Office of the Washington State Climatologist

January 2025 Report and Outlook

January 13, 2025 http://www.climate.washington.edu/

December Event Summary

Mean December temperatures were much above normal across Washington State, with the greatest temperature anomalies in eastern WA. Averaged statewide, December ranked as the 10th warmest in the 130-year record, with average temperatures 4.0˚F above the 1991-2020 normal. December precipitation was above normal for a majority of the state and the largest anomalies relative to normal were also across parts of eastern WA (more in the Climate Summary on page 9). Averaged statewide, December precipitation was 118% of normal, ranking as the 41st wettest.

In this Issue

At the start of December, a strong temperature inversion was in place caused by a nearby high pressure. Inversions are usually associated with colder temperatures near the surface with fog and low clouds as well as poor air quality due to the

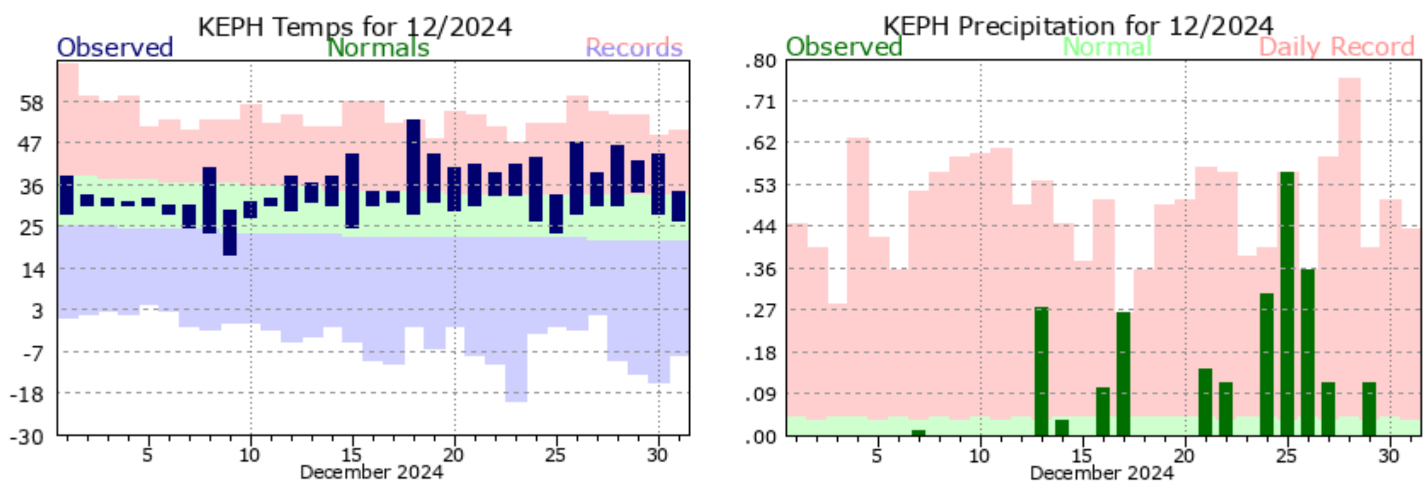


Figure 1: December 2024 daily temperatures (left) and precipitation (right) for Ephrata Airport compared to the 1991-2020 normal (green envelope) and previous records (blue and red envelopes; NWS).

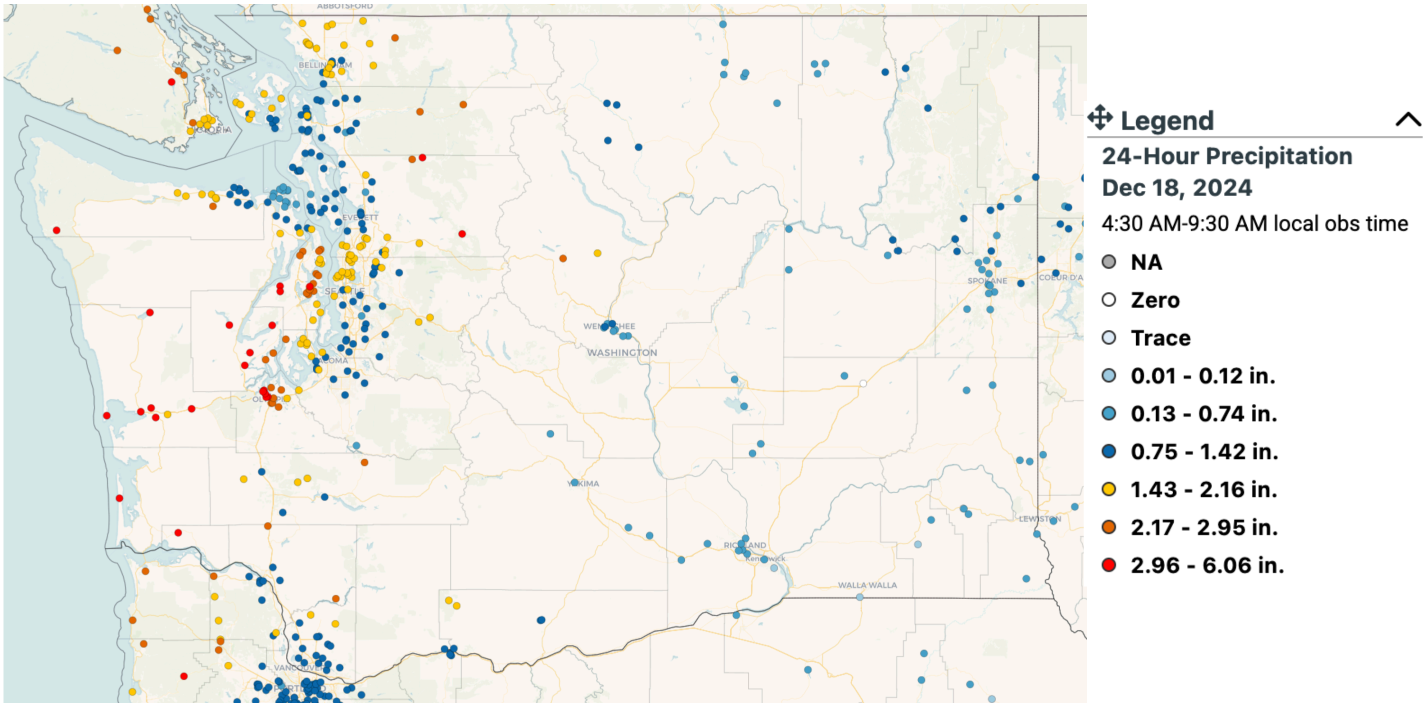


Figure 2: 24-hour precipitation observations on the morning of December 18, 2024 from the CoCoRaHS network.

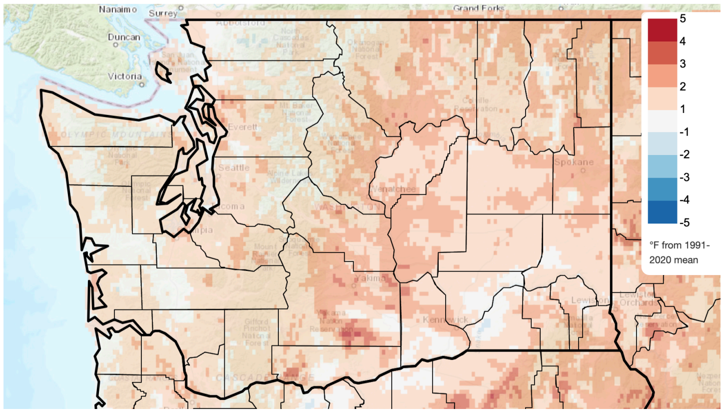
lack of mixing. Temperatures are warmer at higher elevations during inversions, and typically our mountainous areas are clear and out of the clouds. As a result, the start of the month was quite dry.

The dry start to the month is shown in the daily temperature and precipitation time series for Ephrata Airport (Figure 1). The weather was relatively quiet before a pattern shift toward more active weahter occurred mid-month. A windy and wet system moved in on the 17th and 18th, causing wind gusts between 30 and 50 mph across western WA (Figure 2). On the 17th, maximum daily rainfall records were set at Hoquiam (3.05"), Olympia (2.36"), Omak (0.47"), Wenatchee (0.37"), and Ephrata (0.26"). Temperatures were quite mild with several days in a row of daily record maximum temperatures. For example, Dallesport (58°F) and Yakima (55°F - tie) set high temperature records on the 17th, Bellingham (56°F), SeaTac AP (55°F), and Ephrata (54°F - tie) on the 18th, Quillayute (60°F) and SeaTac Airport (59°F) on the 20th, and Quillayute (56°F) and Hoquiam (55°F) on the 21st.

For the remainder of the month the weather pattern was much more active, with gusty winds and precipitation. Overnight on the 23rd into the 24th, strong winds in the Western Cascades Foothills left thousands without power. Multiple roads including Mt. Baker Highway and SR-410 were temporarily closed due to downed trees ahead of one of the busiest travel days of the year. On Christmas Day, Ephrata (0.56") and Ellensburg (0.31") measured record daily maximum precipitation totals. On the 26th, Ephrata (0.35") set another daily record, as did Omak (0.67"). Heavy mountain snow fell on the 25th into the 26th with gusty winds between 30 and 55 mph across western WA.

Finally, we close with a brief examination of the 2024 calendar year rankings. Average temperatures were above normal across all of WA for 2024

2024 Temperature Anomaly



2024 Precipitation Percent of Normal

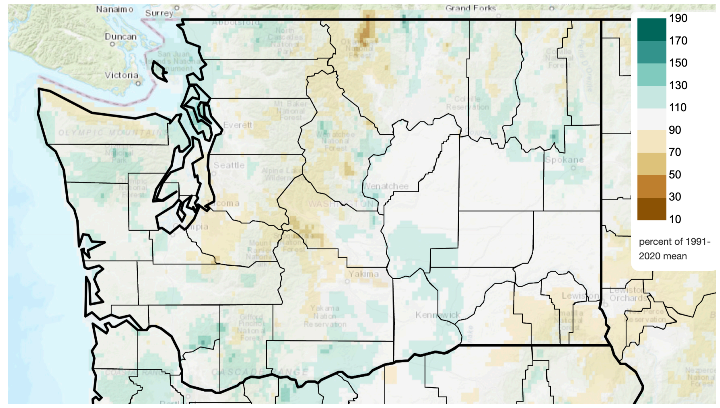


Figure 3: Temperature anomalies and precipitation percent of normal for the 2024 calendar year (Climate Toolbox).

(Figure 3). Averaged statewide, WA temperatures were 1.1°F above the 1991-2020 normal, tying as the 7th warmest year in the 130-year record. 2004, 2014, and 2023 all had the same statewide temperature anomaly. Precipitation was near-normal averaged statewide (97% of normal) ranking right in the middle as the 61st driest (70th wettest). There was more geographic variability in precipitation than for temperature, with parts of the central and northern Cascades, and southeastern WA slightly drier than normal and other isolated areas slightly wetter than normal.

Snowpack and Drought Summary

Snowpack steadily grew throughout December, and most basins have near-median snowpack at the time of this writing. An example of the substantial growth in snow water equivalent (SWE) is shown in Figure 4 for Stevens Pass (elevation 3,950'). The basin average SWE percent of median from the Natural Resources Conservation Service (NRCS) as of January 7 (Figure 5) ranges between 104 and 155% of median for nearly all of the basins. The exceptions are the North Puget Sound and Central Puget Sound basins which are 87 and 81% of median, respectively. The above normal December temperatures were detrimental for snowpack growth in some of the lower elevation stations, as indicated by the red-orange-yellow filled circles in Figure 5. Overall, however, snowpack did relatively well despite the temperatures that were well above average.

The U.S. Drought Monitor has reduced the amount of abnormally dry conditions across eastern WA since the last edition of our newsletter (Figure 6). This change was in response to the above normal precipitation and increased soil moisture in those areas. Abnormally dry (D0) and moderate drought (D1) conditions are still present in the central and northern Cascades and in southeastern WA.

The statewide drought emergency issued by the WA State Department of Ecology in mid-April 2024 is still in effect. Although precipitation deficits have improved across most of the state, the drought emergency will remain in effect until there's a better understanding of how healthy the 2025 snowpack will be.

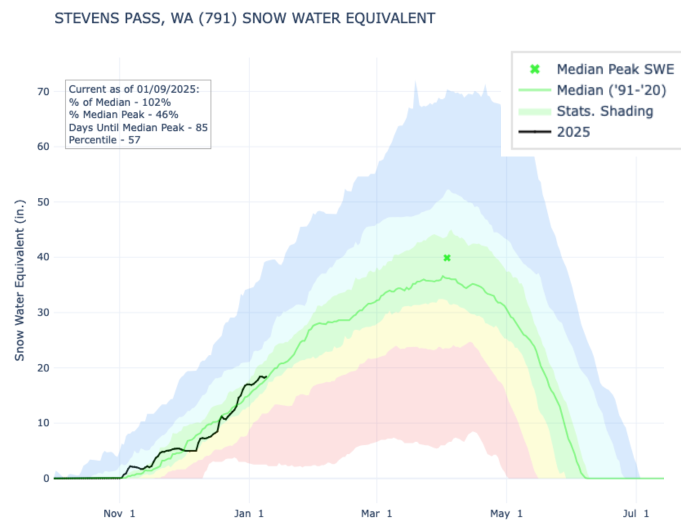


Figure 4: Snow water equivalent (snowpack, in inches) for Stevens Pass from October 1, 2024 to January 7, 2025 (black line) compared to historical percentiles (shading). The 1991-2020 median is illustrated by the green line and the normal range is represented by the green shading (NRCS).

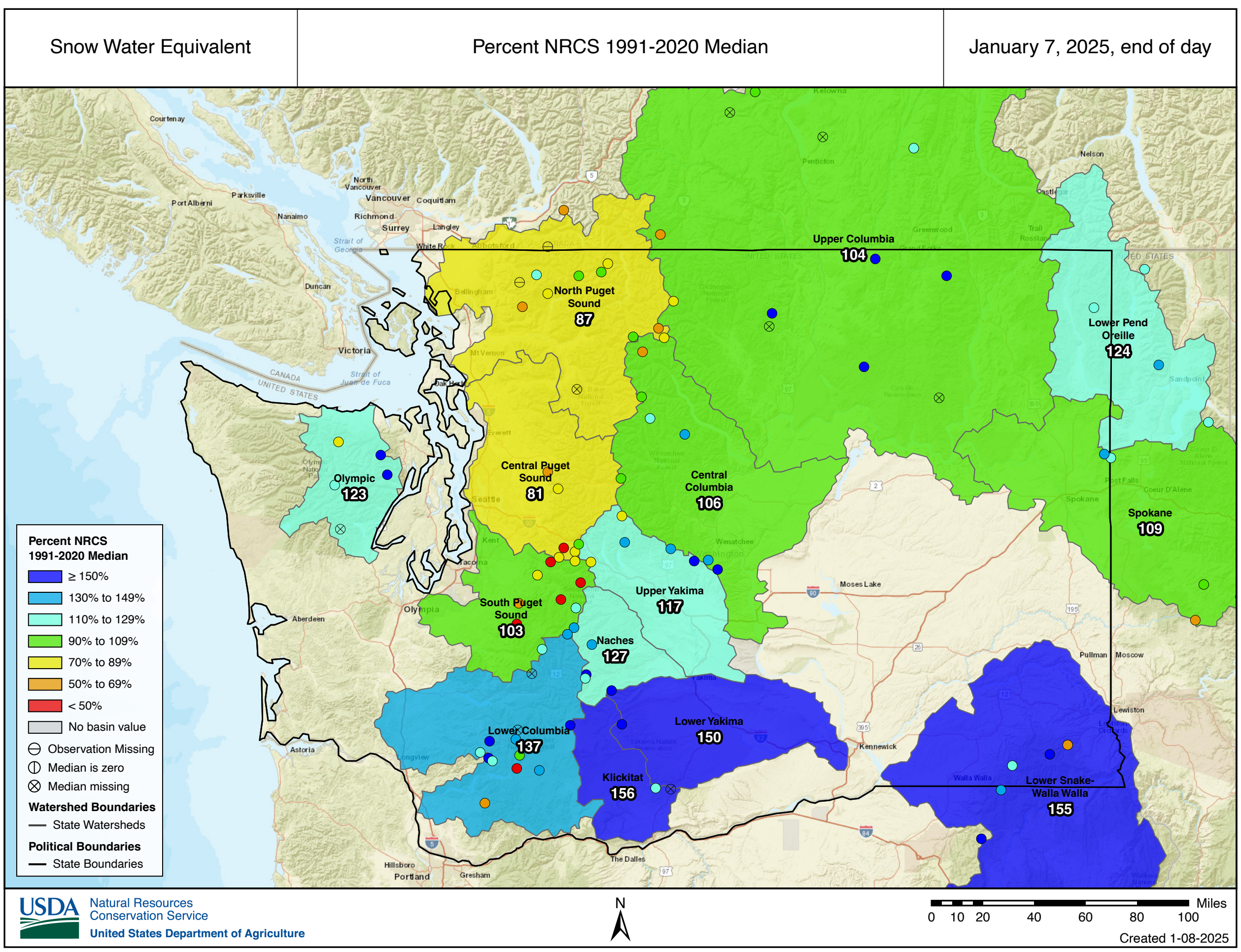


Figure 5: Snowpack (in terms of snow water equivalent) as of January 7, 2025 (NRCS).

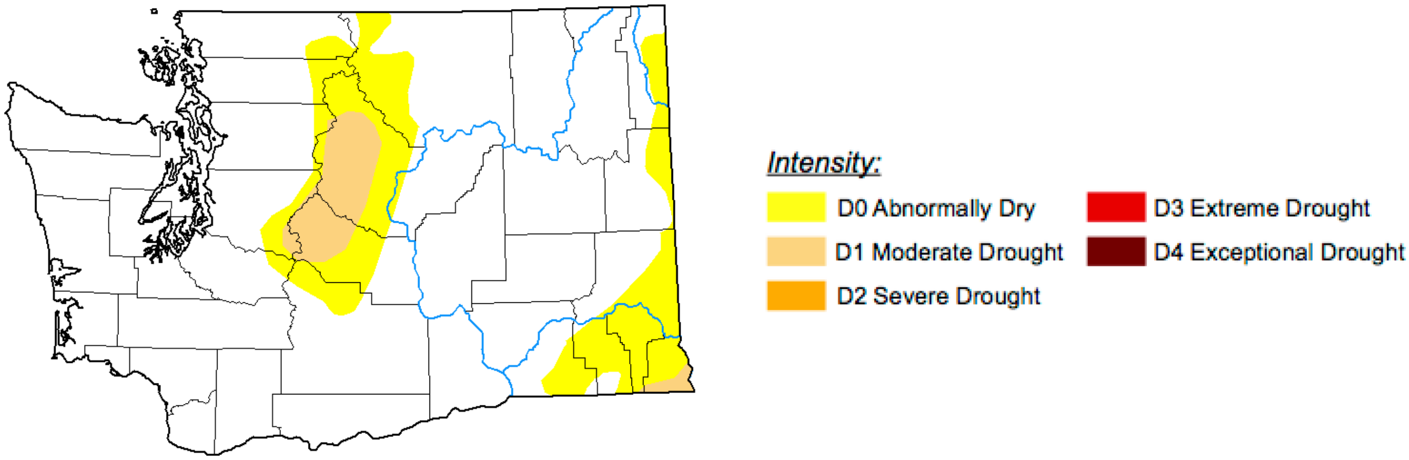


Figure 6: The January 9, 2025 edition of the U.S. Drought Monitor.

Rain on Snow

Climate Matters Series   Author: Nick Bond

This is the time of year when it's not just the climate geeks who are following what's happening with our mountain snowpack. A range of audiences from winter sports enthusiasts to water managers are interested. In particular, many of us dread the warm and heavy precipitation events that intermittently visit the Pacific Northwest because of their potential to melt significant amounts of our cherished snow. The purpose of this month's Climate Matters is two-fold: (1) to review a relatively recent article on projected changes in rain-on-snow (ROS) risks in western North America (Musselman et al. 2018), and (2) to take a peek at the impacts of particularly intense precipitation events on snow water equivalent (SWE) values, using historical daily data from an assortment of SNOTEL locations in WA state.

The paper by Musselman et al. relies on high-resolution (4 km horizontal grid spacing) Weather Research and Forecasting (WRF) model simulations of daily ROS events for 2000-2013 compared with climate change simulations looking at 2071-2100. WRF is a weather model that can be used for either forecasting or climate studies. The authors used ERA-Interim reanalysis data to provide inputs to the model. The future simulations are based on the so-called pseudo-global-warming (PGW) method, where the model inputs (ERA-Interim) are adjusted based on projected changes in climatic conditions (in this case: monthly average temperature, moisture, etc.), based on an average of 19 climate models. The paper does not focus on the accuracy of the WRF results, but does state that the WRF simulations yield ROS patterns and intensities that are similar to what is observed.

The results from the two sets of WRF simulations show that the expected changes in ROS vary significantly across western North America. In particular, they show a decrease in the frequency of ROS events at lower elevations, and an increase in their frequency at higher elevations. More intense ROS events are projected at higher elevations, with consequences for downstream flooding, but these increases are due to heavier rain in the future, not greater snowmelt during those events. Admittedly, there is a lot more to dig into in the Musselman et al. paper; we encourage you to have a look for yourself.

Musselman et al. define an ROS event with flooding potential to be a day requiring a precipitation value of at least 10 mm (0.39 inches), a pre-existing snowpack with a SWE of a least 10 mm, and a snowmelt contribution of at least 20%, compared to the total water (precipitation + snowmelt) produced in the event. The first two of these thresholds seem rather modest by some standards; our most impactful ROS events include daily precipitation values on the order of 100 mm (~3.9 inches) and higher, falling on snowpacks with SWE values also much higher (in the 100s of mm and more). In part for that reason, we decided to analyze heavy precipitation events and their association with changes in SWE, along with air temperature.

We extracted data using the Report Generator application maintained by the Natural Resources Conservation Service (NRCS). We downloaded daily data from 9 SNOTEL stations in WA state: Calamity, Spirit Lake and Spencer Meadow in the southwestern Cascades, Elbow Lake, MF Nooksack and Beaver Pass in the northwestern Cascades, Stampede Pass in the central Cascades, and two locations in eastern WA: Touchet in the Blue Mountains of SE WA and Moses Mountain in Okanogan County. Figure 6 shows a map with the locations of the SNOTEL stations. We picked the clusters in the southwestern and northwestern portions of the Cascades to get a look at small-scale variations in the response of SWE to heavy precipitation.

We extracted daily data, for SWE, average air temperature, and precipitation. The temperature and precipitation values are for each day as a whole; the SWE is the value at the start of the day. We focused on 2-day intervals of heavy precipitation, recognizing that precipitation events can be both shorter and longer than that. In situations when consecutive days had total 2-day precipitation that met the threshold for a "top" event (this happens when there is a single day with really high precipitation), we selected only the latter 2-day period so as not to double count a single event. We also restricted our analysis to events in which the final SWE value was 2 inches and greater as a crude means to avoid including events during which more snow could have melted if it was there in the first place. The final dataset also included only periods where all three variables were available (precipitation, SWE, and temperature), which means some periods of heavy precipitation are not reflected in the composites. Finally, the data records from these stations as made available through NRCS are of varying lengths. All extend back at least 20 years (MF Nooksack and Beaver Pass have the shortest records) and some go back to the 1980s. For consistency's sake it could be argued that it would be preferable to use a common period of analysis,

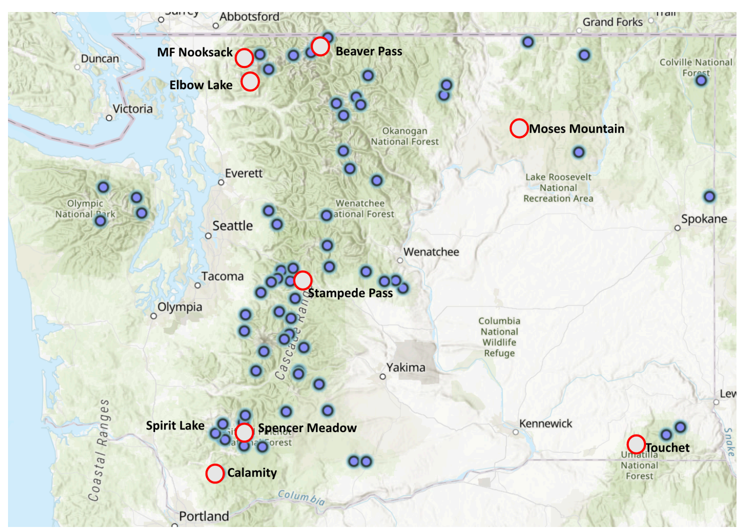


Figure 6: SNOTEL stations in WA with the sites used here labeled with white circles with a red outline (NRCS).

but since our interest was in the most intense events, it seemed reasonable to use the full records at each station.

Our analysis focuses on variables associated with the top 20 precipitation events (matching the criteria listed above) as summarized in Table 1 below. Perhaps the most interesting findings are in the 4th column that lists the means and standard deviations in the 2-day changes in SWE with the 20 top 2-day precipitation events. Note that the trio of Calamity, Spirit Lake and Spencer Meadow in the southwestern Cascades are the only stations that lose SWE on average, and these losses tend to be modest relative to the amount of precipitation. In other words, the run-off during these events is predominantly due to the precipitation itself, not snowmelt. Examination of individual events shows that daily average air temperatures of roughly 35°F represent the transition from increasing to decreasing SWE over the 2-day events. The air temperature of this transition does appear to depend on the amount of pre-existing SWE, with greater SWE values tending to result in less melting at air temperatures in the high 30s (°F) and above. But this effect is mostly manifested only at the stations of Spirit Lake, MF Nooksack, Stampede Pass and Touchet. It makes sense that the latter three stations demonstrate this effect since they tend to have greater snowpacks; it is unclear why Spirit Lake is also part of this group and may just be a fluke. The eastern WA stations of Touchet and Moses Mountain tend to have increases in SWE that are large relative to precipitation amounts as compared with the western stations that tend to have greater extreme precipitation amounts. This makes sense since Touchet and Moses Mountain are cold with even relatively heavy precipitation often falling in the form of

Station/Elevation	2-day Precip (inches)	2-day Air Temp (°F)	Ending SWE (inches)	2-day SWE Change (inches)	Correlation Coeff. SWE Change & Air Temp
Calamity/2500'	6.5±0.6	36.7±5.3	11.6±7.4	-0.2±1.3	-0.38
Spirit Lake/3520'	5.0±1.0	37.1±5.0	6.7±4.3	-1.1±2.9	-0.72
Spencer Meadow/3400'	6.5±0.6	36.5±5.4	12.4±7.5	-0.1±1.4	-0.42
Elbow Lake/3040'	8.1±1.0	37.9±3.4	16.7±14.5	0.1±2.2	-0.76
MF Nooksack/4970'	6.1±0.9	33.8±3.6	22.4±20.8	2.4±3.2	-0.64
Beaver Pass/3620'	5.1±0.6	34.1±2.4	12.0±8.2	2.1±2.1	-0.72
Stampede Pass/3850'	6.6±1.2	33.5±3.7	25.2±20.4	1.5±1.9	-0.71
Touchet/5530'	4.3±0.8	29.4±4.3	17.7±14.8	2.6±2.1	-0.61
Moses Mtn/5530'	2.3±0.4	27.7±6.8	9.5±6.4	2.0±1.1	-0.54

Table 1 Summary Statistics for Top 2-Day Precipitation Events. All but the right-hand column show the average and standard deviation for the top 20 precipitation events with at least 2 inches of SWE remaining afterwards. The right-hand column shows the correlation between the 2-day changes in SWE and 2-day air temperatures for the top 20 precipitation events at each location.

snow. The correlations between the air temperature and change in SWE shown in the right-most column of Table 1 are more or less consistent among the various stations. A negative correspondence between these variables is expected in warmer places where it often switches between rain and snow, even in winter.

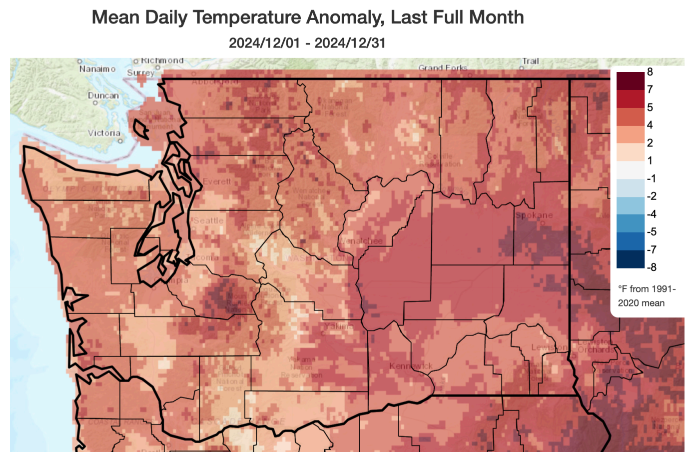
As is typically the case with these pieces, the results summarized here are by no means complete and definitive. Our simple analysis includes a number of arbitrary, untested assumptions and selections that allowed us to take a first look. Nonetheless, it does seem clear that heavy precipitation events do not necessarily lead to declines in our snowpack, at least in terms of SWE and at the higher elevations typical of SNOTEL sites in WA state. And there are intriguing differences between short-term SWE changes at the various stations considered that do not appear to be simply related to elevation. Given their importance, there's plenty of reason to continue to explore and further our understanding of the factors controlling our regional snowpack.

Reference

Musselman, K.N., F. Lehner, K. Ikeda, M.P. Clark, A.F. Prein, C. Liu, M. Barlage, and R. Rasmussen, 2018: Projected increases and shifts in rain-on-snow flood risk over western North America. Nature Climate Change, Vol. 8, 808-812. https://doi.org/10.1038/s41558-018-0236-4

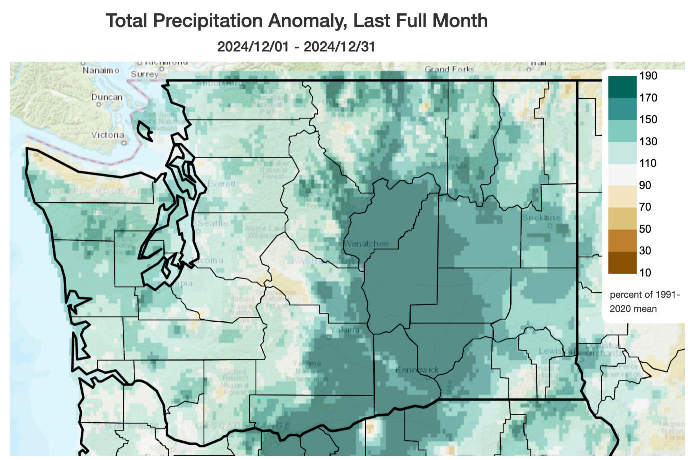
Climate Summary

December average temperatures were warmer than normal across the state. Temperature anomalies exceeded 3˚F for a majority of the state with even greater anomalies, exceeding 5˚F, across Grant, Adams, Lincoln, Spokane, and Whitman counties. Spokane was a particularly warm location relative to normal, with December temperatures 5.4˚F above normal (Table 2).



December temperature (˚F) departure from normal relative to the 1991-2020 normal (Climate Toolbox).

December precipitation was near-normal to above normal for the majority of the state. Most of eastern Washington had above normal precipitation, particularly in the Lower Columbia basin where totals were between 150 and 210% of normal. Ephrata and Pasco measured 208 and 210% of normal precipitation, respectively (Table 2). Some locations in western WA had near-normal precipitation. For example, SeaTac Airport and Vancouver had 95 and 107% of normal precipitation, respectively. There were a few small areas in the northern Olympic Peninsula and in the central Cascades that received slightly below normal precipitation (70-90% of normal).



December total precipitation percent of the 1991-2020 normal (Climate Toolbox).

Lowland snow was nonexistent in western WA due to the above normal temperatures. Spokane received a few instances of light snow on several occasions but the monthly totals only resulted in 30% of normal.

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	42.0	38.9	3.1	10.23	7.85	130	M	1.2	-
Seattle WFO	44.7	41.8	2.9	6.70	5.55	121	0.0	1.7	0
SeaTac AP	43.9	42.0	1.9	5.49	5.72	95	0.0	1.7	0
Quillayute	45.4	41.0	4.4	18.61	13.84	134	M	M	-
Hoquiam	45.1	42.0	3.1	14.40	10.52	137	M	M	-
Bellingham AP	42.7	39.8	2.9	5.36	4.33	124	M	M	-
Vancouver AP	43.5	40.8	2.7	6.50	6.07	107	M	M	-
Eastern Washington									
Spokane AP	34.5	29.1	5.4	3.91	2.34	167	4.1*	13.8	30
Wenatchee	32.8	29.0	3.8	2.18	1.31	166	M	M	-
Omak	31.3	27.9	3.4	2.84	1.95	146	M	M	-
Pullman AP	35.6	31.7	3.9	2.97	2.21	134	M	M	-
Ephrata	34.0	29.6	4.4	2.35	1.13	208	M	M	-
Pasco AP	38.4	34.1	4.3	2.16	1.03	210	M	M	-

Table 2: December 2024 climate summaries for locations around Washington with a climate normal baseline of 1991-2020. M denotes missing data. *One day missing for Spokane snowfall (12/31).

Climate Outlook

La Niña has developed in the tropical Pacific Ocean. As of January 9, the Climate Prediction Center (CPC) changed the status to "La Niña Advisory". The sea-surface temperature (SST) anomalies have cooled across the equatorial Pacific Ocean over the last month and the atmosphere is also showing patterns consistent with La Niña. ENSO models indicate that La Niña will remain weak through the winter and begin to transition to neutral conditions during the period of March-May.

The CPC January temperature outlook (Figure 7) has higher chances of above normal temperatures statewide. The January precipitation outlook is showing higher chances of above normal precipitation across the state. The chances of above normal January precipitation are slightly higher for eastern WA (40-50%) compared to western WA (33-40%).

The January-February-March (JFM) temperature outlook (Figure 8) has higher odds of below normal temperatures for the entire state. JFM precipitation is more likely to be above normal statewide, with the odds tilted to between 40 and 50% chance on the three-tiered scale.

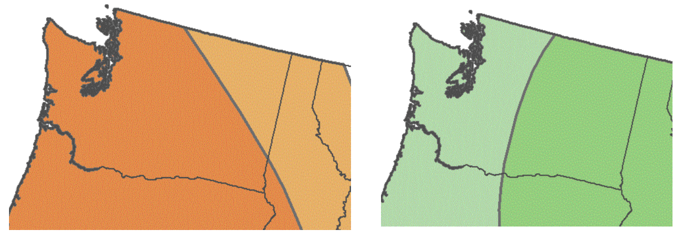
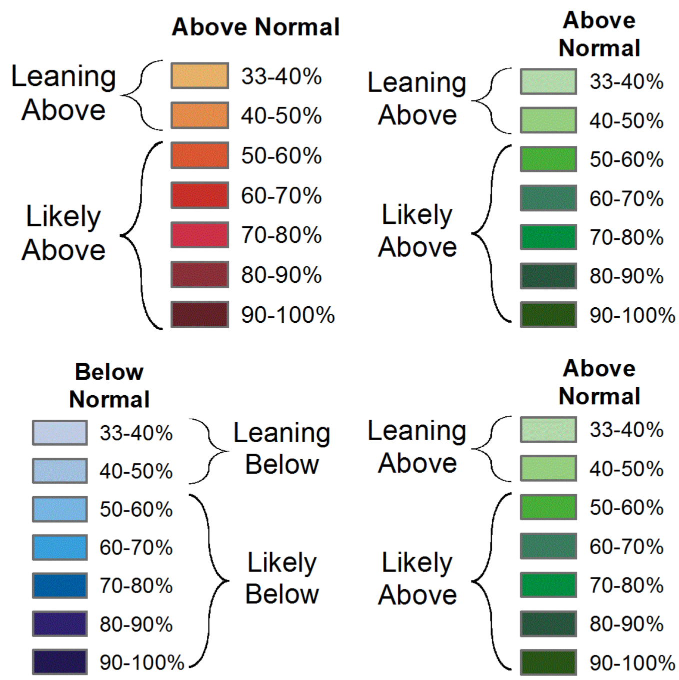


Figure 7: January outlook for temperature (left) and precipitation (right).



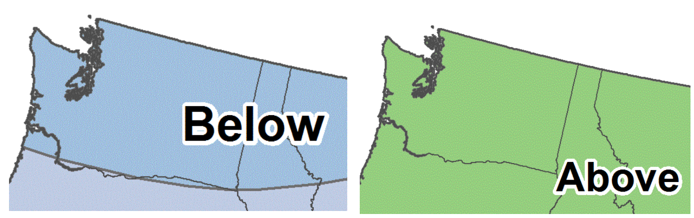


Figure 8: January-February-March outlook for temperature (left) and precipitation (right) (Climate Prediction Center).