Office of the Washington State Climatologist

February 2021 Report and Outlook

February 5, 2021

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

January Event Summary

Mean January temperatures were above normal throughout WA state, with greater anomalies in eastern WA. Precipitation was above normal for most of the state, except for southeastern WA and the northern Puget Sound where precipitation was below normal. Regardless, much above normal precipitation fell during the first half of the month statewide. At SeaTac Airport, for example, the first 15 days of January were the wettest on record (since 1945; 7.69”), followed by 1956 and 2006. The first 15 days of the month at Spokane Airport (Figure 1) were the 8th wettest on record. Figure 1 also shows the tendency for above normal temperatures in the beginning of the month. Both the high **and** the low temperatures were generally above freezing at the Spokane AP site to kick off 2021, causing the early month precipitation to fall as rain at lower elevations.

In this Issue

Snow did accumulate in the mountain locations, however, and the weather was very active to start the month. Heavy rain and wind gusts up to 35-60 mph occurred on the 2nd, and were associated with a strong frontal passage. Several landslides were reported on the 4th (in Hood Canal and on

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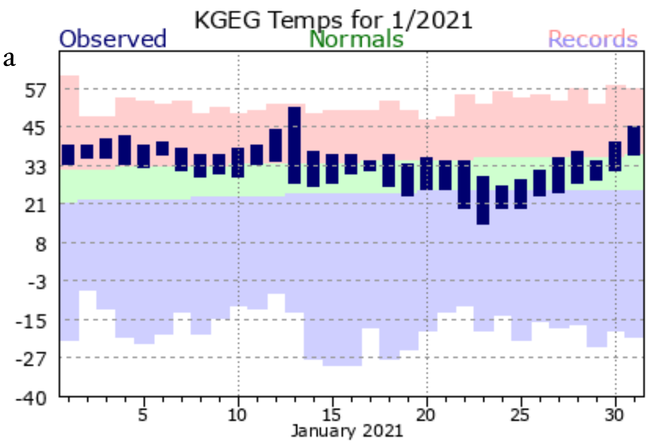

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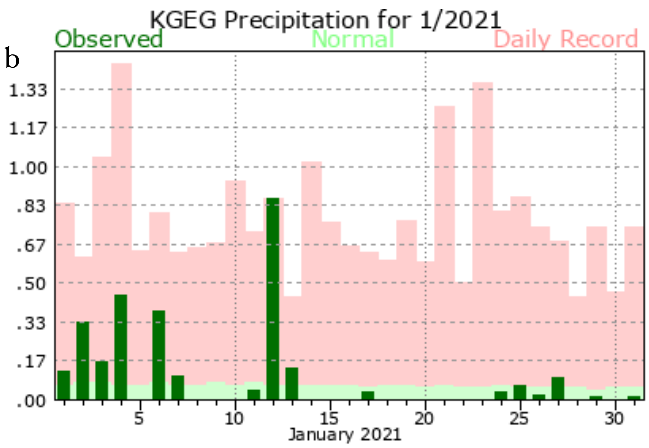

Figure 1: January 2021 (a) daily temperatures and (b) precipitation for Spokane International AP compared to normal (green envelope) and record (red and blue envelopes).

Hwy 2 east of Leavenworth, for example) as well as flooded roads. Conditions remained ideal for landslides over the next several days (KIRO7).

Another high impact storm arrived on the 11th and 12th that caused flooding, power outages, and road closures. High winds (gusts of 40-60 mph) were also associated with this event (overnight on the 12th into the 13th), as a sort of punctuation mark after several days of wild weather. Hoquiam (2.32") set a daily maximum precipitation record on the 11th and SeaTac Airport (2.33") on the 12th. The combined precipitation over two days was impressive for this system; coastal WA recorded between 3 and 9" of precipitation while the inland Puget Sound recorded between 1 and 5".

A relatively cool and dry period followed with a lull in the active weather. Precipitation picked up at the end of the month, however, and cooler temperatures meant that at least some portion of eastern WA received snow from the 20th through the 29th. 24-hr snow observations on the morning of the 27th from the CoCoRaHS network are shown in Figure 2, showing that even some locations on the Olympic Peninsula received snow. Easterly downslope winds caused the eastern Puget Sound locations to miss out on snow accumulation with this one, but 4-6" accumulations were common east of the Cascade Mountains.

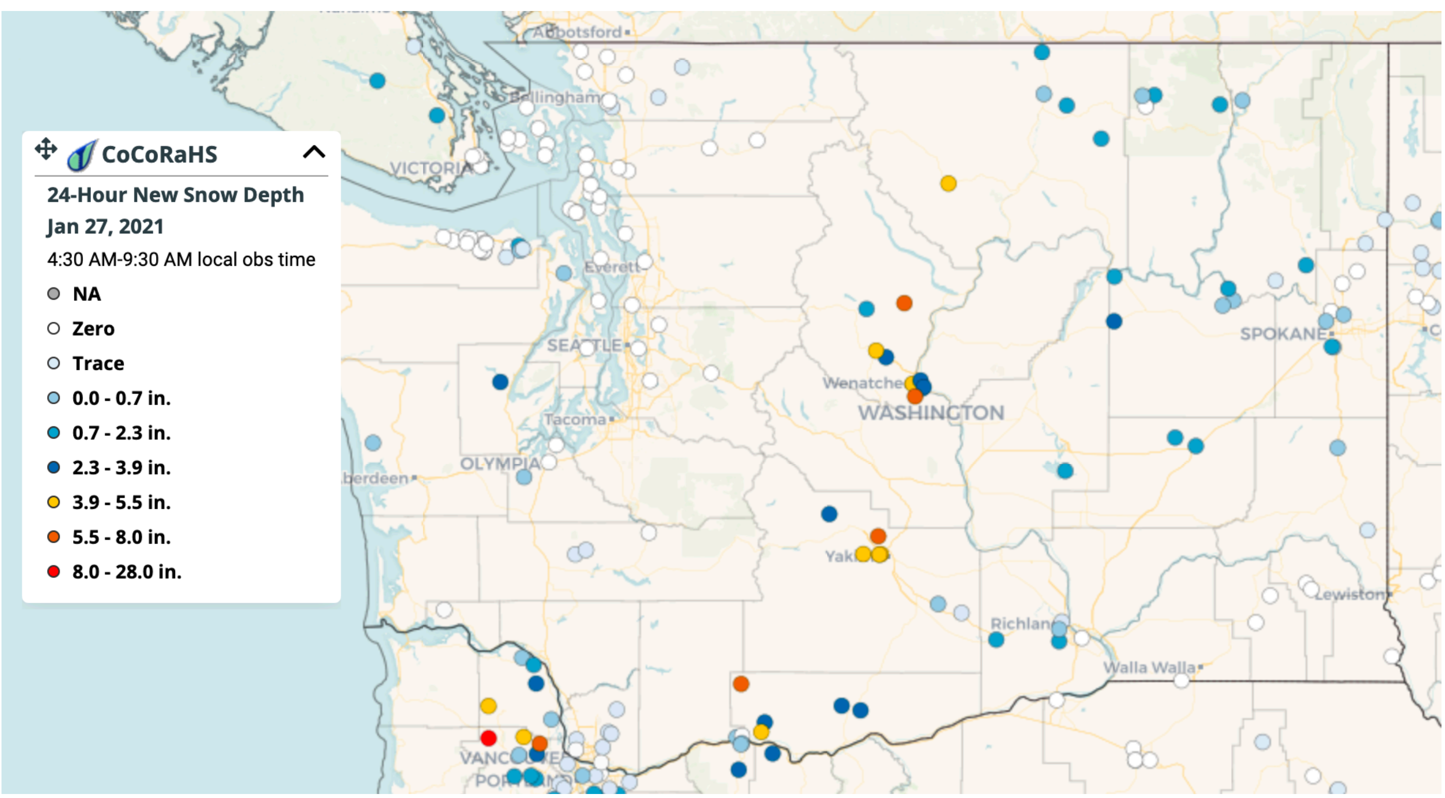

Figure 2: 24-hr snowfall observations ending on the morning of January 27, 2021 from the CoCoRaHS network.

Snowpack and Drought Monitor Summary

Snowpack continued to build in the mountains throughout January. The basin average snow water equivalent (SWE) percent of normal from the Natural Resources Conservation Service (NRCS) as of February 1 is shown in Figure 4. Snowpack is near-normal to above normal throughout the Olympic Mountains and most of the Cascades. The basin averages in the Central Puget Sound, South Puget Sound, Lower Snake-Walla Walla, Lower Pend Oreille, and the Spokane basins are below normal, ranging between 83 and 90% of normal.

Continued improvement in the U.S. Drought Monitor (Figure 5) was made throughout January due to the improvement of many of the short and medium term drought indicators. The area of "extreme drought" (D3) was removed entirely from eastern Yakima and eastern Kittitas counties, and the areas of "severe drought" (D2), "moderate drought" (D1), and "abnormally dry" (D0) conditions are smaller than shown in last month's newsletter. Notably, drought conditions have been erased east of the Cascade crest in northern WA due to continued precipitation and the healthy snowpack.

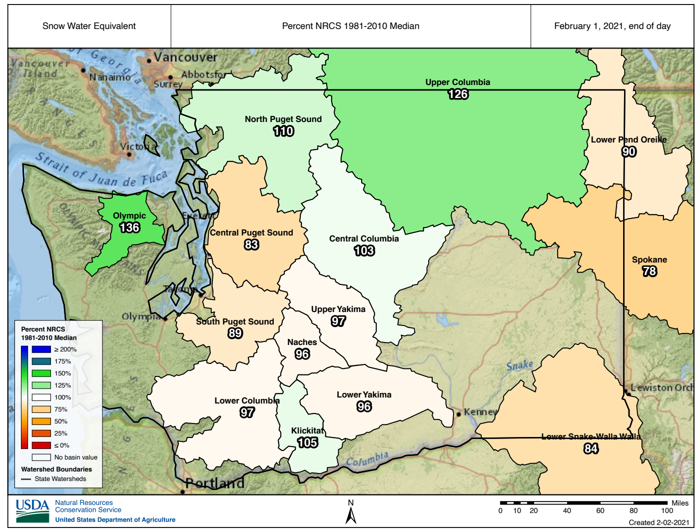

Figure 4: Snowpack (in terms of snow water equivalent) percent of normal for Washington as of February 1, 2021 (from NRCS).

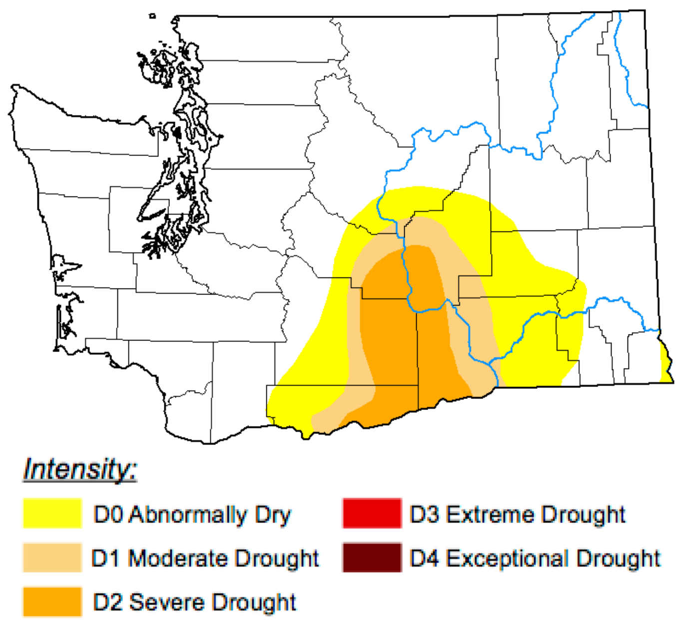

Figure 5: The February 4, 2021 edition of the [U.S. Drought Monitor](https://droughtmonitor.unl.edu).

The CoCoRaHS Corner

Growth of CoCoRaHS in Washington State is breaking records. In December, 11,114 individual precipitation reports accounted for the most ever submitted in a single month. Well, that record was short-lived as 422 observers filed 11,248 reports over the course of January. Over the last decade, 80 of the 100 days with the most precipitation reports come in the last 12 months. The proliferation of reporting is almost certainly fueling better coverage that more accurately captures a precipitation event. For example, the 24 hours prior to the morning of January 12th was very wet - enough water to spur the second most single day observations in the past decade at 385.

On average, stations recorded 1.26" of precipitation, which was the 9th highest single day value. This event also highlighted the spatial variability of extreme precipitation. Shelton 6.5 NNW observed the most precipitation in the state that morning at 5.54". Only 1.6 miles to the southeast, Shelton 4.9 NNW noted exactly 1" less of precipitation than Shelton 6.5 NNW. Lastly, the effort of observers to reliably record precipitation of drier days is commendable. Jan 19th was mostly dry statewide with only ~10% of observers recording a trace or more. Yet, the total precipitation reports only dropped 13% from the notably intense precipitation on the 12th.

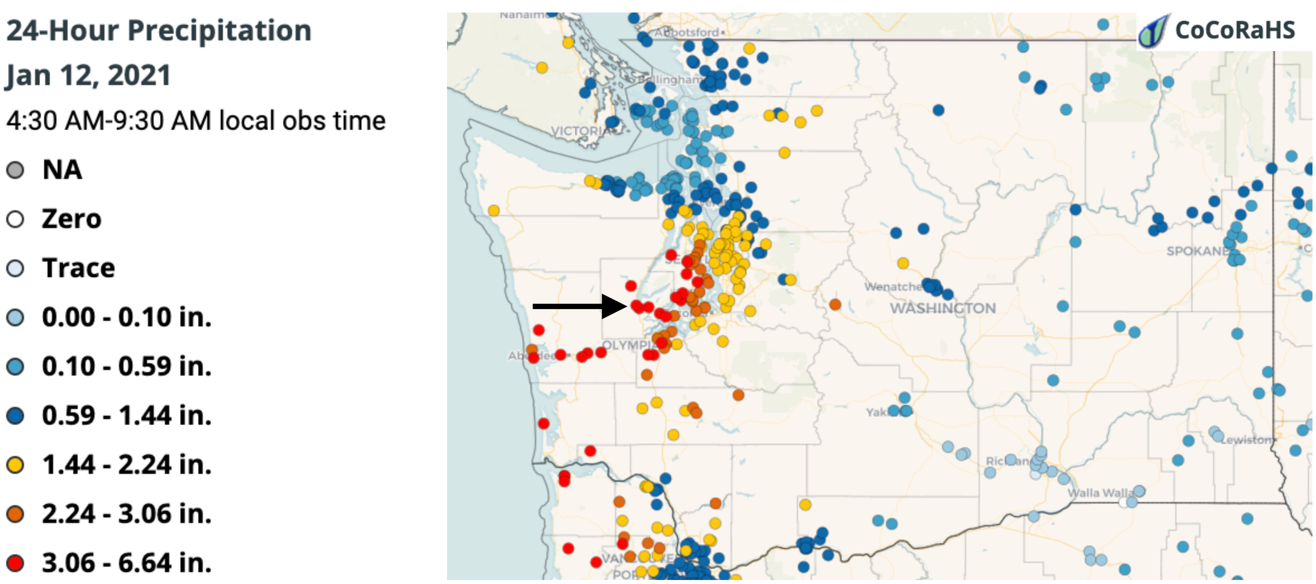

Figure 6: CoCoRaHS map for 24-hour precipitation ending on the morning of Jan 12th. Washington saw the heaviest precipitation in the nation that day. The black arrow signifies the location of Shelton 4.9 NNW and Shelton 6.5 NNW that are virtually indiscernible at the state scale (CoCoRaHS).

Does the Arctic Oscillation Relate to the Variability in the Weather of WA?

A message from the State Climatologist

The term "polar vortex" has been in the news recently, prompting this piece on the connection of the Arctic Oscillation (AO) to the weather of WA. In early January 2021, some attention was given to the polar vortex and the relationship to the sudden stratospheric warming that occurred near the pole (AO+). Those events tend to be followed by a weaker and less symmetric polar vortex, implying a negative state for the Arctic Oscillation (AO-).

When the AO is positive the polar vortex is strong and symmetric with the coldest air essentially bottled up near the North Pole. When the AO is negative, the high latitude circulation includes much more prominent ridges and troughs, with this pattern tending to deliver especially cold air to the mid-latitudes. This delivery occurs in preferred locations, e.g., eastern Asia and northern Europe, but there is considerable variability. Previous work (e.g., Wettstein and Mearns 2002) has documented how the AO relates to the mean and variability in wintertime temperatures in particular locations. Naturally, we are taking on the subject with a focus on WA. We build on a previous piece in this newsletter (Jan 2014 edition), which illustrated the results from some research by Prof. Wallace and his student Greg Ostermeier, which documented the incidence of days of extreme minimum temperatures and precipitation amount vis-a-vis the AO. Our specific interest here is to describe what has happened during past winter months with strongly negative or positive AO values, and in particular how those two sets of months have played out in terms of their means and standard deviations in temperature and precipitation on monthly time scales, and whether they exhibit different magnitudes of day-to-day variability in temperature.

Our analysis considers the years of 1970 through 2020. Our focus is on the 15 winter (DJF) months with the greatest negative values for the AO and the 15 months with the greatest positive values. The tacit assumption is that if there is a signal associated with the AO, it will emerge in comparison of periods when it is strongly positive versus strongly negative. We use the compiled state mean temperature and precipitation anomalies for these months from NOAA's Climate at a Glance. Towards describing the day-to-day variability, we calculated the standard deviation in daily average temperatures from Sea-Tac, Spokane and the Tri-Cities for each of the extreme AO months.

We begin with a map showing the correlation between the 500 hPa geopotential height (Z) and AO during the months of December through February (Fig. 7). Positive values over North Pacific and lower values over Alaska and western Canada imply that positive AO periods tend to be accompanied by enhanced flow aloft from the west-northwest. Similarly, negative AO periods tend to be accompanied by suppressed flow aloft from the west-northwest. A similar map showing the correlation between atmospheric boundary layer temperatures and the AO reveals that positive AO periods tend to include slightly lower than normal temperatures over WA (not shown). But this type of analysis cannot be used to surmise much about the variability, which is why we wanted to dig into the station measurements of temperature and precipitation during the two phases of the AO.

The results from our analysis are summarized in Tables 1-3. Tables 1 and 2 itemize the mean statewide temperature and precipitation anomalies during the AO- and AO+ months, respectively. We were struck by the similarity in the two sets of months. They had nearly identical negative temperature anomalies in an overall sense, with somewhat greater month to month variability among the negative AO months. In terms of precipitation, there has been somewhat greater average negative anomalies, and greater variability, during AO- periods but the differences are modest at best. We included the value of the NINO3.4 index for the months in each set, out of curiosity whether ENSO might help account for the results. It turns out that AO- conditions are favored to an extent during El Niño, due to greater "wave activity" emanating from lower latitudes essentially disrupting the polar vortex. The two sets of months both included a range of NINO3.4 values; both La Niña and El Niño are represented in each set. Conceivably the slight overall difference of a weak tendency for a warm tropical Pacific during the AO- months, and for a cool tropical Pacific during the AO+ months helps damp the direct effects of the AO on the weather of WA. But a quantitative attribution is way outside the scope of the present piece – and given the weakness of the signal seems hardly worth the trouble. Finally, our results based on the daily data for three locations in WA also show that the AO apparently has little effect on the day-to-day variability in temperatures, in an overall sense. There was somewhat greater variability in the temperatures in the Tri-Cities during the positive AO months, which is actually the opposite of what was expected.

We are unsure if there is a moral to this story. Perhaps it suffices to say that the residents of WA should not quake in fear when the weather community begins chattering about the present and future state of the polar vortex, at least from a local yokel perspective.

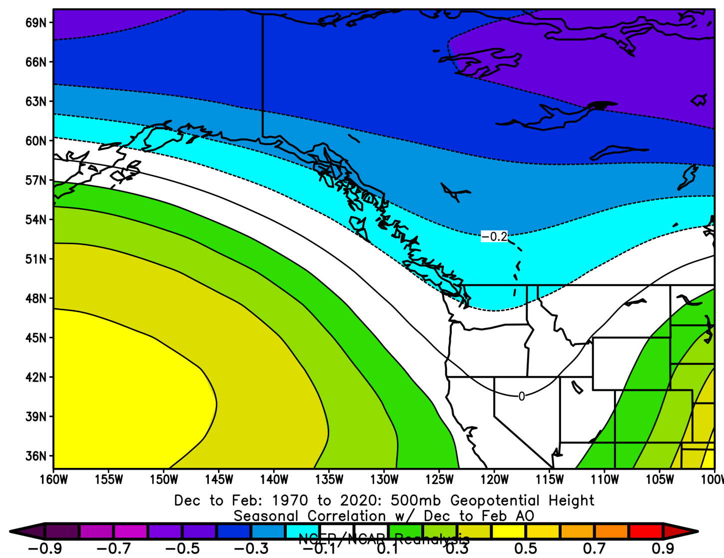

Figure 7: Model reanalysis of the correlation of 500 hPa geopotential height with the Arctic Oscillation ([ESRL]).

Reference:

Wettstein, J.J. and L.O. Mearns (2002): The Influence of the North Atlantic-Arctic Oscillation on Mean, Variance, and Extremes of Temperature in the Northeastern United States and Canada. *J. Climate*, **15**, 3586-3600.

Month	Mean AO	WA T (F)	WA P (in)	NINO3.4
Feb 2010	-4.27	4.2	-1.11	1.22
Jan 1977	-3.77	-4.8	-4.16	0.93
Dec 2009	-3.41	-4.0	-3.08	1.72
Feb 1978	-3.01	1.7	-0.83	0.42
Feb 1986	-2.90	-0.9	1.48	-0.78
Jan 1985	-2.81	-4.6	-5.39	-1.14
Dec 2010	-2.63	1.3	1.23	-1.62
Jan 2010	-2.59	5.4	0.12	1.50
Dec 2000	-2.35	-1.2	-3.06	-0.98
Jan 1979	-2.23	-12.1	-3.89	0.03
Dec 1995	-2.13	1.2	0.58	-1.00
Dec 2005	-2.10	-1.2	0.25	-0.68
Jan 1998	-2.08	1.1	2.09	2.53
Dec 1976	-2.07	1.7	-3.72	0.66
Jan 1980	-2.07	-7.1	-0.78	0.67
Mean	**-2.70**	**-1.29**	**-1.35**	**0.23**
Std. Dev.	**0.68**	**4.57**	**2.36**	**1.23**

Table 1:Negative Arctic Oscillation (AO) values for winter months with respect to the 1970-2000 average.

Month	Mean AO	WA T (F)	WA P (in)	NINO3.4
Jan 1993	3.50	-6.5	-2.03	0.25
Feb 2020	3.42	1.3	0.43	0.42
Feb 1990	3.40	-2.5	1.43	0.23
Feb 1989	3.28	-8.7	-1.50	-1.39
Jan 1989	3.11	1.0	-0.80	-2.04
Jan 2020	2.42	3.3	4.39	0.53
Dec 2006	2.28	-0.1	0.38	1.19
Dec 2011	2.22	0.4	-3.27	-1.04
Jan 2007	2.03	-2.3	-1.01	0.69
Feb 1997	1.89	-0.3	-0.78	-0.36
Dec 2016	1.79	-4.5	-1.54	-0.41
Dec 1988	1.68	0.6	-2.28	-2.24
Feb 1976	1.66	-0.7	1.05	-1.09
Dec 1992	1.62	-3.3	-1.35	0.16
Dec 1991	1.61	3.9	-2.00	1.80
Mean	**2.39**	**-1.22**	**-0.59**	**-0.22**
Std. Dev.	**0.74**	**3.46**	**1.89**	**1.15**

Table 2: As in Table 1, but for the positive AO months.

Month Type	Sea-Tac	Spokane	Tri-Cities
Negative AO	5.28	7.50	6.84
Positive AO	5.12	7.22	8.58

Table 3: Within Month Standard Deviations in Temperature (F)

Climate Summary

Mean January temperatures were generally above normal throughout the state, especially in eastern Washington. Every station in Table 4 recorded above normal temperatures. Quillayute and Hoquiam were fairly close to normal, though on the warmer side. Bellingham was in a warm pocket, notably catching a 60 °F day on the 12th, which helped drive average temperatures 3.8 °F above normal. Most of eastern Washington checked in with average temperatures between 2 to 6 °F above normal (Figure 8). The greatest warm anomalies were centered on Omak and Ephrata, where temperatures were a resounding 6.5 and 6.8 °F above normal, respectively.

Precipitation totals varied throughout the state with higher-than-normal values along the Pacific Coast, the Puget Sound lowlands, and in NE Washington. Typically, Figure 9 is from the High Plains Regional Climate Center, but missing data since January 8th at the Cle Elum station suggested that region was drier than it likely was. The current figure from the WestWide Drought Tracker more accurately depicts January precipitation using other stations in the area that were also on the dry side. On the coast, Hoquiam received 17.27” of precipitation beating out the normally 4” wetter Quillayute, which received 16.21”. Both stations noted above normal precipitation at 167 and 111%, respectively. Wetter than normal conditions were found elsewhere across the state such as 157% of normal in Seattle, 158% in Spokane, and 134% in Pullman. The principal area that received lackluster precipitation totals is the lower Columbia Basin. Pasco, residing in this drier region, saw 0.51” of precipitation (42% of its normal value). Over the past 12 months, Pasco recorded less 75% of normal precipitation on 8 occasions.

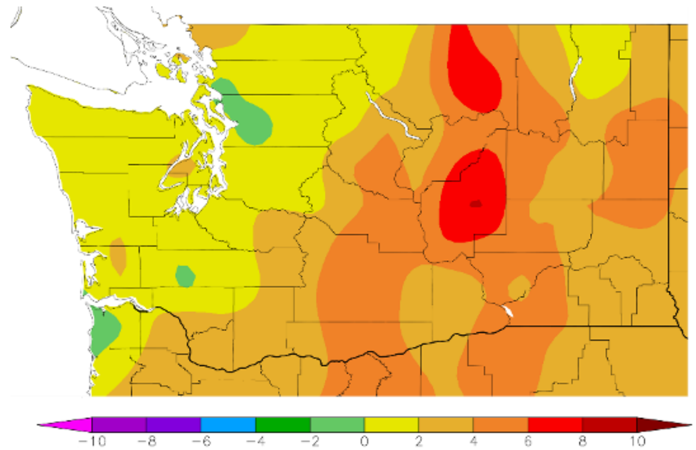

Figure 8: January temperature (°F) departure from normal relative to the 1981-2010 normal (HPRCC).

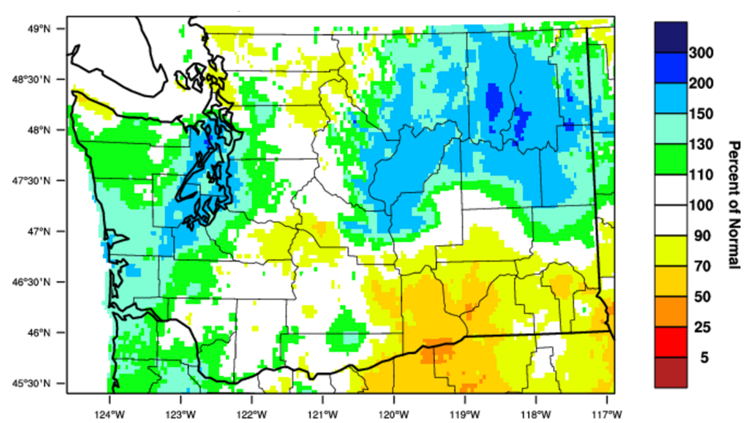

Figure 9: January total precipitation as a percentile of the 1981-2010 normal (WestWide Draught Tracker).

Station	Mean Temperature (°F)			Precipitation (inches)			Snowfall (inches)		
	Avg	Normal	Departure from Normal	Total	Normal	% of Normal	Total	Normal	% of Normal
Western Washington									
Olympia	41.6	39.8	1.8	12.22	7.84	156	M	1.9	M
Seattle WFO	43.7	42.1	1.6	7.61	4.81	158	0.0	0.4	0
SeaTac AP	43.8	42.0	1.8	8.75	5.57	157	0.0	1.4	0
Quillayute	42.2	41.6	0.6	16.21	14.61	111	M	2.0	M
Hoquiam	43.3	42.6	0.7	17.27	10.33	167	M	1.3	M
Bellingham AP	43.0	39.2	3.8	5.06	4.67	108	M	3.4	M
Vancouver AP	44.3	41.6	2.7	7.49	5.50	136	M	M	M
Eastern Washington									
Spokane AP	33.5	29.5	4.0	2.82	1.79	158	3.5	11.4	31
Wenatchee	33.1	29.5	3.6	1.63	1.06	154	M	9.8	M
Omak	33.3	26.8	6.5	3.00	1.89	159	M	M	M
Pullman AP	35.3	31.6	3.7	2.43	1.82	134	0.0	M	M
Ephrata	35.6	28.8	6.8	1.04	0.91	114	M	M	M
Pasco AP	39.0	34.9	4.1	0.51	1.22	42	M	4.8	M
Hanford	39.1	33.4	5.7	0.70	0.94	74	2.6	4.5	58

Table 4: January 2021 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), La Niña conditions are currently present in the equatorial Pacific and are expected to remain intact through the rest of winter. Negative sea surface temperature (SST) anomalies first emerged in May of 2020 and peaked later in the fall. SST anomalies have been slowly rising in the eastern equatorial Pacific and have finally climbed back to near normal values. All ENSO indices are still negative but have sharply risen in the past week with nearly 1°C of warming centered on 120 W. Not only are SST anomalies increasing basin-wide, but sub surface temperatures are slowly rising back to near normal values. By March-April-May, neutral conditions are barely favored to return at 55%.

The CPC one-month prediction for February has increased chances of below normal temperatures across the state. The precipitation outlook is less certain with slightly increased chances of below normal precipitation west of the I-5 corridor, and equal chances of above, below and near-to normal precipitation for the rest of the state.

The three month outlook for February through April has increased chances of below normal temperatures for the entire state. There is slightly more confidence of below normal temperatures in western Washington. The precipitation outlook indicates our wet weather is likely to continue with increased chances of above normal precipitation statewide.

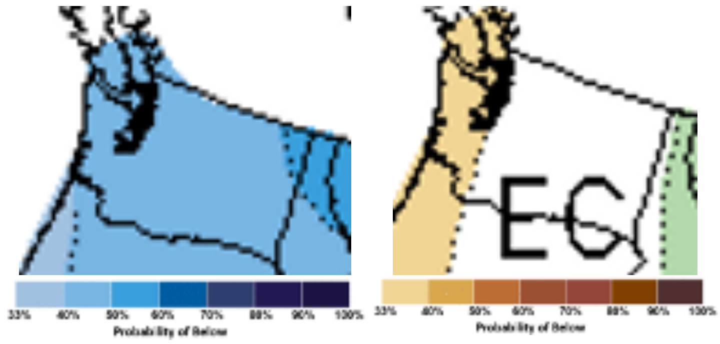

Figure 10: February outlook for temperature (left) and precipitation (right).

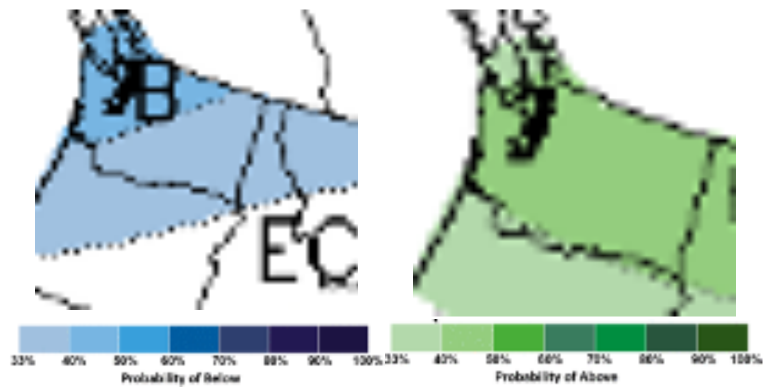

Figure 11: February-March-April outlook for temperature (left) and precipitation (right) ([Climate Prediction Center](#)).