Office of the Washington State Climatologist

August 7, 2015

July Event Summary

For the 3rd consecutive month, average July temperatures were warmer than normal statewide. A few stations broke records, such as SeaTac Airport and Quillayute, for the warmest July on record, and others were within the top 5 warmest (Table 1). It is worth noting that the July average temperature for SeaTac Airport ranked as the warmest *month* on record, not just the warmest July. Total precipitation was below normal for the state, though not as low as other Julys in the past as the ranking is between the 10th and 20th driest for many of the stations in Table 1. Pasco is the exception, which tied 5 other years (2013, 2008, 2007, 2003, 1945) as the driest July with a "trace" recorded.

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Station	July Avg Max Temp (F)	Rank	July Total Precip (in)	Rank	Records Began
Quillayute	63.0	1	0.97	13	1966
Olympia	68.0	2	0.15	12	1948
Hoquiam	63.9	2	0.38	18	1953
Walla Walla	79.9	3	0.04	18	1949
Everett	68.6*	2	0.32*	-	1894
Omak	76.4	3	0.26	12	1991
Bellingham	67.2	2	0.67	-	1949
SeaTac	71.2	1	0.09	9	1945
Wenatchee	80.3	2	0.24	-	1959
Pasco	77.5	5	T	1 (tie)	1945

Table 1: July average temperature and ranking (descending) and July total precipitation and ranking (ascending) along with the period of record for selected WA stations. The precipitation ranking for the stations with dashes is outside of the top 20. *Everett is missing 2 days.

July started out hot with an upper level ridge building in on the 1st. Daily high temperature records were set or tied on the 2nd at Walla Walla (105°F - tie), Pullman (96°F), Olympia (96°F), SeaTac Airport (93°F), and the Seattle Weather Forecasting Office (92°F), for example. More were set on the 3rd at Hanford (108°F), Yakima (107°F), Ephrata (105°F), Omak (104°F), and Pullman (97°F). Daily records were also set for high minimum temperatures at SeaTac (64°F) on the 2nd and Ephrata (77°F) and Omak (69°F) on the 3rd. The warmth continued and the National Weather Service (NWS) had heat advisories in place through the 5th. The first 5 days of the month actually tied August 1981 for the longest stretch of consecutive days at or above 90°F at SeaTac Airport. Wenatchee had 5 consecutive days above 100°F ending on the 4th and tying as the 4th longest stretch. A stretch of more moderate temperatures began on the 6th, with smoke at times in western WA from a large fire in British Columbia. Washington also saw fire starts after the warm spell with some convection in the region. Cooler temperatures and isolated showers moved into the state on the 10th. Wenatchee even recorded a maximum daily precipitation total on the 12th (0.10").

The rest of the month acted like a (low amplitude) seesaw: temperatures warmed again on the 18-20th, but then cooled for the last full week of July with even a little bit of rainfall before ending the month on a hot note, as it started. SeaTac (94°F) and Colville (104°F - tie) recorded record daily high temperatures on the last day of the month (7/31), which was the start of another heat wave that persisted into early August.

Drought Update

The heat and scant precipitation of summer have exacerbated drought in WA State. The Governor declared a statewide drought emergency on May 15, and impacts are being widely felt throughout the state. OWSC produces a weekly drought monitoring report on statewide weather and hydrological conditions as well as drought impacts, which can be read for more details (UW story). The US Drought Monitor has indicated a worsening of the drought in WA State over the last several weeks (Figure 1), largely due to short term precipitation deficits and record low streamflows. The entire state is classified as being in "severe drought" by the monitor, and "extreme drought" has been introduced to parts of the Olympic Peninsula, the east slopes of the Cascades, and the counties bordering Idaho.

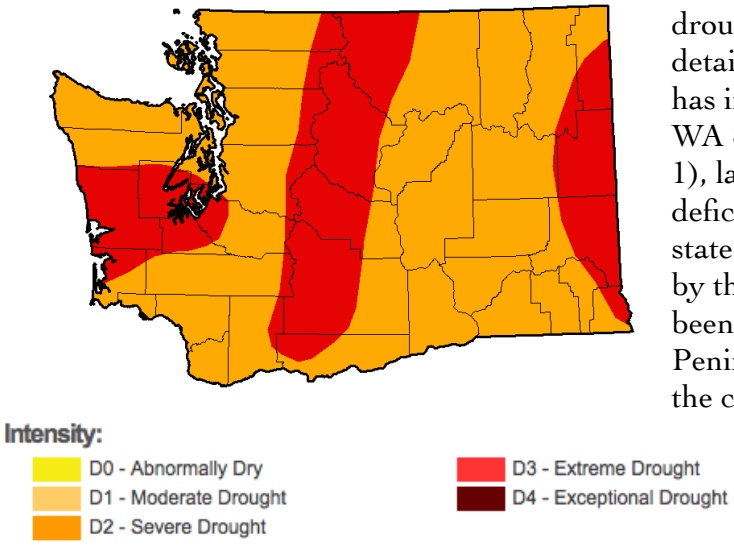


Figure 1: The 4 August 2015 edition of the US Drought Monitor (http://droughtmonitor.unl.edu/).

Minimum Temperatures on the Increase in Summer

A message from the State Climatologist

OWSC is receiving a large number of inquiries about the hot weather this summer and whether it is due to global climate change. The short answer is no, and the recent weather should be thought of as a short-term climate event. But it has got us thinking about the variability and trends in WA state temperatures during summer, and potential explanations for what has been observed.

We begin by presenting time series of seasonal mean (Jun-Sep) maximum and minimum temperatures for WA state from the US Climate Divisional Database, as provided by NOAA at www.ncdc.noaa.gov/cag/. The seasonal mean maximum temperatures (Fig. 2; red trace) are characterized by greater interannual variability but less of an upward trend, compared with the minimum temperatures (Fig. 2; blue trace). In quantitative terms, linear fits to these time series indicate increases of about 1.3°F in the maximum temperatures and about 2.8°F in the minimum temperatures. Concerns with these time series regarding the quality of the data early in the record, adjustments related to changes in siting and instrumentation, and urban heat island and other effects are addressed at this links provided here. So why is the increasing trend in summer minimum temperatures more prominent than in the maximum temperatures?

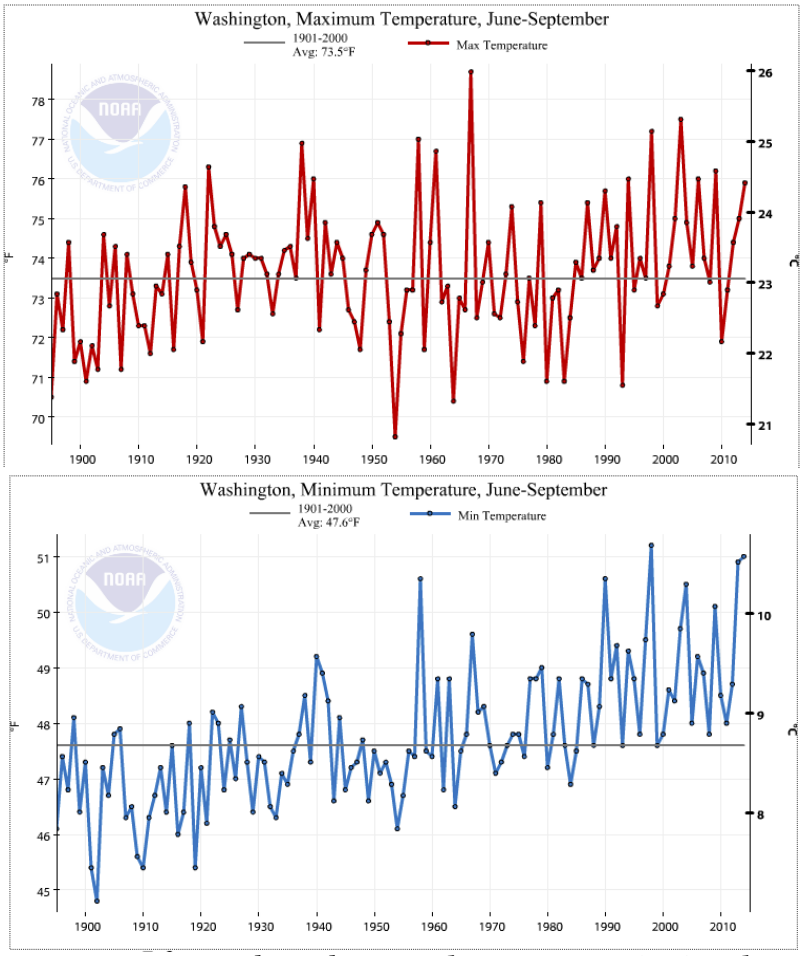


Figure 2: June through September maximum (top) and minimum (bottom) temperatures averaged over WA State from 1895 through 2014 (from NCEI climate division data).

While we cannot explain all of the nuanced differences in the traces, we do have a hypothesis for what has occurred since the middle of the 20th century. There appears to be an increasing trend in the humidity over WA state in summer, and this increase may account for the warmer nighttime temperatures. The humidity record we consider is the average specific humidity of the 1000-850 hPa layer, i.e., the lower 20% of the troposphere, over WA state from the NCEP Reanalysis (blue trace in Fig. 3). This is a synthetic data set, but is closely constrained by the available upper-air observations, in particular the twice-daily rawinsonde soundings from

Quillayute (UIL) and Spokane (OTX) in WA state and Salem (SLE) in Oregon, and represents a reasonable estimate of how the low-level humidity has varied since 1950. This time series features mostly a decline from 1950 to the early 1970s, with a single year that was extremely moist in 1958. This happens to be a year during which sea surface temperatures were as high as they have ever been off the coast of the Pacific NW, up until the summer of 2015. The low-level humidity from the early 1970s to the present has risen systematically if not monotonically, with an overall increase on the order of 8-10%.

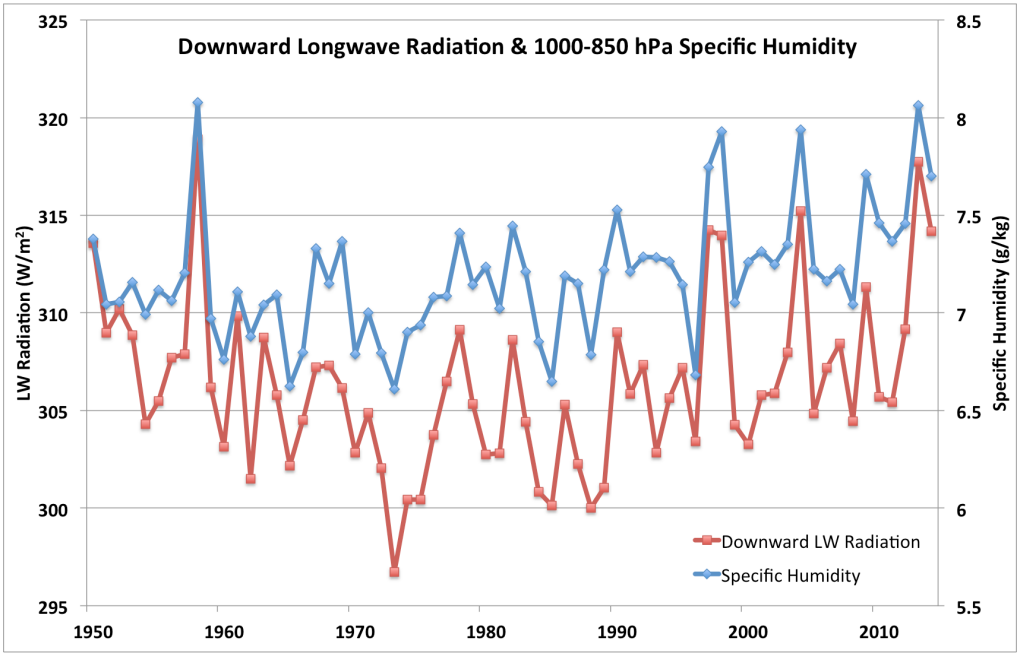


Figure 3: Downward longwave radiation and 1000-850 hPa specific humidity from 1950-2014 from the NCEP/NCAR Reanalysis.

The year-to-year variations in specific humidity are in close correspondence with variations in mean downward longwave radiation at the surface (red trace in Fig. 3), again from the NCEP Reanalysis. The linear correlation coefficient between the two time series is approximately 0.84; the strength of this correspondence is due to the water vapor content being a strong determinant of the emissivity of the atmosphere to longwave radiation. A full treatment of the physics is well beyond the scope of this piece, but in a nutshell, the more moist the atmosphere, the less the optical depth, and the greater the "sky temperature". Of course, the idea that an increase in humidity means less nighttime cooling is not new. Summer evenings are generally pleasant in WA state because our humidities are low, at least compared with most other regions of the US, especially east of the Rocky Mountains.

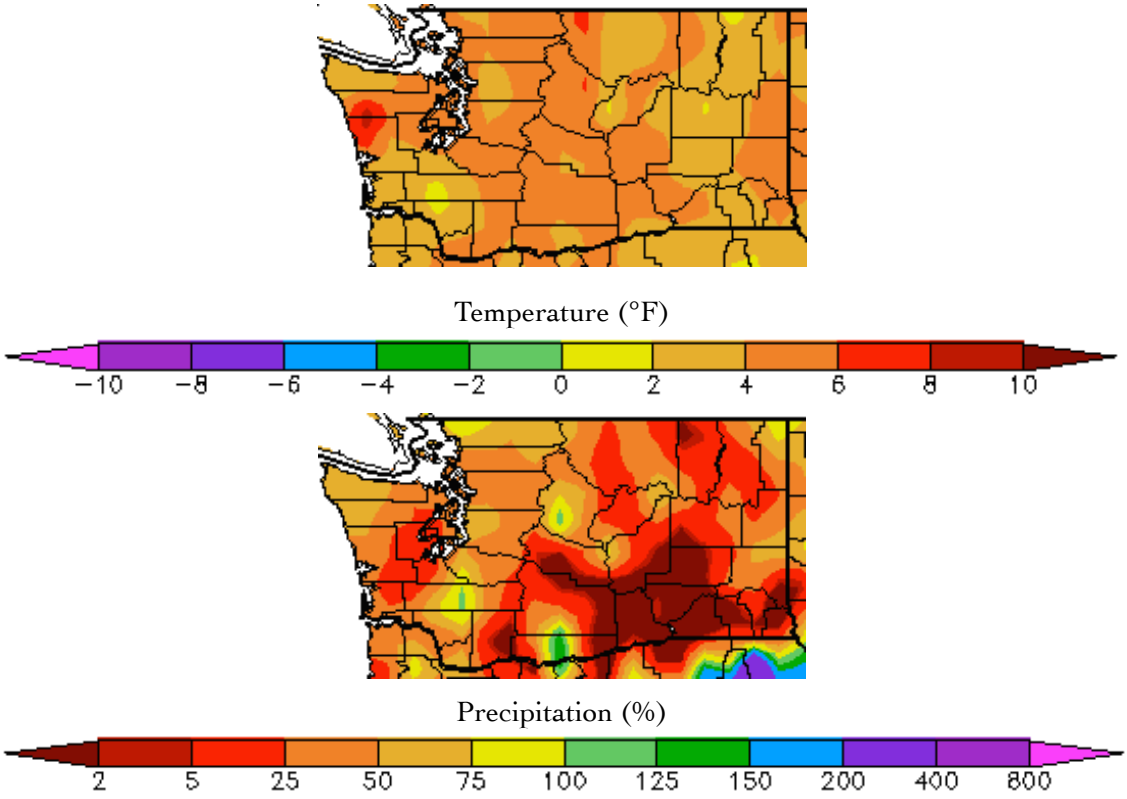
The overall upward trend in the low-level specific humidity appears to be more related to an increase in air temperature rather than any systematic changes in relative humidity (not shown). The time series in 1000-850 hPa air temperature (not shown) closely matches that of the mean maximum temperatures at the surface both in terms of the year-to-year variability (the linear correlation coefficient between the two series is almost 0.9) and of the magnitudes of overall trends. On the other hand, the mean minimum temperatures are more strongly correlated with the specific humidity than the air temperature in the 1000 to 850 hPa layer. In summary, based on the analysis carried out here - and we should insert the caveat that this has

not been peer reviewed - for the period of 1950 to the present, the minimum temperatures appear to have increased more than the maximum temperatures because they essentially reflect the increases in both lower-tropospheric air temperatures and humidity.

Climate Summary

Mean monthly July temperatures were warmer than normal throughout the entire state, though the anomalies were not quite as large as seen across the state for June. According to the map below from the High Plains Regional Climate Center, average July temperatures were between 2 and 6°F above normal for much of the state. The Puget Sound region had average temperature anomalies around 4-5°F above normal (Table 2). Anomalies were more varied east of the Cascades, with Wenatchee as a warm spot with temperatures 6.1°F above normal (Table 2).

Total July precipitation was small, with less than 0.50" falling for a majority of the state. In terms of percentage of normal, nearly the entire state received less than half of its normal July precipitation, which is typically small to begin with. The Lower Columbia Basin saw only 2% of normal precipitation during July, but thunderstorms offered a little more precipitation in other parts of eastern WA. Wenatchee, for example, received 89% of normal precipitation thanks to thunderstorms on the 7th and 12th. In western WA, the Seattle Weather Forecast Office station in north Seattle received an anomalous 131% of normal precipitation due mostly to isolated showers that dropped 0.90" on the 26th (Table 2).



July 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	68.0	63.8	4.2	0.15	0.63	24
Seattle WFO	70.9	65.9	5.0	1.04	0.79	131
SeaTac AP	71.2	65.7	5.5	0.09	0.70	13
Quillayute	63.0	58.9	4.1	0.97	1.98	49
Hoquiam	63.9	59.9	4.0	0.38	1.14	33
Bellingham AP	67.2	62.3	4.9	0.67	1.18	57
Vancouver AP	72.6	68.4	4.2	0.27	0.69	39
Eastern Washington						
Spokane AP	74.2	69.8	4.4	0.19	0.64	30
Wenatchee	80.3	74.2	6.1	0.24	0.27	89
Omak	76.4	72.7	3.7	0.26	0.81	32
Pullman AP	69.6	65.6	4.0	0.54	0.69	78
Ephrata	79.3	74.2	5.1	0.05	0.40	13
Pasco AP	77.5	73.5	4.0	T	0.28	0
Hanford	81.3	77.1	4.2	0.05	0.23	22

Table 2: July 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 is present, and sea surface temperature anomalies in the eastern equatorial Pacific are more than 2°C warmer than normal, according to the Climate Prediction Center (CPC). Averaged over the last four weeks, sea surface temperatures (SSTs) were above normal throughout the entire equatorial Pacific. The "El Niño Advisory" released on 5 March is still in effect. There is about a 95% chance that El Niño conditions will continue through next winter (2015-16), and most ENSO models have the Niño3.4 anomaly staying above 1°C.

The CPC seasonal outlook for August is calling for increased chances of above normal temperatures statewide. August precipitation is a toss up, with equal chances ("EC") of below, equal to, or above normal precipitation expected.

The August-September-October (ASO) CPC outlook is calling for higher than normal temperatures statewide, with the odds of warmer temperatures exceeding 60% for the entire state. For precipitation, there are higher chances of below normal precipitation for much of the state. The darkest brown represents a 40% chance of drier conditions using a tercile system where each outcome (below, equal to, or above) is assigned a 33% chance of occurring in any given period.

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

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