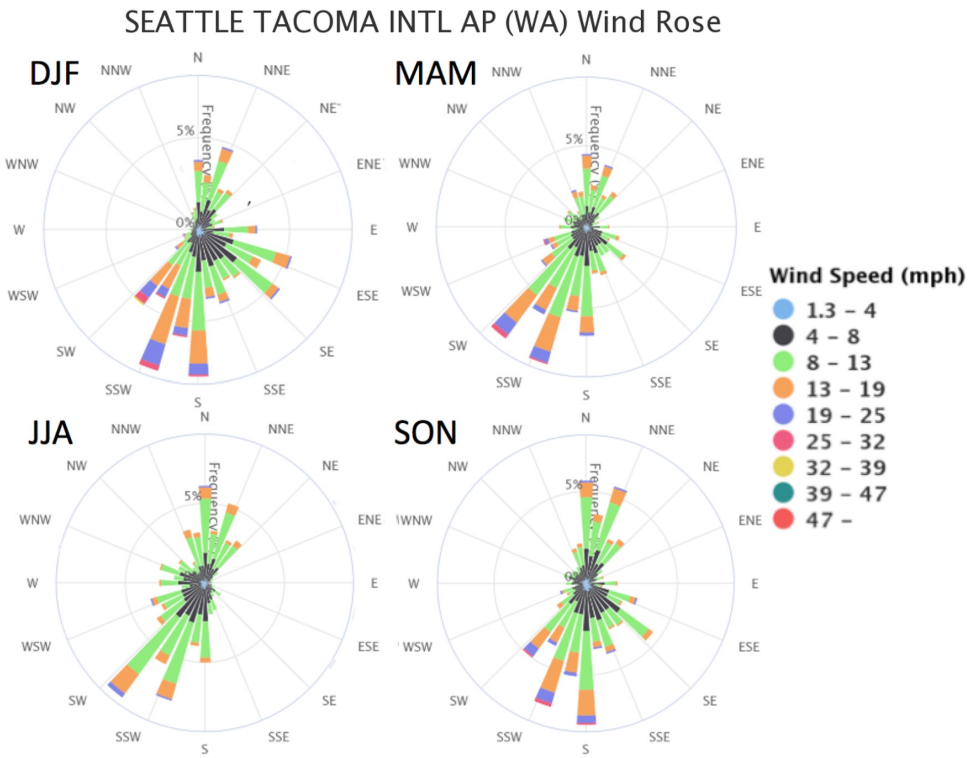


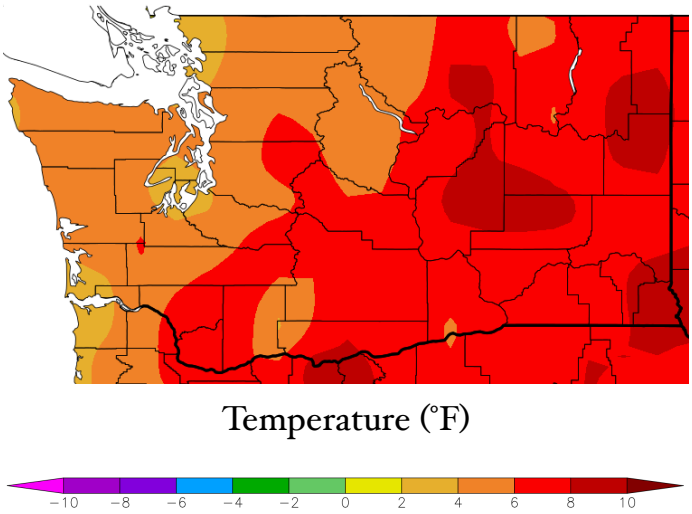
Figure 7: SeaTac Airport seasonal (Dec-Feb, Mar-May, Jun-Aug, and Sep-Nov) winds for the period of record (1945-2021) from MRCC's cli-MATE.

considerably more frequent during the cool part of the year relative to summer. Diurnal effects are more prominent in the summer, during which wind speeds often strengthen in the late afternoon as a result of a combination of the effects of a sea breeze off the Puget Sound and a mountain-valley circulation associated with the west slopes of the Cascade Mountains.

To summarize, the Puget Sound Lowlands boast of a pleasantly moderate climatology. The local topography plays a large role in shaping prevailing weather patterns. Westerly winds arriving from the Pacific bring plenty of moist air to fuel a long wet season of light rain. Proximity to the coast means the division experiences a muted annual cycle in temperatures; the region is not accustomed to bitter cold nor extreme heat. Do you have feedback on our Climate Division Series? Email us, Tweet at us, or connect with us on Facebook.

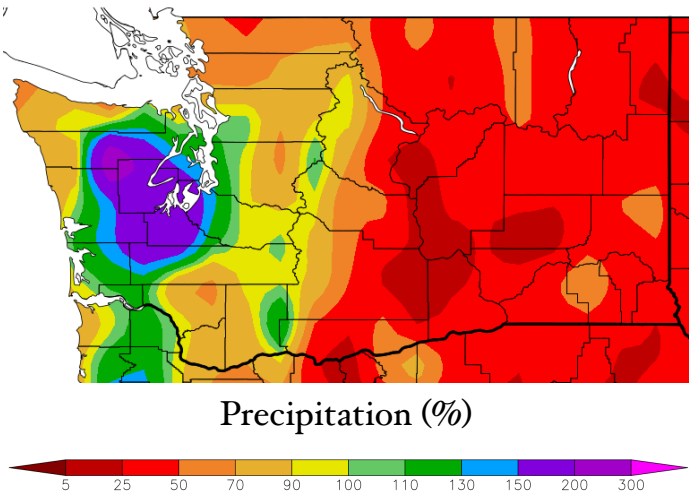
Climate Summary

Average June temperatures were much above normal statewide, according to the map from the High Plains Regional Climate Center. Average monthly temperatures were between 2 and 6°F above normal throughout western WA and even higher in eastern WA (between 6 and 10°F above normal). Spokane and Hanford were an impressive 8.8 and 8.4°F above normal, respectively. The average temperature of 71.1°F at Spokane (Table 3) is much closer to the normal July temperature than what is typically seen in June. The historic heat event at the end of the month helped build these monthly temperature anomalies, of course, but June average temperatures still would have been above normal without it for most of the state. Temperatures were already much above normal prior to the last week of June in eastern WA, and on the warmer side of normal in western WA.



June temperature (°F) departure from normal relative to the 1991-2020 normal (HPRCC).

Total June precipitation was much below normal in eastern WA, with precipitation totals amounting to only between 5 and 50% of normal. Wenatchee, Omak, and Pasco only received 16, 19, and 31% of normal, respectively (Table 3). Precipitation was above normal in the southern and central Puget Sound as well as parts of Olympic Peninsula and southwest WA due to heavy precipitation event mid-month. Olympia received more than double (226% of normal) their normal June precipitation. Not all of western WA was wetter than normal though. Bellingham and Quillayute are notable examples, with 76 and 80% of normal precipitation, respectively (Table 3).



June total precipitation percent of 1991-2020 normal (HPRCC).

Station	Mean Temperature (°F)			Precipitation (inches)		
	Average	Normal	Departure from Normal	Total	Normal	Percent of Normal
Western Washington						
Olympia	63.9	59.1	4.8	3.30	1.46	226
Seattle WFO	66.4	61.4	5.0	2.09	1.57	133
SeaTac AP	66.1	62.0	4.1	1.91	1.45	132
Quillayute	59.0	55.5	3.5	2.64	3.30	80
Hoquiam	62.1	57.1	5.0	2.93	2.01	146
Bellingham AP	64.2	59.8	4.4	1.23	1.61	76
Vancouver AP	69.7	63.3	6.4	1.47	1.61	91
Eastern Washington						
Spokane AP	71.1	62.3	8.8	0.43	1.17	37
Wenatchee	73.6	66.5	7.1	0.08	0.50	16
Omak	73.3	65.1	8.2	0.19	0.98	19
Pullman AP	66.9	59.8	7.1	0.73	1.17	62
Ephrata	75.4	67.2	8.2	0.22	0.65	34
Pasco AP	75.7	67.8	7.9	0.19	0.61	31
Hanford	78.3	69.9	8.4	0.25	0.57	44

Table 3: June 2021 climate summaries for locations around Washington with a climate normal baseline of 1991-2020.

Climate Outlook

According to the Climate Prediction Center (CPC), neutral ENSO conditions are present in the equatorial Pacific Ocean. Over the last 4 weeks, sea surface temperatures (SSTs) in the equatorial Pacific Ocean have been near-normal. The neutral ENSO conditions are expected to persist through the summer. ENSO forecast models are now indicating higher chances of La Niña (62%) developing by October-November-December, and the Climate Prediction Center issued a "La Niña Watch" this morning. There are smaller chances of neutral conditions (35%) and even smaller chances of El Niño (7%) developing by the same period.

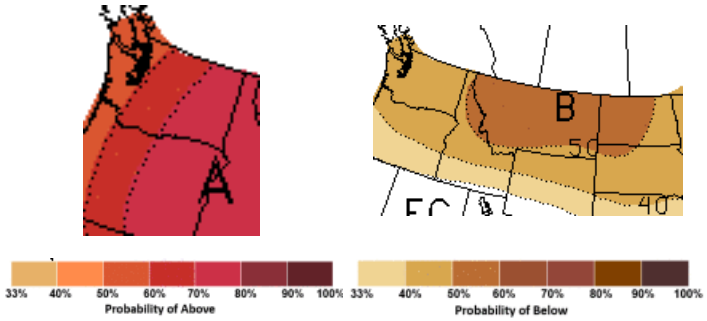


Figure 8: July outlook for temperature (left) and precipitation (right).

The CPC outlook for July (Figure 8) has increased chances of above normal temperatures for all of WA State. The probability of above normal temperatures is highest in eastern WA, with the odds exceeding 70% on the three-tiered system. The remainder of the state has at at least a 50% chance of having above normal July temperatures. July precipitation is more likely to be below normal statewide.

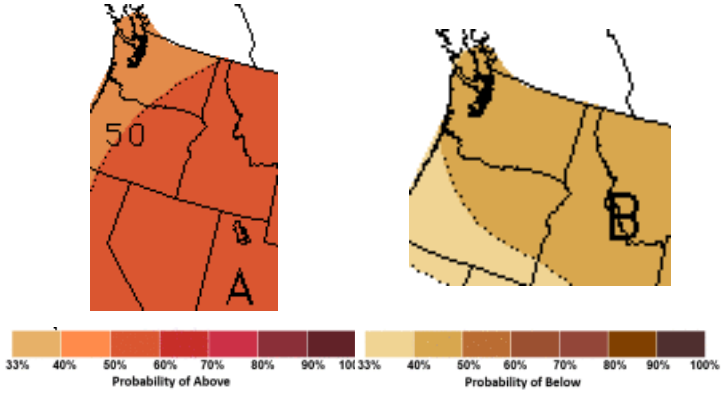


Figure 9: July-August-September outlook for temperature (left) and precipitation (right) (Climate Prediction Center).

The three-month outlook for July-August-September (JAS) shown in Figure 9 shows increased chances of above normal temperatures and below normal precipitation, on average, for the entire state.