

STATE CLIMATE EXTREMES COMMITTEE MEMORANDUM

FROM: Russ Schumacher, Colorado State Climatologist, Colorado Climate Center, Dept. of Atmospheric Science, Colorado State University (SCEC Convener), on behalf of: State Climate Extremes Committee (Schumacher, Stark, Umphlett, Kearns, Arndt)

DATE: 5 October 2019

SUBJECT: Colorado State Maximum Temperature Record

Table of Contents

| | |
|--|----|
| STATE CLIMATE EXTREMES COMMITTEE MEMORANDUM..... | 1 |
| Summary..... | 1 |
| About the SCEC..... | 1 |
| About the Observation..... | 2 |
| Meteorological Plausibility of the Observation..... | 5 |
| Testing of thermograph performance at high temperatures..... | 5 |
| Finding of committee..... | 10 |
| Acknowledgments..... | 11 |

Summary

The maximum temperature observation at the John Martin Dam COOP station on 20 July 2019 was 115°F, which exceeds the established Colorado maximum temperature record of 114°F (set at Las Animas in 1933 and Sedgwick in 1954). This station takes observations at 8:00am, so the high temperature occurred on the afternoon of Friday 19 July. Based on evaluation of the available information and evidence, **the SCEC determined the observation of 115°F to be valid, and establish the new Colorado state record for maximum temperature.**

About the SCEC

This State Climate Extremes Committee (SCEC) was composed of members representing five institutions: the National Weather Service (NWS) Weather Forecast Office in Pueblo, Colorado (WFO Pueblo, which has warning responsibility for Bent County, CO), the NWS Central Region’s Cooperative Observer Program leadership, the Colorado Climate Center (CCC, the state climate office), the High Plains Regional Climate Center, and the National Centers for Environmental Information. 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>.

About the Observation

The observation was taken at the NWS Cooperative Observing (COOP) station at John Martin Dam. The station is located near a US Army Corps of Engineers facility to the east of John Martin Dam and Reservoir in Bent County, Colorado. The NWS in Pueblo noted that this is a very consistent and reliable observer, and that the station is well sited in an open area, separated from the paved road that leads to the facility (Figs. 1-4).

Station metadata (from ACIS):

Station ID: 054388 (Coop)

Latitude: 38.0634 degrees

Longitude: -102.9298 degrees

Elevation: 3814 feet

Data for temperature, precipitation, and snowfall has been consistently recorded at this station since August of 1941.

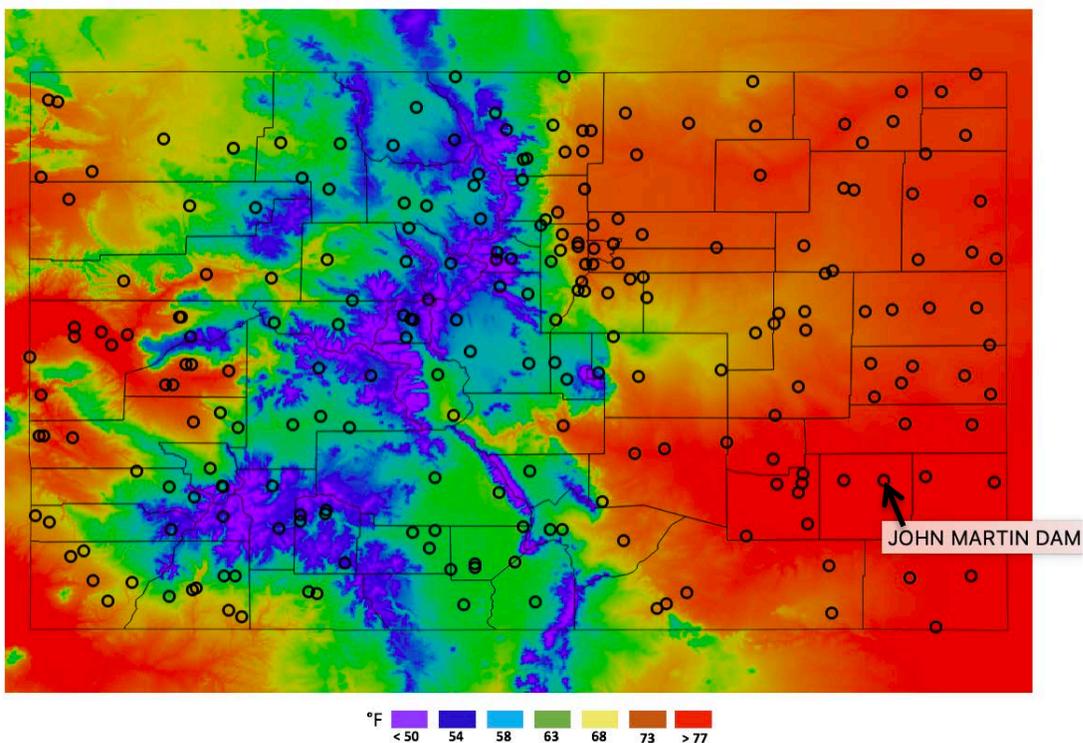


Figure 1: Map of average July temperatures (from PRISM) along with the locations of COOP stations. The John Martin Dam site is highlighted. From http://climate.colostate.edu/normals/t_jul_norm.html



Figure 2: Google Maps view of the station, which is sited in the rectangular area indicated on the image.

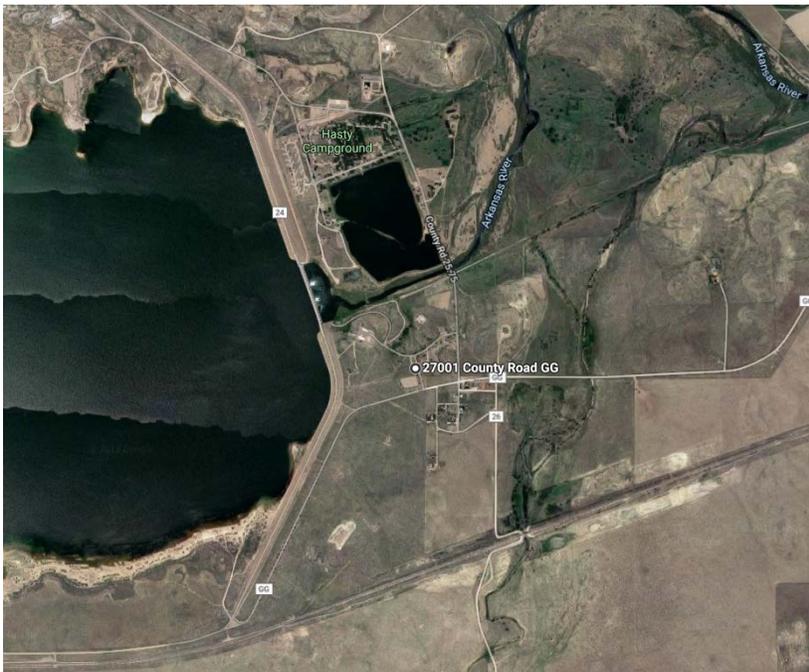


Figure 3: Zoomed-out view to show the station location with respect to the reservoir.



Figure 4: Photo of the John Martin Dam COOP station, taken on April 19, 2018 by Randy Gray of NWS Pueblo. Provided by Michael Nosko.

Michael Nosko of NWS Pueblo visited the station on July 24, 2019, shortly after the record temperature was set. He noted that at some point in the previous two years, the observer had poured a sandy mixture on the ground in the observation area to reduce the need for weed maintenance. This surface can be seen in Fig. 4.

The temperature was recorded on a Belfort thermograph that was used by the COOP observer for weekend measurements, since the site is only routinely staffed on weekdays. The thermograph was housed in a Cotton Region shelter at the site (Fig. 3). Unfortunately, the paper charts used by the thermograph to record the temperature are only explicitly marked with values up to 110°F. (More details on the paper chart will be given below). Three different trained observers viewed the chart and agreed that the marking on the paper was 5°F above the 110°F line, and recorded the maximum temperature as 115°F. Unfortunately, the observer did not realize the possible significance of this temperature measurement, and disposed of the paper chart per their standard practice. Further communication with the observer indicated that the thermograph marking was at least up to a small red line above the 110°F marking.

The station has since been upgraded to a digital Nimbus maximum/minimum thermometer (MMTS), as part of routine NWS upgrade processes for COOP stations. At that time, the thermograph instrument was collected by NWS Pueblo.

Meteorological Plausibility of the Observation

This was clearly a very hot day in southeastern Colorado, with neighboring stations reporting highs of 111 (Lamar ASOS¹), 110 (Lamar COOP), 107 (Las Animas COOP), and 106 (McClave CoAgMET station, in an irrigated field). This was the hottest day of the summer at all of these locations, and new daily records were set at both Lamar stations.

The maximum temperatures between 1 June and 6 August 2019 were compared between these different sites, and the average differences are given in Table 1. On average, the John Martin Dam site reported higher maximum temperatures than all of these sites, with the exception of the Lamar ASOS that had nearly the same average maximum temperatures over this period.

| | | |
|-----------------|--|------------|
| LAMAR COOP | | -2.6153846 |
| LAS ANIMAS | | -0.6721311 |
| LAMAR ASOS | | -0.031746 |
| MCCLAVE COAGMET | | -3.3569231 |

On 20-21 July, the John Martin Dam COOP station had maximum temperatures that were 4 and 3°F warmer than the Lamar ASOS station, respectively, but on the three previous days the TMAX was the same on two of the days and 1°F cooler on the other. There were also other instances of the John Martin station having maximum temperatures 3-4°F higher than the Lamar ASOS (e.g., 9 and 29 June; 5 July). Thus, there does not appear to be a systemic bias at the John Martin station, at least with respect to the Lamar ASOS. The average differences from the other sites likely reflect a combination of meteorological/microclimatic differences and siting differences between these stations.

Testing of thermograph performance at high temperatures

The information outlined above raised several questions about the reliability of the measurement, particularly the performance of the thermograph when the temperature goes literally “off the charts.” Furthermore, robust documentation from the manufacturer about the performance of the thermograph at high temperatures was unavailable. Thus, we pursued additional testing of the thermograph.

NWS Pueblo delivered the thermograph that was previously at the John Martin Dam COOP station to the Colorado Climate Center. On 10 September 2019, Noah Newman, Zach Schwalbe, and Russ

¹ When data are reported for the Lamar ASOS station in this report, the date has been shifted earlier by one day, because the ASOS reports at the end of each calendar day whereas the COOP stations report the following morning.

Schumacher (Noah and Zach are CCC staff and also experienced observers at the Fort Collins COOP station) brought the thermograph along with a known liquid-in-glass (LIG) maximum temperature thermometer to do an intercomparison in a lab oven at Colorado State University. We were also joined by a reporter from Colorado Public Radio.

The thermograph was put on the top rack of the oven and the max-T thermometer was hung below that rack (Fig. 5). We initially started the oven at about 30°C and then brought the thermostat up to 46°C (though the thermostat was likely not well calibrated). The temperature rose over the course of about an hour to the desired temperature range. There were a few issues with the pen pulling away from the paper on the thermograph, which needed to be readjusted a couple times, but this didn't affect the reading itself (just whether or not marks were made on the paper). Over time, according to both thermometers the temperature rose to nearly 119°F in the oven. The LIG recorded just shy of 119°F, and by extrapolation from the paper chart the thermograph had a very similar reading (see below for more details). Based on our measurements, the little red line (above the marked part of the chart) is a bit more than 5°F above the 110°F line. Then, noting the lighter pen marking (where the thermograph was still recording but the pen again started to pull away from the paper), the ruler measurement appears to be just shy of 119°F, in very close agreement with the LIG (Figs. 6-9).



Fig. 5: Photo of the configuration of the thermometers in the oven, with the outer door open but the inner clear door closed. The thermograph is on the top rack and the LIG max-T thermometer is hanging below.



Fig. 6: Zoom-in on LIG thermometer showing a value of nearly 119°F after oven testing.

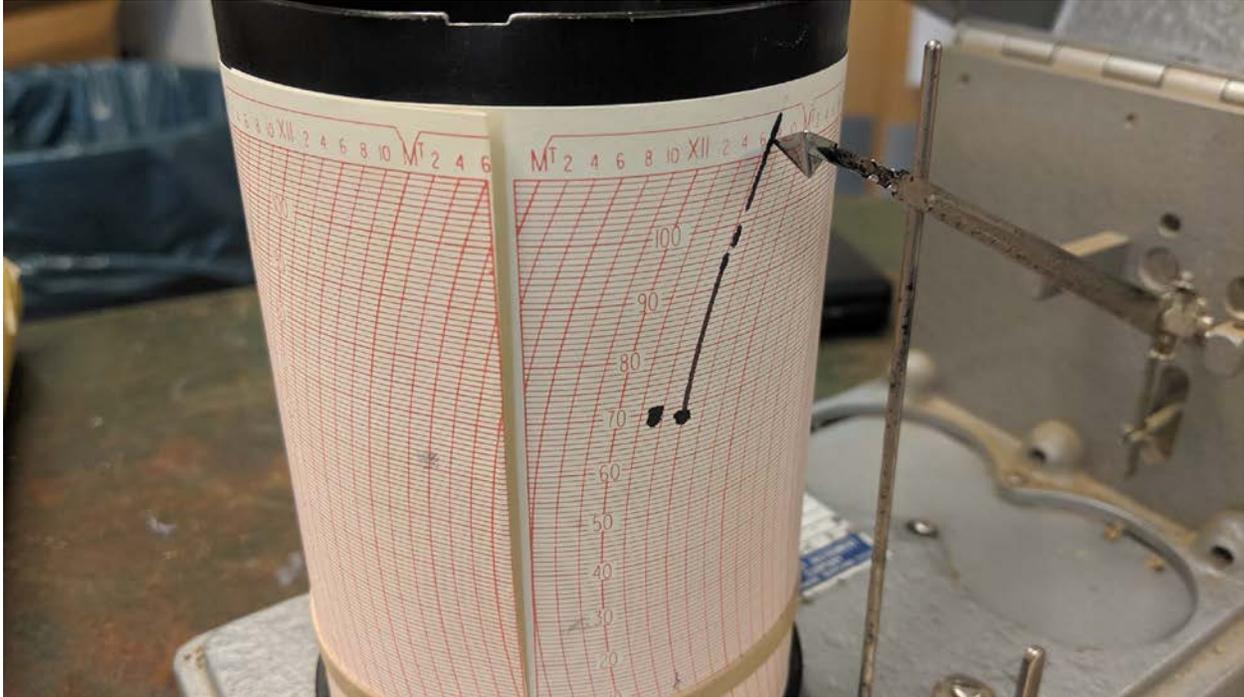


Fig. 7: Photo of thermograph after removal from the oven. Note the markings that extend beyond the darker ink markings, showing the maximum temperature reached (while the pen was no longer marking as well).



Fig. 8: Zoomed photo of thermograph while in the oven, showing the arm at the approximate maximum temperature.

We then conducted some measurements to assess the temperatures on the chart above the 110°F markings. Based on our measurements, shown in Figs. 9-10, the distance from the 110°F line to the red line above it is 0.2". On the main part of the chart, 5°F is a little less than 0.2". Recall from above that the observer stated that the thermograph marking for July 20 reached that small red line, which would correspond to at least 115°F.

The thermograph marking from our testing is nearly 0.6" above 100°F, which corresponds to a temperature of approximately 119°F, in close agreement with the LIG thermometer. Based on the results of our testing, we conclude that the Belfort thermograph operates normally at temperatures at and above 115°F and its measurements can be considered reliable.

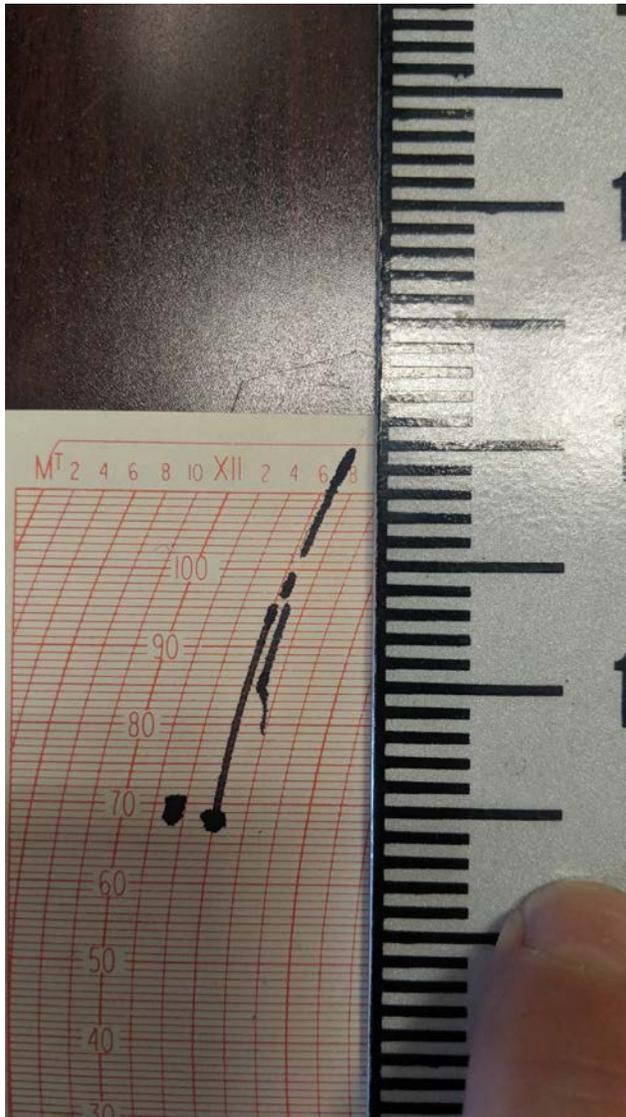


Fig. 9: Measurement of the chart showing that the distance between the 110°F line and the red line above the graduated markings is 0.2". On the main part of the chart, 0.2" corresponds to between 5 and 6°F.

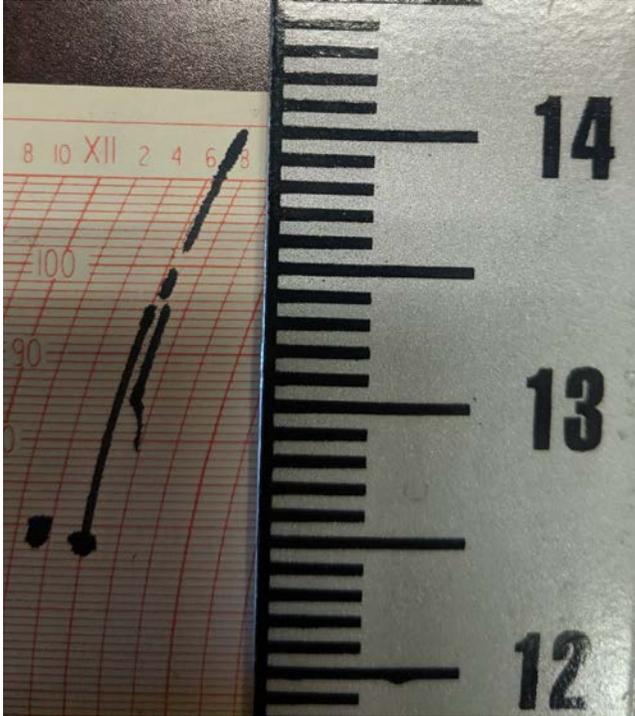


Fig. 10: Measurement of the chart showing that the distance between the 100°F line and the maximum thermograph marking (the lighter marking) is 0.6". On the main part of the chart, 0.6" corresponds to between 18-19°F, leading us to conclude that the maximum temperature recorded by the thermograph was between 118-119°F, in close agreement with the LIG thermometer.

Finding of committee

The observation of a 115°F maximum temperature at the John Martin Dam COOP station raised numerous questions and complications in the process of determining whether or not to establish the observation as a state record. On one hand, there were unfortunate irregularities with the measurement, considering that the thermograph chart only included markings up to 110°F, and that the chart showing the observation was not retained. On the other hand, typical practice for COOP measurements is for a single trained observer to read a thermometer, and in this case three trained observers inspected the chart and agreed that the temperature reading was 115°F. We were also able to confirm through testing that the thermograph operates properly at temperatures above 115°F, that extrapolating the thermograph readings above the markings on the chart is reasonable, and that the temperature recorded on the thermograph on the day in question reached at least 115°F based on the observer's report.

Although the available information does not paint a crystal-clear picture, considering the balance of evidence, we conclude that the observation of a maximum temperature of 115°F on 20 July 2019 at the John Martin Dam COOP station was legitimate and establish it as a new state record for maximum temperature in Colorado.

Committee Members:

- Russ Schumacher, State Climatologist, Colorado Climate Center, Colorado State University
- Tim Kearns, NWS Central Region Cooperative Observer Program Lead
- Natalie Umphlett, Regional Climatologist, High Plains Regional Climate Center
- Jennifer Stark, Meteorologist in Chief, National Weather Service WFO Pueblo, Colorado
- Deke Arndt, Chief, Monitoring Section, National Centers for Environmental Information

Additional Committee Participants:

- Becky Bolinger, Assistant State Climatologist, Colorado Climate Center
- Michael Nosko, Observation Program Lead, NWS WFO Pueblo

Technical contributors:

- Noah Newman and Zach Schwalbe, Colorado Climate Center

Acknowledgments

The SCEC thanks Susan DeLong and Lucas Loetscher of Colorado State University for graciously allowing us to use the laboratory oven.