Climate Change in Colorado – Yes, No, Maybe So?

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Presented at Peak to Prairie Landscape Conference, Colorado Springs, February 8, 2008

Prepared by Odie Bliss

Colorado State University
Knowledge to Go Places

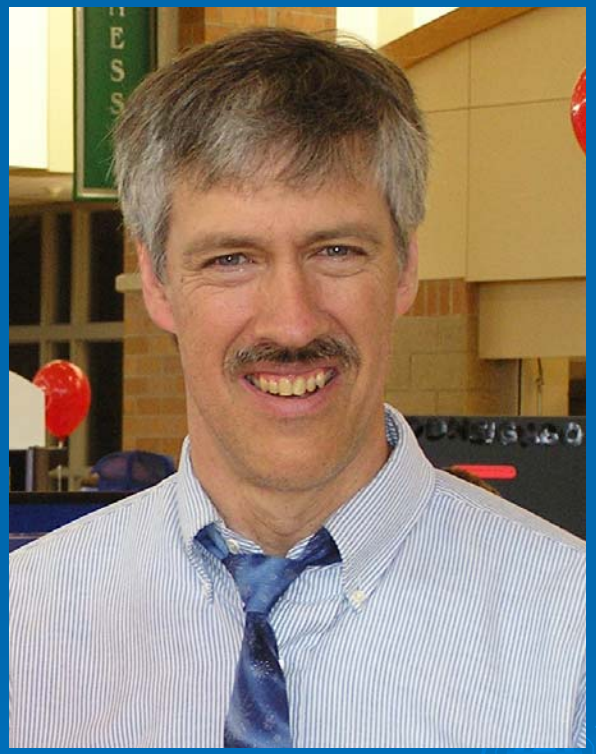

Has our climate changed in the past?

Will our climate change in the future?

So what's the big deal? – Change happens ….

Tom McKee, 1974-1999

Roger Pielke, 2000-2005



Nolan Doesken, 2006 - ??

The Climate of Comfort

- We humans seem to like living in sunny, dry places


We need a reliable supply of water

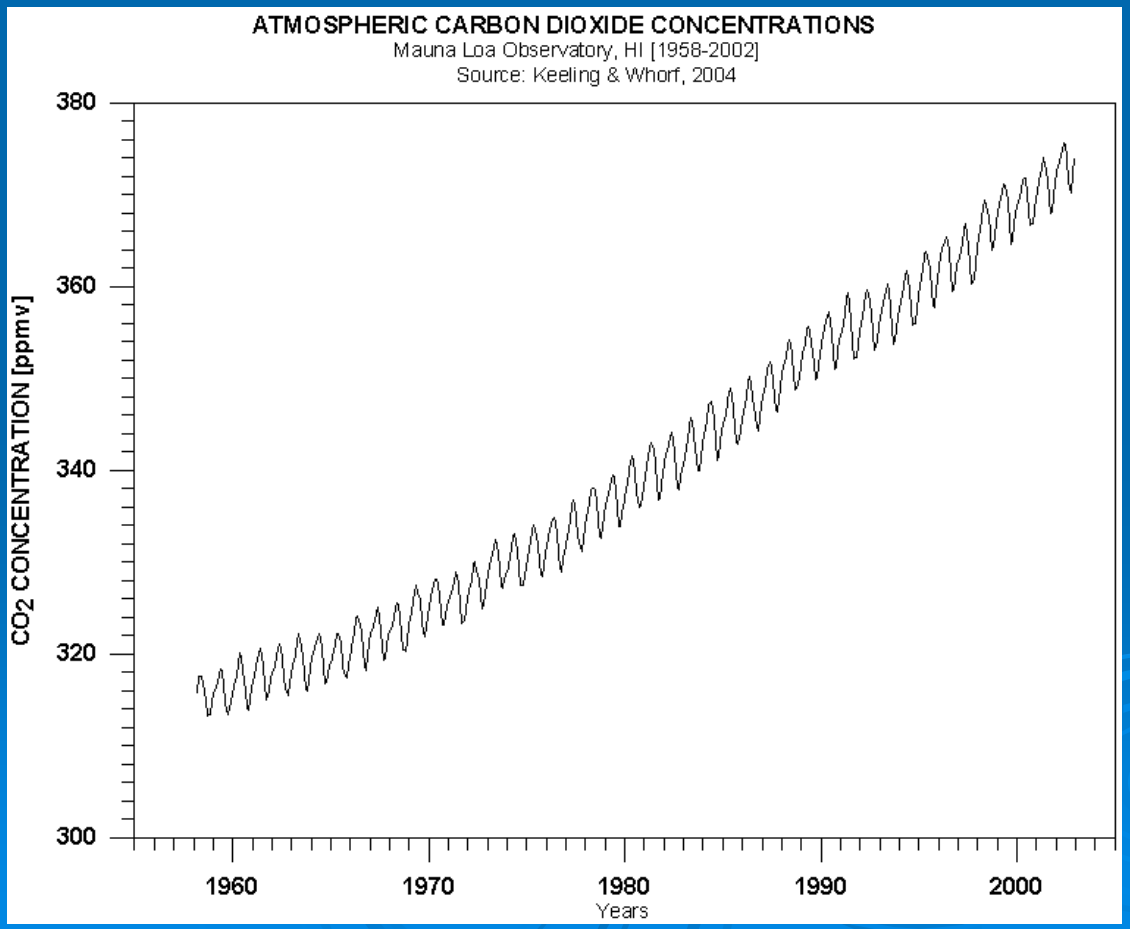
- **We want our search for comfort, food, and water to be inexpensive and take very little of our time**

- **We like to be warm in the winter, cool in the summer, able to travel at will, and able to eat foods and consume goods from around the world – all the time**

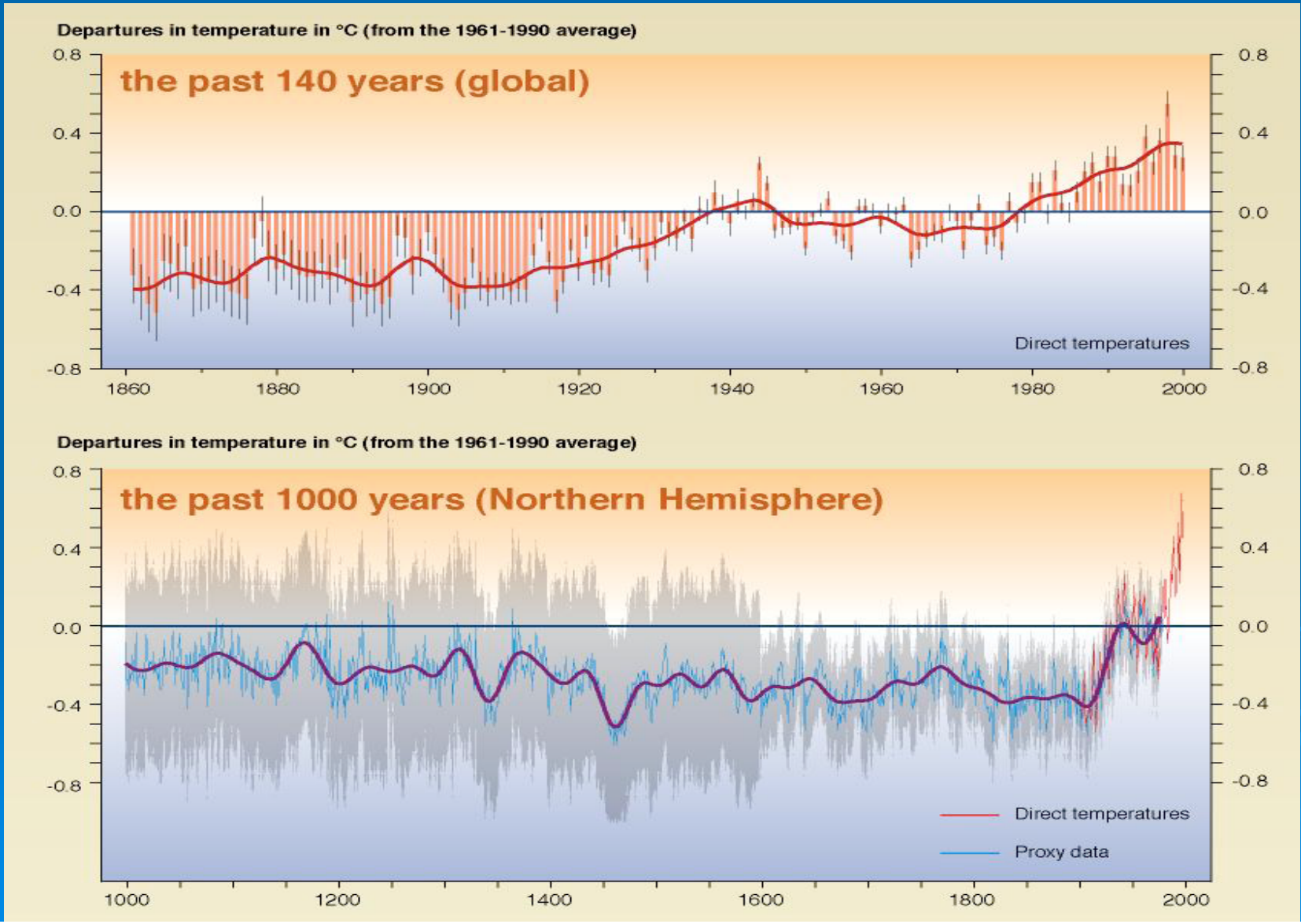
- We've gotten good at "Living Large"

-- to accommodate this, we have become incredible consumers of energy almost without realizing it.

Our consumption of fossil fuels is changing the composition of the atmosphere



By changing the atmosphere we could be changing the climate of the earth



There is a lot of information out there about Climate Change

- If you want to get the latest scoop on the Global Scale read the ***IPCC (Intergovernmental Panel on Climate Change) Report*** at this website

- http://www.ipcc.ch

Summary for Policymakers

- If you want an abbreviated version, read: ***IPCC: Climate Change 2007: The Physical Basis (AR4)***

  http://www.ipcc.ch

  Click on:

  "Summary for Policymakers"

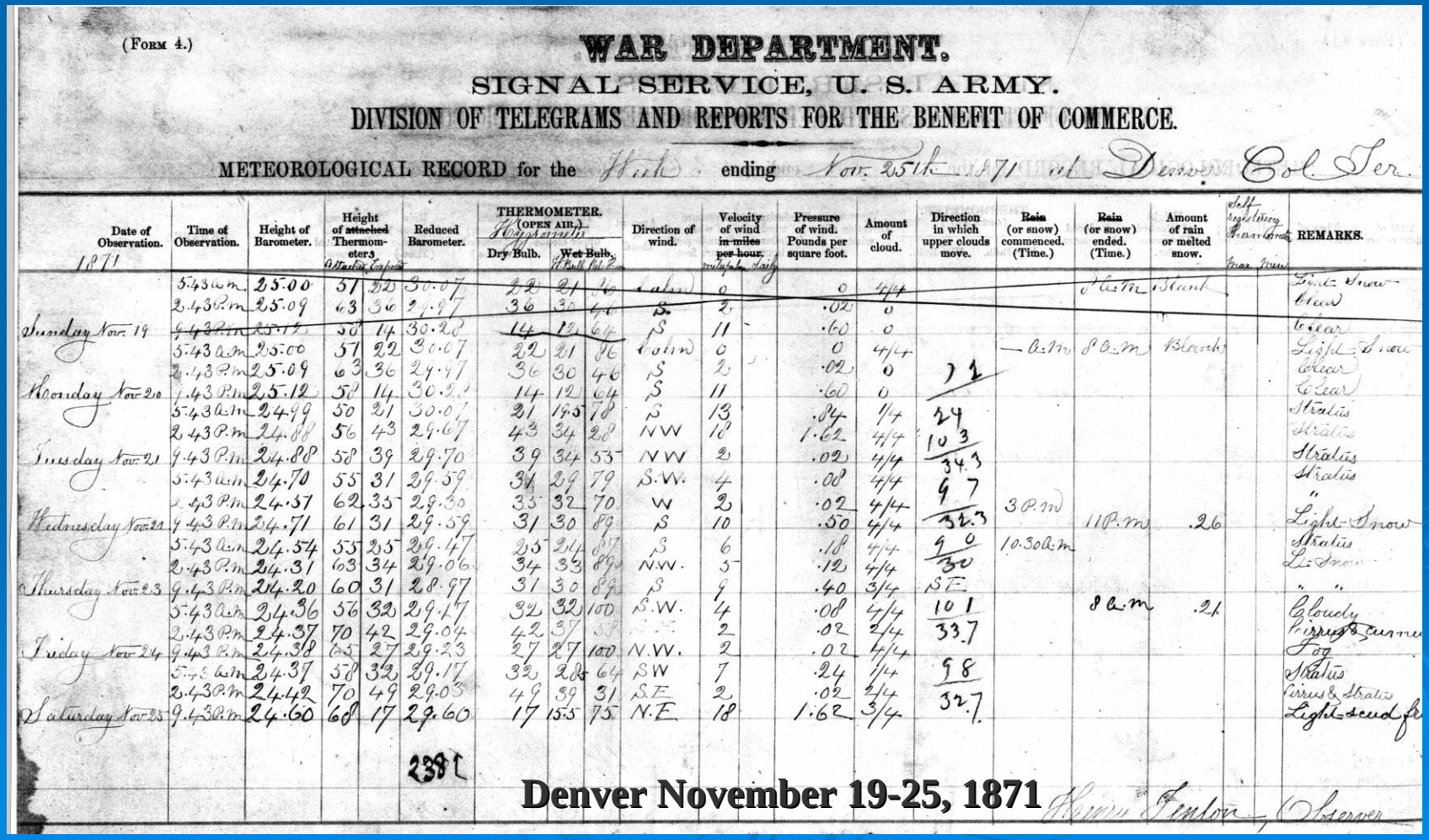
- Those results represent the global majority (consensus) scientific perspective
- There are also minority views

- There may be a consensus regarding Global Climate Change
- Understanding local and regional climate change is much more difficult.

That is the challenge at hand.

Let's begin by understanding our current and recent climate

Systematic weather data collection began in southeast Colorado in the 1870s



(Form 4.)

WAR DEPARTMENT.

SIGNAL SERVICE, U. S. ARMY.

DIVISION OF TELEGRAMS AND REPORTS FOR THE BENEFIT OF COMMERCE.

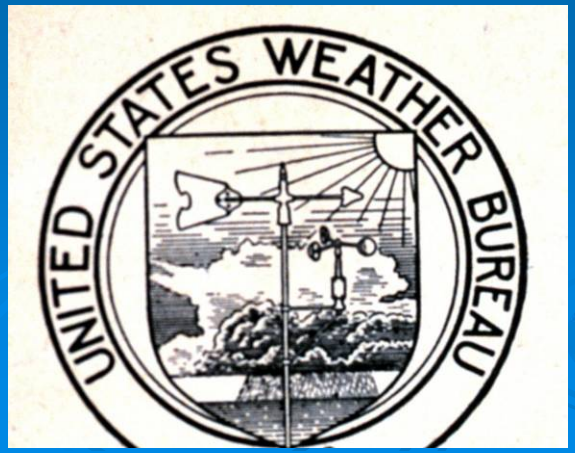
METEOROLOGICAL RECORD for the Week ending Nov. 25th 1871 at Denver Col. Ter.

Date of Observation. 1871	Time of Observation.	Height of Barometer.	Height of ~~attached~~ Thermometers	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.	REMARKS.
	5.43 a.m.	25.00	37 22	30.07	22	21	Calm	0	0	4/4			Plus M	Blank	Fine Snow
	2.43 P.m.	25.09	63 36	29.97	36	30	S.	2	.02	0					Clear
Sunday Nov. 19	9.43 P.m.	25.12	58 14	30.28	14	12	S	11	.60	0					Clear
	5.43 a.m	25.00	37 22	30.07	22	21	Calm	0	0	4/4		— a.m	8 a.m	Blank	Light Snow
	2.43 P.m	25.09	63 36	29.97	36	30	S	2	.02	0	11				Clear
Monday Nov 20	9.43 P.m	25.12	58 14	30.28	14	12	S	11	.60	0					Clear
	5.43 a.m	24.99	50 21	30.07	21	19.5	S	13	.94	1/4	24				Stratus
	2.43 P.m	24.88	56 43	29.67	43	34	NW	10	1.62	4/4	10 3				Stratus
Tuesday Nov 21	9.43 P.m	24.88	58 39	29.70	39	34	NW	2	.02	4/4	34.3				Stratus
	5.43 a.m	24.70	55 31	29.59	34	29	S.W.	4	.08	4/4	9 7				Stratus
	2.43 P.m	24.37	62 35	29.30	33	32	W	2	.02	4/4		3 P.m			"
Wednesday Nov 22	9.43 P.m	24.71	61 31	29.59	31	30	S	10	.50	4/4	32.3		11 P.m	.26	Light Snow
	5.43 a.m	24.54	55 25	29.47	25	24	S	6	.18	4/4	9 0	10.30 a.m			Stratus
	2.43 P.m	24.31	63 34	29.06	34	33	N.W.	5	.12	4/4	30				Li Snow
Thursday Nov 23	9.43 P.m	24.20	60 31	28.97	31	30	S	9	.40	3/4	SE				" "
	5.43 a.m	24.36	56 32	29.17	32	32	S.W.	4	.08	4/4	10 1		8 a.m	.21	Cloudy
	2.43 P.m	24.37	70 42	29.04	42	37	[illegible]	2	.02	2/4	33.7				Drizzling Snow
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	9 8				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
				2381											

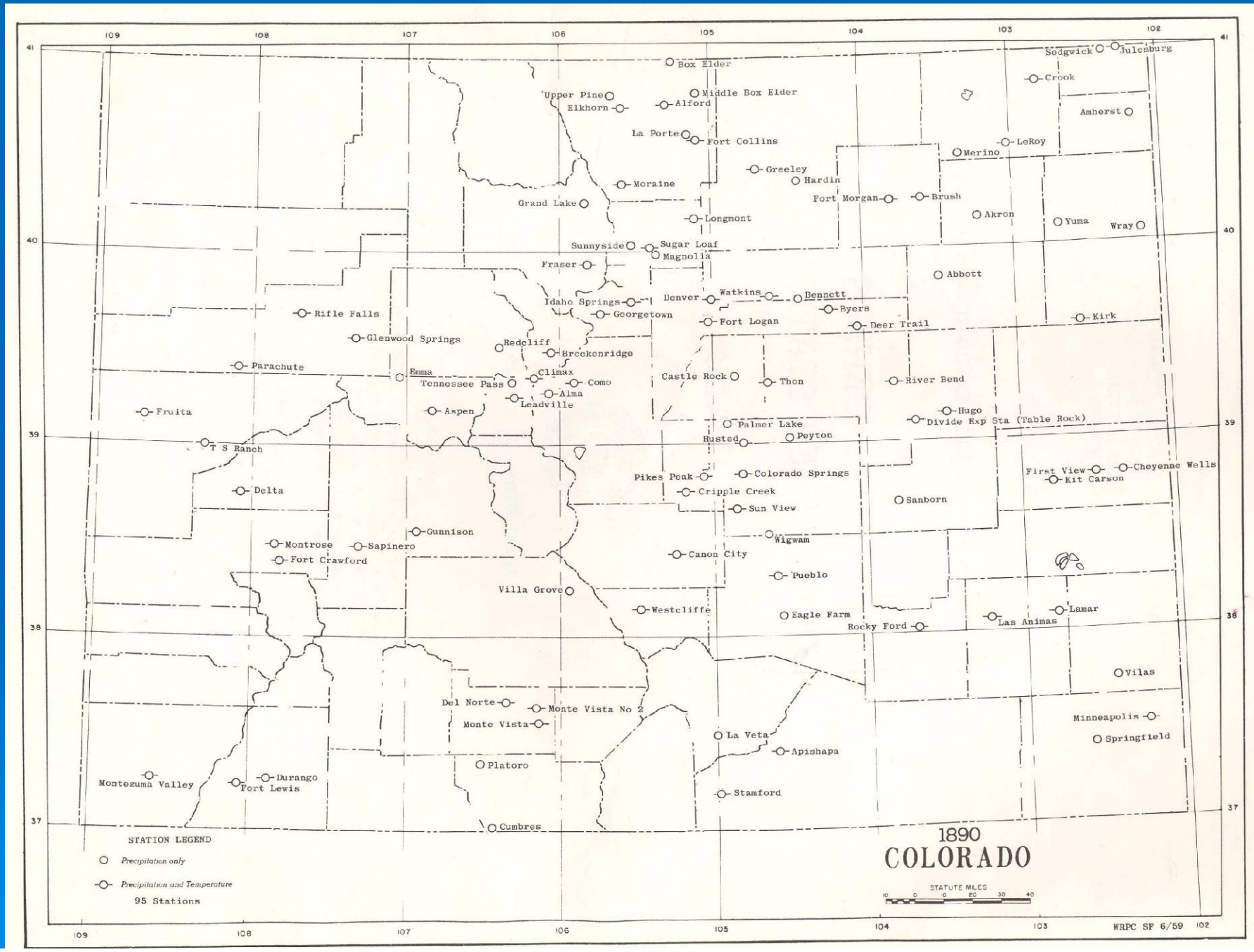
Denver November 19-25, 1871

Signal Service Observer

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

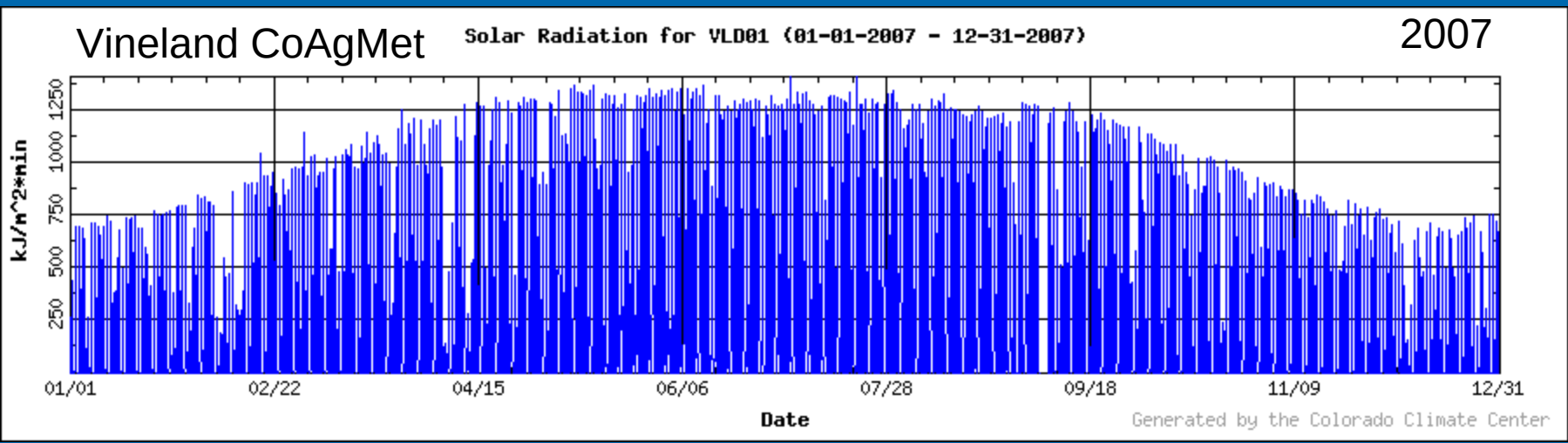
From Kelly Redmond, WRCC

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

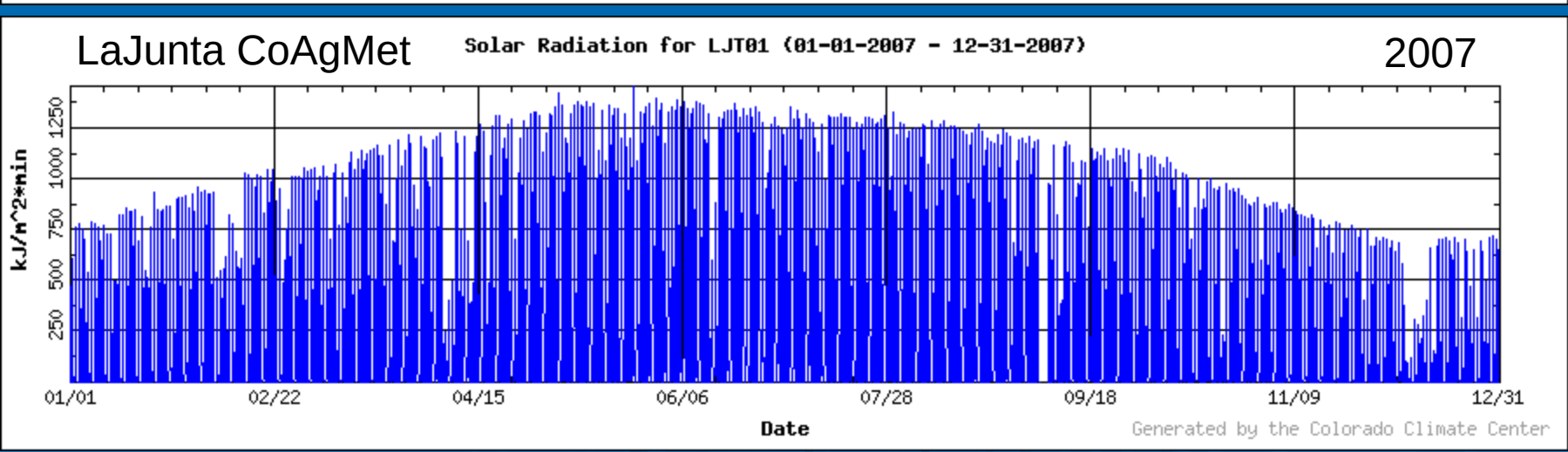

What have we learned from over 120 years of continuous climate monitoring?

Solar radiation is reliable

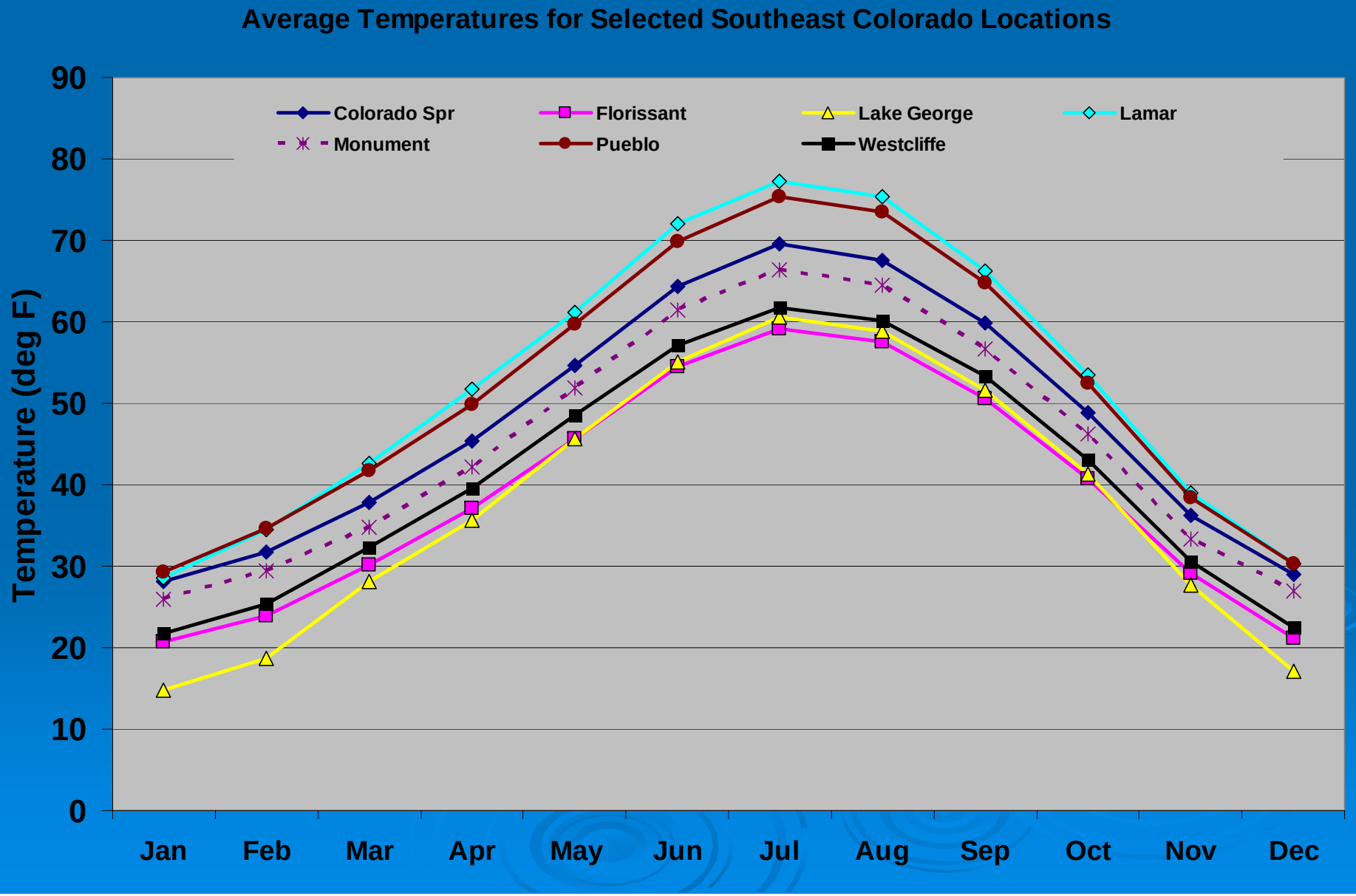
Vineland CoAgMet



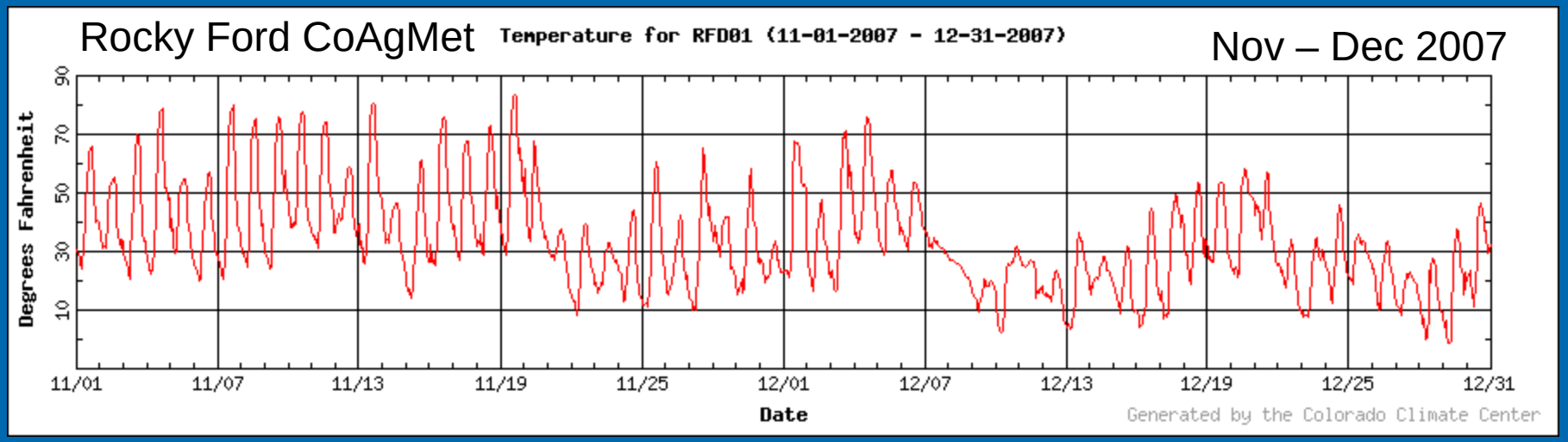
LaJunta CoAgMet

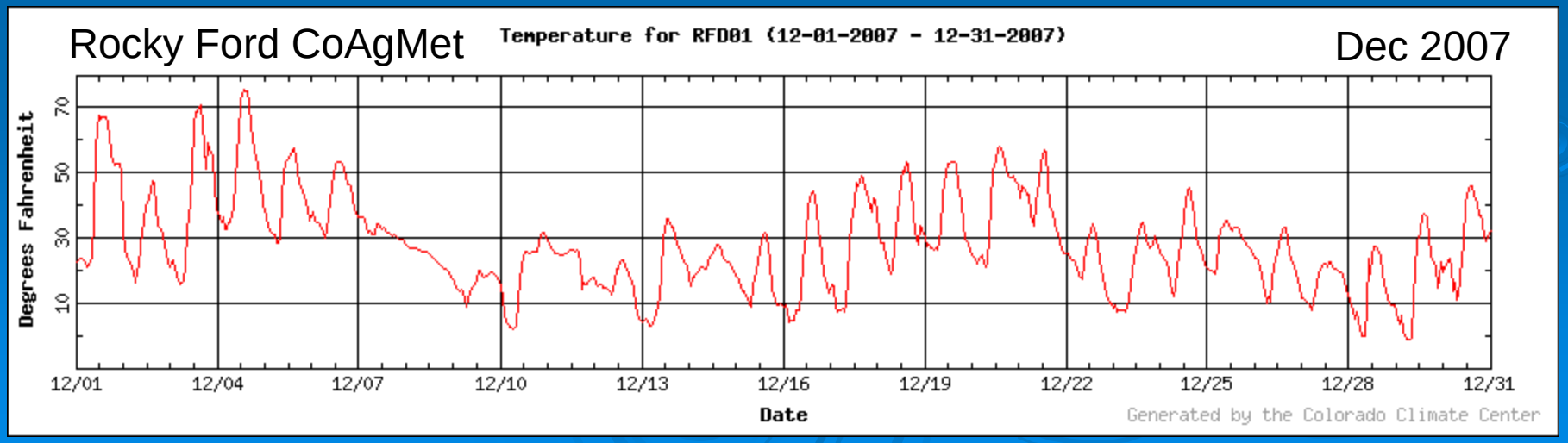


Winters are consistently colder than summers – ☺

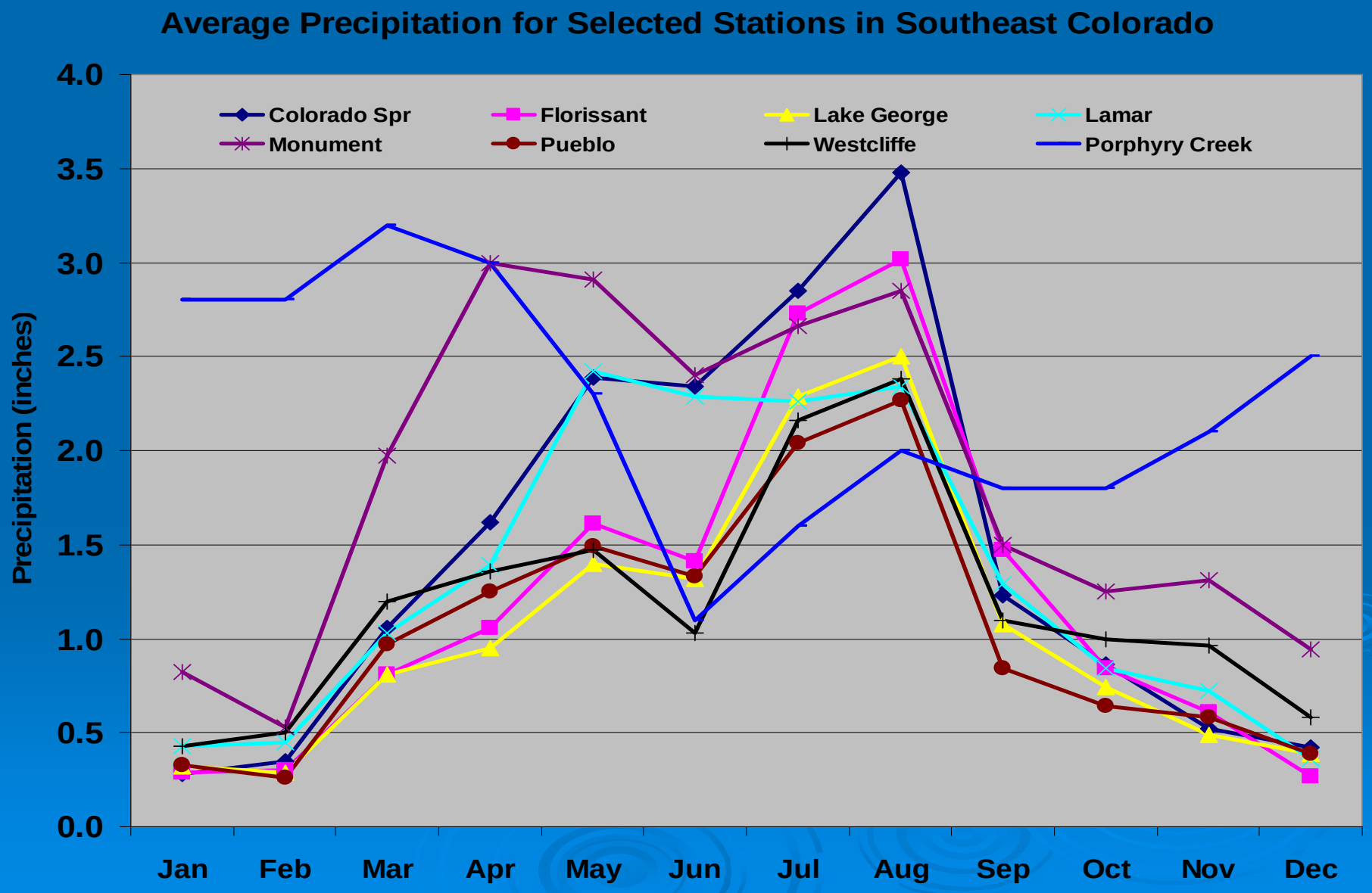


Daily temperatures vary a lot

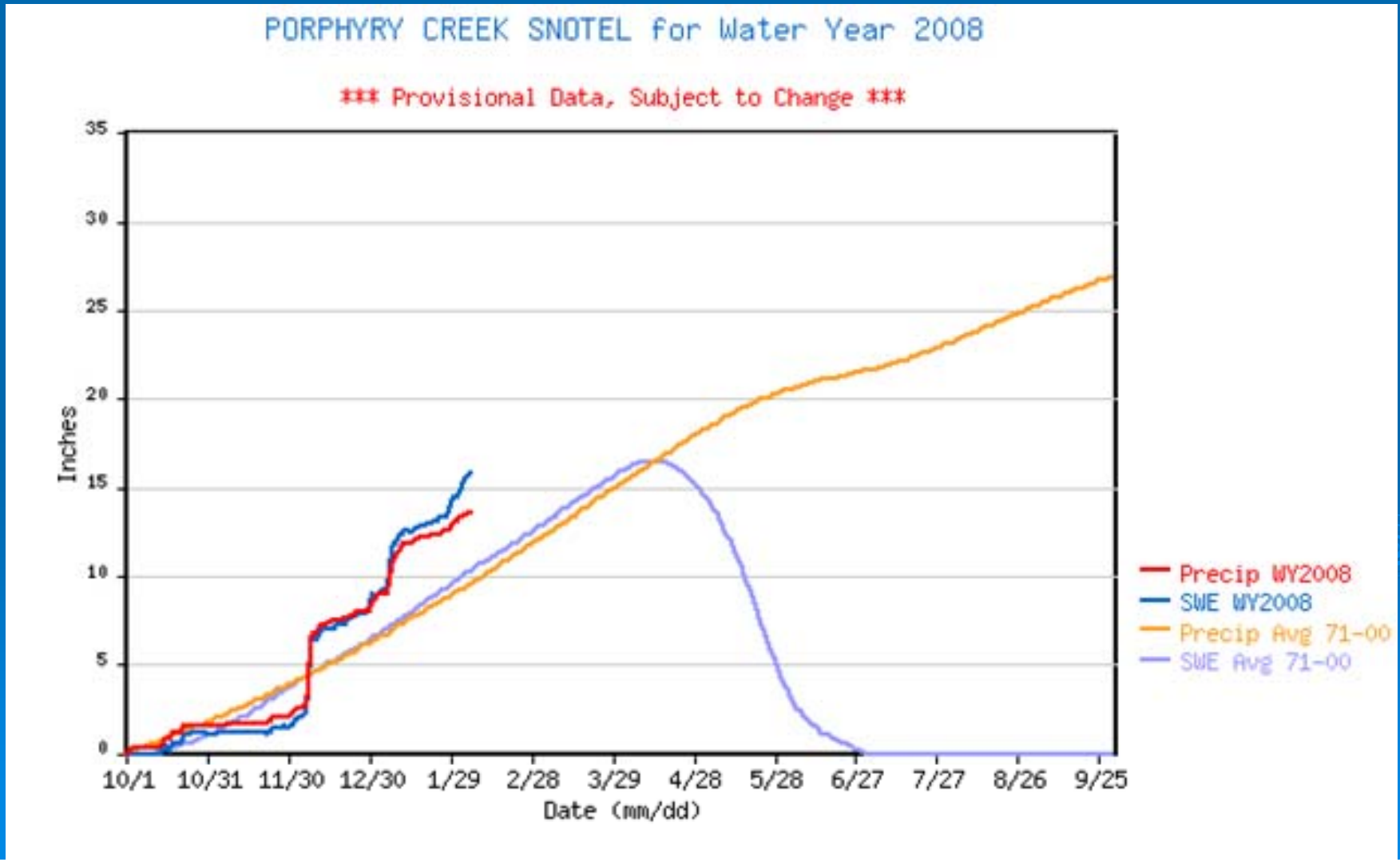




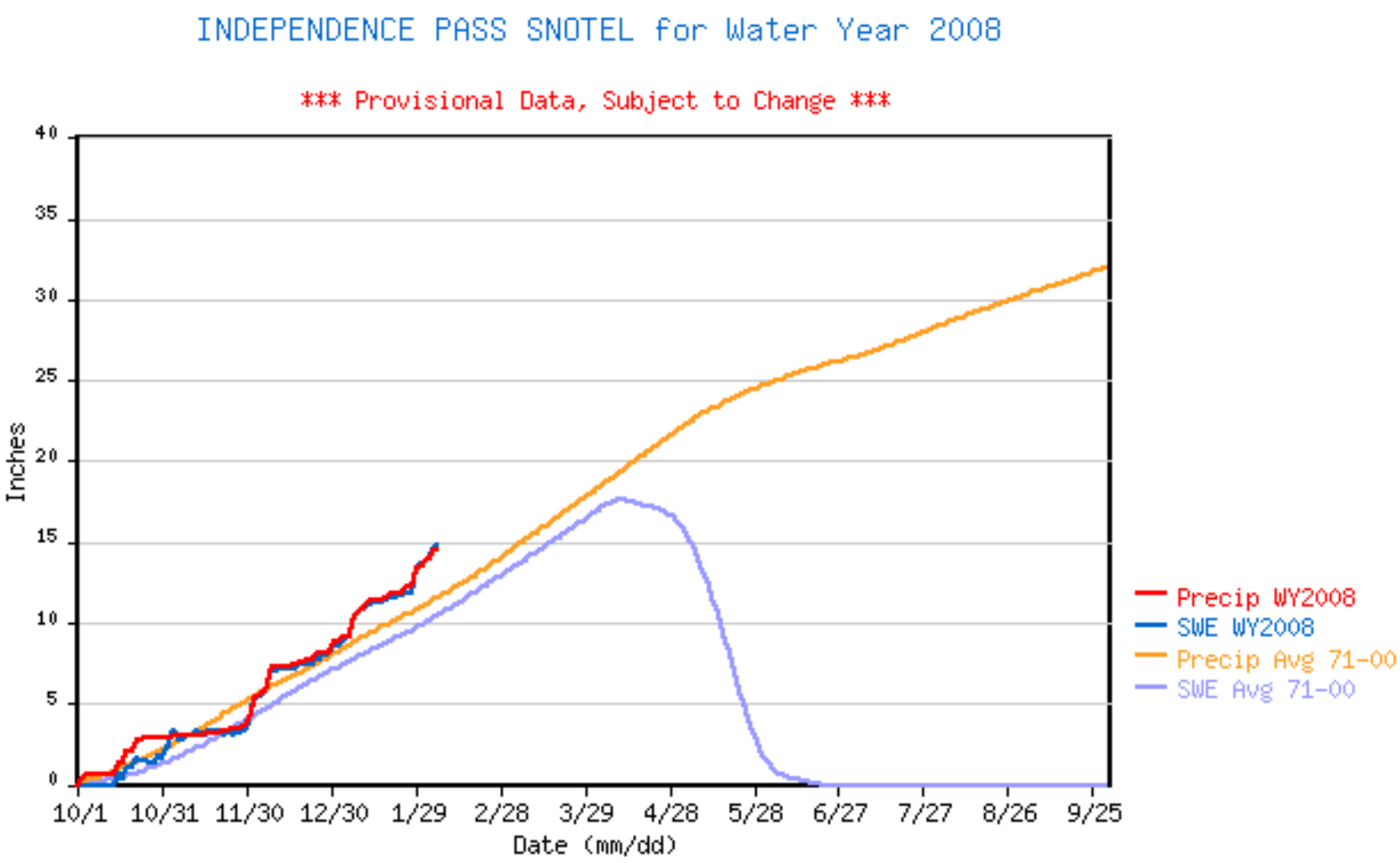
Precipitation also varies seasonally



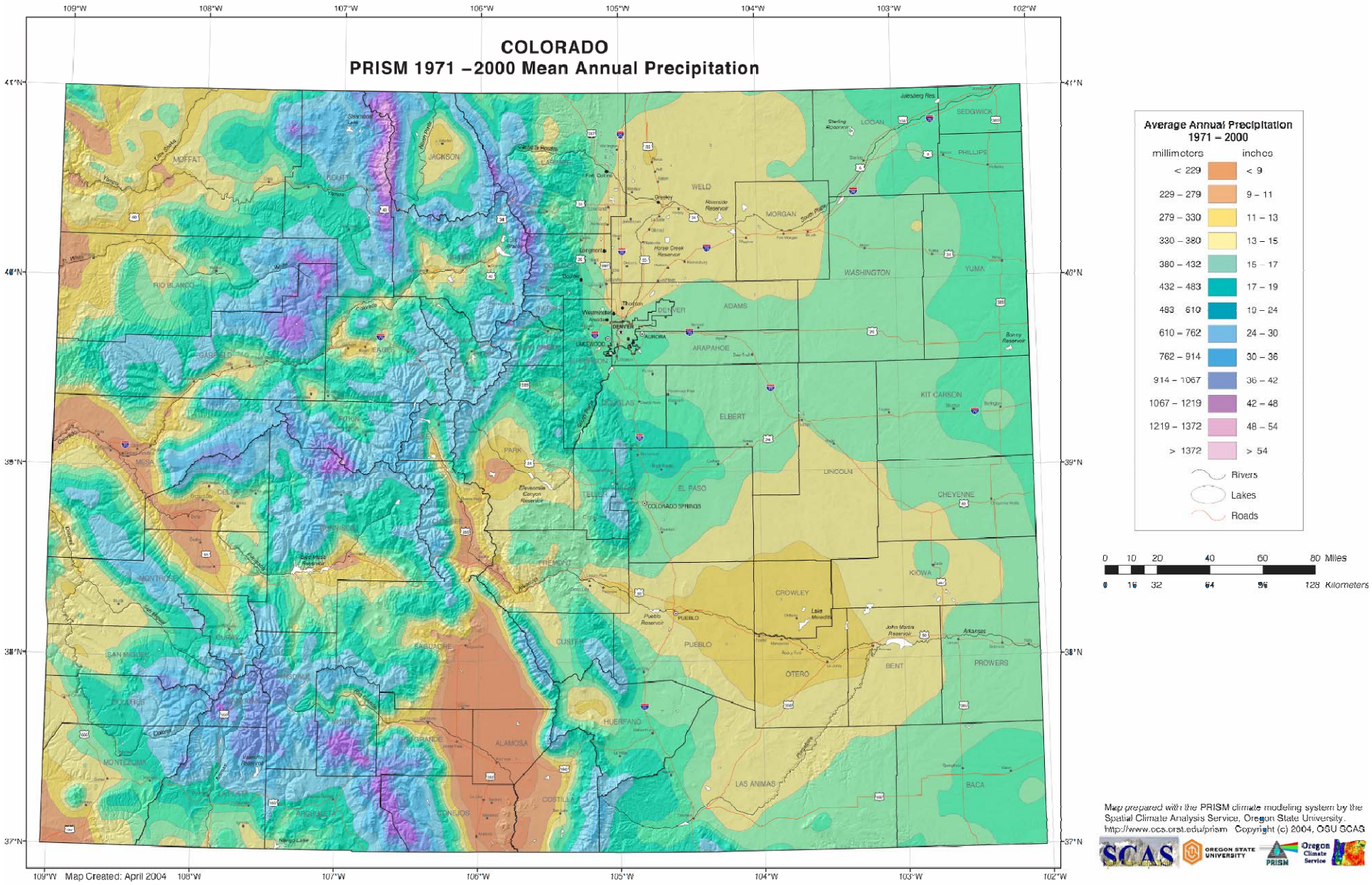
Mountain snow accumulation is very important



Independence Pass Snotel



Colorado Average Annual Precipitation



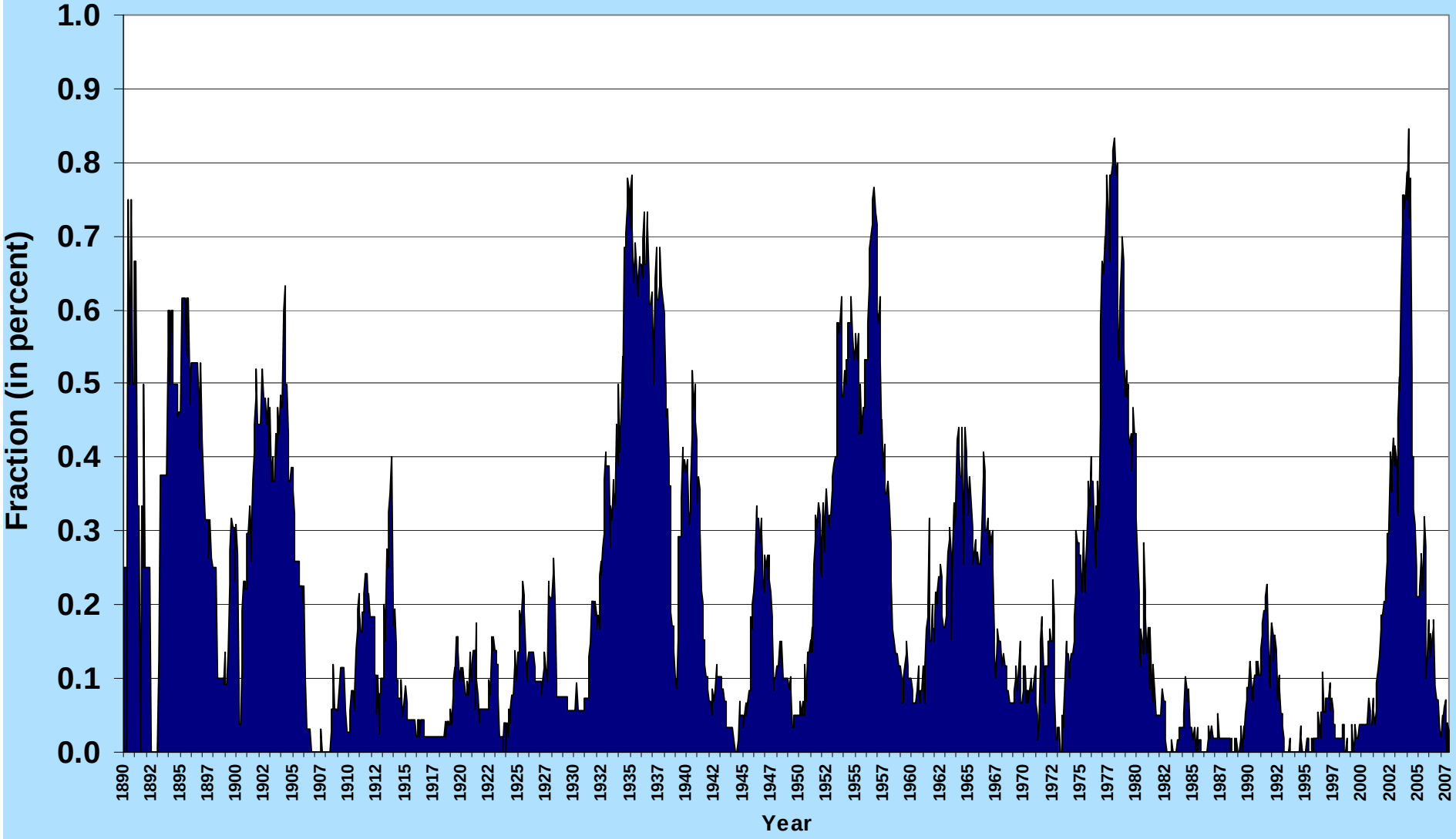
Drought Visits Our Area Regularly

Photo by NRCS

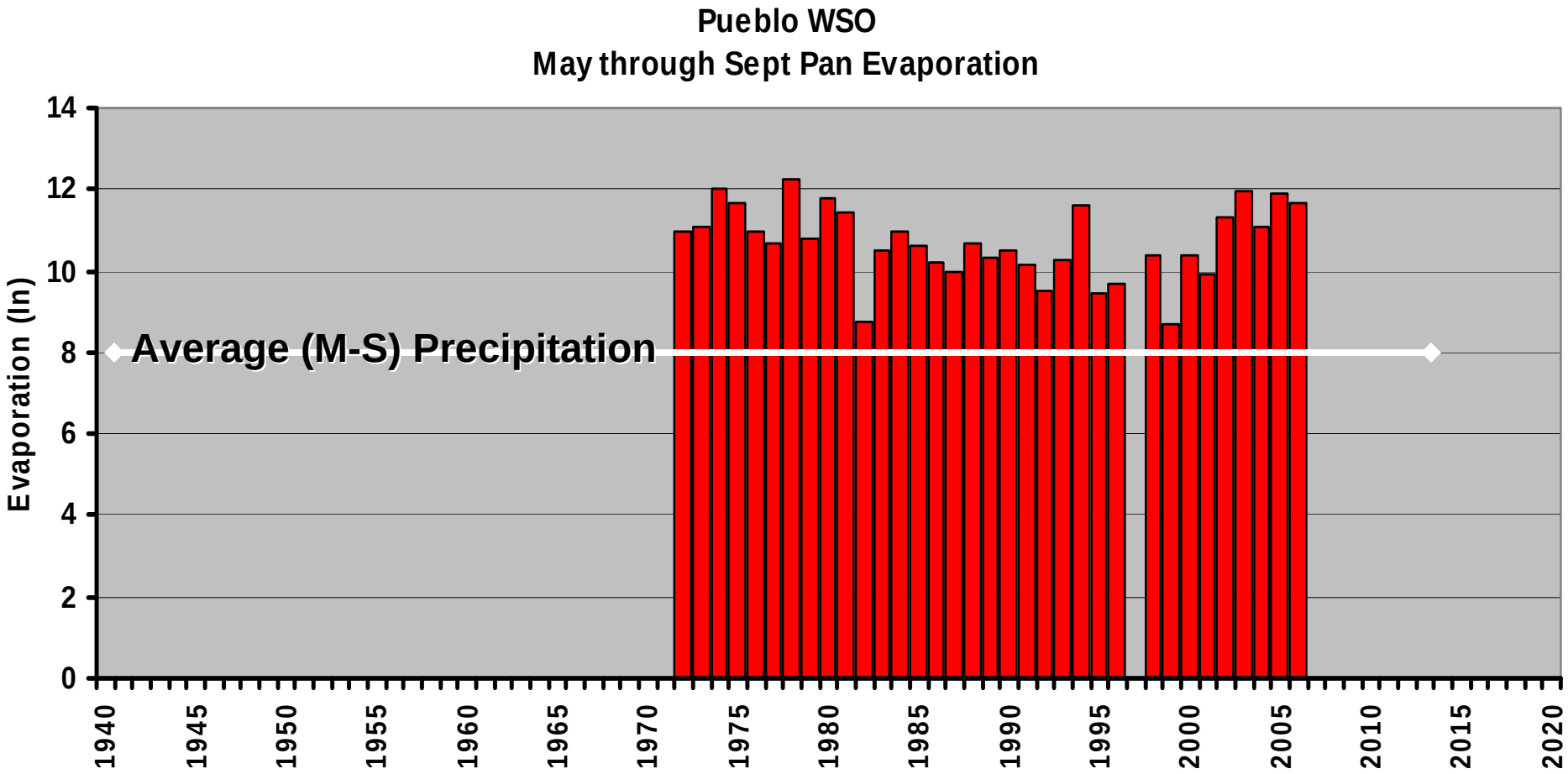
Fraction of Colorado in Drought

Based on 48 month SPI

(1890 - December 2007)



Much of our water evaporates



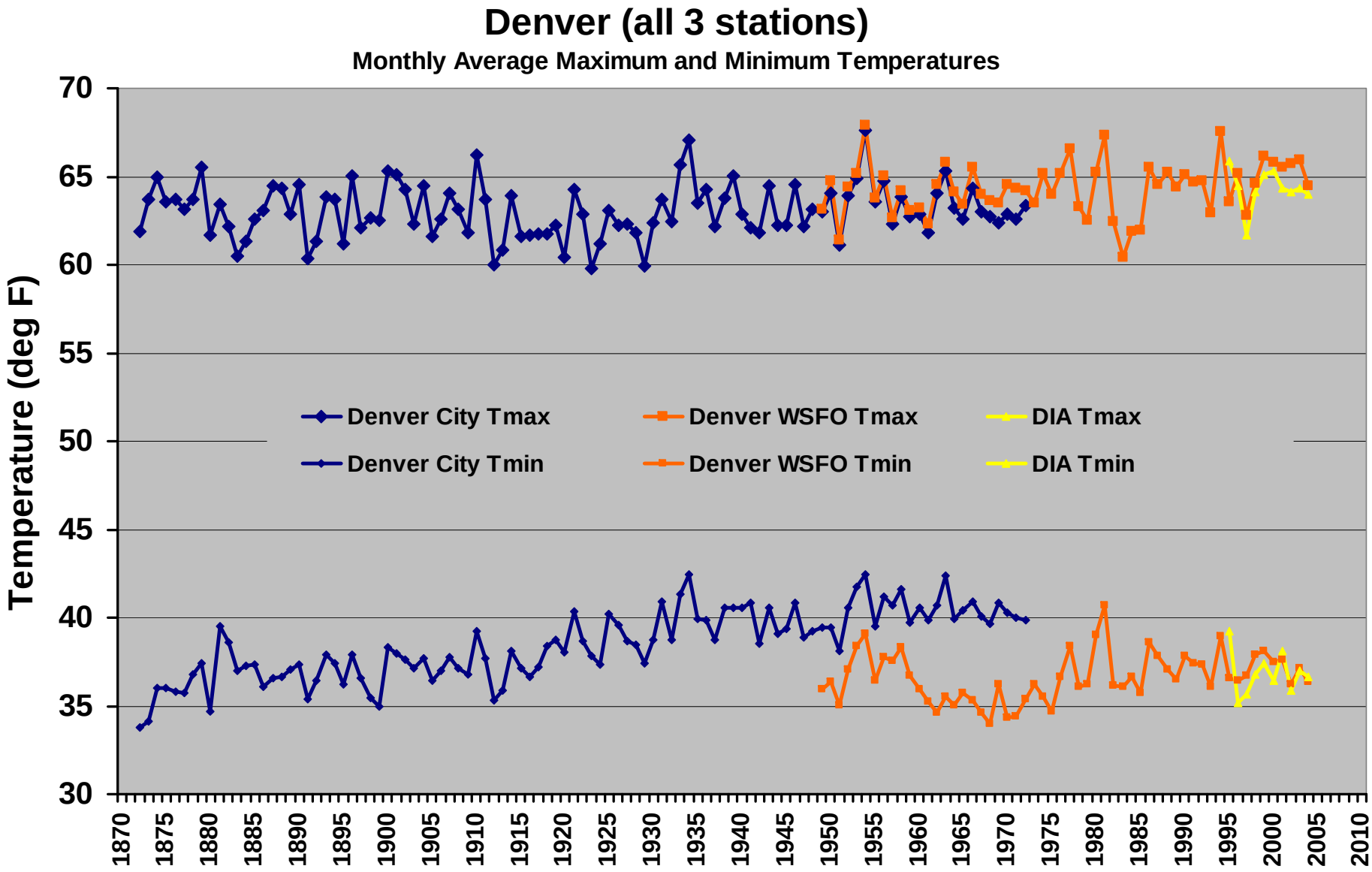
We know a lot about spatial patterns, seasonal cycles, and year-to-year climate variations.

Confidently detecting climatic trends is much more challenging and difficult.

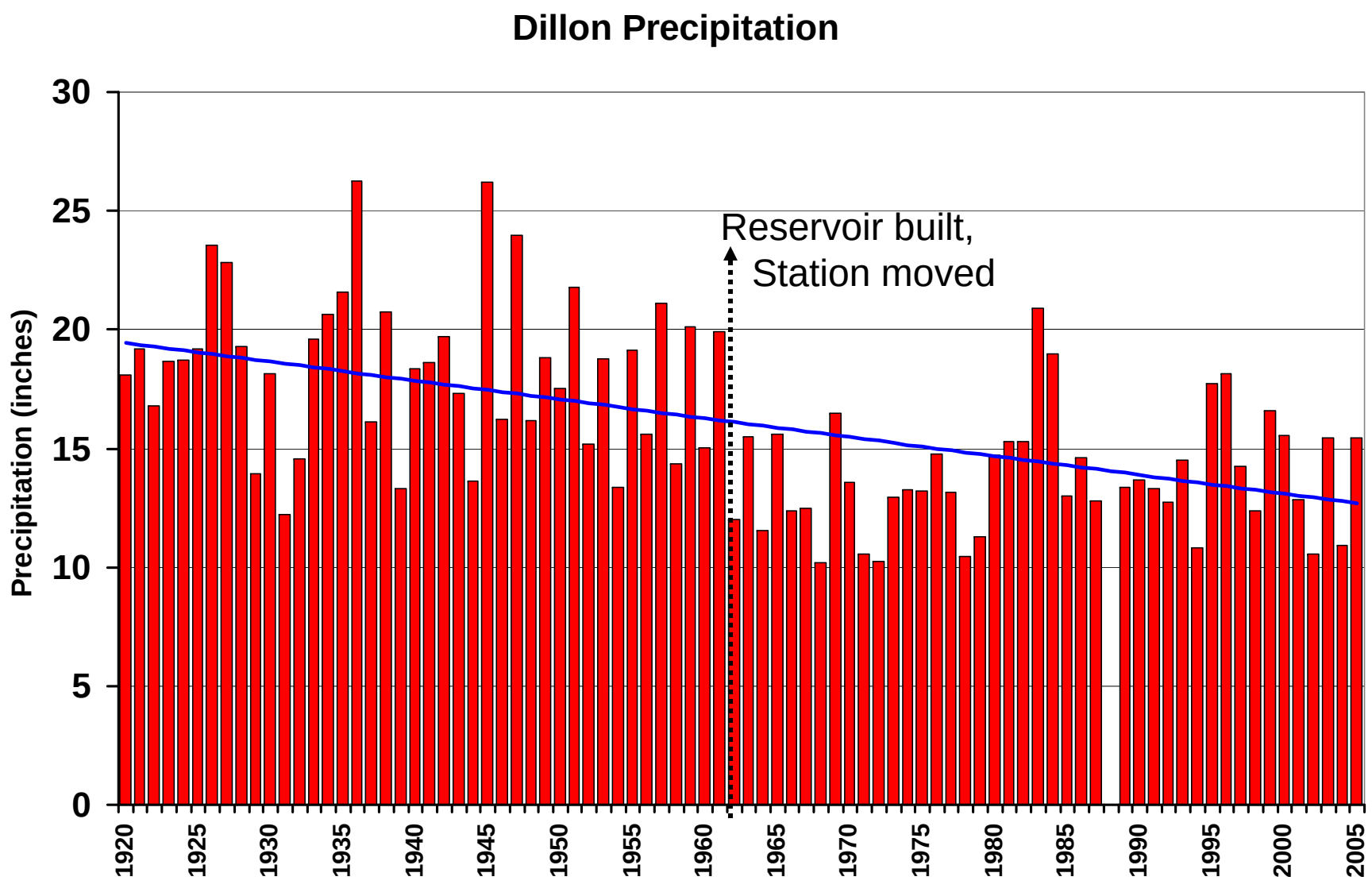
We can find many frustrating limitations to our climate records:

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

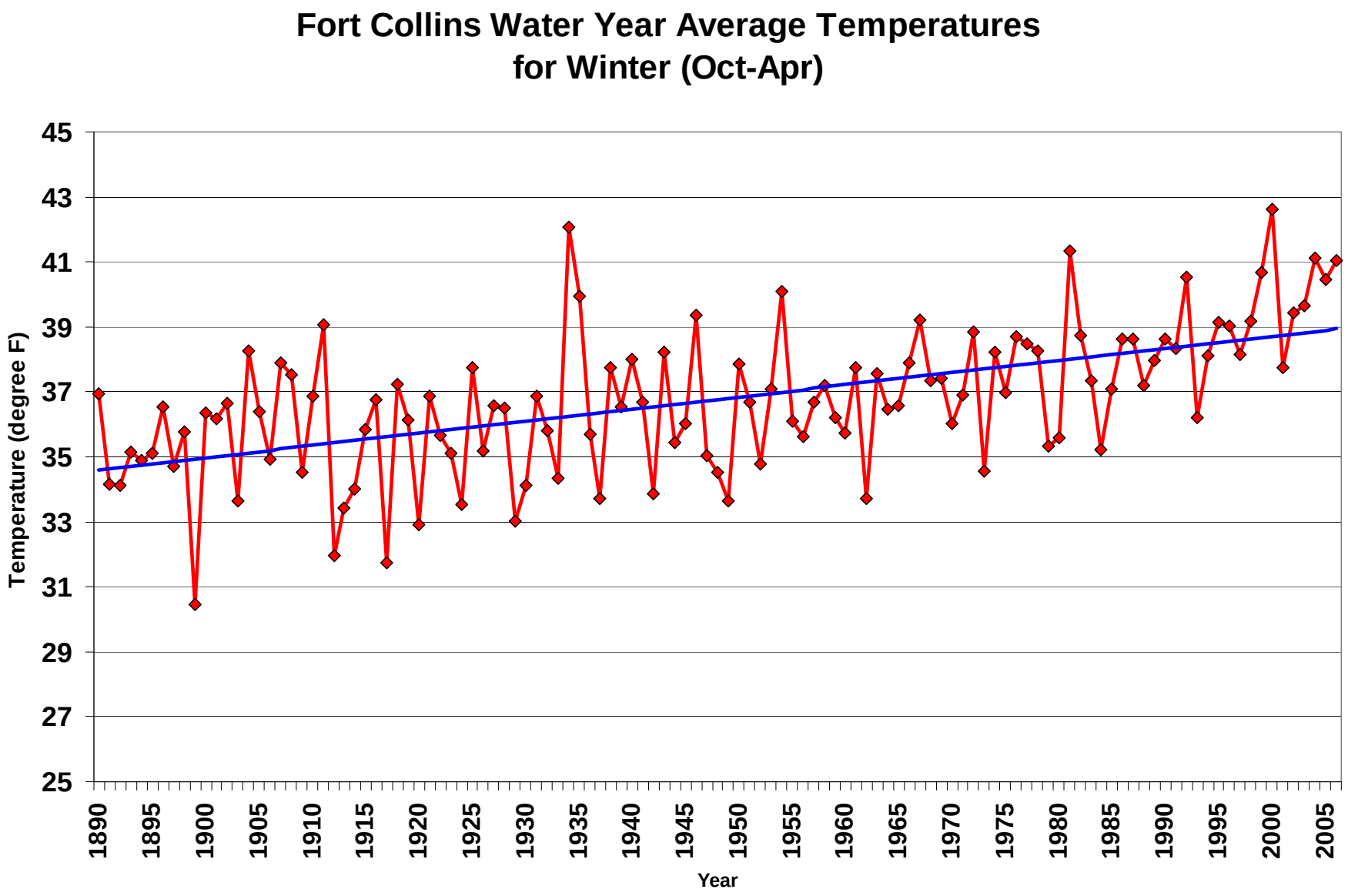
Denver All Stations



Dillon Annual Precipitation

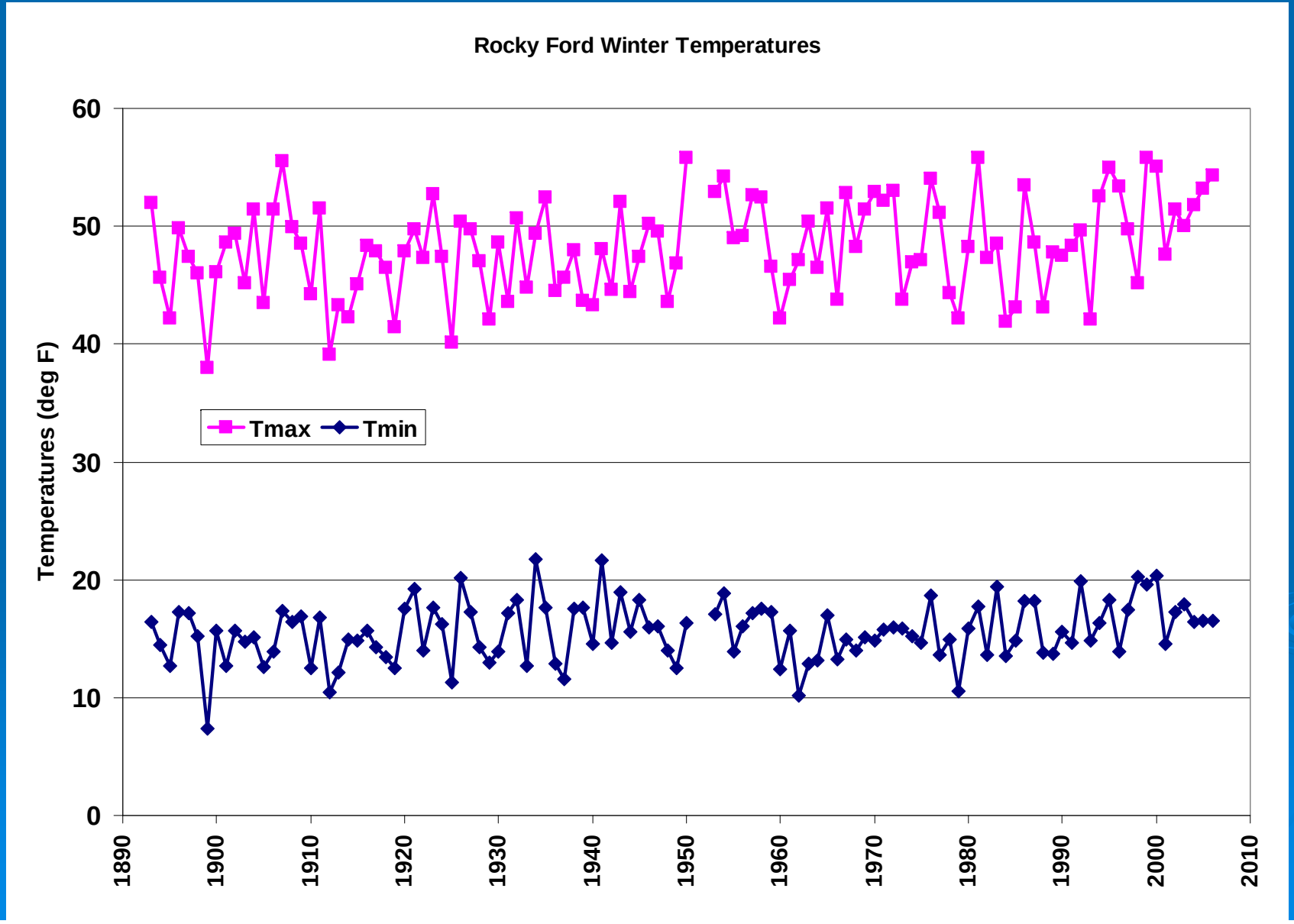


Fort Collins Winter Temperatures

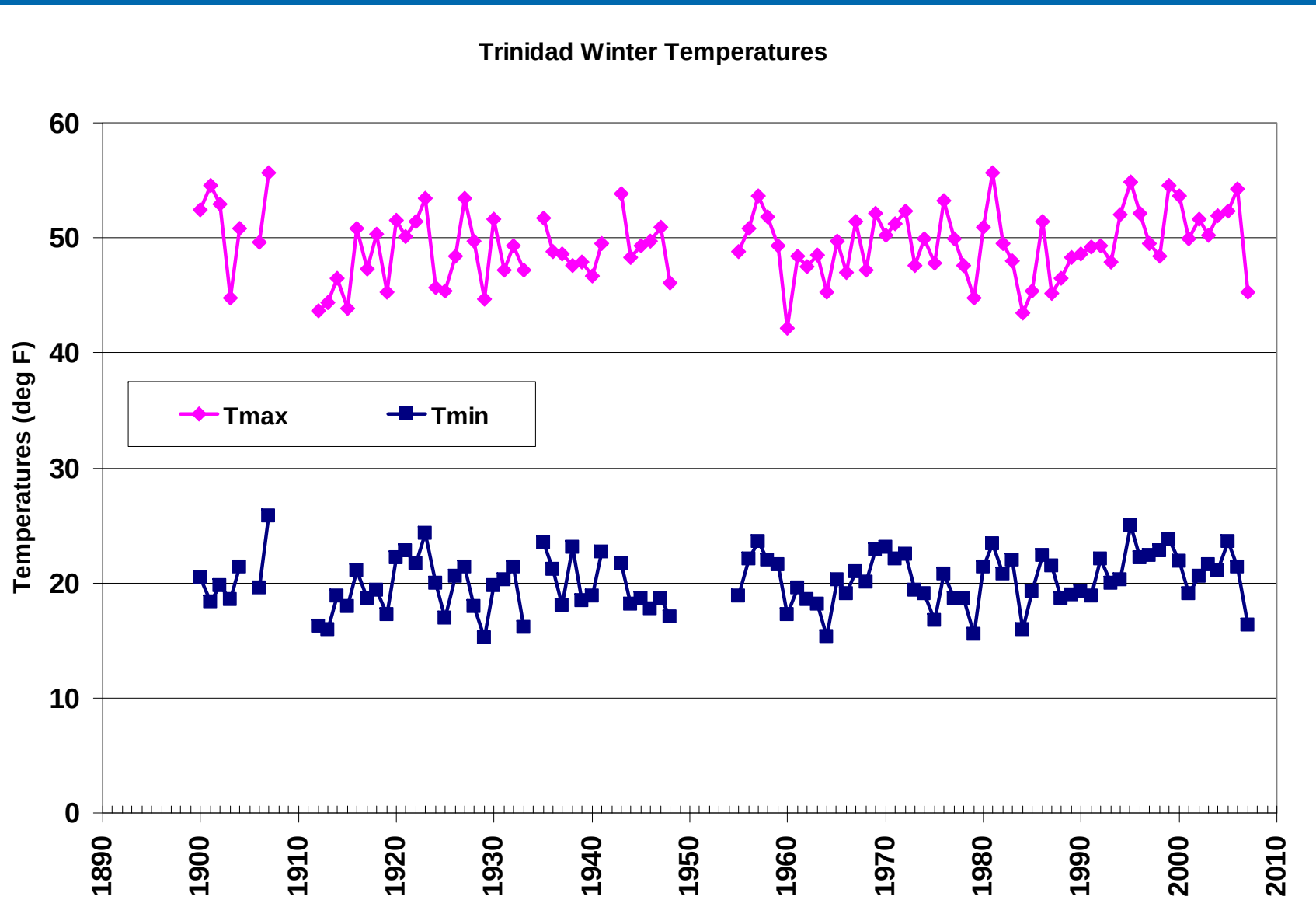


Still, our climate records are more complete, consistent, and widespread than nearly all other forms of long-term environmental monitoring (i.e. we shouldn't whine).

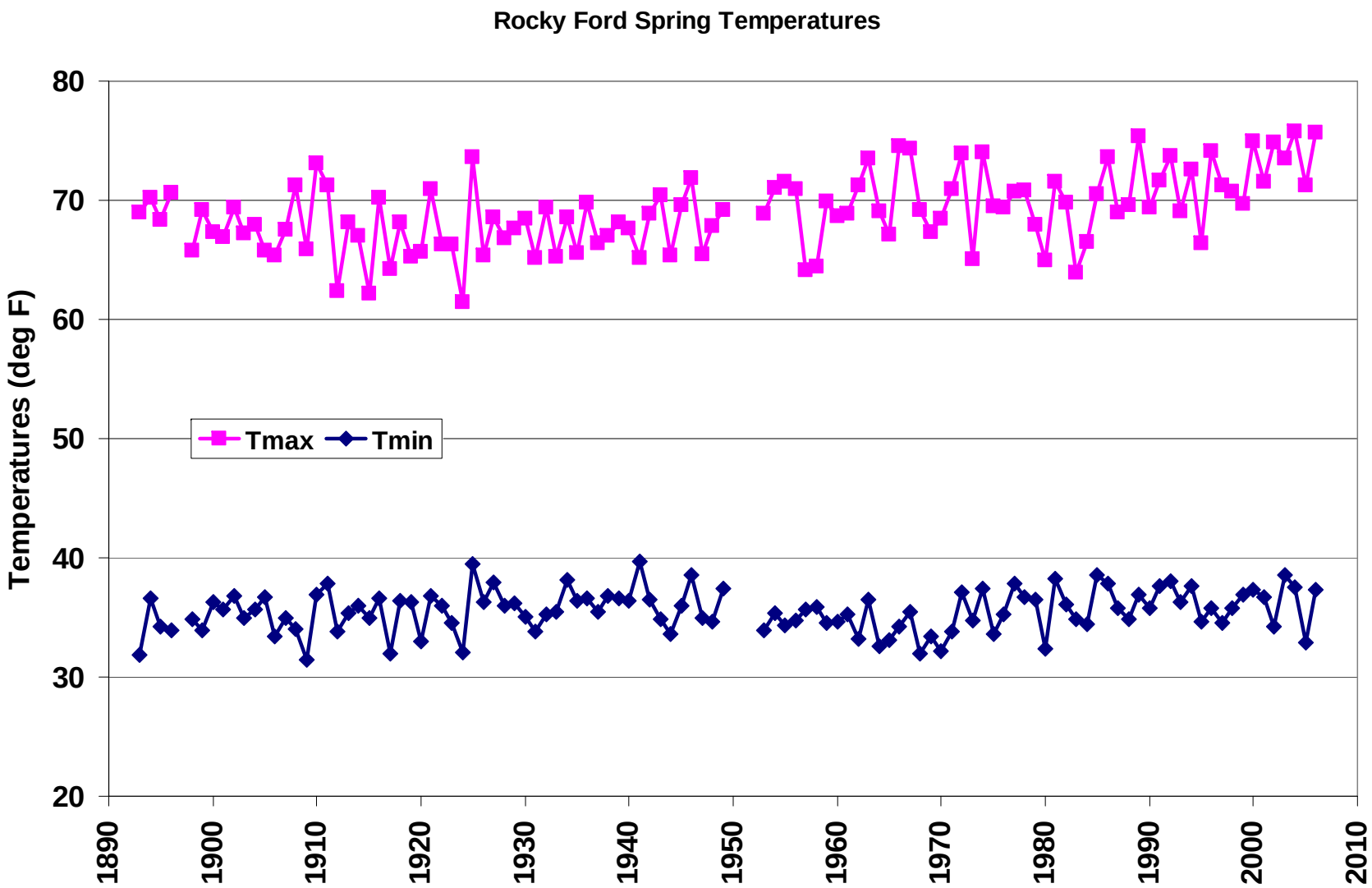
Rocky Ford Winter (DJF) Temperatures



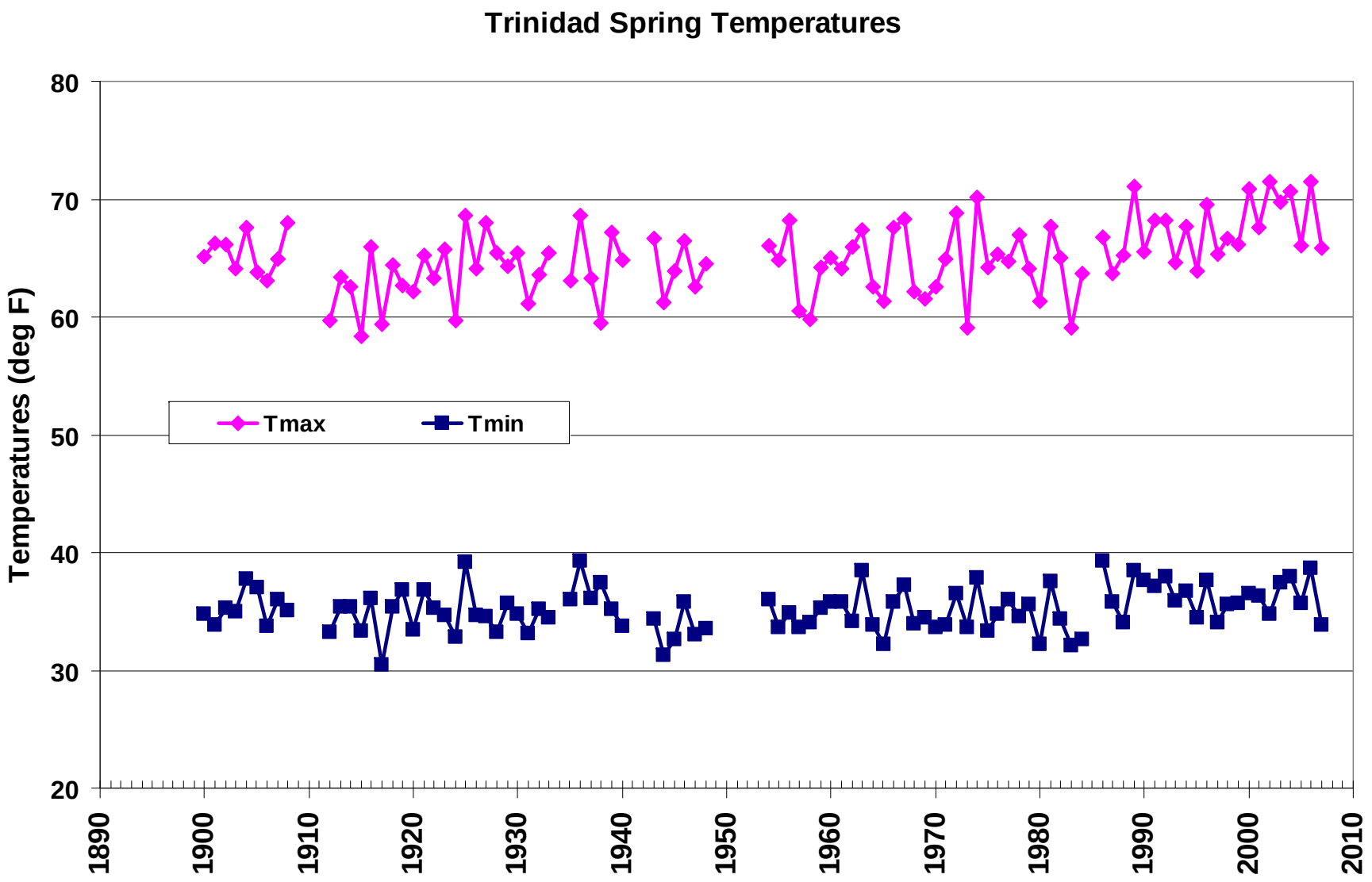
Trinidad Winter (DJF) Temperatures



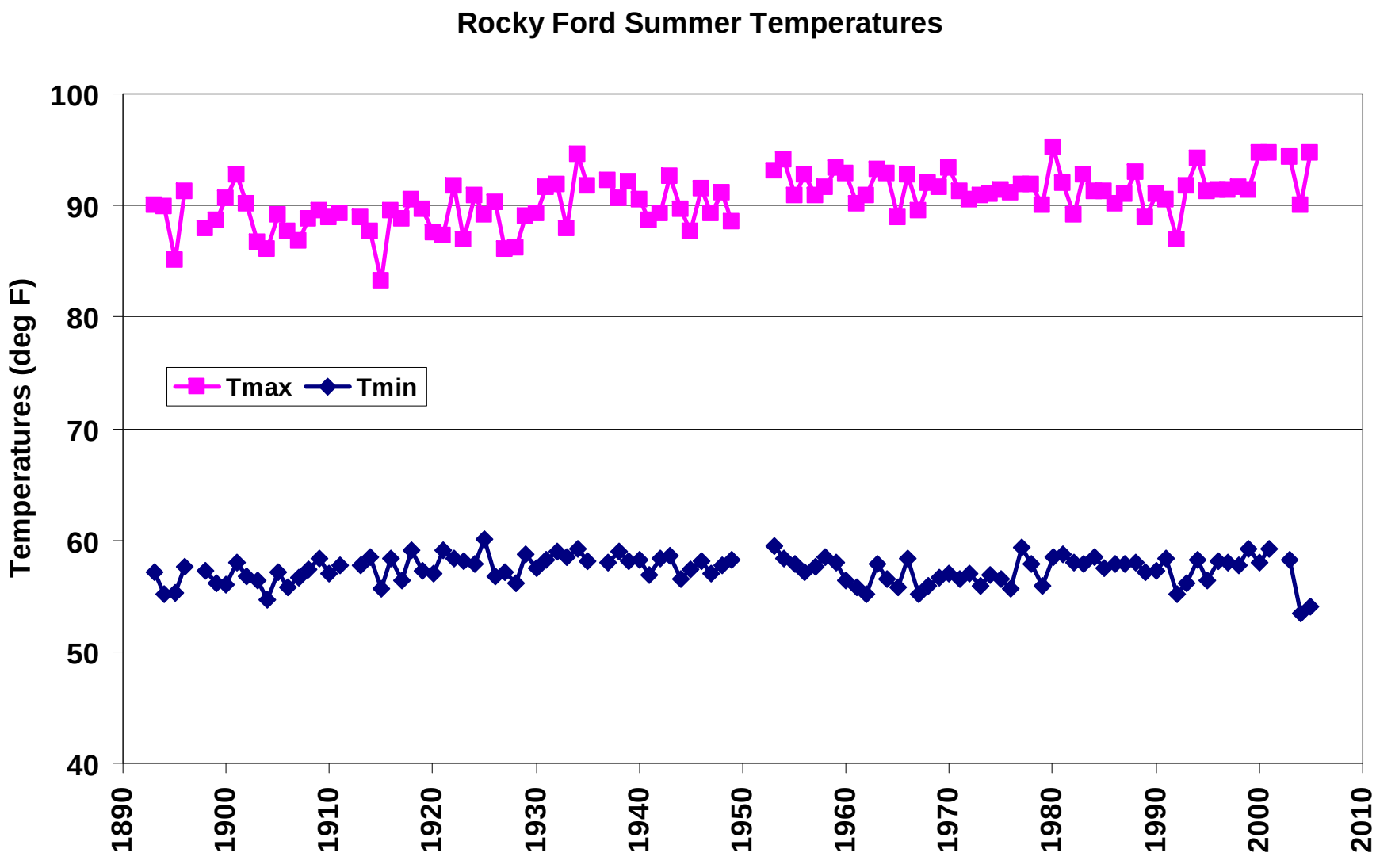
Rocky Ford Spring (MAM) Temperatures



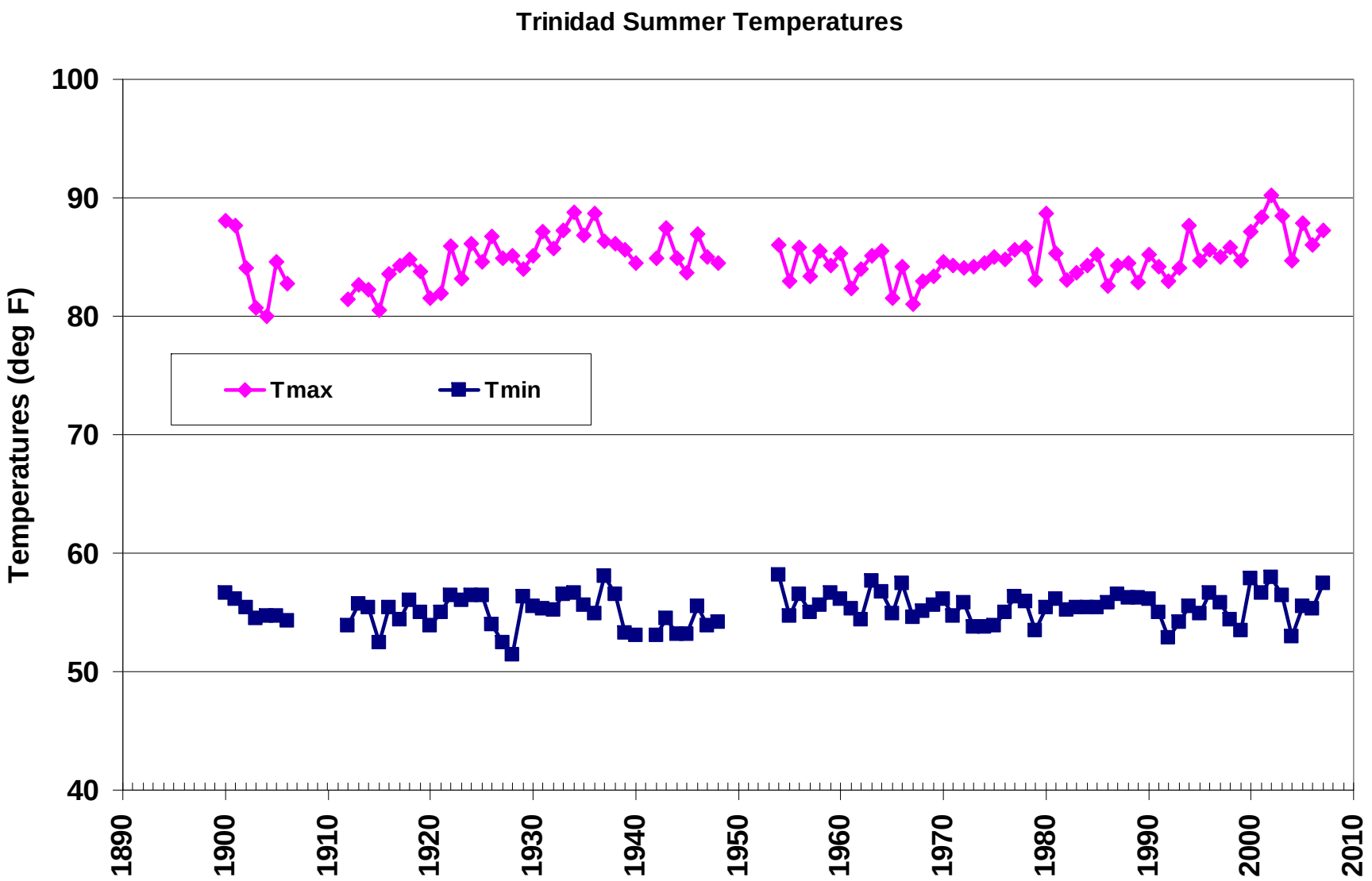
Trinidad Spring (MAM) Temperatures



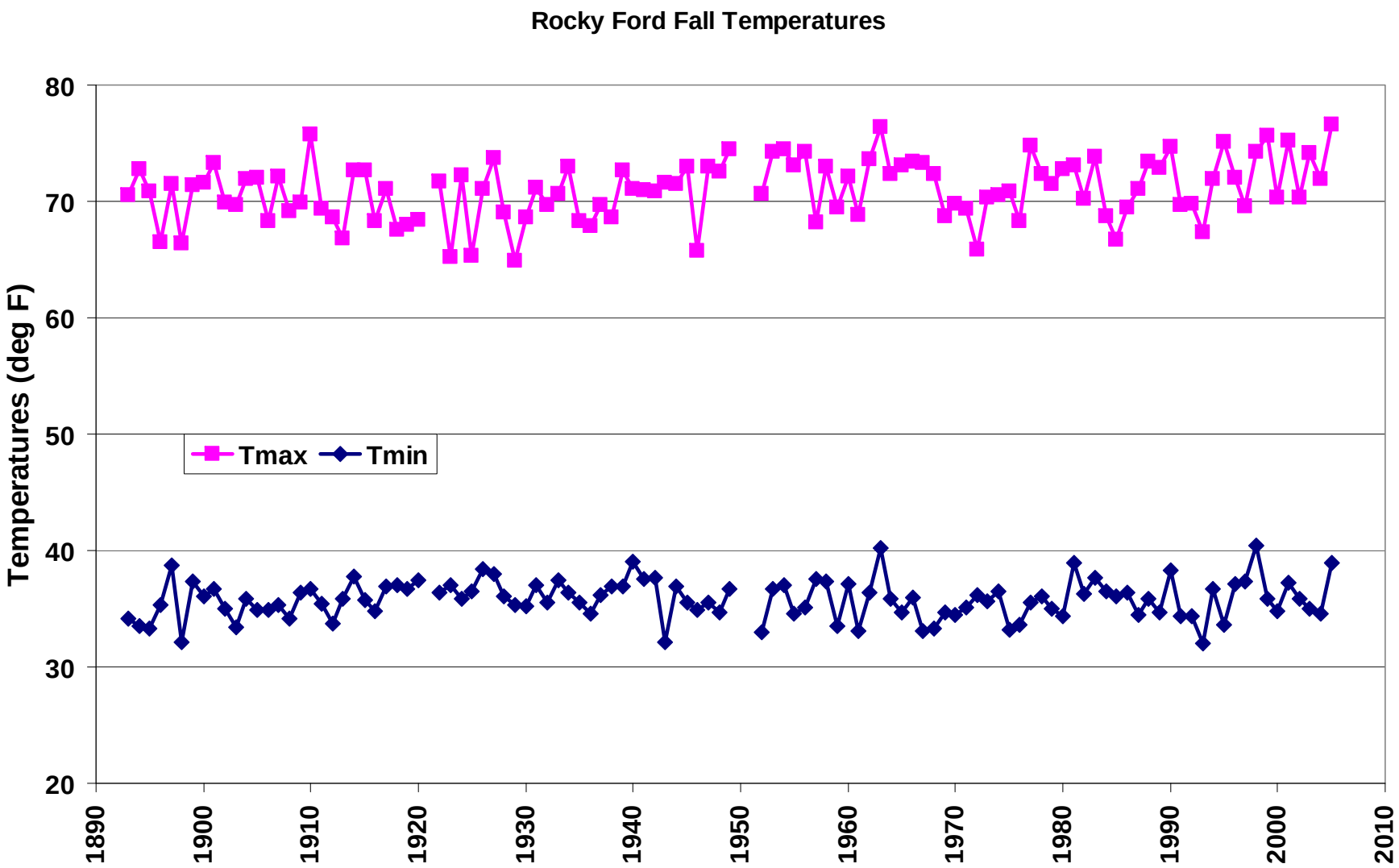
Rocky Ford Summer (JJA) Temperatures



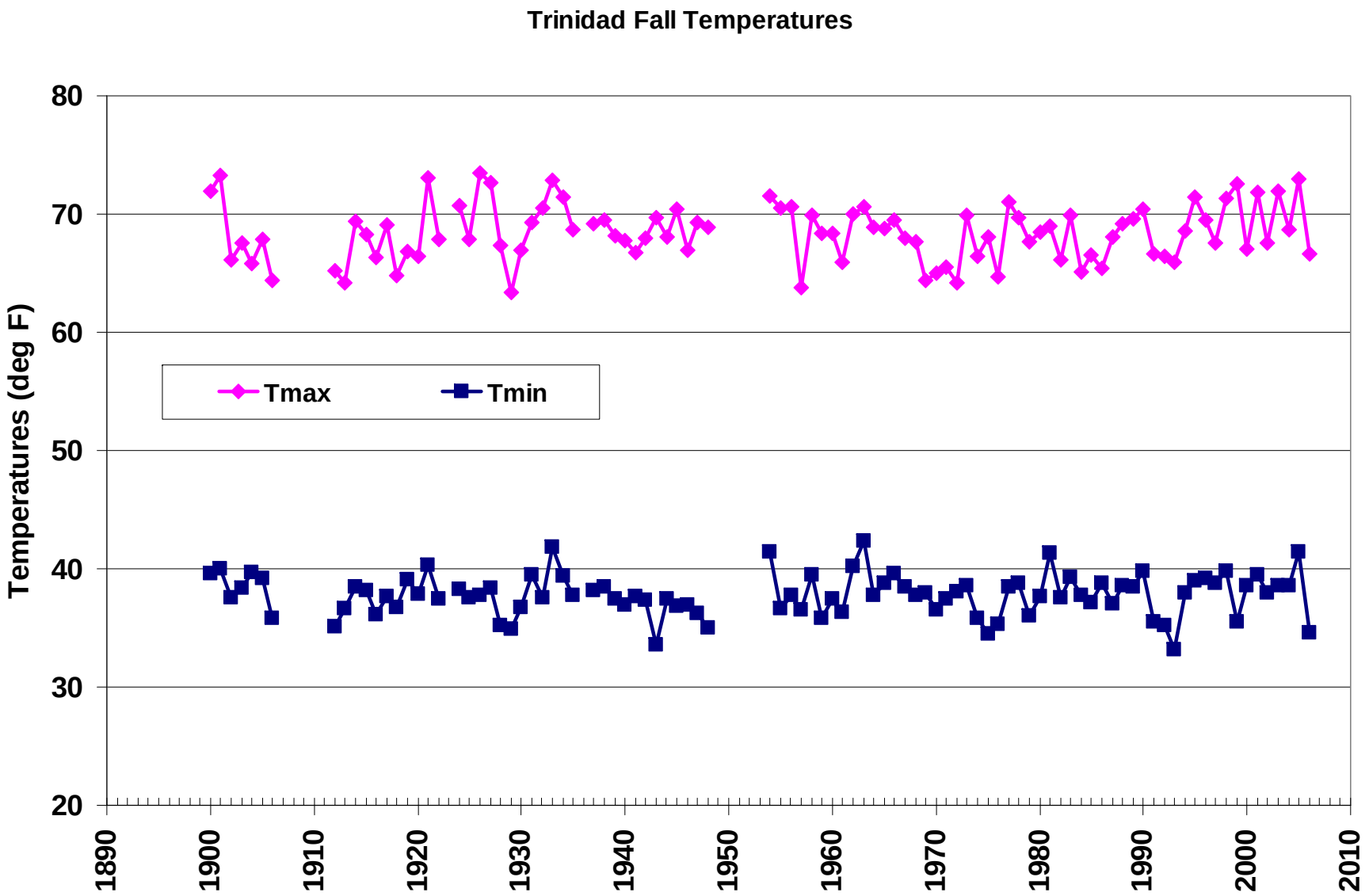
Trinidad Summer (JJA) Temperatures



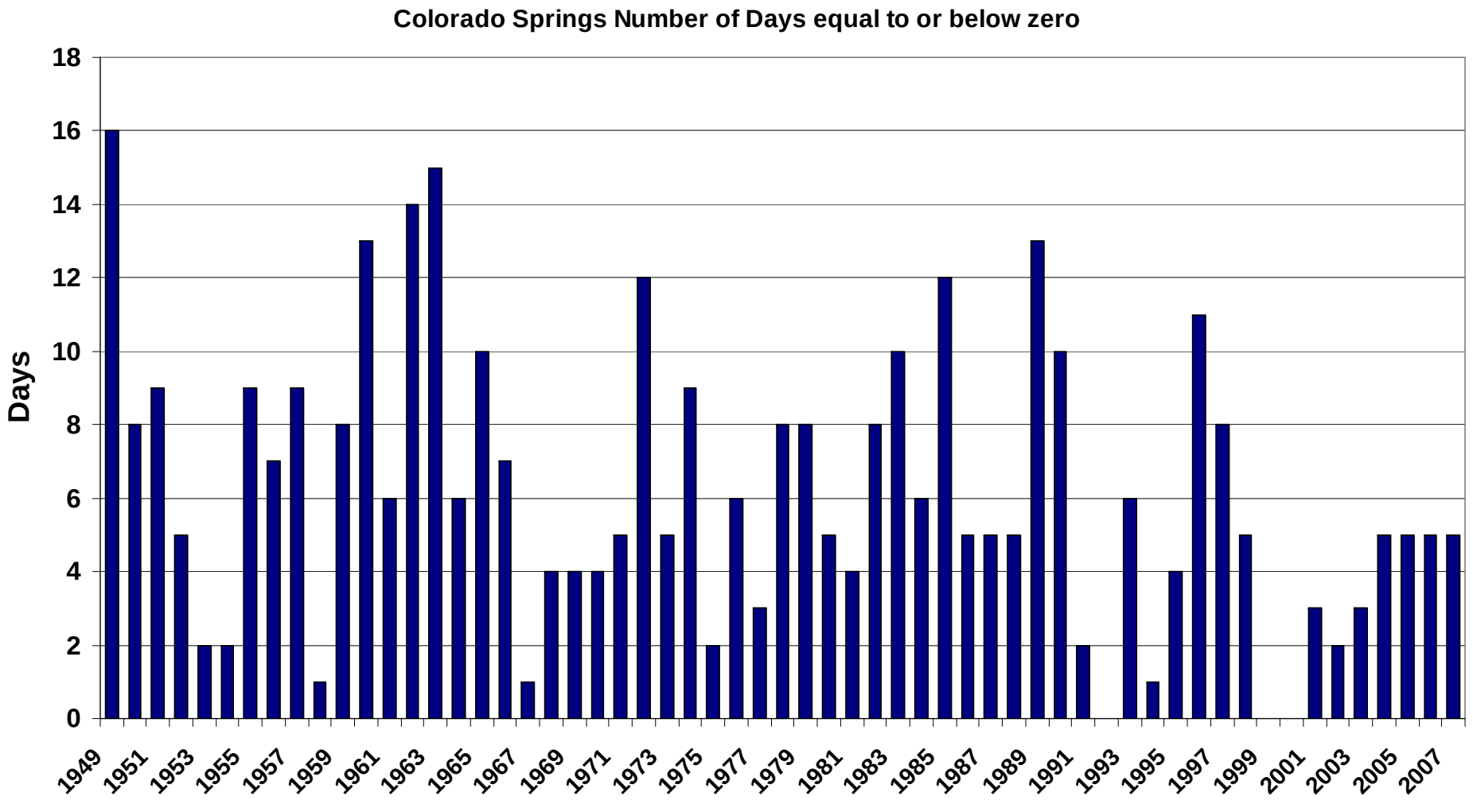
Rocky Ford Fall (SON) Temperatures



Trinidad Fall (SON) Temperatures

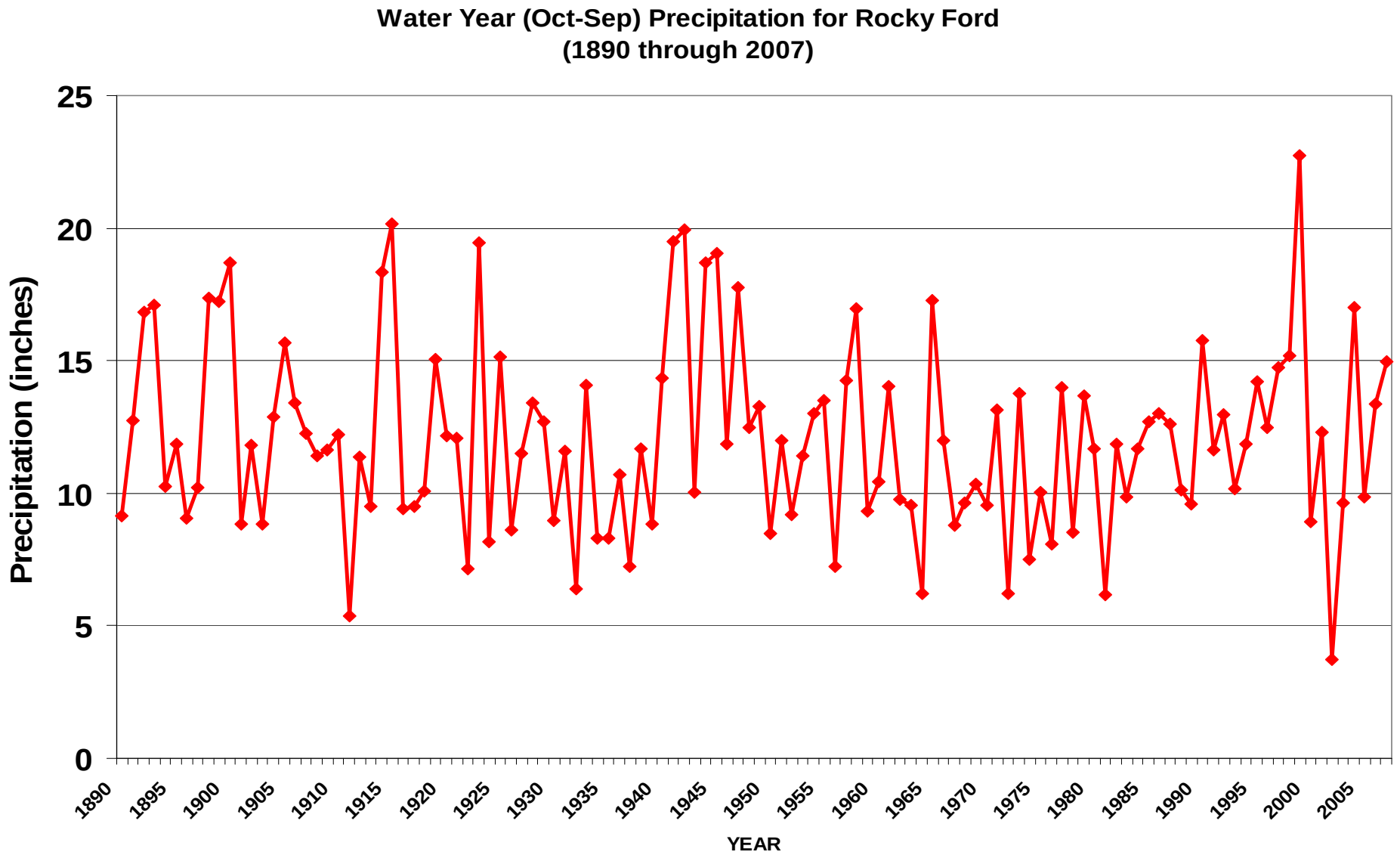


Colorado Springs Number of Days Equal or Less Than Zero

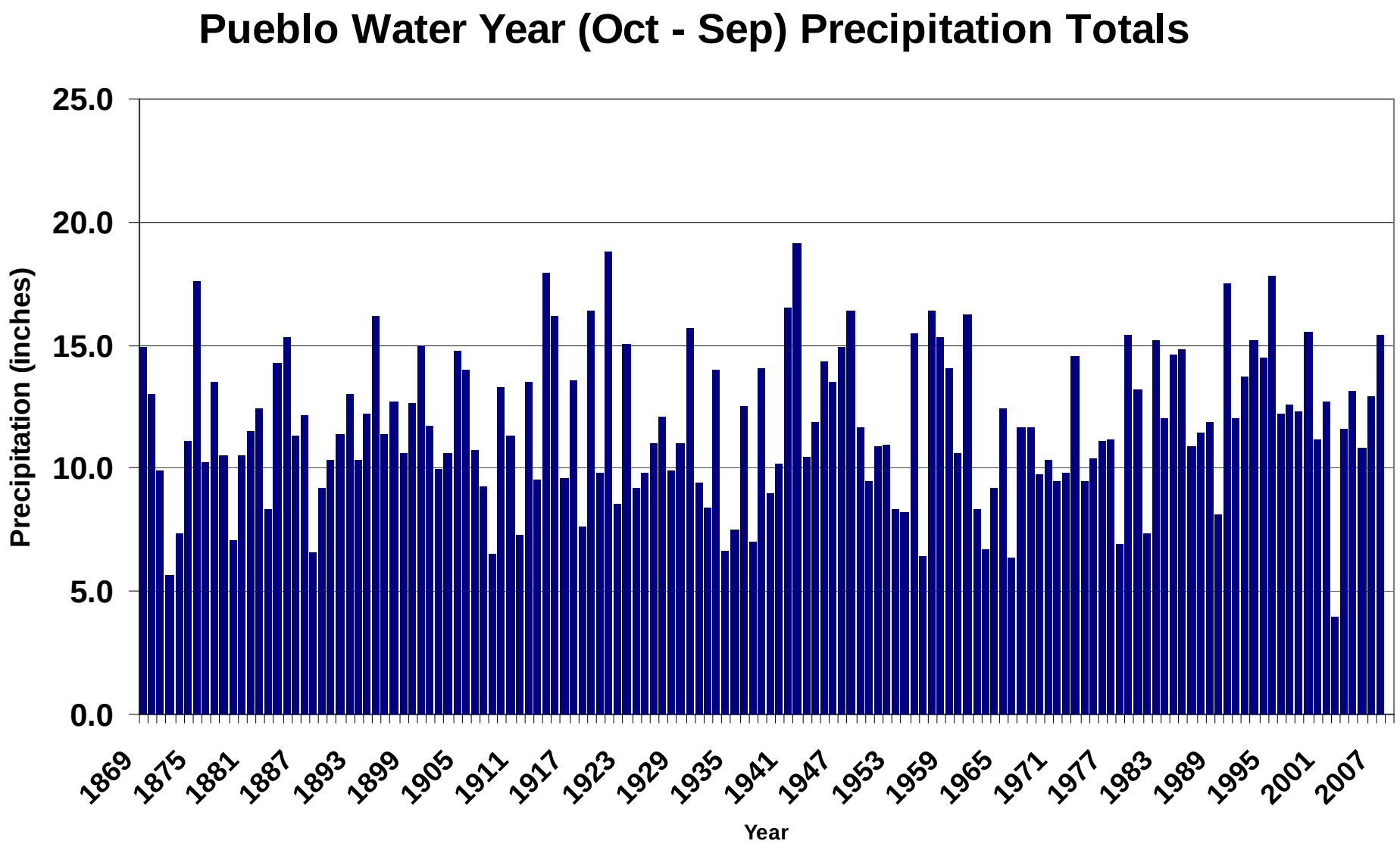


Temperatures are far more stable than precipitation. In fact most other climatic elements (humidity, wind, sunshine and cloudiness, evaporation, etc.) are much more consistent from one year to the next than precipitation

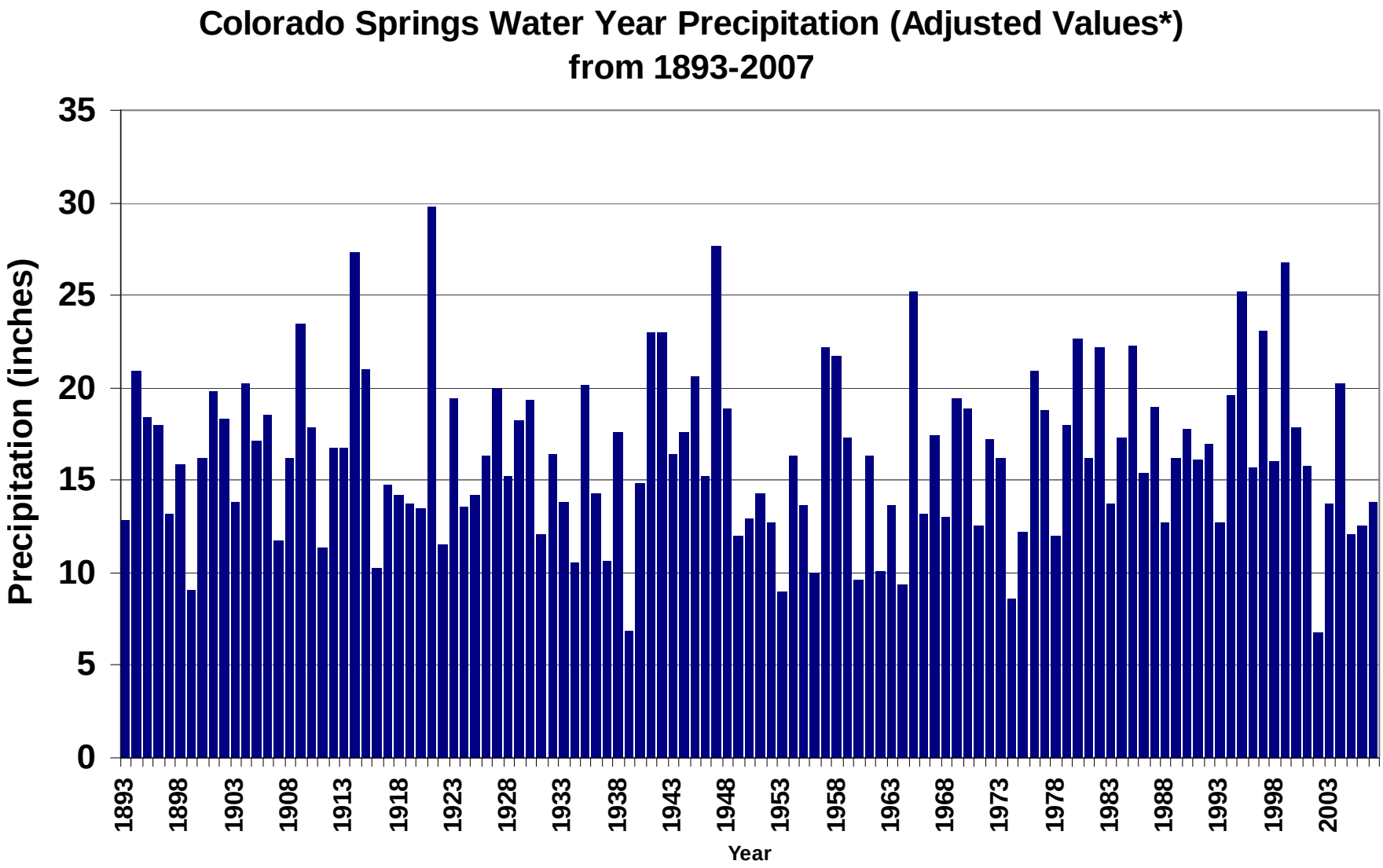
Precipitation varies by as much as 400% from a very dry year to a very wet year



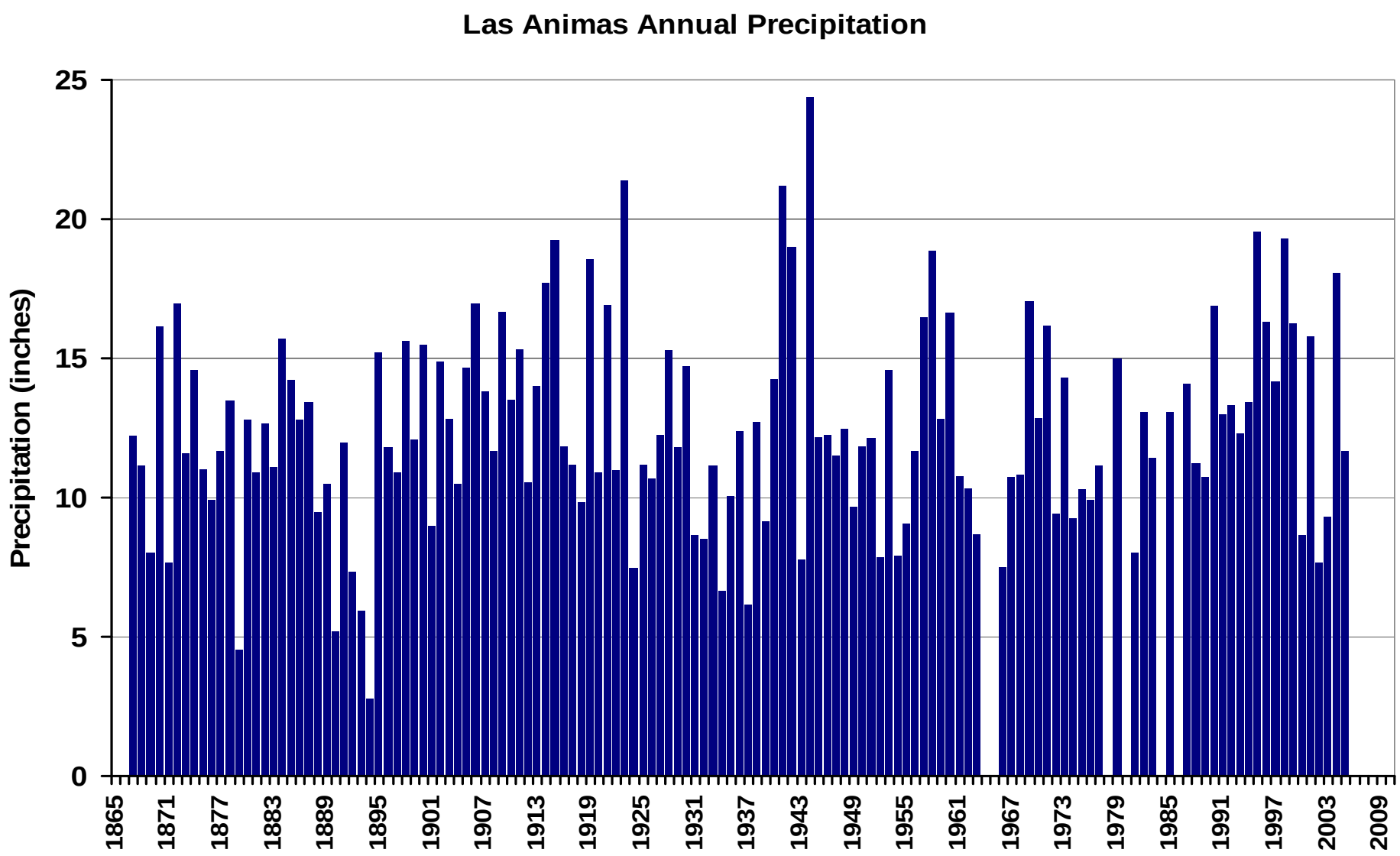
Pueblo Precipitation



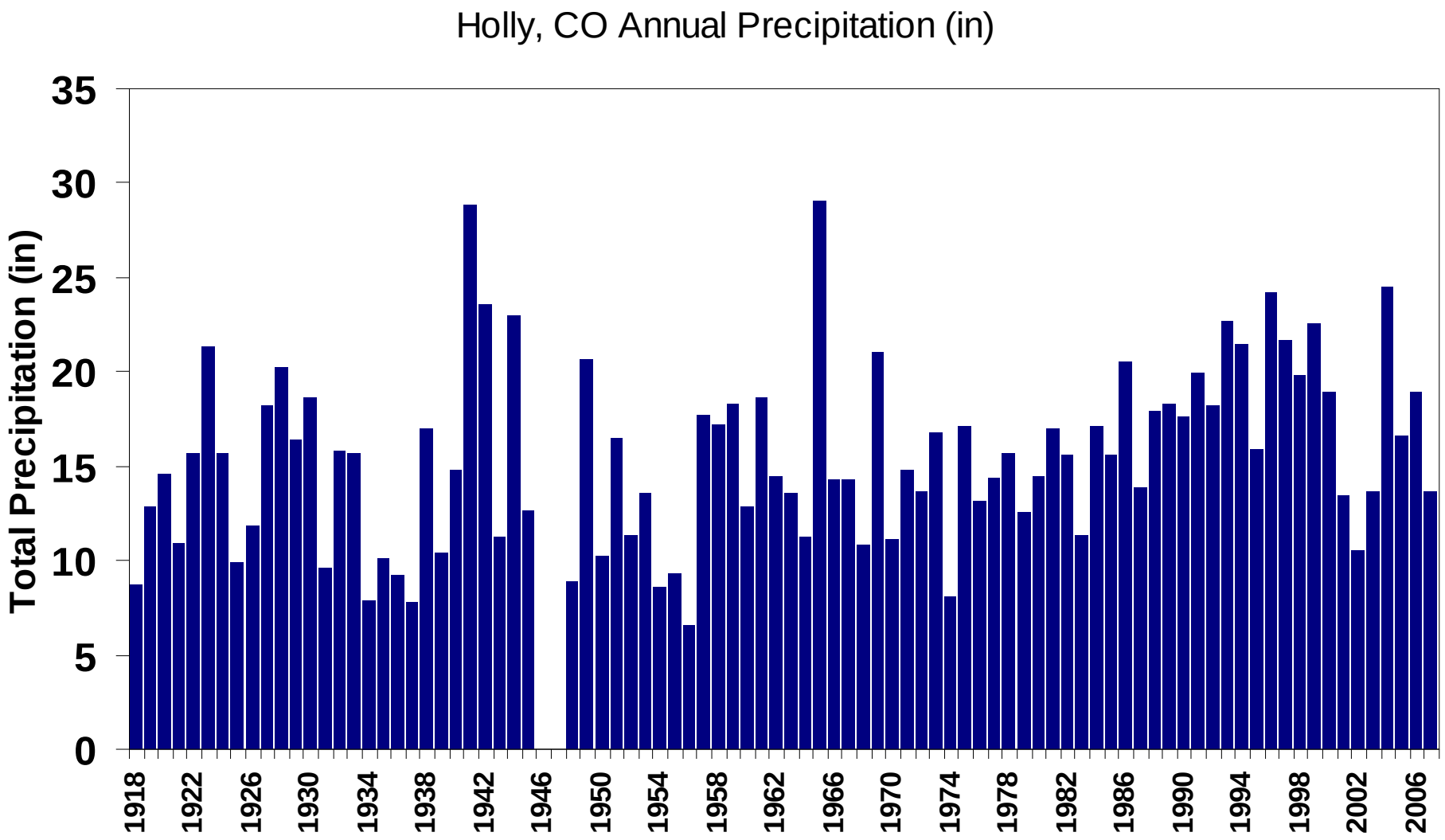
Colorado Springs Precipitation



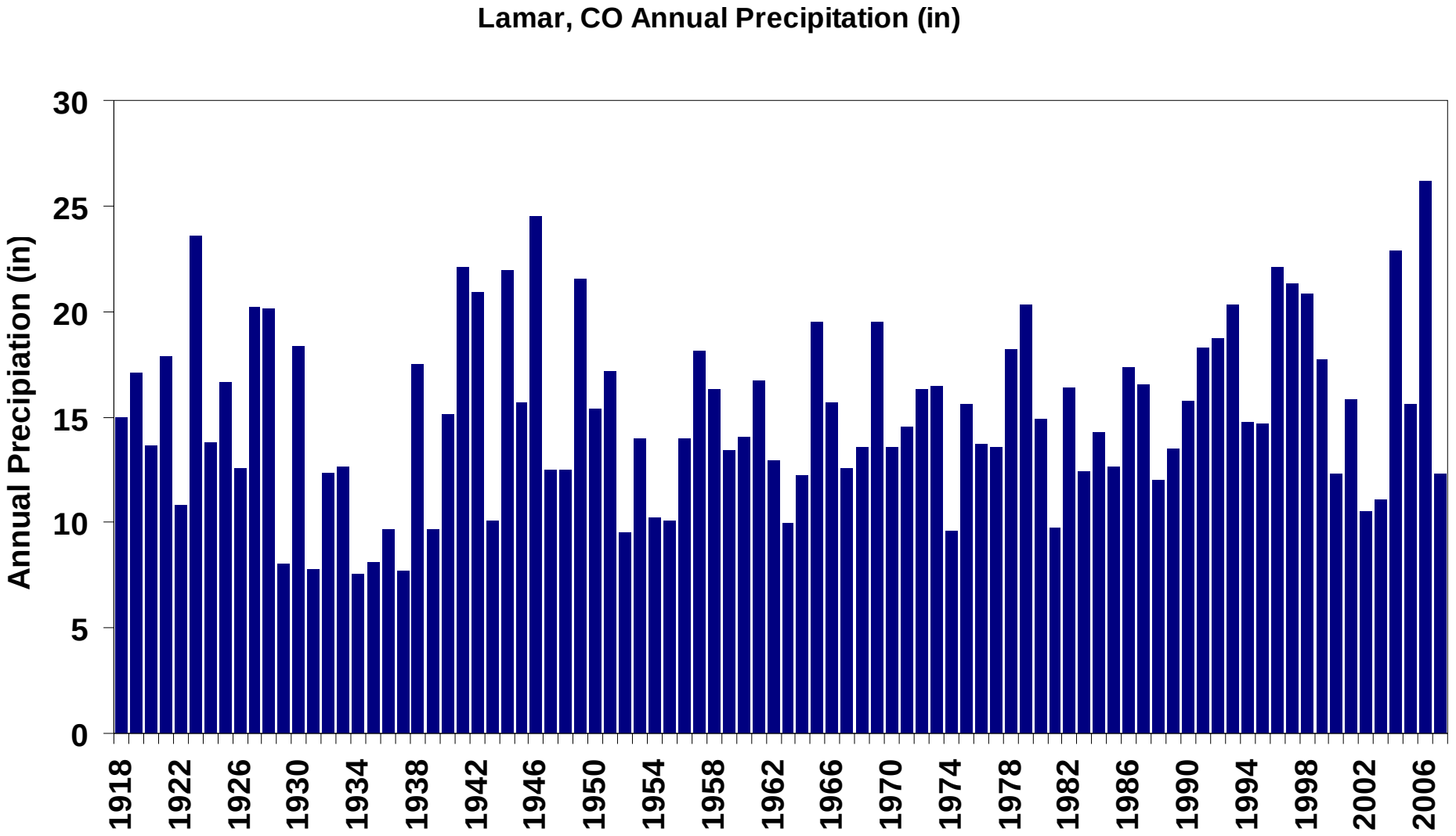
Las Animas Precipitation (annual)



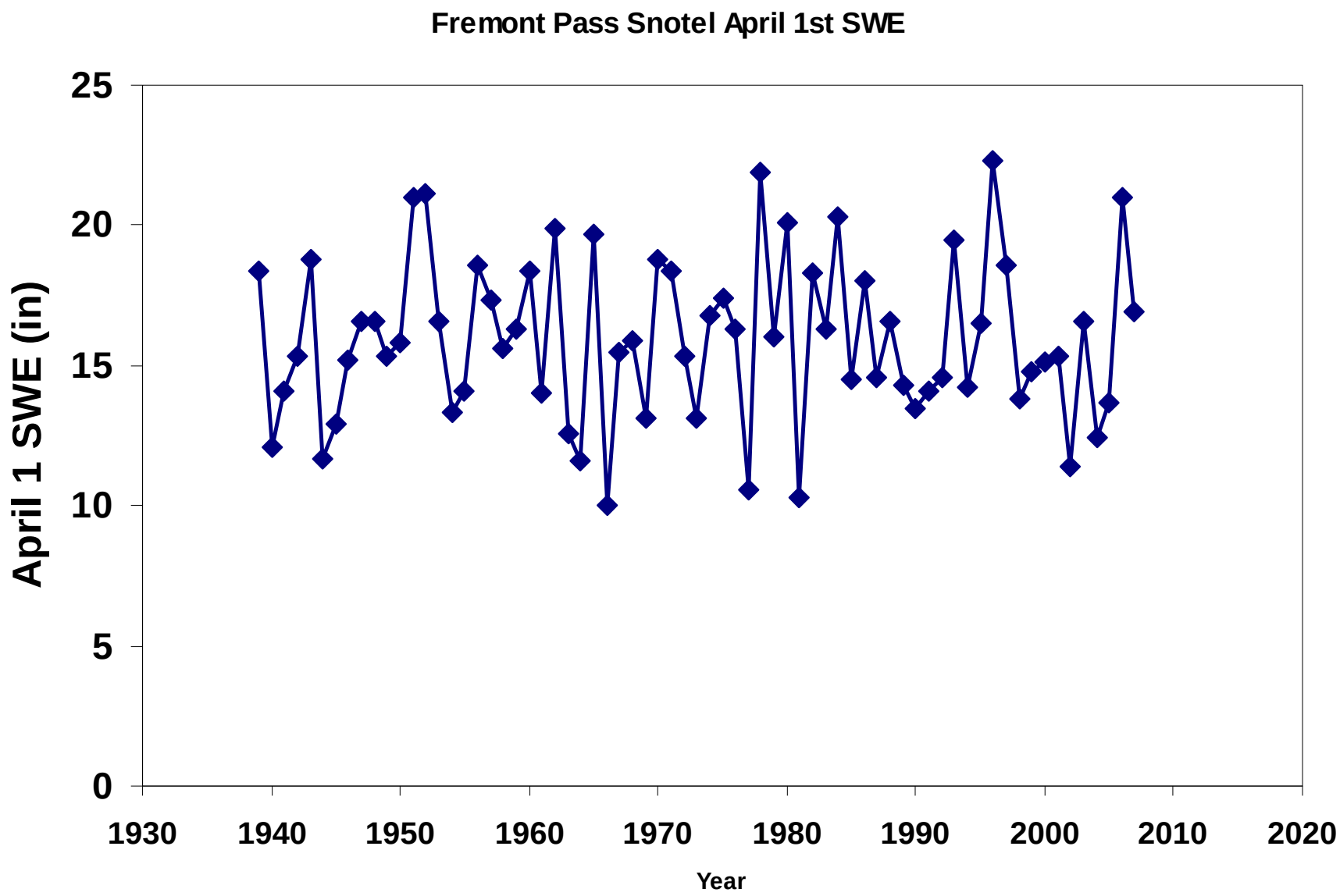
Holly Precipitation (annual)



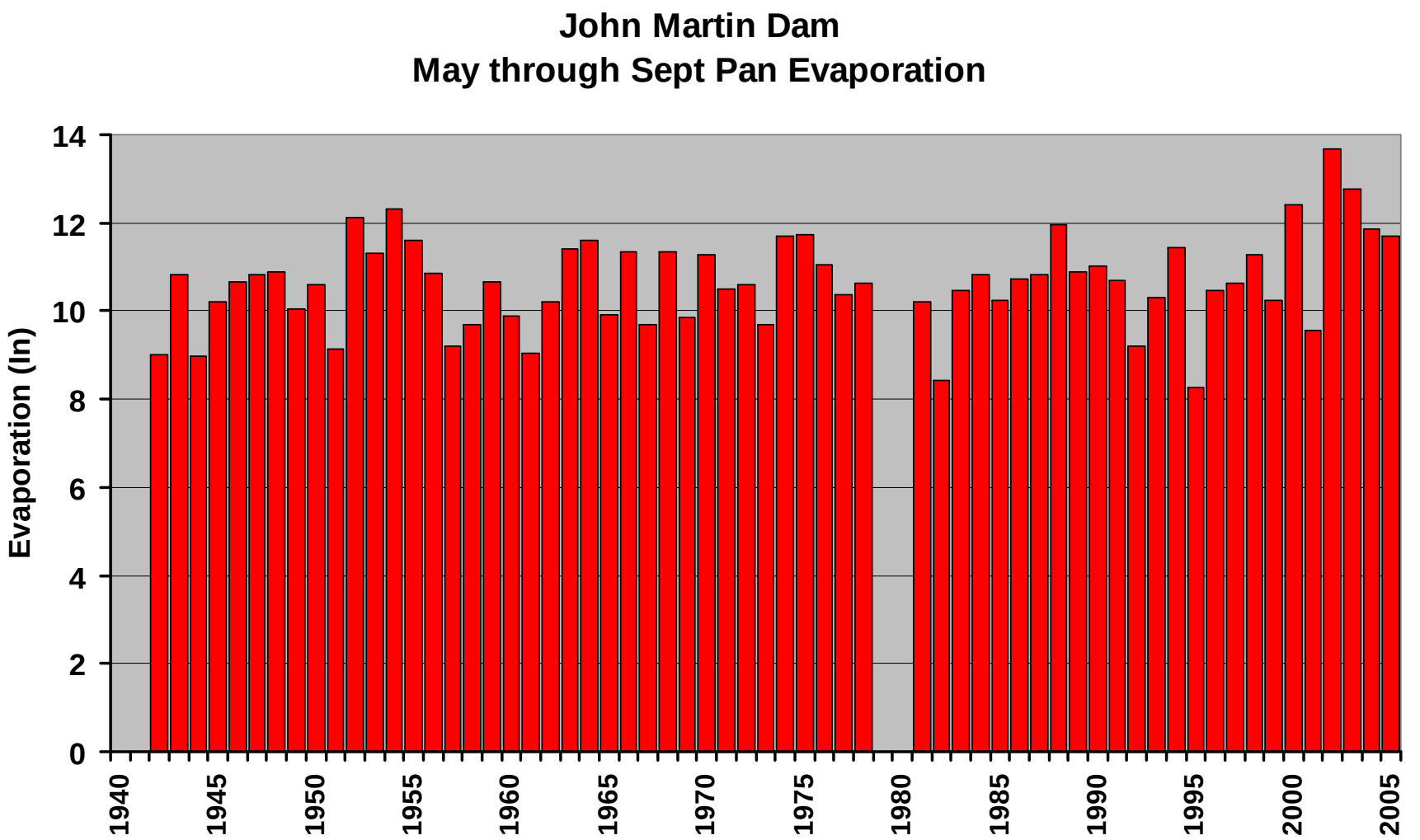
Lamar Precipitation (annual)



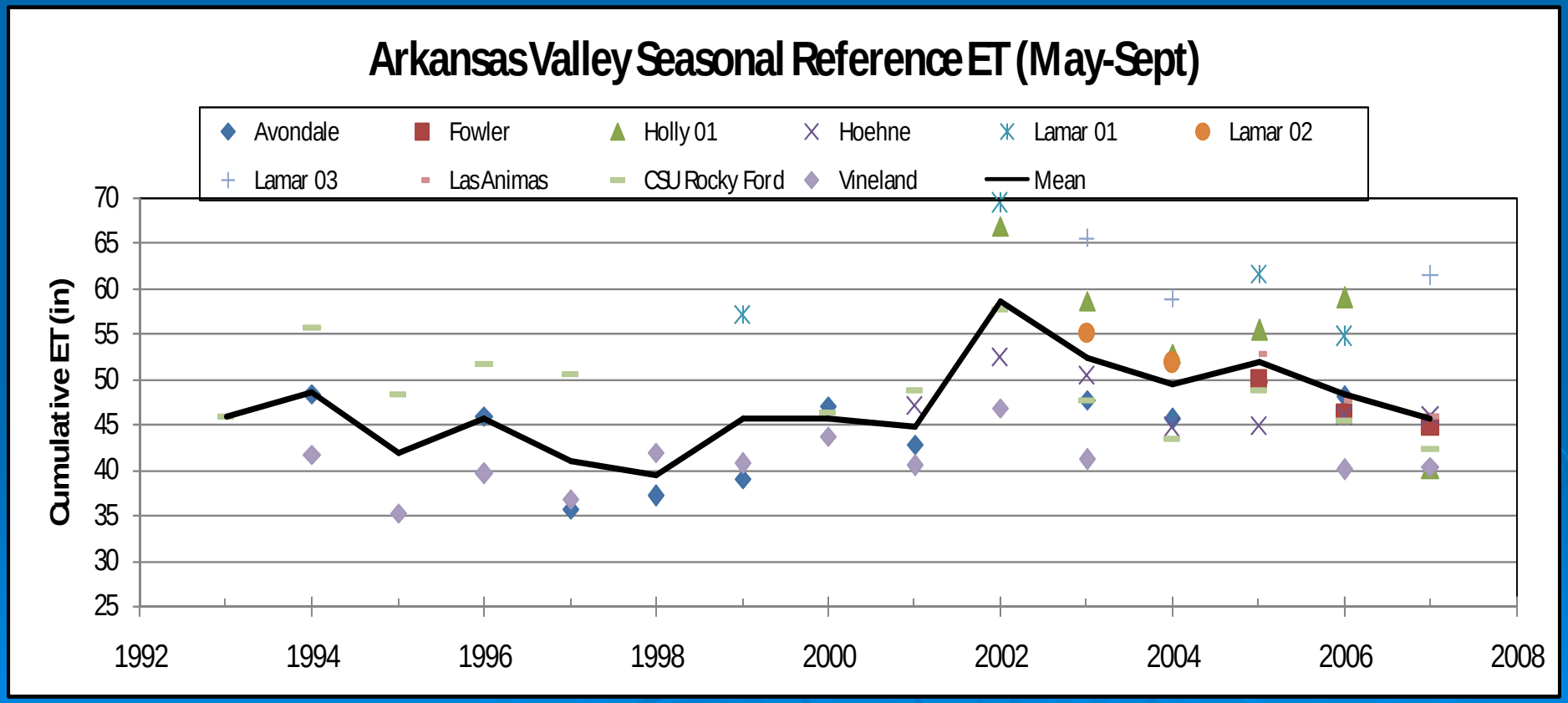
Fremont Pass April 1 Snowpack



John Martin Dam Evaporation



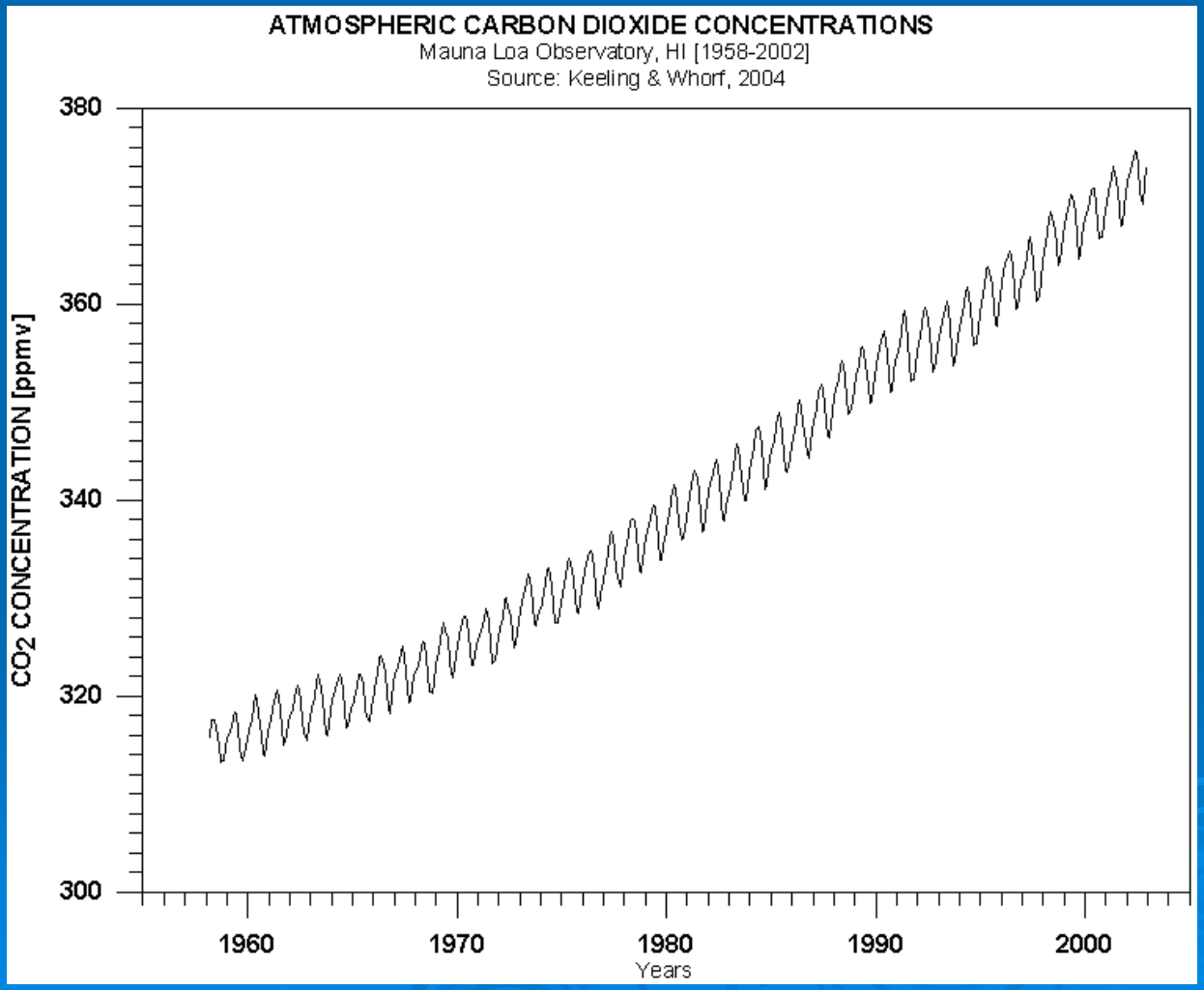
Arkansas Valley CoAgMet Reference ET (May-Sept)



Should we be concerned about Climate Change?

- Any trends so far are subtle, but that may not always be the case

Increases in greenhouse gases are real, large and may continue



So, what comes next?

- You can't just track CO_2 to understand potential climate change

Climate feedbacks are complex

Kinds of Feedbacks:

- Albedo Feedbacks
- Water-vapor Feedbacks
- Lapse-rate Feedbacks
- Cloud Feedback(s)

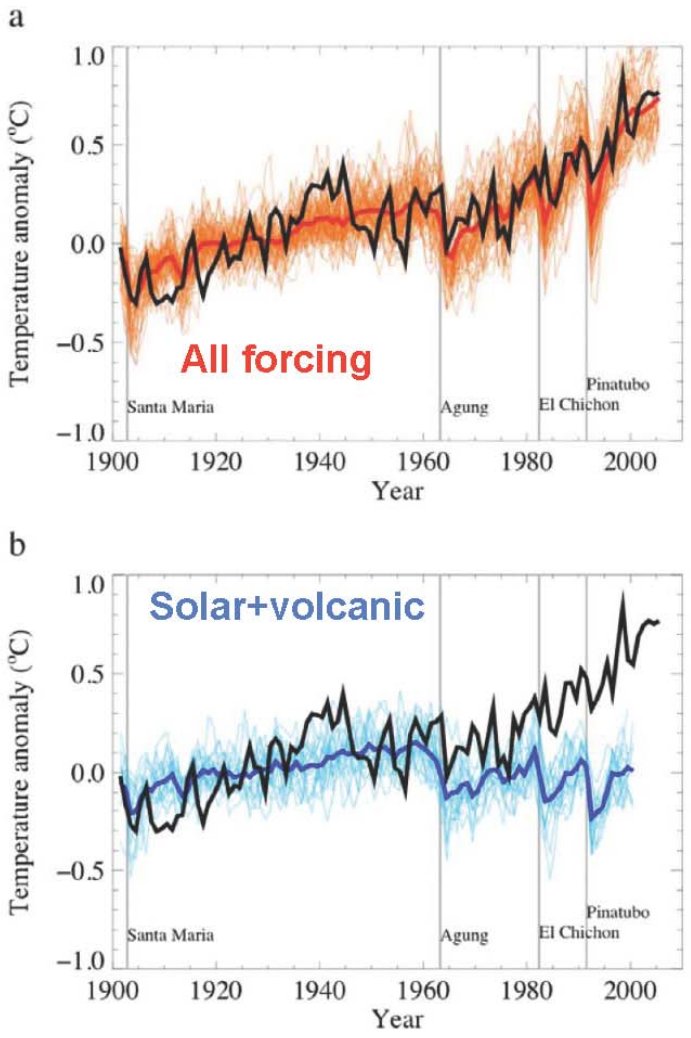
Our current projections are based on imperfect computer models

The observed changes are shown by the black curves.

Results from about 20 models are shown in red (upper panel) and blue (lower panel).

However, these results are not completely convincing, because:

- **Many of the prescribed forcing components are uncertain,**
- **The forcings have not been "standardized," and**
- **Inspection of the model results shows that model-sensitivity is inversely correlated with the strength of the forcing used.**



IPCC

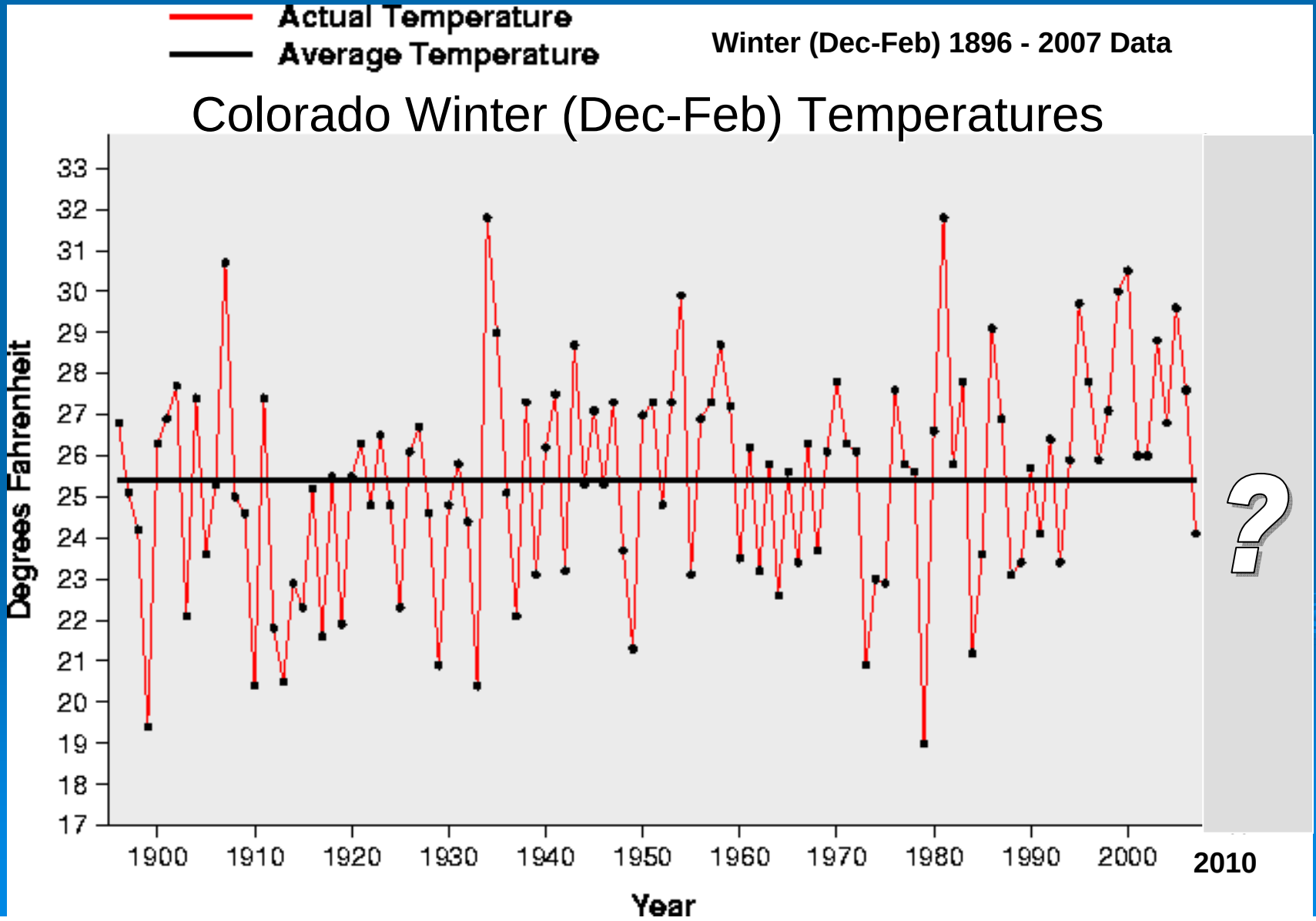
Warming of ~3 K for doubling CO_2
Rising sea level ~ 1 m in 21st century
Stronger storms
More droughts

All based on simulations with complicated computer models.

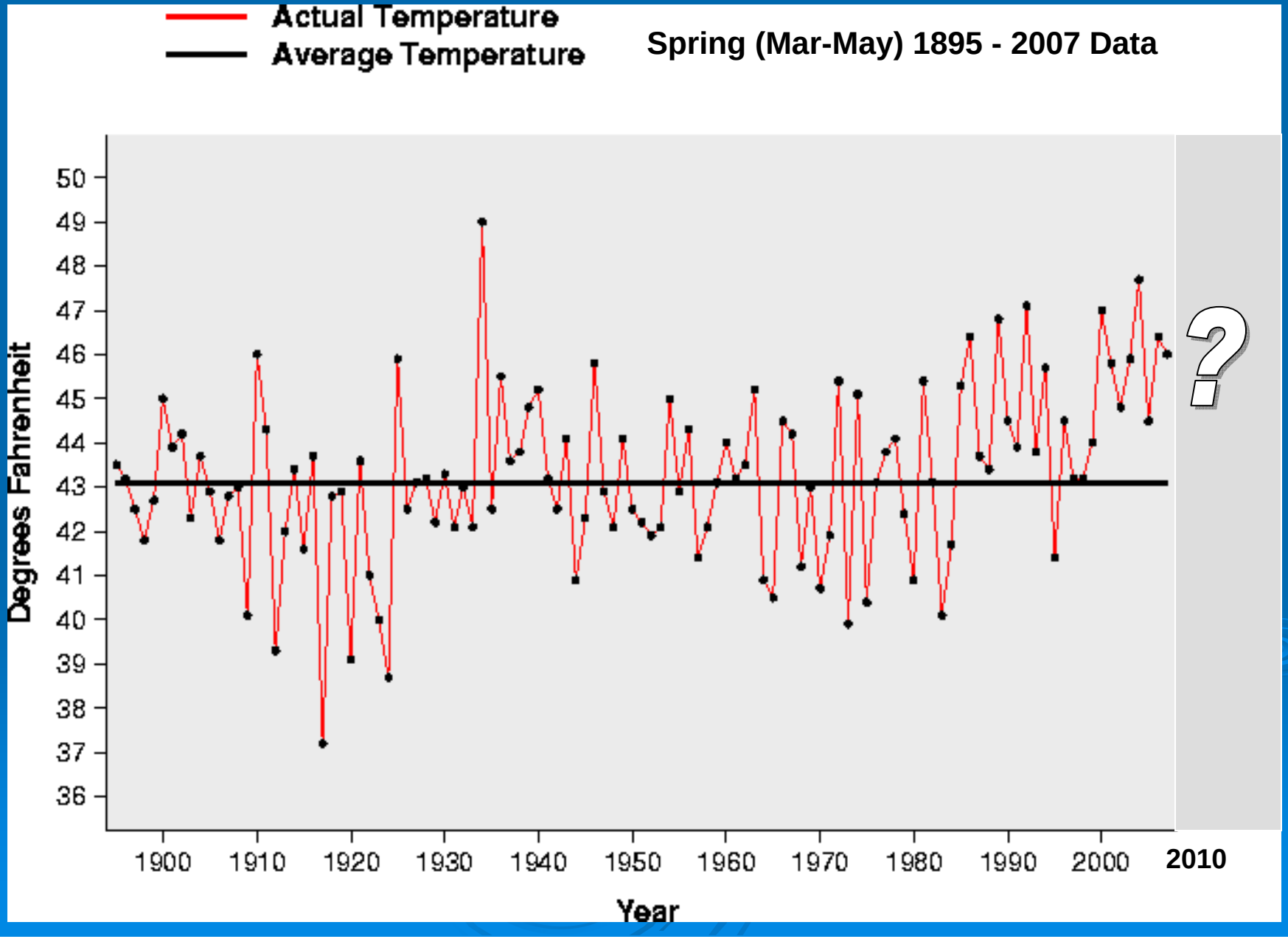
But before we get to that...

Slide taken from Dr. Dave Randall's Climate Change talk

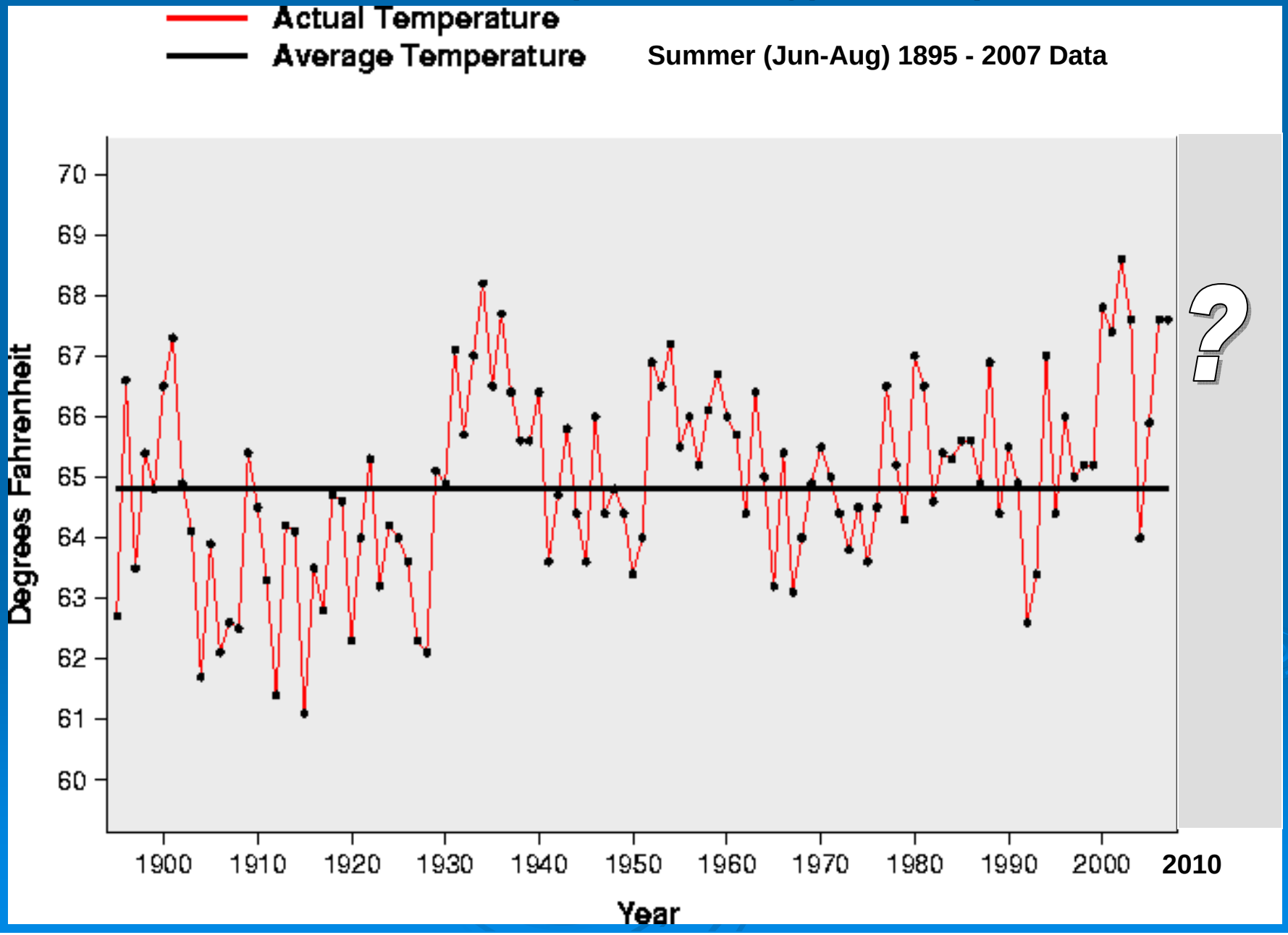
When significant temperature trends begin, we will be able to detect them



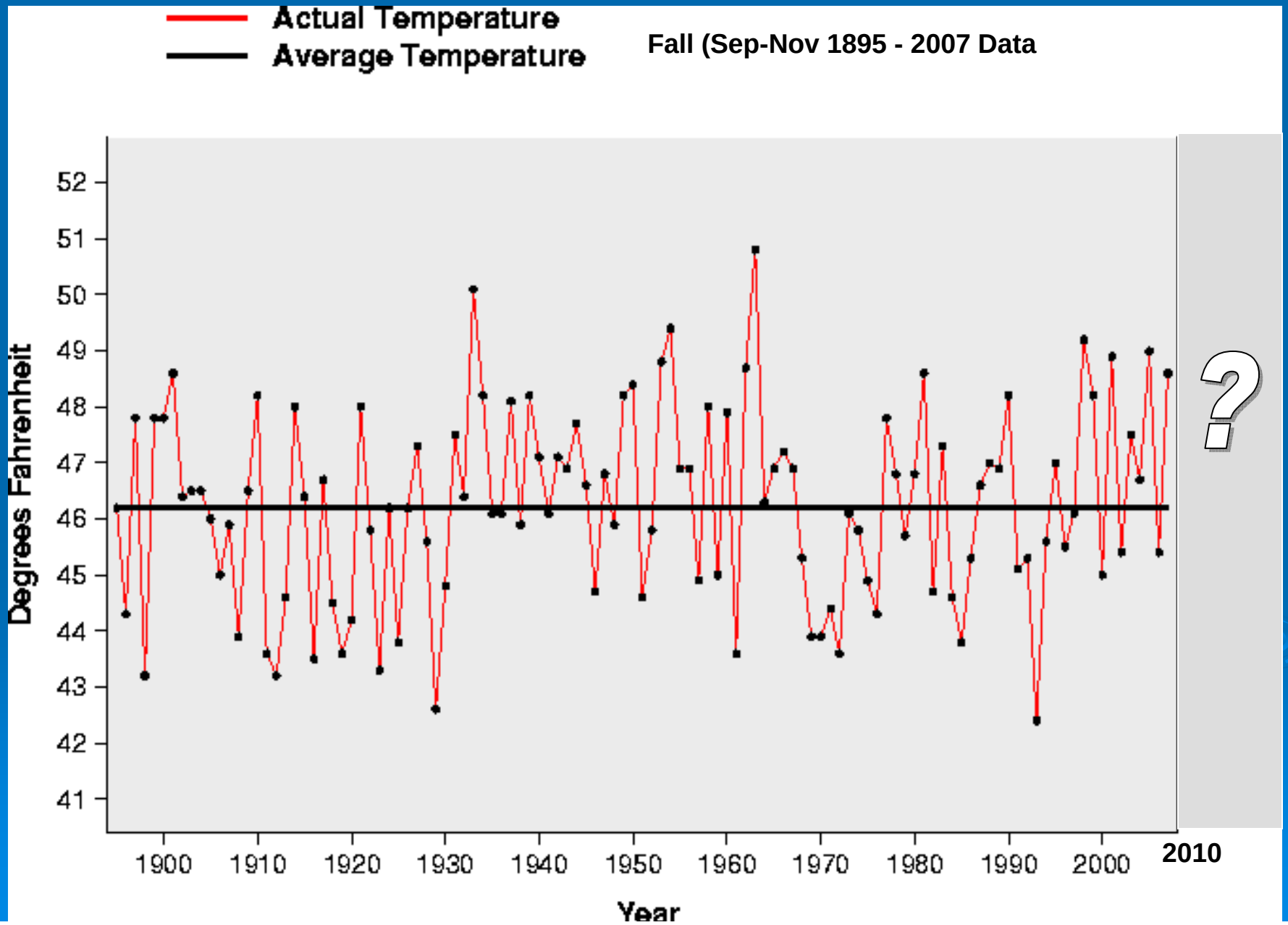
Colorado Spring (Mar-May) Temperatures



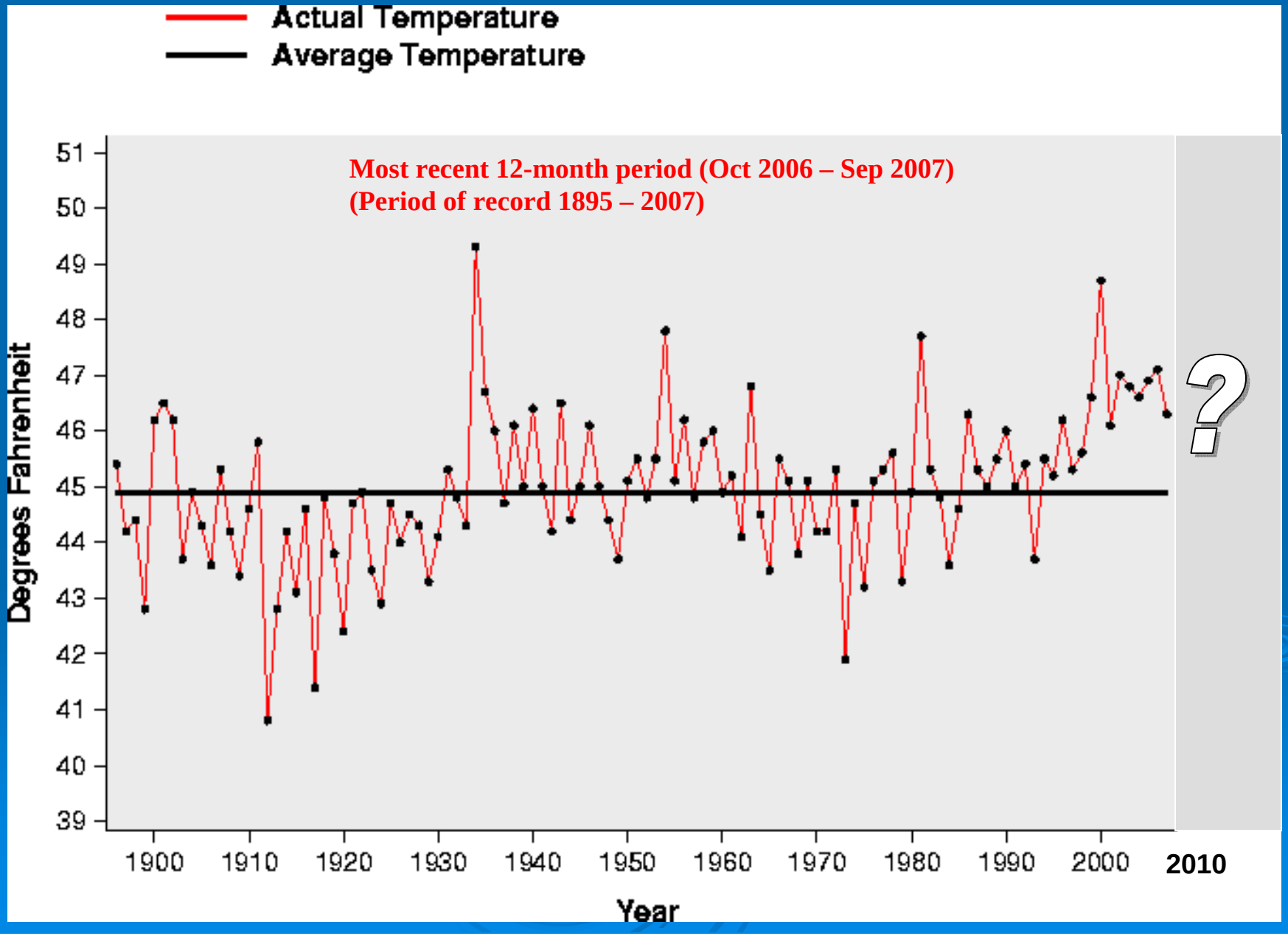
Colorado Summer (Jun-Aug) Temperatures



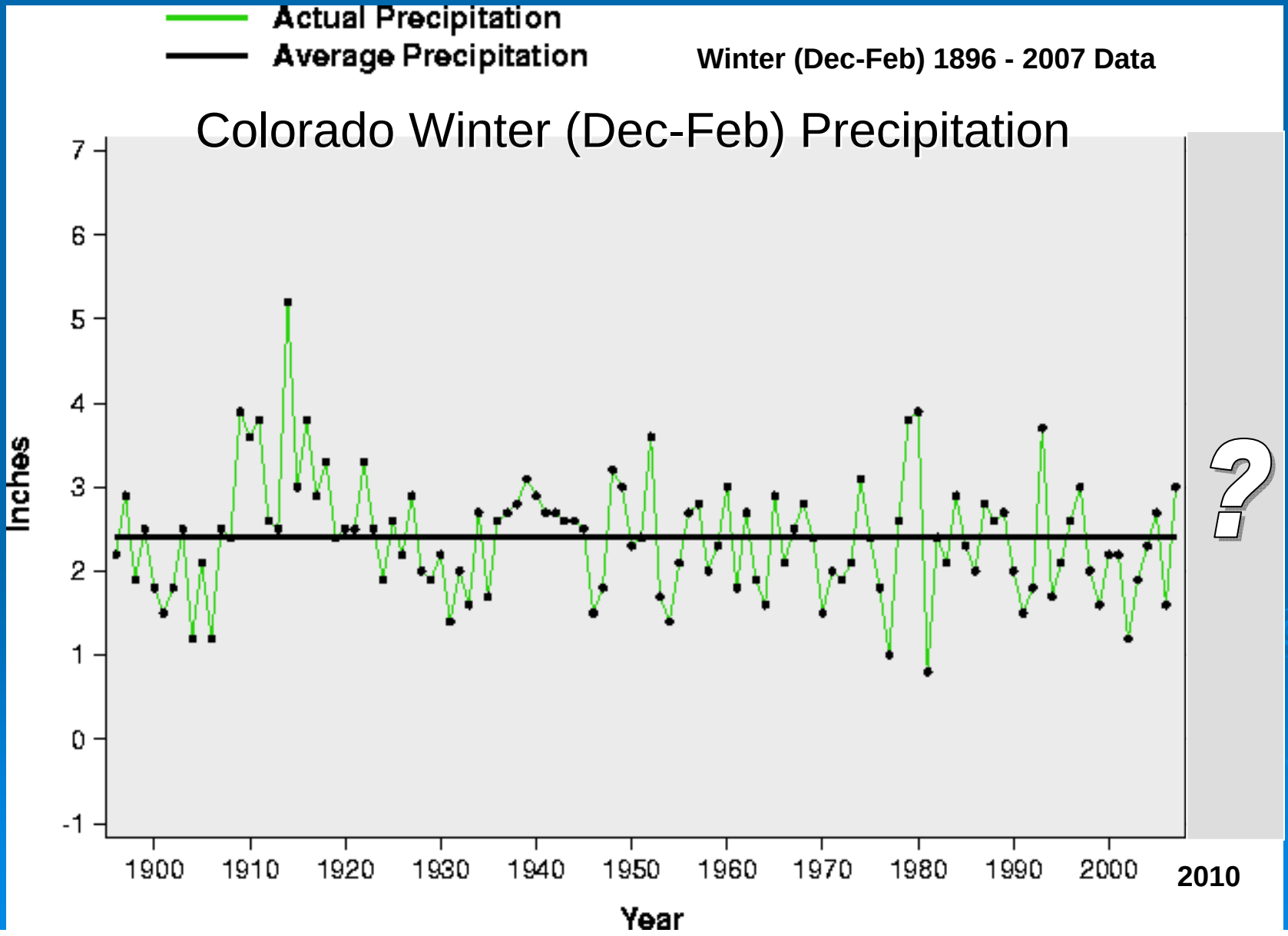
Colorado Fall (Sep-Nov) Temperatures



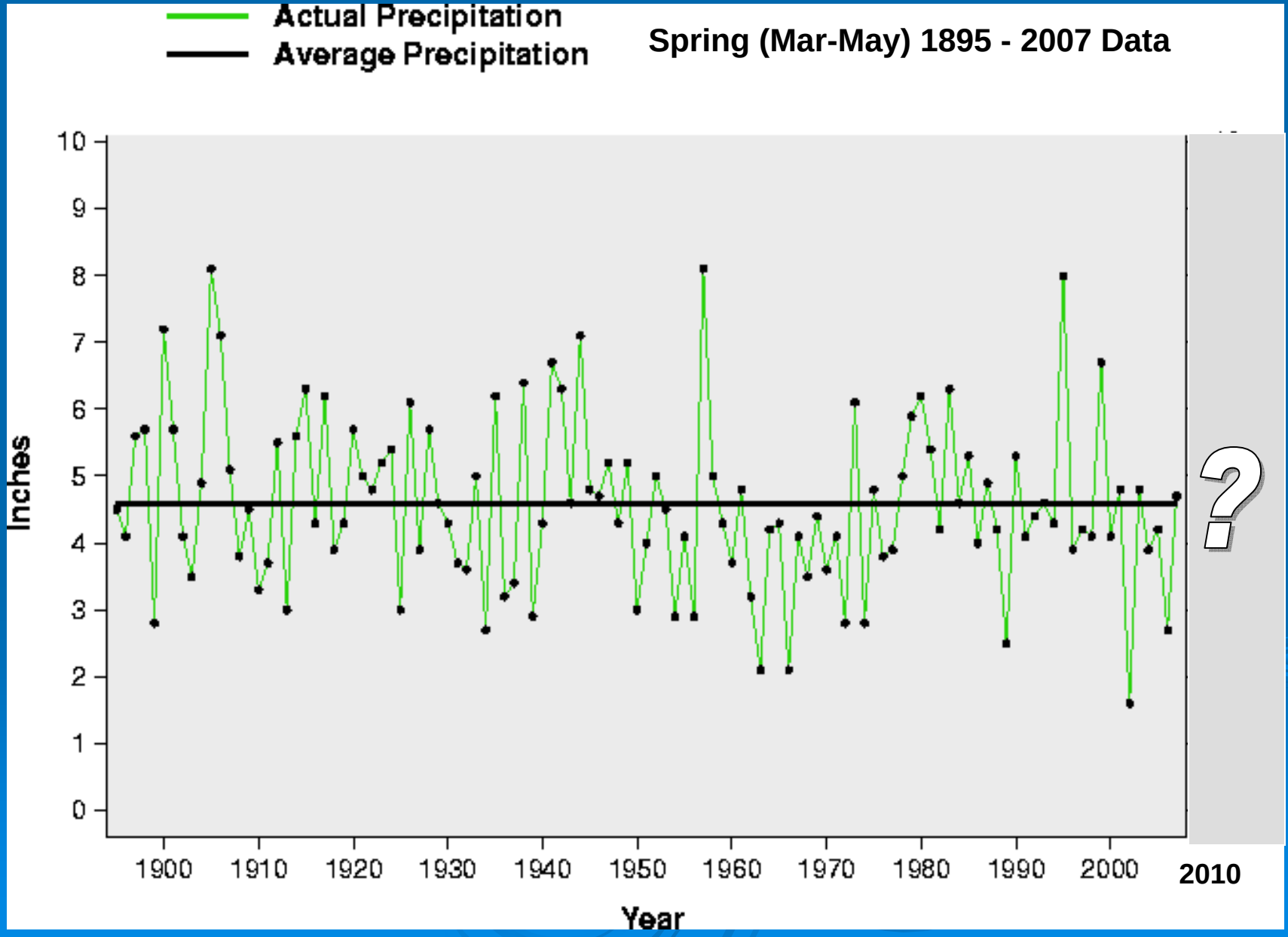
Colorado Temperature in Historic Perspective



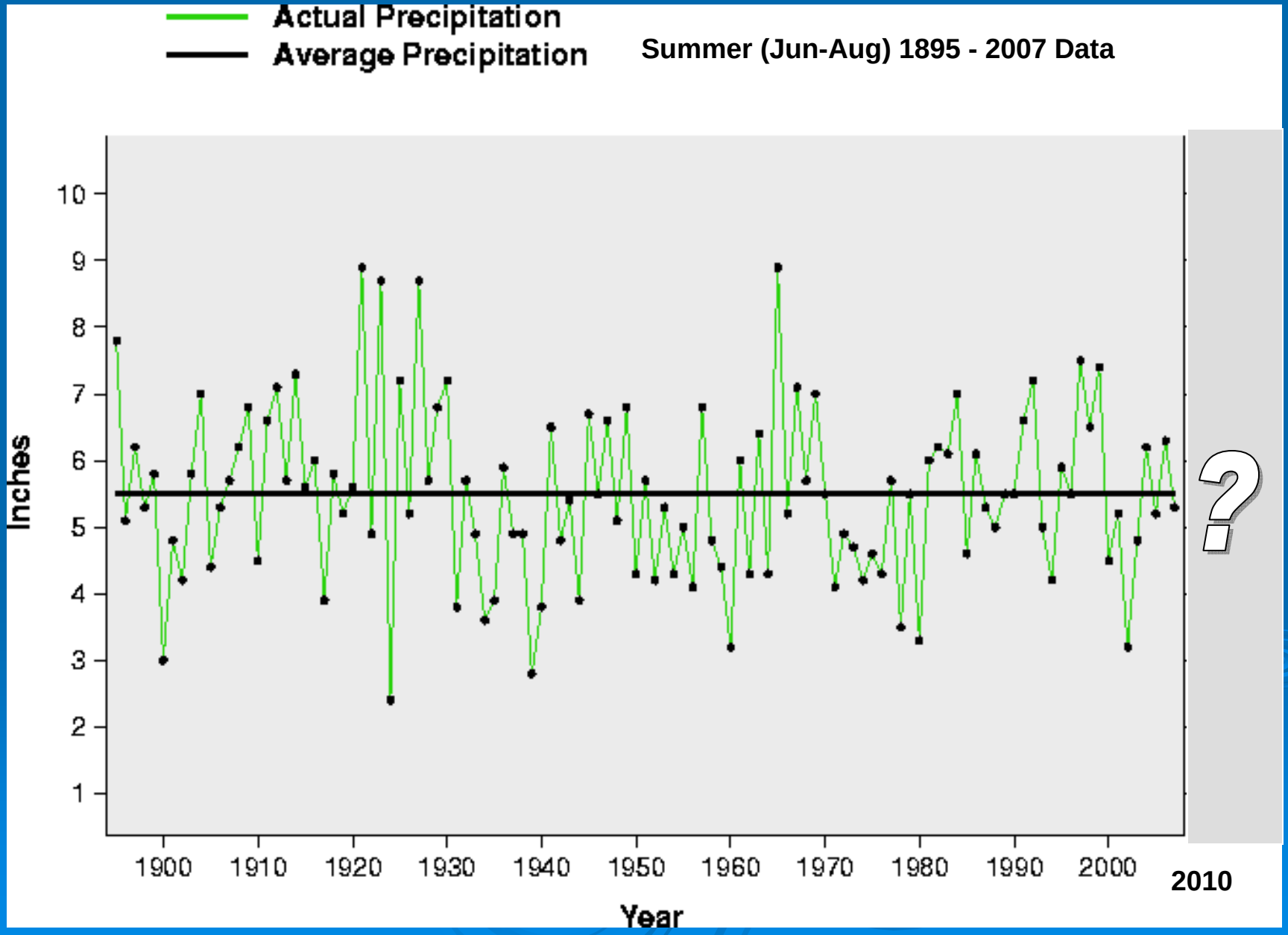
Detecting changes in precipitation will be much more difficult



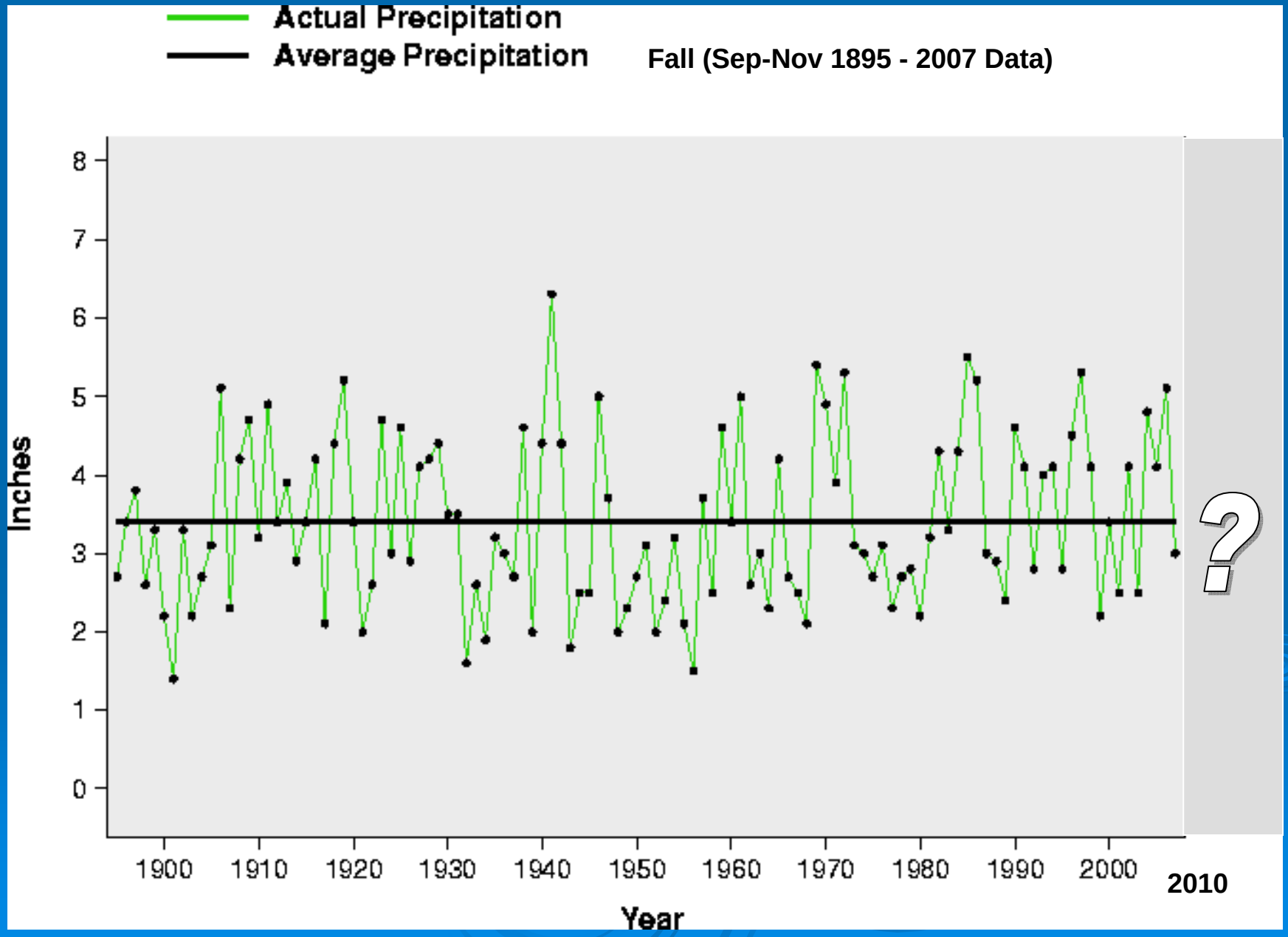
Colorado Spring (Mar-May) Precipitation



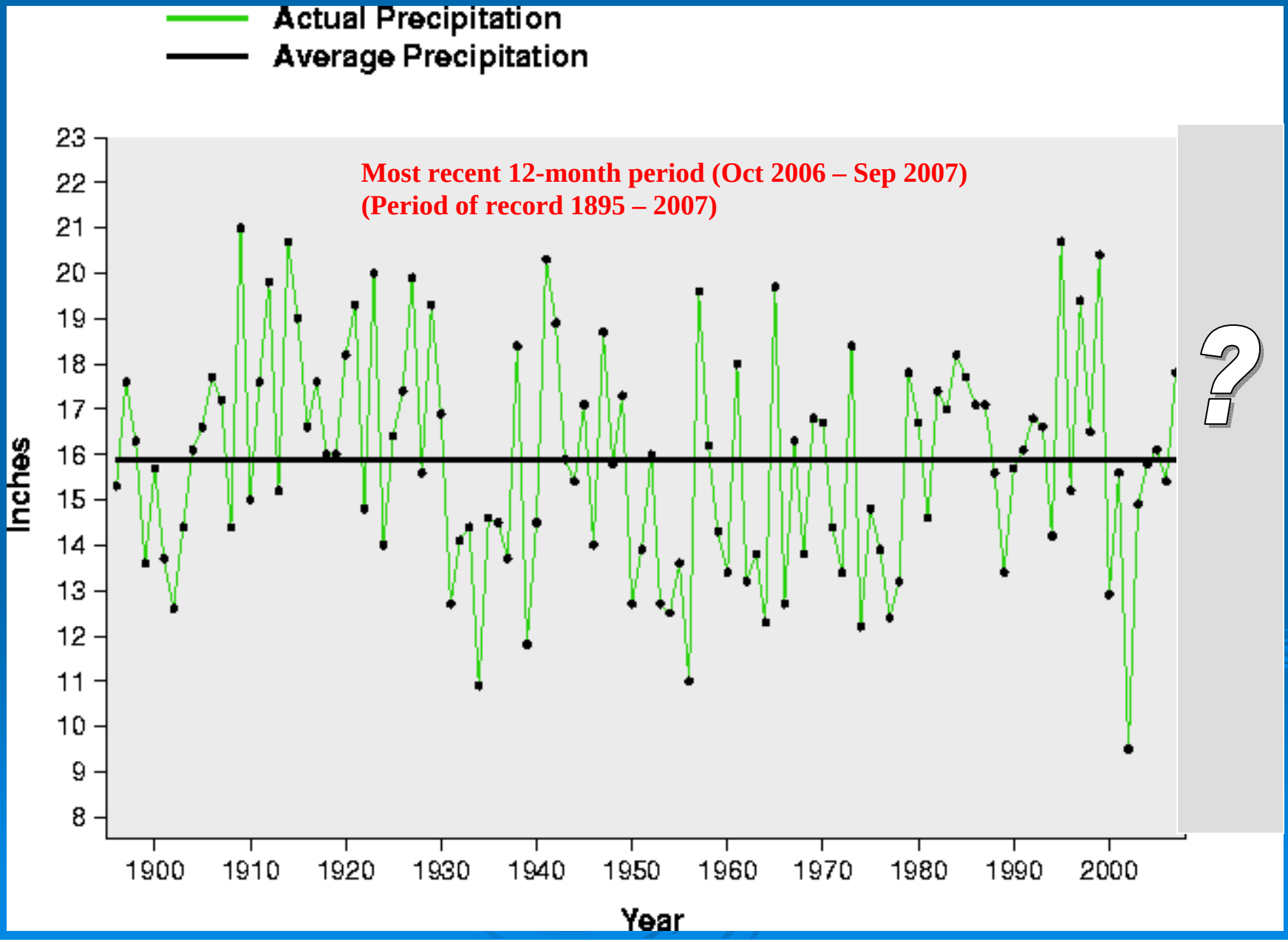
Colorado Summer (Jun-Aug) Precipitation



Colorado Fall (Sep-Nov) Precipitation

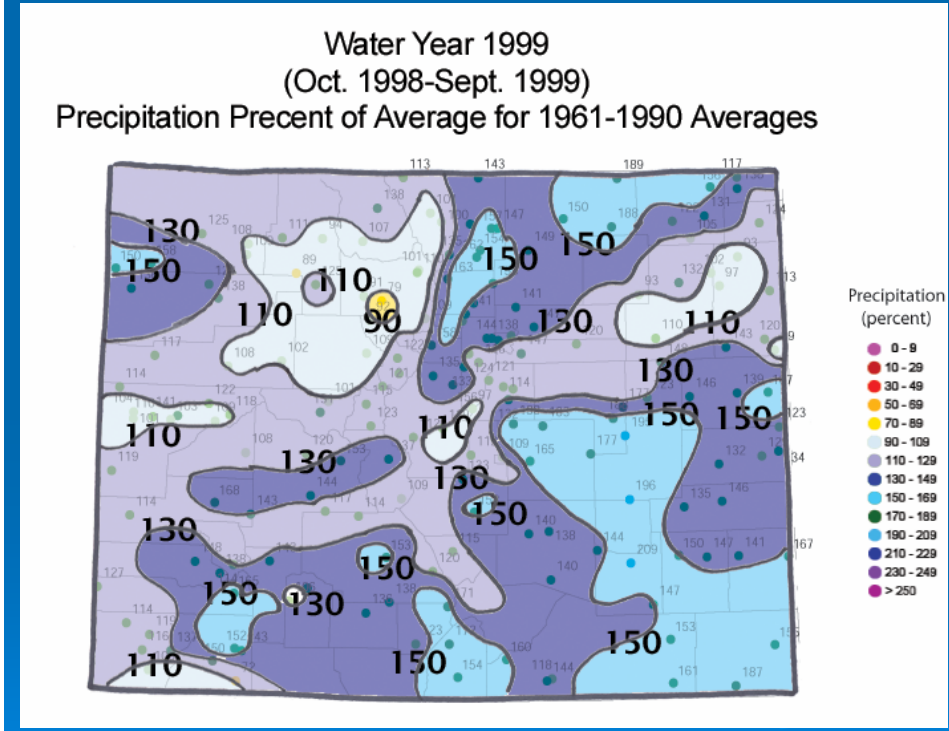


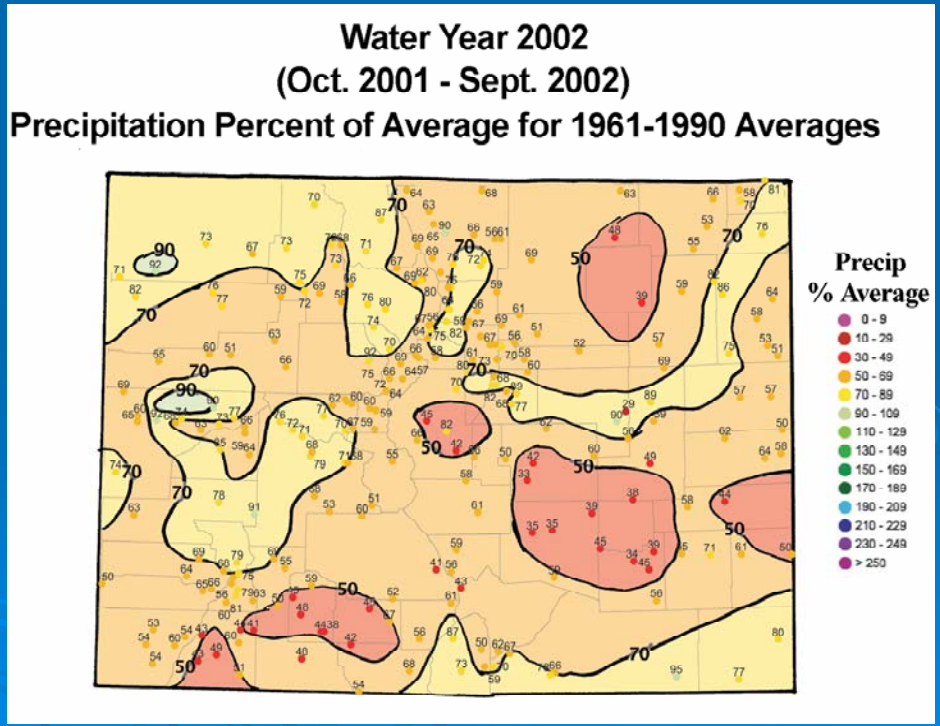
Colorado Precipitation in Historic Perspective



What should we do??

The Colorado Climate Center will continue to monitor Colorado's climate very closely

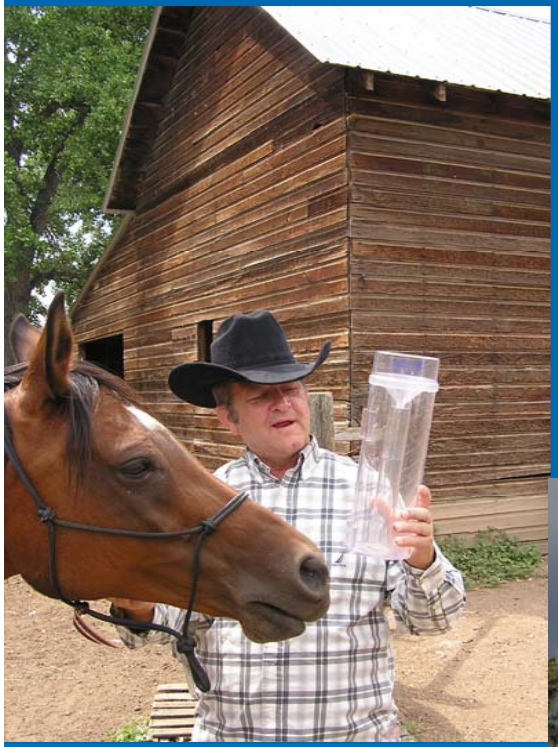




Recent Progress: Colorado Climate Trends Website

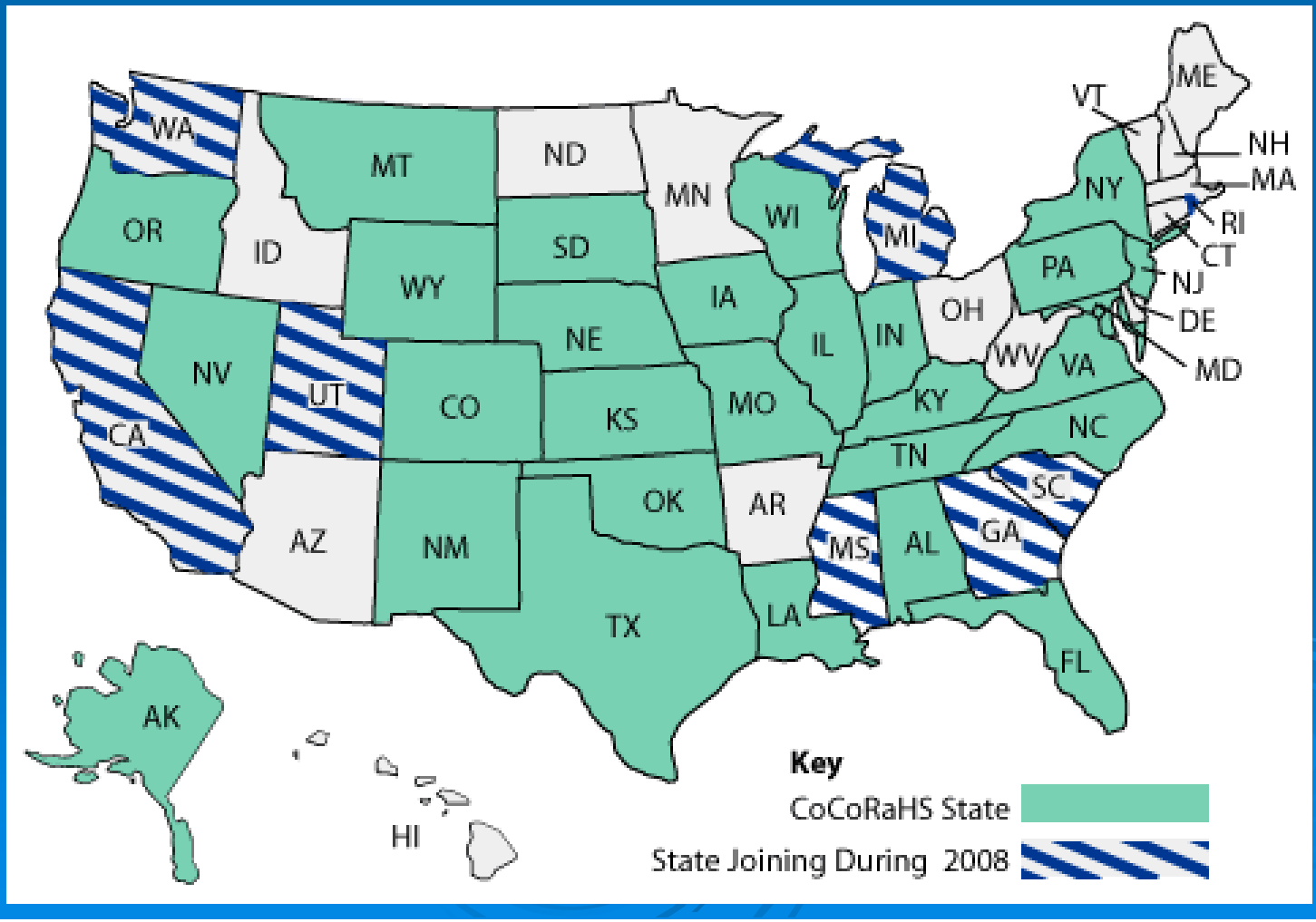
- New website to go operational in June 2008
- Joint collaboration funding by Atmospheric Science Department and CIRA
- Will be a great information asset for the state and university

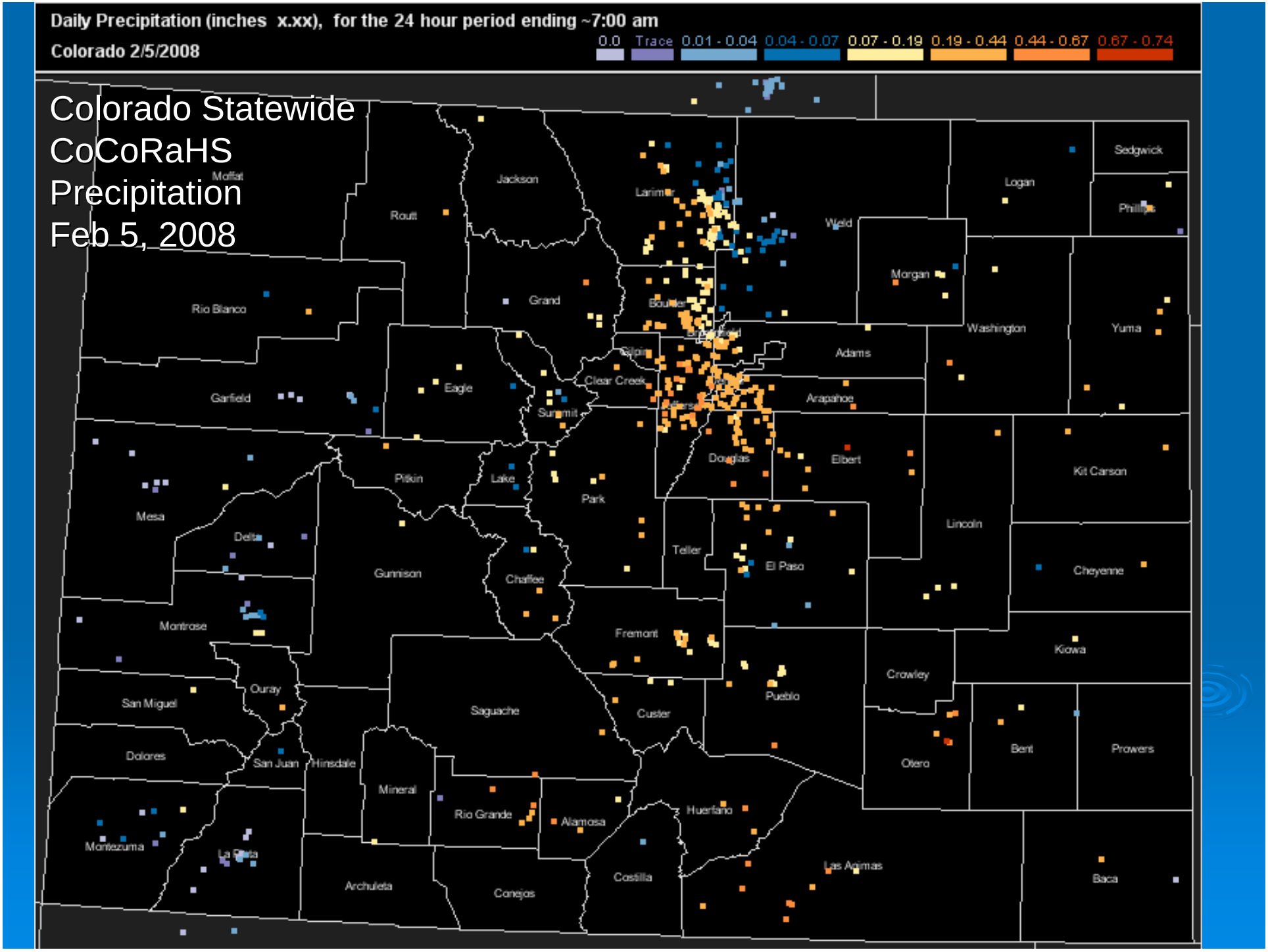
We are also encouraging citizens across the State to help us measure local precipitation

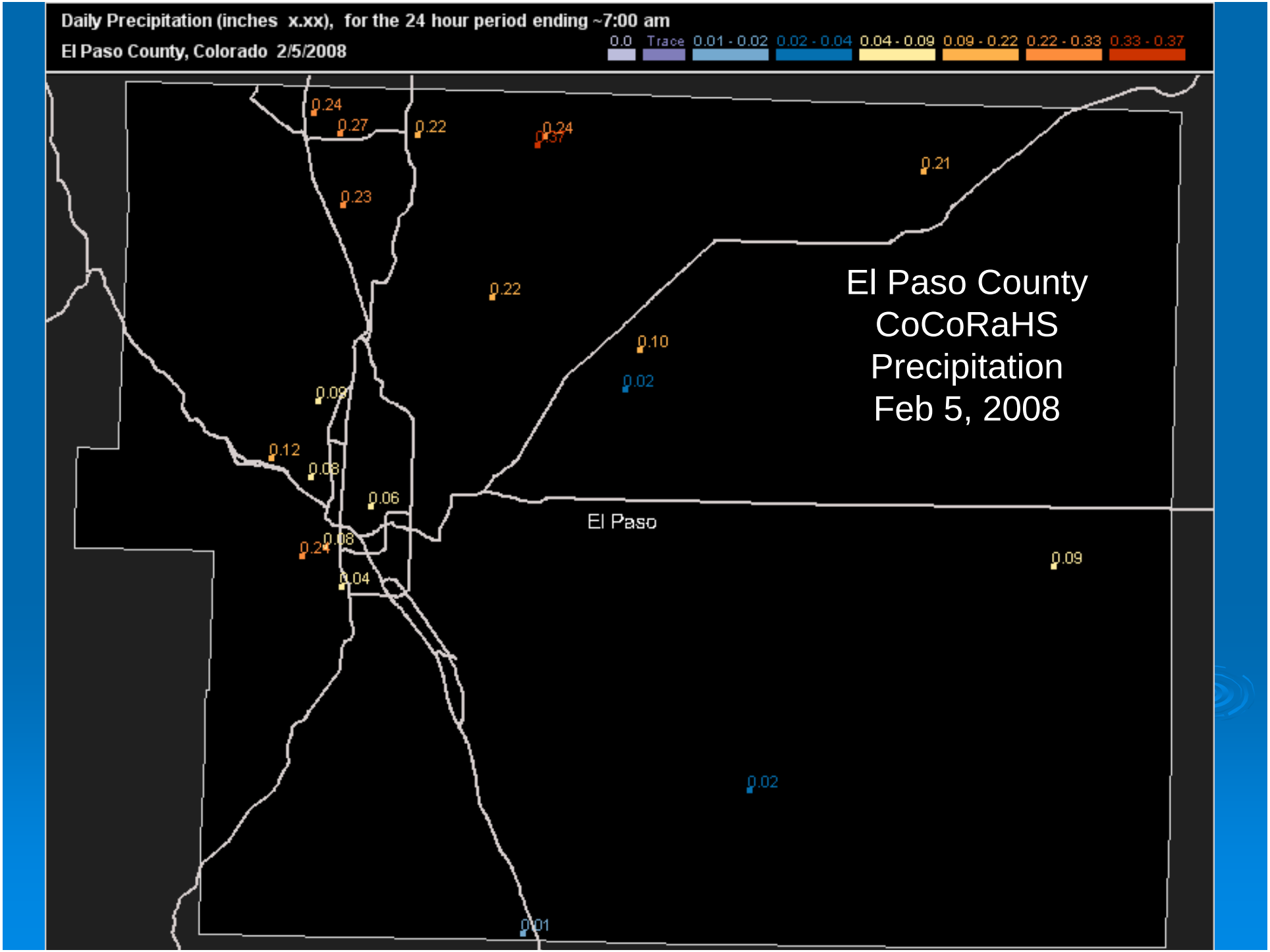


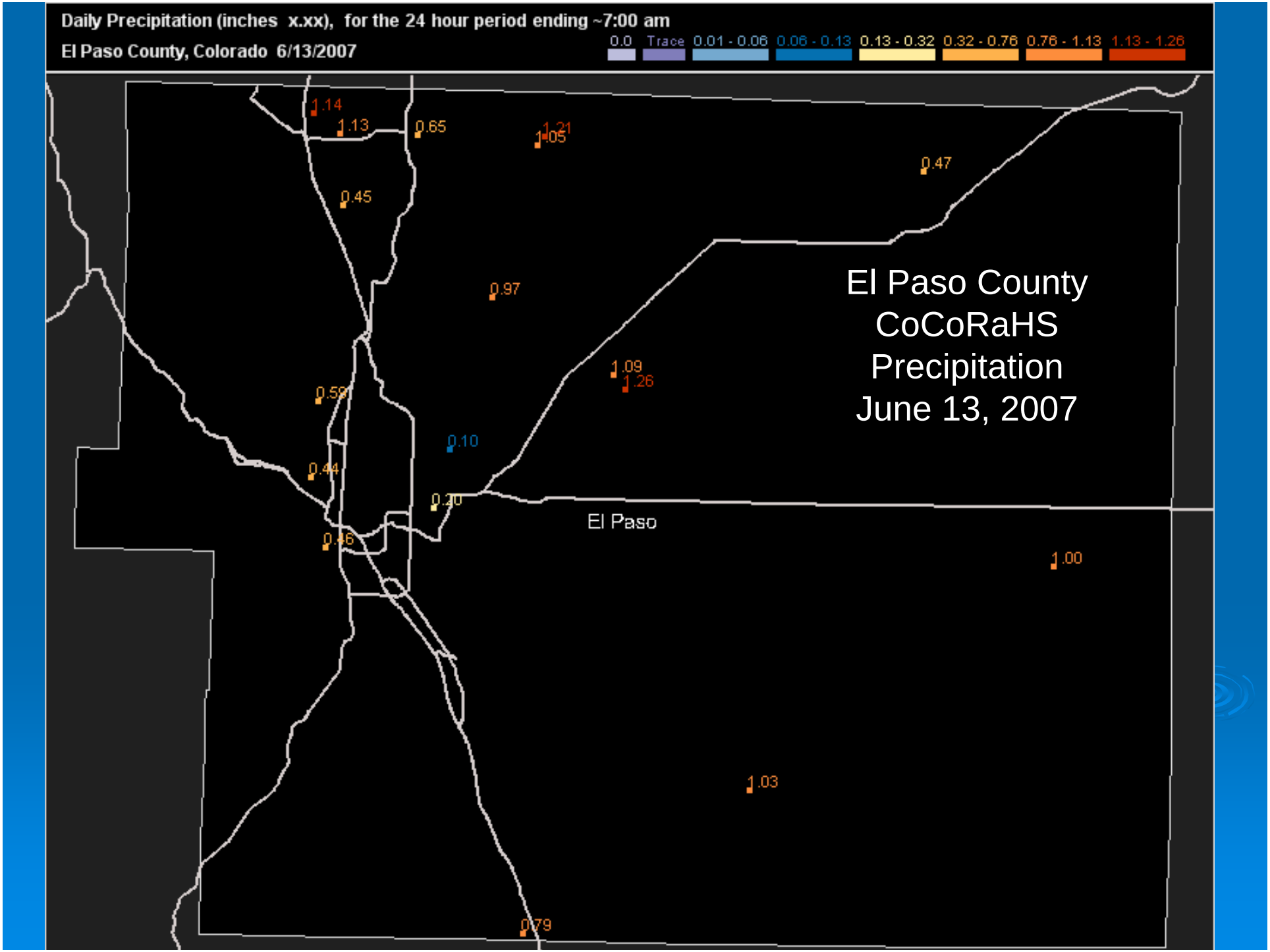
Photos by H. Reges

CoCoRaHS – Community Collaborative Rain, Hail and Snow Network




Daily Precipitation (inches x.xx), for the 24 hour period ending ~7:00 am
Colorado 2/5/2008
0.0
Trace
0.01 - 0.04
0.04 - 0.07
0.07 - 0.19
0.19 - 0.44
0.44 - 0.67
0.67 - 0.74
Colorado Statewide
CoCoRaHS
Precipitation
Feb 5, 2008
Moffat
Routt
Jackson
Larimer
Weld
Logan
Sedgwick
Phillips
Morgan
Rio Blanco
Grand
Boulder
Washington
Yuma
Adams
Garfield
Eagle
Clear Creek
Summit
Arapahoe
Pitkin
Lake
Park
Douglas
Elbert
Kit Carson
Mesa
Delta
Gunnison
Chaffee
Teller
El Paso
Lincoln
Cheyenne
Montrose
Fremont
Kiowa
Ouray
San Miguel
Saguache
Custer
Pueblo
Crowley
Dolores
San Juan
Hinsdale
Mineral
Rio Grande
Alamosa
Huerfano
Otero
Bent
Prowers
Montezuma
La Plata
Archuleta
Conejos
Costilla
Las Animas
Baca


Daily Precipitation (inches x.xx), for the 24 hour period ending ~7:00 am
El Paso County, Colorado 2/5/2008
0.0 Trace 0.01 - 0.02 0.02 - 0.04 0.04 - 0.09 0.09 - 0.22 0.22 - 0.33 0.33 - 0.37
0.24
0.27
0.22
0.24
0.37
0.21
0.23
0.22
0.10
0.02
0.09
0.12
0.08
0.06
El Paso
0.24
0.08
0.04
0.09
0.02
0.01
El Paso County
CoCoRaHS
Precipitation
Feb 5, 2008


Daily Precipitation (inches x.xx), for the 24 hour period ending ~7:00 am
El Paso County, Colorado 6/13/2007
0.0 Trace 0.01 - 0.06 0.06 - 0.13 0.13 - 0.32 0.32 - 0.76 0.76 - 1.13 1.13 - 1.26
1.14
1.13
0.65
1.21
1.05
0.47
0.45
0.97
1.09
1.26
0.58
0.10
0.44
0.20
El Paso
0.46
1.00
1.03
0.79
El Paso County
CoCoRaHS
Precipitation
June 13, 2007

For information and to volunteer, visit the CoCoRaHS Web Site

http://www.cocorahs.org

Support for this project provided by:

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

Colorado Climate Center