Office of the Washington State Climatologist

December 2024 Report and Outlook

December 10, 2024

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

November Event Summary

Mean November temperatures were generally near normal, but most eastern Washington locations experienced above normal temperatures. Averaged statewide, November average temperatures ranked as the 47th warmest in the 130-year record and the average statewide temperature anomaly was +0.7°F. November precipitation varied across the state; it was generally near-normal in western Washington but in eastern Washington precipitation was well above normal. Average statewide, November precipitation was near normal, and ranked 44th wettest in the 130-year record. The average statewide precipitation anomaly was +0.81".

The most notable weather event that occurred last month was the bomb cyclone that developed in the Pacific Ocean on November 18th. The pressure dropped significantly in this low-pressure system, dropping 27 millibars (mb) in just 6 hours. This is an impressive pressure drop considering the definition of a bomb cyclone is a 24 mb drop in 24 hours. After its formation it tracked eastward towards the coast of Washington State, though it never made landfall. Still, strong hurricane-force wind gusts, cold temperatures, and rainfall caused destruction and power outages

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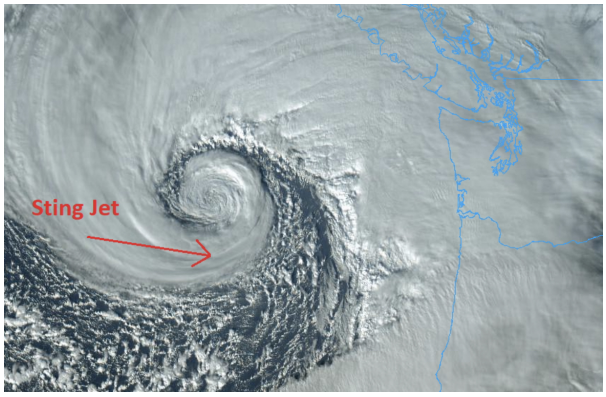

Figure 1: Bomb Cyclone off the coast of Washington on November 20, 2024 from NWS Seattle.

across many communities in the region. Wind gusts of up to 77 mph (category 1 hurricane force wind speeds) were recorded at Mount Rainier. Figure 1 shows the visible satellite image of the bomb cyclone on November 20th, as shared by the National Weather Service office in Seattle.

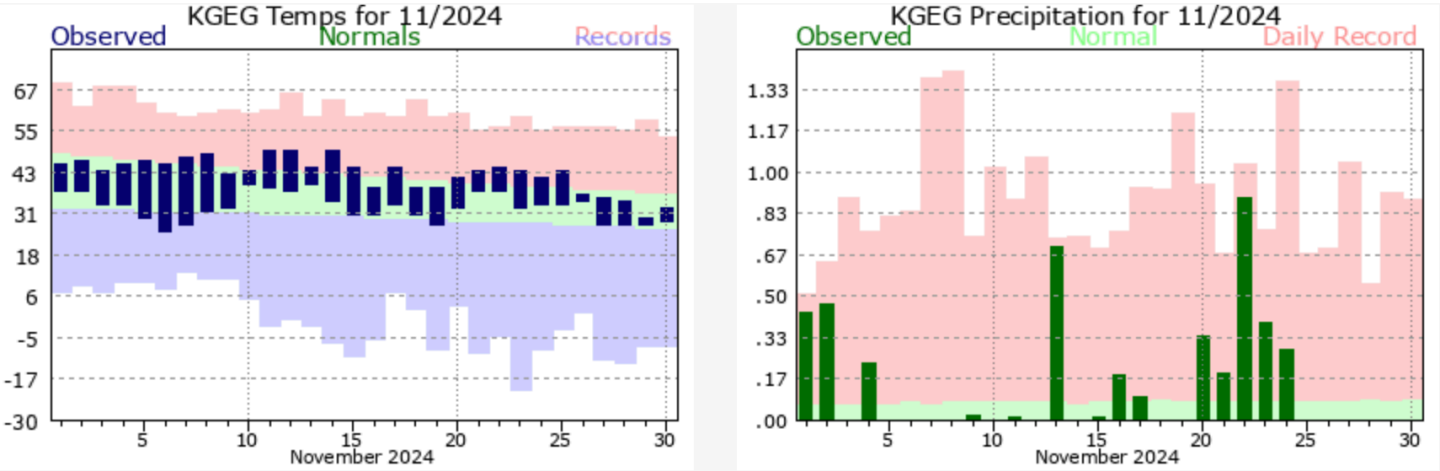

Figure 2: November 2024 daily temperatures (left) and precipitation (right) for Spokane International Airport compared to the 1991-2020 normal (green envelope) and previous records (blue and red envelopes; NWS).

Figure 2 shows the daily temperature and precipitation for Spokane this November. In Spokane, temperatures were generally near normal to above normal for the month, while maximum temperatures in the latter part dipped below normal. Conditions were similar for other eastern Washington locations such as Wenatchee and Ephrata, but locations like Pullman and Omak experienced more below-normal temperatures in the second half of the month. In contrast, SeaTac experienced slightly below normal in the beginning of the month, but temperatures dropped significantly after that, with generally cooler-than-normal temperatures for the majority of the month, some as a result of the bomb cyclone.

November is typically the wettest month of the year in Washington State and some places in eastern Washington received above normal precipitation totals. But western Washington locations such as SeaTac and Olympia received generally normal or only slightly above normal precipitation for the month. Figure 2 shows that Spokane received some substantial precipitation totals in the beginning and middle of the month. The most notable being the week before Thanksgiving from November 20-24.

Figure 3 shows the precipitation totals from volunteer CoCoRaHS observers on the morning of November 20th. The heaviest precipitation occurred in the Olympic Peninsula region as indicated by the red, orange, and yellow points, representative of precipitation totals exceeding 4 inches. Other locations that saw large precipitation totals include Wenatchee, Yakima, and Spokane.

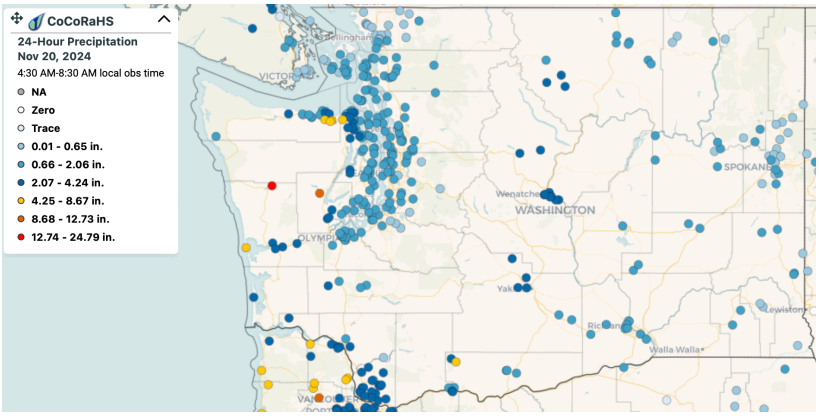

Figure 3: 24-hour total precipitation in inches measured on the morning of November 20th, 2024 from CoCoRaHS volunteer observers.

Streamflow and Drought Summary

This early in the season the snowpack totals are not a good indicator of what to expect over the coming winter. But a few events in early and mid November brought snow, leading to an early start of the snow accumulation season. As of December 1st the basin average snow water equivalent (SWE) percent of median was generally normal to above normal across Washington State (Figure 4, from the Natural Resources Conservation Service, NRCS). The Central Puget Sound has the lowest basin average in the state, with about 79% of the median snowpack. The Lower Yakima and Klickitat basins were in great shape with 245% and 241% of median, respectively.

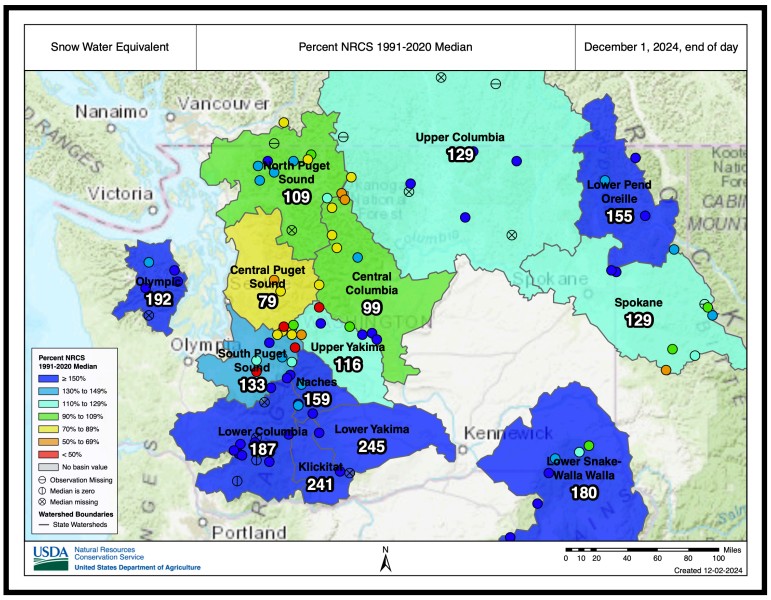

Figure 4: Snowpack (in terms of snow water equivalent) as of December 1, 2024 (NRCS).

Average November streamflows (Figure 5) were near normal for the majority of western Washington apart from parts of the southern Puget Sound which had below normal streamflow conditions. The southern central and northeastern portions of Washington also experienced below normal conditions. Overall, streamflow conditions have improved considerably compared to the previous month's.

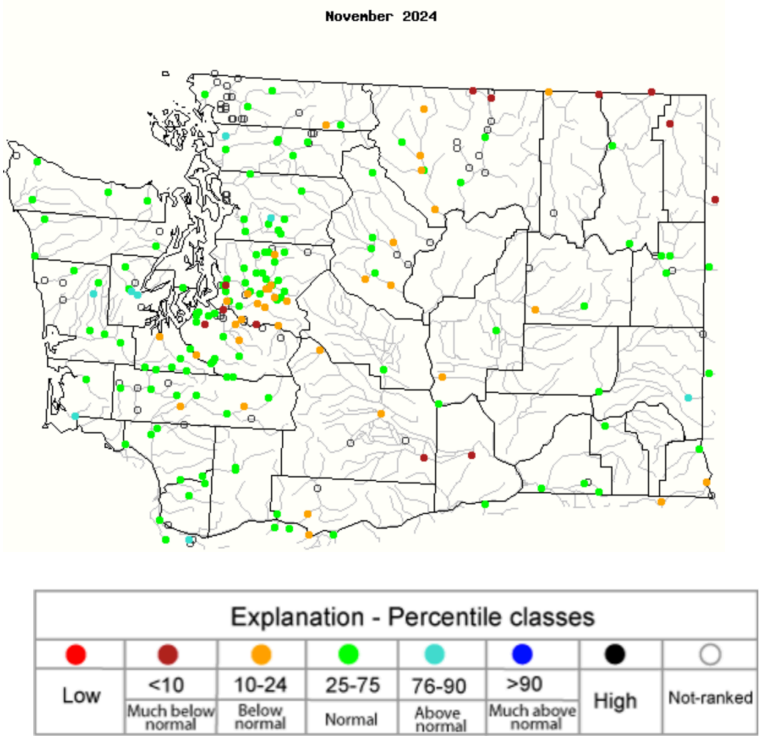

Figure 5: The average November streamflow percentiles (USGS).

The latest update for the U.S. Drought Monitor (Figure 6) shows a complete absence of drought conditions in western Washington and significant improvement for eastern Washington. Western Washington received normal to above normal precipitation totals for the month, which led to the Olympic Peninsula going from "abnormally dry" (D0) to drought-free conditions. Above normal precipitation this month in eastern Washington allowed for improvements in drought intensity. There are no longer areas of "severe drought" (D2) and drought intensity decreased

significantly for most eastern Washington locations. There is no longer drought in the northeastern Washington. Locations that remained similar to the previous report in October are the “moderate drought” (D1) areas in central and southeastern Washington.

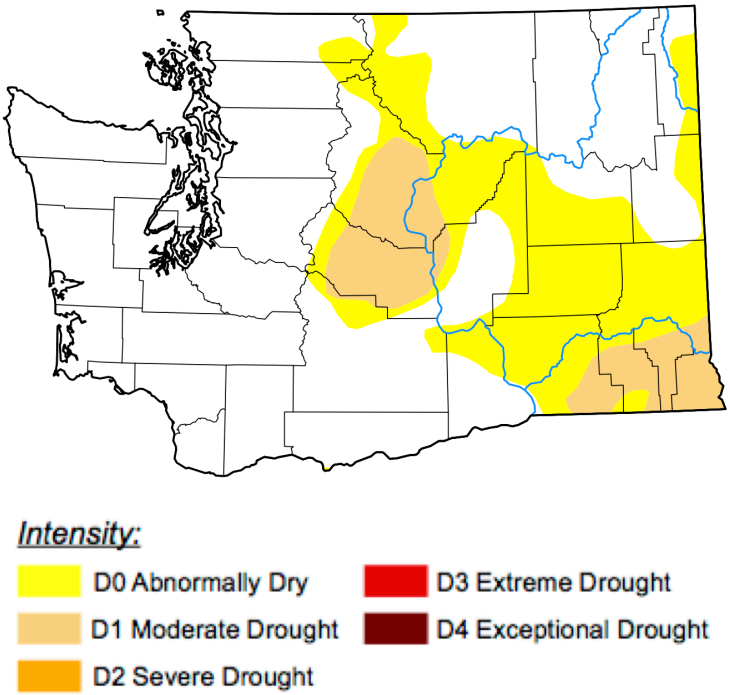

Figure 6: The December 5th, 2024 edition of the US Drought Monitor.

Winter Wind Chill Temperatures in WA State

Climate Matters Series Author: Nick Bond

Regular readers of our newsletter are quite familiar with the usual temperature and precipitation patterns across Washington state during winter. On the regional scale there are notable differences between the maritime conditions prevailing west of the Cascades, and the more continental conditions on the east side. There are also smaller-scale variations, especially relating to the terrain and proximity to water. A variety of resources are available to track down how temperature and precipitation has played out in the historical record at different stations in WA (the climate office is happy to help here if needed). But many weather variables of interest and importance are not as readily accessible. A good example this time of year is the wind chill temperature, i.e., how cold it feels when you account for temperature *and* wind. There are locations such as Olympia Airport and Arlington Airport in the Puget Sound basin that are often colder than other spots nearby, especially during calm, clear winter nights favoring the formation of strong surface-based inversions. But these locations don't necessarily have lower wind chill temperatures, since wind chill also depends on wind speeds. Since intervals of particularly low wind chill temperatures mean increased risks of hypothermia, let's take a closer look.

We got the wind chill data below using the "Hourly-Observed Data" and then "Sub-Daily" and "Threshold Search" options, from the cli-MATE application maintained by the Midwestern Regional Climate Center (MRCC; https://mrcc.purdue.edu/CLIMATE/). The wind chill values compiled by MRCC use the National Weather Service definition (https://www.weather.gov/safety/cold-wind-chill-chart). The wind chill temperature is more sensitive to changes in the wind at lower speeds. For example, with an air temperature of 15°F the wind chill temperature decreases by 12°F as the speed increases from 0 to 10 MPH; an additional increase in speed to 20 MPH results in a further drop in the wind chill temperature of only 5°F. And once the wind speed gets to about 40 MPH, further increases in speed yield only minor decreases in wind chill temperatures (though in those situations perhaps the primary concerns are due to the wind itself!).

We focus here on the number of hours during the past cool seasons (October to March of 1997-98 through 2023-24) with wind chill temperatures below specific thresholds. We selected the threshold of values less than 20°F for the west side of WA, and examined the records for Hoquiam, Olympia, Sea-Tac and Bellingham; for the colder east side we selected a threshold of 10°F and looked at Pasco, Wenatchee, Pullman, and Spokane International Airport. It turns out that hourly wind chill temperatures in the MRCC database do not extend as far back into the past as other meteorological variables. This means these time series are better for looking at year-to-year variability rather than long-term trends.

To set the stage, we first provide some information on the mean winter climate of the 8 WA stations considered here. Table 1 below shows the average daily minimum temperature for winter (Dec-Feb), the average coldest minimum temperature of the year, and the single lowest hourly temperature recorded, all for the 30-year

period of 1991-2020 that is generally used to represent current climatological norms. For good measure, we also throw into Table 1 the single lowest wind chill temperature for the winters of 1997-98 through 2023-24, recognizing that this record starts and ends later than that used for the other metrics.

While the east side of the state has average winter minimum temperatures that are roughly 5-10°F colder than those on the west side, the discrepancies are much more striking in the extremes. On the east side, typical annual minimums run about 15-25 degrees colder, and the very lowest temperatures are something like 20 to 35 degrees colder. There is a similar discrepancy in the extreme wind chill temperatures, where the eastern WA stations have values about 20 to 30 degrees colder. An exception to the balminess characterizing western WA is Bellingham, which often experiences strong northeast winds during its coldest weather, when cold air flows from interior Canada through the Fraser river valley. And Wenatchee stands out a bit on the east side. Its low value of -20°F is actually well above the other three east side stations even though its typical wintertime low temperatures are comparable. Apparently when it gets really cold in Wenatchee, the winds tend to be light. The severe cold snap during the second week of January 2024 featured the lowest wind chill temperatures at five out of eight of the stations examined here, with the other three having values that were close to their extremes dating back to the late 1990s.

Finally, on to the main event. Figure 7 shows the number of hours (October-March, 1997-98 through 2023-24) with wind chill temperatures less than 20°F at the western stations and less than 10°F at the eastern stations. The interannual variations in the duration of low wind chill temperatures are striking, especially west of the Cascades, where there can be over a 10-fold difference from one year to another. Here Bellingham is the clear winner, with an average of about 136 hours a season with wind chill temperatures below the 20°F threshold. Olympia and Hoquiam have the fewest number of hours, at about 30 per year, on average. Of the four stations considered in eastern WA, Spokane comes out on top with on average 167 hours a winter below the threshold of 10°F. Pullman is well behind Spokane, but has slightly more wind chill temperatures than Pasco and Wenatchee. The season of 2016-17

Station	Average Winter Min. Temp.	Average Coldest Min. Temp.	Lowest Min. Temp. Recorded	Lowest Wind Chill Temp.	Date of Lowest Chill
Hoquiam	38	24	15	3	01/12/24
Olympia	33	13	-1	-3	02/10/19
Sea-Tac	38	22	14	-1	01/13/24
Bellingham	34	15	10	-20	01/12/24
Pasco	28	3	-19	-31	01/04/04
Wenatchee	25	4	-15	-20	01/13/24
Pullman	28	-3	-17	-32	01/13/24
Spokane	25	-3	-24	-31	12/22/22

Table 1: Cold Temperature statistics (°F) for December-February in WA State

stands out in terms of wind chill for both sides of the state, with 2008-09 also prominent on the west side. Some of you may remember the latter, because of the crippling snowstorms that occurred in December 2008 throughout WA state, though the winter of 2016-17 was actually 2.5 degrees colder from a statewide perspective. And while such memories can be fleeting, the winter of 2016-2017 must have seemed harsh at the time; statewide average minimum temperatures were much higher in the two previous winters of 2015-16 and 2014-15, specifically by 7.9 and 9.4°F, respectively.

We conclude with the observation that over the short period analyzed here, the numbers of hours with low wind chill temperatures seem to be increasing. What's up with that? Multi-year variations in winter conditions, particularly in the frequency and severity of cold air outbreaks is likely a factor – there happened to be a lull in the late 1990s and early 2000s. But we also suspect that there might be a role involving a change in measurement practices. More specifically, cup and vane anemometer systems were replaced by sonic anemometers in the middle to late part of the 2000s. The legacy Belfort cup anemometers were prone to icing in cold conditions and hence it is conceivable that there were calms reported when there were actually light winds at those times. Sonic anemometers have no moving parts and so are not subject to the same problem. Quantifying the net effect(s) of past changes in wind measurement practices is way beyond what we can do in this newsletter, but we bring it up here as an example of the details that need to be considered when interpreting climate records.

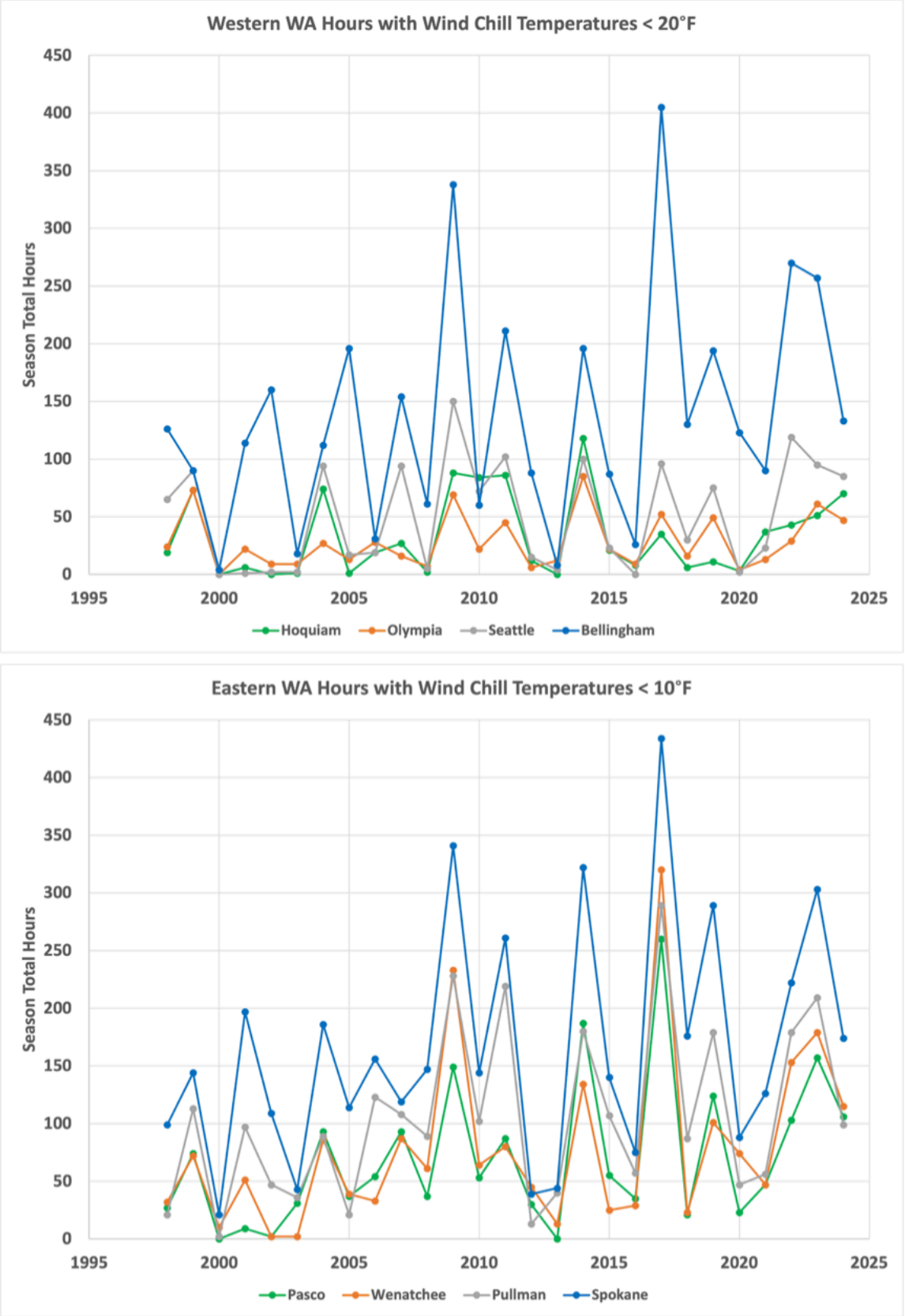

Figure 7: The number of hours with wind chill temperatures below 20°F (top) and below 10°F (bottom) for four western (top) and four eastern (bottom) locations. Data were compiled using hourly data from MRCC's cli-MATE.

Climate Summary

Figure 8 shows that the November average temperatures were generally near normal to above normal throughout the state. A majority of the stations listed in Table 2 for western WA had near-normal November temperatures. The exceptions are Olympia and Quillayute which both had temperatures 1.9°F above normal. Eastern Washington temperatures were above normal with Pasco the warmest relative to normal in Table 2 (+2.7°F above normal). The Olympic and Cascade Mountains had below normal November temperatures overall, which helped aid in the snowpack growth.

Figure 9 shows that the total November precipitation was near to below normal for the majority of western Washington locations. Western Washington precipitation ranged from about 77% and 120% of normal, with most locations receiving below normal precipitation (Table 2). Most of eastern Washington received above normal precipitation ranging between 159-315% for the sites listed in Table 2.

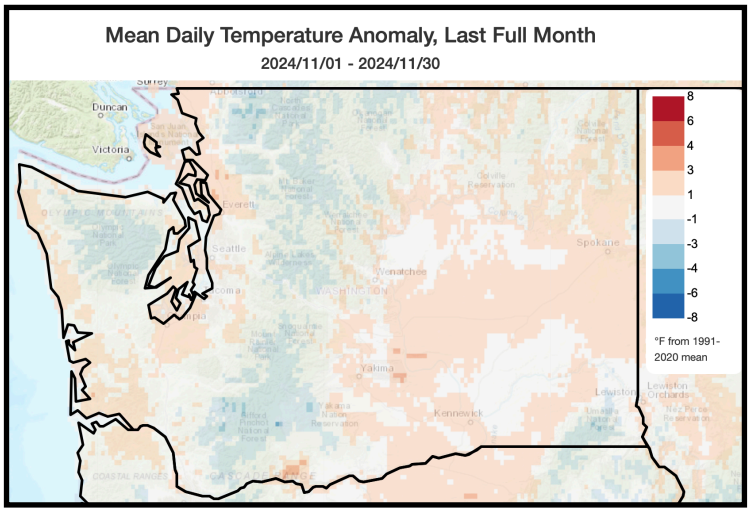

Figure 8: November temperature (°F) departure from normal relative to the 1991-2020 normal (Climate Toolbox).

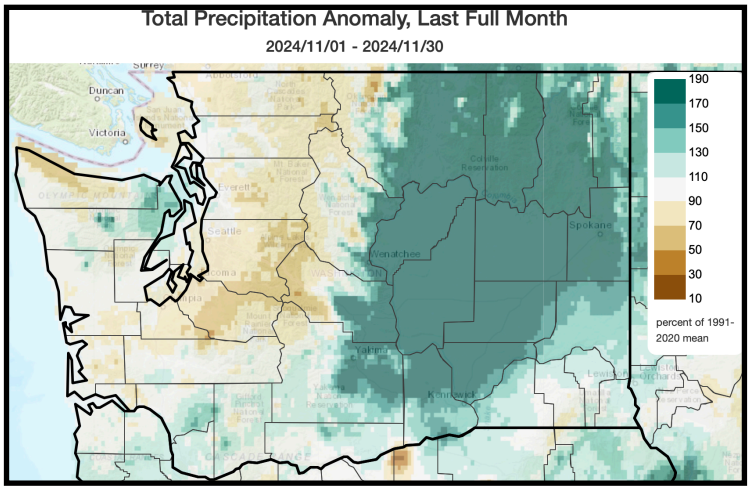

Figure 9: November precipitation departure from normal relative to the 1991-2020 normal (Climate Toolbox).

Station	Mean Temperature (°F)			Precipitation (inches)		
	Average	Normal	Departure from Normal	Total	Normal	Percent of Normal
Western Washington						
Olympia	45.1	43.2	1.9	6.62	8.21	81
Seattle WFO	47.3	46.4	0.9	5.40	5.85	92
SeaTac AP	46.0	46.5	-0.5	4.86	6.31	77
Quillayute	46.6	44.7	1.9	12.20	15.26	80
Hoquiam	46.4	45.9	0.5	12.49	10.95	114
Bellingham AP	45.1	44.5	0.6	4.81	5.20	93
Vancouver AP	47.1	46.2	0.9	6.63	5.51	120
Eastern Washington						
Spokane AP	38.2	36.3	1.9	4.24	2.06	206
Wenatchee	38.9	37.4	1.5	2.27	0.85	267
Omak	37.0	35.9	1.1	3.91	1.24	315
Pullman AP	38.6	38.6	0.0	3.42	2.14	159
Ephrata	39.2	37.6	1.6	2.71	0.86	315
Pasco AP	43.6	40.6	2.7	1.77	0.87	203
Hanford	42.7	40.3	2.4	1.68	0.80	210

Table 2: November 2024 climate summaries for locations around Washington with a climate normal baseline of 1991-2020.

Climate Outlook

According to the Climate Prediction Center (CPC), conditions in the equatorial Pacific Ocean remain ENSO-neutral, and a "La Niña Watch" is still in effect. Eastern and east-central Pacific Ocean sea surface temperatures (SSTs) still ranged between near and below average, whereas the SSTs in the western Pacific Ocean were above average. It is expected that La Niña conditions will become more favorable to appear during November-January (74% chance) and persist through January-March 2025 (61% chance). According to ENSO models, by the November-January period, there's a 26% chance of neutral conditions and no chance (0%) of El Niño.

The CPC December temperature outlook (Figure 10) displays higher chances of above normal temperatures ranging between 40-50% statewide. The precipitation outlook for the coming month shows a likelihood of above normal precipitation expected in eastern Washington. The chances of above normal precipitation in this region range between 33% and 50%. Equal chances of above normal, near-normal, and below normal precipitation are displayed in western Washington.

The three-month December-January-February (DJF) temperature outlook (Figure 11) shows higher chances of below normal temperatures over the whole state. The DJF precipitation outlook indicates elevated chances of above normal precipitation statewide, with chances between 33 and 50% on the three-tiered scale.

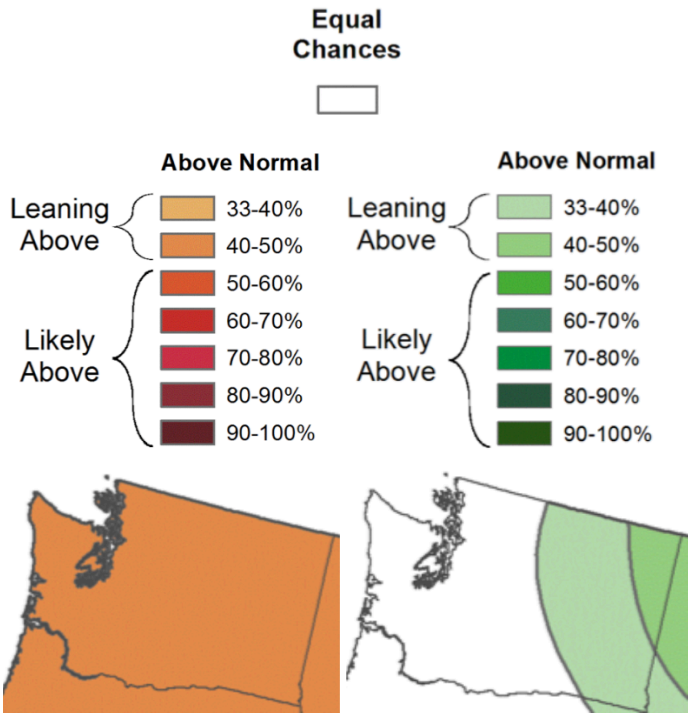

Figure 10: December outlook for temperature (left) and precipitation (right).

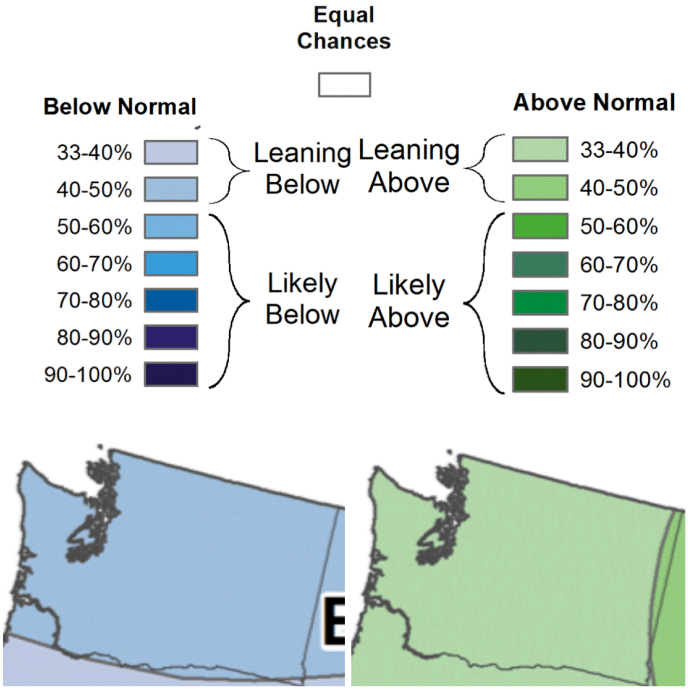

Figure 11: December-January-February outlook for temperature (left) and precipitation (right).
(Climate Prediction Center)