White River Update
Water Year 2023

report to the White River Alliance
January 2024
Bob Dorsett, MD

Image credit: Western Colorado Outdoors

Water year 2023 snapshot

- runoff above normal after big snowpack
- the water year ended dry
- algae
  - USGS report identified low flow, high temperature, and nutrients as primary drivers
  - algae bloomed briefly in July, then disappeared
    - ? related to Bailey Lake discharge
- climate outlook remains grim

Outline:

- Main factors influencing White River discharge
  - temperature
  - precipitation
    - snowpack
    - monsoon
  - soil conditions
    - evapotranspiration
- Overview of water year 2023
- Trends on the White River
- Climate projections

Recap of Colorado's water year 2023

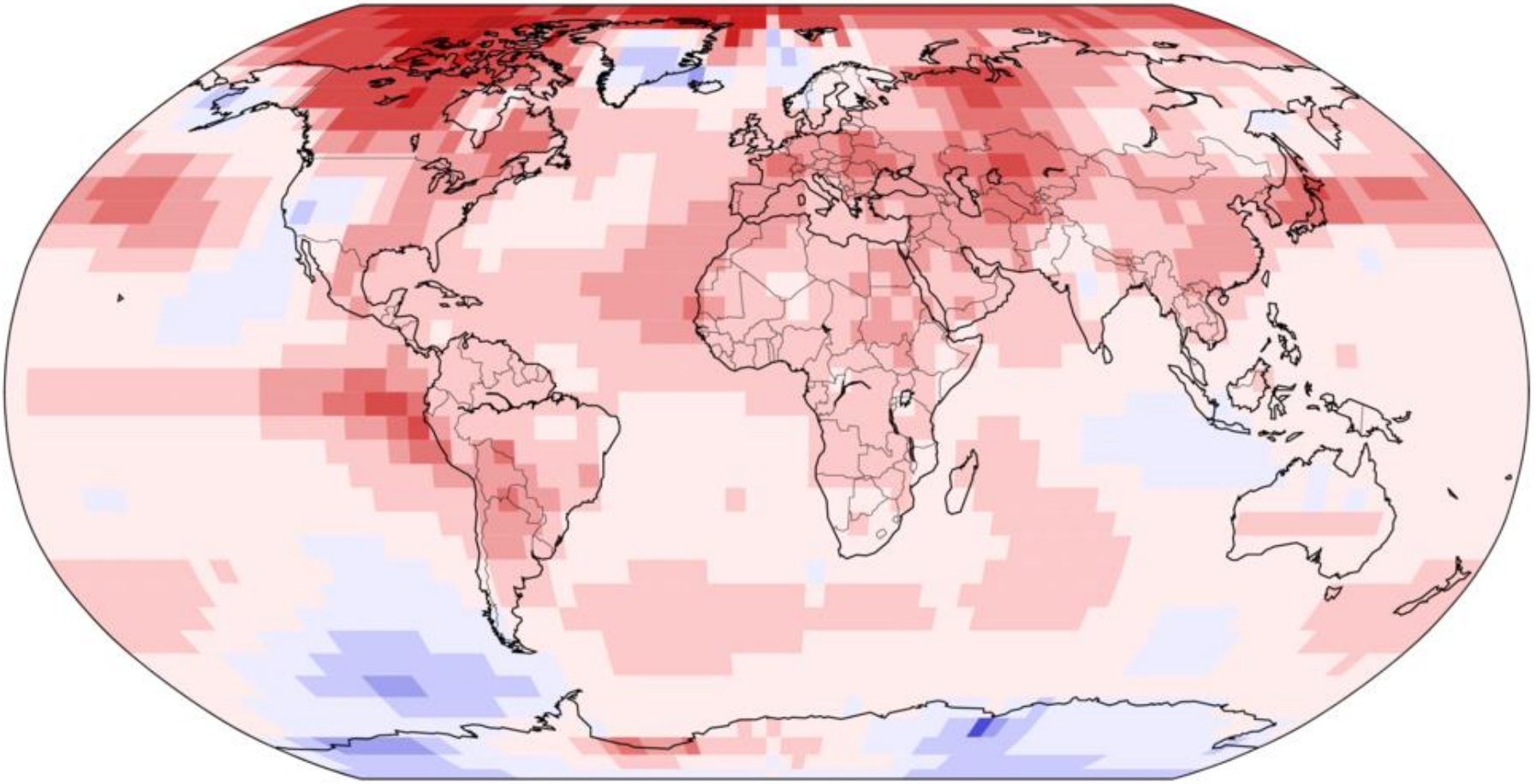
- Relatively cool overall (in contrast to nearly everywhere else on the planet)
- A very big year for snow in Colorado's mountains, especially toward the west side of the state
- Widespread heavy rain in eastern Colorado during May-August with an active severe weather season
- Streamflows were good, reservoirs recharged within Colorado – but not nearly enough water to solve the larger problems in the Colorado River system
- A poor monsoon season and warm temperatures in western Colorado dried out soils and surface conditions to begin water year 2024

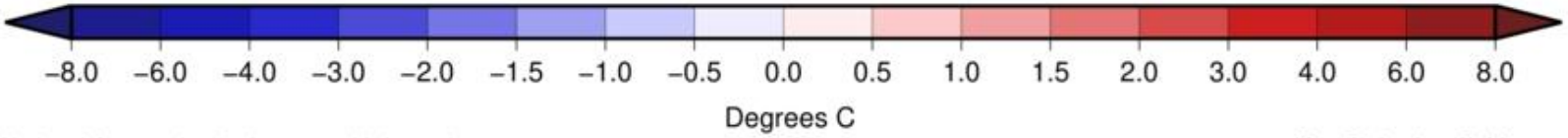
Schumacher, Russ et al. 2023. Water year 2023 in review. Colorado Climate Center.

Land & Ocean Temperature Departure from Average Jan–Dec 2023

(with respect to a 1991–2020 base period)

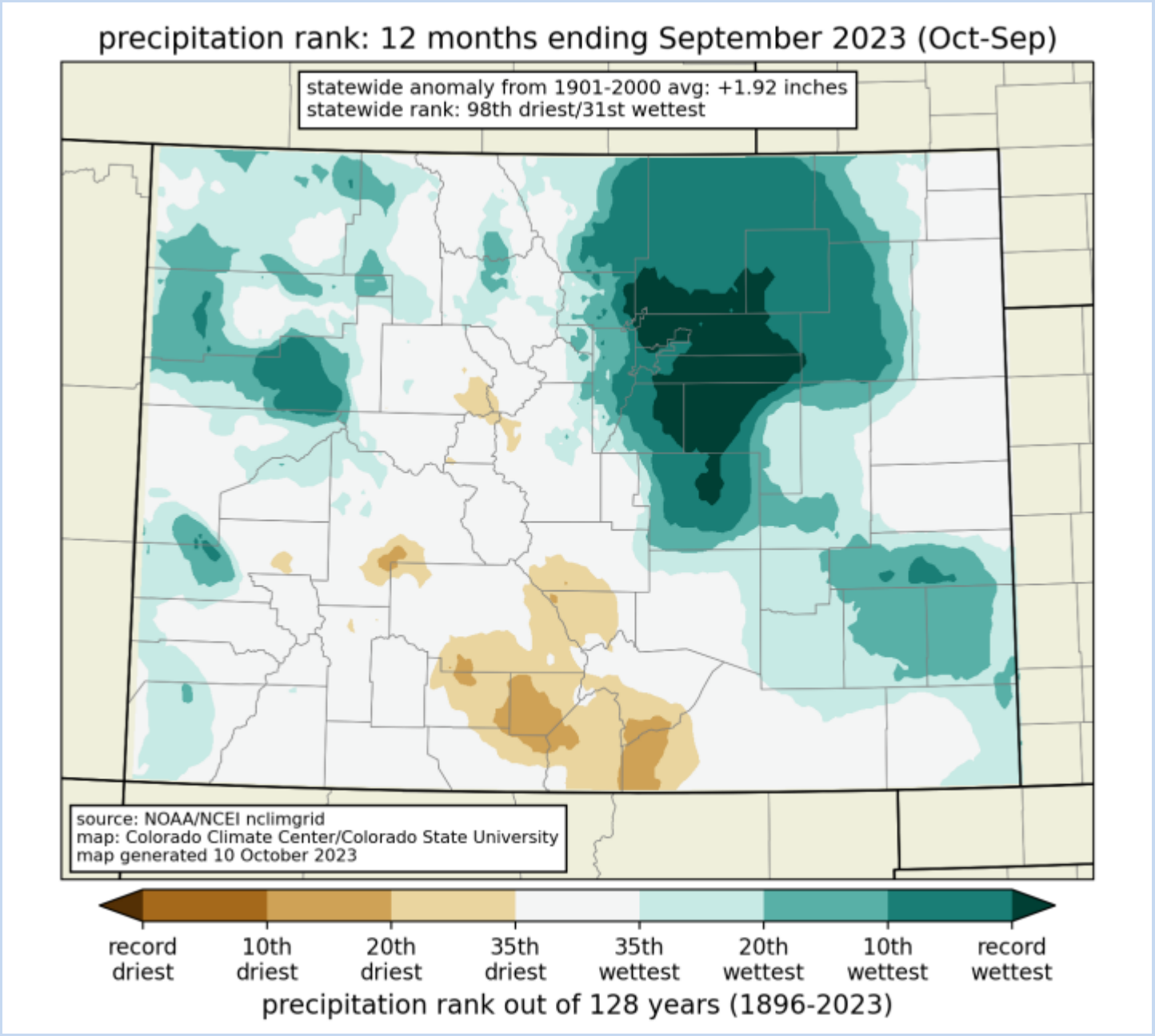
Data Source: NOAAGlobalTemp v5.1.0–20240108



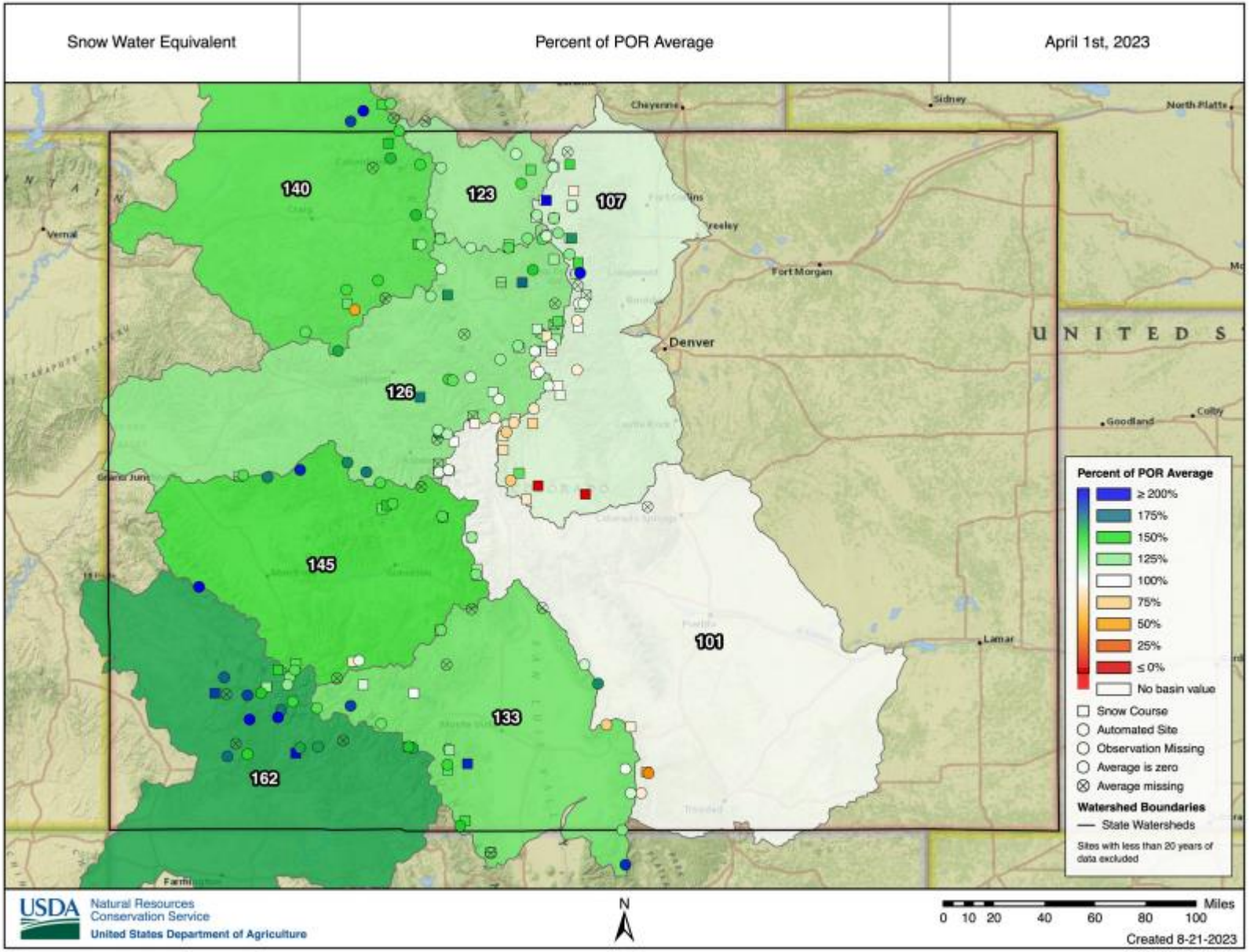


National Centers for Environmental Information

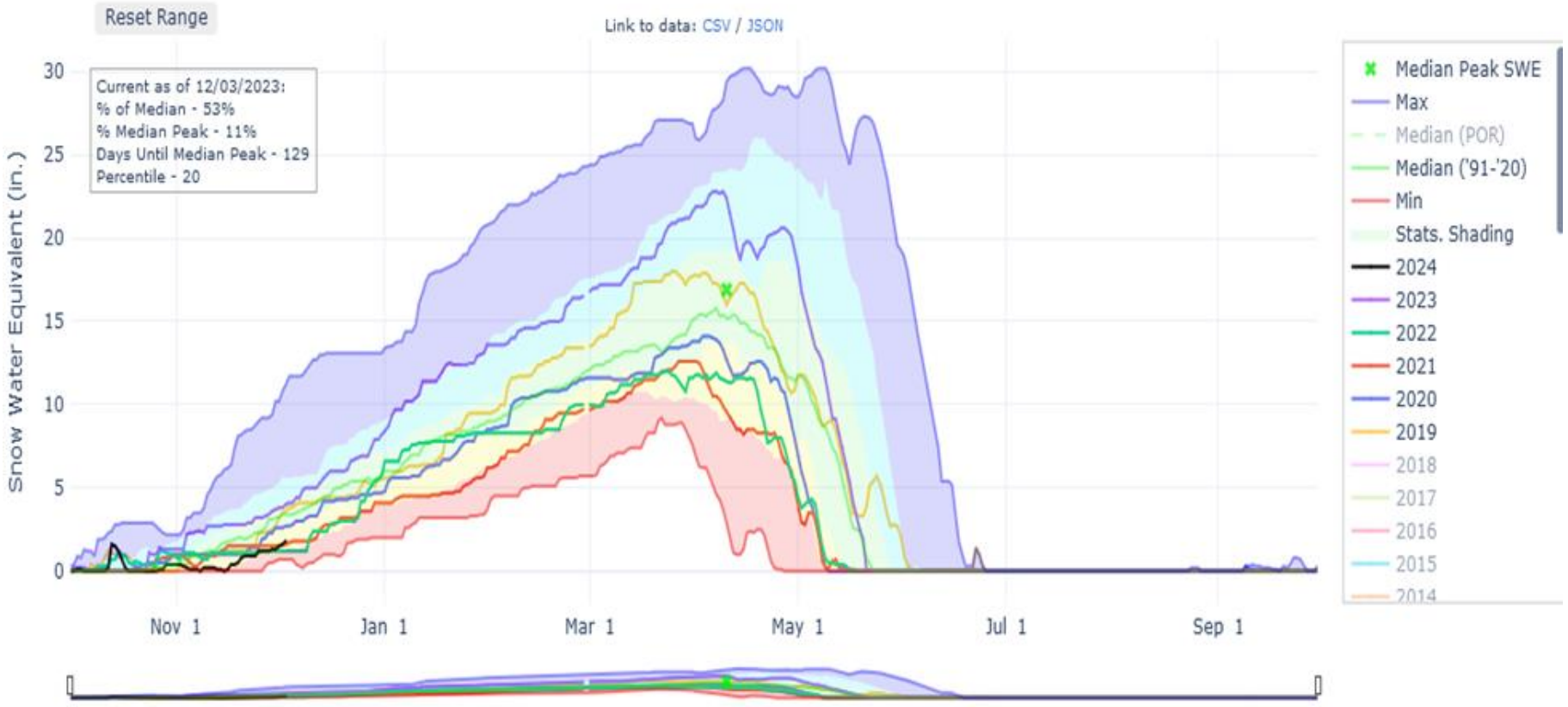
Map Projection: Robinson


precipitation rank: 12 months ending September 2023 (Oct-Sep)
statewide anomaly from 1901-2000 avg: +1.92 inches
statewide rank: 98th driest/31st wettest
source: NOAA/NCEI nclimgrid
map: Colorado Climate Center/Colorado State University
map generated 10 October 2023
record driest
10th driest
20th driest
35th driest
35th wettest
20th wettest
10th wettest
record wettest
precipitation rank out of 128 years (1896-2023)

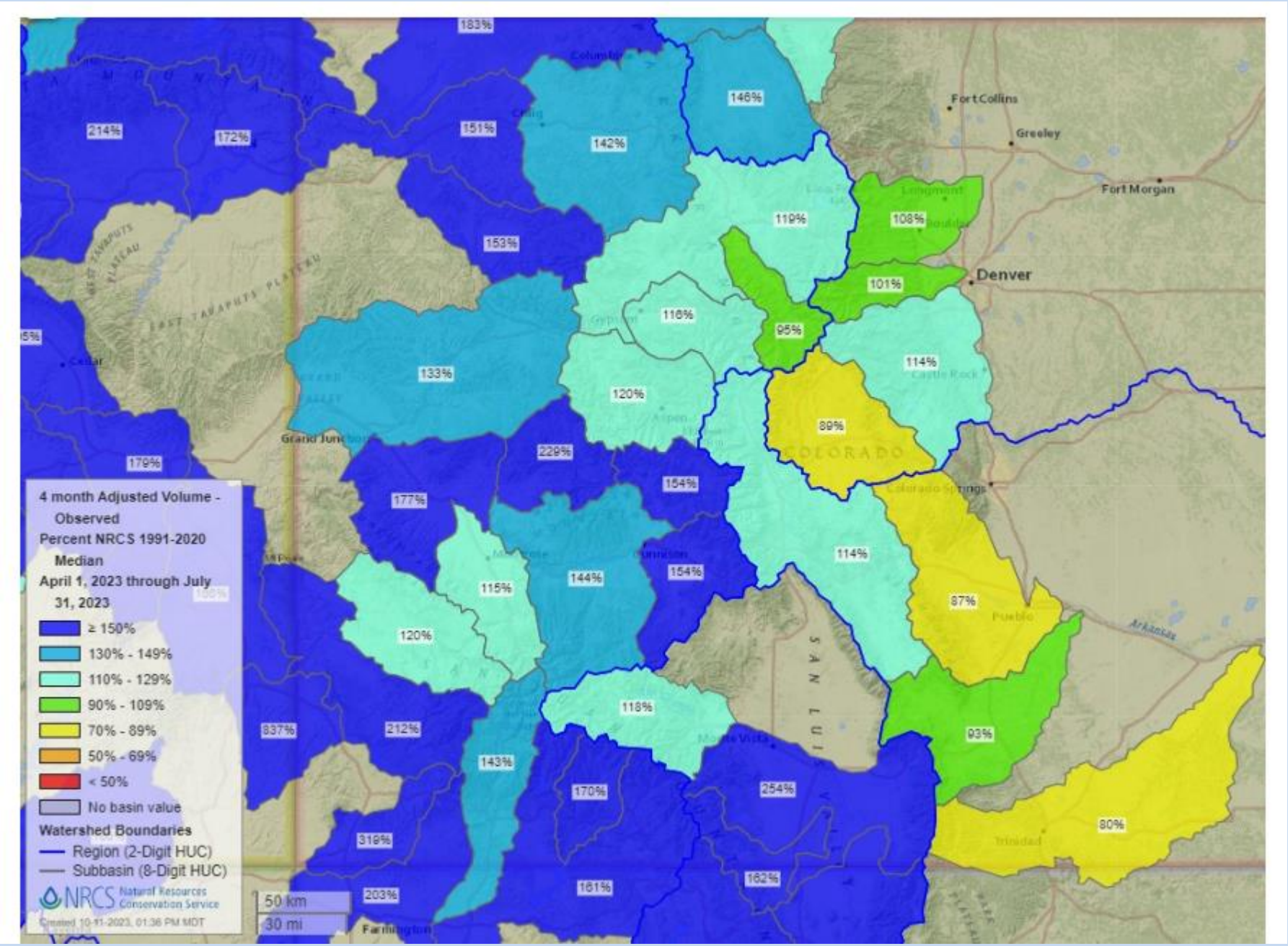
April 2023 snow water equivalent



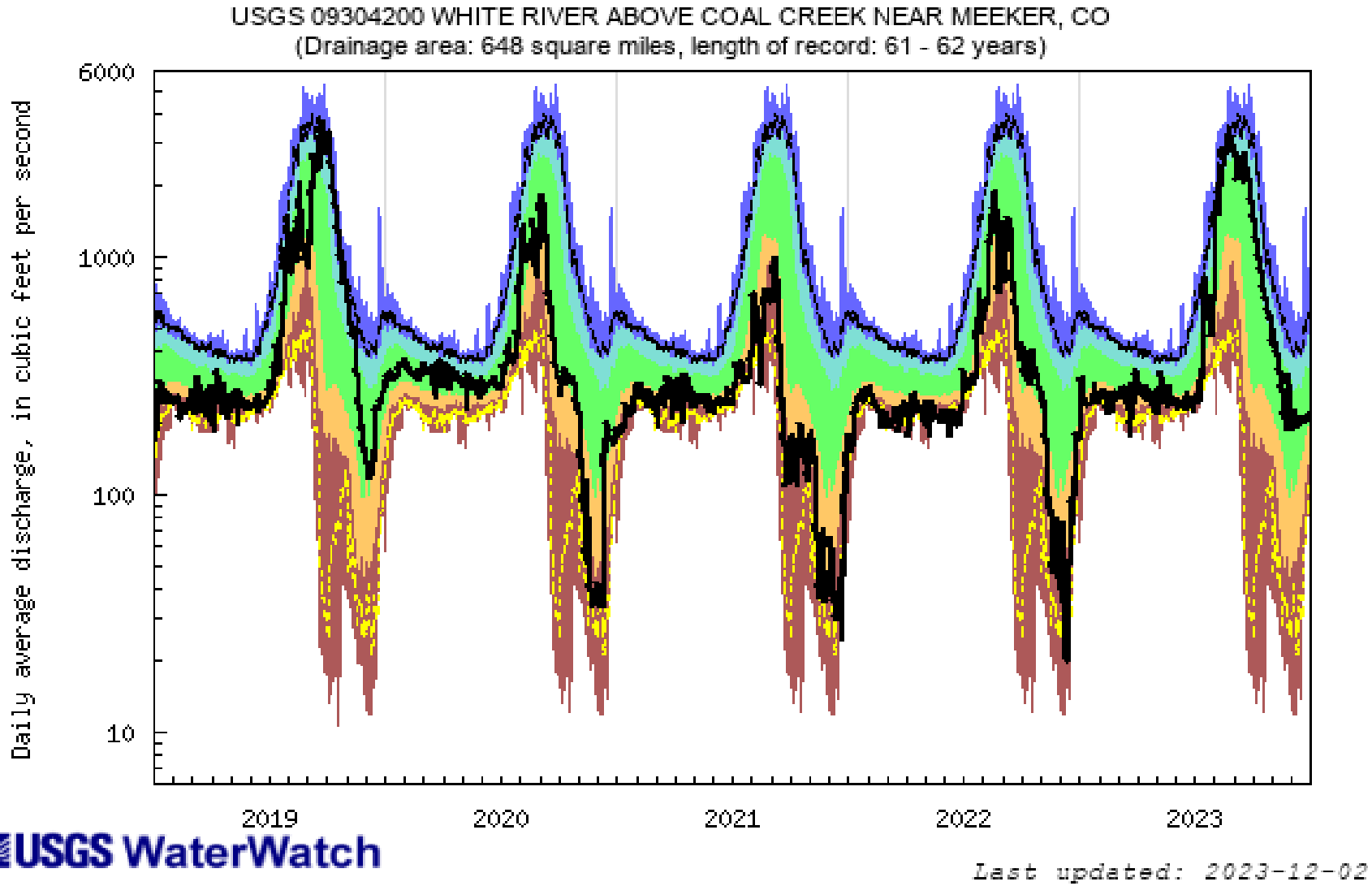
Variability in snowpack: Figure shows snow water equivalent at Burro Mtn. Snotel water years 2019-23.



April – July 2023 mean stream flow percent of 1991 – 2020 median

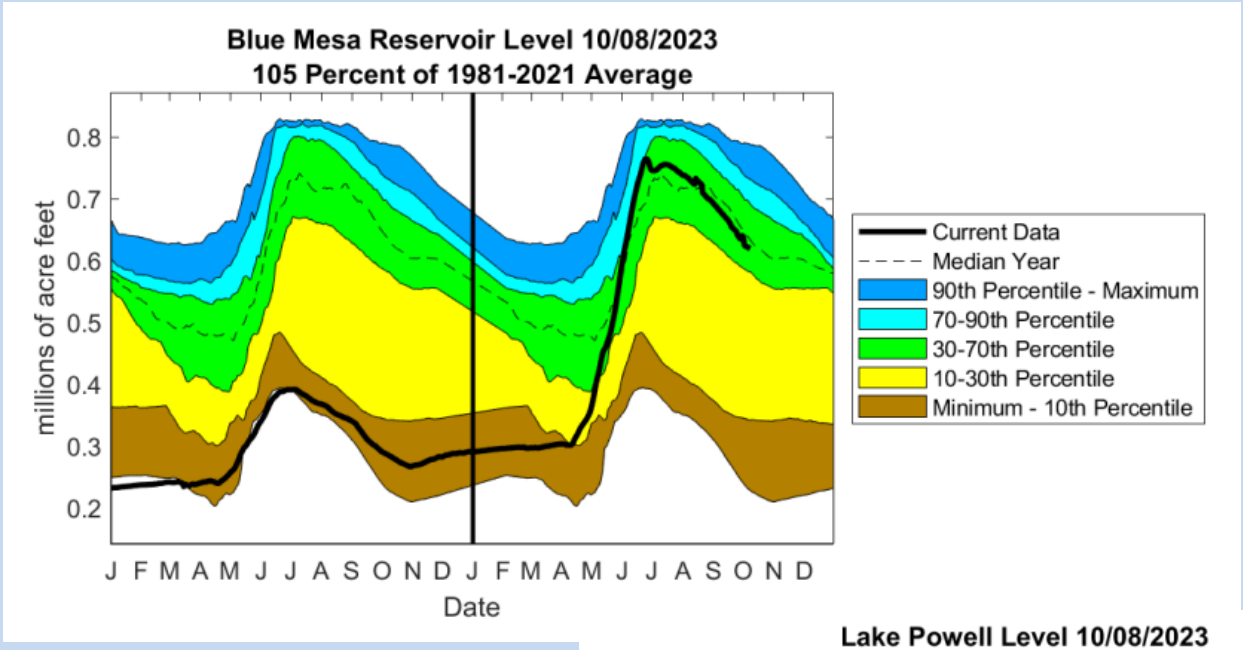


Daily flows reflect snowpack.

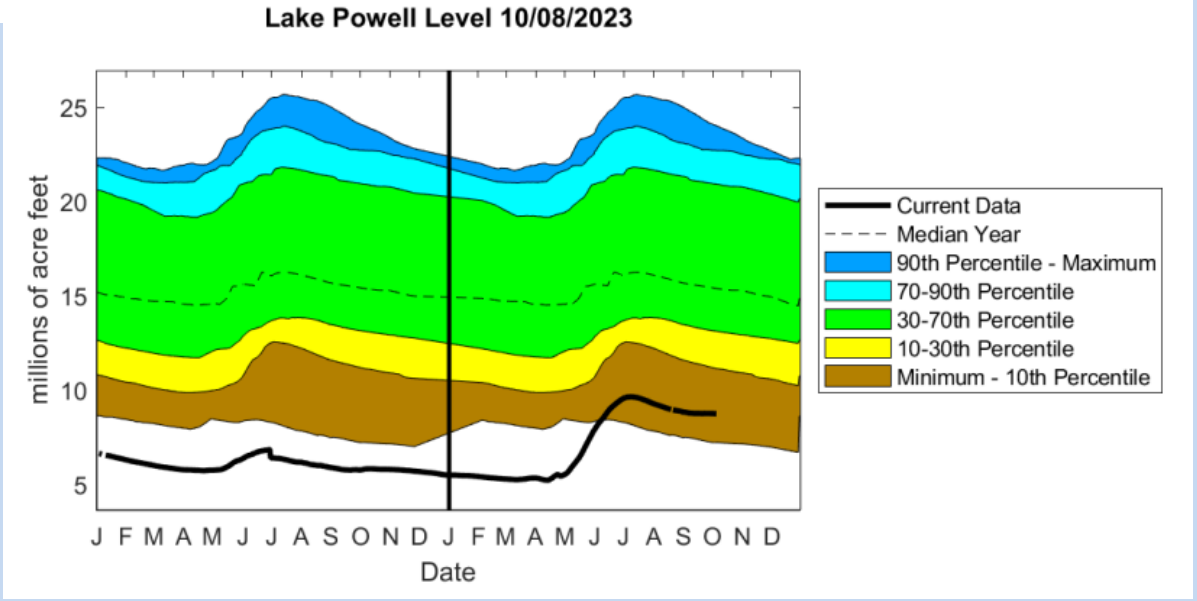


Flow in water years 2019-23 (black line) vs. historical record. Note log scale.

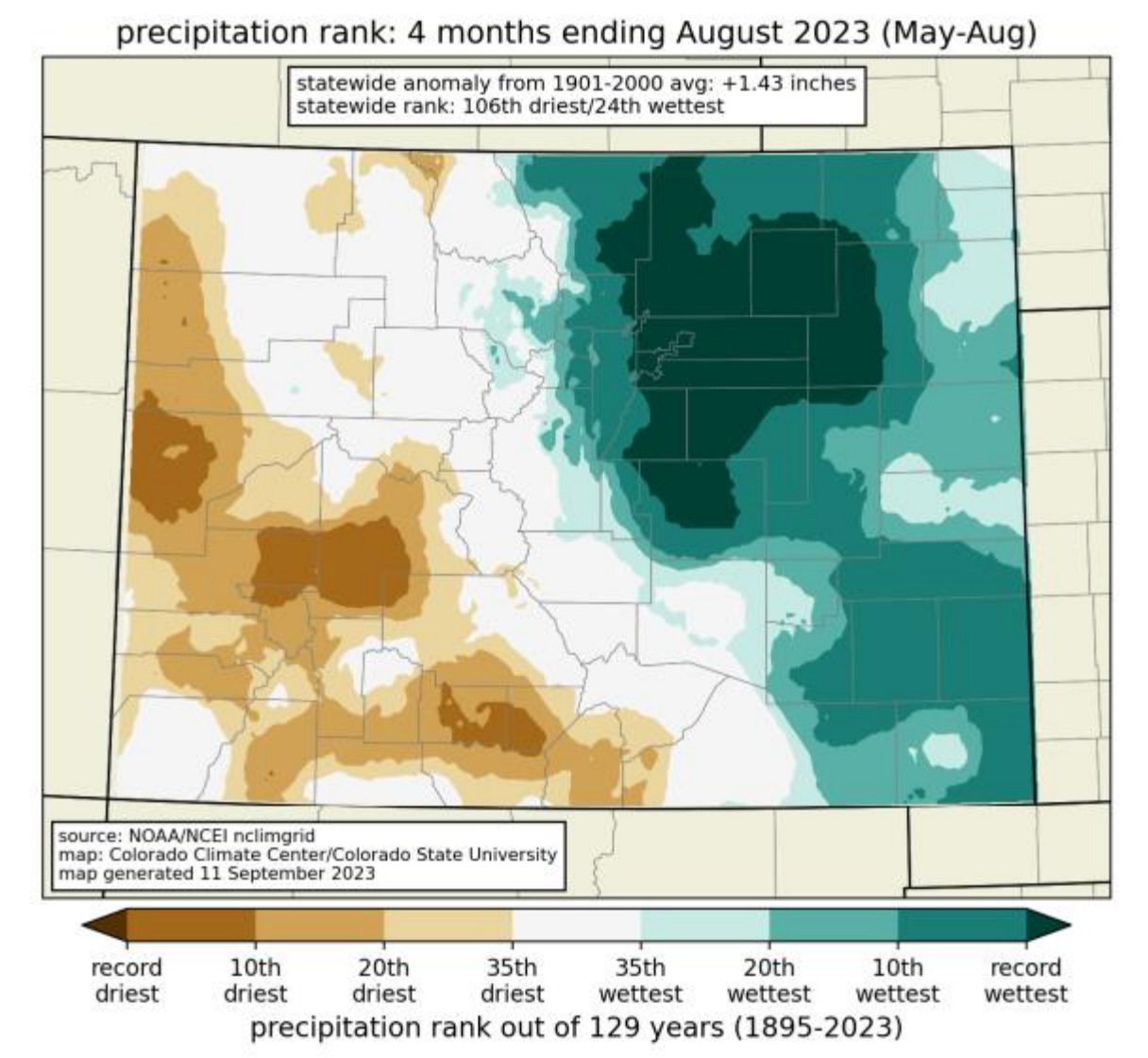
Upper Colorado River basin reservoirs refilled nicely . . .



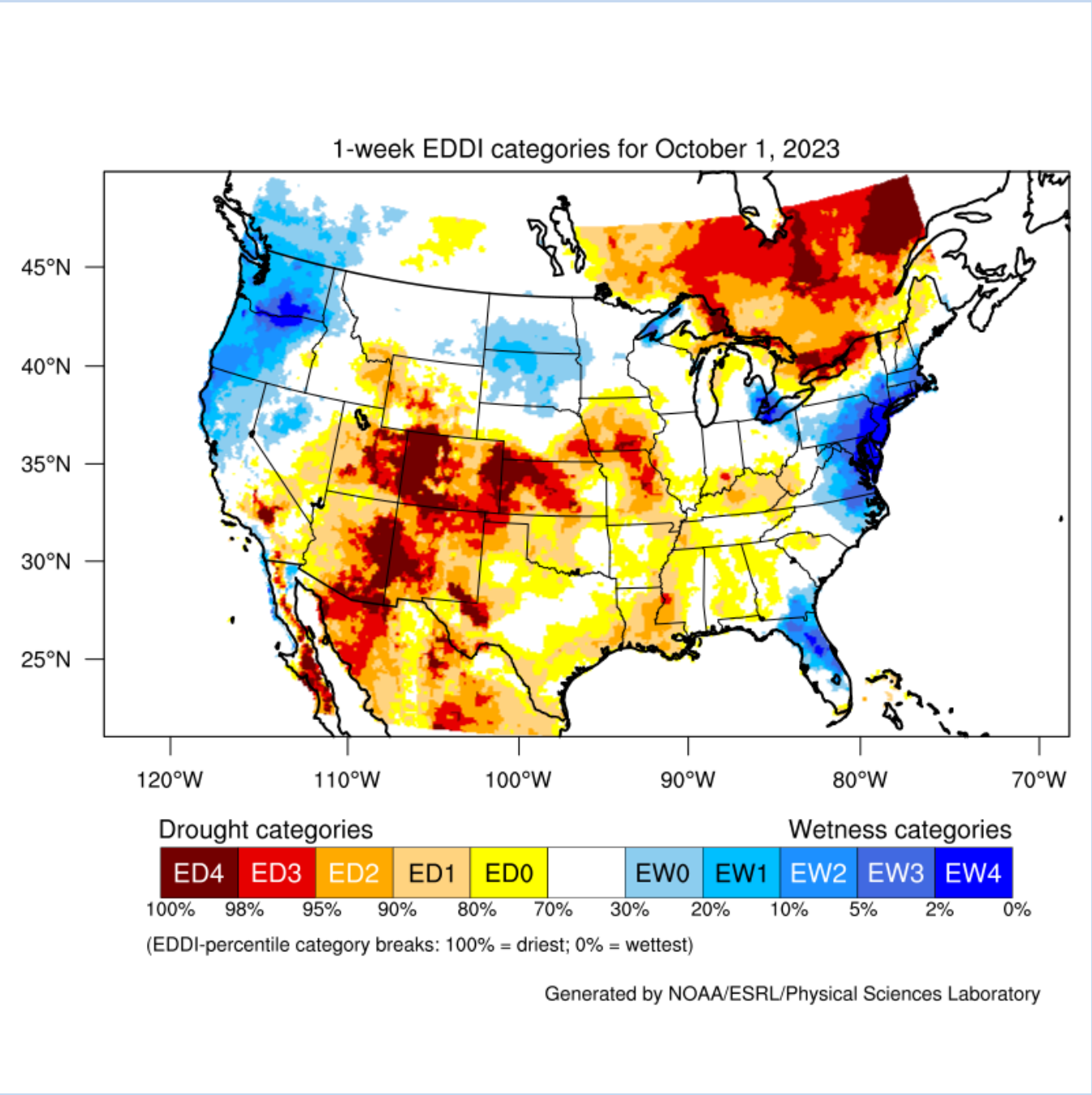
. . . but Powell and Meade need a whole lot more than one good snow year.



The monsoon failed.

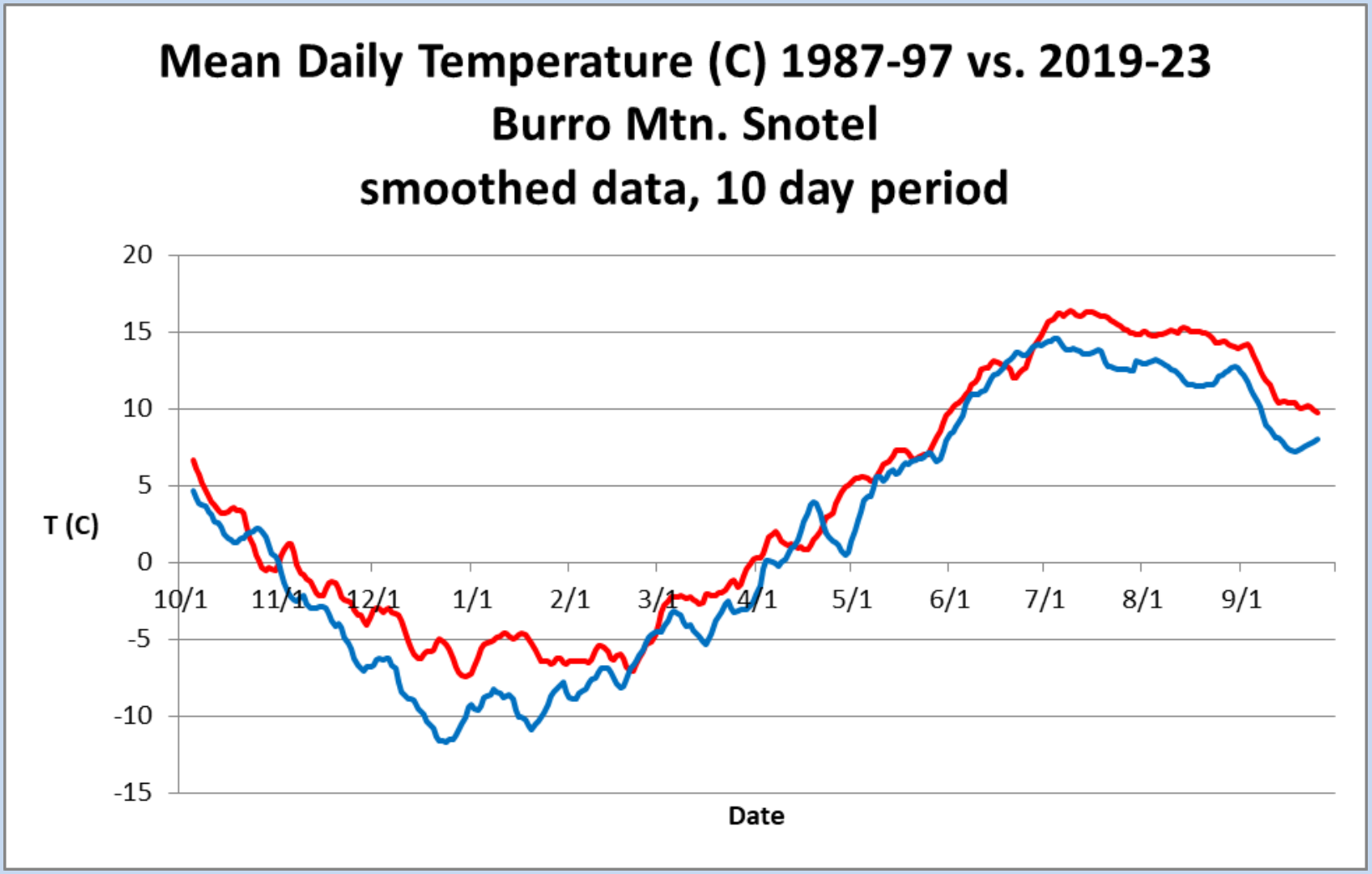


Despite good snowpack, water year 2023 ended dry.

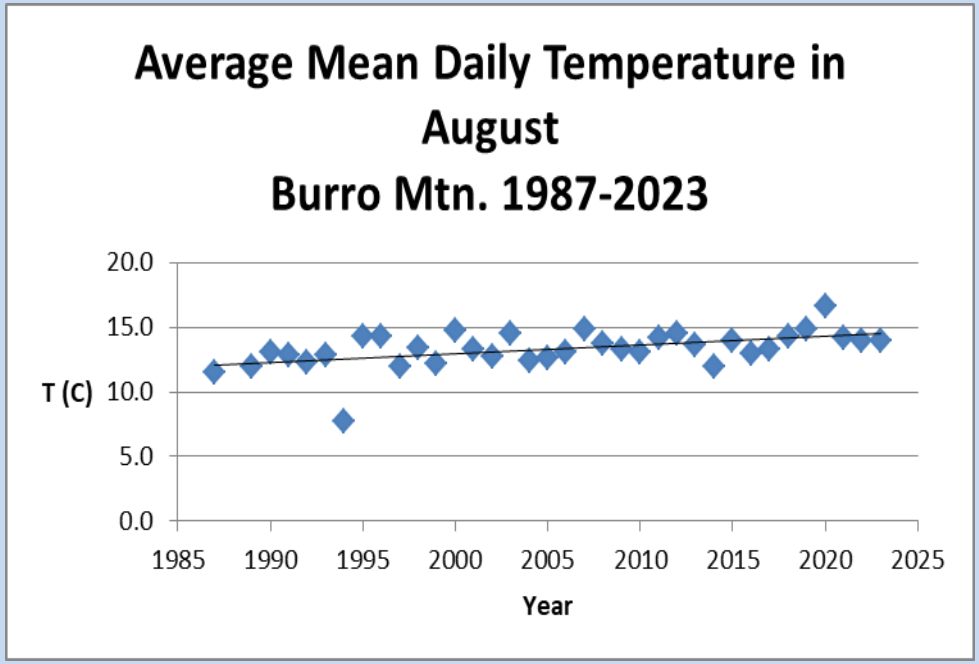


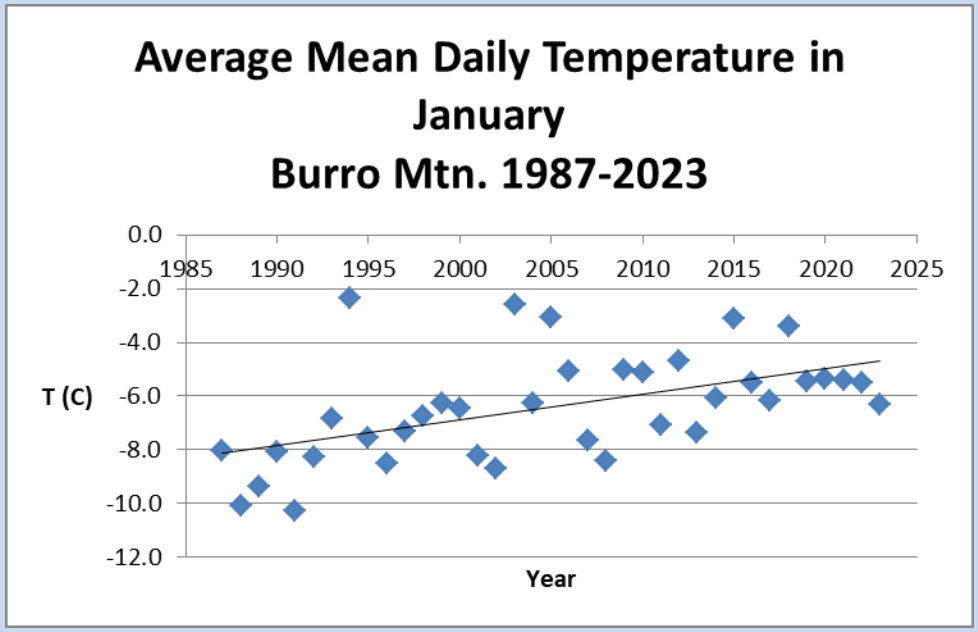
Trends on the upper White River

Mean daily temperatures on the Flat Tops have increased significantly, especially mid-winter and late summer.



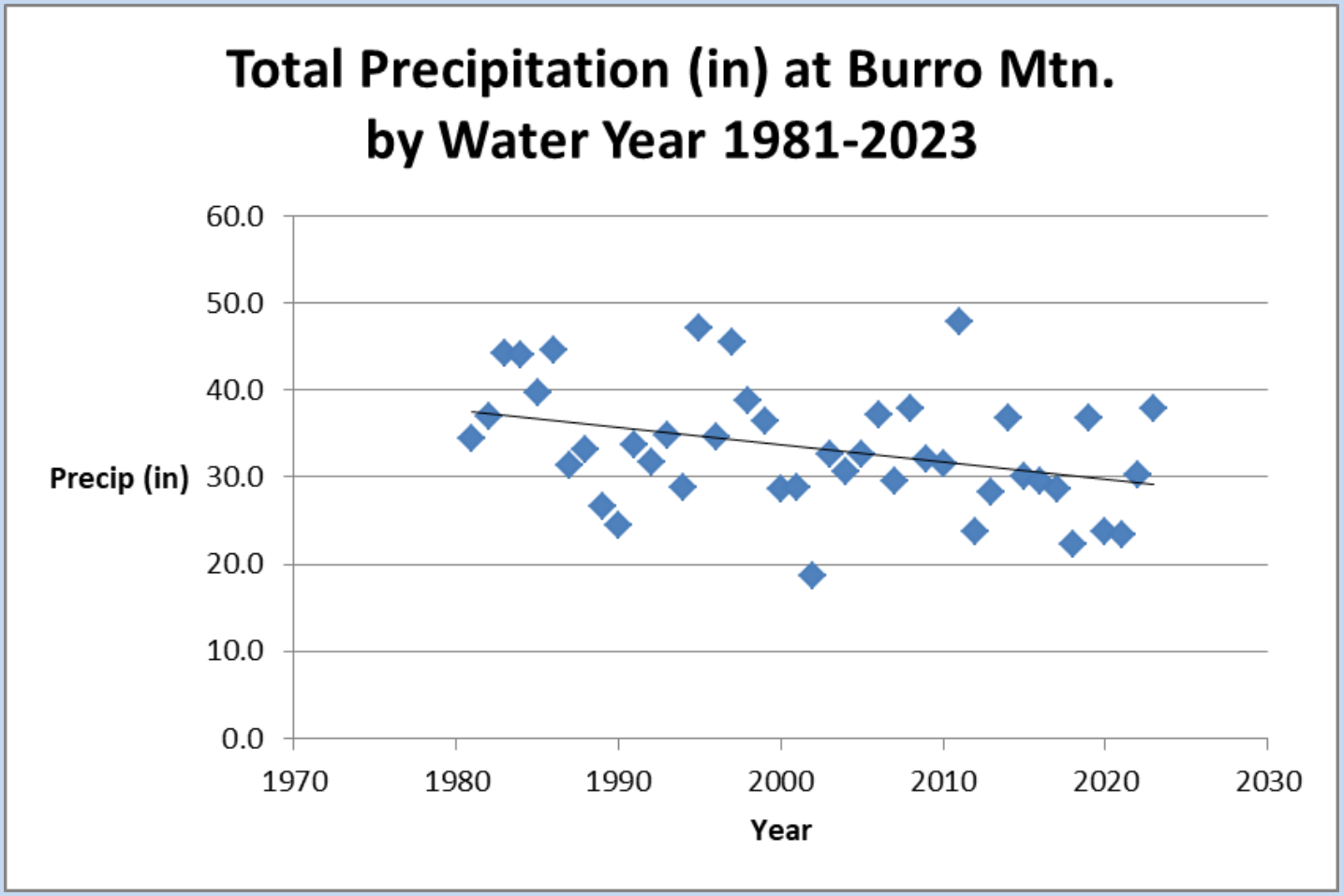
January and August temperatures have increased by about 3.5 C (6.5 F) on the Flat Tops over the past 35 years.



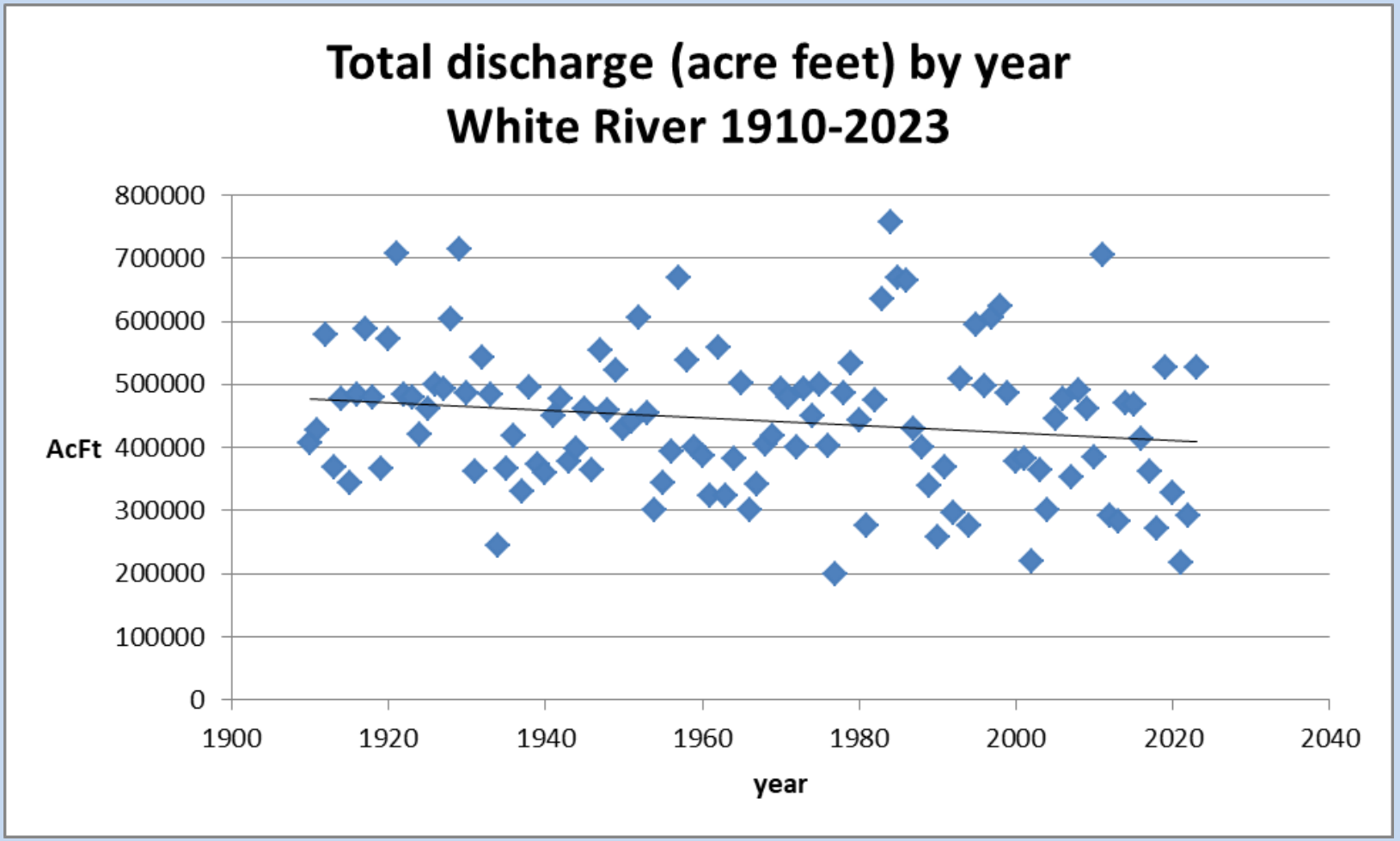


Data from Burro Mtn. Snotel.

Precipitation on the Flat Tops , mostly available in snow pack, is decreasing. There is less water for runoff into the headwaters of the White River.

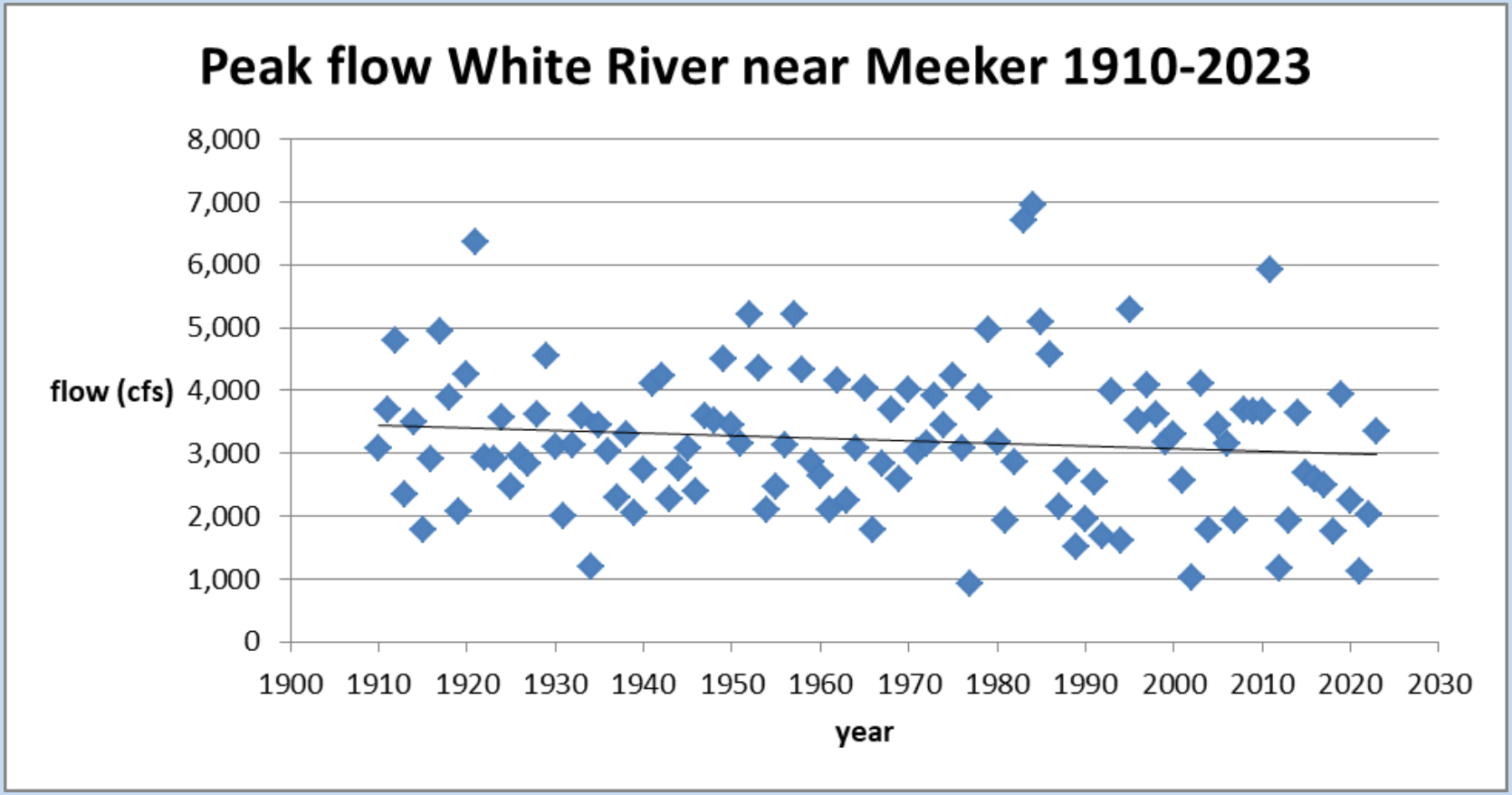


Total yearly runoff in the White River is decreasing, down by about 70,000 acre feet on average over the period of record. That represents about a 14% loss in water volume.

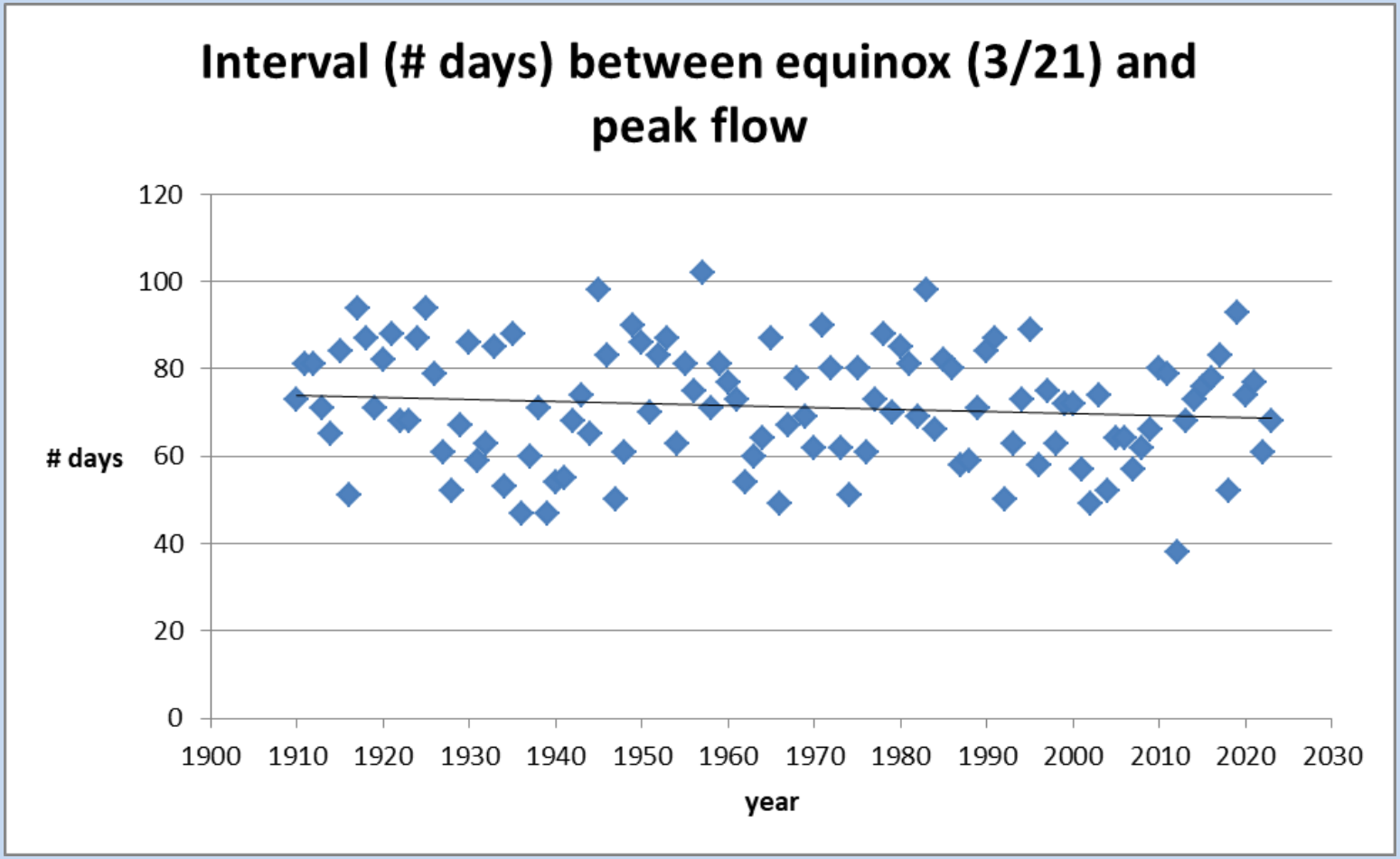


This and following flow data from USGS gauge station 09304500, Near Meeker

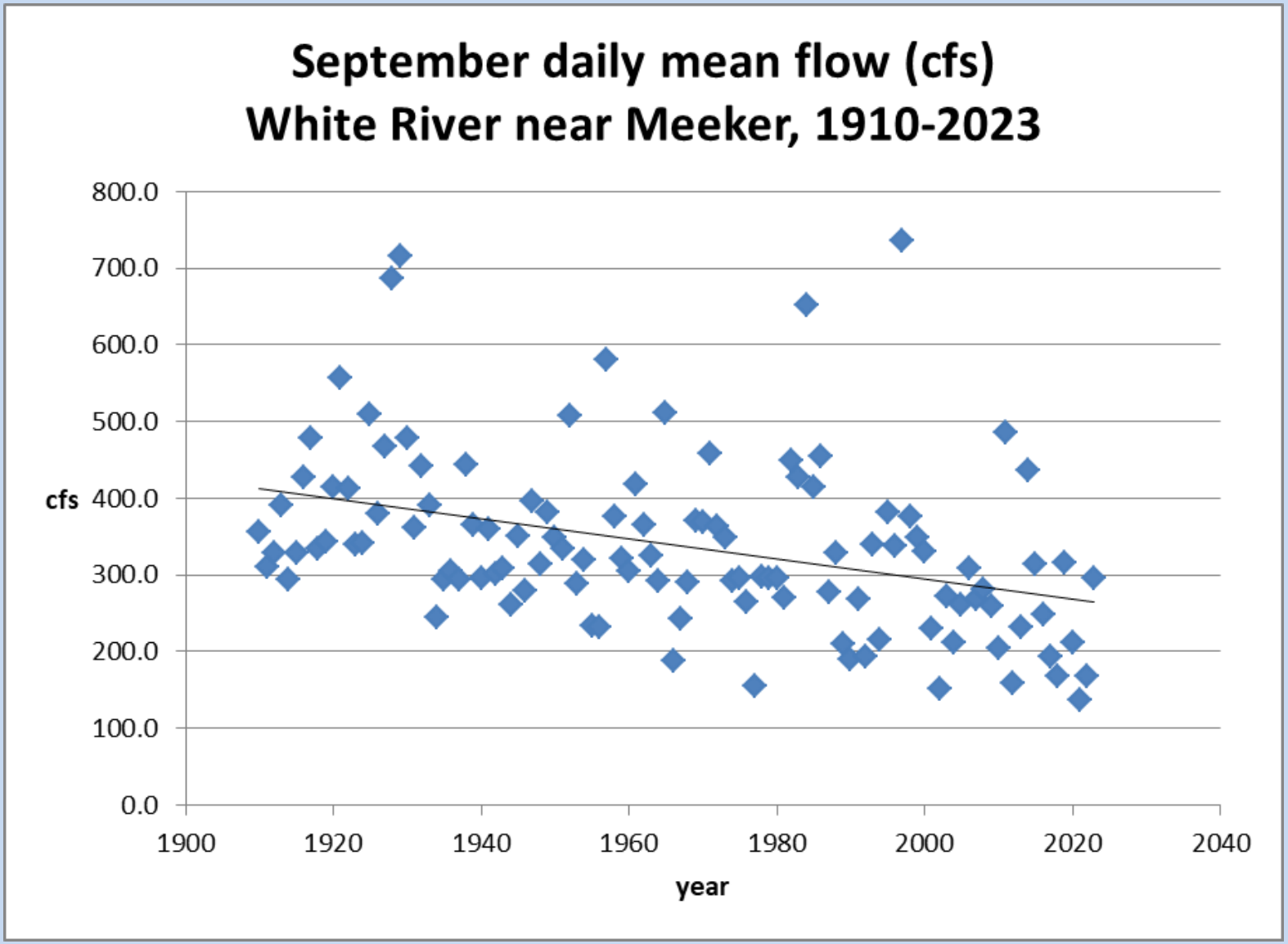
Peak flow is decreasing, now roughly 500 cfs lower on average than it was in 1910. Lower peak flow is less effective at scouring algae off the stream bed, so algae remains on the substrate from one year to the next. Decreased flow has other effects on the river ecosystem as well, including changes in sediment transport and fish habitat.



Spring runoff today occurs earlier than it did in the past. Earlier peak flow results in longer period of low flow in the summer and, potentially, higher water temperatures. Both effects may contribute to algae bloom and to fish stress.

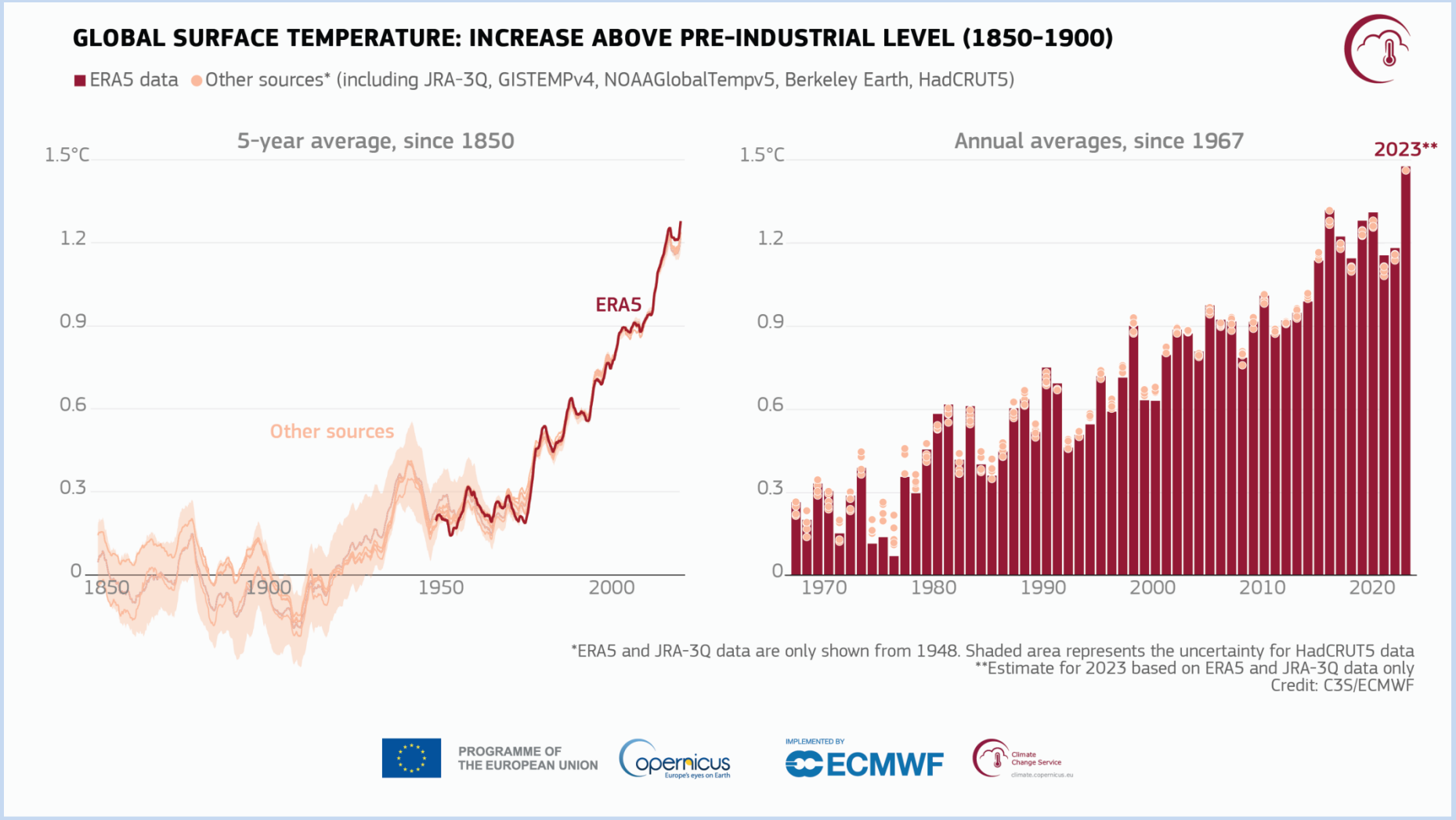


Daily mean flow is decreasing in all months except April (reflecting shift of Spring runoff earlier into April). Decrease in September mean flow is particularly striking.

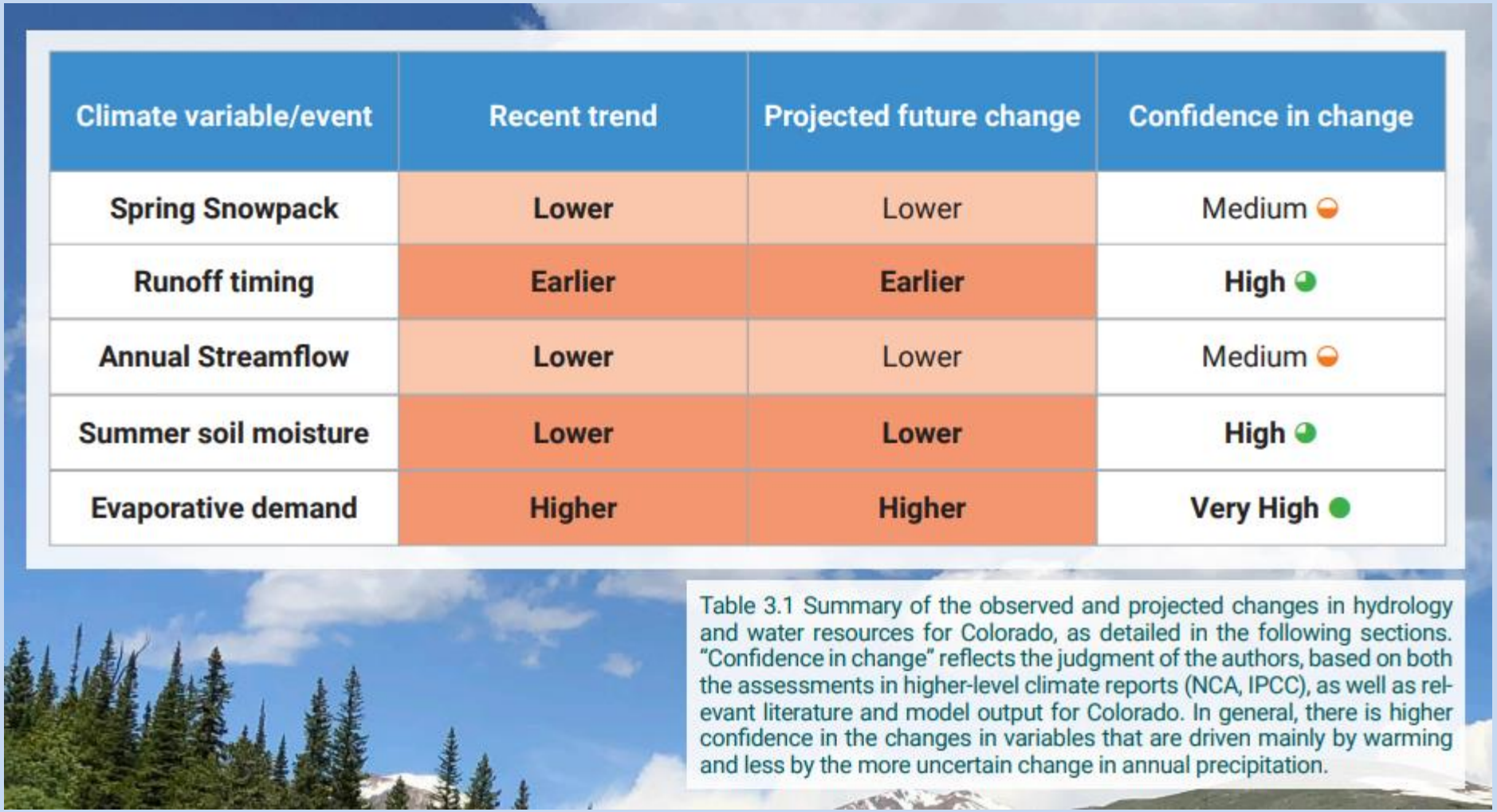


What does the future hold?

Temperature anomalies (C) relative to preindustrial global average temperature. Source: EU Copernicus Climate Center and U.S. NOAA.



Climate Change in Colorado



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

Table 3.1 Summary of the observed and projected changes in hydrology and water resources for Colorado, as detailed in the following sections. "Confidence in change" reflects the judgment of the authors, based on both the assessments in higher-level climate reports (NCA, IPCC), as well as relevant literature and model output for Colorado. In general, there is higher confidence in the changes in variables that are driven mainly by warming and less by the more uncertain change in annual precipitation.

Bolinger, R.A., J.J. Lukas, R.S. Schumacher, and P.E. Goble, 2024: Climate Change in Colorado, 3rd edition. Colorado State University, https://doi.org/10.25675/10217/237323

Snowpack

- April 1 SWE (snow water equivalent) during the 21st century has been 3% to 23% lower than the 1951-2000 average across Colorado's major river basins.
- Future warming will lead to further reductions in Colorado's spring snowpack. Most climate model projections of April 1 SWE in the state's major river basins show reductions of -5% to -30% for 2050 compared to 1971-2000; the individual projections that show increasing snowpack assume large increases in fall-winter-spring precipitation.
- The seasonal peak of the snowpack is projected to shift earlier by a few days to several weeks by 2050, depending on the amount of warming and the precipitation change. This warming-driven shift could be accelerated by increases in dust-on-snow events.

Streamflow

- Since 2000, annual streamflow in all of Colorado major river basins has been 3% to 19% lower than the 1951-2000 average.
- Modeling studies have attributed up to half of the observed decrease in streamflow since 1980 in Colorado river basins to warming temperatures.
- Future warming will act to reduce annual streamflows. Most climate model projections of annual streamflows in the state's major river basins for 2050 show reductions of 5% to 30% compared to 1971-2000.
- Higher future streamflow would require large overall increases in precipitation to offset the effects of warming, an outcome that appears unlikely.
- Summer and fall streamflows are projected to decline significantly by 2050 as the seasonal runoff peak shifts earlier, by 1-4 weeks, due to warming.

Soil moisture

- Modeled soil moisture based on meteorological observations suggests overall declines in high-elevation soil moisture from 1980-2022.
- Future warming will lead to declines in summer (June-August) soil moisture throughout the state. Spring (March-May) soil moisture will likely increase at higher elevations as snowmelt shifts earlier.
- Rapid depletion of soil moisture under warm conditions exacerbates warming. When summer sunshine hits a landscape with dry soil a greater fraction of solar energy directly heats the surface, leading to even warmer conditions.

Evapotranspiration

- The evaporative demand ("thirst") of the atmosphere—as measured by potential evapotranspiration (PET) and Reference ET—has increased across Colorado since 1980, mainly due to the warming trend. Statewide, growing-season PET increased by 5% from 1980-2022.
- Additional future warming will drive greater evaporative demand; all climate model projections show statewide annual PET increasing by 8-17% by 2050, compared to 1971-2000.

Bluff, UT 2022

Meeker, CO 2060

What we can do

- Confronting climate change requires action at global scale
  - a key contribution in our region would be to stop methane leaks in the Uinta and Piceance Basins
- Continue educational efforts to limit nutrients and pesticides in the river
- Continue riparian protection and restoration
- and . . . ?