# Tracking the Climate of Colorado

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**Graphics assistance provided by:**
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**Air and Waste Management Association**
**Rocky Mountain States Section Conference**
**May 15, 2012**

# First -- A short background

- In 1973 the federal government abolished the “State Climatologist” program nationwide leaving Colorado without
- Later that same year, Colorado re-established the State Climate program with support through the Colorado Agricultural Experiment Station at Colorado State University.
- Tom McKee hired in 1974 as State Climatologist

# Our Mission

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

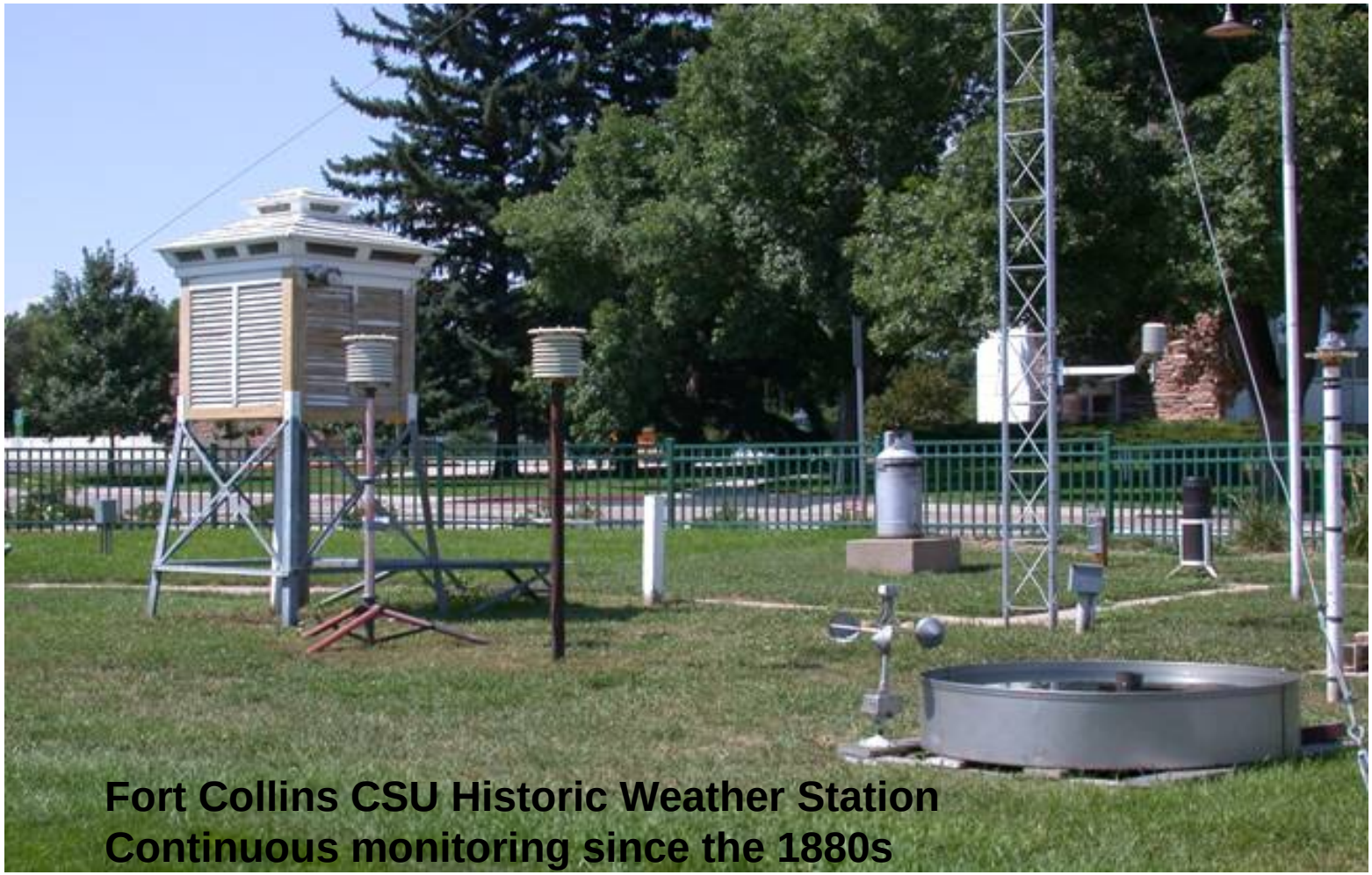
  1) ***Climate Monitoring*** (data acquisition, analysis, and archiving),

  2) ***Climate Research***

  3) ***Climate Services***.(providing data, analysis, climate education and outreach)

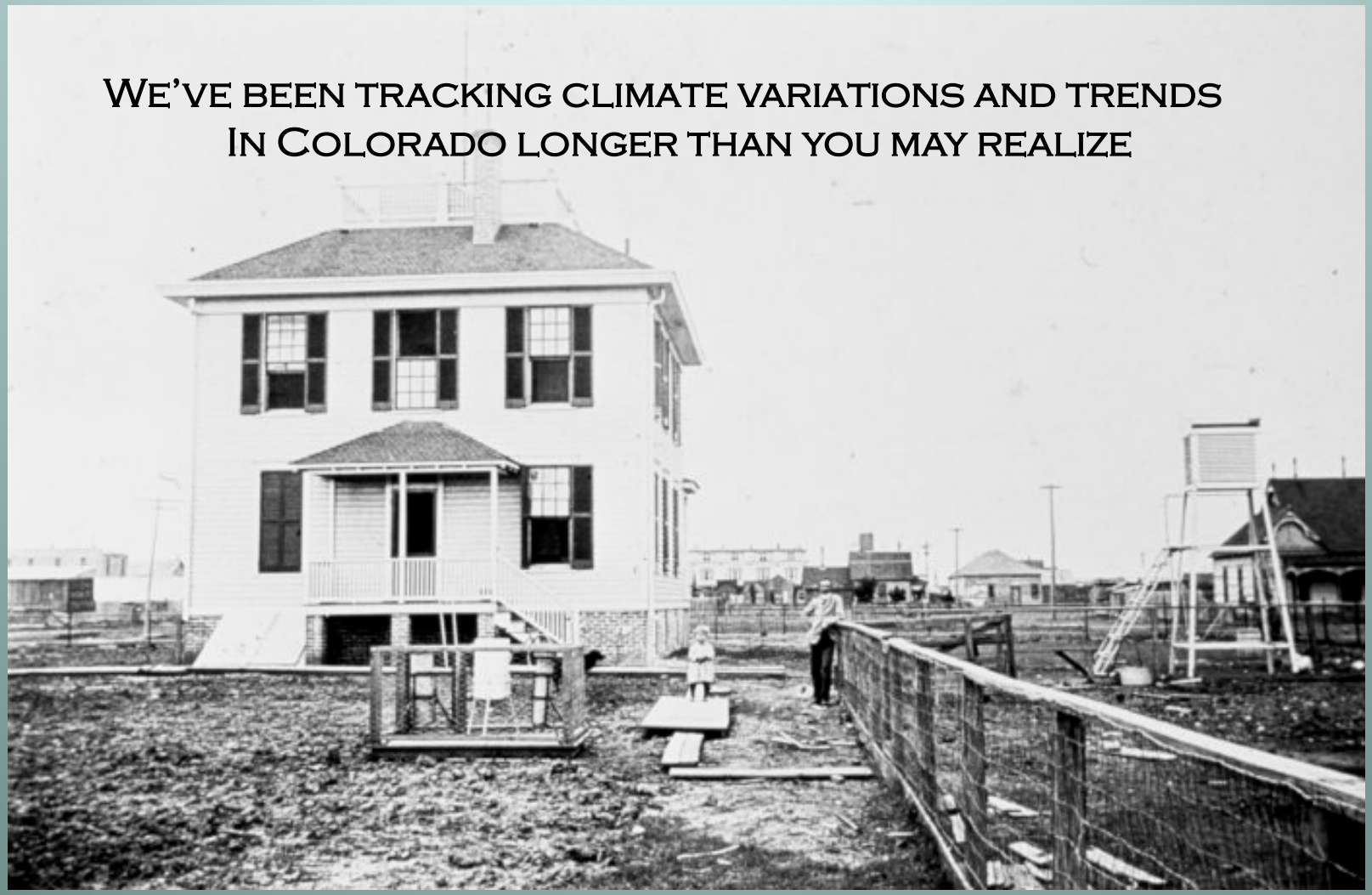
# Monitoring our Climate

- Elements: temperature, precipitation, snow, wind, solar, evaporation, soil temperatures, humidity, clouds, etc.



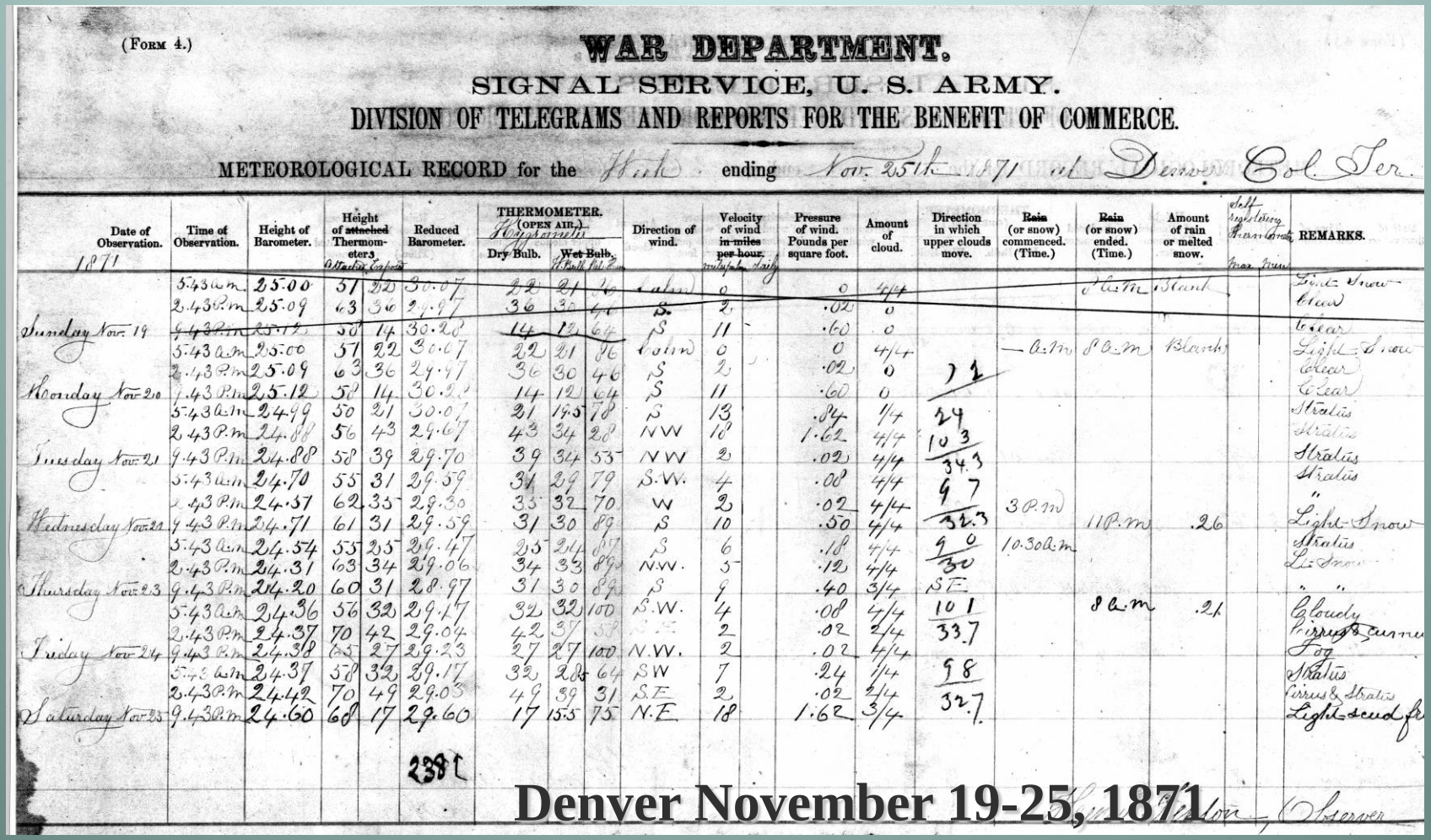
**Fort Collins CSU Historic Weather Station**
**Continuous monitoring since the 1880s**

# Additional background and History




Credit: NOAA Photo Library

# Systematic weather data collection began in Colorado in the 1870s and 1880s



(Form 4.)

**WAR DEPARTMENT.**

SIGNAL SERVICE, U. S. ARMY.

DIVISION OF TELEGRAMS AND REPORTS FOR THE BENEFIT OF COMMERCE.

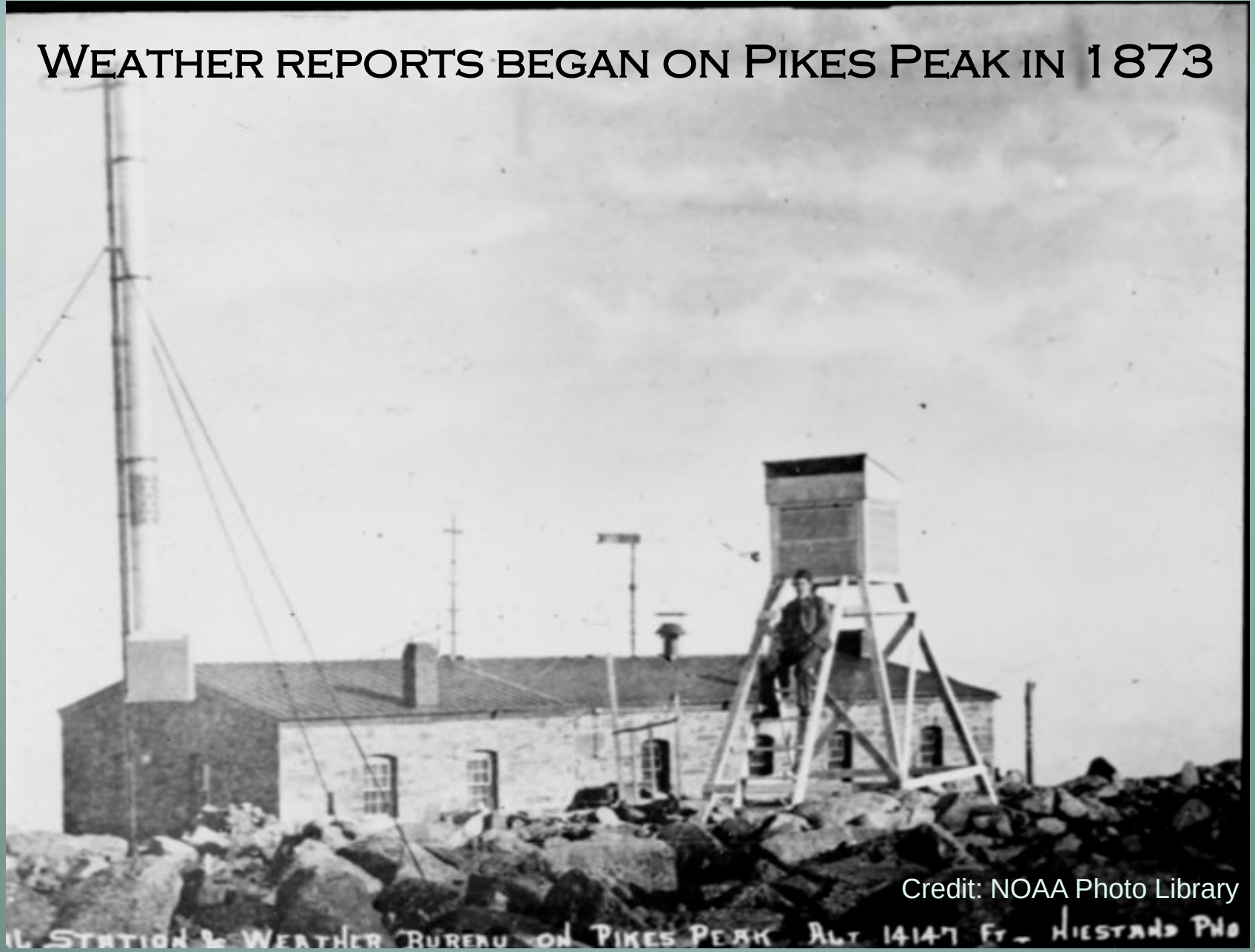
METEOROLOGICAL RECORD for the Week ending Nov. 25th 1871 at Denver Col. Ter.

| Date of Observation. 1871 | Time of Observation. | Height of Barometer. | Height of Thermometer. Attached / Detached | Reduced Barometer. | THERMOMETER. (OPEN AIR.) Dry Bulb. | Wet Bulb. | Direction of wind. | Velocity of wind in miles per hour. | Pressure of wind. Pounds per square foot. | Amount of cloud. | Direction in which upper clouds move. | Rain (or snow) commenced. (Time.) | Rain (or snow) ended. (Time.) | Amount of rain or melted snow. | Self Registering Thermometers. Hour | Min. | REMARKS. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 5.43 a.m. | 25.00 | 37 | 30.07 | 22 | 21 | Calm | 0 | 0 | 4/4 | | | 8 a.m. | Stand. | | | Fine Snow |
| | 2.43 P.m. | 25.09 | 63 | 29.97 | 36 | 30 | S. | 2 | .02 | 0 | | | | | | | Clear |
| Sunday Nov. 19 | 9.43 P.m. | 25.12 | 58 | 30.20 | 14 | 12 | S | 11 | .60 | 0 | | | | | | | Clear |
| | 5.43 a.m. | 25.00 | 37 | 30.07 | 22 | 21 | 86 Calm | 0 | 0 | 4/4 | | — a.m. | 8 a.m. | Stands | | | Light Snow |
| | 2.43 P.m. | 25.09 | 63 | 29.97 | 36 | 30 | 46 S | 2 | .02 | 0 | 72 | | | | | | Clear |
| Monday Nov 20 | 9.43 P.m. | 25.12 | 50 | 30.20 | 14 | 12 | 64 S | 11 | .60 | 0 | | | | | | | Clear |
| | 5.43 a.m. | 24.99 | 50 | 30.07 | 21 | 19.5 | 78 S | 13 | .84 | 1/4 | 24 | | | | | | Stratus |
| | 2.43 P.m. | 24.88 | 56 | 29.67 | 43 | 34 | 28 NW | 10 | 1.62 | 4/4 | 103 | | | | | | Stratus |
| Tuesday Nov 21 | 9.43 P.m. | 24.88 | 58 | 29.70 | 39 | 34 | 53 NW | 2 | .02 | 4/4 | 34.3 | | | | | | Stratus |
| | 5.43 a.m. | 24.70 | 55 | 29.59 | 31 | 29 | 79 S.W. | 4 | .08 | 4/4 | 97 | | | | | | Stratus |
| | 2.43 P.m. | 24.57 | 62 | 29.30 | 33 | 32 | 70 W | 2 | .02 | 4/4 | | 3 P.m | | | | | " |
| Wednesday Nov 22 | 9.43 P.m. | 24.71 | 61 | 29.59 | 31 | 30 | 89 S | 10 | .50 | 4/4 | 32.3 | | 11 P.m. | .26 | | | Light Snow |
| | 5.43 a.m. | 24.54 | 55 | 29.47 | 25 | 24 | 87 S | 6 | .18 | 4/4 | 90 | 10.30 a.m. | | | | | Stratus |
| | 2.43 P.m. | 24.31 | 63 | 29.06 | 34 | 33 | 89 N.W. | 3 | .12 | 4/4 | 30 | | | | | | Le Snow |
| Thursday Nov 23 | 9.43 P.m. | 24.20 | 60 | 28.97 | 31 | 30 | 89 S | 9 | .40 | 3/4 | SE | | | | | | " " |
| | 5.43 a.m. | 24.36 | 56 | 29.17 | 32 | 32 | 100 S.W. | 4 | .08 | 4/4 | 101 | | 8 a.m. | .21 | | | Cloudy |
| | 2.43 P.m. | 24.37 | 70 | 29.04 | 42 | 37 | 58 | 2 | .02 | 2/4 | 33.7 | | | | | | Drizzly & Sunny |
| Friday Nov 24 | 9.43 P.m. | 24.38 | 65 | 29.23 | 27 | 27 | 100 N.W. | 2 | .02 | 4/4 | | | | | | | Fog |
| | 5.43 a.m. | 24.37 | 58 | 29.17 | 32 | 28.5 | 64 SW | 7 | .24 | 1/4 | 98 | | | | | | Stratus |
| | 2.43 P.m. | 24.42 | 70 | 29.03 | 49 | 39 | 31 S.E. | 2 | .02 | 2/4 | 32.7 | | | | | | Cirrus & Stratus |
| Saturday Nov 25 | 9.43 P.m. | 24.60 | 68 | 29.60 | 17 | 15.5 | 75 N.E. | 18 | 1.62 | 3/4 | | | | | | | Light sand fr |

238 C

Denver November 19-25, 1871

# Weather reports began on Pikes Peak in 1873




Reports were sent by telegraph every few hours

Stories abounded in the national media of the rigors of Colorado Climate

# 300 Days of Sunshine!

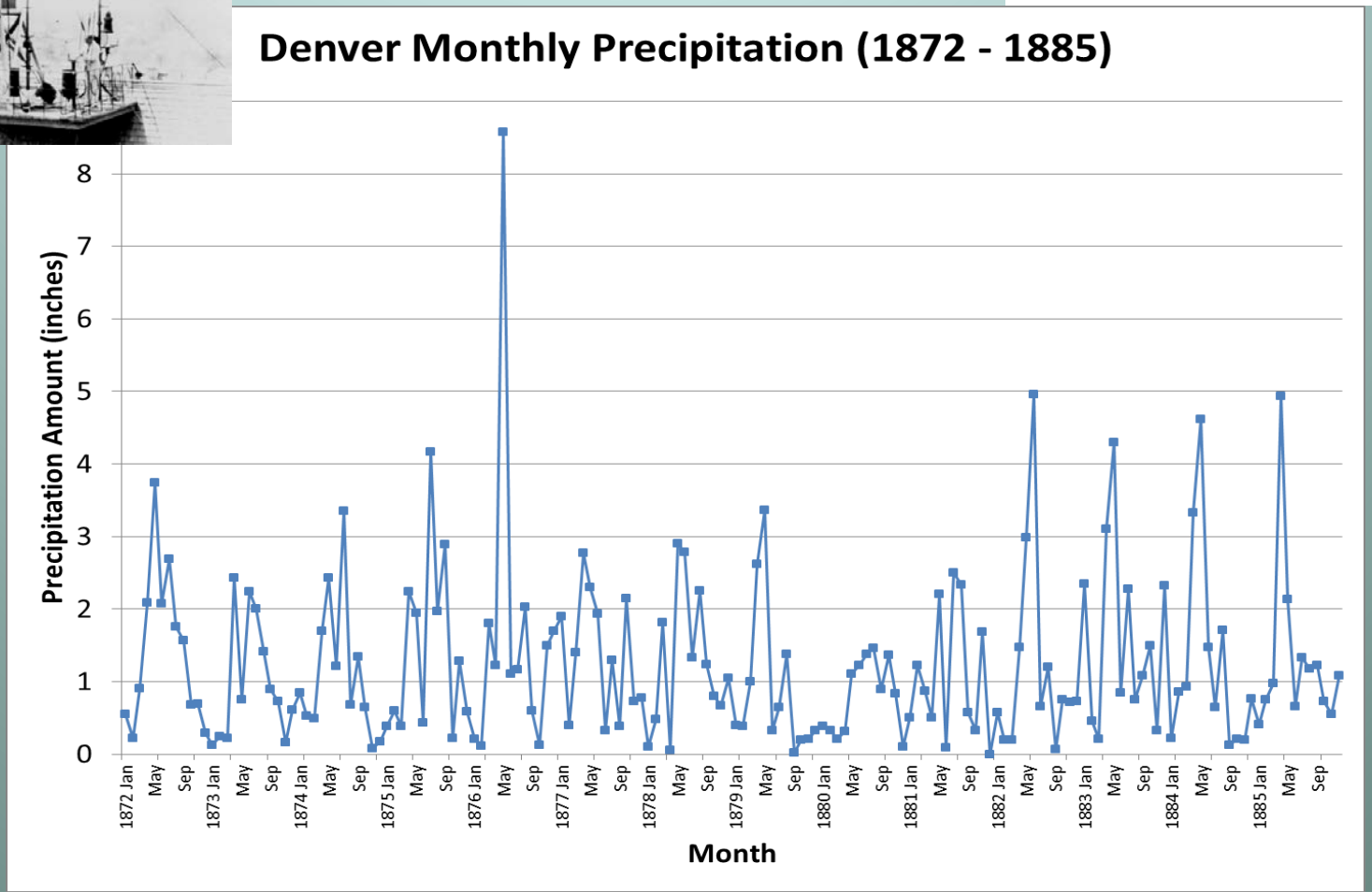
Prior to the about 1859 Colorado was considered to be a useless part of the "Great American Desert"

By the late 1860s Railroad publicist began promoting Colorado's delightful climate – bright sunshine, fresh water and lush vegetation – even before the first official weather stations were installed.

# By 1885 initial "climatology" of Colorado was taking shape

Photo Credit: NOAA Photo Library

The semiarid and highly variable nature of Colorado was identified.

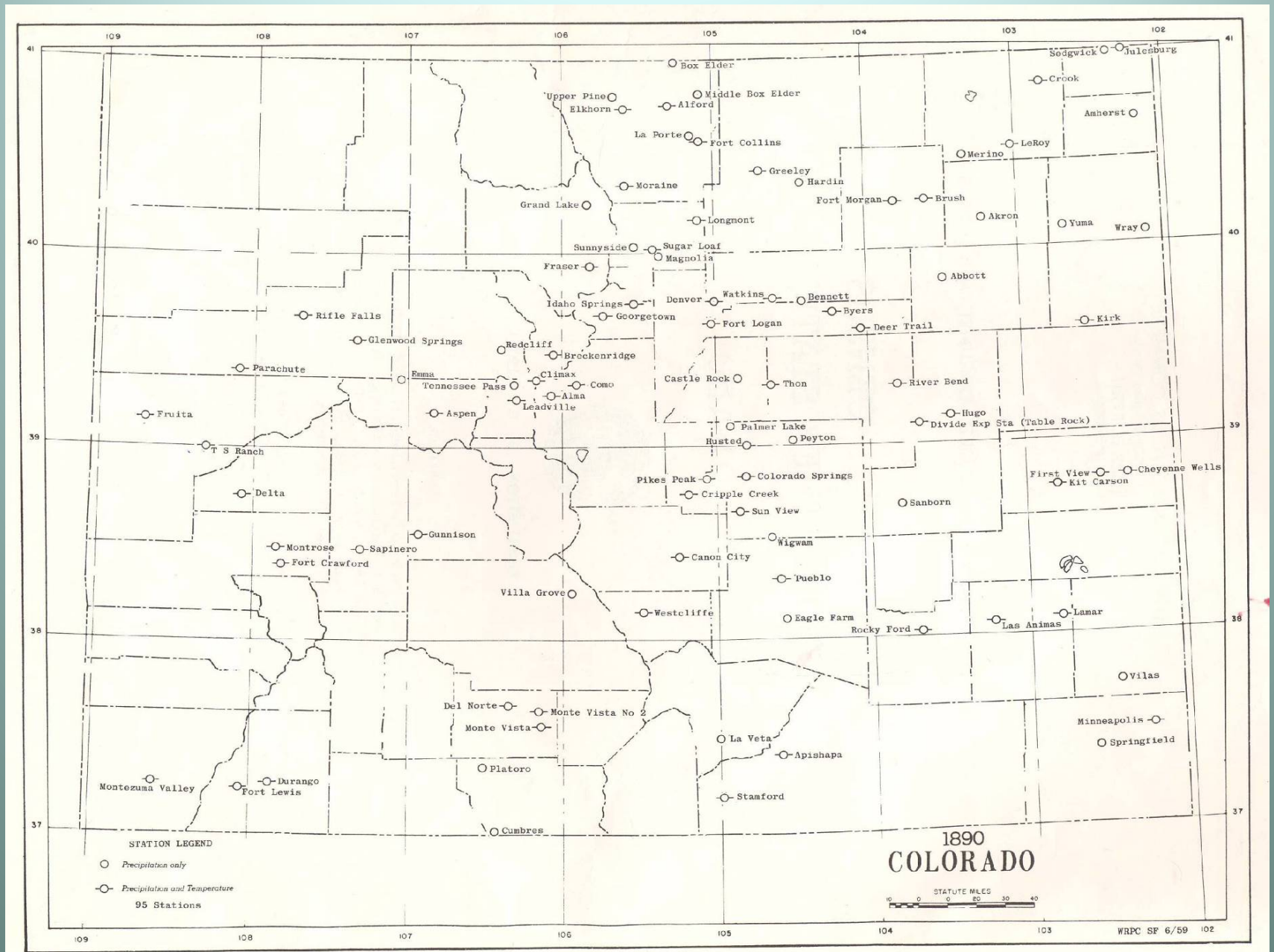


# Colorado State Weather Service

- In the late 1880s the Colorado State Legislature passed legislation supporting the "Colorado State Weather Service".
- $2,000 was appropriated, and an effort was started immediately to establish improved monitoring

This "Weather Service" was short lived. In 1890, the U.S. Department of Agriculture took over "climate monitoring and reporting responsibilities".

# By 1890 a robust statewide weather reporting network was in place



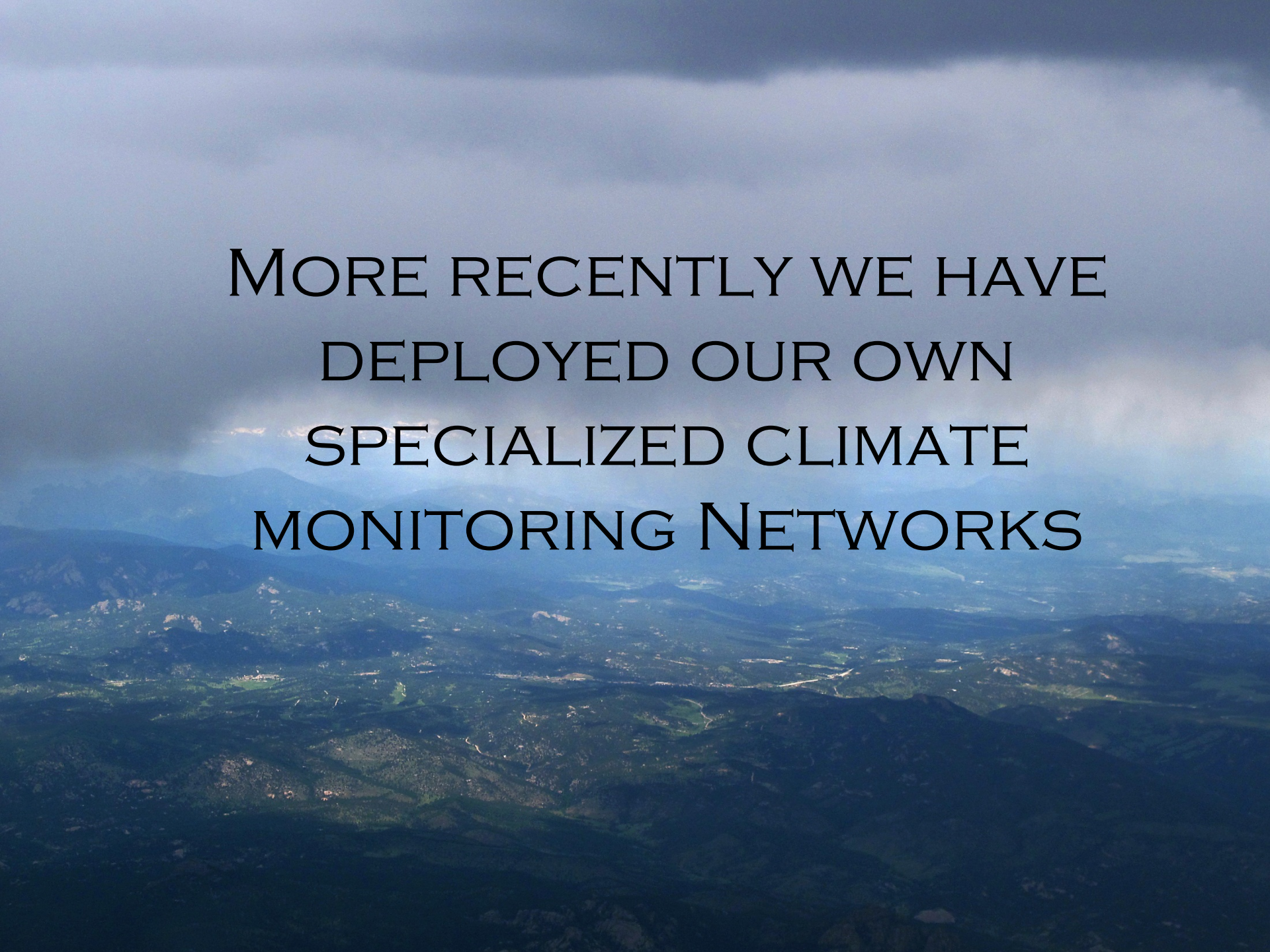
Monitoring has continued ever since – our role has focused on temperature, precipitation, snowpack and other elements affecting water resources

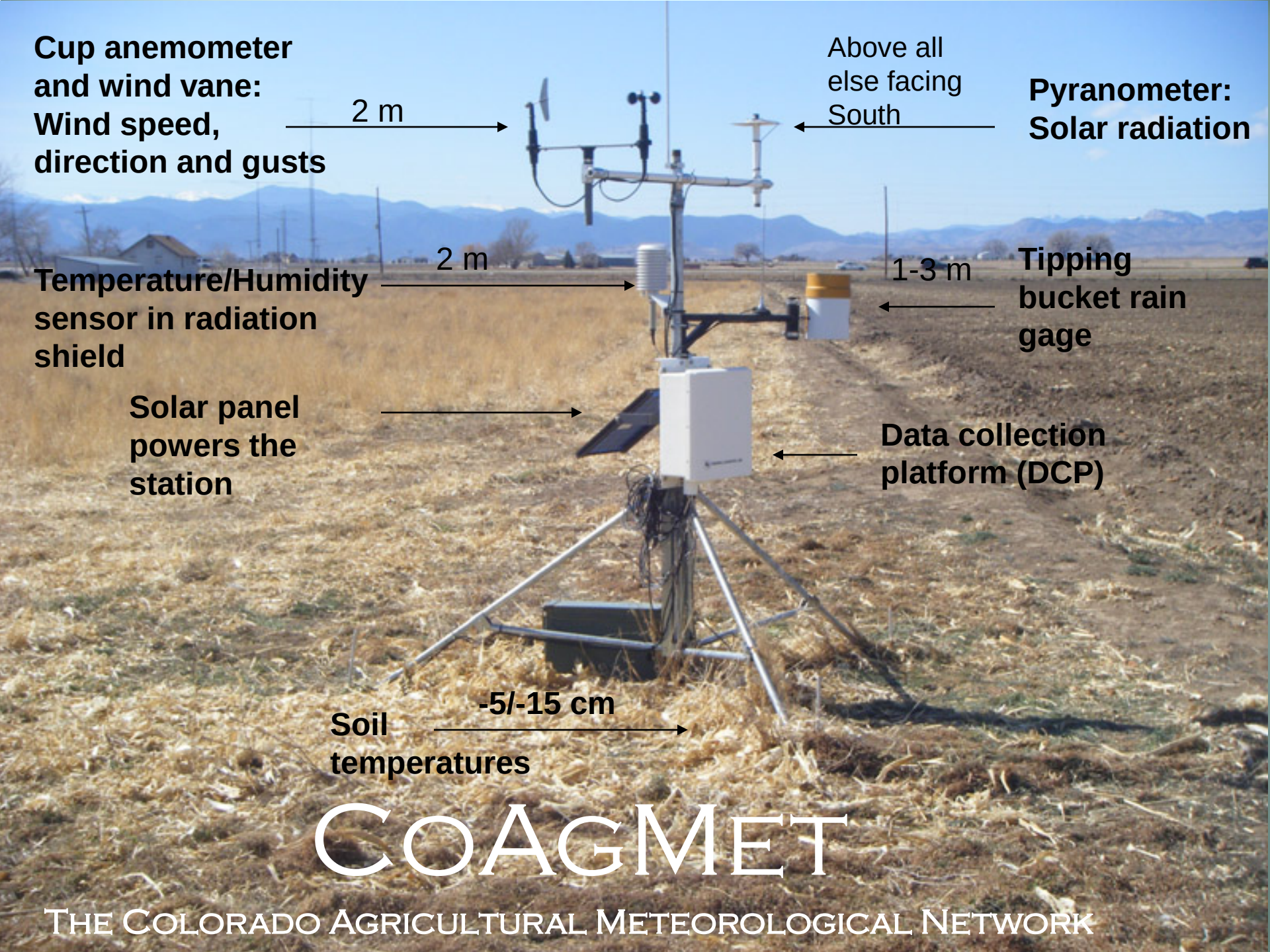
Many of you have become involved in climate monitoring, too – but from a different perspective

# We traditionally relied on data from the National Weather Service and the USDA Nat. Resouces Conservation Service

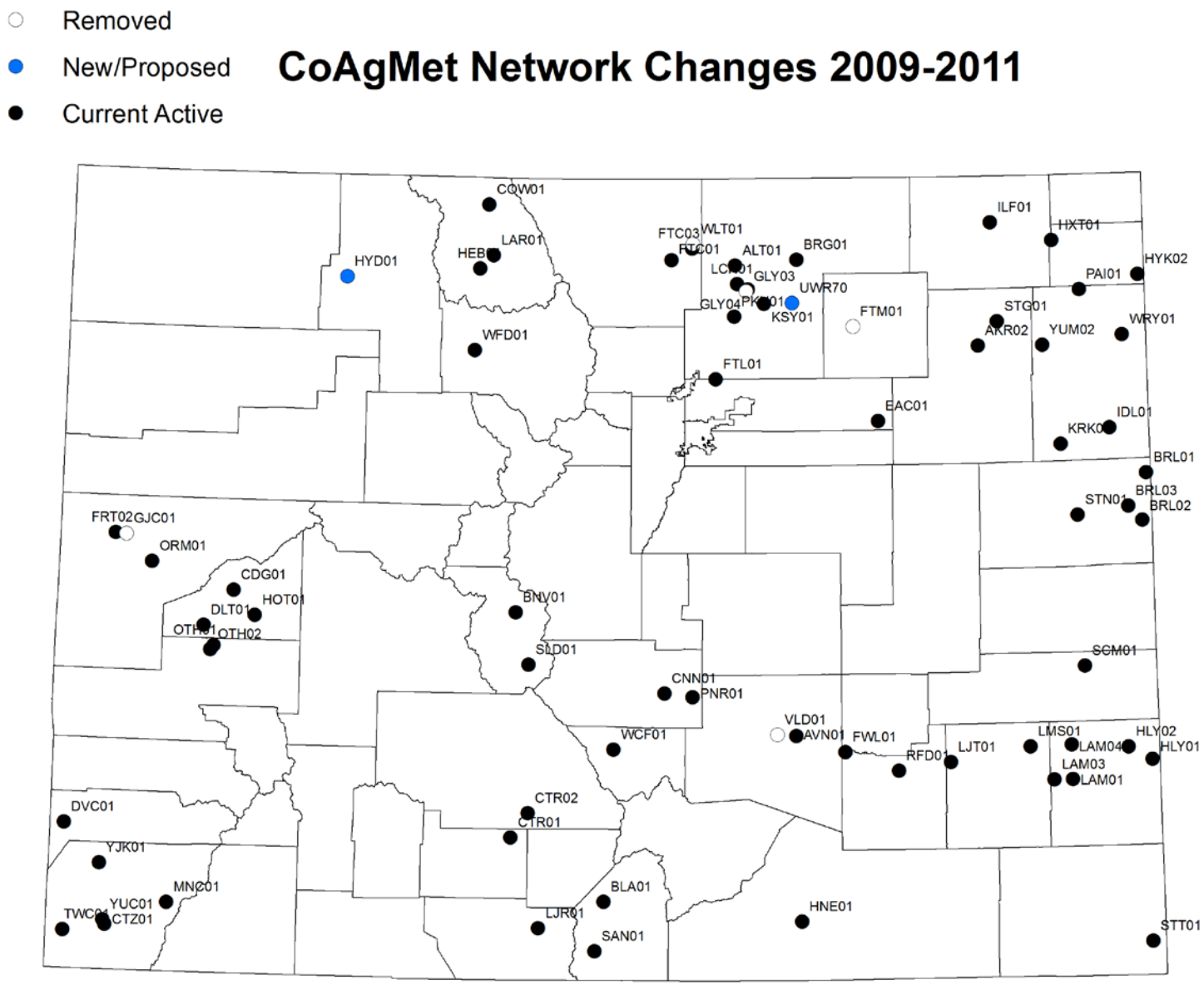
Example of a traditional National Weather Service "Cooperative" weather station in eastern Colorado

Photo by Christopher Davey


More recently we have
deployed our own
specialized climate
monitoring Networks


Cup anemometer and wind vane: Wind speed, direction and gusts
2 m
Above all else facing South
Pyranometer: Solar radiation
2 m
Temperature/Humidity sensor in radiation shield
1-3 m
Tipping bucket rain gage
Solar panel powers the station
Data collection platform (DCP)
-5/-15 cm
Soil temperatures
CoAgMet
The Colorado Agricultural Meteorological Network

# CoAgMet Today



# And our own nationwide volunteer precipitation network


**CoCoRaHS = Community Collaborative Rain, Hail and Snow Network**

**http://www.cocorahs.org**


What have we learned from over 125 years of continuous climate monitoring?

# We Have a Fascinating Climate

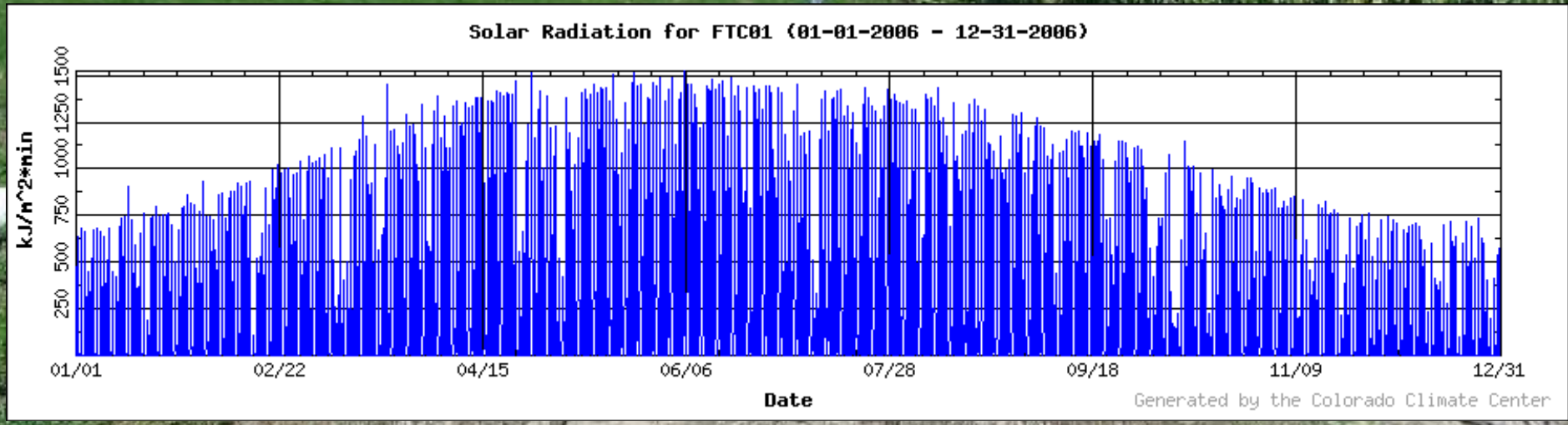
- High elevation (highest state in the Union – by far)
- Mid-Latitude location (lively seasonal changes)
- Interior Continental Location far from atmospheric moisture sources
- Complex Mountain topography

# The Result?

# Generous sunshine and low humidity much of the time

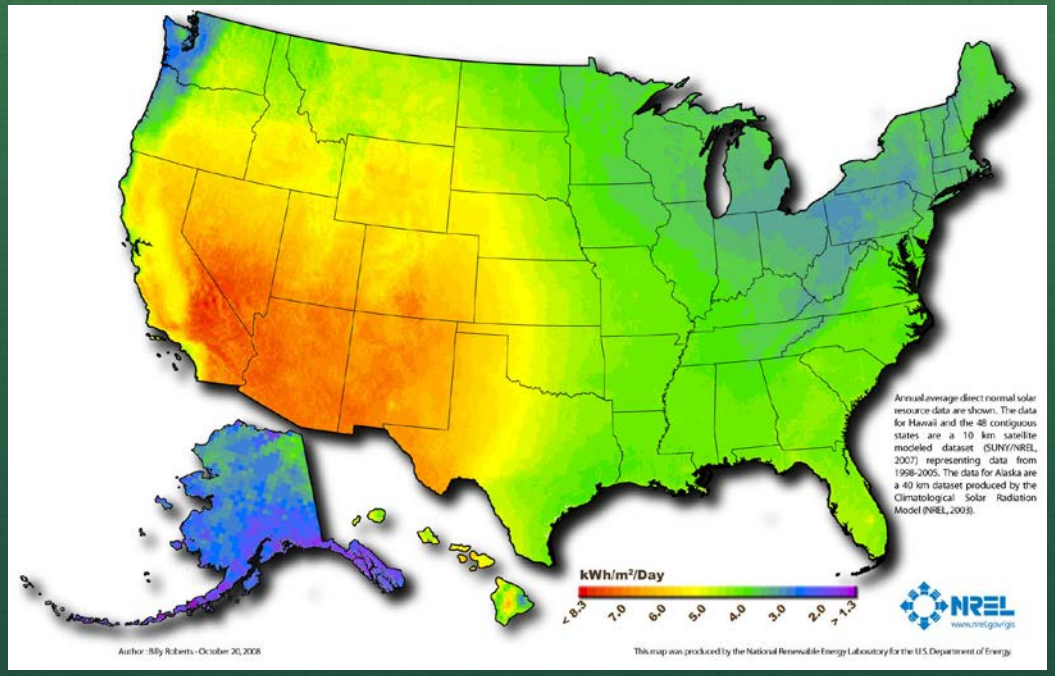
# People like it here

## (the 1870 railroad publicists weren't lying)



# Annual Average Solar Radiation

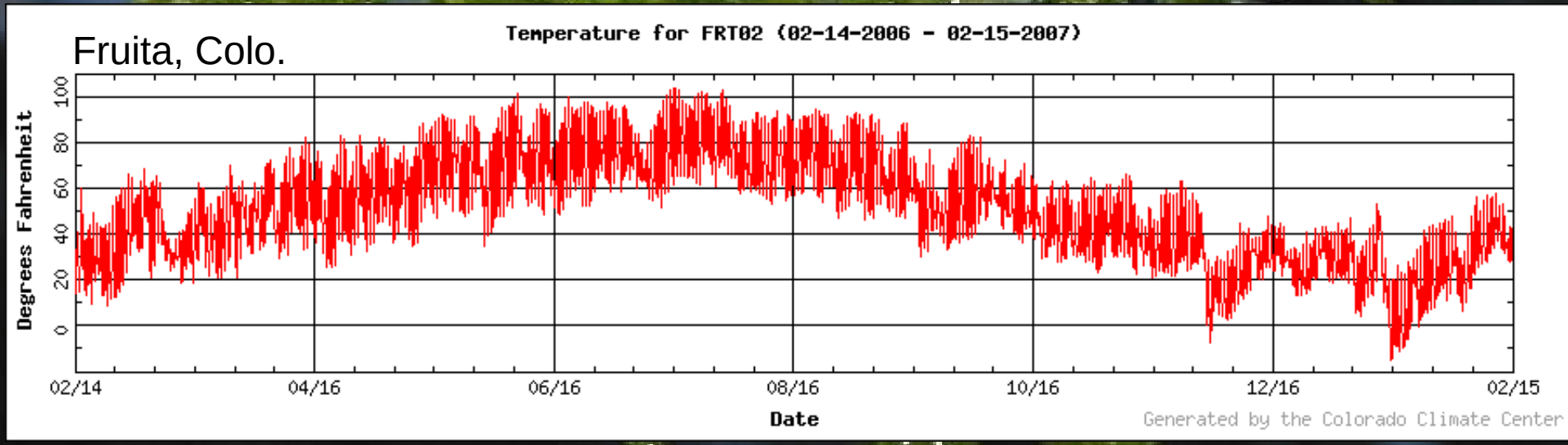
Colorado is a part of the Southwest “Sunbelt” ---- especially southern Colorado



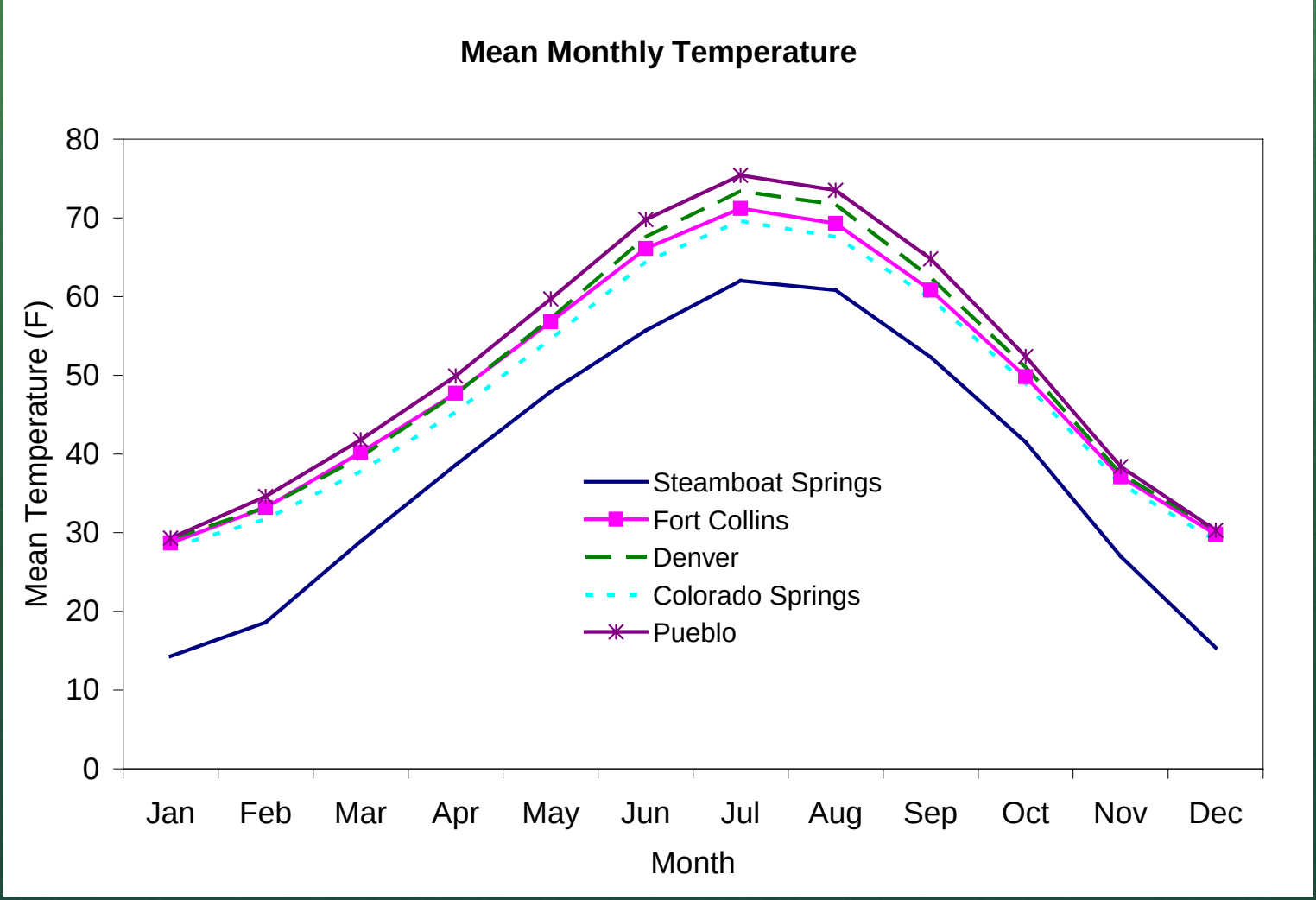

National Renewal Energy Laboratory: www.nrel.gov

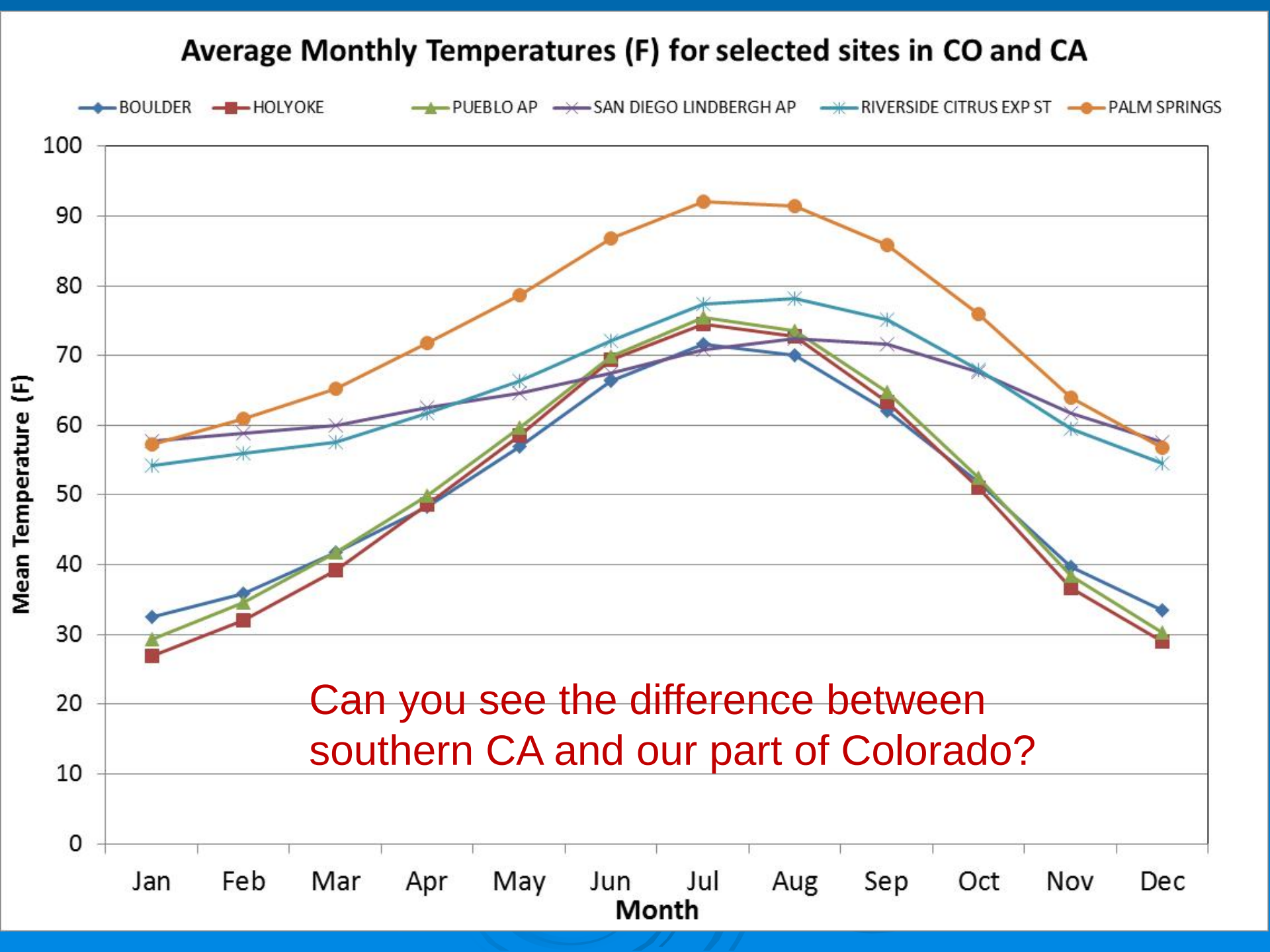
# Large Seasonal Temperature Variations

Fruita, Colo.

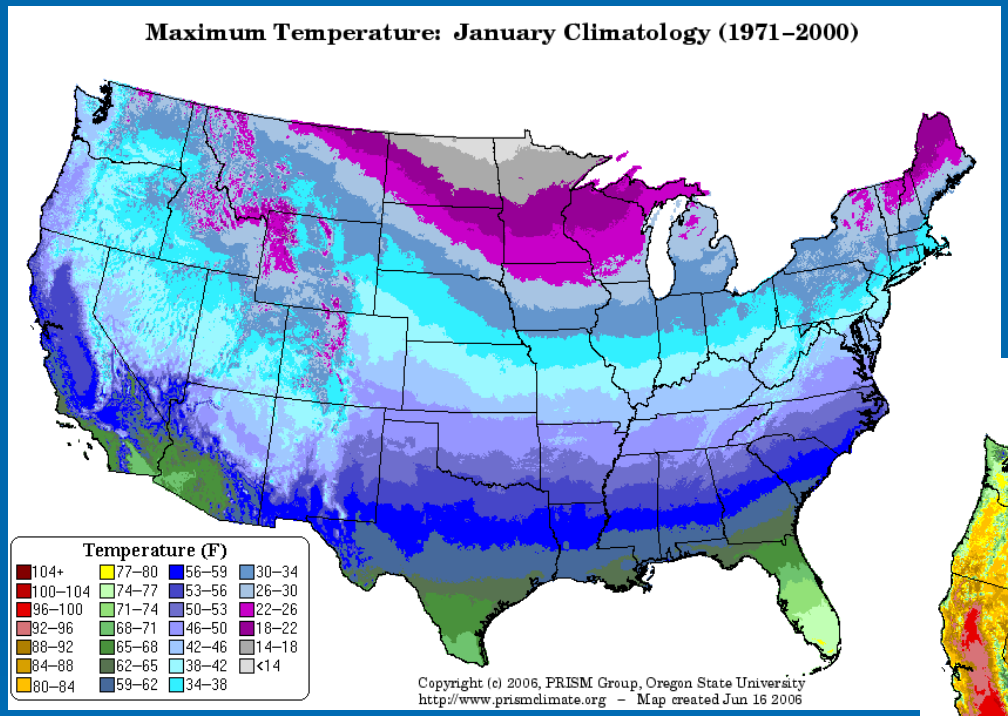


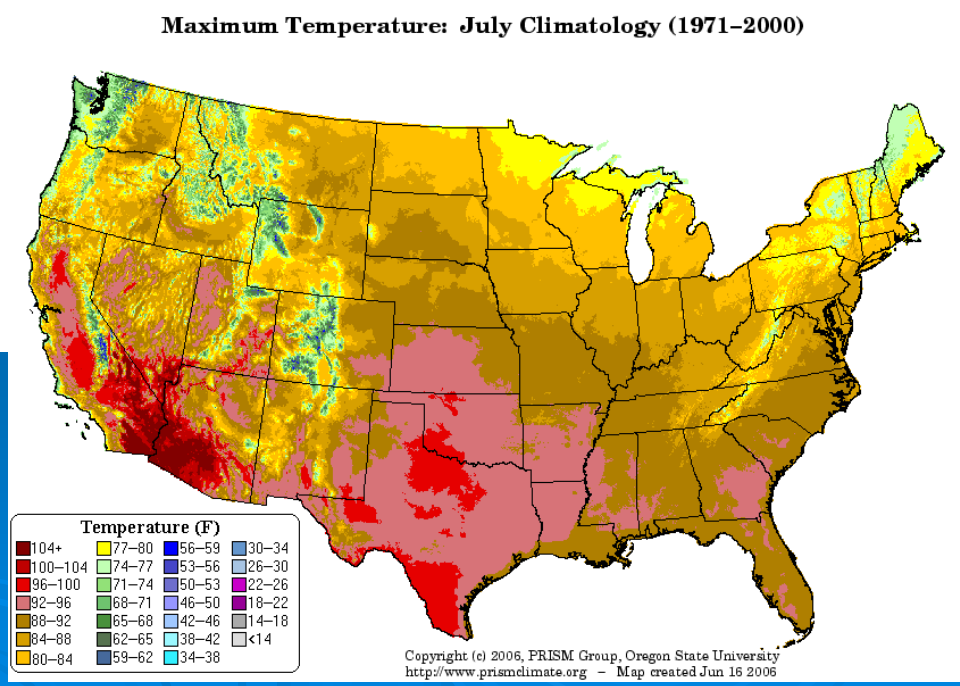
# Mountain Community Temperatures compared to Front Range cities of Colorado




Average Monthly Temperatures (F) for selected sites in CO and CA
BOULDER
HOLYOKE
PUEBLO AP
SAN DIEGO LINDBERGH AP
RIVERSIDE CITRUS EXP ST
PALM SPRINGS
Mean Temperature (F)
100
90
80
70
60
50
40
30
20
10
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
Can you see the difference between southern CA and our part of Colorado?

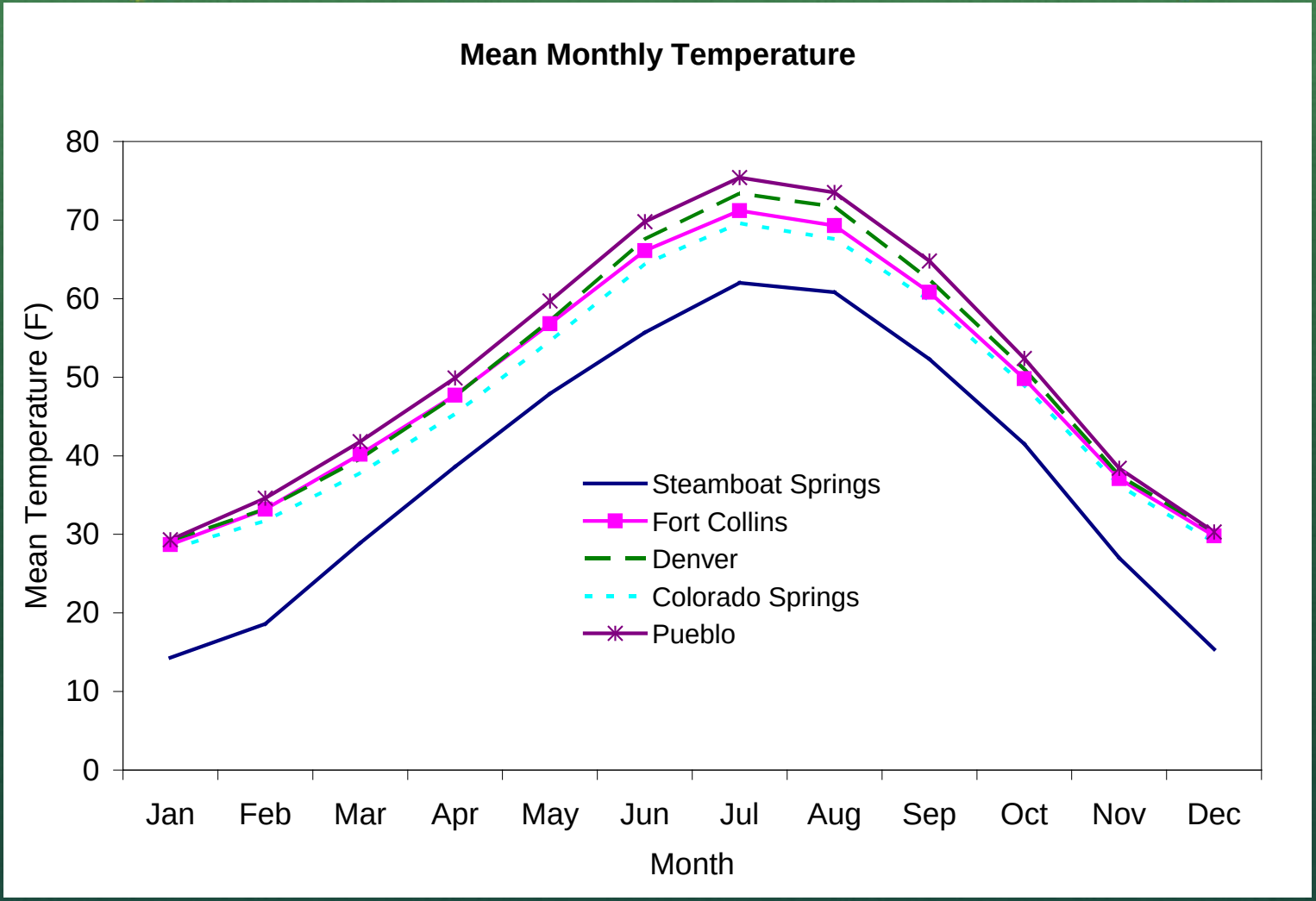
# Complex local variations due to elevation and topography



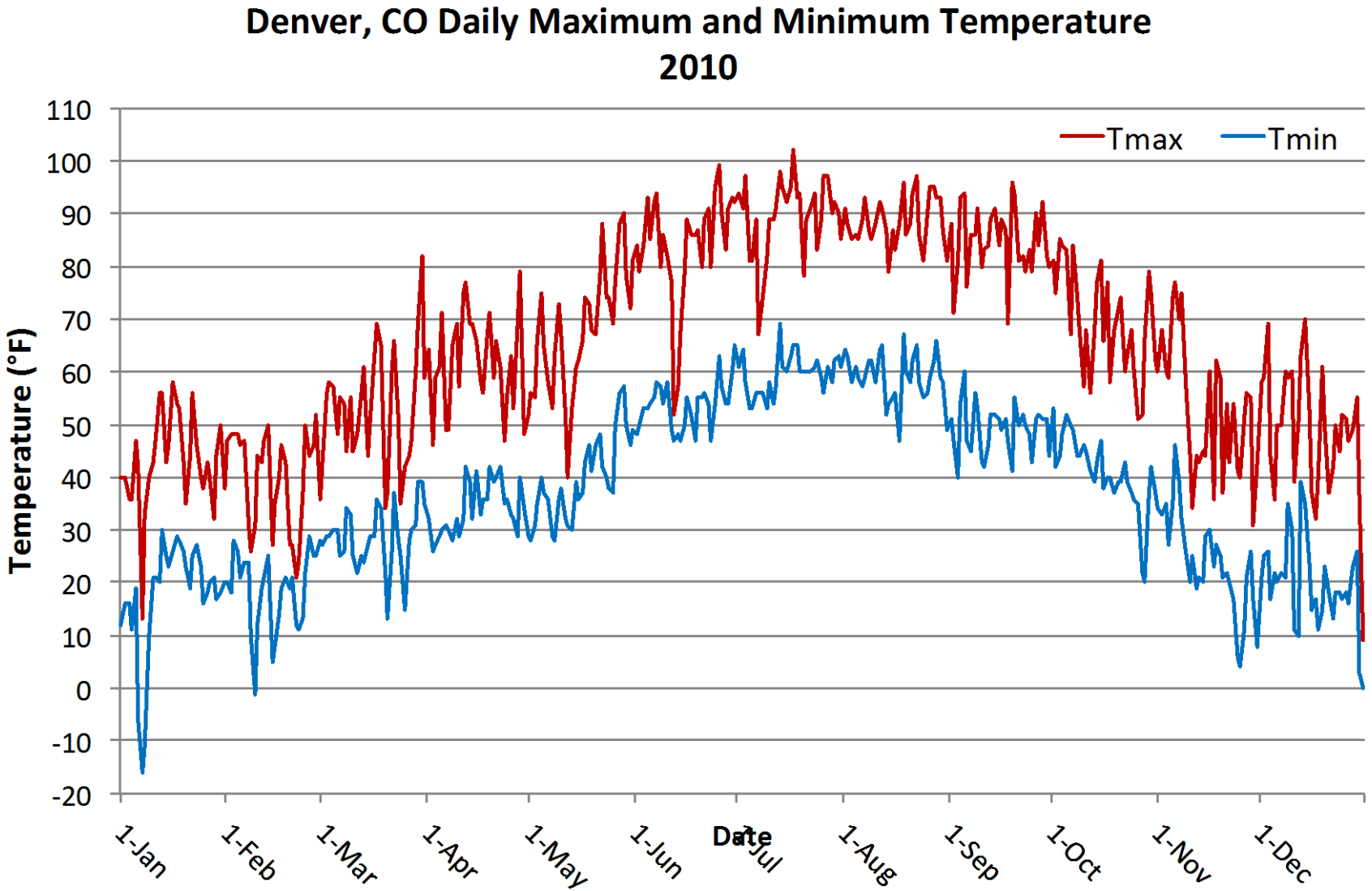




Usually colder in the mountains!

# Nice smooth graphs like this of average monthly temperatures – this is a way of looking at CLIMATE

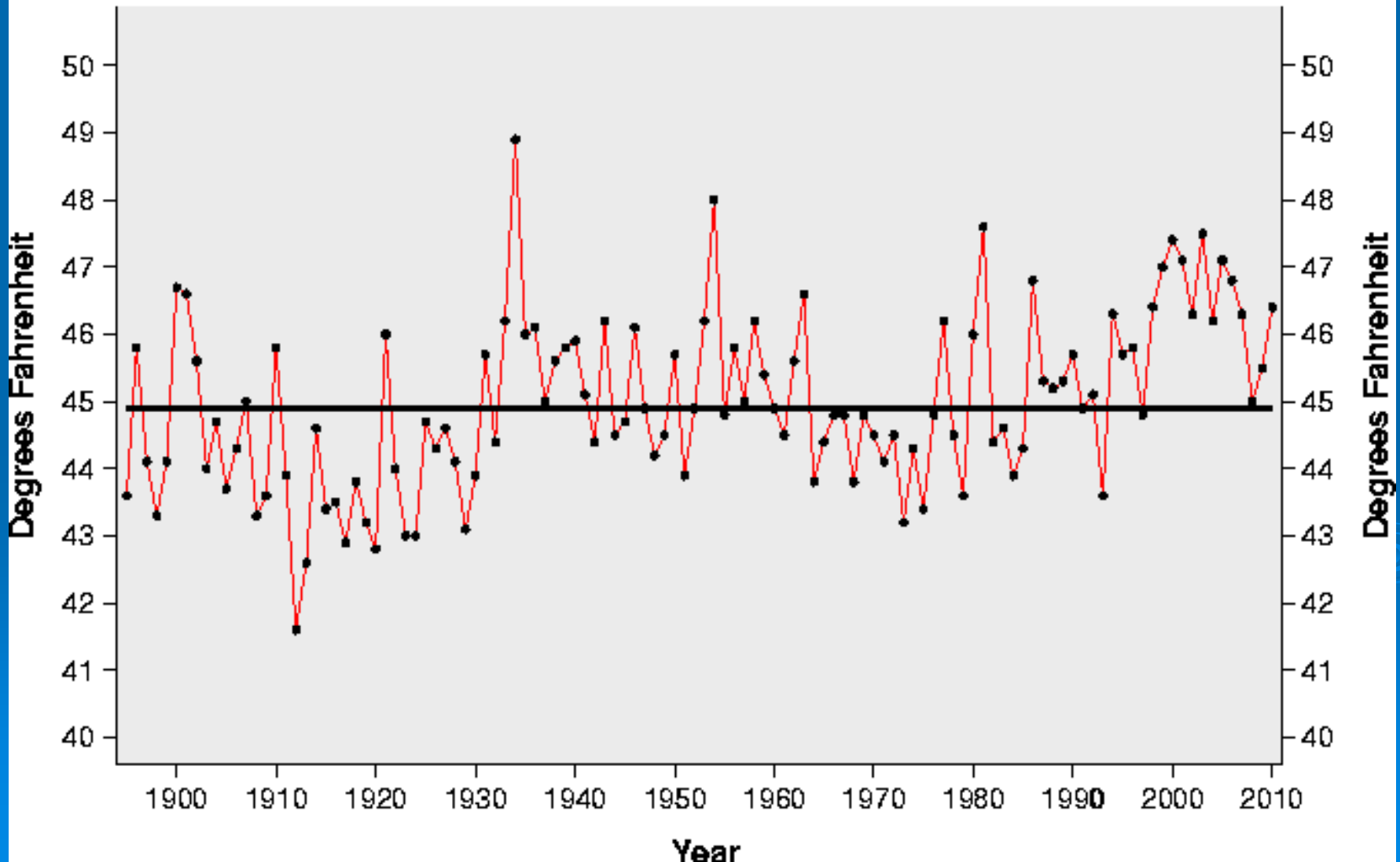


# And this is how daily weather, over time, defines our climate

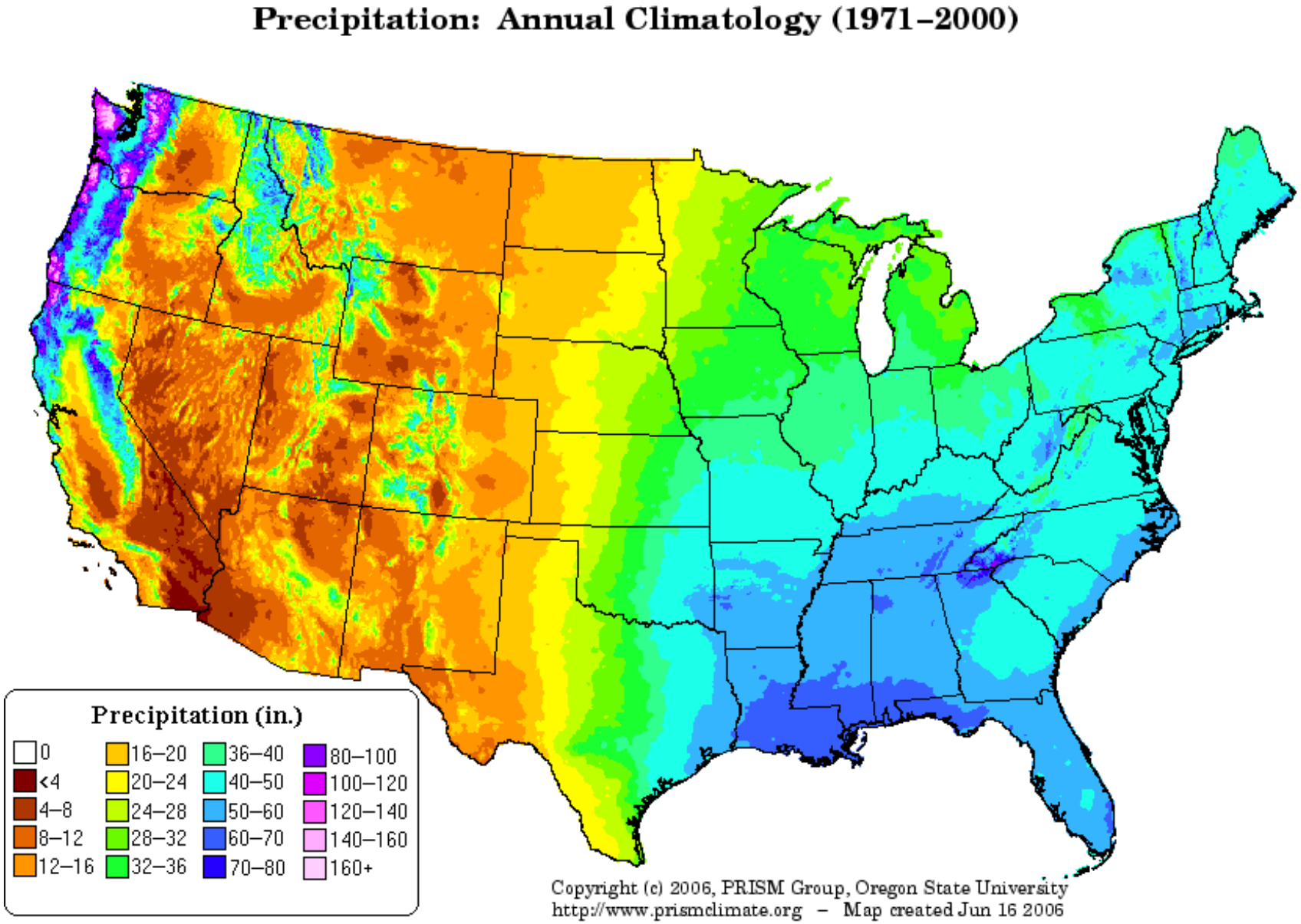


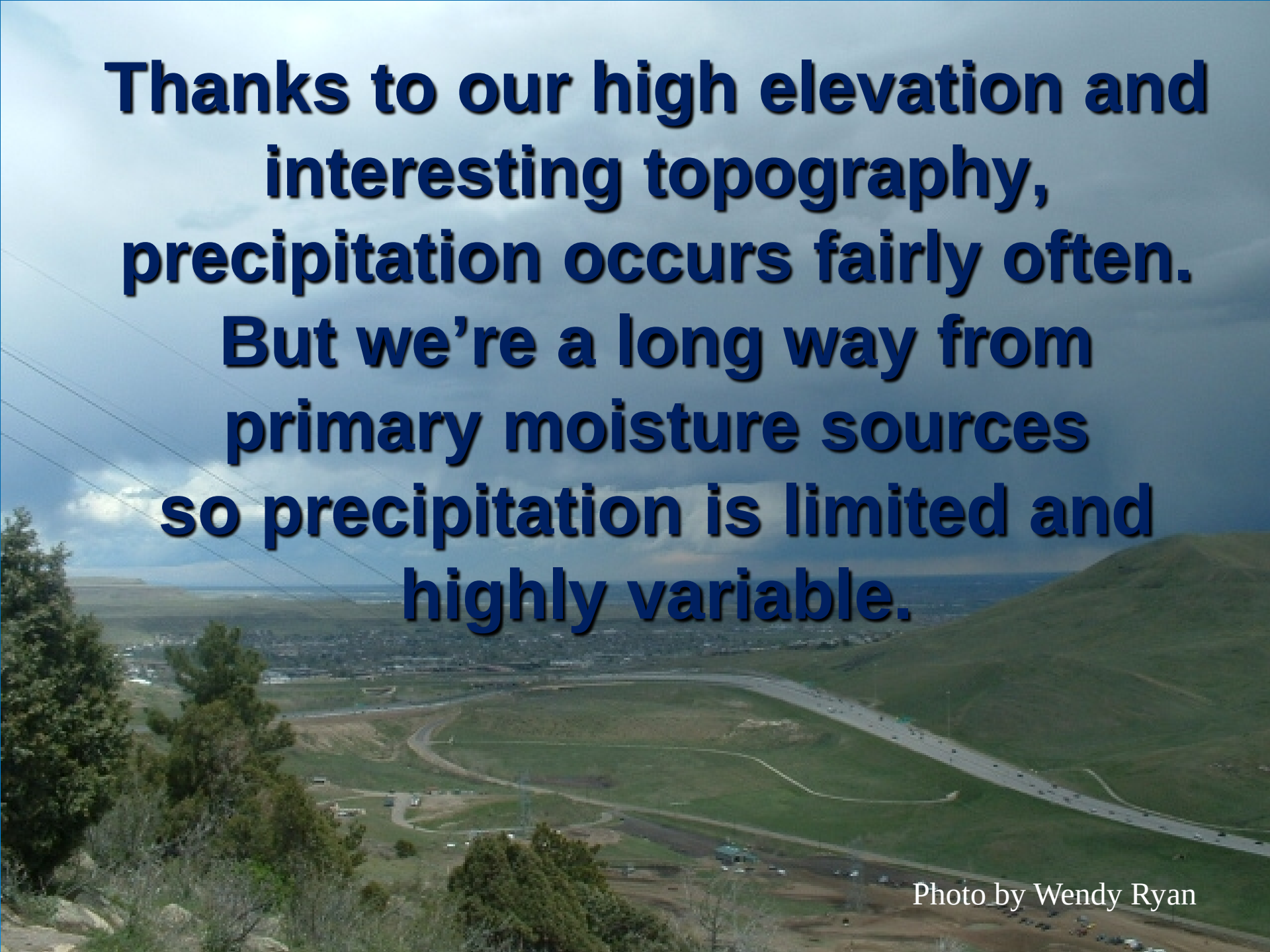
# Relatively Large Year to Year Variations ("Interannual Variabililty")

Colorado Statewide Mean Annual Temperature (1895-2010)

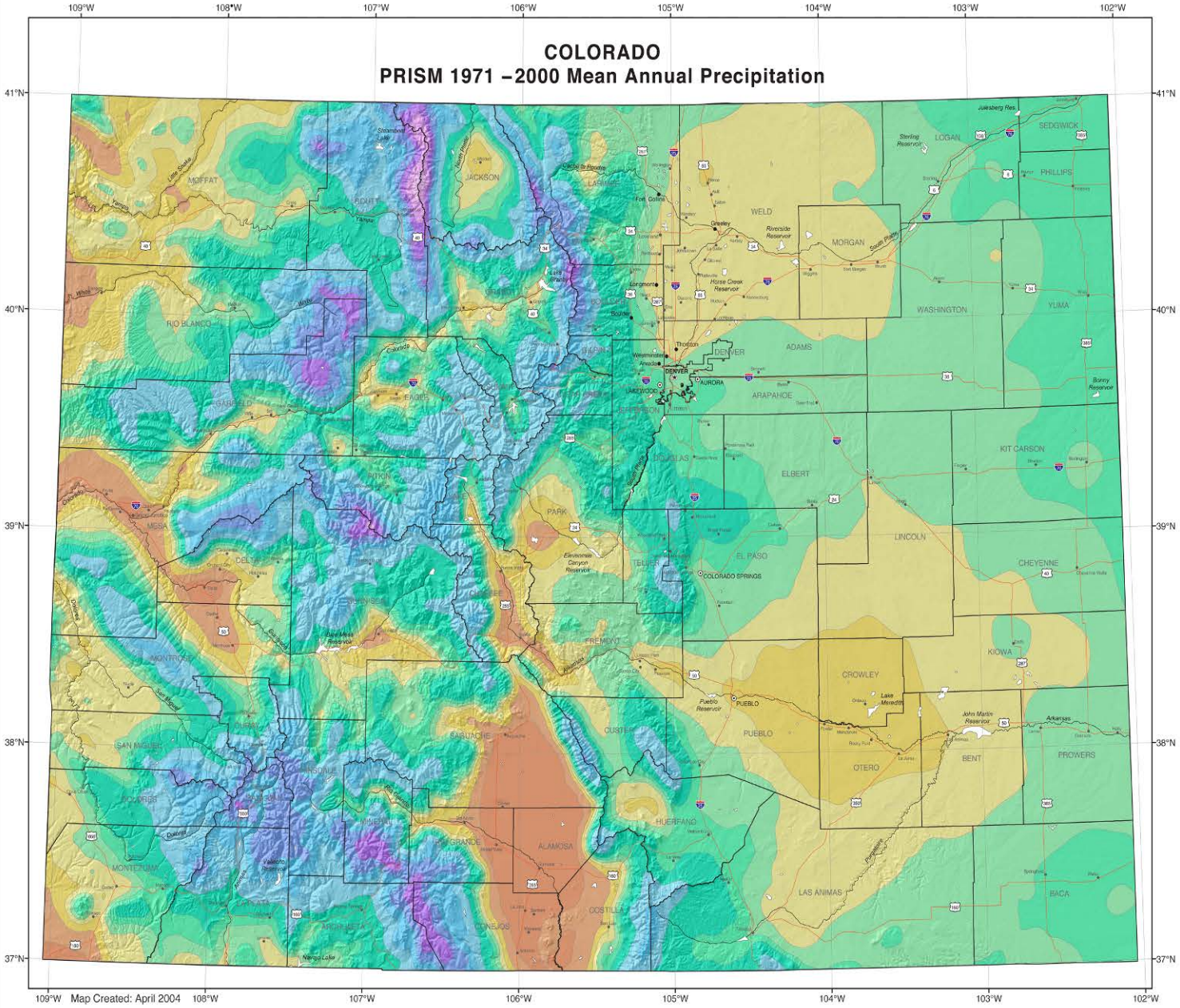


# Where we fit in the national picture




Thanks to our high elevation and interesting topography, precipitation occurs fairly often. But we're a long way from primary moisture sources so precipitation is limited and highly variable.
Photo by Wendy Ryan

# COLORADO
## PRISM 1971 –2000 Mean Annual Precipitation




**Average Annual Precipitation 1971 – 2000**

| millimeters | inches |
|---|---|
| < 229 | < 9 |
| 229 – 279 | 9 – 11 |
| 279 – 330 | 11 – 13 |
| 330 – 380 | 13 – 15 |
| 380 – 432 | 15 – 17 |
| 432 – 483 | 17 – 19 |
| 483 – 610 | 19 – 24 |
| 610 – 762 | 24 – 30 |
| 762 – 914 | 30 – 36 |
| 914 – 1067 | 36 – 42 |
| 1067 – 1219 | 42 – 48 |
| 1219 – 1372 | 48 – 54 |
| > 1372 | > 54 |

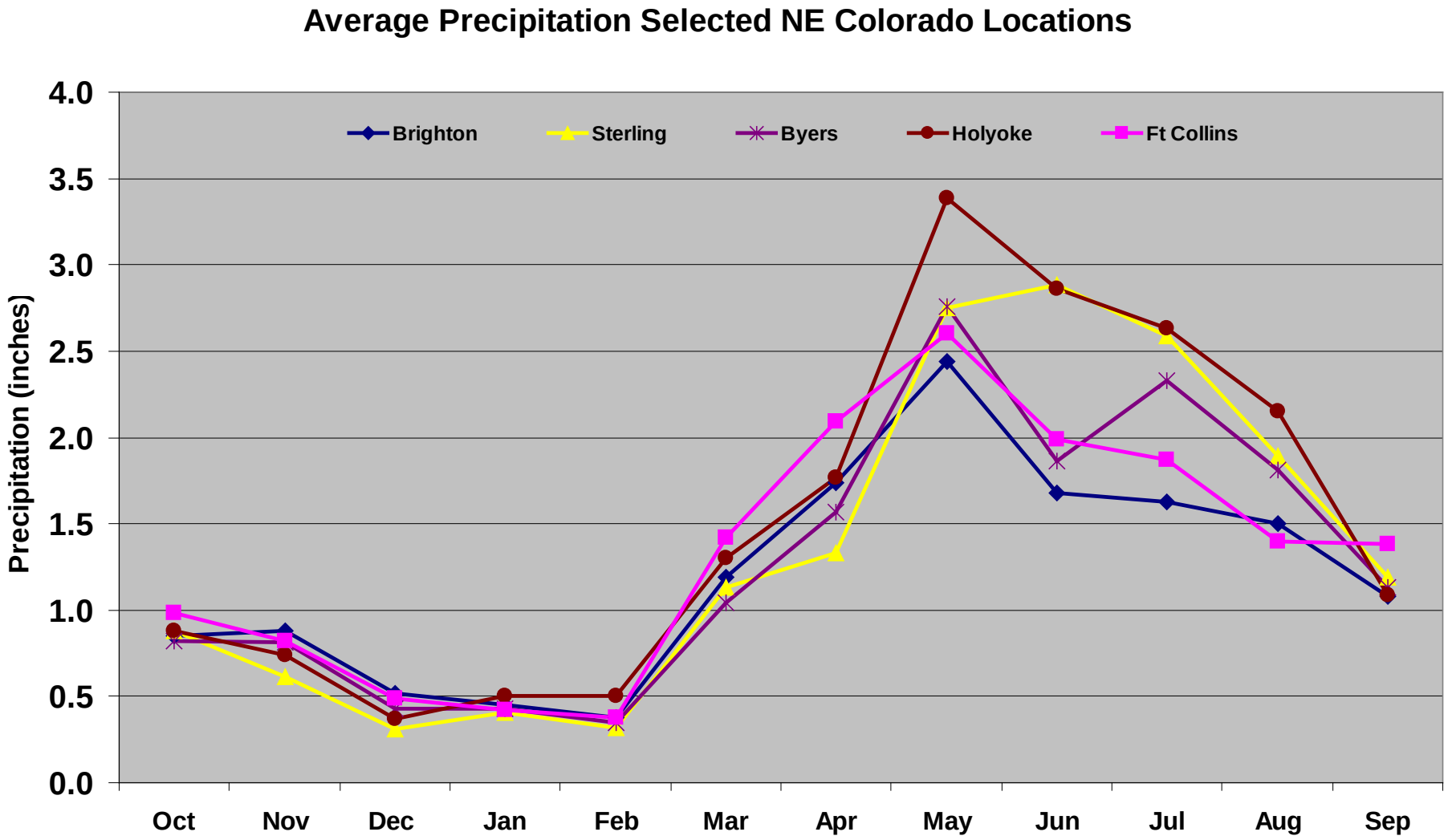
Rivers
Lakes
Roads

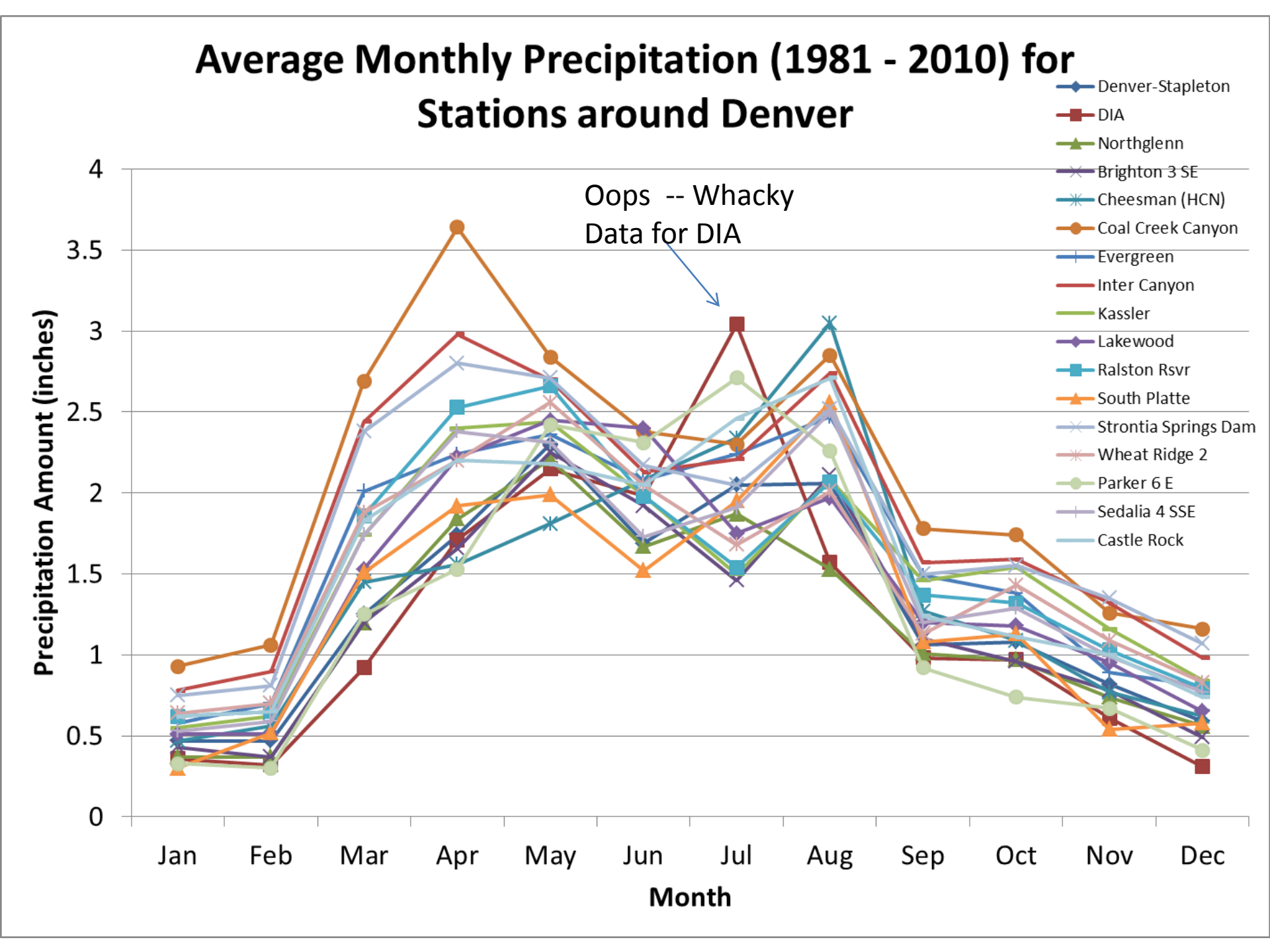
0 10 20 40 60 80 Miles
0 16 32 64 96 128 Kilometers

Map prepared with the PRISM climate modeling system by the Spatial Climate Analysis Service, Oregon State University.
http://www.ocs.orst.edu/prism 

SCAS OREGON STATE UNIVERSITY PRISM Oregon Climate Service

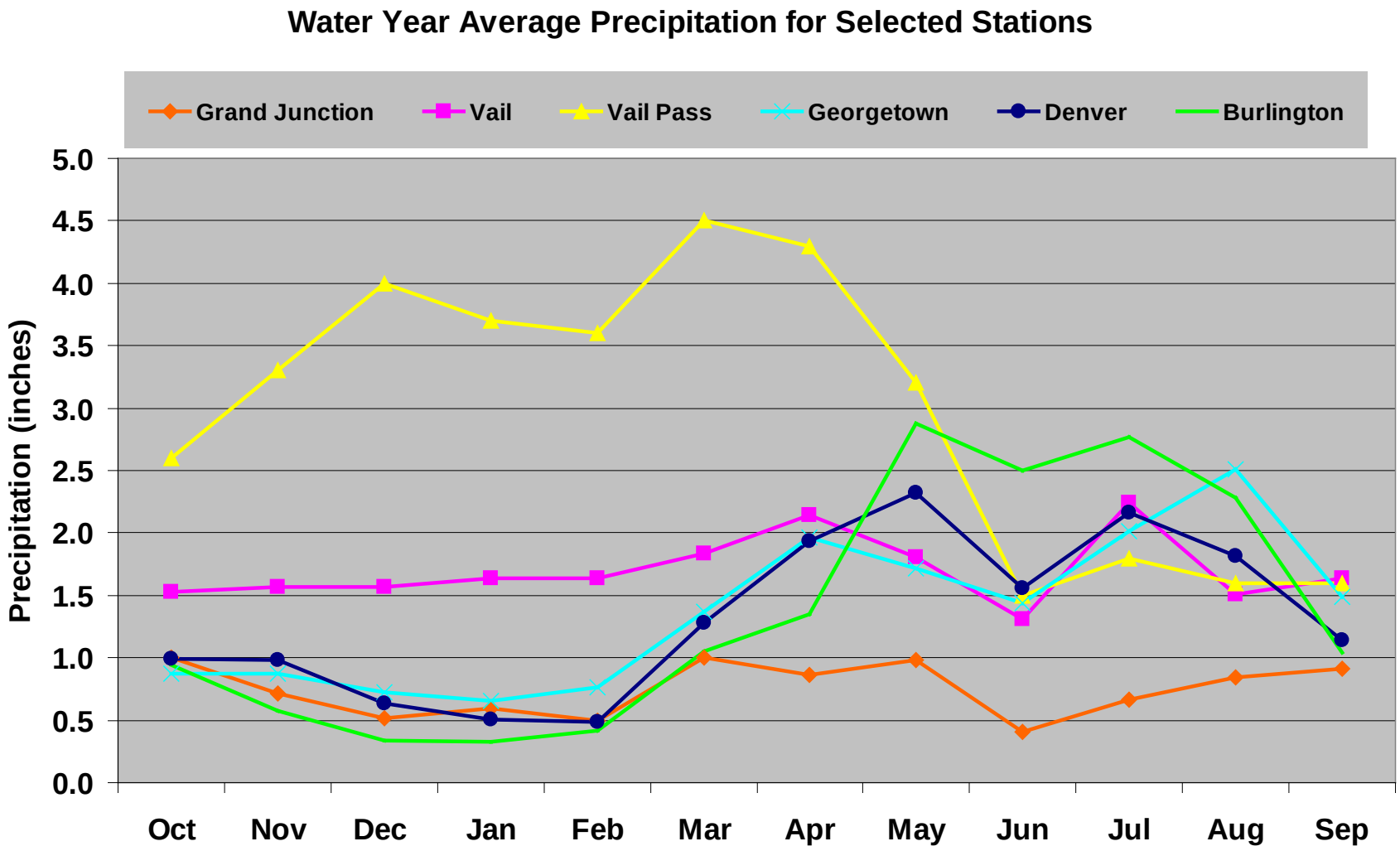
# The mountains block and harvest winter moisture (most years) leaving eastern Colorado dry



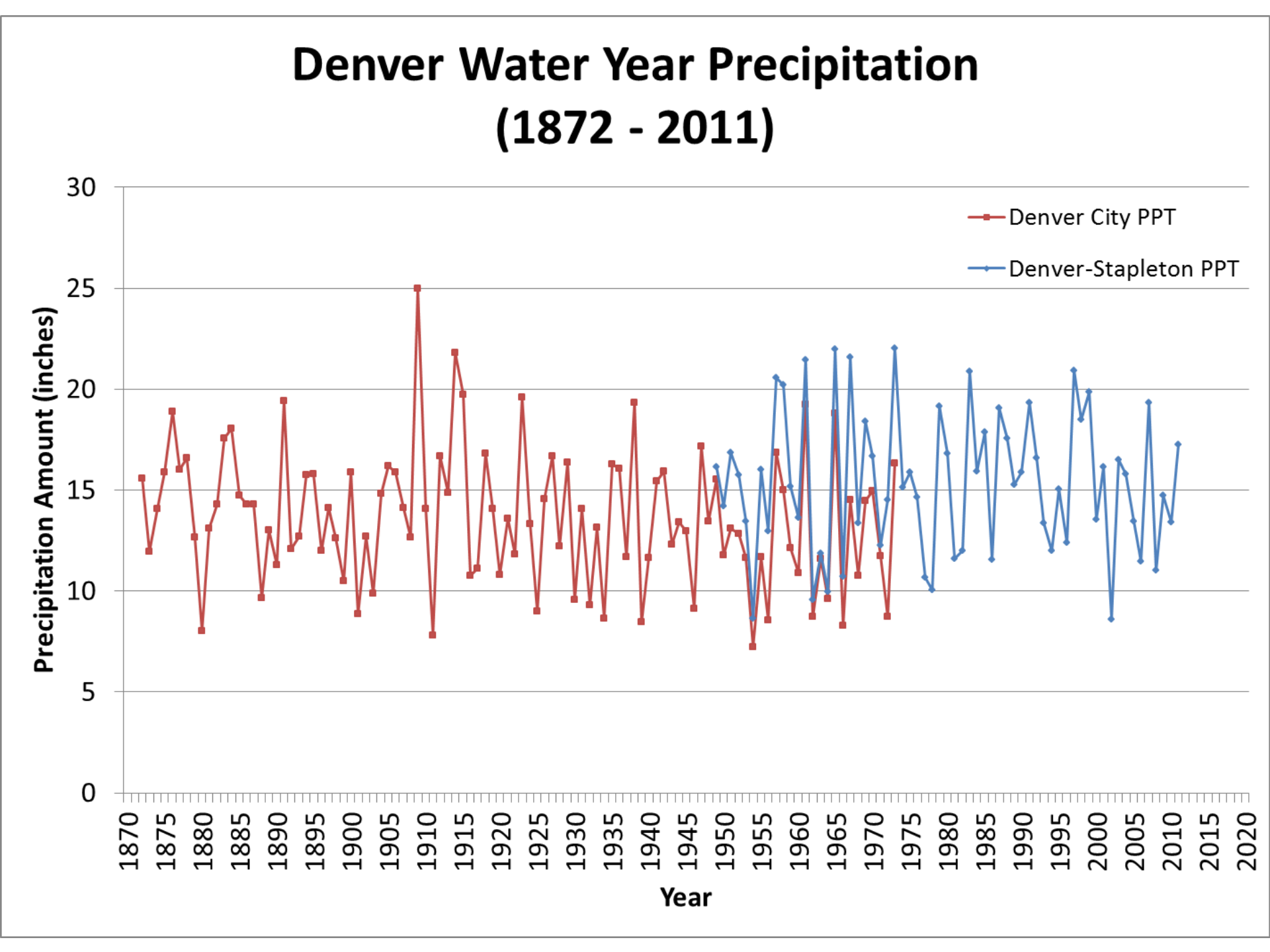

Average Monthly Precipitation (1981 - 2010) for Stations around Denver
Oops -- Whacky Data for DIA
Precipitation Amount (inches)
0
0.5
1
1.5
2
2.5
3
3.5
4
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
Denver-Stapleton
DIA
Northglenn
Brighton 3 SE
Cheesman (HCN)
Coal Creek Canyon
Evergreen
Inter Canyon
Kassler
Lakewood
Ralston Rsvr
South Platte
Strontia Springs Dam
Wheat Ridge 2
Parker 6 E
Sedalia 4 SSE
Castle Rock

# Precipitation patterns in Colorado along I-70

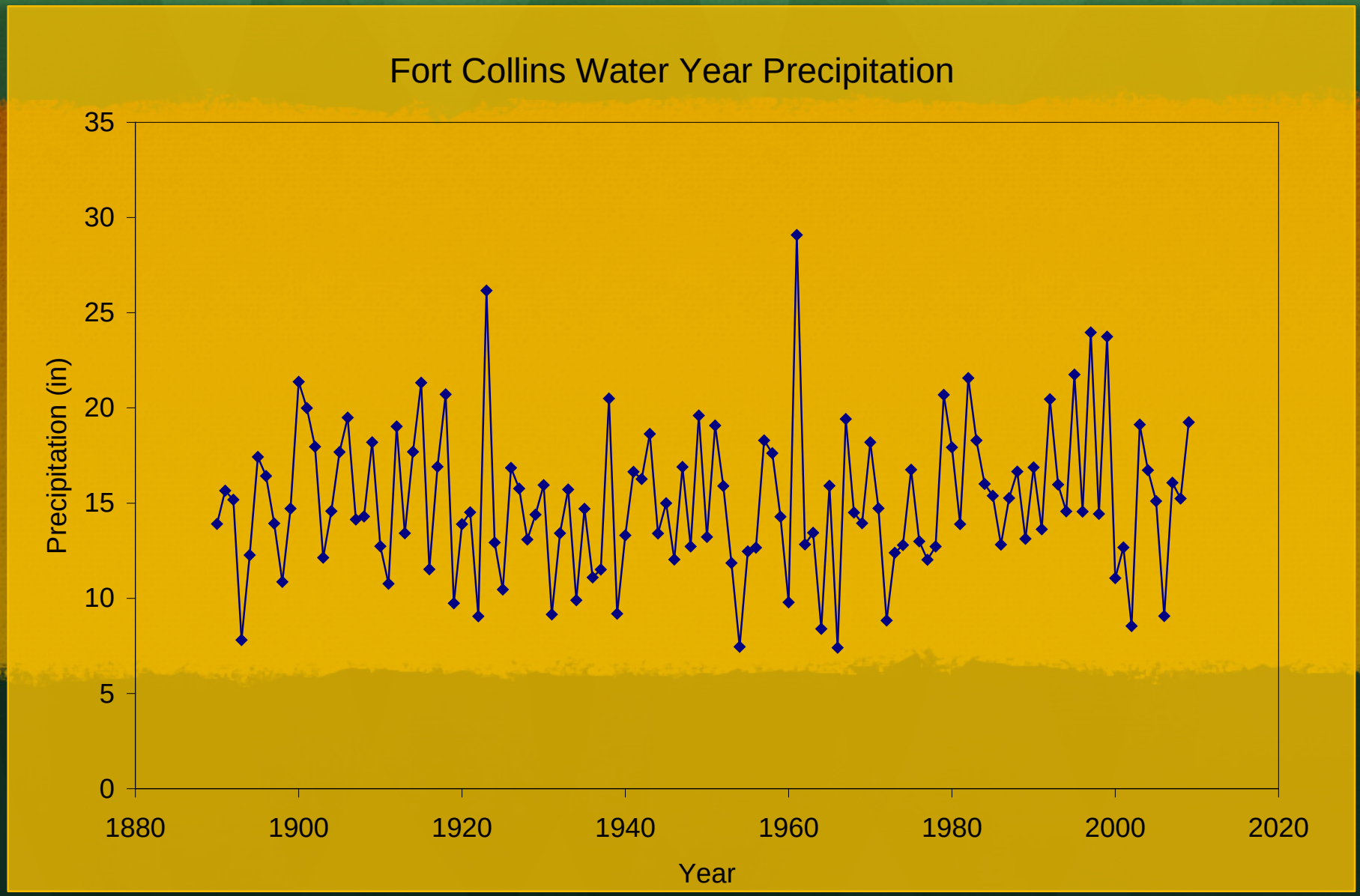
## Seasonal patterns differ elsewhere in Colo.



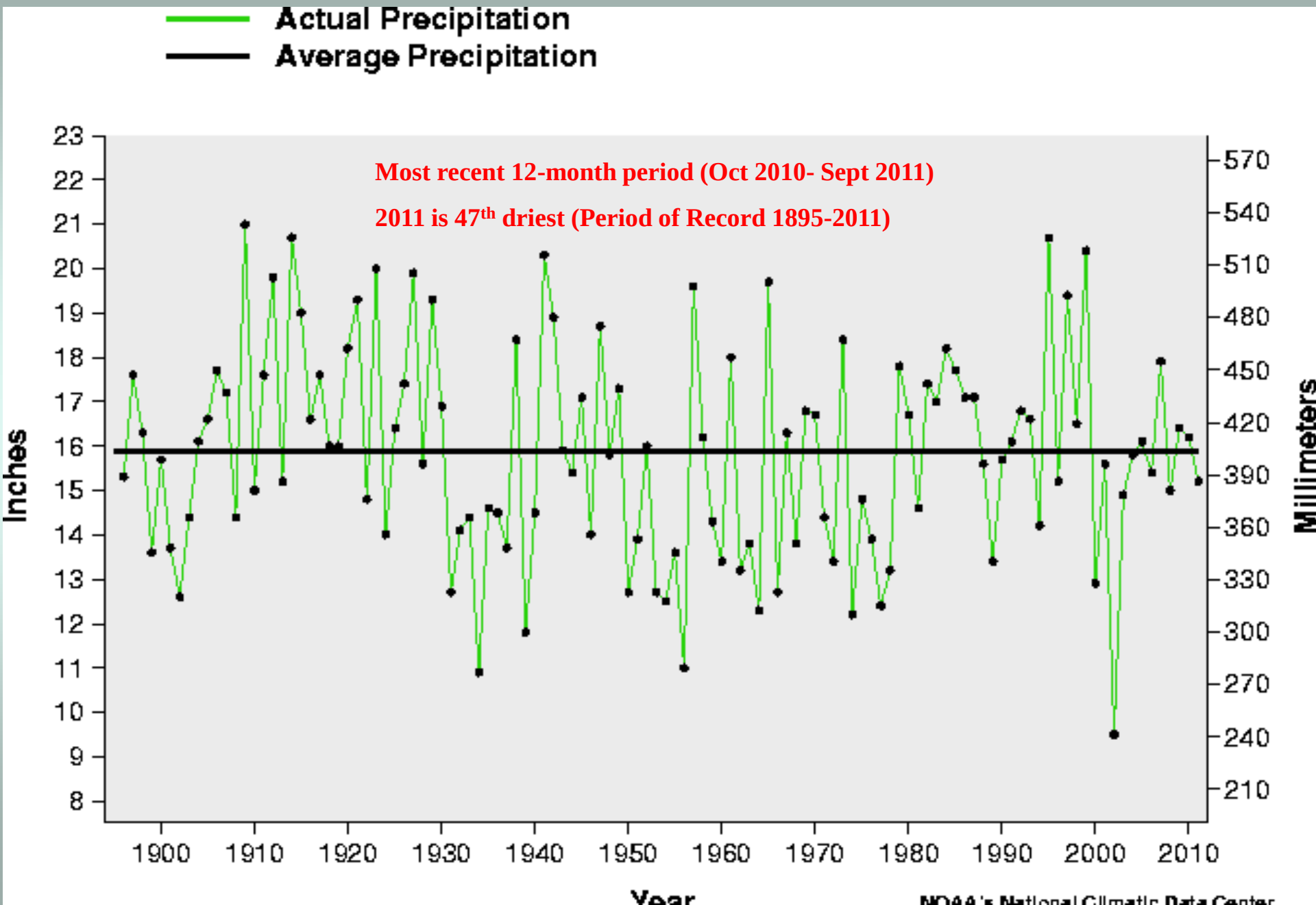
# Large Year-to-Year Variations in Precipitation


Denver Water Year Precipitation
(1872 - 2011)
Precipitation Amount (inches)
0
5
10
15
20
25
30
1870
1875
1880
1885
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
Denver City PPT
Denver-Stapleton PPT

In semi-arid parts of the U.S. precipitation may vary by more than 100% from one year to the next.

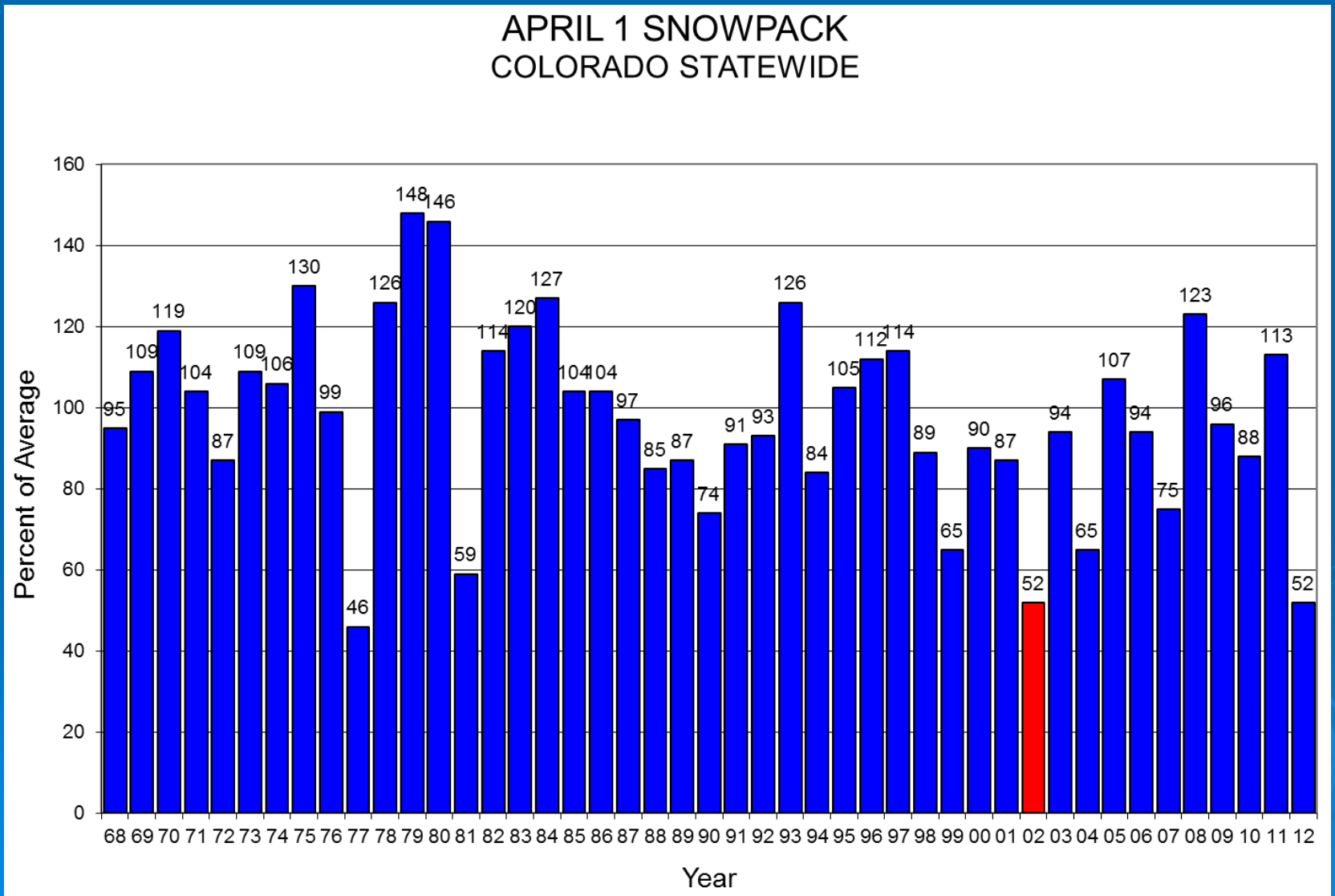


# Colorado Precipitation in Historic Perspective



# Colorado Statewide April 1 Snowpack

**Time Series of April 1 Snowpack – Tracking Variability and Trends**



# And like it or not . . . .

Colorado State University
Knowledge to Go Places

COLORADO CLIMATE CENTER

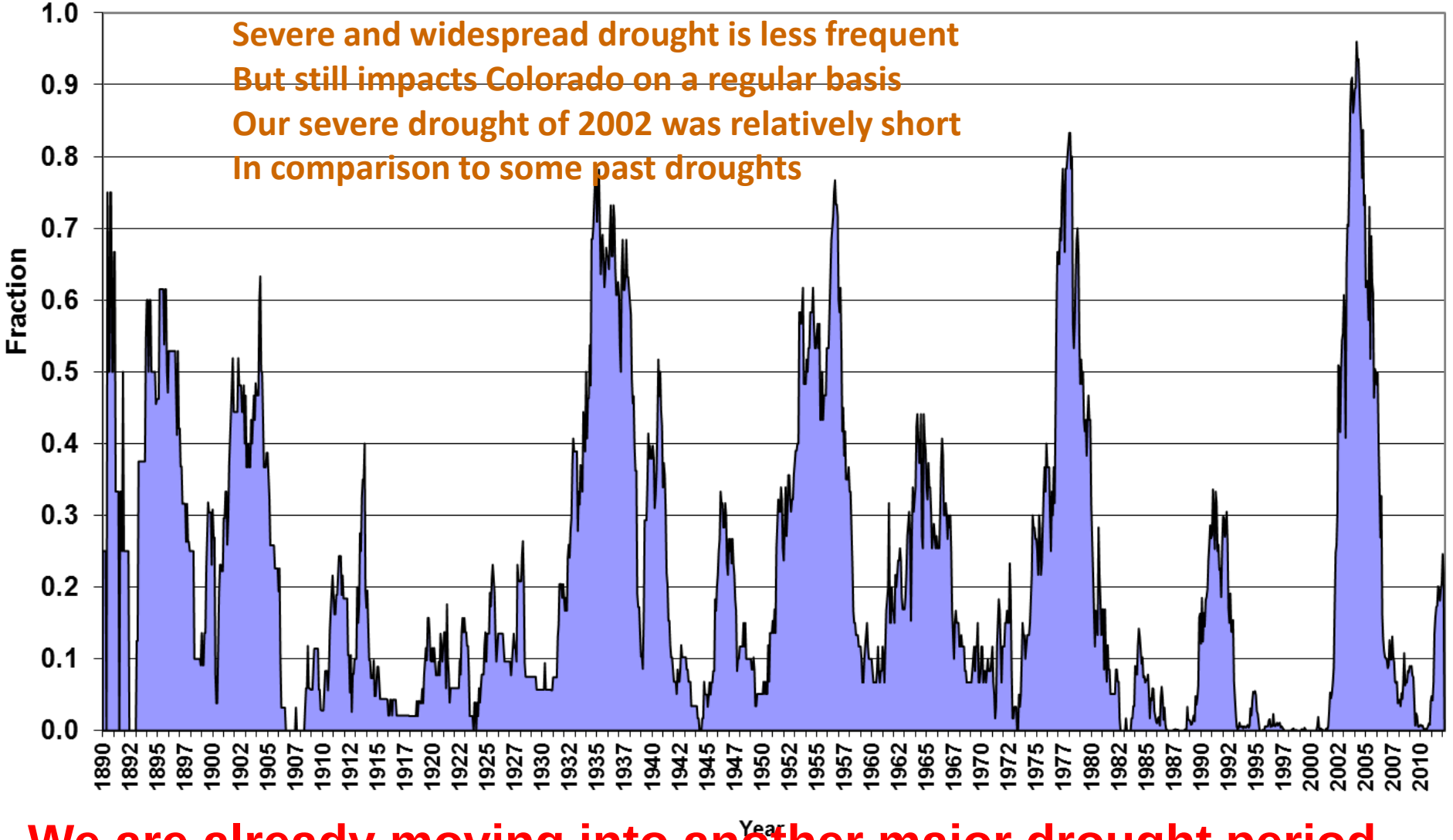
# Drought Visits Our Area Regularly

Photo by NRCS

# Fraction of Colorado in Drought

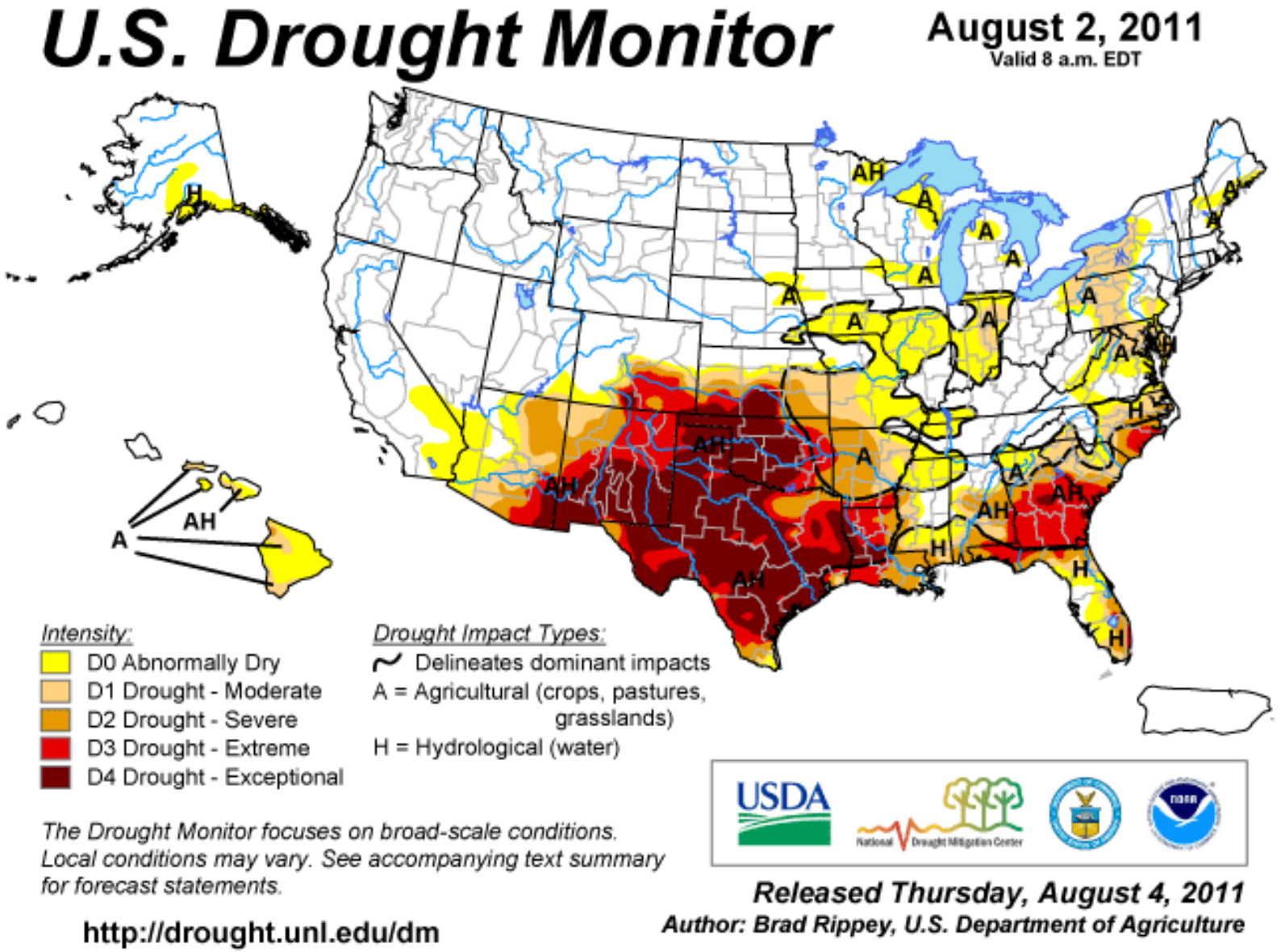
## Based on 48 month SPI (SPI <-1)

(1890 - March 2012)

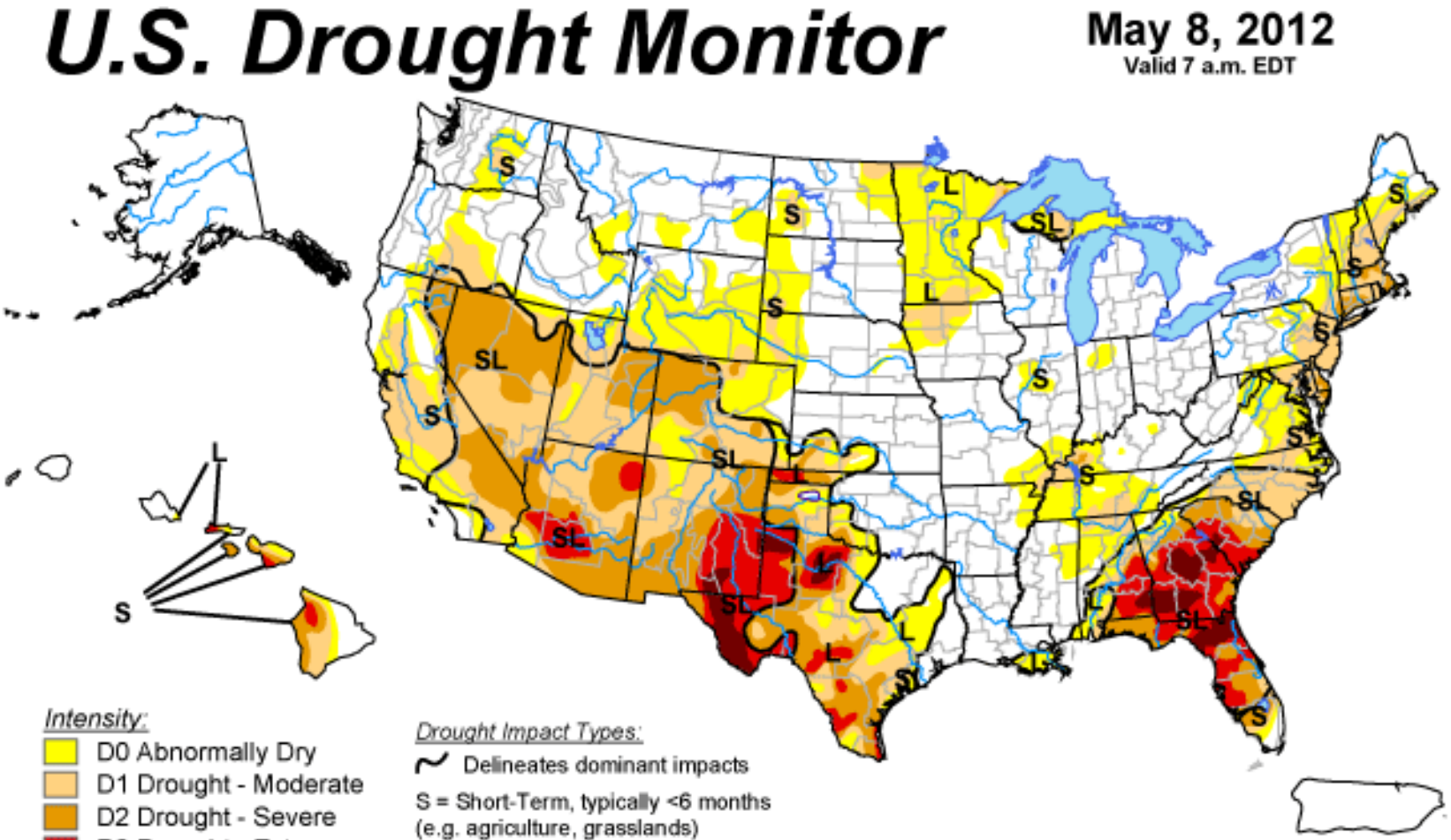



**We are already moving into another major drought period**

# U.S. Drought Status last summer



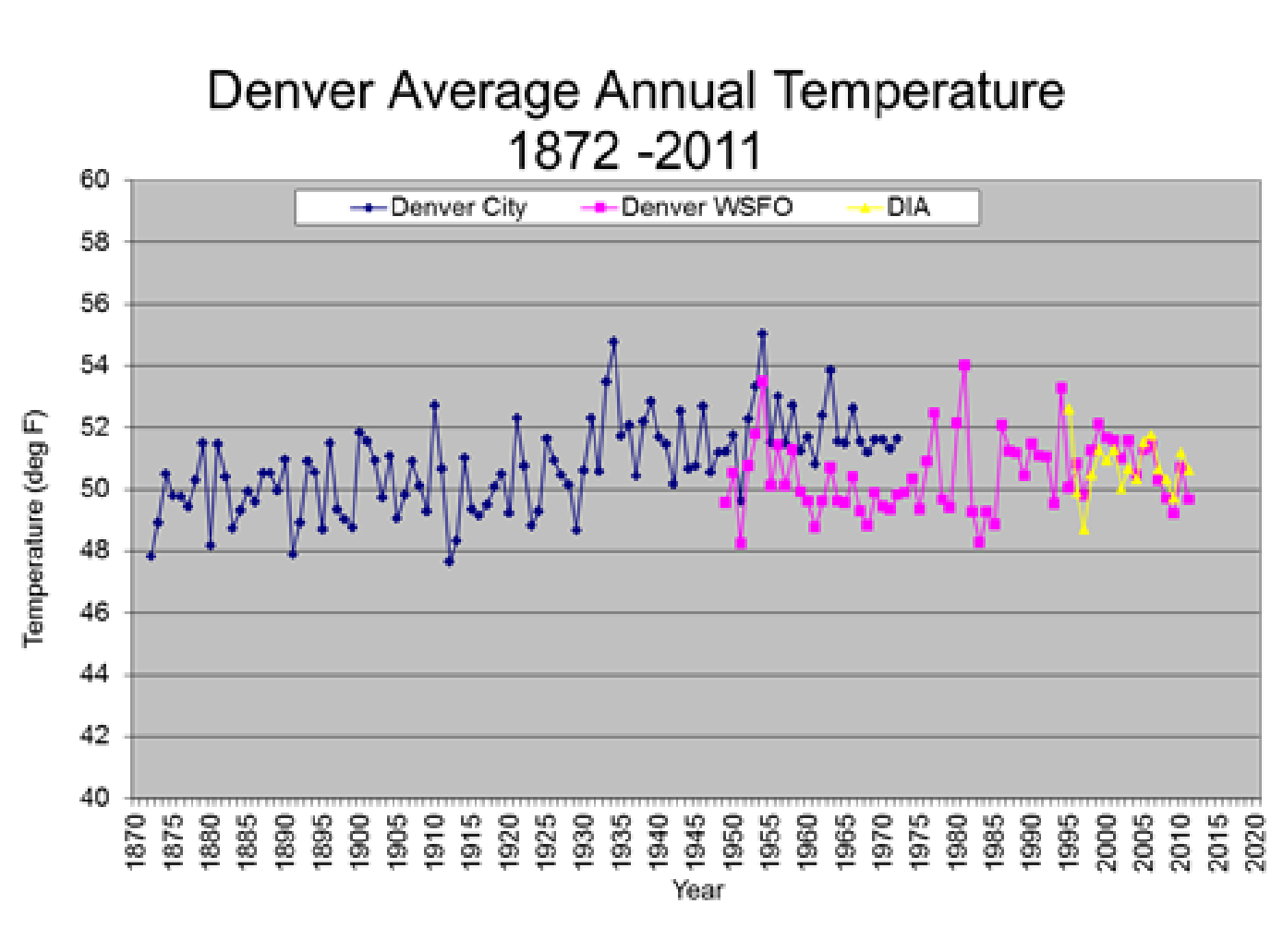
# U.S. Drought Status Last Week



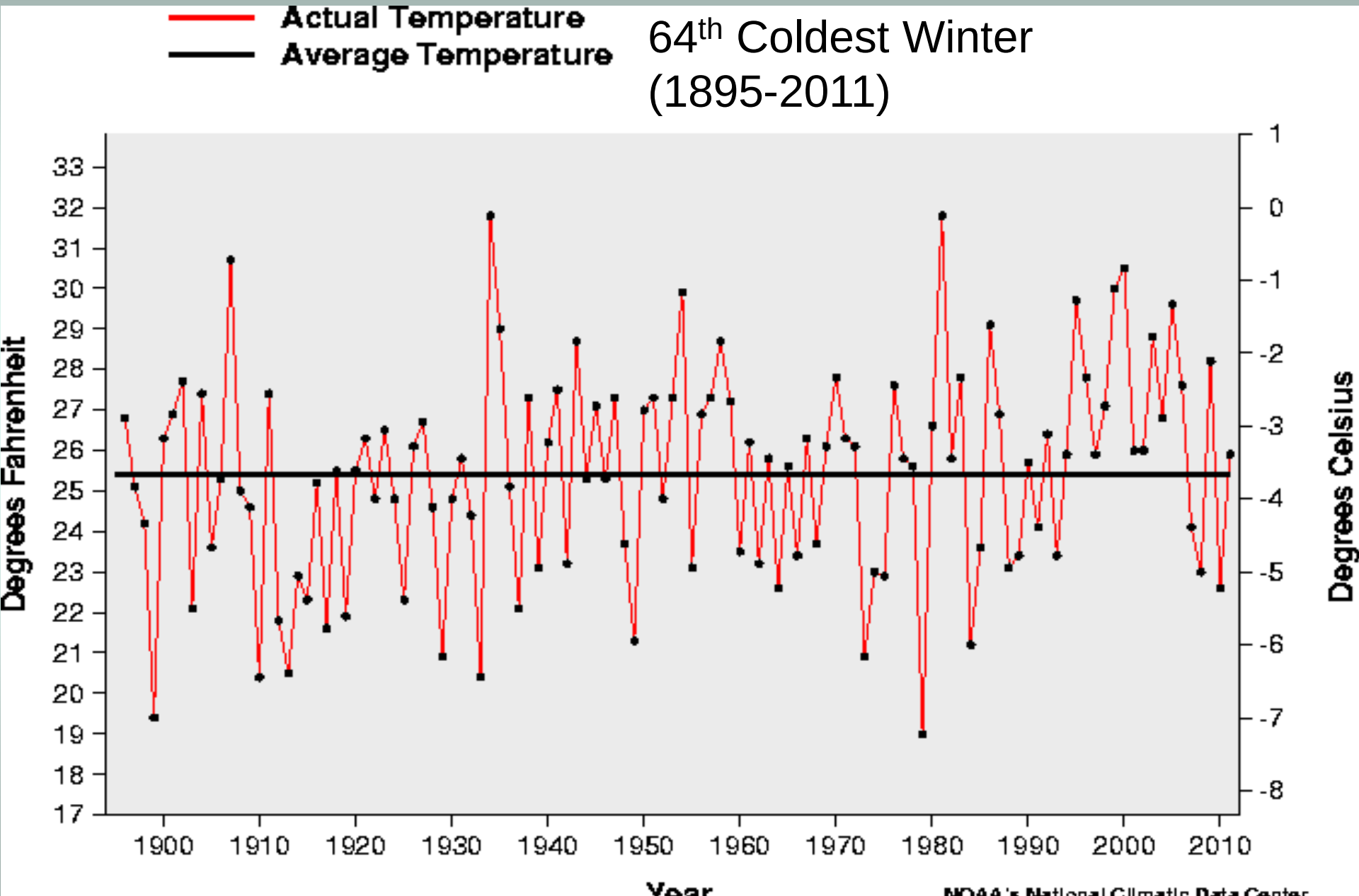

What are our climate data telling us about changes in climate in Colorado?

Confidently detecting climatic trends is much more challenging and difficult than determining spatial patterns, seasonal cycles, or year-to-year variations

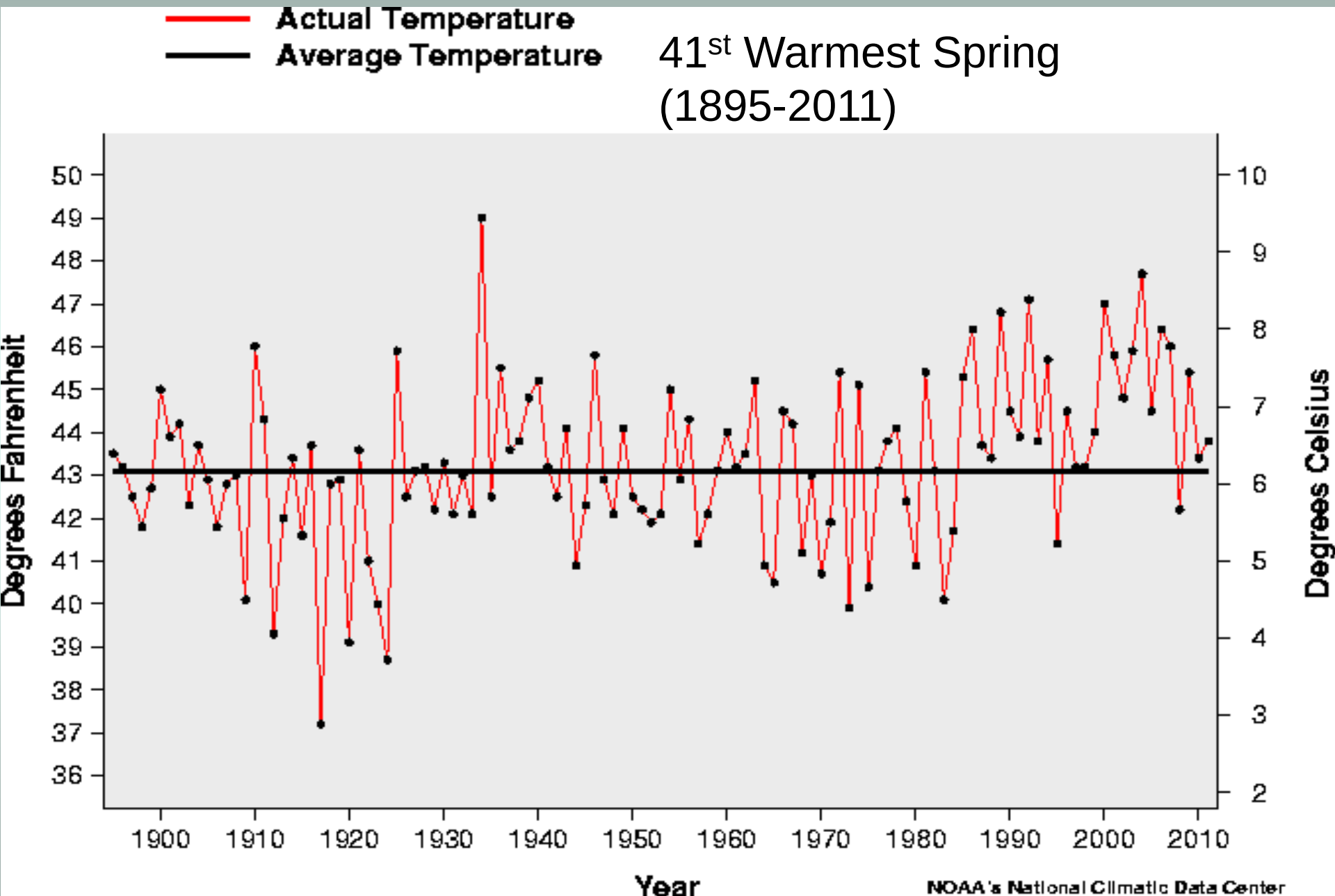
# Lack of historically consistent long-term climate data make it difficult to draw confident conclusions on climate trends in many areas



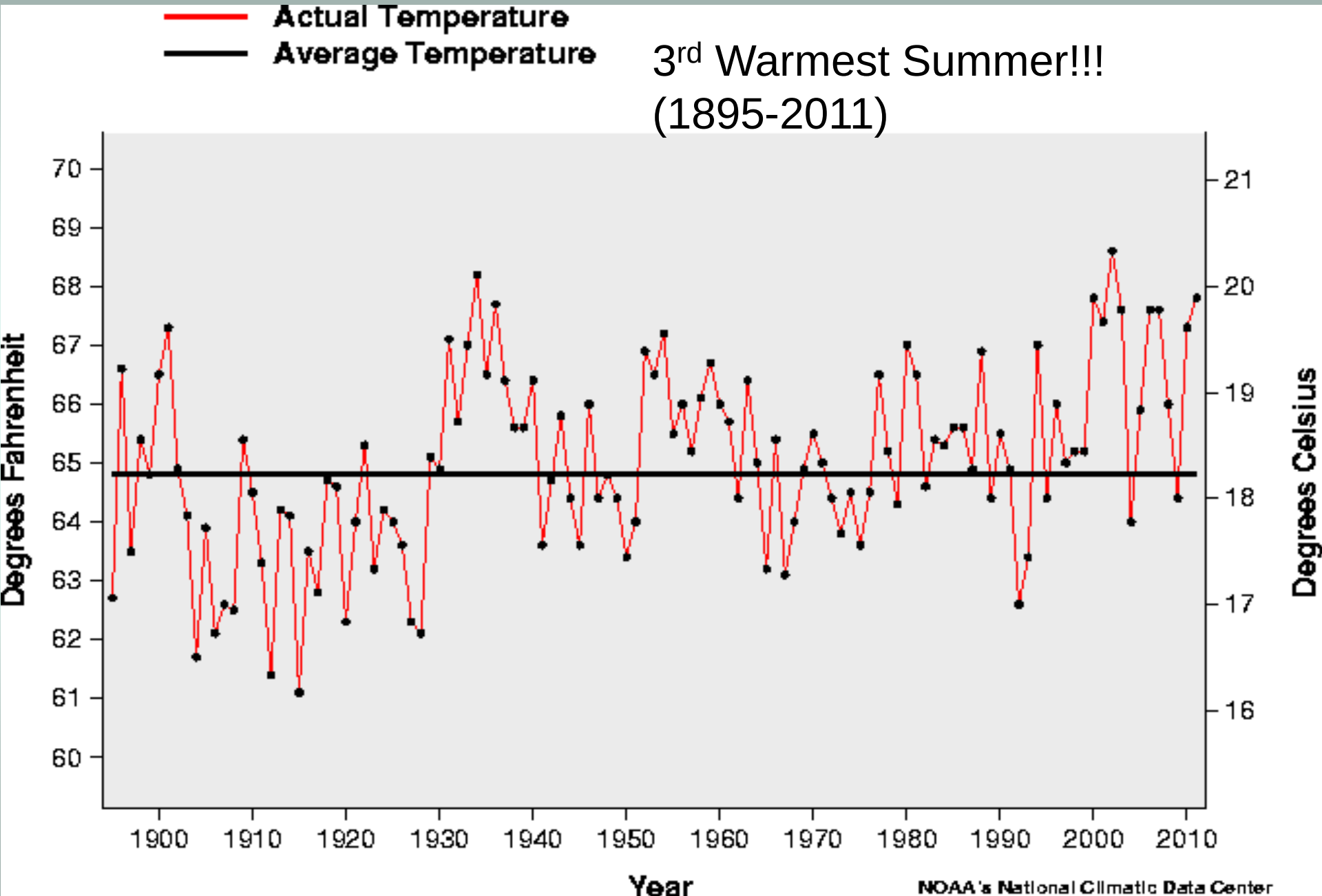
# Colorado Mean Winter (DJF) Temperatures



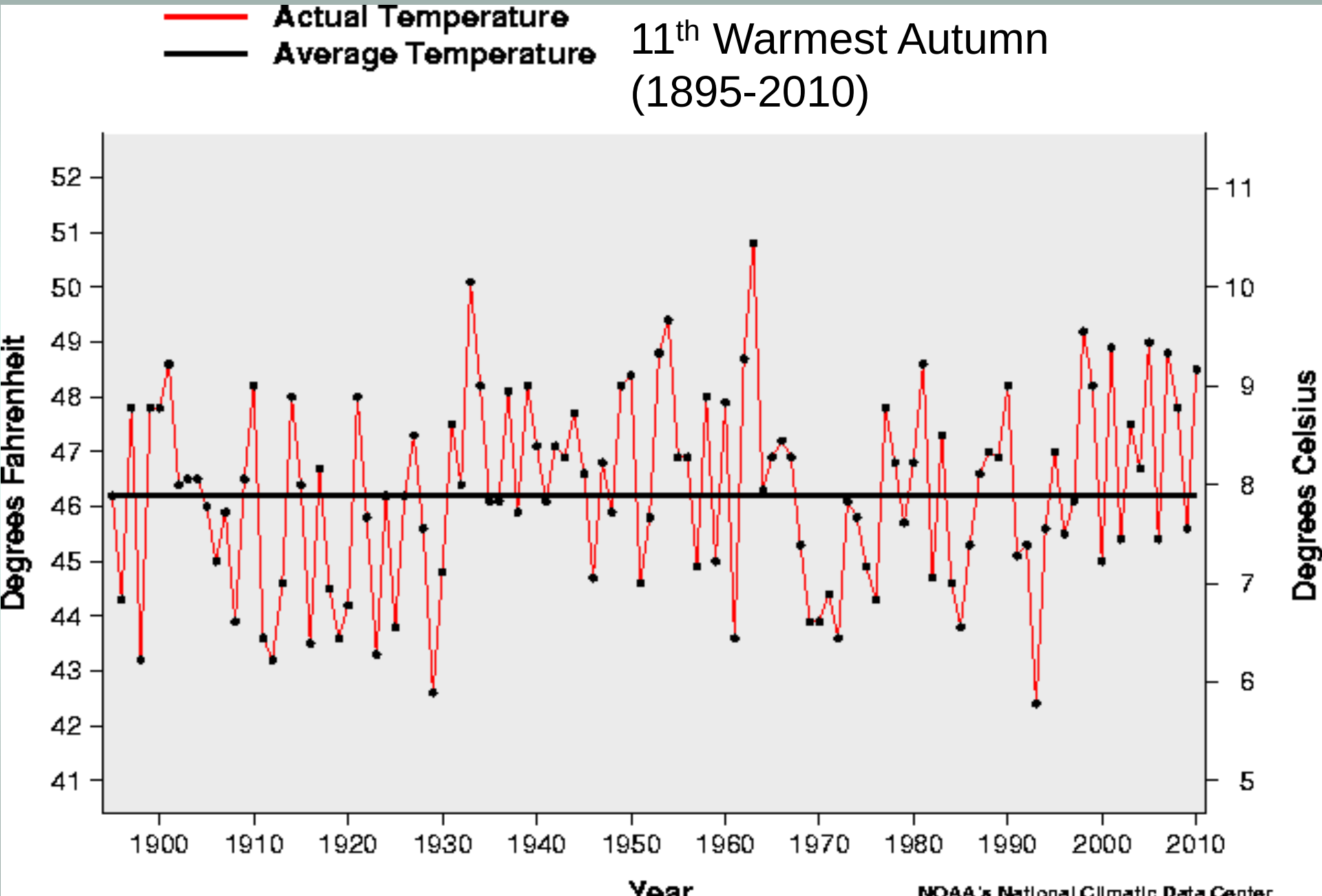
# Colorado Mean Spring (MAM) Temperatures



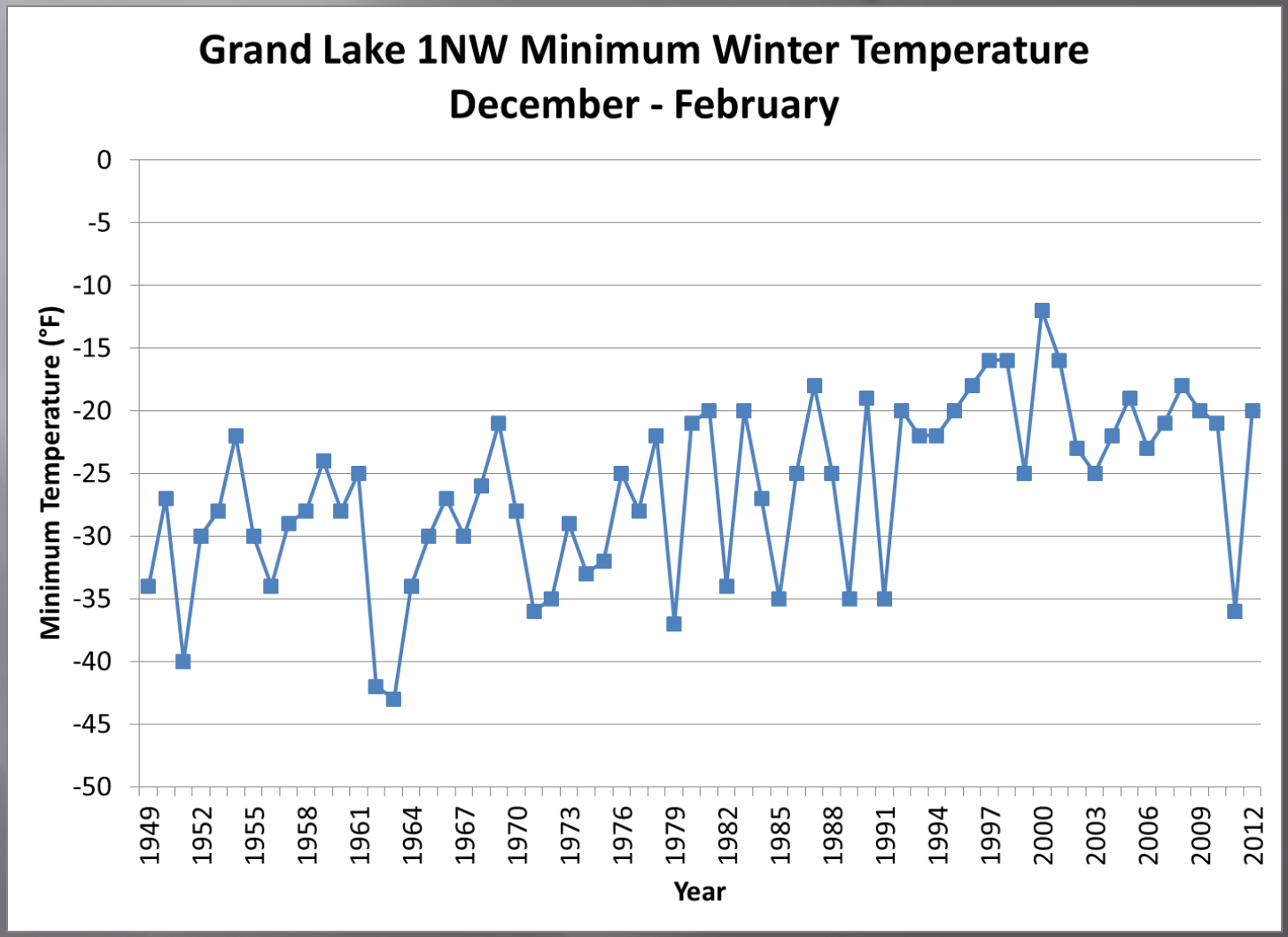
# Colorado Mean Summer (JJA) Temperatures



# Colorado Mean Autumn (SON) Temperatures

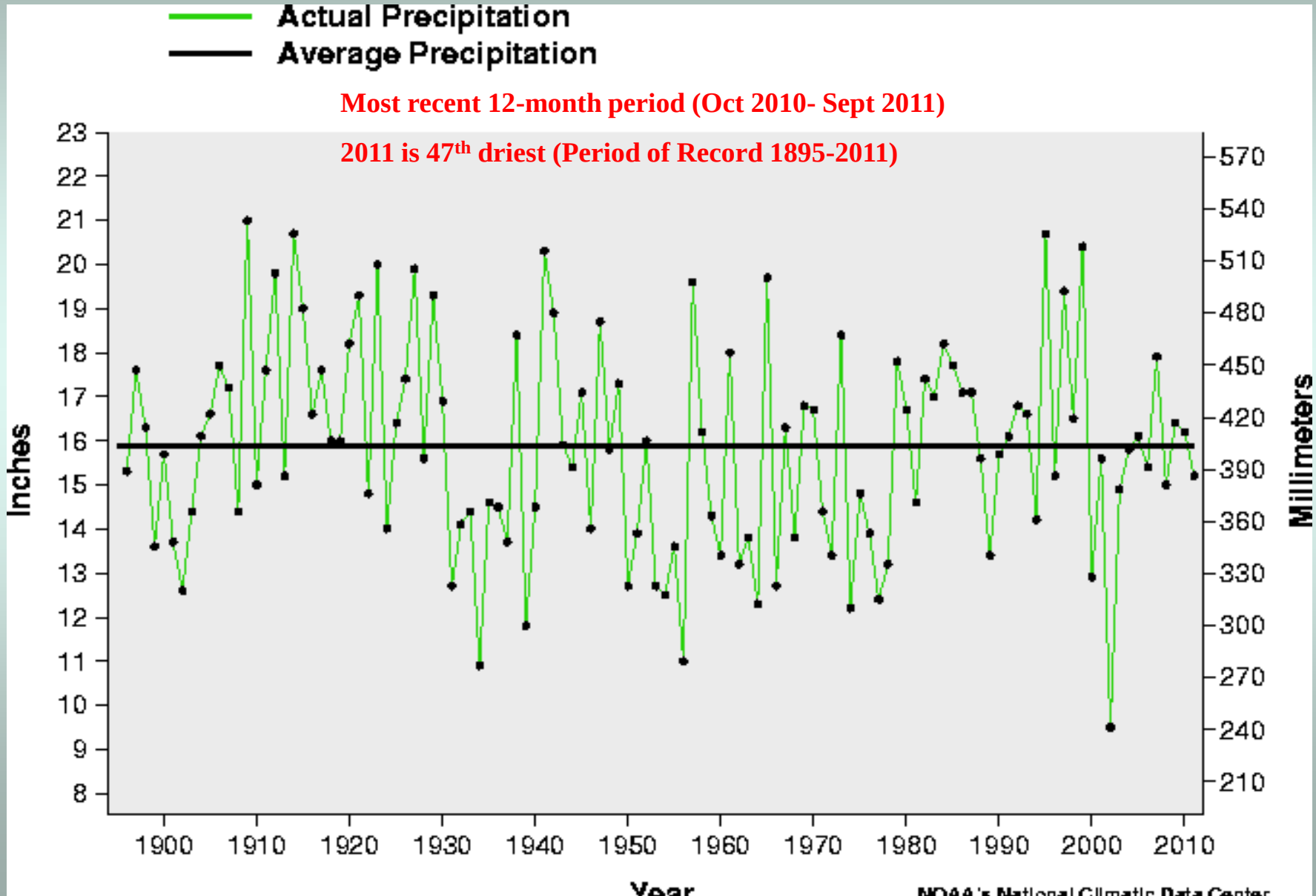


# A key feature of the past 20 years has been a general lack of extreme cold temperatures

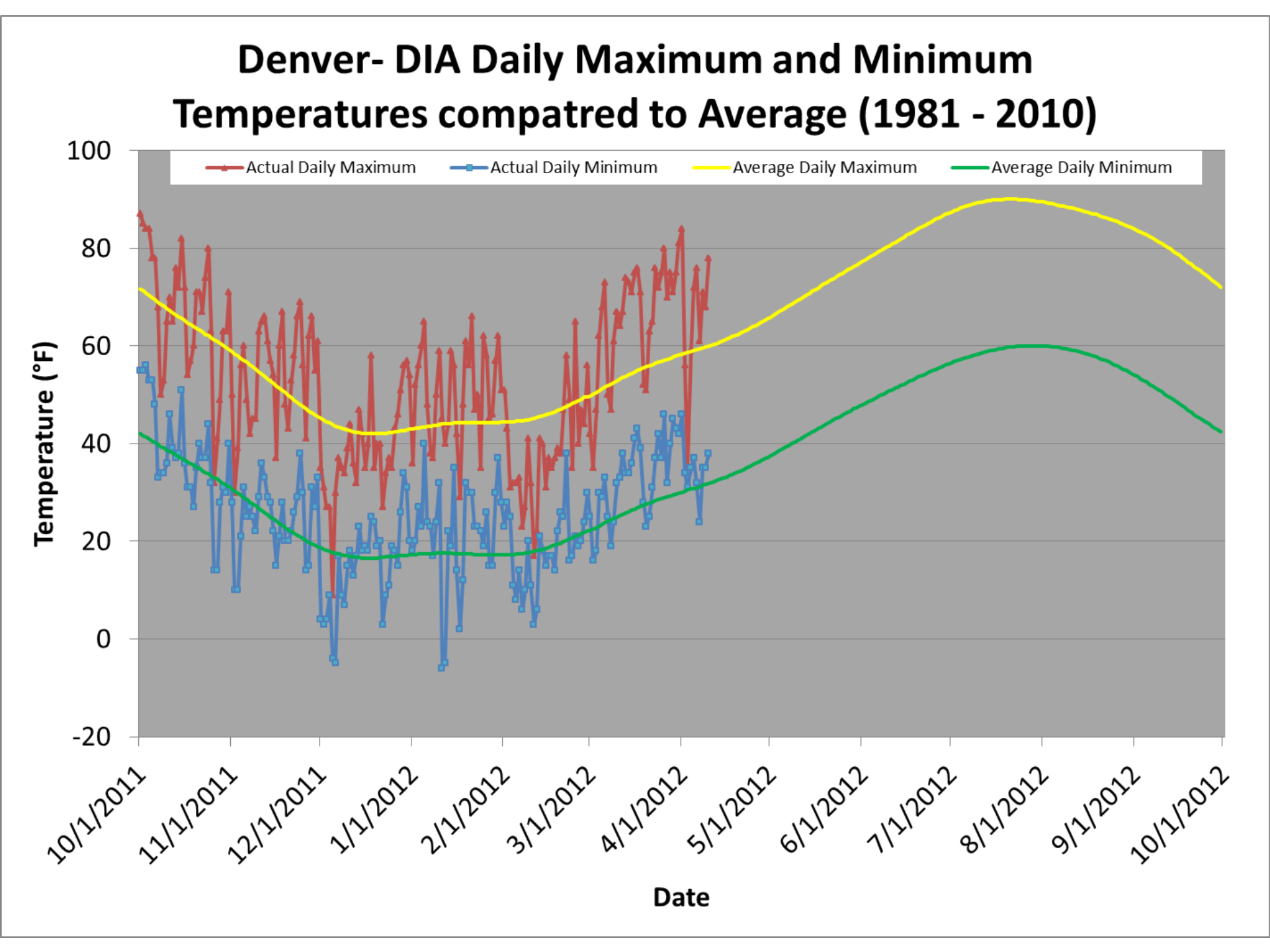


# Most locations in Colorado show a small to modest upward trend in temperatures

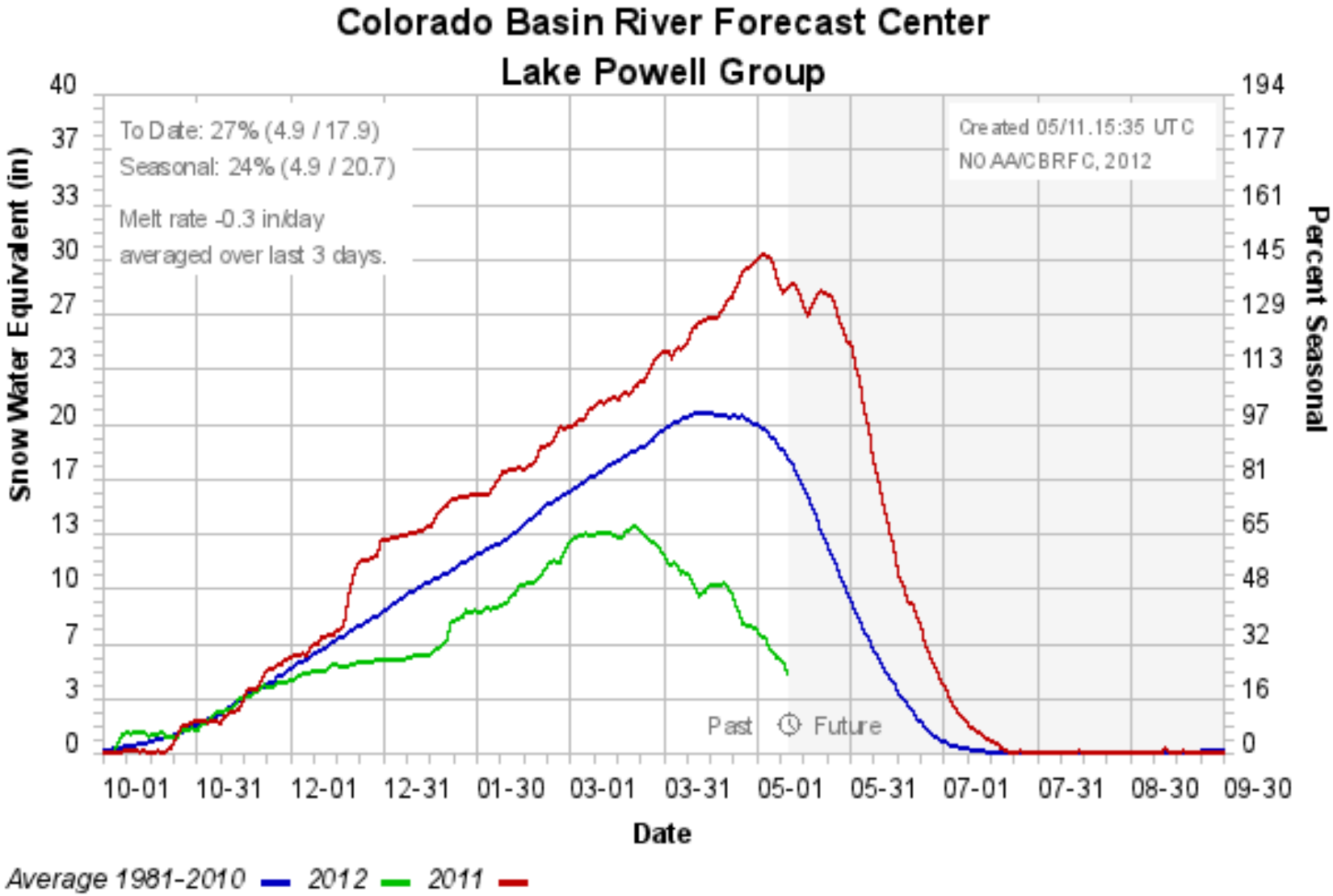
# Colorado Statewide Precipitation History
# Large Variations but no particular trends

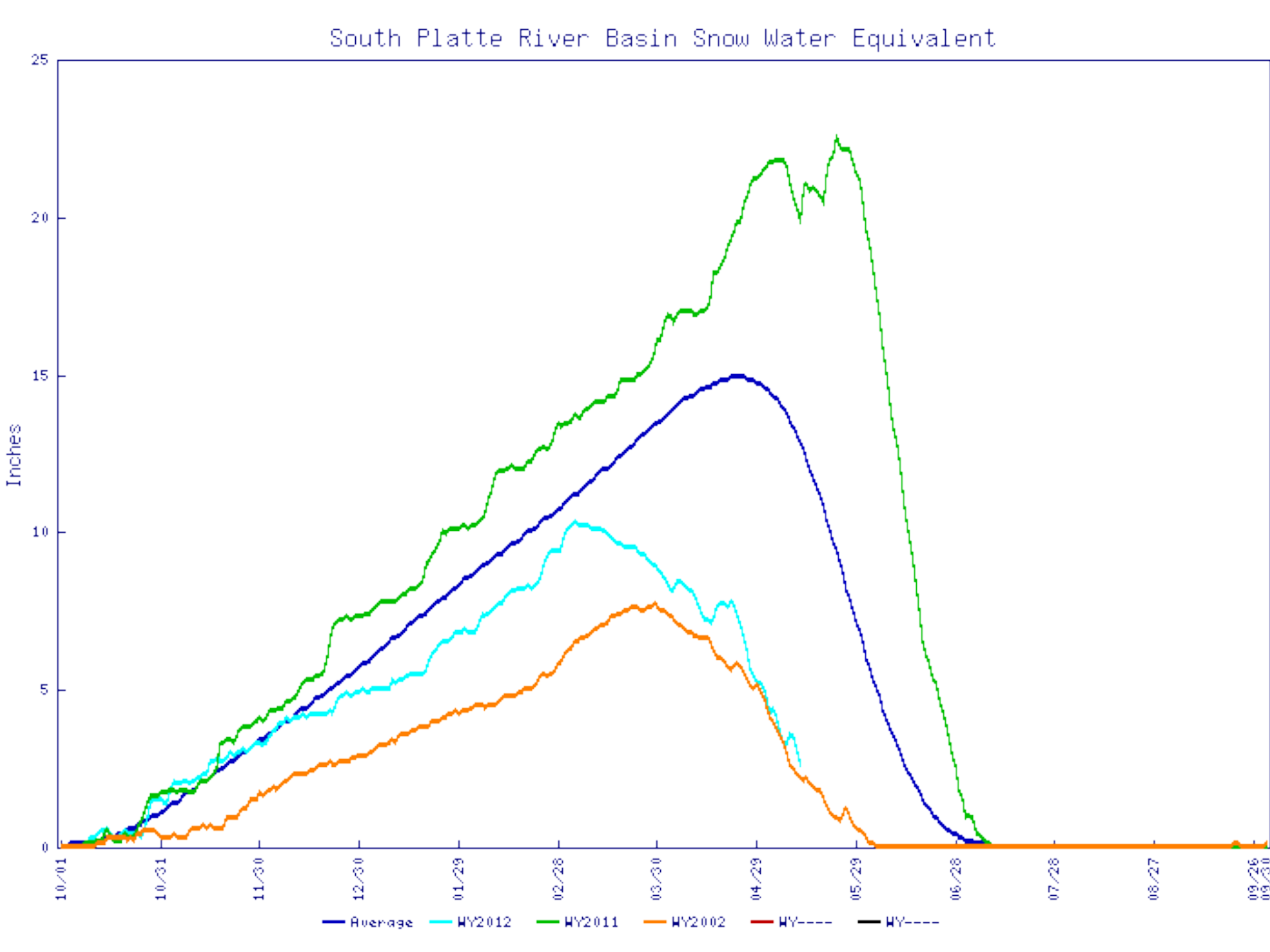


# So, what about this year?


Denver- DIA Daily Maximum and Minimum Temperatures compatred to Average (1981 - 2010)
Actual Daily Maximum
Actual Daily Minimum
Average Daily Maximum
Average Daily Minimum
Temperature (°F)
100
80
60
40
20
0
-20
10/1/2011
11/1/2011
12/1/2011
1/1/2012
2/1/2012
3/1/2012
4/1/2012
5/1/2012
6/1/2012
7/1/2012
8/1/2012
9/1/2012
10/1/2012
Date

# It will be interesting to see how our water supplies hold out with so little remaining snowpack




South Platte River Basin Snow Water Equivalent
Inches
25
20
15
10
5
0
10/01
10/31
11/30
12/30
01/29
02/28
03/30
04/29
05/29
06/28
07/28
08/27
09/26
09/30
Average
WY2012
WY2011
WY2002
WY----
WY----


**www.water2012.org**

# Did you know??  It's a special year here

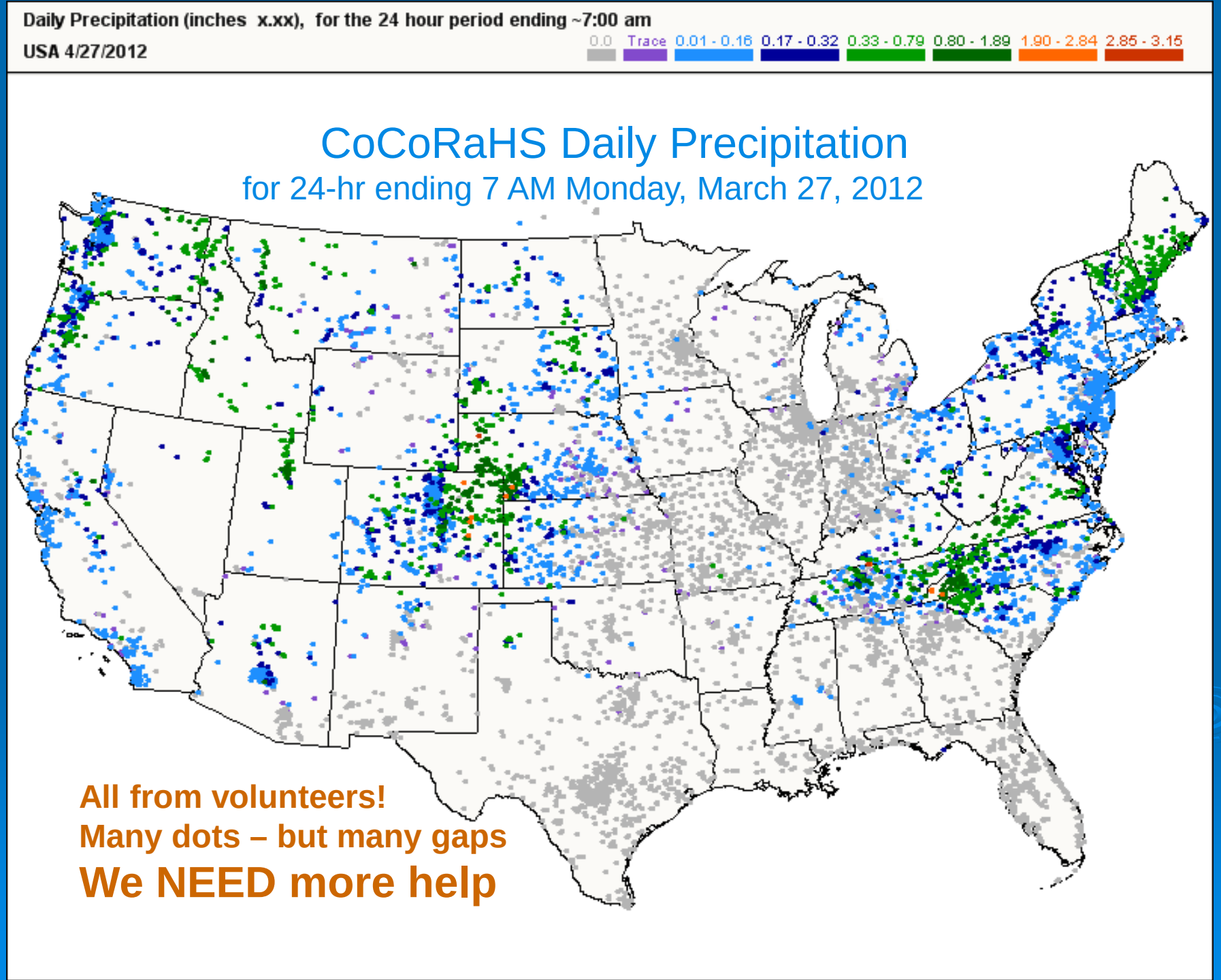
# 2012 Water Celebration

- Please participate in Water 2012 Activities!

- As a part of this statewide "2012 -- Year of Water" celebration, we are encouraging schools, families, individuals – and people like you in Colorado to help us measure and track precipitation.  Because "the weather is our source of water"

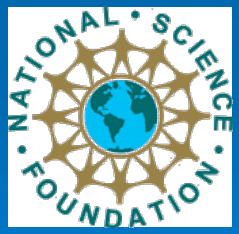
# We are encouraging citizens across the State and Nation to help us measure local precipitation

Photos by H. Reges


Daily Precipitation (inches x.xx), for the 24 hour period ending ~7:00 am
USA 4/27/2012
0.0 Trace 0.01 - 0.16 0.17 - 0.32 0.33 - 0.79 0.80 - 1.89 1.90 - 2.84 2.85 - 3.15
CoCoRaHS Daily Precipitation
for 24-hr ending 7 AM Monday, March 27, 2012
All from volunteers!
Many dots – but many gaps
We NEED more help

# For information and to volunteer, visit the CoCoRaHS Web Site


**http://www.cocorahs.org**





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

# Colorado Climate Center

Data and Power Point Presentations available for downloading

http://ccc.atmos.colostate.edu

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Colorado State University
*Knowledge to Go Places*

COLORADO CLIMATE CENTER