Office of the Washington State Climatologist

January 3, 2014

December Event Summary

In this Issue

December was cold and dry statewide. The below normal precipitation for the month now marks three consecutive months in which precipitation has been less than normal. The October through December period is the second driest Oct-Dec since records began at SeaTac Airport (1948), as well as some other stations around the state. For example, Oct-Dec is the second driest at Hoquiam, Wenatchee, Olympia, and Vancouver. Oct-Dec 1976 is the record driest for all the above locations; only 4.66" of precipitation was measured at SeaTac in 1976, while total Oct-Dec 2013 precipitation is 6.99". Oct-Dec 2013 is within the top 5 driest Oct-Dec periods at many other stations around the state such as Walla Walla, Yakima, Everett, Spokane Airport, and Omak, for example. This dry period has aided in 2013 as a whole coming in as drier than normal (Figure 1). More on how the 2013 calendar year relates to previous years will be included in the February OWSC newsletter.

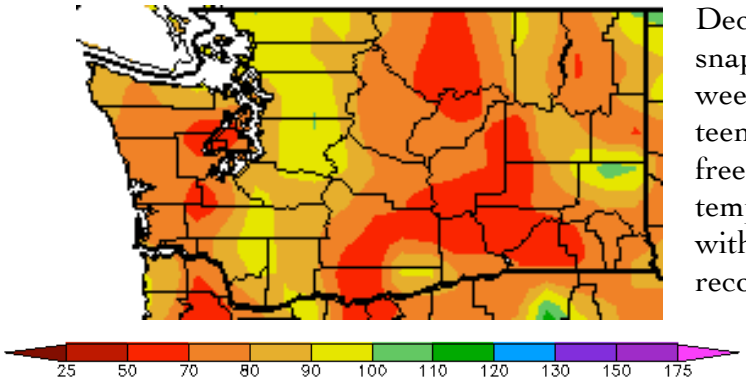


Figure 1: The percent of normal precipitation for WA for the 2013 calendar year (Jan 1-Dec 31). (from HPRCC)

December featured several notable events. A cold snap in the beginning of the month lasted about a week (Dec 3-10). Low temperatures were in the teens and 20s in western WA, with highs below freezing for many of the days. In eastern WA, low temperatures were generally in the single digits with high temperatures in the teens and 20s. A record daily low temperature of -4°F was measured at the Pullman-Moscow Airport on Dec 4. More daily low temperature records were broken or tied on Dec 5 - Pullman-Moscow Airport (-3°F), Vancouver (15°F), Hoquiam (21°F), Quillayute (21°F), SeaTac Airport (23°F), and the Seattle Weather Forecasting Office (24°F). Record low high temperatures were also set that day at Spokane Felts Field (21°F) and Pullman-Moscow Airport (17°F). Some light snow fell overnight on 5th from the Olympic Peninsula through Olympia and Hood Canal, but the snowfall only amounted to about an inch. More record low temperatures were set on Dec 8 at Pullman-Moscow Airport (-11°F), Ephrata (-2°F), and

Vancouver (9°F). Finally, more light snow fell at the end of the cold spell, overnight on the 9th, in southwest WA and the Olympia area, but totals were less than an inch. Warmer air finally moved across the whole state on the 10th and the 11th.

The widespread snow that occurred in western WA in the early morning hours of Dec 20 represents another notable event. The snow amounted to only about an inch in most places, but measured between 2 and 4 inches in some places such as western Whatcom County, Anacortes, near Sequim, the San Juan Islands, and Whidbey Island. The snow measurements on the morning of Dec 20 are shown in the Community, Collaborative, Rain, Hail, and Snow (CoCoRaHS) network map (Figure 2). Note that this is the first measurable snow at the OWSC office on the University of Washington Seattle campus since we began observations in October 2012. We measured 0.8" inches at OWSC. The snow changed over to rain in late morning, and was followed by the wettest day of the month for most of the state (Dec 21).

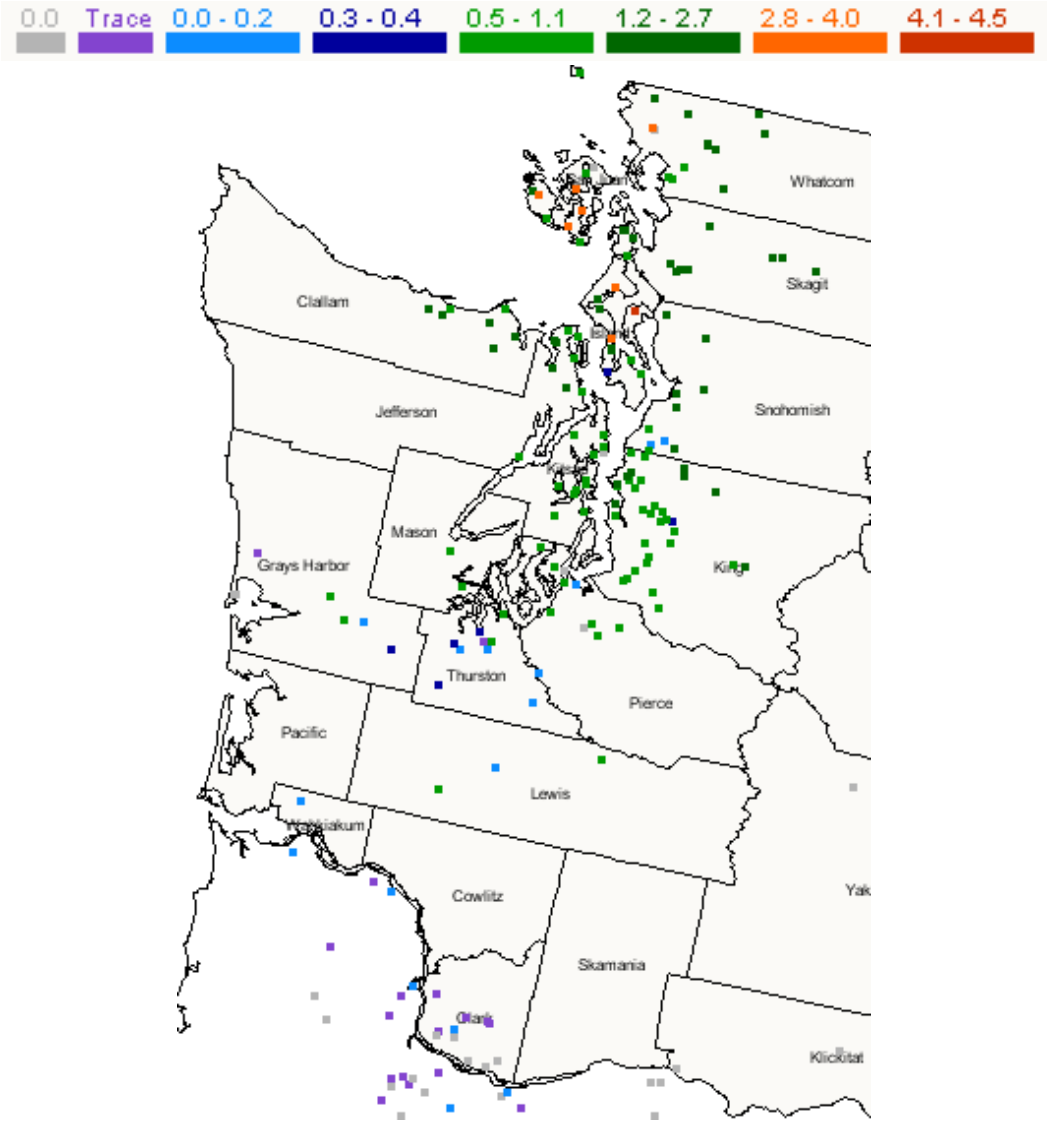


Figure 2: 24-hr snowfall totals from the Community, Collaborative, Rain, Hail, and Snow (CoCoRaHS) network on the morning of December 20, 2013 (between 7 and 9 am).

Snowpack Summary

The WA snow water equivalent (SWE) is much below normal for many WA basins, with lower values relative to normal than in early December (Figure 3). The Central Puget Sound, South Puget Sound, Lower Columbia, Central Columbia, Upper Yakima, and Olympic basins have an average SWE that ranges between 25 and 48% of normal. The North Puget Sound, Lower Yakima, and Upper Columbia are still below normal, but have more than half of the SWE expected for this time of year, ranging between 51 and 68% of normal. The Spokane and Lower Snake basins are faring the best, with the average SWE for each basin at 77 and 82% of normal, respectively. The dry conditions that have existed since October in combination with the subpar snowpack has increased drought concerns. The latest US Drought Monitor depicts "abnormally dry" conditions throughout most of the state (Figure 4), with deteriorating conditions likely.

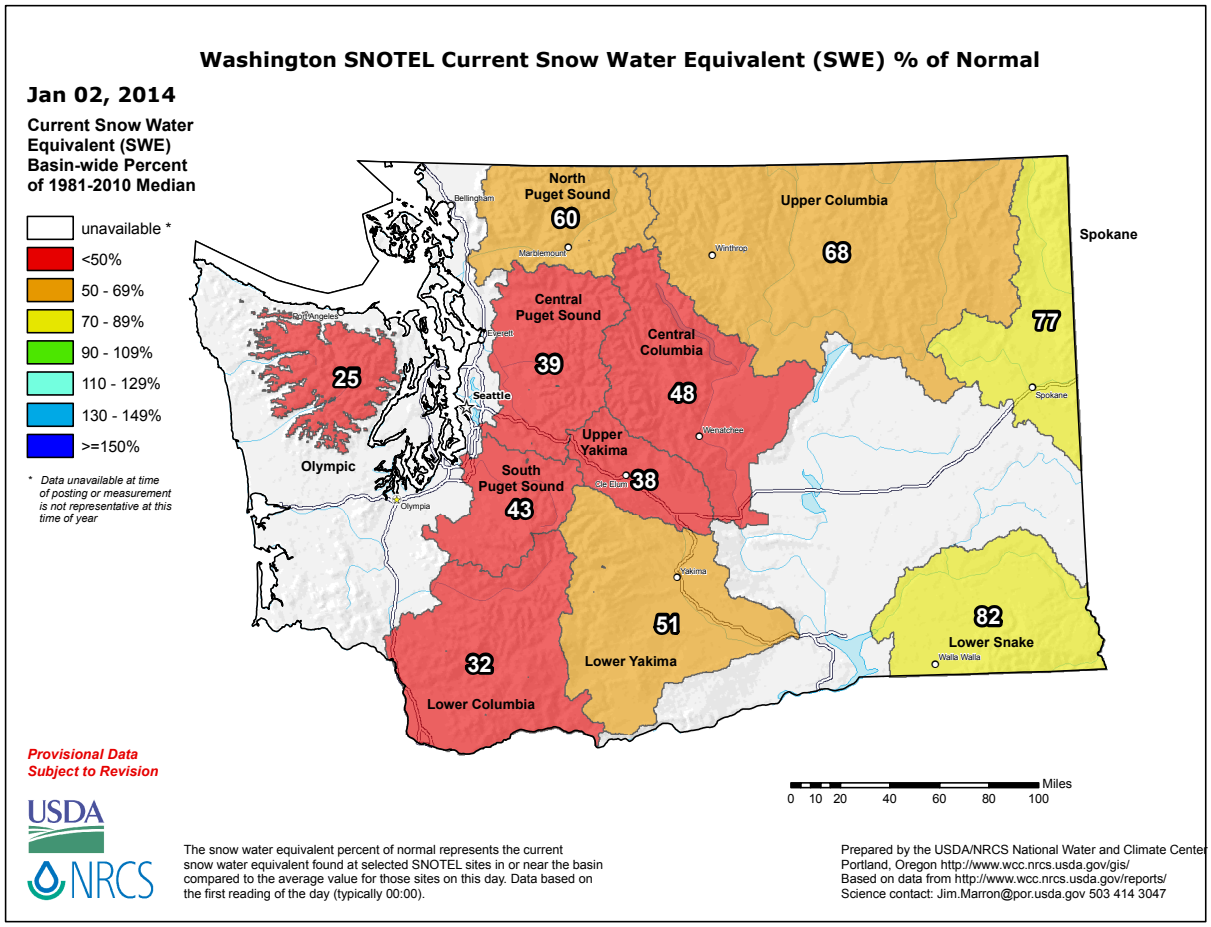


Figure 3: Snowpack (in terms of snow water equivalent) percent of normal for Washington as of January 2, 2014. Image is from the National Resources Conservation Service (NRCS).

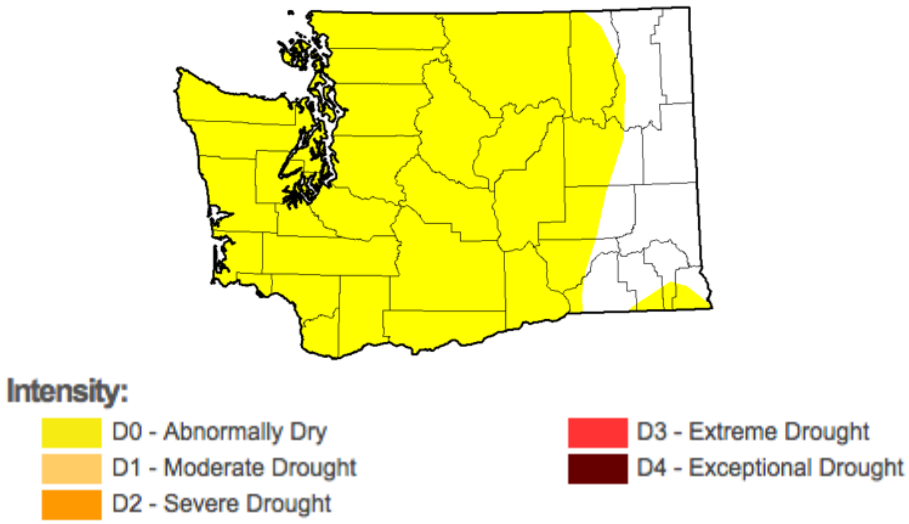


Figure 4: The December 31, 2013 edition of the US Drought Monitor (from the National Drought Mitigation Center).

The Arctic Oscillation and Pacific Northwest Weather

A message from the State Climatologist

The Arctic Oscillation (AO), also known as the Northern Annular Mode (NAM), is an important element of the variability in the weather and climate of the Northern Hemisphere. It relates fundamentally to the state of the flow at northern latitudes, with the positive phase associated with a strong, axisymmetric polar vortex and the negative phase associated with a weak polar vortex, allowing for more prominent large-scale ridges and troughs for the whole hemisphere. The AO/NAM explains about one-third of the variance in the flow of the Northern Hemisphere in the lower stratosphere during winter, and about 20% of the variance in the troposphere. There was essentially a reawakening of interest in the AO/NAM by the climate community in the late 1990s in response to the work by Prof. Mike Wallace at the University of Washington and his student David Thompson (now a professor at Colorado State University); the importance of annular patterns in the atmospheric circulation was recognized by Sir Gilbert Walker and Carl-Gustav Rossby in the 1930s. But all this may seem a matter of academic interest, so why should the man in the street care about the AO?

He should care about it because it often relates to the footing. As illustrated in Figure 5, frigid air of Arctic origin tends to remain bottled up at high latitudes during positive phases of the AO/NAM (left side), and cold-air outbreaks to the mid-latitudes are more likely and dramatic when the AO is in the negative phase (right side). The schematic in Figure 5 highlights the latter effect for the eastern US and Europe…what about our own neck of the woods? Thanks to the efforts of a former student of Mike Wallace, Greg Ostermeier, it is possible to check for oneself on the following website: http://www.jisao.washington.edu/greg/northwest/. Figures 6 and 7 have been lifted off this website and show the ratio of the occurrence of extreme Tmin

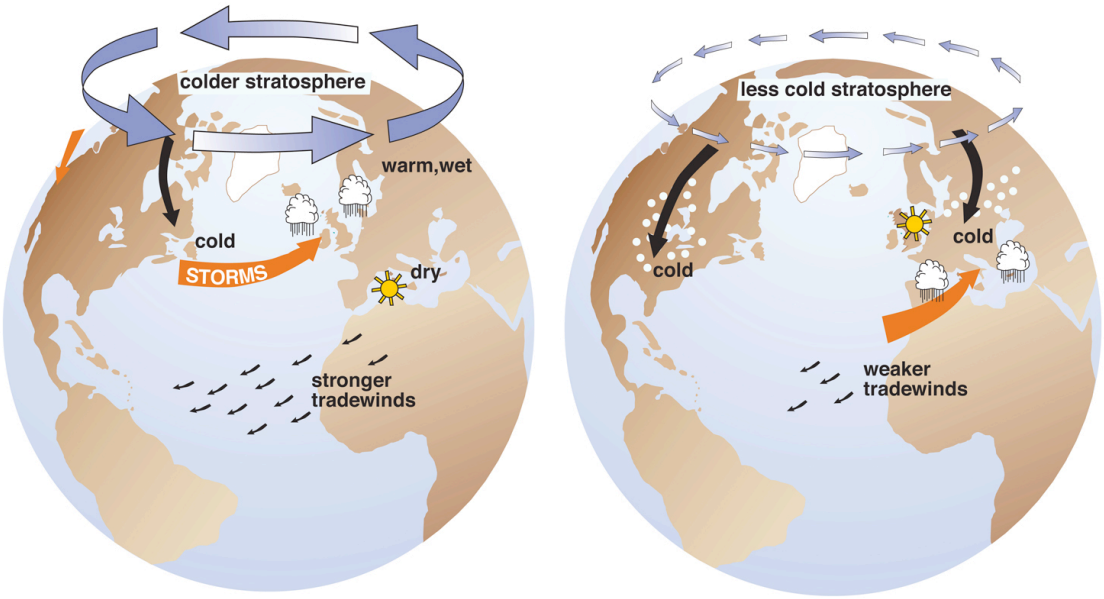


Figure 5: Schematic of the circulation and notable weather accompanying positive (left) and negative (right) states of the AO/NAM. Illustration by J.M. Wallace, University of Washington.

and high precipitation days, respectively, during the positive phase of the AO/NAM versus the negative phase. Note that relatively cold temperatures are associated with a negative state for the AO/NAM in most, but by no means all, stations in Washington state (Fig. 6). This signal is extremely strong in Montana, especially east of the continental divide and basically lacking across the southern portions of Oregon and Idaho. With regards to precipitation, extreme events on the west side of the crest of the Cascade Mountains of Washington and Oregon occur considerably more often during the positive phase of the AO/NAM, with most of the stations to the east including an opposite relationship, but with plenty of exceptions. Additional work (not shown on the aforementioned website) indicates that strong winds in the Puget Sound basin, and especially high waves on the WA coast are roughly 3 times more likely during positive relative to negative phases of the AO/NAM. These results make sense in that a high-amplitude ridge (block) must develop in the central North Pacific in order for our region to be blessed with cold northerly flow out of northwest Canada; a more zonal flow accompanies the landfall of Pacific storms bearing wind and heavy rain. It should be appreciated that the AO/NAM influences just the probability of various kinds of episodic weather events rather than serving as any sort of guarantee one way or another.

The AO/NAM is receiving ongoing attention from the climate community. There would be substantial benefits from being able to predict it beyond the 1-2 week limits of numerical weather prediction (NWP) model simulations. Seasonal forecasts of the sort produced for El Niño-Southern Oscillation (ENSO) are not yet possible. Moreover, because the AO/NAM is a characteristic of the high-latitude atmospheric circulation, its long-range prediction will always be limited by the chaotic nature of this circulation and hence lack of predictability. That being said, there is tentative evidence that the sense of the AO/NAM tends to relate to the sense of the quasi-biennial oscillation (QBO) in the zonal winds of the tropical stratosphere through the former's modulation of interactions between planetary waves and the mean flow.

More controversially, it has been suggested that variations in surface conditions, specifically snow cover over Siberia, and in separate studies, sea ice in the Arctic, are linked to the AO/NAM. There may actually be enough lead time with these effects to stack the deck one way or another, if not assure, the overall sign for the AO/NAM during an upcoming winter. Finally, is global climate change liable to favor a positive or negative state to the AO/NAM? Without going into details, it is safe to say that no firm conclusions have been reached yet. In the meanwhile, the readers of this newsletter are encouraged to keep track of the short-term predictions of the AO/NAM available at a website maintained by NOAA's Climate Prediction Center (http://www.cpc.ncep.noaa.gov/products/precip/CWlink/daily_ao_index/ao.shtml) and dream about what kinds of storms might be on the horizon.

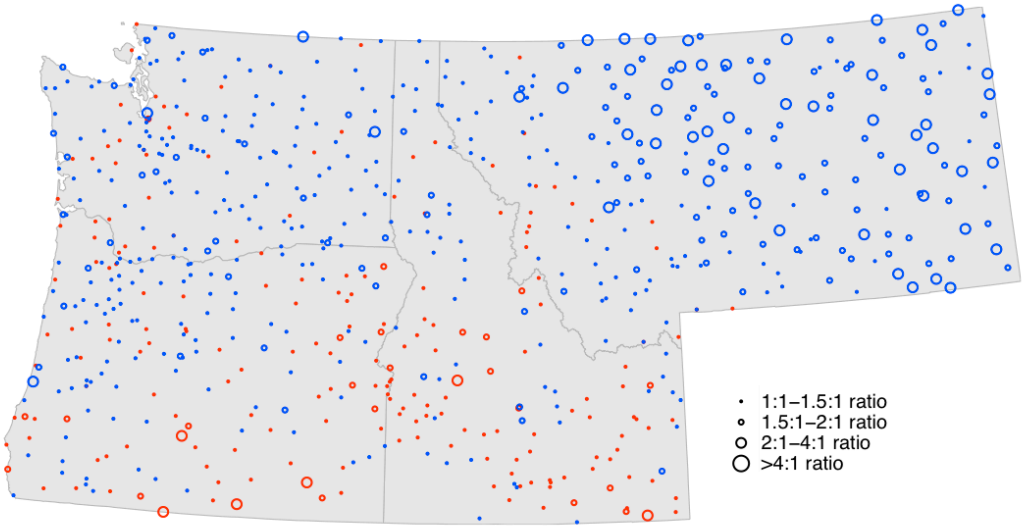


Figure 6: Ratio of extreme low Tmin days (lowest 6.7%) during positive AO/NAM days versus negative AO/NAM days in winter (NDJFM). Red (blue) circles imply more events on positive (negative) AO/NAM days. Includes only stations with >250 days of extreme events. See http://www.jisao.washington.edu/greg/northwest/TMIN/NAM/ for more examples.

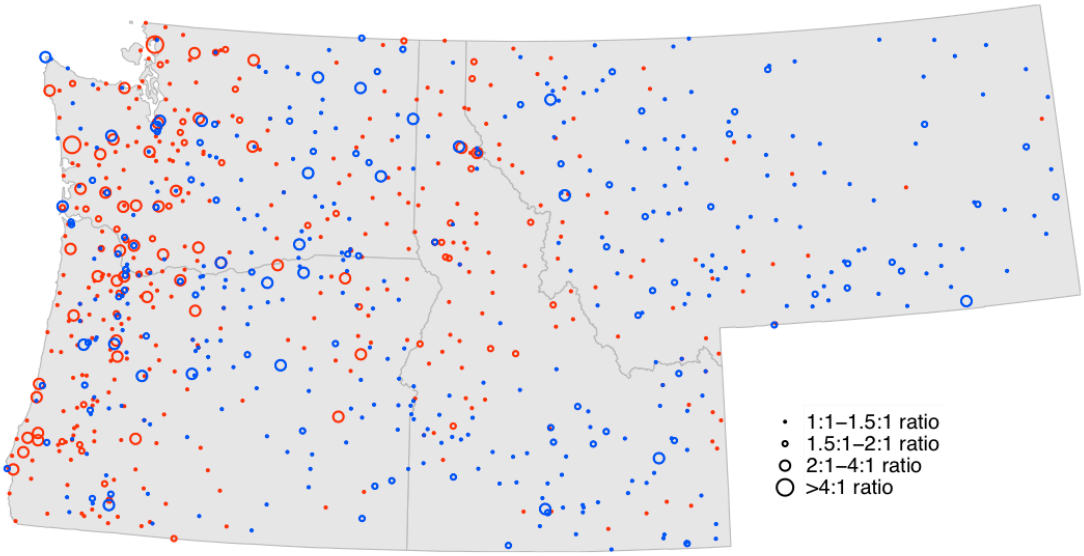
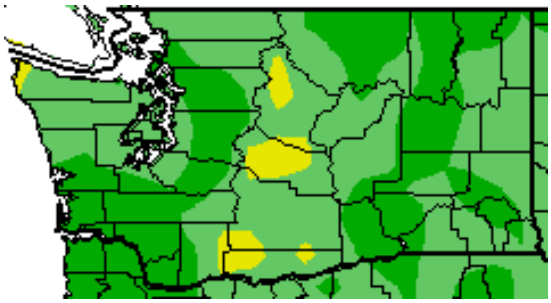


Figure 7: As in Figure 6, but for extreme precipitation days (highest 20%) in winter (NDJFM) for stations with >190 days of extreme events. For more examples, see http://www.jisao.washington.edu/greg/northwest/PRCP/NAM/.

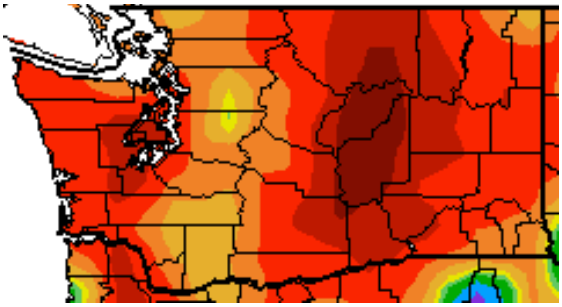
Climate Summary

Mean December temperatures were below normal across most of WA State, according to the map from the High Plains Regional Climate Center shown below. Areas that were more than 3°F below normal include southwestern WA, the foothills on the eastern side of the Puget Sound, and much of eastern WA. Hoquiam, Vancouver, and Pasco, for example, were 3.6, 4.8, and 5.5°F below normal for December, respectively (Table 1).

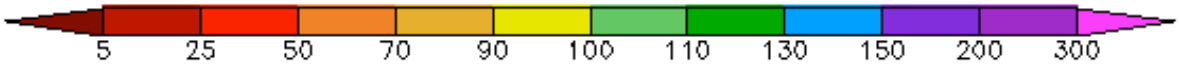
Total December precipitation was much below normal, marking the third consecutive month in which precipitation has been below average in WA State. The eastern slopes of the Cascades Mountains were especially dry, receiving less than 5% of normal precipitation during December. Wenatchee, Hanford, Omak, and Ephrata all received less than 10% of normal precipitation (Table 1), with 8, 6, 4, and 1% of normal, respectively. West of the Cascades fared a little better, with many locations receiving between 25 and 70% of normal precipitation. While at least a "trace" of snow did fall everywhere around the state, the snowfall was below the 30-year December average for all of the locations listed in Table 1.



Temperature (°F)



Precipitation (%)



December temperature (°F) departure from normal (top) and December precipitation % of normal (bottom).
(High Plains Regional Climate Center (http://www.hprcc.unl.edu); relative to the 1981-2010 normal).

	Mean Temperature (°F)			Precipitation (inches)			Snowfall (inches)		
	Avg	Norm	Departure from Normal	Total	Norm	% of Norm	Total	Norm	% of Norm
Western Washington									
Olympia	36.0	38.4	-2.4	2.02	7.46	27	T	2.6	0
Seattle WFO	38.5	41.1	-2.6	1.67	5.43	31	0.9	2.3	39
Sea-Tac	39.7	40.6	-0.9	1.66	5.35	31	1.1	1.7	6
Quillayute	40.3	40.4	-0.1	6.16	12.99	47	T	2.1	0
Hoquiam	38.0	41.6	-3.6	4.25	9.96	43	T	0.4	0
Bellingham AP	35.9	38.1	-2.2	3.14	4.22	74	M	2.9	-
Vancouver AP	35.8	40.6	-4.8	1.52	6.77	22	M	M	-
Eastern Washington									
Spokane AP	25.7	27.4	-1.7	0.68	2.30	17	3.7	14.6	3
Wenatchee	26.1	27.9	-1.8	0.11	1.40	8	M	12.9	-
Omak	22.6	25.7	-3.1	0.11	2.54	4	M	M	-
Pullman AP	27.2	30.1	-2.9	1.41	1.57	90	M	M	-
Ephrata	25.6	27.4	-1.8	0.01	1.24	1	M	7.6	-
Pasco AP	27.6	33.1	-5.5	0.14	1.21	12	T	0.4	0
Hanford	26.9	31.1	-4.2	0.07	1.20	6	0.4	5.9	7

Table 1: December 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.

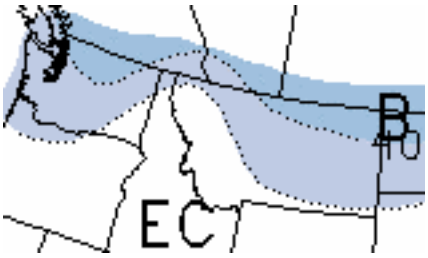
Climate Outlook

The conditions in the equatorial Pacific Ocean are ENSO-neutral, according to the Climate Prediction Center (CPC): http://www.cpc.ncep.noaa.gov/. Averaged over the last 4 weeks, sea-surface temperatures (SSTs) have been above normal in the western equatorial Pacific Ocean, and near-normal in the central to eastern equatorial Pacific. There is a consensus among the model predictions that near-neutral ENSO conditions will persist through the winter and spring 2014.

The CPC three-class outlook for January has equal chances ("EC") of above, equal to, or below normal temperatures and precipitation statewide. Some of the global climate models that are used for seasonal weather predictions are indicating that it will be dry, and others that it will be wet, so a clear signal one way or another is lacking.

The three-month winter temperature and precipitation outlook for January-February-March (JFM) is calling for greater chances of below normal temperatures for most of the state. The chances for colder than normal temperatures are higher for northern WA. The CPC precipitation outlook is indicating equal chances ("EC") of below, equal to, or above normal precipitation for JFM.

January outlook for temperature (left) and precipitation (right) from the CPC.



January-February-March outlook for temperature (left) and precipitation (right) from the CPC.