

State Climate Extremes Committee Memorandum

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SUBJECT: New Value for Washington Maximum Temperature Record at Hanford,
WA

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Summary

In late June 2021, an extremely anomalous heat wave struck the Pacific Northwest. Multiple stations throughout Washington and Oregon broke all-time station records, and in some cases, shattered them by wide margins. Seattle, WA broke its all-time record by 5°F. A number of observations from several different networks reported temperatures exceeding the 118°F all-time Washington state maximum temperature record.

A State Climate Extremes Committee (SCEC) was assembled in early July 2021 to investigate a new potential state record maximum temperature. Conference calls were convened on 8 July, 16 September, 25 October and 8 December. The task of this team was especially challenging given that there were a number of reported temperatures of 118°F or higher, and that most of these reports came from non-National Weather Service (NWS) sources.

After considering the evidence, surrounding observations, and the meteorological situation, the members of the SCEC voted 5-0 to accept the observation taken at station H100F in the Department of Energy Hanford Nuclear Reservation (aka Hanford Site) mesonet of 120°F as the new official maximum temperature record for the state of Washington. **Thus, the Maximum Temperature record for the State of Washington that is true and valid is:**

- **Location:** Hanford
- **Site Type:** Hanford Mesonet
- **Site ID:** H100F
- **Maximum Temperature Record:** 120°F
- **Date:** 29 June 2021

About the State Climate Extremes Committee (SCEC)

The (SCEC) was composed of members representing the National Weather Service Forecast Office in Spokane, Washington, National Weather Service's Western Region Headquarters Integrated Services Division (ISD) in Salt Lake City, Utah, the Western Regional Climate Center in Reno, Nevada, the Office of the Washington State Climatologist in Seattle, Washington, and the National Centers for Environmental Information (NCEI) in Asheville, North Carolina. It is convened to adjudicate potential records for validity. If validated, the observation is considered the state record for that record type. More details about the SCEC are available online at <https://www.ncdc.noaa.gov/extremes/scec/details>.

Extreme Temperature Candidates Considered by the SCEC

The SCEC had a considerable number of temperature reports to consider for potential record tying or setting values. This was in part due to the extreme and widespread nature of this event. But, this was also a result of the recent proliferation of weather observation

networks, as well as the computer sites that accumulate and store the observations (e.g. MesoWest, MADIS). Sorting through all of these reports and weighing their validity was a long task that may be scrutinized by others. Table 1 lists all of the potential temperature observations from 28-29 June 2021 that the team examined.

Table 1 (below and continued on the next page). Washington temperature observations that potentially tied or exceeded the all-time maximum temperature record of 118°F on 28-29 June 2021. Data was obtained from MesoWest and the Hanford Site. *Note: for Hanford Mesonet sites, the reported maximum temperature on MesoWest and in the table below used the instantaneous temperatures, not the 15 minute average temperatures.*

Station ID	Station Name	Agency	Reported Max Temperature	Date
EMBW1	Mill Creek at 5 Mile Bridge near Walla Walla	WA Dept of Ecology	134°F	29 June 2021
E5129	Winona	CWOP	131°F	29 June 2021
TUCW1	Tucannon River near Starbuck	WA Dept of Ecology	126°F	29 June 2021
WALW1	Walla Walla River at East Detour Road	WA Dept of Ecology	124°F	29 June 2021
AGCW1	Asotin Creek above George Creek	WA Dept of Ecology	124°F	29 June 2021
ACRW1	Alpowa Creek at Mouth near Clarkston 8W	WA Dept of Ecology	123°F	29 June 2021
PHAW1	Pataha Creek near Starbuck 7E	WA Dept of Ecology	123°F	29 June 2021
WHIW1	White River near Plain 13NW	WA Dept of Ecology	123°F	29 June 2021
AN639	Darrington	WA Dept of Ecology	120°F	28 June 2021
H100E	Hanford 100F Area	Hanford Mesonet	120°F	29 June 2021
TRCW1	Touchet River at Cummins Rd	WA Dept of Ecology	119°F	29 June 2021
TTWIN	Twin Bridges	WSDOT	119°F	29 June 2021
IR225	SR225 Interchange Hanford	WSDOT	119°F	29 June 2021
TBELO	Beloit Hanford	WSDOT	119°F	29 June 2021
DCRW1	Deadman Creek near Gould City	WA Dept of Ecology	119°F	29 June 2021
ROAW1	Roaring Creek near Entiat 6W	WA Dept of Ecology	119°F	29 June 2021

		Ecology		
PCKW1	Peshastin Creek at Green Bridge Rd near Peshastin 1S	WA Dept of Ecology	119°F	29 June 2021
H100K	Hanford 100K Area	Hanford Mesonet	118.9°F	29 June 2021
H100A	Hanford 100A area	Hanford Mesonet	118.7°F	29 June 2021
HEDNA	Hanford Edna	Hanford Mesonet	118.7°F	29 June 2021
HHMS	Hanford Meteorological Station	Hanford Mesonet	118.6°F	29 June 2021
HWPPS	Hanford WPPS	Hanford Mesonet	118.5°F	29 June 2021
SDQW1	Sol Duc River	WA Dept of Ecology	118.4°F	28 June 2021
HFFTF	Hanford Fast Flux Test Facility	Hanford Mesonet	118.2°F	29 June 2021
KDLS	Dallesport	NWS ASOS	118°F	28 June 2021
MAWW 1	Mayfield	NWS COOP	118°F	28 Jun 2021
KRLD	Richland Airport	FAA	118°F	29 June 2021
TMDHN	Mid Hanford	WSDOT	118°F	29 June 2021
C5018	Troutlake	CWOP	118°F	29 June 2021
IFREN	SR12 at Frenchtown Rd	WSDOT	118°F	29 June 2021
BENT.E	Benton East	WSU AgWeatherNet	117.8°F	29 June 2021

During the first meeting of the SCEC, the group discussed all of these temperature reports. The committee agreed that many were unsuitable for further consideration. These decisions were based on the following:

- Some mesonets are put in place with a goal of high-level meteorological accuracy. Other networks have other non-meteorological goals and weather instrumentation is considered a “nice to have” addition.
- Observation networks that were installed and maintained by local, state or federal government agencies tended to instill a higher level of confidence than commercial or privately owned networks. Maintenance records showing routine calibration and repairs were an important consideration.
- Citizen Weather Observing Program (CWOP) sites are privately owned instruments. As such, factors such as siting, maintenance, etc could not be established and likely do not meet SCEC standards.
- Washington State Department of Ecology instruments are located near roads and rivers for purposes of monitoring environmental quality. It is well-established that these locations are not typically considered ideal for representative temperature measurements. Additionally, the temperature sensors themselves are all located above a metal instrument housing, very near the solar panel and the ventilation at the top of the housing (Fig. 1). Because of these sensor housing issues, the readings seemed to be too extreme (warm bias) to be considered valid.

Thus, the committee felt that the remaining observations were worthy of continued consideration. These included the Hanford mesonet, Washington State DOT, ASOS, COOP and Ag Weather Net. All of these are either federal or state government networks.



Figure 1. Washington State Department of Ecology weather station at Alpowa Creek, WA. The temperature sensor is located on the pole in the shielded unit above the metal instrument housing and solar panel.

In order to gain a better spatial sense of where the hottest temperatures occurred during the afternoon of 29 June 2021, the committee also consulted infrared (IR) imagery from several polar-orbiting satellites. This was also done as an additional quality control step, to provide affirmation that the hottest satellite-sensed IR brightness temperatures were, in fact, located in the same spatial areas where the hottest surface temperatures were observed. The 2100 UTC (1300 Local Standard Time) MODIS Aqua Brightness Temperature image from the afternoon of 29 June 2021 (Fig. 2) clearly indicated that the hottest temperatures in Washington state were located in the vicinity of the Hanford Site area, denoted by a large region of bright pinks and blue speckled areas, annotated just to the right of the center of the image (yellow circle). Although satellite brightness temperature cannot be directly compared to 2 meter ambient air temperature, this imagery still helped the committee to rule out anomalous observations from other parts of the state, which were not corroborated by the satellite imagery, and confirm the extreme heat in the Hanford region.

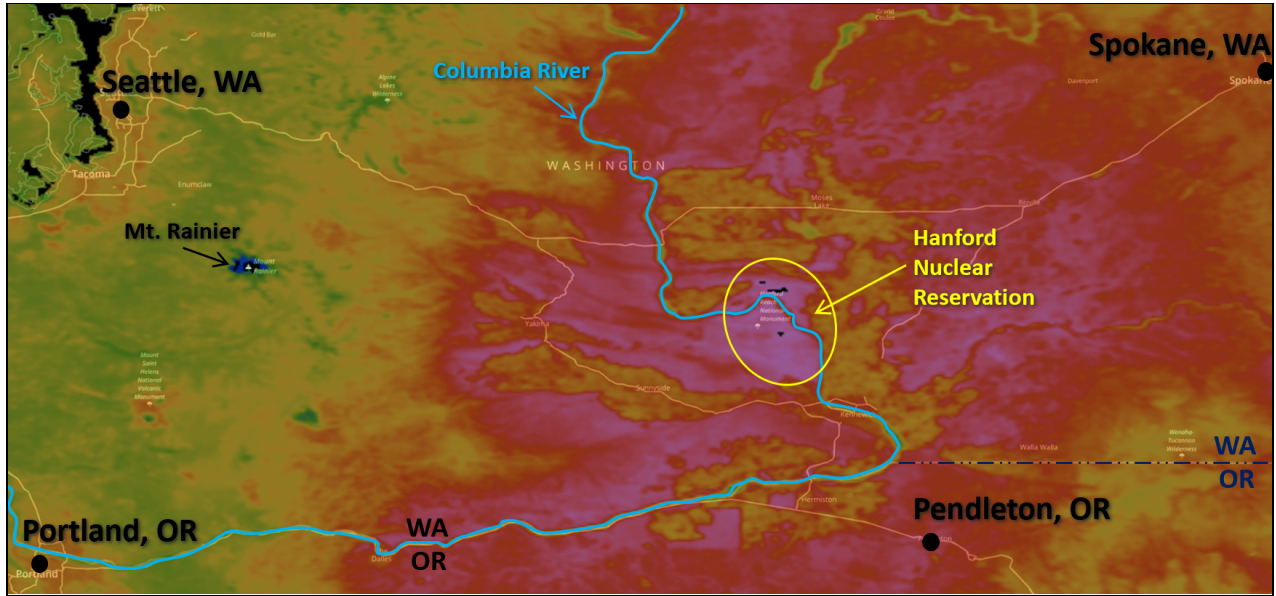


Figure 2. MODIS Aqua brightness temperature around 2110 UTC (210 PM PDT) 29 June 2021. The yellow annotated area highlights the area of hottest MODIS sampled brightness temperature, which also covers the general area of the Hanford Mesonet.

Washington State Department of Transportation (WSDOT) observations were investigated and generally accepted. Their siting in most cases was removed from the highway sufficiently far to mitigate any pavement-warming effects. The network is also well maintained with periodic, and well-documented, calibration visits.

The Hanford Mesonet began on 7 December 1944 with a main station taking hourly observations. Twenty telemetry stations were added in 1982, with additional stations over the subsequent years. Station H100F began observations in March 1986. The mesonet is well maintained with routine annual calibration visits. All of the data is available via request from the Hanford Site (<https://www.hanford.gov/page.cfm/HMS>).

Figure 3 shows the maximum temperatures on 29 June 2021 as recorded by MesoWest. The Hanford mesonet sites exhibited good site-to-site consistency, with all maximum temperatures generally in the 113°F to 119°F range. Additionally, four Washington State DOT temperatures inside the Hanford Site area also recorded high temperatures of 118°F and 119°F. Temperatures around the reservation area also supported the Hanford network readings. Saddle Mountain RAWS (northwest of the Hanford Site) recorded a high of 117°F, while Richland Airport AWOS (bottom of the map) had a high of 118°F.

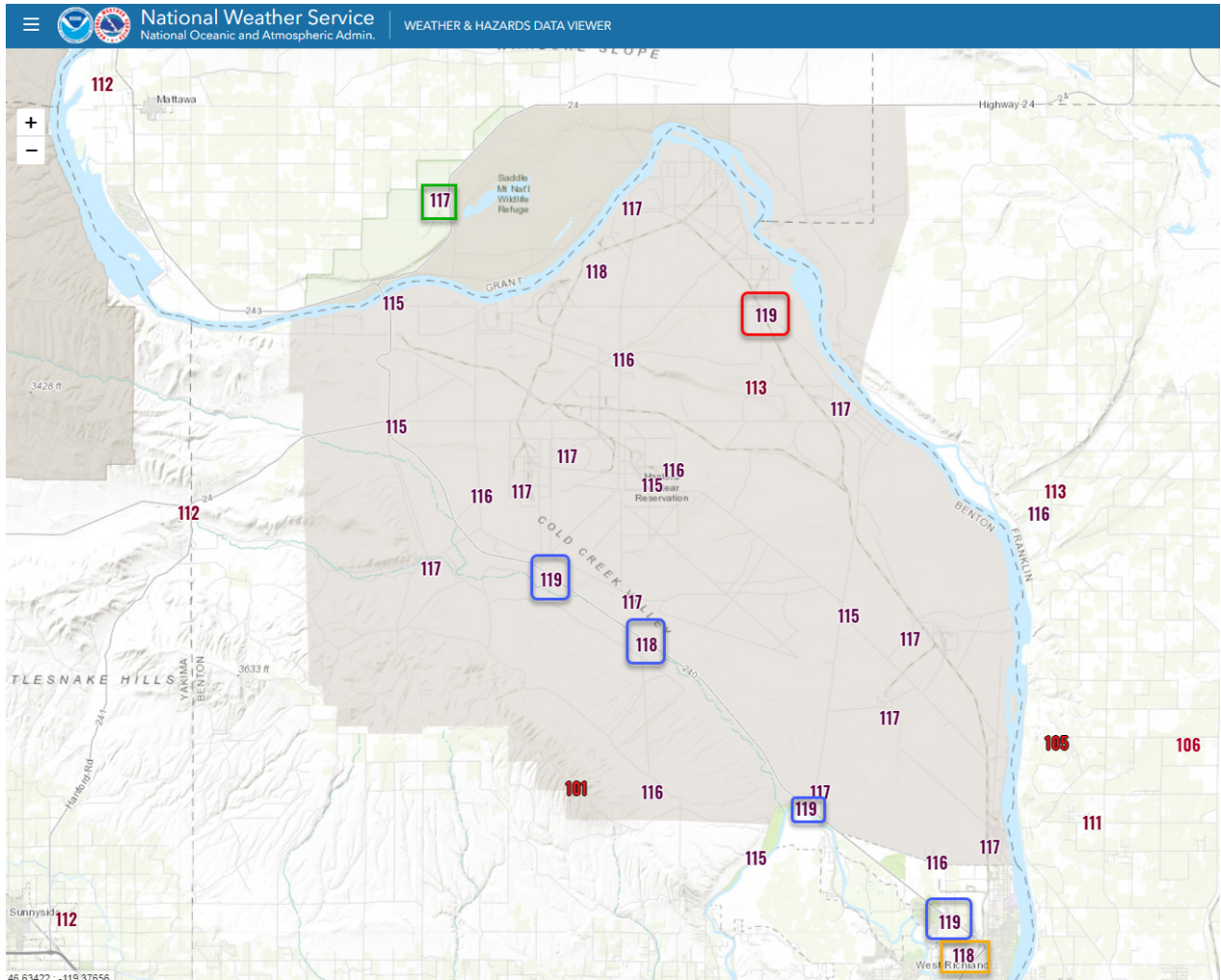


Figure 3. Maximum temperatures recorded in the Hanford area on 29 June 2021. Hanford station H100F is circled in red. Washington State DOT sites are circled in blue. The Richland AWOS is circled in orange. The Saddle Mountain RAWS is circled in green. *Note: for the Hanford mesonet stations, these maximum temperatures are derived from the 15 minute average temperatures, not the instantaneous 5-second temperatures.*

Past Historical Extreme Maximum Temperature Events in Washington State

The current maximum temperature record of 118°F for Washington state was set twice. The first instance dates back to 24 July 1928 at Wahluke in southern Grant County, along the Columbia River. This location was an official NWS Cooperative station, in service from December 1904 to August 1944. The observer, Frederick Koppen, was listed as the “postmaster and orchardist”. Observations from that day showed a number of readings in the area of around 110°F (Fig. 4), but the 118°F at Wahluke was 7 degrees warmer than any nearby COOP location. Still, that reading established the new Washington state record, eclipsing the previous record of 115°F set at Kennewick in 1898. It’s worth noting that the nearest NWS Cooperative observation to Wahluke was Hanford, WA, about 10 miles to the southeast of Wahluke. Hanford reported a temperature of 110°F on that day in 1928. An inspection report in June of 1925 noted that the site had never been inspected, and also requested that the shelter be relocated away from the influence of trees and shrubbery at that time. But there is no indication that the shelter was ever moved.

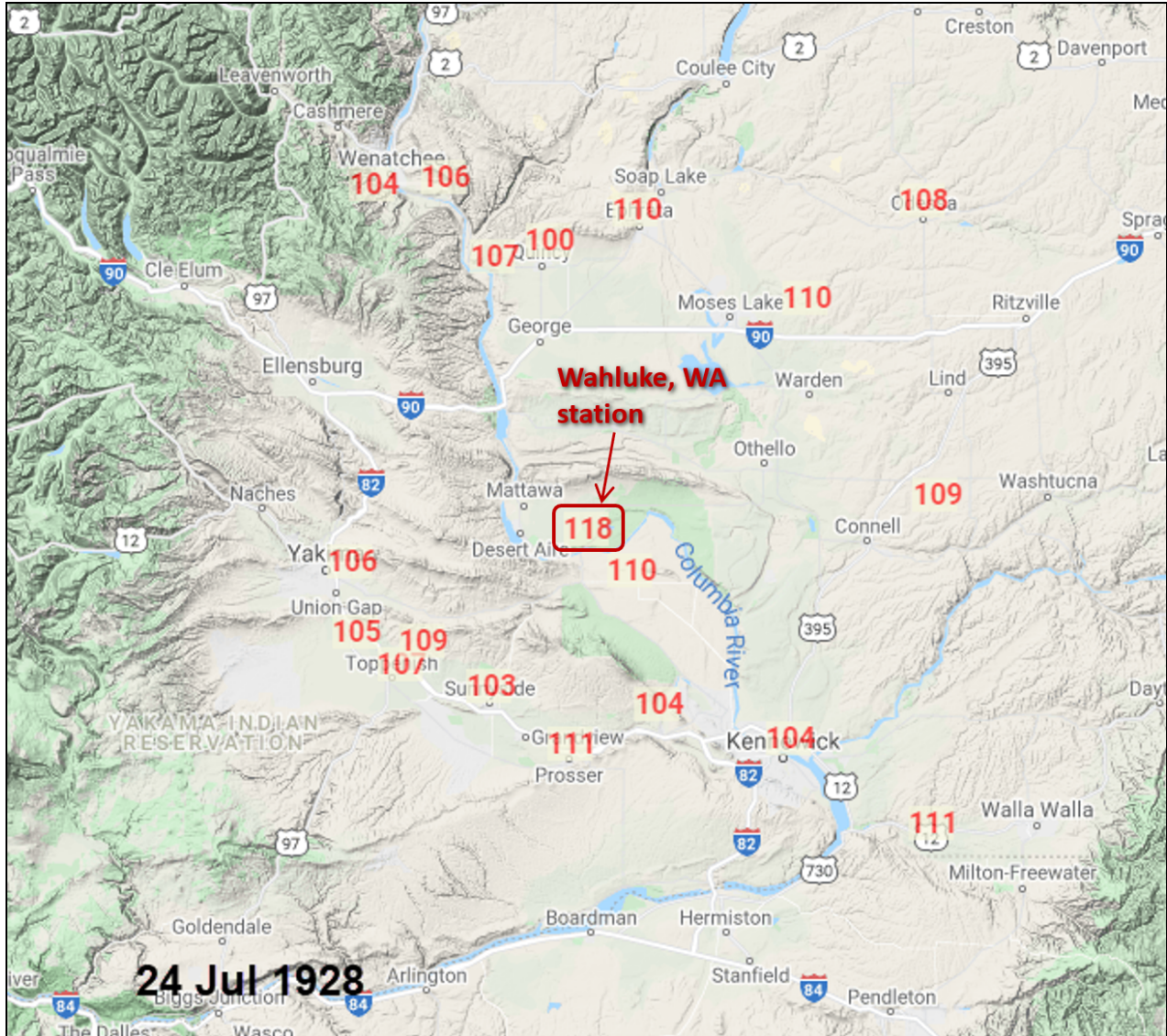


Figure 4. Maximum temperature observations on 24 July 1928. The Wahluke, WA station was located near the center of the image with a reading of 118°F. <http://xmacis.rcc-acis.org/>

This record temperature of 118°F was equaled on 5 August 1961 at the NWS Cooperative site at Ice Harbor Dam, which is located northeast of Tri-Cities, in the comparatively lower elevations of the Snake River valley. Other readings of 113°F and 114°F in the region lend validity to this record temperature reading (Fig. 5). Many locations in eastern Washington set their all-time maximum temperature records during this 1961 event, and as such it was generally recognized as the hottest day in Washington state recorded history. It's worth noting that the Ice Harbor Dam observation site was established only 4 years prior to the 1961 event, in March of 1957. And following the record-setting reading in 1961, the hottest day since 1961 was the 29 June 2021 reading of 109°F.

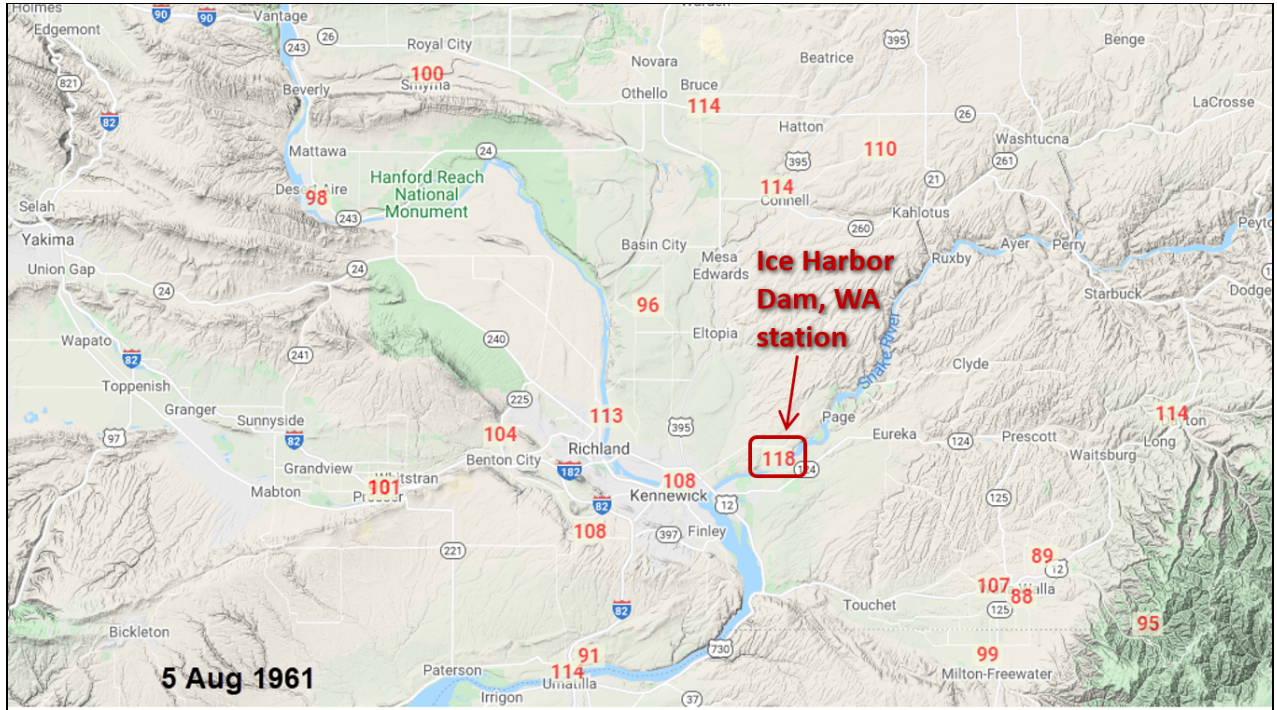


Figure 5. Maximum temperature observations on 5 August 1961. The Ice Harbor Dam, WA station was located near the center of the image with a reading of 118°F. <http://xmacis.rcc-acis.org/>

Meteorological Summary, and Plausibility of the Extreme Maximum Temperature Observations

A period of extreme, and record-breaking heat occurred over the Pacific Northwest, including all of Washington and Oregon, during the last week of June 2021. The event began 24-25 June as an amplified ridge of high pressure throughout the entire depth of the troposphere rapidly strengthened over the Pacific Northwest, with the ridge axis centered over north-central Washington and adjacent areas of southern British Columbia, Canada.

The origins of this ridge of high pressure can be traced back to the Western Pacific where a midlatitude cyclone advected cooler air equatorwards, increasing the north/south temperature gradient, and subsequently enhancing and extending the North Pacific jet stream into the central Pacific (Fig. 6, top row). Around 24 June (Fig. 6, bottom left), this low pressure system underwent cyclogenesis allowing it to not only strengthen but to advect warm and moist subtropical air well into the Pacific Northwest and British Columbia. This in turn shifted the jet stream to the north and amplified the mid-latitude upper level pattern. By 26 June (Fig. 6, bottom right), this amplified pattern resulted in anticyclonic Rossby wave-breaking over western North America creating an anomalous strong ridge that remained relatively stationary through 29 June. Rossby wave breaking is a common planetary-synoptic scale ingredient in regional extreme heat events.

The ability to achieve such warm temperatures with this event was in part due to its persistence. By the morning of 26 June, the Spokane, WA upper air site had already hit its warmest 500 mb temperatures of the event (-2.7 °C) although the warmest surface temperatures did not occur until three days later. Given the stagnant nature of high pressure and the intense June solar radiation, the lower levels of the air mass continued to modify through 0000 UTC 30 June, warming a bit each afternoon. This is demonstrated in Figure 7, which shows the 850 mb temperatures observed at Spokane, WA between 0000 UTC 25 June and 30 June. Each day the warming is observed during the afternoon (0000 UTC) with little to no warming overnight (1200 UTC). This is evidence that most, if not all of the warming during this period, occurred in-situ and speaks to the importance of the longevity of the ridge. Had it not persisted for as long, the air mass would not have had time to develop such warm temperatures and statewide records likely would not have been broken.

This begs the question as to why this ridge was so persistent. It is believed that the persistence of the ridge could be related, at least in part, to tropical cyclone activity in the Western Pacific. It is well known that a tropical cyclone undergoing extratropical transition can and does amplify the downstream flow (Archambault et al 2013; Riboldi et al 2019). In fact, it has been shown that western Pacific tropical activity makes it three times more likely that a blocking ridge of high pressure will develop over the eastern Pacific and/or west coast of North America (Riboldi et al 2018).

Preceding this extreme heat event, a tropical storm developed in the western Pacific on 21 June 2021 and officially became Typhoon Champi on 25 June. On that same day, Typhoon Champi began tracking to the northwest, an indication that it had begun interacting with the midlatitude westerly flow. By this time, the ridge of high pressure had already developed. However, it continued to persist, which may be attributed at least in part to the decaying typhoon being entrained into the mid-latitude westerly flow. And at least in this event, the persistence of such a ridge was likely key to the statewide records being broken.

In addition to the extremely warm air mass and strong deep-layer subsidence contributing to the heat, the location of the center of the ridge axis being to the northeast of Puget Sound and the Willamette Valley meant that easterly downslope winds off the Cascade Mountains also contributed to extreme temperatures to the west of the Cascade crest via adiabatic warming. Another contributor was the extensive soil dryness that encompassed a large portion of Washington and Oregon. Much of the Pacific Northwest had experienced a precipitation deficit, multi-year in some areas, and according to the US Drought Monitor was experiencing moderate to exceptional drought (Fig. 8). Such conditions have been found to be accompanied by higher probabilities of extreme heat waves (e.g., Miralles et al. 2014). Finally, anomalously high dew points across Washington and Oregon undoubtedly played a role in keeping overnight temperatures elevated as water vapor resulted in an enhanced downward longwave radiative heat fluxes. In fact, dew points in the 60°F range were common across coastal Washington and Oregon, with some locations even touching 70°F, which is very unusual for the Pacific Northwest. The intense high pressure ridge persisted through the end of June resulting in a prolonged period of daytime high temperatures well above 100°F in most areas, with overnight lows only falling into the upper 60s to mid 70s in many non-mountainous areas.

Observed temperatures at the Salem, OR, Quillayute, WA, and Spokane, WA upper air soundings revealed the remarkable nature of the warm air mass, with temperatures at the 925, 850, 700, and 500 mb levels for several days that were either at the 99th percentile, or the warmest measured temperatures on record for those upper air sites (Fig. 9). The peak of the heat event west of the Cascades occurred on Monday, 28 June. At the surface, high temperatures reached 108°F in Seattle, WA, 116°F in Portland, OR (see Fig. 9), and 117°F in Salem, OR. Even coastal areas such as Astoria, OR and Forks, WA reached temperatures above 100°F. To the east of the Cascades, extreme heat also affected eastern Washington and eastern Oregon during the same period, but lasted a couple of days longer, through the end of June. Between 27-29 June temperatures reached 109°F in Spokane, WA, 115°F in Pasco, WA, 116°F in Walla Walla, WA, 117°F in Pendleton, OR, and 118°F in Hermiston, OR.

Ultimately, 116 and 128 all-time highest maximum temperature records were broken or tied in Oregon and Washington, respectively (see Fig. 10). This includes several instances where the station broke or tied the previous all-time records set earlier in the extreme heat event.

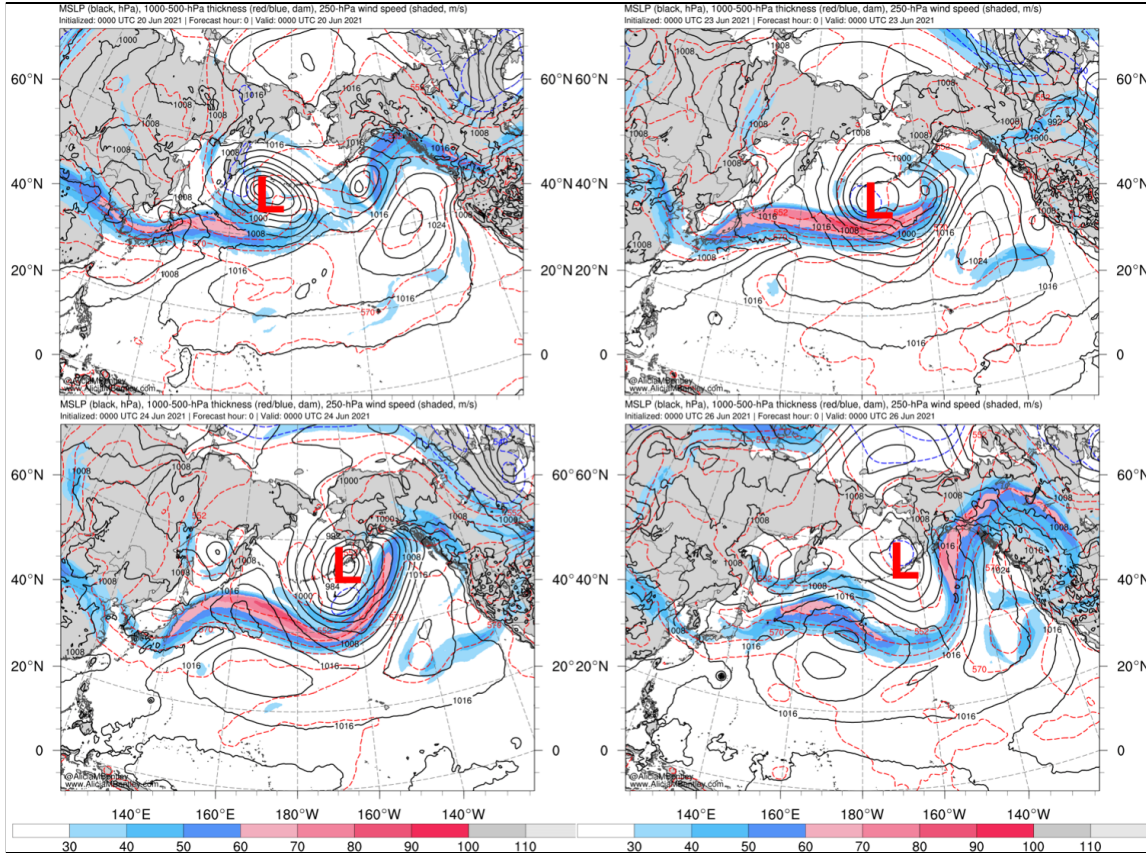


Figure 6. Mean Sea Level Pressure (MSLP; black contours), 1000-500 hPa thickness (colored contours), and 250 hPa winds speeds (shaded) for 0000 UTC 21 June (top left), 0000 UTC 23 June (top right), 0000 UTC 24 June (bottom left), and 0000 UTC 26 June (bottom right).

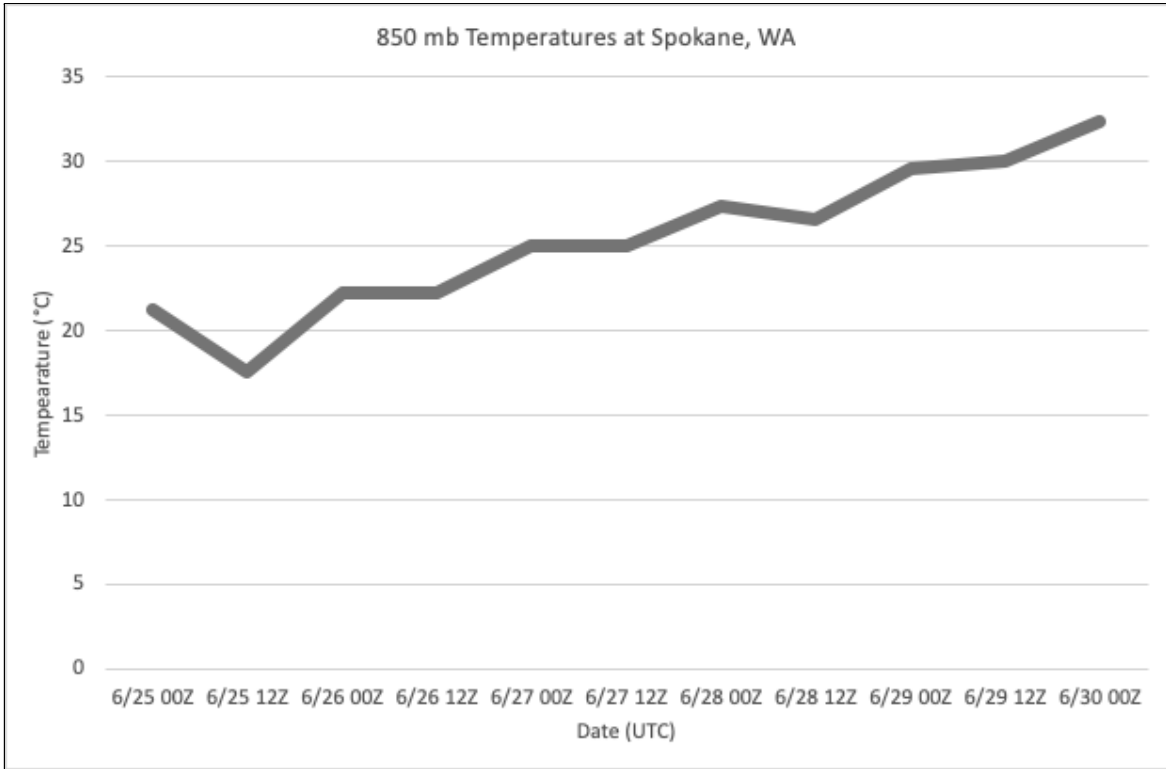


Figure 7. 850 mb temperatures (°C) at Spokane, WA between 0000 UTC 25 June and 0000 UTC 30 June. Each day, the 850 mb temperature warming occurred during the afternoon (0000 UTC) and not at night (1200 UTC) which indicates the warming occurred in-situ.

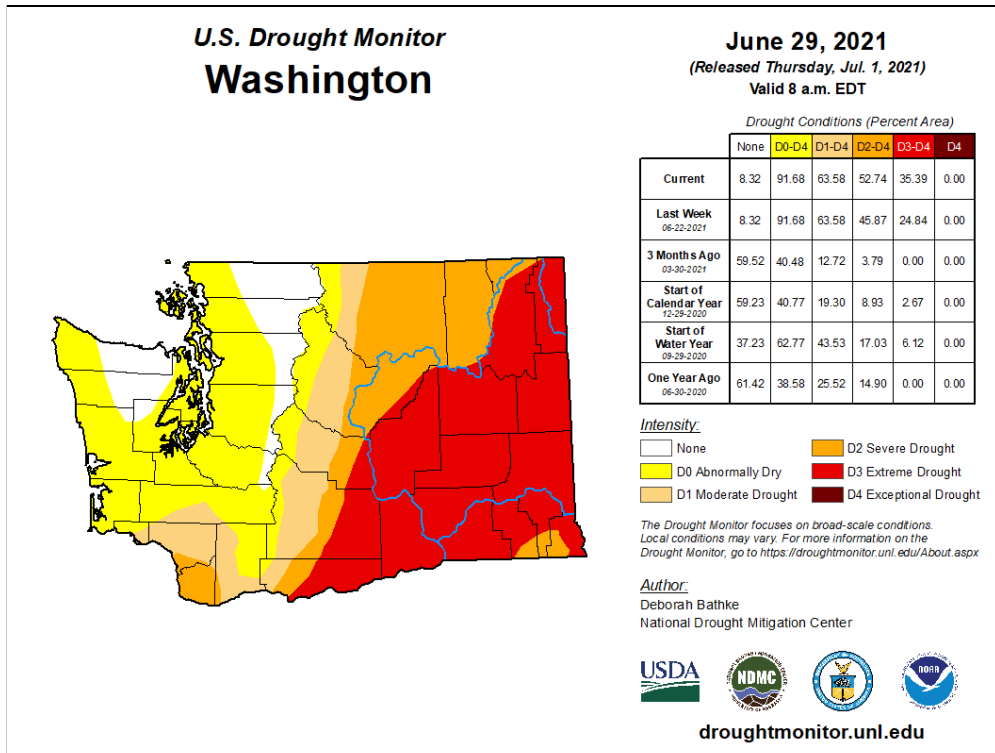


Figure 8. U.S. Drought Monitor for 29 June 2021.

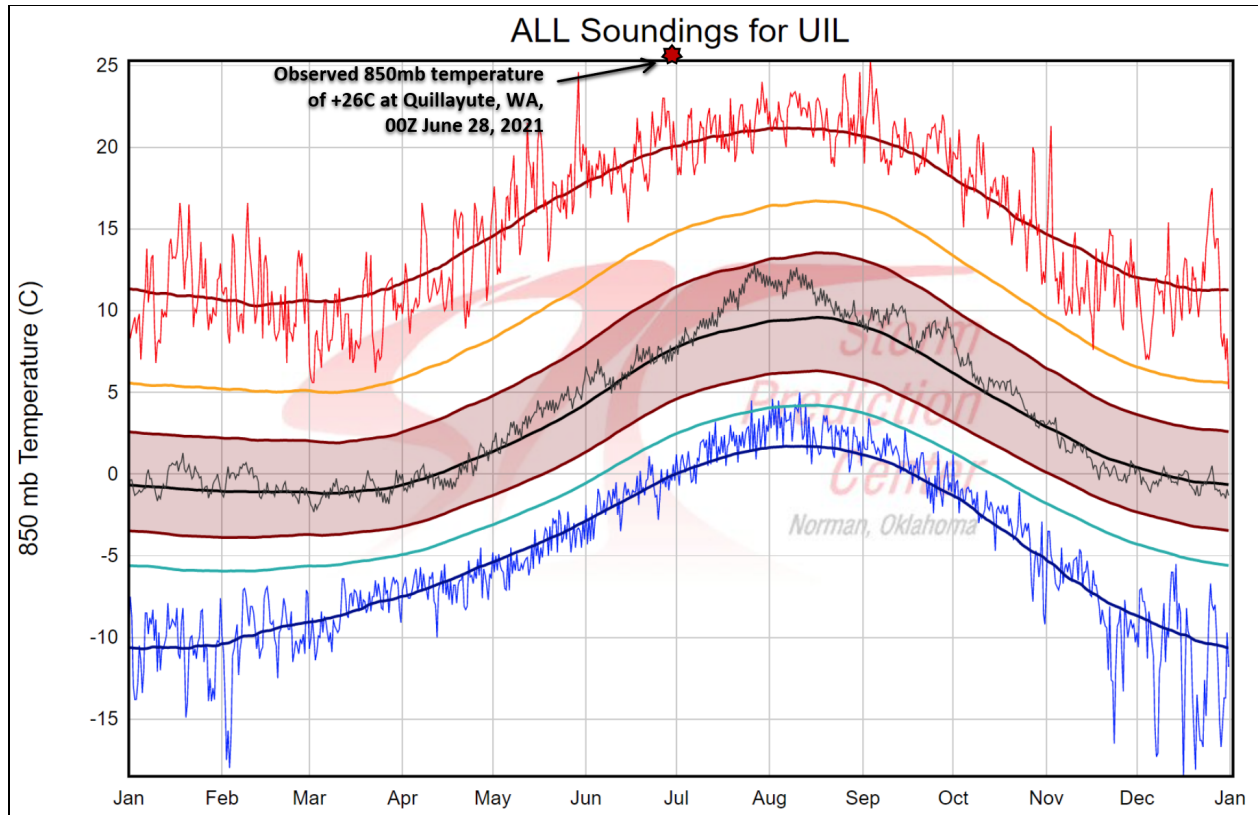


Figure 9. 850 mb temperatures for all soundings at Quillayute, WA (UIL and TTI) TTI period of record spans 1948 through 1966 with UIL existing from 1966 through 2019. The red line indicates the record warmest 850 mb temperature observed each day while the red star represents the observed 850 mb temperature at UIL 0000 UTC 28 June 2021. <https://www.spc.noaa.gov/exper/soundingclimo/>

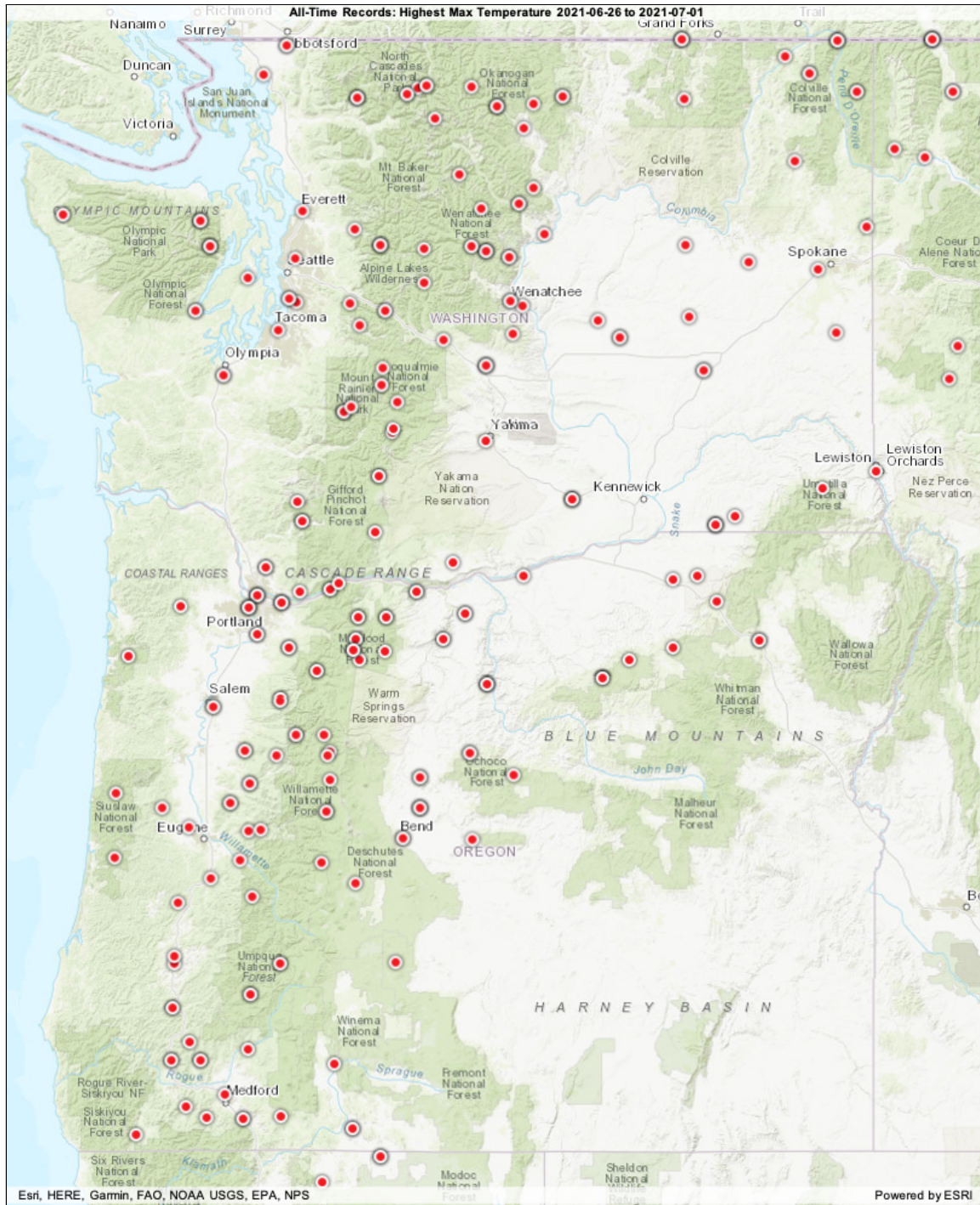


Figure 10. Locations that broke all-time high temperature records during the June 2021 heat wave. Source: <http://xmacis.rcc-acis.org/>

Examination of the Hanford Mesonet Temperature Observations

Investigation of a non-NWS weather network for consideration of a new state extreme temperature provided several challenges. For NWS networks (e.g. COOP and ASOS), instrumentation, siting, measurement and maintenance generally follow established criteria. All of these factors had to be investigated by the Washington SCEC team for the non-NWS networks.

Siting

The landscape of the Hanford Site is largely made up of grass and sagebrush, typical of central Washington. A site visit was conducted by some members of the SCEC team on 1 July 2021 to several stations in the Hanford mesonet, including station H100F (Fig. 11). Comparative temperature measurements were taken near the instrument, as well as away from the graveled area, and no definite bias was detected.

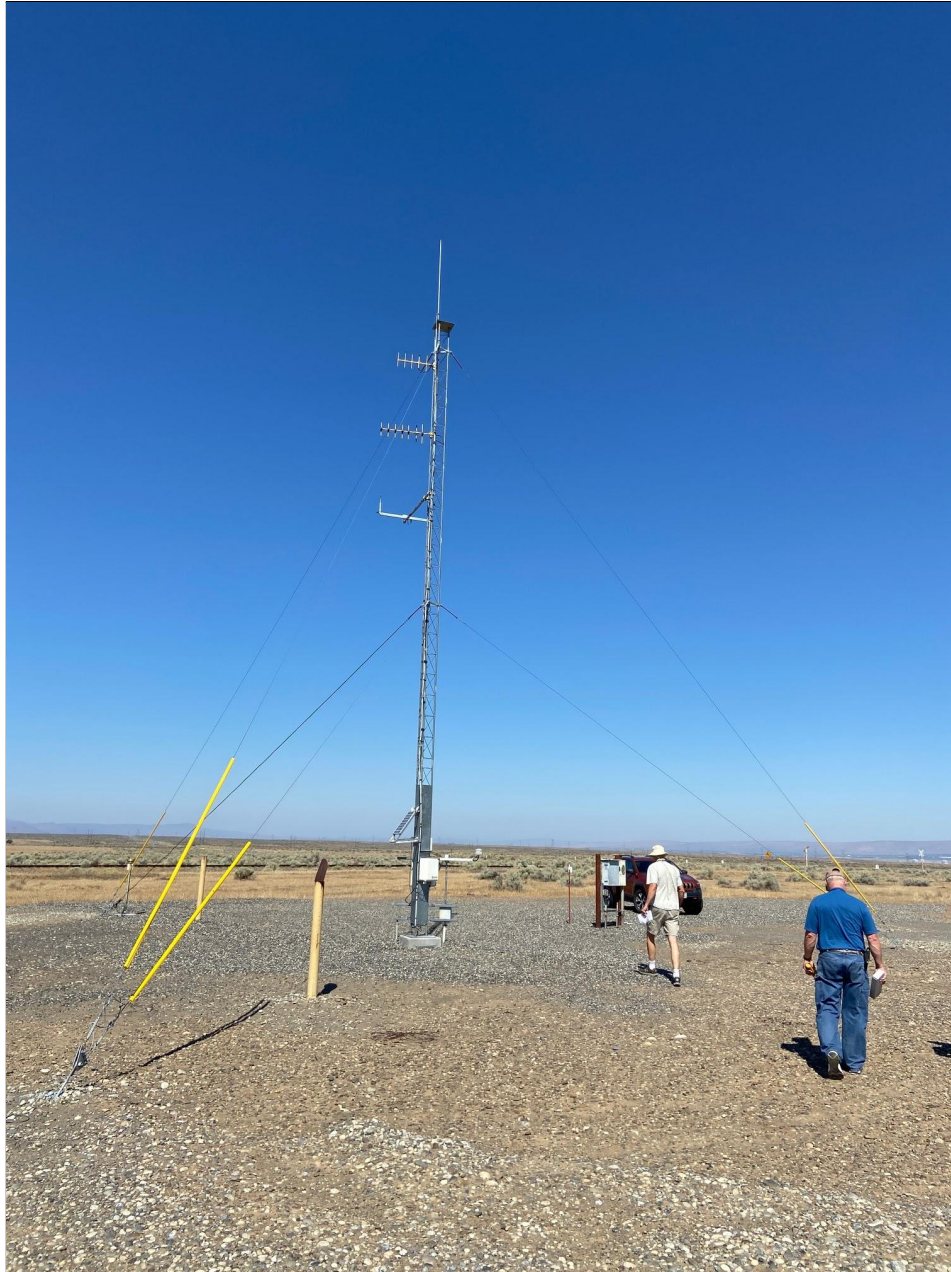


Figure 11. Hanford mesonet station H100F on 1 July 2021. This site was visited by the Washington State Climatologist and NWS Pendleton personnel on this date to investigate the potential record setting temperature on 29 June 2021.

Instrumentation

The Hanford mesonet uses Campbell Scientific 109 sensors for their temperature measurements. According to the manufacturer, these sensors have a +/- 0.1°C error for temperatures in the range of -9.4°F to +118°F (-23°C to +48°C), and a error of +/- 1.0°C for

temperatures in the range of -40°F to +133°F (-40°C to +56°C). These errors are similar to the ASOS and MMTS/NIMBUS sensors used by the NWS.

One of the bigger issues that the committee wrestled with is the reporting frequency and time-averaging. ASOS measures temperature six times per minute, but then averages these into a 5 minute average that is updated each minute. In contrast, NWS COOP instrumentation (i.e. MMTS/NIMBUS) takes an instantaneous temperature measurement every 16 seconds, and does not apply any time-averaging.

In the case of the Hanford mesonet, instantaneous temperatures are measured every 5 seconds. Every 15 minutes, the sensor reports the average temperature over the past 15 minutes, as well as the instantaneous highest and lowest temperatures during that same time period. The 15 minute average temperature is provided to MesoWest and MADIS. The highest and lowest instantaneous temperatures are available from the Hanford Site upon request.

The committee did some minor research into the response times of liquid-in-glass thermometers, since these were the kind of instruments used to record the 1928 and 1961 Washington state records. Overall, response times vary, in large part due to the thickness of the glass, but are typically in terms of seconds, not minutes.

After much discussion and debate, the committee concluded that while the Hanford mesonet instrumentation and measuring is not identical to the NWS instruments, these differences are not substantial enough to dismiss it from consideration. The committee fully recognizes that this issue will likely arise at future SCECs given the increasing proliferation of weather mesonets.

Table 2 shows the observations taken by the H100F sensor on the afternoon/evening of 29 June 2021. Note that the highest Average Temperature was 119°F, but the highest **instantaneous** temperature was 120°F, both recorded between 17:10 and 17:15 PST (6:10 PM PDT and 6:15 PM PDT). It's also worth noting that the maximum instantaneous temperature was also greater than 119.5°F (i.e. rounded up to 120°F) for the preceding two observation periods. Thus the 120°F temperature was actually reached at least three times between 16:30 and 17:15 PST (5:30 PM PDT and 6:15 PM PDT).

Date/Time (PST)	H100F Avg Temp (°F)	H100F Max Temp (°F)	H100F 10m Wind (mph)	H100F 10m Gust (mph)	H100F 10m Wind Dir
6/29/21 12:00	108.8	109.8	6	12	N
6/29/21 12:15	110.0	111.9	6	12	NNW
6/29/21 12:30	110.6	112.0	5	10	NW
6/29/21 12:45	111.2	112.5	5	9	N
6/29/21 13:00	112.5	113.8	5	9	N
6/29/21 13:15	112.9	114.2	6	12	NW
6/29/21 13:30	113.5	114.4	5	8	NW
6/29/21 13:45	114.4	115.6	4	9	SSE
6/29/21 14:00	114.4	115.6	5	10	ENE
6/29/21 14:15	115.1	116.1	6	11	NE
6/29/21 14:30	115.6	116.6	4	11	E
6/29/21 14:45	115.5	116.3	5	12	NE
6/29/21 15:00	116.0	117.1	7	13	NE
6/29/21 15:15	116.6	117.6	6	10	NE
6/29/21 15:30	117.0	117.9	7	11	NE
6/29/21 15:45	116.8	118.2	5	11	SE
6/29/21 16:00	117.3	118.4	6	11	E
6/29/21 16:15	117.4	118.2	5	7	SSE
6/29/21 16:30	118.0	118.8	6	11	SSW
6/29/21 16:45	118.4	119.6	4	10	SSW
6/29/21 17:00	118.4	119.9	4	9	SSW
6/29/21 17:15	119.0	120.0	6	9	SW
6/29/21 17:30	118.0	118.6	3	7	WNW
6/29/21 17:45	118.0	118.7	4	8	N
6/29/21 18:00	118.0	118.8	3	6	SE
6/29/21 18:15	117.8	118.6	6	9	NNE
6/29/21 18:30	117.0	117.6	5	8	NNE
6/29/21 18:45	116.2	116.6	4	6	NNE
6/29/21 19:00	115.6	115.7	4	6	NNE
6/29/21 19:15	114.9	115.5	3	4	NNE
6/29/21 19:30	112.2	114.7	5	8	NNE
6/29/21 19:45	107.9	109.0	7	11	NE
6/29/21 20:00	104.1	106.2	7	8	NE
6/29/21 20:15	100.5	102.1	6	10	NE
6/29/21 20:30	98.4	99.5	6	8	NE
6/29/21 20:45	96.4	97.3	7	10	NE
6/29/21 21:00	95.9	96.3	7	11	NE
6/29/21 21:15	95.1	95.5	8	11	NE
6/29/21 21:30	93.8	94.7	5	11	NNE
6/29/21 21:45	93.1	93.9	3	6	NW

Table 2. Temperature and wind observations from Hanford mesonet station H100F on 29 June 2021. Observations are taken every 5 seconds. Every 15 minutes, the sensor reports the average temperature over the past 15 minutes and the maximum instantaneous temperature over the same time period.

The local time of these extreme temperatures did seem to be rather late in the day, and this caused a bit of concern by the committee. An examination of the wind observations (Table 2) provides a likely explanation. Note that throughout the late morning and early afternoon, the wind direction was primarily from a general northerly direction. At 15:45 PST, the wind shifted to a general southerly direction which continued until 18:15 PST. It was during this time of southerly winds that the hottest temperature was measured at H100F. While it is beyond the scope of this document to determine this cause or relationship, it is noted that northerly winds are a local upslope wind as well as coming from the likely cooler Columbia River, and southerly winds are a local downslope wind.

Temperature Consistency with Neighboring Locations

The SCEC also investigated the consistency of the maximum temperature measurements with neighboring locations. The intent of this was to determine if the H100F station measurement was anomalous in any way. In other words, was the H100F location consistently hotter over time than other locations, such that instrumentation error or poor siting could be suspected? The committee performed two checks to answer this question.

First, a Double Mass Spearman's test (Arndt and Redmond 2004) was performed, comparing H100F to the Richland AWOS as well as the Pasco ASOS (Fig. 12) over nearly 21 years of data. The results of the test showed a high degree of consistency between these temperature observations.

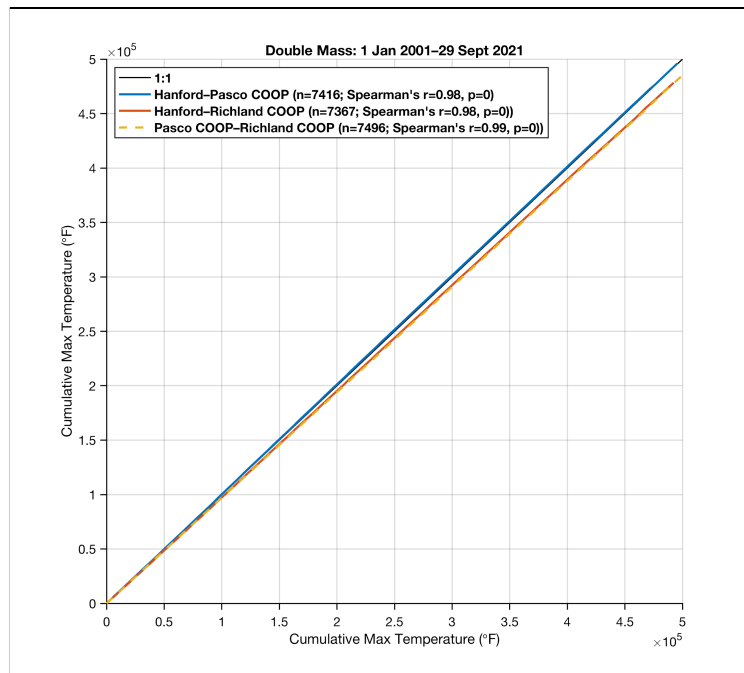


Figure 12. Double mass analysis (Arndt and Redmond 2004) comparing H100F temperatures from 1 January 2001 to 29 September 2021 to the nearby Pasco, WA ASOS and Richland, WA AWOS.

The nearly 1.00 Spearman's correlation between pairs of stations indicates consistency between observations and the linear slope of the cumulative temperature line indicates no abnormalities with the H100F station or changes in the past 21 years (whereas jumps or abrupt changes would signify station moves or other effects).

Secondly, all of the stations in the Hanford mesonet for June-August 2021 were examined to determine how many times each location had the highest daily temperature in the network. In other words, was the H100F station always the hottest location? Table 3 lists, and Figure 13 displays each station in the Hanford mesonet along with its elevation and the number of times the station had the hottest temperature in the network during the summer of 2021. A few things are worth noting:

- In general, the stations with the lowest elevation most frequently had the hottest reading in the network, but there are a number of exceptions.
- In general, the hottest readings typically come from the stations along the Columbia River at elevations below 500 feet elevation (H300A, HEDNA, H100F, HVERN, H100K, H100A).
- Station H100F is not the "hottest" station in the network. It does not appear to have an anomalous location or instrumentation.

- Station HWPPS does appear to have a potential instrumentation or siting problem, since it was the hottest station in the network for the vast majority of the days in the summer of 2021.
- Station HVSTA was often the hottest station in the network, but this is likely a result of being located in the town of Kennewick, away from the majority of the mesonet sensors (i.e. urban heat island effect).

Station	Elev (ft)	Number of days where Station was the hottest in the network
H300A	390	5
HEDNA	410	10
H100F	410	7
HPASC	410	1
HVERN	430	2
HWPPS	449	27
H100K	449	10
HHAMR	450	0
H100A	459	2
HPROS	479	0
HGABW	489	0
HVSTA	502	16
HWYEB	551	0
HBVLY	554	2
HARMY	564	3
HFFTF	571	3
HRING	620	0
H200W	650	4
HPFP	676	1
HRSPG	679	8
H200E	679	0
HHIDF	725	0
HHMS	732	1
HYAKB	794	0
HFRNK	876	0
HGABL	1086	0
HEOC	1240	0

Table 3. List of Hanford mesonet station ID, station elevation, and the number of days June-August 2021 that the station was the hottest in the network.

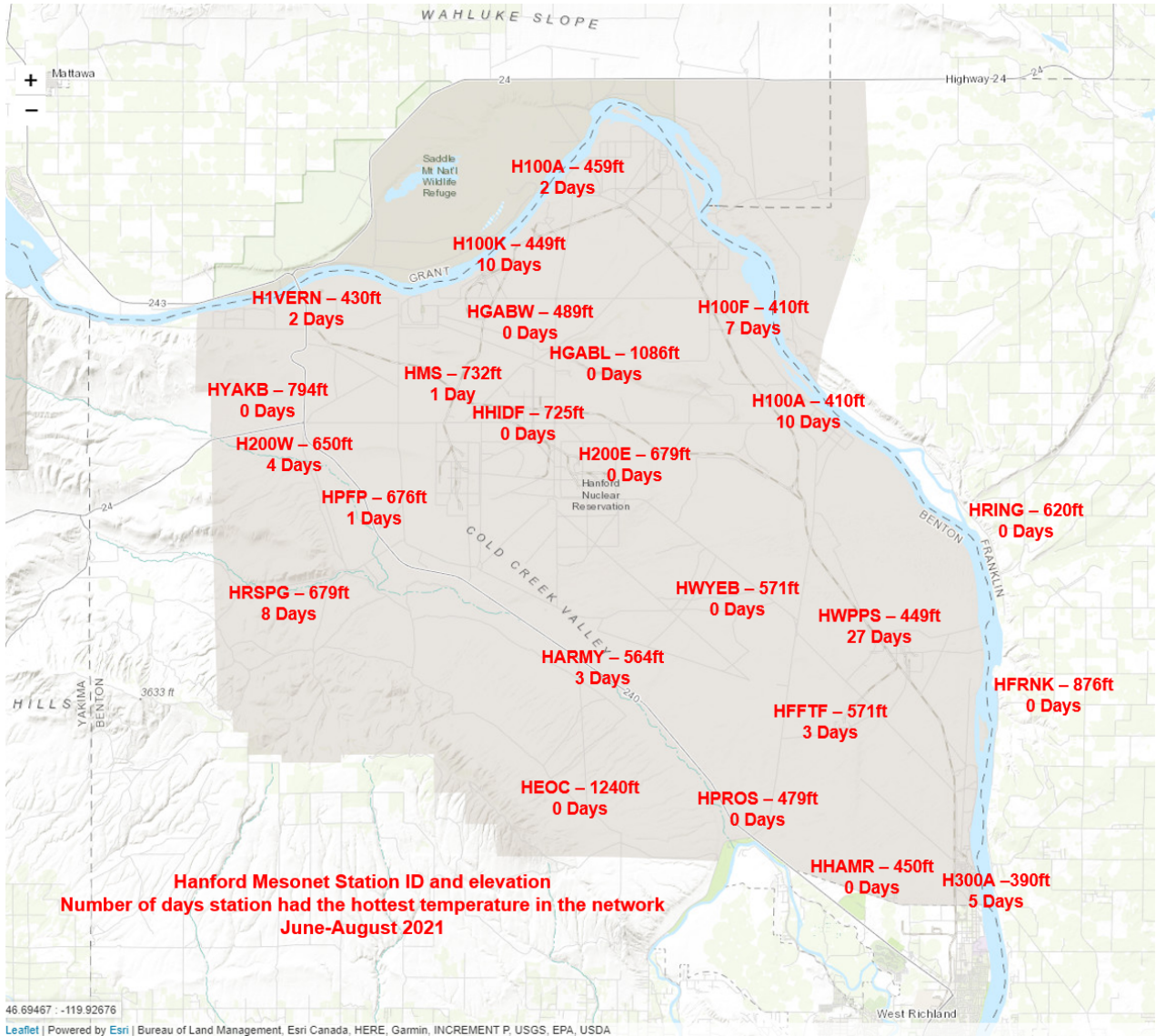


Figure 13. Map of Hanford mesonet station ID, station elevation, and the number of days June-August 2021 that the station was the hottest in the network.

The Hanford mesonet also has a sensor (HPASC) located at the Pasco airport, about $\frac{3}{4}$ of a mile from the ASOS (Fig. 14). A comparison of the daily high temperatures at both sensors was made for the same June-August 2021 period. For station HPASC, the instantaneous high temperature was used, not the 15-minute average temperature. The comparison yielded an average absolute temperature difference of 0.8°F and a bias of 0.1°F, with the Hanford sensor being slightly colder than the ASOS on average. The Hanford temperature sensor at the Pasco airport is the same as that used by the rest of the mesonet network, and receives the same calibration. The agreement between these two different sensors lends confidence to the accuracy of the Hanford mesonet sensors.



Figure 14. Weather observations at the Pasco, WA airport at 3:00pm PDT 29 June 2021. The ASOS sensor is located north of the airport runways, while the Hanford mesonet sensor is located near the airport terminal.

Finding of Committee on Maximum Temperature Record for Washington State

The SCEC voted 5-0 to accept the Hanford H100F station temperature of 120°F as the new Extreme Maximum Temperature record for the State of Washington. There is clear meteorological evidence to indicate the likelihood of an extreme temperature event, and the measurements from surrounding stations adds to confidence in this observation.

The unanimous agreement of the SCEC, based on evidence as stated above, has determined the 120°F maximum temperature measured on 29 June 2021 at Hanford, WA is indeed valid and is the new accepted Extreme Maximum Temperature Record for the State of Washington. The SCEC made their determination on the call held on 8 December 2021.

NCEI Climate Monitoring Chief Decision:

Approved

as recommended in boldface above:

Not approved

returned to SCEC with no action taken:

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Committee Members (Voting):

- Ronald Miller, Meteorologist in Charge, NWS Spokane
- Jeremy Wolf, Meteorologist, NWS Spokane (representing Andrea Bair, Climate Program Leader, NWS Western Region)
- Benjamin Hatchett, Regional Climatologist, Northeast Regional Climate Center
- Nicholas Bond, Washington State Climatologist
- Karin Gleason, National Centers for Environmental Information, Asheville, NC

Additional Washington SCEC contributing participants (Non-voting):

- Karin Bumbaco, Office of the Washington State Climatologist
- Edward Townsend, Science and Operations Officer, NWS Pendleton
- Dan Miller, Science and Operations Officer, NWS Portland
- Mark Turner, Observations Program Leader, NWS Spokane
- James Smith, Observations Program Leader, NWS Pendleton
- Michael Vescio, Meteorologist in Charge, NWS Pendleton
- Brian Warren, Data and Observations Program Manager, NWS Western Region

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