# What Recent Colorado Climate Records are Telling Us About Weather Trends

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Presented at 2007 Colorado Water Congress Annual Convention,
Denver, Colorado, Thursday, January 25, 2007

Prepared by Odie Bliss, Wendy Ryan and Daniel Denison

Colorado State University
*Knowledge to Go Places*

Colorado Climate Center

# Systematic weather data collection began in the South Platte Basin and in other parts of Colorado in the early 1870s

(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 ~~attached~~ Thermometers Attached Cistern | | Reduced Barometer. | THERMOMETER. (OPEN AIR.) Highest Dry Bulb. | Highest Wet Bulb. | Highest Wet Bulb. | Direction of wind. | Velocity of wind ~~in miles per hour.~~ miles per hour. Daily | 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. | Left registering Barometer. Max. Min. | REMARKS. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 5.43 a.m. | 25.00 | 37 | 22 | 30.07 | 22 | 21 | 86 | calm | 0 | 0 | 4/4 | | | Hum | Blank | | Light Snow |
| | 2.43 P.m. | 25.09 | 63 | 36 | 29.97 | 36 | 30 | 46 | S. | 2 | .02 | 0 | | | | | | Clear |
| Sunday Nov. 19 | 9.43 P.m. | 25.12 | 58 | 14 | 30.28 | 14 | 12 | 64 | S | 11 | .60 | 0 | | | | | | Clear |
| | 5.43 a.m. | 25.00 | 37 | 22 | 30.07 | 22 | 21 | 86 | calm | 0 | 0 | 4/4 | | — a.m. | 8 a.m. | Blanks | | Light Snow |
| | 2.43 P.m. | 25.09 | 63 | 36 | 29.97 | 36 | 30 | 46 | S | 2 | .02 | 0 | 72 | | | | | Clear |
| Monday Nov. 20 | 9.43 P.m. | 25.12 | 58 | 14 | 30.28 | 14 | 12 | 64 | S | 11 | .60 | 0 | | | | | | Clear |
| | 5.43 a.m. | 24.99 | 50 | 21 | 30.07 | 21 | 19.5 | 78 | S | 13 | .84 | 1/4 | 24 | | | | | Stratus |
| | 2.43 P.m. | 24.88 | 56 | 43 | 29.67 | 43 | 34 | 28 | NW | 10 | 1.62 | 4/4 | 103 | | | | | Stratus |
| Tuesday Nov. 21 | 9.43 P.m. | 24.88 | 58 | 39 | 29.70 | 39 | 34 | 53 | NW | 2 | .02 | 4/4 | 34.3 | | | | | Stratus |
| | 5.43 a.m. | 24.70 | 55 | 31 | 29.59 | 31 | 29 | 79 | S.W. | 4 | .08 | 4/4 | 97 | | | | | Stratus |
| | 2.43 P.m. | 24.57 | 62 | 35 | 29.30 | 35 | 32 | 70 | W | 2 | .02 | 4/4 | 32.3 | 3 P.m. | | | | " |
| Wednesday Nov. 22 | 9.43 P.m. | 24.71 | 61 | 31 | 29.59 | 31 | 30 | 89 | S | 10 | .50 | 4/4 | 90 | | 11 P.m. | .26 | | Light Snow |
| | 5.43 a.m. | 24.54 | 55 | 25 | 29.47 | 25 | 24 | 87 | S | 6 | .18 | 4/4 | 30 | 10.30 a.m. | | | | Stratus |
| | 2.43 P.m. | 24.31 | 63 | 34 | 29.06 | 34 | 33 | 89 | N.W. | 5 | .12 | 4/4 | | | | | | Lt Snow |
| Thursday Nov. 23 | 9.43 P.m. | 24.20 | 60 | 31 | 28.97 | 31 | 30 | 89 | S | 9 | .40 | 3/4 | S.E. | | | | | " " |
| | 5.43 a.m. | 24.36 | 56 | 32 | 29.17 | 32 | 32 | 100 | S.W. | 4 | .08 | 4/4 | 101 | | 8 a.m. | .21 | | Cloudy |
| | 2.43 P.m. | 24.37 | 70 | 42 | 29.04 | 42 | 37 | 58 | [illegible] | 2 | .02 | 2/4 | 33.7 | | | | | Cirrus & Cumu |
| Friday Nov. 24 | 9.43 P.m. | 24.38 | 65 | 27 | 29.23 | 27 | 27 | 100 | N.W. | 2 | .02 | 4/4 | | | | | | Fog |
| | 5.43 a.m. | 24.37 | 58 | 32 | 29.17 | 32 | 28 | 64 | SW | 7 | .24 | 1/4 | 98 | | | | | Stratus |
| | 2.43 P.m. | 24.42 | 70 | 49 | 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 | 17 | 29.60 | 17 | 15.5 | 75 | N.E. | 18 | 1.62 | 3/4 | | | | | | Light scud fr |

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**Denver November 19-25, 1871**

Henry Fenlon Observer

In the 1880s the Colorado legislature approved and funded the *"Colorado Meteorological Association"* to better monitor and document the climatic resources of our young state.

# BULLETIN

OF THE

# Colorado Meteorological Association.

## 3.

JUNE, 1886.

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Weather records extending through the month of June have been received from nineteen stations, the positions of which will be found upon the hectographed sketch accompanying the bulletin for May. They include all stations whence statistics for that bulletin were derived, with the exception of the ranch near Sanborn, where observations had to be suspended on June 16th. The new stations with their altitudes and the names of observers are as follows:

| | | |
|---|---|---|
| Hugo ..... .. | 5068 | I. B. Perkins, M. D. |
| Idaho Springs ..... | 7500 | Ignatius Zeller. |
| Pandora ..... | 8700 | C. Laforgue. |

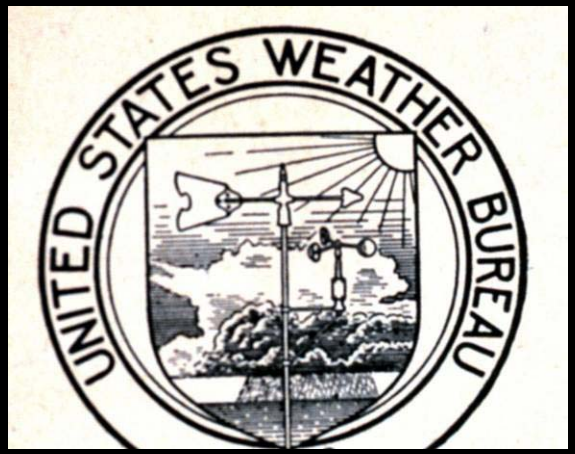
### THE WEATHER OF JUNE, 1886.

The weather of the month may be described under three periods, the first extending from June 1st to 9th, the second including the week from the 10th to the 16th inclusive, and the third comprising the remainder of the month. During the first period, there was first a barometric rise lasting from two to four days at different stations, then a decline of no great magnitude, and finally a rise to a second maximum which terminated the period. The weather was in general cool, and showers were frequent. The first and second days were dates of the most important rainfall of the month, which appears to have been confined to the eastern slope of the continental divide.

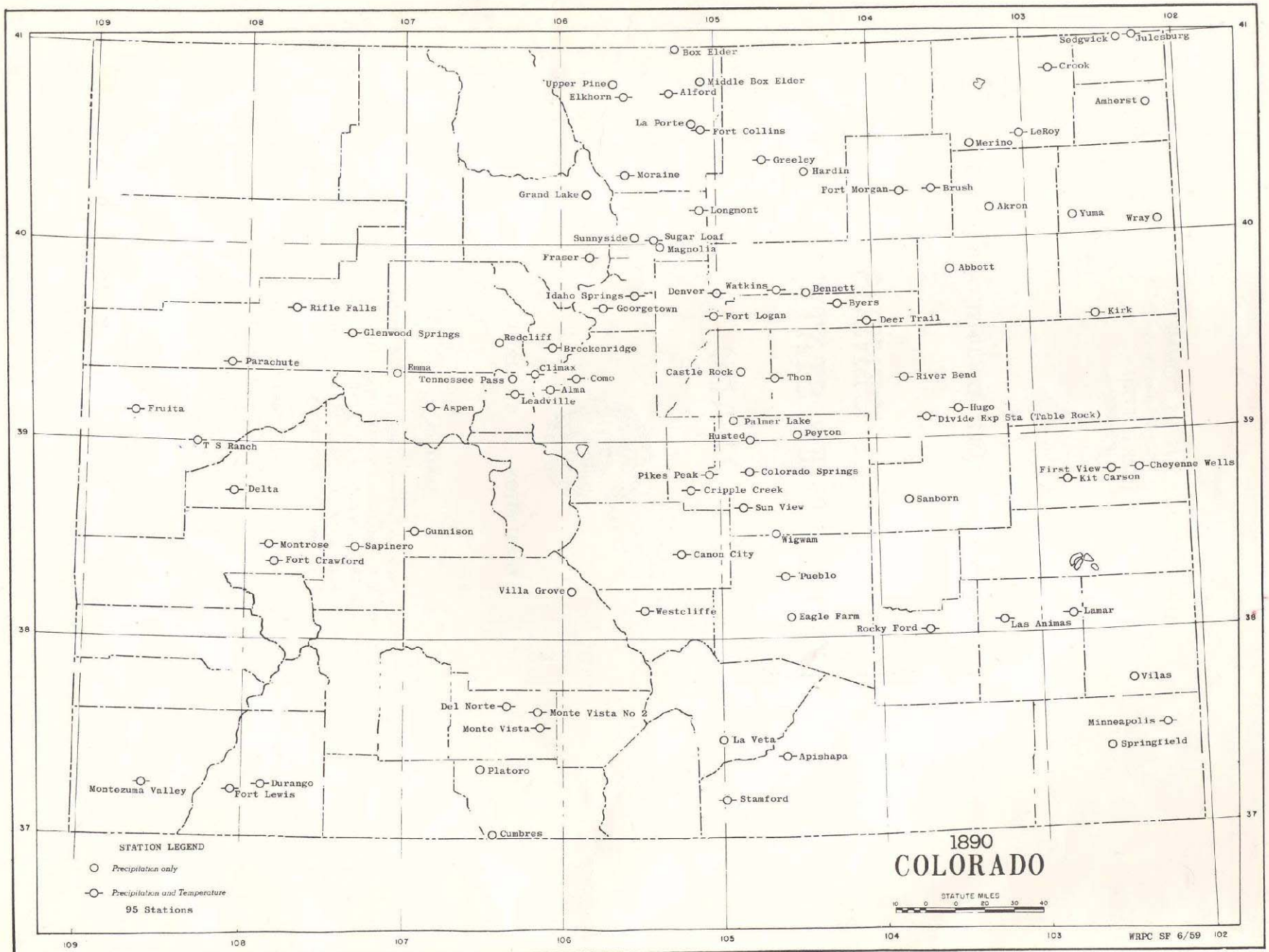
During the second period the barometer descended to the monthly minimum on the 12th, and rose during the four days following. There was no rainfall reported from the western slope, and only local and moderate showers on the eastern side. The 13th and adjacent days were remarkably clear. The temperature of the week was high, declining near the close.

The weather of the third period was quite local in character. The oscillations of the barometer were slight, the lowest daily mean, on the 24th, being generally higher by more than two tenths of an inch than that of the 12th. The precipitation was all or almost all in the form of thunder-showers of small area. Some of these, in the north and northeast of the state were accompanied by violent hail, doing damage to crops which was then estimated to reach a quarter of a million dollars. The temperature was moderate at the beginning of the period, but exhibited a decided increase toward the end of the month.

In 1890 the USDA took over the responsibilities of climate monitoring on a national level, and the first civilian weather service was formed –
the U.S. Weather Bureau



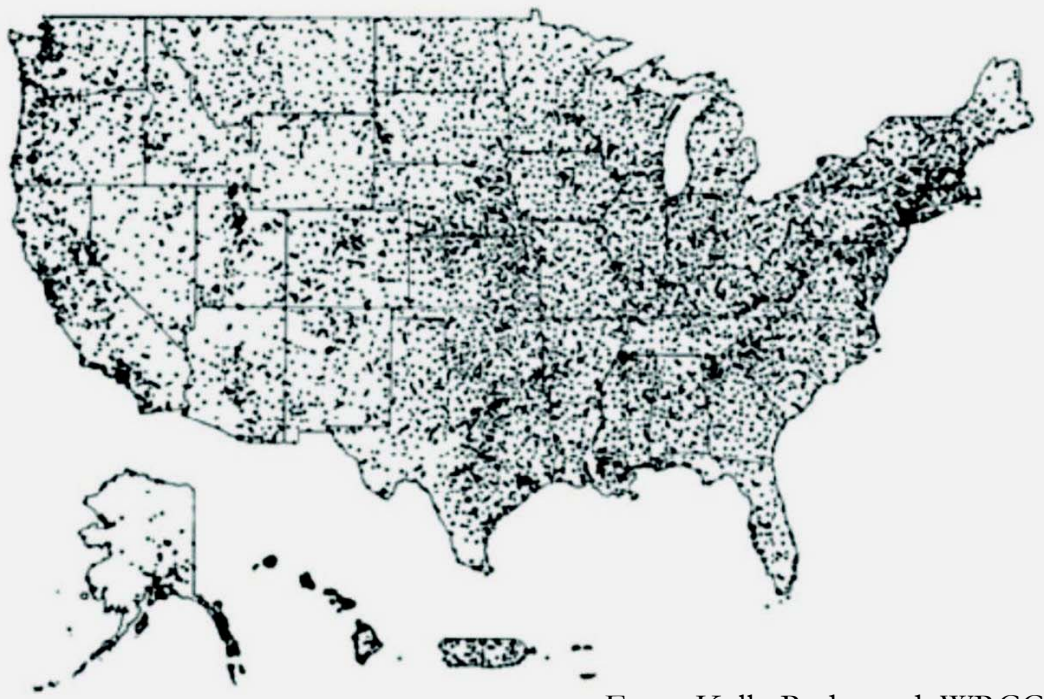
# Colorado Weather Stations in 1890



Since then, the U.S. Weather Bureau/National Weather Service has faithfully maintained an oft taken for granted network of weather stations in Colorado and across the country – the Cooperative Observer Network

Photo by Christopher Davey

# The NWS stations remain the backbone network for long-term climate monitoring



From Kelly Redmond, WRCC

**Approximately 5000 daily max/min temperature stations, 8000 daily precipitation stations, 3000 automated hourly precipitation stations.**

# In recent years, many other organizations have gotten involved in weather measurements

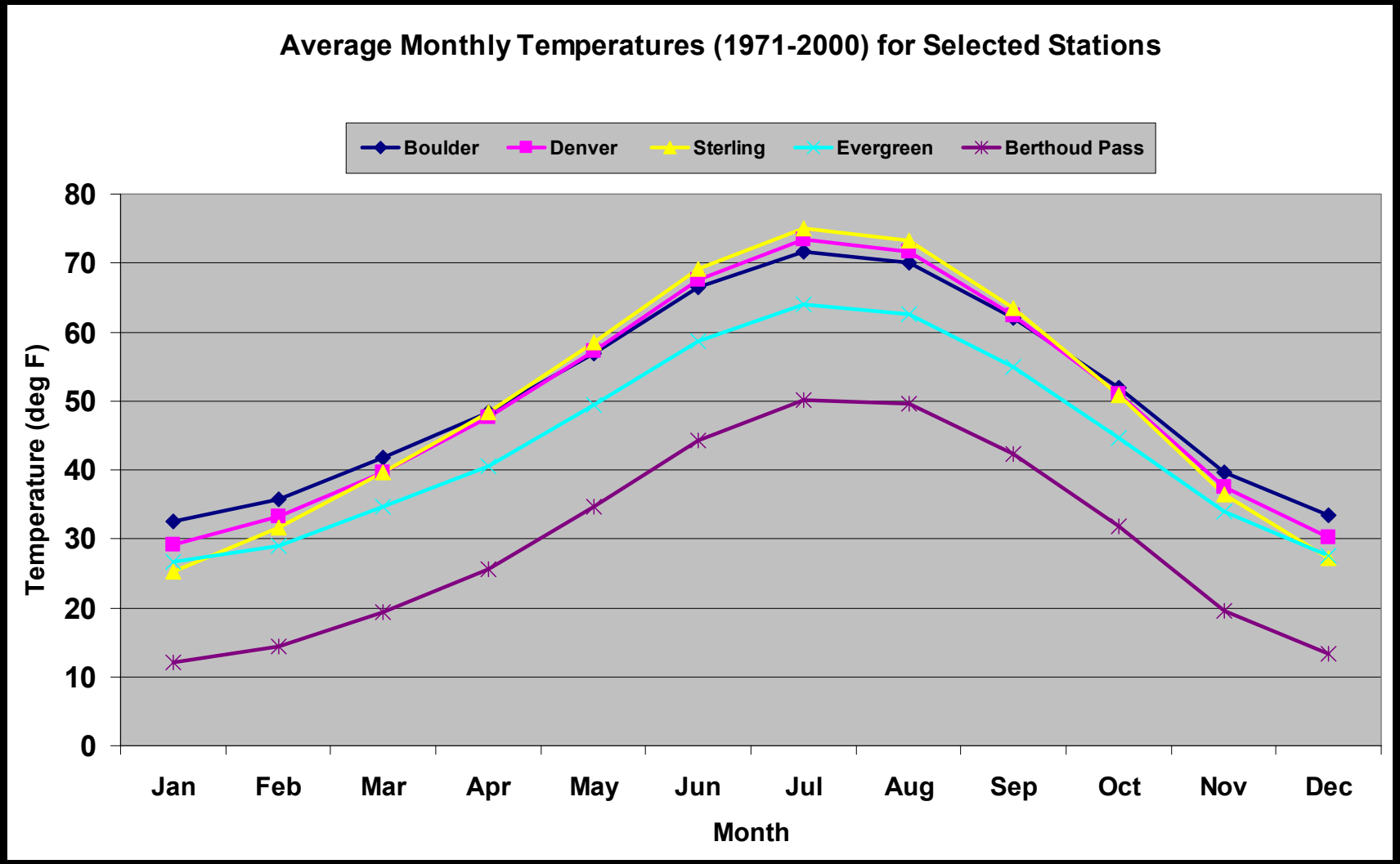




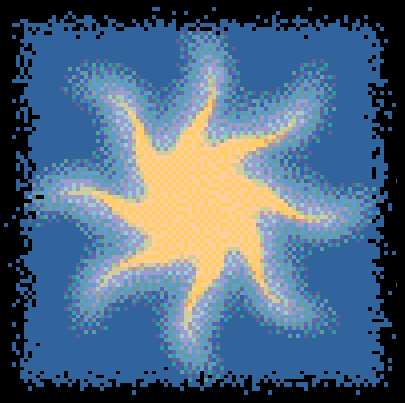


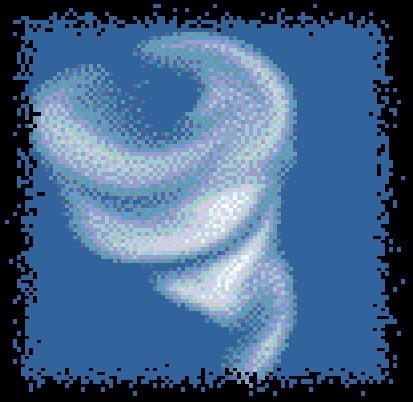
What have we learned from
nearly 120 years of continuous
climate monitoring?

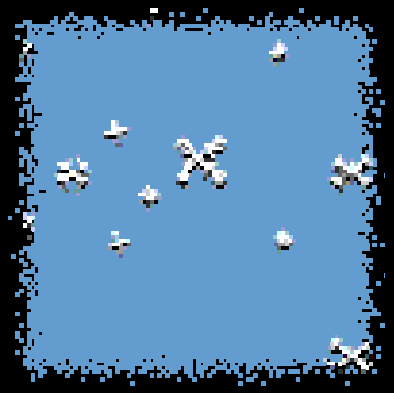
# Winters are consistently colder than summers – ☺

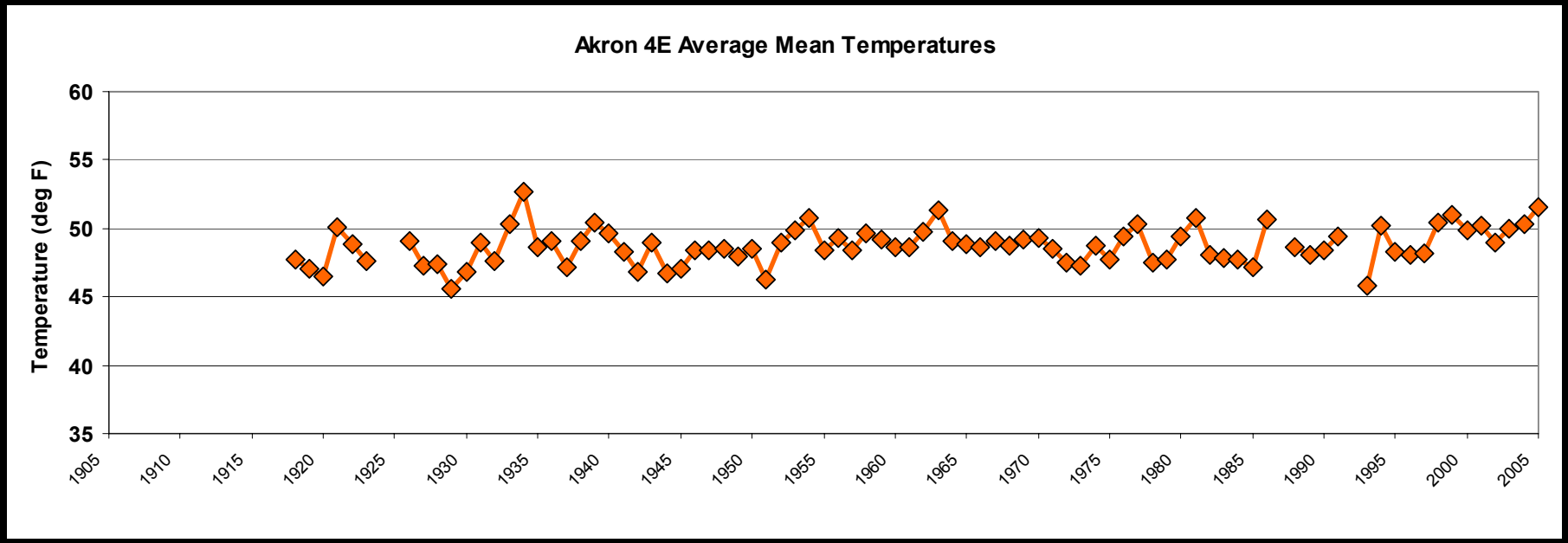


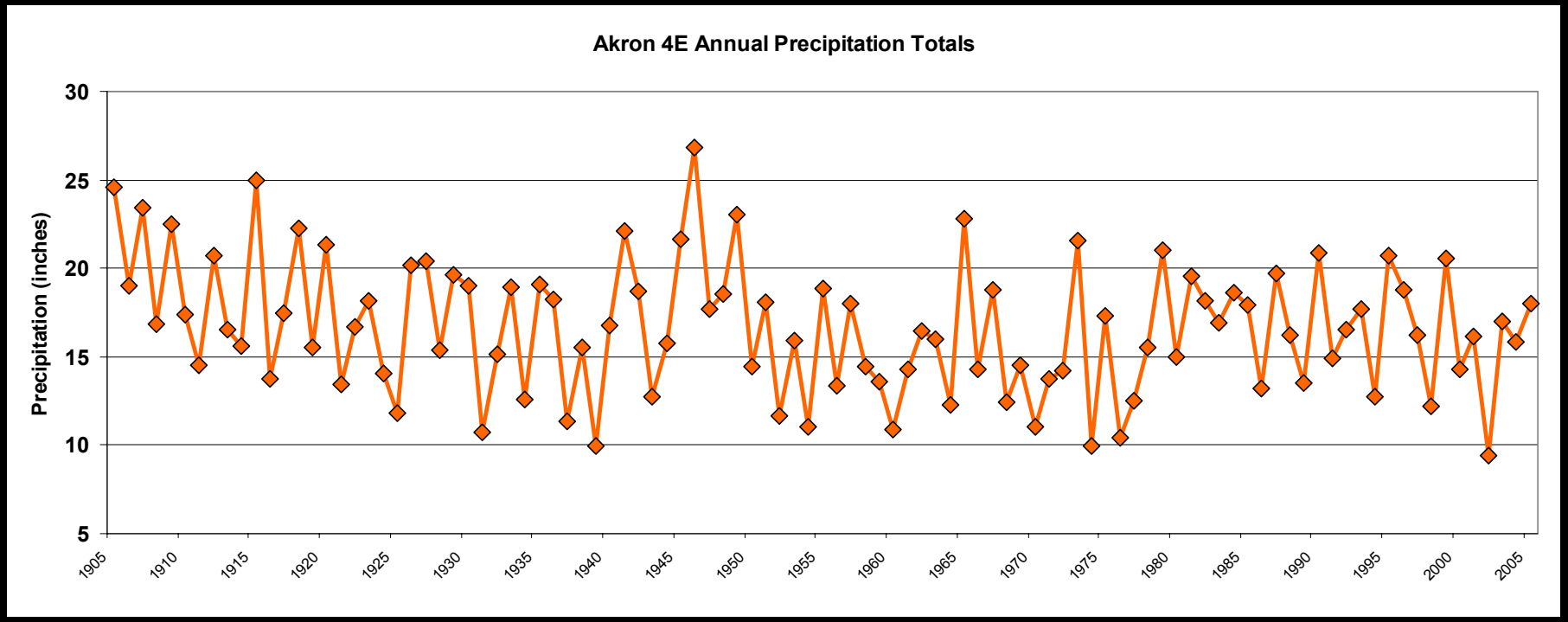
Temperatures are far more stable than precipitation.  In fact most other climatic elements (humidity, wind, sunshine and cloudiness, evaporation, etc.) are much more consistent from one year to the next than precipitation.



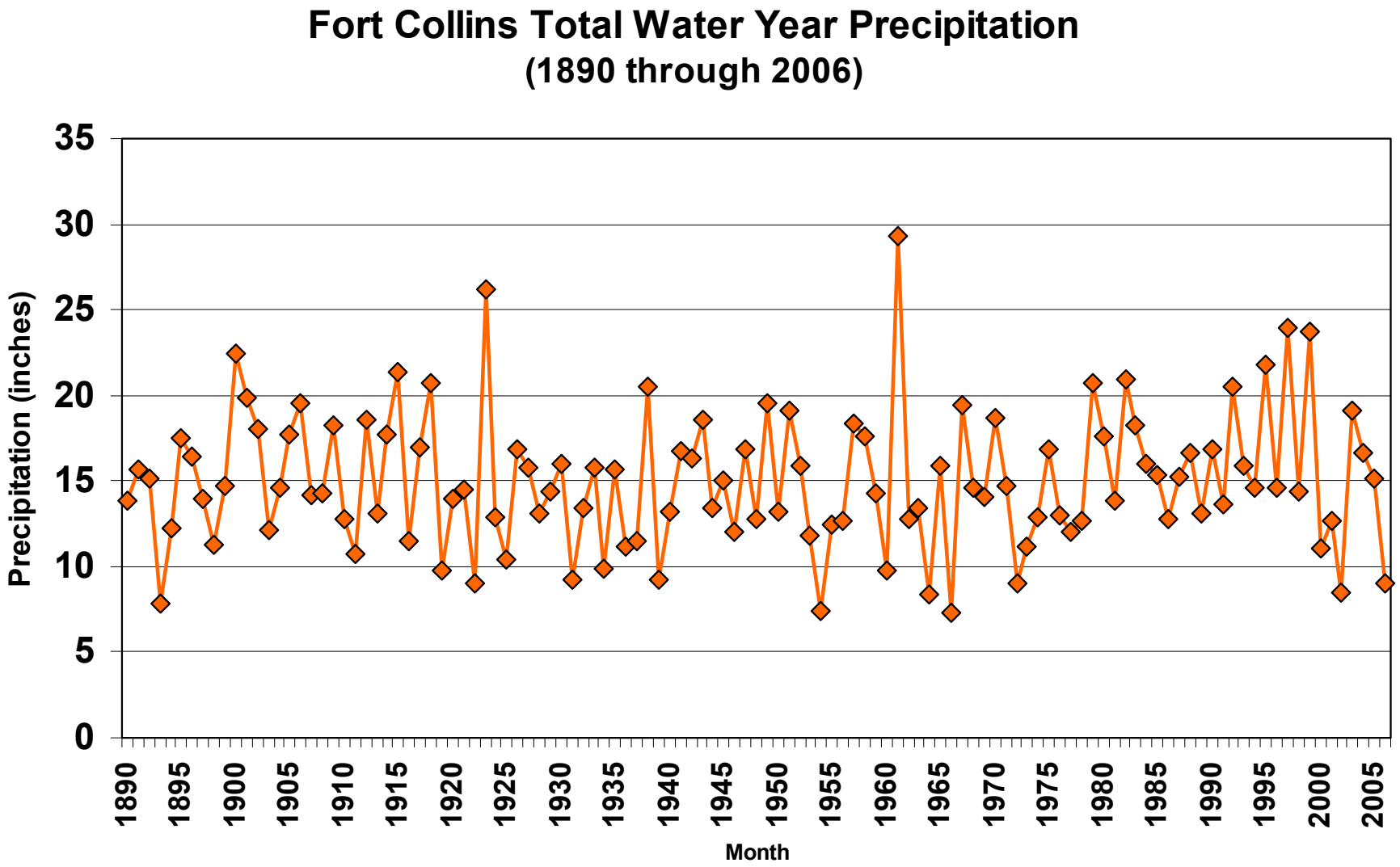





Akron 4E Average Mean Temperatures
Temperature (deg F)
60
55
50
45
40
35
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005


Akron 4E Annual Precipitation Totals
Precipitation (inches)
30
25
20
15
10
5
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005

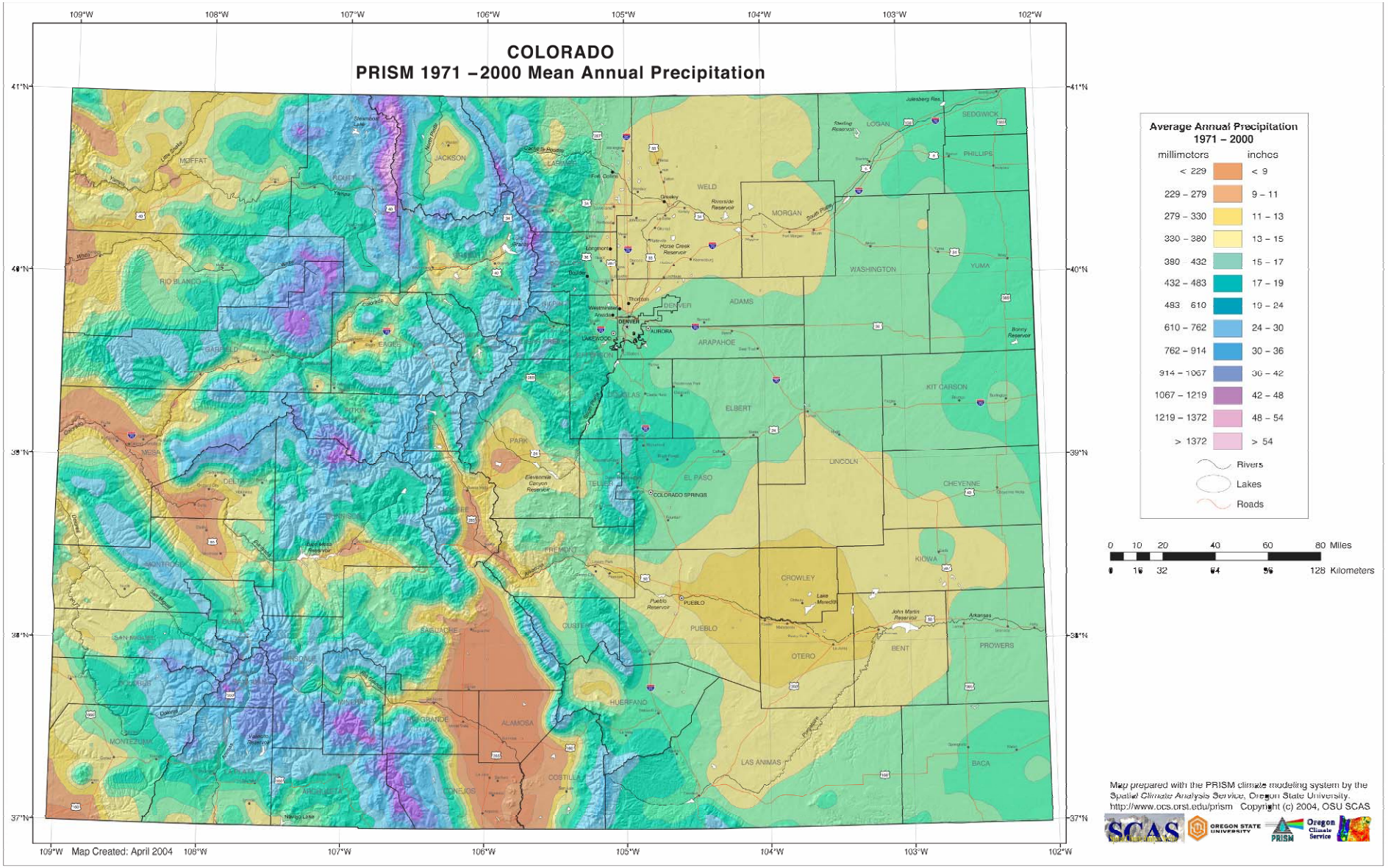
# Precipitation varies by as much as 400% from a very dry year to a very wet year



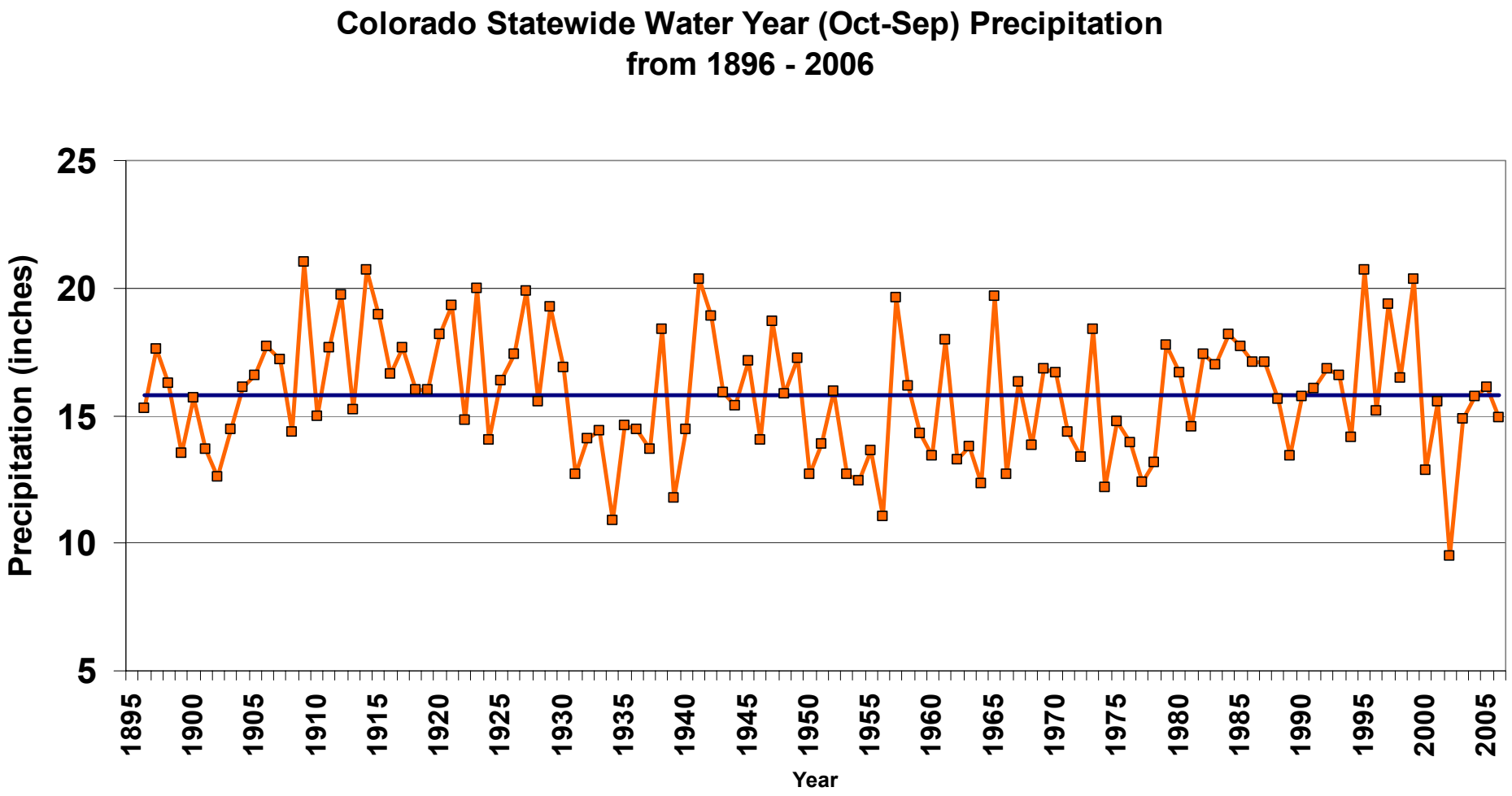
# Drought Visits Our Area Regularly

Photo by NRCS

# Colorado Average Annual Precipitation map



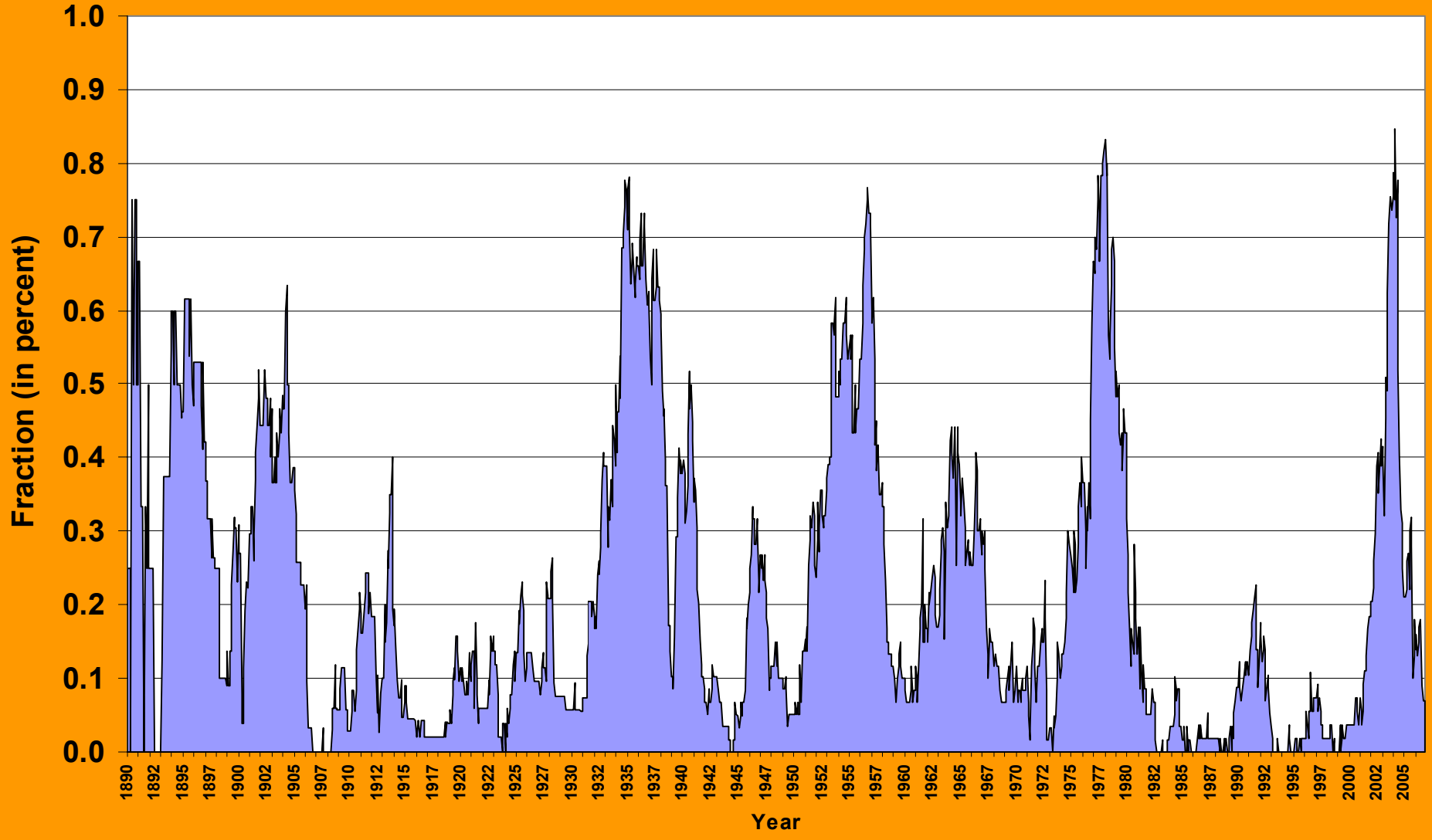
# Colorado Statewide Water Year Precipitation



# Fraction of Colorado in Drought

## Based on 48 month SPI

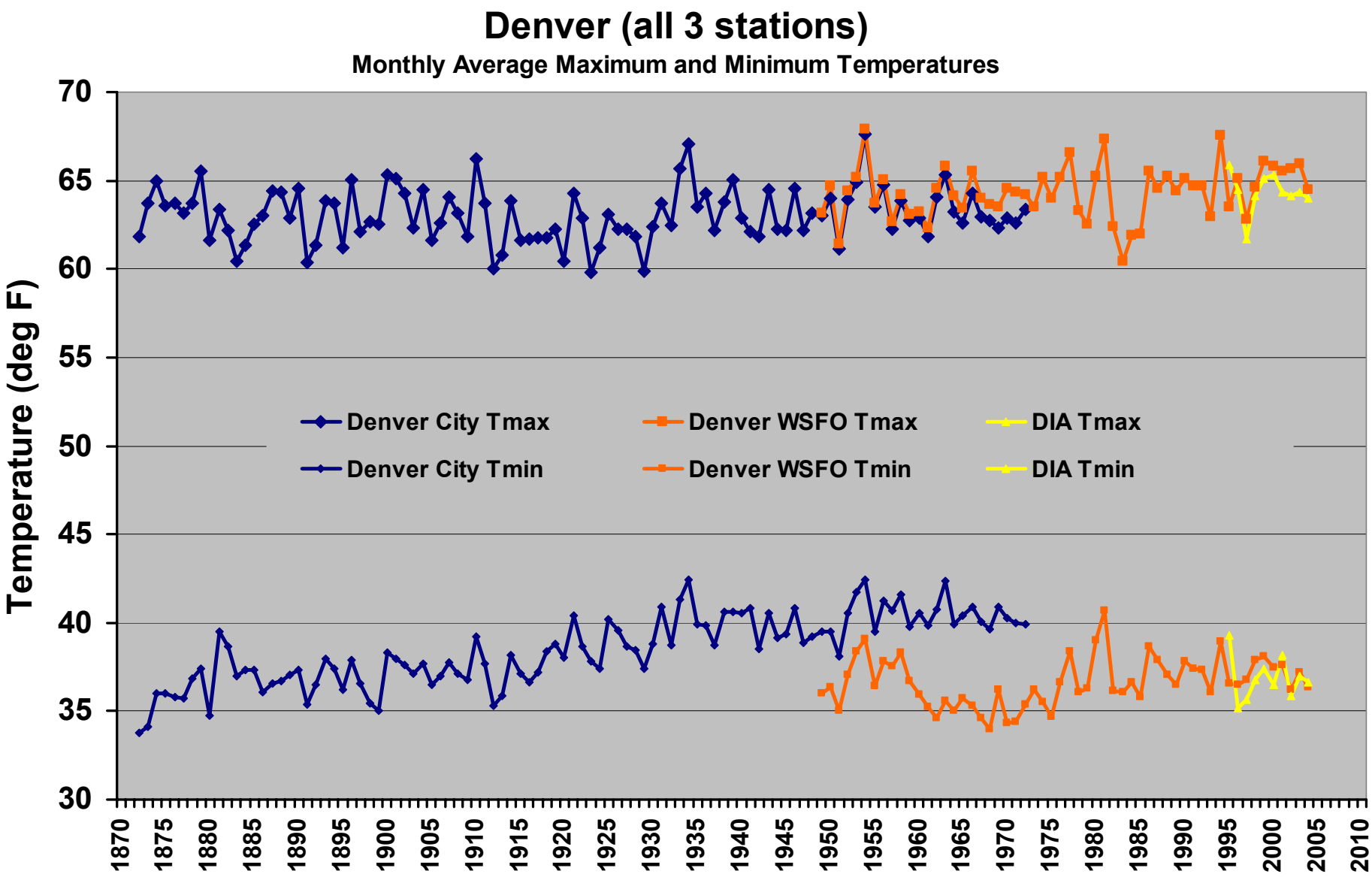
(1890 - Nov 2006)



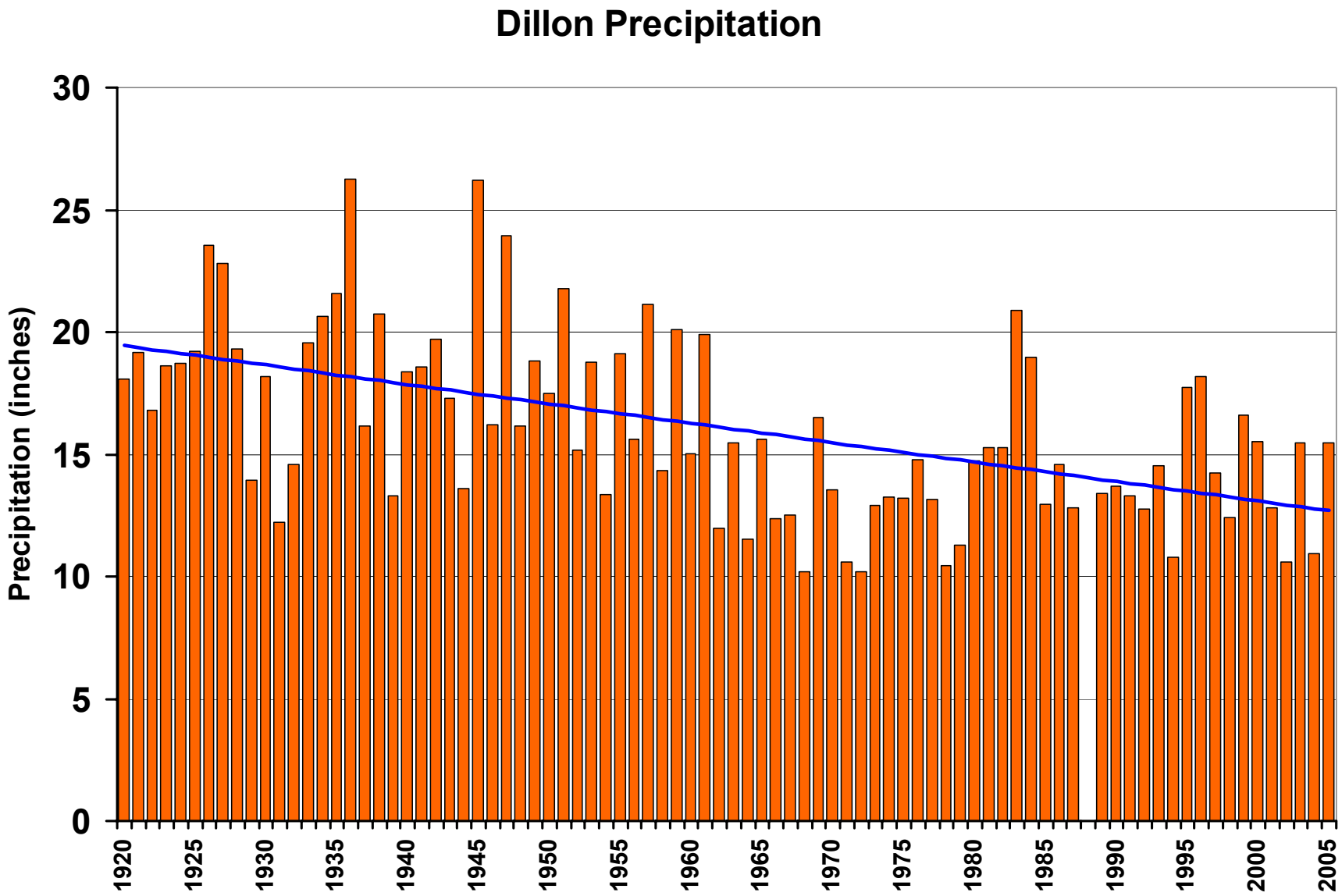
Confidently detecting climatic trends is much more challenging and difficult than determining spatial patterns, seasonal cycles, or year-to-year variations

# We can find many frustrating limitations to our climate records –

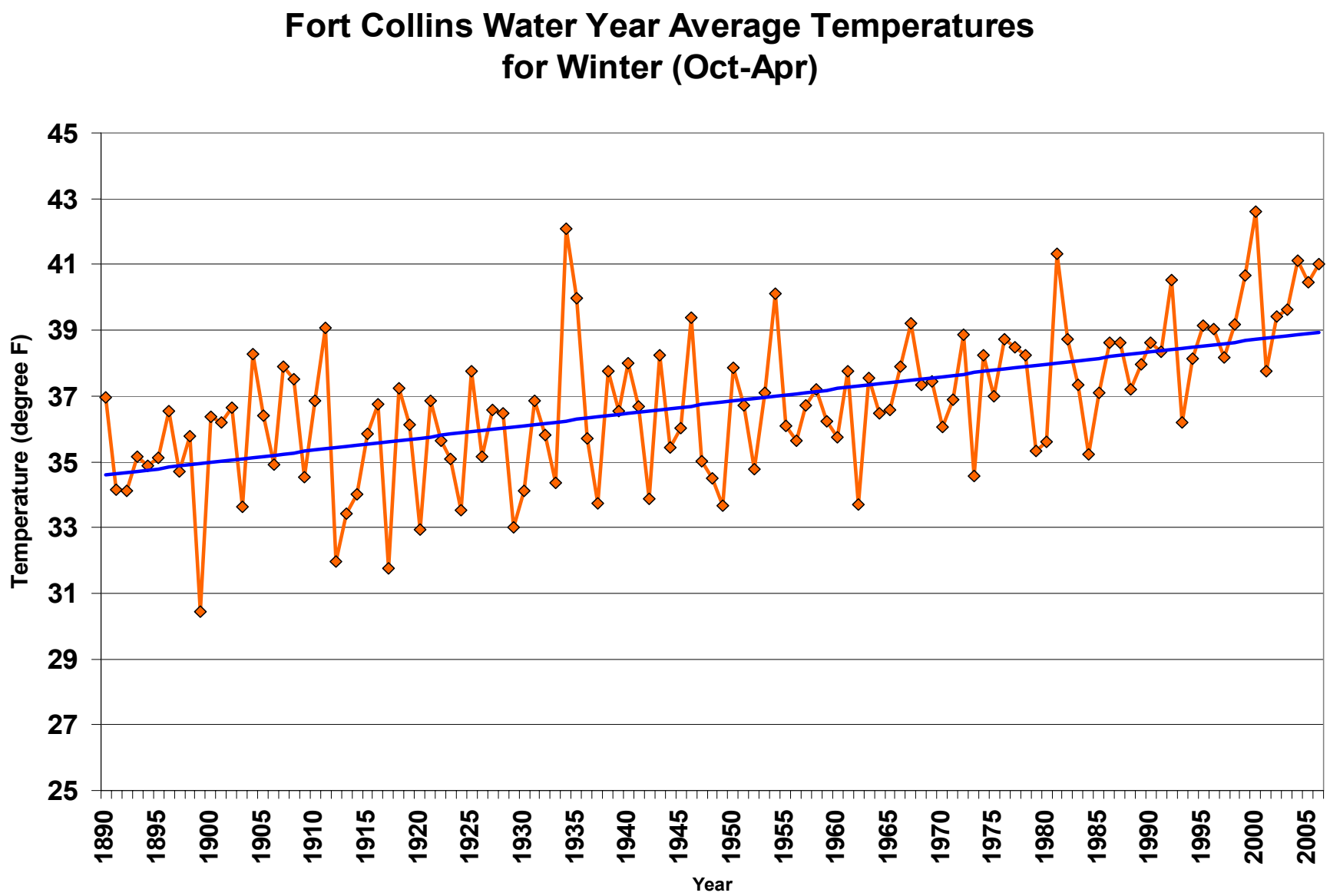
- Changing instrumentation
- Aging weather observers
- Changing environments around our weather stations
- Changing weather station locations
- Automation, etc.


Denver (all 3 stations)
Monthly Average Maximum and Minimum Temperatures
Temperature (deg F)
70
65
60
55
50
45
40
35
30
Denver City Tmax
Denver WSFO Tmax
DIA Tmax
Denver City Tmin
Denver WSFO Tmin
DIA Tmin
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

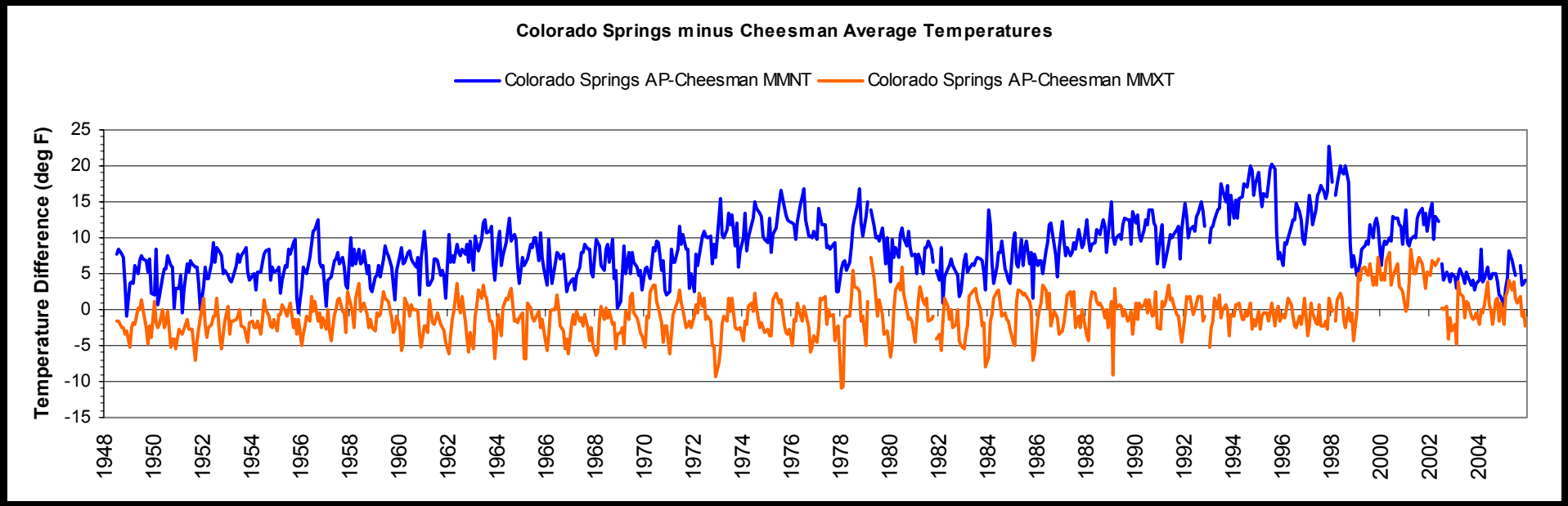
# Dillon Annual Precipitation



# Fort Collins Winter Temperatures

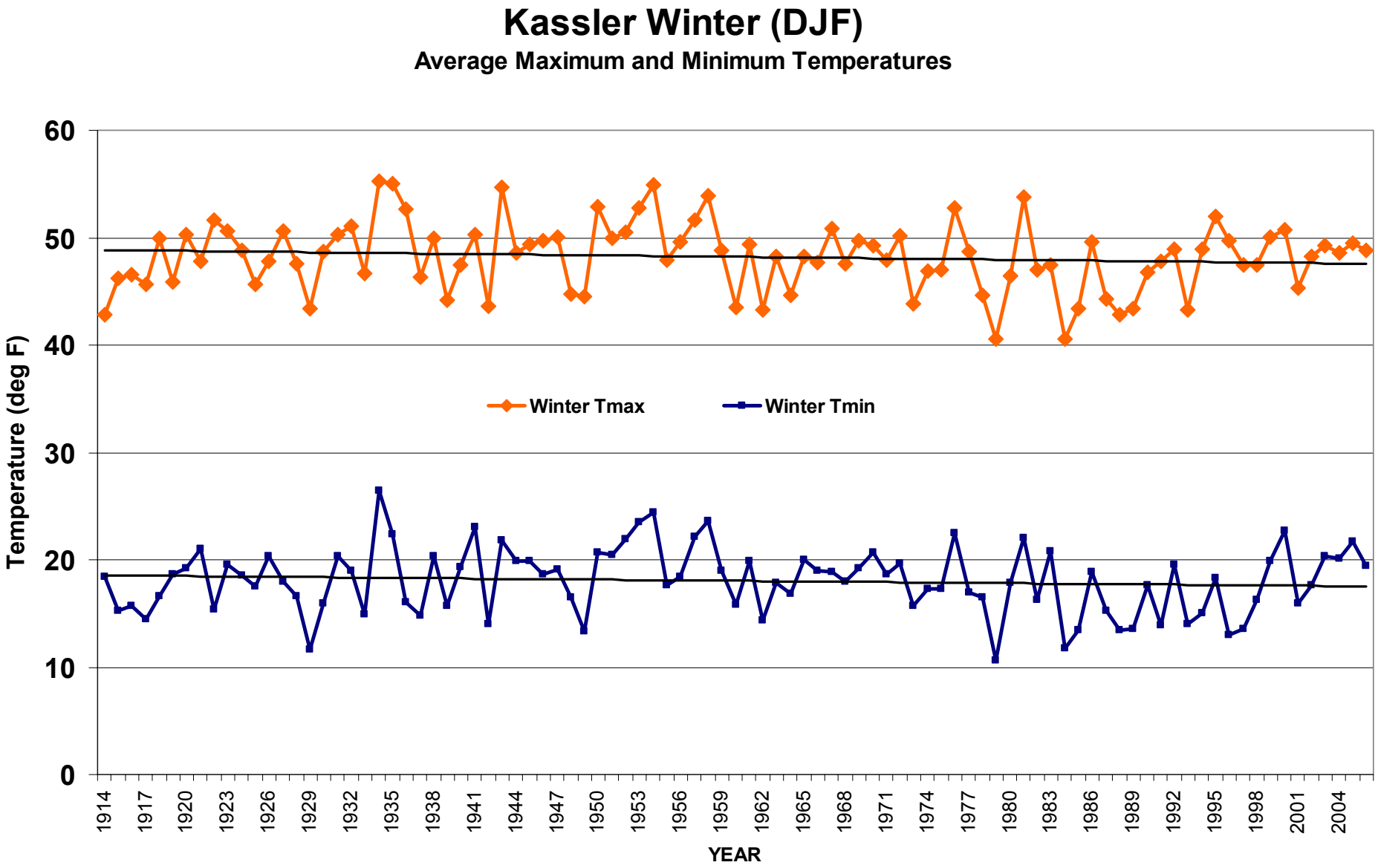


# Colorado Springs minus Cheesman Temperature Difference

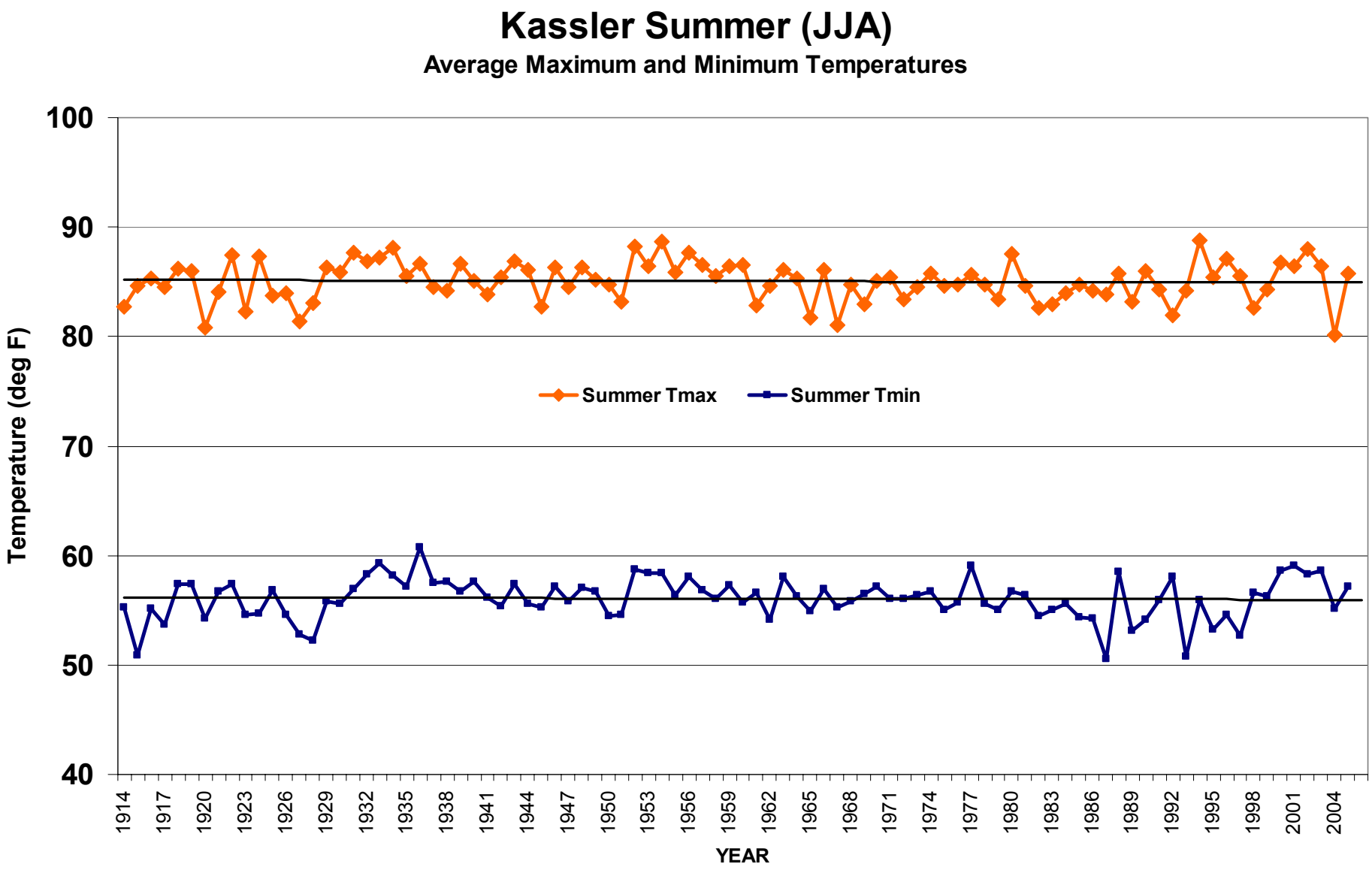


Still, our climate records are more complete, consistent, and widespread than nearly all other forms of long-term environmental monitoring (i.e. we shouldn't whine).

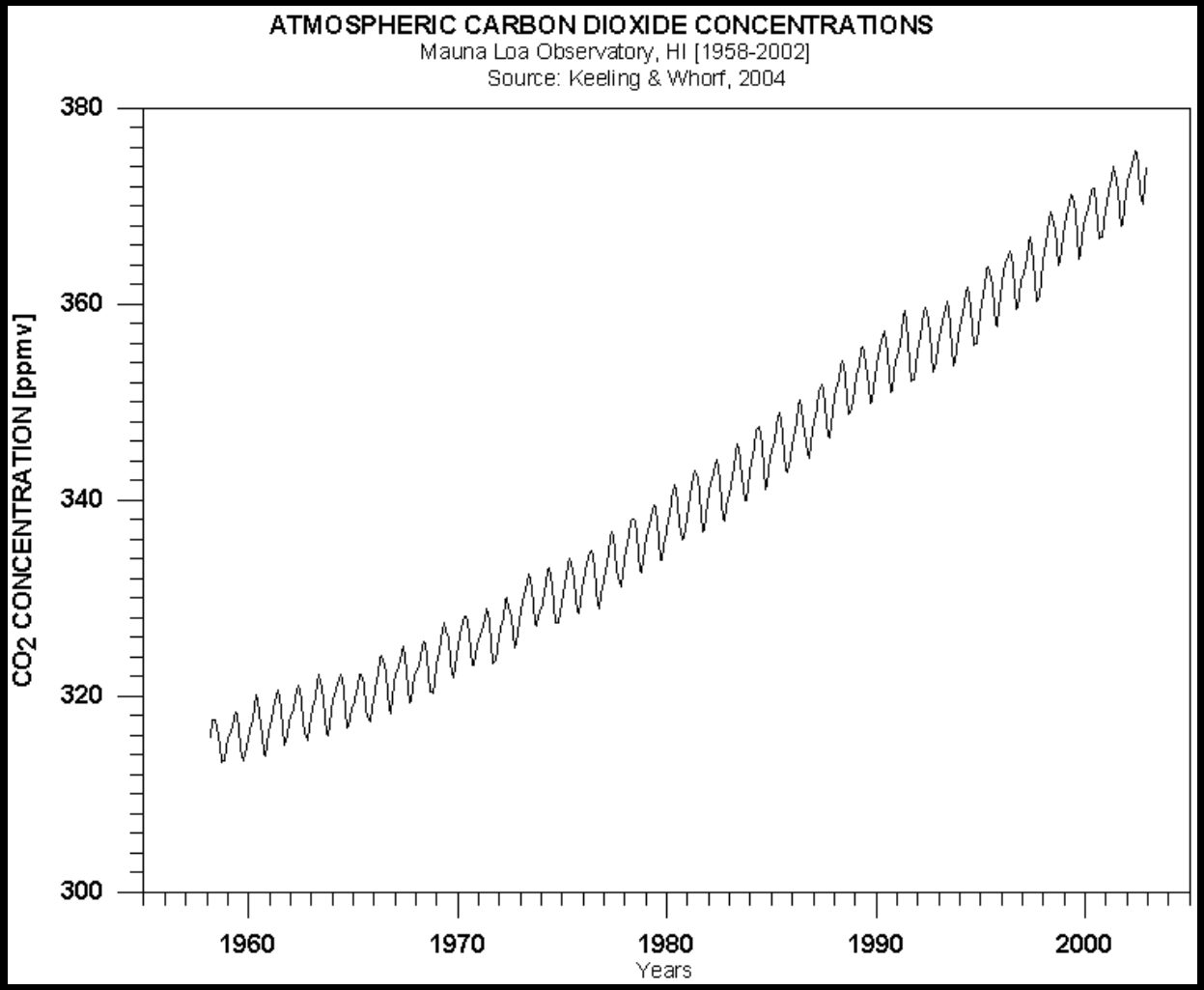
# Kassler Winter Temperatures



# Kassler Summer Temperatures

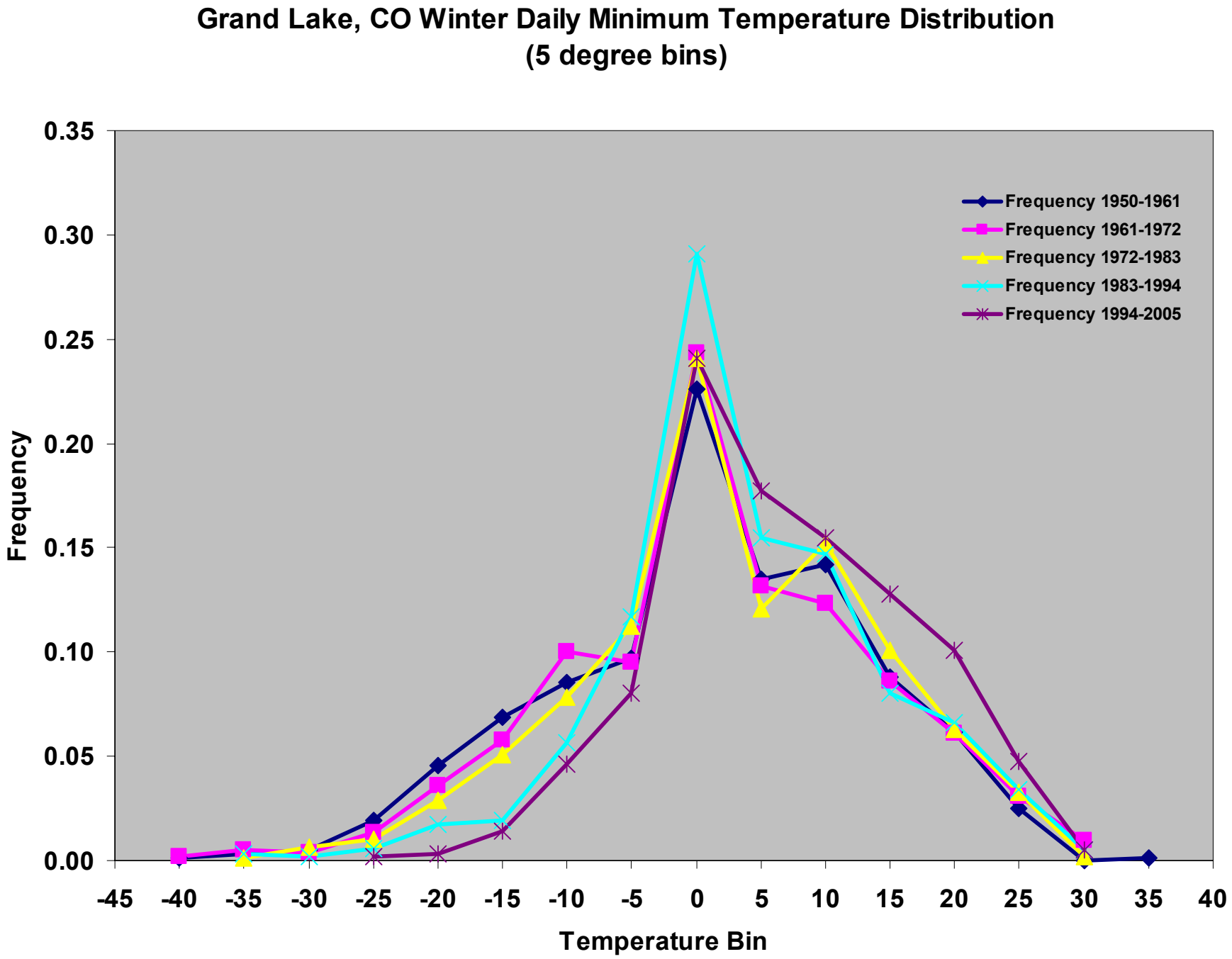


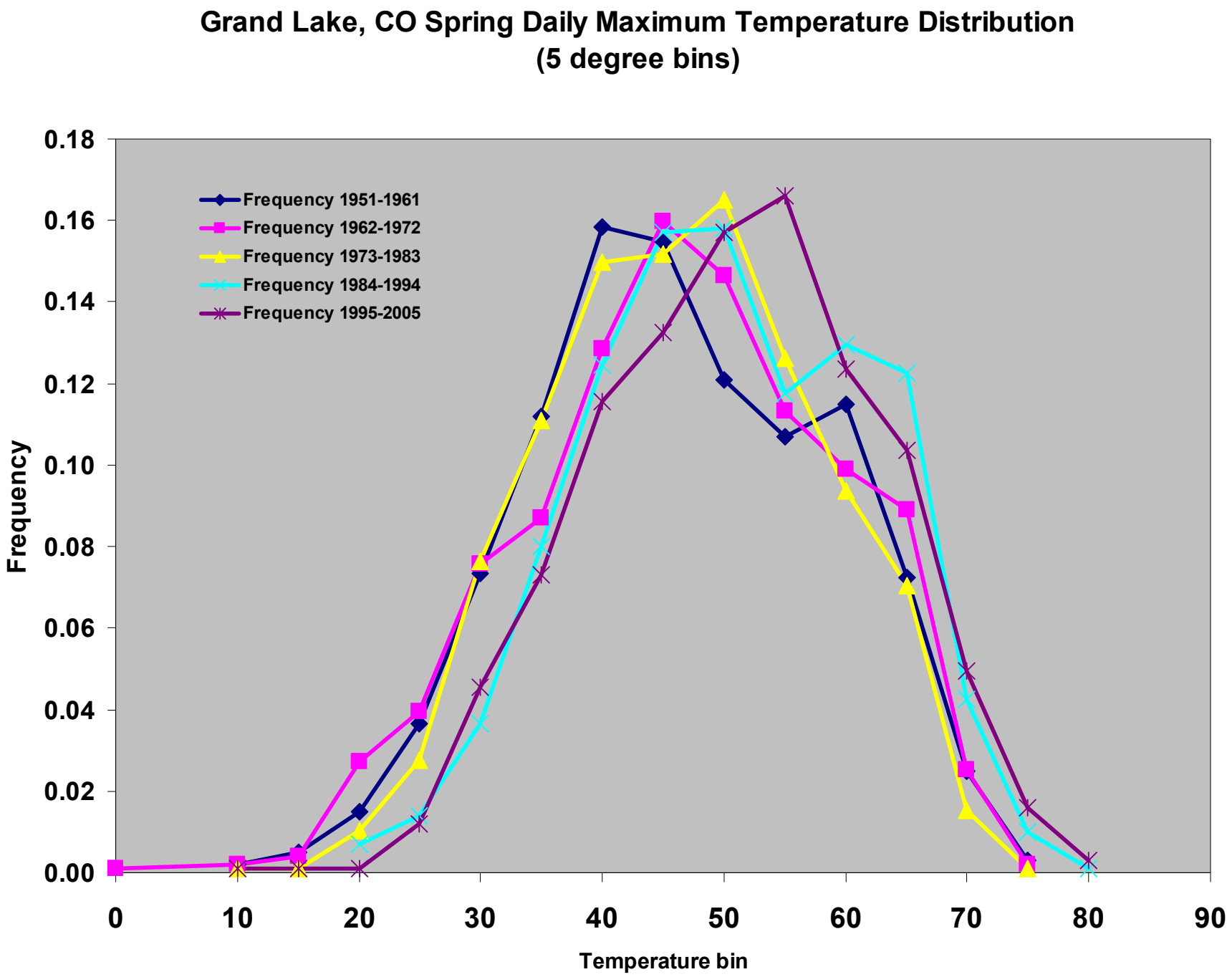
# If climate is changing (man caused or otherwise), it will still be a long time before we can tell if our precipitation patterns are changing.



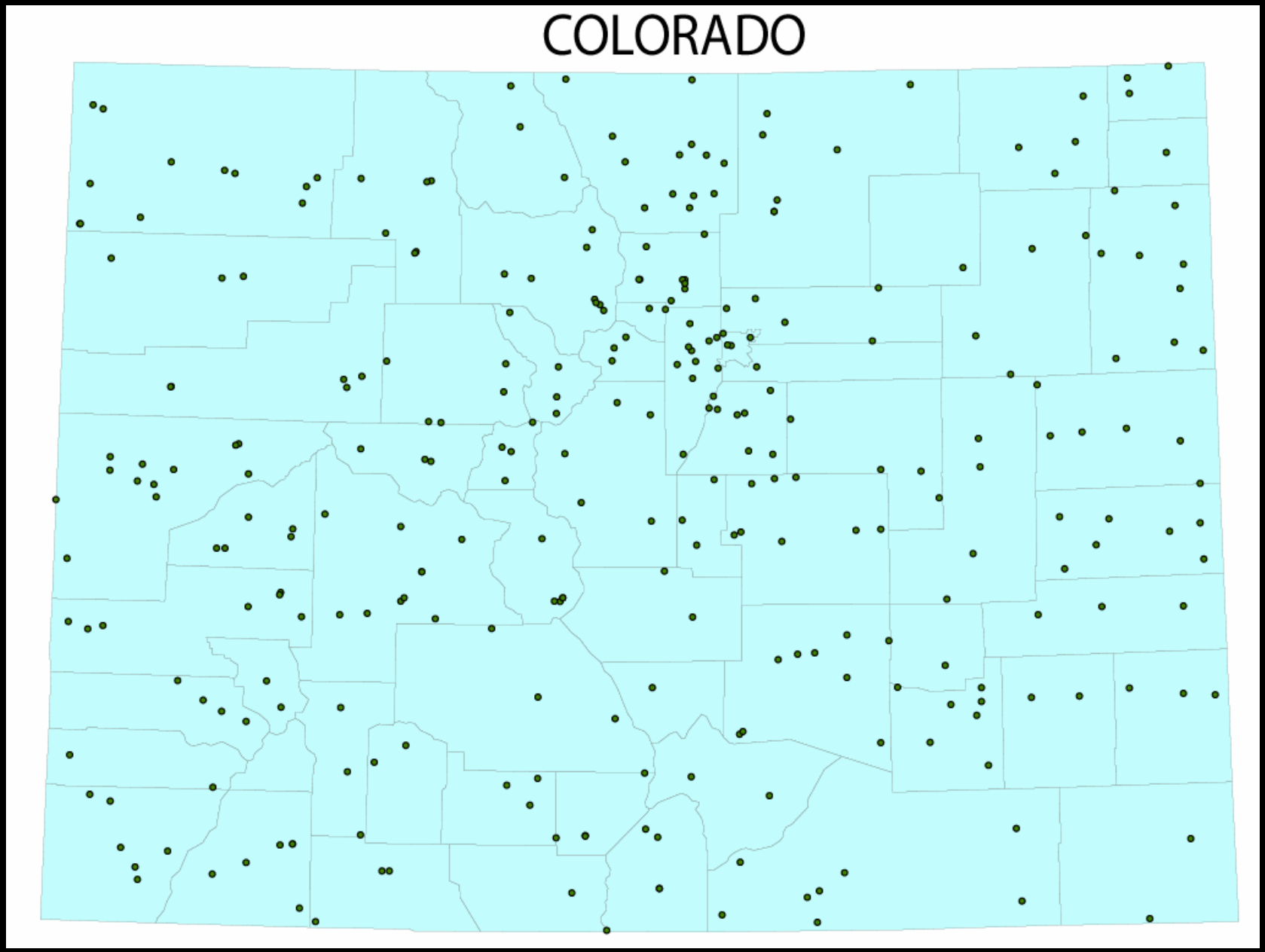
Recently, upward trends in seasonal temperatures have become noticeable in parts of Colorado

That may be significant for water users/planners whether or not precipitation is changing

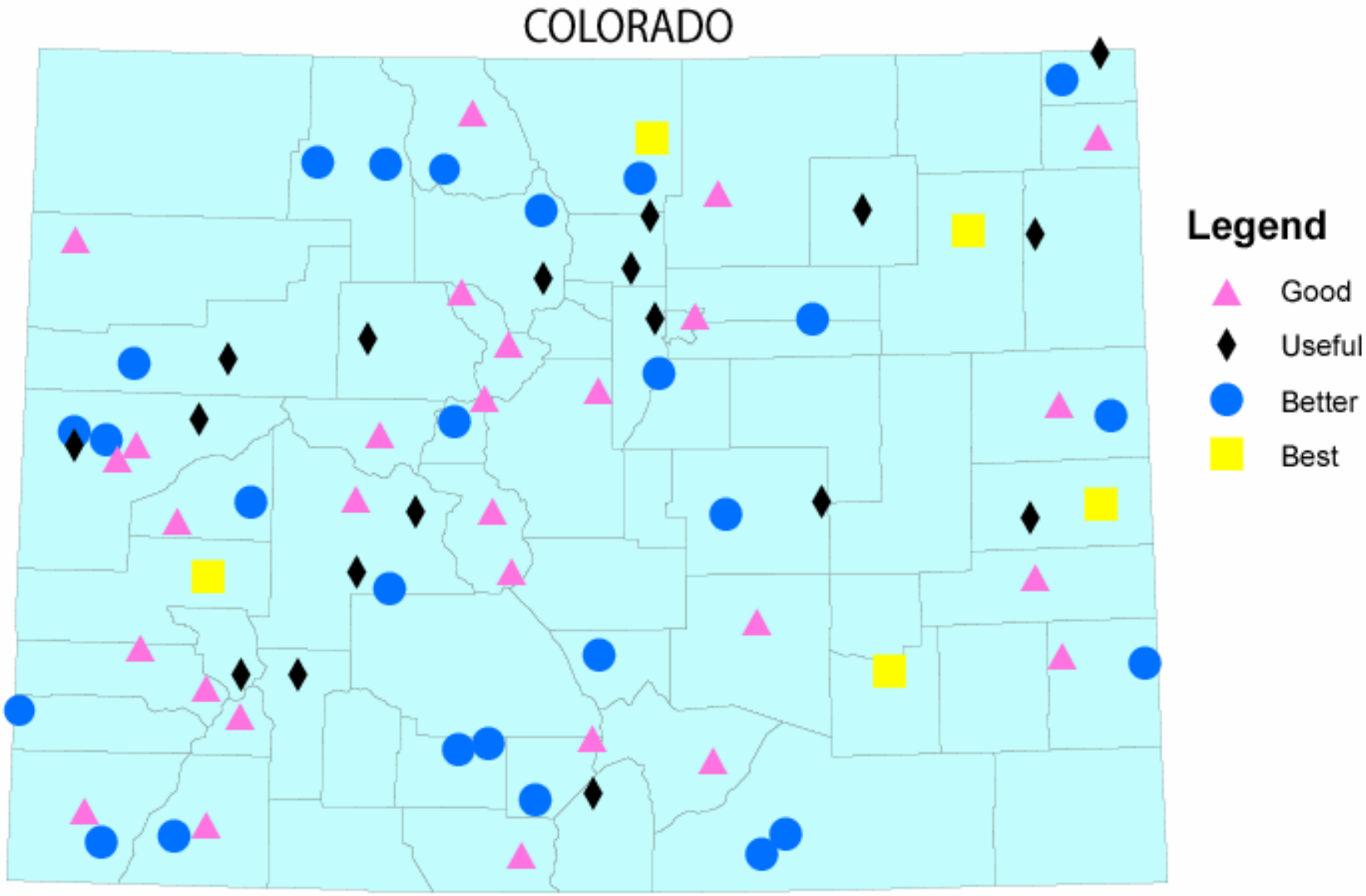

Grand Lake, CO Winter Daily Minimum Temperature Distribution
(5 degree bins)
Frequency
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
-45
-40
-35
-30
-25
-20
-15
-10
-5
0
5
10
15
20
25
30
35
40
Temperature Bin
Frequency 1950-1961
Frequency 1961-1972
Frequency 1972-1983
Frequency 1983-1994
Frequency 1994-2005

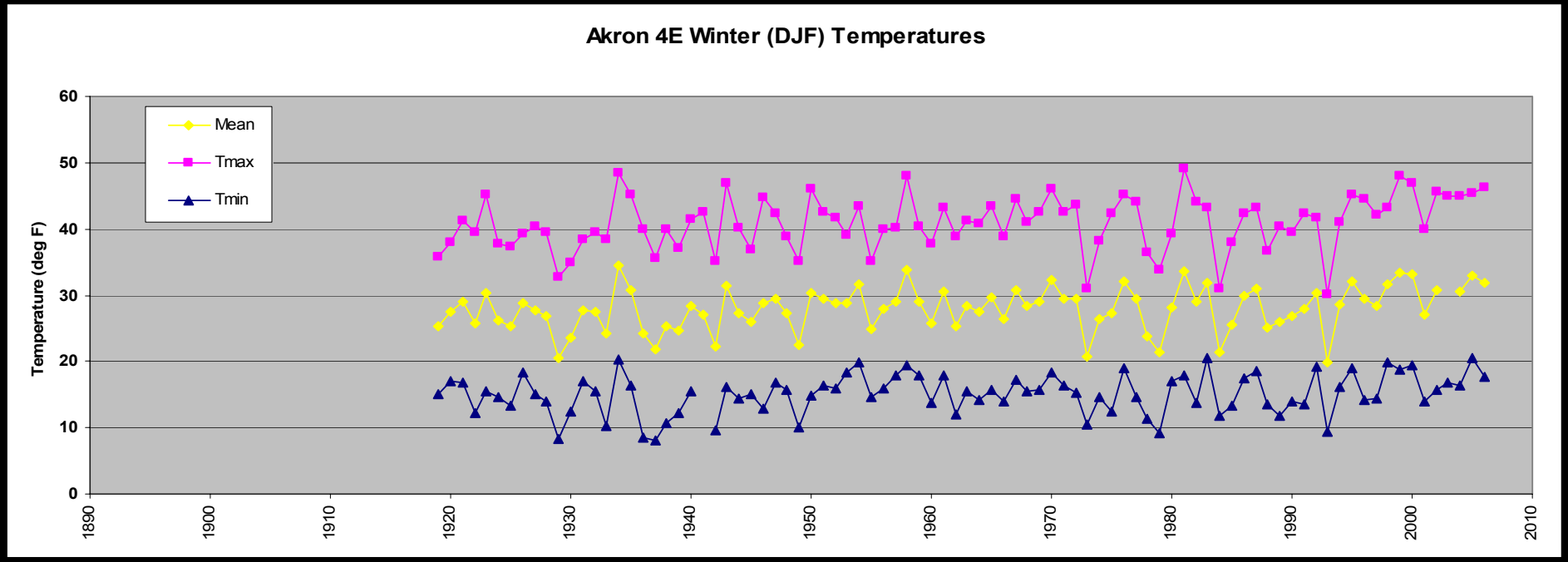

Grand Lake, CO Spring Daily Maximum Temperature Distribution
(5 degree bins)
Frequency 1951-1961
Frequency 1962-1972
Frequency 1973-1983
Frequency 1984-1994
Frequency 1995-2005
Frequency
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
0
10
20
30
40
50
60
70
80
90
Temperature bin

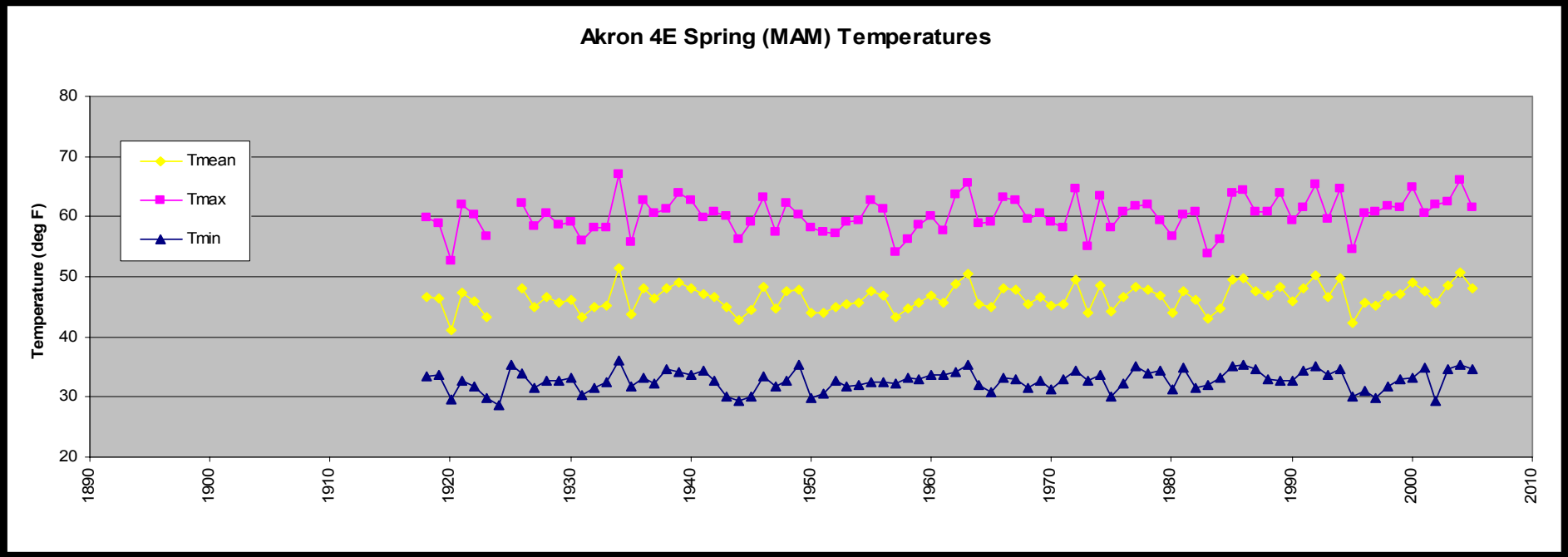
# Colorado Cooperative Stations

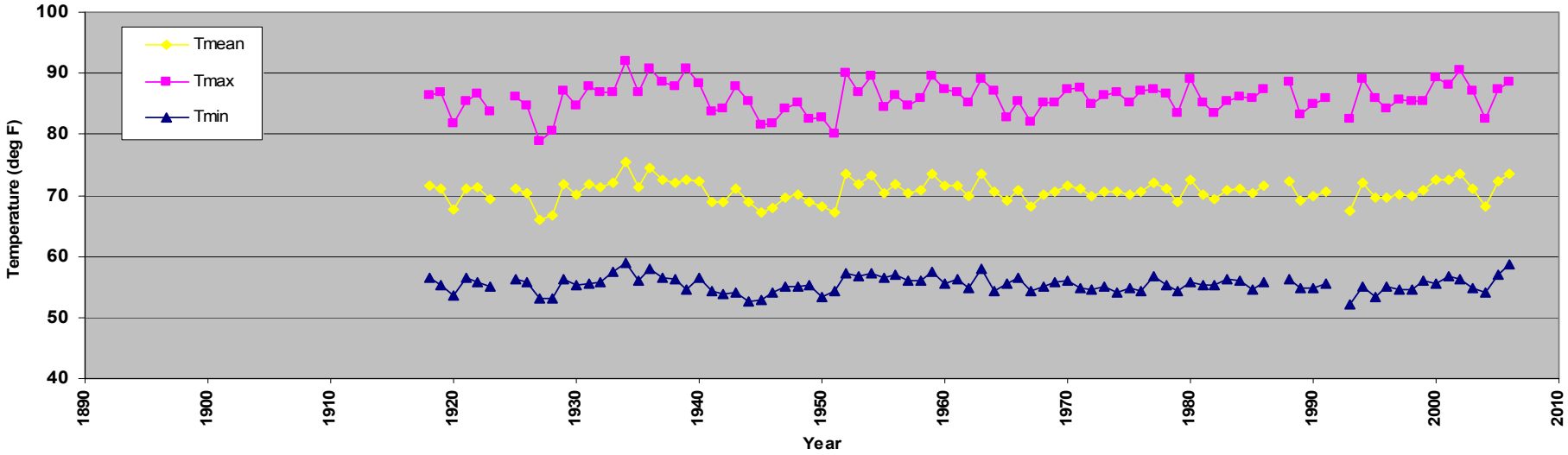


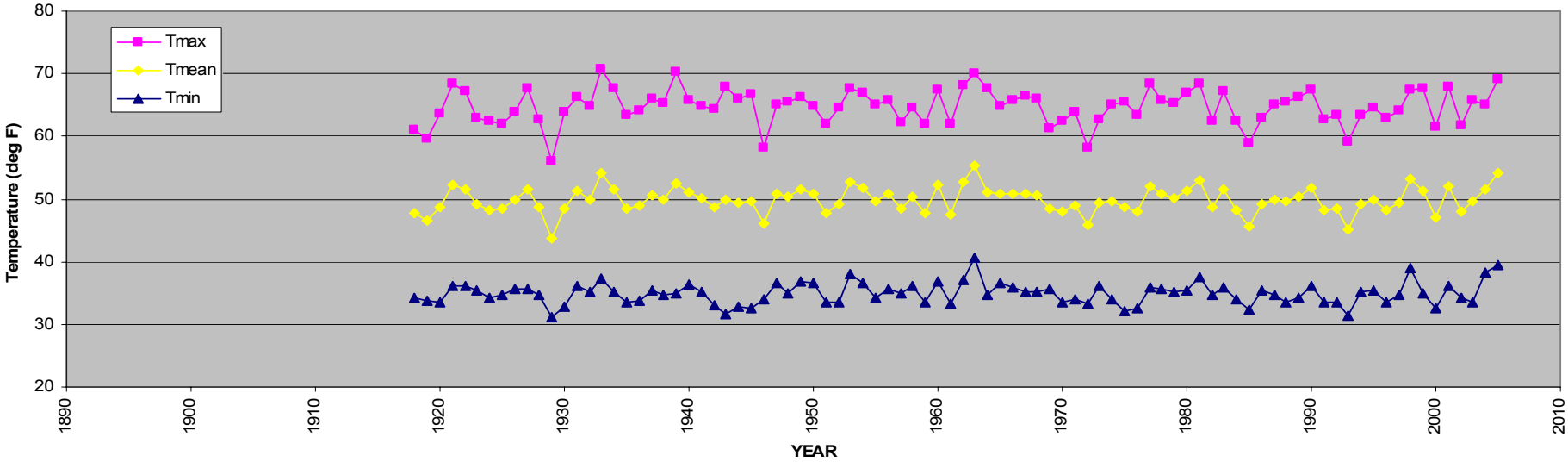
# Long-Term Analysis Stations

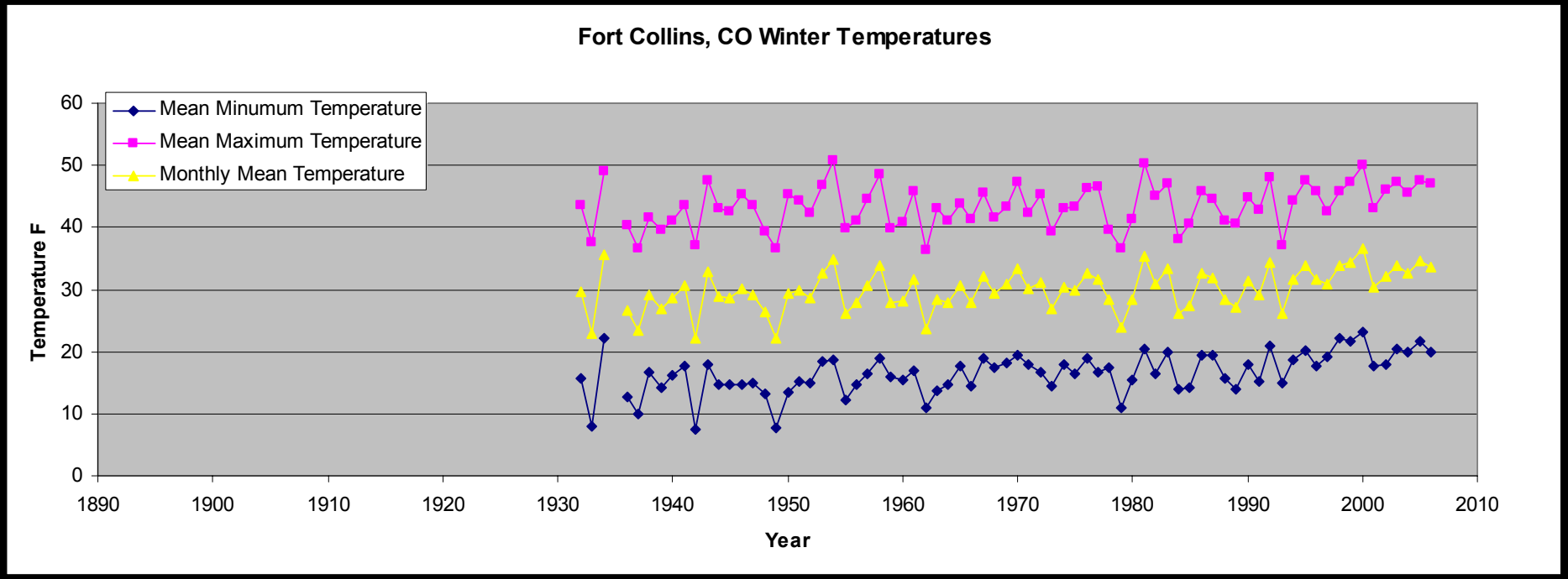


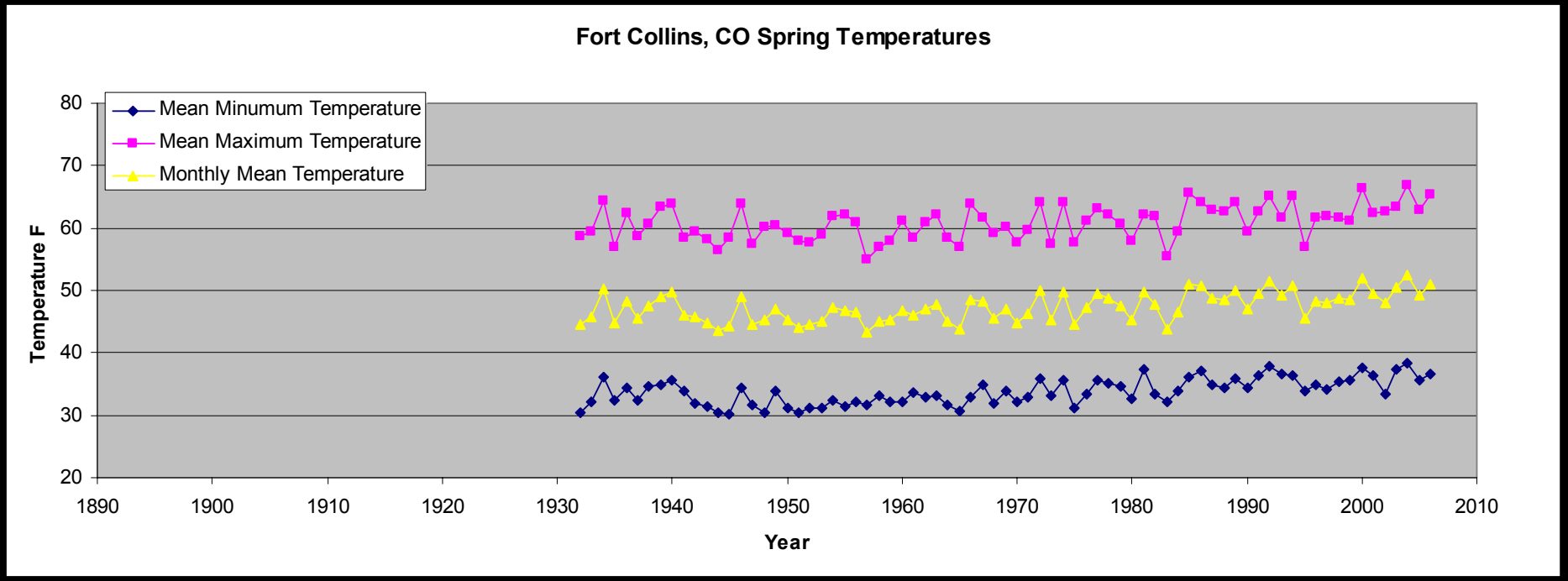

Akron 4E Winter (DJF) Temperatures
Mean
Tmax
Tmin
Temperature (deg F)
0
10
20
30
40
50
60
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010

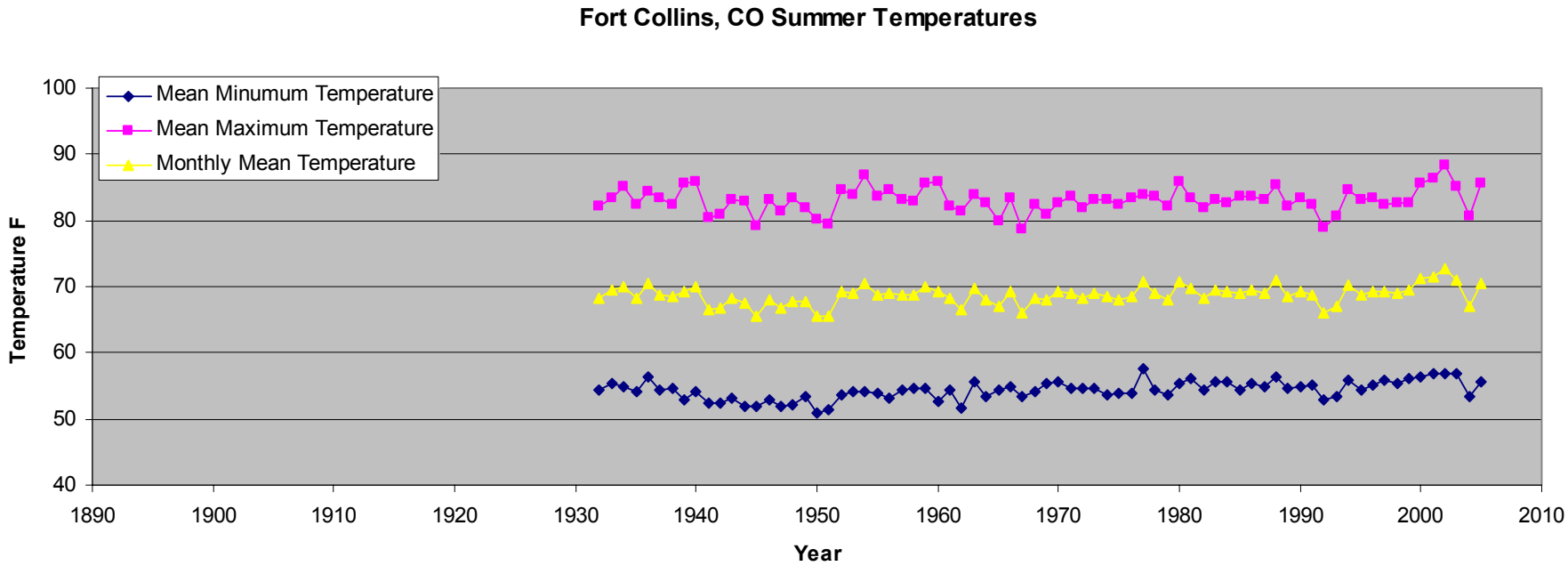

Akron 4E Spring (MAM) Temperatures
Tmean
Tmax
Tmin
Temperature (deg F)
20
30
40
50
60
70
80
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010

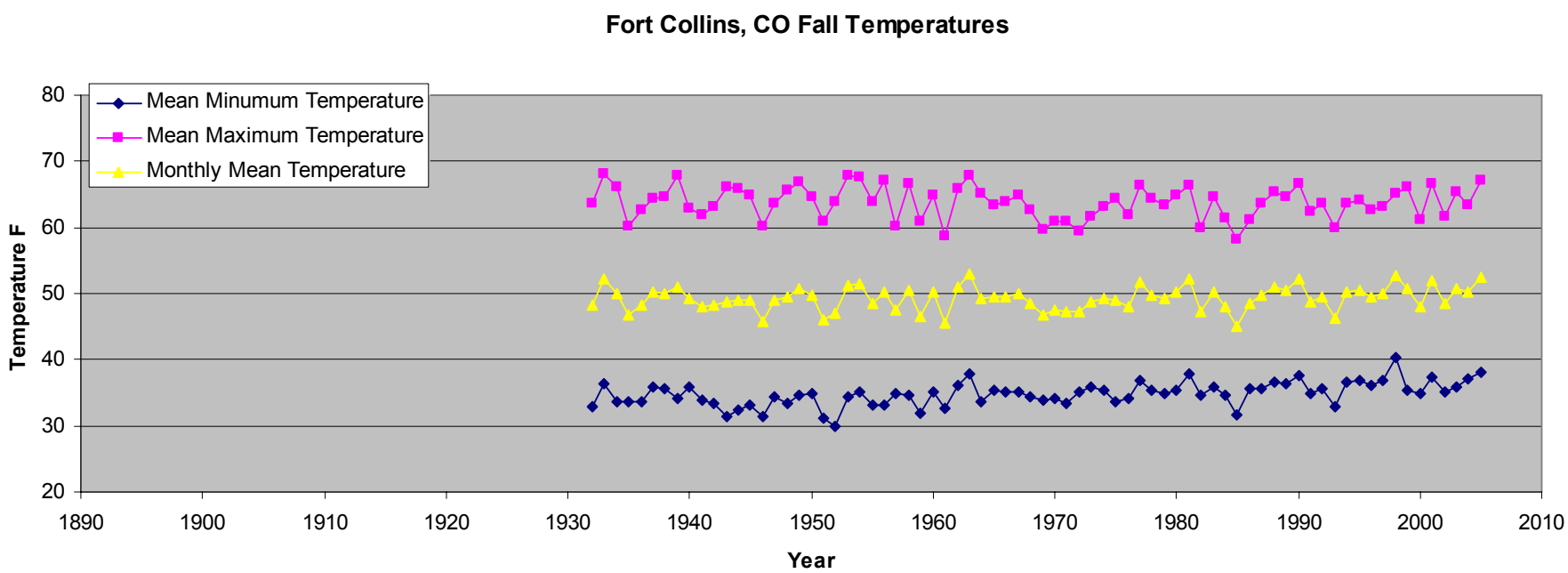

Akron 4E Summer (JJA) Temperatures
Tmean
Tmax
Tmin
Temperature (deg F)
100
90
80
70
60
50
40
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Year

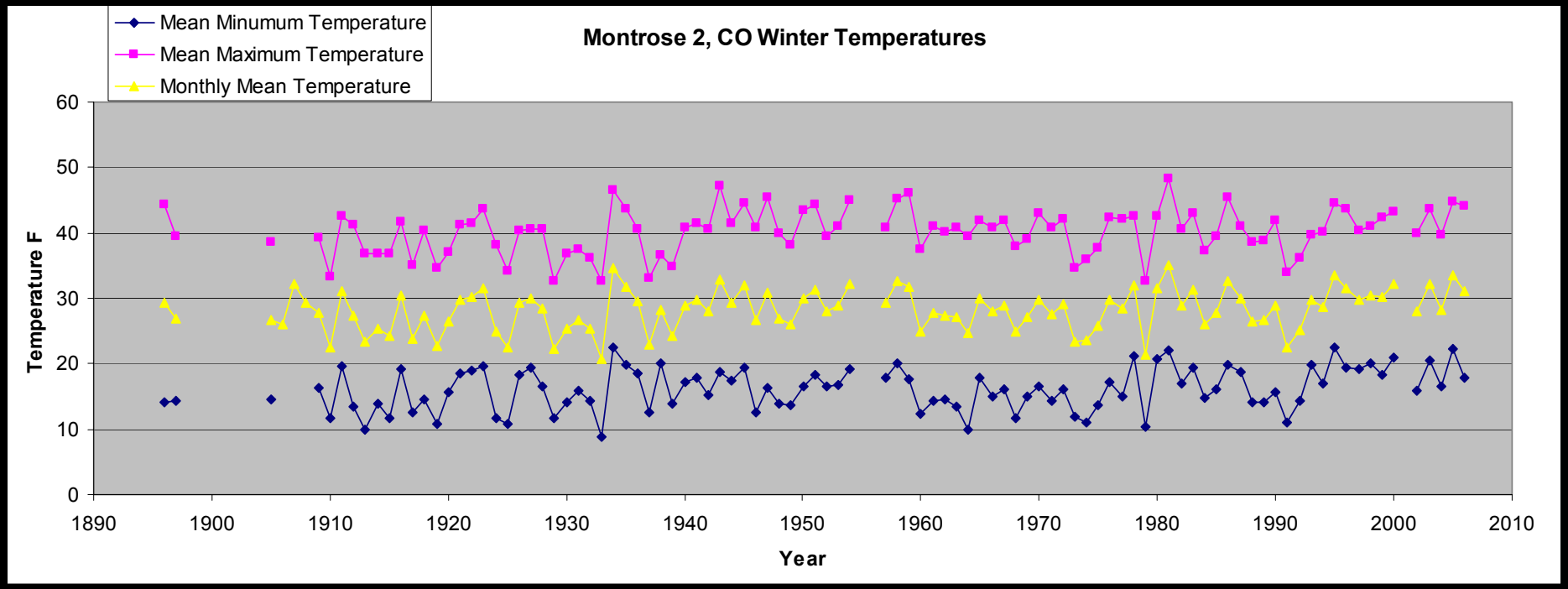

Akron 4E Fall (SON) Temperatures
Tmax
Tmean
Tmin
Temperature (deg F)
80
70
60
50
40
30
20
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
YEAR

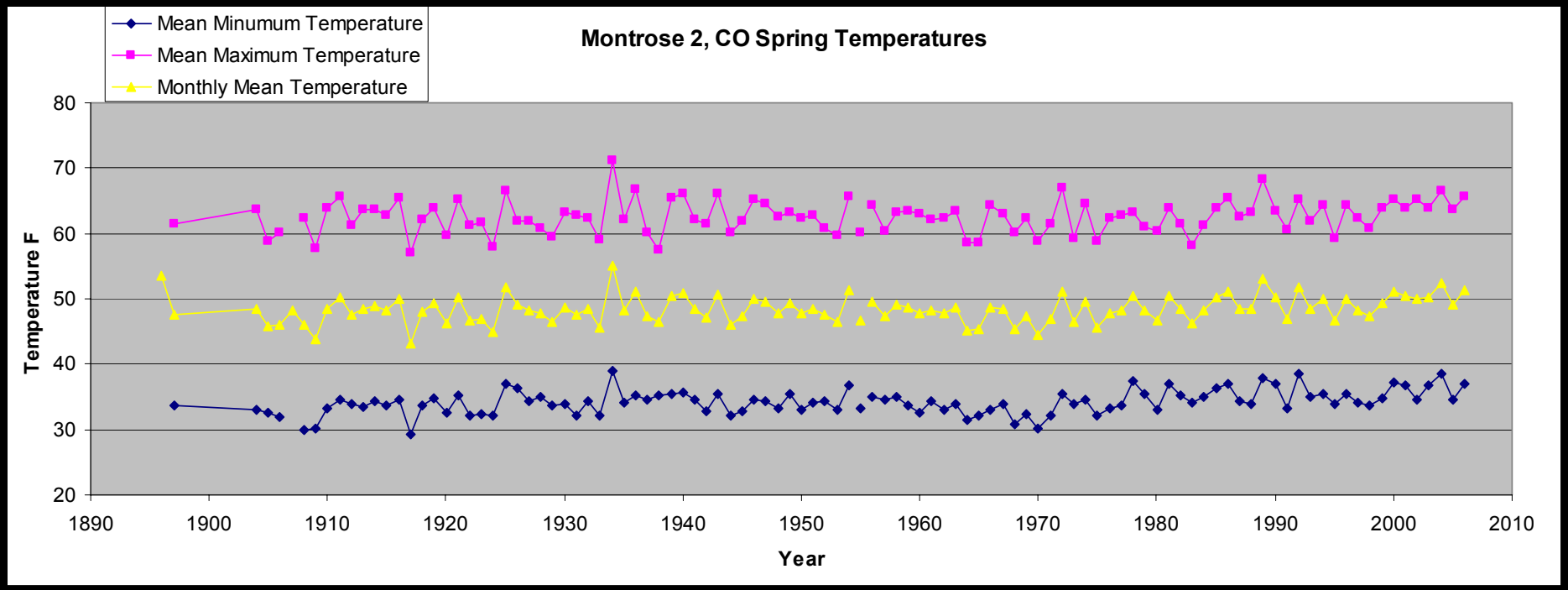

Fort Collins, CO Winter Temperatures
Mean Minumum Temperature
Mean Maximum Temperature
Monthly Mean Temperature
Temperature F
0
10
20
30
40
50
60
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Year

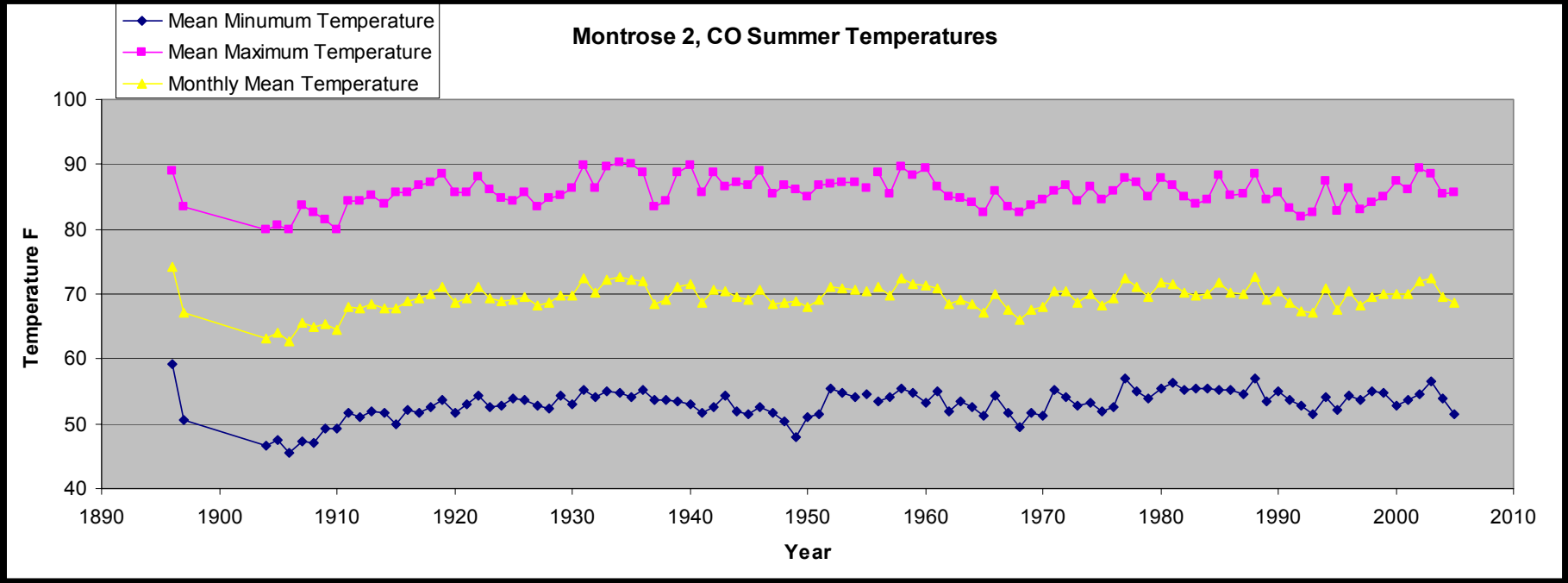

Fort Collins, CO Spring Temperatures
Mean Minumum Temperature
Mean Maximum Temperature
Monthly Mean Temperature
Temperature F
20
30
40
50
60
70
80
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Year

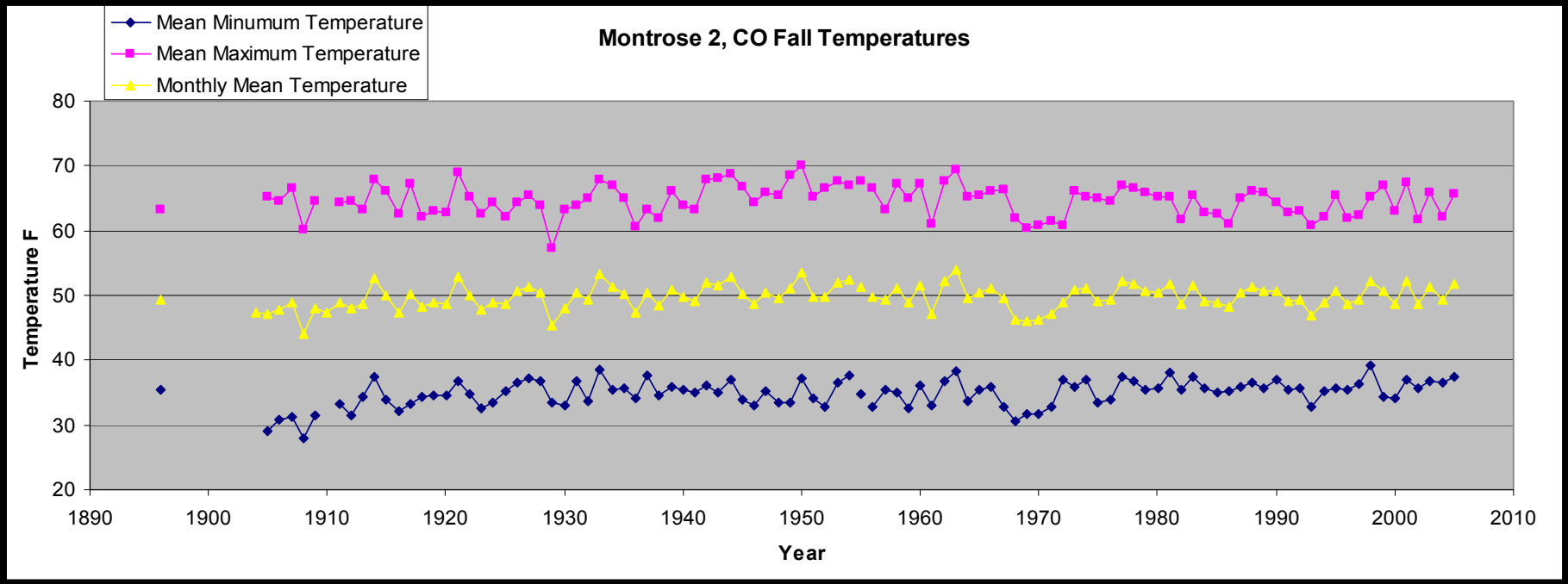

Fort Collins, CO Summer Temperatures
Mean Minumum Temperature
Mean Maximum Temperature
Monthly Mean Temperature
Temperature F
100
90
80
70
60
50
40
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Year

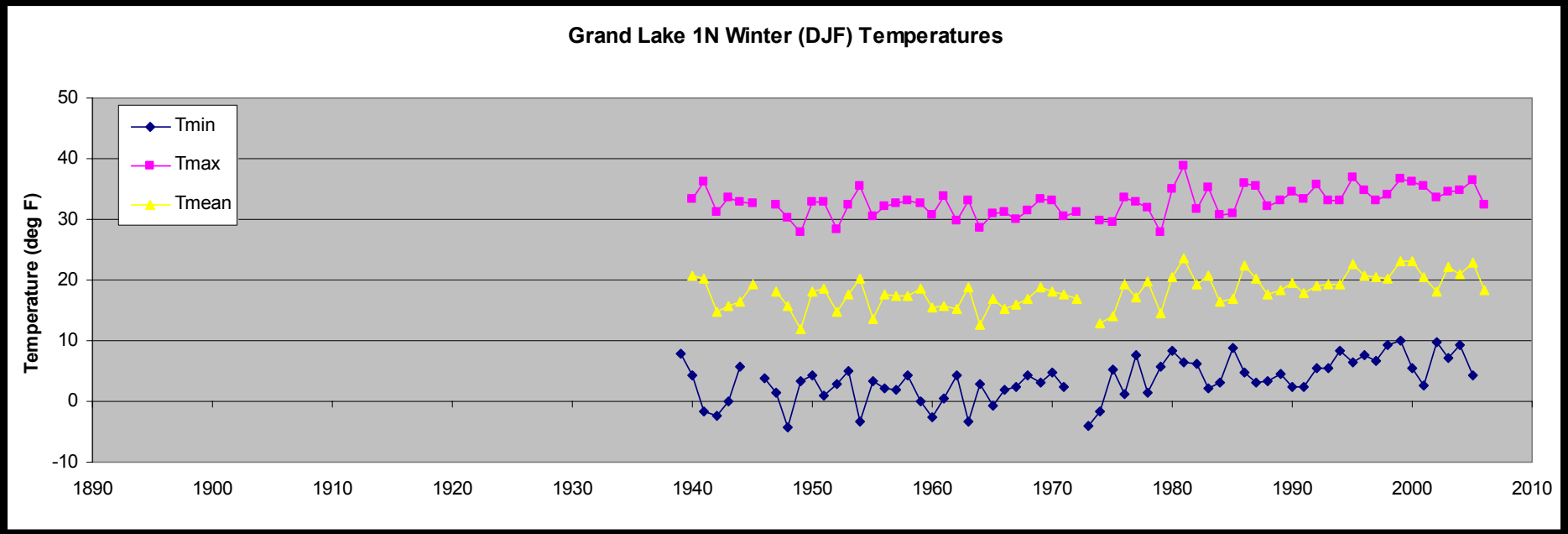

Fort Collins, CO Fall Temperatures
Mean Minumum Temperature
Mean Maximum Temperature
Monthly Mean Temperature
Temperature F
80
70
60
50
40
30
20
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Year

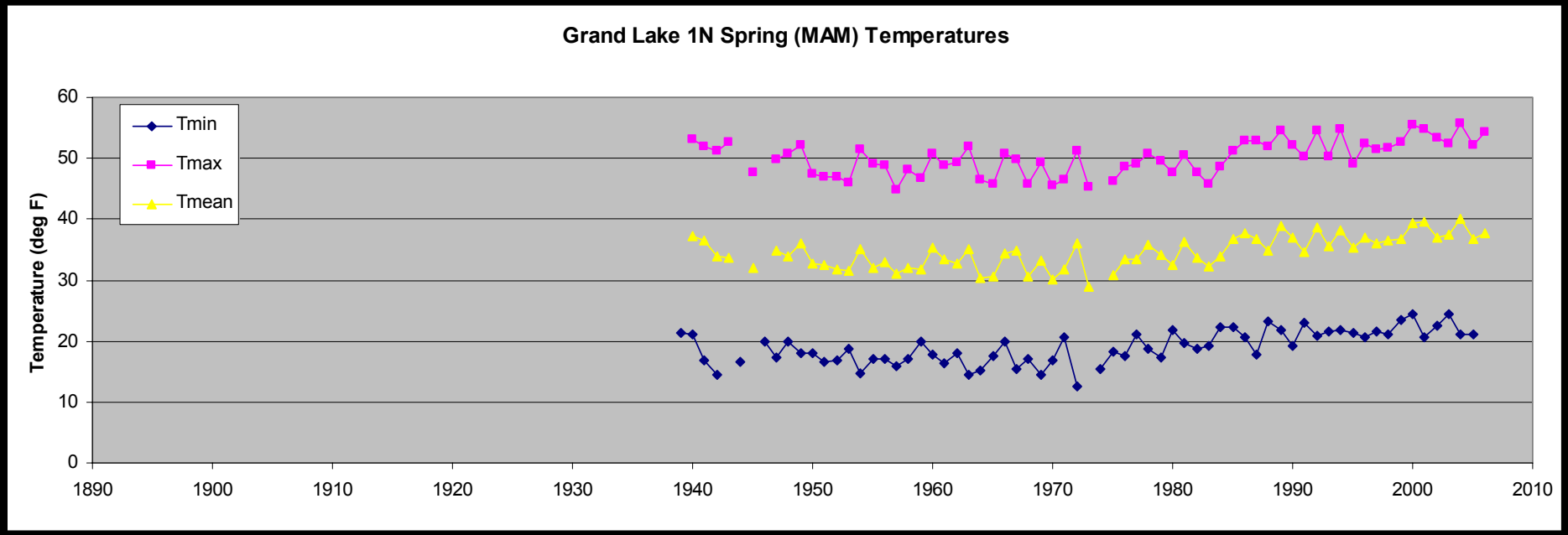

Montrose 2, CO Winter Temperatures
Mean Minumum Temperature
Mean Maximum Temperature
Monthly Mean Temperature
Temperature F
Year
0
10
20
30
40
50
60
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010

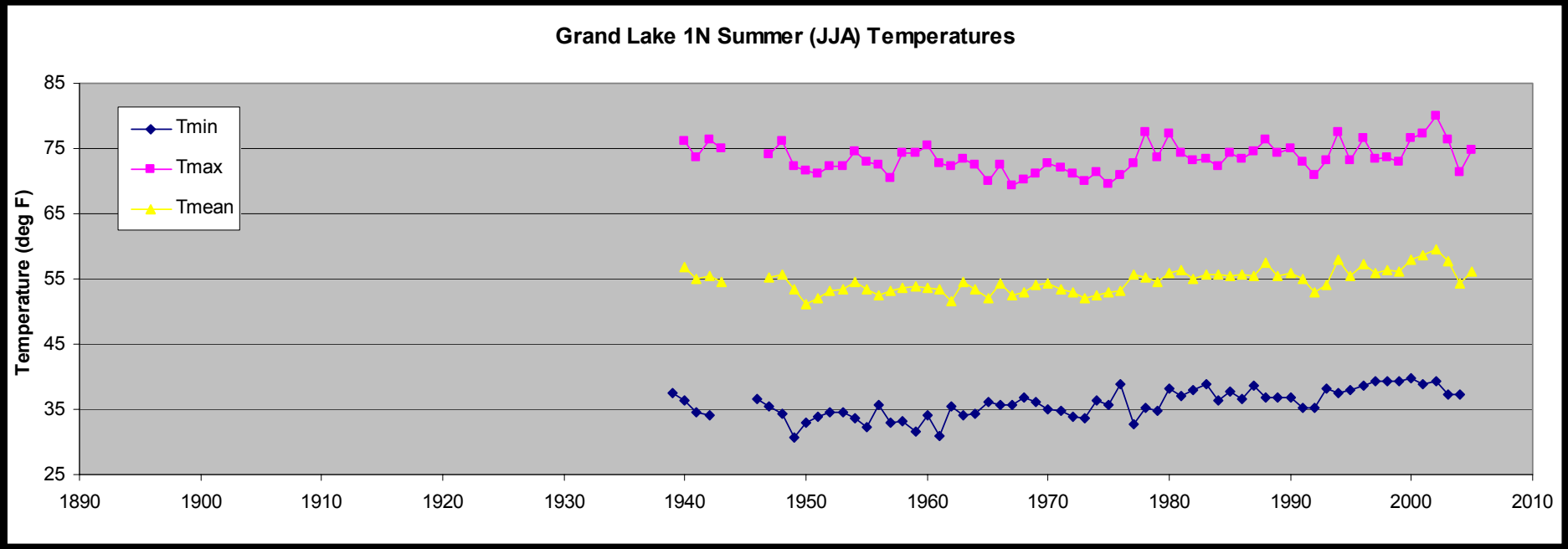

Montrose 2, CO Spring Temperatures
Mean Minumum Temperature
Mean Maximum Temperature
Monthly Mean Temperature
Temperature F
Year
20
30
40
50
60
70
80
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010

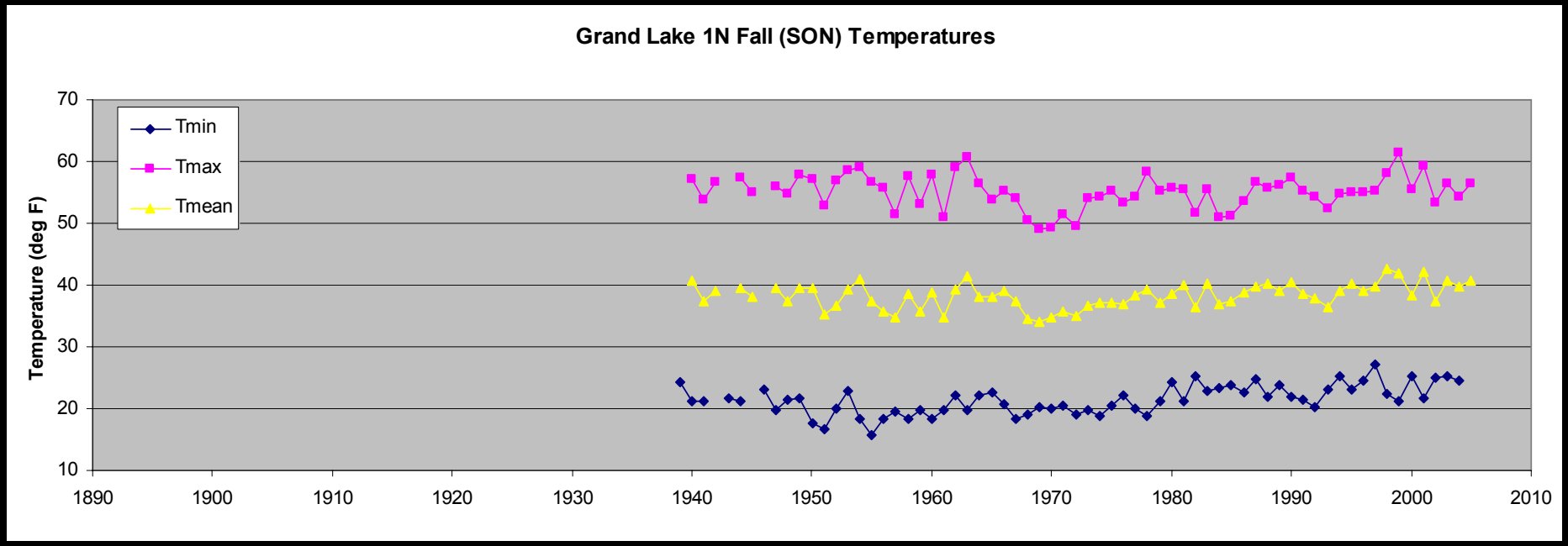

Mean Minumum Temperature
Mean Maximum Temperature
Monthly Mean Temperature
Montrose 2, CO Summer Temperatures
Temperature F
100
90
80
70
60
50
40
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Year


Mean Minumum Temperature
Mean Maximum Temperature
Monthly Mean Temperature
Montrose 2, CO Fall Temperatures
Temperature F
80
70
60
50
40
30
20
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Year


Grand Lake 1N Winter (DJF) Temperatures
Temperature (deg F)
50
40
30
20
10
0
-10
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Tmin
Tmax
Tmean

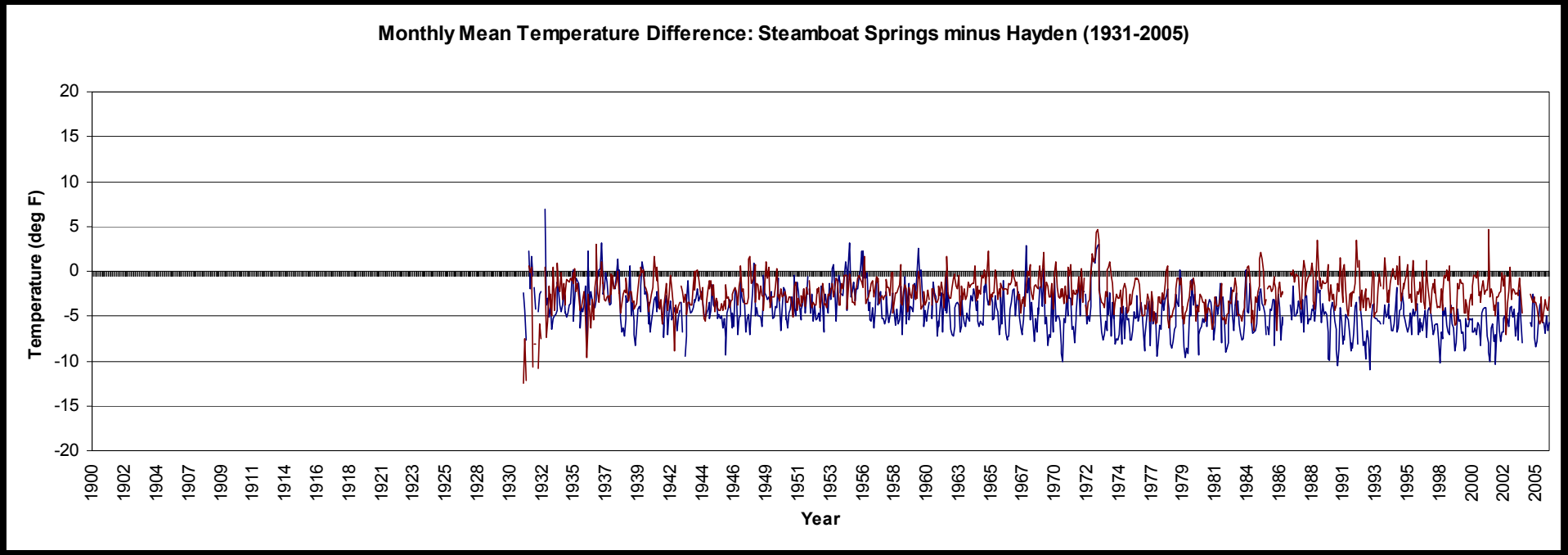

Grand Lake 1N Spring (MAM) Temperatures
Temperature (deg F)
60
50
40
30
20
10
0
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Tmin
Tmax
Tmean


Grand Lake 1N Summer (JJA) Temperatures
Temperature (deg F)
85
75
65
55
45
35
25
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Tmin
Tmax
Tmean

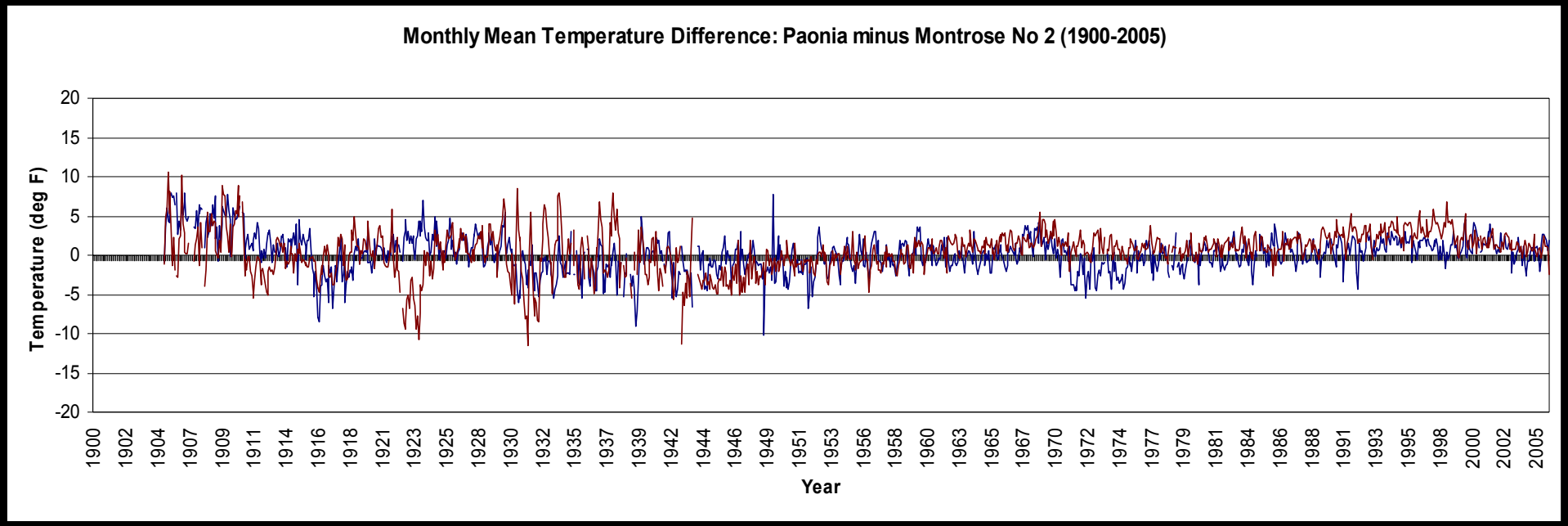

Grand Lake 1N Fall (SON) Temperatures
Temperature (deg F)
70
60
50
40
30
20
10
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Tmin
Tmax
Tmean

# With even the best stations, there is uncertainty

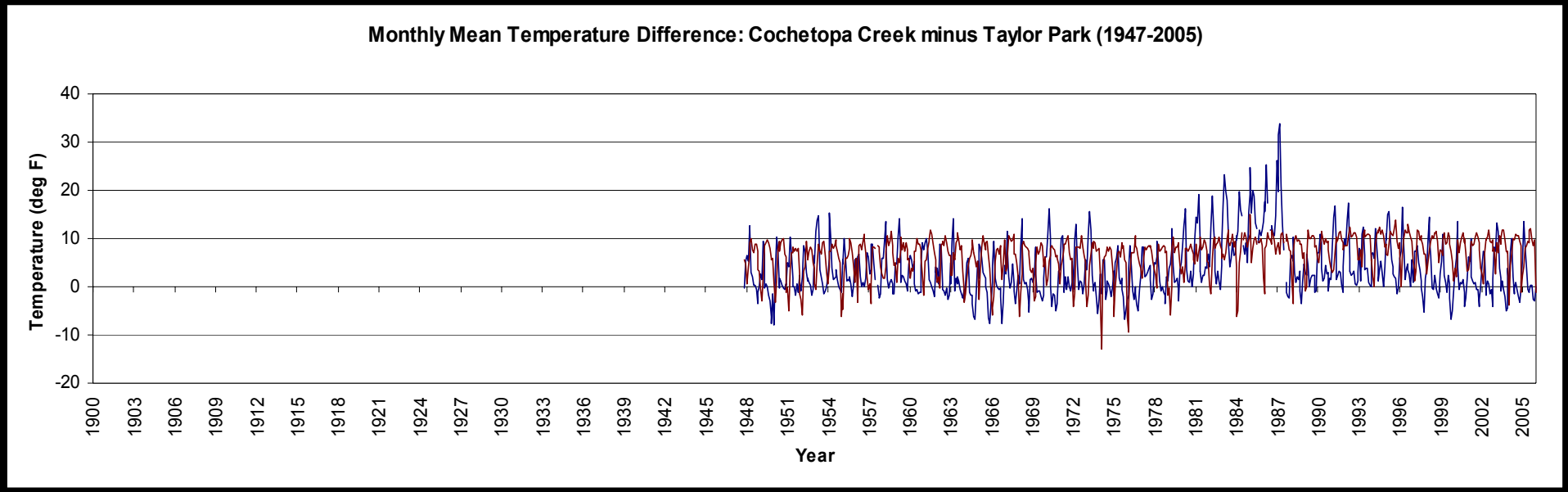
# Steamboat – Hayden Monthly Temperature Differences



# Paonia – Montrose Monthly Temperature Differences

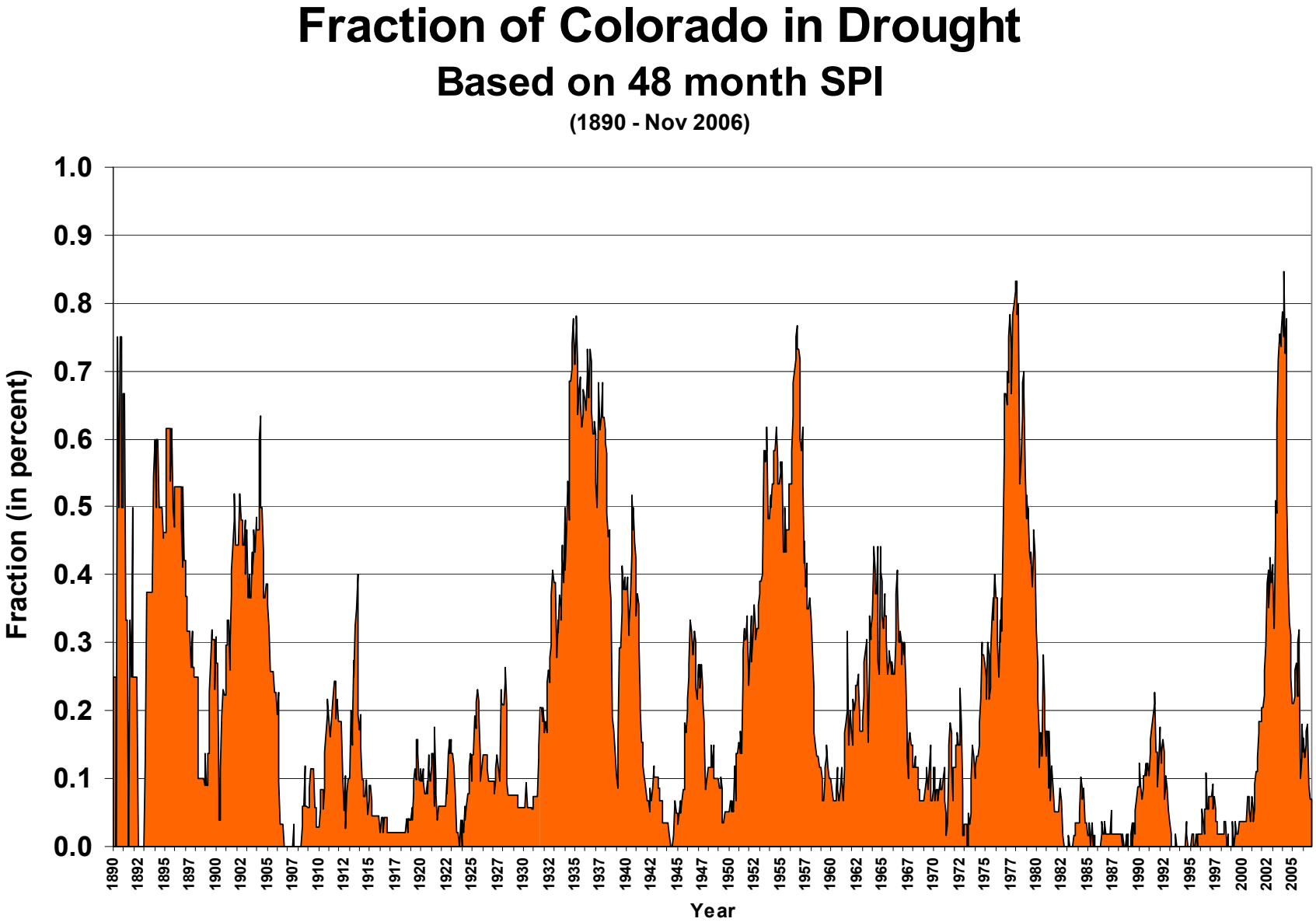


# Cochetopa Creek – Taylor Park Monthly Temperature Differences



# What should we do??

# Always plan for drought!



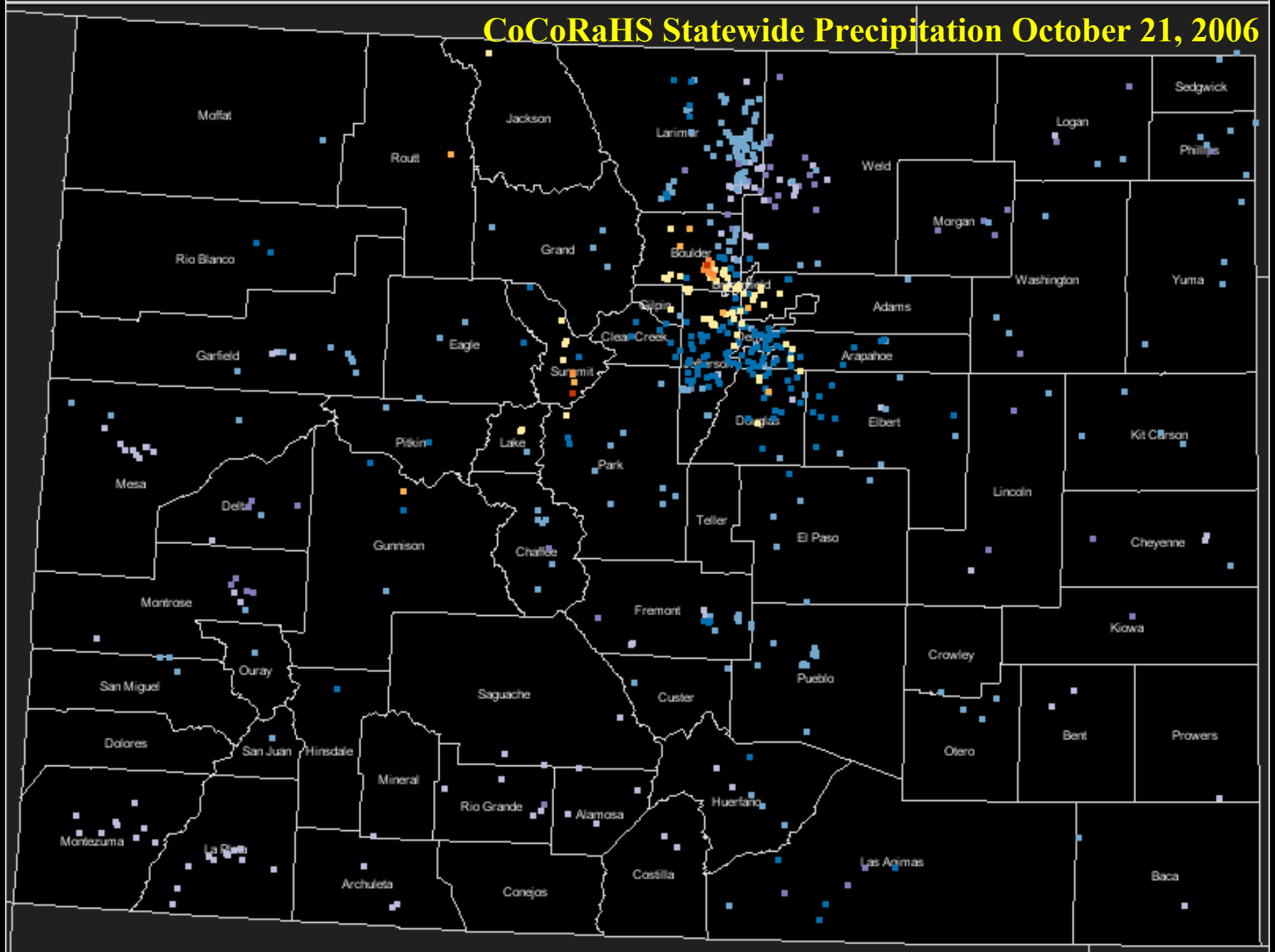
# And have your rain gauge ready

Daily Precipitation (inches x.xx), for the 24 hour period ending ~7:00 am

Colorado 10/21/2006

0.0 | Trace | 0.01 - 0.19 | 0.19 - 0.38 | 0.38 - 0.56 | 0.56 - 0.75 | 0.75 - 0.94 | 0.94 - 1.13

# CoCoRaHS Statewide Precipitation October 21, 2006



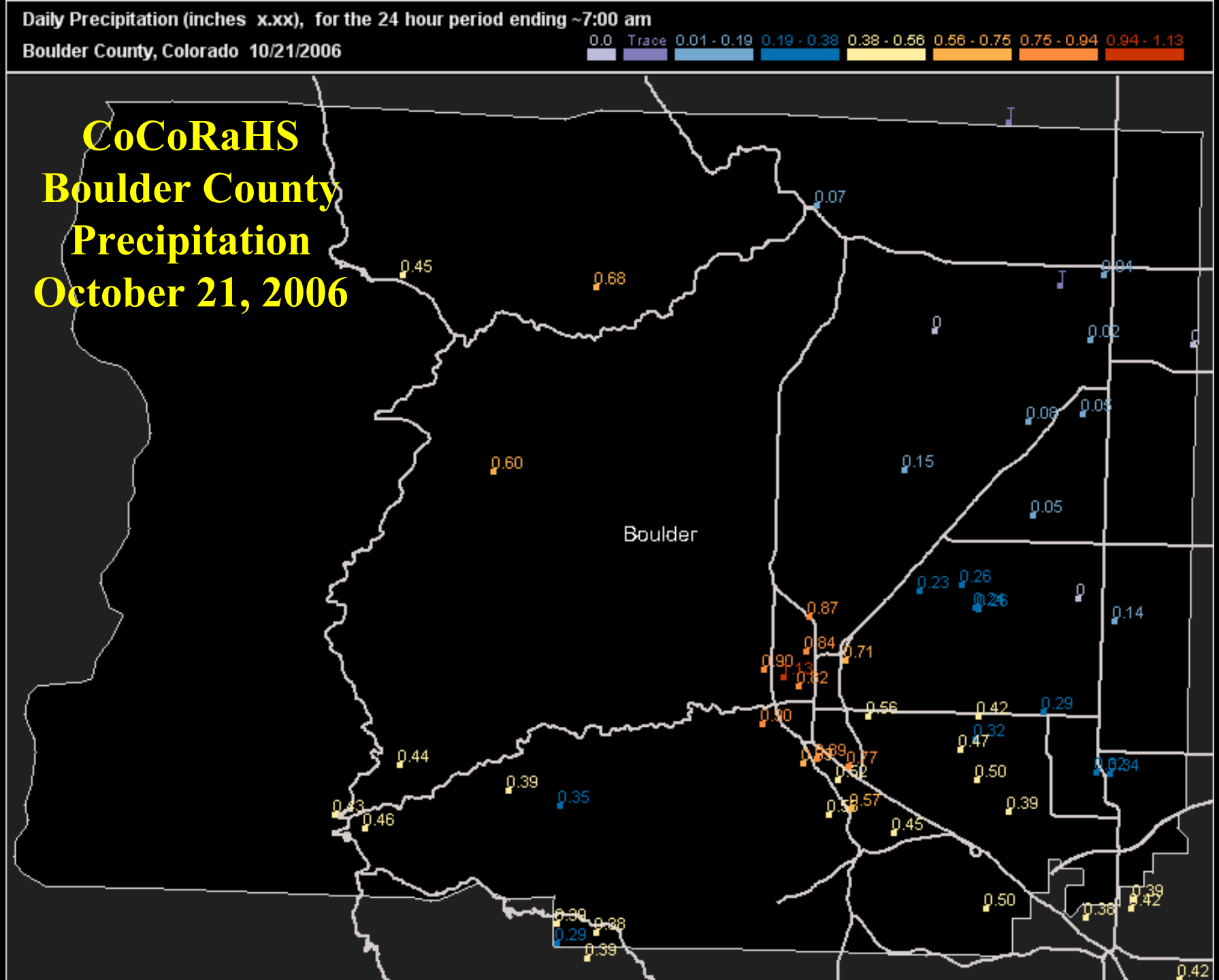
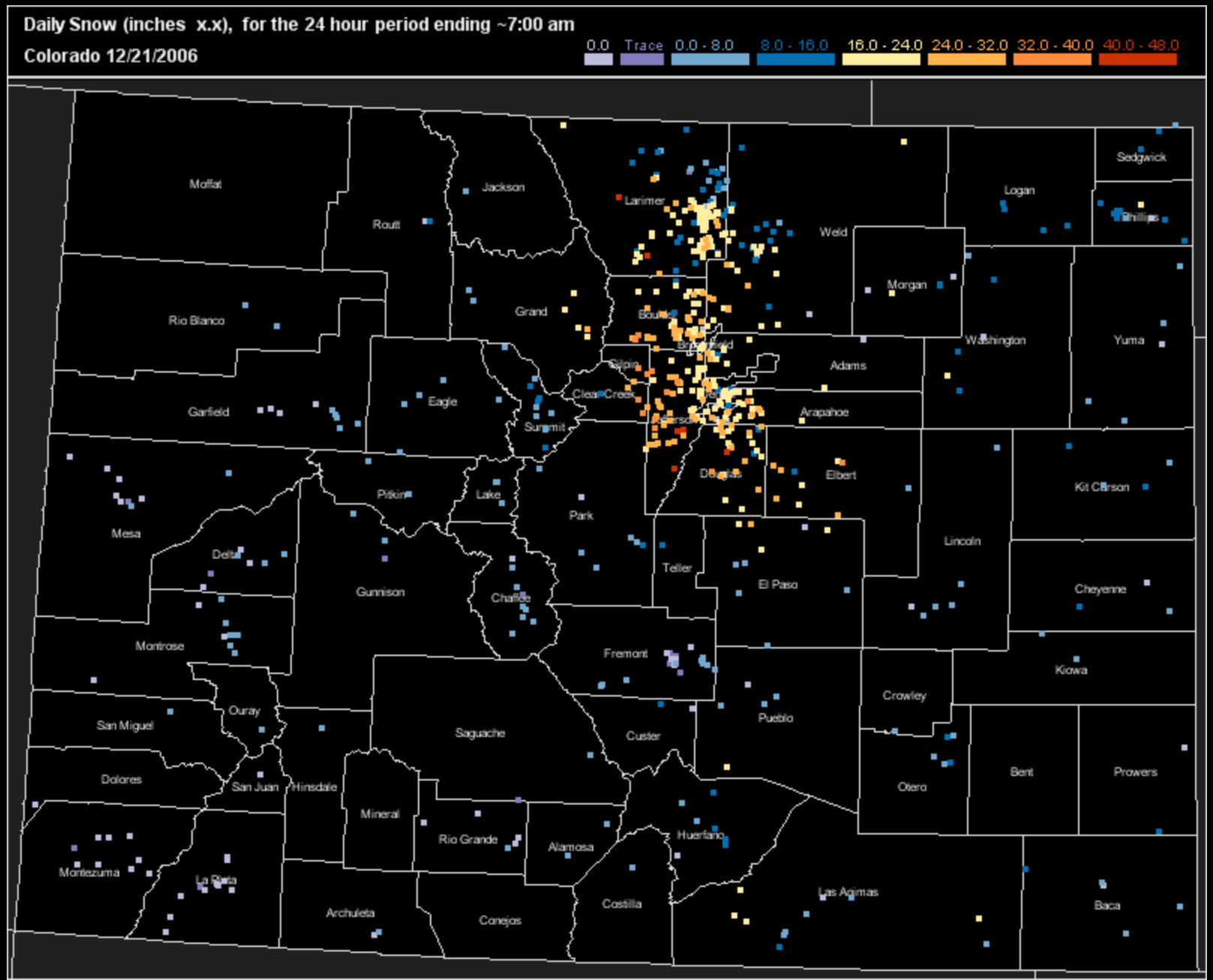
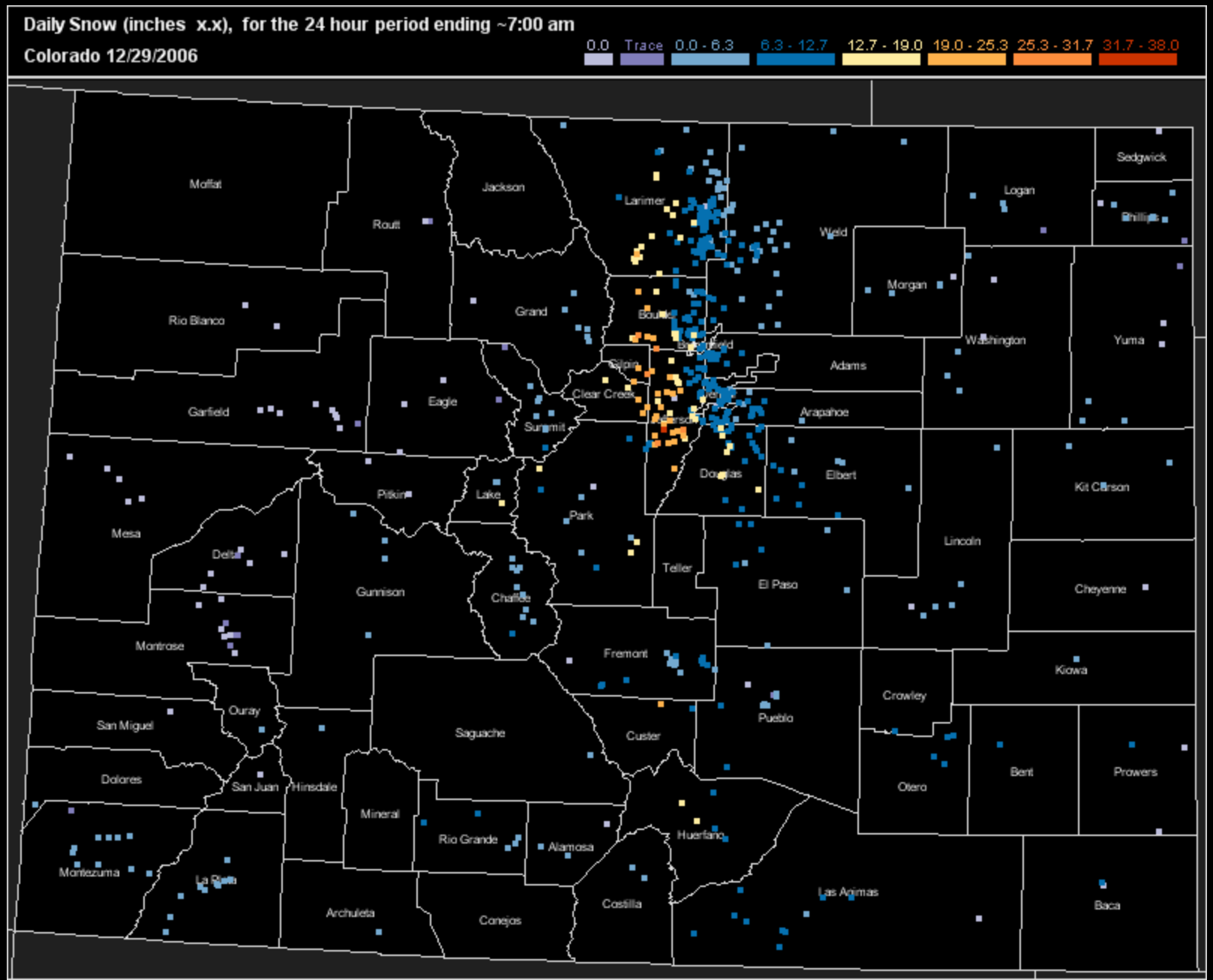

Daily Precipitation (inches x.xx), for the 24 hour period ending ~7:00 am
Boulder County, Colorado 10/21/2006
0.0
Trace
0.01 - 0.19
0.19 - 0.38
0.38 - 0.56
0.56 - 0.75
0.75 - 0.94
0.94 - 1.13
CoCoRaHS
Boulder County
Precipitation
October 21, 2006
Boulder
0.07
0.45
0.68
0.60
0.15
0.05
0.23
0.26
0.14
0.87
0.84
0.71
0.56
0.42
0.29
0.32
0.47
0.50
0.39
0.44
0.39
0.35
0.46
0.45
0.50
0.38
0.42


Photo by M. Wallace, CoCoRaHS observer

# CoCoRaHS snowfall map, Dec 21, 2006 Colorado Statewide



# CoCoRaHS snowfall map, Dec 29, 2006 Colorado Statewide



# For information, visit the CoCoRaHS Web Site

http://www.cocorahs.org

Support for this project provided by
NSF Informal Science Education Program,
NOAA Environmental Literacy Program
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# Colorado Climate Center

Data and Power Point Presentations available for downloading

http://ccc.atmos.colostate.edu

Colorado State University

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Colorado Climate Center