Climate and Water: from the perspective of the Colorado State Climatologist

August 31, 2010

Nolan Doesken
CSU Department of Atmospheric Science

Some topics we'll cover

- What does a State Climatologist do?
- Climate vs. Weather
- Some highlights of our Colorado climate
- The Water Year and why we use it
- Seasonality and variability
- Detecting Climate trends – not so easy
  - Temperature varies some, precipitation varies a lot
- CoCoRaHS – A hobby out of control ☺

First, Some Definitions…

- **Meteorology -** a science that deals with the atmosphere and its phenomena and especially with weather and weather forecasting
- **Weather -** the state of the atmosphere with respect to heat or cold, wetness or dryness, calm or storm, clearness or cloudiness
- **Climate -** the statistical collection of weather conditions at a place over a period of years

Weather vs. Climate

- **Weather**
  - Condition of the atmosphere at any particular time and place, day-to-day state of the atmosphere
- **Climate**
  - Accumulation of daily and seasonal weather events over a long period of time (weeks, months, years and longer)
  - Includes weather and weather extremes (heat waves, cold spells)
  - Long-term averages of weather variables (e.g., temperature, precipitation amount and type, air pressure, humidity, cloudiness, sunshine, wind speed and direction), departures of weather variables from *normals* (more about normals later!)

Weather vs. Climate

- Type of clothing we wear today
- Windows open or closed today? This week?
- If a crop will reach maturity: hail can destroy a crop in a day!
- Warm and rainy for a day: rain*coat*

What *weather* determines

- Type of clothing we buy and keep
- Housing: straw hut vs. brick house
- Crop selection (timing and species): Mangoes are not a good crop in Oklahoma
- Warm and wet for MANY years: rain*forest*

What *climate* determines

In other words -- Climate is what you expect, but the weather is what you get.

So . . . . . What does a State Climatologist do?

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

Colorado State University
Knowledge to Go Places

COLORADO CLIMATE CENTER

We are - - -

- Data gathers
- Historians and archivists
- Climate monitors and analysts
- Research scientists
- Interdisciplinary collaborators
- Teachers and advisors
- Climate interpreters
- Writers and public speakers

The Colorado Climate Center was established by the state in 1973, 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.

Let’s Talk a bit about what I know the most about –

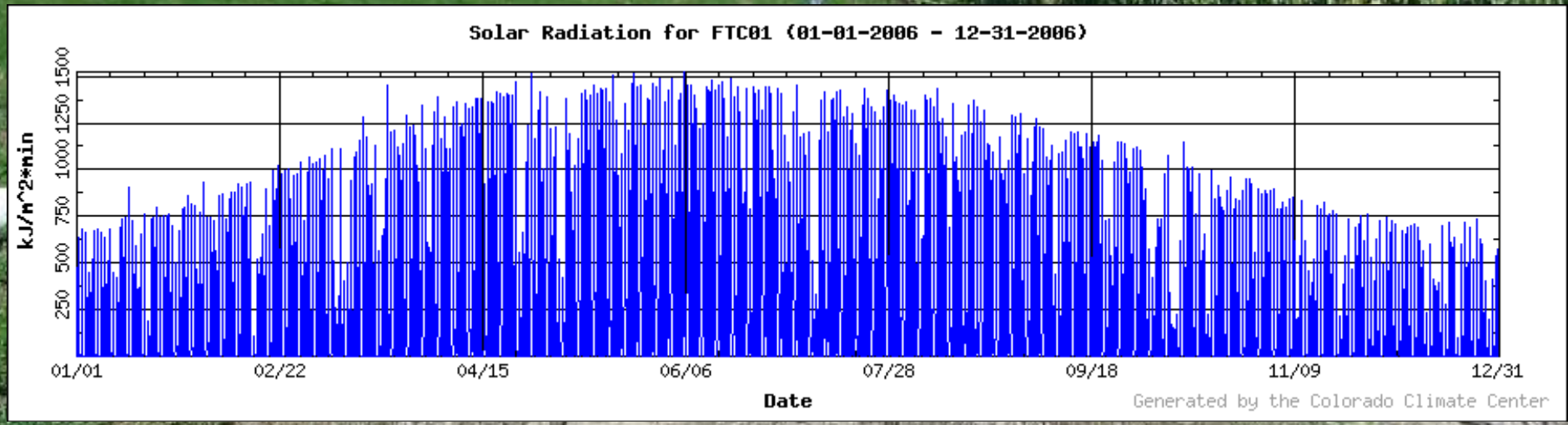
Colorado’s Climate

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

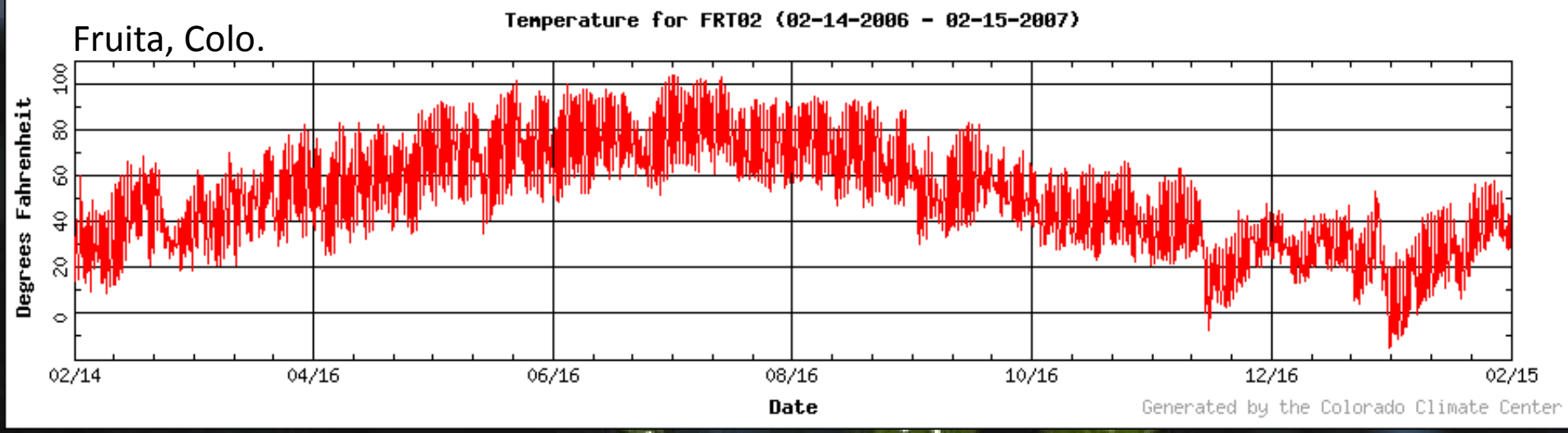
The Result?

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



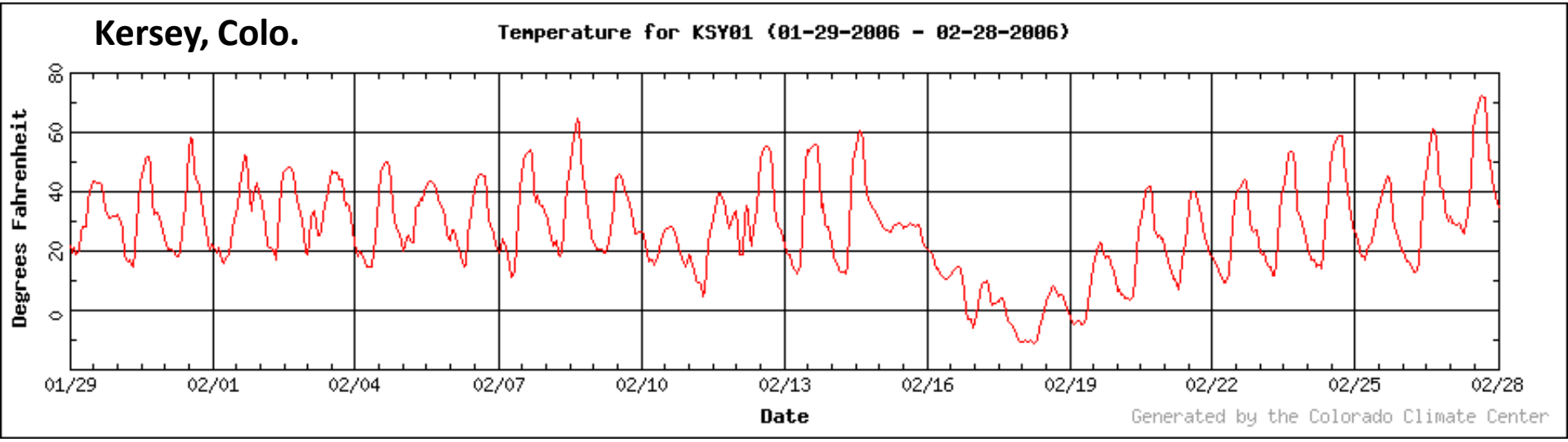
Large Seasonal Temperature Variations

Fruita, Colo.

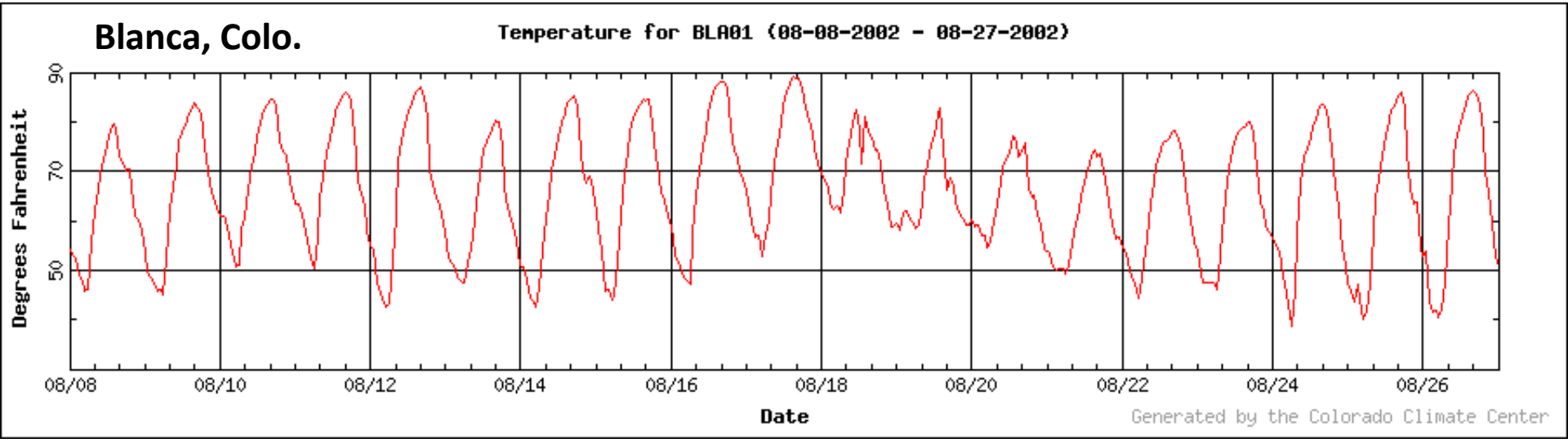


Large diurnal temperature ranges and rapid changes

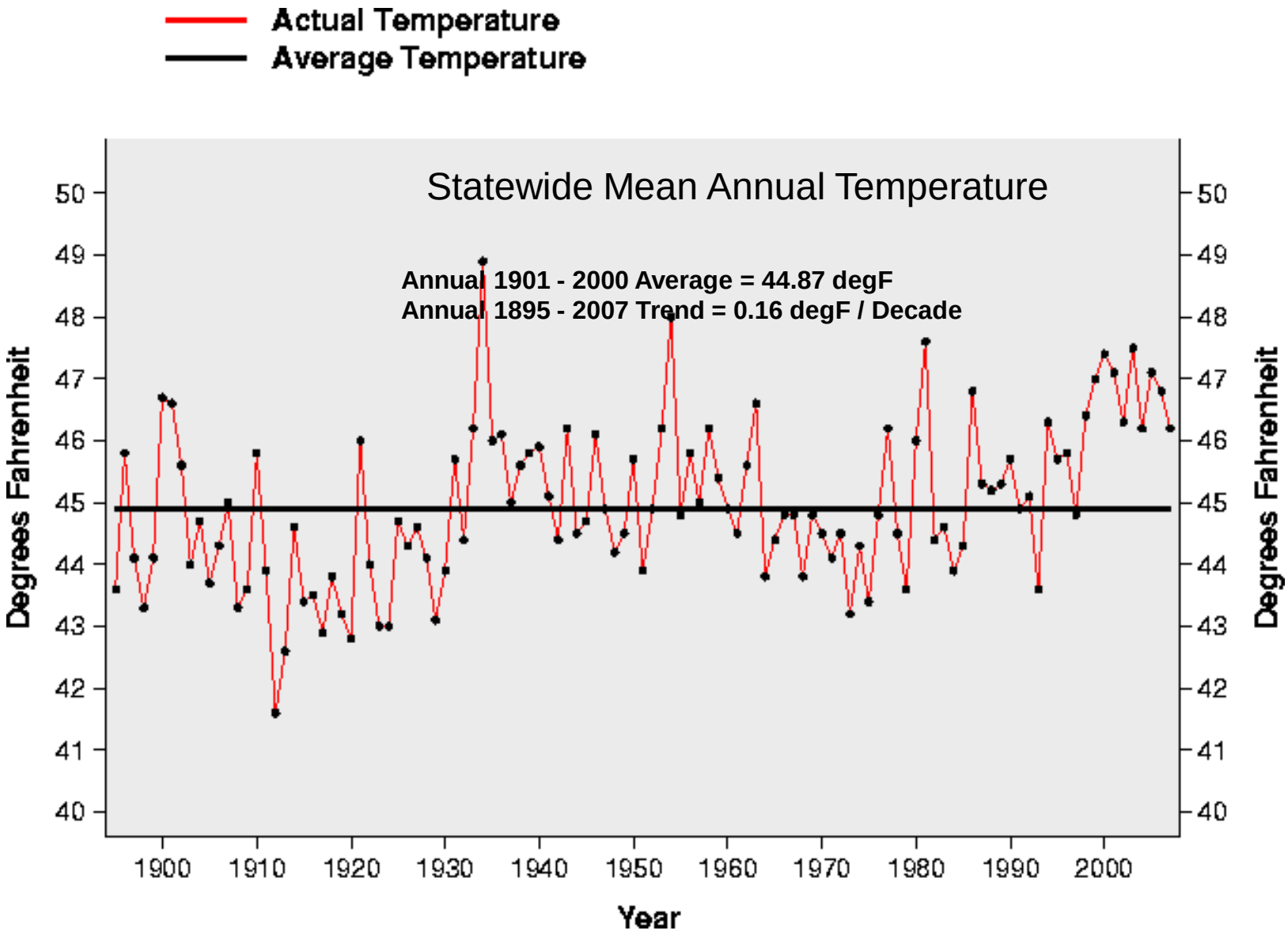
Kersey, Colo.



Blanca, Colo.

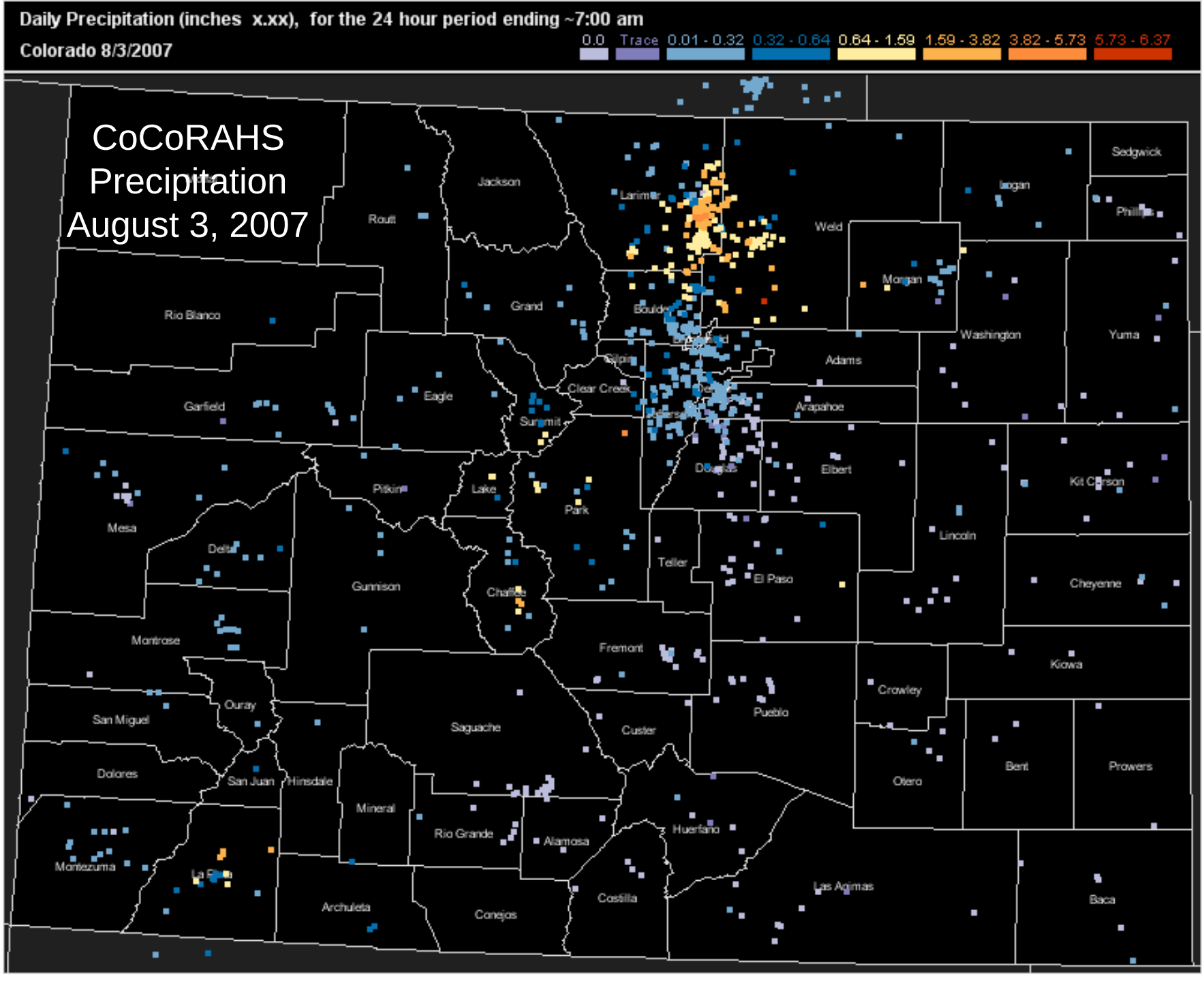


Year to Year Variations in Climate are Expected

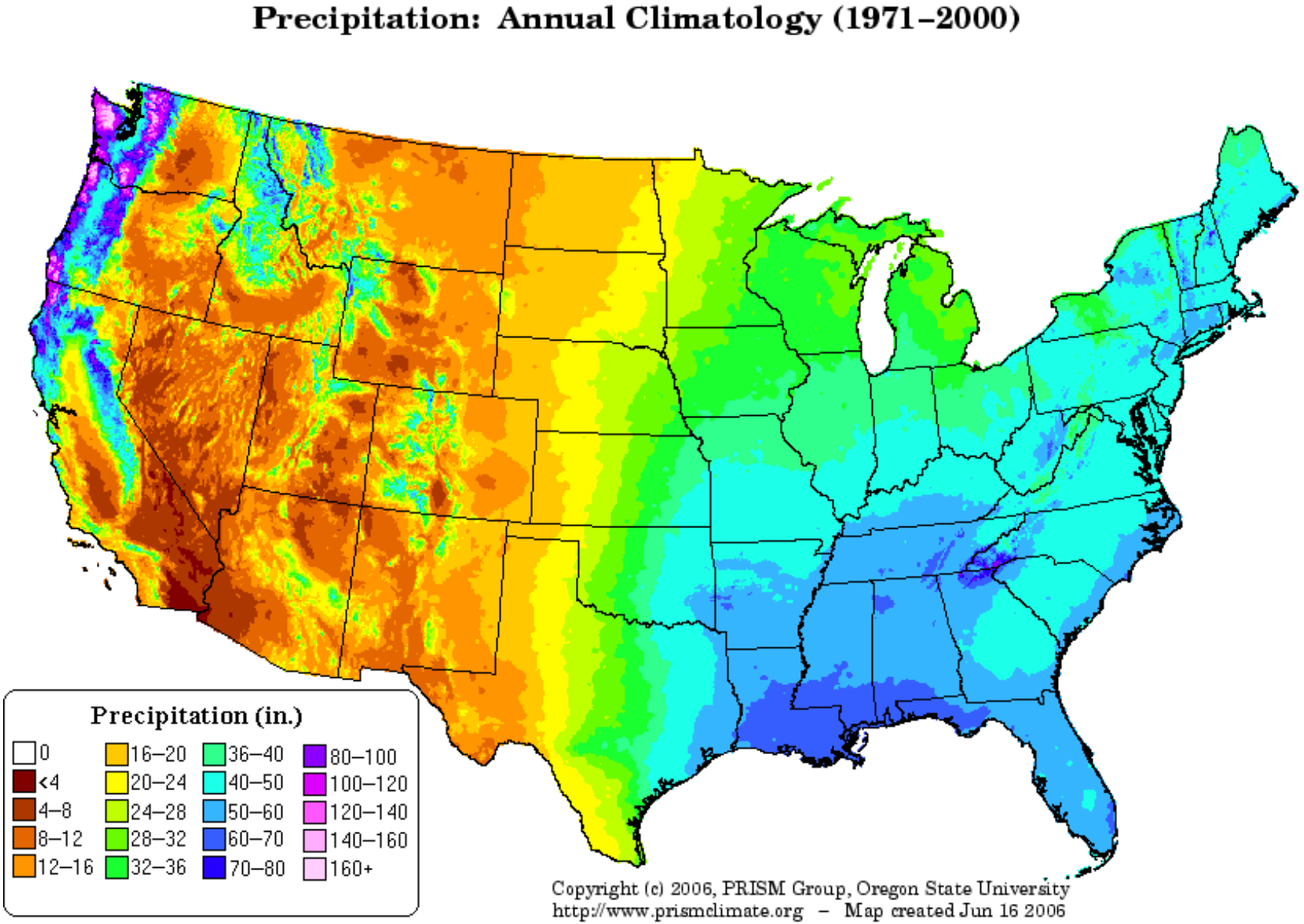


Frequent but highly variable precipitation
(for every “upslope,” there’s a “downslope”)

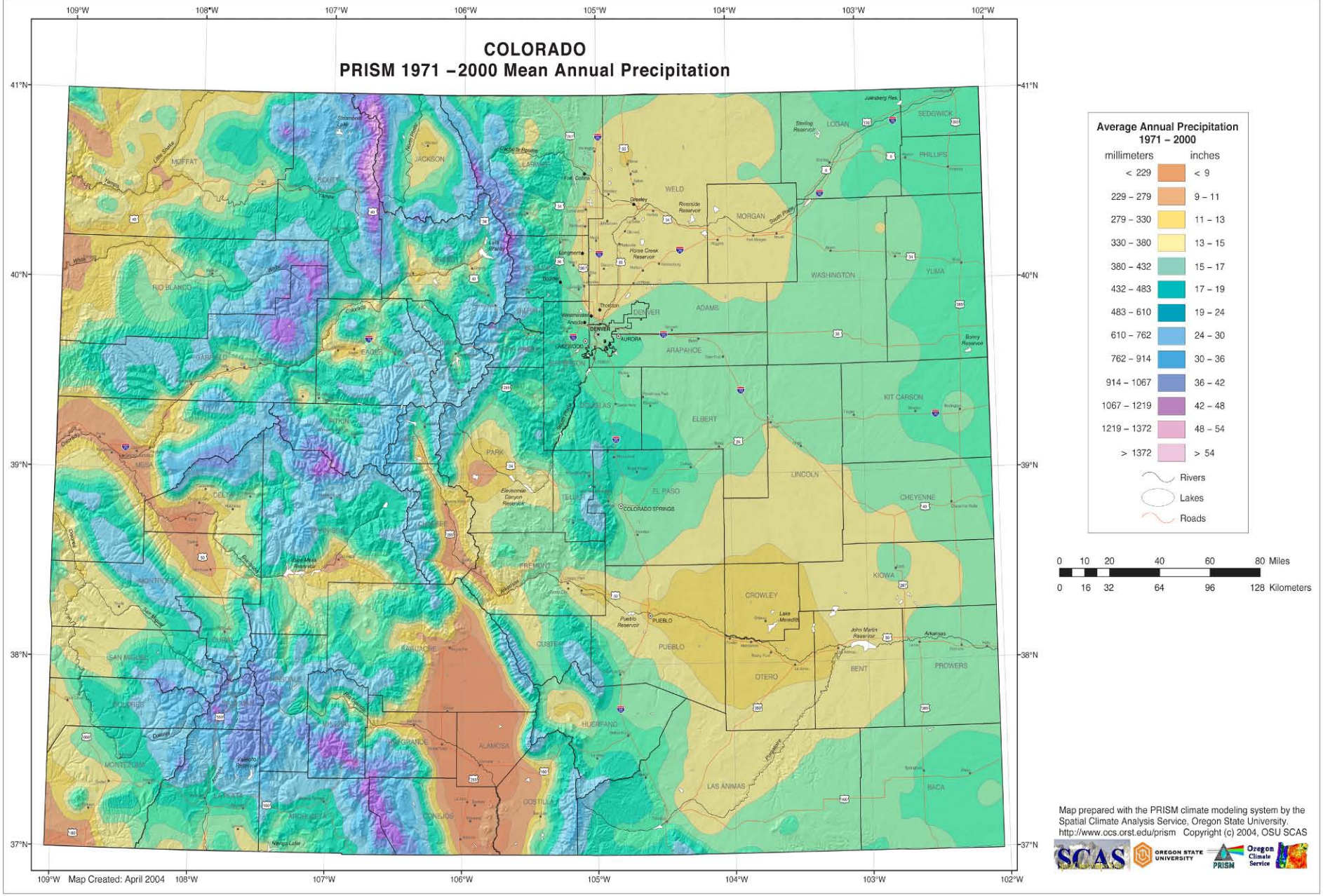
Photo by Wendy Ryan


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
Routt
Jackson
Larimer
Weld
Logan
Sedgwick
Phillips
Rio Blanco
Grand
Boulder
Morgan
Washington
Yuma
Garfield
Eagle
Clear Creek
Summit
Adams
Arapahoe
Elbert
Kit Carson
Pitkin
Lake
Park
Douglas
Lincoln
Mesa
Delta
Gunnison
Chaffee
Teller
El Paso
Cheyenne
Montrose
Fremont
Crowley
Kiowa
Ouray
San Miguel
Saguache
Custer
Pueblo
Otero
Bent
Prowers
Dolores
San Juan
Hinsdale
Mineral
Rio Grande
Alamosa
Huerfano
Montezuma
La Plata
Archuleta
Conejos
Costilla
Las Animas
Baca

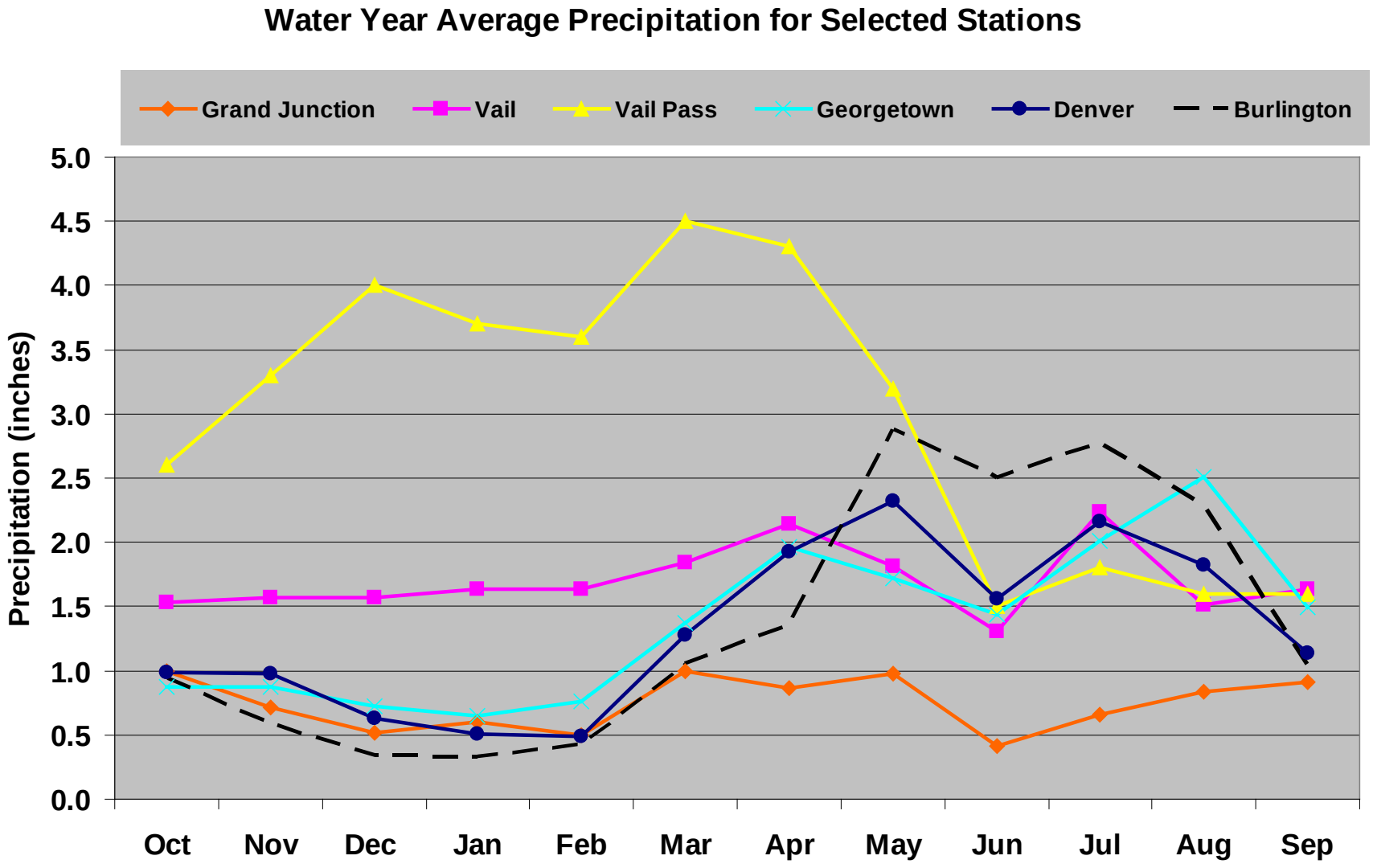
Where we fit in the national picture



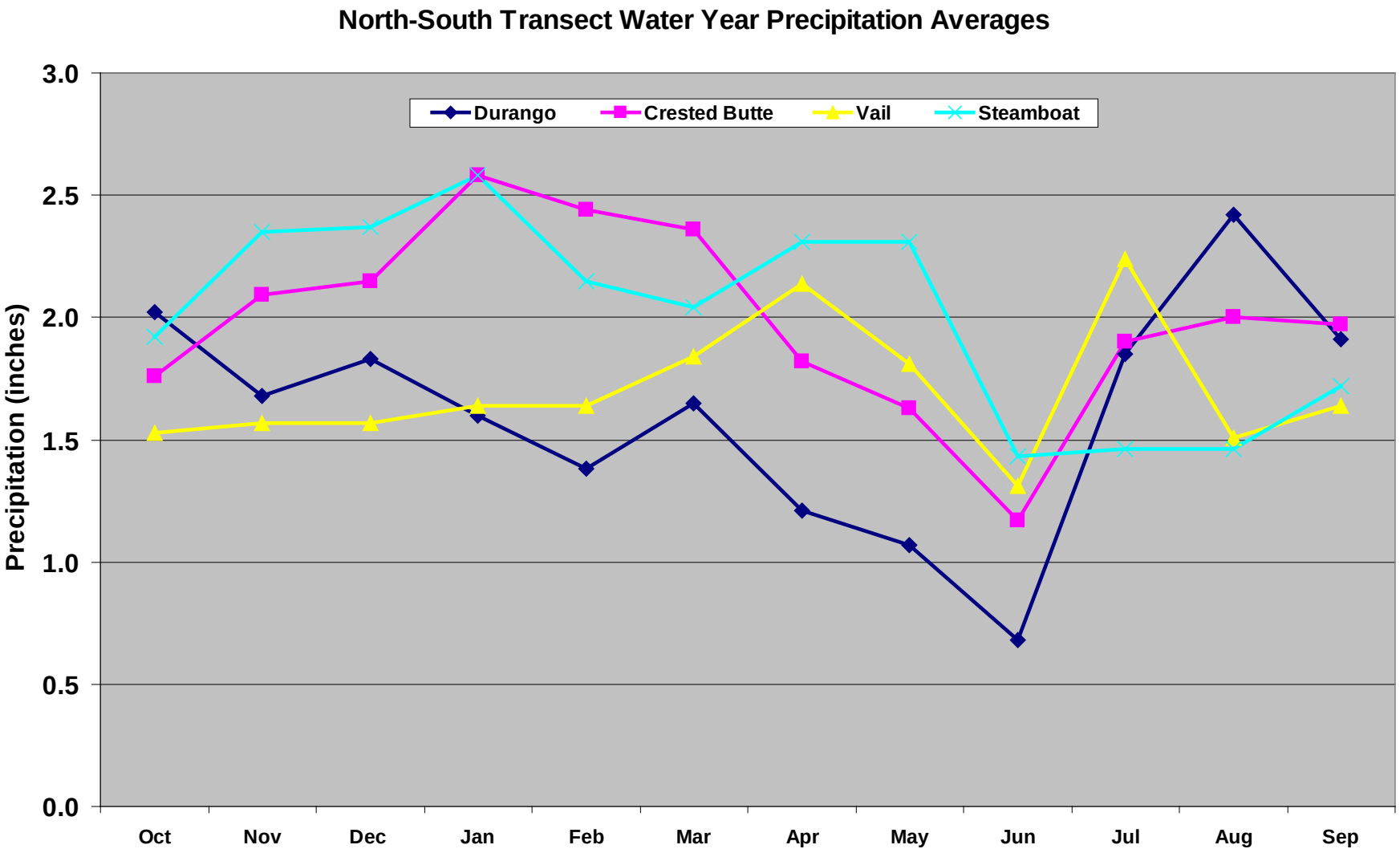
COLORADO
PRISM 1971 –2000 Mean Annual Precipitation



Highly seasonal precipitation patterns with considerable geographic diversity in “seasonality”

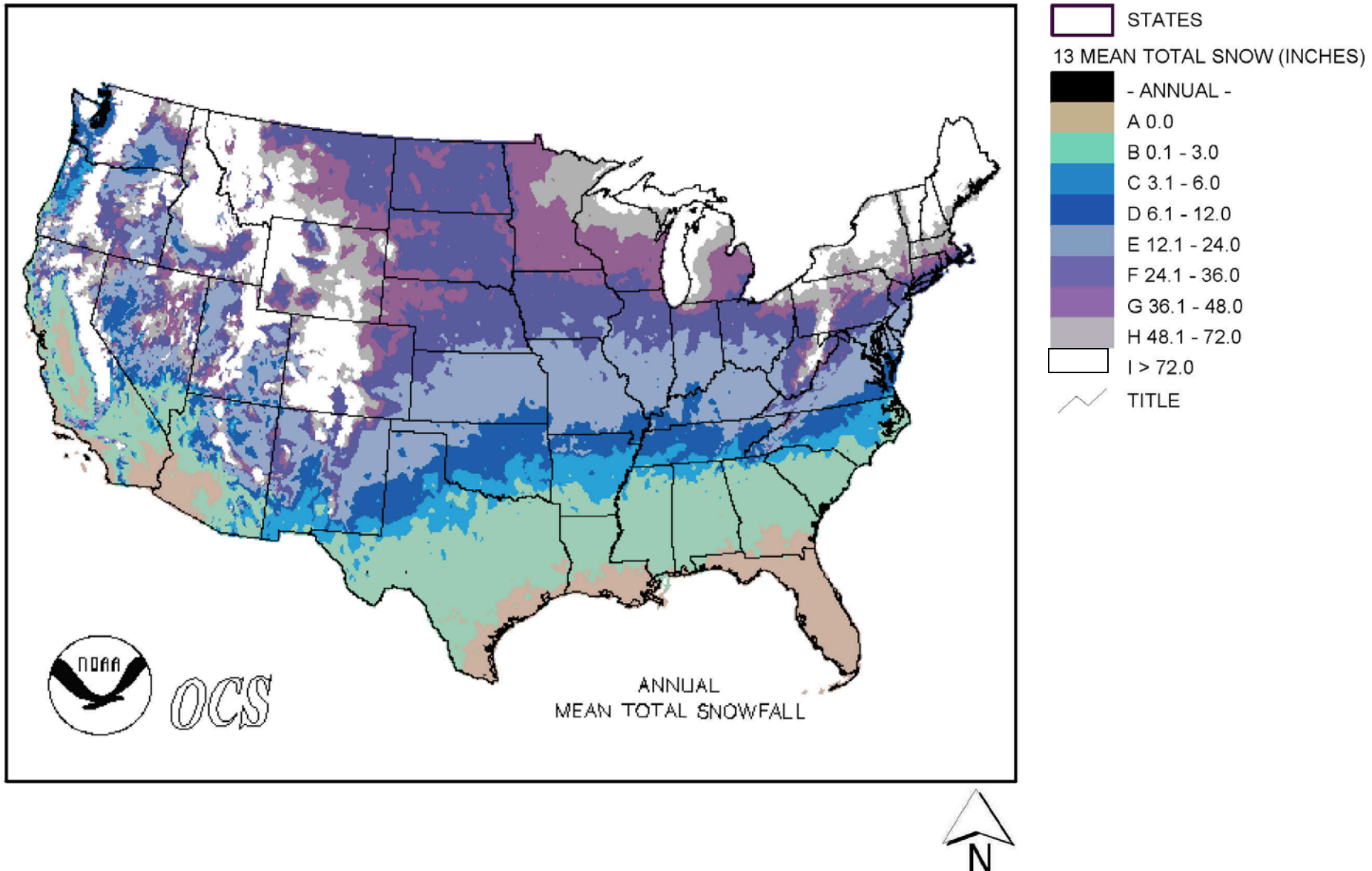


Seasonal Precipitation Averages North-South Transect

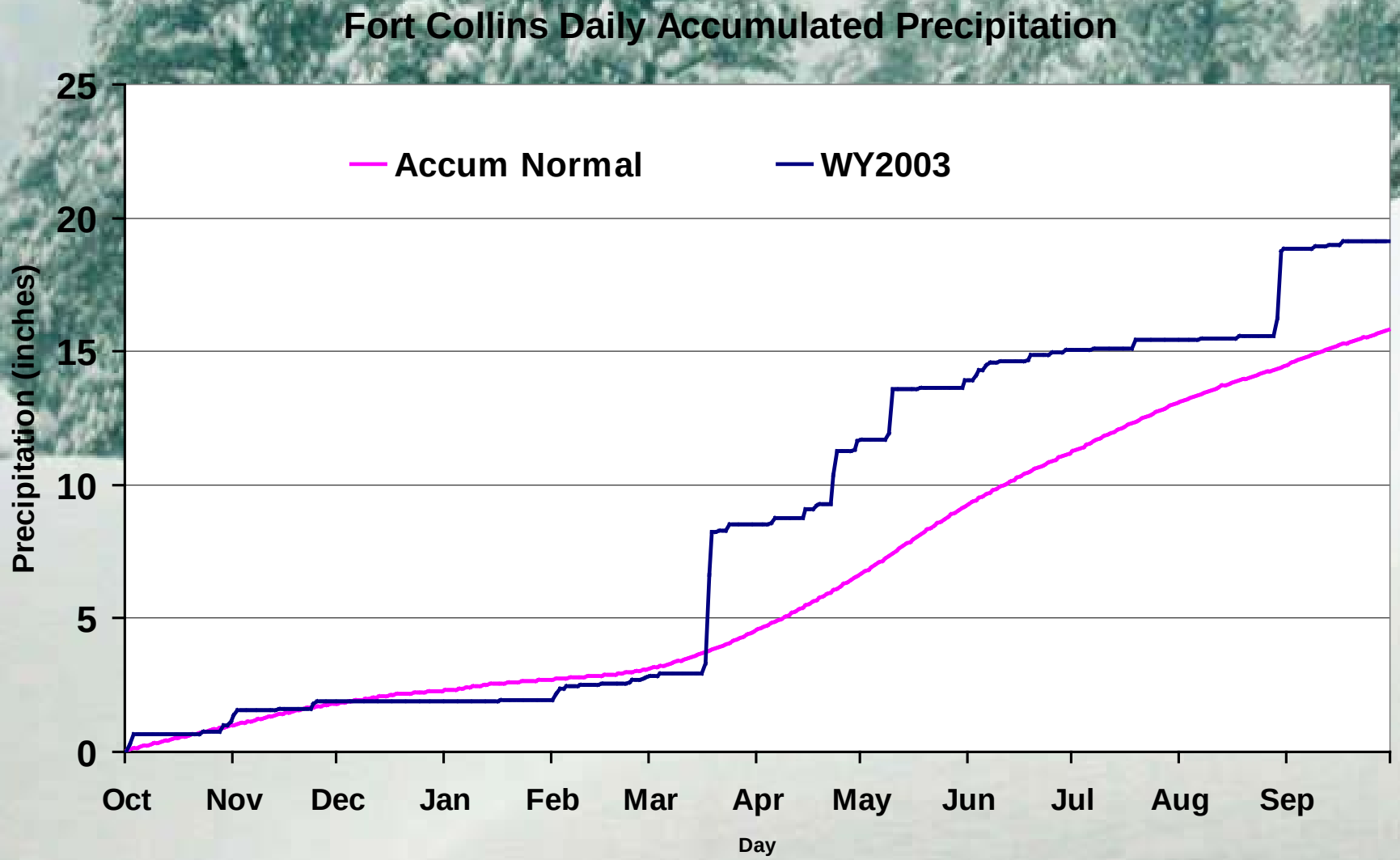


Lots of Snow, sometimes and some places

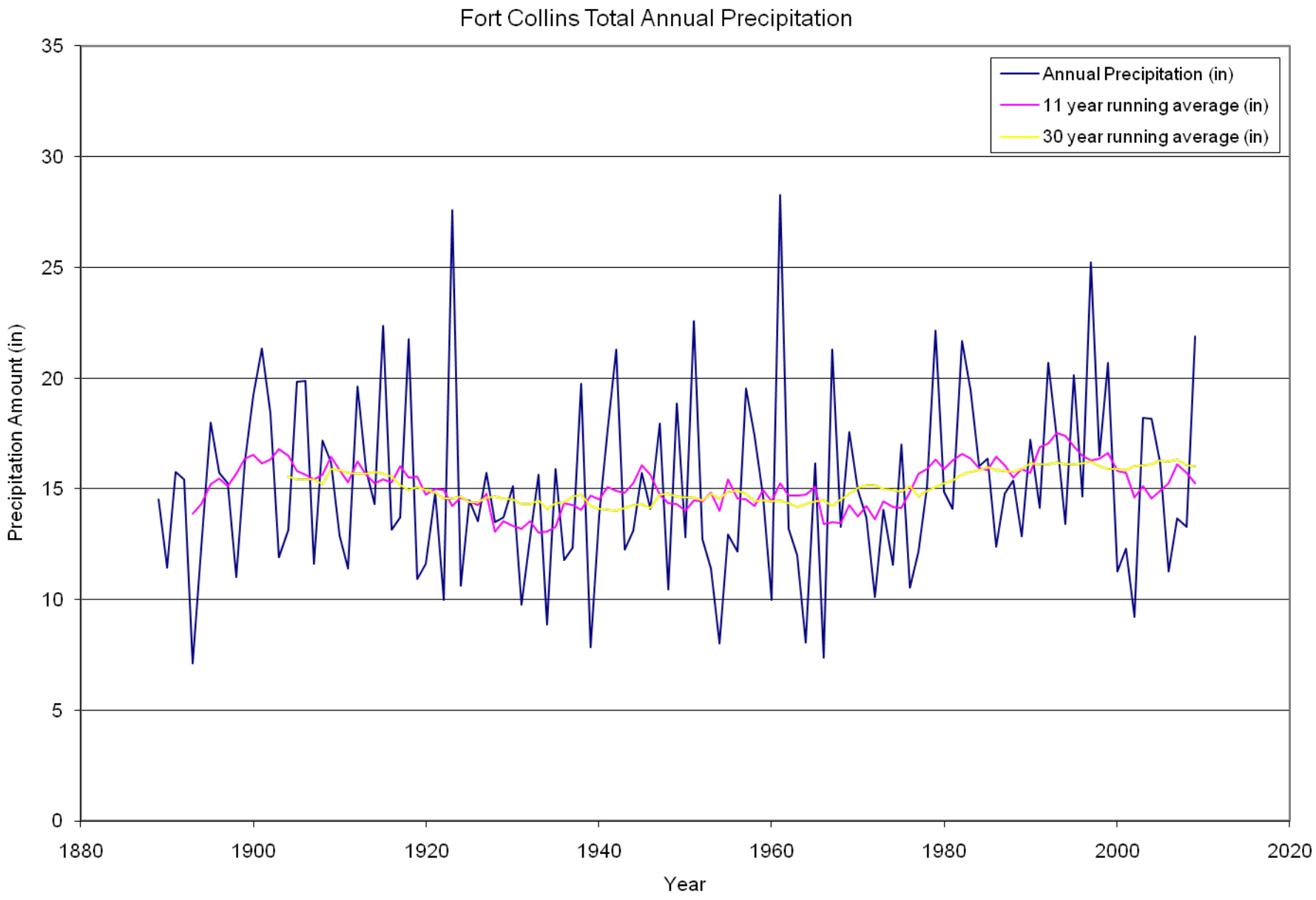
National Annual Average Snowfall



A few storms contribute a large fraction of the annual precipitation in many years



Large Year-to-Year Variations in Precipitation


Fort Collins Total Annual Precipitation
Annual Precipitation (in)
11 year running average (in)
30 year running average (in)
Precipitation Amount (in)
Year
0
5
10
15
20
25
30
35
1880
1900
1920
1940
1960
1980
2000
2020

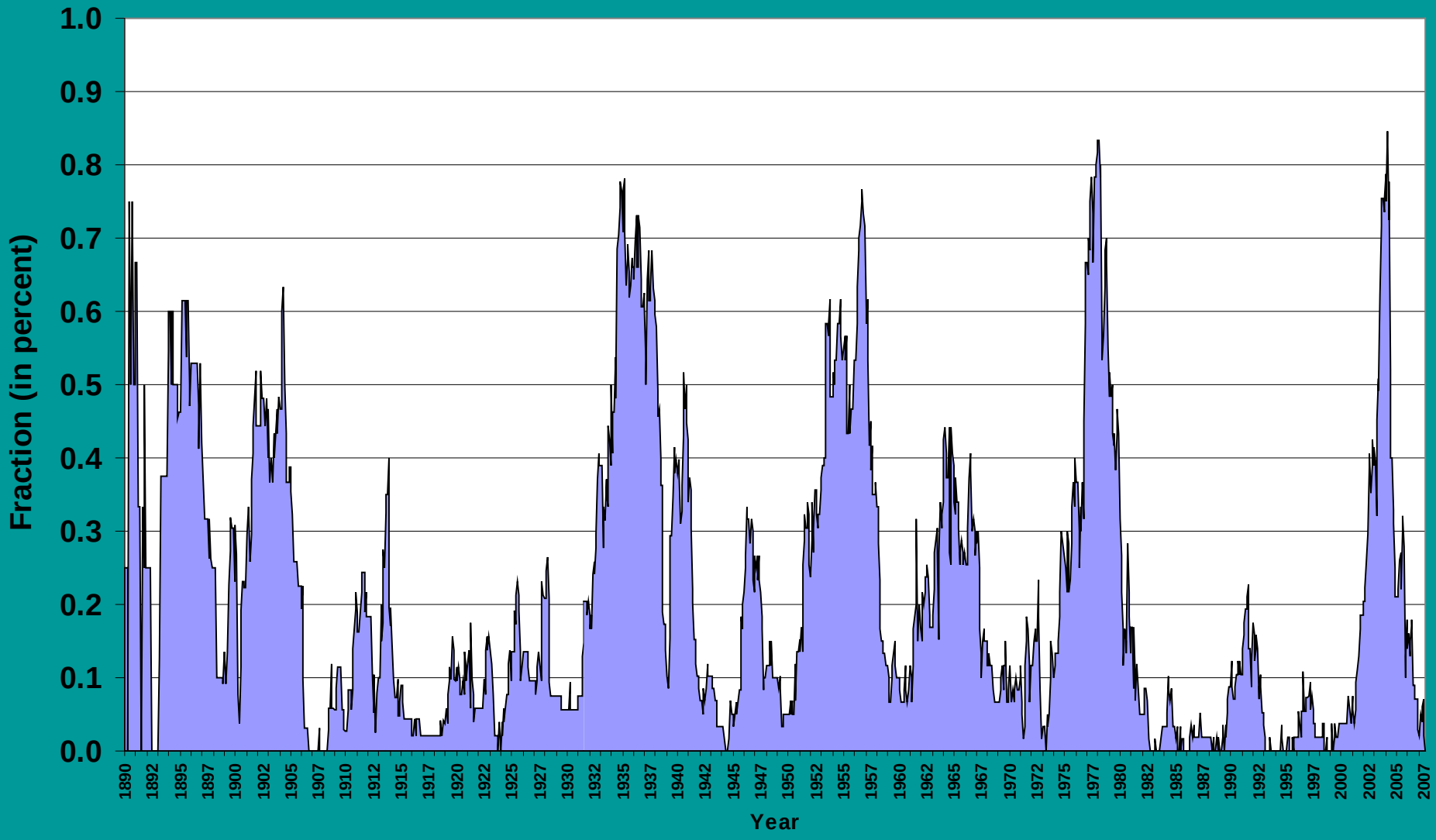
Drought Visits Our Area Regularly

Photo by NRCS

Fraction of Colorado in Drought

Based on 48 month SPI

(1890 - July 2007)



Floods are regular visitors too --

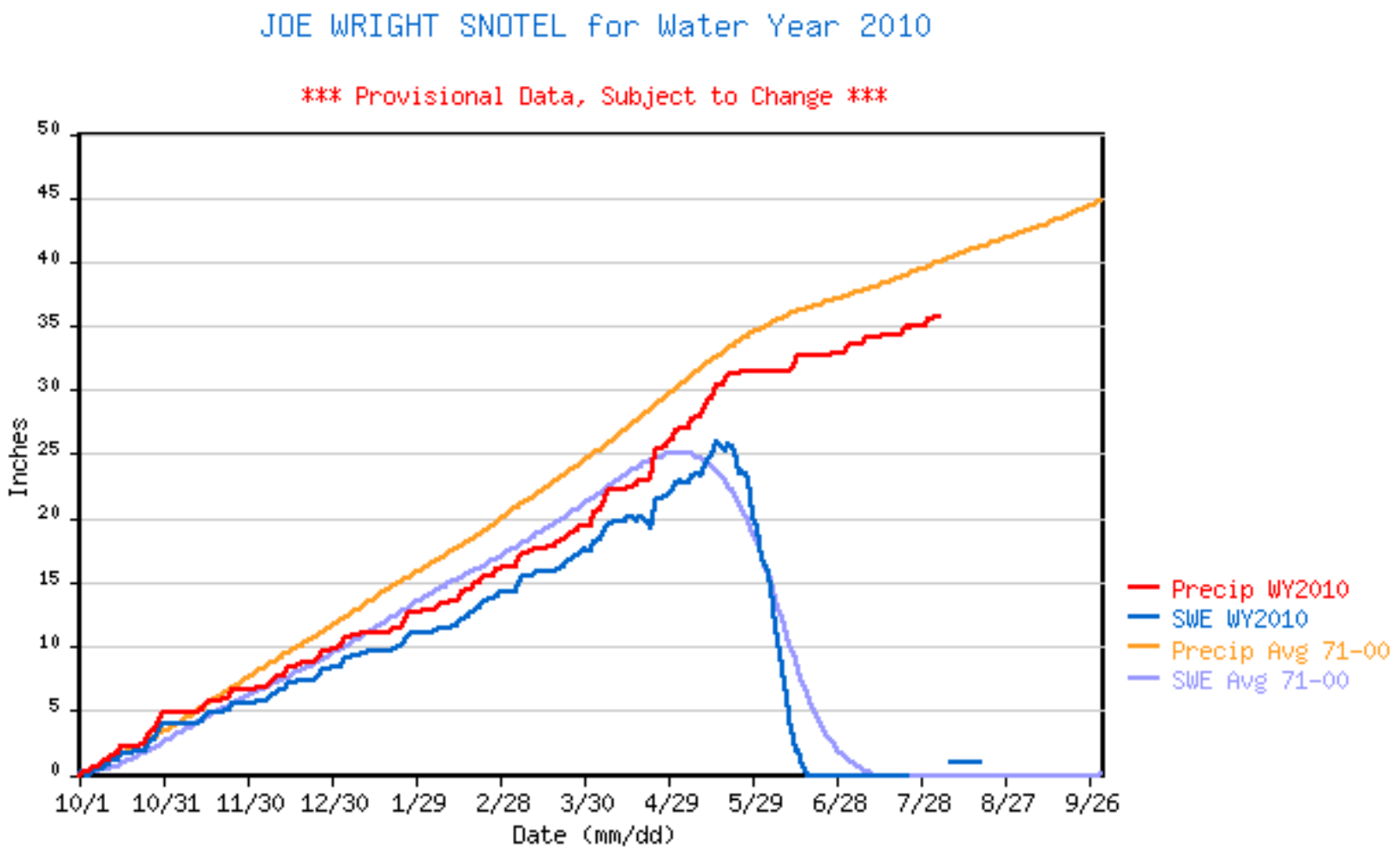
The Fort Collins Flood of July 28, 1997

Of all the many elements of our climate here in Colorado, day in and day out ***the most asked for and needed information is precipitation and the relationship between climate and water resources***

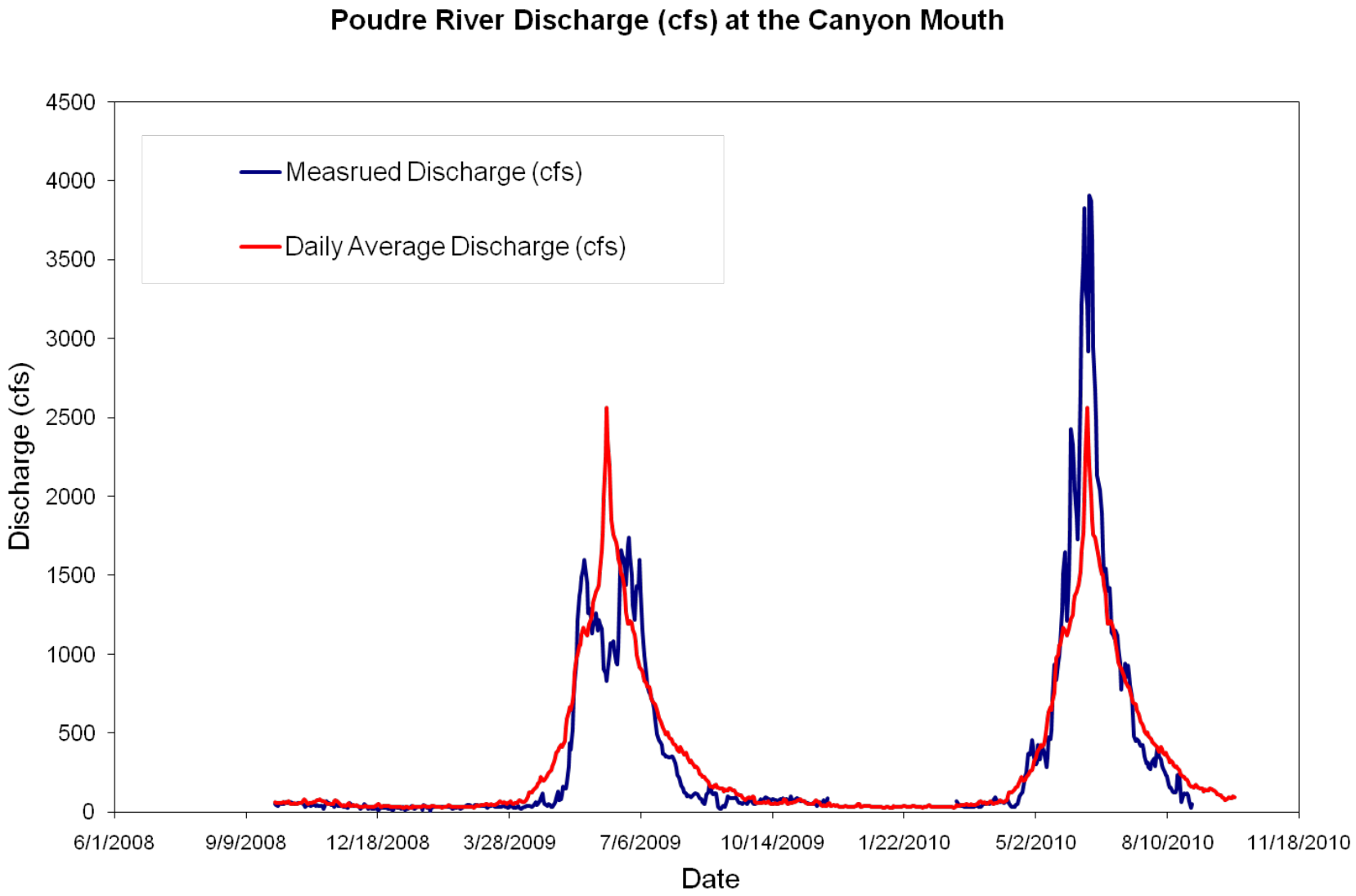
The Water Year

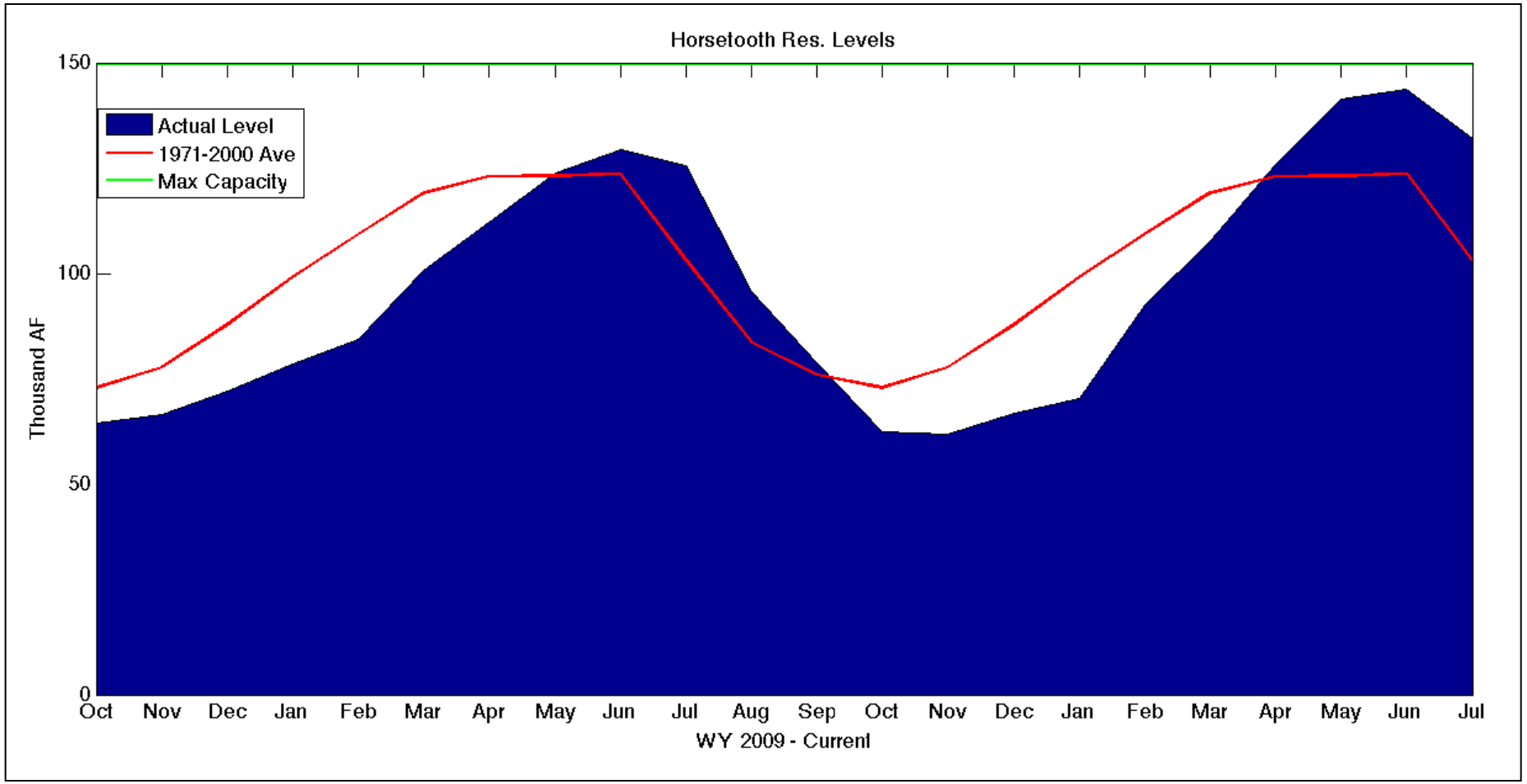
- What is it and why do we use it?
- October 1 through Sept 30
- Corresponds to the water storage – water usage cycle that we live out and experience each year.

Water Year – the snow accumulation, snow melt, runoff annual cycle

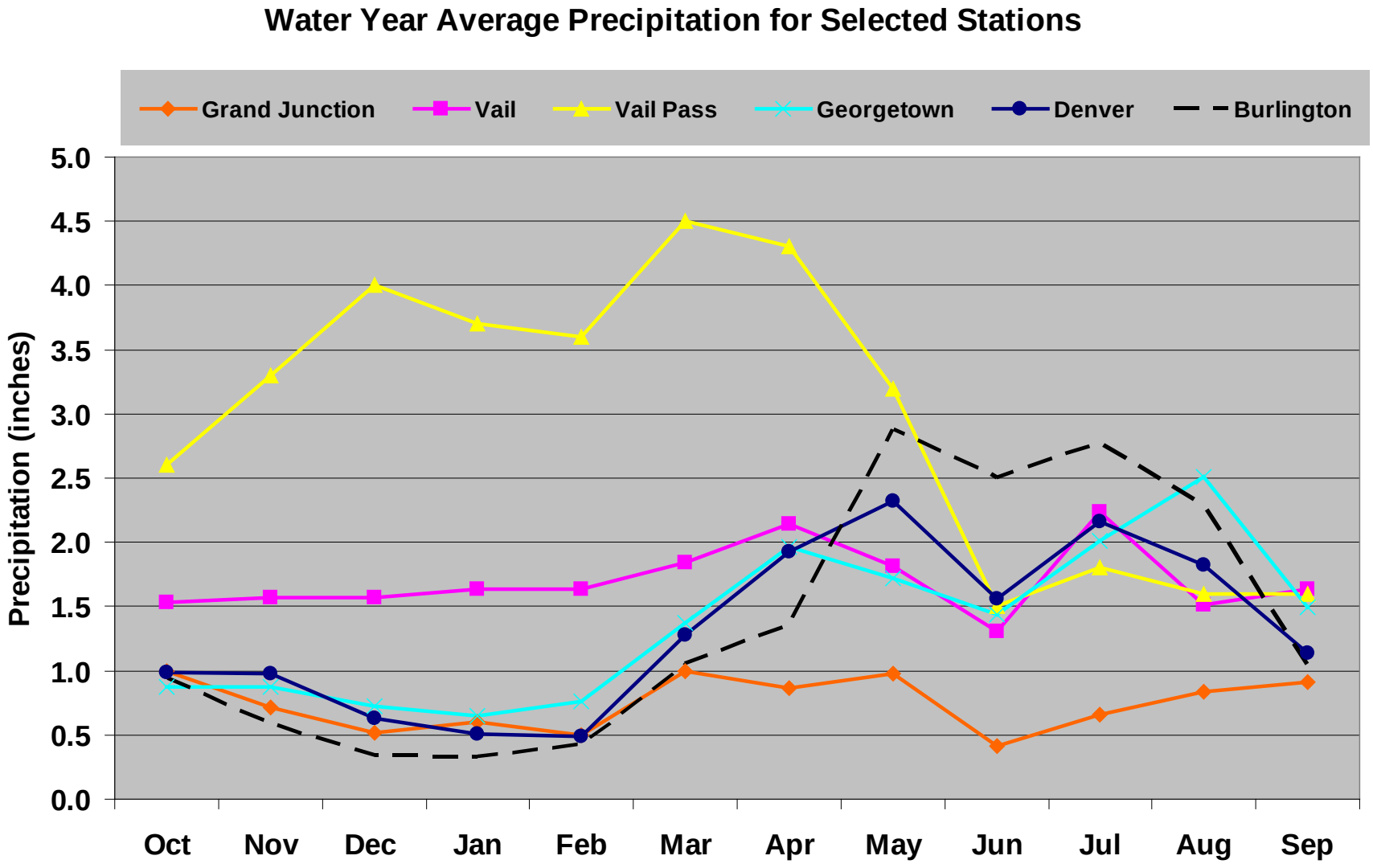


Every Year is Different!

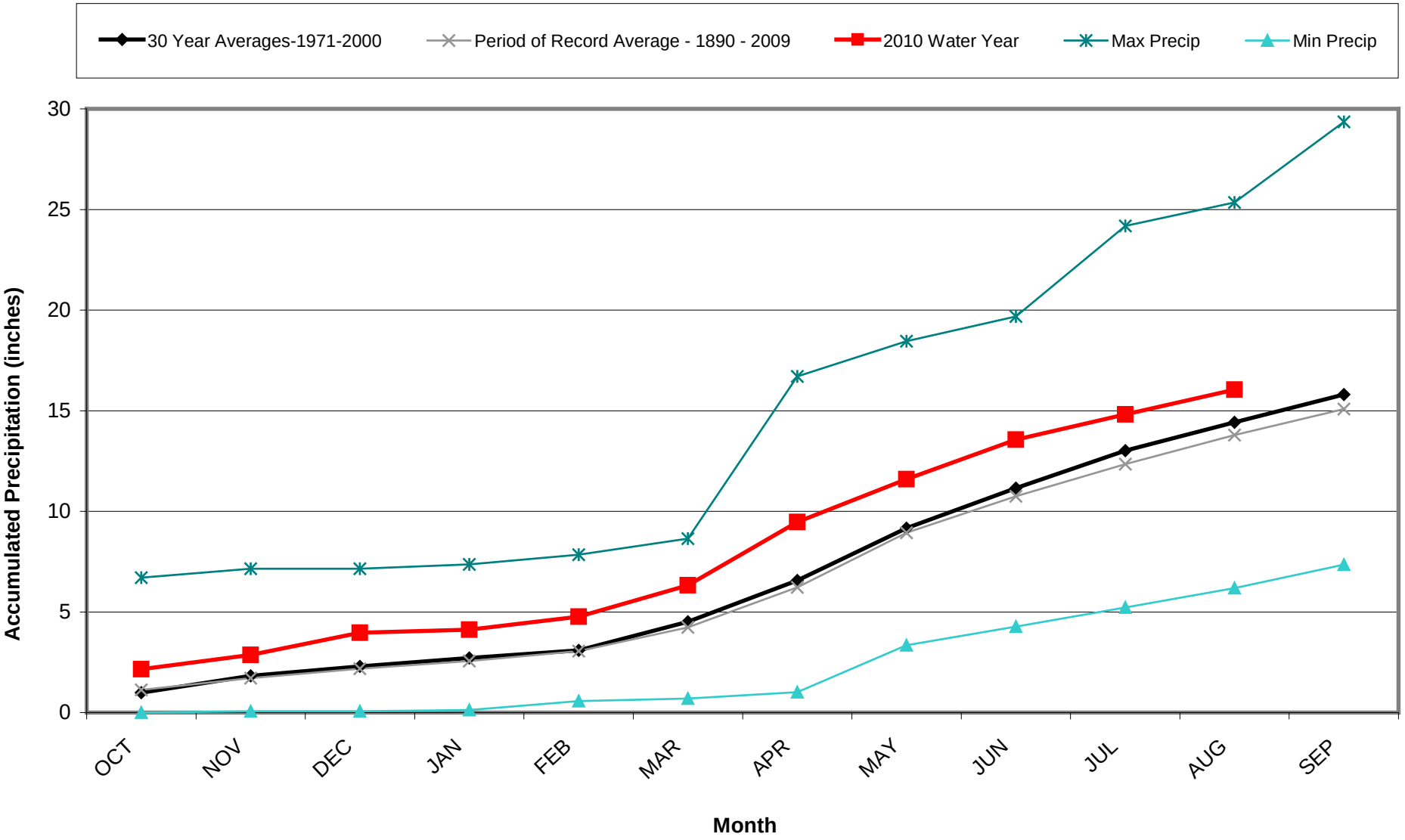



Horsetooth Res. Levels
Actual Level
1971-2000 Ave
Max Capacity
Thousand AF
150
100
50
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
WY 2009 - Current

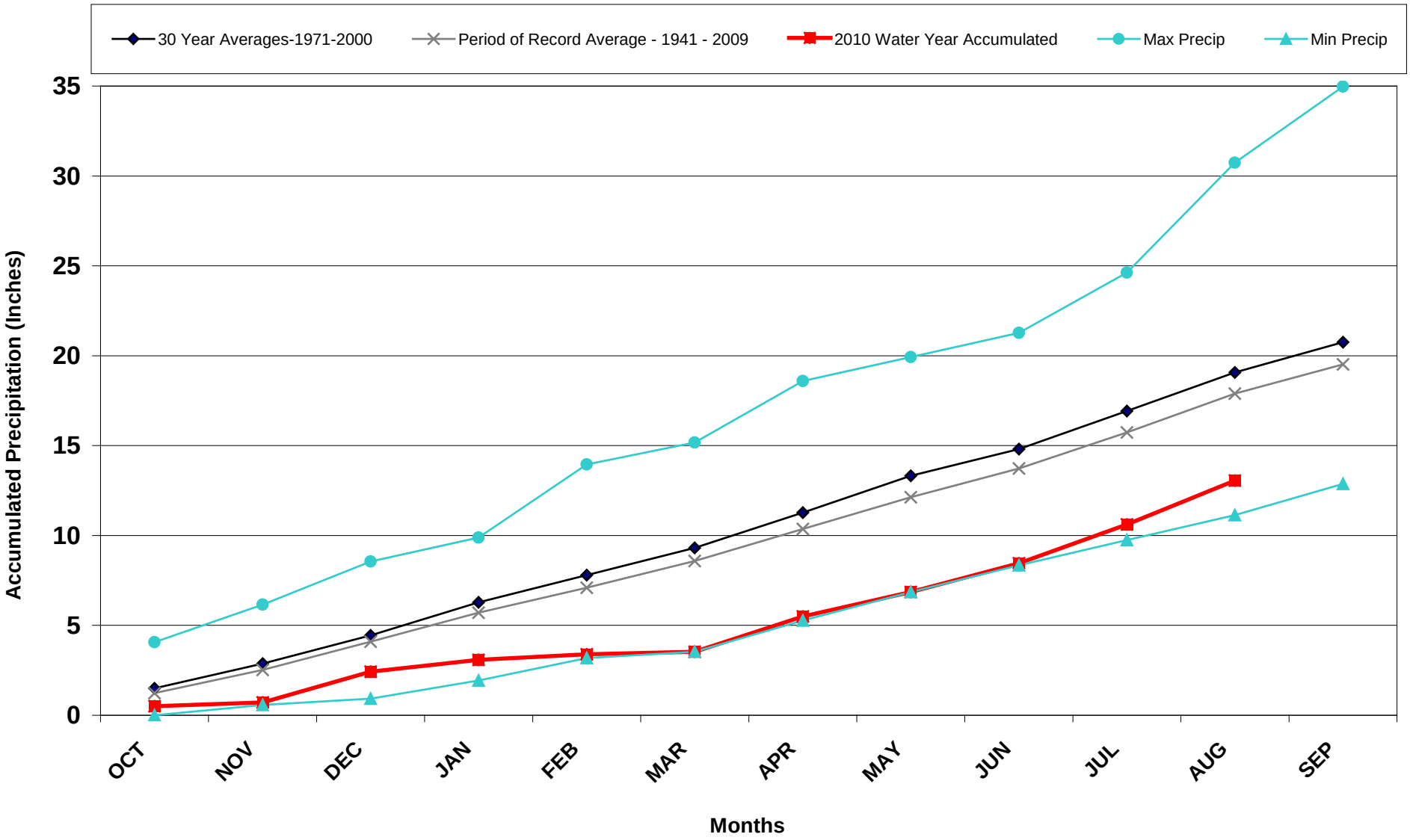
Highly seasonal precipitation patterns with considerable geographic diversity in “seasonality”

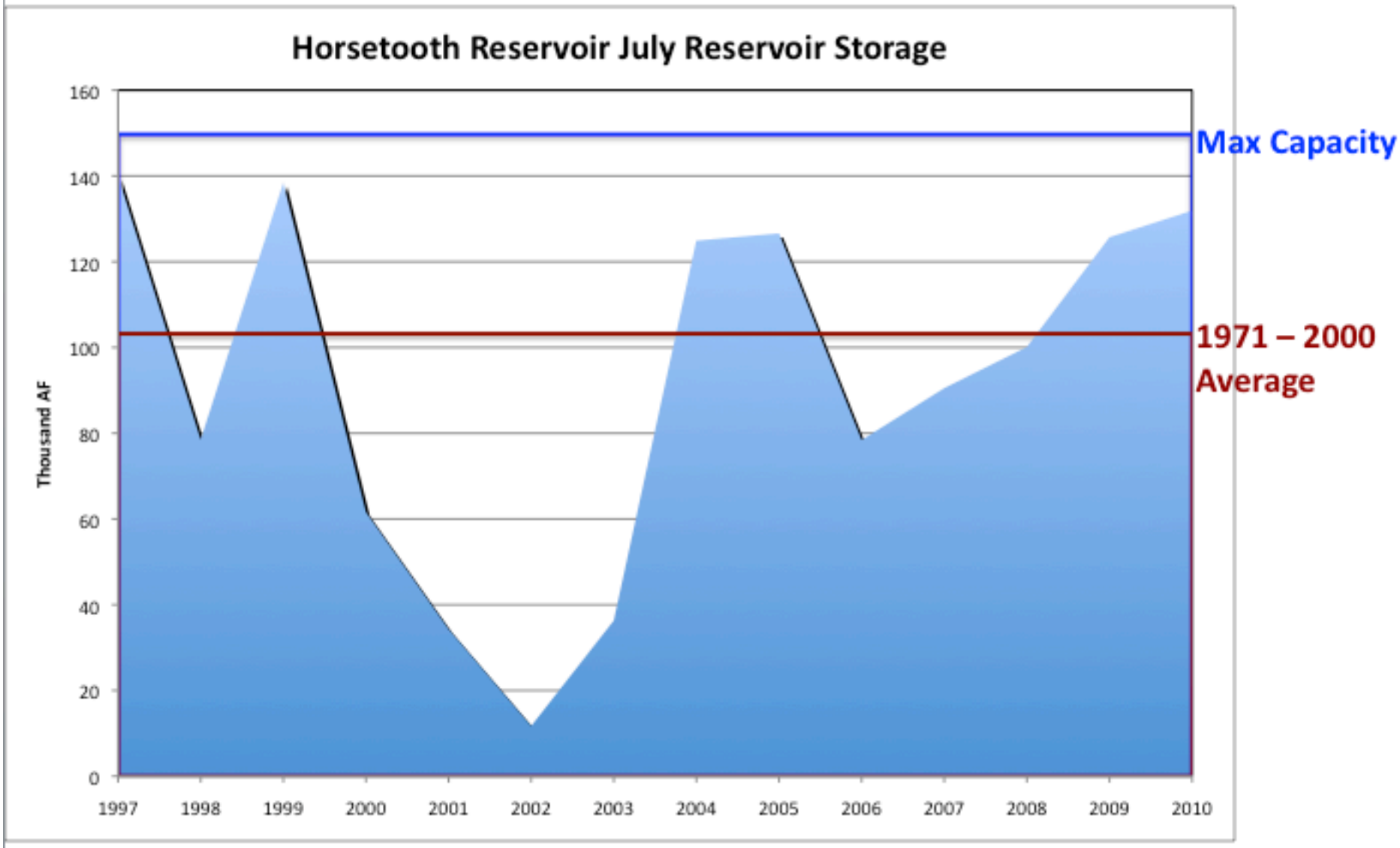


Fort Collins
2010 Water Year



Grand Lake 1 NW
2010 Water Year




Horsetooth Reservoir July Reservoir Storage
Thousand AF
160
140
120
100
80
60
40
20
0
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Max Capacity
1971 – 2000
Average

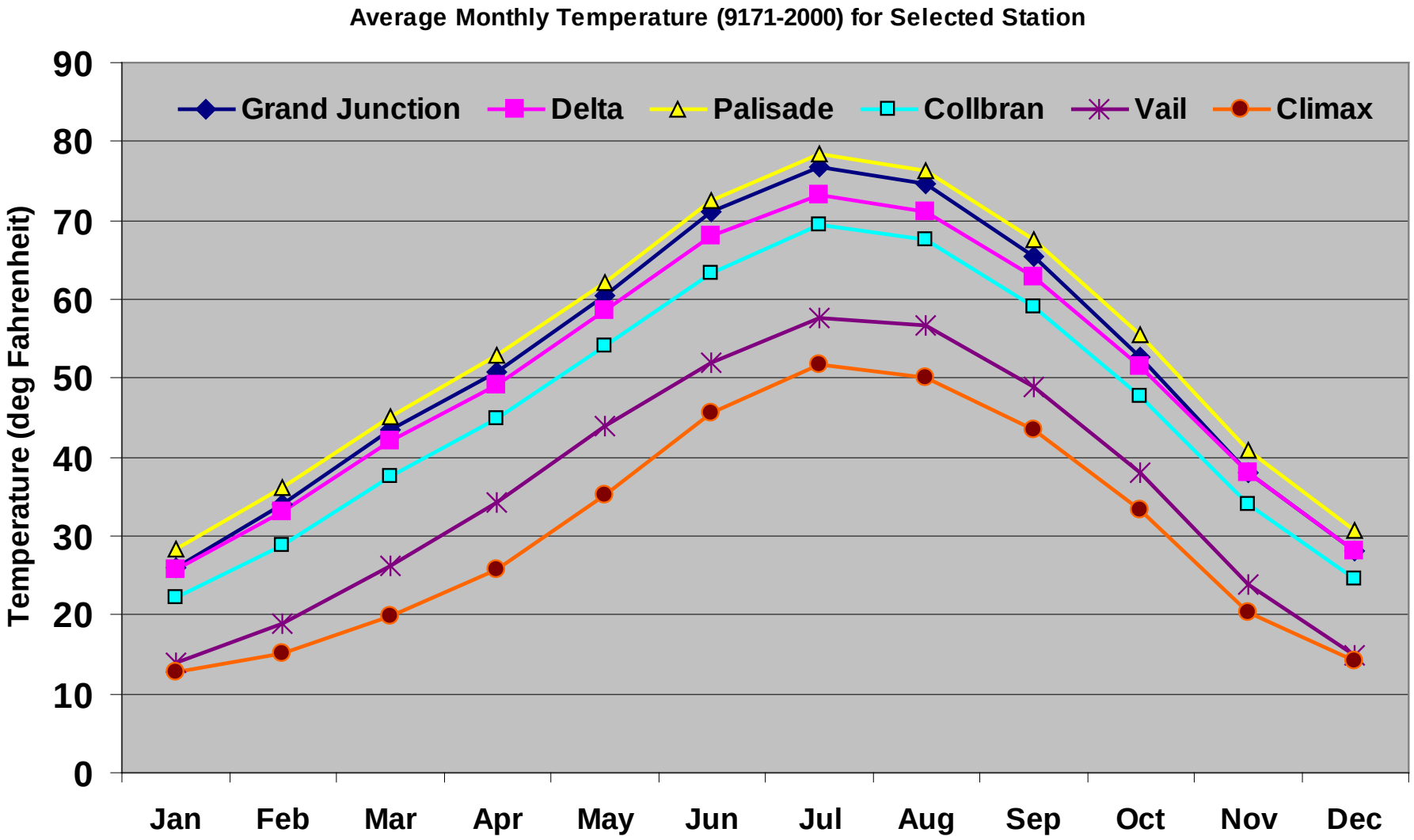
Variability -- -- -- the nature of Climate

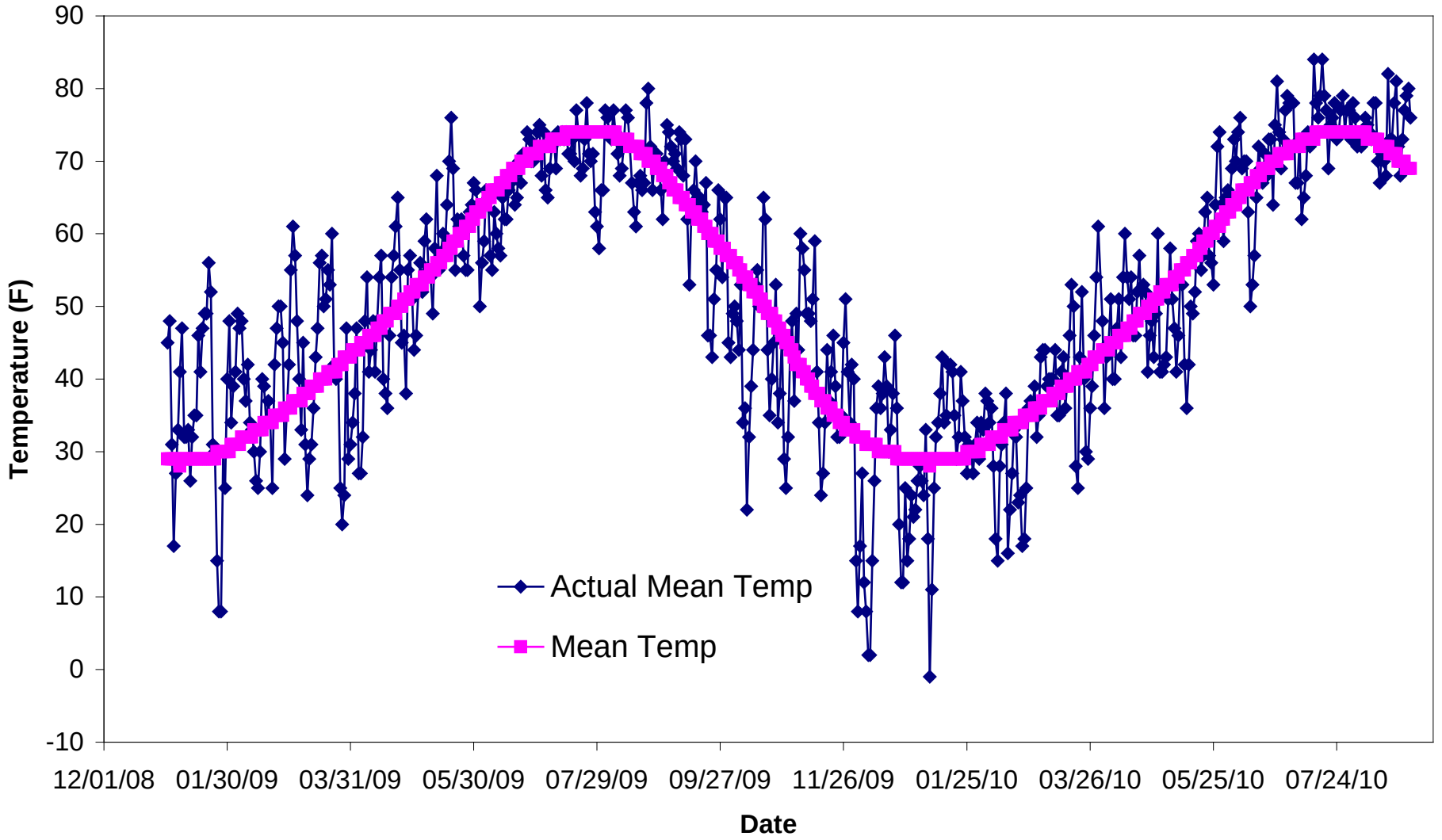
and the “Challenge” for detecting and documenting trends and changes

Temperature -- relatively well behaved – summers always warmer than winters, etc – easier to observer variations over time

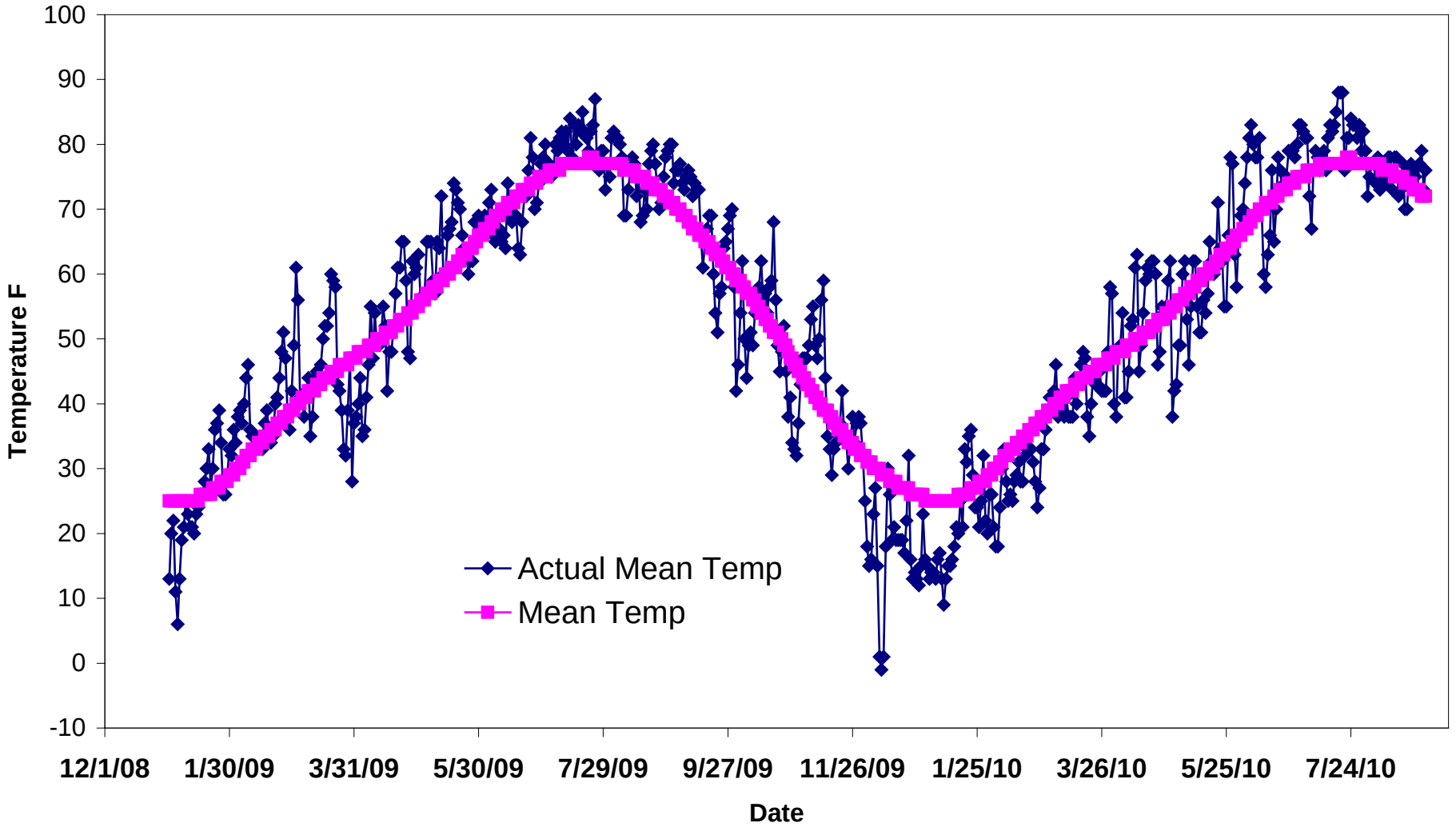
Precipitation, much more variable – trend much more difficult to determine in a modest number of years

Temperatures are different, but annual cycles are similar



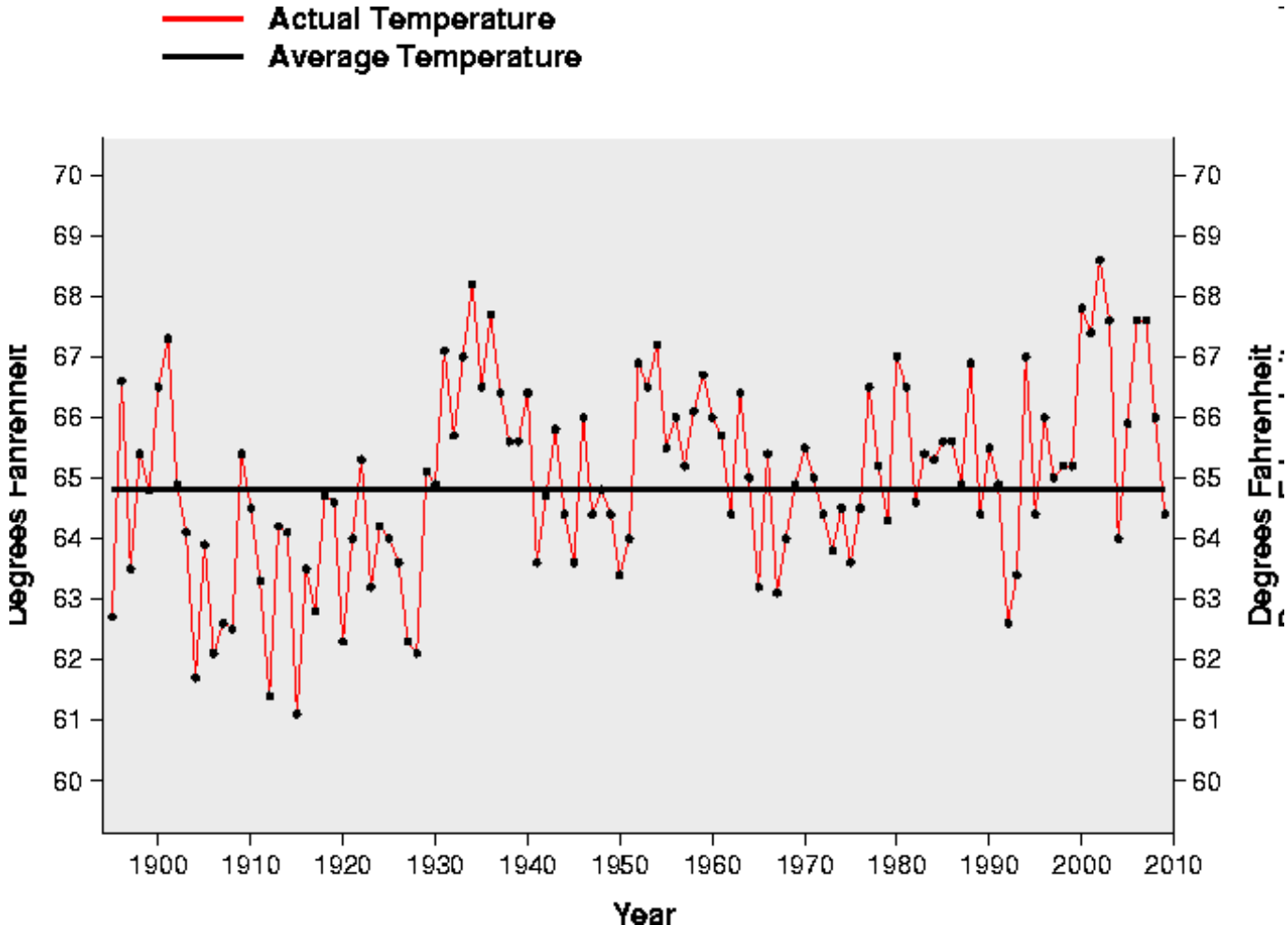

Denver, CO Jan 1, 2009 - August 29, 2010
Mean and Actual Daily Temperature
Temperature (F)
90
80
70
60
50
40
30
20
10
0
-10
12/01/08
01/30/09
03/31/09
05/30/09
07/29/09
09/27/09
11/26/09
01/25/10
03/26/10
05/25/10
07/24/10
Date
Actual Mean Temp
Mean Temp

Grand Junction Jan 1, 2009 - August 29, 2010
Mean and Actual Daily Temperature



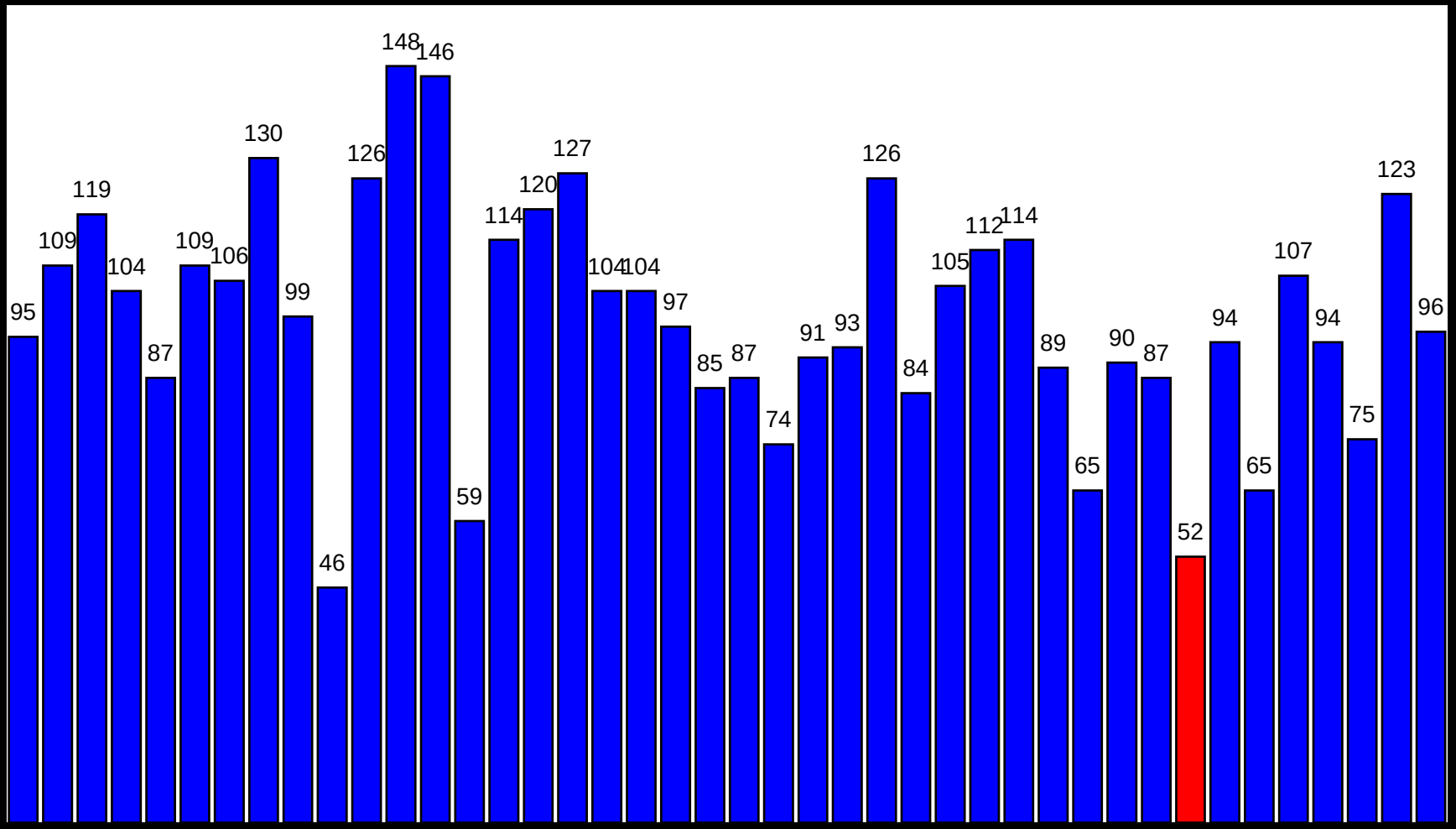
When significant temperature trends begin, we will be able to detect them

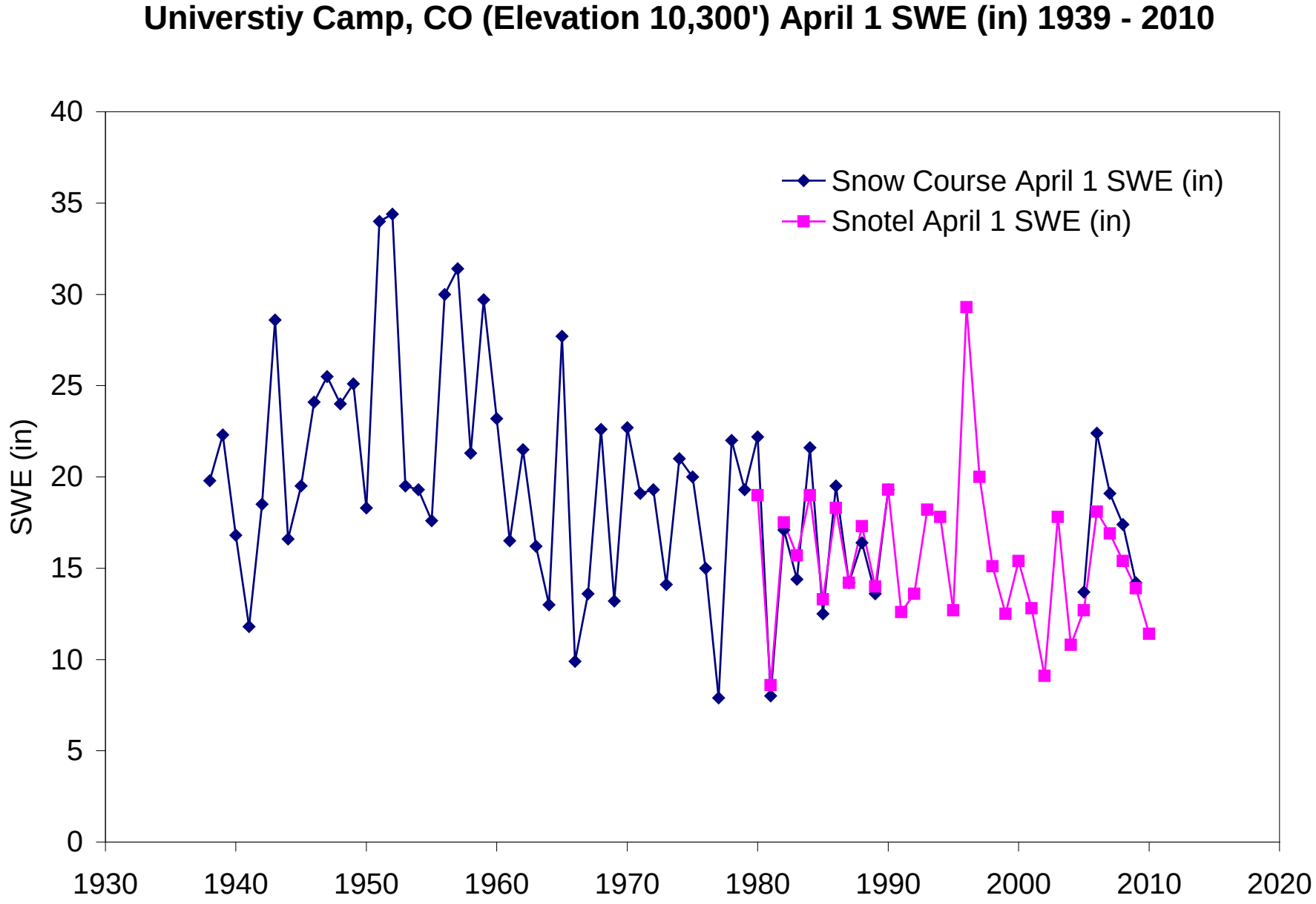
Colorado Statewide Summer Temperatures

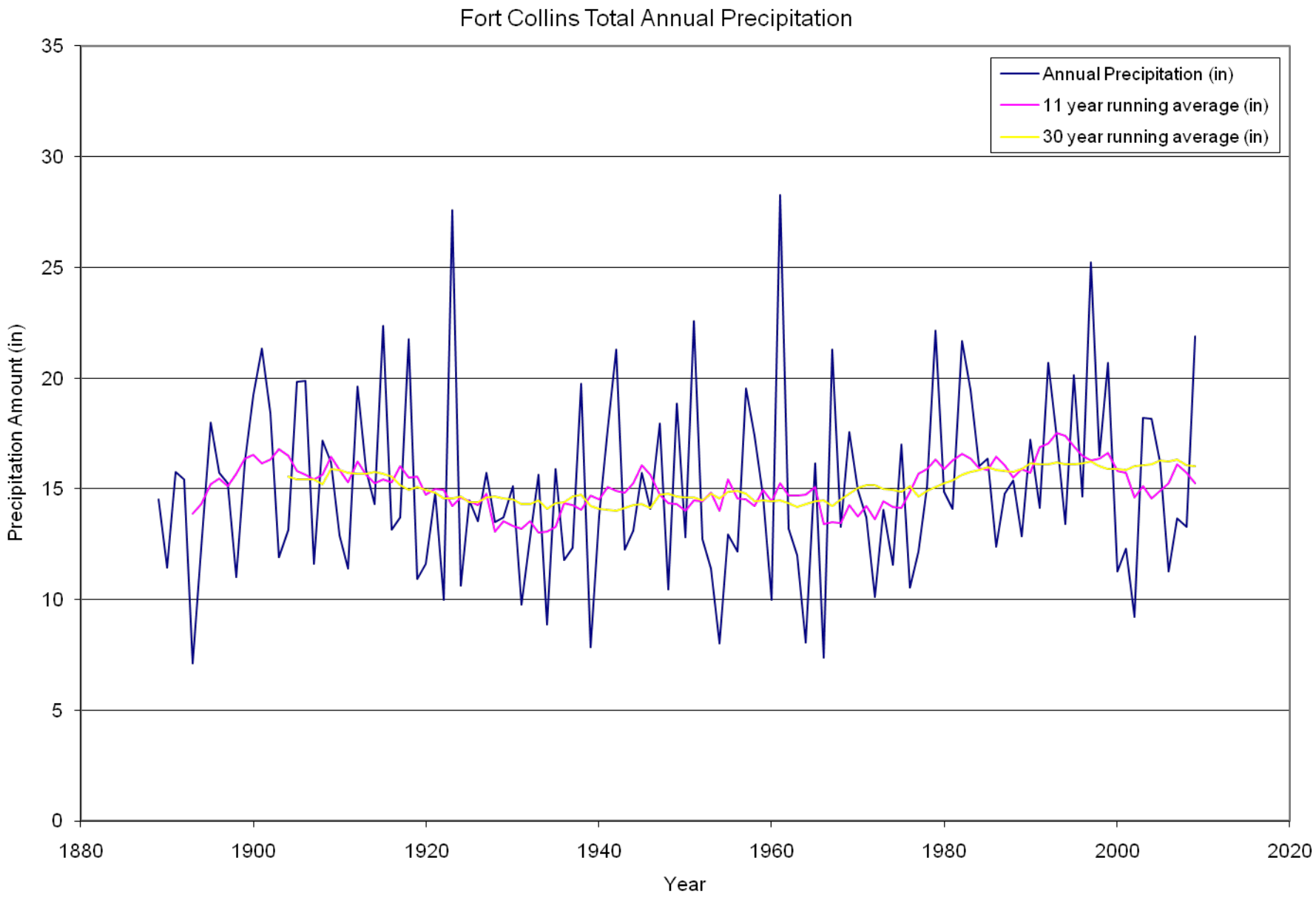


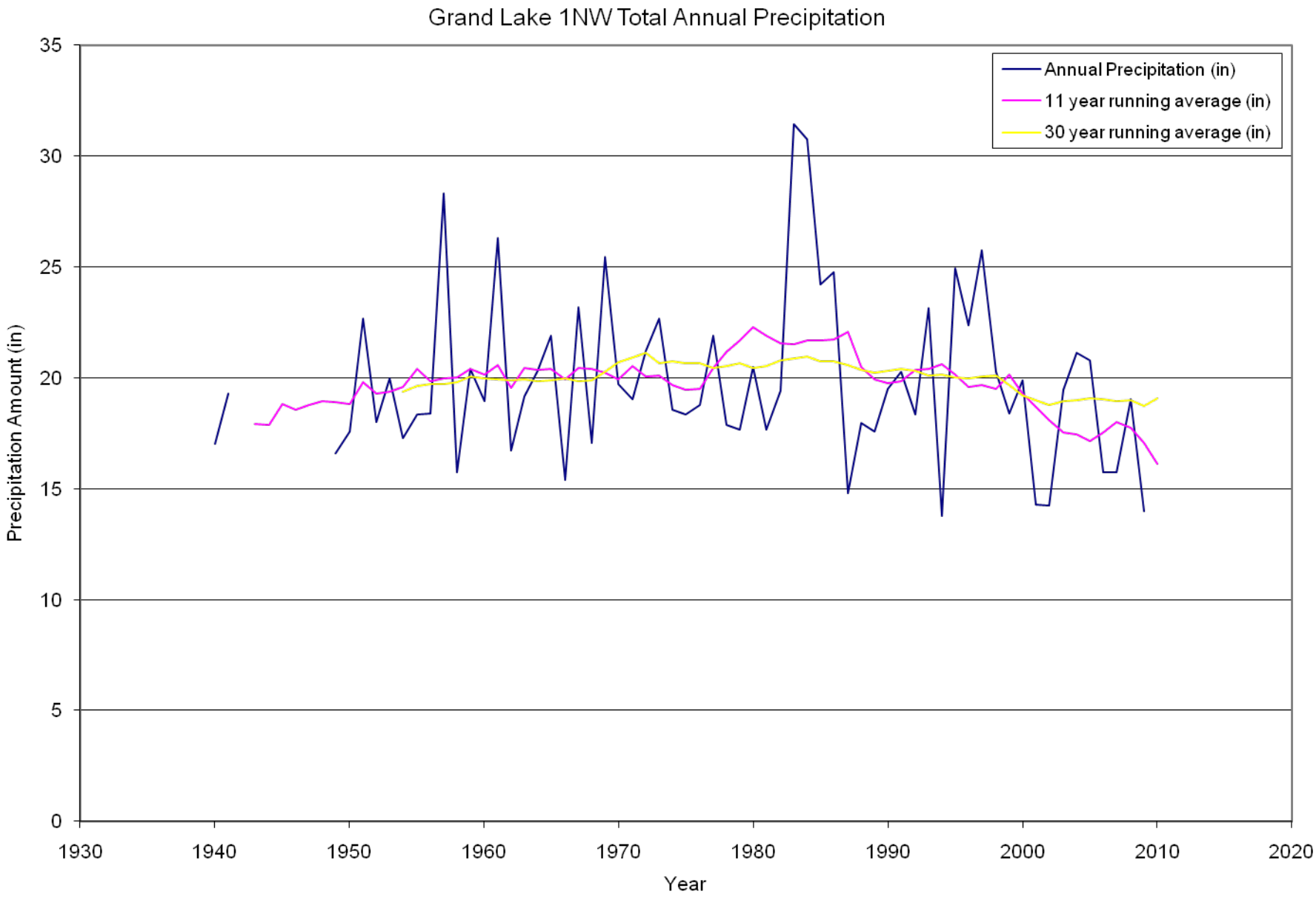
Precipitation and Snowpack – a whole ‘nother animal

Colorado Statewide April 1 Snowpack

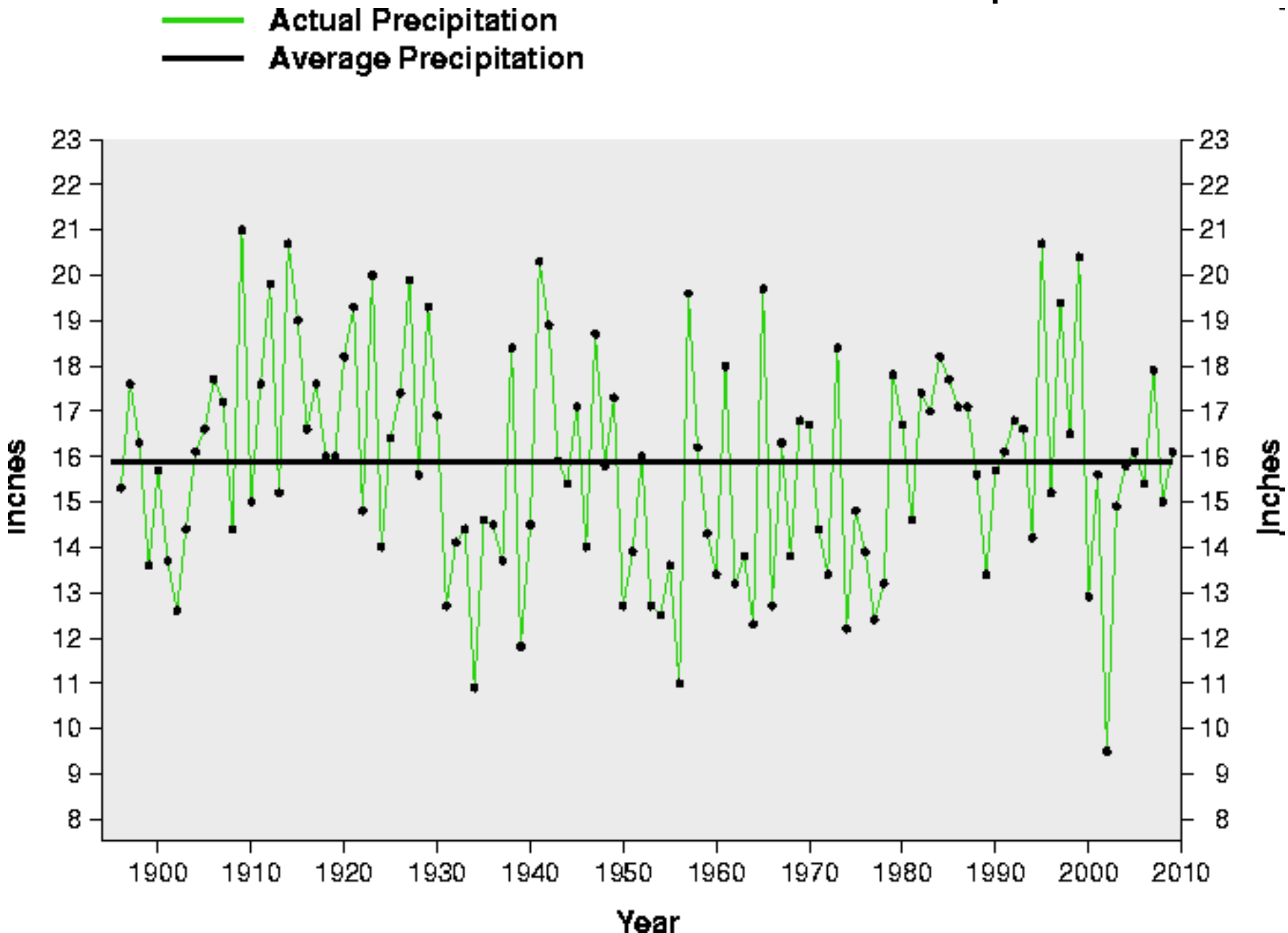



Universtiy Camp, CO (Elevation 10,300') April 1 SWE (in) 1939 - 2010
SWE (in)
0
5
10
15
20
25
30
35
40
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
Snow Course April 1 SWE (in)
Snotel April 1 SWE (in)

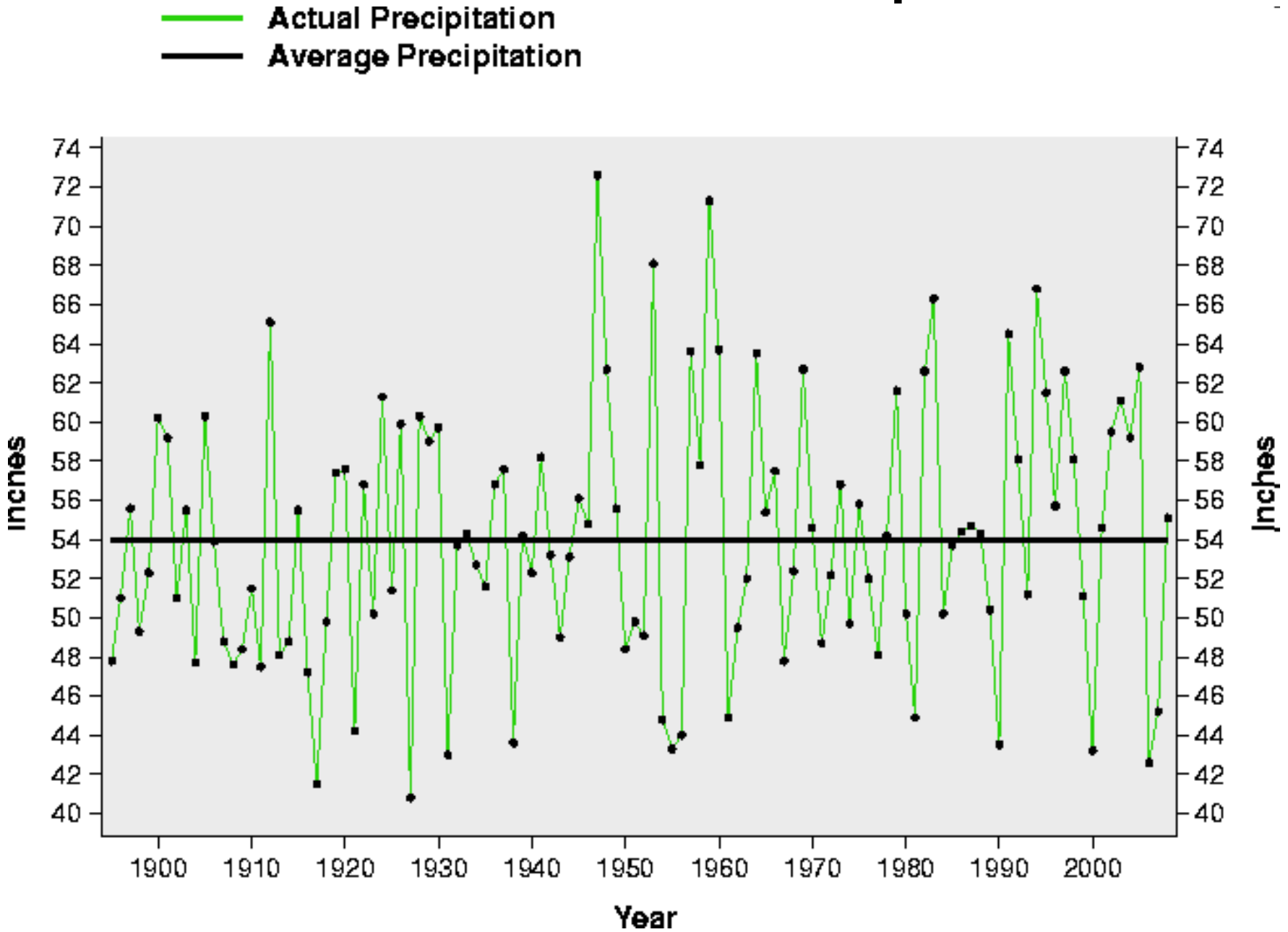

Fort Collins Total Annual Precipitation
Annual Precipitation (in)
11 year running average (in)
30 year running average (in)
Precipitation Amount (in)
Year
0
5
10
15
20
25
30
35
1880
1900
1920
1940
1960
1980
2000
2020


Grand Lake 1NW Total Annual Precipitation
Annual Precipitation (in)
11 year running average (in)
30 year running average (in)
Precipitation Amount (in)
Year
0
5
10
15
20
25
30
35
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020

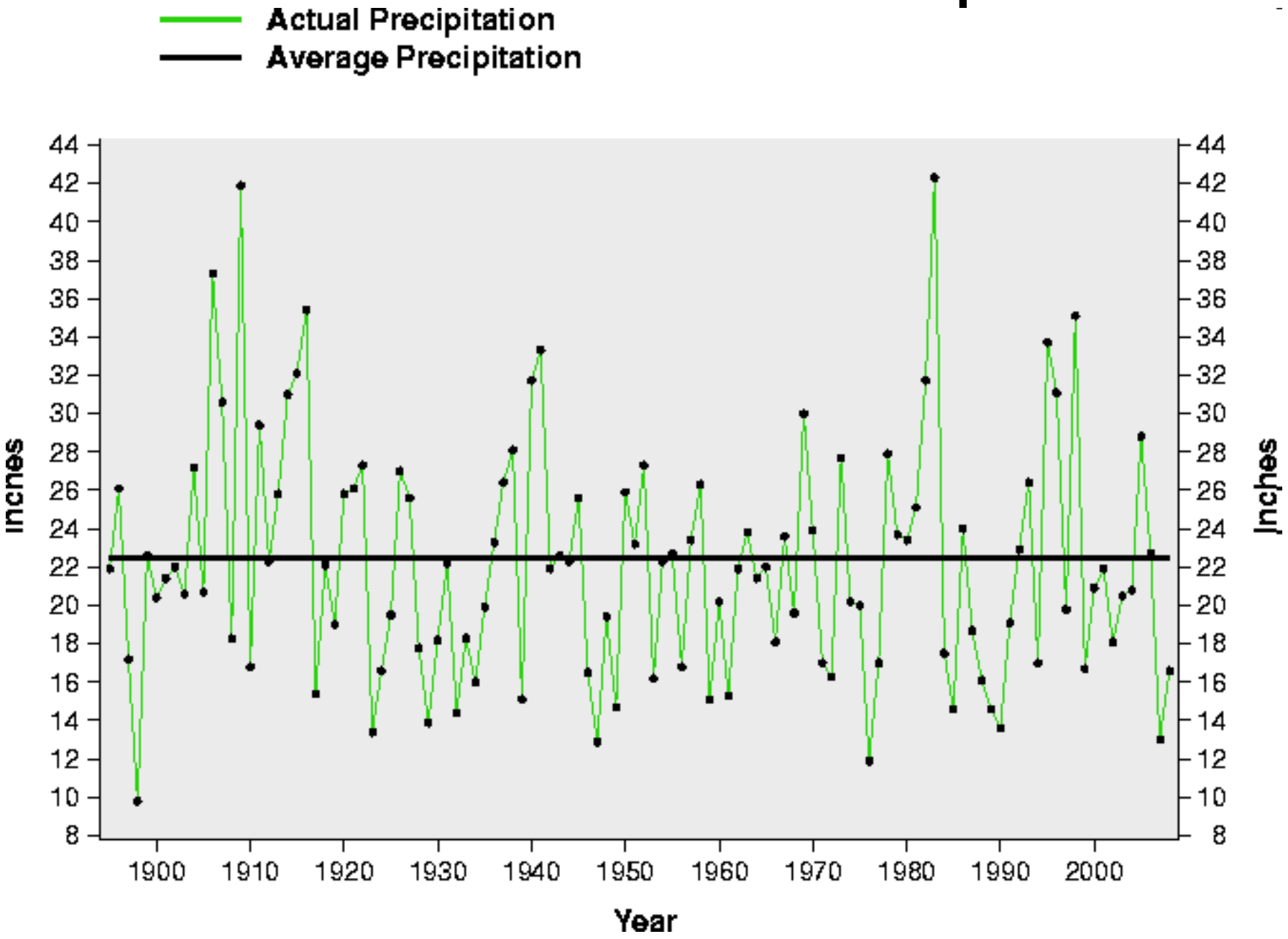
Colorado Statewide Water Year Precipitation



Florida Annual Precipitation



California Annual Precipitation



CoCoRaHS

"Because every drop counts"

"CoCoRaHS is a national grassroots, non-profit, community-based, high-density precipitation network

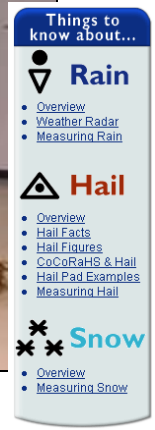
made up of volunteers of all backgrounds and ages . . .

. . . who take daily measurements of "<u>just precipitation</u>" right in their own backyards"

Once trained, our volunteers collect data using low-cost measurement tools . . .

4-inch diameter
high capacity rain gauges

Aluminum foil-wrapped
Styrofoam hail pads



Training is important to assure accurate, high quality data

and report their daily observations on our interactive Web site: **www.cocorahs.org**

My Data Entry : Daily Precipitation Report Form

Precipitation Report Form Submit Data Reset

Station Number : CO-LR-610

Station Name : Fort Collins 3.5 SW

* Denotes Required Field

5/20/2008 *Observation Date

7:00 AM *Observation Time

0.59 *Total Rain and Melted Snow in gauge in inches to the nearest hundredth

(•) Yes ( ) No Report was taken at registered location?

Observation Notes: (This will be available to the public)

It has been so dry, that the cows are now giving powdered milk. Thank God for today's rain!!

New Snow

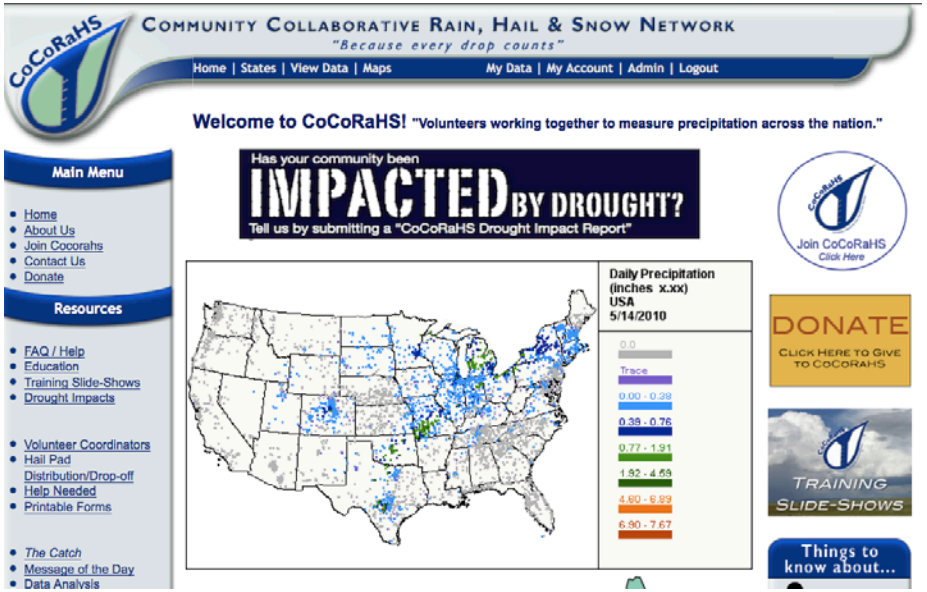
0.0 Depth of new snow in inches to the nearest tenth

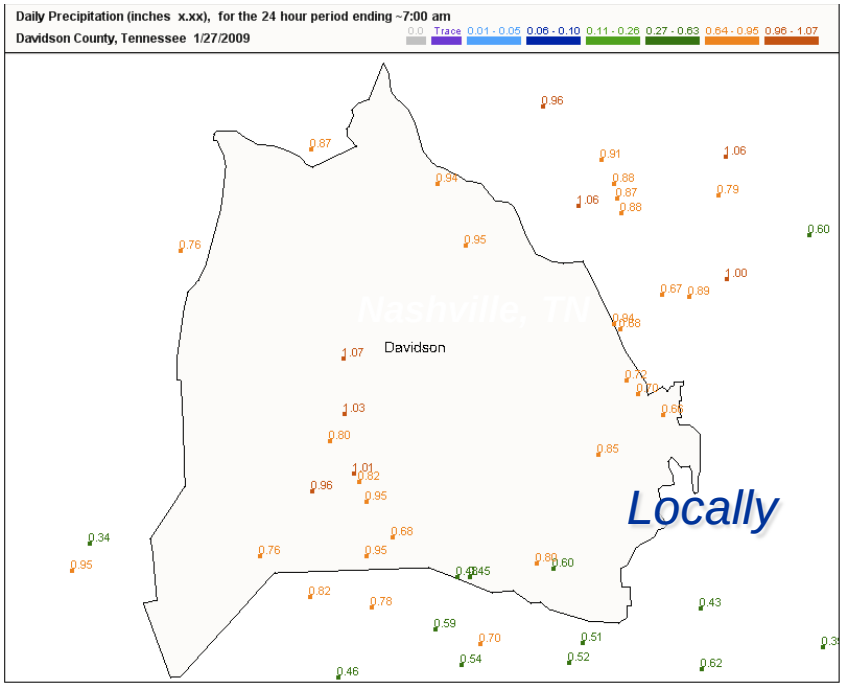
NA Melted value from core to the nearest hundredth

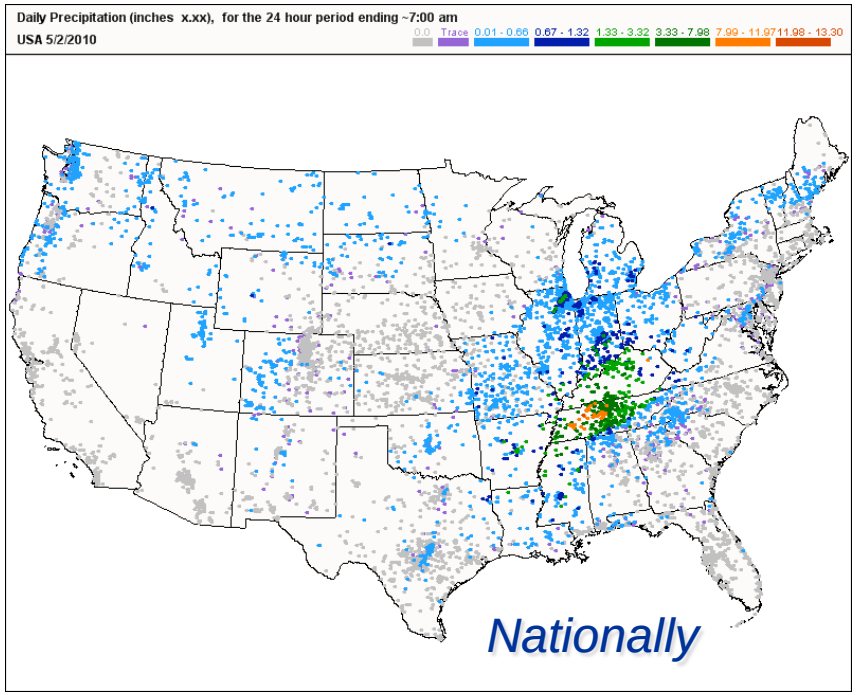
Total Snow on Ground

NA Depth of total snow in inches to the nearest half inch

NA Melted value from core to the nearest hundredth







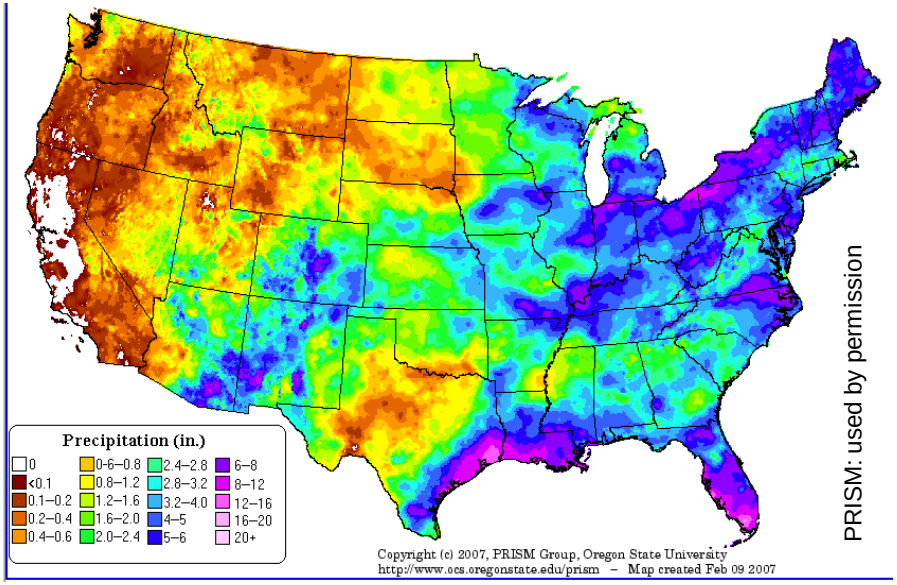
Volunteer's observations are immediately available in map and table form for the public to view.

Date	Time	Station Number	Station Name	Total Precip .ins	New Snow .in	Total Snow .in	State	County	View
1/19/2009	7:00 AM	RI-PR-10	Woonsocket 0.3 W	1.00	11.5	NA	RI	Providence	
1/19/2009	7:00 AM	RI-PR-7	Cranston 1.9 E	0.84	7.0	9.5	RI	Providence	
1/19/2009	8:00 AM	RI-PR-13	Pawtucket 1.4 NE	0.83	8.7	13.0	RI	Providence	
1/19/2009	7:00 AM	RI-PR-11	Providence 3.0 ENE	0.82	9.0	12.0	RI	Providence	
1/19/2009	8:00 AM	RI-WS-8	Saunderstown 2.2 NW	0.73	6.0	NA	RI	Washington	
1/19/2009	8:30 AM	RI-KN-2	East Greenwich 2.3 ESE	0.67	5.5	9.5	RI	Kent	
1/19/2009	7:00 AM	RI-NW-3	Jamestown 2.6 NNW	0.62	5.4	11.0	RI	Newport	
1/19/2009	7:00 AM	RI-WS-7	North Kingstown 3 N	0.59	5.0	9.0	RI	Washington	
1/19/2009	8:30 AM	RI-KN-1	Coventry Center	0.54	8.6	10.0	RI	Kent	
1/19/2009	7:00 AM	RI-WS-6	Narragansett Pier 0.5 N	0.49	4.2	7.5	RI	Washington	
1/19/2009	8:00 AM	RI-WS-9	Charlestown 3.9 NNW	0.46	6.2	9.0	RI	Washington	
1/19/2009	9:00 AM	RI-WS-1	Hope Valley 3.7 S	0.34	3.9	NA	RI	Washington	
1/19/2009	9:30 AM	RI-WS-5	Kingston 0.5 NW	0.31	3.4	8.0	RI	Washington	
1/19/2009	11:59 PM	RI-PR-14	Woonsocket 1.3 ESE	0.13	2.0	12.0	RI	Providence	
1/19/2009	7:00 AM	RI-NW-4	Middletown 1.1 SW	NA	3.0	7.0	RI	Newport	

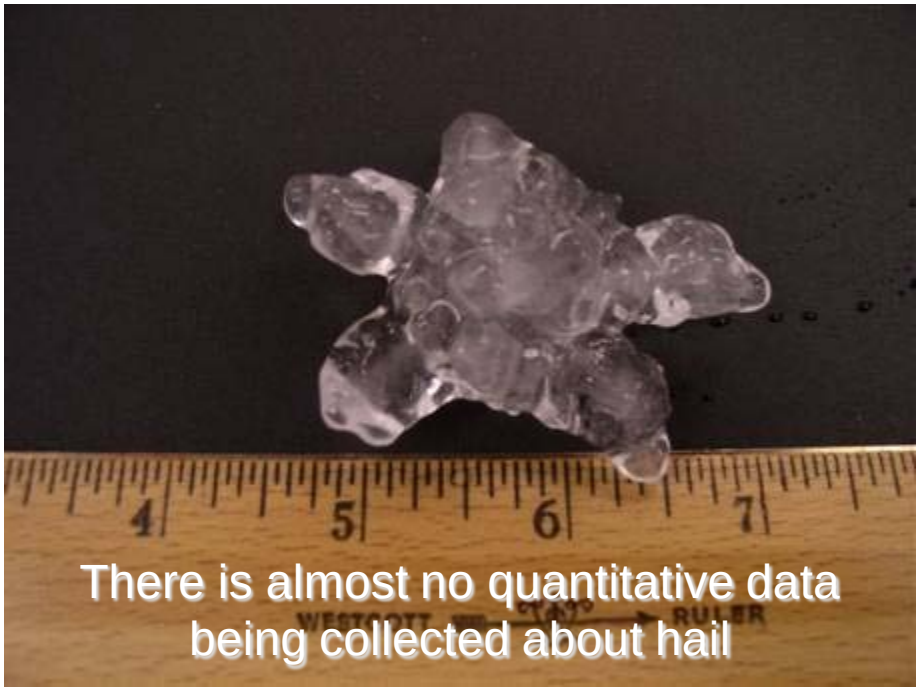
Why CoCoRaHS ??

Precipitation is important and highly variable

Data sources are few and rain gauges are far apart



Measurements from many sources are not always accurate (especially snow)

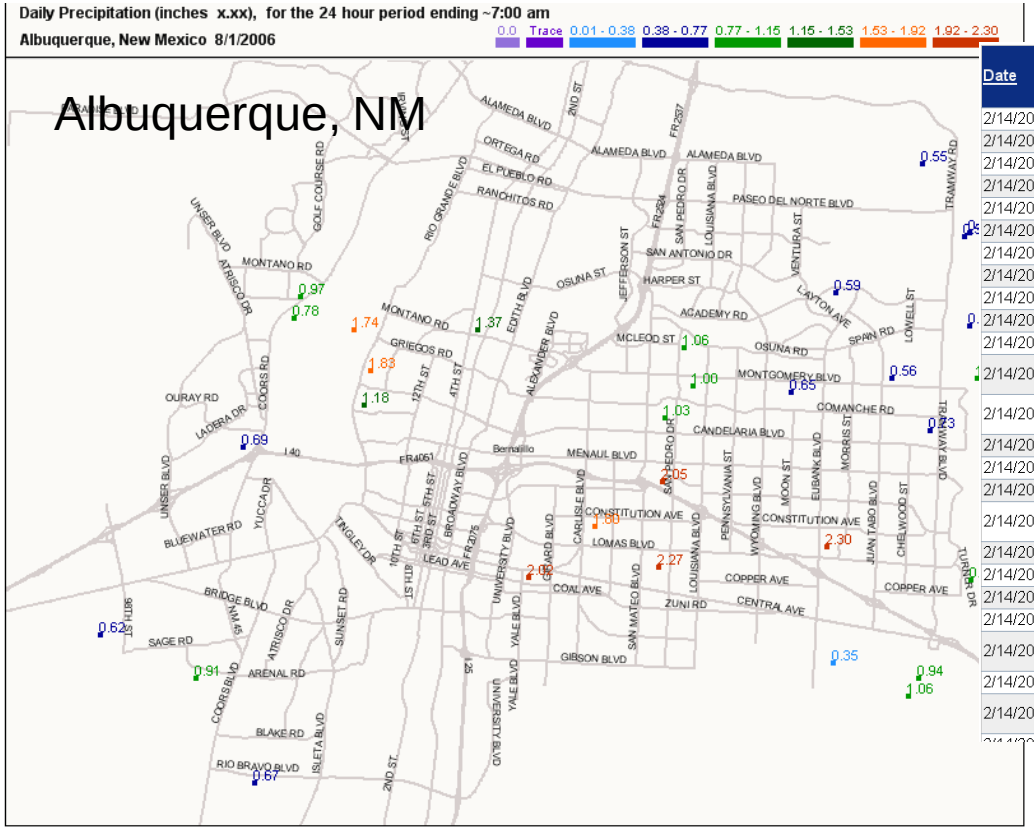


There is almost no quantitative data being collected about hail

Storm reports can save lives

CoCoRaHS's main focus is to provide:

precipitation *data* . . .



Daily precipitation maps:
Rainfall, Hail and Snowfall

Date	Time	Station Number	Station Name	Total Precip .in	New Snow .in	Total Snow .in	State	County	View
2/14/2007	7:00 AM	MD-GR-1	Mc Henry 4.0 SSE	2.85	6.7	12.5	MD	Garrett	
2/14/2007	11:59 PM	MD-MG-8	Gaithersburg 2 WNW	2.80	4.2	4.0	MD	Montgomery	
2/14/2007	10:00 AM	MD-CR-7	Westminster 1.0 W	2.10	5.5	5.5	MD	Carroll	
2/14/2007	7:40 AM	MD-MG-1	Montgomery Village 1.3 SSW	2.05	4.1	3.0	MD	Montgomery	
2/14/2007	5:44 AM	MD-WH-1	Williamsport 2.8 ENE	1.92	2.6	5.0	MD	Washington	
2/14/2007	7:15 AM	MD-CR-3	Mount Airy 0.2 SE	1.90	5.1	5.0	MD	Carroll	
2/14/2007	7:00 AM	MD-CR-6	Taneytown 3.2 NE	1.83	5.0	NA	MD	Carroll	
2/14/2007	7:00 AM	MD-HW-2	Sykesville 1.7 SSE	1.78	5.0	5.0	MD	Howard	
2/14/2007	7:00 AM	MD-HW-12	Sykesville 2.6 SE	1.61	0.0	NA	MD	Howard	
2/14/2007	8:00 AM	MD-MG-3	Potomac 0.9 NNW	1.54	3.2	NA	MD	Montgomery	
2/14/2007	7:00 AM	MD-MG-2	Redland 0.8 NNE	1.52	4.5	4.5	MD	Montgomery	
2/14/2007	7:00 AM	MD-PG-37	Brandywine 6.7 ESE	1.49	T	T	MD	Prince George's	
2/14/2007	7:00 AM	MD-PG-1	Bowie 0.5 E	1.47	1.0	1.5	MD	Prince George's	
2/14/2007	7:00 AM	MD-SM-3	Leonardtown 0.6 NE	1.42	0.0	NA	MD	St. Mary's	
2/14/2007	7:00 AM	MD-CH-7	Waldorf 3.2 SW	1.40	0.8	0.7	MD	Charles	
2/14/2007	7:00 AM	MD-HW-11	Columbia 1.7 W	1.40	3.2	3.5	MD	Howard	
2/14/2007	7:00 AM	MD-PG-7	Camp Springs 1.6 NNW	1.38	1.8	NA	MD	Prince George's	
2/14/2007	4:00 PM	MD-BL-7	White Hall 3.5 NE	1.38	NA	NA	MD	Baltimore	
2/14/2007	7:00 AM	MD-CV-1	Marlton 6.0 E	1.37	0.3	0.0	MD	Calvert	
2/14/2007	7:00 AM	MD-SM-4	Charlotte Hall 3.6 ENE	1.37	0.3	T	MD	St. Mary's	
2/14/2007	7:00 AM	MD-MG-24	White Oak 1.2 N	1.35	2.5	2.0	MD	Montgomery	
2/14/2007	7:00 AM	MD-PG-35	Brandywine 2.5 NNW	1.35	1.0	1.4	MD	Prince George's	
2/14/2007	7:00 AM	MD-WC-1	Vienna 11.3 SSW	1.35	0.0	NA	MD	Wicomico	
2/14/2007	7:00 AM	MD-PG-6	Friendly 1.0 N	1.32	2.4	1.8	MD	Prince George's	

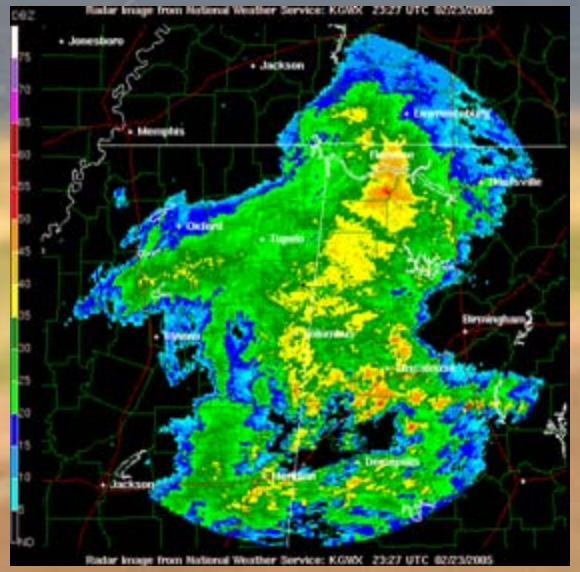
Daily data
in table form

This data allows CoCoRaHS to supplement existing networks and provide many useful results to scientists, resource managers, decision makers and other end users on a timely basis.

CoCoRaHS data are used by many

- National Weather Service
- Other Meteorologists
- Hydrologists
- Emergency Managers
- City Utilities
  - -Water supply
  - -Water conservation
  - -Storm water
- Insurance adjusters
- USDA—Crop production
- Engineers
- Scientists studying storms
- Mosquito control
- Farm Service Agency
- Ranchers and Farmers
- Outdoor & Recreation

- Teachers and Students
  - Geoscience education tool
  - Taking measurements
  - Analyzing data
  - Organizing results
  - Conducting research
  - Helping the community



. . . as well as *educational opportunities*

Things to know about...

Rain

- Overview
- Weather Radar
- Measuring Rain

Hail

- Overview
- Hail Facts
- Hail Figures
- CoCoRaHS & Hail
- Hail Pad Examples
- Measuring Hail

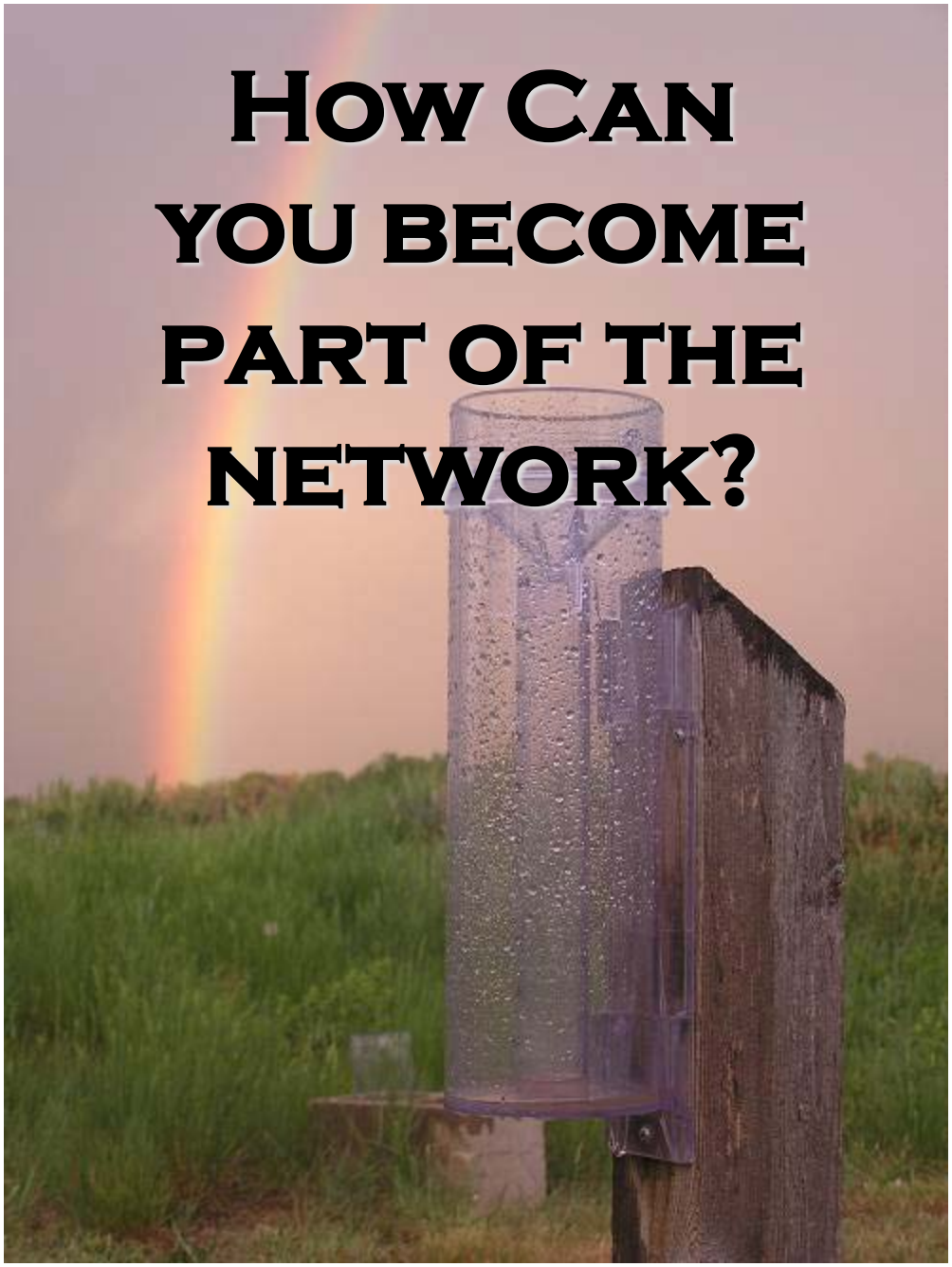
Snow

- Overview
- Measuring Snow

CoCoRaHS hopes to one day achieve a network of . . .

one observer **every square mile**
in **urban** areas

one observer **every 36 square miles**
in **rural** areas



How Can you become part of the network?

Five easy steps

Simply sign-up on the CoCoRaHS web page ***www.cocorahs.org***

Obtain a 4” plastic rain gauge (info available on web site)

View the “training slide show” or attend a training session

Set-up the gauge in a “good” location in your backyard

Start observing precipitation and report on-line daily


Just 5 minutes a day!
It's easy and fun!
We're Cuckoo For CoCoRaHS!
www.cocorahs.org