Office of the Washington State Climatologist

November 2022 Report and Outlook

November 8, 2022

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

October Event Summary

Mean October temperatures were well above normal statewide, and the anomalies were especially large in eastern WA. Averaged statewide, October ranks as the warmest since records began in 1895, with a temperature 6.6°F above the 1991-2020 normal. Table 1 shows October temperature rankings for some individual stations in WA; most locations in the state were in the top ten category. October precipitation was below normal for nearly the entire state with some notable exceptions in southeastern WA. Averaged statewide, the month ranks as the 37th driest.

In last month's newsletter, we suggested that in general, September 1 was a better date for the start of fall in western WA while astronomical fall fit better with the historical weather data for a few stations representing eastern WA. That didn't hold true for 2022. What is interesting about our most recent October is that there was a very distinct shift from our continued warm and dry summer weather to weather more typical of fall. Fall clearly began on October 21 this year, nearly a month after astronomical fall. Figure 1 shows the

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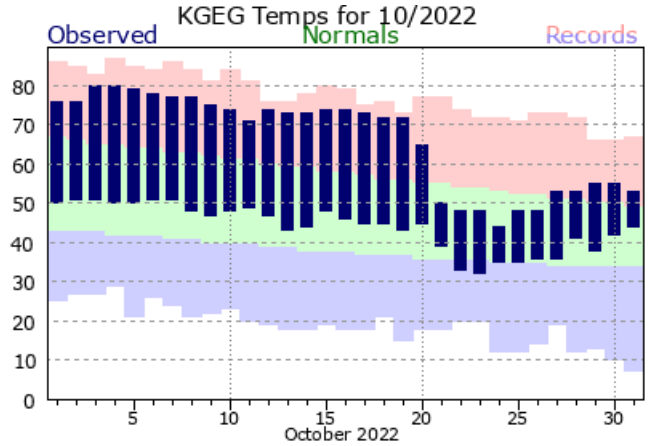


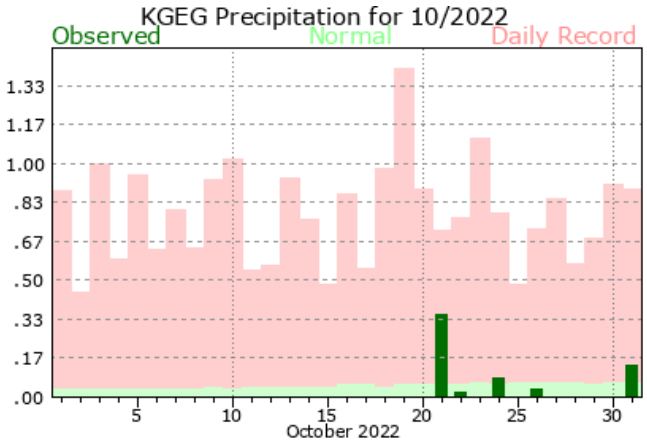


Figure 1: October 2022 daily temperatures for Spokane Airport compared to the 1991-2020 normal (green envelope) and previous records (blue and red envelopes; NWS).

daily temperature and precipitation values for Spokane International Airport, where you can see temperatures moderate and rain begin on the 21st.

Before that shift, October felt very much like a continuation of summer, with above normal temperatures and below normal precipitation. Record high daily temperatures in the 70s, 80s, and even near 90 were set through October 20 around the state. Here are just a few examples: Bellingham (75°F), SeaTac (80°F), Quillayute (82°F), and Olympia (83°F) set daily high temperature records on the 2nd; Ellensburg (82°F - tie), Yakima (83°F), Pasco (87°F), and Dallesport (88°F) set records on the 10th; Ellensburg (78°F), Yakima (79°F - tie), Bellingham (80°F), Dallesport (80°F - tie), Olympia (85°F), Vancouver (86°F), and SeaTac (88°F) set records on the 16th.

The persistent ridge of high pressure was also conducive for continued wildfire activity into October. There were even some new fires, such as the Nakia Creek fire that threatened evacuations near Vancouver, that contributed to widespread poor air quality west of the Cascades. Wildfire smoke got especially bad on the 19th and 20th in the Seattle-Metro area, where air quality levels were registered in the "hazardous category". Figure 2 shows the 24-hour average PM2.5 for one Seattle site for the month of October.

We would venture a guess that the switch to more seasonal temperatures with accompanying rainfall was a welcome relief for most WA residents, authors of this newsletter included. A couple maximum daily rainfall records were set during this time too, with Walla Walla measuring 0.85" on the 22nd and Bellingham measuring 1.67" on the 30th. Precipitation was especially heavy on the 30th, with 2" rainfall measurements common throughout western WA, except for the central Puget Sound region, which then was in the rainshadow of the Olympic Mountains.

Station	October Average Temperature (°F)	Rank	Records Began
Omak	57.1	1	1998
Spokane AP	55.0	1	1881
SeaTac AP	57.6	2	1945
Yakima AP	56.6	2	1946
Wenatchee Pangborn AP	57.6	2	1960
Quillayute	54.5	3	1966
Bellingham AP	54.0	3	1949
Olympia	54.3	4	1941
Pullman 2 NW	53.7	6	1941

Table 1: October average temperature rankings (warmest to coldest) for selected WA locations.

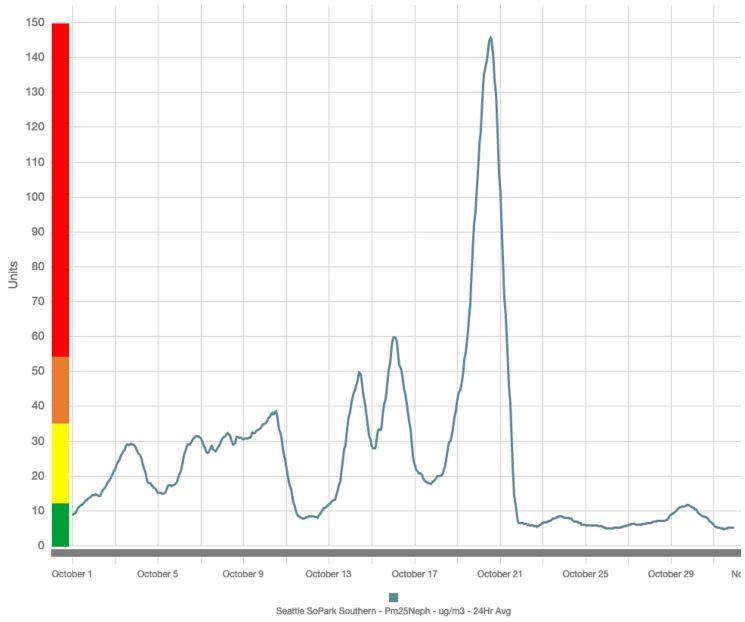


Figure 2: October 24-hr average PM2.5 (ug/m3) for Seattle SoPark Southern station (from Puget Sound Clean Air Agency) with equivalent Air Quality Index values on the y-axis.

Streamflow and Drought Summary

Average October streamflow (Figure 3) was below normal to much below normal for most of the state. When compared to the average September streamflows, some locations such as the northern areas of the Olympic Peninsula, had improving streamflows while others, such as Chelan and Okanogan counties, had declining streamflows. The switch to wetter weather on the west side of the Cascades resulted in substantial increases despite the month still averaging well below normal.

Compared to the U.S. Drought Monitor map that was featured in our last newsletter, the drought depiction has worsened throughout western WA and in north central WA. Figure 4 shows the introduction of "severe drought" in western WA and expansion of "moderate drought" in eastern WA. At the time of this writing, early November rain has switched the direction of Drought Monitor changes and brought some improvements west of the Cascade crest.

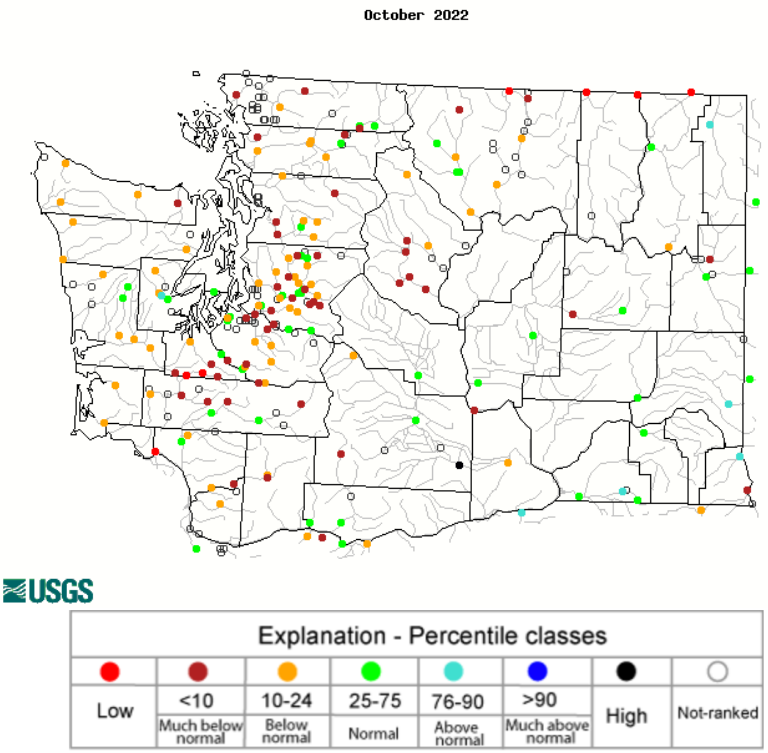


Figure 3: October 2022 average streamflow for WA (USGS).

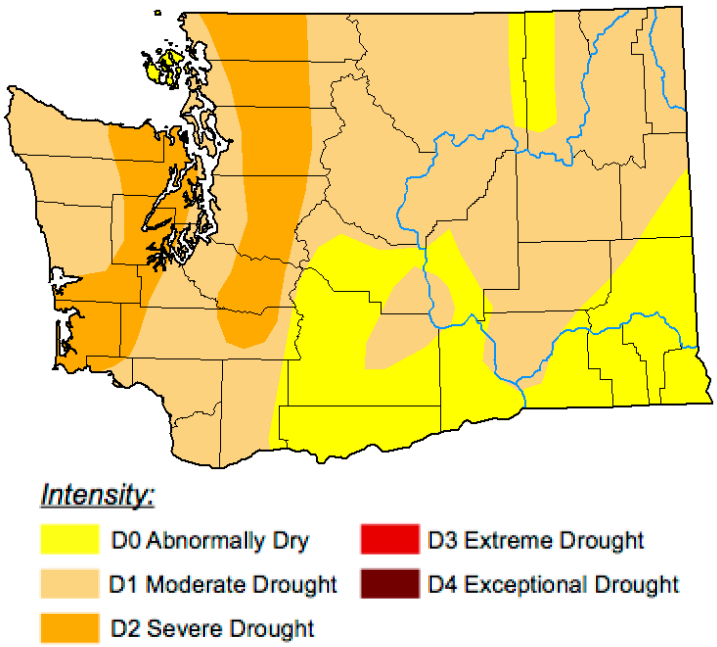


Figure 4: The November 3, 2022 edition of the U.S. Drought Monitor.

The Near Endless Summer of 2022

A Message from the State Climatologist

After a very wet and cool spring, the Pacific Northwest had an unusually long stretch of warm and dry weather in 2022. The lack of rain was especially pronounced in western Washington, with many locations recording record low totals for the months of July through September. Perhaps even more surprising was how dry it remained until the latter portion of October. As an inveterate viewer of weather maps and numerical weather prediction model output, I was struck by the seemingly ubiquitous ridge of high pressure aloft over the Pacific Northwest extending into western Canada, especially late in the past summer and into fall when we usually get rewarded with more active weather, and at least brushed by disturbances coming into our region off the Pacific Ocean. Therefore, I thought it would be interesting to delve into the regional circulation associated with the unusual weather of the past few months, and the extent to which there is historical precedent for the pattern that prevailed.

The circulation pattern for the period of interest is illustrated here using, what else, 500 hPa geopotential height (Z) anomaly maps, separately for the months of July through September and for the 4-month long interval from the summer solstice to 20 October in its entirety (Figure 5). Systematically positive Z anomalies occurred north of the US-Canada border, accompanied by warm air aloft and implied flow anomalies from slightly south of east, and sinking motion for the lower-middle troposphere over WA and BC. The weaker flow from the Pacific also meant the delivery of relatively warm continental air to a greater extent than normal but not especially dry air; the relative humidity was typical and the specific humidity was actually greater than usual at 925 hPa in the atmospheric boundary layer (not shown). As a consequence, the minimum as well as maximum temperatures were well above normal.

The summer of 2022 featured few days of rain, but does that mean that the ridge was present day in and day out? Figure 6 is a time series of daily 500 hPa Z anomalies at a point at the center of the box shown in Figure 5d. This time series features a preponderance of positive anomaly days, as expected. The hottest weather of the period considered here was during an interval near the end of July, which included positive anomalies of about 100 meters. It does not require as much of a perturbation to get it hot at that time of year. Not surprisingly, the greatest deviations from normal occurred in October given how unusually warm and dry the weather was during that interval. Naturally there were some short periods during which the ridge was absent, but based again on experience, they seem to have been mostly minor and fleeting.

In order to put the results shown above in an historical context, a time series of the average 500 Z for the box encompassing primary anomaly in 2022 shown in Figure 5d was constructed for the months of July through September. Dating back to 1948, the year of 2022 had the greatest heights for the region (Figure 7). A selection bias is recognized; the area over which the 500 hPa Z was averaged was picked on the basis of it being highly anomalous and so 2022 is liable to stand out by construction. Nevertheless, a 75-year record means there were plenty of opportunities to

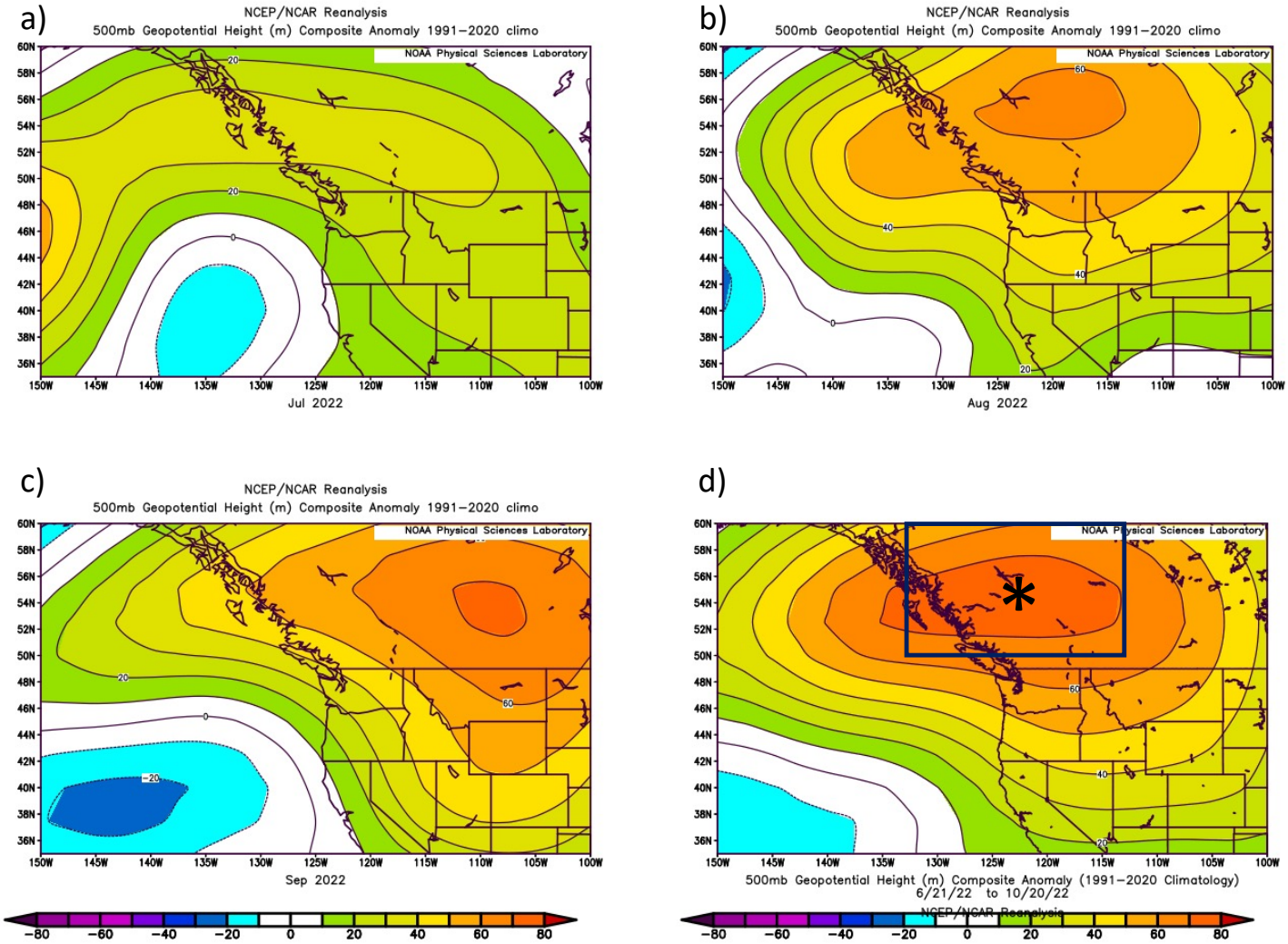


Figure 5: 500 hPa geopotential height (Z) anomalies for a) July 2022, b) August 2022, c) September 2022, and d) June 21-October 20, 2022 from the NCEP/NCAR Reanalysis (PSL).

match it. It is noted that 2012 represents a recent year with the 2nd highest 500 hPa Z in the selected area. It also had a long stretch of dry weather; for example, KSEA recorded only about 1" of rain from July through September versus the normal total of about 3.5". It turns out that 2017 was even drier, and also had abnormally high 500 hPa Z north of the border, but the anomalous ridge in this case did not extend westward over the Pacific and so that year was unremarkable in terms of the index plotted in Figure 7.

We close with somewhat of an aside, and that is with a comment on the overall positive trend in 500 hPa Z shown in Figure 7, particularly after the early 1980s. It turns out that sea level pressure (SLP) and 1000 hPa Z trends for the same area are flat to slightly decreasing. The rise in 500 hPa Z is consistent with an increasing - but not monotonic - trend in lower tropospheric temperatures. In other words, heating has meant expansion of the atmosphere and a corresponding increase in 500 hPa Z. An increase of 1°C averaged over the lowest 500 mb is equivalent to an increase in 1000-500 thickness or 500 hPa Z - if 1000 hPa is unchanged - of about 20 meters. Over the interval shown in Figure 7 the rise in 500 hPa Z is about 25 meters, based on a linear fit, implying a temperature increase of slightly greater than 1°C. Presumably we will observe a continuation of overall rises in

500 hPa Z in the area, and for that matter the Pacific Northwest as a whole, but it might be a while until we surpass that of 2022.

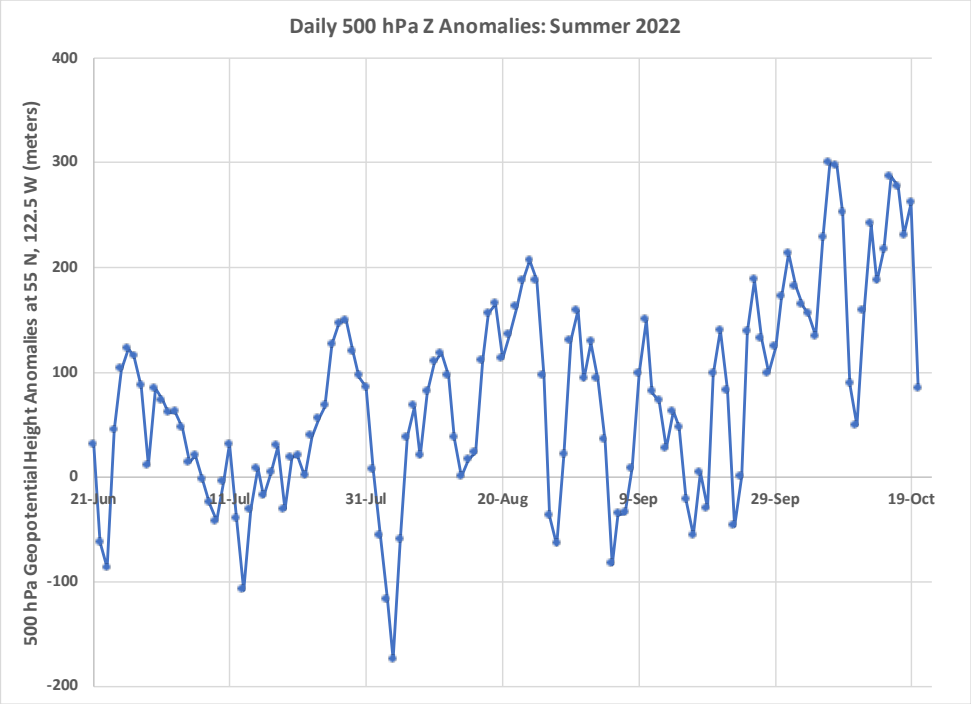


Figure 6: Daily 500 hPa geopotential height (Z) anomalies at the starred location in Figure 5d (PSL).

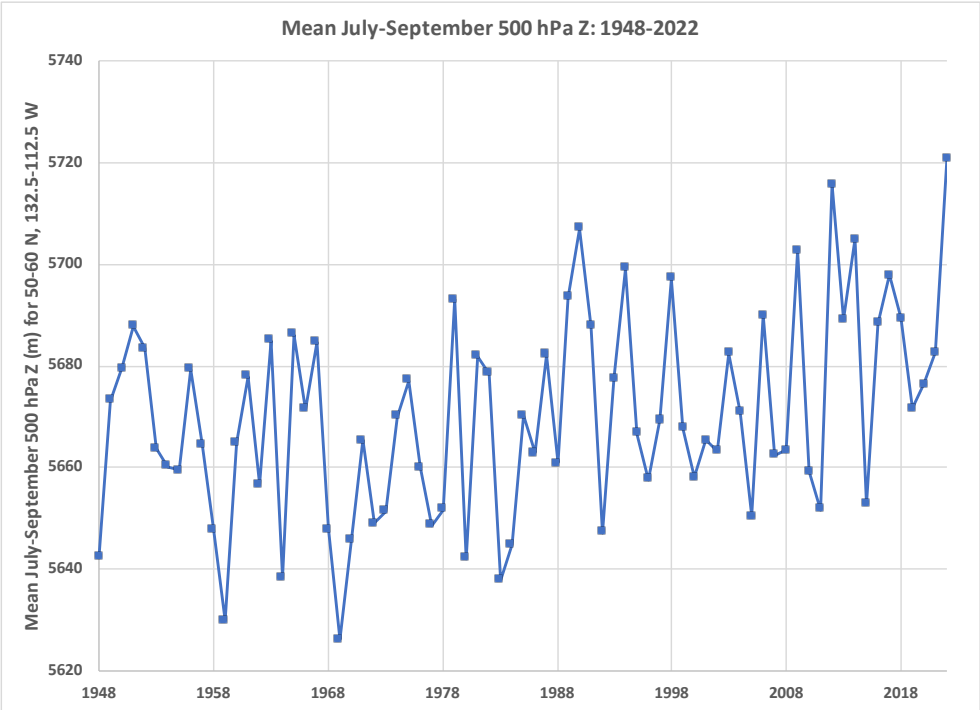
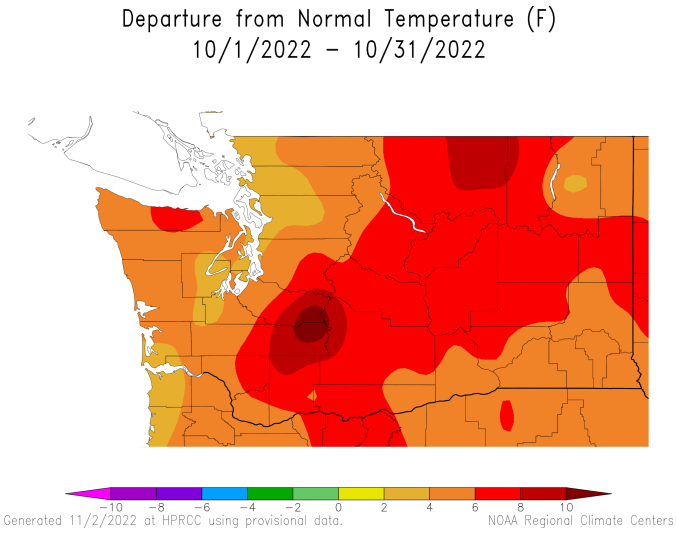


Figure 7: Average July-September 500 hPa geopotential height (Z) anomalies for the area in the box Figure 5d (PSL).

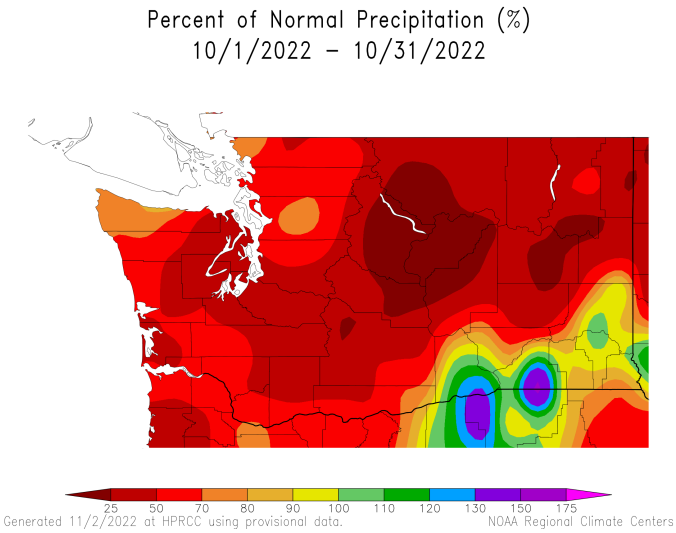
Climate Summary

Average October temperatures were above normal statewide, as shown in the plot from the High Plains Regional Climate Center. Temperature anomalies were much above normal in eastern WA, with temperatures between 6 and 8°F above normal. Omak, for example, was 8.0°F above normal (Table 2). October temperatures were warmer than normal west of the Cascades as well, though the anomalies were not as large. Olympia and Hoquiam were 4.0 and 5.2°F above normal, respectively, and anomalies were between 2 and 6°F above normal for most of western WA. This marks the fourth consecutive month in which temperatures were warmer than normal statewide.



October temperature (°F) departure from normal relative to the 1991-2020 normal (HPRCC).

Despite a switch to wetter conditions at the end of the month, total October precipitation was below normal for most of the state. Precipitation was especially scant in parts of eastern WA such as Wenatchee (0.02") and Ephrata (0.13"). Pasco and Pullman, on the other hand, received above normal precipitation thanks to a handful of rainy days during the second half of the month. Western WA also benefited from the switch to a wetter weather pattern, though precipitation totals didn't reach normal. SeaTac Airport and Quillayute reported 64% and 87% of normal, respectively (Table 2). The exception was Bellingham which measured exactly the 30-year normal, most of which fell on the 30th. Overall, western WA October precipitation was between 50 and 80% of normal.



October total precipitation percent of 1991-2020 normal (HPRCC).

Station	Mean Temperature (°F)			Precipitation (inches)		
	Average	Normal	Departure from Normal	Total	Normal	Percent of Normal
Western Washington						
Olympia	54.3	50.3	4.0	3.17	5.07	63
Seattle WFO	58.4	53.6	4.8	2.80	3.65	77
SeaTac AP	57.6	53.8	3.8	2.51	3.91	64
Quillayute	54.5	50.6	3.9	9.24	10.68	87
Hoquiam	57.7	52.5	5.2	3.68	6.91	53
Bellingham AP	54.0	51.1	2.9	3.85	3.85	100
Vancouver AP	59.8	54.2	5.6	2.69	3.41	79
Eastern Washington						
Spokane AP	55.0	47.9	7.1	0.61	1.37	45
Wenatchee	57.6	50.7	6.9	0.02	0.62	3
Omak	57.1	49.1	8.0	0.26	0.92	28
Pullman AP	53.6	48.4	5.2	1.83	1.59	115
Ephrata	57.7	50.9	6.8	0.13	0.66	20
Pasco AP	58.2	52.1	6.1	0.74	0.66	112
Hanford	59.8	53.4	6.4	0.28	0.62	45

Table 2: October 2022 climate summaries for locations around Washington with a climate normal baseline of 1991-2020.

Climate Outlook

La Niña conditions are still present in the Pacific Ocean and a "La Niña Advisory" remains in effect, according to the Climate Prediction Center (CPC). The weak-to-moderate La Niña is expected to continue through this winter. According to ENSO models, there is a 75% chance of La Niña persisting through the December through February period compared to 25% for neutral conditions. El Niño will not be making an appearance this winter.

The CPC outlook for November (Figure 8) indicates higher chances of below normal temperatures and above normal precipitation statewide. The odds of below normal temperatures are the same across the entire state and just slightly elevated (33-40% on the three-tier scale). The odds of above normal precipitation are highest for southeastern WA (50-60%) and lowest for northwestern WA (33-40%).

The three-month outlook for November-December-January (NDJ) shown in Figure 9 does not show a strong signal for temperature. Average temperatures over NDJ may be below, equal to, or above normal throughout the state. Precipitation, on the other hand, is likely to be above normal for NDJ statewide. The chances of above normal precipitation are slightly higher east of the Cascade crest. The longer-term outlook from the CPC indicates elevated odds of colder than normal temperatures after the first of the year, based on composites associated with past La Niña conditions and seasonal climate model simulations.

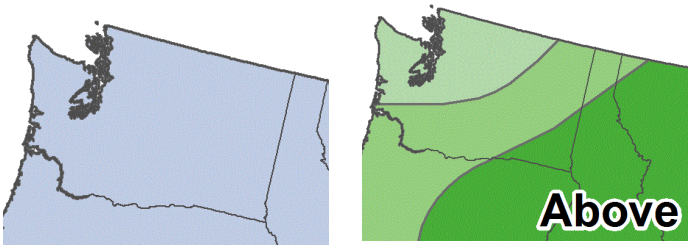
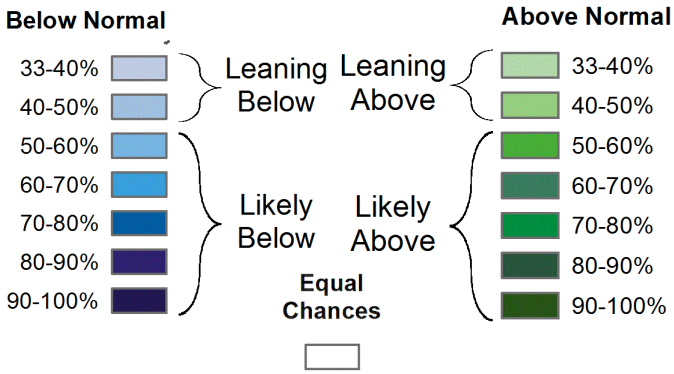


Figure 8: November outlook for temperature (left) and precipitation (right).



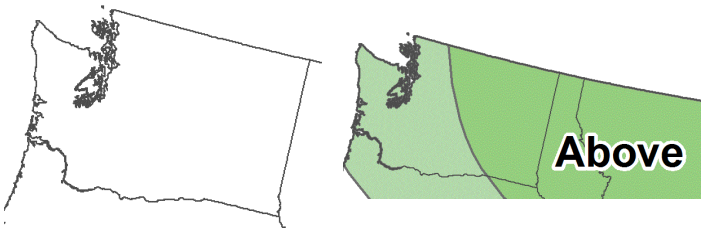


Figure 9: November-December-January outlook for temperature (left) and precipitation (right) (Climate Prediction Center).