

# The state of Colorado's climate

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Director, Colorado Climate Center

Department of Atmospheric Science, Colorado State University



Water Resources and Ag Review  
Committee  
August 2024



ATMOSPHERIC SCIENCE  
COLORADO STATE UNIVERSITY

# Our mission

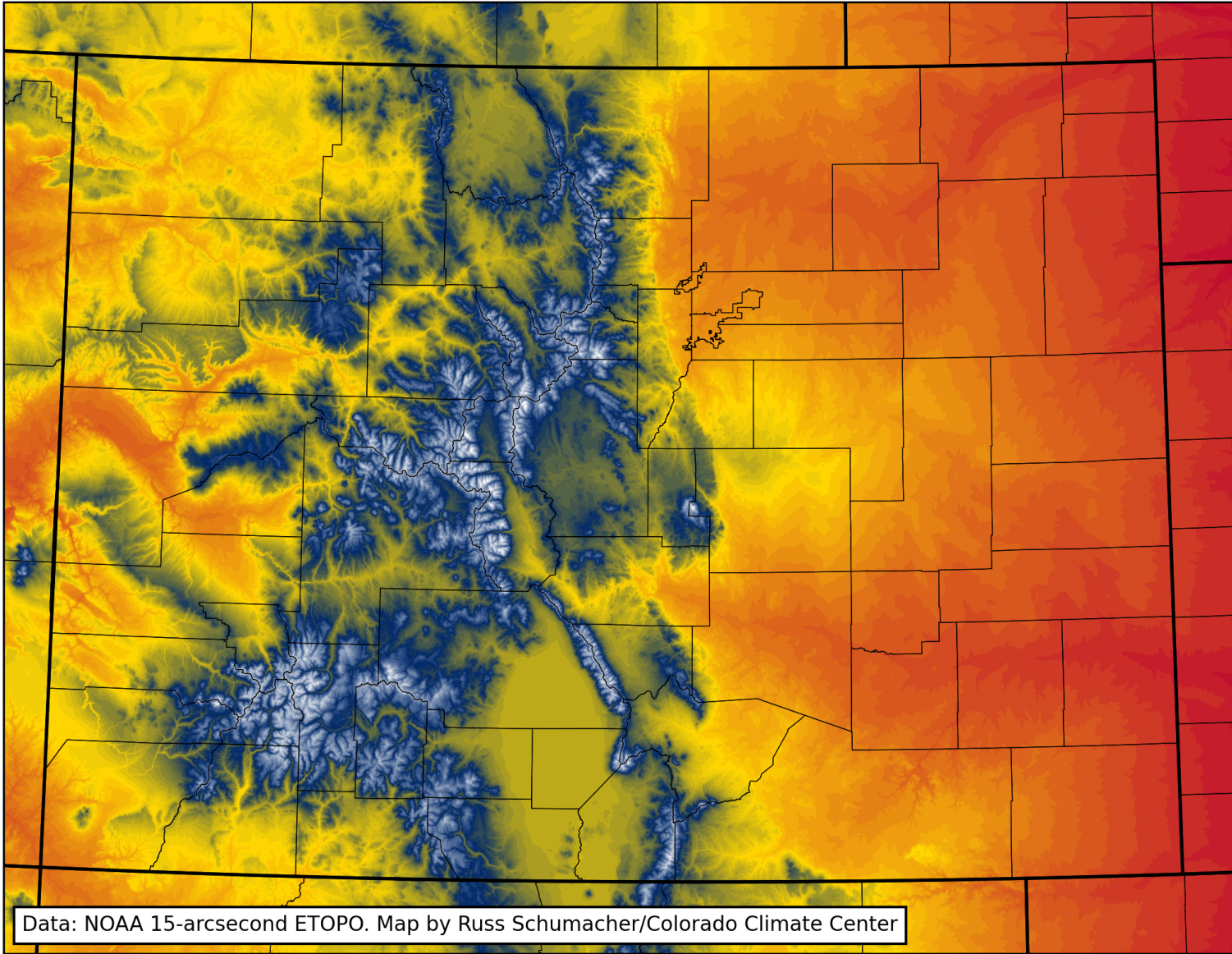
The Colorado Climate Center at CSU provides valuable climate expertise to the residents of the state through its threefold program of:

- 1) ***Climate Monitoring*** (data acquisition, analysis, and archiving)
- 2) ***Climate Research***
- 3) ***Climate Services*** (providing data, analysis, climate expertise, education and outreach)

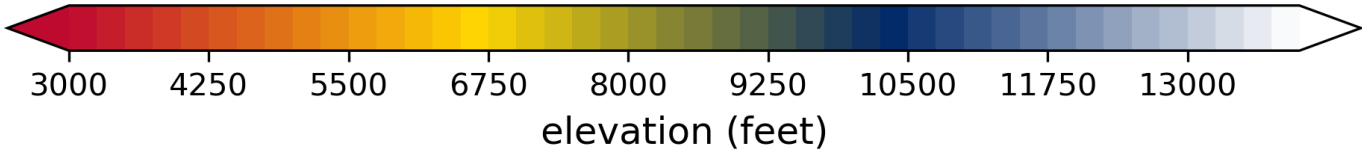




# Topography

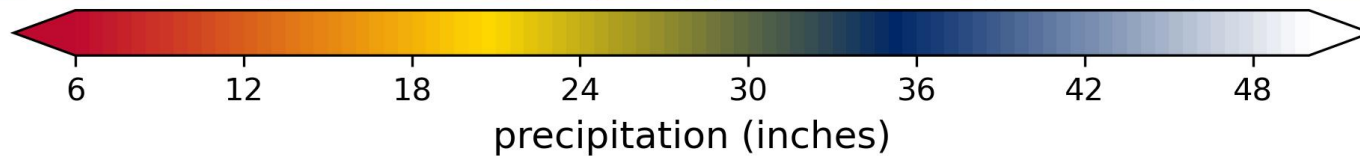
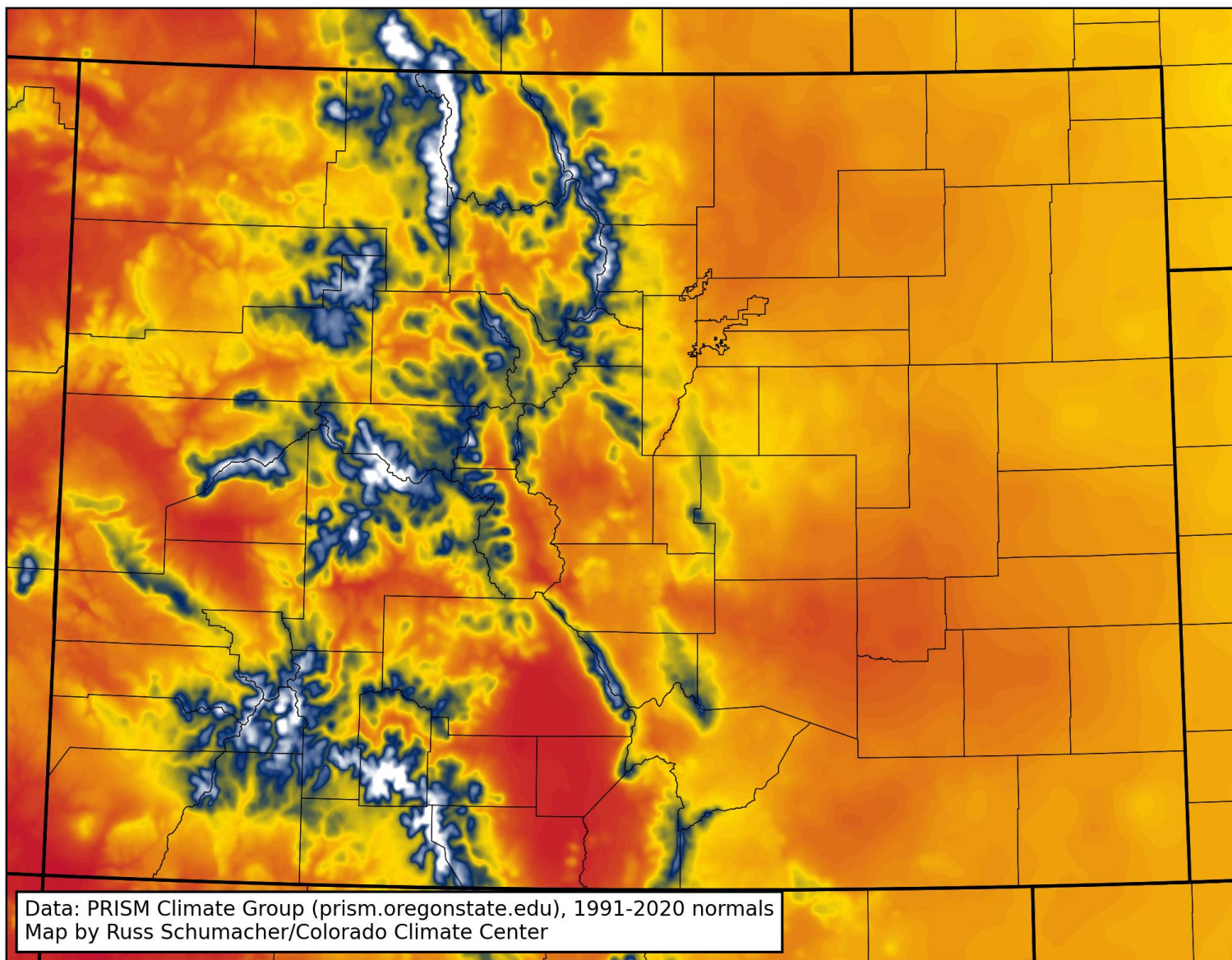


Data: NOAA 15-arcsecond ETOPO. Map by Russ Schumacher/Colorado Climate Center



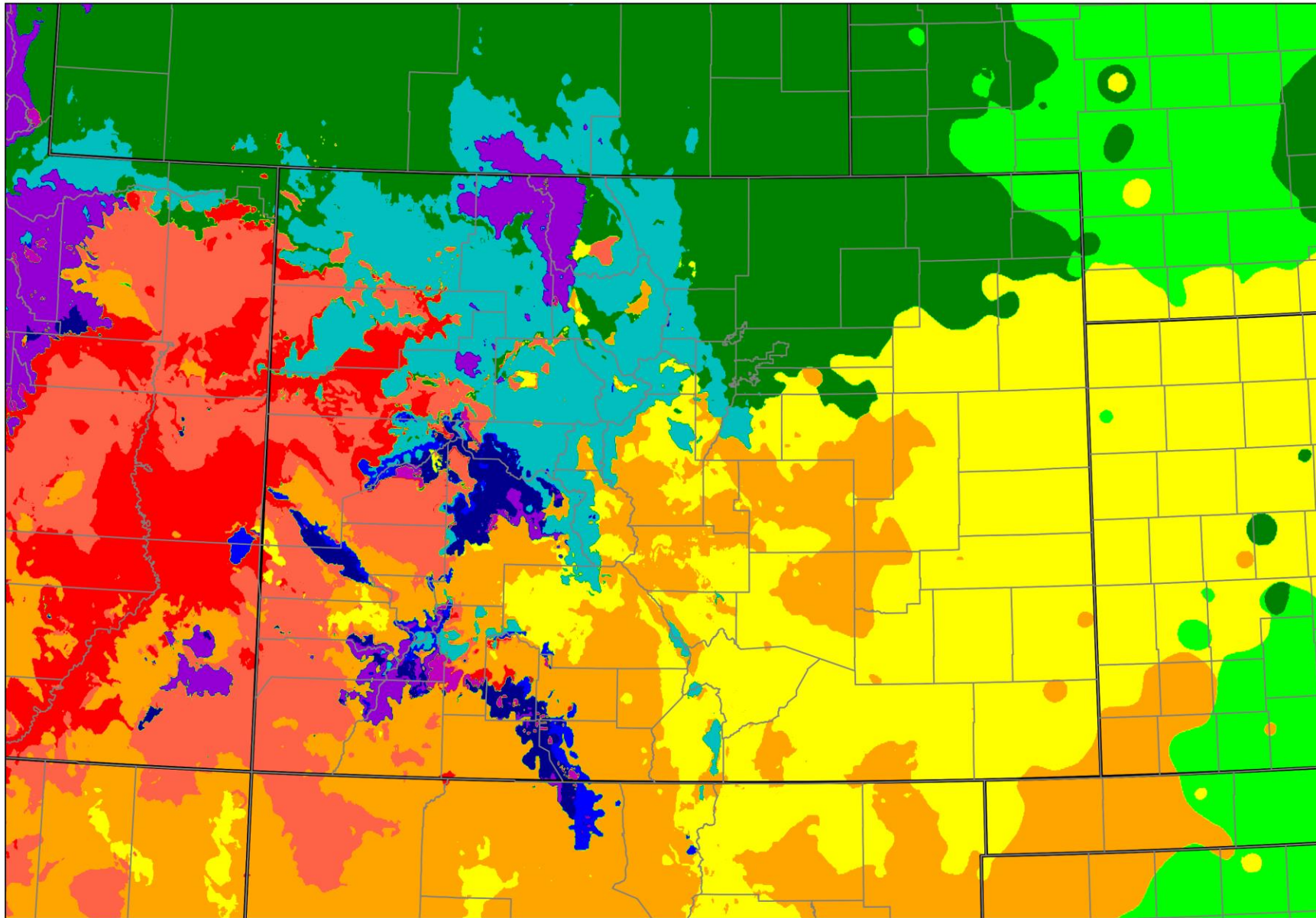
# Annual average precipitation

Data: PRISM Climate Group, [prism.oregonstate.edu](http://prism.oregonstate.edu), 1991-2020 normals





month of maximum average precipitation



**Colorado: the only state where every month is the wettest month on average somewhere**

Month of maximum average precip  
Data: PRISM Climate Group, [prism.oregonstate.edu](http://prism.oregonstate.edu), 1991-2020 normals



Figure: Russ Schumacher/Colorado Climate Center  
Data: PRISM climate group ([prism.oregonstate.edu](http://prism.oregonstate.edu)), 1991-2020 normals

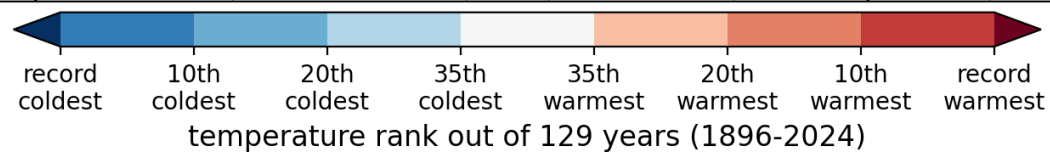
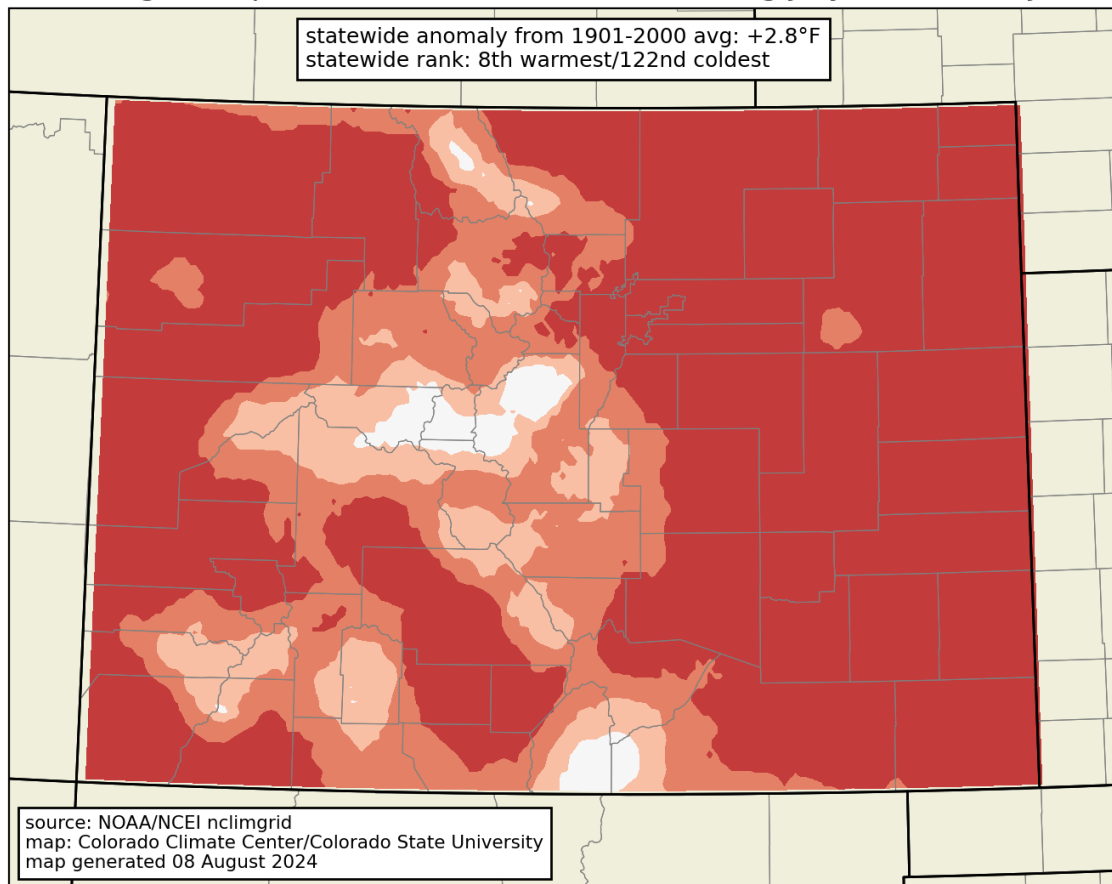
# Roadmap

1. Overview of current water year conditions
2. What we know about the fall and winter outlook
3. Climate change in Colorado
4. Some projects and initiatives





average temperature rank: 10 months ending July 2024 (Oct-Jul)



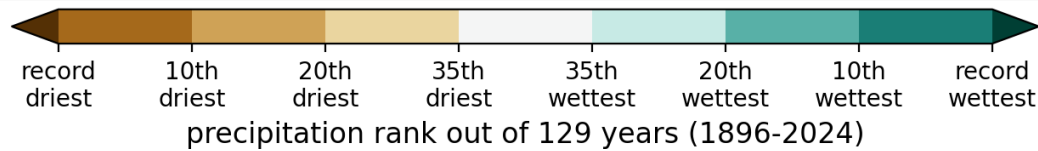
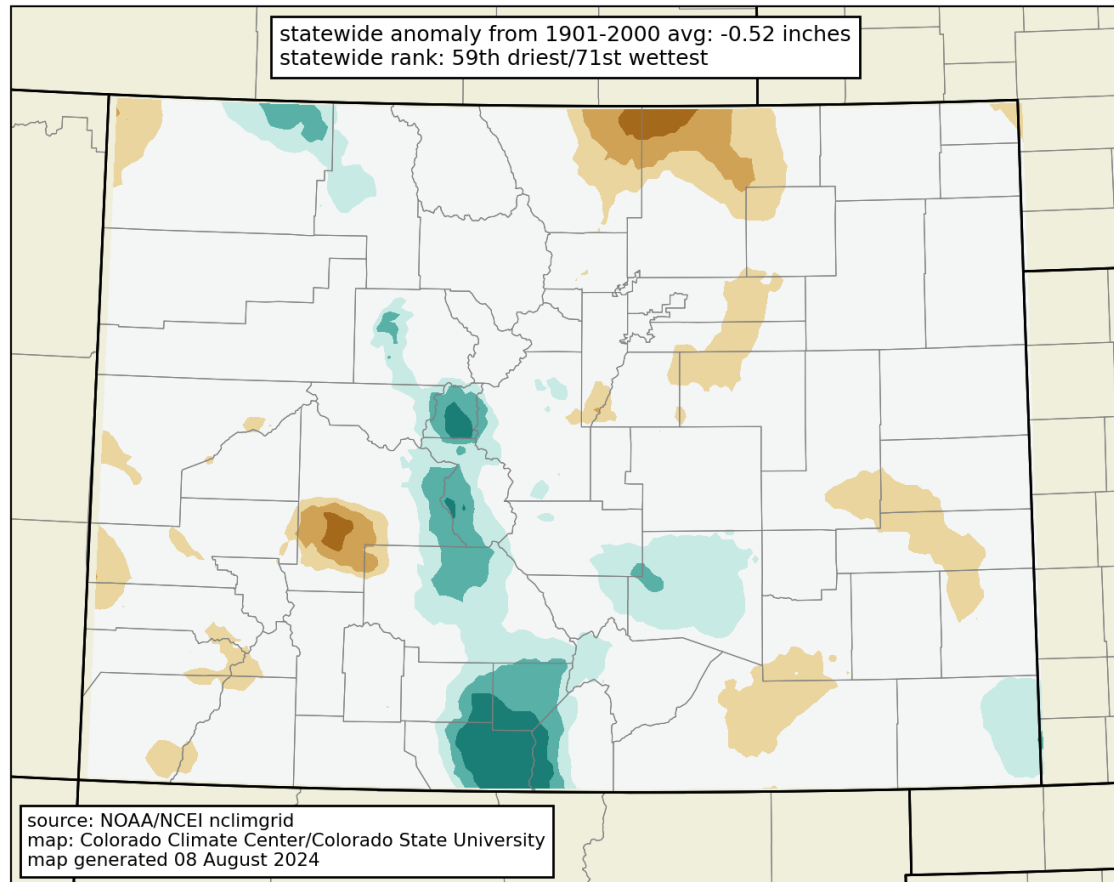
**Statewide: 8<sup>th</sup> warmest October-July (out of 129), warmest first 10 months of a water year since 2018**

## Colorado rankings:

Month	T Rank (of 129 years)	Above, below, or near 20 <sup>th</sup> century avg?
Oct	26 <sup>th</sup> warmest	above
Nov	20 <sup>th</sup> warmest	above
Dec	7 <sup>th</sup> warmest	much above
Jan	51 <sup>th</sup> warmest	near avg
Feb	11 <sup>th</sup> warmest	much above
March	31 <sup>st</sup> warmest	above
April	17 <sup>th</sup> warmest	above
May	49 <sup>th</sup> coolest	near avg
Jun	3 <sup>rd</sup> warmest	much above
Jul	45 <sup>th</sup> warmest	near avg



precipitation rank: 10 months ending July 2024 (Oct-Jul)



**Statewide: 59<sup>th</sup> driest/71<sup>st</sup> wettest October-July (out of 129): slightly below average**

**Colorado rankings:**

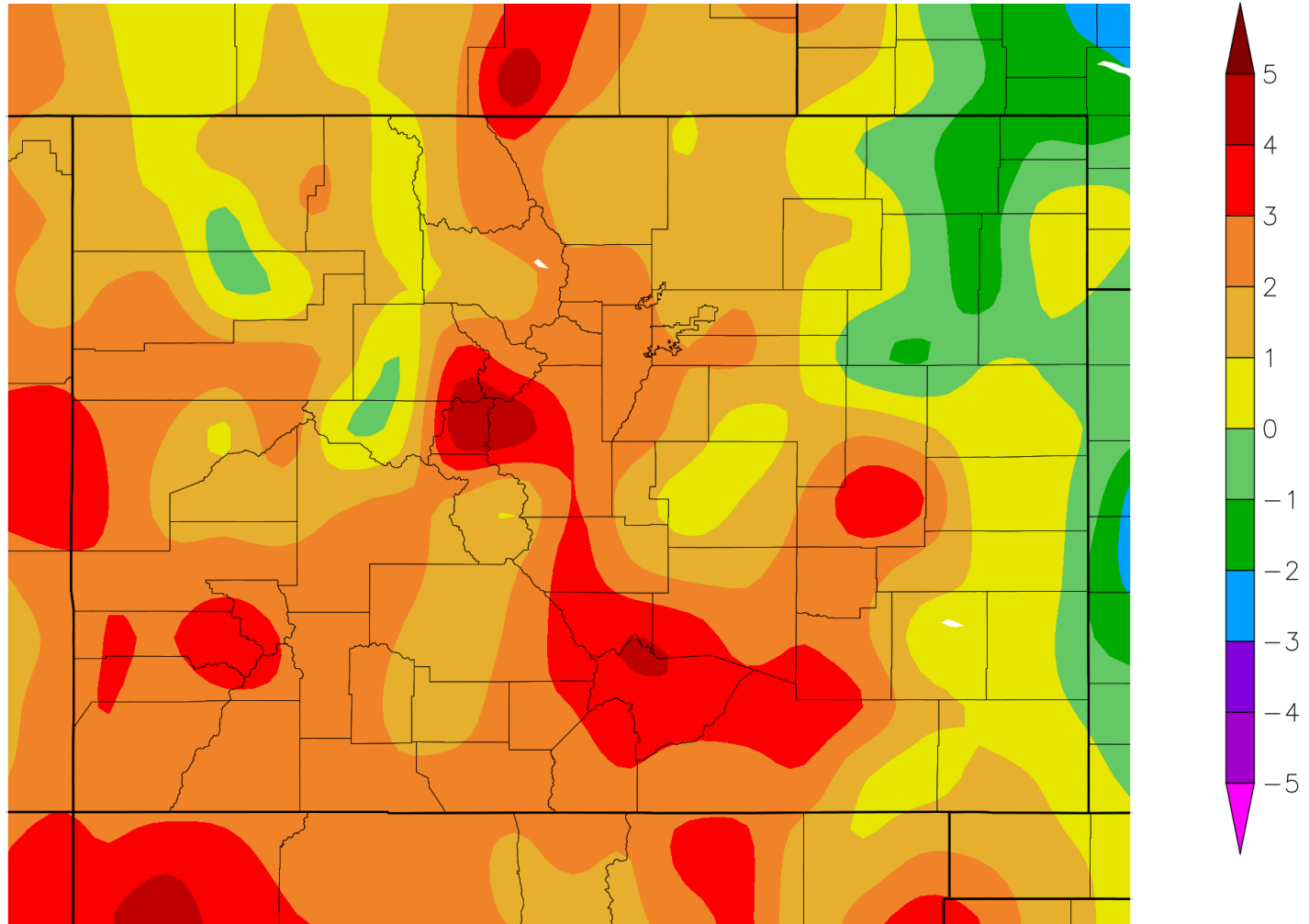
Month	T Rank (of 129 years)	Above, below, or near 20 <sup>th</sup> century avg?
Oct	52 <sup>nd</sup> driest	near avg
Nov	22 <sup>nd</sup> driest	below
Dec	66 <sup>th</sup> driest	near avg
Jan	47 <sup>th</sup> wettest	near avg
Feb	19 <sup>th</sup> wettest	above
Mar	16 <sup>th</sup> wettest	above
Apr	46 <sup>th</sup> driest	near avg
May	58 <sup>th</sup> driest	near avg
Jun	38 <sup>th</sup> wettest	above
Jul	37 <sup>th</sup> driest	below





# Departure from Normal Temperature (F) 8/1/2024 – 8/20/2024

## August temperature so far

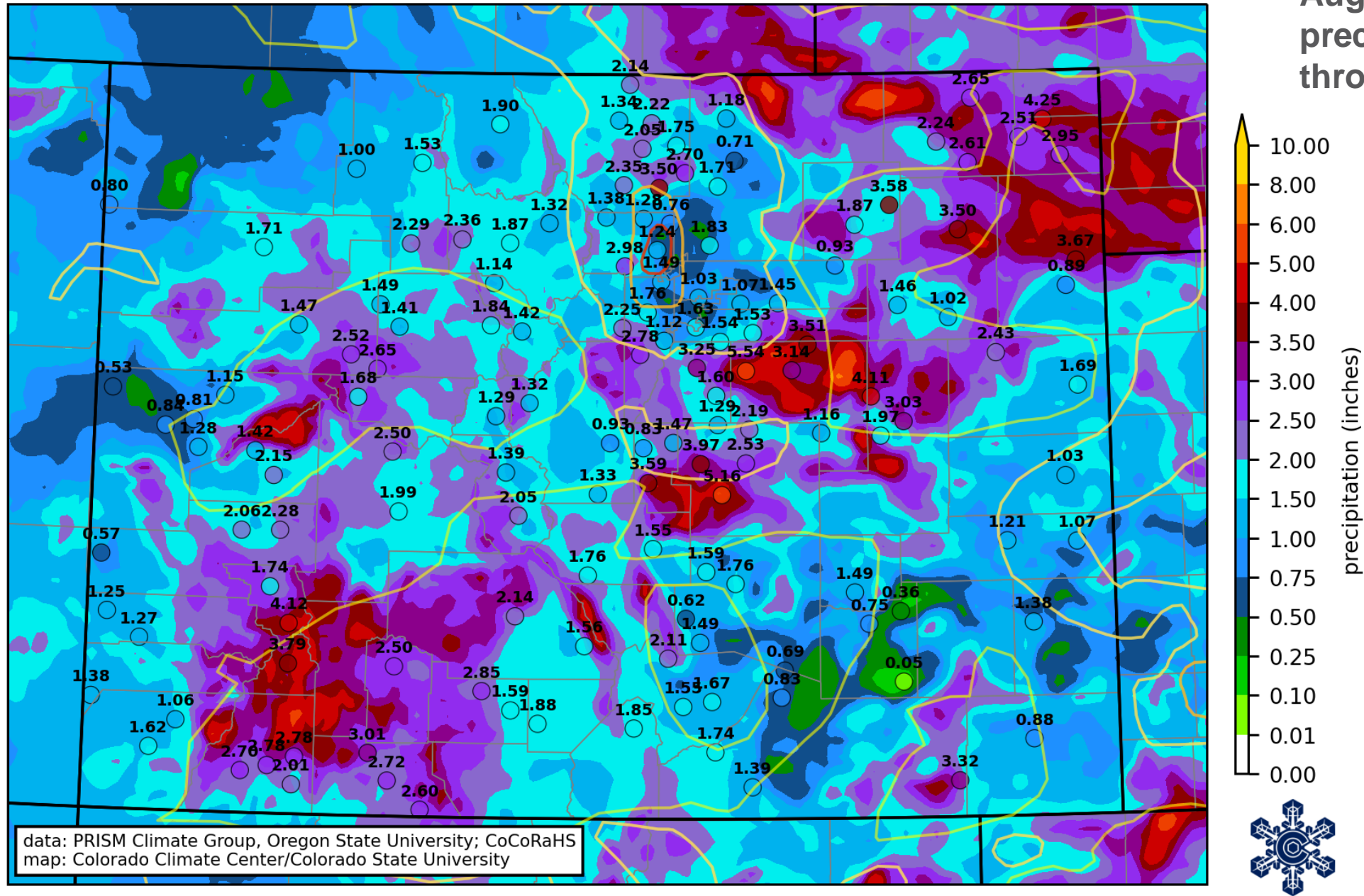


Generated 8/21/2024 at HPRCC using provisional data.

NOAA Regional Climate Centers

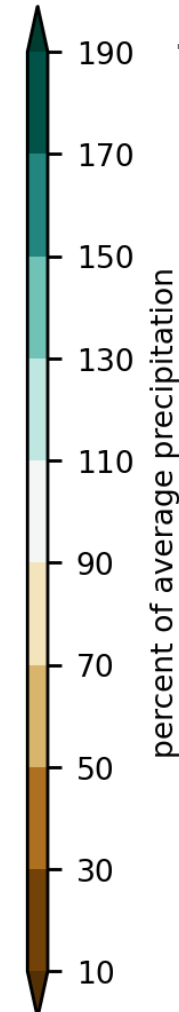
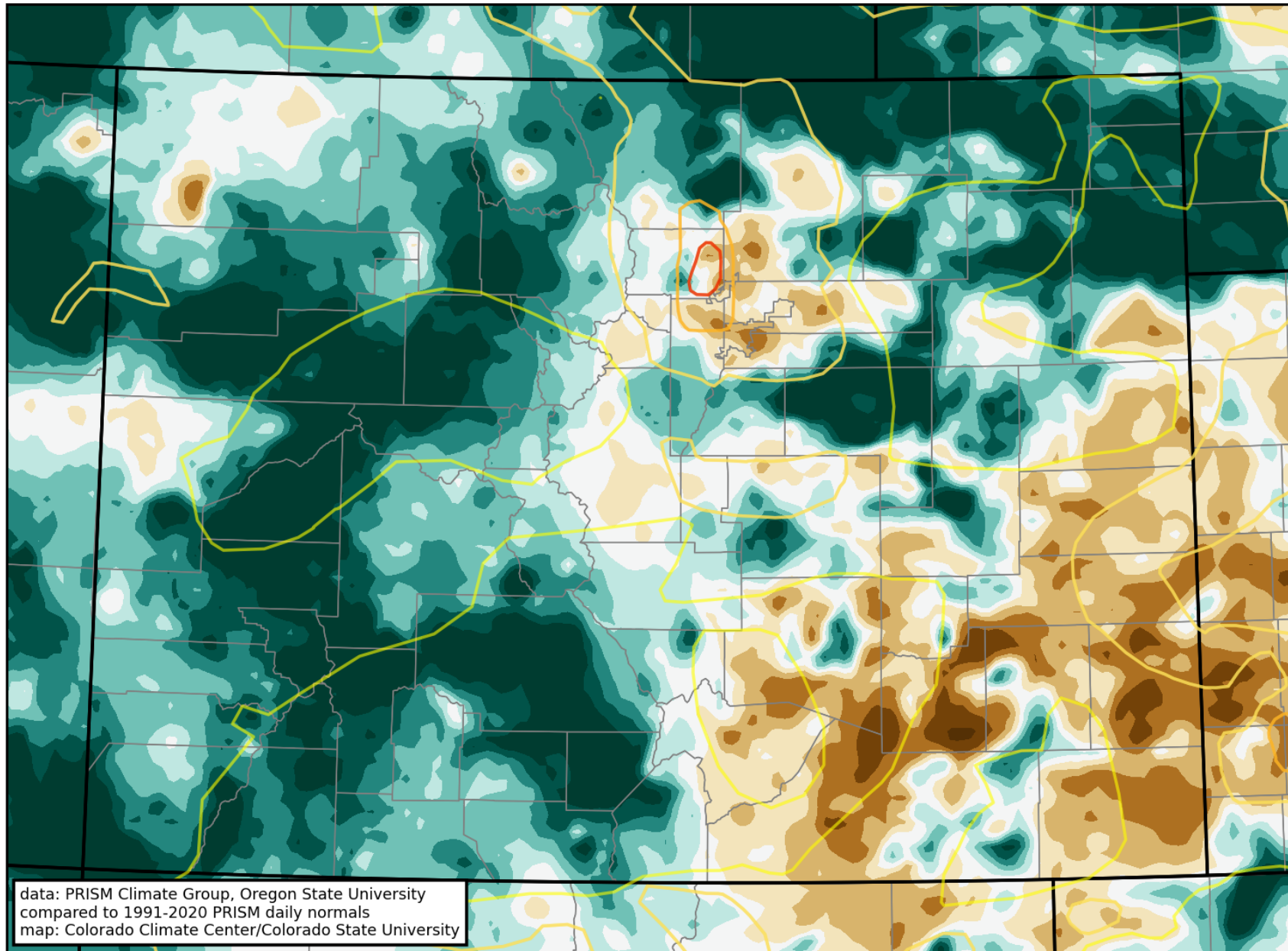


# August precipitation through the 20th





# August percent of normal precipitation through the 20<sup>th</sup>



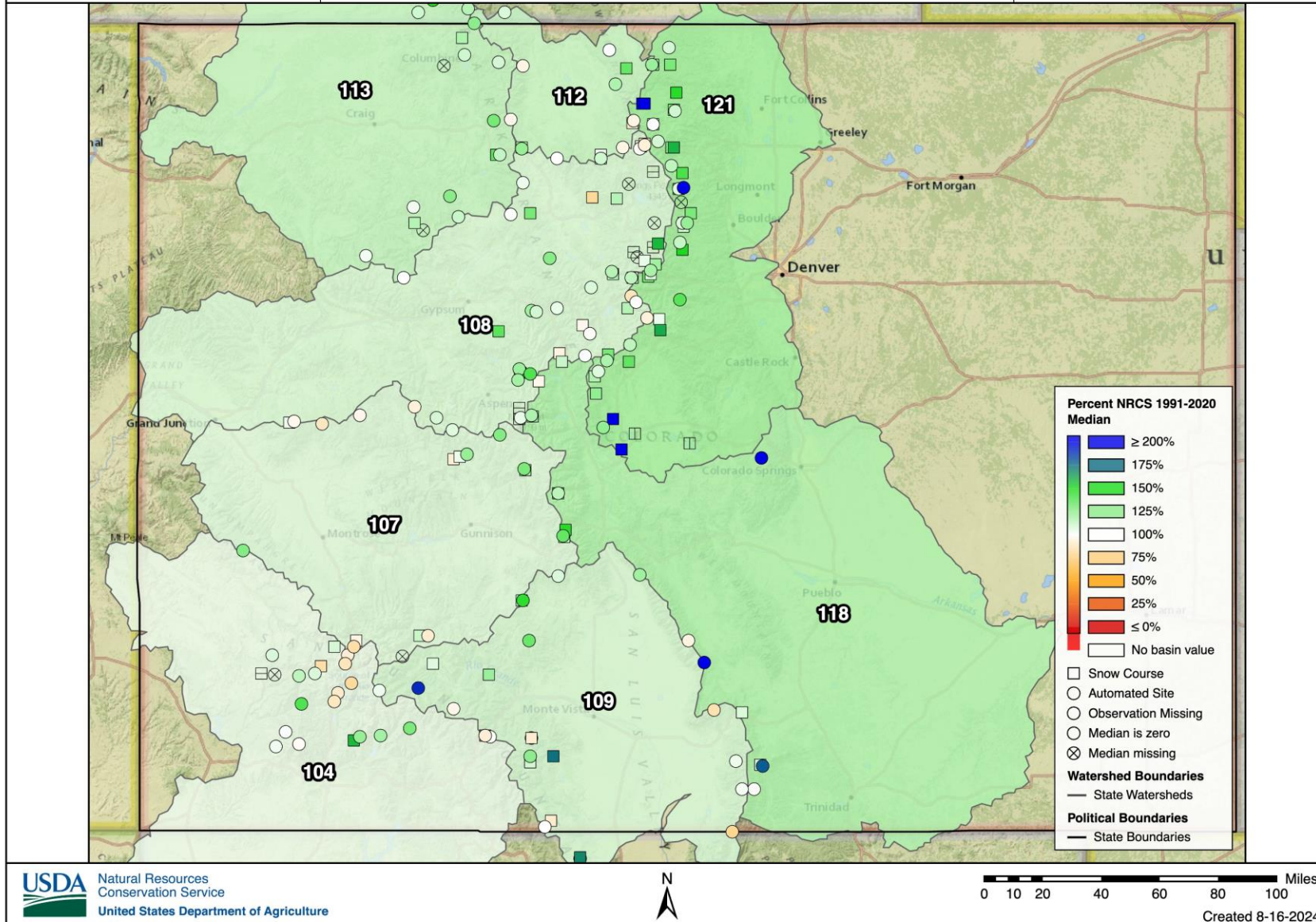
data: PRISM Climate Group, Oregon State University  
compared to 1991-2020 PRISM daily normals  
map: Colorado Climate Center/Colorado State University



Snow Water Equivalent

Percent NRCS 1991-2020 Median

April 1st, 2024



April 1  
snowpack

Percent of  
1991-2020  
median

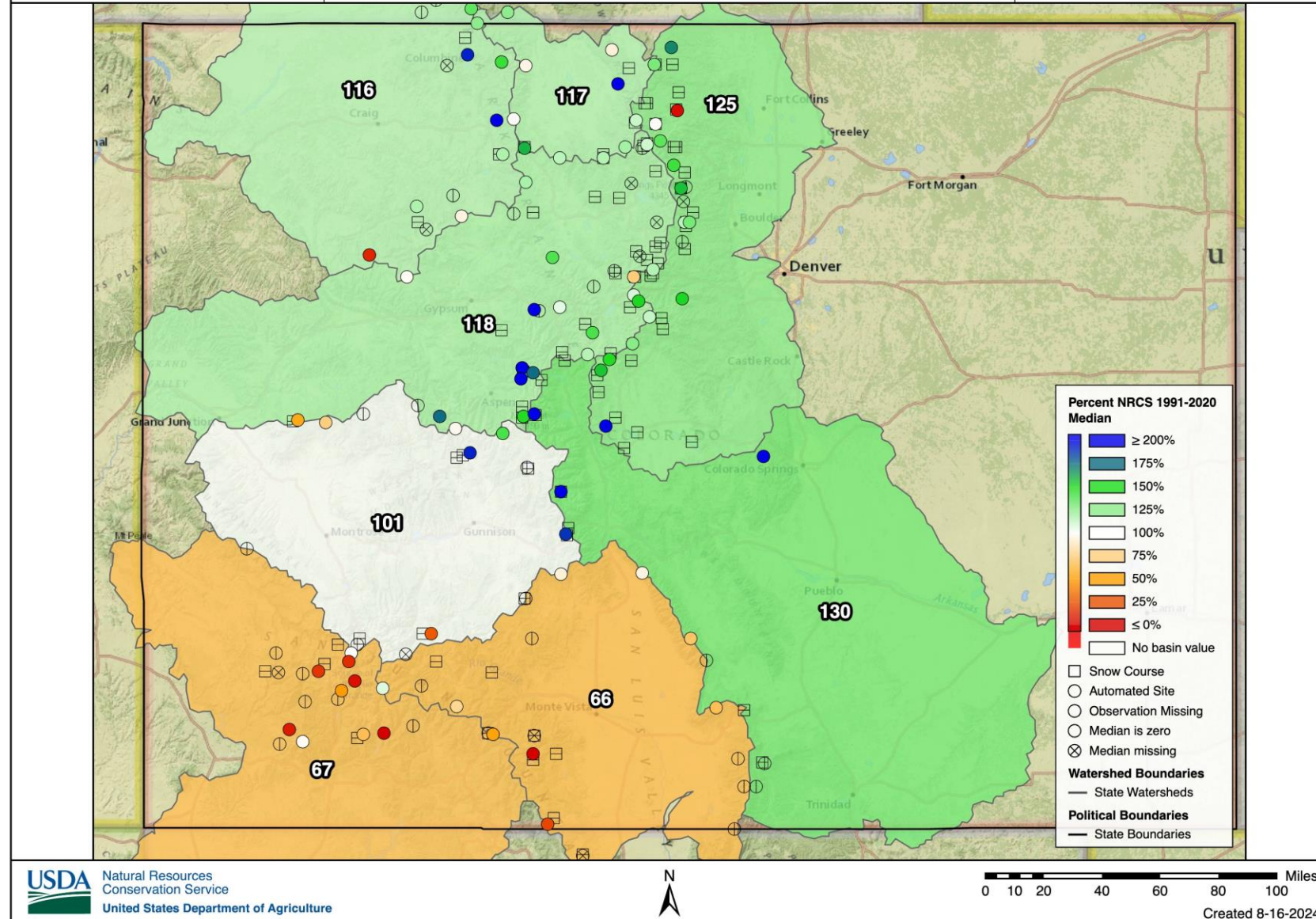




Snow Water Equivalent

Percent NRCS 1991-2020 Median

Middle of May, 2024



May 15  
snowpack

Percent of  
1991-2020  
median

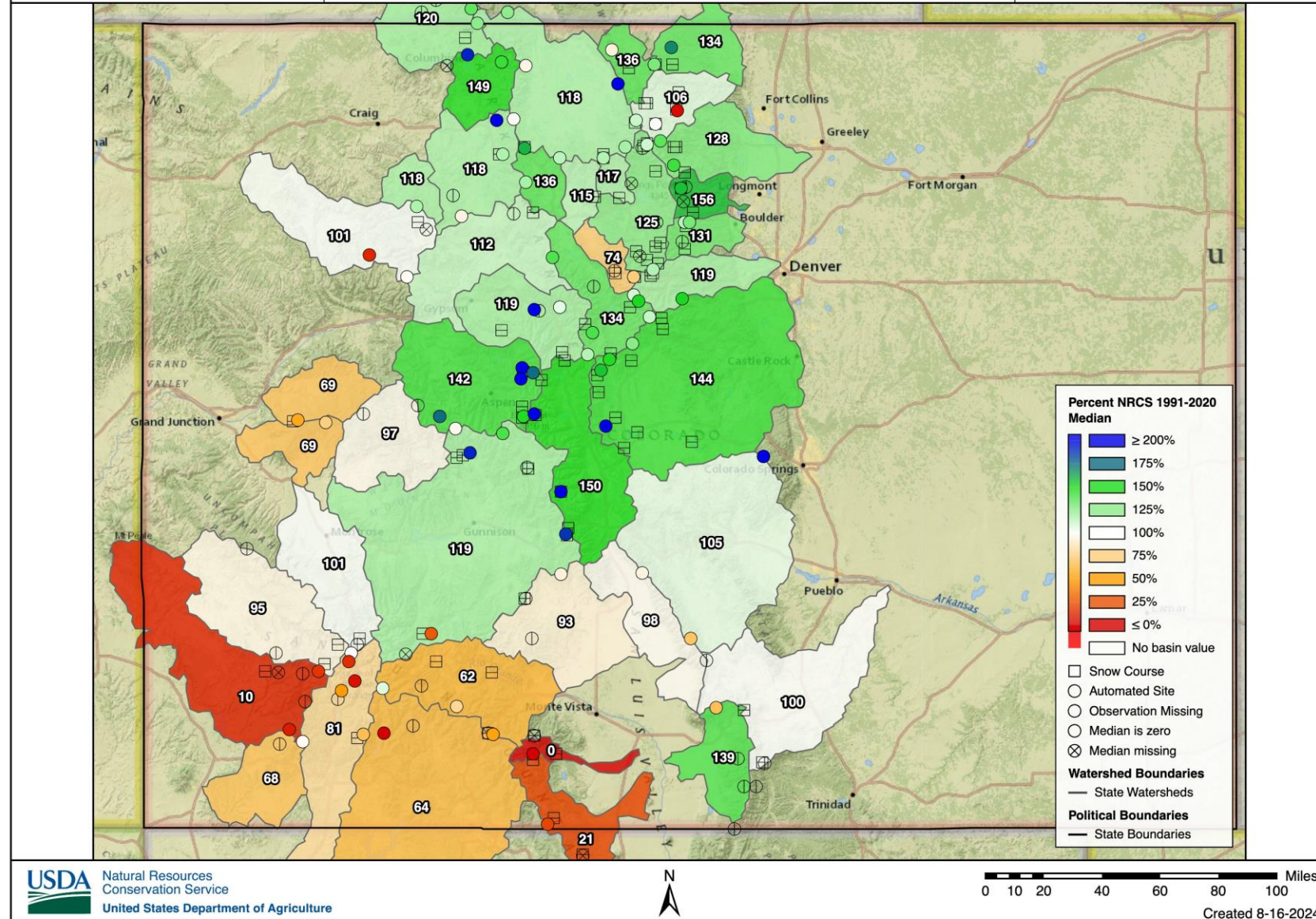




Snow Water Equivalent

Percent NRCS 1991-2020 Median

Middle of May, 2024



May 15  
snowpack

Percent of  
1991-2020  
median

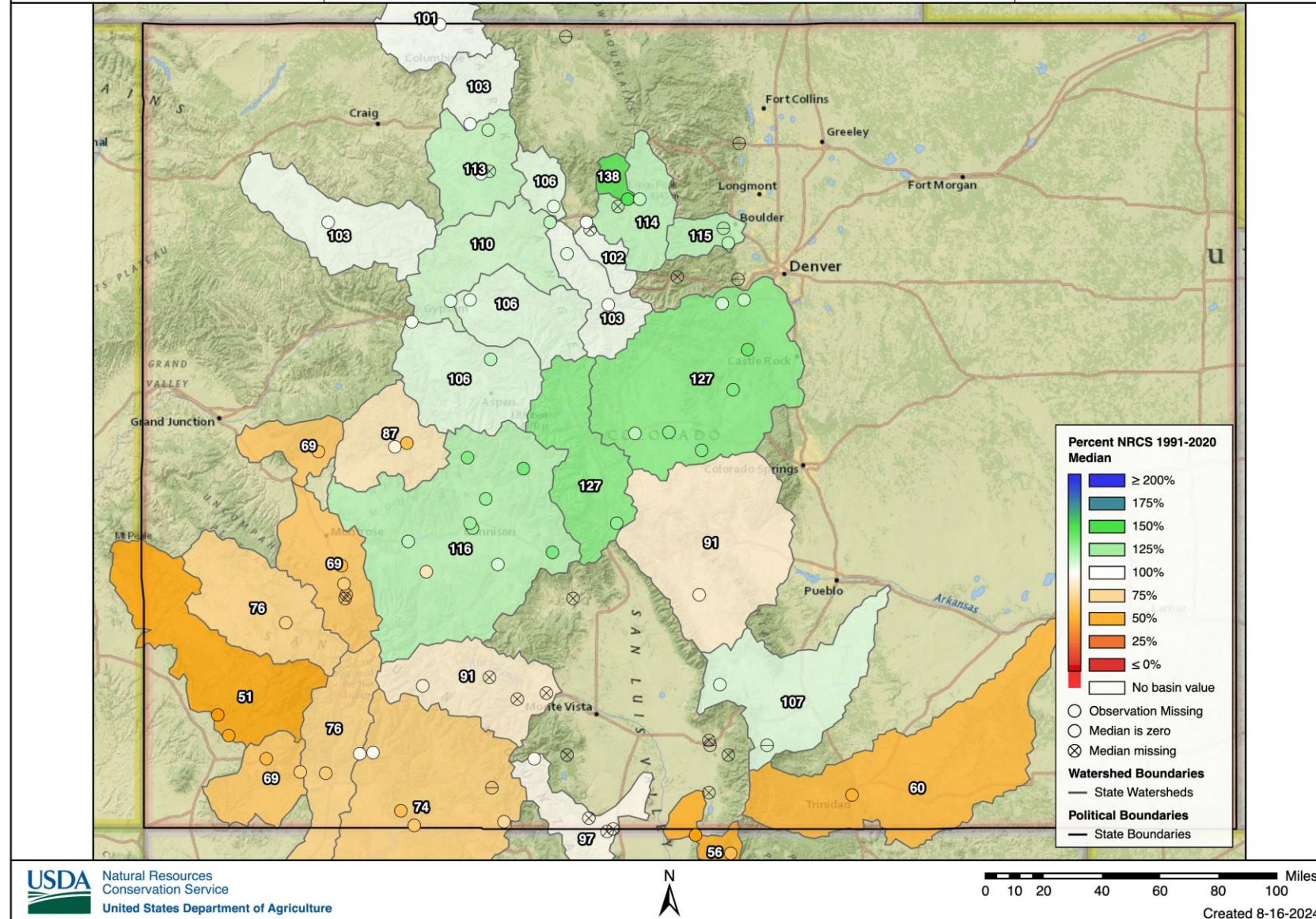




4 month Adjusted Volume, Observed

Percent NRCS 1991-2020 Median

April 1, 2024 - July 31, 2024



April-July  
streamflow  
volume

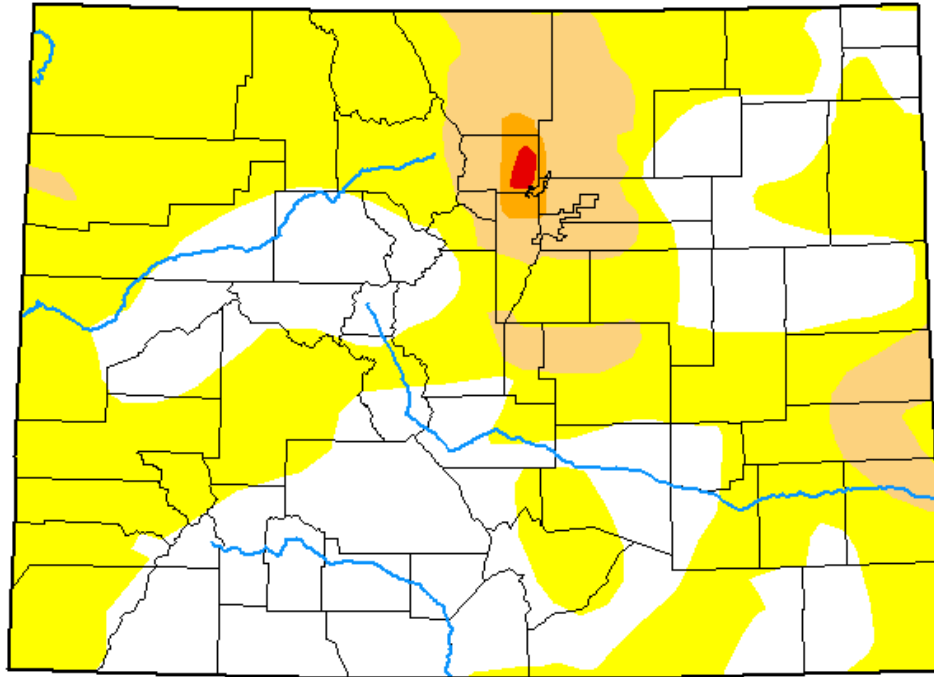
Percent of  
1991-2020  
median





# U.S. Drought Monitor Colorado

**August 13, 2024**  
(Released Thursday, Aug. 15, 2024)  
Valid 8 a.m. EDT



*Drought Conditions (Percent Area)*

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
<b>Current</b>	37.27	62.73	10.11	0.72	0.14	0.00
<b>Last Week</b> <i>08-06-2024</i>	33.97	66.03	12.60	1.86	0.14	0.00
<b>3 Months Ago</b> <i>05-14-2024</i>	60.34	39.66	9.02	1.41	0.00	0.00
<b>Start of Calendar Year</b> <i>01-02-2024</i>	34.65	65.35	29.59	8.85	2.05	0.00
<b>Start of Water Year</b> <i>09-26-2023</i>	65.71	34.29	17.43	2.77	0.00	0.00
<b>One Year Ago</b> <i>08-15-2023</i>	71.82	28.18	15.04	0.00	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:

Curtis Riganti  
National Drought Mitigation Center



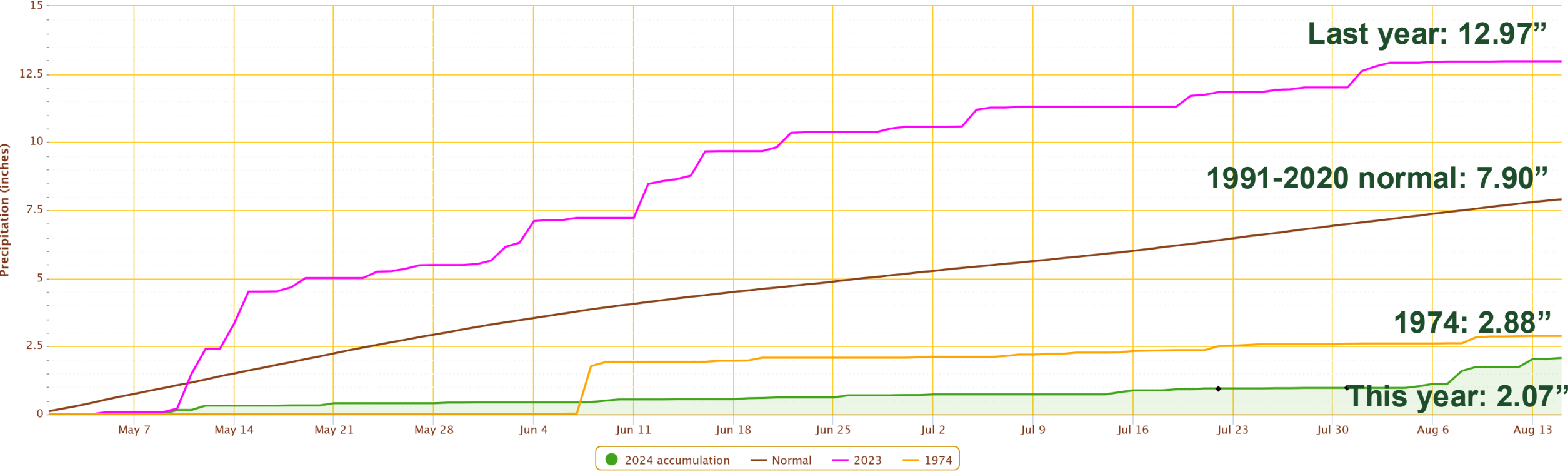
[droughtmonitor.unl.edu](https://droughtmonitor.unl.edu)



# Driest May-June-July on record at Boulder (by far!)

Accumulated Precipitation – BOULDER, CO

Click and drag to zoom to a shorter time interval; green/black diamonds represent subsequent/missing values



Powered by ACIS





## Outlook





# La Niña is on its way back

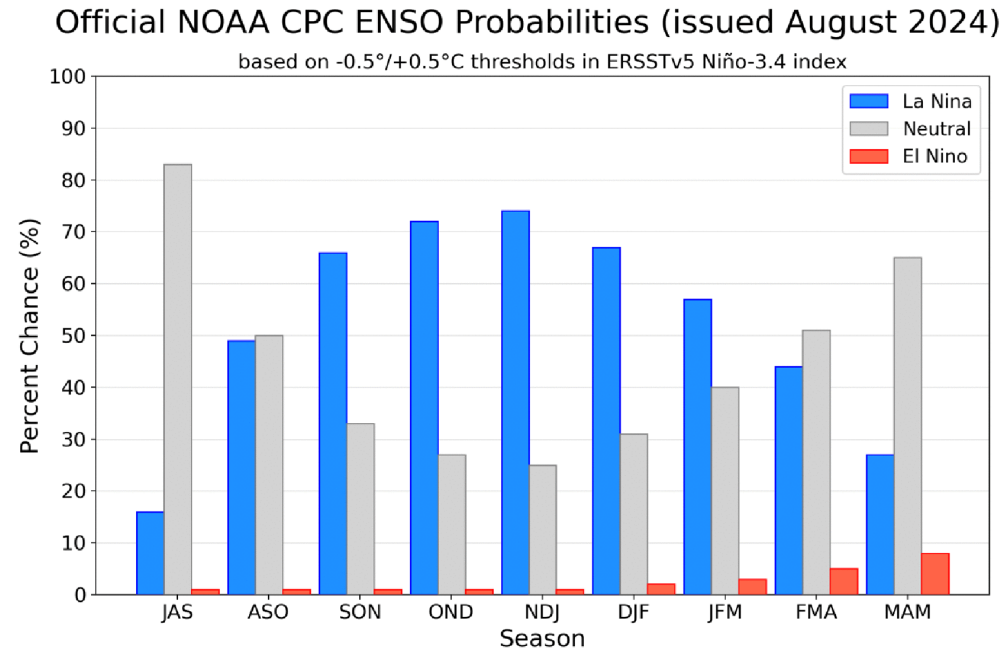


Figure 7. Official ENSO probabilities for the Niño 3.4 sea surface temperature index ( $5^{\circ}\text{N}$ - $5^{\circ}\text{S}$ ,  $120^{\circ}\text{W}$ - $170^{\circ}\text{W}$ ). Figure updated 8 August 2024.

**“ENSO-neutral is expected to continue for the next several months, with La Niña favored to emerge during September-November (66% chance) and persist through the Northern Hemisphere winter 2024-25 (74% chance during November-January)”**

[https://www.cpc.ncep.noaa.gov/products/analysis\\_monitoring/enso\\_advisory/ensodisc.shtml](https://www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_advisory/ensodisc.shtml)

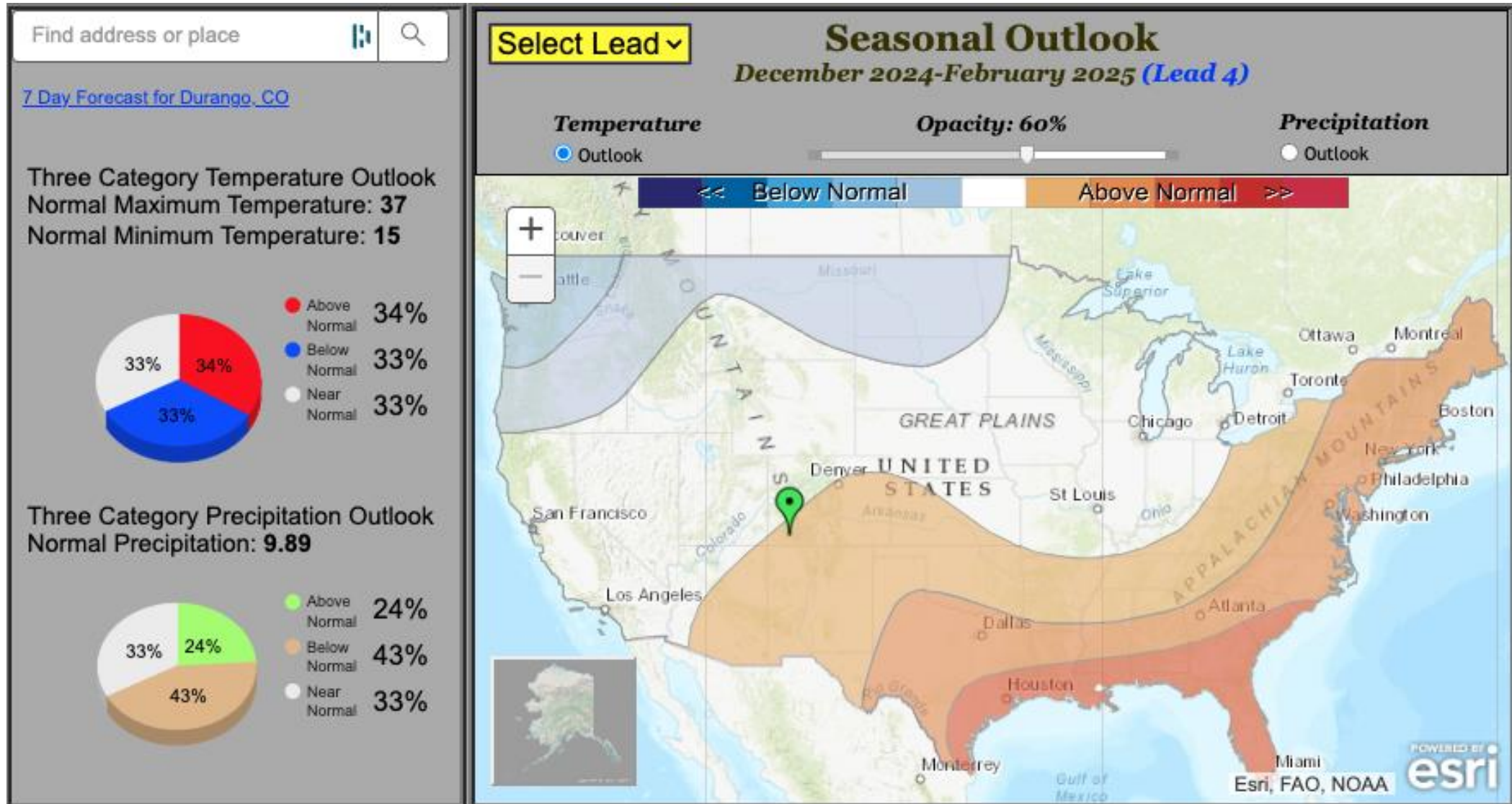




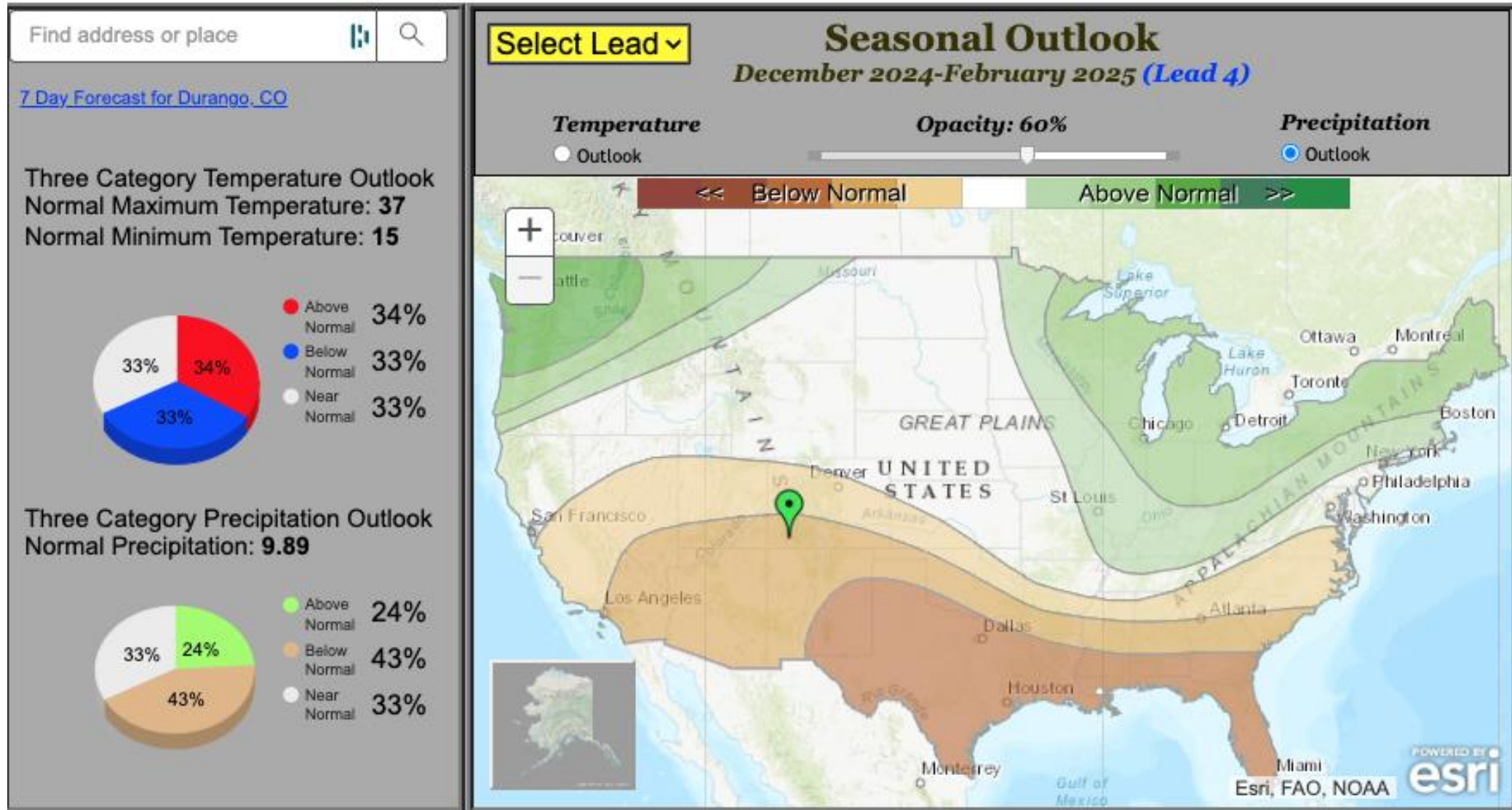




# NOAA's Winter (Dec-Jan-Feb) temperature outlook



# NOAA's Winter (Dec-Jan-Feb) precipitation outlook





# Climate Change in Colorado

Report

Executive Summary

Data and graphics

Resources

Report released in January

- PDF and web-based version
- Interactive graphs and maps of most report figures
- Explore additional graphs and maps online

<https://climatechange.colostate.edu>

Thanks to Becky Bolinger, Jeff Lukas, Peter Goble



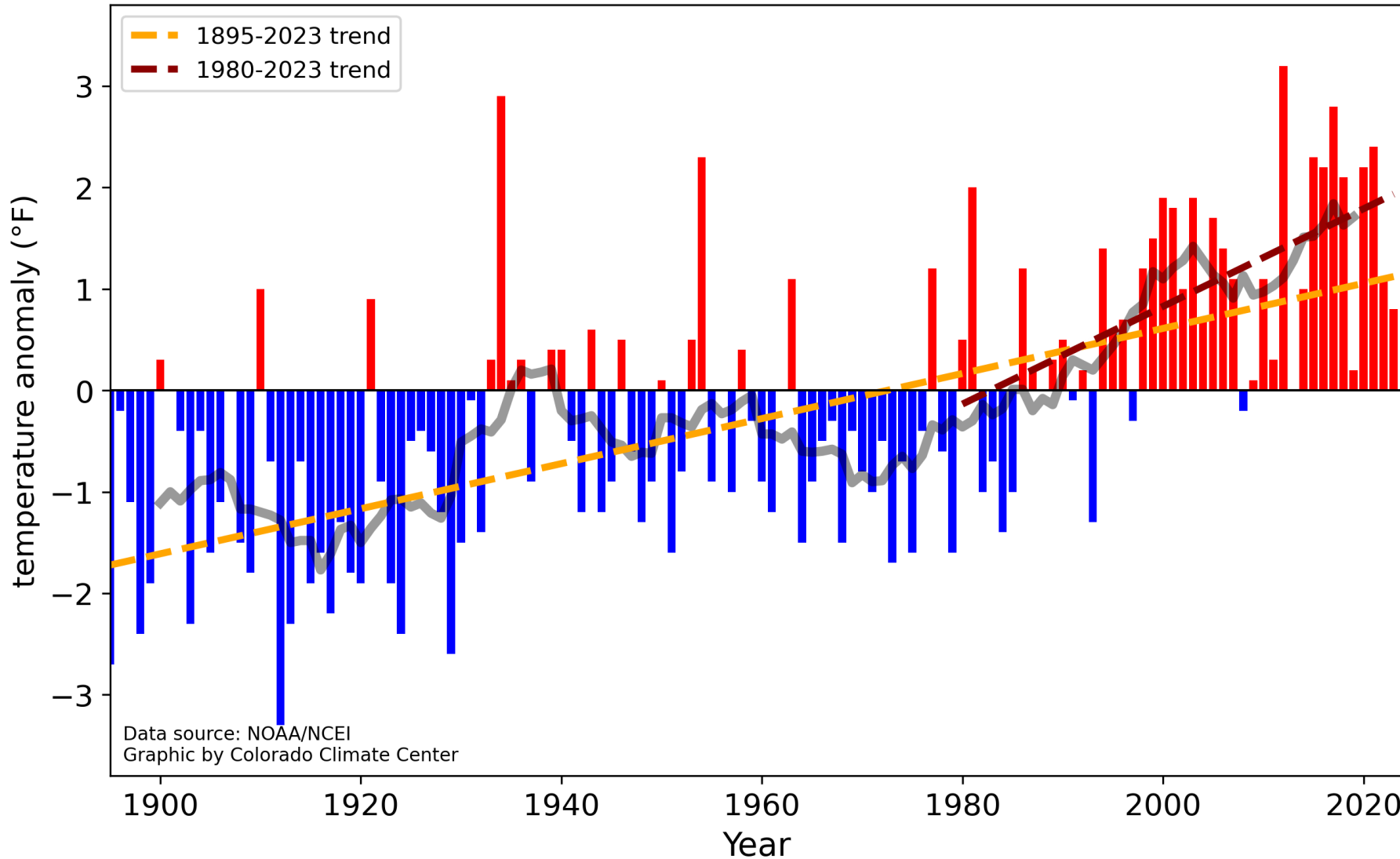
# Chapter 2 – temperature and precipitation

Climate variable/event	Recent trend	Projected future change	Confidence in change
Average Temperature	Warmer	Warmer	<i>Very high</i>
Annual Precipitation	Lower	Uncertain	<i>Low</i>



# Temperature – observed changes

Colorado statewide annual temperature anomaly (°F), with respect to 1971-2000 average



**Globally, calendar year 2023 was the warmest year since global records began in 1850 (by quite a lot)**

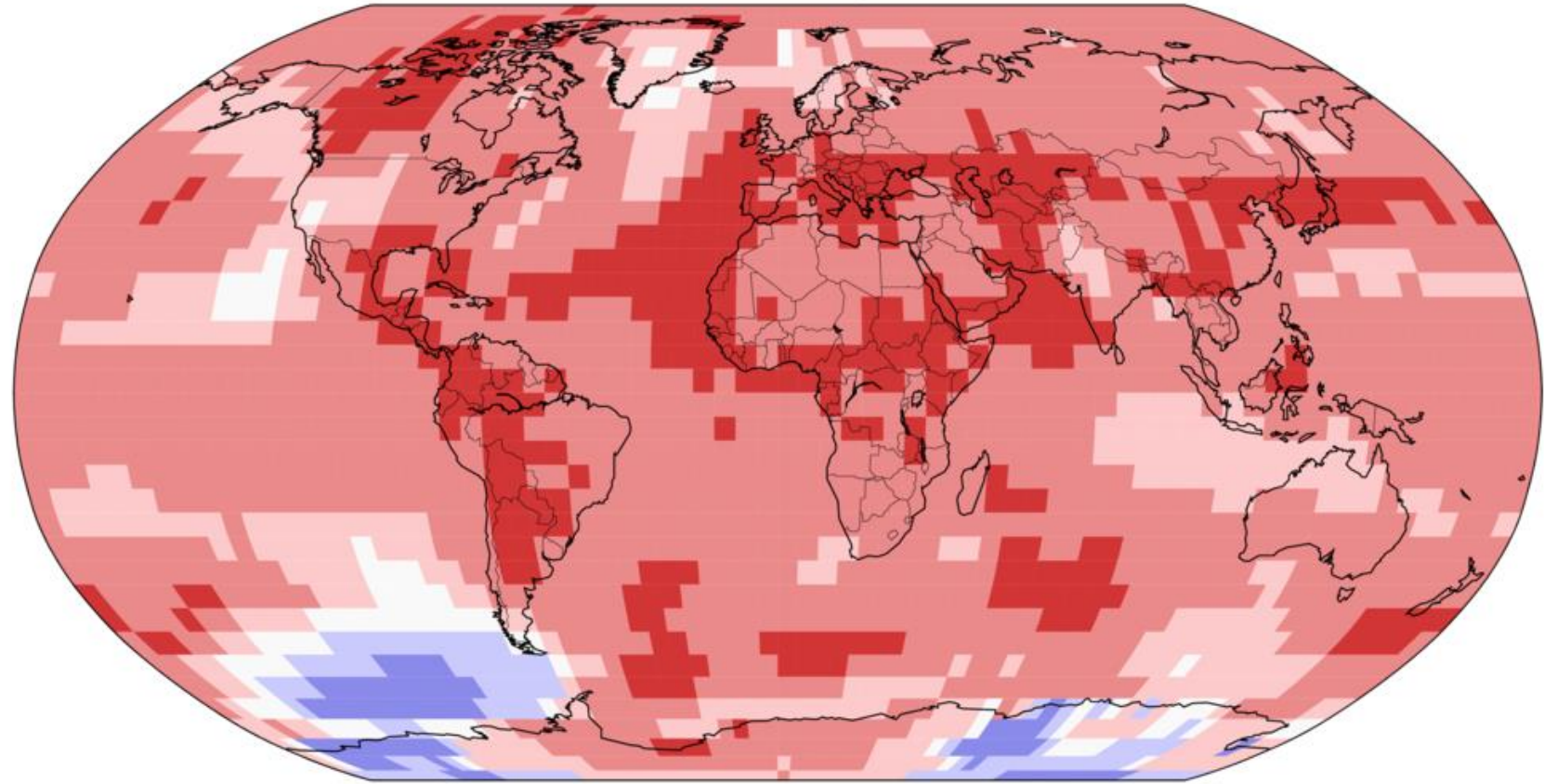
**The western US was a bit of an exception with temperatures closer to average**

**2024 is going to give 2023 a run for its money**

## Land & Ocean Temperature Percentiles Jan–Dec 2023

NOAA's National Centers for Environmental Information

Data Source: NOAA GlobalTemp v5.1.0–20240108



Record Coldest



Much Cooler than Average



Cooler than Average



Near Average



Warmer than Average



Much Warmer than Average



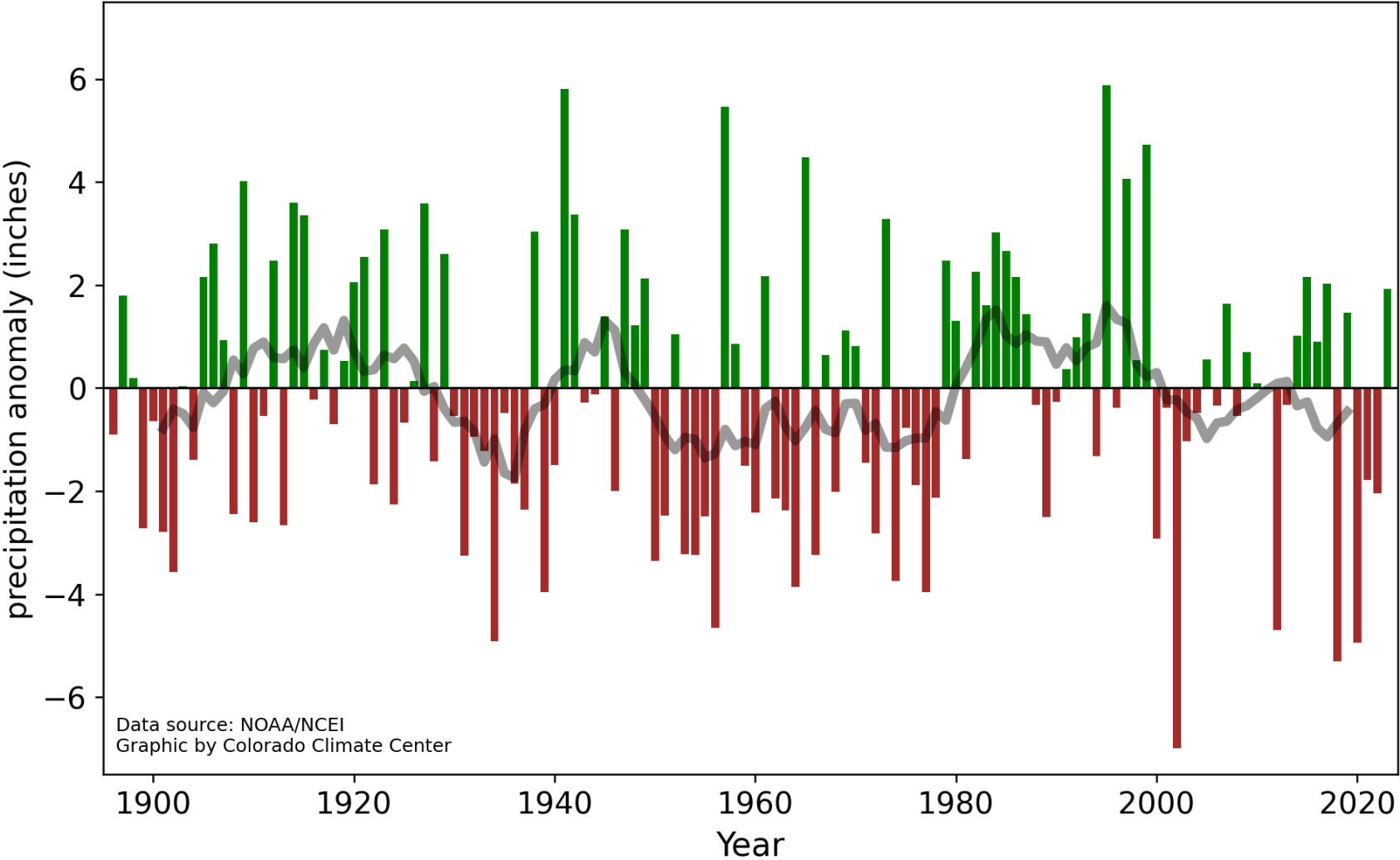
Record Warmest





# Precipitation – observed changes

Colorado statewide water year precipitation anomaly (inches), with respect to 1901-2000 average

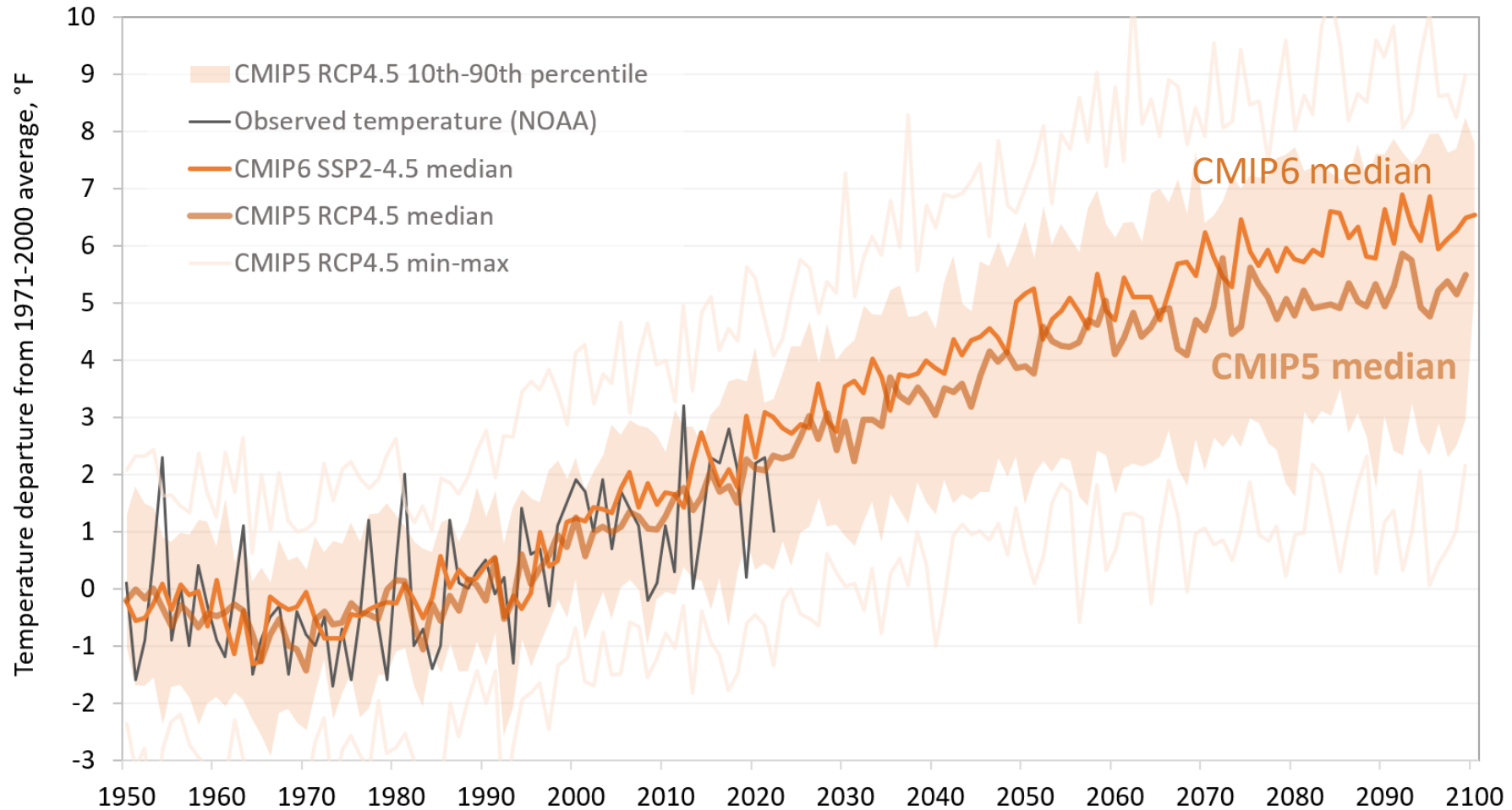


Data source: NOAA/NCEI  
Graphic by Colorado Climate Center

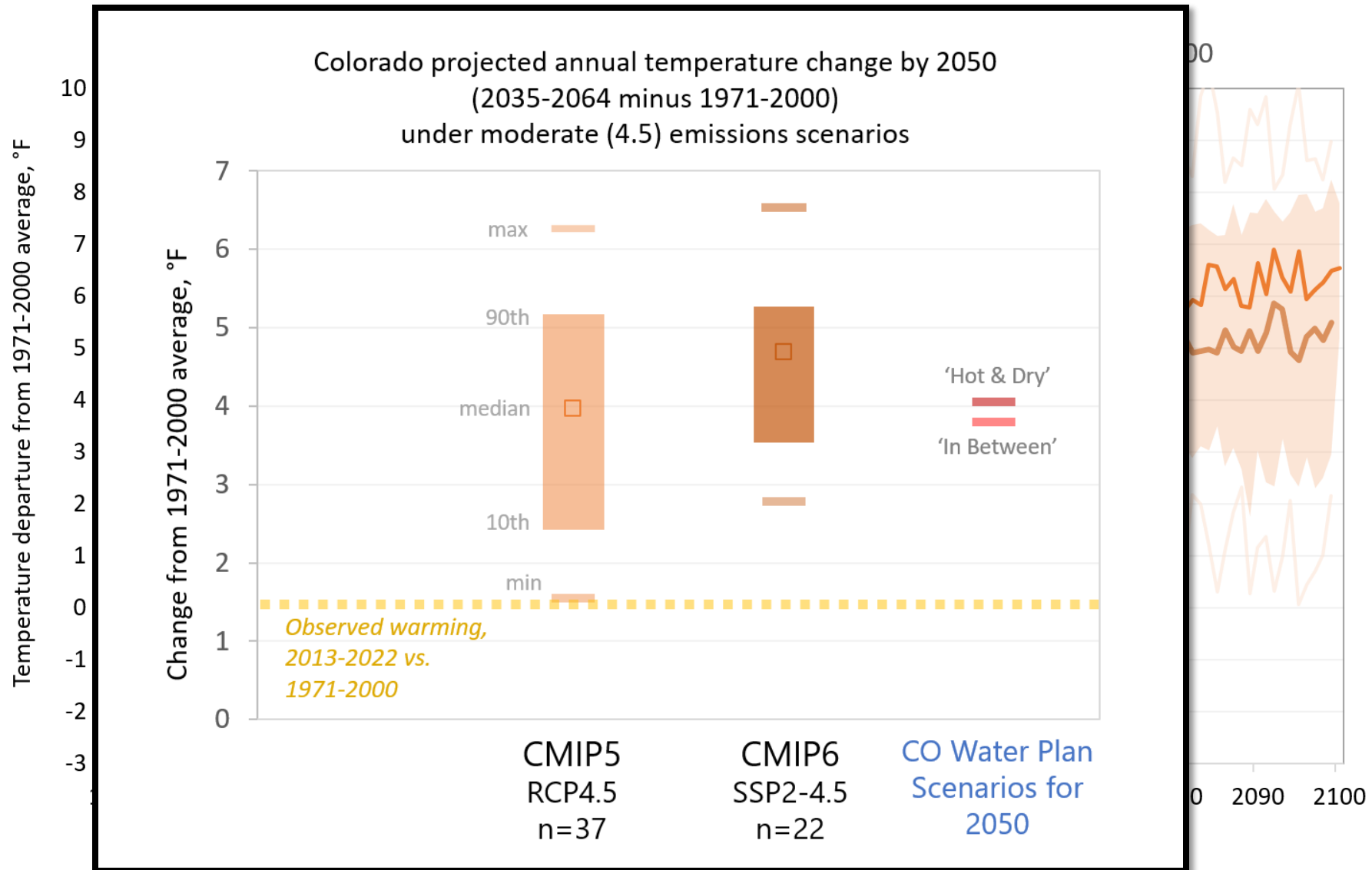


# Temperature – future projections under moderate future emissions scenario

Observed vs. projected Colorado statewide annual average temperature, 1950-2100

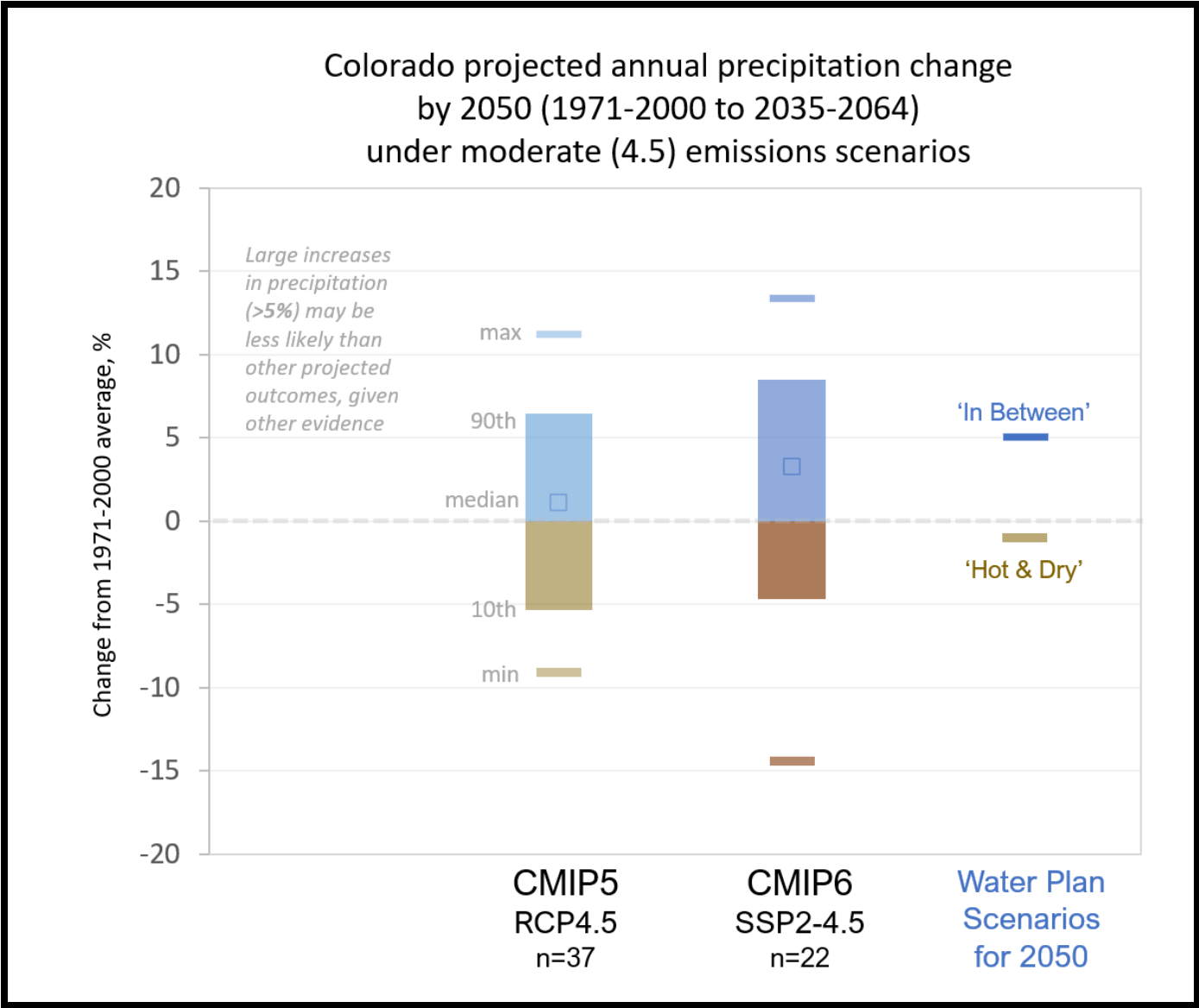


# Temperature – future projections





# Precipitation – future projections



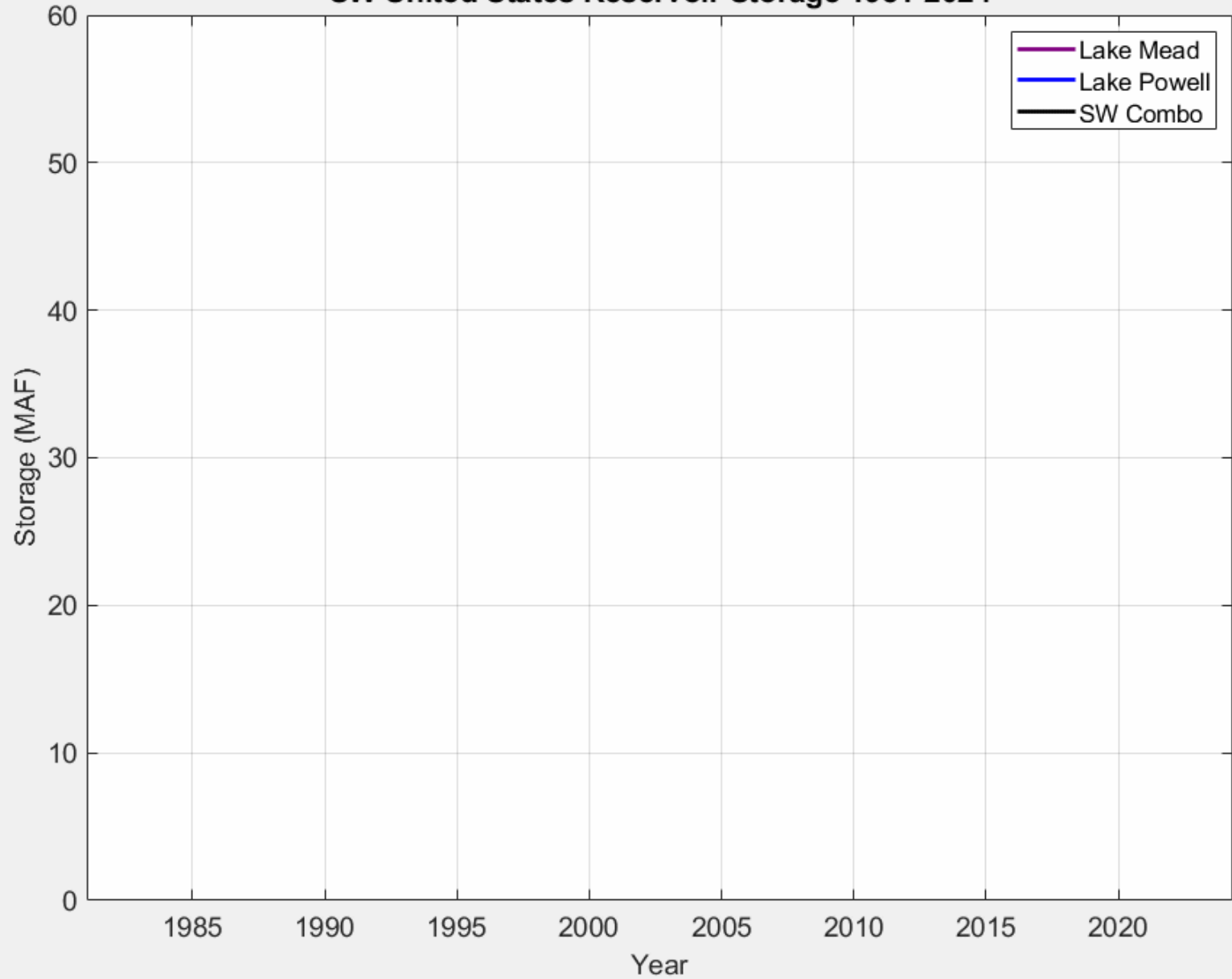
# Chapter 3 – Colorado's water

Climate variable/event	Recent trend	Projected future change	Confidence in change
Spring Snowpack	Lower	Lower	<i>Medium</i>
Runoff timing	Earlier	Earlier	<b>High</b>
Annual Streamflow	Lower	Lower	<i>Medium</i>
Evaporative demand	Higher	Higher	<b>Very high</b>
Summer soil moisture	Lower	Lower	<b>High</b>

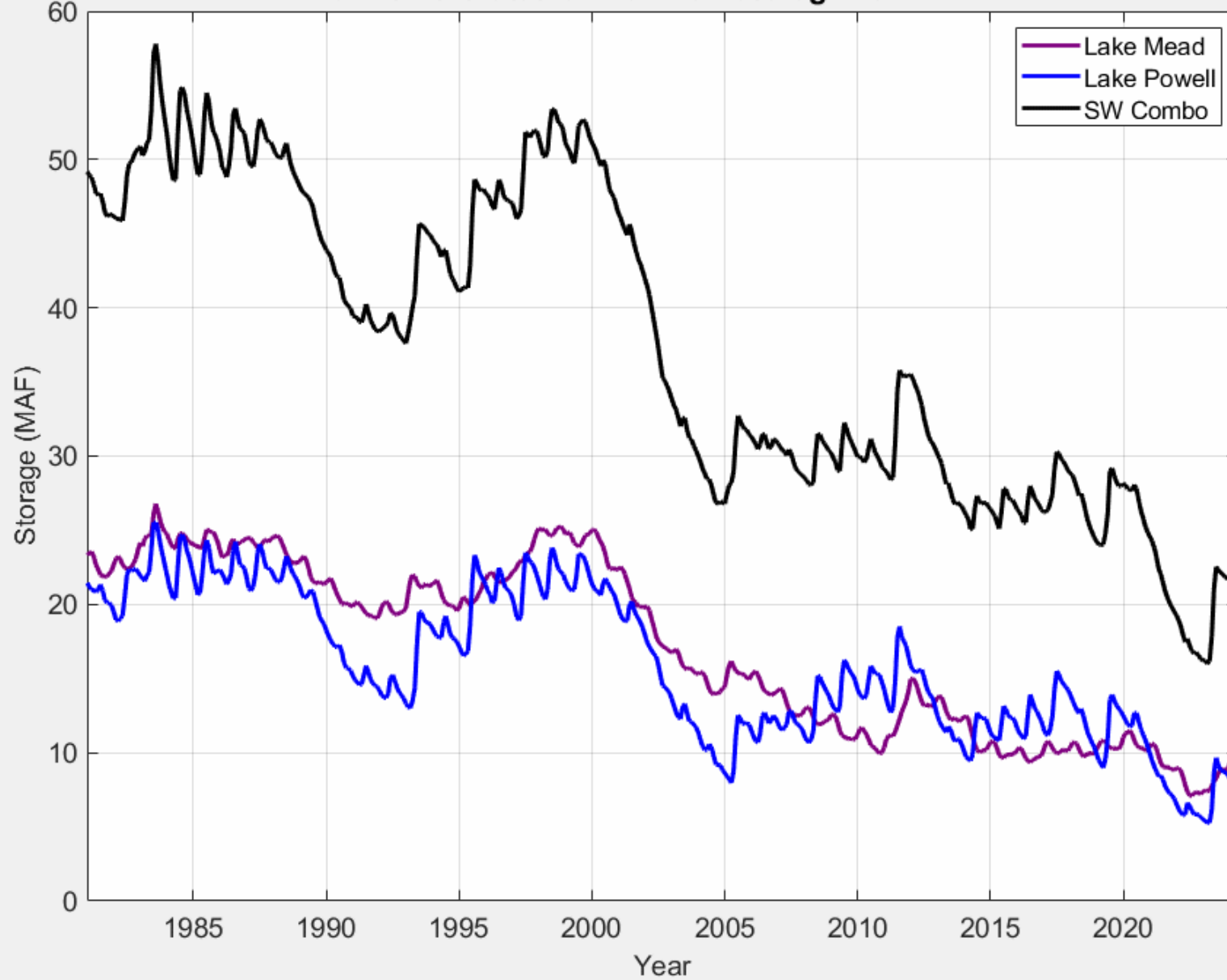




SW United States Reservoir Storage 1981-2024

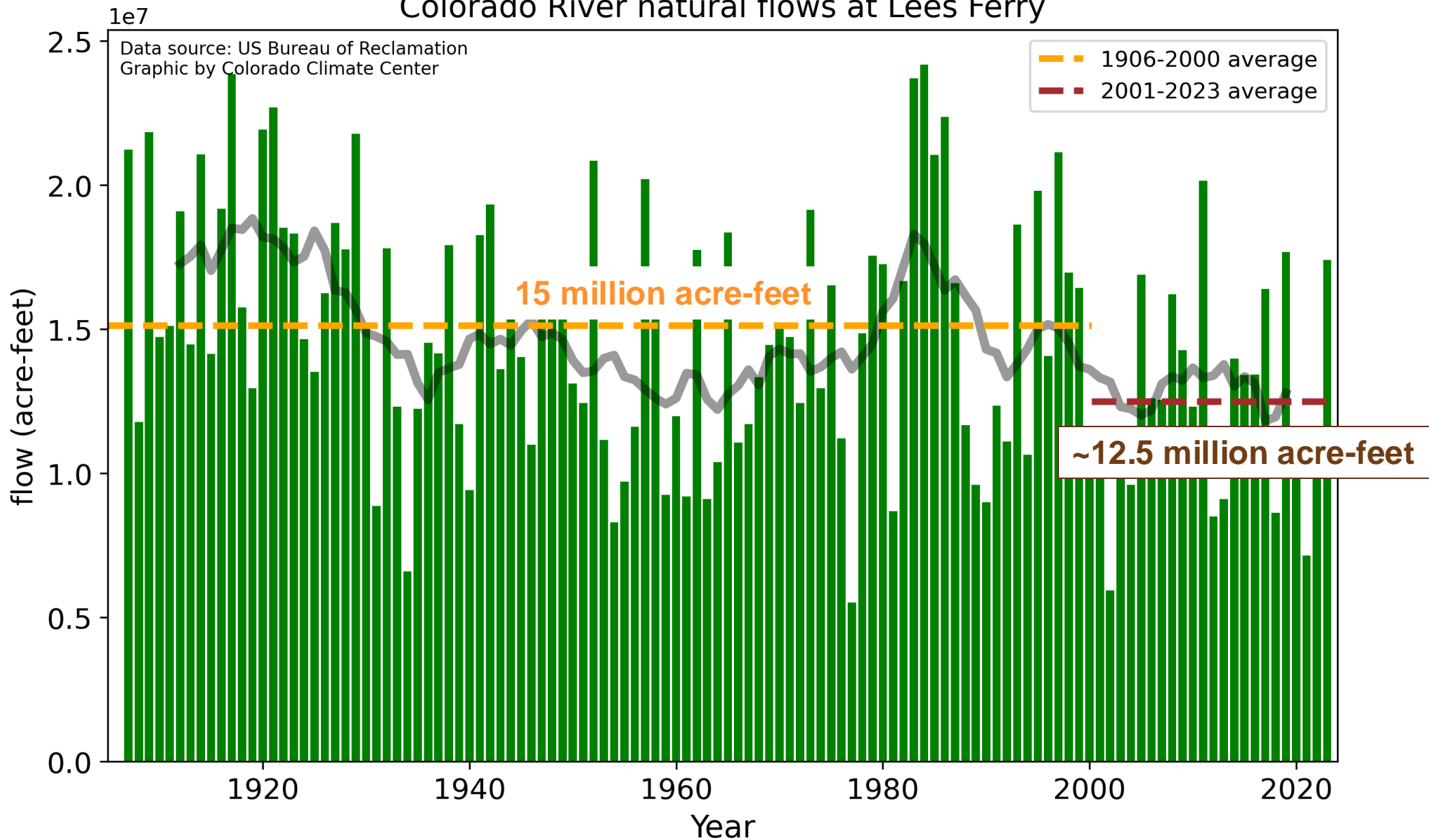


SW United States Reservoir Storage 1981-2024





# Colorado River natural flows at Lees Ferry



# What is drought?

“As with rainbows, each person experiences their own drought.”  
– Kelly Redmond (2002, Bulletin of the American Meteorological Society)



<https://upload.wikimedia.org/wikipedia/commons/e/e1/Drought.jpg>



<https://drought.unl.edu/Images/DustBowl/DB6.png>



<https://twitter.com/bradudall/status/1445500703066103>



Courtesy of Henry Reges



# Types of Drought

To help with drought classification and monitoring, scientists have defined several types of drought:



## Meteorological Drought

When dry weather patterns dominate an area.



## Hydrological Drought

When low water supply becomes evident in the water system.



## Agricultural Drought

When crops become affected by drought.



## Socioeconomic Drought

When the supply and demand of various commodities is affected by drought.



## Ecological Drought

When natural ecosystems are affected by drought.

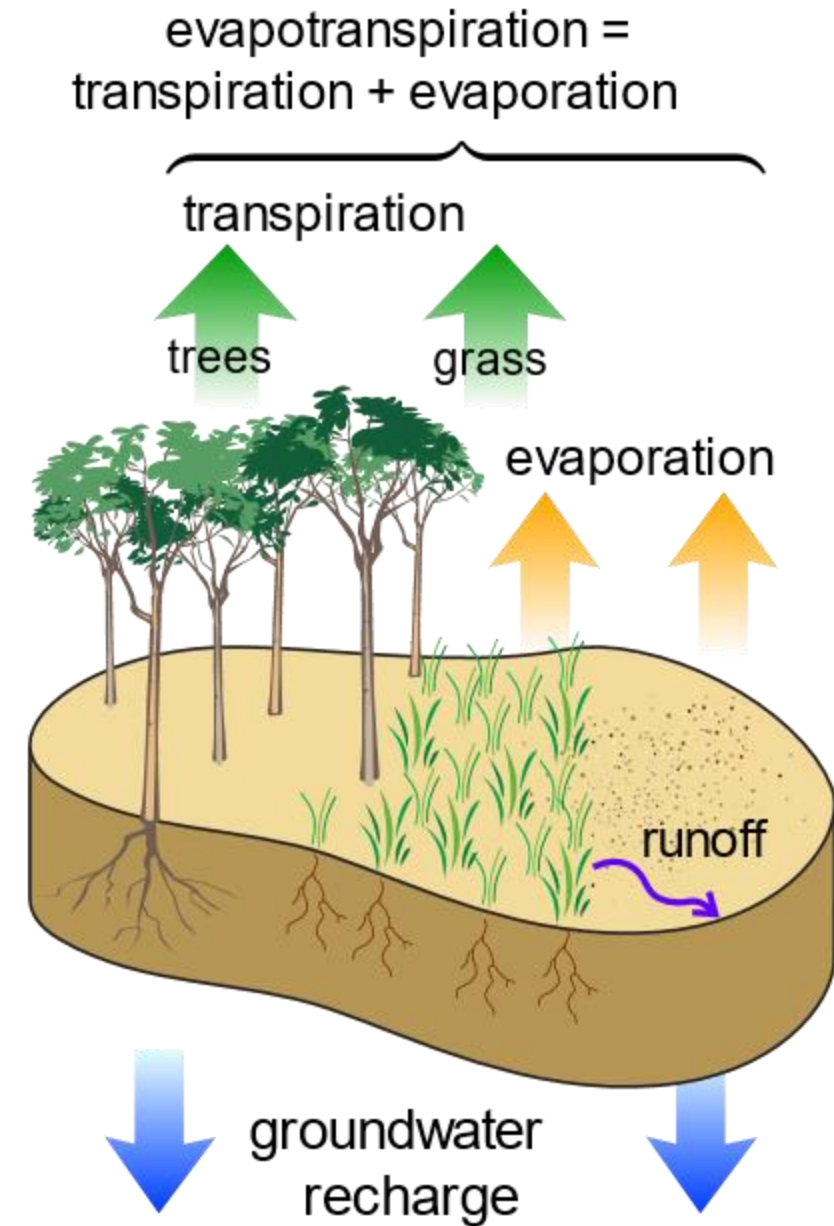
<https://www.drought.gov/what-is-drought/drought-basics>





Warmer, windier, less humid air is “thirstier” for water from soils, crops, forests, etc.

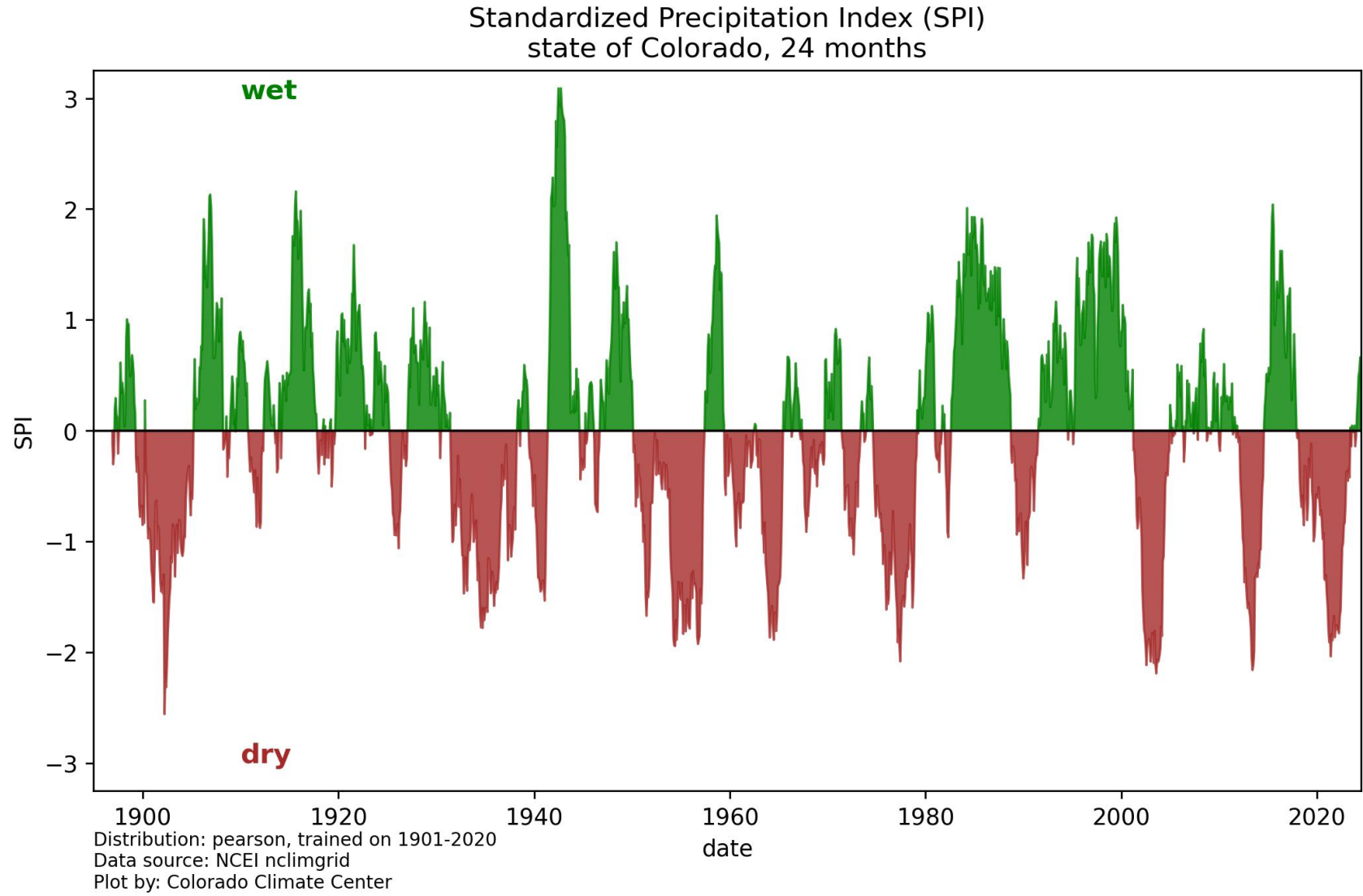
Known as “evaporative demand”



By M. W. Toews - Own work, CC BY 4.0,

<https://commons.wikimedia.org/w/index.php?curid=2843655>

# Wet and dry periods come and go, and droughts have always been a part of our climate...



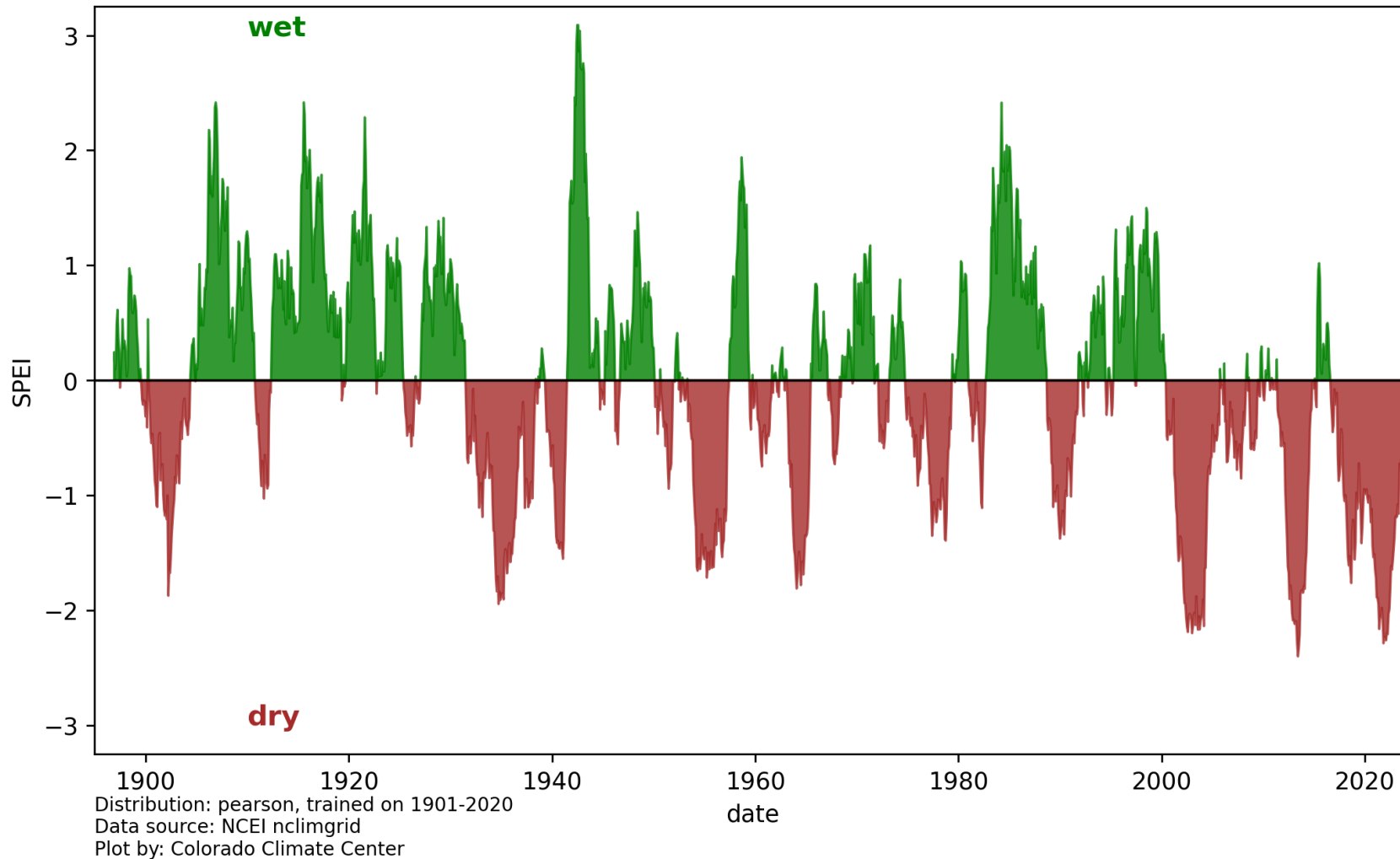
Considers  
precip only

Standardized precipitation index (24 months, Colorado statewide)



# ...but a warmer atmosphere is “thirstier”, making droughts more intense and more likely

Standardized Precipitation-Evapotranspiration Index (SPEI)  
state of Colorado, 24 months



Considers  
precip +  
temperature

Standardized precipitation-evapotranspiration index (24 months, Colorado statewide)

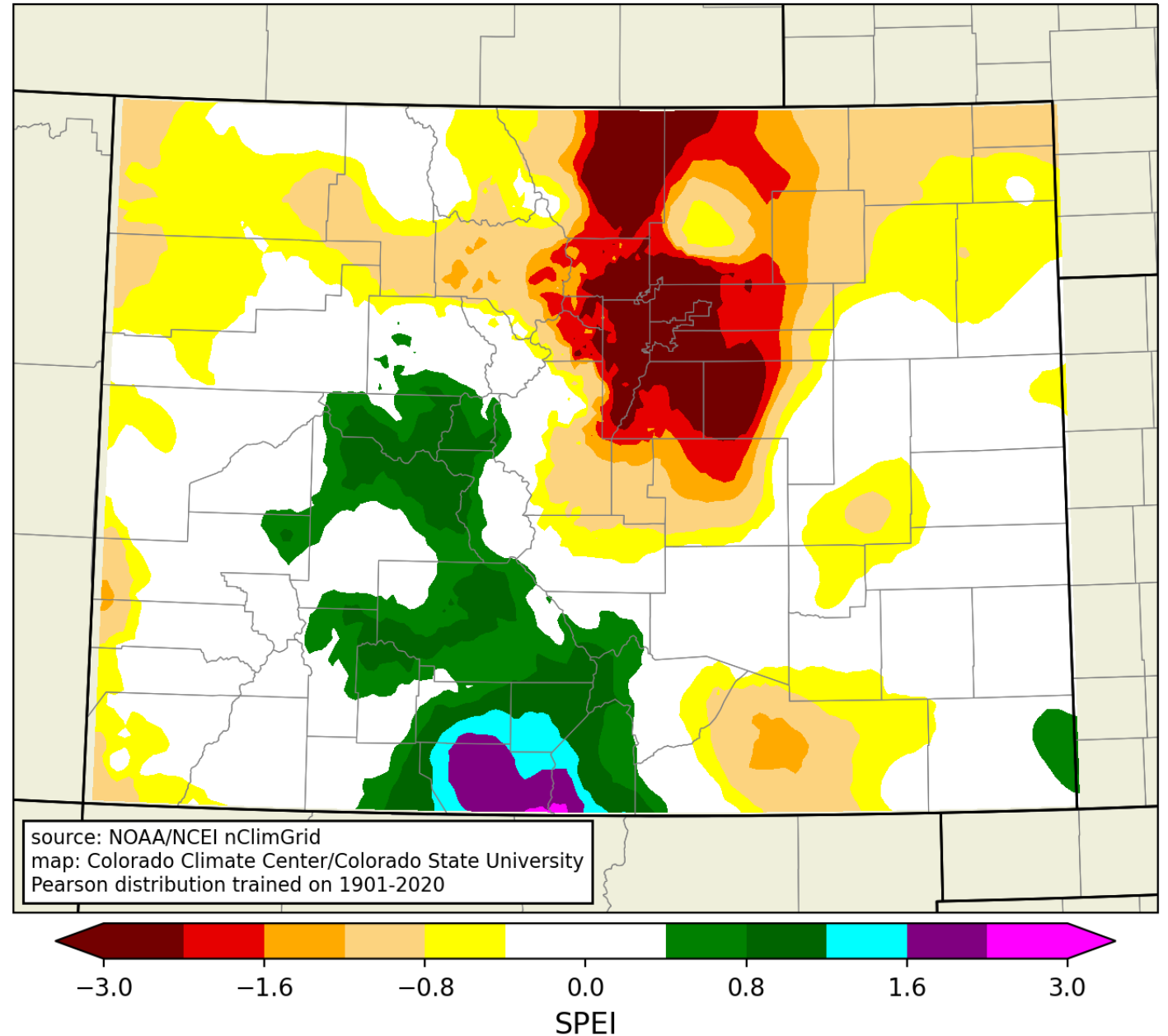




# Last 3 months

Standardized precipitation-  
evapotranspiration index  
(SPEI)

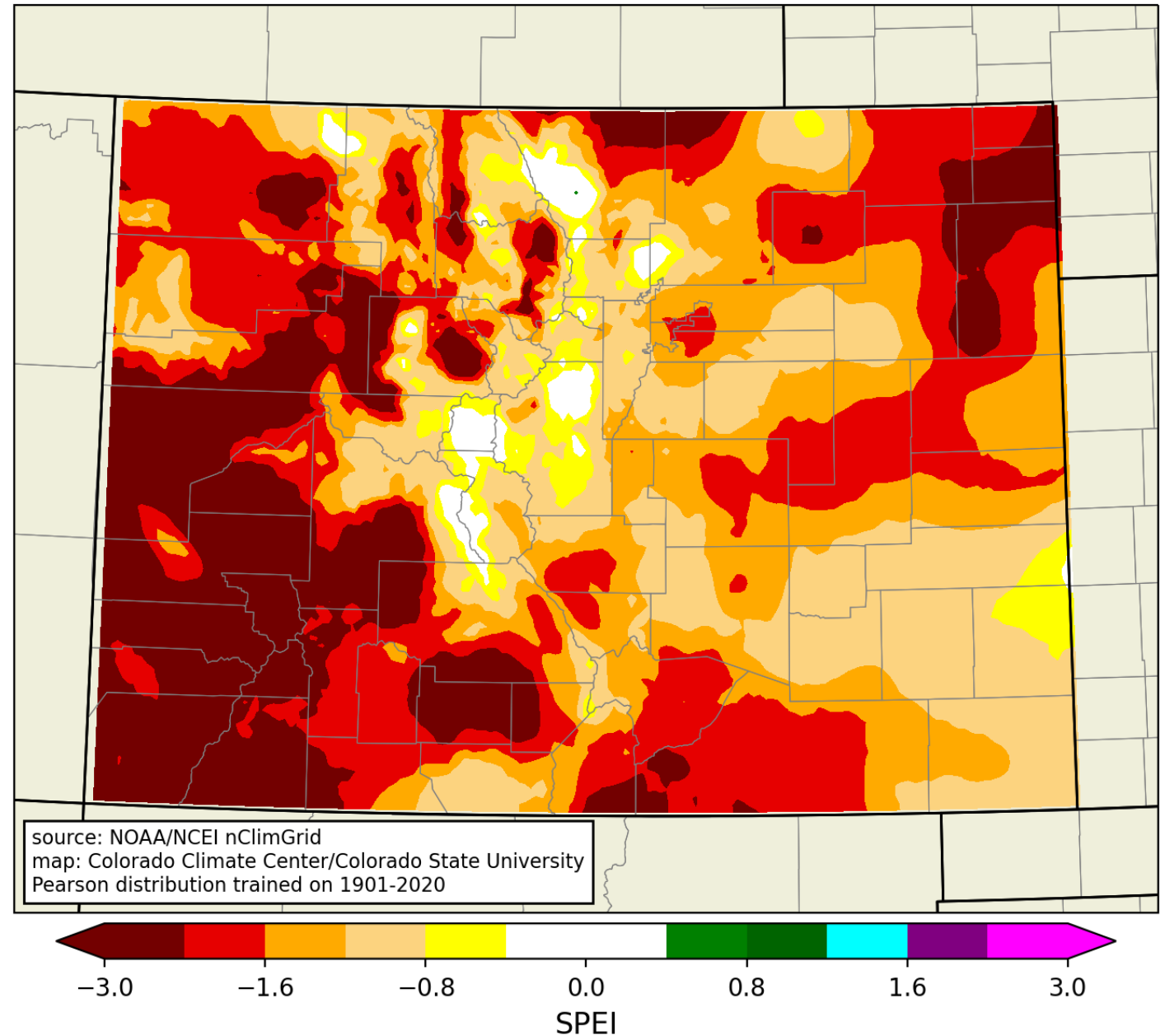
Includes effects of both  
precipitation and  
temperature



# Last 5 years

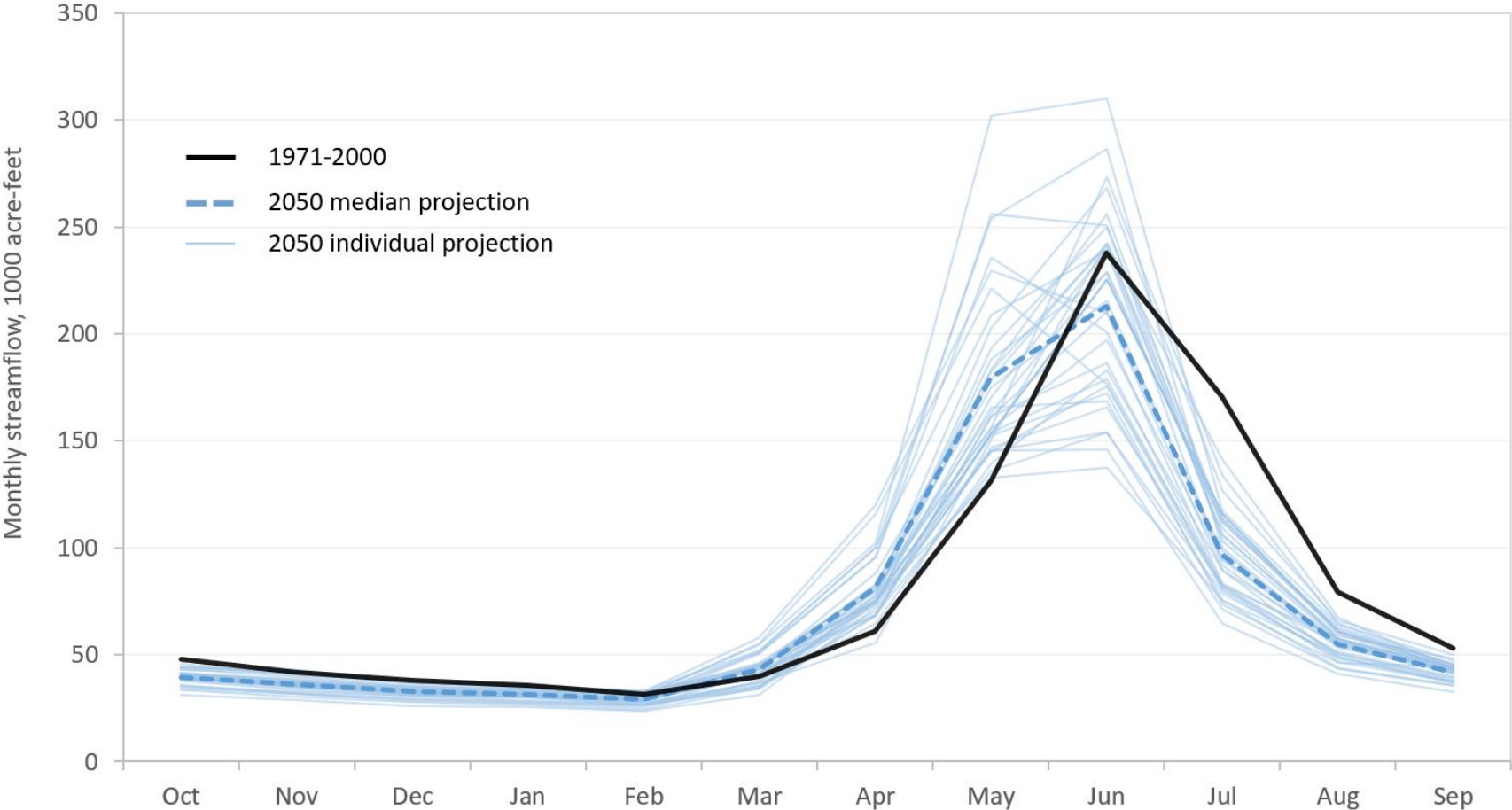
Standardized precipitation-  
evapotranspiration index  
(SPEI)

Includes effects of both  
precipitation and  
temperature



# Streamflow – future projections

Colorado R. near Dotsero, Projected monthly streamflow, 1971-2000 vs. 2050 (2035-2064)  
CMIP5-LOCA-VIC under moderate emissions scenario





# Chapter 4 – Hazards and Extremes

Climate variable/event	Recent trend	Projected future change	Confidence in change
Heat waves	More frequent/intense	More frequent/intense	<b>Very high</b>
Cold waves	Fewer	Fewer	<b>High</b>
Droughts	More frequent/intense	More frequent/intense	<b>High</b>
Wildfire threat	Higher	Higher	<b>High</b>
Extreme precipitation	Higher?	More frequent/intense	<i>Medium</i>
Flooding risk	Mixed	Higher	<i>Medium</i>
Windstorms	Uncertain	Uncertain	<i>Low</i>
Summer storms	Uncertain	More frequent?	<i>Low</i>
Winter storms	Uncertain	Larger storms?	<i>Low</i>
Dust on snow events	Higher dust levels	Higher dust levels	<i>Medium</i>



# Climate Change in Colorado takeaways, Part I

- Observations in past decade have only affirmed the long-term trends as described in the 2014 Report:
  - **More warming everywhere, in all seasons**
  - Precipitation trends less clear, but early 21st century drier than late 20th
- The observed warming alone is already imposing reductions on snowpack, soil moisture, and streamflows
- Some climate extremes and hazards have already become more frequent/intense due to warming: *Heat waves, drought, wildfires*



# Climate Change in Colorado takeaways, Part II

- Latest climate and hydrologic modeling affirms the likely climate *futures* laid out in the 2014 Report:
  - **Yet more warming; total of +2.5°F to +5.5°F by 2050**
    - Or +1°F to +4°F from now to 2050
  - Future precipitation change less certain
  - Snow, soil moisture, streamflow very likely to decline further
- *Heat waves, droughts, and wildfire* will worsen with the additional warming
- *Heavy/extreme precipitation and flooding* likely to worsen as well
- These findings assume a future emissions trajectory roughly in line with current policies – but other trajectories are also possible!

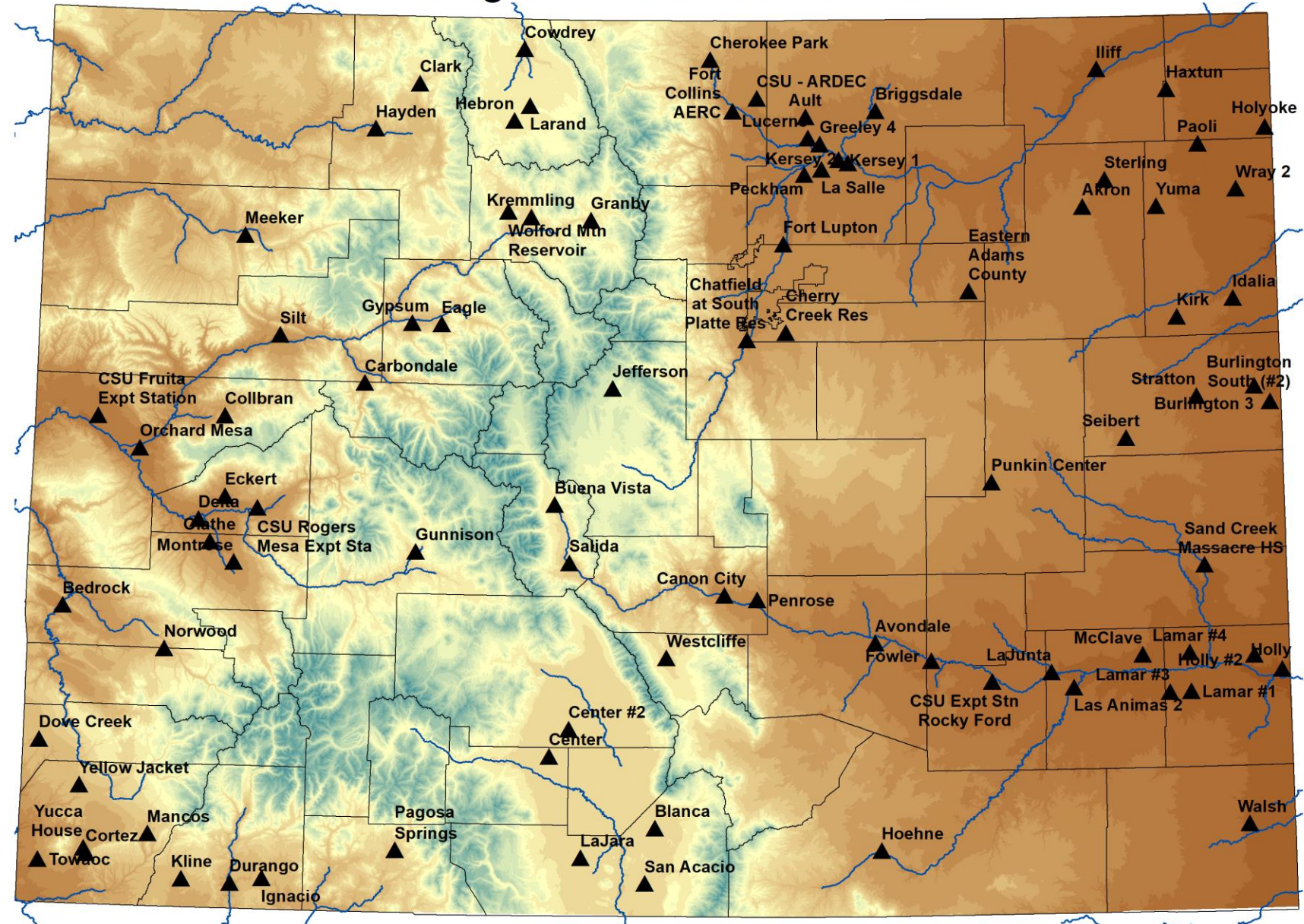




# Colorado Agricultural Meteorological Network (CoAgMET), aka “Colorado’s Mesonet”

Funding sources:  
National Mesonet  
Program, CWCB,  
station sponsors,  
Reclamation, Northern  
Water

## CoAgMET Station Locations





# About the stations

**Anemometer and wind vane: Wind speed, direction and gusts**

2 m

Above all else facing South

**Pyranometer: Solar radiation**

**Temperature/Humidity sensor in radiation shield**

2 m

**Tipping bucket rain gage**

1-3 m

**Solar panel powers the station when the sun shines**

**Data logger**

**Soil temperatures**

**2 and 6 inches below ground**



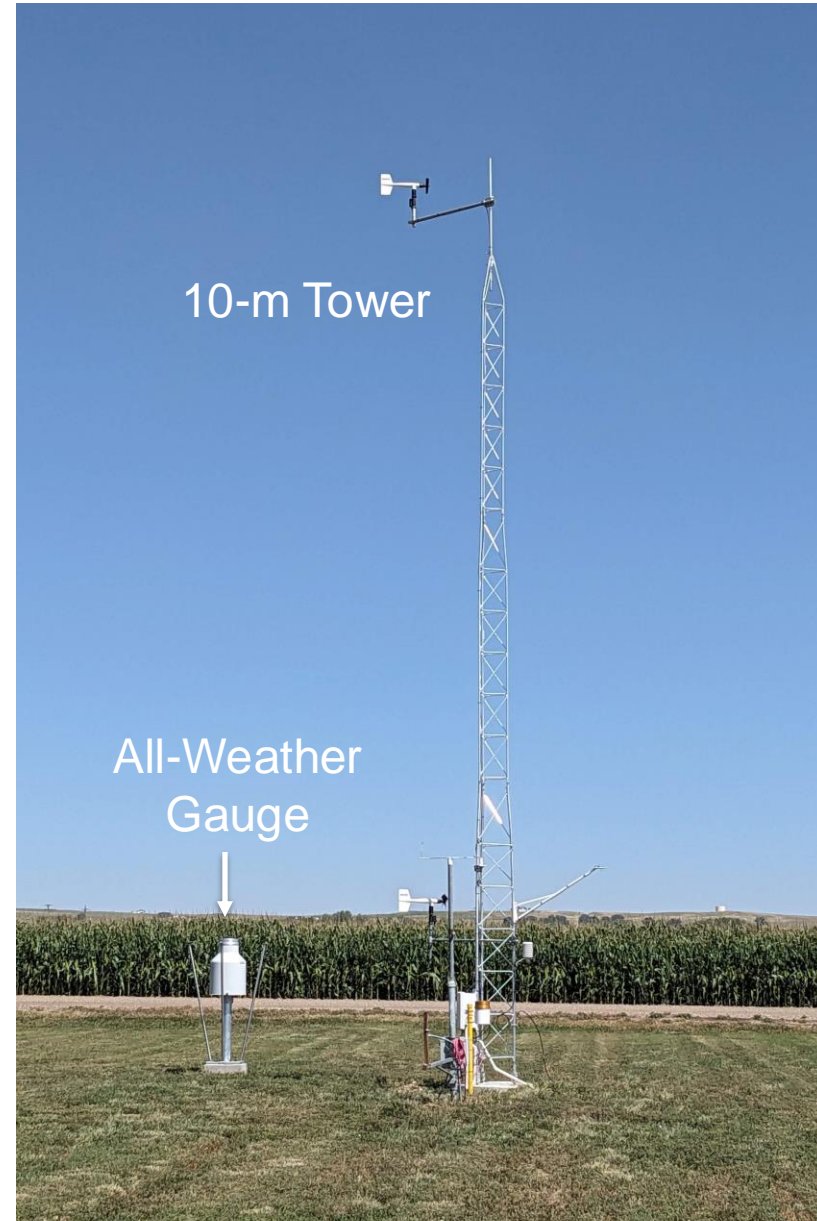
# 10-m towers supported by Colorado Water Conservation Board

## 10-meter Towers

To be consistent with meteorological standards.



RFD01- CSU AVRC, Rocky Ford



10-m Tower

All-Weather  
Gauge

FTC03 – CSU ARDEC, Northeast of Fort Collins



# New website, just released!



## Before:

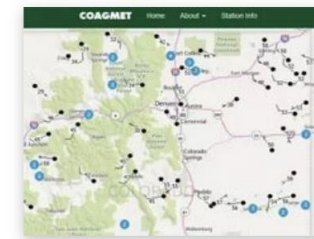
### CoAgMET Homepage

At CoAgMET, we operate a network of agricultural weather stations around the state of Colorado. The data from these stations lets us calculate **Evapotranspiration (ET)** values to model water use for various crops.

### Services

- **Station Data Selector**  
Select a station and view graphs, data tables or climatology for the selected dates and frequency (daily/hourly/5 minute).
- **Crop Water Use (ET)**  
See crop and turf water use.
- **Latest ET Reports** or **Select the date and regions.**  
These are daily reports of water use for various crops.
- **Data API** **new!** **beta**  
Download data in JSON or CSV format (and with no extra junk). You can read the **documentation** or use the **URL builder** to interactively create your request.
- **Maps**  
**Surface conditions** (wind, temperature, dewpoint), precipitation (will return in April) and **gust speeds** at our stations around Colorado. These are the same maps as you see on the right.
- **Daily Summary**  
Daily overview of the whole network for **yesterday** or **select a date.**
- **Station Summary**  
An overview of station weather and ET data for a month.
- **Daily Data**  
A station's raw Weather and ET data for a month.
- **Monthly Data**  
View weather statistics by month for a given year.

### Mapping and metadata by eRAMS



### Surface conditions map




### Gust map



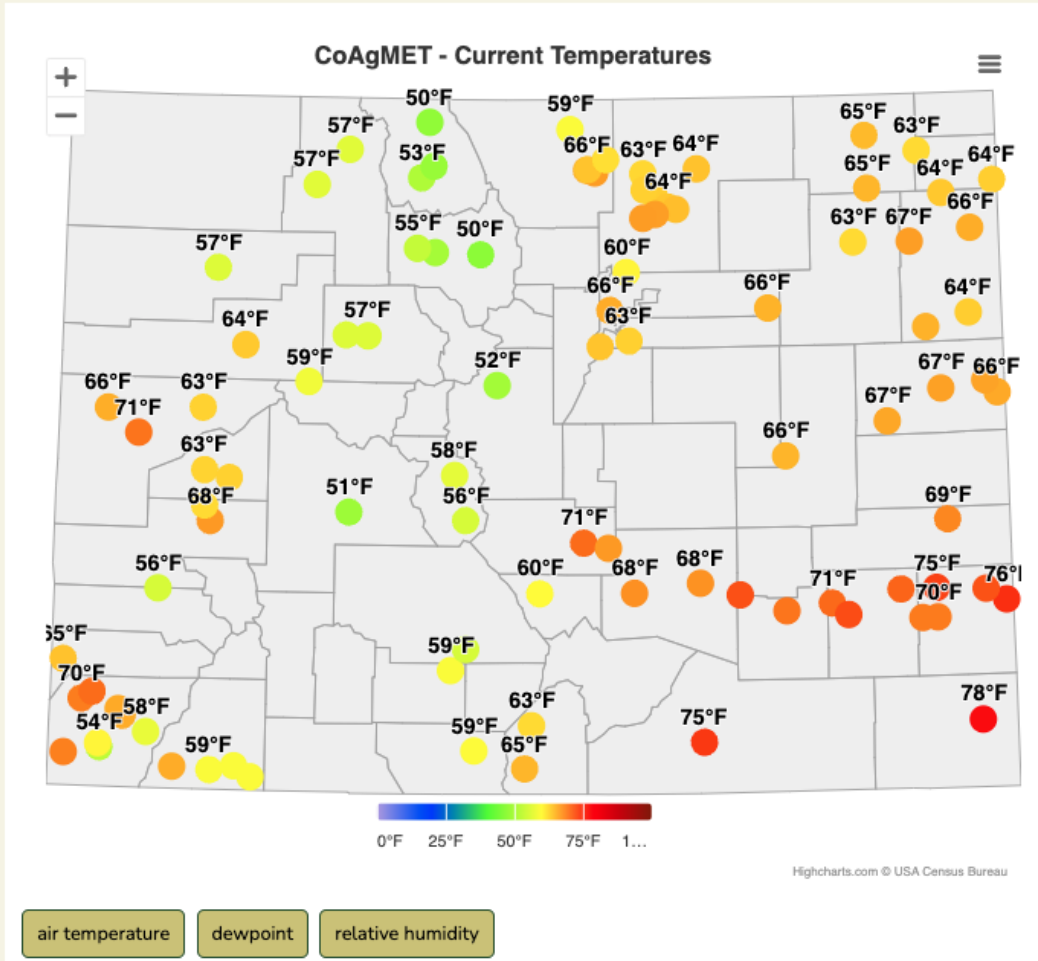
# New website, just released!

[coagmet.colostate.edu](http://coagmet.colostate.edu)

 **COLORADO STATE UNIVERSITY** | COLORADO CLIMATE CENTER | CoAgMET

Home CoAgMET About Daily Maps Ag Weather Conditions Data Access Graphs & Summaries

quick access: [yesterday's summary](#) [surface map](#) [station pages](#)



#### Fort Collins AERC

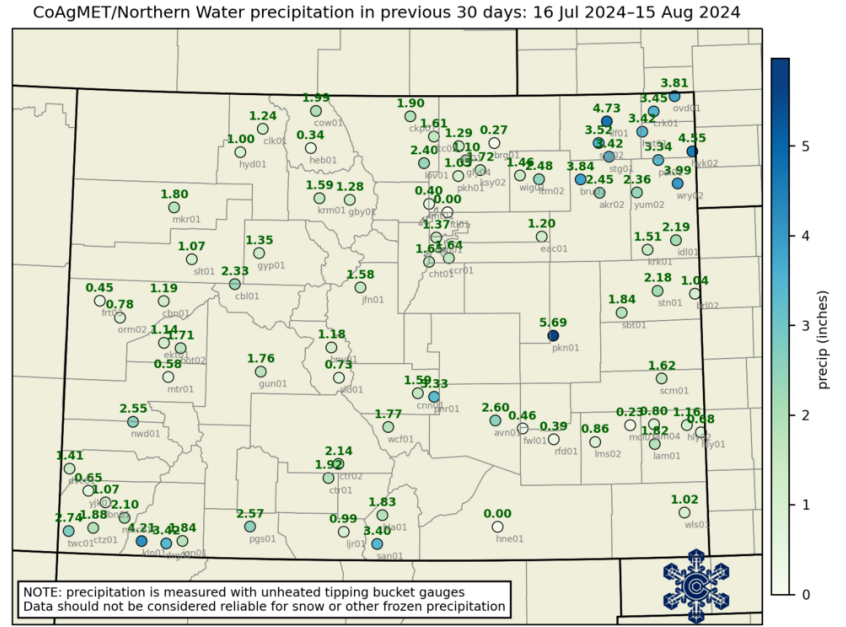
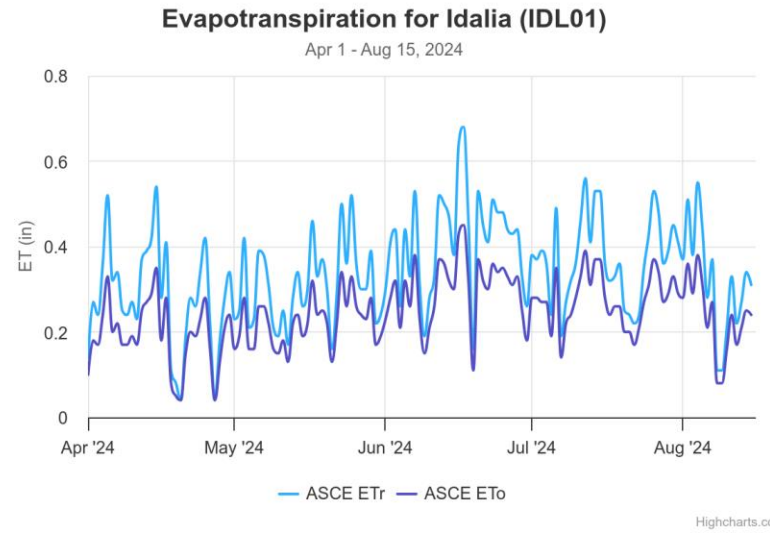
Fort Collins AERC

Observation Time:  
Aug 16, 2024 8:15AM MDT

Temp/Dewpt: 64.3°F / 55.7°F  
Rel. Humidity: 74%  
Winds: Calm

[go to the ftc01 station page](#)  
[view ftc01 weather graphs](#)

# After!





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# Thank you!

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