Office of the Washington State Climatologist

October 2, 2013

September Event Summary

If the September weather across WA State needed to be summarized in only one word it would be "wet". Average temperatures were warmer than normal statewide, mostly due to higher than normal overnight temperatures. Total September precipitation set records in some locations around the state, particularly in the Puget Sound and the east slopes of the Cascade Mountains. The record 2013 September precipitation, the year and amount of the previous record, and the year that records began is shown in Table 1 for some of the locations that ranked as the record wettest September. Note that this September was not the record wettest for the coastal locations; Quillayute and Hoquiam, for example, came in as the 4th and 3rd wettest, respectively. Still, it is interesting that this record precipitation was not foreseen last month at this time. In the beginning of the September, the Climate Prediction Center precipitation outlook had equal chances of below, equal to, or above normal precipitation, with no indication that the month would turn out this wet. More often that not, these monthly outlooks are reasonably good, but in some cases, like this one, the prediction is simply wrong.

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Station	Sept 2013 Precipitation	Previous Record; Year	Records Began
Olympia	9.36"	7.59"; 1978	1948
SeaTac Airport	6.17"	5.96"; 1978	1948
Holden Village	5.89"	4.91"; 1978	1930
Stehekin	5.02"	4.66"; 1959	1906
Boundary Dam	4.69"	3.92"; 1997	1965
Leavenworth	4.04"	3.65"; 1962	1907
Mazama	3.35"	2.44"; 1985	1948

Table 1: Record September 2013 precipitation, the previous record and year of occurrence, and the year that records began at each station.

The wet month was mostly a result of a few very powerful storm systems that impacted the state. The first of these occurred between Sept 4 and Sept 6, bringing heavy rain and a great deal of lightning to the state. Record daily maximum rainfall records were set on Sept 5 at the Seattle Weather Forecasting Office (WFO) (1.38"), SeaTac Airport (1.09"), Olympia (1.01"), and Wenatchee (0.27") with other locations

around western WA recording between 1.50" and 3.50" of precipitation (from CoCoRaHS observers).

There was a break from the autumn-like weather during the 2nd week of September, when a ridge of high pressure settled over the state and brought unseasonably warm temperatures for several days. For example, on Sept 11, high temperature records were set at Moses Lake (98°F), SeaTac (93°F), Olympia (91°F), and the Seattle WFO (89°F). The warm temperatures continued for eastern WA, setting daytime high temperature records in Moses Lake (99°F), Ellensburg (98°F), Ephrata (97°F), and Quincy (96°F) on Sept 12, for example, and in Ephrata (98°F), Wenatchee (97°F), Chief Joseph Dam (95°F), and Walla Walla (94°F) on Sept 13, for example. Daily high temperature records continued to be set on Sept 14 and 15 in eastern WA as well. The warmest weather in WA is generally during July or August. A quirk of the past summer for western WA is that its hottest days were in late June and September. For SeaTac, for example, the warmest summer temperature of 93°F was recorded on June 30 and Sept 11.

Right on cue, however, the first day of fall (Sept 22) was wet and windy around the state. In western WA, wind gusts were between 25 and 45 mph throughout the interior Puget Sound region and up to 50 mph on the coast. Hoquiam Airport received a record daily amount of rainfall on Sept 22 (2.04") which actually ranks as the 3rd wettest September day since records began there (the wettest September day was in 1997 with 2.55").

Arguably, the most interesting storm of the month was the remarkable system that moved in on Sept 28 and 29 - quite a powerful storm for this early in the season. Strong winds were reported as of mid-morning on Sept 29 for the previous 36 hours; some examples include 74 mph at Hurricane Ridge, 53 mph at Hoquiam, 44 mph at Quillayute, 43 mph at Paine Field, 38 mph at Olympia, 36 mph at SeaTac, and 34 mph at Packwood. Record daily maximum precipitation records were set on Sept 28 for Olympia Airport (2.93"), Quillayute (1.93"), Hoquiam (1.78"), SeaTac Airport (1.71"), Vancouver (1.36"), and Seattle WFO (1.31"). For both Olympia and SeaTac, the precipitation on Sept 28 ranks as the wettest September day since records began at each station (1948). For SeaTac, the previous wettest September day occurred in 1978 and 1953 with 1.65"; for Olympia, it occurred in 2010 with 1.67". Precipitation continued into Sept 29 and 30 (see Fig. 1 for 24-hr precipitation totals ending the morning of Sept 30), and the 1.52" that fell in Olympia on Sept 30 ranks as the 4th wettest September day. In eastern WA, some 24-hr precipitation records were set for Sept 29 into Sept 30 at Leavenworth (0.76"), Mazama (0.37"), and Chelan (0.29"), for example. Finally, an EF1 tornado (winds estimated at 110 mph) touched down near Frederickson (located south-east of Tacoma in Pierce County) on Sept 30. No injuries were reported, but there was roof damage, as well as damage to cars, trees, and lamp posts in the area.

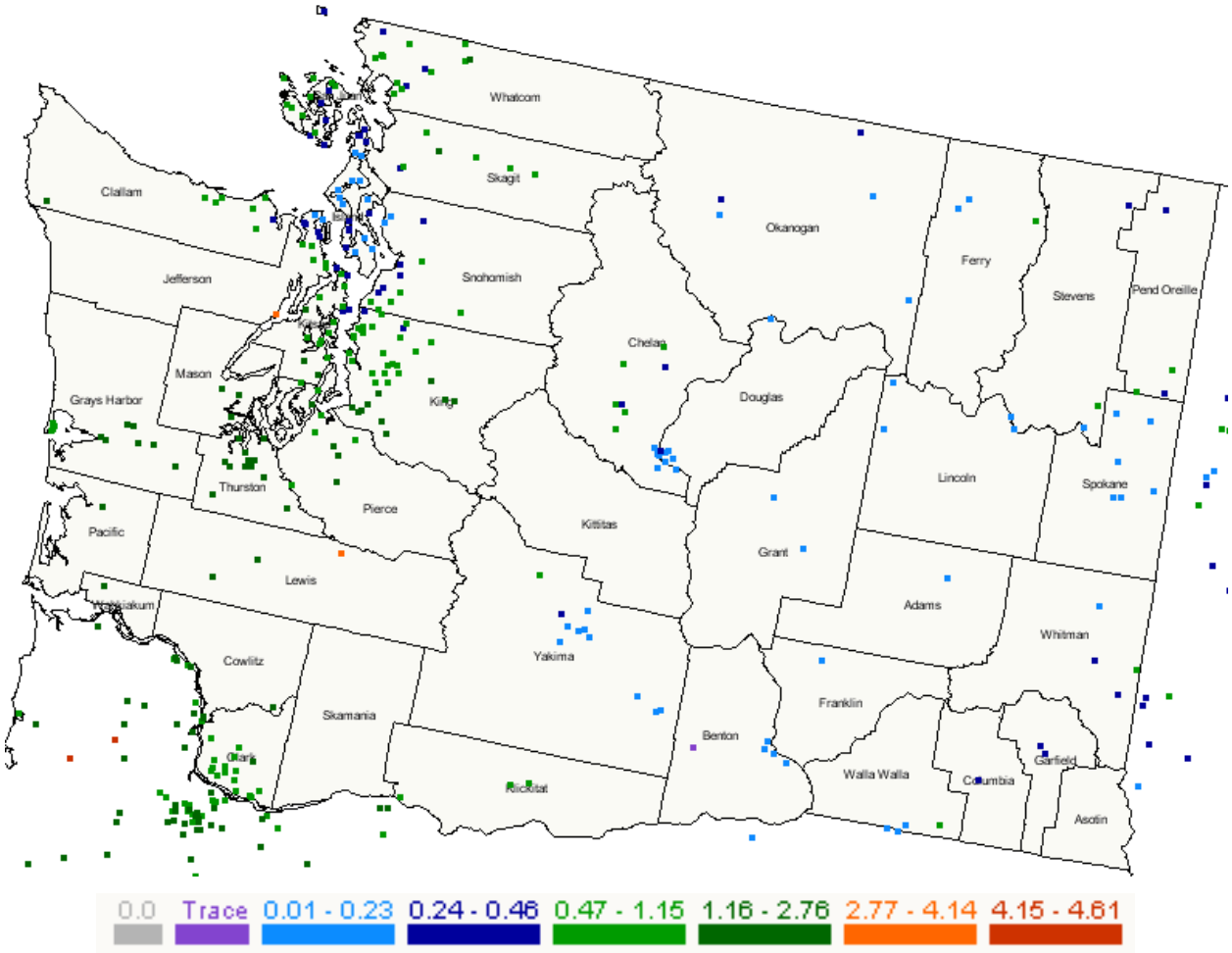


Figure 1: 24-hour precipitation totals from CoCoRaHS observers measured between 6 and 9 am on September 30. (The CoCoRaHS station at OWSC on the University of Washington campus recorded 4.56" of precipitation for the entire month of September.

IPCC Fifth Assessment Report Released

The 5th Assessment Report (AR5) by the Intergovernmental Panel on Climate Change (IPCC) - an international report on the current state of global climate change science with over 250 authors - was released in late September. The Summary for Policymakers is available for download here: http://www.climatechange2013.org/, and the full (2000-page) is also available online. Compared to the previous report released in 2007, there are stronger statements on the likelihood that human activity has caused global climate change (from "very likely" to "extremely likely", a difference from 90 to 95%). In addition, the new report includes greater emphasis on the changing conditions of our oceans. More information from AR5 is planned for the November edition of the OWSC newsletter.

Early Autumn Fog in WA

A message from the State Climatologist

Fog may not seem that dramatic of an element of the weather, but it can actually be a big deal and certainly represent a challenge for forecasters. An obvious impact of fog is on aircraft operations. Thick fog can hamper takeoffs and landings, as well as cause delays on the taxiways. Fog has also been implicated in a number of vessel collisions on the waters of Puget Sound. Examples of these during the early fall include the sinking of the Multnomah after being rammed by the Iroquois in 1911 and a collision between two Washington state ferries, the Sealth and Kitsap, in fog with relatively minor damage in 1991.

Days that include heavy fog, i.e., visibility less than or equal to 0.25 mile, occur during October more often west of the Cascade Mountains than any other region of the lower 48 states (Fig. 2). It is usually of the "radiation fog" variety. It is caused by the cooling of the ground, and the adjacent air, to the dewpoint temperature (saturation) due to a net upward flux or loss of infrared radiation (IR). The cool air near the surface is generally capped by much warmer air of lower density, which serves to inhibit mixing. Completely calm conditions are not usually as favorable for the development of radiation fog as light winds. The latter are accompanied by a modest intensity of turbulence which tends to deepen the cool layer near the surface, which otherwise can be quite shallow. A deeper layer means that much more fog, and once it forms, the fog tends to perpetuate itself. The fog reflects most of the incoming solar radiation, which delays and reduces the daytime heating, thereby keeping the near-surface air cool enough to remain saturated.

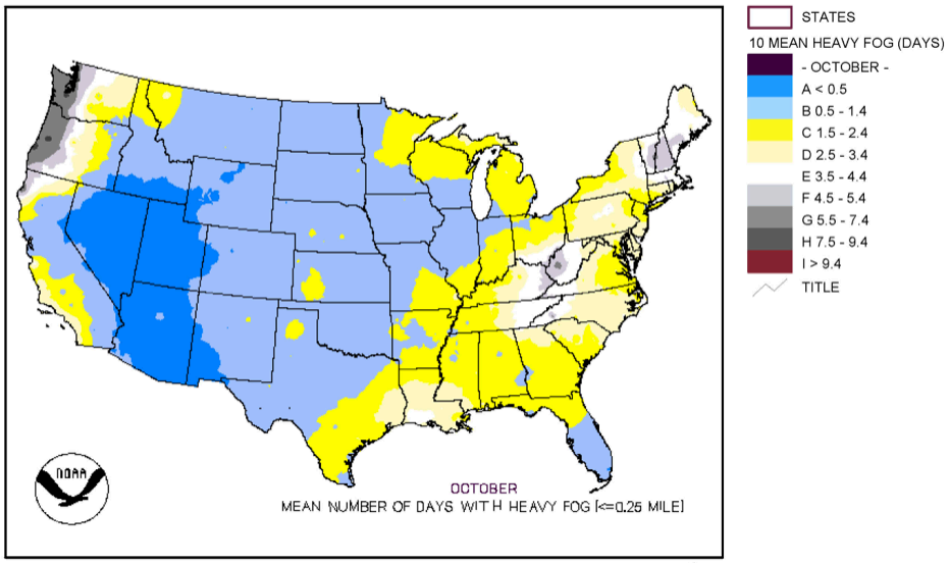


Figure 2: The average (1961-1990) frequency of heavy fog over the US for October (from the National Climatic Data Center).

How does the incidence of fog in early fall compare with that during other times of year? Table 2 itemizes the number of days per month with heavy fog at three western WA stations (Quillayute, Olympia, and Sea-Tac) and three eastern WA stations (Yakima, Moses Lake and Spokane) based on local climatological data (LCD) for 1996-2008 compiled by the Western Regional Climate Center. The table shows that heavy fog is relatively common in western WA in early fall, but also occurs routinely at other times of the year. For eastern WA, heavy fog is

most prevalent in winter (more about this will be included in a future newsletter). Fog is favored in western WA during the early fall because the Pacific storm track is generally situated north of the state into the Gulf of Alaska. When this is the case the air aloft over our region is often relatively dry, and the nights are long enough for considerable radiational cooling. At the same time there can be reasonably moist air near the surface due to evaporation from the ground that has already been wetted to an extent by recent rains and regional waters that are still relatively warm. Moreover, the winds in these synoptic situations are generally light, and so all the ingredients are in place for radiation fog. It is especially common in Olympia since that location tends to cool down at night much more than other western WA locations (Arlington north of Everett is another ice box). Despite the frequency of these fog events in fall, there tends to be less pollution associated with them than in the winter, simply because it isn't quite cold enough for folks to use their wood-burning stoves.

As mentioned above, it is no cinch to accurately forecast fog. It is especially difficult to anticipate how long it will persist and whether it will transition to more of a stratus deck or dissipate in place. One good if not absolutely sure bet is that when it is foggy in the lowlands that it will be sunny and warm in the mountains. Some of the best hiking and climbing in early fall is when it is socked in at low elevations. And one can often estimate how high to go to get out of the gloom through inspection of high-resolution visible satellite images.

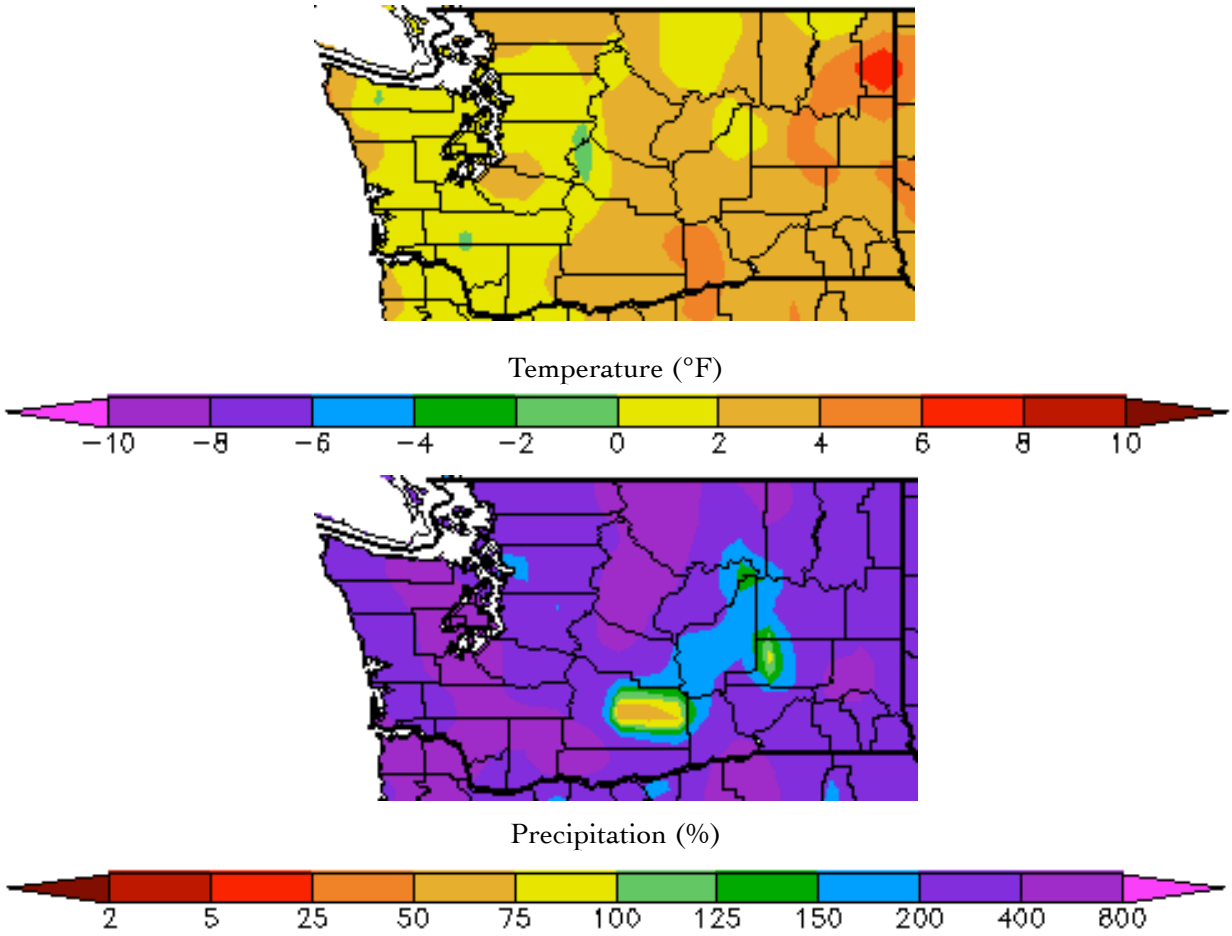
Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Quillayute	2.5	1.3	2	2.5	2.2	2.9	3.2	5.8	6.5	7	3.2	2.8
Seattle	2.8	2.5	0.9	0.4	0.2	0.2	0.4	0.9	2.6	4.4	2.9	4.3
Olympia	10	9.2	6.1	4.9	2.5	1.7	1.3	4	8	10.6	10.7	10.2
Yakima	6	1.8	0.4	0.1	0.1	0	0	0	0.1	0.5	2.8	6.1
Moses Lake	8.8	3.2	1.6	0	0	0	0	0.1	0.2	0.6	4.3	6.6
Spokane	9.6	5.8	2.2	0.6	0.5	0.1	0.2	0.2	0.5	2.9	6.7	7.3

Table 2: Table of frequency of heavy fog by month for Quillayute, Olympia, SeaTac Airport, Yakima, Moses Lake, and Spokane Airport from 1996-2008 from the Western Regional Climate Center.

Climate Summary

Mean September temperatures were above normal across WA. Some locations in western WA had September average temperatures that were closer to normal while temperatures exceeded 2°F above normal in much of eastern WA, according to the High Plains Regional Climate Center map below. An exception to that generalization is the September average temperature at Quillayute; temperatures were 4.7°F above normal (Table 3), ranking as the warmest September average temperature since records began at the airport in 1966. For eastern WA, Pasco is the warmest city listed in Table 3, with temperatures 3.5°F above normal.

Total September precipitation was much higher than normal. Nearly the entire state had precipitation totals that exceeded 200% of normal, according to the HPRCC map below. Some locations had even more than that. SeaTac Airport, for example, had 4 times its usual September precipitation while Olympia received 547% of normal (Table 3). Eastern WA was wetter than normal as well, with Pullman Airport receiving 341% of normal precipitation, the highest in Table 3 for stations east of the Cascade crest.



September temperature (°F) departure from normal (top) and September 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)		
	Average	Normal	Departure from Normal	Total	Normal	Percent of Normal
Western Washington						
Olympia	60.9	58.9	2.0	9.36	1.71	547
Seattle WFO	63.2	61.6	1.6	5.01	1.52	330
Sea-Tac	63.5	61.3	2.2	6.17	1.50	411
Quillayute	61.3	56.6	4.7	9.59	3.82	251
Hoquiam	60.1	58.7	1.4	7.53	2.28	330
Bellingham AP	60.0	57.2	2.8	4.42	1.78	248
Vancouver AP	64.2	63.6	0.6	5.24	1.56	336
Eastern Washington						
Spokane AP	63.0	60.2	2.8	1.56	0.67	233
Wenatchee	66.5	64.4	2.1	0.81	0.34	238
Omak	64.5	62.6	1.9	1.41	0.58	243
Pullman AP	61.1	58.2	2.9	2.66	0.78	341
Ephrata	66.5	63.8	2.7	0.73	0.36	203
Pasco AP	66.9	63.4	3.5	0.99	0.40	248
Hanford	69.2	66.4	2.8	0.42	0.31	135

Table 3: September 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.

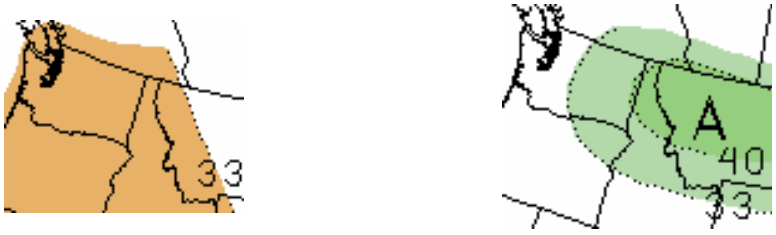
Climate Outlook

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, near-normal in the central equatorial Pacific, and below normal in the eastern equatorial Pacific. There is a consensus among the model predictions that near-neutral ENSO conditions will persist through autumn 2013 and into winter 2014. While both low, the probability of a La Niña developing during winter 2014 is higher (~25%) than that for an El Niño (less than 15%).

The CPC three-class outlook for October has equal chances of below, equal to, or above normal temperatures for the entire state. On the heels of a very wet September, the CPC is calling for persistence with higher chances of above normal precipitation for the western two thirds of the state. Far eastern WA has equal chances of above, equal to, or below normal precipitation.

The three-month temperature outlook for October-November-December (OND) has increased chances of warmer than normal temperatures for the entire state. For precipitation, eastern WA has higher chances of greater than normal precipitation for the three-month period. West of the Cascade crest, there is equal chances of above, equal to, or below normal precipitation for OND.

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



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

These outlooks are based on a tercile system with three classes: below normal, near normal, and above normal, with the thresholds for these categories such that each class occurs, on average, one-third of the time. In situations for which there are equal chances of each outcome, "EC" is denoted on the map. When the odds are tilted one way or another, "A" and "B" is used to denote above-normal and below-normal, respectively.