



# Office of the Washington State Climatologist

## November 2016 Report and Outlook

November 3, 2016

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

### October Event Summary

Mean October temperatures were generally above normal throughout the state, but the total October precipitation is the more interesting story. Precipitation was much above normal for the entire month, with many locations setting record high values for October. Table 1 shows examples of stations that set a new maximum precipitation record in October 2016, breaking records in some cases that were set 60–70 years ago. In addition to setting a new October precipitation record, Spokane Airport also set an **all-time** monthly precipitation record for **any month** in its long record (since 1881). Figure 1 shows they precipitation at Spokane Airport during October (green bars), illustrating just how wet the month was. There were two days in which precipitation approached nearly an inch which is quite a bit for Spokane. SeaTac Airport also set another kind of soggy record, specifically the number of days with measurable rain. October 2016 had 25 days with measurable rain, beating out October 1956, 1950, and 1947 which all had 23 days. Notable locations not listed in Table 1 include Quillayute and Bellingham, which checked in with their 3rd wettest October on record with a whopping 21.08" and 7.40", respectively.

### In this Issue

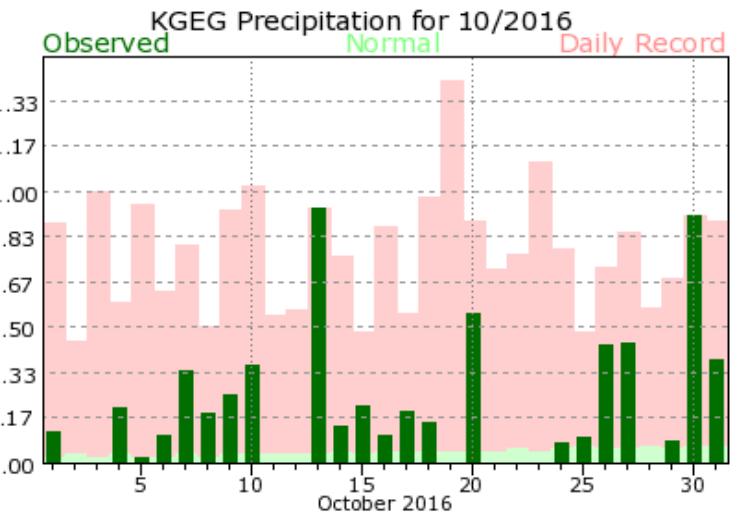
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Station	October Precipitation (in)	Previous Record (in; year)	Records Since
<b>Hoquiam</b>	15.85	14.68"; 1956	1953
<b>Olympia</b>	12.43	10.72"; 2003	1948
<b>SeaTac</b>	10.05	8.96"; 2003	1945
<b>Spokane</b>	6.23	5.41"; 1947	1881
<b>Colville</b>	5.82	4.81"; 1947	1899
<b>Pullman</b>	5.69	4.29"; 1950	1950
<b>Walla Walla</b>	4.55	4.42"; 1950	1930
<b>Pasco</b>	2.58	1.13"; 2000	1945
<b>Ephrata</b>	2.52	1.92"; 1957	1949
<b>Yakima</b>	2.43	2.22"; 1950	1946

**Table 1: The amount of October precipitation that ranks as the wettest on record for several stations in WA. The previous record that was surpassed as well as the record length as also indicated.**

Not surprisingly, most of the daily records set during the month were in regards to precipitation. But there were several periods of windy conditions as well. The first was due to a frontal passage overnight on the 6th that brought rain and then wind behind the front. While the winds weren't exceptional, gusts in western WA did blow between 20 and 50 mph on the 6th and 7th. On the 9th, daily maximum rainfall records were set at Yakima (0.57"), Pasco (0.54"), Ephrata (0.26"), and Wenatchee (0.22"). There was a brief, relatively dry and sunny period from the 10th through the 12th, before a series of storms impacted the state.

The first two storms brought heavy rain and gusty winds on the 13th and 14th. Maximum daily rainfall records were impressive, with Hoquiam (2.50"), the Seattle Weather Forecasting Office (1.76"), SeaTac Airport (1.75"), Olympia (1.61"), Omak (1.08"), Spokane Airport (0.94"), Ephrata (0.56"), Pullman (0.53"), and Wenatchee (0.44") all setting records for the calendar day on the 13th. Daily rainfall records on the 14th were primarily in western WA with Vancouver, Olympia, and SeaTac Airport recording 2.01, 1.36, and 2.06", respectively. On the 15th, a low pressure system with the remains of typhoon Songda (after the storm went through extratropical transition) was projected to bring extreme winds to WA state. The winds ended up not being as strong as originally thought; the main reason is that the track was slightly west of that originally anticipated. There has already been some in-depth analysis on the storm, with many more studies likely to come. Dr. Wolf Read, an expert in PNW wind storms, has already completed a post-mortem of the storm (dubbed the Ides of October Storm). His [website](#) is hosted by OWSC, where a



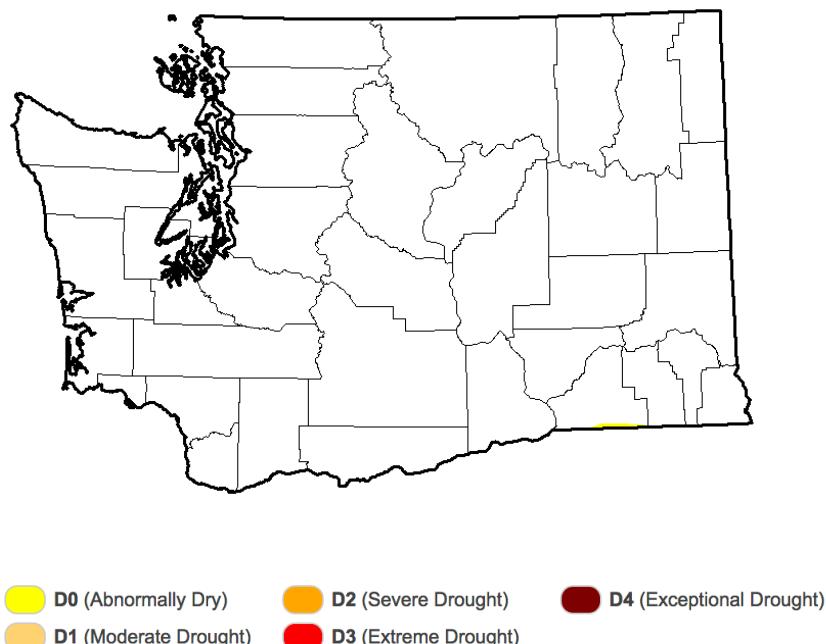
**Figure 1: Daily precipitation values (green bars) for Spokane Airport for October 2016 (from [NWS](#)).**

map of the maximum wind gusts with this storm can be found. More record calendar day rainfall amounts were also set on the 15th. For example, Hoquiam recorded another 2"+ day with 2.11" on the 15th.

The rest of the month remained wet, with some more rainfall records set at Wenatchee (0.55") and Yakima (0.48") on the 26th. The record-breaking continued through the end of the month with Spokane and Pullman setting calendar day rainfall records on the 30th with 0.91" and 0.66", respectively. The month ended with a soaker of a night for the Halloween trick-or-treaters, particularly in the central Puget Sound area.

## Drought Monitor Update

October's record rainfall (and September's normal rainfall west of the Cascade Mountains) has prompted the US Drought Monitor to remove any remaining "abnormally dry", or "D0" conditions, from the depiction. The 25 October edition of the map is shown below (Figure 2), with no drought depiction in WA state. As we enter the cooler months ahead, we will keep a close eye on the snow conditions in our mountains. A few of the October storms brought a little snow to higher elevations, but no significant events as of this writing. At present (Nov 2), about 80% of Washington's rivers and streams are above normal to much above normal.



**Figure 2: The 25 October 2016 edition of the [US Drought Monitor](#).**



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 October. Given the amount of rainfall we received this past month, we have no doubt that you've had plenty of opportunities to report! Here in the office, our own rain gauge recorded an impressive amount of precipitation with 9.92" for the month. After the last couple months of relatively "dry" conditions, October was a much needed change of pace. Please help us spread the word about CoCoRaHS; we're always looking for new volunteers. Those interested can sign up at [www.cocorahs.org](http://www.cocorahs.org).

# Winter Air Pollution in Washington State

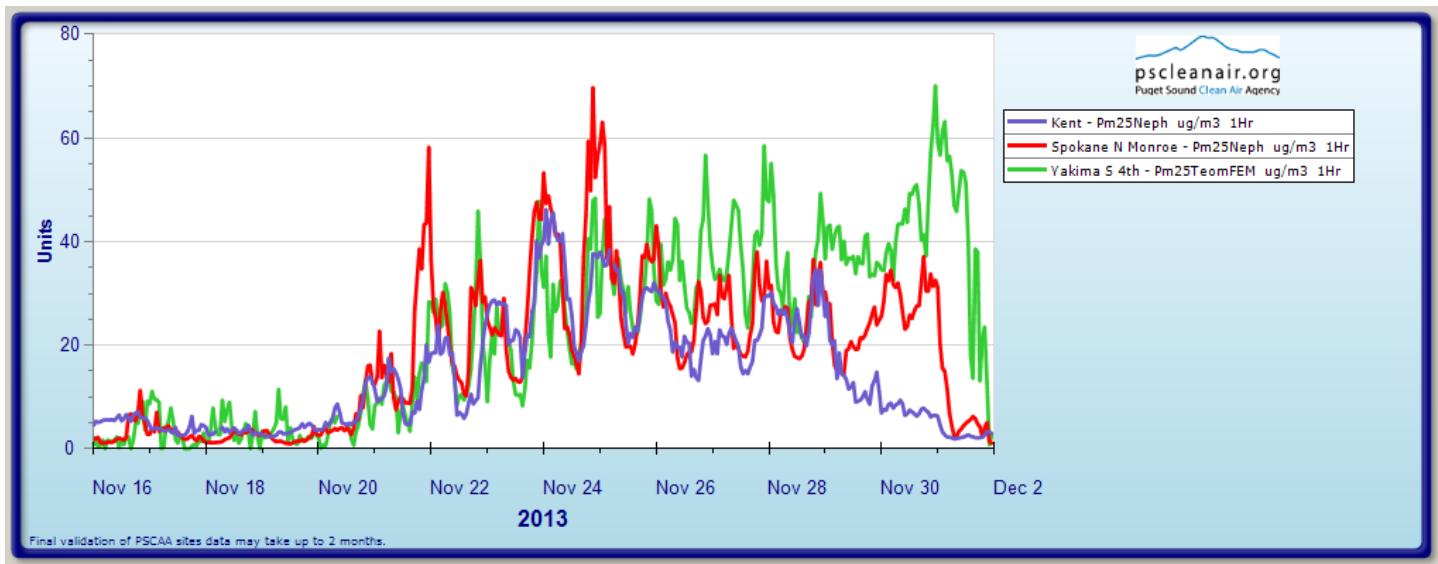
A message from the State Climatologist

Here we revisit a topic discussed in a previous edition of this newsletter (January 2011), and that is particulate pollution during the winter in Washington state. There is some good news, but it remains a public health hazard at times in many parts of the state. A recent online publication from the American Lung Association includes a “[Report Card](#)” for Washington state. By one measure, based on data from 2012 through 2014, every county of the 9 in the state with sufficient data received a “Passing” grade with respect to particulate pollution. From a different perspective the grades for individual counties ranged from A to F! What accounts for the discrepancy?

First the bad news, and the less than stellar grades for some counties. Periods of high particulate pollution occur every winter in WA. They are almost always associated with calm weather and cold nights accompanying high sea level pressure. Commonly there is also reduced cloudiness or even clear skies, which means reduced downward longwave radiative heat fluxes and hence more nighttime cooling. The cold air that forms at the surface tends to persist because of the lack of much wind; the high static stability of the lower atmosphere traps pollution in a shallow layer. The pollution itself is small particulates that in large part is made up of wood smoke from residential sources. Concentrations of particulates less than 2.5 microns in size (PM<sub>2.5</sub>) between 35.5 and 55.5 micrograms/m<sup>3</sup> are in the category of

“Unhealthful to Sensitive Groups”. The “Unhealthful” category is for PM<sub>2.5</sub> in the range of 55.5 to 150 micrograms/m<sup>3</sup>. Of the 9 counties that can be given grades, Pierce and Yakima had enough days with elevated values of PM<sub>2.5</sub> to receive grades of F. On the other hand, Kitsap and Whatcom did not have any days above the threshold and were assigned grades of A. But while that is the kind of report card you liked to show to your parents, those counties do not necessarily deserve much credit, nor do those with poor marks deserve scorn. The propensity for local weather conditions favoring the build-up of PM<sub>2.5</sub> varies widely across WA, in large part due to the terrain, and has an impact on which locations exceed the thresholds.

An example of the concentrations of small particulates (PM<sub>2.5</sub>) that occur during a wintertime air pollution event is illustrated below. Specifically, Figure 3 shows hourly PM<sub>2.5</sub> concentrations from 15 November through 1 December 2013 at monitoring sites in Kent, Yakima, and Spokane. Each site experienced PM<sub>2.5</sub> concentrations in the range of the “Unhealthful to Sensitive Groups” category for a number of hours. Both Yakima and Spokane were in the “Unhealthful” range on multiple days. While there are differences between the time series at these three sites, we were struck by the commonalities for this event, and for that matter, other events that have been examined. The timing of the onset of the episode, and the nature of the ramp-up



**Figure 3: Hourly PM<sub>2.5</sub> concentrations (micrograms/m<sup>3</sup>) at Kent (purple line), Spokane (red line), and Yakima (green line) from 15 November to 1 December 2013 ([PS Clean Air Agency](#)).**

in PM<sub>2.5</sub> concentrations, appears to have been similar from Puget Sound to the far eastern part of WA. In addition, the diurnal cycles are comparable, with nighttime maxima in PM<sub>2.5</sub> concentrations typically about twice as high as the late afternoon minima. On the other hand, the event lasted a few days longer at Yakima and Spokane due to longer persistence of settled weather on the east side of the Cascade Mountain crest. This was particularly the case at Yakima, where the peak PM<sub>2.5</sub> concentrations occurred on the night of 30 November, in which the average wind speed was only 0.8 mph at Yakima Airport that day.

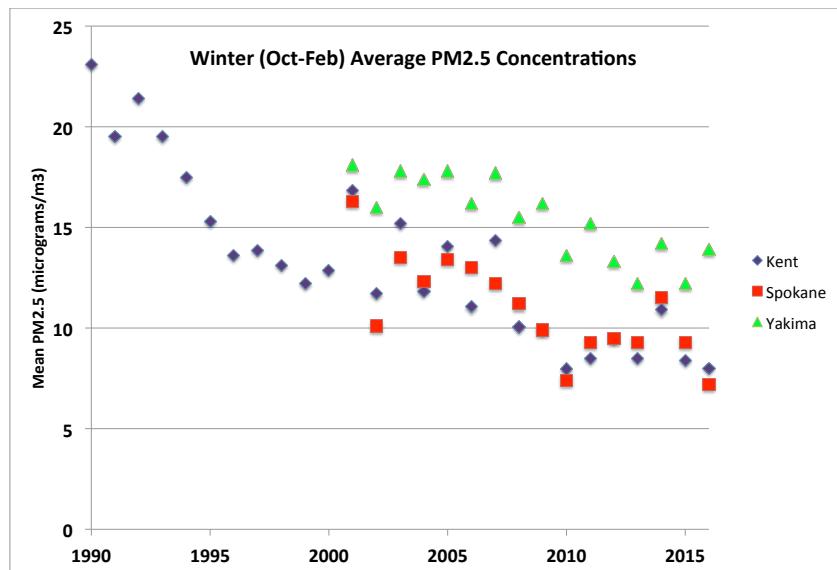
We did a bit of exploring into the relationships between wind speeds and PM<sub>2.5</sub> concentrations in the winter months using data from the Kent site. The linear correlation coefficient between these two variables in terms of daily averages was about -0.6. For the period of the November 2013 event shown above, hourly

values of wind speed and PM<sub>2.5</sub> concentrations have a correlation coefficient of about -0.7. The winds are not the whole story, of course, but in general, fall and winter days with low speeds tend to be the ones with crummy air.

We are pleased to report some good news, and that is that all monitoring locations in WA state during the period of 2012 through 2014 had annual average PM<sub>2.5</sub> concentrations that met the EPA's national air quality standard. This is the reason for the aforementioned "Passing" grade for all the counties of WA with enough data. Moreover, PM<sub>2.5</sub> concentrations exhibit a long-term decline, as shown in terms of winter averages (October through February) for Kent, Spokane and Yakima (Fig. 4). The drop in average concentrations at Kent was especially pronounced from 1990 to 2000; we were unable to easily acquire data prior to 2000 for Spokane and Yakima. The improvements in air quality, in spite of

increasing populations, can be attributed to the phasing out of older and often dirtier wood stoves, and better communication and compliance with burn bans. Perhaps some of the improvement is due to increased temperatures and therefore folks simply not burning up as much wood.

While overall air quality in winter has improved in WA, it does vary from year to year. As shown in Figure 4, PM<sub>2.5</sub> concentrations were higher in the winter of 2013-14 than in 2015-16, for example. Again just considering the winds, and using the arbitrary threshold of an average speed of less than 4 mph as the definition of a low wind speed day, the two winters were compared. The result was 40, 42 and 85 low speed days during the winter of 2013-14 at SeaTac Airport (KSEA), Spokane Airport (KGEG) and Yakima Airport (KYKM), respectively; 23, 27 and 56 low speed days occurred during the winter of 2015-16 for the same locations. Yakima is almost surrounded by higher terrain and the low wind speeds that result likely contribute to its relatively poor air quality. Will the upcoming winter be more like 2013-14 or 2015-16? We will let you know how it plays out.

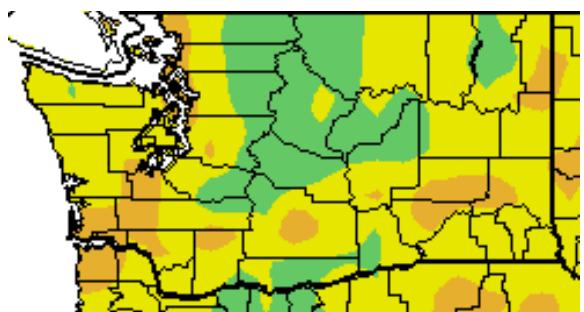


**Figure 4: Average October–February PM<sub>2.5</sub> concentrations for Kent (since 1990), Spokane (since 2000), and Yakima (since 2000). Data from [Puget Sound Clean Air Agency](#).**

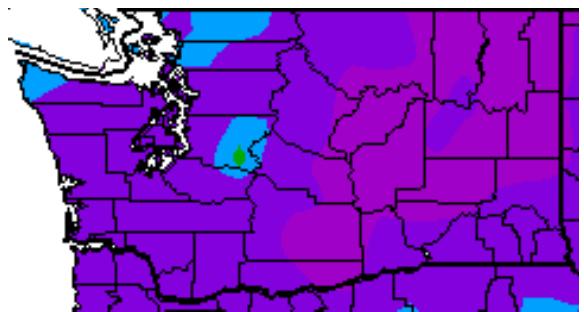
## Climate Summary

Mean October temperatures were mostly above normal for the state, though there were some places where temperatures were closer to normal. In general, mean temperatures were within 2°F of normal for most of the state, according to the High Plains Regional Climate Center map on the right. For example, Olympia and Hoquiam were 2.2°F and 1.5°F above normal, respectively (Table 2). At 3.2°F above normal, Bellingham had the warmest temperature anomaly of the stations listed in Table 2. Eastern Washington had some slightly cooler than normal temperatures this past month; Wenatchee and Ephrata were -0.2°F and -0.1°F below normal, respectively.

Precipitation totals were much higher than normal for the month, with the majority of the state reporting at least 200% of normal. Seattle, SeaTac Airport, and Vancouver received 302, 289 and 268% of normal, respectively (Table 2). According to the precipitation percent of normal map, central and eastern WA ranged an impressive 400-600% above normal. As seen on Table 2, Spokane received 528% of normal, making it one of the wettest spots relative to normal in the state. Other notable percentage totals were Wenatchee and Ephrata who received 461 and 475%, respectively.



Temperature (°F)



Precipitation (%)



**October 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	52.5	50.3	2.2	12.43	4.60	270
Seattle WFO	55.4	53.3	2.1	10.30	3.41	302
SeaTac AP	54.8	52.8	2.0	10.05	3.48	289
Quillayute	51.9	50.0	1.9	21.08	10.49	201
Hoquiam	53.7	52.2	1.5	15.86	6.53	243
Bellingham AP	53.0	49.9	3.2	7.40	3.68	201
Vancouver AP	56.0	53.8	2.2	8.22	3.07	268
Eastern Washington						
Spokane AP	48.4	47.6	0.8	6.23	1.18	528
Wenatchee	50.7	50.9	-0.2	2.03	0.44	461
Omak	49.7	48.9	0.8	3.55	1.08	329
Pullman AP	50.2	47.5	2.7	5.01	1.34	374
Ephrata	50.4	50.5	-0.1	2.52	0.53	475
Pasco AP	54.2	51.9	2.3	2.58	0.65	397
Hanford	54.2	53.1	1.1	2.59	0.49	529

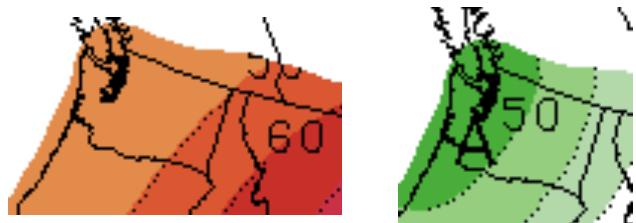
**Table 2: October 2016 climate summaries for locations around Washington with a climate normal baseline of 1981-2010. Note that the Vancouver Pearson Airport and Seattle WFO 1981-2010 normals involved using surrounding stations in NCDC's new normal release, as records for these station began in 1998 and 1986, respectively.**

# Climate Outlook

According to the Climate Prediction Center (CPC), ENSO-neutral conditions are still present in the tropical Pacific Ocean. This past month, however, included the development of stronger and more extensive negative sea surface temperatures (SSTs) in the central and eastern tropical Pacific. As a result, the CPC has re-issued a “La Niña Watch”. Current ENSO models are indicating a likelihood of a weak La Niña during this fall and winter. In quantitative terms, the chances of a La Niña during fall are about 70%, with the chance of it persisting through winter assessed at about 55%.

The CPC seasonal outlook for November is calling for above average temperatures statewide, with southeastern WA having slightly higher chances of warmer than usual temperatures compared to the rest of the state. For precipitation, the outlook favors above average precipitation totals throughout Washington, with western WA and the Olympic Peninsula having a greater chance for above average precipitation for the month.

The November–December–January (NDJ) outlook is calling for equal chances of below, near-normal or above normal temperatures for most of the state. The CPC forecast also calls for slightly higher chances for above average temperatures for southern WA. As for precipitation, the forecast favors slightly higher chances of above average precipitation for the northeast half of WA, while the southwest portion of the state has equal chances of below, near-normal, or above normal precipitation totals.



**November outlook for temperature (left) and precipitation (right)**



**November–December–January outlook for temperature (left) and precipitation (right)**