State Climate Extremes Committee Memorandum

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DATE: February 1, 2022

SUBJECT: Oregon All Time Maximum Temperature Record Tied at Pelton Dam, OR and Moody Farms, OR.

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Summary

In late June 2021, an unusually intense and historic heat wave struck the Pacific Northwest. Many all-time station records were broken throughout Washington and Oregon, and in some cases, records were shattered by wide margins. A number of observations from several different networks reported temperatures that met or exceeded the 119℉ all-time Oregon state maximum temperature record. The heat peaked on the west side of the Cascades on June 28, 2021 and on the east side of the Cascades a day later on June 29, 2021. Table 1 shows the maximum daily temperatures reported at Portland International Airport (PDX) and Pendleton Airport (PDT) during the heatwave. The table shows that the intense heat (temperatures exceeding 100℉) lasted 3 days at PDX and 5 days at PDT. After June 30, 2021, the cooler marine air on the west side of the Cascades slowly filtered into the east side of the state, but temperatures remained elevated through the July 4th weekend east of the Cascades.

Date	Portland Int'l Airport Max T	Pendleton Airport Max T
6/25/2021	95	94
6/26/2021	**108**	104
6/27/2021	**112**	112
6/28/2021	**116**	113
6/29/2021	93	**117**
6/30/2021	79	106
7/01/2021	75	95

Table 1. Daily maximum temperatures at the Portland, OR International Airport and the Pendleton, OR Airport during the heatwave. All-time high temperature readings (denoted by the bold, red text) were set at PDX on three consecutive days, initially breaking the previous record of 107℉ on June 26, 2021, and then subsequently breaking the new record that had been established only the previous day on both June 27 and June 28. The all-time high temperature reading was also tied at PDT on June 29, 2021 (also denoted by the bold, red text).

The Oregon State Climate Extremes Committee (SCEC)

An Oregon State Climate Extremes Committee (SCEC) was assembled on July 1, 2021 to consider new all time state maximum temperature records for Oregon. Conference calls were convened on July 15, 2021 with a voting meeting on December 1, 2021. The intervening work was challenging because there were 16 sites that potentially either tied or broke the all time state record of 119℉ on either June 28, 2021 or June 29, 2021, and all but 3 of the sites were non National Weather Service owned.

The voting members of the Oregon SCEC Committee were:

- Michael Vescio, National Weather Service Pendleton, OR (Committee Lead)
- Karin Gleason, National Centers for Environmental Information (NCEI)
- Daniel McEvoy, Western Region Climate Center
- Larry O'Neill, Oregon State Climate Office
- Brian Warren, National Weather Service, Western Region Headquarters

Work conducted by the Oregon SCEC was completed in close collaboration with the Washington SCEC who were doing their own report on all time maximum temperature records during the June 2021 heatwave in Washington State.

Historical Context

The all-time State of Oregon high temperature record of 119°F was set twice, both times in 1898, but on different dates and in different locations. The first occurrence was in Prineville, OR on July 29, 1898. Figure 1 shows a map of maximum temperatures for July 29, 1898. It is clear from Fig. 1 that Prineville's temperature is high compared to the other observations for that date, and the veracity of the July 29, 1898 Prineville observation has been questioned by some. However, because the Prineville reading is in the official NCEI records, further investigation and discussion of this is beyond the scope of this document and the 2021 Oregon SCEC Committee.

On August 10, 1898, Pendleton, OR also reached 119°F, tying the state record high temperature that had occurred in Prineville only approximately two weeks prior. Figure 2 shows a map of high temperatures for August 10, 1898.

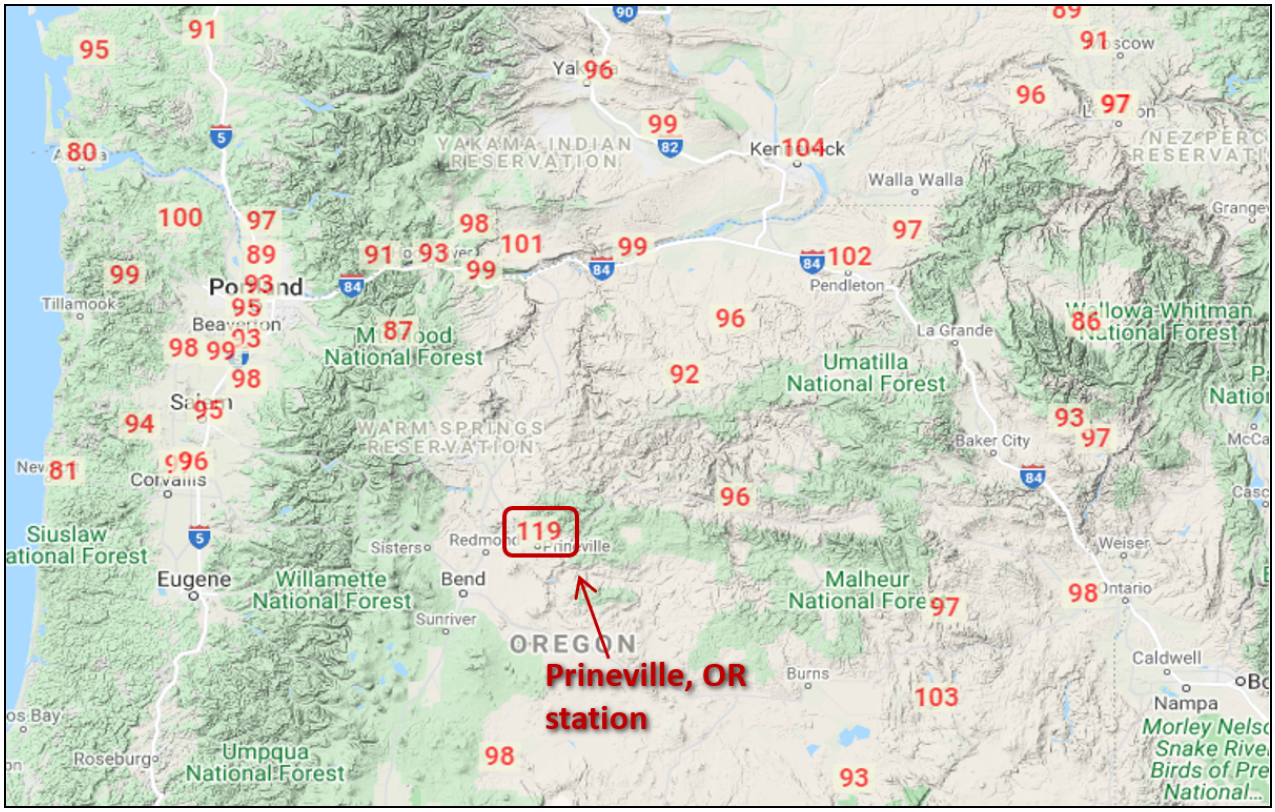

Figure 1. Maximum temperature map for July 29, 1898. The record maximum temperature of 119℉ in Prineville, OR is annotated just to the lower left of the center of the image.

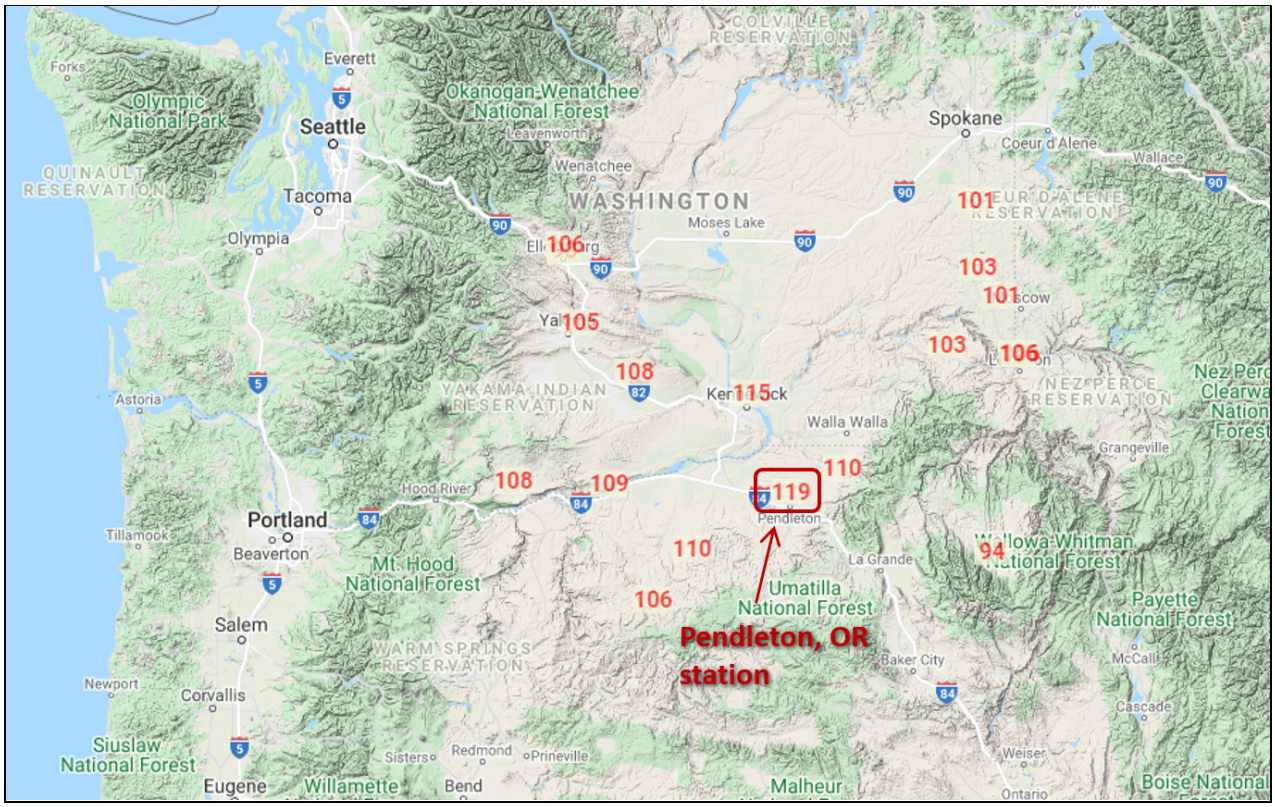

Figure 2. Maximum temperature map for August 10, 1898. The record maximum temperature of 119℉ in Pendleton, OR is annotated just to the right of the center of the image.

Meteorological Summary

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 June 24-25 as a very strong ridge of high pressure throughout the entire depth of the troposphere rapidly strengthened over the Pacific Northwest, centered over north-central Washington and adjacent areas of southern British Columbia, Canada.

The origin 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. 3, top row). Around June 24 (Fig. 3, bottom left), this low pressure system underwent cyclogenesis, allowing it to not only strengthen but also to pull warm mid-latitude 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 June 26 (Fig. 3, bottom right), this amplified pattern resulted in anticyclonic wave breaking

over western North America creating an anomalously strong ridge that remained relatively stationary through June 29.

The ability to achieve such warm temperatures with this event was in part due to its persistence. By the morning of June 26, 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 wouldn't appear until 3 days later. Given the stagnant nature of the high pressure and the intense June solar radiation, the lower levels of the air mass were able to modify through 00Z June 30, warming a bit each afternoon. This is demonstrated by the time series in Fig. 4 which shows the twice-daily 850 mb temperatures observed at Spokane, WA between 00Z June 25 and 30. Each day the warming is observed during the afternoon (00Z) with little to no warming overnight (12Z). This is evidence that most, if not all of the warming during this period occured 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 modify to 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 June 21 and officially became Typhoon Champi on June 25. On that same day, Typhoon Champi began tracking 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 which was absorbed 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. 5). 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 airmass, 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 (see Fig. 6). The peak of the heat event west of the Cascades occurred between Saturday, June 26, and Monday June 28, with the hottest day in most areas being Monday, June 28. At the surface, high temperatures reached 108°F in Seattle, WA; 116°F in Portland, OR (see Fig. 7); and 117°F in Salem, OR. Even coastal areas such as Astoria, OR and Forks, WA also 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 June 27-29 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 max temperature records were broken or tied in Oregon and Washington, respectively (see Fig. 8). This includes several instances where the station broke or tied the previous all-time record set earlier in the extreme heat event. This period of extreme heat also resulted in numerous observing locations across Washington and Oregon registering high temperatures near or above existing all-time state records (119°F for Oregon and 118°F for Washington). In all, 32 observation locations in the state of Washington, and 16 observation locations in the state of Oregon were investigated by National Weather Service Forecast Offices that serve Washington and Oregon for potential new state record high temperatures in the wake of this period of extreme heat.

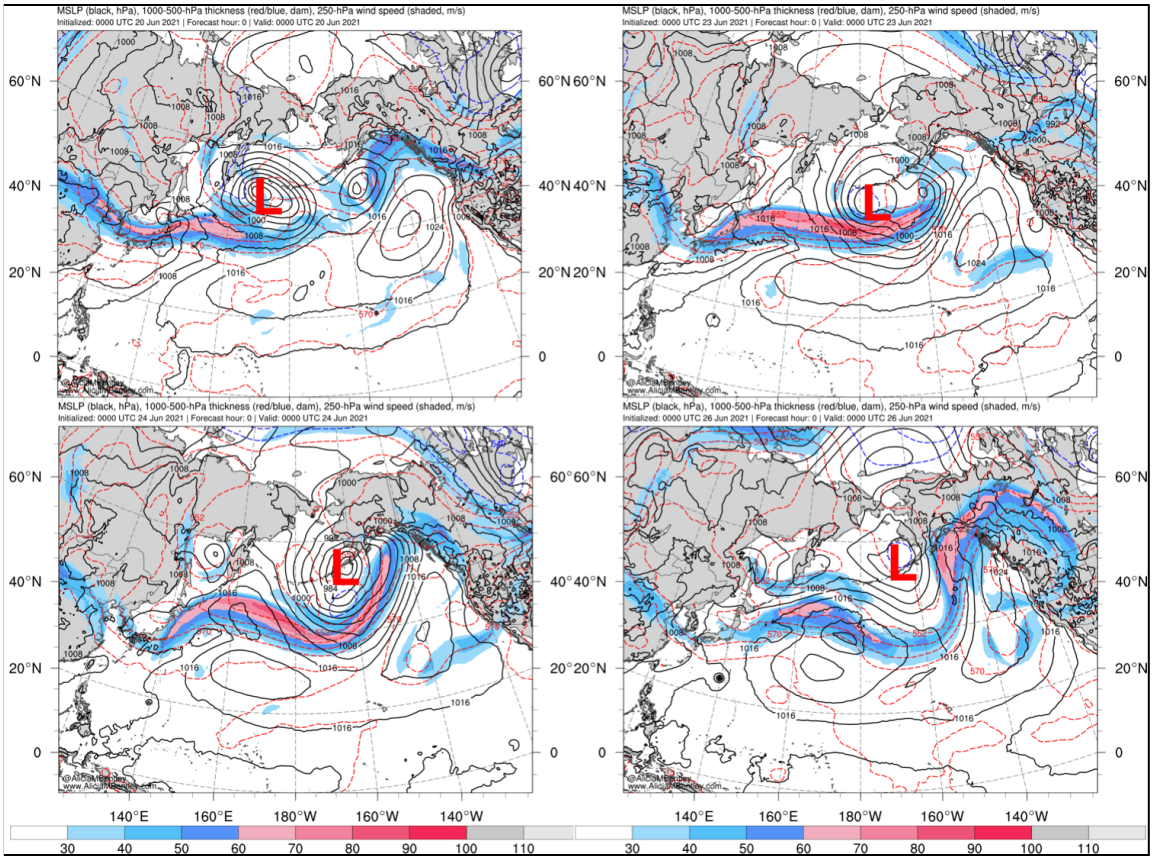

Figure 3. MSLP (black contours), 1000-500 hPa thickness (colored contours), and 250 hPa winds speeds (shaded) for 00Z June 21 (top left), 00Z June 23 (top right), 00Z June 24 (bottom left), and 00Z June 26 (bottom right).

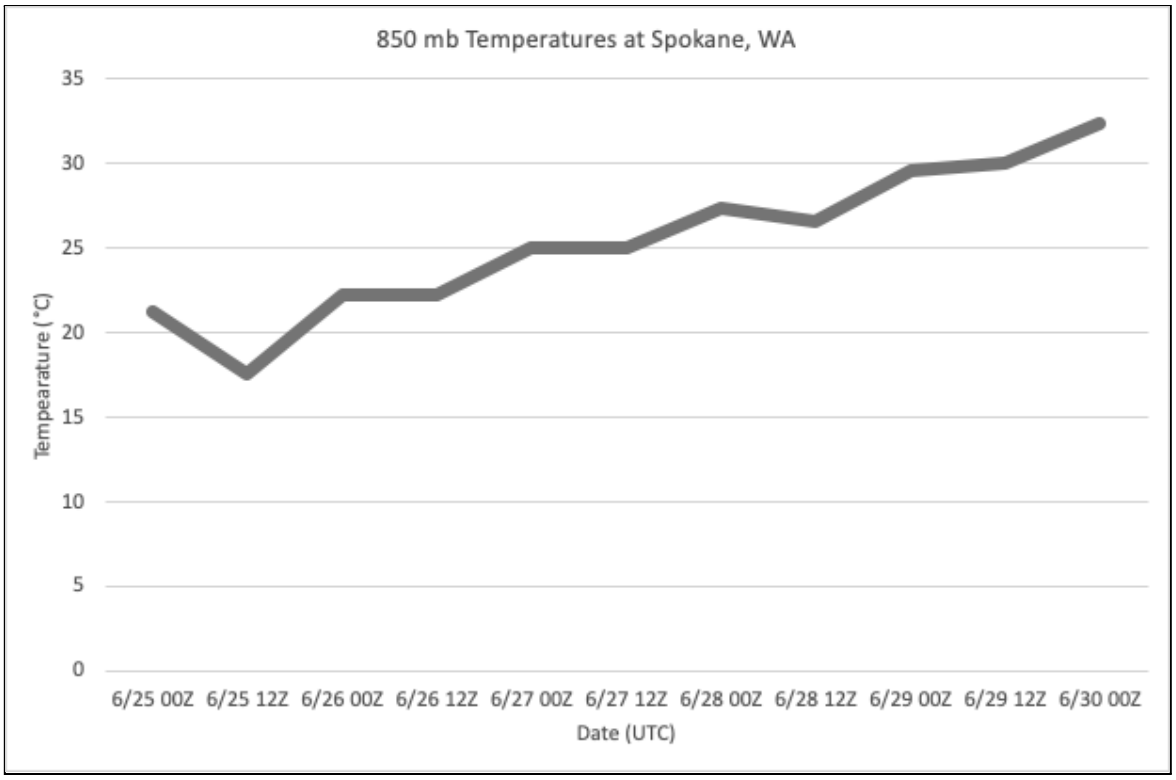

Figure 4. 850 mb temperatures (°C) at Spokane, WA between 00Z June 25 and 00z June 30. Each day, the 850 mb temperature warming occurred during the afternoon (00Z) and not at night (12Z) which indicates the warming occured in-situ.

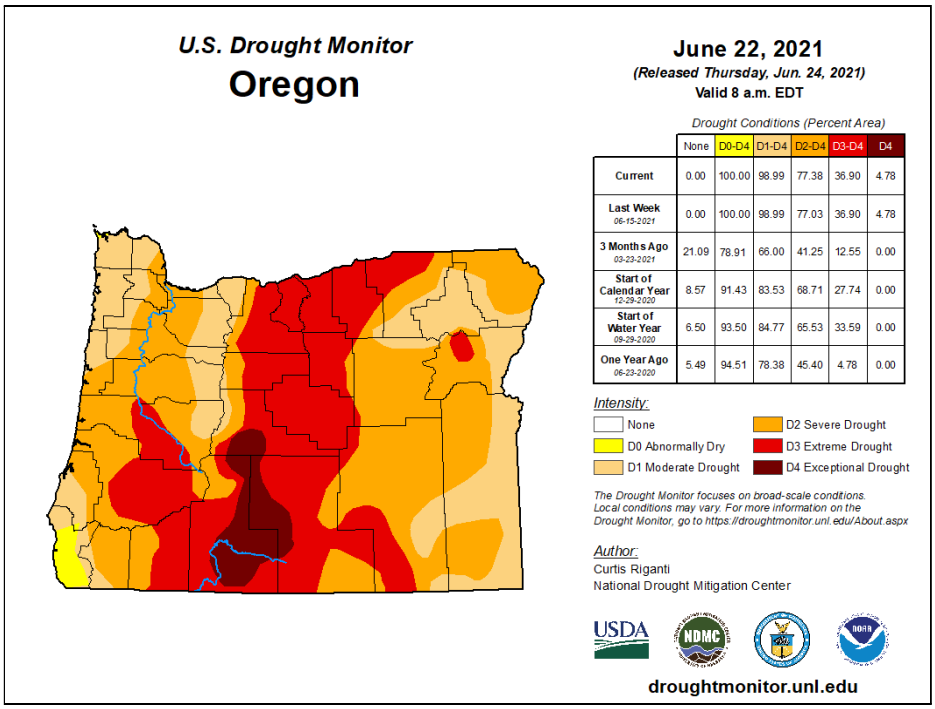

Figure 5. U.S. Drought Monitor for June 29, 2021.

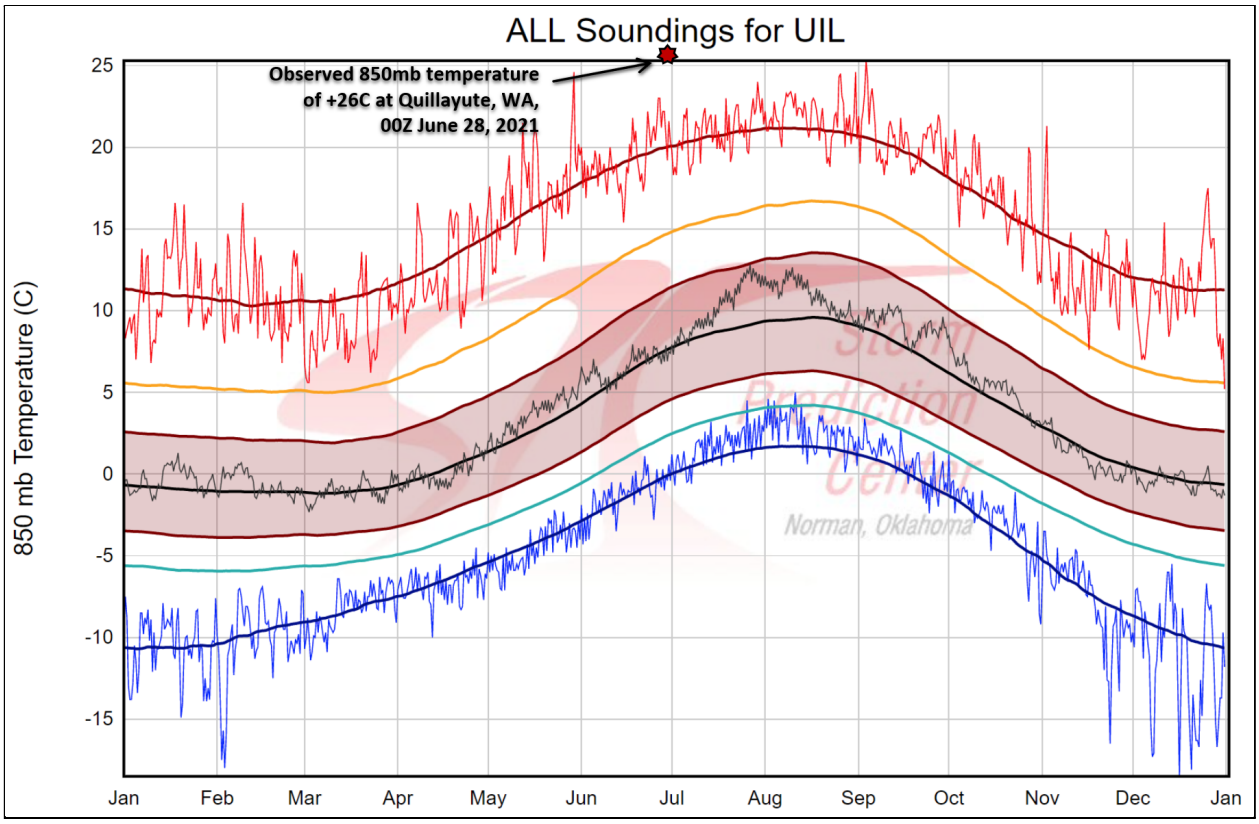

Figure 6. 850 mb temperatures for all soundings at Quillayute, WA (UIL and TTI) TTI period of record spans 1948 through 1966 with UIL existing from 1966 through 2019. The red line indicates the record warmest 850 mb temperature observed each day while the red star represents the observed 850 mb temperature at UIL 00Z June 28, 2021.

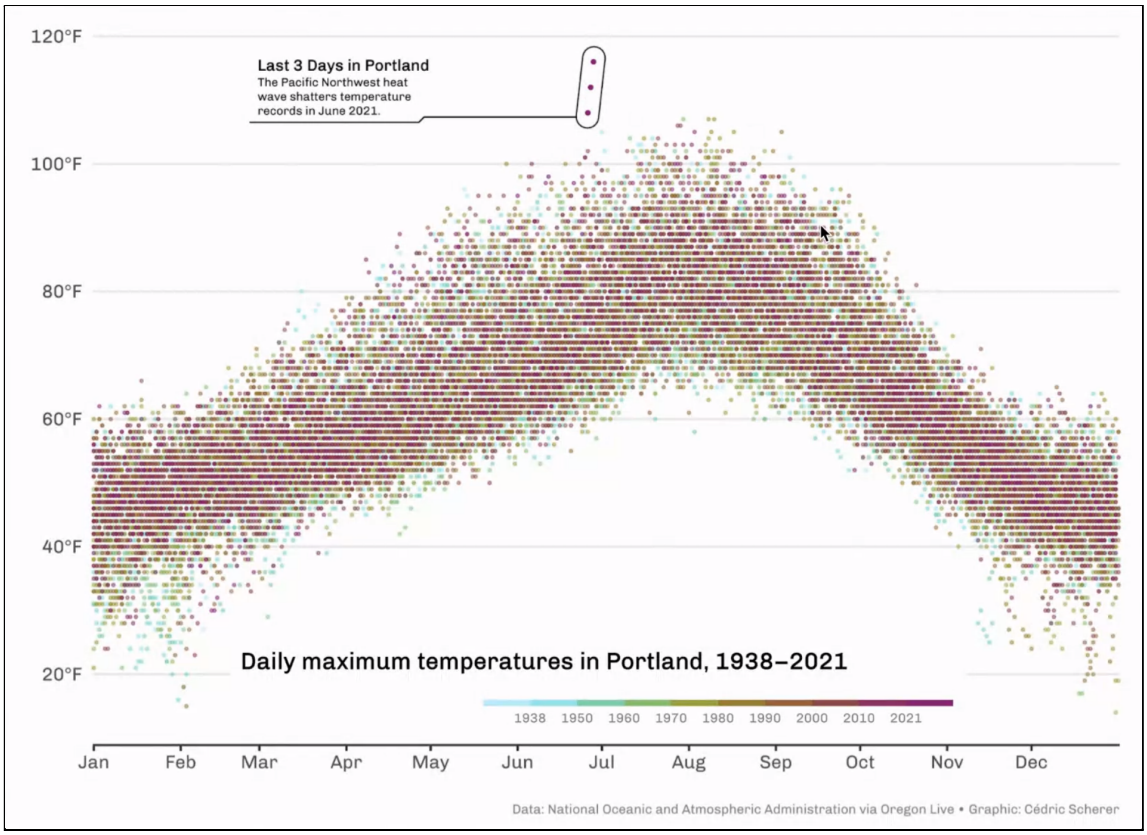

Figure 7. Daily maximum temperatures for Portland, OR between 1938 and 2021. The three warmest days during the 2021 heat event (June 26, 27, and 28) stand out as highly anomalous with the warmest day (116°F) shattering the previous all-time temperature record for the city (107°F).

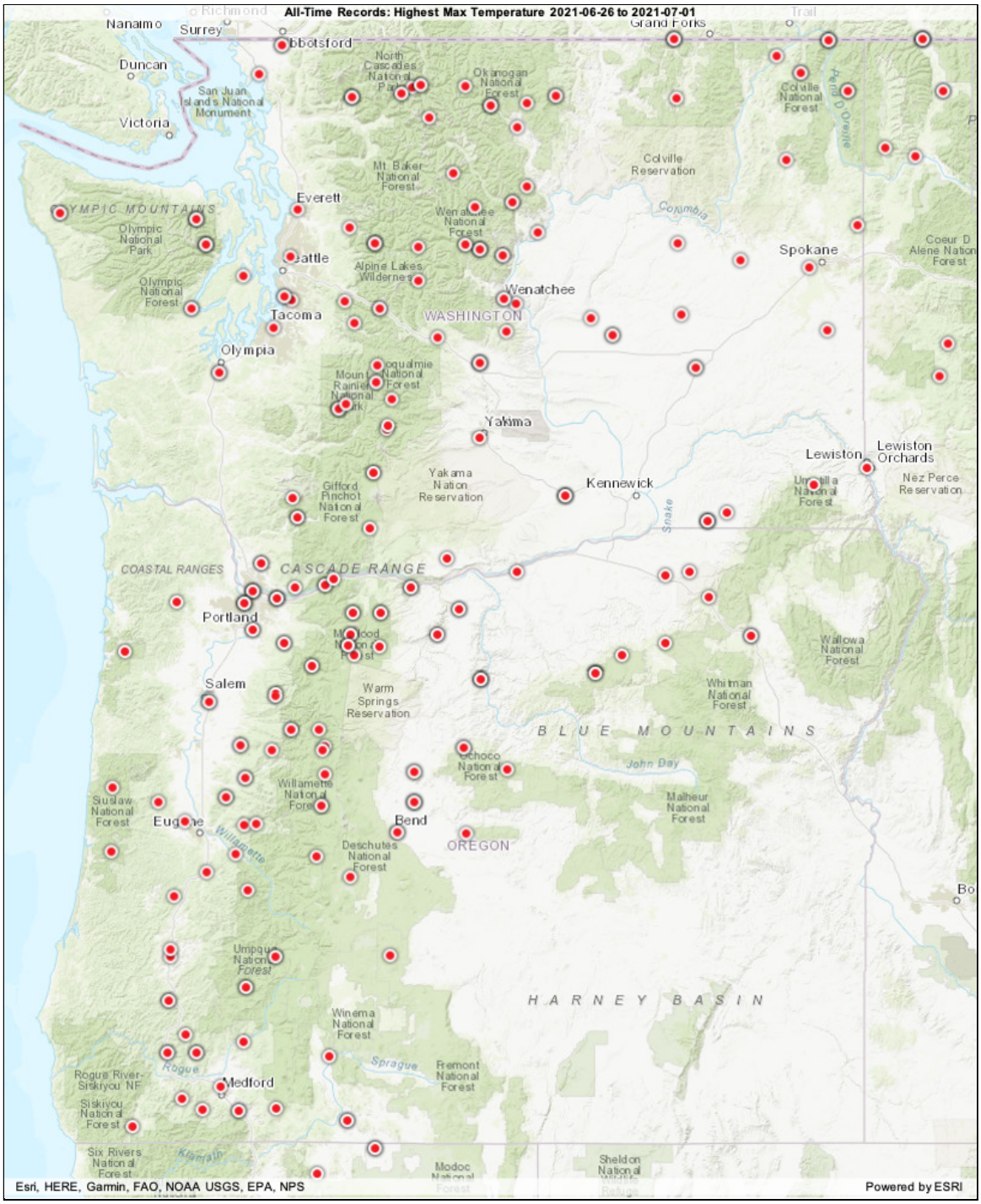

Figure 8. Locations that broke all-time high temperature records during the June 2021 Pacific Northwest heat wave.

Extreme Temperatures Considered by the SCEC

Table 2 provides a listing of the Oregon stations that met or exceeded the all-time state temperature record of 119℉ in June 2021, and their disposition for further consideration after reviewing the available evidence. Most of the stations were eliminated from further investigation due to reporting erroneously high maximum temperatures (122℉ or higher). These temperatures were noticeably higher than surrounding observation sites, and/or had noticeably obvious poor siting of the temperature sensor. With the recent proliferation of observation networks that are non-National Weather Service, and the associated limited or unknown information on the quality of the data sensors, maintenance records, and availability of their historical data, it has become increasingly challenging and time consuming to conduct these investigations. Updated NWS guidance on what qualifies as a "candidate" observation for record purposes may become necessary for similar events in the very near future. For this event, only two observation sites were examined for further consideration and a vote, with both tying the all time record of 119℉ on June 29, 2021:

1. **Pelton Dam COOP Site**
   Established: 5/26/1958
   Latitude: 44.724614 °N
   Longitude: -121.246154 °W
   Elevation: 1504'

2. **Moody Farms East Satellite Agrimet**
   Established: 9/10/2013
   Latitude: 44.87789 °N
   Longitude: -121.07621 °W
   Elevation: 1309'

Observation	Site ID	Link to OB	Max T (℉)	Date	Type of OB	WFO	Eliminated Y/N?
Salem	**KORSALEM195**	Link	131	6/28/21	Weather Underground	PQR	15 degrees higher than surrounding sites, **Eliminated**
9.5 E Rufus	UR058	Link	130	6/29/21	Union Pacific Rail	PDT	Temperature too high, sited next to railroad tracks. **Eliminated**
24.9 S Peola	TRY03		130	6/29/21	USGS	PDT	Temperature jumped from 91 to 192. **Eliminated.**
9.9 NE Arlington	UP110	Link	128	6/29/21	Union Pacific Rail	PDT	Suspect max temps June 27-29, sited next to railroad tracks.. **Eliminated.**
4.8 W Arlington	UP063	Link	123	6/29/21	Union Pacific Rail	PDT	Surrounding sites 111-116, sited next to railroad tracks. **Eliminated**.
Hwy 82 at Bramlet RD	OD201	Link	122	6/29/21	ODOT	PDT	Sporadic temperature reporting, At least 6 degrees warmer than neighbors, **Eliminated.**
10 E Dalles	ODT16	Link	122	6/29/21	ODOT	PDT	5-15 degrees warmer than surrounding sites. **Eliminated.**
Cougar Dam	CGWO3		122	6/28/21	USGS	PQR	Runs 8-10 degrees too warm. Known problem. **Eliminated.**
0.5 S Grants Pass	GPSO3		121	6/28/21	COOP	MFR	+8 degree bias discovered. Max T lowered to 113. **Eliminated.**
6.5 W Pendleton	UP184	Link	120	6/29/21	Union Pacific Rail	PDT	Sensor next to railroad tracks and paved road. **Eliminated.**
Salem	KORSALEM127	Link	120	6/28/21	Weather Underground	PQR	Sited near/over asphalt road and is warmer than surrounding sites. **Eliminated.**
Lebanon	LEBO3		120	6/28/21	COOP	PQR	Inactive site no longer maintained. **Eliminated.**
Lebanon Airport	KORLEBAN27	Link	119	6/28/21	Weather Underground	PQR	Sensor 15-20 feet off ground and over asphalt runway. Maintenance record unknown, **Eliminated.**
Hermiston	AV395	Link	119	6/29/21	CWOP	PDT	Visited and not sited well. Owner said station is uncalibrated. **Eliminated.**
Moody Farms East Satellite	MDEO	Link	119	6/29/21	US Bureau of Reclamation (USBR) Agrimet	PDT	**Passed on for further consideration and a vote**
Pelton Dam	PELO3		119	6/29/21	COOP	PDT	**Passed on for further consideration and a vote**

Table 2. List of sites that recorded Maximum Temperatures of 119℉ or higher on June 28, 2021 and June 29, 2021, and their disposition for further consideration.

Plausibility of Pelton Dam COOP and Moody Farms Stations Tying the All-time Temperature Records

The Pelton Dam COOP station (PELO3), and Moody Farms East Satellite Agrimet (hereafter referred to as Moody Farms, station identifier MDEO) sites are approximately 13.5 miles apart. Figure 9 shows a map of their relative locations in central Oregon. Figure 10 shows a map of the high temperatures on June 29 with mesonet sites around MDEO. These maps contribute to the meteorological plausibility of both sites reaching 119°F on June 29 with several nearby readings of 117-118°F.

In order to gain a better spatial sense of where the hottest temperatures occurred during the afternoon of June 29, 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 MODIS Aqua Brightness Temperature image from the afternoon of June 29 (Fig. 11) clearly indicated that the hottest brightness temperatures in Oregon were located over the comparatively lower elevations of the sharp valleys in the vicinity of Warm Springs, OR, including the locations of both the Moody Farms, and Pelton Dam observation sites. This is denoted by the area annotated in yellow in Fig. 11. Although satellite sampled 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.

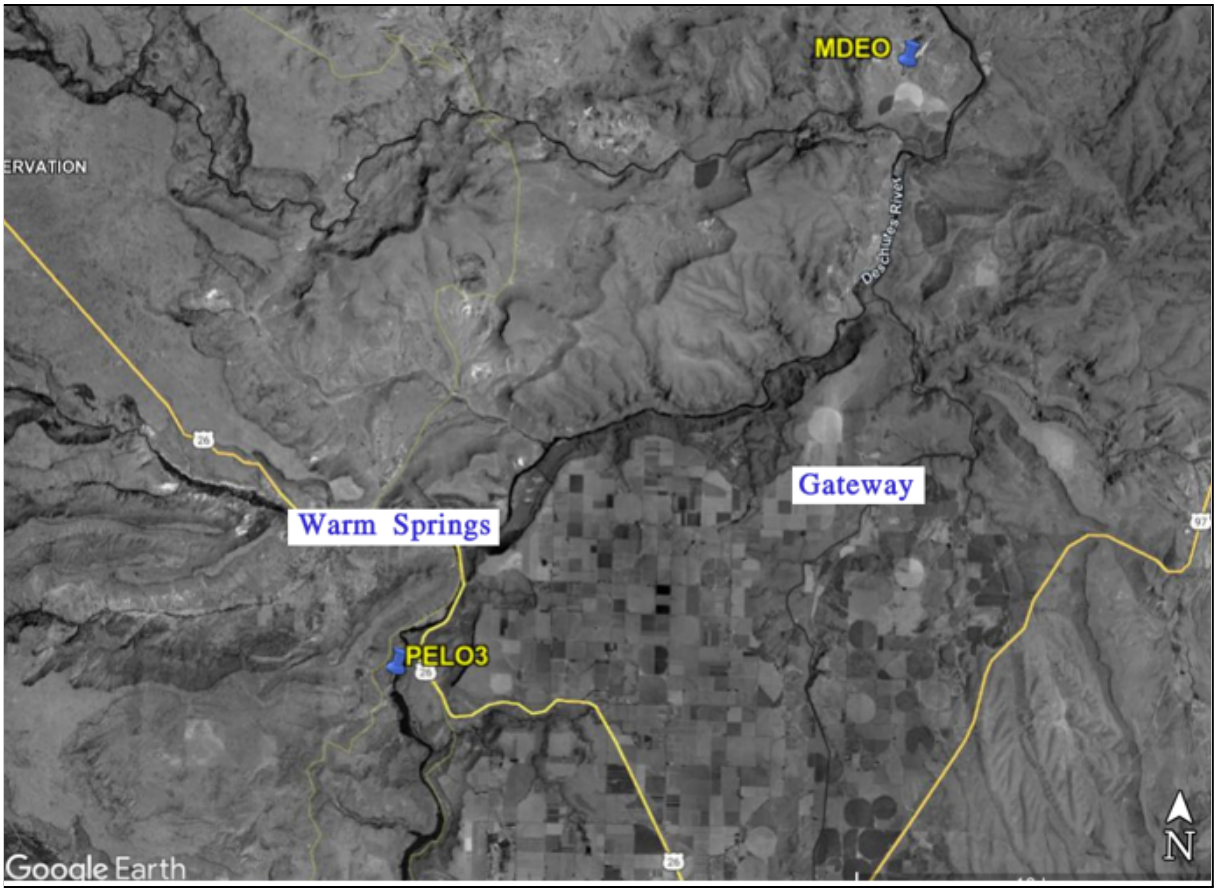

Figure 9. Map showing the locations of Pelton Dam COOP Site (PELO3) and Moody Farms Agrimet site (MDEO).

Figure 10. Map showing maximum temperatures of 4 mesonet sites surrounding MDEO (upper right) on June 29, 2021.

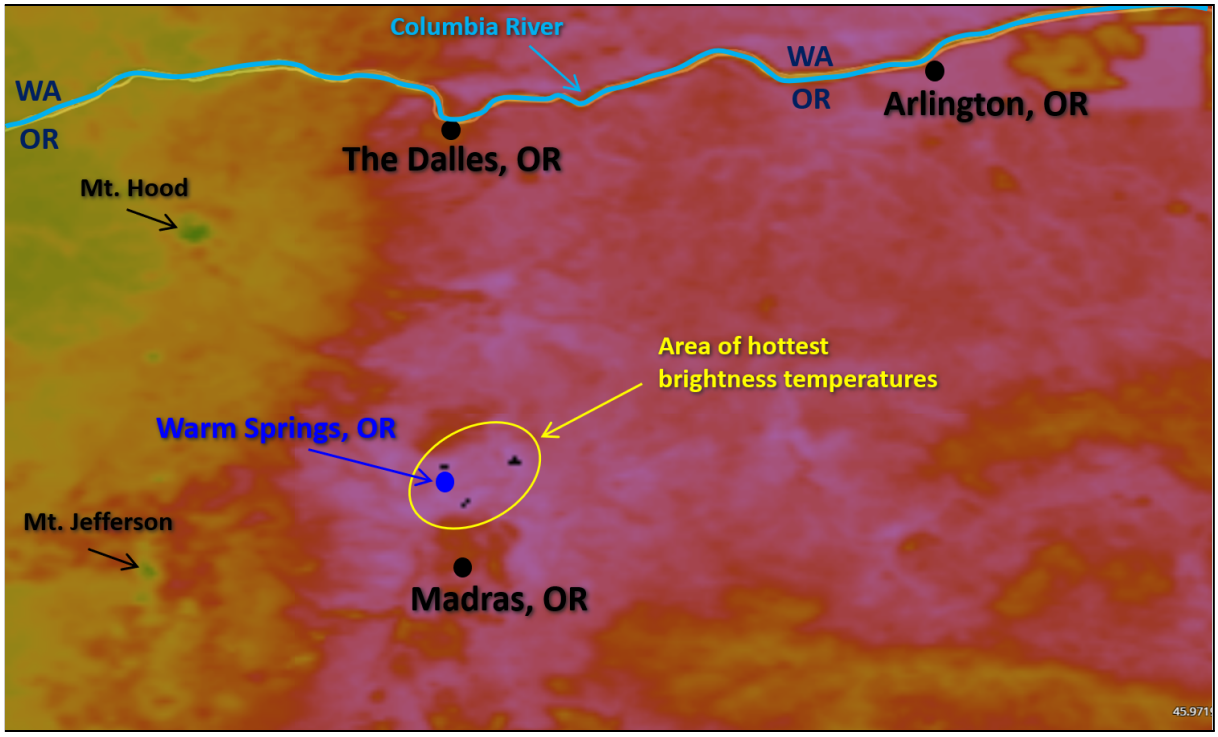

Figure 11. MODIS Aqua brightness temperature around 2110 UTC (210 PM PDT) June 29, 2021. The yellow annotated area highlights the area of comparatively lower elevations around Warm Springs, OR where the hottest MODIS sampled brightness temperatures were located, denoted by the bright pink and patches of black colors. Both the Pelton Dam COOP site and the Moody Farms Agrimet site are within the yellow annotated area and a little over 13 miles apart.

Investigation of Pelton Dam COOP Site (PELO3)

COOP site PELO3 was visited and inspected on July 1, 2021 by the Observing Program Leader (OPL) and Science and Operations Officer (SOO) from NWS Pendleton, OR. Figure 12 is a photograph of the site. The committee felt that there were no issues with the siting of the station. The site uses a Maximum Minimum Temperature System (MMTS) that is connected to a Nimbus temperature display unit. There were a couple of issues with PELO3 discussed by the committee. First, there was excess wire wrapped around the MMTS pole. This could have had the effect of causing a warm bias with the instrumentation. However, on the visit on July 1, the average temperature difference over three measurements between the MMTS compared to a sling psychrometer was -5.3°F, Thus on the day of the visit the station actually had a sizable *cold* bias. The other issue with the site was that a fin on the MMTS was broken off (Fig. 13). The committee felt that this was a common occurrence and had little impact on the quality of observations from the MMTS.

Figure 12. Photograph of Pelton Dam COOP Site (PELO3).

The site is well maintained with site visits having been conducted every year for the past several years including: September 24, 2020 (virtual due to COVID), June 18, 2019, June 11, 2018, April 25, 2017, and June 21, 2016. However, since there was a large cold temperature bias on the day of the site visit on July 1, 2021, the committee assessed how the maximum temperatures at PELO3 compared over time, to a nearby station. An analysis was completed using the Madras, OR AWOS station (KS33) daily maximum temperature data from October 2020 through September 2021. KS33 is the nearest representative ASOS or AWOS to PELO3 (and MDEO). The data is presented in Fig. 14. The plot shows a near linear relationship between the two sites' maximum temperatures which indicates that the observations at PELO3 are stable and consistent.

Figure 13. Photo of Pelton Dam COOP site MMTS showing the damaged fin.

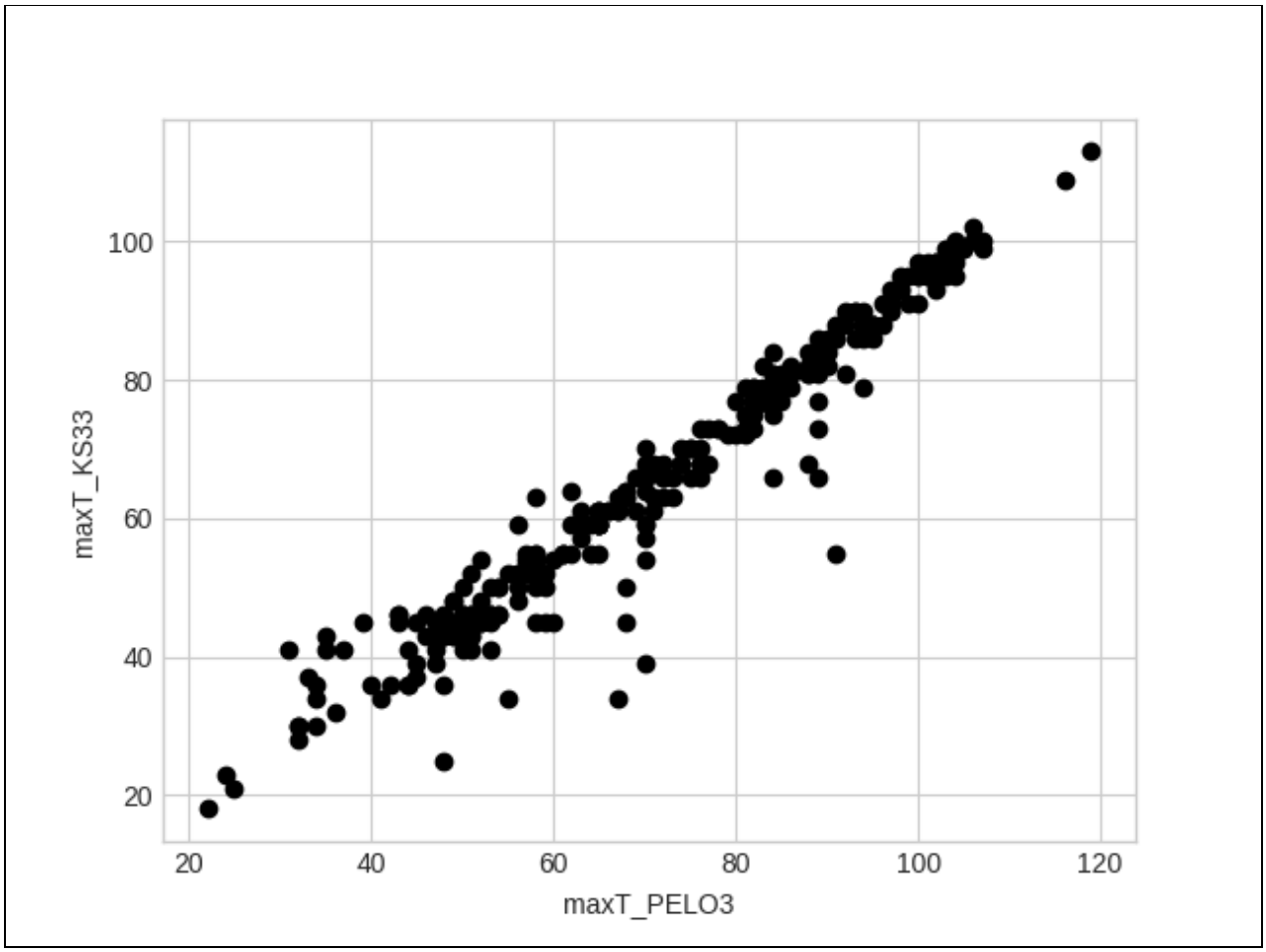

Figure 14. Scatter plot showing the maximum temperatures at PELO3 vs. KS33. The nearly straight line indicates excellent consistency between the two sites.

Investigation of Moody Farms Agrimet Site (MDEO)

Site MDEO was visited on July 12, 2021 by the NWS Pendleton, OR OPL, an NWS Pendleton forecaster, and the Oregon State Climatologist. The site reached a 1-second maximum temperature 119.27℉ between 400 and 415 PM PDT on June 29, 2021. The committee discussed what the minimum time interval should be to qualify for an official maximum temperature. In this case, the data for MDEO is archived and freely available and displayable on the internet by anyone interested. Thus, the committee did not eliminate the 1-second maximum temperature from consideration in this case. The observation platform is very well sited, with no known issues (Fig. 15). The temperature sensor used by MDEO is a Rotronic HC2A with an accuracy of +/- .01°K. Fortuitously, a calibration of the system was conducted at 950 AM on June 29, 2021, the day of the event. A benchmark lab calibrated Rotronic instrument was used to compare with the station temperature. The benchmark reading was 95.56℉ and the station temperature was 95.63℉. Thus, the station was in

excellent working order when it reached 119.27 degrees later on June 29. The same comparative analysis described in the previous section was conducted between KS33 and MDEO to assess consistency. The results of this analysis are shown in Fig. 16. The figure shows that the temperature observations from MDEO are also stable and consistent.

Figure 15. Observation site Moody Farms (MDEO).

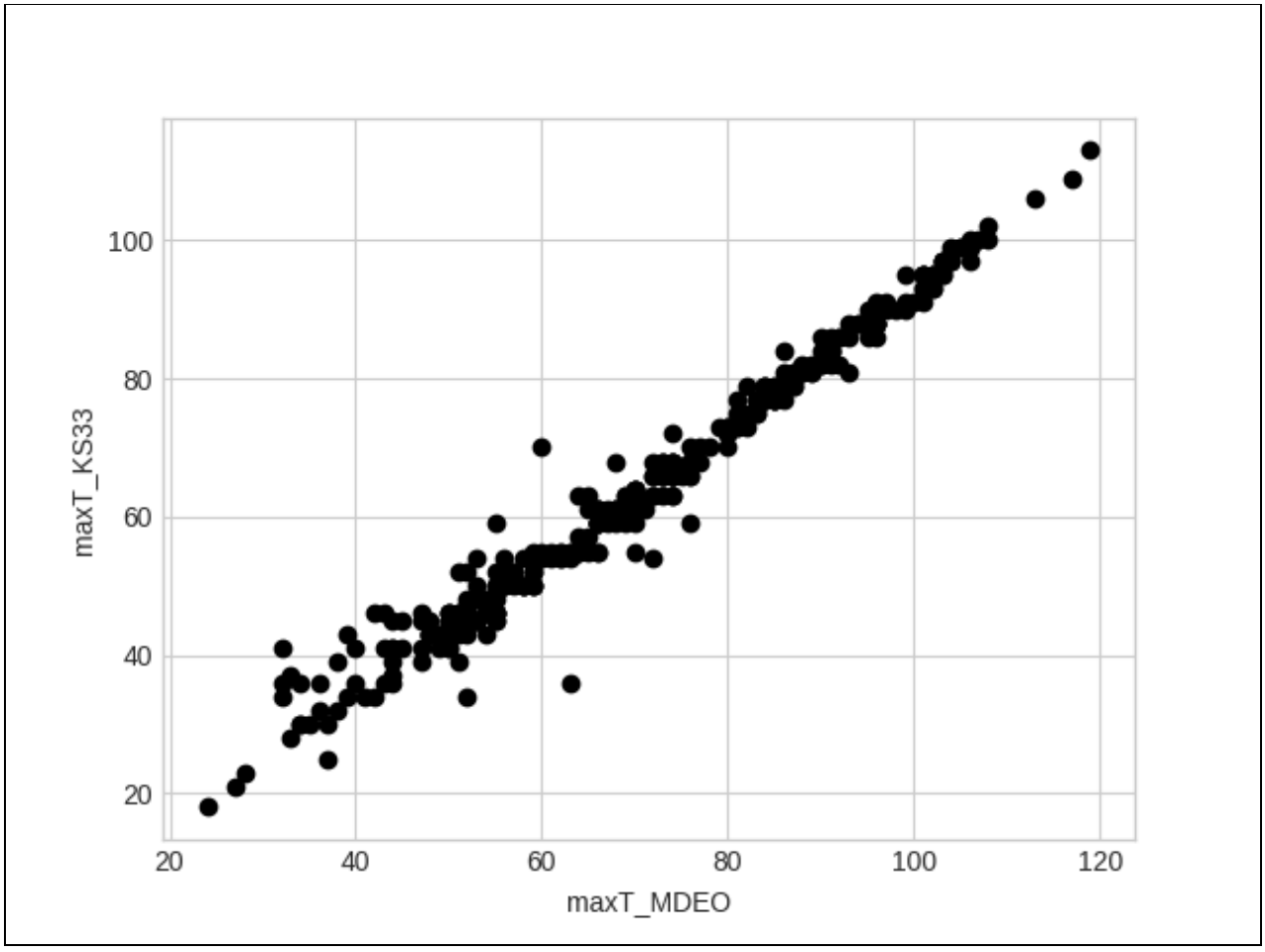

Figure 16. Scatter plot showing the maximum temperatures at MDEO vs. KS33. The nearly straight line indicates excellent consistency between the two sites.

Finding of Committee on Maximum Temperature Records

The SCEC voted 5-0 to accept both the Pelton Dam COOP site and the Moody Farms Agrimet (USBR) site maximum temperature readings of 119°F on June 29, 2021 as tying the all-time record high maximum temperatures for the state of Oregon, also previously set twice, on July 29, 1898, and August 10, 1898.

The unanimous agreement of the SCEC, based on evidence as stated in this report, has determined that the maximum temperatures at Pelton Dam COOP site (PELO3) and Moody Farms Agrimet site (MDEO) did indeed reach 119°F, tying the all-time state record for Oregon. The SCEC made their determination on a conference call held on December 1, 2021.

NCEI Climate Monitoring Chief Decision:

Approved as recommended in boldface above:	Not approved returned to SCEC with no action taken:
VOSE.RUSSELL.STEPHEN.1365831471 Digitally signed by VOSE.RUSSELL.STEPHEN.1365831471 Date: 2022.02.16 15:01:36 -05'00'	

Committee Members (Voting):

- Michael Vescio, National Weather Service Pendleton, OR
- Karin Gleason, National Centers For Environmental Information
- Daniel McEvoy, Western Region Climate Center
- Larry O'Neill, Oregon State Climate Office
- Brian Warren, National Weather Service, Western Region Headquarters

Additional Oregon SCEC contributing participants (Non-voting):

- Ronald Miller, Meteorologist in Charge , NWS Spokane, WA
- Edward Townsend, Science and Operations Officer, NWS Pendleton, OR
- Dan Miller, Science and Operations Officer, NWS Portland, OR
- Kirby Cook, Science and Operations Officer, NWS Seattle, WA
- Travis Wilson, former Science and Operations Officer, NWS Spokane, WA
- Gerald Macke, Observing Program Leader, NWS Portland, OR
- James Smith, Observing Program Leader, NWS Pendleton, OR
- Marcus Austin, Warning Coordination Meteorologist, NWS Pendleton, OR
- Treena Jensen, Warning Coordination Meteorologist, NWS Portland, OR
- Johnny Blagg, Electronics Systems Analyst, NWS Pendleton, OR
- Camden Plunkett, Meteorologist, NWS Pendleton, OR

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