Office of the Washington State Climatologist

October 2020 Report and Outlook

October 7, 2020

http://www.climate.washington.edu/

September Event Summary

Average September temperatures were warmer than normal throughout WA state. Figure 1 shows the mean temperature percentiles for WA, indicating that September temperatures were much above normal to record high in western WA and the Cascade Mountains. Total precipitation, on the other hand, was above normal in western WA and below normal in eastern WA. An interesting feature of the precipitation was that it fell exclusively in the second half of the month; Figure 2 shows the daily precipitation totals for SeaTac Airport, illustrating a completely dry first 13 days of the month.

The start of September was also warmer than usual, with high temperatures in the 90s even in western WA. Record high daily maximum temperatures were set at Hoquiam (85°F) and Walla Walla (99°F) on the 4th, Olympia (91°F - tie), Quillayute (91°F), and Hoquiam (93°F) on the 9th, and Bellingham (85°F), Quillayute (89°F), SeaTac Airport (91°F), and Olympia (91°F) on the 10th, for example. Very strong easterly winds were responsible for the extreme fire growth that occurred in the Pacific Northwest during the second week

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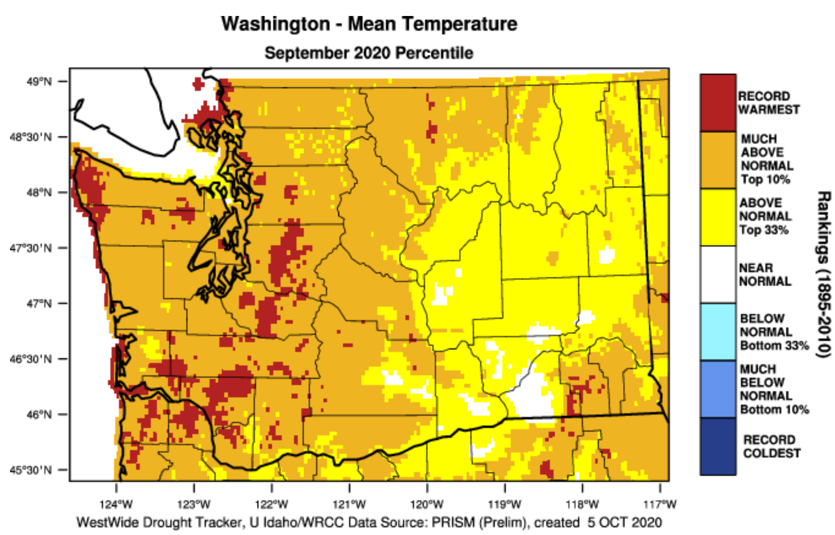


Figure 1: September 2020 mean temperature percentiles (using the 1895-2010 baseline) from WWDT.

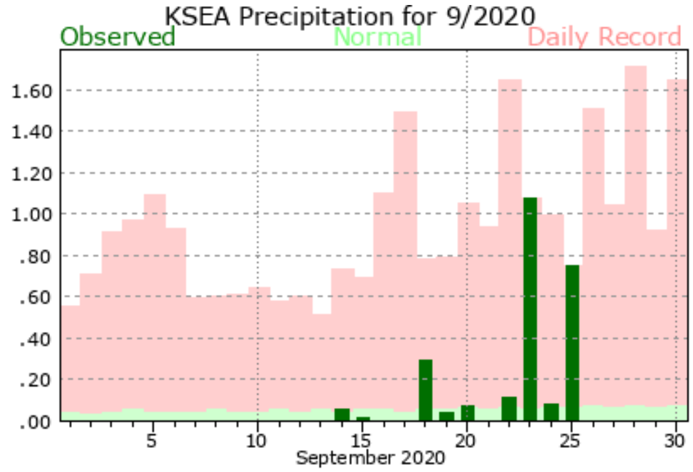


Figure 2: Daily September 2020 precipitation for SeaTac Airport (NWS).

of the month. We examined the daily mean values of the winds at the 850 hPa level (about 5000' above sea level) back to 1950 from the NCEP Reanalysis, specifically, the strength of the easterly component averaged over the area of 45 to 50°N, and 125 to 120°W. This included the western halves of northern Oregon and Washington, and the very southern portion of British Columbia. This measure of the wind was ~10 m/s (~22 mph) on the 8th, which is the 22nd greatest in the entire 70+ year record, and the very strongest during the summer season. Since it was also very warm and dry, we are fortunate that WA did not have more problems on the west slopes of the Cascades.

On the 11th, smoke around the state - from both WA and our neighbors to the south - dropped high temperatures substantially. Our special topic this month (page 4) highlights some of those temperature effects. Typically, a shift to westerly flow would have cleared the smoke out of western WA, but there was such a sizable pool of smoke sitting offshore from the OR and CA fires that extremely poor air quality lasted much longer. There was finally some relief on the 19th and 20th as precipitation moved in.

The precipitation was heavy at times in western WA, and monthly precipitation was brought to above normal values due to a relatively few days of precipitation (8 days in Quillayute and 9 days in Seattle, for example; Figure 2). The Seattle Weather Forecasting Office recorded a maximum daily rainfall amount of 1.35" on the 20th. On the 23rd, Wenatchee (0.30" - tie), SeaTac Airport (1.08"), Olympia (1.23"), and Hoquiam (1.32") recorded maximum daily precipitation records on what was a very wet day statewide.

Finally, the month ended on on a warm note, with temperatures above normal for most of the state. Quillayute had a record high maximum temperatures of 86°F on the 29th.

Registration Open for Water Year Meeting

OWSC has been involved in planning the OR/WA Water Year 2020 Recap and 2021 Outlook Meeting again this year! The event will be virtual, of course, and will be held on the mornings of Wednesday, October 28 and Thursday, October 29, 2020. The meeting will include a weather/climate review of 2020, drought and flooding impacts discussion, and the 2021 outlook provided by NOAA's National Weather Service. We will also have time for plenty of discussion, focusing on water year impacts, an annual water year impacts survey, and an annual impacts assessment. Registration is free but required.

Drought Monitor Update

September precipitation was beneficial for locations in western WA including the Cascade crest, and improvements to the U.S. Drought Monitor depiction were made in those locations (Figure 3). On the other hand, "extreme drought" (D3) was added to a portion of the eastern slopes of the Cascades. This area not only missed out on the precipitation during the second half of September, but water year 2020 ranked among the top 5 driest for several locations within. Low soil moisture provided additional support for the D3 conditions.

September streamflow (Figure 4), on the other hand, was normal to above normal for most of the state due to the heavy rain in the second half of the month. Even on the eastern slopes of the Cascades, streamflows are generally not indicating D3 conditions. There are some exceptions though, namely at the Canadian border and parts of Yakima and Klickitat counties, where streamflows are in the 5 to 10th percentile.

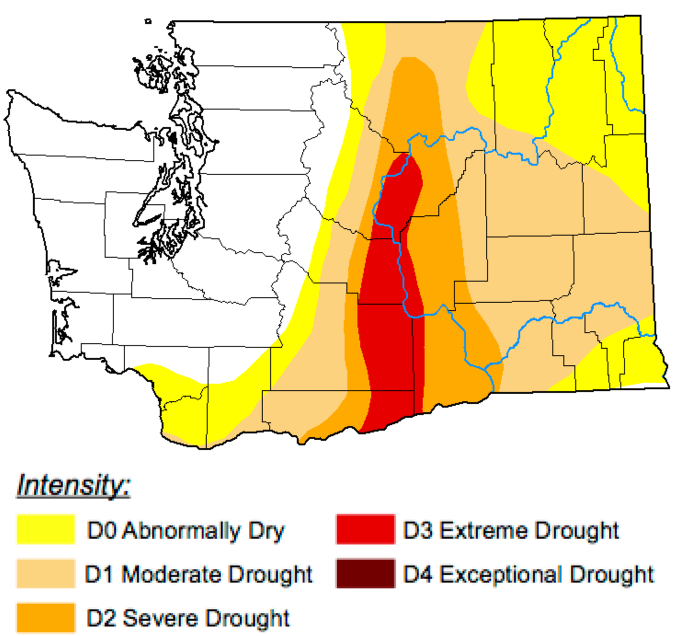


Figure 3: The 1 October 2020 edition of the [U.S. Drought Monitor](#).

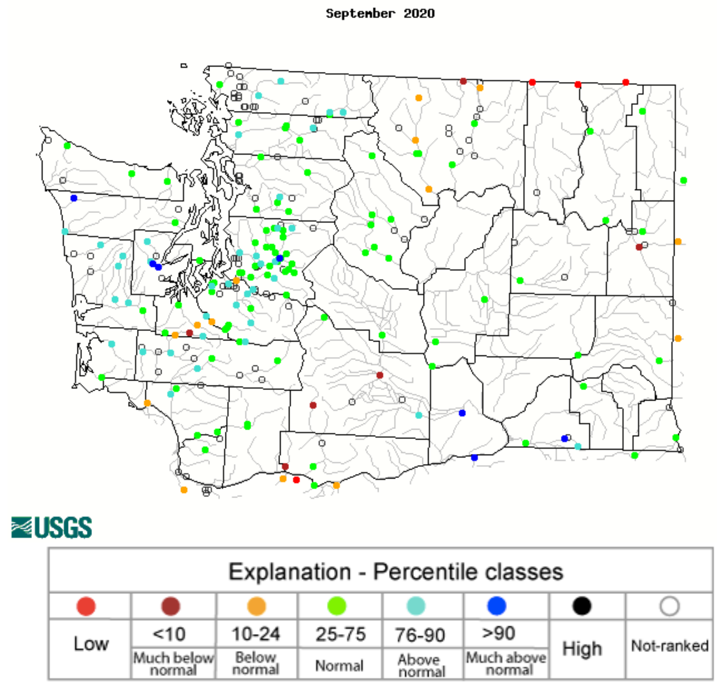


Figure 4: September monthly average streamflow for WA state ([USGS](#)).

The CoCoRaHS Corner

September featured over 10,109 precipitation reports from 408 stations of which 210 submitted reports for each and every day of the month, eerily close to the 212 everyday reporters from August. The strong downpours on the 24th gave impressive tallies, none more than the 4.51" of water that fell at Hoodsport 3.7 WNW, which also featured the most monthly precipitation for any CoCoRaHS station at 8.58". September 30th marks the end of Water Year 2020, and thankfully, the CoCoRaHS website has a succinct summary of the water year for every station which should be available soon.

photo by Henry Reges, CoCoRaHS

Normally, we would continue with the CoCoRaHS Weather and Climate Event, which is a highlight selected from observer submissions of a weather or climate event that is further explored. The hope is to connect with observers beyond just the numbers. Unfortunately, submissions fell off steeply in September to the point which we did not receive any. Submissions can as simple as a sentence and can be submitted via emailing wash.cocorahs@gmail.com.

Cooler Temperatures from the Smoke of September

A message from the State Climatologist

The thick smoke that blanketed much of WA state during a stretch of days in September 2020 is apt to be long remembered. A visible satellite image from the morning of 12 September (Fig. 5) illustrates the grim atmospheric conditions. The event came on the heels of warm and dry weather featuring strong easterly winds – the proximal cause of most of the flare-ups across the region. Here we look into the extent that the cooler temperatures following can be attributed to the smoke.

Our approach has been to compare observed temperatures with estimates of the temperatures if smoke had been absent. The latter are based on model output statistics (MOS) from short-term (24-36 hour) numerical weather prediction model forecasts. In a nutshell, MOS is a type of statistical post-processing that incorporates a combination of prior observations and model-predicted variables into the future as input data, and statistical relationships derived from historical comparisons between model output and

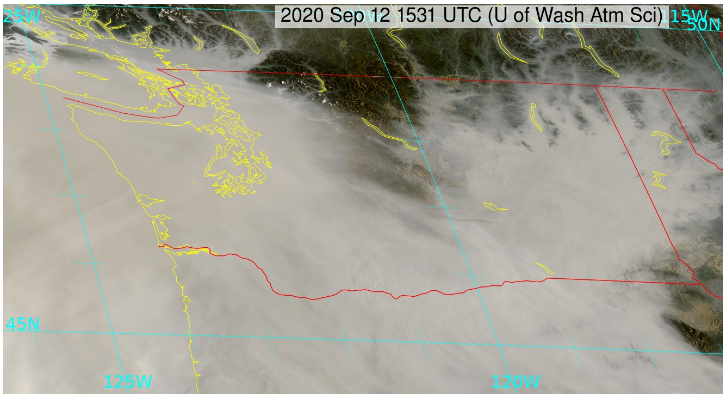


Figure 5: Visible satellite image of smoke from 8:30 am on 12 September.

actual station observations of temperatures, winds, clouds, etc. MOS forecasts can account for model biases and site-specific effects, and have been shown to be quite skillful (e..g., Baars and Mass 2005). An important point for the present application is that the MOS forecasts we consider here for the most part do not account for the smoke that was present, and hence represent a means for crudely estimating what the temperatures would have been without the smoke. More specifically, we compare the observed maximum and minimum temperatures with their MOS counterparts from NOAA's Global Forecast System (GFS) model for Seattle (KSEA) and Omak (OMK) in the Okanogan valley of north-central WA for 5-20 September. We complement these comparisons with time series of the daily values of the air quality index (AQI), and downward shortwave radiation, from nearby stations. The AQI pertains to surface concentrations of PM2.5 and hence low-level smoke, while the insolation relates to vertically-integrated absorption and scattering of the sunlight and hence the impacts of the smoke aloft, and clouds, of course.

We begin with time series of daily AQI and solar radiation for Seattle (Fig. 6a) and Omak (Fig. 6b). Seattle had an AQI exceeding 200 ("very unhealthy") from 11-15 Sept, followed by continuous improvement with clean air by the 19^{th}; OMK was quite smoky on the 8^{th}, had a few days of somewhat better air quality and then again really foul air ("hazardous") from the 12^{th} through 15^{th} with peak particulate concentrations on the 13^{th} and 14^{th}. The solar radiation was inversely related to the AQI at the two locations, but not strictly so, especially in Seattle. For example, the first real smoky days in Seattle (11 September) and Omak (8 September) included only modest declines in solar radiation. The gloomiest days in Seattle (12 and 18 September) were not the smokiest ones. In Seattle, clouds certainly played a varying role in limiting the solar radiation, particularly on the 18^{th} through the 20^{th} as some welcome wet weather moved in.

For the first 7 days of the interval considered here, the observed maximum temperatures ran a bit warmer than MOS in Seattle (Fig. 7a) and close to equal to MOS in Omak (Fig. 7b). But it was a different story for the next 5-6 days, with observed maximum temperatures systematically colder than the 24-hour MOS forecasts. The peak differentials were 11°F at Seattle on 12 September and 15°F at Omak on 13 September. On the 13^{th} there was even a greater differential for Spokane (GEG), which reached only 67°F on a day which MOS had 87°F. It is interesting that the smoky days of 11 September in Seattle and 8 September in Omak lacked much in the way of discrepancies between the observed and MOS maximum temperatures. Conceivably that could be explained by the smoke being mostly just near the ground, and hence while causing poor air quality having a lesser impact on the insolation. That premise is consistent with short-term forecasts from NOAA's High Resolution Rapid Refresh model with smoke (HRRR-Smoke), which indicated considerably

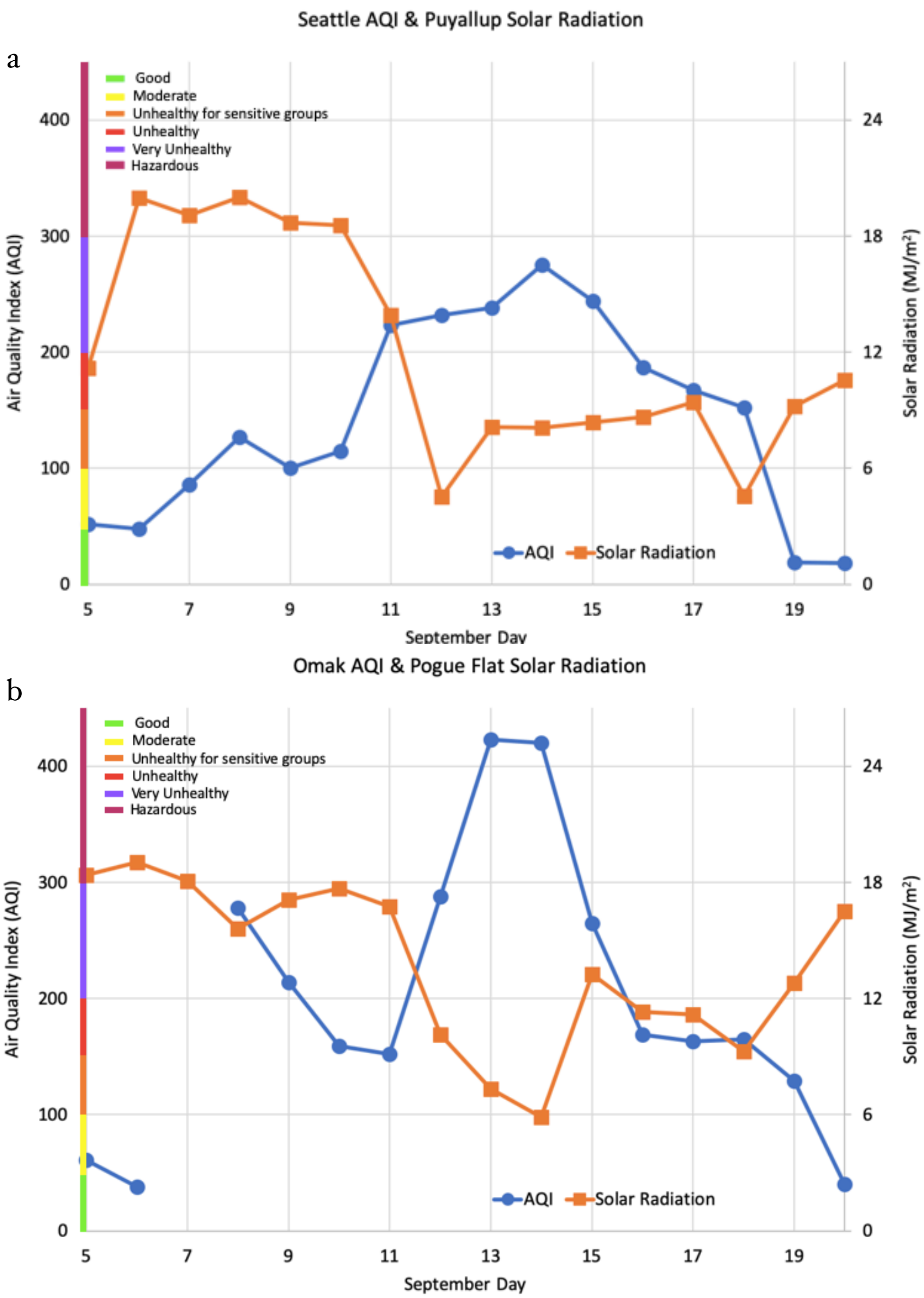


Figure 6: Daily average AQI for (a) Seattle and (b) Omak with daily solar radiation from nearby Puyallup (a) and Pogue Flat (b) WSU's AgWeatherNetwork (AWN) stations for 5-20 September 2020.

greater smoke concentrations at the surface than aloft for Seattle on the 11th and Omak on the 8th (not shown). In addition, arguably there was a significant impact of the smoke in Seattle on the 11th in that MOS had been consistently underpredicting maximum temperatures, and finally got it about right thanks to the smoke. We note that the observed minimum temperatures were also lower than the 36-hour MOS forecasts during the smoky period in Seattle, as opposed to during the cleaner air from the 5th through the 9th, when they tended to be higher. More or less the same sort of effect seems to have occurred in Omak, recognizing that it had decent air quality only near the start, and at the very end, of the interval considered here. This is an interesting result in that one might suppose that a layer of thick smoke would act like a cloud deck in terms of increasing the downward longwave radiation, and ultimately suppressing near-surface cooling at night. But it turns out that because smoke is largely composed of small particles, it has minimal impacts on the longwave radiation (e.g., Sokolik et al. 2019). It appears that it was relatively cold at night largely because the previous days were chilly.

We recognize that this piece belabors the obvious that blocking sunlight results in cooler temperatures but at the same time we thought that the readers of this newsletter would be

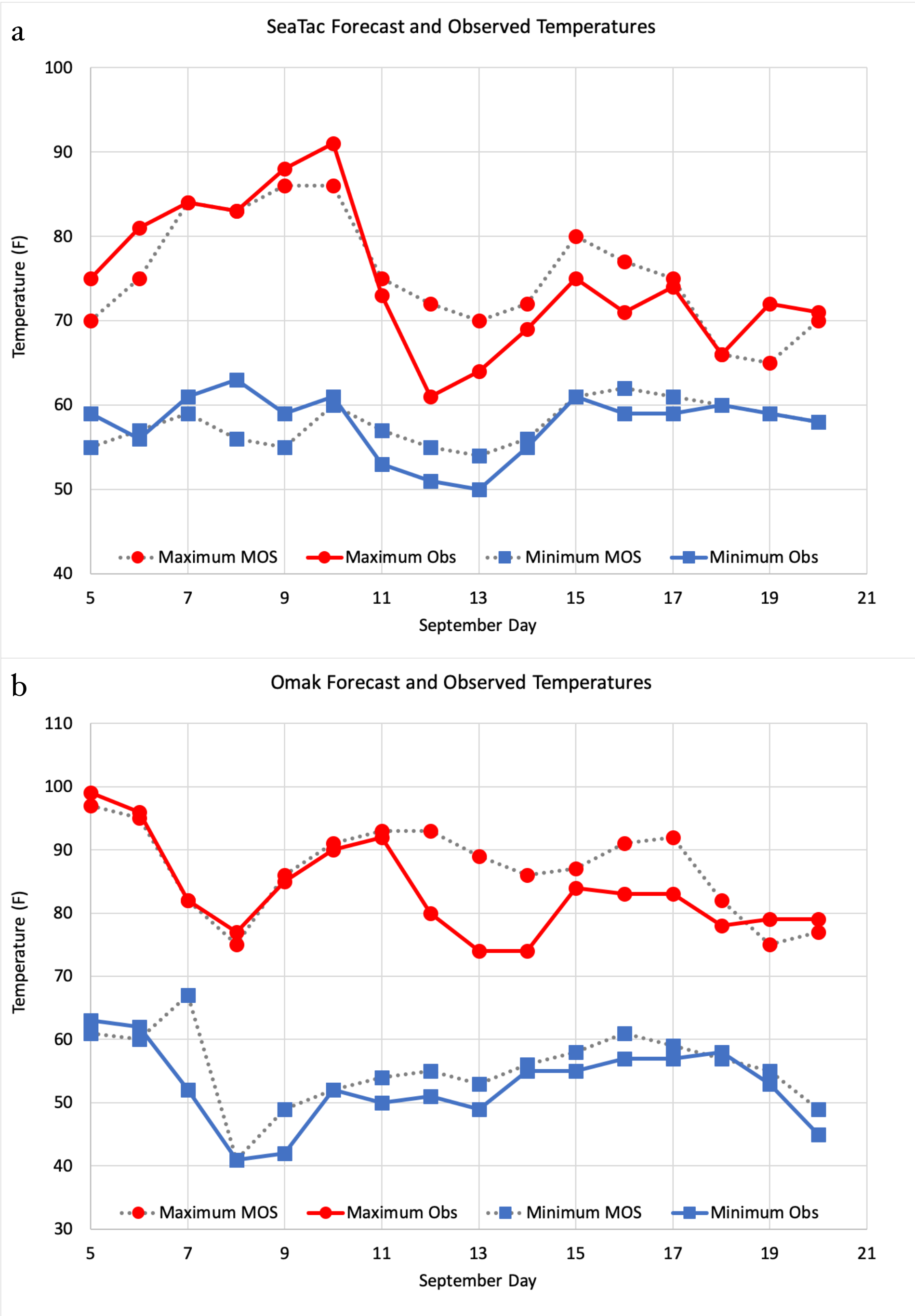


Figure 7: Time series of GFS maximum and minimum temperature forecasts and corresponding observed temperatures for (a) SeaTac Airport (KSEA) and (b) Omak (KOMK) for 5-20 September 2020.

interested in the magnitude of the effect. The situation was complicated by the interactions between smoke and clouds. It was relatively cold in Seattle on 12 September not just from smoke - concentrations were higher the next 3 days - but also because the cool temperatures allowed low water clouds and fog to hang around all day. Moreover, smoke concentrations near the surface do not necessarily correspond with those aloft. We are all glad that the abysmal air quality is behind us, and close with the saving grace that at least the cooler temperatures associated with the smoke helped knock down the vigor of the fires that were raging.

References

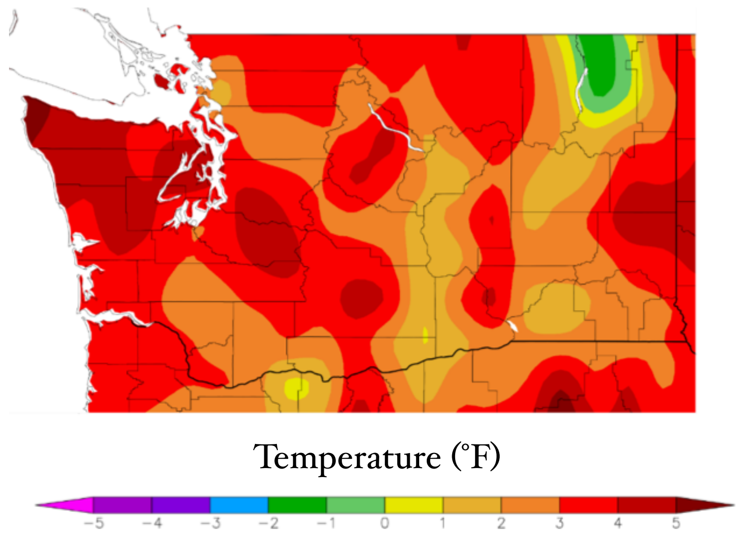
Baars, J. A., and C. F. Mass (2005): Performance of National Weather Service forecasts compared to operational, consensus, and weighted model output statistics. *Wea. Forecast.*, **20(6)**: 1034-1047. doi: 10.1175/WAF896.1

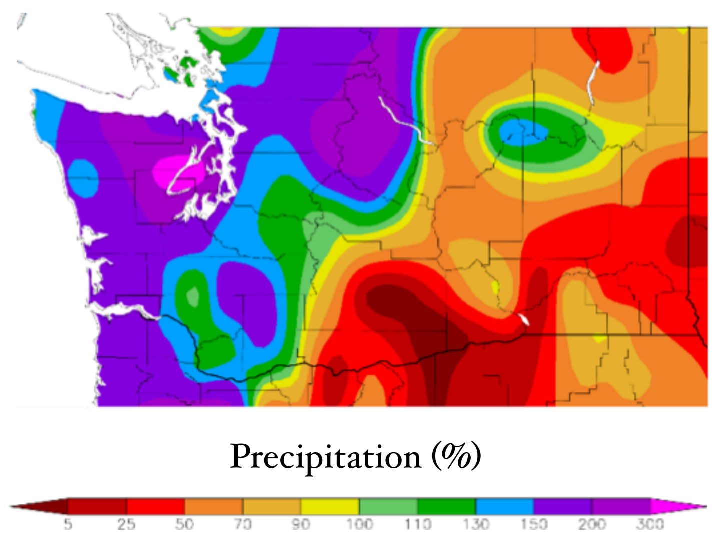
Sokolik, I. N., A.J. Soja, P.J. DeMott, and D. Winker (2019): Progress and challenges in quantifying wildfire smoke emissions, their properties, transport, and atmospheric impacts. *J. Geophys. Res.*, **124**, 13,005–13,025. https://doi.org/10.1029/2018JD029878

Climate Summary

Mean September temperatures were above normal statewide aside for a sliver of below normal temperatures in NE Washington. Warm pockets existed throughout the state, and while temperatures were generally higher in eastern Washington, temperatures were especially warm in western Washington. The northwest tip of the Olympic Peninsula featured the greatest departure from normal with temperatures over 5°F warmer than normal. Quillayute fell on the border of this maxima with temperatures 4.9°F above normal, which was equal to the temperature anomaly in Bellingham. SeaTac also featured notable warmth with temperatures 4.2°F above normal, and in Pullman, the opposite corner of the state, temperatures were 4.0°F above normal (Table 1). While most warm pockets do not appear to be distinctly associated with a geographical region, the central Columbia River Basin had lesser warm anomalies than the neighboring regions. Both Wenatchee and Ephrata, which lie in the central Columbia Basin had temperature anomalies 2°F cooler than nearby Omak.

September precipitation totals are dominated by an east-west divide along the Cascades with well above normal precipitation in western Washington and below normal precipitation in eastern Washington. Impressive precipitation totals in western Washington are mostly due to an atmospheric river event arriving on September 23rd. The Seattle WFO recorded 4.16" or 274% of normal precipitation for September (Table 1), and its nine days of recorded precipitation all came in the later half of the month. Quillayute received just over one inch more precipitation than Seattle WFO, but due to its wetter climate, this value amounted to 134% of normal. The east slopes of the Cascades did not miss out on precipitation as Wenatchee experienced 91% of its normal precipitation, but 35 miles away in Ephrata only 56% of normal precipitation fell - a difference of 0.11". A paltry precipitation sum of 0.05" was recorded in Pasco contributing to the 0.26" of rain that has fallen since July 1st.





September temperature (°F) departure from normal (top) and precipitation percent 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	62.6	58.9	3.7	3.33	1.71	195
Seattle WFO	65.4	61.6	3.8	4.16	1.52	274
SeaTac AP	65.5	61.3	4.2	2.48	1.50	165
Quillayute	61.5	56.6	4.9	5.13	3.82	134
Hoquiam	62.4	58.7	3.7	3.78	2.28	166
Bellingham AP	62.1	57.2	4.9	2.19	1.78	123
Vancouver AP	66.9	63.6	3.3	1.29	1.56	83
Eastern Washington						
Spokane AP	64.1	60.2	3.9	0.33	0.67	49
Wenatchee	66.4	64.4	2.0	0.31	0.34	91
Omak	66.4	62.6	3.8	0.35	0.58	60
Pullman AP	62.2	58.2	4.0	0.17	0.78	22
Ephrata	65.5	63.8	1.7	0.20	0.36	56
Pasco AP	66.8	63.4	3.4	0.05	0.40	13
Hanford	68.1	66.4	1.7	0.18	0.31	58

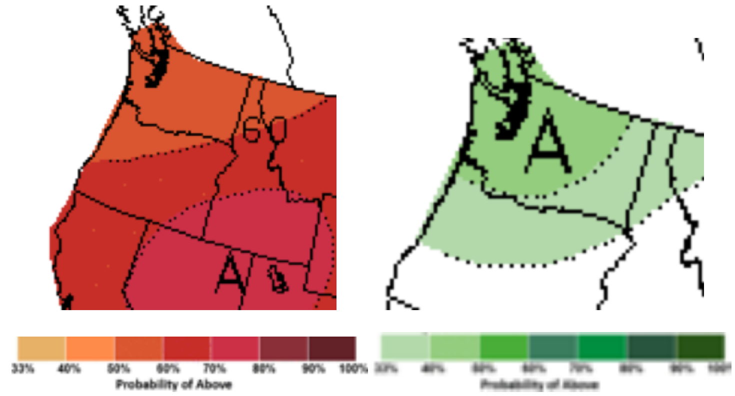
Table 1: September 2020 climate summaries for locations around Washington with a climate normal baseline of 1981-2010. Note that the Vancouver Pearson Airport and Seattle WFO 1981-2010 normals involved using surrounding stations in estimating the normal, as records for these station began in 1998 and 1986, respectively.

Climate Outlook

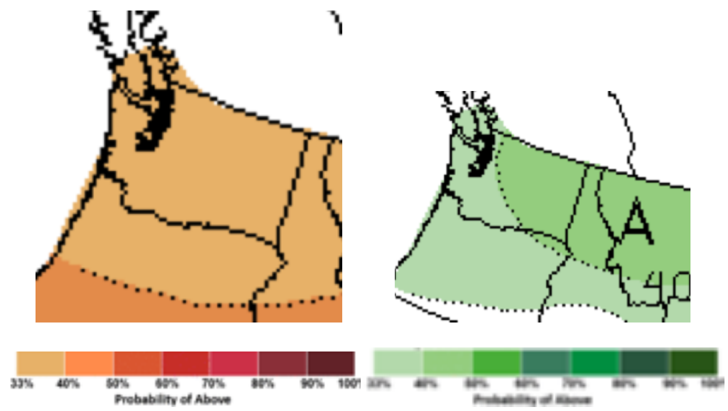
According to the Climate Prediction Center (CPC), La Niña conditions are present in the equatorial Pacific, and are expected to remain in place through winter 2021. During September, the area of below normal sea surface temperatures (SSTs) expanded west across the international dateline to encompass all Niño Regions. While SSTs slightly increased in the eastern equatorial Pacific in the last two weeks, Niño3.4, the principal Niño region for specifying the state of ENSO, featured further cooling by -0.2°C to -1.1°C. Since the last climate outlook, ENSO models have pointed towards a La Niña event lasting through winter. Previously, models were indicating a weak La Niña dissipating in the winter months. ENSO models show a fair amount of confidence with a 74% chance of La Niña persisting through February 2021.

The CPC October temperature outlook has elevated odds in the 50-60% range of above normal temperatures across the entire state. The October precipitation outlook has increased odds of wetter than normal weather across WA, with less of an indication in the SE corner of the state.

The three month (October-November-December) outlook places slightly increased chances of above normal temperatures across the state. In a breakdown akin to the one month prediction, there are increased chances of above normal precipitation statewide, in this case with higher confidence for the northern and eastern portions of WA.



October outlook for temperature (left) and precipitation (right)



October-November-December outlook for temperature (left) and precipitation (right)

(Climate Prediction Center)