

Impacts of Climate Change on Water Resources Planning

Nolan Doesken

State Climatologist, Colorado Climate Center
Atmospheric Science Department
Colorado State University

Presented at Water Conservation Workshop, Grand Junction,
Colorado, July 10, 2007



Prepared by Odie Bliss



Should we be concerned about Climate Change?

Let's first consider our climate history.



Systematic weather data collection began in western Colorado in the 1890s

(Form 4.)

WAR DEPARTMENT.
SIGNAL SERVICE, U. S. ARMY.
DIVISION OF TELEGRAMS AND REPORTS FOR THE BENEFIT OF COMMERCE.

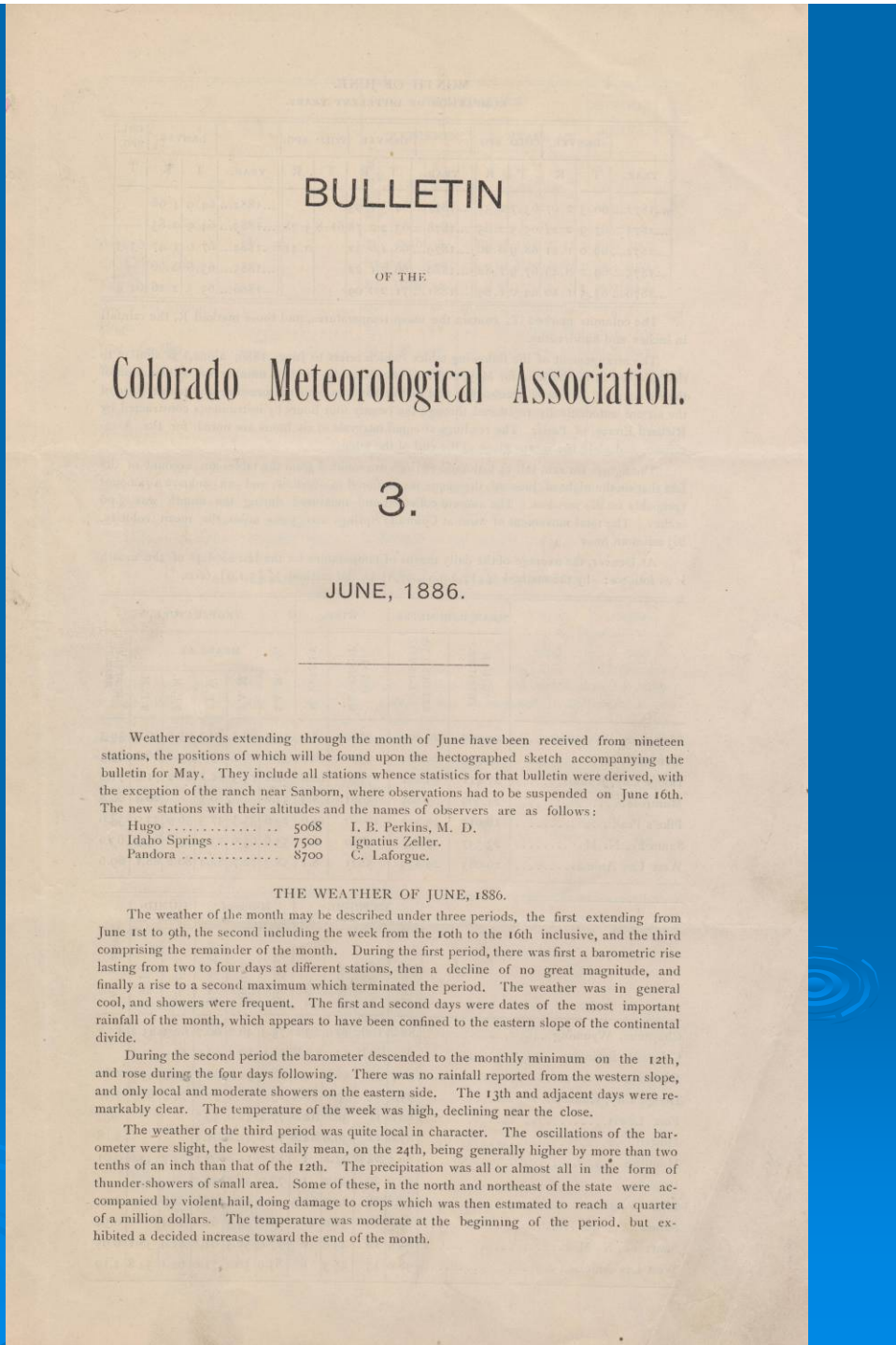
METEOROLOGICAL RECORD for the *Month* ending *Nov. 25th 1871* at *Denver, Col. Ter.*

Date of Observation.	Time of Observation.	Height of Barometer.	Height of attached Thermometers.	Reduced Barometer.	THERMOMETER. (OPEN AIR.)		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.	Remarks.
					Dry Bulb.	Wet Bulb.									
<i>1871</i>	<i>5:43 a.m.</i>	<i>25.00</i>	<i>57 22</i>	<i>30.07</i>	<i>22 21 46</i>	<i>21 18 46</i>	<i>Calad</i>	<i>0</i>	<i>0</i>	<i>4/4</i>		<i>11 a.m.</i>			<i>Light Snow</i>
	<i>2:43 p.m.</i>	<i>25.09</i>	<i>63 36</i>	<i>29.97</i>	<i>36 35 44</i>	<i>35 34 44</i>	<i>S</i>	<i>2</i>	<i>.02</i>	<i>0</i>					<i>Clear</i>
<i>Sunday Nov 19</i>	<i>4:43 p.m.</i>	<i>25.12</i>	<i>58 14</i>	<i>30.28</i>	<i>14 12 64</i>	<i>13 11 64</i>	<i>S</i>	<i>11</i>	<i>.60</i>	<i>0</i>					<i>Light Snow</i>
	<i>5:43 a.m.</i>	<i>25.00</i>	<i>57 22</i>	<i>30.07</i>	<i>22 21 46</i>	<i>21 18 46</i>	<i>Calad</i>	<i>0</i>	<i>0</i>	<i>4/4</i>		<i>11 a.m.</i>	<i>8 p.m.</i>	<i>Blacks</i>	<i>Light Snow</i>
	<i>2:43 p.m.</i>	<i>25.09</i>	<i>63 36</i>	<i>29.97</i>	<i>36 35 44</i>	<i>35 34 44</i>	<i>S</i>	<i>2</i>	<i>.02</i>	<i>0</i>	<i>72</i>				<i>Clear</i>
<i>Monday Nov 20</i>	<i>1:43 p.m.</i>	<i>25.12</i>	<i>58 14</i>	<i>30.28</i>	<i>14 12 64</i>	<i>13 11 64</i>	<i>S</i>	<i>11</i>	<i>.60</i>	<i>0</i>					<i>Light Snow</i>
	<i>5:43 a.m.</i>	<i>24.99</i>	<i>50 21</i>	<i>30.07</i>	<i>21 19 57</i>	<i>18 17 57</i>	<i>S</i>	<i>13</i>	<i>.84</i>	<i>1/4</i>	<i>24</i>				<i>Stratus</i>
	<i>2:43 p.m.</i>	<i>24.88</i>	<i>56 43</i>	<i>29.67</i>	<i>43 34 28</i>	<i>42 33 28</i>	<i>NW</i>	<i>18</i>	<i>1.62</i>	<i>4/4</i>	<i>103</i>				<i>Stratus</i>
<i>Tuesday Nov 21</i>	<i>9:43 p.m.</i>	<i>24.88</i>	<i>58 39</i>	<i>29.70</i>	<i>39 34 53</i>	<i>38 33 53</i>	<i>NW</i>	<i>2</i>	<i>.02</i>	<i>4/4</i>	<i>103</i>				<i>Stratus</i>
	<i>5:43 a.m.</i>	<i>24.70</i>	<i>55 31</i>	<i>29.59</i>	<i>34 29 79</i>	<i>33 24 79</i>	<i>S.W.</i>	<i>4</i>	<i>.08</i>	<i>4/4</i>	<i>97</i>				<i>Stratus</i>
	<i>2:43 p.m.</i>	<i>24.37</i>	<i>62 35</i>	<i>29.50</i>	<i>35 32 70</i>	<i>34 27 70</i>	<i>W</i>	<i>2</i>	<i>.02</i>	<i>4/4</i>	<i>97</i>				<i>"</i>
<i>Wednesday Nov 22</i>	<i>4:43 p.m.</i>	<i>24.71</i>	<i>61 31</i>	<i>29.59</i>	<i>31 30 89</i>	<i>30 29 89</i>	<i>S</i>	<i>10</i>	<i>.50</i>	<i>4/4</i>	<i>52.3</i>	<i>3 p.m.</i>		<i>.26</i>	<i>Light Snow</i>
	<i>5:43 a.m.</i>	<i>24.54</i>	<i>55 25</i>	<i>29.47</i>	<i>25 24 87</i>	<i>24 23 87</i>	<i>S</i>	<i>6</i>	<i>.18</i>	<i>4/4</i>	<i>90</i>		<i>10:30 a.m.</i>		<i>Stratus</i>
	<i>2:43 p.m.</i>	<i>24.31</i>	<i>63 34</i>	<i>29.06</i>	<i>34 33 89</i>	<i>33 32 89</i>	<i>NW</i>	<i>5</i>	<i>.12</i>	<i>4/4</i>	<i>30</i>				<i>Light Snow</i>
<i>Thursday Nov 23</i>	<i>9:43 p.m.</i>	<i>24.20</i>	<i>60 31</i>	<i>28.97</i>	<i>31 30 89</i>	<i>30 29 89</i>	<i>S</i>	<i>9</i>	<i>.40</i>	<i>3/4</i>	<i>SE</i>				<i>"</i>
	<i>5:43 a.m.</i>	<i>24.36</i>	<i>56 32</i>	<i>29.17</i>	<i>32 32 100</i>	<i>31 31 100</i>	<i>S.W.</i>	<i>4</i>	<i>.08</i>	<i>4/4</i>	<i>101</i>		<i>8 a.m.</i>	<i>.21</i>	<i>Cloudy</i>
	<i>2:43 p.m.</i>	<i>24.37</i>	<i>70 42</i>	<i>29.04</i>	<i>42 37 58</i>	<i>41 36 58</i>	<i>S</i>	<i>2</i>	<i>.02</i>	<i>2/4</i>	<i>33.7</i>				<i>Light Snow</i>
<i>Friday Nov 24</i>	<i>9:43 p.m.</i>	<i>24.38</i>	<i>65 27</i>	<i>29.23</i>	<i>27 27 100</i>	<i>26 26 100</i>	<i>N.W.</i>	<i>2</i>	<i>.02</i>	<i>4/4</i>					<i>Fog</i>
	<i>5:43 a.m.</i>	<i>24.37</i>	<i>58 32</i>	<i>29.17</i>	<i>32 28 64</i>	<i>31 27 64</i>	<i>S.W.</i>	<i>7</i>	<i>.24</i>	<i>1/4</i>	<i>98</i>				<i>Stratus</i>
	<i>2:43 p.m.</i>	<i>24.42</i>	<i>70 49</i>	<i>29.03</i>	<i>49 39 31</i>	<i>48 29 31</i>	<i>S.E.</i>	<i>2</i>	<i>.02</i>	<i>2/4</i>	<i>32.7</i>				<i>Stratus</i>
<i>Saturday Nov 25</i>	<i>9:43 a.m.</i>	<i>24.60</i>	<i>68 17</i>	<i>29.60</i>	<i>17 15 75</i>	<i>16 14 75</i>	<i>N.E.</i>	<i>18</i>	<i>1.62</i>	<i>3/4</i>					<i>Light scud fl</i>

2381

Denver November 19-25, 1871 *Henry J. Foster, Observer*

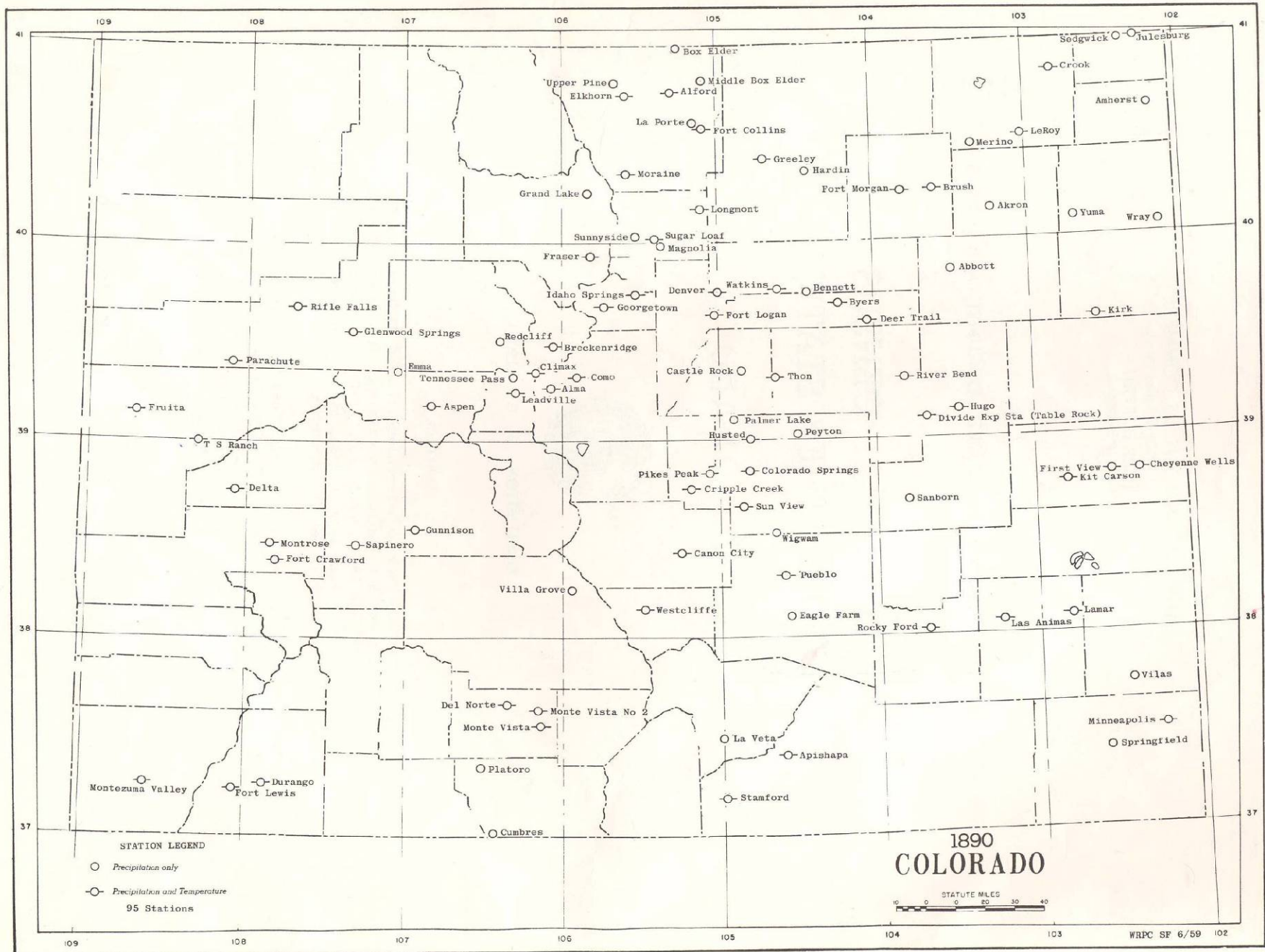
In the 1880s the Colorado legislature approved and funded the “Colorado Meteorological Association” to better monitor and document the climatic resources of our young state.




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

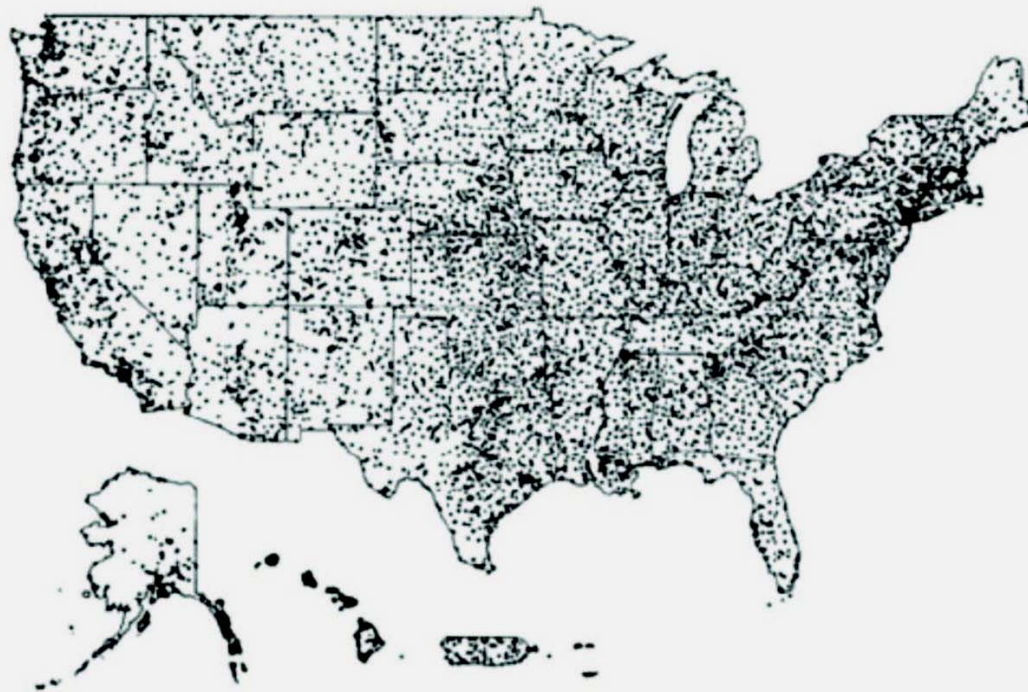




Since then, the U.S. Weather Bureau/National Weather Service has faithfully maintained an oft taken for granted network of weather stations in Colorado and across the country – the Cooperative Observer Network

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

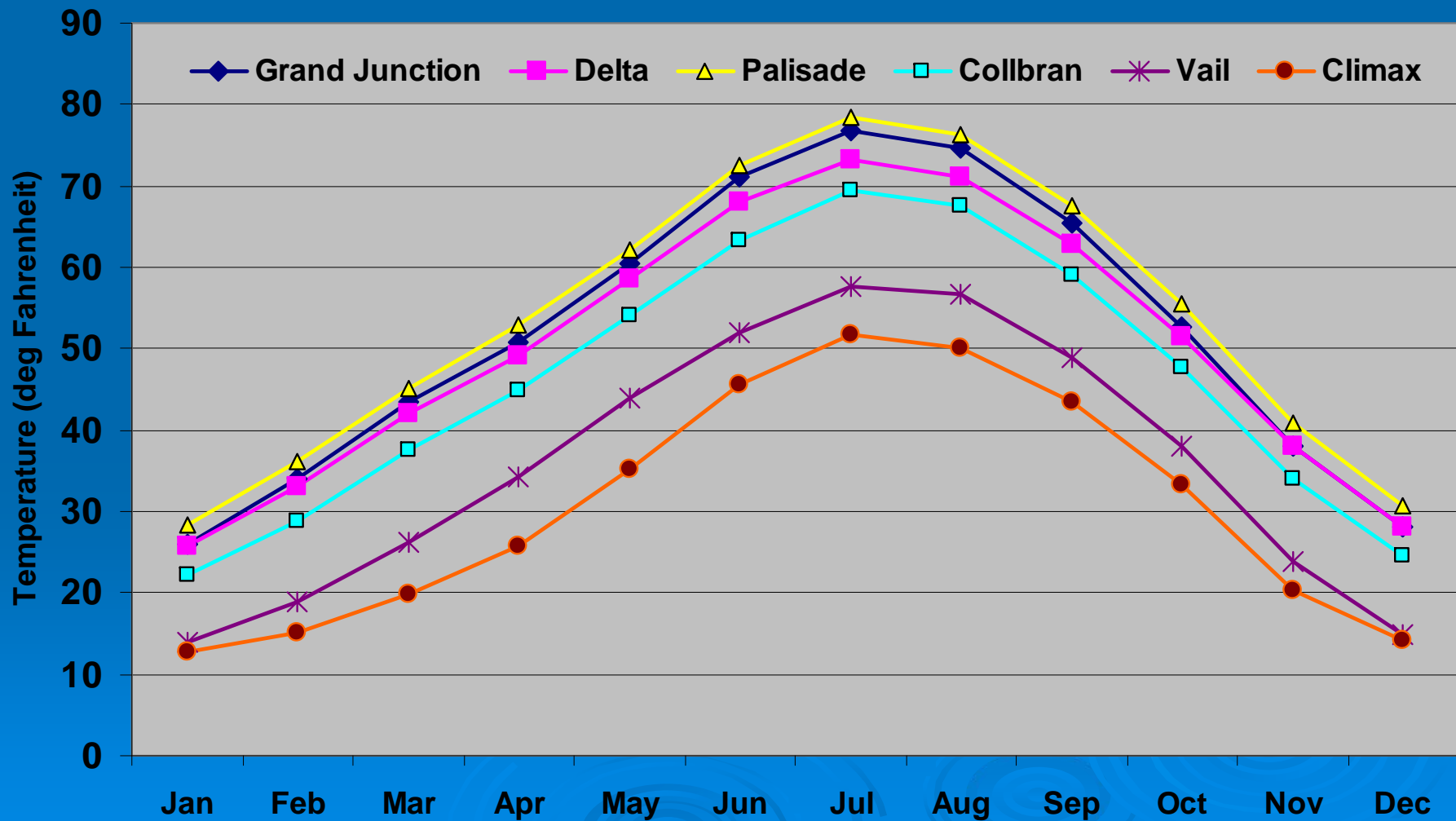


**What have we learned
from nearly 120 years of
continuous climate
monitoring?**

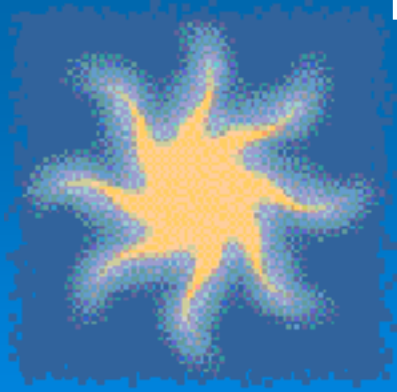


Winters are consistently colder than summers – ☺

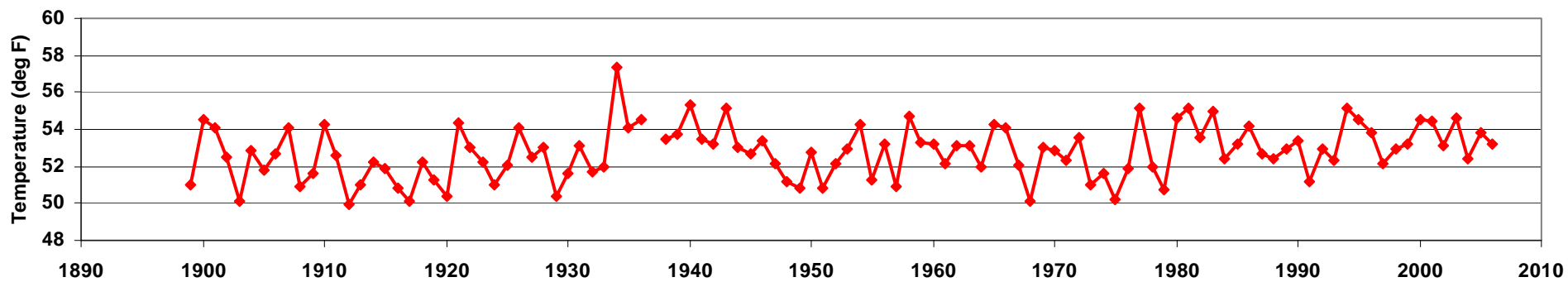
Average Monthly Temperature (9171-2000) for Selected Station



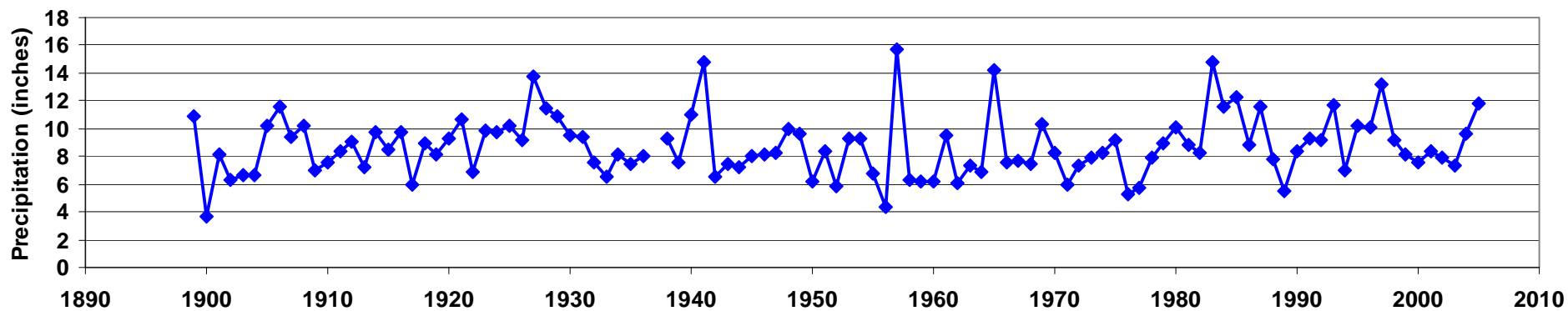
Temperatures are far more stable than precipitation. In fact most other climatic elements (humidity, wind, sunshine and cloudiness, evaporation, etc.) are much more consistent from one year to the next than precipitation



Grand Junction Annual Mean Temperatures

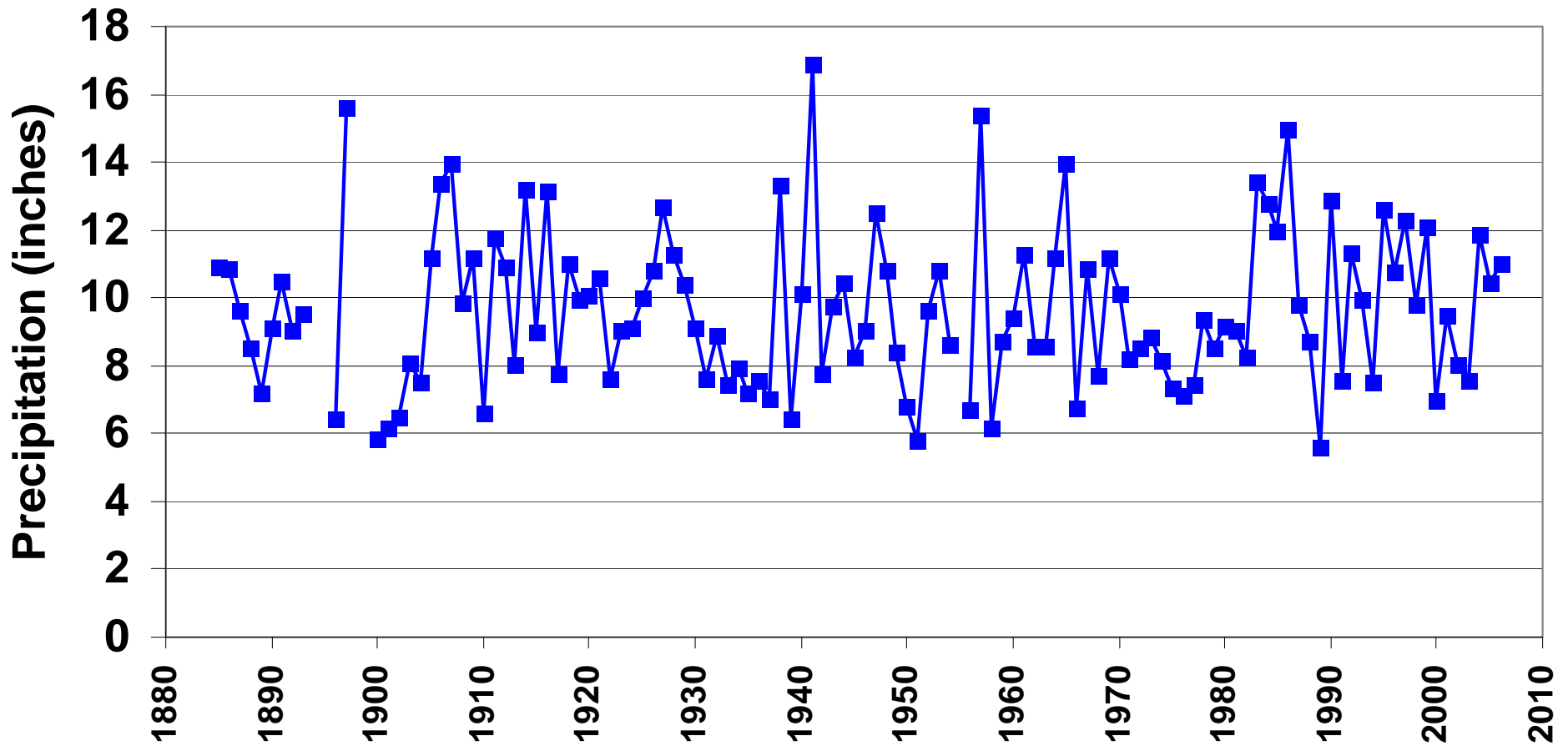


Grand Junction Annual Average Precipitation (inches)

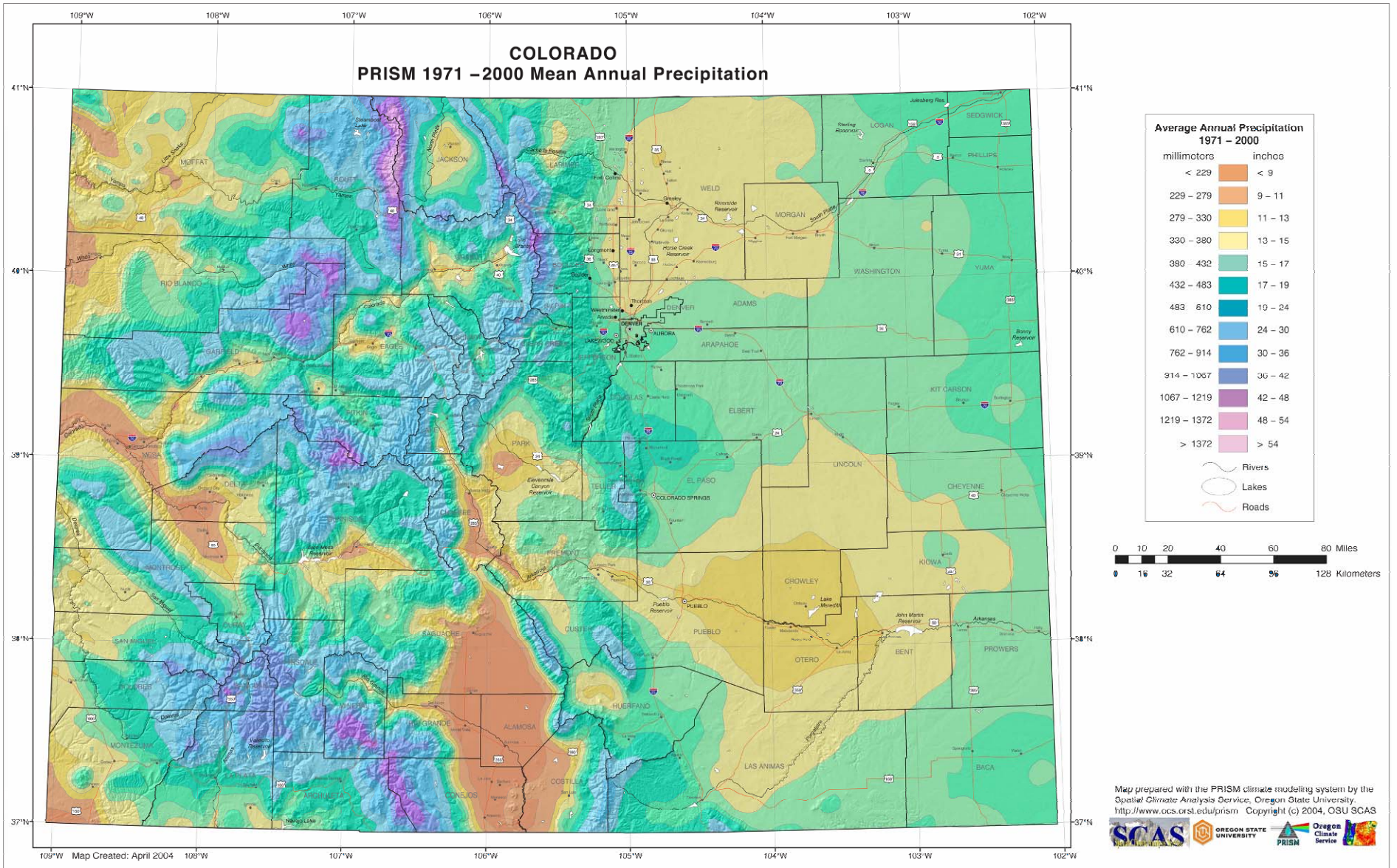


Precipitation varies by as much as 400% from a very dry year to a very wet year

Montrose Annual Precipitation

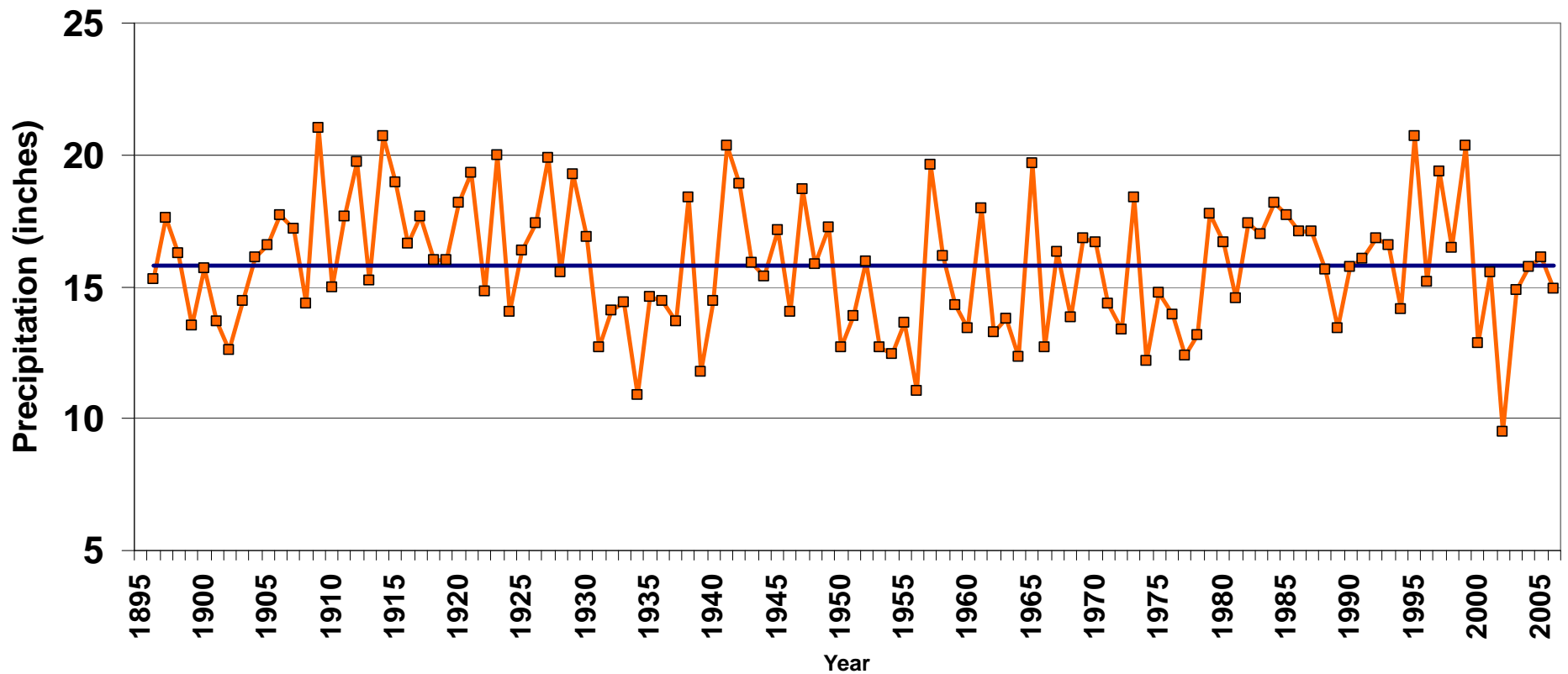


Colorado Average Annual Precipitation



Colorado Statewide Water Year Precipitation

Colorado Statewide Water Year (Oct-Sep) Precipitation
from 1896 - 2006



Drought Visits Our Area Regularly

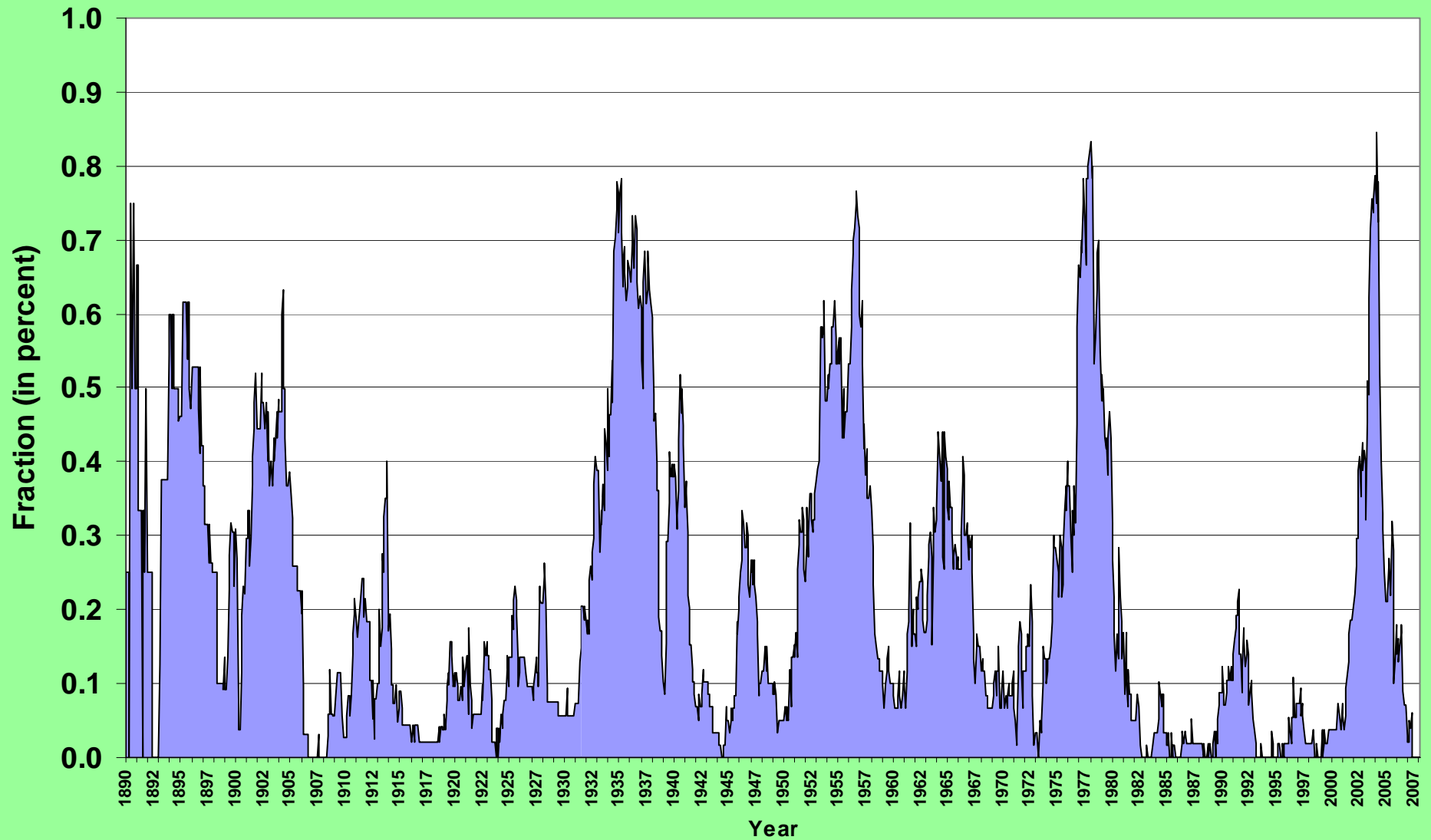


Photo by NRCS

Fraction of Colorado in Drought

Based on 48 month SPI


(1890 - May 2007)



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



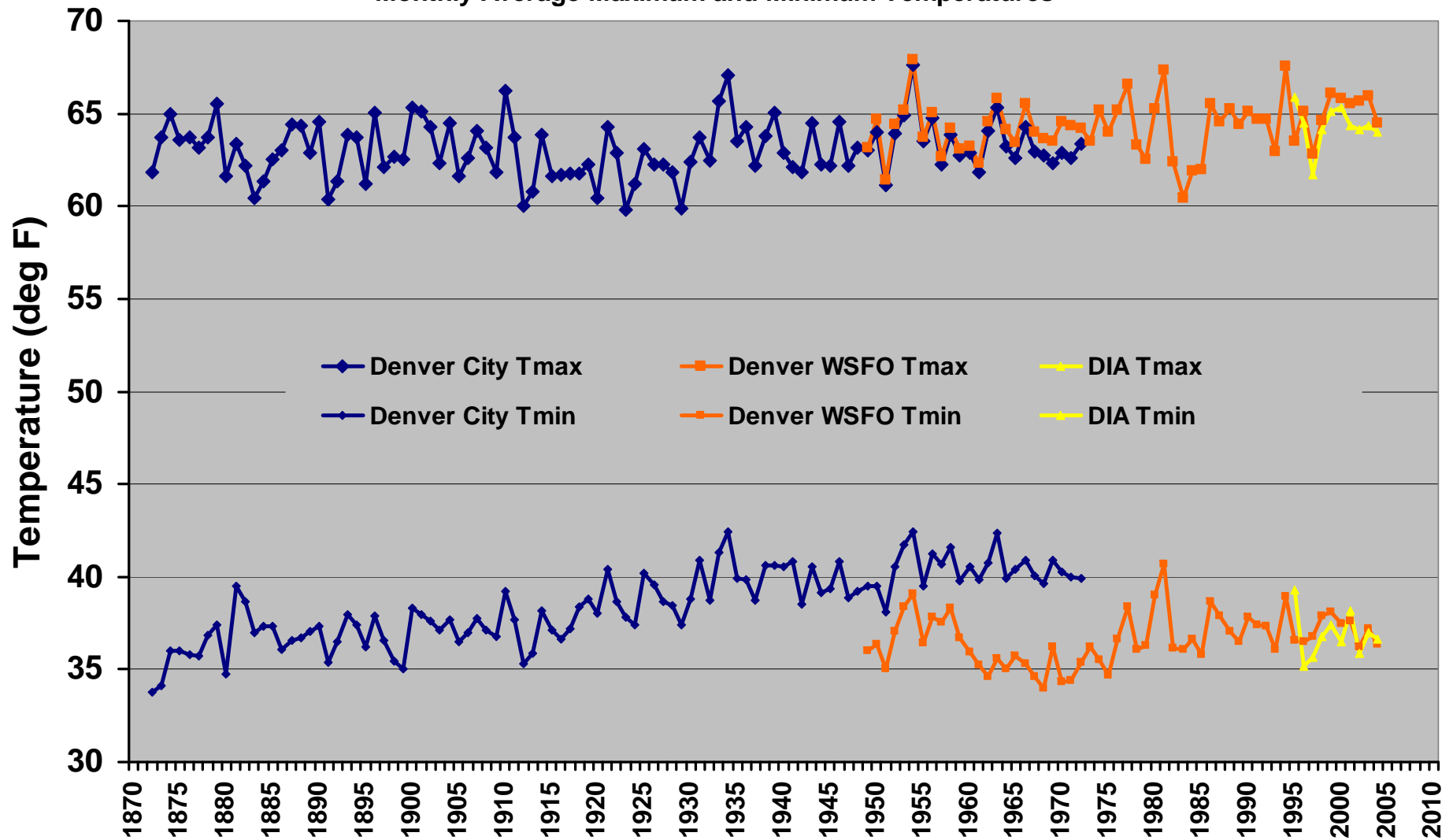
We can find many frustrating limitations to our climate records:

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

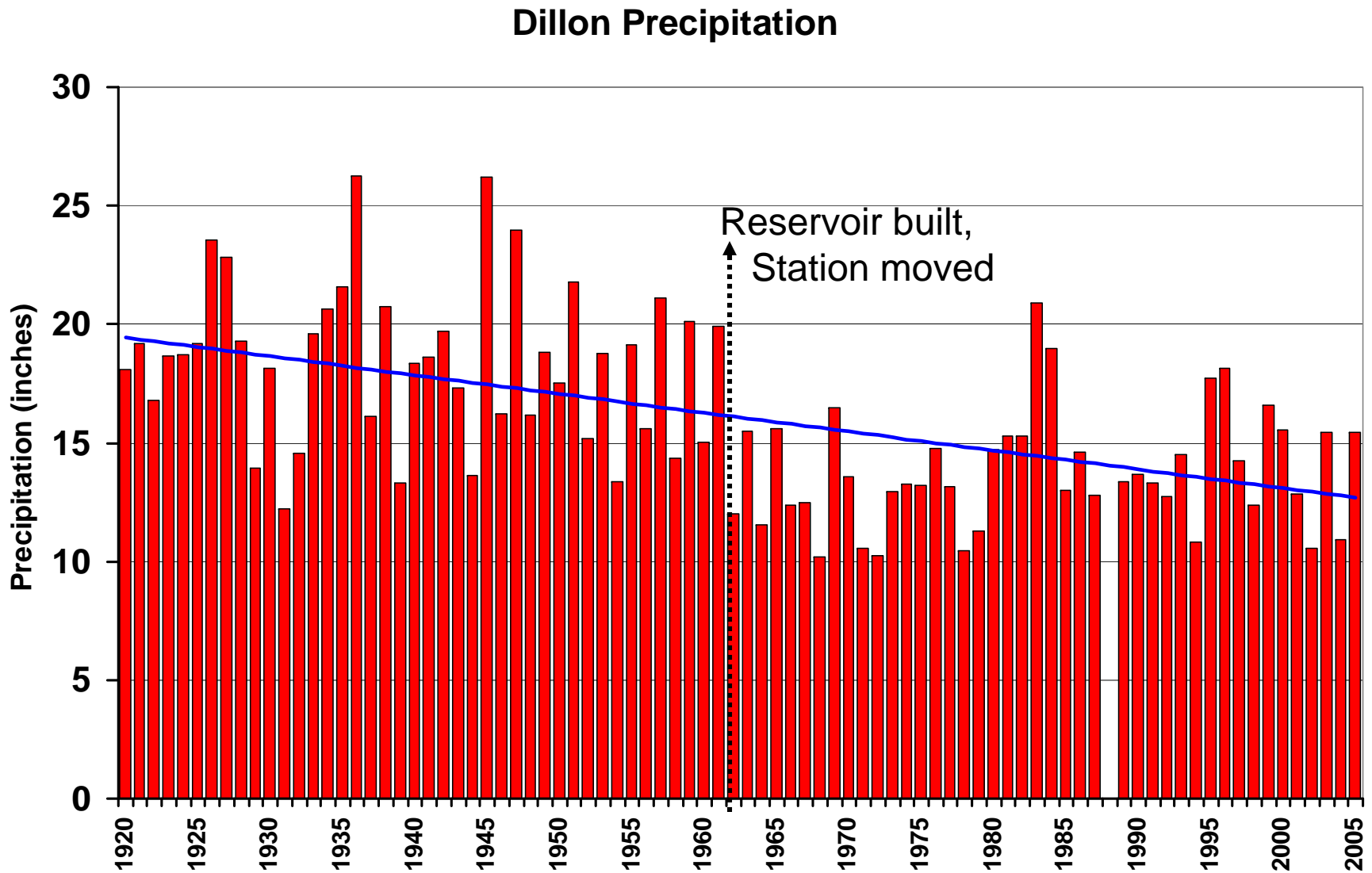
Denver All Stations

Denver (all 3 stations)

Monthly Average Maximum and Minimum Temperatures

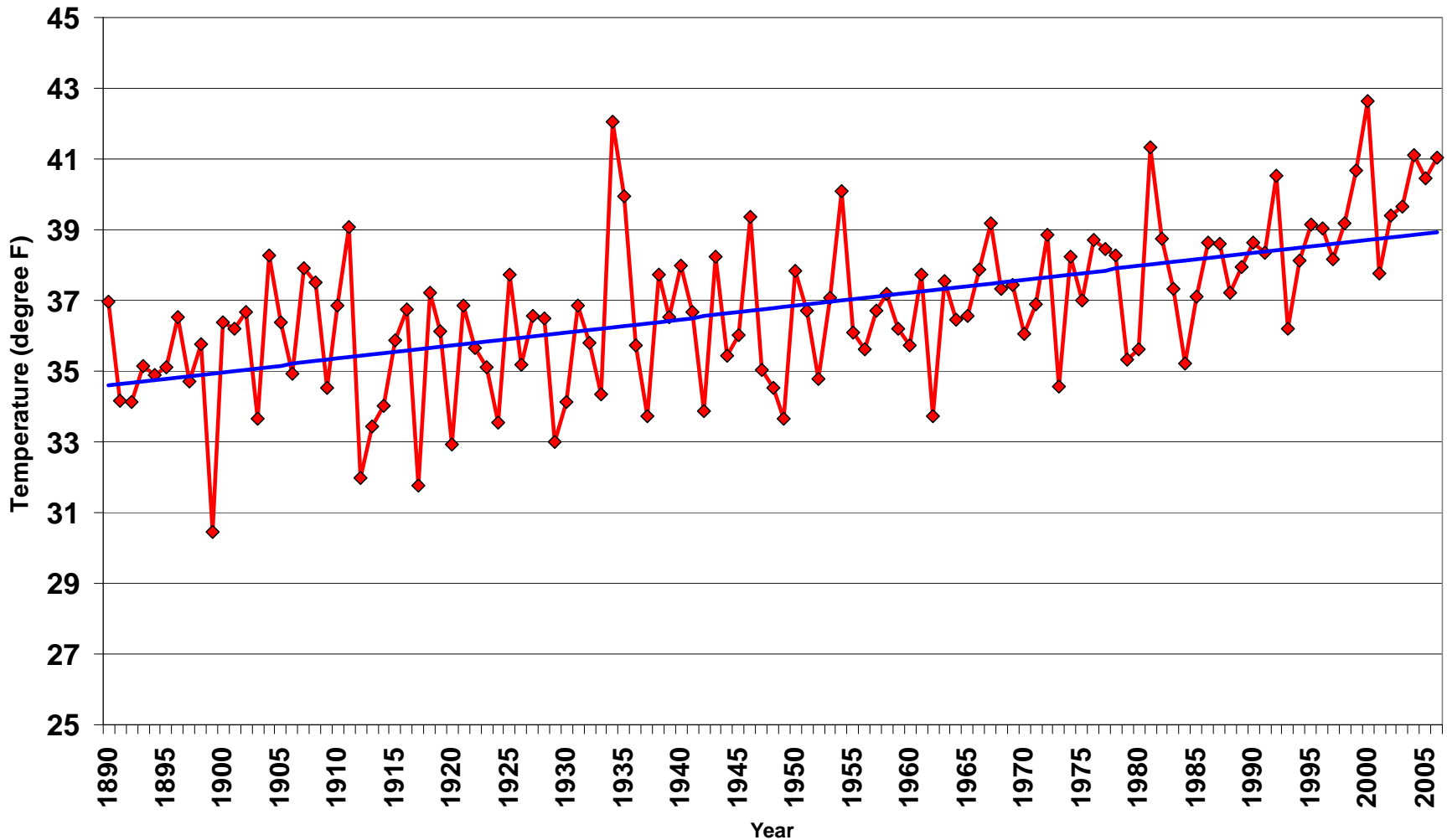


Dillon Annual Precipitation



Fort Collins Winter Temperatures

Fort Collins Water Year Average Temperatures
for Winter (Oct-Apr)

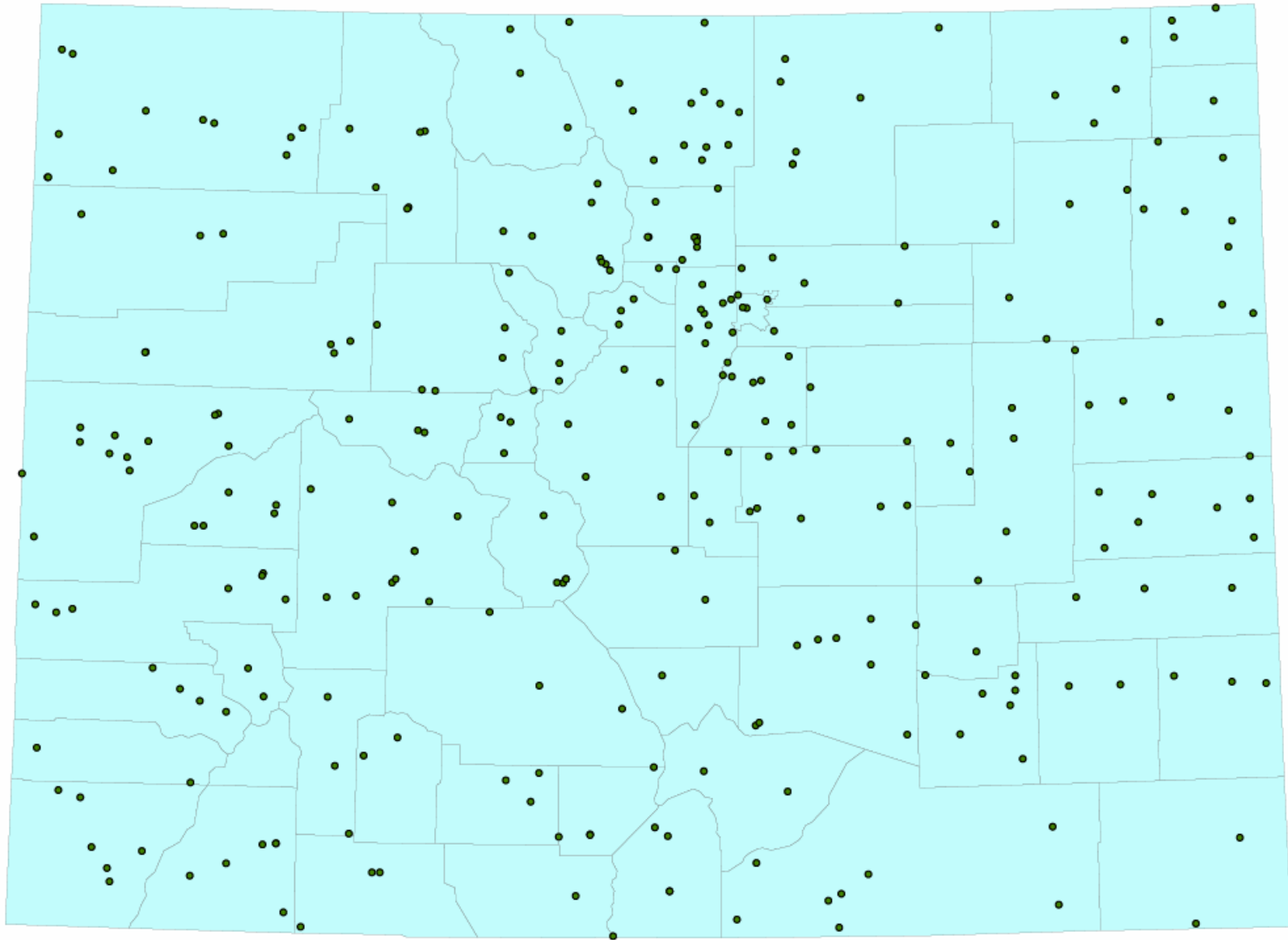


Still, our climate records are more complete, consistent, and widespread than nearly all other forms of long-term environmental monitoring (i.e. we shouldn't whine).



Colorado Cooperative Stations

COLORADO

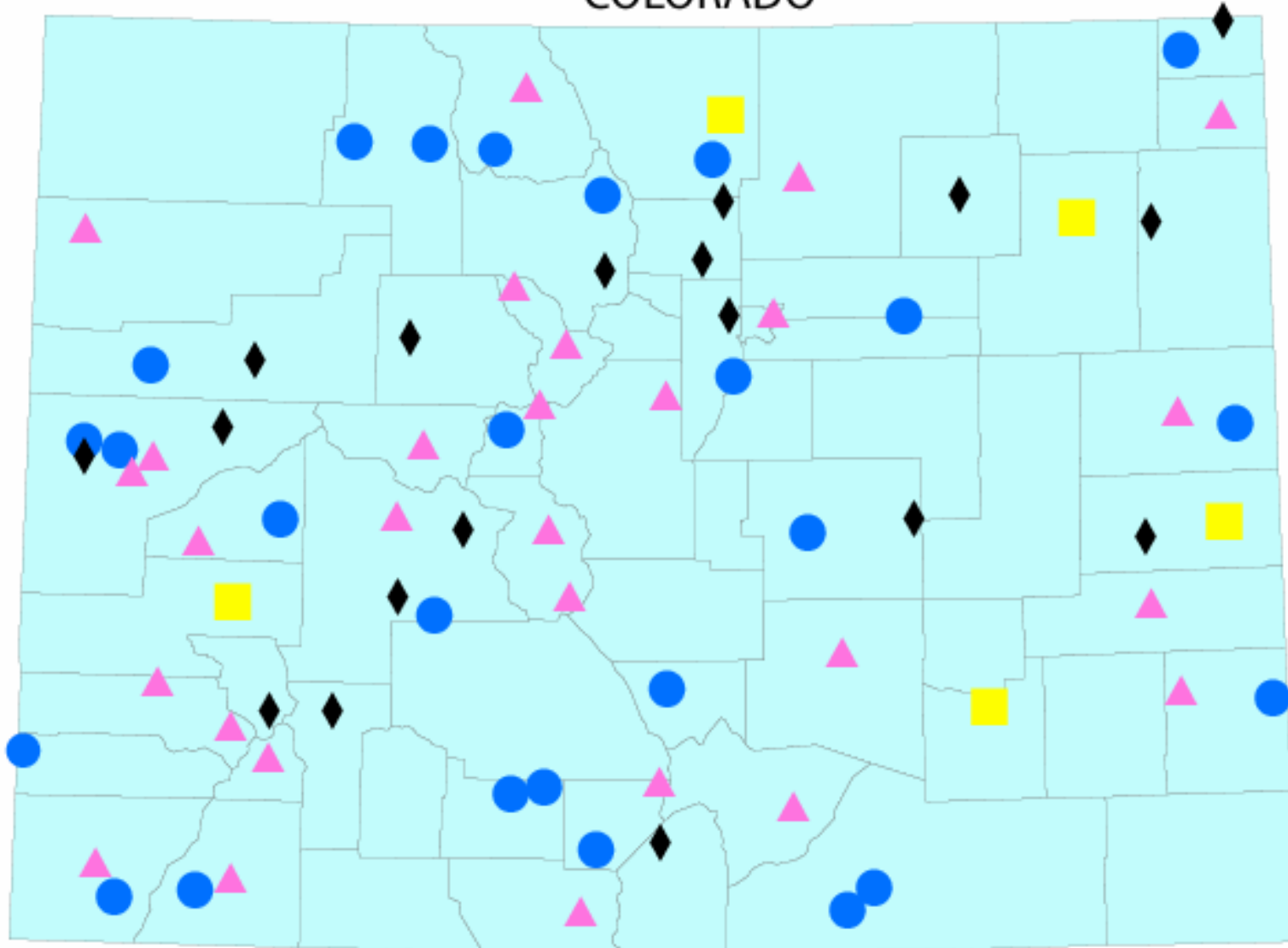



Long-Term Analysis Stations

COLORADO

Legend

- ▲ Good
- ◆ Useful
- Better
- Best



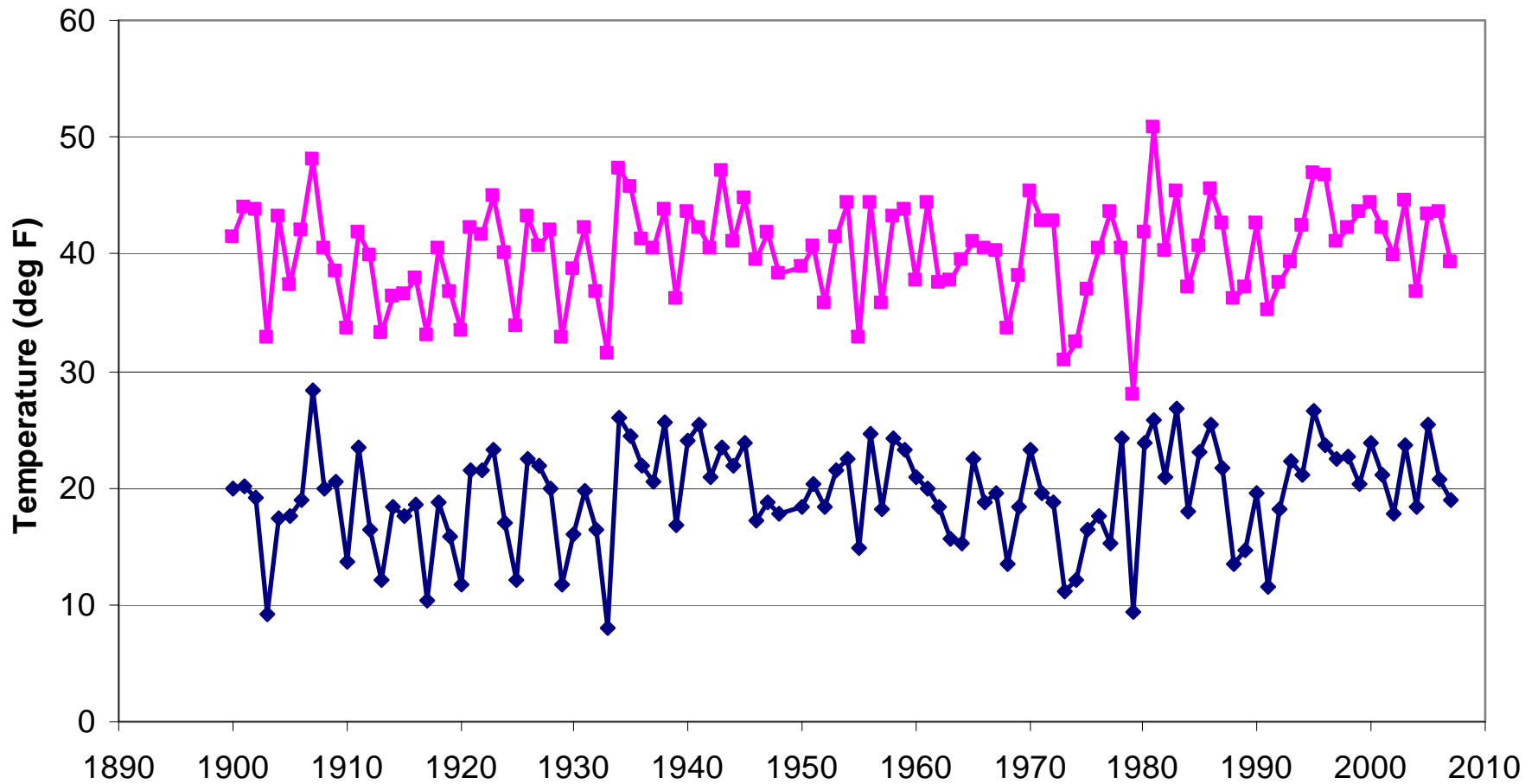


Recently, upward trends in seasonal temperatures have become noticeable in parts of Colorado

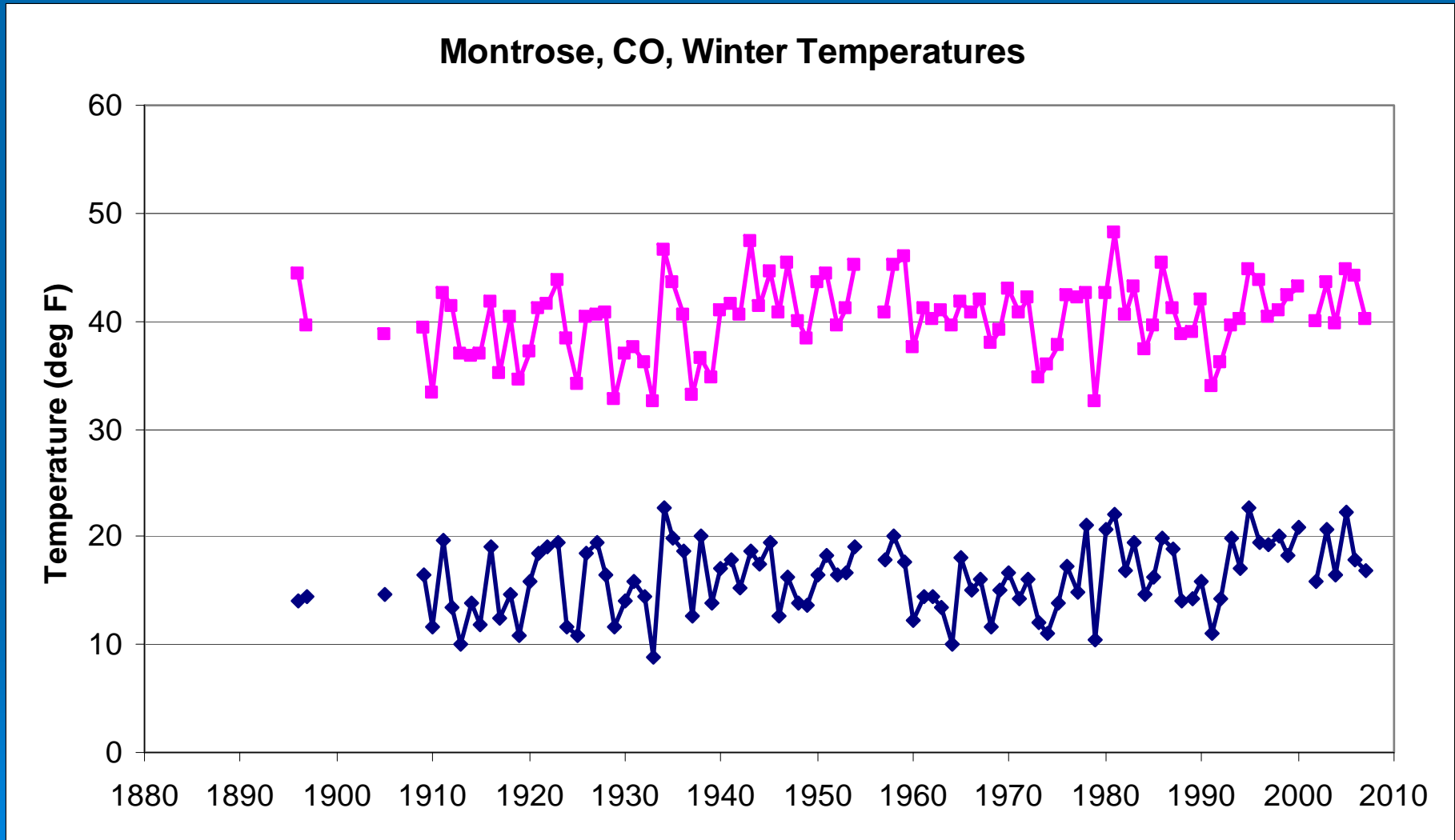
That may be significant for water users/planners whether or not precipitation is changing

Grand Junction Winter Temperatures

Grand Junction, CO, Winter Average Temperatures

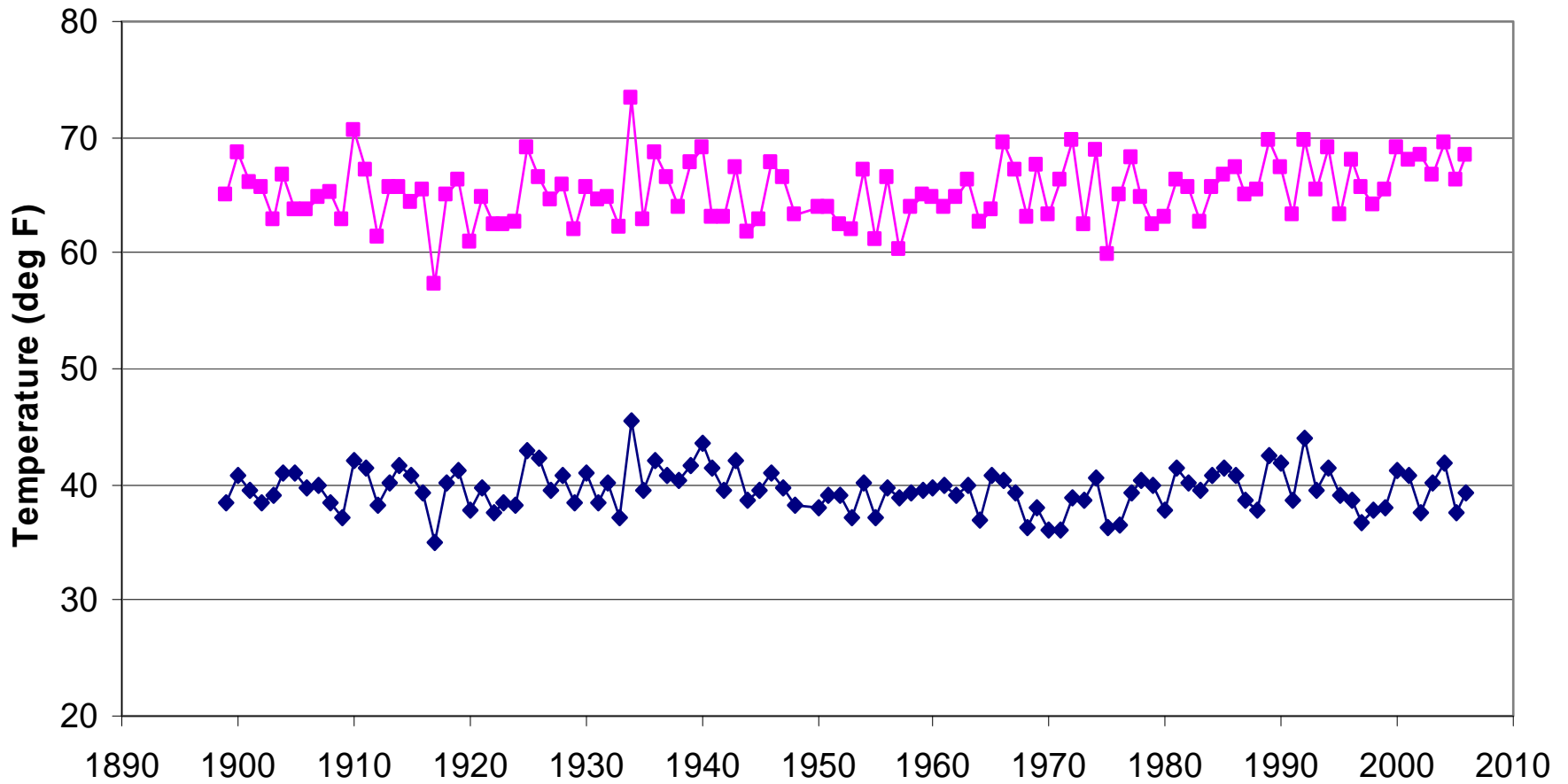


Montrose Winter Temperatures

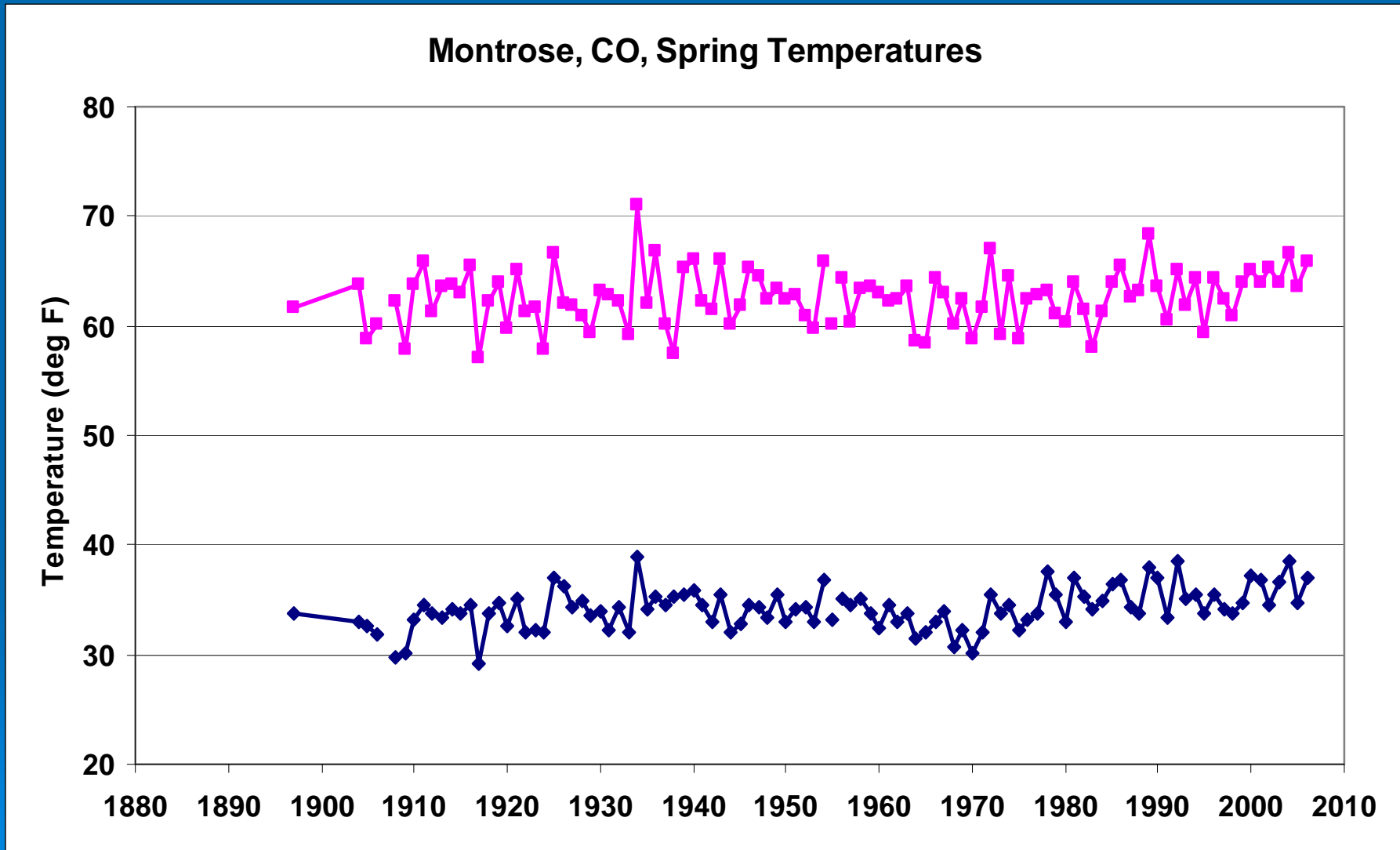


Grand Junction Spring Temperatures

Grand Junction, CO, Spring Average Temperatures

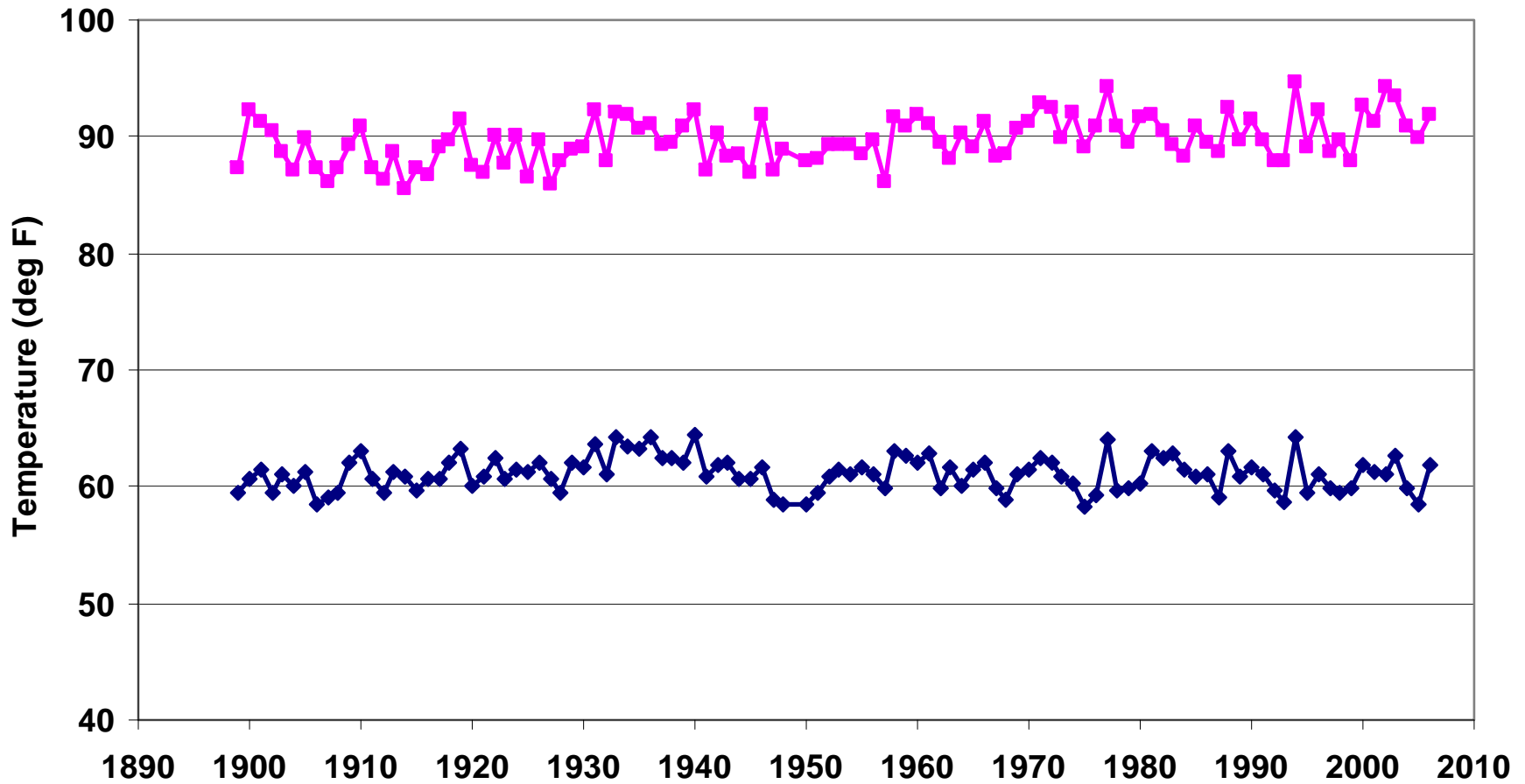


Montrose Spring Temperatures

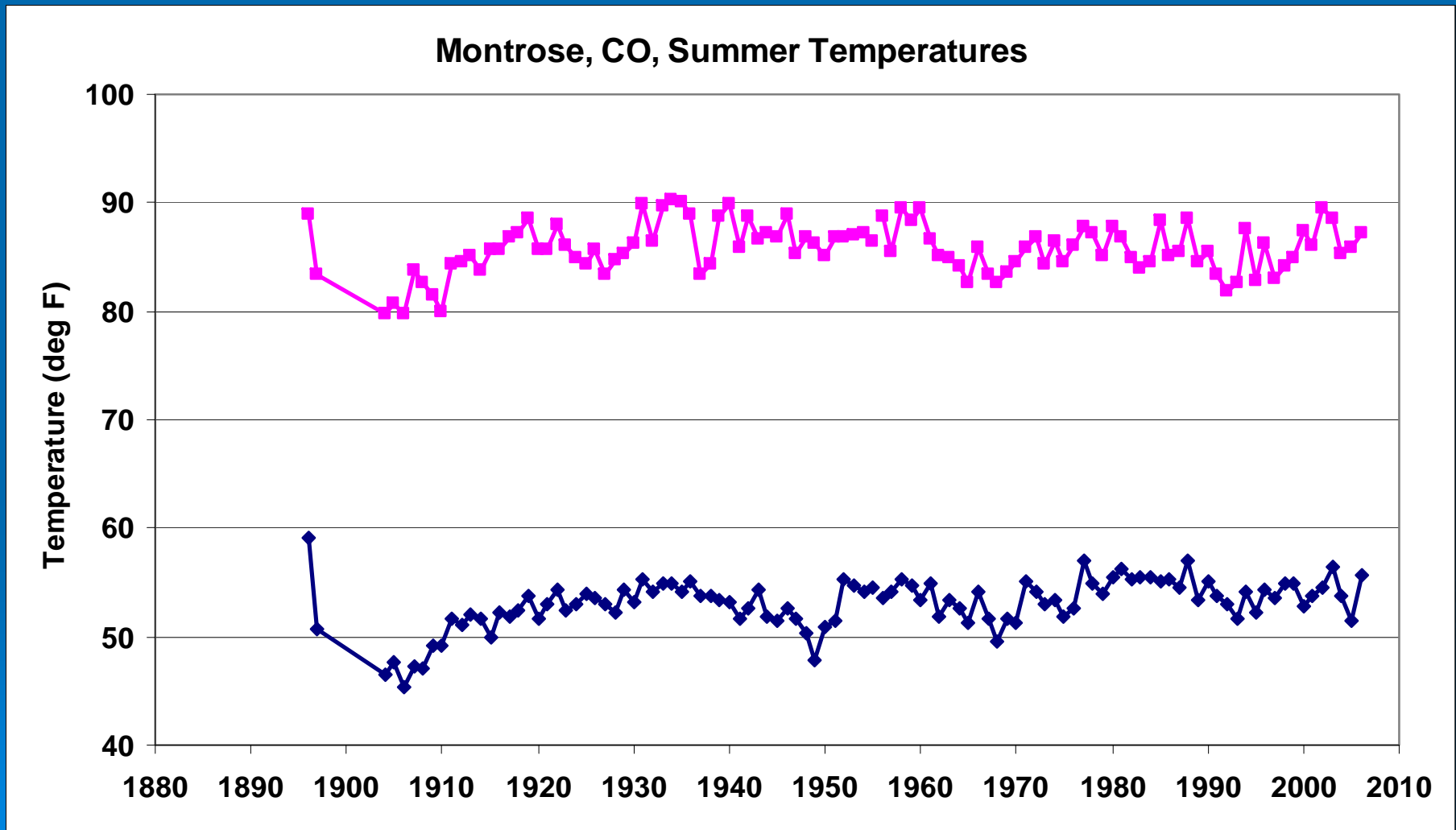


Grand Junction Summer Temperatures

Grand Junction, CO, Summer Average Temperatures

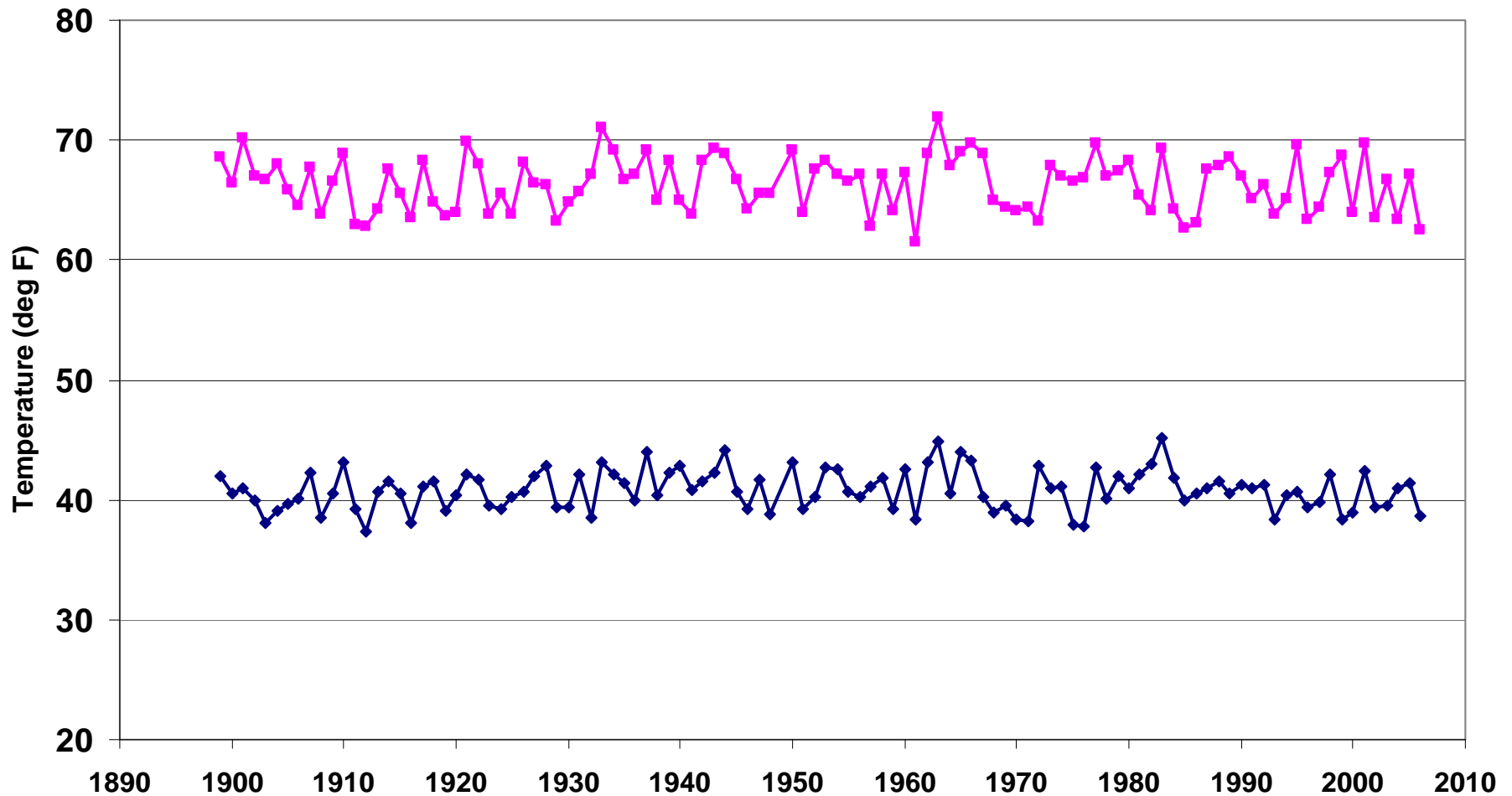


Montrose Summer Temperatures

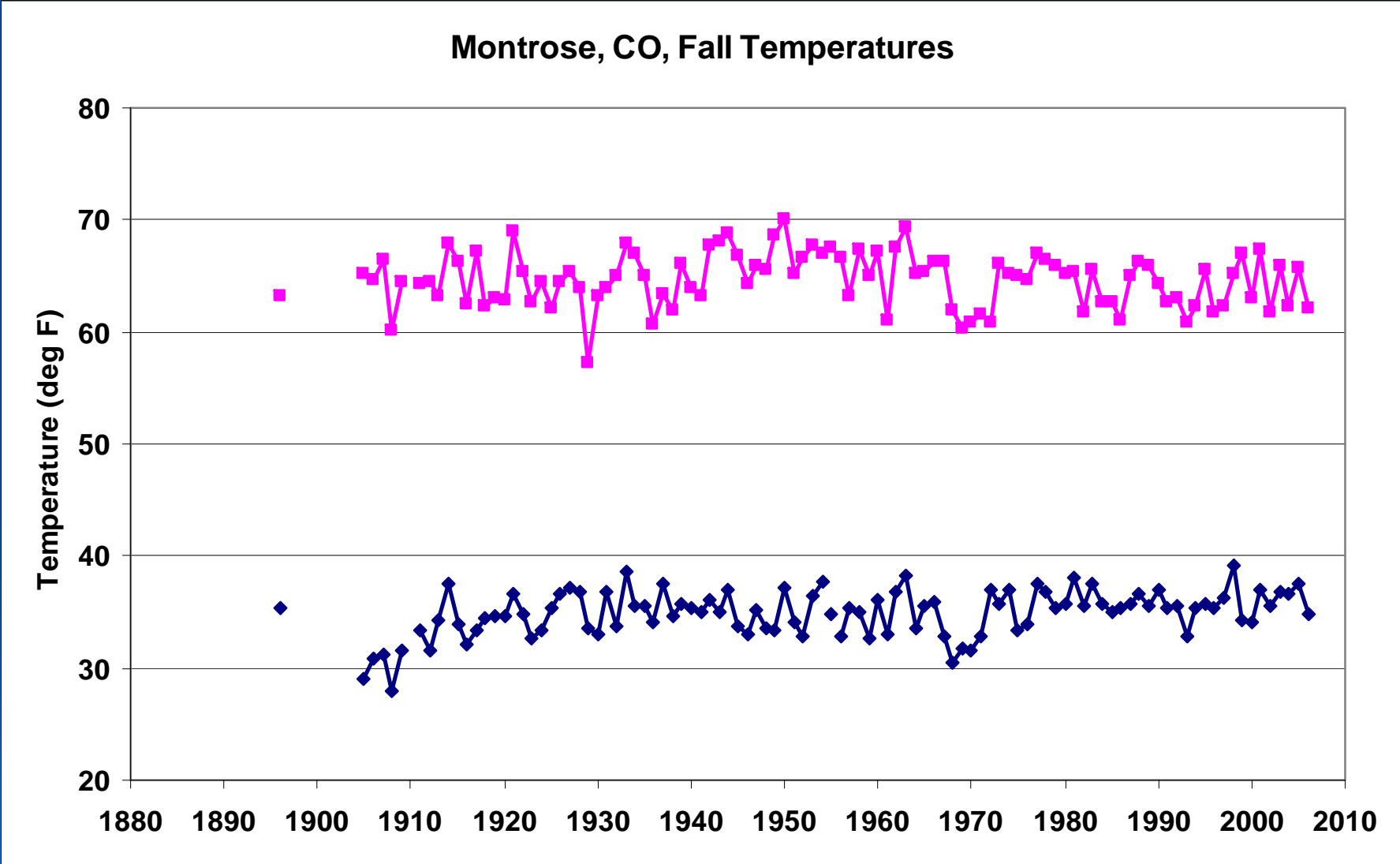


Grand Junction Fall Temperatures

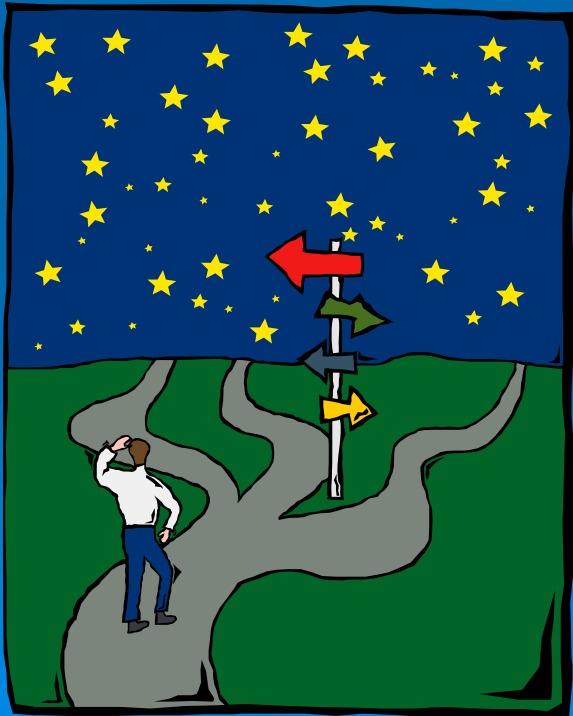
Grand Junction, CO, Fall Average Temperatures



Montrose Fall Temperatures



With even the best
stations, there is
uncertainty

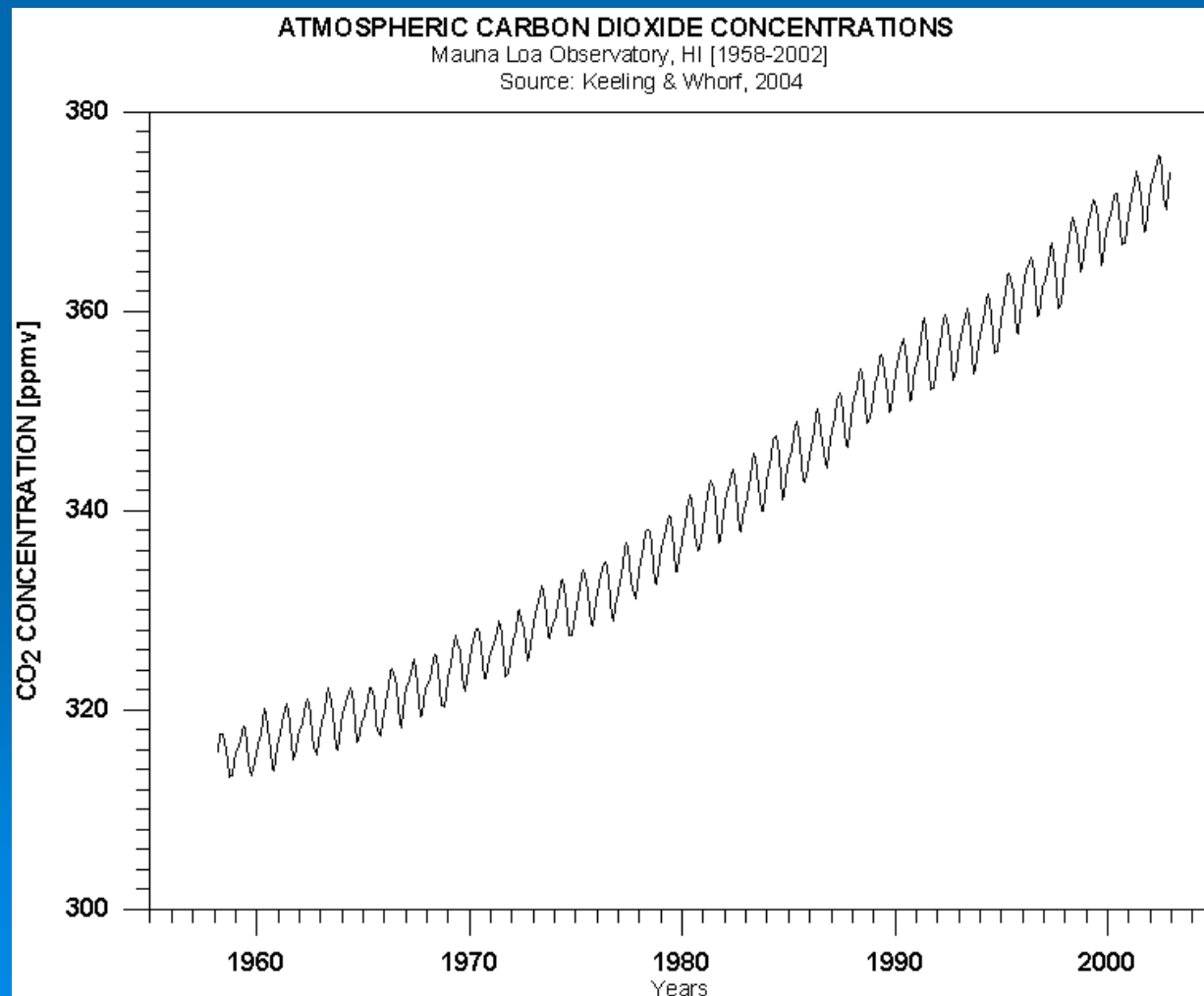


Should Water Resource Planners be concerned about Climate Change?

- The trends so far are subtle, but soon that may not be the case.

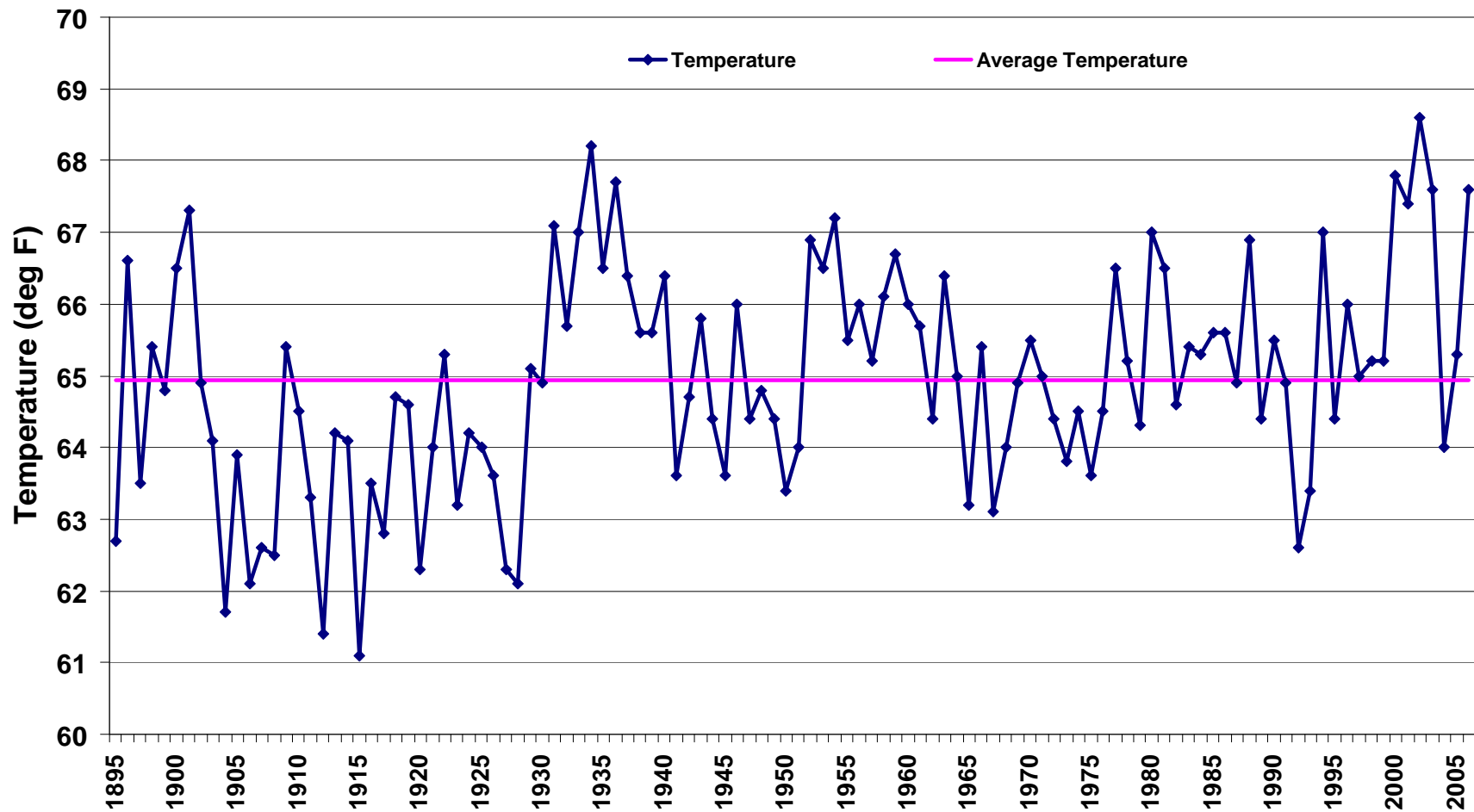


If climate is changing (man caused or otherwise), it will still be a long time before we can tell if our precipitation patterns are changing.



Temperature Trends will be Easier to Detect

Colorado Statewide Average Summer (Jun-Aug) Temperature (1895-2006)

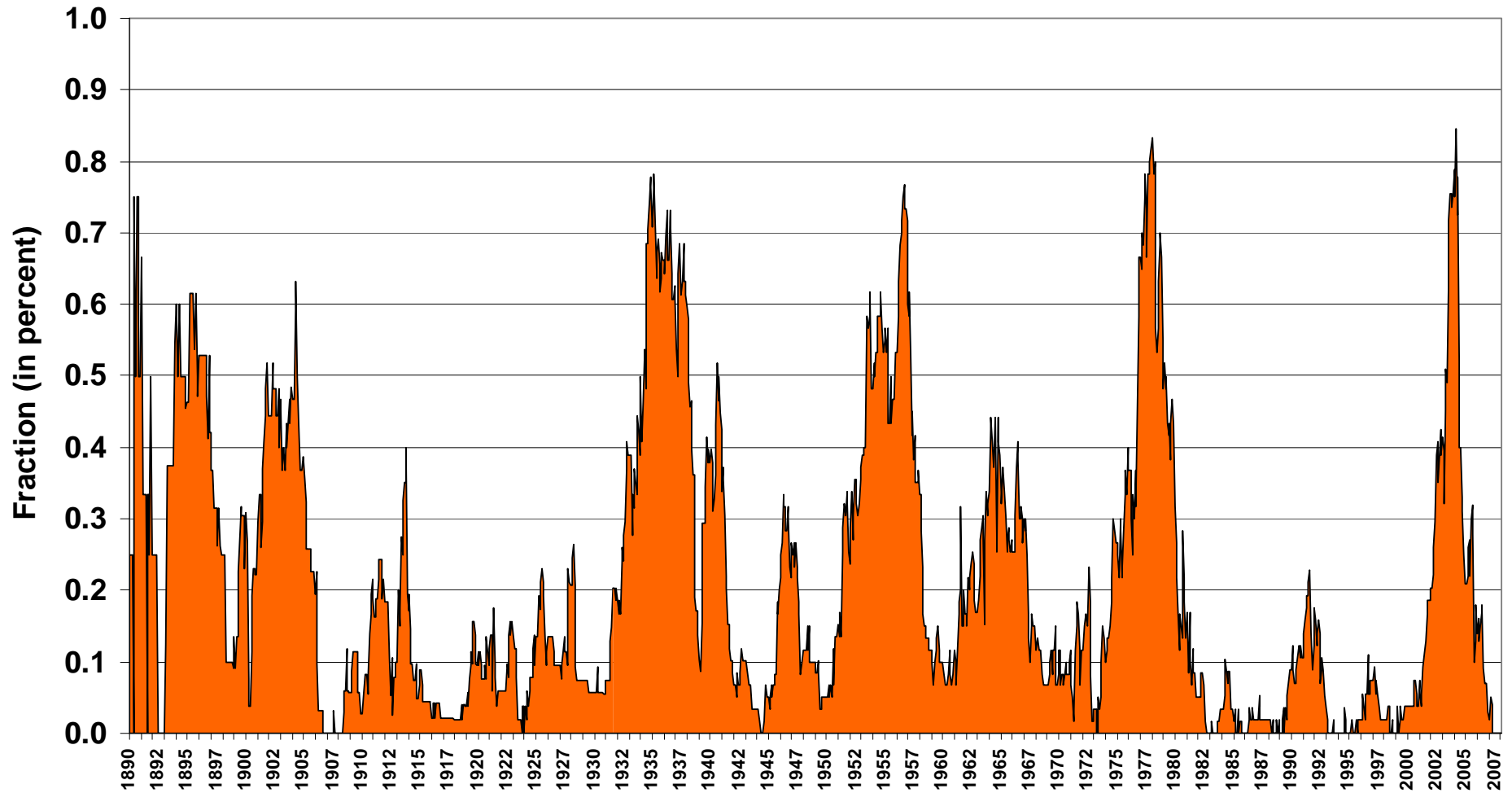


What should we do??



Always plan for drought!

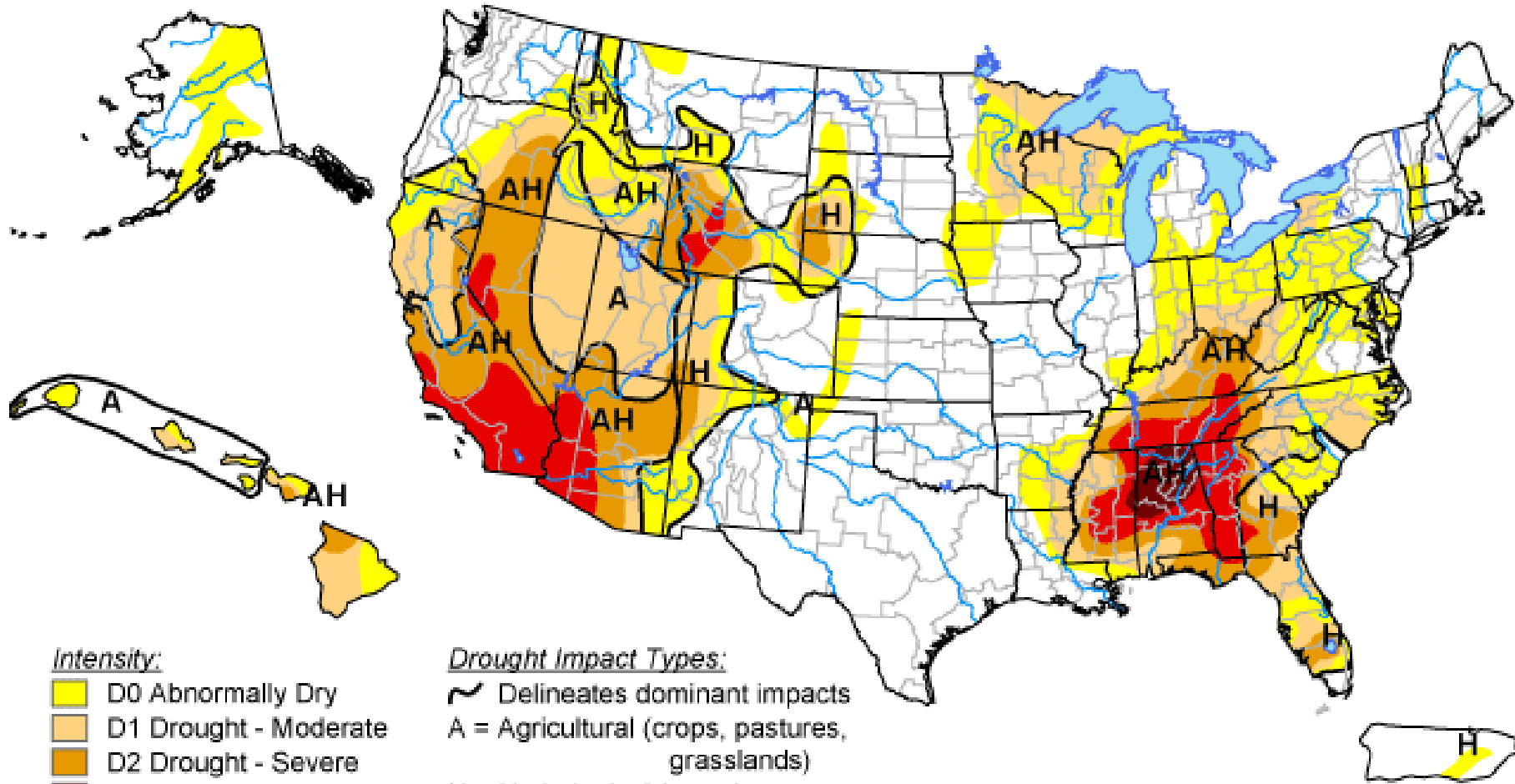
Fraction of Colorado in Drought
Based on 48 month SPI
(1890 - May 2007)








U.S. Drought Monitor

July 3, 2007


Valid 8 a.m. EDT



Intensity:

-  D0 Abnormally Dry
-  D1 Drought - Moderate
-  D2 Drought - Severe
-  D3 Drought - Extreme
-  D4 Drought - Exceptional

Drought Impact Types:

-  Delineates dominant impacts
- A = Agricultural (crops, pastures, grasslands)
- H = Hydrological (water)

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

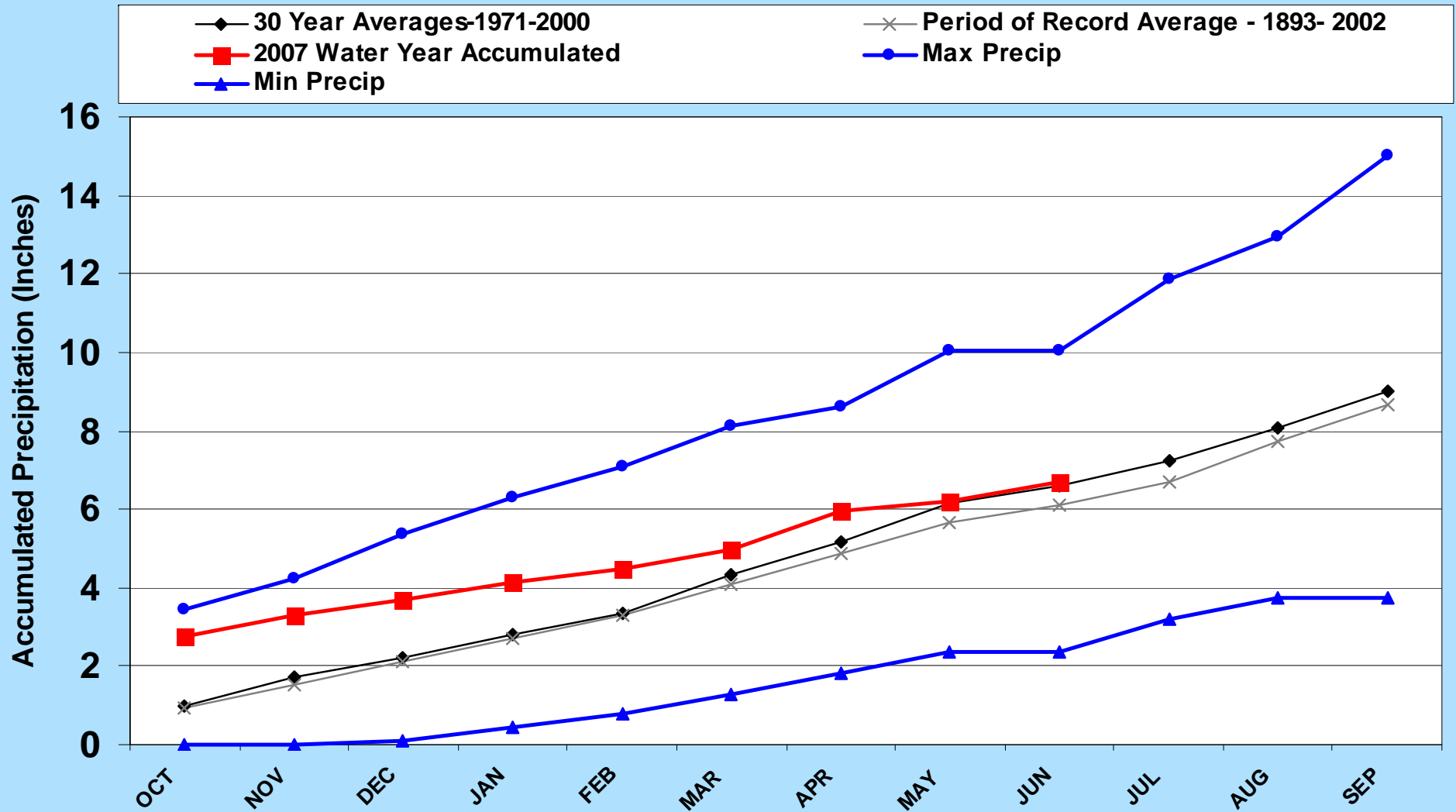
<http://drought.unl.edu/dm>



Released Thursday, July 5, 2007

Author: Douglas Le Comte, CPC/NOAA

Grand Junction WSFO 2007 Water Year



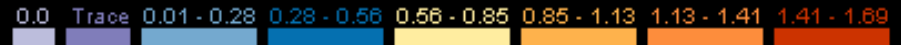
And have your rain gauge ready



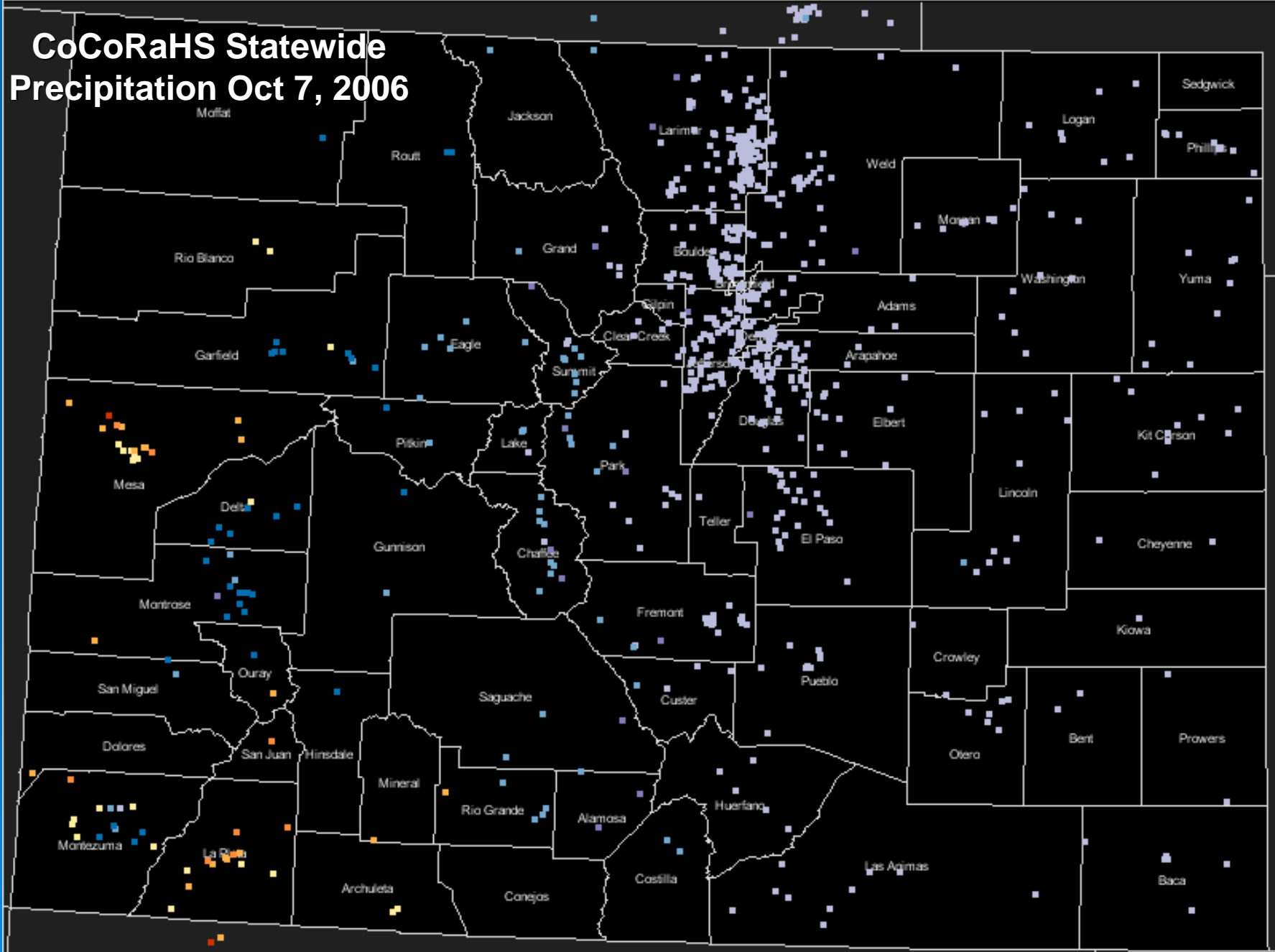
Photo by Marjorie Suedekum

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

Colorado 10/7/2006

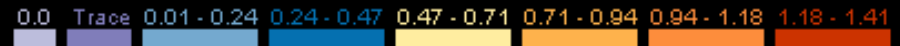


CoCoRaHS Statewide Precipitation Oct 7, 2006

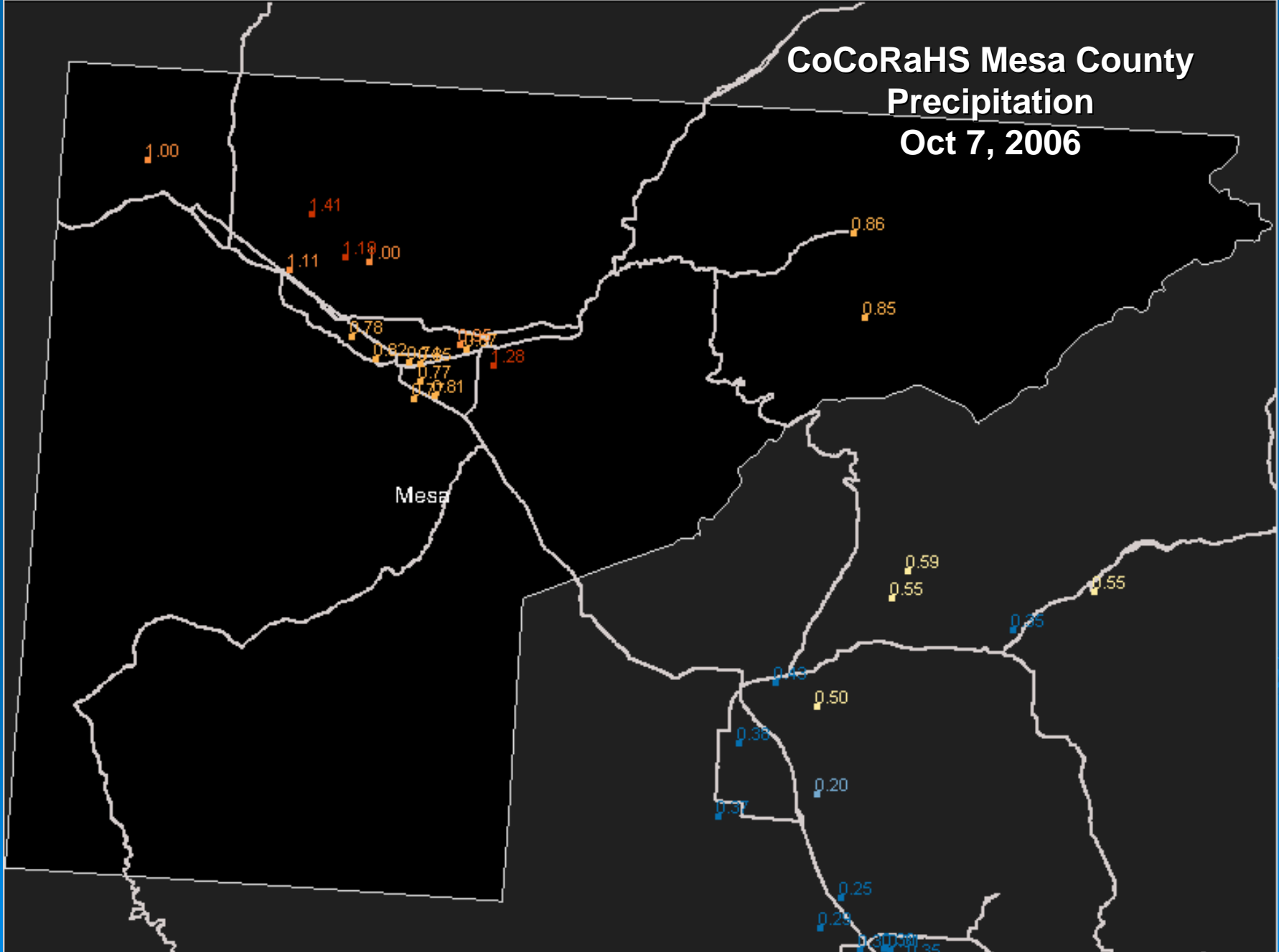


Daily Precipitation (inches x.xx), for the 24 hour period ending ~7:00 am

Mesa County, Colorado 10/7/2006



CoCoRaHS Mesa County Precipitation Oct 7, 2006



Volunteers Needed!!

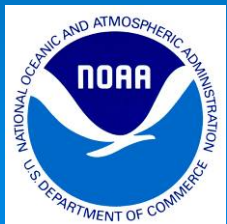


Photos by H. Reges

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
and
many local charter sponsors.

Colorado Climate Center

Data and Power Point Presentations available for downloading

<http://ccc.atmos.colostate.edu>

Colorado
State
University
Knowledge to Go Places

