Office of the Washington State Climatologist

August 2017 Report and Outlook

August 7, 2017

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

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July Event Summary

Mean July temperatures were warmer than average for most of the state. The mean temperature percentiles for the state from the Western Regional Climate Center are shown in Figure 1. With the exception of the coast which was near normal, last month's temperatures were warmest relative to normal in northeast WA where temperatures ranked in the top 10% compared to other Julys (Figure 1). For the most part, temperatures statewide were unexceptional. A few locations recorded new daily maximum temperatures earlier in the month: Yakima (103°F) and Kennewick (105°F) on the 6th and 7th, respectively.

Total July precipitation is the more interesting story. It was remarkably dry with many places receiving no measurable precipitation for the entirety of the month. This occurred at locations both west (e.g., SeaTac) and east (e.g., Wenatchee) of the Cascade Mountains.

The departure from normal precipitation map (Figure 2) shows that many locations in WA had between 1 and 2 inches below normal precipitation for the month. While it may not sound like a significant amount, there is typically little precipitation during the summer.

Overall, the dry conditions have not significantly affected the current streamflow or the forecast for the upcoming months (see "Drought and Streamflow Update" for more information). Unfortunately, the dry conditions were conducive to wildfires. Lightning caused several fires such as the North Fork Hughes Fire in the Salmo-Priest Wilderness which was still active at the time of this writing (August 4). The National Interagency Fire Center indicates that much of eastern WA is presently in the "High" category of fire danger.

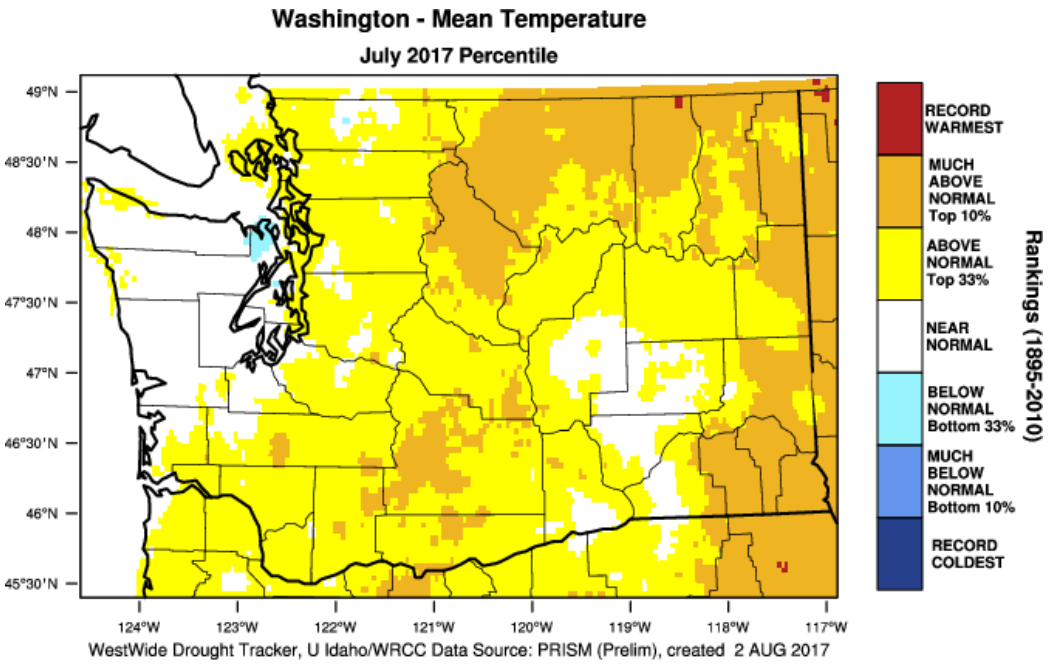


Figure 1: July mean temperature percentiles for WA State (from WRCC).

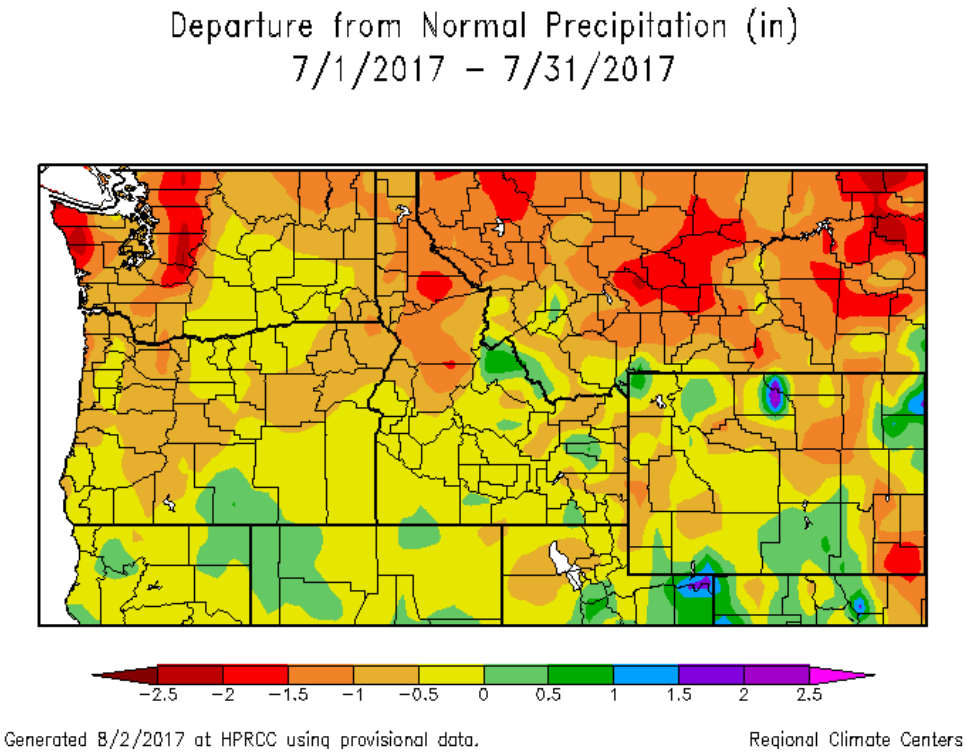


Figure 2: July precipitation (inches) departure of normal. (High Plains Regional Climate Center; relative to the 1981-2010 normal).

Drought and Streamflow Update

Since last month's newsletter, there has been some change in the WA state depiction on the US Drought Monitor. The US Drought Monitor map (Figure 3) released on August 1 shows "abnormally dry" conditions in the Puget Sound area, in addition to parts of central and northern WA. Though July was extremely dry, the 28-day average streamflows (Figure 4) as of August 3 are normal throughout a majority of the state. Several of the streams in western WA are running dry, however, with many streams between the 10th and 24th percentile (Figure 4). Despite these recent conditions, the April-September water supply forecast from the National Weather Service Northwest River Forecast Center remains normal to above normal for the state.

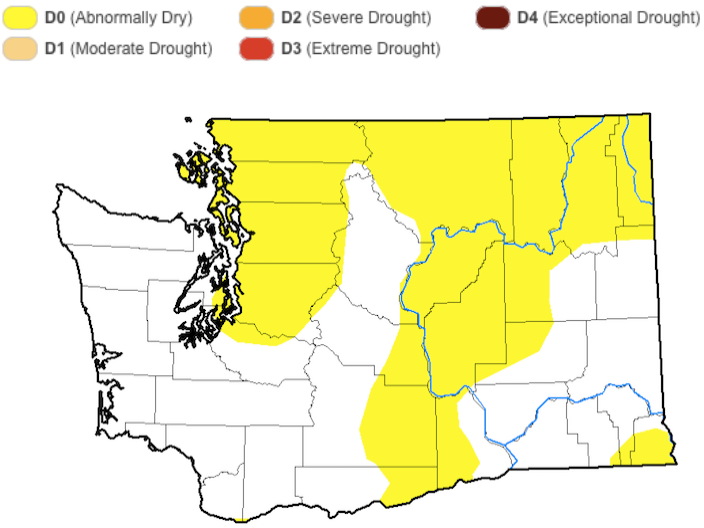


Figure 3: The 1 August 2017 edition of the US Drought Monitor.

photo by Henry Reges, CoCoRaHS

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

Thank you to all of our CoCoRaHS volunteers for taking the time to read your rain gauges and submit your observations. Did you know that you can keep track of the number of daily rainfall reports submitted? Just go to "Rainy Days Report" (https://www.cocorahs.org/ViewData/RainyDaysReport.aspx), specify a date range and select the location. We were curious about how many reports observers have been submitting over the past couple of months which are as follows: May (9,221 reports), June (8,632 reports) and July (8,234 reports). The biggest drop off was between May and June as we transitioned into drier conditions. There wasn't much difference between June and July which is great! We know that it's not very exciting to be reporting zeros but we wanted to thank you for keeping up the good work.

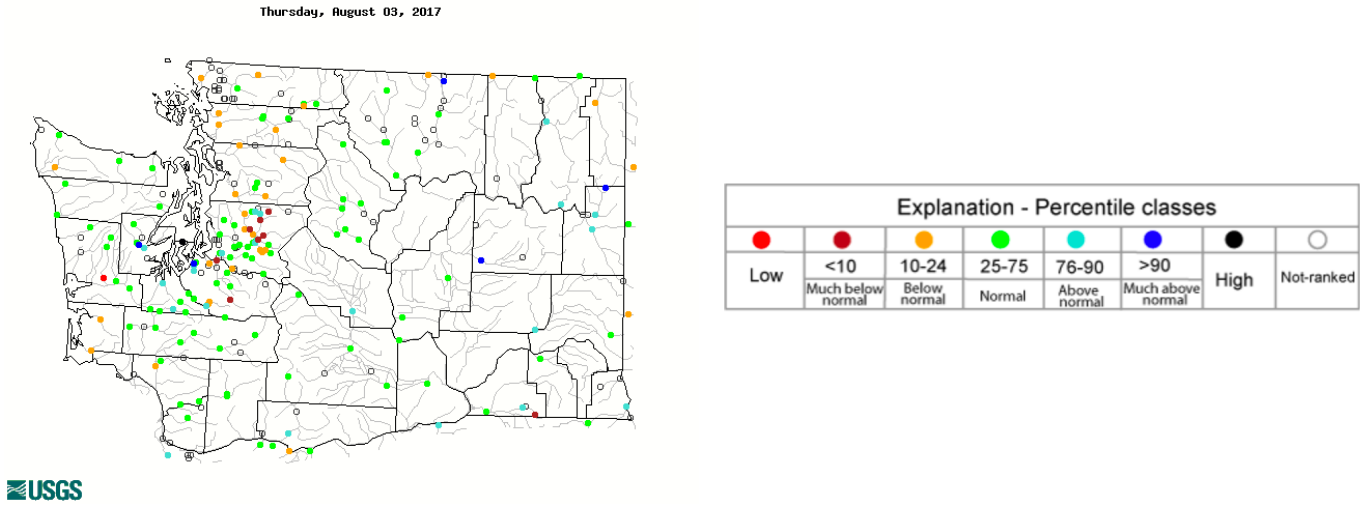


Figure 4: The 28-day average streamflow as of 3 August 2017 for WA. From USGS.

Prediction of Mean Summer Temperatures in Washington State

A message from the State Climatologist

Recent work at OWSC has led us to ponder just how predictable summer mean temperatures are in Washington state. We constructed a simple model for a workshop on El Nino-Southern Oscillation (ENSO) and the seasonal weather of the western US with this question in mind. The model is based on NE Pacific ocean conditions, which have been of special interest and importance due to the marine heat wave in the NE Pacific of 2014-16.

There is a body of existing research showing that ENSO provides much of the current predictability in the seasonal weather of the Pacific Northwest. Most of this work has focused on the winter season, and we thought it might be interesting to explore the connections between our weather and the state of the tropical Pacific in summer. Previous work based on atmospheric model experiments has shown that regional atmospheric pressure/circulation patterns are relatively insensitive to prescribed sea surface temperature (SST) anomalies in the NE Pacific. On the other hand, the atmospheric boundary layer of about a kilometer in depth is typically in quasi-equilibrium with the SST on length scales of hundreds of kilometers. Because the prevailing level flow into WA generally includes a component from the west, there is the potential for our surface air temperature, and humidity, to be systematically impacted by the regional SST. Moreover, because the ocean has a relatively long "memory" due to its thermal inertia, it would seem to provide some predictability, as explored here.

We have evaluated statistical relationships between observed seasonal temperatures and indices for ENSO (specifically the NINO3.4 index) and the regional SST (averaged over a box

extending from 40 to 50°N and 140 to 125°W). We used the framework of a Generalized Additive Model (GAM), which is similar to the technique of multiple linear regression, with the additional less-restrictive feature of allowing nonlinear relationships between predictors and the predictand, i.e., the variable of interest (Hastie and Tibshirani 1990). We constructed and evaluated a variety of GAMs, and also conducted tests in which the early portion of the record is used for training, and the latter portion is used for validation and prediction. The atmospheric circulation anomalies responsible for seasonal weather signals also impact ocean conditions, so here we focus on the regional SST in the month of May prior to the forecast period.

The results from a GAM predicting WA summer (June-August) temperatures using summer values of NINO3.4 and May values of regional SST are summarized here. For the period of 1949 through 2016, NINO3.4 is only marginally linked to summer temperatures, but the regional SST is related with a high degree of statistical significance (confidence level > 99.9%). The two predictors in combination account for about 27% of the variance in WA summer temperatures. The model performs better for the west side of the state (e.g., explains 40% of the variance in summer temperatures in the Puget Sound lowlands climate division). The functional forms in the relationships are illustrated in Figures 5 and 6 for NINO3.4 and the regional SST, respectively. A weak linear fit, with substantial uncertainty in the magnitude of the slope, was found for NINO3.4 with higher values of this index corresponding with warmer than normal summer WA temperatures. The fit for the regional SST was not linear, with higher SSTs corresponding with considerably higher summer temperatures. Note that there are greater spreads in the fit (as indicated by the dashed lines) for extreme values of this predictor, which makes sense since these years are relatively few in number.

We also present the results of using a GAM based on the first two-thirds of the period (1949-1992) as a training data set, to make predictions for the last one-third of the period (1993-2016). The version used here incorporates year as a predictor, to account for long-term temperature trends. The predictions with validating observations are plotted in Figure 7. The simple GAM predicts year-to-year variations in statewide summer temperatures that tend to correspond with, but not match, the observations. The model tends to predict temperatures that are too low during the

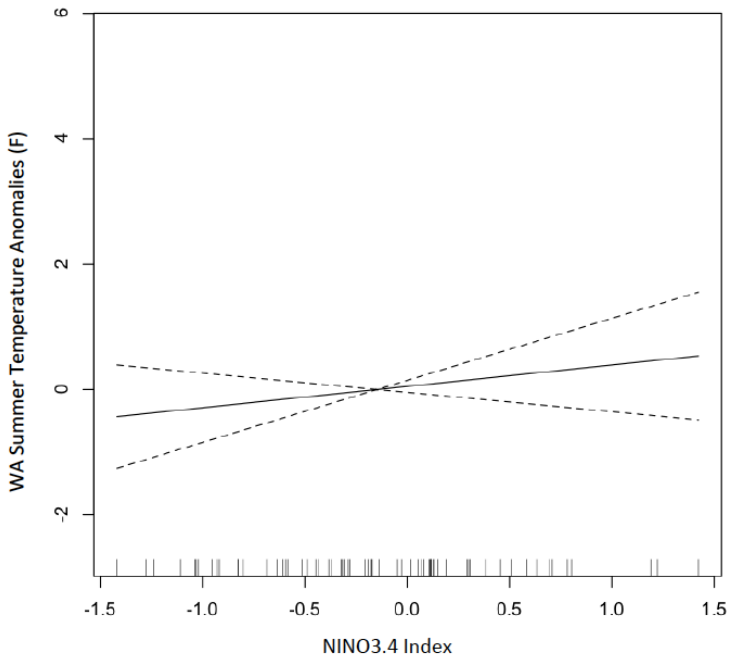


Figure 5: Fitted relationship between NINO3.4 index (x-axis) and WA state mean summer (JJA) temperature anomalies (y-axis; deg. F) based on a GAM using data from 1949 through 2016. The tick marks on the x-axis indicate the individual values of the NINO3.4 index in the years used in the model fit. The dashed lines indicate 95% confidence limits.

hotter summers. An interesting exception is the record hot summer of 2015; the model was actually too warm for that year in association with a NINO3.4 value of 1.2° and an average SST of 12.2°C, the latter being well above any other year in the period considered. The prediction from the model for 2017 is also indicated in Figure 7. Given that statewide temperatures were above normal during June and July, and the absolutely torrid start to the month of August, we strongly suspect that observed temperatures for the summer of 2017 will be much higher than predicted. The discrepancy illustrates the challenge of seasonal weather forecasts and in particular their intrinsic limitations.

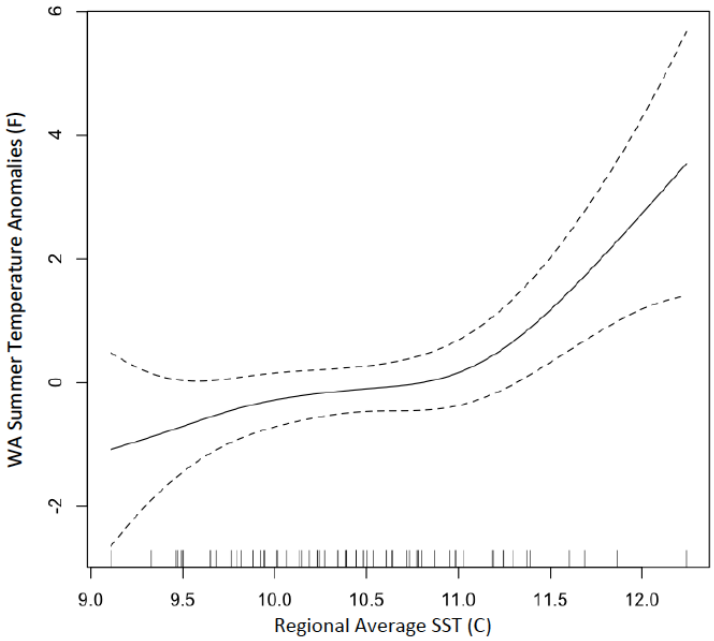


Figure 6: As in Fig. 5, but for the relationship between the May regional average SST (x-axis; deg. C) and WA state mean summer (JJA) temperature anomalies (y-axis; deg. F)

References

Hastie, T., and R. Tibshiran (1990): Generalized Additive Models. Chapman and Hall, London.

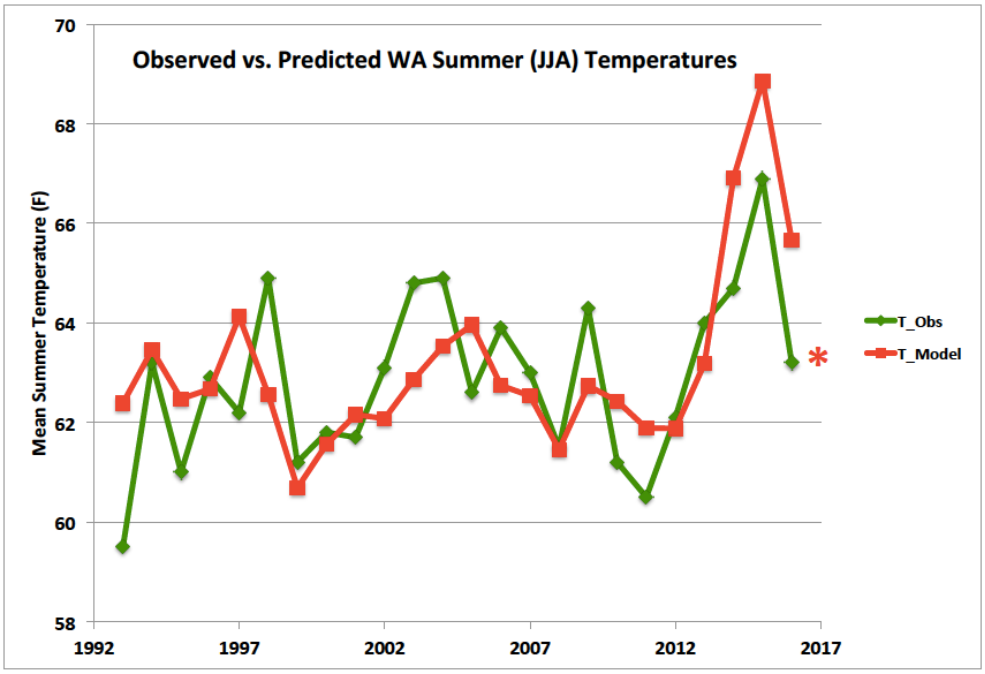
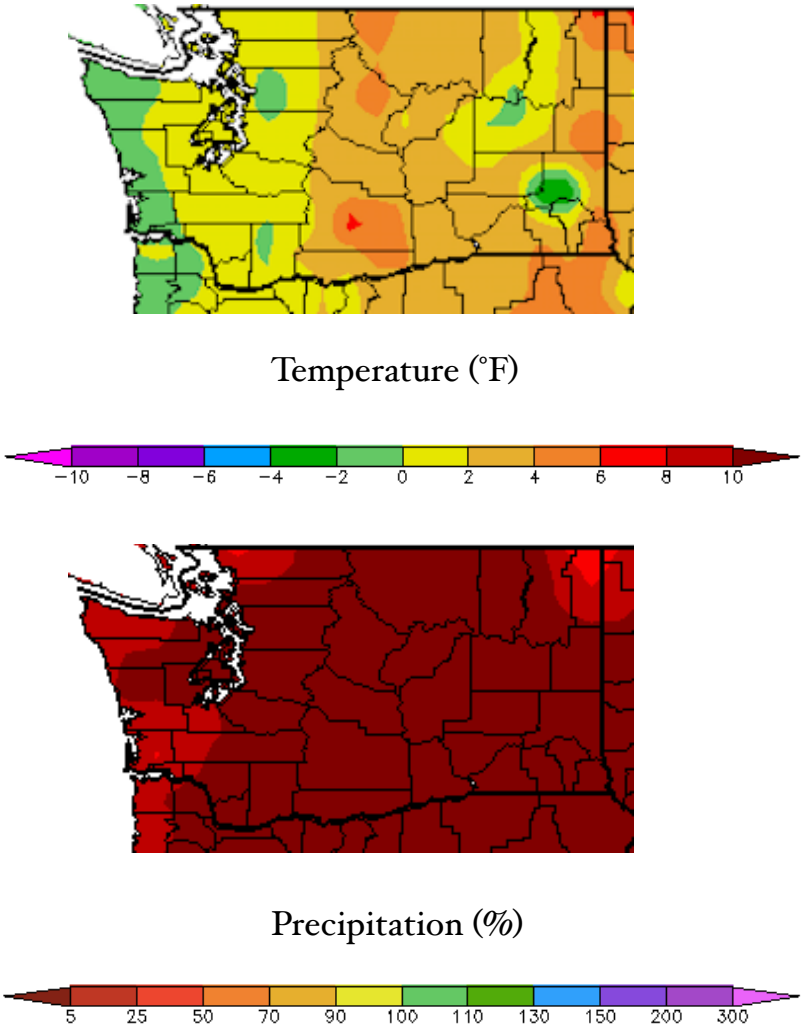


Figure 7: Predicted mean summer (JJA) air temperatures in WA (red trace) for the years of 1993-2016 from a GAM using the summer (JJA) NINO3.4 and the May regional average SST as predictors, and a training data set of the years of 1949-1992. A prediction for 2017 (red star) is included based on the observed SST in May 2017 and a forecast of 0.4 for the NINO3.4 index. The green trace shows the observed mean JJA air temperatures.

Climate Summary

Mean monthly July temperatures were warmer than normal throughout the most of the state. According to the map on the right from the High Plains Regional Climate Center, average July temperatures were between 2 and 6°F above normal statewide, though the coast was actually a few degrees cooler than average. Most of the warmer temperature anomalies were found east of the Cascades. Wenatchee and Spokane were particularly warm last month with average temperatures 3.2 and 4.7°F above normal, respectively.

Total July precipitation was nonexistent, with most of the state receiving almost less than 5% of normal. Many locations, such as Hanford and Ephrata did not receive any measurable precipitation (Table 1). Generally, western WA fared slightly better in the sense that some places did receive measurable precipitation. For example, Quillayute and Hoquiam received 12 and 9% of normal precipitation with 0.24" and 0.10", respectively.



July 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)		
	Avg	Normal	Departure from Normal	Total	Normal	% of Norm
Western Washington						
Olympia	64.8	63.8	1.0	0.05	0.63	8
Seattle WFO	67.0	65.9	1.1	0.03	0.79	4
SeaTac AP	67.3	65.7	1.6	T	0.70	0
Quillayute	58.8	58.9	-0.1	0.24	1.98	12
Hoquiam	60.3	59.9	0.4	0.10	1.14	9
Bellingham AP	63.5	62.3	1.2	M*	1.18	M
Vancouver AP	69.5	68.4	1.1	T	0.69	0
Eastern Washington						
Spokane AP	74.5	69.8	4.7	T	0.64	0
Wenatchee	77.4	74.2	3.2	0	0.27	0
Omak	75.6	72.7	2.9	0	0.81	0
Pullman AP	70.3	65.6	4.7	0.02	0.69	3
Ephrata	76.7	74.2	2.5	0	0.40	0
Pasco AP	76.5	73.5	3.0	T	0.28	0
Hanford	80.3	77.1	3.2	T	0.18	0

Table 1: July 2017 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 NCDC's new normal release, as records for these station began in 1998 and 1986, respectively. "M" denotes missing data.

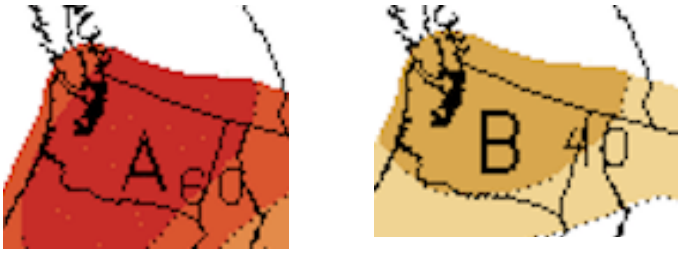
***The precipitation gauge at the Bellingham station is still underreporting so precipitation information is unavailable for July**

Climate Outlook

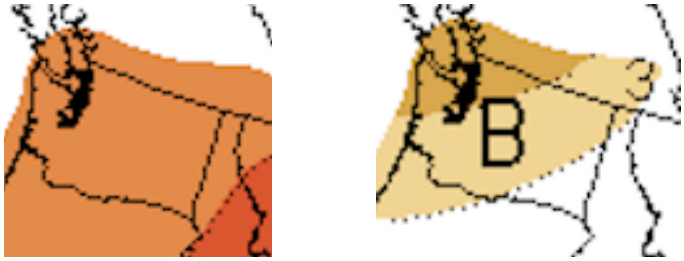
ENSO-neutral conditions are still present in the equatorial Pacific, according to the Climate Prediction Center (CPC). Over the course of the last 4 weeks, sea-surface temperatures (SSTs) have remained slightly above normal in the western and east central Pacific Ocean while remaining near normal everywhere else. Current models are indicating slightly higher chances of neutral conditions (55%) continuing through fall 2017.

The CPC seasonal outlook for August is calling for increased chances of above average temperatures statewide. For August precipitation, precipitation is favored to be below average. Most of the state with the exception of southeast WA has chances exceeding 40% of below average precipitation.

The August-September-October (ASO) outlook is calling for higher than normal temperatures statewide. With regards to precipitation, the outlook indicates that for most of WA, there are increased chances for below average precipitation. Southeast WA is the only place where conditions favor equal chances of below, near normal, or above normal precipitation totals.



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



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