# Office of the Washington State Climatologist

November 2021 Report and Outlook

November 5, 2021

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

## October Event Summary

Mean October temperatures were generally near-normal in Washington State. Temperatures were on the cooler side west of and including the Cascade Mountains and on the warmer side in eastern WA. There was variability in precipitation totals as well, with western and northern WA receiving above normal October precipitation and parts of eastern WA receiving below to near-normal precipitation.

The first half of the month was generally colder than normal, especially for western WA. Figure 1 shows the daily maximum and minimum temperatures for Spokane International Airport. A cold frontal passage on the 5th dropped temperatures markedly around the state, and ushered in a longer period of colder than normal temperatures. On the 12th, record low minimum temperature records were set at SeaTac Airport (36°F) and Hoquiam (36°F - tie) with below freezing temperatures in some non urban areas. The 13th was another cold day, setting a record low daily max temperature at Pullman (43°F), and with a trace of snow falling at Spokane Airport.

Temperatures moderated around the 15th as a shift in the weather pattern brought heavy rain to the coast and the northern Puget Sound. Quillayute set a maximum daily rainfall record of

### In this Issue



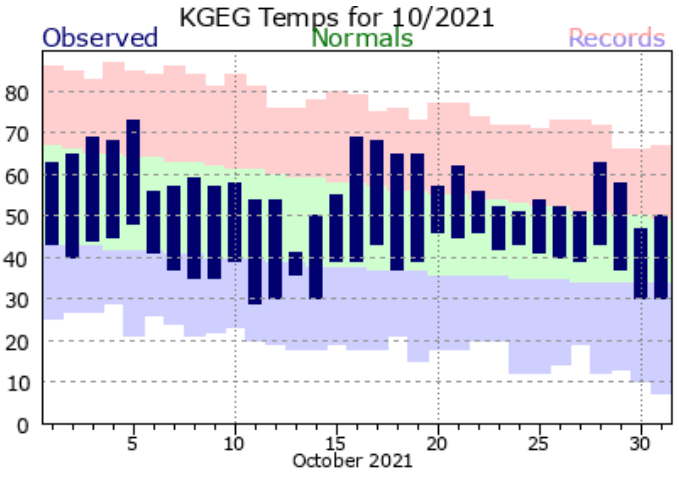



**Figure 1: Daily maximum and minimum temperatures for Spokane International Airport during October 2021 compared to the 1991-2020 normal (green envelope; NWS).**

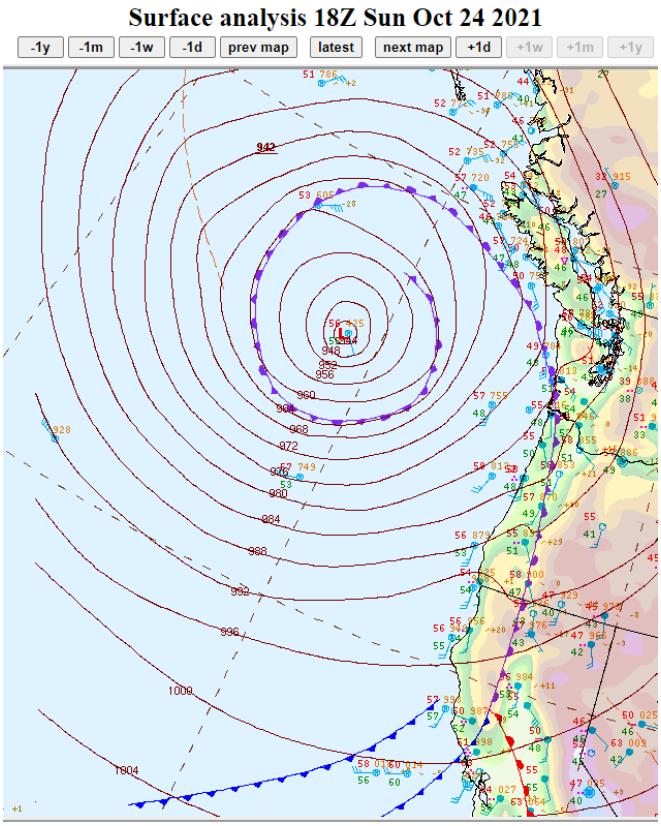



**Figure 2: The 942 hPa low pressure off the WA coast on October 24 (NWS WPC).**

2.89" on the 15th. Rainy weather continued for most of western WA and fell statewide on the 21st, persisting for the remainder of the month (aside from a dry Halloween weekend). A strong low pressure system (with a central pressure of ~960 hPa) formed off the coast of WA on the 21st, but was associated with just a typical frontal passage over land. Maximum daily rainfall records were set at Pasco (0.34") on the 22nd and Yakima (0.48") on the 24th.

A even stronger low pressure system set up over the WA coast on the 24th - with a record low reading of 942 hPa according to the NWS Weather Prediction Center (Figure 2). While most of the impacts such as heavy rain were directed at northern California in this particular instance, there were still strong winds and power outages in WA on the 24th and 25th. Wind gusts were generally in the 40-50 mph range for western WA, but Paine Field in Snohomish County recorded a 61 mph gust on the afternoon of the 24th.

Heavy rain fell again on the 28th, setting some maximum daily rainfall records at SeaTac Airport (1.99"), the Seattle Weather Forecasting Office (1.77"), and Bellingham (1.27"). Figure 3 shows the 24-hr precipitation totals measured on the morning of the 29th by CoCoRaHS observers, indicating that the central Puget Sound region got the brunt of the rainfall. Finally, the month ended with a dry weekend, giving trick-or-treaters the opportunity to display their costumes without rain jackets and boots getting in the way!

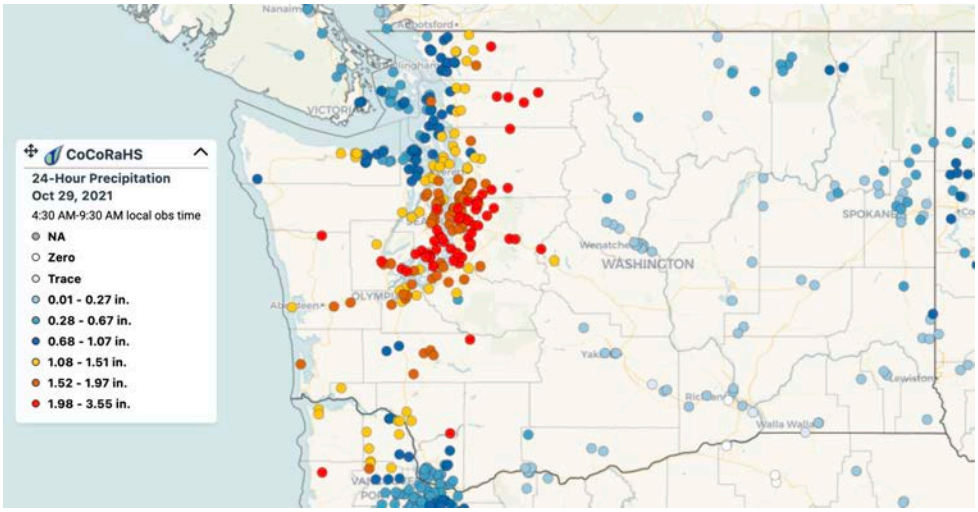



**Figure 3: 24-hr CoCoRaHS observations on the morning of October 29, 2021 (CoCoRaHS).**

# Streamflow and Drought Summary

Above normal October precipitation for portions of WA State and periods of heavy rainfall has resulted in above normal monthly streamflows for the Olympic Peninsula, southwest WA, and parts of the central and northern Puget Sound (Figure 4). Average October streamflow is near-normal throughout the rest of western WA and most of eastern WA. A few gauges, such as those on the Yakima, Spokane, and Methow Rivers, remain below normal for the month. There were a few instances of mountain snow in October but we have yet to receive widespread significant snow accumulation and are not showing the snow water equivalent percentages of median this early in the season.

Continued precipitation in western and northern WA, coupled with improvements to streamflow and soil moisture has meant that further improvements were made to the U.S. Drought Monitor over the last month. Figure 5 shows the November 4 edition of the U.S. Drought Monitor with most of the drought and "abnormally dry" conditions removed from western WA. The extent of the D4 ("exceptional drought") and D3 ("extreme drought") have been reduced from the north as well.

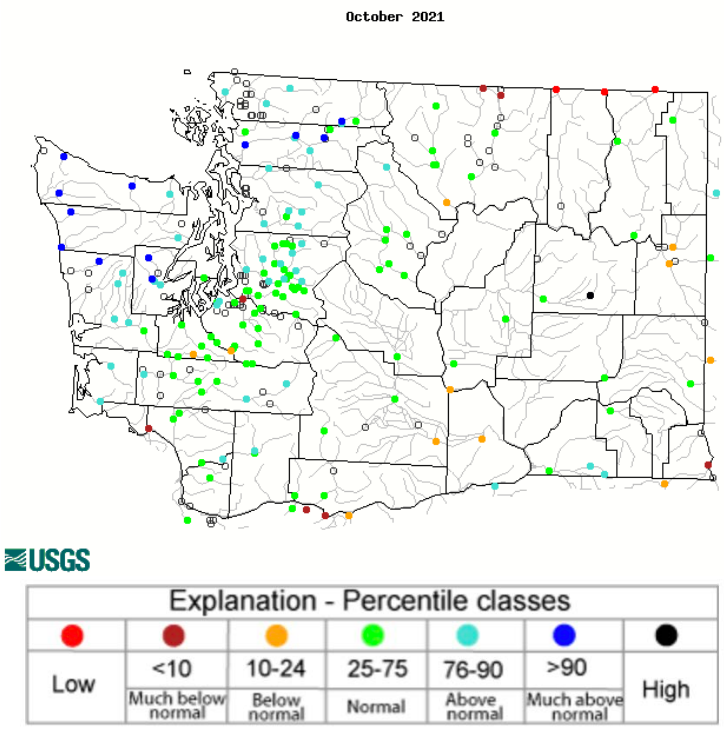



**Figure 4: September average streamflow for WA (from USGS).**

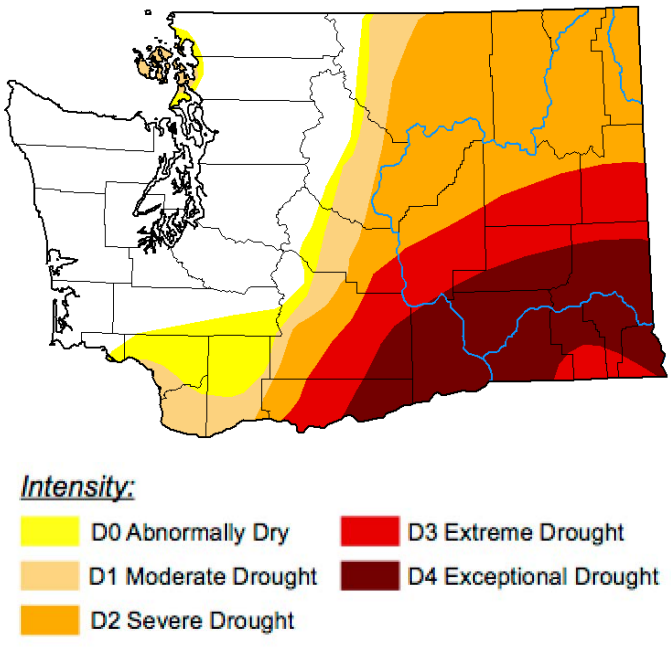



**Figure 5: The November 4, 2021 edition of the U.S. Drought Monitor.**

**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 and partners have developed Condition Monitoring Observer Reports on Drought (CMOR-drought), a short survey that allows the public to enter their observations regarding crops, water supply, fire, etc.

photo by Henry Reges, CoCoRaHS

## Community, Collaborative Rain, Hail, and Snow (CoCoRaHS) Corner

Washington CoCoRaHS observers said goodbye to the last remaining vestiges of September sunshine in favor of spooky October gloom. Observers made a total of 11,029 observations in this month – 646 more than in September. 65% of observations recorded some amount of precipitation, up from 36% in the previous month. 13 new observers joined the CoCoRaHS network in Washington State this month. Hopefully new and veteran observers alike are gearing up for the thick of the rainy season.

The highest one-day total for October hailed from Issaquah, WA. At 6:20 AM on October 29th, one intrepid observer recorded a total of 3.20" in their rain gauge. They were not alone – only ten of the top 100 one-day totals were recorded on a day other than the 29th. A number of stations across King County reflected the same deluge (pictured in Figure 3 above). One significant weather report from Seattle described the event: "Relatively brief (23 hrs: 10/28 11a-10/29 10a) atmospheric river event with light to heavy rain for entire duration." Another observer from Tacoma spoke of puddles over a foot deep and leaves clogging storm drains.

Other reports of high one-day totals came from Clallam, Skagit, and Snohomish Counties.

Most observers who wrote Condition Monitoring Reports continued to see improving conditions. The summer's drought seems to finally be improving in most places. Precipitation and high humidity have reportedly replenished soil moisture and increased streamflow. Gardeners even spoke of protecting their crops from overnight frost. The scars of the summer still remain, though; said one observer from Okanogan County, "Soil in the hotly burned areas of this summer's forest fires is like moondust, I sink in over my boot tops in some areas."

## Oregon-Washington 2021 Water Year Recap and 2022 Outlook Meeting

It's not too late to register for the 16th annual OR/WA Water Year 2021 Recap and 2022 Outlook meeting. The meeting will be held virtually on the mornings of November 16 and November 17, 2021. Registration is free but required. The goal of this meeting is to share and gather information regarding climate impacts of the 2021 water year, with a focus on the exceptional drought that was widespread across the region. Both days will include time for discussion and peer-to-peer learning, in addition to hearing from the forecast experts about the 2022 water year.

In addition, the end-of-water-year survey that focuses on collecting PNW water year impacts due to either abnormally dry or abnormally wet conditions is now open. This survey helps inform an annual PNW Water Year Impacts Assessment and will also be discussed at the water year meeting.

# Sea Level Rise Projections and Visualizations

Written by: Haley Staudmyer

On October 31st, the 2021 United Nations Climate Change Conference (COP26) began in Glasgow, Scotland. There, the parties to the Paris Agreement are expected to ramp up their commitments to reducing greenhouse gas emissions so that the world may prevent some of the worsening effects of climate change. In this month's spotlight, we hope to give our readers an idea of what tangible impacts these decisions may have on Washingtonians by discussing predictions of sea level rise on our coast under different emissions scenarios.

Global average sea levels are rising because of increasing global average temperatures. There are multiple mechanisms behind sea level rise, with some being more obvious than others. The most important cause is the melting of ice. Although its disappearance will be harmful for other reasons, sea ice won't contribute to sea level rise – only ice that resides on land, like glaciers, will. Most of the potential for sea level rise via meltwater comes from the ice sheets on Greenland and Antarctica. If all the ice on Greenland were to melt, we could expect 24 feet of sea level rise (IPCC); if all the ice on Antarctica melted, we could expect 191 feet of sea level rise (Winkelmann et al. 2015). Complete melting of either the Greenland or Antarctic ice sheets won't happen any time soon, but the longer we wait to rein in greenhouse gas emissions, the greater and fast the melt.

Since 1880, global average sea level has risen between 8 and 9 inches, but most of that has not come from the melting of the ice sheets. For now, sea level rise mostly comes from the melting of glaciers as well as a process known as thermal expansion. As human-caused greenhouse gas emissions warm the atmosphere, so too do they warm the ocean. Warm water takes up more volume than cold, dense water. This is the same phenomenon observed in mercury thermometers; the red mercury rises as temperature increases. This increase in ocean volume rather than mass contributes a significant amount to sea level rise.

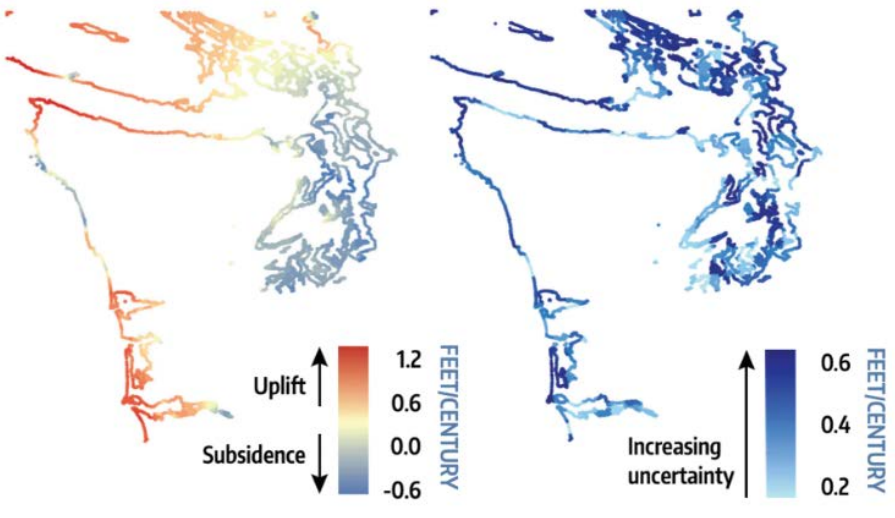



**Figure 6:** Vertical land movement best estimate rates (left) expressed in rates of feet/century, and their uncertainties (1 standard deviation, right) as estimated for Washington's coastlines. Figure from the Projected Sea Level Rise for Washington State assessment.

There are many other local factors that may affect sea level rise. Smaller contributors include the construction of man-made water reservoirs, groundwater extraction, ENSO events, and the change in

**PROJECTED RELATIVE SEA LEVEL CHANGE FOR 2100**
(feet, averaged over a 19-year time period)

| Location | Vertical Land Movement Estimate | Greenhouse Gas Scenario | Central Estimate (50%) | Likely Range (83-17%) | Higher magnitude, but lower likelihood possibilities | | |
|---|---|---|---|---|---|---|---|
| | | | | | 10% probability of exceedance | 1% probability of exceedance | 0.1% probability of exceedance |
| Tacoma (47.3N, 122.4W) | -0.5 ± 0.2 | Low | 2.1 | 1.5-2.7 | 3 | 4.6 | 7.9 |
| | | High | 2.5 | 1.9-3.3 | 3.6 | 5.3 | 8.8 |
| Neah Bay (48.4N, 124.6W) | 1.1 ± 0.3 | Low | 0.5 | -0.1 - 1.2 | 1.5 | 3.1 | 6.3 |
| | | High | 1 | 0.3 - 1.7 | 2 | 3.8 | 7.4 |
| Taholah (47.4N, 124.3W) | 0.3 ± 0.5 | Low | 1.3 | 0.6-2.1 | 2.4 | 3.9 | 7.1 |
| | | High | 1.7 | 1.0-2.6 | 2.9 | 4.6 | 8.1 |

**Table 1:** Relative sea level projections, in feet, for three locations along Washington's Coastline; the Taholah, Neah Bay, and Long Beach. Projections are expressed in terms of the "probability of exceedance" for 2100 (2090-2109) under two different greenhouse gas scenarios (RCP 4.5 ["Low"] and RCP 8.5 ["High"]; van Vuuren et al., 2011). Projected changes are assessed relative to contemporary sea level, defined as the average sea level over the 19-year period 1991-2009. Figure from the Projected Sea Level Rise for Washington State assessment.

gravitational pull of glaciers and ice sheets as they melt. One of the most important factors for determining future sea level rise across Washington's coastlines is local trends in land elevation. Land sinks and rises in response to the movements of tectonic plates. This can either amplify or offset other changes in sea level rise.

In 2018, the Climate Impacts Group's Washington Coastal Resilience Project released the Projected Sea Level Rise for Washington State assessment to provide state leaders the tools and information needed to prepare for future sea level rise. The assessment created estimates of uplift and subsidence along all of Washington's coastlines to factor into their estimates of future sea level rise. As seen in Figure 6, Washington's coastlines are not universally experiencing uplift or subsidence. Some parts of Washington, like the Puget Sound area, are sinking at rates slower than half a foot per century. The majority of Washington's coastlines farther west are actually rising. In some places, the uplift is to the tune of a foot or more per century. This uplift will not be enough to offset sea level rise entirely, but it will prevent the impacts of sea level rise from being worse. On the contrary, the subsidence in the Puget Sound region will worsen these impacts.

Table 1, taken from the assessment, provides estimates of sea level rise for three different locations along Washington's coastlines for both low and high emissions scenarios. The first location, Tacoma, is experiencing subsidence, and as a result is projected to see the most sea level rise of the three. In a low or high greenhouse gas emissions scenario, the report gives a 50% chance for more than two feet of sea level rise by 2100. In contrast, Neah Bay, which is experiencing uplift, has a 50% chance of seeing a foot of sea level rise by 2100 under a high greenhouse gas emissions scenario. That is less than half as much sea level rise as is predicted for Tacoma under the same conditions. Under a low greenhouse gas emissions scenario, Neah Bay has a 50% chance of seeing just half a foot of sea level rise. Taholah is experiencing very little vertical movement, and as such, its sea level rise projections lie somewhere between Neah Bay's and Tacoma's. The Washington Coastal

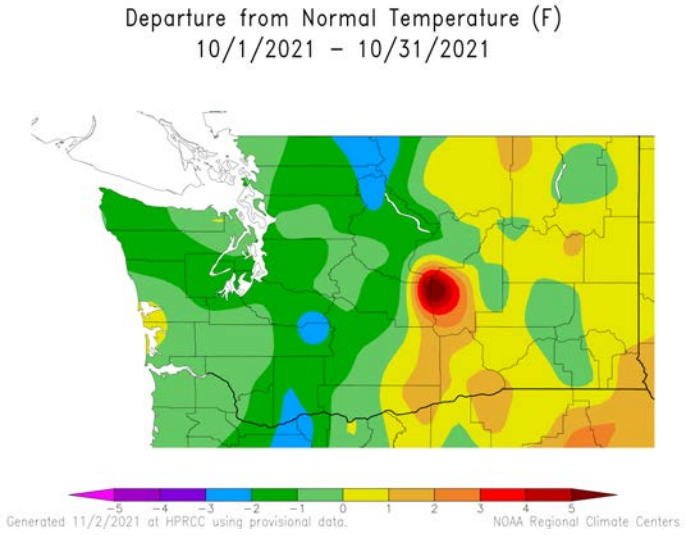
Resilience Project published interactive online tools alongside the assessment so that anyone may gain a better understanding of sea level rise projections for 171 different locations along Washington's coast.

Why does sea level rise matter? About 40% of the world's population lives within 100 kilometers of the coast. According to NOAA, nearly 70% of Washingtonians live in coastal regions. Most prominently, portions of these regions and peoples will be subject to more frequent and costly flooding, but there are plenty of impacts from sea level rise that aren't so obvious. Coastal bluffs and shorelines will be subject to erosion, changing the very shape of our state. Importantly, these coastal areas are of the utmost importance to the Indigenous tribes that have inhabited the regions for generations; sea level rise may destroy their ancestral homes. Low-lying land areas will be subject to saltwater intrusion with implications for agriculture, and marine ecosystems will also be impacted by changes in estuaries, tidelands and other crucial nearshore habitats. Washington's economy relies heavily on the health of these ecosystems and communities; not only are flood damages costly, but so too are the losses from reduced tourism, impacts on fisheries and ecosystems, and aquifer contamination.

Sea level rise is just one example of why the decisions we make today have lasting implications for the future. For the three locations listed in Table 1, the difference between a low or high greenhouse gas emission scenario is about half a foot of sea level rise. At the time this newsletter is published, world leaders are gathered in Scotland determining the future for generations of Washingtonians to come. Every emissions reduction pledge from every country has implications for nearly 70% of Washingtonians' backyards and communities from a sea level rise perspective alone. The other 30% are impacted just as much through lenses of heat waves, fires, or other climate changes. Will our state look back at the efforts of leaders at COP26 and think it was enough? Only time will tell.

# Climate Summary

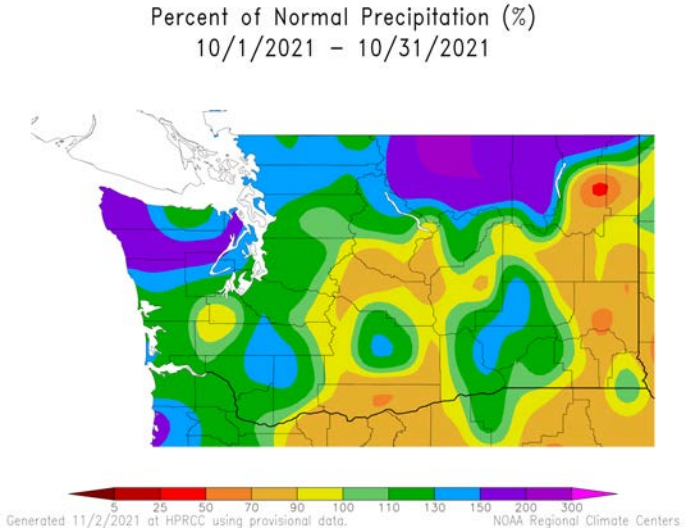
Average October temperatures were near-normal for much of WA State. The map from the High Plains Regional Climate Center on the right-hand-side shows many areas within 1.0°F of normal. In general, areas on the western side of the Cascades were on the cooler side while areas east of the Cascades were on the warmer side. Note that the bull's eye of much above normal temperatures near Quincy, WA is an artifact of bad temperature readings at that station and that data should be thrown out once quality control checks are implemented. Nevertheless, October temperatures were still slightly on the warmer side for a few stations in eastern WA. Pasco, for example, was 2.1°F above normal for the month (Table 2). For western WA, average temperatures at SeaTac Airport were 2.0°F below normal for the month.




Temperature (°F)

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

Total October precipitation was near to above normal for a majority of WA State. Precipitation totals relative to normal were highest at Omak and Quillayute, with each station reporting 187 and 183% of normal, respectively. Of course, that is all relative; Quillayute received 17.81 more inches of precipitation than Omak. Still, above normal precipitation is welcome for eastern WA, where drought conditions has been persistent. Some eastern WA locations were quite as wet for October, totaling between 70 and 90% of normal precipitation. Spokane Airport, for example, received 85% of normal October precipitation (Table 2).




Precipitation (%)

**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 | 49.8 | 50.3 | -0.5 | 5.39 | 5.07 | 106 |
| Seattle WFO | 53.0 | 53.6 | -0.6 | 4.60 | 3.65 | 126 |
| SeaTac AP | 51.8 | 53.8 | -2.0 | 5.76 | 3.91 | 147 |
| Quillayute | 49.7 | 50.6 | -0.9 | 19.53 | 10.68 | 183 |
| Hoquiam | 53.1 | 52.5 | 0.6 | 7.64 | 6.91 | 111 |
| Bellingham AP | 50.8 | 51.1 | -0.3 | 4.49 | 3.85 | 117 |
| Vancouver AP | 53.2 | 54.2 | -1.0 | 3.73 | 3.41 | 109 |
| Eastern Washington | | | | | | |
| Spokane AP | 48.5 | 47.9 | 0.6 | 1.17 | 1.37 | 85 |
| Wenatchee | 50.1 | 50.7 | -0.6 | 0.58 | 0.62 | 94 |
| Omak | 49.7 | 49.1 | 0.6 | 1.72 | 0.92 | 187 |
| Pullman AP | 47.9 | 48.4 | -0.5 | 1.59 | 1.59 | 100 |
| Ephrata | 50.5 | 50.9 | -0.4 | 0.77 | 0.66 | 117 |
| Pasco AP | 54.2 | 52.1 | 2.1 | 0.88 | 0.66 | 133 |
| Hanford | 54.3 | 53.4 | 0.9 | 0.81 | 0.62 | 131 |

**Table 2: October 2021 climate summaries for locations around Washington with a climate normal baseline of 1991-2020.**

# Climate Outlook

On October 14, the Climate Prediction Center ENSO Alert Status was changed to "La Niña Advisory" due to La Niña conditions developing in the equatorial Pacific Ocean. Over the last month, the sea surface temperatures (SSTs) in the equatorial Pacific Ocean were below normal everywhere except in its far western potion. According to ENSO models as a group, there is an 87% chance that the La Niña conditions will persist through the December-January-February period.

The CPC outlook for November (Figure 7) shows equal chances of below, equal to, or above normal temperatures statewide. For November precipitation, there are increased chances of above normal precipitation for the entire state. The likelihood of above normal November precipitation is slightly higher for eastern WA (40-50% chance on the three-tier scale) compared to western WA (33-40% chance).

The three-month outlook for November-December-January (NDJ; Figure 8) is calling for higher chances of below normal temperatures west of and including the Cascade Mountains. The remainder of the state has equal chances of below, equal to, or above normal temperatures for NDJ. For precipitation, there are increased chances of above normal precipitation statewide, with the odds between 40 and 50% on the three-tiered scale.

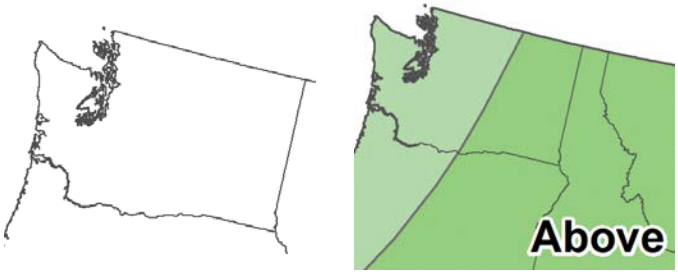



**Figure 7: November outlook for temperature (left) and precipitation (right).**

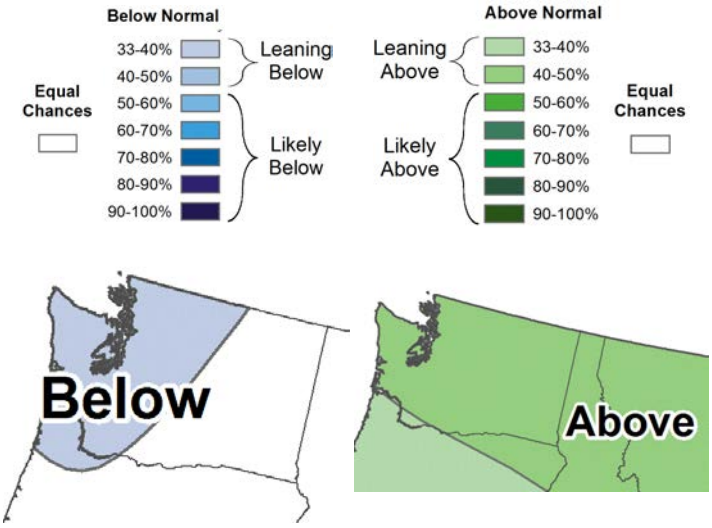



**Figure 8: November-December-January outlook for temperature (left) and precipitation (right) (Climate Prediction Center).**