Office of the Washington State Climatologist

December 2016 Report and Outlook

December 8, 2016

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

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November Event Summary

Mean November temperatures were much above normal throughout the state. Averaged statewide, November was the warmest on record since records began in 1895, averaging 6.2°F above the 1981-2010 normal. Individual weather stations throughout the state set records too, with examples listed in Table 1. Many locations not only set new record high values for November, but did so several days in a row. For example, SeaTac recorded new maximum temperatures of 66°F and 70°F for 11/7 and 11/8, respectively. The 8th wasn't just a record-setting day for SeaTac. Many other stations throughout the state reported new daily maximum temperatures, as well: Olympia (70°F), Quillayute (63°F), Bellingham (73°F), Seattle (71°F), Spokane (61°F), Wenatchee (60°F), La Crosse (70°F), and Lind (68°F).

Though the majority of new records were in regards to temperature, the earlier part of November included some new maximum daily precipitation totals. On the 5th, Bellingham and SeaTac Airport reported record rainfall totals of 2.05" and 1.31", respectively. Total precipitation for the month was variable throughout the state, with Western WA receiving normal to above normal and Eastern WA receiving below normal amounts, in general.

Station	November Avg Temperature Anomaly (°F)	Rank	Records Since
SeaTac AP	5.5	1	1953
Hoquiam	4.8	1	1953
Wenatchee	8.2	1	1959
Quillayute	4.4	1	1966
Pullman	8.0	1	1998
Vancouver	5.4	1	1996
Bellingham	7.2	1	1949
Olympia AP	4.6	2	1948
Spokane AP	7.8	4	1881

Table 1: November average temperature anomalies and their ranking with respect to the historical record for selected WA stations.

Snowpack Update

With the warmer than normal temperatures this past November, particularly in the beginning of the month, there was limited snow in the mountains. By the end of the month, however, our mountains did receive a few good storms with several basins off to a good start for the season. The snow water equivalent (SWE) percent of normal averaged for each basin in WA is shown in Figure 1 from the Natural Resources Conservation Service. As of Dec 1, the Olympic, North Puget Sound, Lower Columbia, and Upper Columbia basins all have normal to above normal (96-270% of normal) SWE. The Central Puget Sound and Central Columbia basins with 86 and 78% of normal, respectively, aren't too far behind. The remaining basins - Lower Snake, Spokane, Lower and Upper Yakima, and South Puget Sound - are lagging a bit behind for this time of year with between 47 and 67% of normal SWE. Since it's still early in the snow season, there is plenty of time for those basins to get snow.

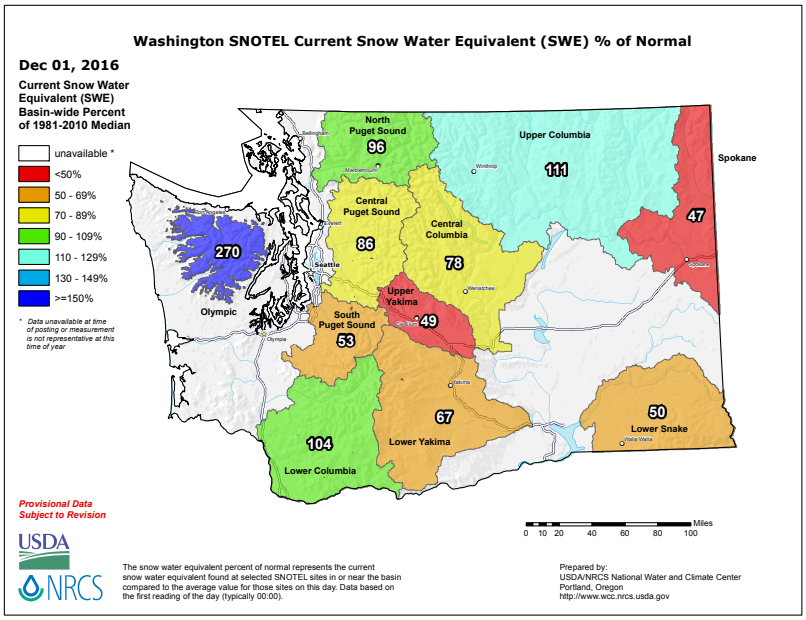


Figure 1: Snowpack (in terms of snow water equivalent) percent of normal for Washington as of December 1, 2016 (from the Natural Resources Conservation Service).

photo by Henry Reges, CoCoRaHS

Community, Collaborative Rain, Hail, and Snow (CoCoRaHS) Network

Thank you to all of our CoCoRaHS volunteers for taking the time to read your rain gauges daily and reporting your observations for the month of November. As we transition into colder weather, some of you will no doubt head south to spend the winter in sunnier conditions. Along with everything else, don't forget to pack your rain gauge! You can have multiple stations associated with your account so that you can keep reporting through the winter. To get set up with a station name and number for your new station, send an e-mail to info@cocorahs.org.

Trends in Lowland Snow in Washington State

A message from the State Climatologist

Most readers of this newsletter are probably aware of the warming of winter temperatures in Washington state. In specific terms, from near the end of World War II to the present, average winter (November through February) temperatures have increased by about 2°F. Much of that overall warming is due to the late 1940s and early 1950s being especially cold, in the context of the entire observational record going back to the 1890s. Moreover, we have not had a really cold winter since the early 1990s. The sense of the long-term change in winter precipitation is not as obvious, and for good reason, since there is a great deal of year-to-year variability on top of overall trends that are weak to negligible. How about lowland snow? Of course, there are plenty of societal impacts with this aspect of our winter weather, and we thought a survey of the historical data would be of interest.

As with many if not most elements of the climate, the story is not so simple. Notably, the variability in the climate on decadal time scales complicates matters. In addition, trends in snowfall might be expected to vary across the state, at least in part due to the lower frequency of cold air at low levels on the west side of the Cascades. While we have made an attempt to account for these factors, we also admit our analysis is more "quick and dirty" rather than comprehensive. For example, we have simply omitted years with too many missing days of data in calculating averages. Nevertheless, we feel that the results are reasonable and valid in a broad sense. An additional point worth making is that the cold air and moisture required for a major snowfall do not coincide very often, especially on the milder west side. Rare extreme events adversely affect the statistical reliability of the results. Therefore here we also consider how the average number of cold days per winter has changed over time at various locations. For this purpose, we define a cold day as one for which the maximum temperature is 32°F or less for eastern WA locations, and 36°F or less for western WA locations. We use a less restrictive standard for the western WA to include more days; the threshold used represents unusually cold conditions during which precipitation could be in the form of snow.

Time series of winter totals of snowfall and number of cold days are shown for SeaTac Airport in Figure 2. There has been a clear decline at SeaTac in winter snowfall and number of cold days. Winters lacking snow and cold days occurred occasionally in the first portion of the period but not as often as in recent years. The two big year snow years of 1949-50 and 1968-69 really stand out, with the 20+ inches of 2008-09 being a notable exception among the wimpy winters of the last couple of decades. We still get at least a few cold days most winters but these days are not always accompanied by much, if any, snow. Some

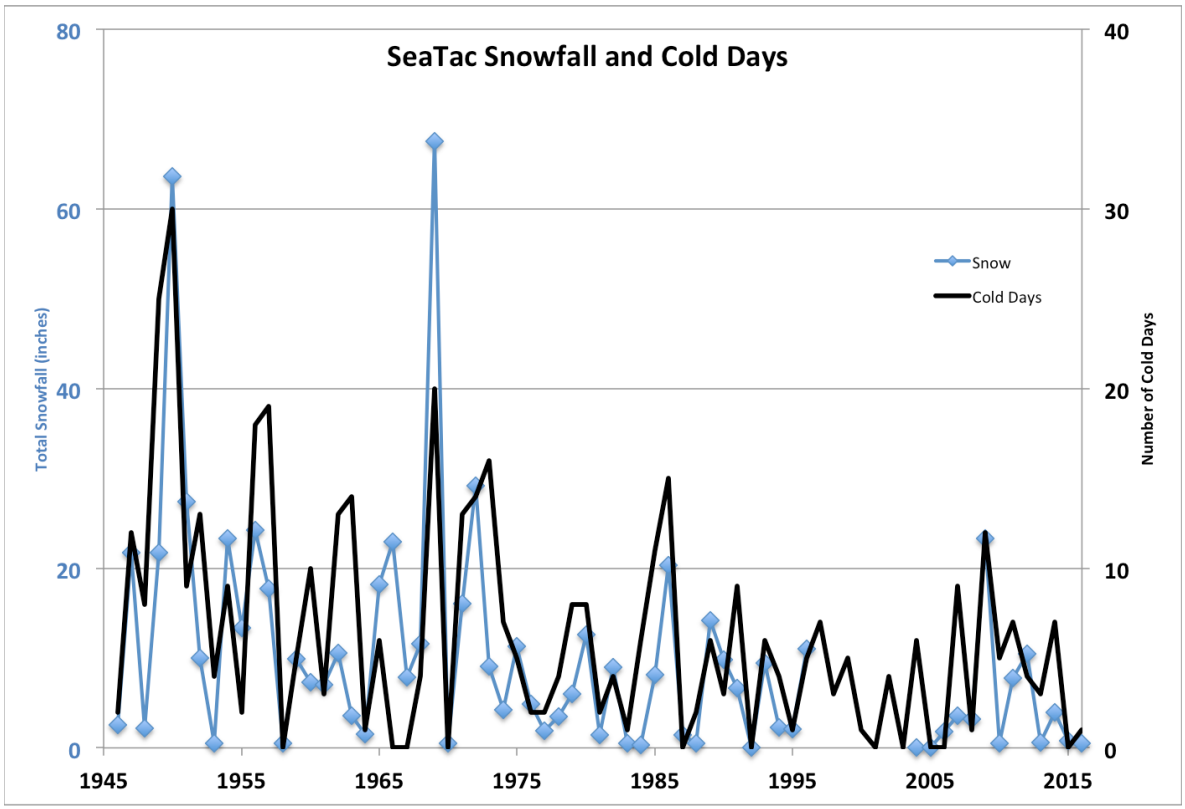


Figure 2: Annual November-February total snowfall (blue) and total number of days 36°F or below (black) for SeaTac Airport.

of these periods feature high pressure and calm winds resulting in the development of surface-based inversions and persistent, shallow layers of cold air. Those situations are not nearly as fun for kids aged 4 to 84.

Equivalent time series are plotted for Yakima Airport and Spokane in Figures 3 and 4, respectively. These time series have quite different characteristics than their counterparts for SeaTac. Simply put, there does not seem to be much in the way of long-term trends in winter snowfall totals or number of cold (freeze) days. The last 15 years or so at Yakima have lacked any especially high snowfall totals or number of cold days, but given the noisy time series the linear trends are not statistically significant. Spokane has featured remarkable consistency in the severity of its winters in terms of the measures used here, with lots of interannual variability. The snowiest winter at Spokane (97.7") in a record extending back to the 1890s occurred relatively recently in 2008-09.

So is SeaTac more typical or an aberration for the west side of the state? For this reason we examined a couple more stations, Hoquiam on the coast and Sedro Wooley near the mouth of the Skagit River, with decent records. For these two locations, and the additional east side location of Pomeroy near the southeastern corner of WA, we computed average total winter snowfalls and numbers of cold days for three different periods: 1948-1970, 1971-1993 and 1994-2016. We picked these periods to be long enough to yield reasonable averages and with breaks that

do not coincide with the major shift in the regional climate that occurred in the late 1970s. For those three stations, and the three stations with plotted time series discussed above, mean values of winter total snowfall and number of cold days are itemized in Tables 2 and 3, respectively. The other west side locations of Hoquiam and Sedro Wooley also have had less snow and fewer cold days in the more recent third of the interval considered here. The results for Pomeroy resemble those for Yakima and Spokane.

The bottom line for snow enthusiasts: historical trends appear to be much more favorable for eastern Washington state. That being said, the climate has plenty of tricks up its sleeve. An odd and unexpected deal of the cards, such as the Puget Sound region getting buried, is still possible. Take a wild guess whether the OWSC wants something like that to happen.

Station	Average Snowfall 1948-70	Average Snowfall 1971-93	Average Snowfall 1994-2016
Hoquiam	7.4	3.6	2.6
SeaTac AP	16.2	7.8	4.5
Sedro Wooley	12.8	7.5	5.3
Yakima	24.6	23.8	19.8
Pomeroy	9.9	12.9	8.4
Spokane	54.1	47.0	43.2

Table 2: Average snowfall (inches) for November-February for 3 different historical periods.

Station	Average # Cold Days 1948-70	Average # Cold Days 1971-93	Average # Cold Days 1994-2016
Hoquiam	3.8	4.3	2.3
SeaTac AP	9.3	6.3	3.7
Sedro Wooley	10.2	8.1	5.2
Yakima	21.4	24.6	18.2
Pomeroy	16.7	17.3	15.7
Spokane	36.7	38.8	32.9

Table 3: Average number of cold days during November-February for 3 different historical periods.

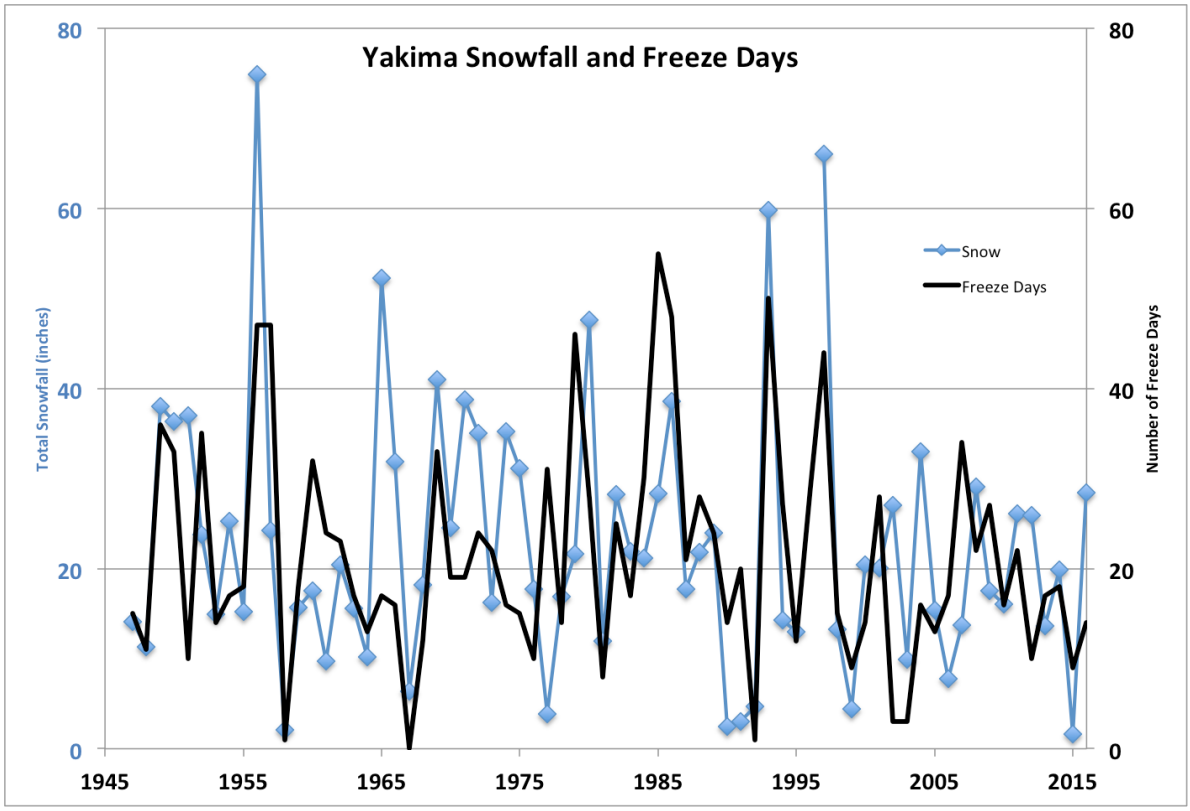


Figure 3: As in Figure 2, except cold days are defined as 32°F or below.

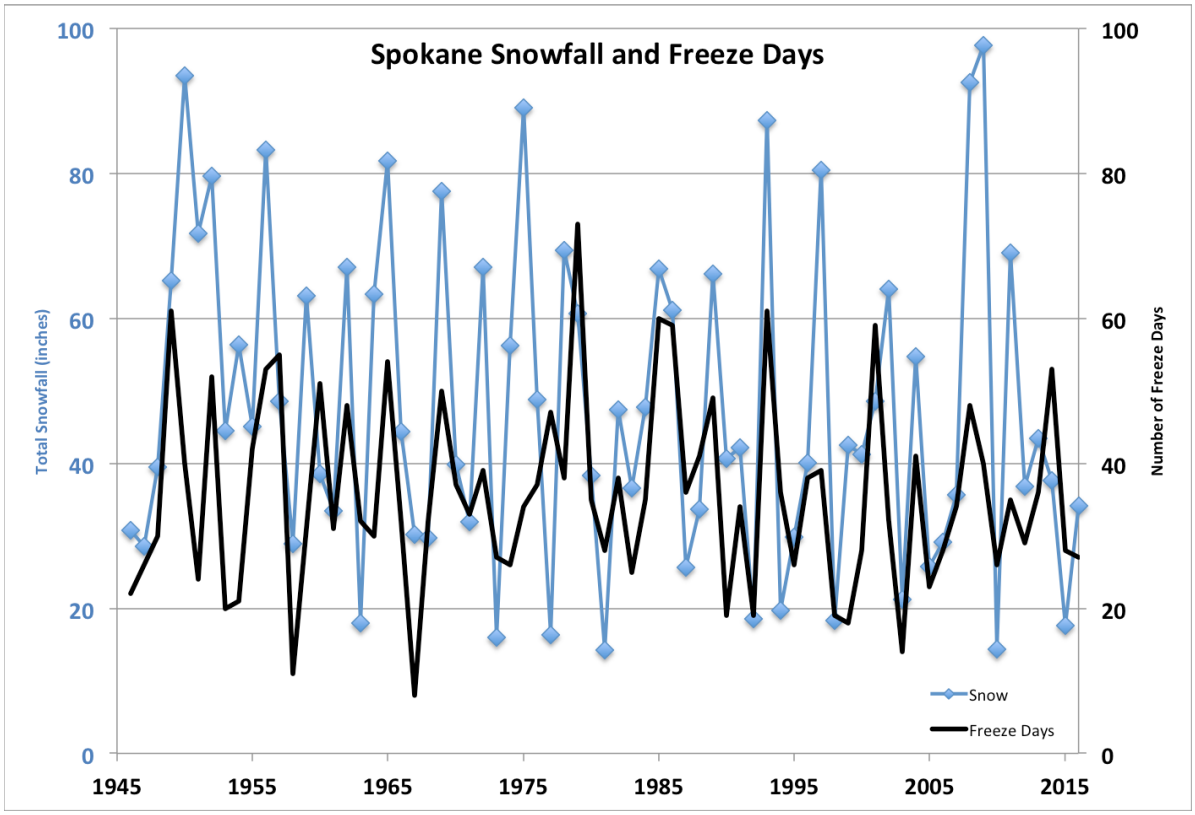
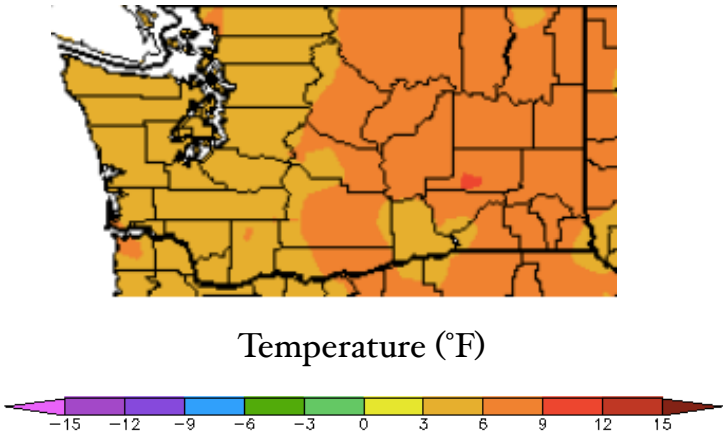


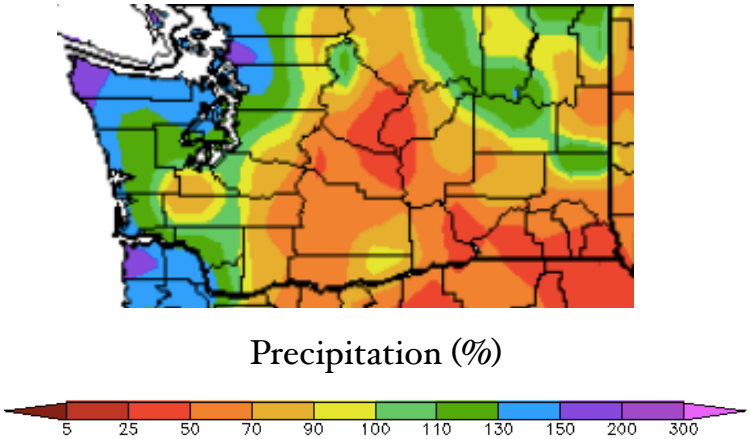
Figure 4: As in Figure 3 but for Spokane.

Climate Summary

Mean November temperatures were much warmer than normal for the entire state. Most of Eastern WA was at least 6°F warmer than normal, according to the map below from the High Plains Regional Climate Center. Western WA was not quite as warm but still had temperature anomalies between 3 and 6°F above normal. For example, Hoquiam and Vancouver were 4.8 and 5.4°F above normal, respectively (Table 4). Some locations in eastern WA saw monthly temperature anomalies of an impressive 7 or 8°F above normal. Pullman was a warm spot, with a November temperature anomaly of 8.5°F (Table 4).

Total November precipitation was less uniform statewide, with some notable differences between the western and eastern part of the state. In general, western WA fared better, with most locations reporting precipitation totals that were above their respective normals. On the other hand, most locations in eastern WA were below 80% of their respective normals, and some locations were quite dry. One of the driest spots was Wenatchee - it only received 34% of normal precipitation (Table 4). Omak represented an exception, with 120% of normal precipitation.





November temperature (°F) departure from normal (top) and precipitation percent of normal (bottom).

(High Plains Regional Climate Center; relative to the 1981-2010 normal).

	Mean Temperature (°F)			Precipitation (inches)		
	Average	Normal	Departure from Normal	Total	Normal	Percent of Normal
Western Washington						
Olympia	47.9	43.3	4.6	9.28	8.63	108
Seattle WFO	51.3	46.2	5.1	7.71	5.84	132
SeaTac AP	50.9	45.4	5.5	6.48	6.57	99
Quillayute	48.6	44.2	4.4	25.72	15.52	166
Hoquiam	50.6	45.8	4.8	15.92	11.17	143
Bellingham AP	50.4	43.2	7.2	7.76	5.80	134
Vancouver AP	51.8	46.4	5.4	6.88	5.91	116
Eastern Washington						
Spokane AP	43.5	35.7	7.8	1.57	2.30	68
Wenatchee	45.8	37.6	8.2	0.38	1.11	34
Omak	43.5	35.9	7.6	1.94	1.61	120
Pullman AP	45.5	37.0	8.5	1.85	2.29	81
Ephrata	45.2	37.0	8.2	0.76	1.06	72
Pasco AP	46.8	41.3	5.5	0.54	1.09	50
Hanford	47.3	40.5	6.8	0.57	0.95	60

Table 4: November 2016 climate summaries for locations around Washington with a climate normal baseline of 1981-2010. Note that the Vancouver Pearson Airport and Seattle WFO 1981-2010 normals involved using surrounding stations in NCDC's new normal release, as records for these station began in 1998 and 1986, respectively.

Climate Outlook

According to the Climate Prediction Center (CPC), La Niña conditions are present in the tropical Pacific Ocean. While the past couple of months indicated a strengthening in the negative sea surface temperatures (SSTs) in the central and eastern tropical Pacific, this past month saw the negative anomalies remain essentially constant in magnitude. The CPC's "La Niña advisory" is still in effect. Current ENSO models predict a 55% chance of a relatively weak La Niña persisting through winter 2016-17 (Dec-Feb).

December outlook for temperature (left) and precipitation (right)

The CPC seasonal outlooks are lining up with expected La Niña impacts for the region. There are higher chances of below average temperatures for December statewide, with northeastern WA having slightly higher chances of colder than usual temperatures compared to the rest of the state. For December precipitation, the outlook favors higher chances of above normal precipitation totals throughout all of WA. Eastern WA has slightly higher chances for above normal precipitation for the month.

December-January-February outlook for temperature (left) and precipitation (right)

The December-January-February (DJF) outlook is calling for equal chances of below, near-normal, or above normal temperatures for the entire state. With precipitation, the CPC forecast favors higher chances for above average precipitation east of the Cascades while Western WA has equal chances of below, near-normal, or above normal precipitation totals for DJF.