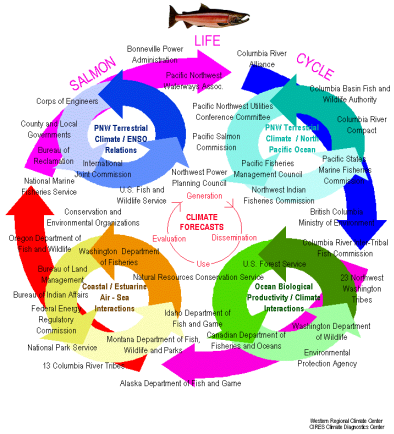
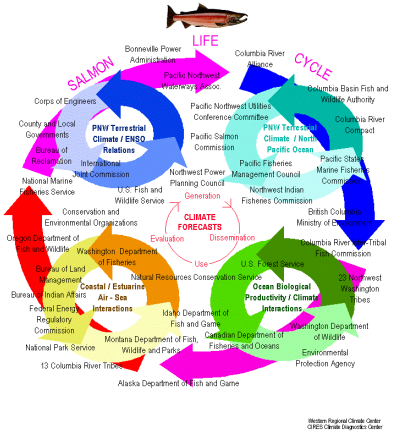
The Same River Twice:

Applied Climatology in a Changing Environment





Kelly T. Redmond

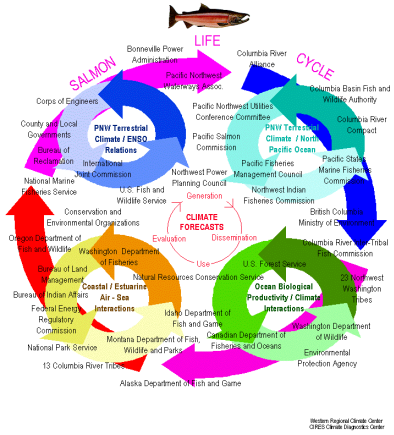
Western Regional Climate Center

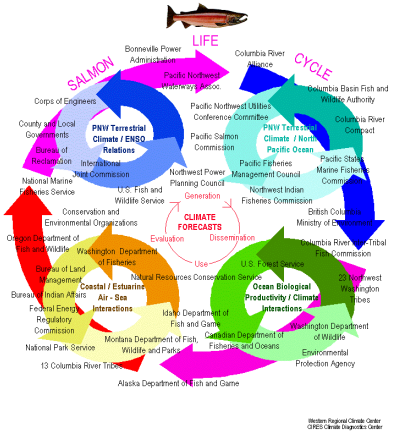
Desert Research Institute

Reno Nevada

17th AMS Conference on Applied Climatology

Whistler BC 2008 August 11-14





Western Regional Climate Center
CIRES Climate Diagnostics Center

BAMS, March 1997

“No man ever sets foot in the same river twice,

for it’s not the same river and he’s not the same man.”

Heraclitus of Ephesus 535-475 BC

Starting point:

“Applied Climatology: A Glorious Past – An Uncertain Future”

Stan Changnon, 1995, 9th AMS Conference on Applied Climatology, Dallas, January 15-20

Issues

1) **Whether data and information were being effectively used**
2) **Significant problems with data**
3) **Gaps between users (or potential users) and providers of data and information.**

Concern about an uncertain future for applied climate

Field in the midst of an identity crisis, thus not sufficiently appreciated or understood

AMS 14th Conference on Applied Climatology
The Lifelong Work of Stan Changnon 13 January 2004

What's new ? (ktr)

External (world at large)

- Computing
- The Web
- Powerpoint everywhere
- An increasingly interdisciplinary mindset
- Health of the environment concerns
- Climate change prospects
- Service mentality resurrected

Internal (to climate services community)

- State climate programs more active and visible
- Regional Climate Center program
- Regional Integrated Sciences and Assessments program

And a second look:

“Applied Climatology: The Golden Age Has Begun”

Stan Changnon, 2005. Bulletin of the American Meteorological Society, July, 86(7), 915-919.

Even so, still some issues:

1) **Teaching of applied climatology still too limited**
2) **Adequacy of instrumentation and data collection**
3) **Outreach and awareness still not sufficient**
4) **Better information on impacts of extremes**
5) **Need better information on climate change effects**

What is applied climatology? Stan Changnon (2005):

"My interpretation is that applied climatology describes, defines, interprets, and explains the relationships between climate conditions and countless weather-sensitive activities."

Its work ranges over four basic areas:

1) **Design of structures and planning of activities**

2) **Assessments of current and past conditions, including evaluation of extreme events**

3) **Study of the relationships between weather / climate conditions and those in other parts of the physical and socioeconomic worlds**

4) **Operation of weather-sensitive systems that employ climatic information in making decisions**

What is changing?

Many of the underlying issues remain the same,
but what is changing is the context.

1) **Changes in climate (the physical system)**

2) **Changes in the understanding of climate**

3) **Changes in needs for climate information**

Old, familiar needs

New needs, new applications, more sophisticated applications

Five themes of interest

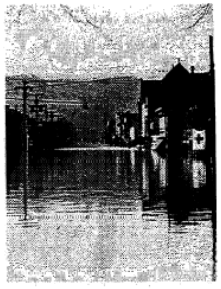
1. Climate stationarity, evolving statistics, challenges /opportunities
2. Observational underpinnings for climate applications
3. Quality control, and quality control of quality control
4. Mountain climates, and related scale issues
5. The role of a National Climate Service

A preliminary: Applications as forecasts

An implicit assumption that has pervaded much of applied climatology

- **Past is Prologue**
  - **Past statistics = Future statistics**
- **The decision that uses the information is about the future**
- **Therefore, past values often de facto forecasts**
  - **Not explicitly recognized as such**
- **Past is considered reliable guide to the future**
- **Climate stationarity is implicit in this assumption**
- **Huge societal investments ($B, $$B, $$$B)**

Bulletin 17 B



Guidelines For Determining

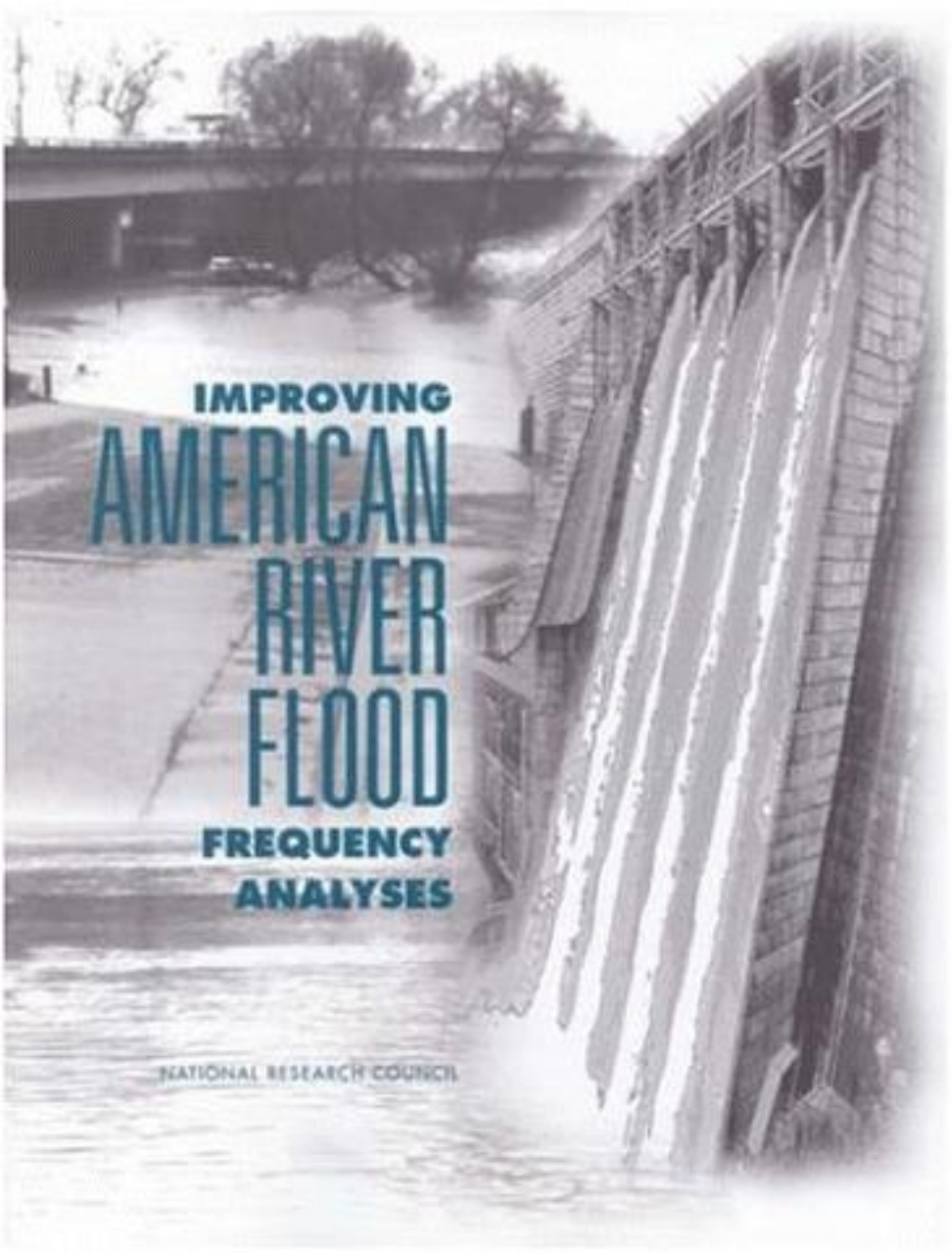
Flood Flow Frequency

Bulletin # 17B
of the
Hydrology Subcommittee

Revised September 1981
Editorial Corrections March 1982

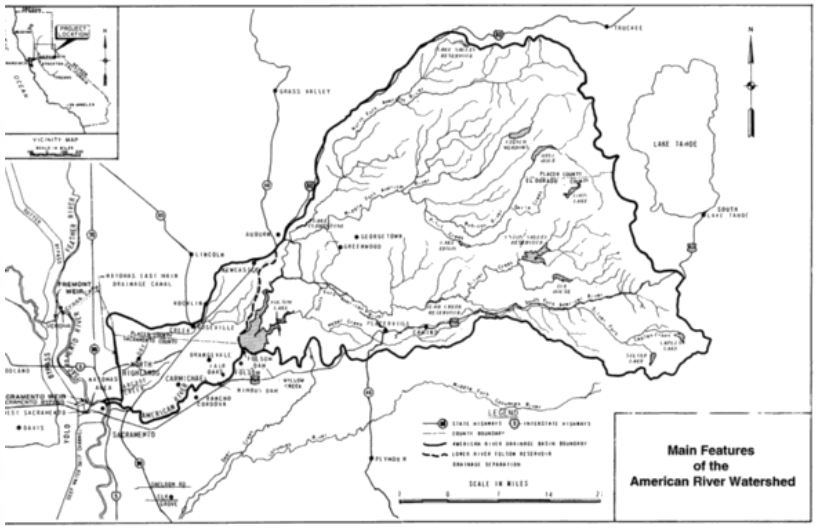
INTERAGENCY ADVISORY COMMITTEE
ON WATER DATA

U.S. Department of the Interior
Geological Survey
Office of Water Data Coordination
Reston, Virginia 22092

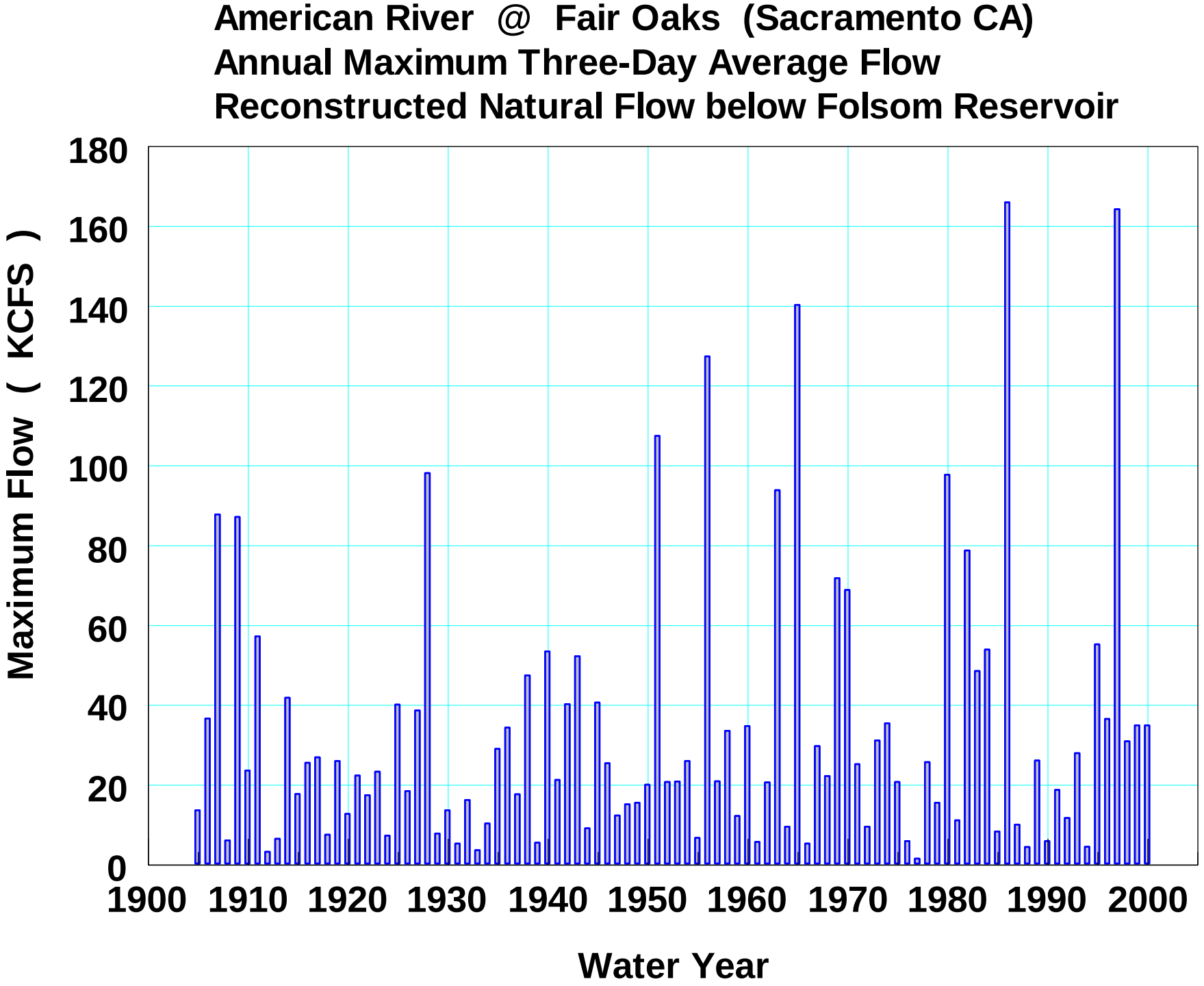


National Research Council

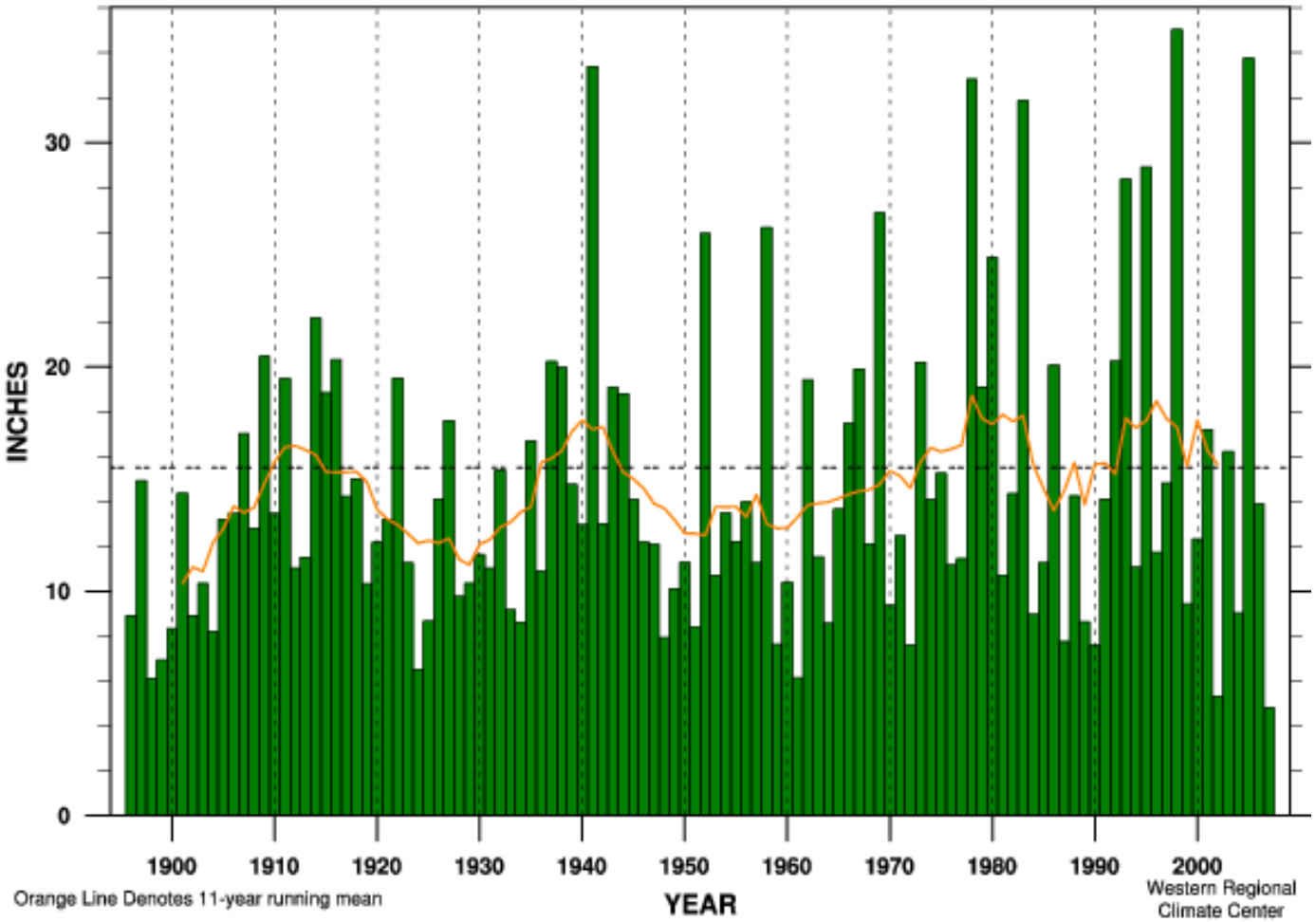
January 1999



IGURE 1.1 Main features of the American River watershed. SOURCE: Sacramento District, USACE, 1991.


American River @ Fair Oaks (Sacramento CA)
Annual Maximum Three-Day Average Flow
Reconstructed Natural Flow below Folsom Reservoir
Maximum Flow (KCFS)
180
160
140
120
100
80
60
40
20
0
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
Water Year

South Coast Region
Precipitation Oct-Sep

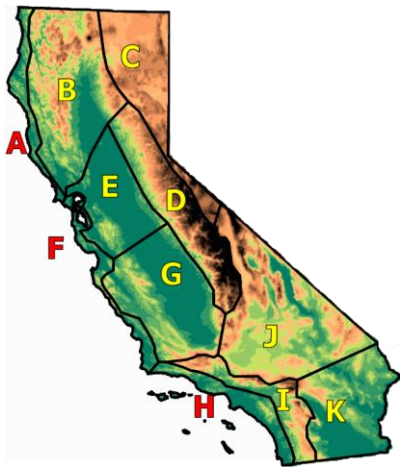


Linear Trend 1895-present	+ 3.60 ± 3.72 in.	(+ 23 ± 23%) per 100 yr	
Linear Trend 1949-present	+ 4.82 ± 12.01 in.	(+ 31 ± 77%) per 100 yr	
Linear Trend 1975-present	- 8.52 ± 34.69 in.	(- 54 ± 223%) per 100 yr	
Wettest Year	35.03 in. (225%)	in 1998	MEAN 15.51 in.
Driest Year	4.81 in. (31%)	in 2007	STDEV 7.57 in.
Oct-Sep 2007	4.81 in. (31%)		RANK 1 of 112

Water Year Oct-Sep Precip

South Coastal California

1895/96 thru 2006/07



Karl and Knight, 1998. Fraction of annual total from upper 10th percentile, US Average.

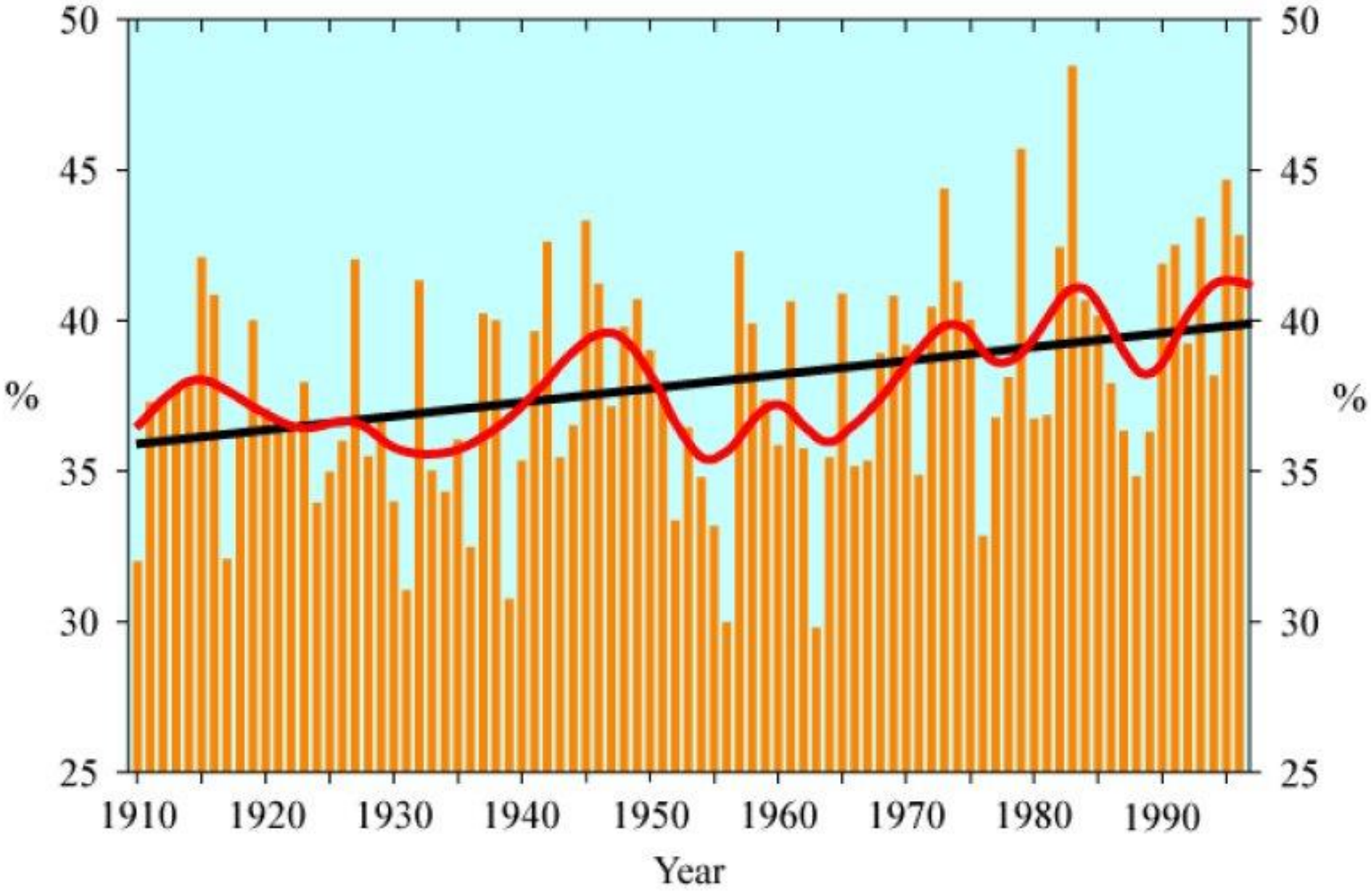
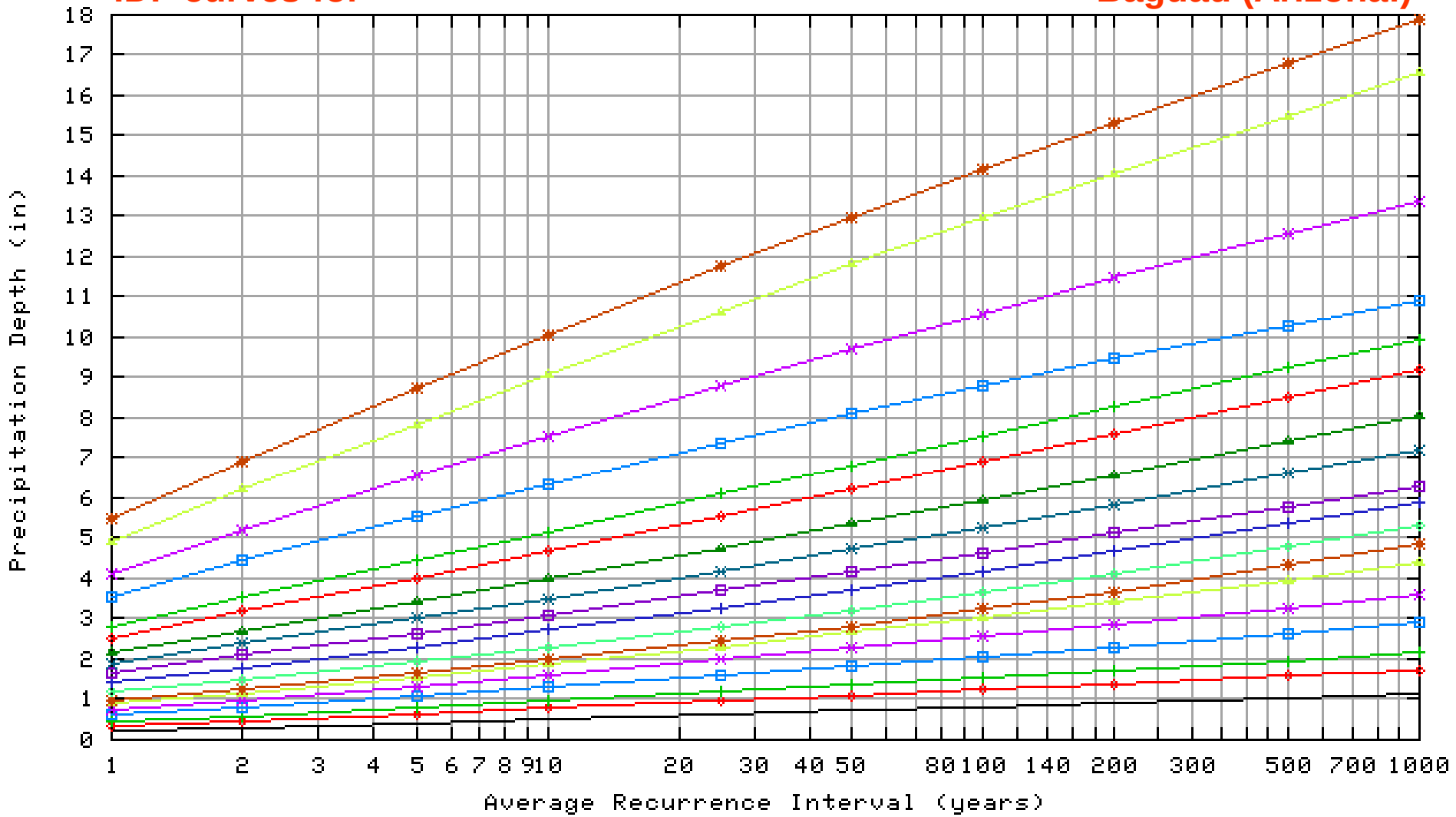


FIG. 2. Time series of the percent contribution of the upper 10 percentile of daily precipitation events to the total annual precipitation area-averaged across the United States. Smooth curve is a nine-point binomial filter, and the trend is also depicted.

Partial duration based Point Precipitation Frequency Estimates - Version: 4

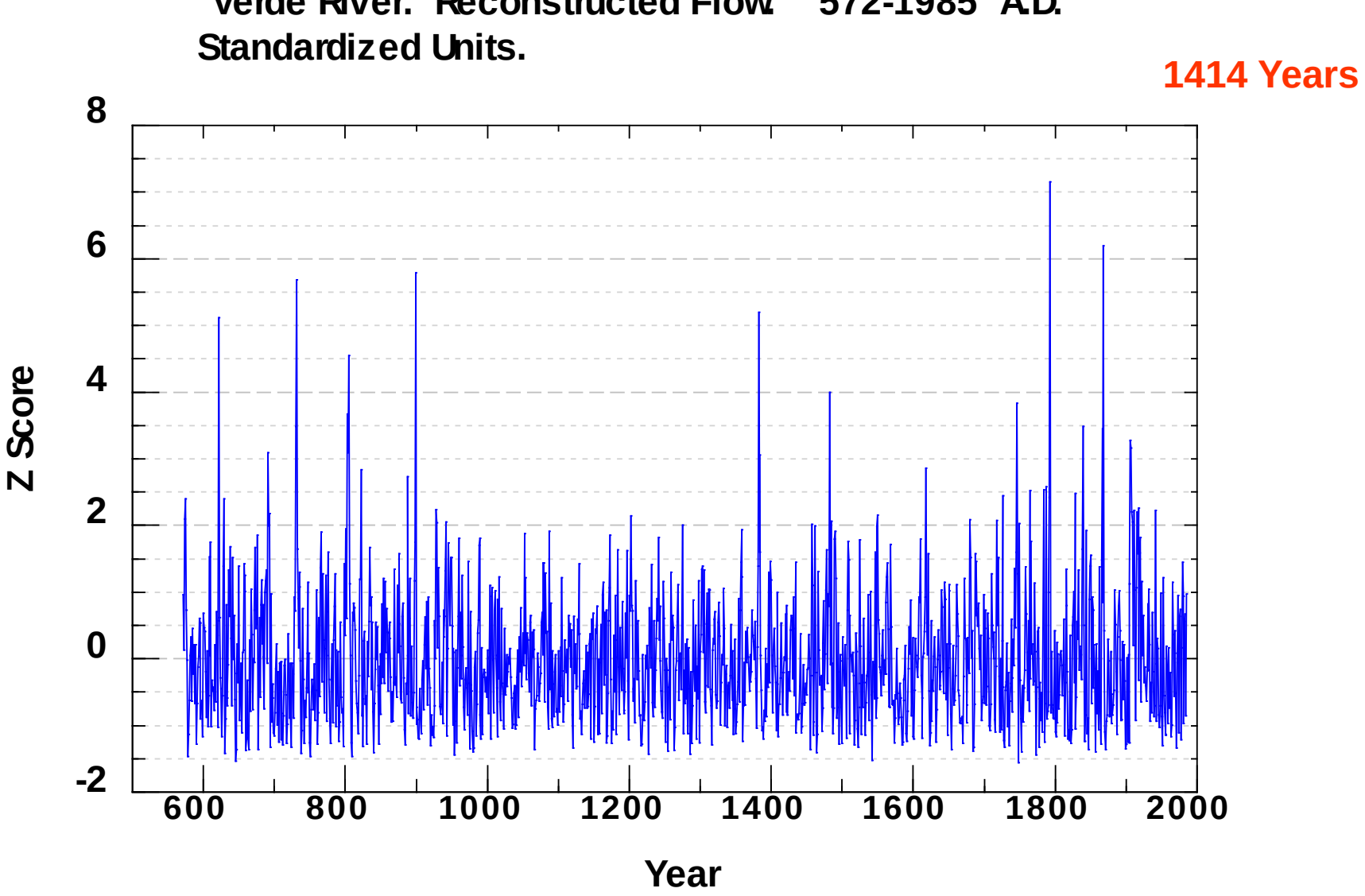
34.5672 N 113.1778 W 3802 ft

IDF curves for Bagdad (Arizona!)

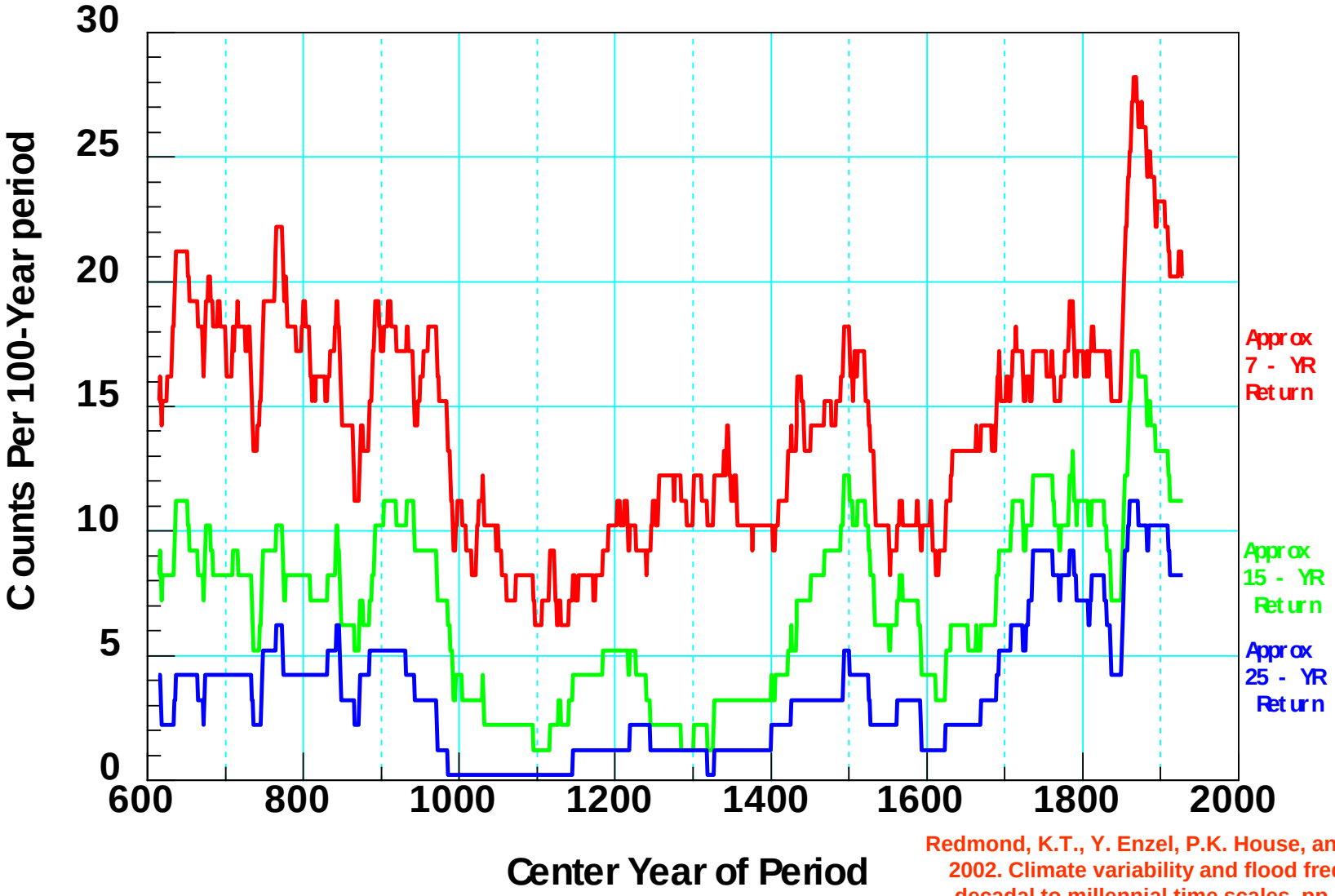


Fri Aug 08 16:35:55 2008

Duration			
5-min	120-m	48-hr	30-day
10-min	3-hr	4-day	45-day
15-min	6-hr	7-day	60-day
30-min	12-hr	10-day	
60-min	24-hr	20-day	



Redmond, K.T., Y. Enzel, P.K. House, and F. Biondi, 2002. Climate variability and flood frequency at decadal to millennial time scales. pp. 21-45, in *Principles and Applications of Paleoflood Hydrology,* editors: P.K. House, R.H. Webb, and V.R. Baker, American Geophysical Union, 385 pp.



Redmond, K.T., Y. Enzel, P.K. House, and F. Biondi, 2002. Climate variability and flood frequency at decadal to millennial time scales. pp. 21-45, in *Principles and Applications of Paleoflood Hydrology*, editors: P.K. House, R.H. Webb, and V.R. Baker, American Geophysical Union, 385 pp.

1. "Stationarity is dead" *

Stationarity was never really fully alive.

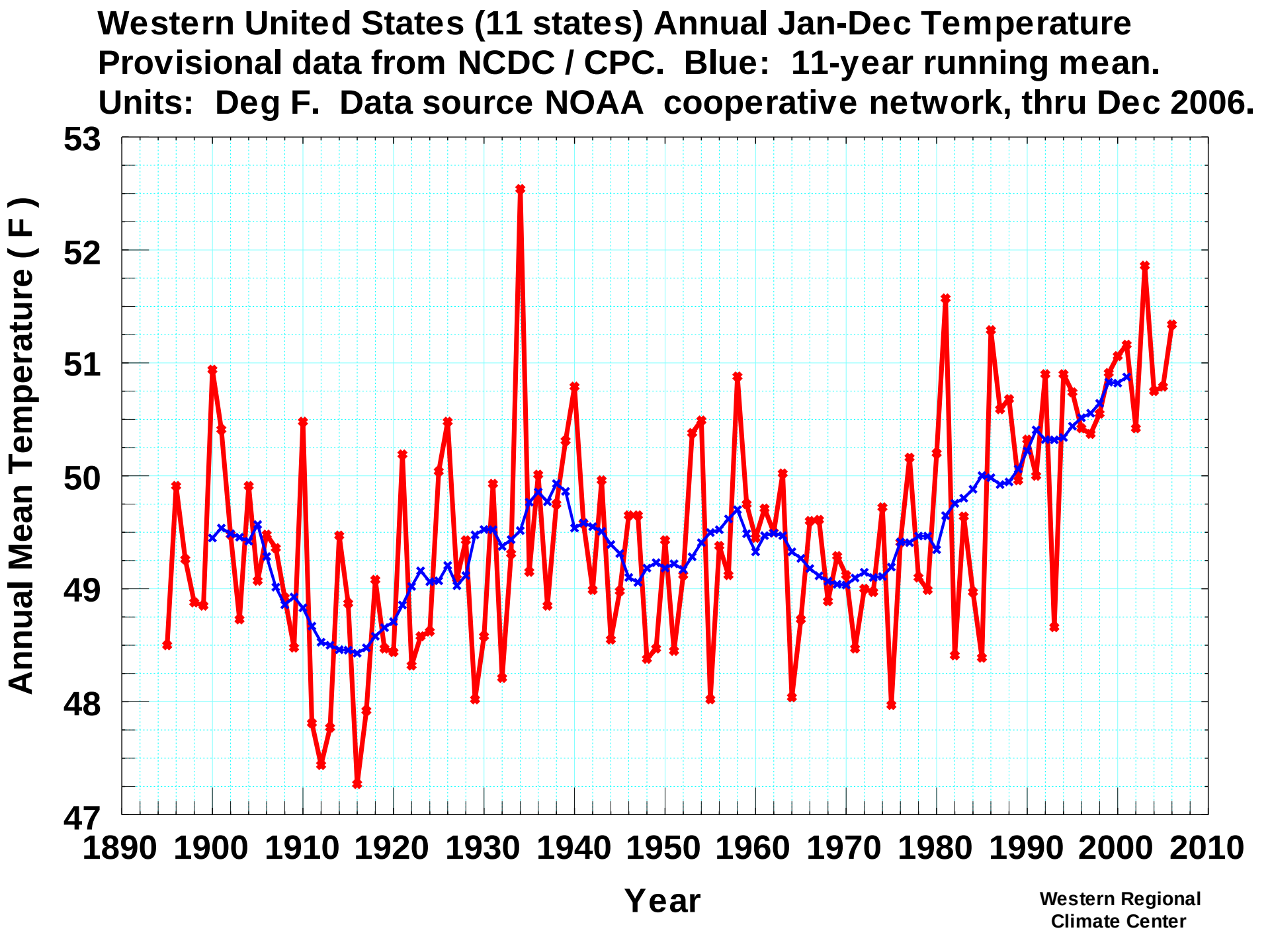
"The history of climate is a nonstationary time series." *

Corollary:

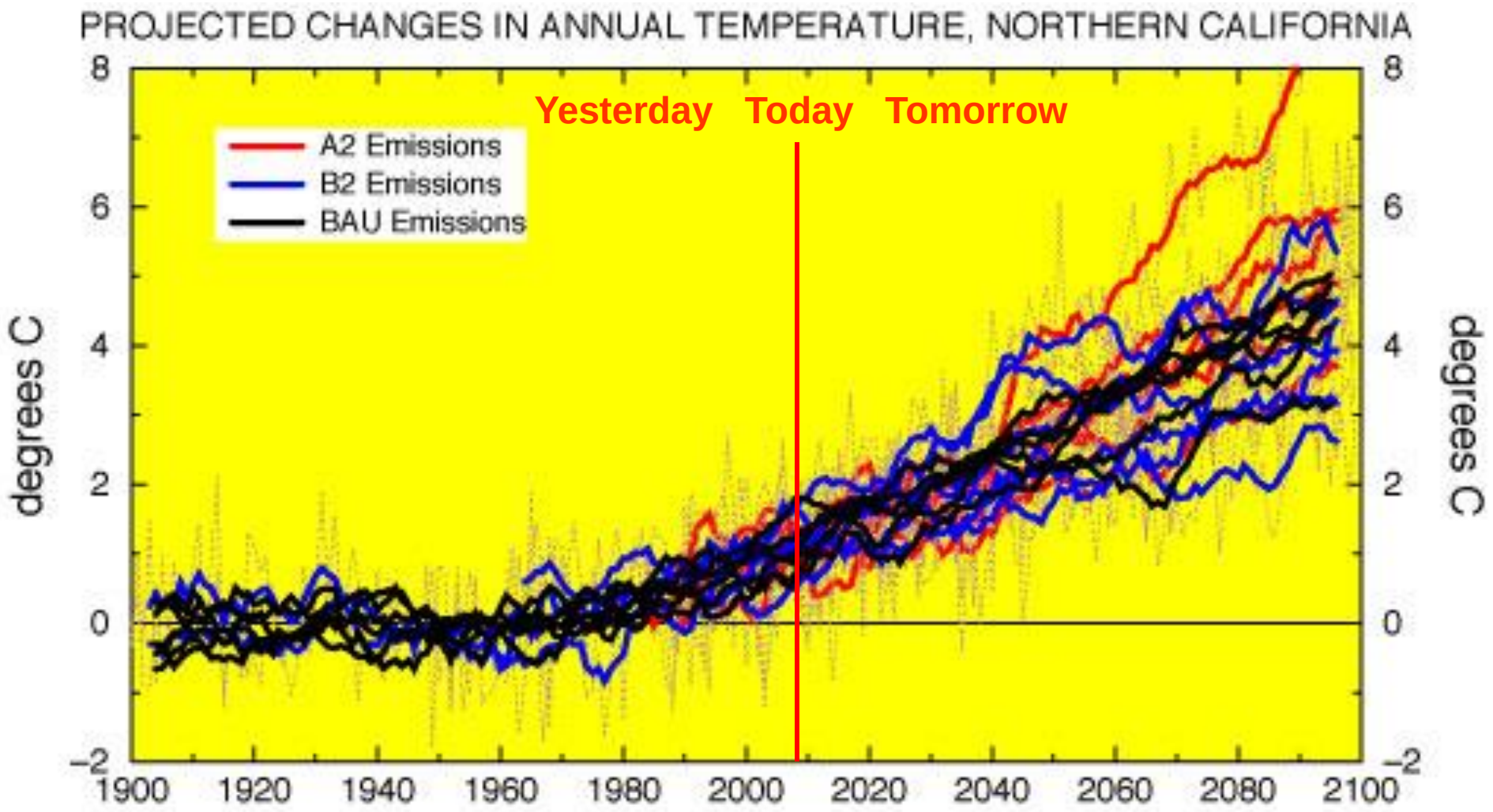
There are no true climatic "normals".

* P.C.D. Milly, Julio Betancourt, Malin Falkenmark, Robert M. Hirsch, Zbigniew W. Kundzewicz, Dennis P. Lettenmaier, Ronald J. Stouffer, 2008. Stationarity is dead: Whither water management?. Science, 319 (5863), 573-574, 1 Feb 2008.

* Reid A. Bryson, 1997. The Paradigm of Climatology: An Essay. Bulletin of the American Meteorological Society, 78(3), 449-455.


Western United States (11 states) Annual Jan-Dec Temperature
Provisional data from NCDC / CPC. Blue: 11-year running mean.
Units: Deg F. Data source NOAA cooperative network, thru Dec 2006.
Annual Mean Temperature (F)
53
52
51
50
49
48
47
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Year
Western Regional
Climate Center

Courtesy of Mike Dettinger, USGS / Scripps.



Dettinger MD. 2005. From climate change spaghetti to climate-change distributions for 21st Century California. San Francisco Estuary and Watershed Science. Vol. 3, Issue 1, (March 2005), Article 4. http://repositories.cdlib.org/jmie/sfews/vol3/iss1/art4

Stationarity, if even alive, is not feeling well … "under the weather"

The "present future" will slowly depart from its "prior future"

Stationarity slowly but progressively becoming a less valid assumption

How much until this departure is "significant" ?
(not so much in statistical terms, but in practical terms)

Major question looming: How do we adjust all the statistics of the past to reflect the expected future?

This is a *very big* challenge / opportunity for Applied Climatology

A growth industry

Methodology
Application of that methodology
Acceptance of that methodology

2. Observations: Real climate change versus fake climate change

Change (and variability):

Is it observational methodology, or is it climate ???

Is it perception or is it reality ?

Is it the perceiver or the perceived ?

Do we trust the data ???

The bigger (real) question:

Is what we think we believe really true ??

Observations:

A perpetual preoccupation among applied climatologists

Consistency through time as a hallmark of climate observations.

A necessity, not just a convenience.

What is the depth of our commitment to this issue?

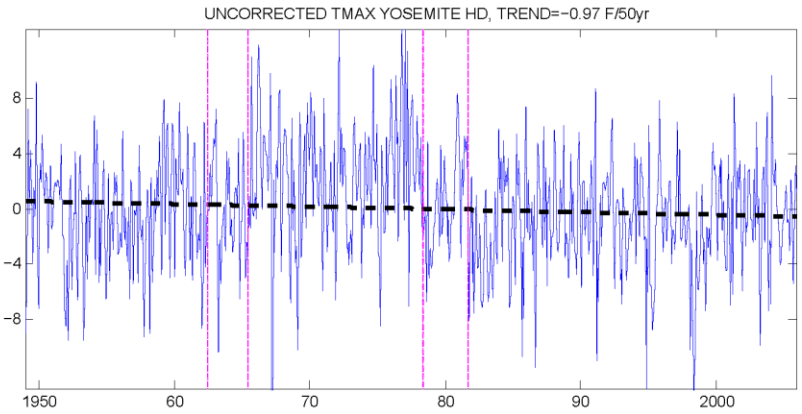
The value of an observational record increases nonlinearly with its length.

Some things can only be discovered from long records.

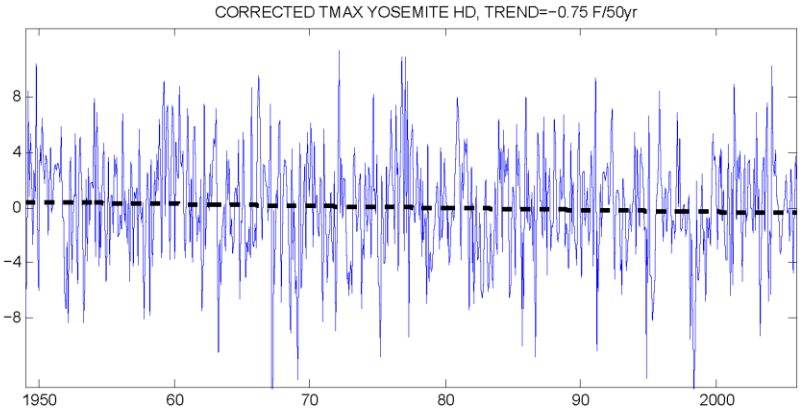
1. **Keep observations going.**

2. **QC – Keep obs honest and accurate and representative**
   (side question: representative of what ?)

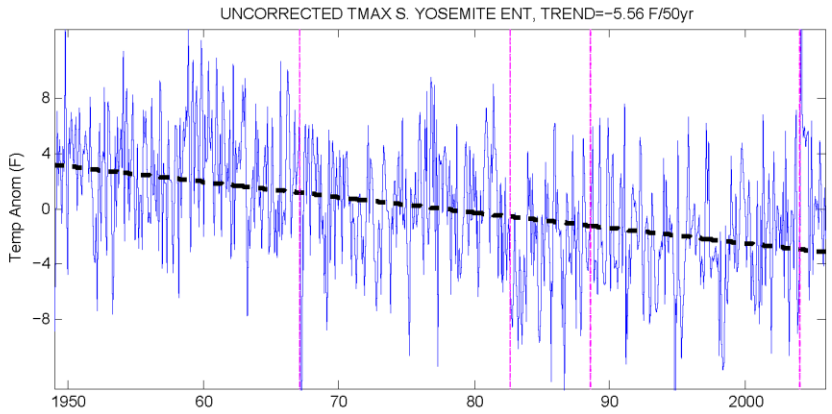
Yosemite Valley TMAX



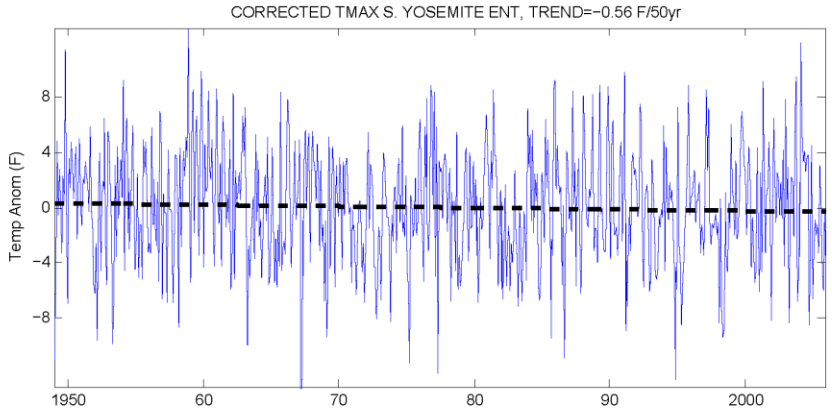
1950 2005



Yosemite South Entrance TMAX



1950 2005

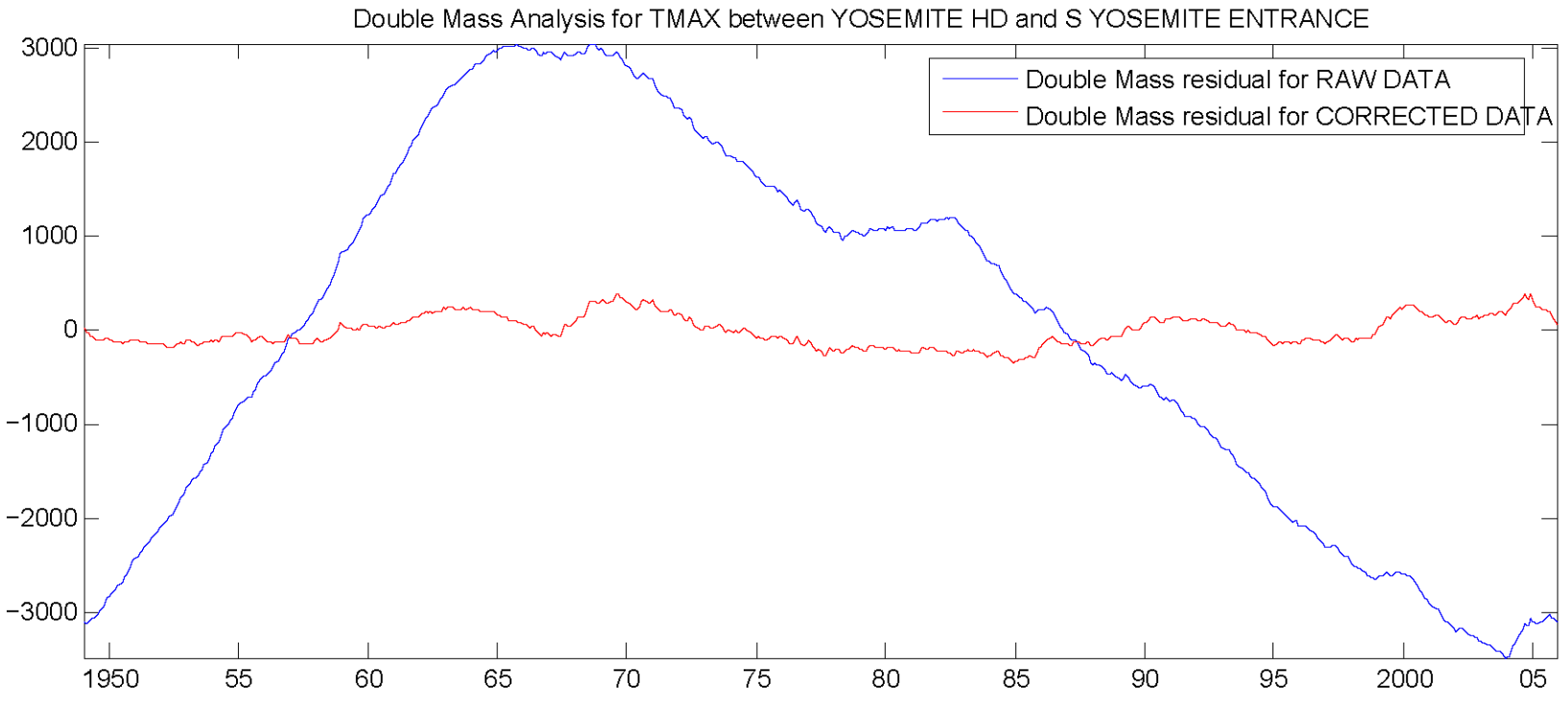


John Abatzoglou

Student Version of MATLAB

Student Version of MATLAB

Double Mass comparison of Yosemite Valley and South Entrance TMAX



1950 **2005**

updated 1:47 a.m. EDT, Wed March 12, 2008

Vatican lists new sinful behaviors

STORY HIGHLIGHTS

NEW

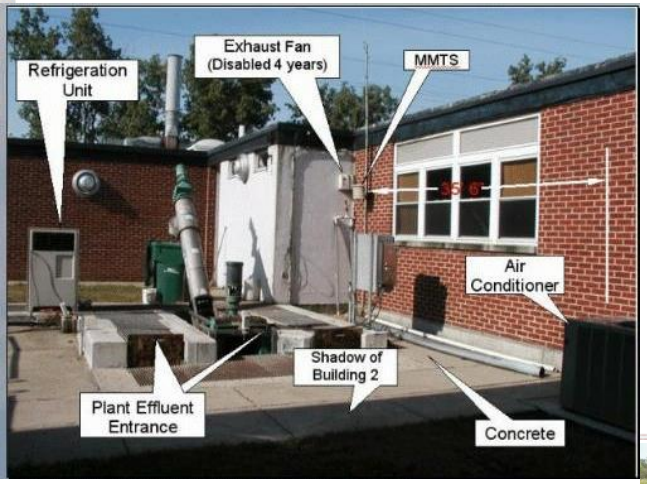
- Drugs, pollution, genetic manipulation are now included
- Update announced in Vatican daily, "L'Osservatore Romano"
- Sinners risk burning in hell unless absolved through confession and penitence
- Recent survey finds 60 percent of Italian Catholics don't go to confession

Next Article in Living »

READ | VIDEO

TEXT SIZE

ROME, Italy (AP) -- A Vatican official has listed drugs, pollution and genetic manipulations as well as social and economic injustices as new areas of sinful behavior.



Ctsy: surfacestations.org

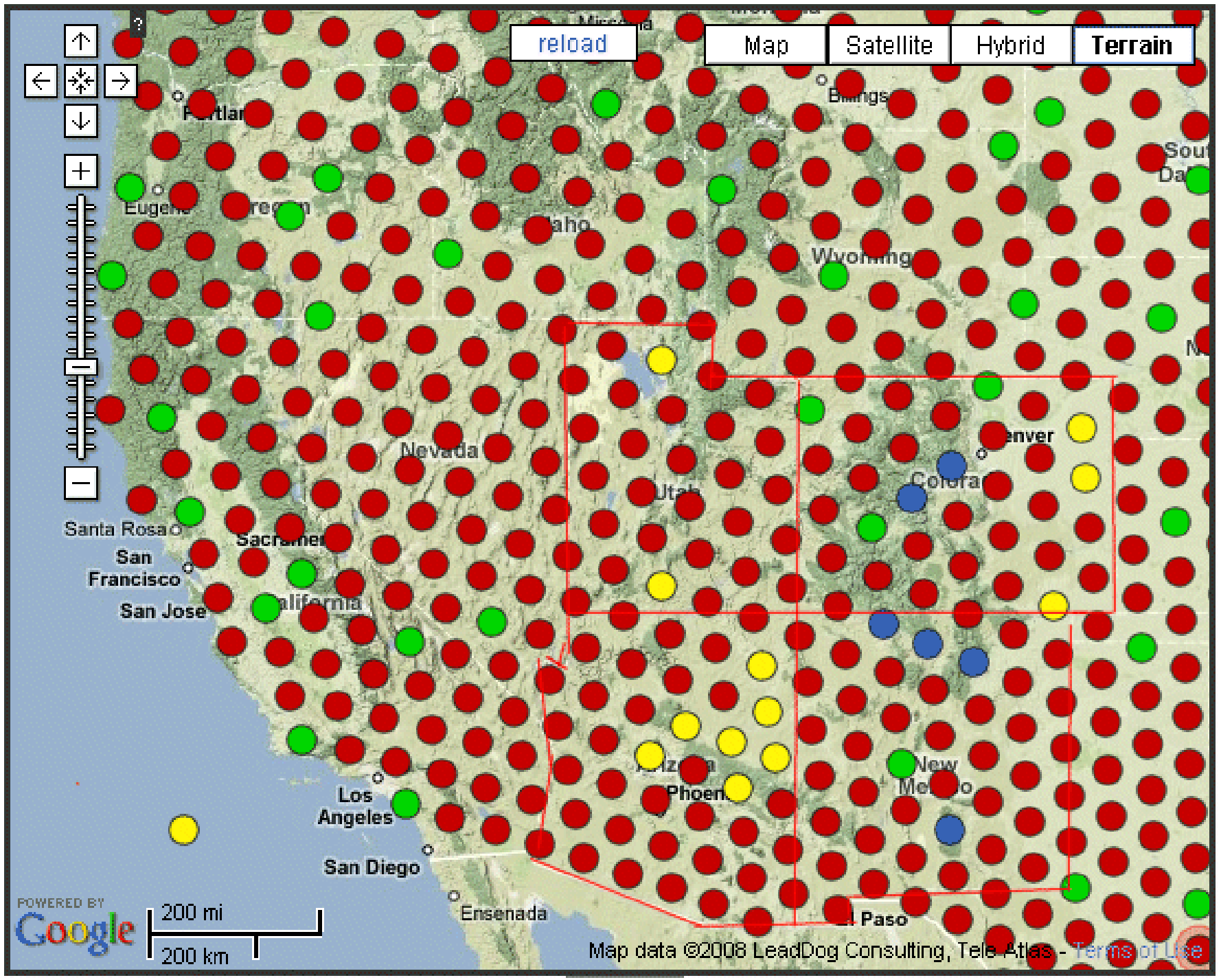
Monsignor Gianfranco Girotti said in an interview published on Sunday by the Vatican's daily newspaper, L'Osservatore Romano, that known sins increasingly manifest themselves as behavior that damages society as a whole.

Girotti, who heads the Apostolic Penitentiary, a Vatican body that issues decisions on matters of conscience and grants absolutions told the paper that whilst sin used to concern the individual mostly, today it had a mainly a social resonance, due to the phenomenon of globalization.

Catholic teaching distinguishes between lesser, so-called venial sins, and mortal sins

Kelly Redmond

Chinle Airport, Arizona. HCNM prospect. View to the North, East, West, and South.



HCNM Grid

50 km Radius

Green CRN

Red TBD

Yellow Survey Done

Blue In prog

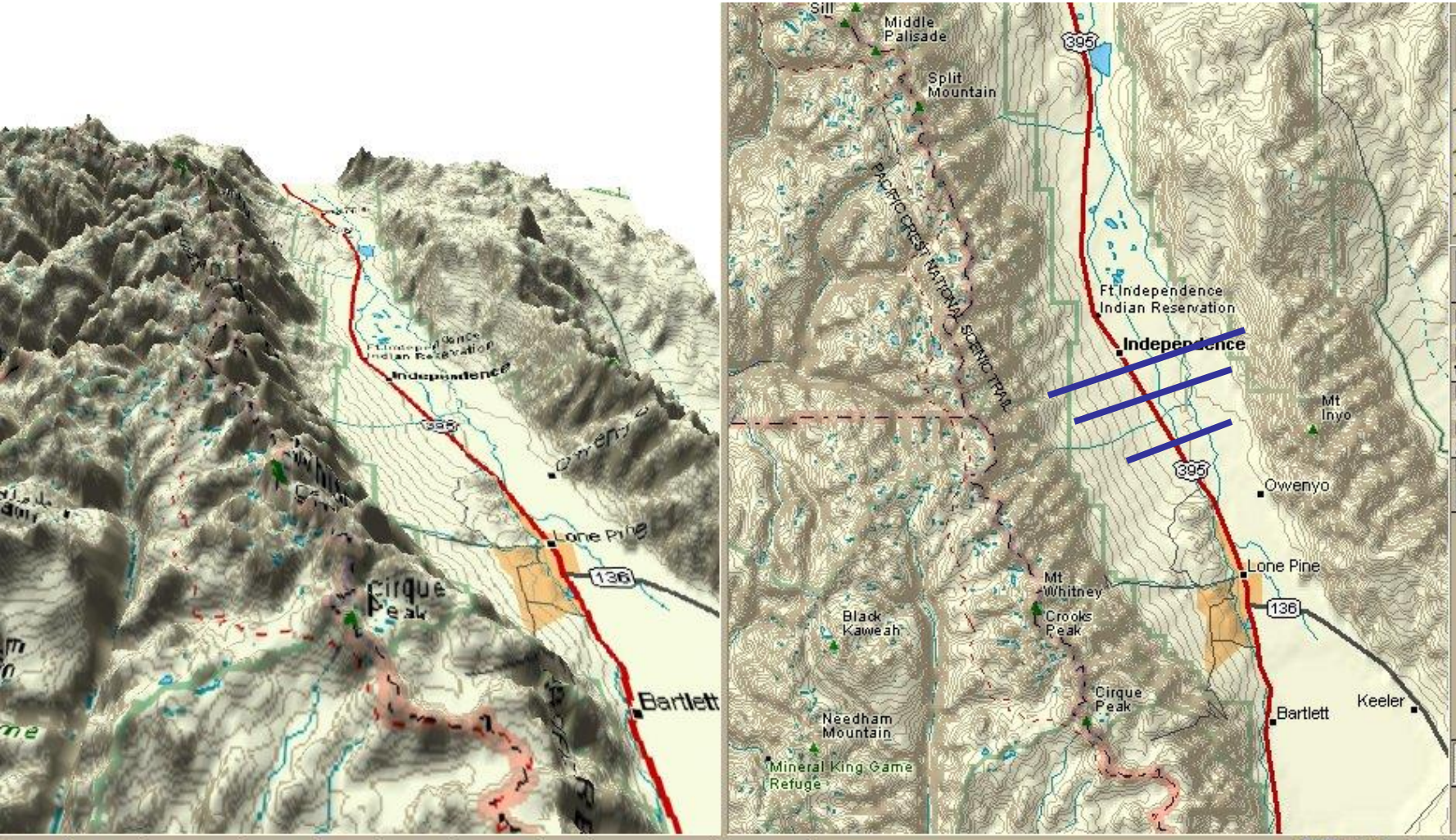
HCN-M Bonus. Security Guards !!

Dave Simeral, WRCC

TREX – Terrain Induced Rotors Experiment
Independence CA Owens Valley

6 mi

10 km



Find | Print | MapData | Draw | GPS | Route | Profile | 3-D | Map Display | NetLink

Pitch 39°

Rotation N

Vertical Exaggeration 1x 2x 4x 8x

Progress 100 %

GPS Cursor: Pin

Use Hardware Acceleration

Close 3-D Map

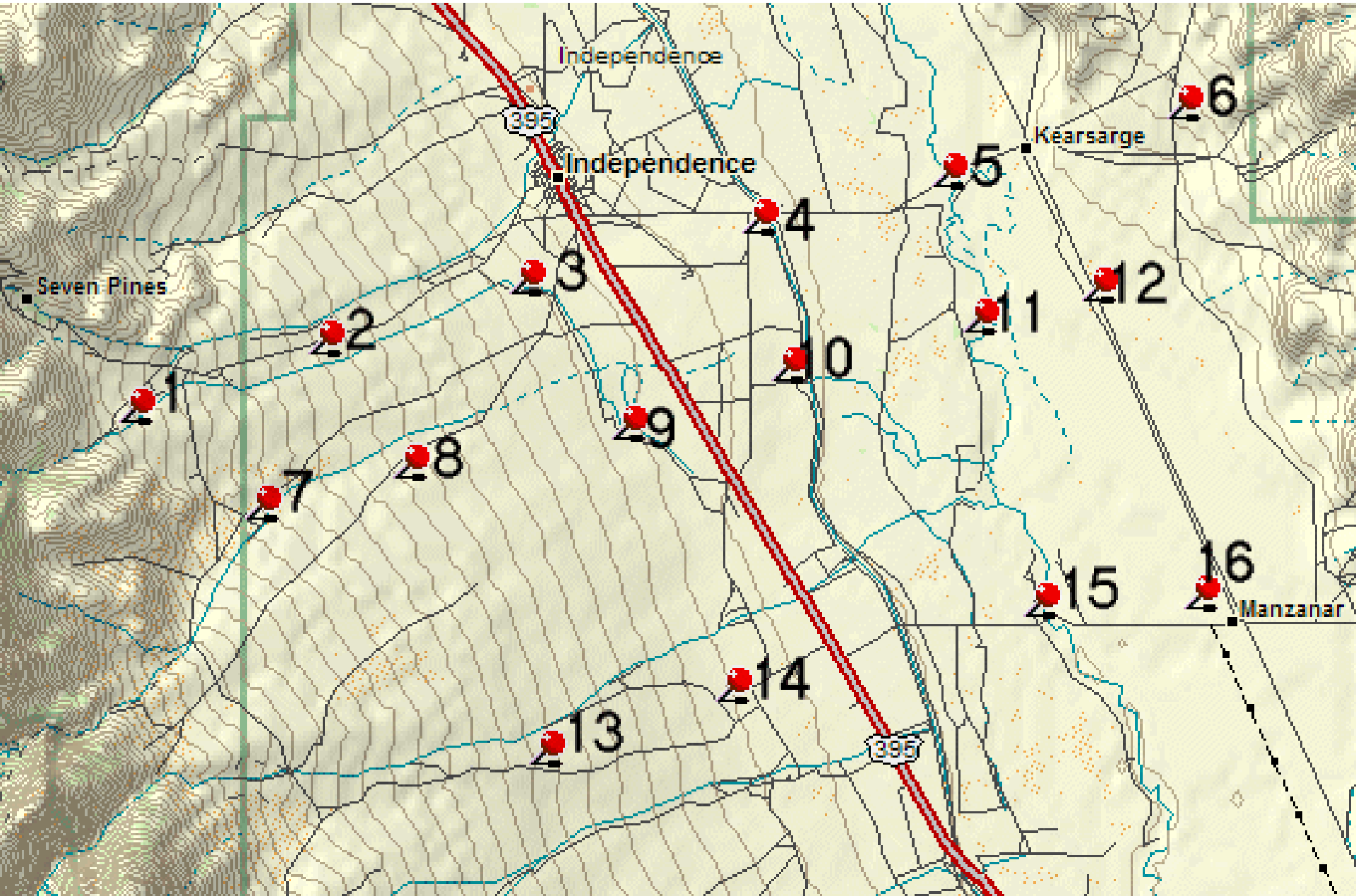
Shading

Horizon

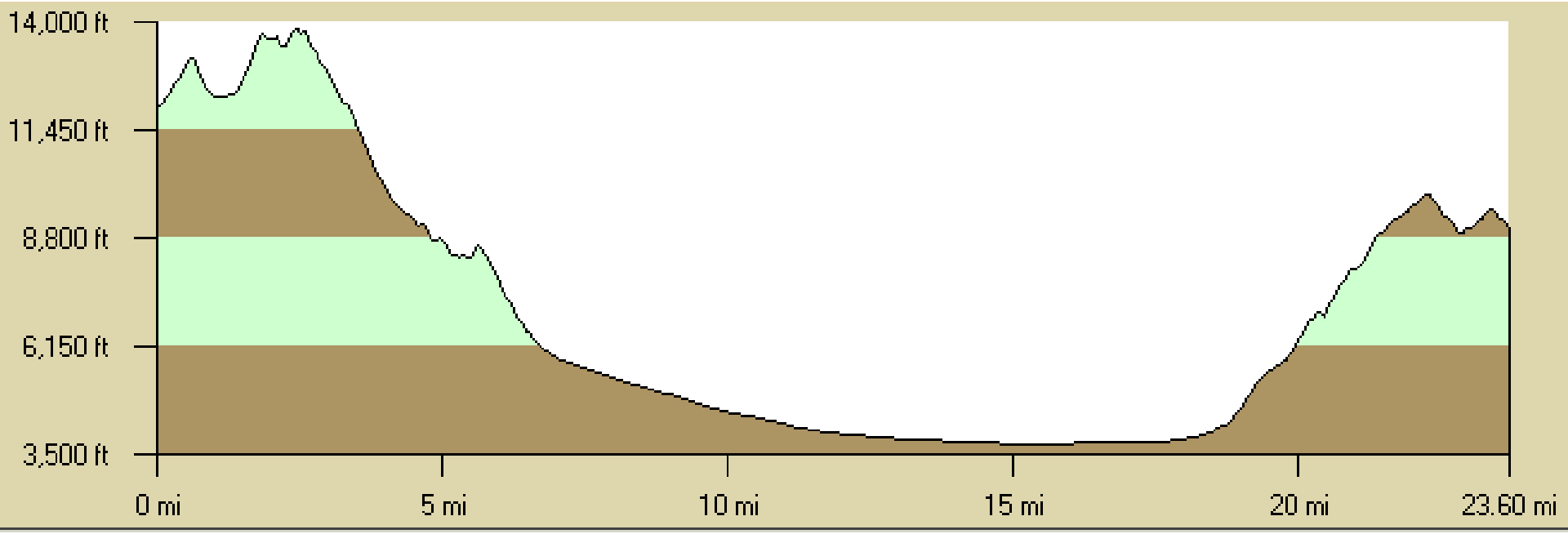
3-D Objects

TREX – Terrain Induced Rotors Experiment
Independence CA Owens Valley

1 km
1 mile



Elevation Transect Across Owens Valley south of Independence CA
Vertical Exaggeration Approximately 4 X

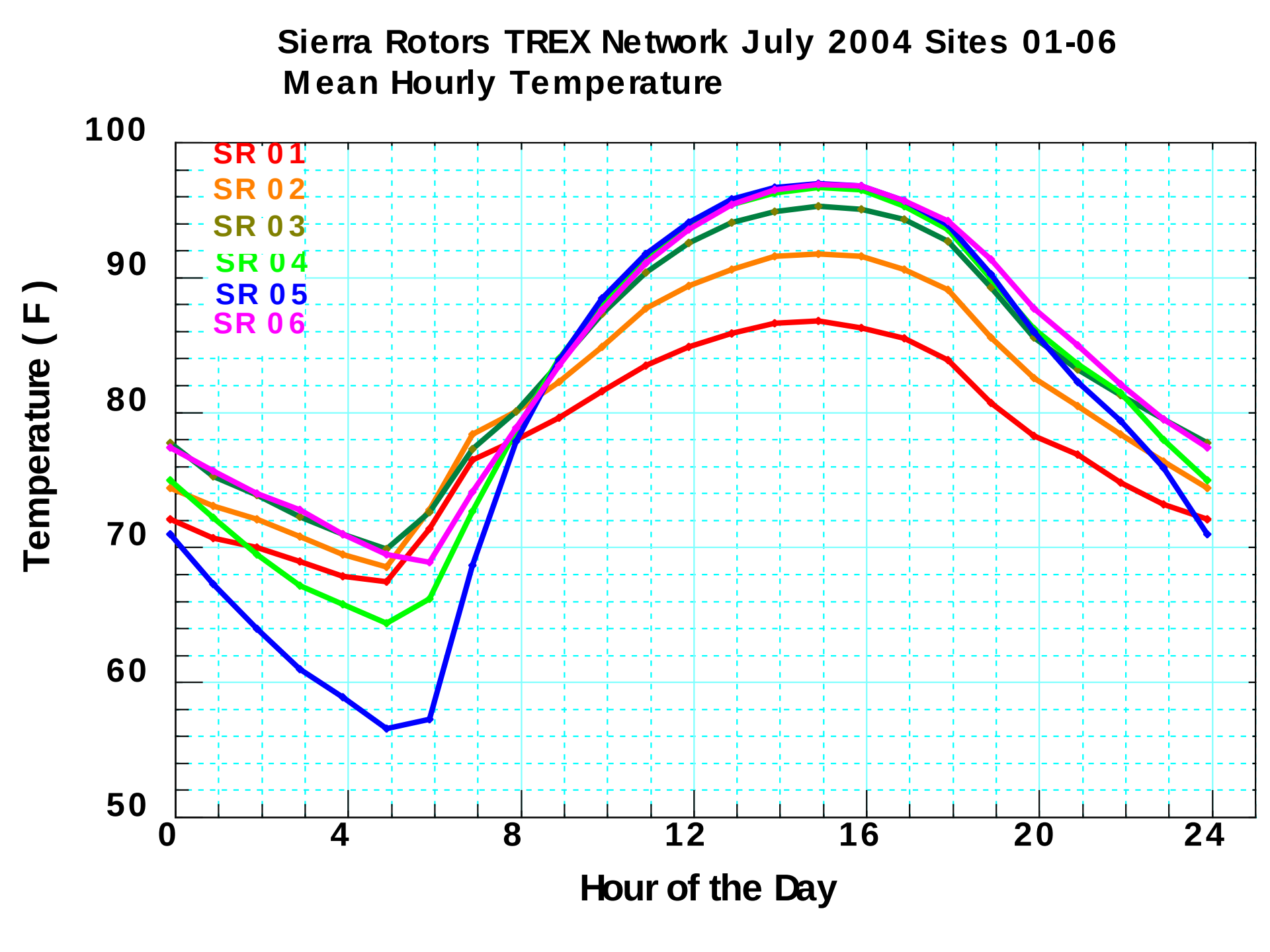


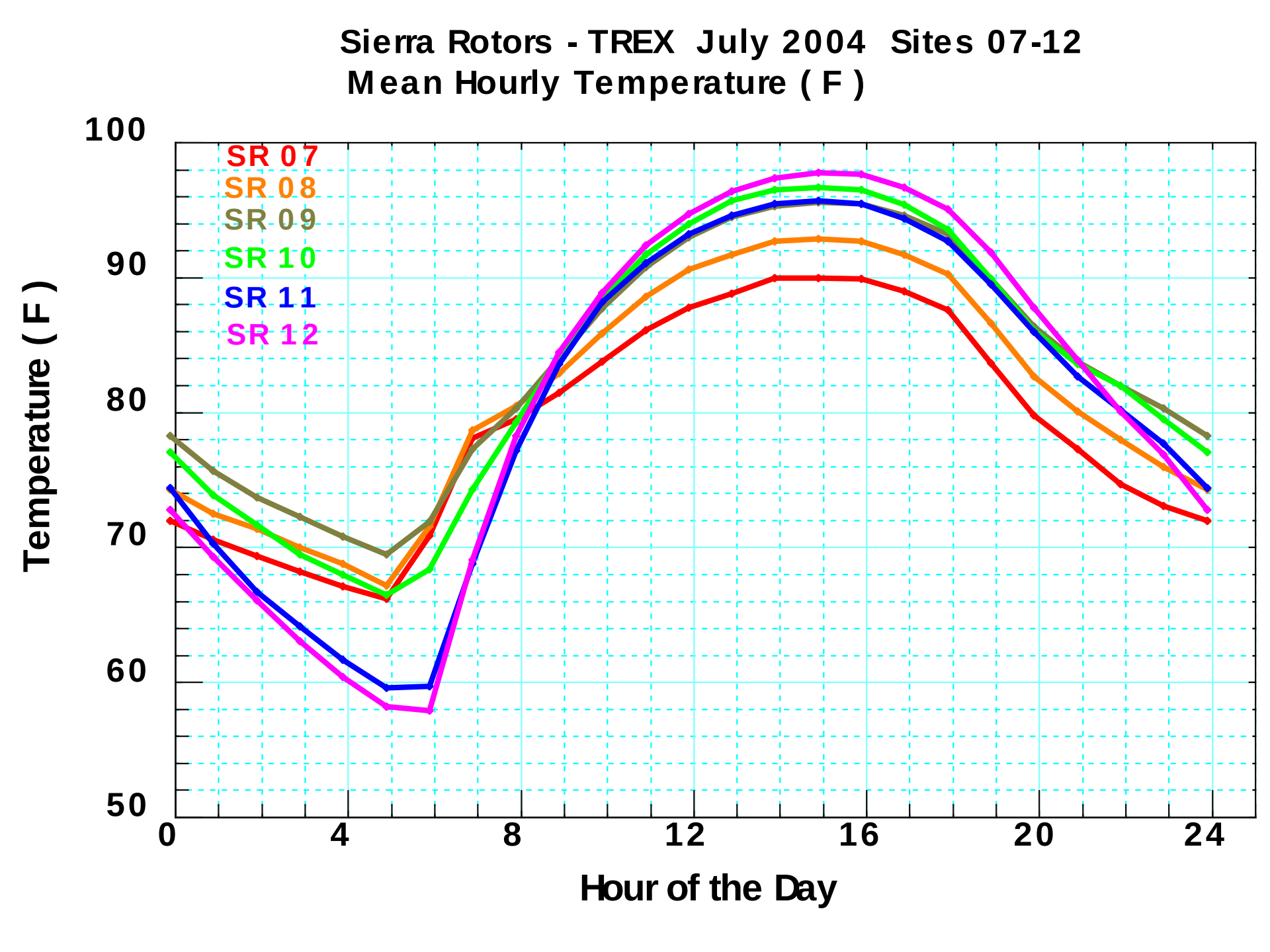

TREX Site 05 Looking South

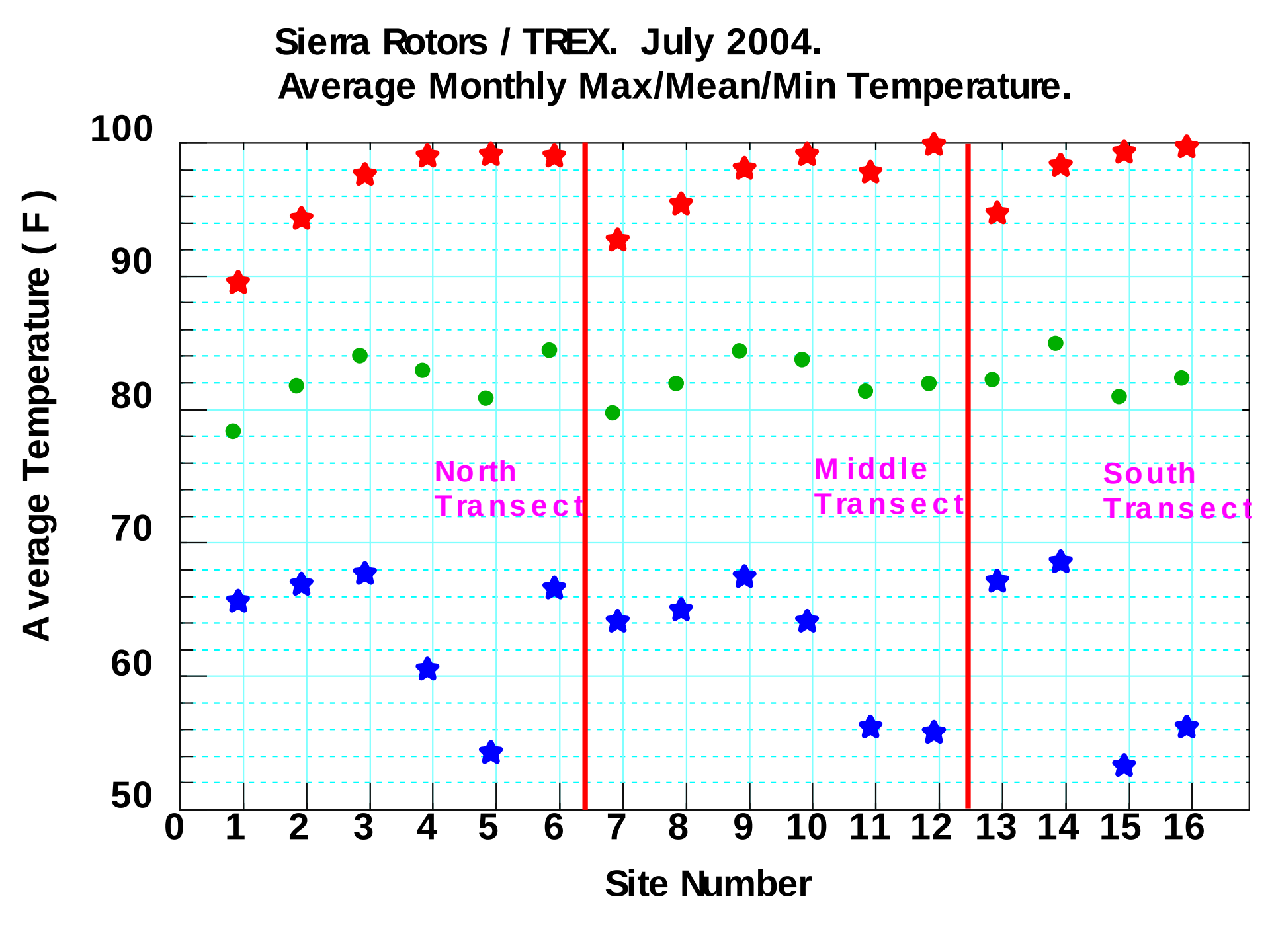

TREX Site 05 Looking West

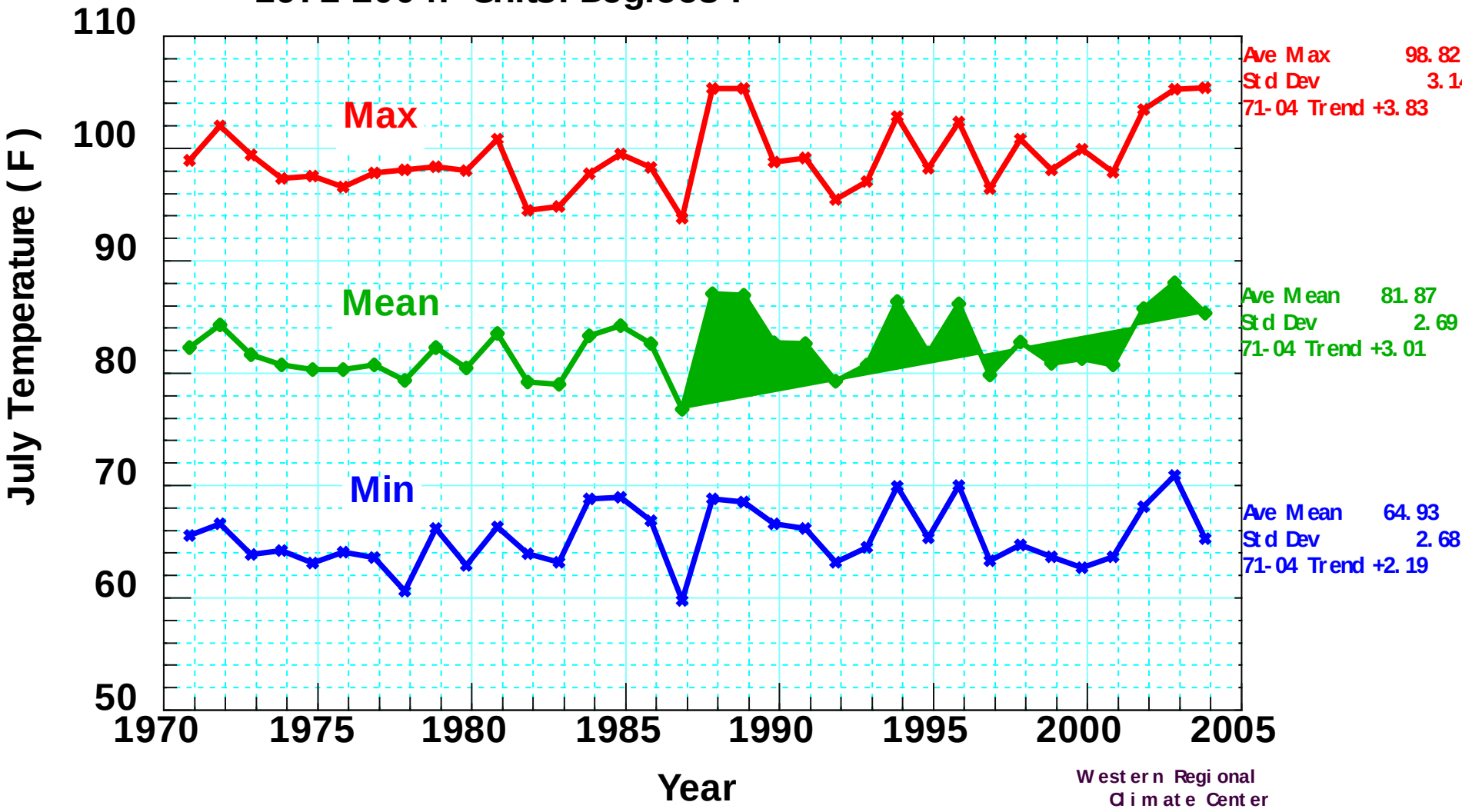

TREX Site 05 Looking North

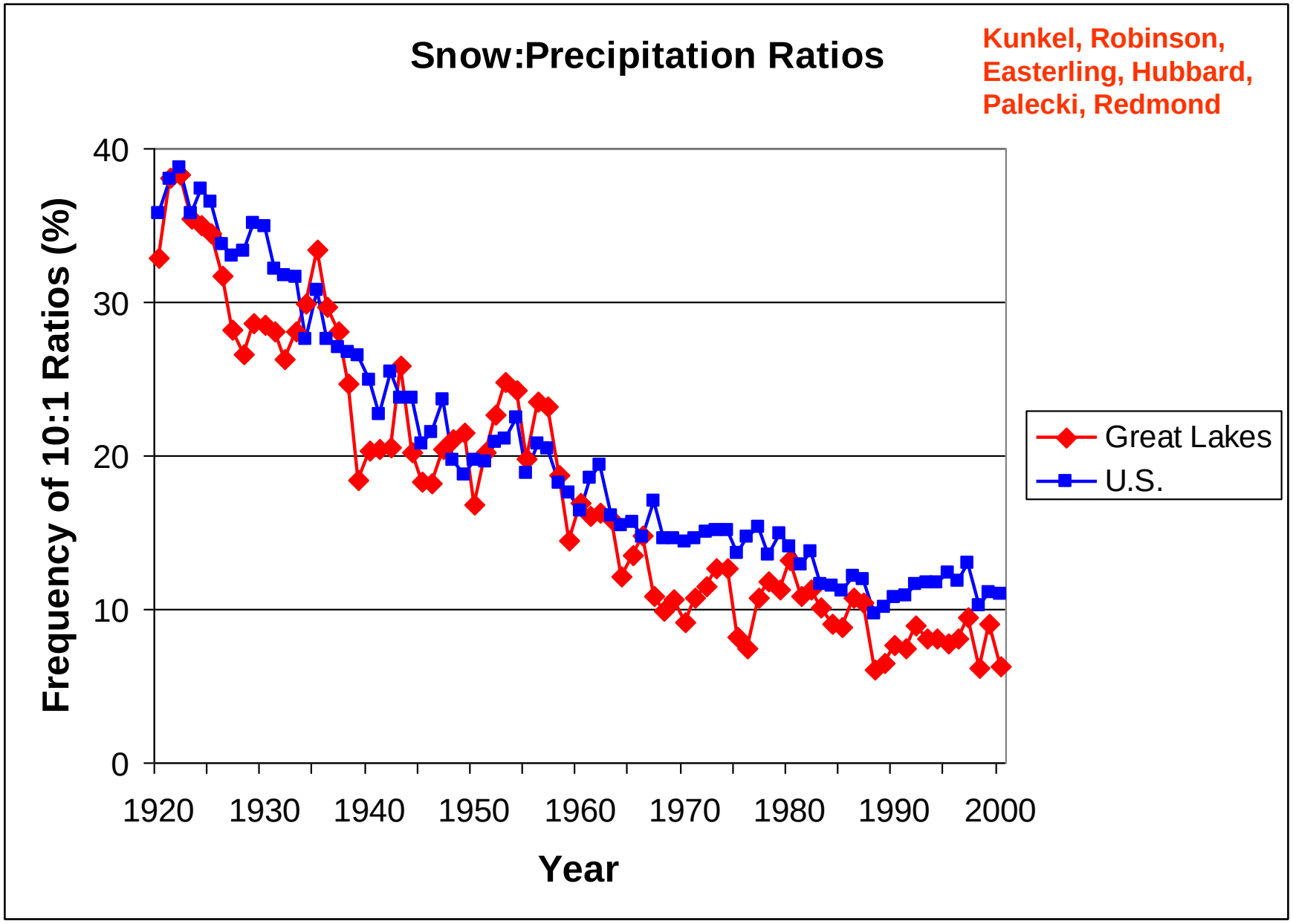
TREX Site 05 Looking East


Sierra Rotors TREX Network July 2004 Sites 01-06
Mean Hourly Temperature
SR 01
SR 02
SR 03
SR 04
SR 05
SR 06
Temperature (F)
100
90
80
70
60
50
0
4
8
12
16
20
24
Hour of the Day

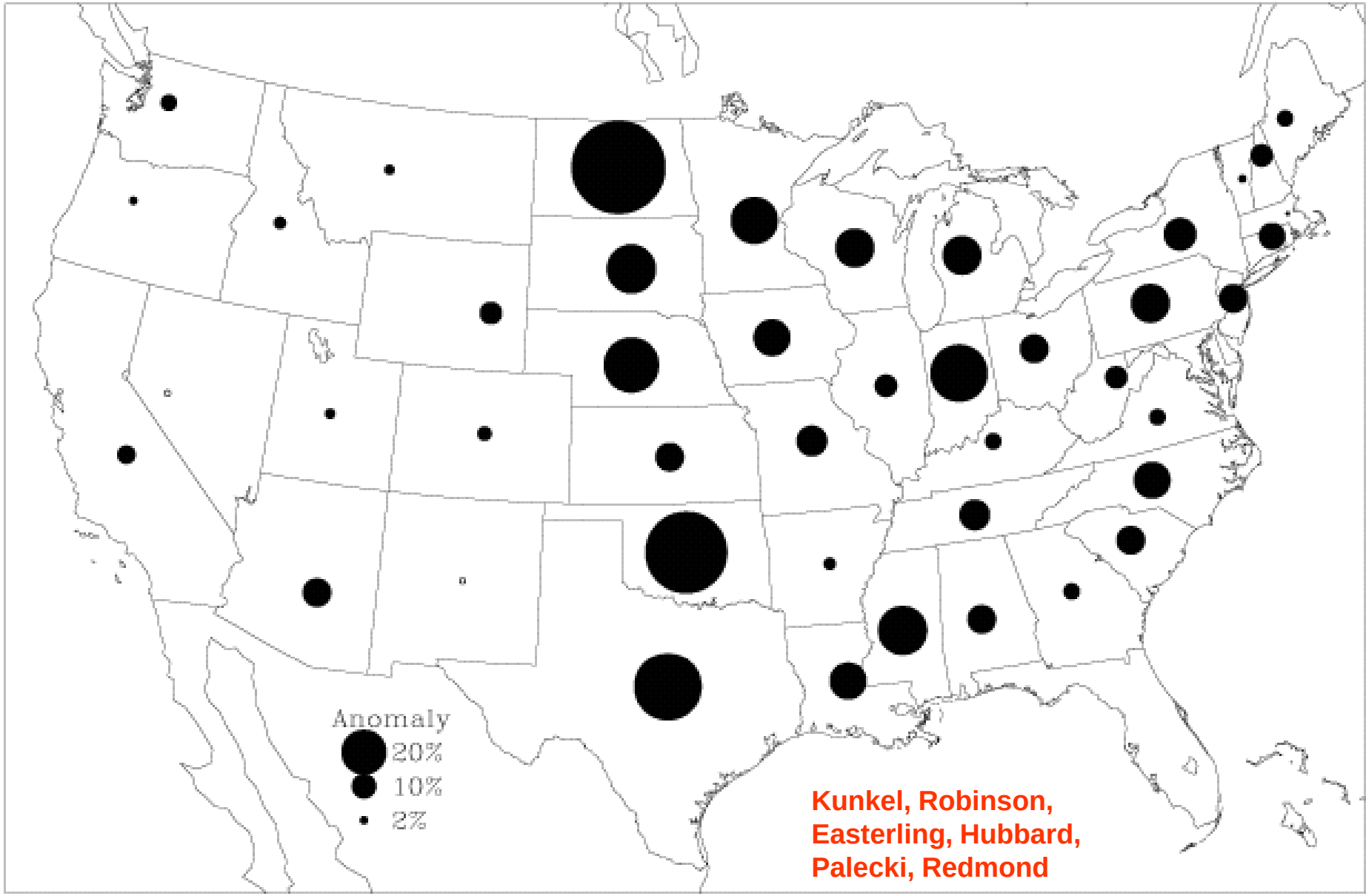

Sierra Rotors - TREX July 2004 Sites 07-12
Mean Hourly Temperature (F)
SR 07
SR 08
SR 09
SR 10
SR 11
SR 12
Temperature (F)
100
90
80
70
60
50
0
4
8
12
16
20
24
Hour of the Day

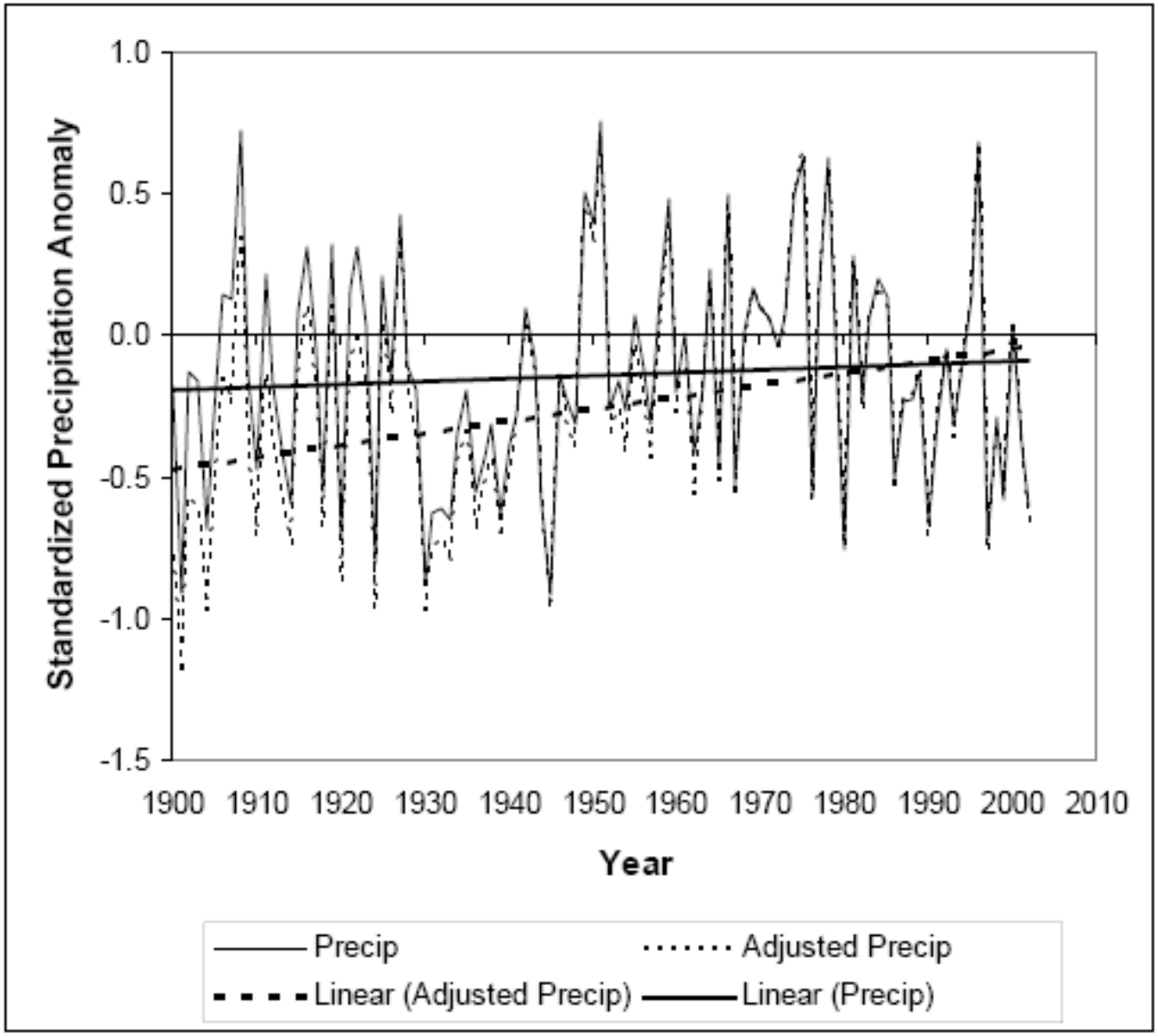

Sierra Rotors / TREX. July 2004.
Average Monthly Max/Mean/Min Temperature.
Average Temperature (F)
100
90
80
70
60
50
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Site Number
North Transect
Middle Transect
South Transect


Independence CA NWS Coop Station.
Average July Max / Mean / Min Temperature.
1971-2004. Units: Degrees F
July Temperature (F)
110
100
90
80
70
60
50
1970
1975
1980
1985
1990
1995
2000
2005
Year
Max
Mean
Min
Ave Max 98.82
Std Dev 3.14
71-04 Trend +3.83
Ave Mean 81.87
Std Dev 2.69
71-04 Trend +3.01
Ave Mean 64.93
Std Dev 2.68
71-04 Trend +2.19
Western Regional
Climate Center


Snow:Precipitation Ratios
Kunkel, Robinson, Easterling, Hubbard, Palecki, Redmond
Frequency of 10:1 Ratios (%)
40
30
20
10
0
1920
1930
1940
1950
1960
1970
1980
1990
2000
Year
Great Lakes
U.S.

Snow to Precip Ratio, %10 to 1, (1930–1950)–(1980–2000)





Kunkel, Robinson, Easterling, Hubbard, Palecki, Redmond

Figure 8. Time series of precipitation from snowfall events averaged for 48 stations with mean annual snowfall > 100 cm and less than 10% missing data for 1900-2000. Observed and linear best fit (adjusted) values are shown by the solid (dashed) lines.

The Price of Data Quality is Eternal Vigilance.

- Thomas Cooperative Observer Jefferson

3. The Essence of Quality Control

The evaluation and improvement of imperfect data

by making use of other imperfect data.

QC: Observation quality

Type I errors : Reject good values ("good" = correct, valid)

Type II errors : Accept bad values ("bad" = incorrect, not valid)

Often is a trade-off between Type I and Type II error detection

Mis-edits: presently, with SOD, about 60 % are bad edits of good data

Vetting of QC process. QC the QC. Matte Menne and Imke Durre.

Bias detection. Catching subtle errors. PRISM Nipher example.

QC in mountains and complex terrain.

- Scale issues.
  - Fine scale structure in climate averages.
  - Fine scale structure in the spatial correlation field.
  - Differences among elements in the spatial correlation field.
  - Time scale differences in the spatial correlation field.
- Upwind versus downwind precipitation correlation fields.

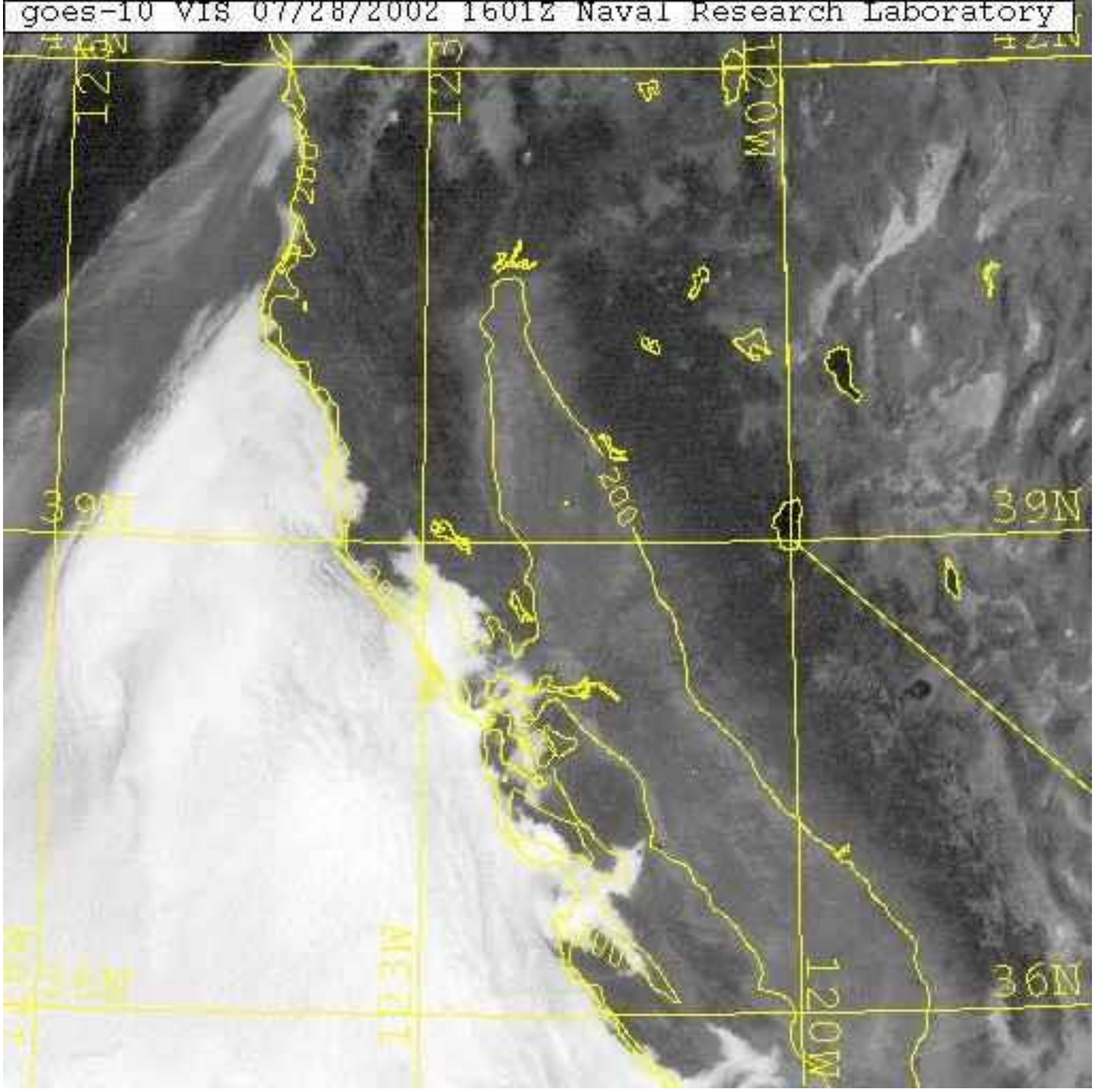
QC: Observation quality - 2

Spatial correlation structures

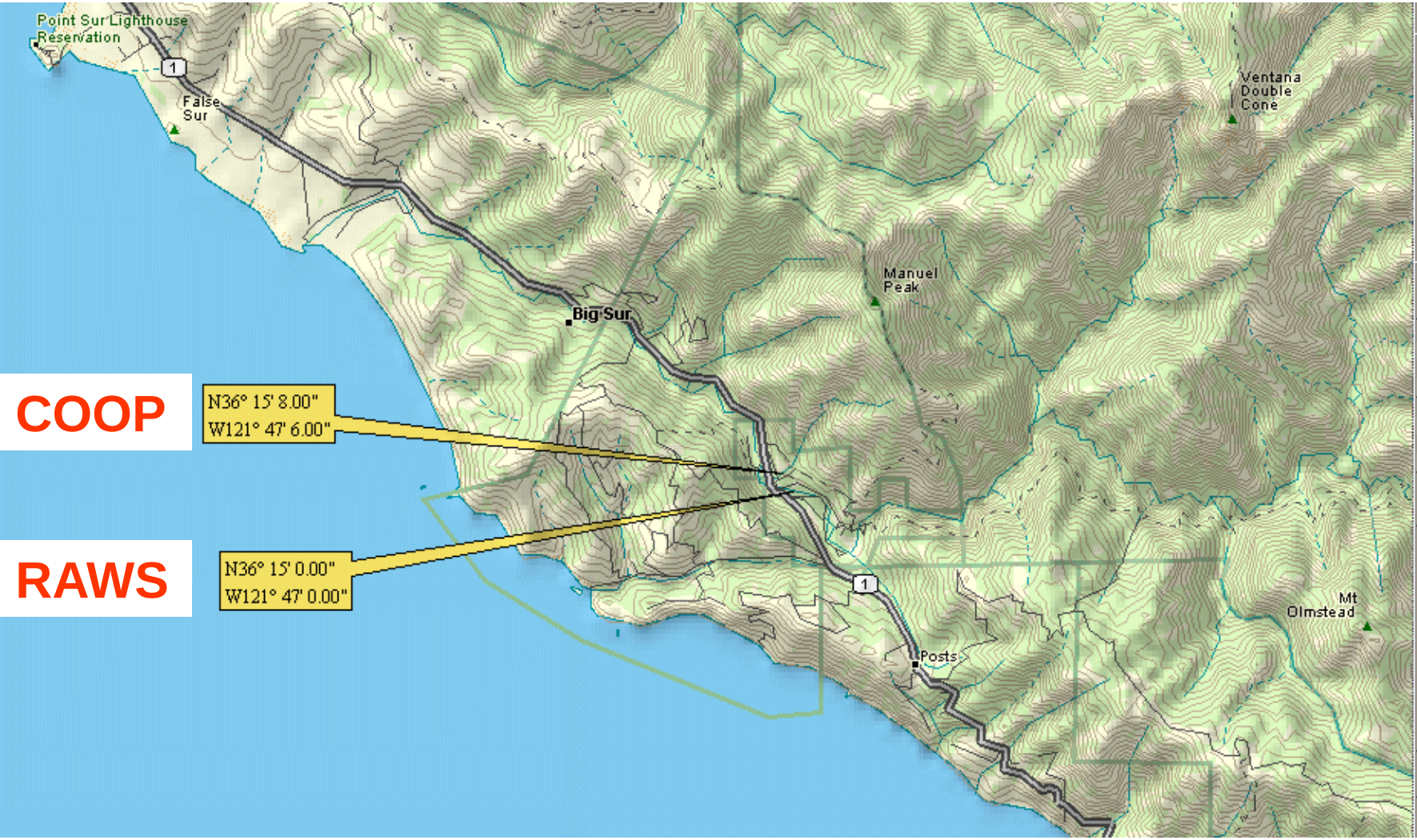
- Time scale dependent
- Seasonal
- Asymmetries – topographic orientation and elevation
- Surface state – presence / absence of snow cover

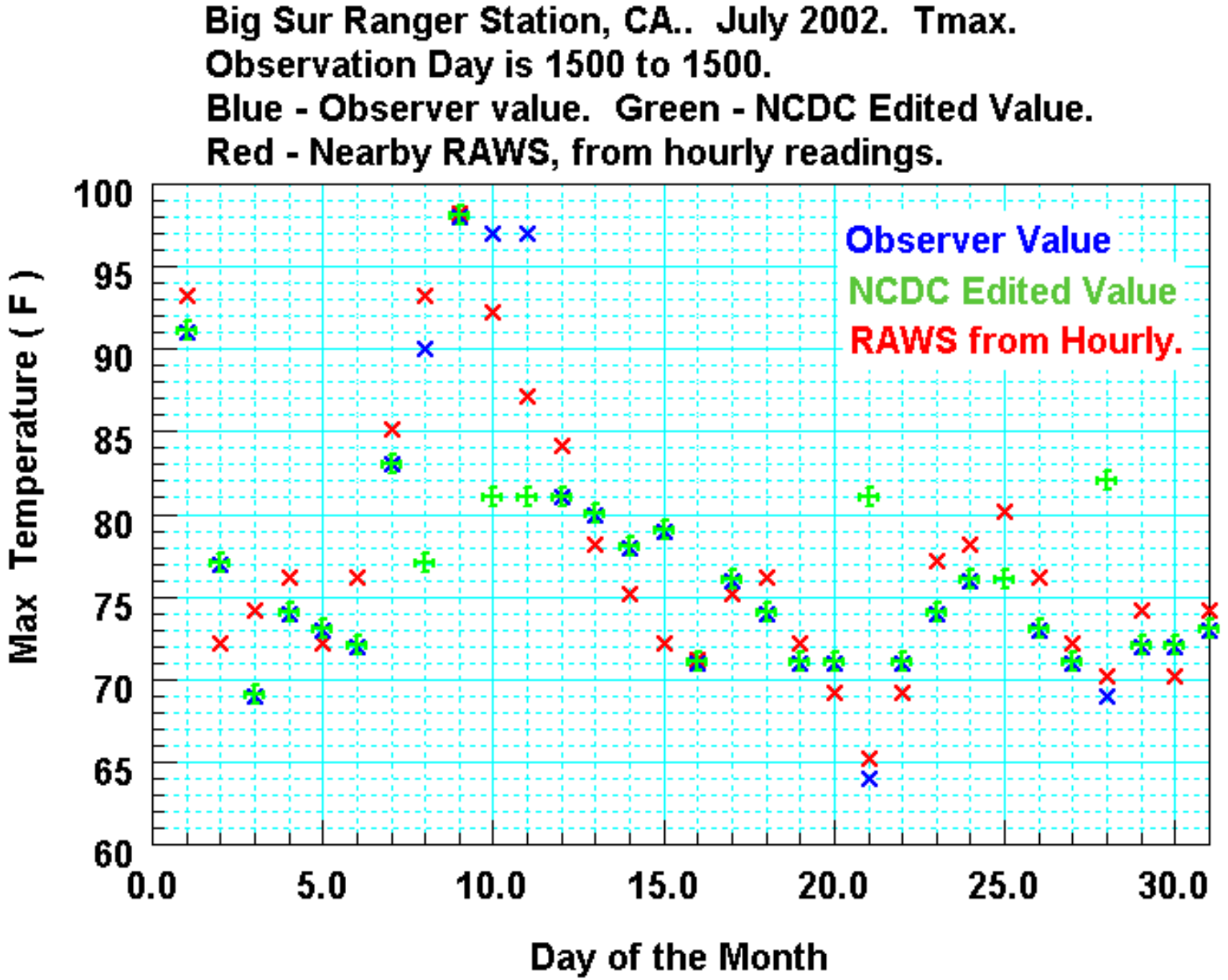
Baker / Rainier, Corvallis Water Bureau, Pescadero floods

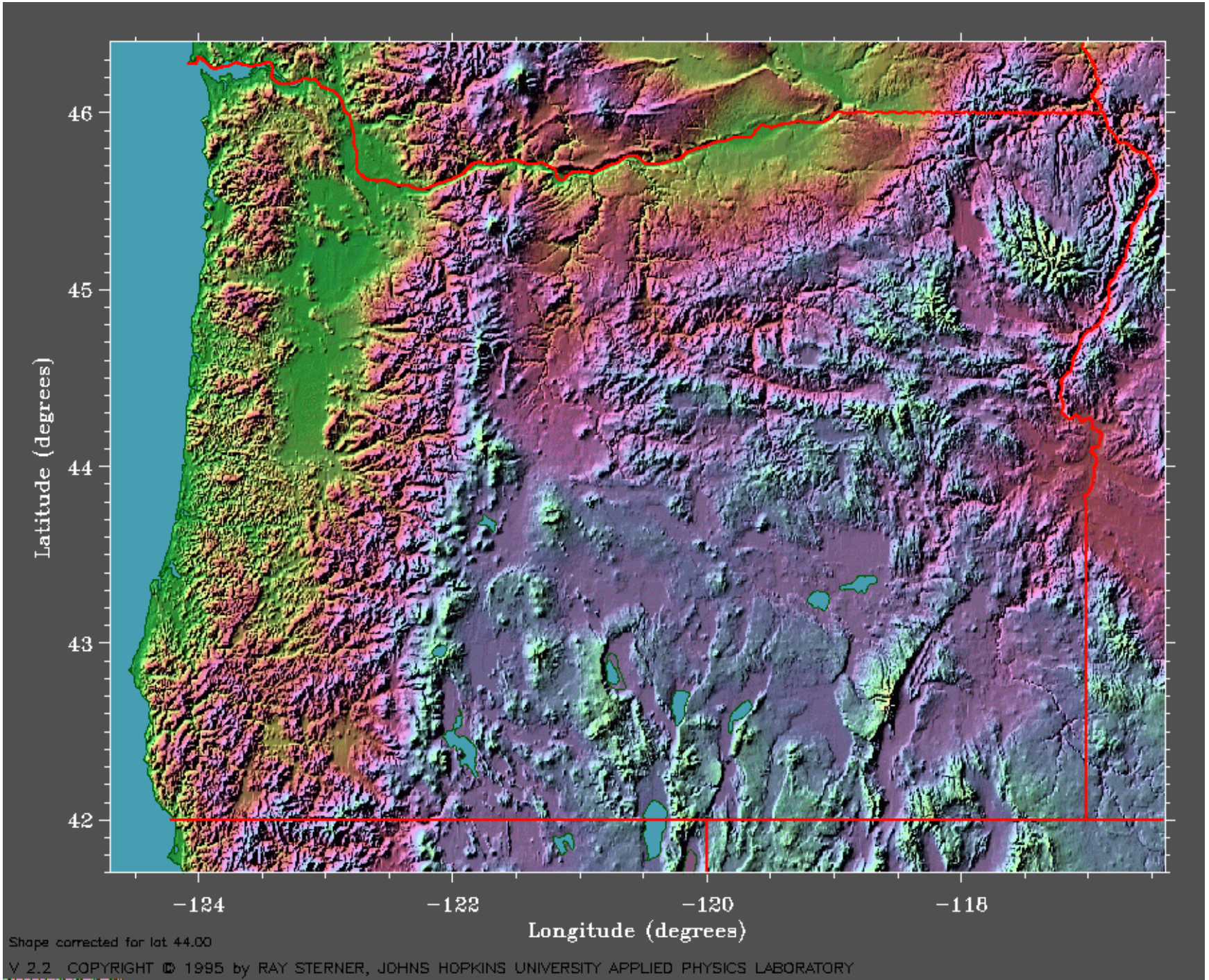
“Official” records versus credible records


goes-10 VIS 07/28/2002 1601Z Naval Research Laboratory
120W
39N
36N
120W
200
200

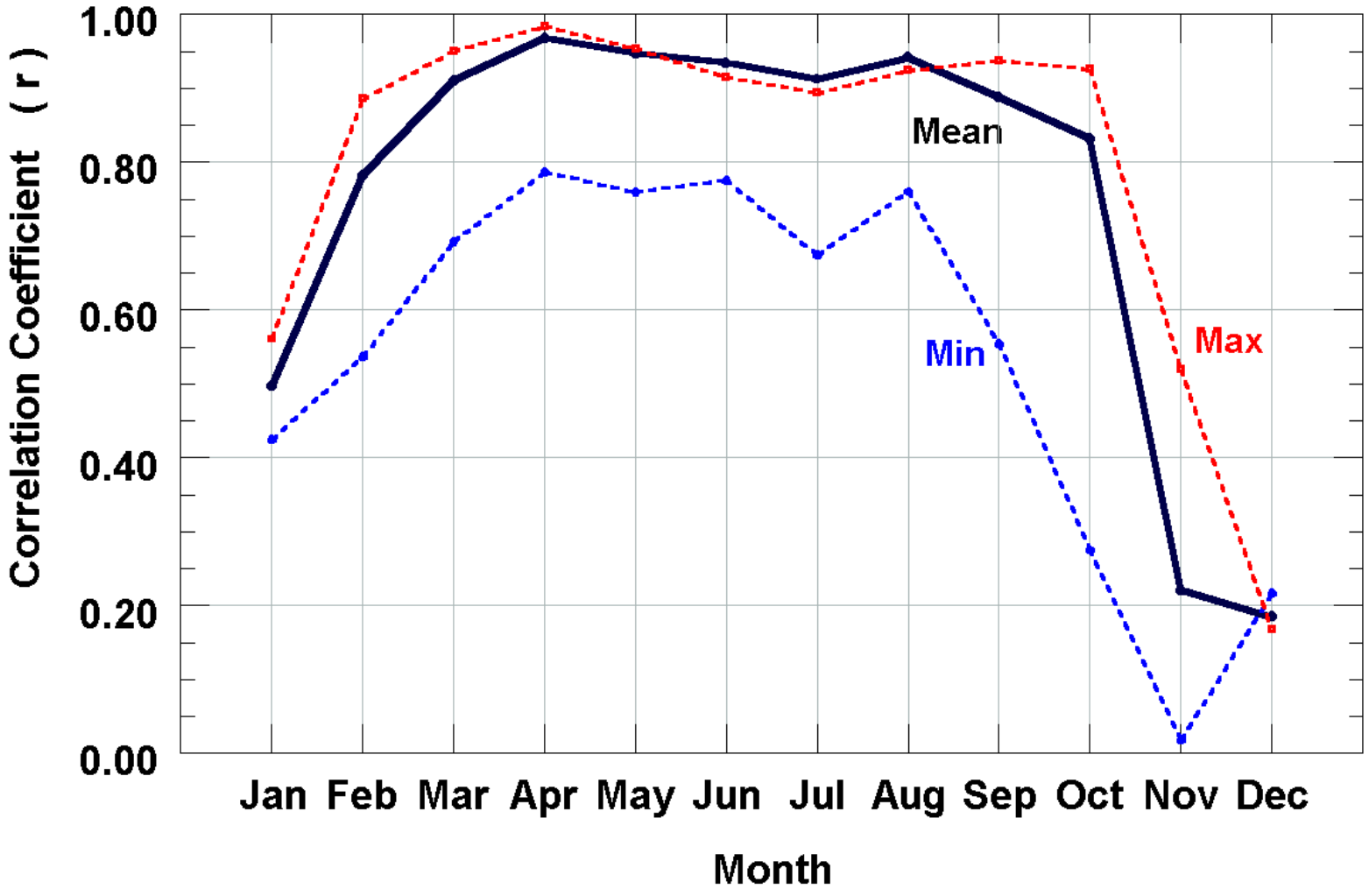
Big Sur Ranger Station



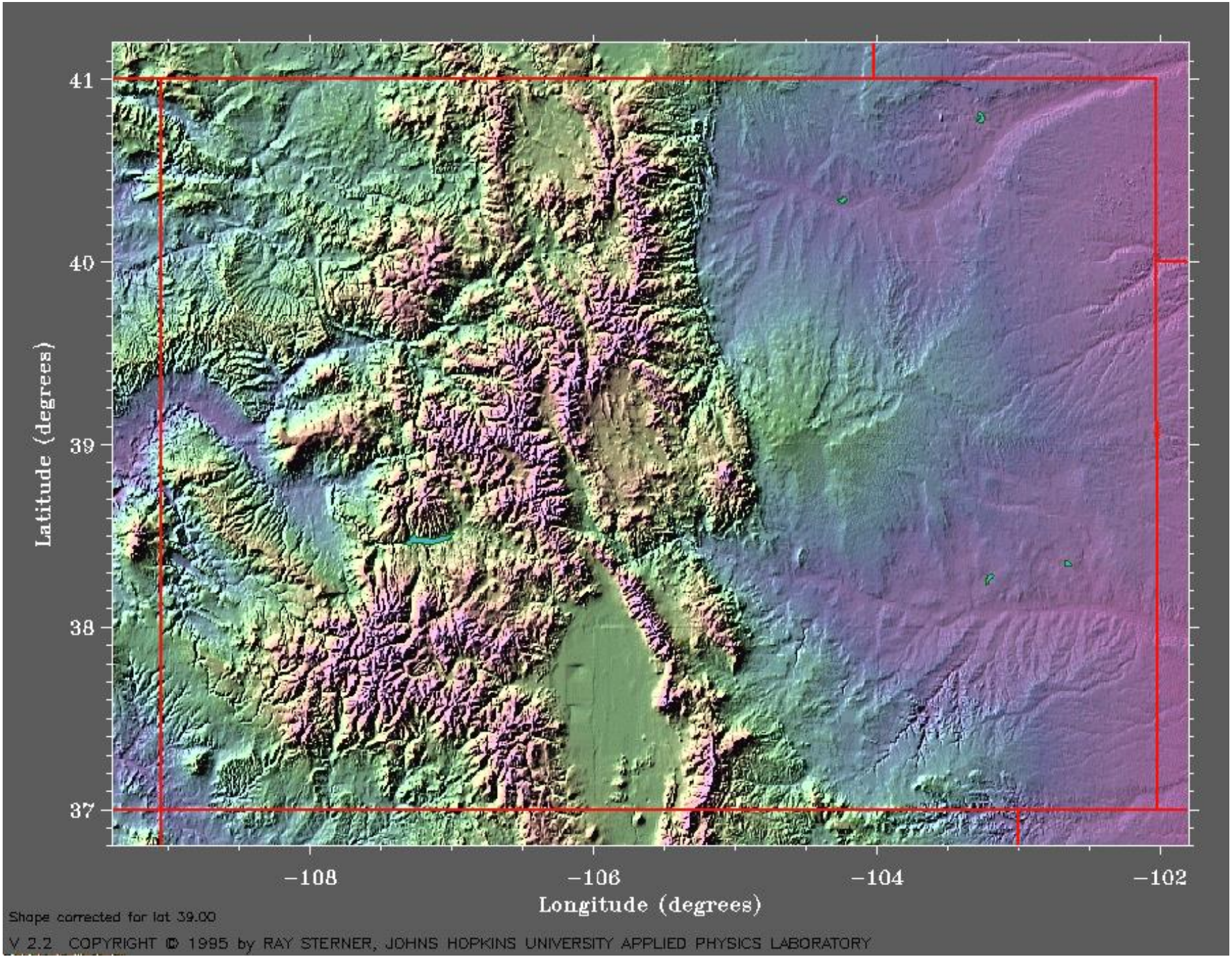

Big Sur Ranger Station, CA.. July 2002. Tmax.
Observation Day is 1500 to 1500.
Blue - Observer value. Green - NCDC Edited Value.
Red - Nearby RAWS, from hourly readings.
Observer Value
NCDC Edited Value
RAWS from Hourly.
Max Temperature (F)
100
95
90
85
80
75
70
65
60
0.0
5.0
10.0
15.0
20.0
25.0
30.0
Day of the Month


46
45
44
43
42
Latitude (degrees)
−124
−122
−120
−118
Longitude (degrees)
Shape corrected for lat 44.00
V 2.2 COPYRIGHT © 1995 by RAY STERNER, JOHNS HOPKINS UNIVERSITY APPLIED PHYSICS LABORATORY

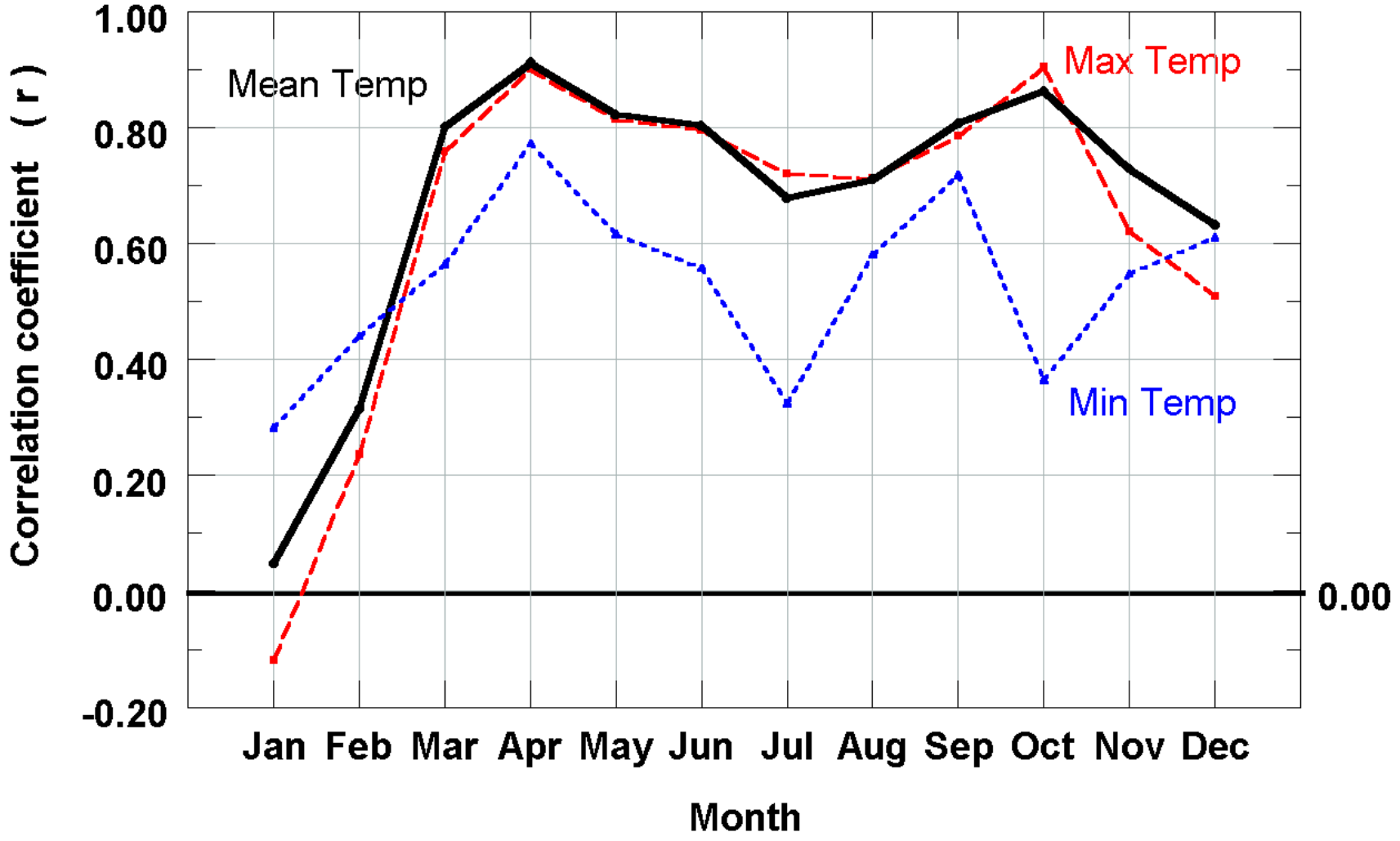
Correlation between Medford and Sexton Summit Monthly Temperatures.
Approx 45 years within the interval 1942-1992.
Mean, Max, and Min monthly mean temperatures.



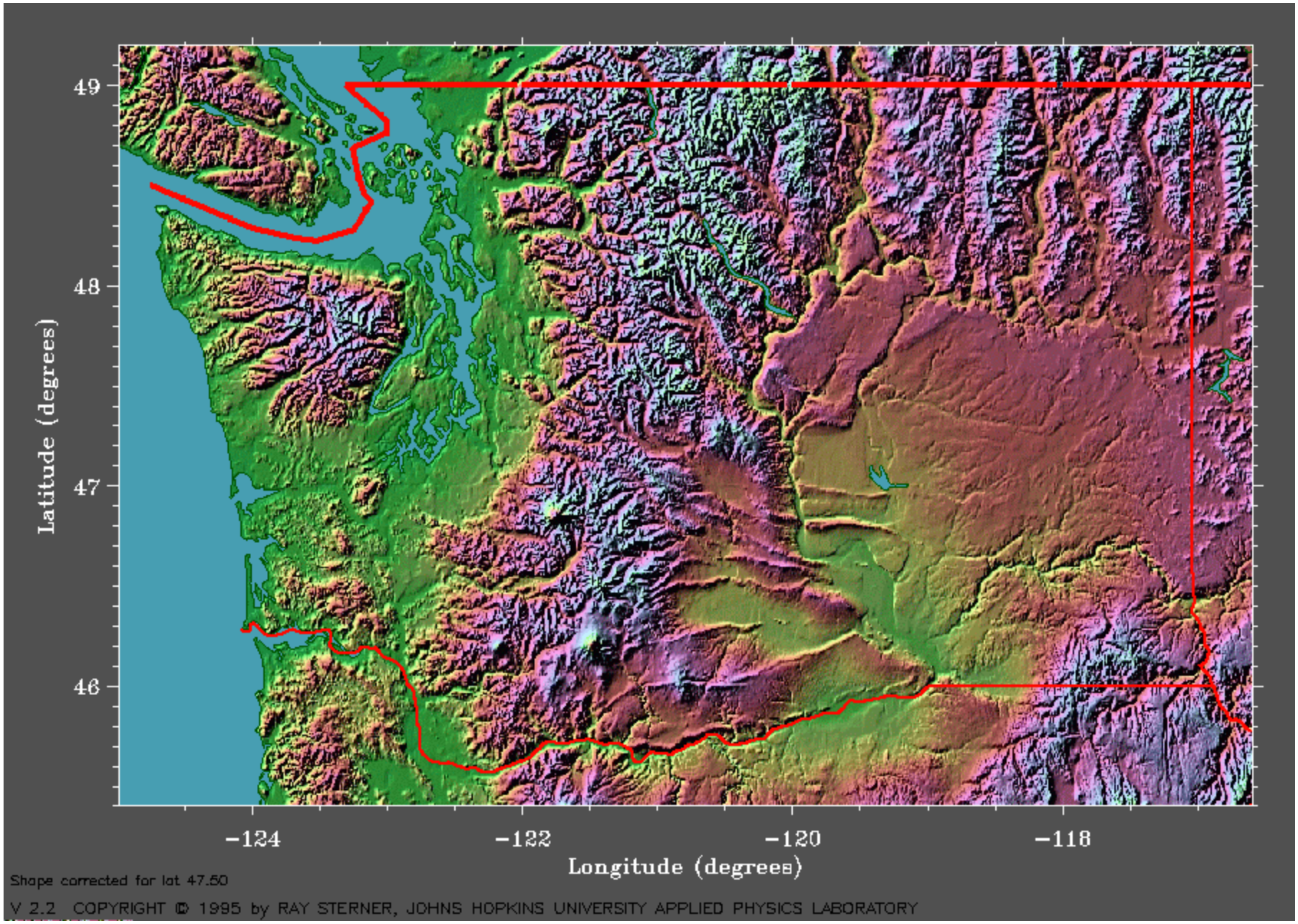
K. Redmond, 2003. p 29-48, Water and Climate in the Western United States. U Colorado Press.


41
40
39
38
37
Latitude (degrees)
−108
−106
−104
−102
Longitude (degrees)
Shape corrected for lat 39.00
V 2.2 COPYRIGHT © 1995 by RAY STERNER, JOHNS HOPKINS UNIVERSITY APPLIED PHYSICS LABORATORY

Wolf Creek Pass - Alamosa CO correlations 1958-1999.
Mean monthly temperature (black, solid).
Mean monthly maximum temperature (red, dashed).
Mean monthly minimum temperature (blue, dotted).

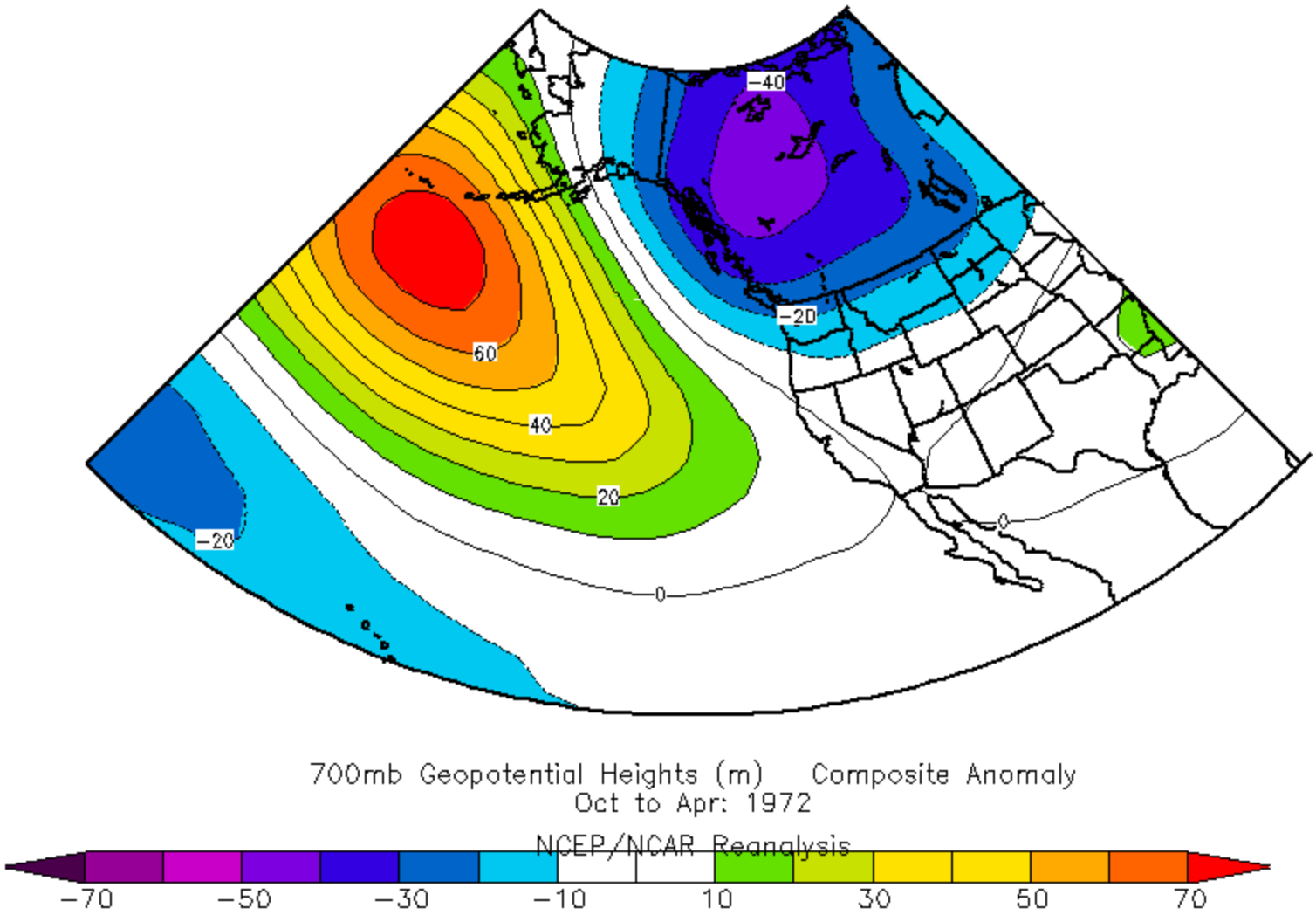


K. Redmond, 2003. p 29-48, Water and Climate in the Western United States. U Colorado Press.


49
48
47
46
Latitude (degrees)
−124
−122
−120
−118
Longitude (degrees)
Shape corrected for lat 47.50
V 2.2 COPYRIGHT © 1995 by RAY STERNER, JOHNS HOPKINS UNIVERSITY APPLIED PHYSICS LABORATORY

1971-72 Oct – Apr 700 mb Height Departure From Average

Snowy at Rainier Paradise

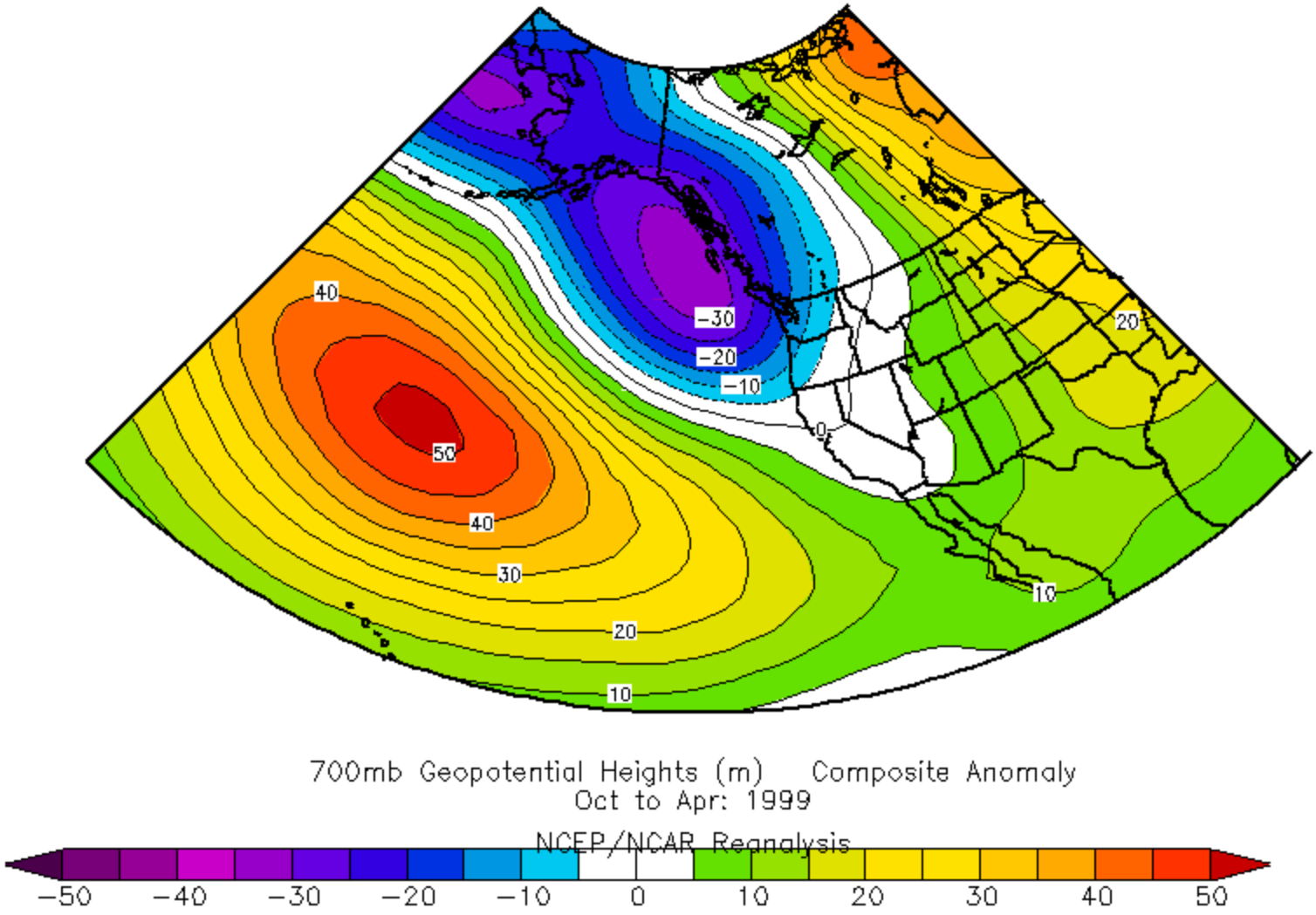


NOAA–CIRES/Climate Diagnostics Center

K. Redmond, WRCC, with CDC graphics.

1998-99 Oct – Apr 700 mb Height Departure From Average

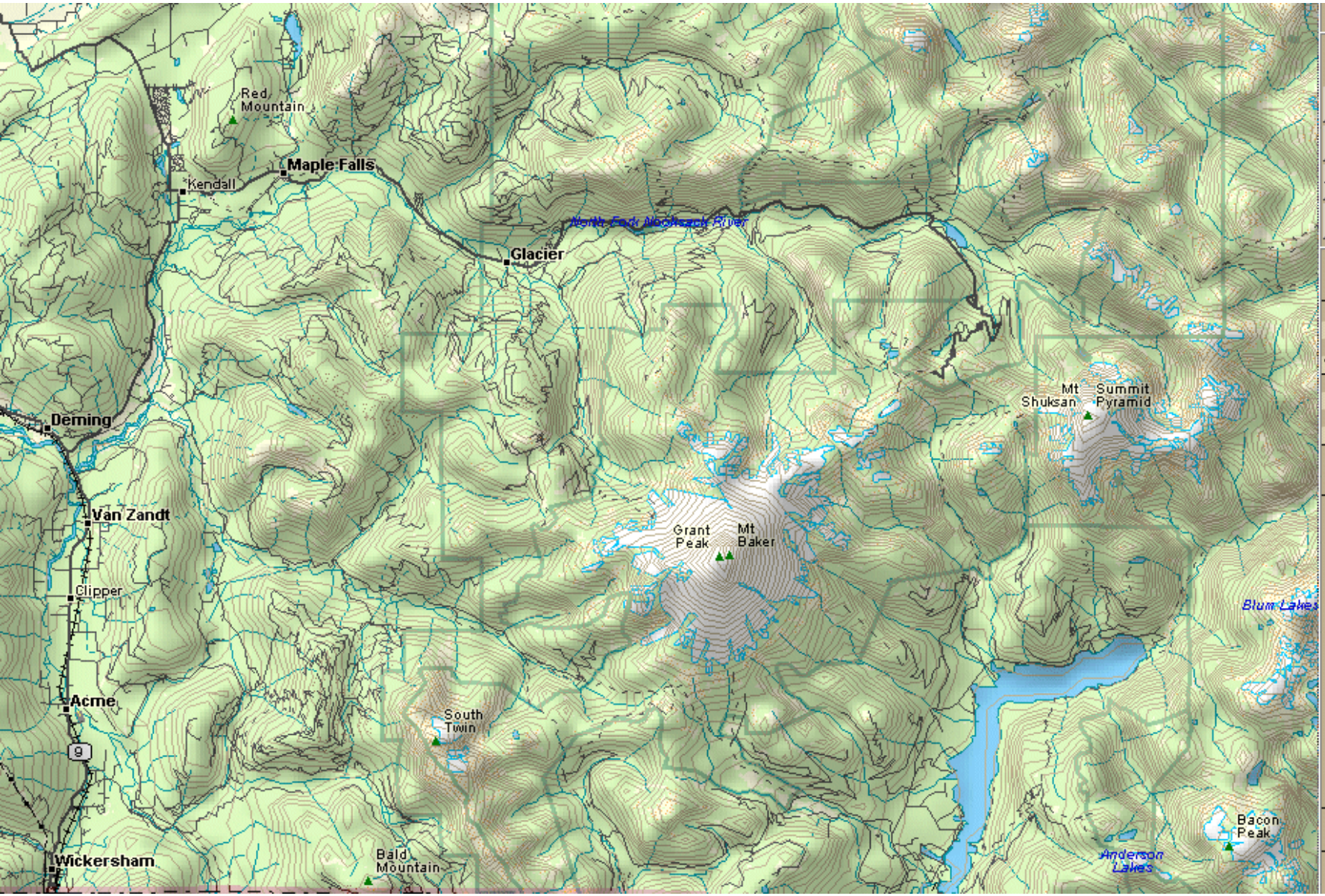
Snowy at Mt Baker Ski Area



NOAA–CIRES/Climate Diagnostics Center

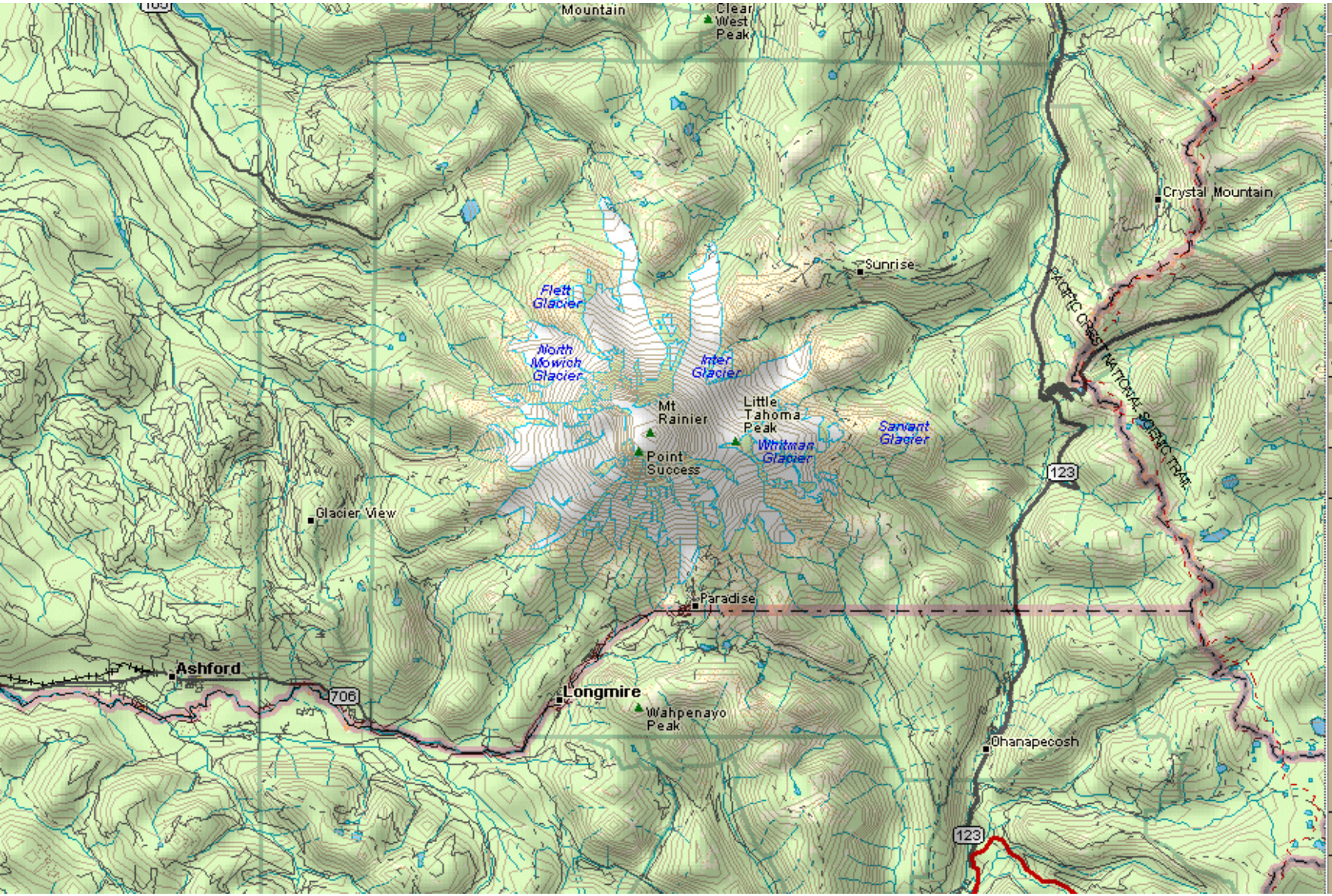
K. Redmond, WRCC, with CDC graphics.

Mount Baker Snowfall 1141+ inches (1998-1999)



K. Redmond, WRCC, with DeLorme graphics.

Mount Rainier Snowfall 1122 inches (1971-1972)



K. Redmond, WRCC, with DeLorme graphics

4. Mountain climate relations to human society

CIRMOUNT
(Consortium for Integrated Climate Research in Western Mountains)

High elevation climate behavior matters to low elevation populations
Footprint of civilization extends upstream to headwaters
Large populations depend on mountain resources

Mountain climate understanding:

Climate base state, and its variability, in complex or elevated terrain is accessible to physical understanding.

Is not sufficient to simply say “it’s too complicated”

Mapping New Terrain

Climate Change and America's West

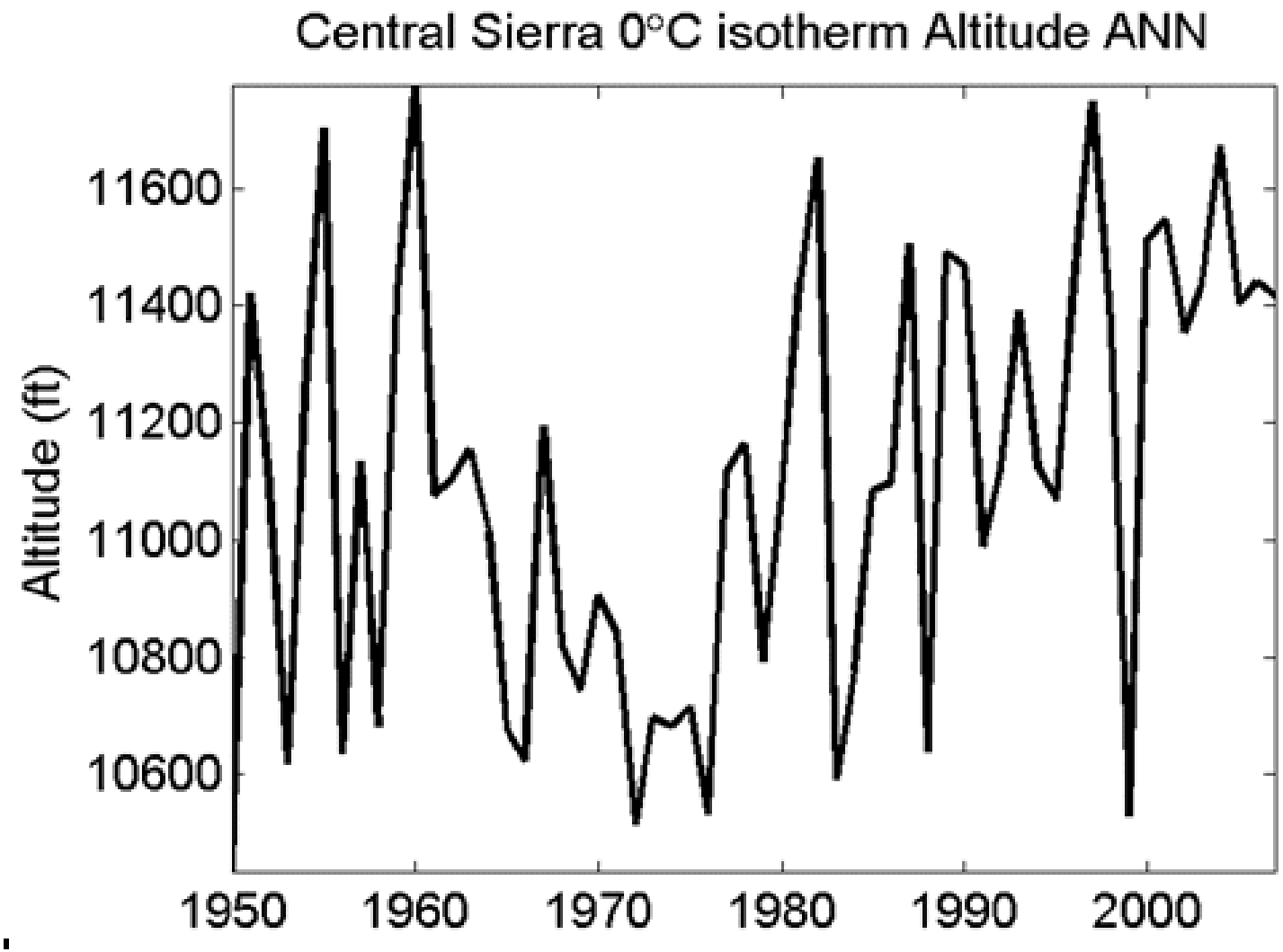
Anticipating Challenges to Western Mountain Ecosystems and Resources

The Consortium for Integrated Climate Research in Western Mountains (CIRMOUNT)

July 2006


Mt Warren Summit Station 12,327 ft

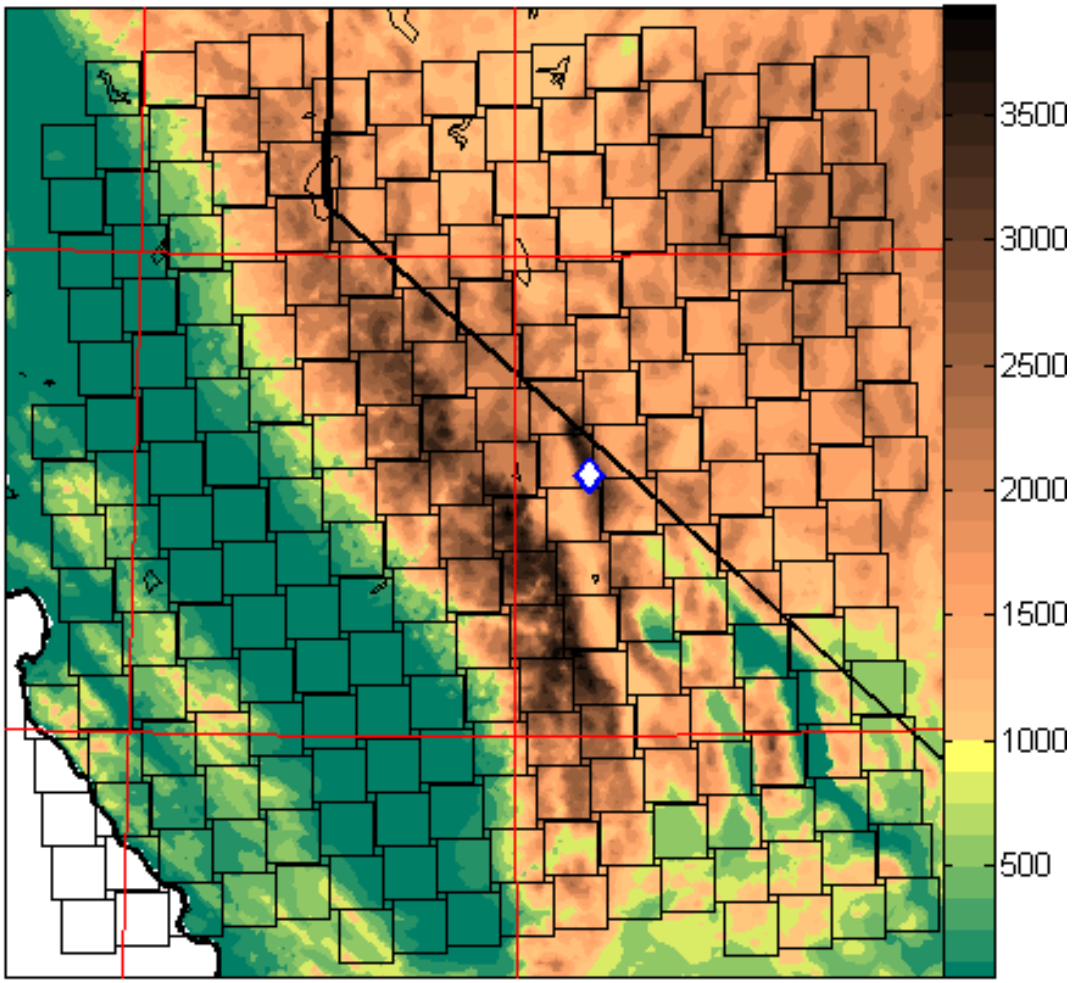
Mean Annual Freezing Level near Maricopa CA. Fig ctsy John Abatzoglou.




20 February 2007

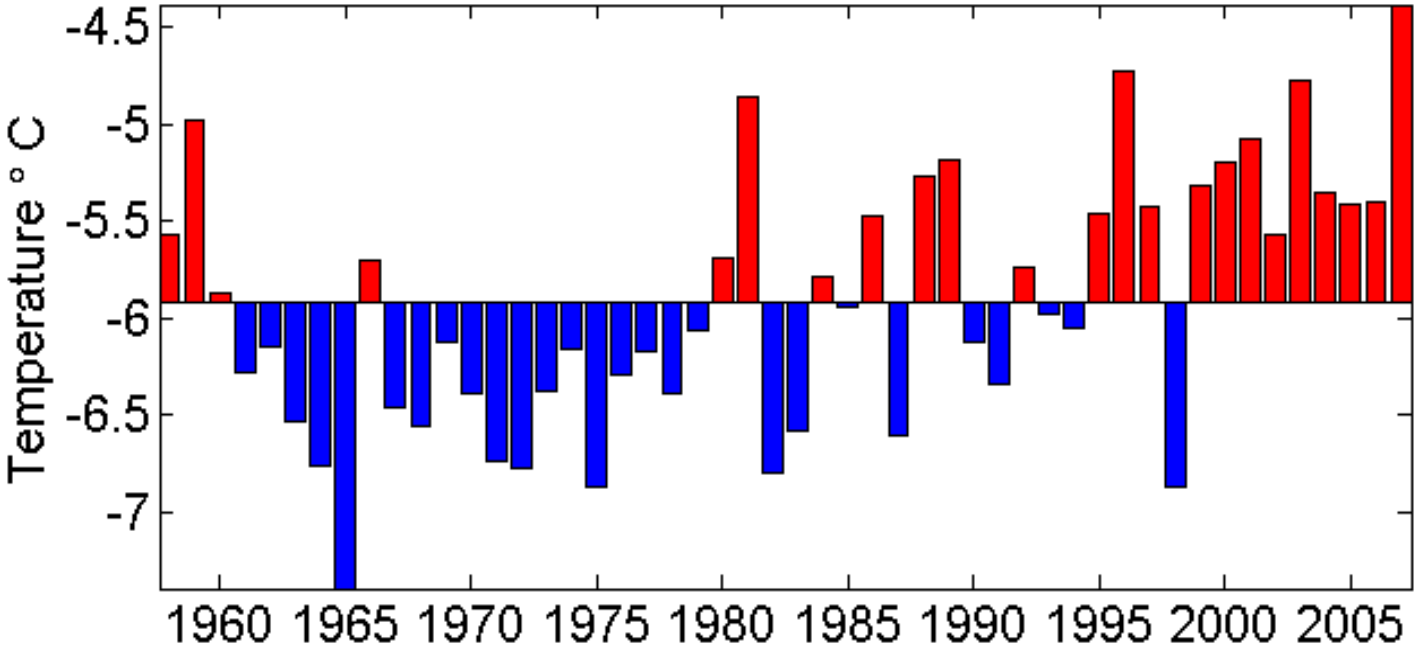

White Mtn Summit, 14246 ft
Reconfigured July 2004

White Mountain Research Station Summit Station. 14,245 feet. White diamond.
North American Regional Reanalysis grid. 32 km, 3-hourly, 29 levels.



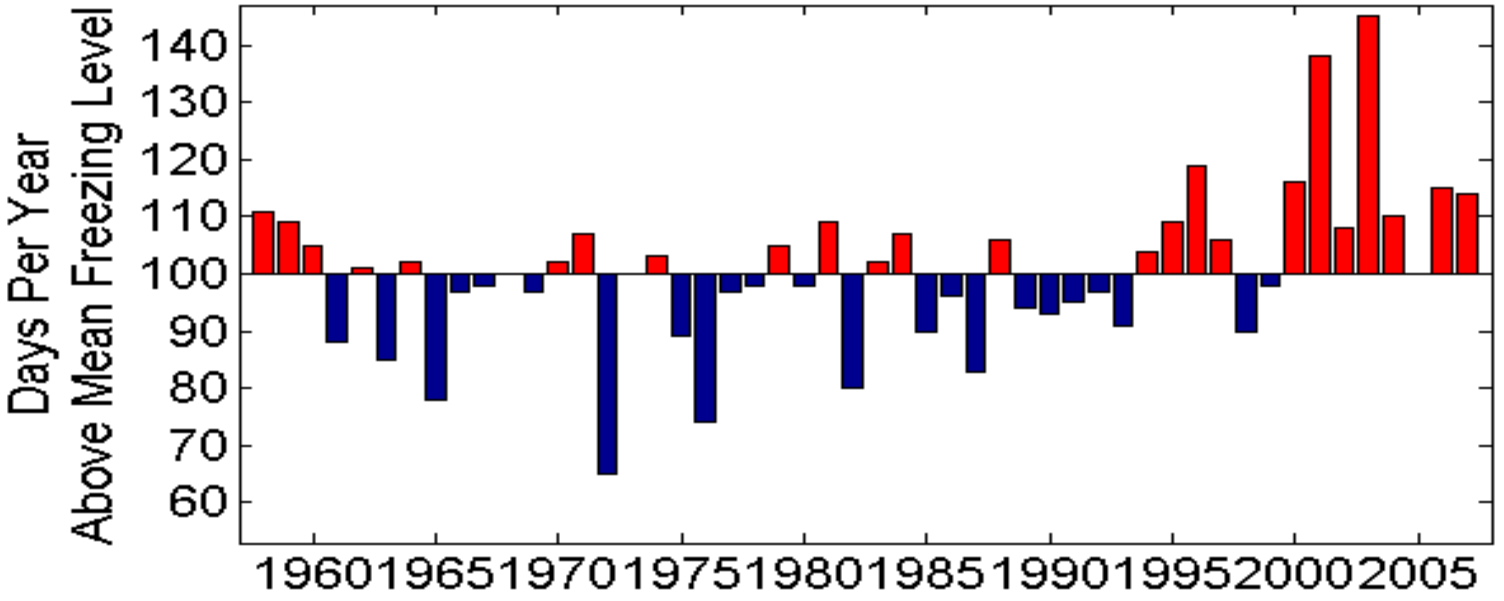
John Abatzoglou
Kelly Redmond

White Mountain Summit Temperature. 14,245 feet. Reconstructed from Global Reanalysis.
99 % of NARR-derived temperatures are within +/- 3 Deg C. ~1000 days of coincident values.



Mean Annual Temperature 1958-2007

Trend 0.24 C/decade, 30% greater than California Statewide. Trends greatest above 6000 feet. Freezing level In spring: trend 1958-2008 170 ft/decade 52 m/decade



Days with Mean Daily Temperature Above Freezing (0 C)

John Abatzoglou
Kelly Redmond

Elements of Applied Climatology

Observations
Operational products
Tools
Interactions with users
Outreach, training and education
Learning from and advising the research infrastructure
- **Pipeline to and from the national research infrastructure**

Public and private activities
Providing what is needed versus what is wanted
- **The skill in Applied Climatology is in distinguishing between these**

Additional western consideration

- **Knowledge of the 3-dimensional field of evolving climate at a scale of 0.5-1.0 km**

Applied Climatology and a National Climate Service (NCS) - 1

Thoughts after Vail June 2008 Workshop

Needs and applications are increasing and diversifying

General feeling that the present structure

- **Is not delivering all that is needed**
- **Is not able to deliver all that is needed**
- **Needs to be more responsive**
- **Is not internally wired and interconnected well enough**
- **Does not understand enough about the decision environment**
- **Does not have sufficient problem focus: user pull vs. provider push**

Climate Change is the motivation …..

- **Increasingly embraced by the public**
- **New problem, novelty factor**
- **Unprecedented type of problem**
- **The play is bigger than any actor**
- **No single entity has a corner on the problem**
- **Multi-partner solutions needed**

….. But, climate change not necessary to justify NCS

Applied Climatology and a National Climate Service (NCS) - 2

Agencies and organizations are looking (pleading) for help
- Adaptation a major theme (Roger)
- Long tradition of improving adaptation to the present climate
- More and better data, and access to data, are constant refrain
- Turning data into information
- Big need for tools

Drought and NIDIS as a good test case

Boldness and vision vs. Incrementalism (Vail meeting, Eileen)

Western and mountain needs, in addition

Data quality, completeness, density, accessibility, scale issues (Chris)

Fine scale structure in temporal evolution of 3-D spatial patterns (Chris, Jessica)
- Need to observe
- Need to describe
- Need to understand

Student teachers visit national park for outside-the-box teaching

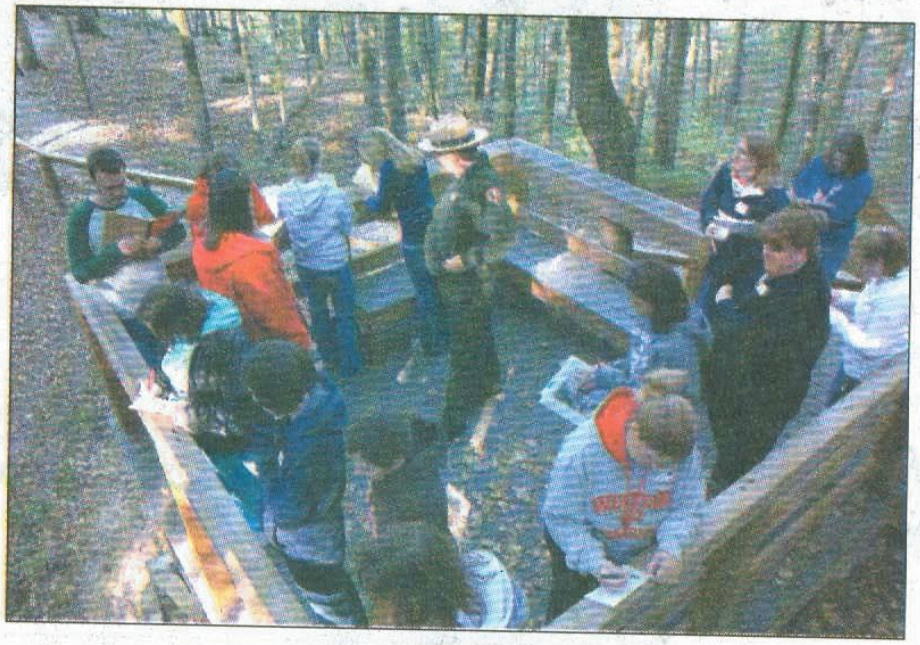
By NATALIE JORDAN
The Daily News
njordan@bgdailynews.com/783-3243

A group of Western Kentucky University students paid close attention Thursday to Mammoth Cave National Park instructor William Beasy at the park.

"You can make it a math activity (or) make it a language activity," he said to the group as he showed casts of animal footprints from the park.

Each semester, the university's education students are required to take part in the park's environmental education program before they complete student teaching. Students got a firsthand look Thursday at how to teach across a curriculum without standing at a board in a classroom all day.

"This is part of the science class we have to take before we become student teachers, so it's a required



Figuring out the length and height of animals by their footprints was just part of what students were learning at the park. In addition

classes three to four times a year. "What they're learning will be relevant in their classrooms, especially science ... science can be an

fessor at the university's Bowling Green campus. The WKU students – who will teach kindergarten through sixth-grade – use one semester to learn math, science and social studies, she said.

"All of these students are going to be future teachers, and we felt it's important for them to get out. By spending time up here, they'll see the value of hands-on learning," Huss said. "A lot of children can learn from their local environments."

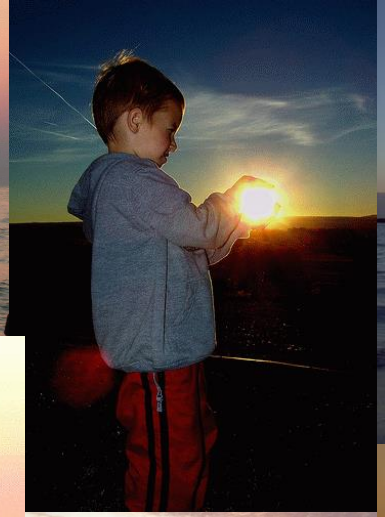
The information the students picked up could definitely be incorporated into the classroom, Adcock said.

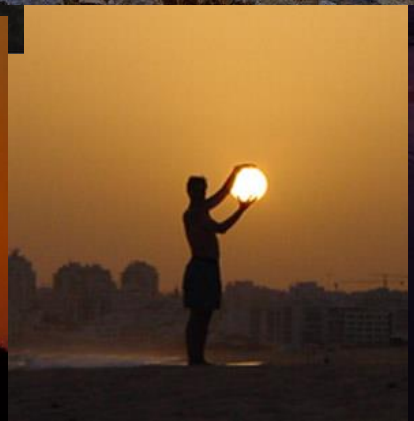
"It's been interesting," said senior elementary education major Becky Scheitlin, 24, of Radcliff. "They've given us a lot of ideas on how to use the cave and implement science in a fun way."

But, if you are inside a box and thinking, could you be described as thinking outside the box? Or, conversely, if you were outside of a box and thinking, would all your thinking be outside the box? Or, if you were outside the box and wanted to think of something that is inside the box, would that be impossible?
The mind reels.
Glen

Courtesy Glen Conner, Kentucky State Climatologist Emeritus, 2007 Oct 15

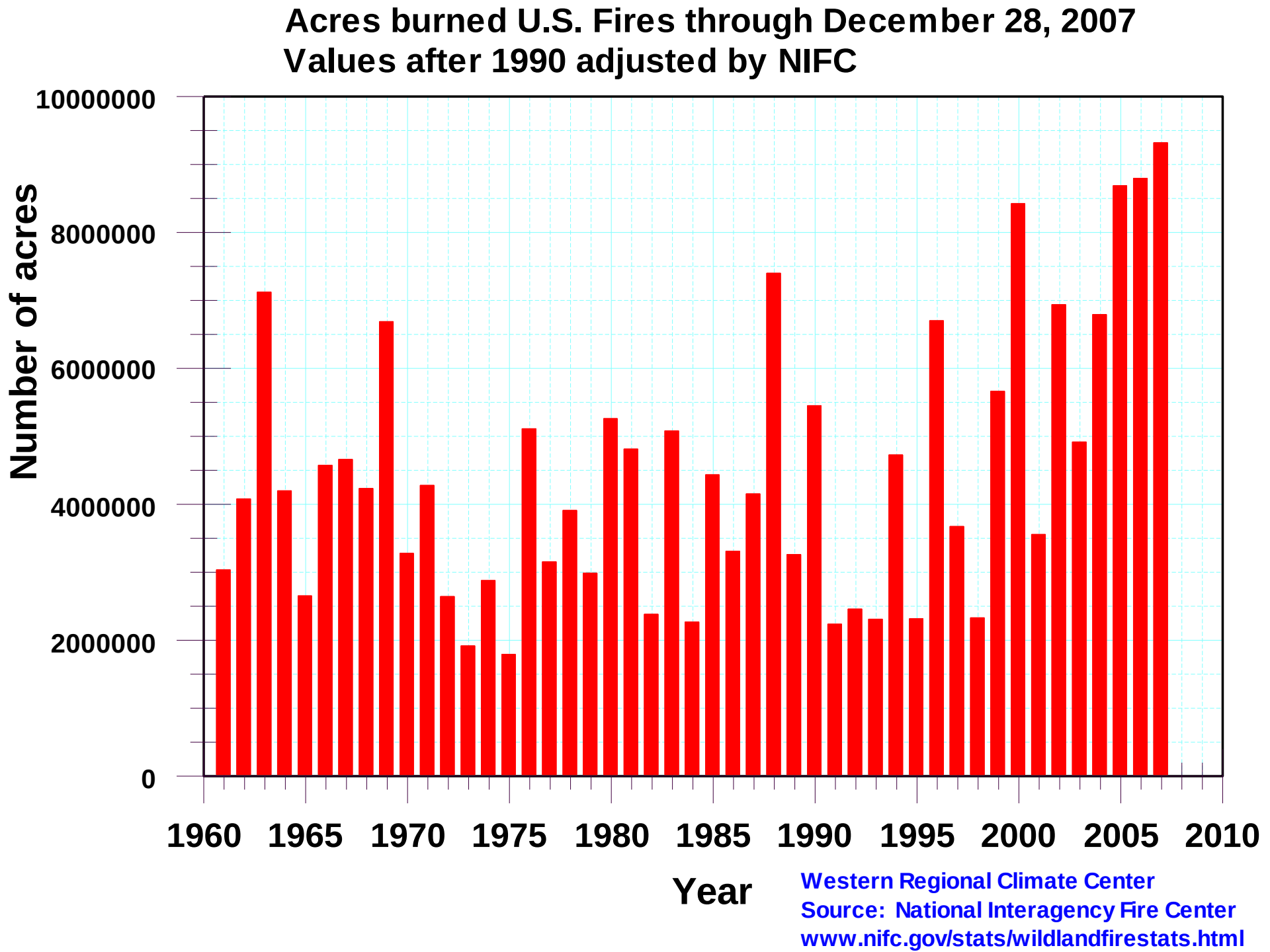
Let’s be creative !!!

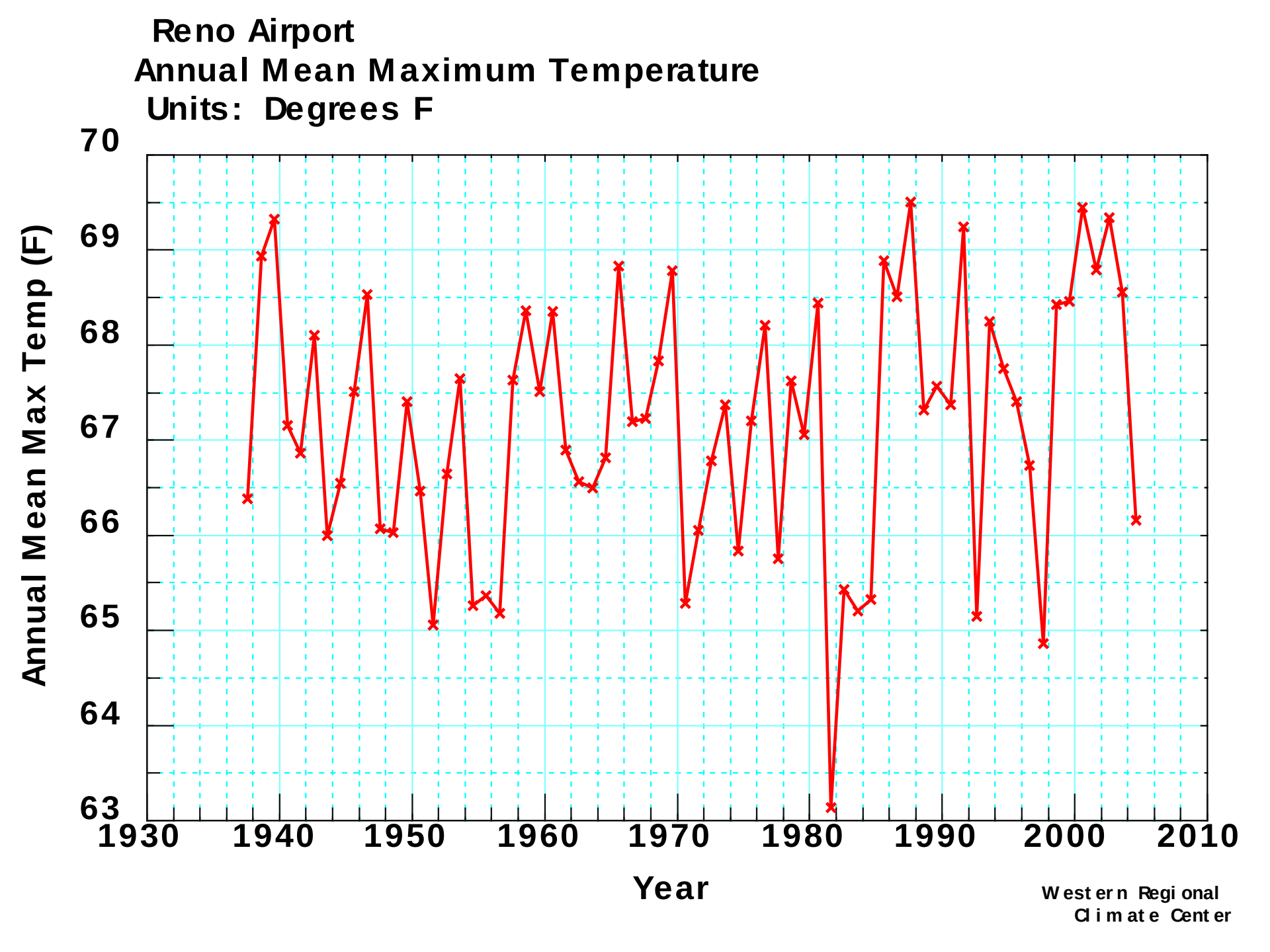


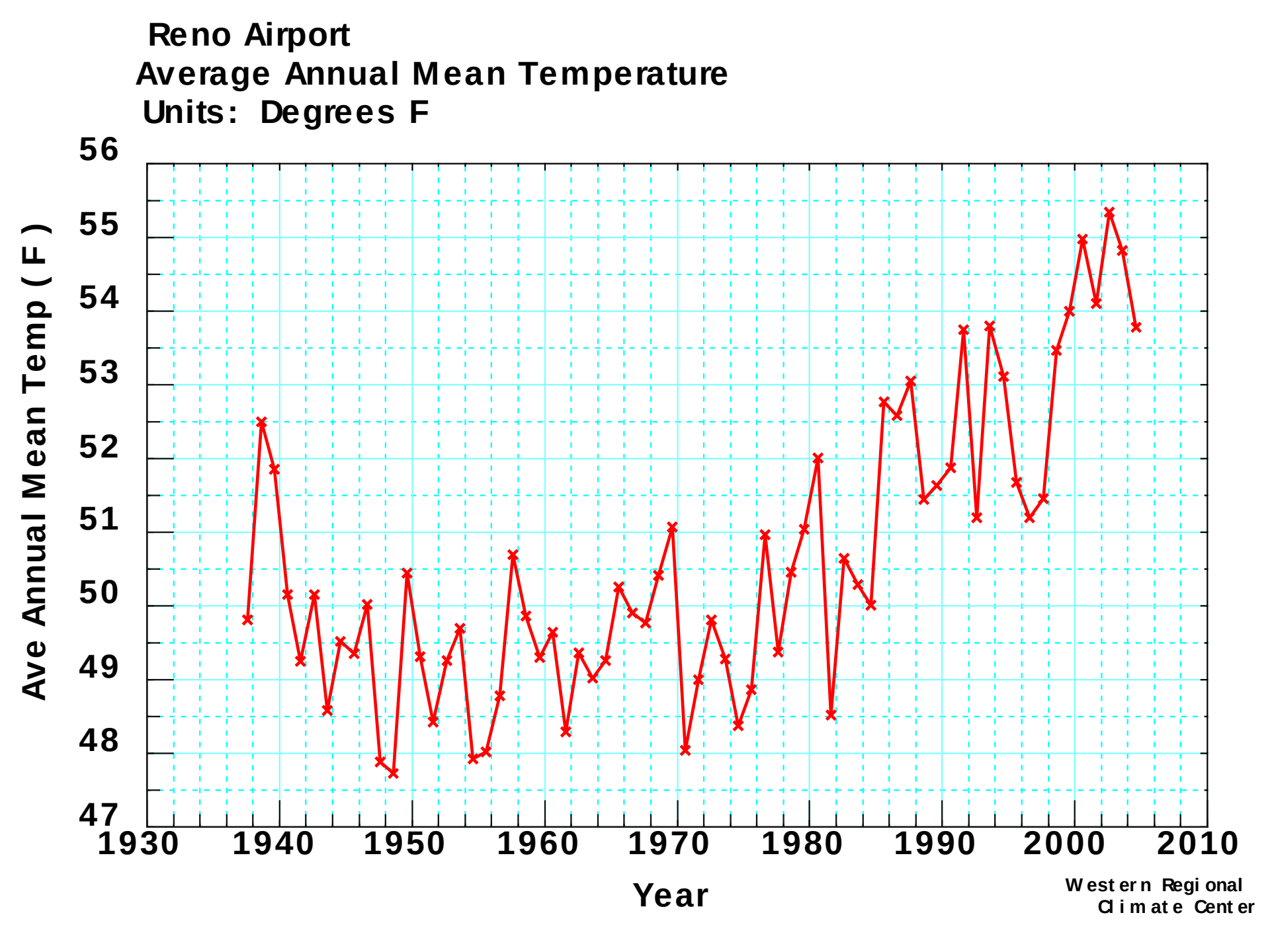



Thank You.

Discards

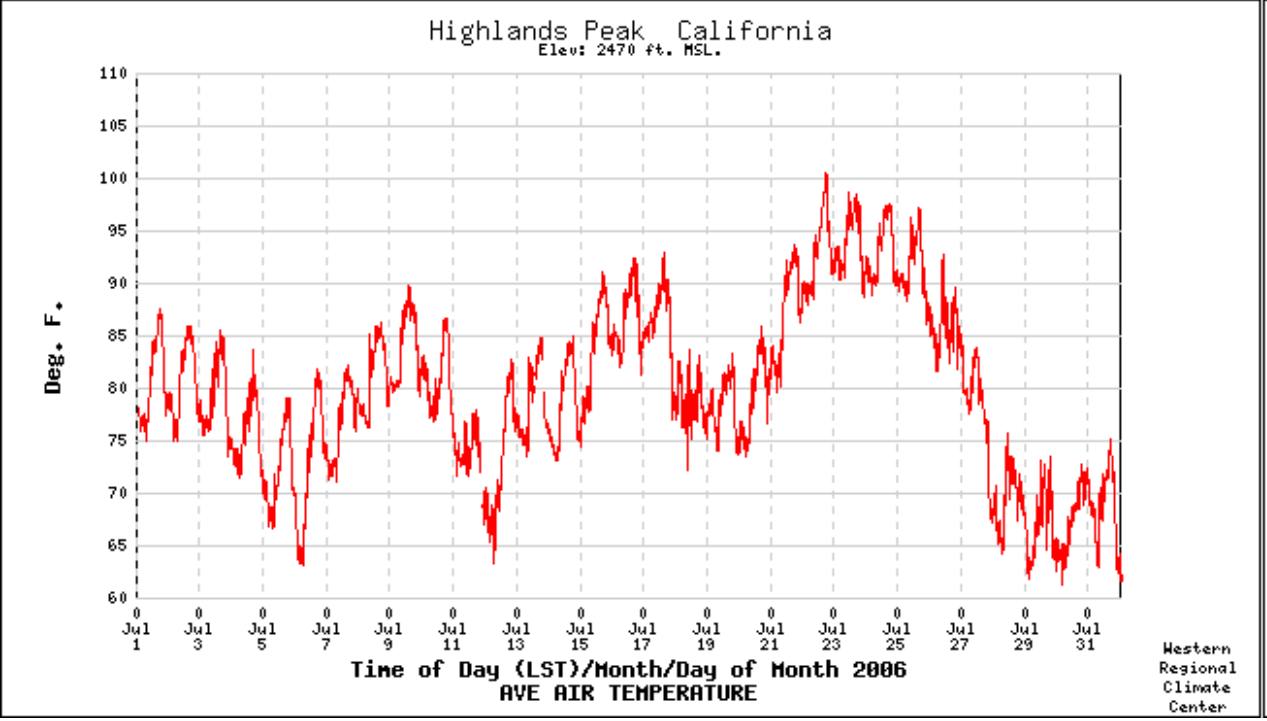

Acres burned U.S. Fires through December 28, 2007
Values after 1990 adjusted by NIFC
Number of acres
10000000
8000000
6000000
4000000
2000000
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Year
Western Regional Climate Center
Source: National Interagency Fire Center
www.nifc.gov/stats/wildlandfirestats.html


Reno Airport
Annual Mean Maximum Temperature
Units: Degrees F
Annual Mean Max Temp (F)
70
69
68
67
66
65
64
63
1930
1940
1950
1960
1970
1980
1990
2000
2010
Year
Western Regional
Climate Center


Reno Airport
Average Annual Mean Temperature
Units: Degrees F
Ave Annual Mean Temp (F)
56
55
54
53
52
51
50
49
48
47
1930
1940
1950
1960
1970
1980
1990
2000
2010
Year
Western Regional
Climate Center

Whale Point, 400 ft

Highlands Peak, 2500 ft



Statistics

Begin Date/Time
July 1, 2006
:00 LST

End Date/Time
July 31, 2006
23:50 LST

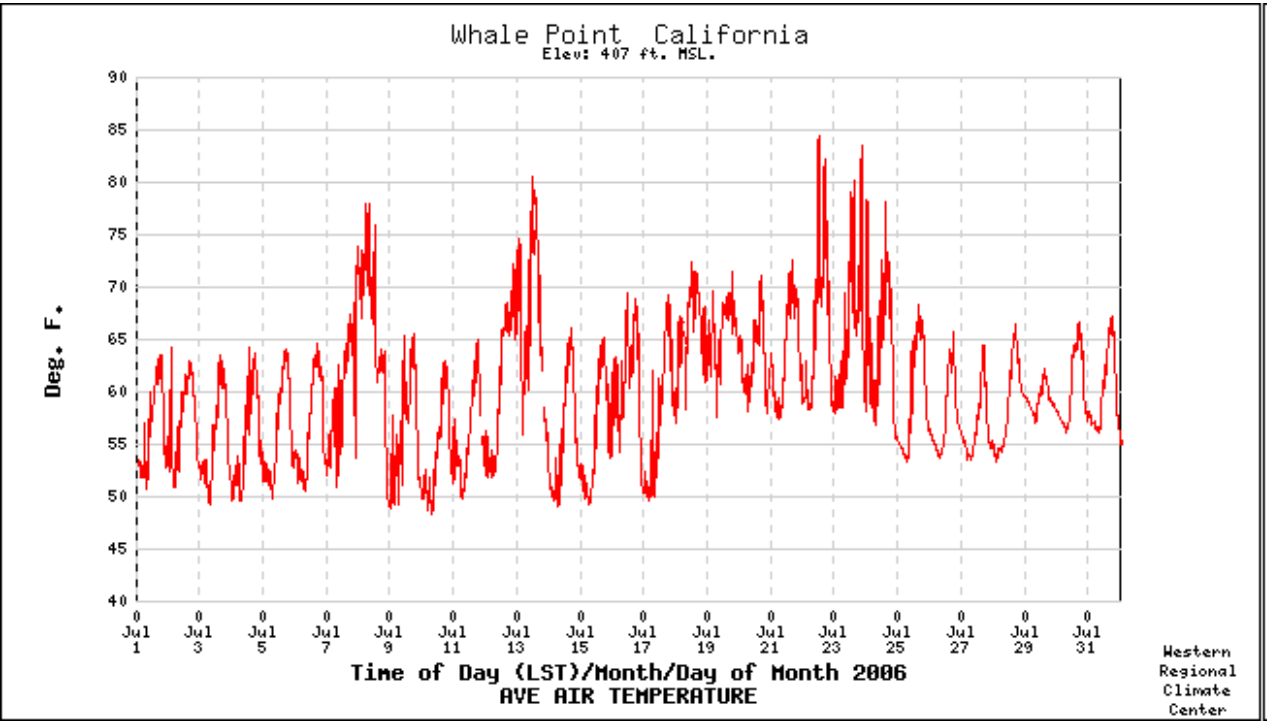
AVE AIR TEMPERATURE
Deg. F.

Average
79.9

Max. | Min.
100.5 | 61.3

2006 California Heat Wave

Highlands Pk 2500 ft



Statistics

Begin Date/Time
July 1, 2006
:00 LST

End Date/Time
July 31, 2006
23:50 LST

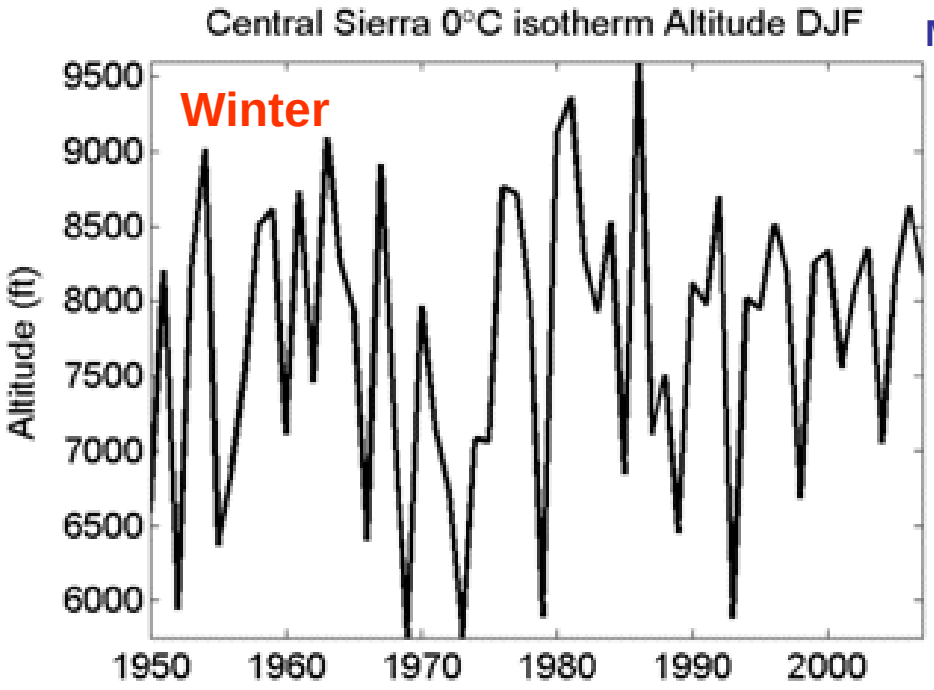
AVE AIR TEMPERATURE
Deg. F.

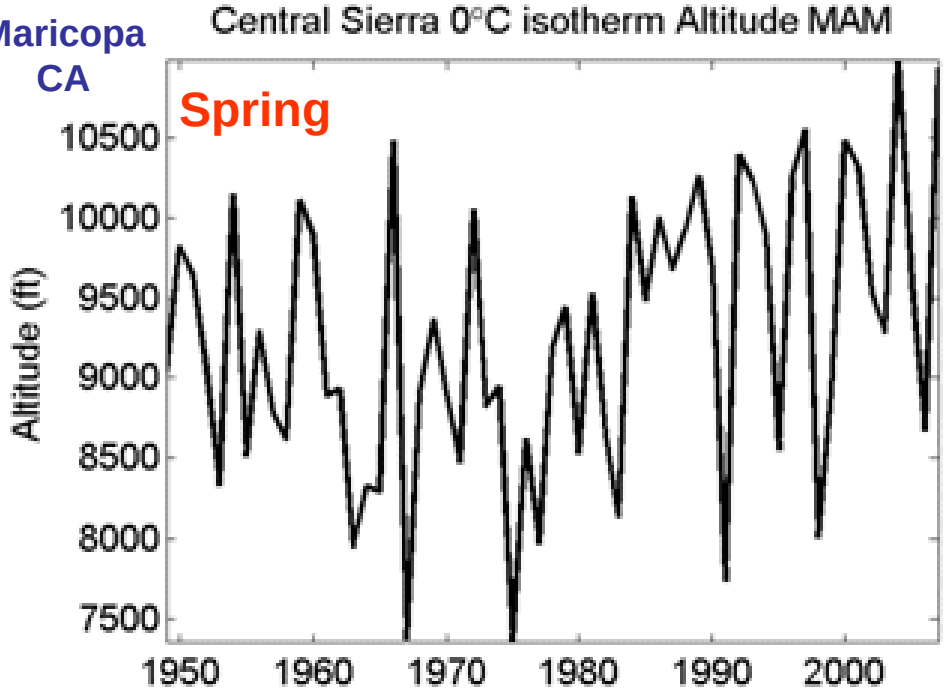
Average
59.8

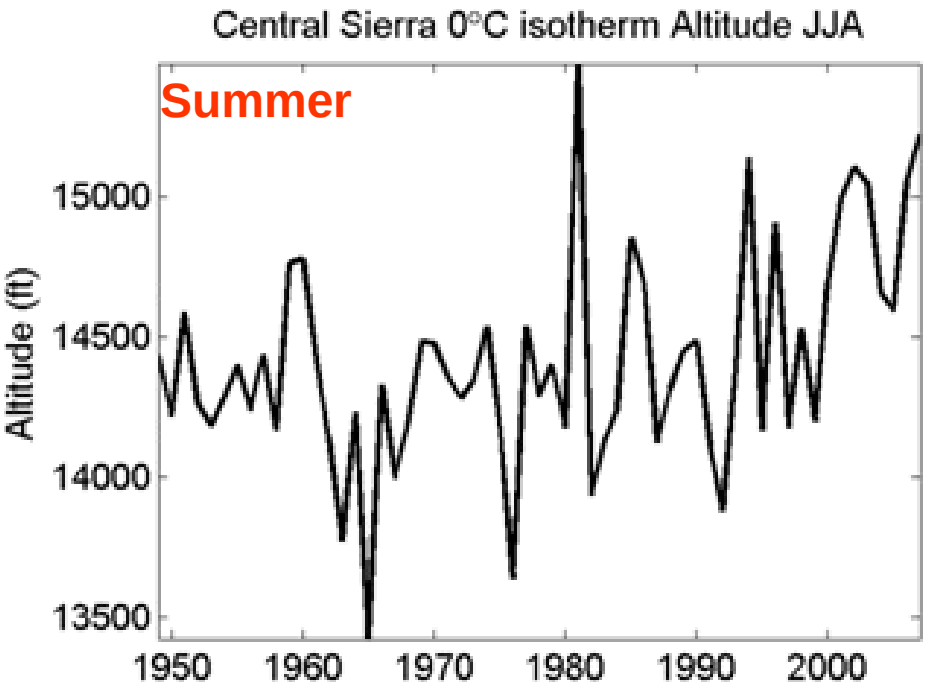
Max. | Min.
84.4 | 48.3

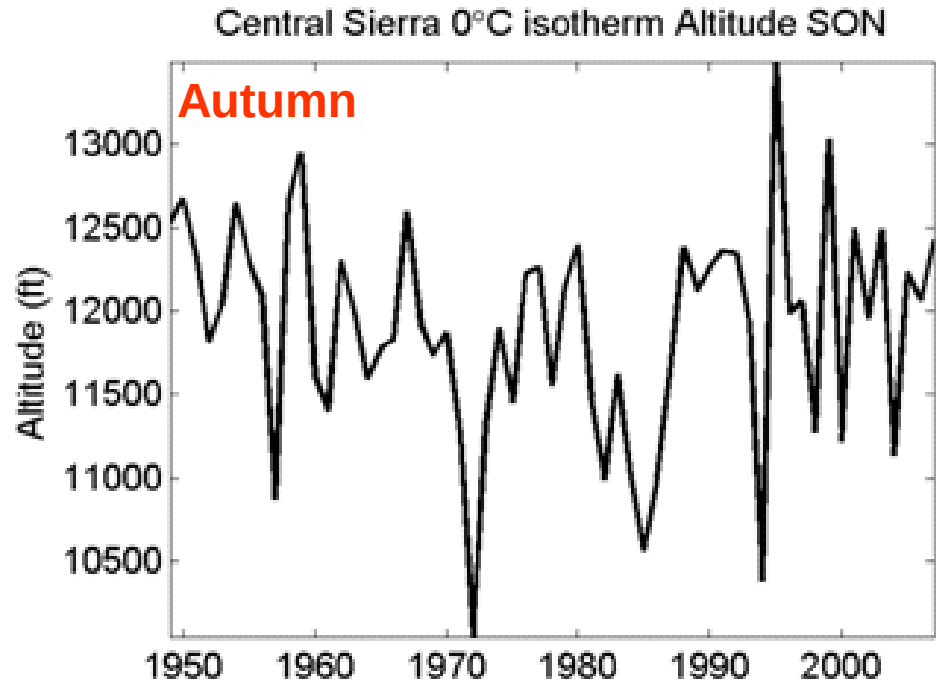
Whale Pt 400 ft

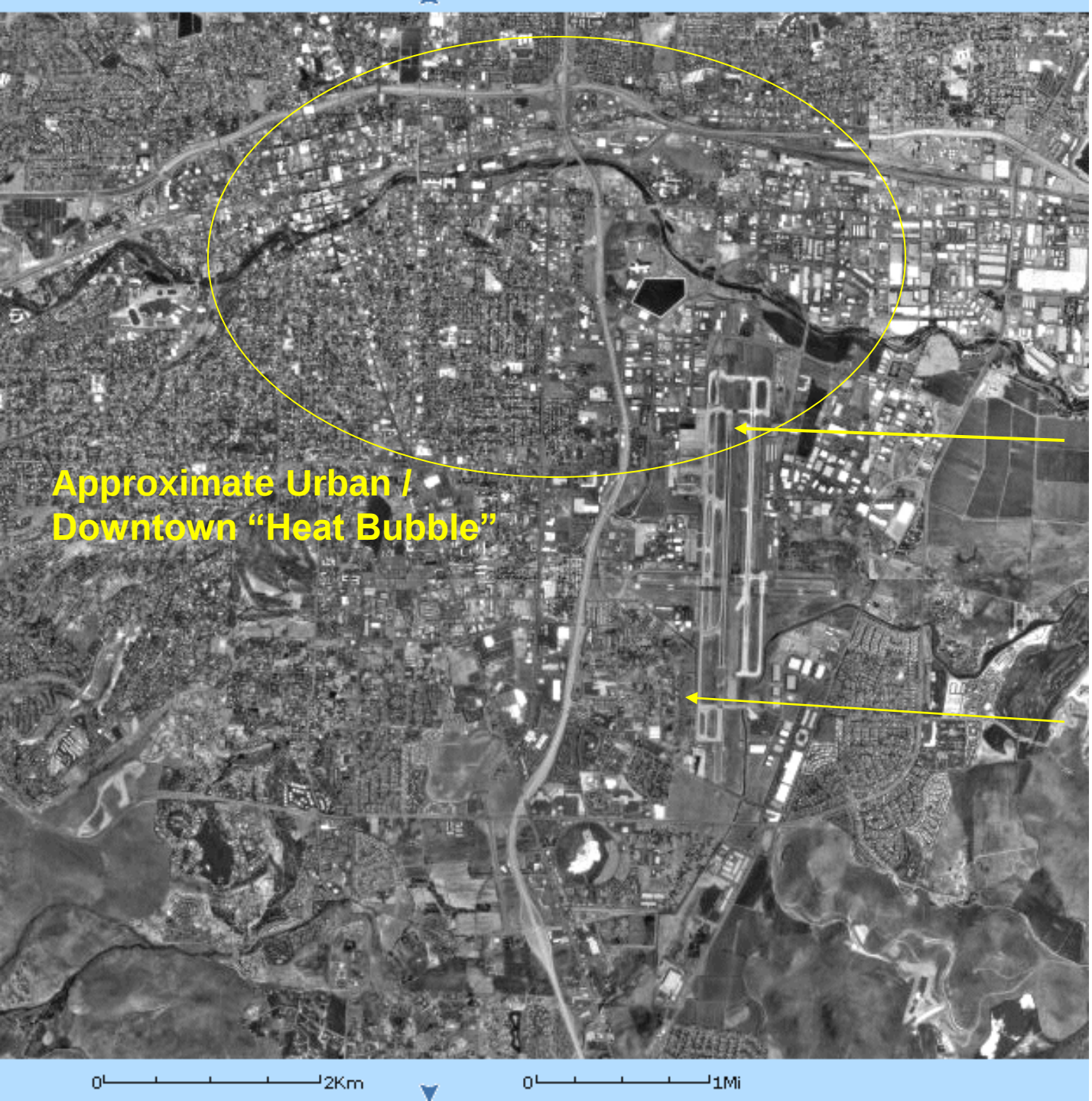
Maricopa
CA


Central Sierra 0°C isotherm Altitude DJF
Winter
Altitude (ft)
9500
9000
8500
8000
7500
7000
6500
6000
1950
1960
1970
1980
1990
2000


Central Sierra 0°C isotherm Altitude MAM
Spring
Altitude (ft)
10500
10000
9500
9000
8500
8000
7500
1950
1960
1970
1980
1990
2000


Central Sierra 0°C isotherm Altitude JJA
Summer
Altitude (ft)
15000
14500
14000
13500
1950
1960
1970
1980
1990
2000


Central Sierra 0°C isotherm Altitude SON
Autumn
Altitude (ft)
13000
12500
12000
11500
11000
10500
1950
1960
1970
1980
1990
2000



Reno Airport

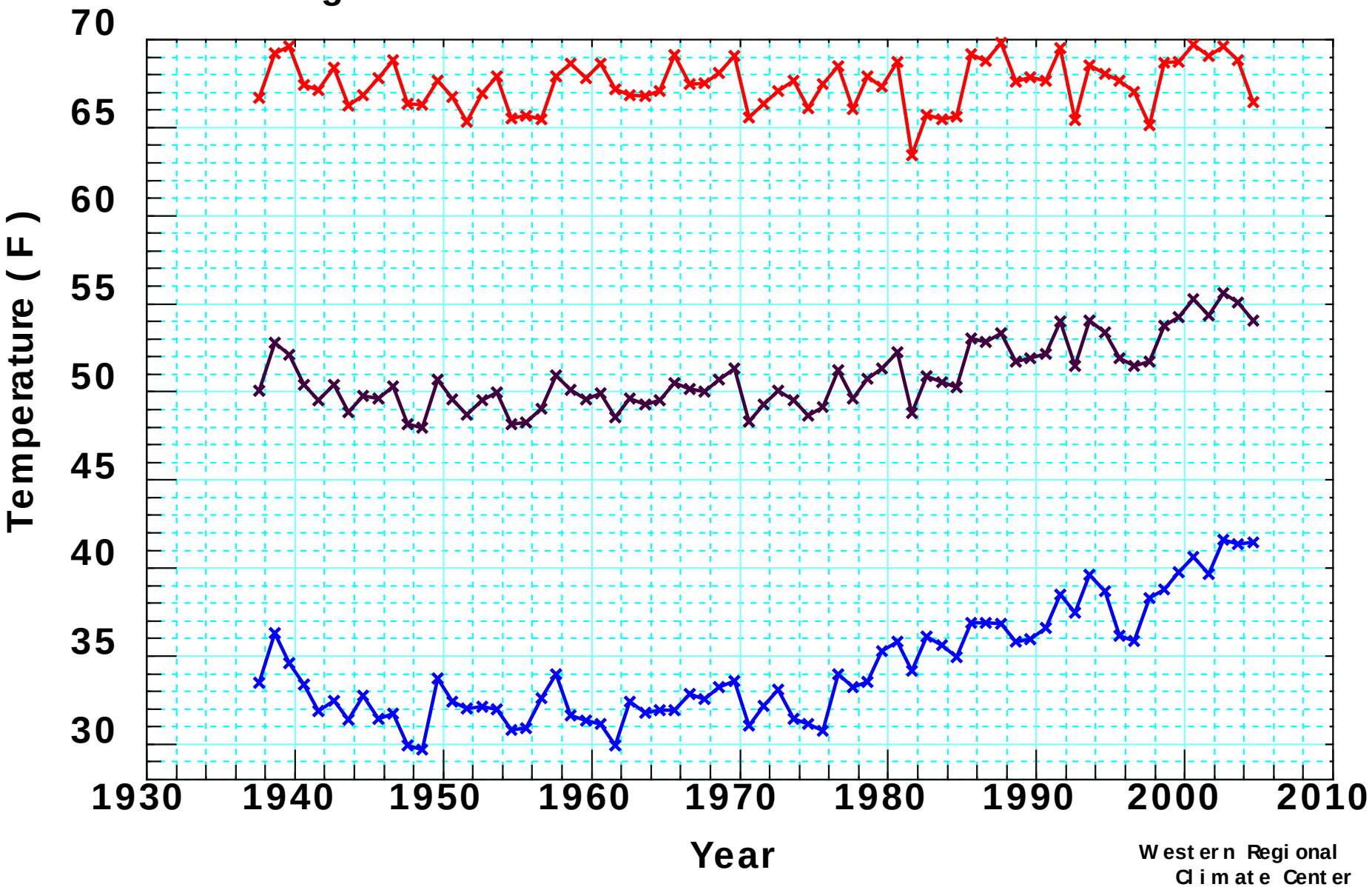
(KRNO)

KRNO ASOS (between runways)

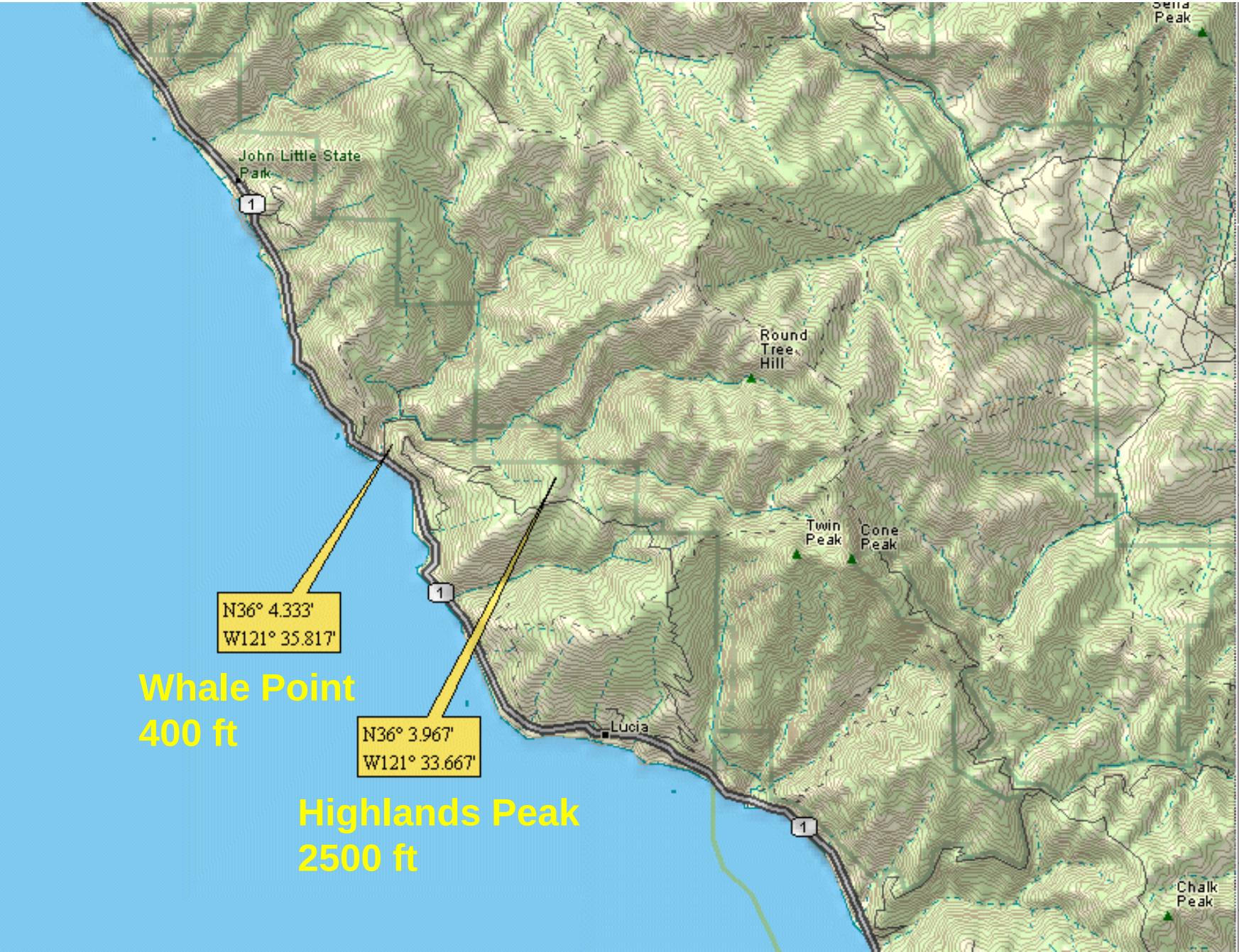
Temporary ASOS ("not windy enough")

****

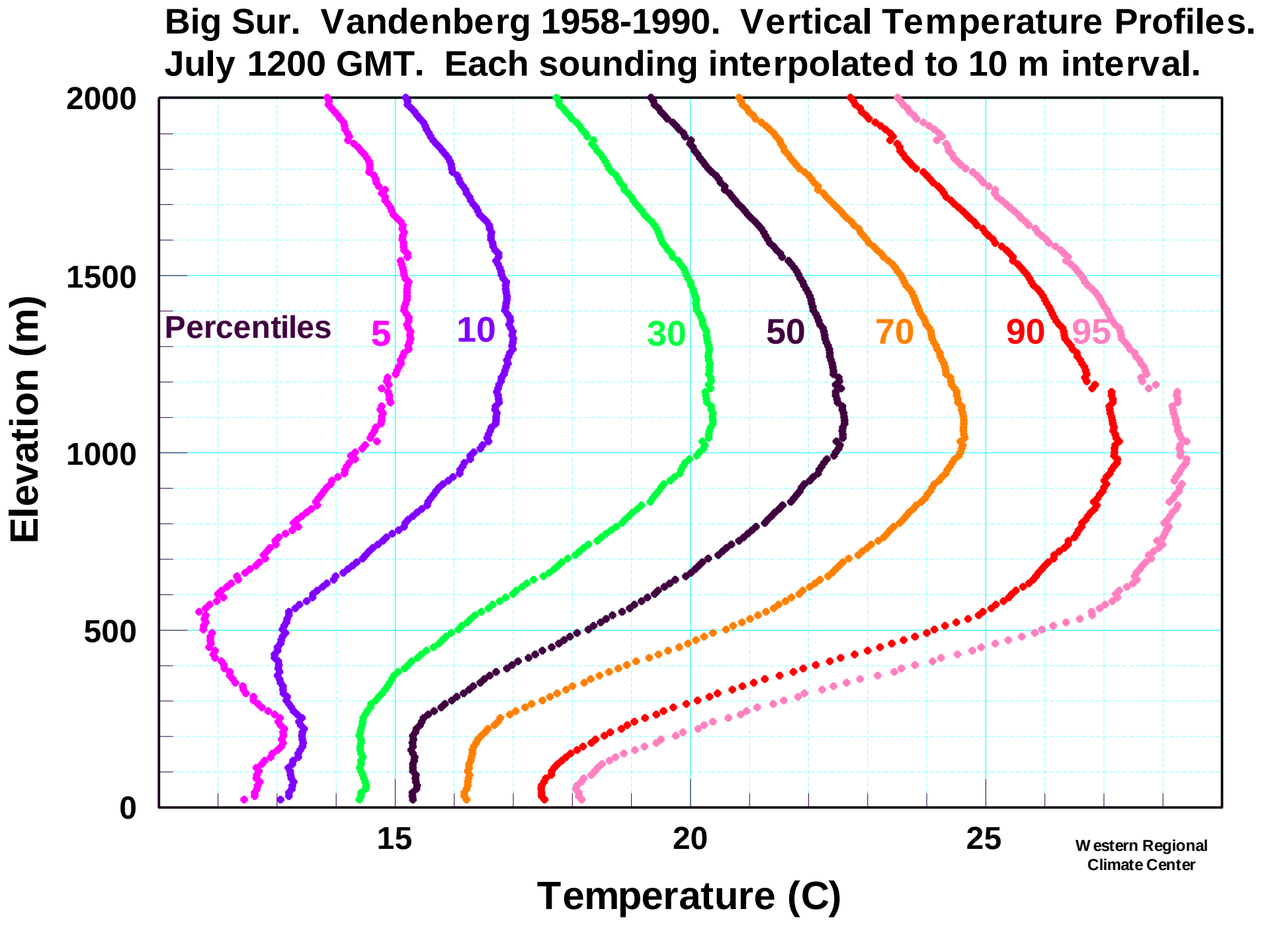
Temperature differences can be 6-8 degrees F from one end of runway to the other, at night.

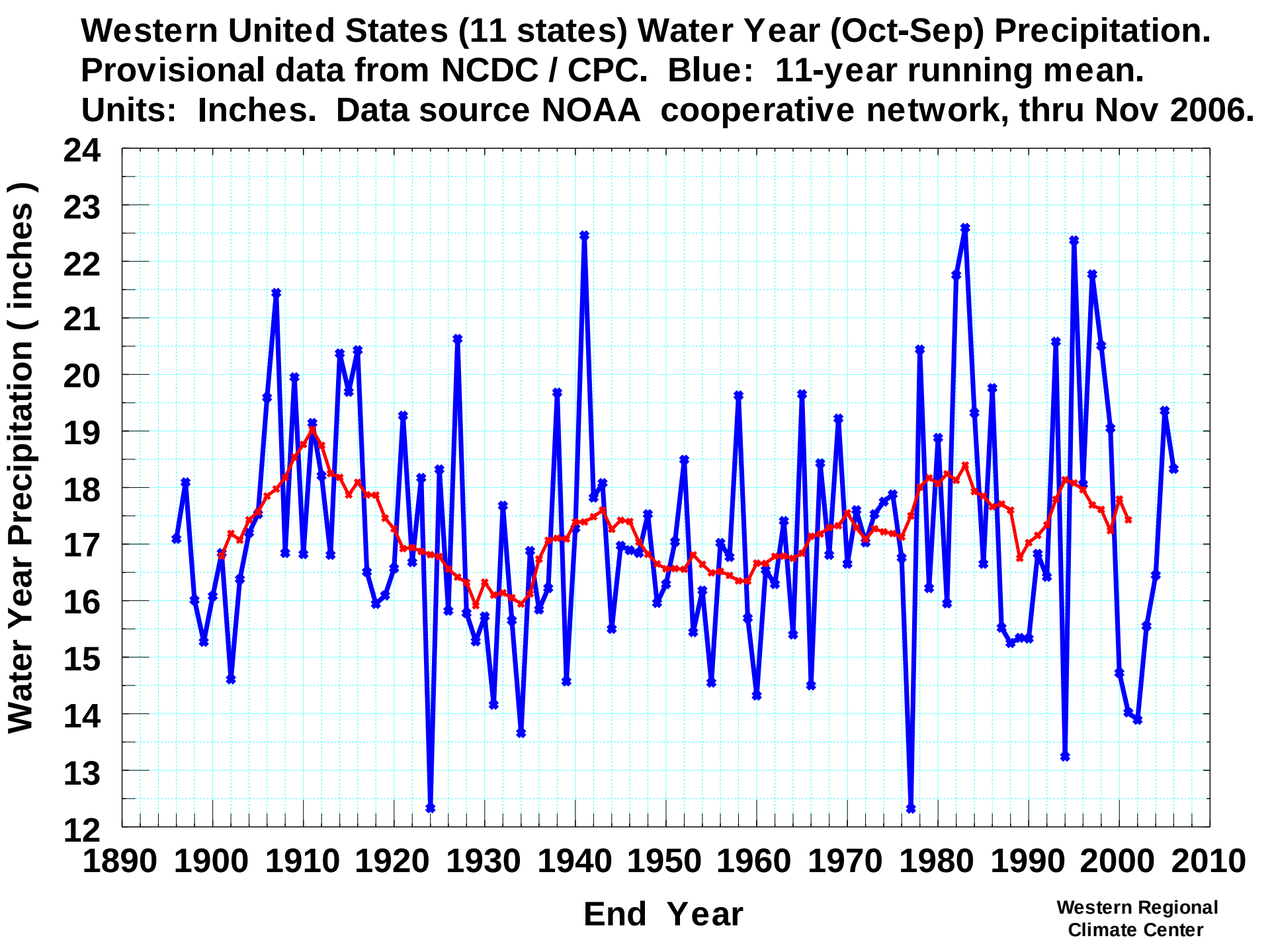

Reno Airport.
Mean Annual Max, Mean, Min Temperature.
Units: Degrees F
Temperature (F)
70
65
60
55
50
45
40
35
30
1930
1940
1950
1960
1970
1980
1990
2000
2010
Year
Western Regional
Climate Center

Whale Point (400 ft) and Highlands Peak (2500 ft), Big Sur. 2 miles apart.



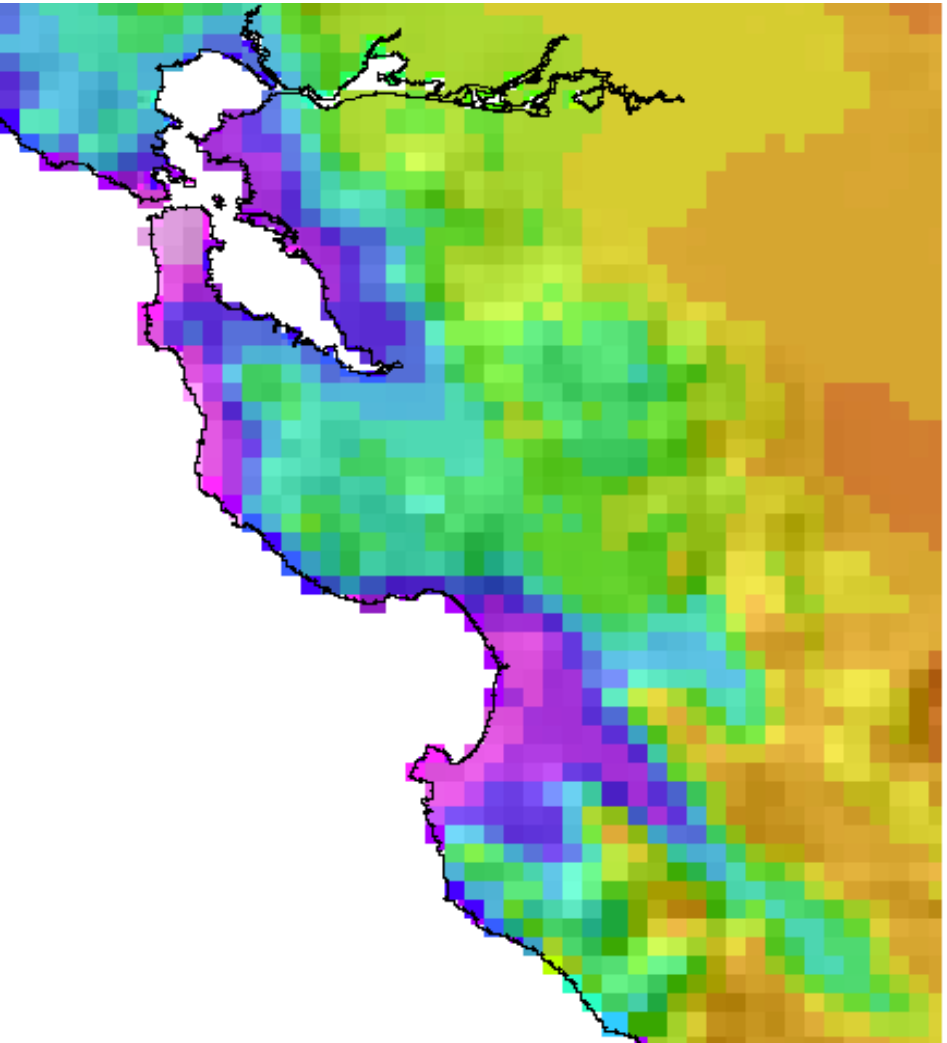
Big Sur, Whale Point, Big Creek UC Reserve, 400 ft


Big Sur. Vandenberg 1958-1990. Vertical Temperature Profiles.
July 1200 GMT. Each sounding interpolated to 10 m interval.
Elevation (m)
2000
1500
1000
500
0
Percentiles
5
10
30
50
70
90
95
15
20
25
Temperature (C)
Western Regional
Climate Center

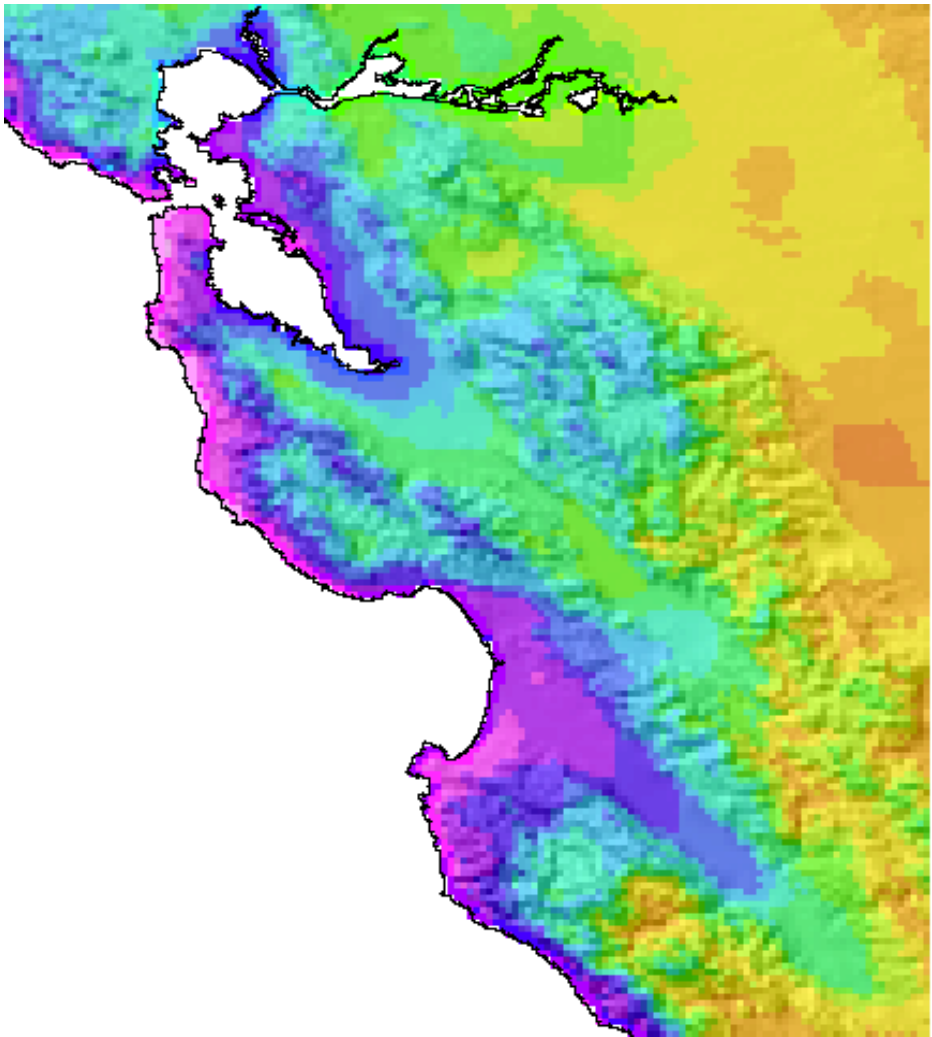

Western United States (11 states) Water Year (Oct-Sep) Precipitation.
Provisional data from NCDC / CPC. Blue: 11-year running mean.
Units: Inches. Data source NOAA cooperative network, thru Nov 2006.
Water Year Precipitation (inches)
24
23
22
21
20
19
18
17
16
15
14
13
12
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
End Year
Western Regional
Climate Center

July Maximum Temperature -- Central California Coast

1961-1990 (4 km)

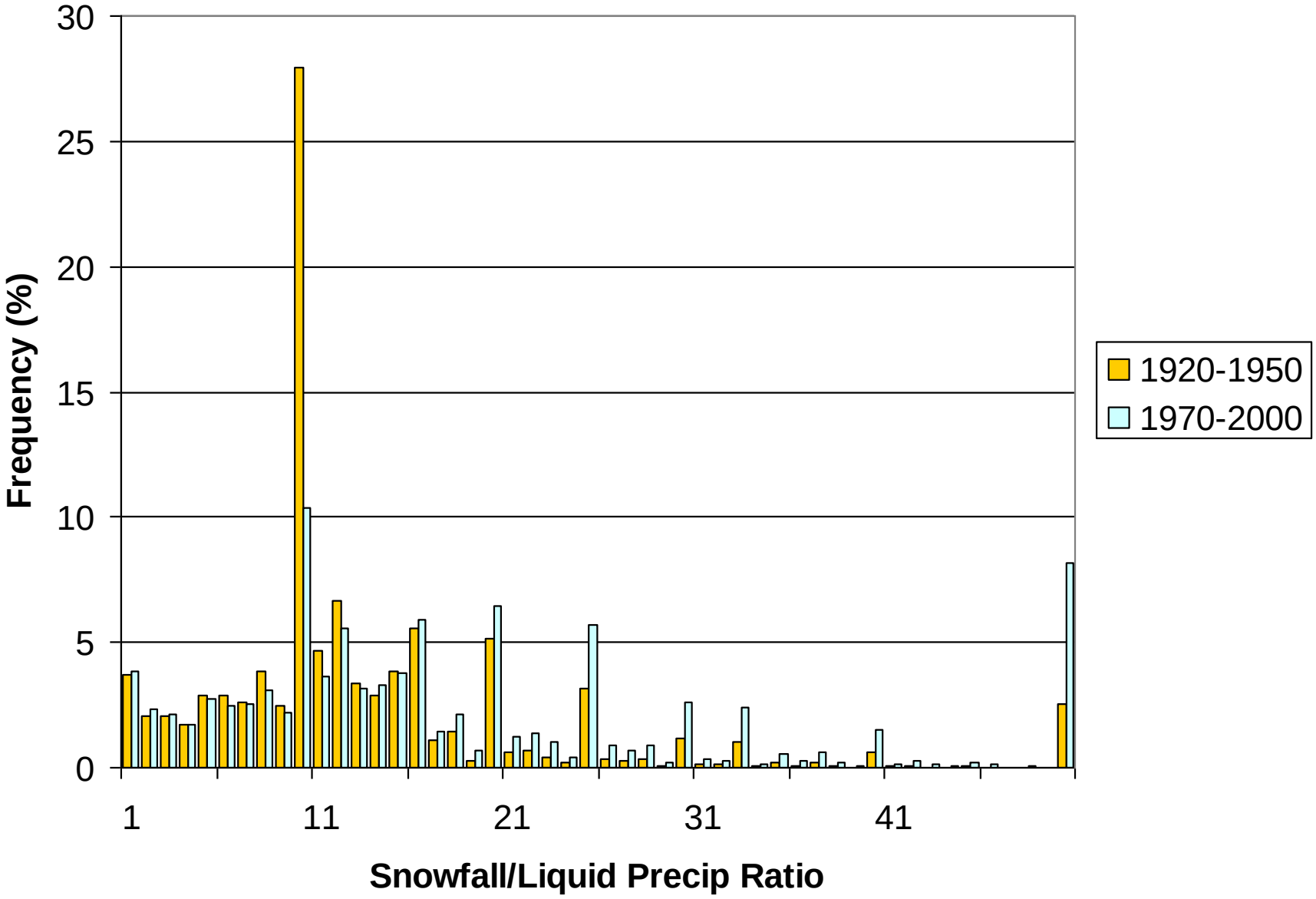


1971-2000 (1 km)



Lake Effect Snow Belt

Kunkel, Robinson,
Easterling, Hubbard,
Palecki, Redmond



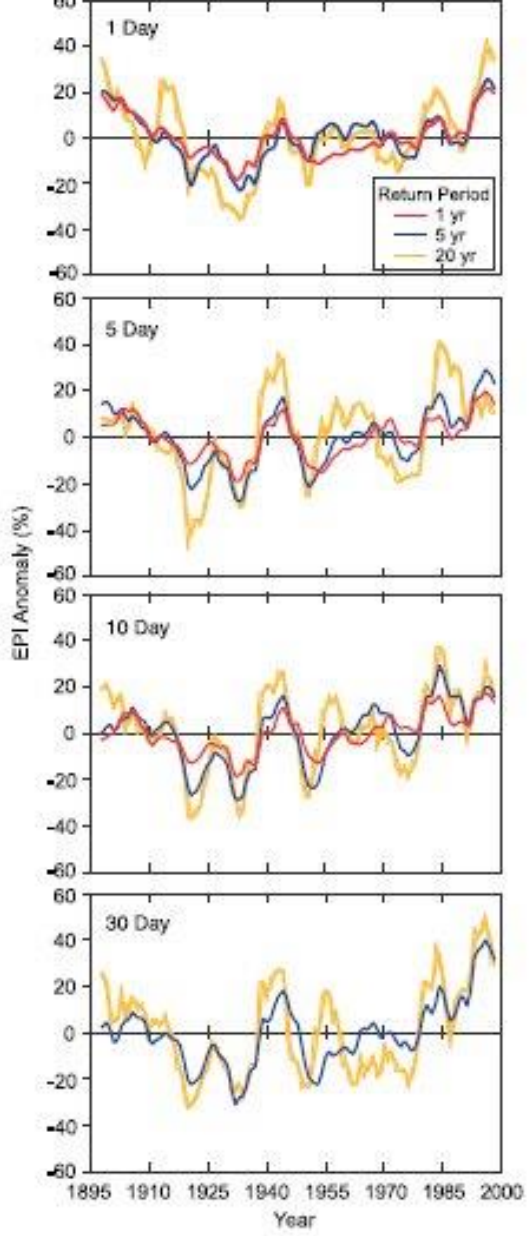


Figure 2. Time series of anomalies of the Extreme Precipitation Index, expressed in %, for various combinations of duration and return period. The time series have been smoothed with a 7-yr moving average filter. Return periods of 1 year (red), 5 years (blue), and 20 years (orange) are plotted on each graph.

1-Day

5-Day

10-Day

30-Day

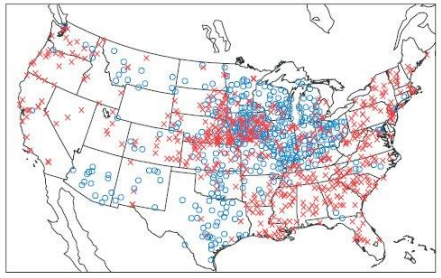


Figure 1. Location of stations with less than 10% missing daily precipitation data for 1895–2000. The symbol 'o' (in blue) indicates that long-term data were available prior to CDMP while the symbol 'x' (in red) indicates newly available long-term stations.

Extreme Precipitation Index

United States

1895-2000.

Selected durations

And

Return periods (1, 5, 20 yrs)

(Station density effects removed)

Ken E. Kunkel, Dave R. Easterling, Kelly T Redmond, and Ken G. Hubbard, 2003.

Temporal variations of extreme precipitation events in the United States: 1895-2000.

Geophysical Research Letters, 30:1717.