The weather and climate of western Colorado: How does it affect wine grapes and what might climate change bring?

Russ Schumacher and Peter Goble

Colorado Climate Center
Department of Atmospheric Science, Colorado State University

COLORADO CLIMATE CENTER

VinCo annual conference
January 2021

ATMOSPHERIC SCIENCE
COLORADO STATE UNIVERSITY

Brief history of the CCC

- Until 1973, the federal government operated a “state climatologist” program – but in in 1973 this was abolished
- Later that same year, Colorado established the Colorado Climate Center at CSU with support through the Colorado Agricultural Experiment Station

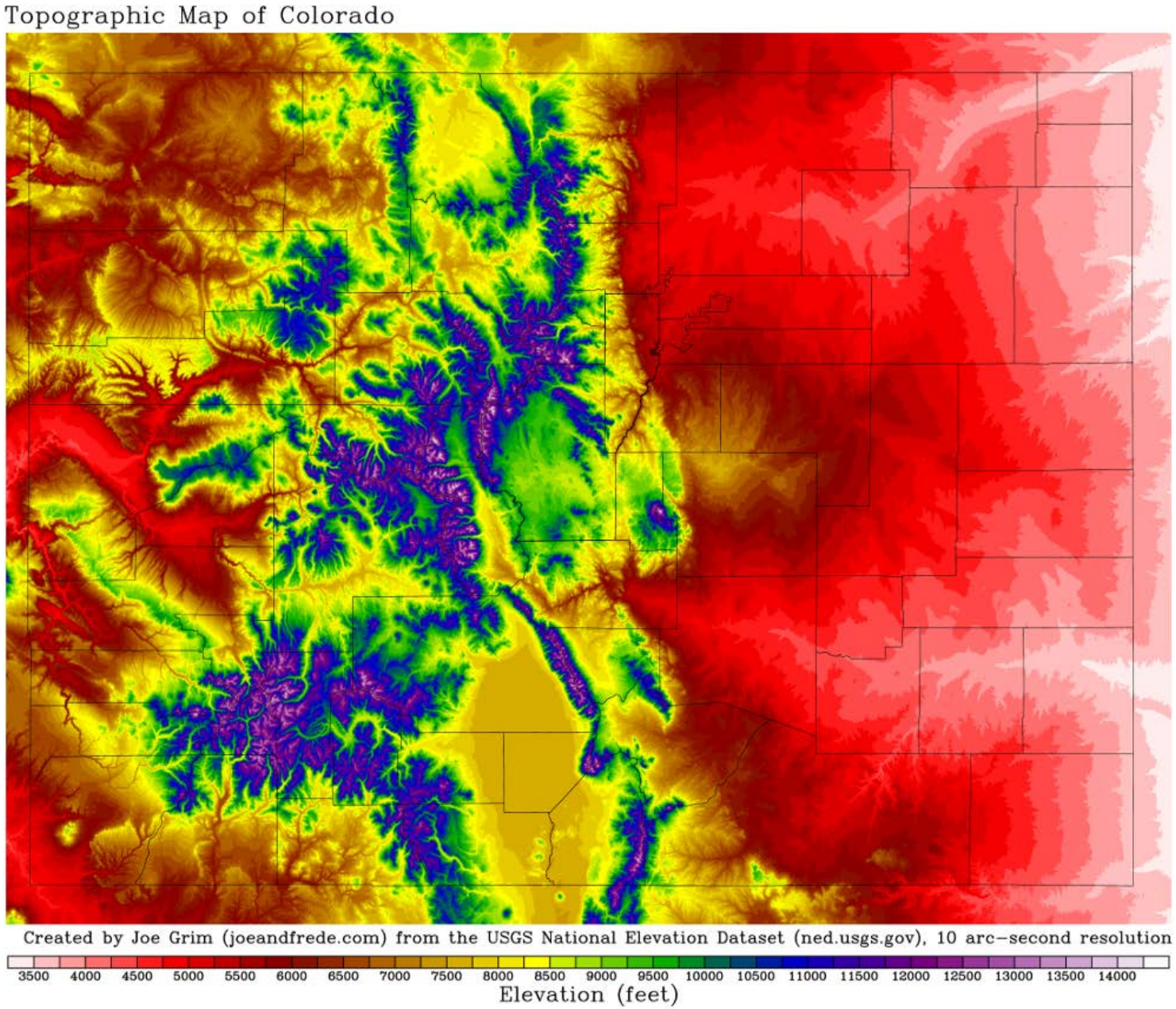
Our mission

The Colorado Climate Center at CSU provides valuable climate expertise to the residents of the state through its threefold program of:

1) ***Climate Monitoring*** (data acquisition, analysis, and archiving)

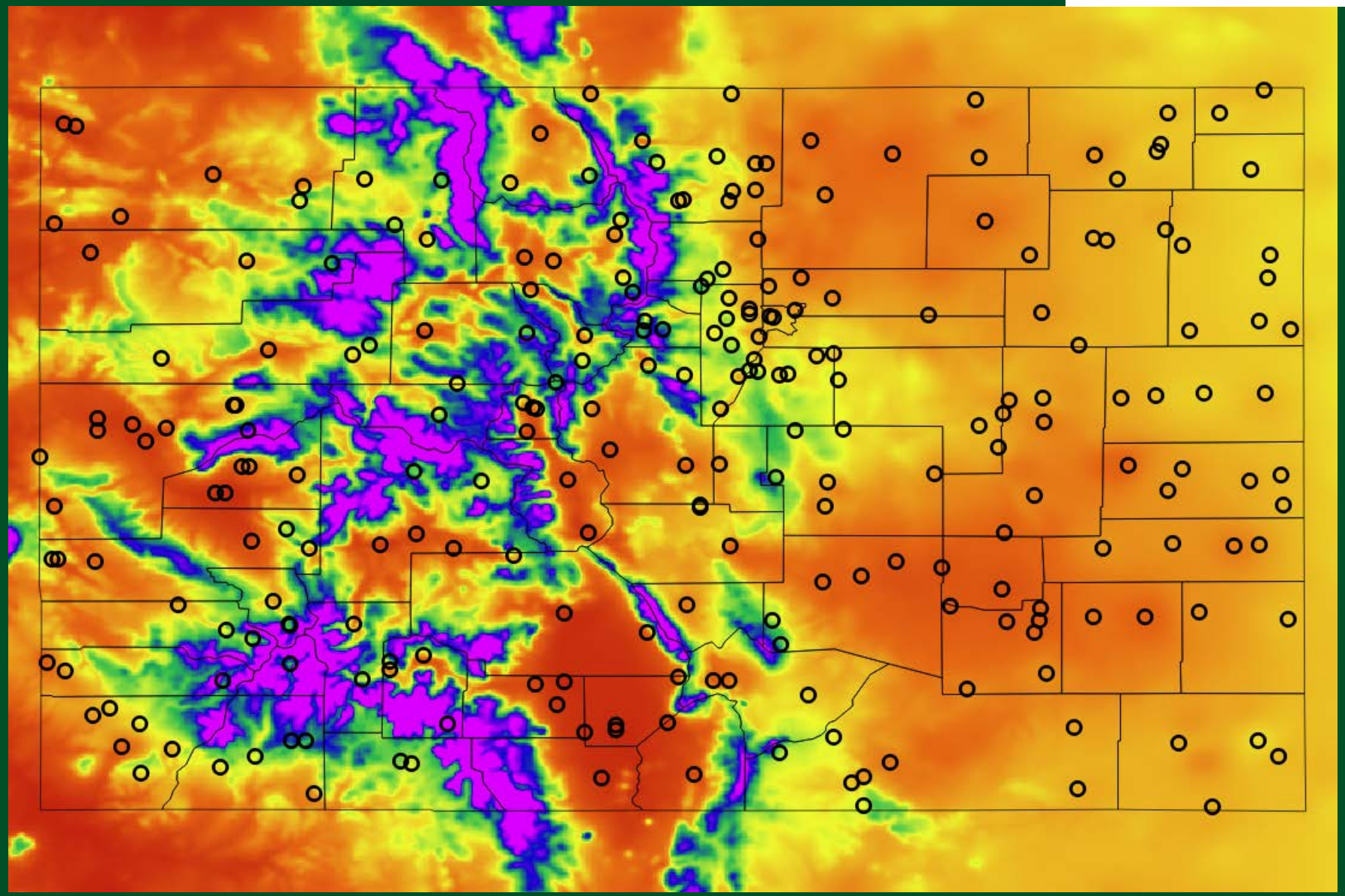
2) ***Climate Research***

3) ***Climate Services*** (providing data, analysis, climate expertise, education and outreach)



http://www.joeandfrede.com/colorado/misc_trip_reports/colorado_topo_med_res.png

Annual average precipitation



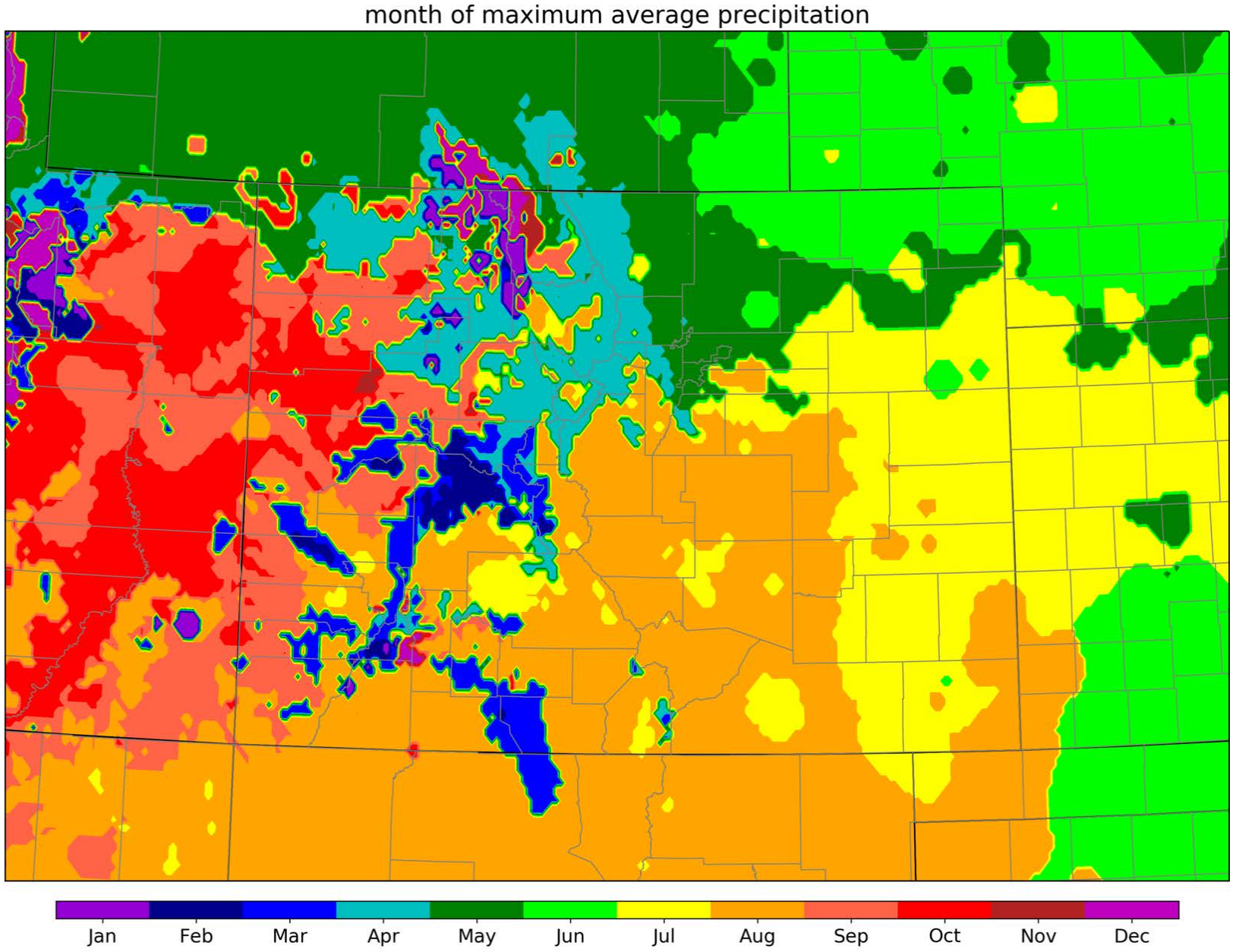
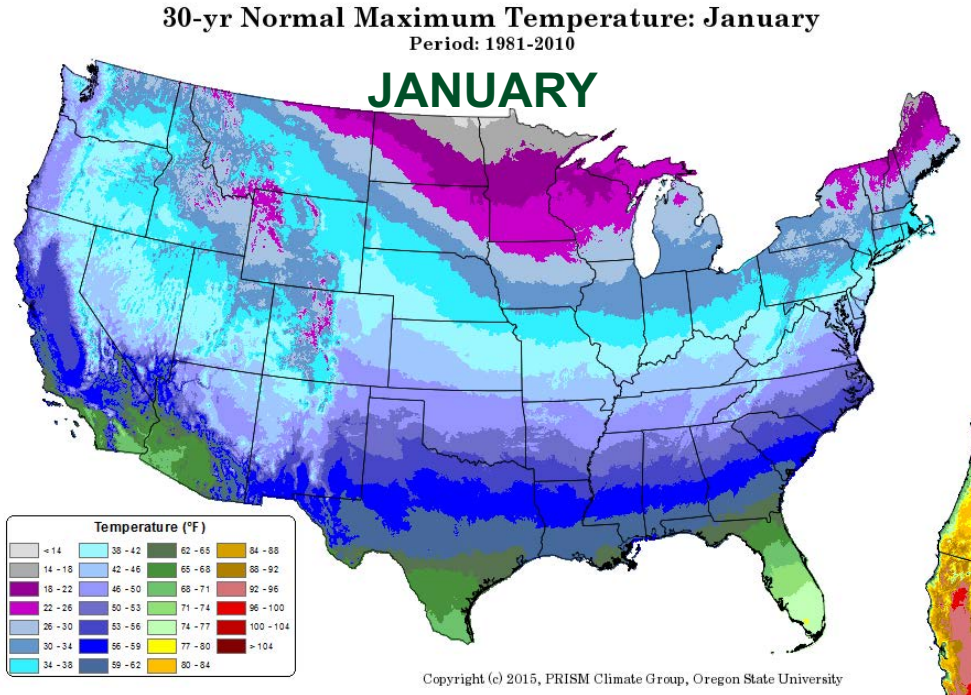


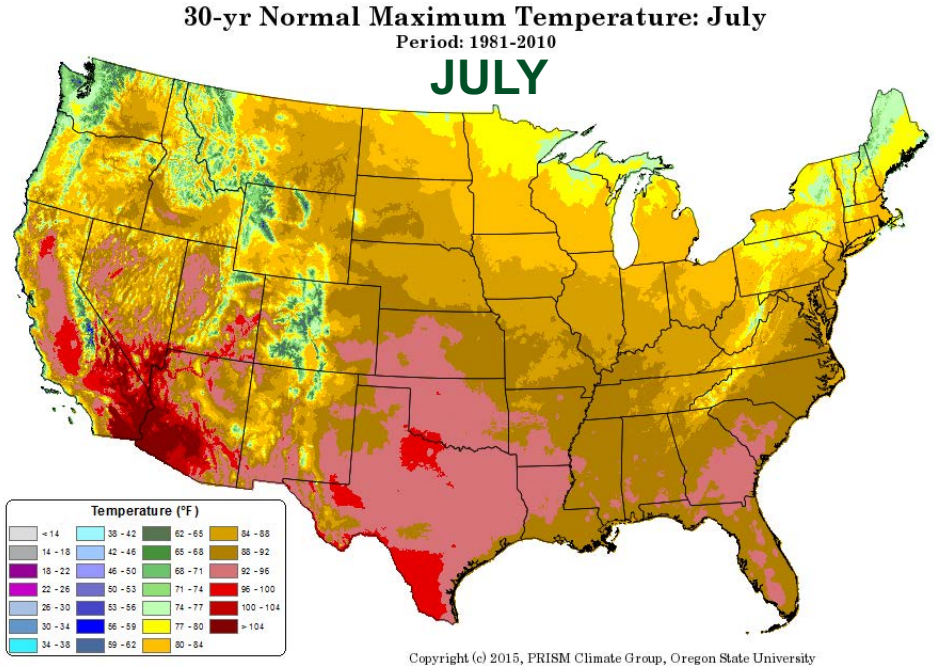
Figure: Russ Schumacher/Colorado Climate Center
Data: PRISM climate group (prism.oregonstate.edu)

Seasonal precipitation in Colorado varies greatly from place to place

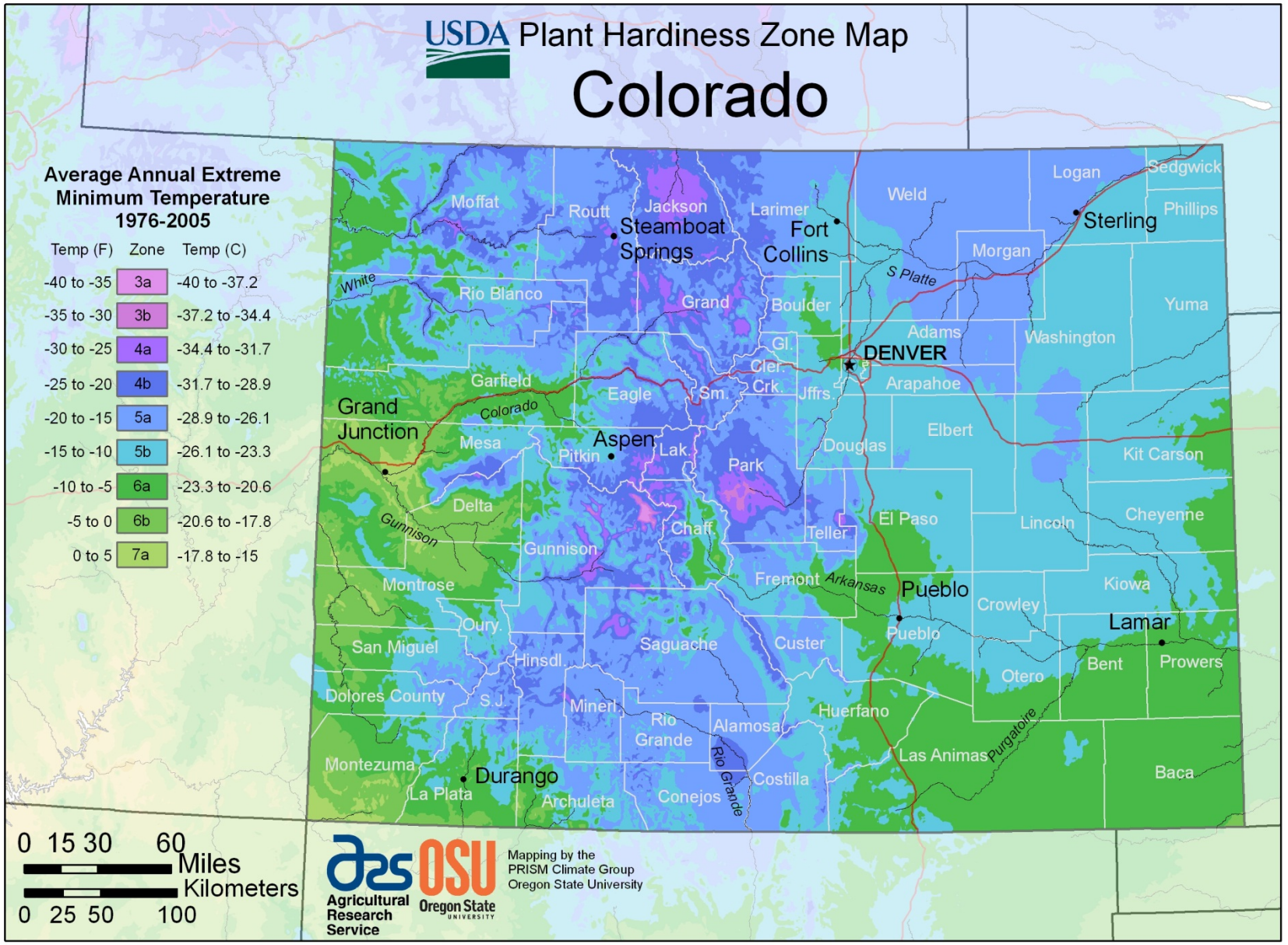
Month of maximum average precip
Data: PRISM Climate Group, prism.oregonstate.edu

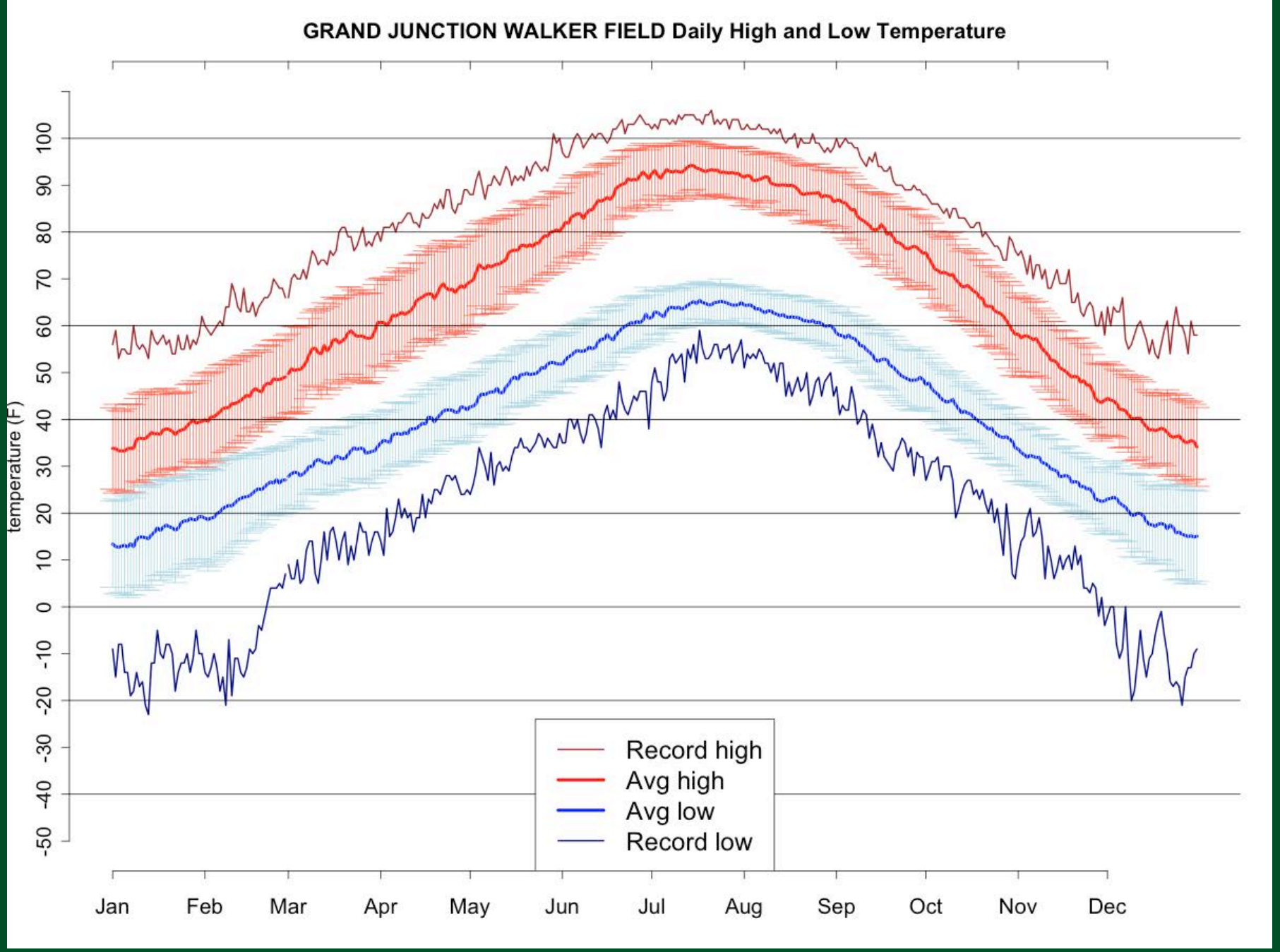
Complex temperature variations due to elevation and topography

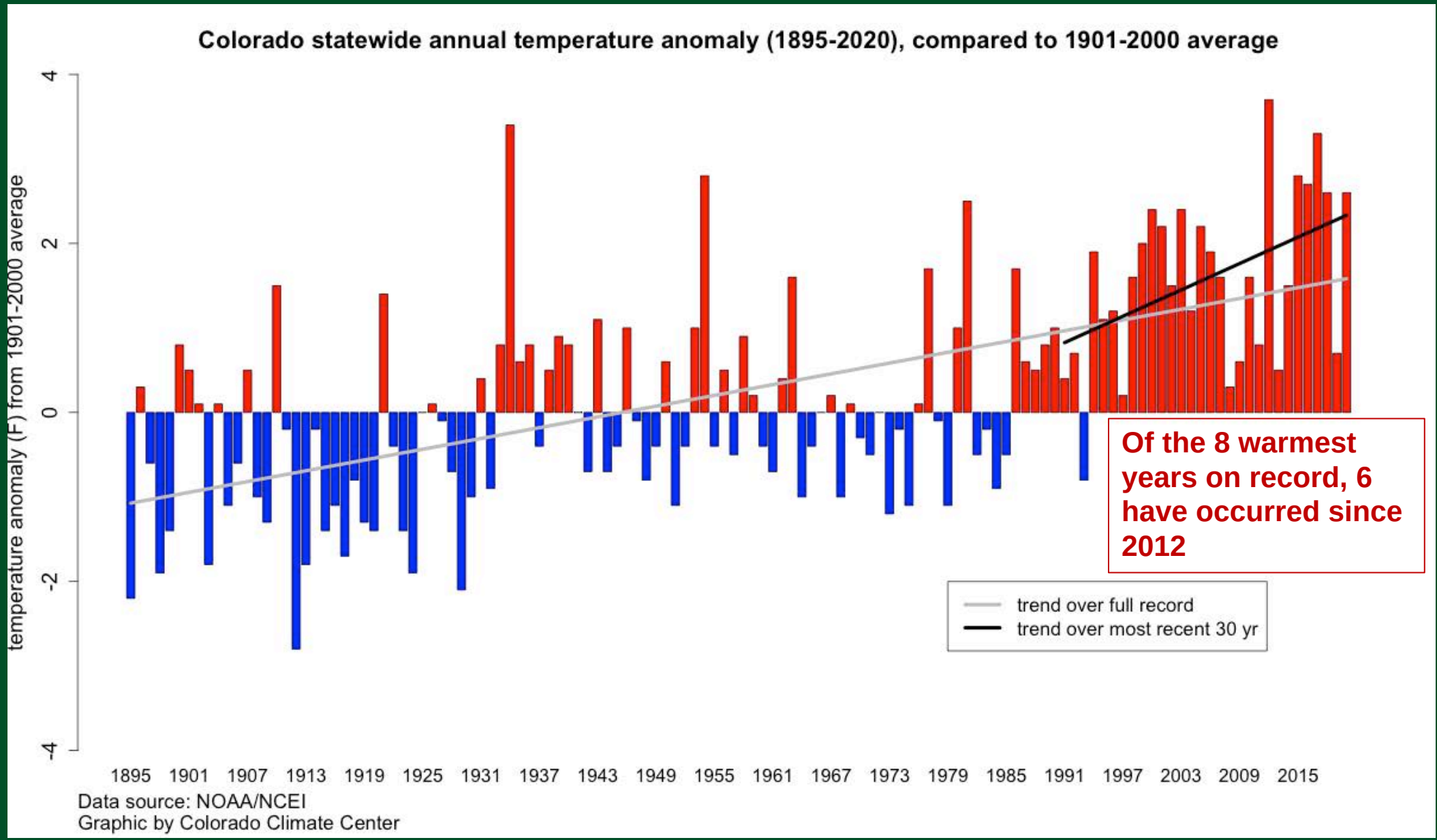


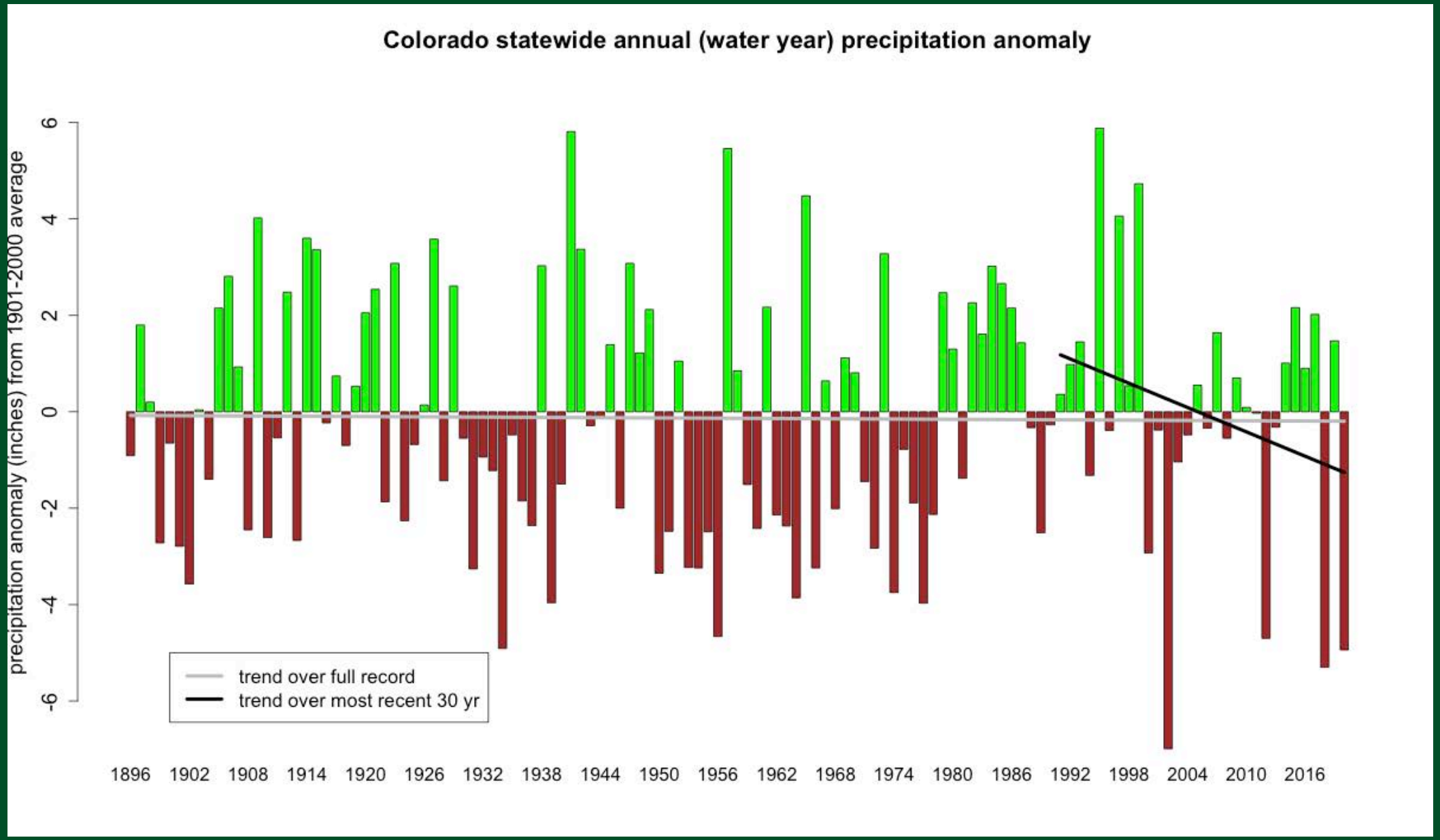


Usually colder in the mountains!

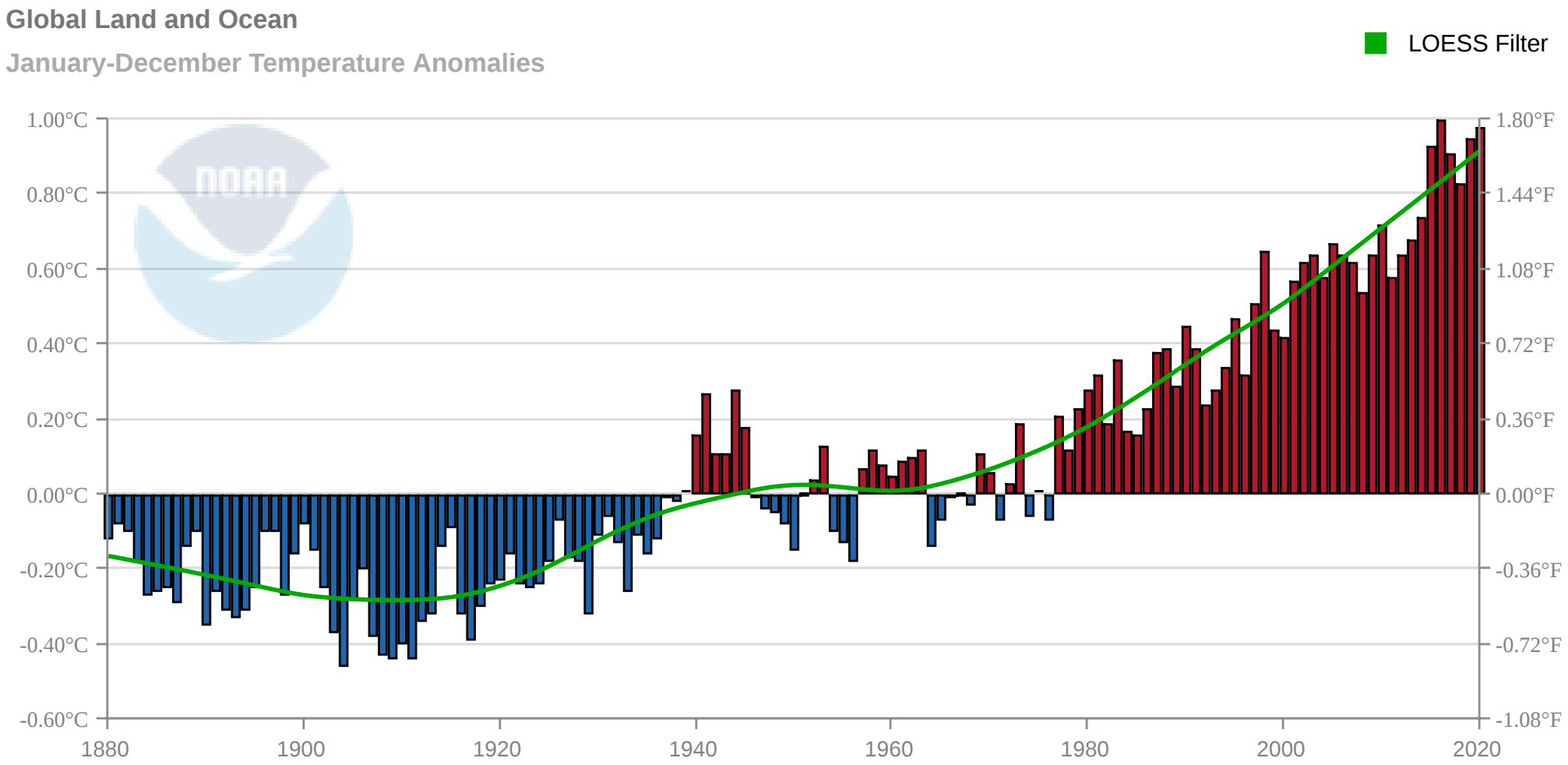

USDA Plant Hardiness Zone Map
Colorado
Average Annual Extreme Minimum Temperature 1976-2005
Temp (F) Zone Temp (C)
-40 to -35 3a -40 to -37.2
-35 to -30 3b -37.2 to -34.4
-30 to -25 4a -34.4 to -31.7
-25 to -20 4b -31.7 to -28.9
-20 to -15 5a -28.9 to -26.1
-15 to -10 5b -26.1 to -23.3
-10 to -5 6a -23.3 to -20.6
-5 to 0 6b -20.6 to -17.8
0 to 5 7a -17.8 to -15
0 15 30 60 Miles
0 25 50 100 Kilometers
Agricultural Research Service
Oregon State University
Mapping by the PRISM Climate Group Oregon State University
Moffat
Routt
Jackson
Steamboat Springs
Larimer
Fort Collins
Weld
Logan
Sedgwick
Phillips
Sterling
Morgan
S Platte
White
Rio Blanco
Grand
Boulder
Yuma
Adams
Washington
Gl.
DENVER
Clear Crk.
Arapahoe
Garfield
Eagle
Sm.
Jffrs
Grand Junction
Colorado
Elbert
Mesa
Aspen
Pitkin
Lak.
Douglas
Kit Carson
Park
Delta
El Paso
Cheyenne
Gunnison
Chaff.
Teller
Lincoln
Gunnison
Fremont
Arkansas
Pueblo
Kiowa
Montrose
Crowley
Oury.
Lamar
Pueblo
San Miguel
Saguache
Custer
Hinsdl.
Bent
Prowers
Otero
Dolores County
S.J.
Miner.
Huerfano
Rio Grande
Alamosa
Las Animas
Purgatoire
Montezuma
Durango
Costilla
Baca
La Plata
Archuleta
Conejos
Rio Grande


GRAND JUNCTION WALKER FIELD Daily High and Low Temperature
temperature (F)
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Record high
Avg high
Avg low
Record low

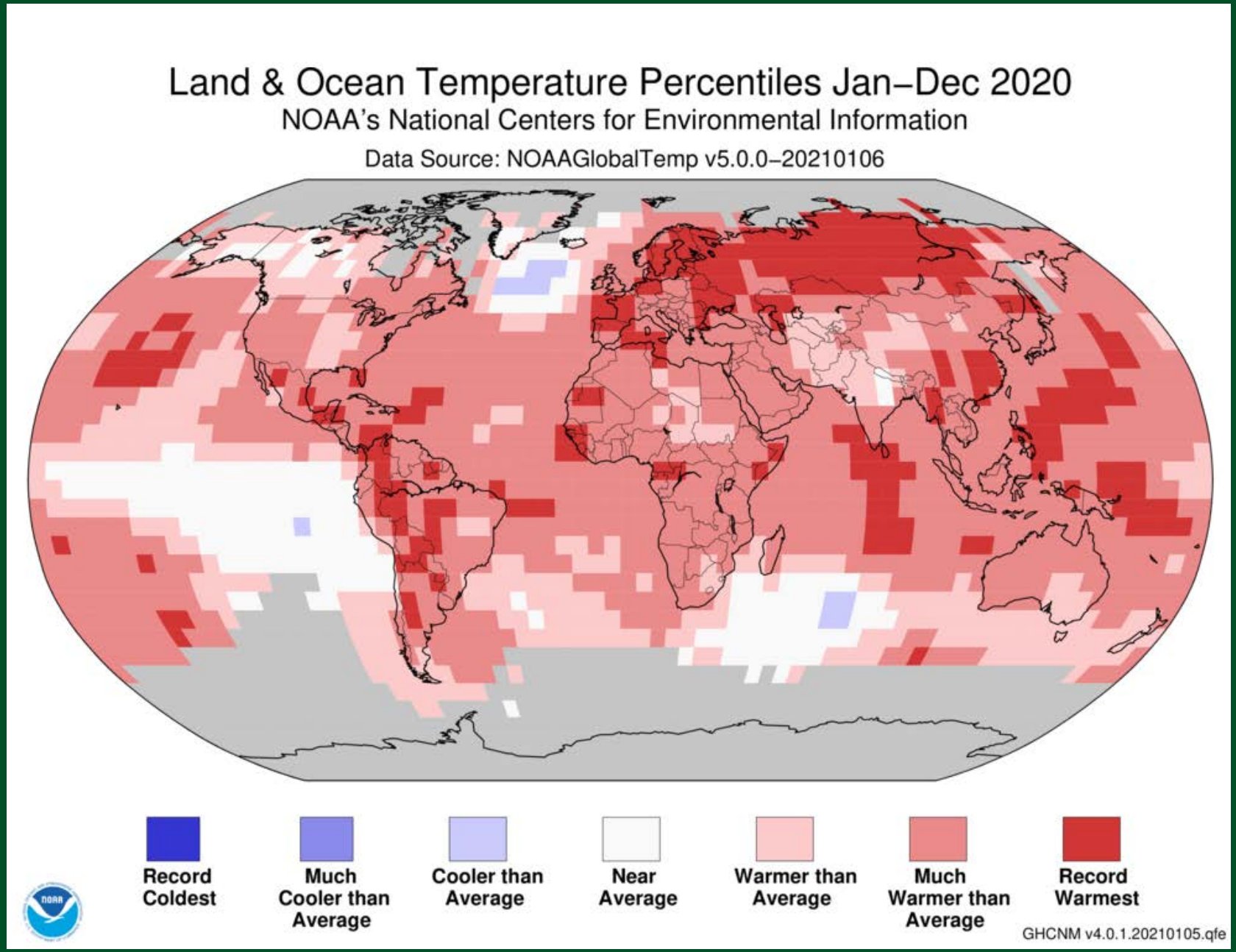

Colorado statewide annual temperature anomaly (1895-2020), compared to 1901-2000 average
temperature anomaly (F) from 1901-2000 average
4
2
0
-2
-4
1895
1901
1907
1913
1919
1925
1931
1937
1943
1949
1955
1961
1967
1973
1979
1985
1991
1997
2003
2009
2015
Of the 8 warmest years on record, 6 have occurred since 2012
trend over full record
trend over most recent 30 yr
Data source: NOAA/NCEI
Graphic by Colorado Climate Center


Colorado statewide annual (water year) precipitation anomaly
precipitation anomaly (inches) from 1901-2000 average
6
4
2
0
-2
-4
-6
trend over full record
trend over most recent 30 yr
1896
1902
1908
1914
1920
1926
1932
1938
1944
1950
1956
1962
1968
1974
1980
1986
1992
1998
2004
2010
2016

Global temperature anomalies

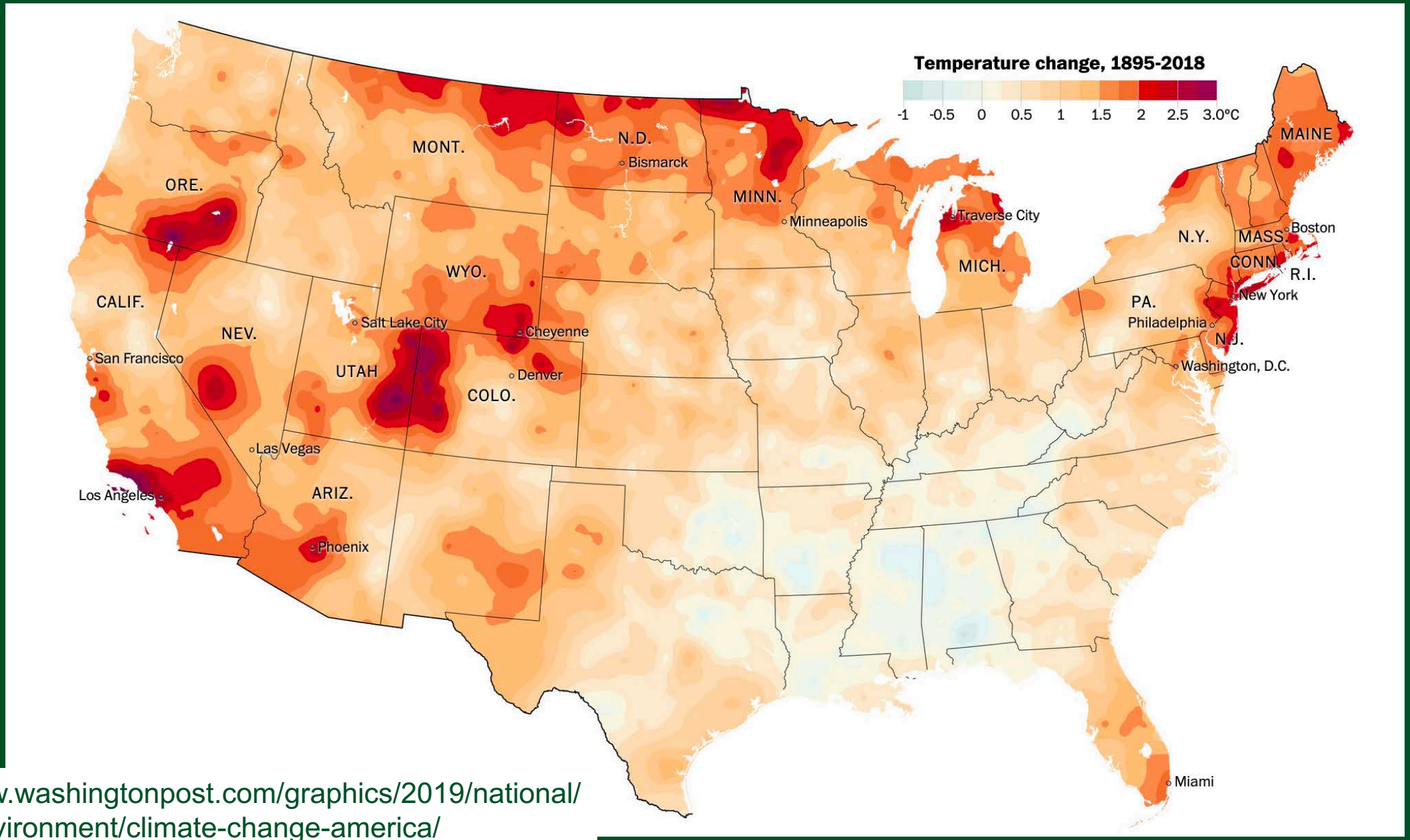


Globally, 2020 was 2nd warmest on record



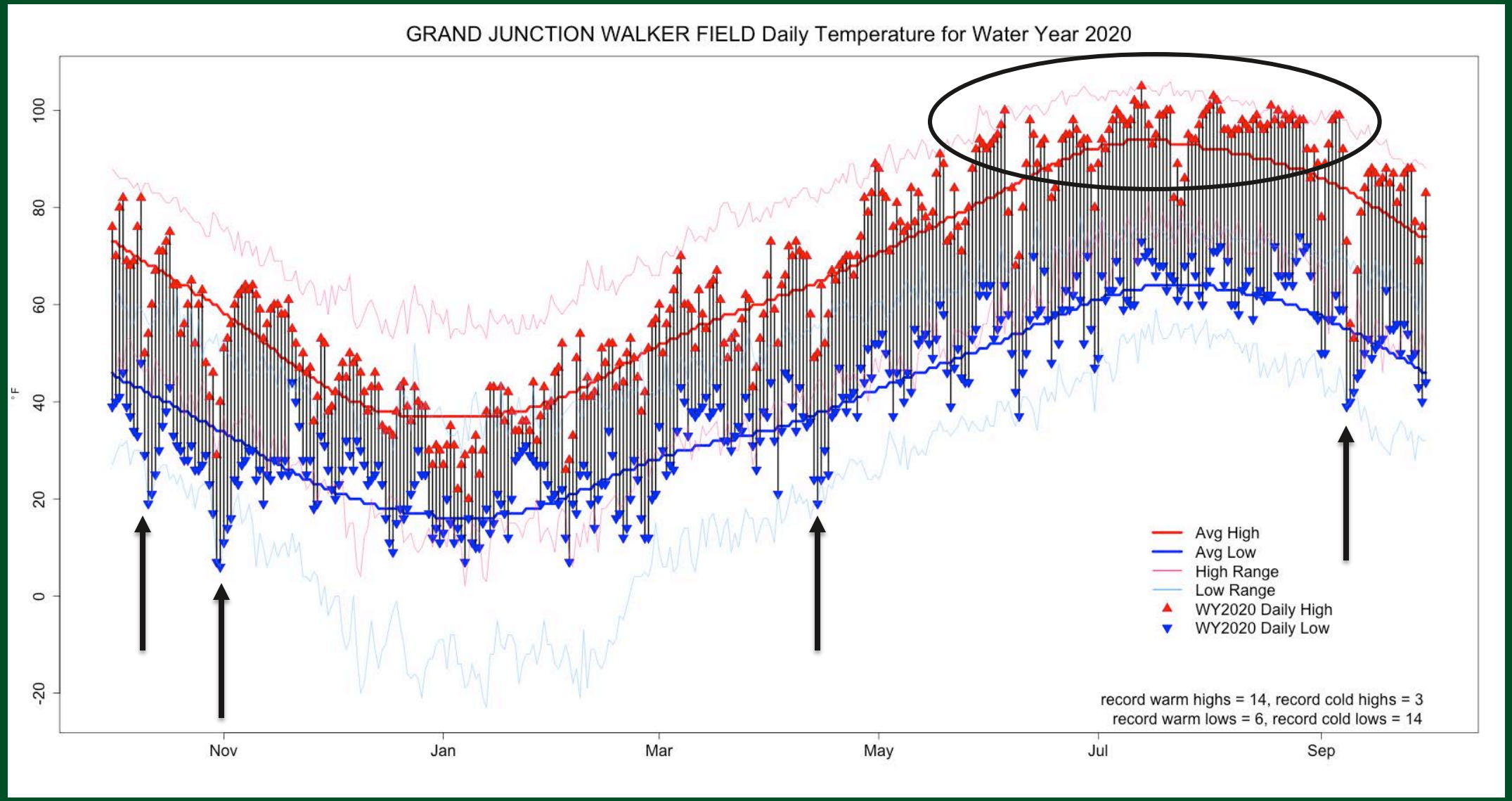
Globally, 2019 was 2nd warmest on record

The interior west has warmed more than almost anywhere else in the US

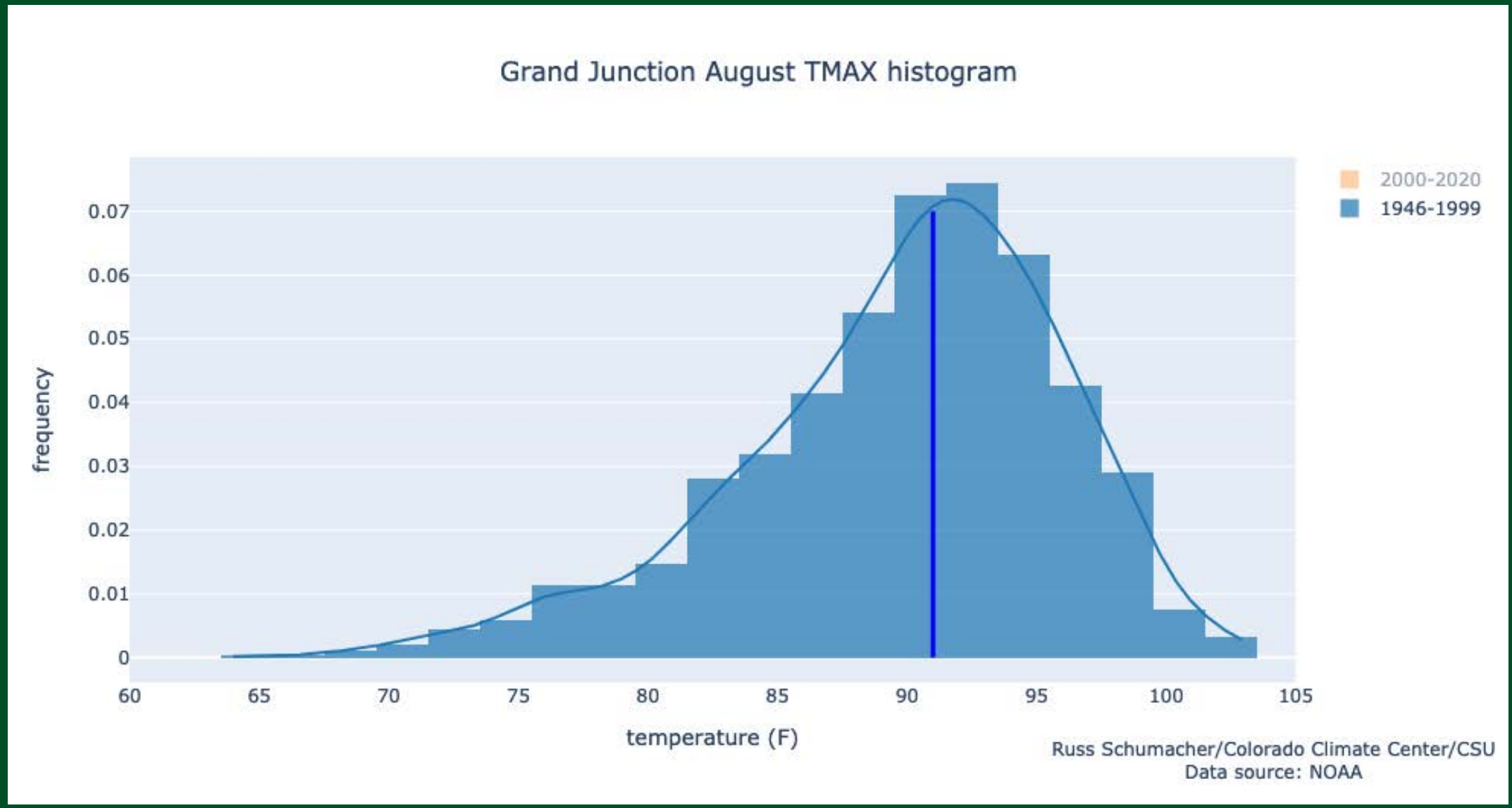


https://www.washingtonpost.com/graphics/2019/national/climate-environment/climate-change-america/

Water year 2020 temperatures: Grand Junction



High temperatures in Grand Junction in August



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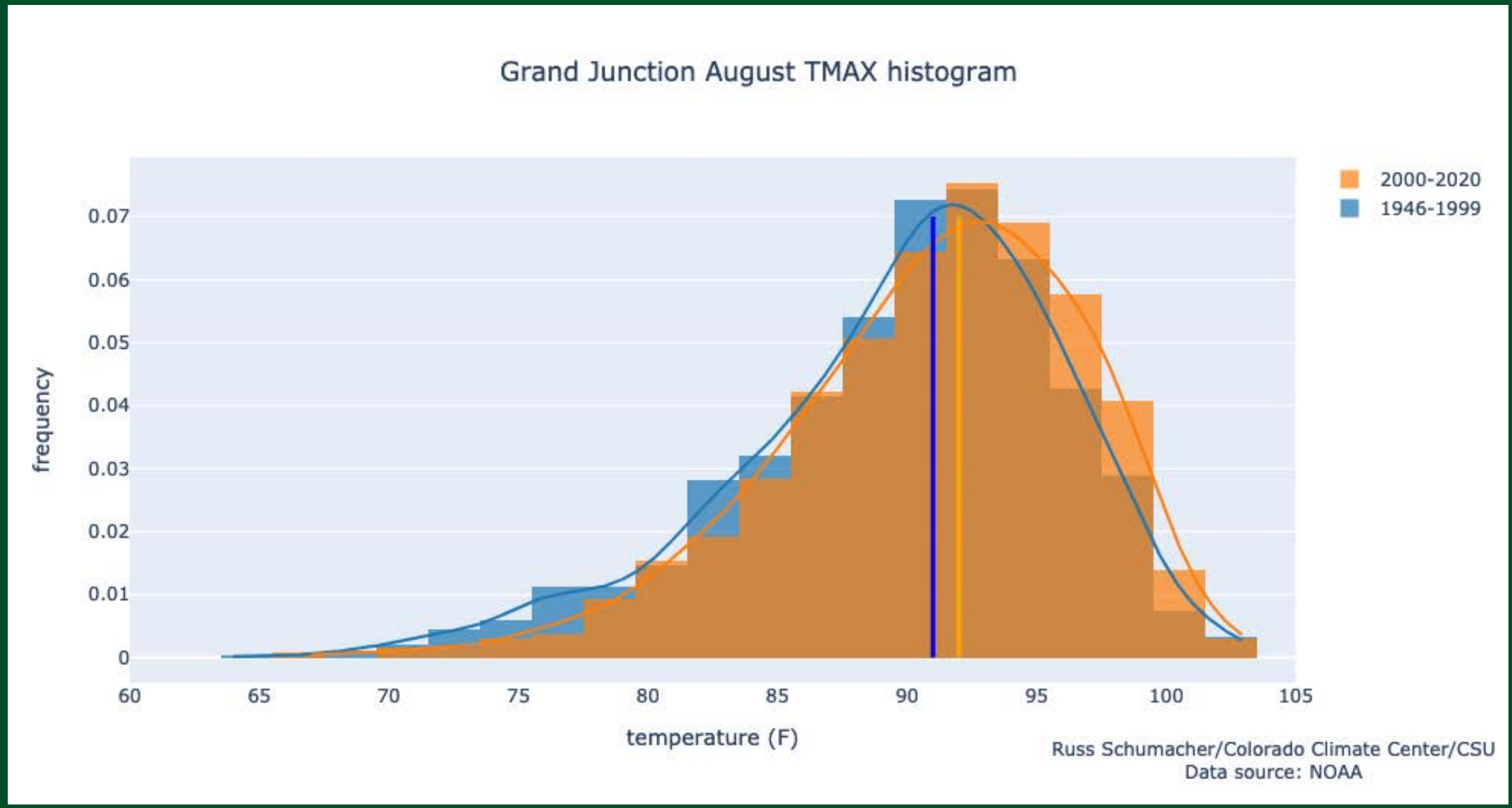
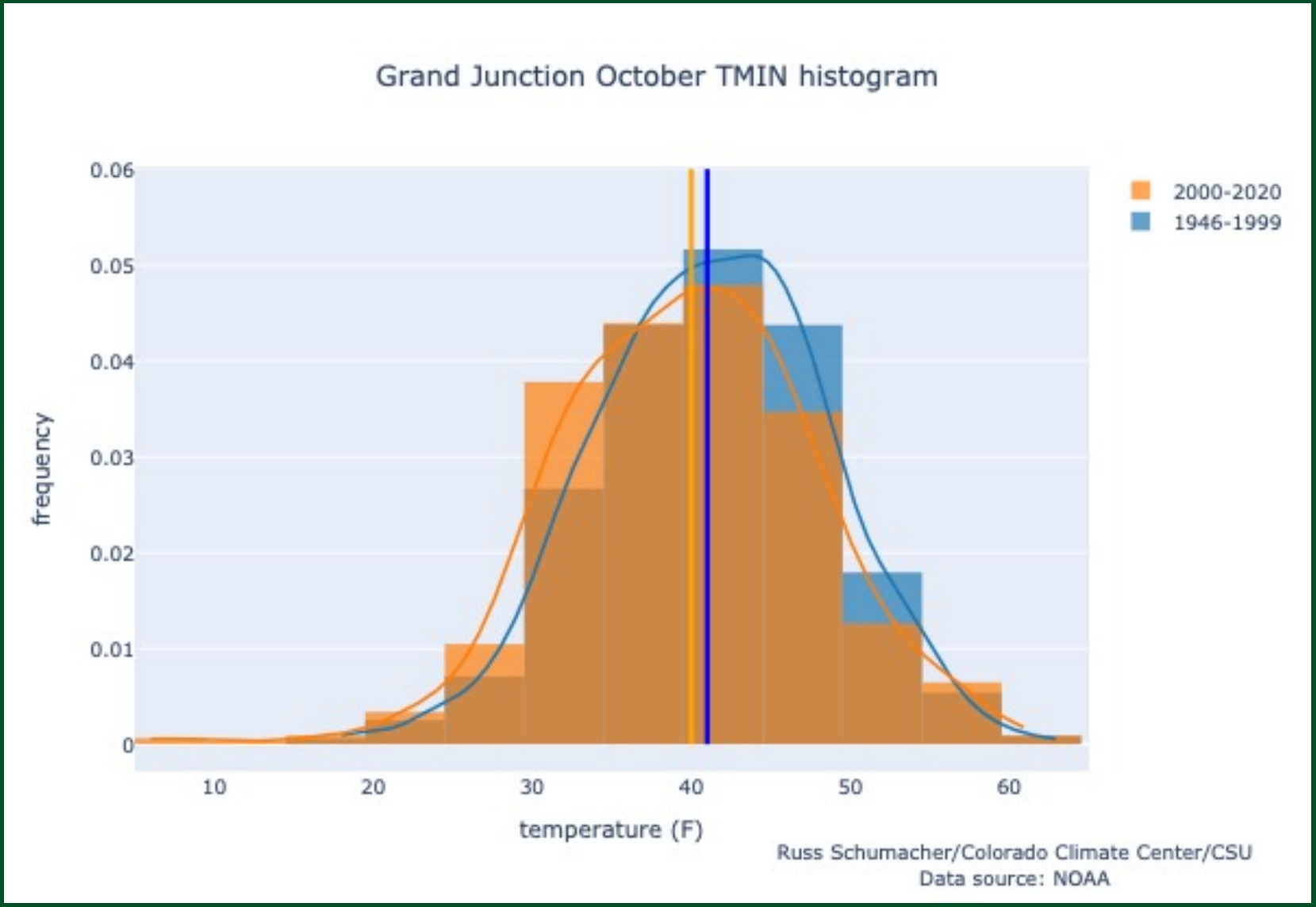


Low temperatures in Grand Junction in October

Are cold nights in the fall happening more frequently?



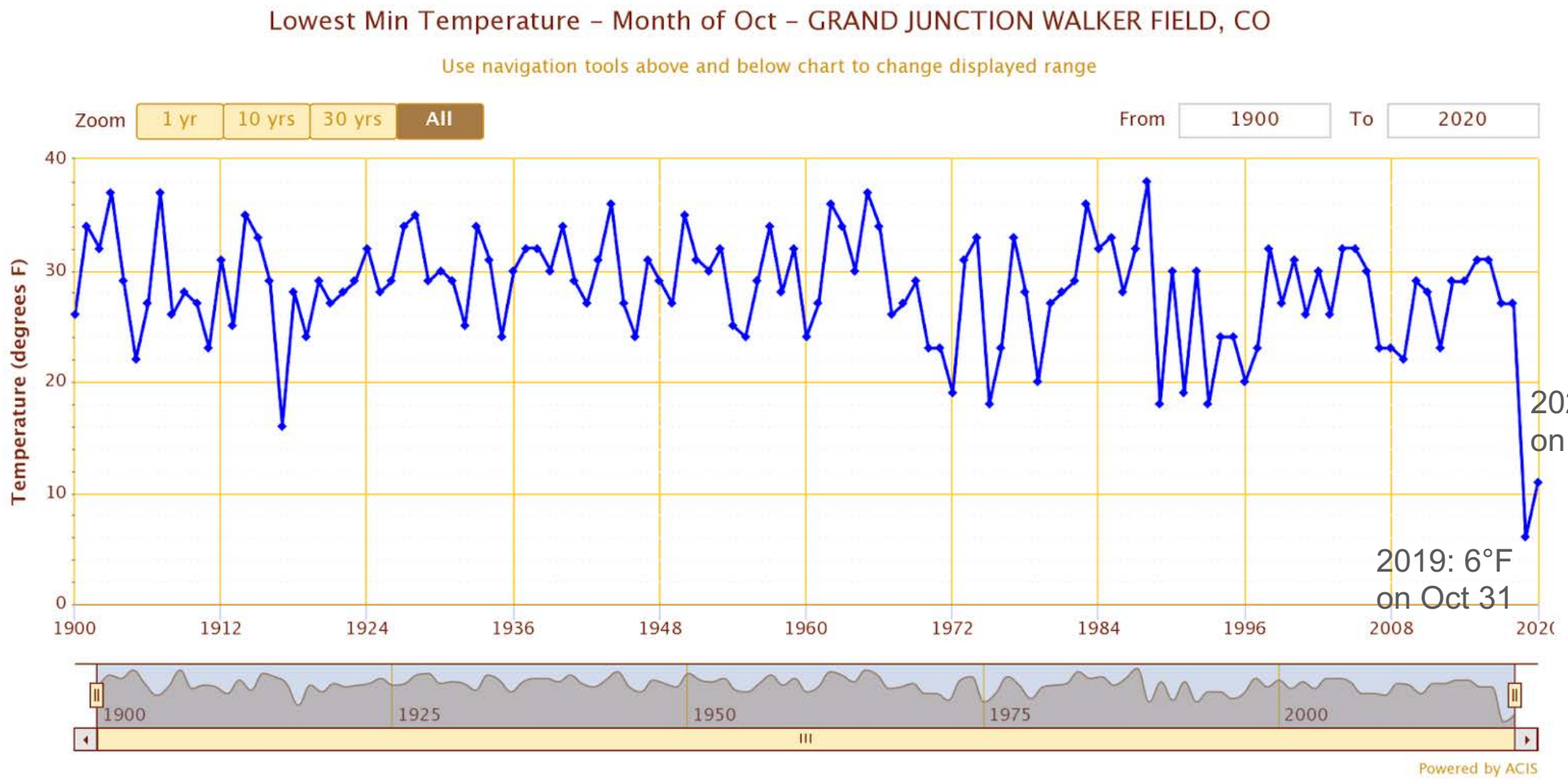
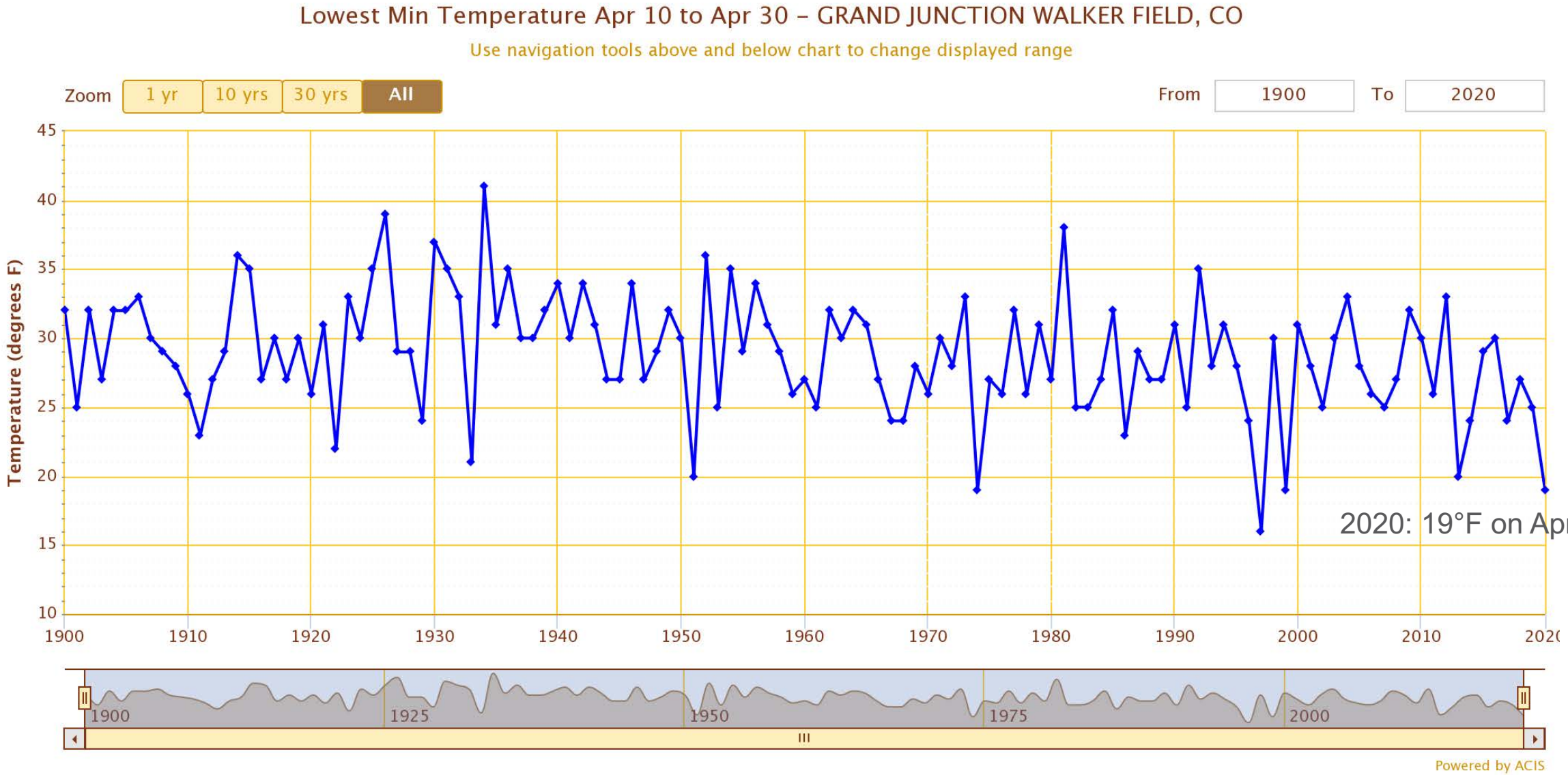
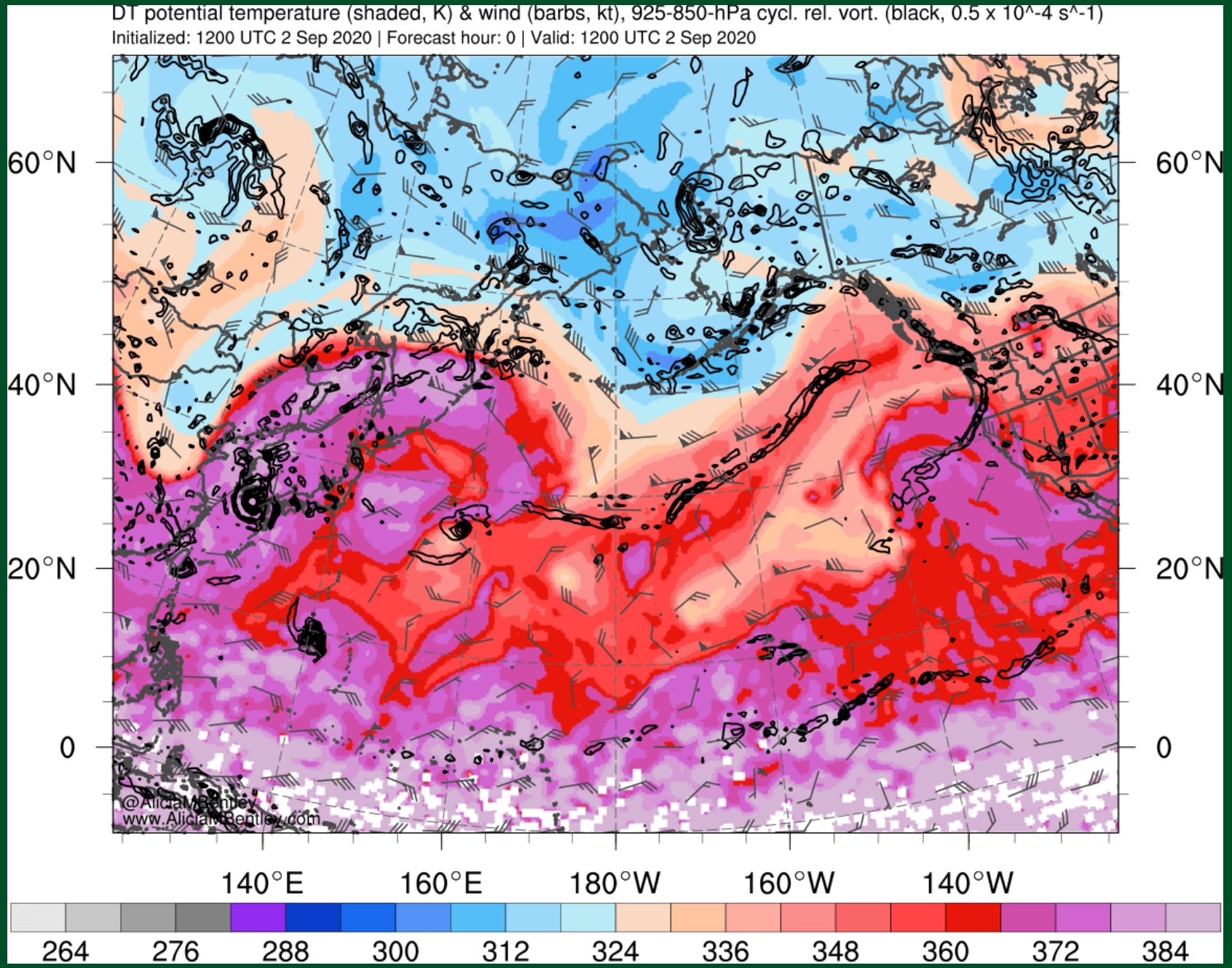


Figure 1: Lowest daily minimum temperatures recorded in October for each year from 1900 - 2020 at Walker Field in Grand Junction, CO

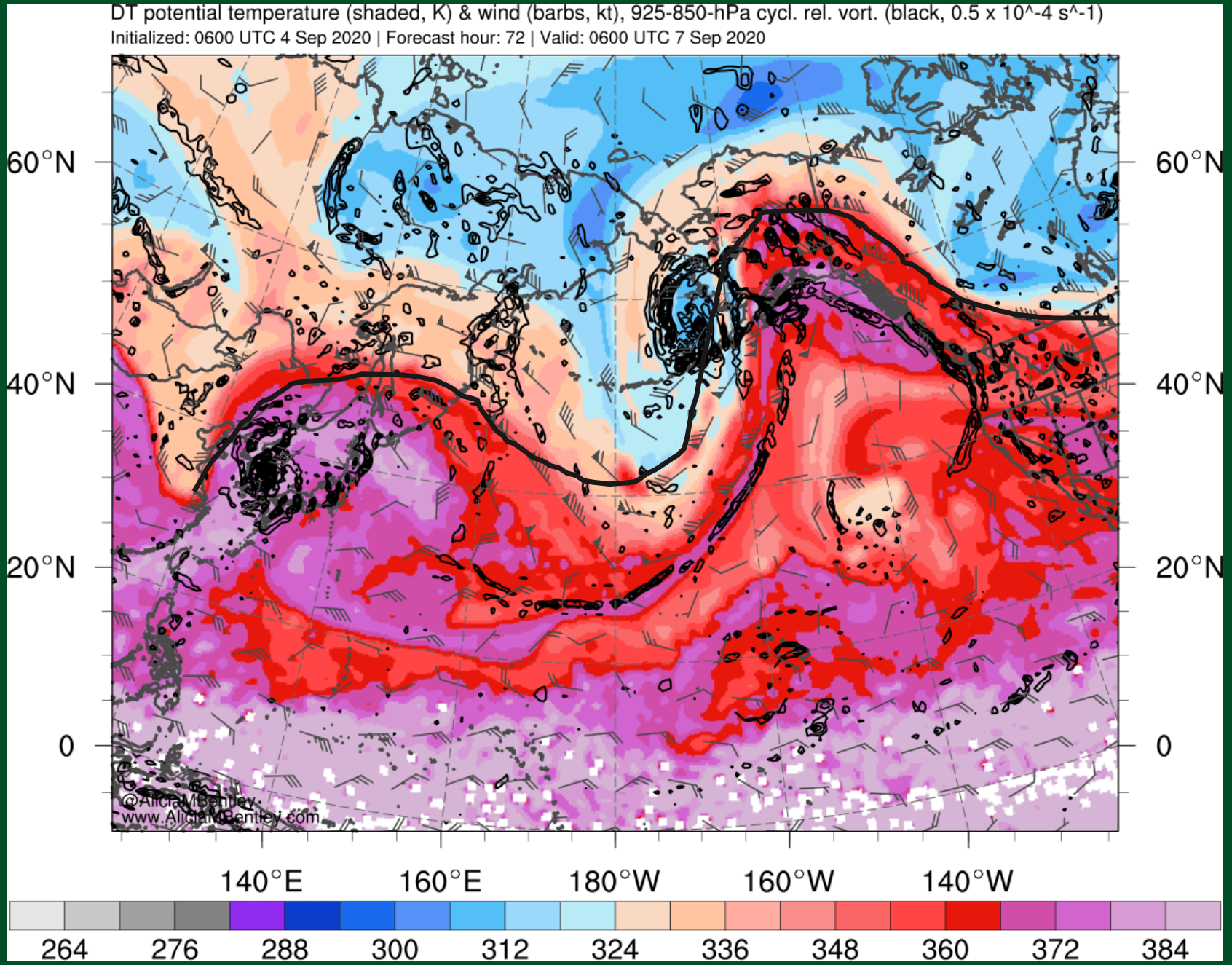


2020: 19°F on April 14

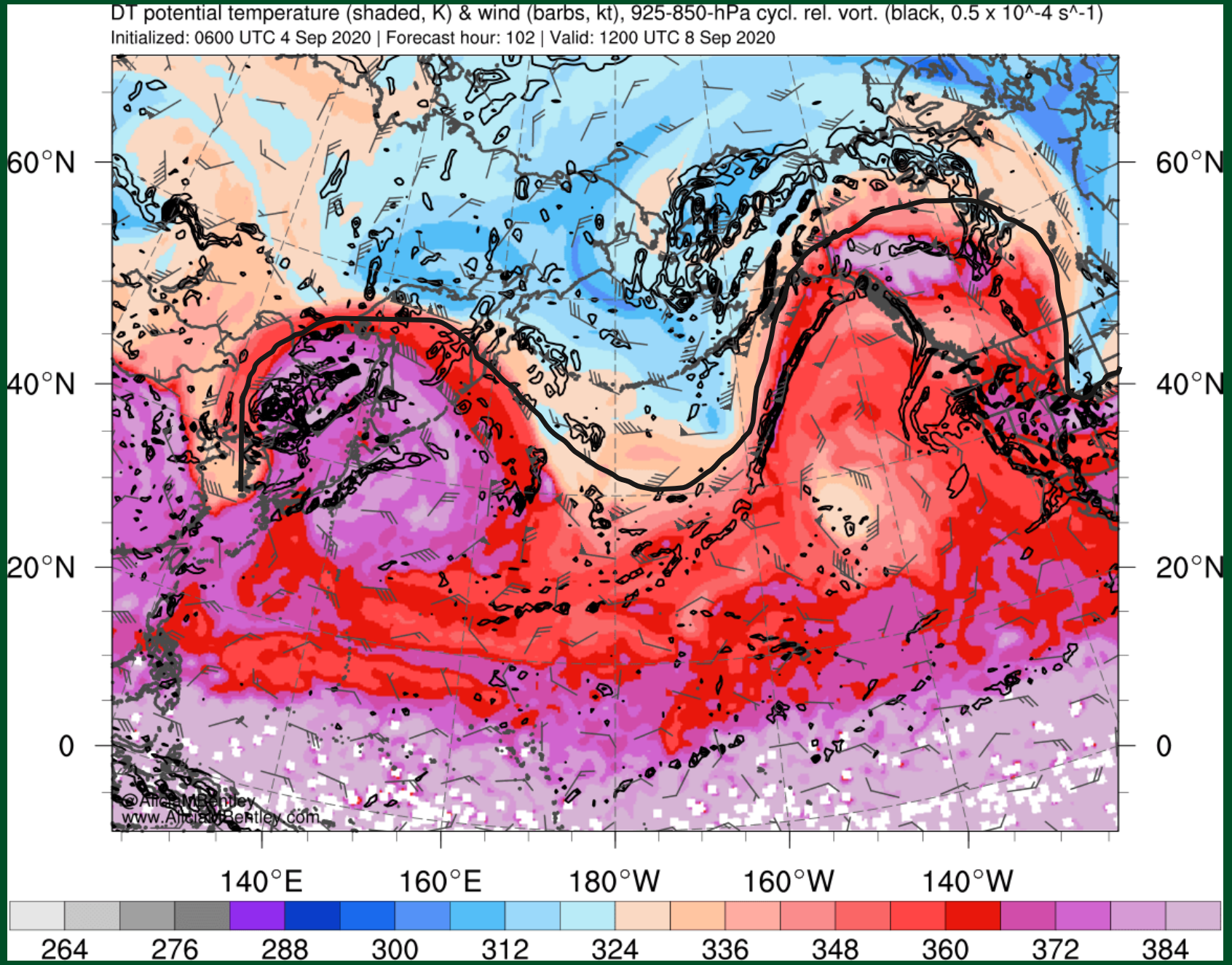
Lowest temperature between April 10 – April 30



September 2020 roller coaster



September 2020 roller coaster

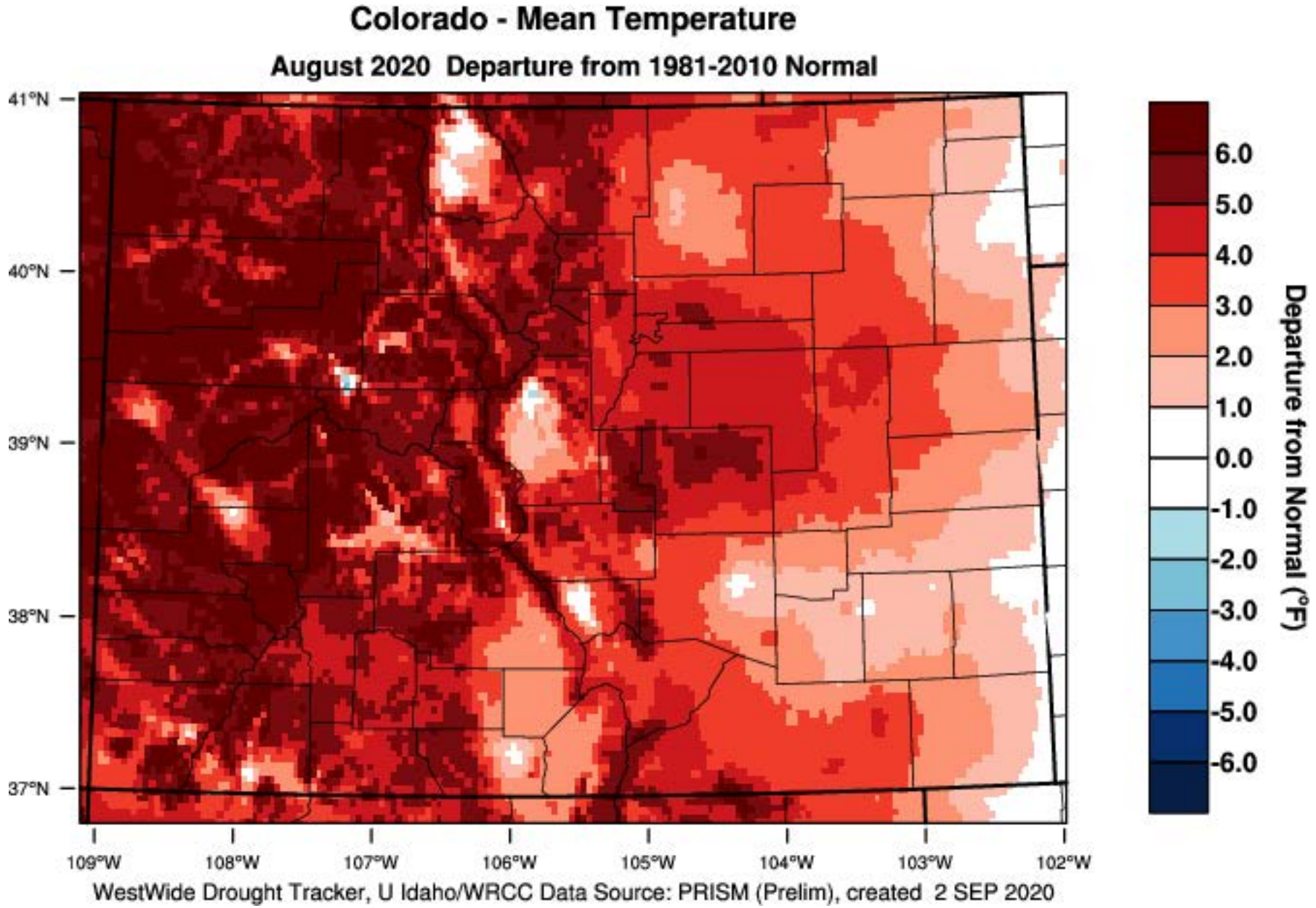


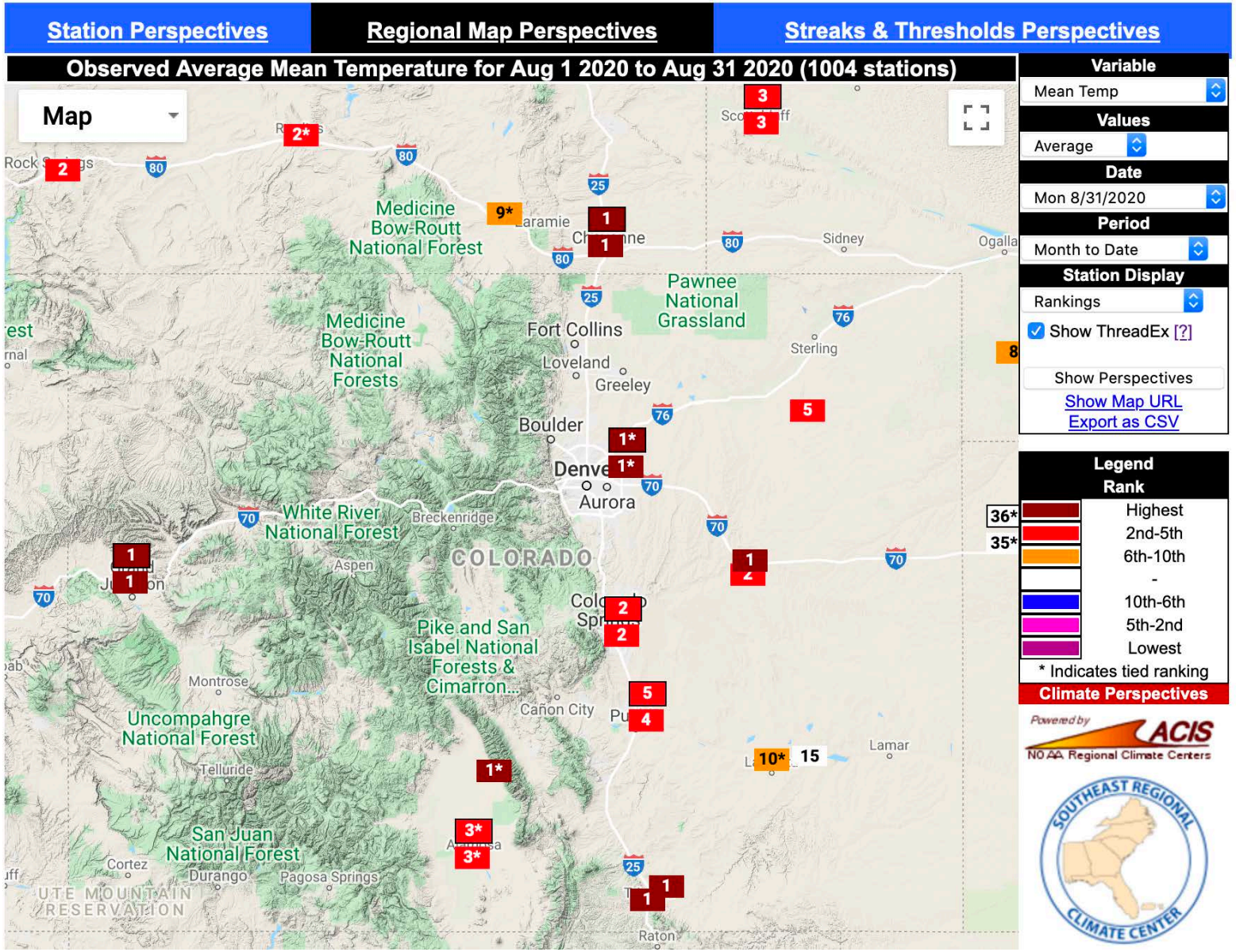
September 2020 roller coaster

August 2020 was the most extreme hot, dry summer month in recorded history for western Colorado

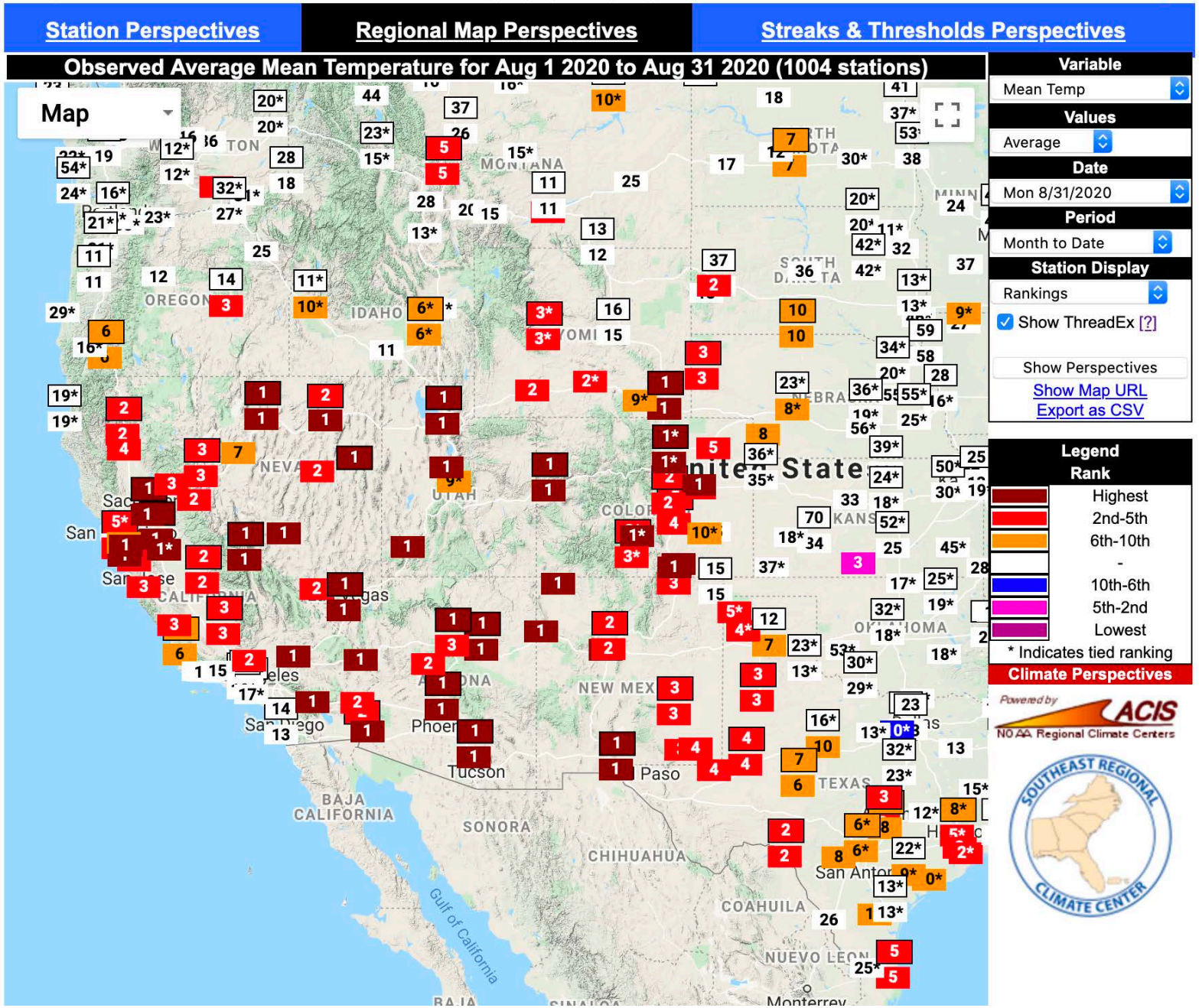
Pine Gulch Fire, August 16, 2020

https://upload.wikimedia.org/wikipedia/commons/thumb/0/0a/2020_08_17-14.56.09.136-CDT.jpg/1280px-2020_08_17-14.56.09.136-CDT.jpg


Colorado - Mean Temperature
August 2020 Departure from 1981-2010 Normal
41°N
40°N
39°N
38°N
37°N
109°W
108°W
107°W
106°W
105°W
104°W
103°W
102°W
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
Departure from Normal (°F)
WestWide Drought Tracker, U Idaho/WRCC Data Source: PRISM (Prelim), created 2 SEP 2020

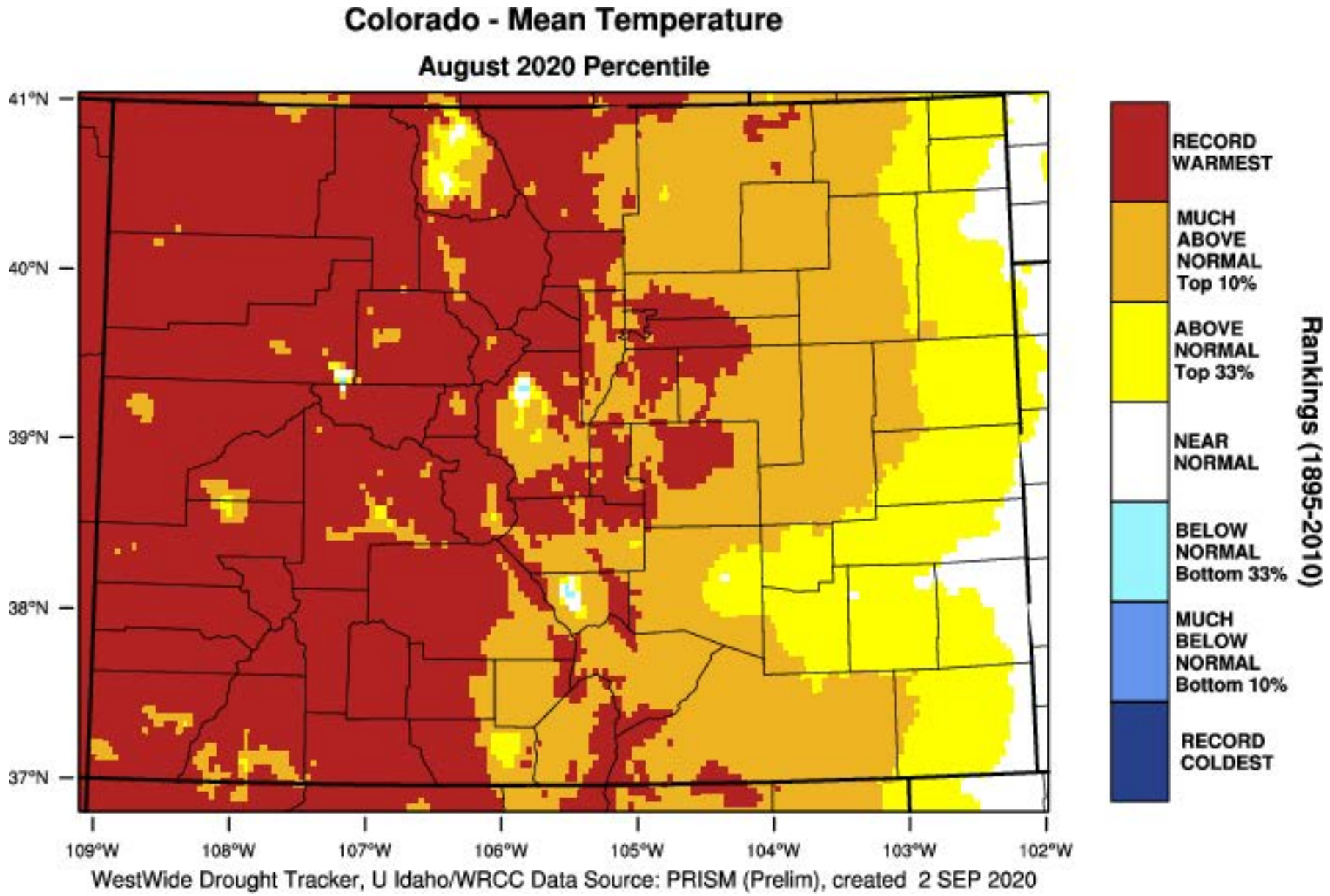


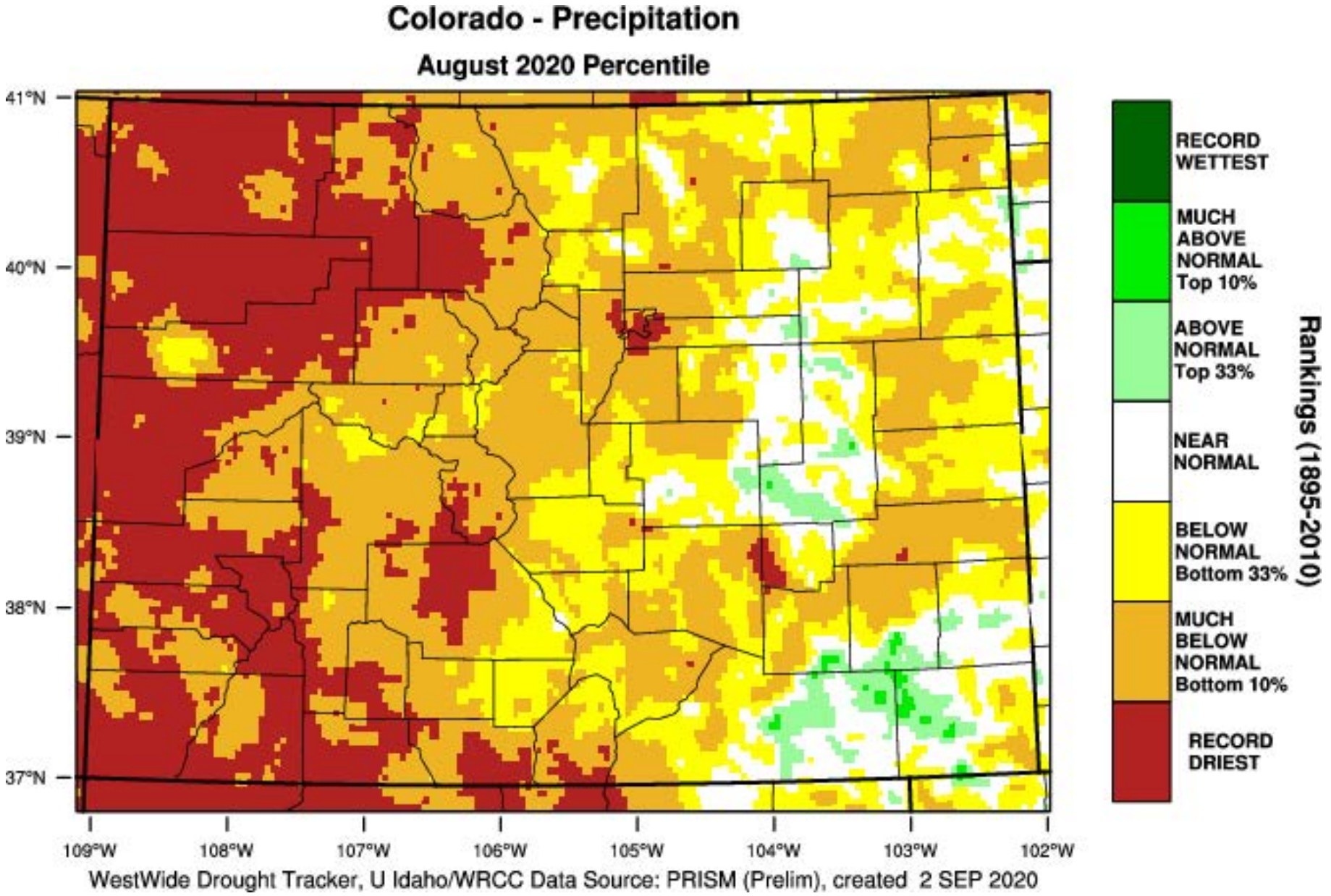
August temperature rankings at long-term stations



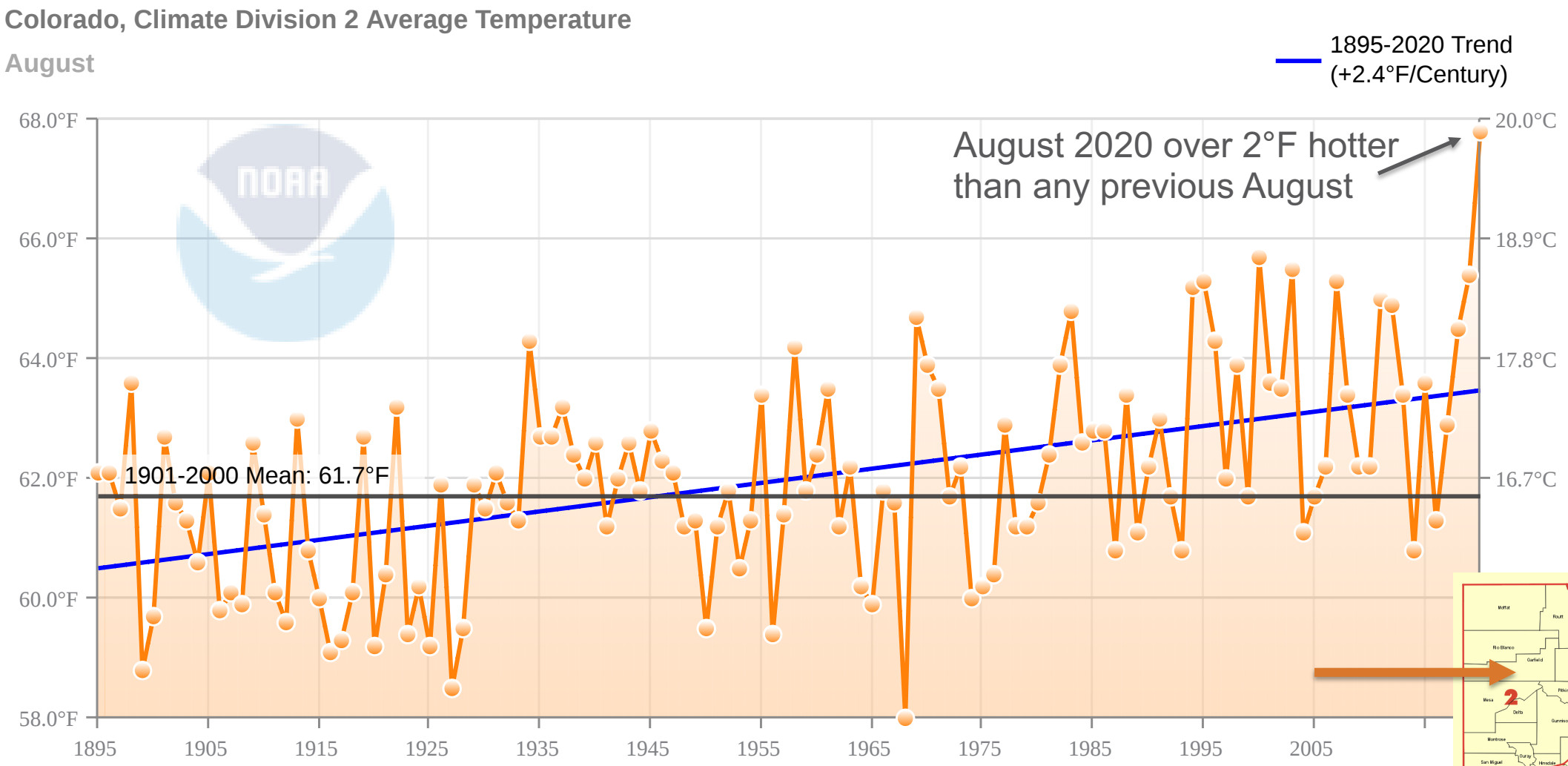
August temperature rankings at long-term stations

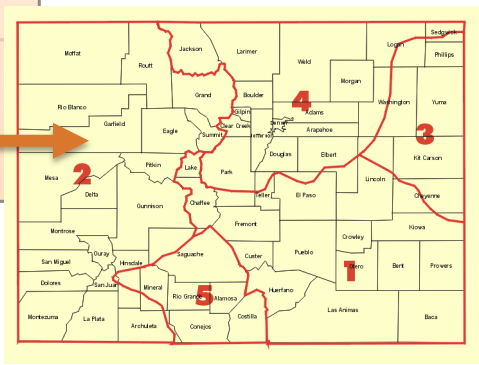
Hottest August on record at Phoenix, Tucson, Las Vegas, Salt Lake City, Grand Junction, Denver (tie), Cheyenne, Farmington, Sacramento, …


Colorado - Mean Temperature
August 2020 Percentile
41°N
40°N
39°N
38°N
37°N
109°W
108°W
107°W
106°W
105°W
104°W
103°W
102°W
RECORD WARMEST
MUCH ABOVE NORMAL Top 10%
ABOVE NORMAL Top 33%
NEAR NORMAL
BELOW NORMAL Bottom 33%
MUCH BELOW NORMAL Bottom 10%
RECORD COLDEST
Rankings (1895-2010)
WestWide Drought Tracker, U Idaho/WRCC Data Source: PRISM (Prelim), created 2 SEP 2020

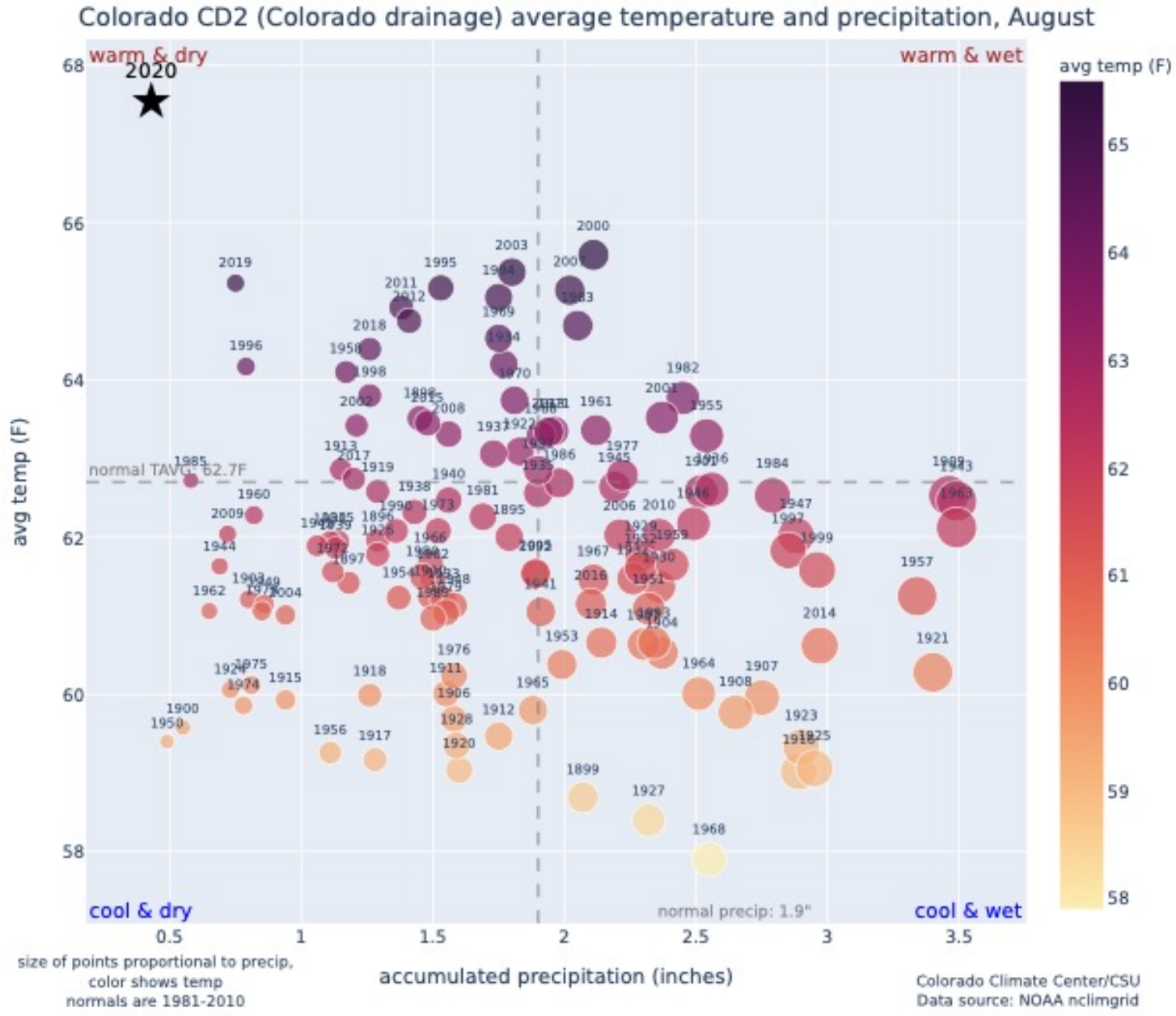

Colorado - Precipitation
August 2020 Percentile
41°N
40°N
39°N
38°N
37°N
109°W
108°W
107°W
106°W
105°W
104°W
103°W
102°W
RECORD WETTEST
MUCH ABOVE NORMAL Top 10%
ABOVE NORMAL Top 33%
NEAR NORMAL
BELOW NORMAL Bottom 33%
MUCH BELOW NORMAL Bottom 10%
RECORD DRIEST
Rankings (1895-2010)
WestWide Drought Tracker, U Idaho/WRCC Data Source: PRISM (Prelim), created 2 SEP 2020

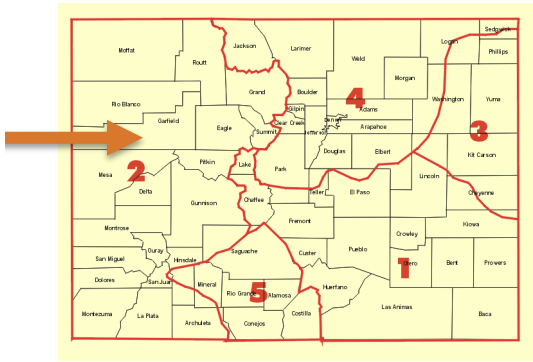
August temperature, western Colorado



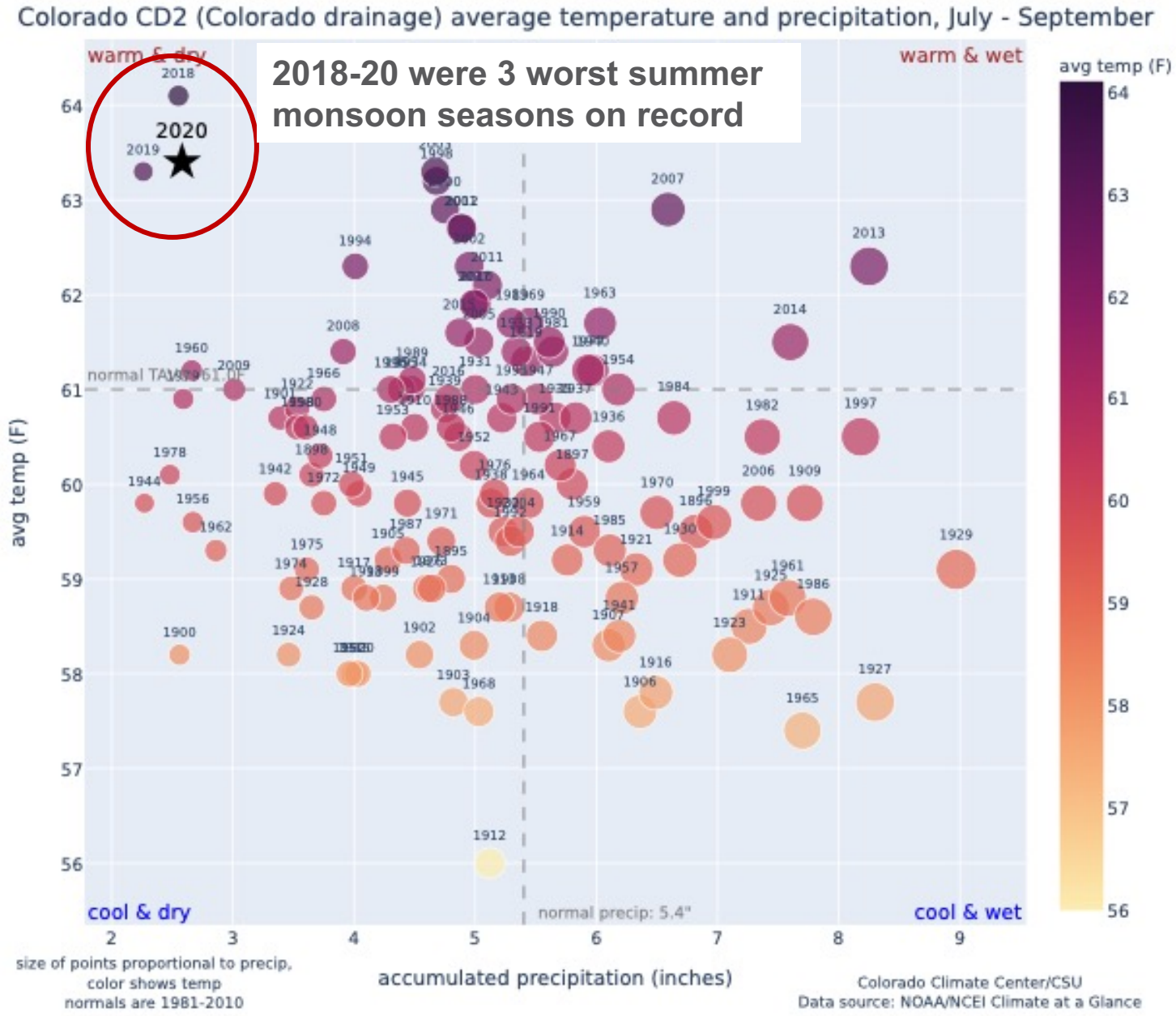


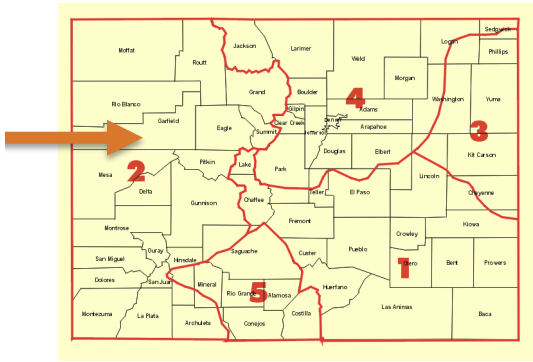
Temperature and precipitation, August, western Colorado





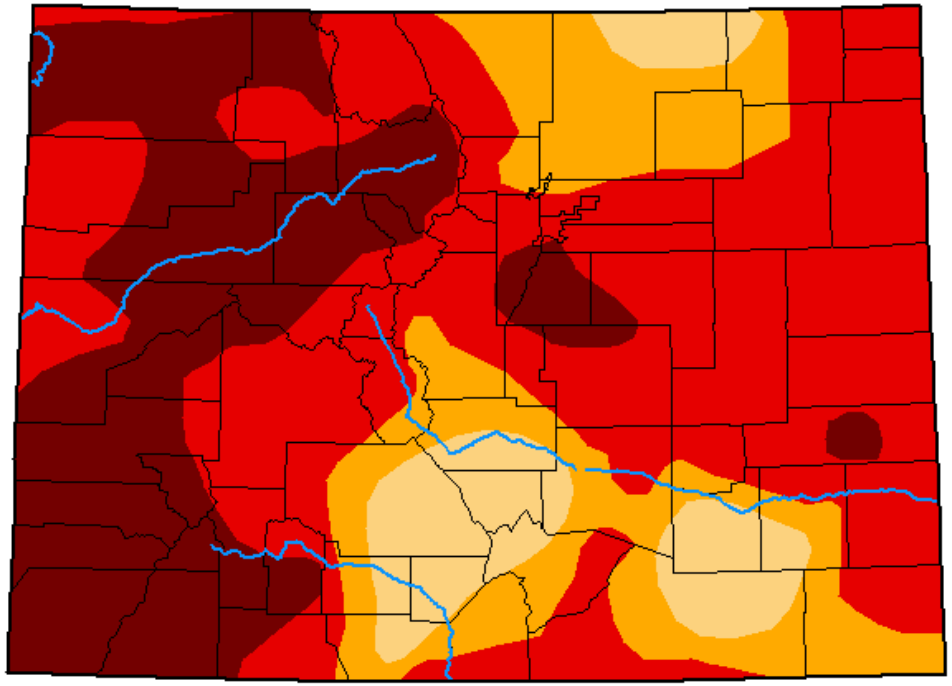
Temperature and precipitation, July-August-September in western Colorado





Current drought situation

U.S. Drought Monitor
Colorado



January 19, 2021
(Released Thursday, Jan. 21, 2021)
Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	0.00	100.00	100.00	91.06	73.63	27.59
Last Week *01-12-2021*	0.00	100.00	100.00	91.03	73.63	27.59
3 Months Ago *10-20-2020*	0.00	100.00	100.00	97.26	77.72	21.82
Start of Calendar Year *12-29-2020*	0.00	100.00	100.00	93.73	76.17	27.60
Start of Water Year *09-29-2020*	0.00	100.00	99.29	89.35	52.88	2.64
One Year Ago *01-21-2020*	22.39	77.61	51.19	13.84	0.00	0.00

Intensity:

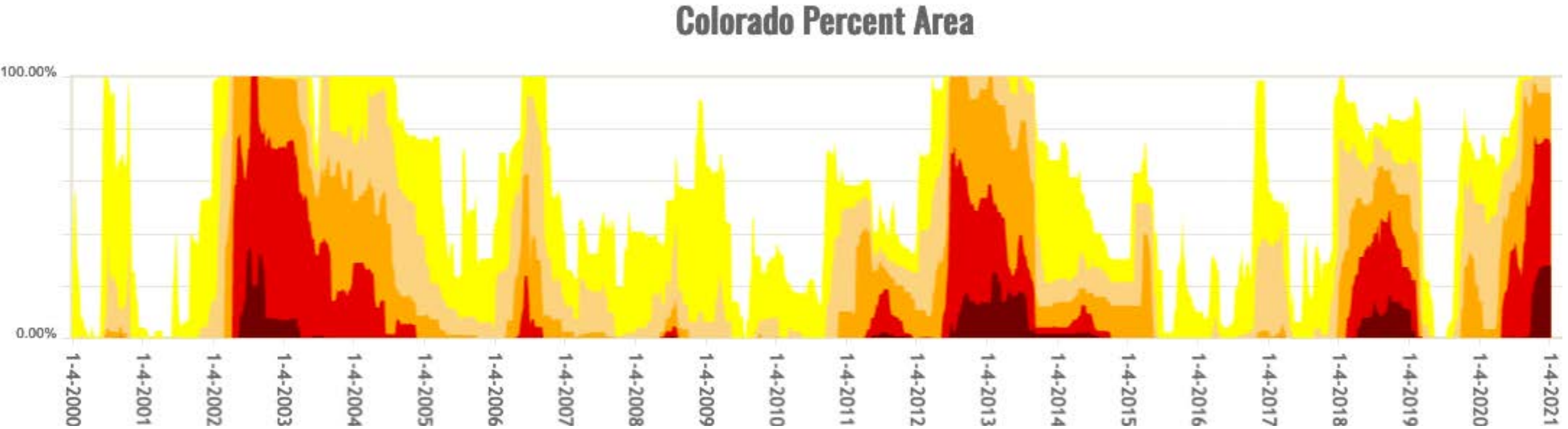
- None
- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. For more information on the Drought Monitor, go to https://droughtmonitor.unl.edu/About.aspx

Author:
Richard Tinker
CPC/NOAA/NWS/NCEP

droughtmonitor.unl.edu

Percent of Colorado in drought (since 2000)

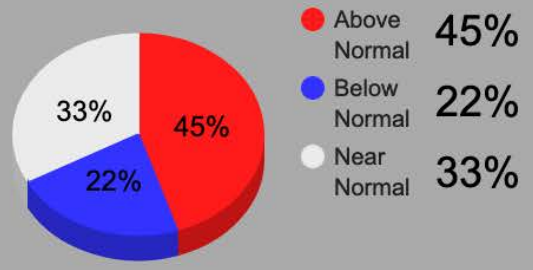


NOAA outlook for Feb-March-April

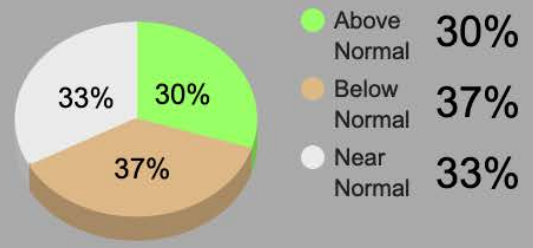
Find address or place

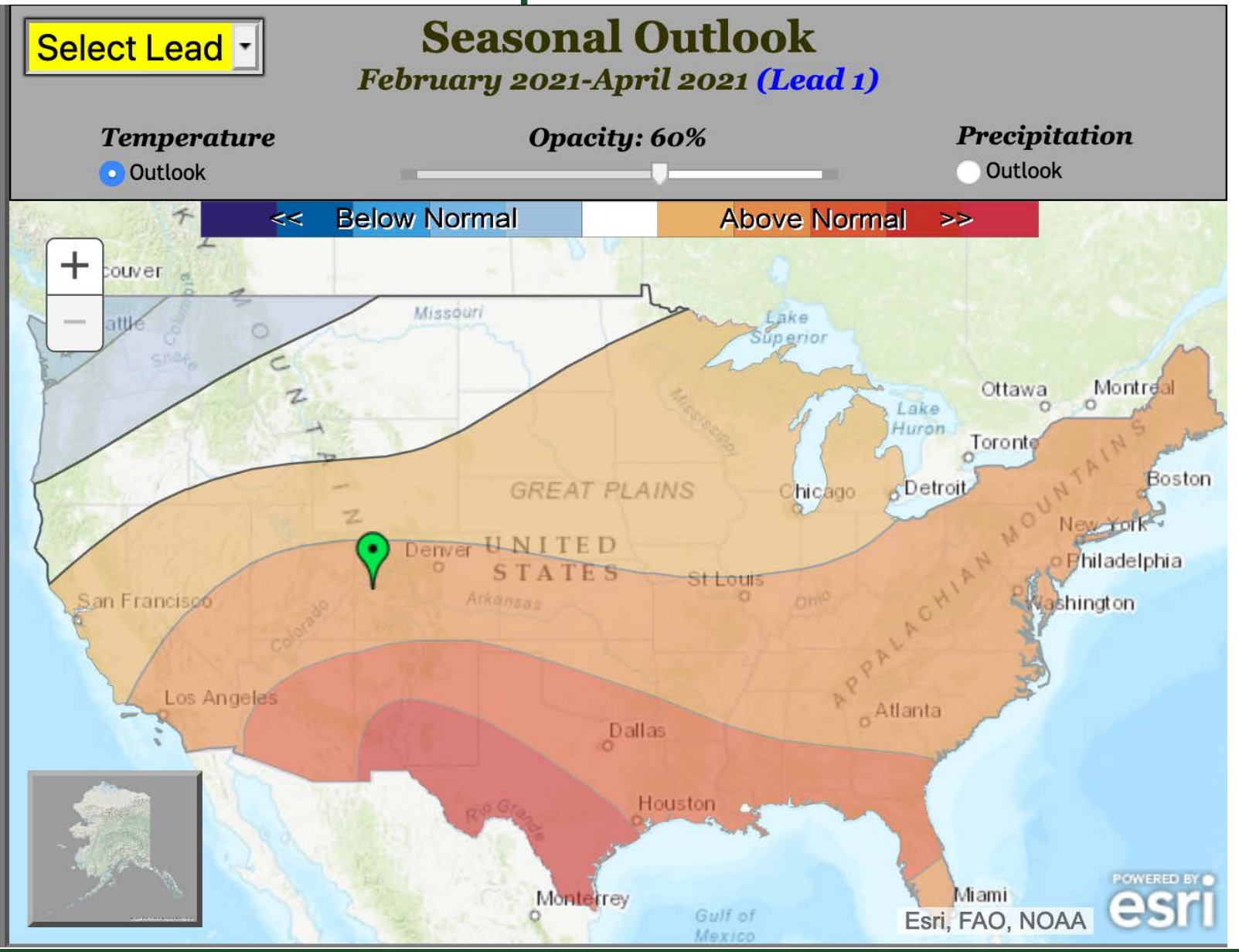
7 Day Forecast for Delta, CO

Three Category Temperature Outlook
Normal Maximum Temperature: **50**
Normal Minimum Temperature: **26**



Three Category Precipitation Outlook
Normal Precipitation: **3.99**





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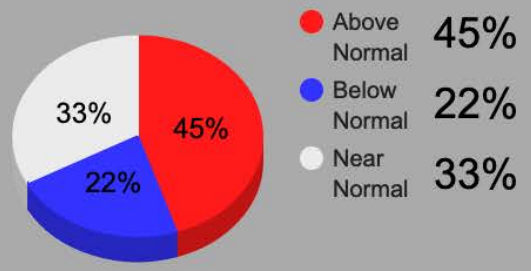

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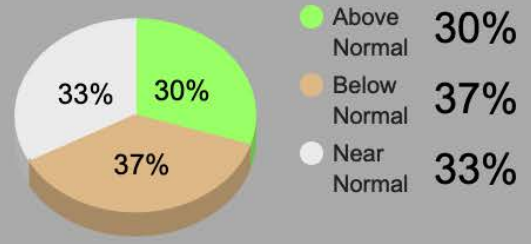
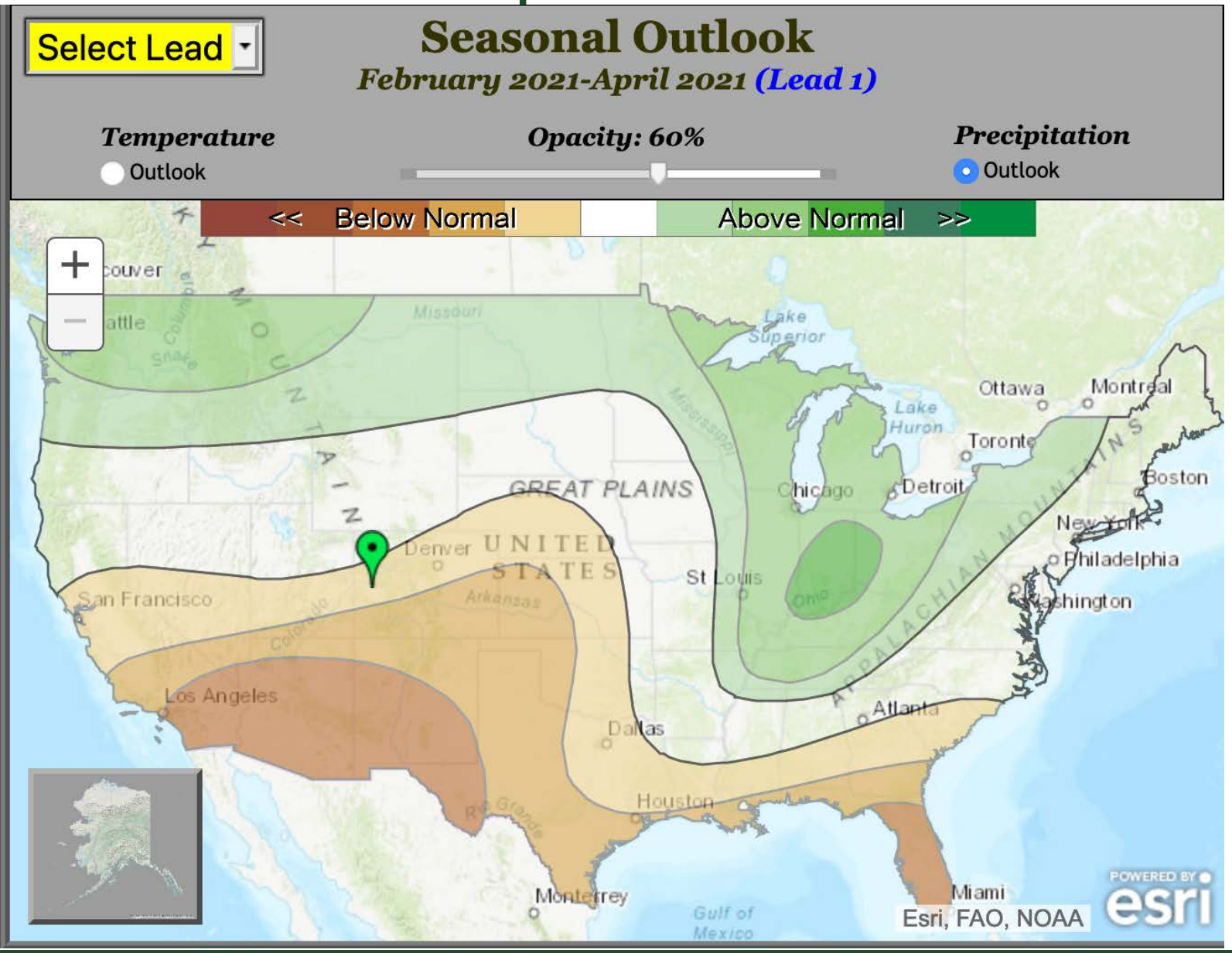
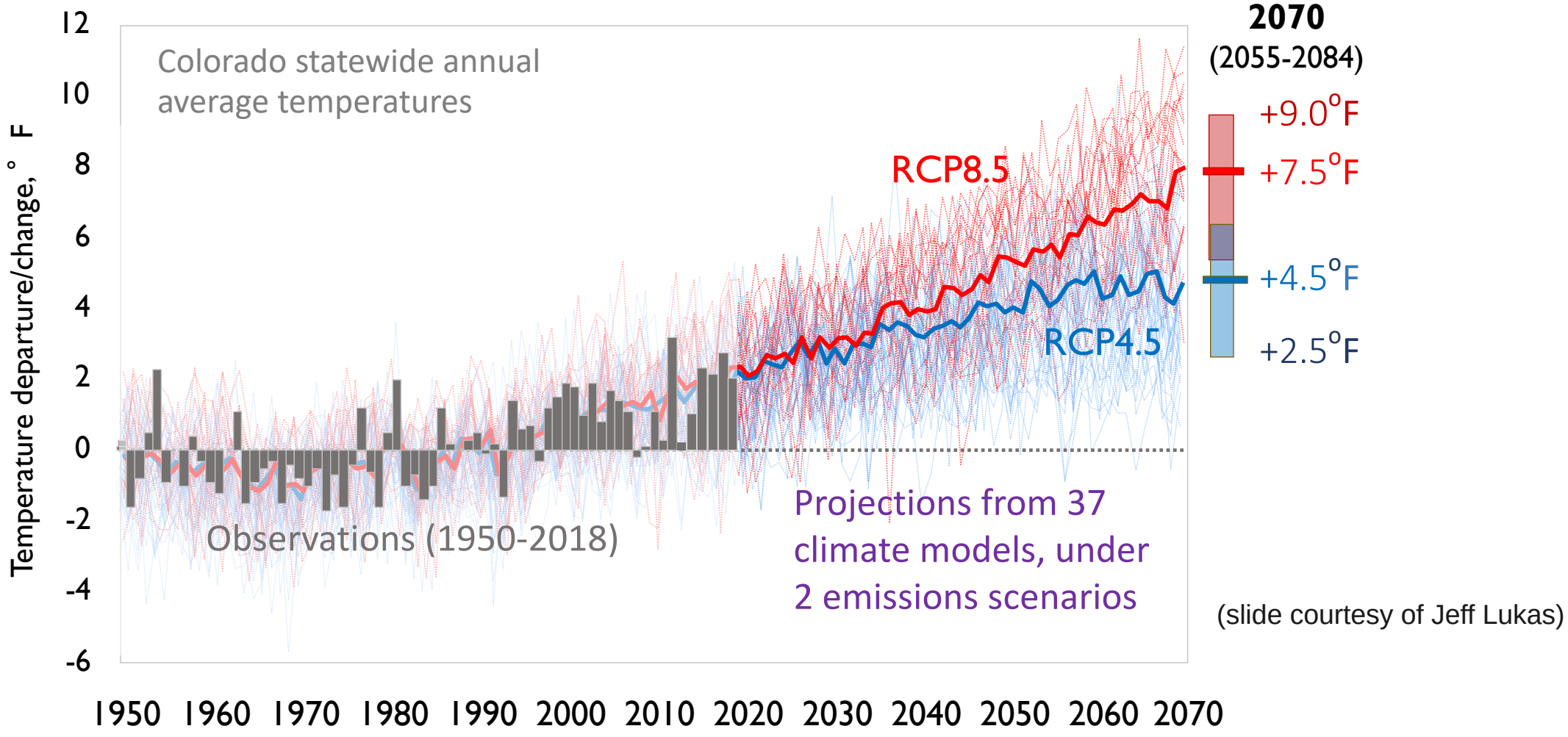




Average temperature increase of 2.5-5°F, for middle-of-the-road emissions scenario



(slide courtesy of Jeff Lukas)

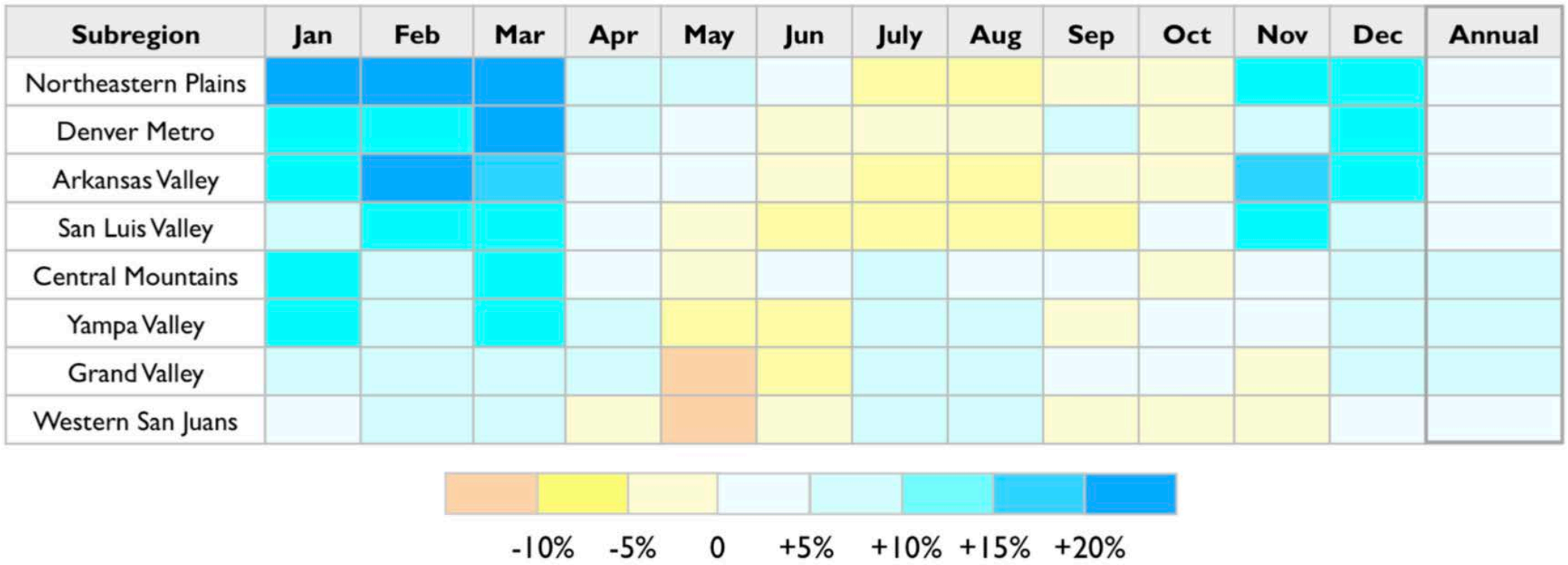
Figure adapted and updated from Lukas et al. 2014, *Climate Change in Colorado*
Observed Data: (1900-2017) NOAA NCEI; http://www.ncdc.noaa.gov/cag/; (2018) METDATA/gridMET (U. of Idaho) rescaled to match NOAA average (https://app.climateengine.org/)
Projection Data: https://gdo-dcp.ucllnl.org/downscaled_cmip_projections/

TABLE 5-1. Projected monthly temperature change for eight subregions under RCP 4.5 for 2035–2064

Subregion	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Annual
Northeastern Plains													
Denver Metro													
Arkansas Valley													
San Luis Valley													
Central Mountains													
Yampa Valley													
Grand Valley													
Western San Juans													

Precipitation is a lot more complicated...

TABLE 5-2. Projected monthly precipitation change for eight subregions under RCP 4.5 for 2035–2064



From Lukas et al. (2014), *Climate Change in Colorado*

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FIGURE 5-1. Projected temperature and precipitation for the western U.S. under RCP 4.5 for 2035–2064

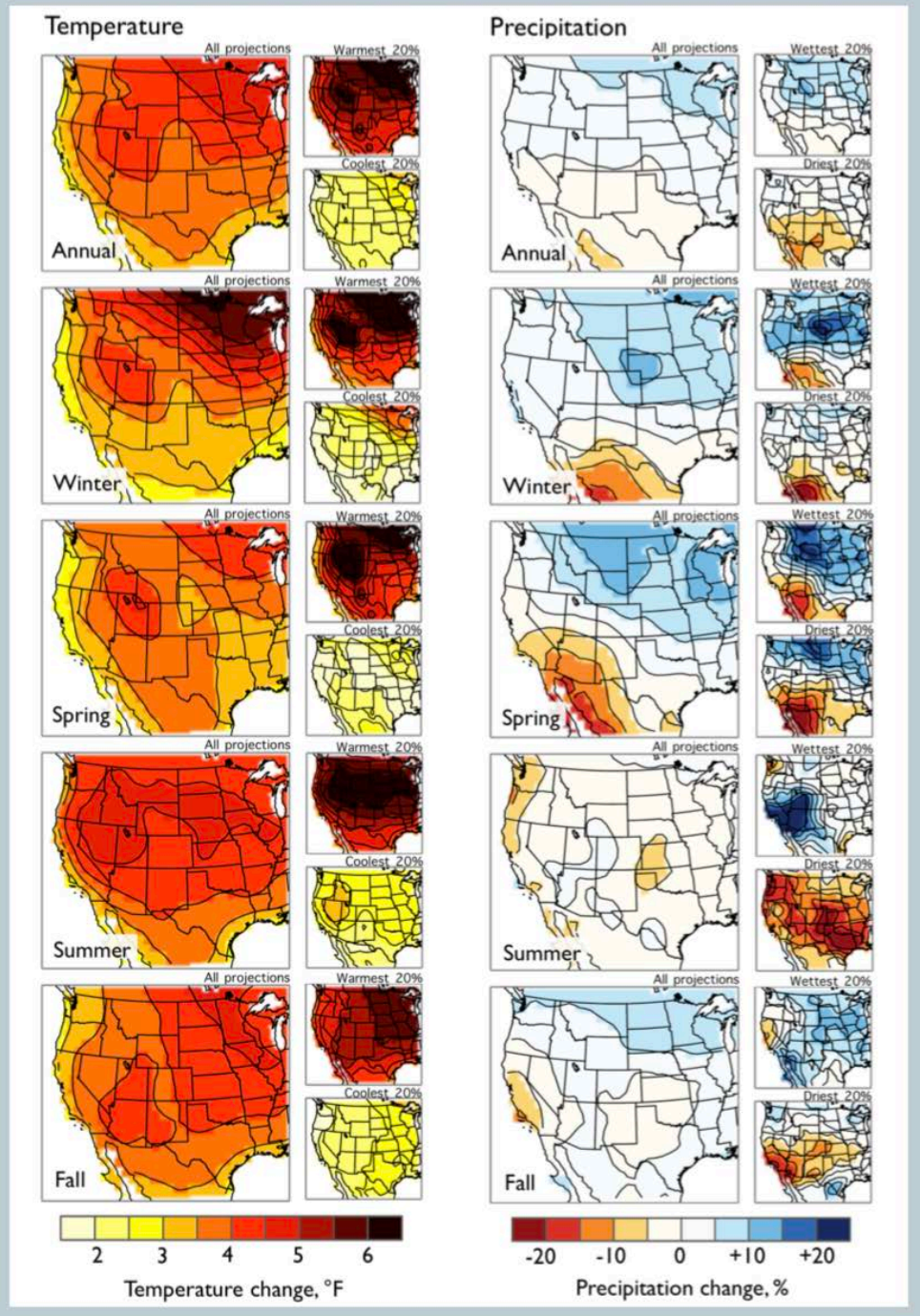
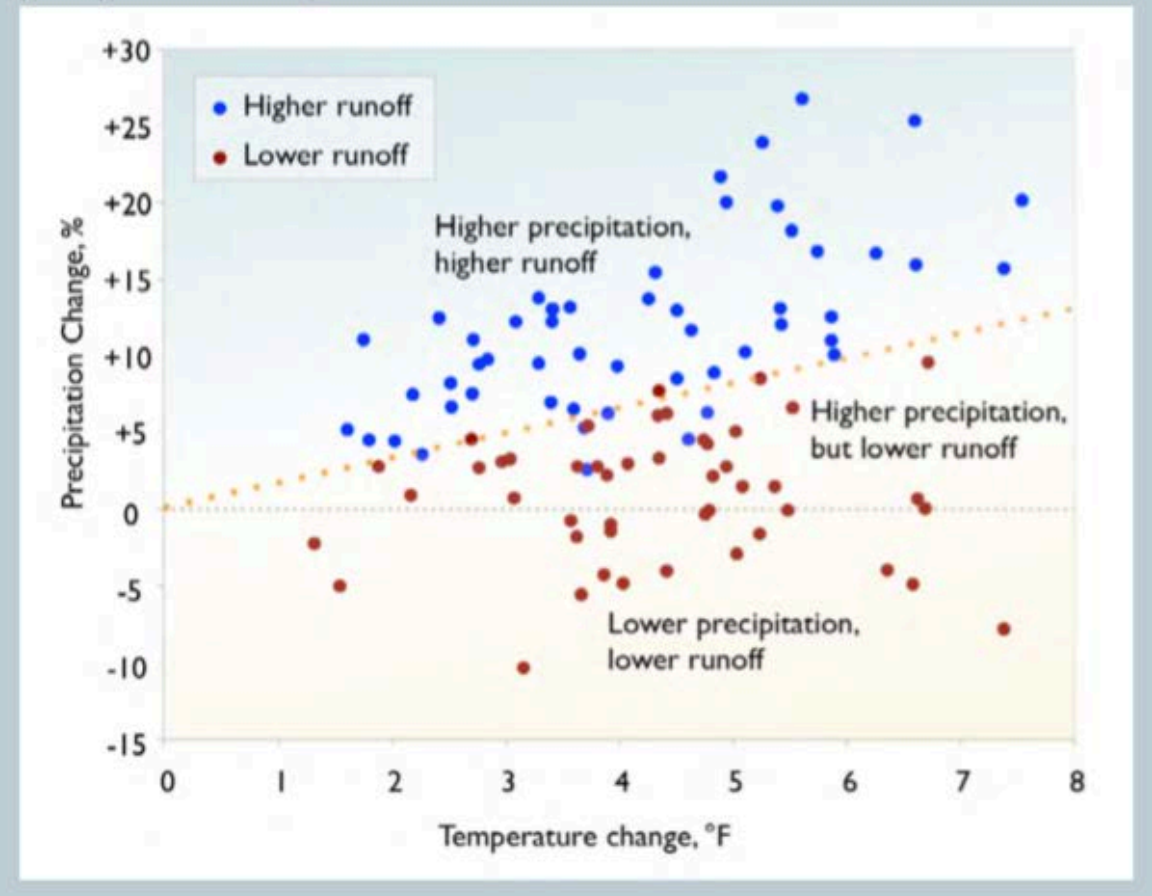


FIGURE 5-14. Direction of projected annual runoff change for the Colorado River as a function of projected temperature change and precipitation change



From Lukas et al. (2014), *Climate Change in Colorado*

Climate change is water change

- Remember that even if precipitation doesn't change (or increases slightly), higher temperatures...
- Cause more evaporation & evapotranspiration
  - Puts stress on plants requiring irrigation; can reduce reservoir levels
  - We have always had & will always have droughts in CO, but this will make them worse
- Can lead to earlier/faster spring snowmelt
  - Changes the expected time of water availability in rivers

Summary (1)

- We've seen warming in Colorado across all seasons, with the largest trend since about 1980
- No long-term trends have been detected for statewide precipitation
  - The last 20 years have been very dry, though
- Peak snowpack (SWE) has a small downward trend, and the timing of the peak has shifted earlier, owing to both higher temps and dust-on-snow
- Long-term warming is expected to continue (with high confidence); future changes in precipitation are much less certain
- For most types of extreme/hazardous weather, it remains challenging to establish a climate-change fingerprint, aside from changes in occurrence of extreme heat/cold
  - Some, like wildland fire, have been influenced by climate change, but challenging to separate from other influences

Summary (2)

- By 2050, the climate of Colorado will still be recognizable as the climate of Colorado:
  - Plenty of snow in the mountains most winters
  - Summers with warm days and (relatively) cool nights
  - Highly variable precipitation from year to year
  - Regular problems with droughts, floods, fires, water availability, and severe weather
- But:
  - The snowpack is likely to melt earlier in the spring
  - More frequent occurrence of warm weather, less frequent extreme cold
  - When droughts happen, they will likely be worse (mainly owing to increased evaporation) – increasing threats to water supply
  - Destructive fires more likely during drought years (both warmer climate + more structures in WUI)
  - Not clear what changes there will be to other hazards like extreme rainfall, severe weather, etc.

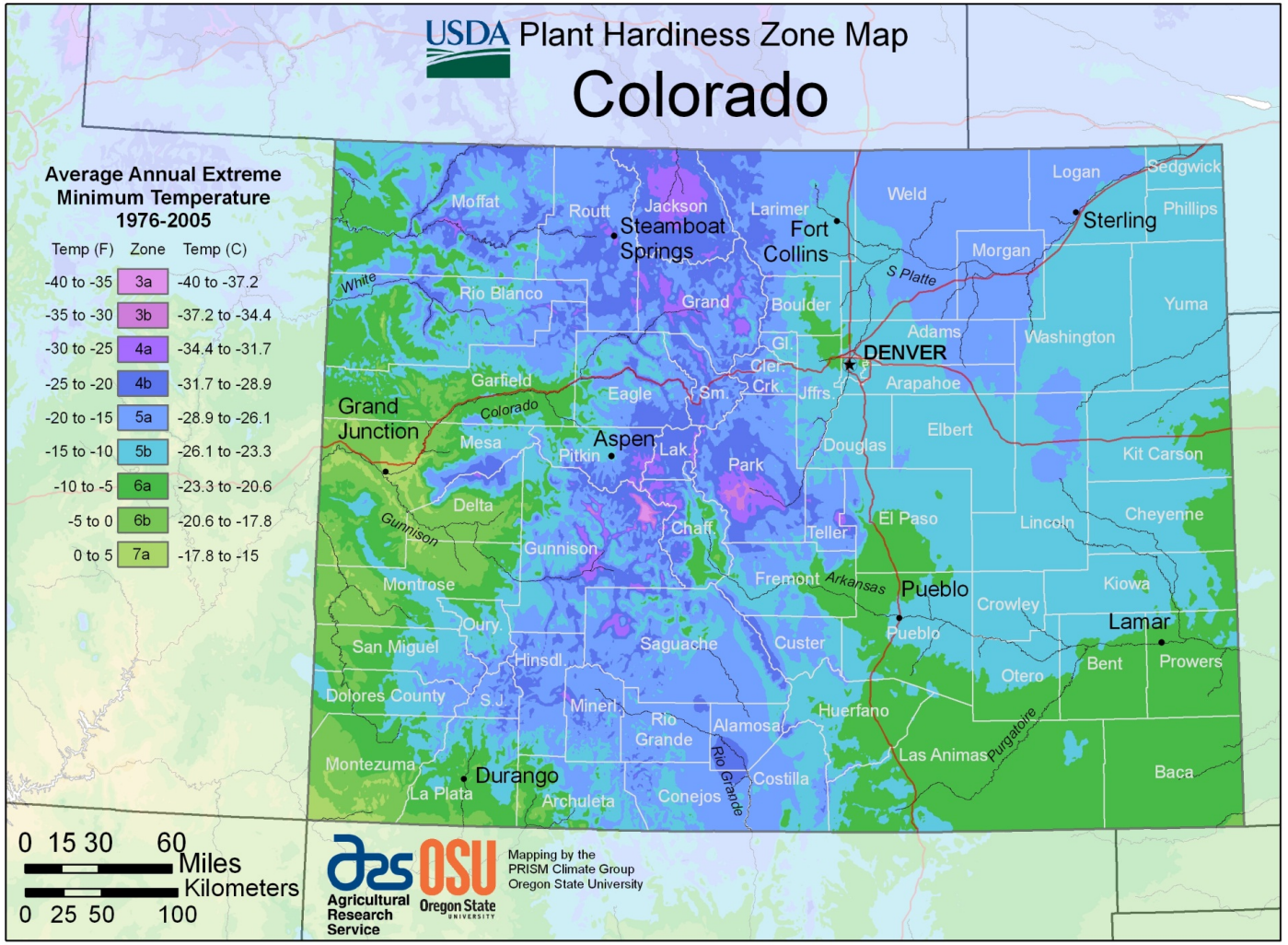
Can We Grow Grapes in More Parts of Colorado?

Peter Goble, Russ Schumacher

January 21, 2021

COLORADO CLIMATE CENTER

ATMOSPHERIC SCIENCE
COLORADO STATE UNIVERSITY



Motivation

Western Colorado's warm, dry summers, chilly nights, and access to mountain river water make it a near ideal spot to grow wine grapes

It's just a little bit too cold!

The largest limiting factor to expansion of the wine grape industry on the west slopes is cold winter nights, but there must be overlooked areas

The climate is expected to warm. Are there areas that are on the fringe of being viable that we can leverage in the future?

Fremont and Montezuma Counties

- Both Fremont and Montezuma Counties have some history of growing grapes and a few successful vineyards
- Viticulture is not as well established as the Palisade, Grand Junction area, so these areas make interesting test cases

Methods

- Use daily minimum temperature data from the Parametrized Regression on Independent Slopes Model (PRISM) to track the frequency of killing freezes
- Use higher resolution data to downscale PRISM to resolution of half mile
- Deploy temperature sensors on landowners' properties in Montezuma and Fremont Counties to sanity check model
- Focus on areas where there is potential to begin or expand viticultural operations

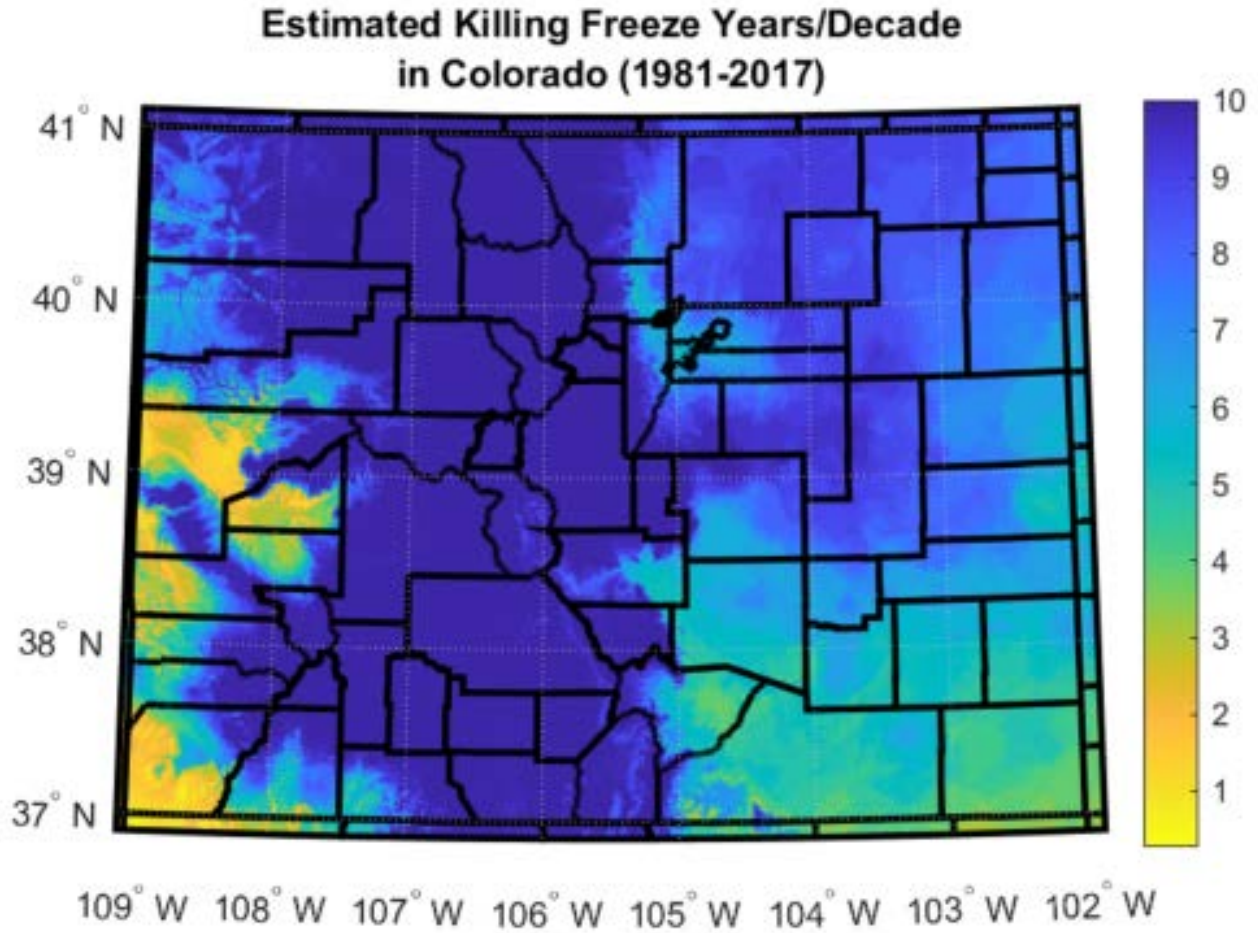
Killing Freeze Definitions

- Lethal temperature for vines is a function of a number of factors
- Vines adapt best to low temperatures when conditions change gradually with the season
- Some types of grapes are much more cold hardy than others
- Here are the criteria we used for assessing a killing freeze for European Varieties (parameters tweaked for cold-hardy hybrids):

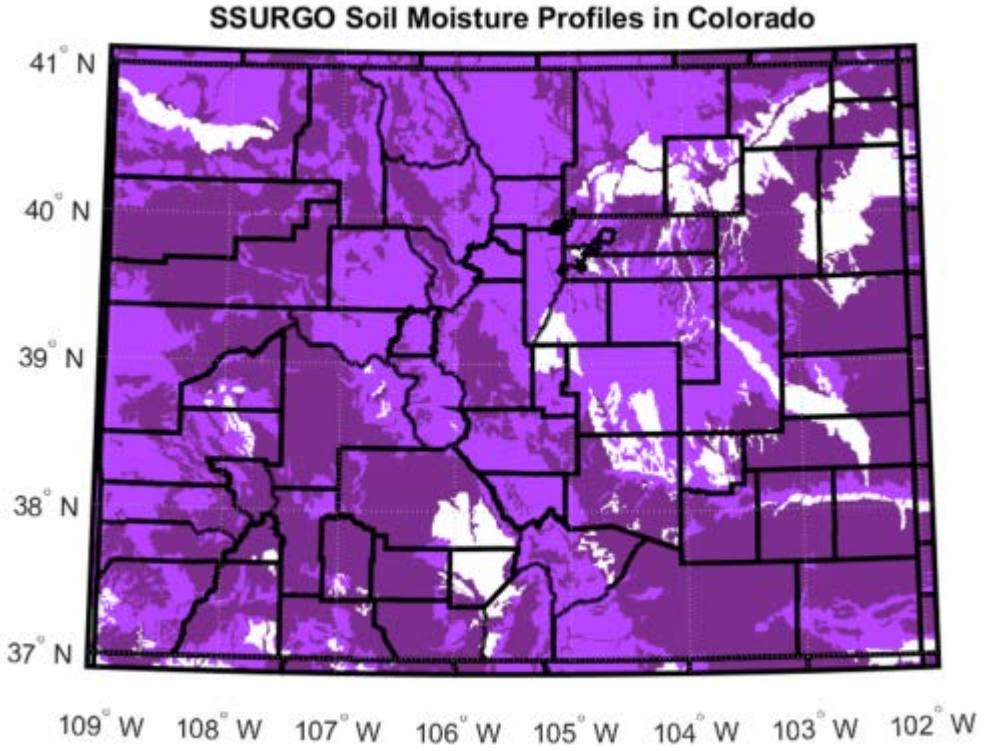
i. A rapid onset of seasonally-unprecedented cold air in fall (temperatures in October of less than 10F, and at least 10F cooler than the season's previous coldest air, or temperatures of less than 0F in November, and at least 10F cooler than the season's previous coldest air
ii. Deep cold in early winter (below -5F before January 1st)
iii. Extreme cold in mid-or-late winter (below -15F anytime)
iv. A hard spring freeze (28F or lower) following bud break (estimated as May 15th)
v. A fall freeze (32F or lower) prior to harvest (estimated as September 30th)

Where Do Killing Freezes Happen?

- Everywhere in the state
- However, the Palisade area has the fewest
- The Four Corners and Paradox Valley areas also experience a relatively low number of killing freeze years
- Southeast Colorado is interesting. It is relatively hospitable in the shoulder seasons in most years, but experiences lower wintertime temperatures



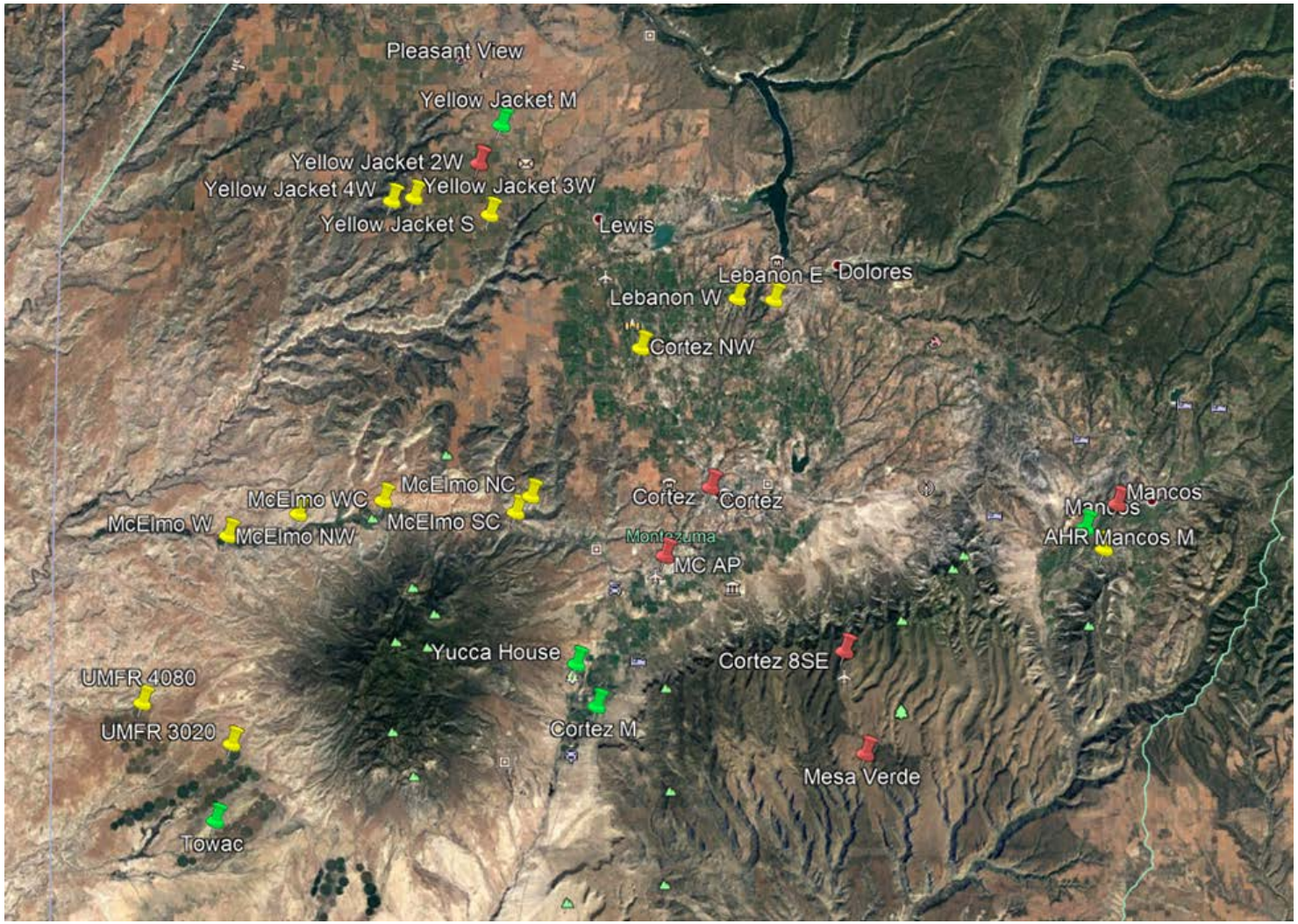
What About Land Quality?



- Some areas were ruled out due to poor soil quality
- We used soil survey information from USGS to rule out areas with sandy soils or hard clay (poor water retention)
- Areas depicted in white on the map shown here were not considered suitable for viticultural exploration

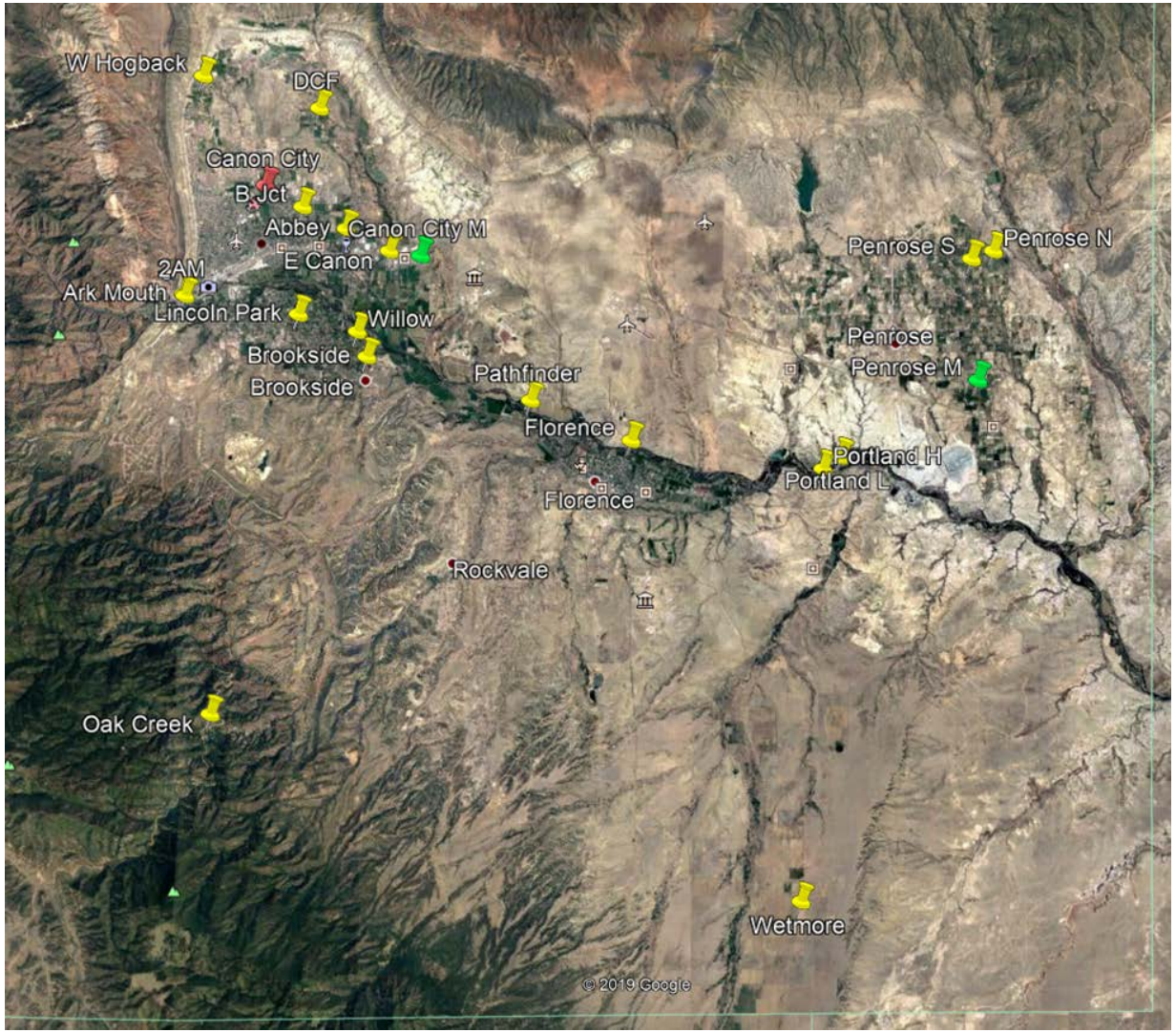
Thermometer Network (Montezuma County

- The town of Cortez sits in a valley that is generally too cold
- We tried to recruit volunteers on hillsides to the north, in McElmo Canyon, and down on the Ute Mountain Farm and Ranch



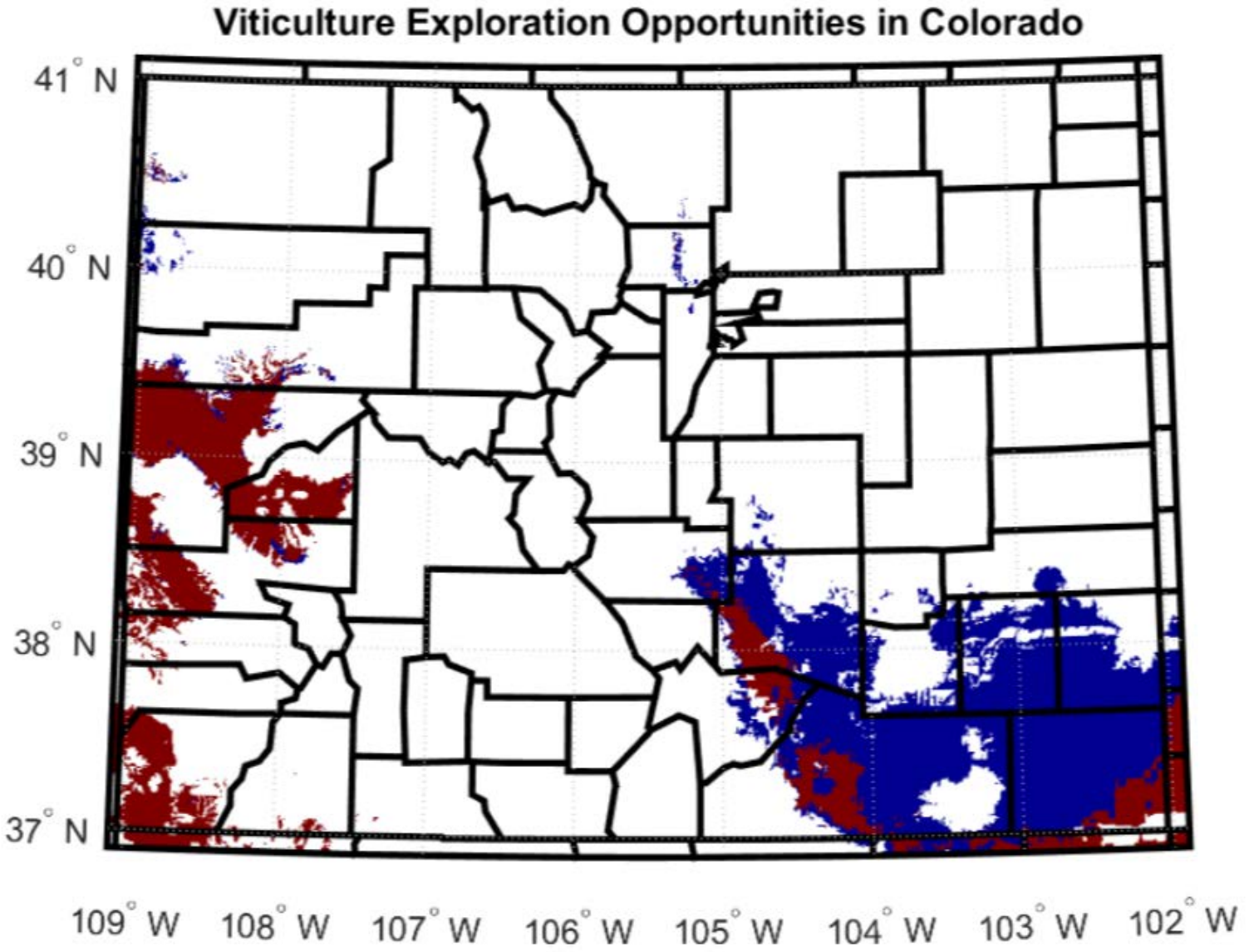
Thermometer Network (Fremont County)

- High concentration of stations in and around Cañon City
- Looking for differences between stations nestled against hills and stations further east
- We would like to get a better look at conditions further south



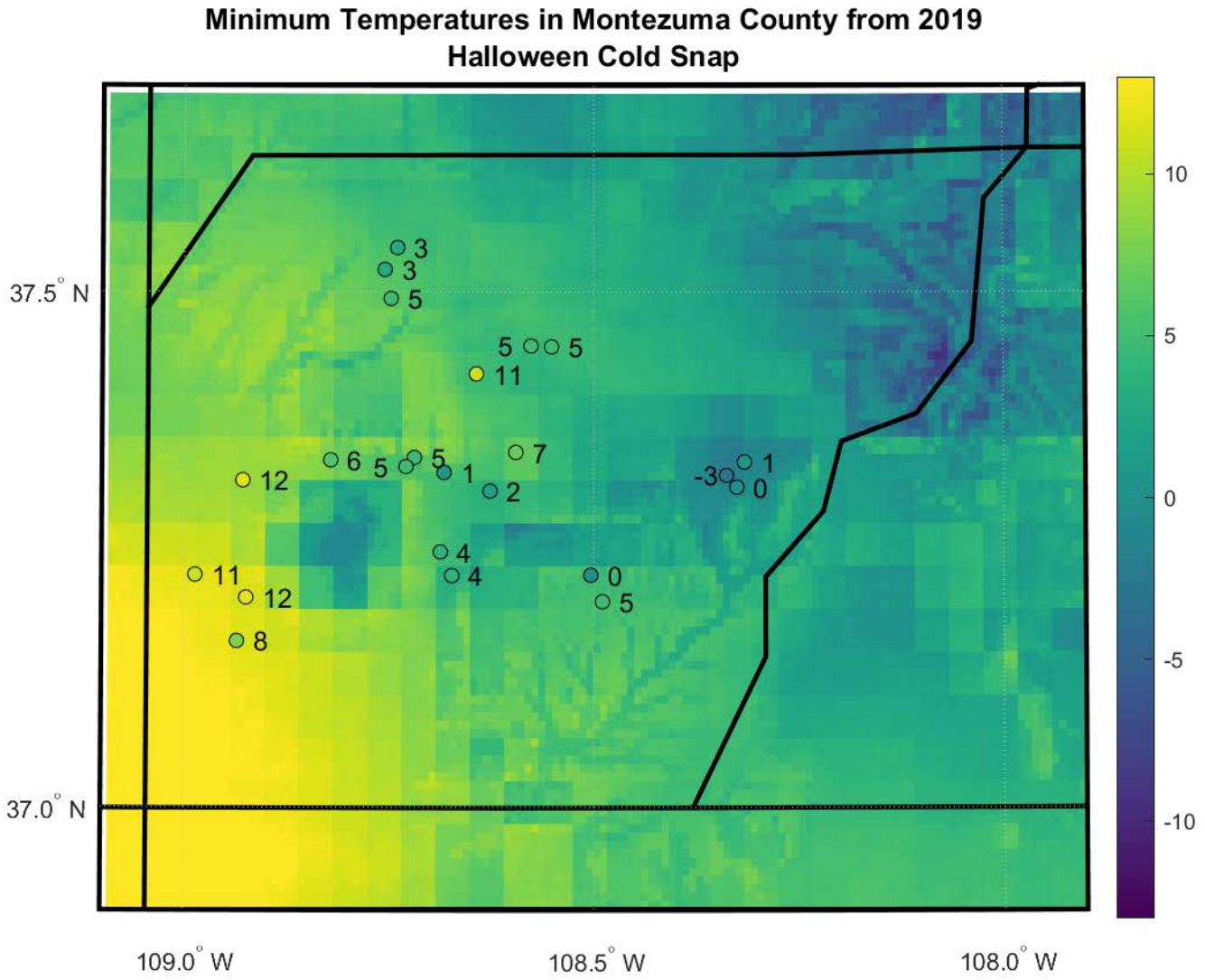
Model Results

- Areas in red experienced four or fewer killing frost years/decade for European varieties
- Areas in blue received four or fewer killing frosts/decade for cold-hardy hybrids
- Maps available at climate.colostate.edu/climate_wine
- How does this model compare to observations?



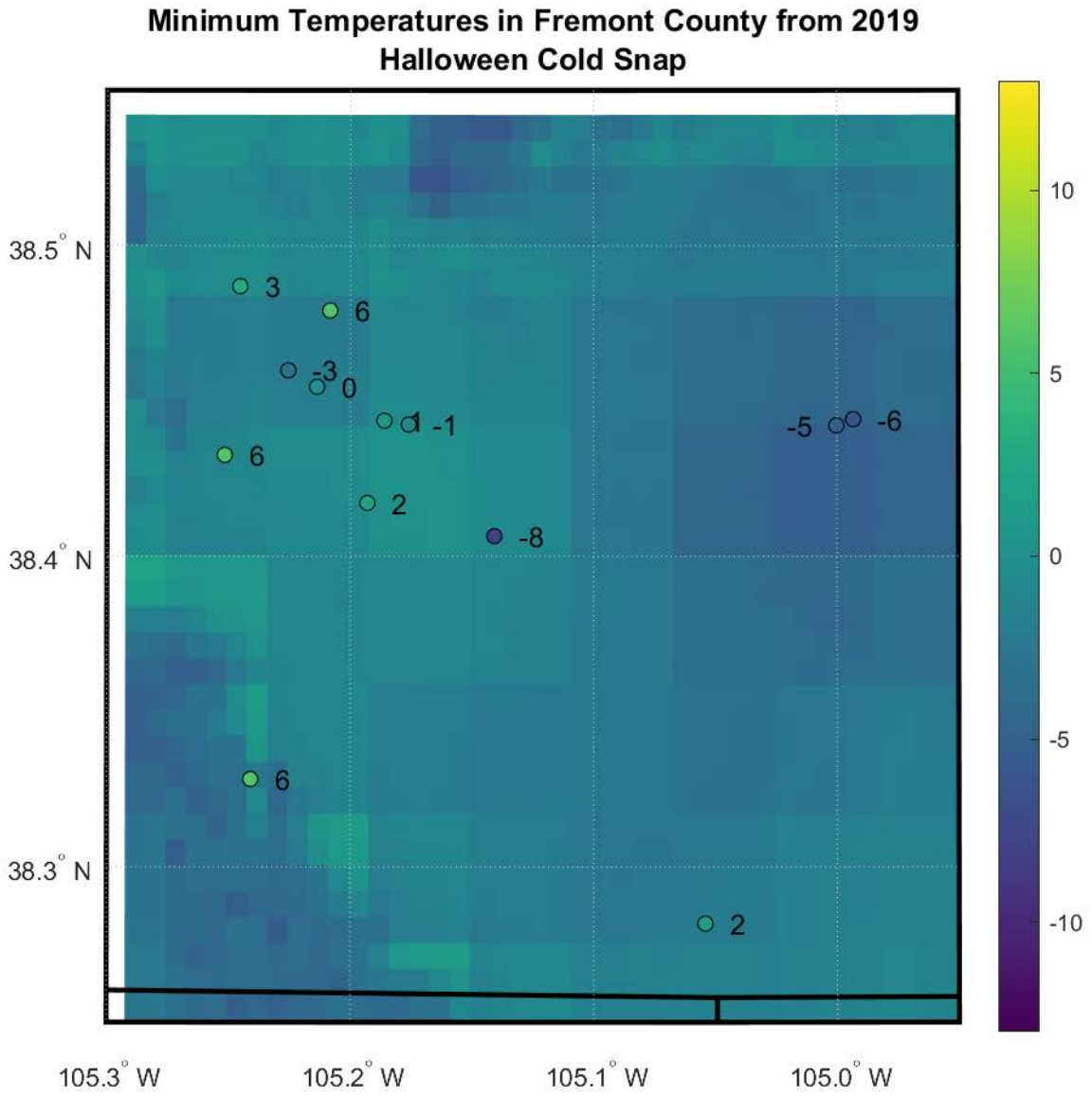
Comparisons

- For most killing freezes there was fairly strong agreement between the model and observations. Here is an example of good agreement:
- Areas near Yellow Jacket stayed over five degrees warmer than indicated by models, but differences were typically smaller



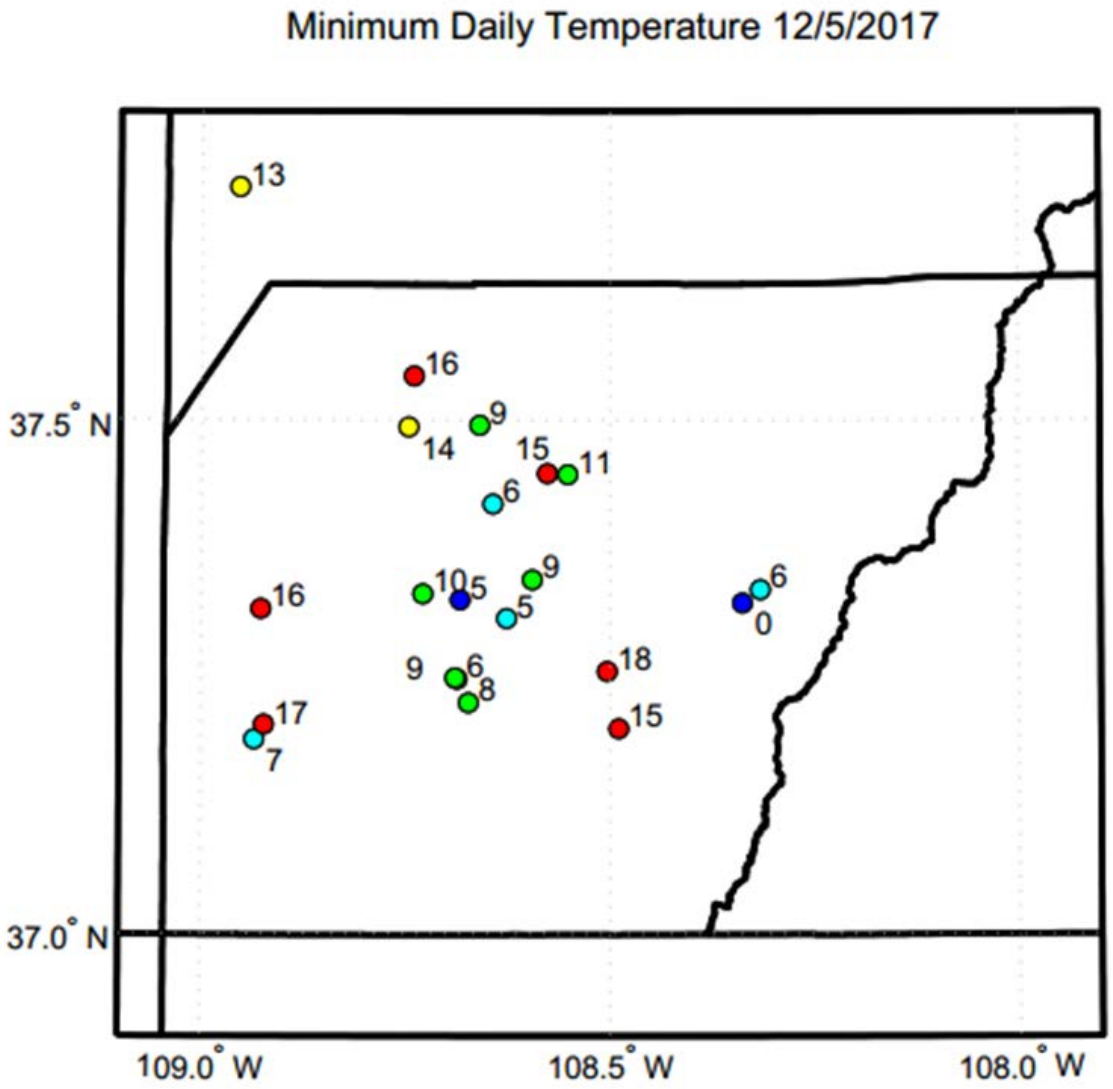
Comparisons

- In Fremont County the model generally adheres to the same overall pattern as observations, but underestimates the spread driven by microclimates
- Pathfinder Park was over five degrees cooler than estimated in this case while stations north and west of Cañon City were warmer



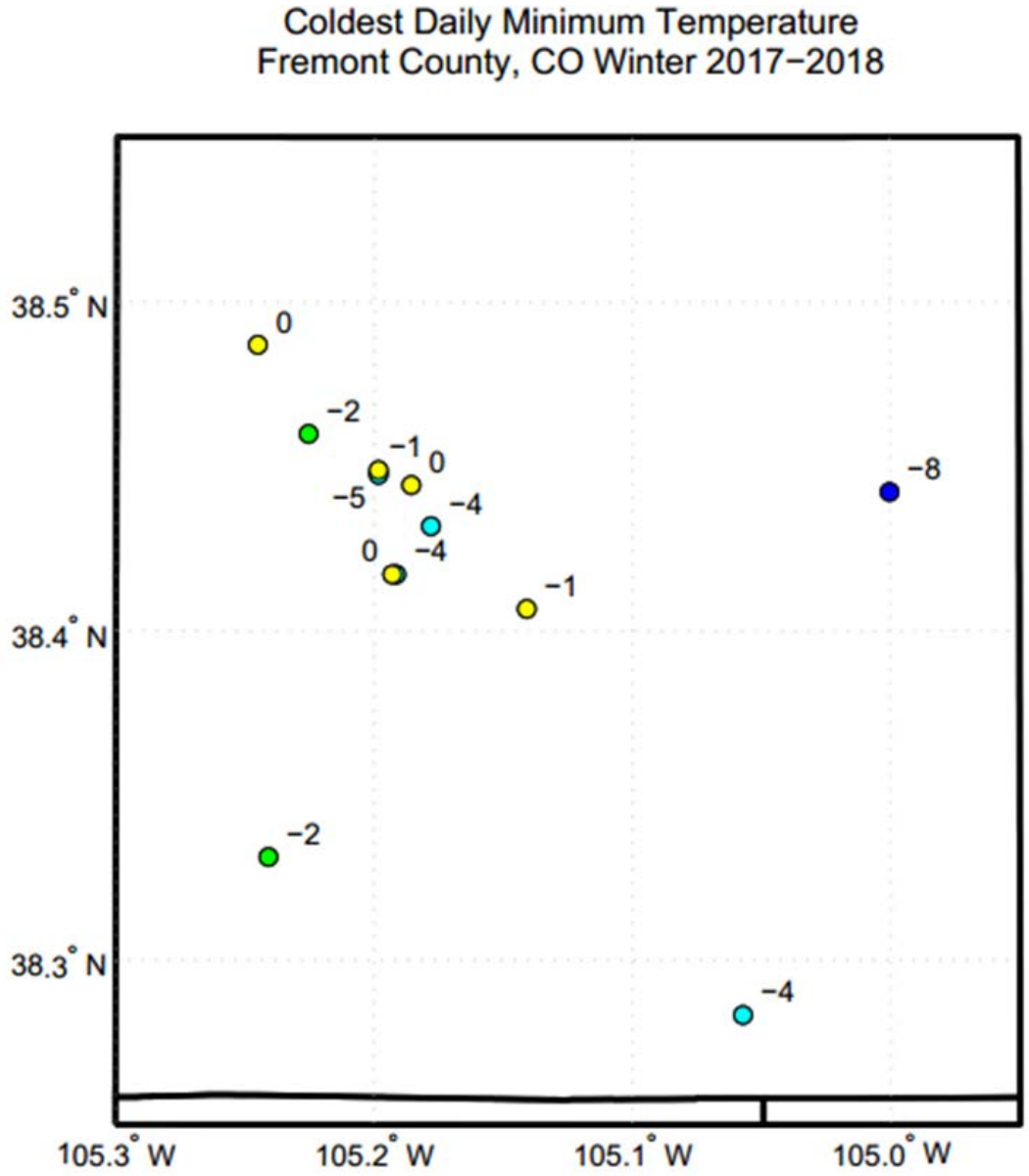
Older Maps

- We have been tracking temperatures in these areas since 2017. Here is an older example:



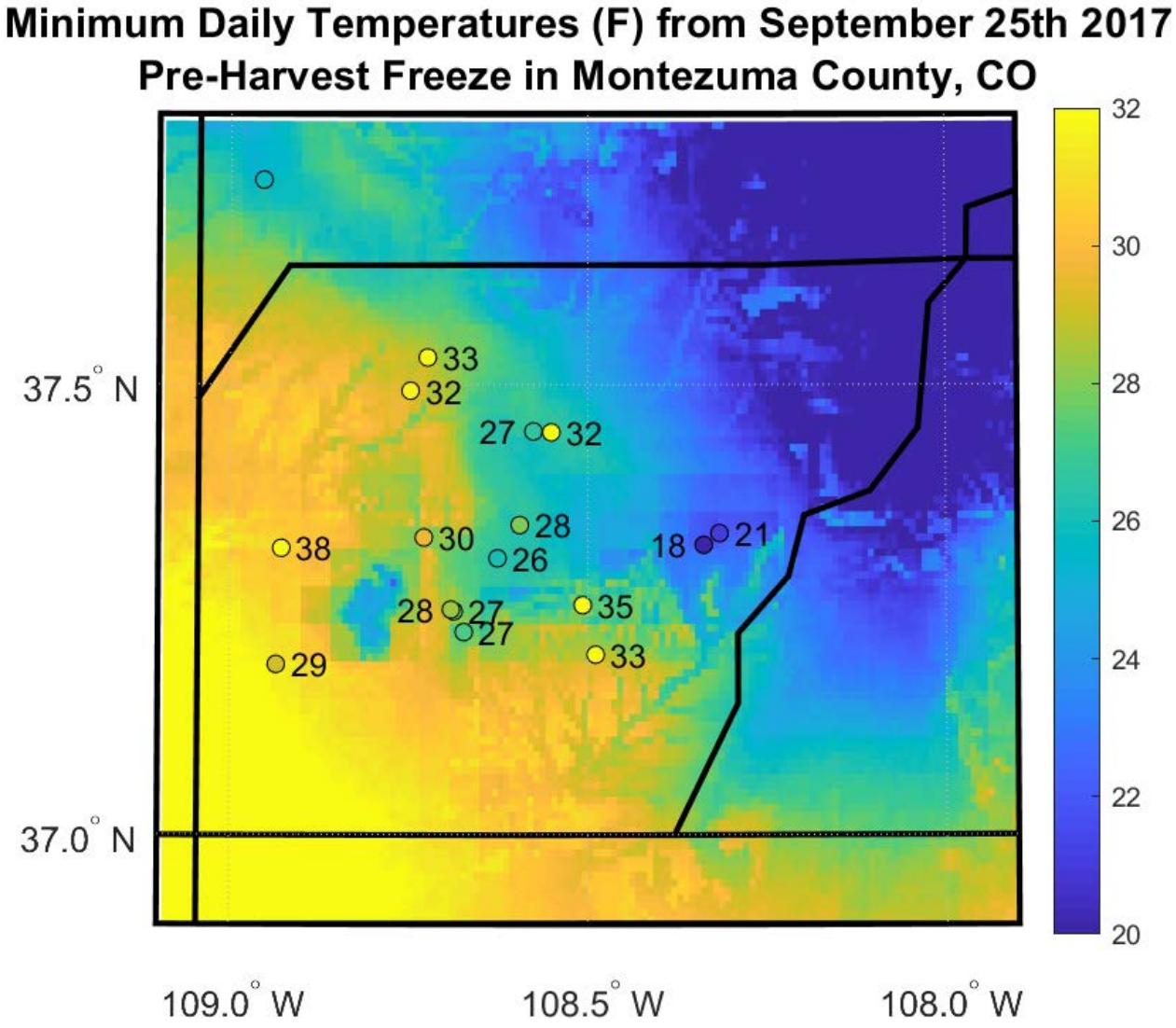
Older Maps

- Another older example for Fremont County

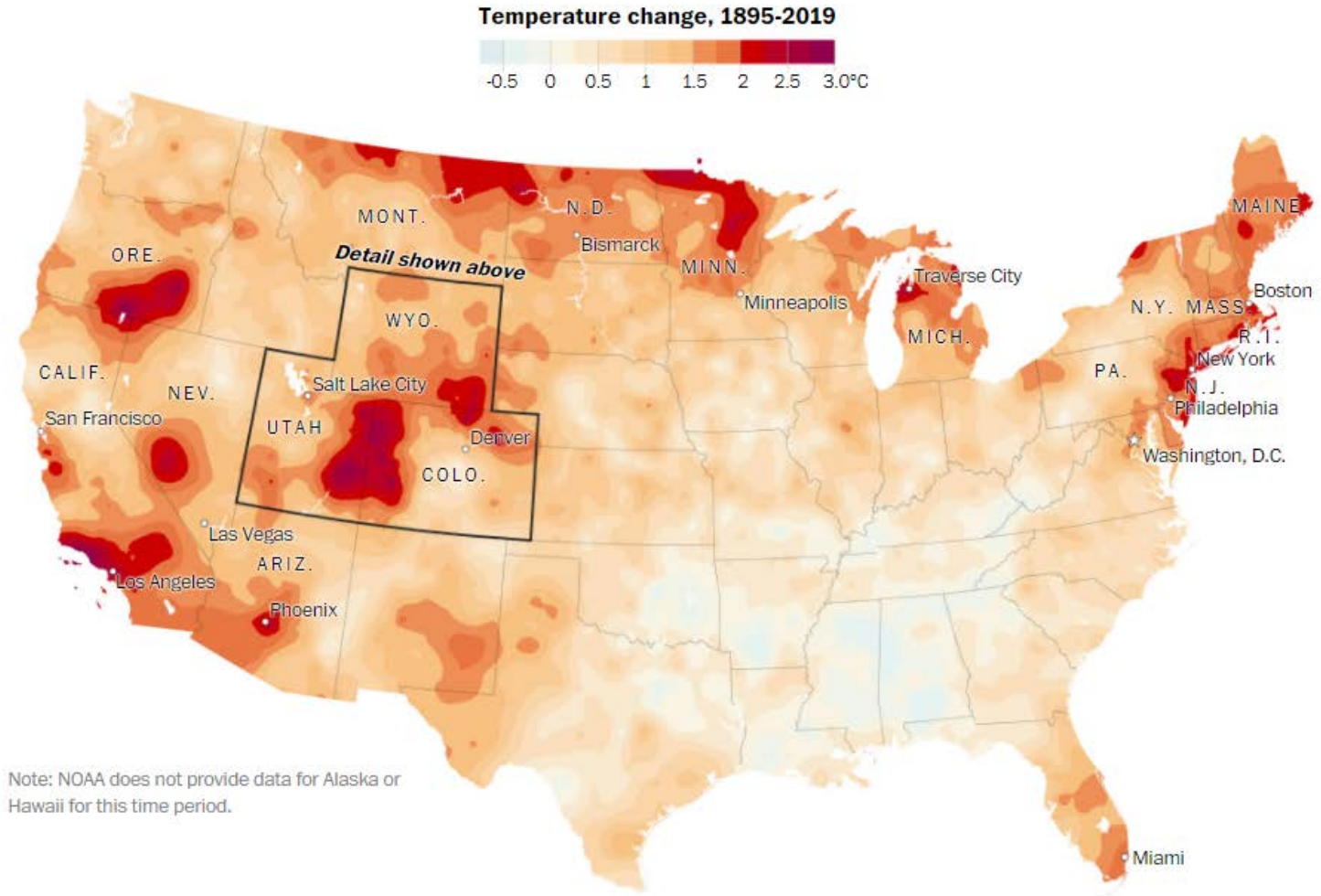


Comparisons

- There were a few examples of poor agreement between models and observations
- The model sometimes underestimates the strength of the nocturnal temperature inversion. That is to say, elevation-driven differences are underestimated
- Here the Mesa Verde station was eight degrees warmer than the model estimated despite good agreement between models and observations in the valleys



Western Colorado has Warmed Faster Than Anywhere in the Nation!



Credit: Washington Post

Data Source: NOAA

And Yet…

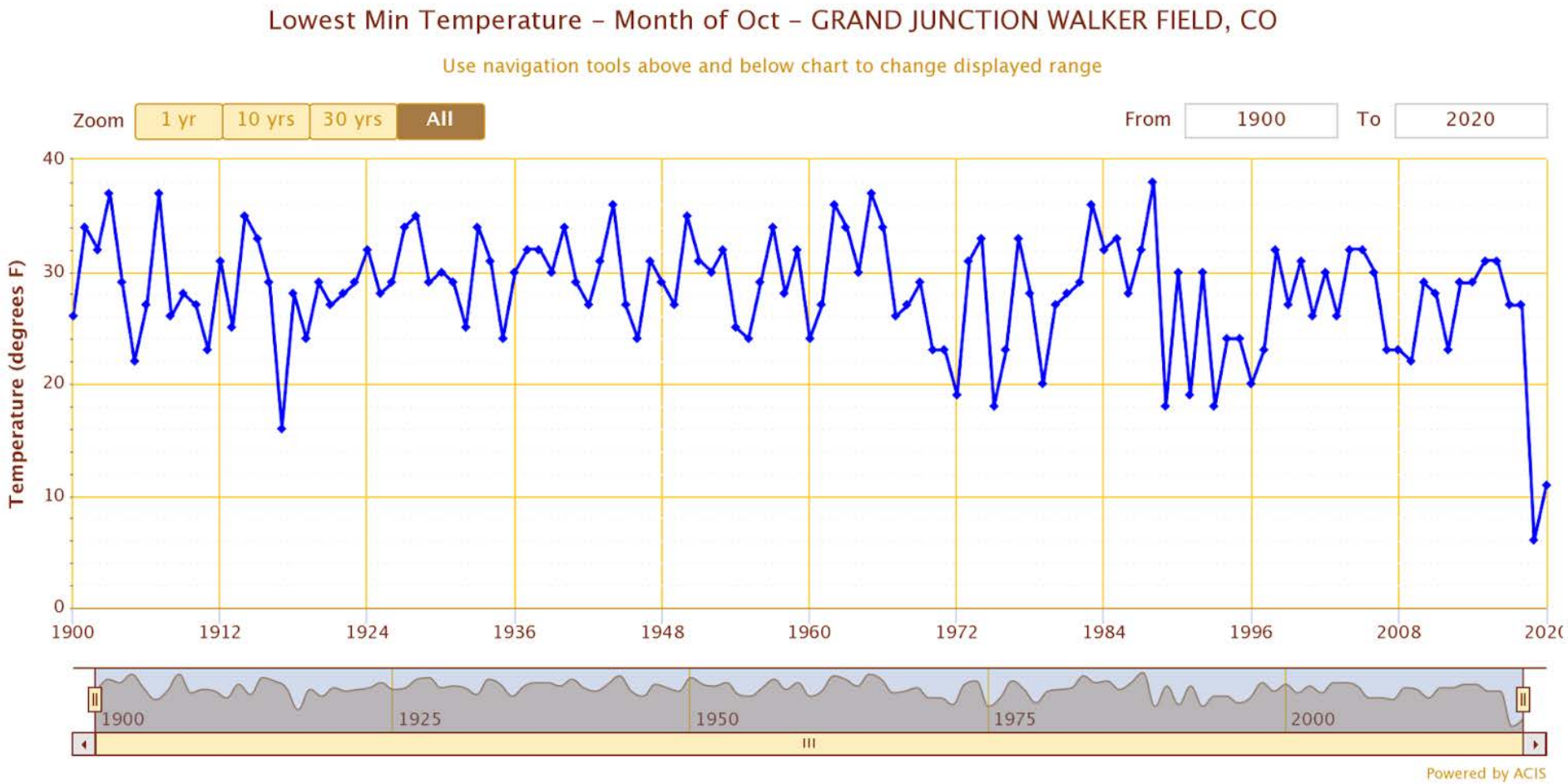


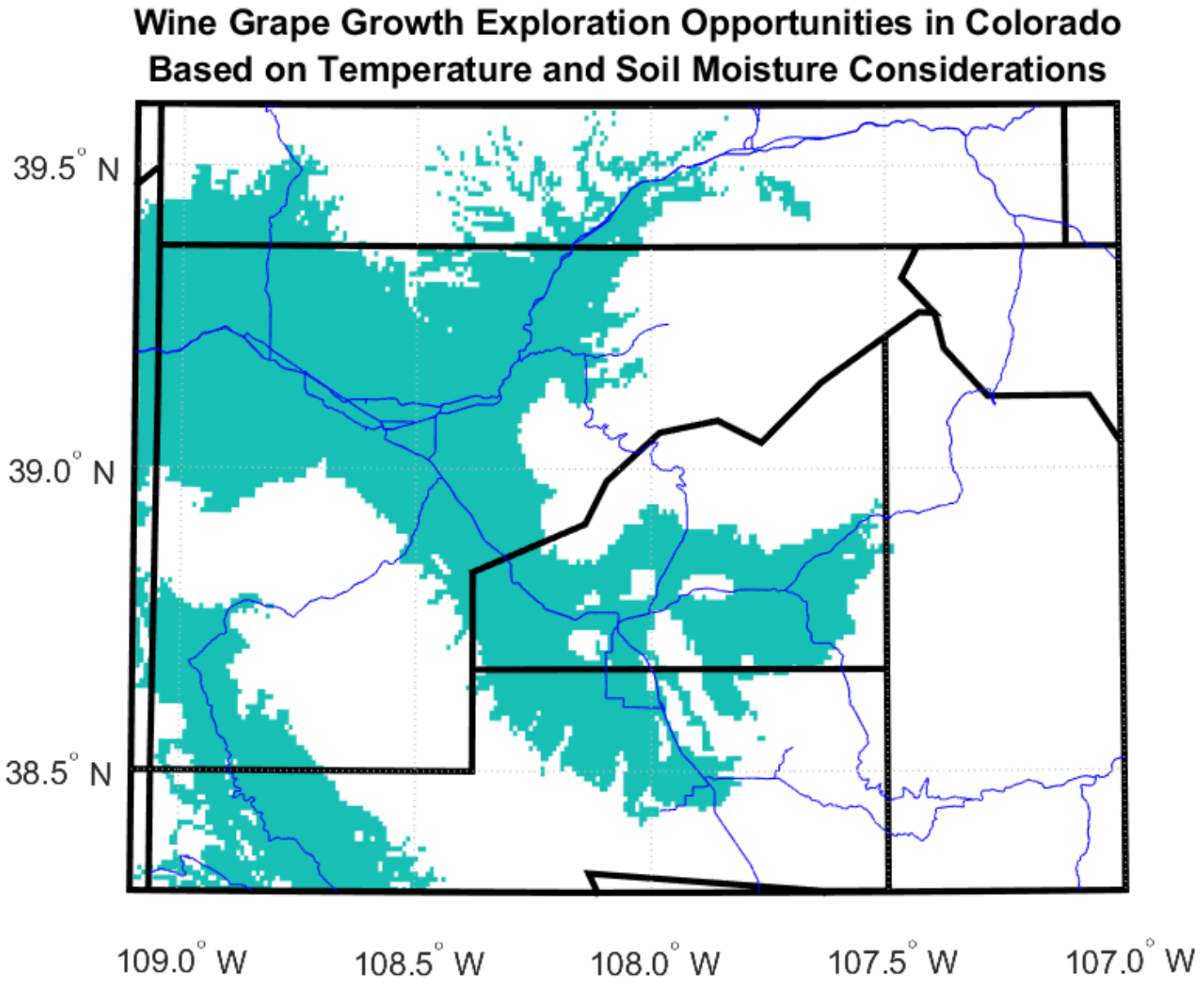
Figure 1: Lowest daily minimum temperatures recorded in October for each year from 1900 - 2020 at Walker Field in Grand Junction, CO

Summary of Findings

- Findings largely confirm what is known about where grapes succeed in Colorado, but not without some surprises
- Both models and observations confirm Cañon City is a warm spot, but things get colder quickly in all directions but south
- Montezuma County offers a number of warm pockets where grapes could succeed: (western McElmo Canyon, Mancos River Valley near State Line, west of Yellow Jacket, north of Cortez)
- Where we want to know more: **Is the Paradox Valley really hospitable for grapes? How much opportunity does the east side of the Wet Mountains offer? Could Lamar be a hot spot for cold-hardy hybrids?**
- Just because this study does not recommend an area for growing grapes doesn't guarantee failure (or vice versa)
- Colorado is getting warmer, but we don't see convincing trends yet in the number of killing freeze years. The last two Octobers have seen brutal lows

Opportunities

- We are happy to provide these data to individuals who are growing or considering growing grapes
- We can produce maps more zoomed in for your area with additional GIS layers for clarity
- If you live in Montezuma or Fremont Counties, and would like to participate, let's get in touch!



Thank you!

http://climate.colostate.edu/

russ.schumacher@colostate.edu

peter.goble@colostate.edu

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