Office of the Washington State Climatologist

January 2020 Report and Outlook

January 7, 2020

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

December Event Summary

Mean December temperatures were above normal statewide, with greater temperature anomalies in eastern WA. From a historical perspective, the warm temperatures were in the top third of the record for most of the state. Total December precipitation was normal to above normal in parts of the central and southern Puget Sound and western North Cascades, but below normal for most of the rest of the state.

In this Issue

December Event Summary.........................1

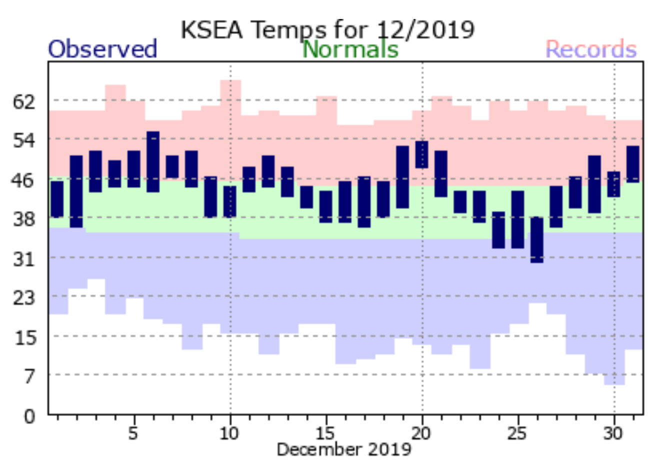
Snowpack and Drought Monitor Update...3

Snow depth vs. snow water equivalent in the Cascades..4

Climate Summary 7

Climate Outlook 9

The start of December was relatively mild and dry around the state, with the dry weather a continuation of November conditions (Figure 1 shows daily temperature and precipitation for SeaTac Airport). Western WA was on track for another dry month until heavy rain began on December 19. Notably, it rained for nearly 52 consecutive hours in Seattle, with precipitation ending the afternoon of the 21st. Initially, the rain in the lowlands translated into snow in Cascade



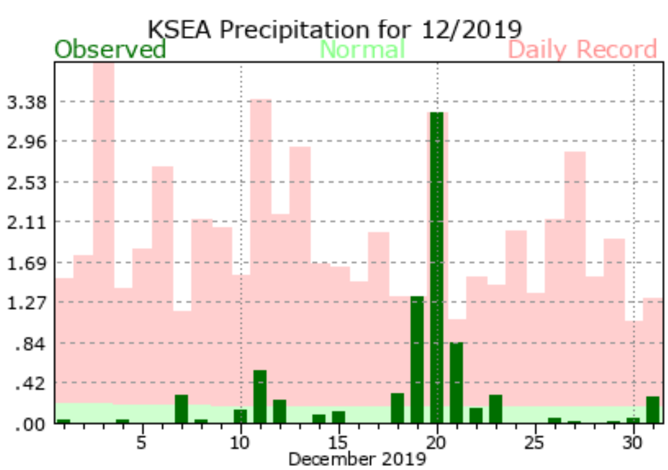


Figure 1: Daily December 2019 (left) maximum and minimum temperatures and (right) precipitation at SeaTac Airport compared to normal (green envelope) and records (red and blue bars). [NWS]

Mountains but then the freezing levels rose on the 20th with the incoming atmospheric river.

There were several days of precipitation records, some urban flooding, and moderate river flooding in western WA as well (KIRO7). For example, daily rainfall records were set at SeaTac Airport (1.32") and Olympia Airport (2.17") on the 19th. But those pale in comparison to the amount of precipitation on the 20th. SeaTac Airport (3.25"), Olympia (2.87"), the Seattle Weather Forecasting Office (WFO; 2.64"), Hoquiam (2.35"), and Bellingham Airport (1.02") set daily rainfall records on the 20th. The SeaTac rainfall ranked as the 5th wettest day in the historical record (records began in 1945); the wettest was on 10/20/2003 with 5.02".

The orientation of the atmospheric river was such that there was heavy rain in the south and central Sound but shadowing by the Olympic Mountains for the north Sound. This is illustrated nicely in the 24-hr precipitation total map from CoCoRaHS ending on the morning of the 21st (Figure 2). While the orange circles represent 24-hr totals between about 2.4 and 3.5", the precipitation totals near Oak Harbor on Whidbey Island were only about 0.75". Another example is on the coast. The green circle east of La Push on the coastal Peninsula only represents 0.54" of precipitation, illustrating the limited spatial extent of this precipitation event.

The coast got their share of precipitation on the last day of the year, however, as another storm system impacted the state. This time, the flow was primarily westerly so the Seattle area was impacted by the Olympic Mountain rainshadow. Quillayute measured a daily record of 3.85" on the 31st while SeaTac AP measured a run-of-the-mill 0.26". There were some high winds associated with this event as well. For example, winds gusted to 39 mph at Bellingham Airport, 40 mph in Tacoma, 43 mph in Seattle, 47 mph in Friday Harbor, and 68 mph at Snoqualmie Pass on New Years Eve.

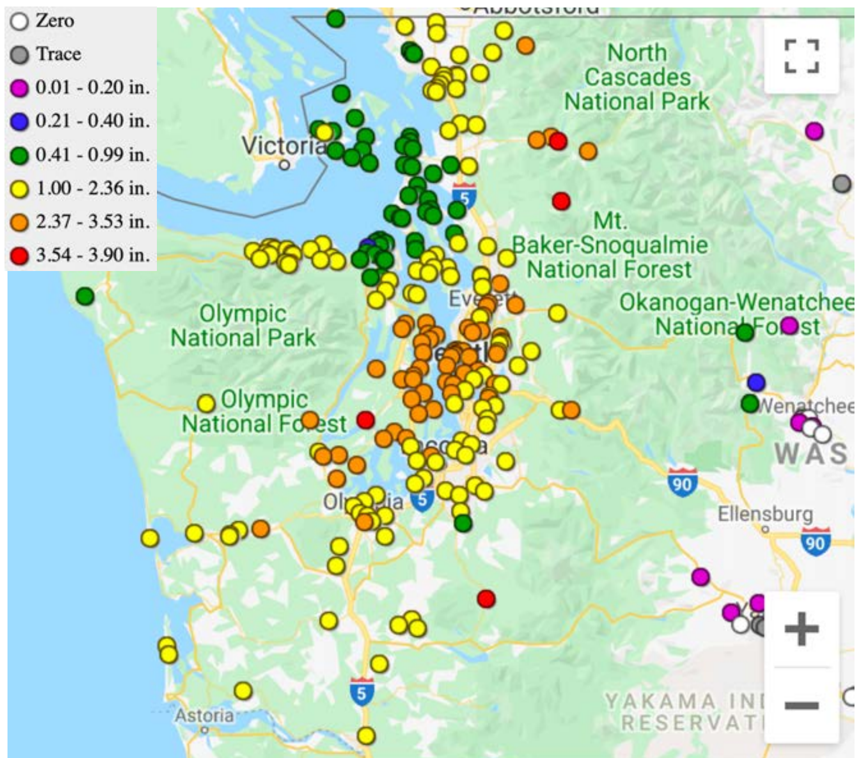


Figure 2: 24-hr precipitation totals ending between 7 and 9 am on December 21, 2019 (CoCoRaHS).

Snowpack and Drought Monitor Update

There were some gains in mountain snowpack during the month of December, but ultimately the warm temperatures caused a good portion of the precipitation to fall as rain instead of snow. For the southern Cascades, December was also drier than usual. The basin average snow water equivalent (SWE) percent of normal from the Natural Resources Conservation Service (NRCS) as of January 1 is shown in Figure 3. Compared to the basin average percentages of normal in early December, nearly every basin has improved. The exception is the Middle-Columbia Hood basin in the southern Cascades, where the January 1 SWE percent of normal is only 29% of normal (down from 36% of normal Dec 1). Despite the improvement, SWE is still much below normal statewide.

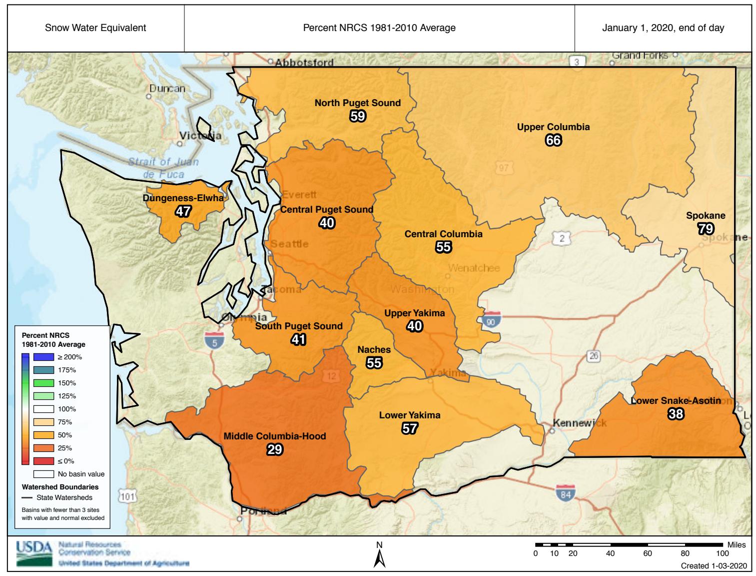


Figure 3: Snowpack (in terms of snow water equivalent) percent of normal for Washington as of January 1, 2020 (from [NRCS]).

The latest U. S. Drought Monitor (Figure 4) takes this lack of SWE into account, as well as the drier than normal fall, with the addition of "moderate drought" (D1). But the heavy precipitation in the second half of December in the Puget Sound lowlands and resulting rebounding streamflows has carved out some improvements in the state as well. Overall, most of WA is classified as at least "abnormally dry".

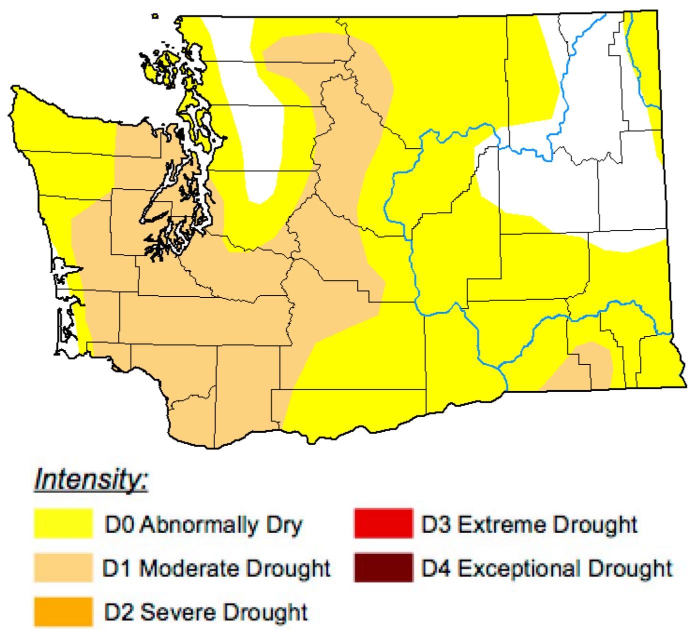


Figure 4: The 2 January 2020 edition of the [U.S. Drought Monitor].

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.

Snow Depth versus Snow Water Equivalent in the Cascades of Washington State

A message from the State Climatologist

Winter has arrived in earnest and the snow is finally starting to pile up in the mountains of Washington state. There are two principal measures of the snowpack: snow depth and snow water equivalent (SWE). Skiers and snowboarders tend to care more about the former. Water managers mostly monitor the latter, since SWE represents the amount of water in the snowpack that helps get us through our dry summers. The density of snow can vary substantially, of course, with colder temperatures typically associated with light, powdery snow and warmer temperatures associated with the wet, dense snow sometimes known as "Cascade concrete". But day in and day out, and for snowpack in WA as a whole, how do they relate to one another? In other words, knowing one do you know the other? There has been a lot of work on this subject, with recent work even developing a simple snow depth to SWE conversion (Hill et al. 2019), but let's take close look at a few WA stations.

Towards that end, we draw upon daily data from 5 stations along the spine of the Cascades, from north to south Harts Pass (6490'), Stevens Pass (3950'), Stampede Pass (3850'), White Pass (4440') and Lone Pine (3930') from the Natural Resources Conservation Service (https://wcc.sc.egov.usda.gov/reportGenerator/). Relatively complete data sets for snow depth at these stations only go back to about 2007, so we will be examining relationships between depth and SWE rather than trends. This period did feature some cool, snowy winters such as 2010-11, and some much more miserable examples, especially the warm drought year of 2014-15. Data from the months of January and April are considered, with a focus on the ratio of depth to SWE.

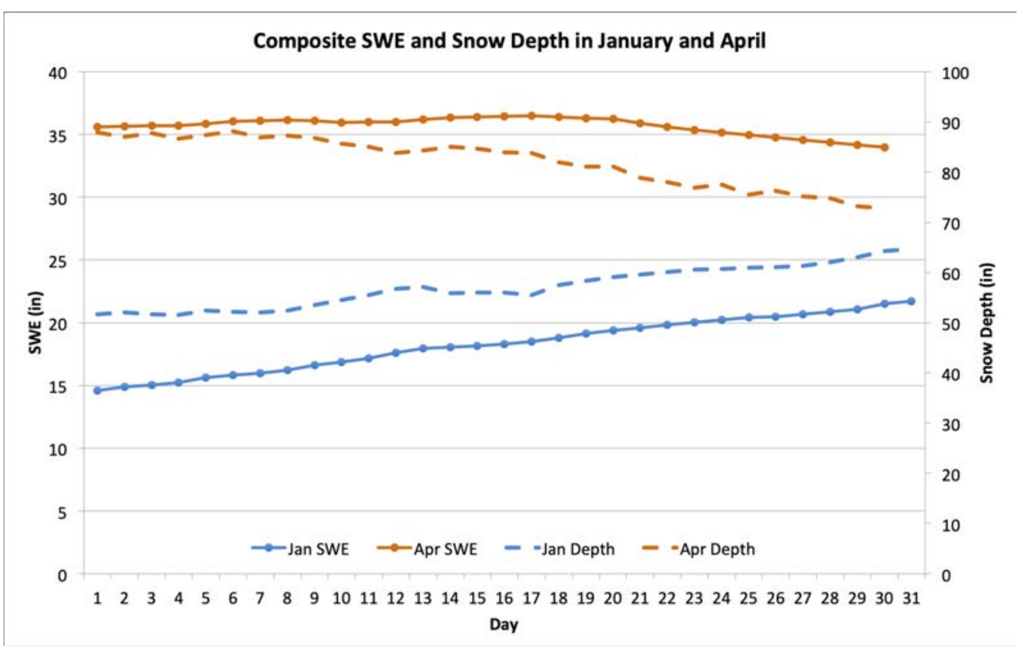


Figure 5: Mean snow depth and SWE (inches) versus day of month for January and April for all 5 stations.

First, we averaged all the data for each day of the month at each site, and then formed a grand average for the 5 sites. The results of this exercise are shown in Figure 5. On average, January starts out with a depth and SWE of 51.6 and 14.6", respectively, and ends with a depth and SWE of 64.6 and 21.7". Over the course of the month, there is greater growth in a proportional sense in SWE than in depth. More specifically, the average ratio of depth to SWE goes from about 3.5 to 3. The month of April starts out with an average depth and SWE of 87.9 and 35.6”, respectively, and ends up with 72.8 and 34.0”. By the end of the month that ratio is only about 2.1. This signifies a very “ripe” snowpack, with the high water content of the snow implying that melting is underway or imminent.

We next examined the daily variability in snow depth and SWE. Correlations between daily values considering all years during January was between 0.92 and 0.96 at four of the sites; Harts Pass was somewhat lower at 0.86. During April, the correlation coefficient was between 0.90 and 0.96 with Harts Pass again exhibiting the most variability. Removal of the daily climatology and hence the seasonal cycle in the ratio between snow depth and SWE did not impact the correlation much – the year-to-year variability is much greater than that effect. This is illustrated in a scatterplot of daily anomalies in depth and SWE at Stampede Pass for the month of January (Figure 6). We were struck by the tightness of the linear relationship between the two variables, with the exception of the very highest values of SWE, which apparently can be accompanied by a sort of roll-off in snow depth anomalies.

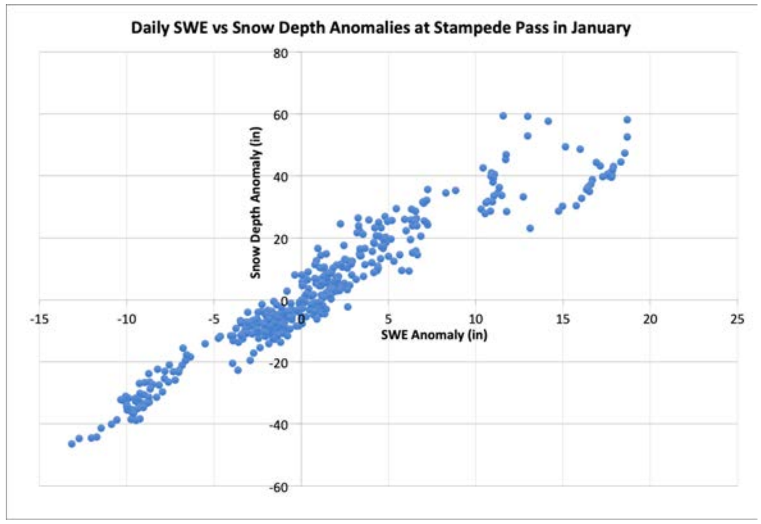


Figure 6: Scatterplot of SWE anomalies versus snow depth anomalies (inches) during January at Stampede Pass (climatological daily averages removed).

We next explore the possible differences between stations and years. Table 1 shows mean snow depths and SWEs, and their ratio, for each of the five stations in January and April. We were surprised to see that this ratio was on the low side (i.e., there tends to be denser snow) at Harts Pass since it is at a higher elevation than the others. Could this be attributable to it getting snow earlier in the season that then packs down, or could some other factor be at play? One might suppose that there are substantial year-to-year fluctuations in the ratio of depth to SWE and so we looked into that. Our approach was to calculate the average depth and SWE at each station during the month of January for each year; the results are plotted in Figure 7.

	Harts Pass	Stevens Pass	Stampede Pass	White Pass	Lone Pine
January Depth	74.0	64.8	51.9	38.7	56.1
January SWE	25.2	18.5	16.4	11.3	20.0
January Ratio	**2.9**	**3.5**	**3.2**	**3.4**	**2.8**
April Depth	99.6	88.2	76.9	55.6	90.6
April SWE	46.9	33.7	34.0	21.6	42.1
April Ratio	**2.1**	**2.6**	**2.3**	**2.6**	**2.2**

Table 1: Mean monthly values of snow depth and SWE for each station.

Again, we found a remarkably tight correspondence between the two measures of the snow pack. We expected that warm years with disproportionate amount of rain versus snow would lead to lower ratio of depth to SWE but does not seem to be the case. Perhaps this effect is effectively countered by the extra weight of a thicker snowpack, leading to compression.

A takeaway from our quick analysis is that the snow depth strongly co-varies with SWE in the Washington Cascades, at least at the locations considered here. This may have implications for monitoring the SWE in our mountains in a cost-effective manner using remotely-sensed snow depths from lidars or the equivalent.

Reference:

Hill, D.F. and CoAuthors (2019): Converting snow depth to snow water equivalent using climatological variables. *The Cryosphere*, **13**, 1767-1784.

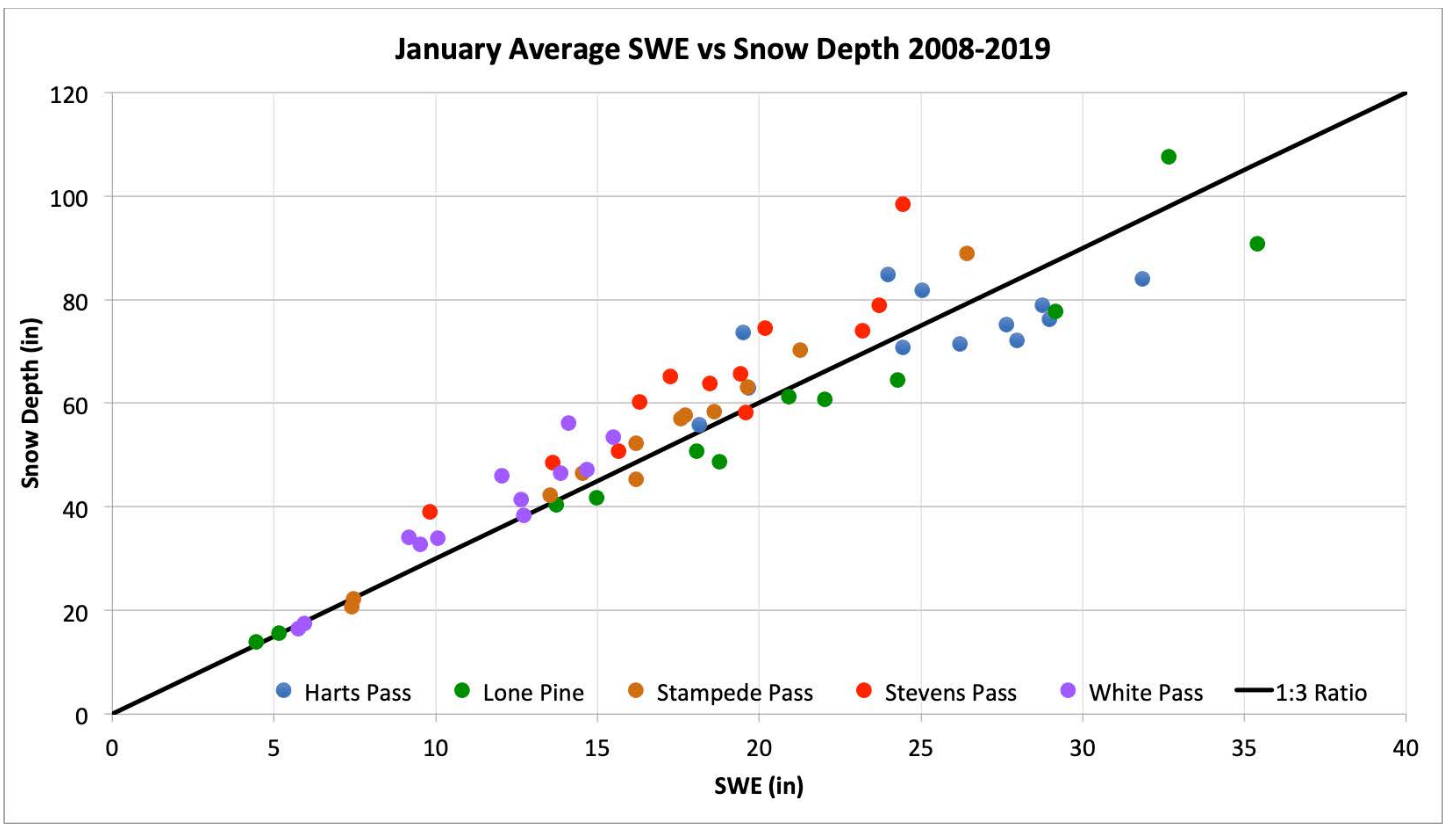
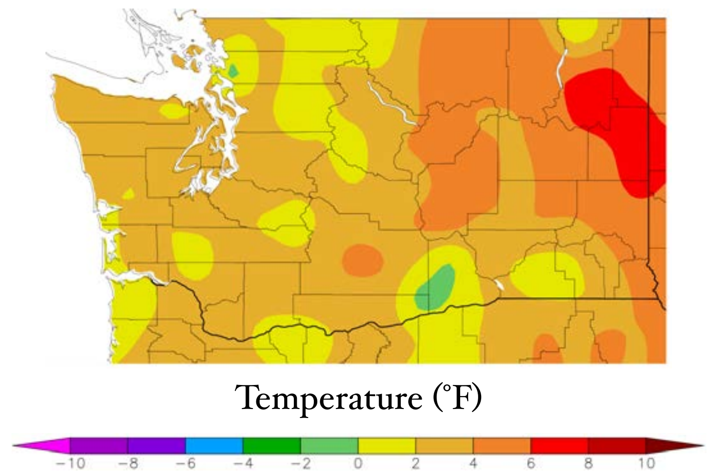


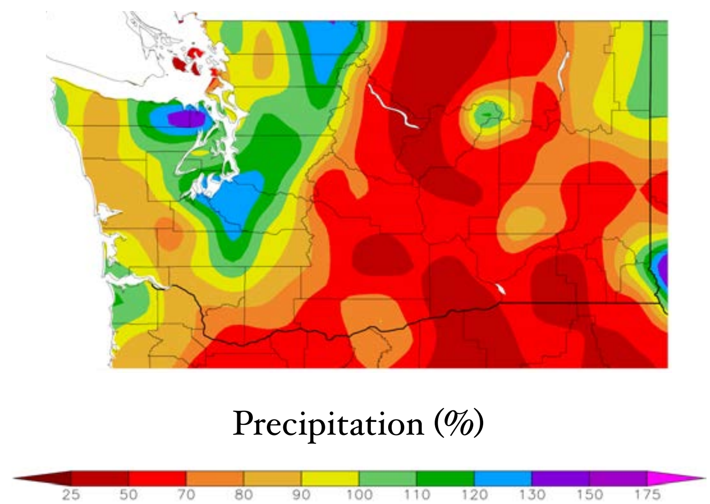
Figure 7: Scatterplot of January average SWE versus January average snow depth for Harts Pass (blue), Lone Pine (green), Stampede Pass (brown), Stevens Pass (red), and White Pass (purple) with 1:3 line included.

Climate Summary

Mean December temperatures were above normal statewide, according to the map from the High Plains Regional Climate Center on the right-hand side. Temperature anomalies in eastern WA were larger than in western WA, with 4-5°F anomalies widespread. For example, Ephrata and Pullman were 4.4 and 5.4°F above normal, respectively (Table 2). Spokane was even warmer relative to normal, with mean December temperatures 6.0°F above normal. Western WA experienced lesser warm anomalies, with temperatures running mostly between 2 and 4°F above normal. For example, Quillayute and SeaTac Airport were 2.6 and 3.9°F above normal, respectively (Table 2).

Total December precipitation was varied relative to normal throughout the state. In general, western WA saw near to above normal December precipitation while eastern WA saw below normal precipitation. But there are exceptions. Notably, the WA coast, northern Puget Sound, and southwest WA received below normal precipitation. Vancouver, for example, only received 69% of normal precipitation (Table 2). The southern and central Puget Sound regions were the winners in terms of precipitation, receiving between 110 and 150% of normal precipitation. On the other hand, eastern WA precipitation was much below normal, ranging between 25 and 70% of normal. Omak, for example, only received 38% of normal precipitation (Table 2). Far northeastern and southeastern WA were the exceptions for eastern WA, with near-normal December precipitation. Pullman, for example, recorded 110% of normal precipitation.





December 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	42.0	38.4	3.6	9.44	7.46	127	M	2.6	-
Seattle WFO	44.2	41.1	3.1	7.31	5.43	135	0	2.3	0
SeaTac AP	44.5	40.6	3.9	7.96	5.35	149	0	1.7	0
Quillayute	43.0	40.4	2.6	14.69	12.99	113	0	2.1	0
Hoquiam	43.7	41.6	2.1	10.09	9.96	101	0	0.4	0
Bellingham AP	42.8	38.1	4.7	4.35	4.22	103	0	2.9	0
Vancouver AP	42.6	40.6	2.0	4.67	6.77	69	M	M	-
Eastern Washington									
Spokane AP	33.4	27.4	6.0	2.14	2.30	93	10.5	14.6	72
Wenatchee	31.1	27.9	3.2	0.73	1.40	52	M	12.9	-
Omak	31.5	25.7	5.8	0.84	2.20	38	M	M	-
Pullman AP	35.5	30.1	5.4	1.72	1.57	110	M	M	-
Ephrata	31.8	27.4	4.4	0.64	1.24	52	M	7.6	-
Pasco AP	36.5	33.1	3.4	0.47	1.21	39	M	0.4	-
Hanford	34.2	31.1	3.1	0.55	1.20	46	0.6	5.9	10

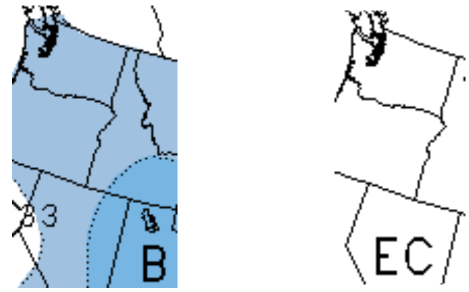
Table 2: December 2019 climate summaries for locations around Washington with a climate normal baseline of 1981-2010. Note that the Vancouver Pearson Airport and Seattle WFO 1981-2010 normals involved using surrounding stations in estimating the normal, as records for these station began in 1998 and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

Climate Outlook

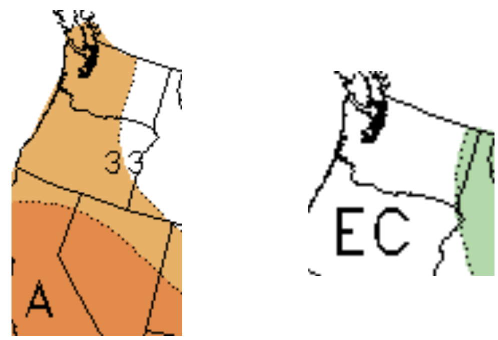
According to the Climate Prediction Center (CPC), neutral ENSO conditions are present in the equatorial Pacific. There has been little change in the magnitude of the sea surface temperature (SST) anomalies over the last month, with SSTs being near to above normal in the equatorial Pacific Ocean. The equatorial atmospheric patterns are also consistent with ENSO-neutral. ENSO forecast models show a continuation of ENSO-neutral conditions through the winter and spring. For the January-February-March period, there is a 69% chance of neutral conditions compared to much lower chance of El Niño (27%) or La Niña (4%) development.

The CPC January temperature outlook has increased chances of below normal temperatures statewide. This outlook is of 31 December, and represents an updated prediction of cooler weather relative to the outlook released two weeks prior. For January precipitation, the outlook calls for equal chances of below, equal to, or above normal precipitation statewide.

The CPC January-February-March (JFM) seasonal temperature outlook shows higher chances of above normal temperatures for the western two-thirds of the state. The eastern third of WA has equal chances of below, equal to, or above normal temperatures for JFM. Similar to the January outlook, there are equal chances of below, equal to, or above normal precipitation for nearly the entire state as well for the three-month period.



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



January-February-March outlook for temperature (left) and precipitation (right)

(Climate Prediction Center)