Office of the Washington State Climatologist

July 1, 2013

June Event Summary

Mean June temperatures and total precipitation for WA State were highly variable. In very general terms, eastern WA was wet and cool while western WA was warm and dry. There were several locations in eastern WA with total June precipitation among the top ten wettest. The figure in the "Climate Summary" section shows the wettest part of the state relative to normal. Sunnyside had its second-wettest June since records began in 1895 (total: 2.43"; record: 2.47" in 1938), Moses Lake its third-wettest since 1949 (total: 1.67"; record: 2.08" in 1951), and Ephrata its sixth-wettest since 1949 (total: 1.39"; record: 1.90" in 1984).

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There were a few periods of cool and showery weather throughout the month that contributed to the near-record precipitation totals in parts of eastern WA. The most notable began on 18 June and continued for several days. A low pressure system passed to the south of WA, spinning in moisture that moved from east to west. This period was especially wet for eastern WA. Many maximum rainfall calendar day records were broken on 20 June (e.g., Republic: 0.90", Grand Coulee: 0.84", Omak: 0.54", Bellingham AP: 0.95", Seattle Weather Forecasting Office: 0.95"). Figure 1 shows the 24-hr precipitation measured on the morning of 21 June around the state. This wet period was also quite cool with widespread **high** temperatures in the 50s and low 60s. It was especially chilly in eastern WA, with some high temperatures setting records as the coldest high temperature for the date (e.g., high temperature in Pullman on 20 June was 52°F).

The early part of the last week of June (24-26) was another notable period of the month. High humidity was accompanied by widespread showers, and scattered thunderstorms. Maximum daily rainfall records were set on 25 June at Hoquiam (0.48"), SeaTac Airport (0.39"), and the Seattle WFO (0.34"). However, June ended with warm temperatures, and there were some stations that set calendar day high temperature records on 30 June (e.g., Bellingham Airport: 87°F and Hoquiam: 82°F).

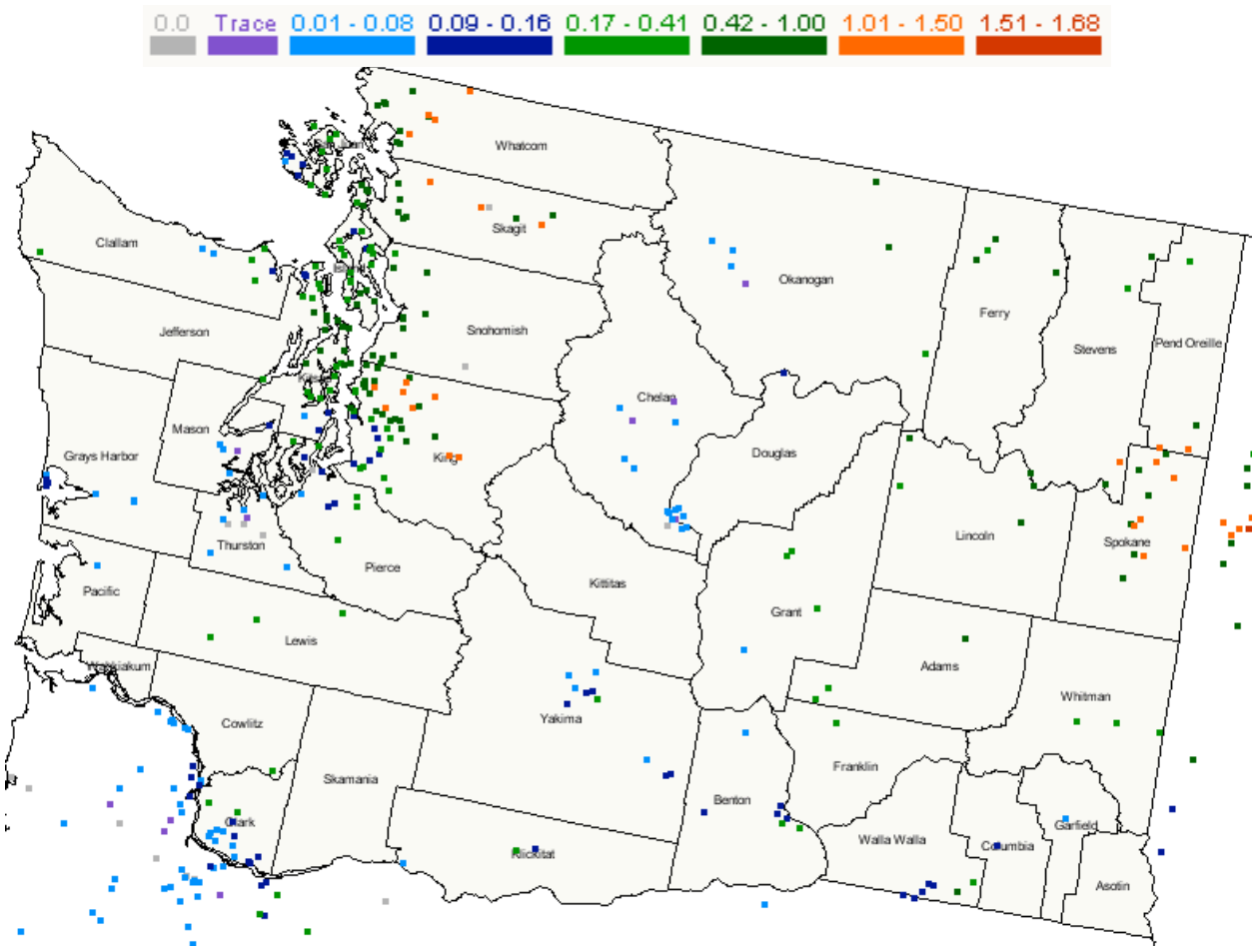


Figure 1: 24-hour precipitation ending between 7 and 9 am on 21 June, 2013 (from CoCoRaHS observers).

CoCoRaHS

Greetings, CoCoRaHS observers! CoCoRaHS stands for Community, Collaborative Rain, Hail and Snow, and we have quite a network of volunteer observers throughout the state. For those of you that observe in western WA, the Seattle National Weather Service Office now has a product on their site that lists all of the western WA morning precipitation reports: http://www.wrh.noaa.gov/sew/get.php?wfo=sew&sid=SEW&pil=LCO. Observations are only included if they are made **and** reported by 9 am. If you have any doubt that your observations are actually being used, please let this be a reminder that they are. The CoCoRaHS station located at OWSC reported 1.64" of precipitation for June, once again in between the total for SeaTac (1.30") and the Seattle WFO (1.91").

Summer Water Supply

The National Weather Service Northwest River Forecast Center water supply forecast (Figure 2) projects normal to above normal streamflow for much of the state through September 2013. All western WA rivers and most eastern WA rivers are expected to have normal (90-110%), above normal (110-125%), or much above normal (125-150%) streamflow due to the abundant winter snowpack. Lower streamflow than average is projected for southeastern WA - specifically, the Snake River at Lower Granite Dam (50-75%) and just over the border in the Grande Ronde River at Troy, OR (75-90%) and Clearwater River at Spalding, ID (75-90%).

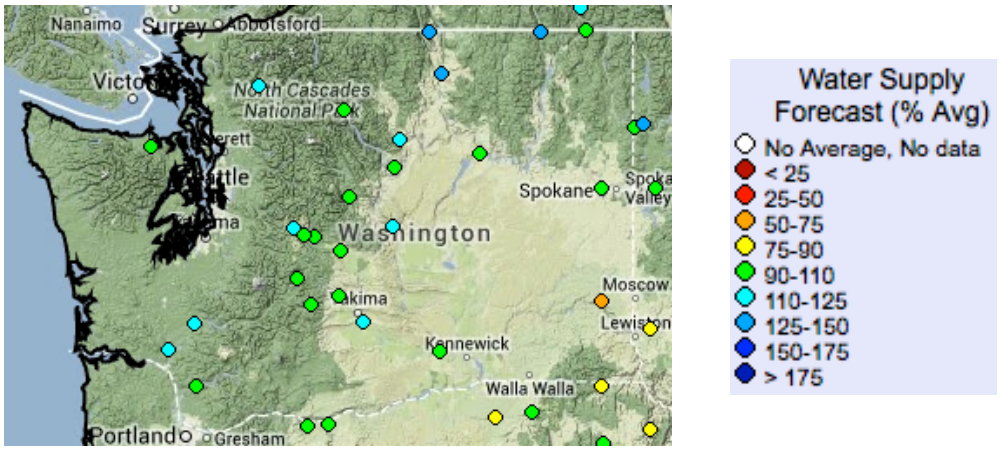


Figure 2: WA streamflow forecast through September 2013 from the NWS Northwest River Forecast Center (released 28 June 2013).

Western WA Heat Waves

A message from the State Climatologist

As we enter the summer months, it is timely to discuss a research paper that was recently published in the Journal of Applied Meteorology and Climatology (Bumbaco et al. 2013). OWSC collaborated with the Oregon Climate Service at Oregon State University to examine the historical record of heat waves occurring west of the Cascade Mountains in both Washington and Oregon. The record-breaking heat wave that occurred at the end of July 2009 was the motivation behind looking into these events in more detail. A summary of a few of the main findings is presented here.

We evaluated western WA and OR together, and used 37 stations to form a regional temperature time series. The heat waves were defined as three consecutive days above the 99th percentile for the maximum and minimum temperature anomalies, separately. This translated into daytime heat waves that were 17.1°F above normal and nighttime heat waves that were 8.3°F above normal for three consecutive days. For Seattle, for example, these anomalies are equivalent to the maximum threshold of 89.4°F and minimum threshold of 61.5°F.

The historical daytime heat events are shown in Figure 3a and the nighttime heat events in

Figure 3b. For the purposes of this overview, ignore the blue dots, and consider only the red and black symbols. There were 13 daytime events and 15 nighttime events identified in the record. Five of the heat waves (in 1941, 1942, 1981, 2006, and 2009) were in both the daytime and nighttime sets; the other 18 individual events were of just one type. The average start dates of both types were at the end of July: 23 July for the daytime events and 26 July for the nighttime events. The earliest heat event in the record began on 30 June and was both a daytime and nighttime event (in 1942). The latest heat event began on 10 August (1977) for the daytime events and 27 August (1935) for the nighttime events. Note a clustering of nighttime events at the end of the record in Figure 3b. A trend analysis was performed on the events identified and there is a statistically significant increasing trend in the frequency of nighttime events in western WA and OR. This upward trend is consistent along the west coast, as was also found in California (Gerhunov et al. 2009). Despite the record-breaking heat event in 2009 that was a daytime event as well as a nighttime event, no trend was found in the frequency of magnitude of the daytime events.

Using the 20th Century Reanalysis (http://www.esrl.noaa.gov/psd/data/20thC_Rean/), composite patterns of several atmospheric properties associated with the daytime and nighttime categories of heat waves were also constructed (not shown). Many similarities between the two types of events were found; for example, a prominent ridge at the 500 mb level (mid-troposphere) is needed to help produce downslope warming over the west side of the Cascade Mountains. This mechanism appears to be particularly important for getting the days hot. For the nighttime events, we found higher precipitable water content, particularly at the beginning of an event. This result suggests that high nighttime temperatures are more related to downward longwave radiative fluxes, as mediated by moisture aloft, as opposed to downslope warming like the daytime events. These differences, especially at the onset of a heat event, may be especially valuable in an operational setting for discriminating between daytime (e.g., stronger ridge and lack of moisture) and nighttime (e.g., higher humidity and weaker sea level pressure gradient) events.

More information on this study can be found in the research paper that is available online here: http://journals.ametsoc.org/doi/abs/10.1175/JAMC-D-12-094.1. While some folks may wish on shooting stars for these types of weather events, it is important to keep in mind that they can have significant societal impacts. Residents of western WA and OR are quite vulnerable to heat as they typically do not have air conditioning and are not acclimated to hot weather. A preliminary analysis of western WA hospitalizations shows a 50% increase in heat-related hospitalizations during the summers with heat events defined in our study, and other studies (e.g., Jackson et al. 2010) have shown measurable negative health impacts from heat in the Pacific Northwest. OWSC plans to examine further the events defined here, with a focus on determining the characteristics that are most closely linked to regional human health.

References:

Bumbaco, K.A., K.D. Dello, and N.A. Bond, 2013: History of Pacific Northwest heat waves: Synoptic pattern and trends. *J. Appl. Meteorl. Climatol.* e-View doi: http://dx.doi.org/10.1175/JAMC-D-12-094.1.

Gershunov, A., D.R. Cayan, and S.F. Iacobellis, 2009: The great 2006 heat wave over Califor-

nia and Nevada: Signal of an increasing trend. *J. Climate*, **22**, 6181-6203.

Jackson, J.E., and Coauthors, 2010: Public health impacts of climate change in Washington State: Projected mortality risks due to heat events and air pollution. *Climatic Change*, **102**, 159-186.

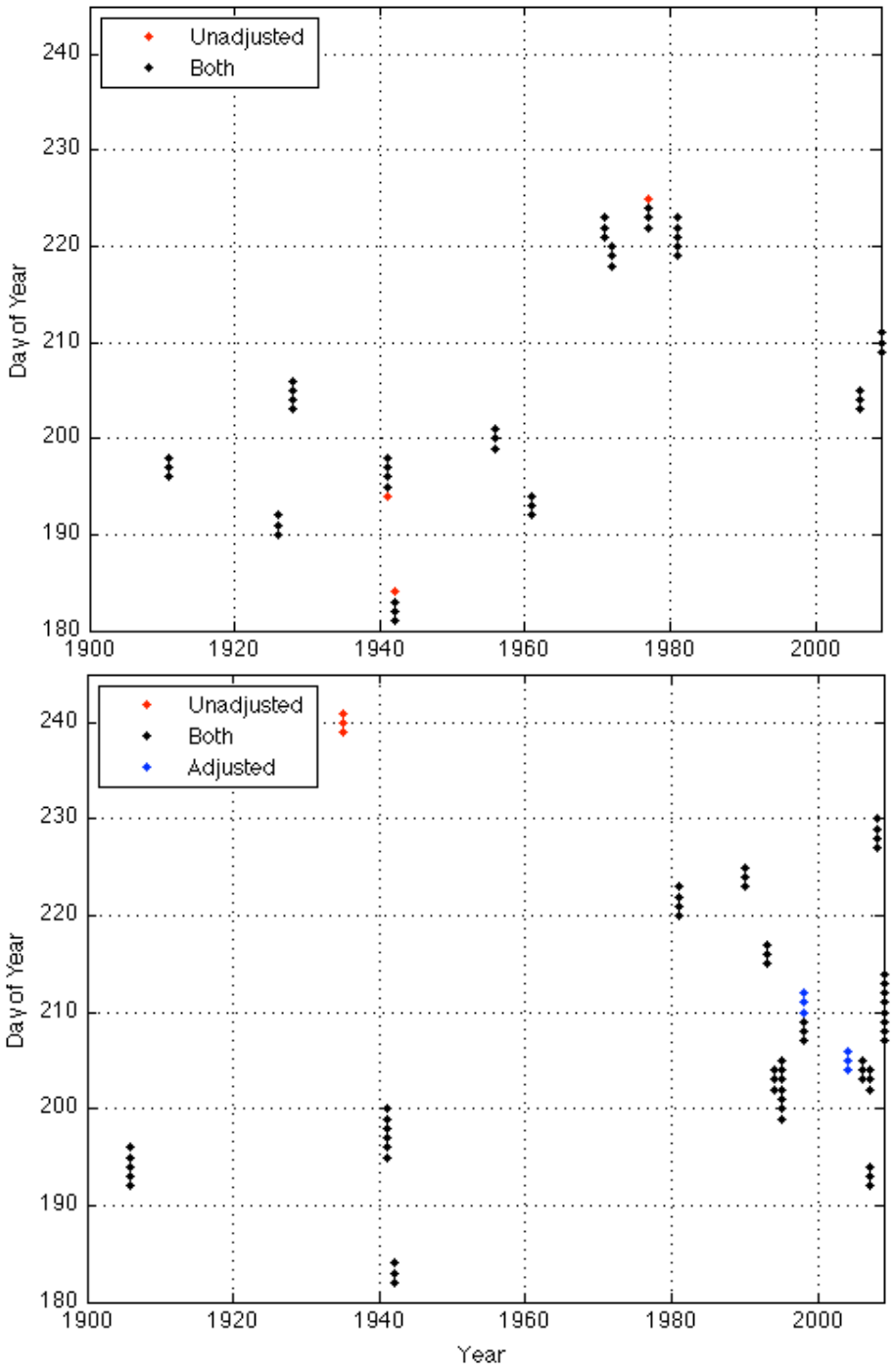


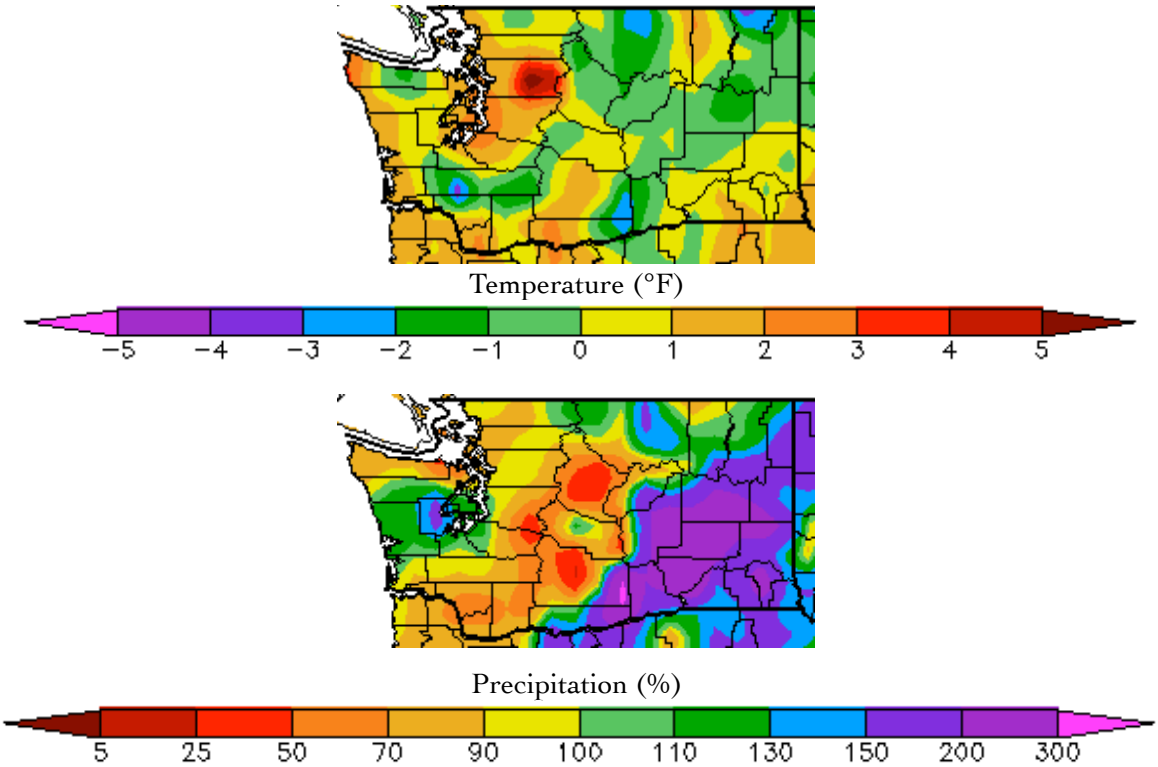
Figure 3: The historical (1901-2009) (a) daytime and (b) nighttime events based on daily US Historical Climate Network data. The day of year ranges from 180 (29 June) to 245 (2 September).

Climate Summary

Mean June temperatures were above normal through most of western WA and cooler than normal in parts of eastern WA, according to the High Plains Regional Climate Center map below. The warm western WA temperatures ranged between 1 and 4°F above normal, though parts of southwestern WA were between 1 and 2°F below normal for the month. Eastern WA temperatures were closer to normal (within 1°F of normal), but trended towards the cooler side (between 1 and 2°F below normal). The newest station addition to the newsletter, Sunnyside - in south central WA, was a cool spot with average monthly temperature 3.6°F below normal (Table 1).

Total June precipitation was much higher than normal in eastern WA, and generally less than normal through the rest of the state. In eastern WA, precipitation in terms of percent of normal ranged between 150 to over 300% of normal in the wettest locations. Sunnyside was again an extreme, reporting 450% of normal precipitation (Table 1). On the other hand, central WA was quite dry, reporting between 25 and 70% of normal precipitation. The northern Olympic Peninsula, the northern Puget Sound, and southwestern WA were also on the dry side with between 70 and 90% of normal precipitation. The south and central Puget Sound and the Olympics had near-normal to above normal precipitation for June.

As noted in the June edition of the OWSC newsletter, we no longer include the Yakima Airport site in Table 1, and are now using a COOP station in Sunnyside and the Department of Energy station at the Hanford site. The locations of the stations listed in Table 1 are shown as blue dots in the Figure 4 (Hanford and Sunnyside are depicted as stars).



June temperature (°F) departure from normal (top) and June 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	61.1	59.1	2.0	1.86	1.76	106
Seattle WFO	63.9	61.0	2.9	1.91	1.63	117
Sea-Tac	64.8	60.9	3.9	1.30	1.57	83
Quillayute	58.9	55.3	3.6	2.90	3.50	83
Bellingham AP	60.8	58.5	2.3	1.62	1.86	87
Vancouver AP	64.7	63.3	1.4	1.75	1.79	98
Eastern Washington						
Spokane AP	61.7	62.1	-0.4	1.86	1.25	149
Wenatchee	67.0	66.7	0.3	0.57	0.60	95
Omak	64.7	65.5	-0.8	1.75	1.23	142
Pullman AP	59.5	58.6	0.9	1.81	1.08	168
Ephrata	66.6	66.6	0	1.39	0.61	228
Pasco AP	68.3	67.5	0.8	1.06	0.68	156
Hanford	69.8	69.6	0.2	1.36	0.51	267
Sunnyside	64.0	67.6	-3.6	2.43	0.54	450

Table 1: June 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.

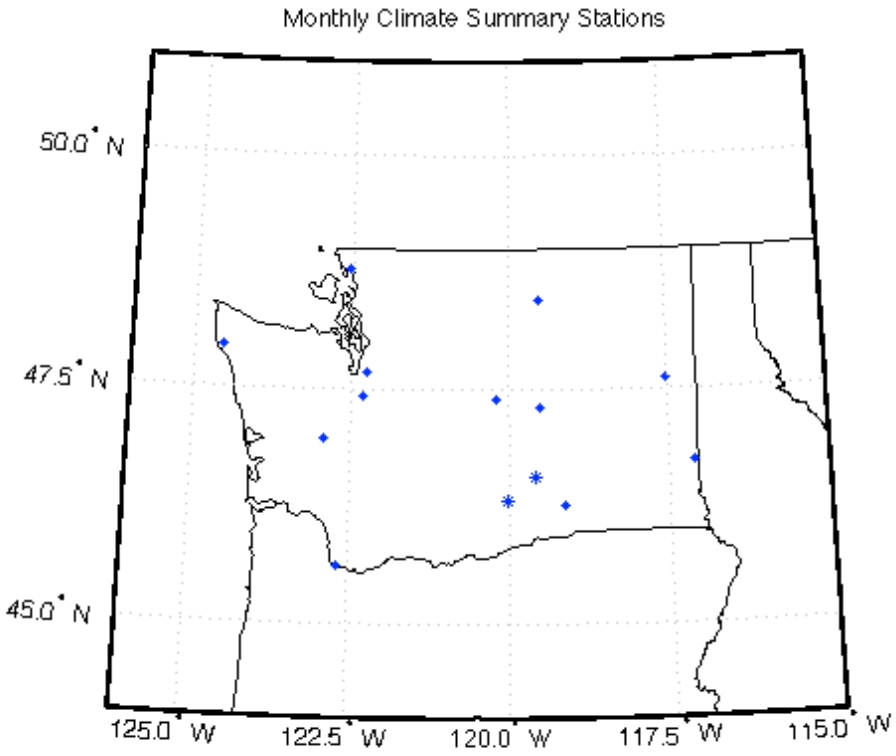


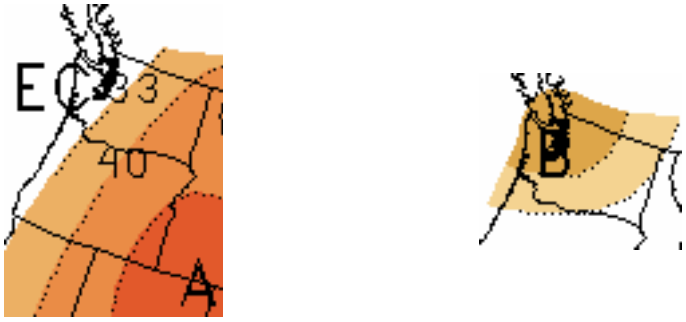
Figure 4: The locations of the stations listed in Table 1.

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/. Sea-surface temperatures (SSTs) are currently near-normal in the western and central equatorial Pacific Ocean and below normal in the eastern equatorial Pacific. The SSTs in the eastern equatorial Pacific have warmed in the last 4 weeks. There is a consensus among the model predictions that near-neutral ENSO conditions will persist through summer 2013.

The CPC three-class outlook for July has increased chances for warmer than normal temperatures for the eastern two-thirds of the state. For western WA, there are equal chances of below, equal to, or above normal July temperatures. There is a higher likelihood of below normal precipitation for virtually all of WA State during July.

The three-month temperature outlook for July-August-September (JAS) has increased chances of above normal temperatures for most of eastern WA. The rest of the state has equal chances of below, equal to, or above normal temperatures. The total precipitation for JAS is expected to be below normal statewide.



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

July-August-September 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.