



Office of the Washington State Climatologist

August 3, 2012

July Event Summary

Mean July temperatures were cooler than normal west of the Cascade Mountains, while the rest of the state, similar to the rest of the country, was warmer than normal. Precipitation, on the other hand, was mixed across the state, with some areas receiving much higher than normal precipitation and others much below. The variation in statewide precipitation was due to the hit-and-miss nature of the convective storms that flared up during the middle of the month.

In this Issue

July Event Summary.....	1
OWSC Recent Activities...	3
Heat and Ozone.....	3
Climate Summary.....	6
Climate Outlook.....	8



Figure 1: Flash flooding in downtown Omak on July 20, 2012 (from 7/24 Wentachee World:

<http://www.wenatcheeworld.com/news/2012/jul/24/region-still-cleaning-up-from-a-week-of-damaging/>).

An unusually high number of thunderstorms, some severe, occurred in the state during July. Eastern WA saw extensive damage from a string of thunderstorms that caused flash flooding, high winds, downed trees, power outages, mudslides, highway closures, and even one death in Ferry County. Governor Gregoire declared a state of emergency for Ferry County, where a lot of the damage was focused, and 15 other counties in WA: Adams, Benton, Chelan, Douglas, Franklin, Garfield, Grant, Jefferson, Kitsap, Kittitas, Klickitat, Okanogan, Pend Oreille, Walla Walla, and Yakima Counties (<http://www.governor.wa.gov/news/news-view.asp?pressRelease=1944&newsType=1>).

The bulk of the damage occurred on July 20. Figure 1 shows the flash flooding in downtown Omak on July 20, where the water was knee deep. Just 5 days prior, flash flooding occurred southwest of Omak, in Malott, from a thunderstorm on July 15. Images of that flood can be seen here:

<http://www.omakchronicle.com/nws/n120717b.shtml>.

In the same area, just southwest of Mansfield, lightning from the same storm sparked a fire. The monthly July precipitation in Omak is quite remarkable (and ranked as the 3rd wettest July since 1909; 1992 and

1993 were wetter). Omak received about 400% of their normal July precipitation last month and more than half of that was received in 1 day (55%; 1.76"), on July 20. The majority of the rest of the monthly precipitation fell on July 15 and 17, all from thunderstorms.

There was abundant thunderstorm activity on the west side of the Cascades as well, which is uncommon. Seattle Tacoma International Airport (SeaTac) typically reports either 0 or 1 thunderstorm every July (based on data for the last 30 years). This July, there were 4 separate thunderstorm events at SeaTac; the previous maximum was 2 events during July in the 30-year record. Figure 2a shows a radar image from the Camano Island radar at 8:49 am on July 20, the same day that had damaging thunderstorms east of the Cascades later in the day (Figure 2b). The oranges and reds show the regions with high rainfall rates often accompanied by lightning. A new daily record precipitation was set at SeaTac from this storm, with 0.60" falling on 7/20.

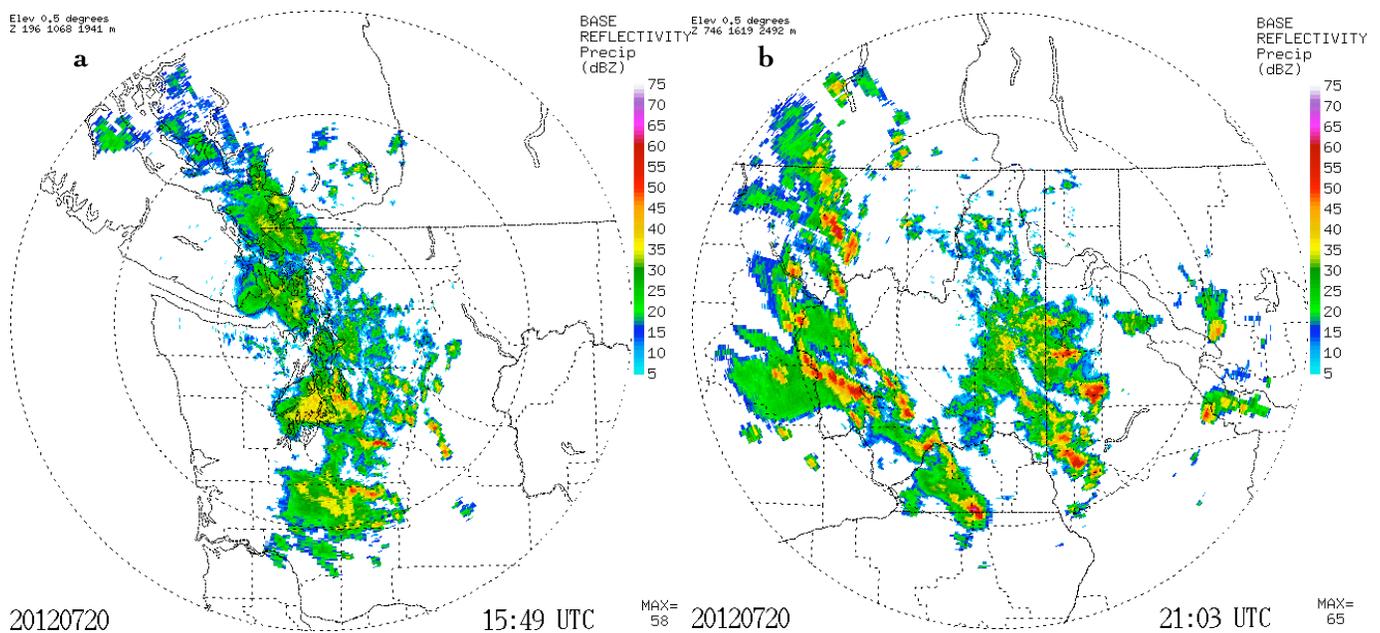


Figure 2: Camano Island Radar (a) and Spokane Radar (b) showing thunderstorm activity on July 20, 2012. The western WA image is from 8:49 am and the eastern WA image is from 2:03 pm.

July OWSC Activity Highlights

July was a busy month for OWSC! Besides our normal research and outreach activities, there are two special events highlighted here:

- OWSC attended the annual meeting of the American Association of State Climatologists (AASC) in muggy and sunny Destin, FL where we received updates and new climate information from our NOAA, Regional Climate Center, and State Climatologist partners. OWSC and Oregon Climate Services put in a bid to co-host the 2014 AASC meeting in the beautiful Columbia River Gorge and won. We are looking forward to showing off our region of the US to our AASC colleagues.
- Assistant State Climatologist, Karin Bumbaco, spent a morning teaching the University of Washington's DO-IT Scholars as a part of their Summer Program. A brief summary of the session can be found here: <http://jisao.washington.edu/education/k-12/DO-IT>.

Hot Summer Weather and Low-level Ozone Concentrations

A message from the State Climatologist

Ozone (O_3) is an important pollutant in many regions, especially during summer months, and Washington State is no exception. While O_3 is beneficial in the upper-atmosphere through its absorption of damaging ultraviolet (UV) radiation, it is harmful near the surface. It tends to cause reduced lung function, which is of special concern to those with compromised respiratory systems, but can also affect otherwise healthy individuals. Ozone at ground level can also damage agricultural crops and forests. Certain locations in Washington, particularly the west foothills of the Cascade Mountains, are more prone to experience O_3 concentrations above a standard of 75 ppb established by the Environmental Protection Agency (EPA) as a threshold for human health considerations. The air chemistry involving O_3 is rather complicated. In a nutshell, direct emissions of O_3 are minimal and instead most O_3 forms when key precursor chemical constituents, namely nitrogen oxides (NO_x) and volatile organic compounds (VOC), react in the presence of sunlight. This process is enhanced during warm weather. The objective of the present note is to examine the relationship between day-to-day variations in the weather and peak concentrations of O_3 in the Puget Sound region and Spokane.

Our analysis is based on the following data: (1) daily maximum 8 hr O_3 concentrations from Enumclaw (Mud Mountain Dam) and Spokane for 2001-2011 from the Puget Sound Clean Air Agency, and (2) daily maximum air temperatures from SeaTac (SEA) and Spokane International Airport (GEG). We use the O_3 record at Enumclaw because it is a location that is out of compliance with the EPA standard relatively frequently. Comparisons between the daily maximum air temperatures and O_3 concentrations for the two pairs of sites were made for the months of July and August during both cool and warm summers; for brevity's sake results are shown here just for the warm summer of 2009. We also examined the values of

peak O₃ concentration during heat waves in the Seattle area, arbitrarily defined as those periods during which temperatures at SEA reached 90°F or higher.

Time series of daily maximum air temperature and O₃ concentration for July through August of 2009 are plotted here for SEA and Enumclaw (Fig. 3a) and GEG and Spokane (Fig. 3b). There is a striking correspondence between hotter (cooler) days and higher (lower) O₃ concentrations in western WA; the correlation coefficient between the two time series is 0.84 (other years had comparable values). There is also a positive relationship between

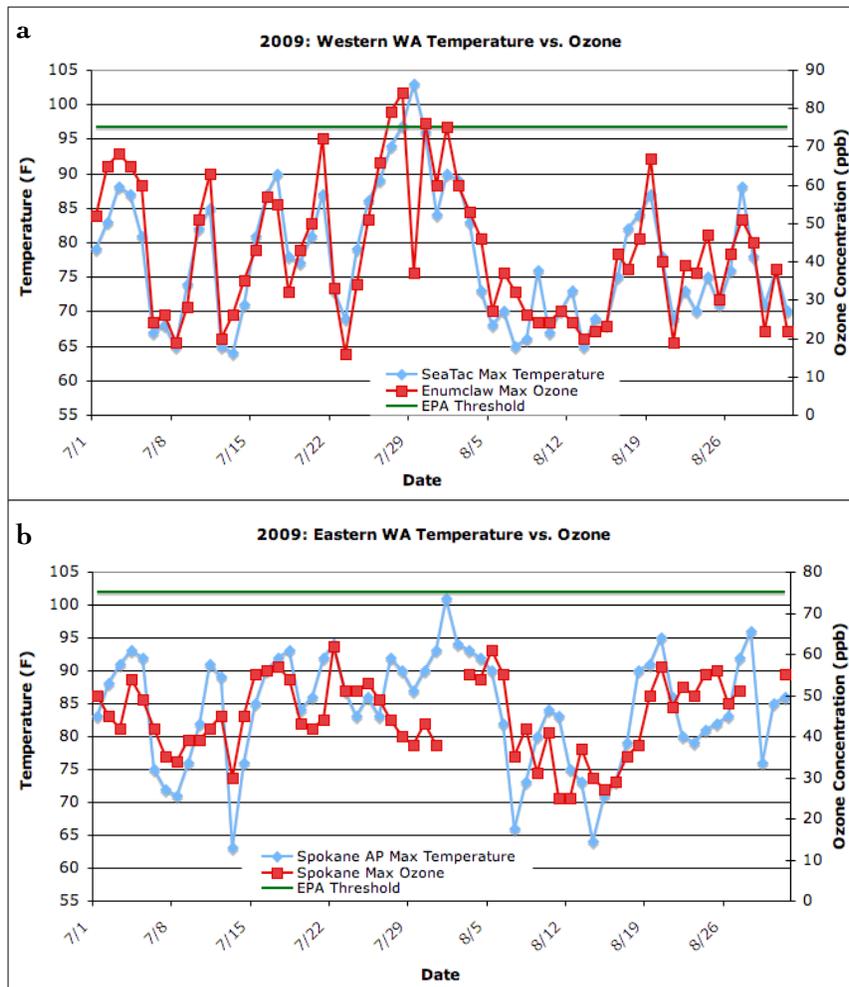


Figure 3: July and August 2009 maximum temperature (blue) and ozone concentration (red) for a) Seattle (max T) and Enumclaw (O₃) and b) Spokane. The green line represents the EPA threshold for O₃ to impact human health.

temperature and O₃ in Spokane, but with a lower value for the correlation coefficient (0.62 in 2009). Note that while temperatures are generally hotter in Spokane than in Seattle, peak O₃ concentrations (smog events) are greater in western WA. This difference can be attributed primarily to the higher population in the Puget Sound region, and hence greater emissions of NO_x and VOC.

It is clear that unseasonably warm and sunny days are typically accompanied by elevated ozone levels. But are the very hottest days necessarily the most polluted? The scatterplot of maximum air temperature at SEA versus maximum O₃ concentration at Enumclaw for all of the heat waves at SEA since 2000 (Fig. 4) suggests otherwise. There have been 5 of these heat waves for which the peak temperature was 90°F, and the maximum O₃ concentrations have ranged from 55 to 99 ppb, i.e., from the lowest to the second-highest in the set. The all-time record heat of July 2009, including a 103°F at SEA, was accompanied by elevated O₃, but six other heat waves in the last decade had higher levels. The time series for 2009 shown in Fig. 3a hints at a possible explanation. Specifically, note that a somewhat lower value of maximum O₃ was recorded at Enumclaw on the hottest day at SEA (29 July). During that particular

temperature and O₃ in Spokane, but with a lower value for the correlation coefficient (0.62 in 2009). Note that while temperatures are generally hotter in Spokane than in Seattle, peak O₃ concentrations (smog events) are greater in western WA. This difference can be attributed primarily to the higher population in the Puget Sound region, and hence greater emissions of NO_x and VOC.

It is clear that unseasonably warm and sunny days are typically accompanied by elevated ozone levels. But are the very hottest days necessarily the most polluted? The scatterplot of maximum air temperature at SEA versus maximum O₃ concentration at Enumclaw for all of the heat waves at SEA since 2000 (Fig. 4) suggests otherwise. There have been 5 of these heat

day, southeasterly winds were observed at North Bend, WA in the Cascade foothills, while 28 and 30 July had winds from the northwest (not shown). It appears that air originating from the urban portion of the Puget Sound did not make it all the way into the foothills on 29 July. As an aside, stations near the Sound such as SEA and Boeing Field had northwesterly winds on all three afternoons. It makes sense that the details in air trajectories would be important to the peak O_3 concentrations in any particular spot, but a complete analysis is well beyond our present scope. The bottom line is that the hottest days do not necessarily have the very highest O_3 concentrations.

Additional information on ozone in the Pacific Northwest is available from the Puget Sound Clean Air Agency, among other organizations. In general, O_3 is limited more by VOC rather than NO_x in this region. A major source of both constituents is vehicular emissions. Conifer trees can also be a significant source of VOC, and in turn, can be adversely impacted by high O_3 levels. Forecasts for O_3 out to about 2 days are available on WSU's Airpact website (<http://lar.wsu.edu/airpact/>). When hot weather is expected, everyone can do their part in minimizing smog by trying to limit use of motorized vehicles and to reduce other sources of VOC and NO_x . Besides isn't it better to be sipping a cool drink in the shade rather than stuck in traffic during that kind of weather?

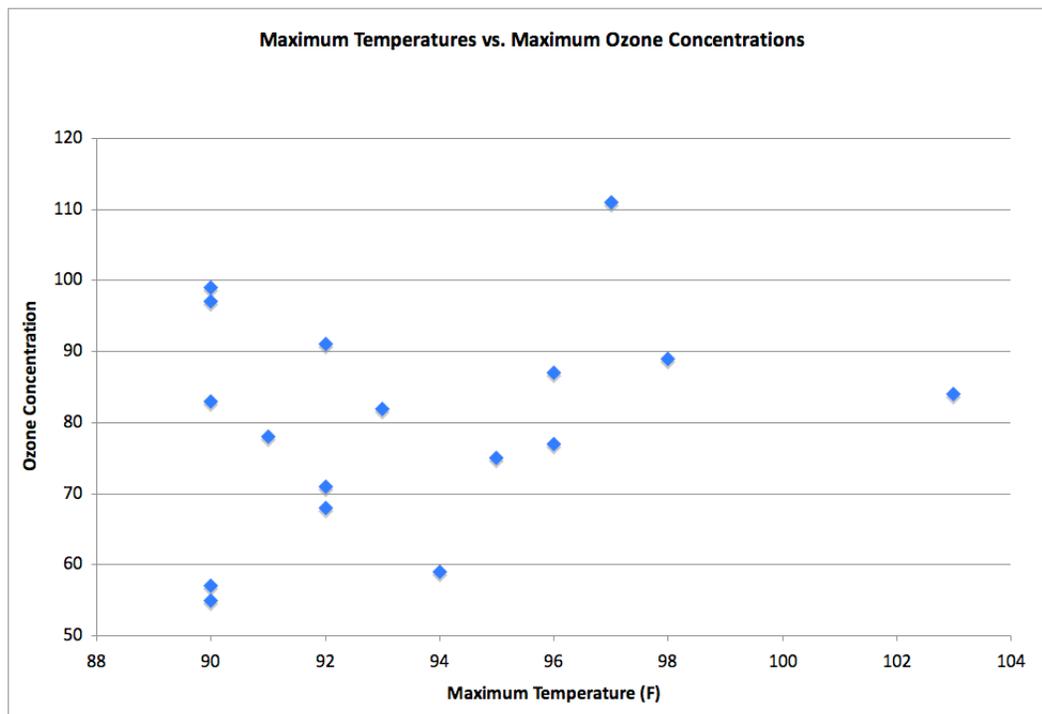


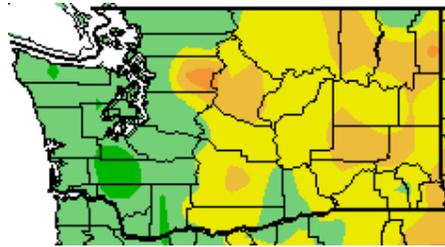
Figure 4: Scatterplot of maximum temperature at SEA (°F) versus maximum 8-hr O_3 concentrations (ppb) at Mud Mountain Dam in Enumclaw. Each maximum represents the peak value over a period from the day before to the day afterwards during which the maximum temperature at SEA reached 90°F or higher. The data is from 2001-2011.

Climate Summary

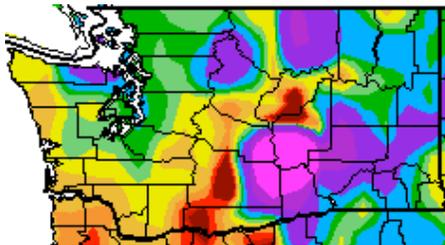
Average July temperatures west of the Cascade Mountain crest were near-normal to below normal (to about -2°F), as shown in the map from the High Plains Regional Climate Center below and indicated in Table 1. The central and southern Puget Sound region was on the cooler end of the spectrum, with temperatures about 1.5°F below normal (Table 1).

Vancouver was an exception with the average July temperature matching exactly the 30-year normal (Table 1). East of the Cascade crest was warmer than normal during July, with the average temperatures up to about 4°F above normal. There was of course a range in the departures from normal on the east side as well; for example, Omak was closer to normal (0.8°F; Table 1) and Yakima much warmer than normal (3.6°F; Table 1).

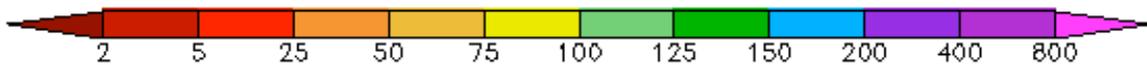
Total July precipitation varied throughout the state, and was much above normal in parts of southeast, northeast, and north central WA (Table 1), mostly from thunderstorm activity. Precipitation was also above normal throughout the Puget Sound region, with SeaTac precipitation at 149% of normal. The coast, southwest WA, and parts of central WA were drier than normal, with Yakima a dry spot, only receiving 18% of normal precipitation.



Temperature (°F)



Precipitation (%)



July temperature (°F) departure from normal (top) and July precipitation % of normal (bottom). (High Plains Regional Climate Center (<http://www.hprcc.unl.edu>); relative to the 1971-2000 normal).

	Mean Temperature (°F)			Precipitation (inches)		
	Average	Normal	Departure from Normal	Total	Normal	% of Normal
Western Washington						
Olympia	62.6	63.8	-1.2	0.90	0.63	143
Seattle WFO	64.6	65.9	-1.3	1.70	0.79	215
Sea-Tac	64.3	65.7	-1.4	1.04	0.70	149
Quillayute	58.0	58.9	-0.9	1.93	1.98	97
Bellingham AP	62.0	62.3	-0.3	1.70	1.18	144
Vancouver	68.4	68.4	0	0.24	0.69	35
Eastern Washington						
Spokane AP	72.1	69.8	2.3	0.84	0.64	131
Wenatchee	76.3	74.2	2.1	0.37	0.27	137
Omak	73.5	72.7	0.8	3.21	0.81	396
Pullman AP	67.2	65.6	1.6	0.20	0.69	29
Ephrata	75.6	74.2	1.4	0.87	0.40	218
Pasco AP	76.1	73.5	2.6	0.60	0.28	214
Yakima AP	74.2	70.6	3.6	0.04	0.22	18

Table 1: July 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 continue to be ENSO-neutral. The Climate Prediction Center (CPC) released an “El Niño Watch” in early June (updated in July), indicating that there’s about a 50% chance that an El Niño will develop by boreal autumn (http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_advisory/ensodisc.html). In the last 4 weeks, sea-surface temperature (SST) anomalies have been between 0.5°C and 1°C in the eastern Pacific Ocean, according to the CPC. Most forecasters are leaning towards the development of El Niño in the upcoming winter season due to the skill that the dynamical models have at this time of year; those models are indicating relatively warm winter SSTs. On the other hand, most of the statistical models are predicting neutral conditions to last throughout next winter so there’s still a chance that the neutral conditions will persist. The chances of another La Niña occurring remain very small.

The CPC three-class temperature outlook for August calls for increased chances of below normal temperatures for the westernmost region of the state and for increased chances of above normal temperatures for the easternmost region of the state. The central portion has equal chances of below, equal to, or above normal August temperatures. The August precipitation outlook indicates below normal precipitation, with higher chances of drier conditions west of the Cascade Mountains. It bears mentioning that the most recent set of Numerical Weather Prediction model runs suggest the entire state may be on the warm side during the first half of August.

The CPC 3-month seasonal outlook for August-September-October (ASO) has equal chances of below, equal to, or above normal temperatures for the whole state. The ASO precipitation outlook indicates higher chances of below normal precipitation for the western third of the state while the remainder of the state has equal chances of below, equal to, or above normal precipitation.



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



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