Office of the Washington State Climatologist

June 4, 2013

May Event Summary

Mean May temperatures were warmer than normal for WA state, and total precipitation was greater than normal with some exceptions (such as the central Puget Sound and parts of eastern WA). But perhaps a more fitting summary for the month would be: "the tale of two Mays". May began incredibly dry with high temperatures 10-15°F above normal before cooling to normal-to-below normal with higher than normal rainfall for many places for the second half of the month. Figure 1 shows the daily high and low temperatures at Spokane Airport, illustrating the transition that occurred on the 13th.

SeaTac did not record any precipitation for the first 11 days of the month which is the second-driest start to the month since records began (in 1945). The driest start to May occurred in 1946 according to the National Weather Service Seattle Weather Forecasting Office (WFO). Many high temperature records were set across the state during the warm start to the month. For example, on May 5 Quillayute (88°F), Hoquiam (87°F), and the Seattle WFO (80°F) all recorded daily high temperature records. The warmth was impressive in eastern WA as well: on May 10, Hanford (98°F), Moses Lake (94°F), Wenatchee (92°F), Colville (92°F), and Winthrop (91°F) all set record high temperatures. The warm temperatures caused minor flooding on some snowmelt-dominated rivers in eastern WA during the first half of the month (e.g., Naches River near Naches, Okanogan River near Tonasket, and Stehekin River at Stehekin).

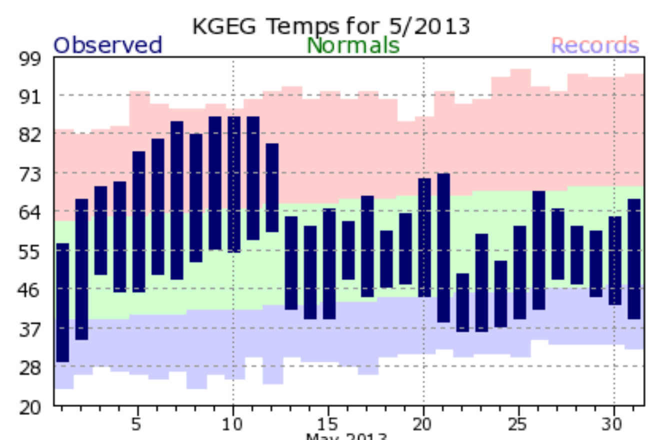


Figure 1: Daily high and low temperatures at Spokane Airport for May 2013. The green envelope represents the normal temperature range (NWS).

The weather pattern shifted on the 12/13th, and the remainder of the month was much cooler and wetter in most locations. Notable events include thunderstorms and high winds on the 13th and cool and wet weather on the 21st/22nd. Late-season high elevation snow was measured on the 21st, and record low **high** temperatures were recorded on the 22nd:

Winthrop (49°F), Omak (50°F), Vancouver (50°F), SeaTac (52°F), Lind (53°F), Chief Joseph Dam (53°F), Priest Rapids Dam (56°F), etc. Yakima set maximum daily precipitation records on the 21st (0.49”), the 22nd (0.94”), the 24th (0.70”), and the 29th (0.31”) resulting in the 3rd wettest May on record (2.48”). The record was set in 1948 with 2.76” and 2011 was also wetter (2.55”).

Snowpack Summary

Even though the mountain snowpack has begun to melt, the June 3 snow water equivalent (SWE) values from the National Resources Conservation Service (Figure 2) still remain above normal for a majority of the state. The SWE percentage of normal becomes a tricky measurement at this time of year since some locations may already be melted out, but the Olympia, North Puget Sound, Central Puget Sound, South Puget Sound, Lower Columbia, Upper Columbia, Central Columbia and Upper Yakima basins all remain above normal (119-245% of normal). The Spokane and Lower Yakima basins are near-normal with 105 and 104% of normal, respectively. Finally, the Lower Snake basin is reporting below normal SWE with 85% of normal.

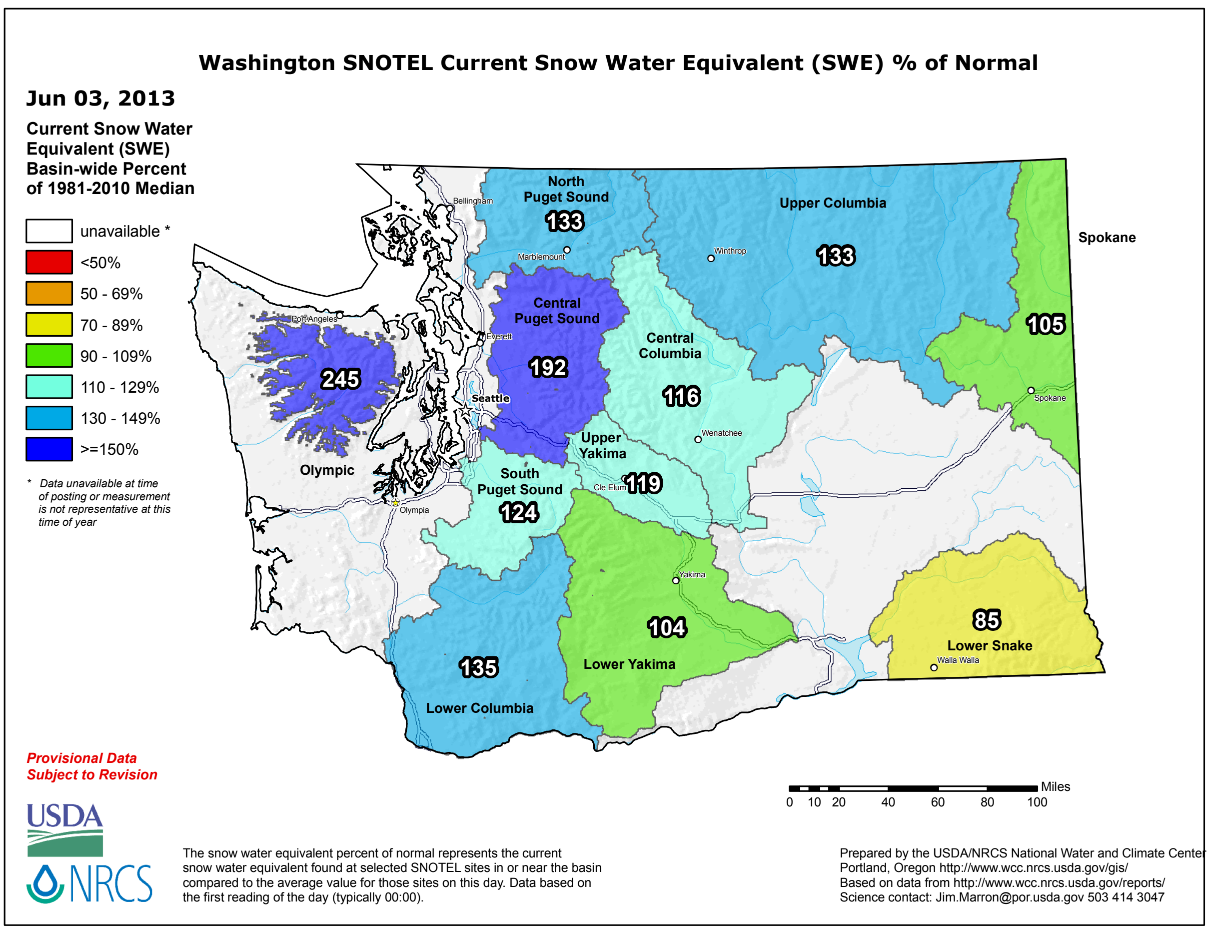


Figure 2: Snowpack (in terms of snow water equivalent) percent of normal for Washington as of June 3, 2013. Image is from the National Resources Conservation Service (NRCS).

Summertime Evapotranspiration in Eastern WA

A message from the State Climatologist

Evapotranspiration (ET) refers to the total flux of water vapor from the land to the atmosphere. It includes two contributions: (1) evaporation from the ground and (2) the loss of water from plants, or transpiration, primarily through their leaves. ET is a key component of the water cycle, especially when the weather is warm and hence the evaporation rate and the growth of plants are often substantial. The potential or reference ET represents the flux of water vapor from a location with a low cover of vegetation covering the ground, and enough soil moisture so that the movement of water within this vegetation is not limited. In other words, the potential ET is essentially the actual ET when there is adequate soil moisture. It is calculated on the basis of the energy available for evaporation from the ground and transpiration from the vegetation.

The focus of the present summary is to examine how to potential ET during summer has varied in the Columbia Basin of eastern WA since the late 1980s, and the causal factors for these variations. Many crops in eastern Washington State are irrigated, and the potential ET minus precipitation relates to the amount of water that must be delivered to maintain adequate soil moisture through the dry summer months. This highlight constitutes the preliminary stages of a more thorough study that is in progress, and has been undertaken to complement the research carried out by OWSC on historical heat waves on the western side of the Cascade Mountains (Bumbaco et al. 2013).

We use daily values of potential ET estimated by the Kimberly-Penman method as provided by the Pacific Northwest Cooperative Agricultural Weather Network (AgriMet) under the auspices of the US Bureau of Reclamation. These data are available from the following website: http://www.usbr.gov/pn/agrimet/webarcread.html. Four low elevation stations in eastern WA have records extending back to the 1980s (George, Harrah, Lind, and Odessa). Here we consider the data from these four station for the months of June, July, and August for the period of 1987-2012. The Kimberly-Penman formulation is based on the measurements of minimum and maximum daily temperatures, relative humidity, daily solar radiation, and daily wind run (i.e., the daily mean wind speed multiplied by 24 hours) from the AgriMet weather stations. It combines the effects of the estimated net radiative heating, the sensible heat flux through the soil, and the heat transferred by the wind to quantify the energy available for ET.

As context for the regional results that follow, we first consider a map of the ratio of actual (not potential) ET to precipitation (P) for the US as a whole (Fig. 3; reproduced from Sanford and Selnick 2012). Note the large variations in ET/P across the Pacific Northwest. The low values (<0.4) of this ratio for western WA signify that the run-off exceeds the ET in the mean. In fact portions of WA State have the dubious honor of having among the lowest values of ET/P in the lower 48 states. Residents of these regions, for example the southwest side of the Olympic Mountains, can attest to the copious precipitation that makes the ET/P ratio so low. On the other hand, the fraction of precipitation lost to ET is greater than 1 in the Columbia basin of WA, as for some other arid regions of the western WA. For this to occur water must be supplied, and in the case of eastern Washington it is largely by the Columbia River and its tributaries with source waters in higher and wetter areas. With this in mind, has there been much variability over the last 25 years in the potential ET and hence water required in the Columbia basin during summer? We were surprised by what we found.

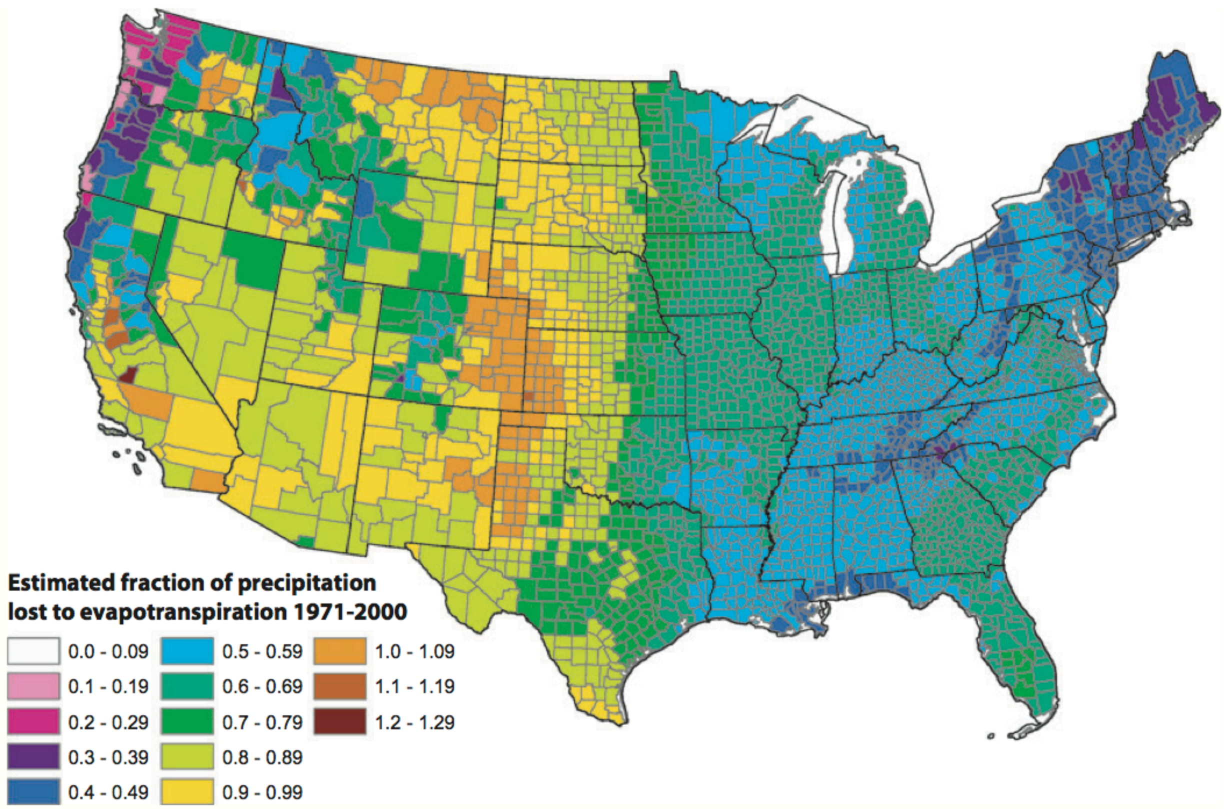


Figure 3: The mean ratio of actual ET to precipitation for the entire US (from Sanford and Selnick, 2012).

Time series of seasonal mean potential ET for the 4 eastern WA stations considered (Fig. 4) reveal not just the expected year-to-year fluctuations, but also prominent upward trends in ET over the period of record. The overall changes are equivalent to and extra 4" of water required in recent versus early years. The magnitude of this change motivated us to delve into the cause(s). We first examined how the time series of potential ET compared with their counterparts for mean air temperature (not shown). This exercise indicated that interannual variability in seasonal mean potential ET has a positive correspondence with temperature (with correlation coefficients of ~0.6 for the individual stations). On the other hand, negligible trends in temperature have occurred over the interval considered and so temperature does not seem to be associated with the overall increase found in potential ET. We also checked the seasonal mean values of solar radiation, humidity, and wind and something interesting turned up. Specifically, the period of record has features a general increase in solar radiation at all four stations, as shown in Figure 5. The trends in humidity are negligible; the winds have increased slightly (not shown). Summers in eastern WA that are relatively sunny with high potential ET tend to be associated with positive 500 hPa geopotential height anomalies, but we have no real explanation for the trends found here.

OWSC plans to pursue the subject of summer ET in eastern WA. This research will include analysis of the day-to-day variability in potential ET. The specific direction of this work will involve determining the regional atmospheric circulation patterns associated with anomalous ET on 1-3 day time scales. These results will be used to determine whether it is feasible to infer potential ET from global climate model simulations of these circulation patterns. If so, empirical downscaling may represent a reasonable means for estimating how potential ET is liable to change over future decades.

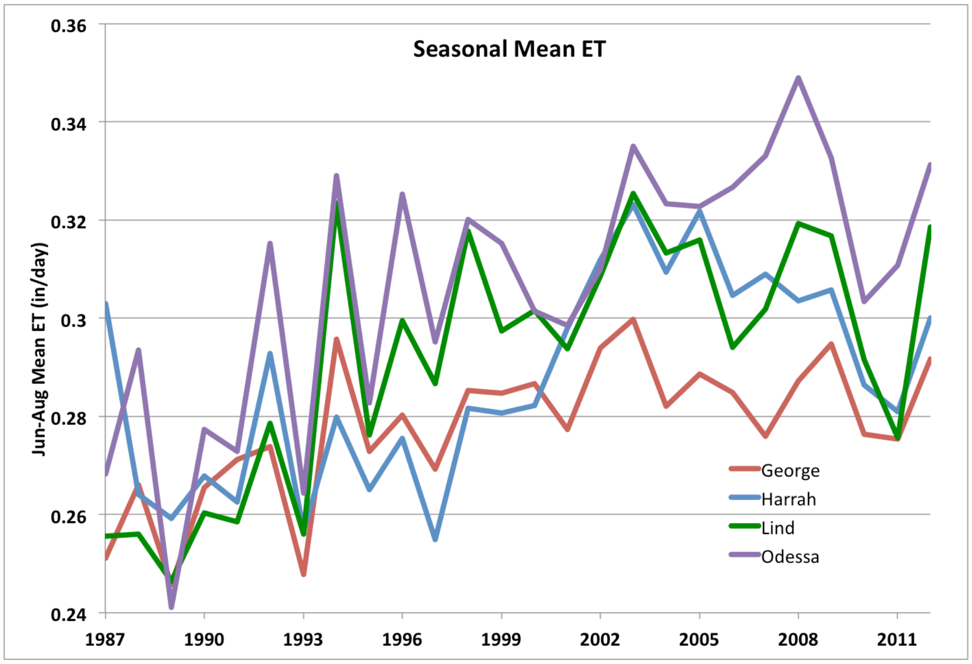


Figure 4: The summer mean potential ET for four sites in eastern WA from the AgriMet Network from 1987 through 2012.

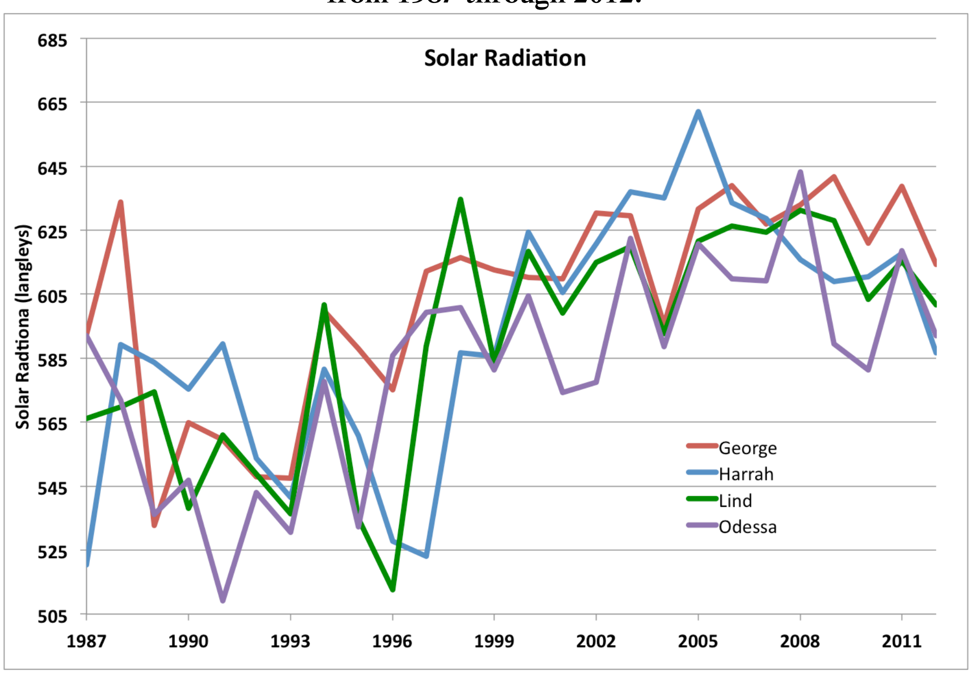


Figure 5: Summer average solar radiation measured at the 4 AgriMet sites from 1987 through 2012.

References:

Bumbaco, K.A., K.D. Dello, and N.A. Bond, 2013: History of Pacific Northwest heat waves: Synoptic pattern and trends. *J. Appl. Meteor. Climatol.* [in press]

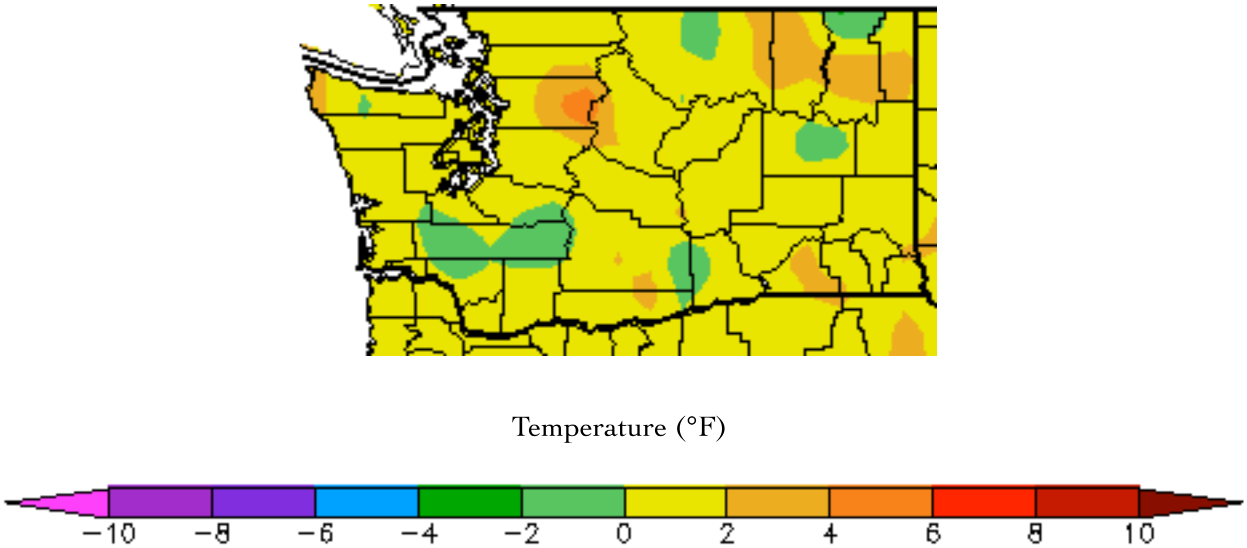
Sanford, W.E., and D.L. Selnick, 2012: Estimation of evapotranspiration across the continental United States using a regression with climate and land-cover data. J. *Amer. Water Res. Assoc.*, **49**(1): 217-230.

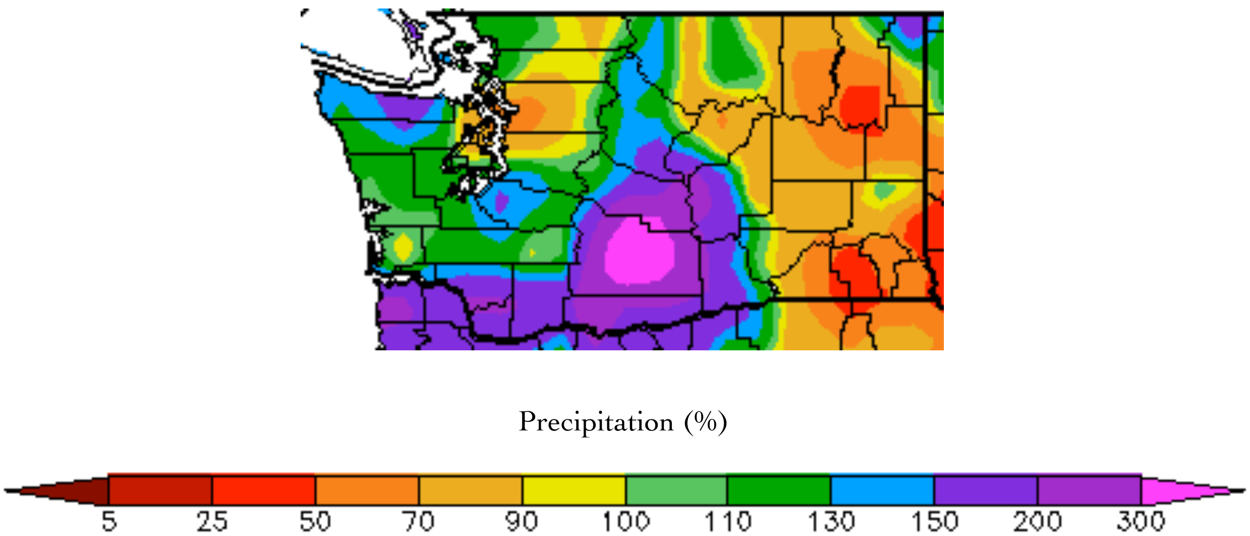
Climate Summary

Mean May temperatures were between 1.5 and 2°F above normal for most of WA State, as shown in the High Plains Regional Climate Center (HPRCC) temperature departure from normal map on the next page. There were a few warm spots: Quillayute, for example, was 3.4°F above normal (Table 1) and the north Cascades were between 2 and 6°F above normal for the month. None of the towns and cities listed in Table 1 had below normal average May temperatures, but the map does show a few cool spots in southwestern WA and northeastern WA.

Total May precipitation was above normal throughout most of western WA, and extremely high for the southeastern slopes of the Cascades including Yakima (428% of normal) and Wenatchee (199% of normal). The northern Olympic Peninsula, Vancouver (198% of normal), and Olympia (138% of normal) were the wettest places in western WA when compared to normal. The central Puget Sound was the exception with precipitation ranging between 70 and 90% of normal for most of that area. Everett and Arlington received 87 and 73% of normal precipitation, for example. The precipitation difference between SeaTac Airport (2.38") and the Seattle WFO (1.27"; in north Seattle) is an interesting aspect of Table 1. OWSC is located in between the two sites, and we recorded 1.45" for May, illustrating a decrease in precipitation from south to north across Seattle. Much of eastern WA was also on the dry side, especially in the southeast section of the state. Pullman and Spokane only received 53 and 49% of normal precipitation, for example (Table 1).

[**Note Upcoming Changes**: The average monthly temperatures at the Yakima station have been much warmer than normal for the last several months. This appears to have been caused, in part, by recent paving near the location of the instruments. The station may no longer be the best indicator of the climate record in that region, and we will use a different nearby station for forthcoming newsletters. We used Yakima for this edition to illustrate the precipitation anomalies.]





May temperature (°F) departure from normal (top) and May 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	55.6	54.2	1.4	3.21	2.33	138
Seattle WFO	58.0	56.0	2.0	1.27	2.16	59
Sea-Tac	58.6	56.0	2.6	2.38	1.94	123
Quillayute	54.7	51.3	3.4	6.87	5.11	134
Bellingham AP	55.5	53.8	1.7	2.57	2.48	104
Vancouver AP	59.0	58.1	0.9	4.89	2.47	198
Eastern Washington						
Spokane AP	56.9	55.1	1.8	0.80	1.62	49
Wenatchee	61.0	59.8	1.2	1.35	0.68	199
Omak	58.9	58.1	0.8	1.57	1.31	120
Pullman AP	55.0	53.2	1.8	0.82	1.56	53
Ephrata	61.0	59.3	1.7	0.70	0.65	108
Pasco AP	61.7	60.7	1.0	0.62	0.73	85
Yakima AP	60.3	57.1	3.2	2.48	0.58	428

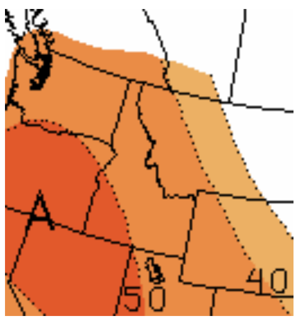
Table 1: May climate summaries for locations around Washington with a climate normal baseline of 1981-2010. Note that the Vancouver Pearson Airport and Seattle WFO 1981-2010 normals involved using surrounding stations in NCDC's new normal release, as records for these station began in 1998 and 1986, respectively.

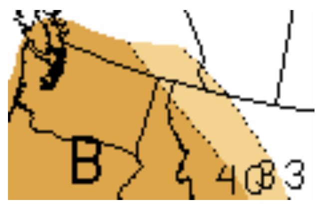
Climate Outlook

The conditions in the equatorial Pacific Ocean are ENSO-neutral, according to the Climate Prediction Center (CPC): http://www.cpc.ncep.noaa.gov/. In the last 4 weeks, sea-surface temperatures (SSTs) have been near-normal in the western and central equatorial Pacific Ocean while below normal SSTs have strengthened in the eastern equatorial Pacific (exceeding -1°C). There is a consensus among the model predictions that near-neutral ENSO conditions will persist through summer 2013.

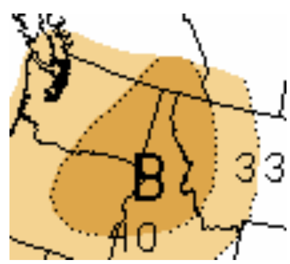
The CPC three-class outlook for June has increased chances for both warmer than normal temperatures and below normal precipitation for the entire state.

The three-month summer temperature outlook (June-July-August; JJA) has increased chances of above normal temperatures for southeastern WA. The rest of the state has equal chances of below, equal to, or above normal temperatures. For precipitation, the total precipitation for JJA is expected to be below normal, with a higher likelihood of reduced rainfall in eastern WA.





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



June-July-August outlook for temperature (left) and precipitation (right) from the CPC.