The Climate of Colorado
– past, present and future

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Presented to the
Colorado Air Quality Control Commission
Fort Morgan, CO October 15, 2009

Colorado State University
Knowledge to Go Places

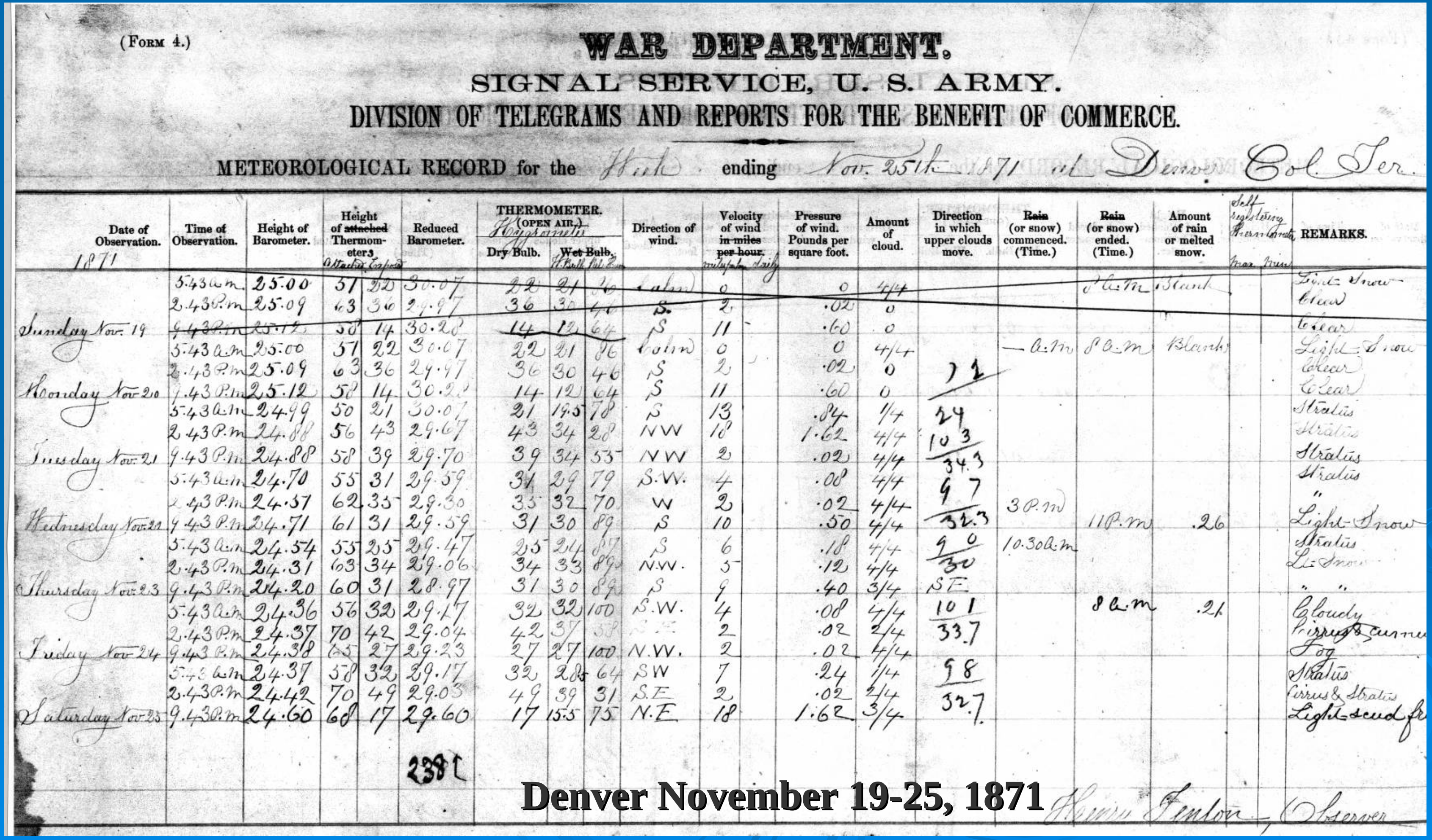
Mission

- The Colorado Climate Center was established by the state in 1974, through the Colorado State University Agricultural Experiment Station, to provide information and expertise on Colorado's complex climate. Through its threefold program of ***Climate Monitoring*** (data acquisition, analysis, and archiving), ***Climate Research*** and ***Climate Services***, the Center is responding to many climate related questions and problems affecting the state today.

Should we be concerned about Climate Change here in Colorado?

First let's consider our current climate and our observed climate history

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



(FORM 4.)

WAR DEPARTMENT.

SIGNAL SERVICE, U. S. ARMY.

DIVISION OF TELEGRAMS AND REPORTS FOR THE BENEFIT OF COMMERCE.

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

Date of Observation. 1871	Time of Observation.	Height of Barometer.	Height of ~~attached~~ Thermometers: Attached	Exposed	Reduced Barometer.	Thermometer (Open Air) Hygrometer: Dry Bulb.	~~Wet Bulb.~~ W. Bulb	Rel. Hum.	Direction of wind.	Velocity of wind ~~in miles per hour.~~ miles per hour	Pressure of wind. Pounds per square foot.	Amount of cloud.	Direction in which upper clouds move.	~~Rain~~ (or snow) commenced. (Time.)	~~Rain~~ (or snow) ended. (Time.)	Amount of rain or melted snow.	Self registering Thermometer: Max	Min	REMARKS.
	~~5.43 a.m~~	~~25.00~~	~~57~~	~~22~~	~~30.07~~	~~22~~	~~21~~	~~86~~	~~Calm~~	~~0~~	~~0~~	~~4/4~~			~~8 a.m~~	~~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	57	22	30.07	22	21	86	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	46	S	2	.02	0	7 1						Clear
Monday Nov 20	9.43 P.m	25.12	58	14	30.22	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	18	1.62	4/4	10 3						Stratus
Tuesday Nov. 21	9.43 P.m	24.88	58	39	29.70	39	34	55	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	9 7						Stratus
	2.43 P.m	24.37	62	35	29.30	35	32	70	W	2	.02	4/4		3 P.m					"
Wednesday Nov. 22	9.43 P.m	24.71	61	31	29.59	31	30	89	S	10	.50	4/4	32.3		11 P.m	.26			Light Snow
	5.43 a.m	24.54	55	25	29.47	25	24	87	S	6	.18	4/4	9 0	10.30 a.m					Stratus
	2.43 P.m	24.31	63	34	29.06	34	33	89	N.W.	5	.12	4/4	30						Lt. Snow
Thursday Nov. 23	9.43 P.m	24.20	60	31	28.97	31	30	89	S	9	.40	3/4	SE						" "
	5.43 a.m	24.36	56	32	29.17	32	32	100	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	58	S.E.	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	28.5	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

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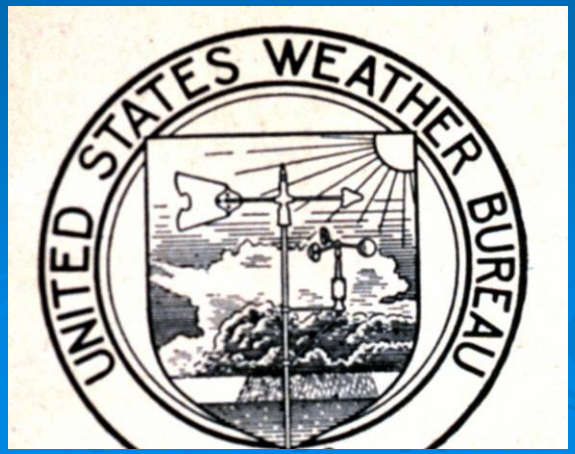
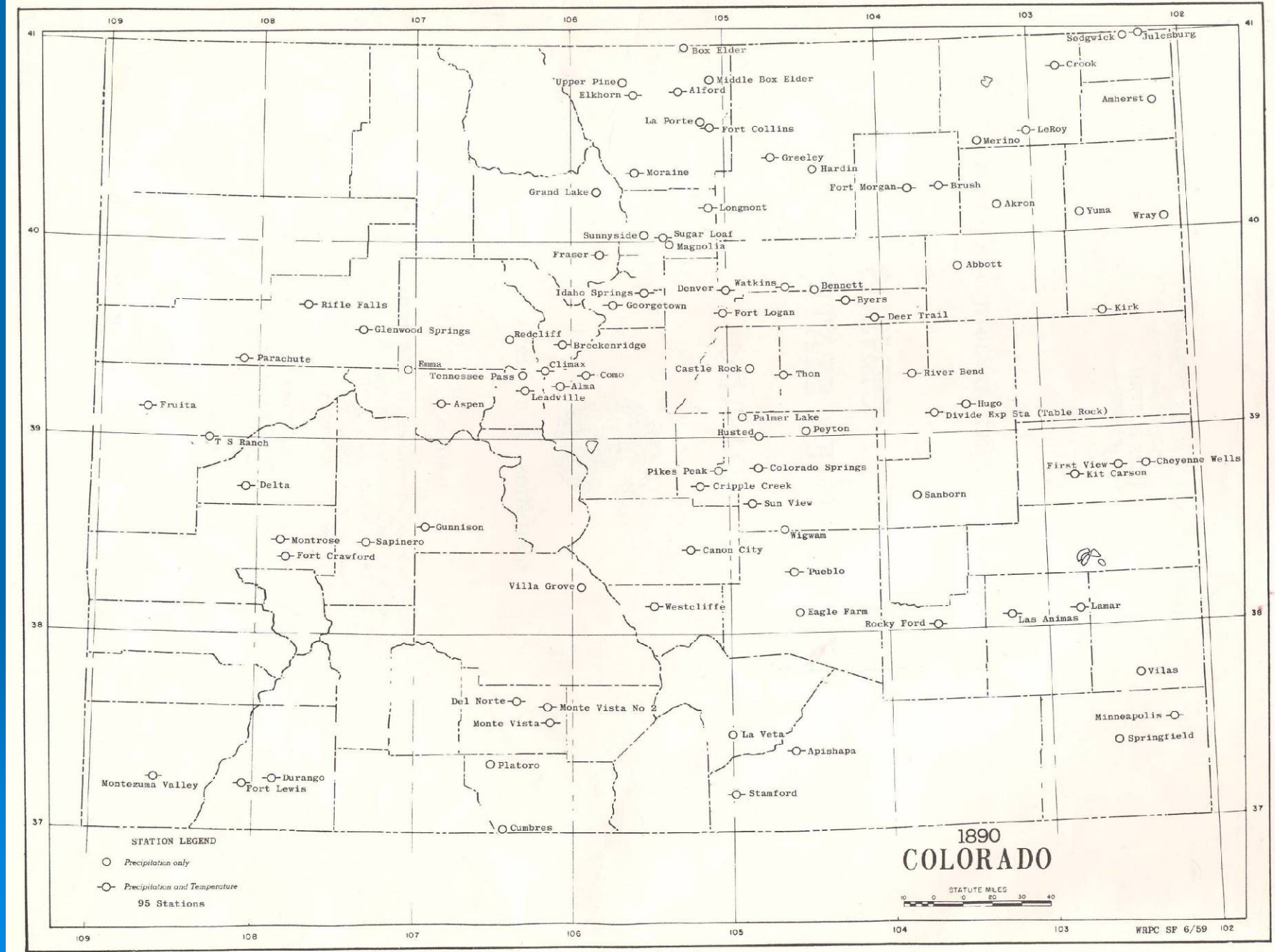
Henry Fenton, Observer

Denver November 19-25, 1871

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

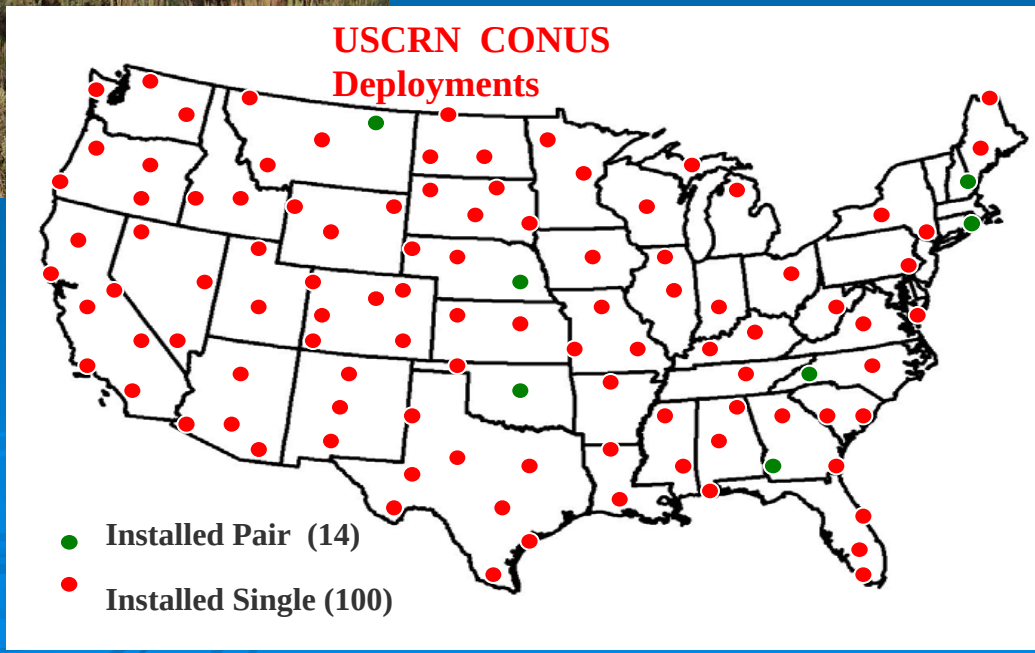
From Kelly Redmond, WRCC

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

- Add slide here about CRN
- “New observing network have been added recently to help track national climate trends”

U.S. Climate Reference Network (CRN)

- New observing networks have been added recently to help track national climate trends



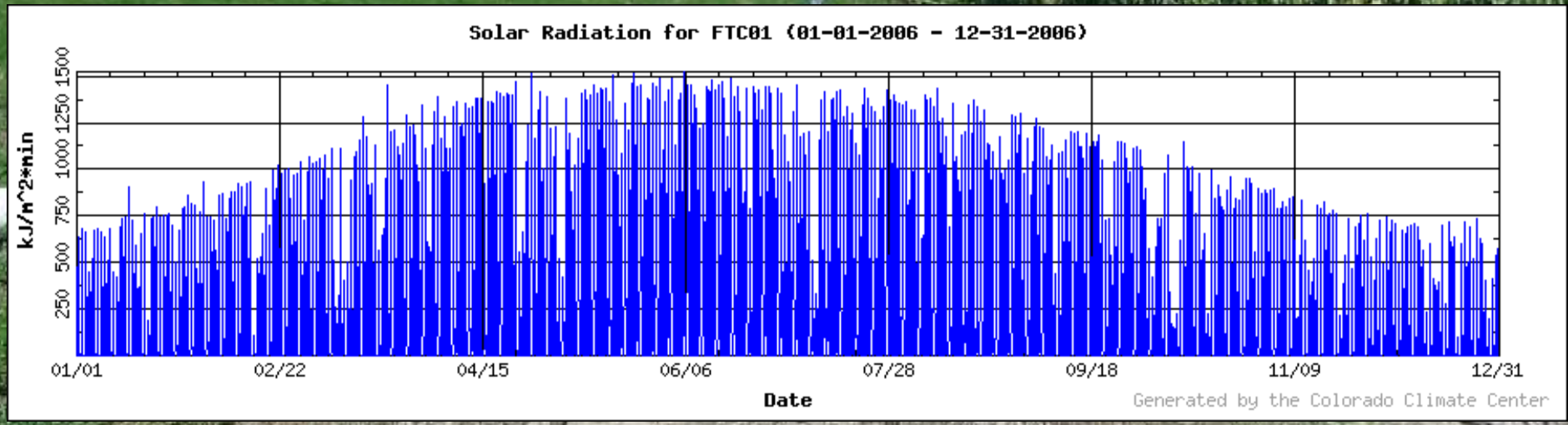

What have we learned from nearly 120 years of continuous climate monitoring?

What's so Amazing about Colorado?

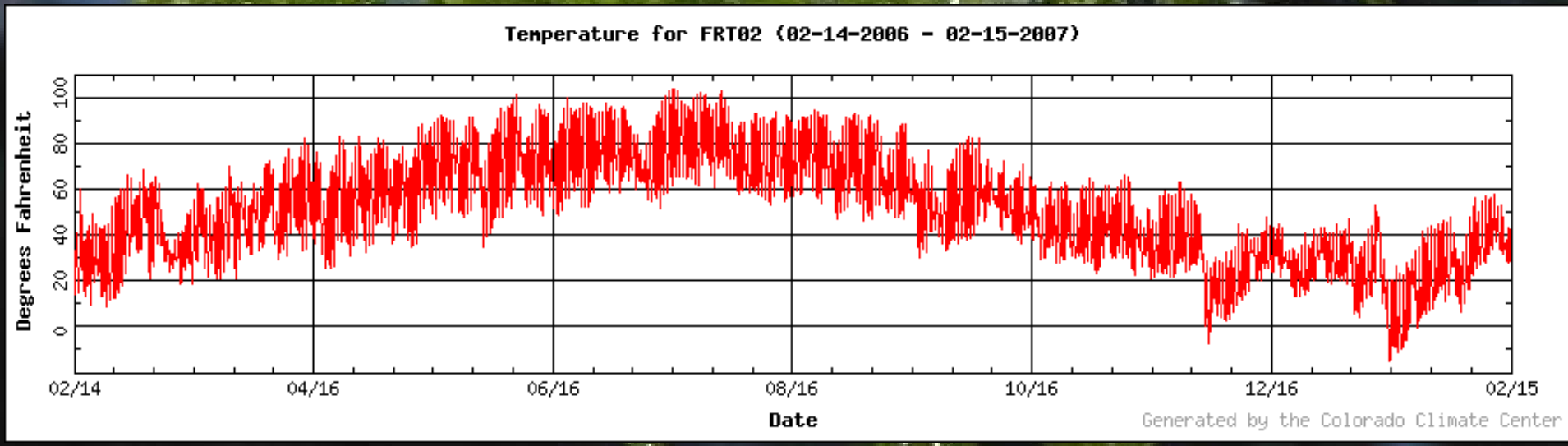
- High elevation (highest state in the Union – by far)
- Mid-Latitude location (lively seasonal changes)
- Interior Continental Location far from atmospheric moisture sources
- Complex Mountain topography

The Result?

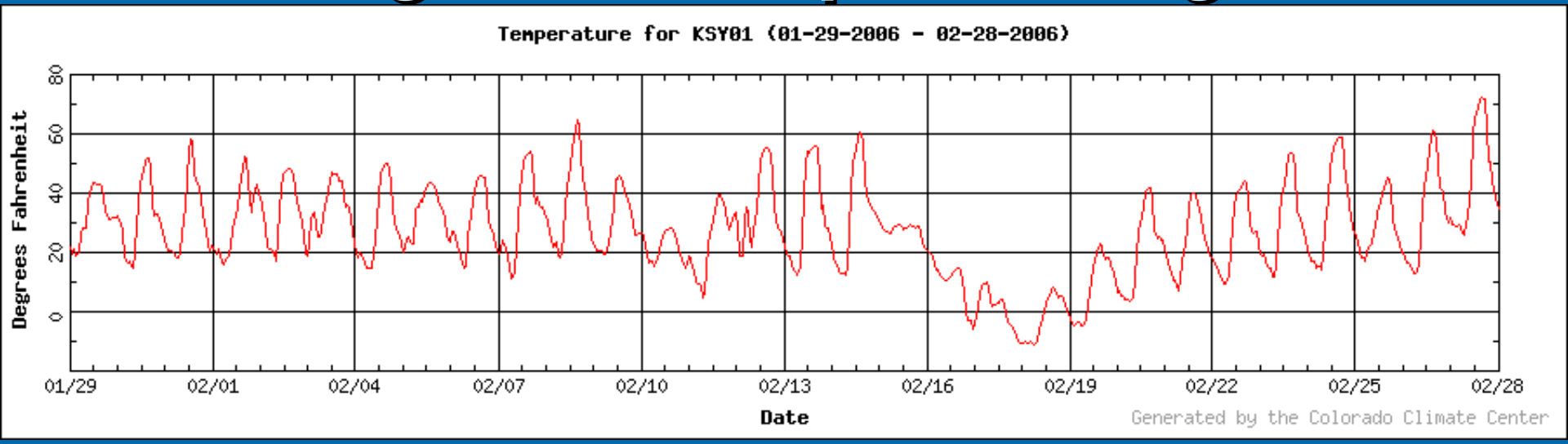
Generous sunshine and low humidity, i.e. people like it here

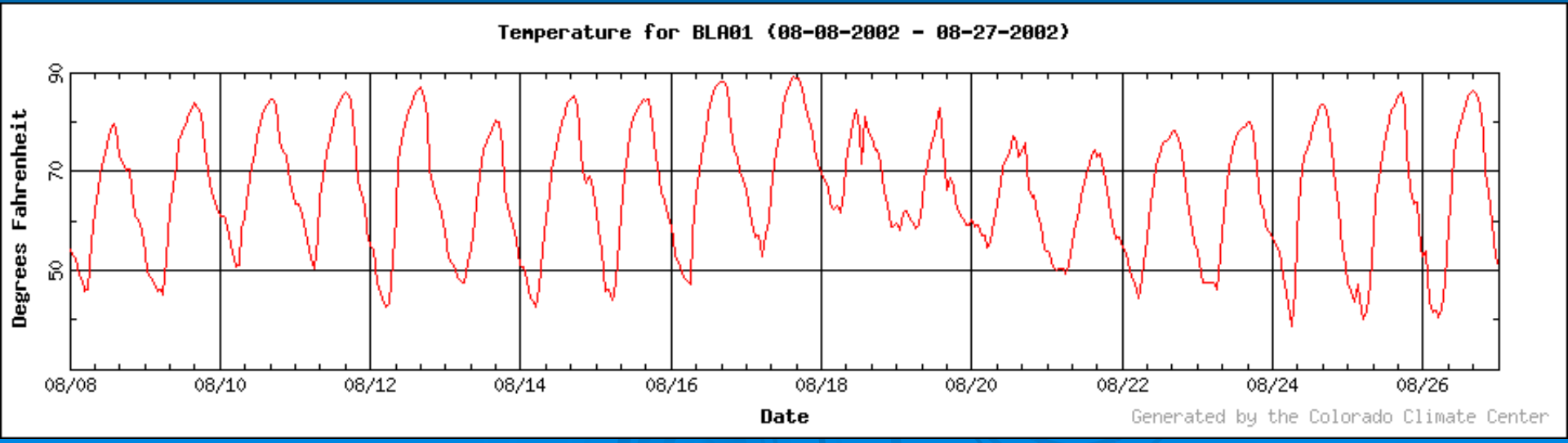


Large Seasonal Temperature Variations

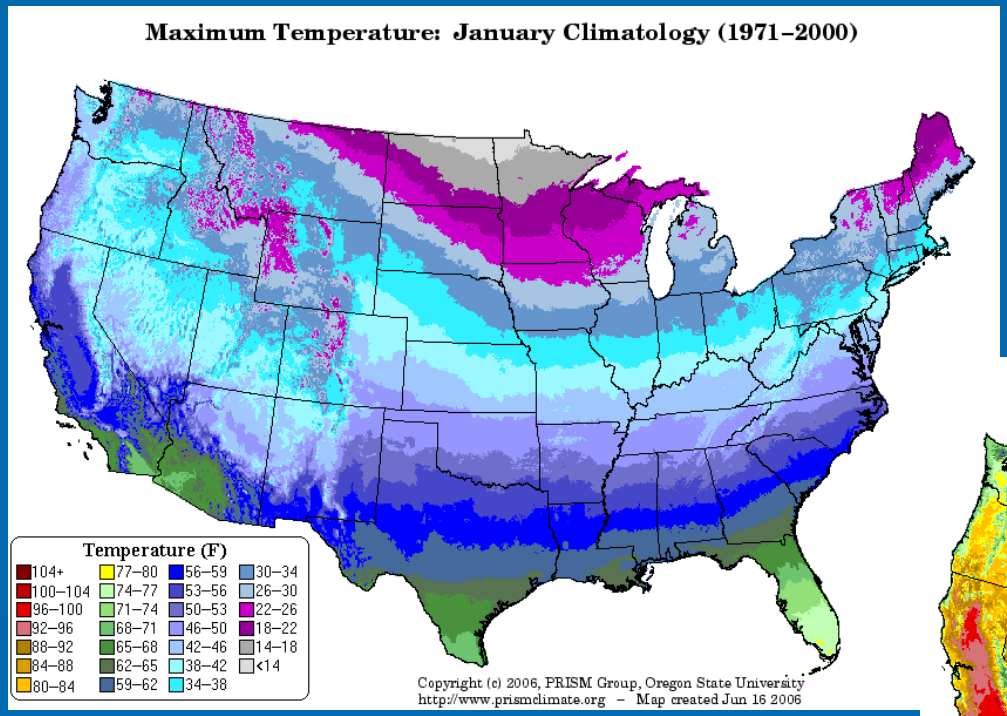


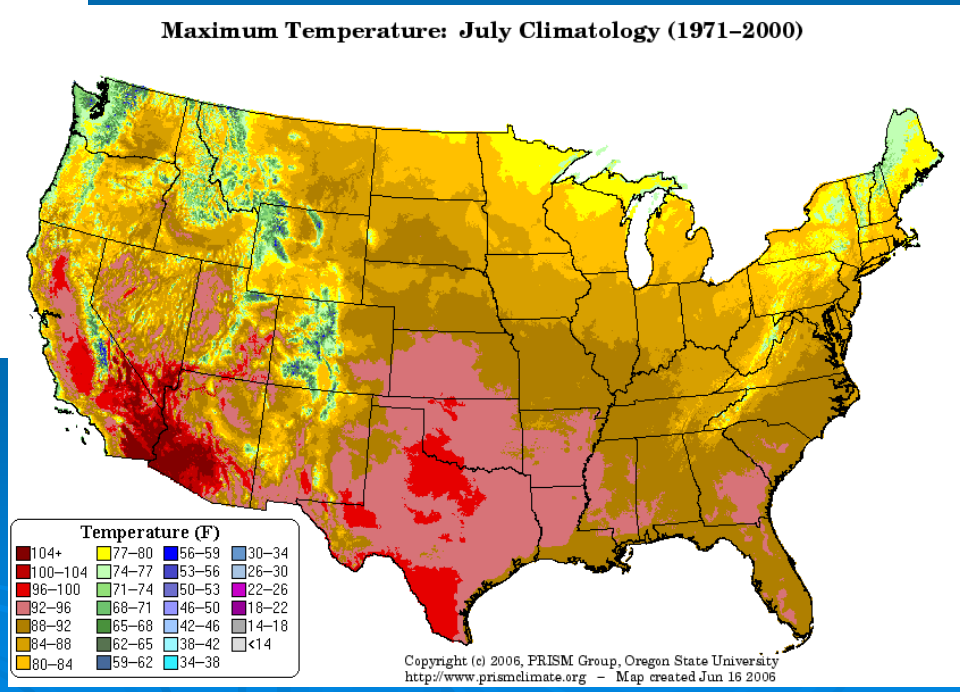
Large diurnal temperature ranges and rapid changes



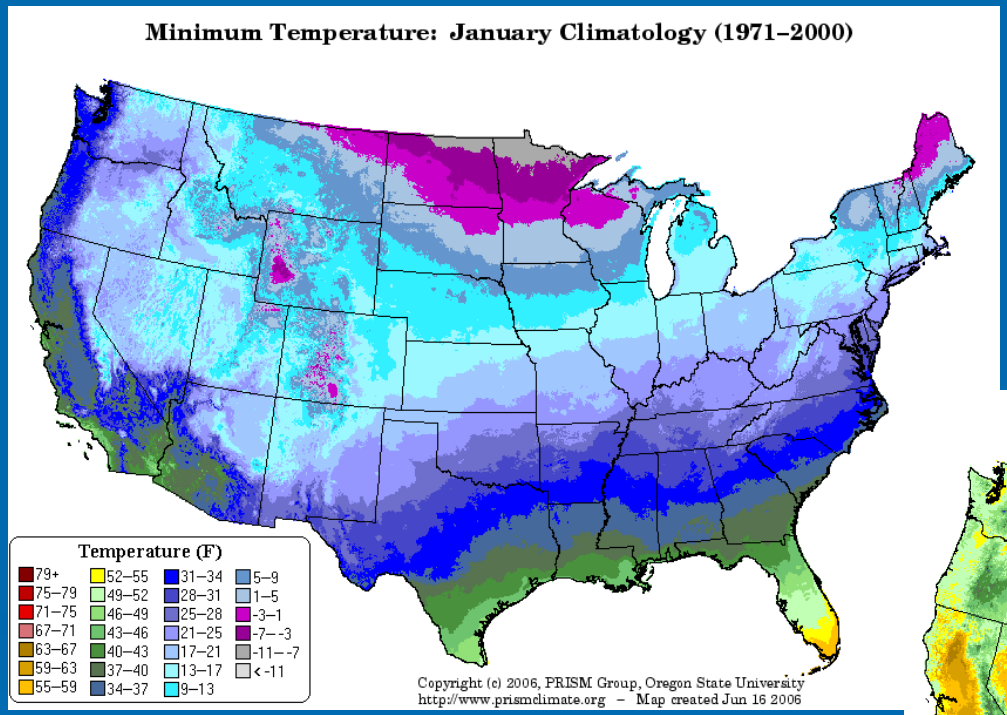


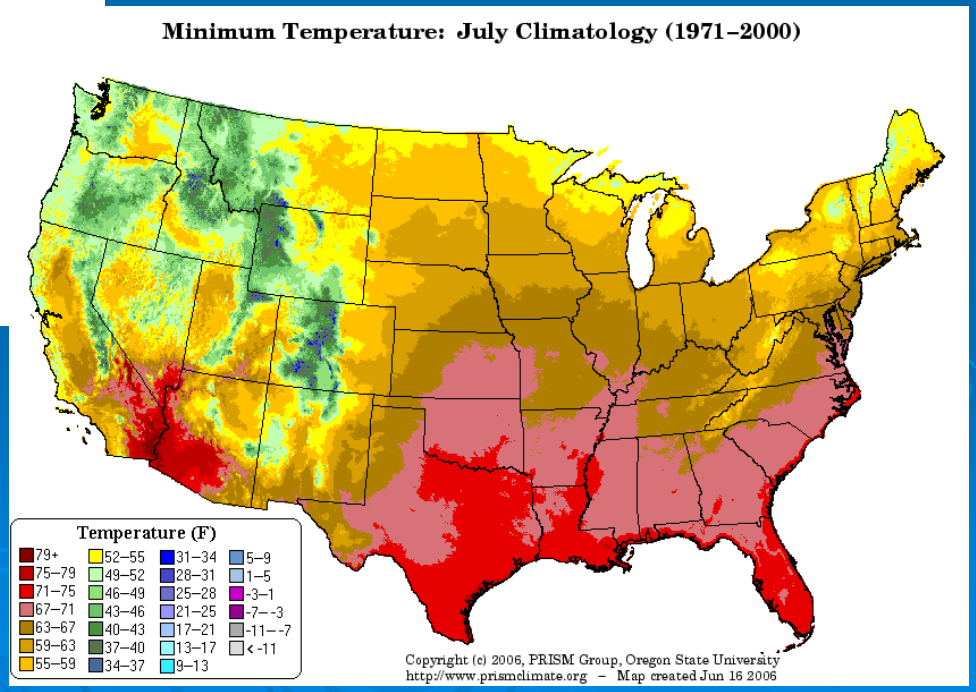
Average Maximum Temperature



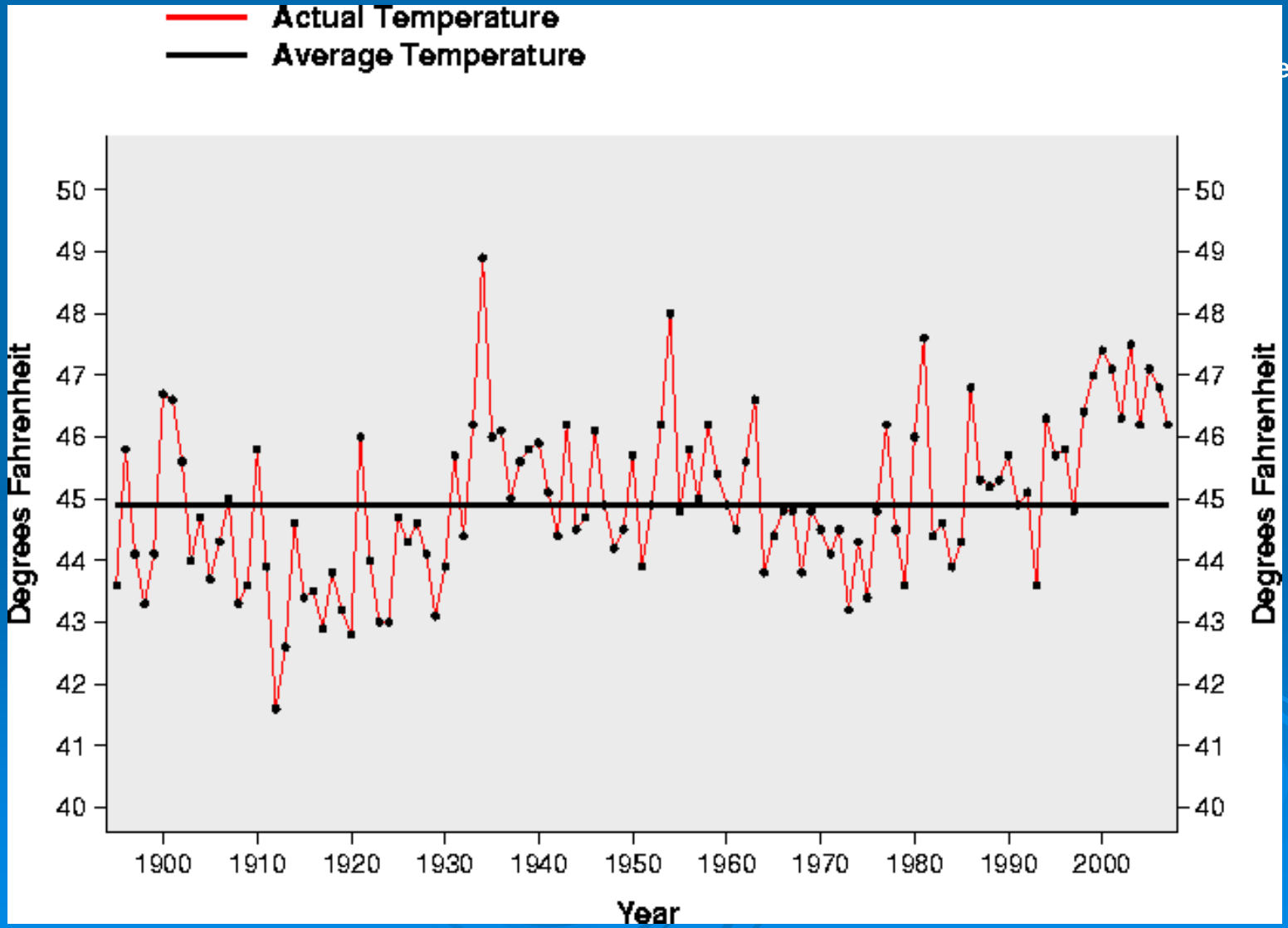


Average Minimum Temperature

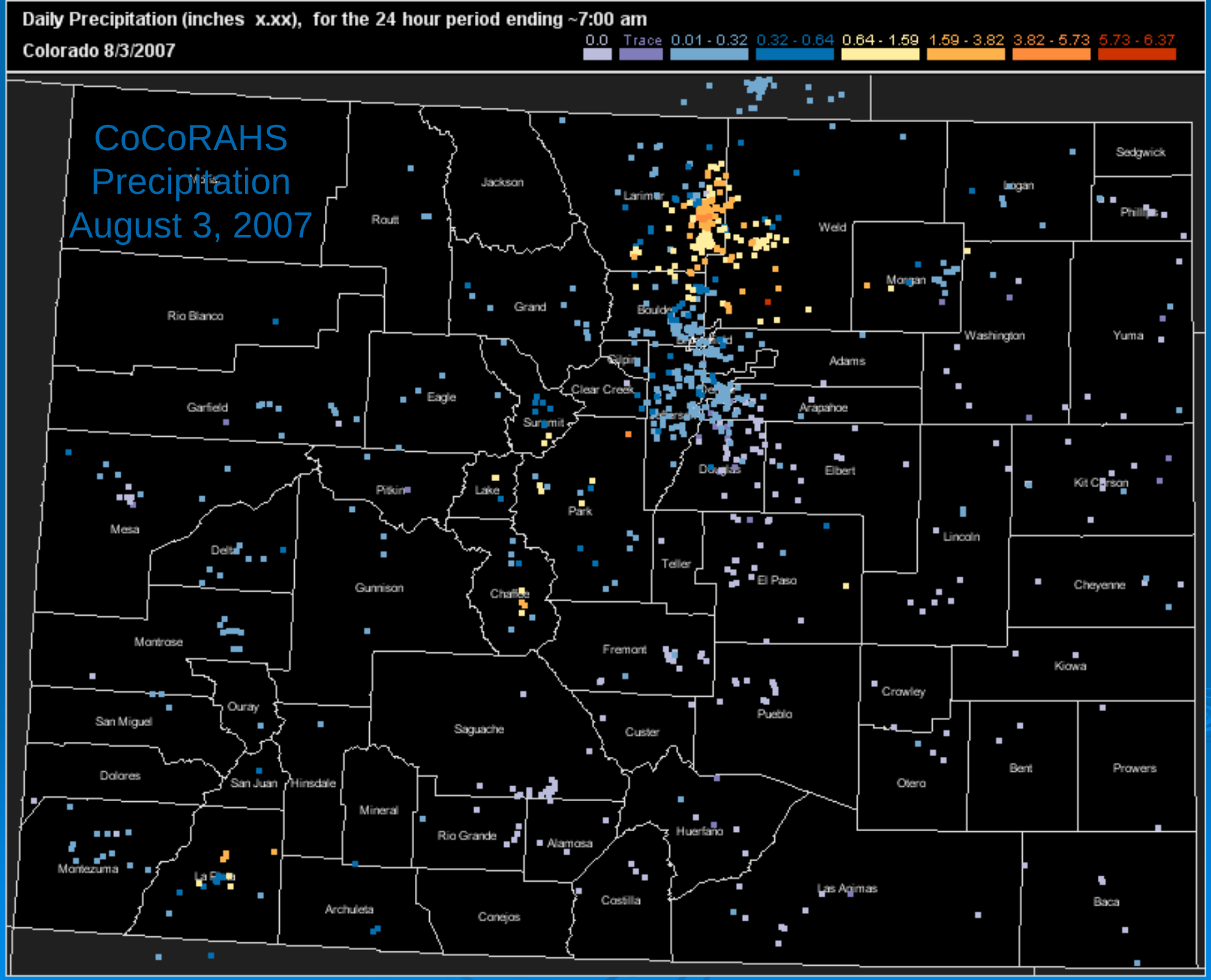




Statewide Mean Annual Temperature

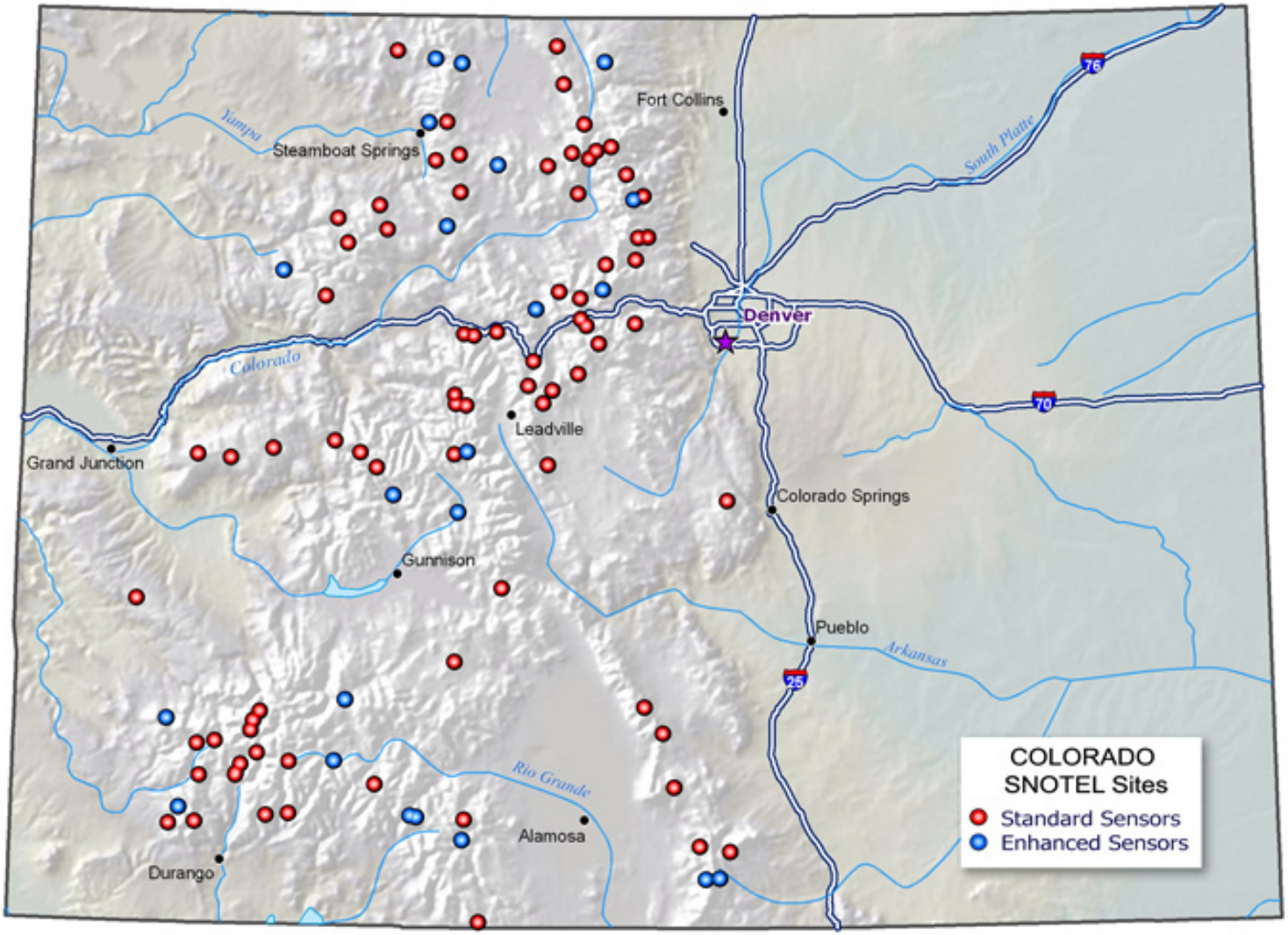



Frequent but highly variable precipitation
(for every “upslope,” there’s a “downslope”)
Photo by Wendy Ryan


Daily Precipitation (inches x.xx), for the 24 hour period ending ~7:00 am
Colorado 8/3/2007
0.0
Trace
0.01 - 0.32
0.32 - 0.64
0.64 - 1.59
1.59 - 3.82
3.82 - 5.73
5.73 - 6.37
CoCoRAHS
Precipitation
August 3, 2007
Jackson
Routt
Larimer
Weld
Logan
Sedgwick
Phillips
Rio Blanco
Grand
Boulder
Morgan
Washington
Yuma
Garfield
Eagle
Clear Creek
Summit
Adams
Arapahoe
Douglas
Elbert
Kit Carson
Pitkin
Lake
Park
Mesa
Delta
Gunnison
Chaffee
Teller
El Paso
Lincoln
Cheyenne
Montrose
Fremont
Kiowa
Ouray
San Miguel
Saguache
Custer
Pueblo
Crowley
Otero
Bent
Prowers
Dolores
San Juan
Hinsdale
Mineral
Rio Grande
Alamosa
Huerfano
Las Animas
Baca
Montezuma
La Plata
Archuleta
Conejos
Costilla

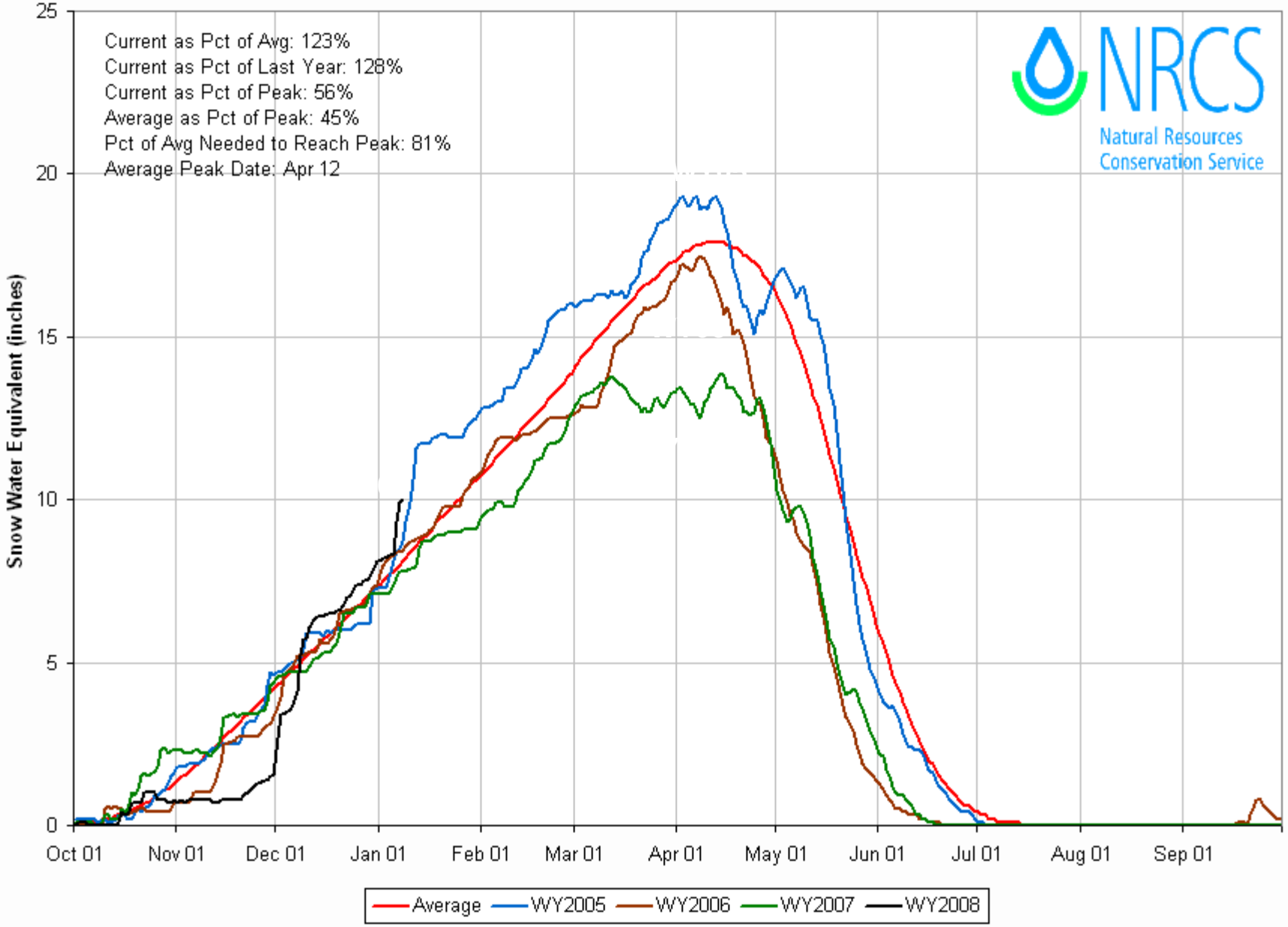
Lots of Snow, sometimes and some places

NRCS Colorado Snotel Sites

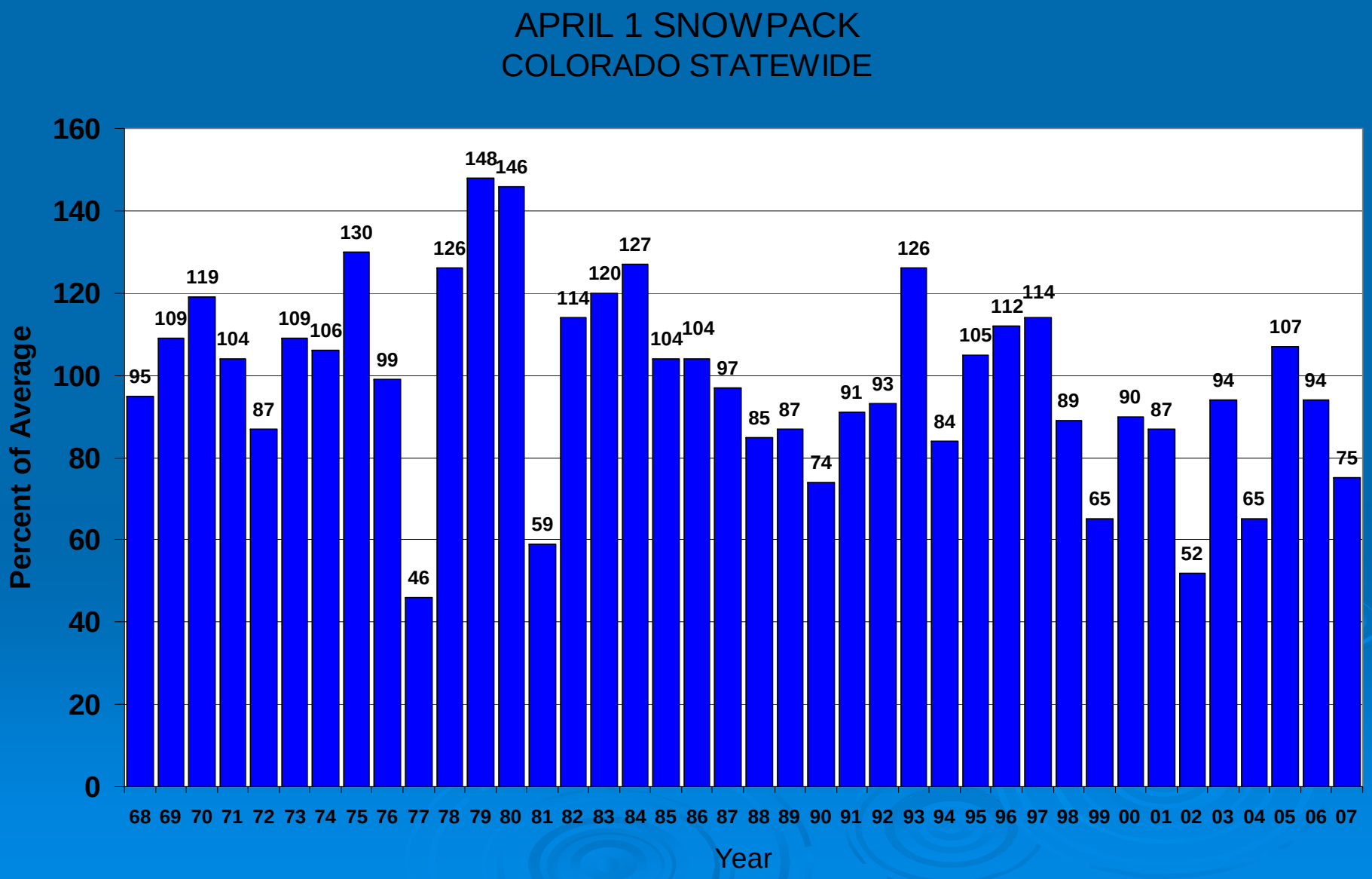


Colorado Statewide Time Series Snowpack Summary

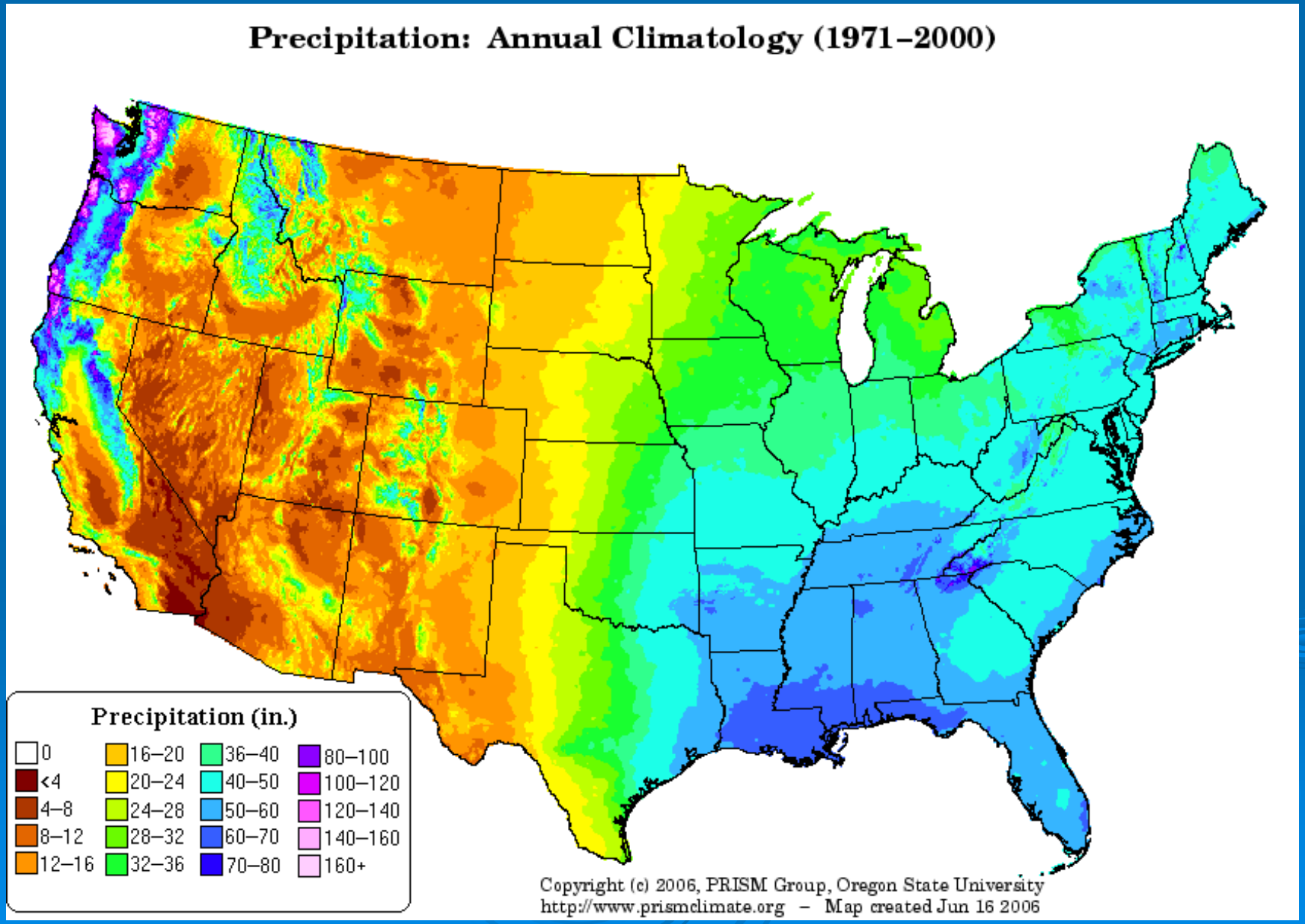
Based on Provisional SNOTEL data as of Jan 08, 2008



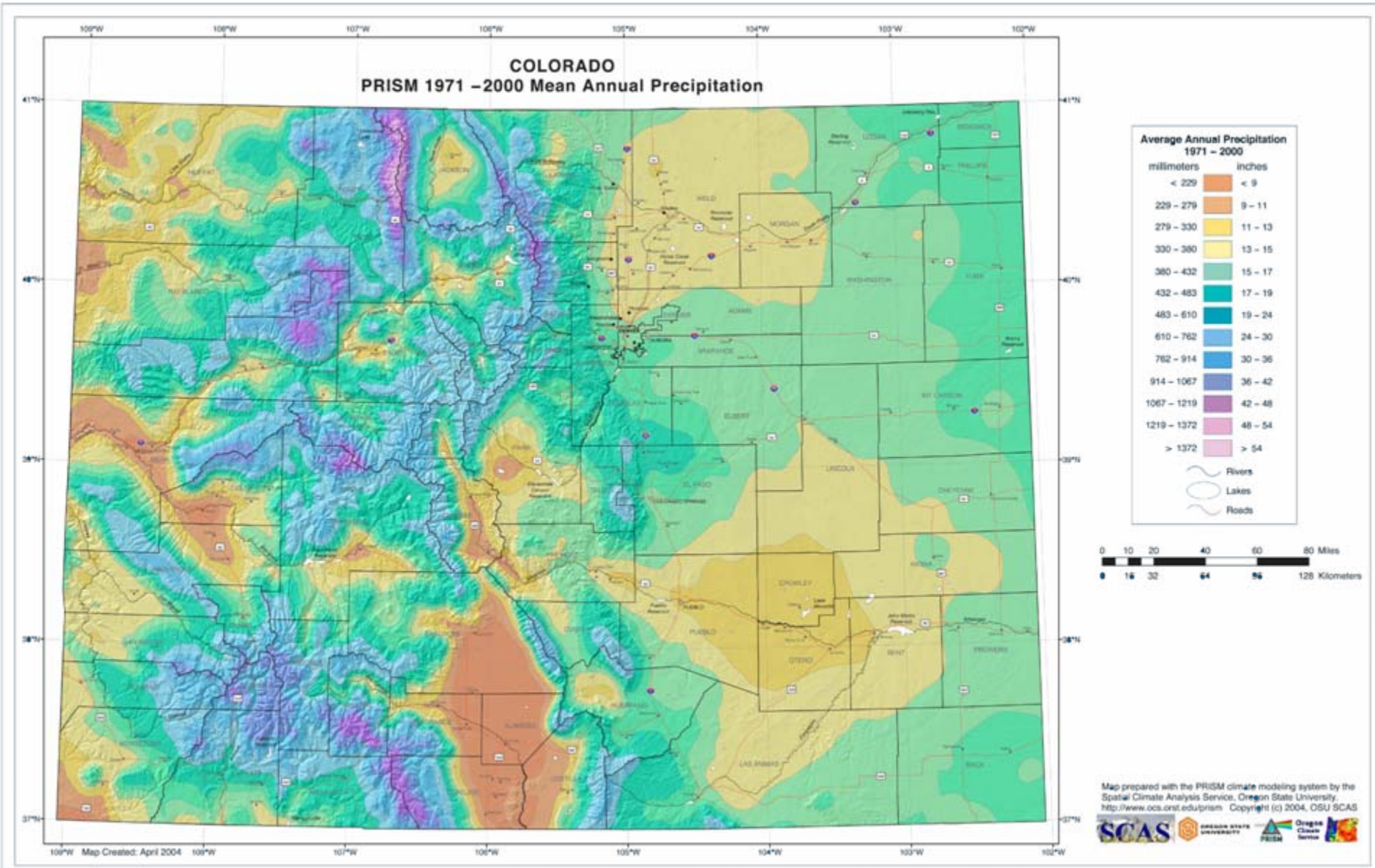
April 1 Snowpack



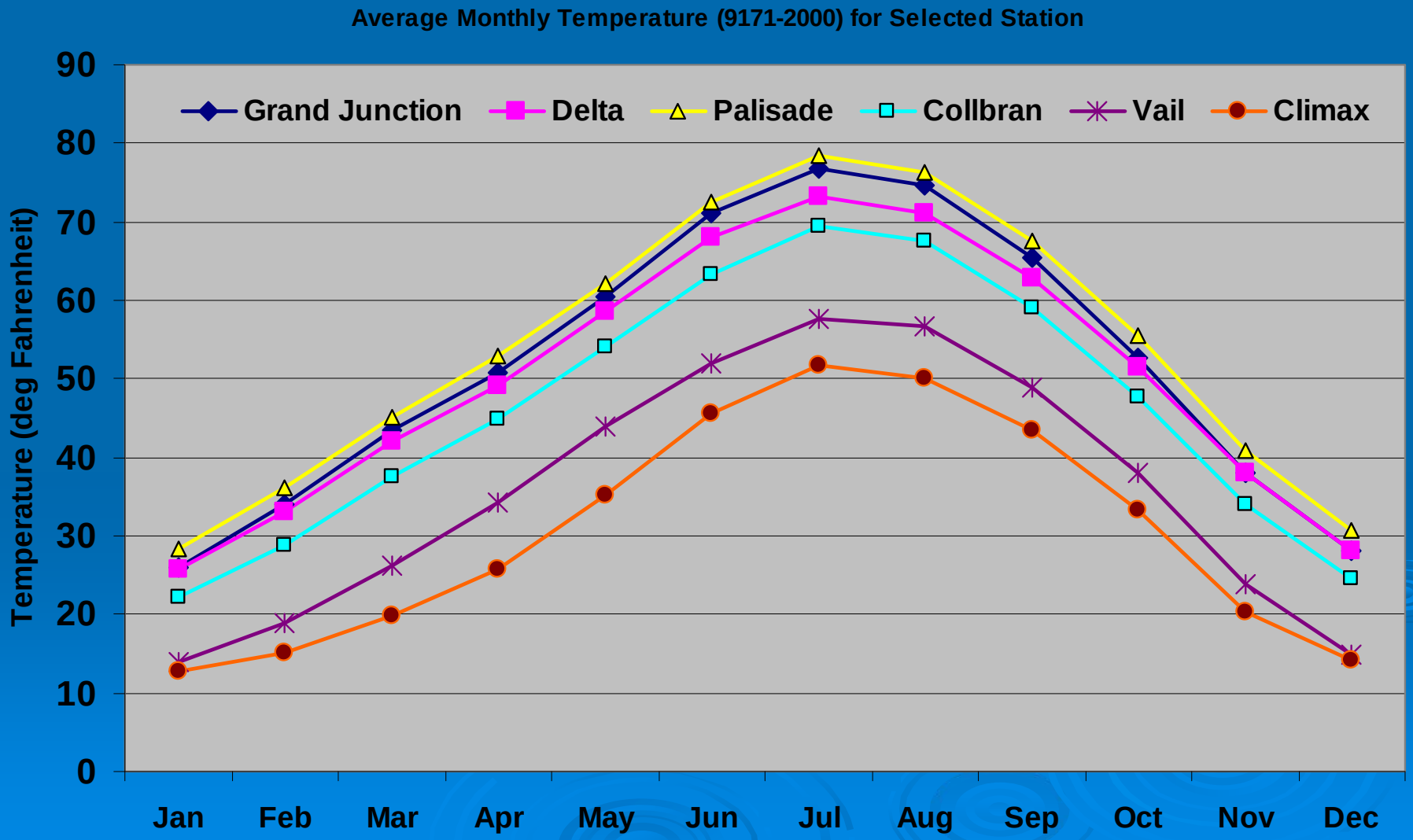
Where we fit in the national picture



Colorado Average Annual Precipitation



Winters are consistently colder than summers – ☺



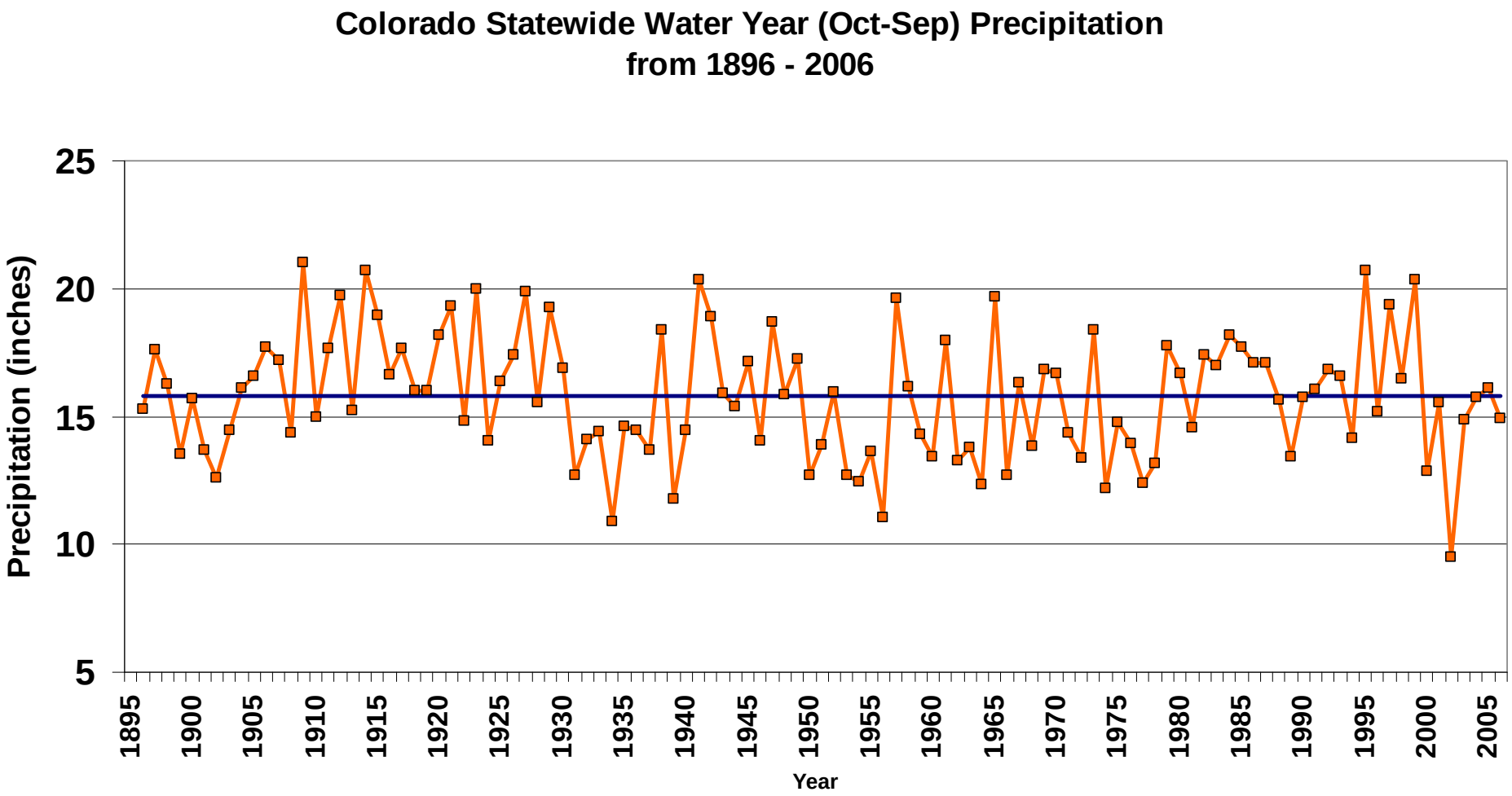
- *precipitation varies seasonally, and seasonal pattern vary greatly from one part of Colorado to another -- not sure I have the best order yet for these slides

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




- Insert an example station – FCL or Rocky Ford – and update the statewide graph

Colorado Statewide Water Year Precipitation



Drought Visits Our Area Regularly

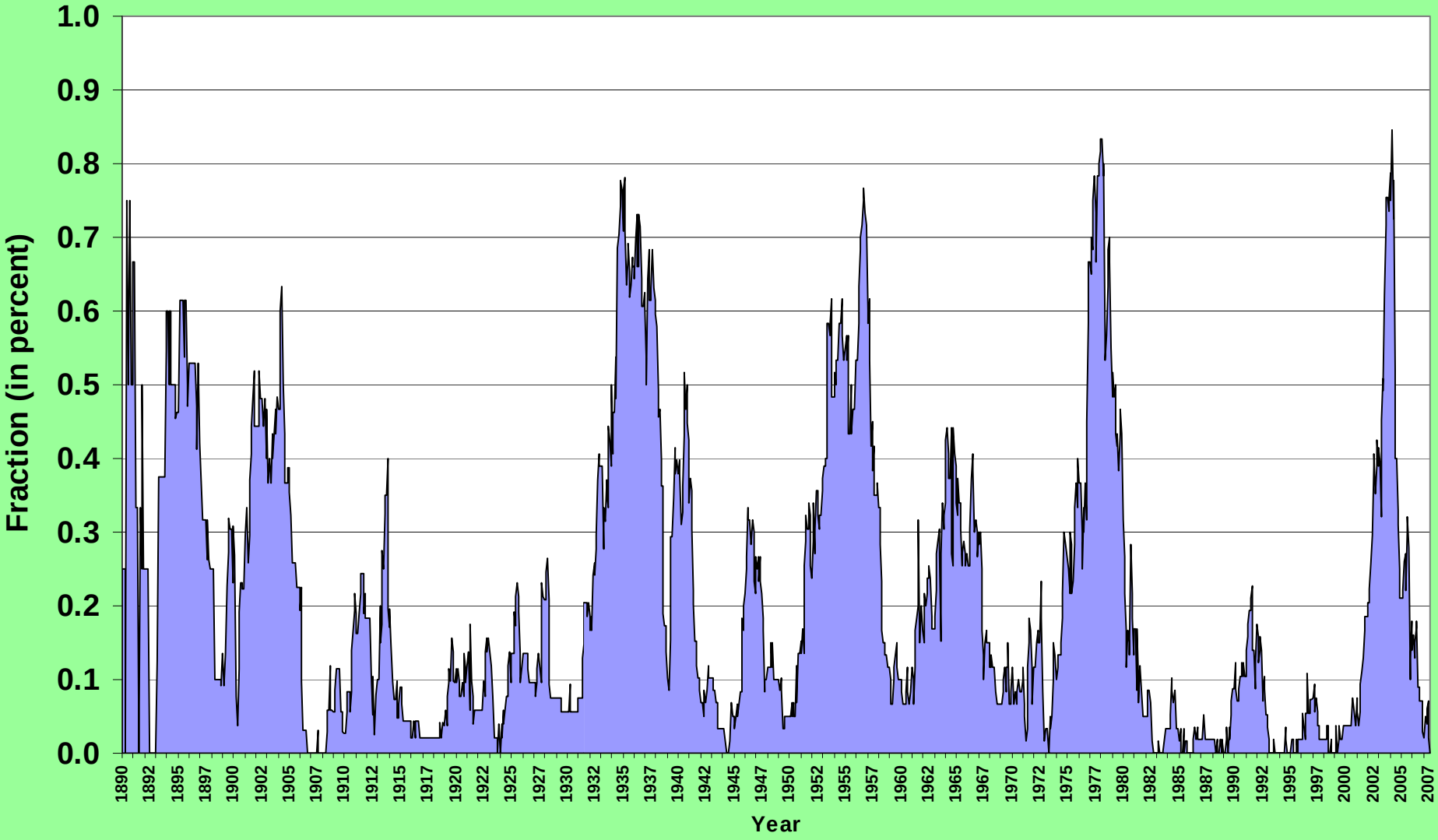
Photo by NRCS

- Insert 3-month SPI time series and update this 48 month one

Fraction of Colorado in Drought

Based on 48 month SPI

(1890 - July 2007)



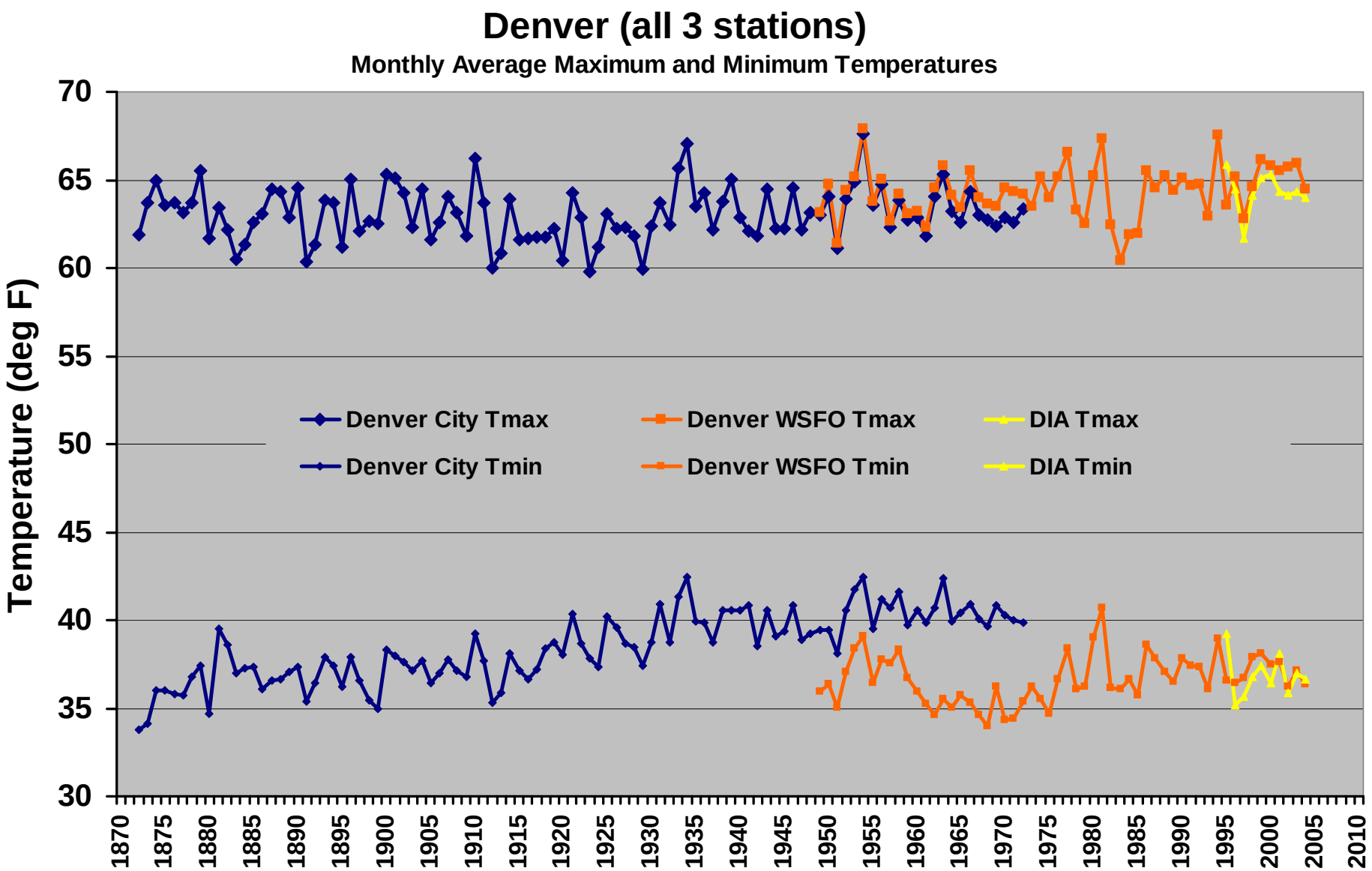
Confidently detecting climatic trends is much more challenging and difficult than determining spatial patterns, seasonal cycles, or year-to-year variations

We can find many frustrating limitations to our climate records:

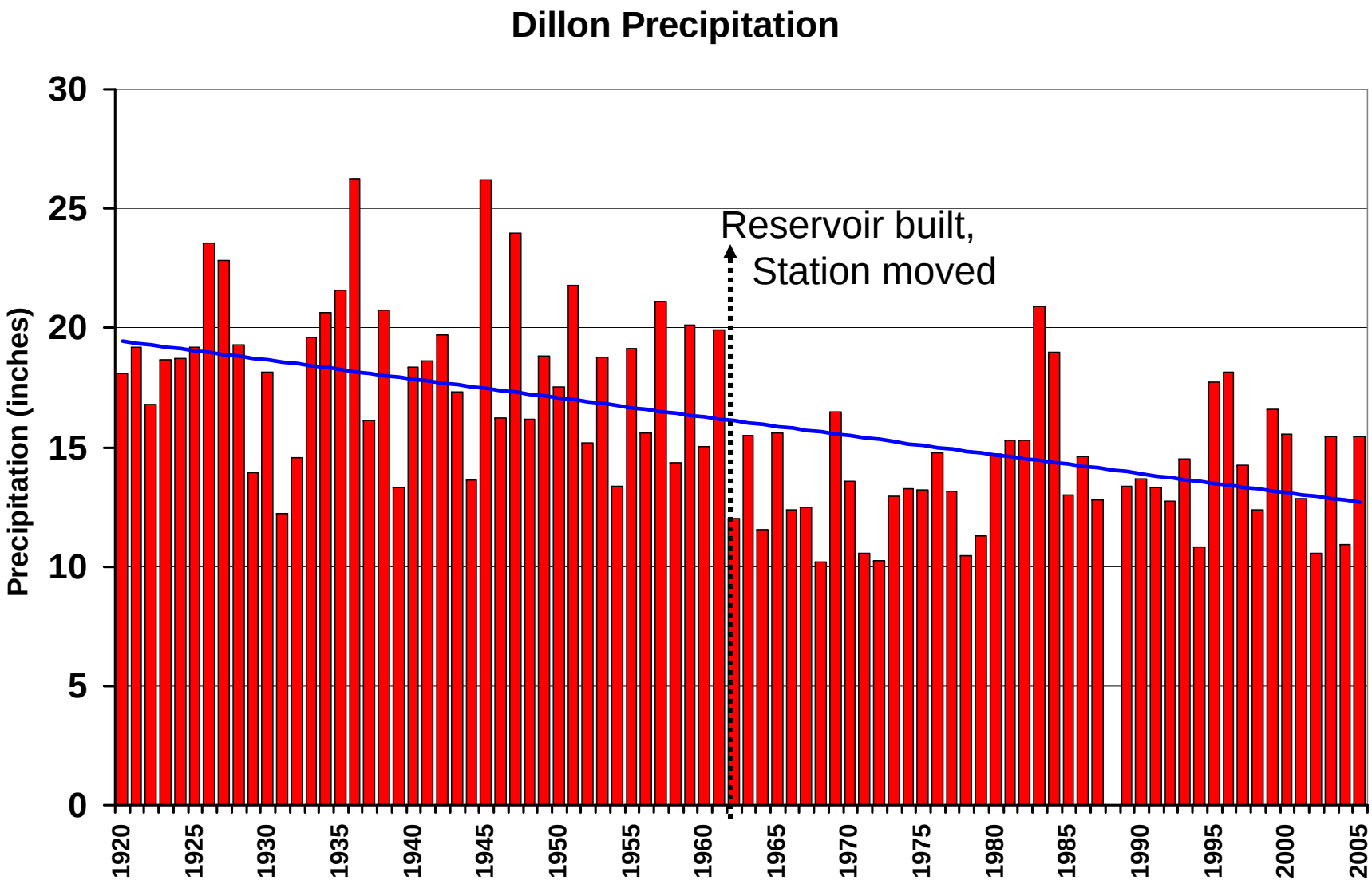
- Changing instrumentation
- Changing environments around our weather stations
- Changing weather station locations and observation times
- Automation, etc.

- Wendy – would be nice if these next three slides could be updated – but don’t waste a lot of time doing it I.E. for Denver

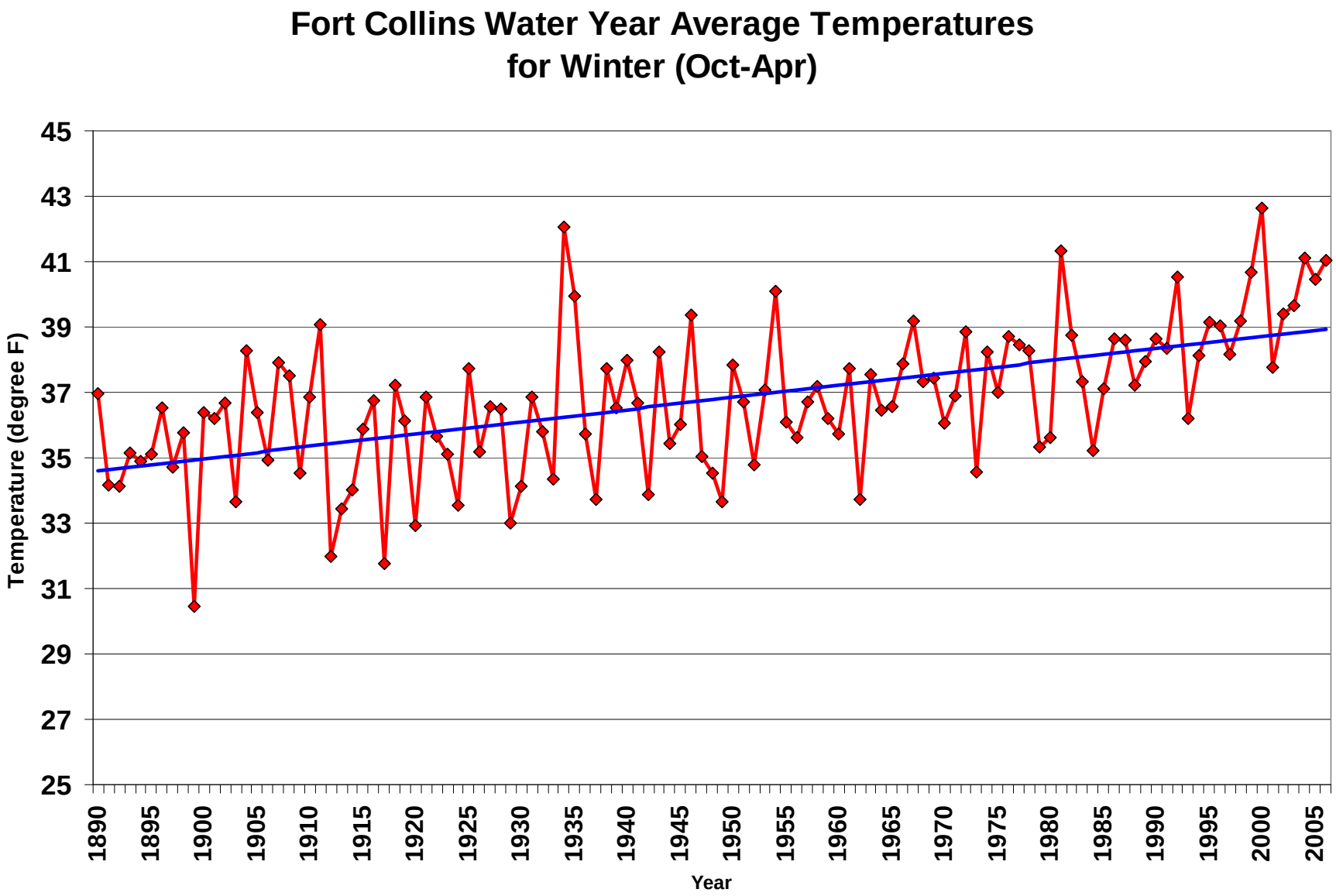
Denver All Stations



Dillon Annual Precipitation

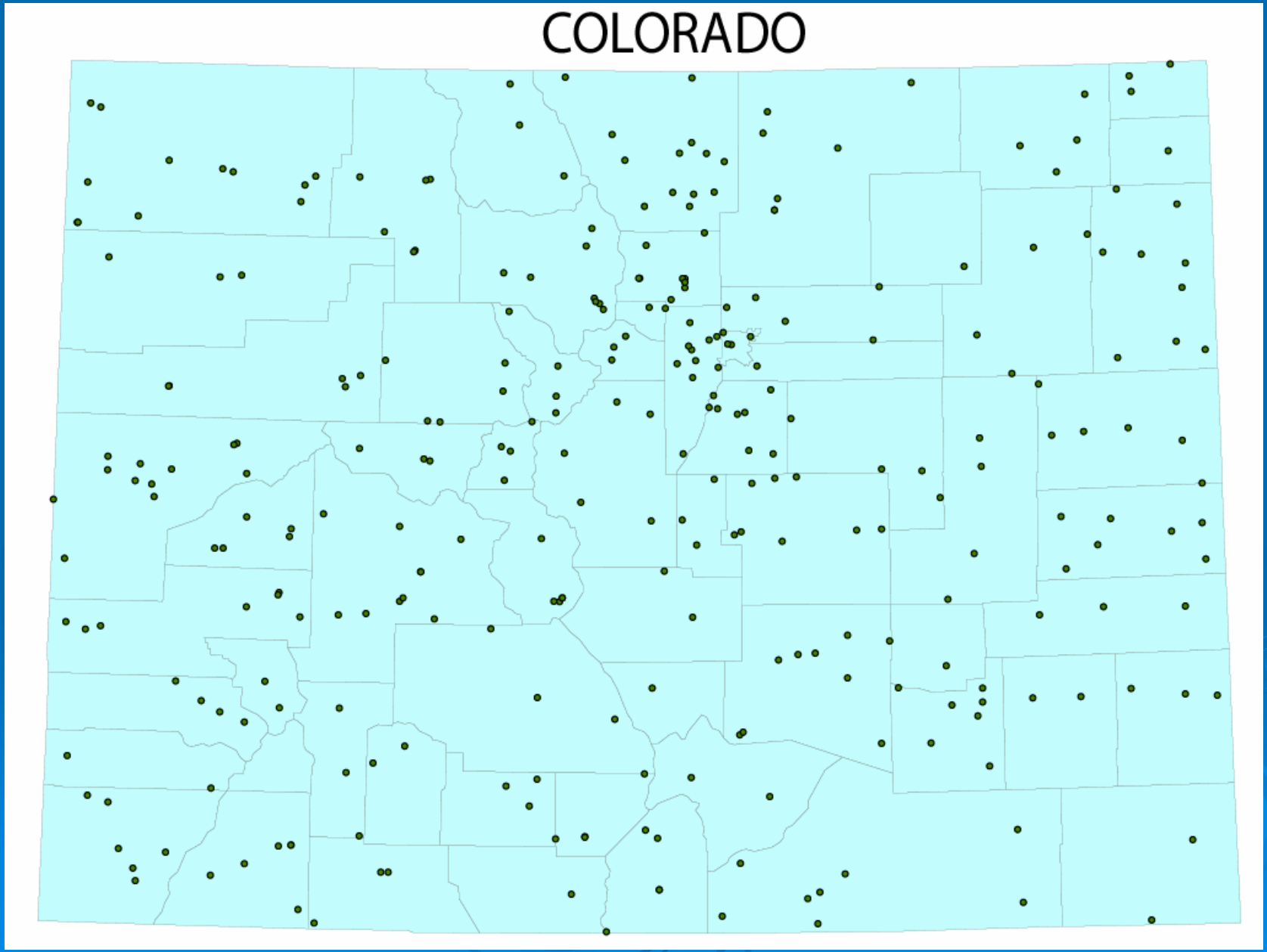


Fort Collins Winter Temperatures

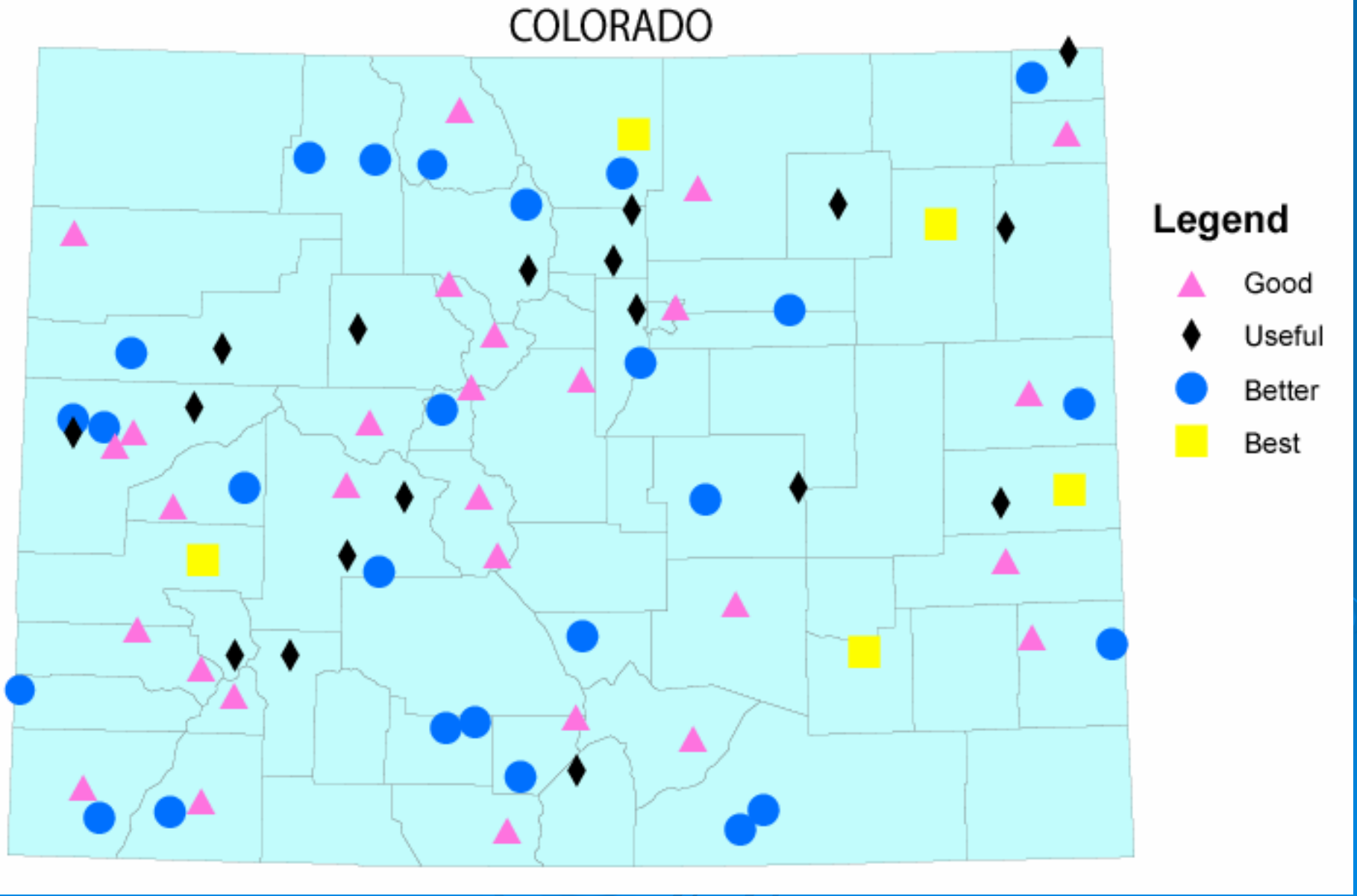


Still, our climate records are more complete, consistent, and widespread than nearly all other forms of long-term environmental monitoring (i.e. we shouldn’t whine).

Colorado Cooperative Stations



Long-Term Analysis Stations



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

Precipitation continues to vary greatly but with no discernable long-term trend

- Wendy, put in a slide here that features the new Climate Trends website and then shows some good selected examples

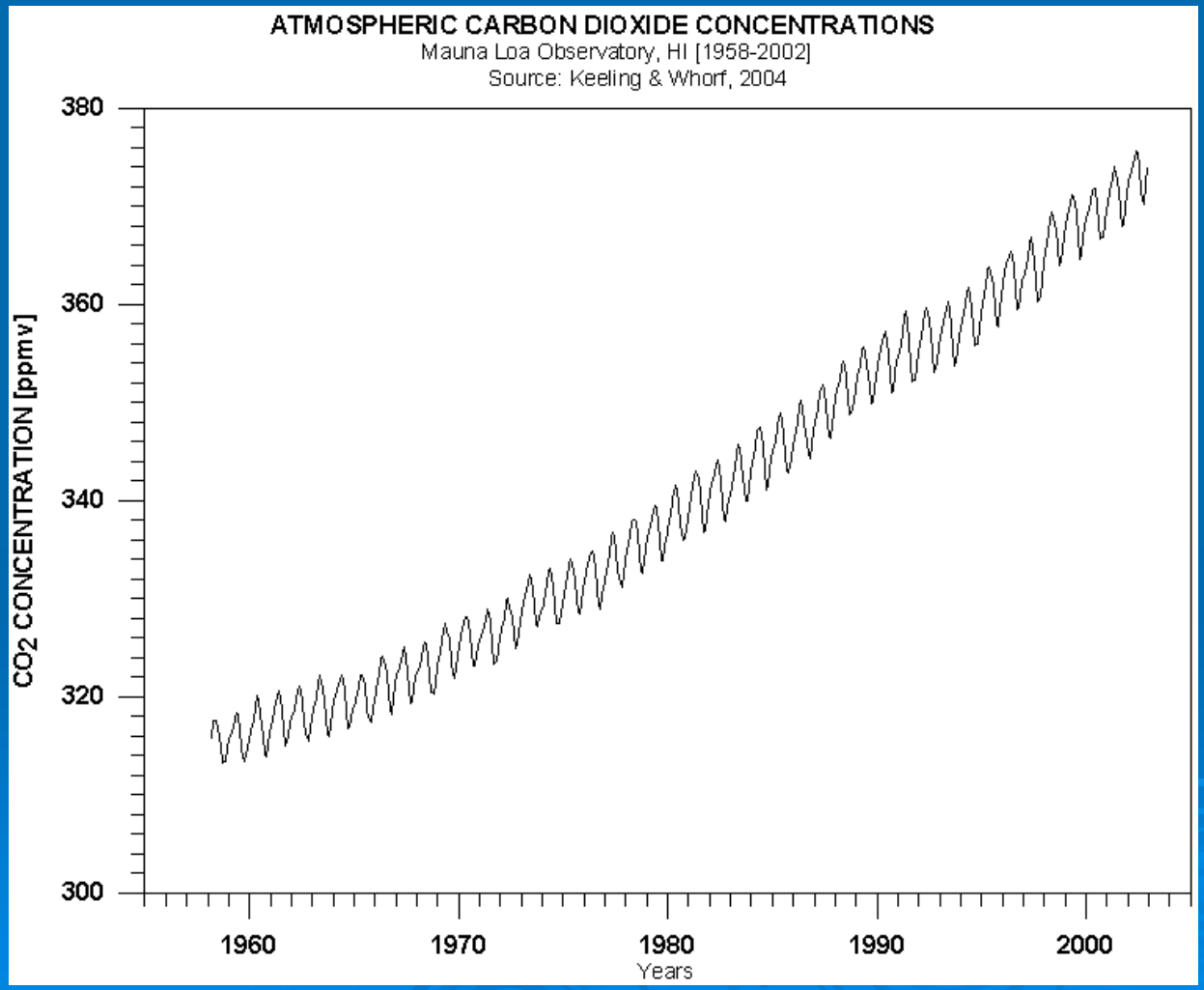
With even the best stations, there is uncertainty

Should Planners be concerned about Climate Change?

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

- Wendy ,can you update the following CO2 slide

Increases in greenhouse gases are real and large



- I will paste in a set of slides here from yesterday's workshop that show projected temperatures based on 3 CO2 emissions scenarios.

Summary for Policymakers

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

http://www.ipcc.ch

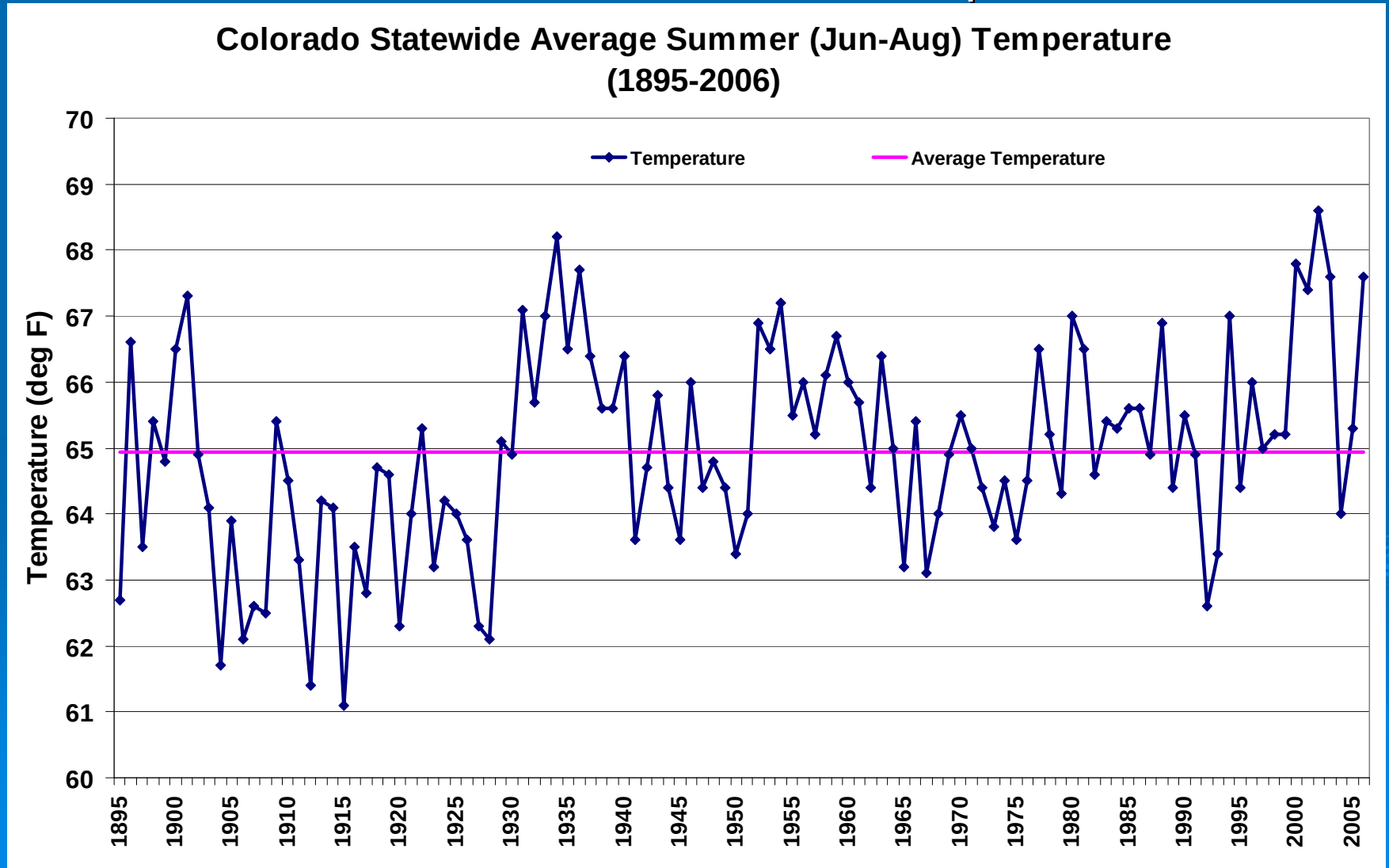
Click on:

“Summary for Policymakers”

- And update these next ones, too

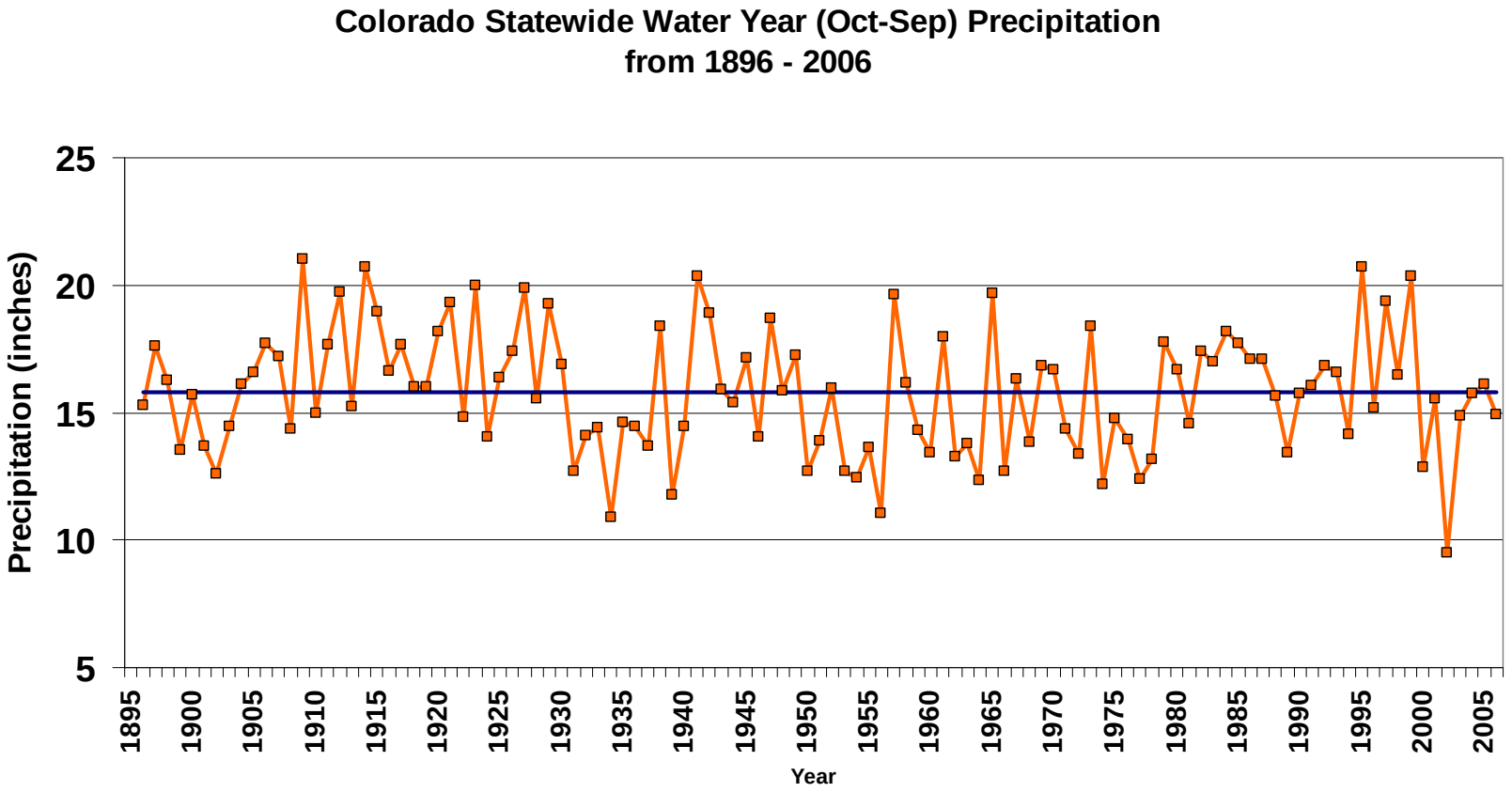
When significant temperature trends begin, we will be able to detect them

Colorado Statewide Summer Temperatures



Detecting changes in precipitation will be much more difficult

Colorado Statewide Water Year Precipitation

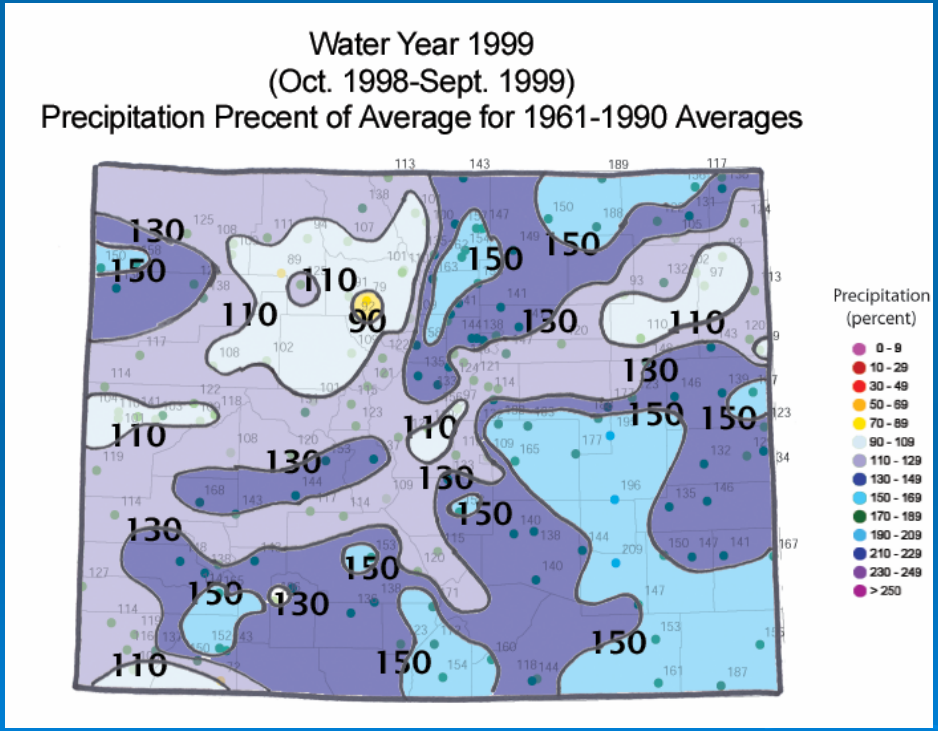


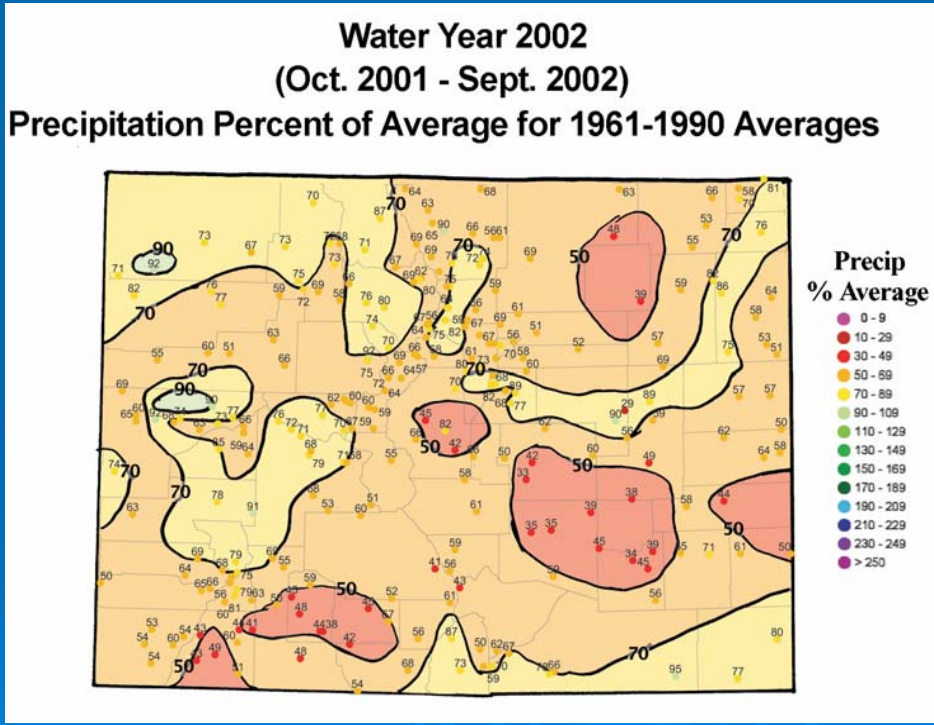
- Insert a couple of your NRCS SNOTEL,Snowcourse time series updated to recent and put a caption

- “Time series of April 1 Snow Water equivalent -- this is affected by both temperature and precipitaton”

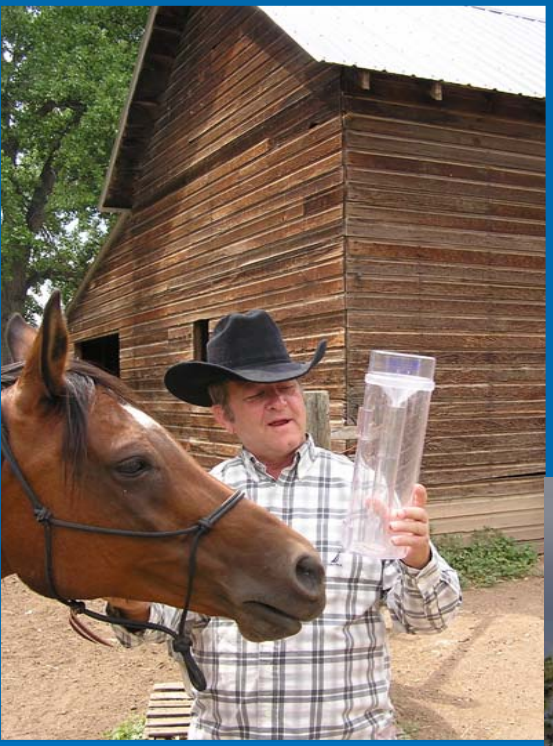
What should we do??

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





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



Photos by H. Reges

For information and to volunteer, visit the CoCoRaHS Web Site

http://www.cocorahs.org

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

Colorado Climate Center

Data and Power Point Presentations available for downloading

http://ccc.atmos.colostate.edu

Colorado State University
Knowledge to Go Places

Colorado Climate Center