Office of the Washington State Climatologist

January 2023 Report and Outlook

January 10, 2023

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

December Event Summary

Mean December temperatures were well below normal statewide, and the anomalies were especially large in eastern WA. This marks two consecutive months with below normal temperatures for the state. Figure 1 shows the November-December 2022 temperature anomalies (compared to the old 1981-2010 normal period) with most of eastern WA between 4 and 8°F below normal. For just December, several stations ranked among the top ten coldest on record (Table 1). Averaged statewide, December ranked as the 17th coldest on record, with anomalies -4.7°F below normal. December precipitation was normal to above normal for most of WA, particularly east of the Cascade Mountains. Some locations in western WA received below normal precipitation.

The month began colder than normal, and with snow, even in the Puget Sound lowlands. Several

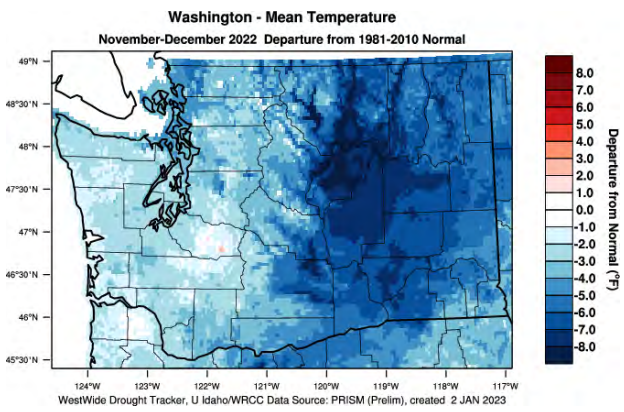

Figure 1: Average November-December 2022 temperature anomalies compared to the 1981-2010 normal (WWDT).

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Station	December Average Temperature (°F)	Rank	Records Began
Pasco Tri Cities	25.7	1	1998
Wenatchee Pangborn AP	19.9	3	1960
Vancouver Pearson	38.3	4	1998
Yakima AP	23.1	5 (tie)	1946
Bellingham AP	34.5	9 (tie)	1949
Pullman 2 NW	26.0	10 (tie)	1941
Spokane AP	23.5	15	1881

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

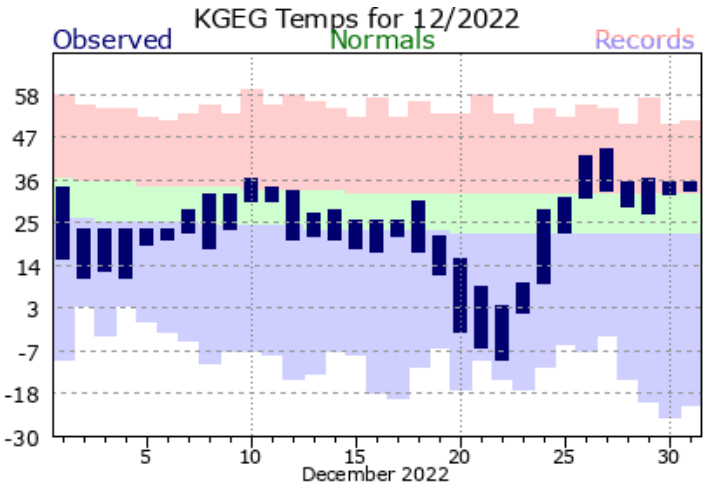


Figure 2: December 2022 daily temperatures for Spokane International Airport compared to the 1991-2020 normal (green envelope) and previous records (blue and red envelopes; NWS).

record low temperature records were set early (e.g., 17°F at Bellingham on the 1st, 6°F at Ellensburg on the 2nd and the 4th), and temperatures at Spokane International Airport were well below normal for the first week of December (Figure 2).

Another, more anomalous cold snap occurred later in the month, beginning on the 19th. Low elevation snow was widespread in the central and northern Puget Sound region; Figure 3 shows the 24-hour snowfall totals on the morning of the 20th. Temperatures were downright frigid as the arctic air settled into the state. Pullman-Moscow Airport recorded a daily record low temperature of -20°F on both the 21st and 22nd. Wenatchee Pangborn Airport and Ellensburg set low temperature records of -7 and -8°F, respectively, on the 21st, while Ellensburg (-9°F) set another daily low temperature record in the 22nd.

Temperatures warmed rapidly on the 23rd, but not before freezing rain wreaked havoc on the Puget Sound region. More details on that event can be found below (Page 5), but the event significantly impacted travel by making roads impassable and closing down all runways at SeaTac Airport for hours, and caused power outages (photo).

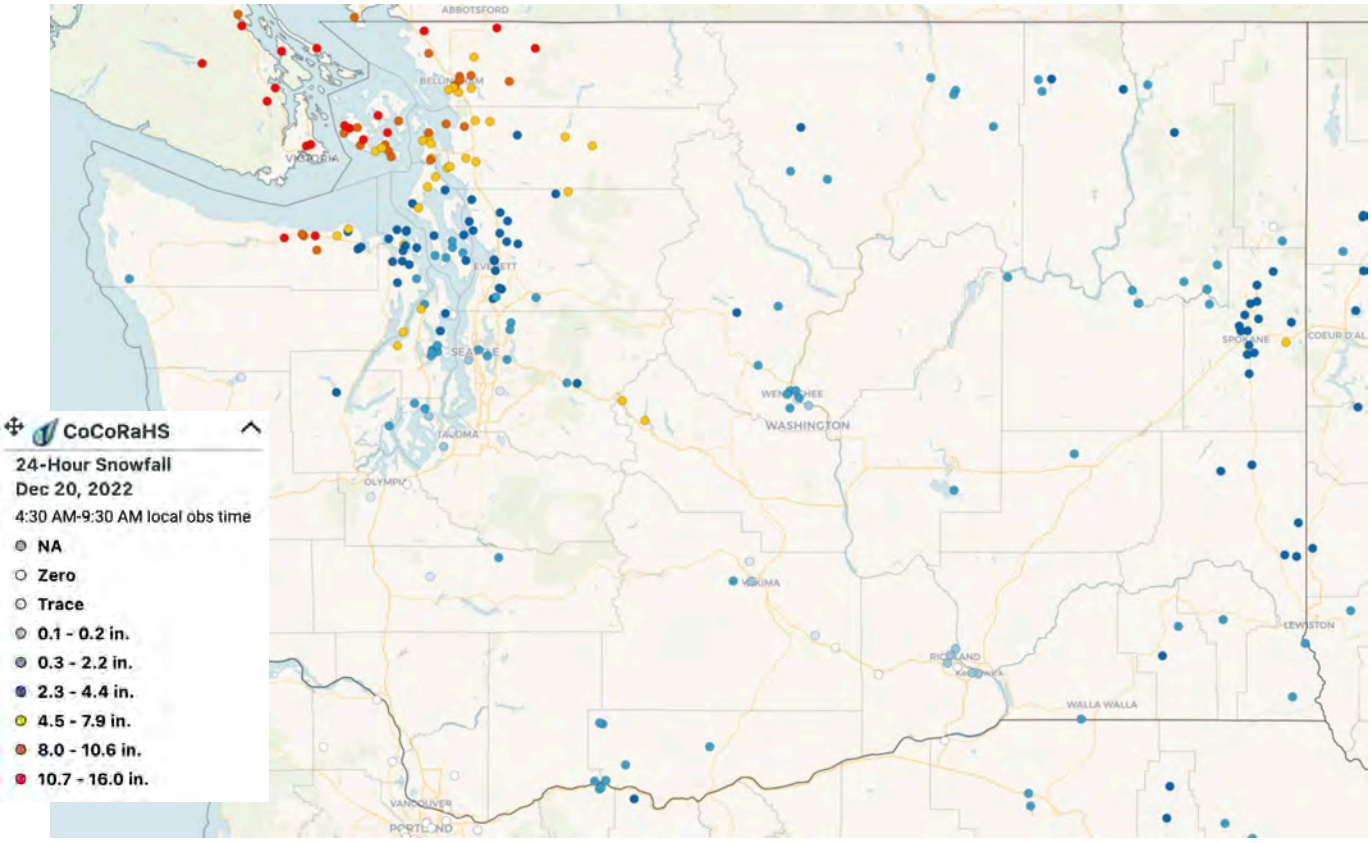


Figure 3: 24-hour snowfall observations on the morning of December 20, 2022 (from CoCoRaHS).

Temperatures rapidly warmed on the 24th, as the winds shifted to out of the southwest or south and precipitation fell as rain. Quillayute (2.57") and SeaTac AP (1.52") recorded record high rainfall amounts on the 24th. Christmas Day was very mild in western WA, and Quillayute (56°F) set a record daily high temperature. The month ended with above normal temperatures, accompanied by winds and precipitation at times. Daily maximum rainfall records were set at Spokane (0.79") on the 27th and Wenatchee Pangborn (0.36") on the 30th.

Ice covered tree on December 23, 2022 in Burien (Seattle Times; Ellen M. Banner)

Snowpack and Drought Summary

Snowpack steadily grew statewide throughout December. The basin average snow water equivalent (SWE) percent of normal from the Natural Resources Conservation Service (NRCS) as of January 1 (Figure 4) was normal to above normal throughout most of WA State. The Central Puget Sound, Spokane, Lower Snake-Walla Walla, Upper Columbia, Lower Pend Oreille, Lower Columbia, Upper Yakima, and South Puget Sound basins had above normal SWE. The remaining basins were near-normal as of January 1, with the Olympic basin being the only exception with 80% of normal SWE.

Average December streamflow improved relative to the monthly averages since the start of the water year to near-normal for most rivers in western WA (not shown), though many in eastern WA remained below normal because the extremely cold temperatures produced ice, which can both cause temporary dams to form and compromise streamflow measurements. As a result of more normal streamflows, growing snowpack, and water year precipitation being normal to above normal in some eastern WA locations, there were some further improvements made to the U.S. Drought Monitor (Figure 5). Specifically, coastal and southwest WA are now drought-free, as well as some areas in north central WA. In addition, some "moderate drought" was removed to align better with the recent improvements in short to medium term precipitation.

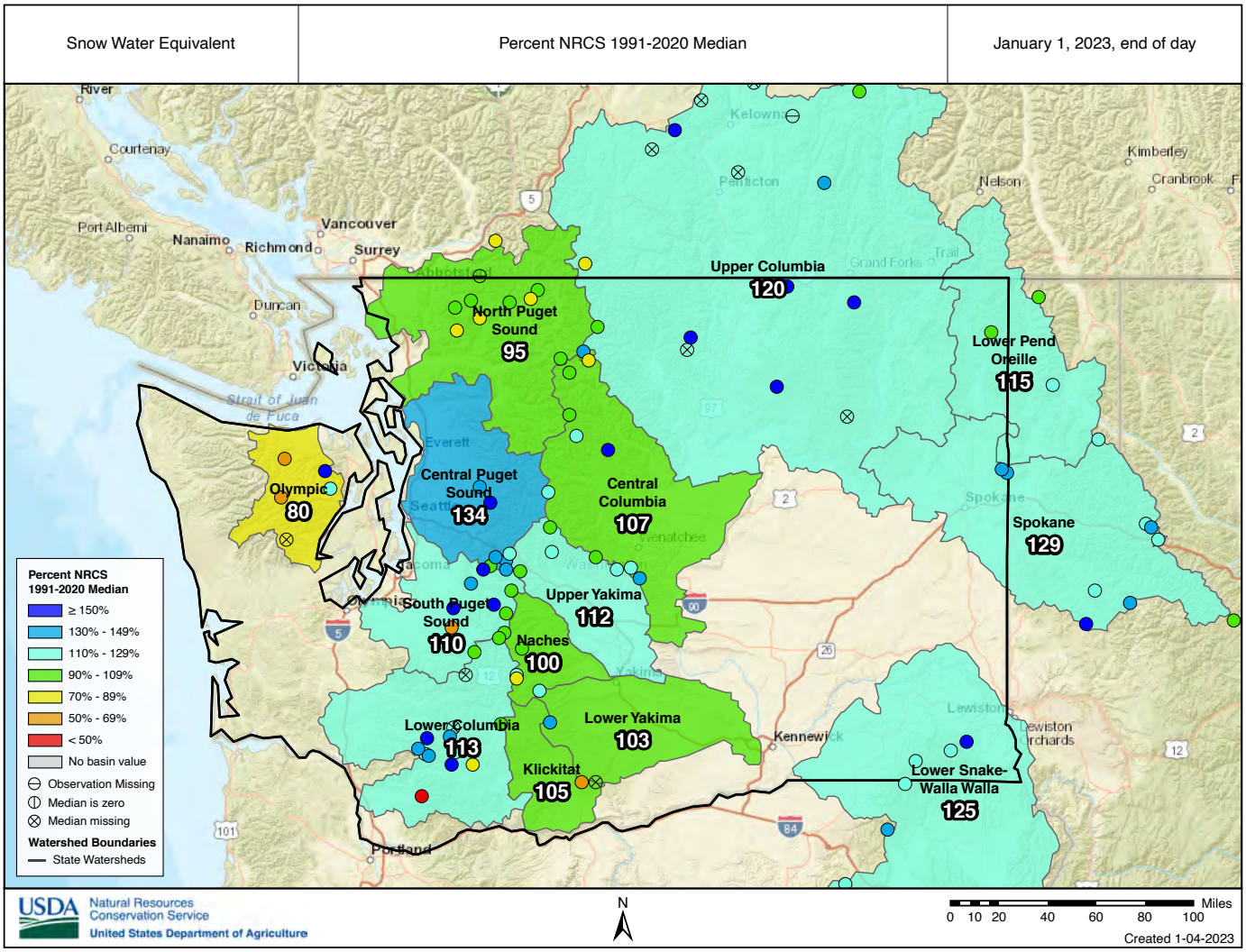


Figure 4: Snowpack (in terms of snow water equivalent) percent of normal for Washington as of January 1, 2023 (NRCS).

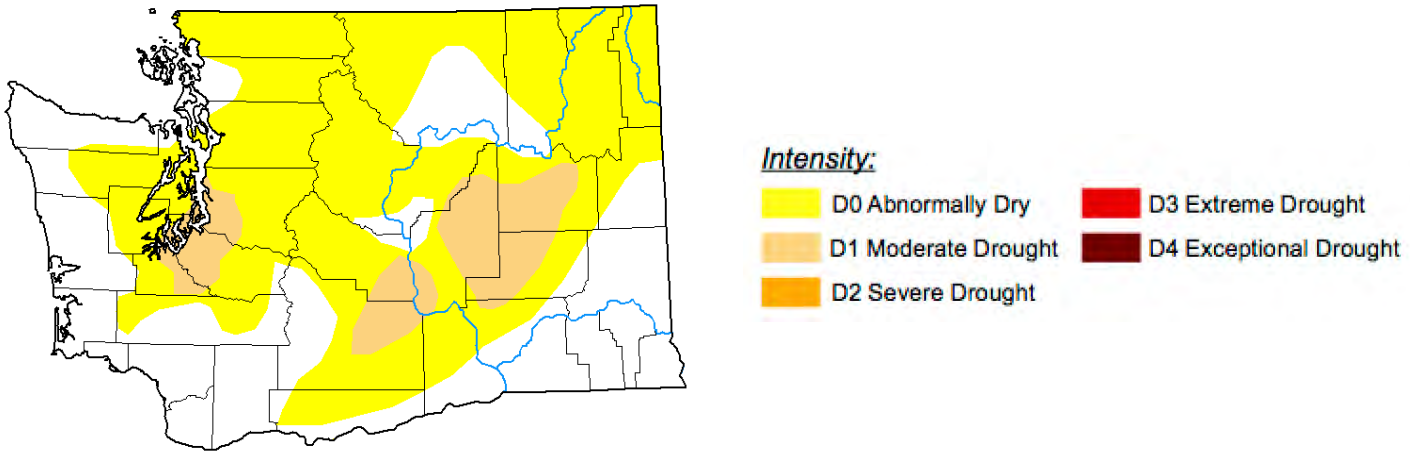


Figure 5: The January 5, 2023 edition of the U.S. Drought Monitor.

Freezing Rain in Washington State

A Message from the State Climatologist

Most everyone in the Puget Sound region on 23 December 2022 must have been impressed by the freezing rain that occurred that day. This event featured extremely slippery roadways and outside walkways; at least no one we have spoken with recalls a time when it was more treacherous to get around. Our objective here is to provide a bit of climate context for this event based on previously published work.

Before we get started, let's briefly review the situation on 23 December. Without going into all the gory details, freezing rain requires cold, sub-freezing air near the surface overlaid by warm air in the presence of precipitation, of course. Surface air temperatures were generally in the middle to upper 20s (°F) during the late night and early morning of 23 December 2022, and there was definitely warm air aloft, with the 12 UTC (4 AM local) weather balloon sounding from Salem, OR indicating a temperature of 5.0°C (41°F) and southwest winds of 45 knots at the 850 hPa level (about 4800 feet above ground level). The overall magnitude of the inversion in this sounding was an impressive 14°C. The cold air at the surface was maintained by easterly cross-Cascade mountain flow, with temperatures along the east flank of the Cascades mostly in the single digits. The precipitation that occurred that morning fell on a surfaces ranging from bare to scant amounts of packed down snow, resulting in essentially sheets of ice. Previous events have often occurred when there has been more snow on the ground, and again based on personal experience, with less dire consequences. At least that was the case during the 19 January 2012 event in the Puget Sound

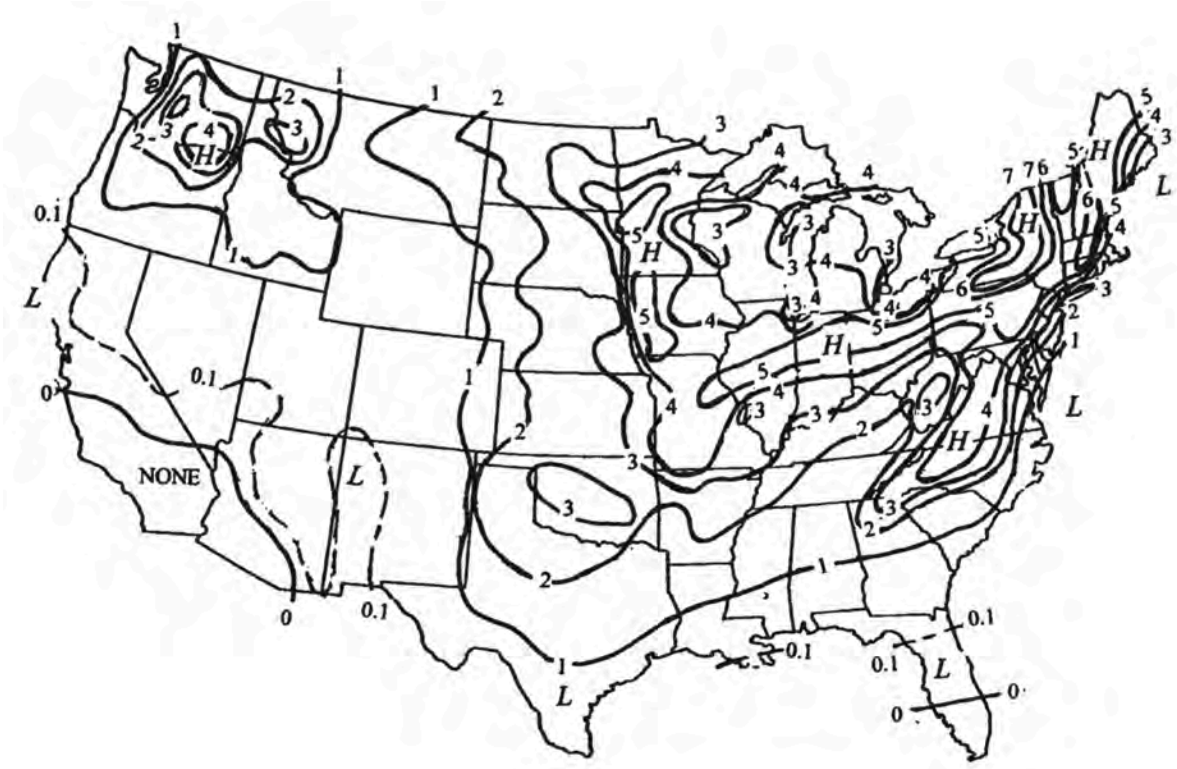


Figure 6: Average annual number of days with freezing rain from 1948-2000 (from Degelia et al. 2016 and Chagnon and Karl 2003).

basin, which actually included mostly greater precipitation amounts both prior to and during the interval with freezing rain, but a somewhat different regional weather pattern that included not as frigid air east of the Cascades and not as warm air aloft. Freezing rain was also reported in the southern portion of Puget Sound during late December 1996 after a period of substantial snowfall in the transition to warmer temperatures and heavy rain. The freezing rain in these situations occurred in western Washington, but certainly eastern Washington gets its share, as will be elaborated upon below. From an event perspective the year of 2017 stands out, during which eastern Washington experienced significant ice storms in January, February and December, as described in the NOAA Storm Events Database.

There has been past work on the distributions of the historical mean in the frequency of freezing rain, and changes over time in these frequencies. With regards to the former, we reproduce a map (Fig. 6) from the review of ice storms by Degelia et al. (2016), which itself was lifted from Chagnon and Karl (2003). Figure 6 shows the average annual number of days with freezing rain for the years of 1948 through 2000, and so is somewhat out of date. That being said, presumably the overall patterns shown are reasonably valid. Some readers may be surprised by the local maximum in frequency in the Columbia Basin of eastern WA. But the residents of that region are liable to be OK with this portrayal in that the "cold pool" that often settles into this lower-elevation region (Whiteman et al. 2001) can be accompanied by relatively warm air aloft with stratus cloud decks thick enough to produce freezing precipitation. This precipitation is more often in the form of small drizzle droplets (or small ice pellets) versus rain; we wonder whether this distinction is captured in the records used by Changnon and Karl (2003) that rely on manual observations. The map in Figure 6 also is just a crude representation of known spatial variations in the incidence of freezing rain. In particular, it is well-known that the Columbia River gorge is prone to ice storms, and there is barely a hint of such a feature. The Cascade Mountain passes also experience frequent, and also highly consequential, bouts of freezing rain. But an important takeaway is that eastern WA state and northern OR experience freezing rain relatively often compared to the rest of the western US.

A study of the trends in freezing rain frequency has been carried out by Groisman et al. (2016). Shown here as Figure 7 is a map for the US indicating changes in the number of days per year in freezing rain between the decade of 2005-2014 and the previous 3 decades of 1975-2004. For events as rare as freezing rain, especially in some parts of the US including western WA, a period of 10 years is a short interval to construct meaningful averages. We also wonder how much of a problem, i.e., the errors introduced in comparing present to past frequencies, relates to the change from manual to automatic observations. At any rate, their analysis shows that the northwestern portion of WA underwent an increase in frequency in these events, while most stations considered in the interior of the Pacific NW indicate a decrease in frequency. It is unclear to us how the frequency of freezing rain is liable to evolve in association with global warming. Conceivably the trends will play out differently for the west side of the Cascades where surface temperatures in the lowlands tend to be above freezing and freezing temperatures become that much less common versus the east side. Eastern Washington surface temperatures during winter tend to be cooler, of

course, and may be below the freezing point consistently enough such that changes in frequency will be minimal, or even increase if air temperatures aloft warm above freezing more often, while accompanied by precipitation, during those chilly situations.

References

Changnon, S.A., and T.R. Karl (2003): Temporal and spatial variations of freezing rain in the contiguous United States: 1948-2000. *J. Appl. Meteorol.*, **42**, 1302-1315, doi:10.1175/1520-0450

Degelia, S. K., J.I. Christian, J.B. Basara, T. J. Mitchell, D.F. Gardner, and S.E. Jackson (2015): An overview of ice storms and their impact in the United States. *Intl. J. Climatol.*, **36(8)**, 2811–2822, doi:10.1002/joc.4525

Groisman, P.Y, O.N. Bulygina, X. Yin, R.S. Vose, S.K. Gulev, I. Hanssen-Bauer, and E. Forland (2016): Recent changes in the frequency of freezing precipitation in North America and Northern Eurasia. *Environ. Res. Lett.*, **11**, doi:10.1088/1748-9326/11/4/045007.

Whiteman, C.D., S. Zhong, W.J. Shaw, J.M. Hubbe, X. Bian, and J. Mittelstadt (2001): Cold pools in the Columbia Basin. *Wea. Forecast.*, **16**, 432-447, doi:10.1175/1520-0434(2001)016

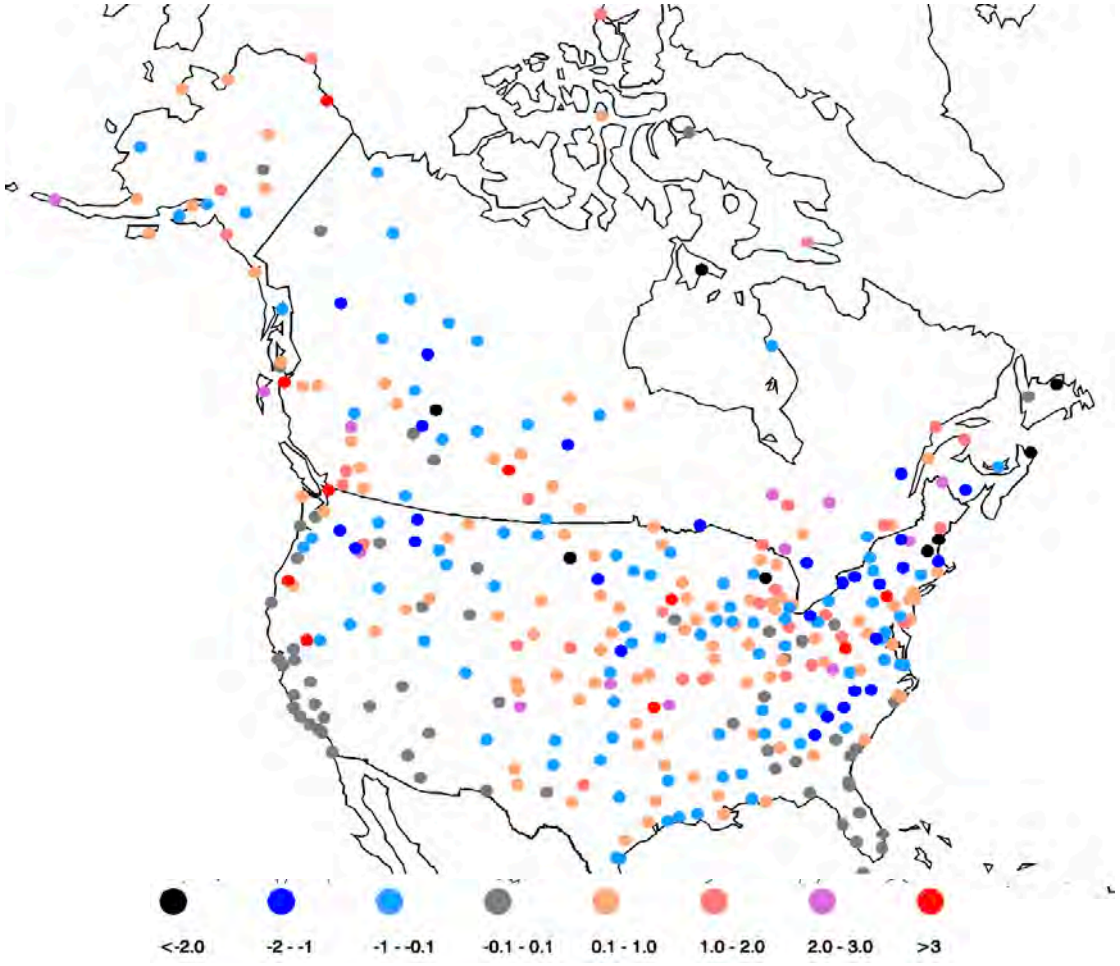
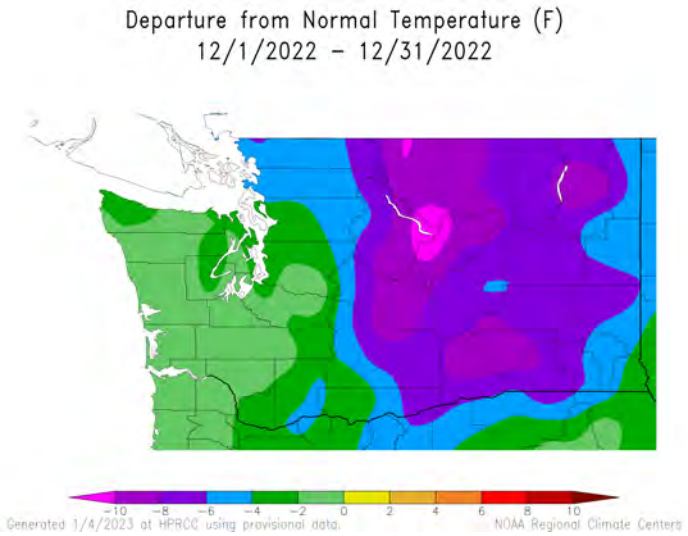


Figure 7: Changes in the number of days of freezing rain per year between 2005-2014 and 1975-2004 (from Groisman et al. 2016).

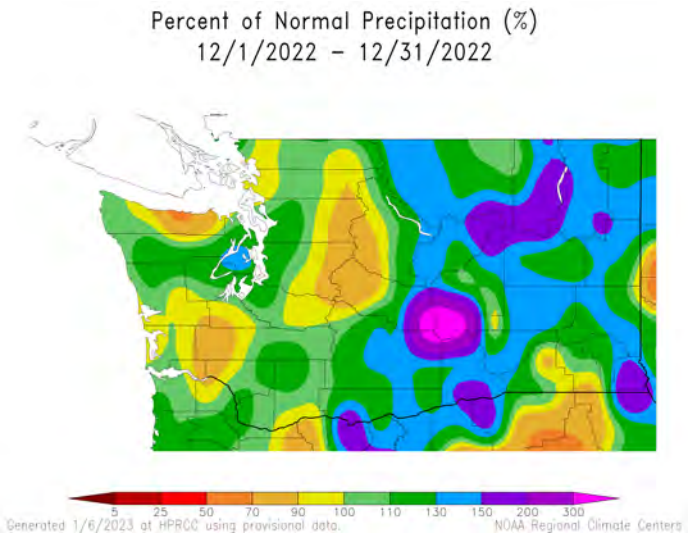
Climate Summary

Similar to November, average December temperatures were much below normal statewide, with the largest anomalies across eastern WA. Temperatures were between 6 and 10°F below normal for a large area of eastern WA, as shown in the map from the High Plains Regional Climate Center. Wenatchee temperatures were especially anomalous, with the average December temperature below 20°F, 9.1°F below normal. All of the stations east of the Cascade crest featured in Table 2 were decidedly cold, with monthly averages below 26°F. While still below normal, western WA average December temperatures were more moderate and above freezing, as usual for the month. Temperatures ranged between 1 and 6°F below normal in western WA.



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

Total December precipitation was variable throughout the state. The anomalously wet bull's eye over Priest Rapids Dam should be ignored as it is due to some faulty observations and will subsequently be removed from the climate record. But otherwise, eastern WA tended toward above normal precipitation for the month of December while western WA tended toward normal to below normal precipitation. Bellingham, for example, received 76% of normal precipitation (Table 2) while the central Puget Sound received normal to above normal precipitation.



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

Station	Mean Temperature (°F)			Precipitation (inches)			Snowfall (inches)		
	Avg	Norm	Departure from Normal	Total	Norm	Percent of Normal	Total	Norm	Percent of Normal
Western Washington									
Olympia	37.8	38.9	-1.1	7.73	7.85	98	-	-	-
Seattle WFO	39.3	41.8	-2.5	7.06	5.55	127	1.6	1.7	94
SeaTac AP	38.8	42.0	-3.2	7.55	5.72	132	4.7	1.7	276
Quillayute	39.4	41.0	-1.6	14.74	13.84	107	-	-	-
Hoquiam	M	42.0	M	11.14	10.52	106	-	-	-
Bellingham AP	34.5	39.8	-5.3	3.28	4.33	76	-	-	-
Vancouver AP	38.3	40.8	-2.5	6.88	6.07	113	-	-	-
Eastern Washington									
Spokane AP	23.5	29.1	-5.6	3.59	2.34	153	16.9	13.8	122
Wenatchee	19.9	29.0	-9.1	1.86	1.31	142	-	-	-
Omak	19.6	27.9	-8.3	2.34	1.95	120	-	-	-
Pullman AP	25.8	31.7	-5.9	3.02	2.21	137	-	-	-
Ephrata	22.8	29.6	-6.8	1.37	1.13	121	-	-	-
Pasco AP	25.7	34.1	-8.4	0.59	1.03	57	-	-	-
Hanford	24.7	32.6	-7.9	1.48	1.08	137	7.8	4.4	177

Table 2: December 2022 climate summaries for locations around Washington with a climate normal baseline of 1991-2020. Hoquiam monthly temperature data are missing due to faulty observations.

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). Below normal sea-surface temperatures are present throughout the central and eastern equatorial Pacific Ocean and the atmospheric response is consistent with La Niña. ENSO models are split on whether the La Niña will persist (50%) through the January-March period or begin to transition to neutral conditions (50%). Neutral ENSO conditions are more likely in the spring period (March-May; 78%).

The CPC outlook for January (Figure 8) is calling for higher chances of above normal temperatures throughout most of WA state. The southeastern portion of the state has equal chances of below, equal to, or above normal temperatures for January. For precipitation, January has higher chances of receiving above normal precipitation for a majority of Washington. The northeastern portion of the state has equal chances of below, equal to, or above normal January precipitation.

The three-month outlook for January-February-March (JFM; Figure 9) differs from the January temperature outlook, and is more aligned with the typical La Niña teleconnections. There are higher chances of below normal JFM temperatures statewide, with the odds between 50 and 60% on the three-tiered scale for the northwestern-most portion of Washington. JFM precipitation is expected to be above normal statewide, though the probabilities of that occurring (between 33 and 40%) are lower than those for below normal temperatures.

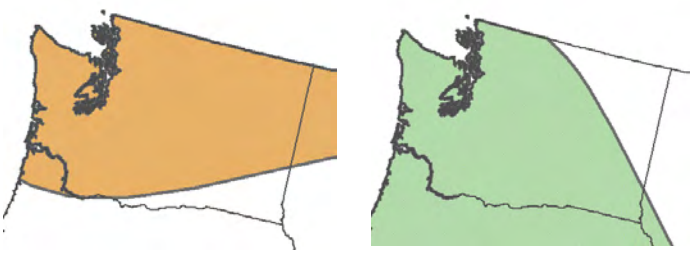


Figure 8: January outlook for temperature (left) and precipitation (right).

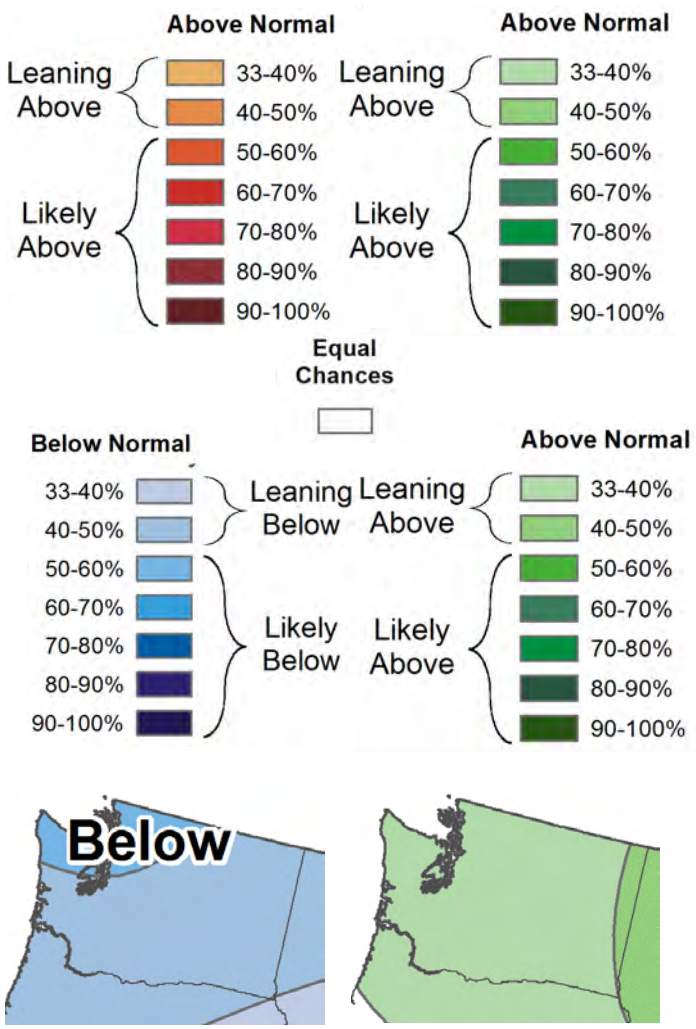


Figure 9: January-February-March outlook for temperature (left) and precipitation (right) (Climate Prediction Center).