Precipitation extremes in Colorado

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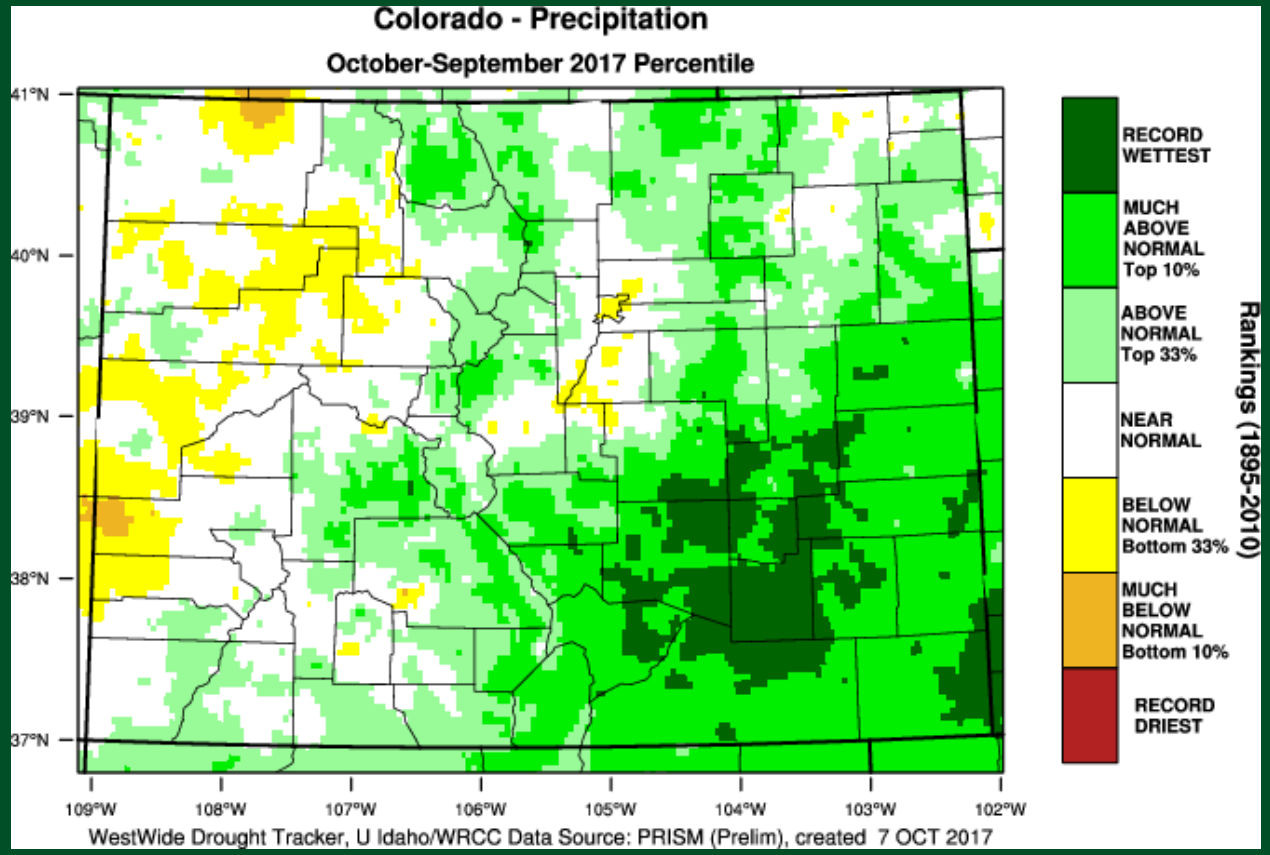
Along with: Peter Goble, Becky Bolinger, Zach Schwalbe, Nolan Doesken

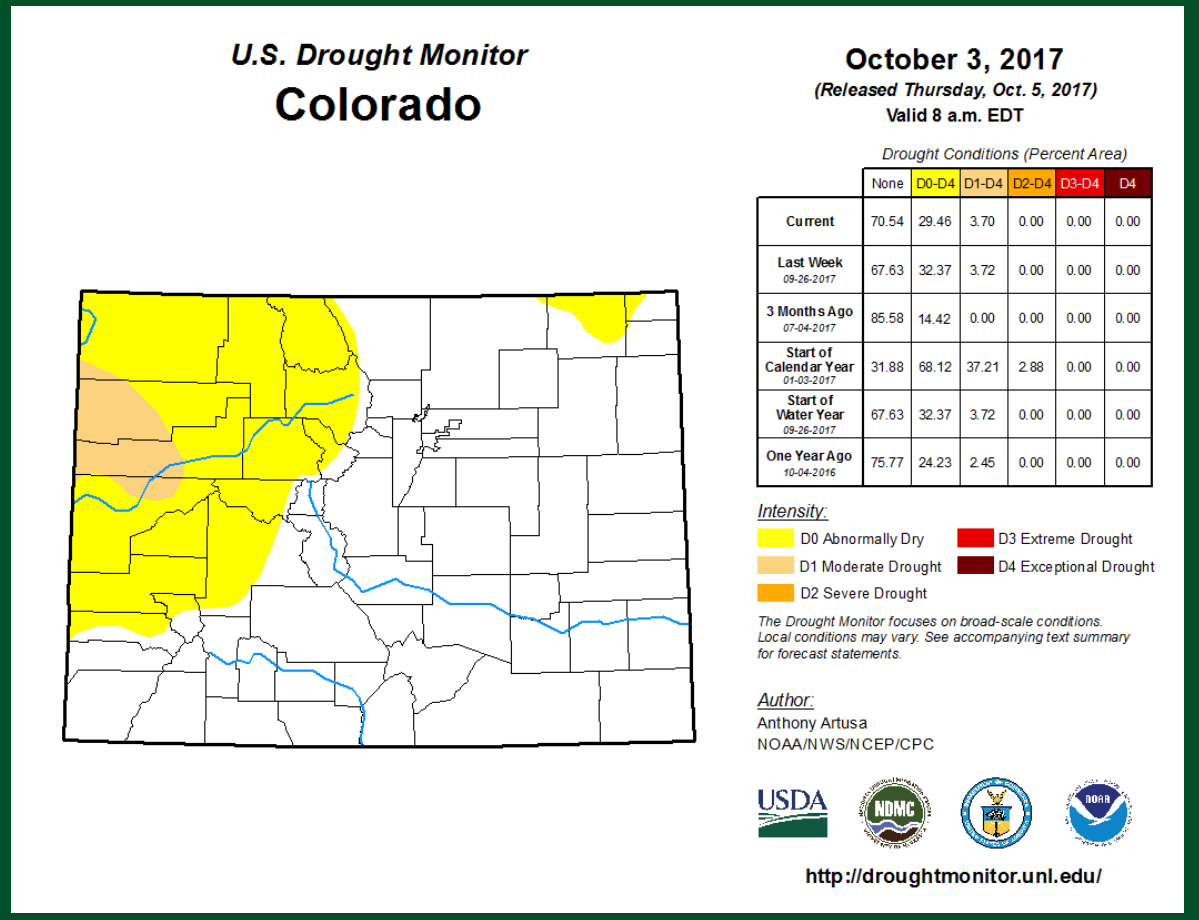
Colorado Water Congress
25 January 2018

https://www.atmos.colostate.edu/images/NolanWhiteHouse.jpg

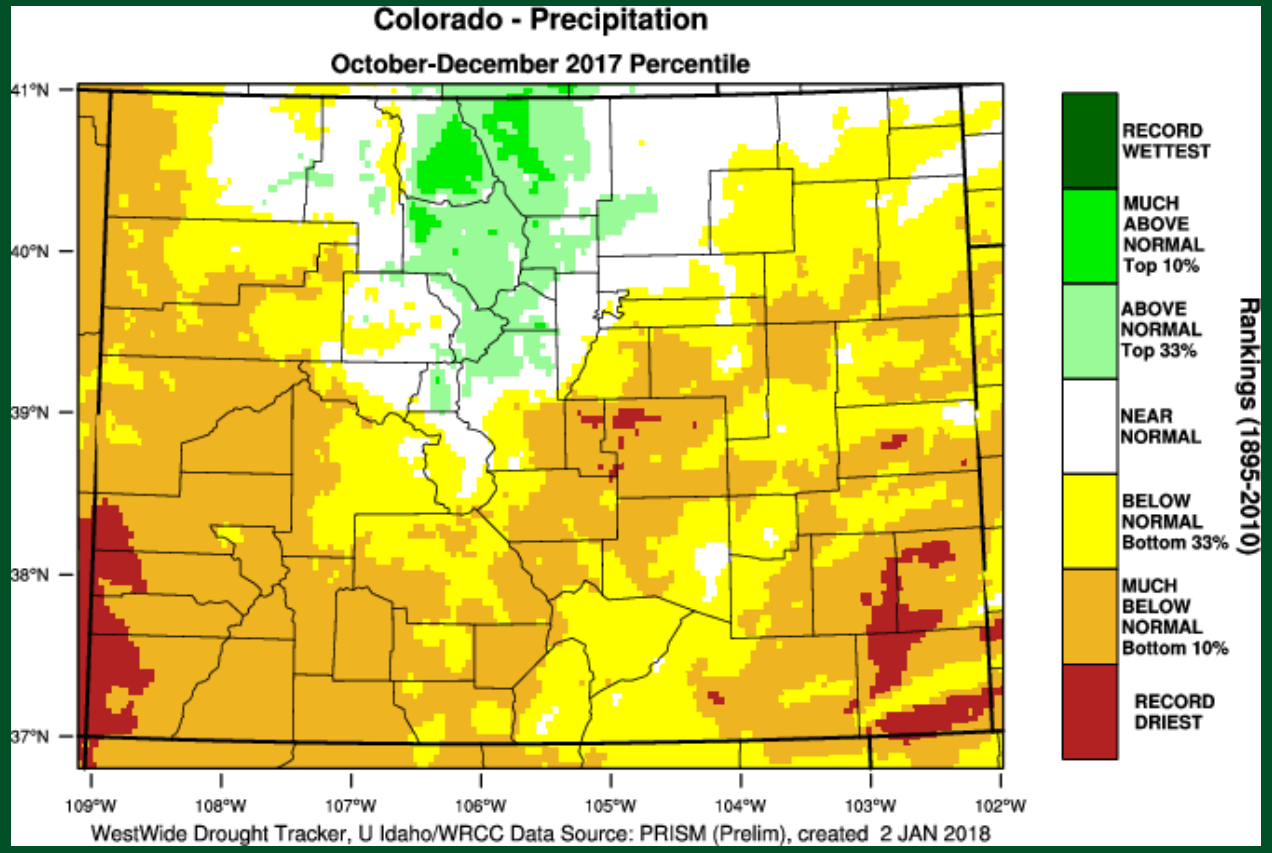
Looking back to Water Year 2017...

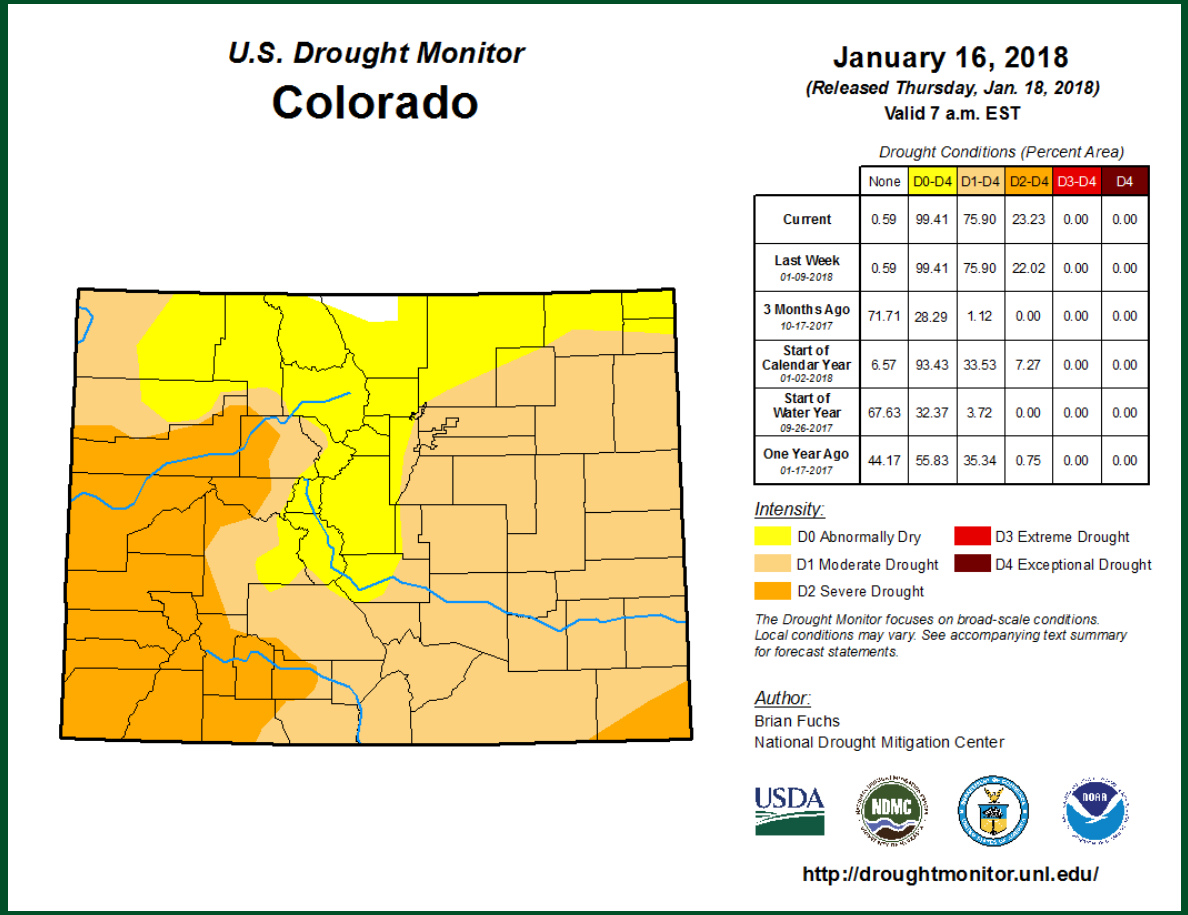


30th wettest water year on record

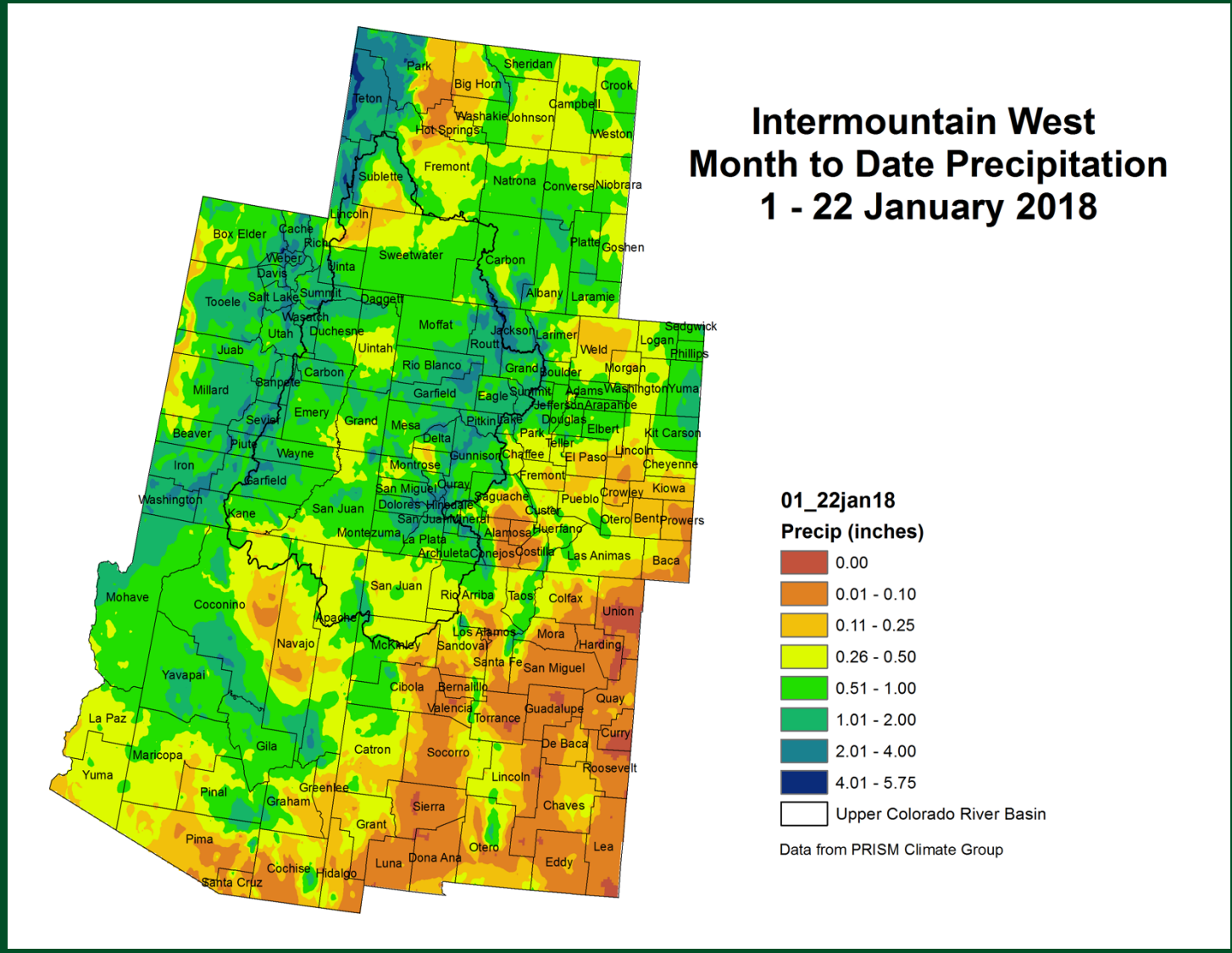


But since: not a good start to WY 2018...





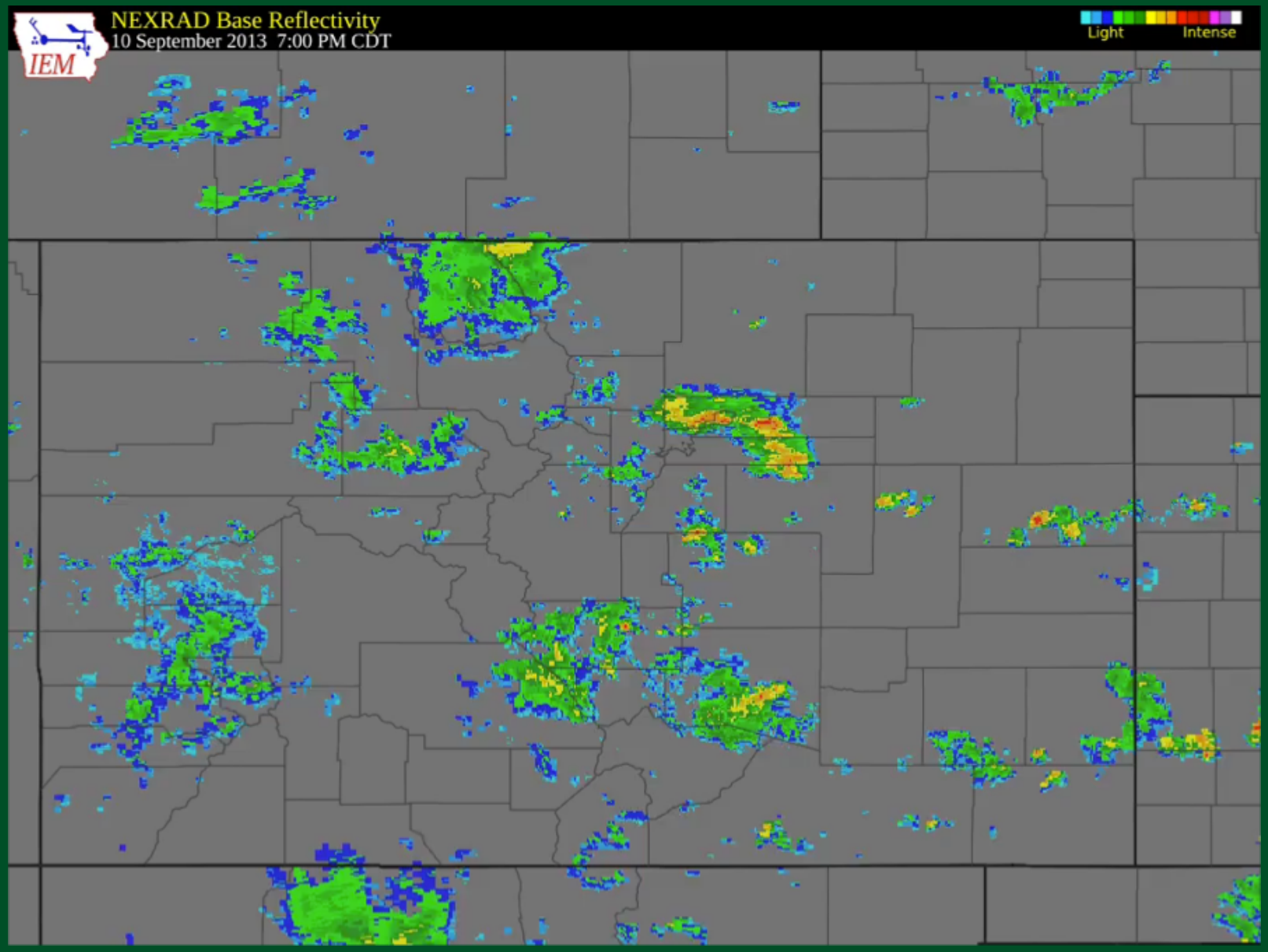
January 2018: a little better, but still a long way to go



For more see http://climate.colostate.edu/~drought

Even when we’re in drought, we can’t forget to think about floods...

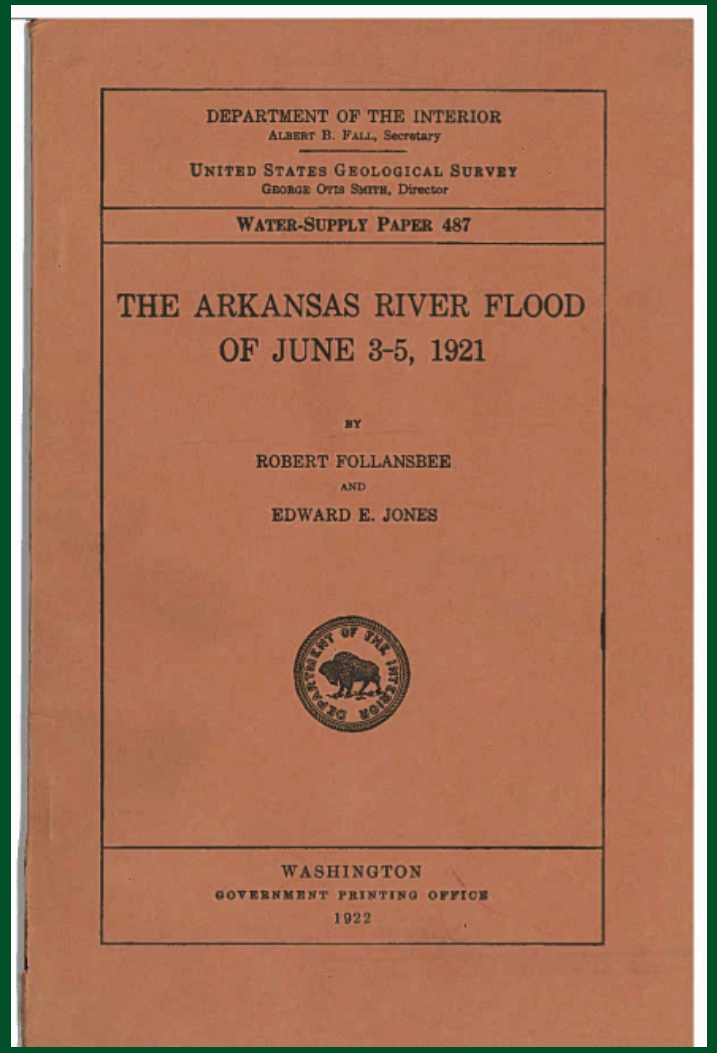
A variety of time and space scales in a week of extreme rainfall



Animation from 6:00pm September 10 – 6:00am September 16 2013

One image every 30 minutes

Of course floods aren't new in Colorado!



DEPARTMENT OF THE INTERIOR
ALBERT B. FALL, Secretary

UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, Director

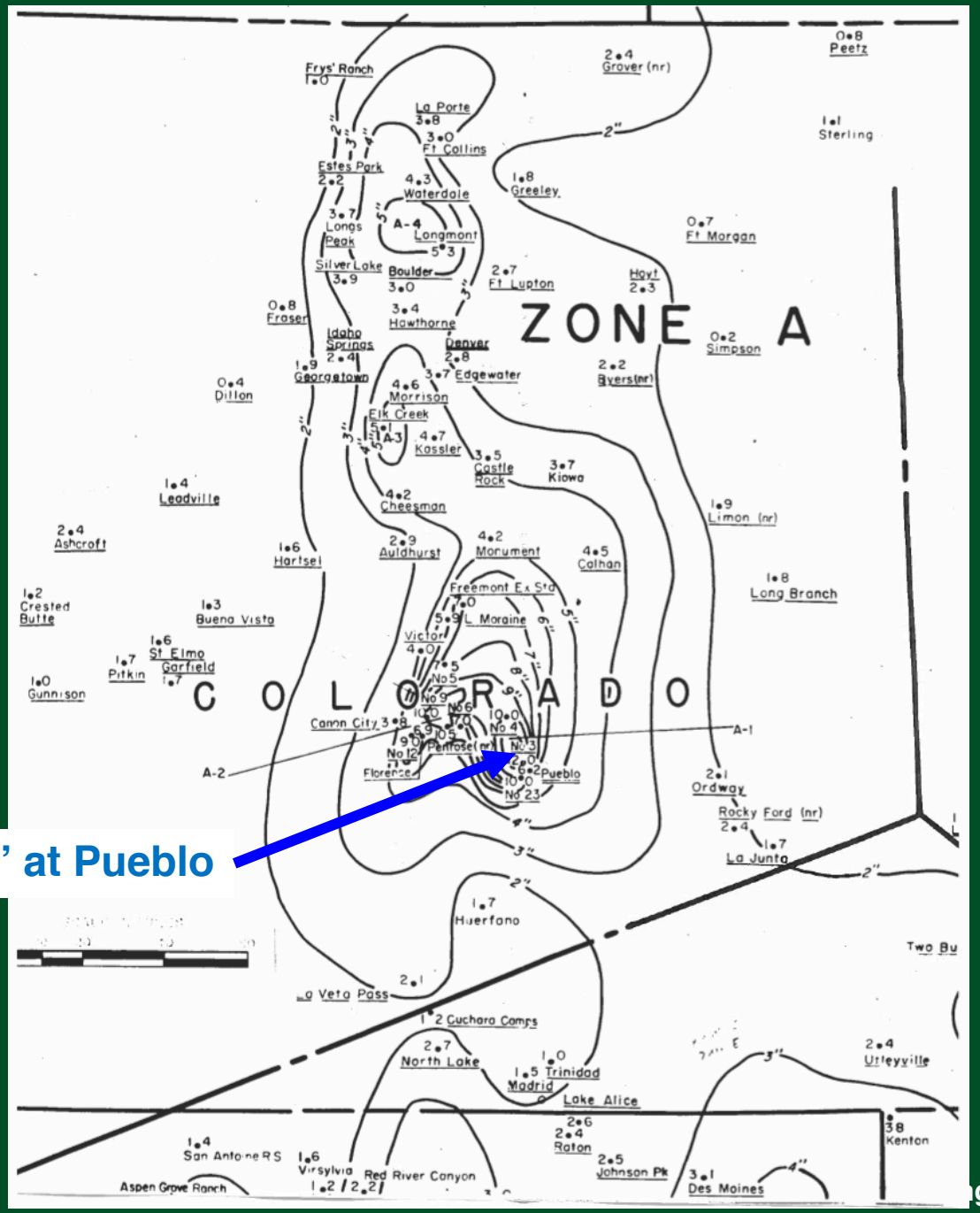
WATER-SUPPLY PAPER 487

THE ARKANSAS RIVER FLOOD OF JUNE 3-5, 1921

BY

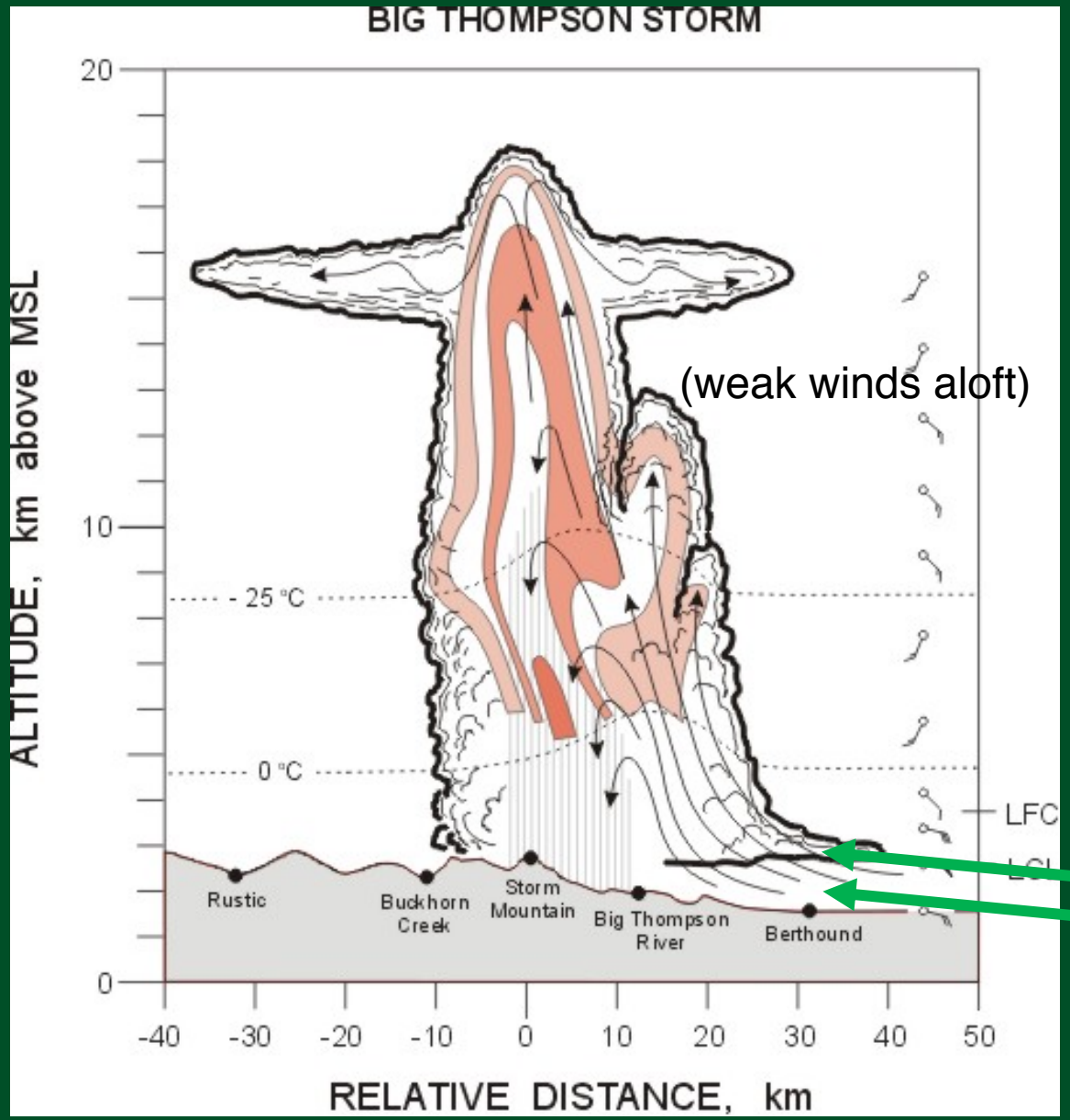
ROBERT FOLLANSBEE
AND
EDWARD E. JONES

WASHINGTON
GOVERNMENT PRINTING OFFICE
1922

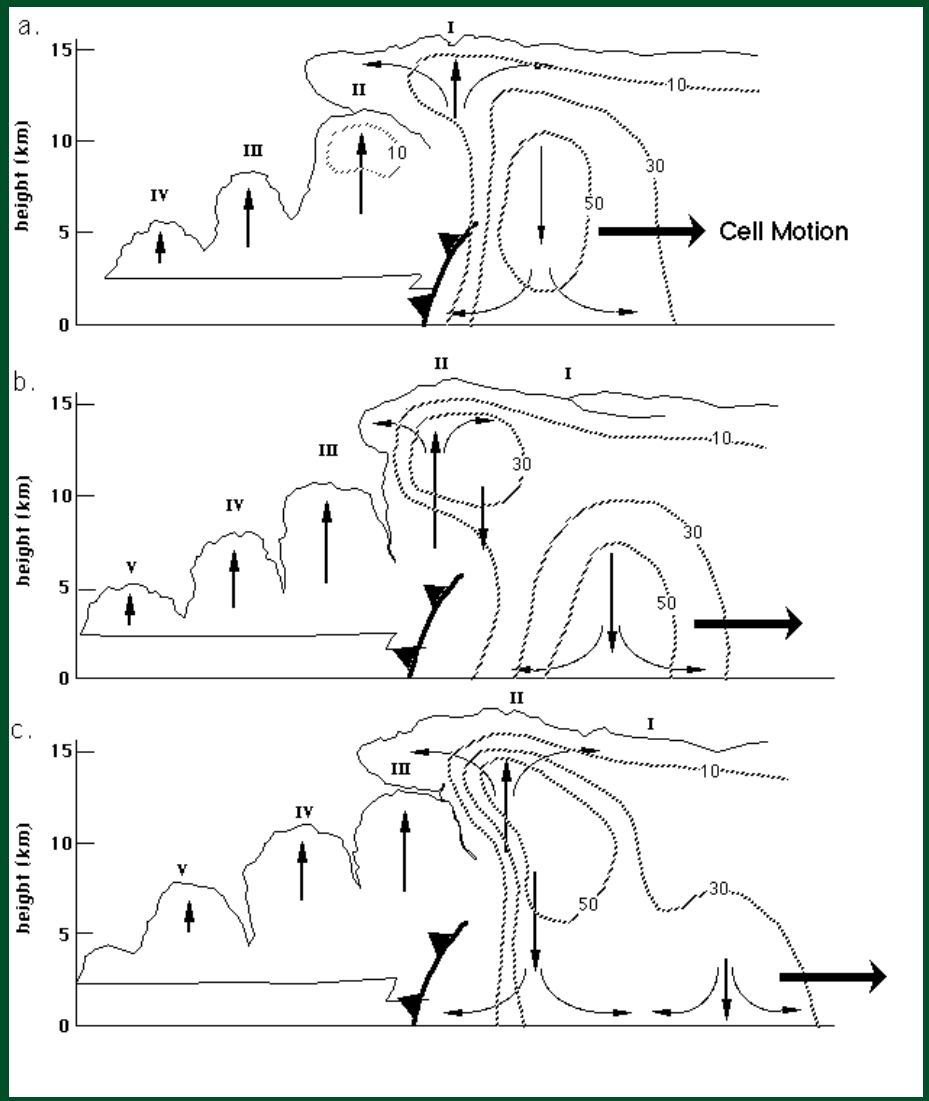


Ingredients for extreme rainfall

- Simply: $P = \overline{R}D$ (precipitation equals average rainfall rate times duration)
  - Or, in other words: the most rain falls where it rains the hardest for the longest!
  - This is sometimes called the “First Law of Quantitative Precipitation Forecasting”
- To get a high rain rate: need moist air going up!
  - Strong thunderstorms; forcing air up a mountain; etc.
  - Here in Colorado, usually it’s the moisture that’s lacking



(weak winds aloft)

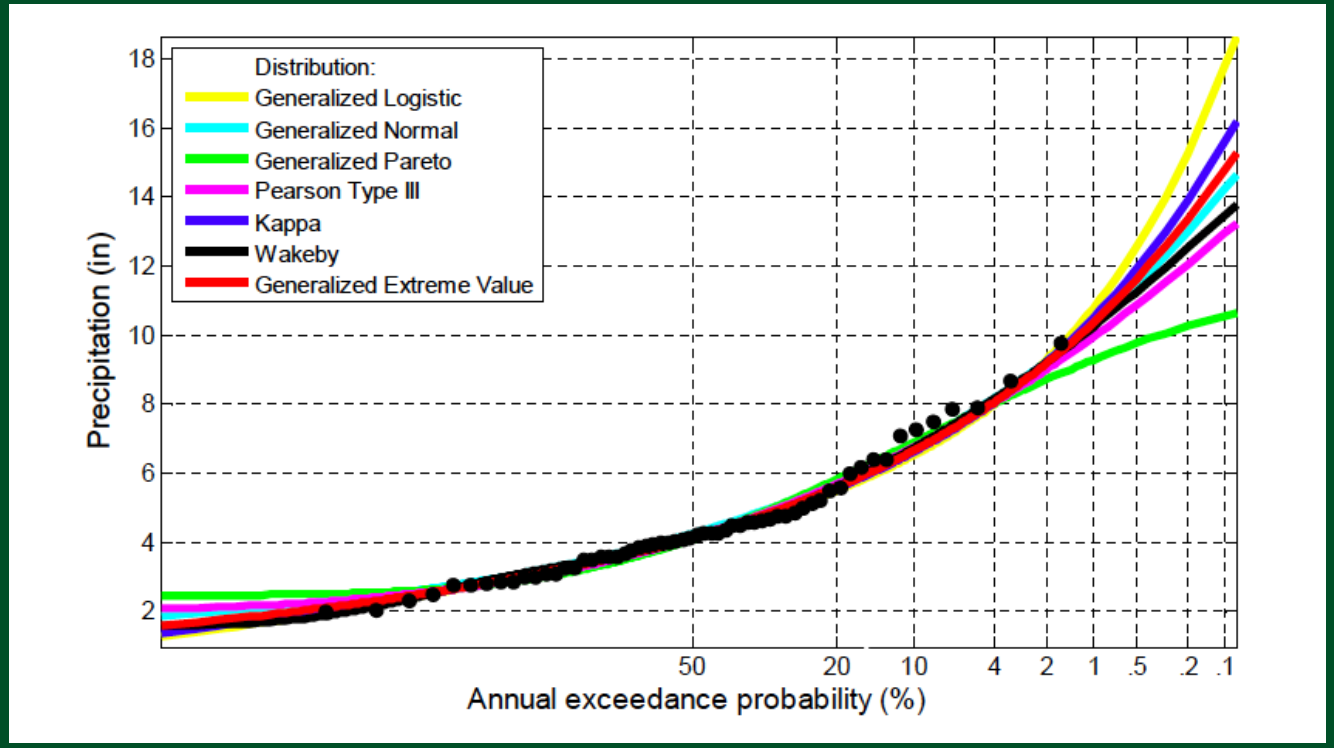


From Doswell et al. (1996)

https://www.ems.psu.edu/~lno/Meteo437/BigThompX.jpg

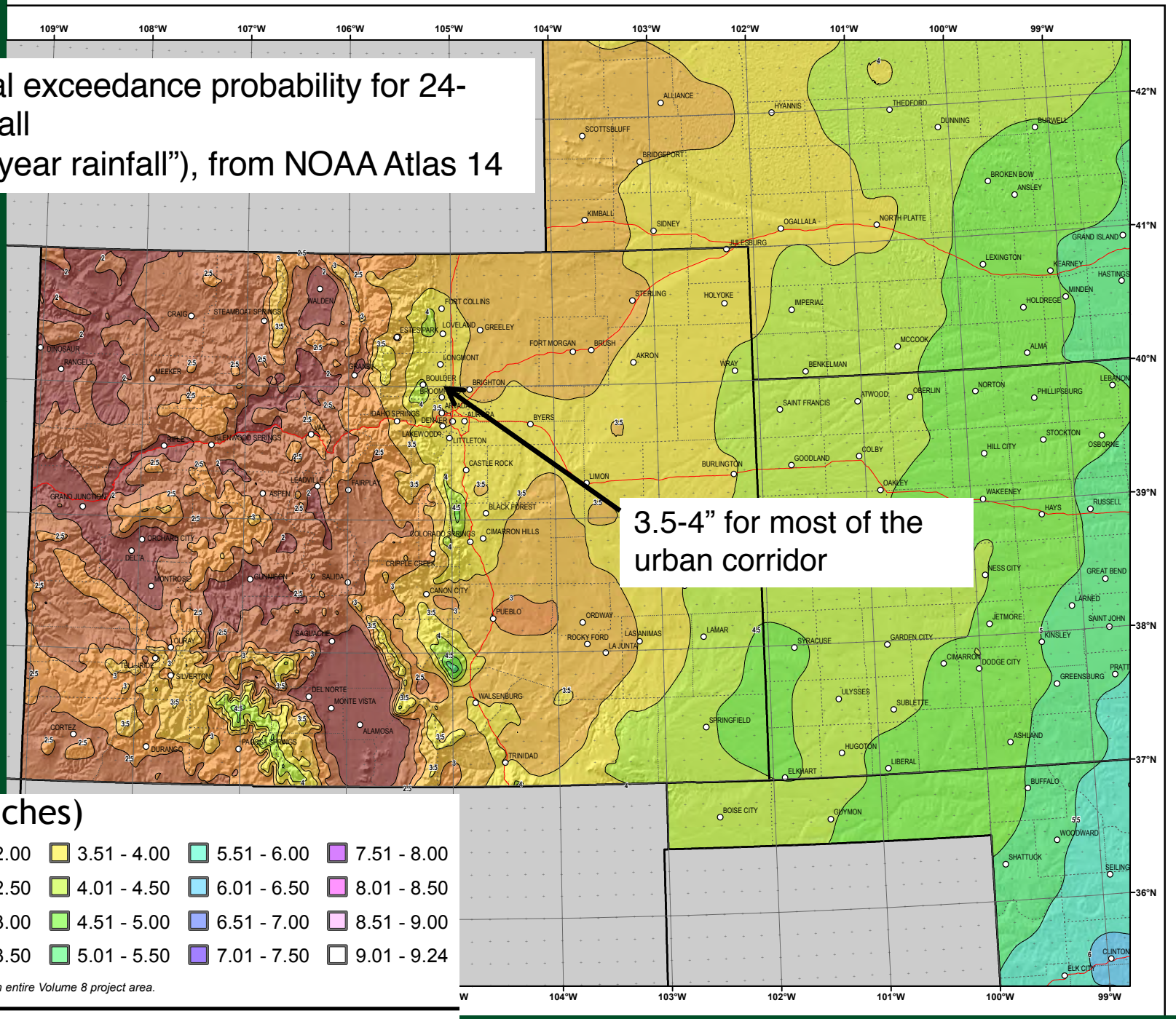
How often does heavy rain fall?

- Using past rainfall data and statistical techniques, it's possible to estimate an "annual exceedance probability" for a given rainfall duration at a location
- For example, you could find the 24-hr rain amount that has a 10% probability of happening in any year
  - This is sometimes referred to as a "10-year rainfall", though that terminology can be confusing
- These calculations are subject to big uncertainties for low probabilities, since the data record doesn't go back forever



Example from a station in Florida, from NOAA Atlas 14, volume 9

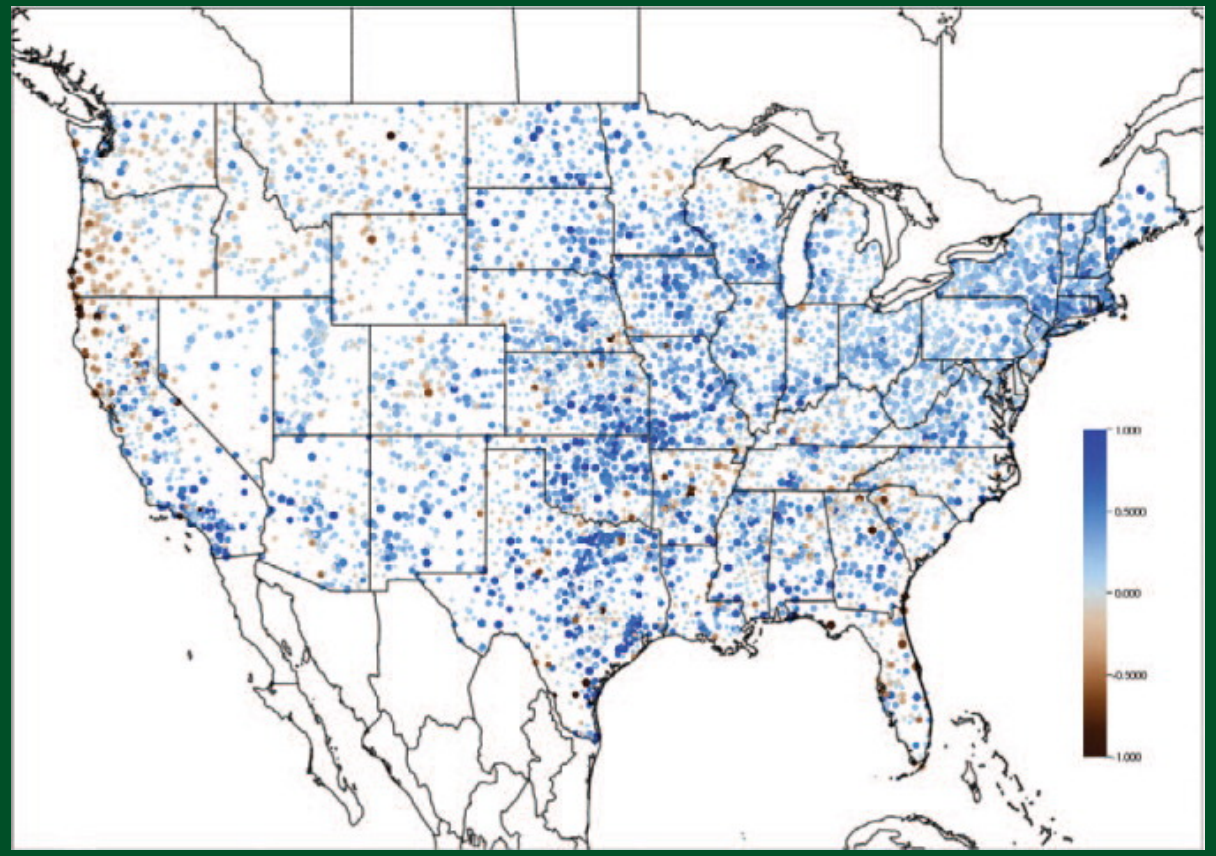
4% annual exceedance probability for 24-hour rainfall
(i.e., “25–year rainfall”), from NOAA Atlas 14



Trends for extreme rainfall in US

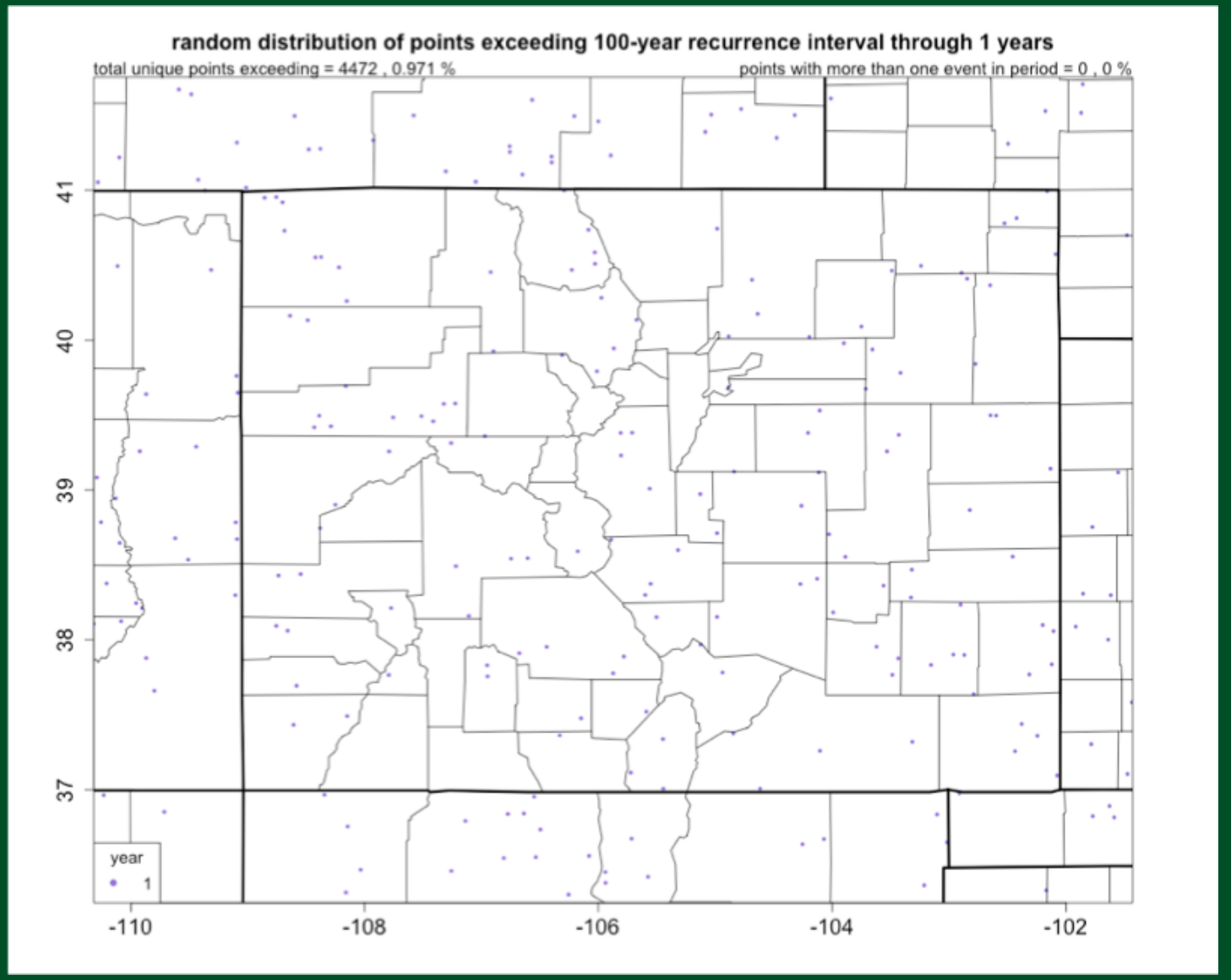
- Heavy rainfall is becoming more frequent in many parts of the US, especially the Great Plains and Northeast…not so much in Colorado
- When aggregating over Colorado, no significant observed trends in heavy precipitation

From Kunkel et al. (2013, *BAMS*)



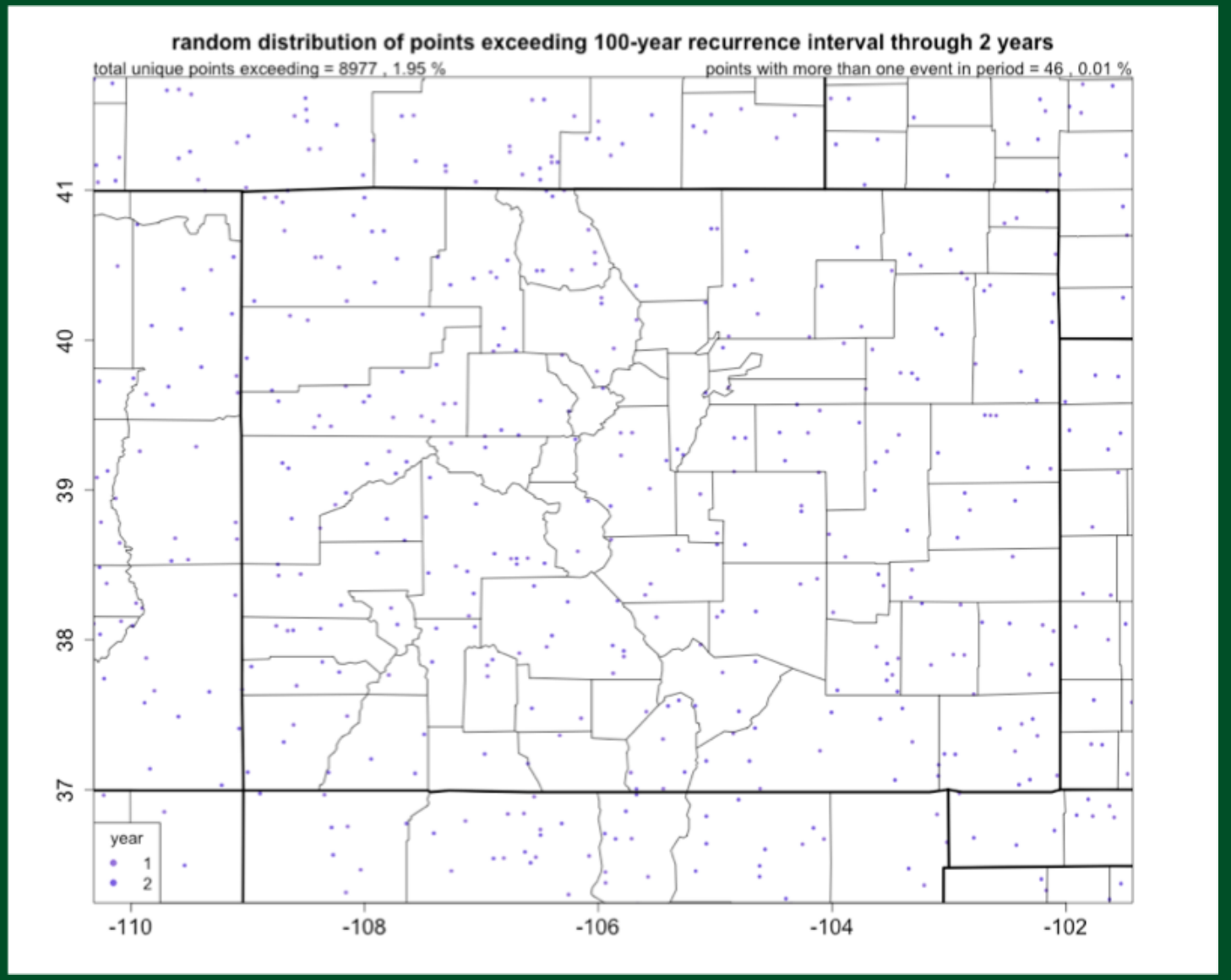
Changes in the "20-year rain event" over 1948-2010 (inches)
Blue colors indicate that the 20-year rain event has become wetter, or in other words, a given amount of rainfall occurs more frequently now than it did in the past

What if we had a random scattering of “100-year rain events” ?



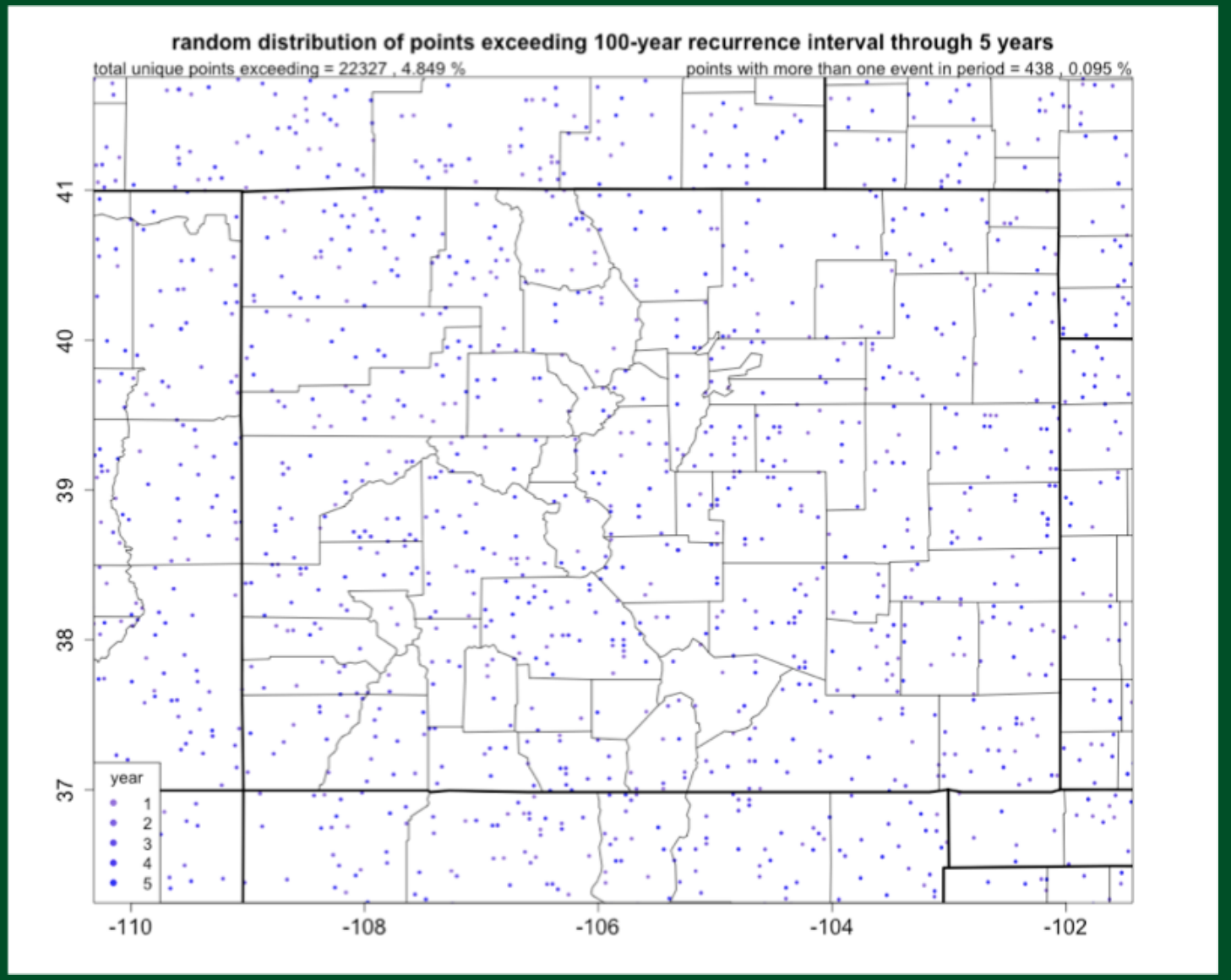
After 1 year:
263 “100-year rainstorms” on this map

What if we had a random scattering of “100-year rain events” ?



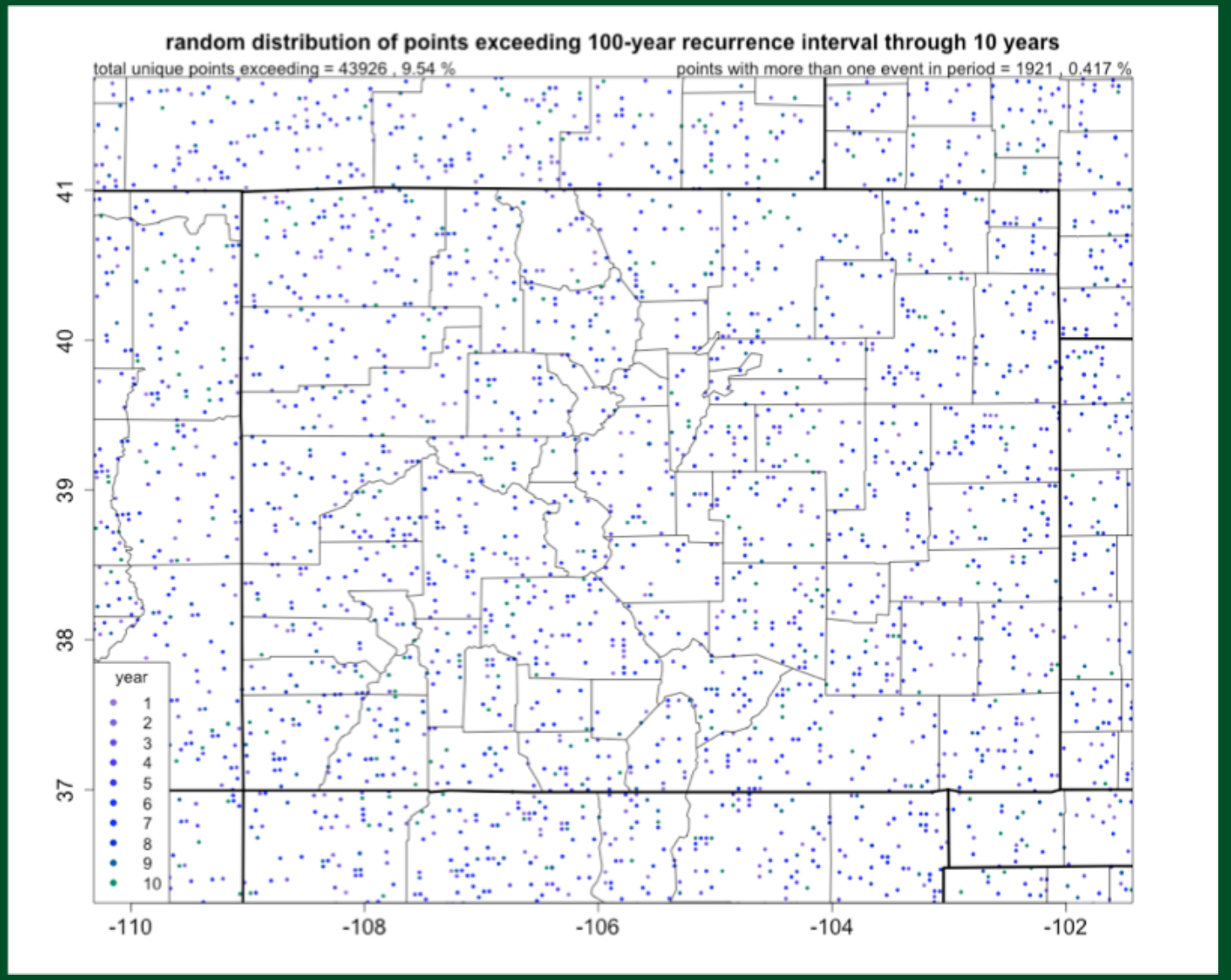
After 2 years

What if we had a random scattering of “100-year rain events” ?



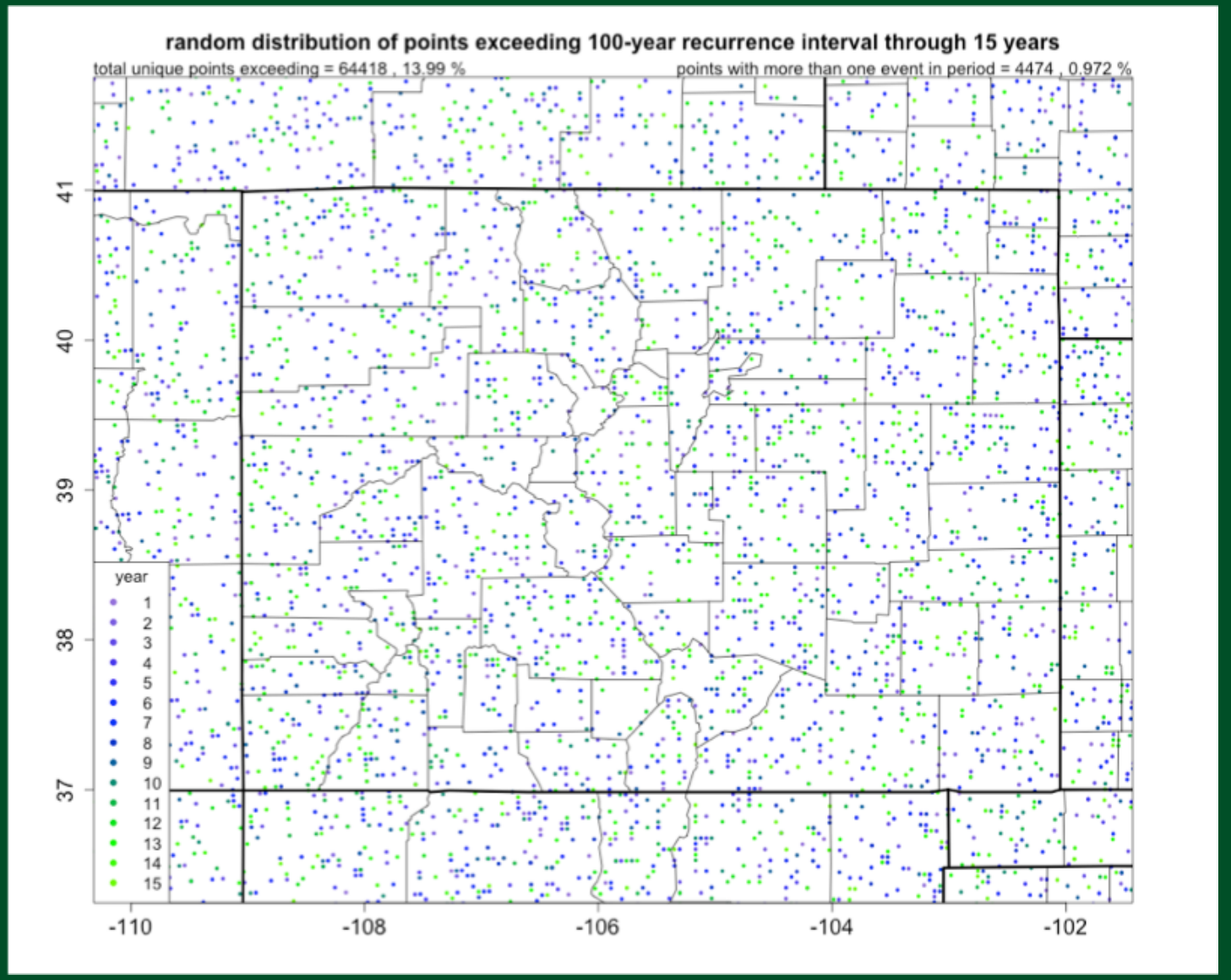
After 5 years

What if we had a random scattering of “100-year rain events” ?



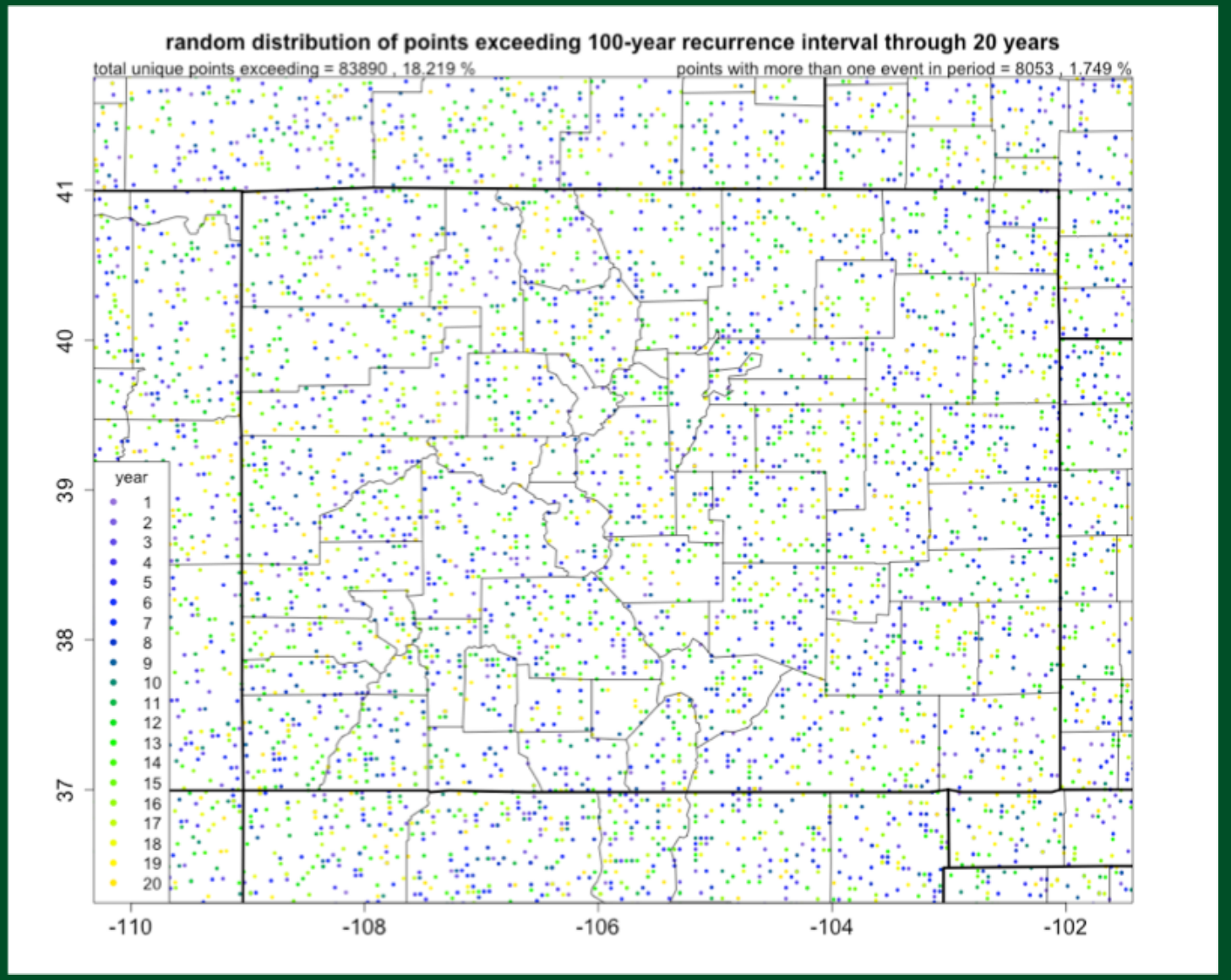
After 10 years

What if we had a random scattering of “100-year rain events” ?



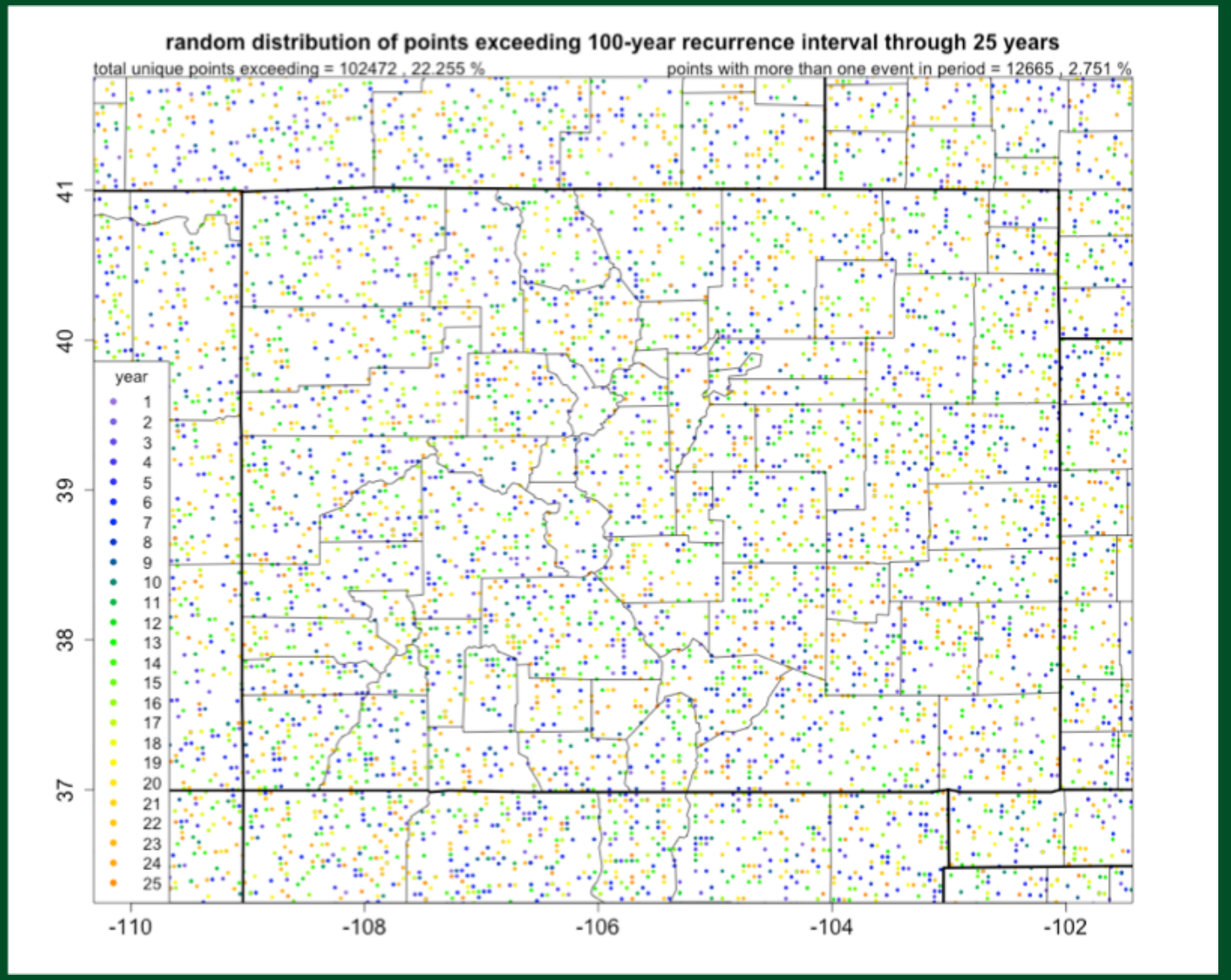
After 15 years

What if we had a random scattering of “100-year rain events” ?



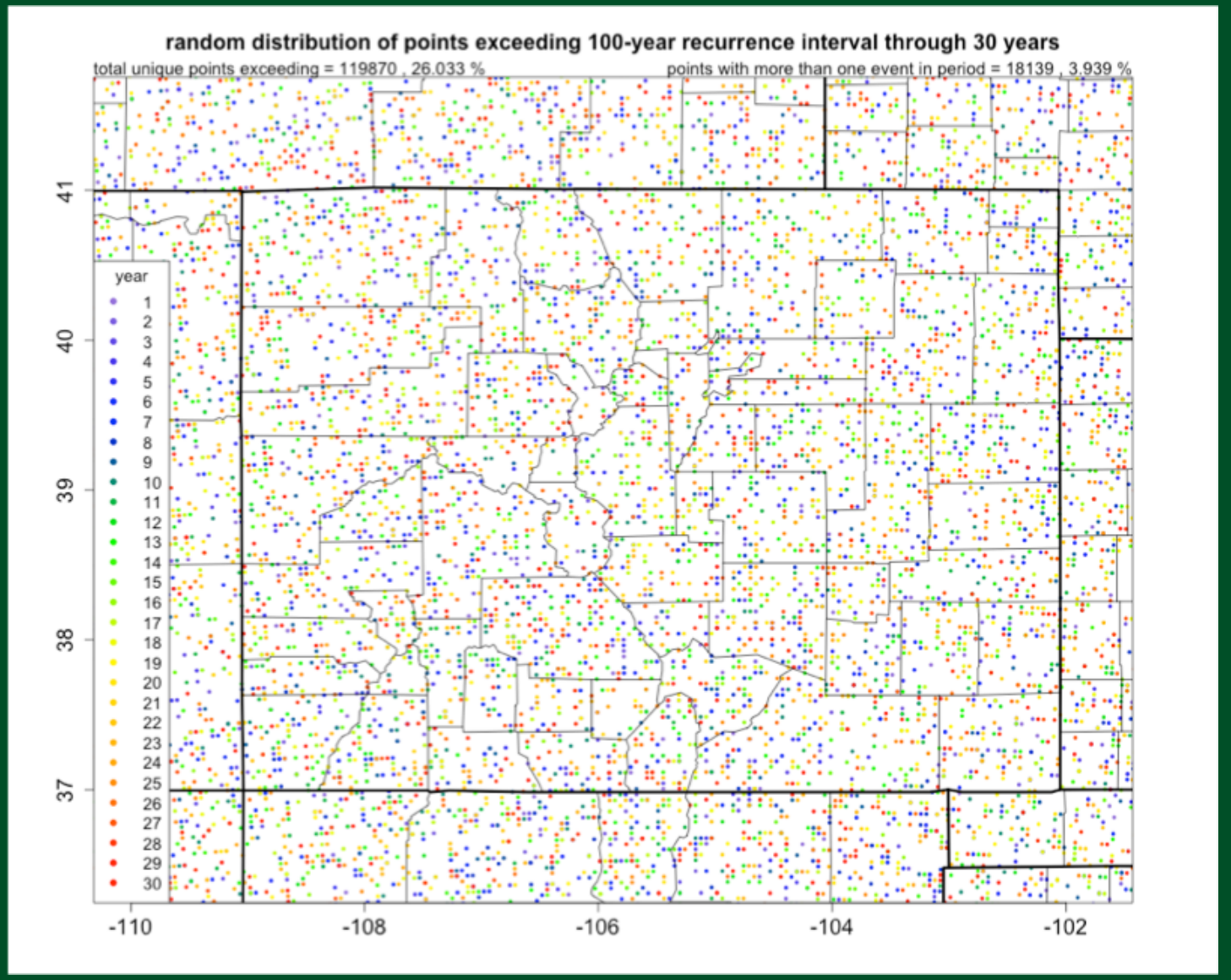
After 20 years

What if we had a random scattering of “100-year rain events” ?



After 25 years

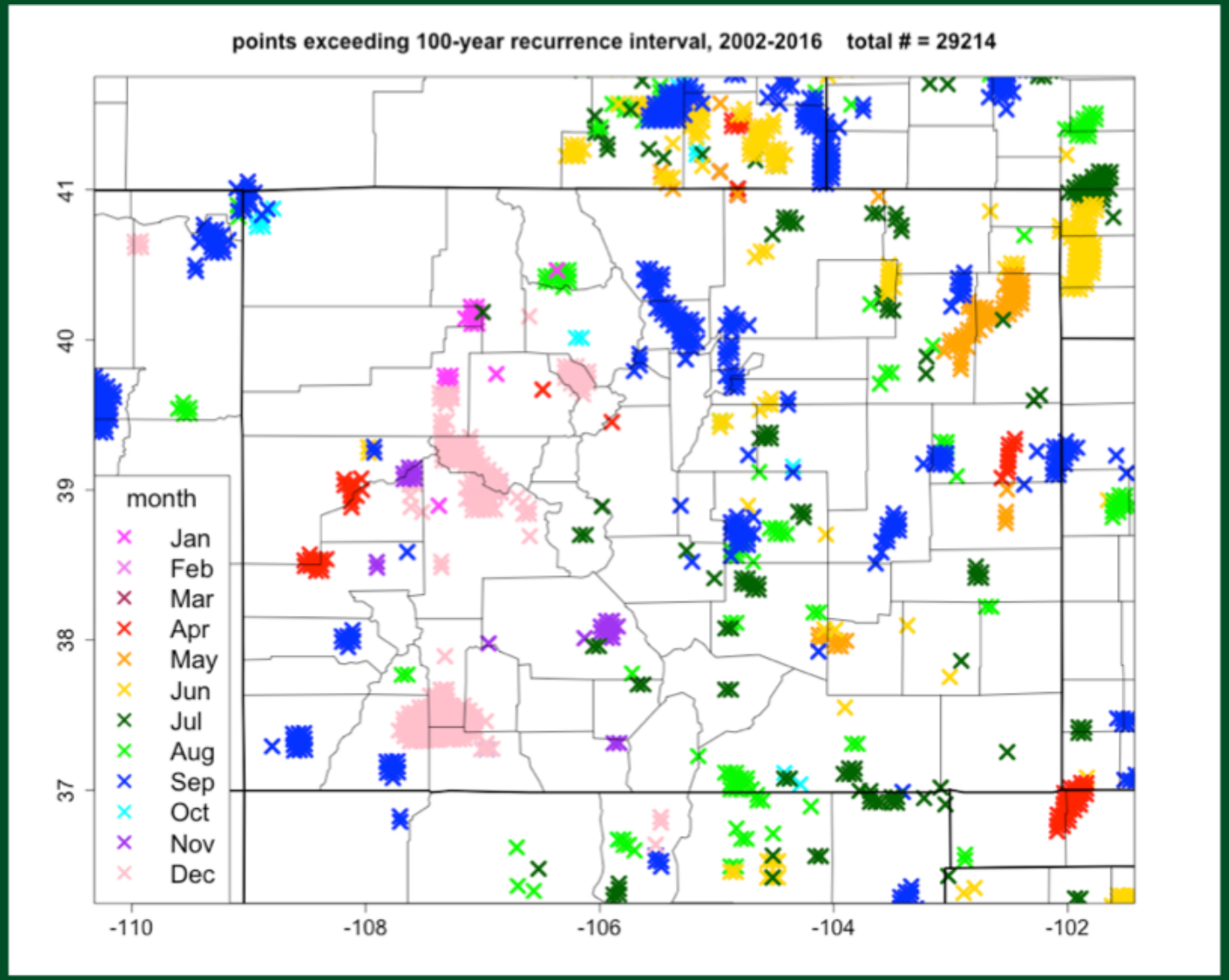
What if we had a random scattering of “100-year rain events” ?



After 30 years, each point has a 26% chance of seeing a 100-year rain event!

And a 4% chance of getting more than one of them!

Actual “100-year rain events”, 2002-2016



Data: NOAA Stage IV analysis

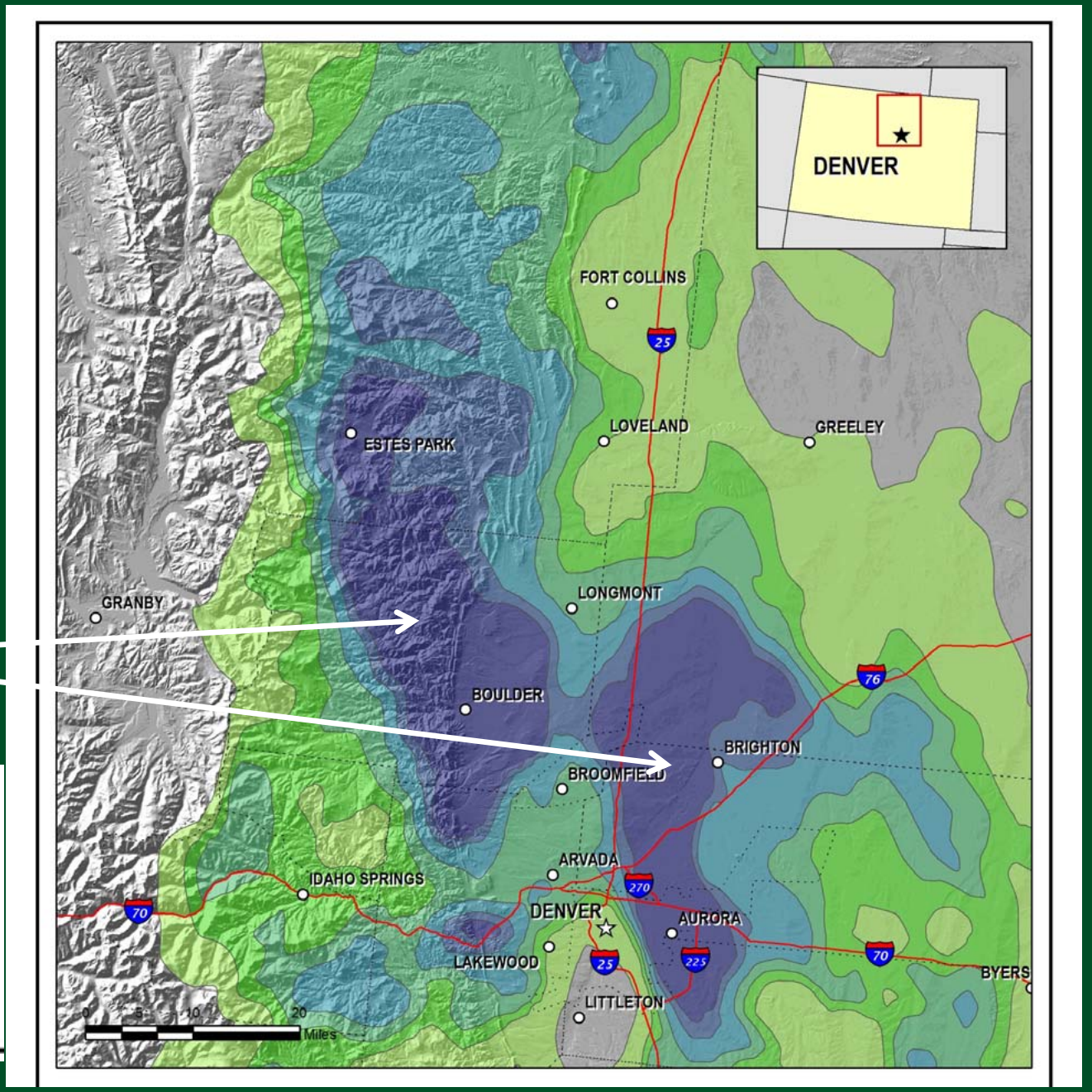
Points exceeding the 100-year recurrence threshold for 24-hr rainfall

Some of these events you probably remember (Sept 2013), but most you probably don’t

This is because “unusual” rain doesn’t always result in “unusual” flooding

Exceedance probabilities for 7-day rainfall based on NOAA Atlas 14

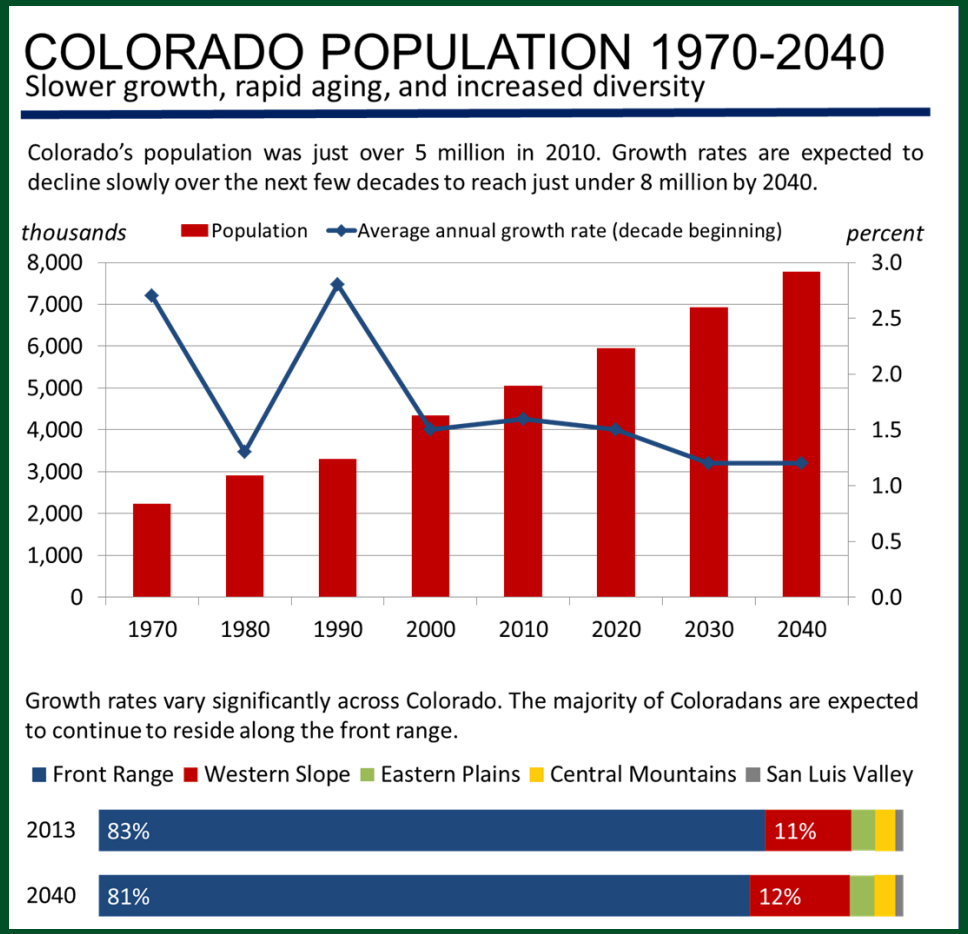
Areas with <=0.01% probability (i.e., a "1000-year rainfall"



From http://www.nws.noaa.gov/oh/hdsc/aep_storm_analysis/8_Colorado_2013.pdf

What to expect in the future?

- As the climate continues to warm, more days with very high moisture values will occur
  - But will those translate into actual extreme rain events? Recall that moisture is only one ingredient
- Most indications are that heavy rain will become more likely
  - But will that be true over Colorado? Not yet clear.
- **Even with these uncertainties, do we feel well prepared for even *today's* extreme rainfall and flooding?**
- And what if we add 2-3 million more people (and associated infrastructure), many of them along the flood-vulnerable Front Range?



https://demography.dola.colorado.gov/demography/infographics/#infographics

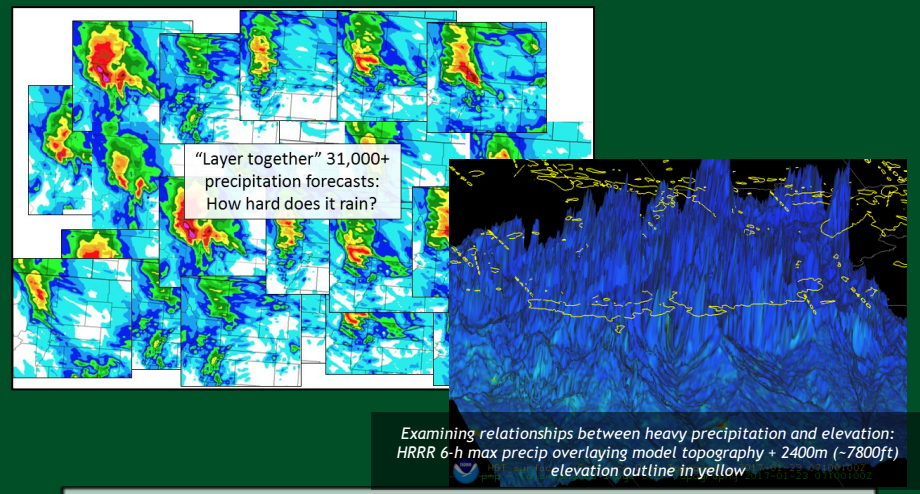
Ongoing study to update “probable maximum precipitation” in Colorado and New Mexico for dam safety

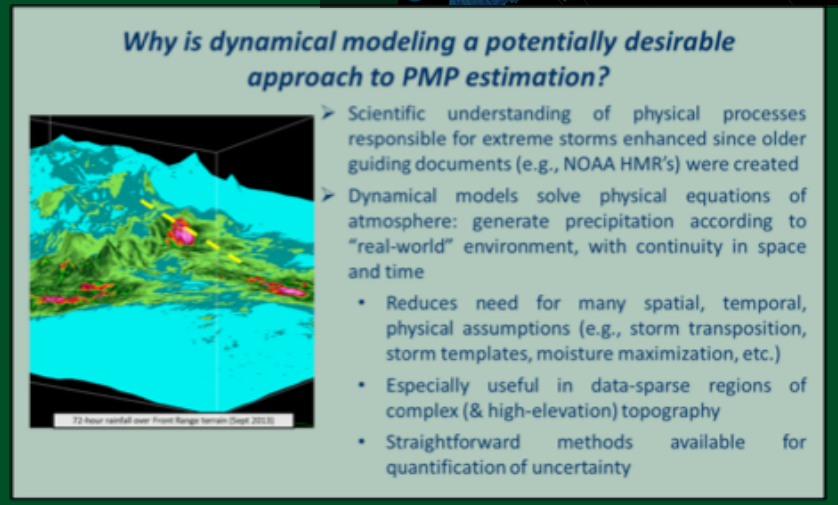
Colorado and New Mexico have sponsored a study to update precipitation frequency estimates for dam safety purposes

- Task 1 (Applied Weather Associates) updating conventional deterministic “storm-based” methods.
- Task 2 (Extreme Precipitation Group, MetStat) developing a risk-based (probabilistic) regional precipitation frequency estimation tool to enable annual exceedance estimates of Task 1 results.
- Task 3 (NOAA Earth System Research Laboratory) includes a proof-of-concept scope utilizing NOAA’s state-of-the-art High Resolution Rapid Refresh (HRRR) physically-based dynamical weather prediction model.

Lots of collaboration between state, federal, and private sectors! Look for a final report in ~June 2018.

(info from Kelly Mahoney, NOAA and Bill McCormick, DWR)

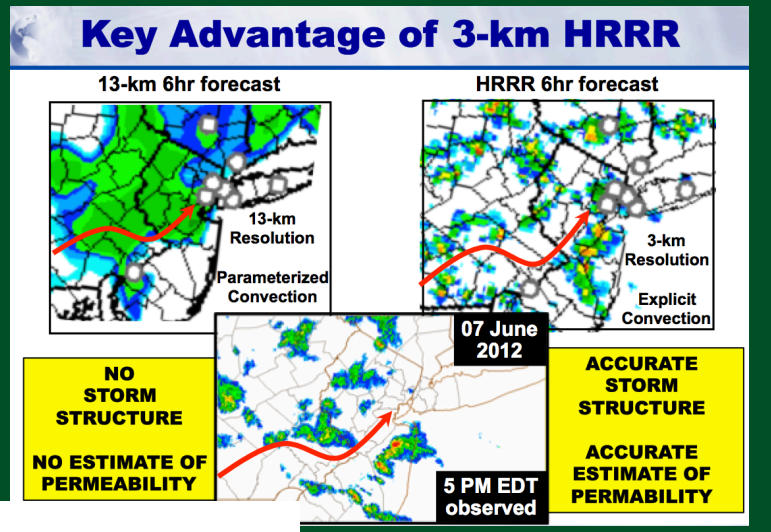




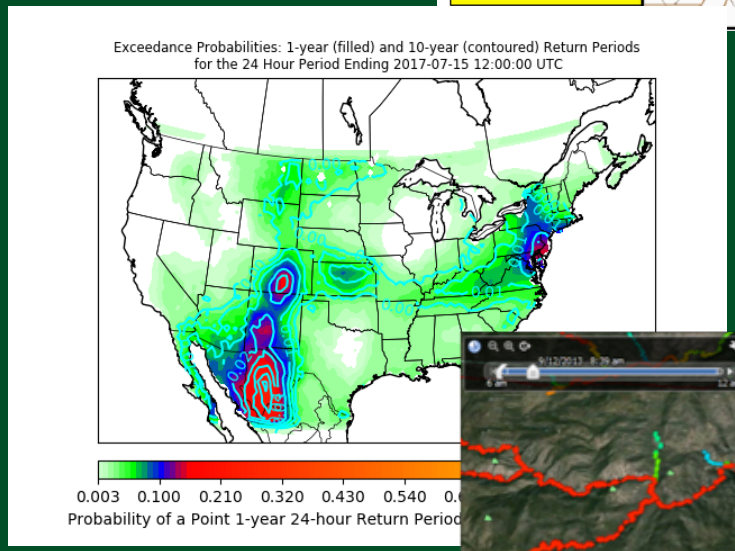
Forecasting advances

- Rainfall – and especially heavy rainfall – remains very difficult to predict
- But some major advances have been taking place: models with better resolution, “ensembles” of models, statistical processing of model forecasts, flood forecasts, etc.
- Expect rainfall forecasts to get better – but don’t expect to know whether it’ll rain on your house but not your neighbor’s!

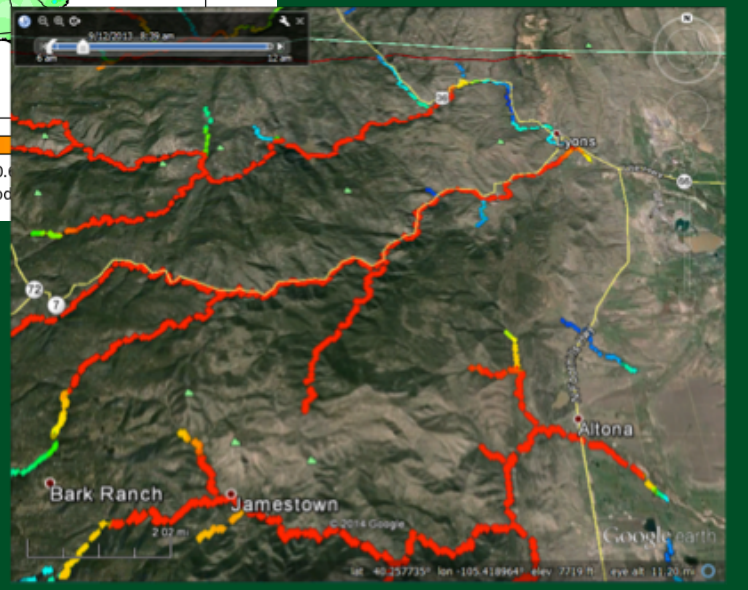
(NOAA)



(CSU)

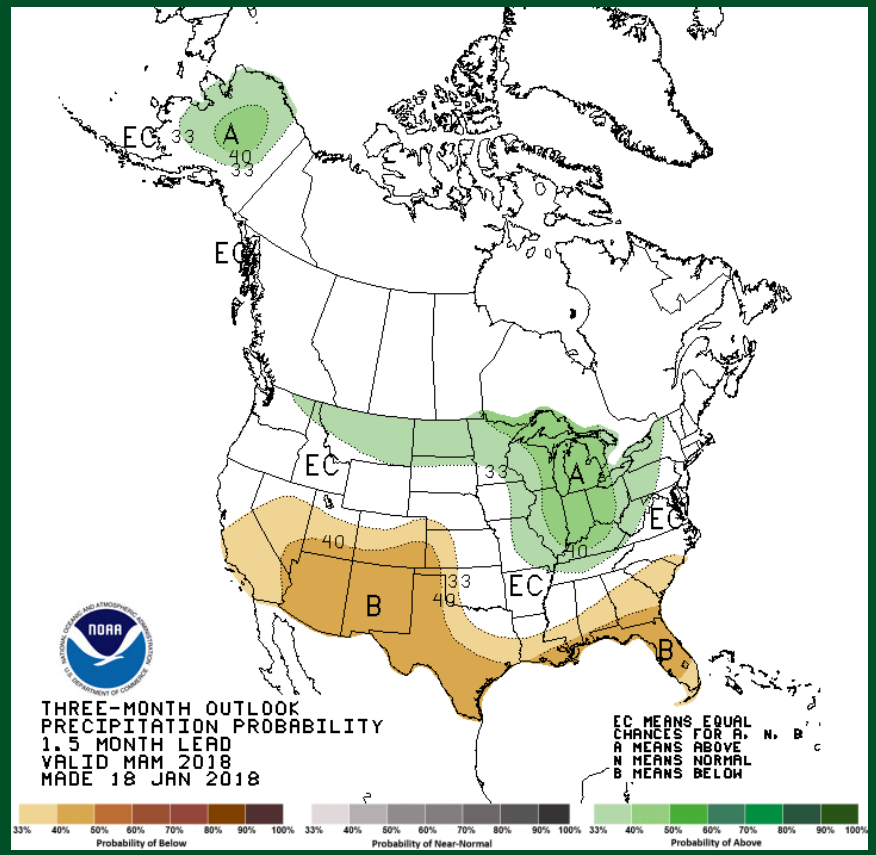


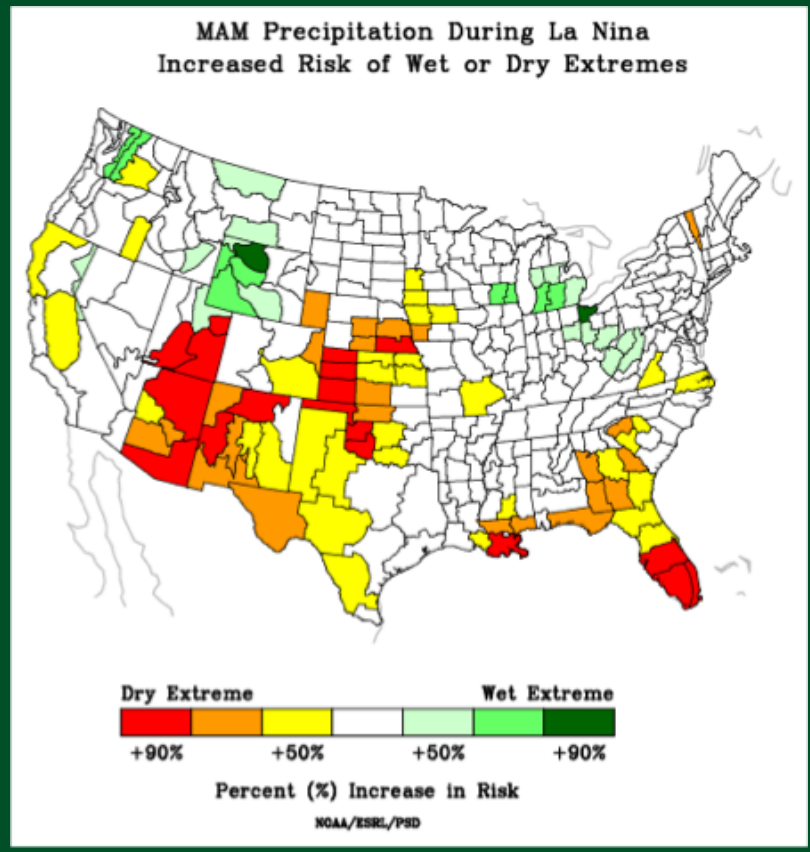
(NCAR)

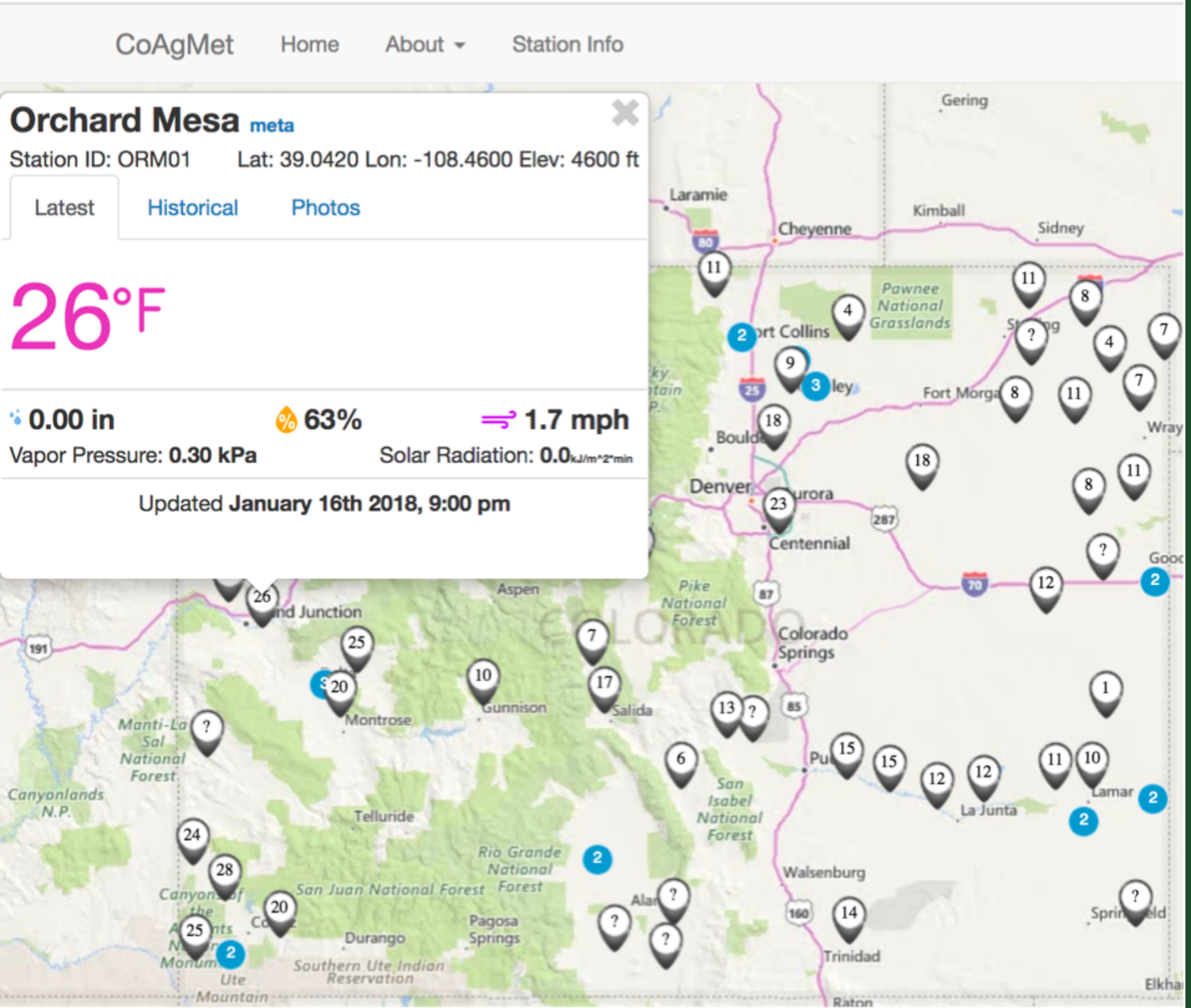


Outlook for precip (and extreme events?) in relation to La Nina

- We're currently in La Niña conditions – cool water in the eastern Pacific Ocean
- This tends to divide the state, with near, or slightly wetter than normal in the north, and dry in the south
- Outlooks show an increased chance of a dry spring
- But there is at least some precedent for wet spring following a La Niña winter (April 1999 as one example)







COLORADO CLIMATE CENTER

CoAgMET

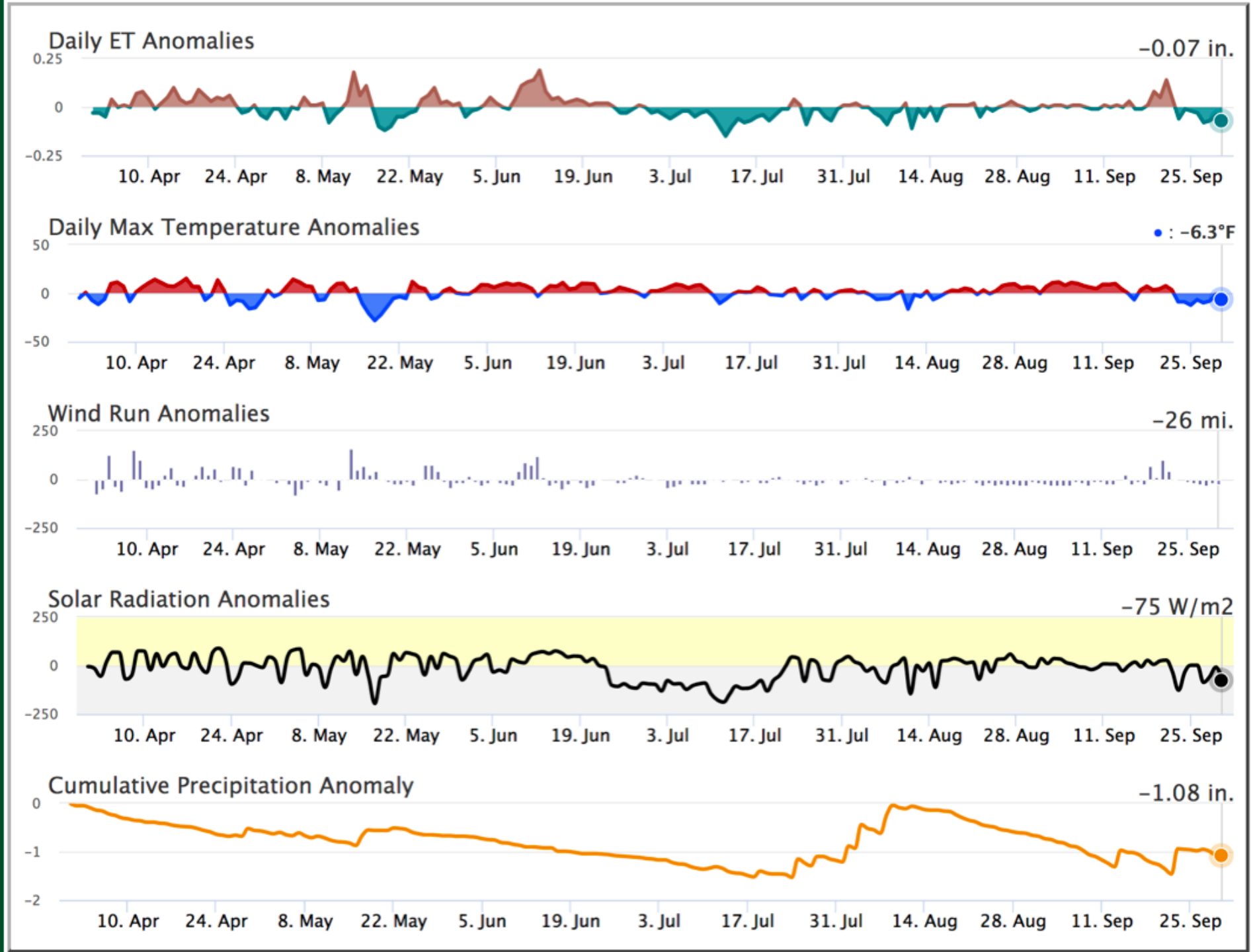
- 75 stations
- 10 proposed for west slope
- 44 5-minute stations

- interactive mapping through eRAMS
- includes
  - time series charts
  - site photos

coagmet.colostate.edu

Growing season summaries at long-term stations: Olathe (2017)

http://climate.colostate.edu/2017ET/et_summary_oth_anom.html



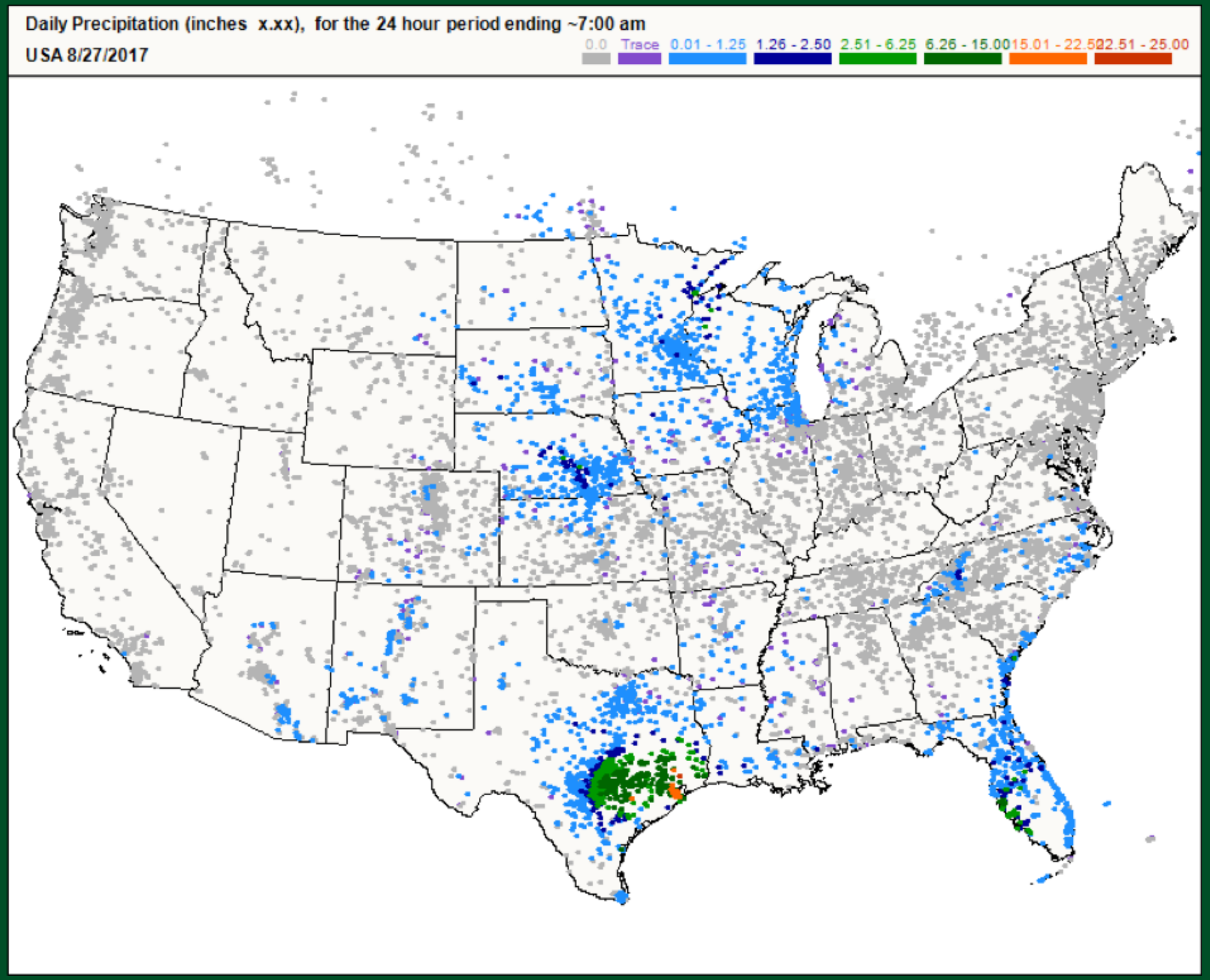
And finally, the all-important question:
“Do you have a rain gauge?”

If you are interested in weather and the variations in precipitation, please join the Community Collaborative Rain, Hail and Snow Network

http://www.cocorahs.org

or see me today

CoCoRaHS data in Hurricane Harvey, August 2017



Thank you for the opportunity to be here!

http://climate.colostate.edu/

russ.schumacher@colostate.edu

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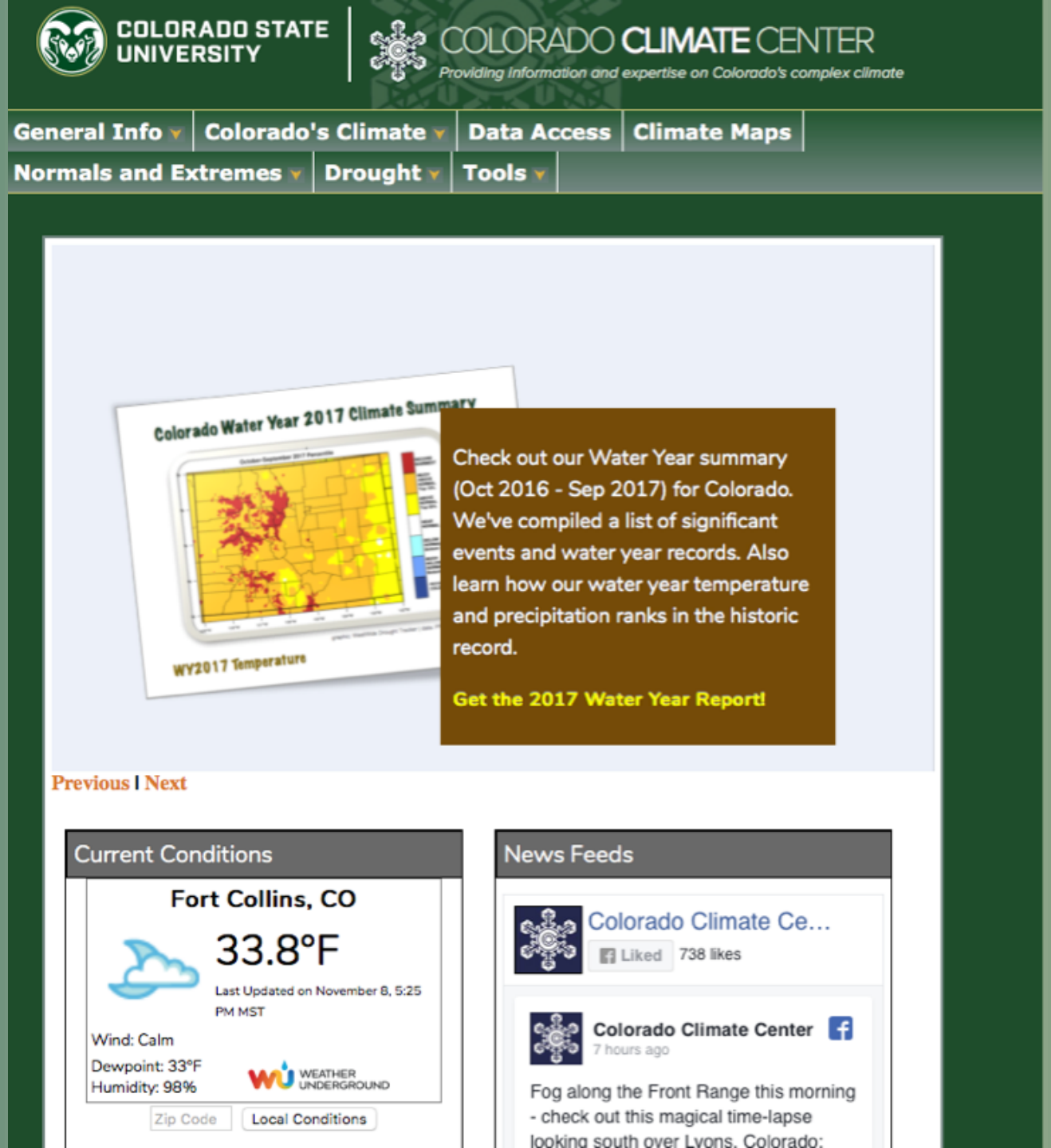
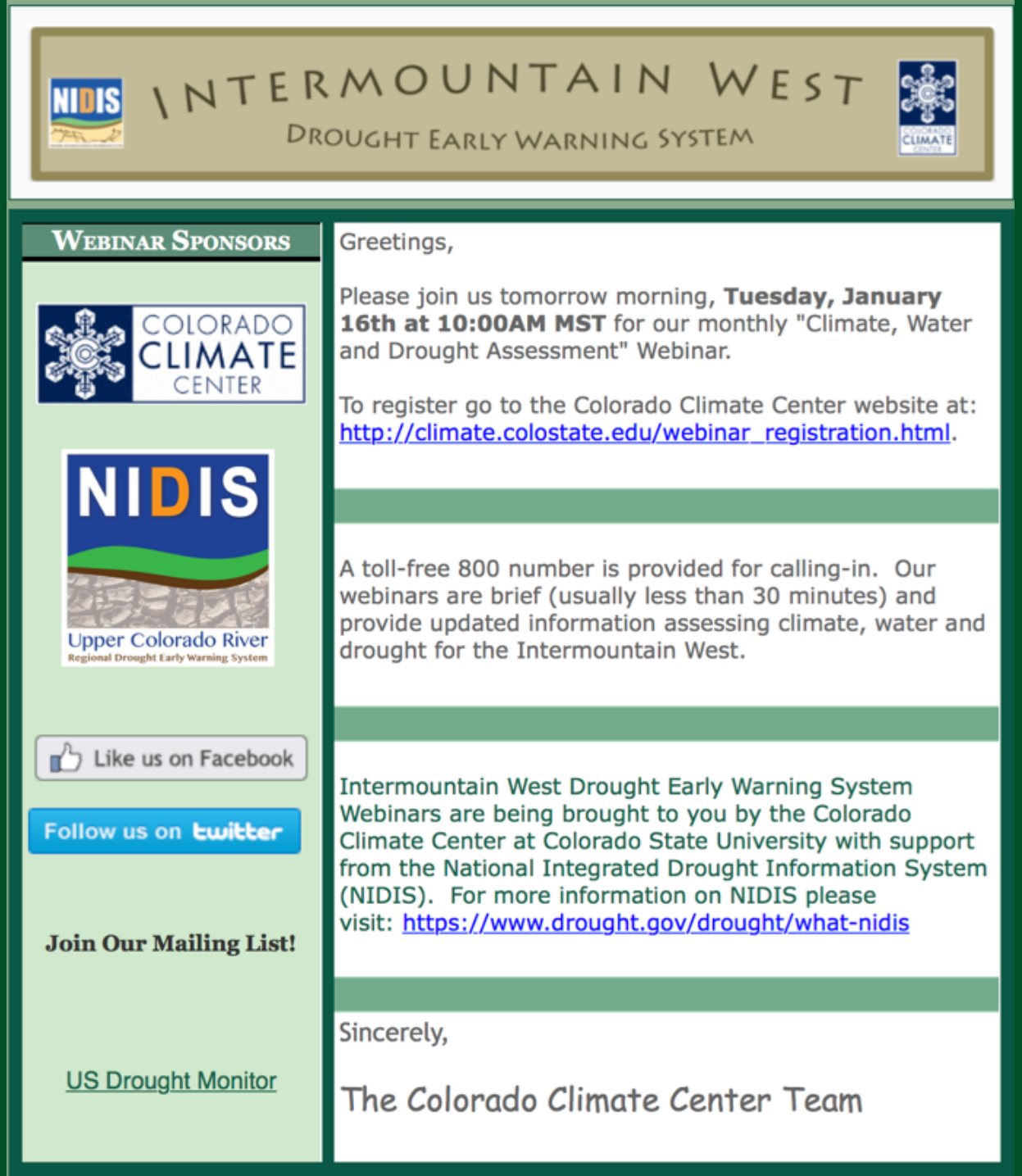
Backup slides



new website features at **climate.colostate.edu**

- ❑ **Data Access**
- ❑ **Climate Maps (coming soon)**
- ❑ **Climate Normals**
- ❑ **Climate Extremes**
- ❑ **Tools**



Intermountain West drought early warning system

We lead monthly webinars on the drought situation in the intermountain west (might become every 2 weeks if drought worsens)

Register at http://climate.colostate.edu/webinar_registration.html

See graphics at http://climate.colostate.edu/~drought/