



# Office of the Washington State Climatologist

## September 2019 Report and Outlook

September 6, 2019

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

### August Event Summary

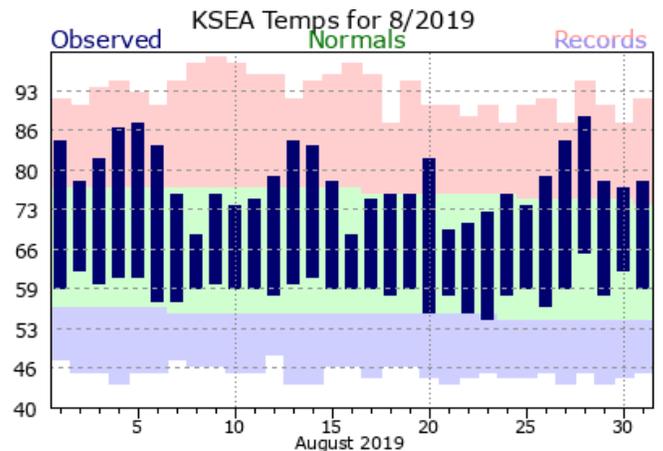
Mean August temperatures were warmer than normal throughout WA state. August precipitation, as in July, was variable across the state with some areas of central WA receiving much above normal precipitation and others, such as northern Puget Sound, receiving much below normal precipitation. Averaged statewide, those anomalies essentially cancel each other out leaving statewide total August precipitation very close to normal (-0.01" anomaly compared to 1981-2010 reference period). The temperature was 1.7°F warmer than normal averaged statewide.

The month started off on a wet note for western WA at least, with Quillayute setting a maximum daily rainfall record on the 1st with 0.81". The CoCoRaHS observer at Quinault on the Olympic Peninsula measured an impressive 24-hour precipitation total of 1.46" on the morning of the 2nd. But after the wet start, we entered a relatively quiet period with warmer (especially with respect to minimum temperatures) and drier conditions compared to normal (Figure 1). On the 3rd, a record warm minimum temperature was set at Vancouver (64°F). On the 6th, Omak set a daily maximum temperature record with a toasty 104°F. Many eastern WA locations were dealing with

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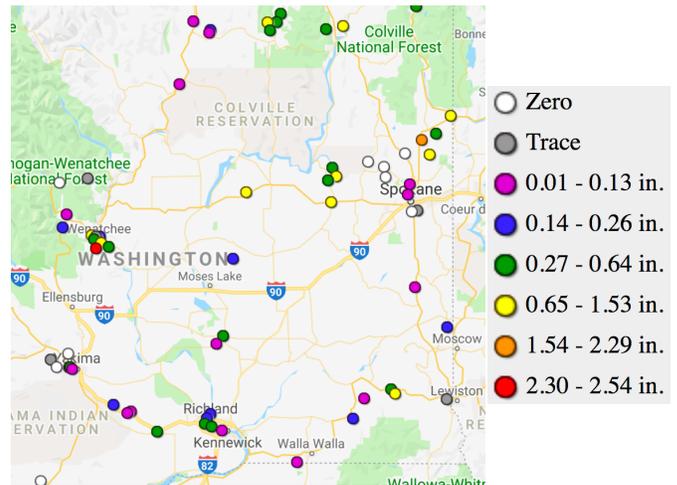
smoke from the Colville Reservation fire during this period as well, with particularly poor air quality in Spokane.



**Figure 1: Daily August maximum and minimum temperatures for SeaTac International Airport compared to normal (green envelope) and historical records (red and blue envelopes).**

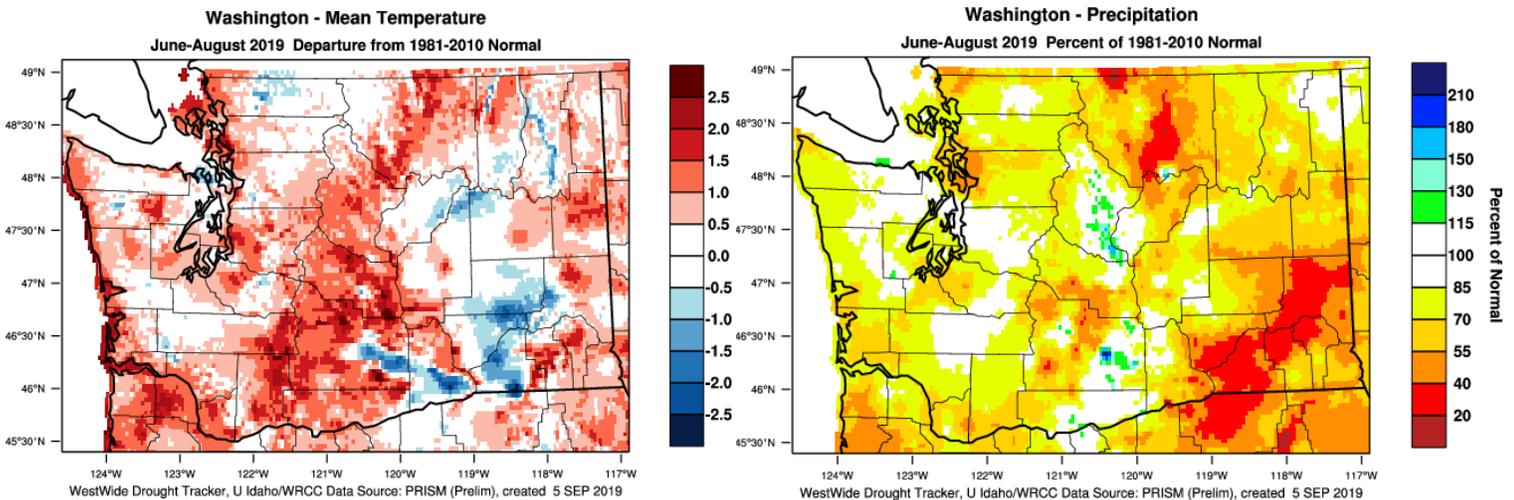
The weather pattern shifted on the 10th, however, with a fall-like system bringing widespread rain from the 9th through the 11th. On the 9th, a daily maximum precipitation amount was recorded at Wenatchee (0.22"). The frontal passage on the 10th caused instability in eastern WA resulting in numerous thunderstorms. Figure 2 shows the 24-hr precipitation measurements from CoCoRaHS observers ending on the morning of the 11th, illustrating the hit-or-miss variability in the eastern WA precipitation. On the 11th, an impressive 1.72" was recorded at Hanford, a maximum daily precipitation record. The Seattle Weather Forecast Office (0.68"), SeaTac Airport (0.38"), Spokane Airport (0.36"), and Olympia Airport (0.21") also recorded maximum daily precipitation records on that day.

After our first taste of fall, the state dried out for a period of warmer than normal temperatures and little rainfall. Another frontal passage occurred on the 21st/22nd, bringing at least some precipitation for the state but not as much as earlier in the month. We then entered another dry/warm period and set a record maximum temperature at Hoquiam (92°F) on the 27th. Some light and spotty rain closed out August.



**Figure 2: 24-hr precipitation totals ending on the morning (between 7 and 9 am) of August 11, 2019 (CoCoRaHS).**

With the conclusion of August, we thought it would be useful to review the average temperature and total precipitation throughout the state from June through August (Figure 3). Overall, the summer has been slightly warmer and drier than normal, but neither of these anomalies are very extreme. In the warmest locations, temperatures were only about 2°F warmer than usual, which is a far cry from some of our very warm recent summers in WA. Averaged statewide, the June through August average temperature anomaly is only +0.6°F. For precipitation, the anomalies have been a little more extreme, with parts of southeastern and north central WA only receiving between 20



**Figure 3: June-July-August average temperature departures from normal (left) and total precipitation percent of normal (right; from [WWD](#)).**

and 40% of normal. Averaged statewide, the precipitation percent of normal is 73%. Still, there are several areas that experienced near-normal temperatures or near-normal precipitation (see all of the white areas in Figure 3) making this summer much more mild than some of others over the last few years.

## New Website!

The OWSC website has a new, fresh look: [www.climate.washington.edu](http://www.climate.washington.edu) (Figure 4)! While we have updated all the links on the site and added some new resources, most of the content is still the same. We hope that this site is easier to navigate than our old website, but please let us know if you have trouble finding an old favorite page. If you manage a website yourself, it's a good

time to check any links you may have on your page that go to the OWSC page, as many of our URLs have changed. And, feedback? We'd love to hear it! You can use the brand new "Contact Us" form on our new page.



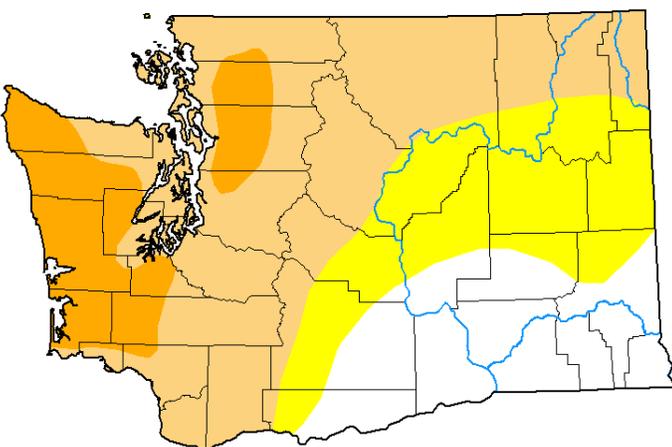
**Figure 4:** The new homepage of [www.climate.washington.edu](http://www.climate.washington.edu).

# Drought Update

With some August precipitation in parts of eastern WA, there were some small improvements made to the U.S. Drought Monitor since last month's newsletter (Figure 5). Namely, some "abnormally dry" (D0) conditions were eliminated in eastern Yakima and Klickitat counties and "moderate drought" (D1) was trimmed in Douglas, Ferry, Stevens, and Pend Oreille counties. But these changes are relatively small, in part due to the warmer than normal temperatures experienced in August nearly statewide, but also the precipitation deficits on longer time scales. Streamflow has also remained very low throughout much of the state, even with the spotty, recent precipitation. Figure 6 shows the average August streamflow, which looks very similar to the average July streamflows, with many streams in the "much below normal" category (below the 10th percentile). The state drought declaration remains in effect for the 27 watersheds as declared in April and May of this year.

## 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 has developed a [Drought Impact Reporter](#) that allows the public to enter their observations regarding crops, water supply, fire, etc. in a short survey and we would appreciate your input.

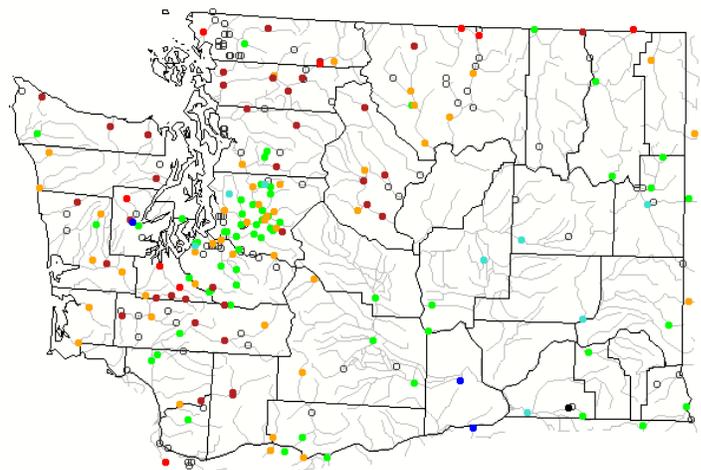


### Intensity:

- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

**Figure 5: The 5 September 2019 edition of the [U.S. Drought Monitor](#).**

August 2019



Explanation - Percentile classes							
<span style="color: red;">●</span>	<span style="color: orange;">●</span>	<span style="color: green;">●</span>	<span style="color: cyan;">●</span>	<span style="color: blue;">●</span>	<span style="color: black;">●</span>	<span style="border: 1px solid black; border-radius: 50%; width: 10px; height: 10px; display: inline-block;"></span>	
Low	<10 Much below normal	10-24 Below normal	25-75 Normal	76-90 Above normal	>90 Much above normal	High	Not-ranked

**Figure 6: Monthly August average streamflow percentile ([USGS](#)).**

# Ocean Weather Ship Papa: A Precipitation Time-Series

Written by Madeline Talebi with an Introduction by Nick Bond

Ocean Weather Ship (OWS) Papa (P) at 50°North, 145°West was occupied almost continuously from December 1949 to August 1981 by the Canadian Weathership Program (Figure 7). These ships collected high-quality meteorological and oceanographic data that represent valuable time series for a remote location in the Northeast Pacific Ocean. The Ocean Climate Station (OCS) Program based at NOAA's Pacific Marine Environmental Laboratory (PMEL) has maintained a moored buoy at Station P since 2007, and the observations from this buoy offer the opportunity to compare present with past conditions. The upper ocean apparently is freshening at this location, and there is interest in determining whether this trend can be attributed to a tendency for greater rainfall. With that in mind, a course of investigation led by Madeline Talebi, an undergraduate from the University of California, Irvine, was taken on under the auspices of JISAO's 2019 Summer Internship Program.

There are often challenges working with historical data (which does not improve with age like wine!) and this project was no exception. The following account from Madeline describes the tortuous path that she took to collect, process, and eventually curate the OWS Station P data. Her efforts are of benefit to not just the OCS group at PMEL, but the entire community interested in air-sea interactions in the Northeast Pacific.

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After countless dead ends, I was able to break some ground with the help of Thomas Cram at the National Center for Atmospheric Research



**Figure 7: Location of Station Papa in the north Pacific Ocean ([source](#)).**

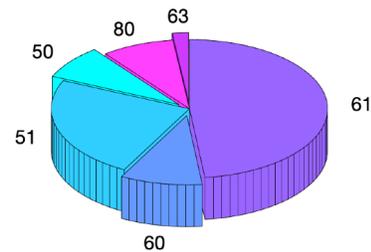
(NCAR) when I was directed towards the International Comprehensive Ocean-Atmosphere Data Set (ICOADS) located on the NCAR website database. The ICOADS datasets are managed by Zaihua Ji. After narrowing a global dataset with various archived data to the specific coordinates of OWS P as well as making sure to include any and all of the significant meteorological data, I was able to compile most of what I was looking for. However, there is one hitch in this story. It seems that the one piece of data that has not been successfully found, at least based off of the research that I have done, are the precipitation accumulations. Based on publications having to do with ocean weather ships in general as well as Station P, precipitation measurements were usually measured every three hours in millimeters. This data, however, is said to have been “purged” according to John L. Knox. As discussed by Knox, the data was once archived,

but has since been discarded due to the reasoning that this data would be of little use and significance in the future! The only precipitation measurements that have been gathered have come from “active or retired technicians, meteorologists, and oceanographers” who had worked on OWS P at some point [Knox, 1991]. Public access to these measurements seems to be limited or even nonexistent because I was unable to locate any definitive precipitation accumulation measurements. However, I did come across a paper by Gilbert Brian Tucker titled, *Precipitation Over the North Atlantic*. In his paper, he discusses how he derived an algorithm that pulls from the present weather codes in order to estimate precipitation accumulations. As acknowledged by several authors including John Knox, Mary Ann Jenkins, W. C. Wong, and Gilbert Brian Tucker, precipitation measurements were rarely taken on ocean weather ships due to the many difficulties in ensuring accuracy as well as precision. Factors such as the size, position, and type of rain gauge all had an effect on the amount of error that a rain measurement would have. As an aside, that is why the OWS P precipitation data is so valuable because very few weather ships even attempted to master this technique. Tucker’s paper was able to shed some light on an alternative route that uses present weather code data and three coefficients,

X, Y, and Z, that are derived based on the ocean region in evaluation.

Since Tucker’s coefficients are directly linked to the North Atlantic, his coefficients are not practical for analysis in a region that is located in the North Pacific. However, Jenkins et al. (1993) were able to derive new coefficients with the algorithm that Tucker had utilized. For the purposes of specifying Station P precipitation, I focused on the 50 to 99 range because these are the codes signifying precipitation amounts that can be estimated using Tucker’s algorithm. It turns out there are only 6 of these codes (Figure 8; Table 1) that were reported often enough at OWS P to contribute meaningfully to precipitation totals, as also indicated in Jenkins et al. (1993).

6 of the Most Common Present Weather Codes



**Figure 8: Fraction of reports including precipitation by present weather code category.**

Present Weather Code	Translation
50	Drizzle, not freezing, intermittent: slight at the time of obs.
51	Drizzle, not freezing, continuous: slight at the time of obs.
60	Rain, not freezing, intermittent: slight at the time of obs.
61	Rain, not freezing, continuous: slight at the time of obs.
63	Rain, not freezing, continuous: moderate at the time of obs.
80	Rain shower(s), slight

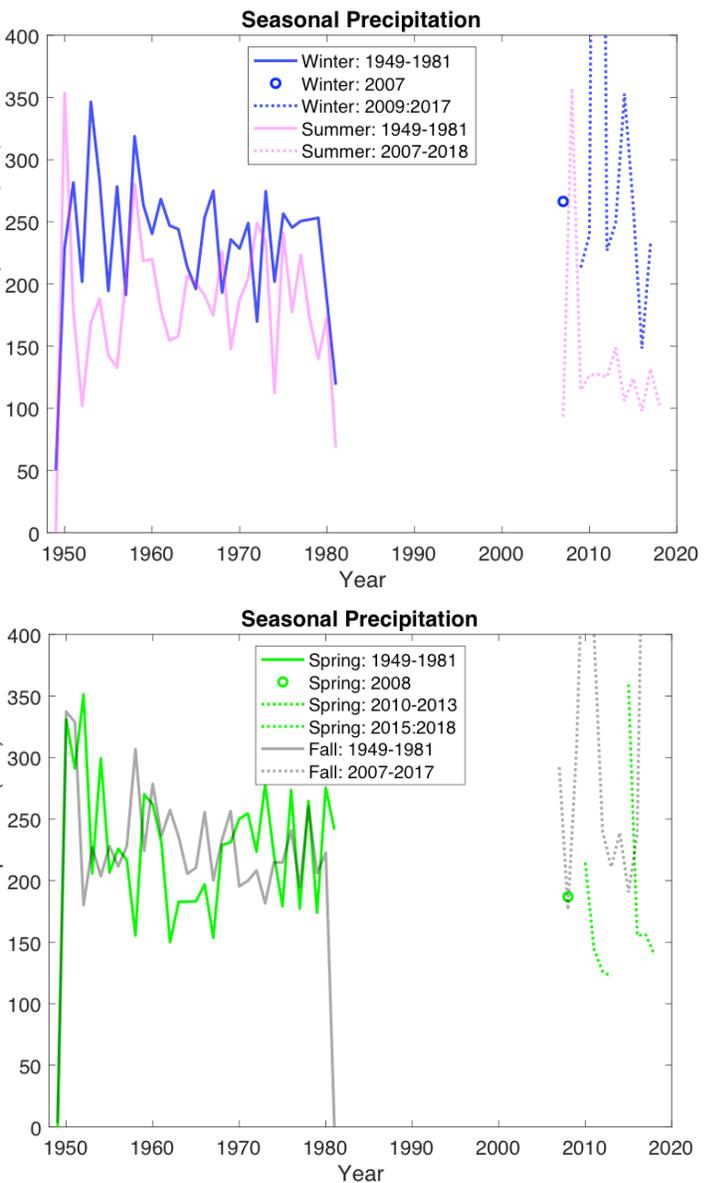
**Table 1: Descriptions of the 6 weather code categories used.**

I used MATLAB and Tucker’s algorithm with coefficients indicated by Jenkins and Wong (1993) to generate time series of seasonal precipitation totals that are displayed in Figure 9. All of the data is from ICOADS except for a period from December 1972 to August 1979 when OWS is missing in the ICOADS data repository. This period was filled in with OWS P data previously collected by the University of Washington’s Applied Physics Laboratory (APL) for a project on ocean waves. The low amounts of precipitation at the very beginning and end of the weather ship deployment, i.e., the years of 1949 and 1981, are due to incomplete data (Figure 9).

The process of obtaining this data from Ocean Weather Ship Papa was quite the adventure. When one avenue led me to a dead end, I tasked myself with back tracking and problem solving to find the next avenue to pursue. I am pleased with the progress made thus far on this data quest, but I know that there is much more that can be analyzed in order to connect some missing links and draw conclusions. With what I have compiled, there does appear to be a general trend with the amount of precipitation. The more recent rain accumulation data spanning 2007 to 2018, as seen in Figure 9, illustrates an average increase in rain when compared to the 1949 to 1981 timeseries, especially for the fall season. So, what does this mean? At least the sense of the change in precipitation totals is consistent with the freshening at Station P, but whether it is the primary cause is yet to be determined.

## References

Tucker, G. B., (1961): Precipitation over the North Atlantic Ocean. *Quart. J. Royal. Meteorological Society*, 87, 147-158.



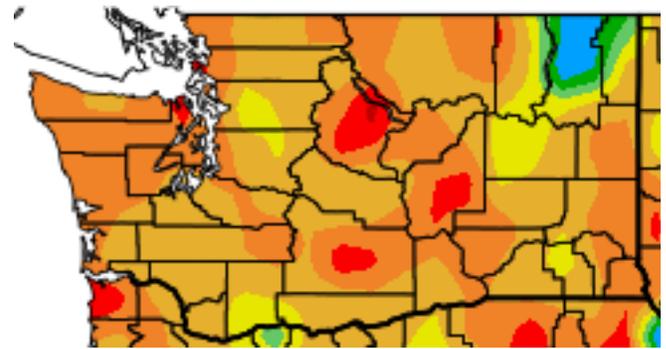
**Figure 9: Total seasonal precipitation at OWS P estimated using present weather reports from the Canadian Weathership Program (solid lines) and observed by a moored buoy (dotted lines). The left panel refers to winter (blue) and summer (pink); the right panel refers to spring (green) and fall (black). The low precipitation seasons shown in 1949 and 1981 are the result of missing data.**

Jenkins, M.A., W.C. Wong, K. Higuchi, and J.L. Knox (1993): Precipitation at Ocean Weather Station “P”. *J. Climate*, 7, 792-806.

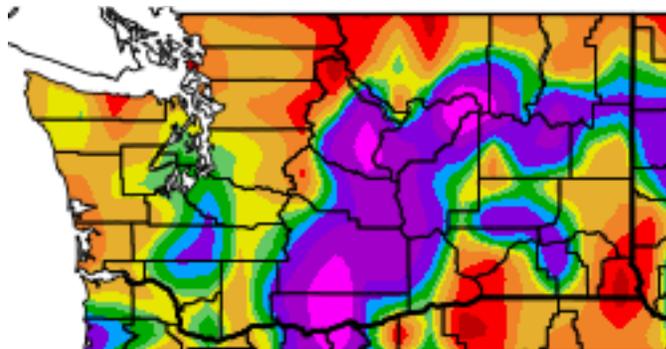
# Climate Summary

Mean August temperatures were above normal for nearly the entire state, with average temperatures ranging between 1 and 3°F above normal. Hoquiam, Pullman, and Pasco were warm spots, with temperatures 3.4, 3.0, and 3.0°F above normal, respectively (Table 2). The one exception is Stevens county in northeastern WA, which recorded below normal temperatures (between 1 and 3°F below normal) for the month.

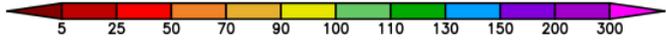
Total August precipitation relative to normal was mixed across the state, with some locations receiving much above normal precipitation such as Hanford (1306% of normal) and others receiving much below normal precipitation such as Hoquiam (29% of normal). More specifically, the Olympic Peninsula, coast, and northern and central Puget Sound were drier than normal, with precipitation amounts ranging between 25 and 90% of normal. Central WA, including Wenatchee, Ephrata, Yakima, and Hanford were much wetter than normal, with totals at least 150% of normal. The Seattle and southern Puget Sound regions were near-normal to above normal for August as well, though the totals relative to normal were not as impressive as the eastern WA percentages despite the total precipitation amount being higher (Table 2).



Temperature (°F)



Precipitation (%)



**August temperature (°F) departure from normal (top) and precipitation percent of normal (bottom). (High Plains Regional Climate Center; relative to the 1981-2010 normal).**

	Mean Temperature (°F)			Precipitation (inches)		
	Average	Normal	Departure from Normal	Total	Normal	% of Normal
Western Washington						
Olympia	65.4	64.1	1.3	0.80	0.94	85
Seattle WFO	68.5	66.5	2.0	1.33	0.97	137
SeaTac AP	69.1	66.1	3.0	1.20	0.88	136
Quillayute	62.3	59.6	2.7	1.68	2.49	67
Hoquiam	64.0	60.6	3.4	0.38	1.31	29
Bellingham AP	65.0	62.5	2.5	0.90	1.23	73
Vancouver AP	70.1	69.2	0.9	0.59	0.77	77
Eastern Washington						
Spokane AP	72.1	69.3	2.8	0.48	0.59	81
Wenatchee	75.2	73.5	1.7	0.53	0.20	265
Omak	74.3	72.4	1.9	0.36	0.49	73
Pullman AP	68.7	65.7	3.0	0.63	0.63	100
Ephrata	75.4	72.9	2.5	0.29	0.19	153
Pasco AP	75.8	72.8	3.0	0.19	0.27	70
Hanford	77.3	75.8	1.5	2.35	0.18	1306

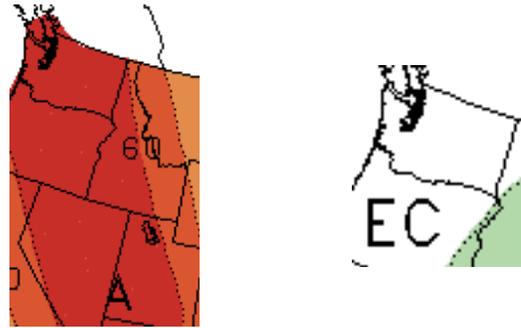
**Table 2: August 2019 climate summaries for locations around Washington with a climate normal baseline of 1981-2010. Note that the Vancouver Pearson Airport and Seattle WFO 1981-2010 normals involved using surrounding stations in estimating the normal, as records for these station began in 1998 and 1986, respectively.**

# Climate Outlook

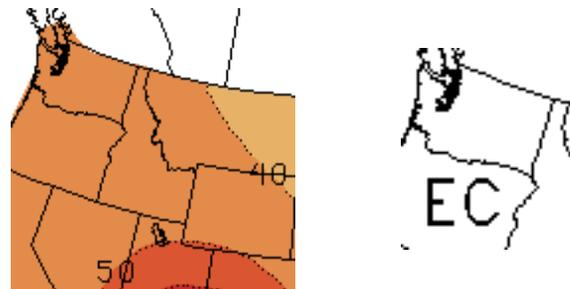
According to the Climate Prediction Center (CPC), El Niño weakened to neutral ENSO conditions in early August, and the final “El Niño Advisory” was issued on the 8th. Over the last month, equatorial sea surface temperature (SST) anomalies have been below normal in the eastern Pacific and above normal in the western and central Pacific, but have weakened overall. Models indicate a continuation of ENSO-neutral conditions into the fall and winter. Currently, the official CPC/IRI forecast indicates a 58% chance of neutral ENSO conditions, 29% chance of El Niño, and 13% chance of La Niña for the October through December 2019 period.

The CPC September temperature outlook calls for increased chances of above normal temperatures statewide, with the odds exceeding 60% on the three-tier system for the entire state. September precipitation is uncertain, as there are equal chances of below, equal to, or above normal precipitation statewide.

The CPC fall (SON; September-October-November) seasonal temperature outlook calls for warmer than normal temperatures statewide, with chances between 40 and 50% on the three-tier system. Similar to the September outlook, the precipitation outlook for the longer SON period indicates equal chances of either below, equal to, or above normal precipitation statewide.



**September outlook for temperature (left) and precipitation (right)**



**September-October-November outlook for temperature (left) and precipitation (right)**

**(Climate Prediction Center)**