Office of the Washington State Climatologist

April 3, 2013

March Event Summary

In this Issue

Average March temperatures were near-normal for most of the state, with a tendency to be on the warm side. With the exception of parts of the Olympic Peninsula, northern Puget Sound, and east slopes of the central and south Cascades, March was drier than normal. Because this occurred on the heels of a dry February and January, we examined the precipitation totals from January 1, 2013 through March 31, 2013 and found that many stations have precipitation that ranks among the top ten driest in the historical record (Table 1). While drought is not an immediate concern for most of these areas (many locations had a wet October-December period; the snowpack is mostly in good shape), the southern portion of the state, particularly southeastern WA where there are longer-term precipitation deficits, are areas that will be monitored closely. It is worth noting that stations from Everett through the northern Puget Sound are not included in the table below because they have had more precipitation, and so this year does not rank in even the top 30 driest starts to the year.

Station	Jan-Mar Precip	Rank	Records Began	Record (Year)
Vancouver 4 NNE	5.10”	1	1900	-
Omak	1.56”	2	1909	0.46” (1920)
Yakima	0.90”	3	1947	0.74” (1964)
Winthrop	1.72”	4	1906	1.10” (1929)
Walla Walla	3.03”	4	1949	2.66” (1977)
Pullman	3.80”	5	1941	2.20” (1977)
SeaTac	8.48”	6	1948	5.77” (1985)
Wenatchee	1.15”	6	1960	0.58” (1988)

Station	Jan-Mar Precip	Rank	Records Began	Record (Year)
Olympia	11.83”	7	1948	7.93” (1985)
Hoquiam	18.98”	11	1954	10.88” (1985)
Spokane AP	3.19”	13 (tie)	1881	1.91” (1920)

Table 1: The total January through March precipitation for several WA locations. The ranking (in terms of the driest), period of record, and the year and amount of the driest Jan-Mar period are also listed for each station.

With regards to the weather highlights in March: the first day of the month was mild, especially east of the Cascade Mountain crest where record high daily temperatures were set at Omak (58°F), Wenatchee (63°F), and Yakima (68°F)on 3/1. The weather remained relatively calm for the next several days with sunny skies and minimum temperatures mostly below freezing until rain (and snow in northeastern WA) arrived statewide on 3/6. Some locations in eastern WA set daily precipitation records: Ephrata recorded 0.43” and Wenatchee 0.38” on that day. The next notable system impacted the northern Olympic Peninsula and northern Puget Sound on 3/13 and 3/14 setting daily precipitation records at Quillayute on 3/13 (2.02”) and 3/14 (1.26”).

Heavy mountain snow fell between 3/19 and 3/21 as a series of storms impacted the state. In the western WA lowlands, rain and strong winds persisted through much of this period. Parts of eastern WA received snow on 3/20 (Mazama set a 24-hr snowfall record ending at 10 am on 3/20 of 4.8”), and there was even some western WA lowland snow on 3/21 and 3/22, particularly near Everett in association with the Puget Sound Convergence Zone. Shortly after the wintry weather on the vernal equinox, however, the skies dried out and warmed up. Many stations across WA reached 70°F for the first time this calendar year during the last weekend in March, and some set daily records. For example, record high daily temperatures were recorded at the Seattle Weather Forecasting Office (69°F), Quillayute (73°F), and Hoquiam (71°F) on 3/30 and at Ephrata (73°F) and Moses Lake (74°F) on 3/31.

CoCoRaHS March Madness

Our network of backyard precipitation observers in the Community Collaborative Rain Hail and Snow (CoCoRaHS) network is getting bigger! We recruited 14 new observers during March, tying for 21st place in the national March Madness competition. Texas won the CoCoRaHS Cup, with an impressive 226 new volunteers. In the per capita results, Wyoming won with 75 new observers during March. Just because March is over, doesn’t mean you still can’t spread the word about CoCoRaHS. We seek more volunteers in WA State, especially east of the Cascade crest. New volunteers can sign up at www.cocorahs.org.

The CoCoRaHS station located at OWSC on the University of Washington campus received 2.51 inches of precipitation for March, which is lower than the measurements at SeaTac Airport and the Seattle Weather Forecasting Office. How does your CoCoRaHS station measure up to the official weather stations?

Snowpack Summary

Despite the drier than normal conditions over much of the state since January 1, the April 1 snow water equivalent (SWE) values indicate a healthy WA snowpack (Figure 1). The Olympic, North Puget Sound, Central Puget Sound, South Puget Sound, and Lower Columbia basins all have above normal snowpack, ranging from 110 to 131% of normal. The Upper Columbia, Central Columbia, Upper Yakima, and Lower Yakima basins all have near-normal snowpack (ranging from 91 to 106% of normal). The Spokane and Lower Snake basins have below normal snowpack, with values of 88 and 87% of normal, respectively. We are monitoring southeast WA due to the combination of below normal precipitation values in the short and long-term and the lower than normal snowpack.

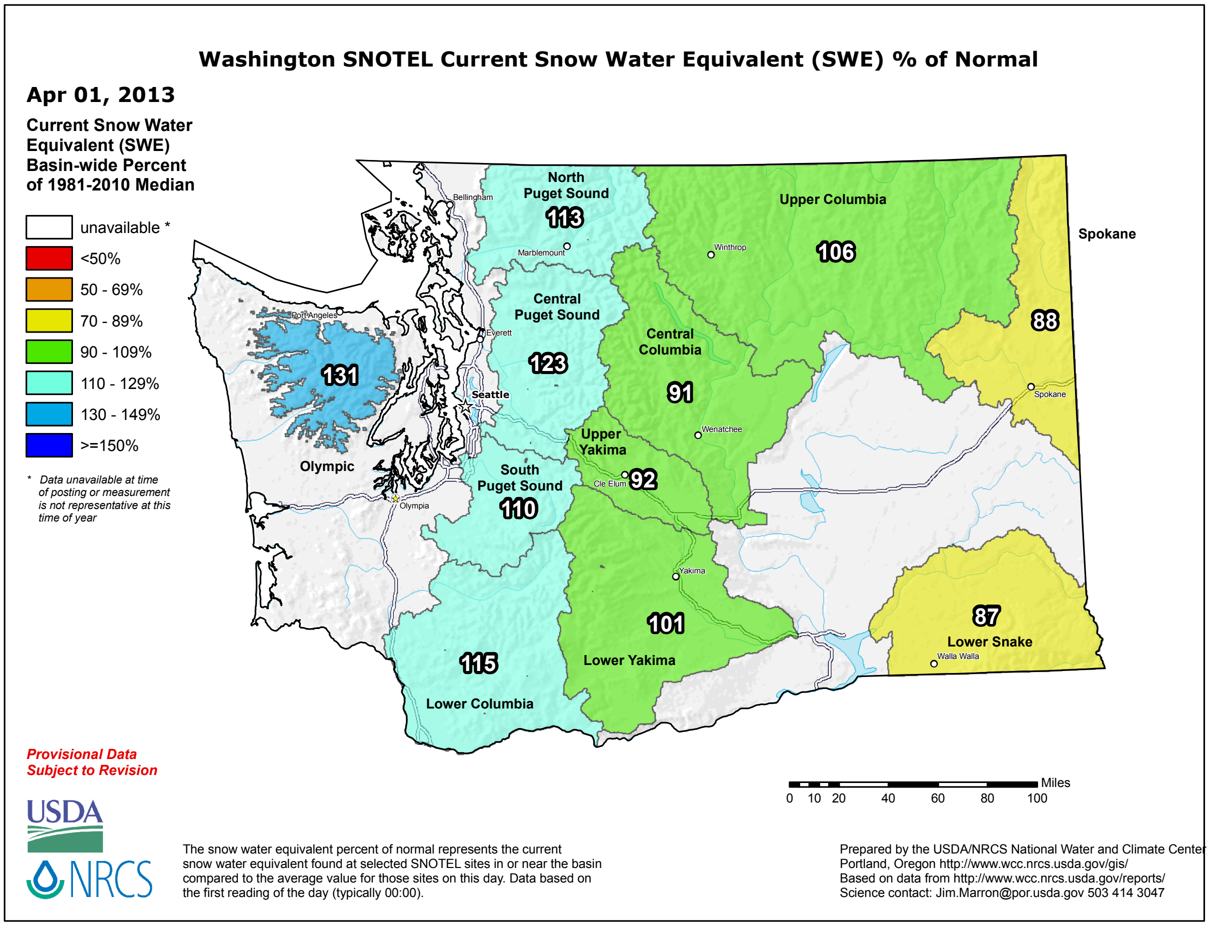


Figure 1: Snowpack (in terms of snow water equivalent) percent of normal for Washington as of April 1, 2013. Image is from the National Resources Conservation Service (NRCS).

WA State Tornadoes during Spring

A message from the State Climatologist

The most significant tornado outbreak in Washington State history occurred on 5 April 1972. Clark County was hit particularly hard, with an early afternoon tornado of F3 intensity causing 6 fatalities and injuries to 300 others. Later that same day, another F3 tornado struck Lincoln County, with fortunately only a single injury. Spring is known as the favored season for strong thunderstorms in many parts of the world. Is this the case for Washington? We experience fewer thunderstorms per unit area than any of the other lower 48 states so WA is not exactly a hotbed for convection (pun intended). That being said, there is a tendency for thunderstorms to occur more frequently from early spring into early summer in most parts of the state. It is also the time of year for our rare tornadoes, as discussed in Cliff Mass' book "The Weather of the Pacific Northwest". The purpose of the present contribution is to document how many tornadoes of F1 and stronger intensity have occurred during spring (April through June) since 1950, with separate consideration of those on the west and east sides of the Cascade Mountains. We are interested in determining how regional atmospheric conditions compare for west side versus east side tornadoes.

Data on the occurrence of tornadoes in Washington State for the years 1950-2000 are available at www.tornadoproject.com, and for the years of 2000-2012 from that National Climatic Data Center's Storm Events Database at www.ncdc.noaa.gov/stormevents. Our focus is on tornadoes of F1 and strong intensities partly because of underreporting of F0 events in the earlier record, at least relative to the more recent set compiled by NCDC. It is plausible that F0 events are more likely to be missed or misinterpreted because of their weaker winds. Moreover, it is the stronger tornadoes that generally have societal impacts. The events are itemized in Tables 2 and 3 for western and eastern Washington, respectively. The atmospheric conditions during these storms were assessed using 6-hour means from the NCEP Reanalysis. These storms were examined in an individual and a composite sense; the atmospheric variables considered were 500 hPa geopotential heights, winds and air temperatures, 700 hPa vertical velocity, 925 hPa air temperature and specific humidity, and sea level pressure. A sub-set of this information is included here.

Date	County	Intensity	500 hPa Flow
5 April 1972	Clark	F3	SW
12 June 1978	Pierce	F1	SW
13 May 1986	Snohomish	F2	W
29 June 1989	Clark	F1	S
31 May 1997	Pierce	F1	SW
27 June 2001	Pierce	F1	SW
27 May 2004	Thurston	F1	SW
18 May 2005	Snohomish	F1	SW

Table 2: Western WA tornadoes (F1 and stronger) during April-June.

A total of 8 events with tornadoes of F1 intensity and greater have occurred in April through June since 1950 in western Washington (Table 2); a total of 14 events have occurred during the same period east of the Cascade crest (Table 3). For the other three-quarters of the year,

Date	County	Intensity	500 hPa Flow
15 June 1954	Spokane	F2	SW
30 April 1957	Yakima	F2	Weak S
6 May 1957	Spokane	F2	Weak N
26 June 1958	Walla Walla	F2	SW
29 June 1970	Spokane	F1	Weak S
5 April 1972	Grant, Lincoln	F2, F3	SW
1 May 1979	Lincoln	F1	Weak NW
22 June 1981	Spokane	F1	W
3 May 1982	Okanogan	F1	W
23 April 1983	Franklin	F1	SW
12 April 1984	Spokane	F1	Weak W
30 May 1987	Okanogan	F1	SW
31 May 1997	Lincoln, Stevens	F1, F1	SW
6 May 2009	Lincoln	F1	Weak W

Table 3: As in Table 2, except for eastern WA.

there have been 9 cases on the west side and 13 cases on the east side. This implies that these types of storms occur three times more frequently in spring, on average, compared with the remainder of the year in an overall sense. Tables 2 and 3 include a property of the regional atmospheric structure, specifically the sense of the flow aloft at 500 hPa (typically between 5 and 6 km). We were struck with the consistency in this flow among the cases comprising the western Washington tornadoes. Markedly less consistency was found for the eastern Washington cases. This result is borne out by composite maps for the vector wind at 500 hPa for the western cases (Fig. 2a) and for the eastern cases (Fig. 2b). The directions of the composite flow in the two sets are similar, but the magnitude is less for the eastern cases because of averaging out of the differences between individual events.

There are also differences in the mean in the nature of the temperature profiles for the two sets of storms. For those on the west side, the atmospheric boundary layer (the lower layer of the atmosphere that is directly influenced by the surface) has been 1-1.5°C cooler than normal, as indicated in 925 hPa air temperature anomaly map shown in Figure 3a. This may not seem to make sense, but these cases do feature lower than normal static stability in that 500 hPa air temperature anomalies are even more negative (not shown). Moreover, while the atmospheric boundary later is on the chilly side, it also includes positive specific humidity anomalies of about 0.5 to 1 g kg^{-1}. The eastern WA tornadoes have occurred in an environment with boundary layer temperature that are 0.5 to 1°C warmer than normal (Fig. 3b), boundary layer humidity anomalies of positive 1.5 g kg^{-1}, and 500 hPa air temperatures that are near normal. In other words, the convective instability is associated more with cool temperatures aloft for the western WA events, and warm and moist air at low levels for their eastern WA counterparts. Both the western and eastern tornadic events include low-level flow from the northwest in the mean. This was especially the situation for the eastern WA events, which was not expected. The backing in the winds with height means that our tornadoes tend to occur in conditions of cold advection, as opposed to the veering of the winds and warm advection that typically characterizes the environment for the supercell thunderstorms that spawn tornadoes east of the Rocky

Mountains. The dynamical implication of this difference is well beyond our present scope but surely are manifested in a variety of ways. Finally, for readers interested in more about tornadoes in the Pacific Northwest, we recommend the aforementioned book authored by Cliff Mass, which includes maps showing their favored locations and a discussion of how they can form in association with the Puget Sound Convergence Zone.

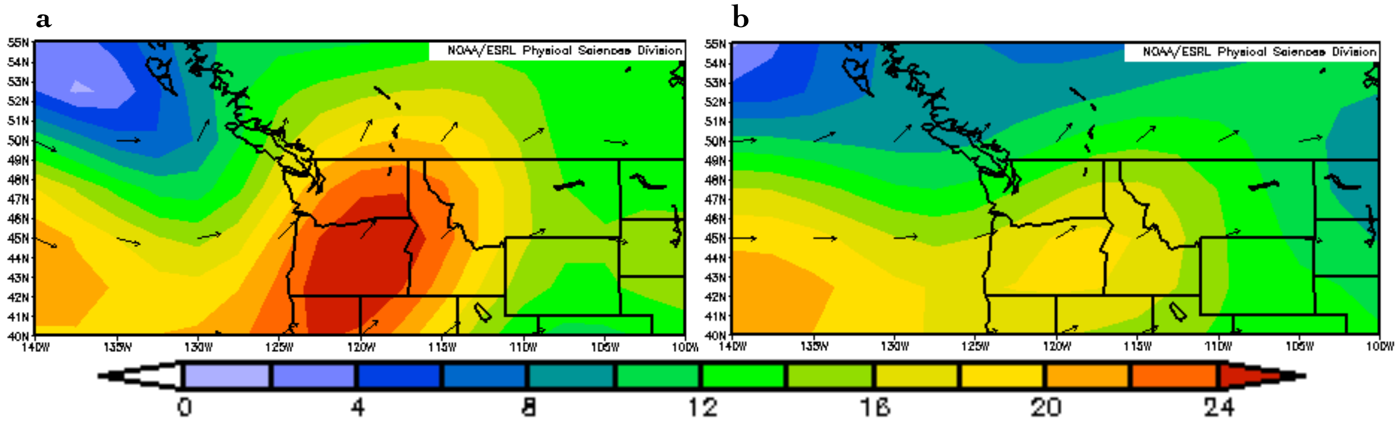


Figure 2: The composite mean 500 hPa winds for (a) the western WA tornadoes and (b) the eastern WA tornadoes (from ESRL).

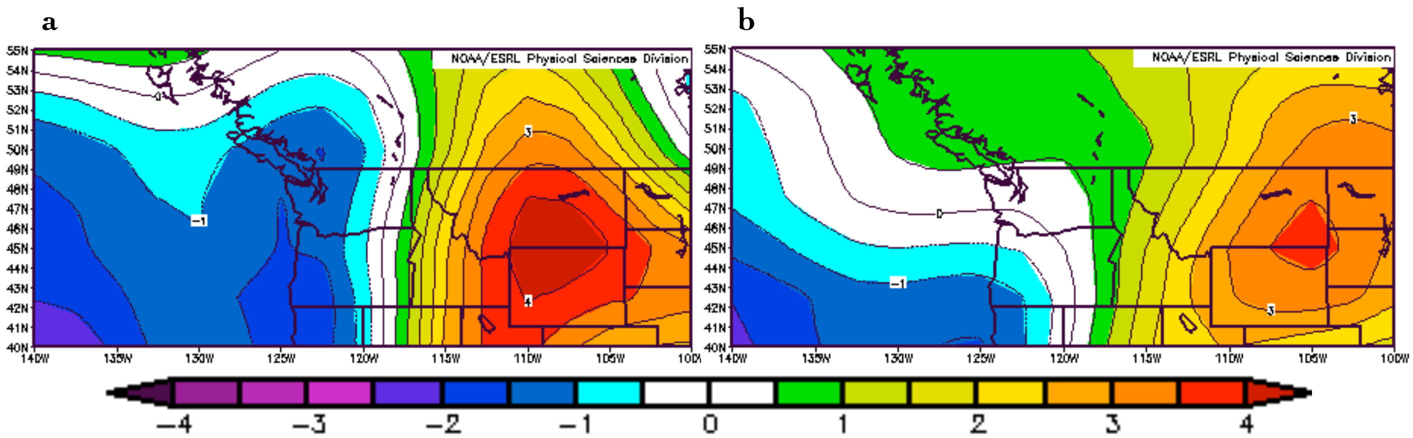


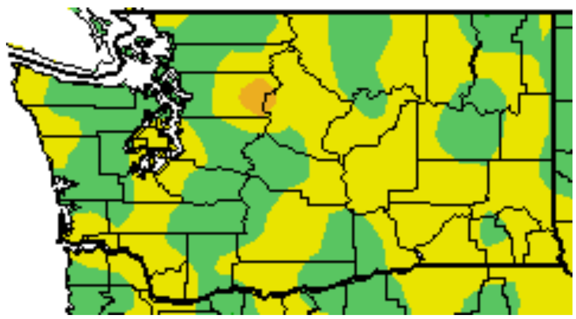
Figure 3: The composite 925 hPa air temperature anomalies for (a) the western WA tornadoes and (b) the eastern WA tornadoes (from ESRL).

Reference: Mass, C., 2008: The Weather of the Pacific Northwest, University of Washington Press, Seattle, WA.

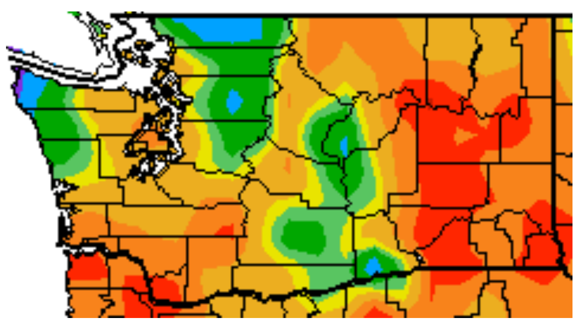
Climate Summary

Mean March temperatures were above normal for most of the state, as illustrated by the High Plains Regional Climate Center (HPRCC) temperature departure from normal map below. Most of the cities were about 1-2°F above normal for the month (Table 4). There were some cool spots though, such as the eastern Olympic Peninsula, the north Puget Sound, south Cascades, and some scattered areas in eastern WA. Note that the anomalous warmth at Yakima of 2.3°F included in Table 4 should be viewed with caution as there is some evidence of a faulty temperature sensor there.

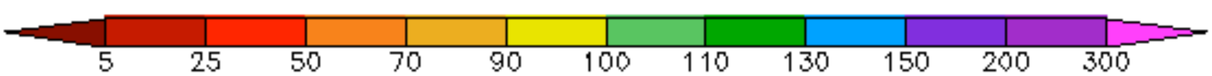
Total March precipitation was below normal for most of the state, especially in southwest and eastern WA, where the precipitation percent of normal map indicates values between 25 and 70% of normal. Most of the Puget Sound region received between 70 and 90% of normal precipitation, as well as parts of central and northeastern WA. The western Olympic Peninsula, northern Puget Sound, and east slopes of the south and central Cascades did receive normal to above normal precipitation. Yakima, Wenatchee, and Quillayute received 124, 127, and 148% of normal precipitation, respectively (Table 4).



Temperature (°F)



Precipitation (%)



March temperature (°F) departure from normal (top) and March 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)			Snowfall (inches)		
	Avg	Norm	Departure from Normal	Total	Norm	% of Norm	Total	Norm	% of Norm
Western Washington									
Olympia	45.1	44.5	0.6	3.88	5.29	73	0	0.7	0
Seattle WFO	47.5	46.6	0.9	2.99	3.51	85	0	0	0
Sea-Tac	47.9	46.5	1.4	2.74	3.72	74	0	0.8	0
Quillayute	45.9	44.1	1.8	15.99	10.83	148	0	0.7	0
Bellingham AP	44.8	44.2	0.6	3.16	3.22	98	0	0.7	0
Vancouver	47.7	48.0	-0.3	1.58	3.57	44	M	M	M
Eastern Washington									
Spokane AP	41.2	40.2	1.0	0.82	1.61	51	0.9	3.5	26
Wenatchee	44.0	44.1	-0.1	0.81	0.64	127	M	1.0	M
Omak	42.4	41.5	0.9	0.77	1.17	66	M	M	M
Pullman AP	41.2	40.6	0.6	0.97	2.05	47	M	M	M
Ephrata	43.4	43.0	0.4	0.54	0.68	79	M	0.8	M
Pasco AP	46.5	46.3	0.2	0.23	0.79	29	0	M	M
Yakima AP	45.5	43.2	2.3	0.77	0.62	124	0	0.7	0

Table 4: March climate summaries for locations around Washington with a climate normal base-line 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. The average temperature at the Bellingham AP site is an estimate due to a faulty temperature sensor; the sensor was replaced in early March.

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 equatorial Pacific Ocean except for in the eastern equatorial Pacific where an area of above normal SSTs (above 0.5°C) has developed. There is a consensus among the model predictions that near-neutral ENSO conditions will persist through spring and summer 2013.

The CPC three-class outlook for April is a toss up: there are equal chances of below, equal to, or above normal temperatures and precipitation for the month. Its counterpart for the three-month period of April-May-June (AMJ) has increased chances of below normal temperatures for the entire state (exceeding 40%). For precipitation, there are equal chances of below, equal to, or above normal precipitation for most of the state. The southern-most part of the state, especially on the western side of the state, is an exception with increased odds of below normal precipitation for AMJ.

The international multi-model ensemble (IMME) of global climate models (not shown) agrees that the remainder of spring is likely to be on the dry side, but with near normal or even warm temperatures. Sound to good to be true? These models, even as a group, do not always get it right, so only time will tell.

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

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