



Office of the Washington State Climatologist

October 2018 Report and Outlook

October 3, 2018

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

September Event Summary

Mean September temperatures were near to below normal throughout WA state. Precipitation, on the other hand, was variable throughout the state with a large dichotomy between western and eastern WA. September precipitation was generally above normal in western WA and much below normal in eastern WA. Even with below normal temperatures and wetter than normal conditions west of the Cascade Mountains, the dry season of May through September was warmer and drier than normal for nearly the entire state (Figure 1). There are more exceptions regarding temperature, where cooler than normal September and June temperatures in some locations resulted in near-normal temperatures.

In this Issue

-
- September Event Summary.....1
- Drought and Streamflow Update.....3
- CoCoRaHS Note.....3
- ENSO and Early Season Snow.....4
- Climate Summary.....7
- Climate Outlook.....9

September 30 also marks the end of the 2018 Water Year (October 1, 2017-September 30, 2018); the water year anomalies are shown in Figure 2. On this longer time scale, temperatures were near-normal (within 1°F) throughout most of WA with

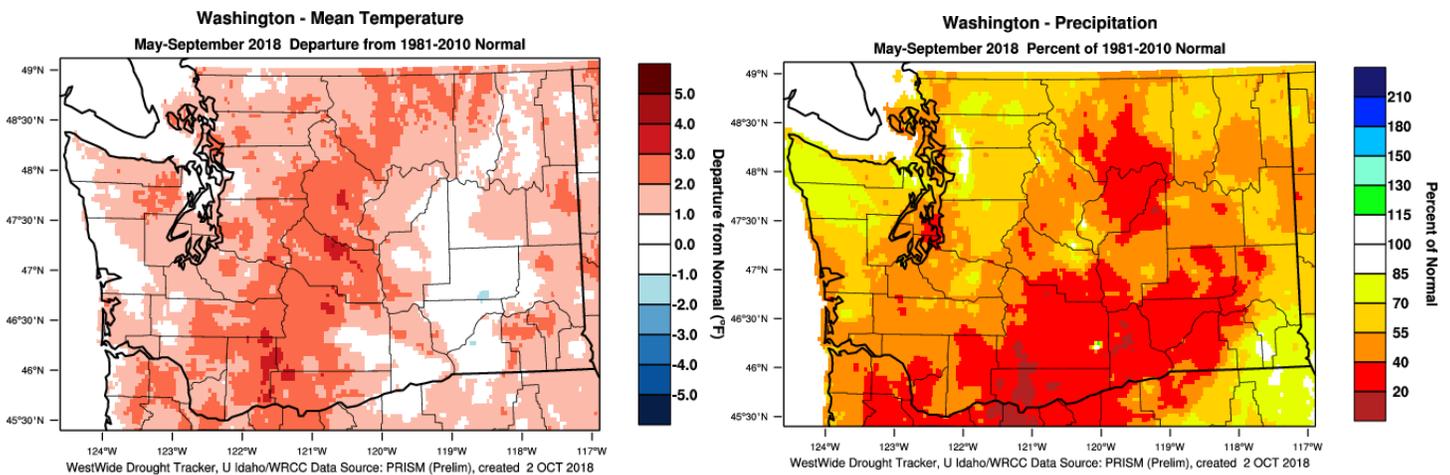


Figure 1: May-September departure from normal (a) temperature and percent of normal (b) precipitation for WA State (WWDT).

the exception of the central and southern Cascades where there were positive anomalies of 1-2°F. Water year precipitation was near-normal for most of the state, with areas of above normal precipitation in the northern half of the state and areas of below normal precipitation in the southern half of the state. The seasonal anomalies were much more pronounced (positive and negative) than the overall water year anomalies.

In terms of September’s weather events, the month was relatively quiet. Table 1 lists the monthly precipitation totals for several locations in eastern WA that ranked among the top ten driest. In contrast, Olympia Airport set a record daily maximum precipitation record of 0.51” on the 11th.

| Station | September Precipitation (inches) | Rank | Records Began |
|--------------------|----------------------------------|----------|---------------|
| Pasco | Trace | 1 (tie) | 1945 |
| Walla Walla | Trace | 2 (tie) | 1949 |
| Yakima | 0.01” | 6 (tie) | 1946 |
| Pullman | 0.02” | 3 (tie) | 1940 |
| Richland | 0.02” | 12 (tie) | 1944 |
| Spokane AP | 0.02” | 6 | 1881 |

Table 1: September 2018 precipitation, its ranking (driest to wettest), and the year that records began at selected eastern WA stations.

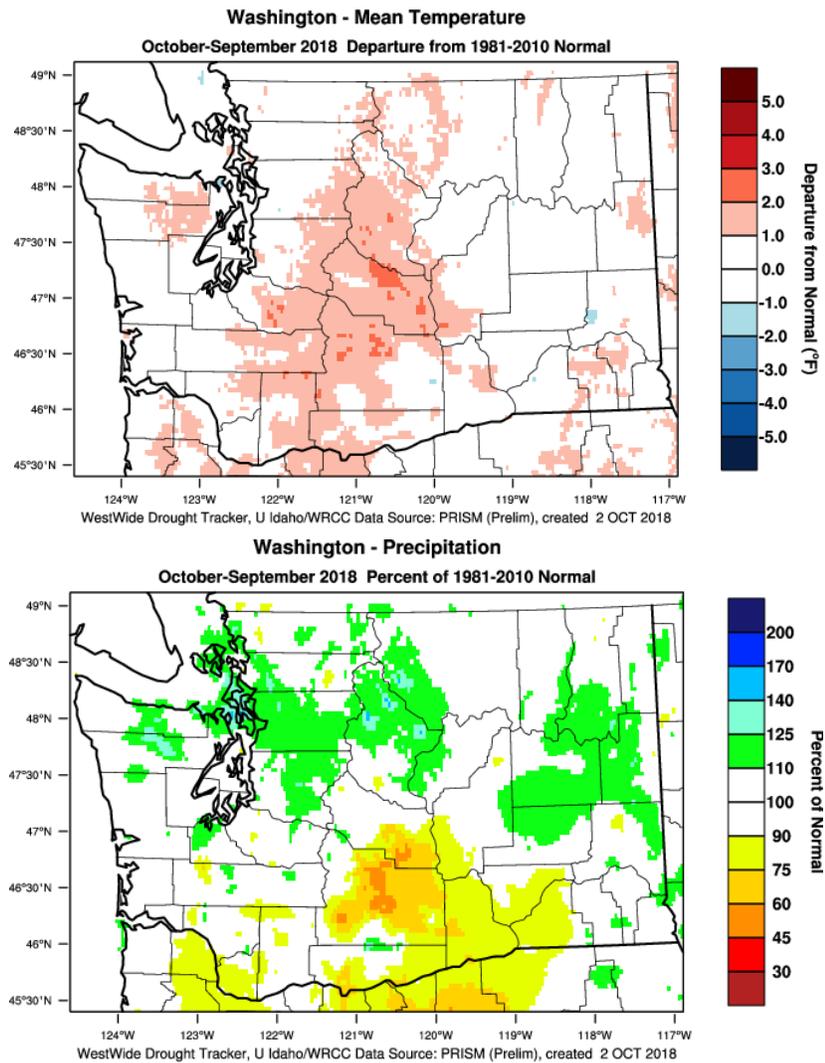


Figure 2: Water year 2018 (Oct 2017-Sept 2018) departure from normal (a) temperature and percent of normal (b) precipitation for WA State (WWDT).

Drought Monitor and Streamflow Update

The U.S. Drought Monitor map (Figure 3) has shown improvement in drought conditions around WA since our last newsletter. Coastal WA, the Olympic Peninsula, and northern and central Puget Sound have all shown improvement in line with the above normal September precipitation. The above normal precipitation has also improved streamflows and soil moisture in those regions as well. “Severe drought” (D2) remains in parts of southwestern WA where conditions have not improved. In contrast, there was expansion of “moderate drought” conditions in Chelan and Kittitas counties where below normal precipitation has continued.

Figure 4 shows the monthly average September streamflow with improvements in western WA. However, an area of below normal monthly streamflows remain in portions of southwest WA where the area of “D2” remains.

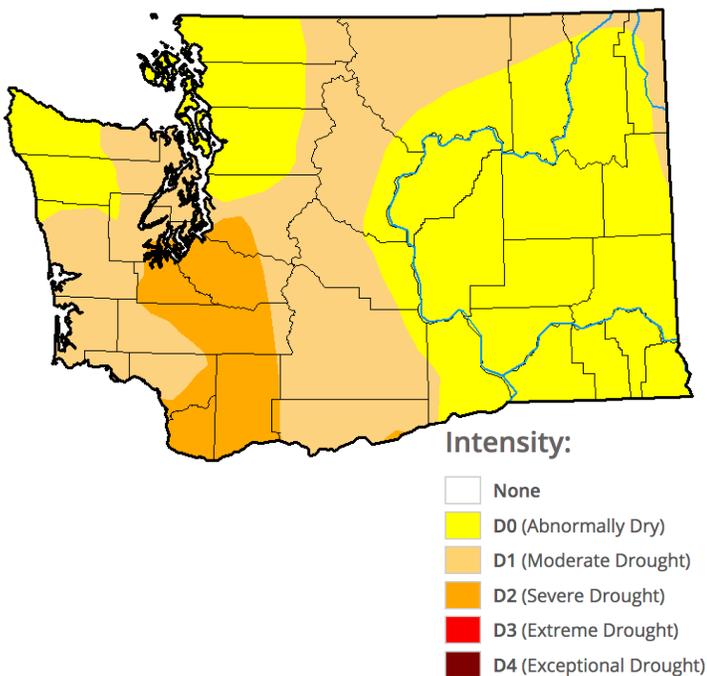


Figure 3: The September 27, 2018 version of the [U.S. Drought Monitor](#).

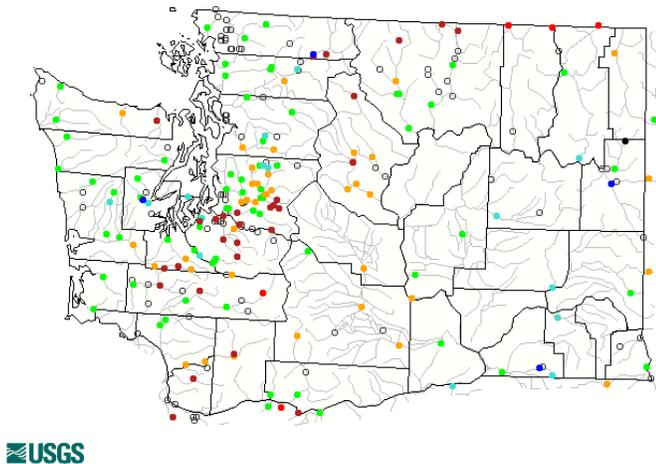


photo by Henry Reges, CoCoRaHS

Community, Collaborative Rain, Hail, and Snow (CoCoRaHS) Network

Greetings, CoCoRaHS observers! October 1st marked the first day of the 2019 water year. Happy New Water Year! We hope you take this opportunity to start fresh with recording your daily precipitation totals if you’ve been lax over the summer. For those observers that reliably entered their “zeros” during our dry season, thank you very much for your efforts.

As always, please help us spread the word about CoCoRaHS. You can direct friends and family to sign up to volunteer at www.cocorahs.org.



| Explanation - Percentile classes | | | | | | | |
|----------------------------------|--------------------------|-----------------------|-----------------|-----------------------|--------------------------|------|------------|
| | | | | | | | |
| Low | <10 Much below normal | 10-24 Below normal | 25-75 Normal | 76-90 Above normal | >90 Much above normal | High | Not-ranked |

Figure 4: WA State average September streamflows from [USGS](#).

Effects of ENSO on Early Season Snowfall in the Washington Cascades

A message from the State Climatologist

Most readers of this newsletter are probably aware that El Niño winters tend to result in relatively skimpy snowpacks, and that El Niño development is more likely than not during the upcoming winter. But there is more to it than just that. Keen observers of the climate of the Pacific Northwest (PNW) may know or have noticed that El Niño's effects often only kick in after the first of the calendar year. We thought it worthwhile to pursue this matter, with two objectives. The first objective is to simply examine the correspondence between El Niño events of modest magnitude (as expected this go around) and early season snowfall in the Washington Cascades. The second is to explore how well an empirical model based on large-scale predictors can account for the variability observed in our snowpack on 1 January. The present piece represents a companion to one published in the January 2016 edition of this newsletter, which also considered ENSO and our weather during the early portion of the cool season.

Our focus will be on the year-to-year variability in a composite measure of snow water equivalent (SWE) on 1 January for the Washington Cascades from 1983-2018. This composite consists of the average SWE at the 5 SNOTEL stations from north to south of Harts Pass, Stevens Pass, Stampede Pass, White Pass, and Lone Pine. We realize that from some perspectives, especially winter sports, snow depth may be of greater interest than SWE. Here we focus on the latter, in part because of the consistency of the data record from the SNOTEL stations used here, and because a reasonable value for the SWE is generally necessary for decent ski conditions in the mountains anyway. Figure 5 shows the time series of composite SWE on 1 January, with the years of weak-moderate El Niño indicated with red dots. The very strong El Niño events of 1982-83, 1997-98 and 2015-16 are not highlighted. There is some ambiguity in the classification of the events for the winters of 1987-88 and 2009-10. We choose to classify the former as moderate-

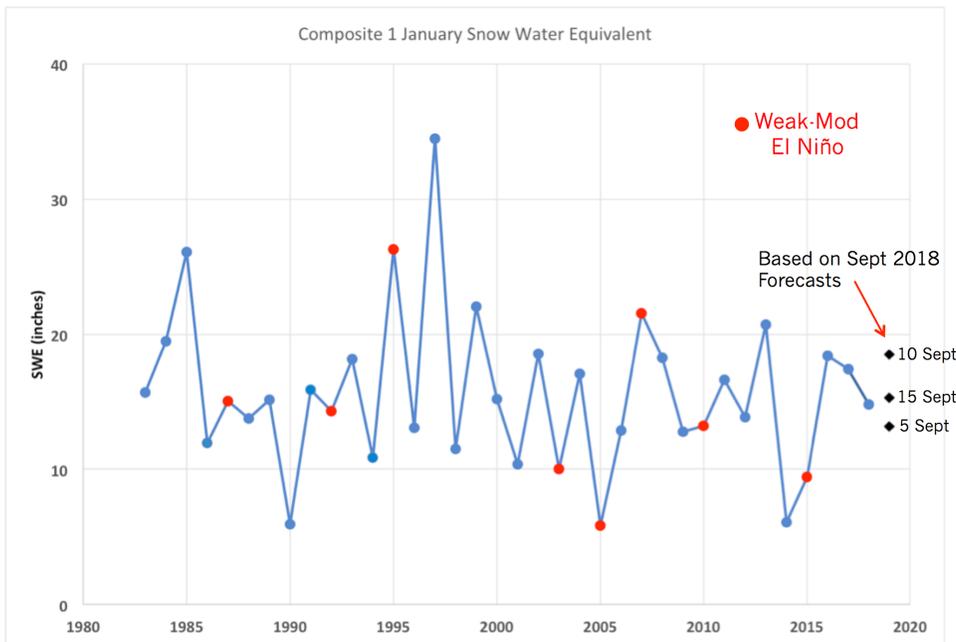


Figure 5: Composite values of snow water equivalent (SWE) in inches on 1 January for 1983-2018. Red dots indicate years with weak-moderate El Niño events. The three black diamonds at the right show forecast values of SWE for 1 January 2019.

strong (it does not get a red dot) and the latter as moderate (it gets one) on the basis of their expressions in terms of anomalous deep convection in the eastern equatorial Pacific. The main point here is that during past weak-moderate El Niño events there does not seem to be much if any signal in terms of the composite 1 January SWE. While the years of 2003, 2005 and 2015 had SWE values well below average for the period, the years of 1995 and 2007 had values that were well above average. Note also that the greatest SWE back to 1983 occurred in 1997, where the equatorial Pacific was on the cool side but not technically a La Niña, due especially to the large positive anomalies at White Pass and Lone Pine. Figure 5 also includes a set of 3 black diamonds for the year of 2019. These are not observations, of course, but rather forecasts, as detailed below.

As stated above, we are interested in how well the early season snowfall corresponds with large-scale climate-related variables. Towards that end, a relatively simple empirical model using the generalized additive model (GAM) framework was constructed, with the composite 1 Jan SWE as the predictand. The four predictors included were mean values of the NINO_{3.4} index during September-November, the regional SST off the coast of the PNW during September, the 500 hPa geopotential height (Z) over WA and OR during November-December, and the 850 hPa zonal wind (U) for western WA and OR during

November-December. The main goal here was to explore the strength of the relationships between the predictors and SWE, and secondarily, use those relationships to make some projections for the SWE on 1 January 2019. The GAM framework represents an easy way to assess the relative importance of the predictors. The 500 hPa Z (essentially whether there's a ridge of high pressure or a trough of low pressure over the PNW) was the big winner, both in terms of the variance in SWE explained and statistical significance. The GAM fit a linear relationship between the 500 hPa Z and the SWE, with lower heights associated with greater SWE. In second place was the 850 U, with greater values tending to be associated with greater SWE, presumably due to stronger onshore flow resulting in heavier precipitation. Of much less importance were the SST anomalies in September off the PNW coast

and the NINO_{3.4} index in September–November. Warmer regional SSTs tend to be followed by a bit less SWE; the weakness in this relationship can probably be attributed to the September SST not being that representative of ocean temperatures later in the winter, and of course, the overriding importance of the regional atmospheric circulation to mountain snowfall. The lack of a relationship between the NINO_{3.4} index for ENSO and SWE is consistent with the results shown in Figure 1. The GAM based on the four predictors fit the observed SWE quite well (Fig. 6), with the exception of the aforementioned oddball winter of 1996–97.

The GAM discussed above can be run in predictive mode. Using the relationships based on the observational record from 1982–83 through last winter, and observations and forecasts of the 4 predictors, predictions were made for the composite SWE on 1 January 2019. We used a known value for the regional SST in September, relatively short-term forecasts for NINO_{3.4} in SON from IRI, and forecasts for the 500 hPa Z and 850 hPa U in November–December from NOAA/CPC’s CFSv2 climate model. The latter two predictors are much more important, and uncertain, and therefore we used the data from separate CFS simulations initialized on 5, 10 and 15 September. The resulting 3 individual projections for the 1 January 2019 SWE are shown in Figure 5. All three projections are essentially in the middle of the pack with respect to the observed record back to the early 1980s.

To be sure, these forecasts are mostly for giggles. Additional research would be required to establish the most reliable model(s) for projecting early season snowfall in the Cascades; with GAMs there is the danger of overfitting. On the other hand, we

feel that our results justify two takeaway points: ENSO does not seem to be a significant factor, and the mean circulation is a strong determinant, of snow accumulations in the Cascade Mountains during the early winter.

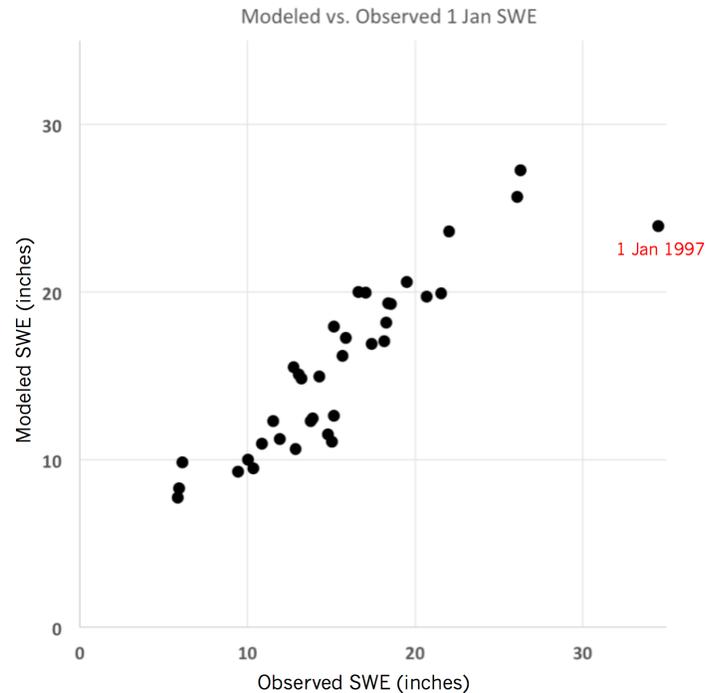
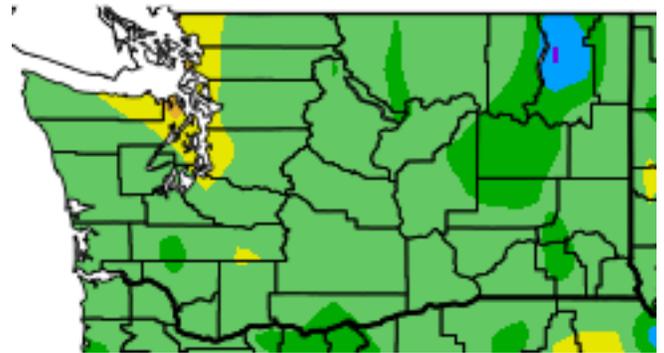


Figure 6: Observed values of composite 1 January SWE (x-axis) versus modeled SWE (y-axis) based on a generalized additive model (GAM) using 500 hPa Z, 850 hPa U, regional SST, and NINO_{3.4} as predictors.

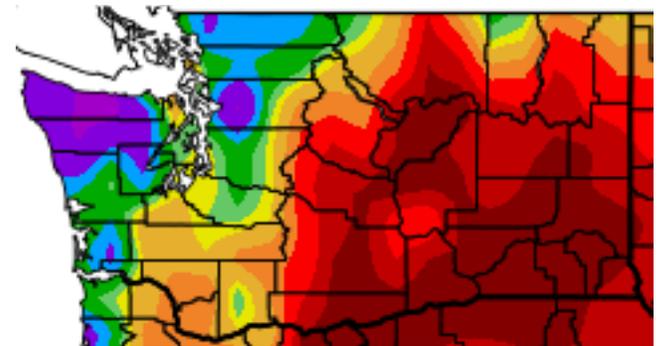
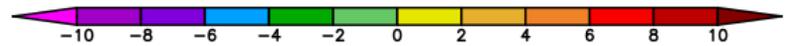
Climate Summary

In contrast to the preceding two months, mean September temperatures were below normal to near-normal for nearly the entire state. The coolest anomalies were in eastern WA, where Wenatchee and Ephrata were 1.5 and 1.6°F below normal, respectively (Table 2). Northeastern WA had monthly temperatures between 2 and 6°F below normal, according to the map on the right from the High Plains Regional Climate Center. The Puget Sound region was on the warmer side of normal, though most areas were still within 1°F of normal (e.g., Seattle area).

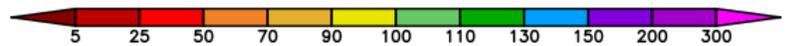
Total September precipitation was vastly different for western WA versus eastern WA. Most of western WA received above normal precipitation while eastern WA received very little, as illustrated by the map on the right hand side. The Olympic Peninsula received the most precipitation, both in actual amount and relative to normal (between 130 and 300% of normal). Quillayute recorded almost 6" for the month, at 154% of normal (Table 2). The central and northern Puget Sound received near-normal to above normal precipitation as well. Thurston, Lewis, Cowlitz, Skamania, and Clark counties did not benefit like their western WA neighbors, only receiving between 50 and 90% of normal precipitation (e.g., Vancouver had 78% of normal precipitation; Table 2). But the lack of precipitation was even more stark east of the Cascade crest. Ephrata and Pasco only recorded a "trace" (0% of normal) while the rest of the locations listed in Table 2 received less than 10% of normal.



Temperature (°F)



Precipitation (%)



September 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 | 58.0 | 58.9 | -0.9 | 2.06 | 1.71 | 120 |
| Seattle WFO | 62.3 | 61.6 | 0.7 | 1.41 | 1.52 | 93 |
| SeaTac AP | 62.3 | 61.3 | 1.0 | 1.04 | 1.50 | 69 |
| Quillayute | 56.2 | 56.6 | -0.4 | 5.89 | 3.82 | 154 |
| Hoquiam | 59.5 | 58.7 | 0.8 | 2.15 | 2.28 | 94 |
| Bellingham AP | 58.6 | 57.2 | 1.4 | 2.61 | 1.78 | 147 |
| Vancouver AP | 62.9 | 63.6 | -0.7 | 1.22 | 1.56 | 78 |
| Eastern Washington | | | | | | |
| Spokane AP | 59.6 | 60.2 | -0.6 | 0.02 | 0.67 | 3 |
| Wenatchee | 62.9 | 64.4 | -1.5 | 0.01 | 0.34 | 3 |
| Omak | 61.6 | 62.6 | -1.0 | 0.05 | 0.58 | 9 |
| Pullman AP | 56.8 | 58.2 | -1.4 | 0.02 | 0.78 | 3 |
| Ephrata | 62.2 | 63.8 | -1.6 | T | 0.36 | 0 |
| Pasco AP | 62.8 | 63.4 | -0.6 | T | 0.40 | 0 |
| Hanford | 65.4 | 66.4 | -1.0 | 0 | 0.30 | 0 |

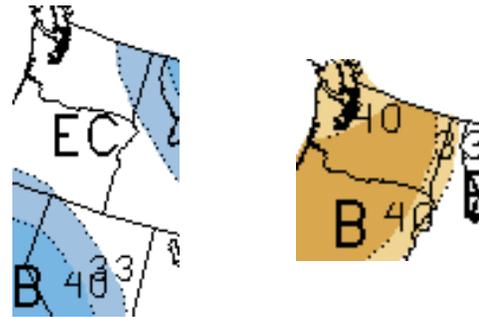
Table 2: September 2018 climate summaries for locations around Washington with a climate normal baseline of 1981-2010. Note that the Vancouver Pearson Airport and Seattle WFO 1981-2010 normals involved using surrounding stations in estimating the normal, as records for these station began in 1998 and 1986, respectively.

Climate Outlook

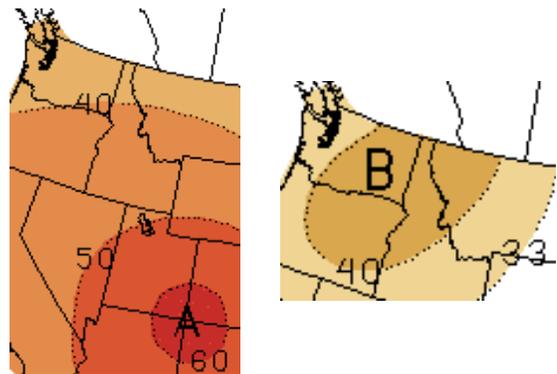
ENSO-neutral conditions are still present in the tropical Pacific Ocean at the time of this writing. Sea surface temperature anomalies over both the last week and the last 4 weeks have been near-normal to above normal in the equatorial Pacific. Some modest warming has occurred in portions of the central and eastern equatorial Pacific. The Climate Prediction Center (CPC) issued an “El Niño Watch” in August that is still in effect, and ENSO models indicate El Niño development by winter is probable. The highest chances of an El Niño are at about 65% during the December through February periods.

The October temperature outlook from the CPC has equal chances of below, equal to, or above normal temperatures for most of the state. Northeastern WA, on the other hand, has elevated odds of below normal temperatures for the month. The October precipitation outlook indicates increased chances of below normal precipitation for the entire state.

The October-December CPC seasonal outlook is calling for slightly increased chances of above normal temperatures statewide. For precipitation, below normal precipitation is expected for nearly the entire state, with higher likelihood of below normal precipitation for eastern WA.



October outlook for temperature (left) and precipitation (right)



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

(Climate Prediction Center)