# Office of the Washington State Climatologist

September 2018 Report and Outlook

September 10, 2018

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

## August Event Summary

Mean August temperatures were generally warmer than normal in western WA and near-normal in eastern WA. August precipitation, on the other hand, was consistently much below normal for nearly the entire state. Beginning in May, the last 4 months have been much drier than usual for nearly the entire state. Figure 1 shows the May-August 2018 percent of normal precipitation for WA, indicating only 20-40% of normal for large areas of the state. Averaged statewide, May-August ranks as the 3rd driest on record (since 1895) behind 2003 and 1938. Despite the near-normal temperatures in parts of the state in August, temperatures have otherwise been consistently warm throughout the dry season, with May-August ranking as the 3rd warmest on record (behind 1958 and 2015) statewide with a +2.4°F anomaly.

As for the weather progression throughout the month, a mild start to the month gave way to above normal temperatures during the first full week of August, as pictured in the daily temperature plot for Olympia (Figure 2). Some daily maximum temperature records were broken during this stretch; for example, on the 7th, Bellingham (87°F) and Seattle Weather Forecasting Office (89°F) set records. Olympia reached 96°F on the 8th (not a daily record), the warmest temperature recorded there for the month (Figure 2). Much warmer temperatures were recorded in

### In this Issue



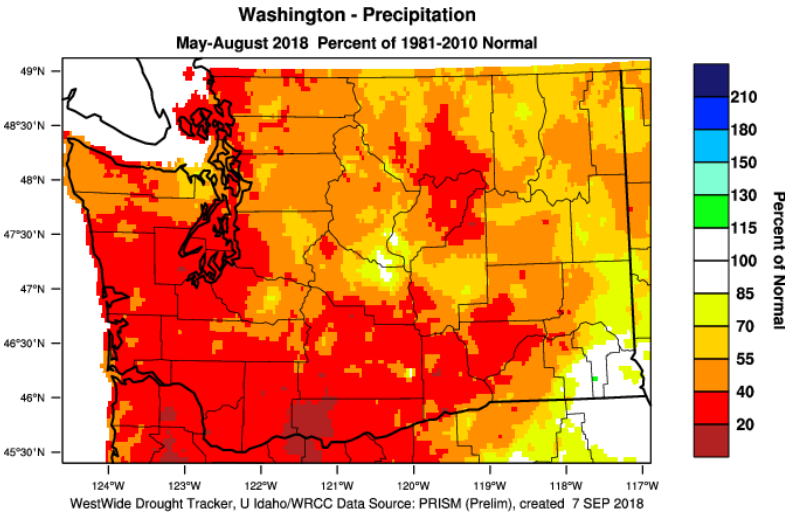



**Figure 1: May-August percent of normal precipitation for WA State (WWDT).**

eastern WA shortly thereafter with record daily highs set at Odessa (109°F), Omak (105°F), Pullman (105°F), Spokane Airport (103°F - tie), and Plain (100°F) all on the 9th.

Another round of warmer than normal temperatures occurred in western WA late in the month, with daily high temperature records set at Bellingham (87°F) on the 20th and at SeaTac Airport (91°F) and Hoquiam (87°F) on the 21st. Temperatures cooled to normal at the end of the month, with some daily low temperatures even falling below normal (shown in Figure 2), which did not happen very often this summer.

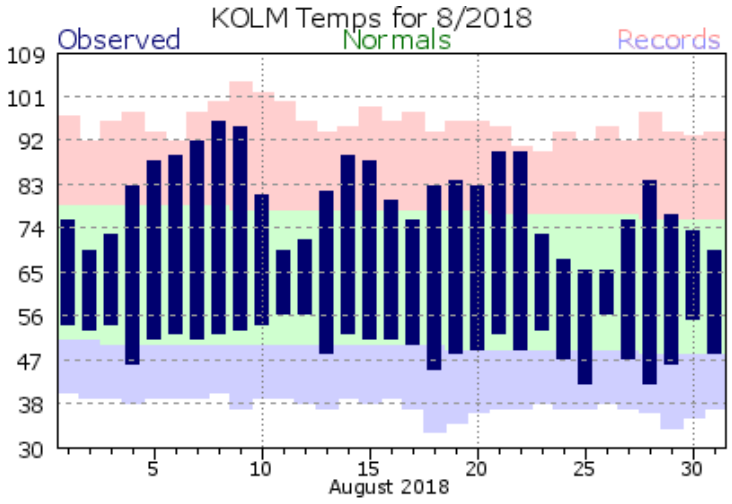



**Figure 2: Daily August 2018 temperatures (dark blue bars) for Olympia Airport with the normal range of temperatures (green envelope) and historical records (red and blue envelopes). NWS**

We would be remiss in not mentioning the persistent wildfire smoke in WA state during the month of August. In fact, there were times where air quality in the Pacific Northwest was the worst in the country. Numerous wildfires were burning in WA, but much of the smoke originated in British Columbia and Oregon, both of which have had very active fire seasons. Figure 3 shows the particulate matter less than 2.5 microns (PM2.5, or the tiny particles that can get deep into a person's lungs) for monitoring sites in Seattle, Spokane, and Wenatchee during August with lines indicating how the PM2.5 corresponds to the Air Quality Index. The poor air quality is remarkable, with several days in the "Unhealthy" category even in Seattle.

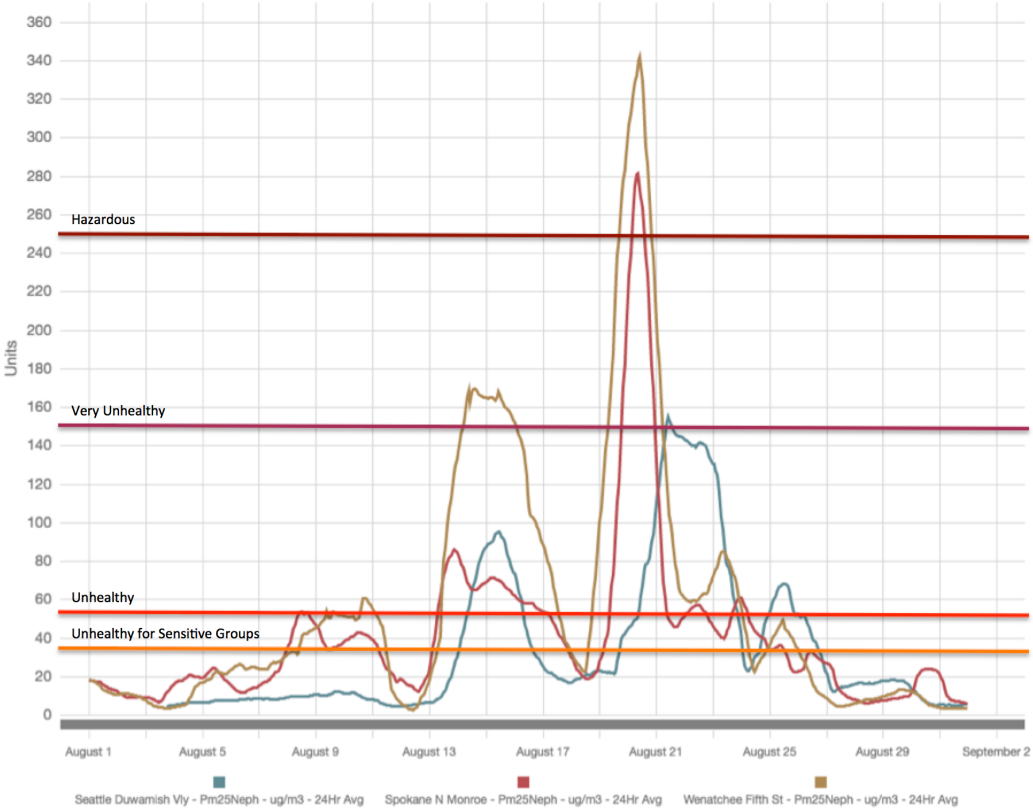



**Figure 3: 24-hr average PM2.5 concentrations (ug/m3) for Seattle, Spokane, and Wenatchee during August 2018 (from Puget Sound Clean Air Agency).**

# Drought Monitor and Streamflow Update

The warmer and drier than normal August conditions and continued deterioration of streamflows have prompted the U.S. Drought Monitor to worsen the depiction of drought conditions in the state (Figure 4). Since last month's newsletter, both "moderate drought" (D1) and "severe drought" (D2) have been expanded in western WA and across the northern border of the state. Low soil moisture, lack of precipitation, and near record low streamflows all support this depiction.

The monthly average August streamflow is shown in Figure 5, indicating streamflows below the 10th percentile in southwestern WA, the Olympic Peninsula, parts of the Puget Sound region, and the WA-Canadian border. Many more streams are in the 10th-24th percentile range, mostly west of the Cascade Mountains.

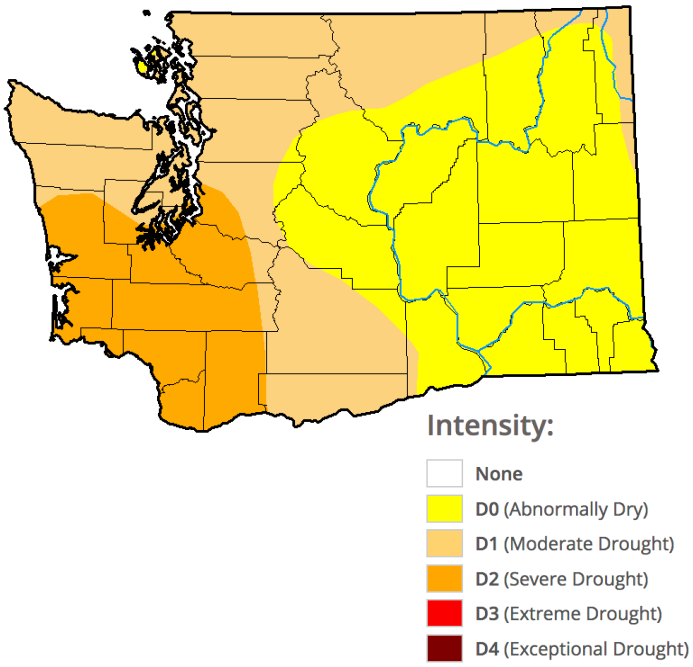



**Figure 4: The September 6, 2018 version of the U.S. Drought Monitor.**


photo by Henry Reges, CoCoRaHS

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

Greetings, CoCoRaHS observers! There has been little to report during our dry months (though hopefully you've still been reporting your "zeros"), but our wet season is on the horizon. In preparation for the new water year beginning on October 1 (less than a month away!), now is a good time to clean out your rain gauge. CoCoRaHS recommends cleaning with dish soap and a bottle brush. OWSC has found that rolled up newspaper works just as well as a bottle brush to remove any grime built up in the inner measuring tube.

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.

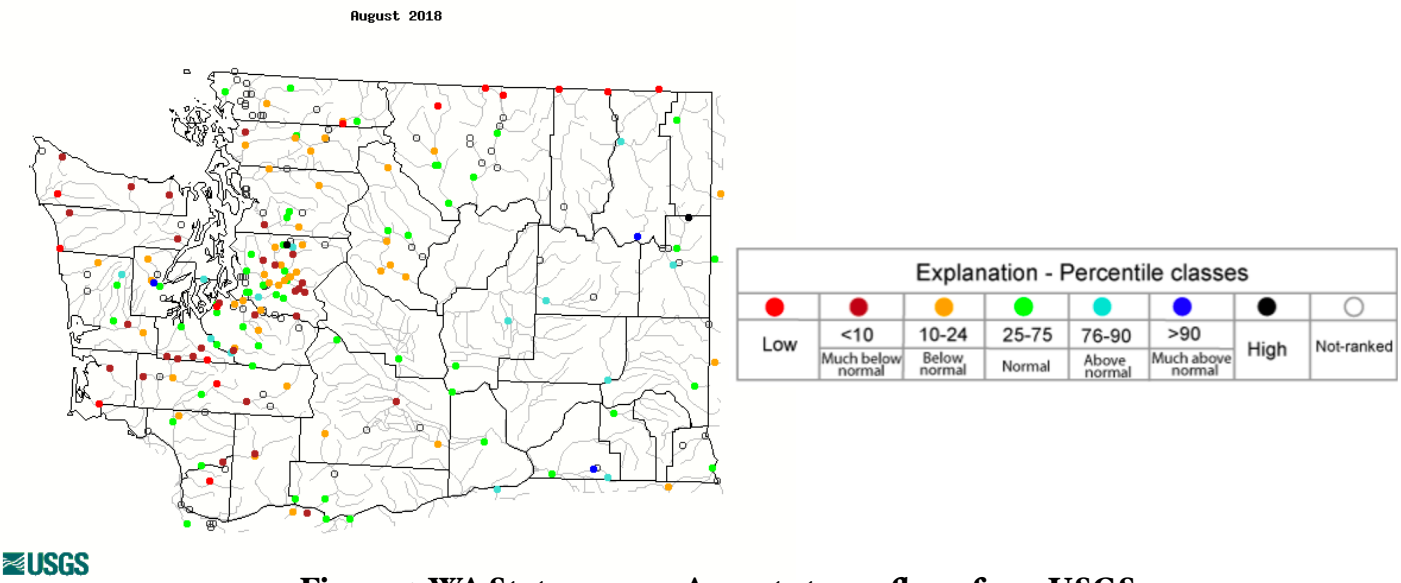



**Figure 5: WA State average August streamflows from USGS.**

# New Visualization: Updated PNW Temperature, Precipitation, and Snow Water Equivalent Trend Tool

## A message from the State Climatologist

OWSC, in partnership with UW's Climate Impacts Group, is pleased to announce that our new Pacific Northwest Trend Analysis tool is now available for exploration: http://www.climate.washington.edu/trends/. An older and outdated version of this tool using the Google Maps interface was formerly the most popular tool on OWSC's website, allowing users to select and view trends in the PNW for temperature, precipitation, and snow water equivalent. The tool was migrated to Tableau (https://www.tableau.com/) and the upgrades made are highlighted here. We want to acknowledge the work of our former assistant, Matthew Rogers – now a graduate student at the University of Oklahoma - who primarily built the visualization.

The Trend Analysis tool allows the user to view time series and calculate linear trends in monthly average, maximum, and minimum temperatures, precipitation, and snow water equivalent (SWE) for any selected time period within the period of record for the particular station. Each of these variables is accessible using the separate tabs on the top of the visualization (Figure 6). For temperature and precipitation, the user can select stations in Washington, Oregon, Idaho or western Montana (hereafter "Pacific Northwest") while the monthly snow water equivalent data (available on the first of January through April) is only available for Washington State. Seasonal averages (e.g., July through August or December through February) are additional options for the temperature and precipitation variables.

The primary goal of migrating the Trend Analysis tool into Tableau was to improve its functionality and aesthetics. But with rebuilding the interface came other opportunities for improvement. The tool now indicates on both the map and on the table on the left-hand side of the page whether the selected trend is significant at the 95%

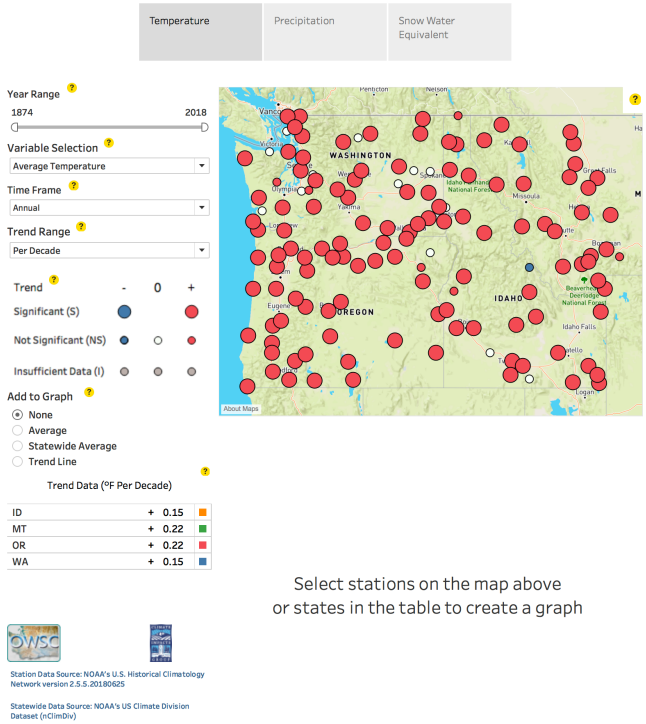



**Figure 6: The homepage for the PNW Temperature, Precipitation, and SWE Trend Analysis Tool for average temperatures. Note the gray tabs on the top for different variables.**

confidence level threshold. Figure 7a shows an example for fall average temperatures at Port Townsend and Cushman Powerhouse stations. The former has a significant warming trend as signified by the "S" in the legend while the latter is not significant ("NS"). The size of the station marker on the map is also determined by the significance of the trend with the larger circles indicating significance and the smaller circles lack of significance (Figure 7b). Hovering the mouse over each of the station markers shows the rate of change, as well as the elevation and the year range for each station. We use a two-tailed t-test with effective degrees of freedom to determine significance. Since short climate records can yield spurious trends, statistical significance is not determined for any time period less than 30 years, and gray circles are shown on the map instead.

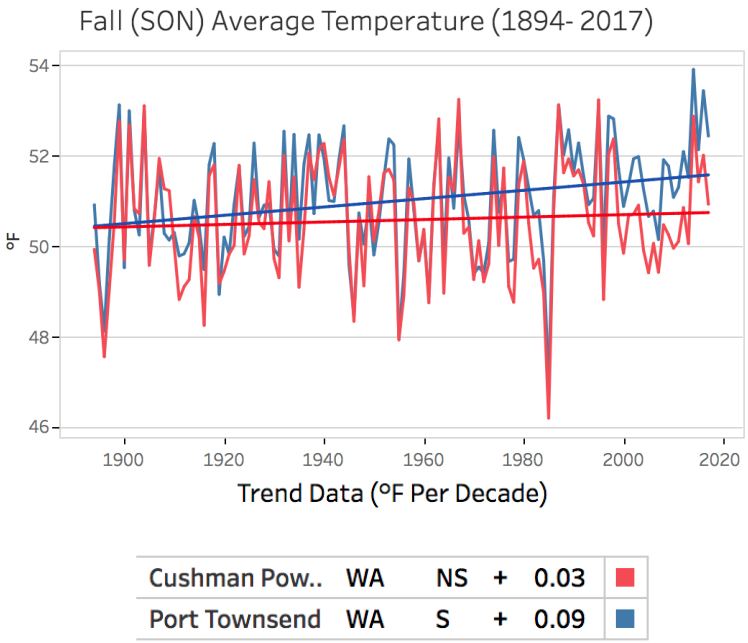



**Figure 7a: Fall (Sept-Nov) average temperature time series for Cushman Powerhouse and Port Townsend on the Olympic Peninsula. The trend is not significant for Cushman Powerhouse but is significant at the 95% confidence level for Port Townsend.**

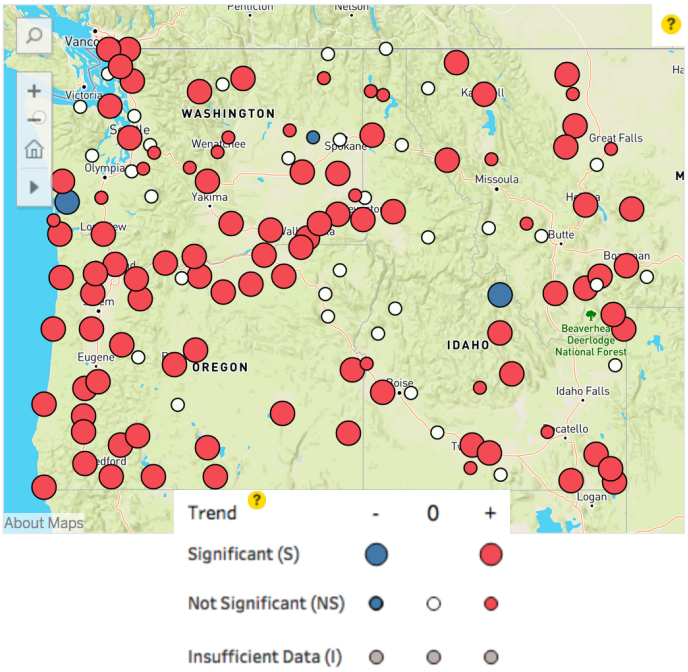



**Figure 7b: Fall (Sept-Nov) average temperature trends at each station for the period of record. The large, red dots indicate significant increasing trends. The increasing temperature trend vastly outnumber the two significant, decreasing temperature trends (large, blue dots).**

Some other properties of the tool include the ability to select any time period from the earliest data available, in 1874, to the most recent, in 2018. Another user-requested option is the ability to view the change in temperature, precipitation, or SWE per year, per decade, or over the entire period selected. The change in precipitation and SWE over the time period is also expressed in percent change, in addition to the absolute change in inches. Finally, the user has the option to select multiple stations at once, and average over those selections. A help guide for the map selection options (Figure 8) is included on the page with the Trend Analysis tool since the steps for selecting multiple stations may not be obvious. The user needs to select any of the last 3 options that appear under the "arrow" button as indicated in the help guide to select multiple stations from the map. The small, yellow circles with the question marks embedded throughout the visualization also provide some explanation of the various options.

Specifics on the data sets used in the Trend Analysis tool are described below, and links are provided for all of the data sources within the visualization. Enjoy exploring the new visualizations and please let us know if any bugs or glitches are encountered.

Data sources:
We used NCEI's USHCN version 2.5 data for our monthly temperature input data, which uses an objective method to identify any non-climatic trends in the time series that may have resulted from station moves, urbanization, instrument changes, and changes in the time of observation (Menne et al. 2009). The objective method is based primarily on comparisons to nearby stations, and makes the dataset ideal for examining trends. The USHCN version 2.5 data also provides monthly precipitation data, but those data are not adjusted for systematic biases so more caution

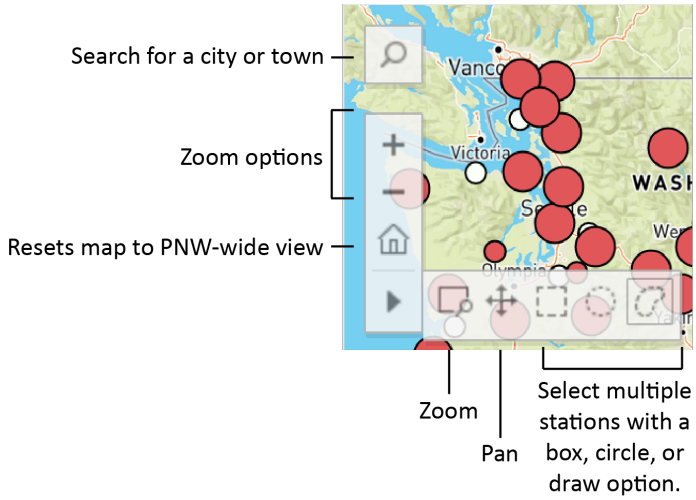



**Figure 8: Key for how to control the map and select multiple stations.**

should be used in interpreting the trends there. The temperature and precipitation data included in the tool is for 137 stations spanning Washington, Oregon, Idaho, and western Montana. Statewide average temperature and precipitation data for the 4 states included in the visualization are from NCEI's climate division dataset; even though only western Montana stations are included in the tool, the Montana statewide average is for the entire state. The monthly snow water equivalent (SWE) data are from the NRCS snow course data set for WA State only (49 stations), and did not undergo an additional quality control process beyond that carried out by NRCS.

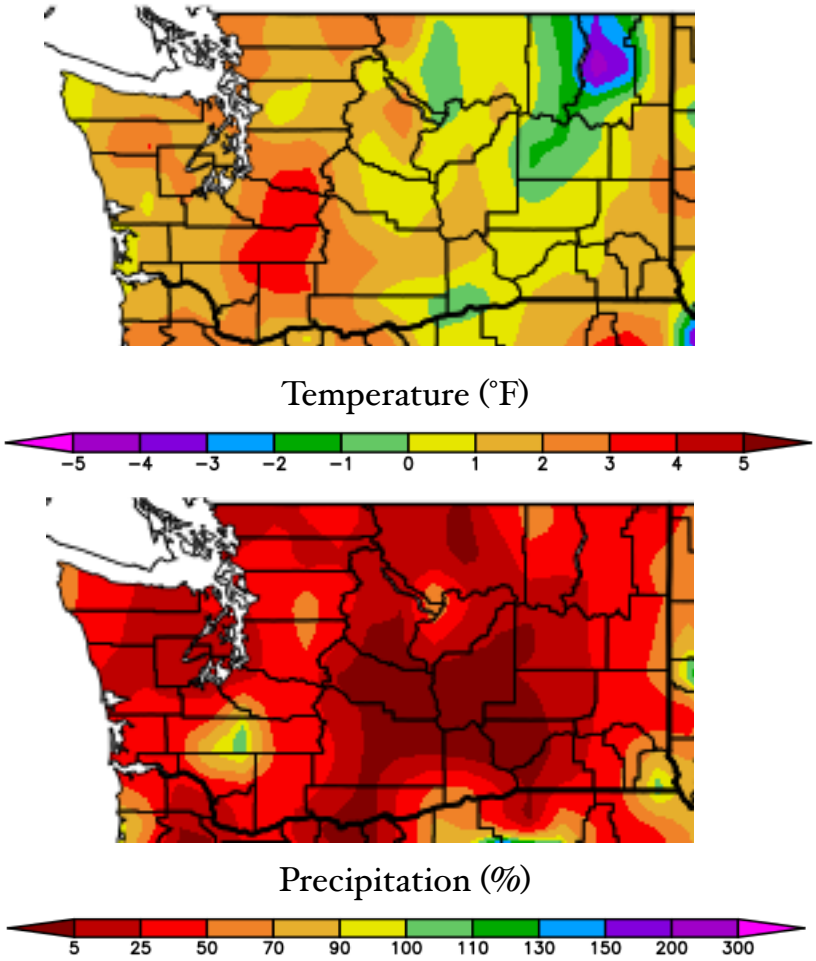
Reference

Menne, M.J., C.N. Williams, and R.S. Vote (2009): The U.S. Historical Climatology Network Monthly Temperature Data, Version 2, *BAMS*, 993-1007.

# Climate Summary

Mean August temperatures were warmer than normal for most of WA State, but there were portions of eastern WA with near-normal to below normal temperatures. Western WA stations were largely between 2 and 3°F above normal such as Seattle (2.0°F or 2.7°F above normal depending on the station), Hoquiam (1.9°F above normal), and Bellingham (2.6°F above normal). East of the Cascade crest, Wenatchee, Omak, Pasco, and Hanford were all near-normal (albeit slightly on the warmer side), with persistent smoke from wildfires likely playing a role in keeping temperatures lower. Below normal temperatures are even indicated on the map on the right from the High Plains Regional Climate Center in Ferry, Stevens, and Lincoln counties. In contrast, Pullman saw anomalies similar in magnitude to those recorded in western WA, with temperatures 2.7°F above normal for August.

Total August precipitation was much below normal throughout WA State, with some locations in eastern WA (e.g., Wenatchee, Ephrata, and Pasco) only receiving a "trace" for the entire month. Of the locations listed in Table 1, Quillayute received the most precipitation with 1.44", but that was still only about half of what normally falls in August. Other locations around the state received 25% of normal or less for the month.




**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 | 65.8 | 64.1 | 1.7 | 0.17 | 0.94 | 18 |
| Seattle WFO | 68.5 | 66.5 | 2.0 | 0.28 | 0.97 | 29 |
| SeaTac AP | 68.8 | 66.1 | 2.7 | 0.20 | 0.88 | 23 |
| Quillayute | 60.1 | 59.6 | 0.5 | 1.44 | 2.49 | 58 |
| Hoquiam | 62.5 | 60.6 | 1.9 | 0.23 | 1.31 | 19 |
| Bellingham AP | 65.1 | 62.5 | 2.6 | 0.27 | 1.23 | 22 |
| Vancouver AP | 70.8 | 69.2 | 1.6 | 0.09 | 0.77 | 12 |
| Eastern Washington | | | | | | |
| Spokane AP | 70.7 | 69.3 | 1.4 | 0.17 | 0.59 | 29 |
| Wenatchee | 74.1 | 73.5 | 0.6 | T | 0.20 | 0 |
| Omak | 72.8 | 72.4 | 0.4 | 0.02 | 0.49 | 4 |
| Pullman AP | 68.4 | 65.7 | 2.7 | 0.32 | 0.63 | 51 |
| Ephrata | 74.1 | 72.9 | 1.2 | T | 0.19 | 0 |
| Pasco AP | 73.2 | 72.8 | 0.4 | T | 0.27 | 0 |
| Hanford | 76.5 | 75.8 | 0.7 | 0.01 | 0.23 | 4 |

**Table 1: August 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.**

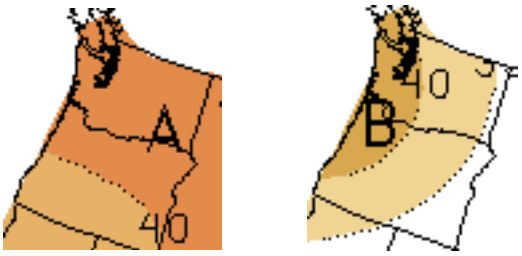
# Climate Outlook

ENSO-neutral conditions are still present in the tropical Pacific Ocean with equatorial sea surface temperatures (SSTs) largely near-normal. SSTs in the Niño4 region (central equatorial Pacific) are the exception and are above normal on the monthly and weekly time scale. An "El Niño Watch" was issued by the CPC in August, and ENSO models are indicating El Niño development during the September-November season. The probability of El Niño is at about 70% during winter 2018-19.

The September temperature outlook from the CPC has equal chances of below, equal to, or above normal temperatures for the entire state. The September precipitation outlook, on the other hand, indicates increased chances of below normal precipitation for the entire state.

The fall (September-November) CPC seasonal outlook is calling for 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 western WA.


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




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

**(Climate Prediction Center)**