Our Climate – Where is it taking us?

Nolan Doesken
Colorado State University

?

Graphics by Zach Schwalbe

Topics for today

- Colorado Climate Basics
- Historical data and observed trends
- What will our future climate be like
- What will this mean for our rivers

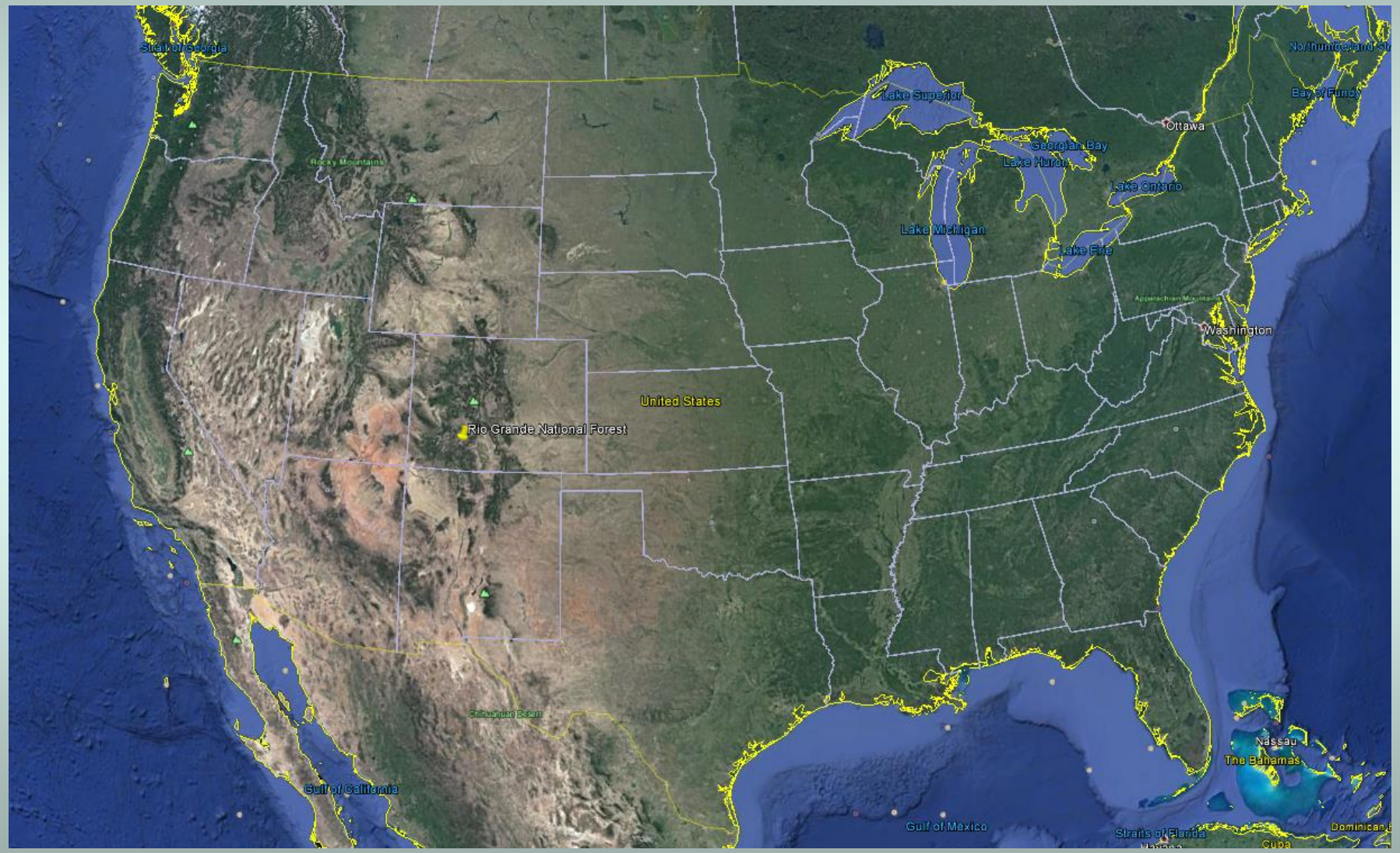
Volunteer Opportunity

CoCoRaHS

How to access our weekly climate, water and drought updates

So let’s step back

Where we are on the planet controls much about our climate



That isn’t changing much is it

The Ingredients for our Colorado Climate

- High elevation (highest state in the Union – by far)
- Mid-Latitude location (lively seasonal changes)
- Interior Continental Location far from atmospheric moisture sources
- Complex Mountain topography
- Solar energy and seasonal cycles drive our climate

These factors do not change year to year, but the weather does

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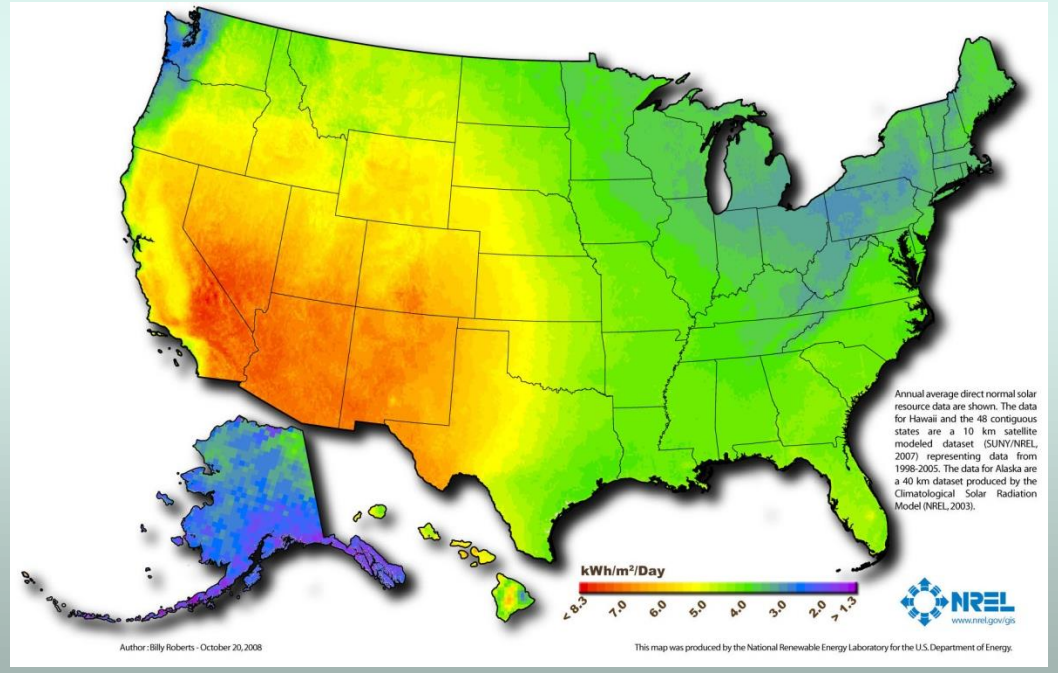
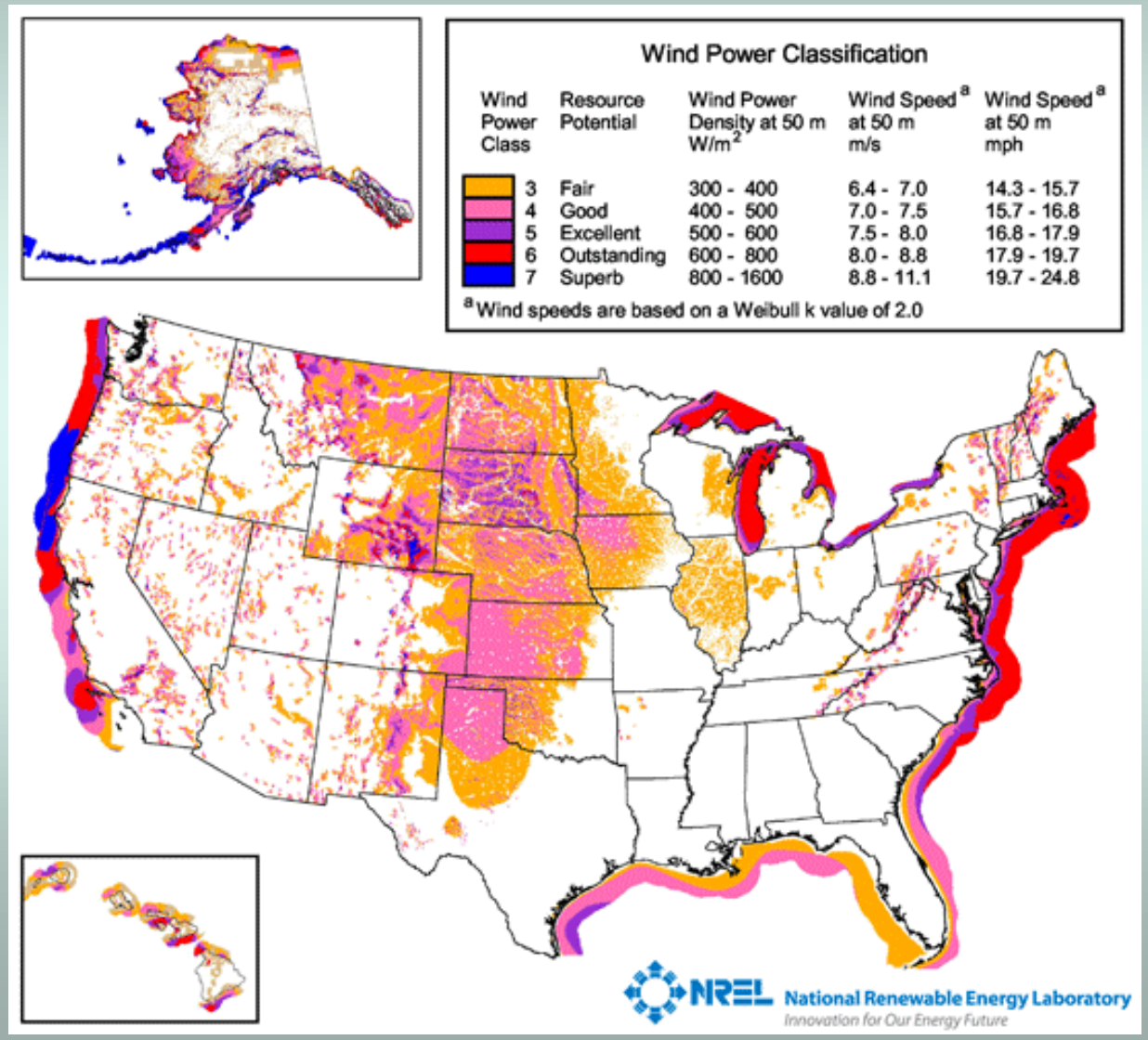
Colorado is a sunny place. People like sunshine!

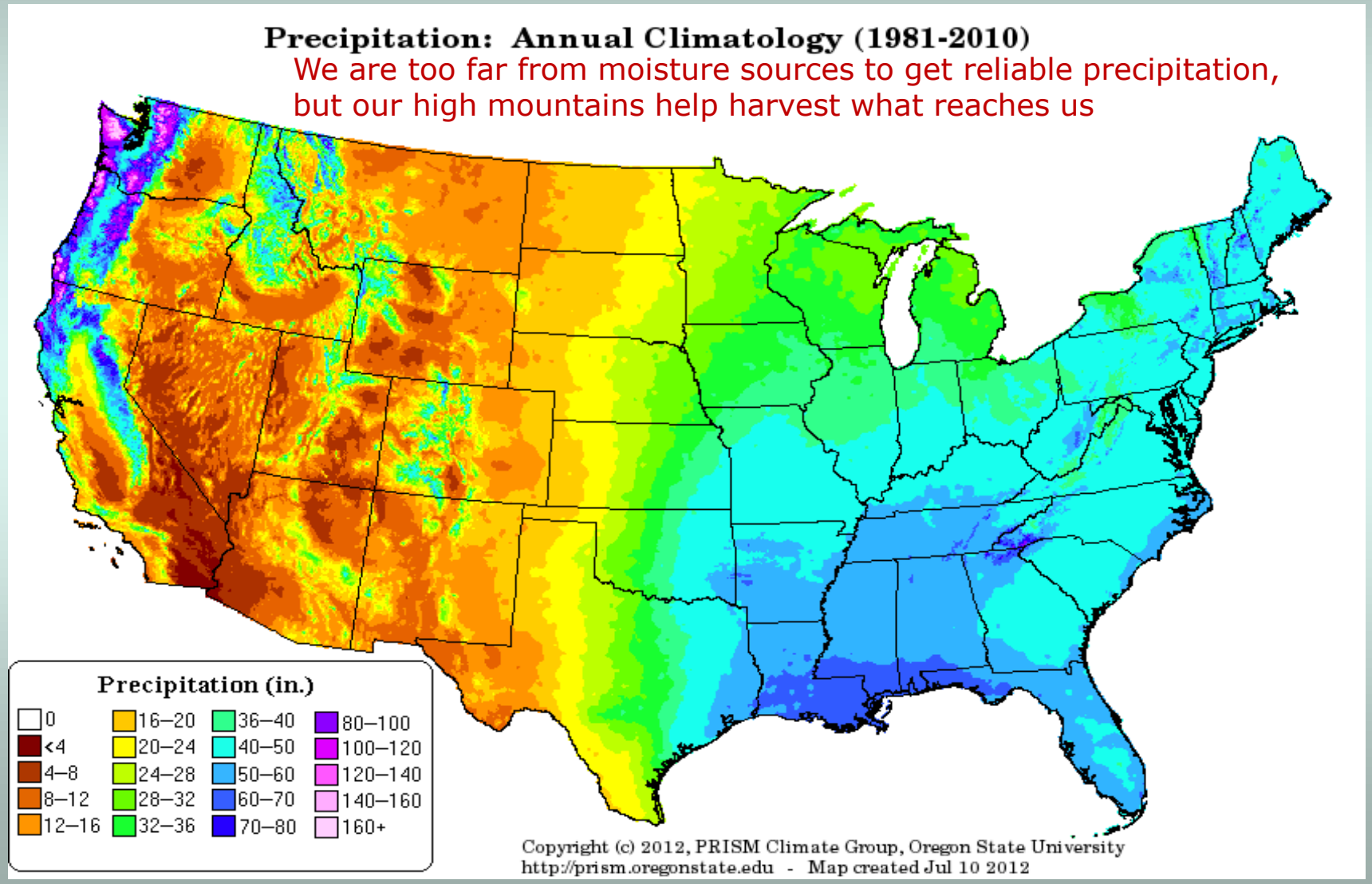


National Renewal Energy Laboratory: www.nrel.gov

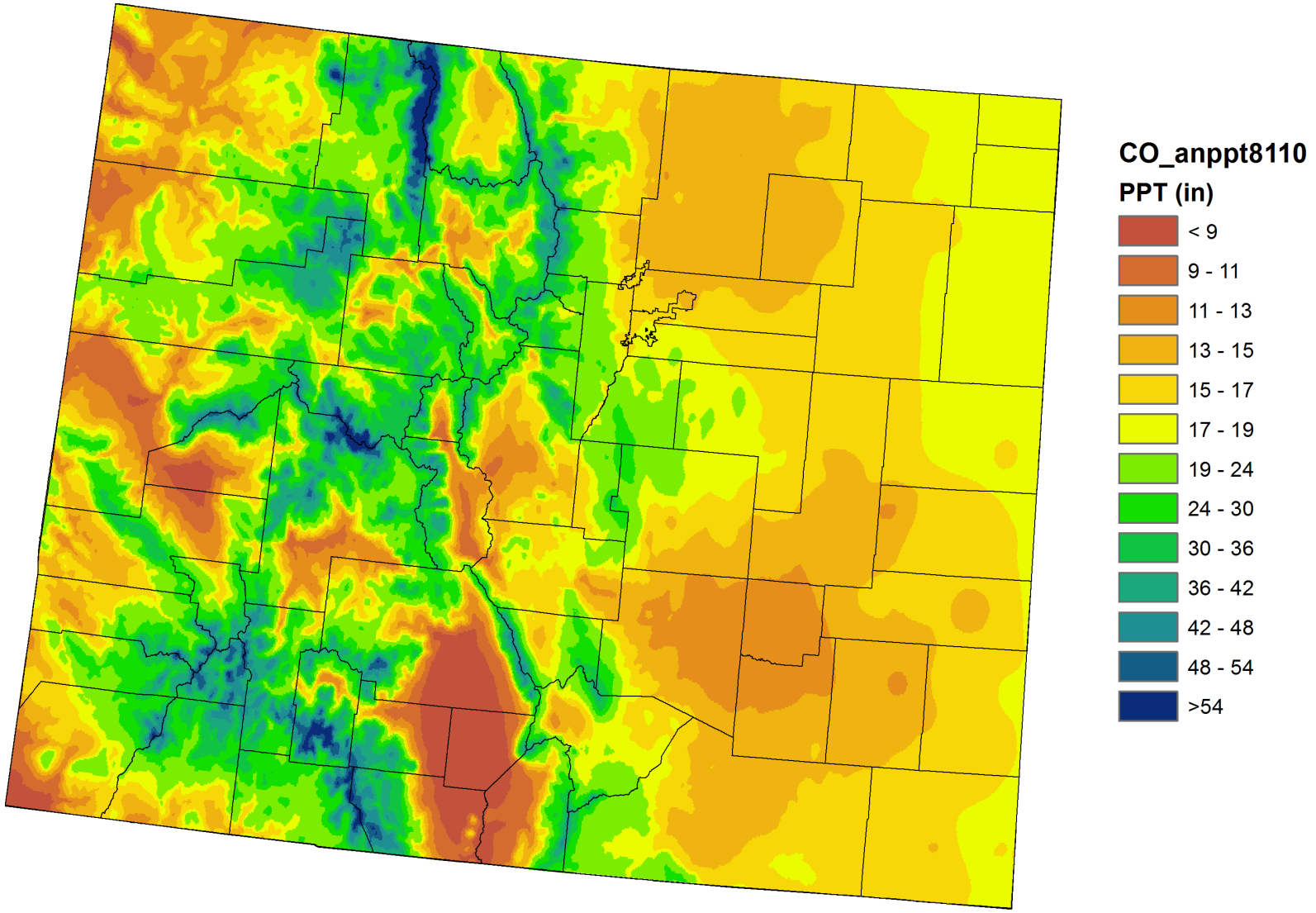
The winds blow, but not as persistently as some places



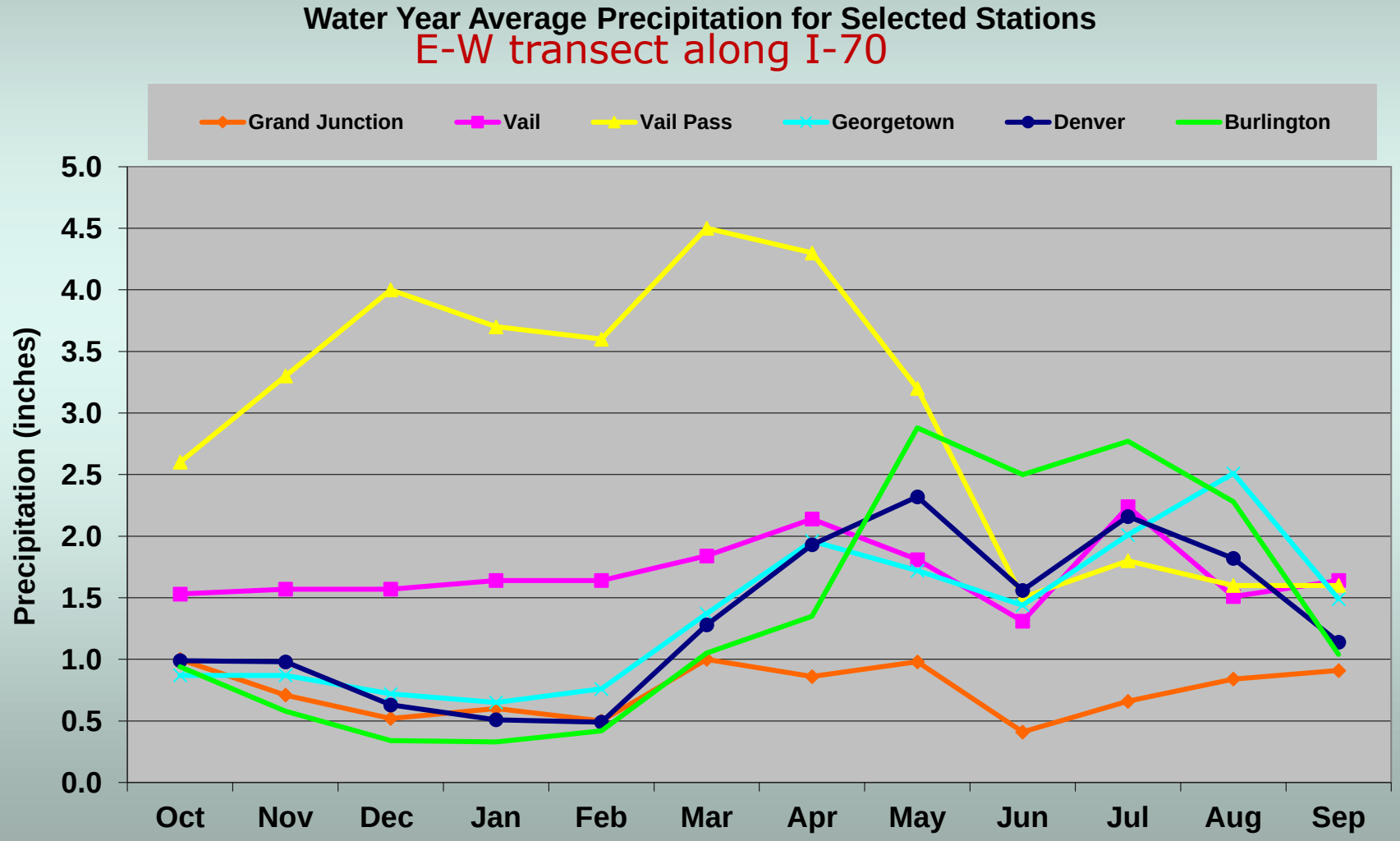
Here is our "precipitation climate". What does this show?

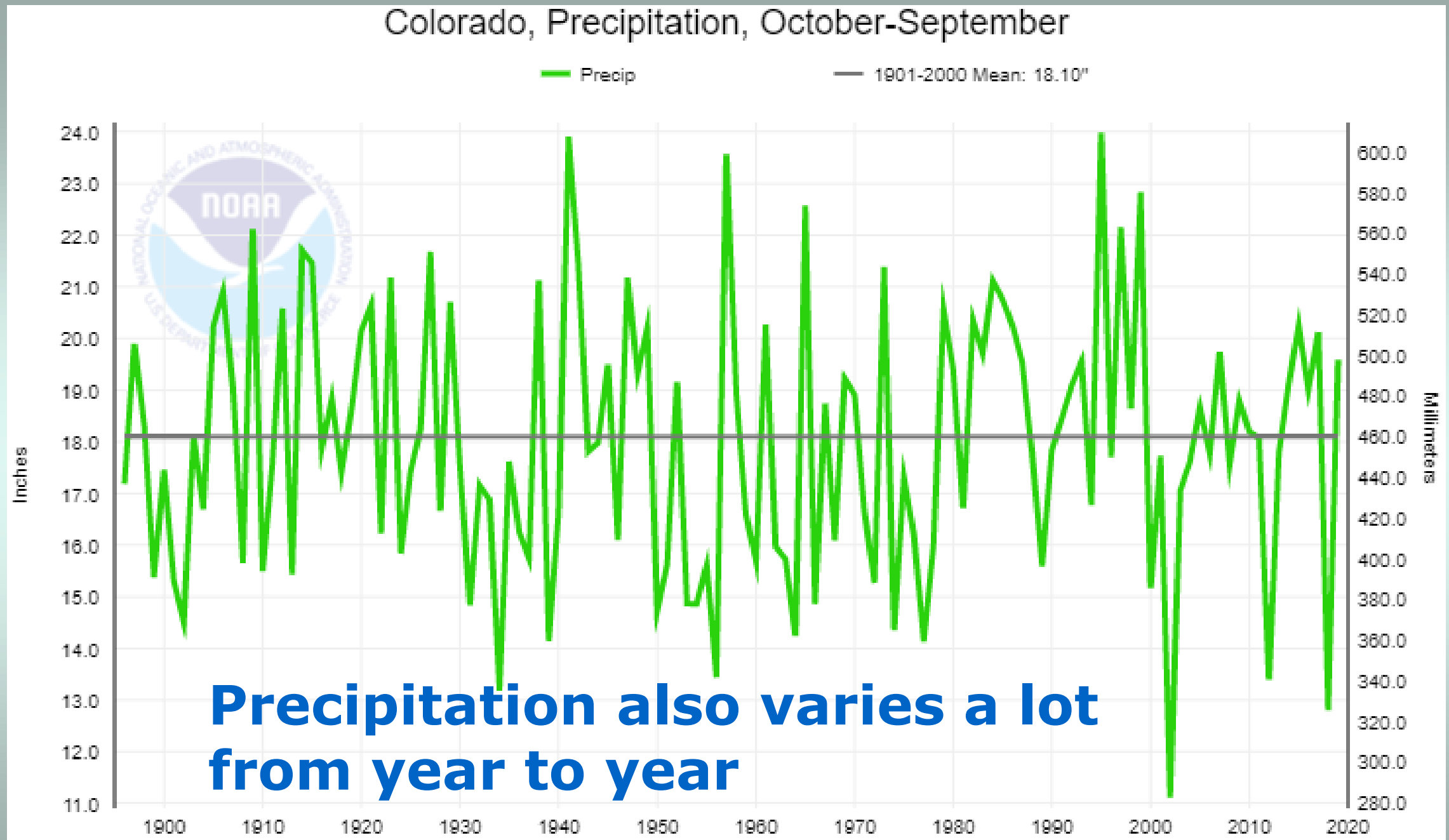


Colorado Annual Average Precipitation (in) 1981-2010

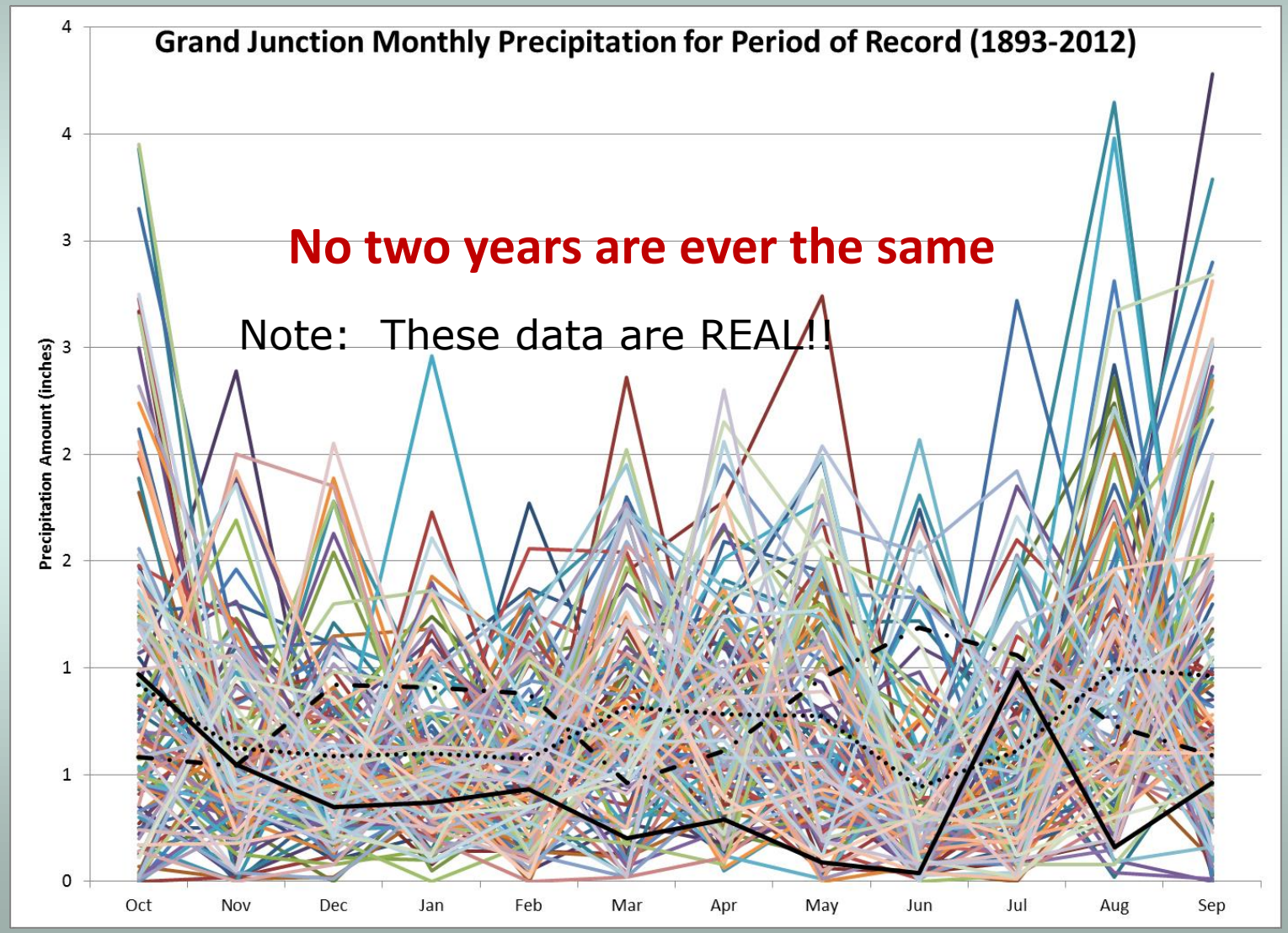


Precipitation in Colorado varies greatly from place to place with changing seasons




Colorado, Precipitation, October-September
Precip
1901-2000 Mean: 18.10"
Inches
Millimeters
24.0
23.0
22.0
21.0
20.0
19.0
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
600.0
580.0
560.0
540.0
520.0
500.0
480.0
460.0
440.0
420.0
400.0
380.0
360.0
340.0
320.0
300.0
280.0
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Precipitation also varies a lot from year to year

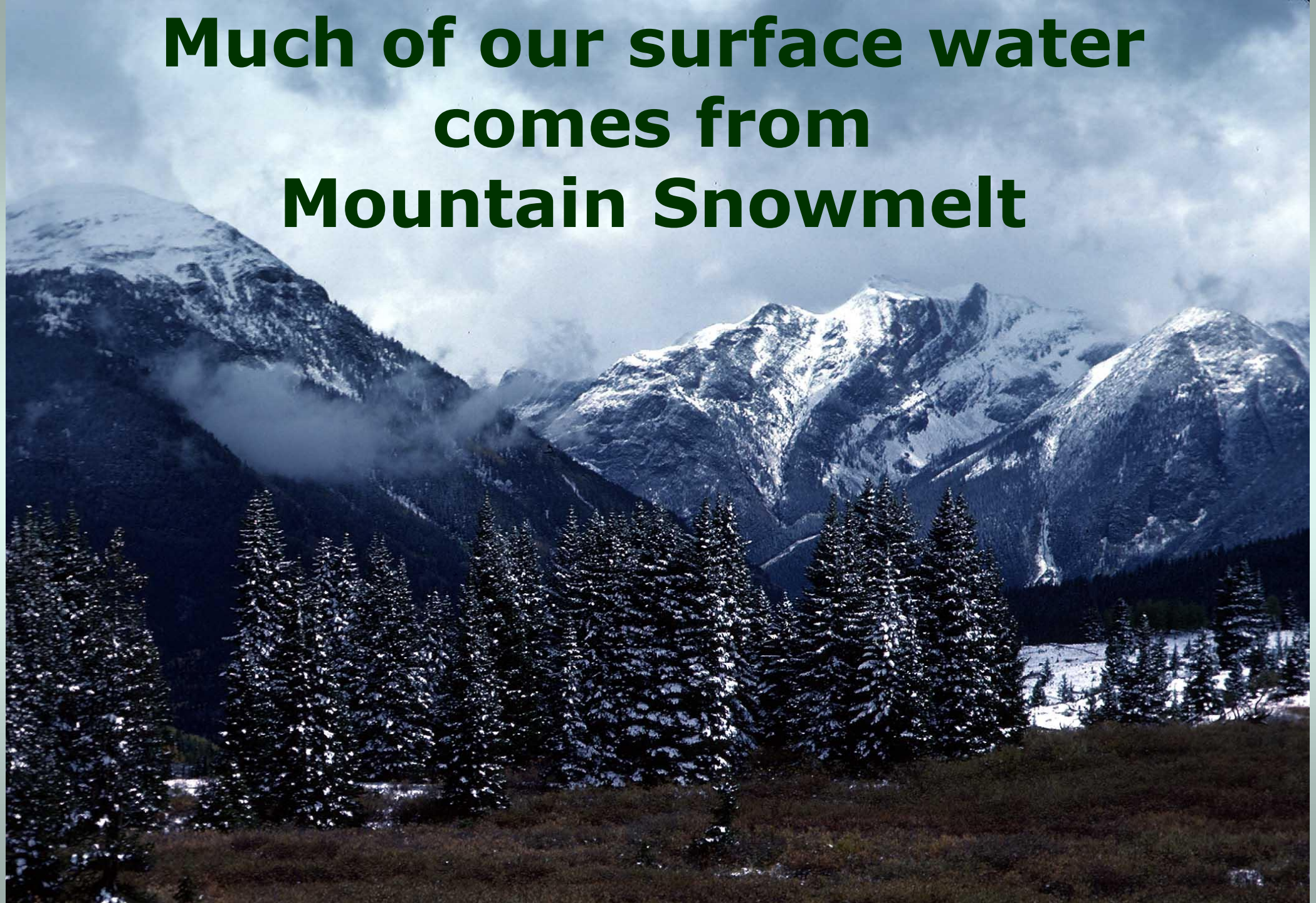
Interannual precipitation variability drives us crazy and keep us off balance



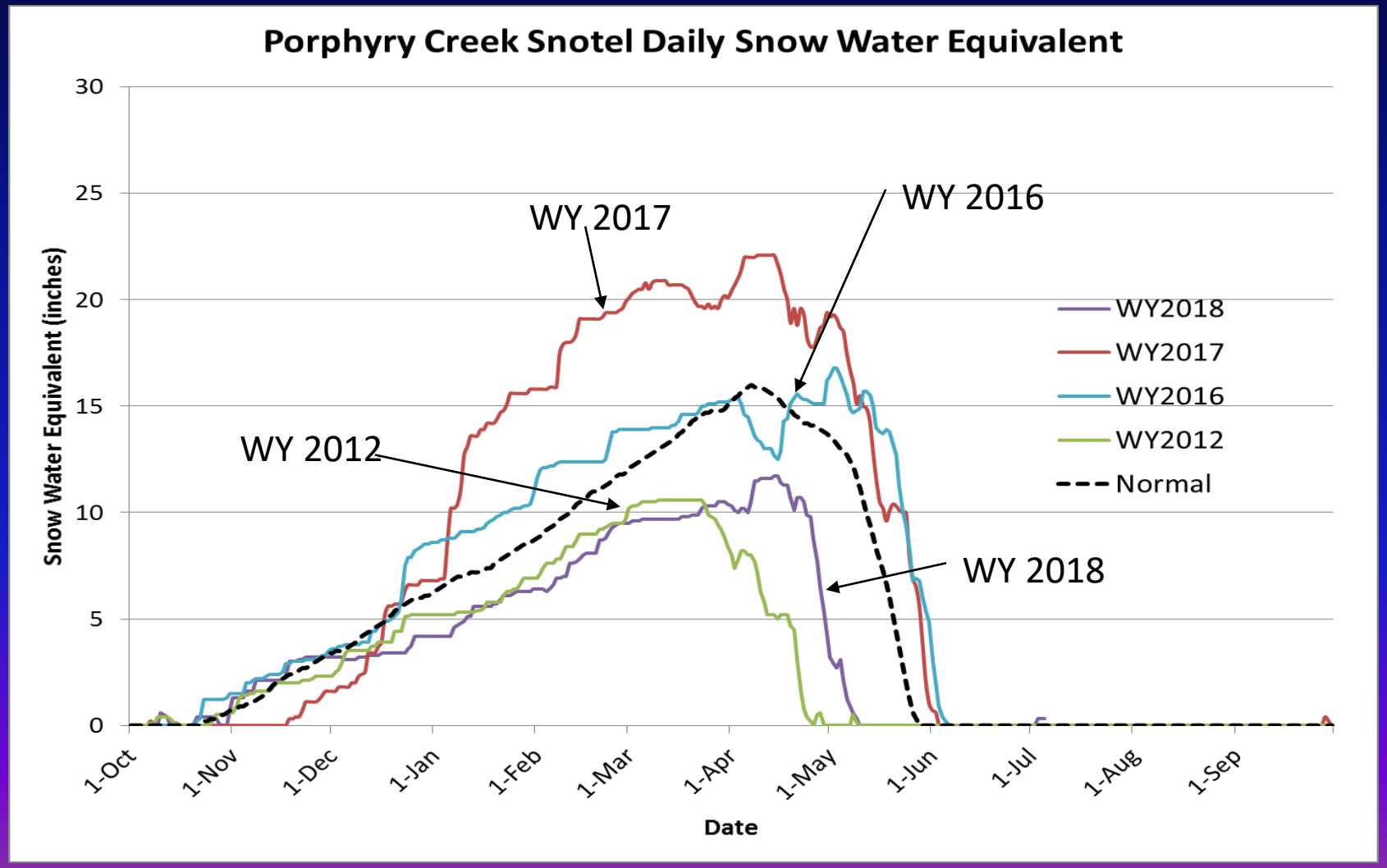
Sometimes we get too much

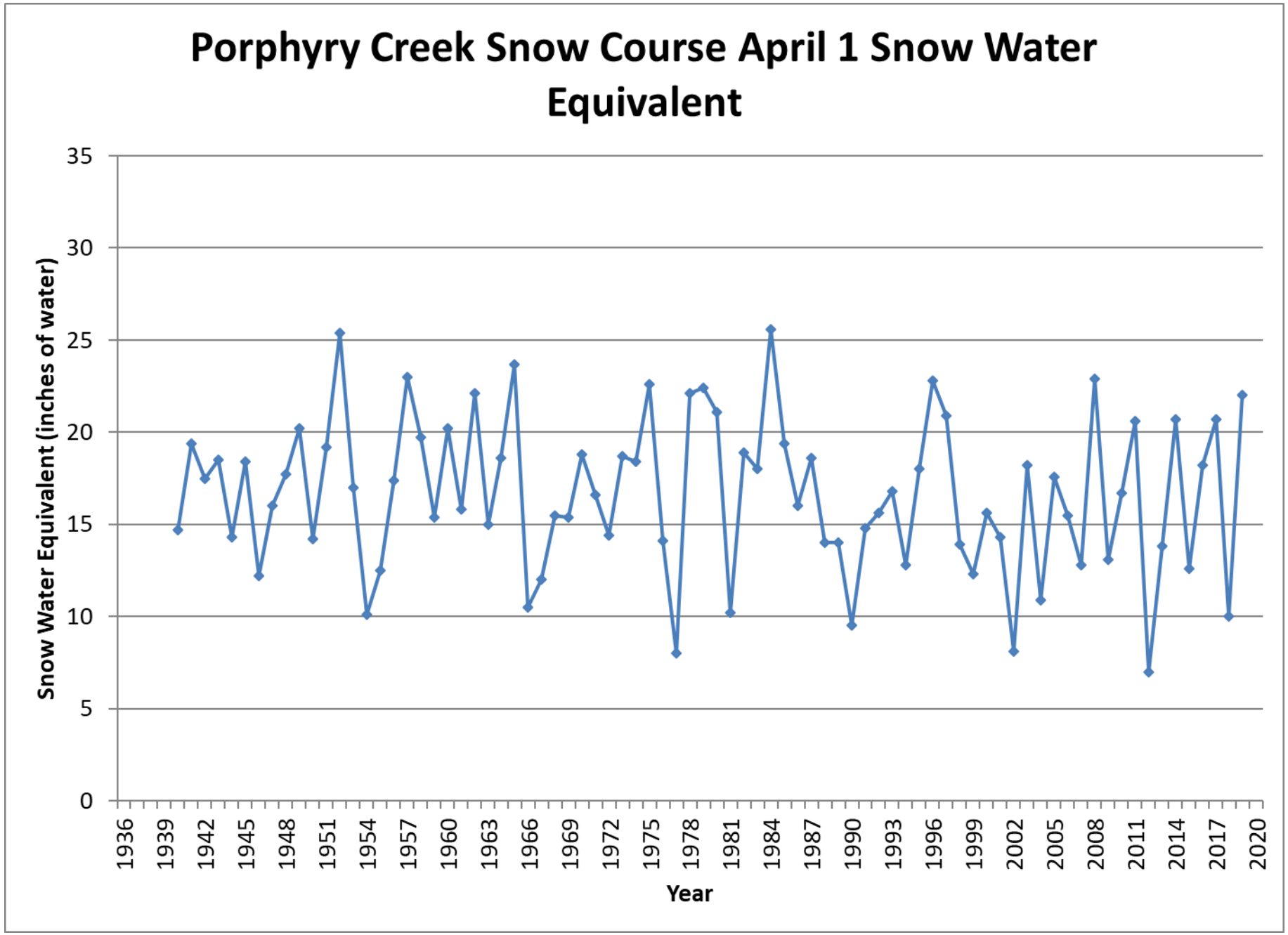
But often too little

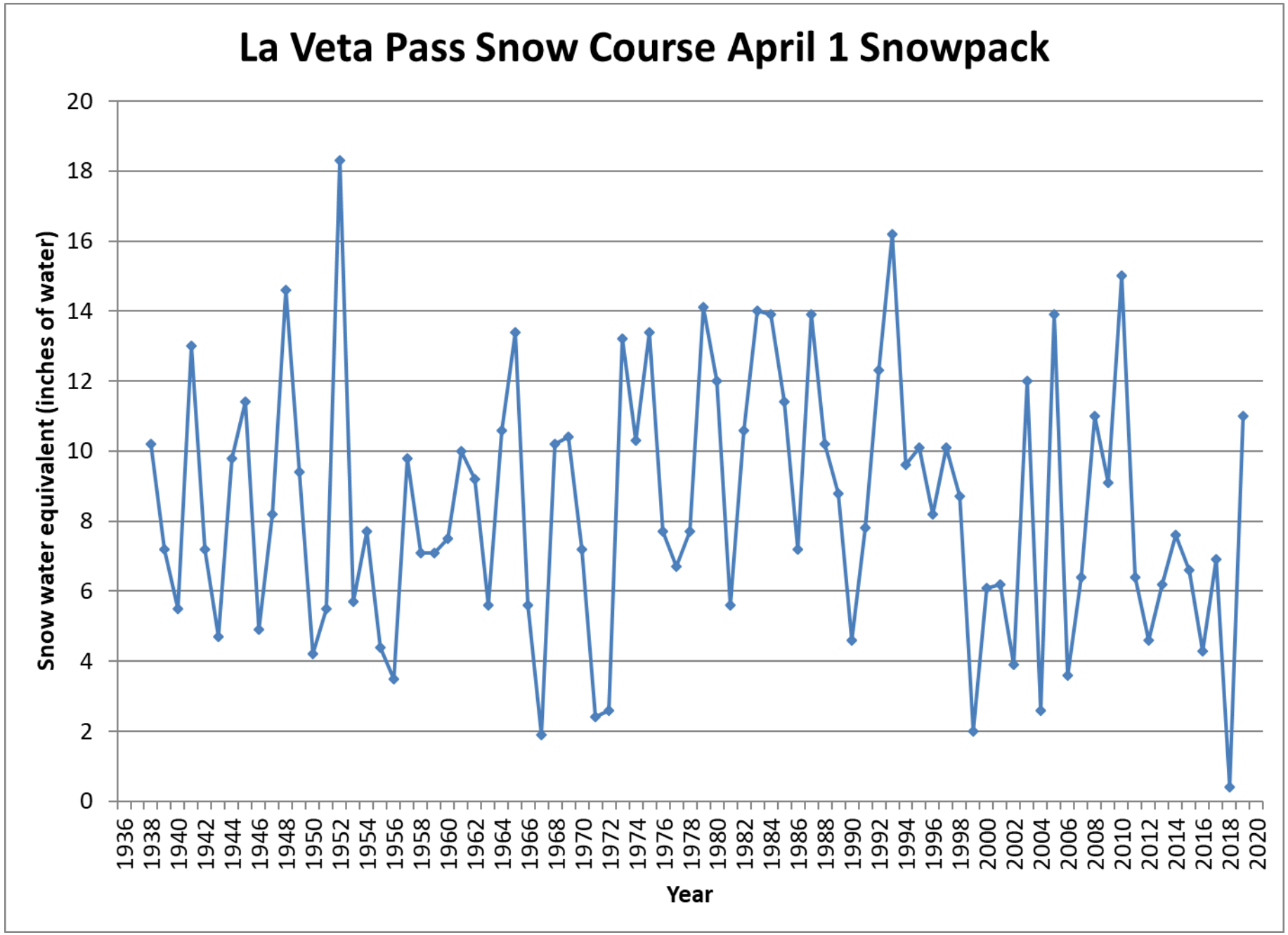
Much of our surface water comes from Mountain Snowmelt



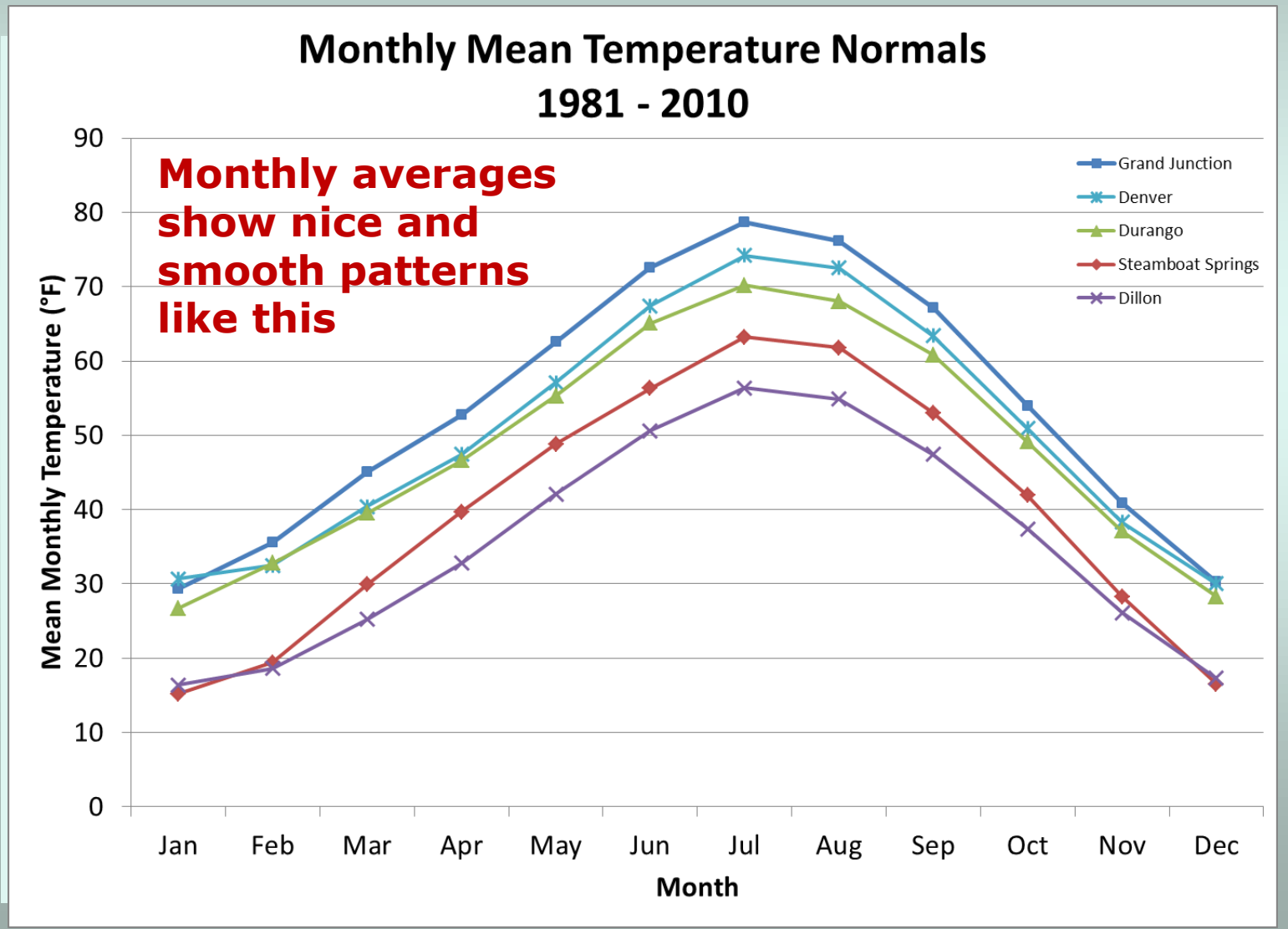
Some years are better than others, and WY 2018 wasn't much to brag about



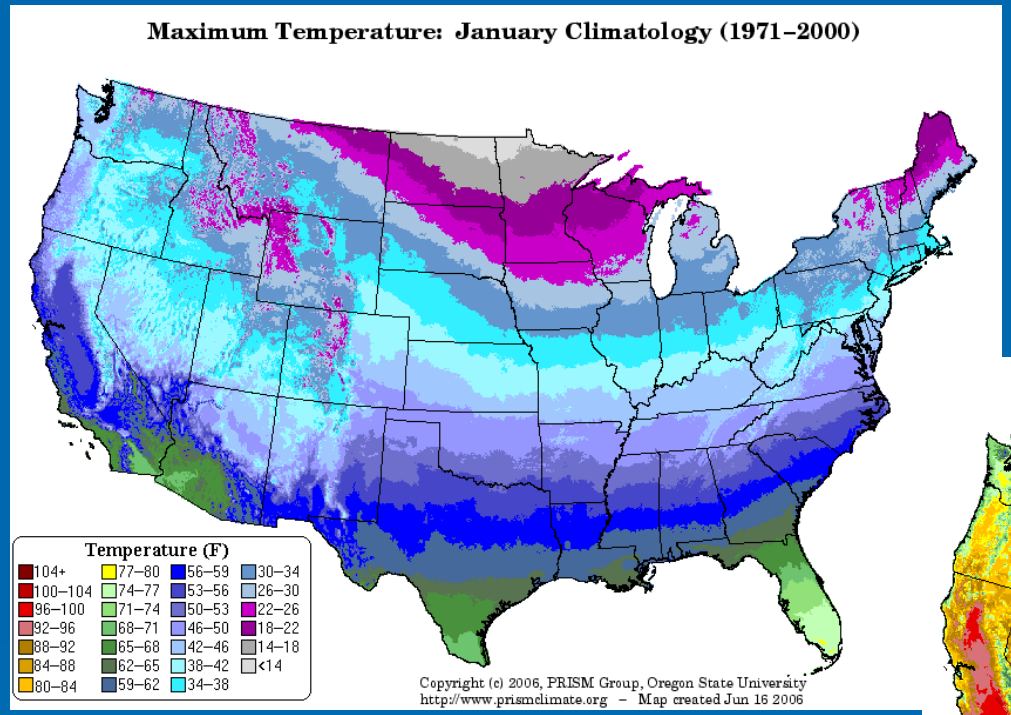

Porphyry Creek Snow Course April 1 Snow Water Equivalent
Snow Water Equivalent (inches of water)
35
30
25
20
15
10
5
0
1936
1939
1942
1945
1948
1951
1954
1957
1960
1963
1966
1969
1972
1975
1978
1981
1984
1987
1990
1993
1996
1999
2002
2005
2008
2011
2014
2017
2020
Year


La Veta Pass Snow Course April 1 Snowpack
Snow water equivalent (inches of water)
0
2
4
6
8
10
12
14
16
18
20
1936
1938
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
Year

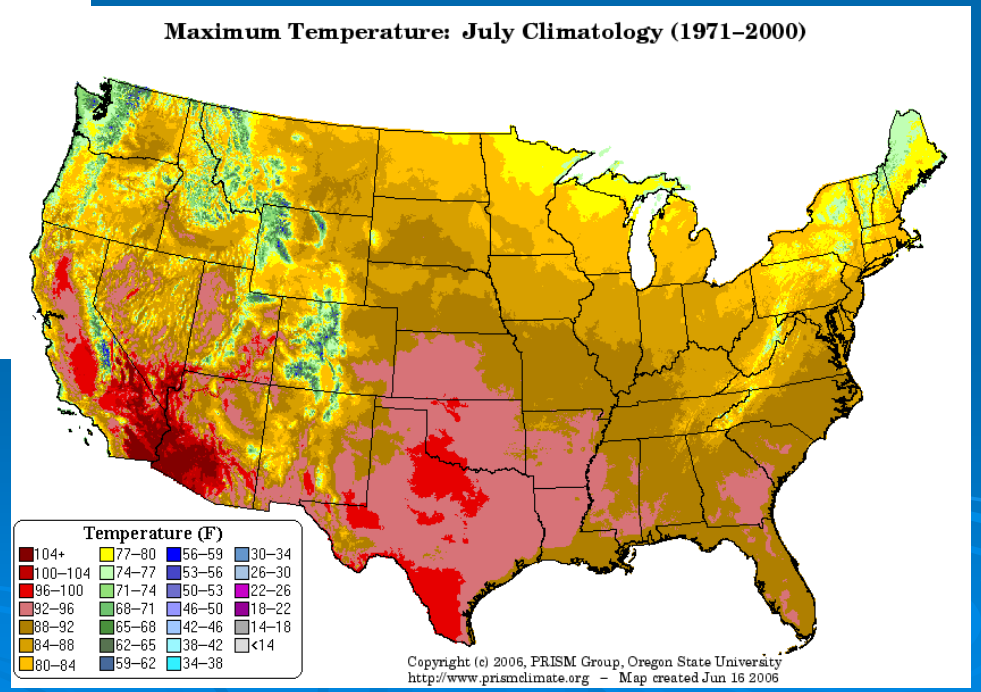
Temperatures are a bit easier to deal with. Summers continue to be warmer than winter



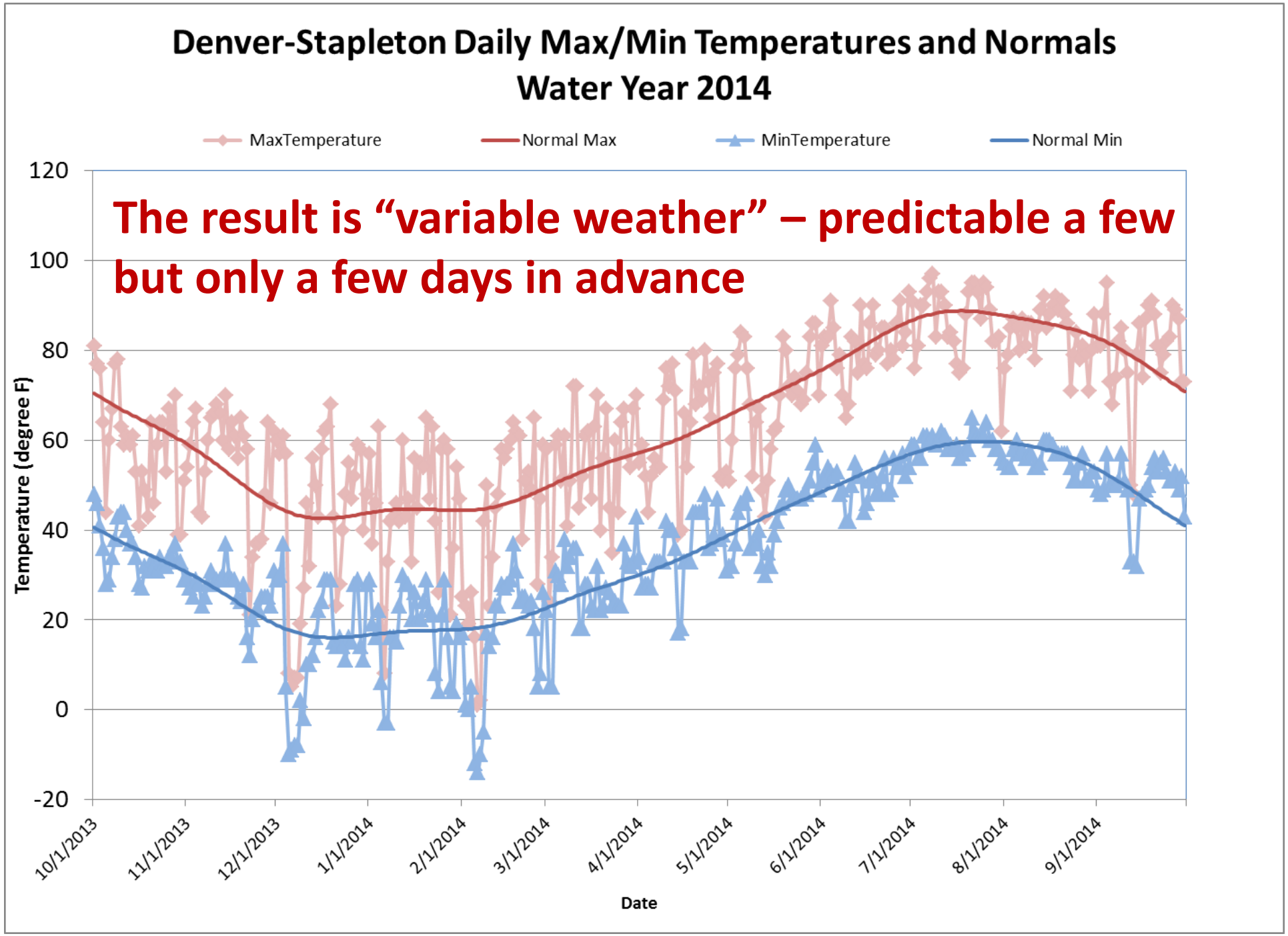
Temperatures are affected by elevation and topography

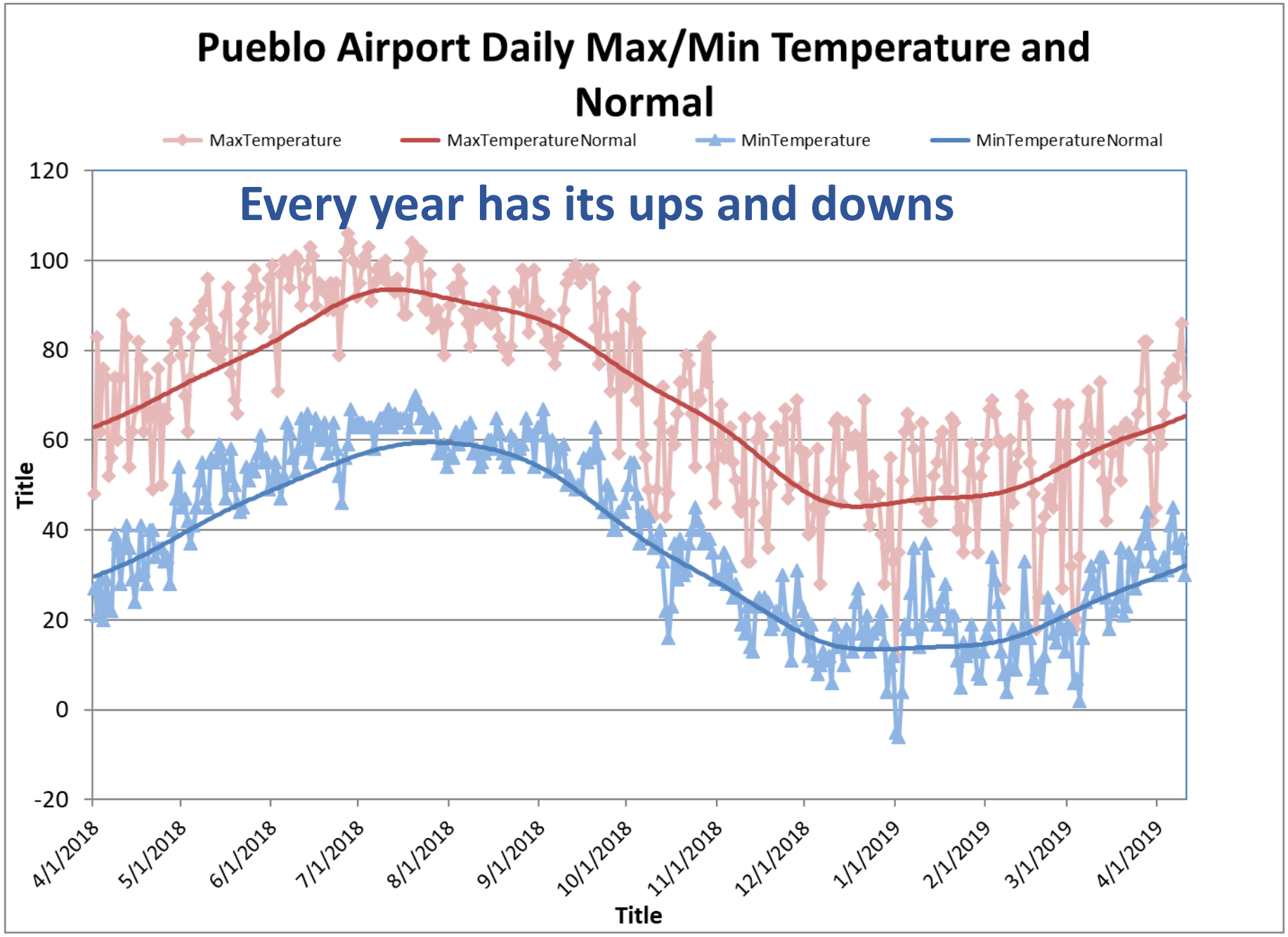


Not just latitude like in the Midwest.

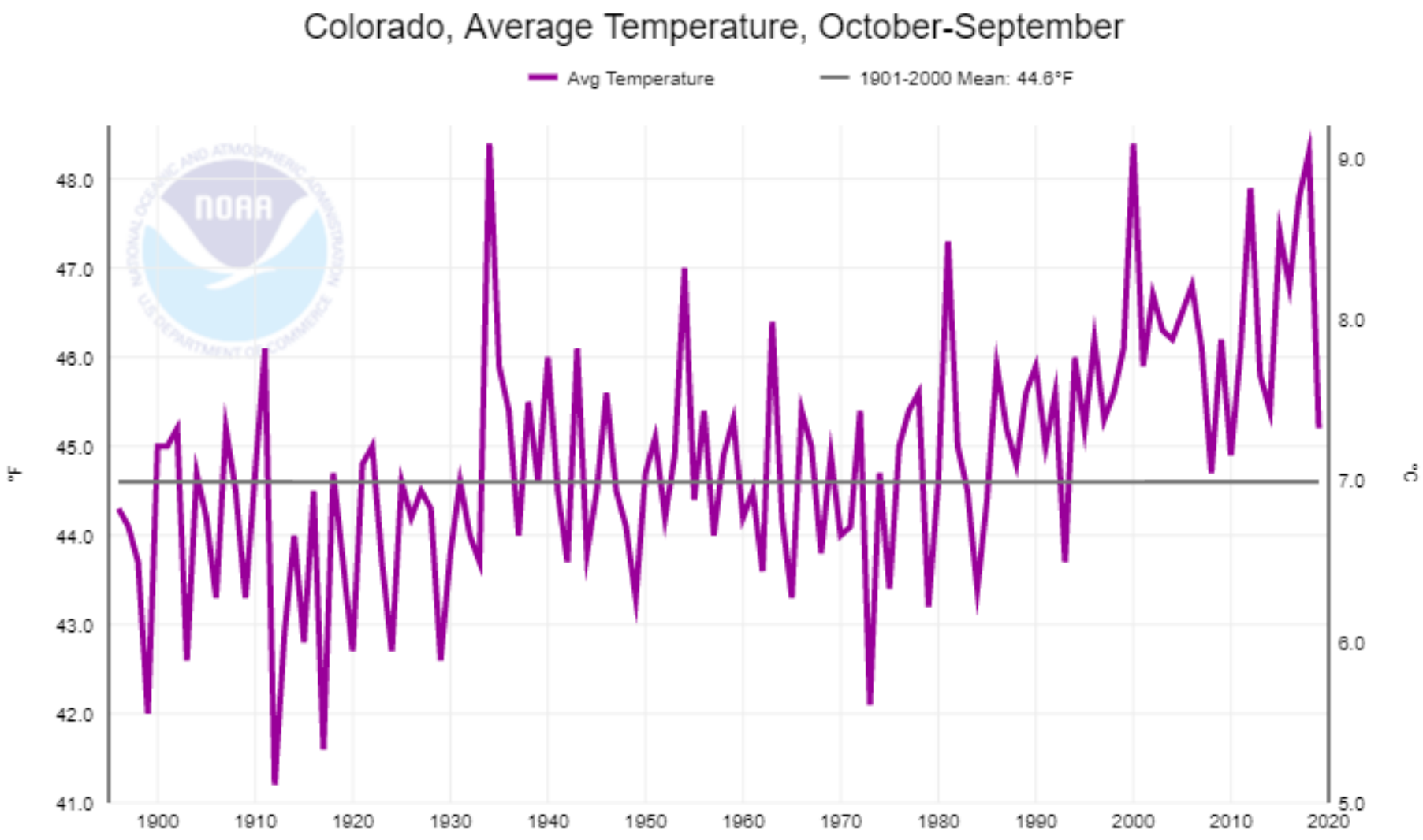


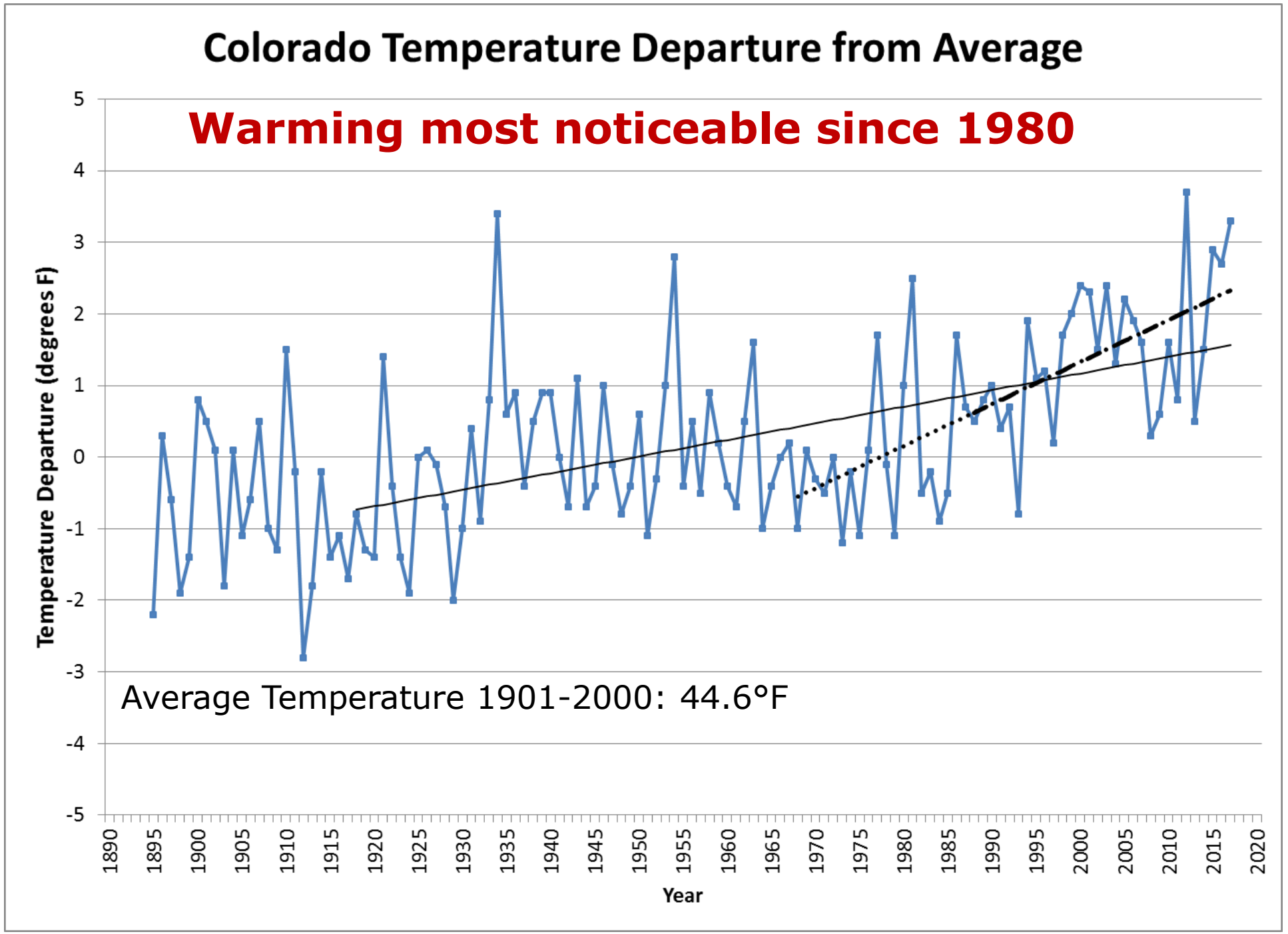
Usually colder in the mountains!

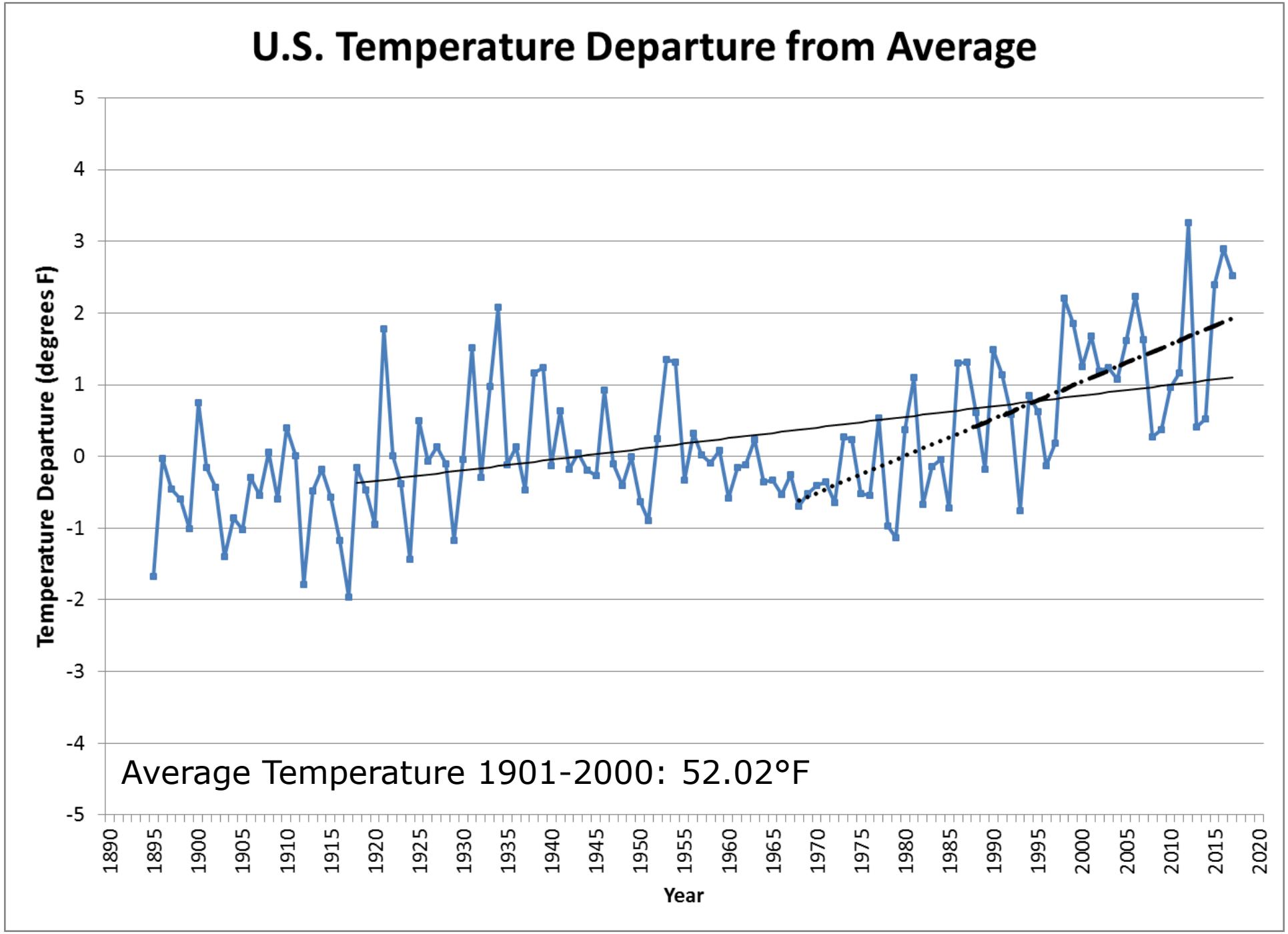

Denver-Stapleton Daily Max/Min Temperatures and Normals
Water Year 2014
MaxTemperature
Normal Max
MinTemperature
Normal Min
The result is “variable weather” – predictable a few but only a few days in advance
120
100
80
60
40
20
0
-20
Temperature (degree F)
10/1/2013
11/1/2013
12/1/2013
1/1/2014
2/1/2014
3/1/2014
4/1/2014
5/1/2014
6/1/2014
7/1/2014
8/1/2014
9/1/2014
Date

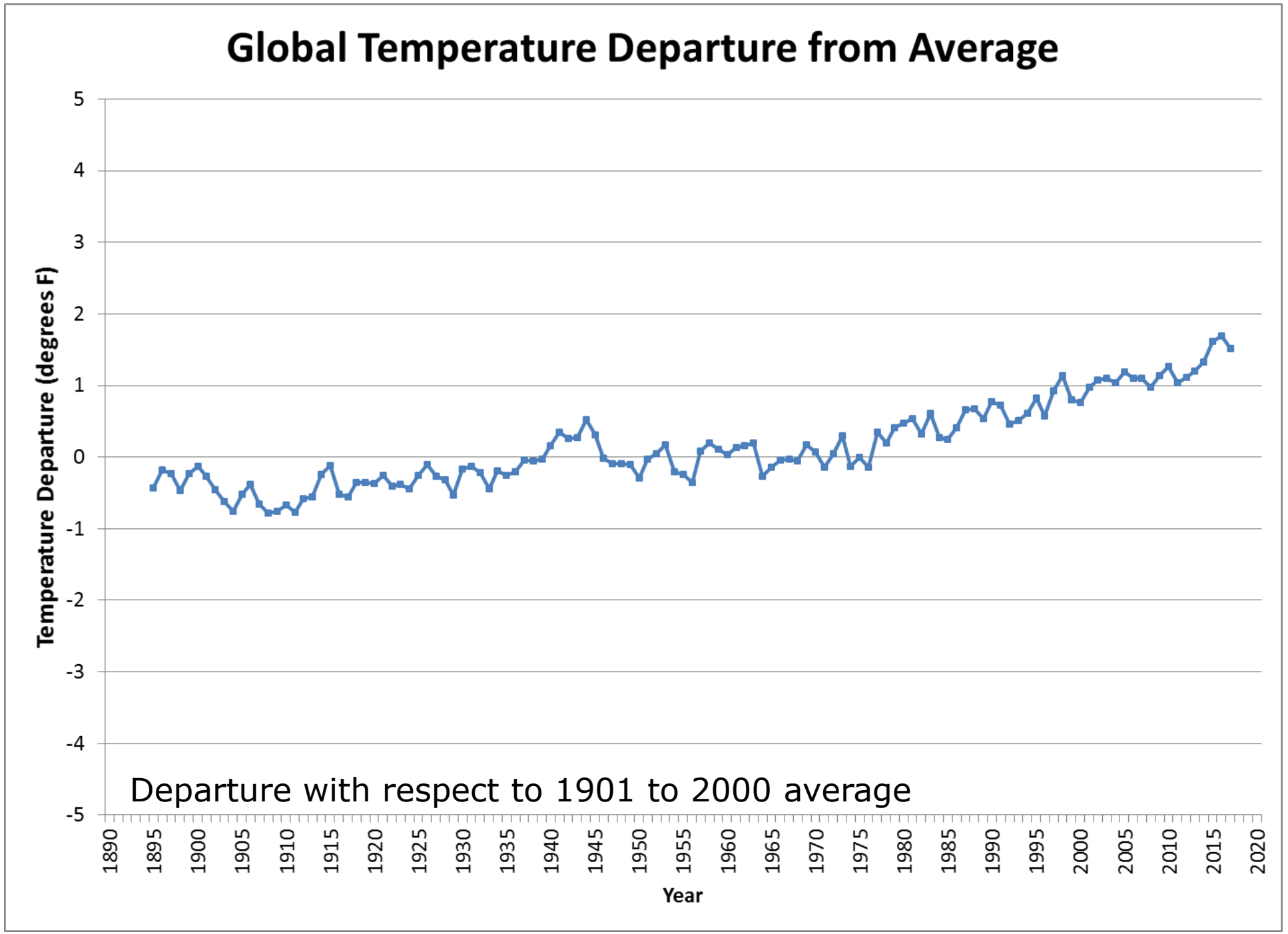

Pueblo Airport Daily Max/Min Temperature and Normal
MaxTemperature
MaxTemperatureNormal
MinTemperature
MinTemperatureNormal
Every year has its ups and downs
120
100
80
60
40
20
0
-20
Title
4/1/2018
5/1/2018
6/1/2018
7/1/2018
8/1/2018
9/1/2018
10/1/2018
11/1/2018
12/1/2018
1/1/2019
2/1/2019
3/1/2019
4/1/2019
Title

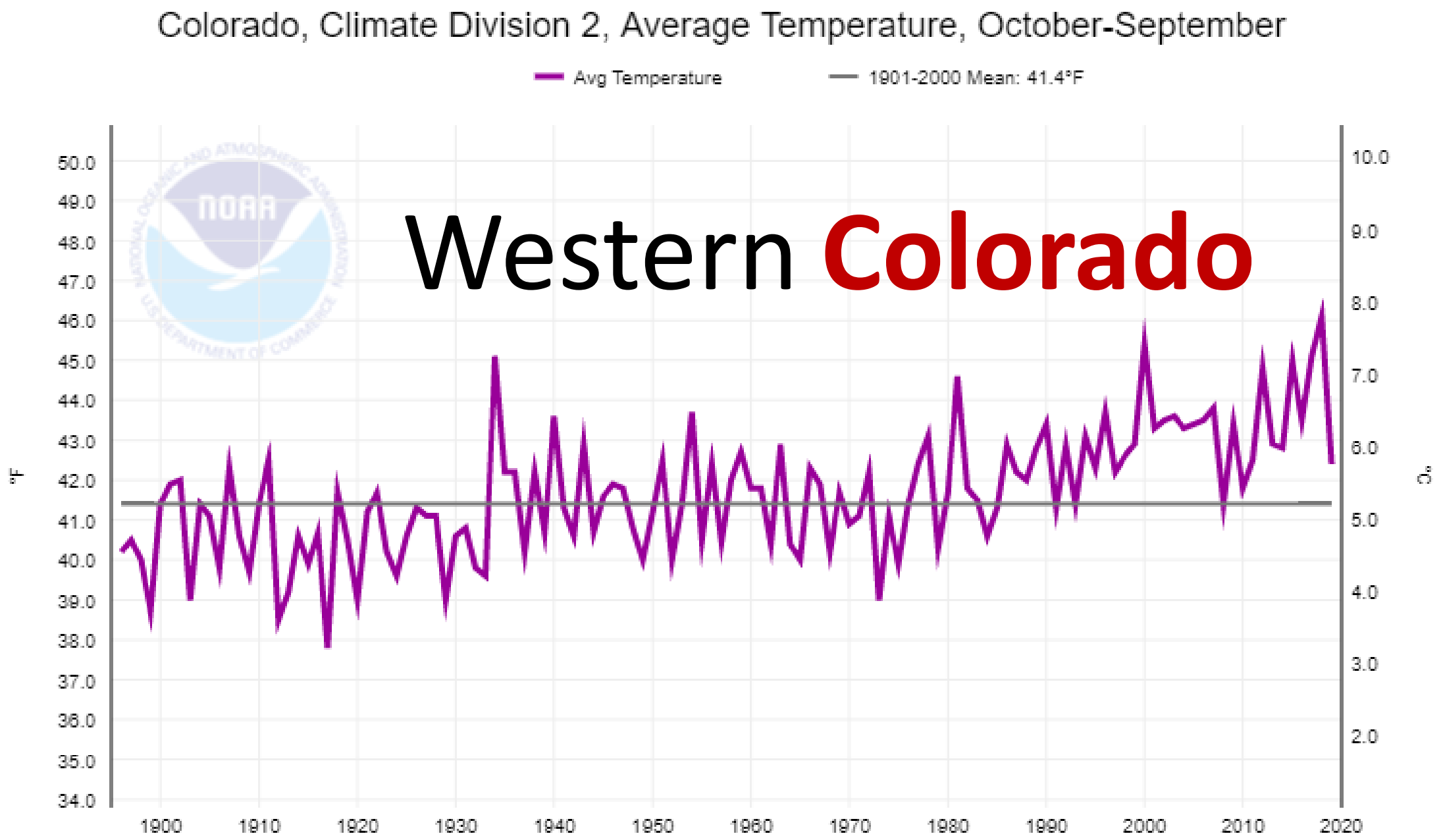
Temperatures also vary from year to year




Colorado Temperature Departure from Average
Warming most noticeable since 1980
Temperature Departure (degrees F)
5
4
3
2
1
0
-1
-2
-3
-4
-5
Average Temperature 1901-2000: 44.6°F
1890
1895
1900
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Year


U.S. Temperature Departure from Average
Temperature Departure (degrees F)
5
4
3
2
1
0
-1
-2
-3
-4
-5
1890
1895
1900
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Year
Average Temperature 1901-2000: 52.02°F


Global Temperature Departure from Average
Temperature Departure (degrees F)
5
4
3
2
1
0
-1
-2
-3
-4
-5
1890
1895
1900
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Year
Departure with respect to 1901 to 2000 average


Colorado, Climate Division 2, Average Temperature, October-September
Avg Temperature
1901-2000 Mean: 41.4°F
Western Colorado
°F
°C
50.0
49.0
48.0
47.0
46.0
45.0
44.0
43.0
42.0
41.0
40.0
39.0
38.0
37.0
36.0
35.0
34.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020

Summary

-- We've got a great climate but with some interesting challenges. Here is what we've noted so far

-- Temperatures in Colorado are warming, especially since 1980

-- More really warm days, fewer really cold days

-- Trends in Colorado are similar to U.S and Globe but a bit sharper rises in Western CO

-- Growing season longer but irregular

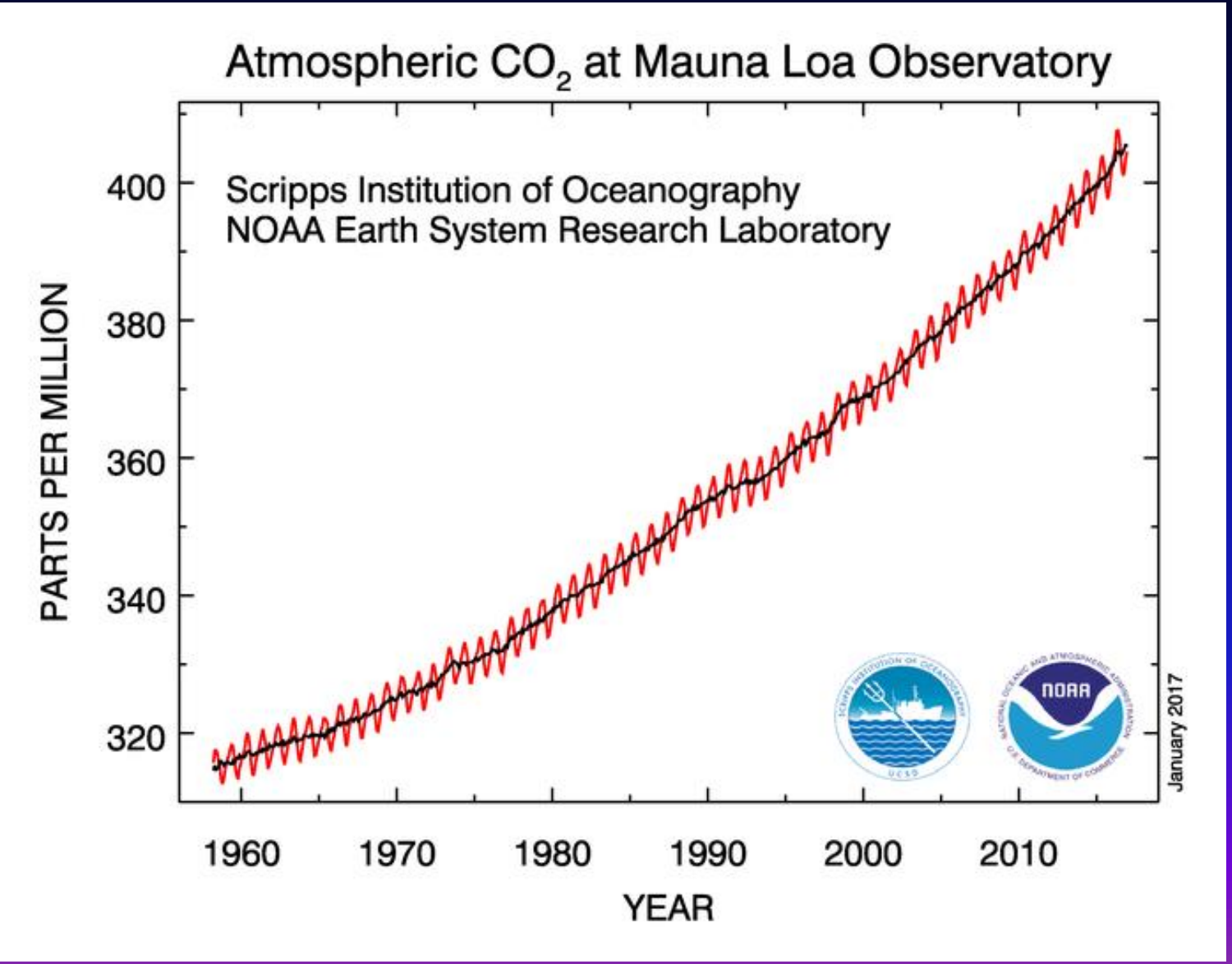
-- No significant trends in precipitation yet

-- Recent drought episodes have been hotter

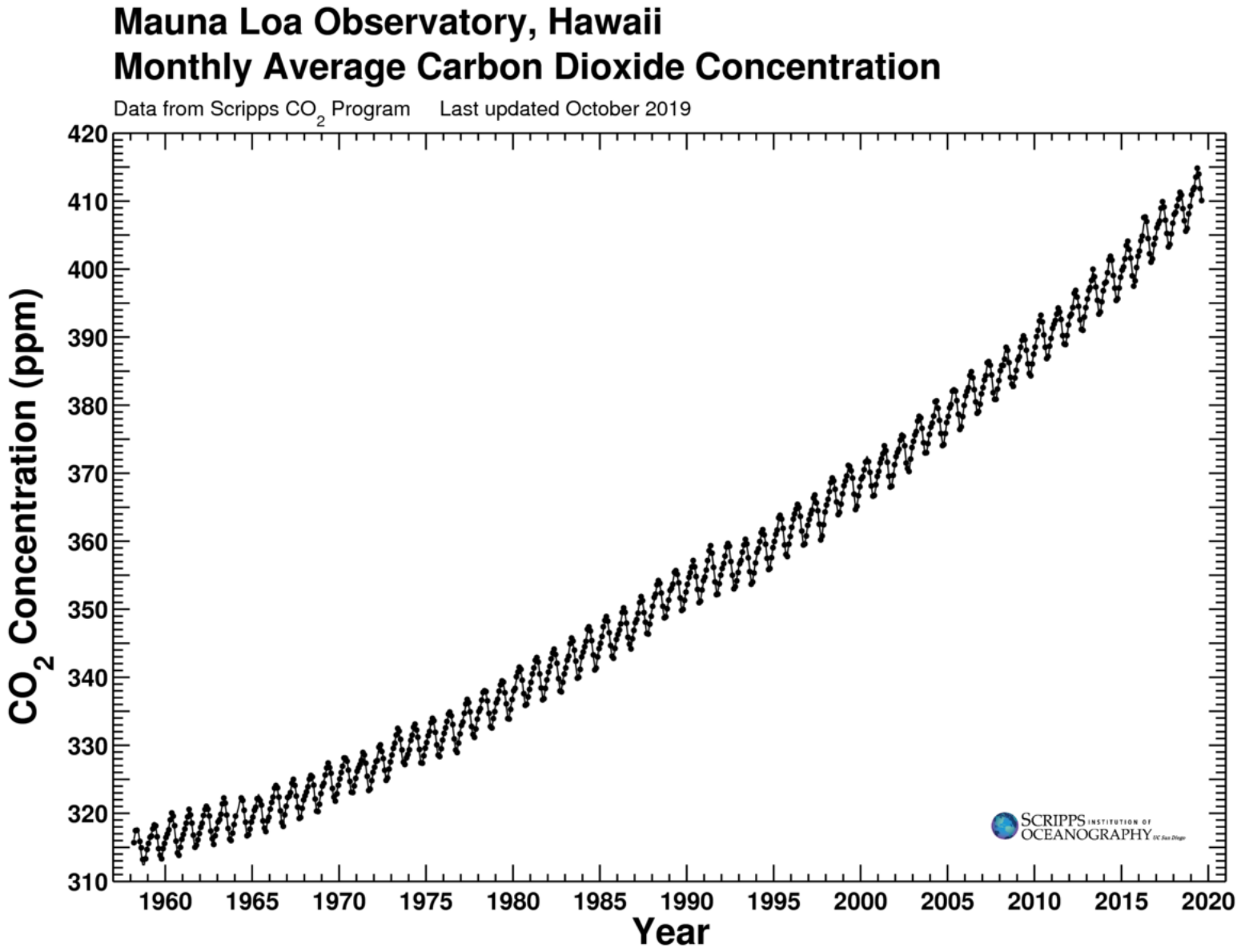
-- April 1 snowpack declining

Insert a hydrograph or two.

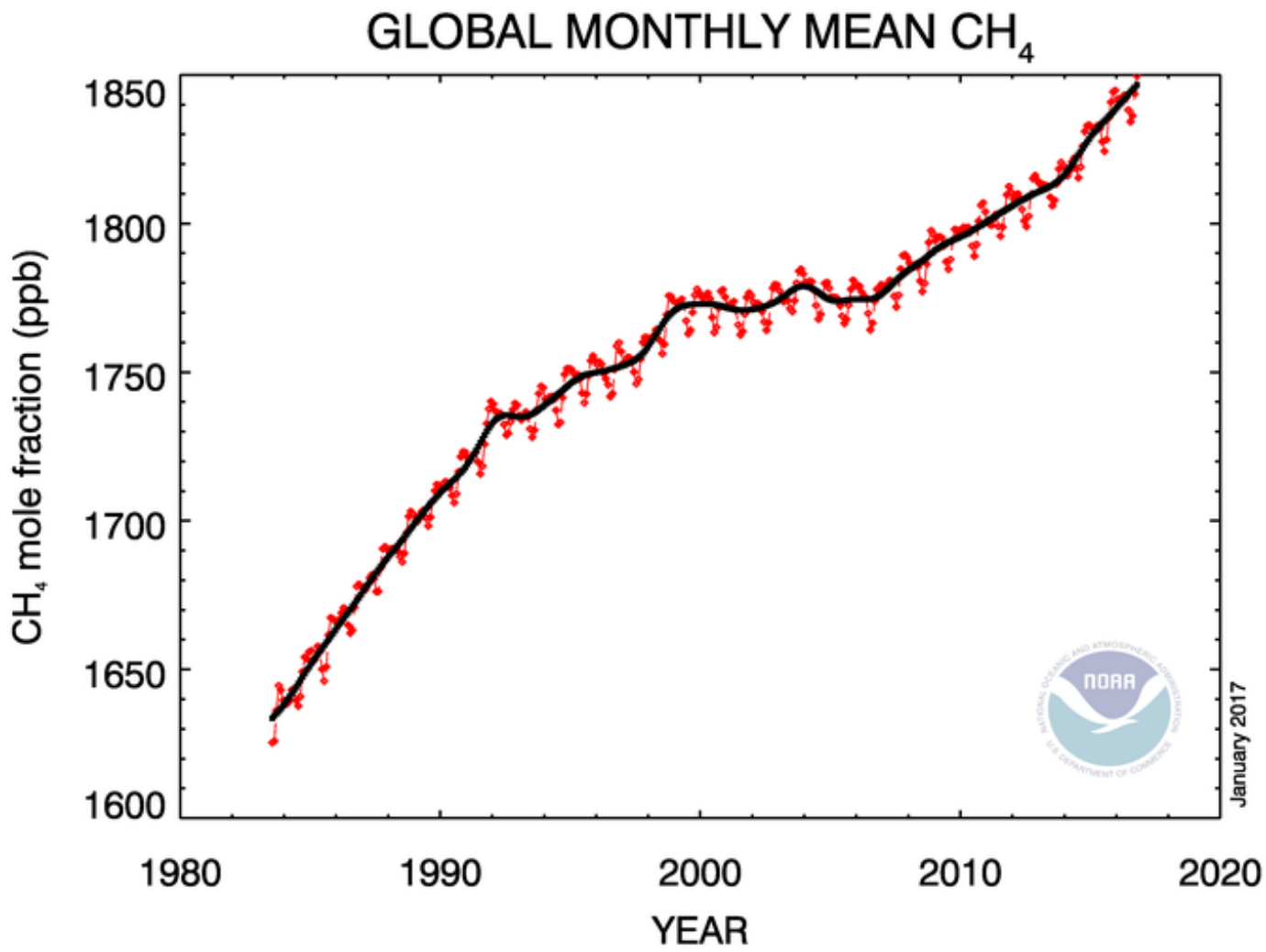
And then there's this



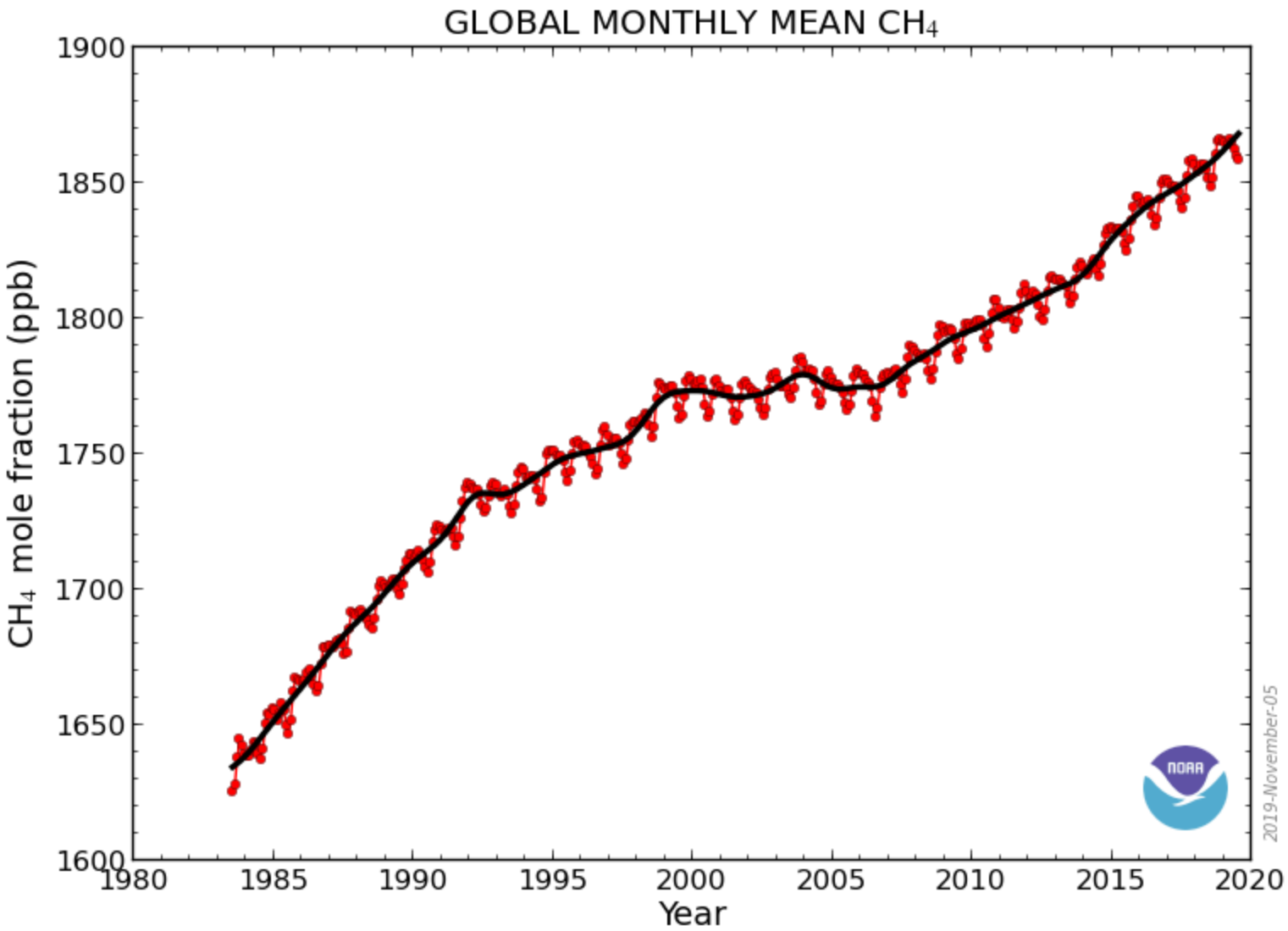
CO2 at Mauna Loa Observatory



And Methane too – what to do?



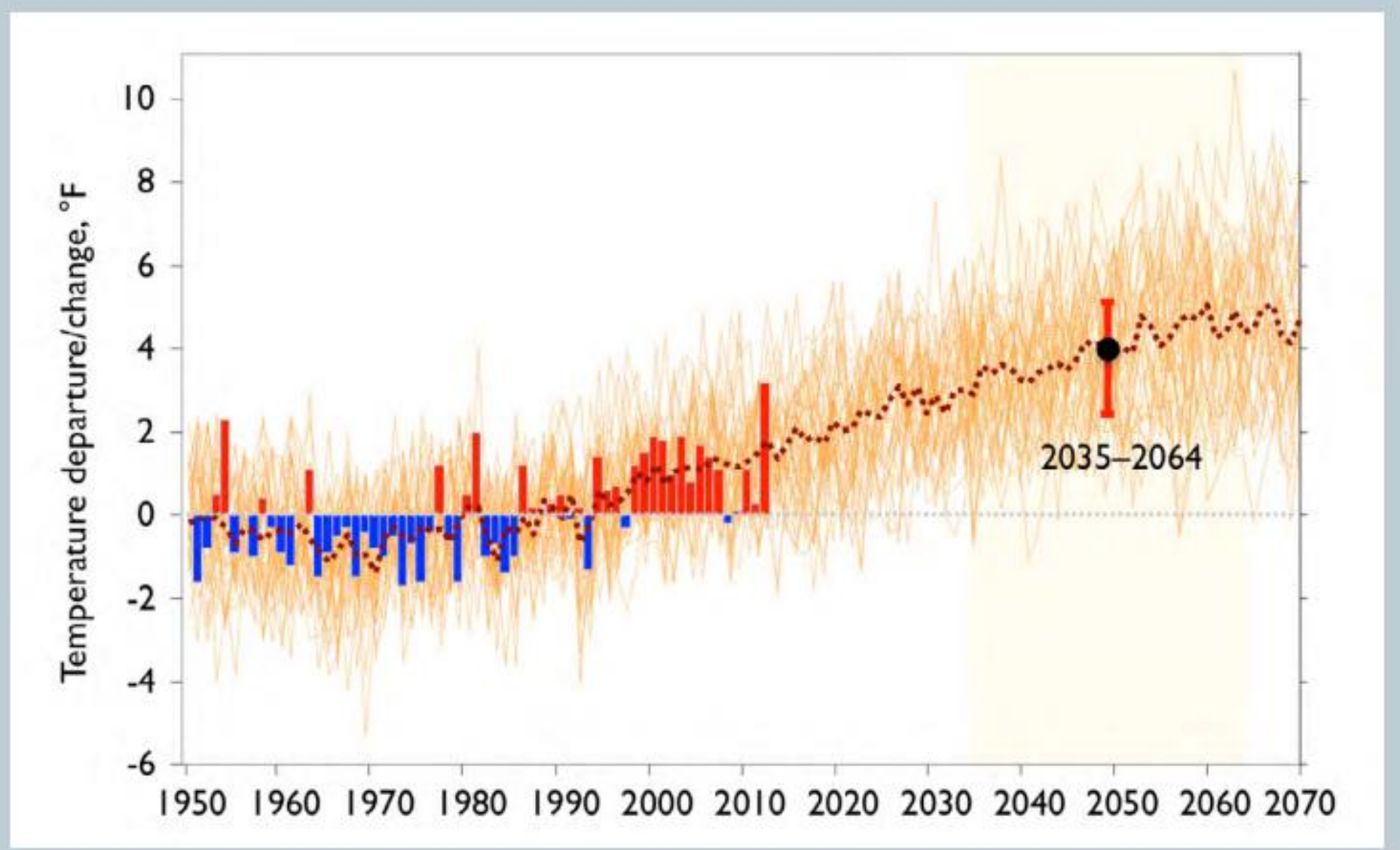
Global Monthly Mean CH4 (Methane)



What does this mean?

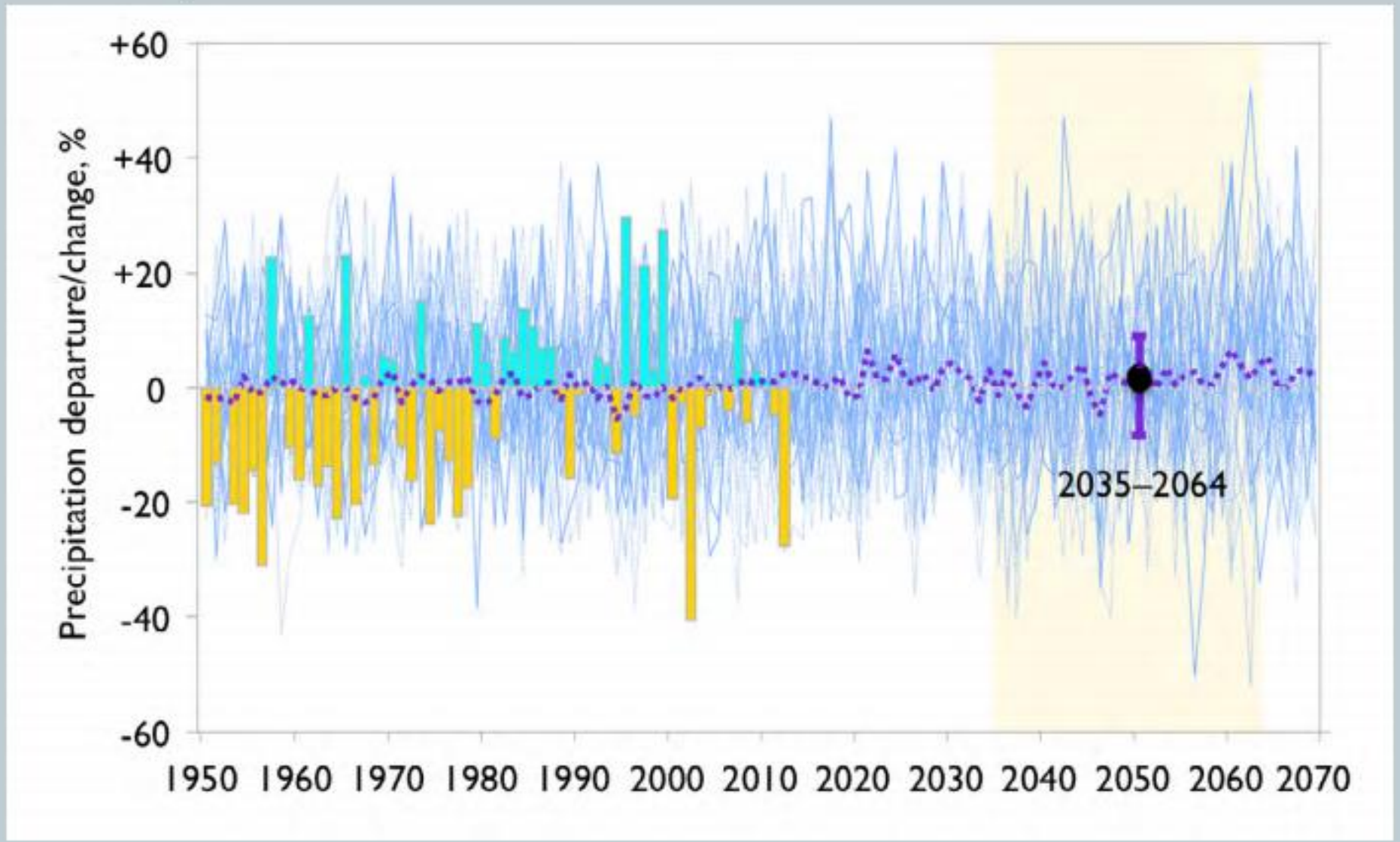
There is high confidence that we will continue to warm

FIGURE 5-2. Projected Colorado annual temperature under RCP 4.5 compared to observations



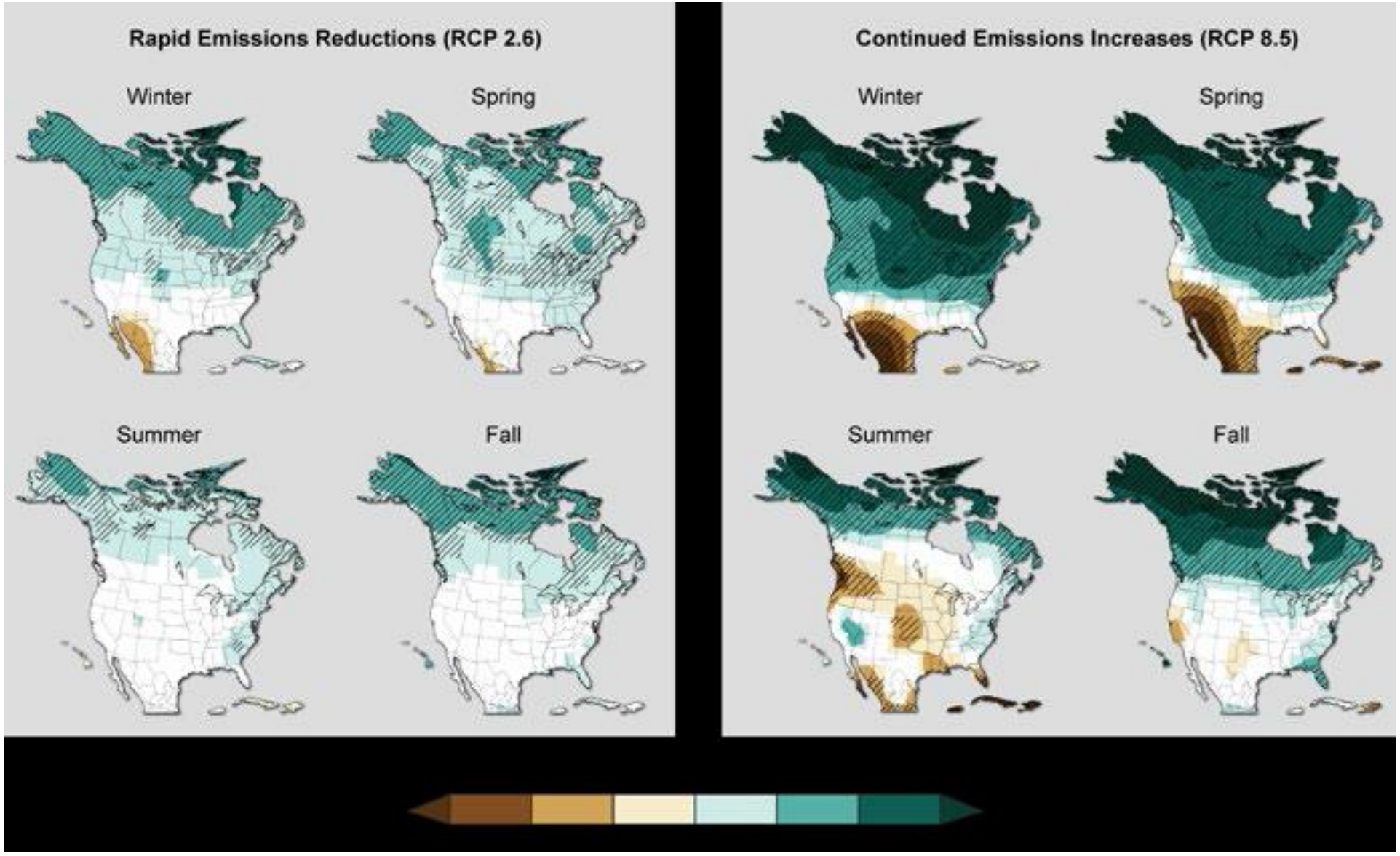
Future changes in precipitation are much more uncertain for our part of the globe

FIGURE 5-4. Projected Colorado annual precipitation under RCP 4.5 compared to observations



But more certain for areas both north and south of us.

Precipitation Scenarios



The impacts may be most noticeable in spring and summer -- and less obvious in winter

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

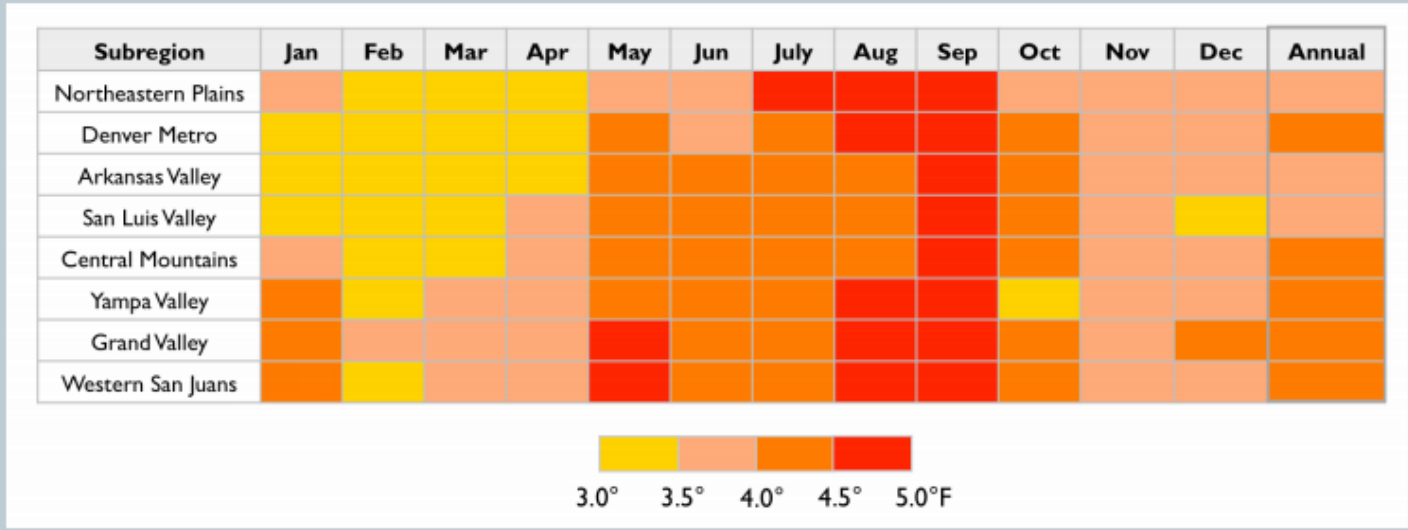
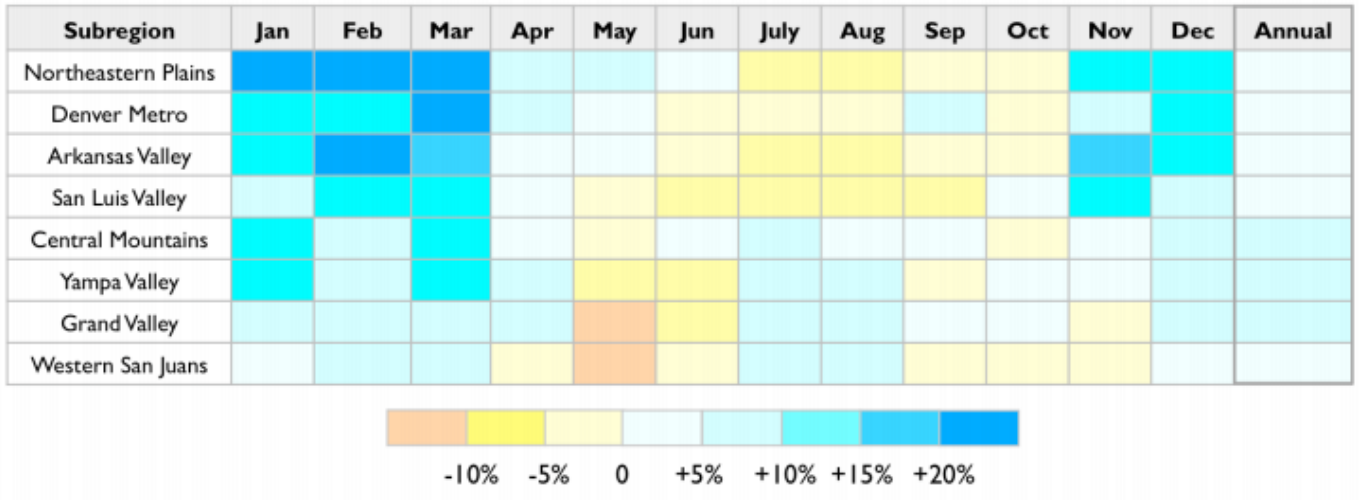


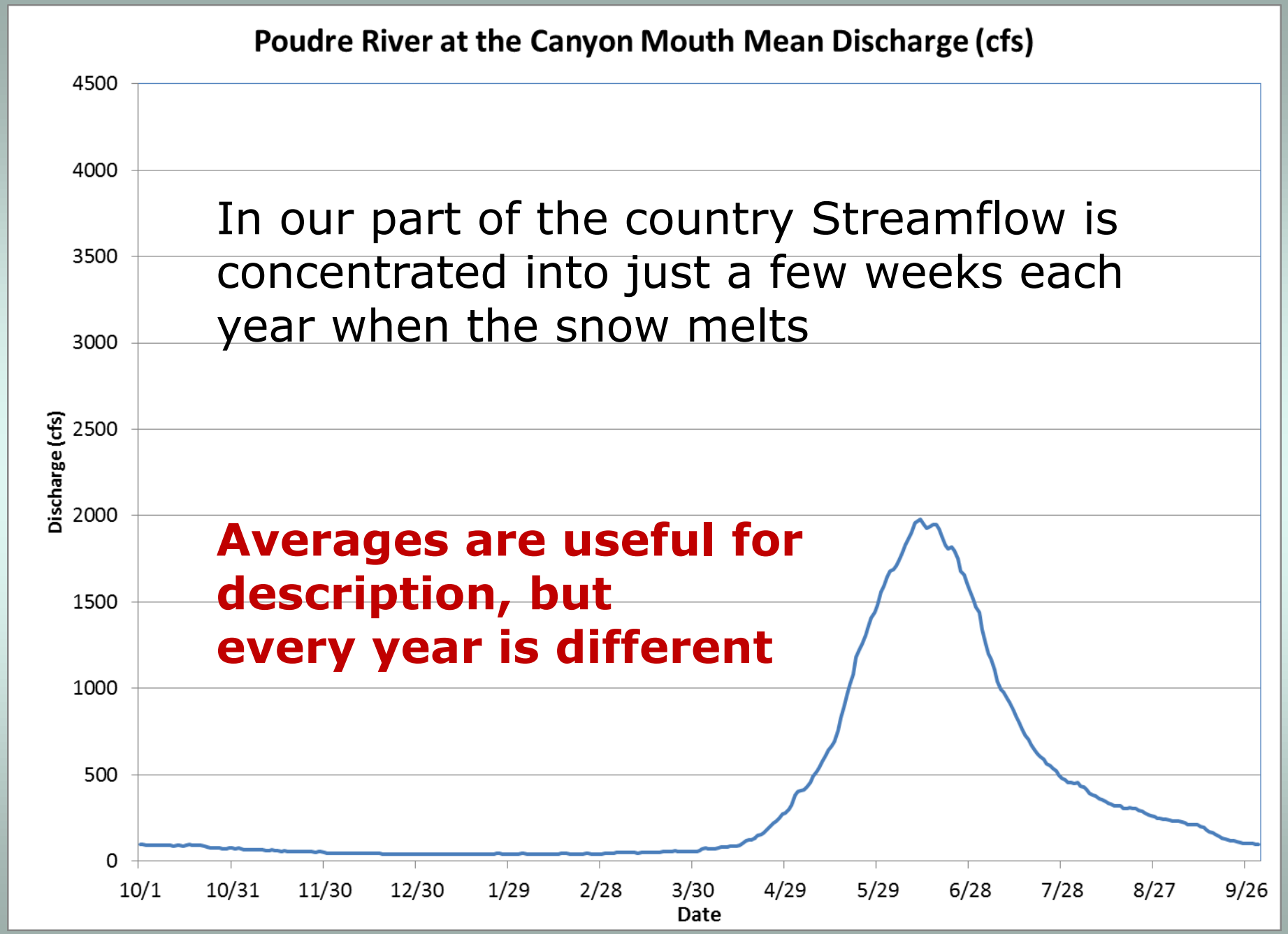
Table 5-1. Median downscaled projected increase in monthly temperature (°F) under RCP 4.5 for the eight subregions for mid-century (2035–2064) compared to 1971–2000, from 37 climate model projections. (Source: BCSD statistically downscaled CMIP5 projections, Reclamation 2013; http://gdo-dcp.ucllnl.org/downscaled_cmip_projections/)

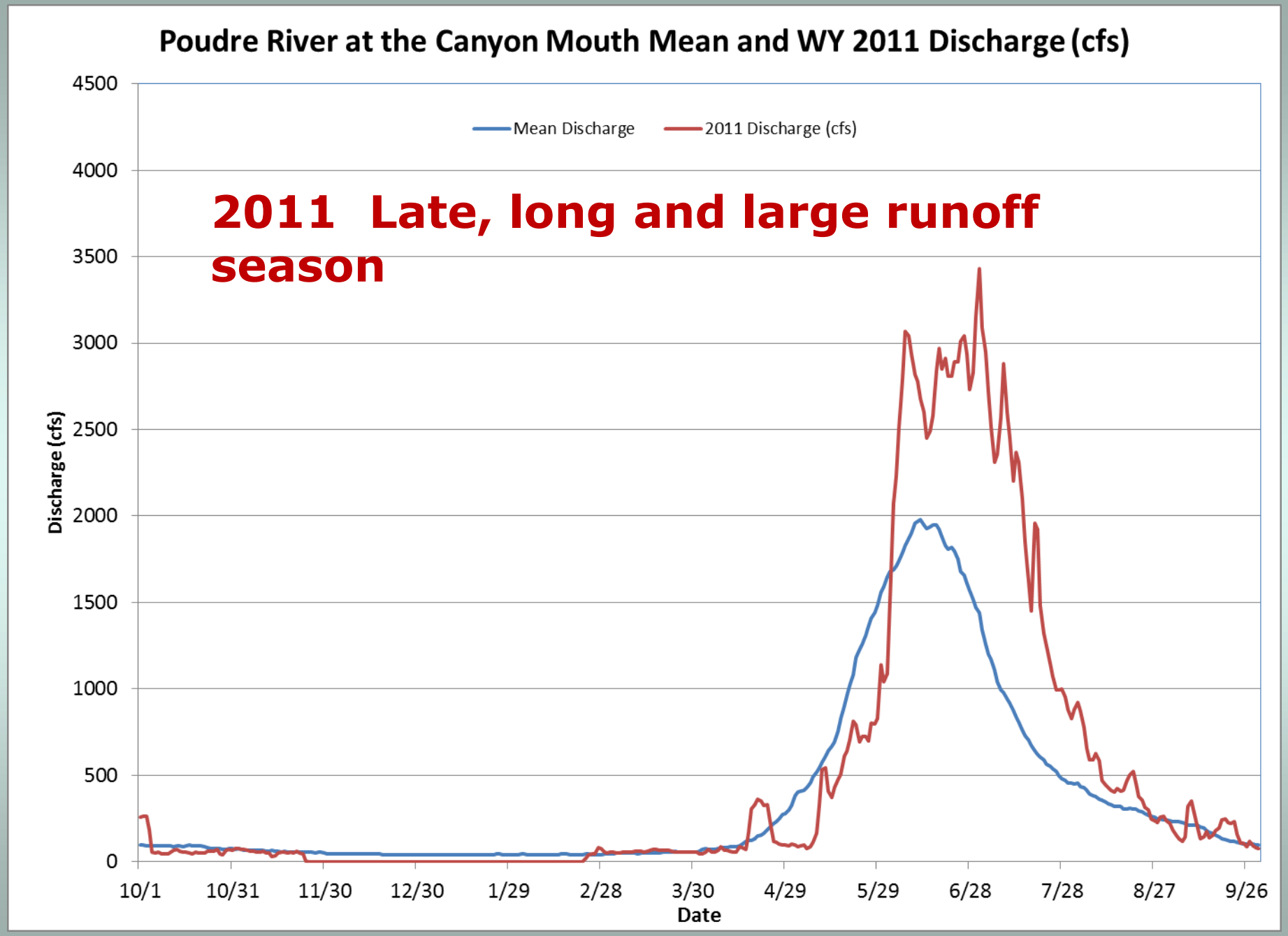
TABLE 5-2. Projected monthly precipitation change for eight subregions under RCP 4.5 for 2035–2064

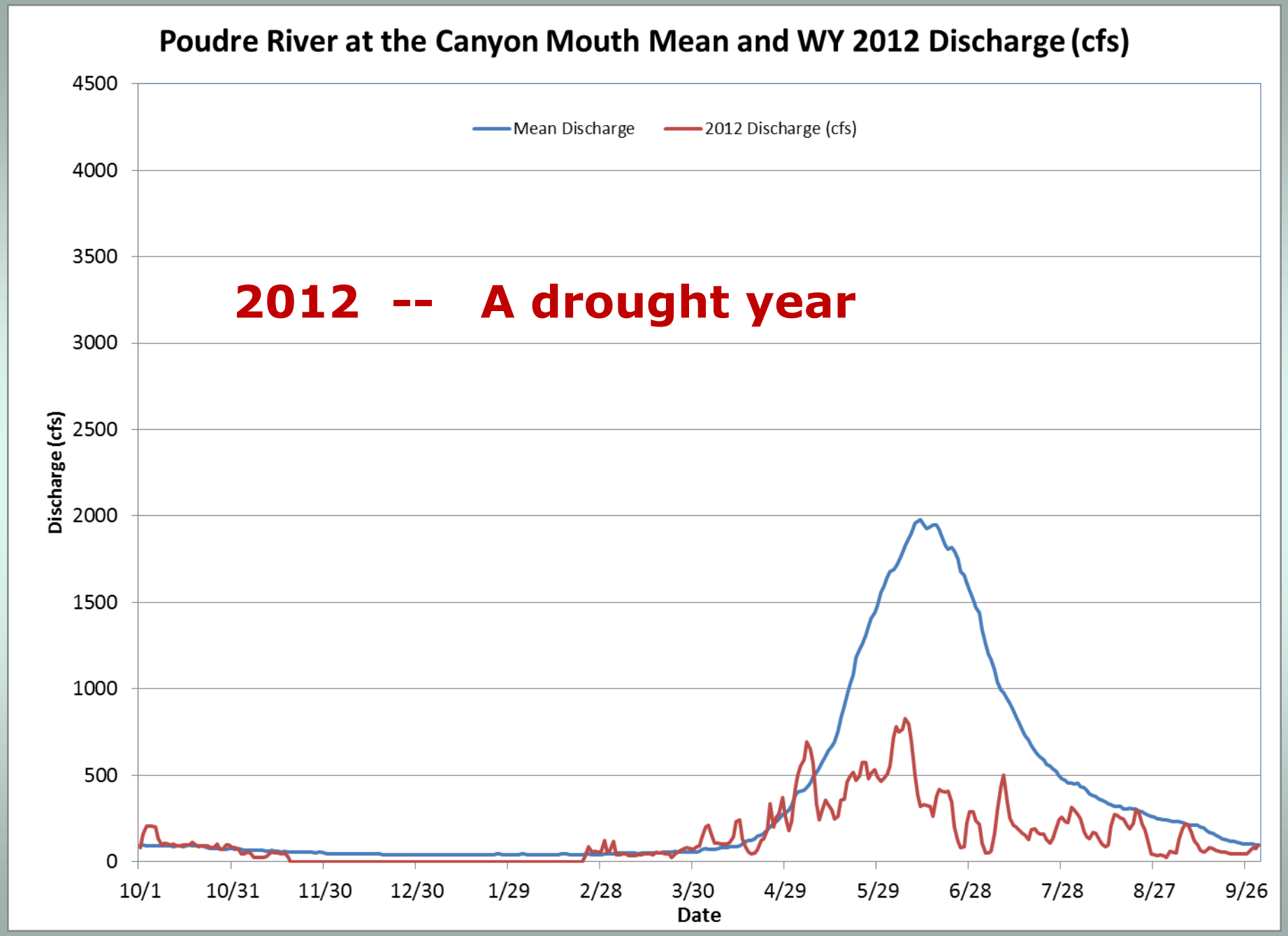


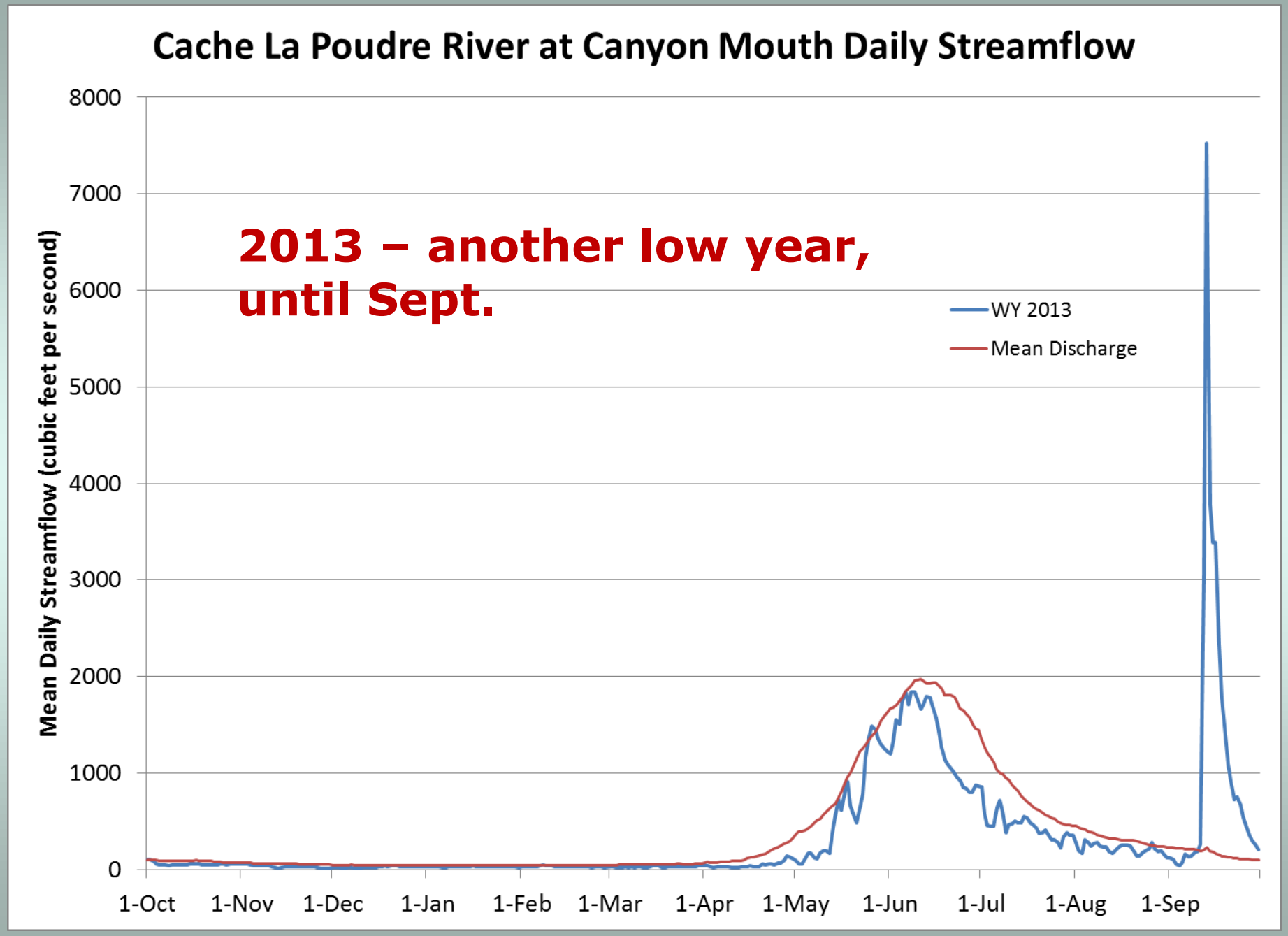
What this means for our rivers is probably not what you want to hear

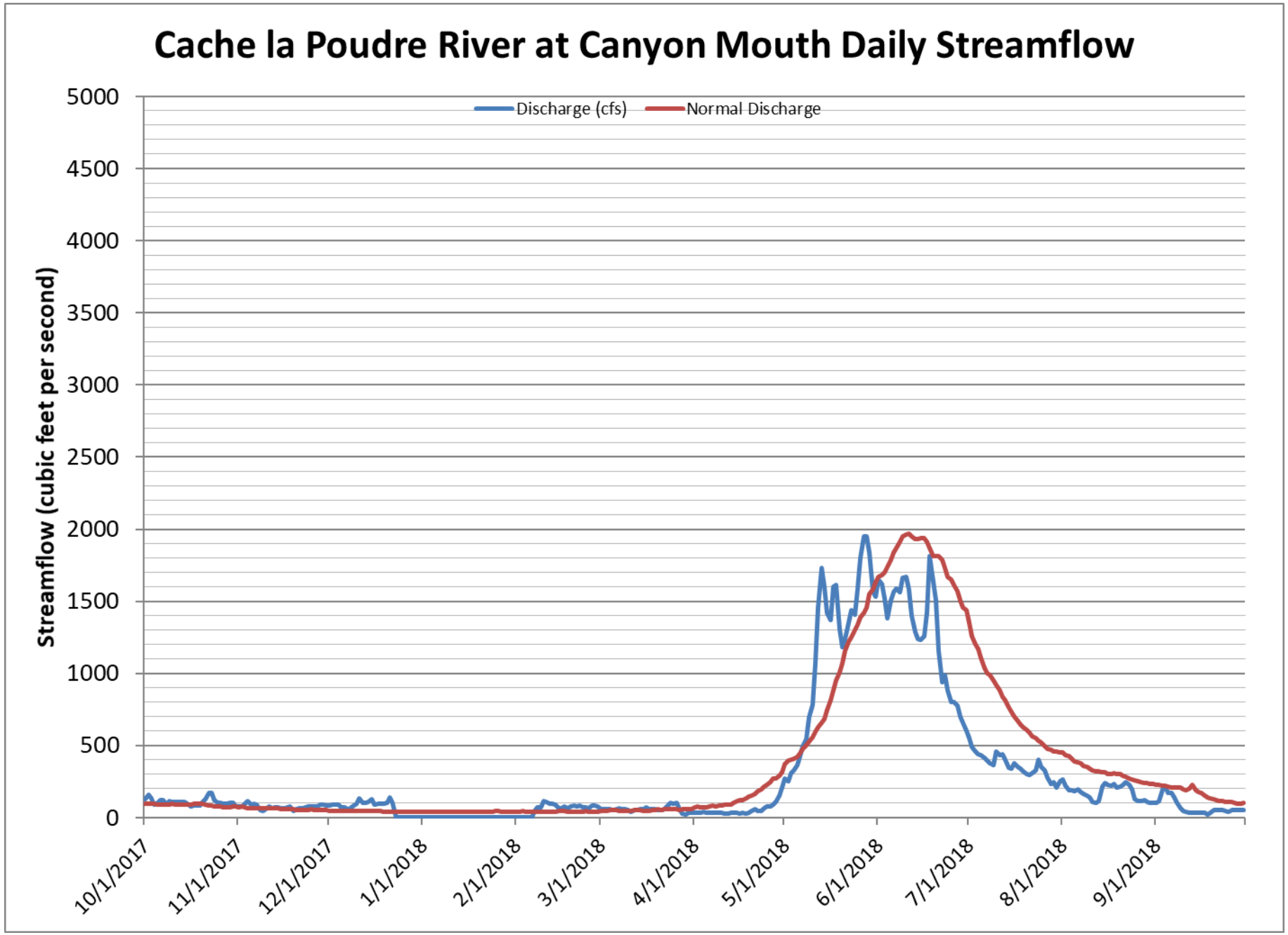
Streamflow–
the Great Climate Integrator

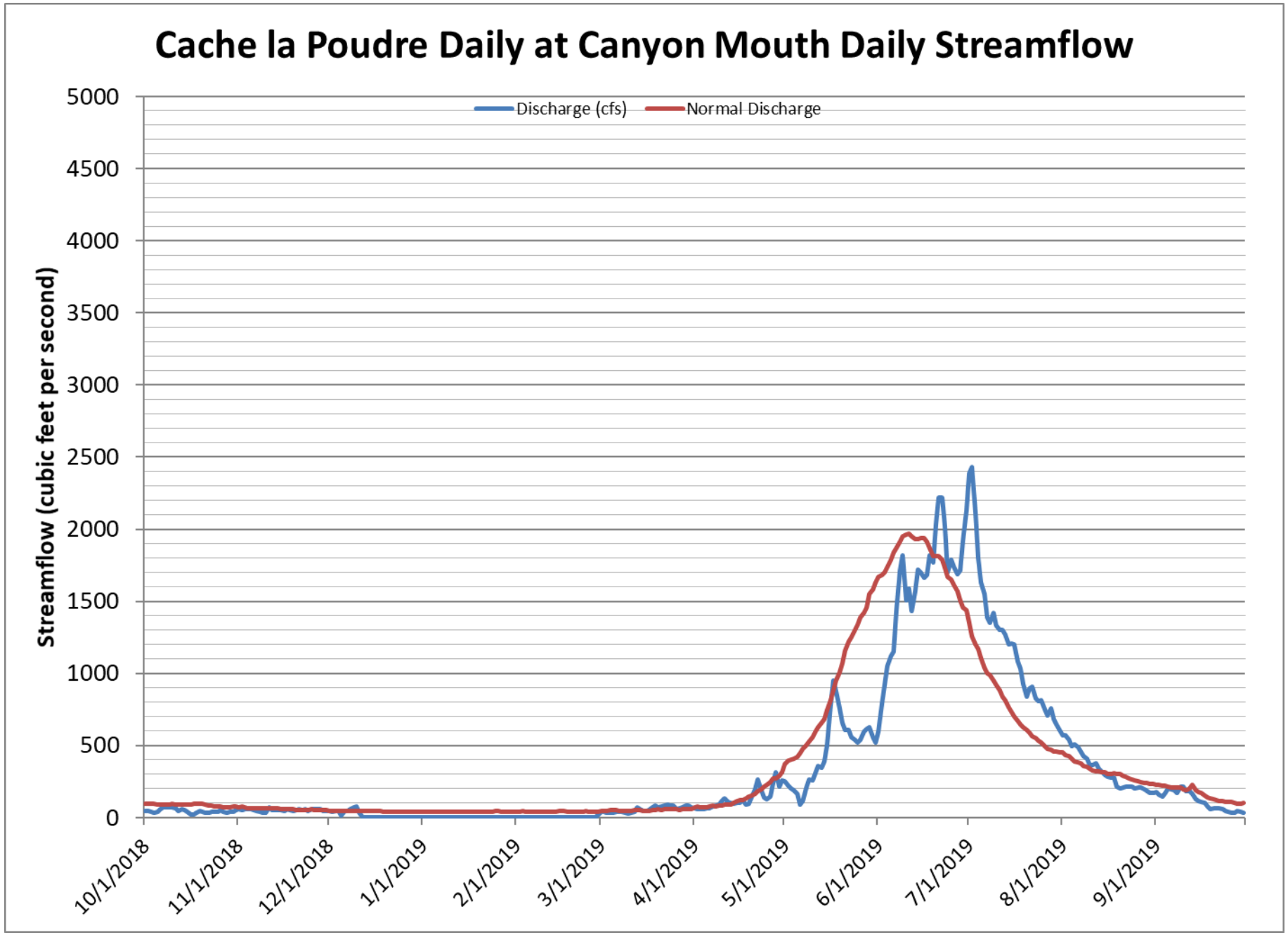

Poudre River at the Canyon Mouth Mean Discharge (cfs)
In our part of the country Streamflow is concentrated into just a few weeks each year when the snow melts
Averages are useful for description, but every year is different
Discharge (cfs)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
10/1
10/31
11/30
12/30
1/29
2/28
3/30
4/29
5/29
6/28
7/28
8/27
9/26
Date

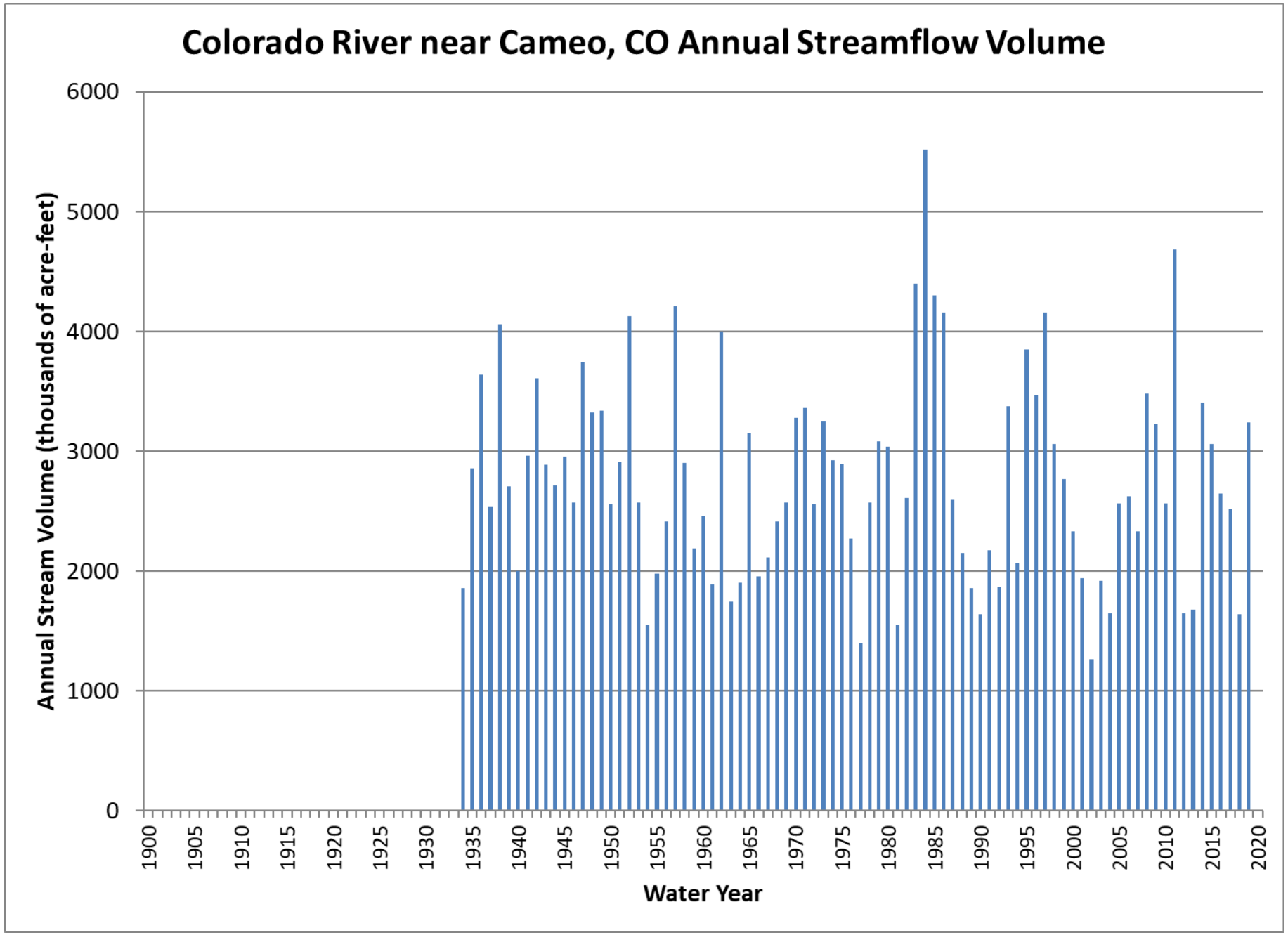

Poudre River at the Canyon Mouth Mean and WY 2011 Discharge (cfs)
Mean Discharge
2011 Discharge (cfs)
2011 Late, long and large runoff season
Discharge (cfs)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
10/1
10/31
11/30
12/30
1/29
2/28
3/30
4/29
5/29
6/28
7/28
8/27
9/26
Date

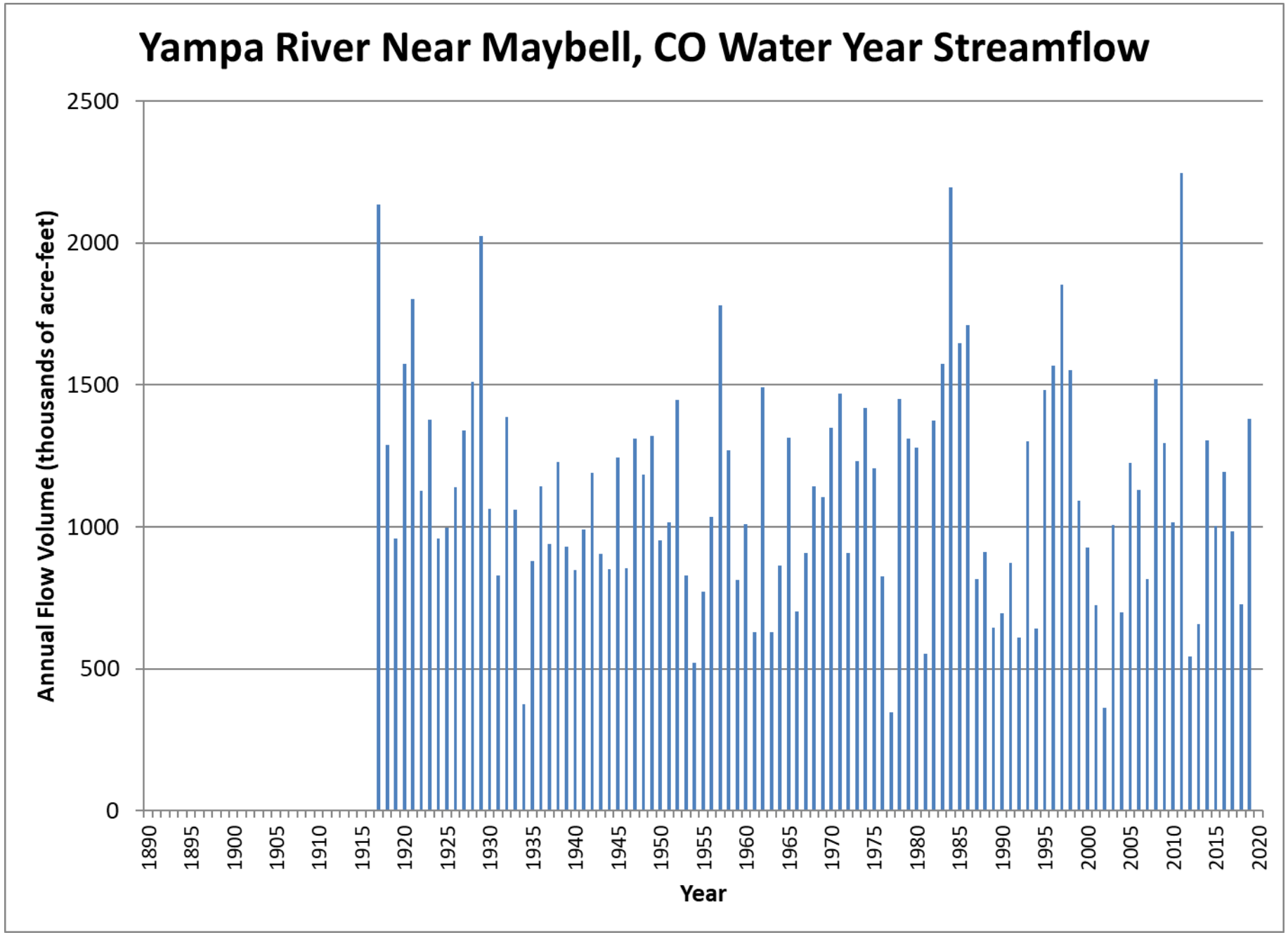

Poudre River at the Canyon Mouth Mean and WY 2012 Discharge (cfs)
Mean Discharge
2012 Discharge (cfs)
2012 -- A drought year
Discharge (cfs)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
10/1
10/31
11/30
12/30
1/29
2/28
3/30
4/29
5/29
6/28
7/28
8/27
9/26
Date

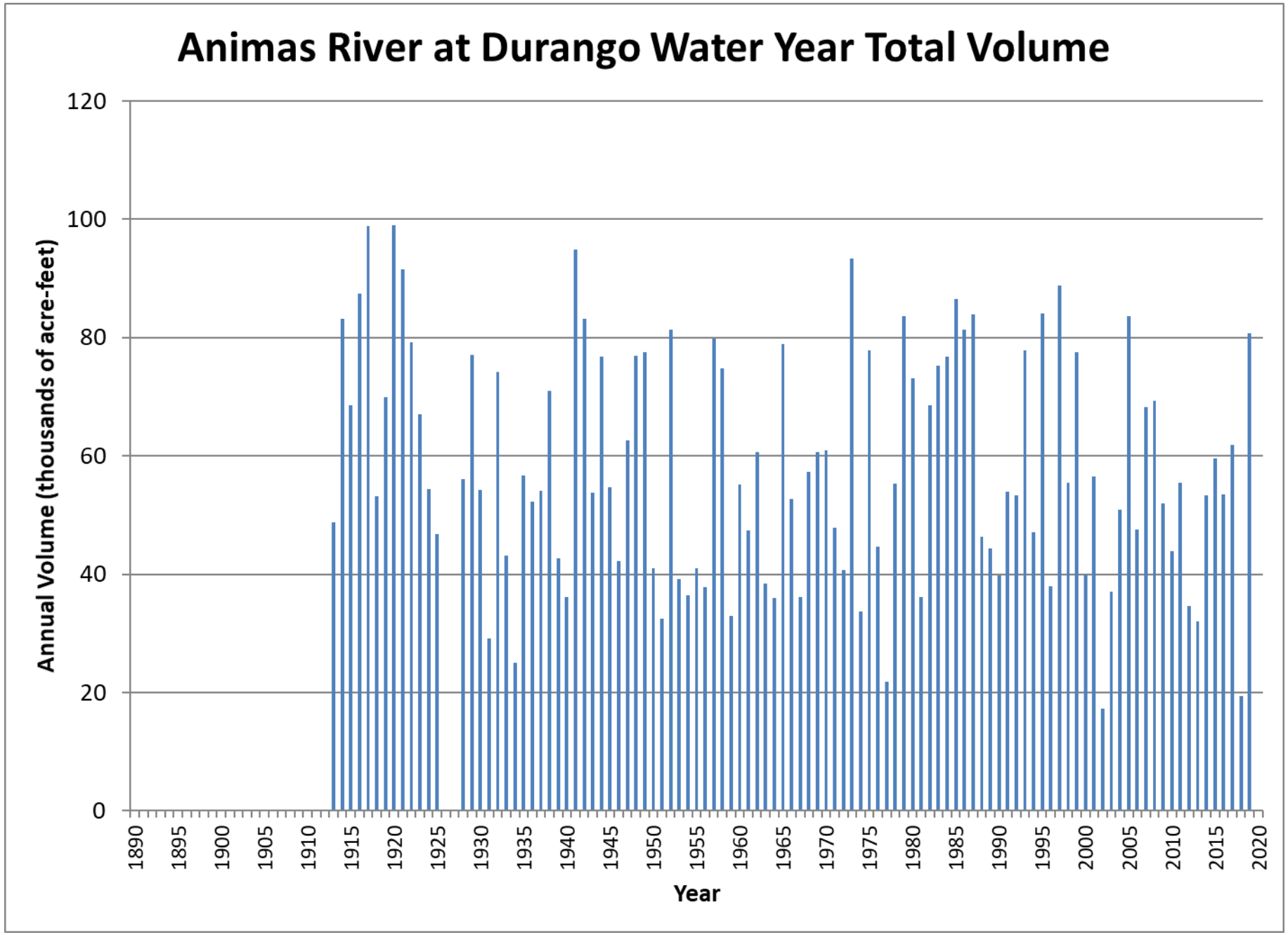

Cache La Poudre River at Canyon Mouth Daily Streamflow
2013 – another low year, until Sept.
Mean Daily Streamflow (cubic feet per second)
8000
7000
6000
5000
4000
3000
2000
1000
0
WY 2013
Mean Discharge
1-Oct
1-Nov
1-Dec
1-Jan
1-Feb
1-Mar
1-Apr
1-May
1-Jun
1-Jul
1-Aug
1-Sep

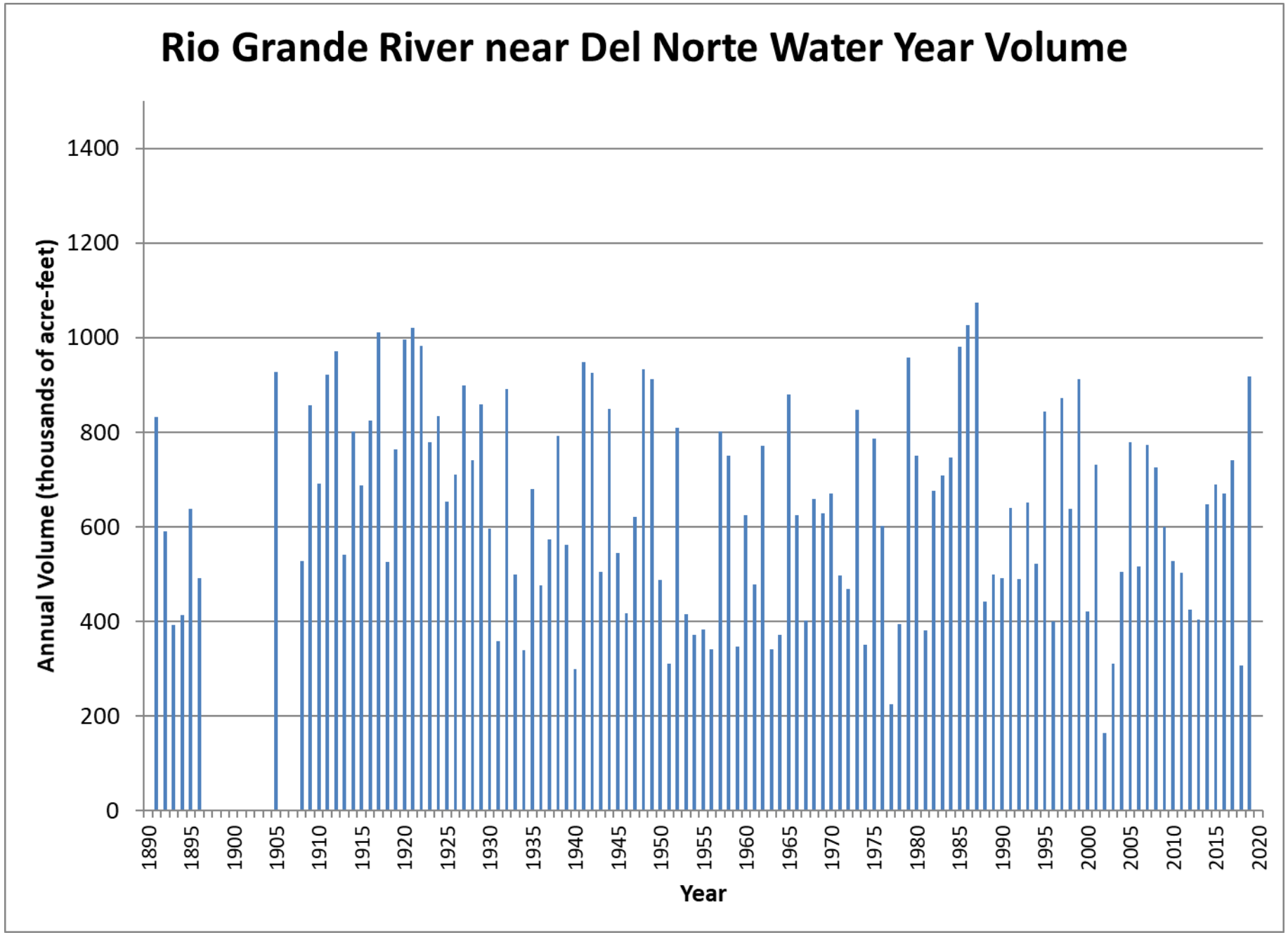

Cache la Poudre River at Canyon Mouth Daily Streamflow
Discharge (cfs)
Normal Discharge
Streamflow (cubic feet per second)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
10/1/2017
11/1/2017
12/1/2017
1/1/2018
2/1/2018
3/1/2018
4/1/2018
5/1/2018
6/1/2018
7/1/2018
8/1/2018
9/1/2018

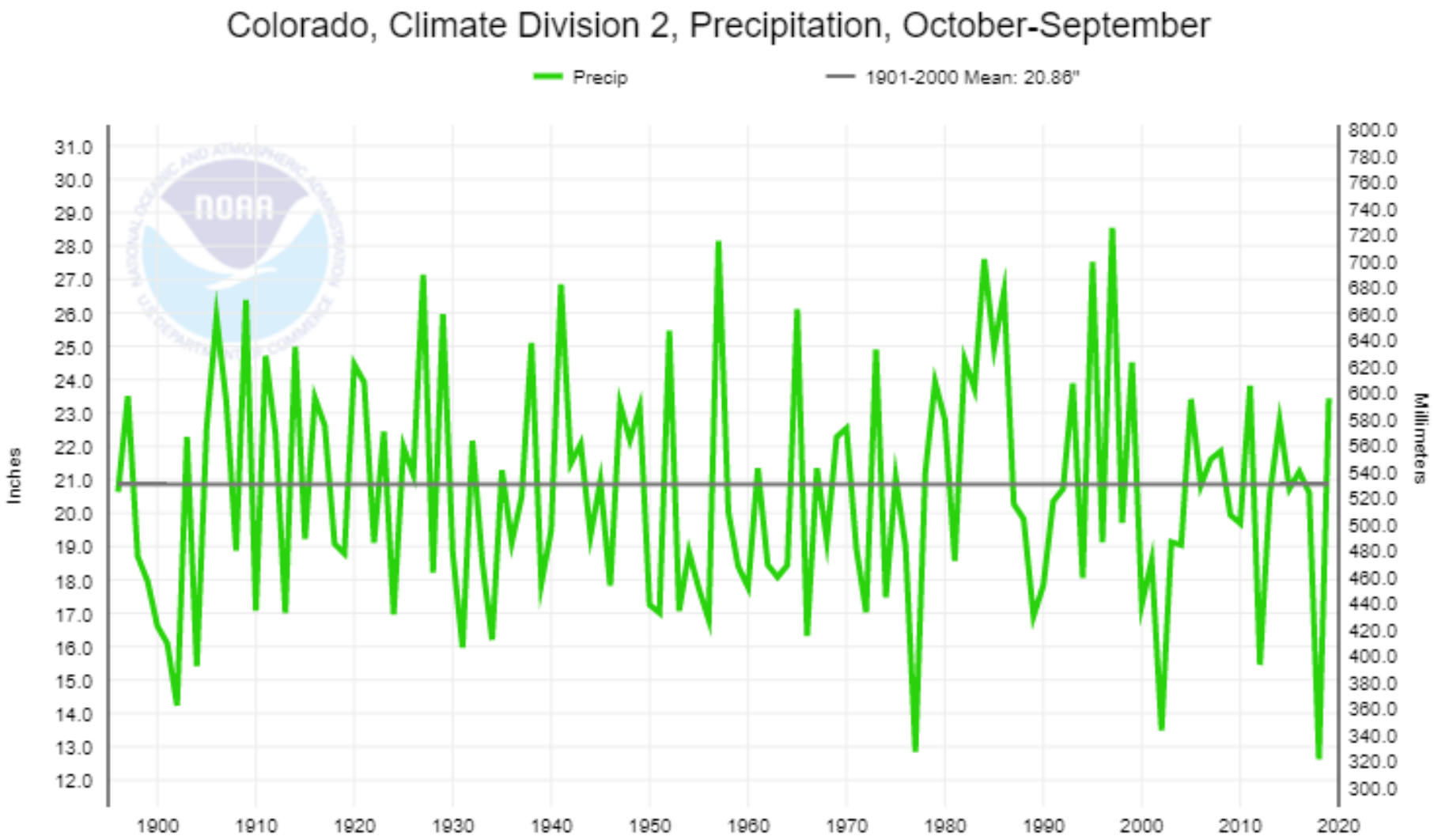

Cache la Poudre Daily at Canyon Mouth Daily Streamflow
Discharge (cfs)
Normal Discharge
Streamflow (cubic feet per second)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
10/1/2018
11/1/2018
12/1/2018
1/1/2019
2/1/2019
3/1/2019
4/1/2019
5/1/2019
6/1/2019
7/1/2019
8/1/2019
9/1/2019


Colorado River near Cameo, CO Annual Streamflow Volume
Annual Stream Volume (thousands of acre-feet)
6000
5000
4000
3000
2000
1000
0
1900
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Water Year


Yampa River Near Maybell, CO Water Year Streamflow
Annual Flow Volume (thousands of acre-feet)
2500
2000
1500
1000
500
0
1890
1895
1900
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Year


Animas River at Durango Water Year Total Volume
Annual Volume (thousands of acre-feet)
120
100
80
60
40
20
0
1890
1895
1900
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Year

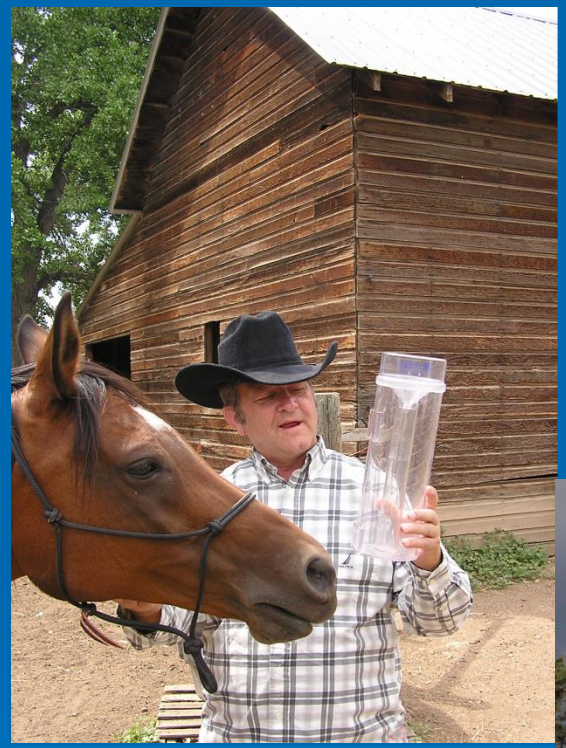

Rio Grande River near Del Norte Water Year Volume
Annual Volume (thousands of acre-feet)
0
200
400
600
800
1000
1200
1400
1890
1895
1900
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Year


Colorado, Climate Division 2, Precipitation, October-September
Precip
1901-2000 Mean: 20.86"
Inches
Millimeters
31.0
30.0
29.0
28.0
27.0
26.0
25.0
24.0
23.0
22.0
21.0
20.0
19.0
18.0
17.0
16.0
15.0
14.0
13.0
12.0
800.0
780.0
760.0
740.0
720.0
700.0
680.0
660.0
640.0
620.0
600.0
580.0
560.0
540.0
520.0
500.0
480.0
460.0
440.0
420.0
400.0
380.0
360.0
340.0
320.0
300.0
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020

And Now!

A Public Announcement

I have a favor to ask you



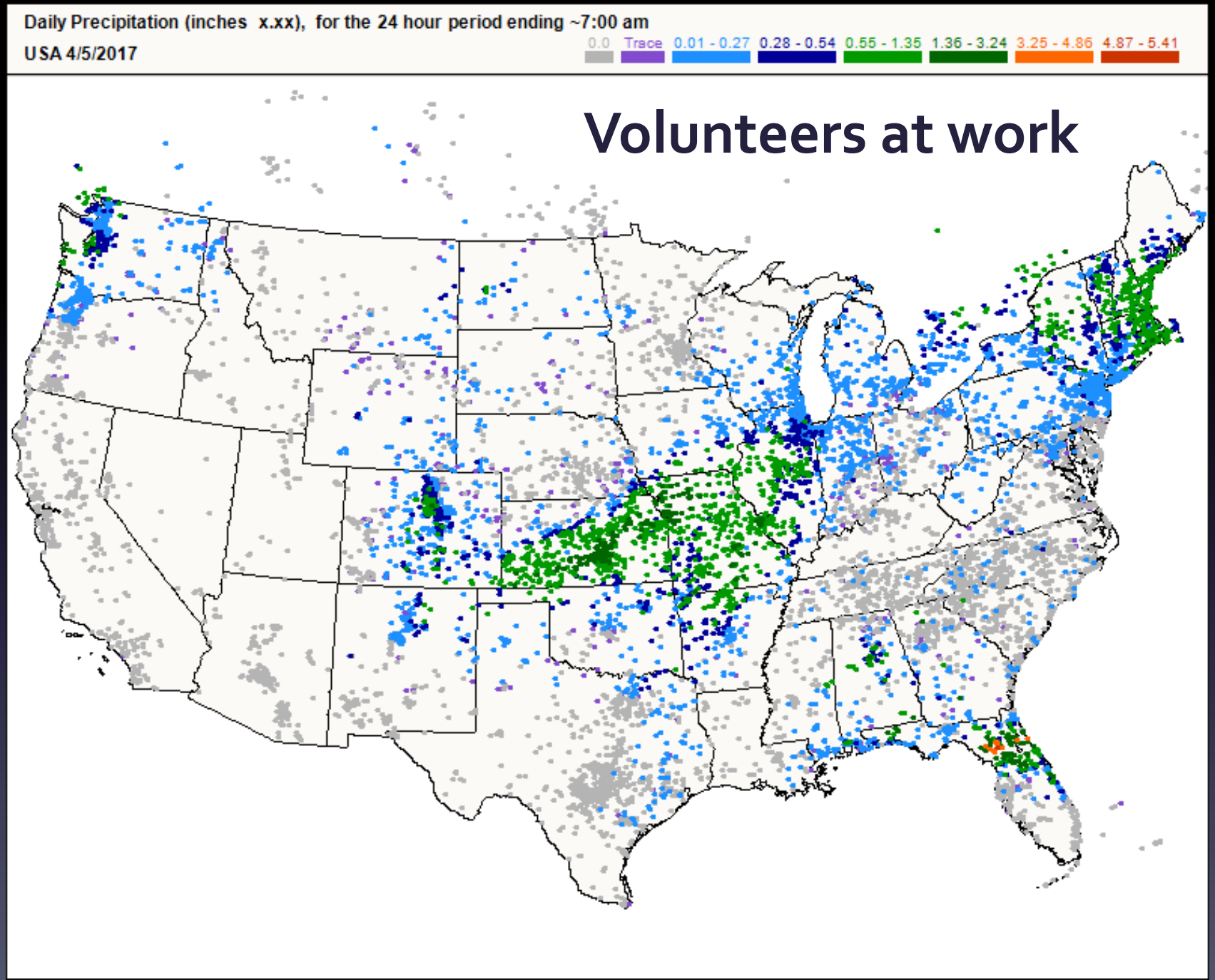
THANKS to you who measure or provide support

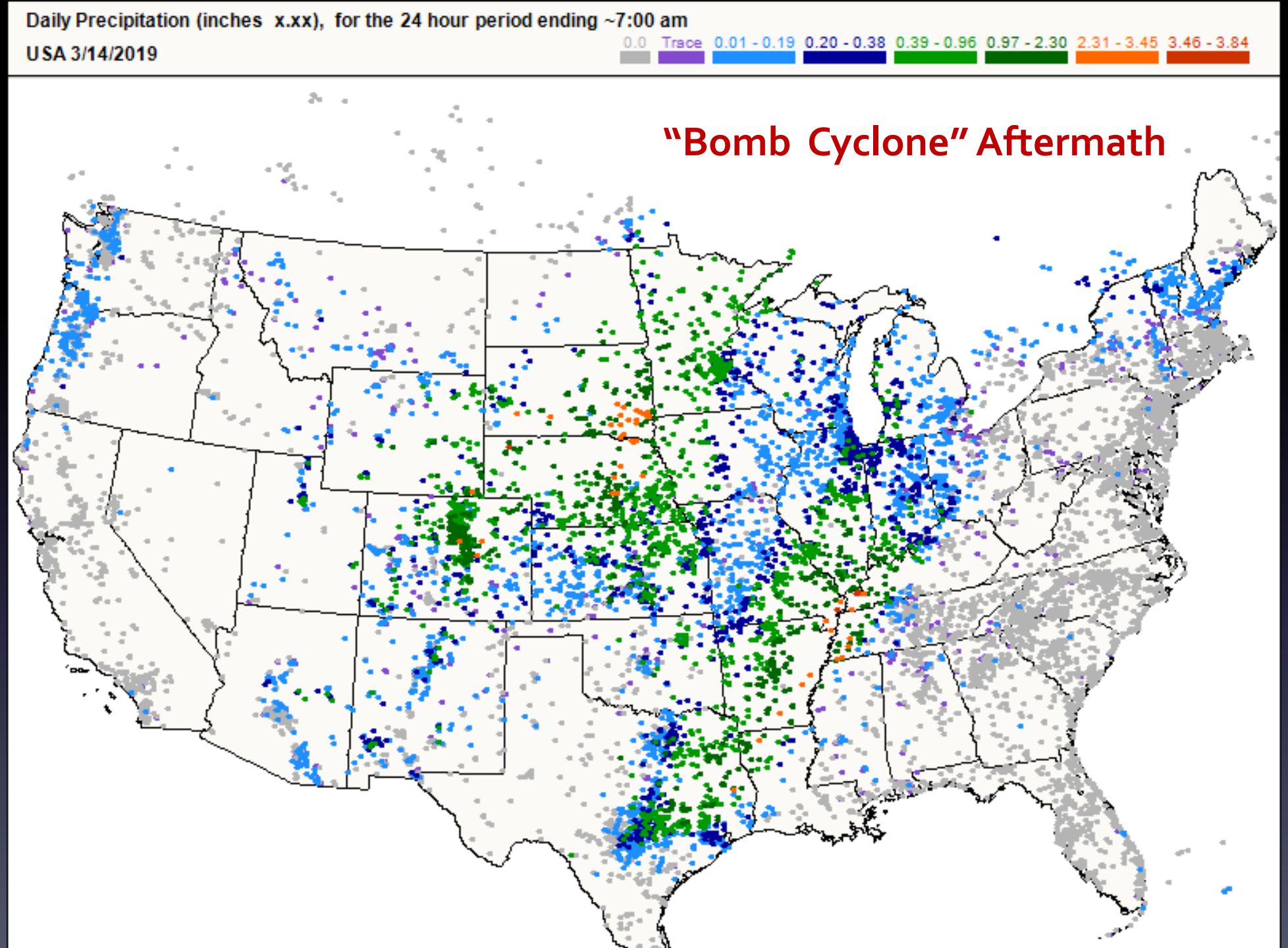
Photos by H. Reges

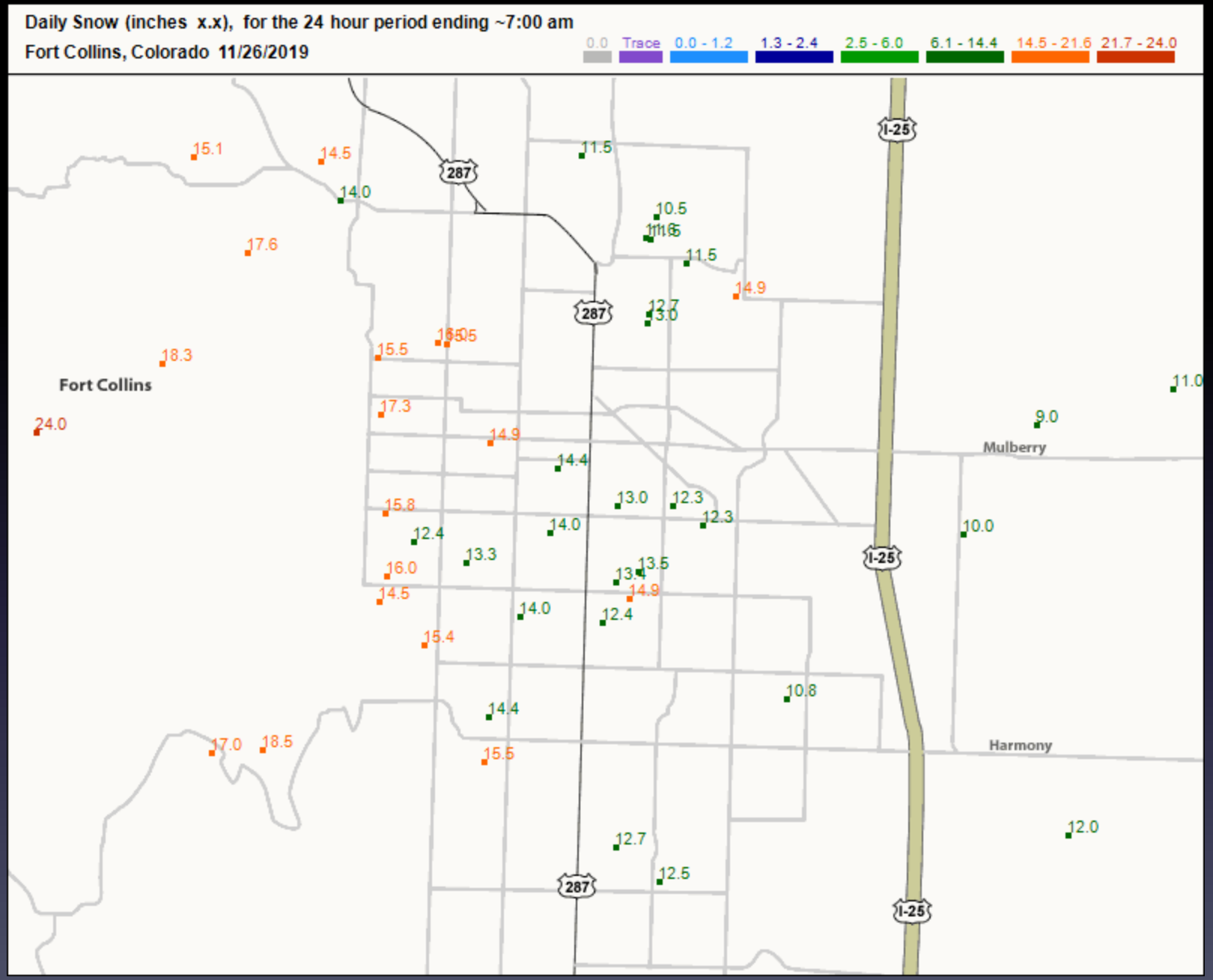
If you are interested in contributing your DOT ON THE MAP, please join the Community Collaborative Rain, Hail and Snow Network

http://www.cocorahs.org

or see me today


Daily Precipitation (inches x.xx), for the 24 hour period ending ~7:00 am
USA 4/5/2017
0.0
Trace
0.01 - 0.27
0.28 - 0.54
0.55 - 1.35
1.36 - 3.24
3.25 - 4.86
4.87 - 5.41
Volunteers at work


Daily Precipitation (inches x.xx), for the 24 hour period ending ~7:00 am
USA 3/14/2019
0.0
Trace
0.01 - 0.19
0.20 - 0.38
0.39 - 0.96
0.97 - 2.30
2.31 - 3.45
3.46 - 3.84
"Bomb Cyclone" Aftermath


Daily Snow (inches x.x), for the 24 hour period ending ~7:00 am
Fort Collins, Colorado 11/26/2019
0.0
Trace
0.0 - 1.2
1.3 - 2.4
2.5 - 6.0
6.1 - 14.4
14.5 - 21.6
21.7 - 24.0
I-25
287
Fort Collins
Mulberry
Harmony
15.1
14.5
14.0
11.5
10.5
17.6
11.5
14.9
12.7
13.0
18.3
15.5
17.3
24.0
14.9
14.4
9.0
11.0
15.8
13.0
12.3
12.3
12.4
14.0
10.0
13.3
16.0
13.5
14.5
14.9
14.0
12.4
15.4
10.8
14.4
17.0
18.5
15.5
12.7
12.5

For information and to volunteer, visit the CoCoRaHS Web Site

www.cocorahs.org

OR SEE ME TODAY!

Support for this project provided by
NSF Informal Science Education Program,
NOAA Environmental Literacy Program
and
many local charter sponsors.

Thank you!

http://climate.colostate.edu/

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