

Let's Talk Climate!

**Nolan Doesken
Colorado Climate Center
Colorado State University**

**Yampatika Seminar
February 16, 2011
Steamboat Springs, Colorado**

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.

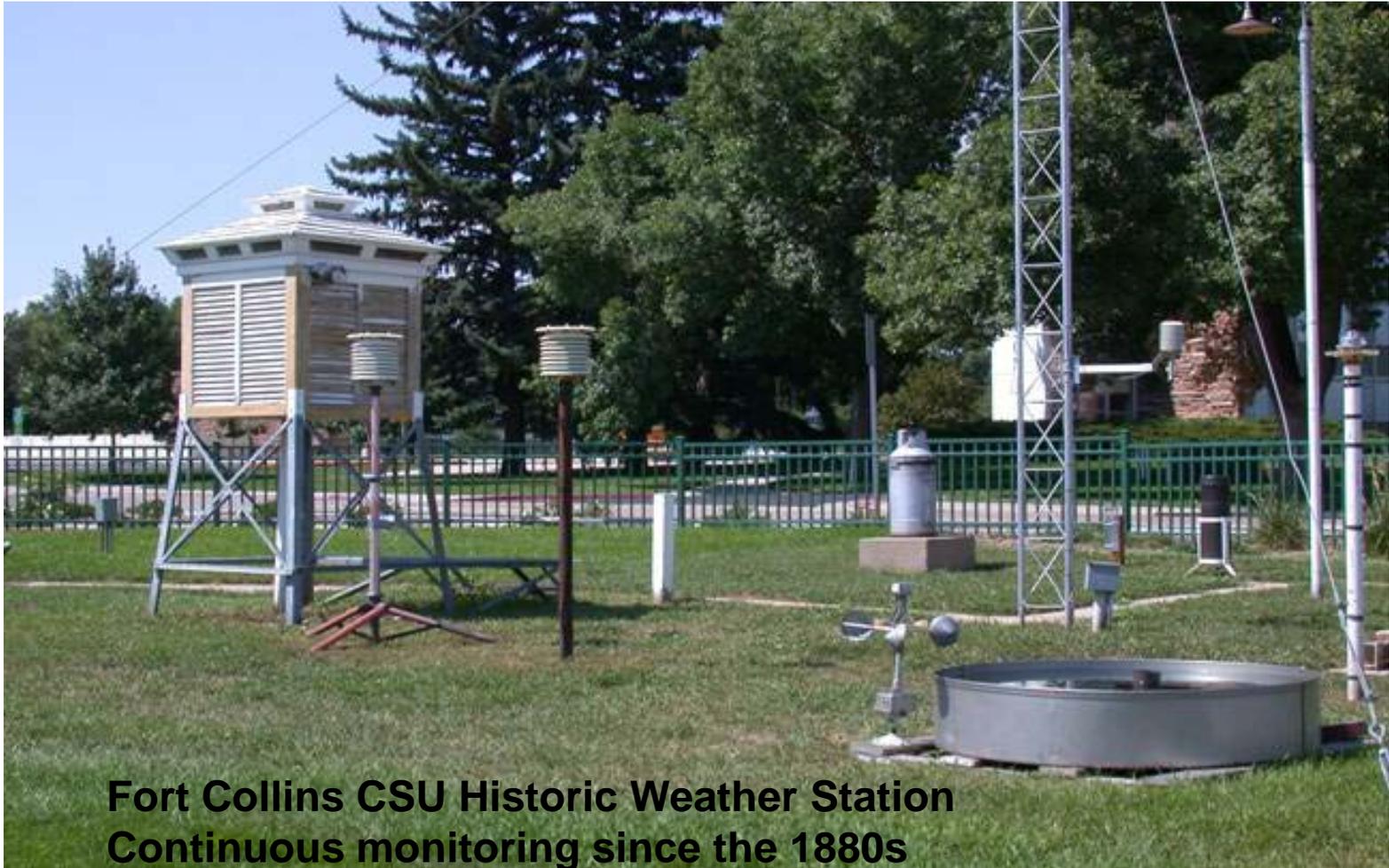


Our Mission

- 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

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.

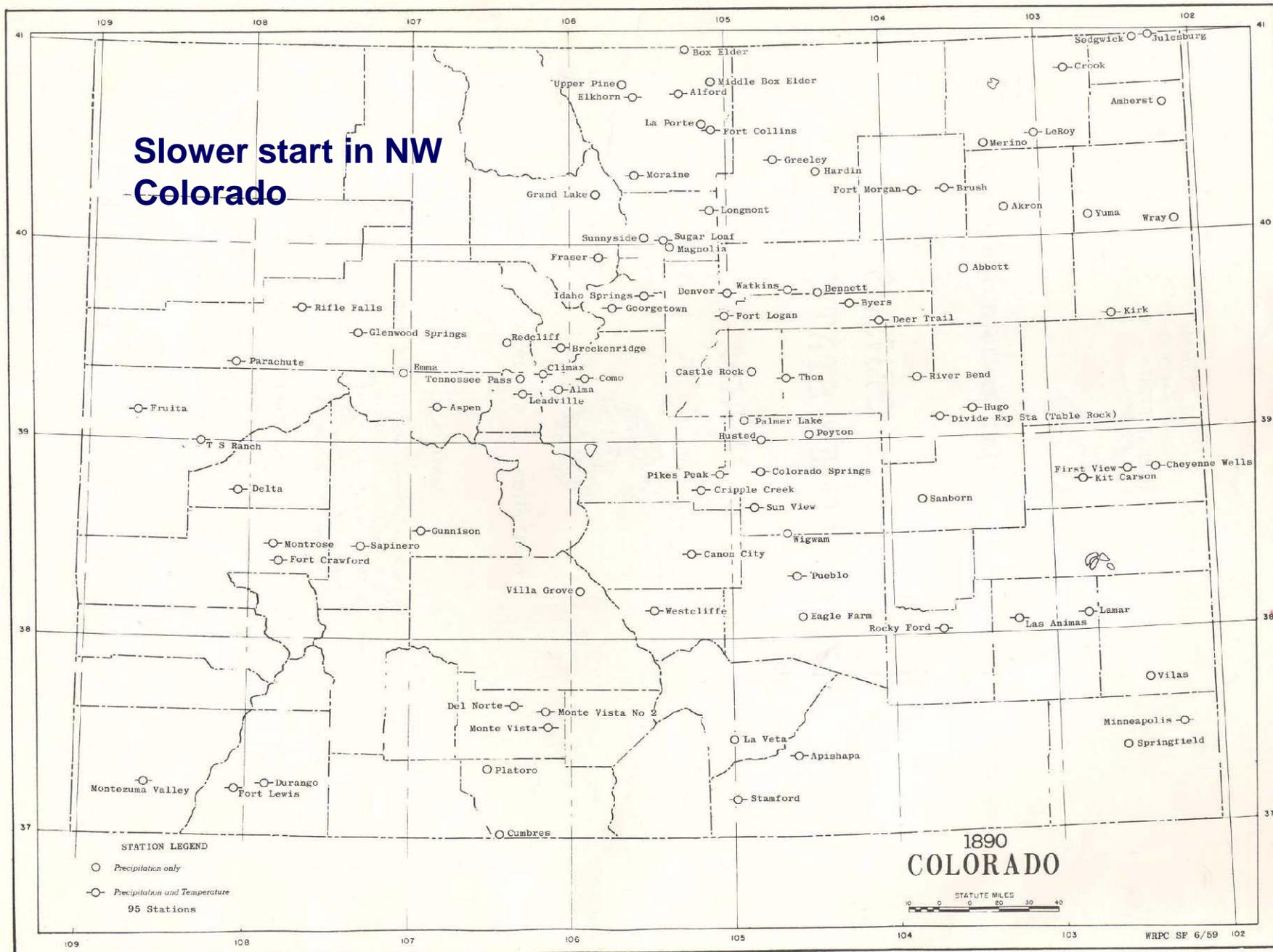
METEOROLOGICAL RECORD for the *Week* ending *Nov. 25th 1871* at *Denver, Col. Ter.*

Date of Observation.	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>Sunday Nov 19</i>	<i>5:43 a.m.</i>	<i>25.00</i>	<i>57 32</i>	<i>30.07</i>	<i>22 21 46</i>	<i>46</i>	<i>S</i>	<i>0</i>	<i>0</i>	<i>4/4</i>		<i>8 a.m.</i>			<i>Thin Snow - clear</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>44</i>	<i>S</i>	<i>2</i>	<i>.02</i>	<i>0</i>					<i>Clear</i>	
<i>Monday Nov 20</i>	<i>4:43 a.m.</i>	<i>25.12</i>	<i>58 14</i>	<i>30.20</i>	<i>14 12 64</i>	<i>64</i>	<i>S</i>	<i>11</i>	<i>.60</i>	<i>0</i>		<i>8 a.m.</i>	<i>8 p.m.</i>	<i>Blacks</i>	<i>Light Snow - clear</i>	
	<i>2:43 p.m.</i>	<i>25.09</i>	<i>63 36</i>	<i>29.97</i>	<i>36 30 46</i>	<i>46</i>	<i>S</i>	<i>2</i>	<i>.02</i>	<i>0</i>	<i>7 2</i>				<i>Clear</i>	
<i>Tuesday Nov 21</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>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>28</i>	<i>NW</i>	<i>10</i>	<i>1.62</i>	<i>4/4</i>	<i>10 3</i>				<i>Stratus</i>	
<i>Wednesday Nov 22</i>	<i>4:43 p.m.</i>	<i>24.88</i>	<i>58 39</i>	<i>29.70</i>	<i>39 34 53</i>	<i>53</i>	<i>NW</i>	<i>2</i>	<i>.02</i>	<i>4/4</i>	<i>34 3</i>				<i>Stratus</i>	
	<i>5:43 a.m.</i>	<i>24.70</i>	<i>55 31</i>	<i>29.59</i>	<i>31 29 79</i>	<i>79</i>	<i>S.W.</i>	<i>4</i>	<i>.08</i>	<i>4/4</i>	<i>9 7</i>				<i>Stratus</i>	
<i>Thursday Nov 23</i>	<i>2:43 p.m.</i>	<i>24.37</i>	<i>62 35</i>	<i>29.30</i>	<i>35 32 70</i>	<i>70</i>	<i>W</i>	<i>2</i>	<i>.02</i>	<i>4/4</i>	<i>9 7</i>	<i>3 p.m.</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>89</i>	<i>S</i>	<i>10</i>	<i>.50</i>	<i>4/4</i>	<i>32.3</i>	<i>11 p.m.</i>	<i>.26</i>		<i>Light Snow - Stratus</i>	
<i>Friday Nov 24</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>87</i>	<i>S</i>	<i>6</i>	<i>.18</i>	<i>4/4</i>	<i>9 0</i>	<i>10.30 a.m.</i>			<i>Light Snow - 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>89</i>	<i>NW</i>	<i>5</i>	<i>.12</i>	<i>4/4</i>	<i>30</i>				<i>Light Snow</i>	
<i>Saturday Nov 25</i>	<i>4:43 p.m.</i>	<i>24.20</i>	<i>60 31</i>	<i>28.97</i>	<i>31 30 89</i>	<i>89</i>	<i>S</i>	<i>9</i>	<i>.40</i>	<i>3/4</i>	<i>S.E.</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>100</i>	<i>S.W.</i>	<i>4</i>	<i>.08</i>	<i>4/4</i>	<i>10 1</i>	<i>8 a.m.</i>	<i>.21</i>		<i>Cloudy - Stratus</i>	
<i>Sunday Nov 26</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>58</i>	<i>2</i>	<i>2</i>	<i>.02</i>	<i>2/4</i>	<i>33.7</i>				<i>Fog - Stratus</i>	
	<i>4:43 p.m.</i>	<i>24.38</i>	<i>65 27</i>	<i>29.23</i>	<i>27 27 100</i>	<i>100</i>	<i>N.W.</i>	<i>2</i>	<i>.02</i>	<i>4/4</i>					<i>Fog</i>	
<i>Monday Nov 27</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>64</i>	<i>SW</i>	<i>7</i>	<i>.24</i>	<i>1/4</i>	<i>9 8</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>31</i>	<i>S.E.</i>	<i>2</i>	<i>.02</i>	<i>2/4</i>	<i>32.7</i>				<i>Stratus & Stratus</i>	
<i>Saturday Nov 28</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>75</i>	<i>N.E.</i>	<i>18</i>	<i>1.62</i>	<i>3/4</i>					<i>Light scud fr</i>	

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

Colorado Weather Stations in 1890



What's so Amazing about Colorado?

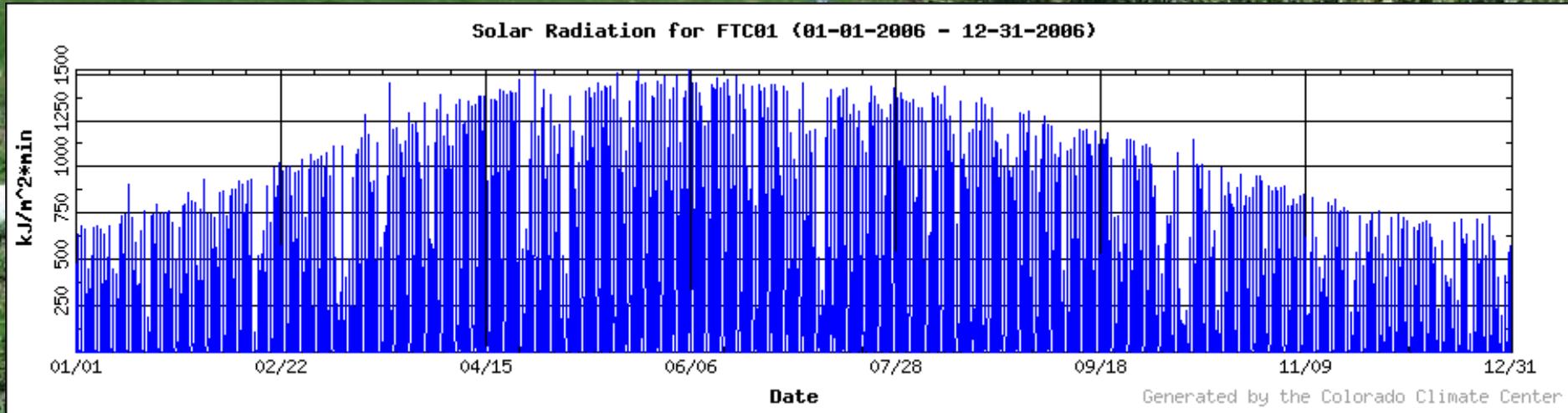
Four “Climate Controls”

- High elevation (Colorado is the 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?



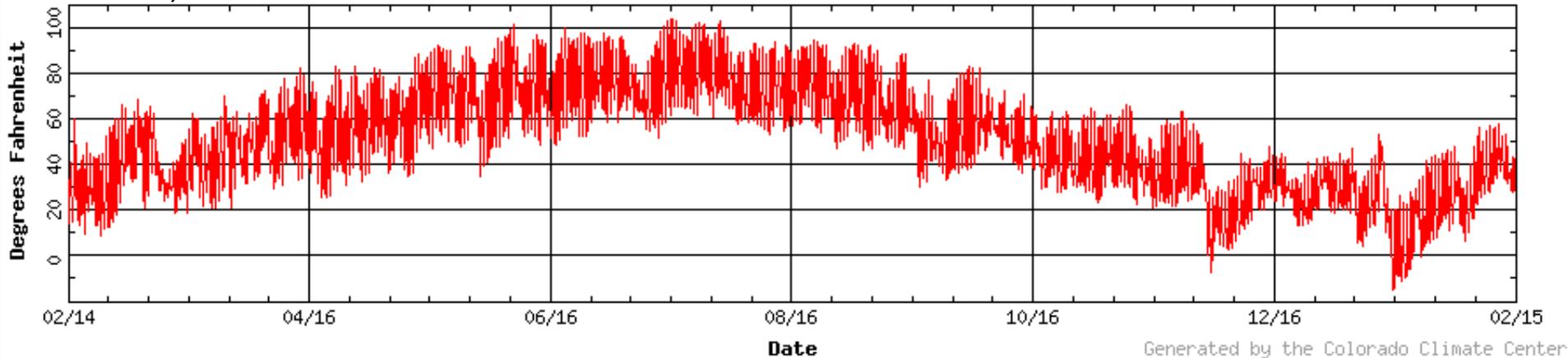
Generous sunshine and low humidity, i.e. people like it here



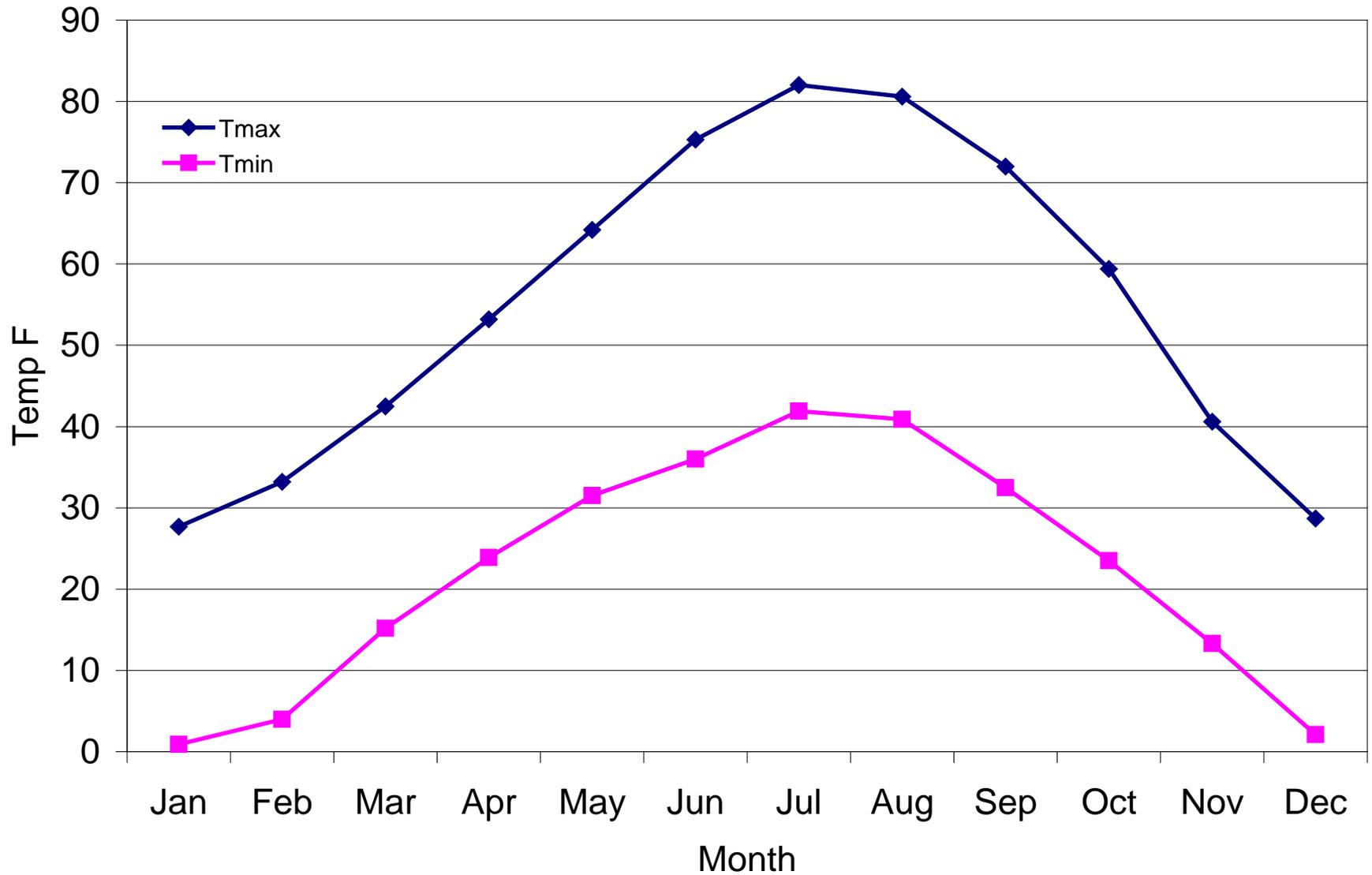
Large Seasonal and diurnal Temperature Variations

Fruita, Colo.

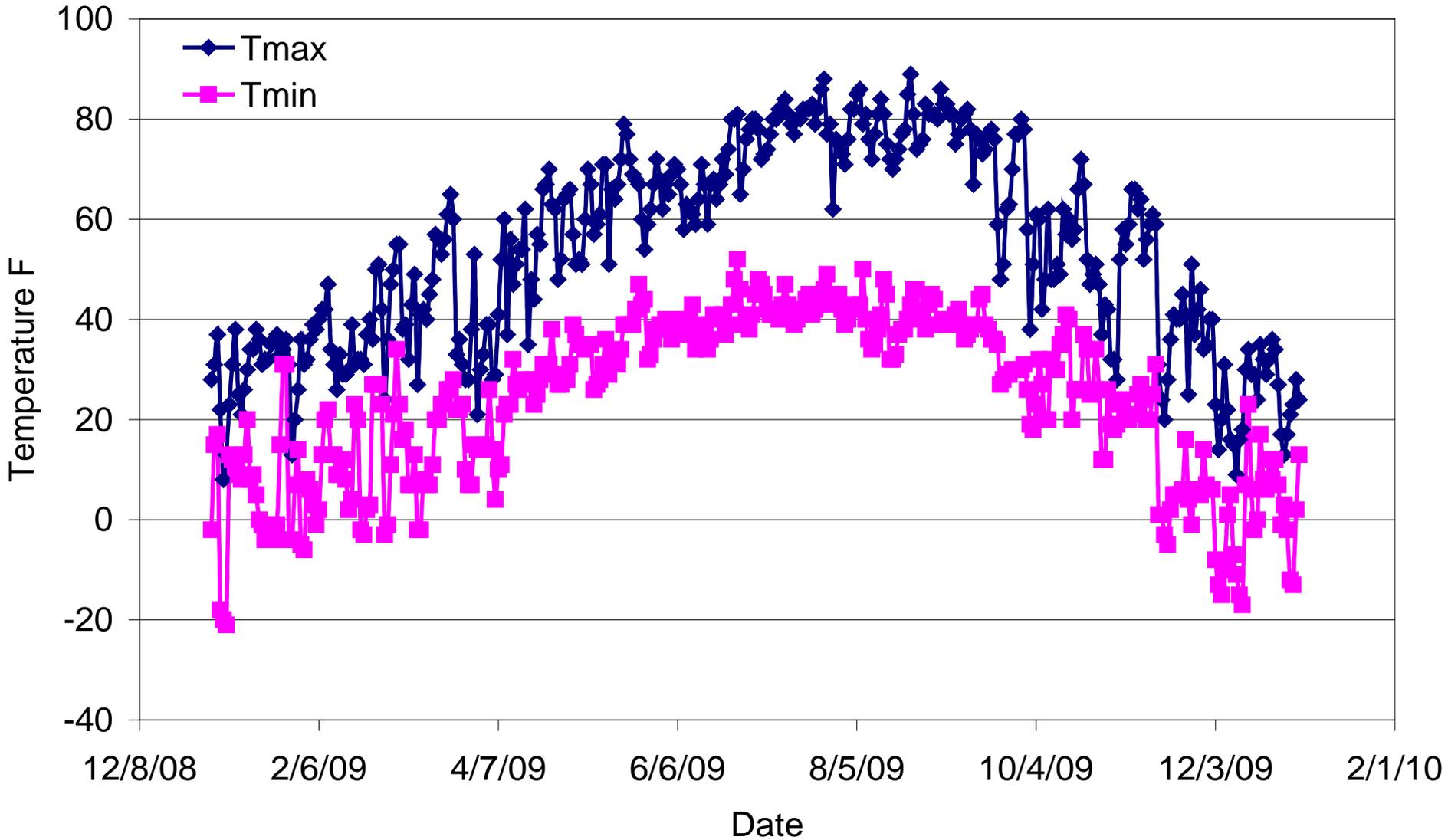
Temperature for FRT02 (02-14-2006 - 02-15-2007)



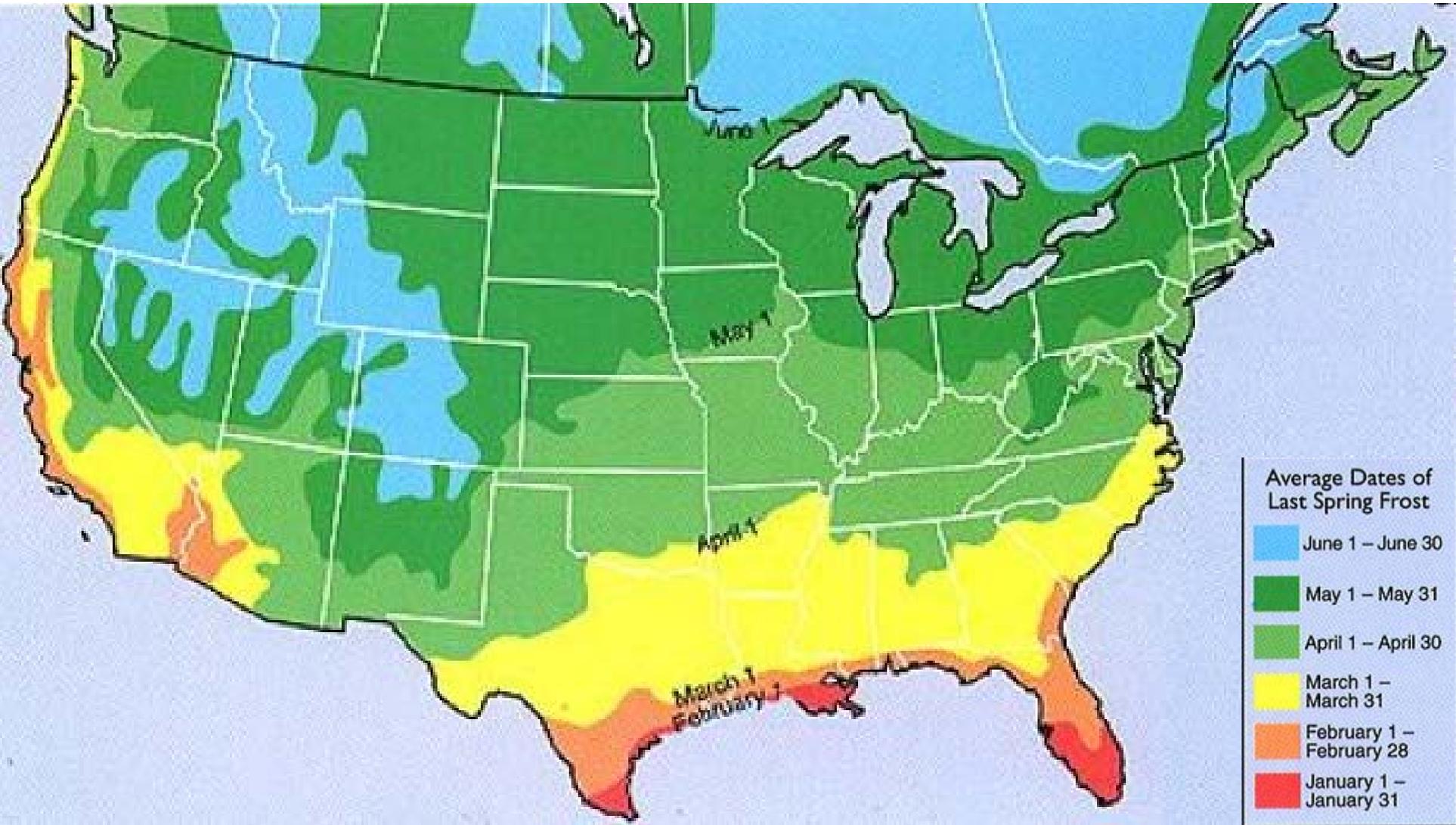
Steamboat Springs, CO Monthly Mean Maximum and Minimum Temperatures



Steamboat Springs, CO Daily Tmax and Tmin for 2009



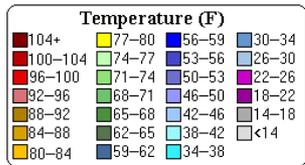
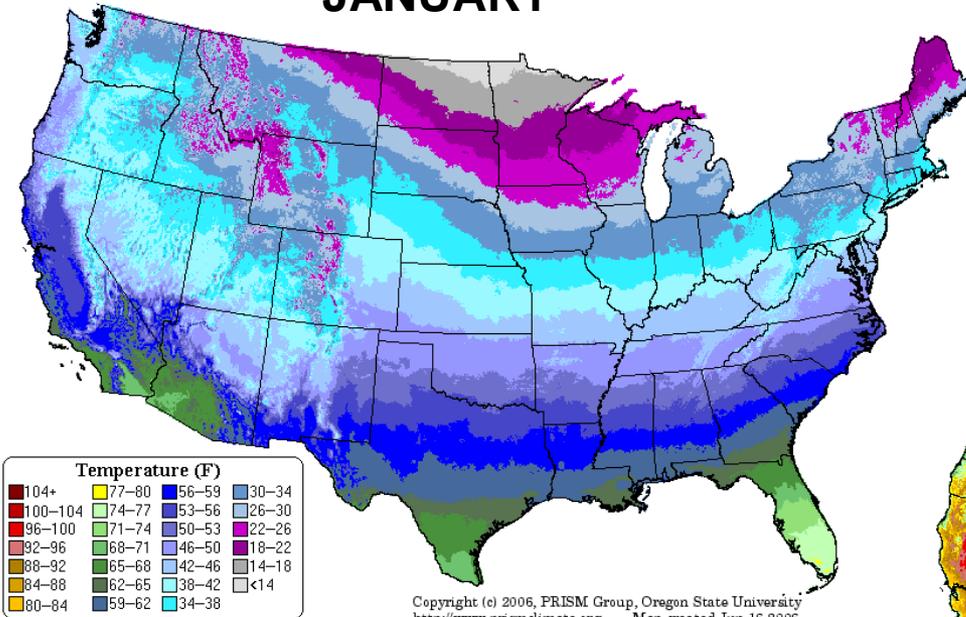
Routt County – a cool place to live



Average Maximum Temperature

Maximum Temperature: January Climatology (1971–2000)

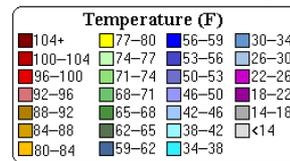
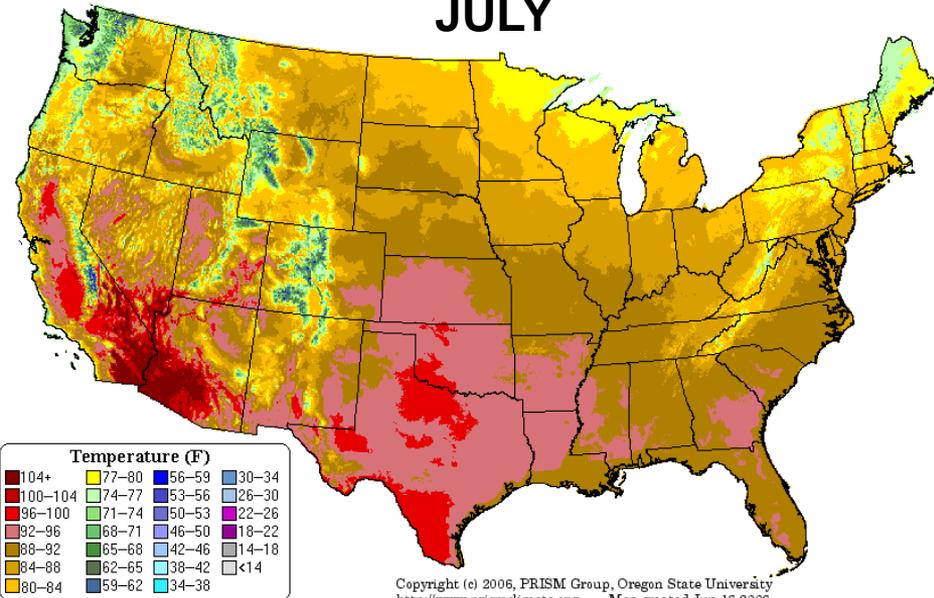
JANUARY



Copyright (c) 2006, PRISM Group, Oregon State University
<http://www.prismclimate.org> - Map created Jun 16 2006

Maximum Temperature: July Climatology (1971–2000)

JULY



Copyright (c) 2006, PRISM Group, Oregon State University
<http://www.prismclimate.org> - Map created Jun 16 2006

**Frequent but highly variable
precipitation
(for every “upslope,”
there’s a “downslope”)**

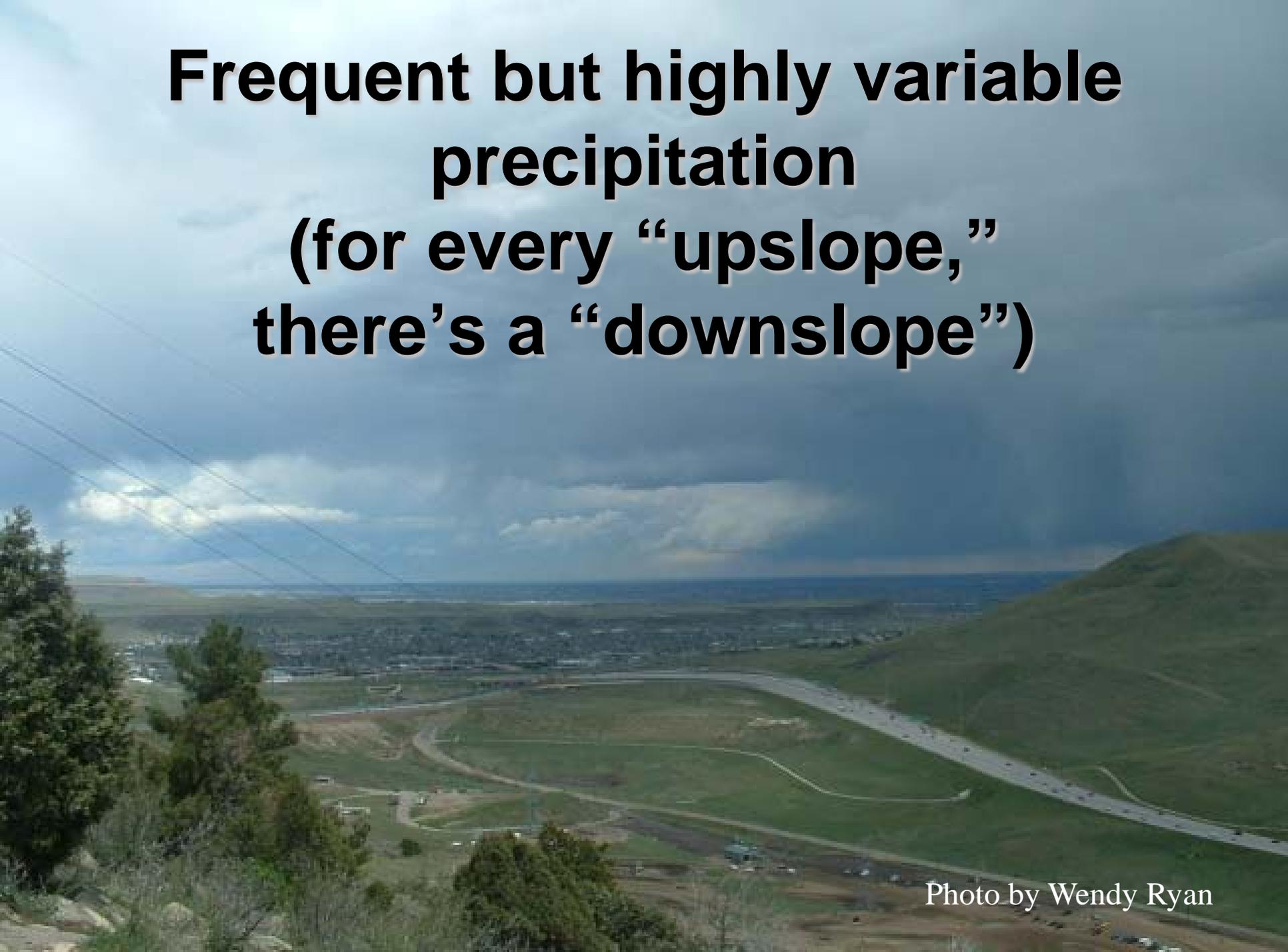
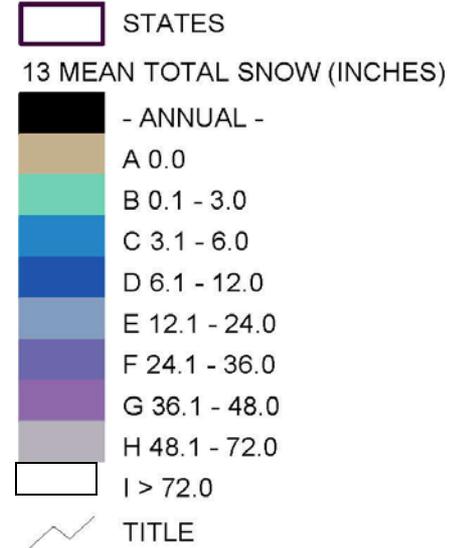
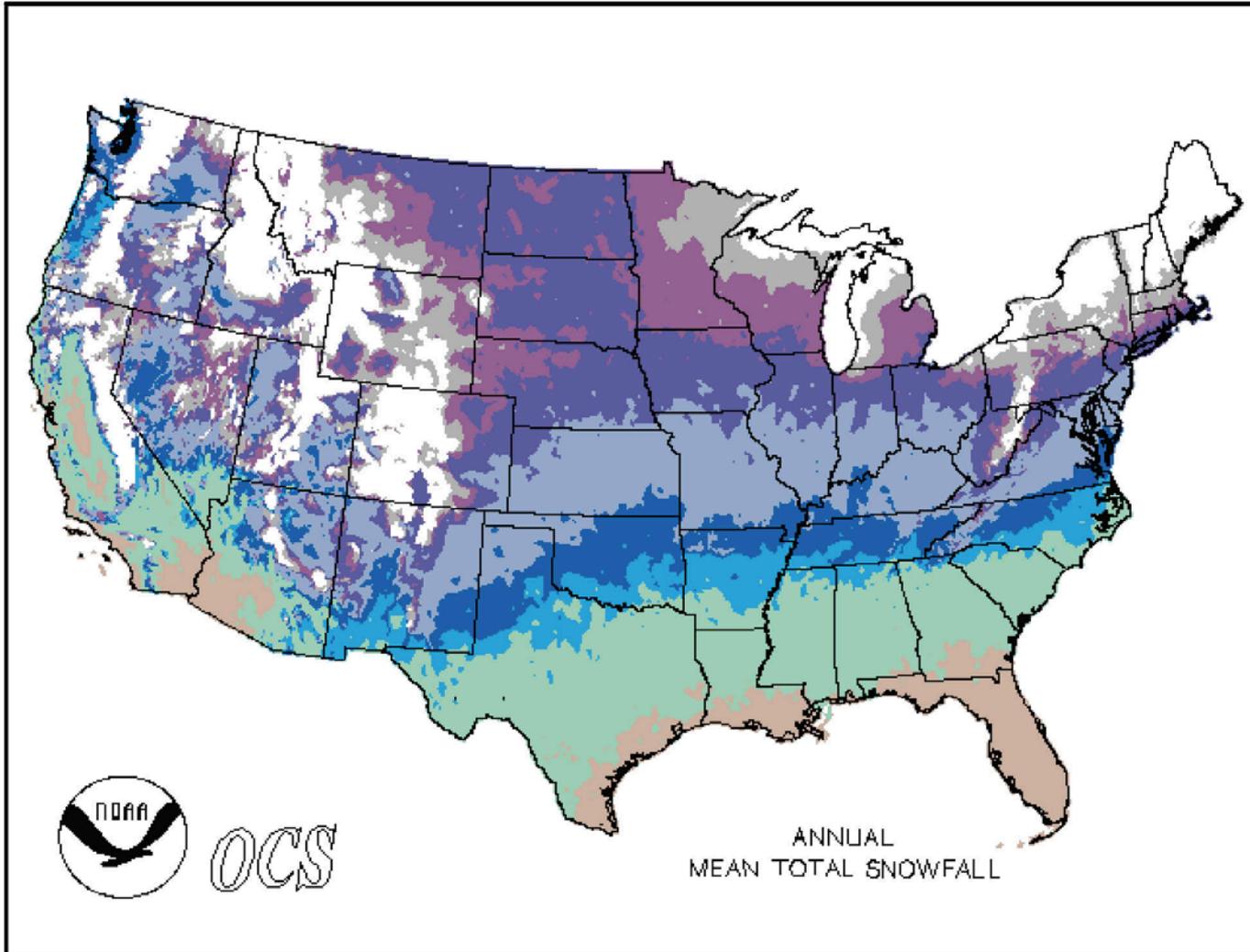


Photo by Wendy Ryan

**Lots of Snow,
sometimes and some places**



National Annual Average Snowfall



OCS



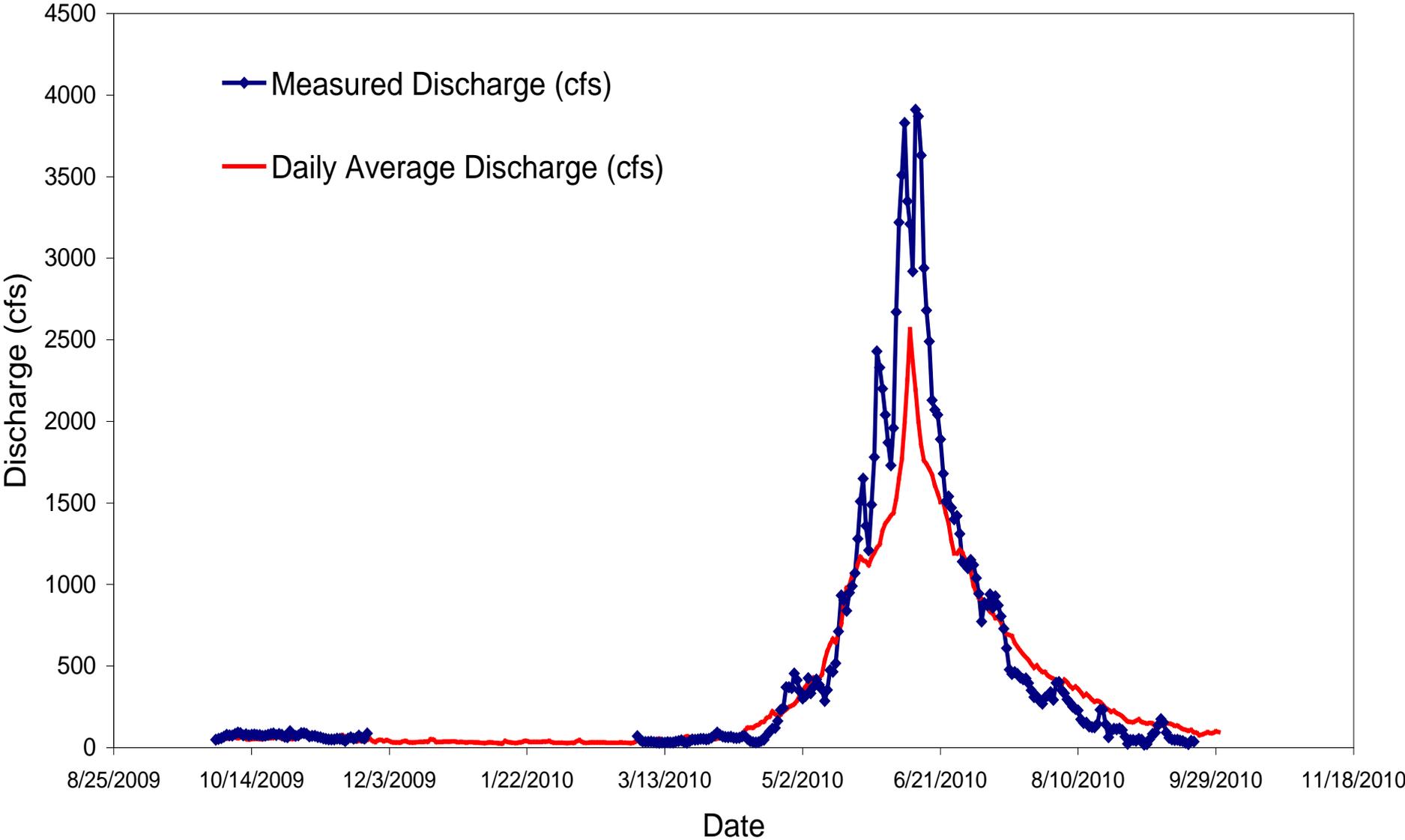
Routt County is normally
Colorado's most consistently
snowy region of the state –
considering the modest mountains
and elevation

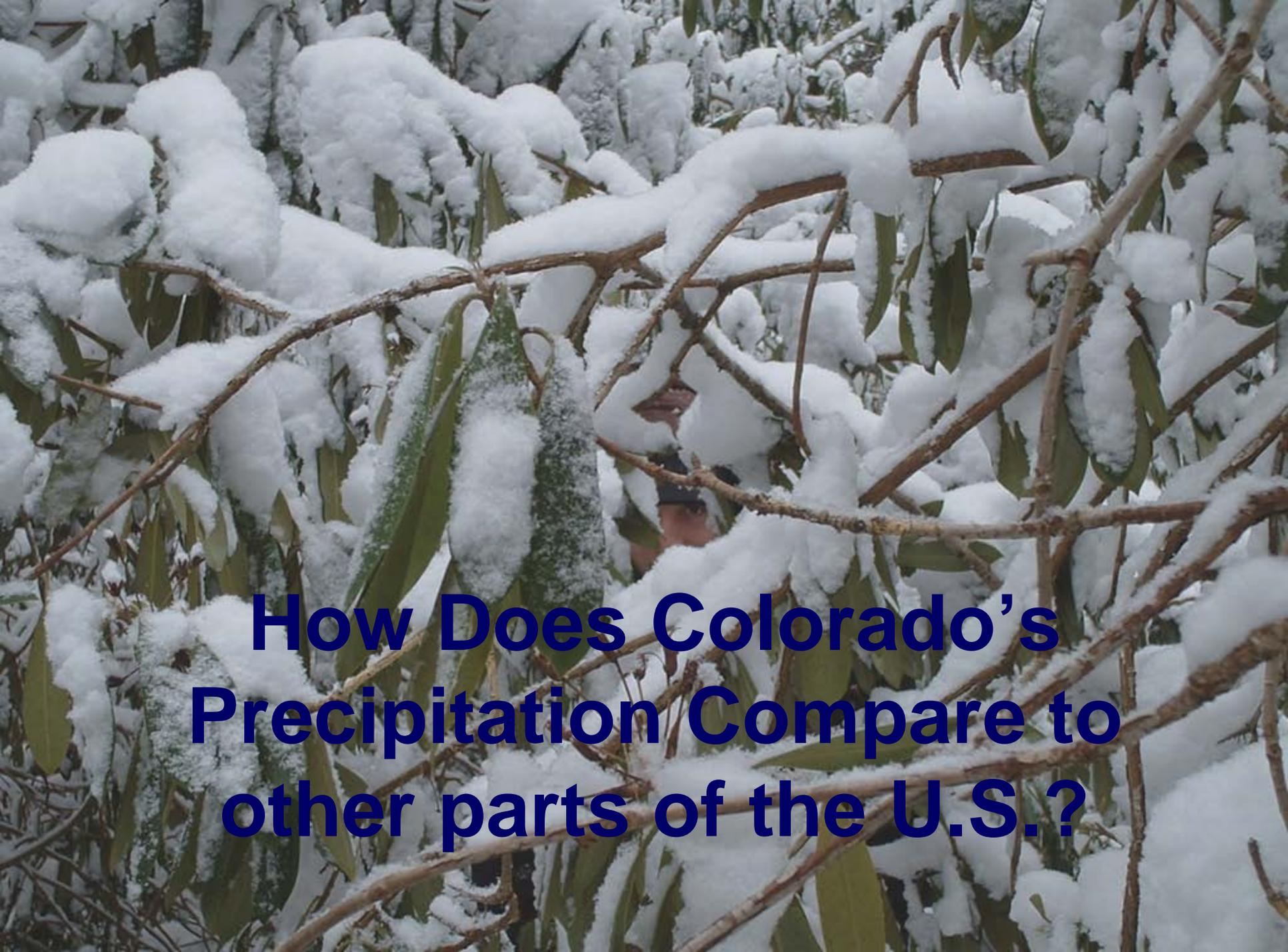


Most Surface Water Supplies in Colorado Come From Mountain Snowmelt



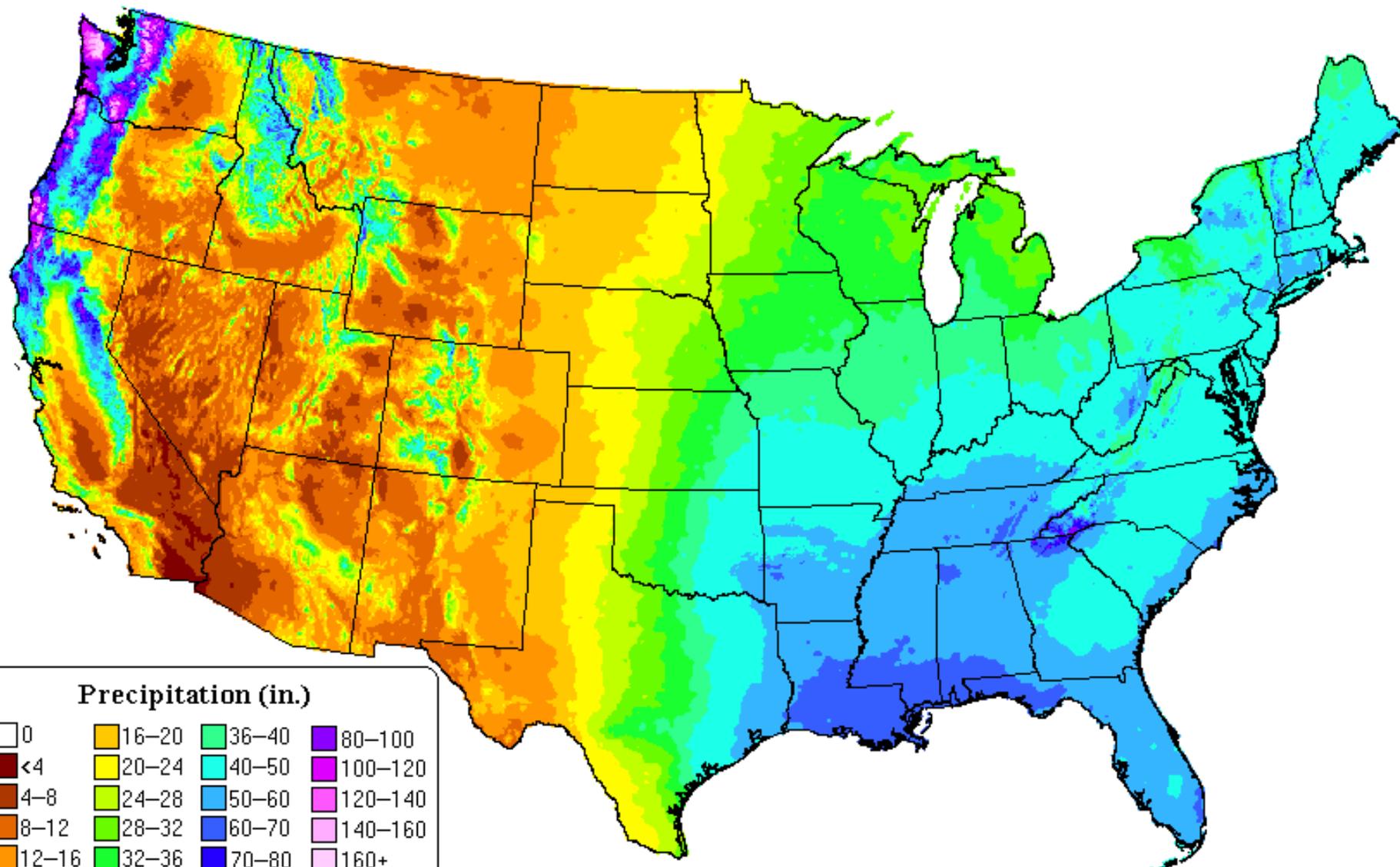
Poudre River Discharge (cfs) at the Canyon Mouth for Water Year 2010





**How Does Colorado's
Precipitation Compare to
other parts of the U.S.?**

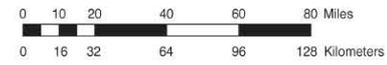
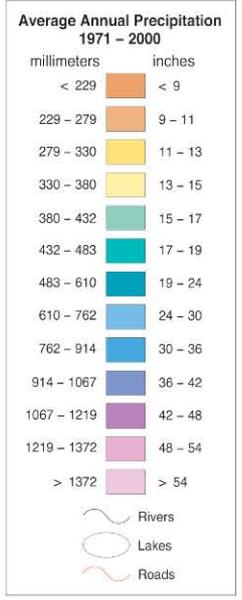
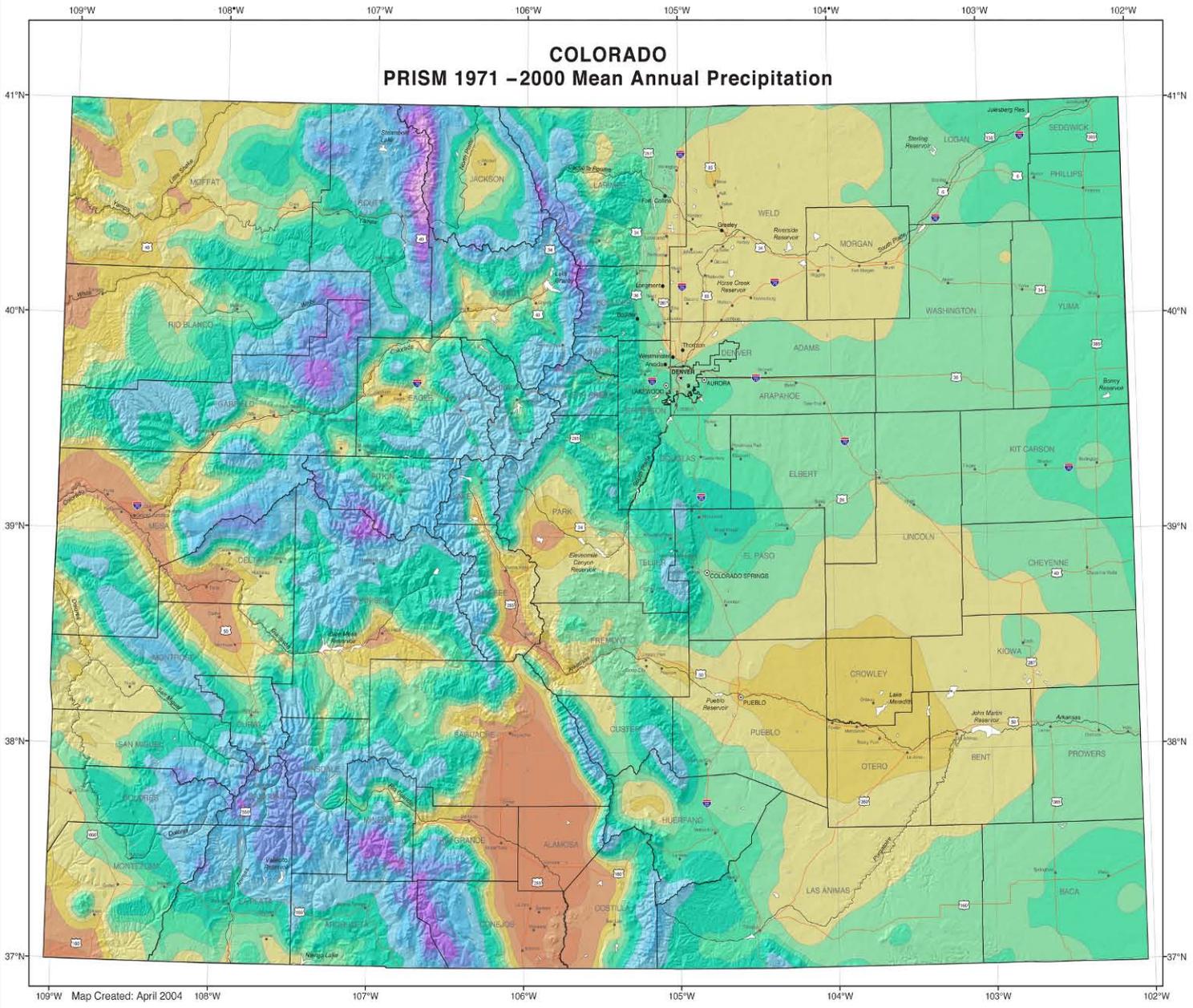
Precipitation: Annual Climatology (1971–2000)



Copyright (c) 2006, PRISM Group, Oregon State University
<http://www.prismclimate.org> - Map created Jun 16 2006

COLORADO

PRISM 1971 – 2000 Mean Annual Precipitation

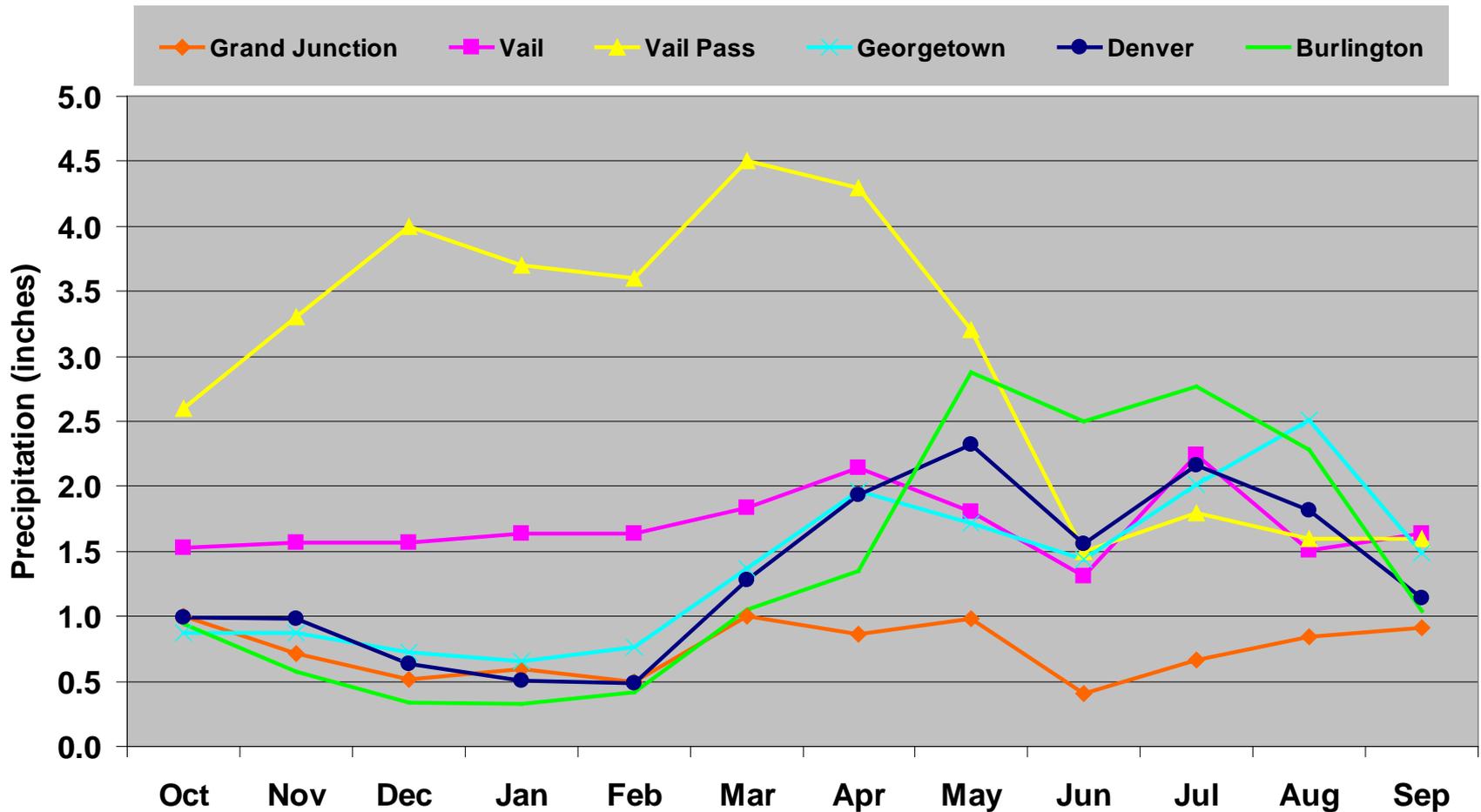


Map prepared with the PRISM climate modeling system by the Spatial Climate Analysis Service, Oregon State University.
<http://www.ocs.orst.edu/prism> Copyright (c) 2004, OSU SCAS



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

Water Year Average Precipitation for Selected Stations



Colorado Experiences Large Year-to-Year Variations in Precipitation

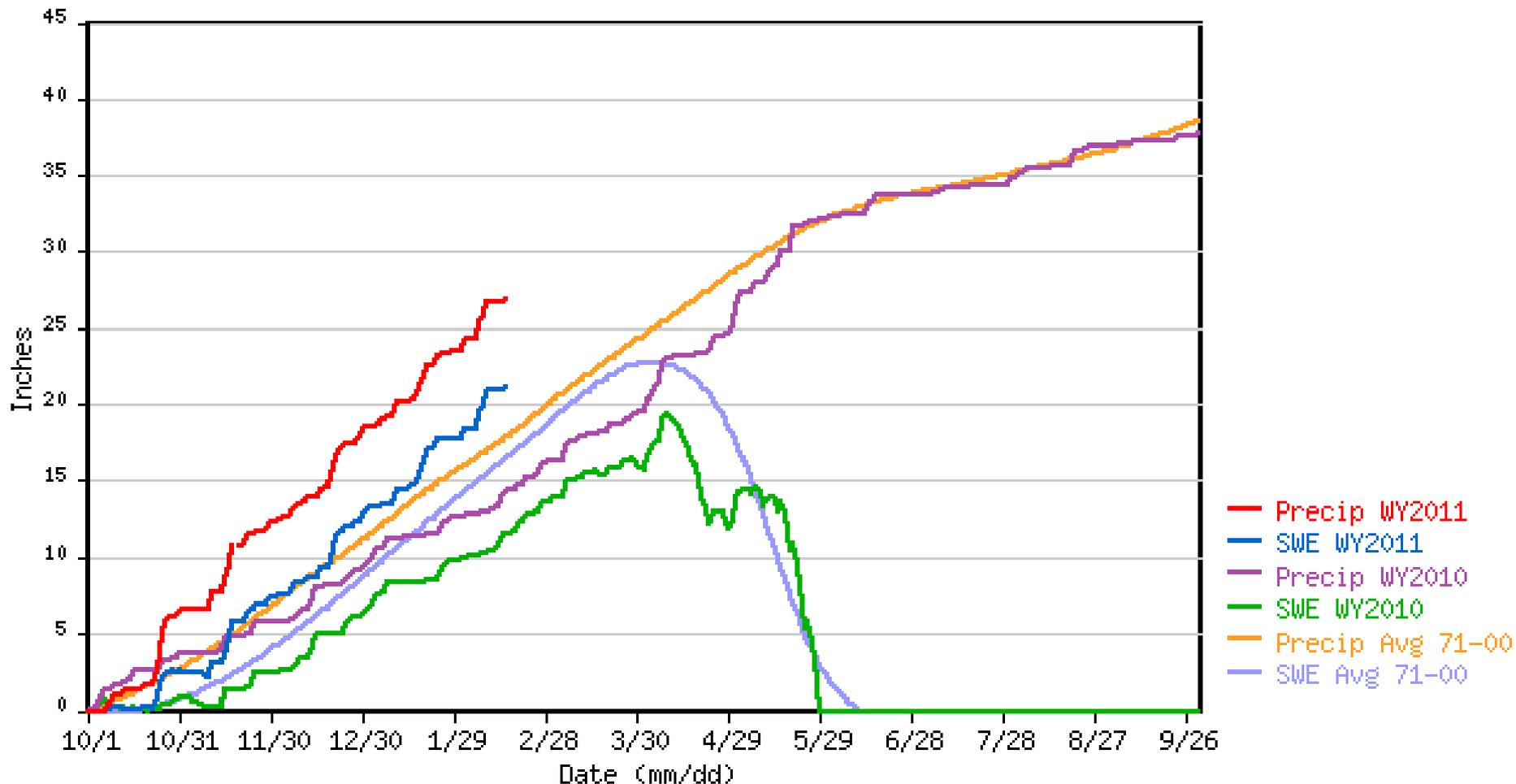


**No two years
are ever alike**

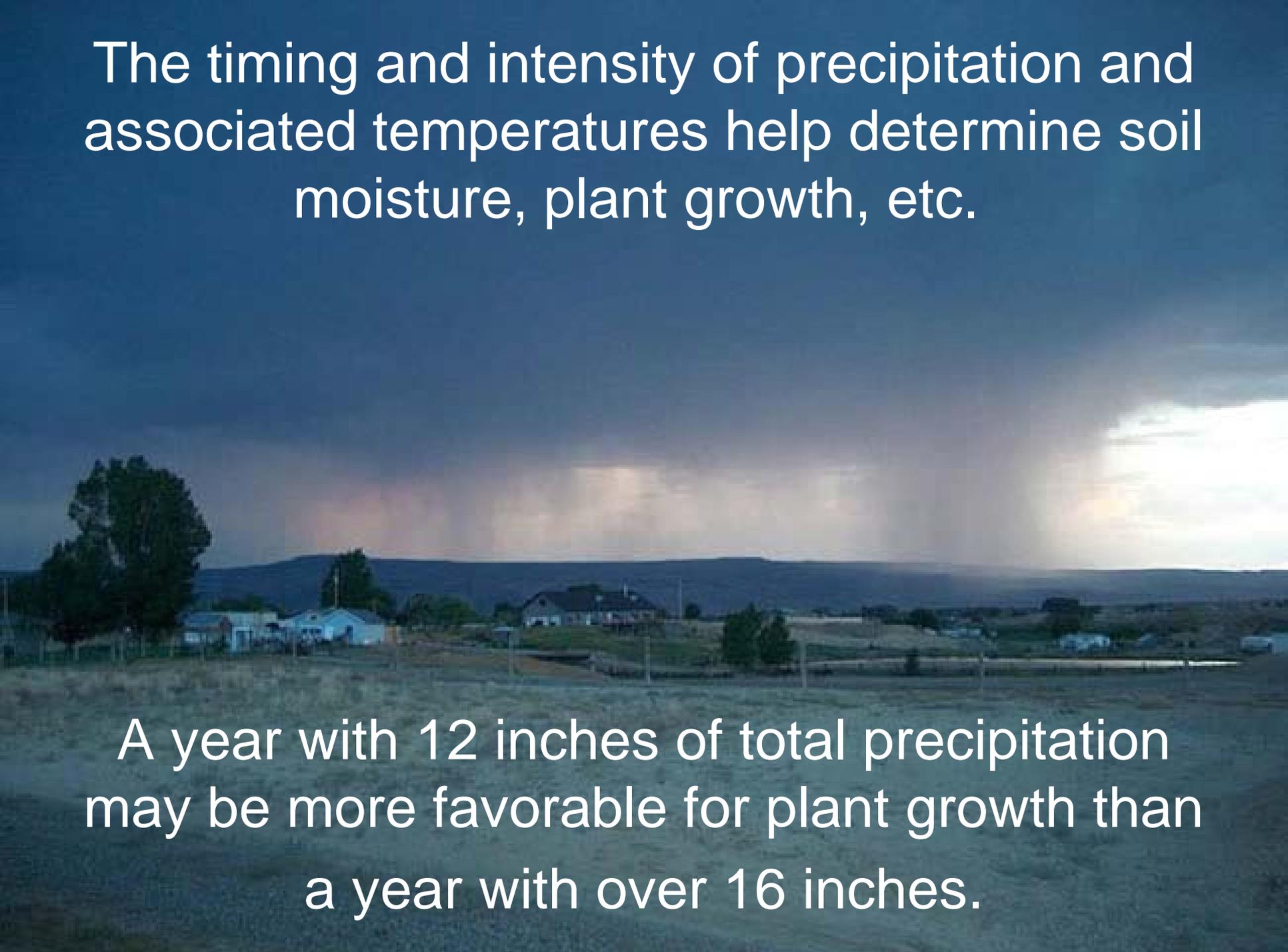
Dry Lake Snotel WY 2010 and 2011

DRY LAKE SNOTEL as of 02/15/2011

*** Provisional Data, Subject to Change ***



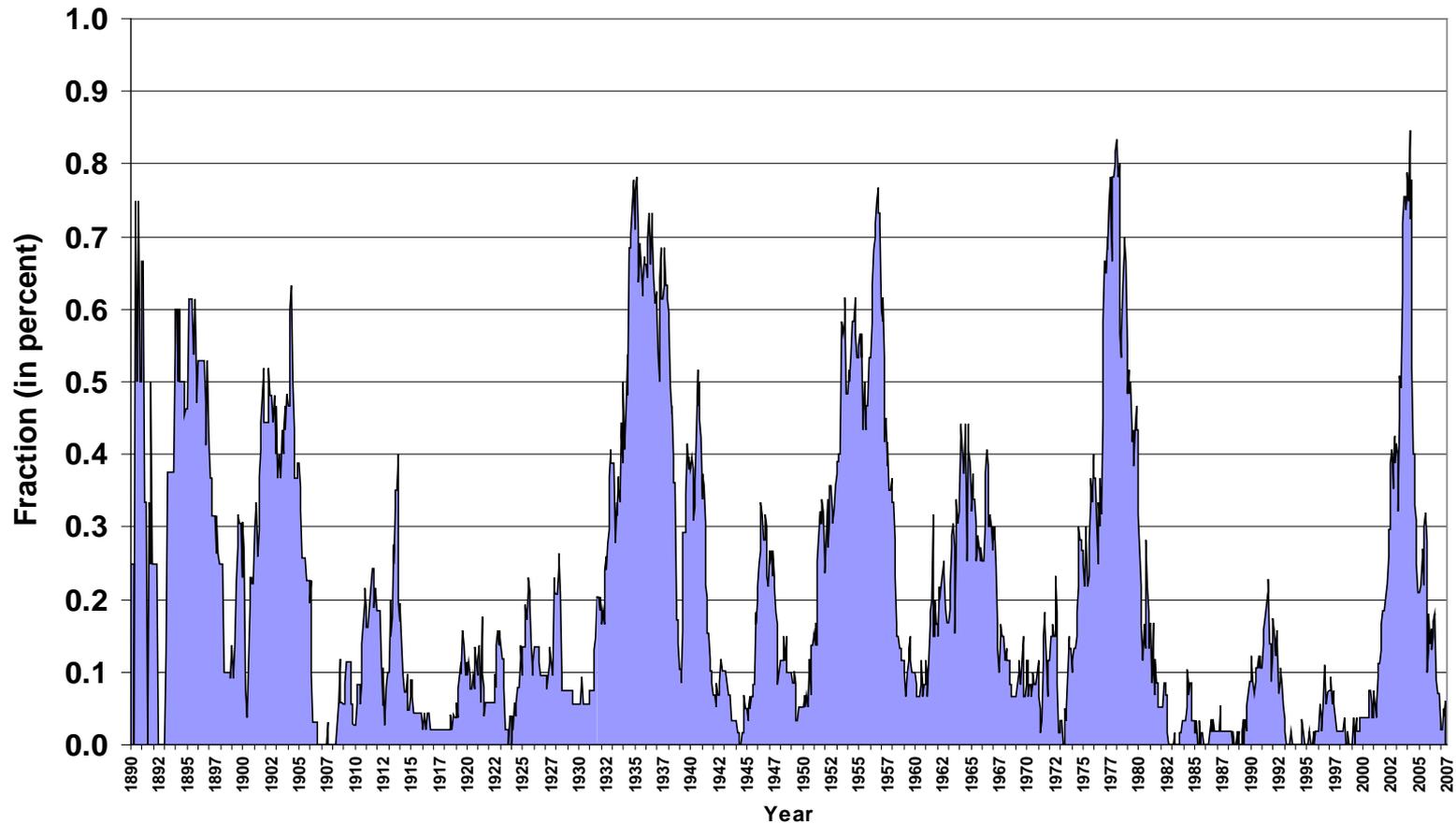
The timing and intensity of precipitation and associated temperatures help determine soil moisture, plant growth, etc.



A year with 12 inches of total precipitation may be more favorable for plant growth than a year with over 16 inches.

Drought – a regular visitor to Colorado

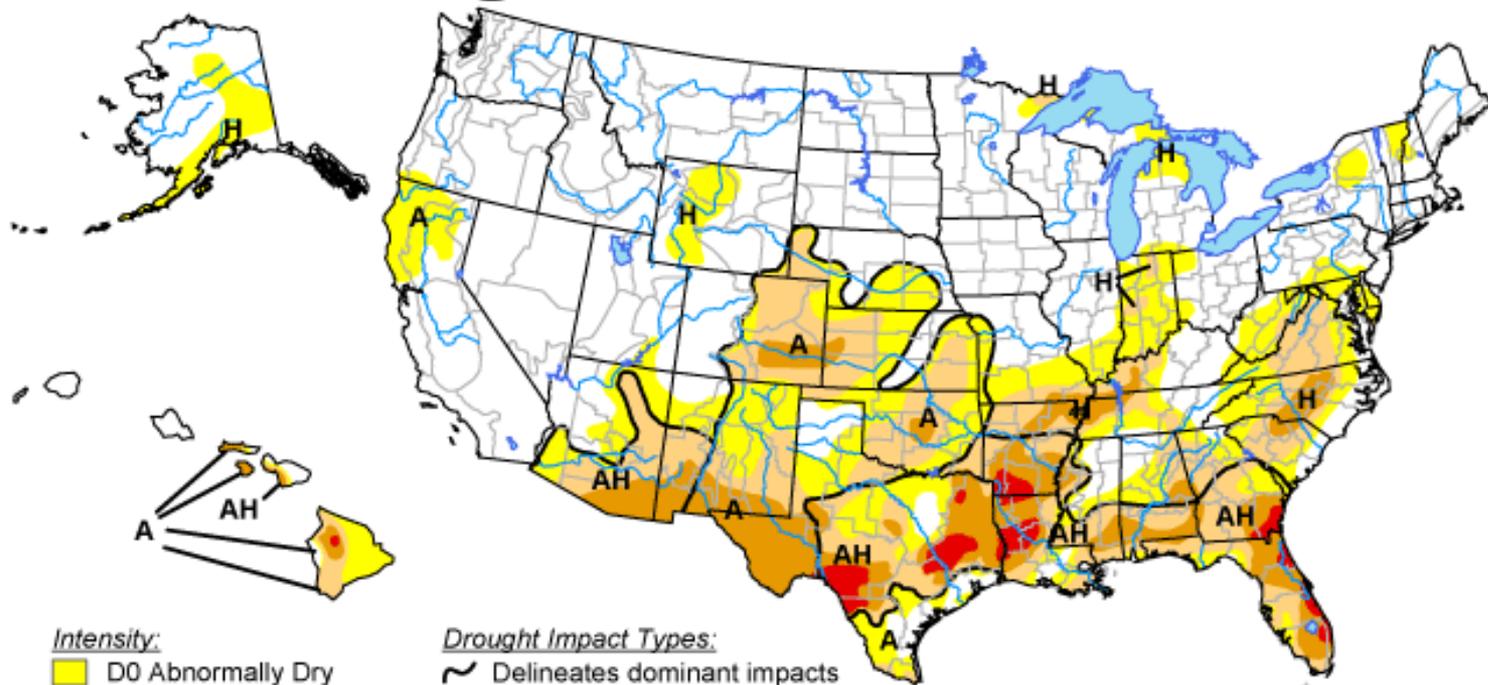
Fraction of Colorado in Drought
Based on 48 month SPI
(1890 - May 2007)



Recent U.S. Drought Status

U.S. Drought Monitor

February 8, 2011
Valid 7 a.m. EST



Intensity:

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

Drought Impact Types:

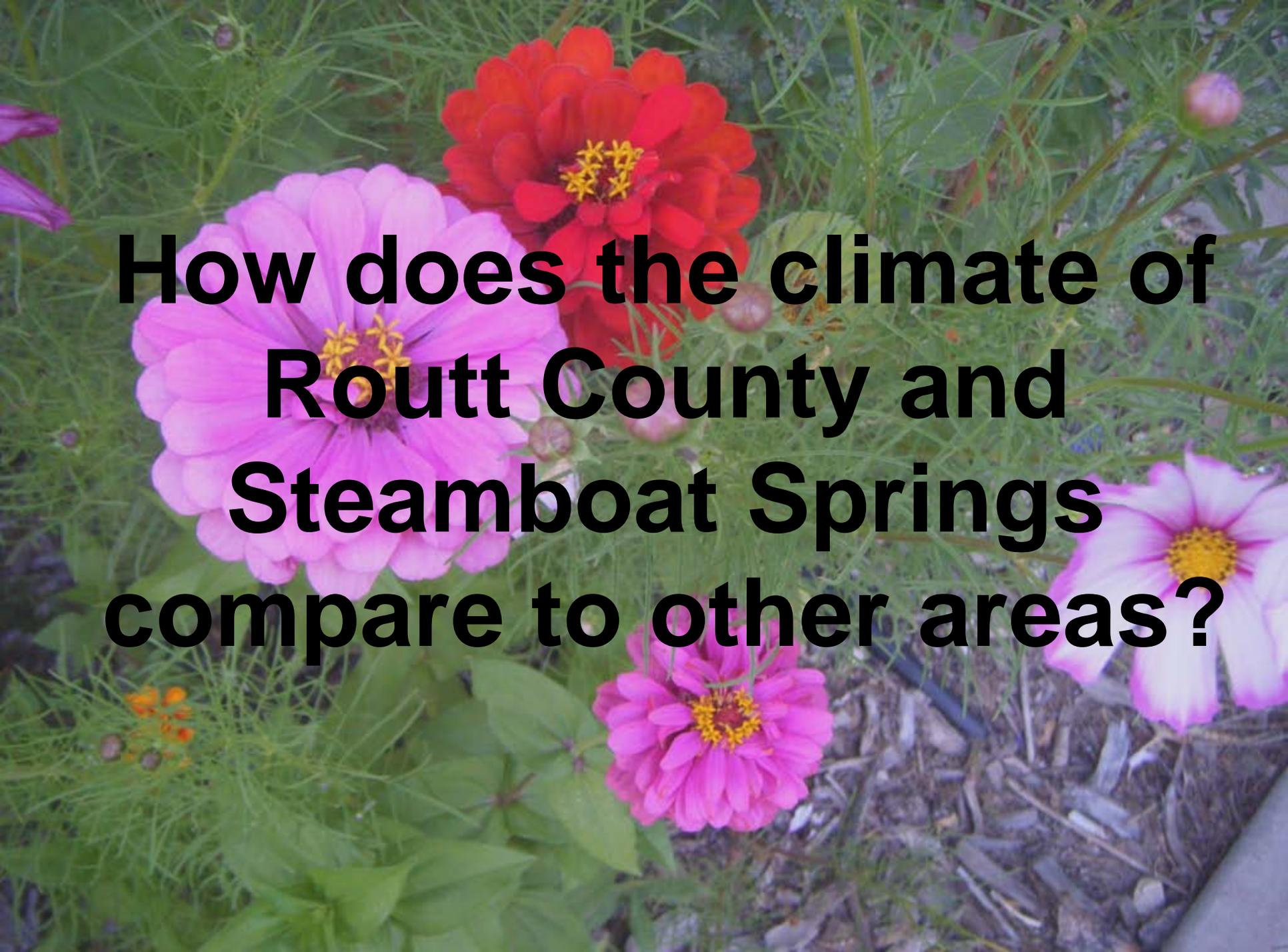
-  Delineates dominant impacts
- A = Agricultural (crops, pastures, grasslands)
- H = Hydrological (water)

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, February 10, 2011
Author: Matthew Rosencrans, NOAA/NWS/NCEP/CPC



**How does the climate of
Routt County and
Steamboat Springs
compare to other areas?**

CITIES

co_dem_ft

Elevation



Moffat

Larimer

WALDEN

Jackson

CRATE

Routt

WALDEN

STEAMBOAT SPRINGS

OAK CREEK

YAMPA

Rio Blanco MEEBEE

Grand

GRANBY

KREMHLING

HOT SULPHUR SPRINGS

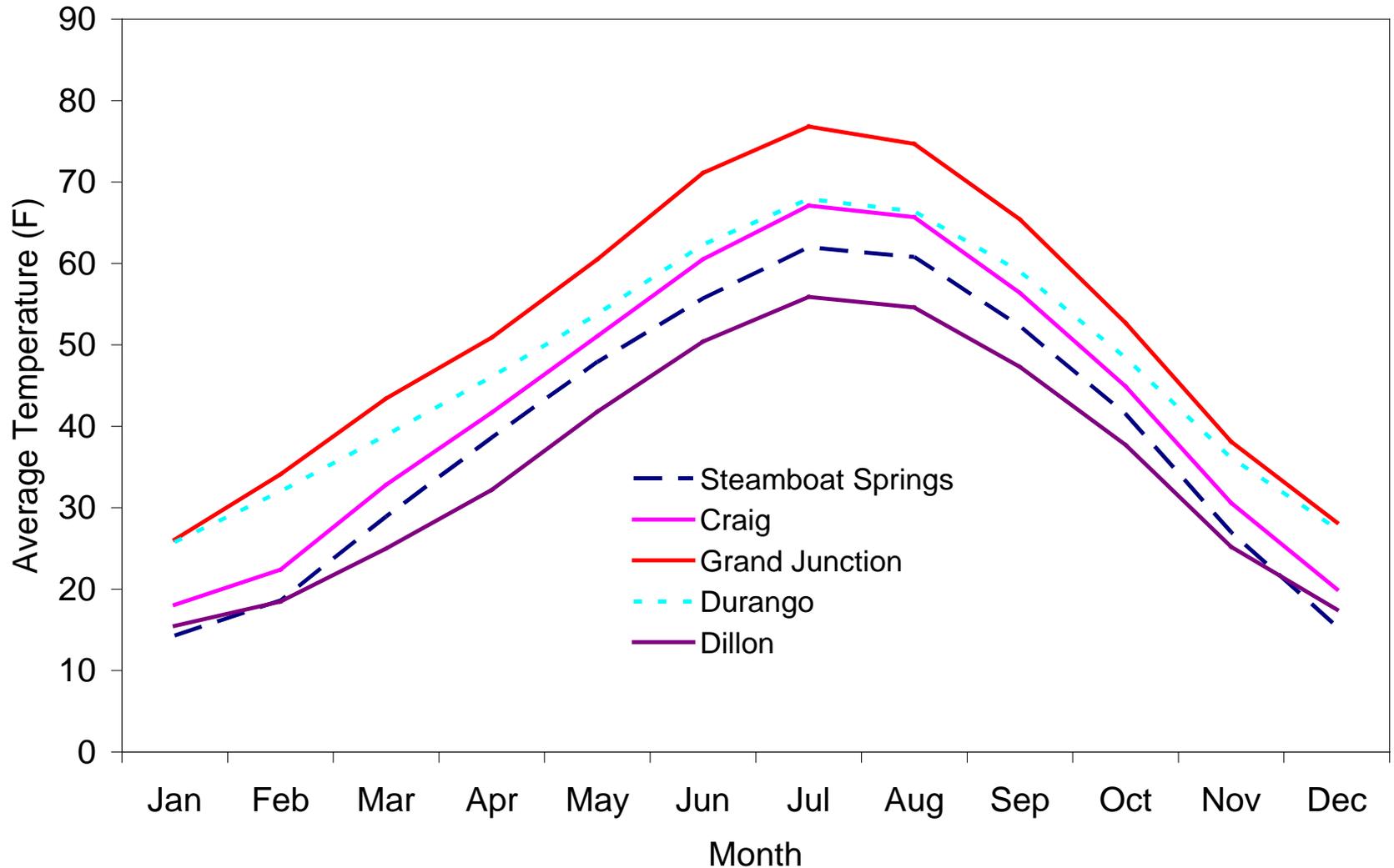
Garfield

Eagle

Summit

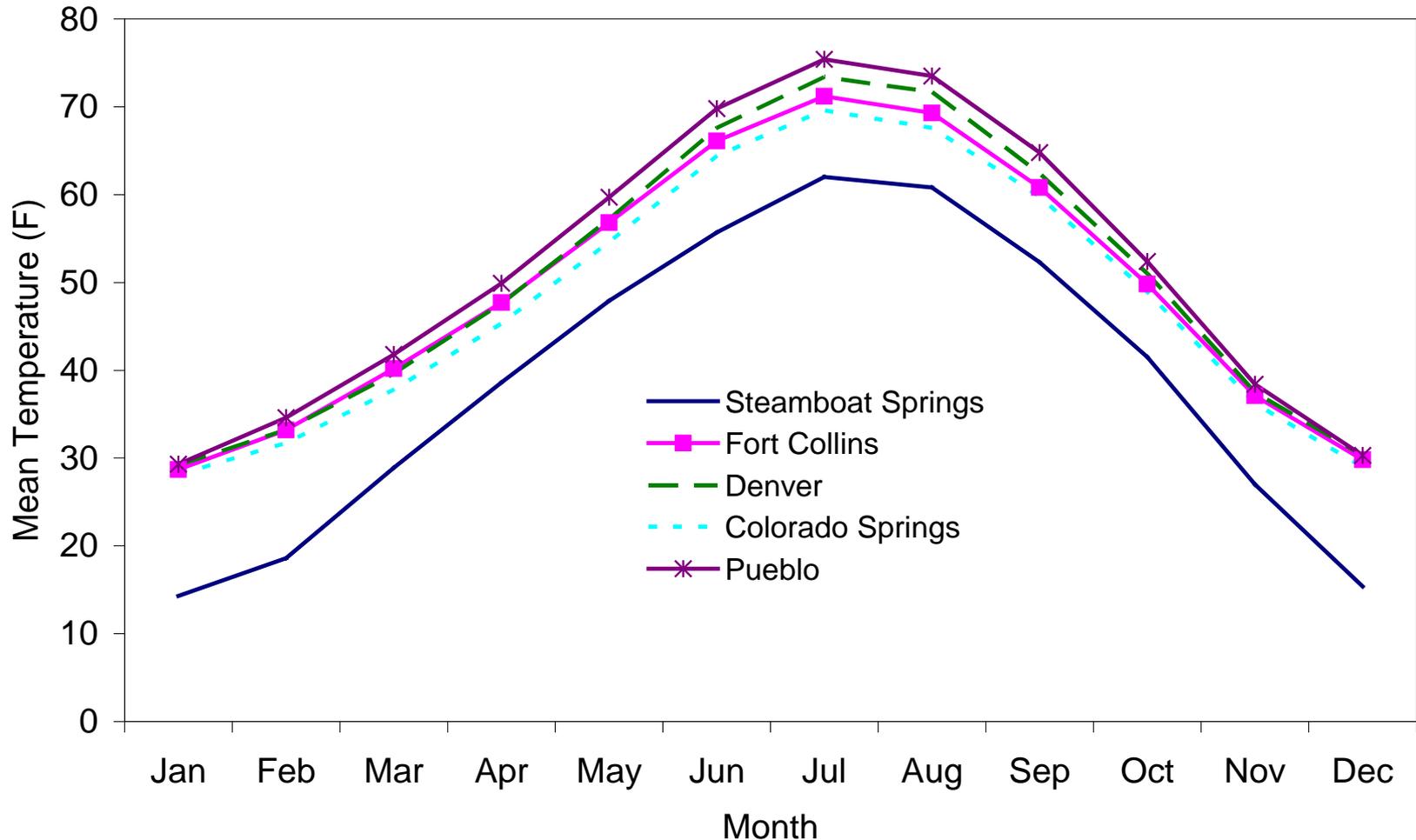
Temperatures compared to other parts of western Colorado

Mean Monthly Temperature



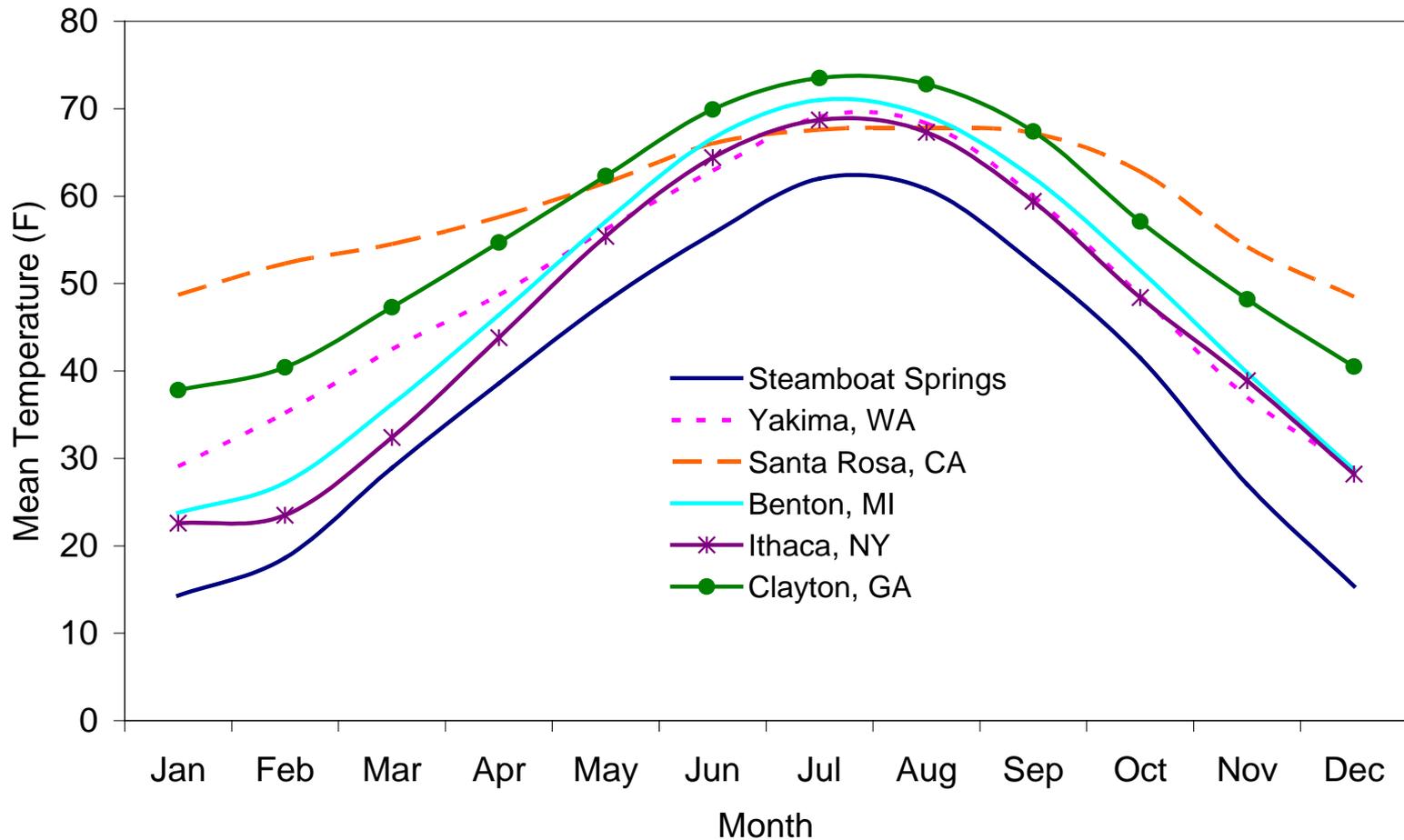
Temperatures compared to the Front Range cities of Colorado

Mean Monthly Temperature



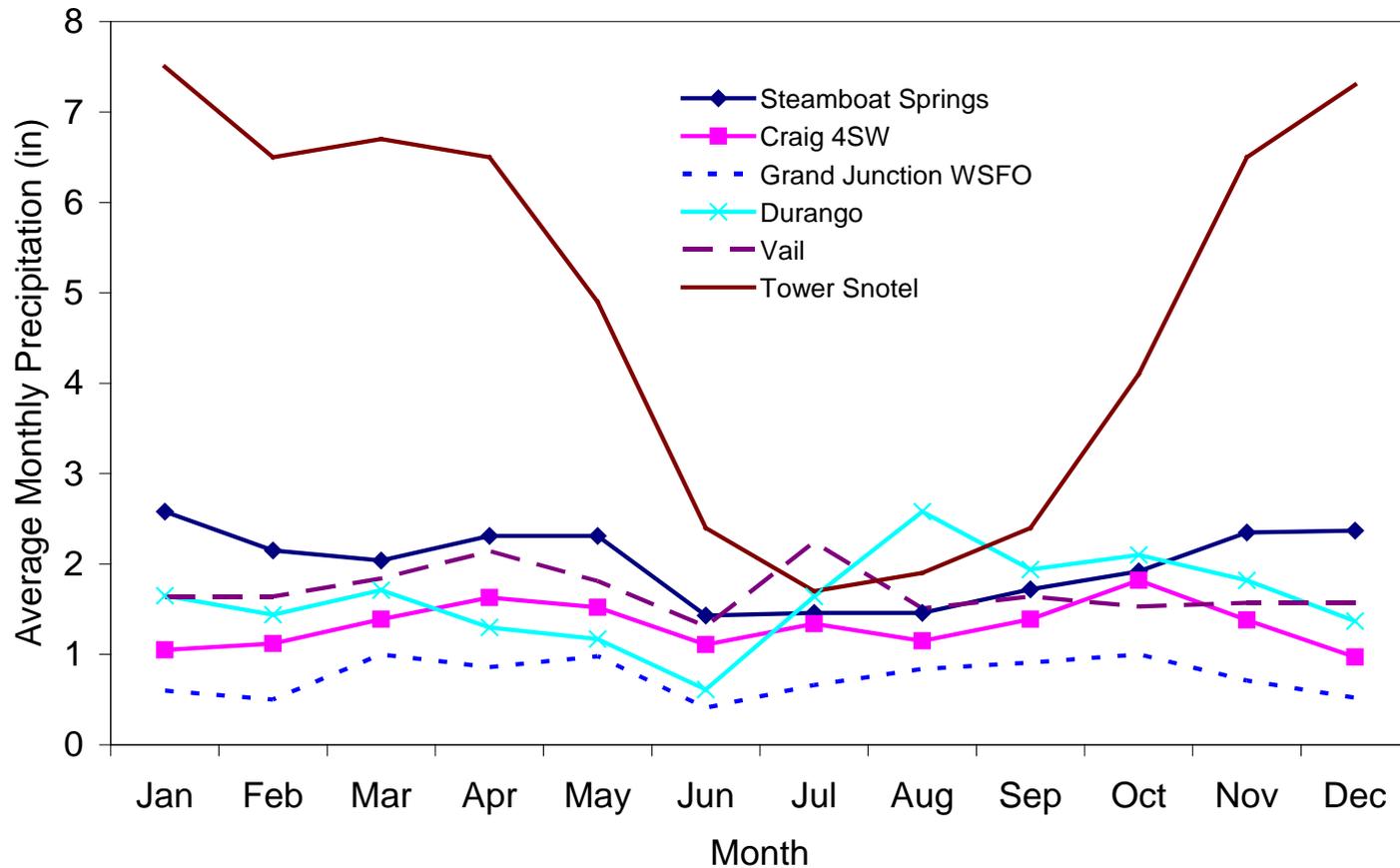
Temperatures compared to other parts of the United States

Mean Monthly Temperature



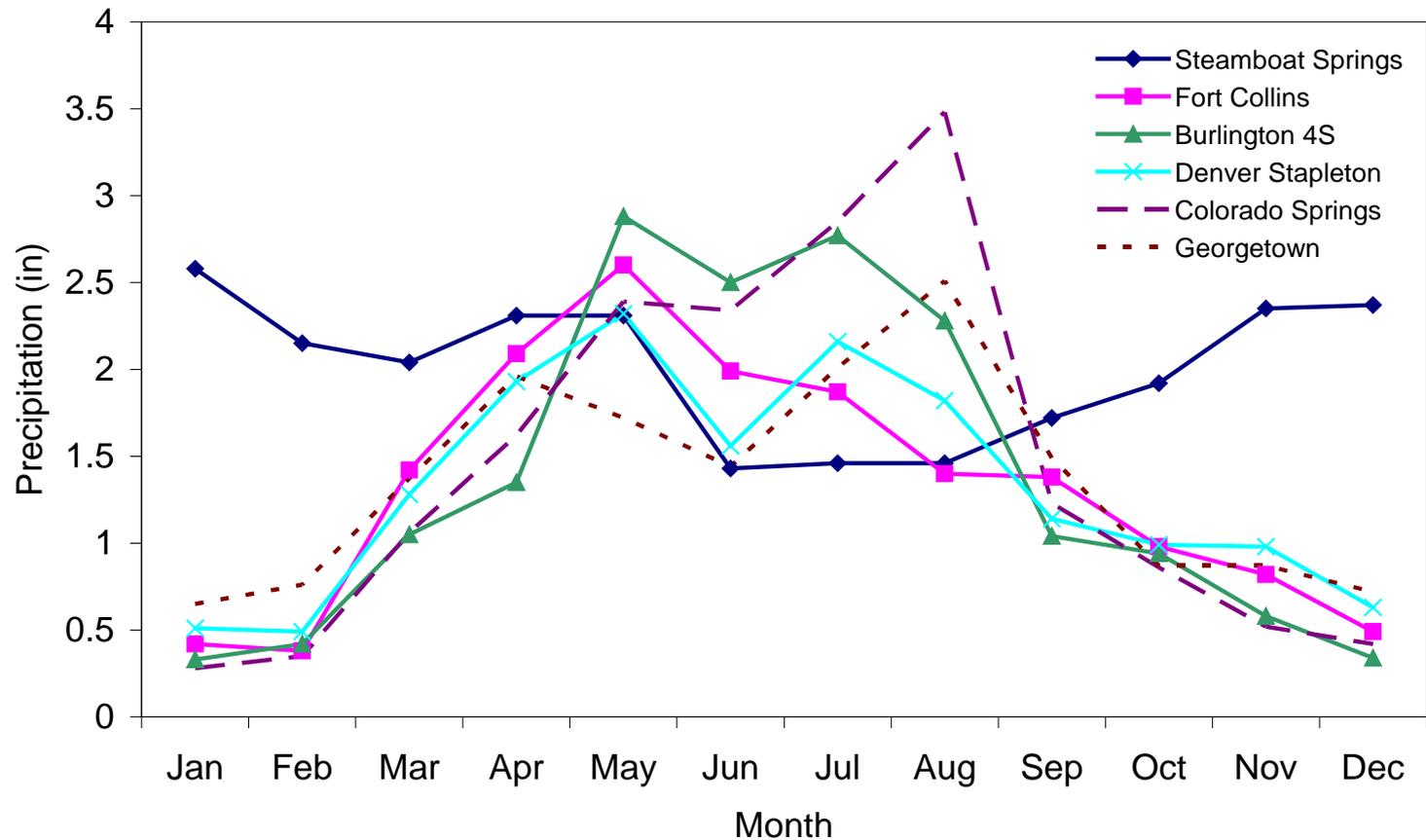
Precipitation compared to other parts of western Colorado

Average Monthly Precipitation



Precipitation compared to the Front Range and eastern Colorado

Average Monthly Precipitation



So

Are we seeing any long term
changes here in Western
Colorado?





For much of Colorado, upward trends in seasonal temperatures are being observed and analyzed.

However, precipitation continues to vary greatly and no discernable long-term trends have yet been detected

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



Why is that?

- Because climate is already naturally variable
- Also, our observations cover only relatively short periods and our weather stations are imperfect

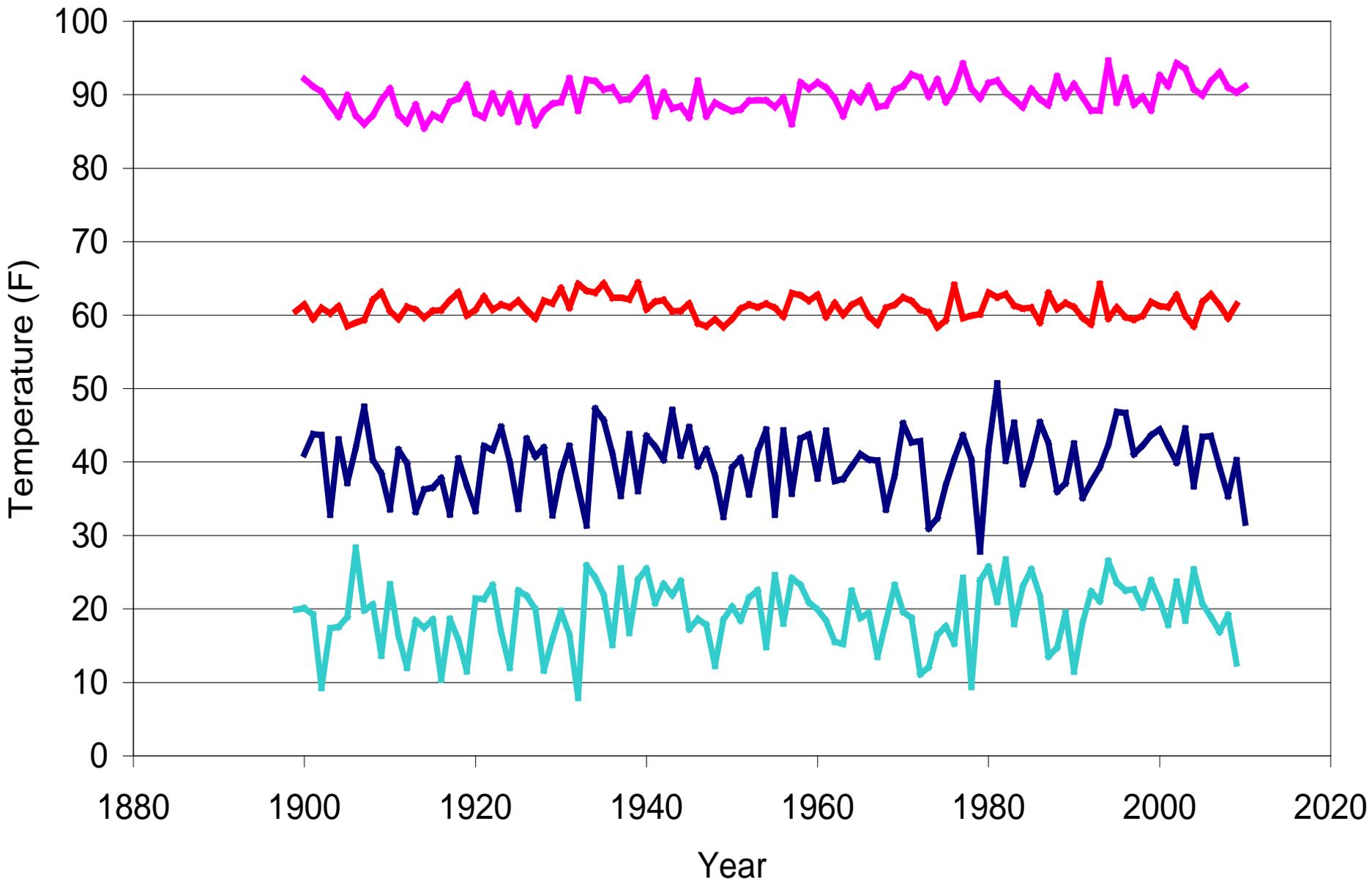


Still, our climate records are more complete, consistent, and widespread than nearly all other forms of long-term environmental monitoring (i.e. we shouldn't whine).



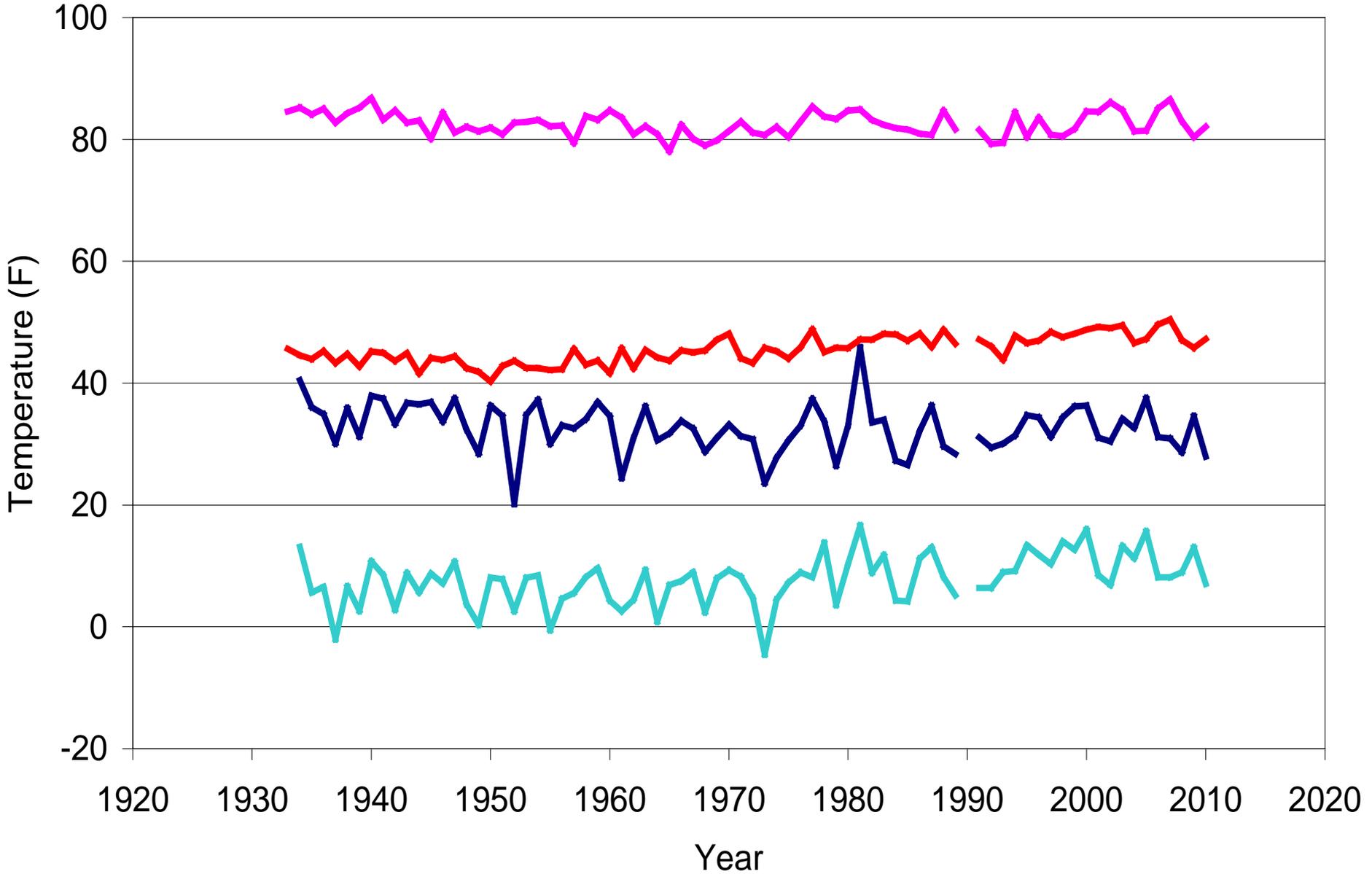
Grand Junction Seasonal Maximum and Minimum Temperatures

Winter Maximum Summer Maximum Winter Minimum Summer Minimum



Hayden Seasonal Maximum and Minimum Temperatures

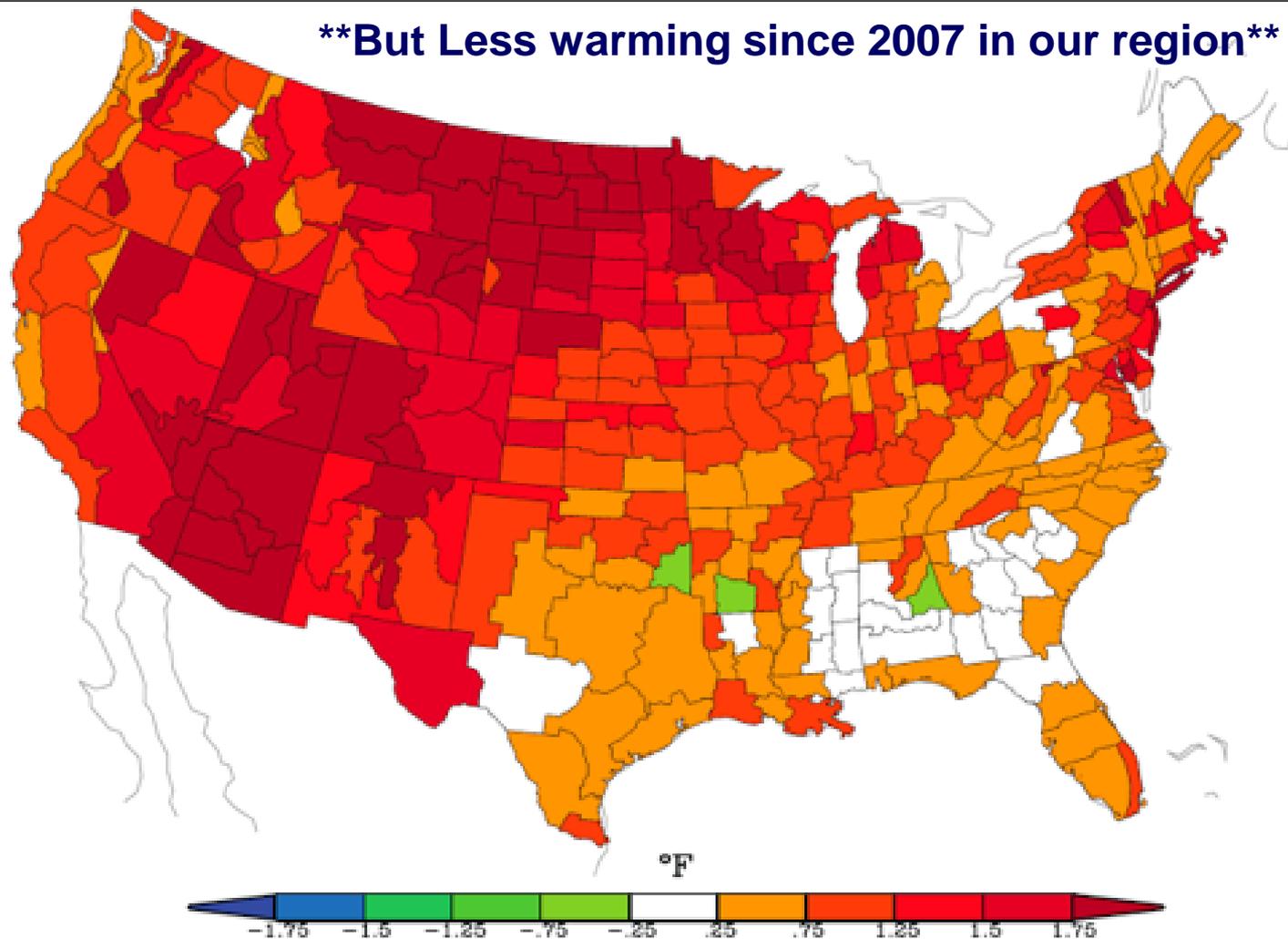
Winter Maximum Summer Maximum Winter Minimum Summer Minimum



It may not look like much on these graphs, but there has been an upward trend in temperatures over the past 50+ years over the western U.S.

Figure 3. The Interior West: Epicenter of Warming in the Contiguous U.S. (2000 - 2007 Average Temperatures Compared to 20th Century Averages)

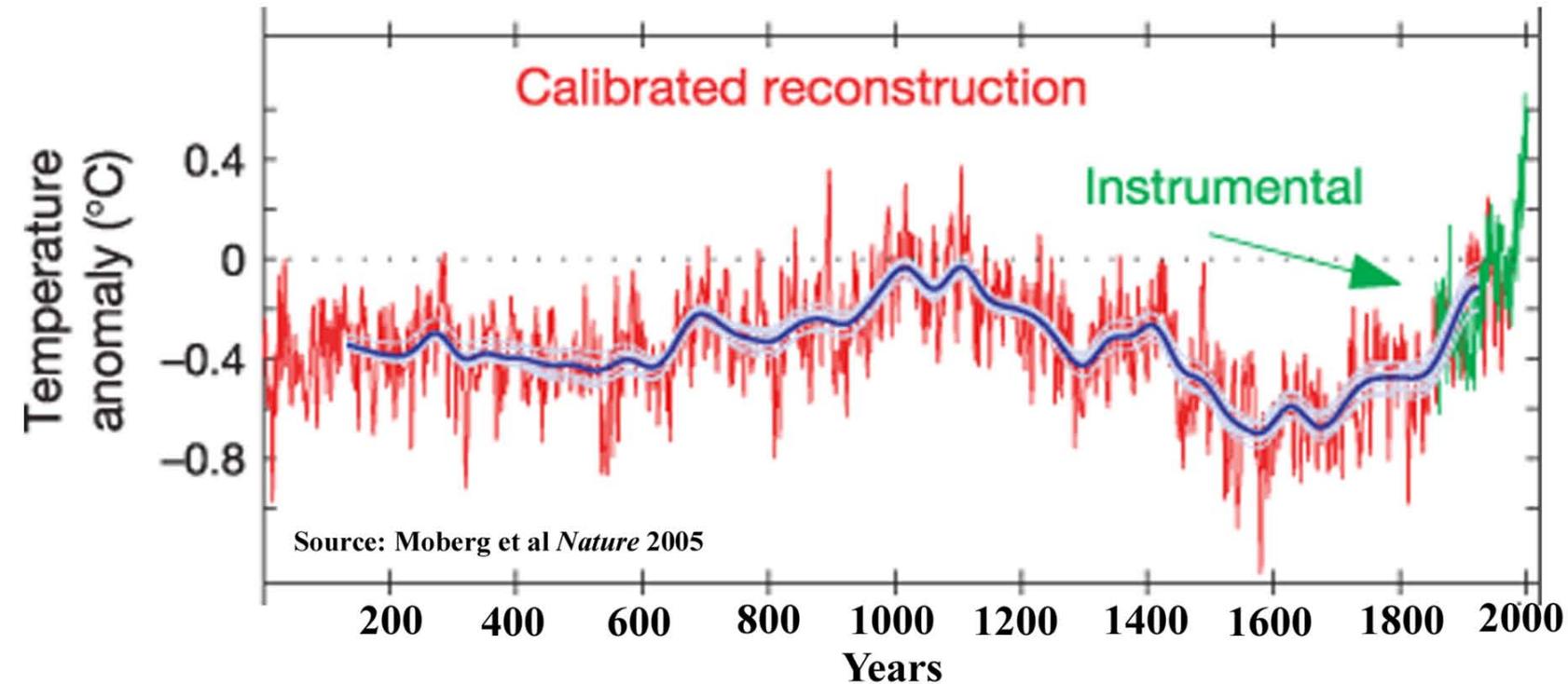
****But Less warming since 2007 in our region****



Average temperatures in 2000 - 2007 compared to averages for 1901 - 2000. Source: Dr. Martin Hoerling, National Oceanic and Atmospheric Administration.

Globally, this warming is apparent and unusual...

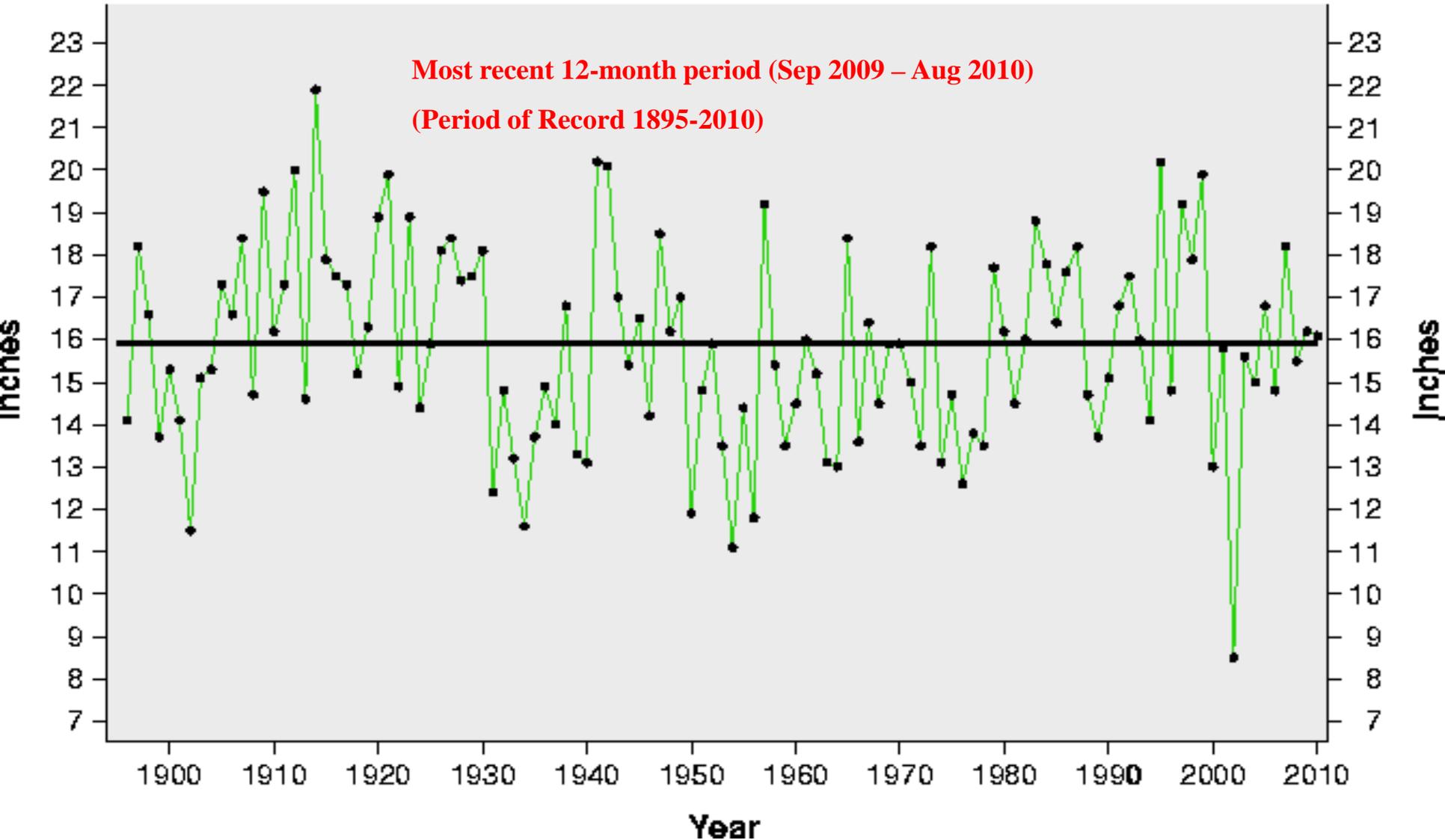
2000 Year Northern Hemisphere Reconstruction of Surface Air Temperatures



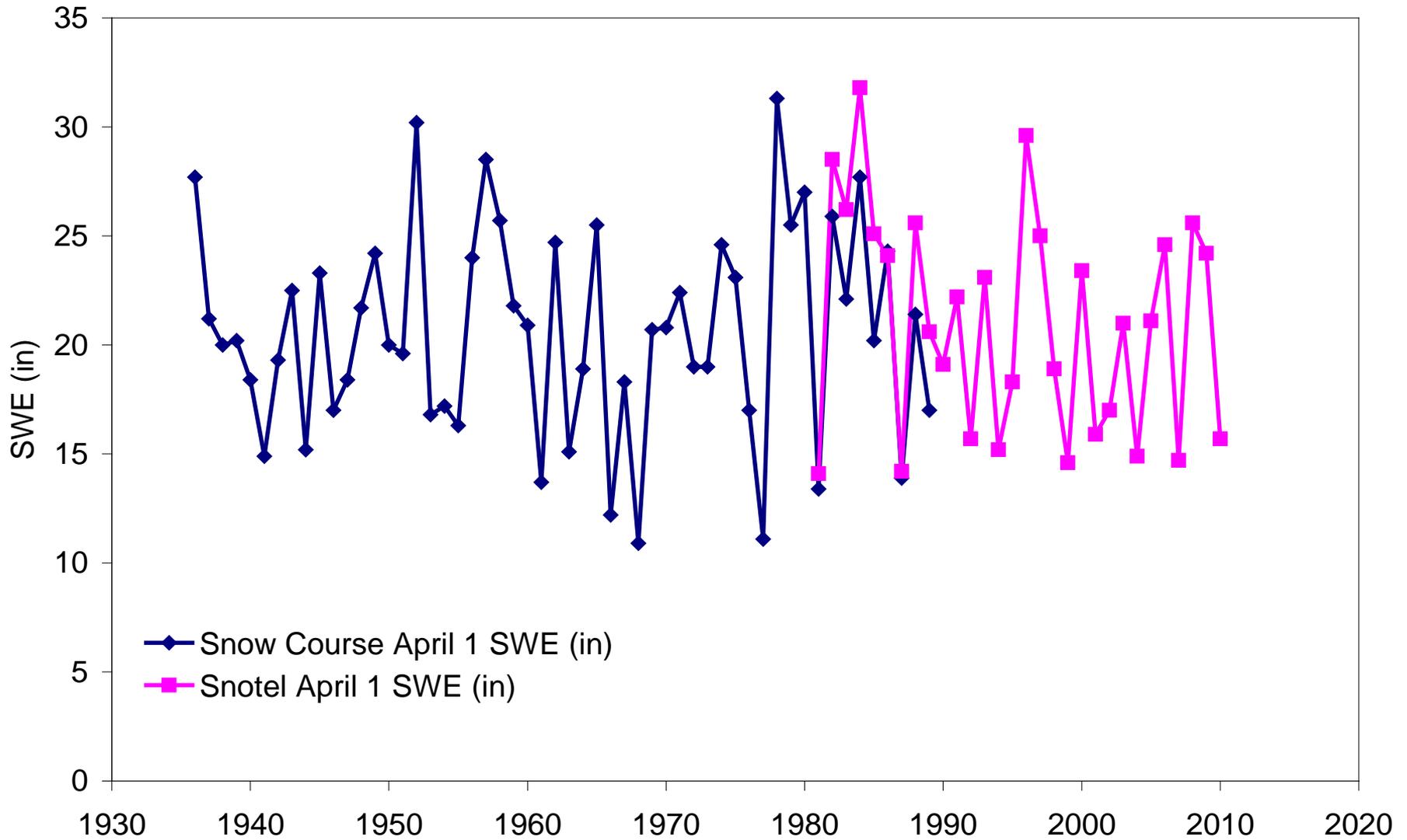
Figuring out what's going on with precipitation and snowpack is proving to be more challenging --- and that's to be expected because precipitation is SO variable to begin with

Colorado Precipitation in Historic Perspective

- Actual Precipitation
- Average Precipitation

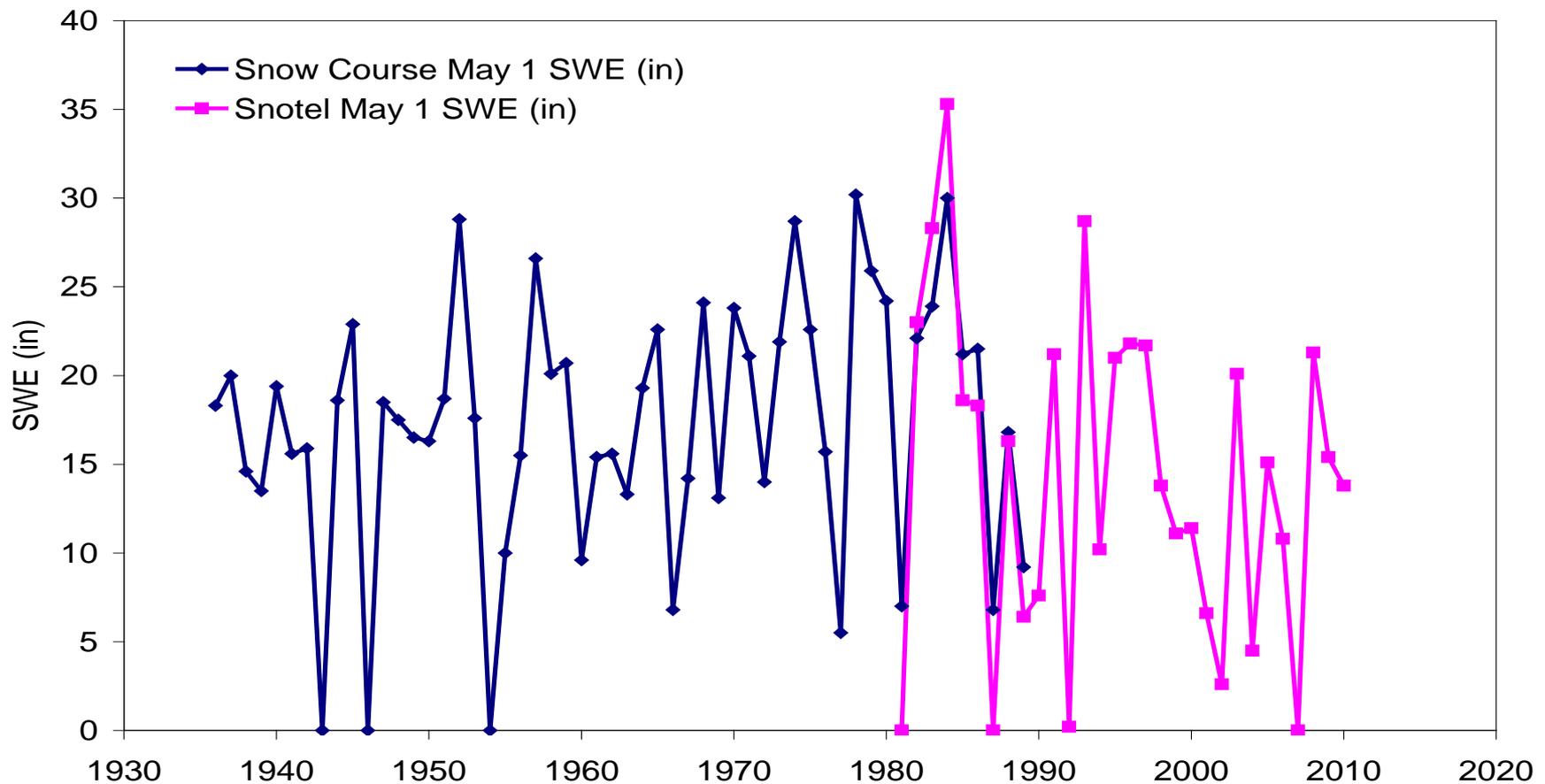


Dry Lake, CO (Elevation 8,400') April 1 Snow Water Equivalent

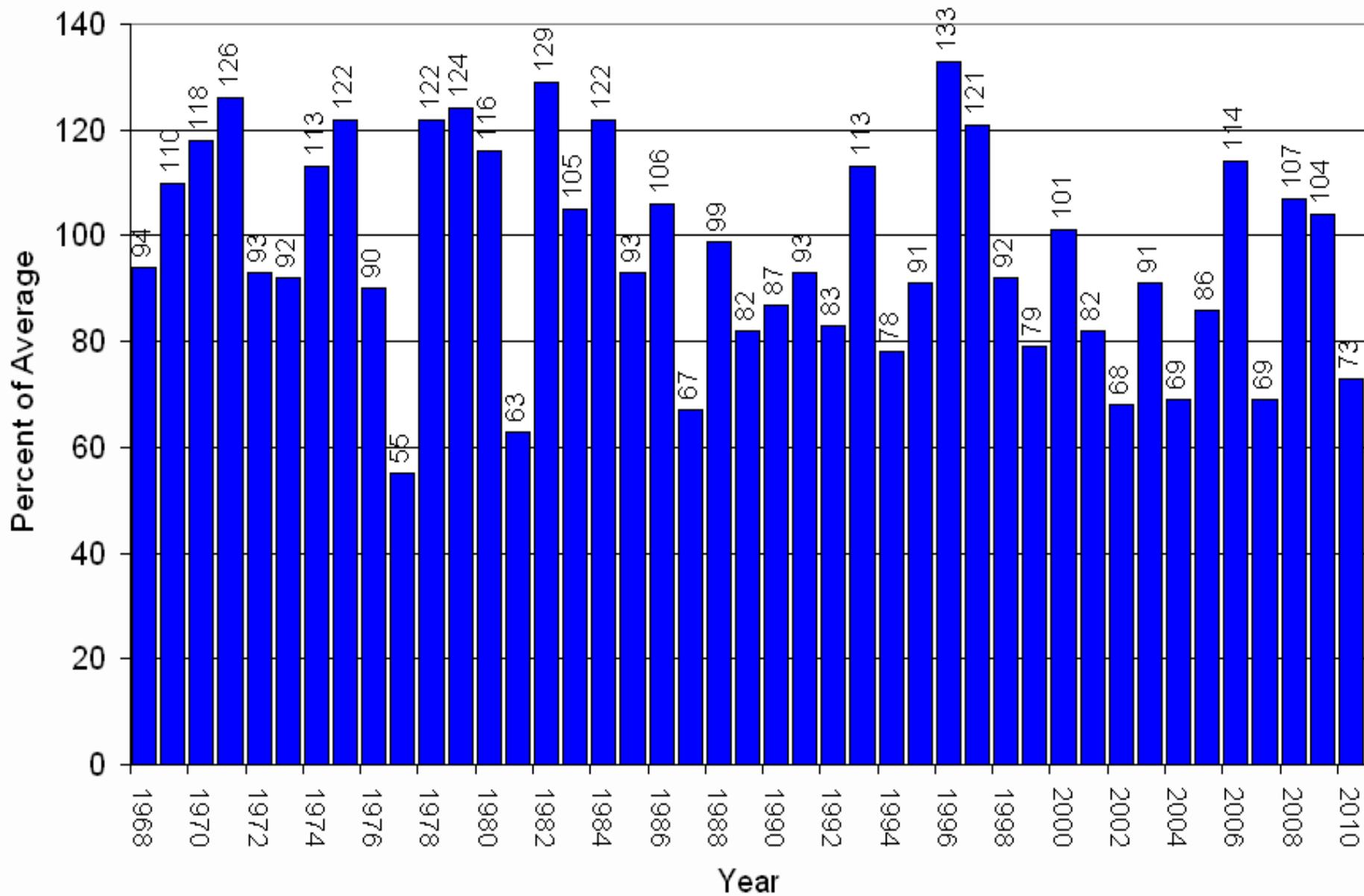


There is some evidence of earlier snowmelt, but it is less obvious here than in other parts of the West

Dry Lake, CO (Elevation 8,400') May 1 Snow Water Equivalent



April 1 Total Yampa & White River Basins Snowpack



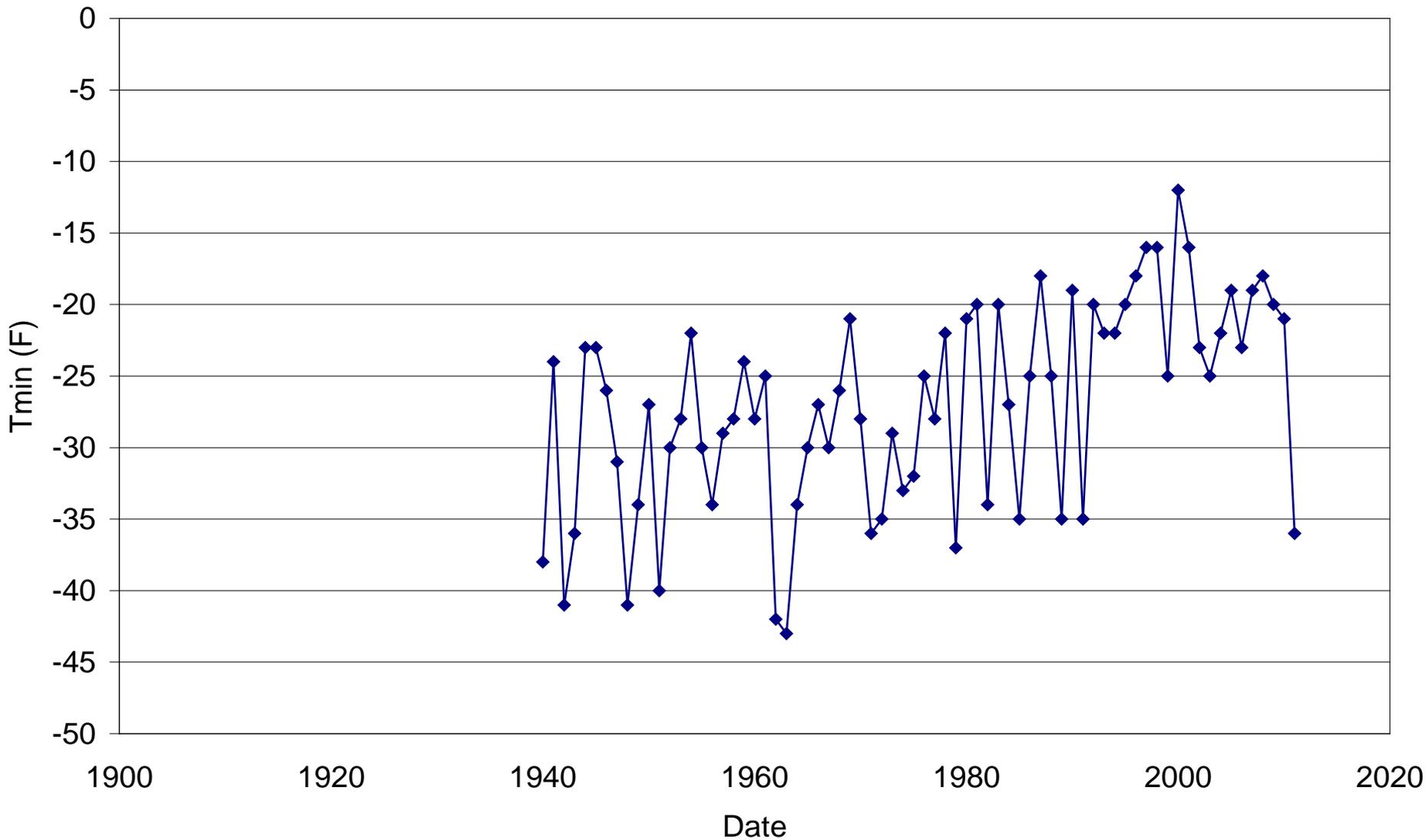
So, what about this winter?



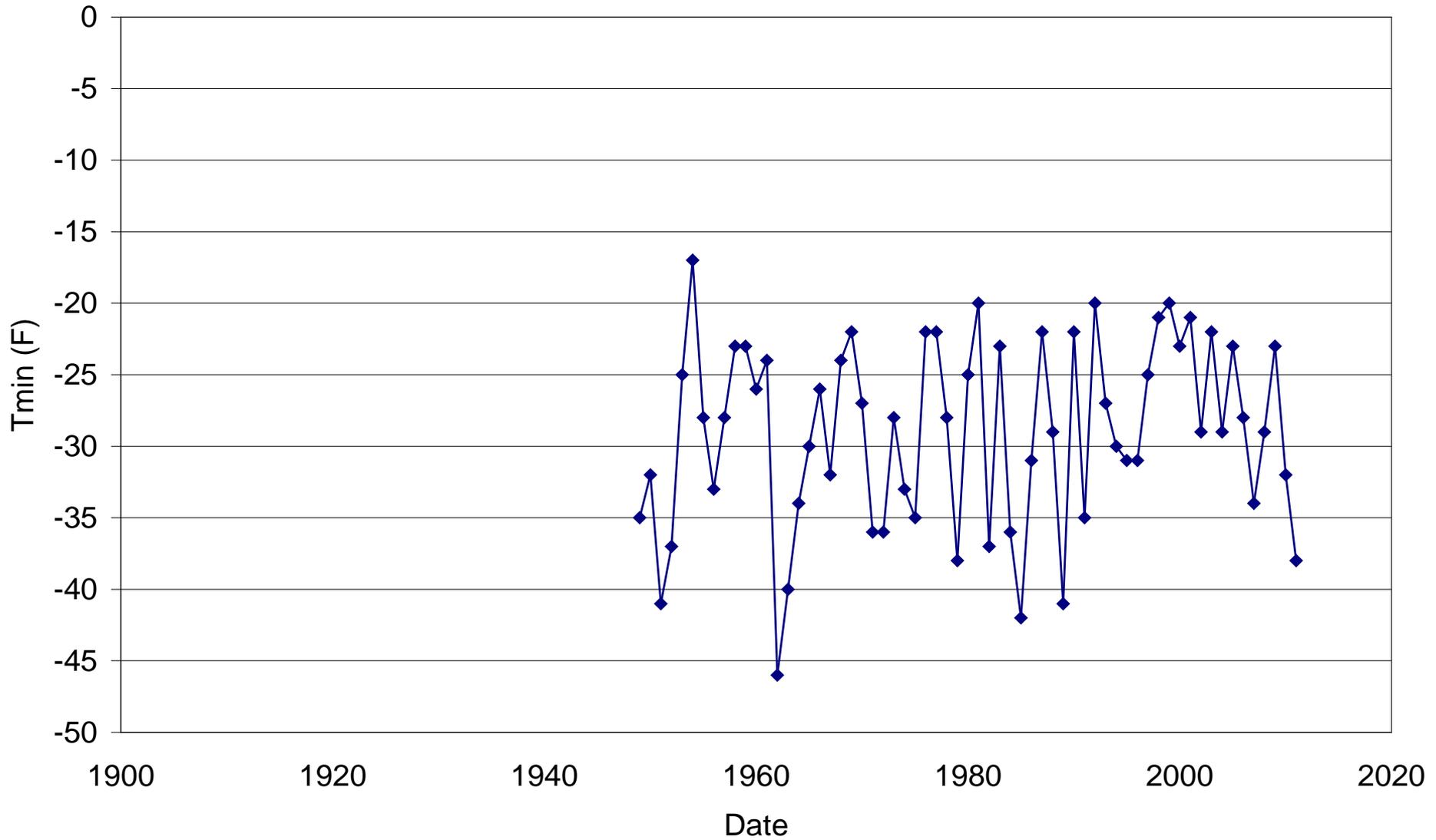
Two questions for you

- 1) How long has it been since we last had temperatures as cold as what we experienced early this month?
- 2) How long has it been since we've had this much snow on the ground in mid February?

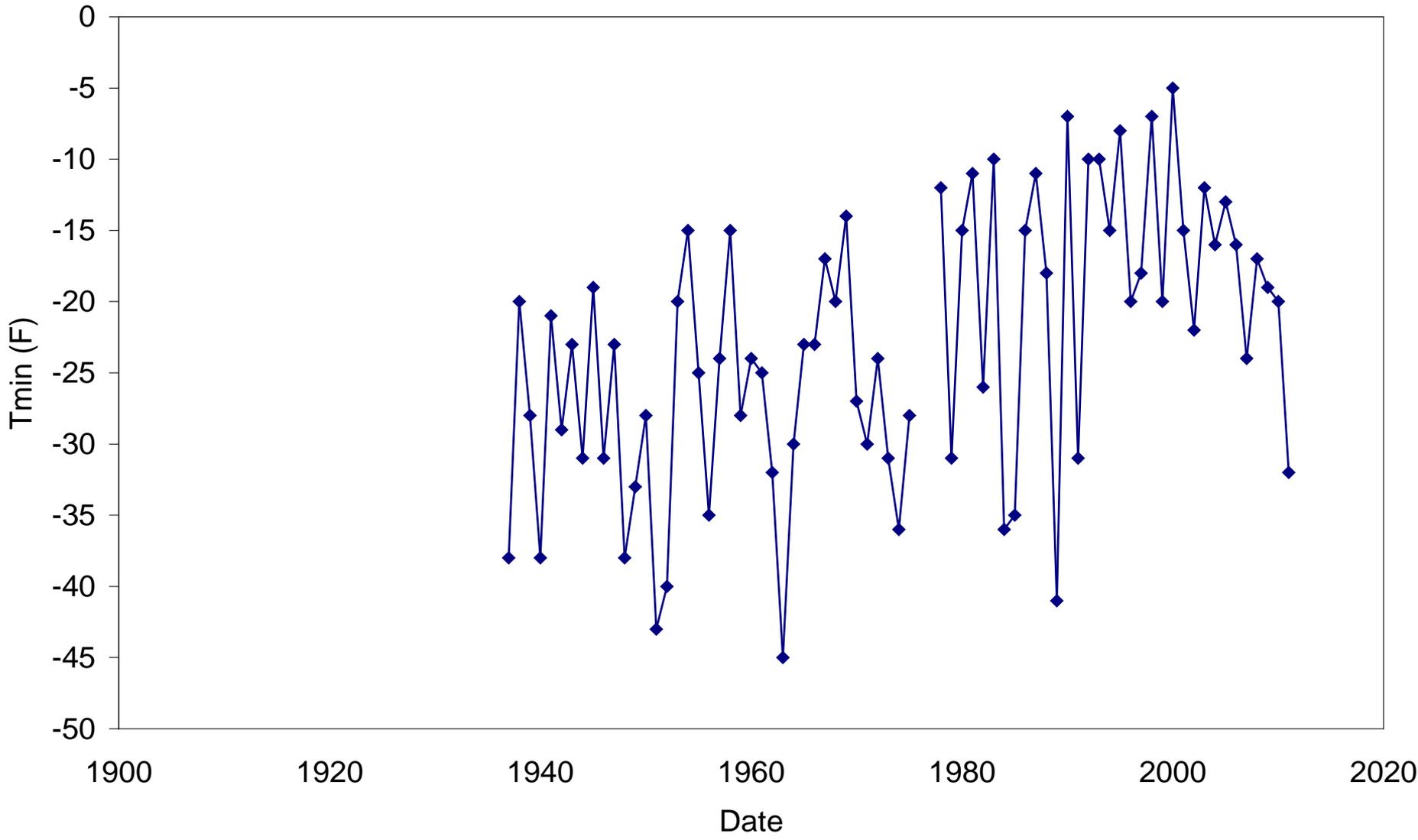
Grand Lake 1NW Coldest Winter Temperature



Grand Lake 6SSW Coldest Winter Temperature

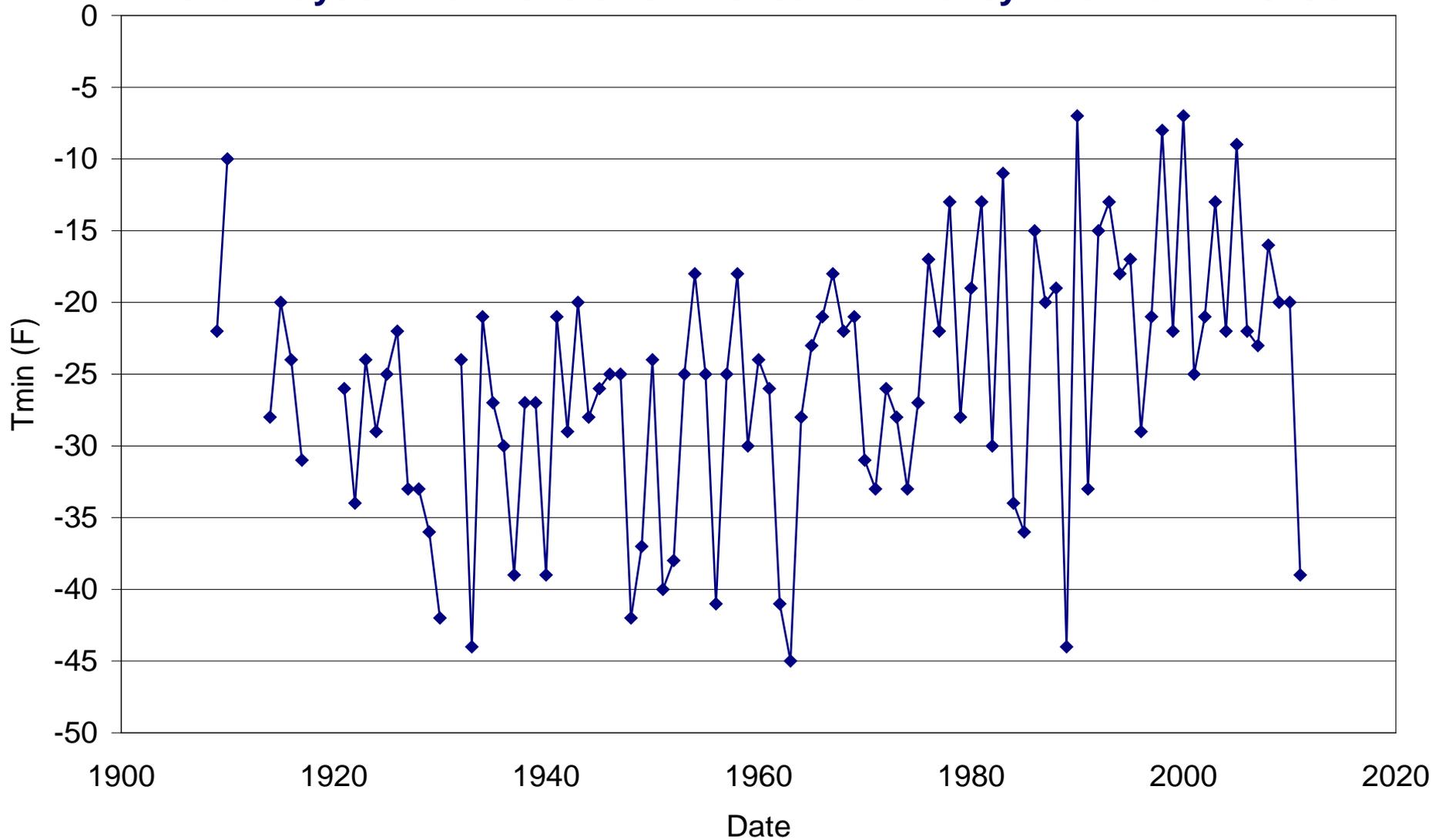


Craig/Craig 4SW Coldest Winter Temperature



Hayden Coldest Winter Temperature

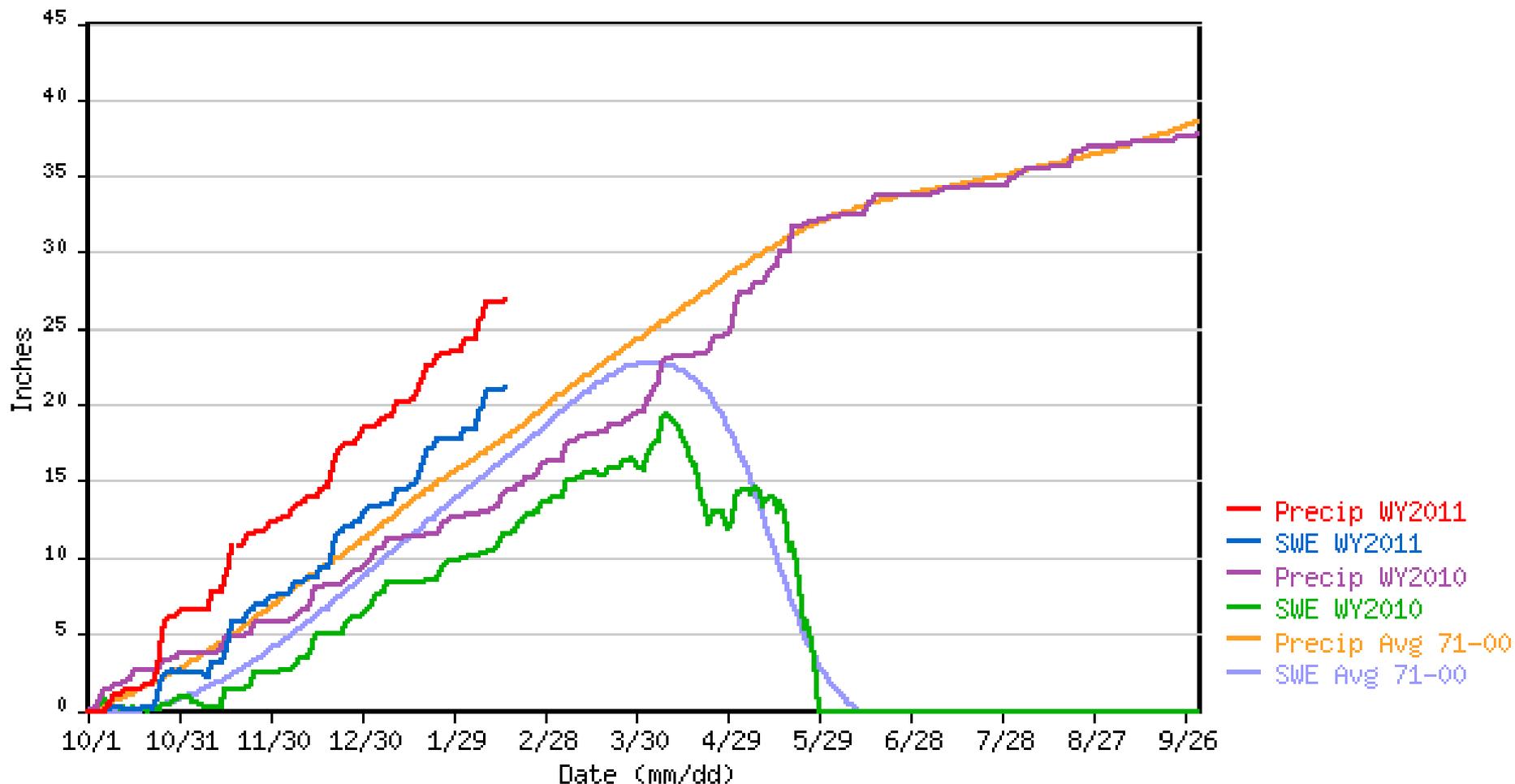
**** Note: Hayden weather station moved from valley to bench in 1970s**



Dry Lake SNOTEL WY 2010 and 2011

DRY LAKE SNOTEL as of 02/15/2011

*** Provisional Data, Subject to Change ***



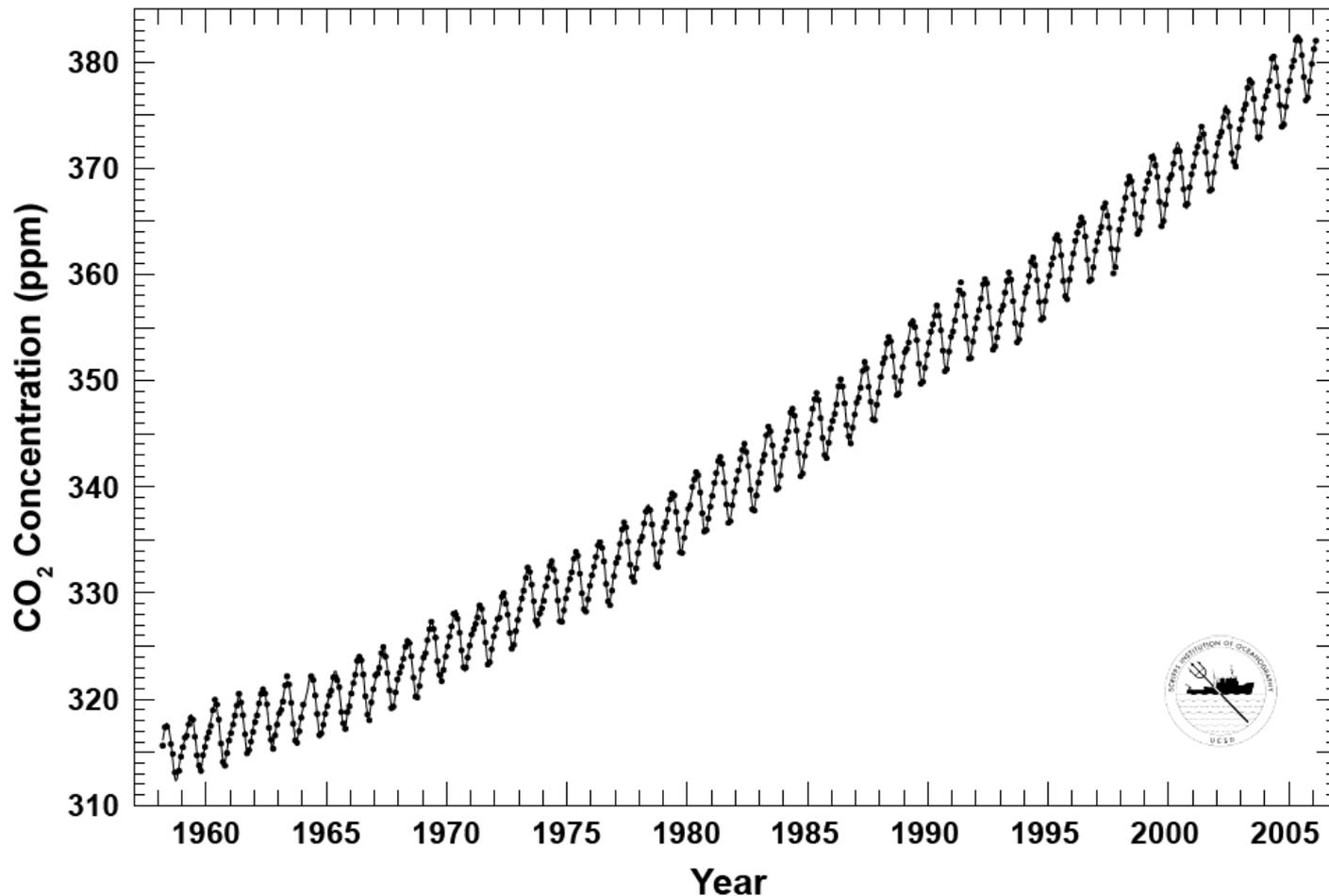
What about the future

Increases in greenhouse gases are real, large and continuing

Mauna Loa Observatory, Hawaii Monthly Average Carbon Dioxide Concentration

Data from Scripps CO₂ Program

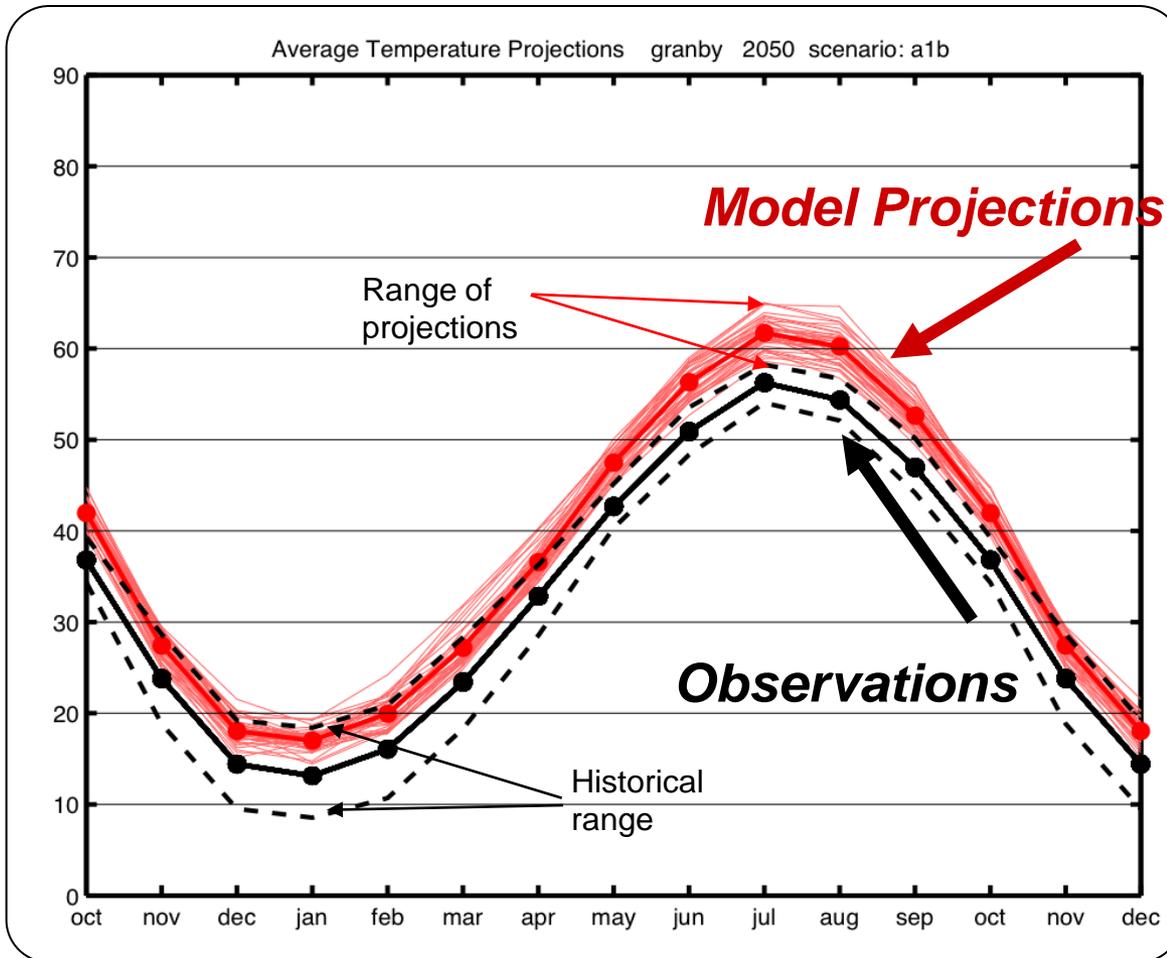
Last updated February 2006





Of course, there is uncertainty, but from the best available scientific understanding, warming is likely to continue and accelerate.

Projections: Temperature near Steamboat



**Summers warm
more than winters**

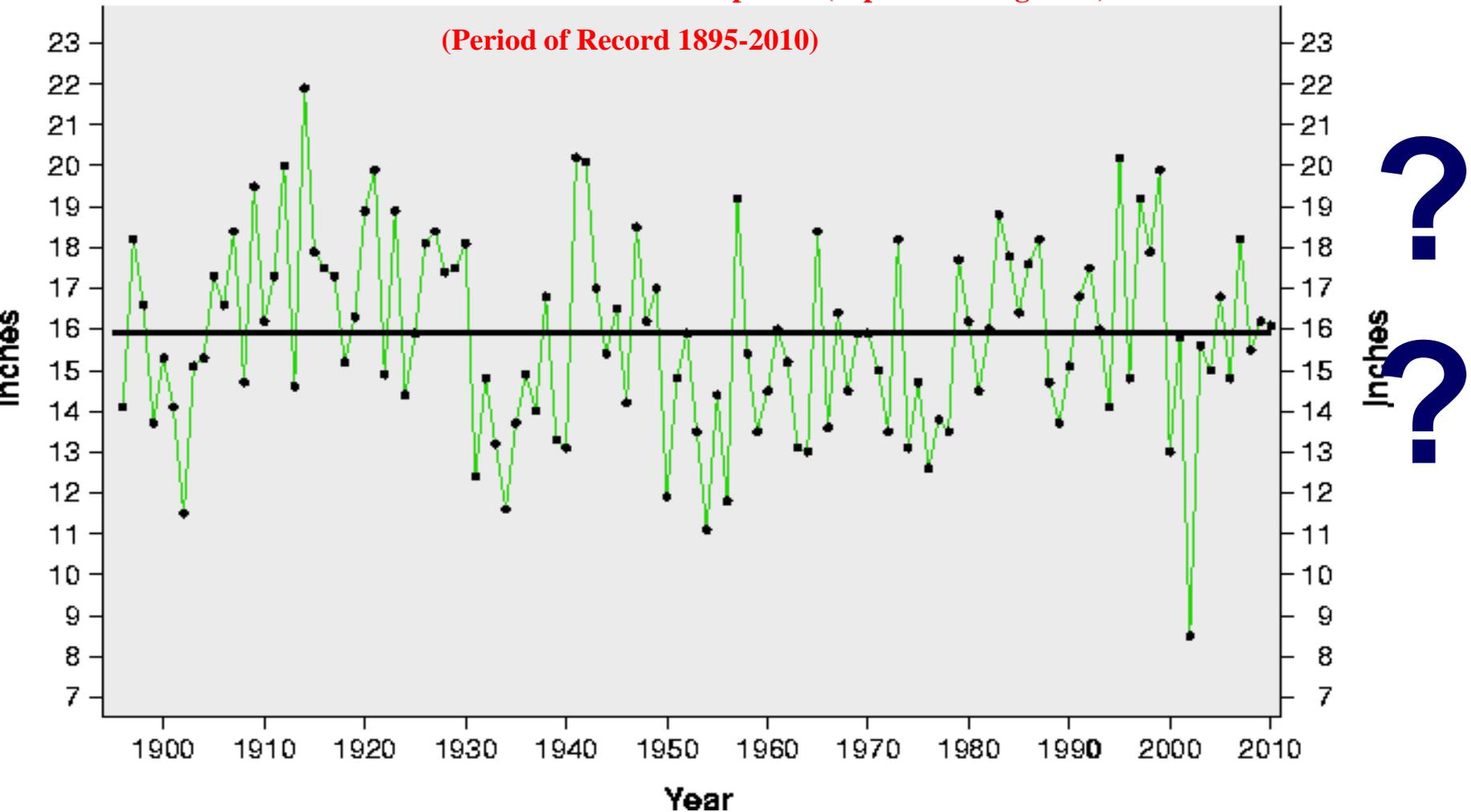
**Average summer
temps similar to
hottest days in the
past few years**

Earlier spring

Precipitation is harder to say

— Actual Precipitation
— Average Precipitation

Most recent 12-month period (Sep 2009 – Aug 2010)
(Period of Record 1895-2010)



The future will unfold and we can observe it together

Colorado State University

Colorado Climate Trends

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[Colorado Climate Center](#) » [Climate Trends](#) » [Home](#)

Search by Google

Welcome to the Colorado Climate Trends Website

[Climate Trends](#) | [Station Map](#) | [Station Info](#) | [Data Access](#) | [Links + Resources](#) | [About](#)

Climate Trends of Colorado



Welcome! The climate of Colorado is a valued natural resource affecting our lives and livelihoods. By nature, climate is variable. No two years are ever exactly alike. Instrumental observations of our climate dating back to the late 1800s give a sense of our average climate, typical variations, extremes and long-term trends. (For a description of historic weather observations in Colorado, click here). Tracking temperatures and precipitation through history reveal seasonal patterns, cold and warm periods, and episodes of drought and abundant water.

Today there is great interest in climate change. If our state is warming, these data will show it. This Website lets you view, graph and download historic temperature and precipitation data for selected weather stations in Colorado having the longest and most consistent historical data. Historic consistency is critical for accurately assessing climate trends. There have been hundreds of weather stations operated in Colorado since the 1890s, but very few have data that are complete and consistent. Even the best stations selected for this site are imperfect.

For each station shown here, a description of the history of the station is provided so that data users will know what factors may have affected the long-term time series. To learn more

<http://climatetrends.colostate.edu>

National Weather Service Co-op Program

Weather observations in Colorado using thermometers and rain gauges date back to the late 1800s. Some of the earliest weather stations were established in the

largest cities during the 1870s by the U.S. Signal Service. In the 1880s Colorado formed a "State Weather Service" and began setting up more basic weather stations in smaller towns and rural areas. By 1890, the first nationwide civilian weather service was formed within the U.S. Department of Agriculture. State networks, such as Colorado's were combined to form a single nationwide volunteer weather observing network. This same network continues today managed by the National Weather Service. What began as a few dozen stations in the 1880s grew to over 200 in the 1940s and 50s and continues today.



National Weather Service
Cooperative Observer Program

This website is a resource that anyone can use to keep tabs on Colorado's observed climate – its variations and trends.

<http://climatetrends.colostate.edu>

And by the way, we could use your help





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

<http://www.cocorahhs.org>

or see me today



CoCoRaHS (Community Collaborative Rain, Hail and Snow) – A simple but effective way to help scientists track Colorado Climate



<http://www.cocorahs.org>



Join Us! Visit the CoCoRaHS Web Site <http://www.cocorahs.org>





2) Help us Celebrate “Water 2012”

Our goal -- a rain gauge at every school in Colorado to help spread experience, knowledge and appreciation for where our water comes from -- help sponsor your favorite school(s) contact me

“A Rain Gauge at Every School”

Seeking:

- **Sponsors** to purchase gauges
- **Mentors** to assist/train teachers
- **Teachers** to participate with students



Contact: Noah Newman: noah@cocorahs.org

Or Nolan Doesken nolan.doesken@colostate.edu

**Colorado: It's a great place
but we have to be ready for anything**



Photo by Lynn Kral, Loveland, January 2006

Colorado Climate Center

Data and Power Point Presentations available for downloading

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

Nolan.Doesken@Colostate.edu

