



Office of the Washington State Climatologist

November 10, 2015

October Event Summary

Mean October temperatures were much warmer than normal across the state while precipitation percent of normal was varied. In general terms, most of the state had near-normal to above normal precipitation, except for the Lower Columbia basin and southeastern WA where precipitation was below normal. Precipitation did not break any monthly records, however, as opposed to temperature. Averaged over the entire state, October average temperatures ranked as the warmest October on record. Table 1 lists the rankings (from warmest to coldest)

In this Issue

Oct Event Summary.....	1
CoCoRaHS.....	2
New Website Content.....	2
Snowpack Update.....	3
Sea Level during El Niño..	4
Climate Summary.....	7
Climate Outlook.....	9

Station	Rank
Wenatchee	1
Yakima	1
Omak	1
Arlington	2
Hoquiam	2
Olympia AP	2
Spokane AP	2
Bellingham	2
SeaTac AP	2
Everett	3
Pullman	3
Walla Walla	4

Table 1: The ranking (warmest to coldest) of October average temperature for selected WA locations.

for several towns/cities in WA state.

Average monthly temperatures were largely in the mid to upper-50s for **both** eastern and western WA locations, ranking among the top 2 warmest Octobers for many sites. Figure 1 shows the daily temperatures for Spokane Airport for the month, where maximum and minimum temperatures were above normal for nearly the entire month. Record daily maximum temperatures were set at several locations throughout the month. For example, Spokane Airport recorded a record high of 75°F on the 17th. On the 30th, temperatures were well into the 70s in the warm sector of a wet storm system that moved in, setting high temperature records at Wenatchee (73°F), Moses Lake (73°F), Ephrata (74°F), Yakima (74°F), and Grand Coulee Dam (67°F).

Despite precipitation not being record-setting on a monthly scale, there were several instances of heavy precipitation that broke daily records. For example, on the 10th, record maximum rainfall was recorded at SeaTac Airport (1.13") and the Seattle Weather Forecast Office (0.99"). Another rainfall record was set at SeaTac Airport (1.08") on the 31st, a day where upwards of 2-3" of precipitation fell in parts of western WA, particularly the southern Puget Sound area. The mountains received even greater amounts (~5"), with the precipitation mostly as rain except for the highest elevations.

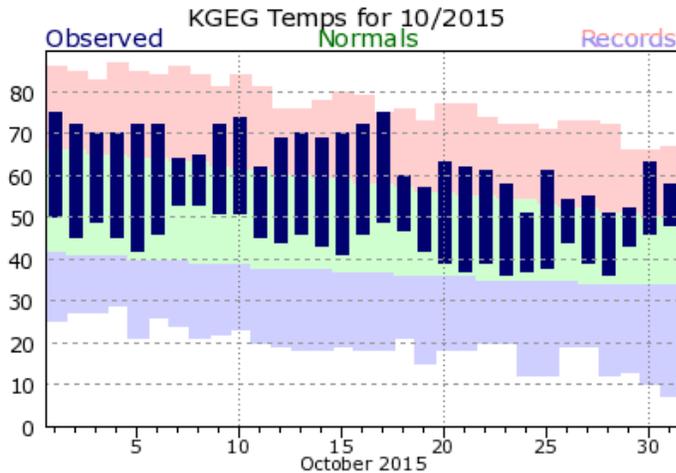


Figure 1: October 2015 daily maximum and minimum temperature (bars) for Spokane Airport. The shading represents the normal temperature range (green), the record cold (blue), and the record warm (red) over the historical record (from the National Weather Service).

Community, Collaborative, Rain, Hail, and Snow Network

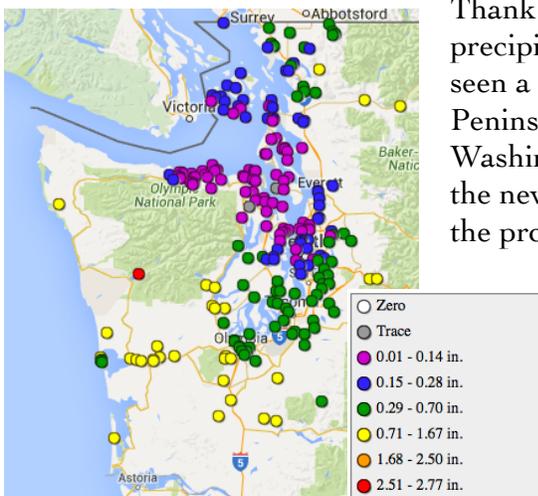


Figure 2: 24-hour precipitation measurements for western WA from CoCoRaHS observers measured on the morning of October 30.

Thank you, CoCoRaHS observers, for entering your daily precipitation reports during the month of October. We’ve seen a fantastic increase in volunteers on the Olympic Peninsula since we’ve partnered with the University of Washington OLYMPEX field campaign aiming to validate the new NASA precipitation satellite (more information on the project can be found in last month’s newsletter). Figure 2 shows 24-hr precipitation measurements on the morning of October 30 in western WA from our CoCoRaHS network. Note how clearly the rain-shadow on the northeastern side of the Olympics can be seen now that we have more observers on Peninsula. The precipitation on the northeastern side was mostly under 0.10” while well over an inch (and even 2.70” near Lake Quinault) fell on the coast and the southwestern side of the Olympics.

New Content on the “Storm King” Website

OWSC hosts “The Storm King” archive of Pacific Northwest windstorms written by local storm guru Dr. Wolf Read on our website: <http://www.climate.washington.edu/stormking/>. While OWSC does not contribute to the content presented here, we do recognize the great value of the detail Dr. Read provides for these historic events. Updating the website had been stalled for several years while Dr. Read completed his PhD, but we are happy to announce that content is being updated again. A summary of the windstorm of 11 December 2014 is now posted, and please continue to look for updates in the coming months.

Snowpack and Drought Update

The last week of October brought the first snows of the season to WA mountains. Figure 3 shows the snow water equivalent (SWE) percent of normal averaged for each basin in WA from the National Resources Conservation Service at the time of this writing. The percentages are generally below normal but need to be taken with a grain of salt considering that “normal” snow water equivalent for this time of year is still low. The Upper Columbia basin is the exception, showing near-normal SWE. Otherwise, the Olympic, Central Puget Sound, Central Columbia, Upper Yakima, and Spokane are still waiting for substantial snow as they are less than 50% of normal. Despite the lack of snow, there were improvements made to the depiction of drought in WA state on US Drought Monitor (Figure 4) over the last month. Much of western WA has improved from “severe drought” to “moderate drought” and these improvements are largely a response to increased rain on the west side of the Cascade Mountains, particularly over Halloween weekend. There has also been some improvement in north central and northeastern WA in response to above normal precipitation on shorter time scales during the past two months.

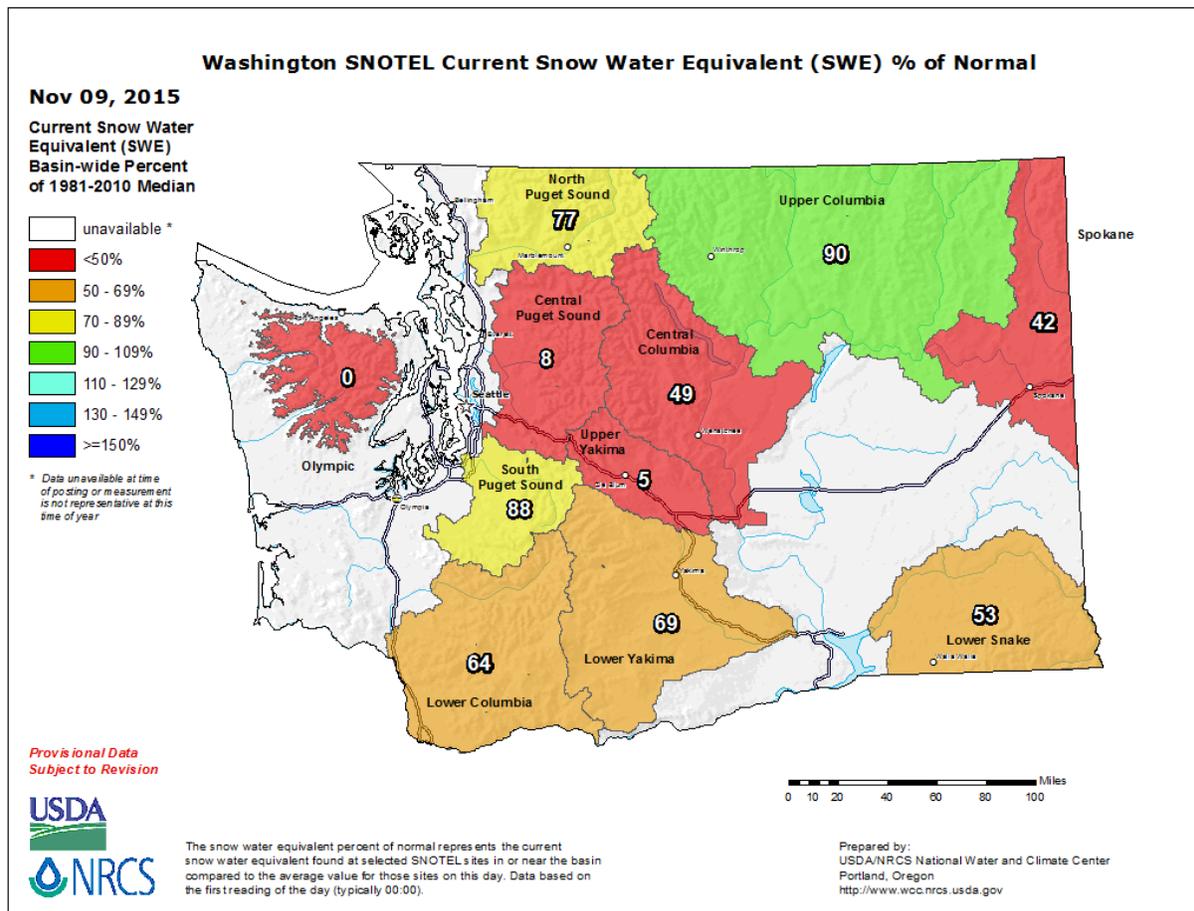


Figure 3: Snowpack (in terms of snow water equivalent) percent of normal for Washington as of November 9, 2015 (from the National Resources Conservation Service).

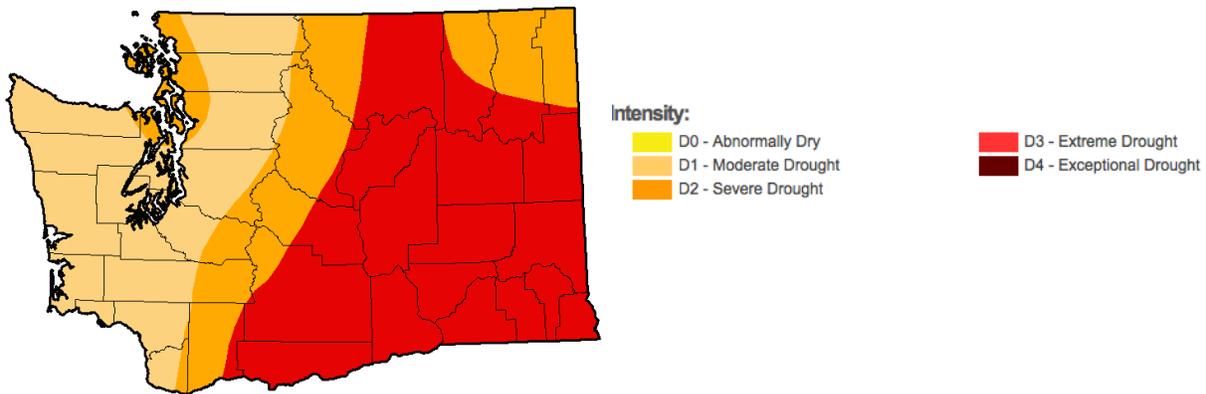


Figure 4: The 3 November 2015 edition of the US Drought Monitor (<http://droughtmonitor.unl.edu/>).

Sea Level in WA during El Niño Winters

A message from the State Climatologist

As readers of this newsletter are aware, the tropical Pacific is currently in an El Niño state. Such conditions in the tropical Pacific have usually, but not always, been accompanied by relatively warm winters in the mean for the Pacific Northwest. El Niño winters also tend to be on the dry side, with plenty of exceptions. The mean seasonal weather is of interest and relevance, naturally, but short-term, episodic events are often just as or more important. Here we focus on a particular type of event related to El Niño that may not get much attention: coastal flooding. The objective of this piece is to illustrate the correspondence between past El Niño events and especially high sea level, and the implications for coastal flooding.

The present analysis is based on direct observations of sea level from tide gauges maintained by the National Oceanic and Atmospheric Administration (NOAA) for the period of January 1980 through August 2015. The specific parameter considered is the monthly mean higher high water (MHHW), which represents the average height of the highest tide each day in feet, and can relate to the potential for coastal flooding. Actual flooding generally requires the juxtaposition of a high astronomical tide, and a storm/wind induced rise in sea level. Relatively high astronomical tides are favored in winter, and January is usually the month of the year with the greatest MHHW for WA state.

A time series of MHHW for Toke Point, WA (#9440910) at the northwest end of Willapa Bay is shown in Figure 5. The months with MHHW greater than 1.5 feet are labeled; 4 out of 5 of these months are during El Niño winters. The maximum during the period was in January 1998, which coincides with the extreme El Niño of 1997-98. The magnitude of the El Niño signal might be greater than would be supposed. Specifically, El Niño elevates MHHW on the order of 0.5 to 1 foot, an effect that is sufficient to cause a significantly greater threat of flooding in sensitive locations.

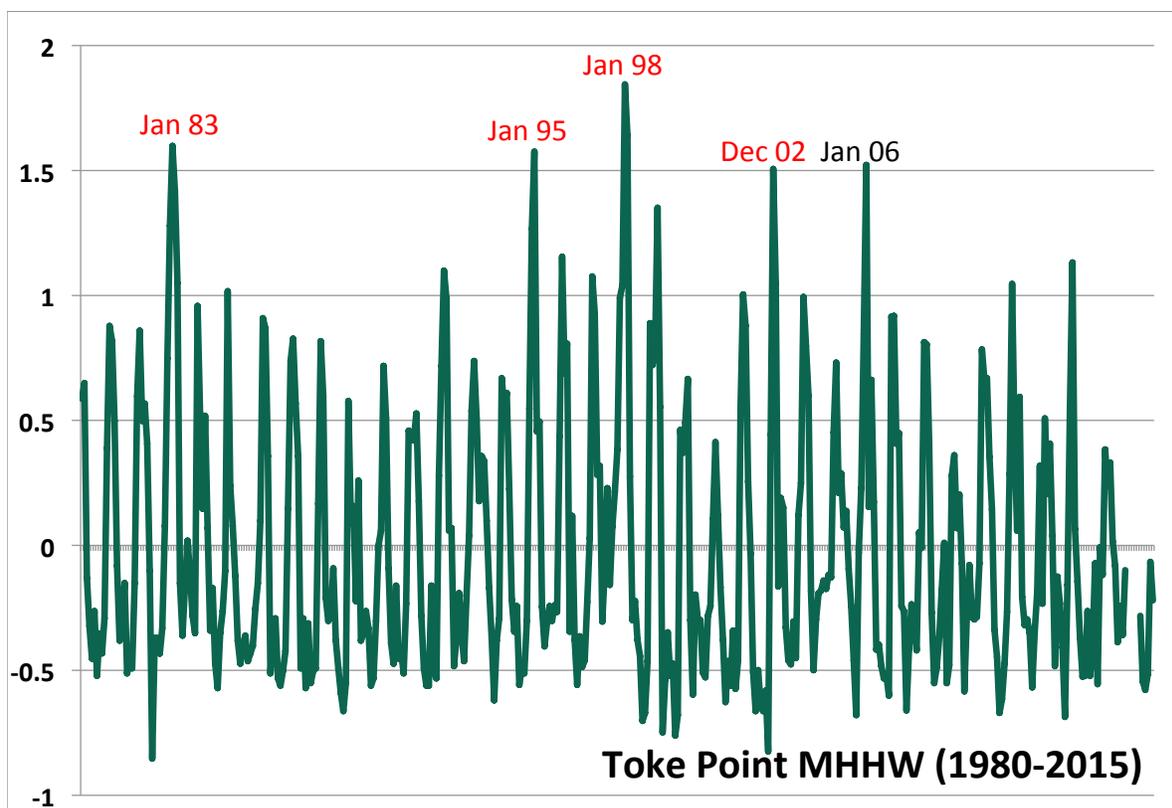


Figure 5: Monthly higher high water (MHHW) in feet at Toke Point, WA for January 1980 through August 2015. The months with MHHW exceeding 1.5 feet are noted; red (black) labels indicate El Niño (neutral) conditions.

Elevated sea levels during El Niño are not restricted to the coastal zone but rather also occur in the interior waters of Puget Sound. A scatter plot for the MHHW at Toke Point versus Seattle (Figure 6) features a strong positive correspondence; the correlation coefficient between the two time series is ~ 0.84 . In other words, perturbations in coastal sea level are also manifested in the inland waters, through a complicated adjustment process outside the scope of the present piece.

How does El Niño influence sea level along the coast of the Pacific Northwest? There are four potential (not completely independent) mechanisms: (1) the inverse barometer effect (i.e., negative sea level pressure anomalies raise ocean levels), (2) the steric effect associated with the expansion of warmer than normal water, (3) regional winds and hence onshore-directed upper-ocean transports, and (4) coastally-trapped oceanic disturbances (e.g., Kelvin waves) due to remote forcing. For the coastal region of WA generally (3) dominates, with contributions from (2) and (4). The southerly wind anomalies that occur during most El Niño winters are accompanied by onshore-directed Ekman transports, with variability within the winter season due to the non-steady nature of the winds. A schematic illustrating this mechanism is included in Figure 7. For orientation with respect to the present application, imagine you are hovering over the ocean west of the WA coast, looking towards the southeast. Bromirski et al. (2011) provide more information about the processes controlling sea level along the west coast of the US, and their relationships to climate fluctuations such as the Pacific Decadal Oscillation (PDO).

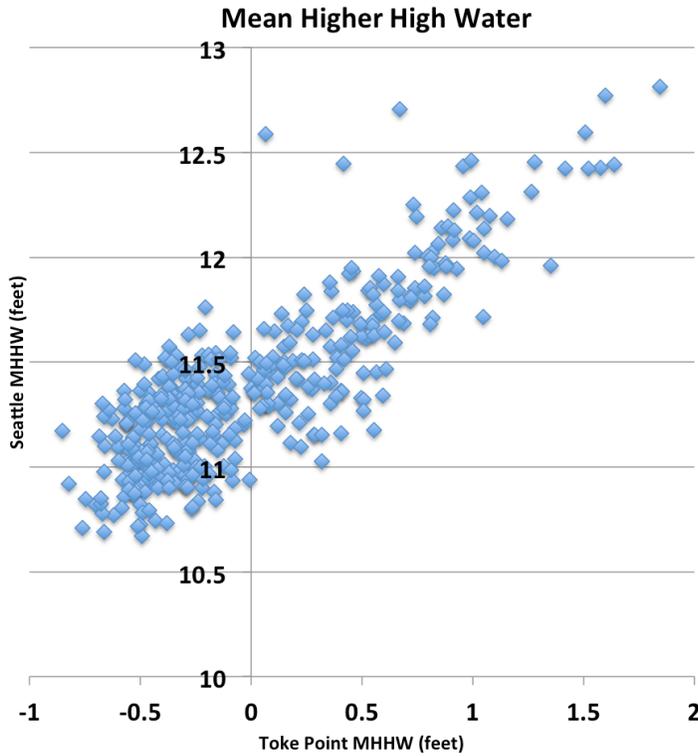


Figure 6: Scatter plot of MHHW (feet) at Toke Point (x-axis) versus Seattle (y-axis) for the period of January 1980 through August 2015.

In summary, we can expect a relatively high mean sea level this winter due to El Niño. As mentioned above, it is a matter of chance whether this results in any major inundations, or rather merely the nuisance of minor flooding at times. To put it in perspective, the magnitude of the temporary rise in sea level that will probably occur this winter is comparable to the systematic rise in sea level projected to occur in our waters by roughly the middle of the 21st century due to global climate change.

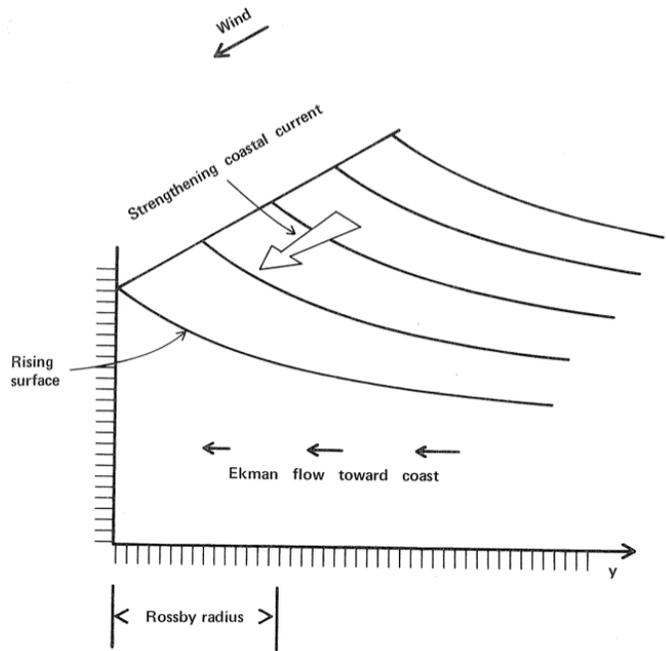


Figure 7: Schematic illustrating the effects of along-shore winds on coastal sea level in the Northern Hemisphere (excerpted from Gill, A.E.: Atmosphere-Ocean Dynamics, Academic Press, 1982)

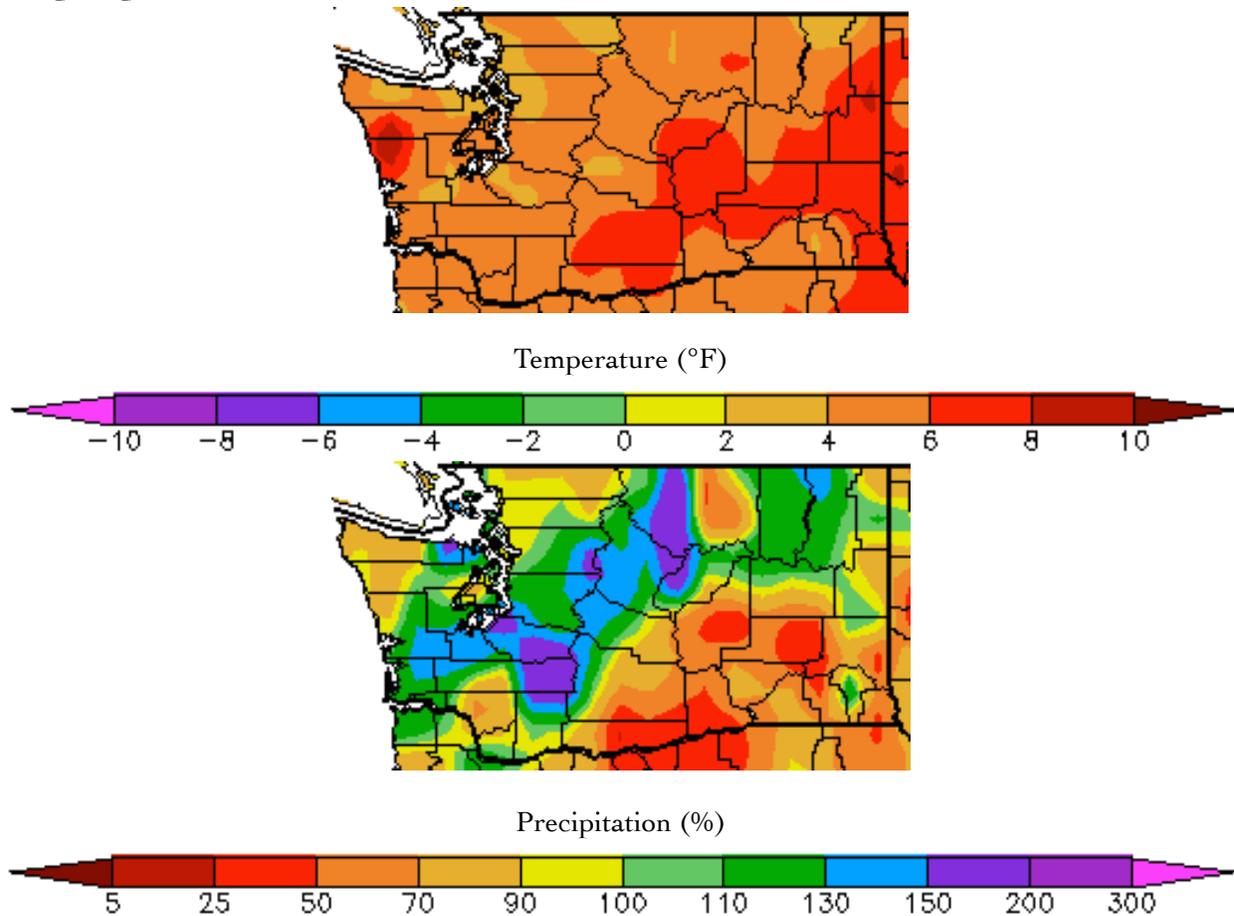
Reference

Bromirski, P.D., A.J. Miller, R.E. Flick, and G. Auad (2011): Dynamical suppression of SLR along the Pacific coast of North America: Indications for imminent acceleration, *J. Geophys. Res. – Oceans*, 116, C07005, doi:10.1029/2010JC006759.

Climate Summary

After a respite in September from the persistent warmer than normal temperatures since the first of the year in WA State, October continues the previous trend with warmer than normal temperatures statewide. The mean temperature anomalies are quite impressive, with parts of eastern WA between 6 and 8°F warmer than normal. Spokane Airport, Wenatchee, and Pullman are a few of the locations with these strong positive anomalies, with the remainder of the state experiencing temperatures largely between 4 and 6°F warmer than normal (Table 2). In western WA, Quillayute was another warm spot with average temperatures 5.5°F warmer than normal while SeaTac Airpot had about a 4.4°F temperature anomaly for the month.

Total October precipitation relative to normal varied across the state (Table 2). The good news first: the southern and central Puget Sound, parts of the Olympic Peninsula, the southern and central Cascades, and parts of northern eastern WA all received near-normal to above normal precipitation, with values between 110 and 200% of normal. Meanwhile, much of the Lower Columbia basin and southeastern WA received very little precipitation - less than an inch - with precipitation percent of normal values between 25 and 70% of normal. The northwestern Peninsula and the northern Puget Sound received near-normal to slightly below normal precipitation for the month.



*October temperature (°F) departure from normal (top) and precipitation % 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	54.5	50.3	4.2	6.68	4.60	145
Seattle WFO	57.5	53.3	4.2	3.83	3.41	112
SeaTac AP	57.2	52.8	4.4	4.81	3.48	138
Quillayute	55.5	50.0	5.5	9.78	10.49	93
Hoquiam	57.2	52.2	5.0	6.29	6.53	96
Bellingham AP	54.5	49.8	4.7	3.40	3.68	92
Vancouver AP	58.5	53.8	4.7	3.25	3.07	106
Eastern Washington						
Spokane AP	54.3	47.6	6.7	1.14	1.18	97
Wenatchee	58.4	50.9	7.5	0.36	0.44	81
Omak	54.8	48.9	5.9	0.62	1.08	57
Pullman AP	54.9	47.5	7.4	1.51	1.34	113
Ephrata	57.7	50.5	7.2	0.28	0.53	53
Pasco AP	57.3	51.9	5.4	0.42	0.65	65
Hanford	59.8	53.1	6.7	0.28	0.49	57

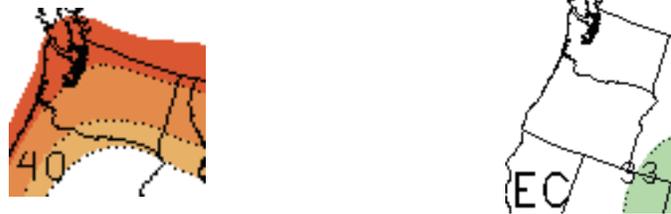
Table 2: October 2015 climate summaries for locations around Washington with a climate normal baseline of 1981-2010. Note that the Vancouver Pearson Airport and Seattle WFO 1981-2010 normals involved using surrounding stations in NCDC's new normal release, as records for these station began in 1998 and 1986, respectively. M denotes missing data.

Climate Outlook

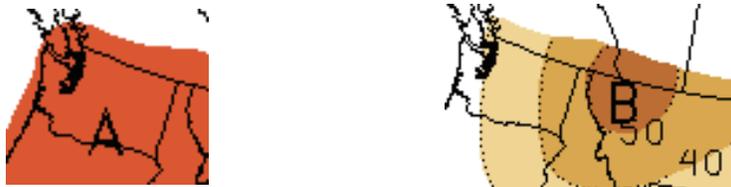
El Niño conditions in the tropical Pacific Ocean are still present and are expected to continue through the winter of 2015-16, according to the Climate Prediction Center (CPC). Averaged over the last month, sea surface temperature (SST) anomalies exceed 3°C in the central and eastern equatorial Pacific, and the weekly SST departures from normal have strengthened in all of the Niño regions since the last newsletter. The “El Niño Advisory” released by the CPC on 5 March is still in effect. ENSO forecast [models](#) are nearly unanimous in a strong El Niño lasting through the winter of 2015-16 and there is over a 70% chance that the conditions will persist through the spring of 2016. The CPC is taking the El Niño into account, as well as other factors in their seasonal outlooks.

The CPC seasonal outlook for November is calling for increased chances of above normal temperatures statewide, with the chances of warmer than normal temperatures highest (>50% on a three-tier system) for the Peninsula and for the northernmost section of the state. November precipitation is more uncertain: there are equal chances that there will be below, equal to, or above normal precipitation for the entire state.

The November-December-January (NDJ) CPC outlook is calling for higher than normal temperatures statewide, with the odds of warmer temperatures exceeding 50% for the whole state. For precipitation, there are higher chances of below normal precipitation for most of the state, with odds of below normal precipitation highest for eastern WA. The Olympic Peninsula and southwest WA have equal chances of below, equal to, or above normal precipitation.



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



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