Office of the Washington State Climatologist

April 2019 Report and Outlook

April 3, 2019

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

March Event Summary

Mean March temperatures were much below normal in eastern Washington, and ranged from below normal to above normal in western WA. Figure 1a shows the temperature percentiles for WA based on the 1895-2010 historical records, indicating that temperatures in some portions of the Lower Columbia Basin in record territory. Average March temperatures in Wenatchee, Richland, Pasco, and Walla Walla, for example, all ranked as the coldest on record (Table 1). Records were set regarding precipitation as well. March precipitation was below normal statewide, with precipitation percentiles indicating March 2019 in western WA among the bottom 10% of the historical record (Figure 1b). Sequim and Quillayute recorded their driest March on record, for example (Table 2).

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The month began cold statewide, in a continuation of the overall weather regime of February. Spokane (-1°F) and Goldendale (4°F) set record low temperature records on the 1st, and record low temperatures continued to be set through the 15th. On the 4th, record low temperatures were set at Pullman (-9°F), Wenatchee (4°F), Goldendale (1°F),

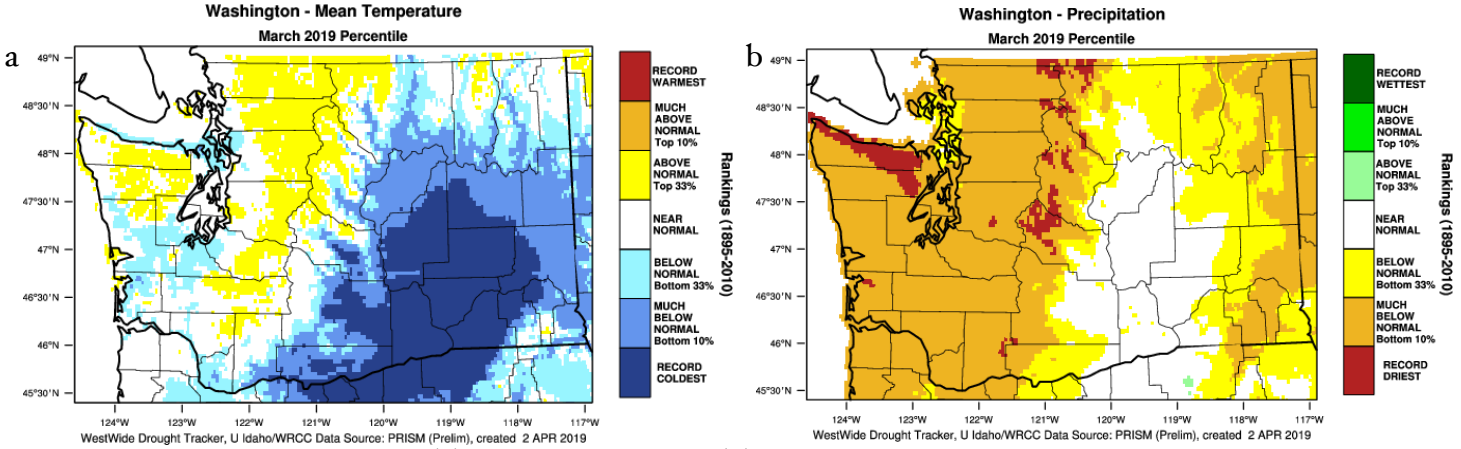


Figure 1: March 2019 (a) temperature and (b) precipitation percentiles compared to the 1895-2010 historical record (WWDT).

Station	Average March Temperature (°F)	Rank	March Average Temperature Record	Records Began
Wenatchee	35.9	1	-	1959
Richland	36.0	1	-	1944
Pasco	35.5	1	-	1945
Walla Walla	37.8*	1	-	1949
Pullman	33.0	2	29.9°F; 1955	1940

Table 1: Average March temperature rankings for selected eastern WA stations. *Walla Walla has 1 missing day.

Station	Total March Precipitation (in)	Rank	March Precipitation Record	Records Began
Sequim	0.14	1	-	1980
Quillayute	1.51	1	-	1966
Olympia	1.39	2	0.48"; 1965	1941
SeaTac AP	1.37	2	0.57"; 1965	1945
Bellingham AP	1.08	3	0.76"; 1965	1949
Hoquiam	1.96	3	1.39"; 1965	1953

Table 2: Total March precipitation rankings for selected western WA stations.

Kennewick (8°F), and Olympia (16°F). Both the Pullman and Wenatchee low temperatures on the 4th set new monthly low temperature records, demonstrating the extent of the cold that gripped the state. In western WA, Quillayute set low temperature records of 21°F or 22°F on the 6th, 9th, and 10th.

In a complete reversal, the second half of March was much warmer than normal, especially west of the Cascades Mountains. Record high temperatures were set throughout western WA from the 17th through the 20th. For example, Quillayute (81°F), SeaTac Airport (79°F), Hoquiam (79°F), Olympia (78°F), Bellingham (74°F) all set record high temperatures on the 19th. These temperatures for SeaTac Airport, Quillayute, and Hoquiam set all-time record high temperatures for March.

The swing in March temperatures was impressive (Figure 2). SeaTac Airport, for example, had its largest difference between the highest maximum temperature (79°F) and lowest maximum temperature (40°F) for any March on record: 39°F. The 51°F difference between the highest maximum temperature and lowest minimum temperature (28°F) was second in the record to March 1955 (T max: 64°F; T min: 11°F). going back to 1945. The warm spell in eastern WA for the second half of March wasn't quite as impressive. Spokane Airport had its 6th largest temperature spread in March maximum temperature of 41°F (highest T max: 62°F; lowest T max: 23°F) but has a much longer record (since 1881).

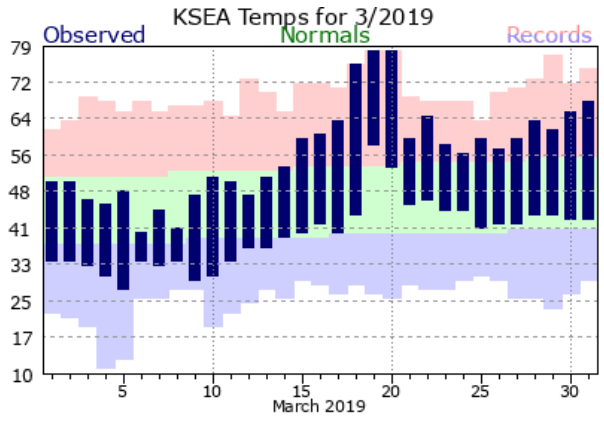


Figure 2: Daily March 2019 temperatures (dark blue bars) for SeaTac Airport compared to normal (green envelopes) and historical records (red and blue bars). NWS

Snowpack and Drought Update

The drier than normal March conditions did not help snowpack across the state, and the snowpack percentages of normal on April 1 are lower than they were a month ago. For many sites, snow water equivalent (SWE) built during the cooler, wetter first half of the month but began to drop mid-month when western WA and the Cascades were warmer than normal. The April 1 basin average snow water equivalent (SWE) percent of normal from the Natural Resources Conservation Service is shown in Figure 3. The Lower Snake-Asotin and Lower Yakima basins are doing the best, with near-normal values of 102 and 92% of normal, respectively. Snowpack in the rest of the state is below normal, ranging from 64 to 86% of normal.

The drier than normal February and March conditions prompted the U.S. Drought Monitor map (Figure 4) to add "abnormally dry" - D0 - conditions to western WA and expand the coverage of "moderate drought" in north central WA.

OWSC and the WA Department of Ecology need more help tracking impacts from drought in WA 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. Your on-the-ground observations are critical for us to understand the broad picture of potential drought in state. Please considering entering a report; the impact reporting is accessible via the National Integrated Drought Information System (NIDIS) Washington page as well.

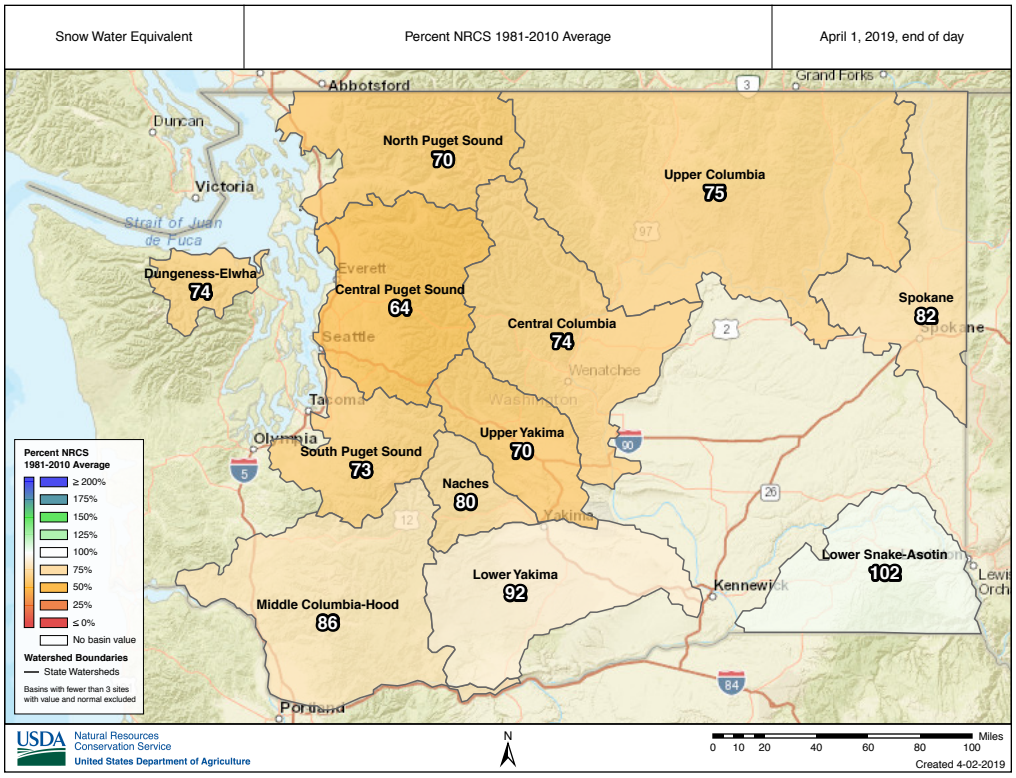


Figure 3: Snowpack (in terms of snow water equivalent) percent of normal for WA as of 1 April 2019 (NRCS).

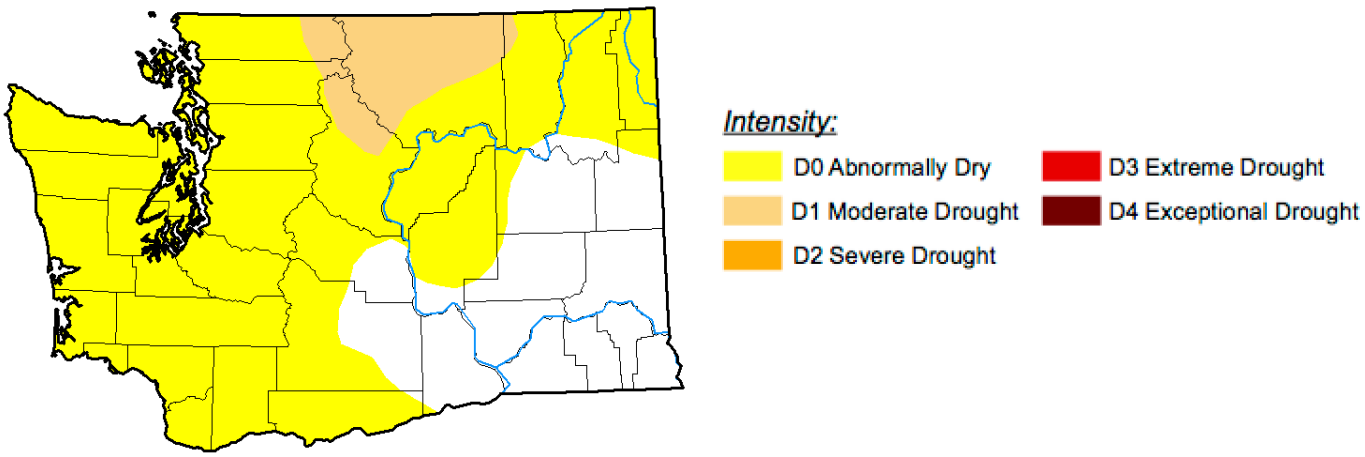


Figure 4: The 28 March 2019 edition of the US Drought Monitor.

Melting of the Cascade Mountain Snowpack in Spring

A message from the State Climatologist

The date of 1 April is often considered the end of winter for the Cascade Mountains of the Pacific Northwest. Snow can continue to fall in the high country, of course, but the vast majority of the accumulation has generally occurred by that time of year. This means that the main issue involving our precious snowpack now is not so much how much there will be but rather how long will it last. Sometimes it hangs around well into summer and other times it melts and runs off quickly. And the latter implies not just less water in the snowpack "reservoir" for summer, but can lead to significant flooding, as for the Okanogan River in north central WA in 2018. With that in mind, we have examined recent trends in the melting, arbitrarily defined as the difference in the snow water equivalent (SWE) on 1 June versus 1 April, and how closely mean weather conditions relate to the changes in snowpack over that two-month period. We assume SWE values are important on 1 June because that is when irrigation demands go up, and freshwater ecosystems can start to become adversely impacted by low streamflows.

The present analysis uses SWE data on the first day of the month from 5 sites along the spine of the Cascades (Harts Pass at 6490', Stevens Pass at 3950', Stampede Pass at 3850', White Pass at 4440' and Lone Pine at 3930'). Data are available for all 5 of these stations for the years of 1983 through 2018 from the Natural Resources Conservation Service (NRCS). The weather data considered are the monthly mean values of temperature and precipitation for April and May from the Cascades Mountains West (#5) and East Slope Cascades (#6) climate divisions of WA. As an aside, it turns out the average of these two temperatures is closely related to the corresponding 850 hPa temperatures from the NCEP Reanalysis (linear correlation coefficient ~.97).

Time series of the composite April 1 SWE, and the composite decrease in SWE from 1 April to 1 June, are plotted in Figure 5. Both time series feature prominent year-to-year variations and little in the way of systematic trends. The latter result is no big surprise since a 36-year record is on the

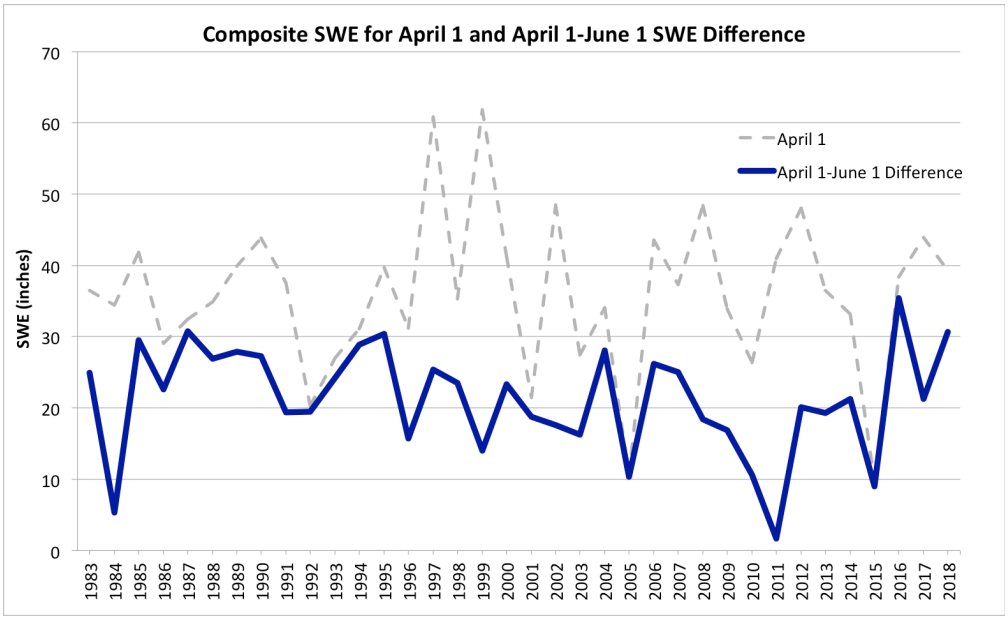


Figure 5: Composite values of the snow water equivalent (SWE) in inches on 1 April (gray, dashed line), and change in SWE from 1 April to 1 June (blue) for 1983-2018.

short side for identifying climate trends. If there is not much snow to begin with obviously there is not that much to melt (such as in 2005 and 2015), but there are years with lots of snow on 1 April without much of a melt/decrease during the following two months (notably 1984 and 2011).

We expect that snowmelt will be positively related to temperature but just how strong is this relationship? The linear correlation coefficient between the composite 1 April to 1 June decrease in SWE with the climate divisions' temperature for April and May is about 0.67; a scatter plot between the two variables is shown in Figure 6. A fairly tight linear relationship is found with the exception of the outliers represented by the years of 1992, 2005 and 2015. The temperatures these years were evidently warm enough to melt more snow, but there simply was not that much to begin with on 1 April. With those three years removed, the linear correlation coefficient between the decrease in SWE and temperature increases to about 0.9, indicating quite an impressive relationship.

There remains some variability in SWE decrease not strictly related to temperature and we were curious about how precipitation in spring relates to changes in snowpack. The sense of the linkage is not obvious because conceivably more precipitation could serve to melt more snow or conversely, more precipitation could result in more snowfall, especially in April, which would counter the melting. Considering the two months of April and May as a whole, the overall result was that there was a tendency for less of a decrease in SWE during years of greater precipitation (r-0.4). In other words, precipitation in spring may tend to enhance the snowpack rather than melt it. This is plausible in that the "ripe" snowpacks of early spring generally include channels that allow liquid water entering the top of the snowpack to drain out without much melting. Finally, it bears noting that temperature and precipitation are not independent variables – conceivably the negative correlation found here is simply due to the negative correspondence between temperature and precipitation. It is possible to use multivariate statistical models to investigate the interdependency of these kinds of linkages, but such an analysis is beyond the scope of the present effort.

The results shown here may have some meaningful implications. If on 1 April we knew what the mean temperatures were going to be in

the Cascades during the next couple of months (and 850 hPa temperatures are sufficient), it looks like we would also be able to make reliable projections of how much SWE would be left on 1 June, at least for the Cascades as a whole. That is a big if, of course. But it is intriguing that other aspects of the weather in spring (e.g., cloud cover) do not seem to really matter.

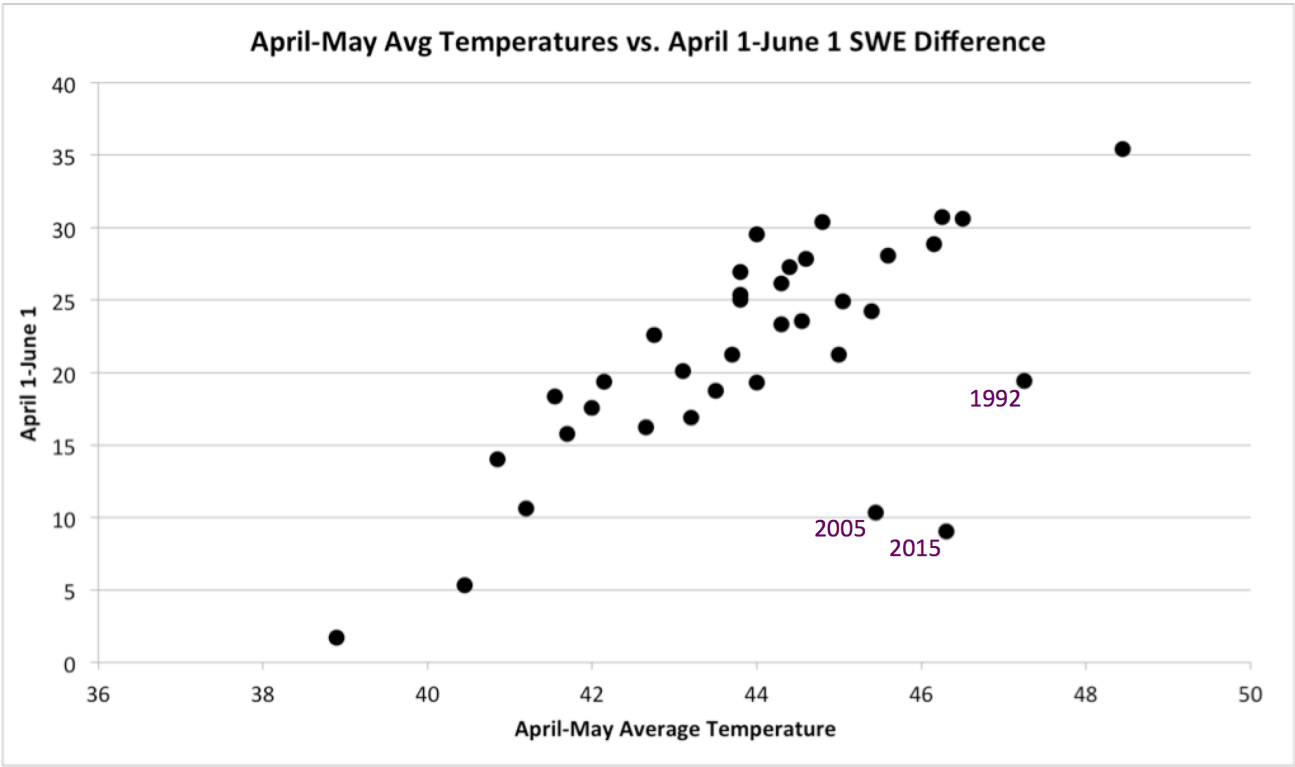


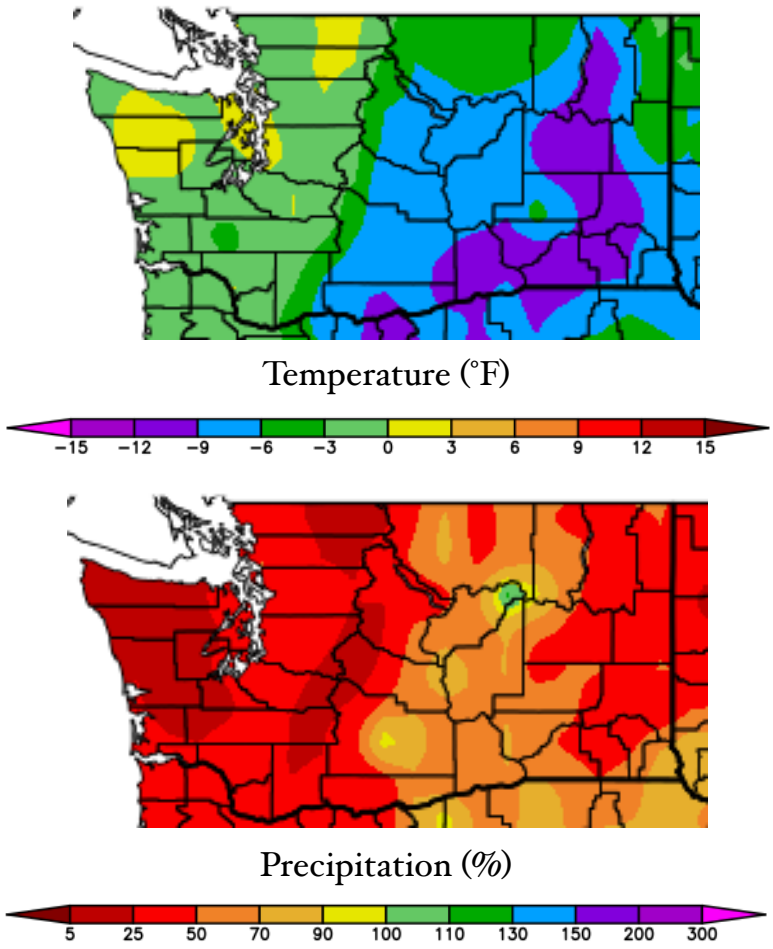
Figure 6: Composite values of the change in SWE from 1 April to 1 June (y-axis) versus April-May mean temperatures for the West Cascade and East Slopes Cascade climate divisions (x-axis) for 1983-2018. The 3 outliers mentioned in the text are labeled in purple.

Climate Summary

Mean March temperatures were below normal for a majority of the state, with the largest cold anomalies east of the Cascade Mountains. As seen on the map from the High Plains Regional Climate Center (right), average March temperatures were between 6 and 12°F below normal in most of eastern WA. Specific stations, such as Wenatchee and Pasco, saw average March temperatures 8.2 and 10.8°F below normal, respectively. Spokane Airport was 5.6°F below normal for the month (Table 3). The anomalies in western WA were smaller, with temperatures generally within 3°F of normal. In Table 3, Vancouver was a cool spot, with temperatures 3.2°F below normal. On the other hand, there were a few locations with near to above normal temperatures. Bellingham and Seattle, for example, were near-normal with anomalies of +0.1 and +0.8°F, respectively.

Total March precipitation was much below normal throughout the state, especially west of the Cascade Mountains. The Olympic Peninsula was especially dry, receiving only between 5 and 25% of its normal precipitation. Quillayute, for example, only measured 14% of normal in a month where nearly 11" of precipitation is supposed to fall (Table 3). Precipitation in eastern WA was below normal as well, with percentages ranging between 25 and 75% of normal. Pullman and Spokane were dry spots, with 32 and 44% of normal, respectively.

Additionally, there was some snowfall during the beginning of the month, which was very close to normal for the stations that reported.



March 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)			Snowfall (inches)		
	Avg	Norm	Departure from Normal	Total	Norm	% of Norm	Total	Norm	% of Norm
Western Washington									
Olympia	42.7	44.5	-1.8	1.39	5.29	26	0	0.7	0
Seattle WFO	47.4	46.6	0.8	1.60	3.51	46	0.1	0	-
SeaTac AP	48.4	46.5	1.9	1.37	3.72	37	0.8	0.8	100
Quillayute	44.0	44.1	-0.1	1.51	10.83	14	0	0.7	0
Hoquiam	47.3	46.0	1.3	1.96	6.99	28	0	0	0
Bellingham AP	44.3	44.2	0.1	1.08	3.22	34	0	0.7	0
Vancouver AP	44.8	48.0	-3.2	1.61	3.57	45	M	M	-
Eastern Washington									
Spokane AP	34.6	40.2	-5.6	0.71	1.61	44	3.8	3.5	109
Wenatchee	35.9	44.1	-8.2	0.46	0.64	72	M	M	-
Omak	37.0	41.5	-4.5	0.57	1.19	48	M	M	-
Pullman AP	32.7	40.6	-7.9	0.65	2.05	32	M	M	-
Ephrata	35.9	43.0	-7.1	0.41	0.68	60	M	M	-
Pasco AP	35.5	46.3	-10.8	0.47	0.79	59	M	M	-
Hanford	37.4	46.5	-9.1	0.44	0.57	77	4.4	0.4	1100

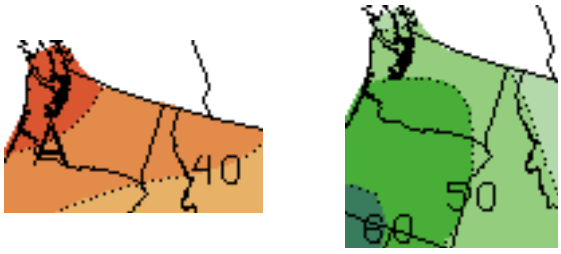
Table 3: March 2019 climate summaries for locations around Washington with a climate normal baseline of 1981-2010. Note that the Vancouver Pearson Airport and Seattle WFO 1981-2010 normals involved using surrounding stations in estimating the normal, as records for these station began in 1998 and 1986, respectively.

Climate Outlook

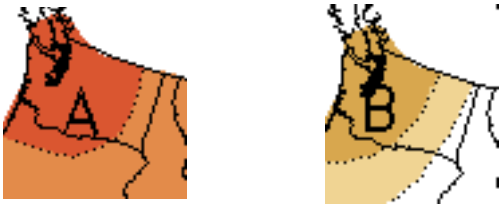
Weak El Niño conditions are present in the tropical equatorial Pacific, with sea surface temperature anomalies remaining above normal and enhanced convection remaining over the Date Line. The "El Niño Advisory" issued by the Climate Prediction Center on February 14 is still in effect. There is an 80% chance that the El Niño will last through the spring, and a 60% chance that it will last through summer. While the majority of the impacts to WA weather from El Niño are typically seen during the winter, there is a tendency for warmer and drier than normal springs during past El Niño events.

The latest outlook for April from the CPC calls for increased chances of above normal temperatures for all of WA state, with higher chances of warmer than normal temperatures in western WA. April precipitation is likely to be above normal statewide, and there are higher chances of above normal precipitation across the southern half of the state.

The CPC April-May-June seasonal temperature outlook calls for warmer than normal temperatures statewide, with chances exceeding 50% on the three-tiered system. There are higher chances of below normal April-June precipitation for nearly the entire state. A small sliver of eastern WA near the Idaho border has equal chances of below, equal to, or above normal precipitation for the 3-month period.



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



April-May-June outlook for temperature (left) and precipitation (right)

(Climate Prediction Center)