Recapping Water Year 2021

Peter Goble, Service Climatologist

Russ Schumacher, State Climatologist

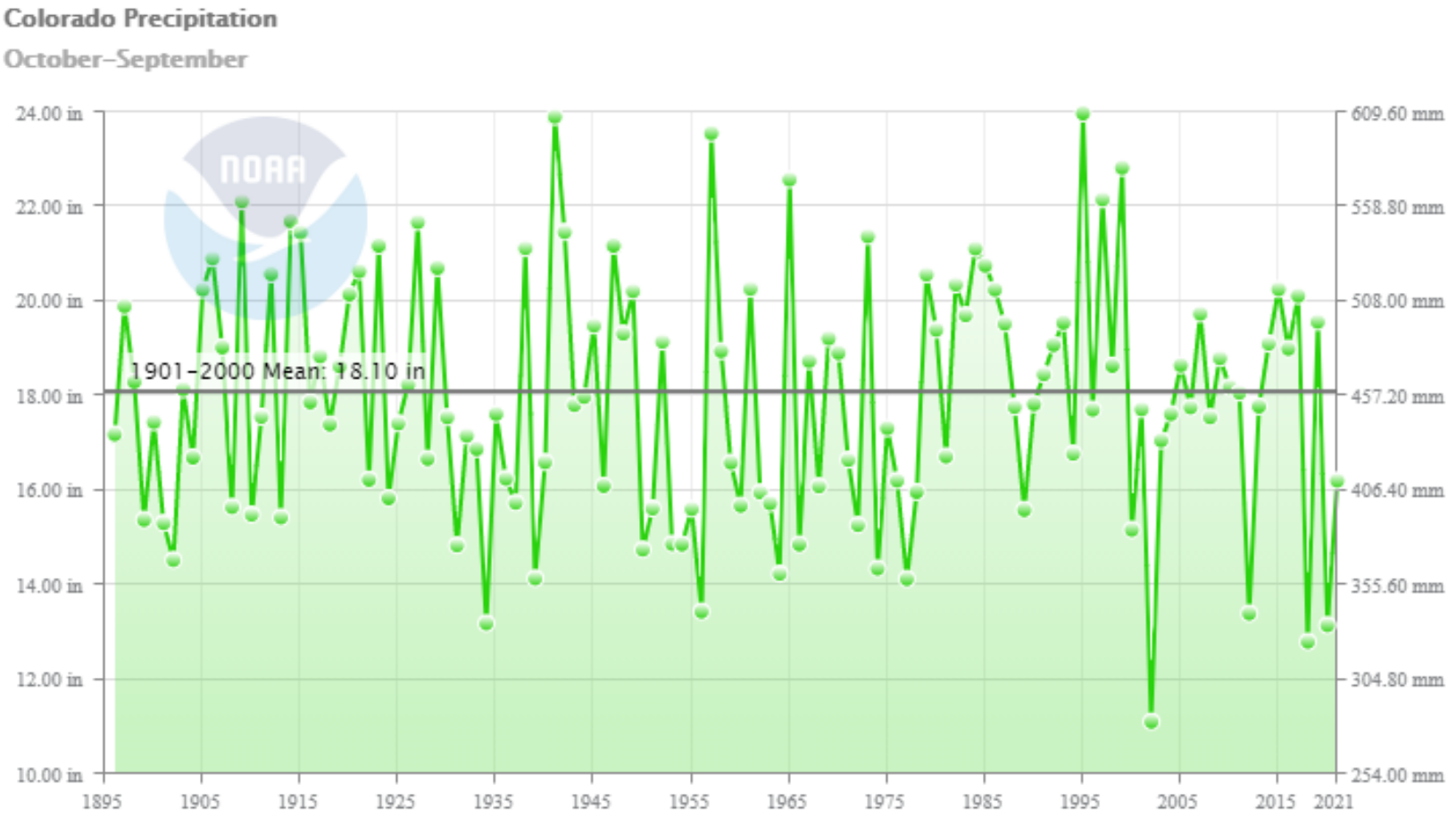
Becky Bolinger, Assistant State Climatologist

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ATMOSPHERIC SCIENCE
COLORADO STATE UNIVERSITY

Today's Roadmap

- Water Year (WY) 2021 Overview
- WY 2021 Timeline
- Events and Extremes
- Seasonal Outlook

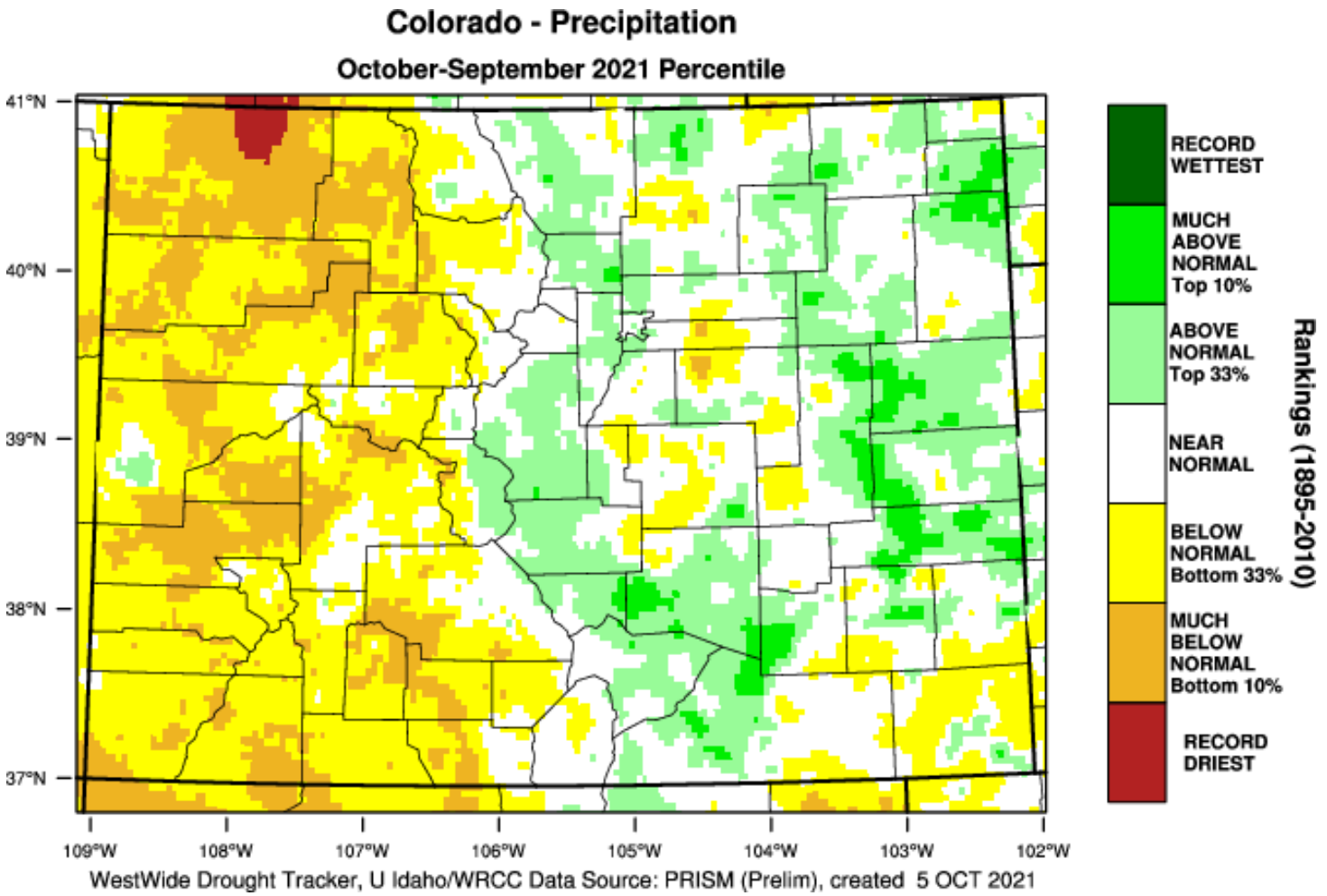


35th driest year on record

16.21” on average

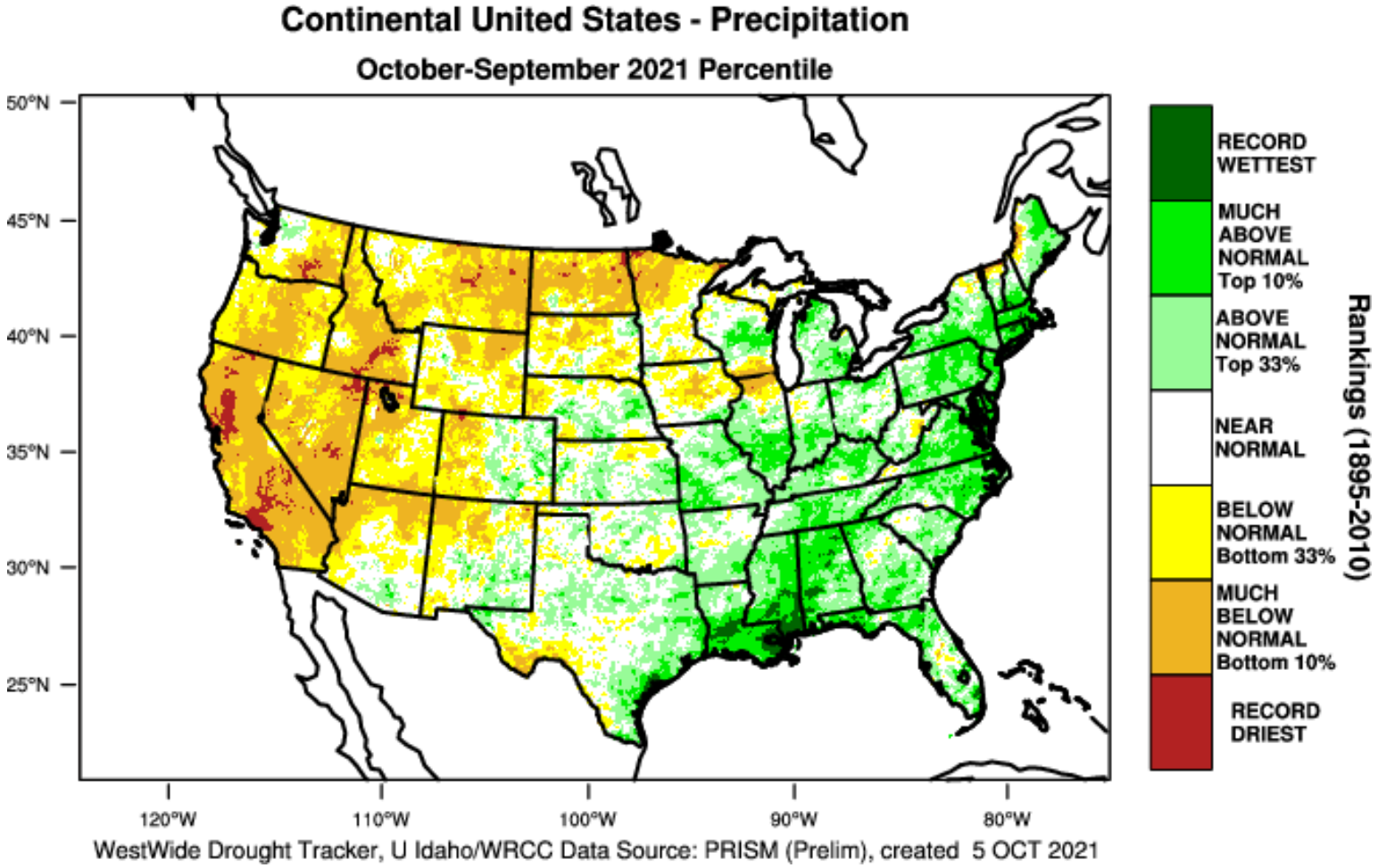
1.89” below long-term average

Two of the five driest years on record occurred in the last four years



Much drier than normal on the west slopes again

Water supply problems growing



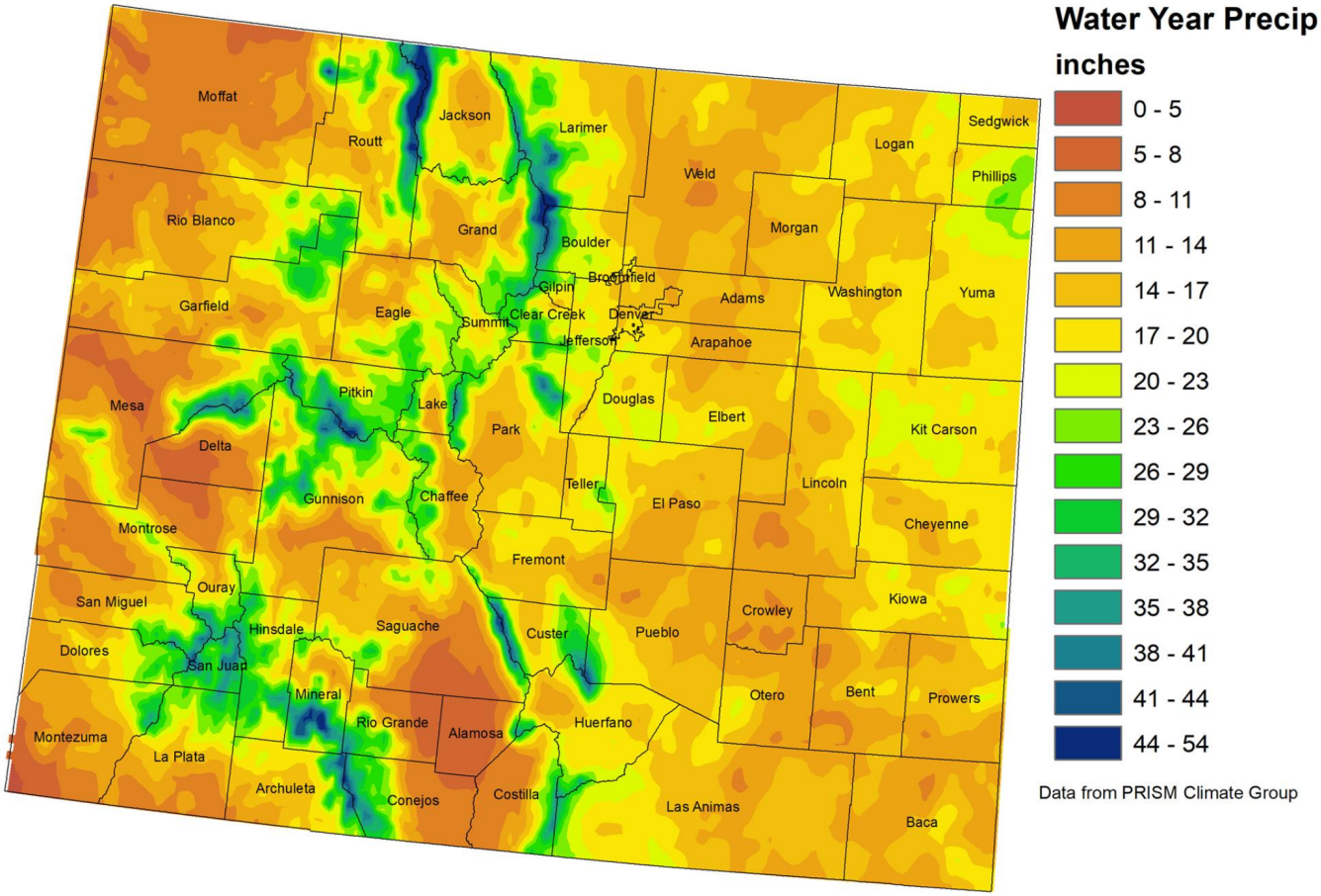
Another year of drier than normal west, wetter than normal east

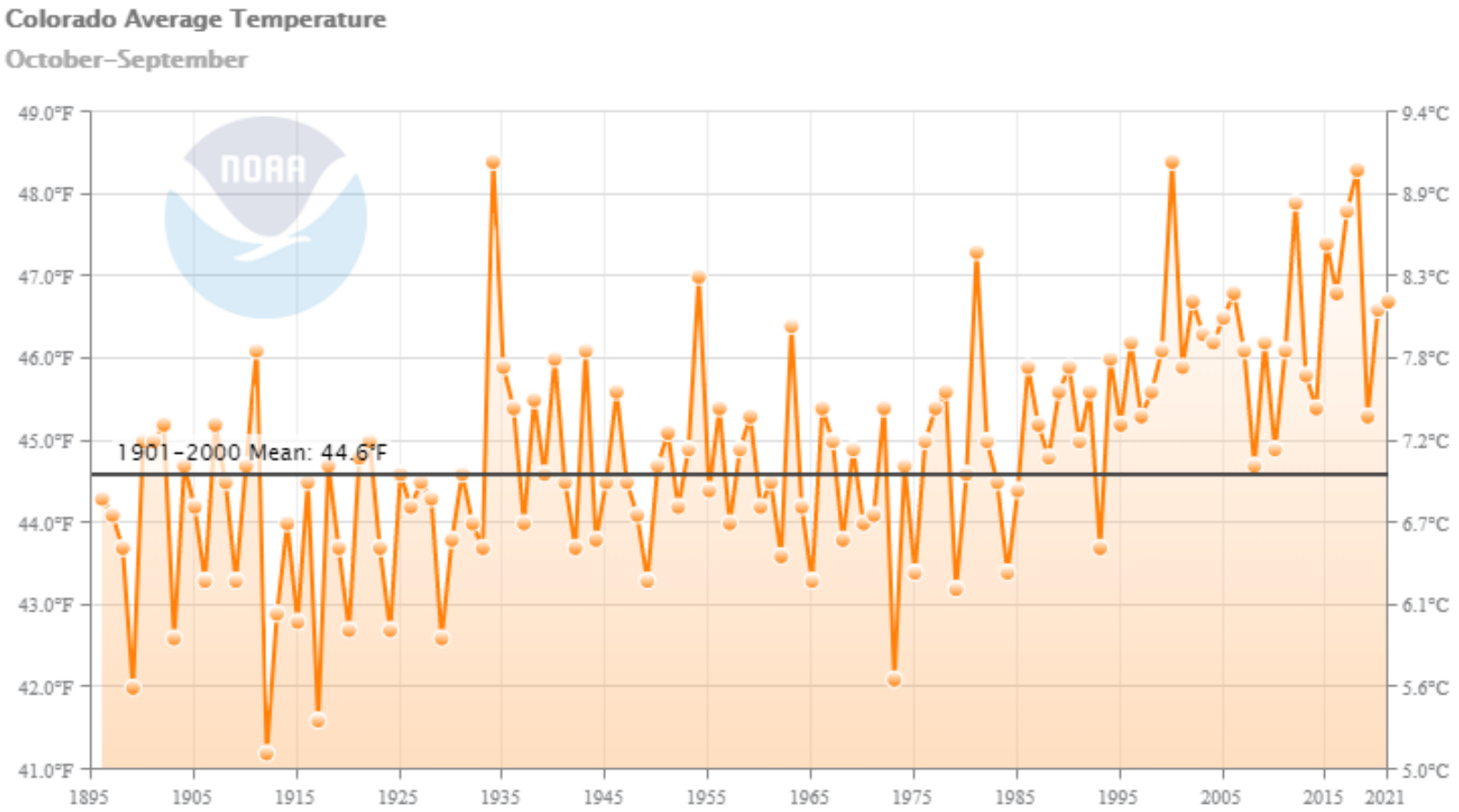
Rich got richer and poor got poorer

Four Corners failed to amass 5” of precipitation this water year

Parts of Moffat County in D4 drought all year

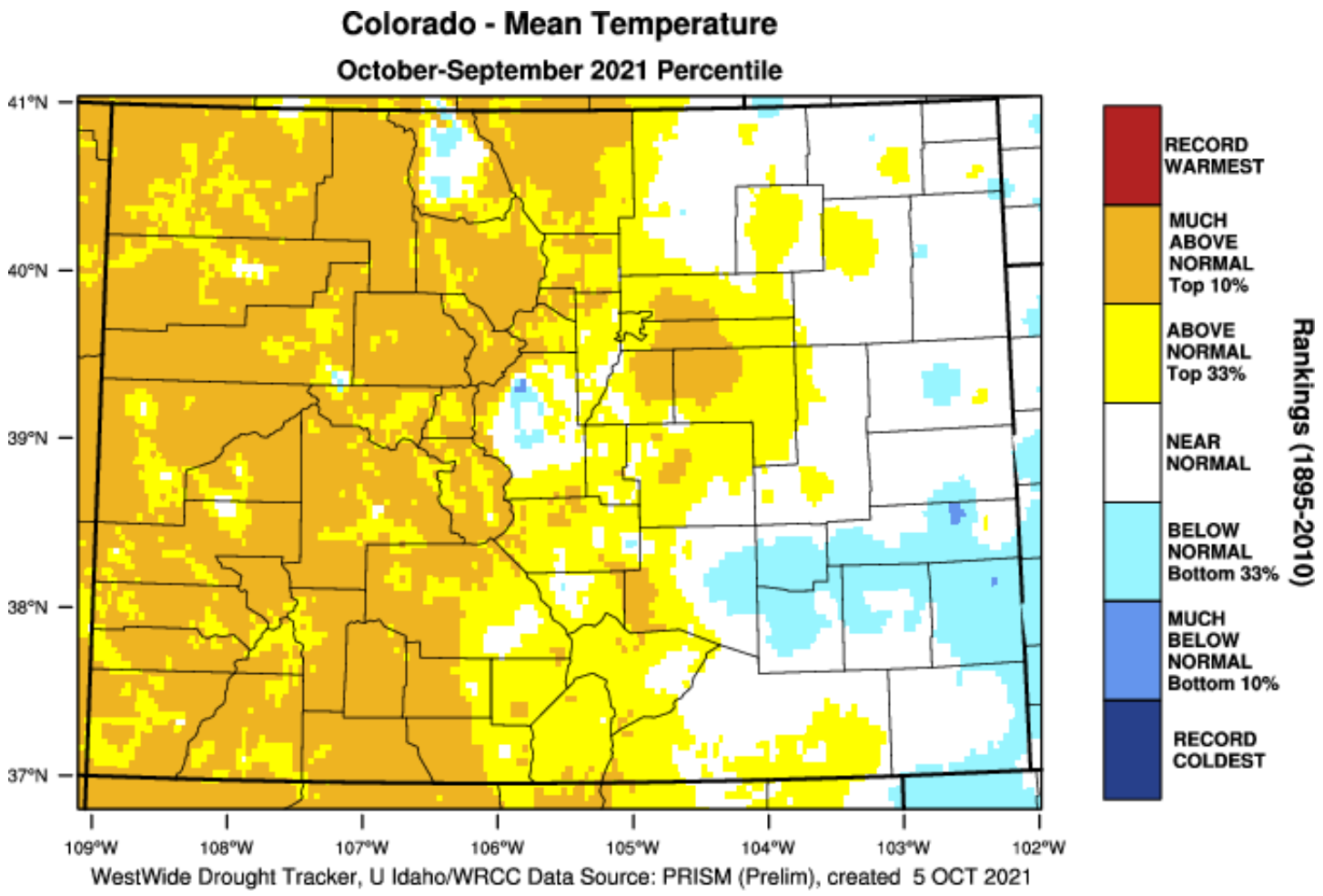
Colorado Water Year 2021 Precipitation
October 2020 - September 2021





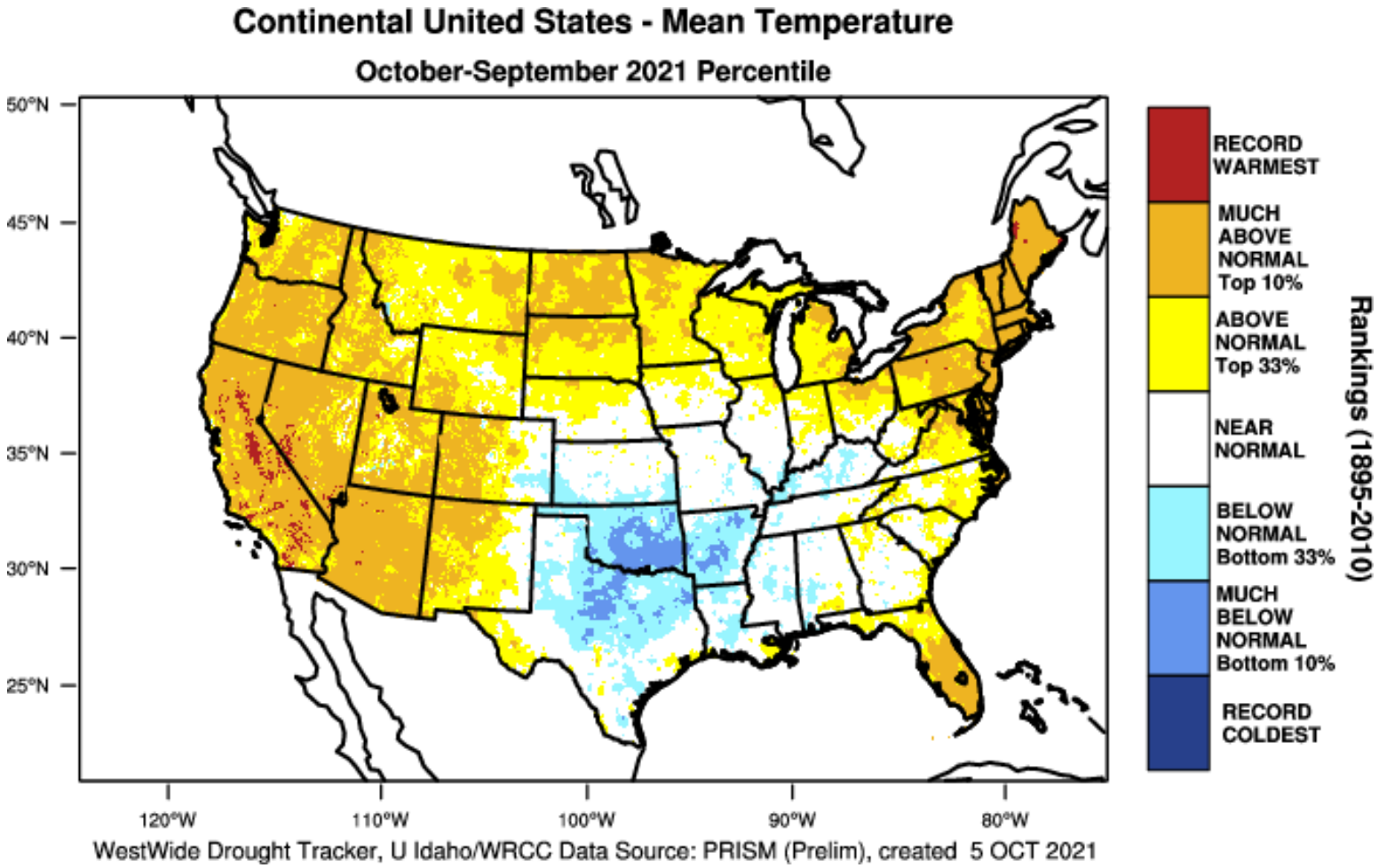
11th warmest year on record

Pretty par for the course for the last couple decades



Warm conditions on the west slopes

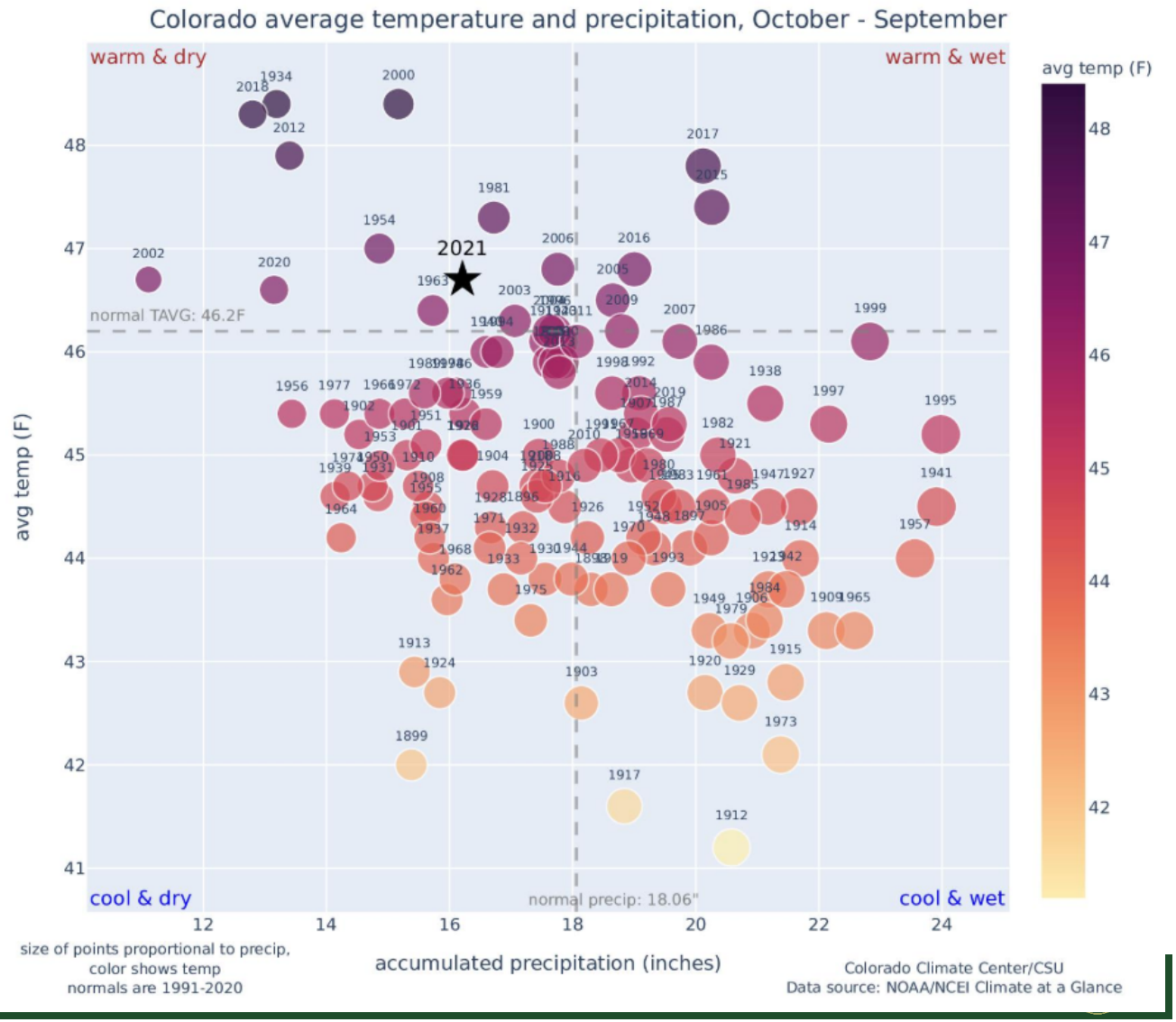
Near normal temperatures on the plains



Cool anomalies over the center of the southern plains, but warmer than normal temperatures elsewhere

Much wetter than last year

Still in the warm, dry “quadrant”



Month	T Rank (of 127 years)	Above, below, or near avg?
Oct	52nd warmest	average
Nov	7th warmest	above
Dec	46th warmest	average
Jan	33rd warmest	above
Feb	26th coolest	below
Mar	46th warmest	average
Apr	59th coolest	average
May	62nd warmest	average
Jun	6th warmest	much above
Jul	16th warmest	above
Aug	15th warmest	above
Sep	3rd warmest	much above

Month	P Rank (of 127 years)	Above, below, or near avg?
Oct	16th driest	below
Nov	44th driest	average
Dec	59th driest	average
Jan	38th driest	below
Feb	57th wettest	average
Mar	20th wettest	above
Apr	18th driest	below
May	11th wettest	much above
Jun	50th driest	average
Jul	64th wettest	average
Aug	19th driest	below
Sep	53rd driest	average

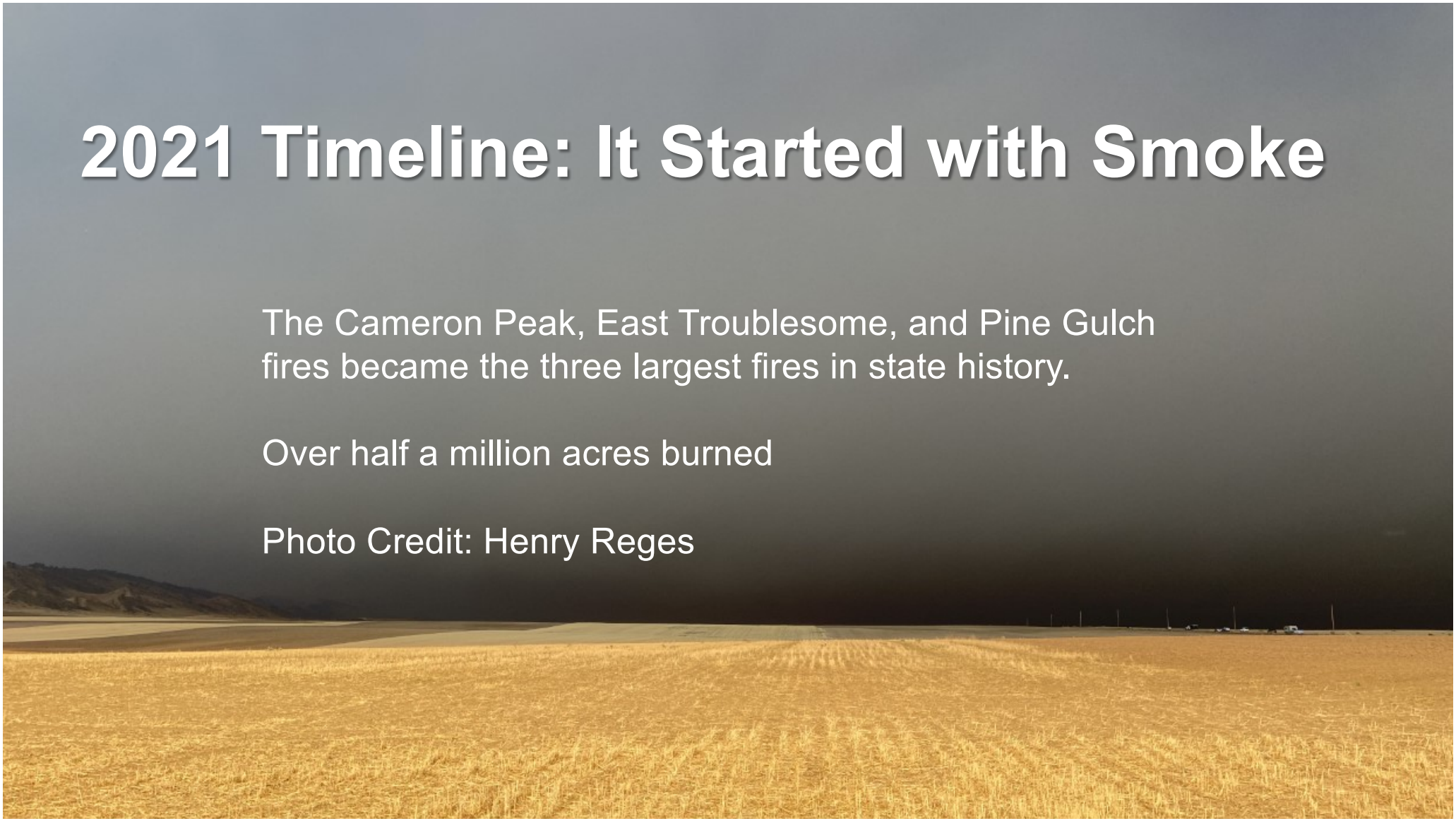
Month	T Rank (of 127 years)	Above, below, or near 20th century avg?
Oct	52nd warmest	near avg
Nov	7th warmest	much above
Dec	46th warmest	near avg
Jan	33rd warmest	above
Feb	26th coolest	below
Mar	46th warmest	near avg
Apr	69th warmest	near avg
May	50th warmest	near avg
Jun	6th warmest	much above
Jul	11th warmest	much above
Aug	15th warmest	above
Sep	3rd warmest	much above

Month	P Rank (of 127 years)	Above, below, or near 20th century avg?
Oct	16th driest	below
Nov	44th driest	near avg
Dec	59th driest	near avg
Jan	38th driest	below
Feb	71st driest	near avg
Mar	20th wettest	above
Apr	18th driest	below
May	11th wettest	much above
Jun	50th driest	near avg
Jul	64th driest	near avg
Aug	19th driest	below
Sep	53rd driest	near avg

Records Broken in 2021

Daily records						
Month	High max T	High min T	Low max T	Low min T	Precipitation	Snowfall
Oct-20	437	365	233	374	35	42
Nov-20	352	388	31	13	64	9
Dec-20	216	70	33	22	60	27
Jan-21	35	69	20	14	72	31
Feb-21	34	64	241	175	101	64
Mar-21	63	85	24	20	140	64
Apr-21	293	158	106	131	38	39
May-21	86	139	83	29	127	26
Jun-21	679	450	131	15	85	0
Jul-21	110	320	16	12	133	0
Aug-21	63	149	4	85	9	0
Sep-21	447	249	30	2	55	0
TOTAL	2815	2506	952	892	919	302
	warm records:	5321	cold records:	1844		

2021 Timeline: It Started with Smoke



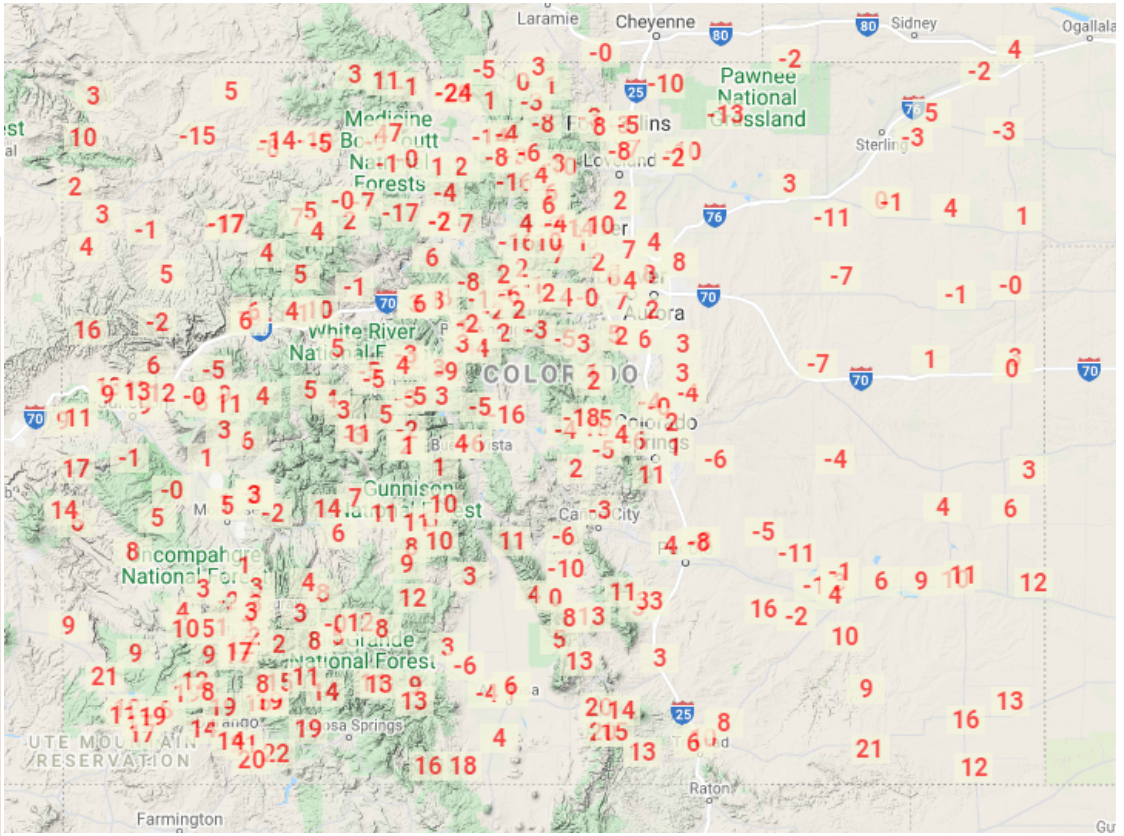
The Cameron Peak, East Troublesome, and Pine Gulch fires became the three largest fires in state history.

Over half a million acres burned

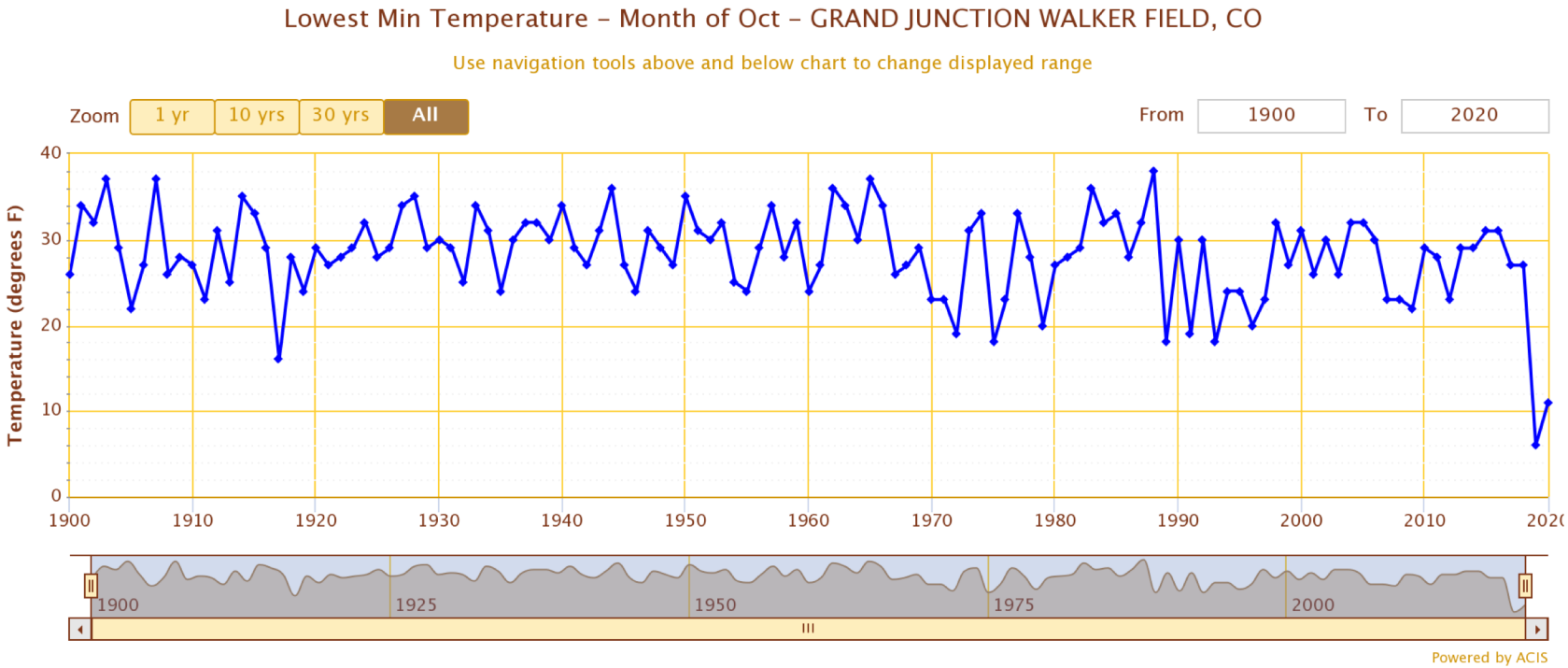
Photo Credit: Henry Reges

October was also cold?

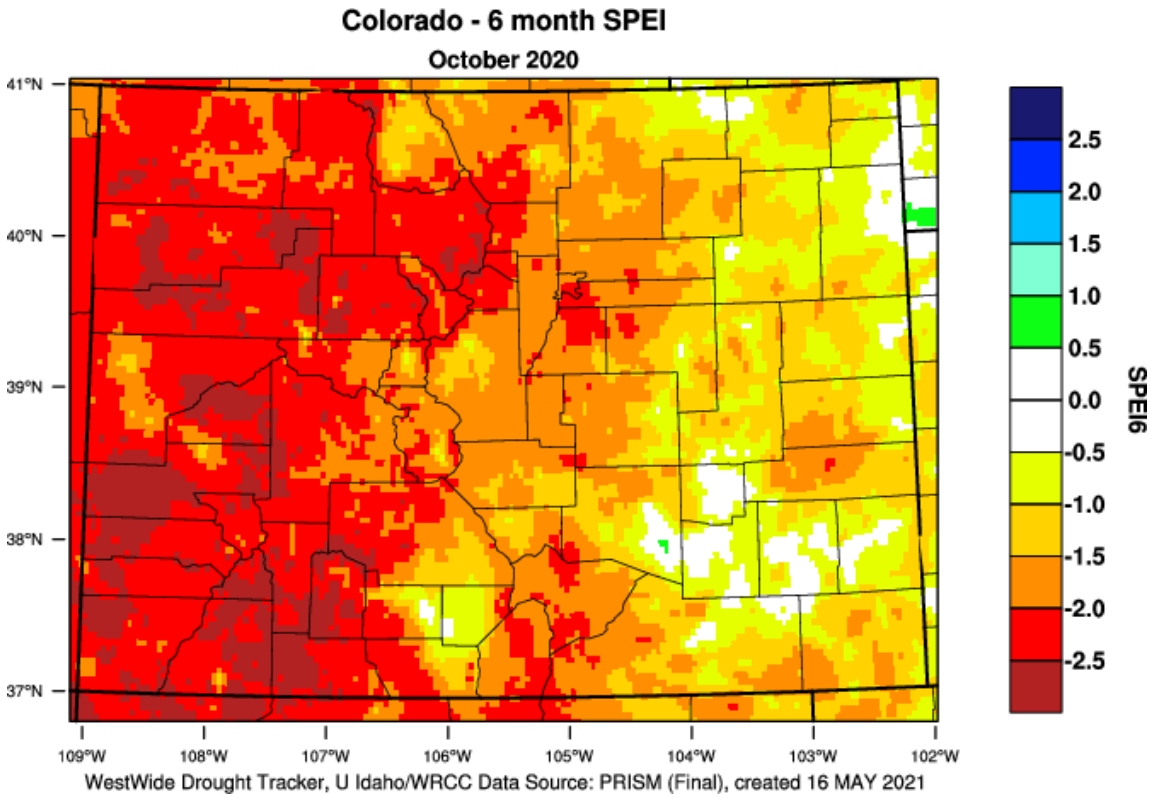
Name	Station Type	Min Temperature
WALDEN	COOP	-28
WALDEN JACKSON COUNTY AIRPORT	WBAN	-24
LAKE GEORGE COLORADO	RAWS	-18
MEEKER	COOP	-17
MEEKER AIRPORT	WBAN	-17
PORCUPINE CREEK COLORADO	RAWS	-17
FLORISSANT FOSSIL BED	COOP	-16
ANTERO RESERVOIR	COOP	-16
FRASER	COOP	-16
HARBISON MEADOW COLORADO	RAWS	-16
MAYBELL	COOP	-15
CRAIG MOFFAT COUNTY AP	WBAN	-14
GOULD 4SE S.F.S.P	COOP	-14
BRIGGSDALE	COOP	-13
ORDWAY 4 W	COOP	-11
WOODROW 6NNE	COOP	-11
DILLON 1 E	WBAN	-10
WESTCLIFFE	COOP	-10
GREELEY WELD COUNTY AIRPORT	WBAN	-10
HAYDEN	COOP	-10
ESTES PARK 3 SSE	COOP	-10
NUNN 7 NNE	WBAN	-10



Two straight years of unprecedented October cold in Grand Junction



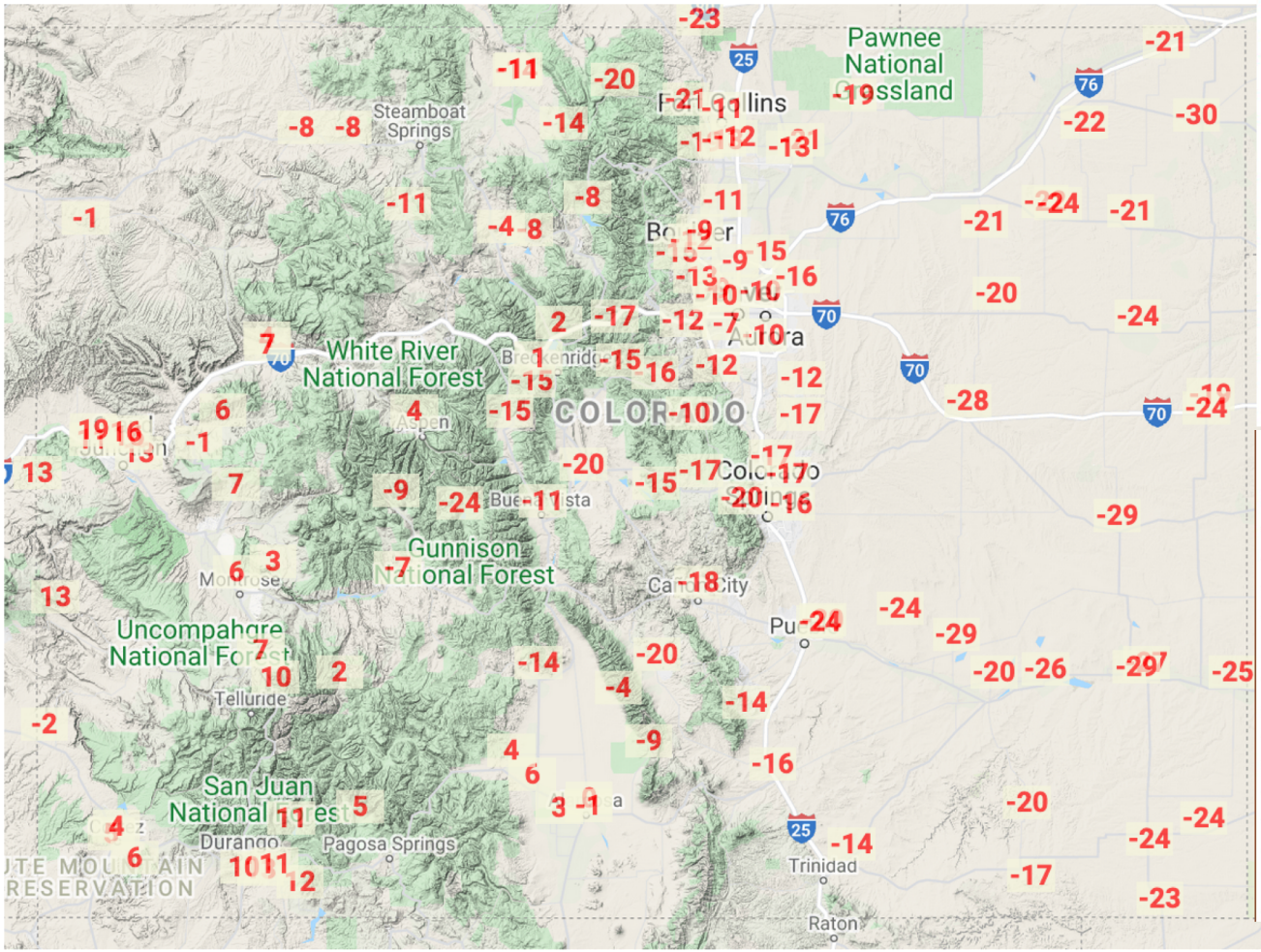
2021 Drought Timeline



- A hot, dry summer/fall draws down soil moisture prior to entering snowpack season in WY 2021
- This is going to mean that even an average snowpack will not entirely replenish our water supplies
- When snow melts, soil moisture is replenished before water feeds into rivers

*SPEI is a metric that combines influence from temperature and precipitation on water balance (warm colors -> hot/dry)

Minimum temps on 14-15 February



Minimum 1-Day Mean Min Temperature for HOLYOKE, CO

Click column heading to sort ascending, click again to sort descending.

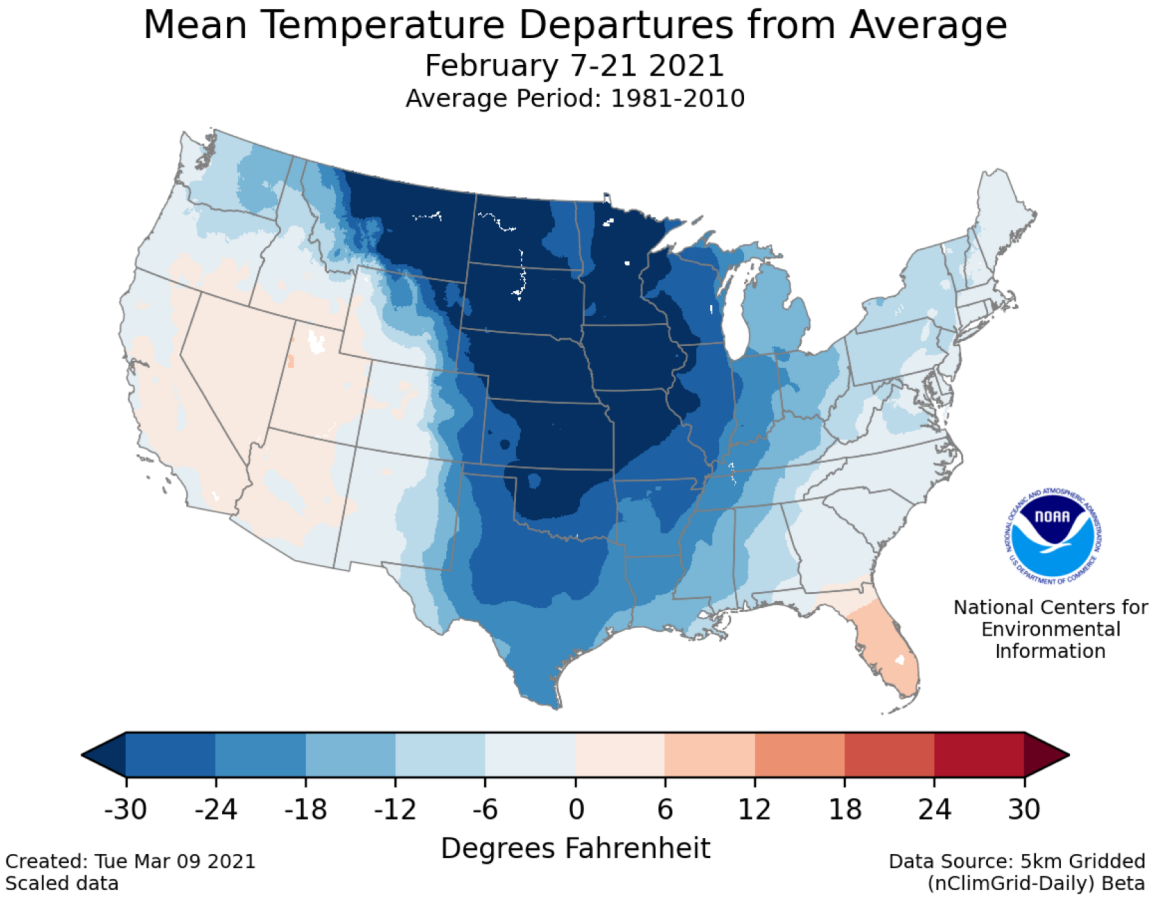
Rank	Value	Ending Date
1	-36.0	1899-02-12
2	-35.0	1919-12-09
3	-33.0	1989-12-23
-	-33.0	1989-12-22
5	-30.0	2021-02-15
-	-30.0	1901-12-15
-	-30.0	1901-12-14
8	-28.0	1919-12-10
-	-28.0	1899-02-11
10	-27.0	1933-02-08
Last value also occurred in one or more previous years.		
Period of record: 1897-02-15 to 2021-02-15		

Minimum 1-Day Mean Min Temperature for LAMAR, CO

Click column heading to sort ascending, click again to sort descending.

Rank	Value	Ending Date
1	-30.0	1899-02-12
2	-29.0	1949-01-30
3	-27.0	2021-02-15
-	-27.0	1948-01-28
5	-24.0	1942-01-05
6	-23.0	1989-12-22
-	-23.0	1961-12-12
-	-23.0	1948-03-10
-	-23.0	1932-12-12
10	-22.0	1984-01-19
Last value also occurred in one or more previous years.		
Period of record: 1893-01-01 to 2021-02-15		

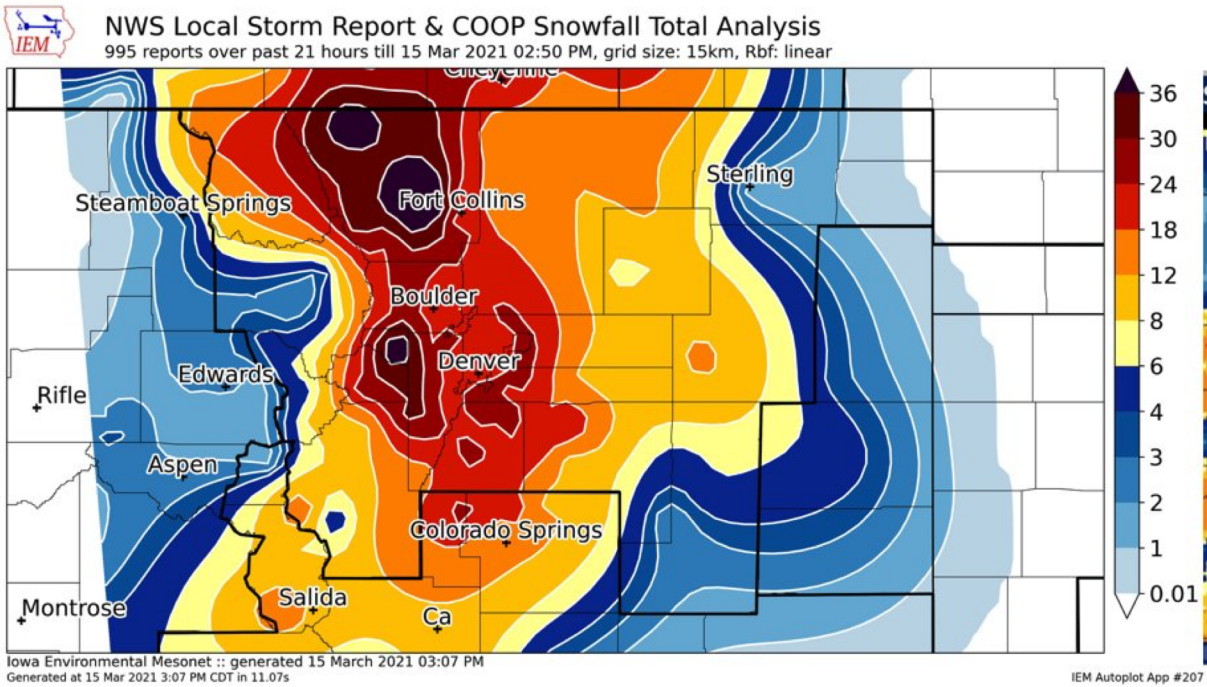
February 2021 cold snap



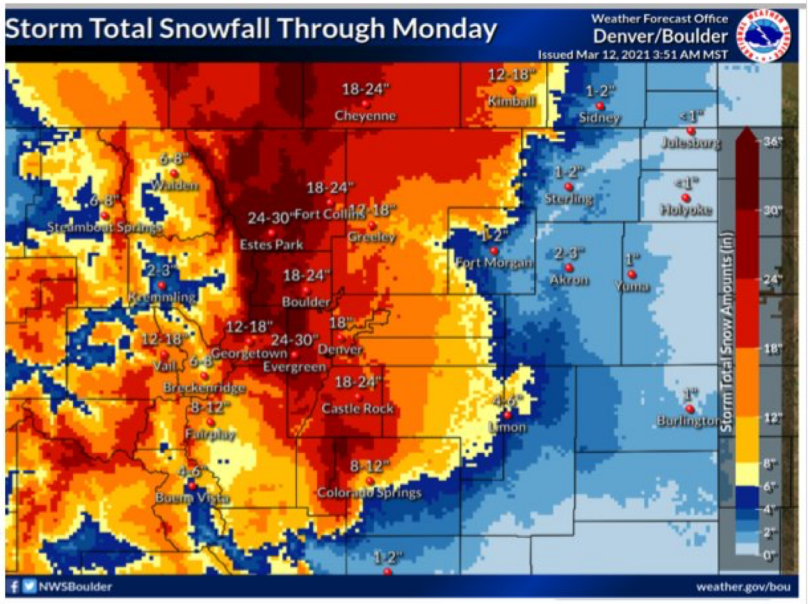
https://www.ncdc.noaa.gov/sotc/synoptic/202102

The “Pi Day” storm (March 14-15) brought huge snow amounts to the Front Range

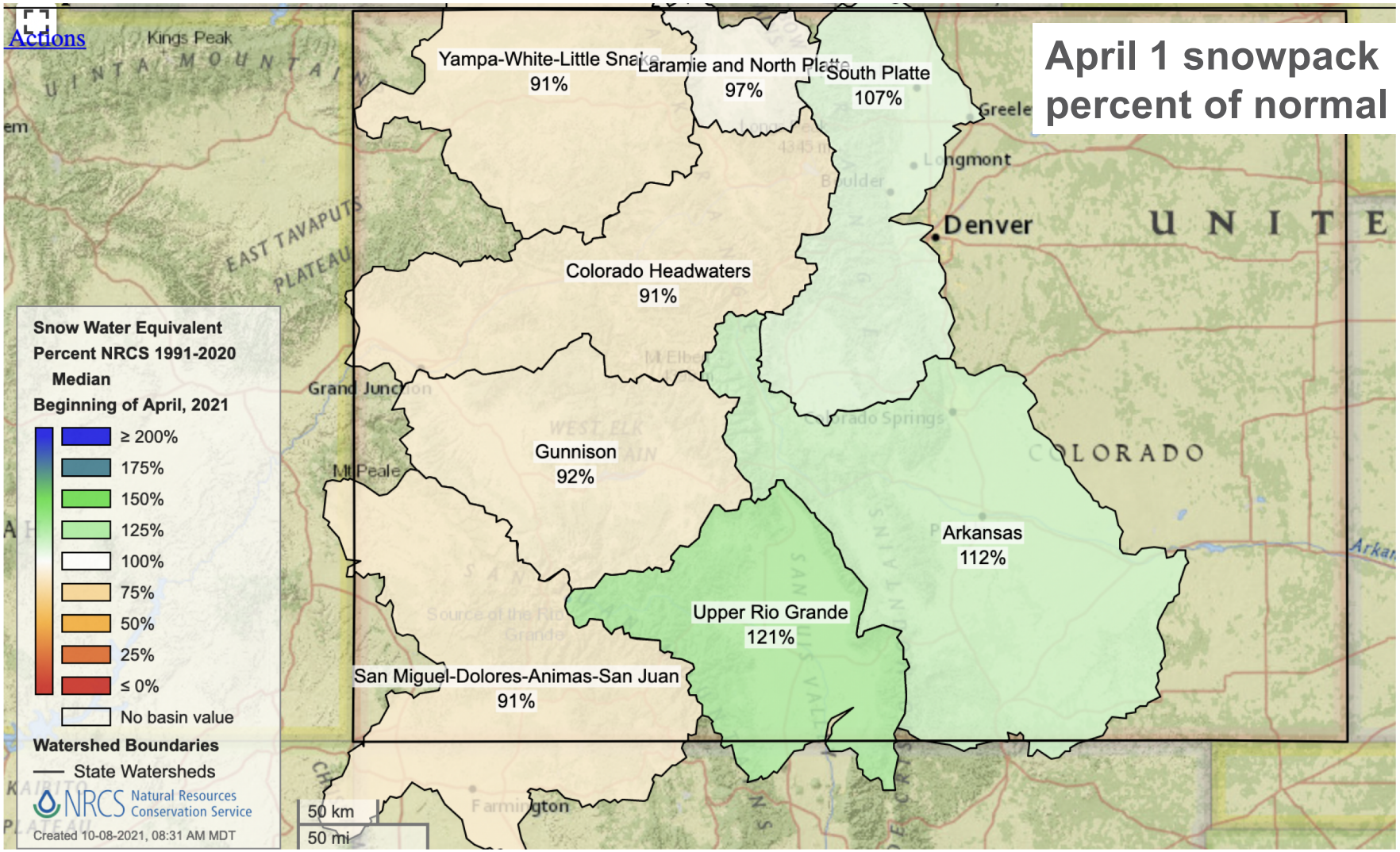
Observed snow from “Pi Day” storm

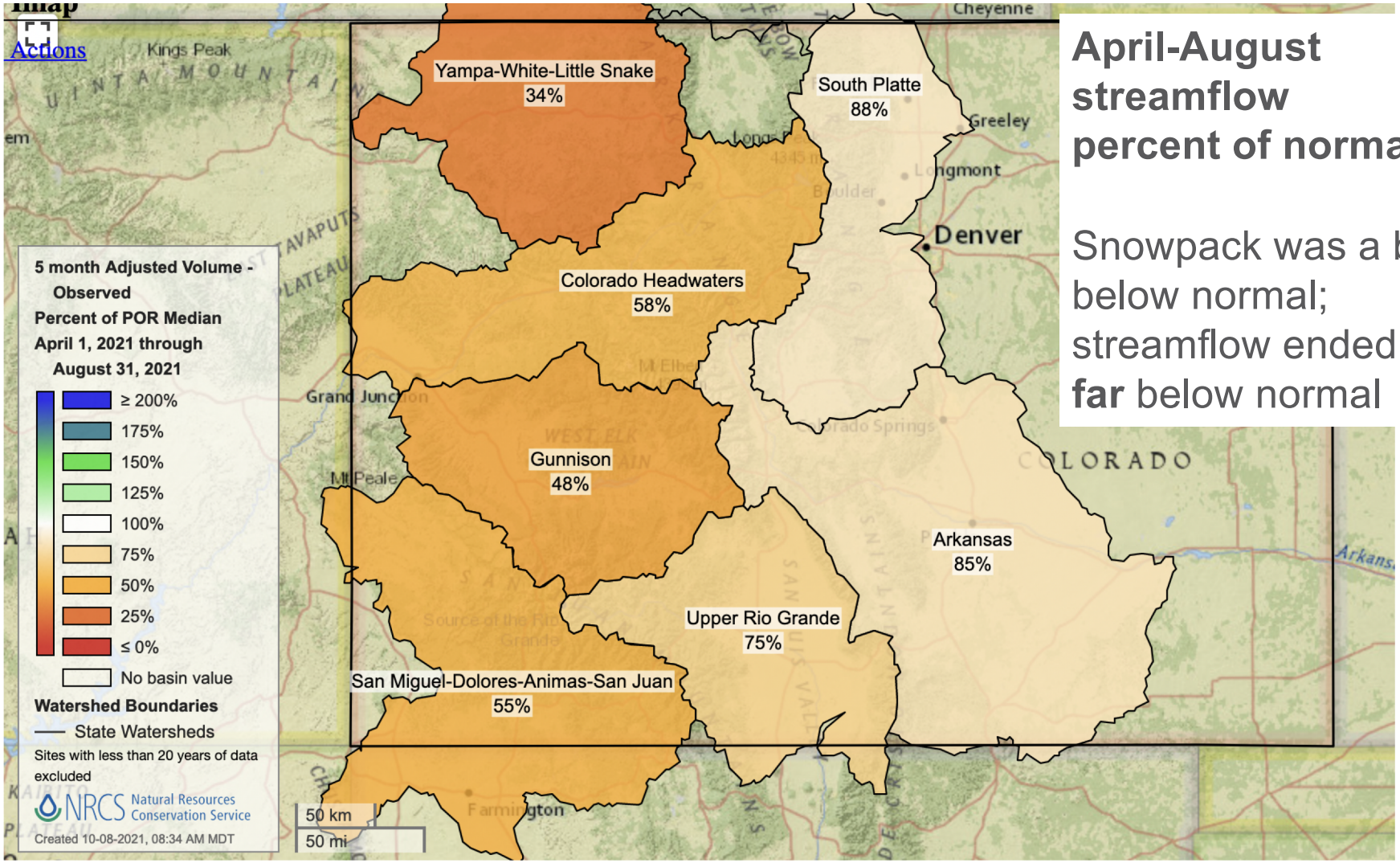


National Weather Service forecast issued March 12



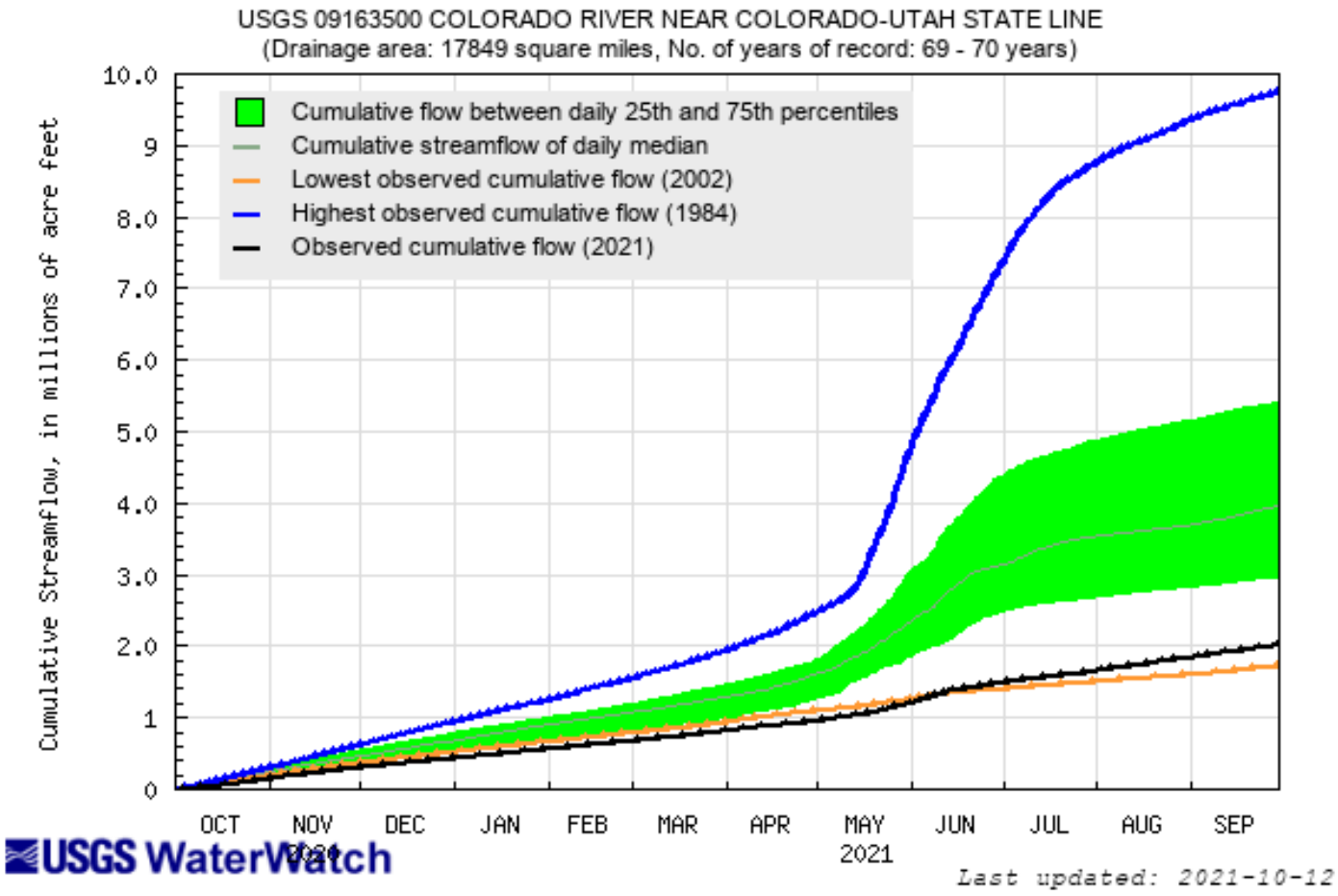
April 1 snowpack percent of normal





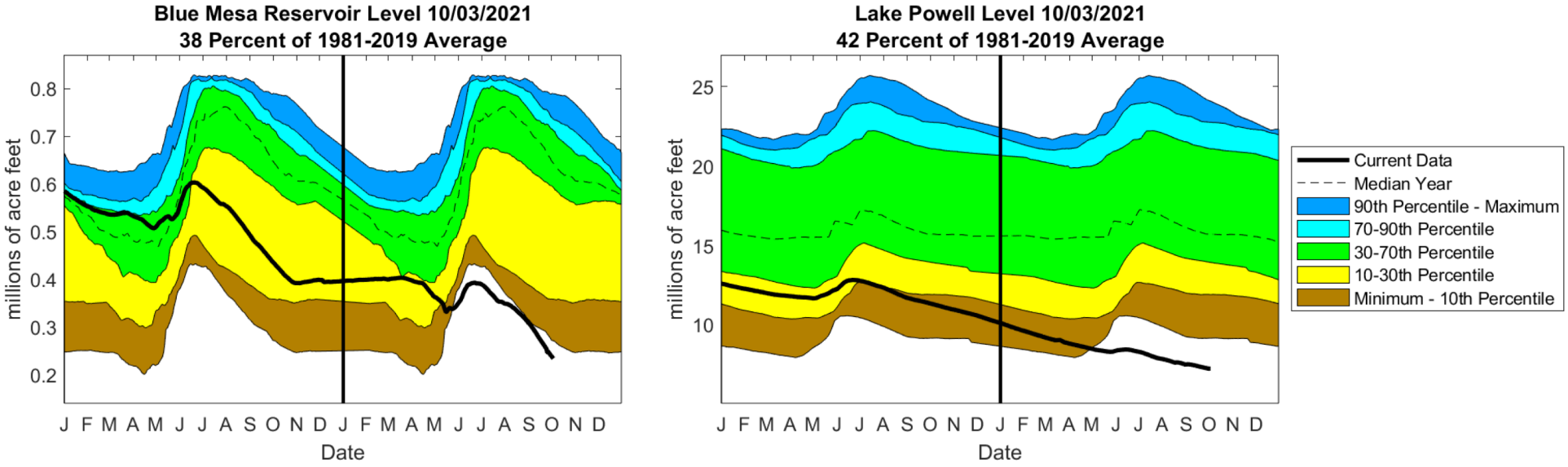
April-August streamflow percent of normal

Snowpack was a bit below normal; streamflow ended up **far** below normal



Summer precipitation was beneficial for staving off large fires, but didn't make a large difference in cumulative streamflow

Reservoirs in Colorado and throughout the southwest US reached concerningly low levels

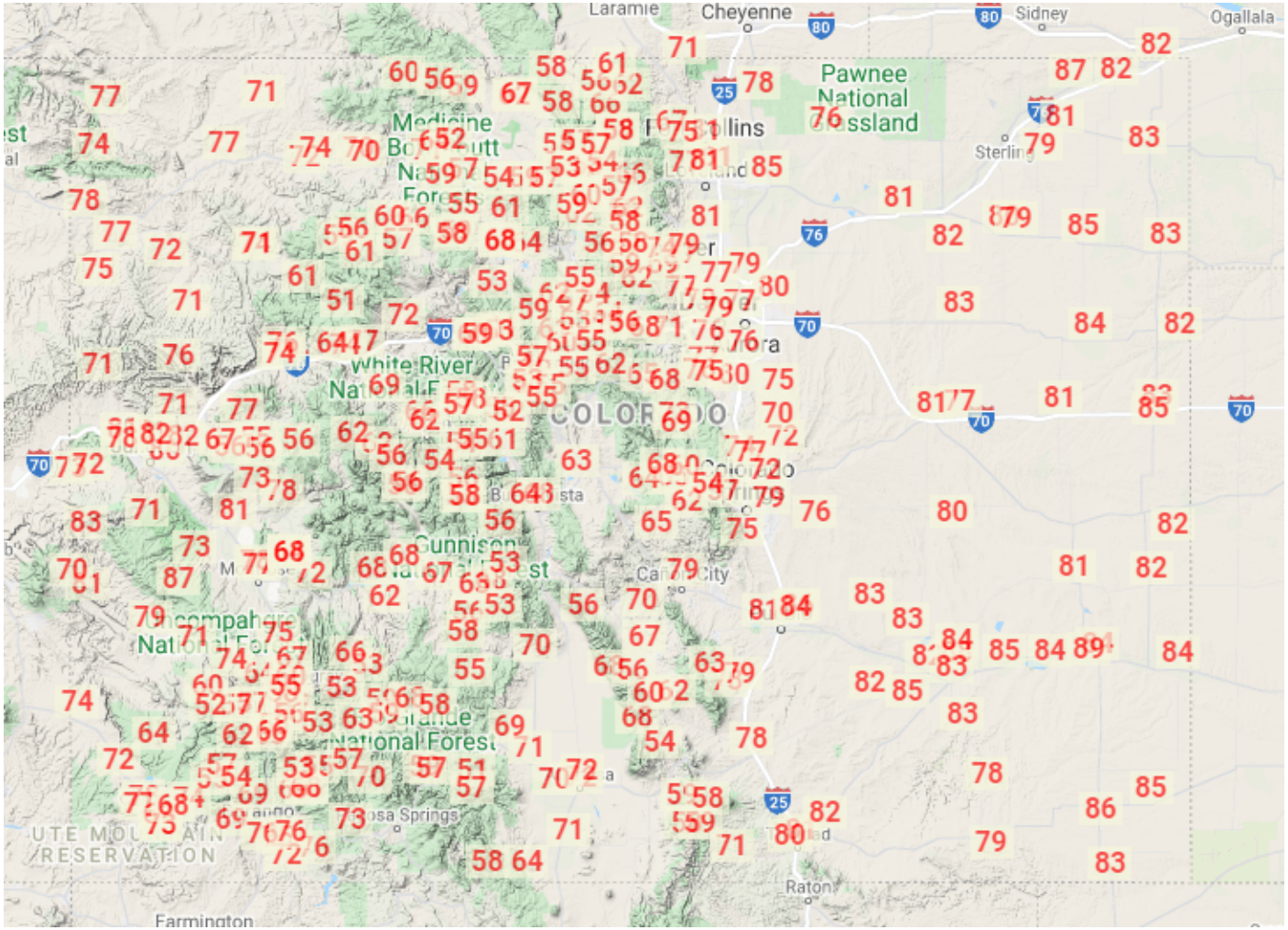


See others on our drought page:
https://climate.colostate.edu/drought/

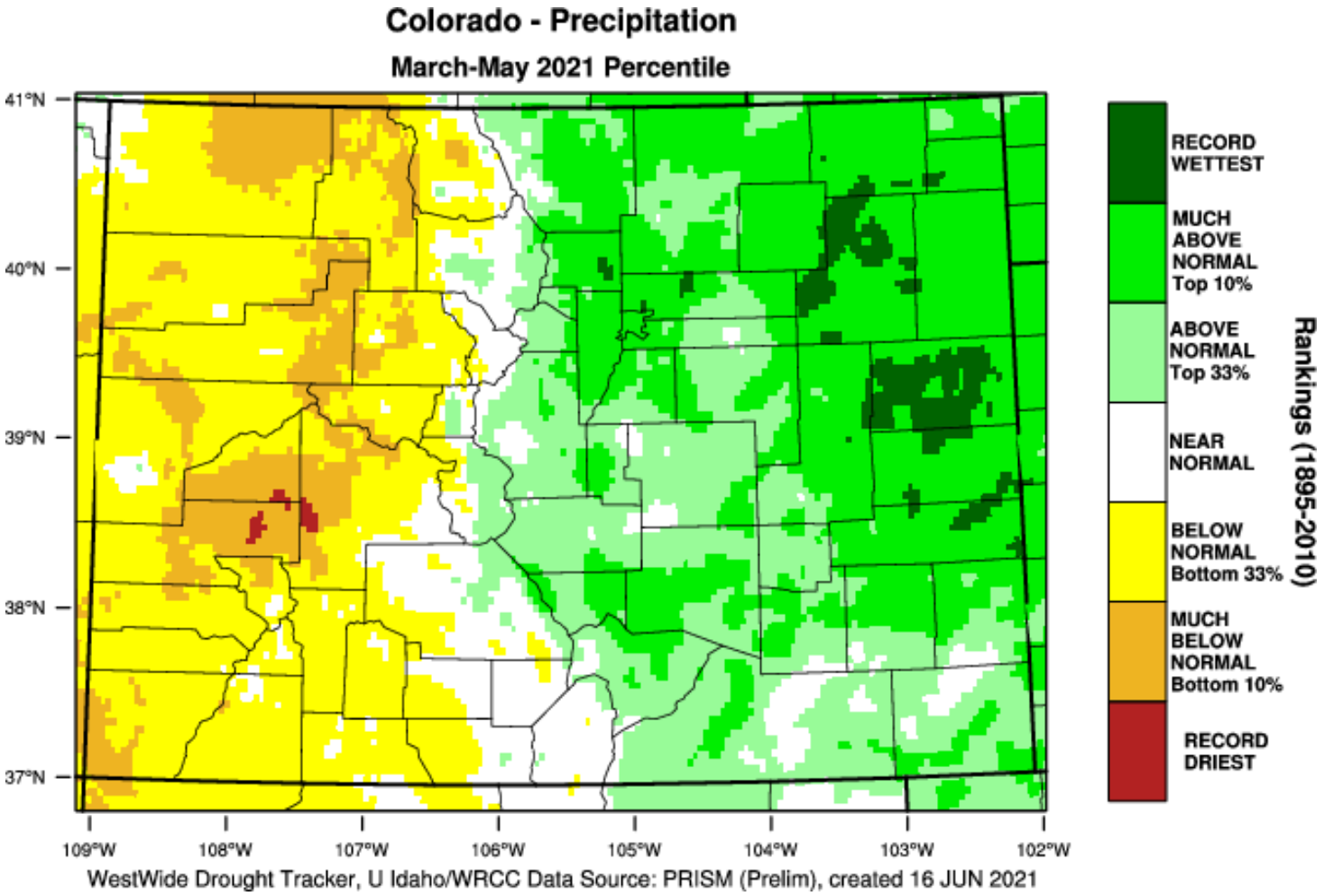
Easter Sunday Temperatures

90 degrees at Burlington the next day (4/5)

60 degree highs in the mountains, but still during ski season



May rains were timely out east

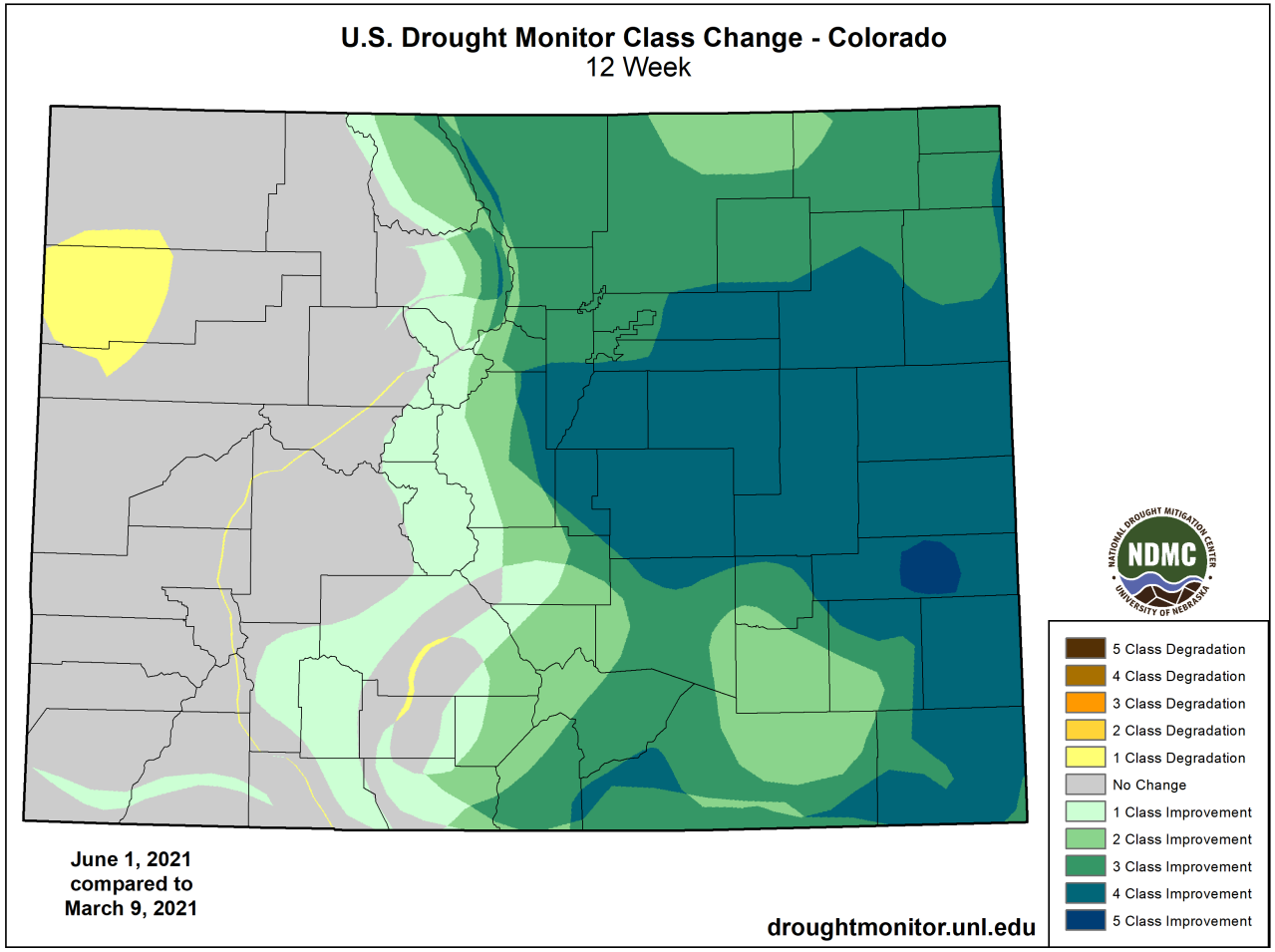


May rains were timely out east

Colorado experienced its 11th wettest May on record

This rain was mostly focused on the eastern plains

Akron experienced its wettest spring on record, but went on to have its second driest summer on record



June 12-19: A scorching week

All-time record high temperature tied at:

- Cortez (102°F), on both June 16 and 17
- Antero Reservoir (88°F), June 16

New June record high at Antero Reservoir (88°F), June 16

June record high tied at:

- Cortez (102°F), June 16 and 17
- Grand Junction (105°F), June 16
- Colorado National Monument (104°F), June 17
- Vallecito Dam (92°F), June 16

Streaks of daily record high temps:

- Alamosa: 6 straight record highs (June 12-17)
- Cortez: 6 straight record highs (June 14-19)
- Five straight days of record highs at Altenbern, Antero Reservoir, Del Norte, Dillon, Leadville, Grand Lake
- Four straight days of record highs at Crested Butte, Colorado National Monument, Grand Junction, Hayden, Monte Vista, Palisade
- Three straight days of record highs at Briggsdale, Denver, Fort Collins, Steamboat Springs, Yuma

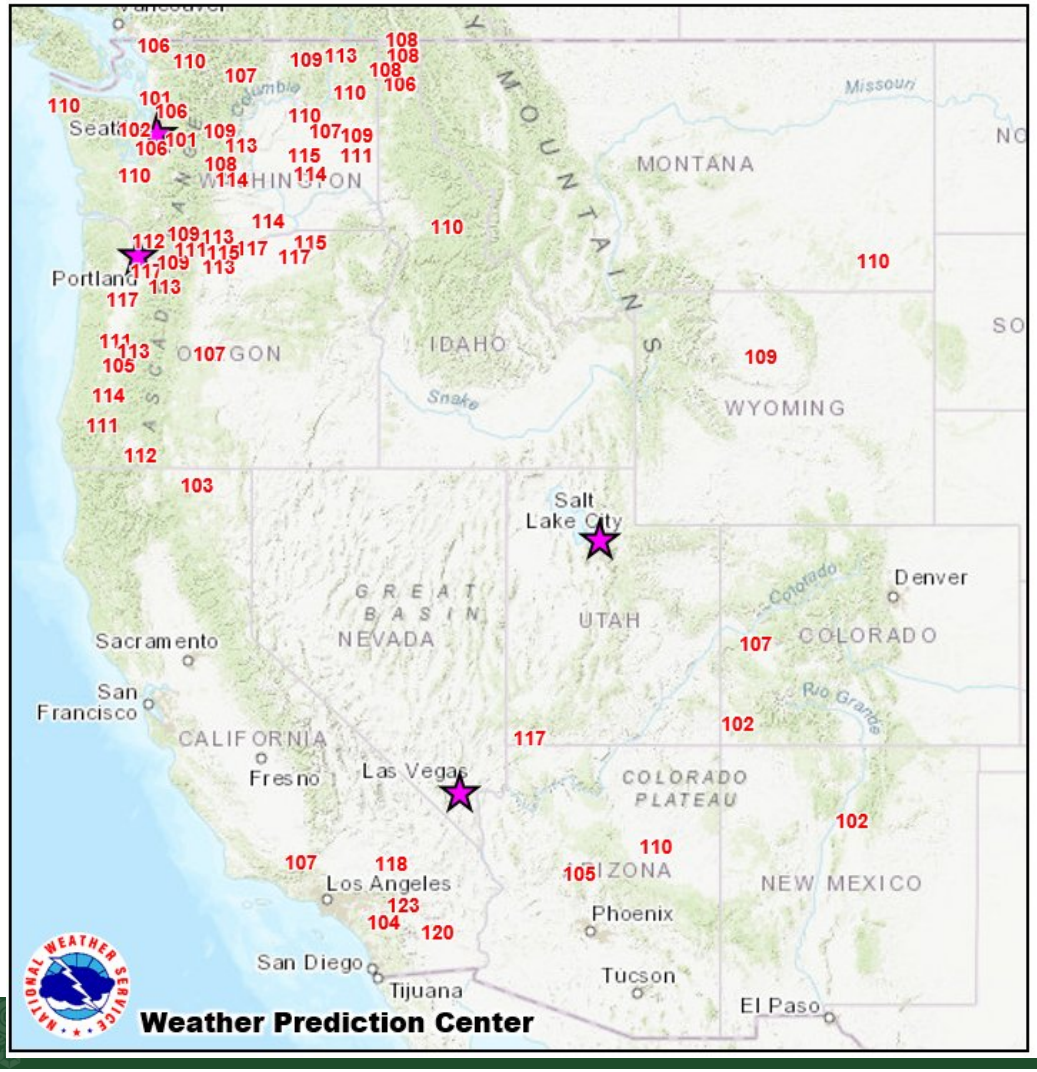
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Stations with at least 50 years of records

July 9, 2021:

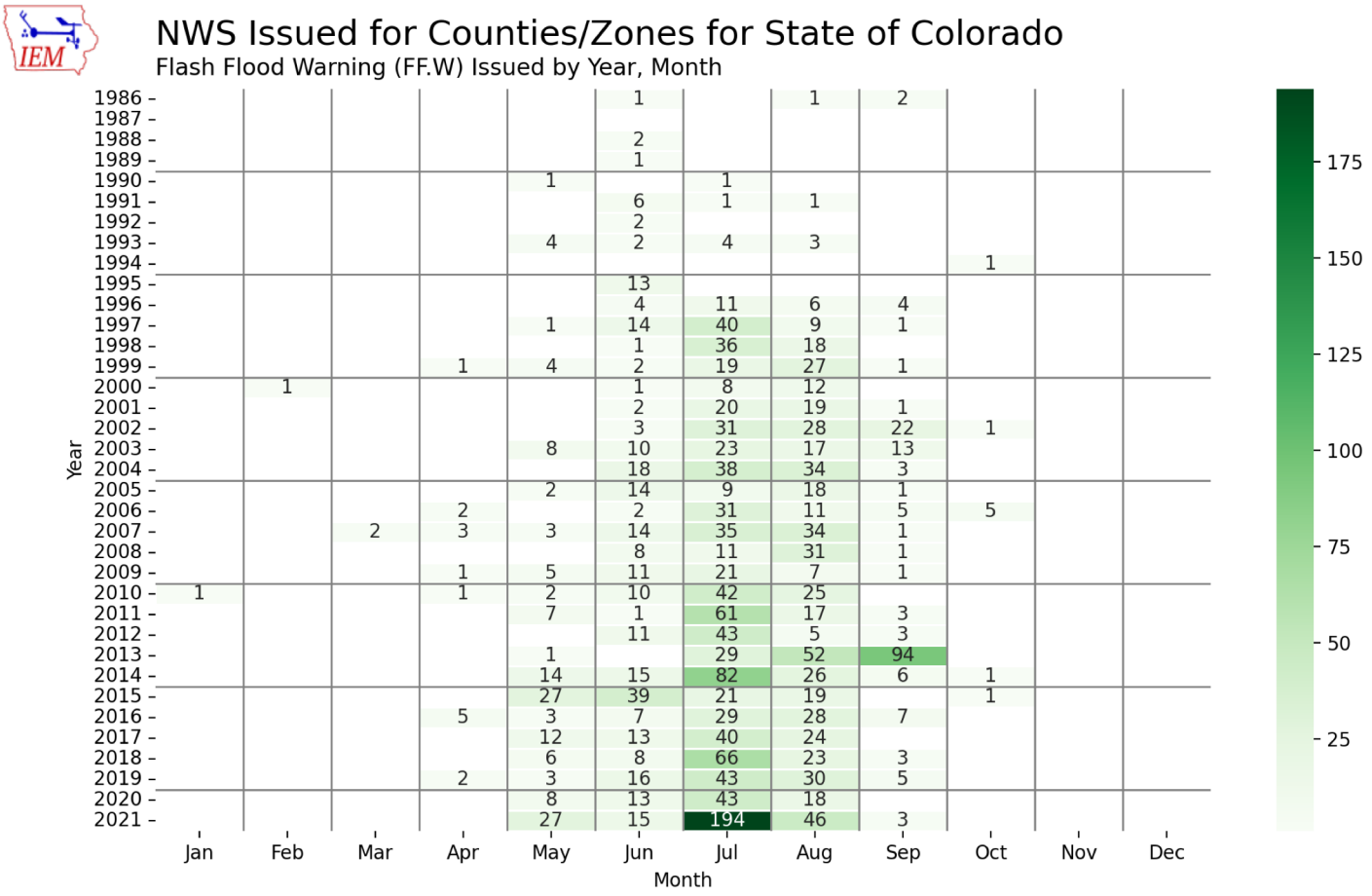

NEW ALL-TIME RECORD
SET IN GRAND JUNCTION
107
(2021)
106
(2005)
Grand Junction CO
NATIONAL WEATHER SERVICE
OCEANIC AND ATMOSPHERIC ADMINISTRATION
PHOTO: NWS

RECORD-BREAKING SUMMER 2021 IN THE WEST



- **Red numbers** indicate all-time heat records at sites with at least 75 years of records (at least back to WWII era)
- Numerous other daily and monthly records are not plotted here. Complete data for June 1 to July 8 only; a few records plotted for July 9 to 11.
- Pink stars (★) indicate several of the largest cities in the Western U.S. that at least tied their all-time heat records: Seattle (*108, Jun 28*), Portland (*116, Jun 28*), Salt Lake City (*t-107, Jun 15*), and Las Vegas (*t-117, Jul 10*).
- Per a NWS Portland Record Event Report, 117 in Salem, Oregon may be the hottest temperature on record west of the Cascades in the Pacific Northwest
- Several potential state heat records in Washington will be investigated, including 118 at the Dallesport Airport in the Columbia River Gorge
- California, Nevada, Arizona, Utah, and Idaho had their hottest June on record. Oregon, Washington, Montana, and Wyoming had their second hottest June.

All temperatures are in degrees Fahrenheit



Generated at 25 Oct 2021 3:26 PM CDT in 1.81s

IEM Autoplot App #171

Figure as seen in Denver Post

Floods During Drought?

- Record number of flash flood warnings in Colorado
- Floods occur easily over burn scars (hydrophobic soils), so an active monsoon season + many burn scars led to lots of warnings

Black Hollow Flood, Poudre Canyon

- Flash flooding occurred on burn-scarred land high up in the Poudre Canyon July 21st, 2021
- 4 people were killed
- https://www.larimer.org/spotlights/2021/07/21/black-hollow-poudre-canyon-flooding-information



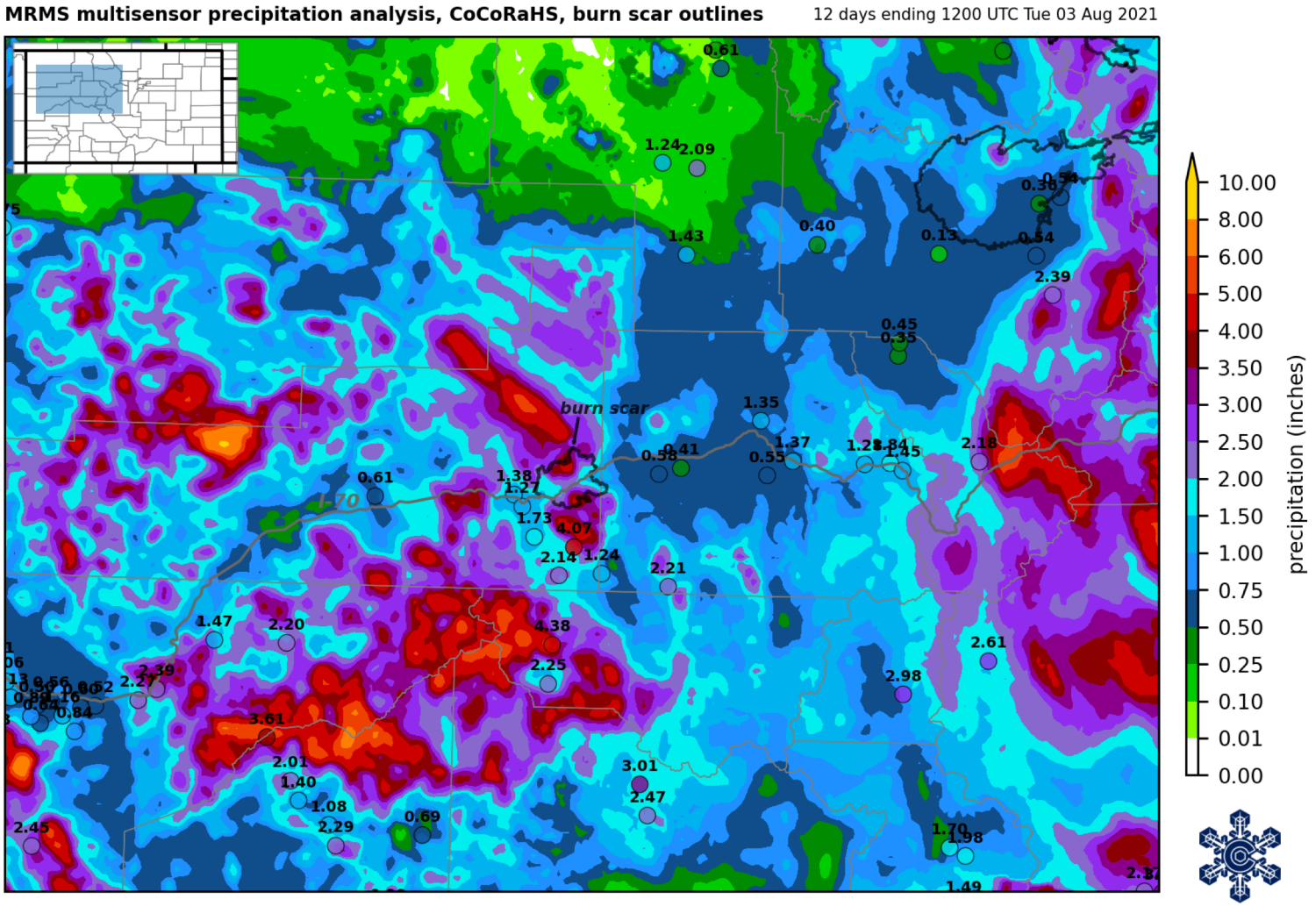
Glenwood Canyon debris flow

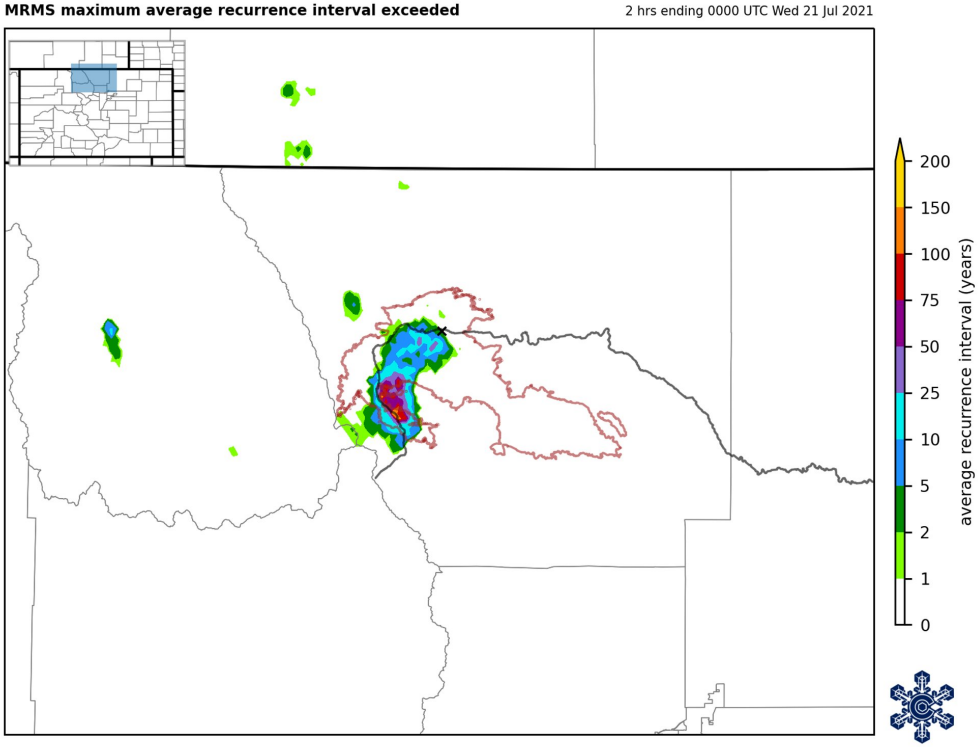


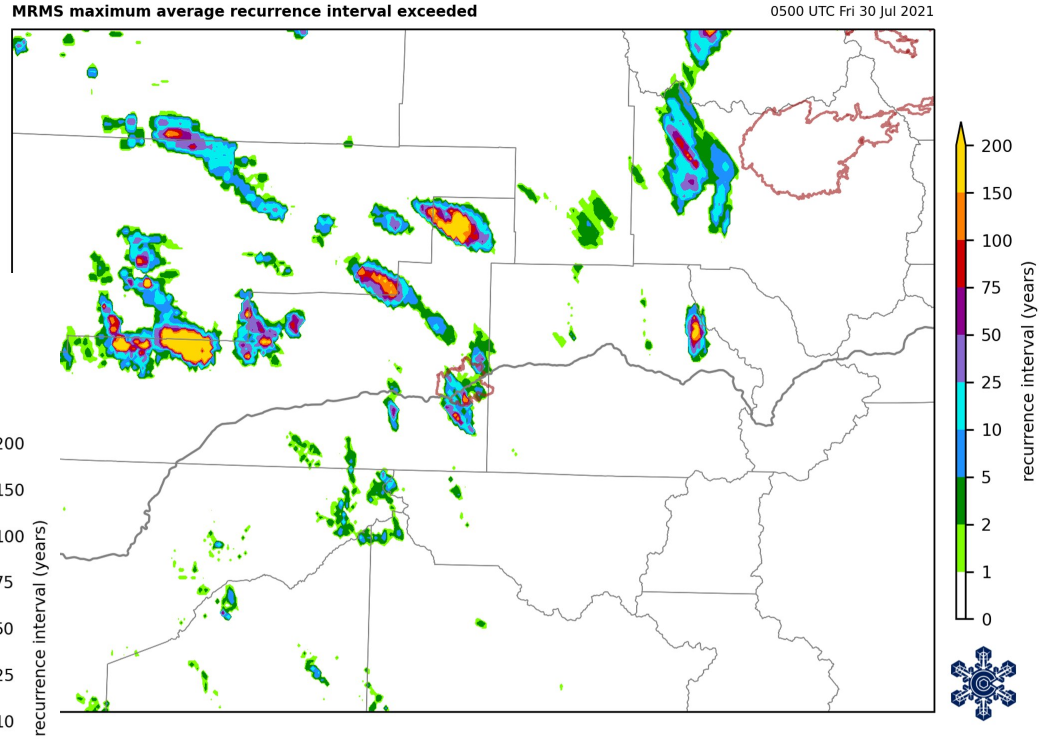
I-70 flash flood and debris flow

12-day total precipitation (July 22 – August 3)

NOAA MRMS precipitation dataset + CoCoRaHS observations







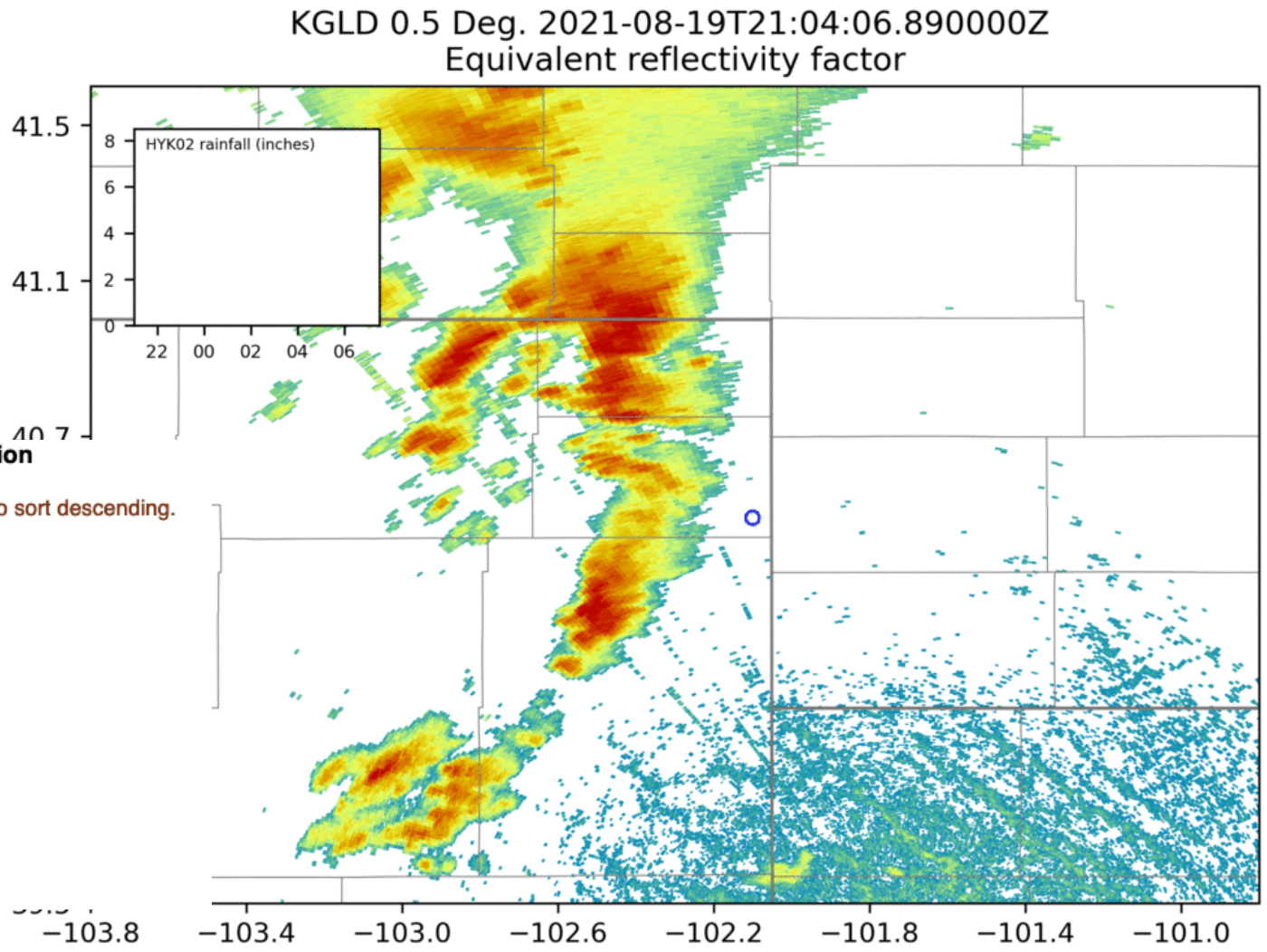
Return frequencies for flooding events

Notable rain gauge data from Grizzly Creek burn scar

- **July 29: Coffee Pot (USGS): 0.98” in 12 minutes, 1.59” in 20 minutes, 1.76” in 30 minutes, 2.03” in 60 minutes**
- **July 29: Deadmans Creek (USGS): 0.99” in 25 minutes, 1.57” in 60 minutes, 1.96” in 100 minutes**
  - Somewhere between 1/200 and 1/1000 probability of occurring in a given year at these two stations
- July 29: Bair Ranch 0.4W (CDOT): 1.03” in 15 minutes, 1.1” in 20 minutes; 1.2” in 30 minutes
- July 29: East Fork Dead Horse Creek (USGS): 0.82” in 45 minutes, 0.98” in 60 minutes
- July 29: Cinnamon Creek (USGS): 0.69” in 12 minutes, 0.87” in 25 minutes
- July 31: East Fork Dead Horse Creek (USGS): 0.76” in 11 minutes, 1.09” in 36 minutes

Holyoke had nearly half its annual rainfall in a few hours.

A CoAgMET station southeast of Holyoke received 8.11” of rain on the night of August 19



Maximum 1-Day Total Precipitation for HOLYOKE, CO

Click column heading to sort ascending, click again to sort descending.

Rank	Value	Ending Date
1	4.55	1936-07-29
2	4.26	2021-08-20
3	3.63	1902-09-22
4	3.54	1908-10-19
5	3.53	1951-05-15
6	3.51	2009-06-02
7	3.24	1938-07-15
8	3.02	2004-07-16
9	3.00	1963-07-27
-	3.00	1919-09-02
Period of record: 1893-01-26 to 2021-08-20		

Burlington Blowdown:

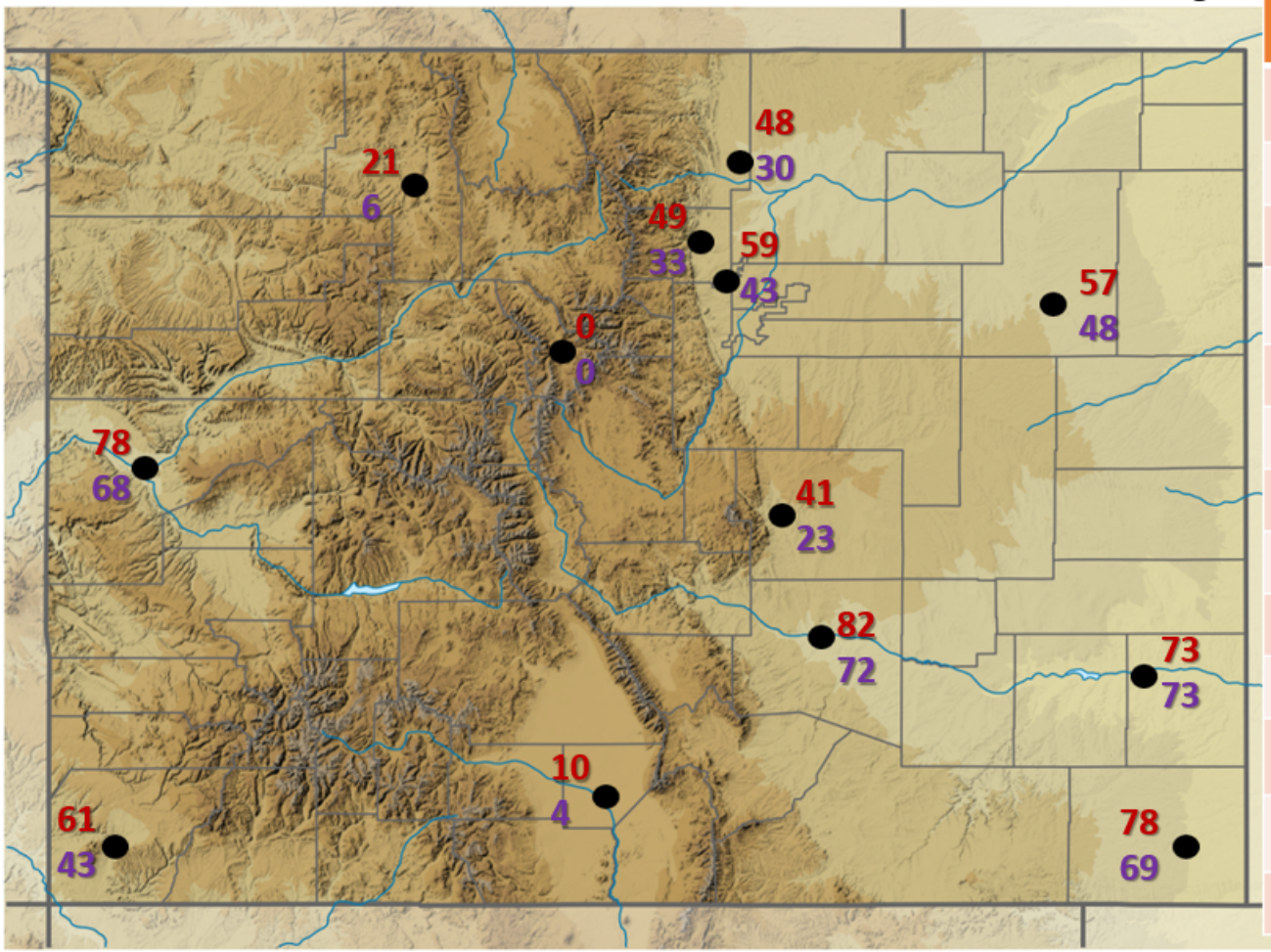
A dangerous microburst hit east Burlington on September 1st, 2021

Peak winds were estimated at 115mph

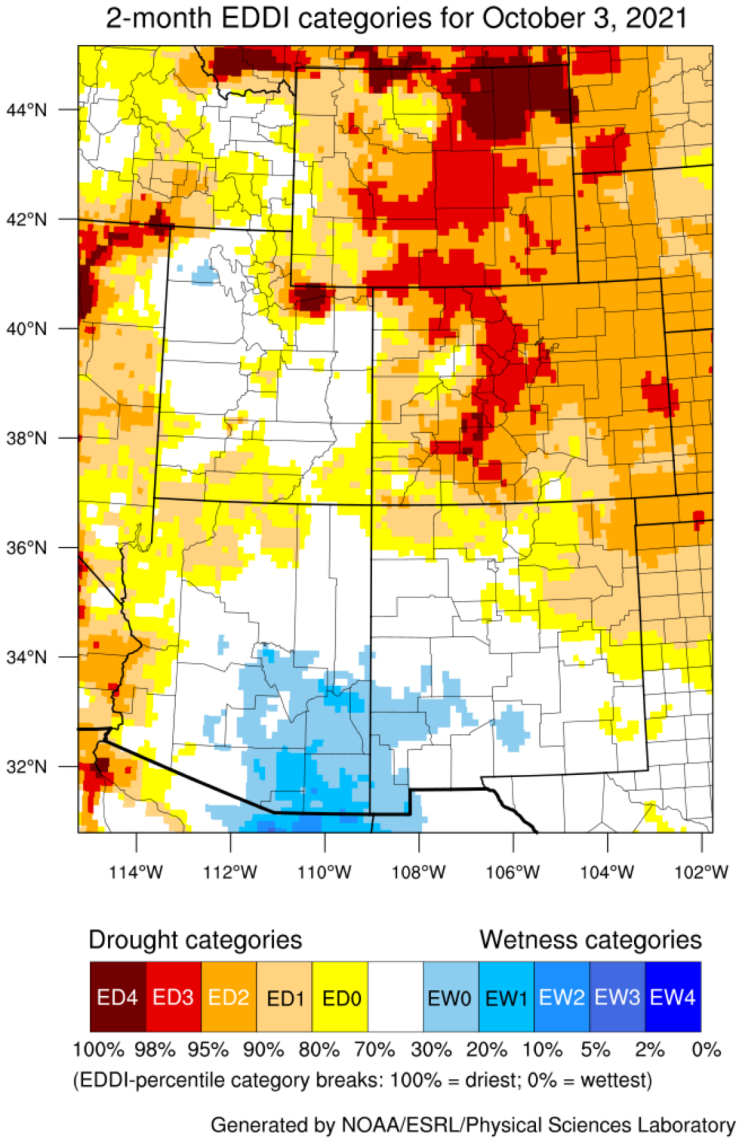
Nobody was injured or killed



Number of 90 Degree Days in 2021



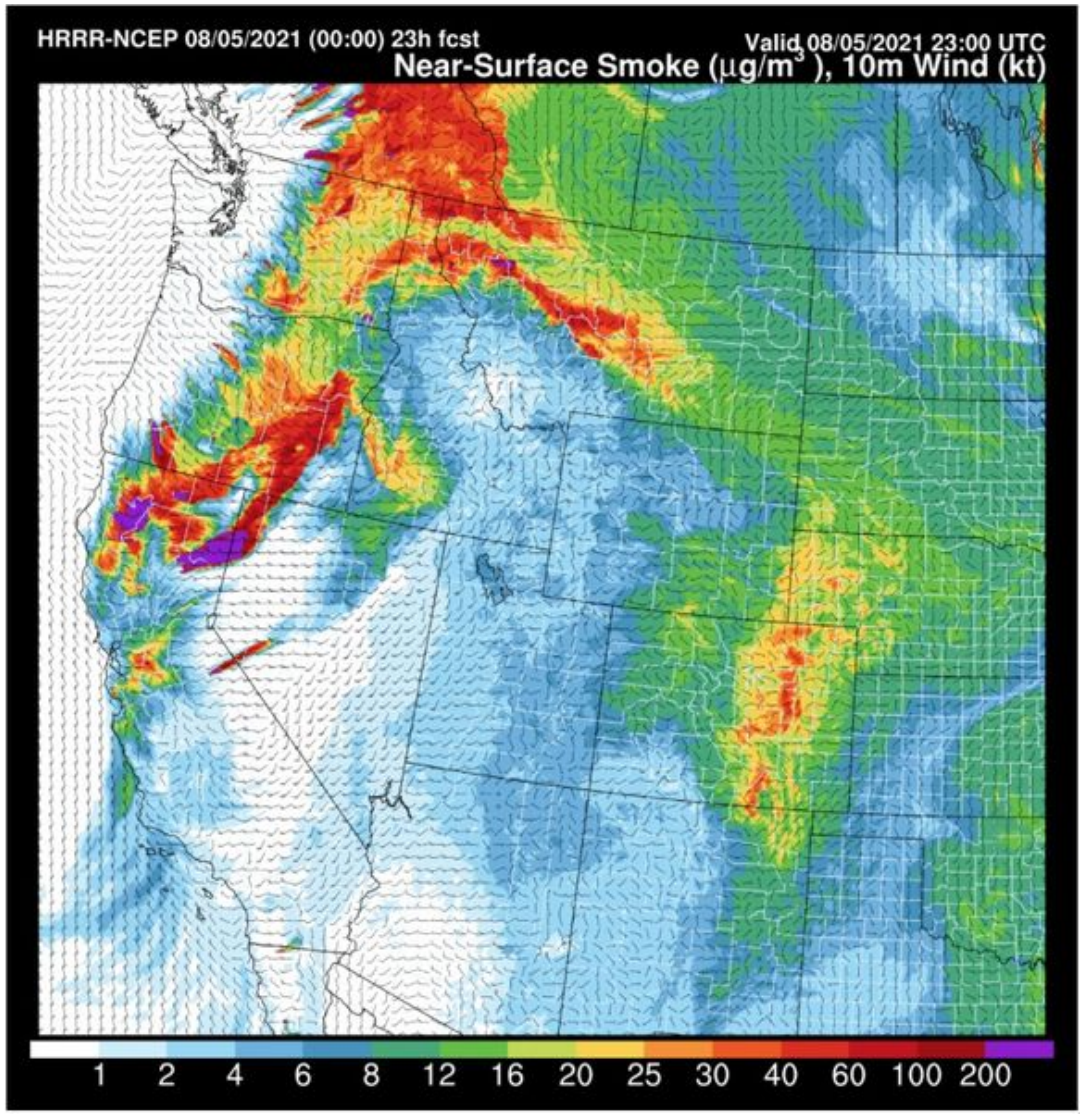
City	N Days	1991-2020 Average	Rank	Records Begin
Fort Collins	48	30	3rd	1893
Boulder	50	33	10th	1893
Denver	61	43	4th	1948
Colorado Springs	41	23	4th	1948
Pueblo	87	72	4th	1954
Akron	59	48	9th	1937
Lamar	78	73	62nd	1893
Walsh	84	69	5th	1967
Dillon	0	0	---	1910
Alamosa	10	4	3rd	1948
Steamboat Springs	21	6	4th	1893
Grand Junction	78	68	9th	1900
Cortez	61	43	3rd	1911



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Evaporative Demand Drought Index

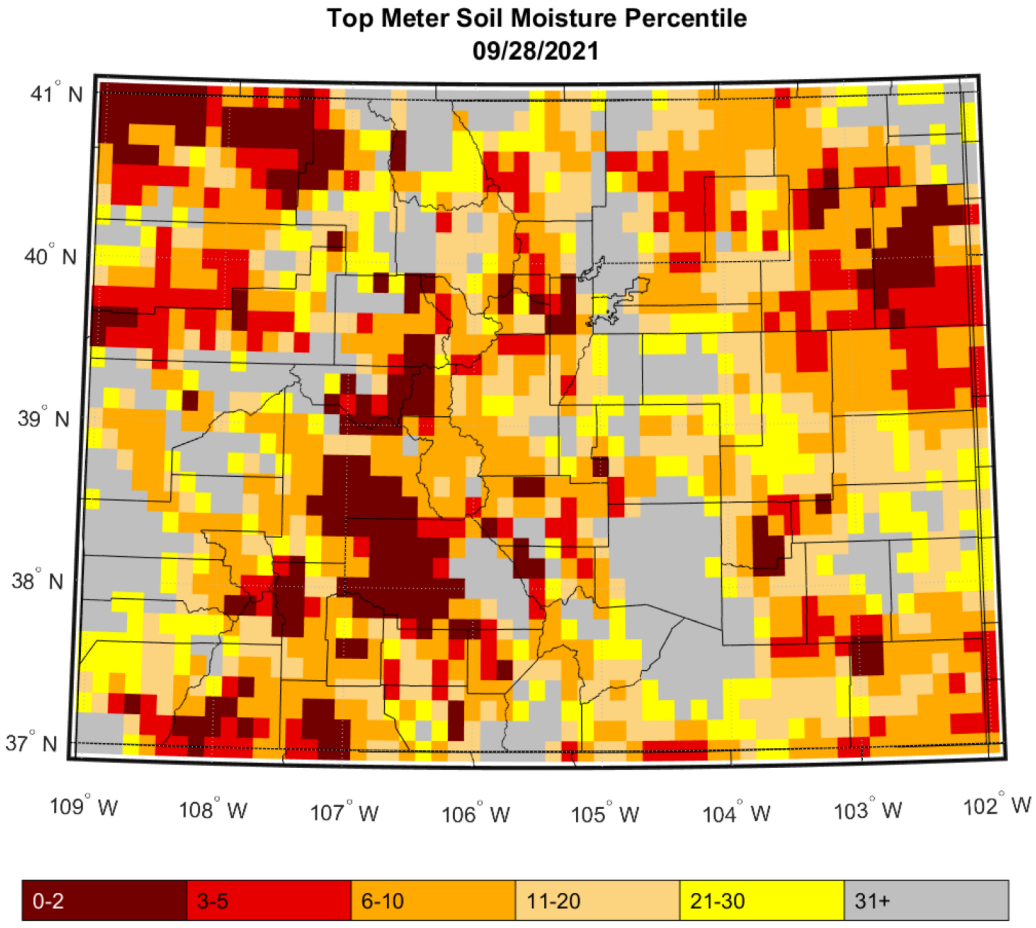
Evaporative demand was once again high in late summer into fall, though not nearly as bad as last year



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Air Quality

Smoky conditions were commonplace for much of July and August, this time due to out of state wildfires



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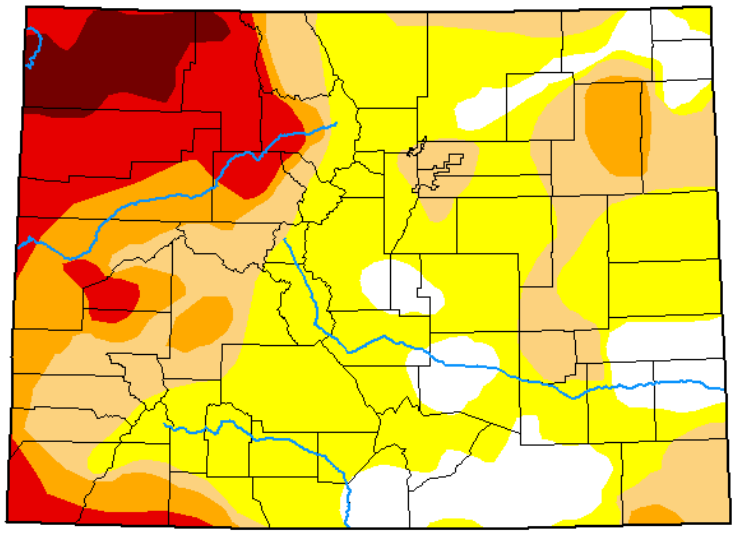
Soil moisture

This was looking pretty good as of early summer, but dryness in the late summer and fall started to show up in soil moisture

Long Term Drought Remains

U.S. Drought Monitor

Colorado



September 28, 2021

(Released Thursday, Sep. 30, 2021)

Valid 8 a.m. EDT

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	12.72	87.28	46.42	26.30	15.05	3.91
Last Week *09-21-2021*	16.92	83.08	40.94	24.58	15.05	3.91
3 Months Ago *06-29-2021*	54.48	45.52	41.62	36.37	29.95	17.52
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 *09-29-2020*	0.00	100.00	99.29	89.35	52.88	2.64

Intensity:

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

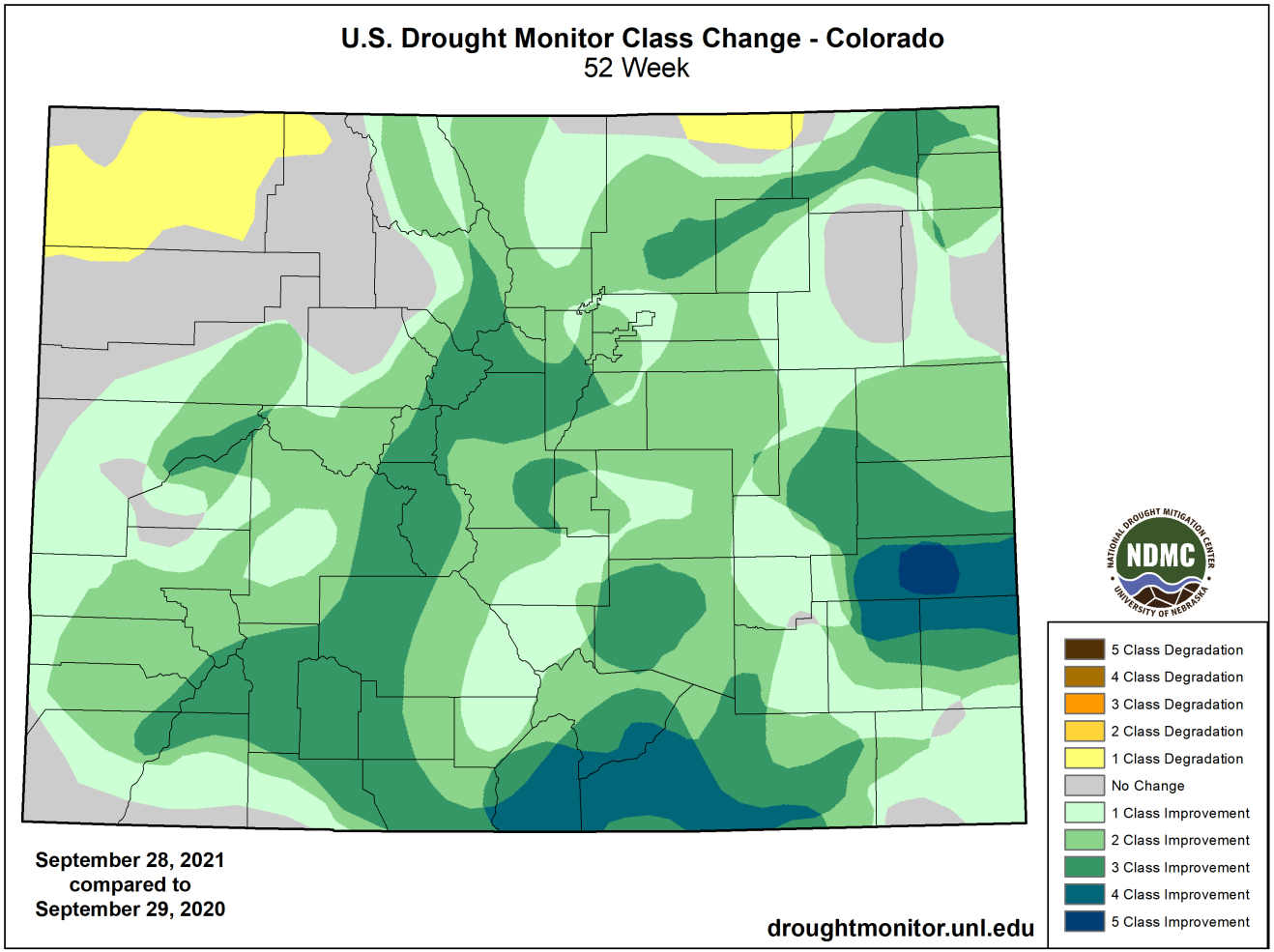
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. For more information on the Drought Monitor, go to https://droughtmonitor.unl.edu/About.aspx

Author:

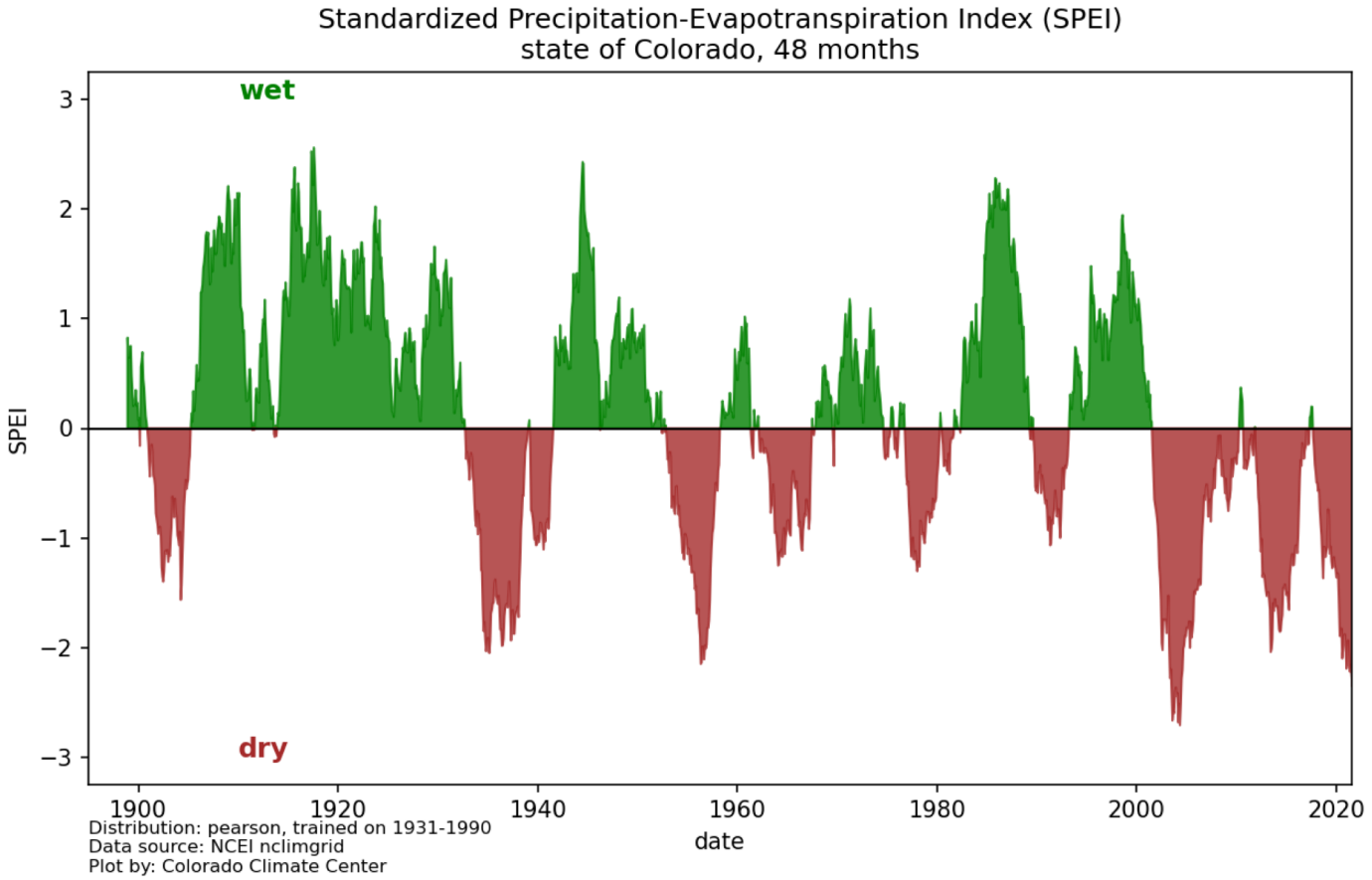
Brian Fuchs
National Drought Mitigation Center

droughtmonitor.unl.edu

But things are better than last year



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



Considers precip + temperature

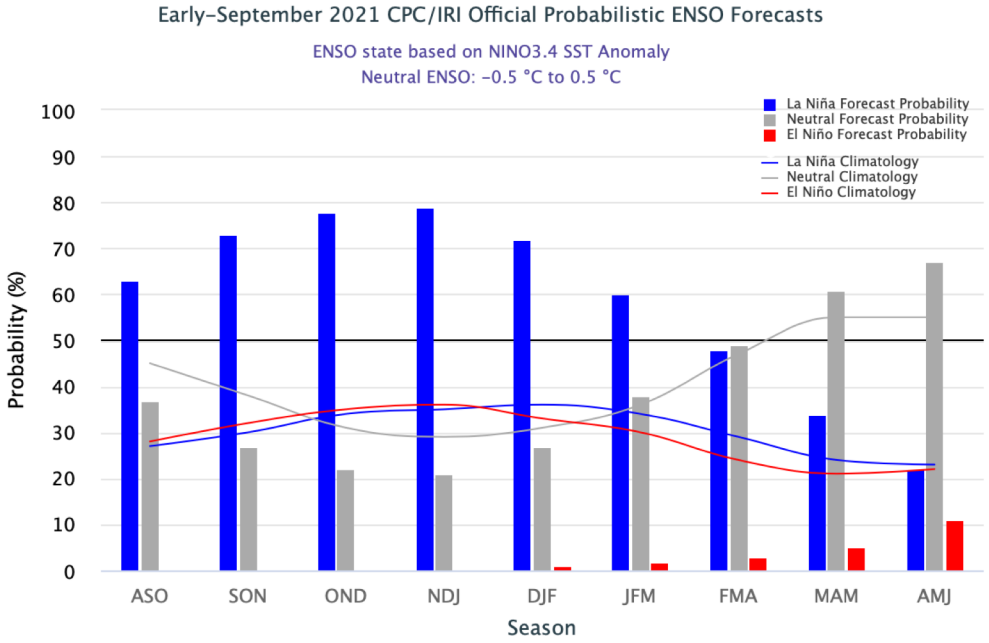
Standardized precipitation-evapotranspiration index (48 months, Colorado statewide)

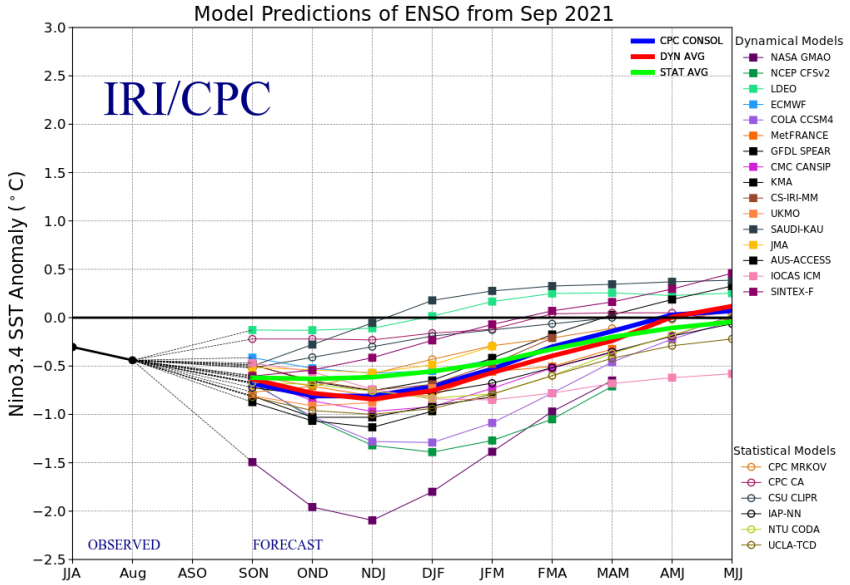
Seasonal Outlook

- Similar to a mogul run, our seasonal weather is the net result of several weather events, each of which are difficult to predict



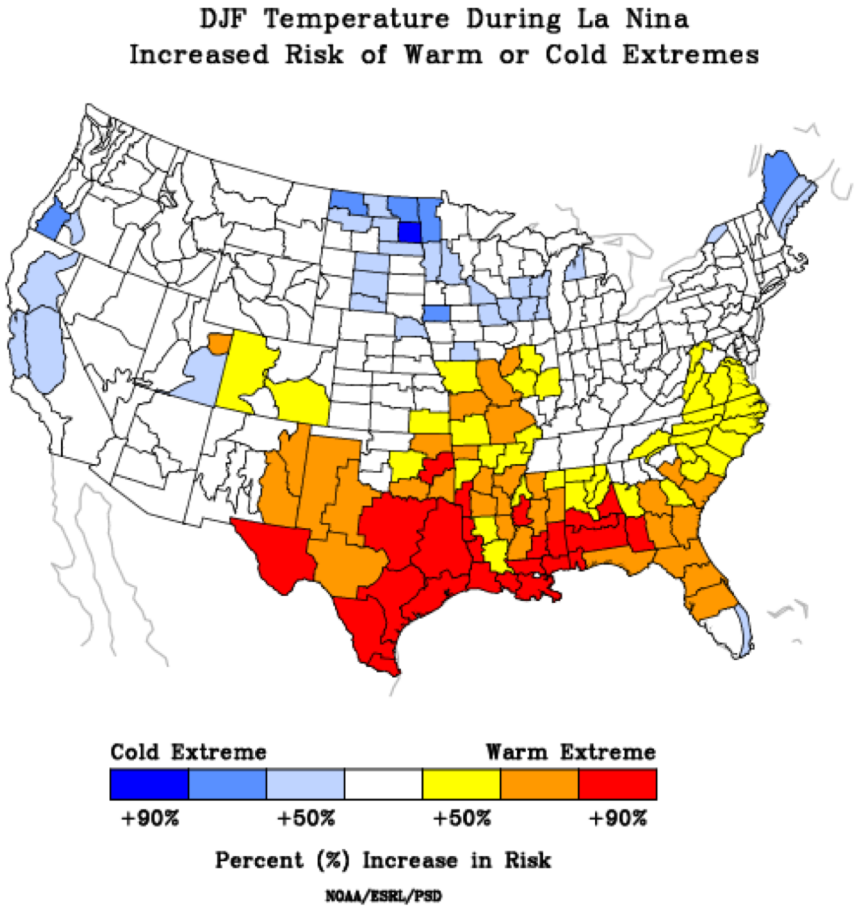
La Niña this winter and likely spring

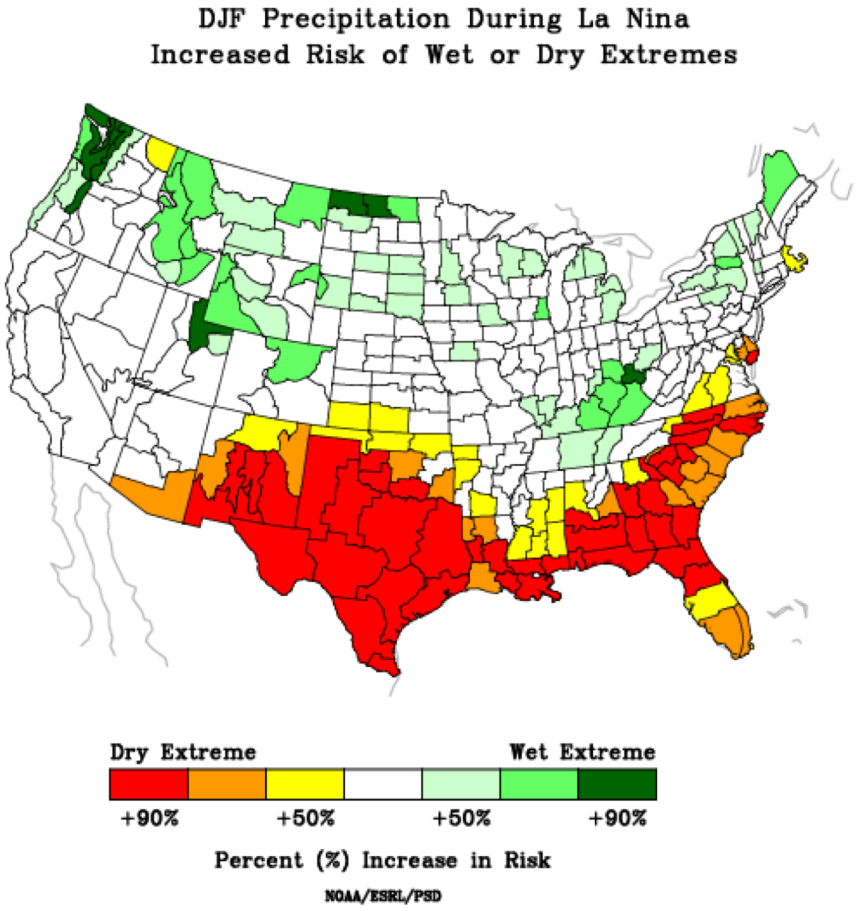




A week La Niña is likely this winter. This will be the second straight year of La Niña. The last two 2nd year La Niñas were 2012 and 2018.

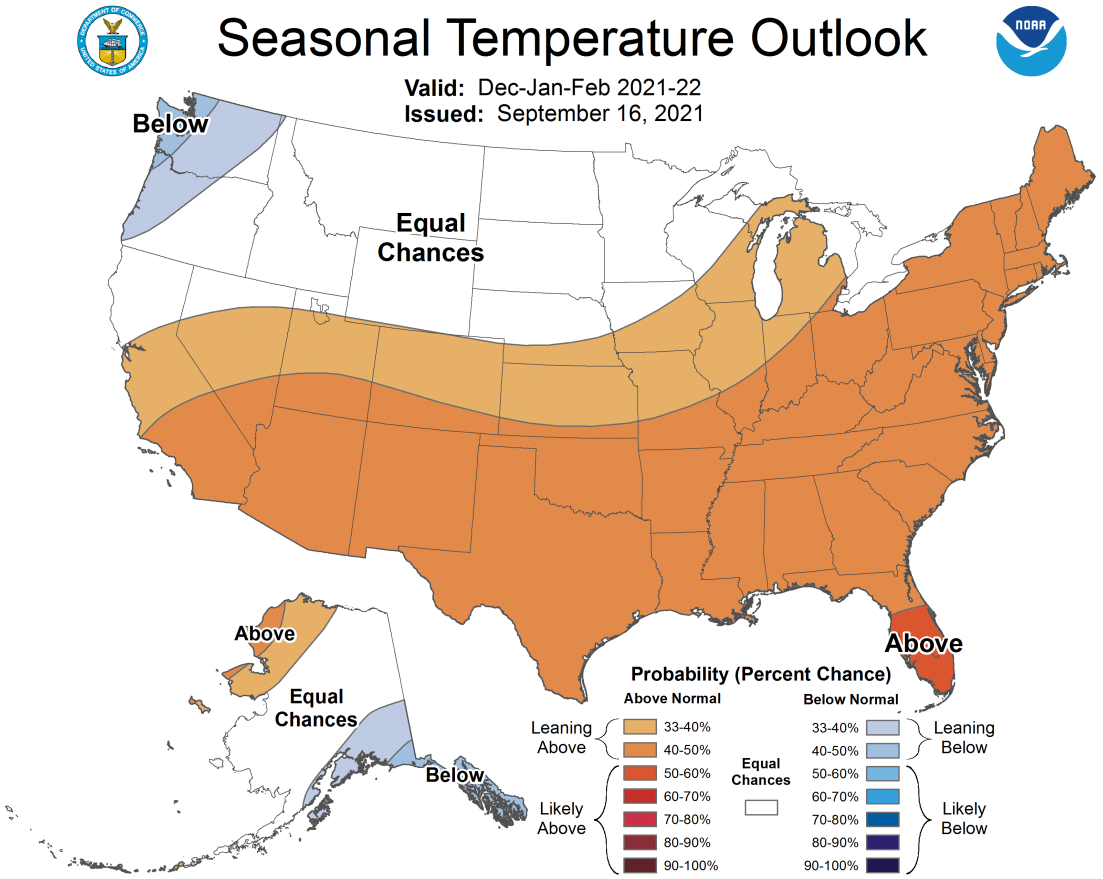
What's La Niña mean for fall/winter?





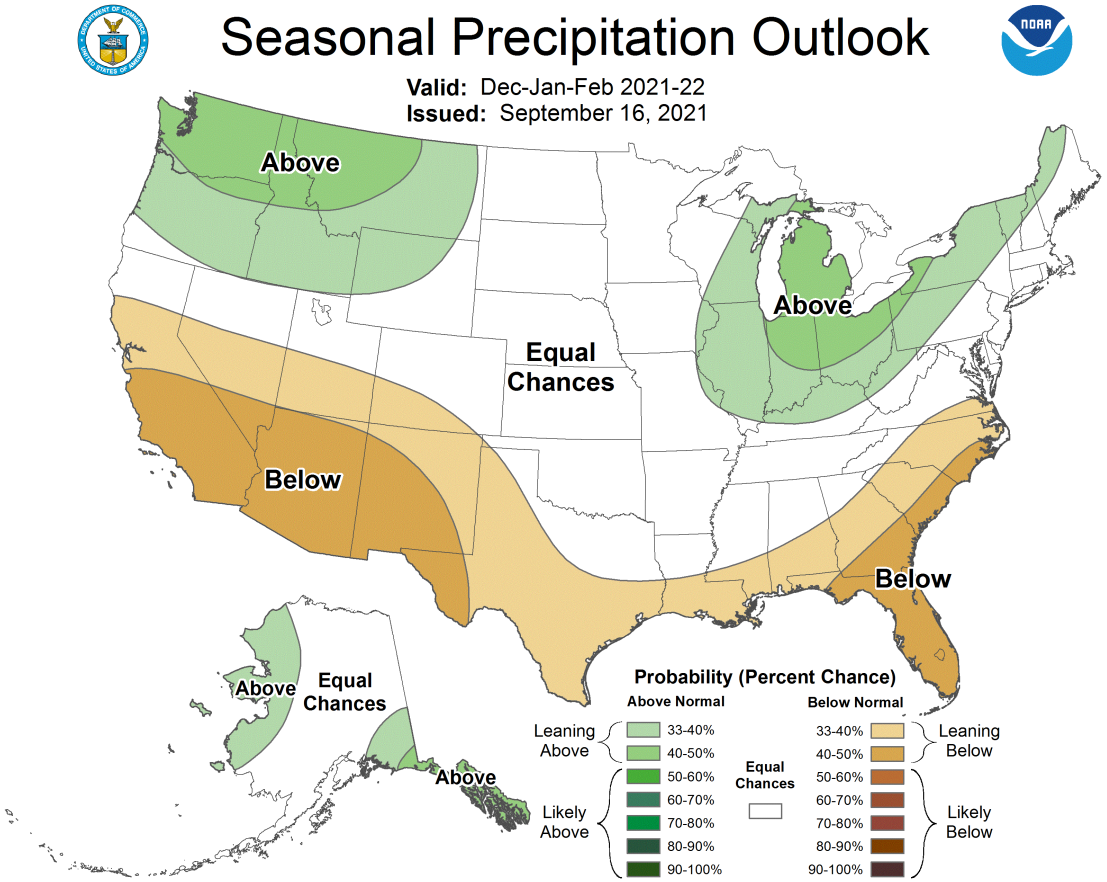
Climate Prediction Center Forecast

- December –February Temperature forecast
- Warm colors = increased chance of above normal
- Cool colors = increased chance of below normal
- The combination of global greenhouse gas-driven trends, and a dry land surface both elevate the odds of warmer than normal temperatures



Climate Prediction Center Forecast

- December – February precipitation forecast
- Greens = increased chance of above normal precip
- Browns = increased chance of below normal precip
- La Niña years are typically dry in fall, but that changes in winter



Seasonal outlook

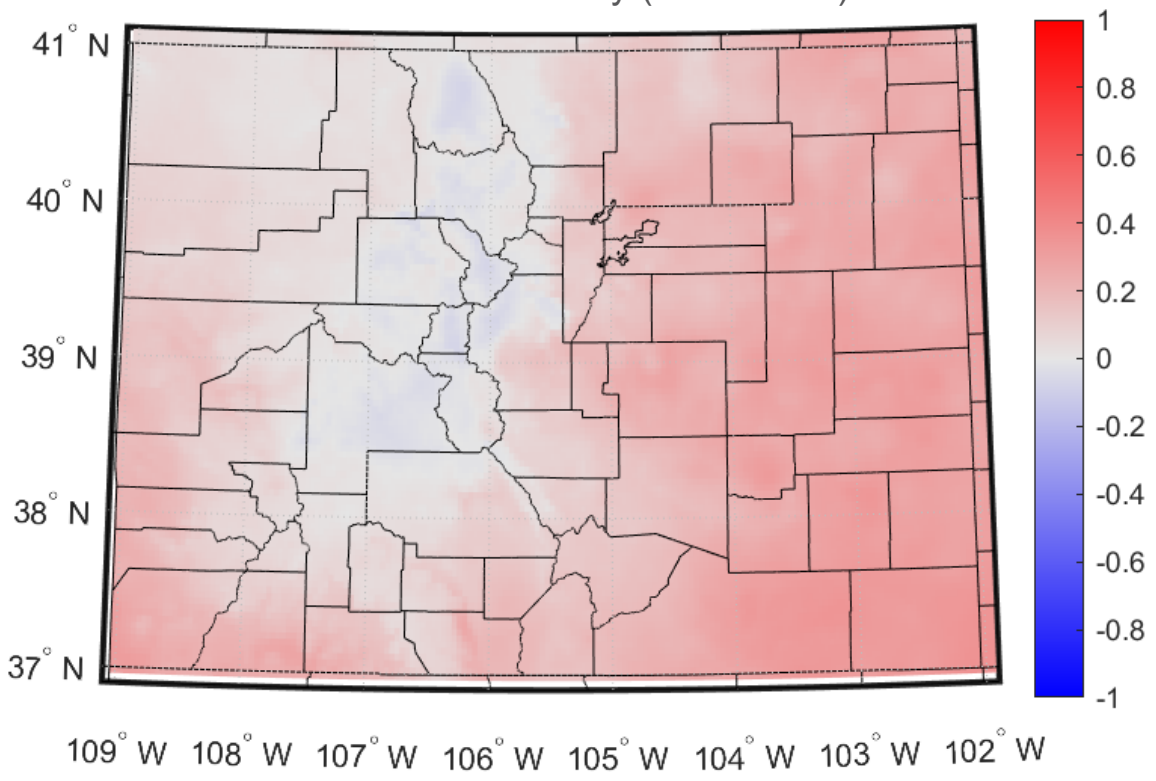
La Niña generally means more moisture to the north, less to the south

La Niña may lead to snowier winters in the northern Rockies

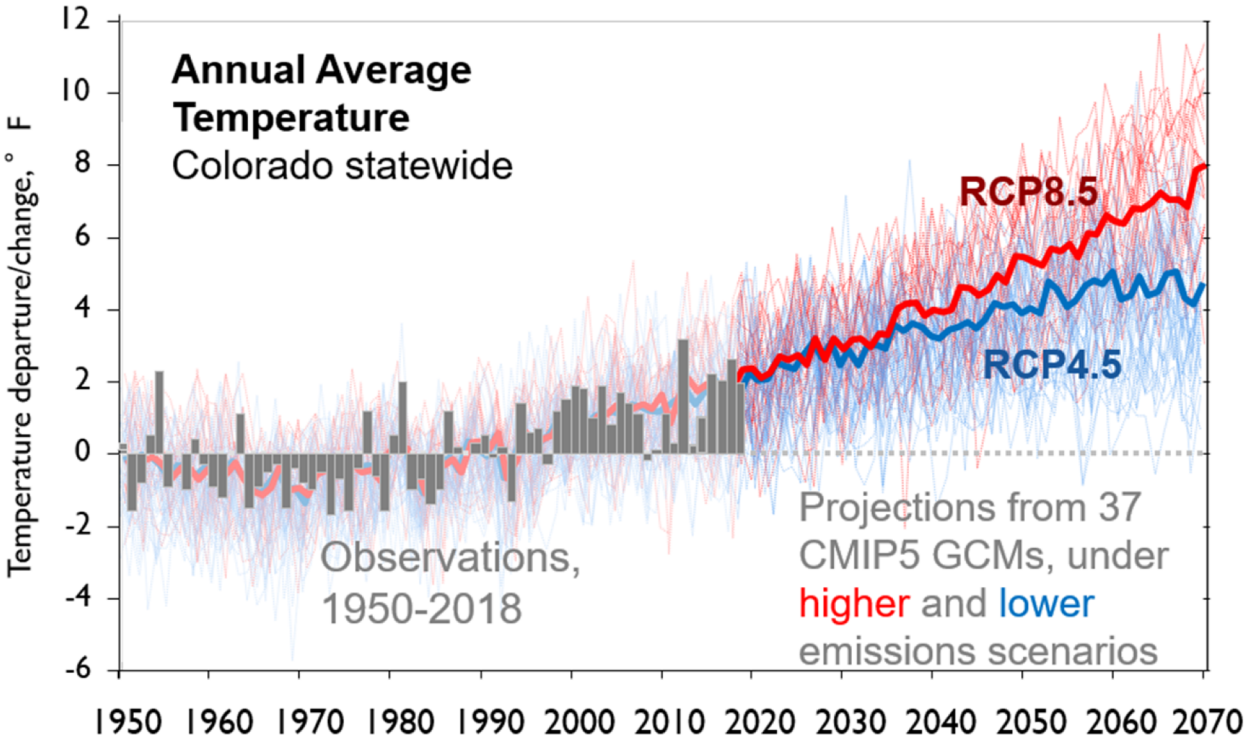
Second year La Niñas have been dry in recent decades

Expect snow in the northern Rockies and wind in the Ark Valley

Correlation between seasonal precipitation and ENSO MEI for December-February (1951-2020)



Long-term Planning



- Colorado is going to continue to warm, and that disrupts every part of our water cycle
- Some years will be good, but dry years will sting more with time
- The largest source of uncertainty in future climate is human actions, but expect trends to continue for the foreseeable future
- Our long-term plans need to be tailored for a more drought-prone, fire-prone state

Source: Updated and adapted from Lukas et al. (2014), Climate Change in Colorado

In Summation

- WY 2021 started with unprecedented wildfires. Conditions have improved since then, but we have a long way to go
- Low soil moisture and base flows lead to a below normal runoff despite decent snowpack. Western Colorado, and the Western US, remains in hydrological drought
- Big rains and snows brought significant relief to eastern Colorado this year, but we're drying again
- We had our first active monsoon season in western Colorado since 2017. This lead to an unprecedented number of localized flash flood warnings, but did not fill our reservoirs
- Second year La Niña does not bode well for recovery

Thanks, and let's keep in touch!

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