Western Regional Climate Center

Desert Research Institute

Climate Monitoring Across Multiple Scales in Western North America

Kelly Redmond

Western Regional Climate Center

Desert Research Institute

Reno Nevada

Forum on Ecoregional Monitoring for the National Wildlife Refuge System and Other Public Lands across Alaska
Anchorage and Girdwood AK 14-16 April 2009

Western Regional Climate Center

Historical Climate Information
Western U.S. Historical Summaries; Precipitation Maps; Station Inventories; Wind and Evaporation Data; Coastal Water Table; State Narratives; Station Descriptions; Anomalies.

Current Observations, Forecasts and Monitoring
Nat'l Weather Service Current and Past 24-hour Reports; Snotel; Climate Prediction Center Outlooks; Satellite and Radar Imagery; SPI; Anomalies; Divisional Climate Plots; ACIS; CoCoRaHS.

WRCC Projects
El Nino & La Nina; CEMP; WET; BLM RAWS; Yucca Mtn; Current Weather Plots; NSOE; Snotel; CoCoRaHS; California Climate Data Archive; Photo Gallery; Webcam; WxCoder.

More Climate Information
Solar Radiation; Sunrise/Sunset Information (USNO); WGA data and information; Nat'l Climatic Data Center; Climate Prediction Center; CEFA; Nat'l Drought Mitigation Center.

Educational and Travel Pages
Terms; More about Weather and Climate - for teachers and kids! Climate for resorts and Nat'l parks around the West.

About the WRCC
Staff; Funding; Overview of WRCC; DRI Home Page; INTERNAL.

WRCC Supports a Three-Partner National Climate Services Program - the Partners Include:
National Climatic Data Center (NCDC), Regional Climate Centers (RCC's), and State Climate Offices.

Address:
WRCC
2215 Raggio Parkway
Reno, NV 89512
(775) 674-7010 - phone
(775) 674-7016 - fax

Hours:
Mon - Thurs 8-4pm

wrcc@dri.edu

Background

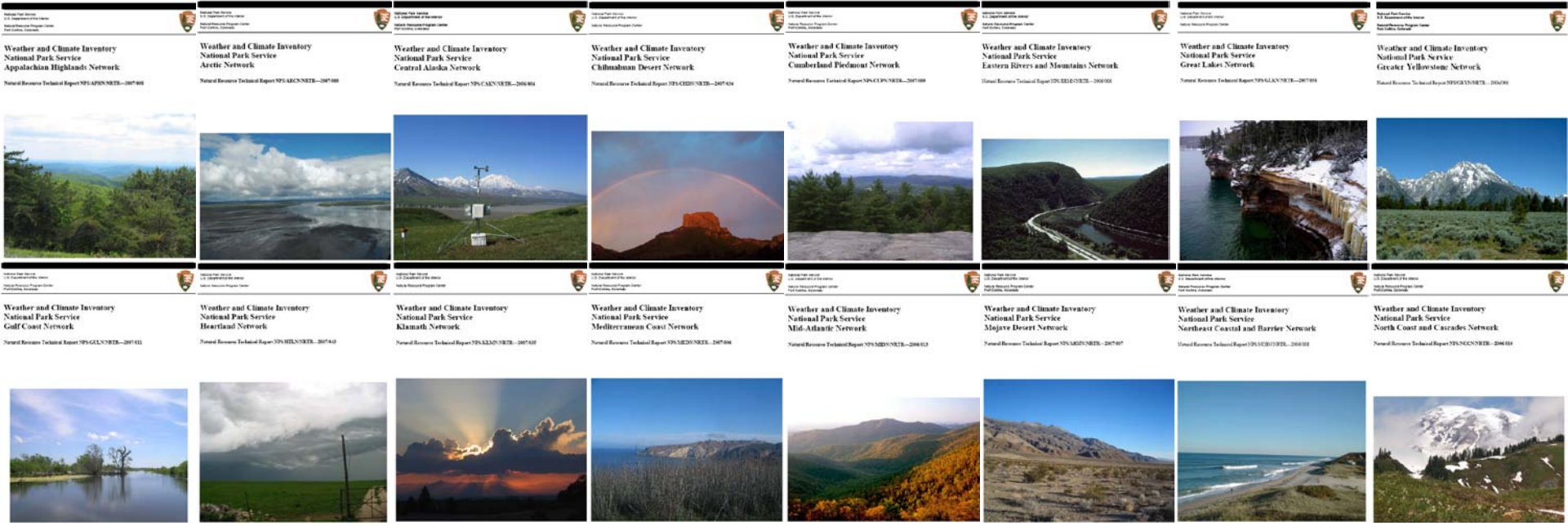
Descriptions of a few major networks

Multipurpose networks

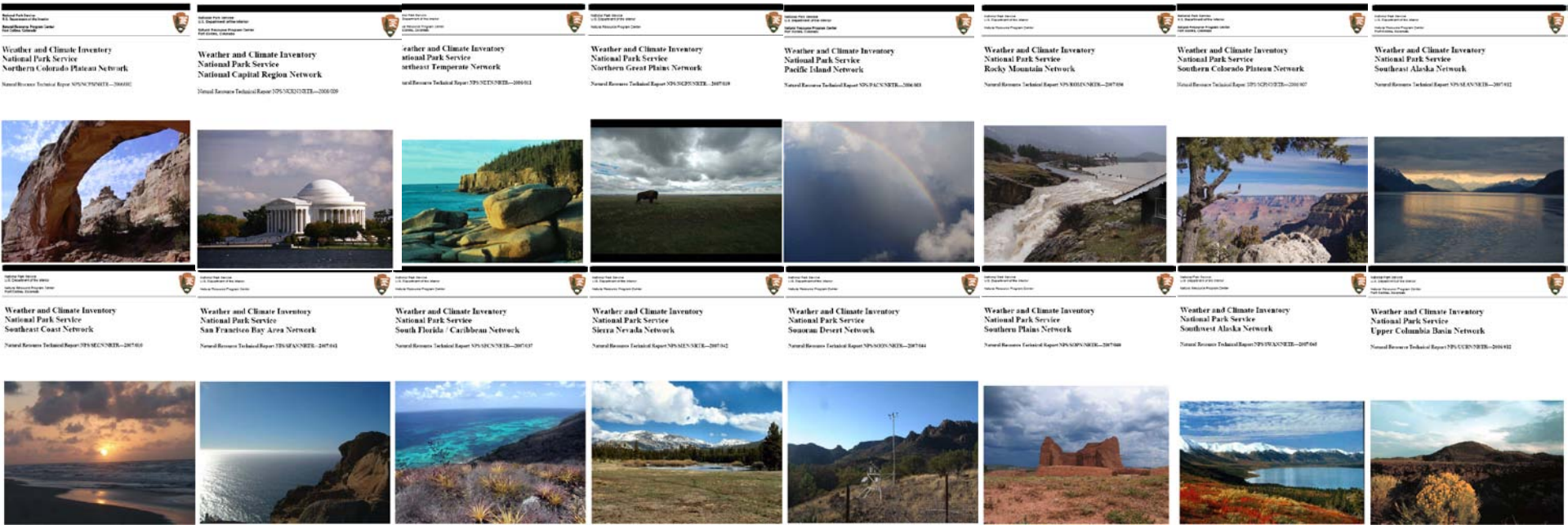
Mission supportive networks with more restrictive focus (initially)

Specialty networks

General thoughts



32 Networks. **32 Climate Inventory Reports.** **www.wrcc.dri.edu/nps**



National Park Service
U.S. Department of the Interior

Natural Resource Program Center
Fort Collins, Colorado

Weather and Climate Inventory
National Park Service
Arctic Network

Natural Resource Technical Report NPS/ARCN/NRTR—2007/005

Arctic Network

National Park Service
U.S. Department of the Interior

Natural Resource Program Center
Fort Collins, Colorado

Weather and Climate Inventory
National Park Service
Central Alaska Network

Natural Resource Technical Report NPS/CAKN/NRTR—2006/004

Central Alaska Network

National Park Service
U.S. Department of the Interior

Natural Resource Program Center

Weather and Climate Inventory
National Park Service
Southwest Alaska Network

Natural Resource Technical Report NPS/SWAN/NRTR—2007/045

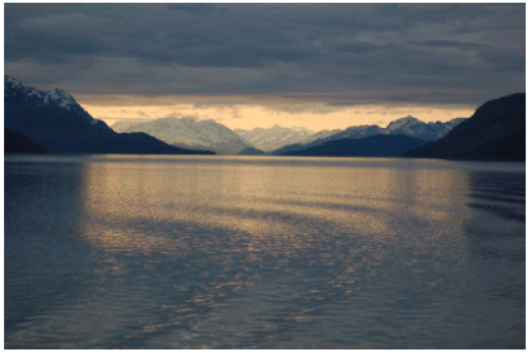
Southwest Alaska Network

National Park Service
U.S. Department of the Interior

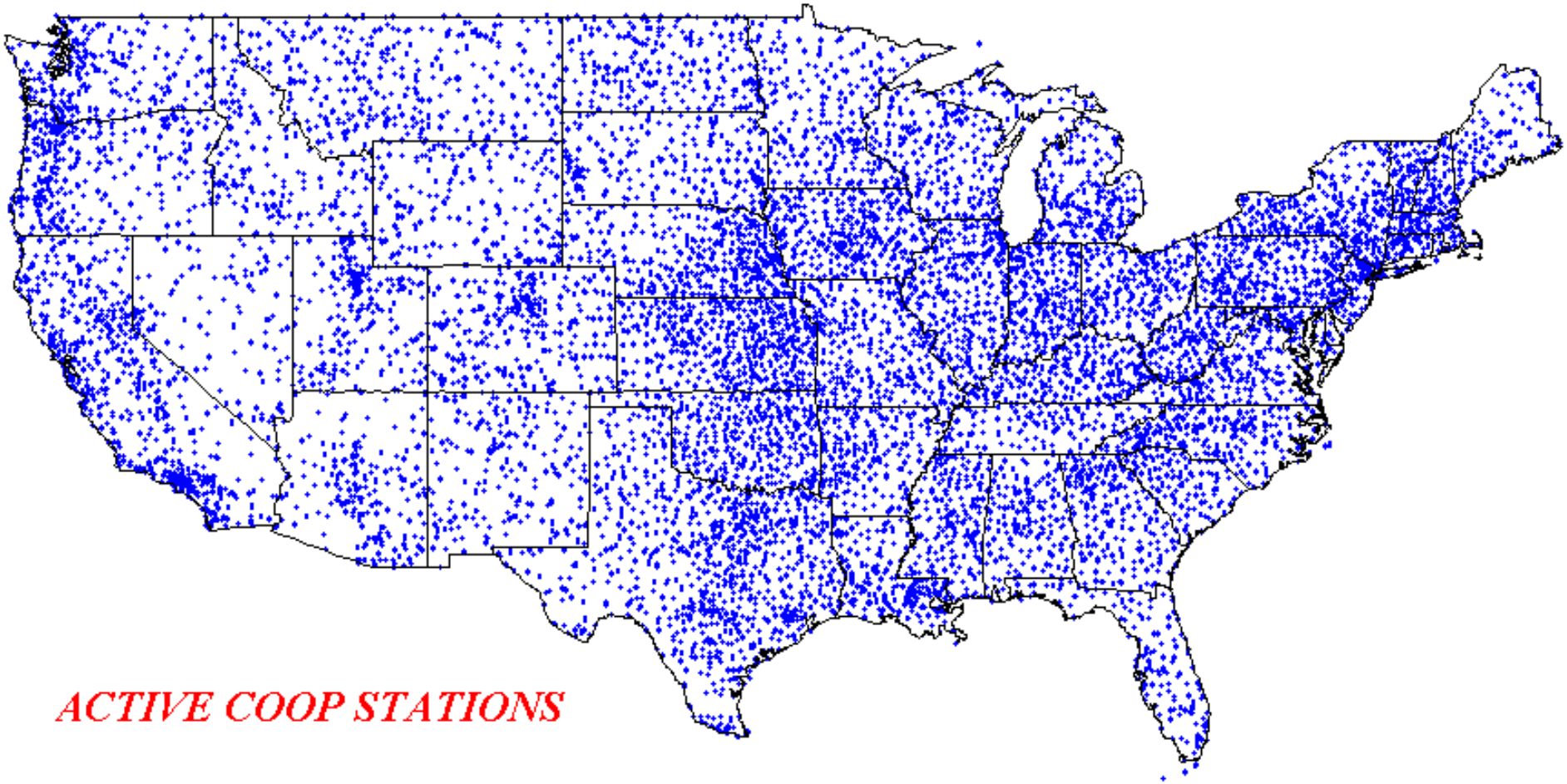
Natural Resource Program Center
Fort Collins, Colorado

Weather and Climate Inventory
National Park Service
Southeast Alaska Network

Natural Resource Technical Report NPS/SEAN/NRTR—2007/012



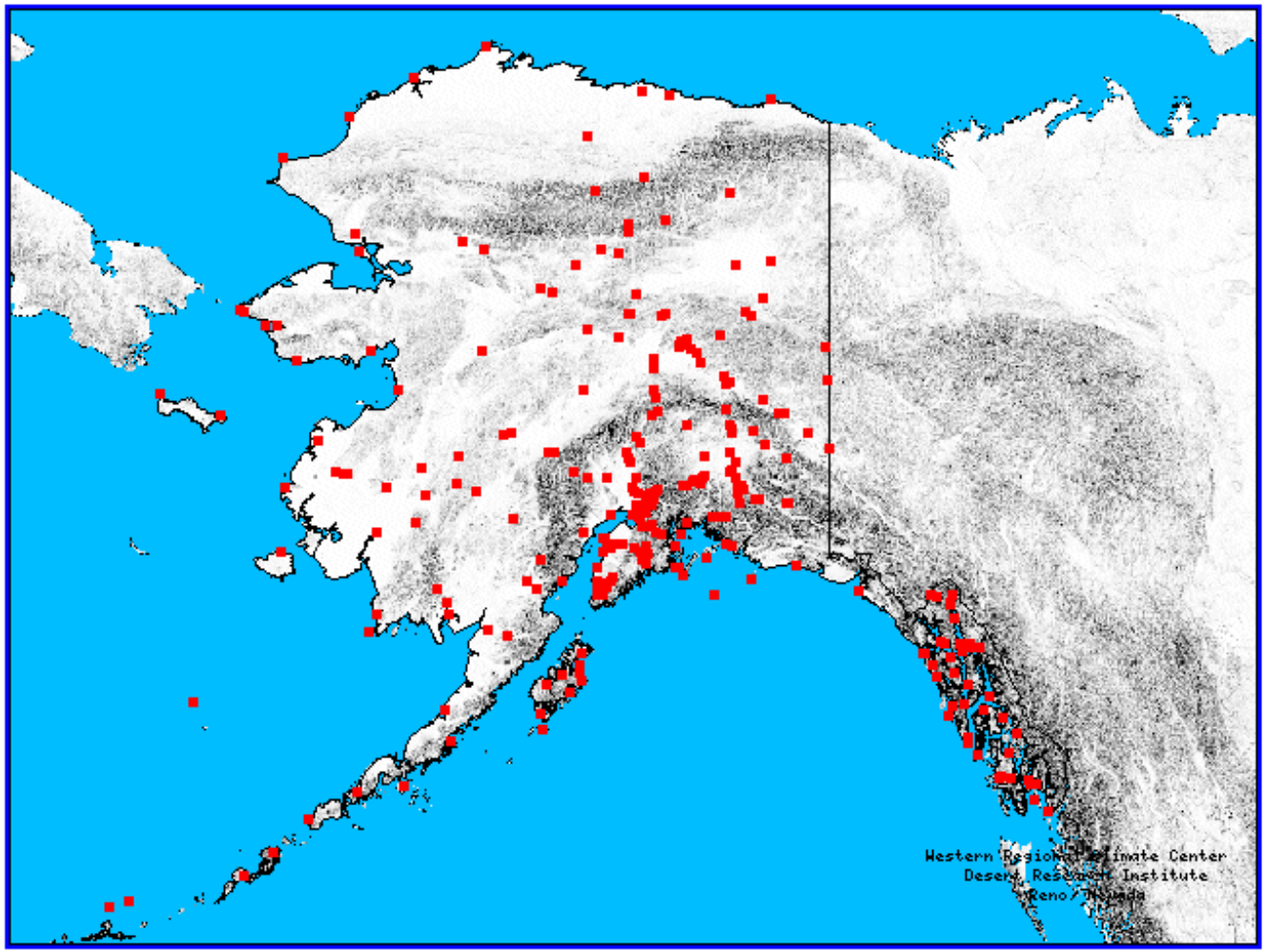
Southeast Alaska Network


ACTIVE COOP STATIONS

NWS Coop sites with enough data for Temperature Summary ~ 5 yrs

Alaska

Adult Conservation Cam
Alaska Pacific University
Aleknagik
Allakaket
Alpine Inn
Alyeska
Ambler West
Anaktuvuk Auto
Anchorage Park Strip
Anchorage Wscmo Ap
Anchorage Wb Airport
Anchorage 4 Ese
Anderson Lake
Angoon
Aniak Ap
Annette Wb Airport
Annex Creek
Arctic Village
Attu N A U
Auke Bay
Baranof
Barrow Wso Airport
Barter Island Wso Airpo
Bear Cove
Beaver Falls
Beluga
Bens Farm
Bethel Wso Airport



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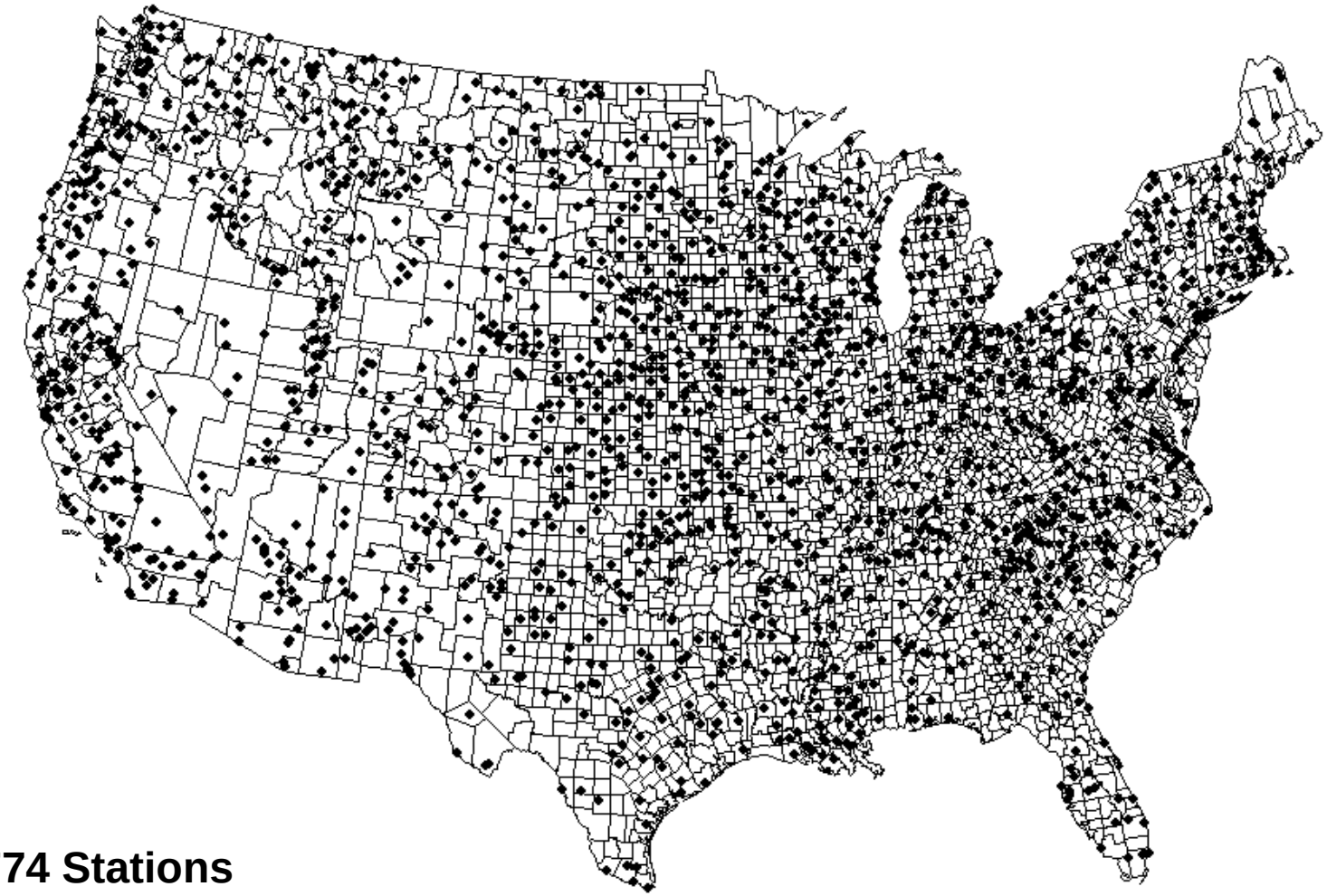
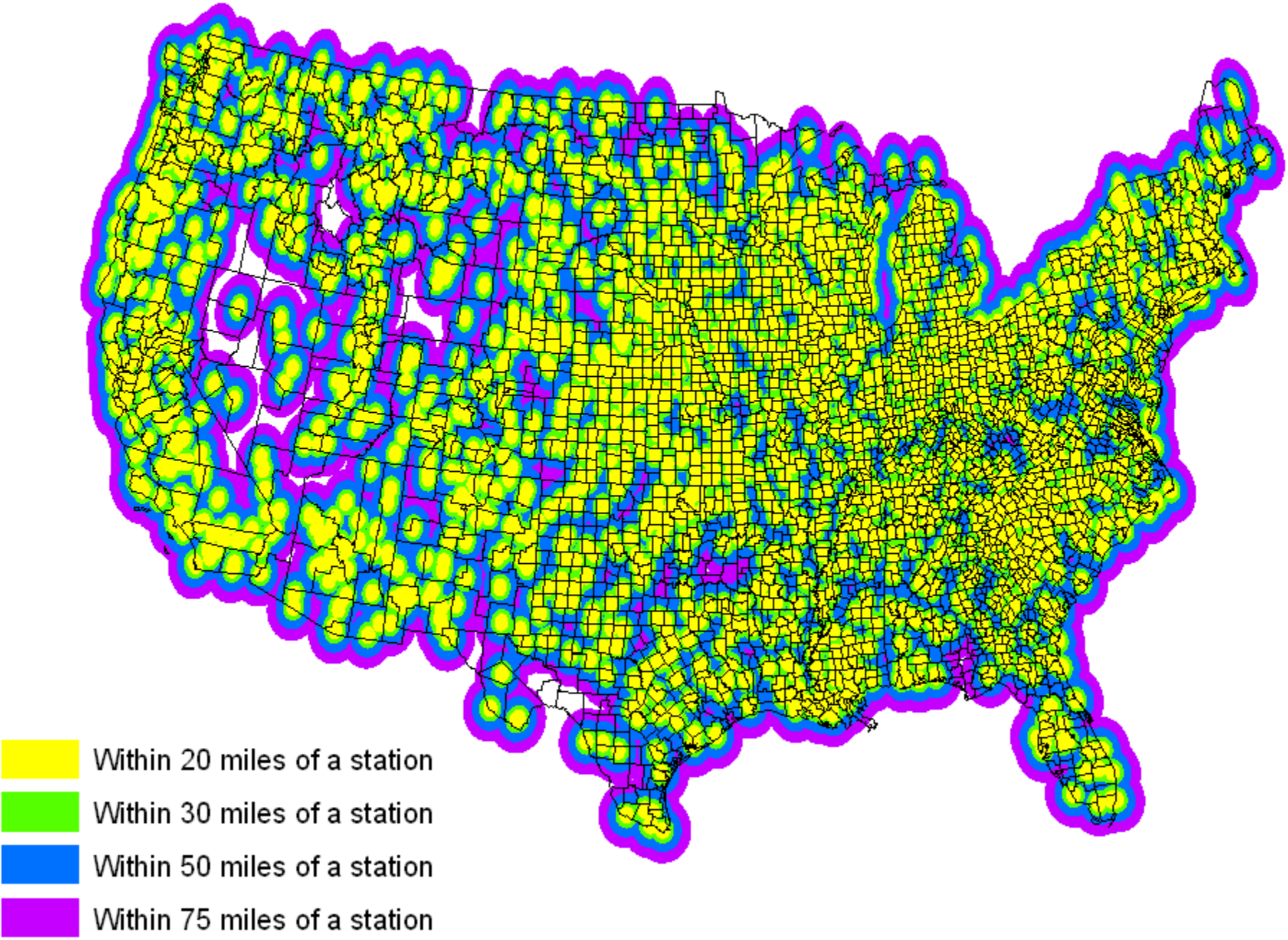
Stations with 50 Plus Years of Data

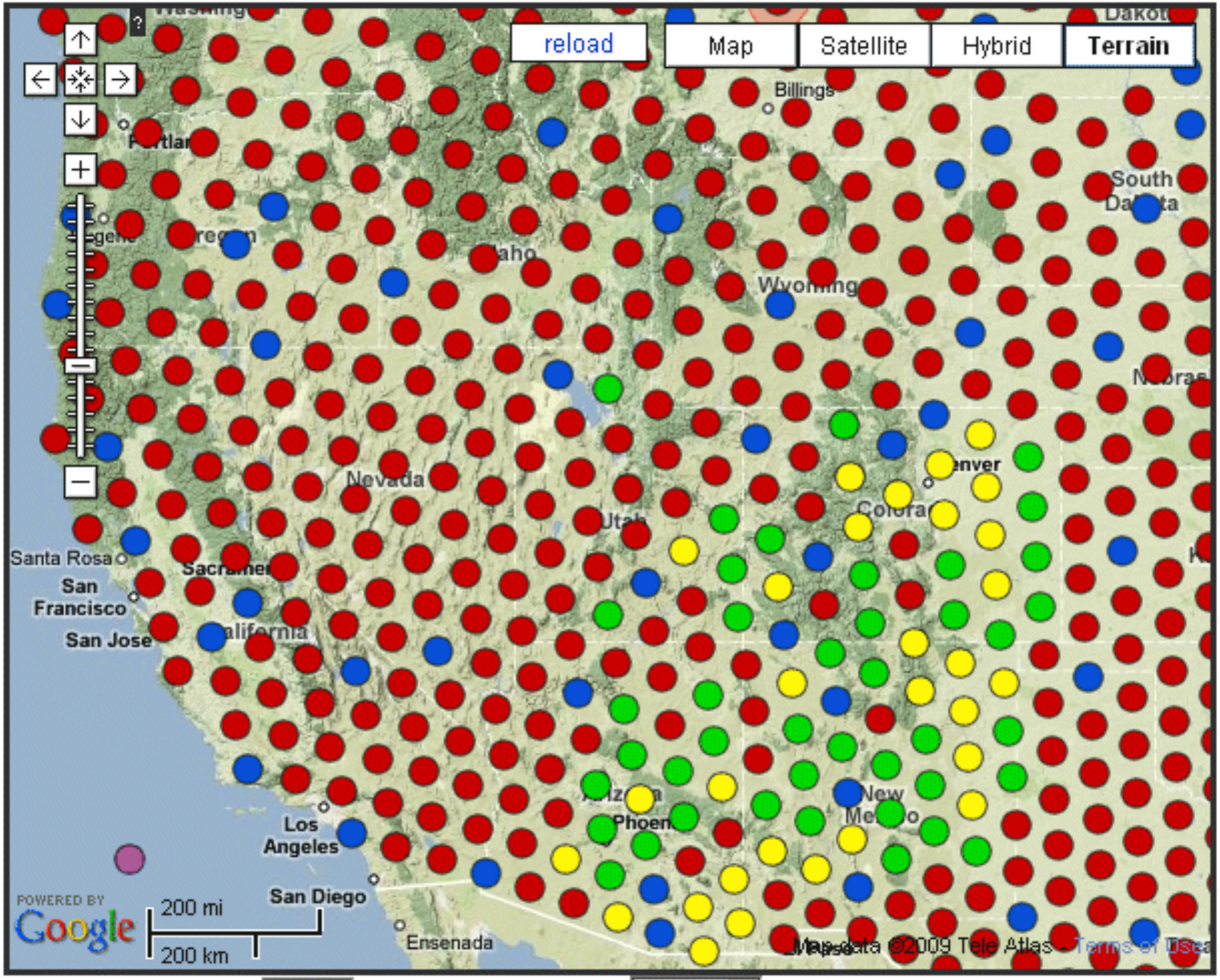


1774 Stations

Courtesy Brian Fuchs, National Drought Mitigation Center

Stations with 50 Plus Years of Data Buffers

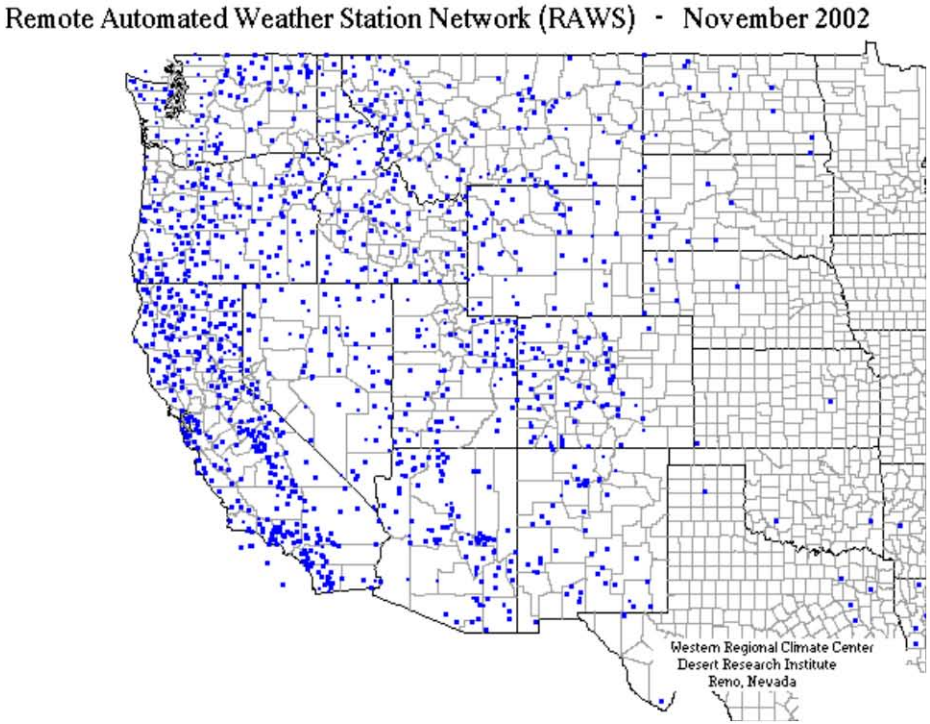




Number of locations 2185 Location Icon shows Type

HCN-M

April 13 2009



Remote Automated Weather Stations

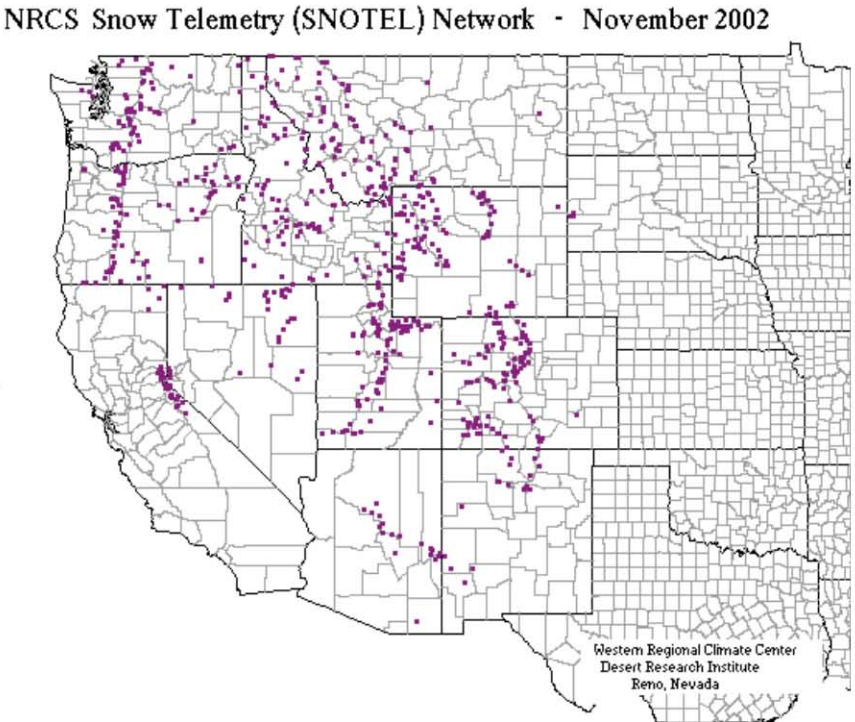
RAWS

1100 Active

700 Inactive

Update 2009: Now about 1600 sites meeting FPA (Fire Program Analysis) standards, approx 2000 live, 2400 total.

Hourly met obs (T, P, RH, WD, WS, Gst, Solar, BP, Tfuel), except not all-weather precip gauges, usually no power.



Now approx 750 sites, all weather, reliable, good track record, T, P, SD and SWE, now mostly hourly, resolution 0.1 inch, short records, no sites yet set aside as benchmark references.

Closest thing we have to a Westwide hydro network.

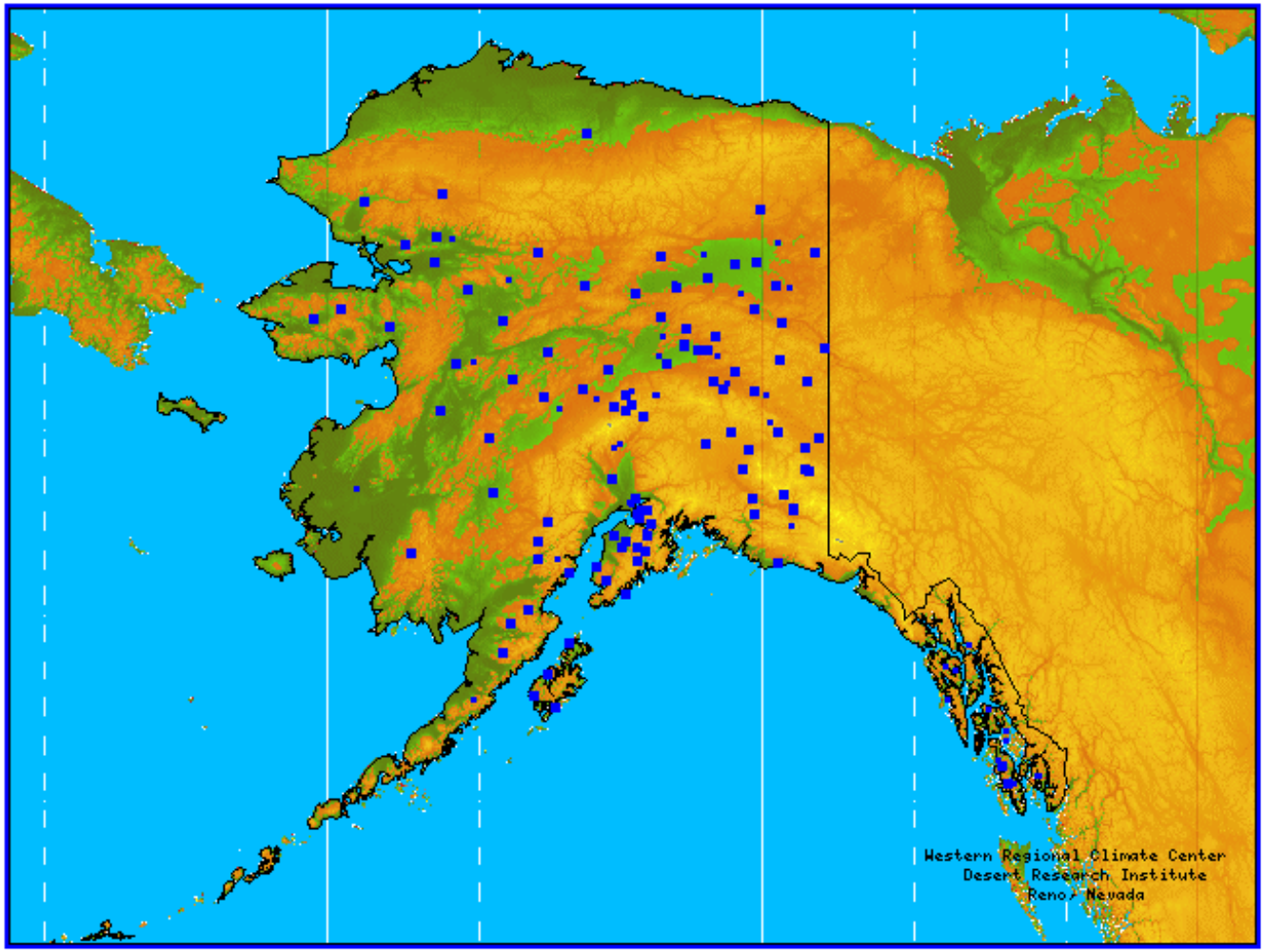
Snowfall Telemetry

SNOTEL

700 Active

RAWS sites

100 Mile Creek Alaska
Alcan Hwy MI-1244 Alaska
Angel Creek Alaska
Black Cape Alaska
Birch Creek Alaska
Bear Mtn. Alaska
Ben Creek Alaska
Bering Glacier Alaska
Beaver (WBQ) Alaska
Big Lake Alaska
Black Lake Alaska
Bentalit Alaska
Bolio Alaska
Booth Lake Alaska
Broadview Alaska
Cape Kiavak Alaska
Campbell Creek Alaska
Caribou Peak Alaska
Chatanika Alaska
Chicken Creek Alaska
Chief Cove Alaska
Chigmit Mtns Alaska
Chisana Alaska
Chalkyitsik Alaska
Chistochina Alaska
Chitna Alaska
Chicken Alaska
Coal Creek Alaska
Cottonwood Alaska
Coville Alaska



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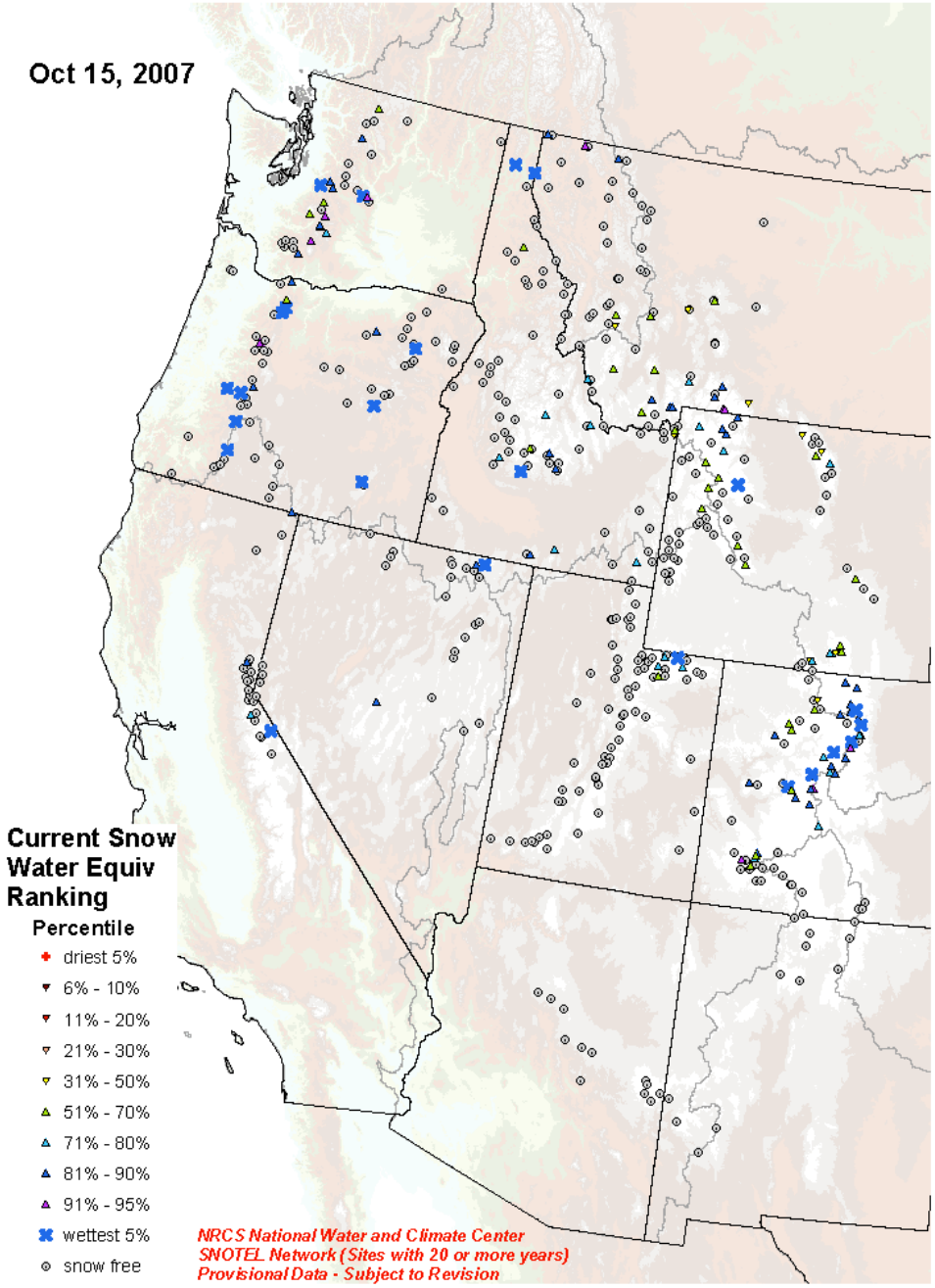
Location: 100 Mile Creek Alaska (RAWS)

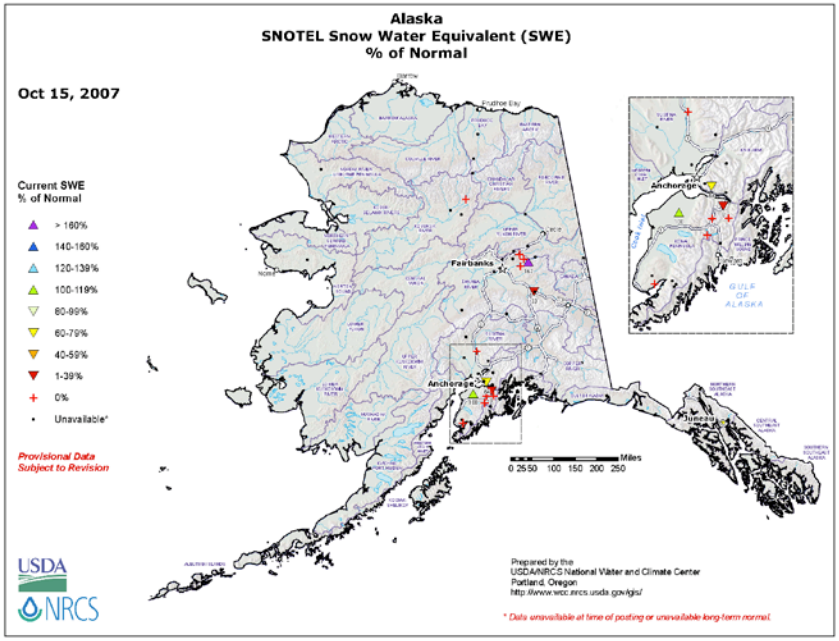
Select a site by placing mouse cursor over a site. Site name will appear in location box below the map if brow

Mather RAWS 9268 ft
Great Basin Nat Park

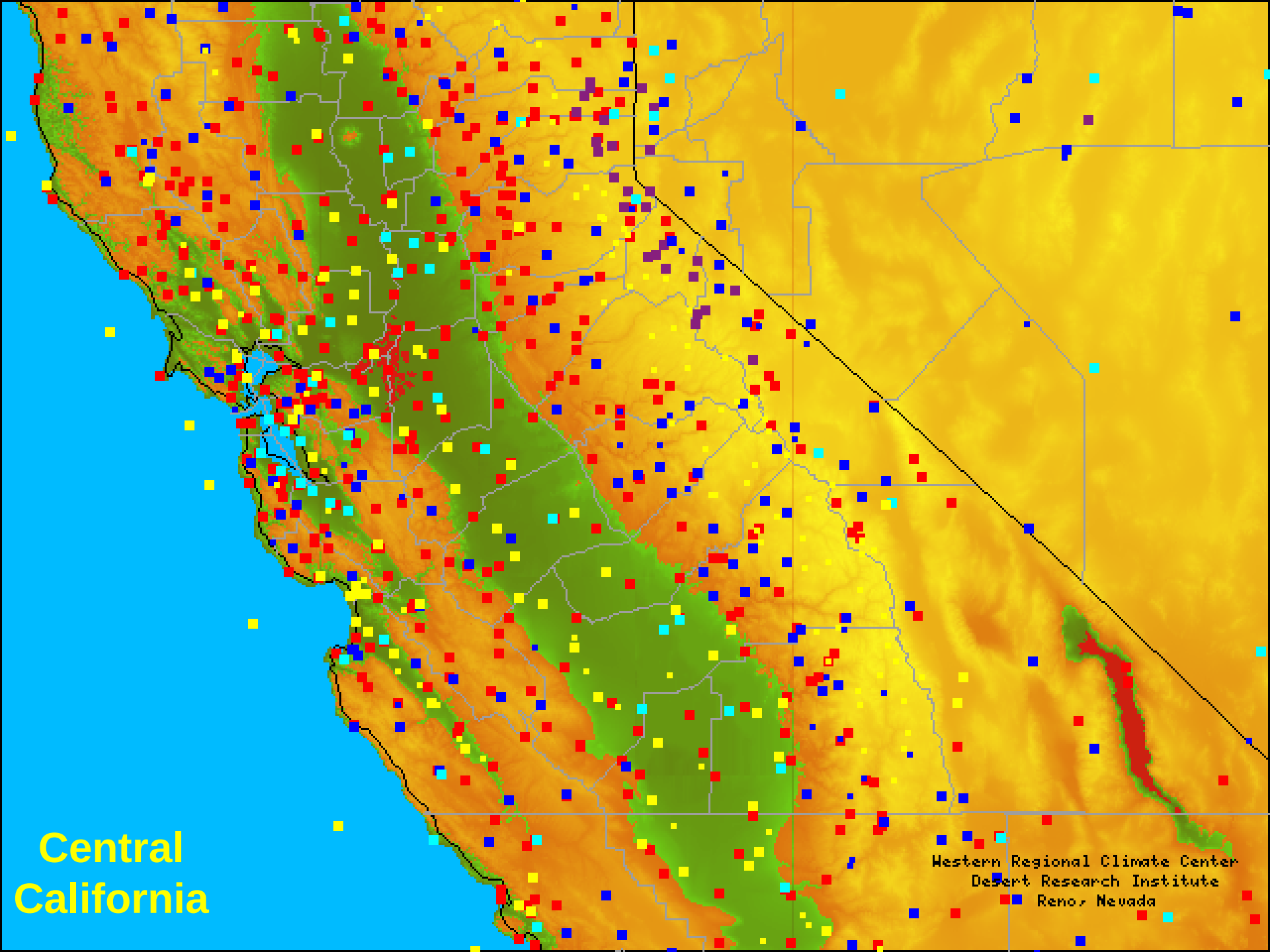
Mather RAWS 9268 ft
Great Basin Nat Park

SNOTEL Locations





June Lake Snotel.
Sasquatch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California
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Observing Weather and Climate from the Ground Up: A Nationwide Network of Networks

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Authors:
Committee on Developing Mesoscale Meteorological Observational Capabilities to Meet Multiple Needs, National Research Council
Authoring Organizations

Description:
Detailed weather observations on local and regional levels are essential to a range of needs from forecasting tornadoes to making decisions that affect energy security, public health and safety, transportation, agriculture and all of our economic interests. As technological capabilities ...
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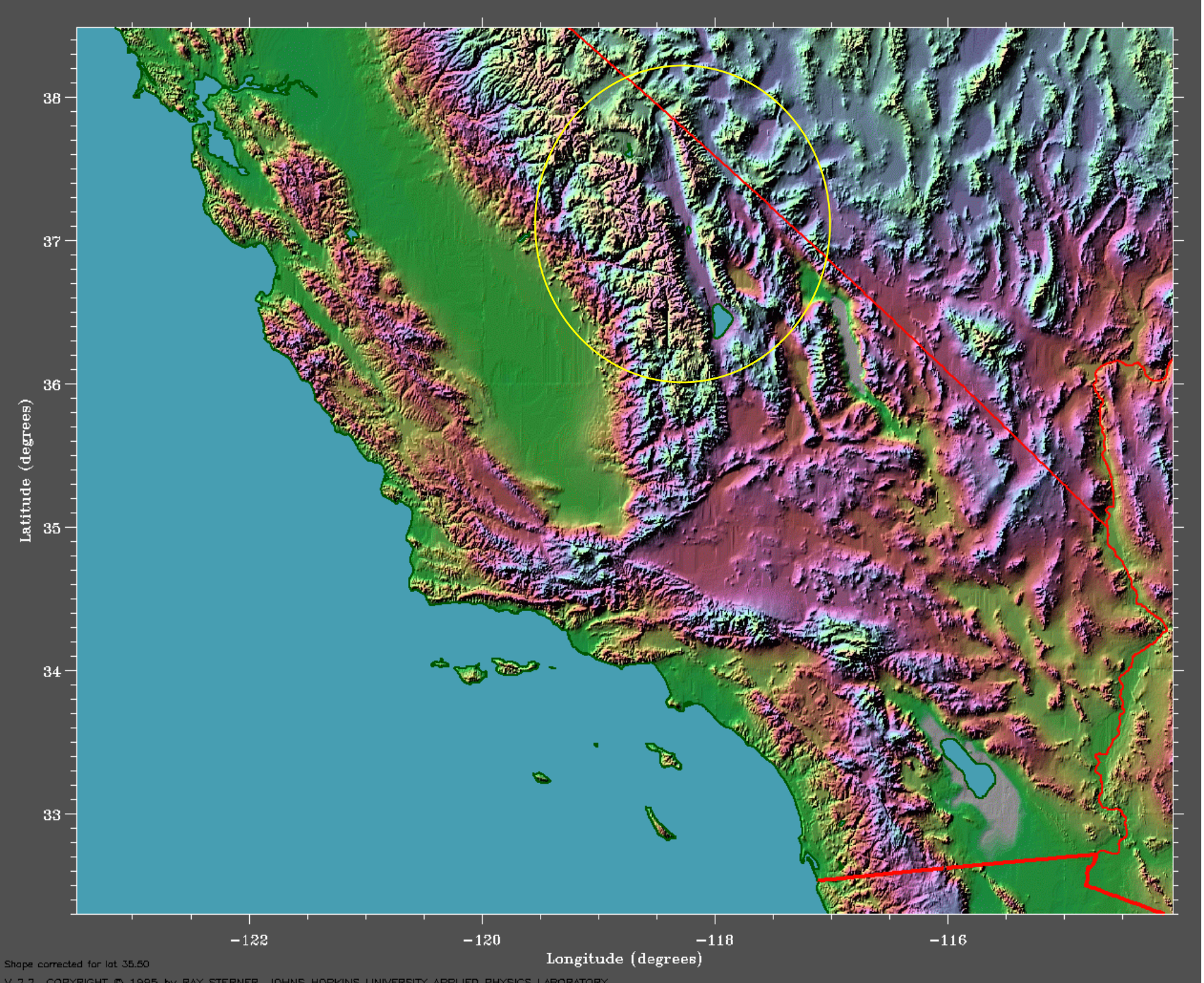
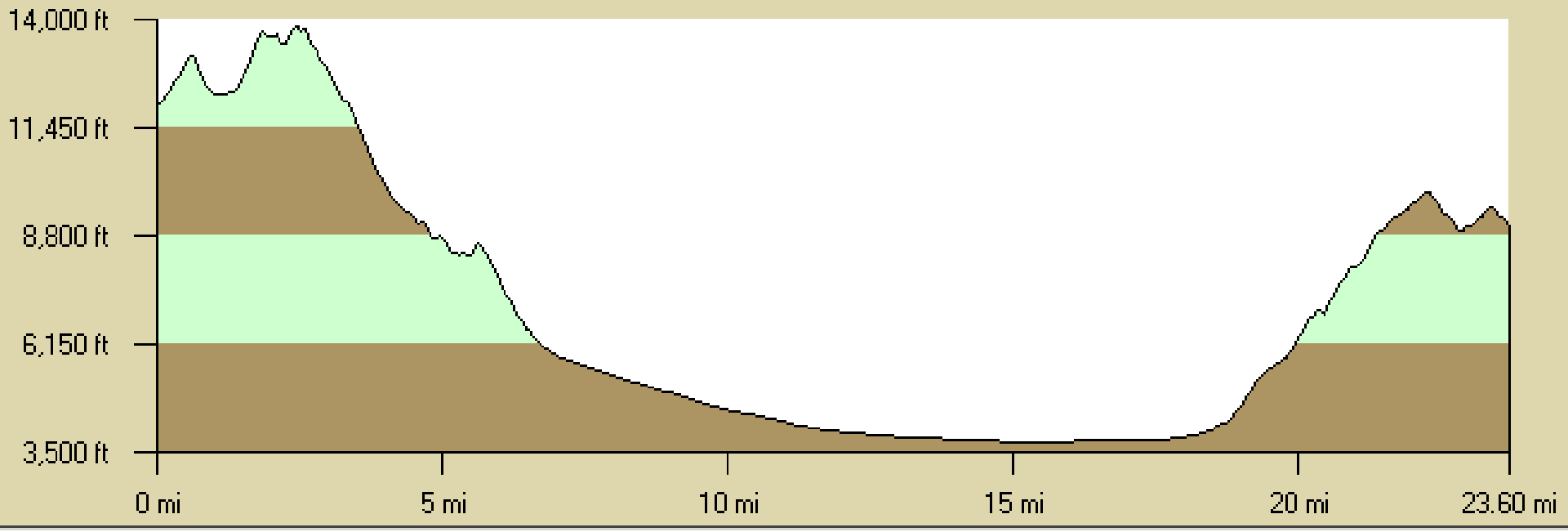
Transect or cluster networks to help define gradients or fine spatial structure


38
37
36
35
34
33
Latitude (degrees)
−122
−120
−118
−116
Longitude (degrees)
Shape corrected for lat 35.50
V 7.7 COPYRIGHT © 1995 by RAY STERNER JOHNS HOPKINS UNIVERSITY APPLIED PHYSICS LABORATORY

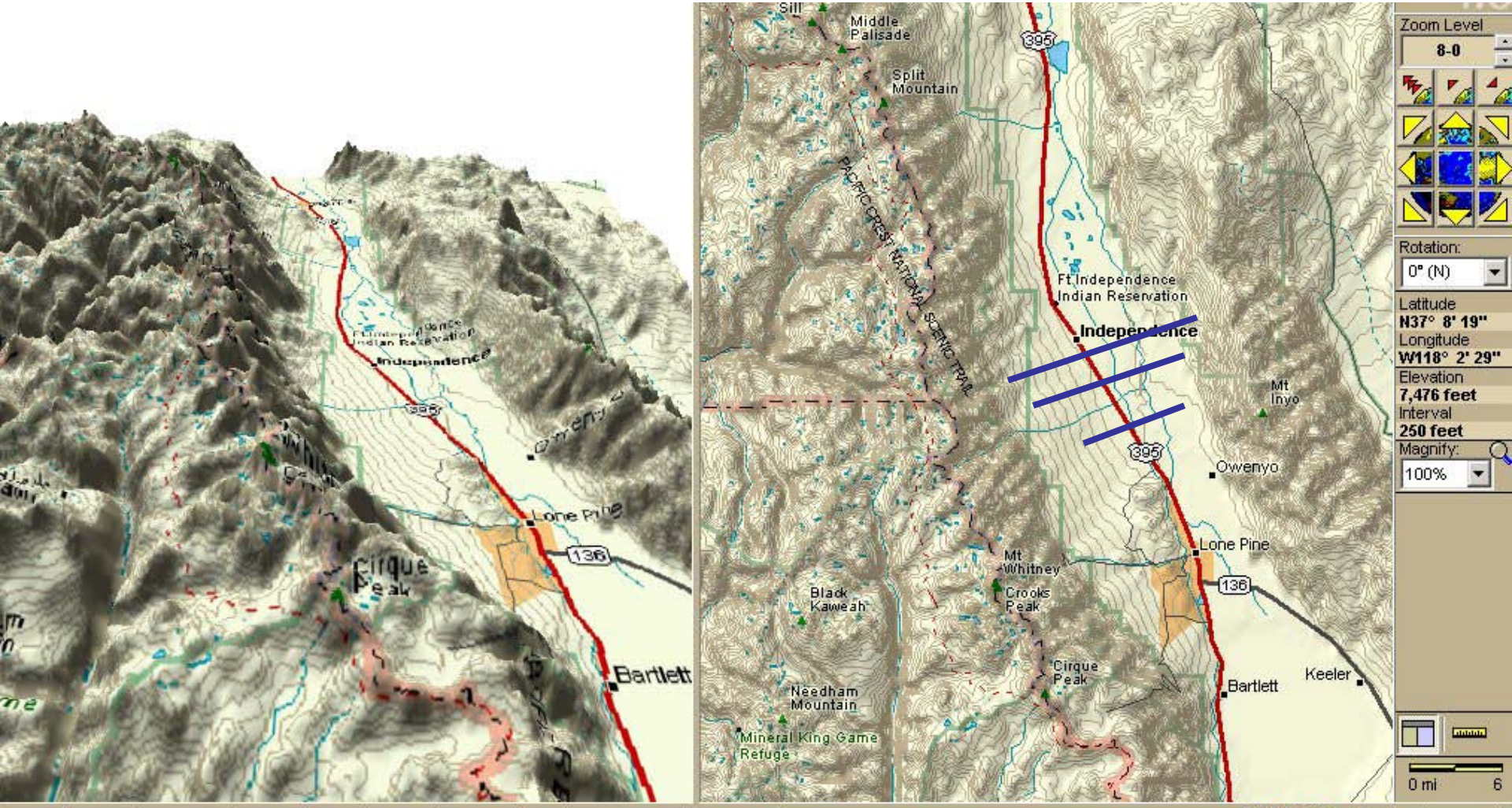
Elevation Transect Across Owens Valley south of Independence CA
Vertical Exaggeration Approximately 4 X



TREX – Terrain Induced Rotors Experiment
Independence CA Owens Valley

6 mi

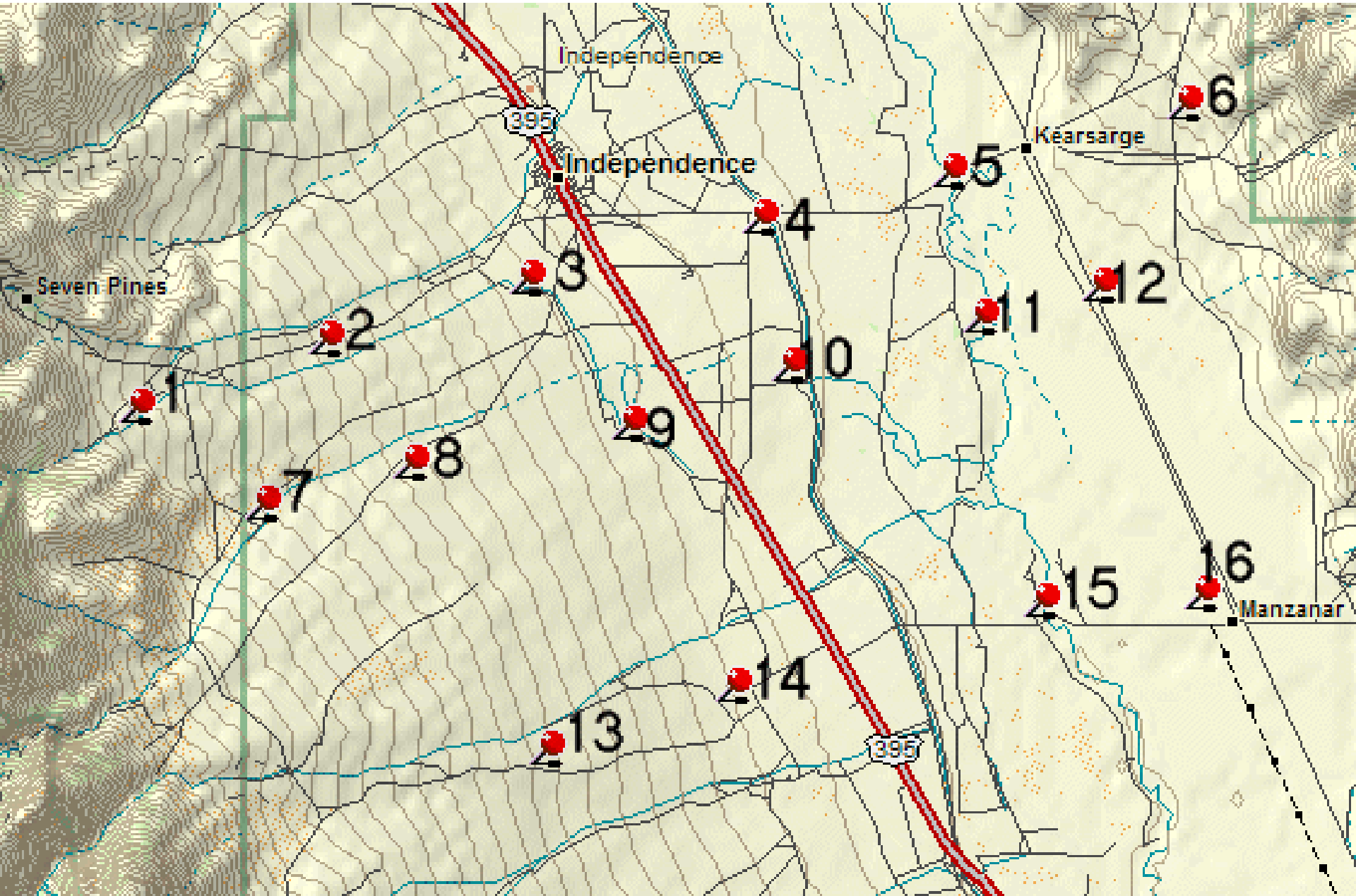
10 km



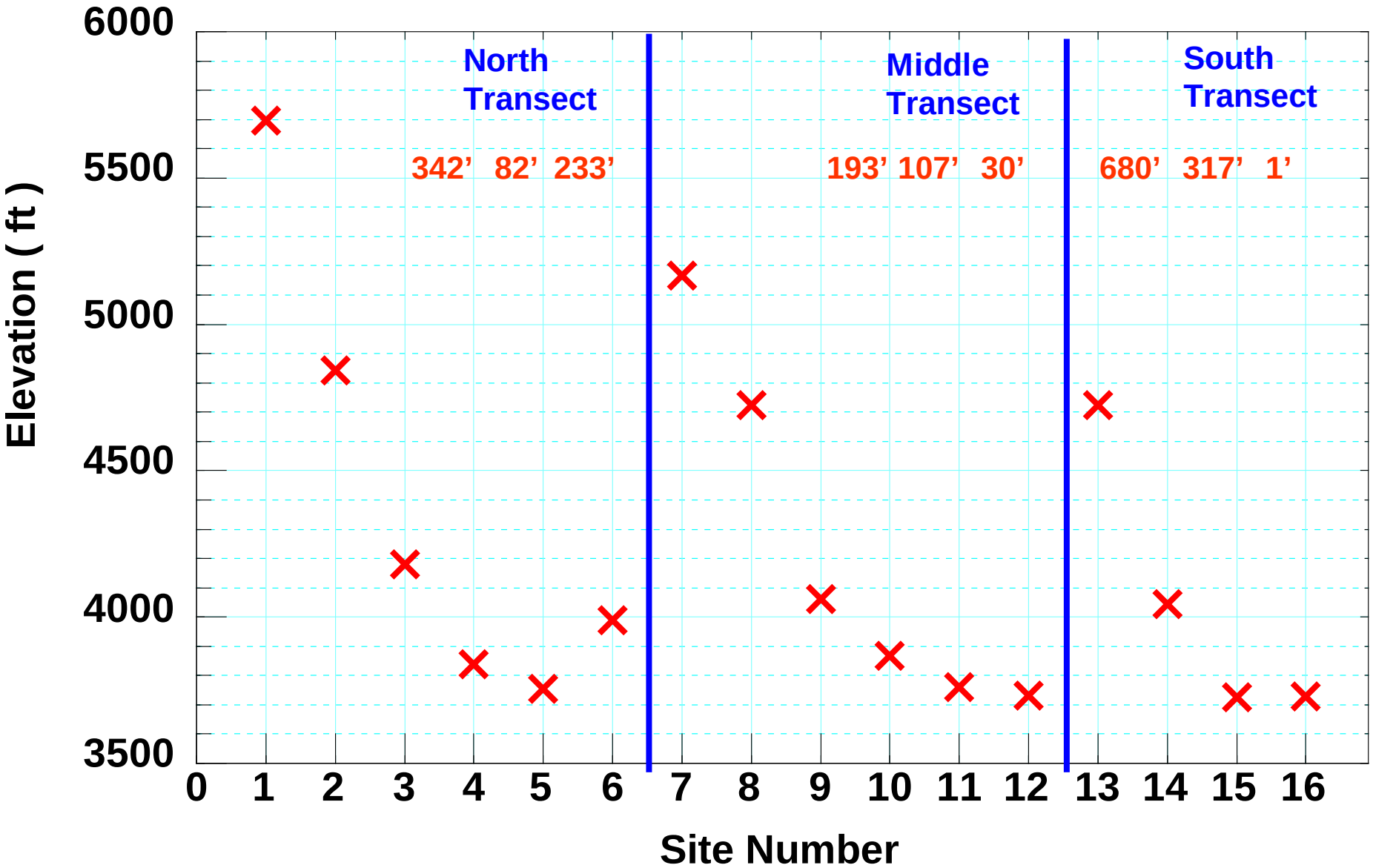
TREX – Terrain Induced Rotors Experiment
Independence CA Owens Valley

1 km

1 mile



Sierra Rotors / TREX Station Elevation Profiles by Transect.



Elevation difference between adjoining stations

TREX Site 05 Looking South

TREX Site 05 Looking West

TREX Site 05 Looking North

TREX Site 05 Looking East

Daily Summary for

Prev Day **June 16, 2005** Next Day

Station	Wind Ave. mph	Wind V. Dir. Deg	Wind Max. mph	Air Temperature Mean Deg. F.	Air Temperature Max Deg. F.	Air Temperature Min Deg. F.	Humidity Mean Percent	Humidity Max Percent	Humidity Min Percent	Dew Point Deg. F.	Wet Bulb Deg. F.	Baro. Press. in. Hg.	Battery Voltage Mean volts	Battery Voltage Max volts	Battery Voltage Min volts
SR #1	10.2	231	52.8	68.7	80.9	58.0	18	30	10	23	47	24.24	12.8	13.2	12.3
SR #2	8.4	240	48.1	72.2	84.7	59.6	16	28	10	23	48	24.99	12.7	13.2	12.2
SR #3	8.8	265	42.9	74.2	88.5	58.5	17	32	9	25	50	25.58	12.7	13.3	12.2
SR #4	9.1	294	46.4	73.4	90.1	54.0	19	42	8	27	50	25.88	12.7	13.1	12.2
SR #5	8.5	287	41.3	72.0	91.5	47.5	23	55	9	28	49	25.95	12.6	13.2	12.2
SR #6	8.4	276	32.2	75.5	90.0	59.7	16	25	9	25	50	25.74	12.7	13.2	12.2
SR #7	7.6	220	34.5	70.9	83.3	57.0	17	29	9	23	48	24.69	12.7	13.2	12.2
SR #8	8.3	192	35.7	72.7	86.7	56.4	17	31	9	24	49	25.08	12.7	13.2	12.2
SR #9	8.5	216	36.1	75.2	89.7	59.4	16	26	9	24	50	25.66	12.6	13.1	12.0
SR #10	8.2	284	39.0	74.7	90.4	55.5	17	40	9	26	50	25.85	12.7	13.1	12.2
SR #11	8.1	281	38.2	72.5	90.8	48.1	21	50	8	28	49	25.94	12.7	13.3	12.2
SR #12	8.1	283	35.3	73.2	91.9	48.7	20	45	8	27	49	25.96	12.6	13.2	12.2
SR #13	8.9	185	39.8	73.2	86.9	59.5	15	25	9	22	48	25.09	12.6	13.2	12.1
SR #14	8.8	180	35.5	76.1	89.3	62.0	15	26	9	24	50	25.69	12.7	13.2	12.2
SR #15	8.3	213	34.6	73.6	91.5	46.5	21	54	9	28	50	25.97	12.7	13.4	12.2
SR #16	8.1	223	33.1	74.8	92.0	49.4	18	42	8	26	50	25.97	12.7	13.2	12.1

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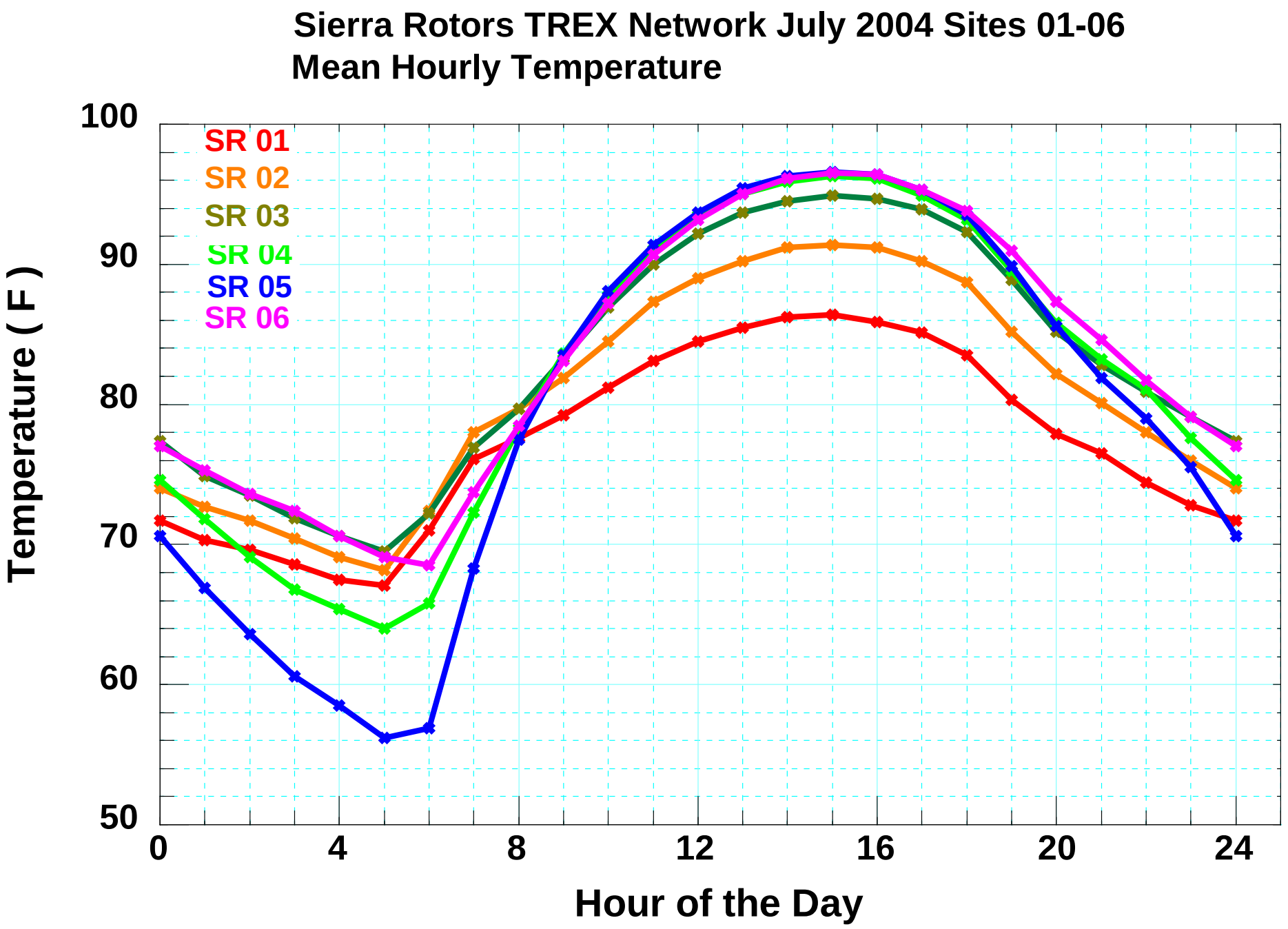
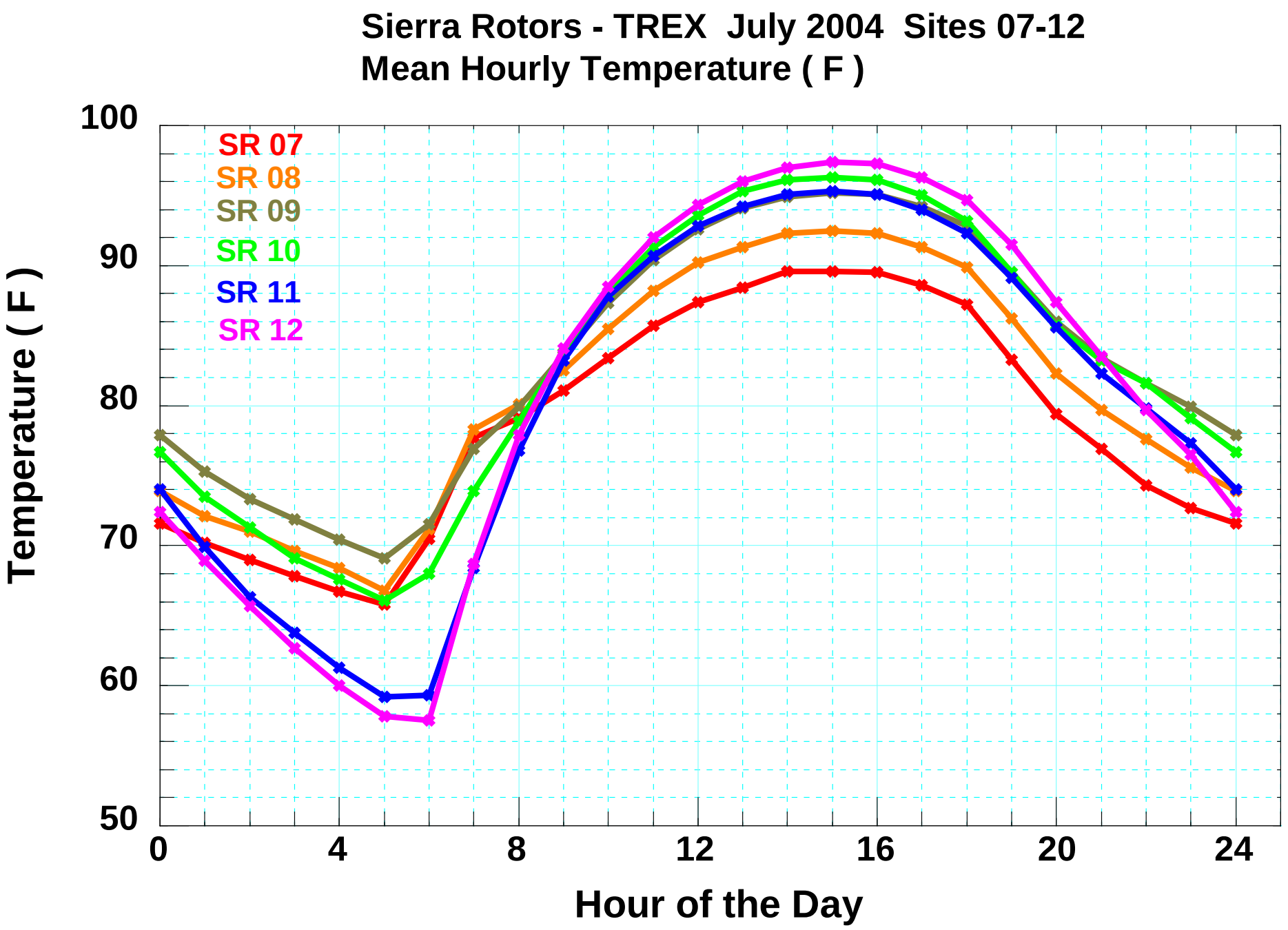
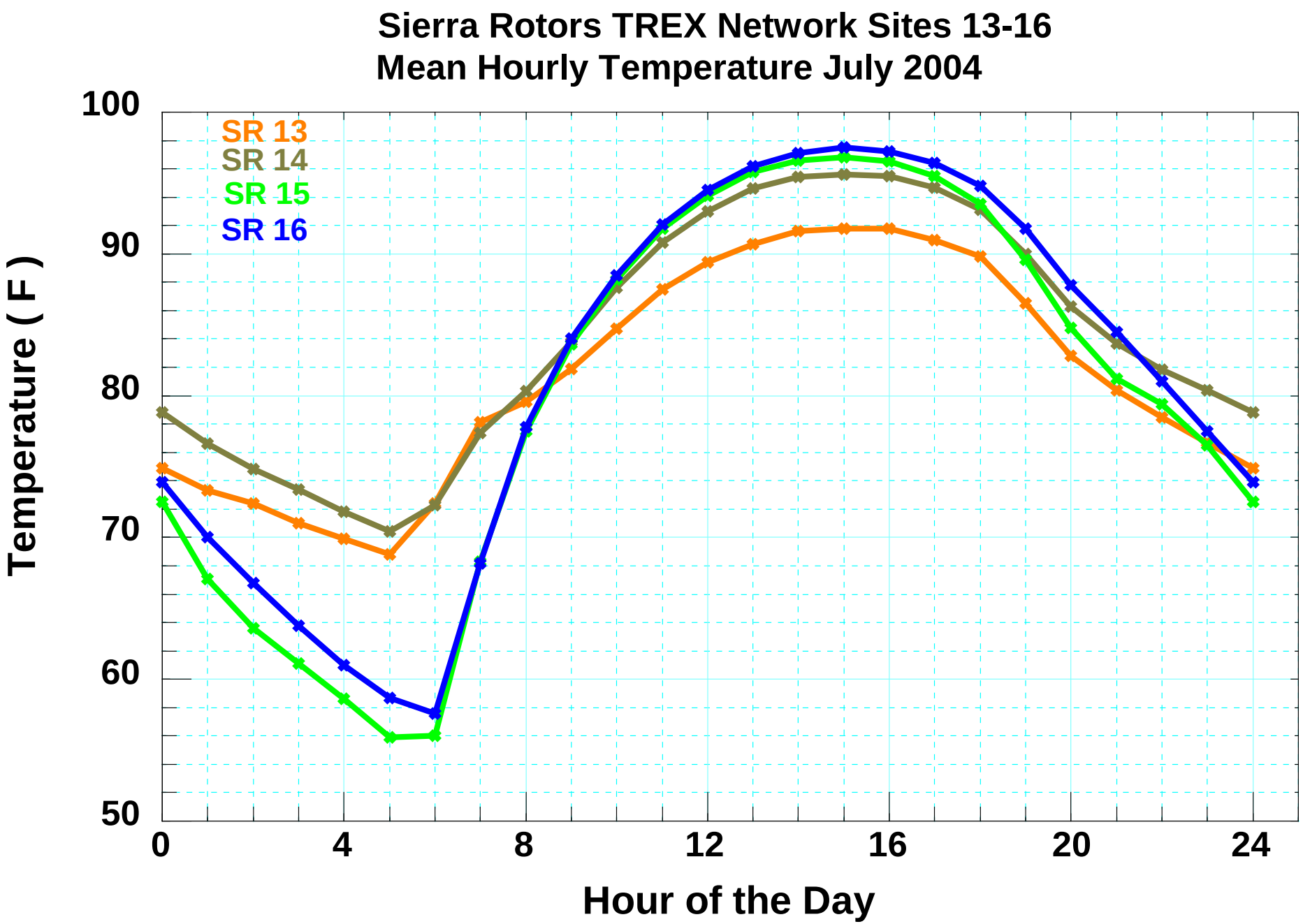
Data are subject to further review and editing. Please refer any questions to the Western Regional Climate Center.

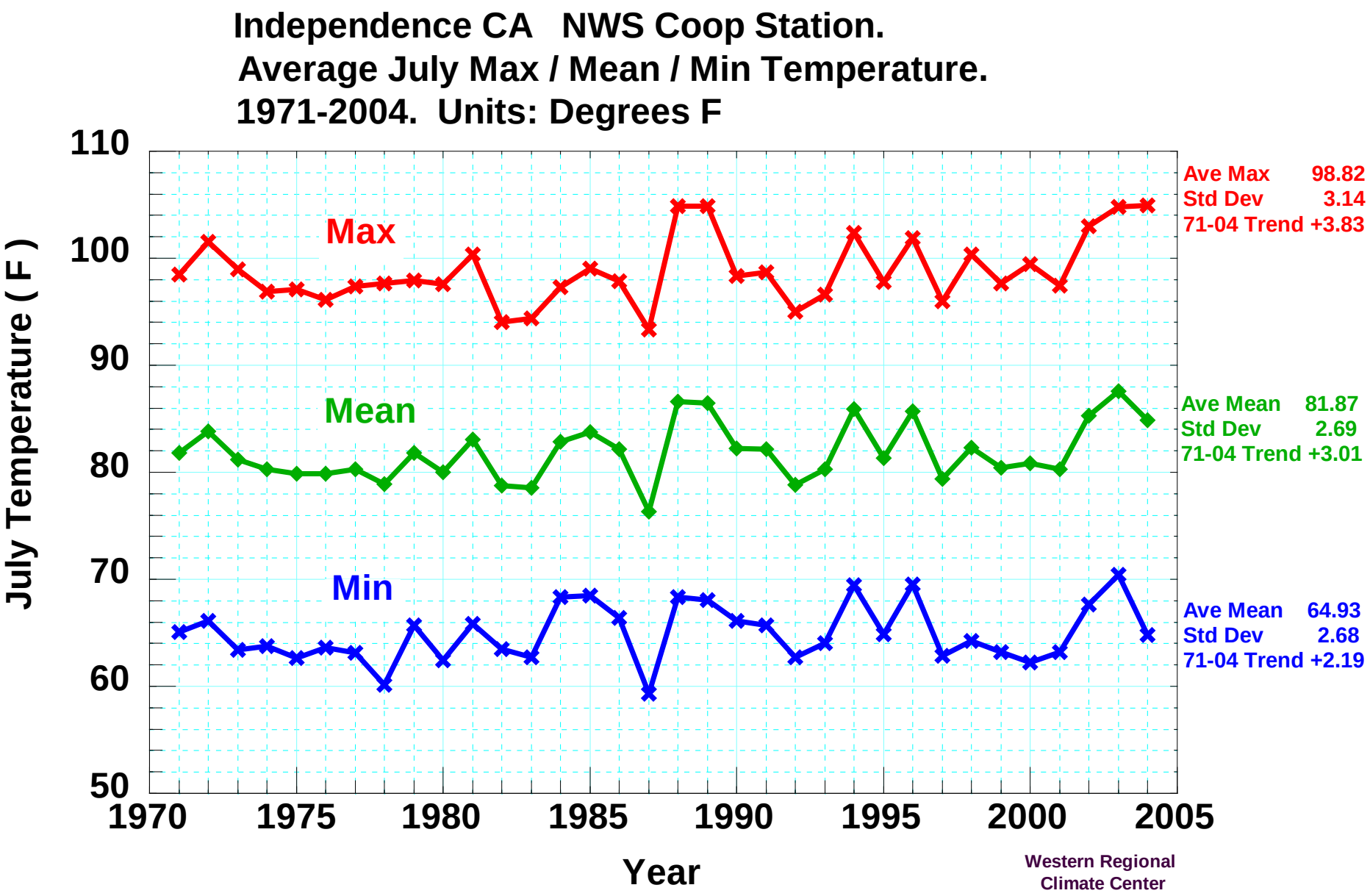
° 1 ly = 1 cal/cm² = 4.1855 J/cm² = 3.6855 BTU/ft² = .01163 KW/m²

* Incomplete data. Listed data compiled from available data.


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 Network Sites 13-16
Mean Hourly Temperature July 2004
SR 13
SR 14
SR 15
SR 16
Temperature (F)
100
90
80
70
60
50
0
4
8
12
16
20
24
Hour of the Day


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

ECCM Strategy as of April 2005

Special California CRN stations appear to be too expensive for ECCM

One or two transects from the near shore ocean to far western Great Basin.

Augment selected Sierra mountaintops.

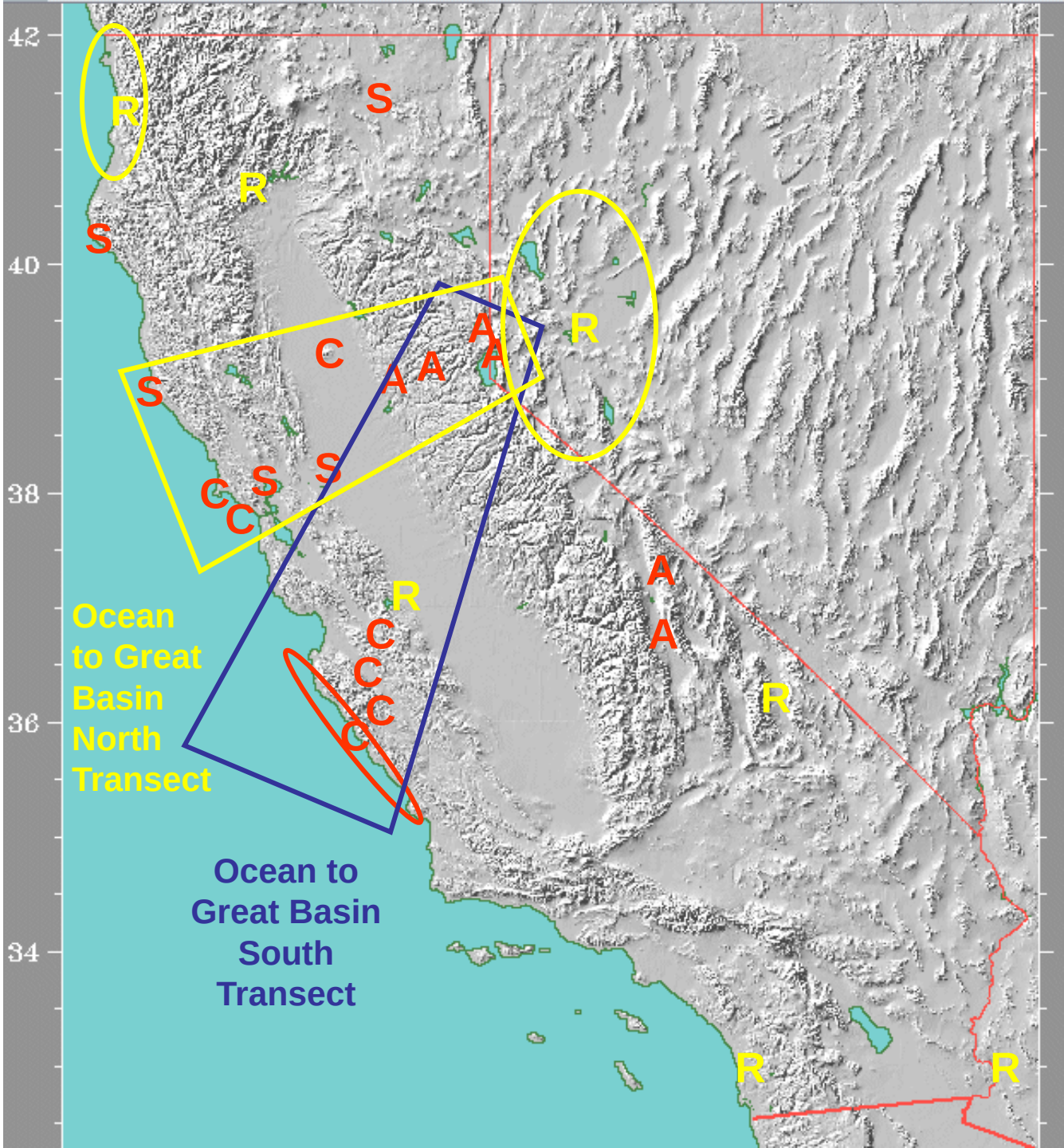
Leverage other current and planned projects.

R – Existing or "expected" national CRN

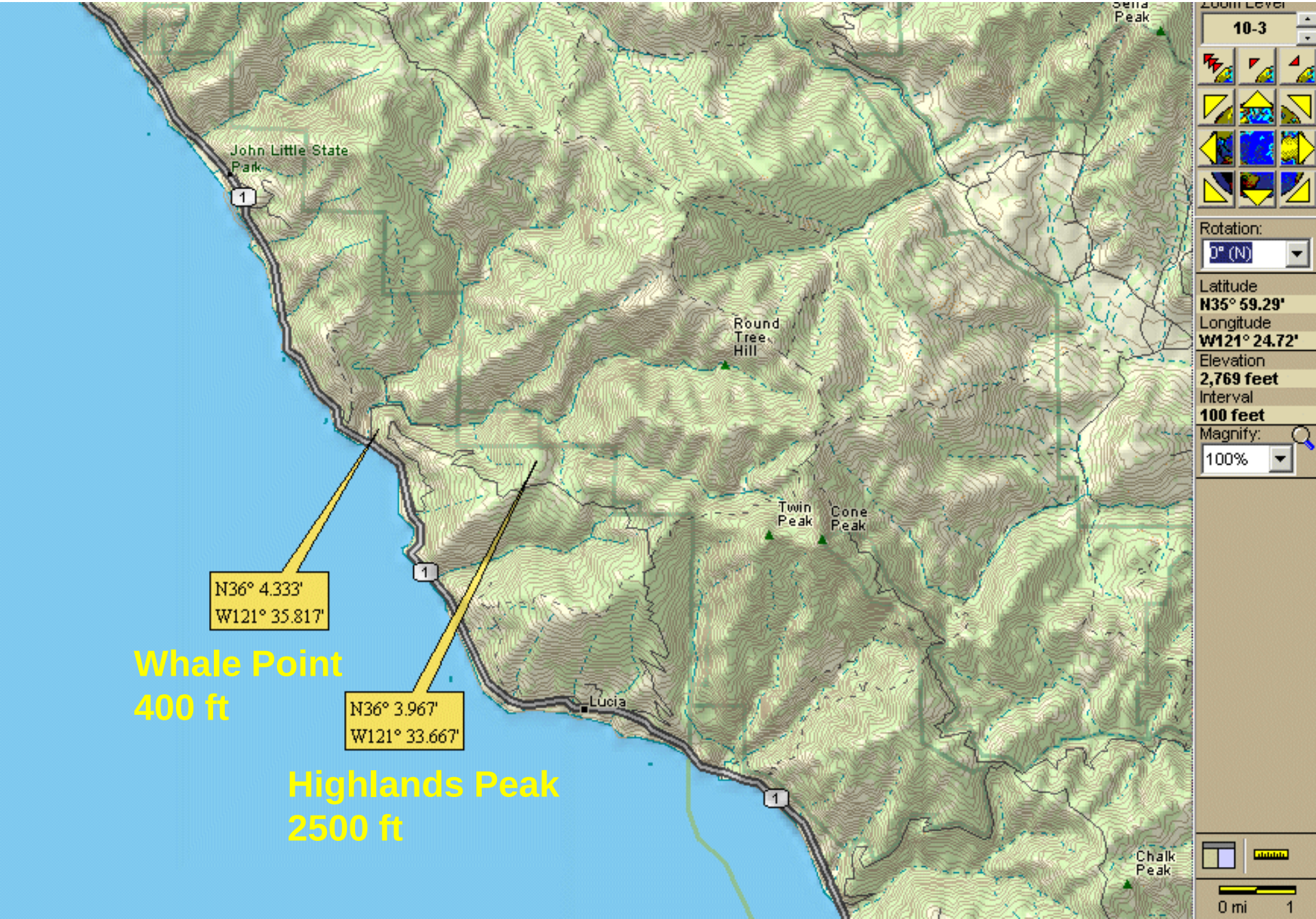
C – Potential New California Climate Monitoring Site

A – Potential Augmentation Site

S – Additional sites of opportunity



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



Mapping New Terrain

Climate Change and America's West

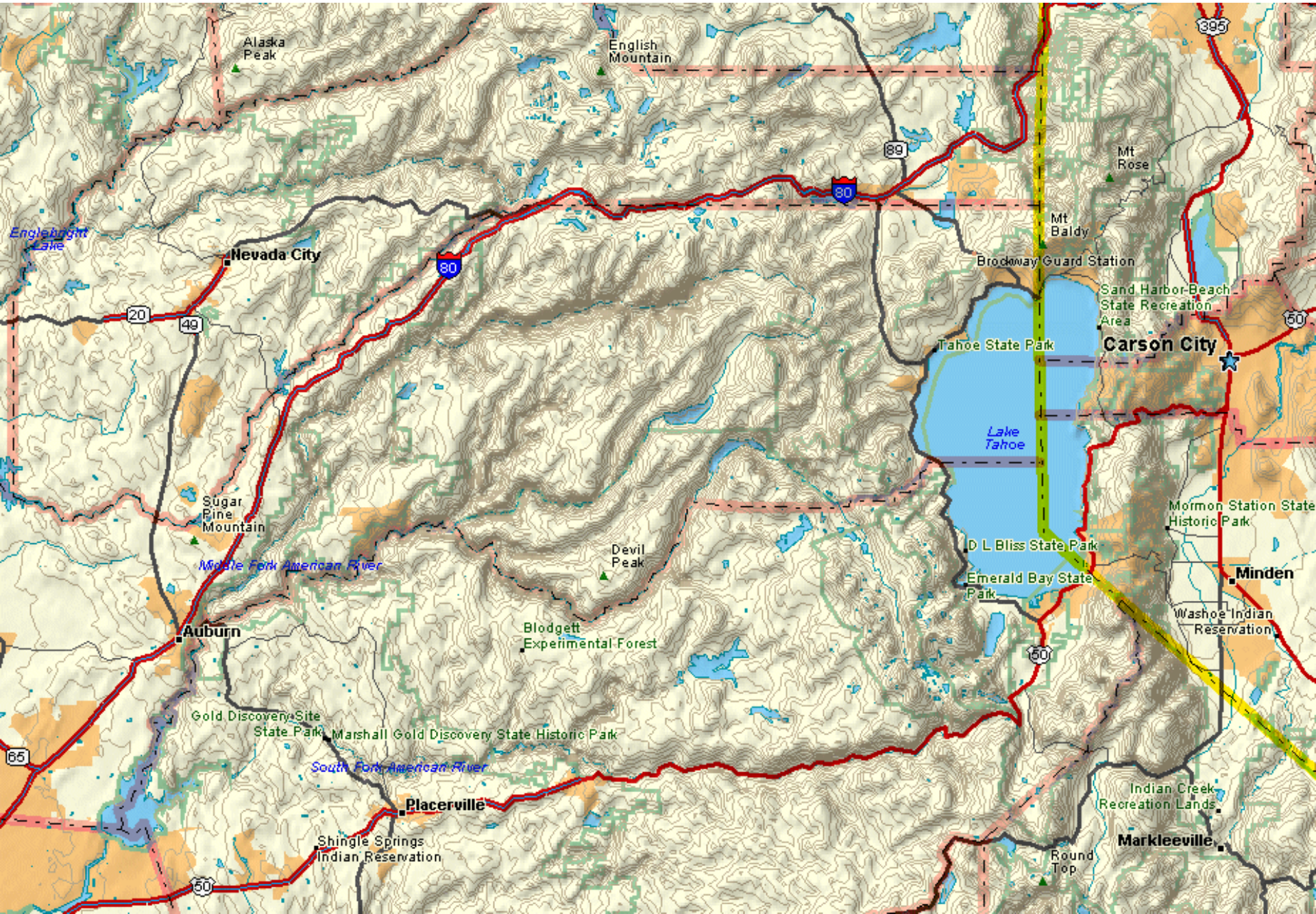
Anticipating Challenges to Western Mountain Ecosystems and Resources

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

July 2006

Crater Lake NWS Cooperative Station

NOAA Hydrometeorological Test Bed -- North Fork American River



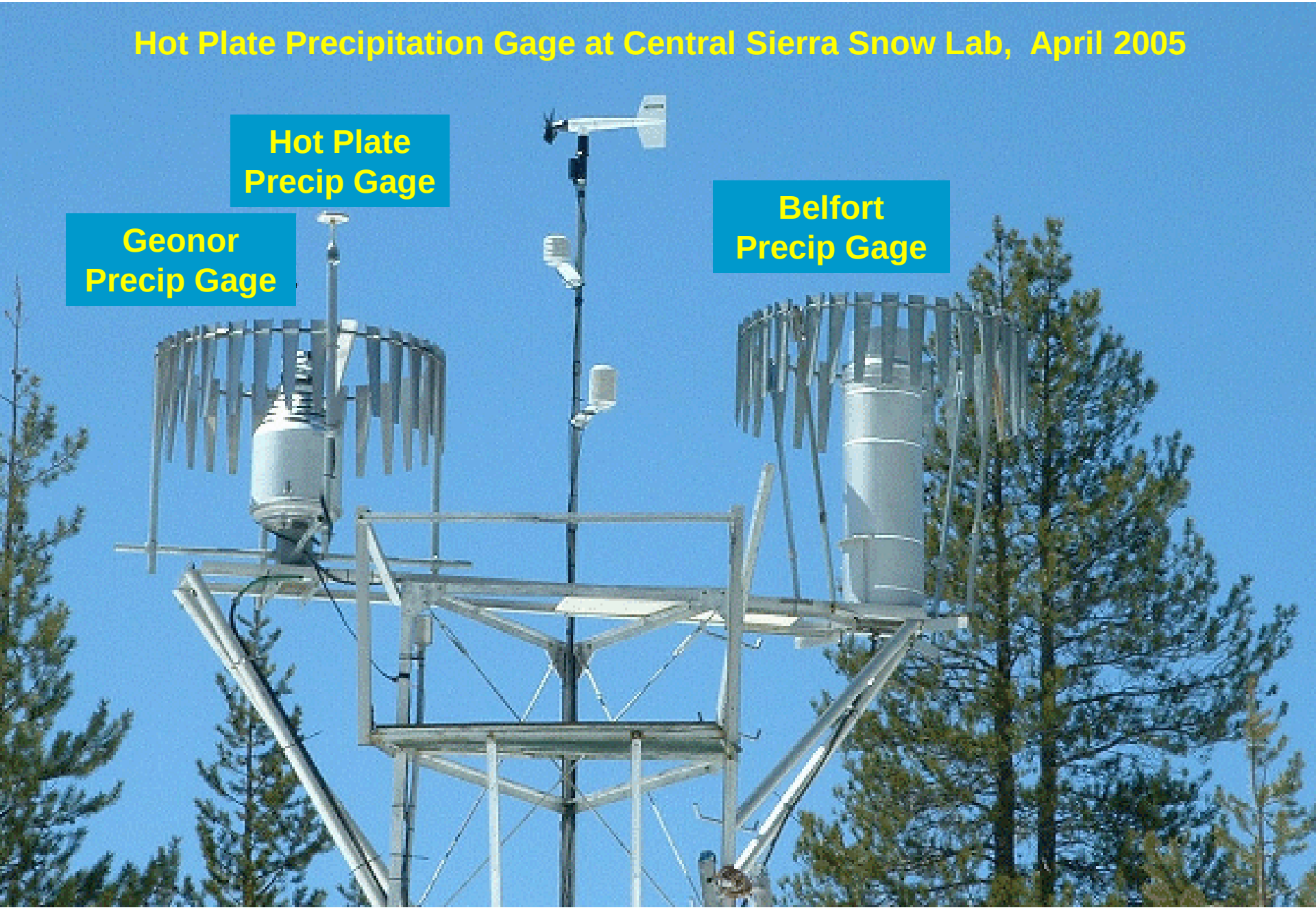
2005 October 23

Sugar Bowl

South **Central Sierra Snow Lab** **East**

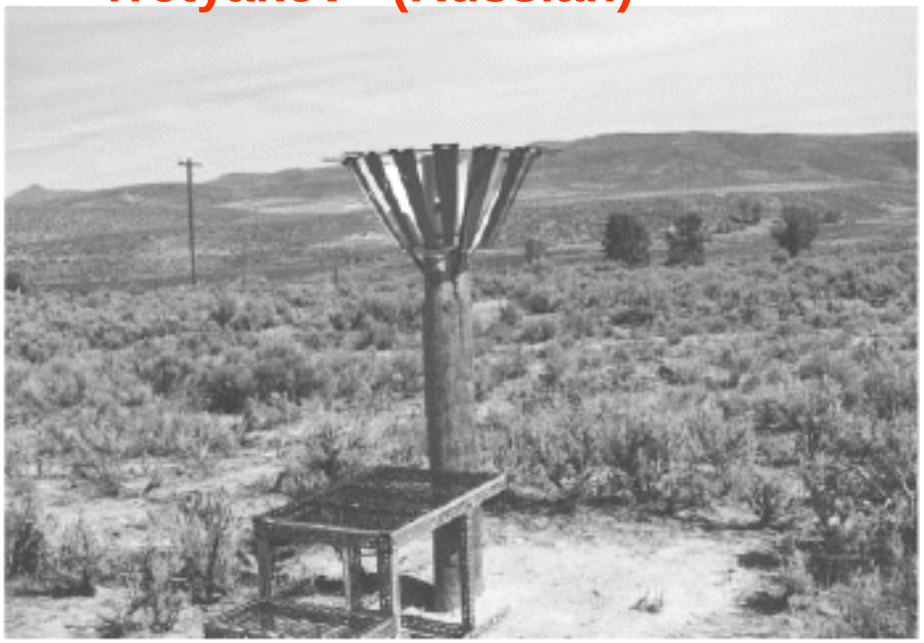
Photo: Dave Simeral

Hot Plate Precipitation Gage at Central Sierra Snow Lab, April 2005

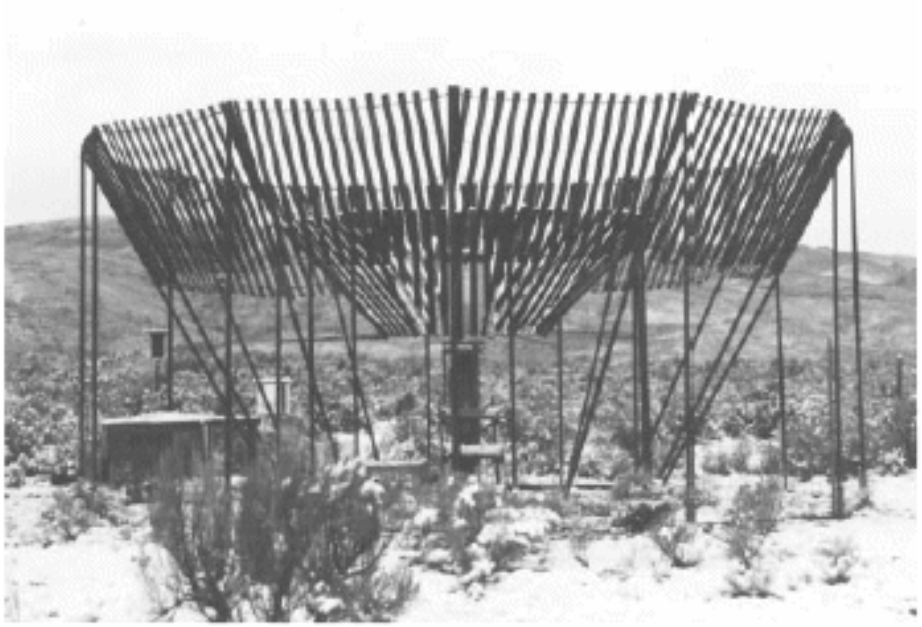


(a) DFIR (Double Fence Intercomparison Reference) (CRN)

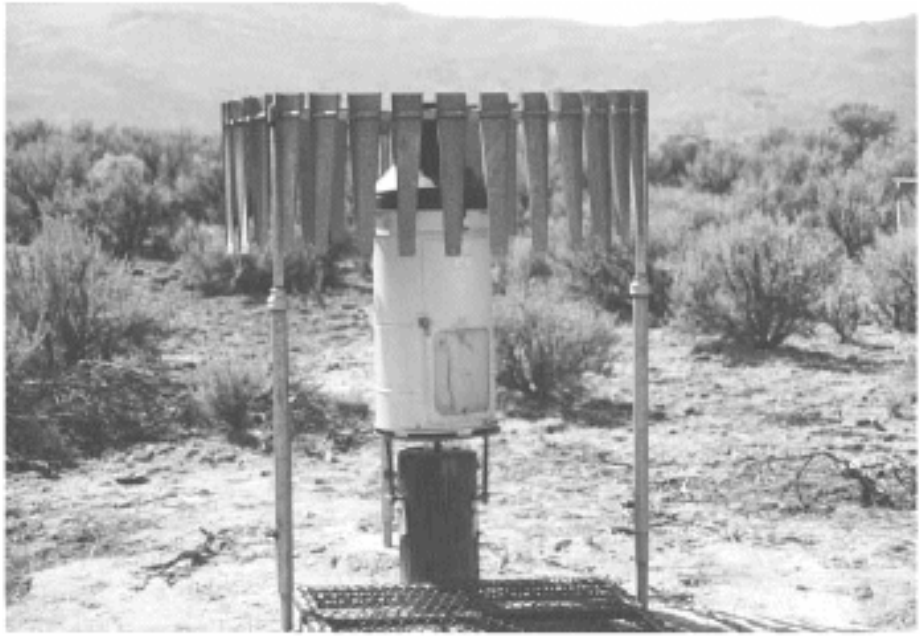
(b) Tretyakov (Russian)



(c) Wyoming Shield with Universal



(d) Universal with Alter Shield



(e) **Nipher (Canada)**

(f) **Dual-Gage Shielded / Unshielded**

FIG. 1. Photographs of various gauges and wind shields. (a) DFIR; (b) Tretyakov gauge; (c) Wyoming shield with Universal recording gauge; (d) Alter shield with universal recording gauge; (e) Canadian Nipher snow gauge; (f) Dual-gauge measuring system (bridled shield and unshielded universal recording gauges); (g) NWS 8" nonrecording gauge, with the rainfall collector off as used for snowfall measurement;

(g) **NWS 8" Standard Rain Gage**

Daqing Yang, Barry E. Goodison, John R. Metcalfe, Valentin S. Golubev, Roy Bates, Timothy Pangburn, Clayton Hanson, 1998. Accuracy of NWS 8" Stnadard Nonrecording Precipitation Gauge: Results and Application of WMO Intercomparison. Journal of Atmospheric and Oceanic Technology, 15 (2), 54-68.

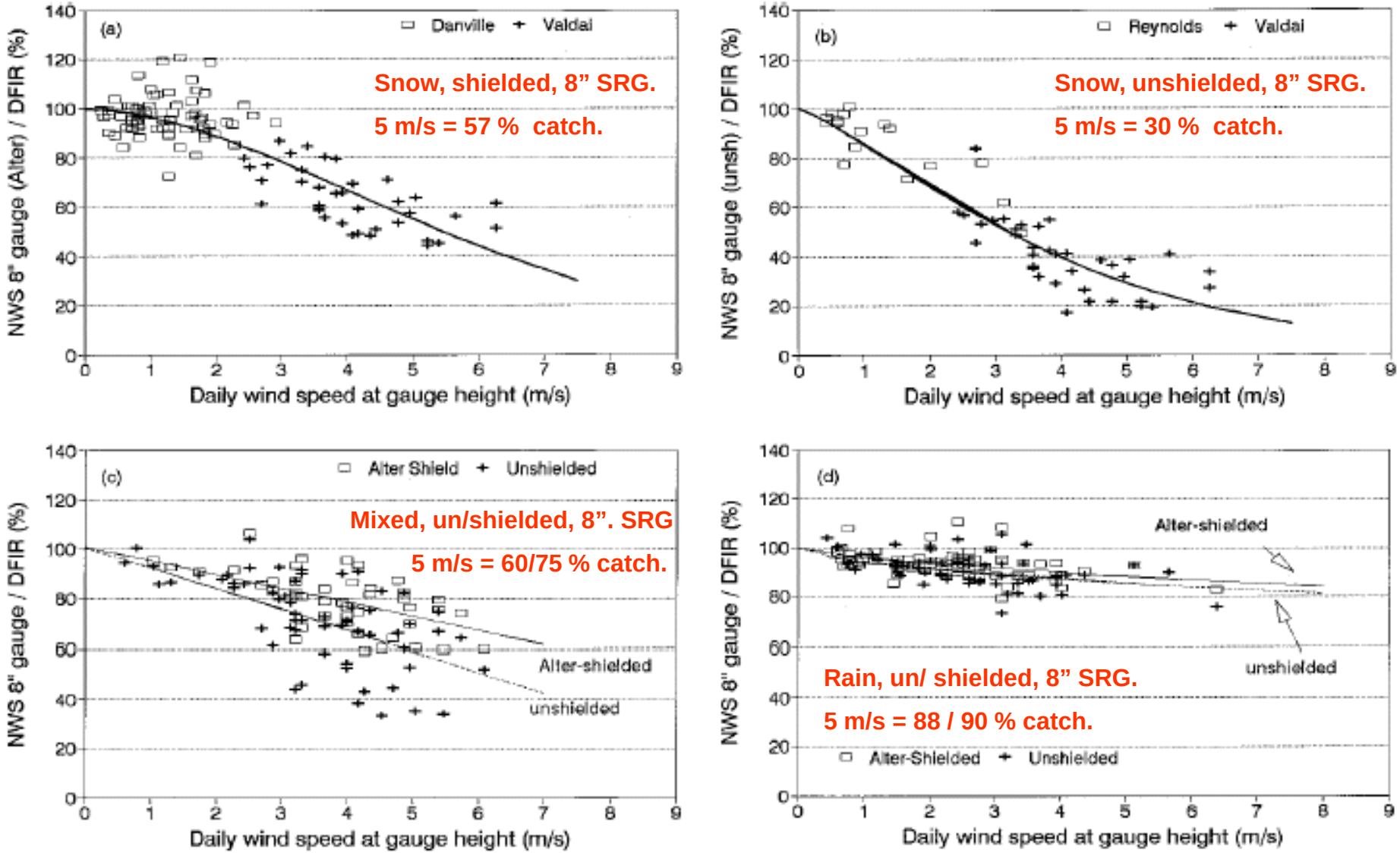


FIG. 3. Daily catch ratio (%) of the NWS 8″ nonrecording gauge to the DFIR as a function of daily wind speed (m s^{-1}) at the gauge height for (a) Alter shielded, snow; (b) unshielded, snow; (c) Alter shielded and unshielded, mixed precipitation; and (d) Alter shielded and unshielded, rain.

Daqing Yang, Barry E. Goodison, John R. Metcalfe, Valentin S. Golubev, Roy Bates, Timothy Pangburn, Clayton Hanson, 1998.

Accuracy of NWS 8" Stnadard Nonrecording Precipitation Gauge: Results and Application of WMO Intercomparison.

Journal of Atmospheric and Oceanic Technology, 15 (2), 54-68.

WMO Solid Precipitation Measurement Intercomparison Project.

Ten sites. US: Reynolds Creek ID. Danville VT.

"At least 54 gage types used around the world"

Rainfall differences usually within 5 percent.

Snowfall differences are up to 110 percent.

- At 6 m/s, catch efficiency 20-70 percent for national gages.
- Shielded gages can measure up to 70 percent more snow than unshielded.

Snowfall measurement differences are a function of

- Gage design
- Gage installation
- Shielding presence
- Shielding type
- Type of precipitation (snow, rain, mixed)
- Temperature (of snow)
- Wind speed

Daqing Yang, Barry E. Goodison, John R. Metcalfe, Valentin S. Golubev, Roy Bates, Timothy Pangburn, Clayton Hanson, 1998. Accuracy of NWS 8" Stnadard Nonrecording Precipitation Gauge: Results and Application of WMO Intercomparison. Journal of Atmospheric and Oceanic Technology, 15 (2), 54-68.

Daqing Yang, Barry Goodison, John Metcalfe, Paul Louie, Esko Elomaa, Clayton Hanson, Valentin Bolubev, Thilo Gunther, Janja Milkovic, and Milan Lapin, 2001. Compatibility evaluation of national precipitation gage measurements. Journal of Geophysical Research, 106, D2, 1481-1491, Jan 27, 2001.

Slide Mountain Toward NW

Operations? or testing ?

Ice
+
Wind
+
Imbalance
+
Shaking
+
Clouds
+
Battery Discharge
+
Persistence
=
“Interesting data”

Ward Peak. Lake Tahoe Basin. 8600 feet.

Photo: Arlen Huggins

Mt Warren Toward NE

Mt Warren Anemometer

Mt Warren Summit Station 12,327 ft

Mt Warren Toward North

Mt Warren Toward West

Mt Warren Toward South

Mt Warren Toward East

2003 March 10

White Mountain Summit.

Highest active live transmission station in North America.

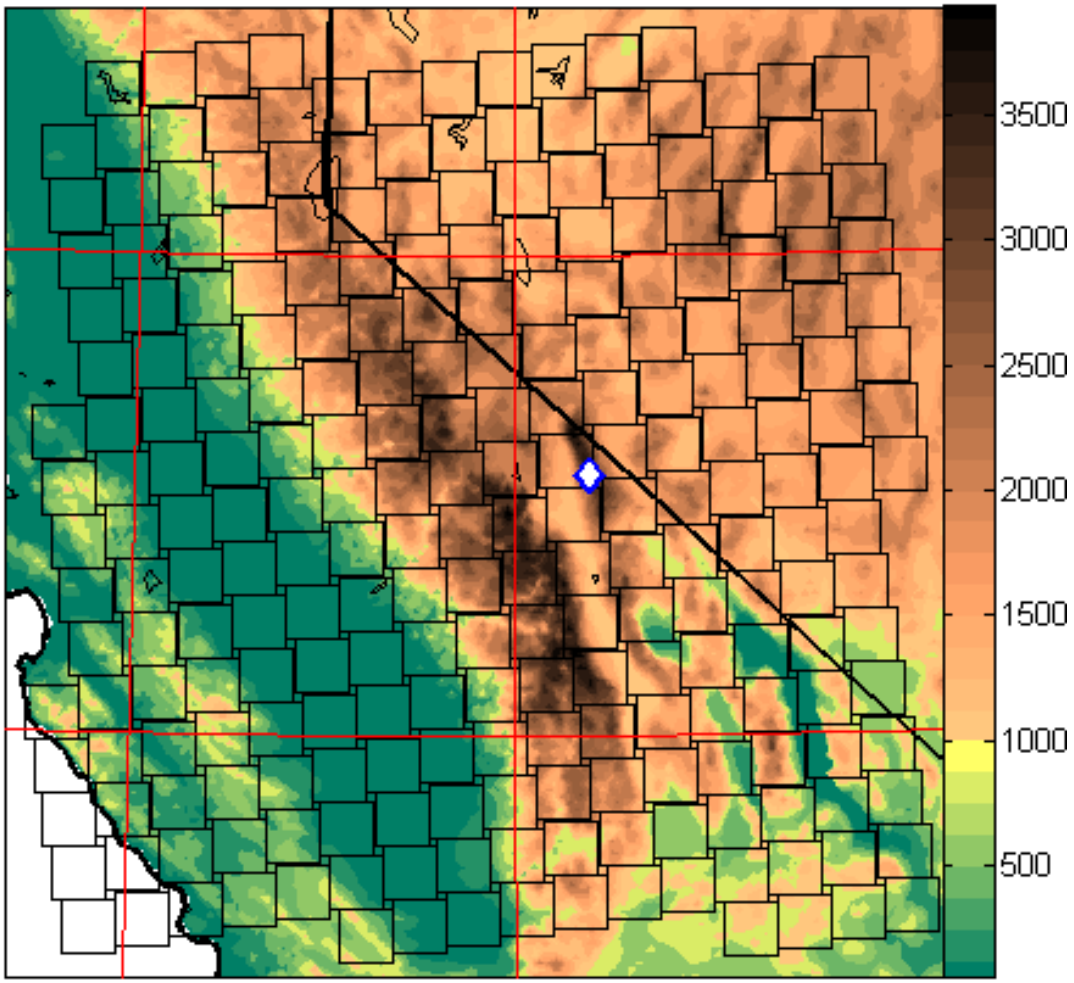
14246 ft. / 4342 m.

Summer 2003

White Mtn Summit, 14246 ft
Reconfigured July 2004

White Mtn Summit
Wind braces July 2004

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



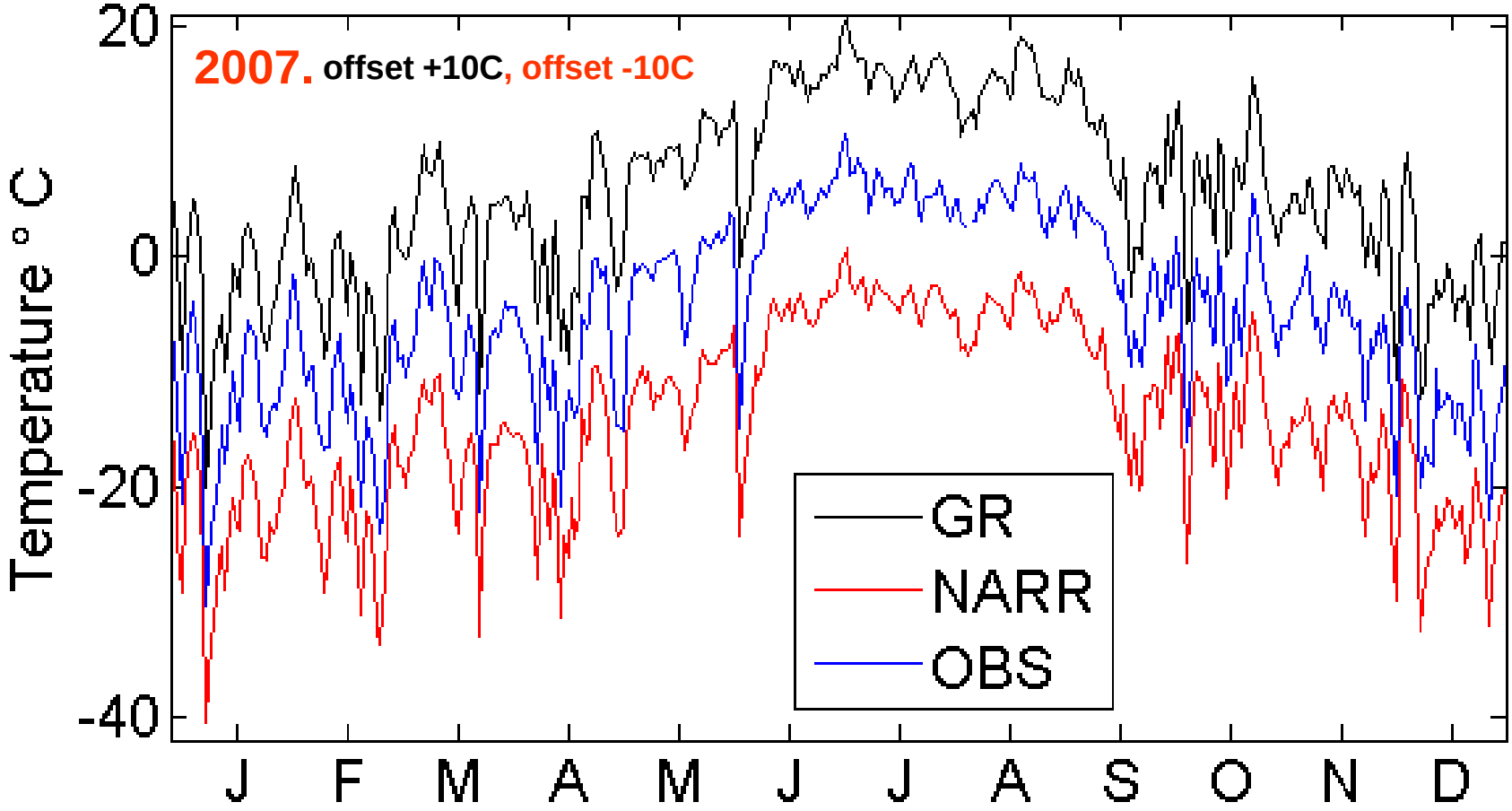
John Abatzoglou
Kelly Redmond

White Mountain Research Station Summit Station. 14,245 feet.

Mean Daily Temperature Observations. Complete days Sep 2003-May 2008. 70% of all days.

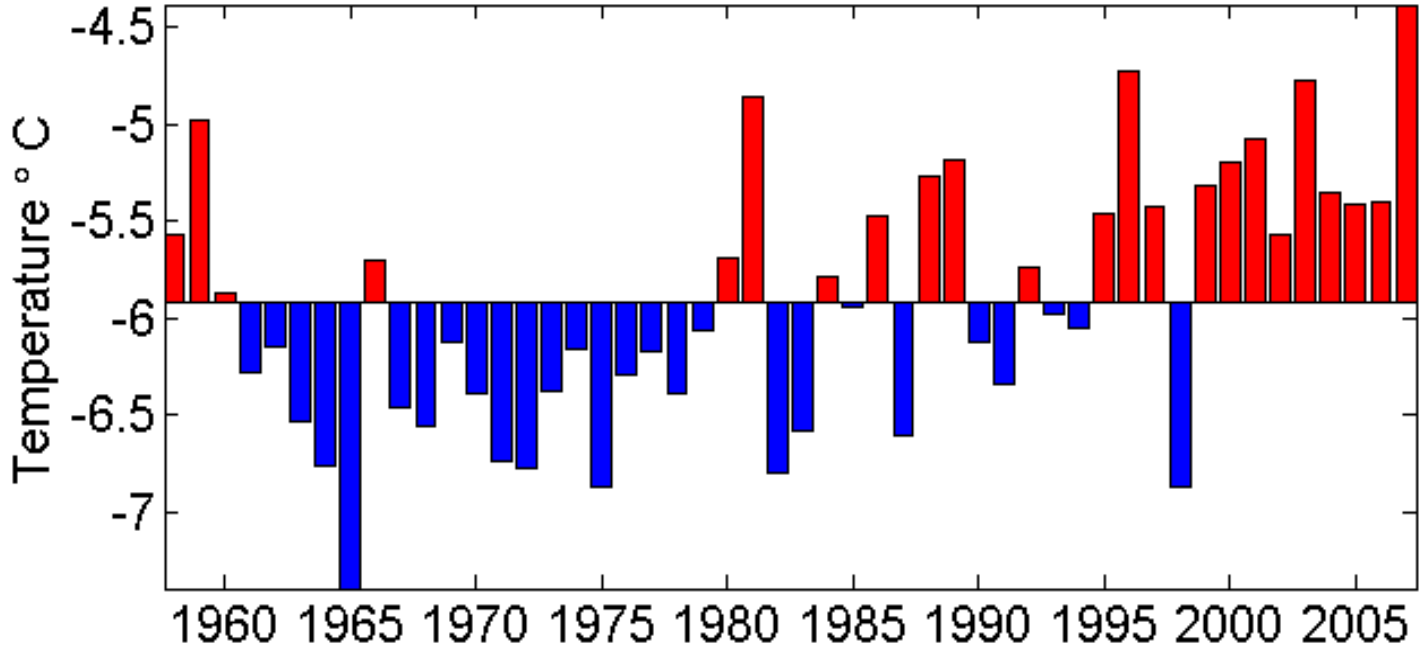
NARR. Reconstructed from North American Regional Reanalysis, 32 km, 29 levels. r = 0.985 (0.98 winter, 0.93 summer). 99 percent of all reconstructed values within 3 deg C of obs.

GR. Reconstructed from Global Reanalysis. r = 0.97



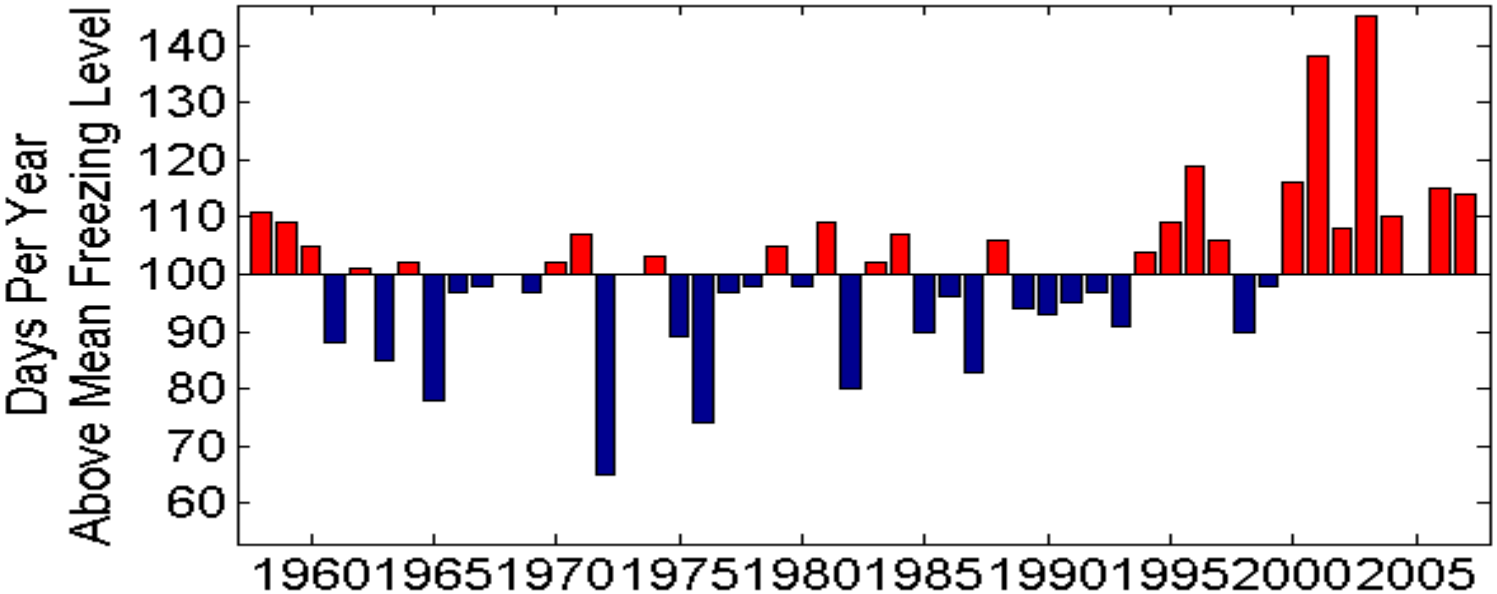
John Abatzoglou
Kelly Redmond

White Mountain Summit Temperature. 14,245 feet. Reconstructed from Global Reanalysis.



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

Desert Research Institute, Storm Peak Laboratory. Steamboat Ski Area, Steamboat CO. (Randy Borys)

2005 February 13. Storm Peak Lab. ctsy Dave Simeral.

2005 February 13. Storm Peak Lab.
ctsy Dave Simeral.

There are few

- **long-term**
- **in-situ**
- **high-altitude**
- **systematic**
- **climate-quality**

observational time series

with daily/hourly resolution for

the mountainous western United States and North America.

These are crucial to success of research to tie climate to physical and biological processes, on many time scales.

How can we improve this?

Why is high elevation climate undersampled?

- **Harsh physical environment**
  - **Sensors and equipment**
  - **Maintenance**
  - **Access**
  - **Communications**
  - **Time**
  - **Budgets**
- **Human presence limited, often seasonal.**
- **Electrical power for heating often not available**
- **Permitting, aesthetics, wilderness, etc**
- **Most precipitation is frozen**

ID Arco 17 SW, Craters of the Moon National Monument & Preserve (Hdq. Area)

43.5 N 113.6 W 5955’

July 10, 2003

AK Barrow 4 ENE, NOAA (CMDL Observatory)

71.3 N 156.6 W 15’

Non-Commissioned

July 22, 2002

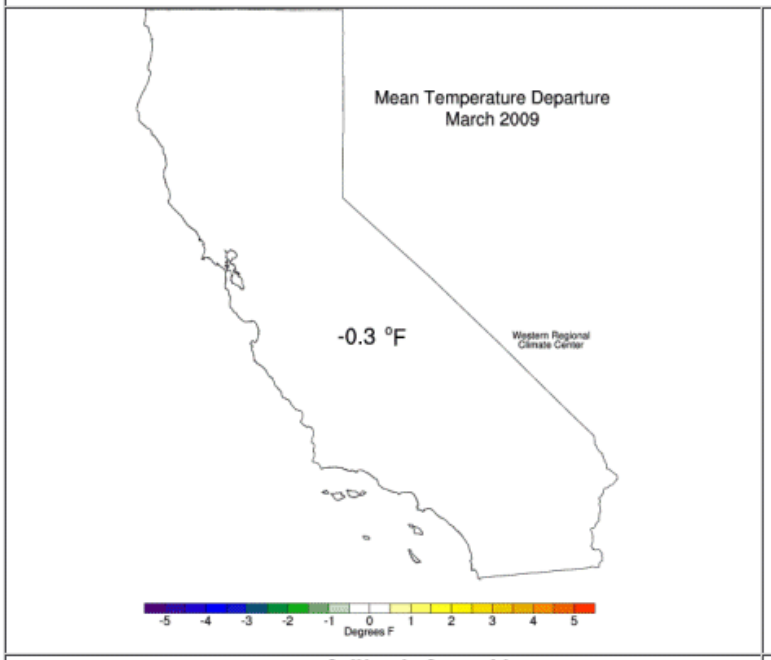
California Climate Tracker

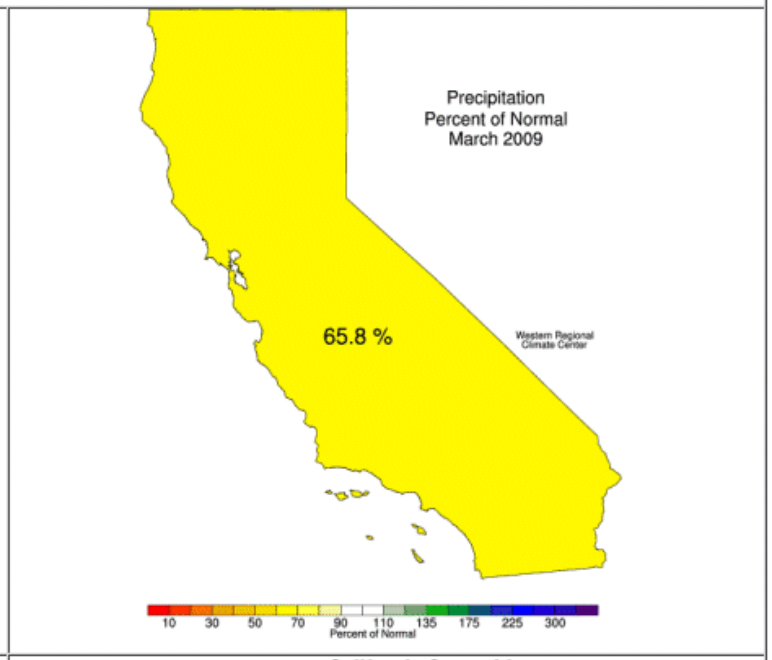
Tracking Climate Variability and Change for the State

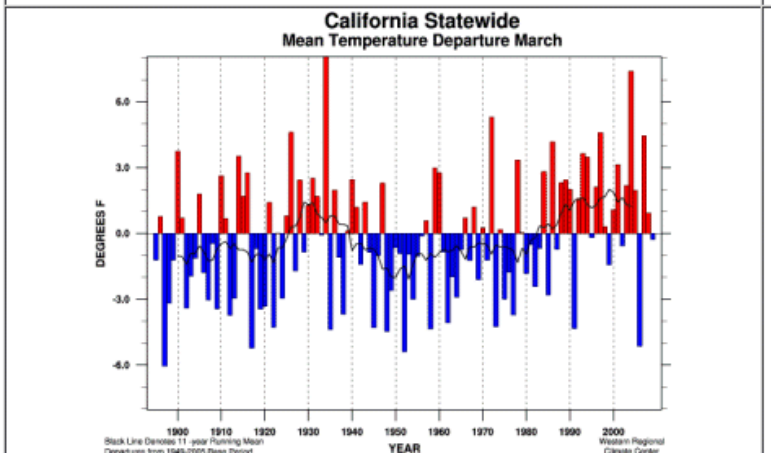
Explore Climate Products

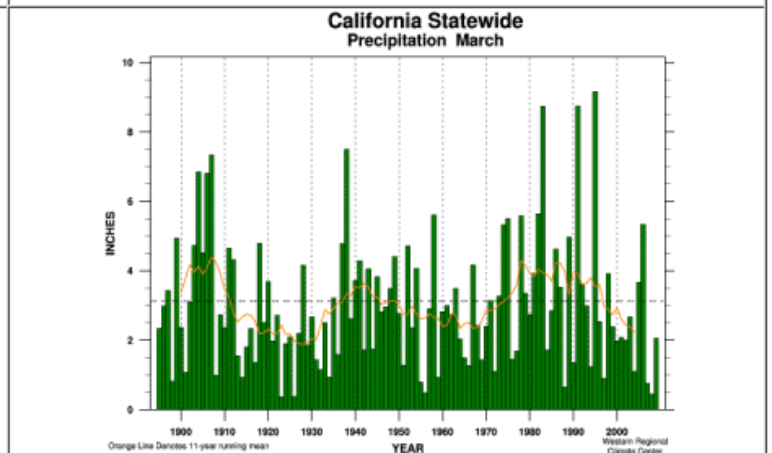
Much appreciation to John Abatzoglou

MARCH 2009





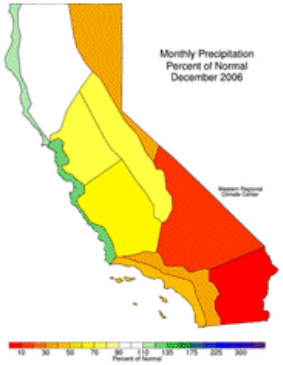




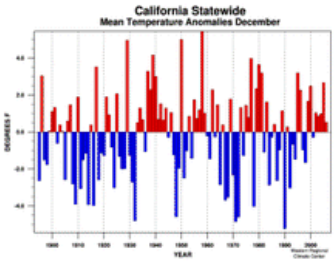
California Climate Tracker

Select from the Menu to the Right

Latest Graphics



Time Series



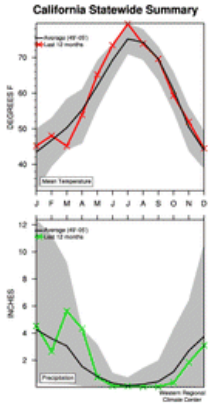
Latest Graphics

Select Region
Select Element
Select Data Type
Select Time Period
Select

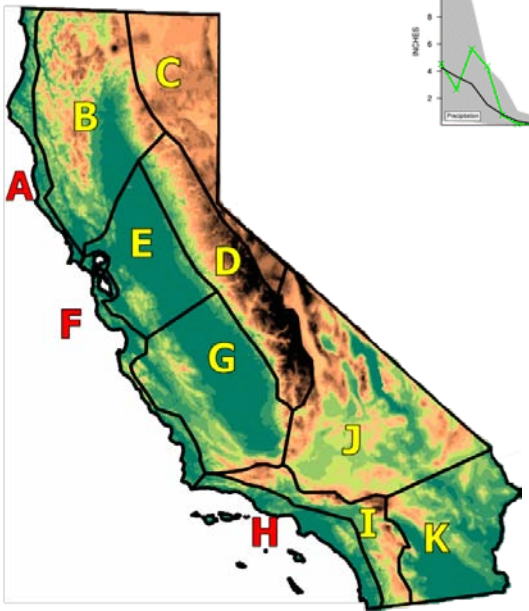
Time Series

Select Region
Select Element
Select Time Period
Select

Last 12 Months



- Climate region data: 1895 to present
- Averages taken from: 1949-2005



Time Series

Sierra

Select Region
Statewide
Sierra
Northeast
North Central
Sacramento-Delta
San Joaquin Valley
North Coast
Central Coast
South Coast
South Interior
Mohave
Sonoran

Time Series

Select Region

Select Element

Select Element
Maximum Temperature
Minimum Temperature
Mean Temperature
Precipitation
Temperature Summary

Time Series

Select Region

Select Element

Select Time Period

March
April
May
June
July
August
September
October
November
December
Winter (DJF)
Spring (MAM)
Summer (JJA)
Autumn (SON)
Calendar Year (Jan-Dec)
Water Year (Oct-Sep)
Water Year (Jul-Jun)
January to Present
October To Present
July To Present

Summary of the Past 12 Months

Select Region GO

Climate Regions
Plot Data

More Info
Retrieve Data

Back to the California Climate Tracker
Non-Frames Version

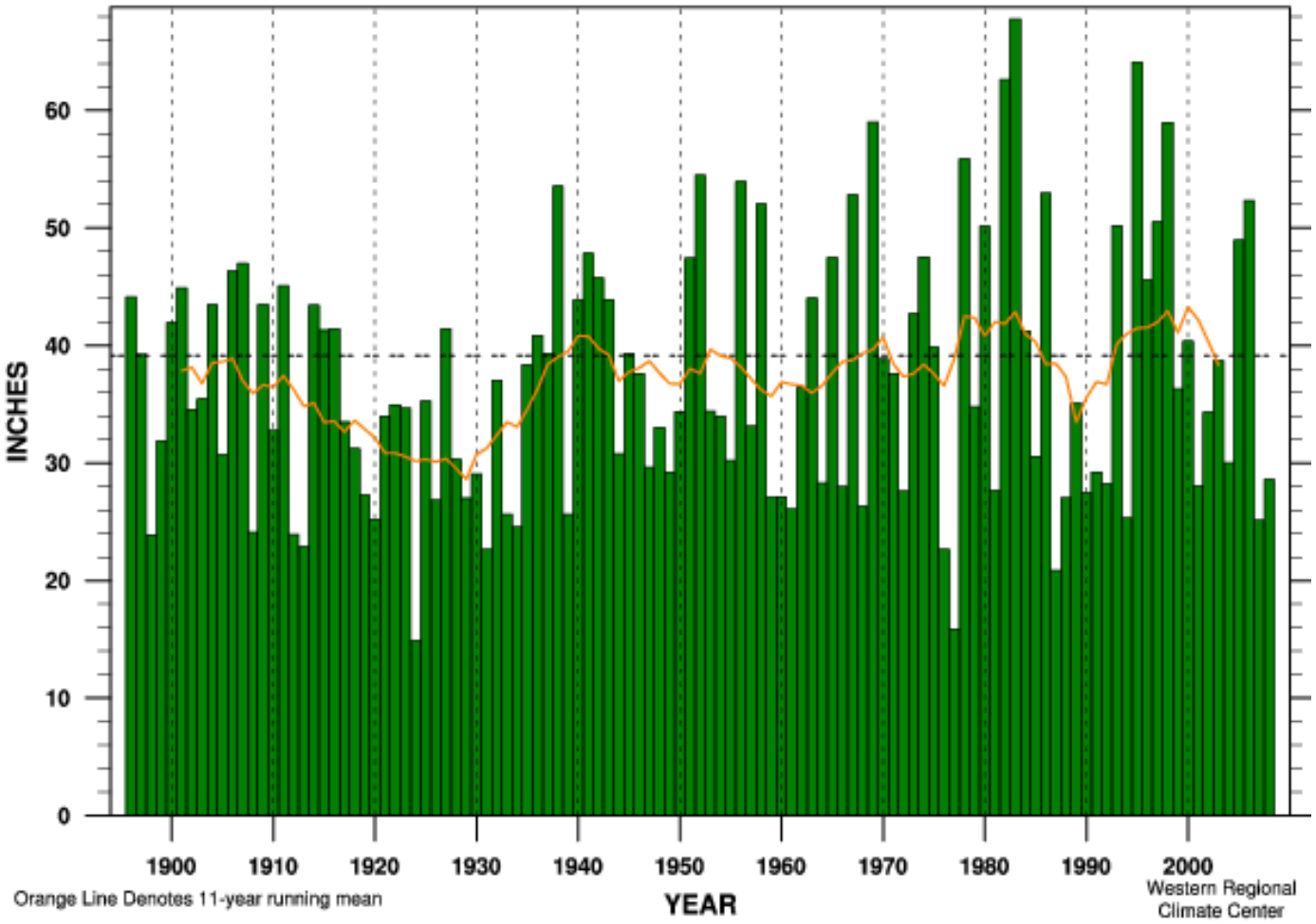
Western Regional Climate Center

DRI Desert Research Institute

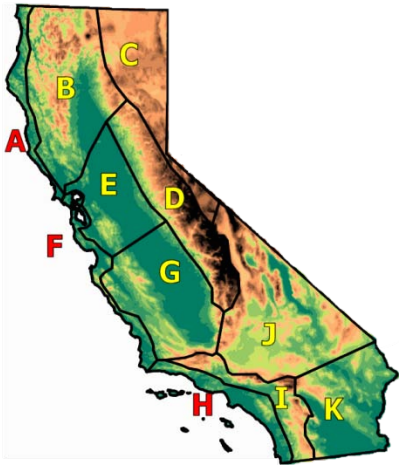
Powered by ACIS
NOAA Regional Climate Centers

Several types of summaries And presentations available.

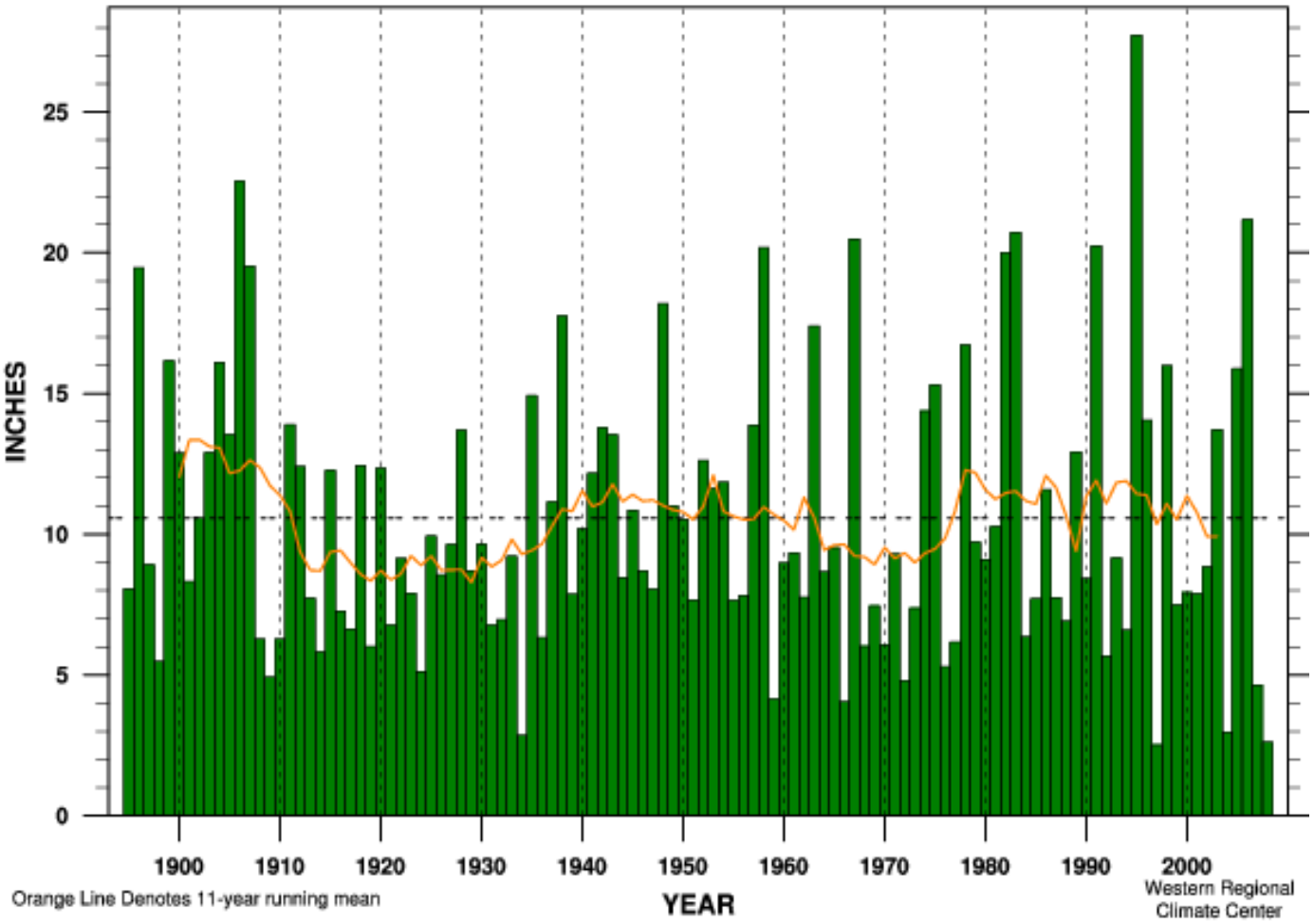
Sierra Region
Precipitation Oct-Sep



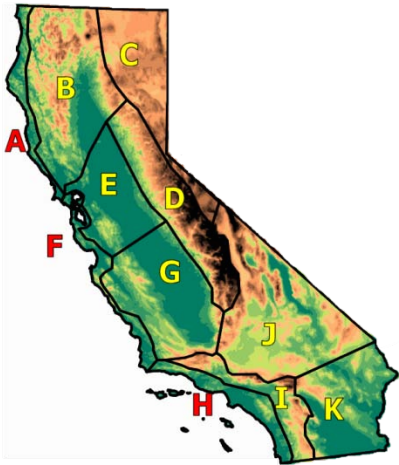
Linear Trend 1895-present	+ 4.88 ± 6.09 in.	(+ 12 ± 15%) per 100 yr	
Linear Trend 1949-present	+ 0.58 ± 19.02 in.	(+ 1 ± 48%) per 100 yr	
Linear Trend 1975-present	+ 0.11 ± 52.49 in.	(+ 0 ± 134%) per 100 yr	
Wettest Year	67.79 in. (173%) in 1983	MEAN	39.15 in.
Driest Year	14.89 in. (38%) in 1924	STDEV	12.33 in.
Oct-Sep 2008	28.61 in. (73%)	RANK	31 of 113



Sierra Region
Precipitation Mar-May

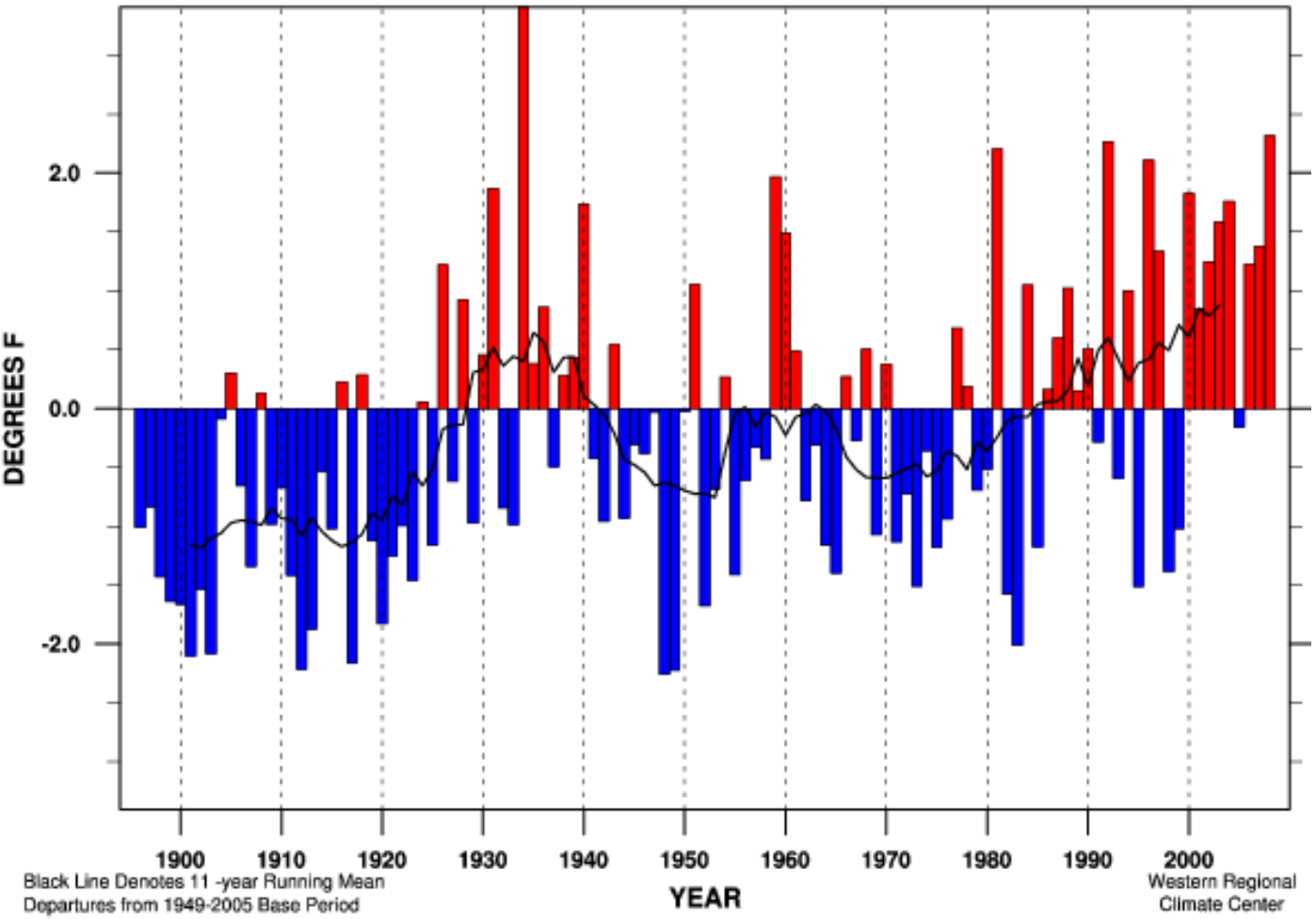


Linear Trend 1895-present	- 0.19 ± 2.75 in.	(- 1 ± 26%) per 100 yr	
Linear Trend 1949-present	+ 0.30 ± 8.12 in.	(+ 2 ± 76%) per 100 yr	
Linear Trend 1975-present	- 5.86 ± 21.90 in.	(- 55 ± 207%) per 100 yr	
Wettest Year	27.73 in. (262%)	in 1995	MEAN 10.57 in.
Driest Year	2.52 in. (23%)	in 1997	STDEV 5.20 in.
Mar-May 2008	2.61 in. (24%)		RANK 2 of 114

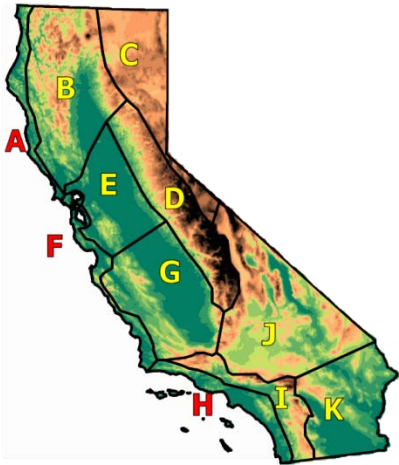


Sierra Region

Mean Temperature Departure Oct-Sep

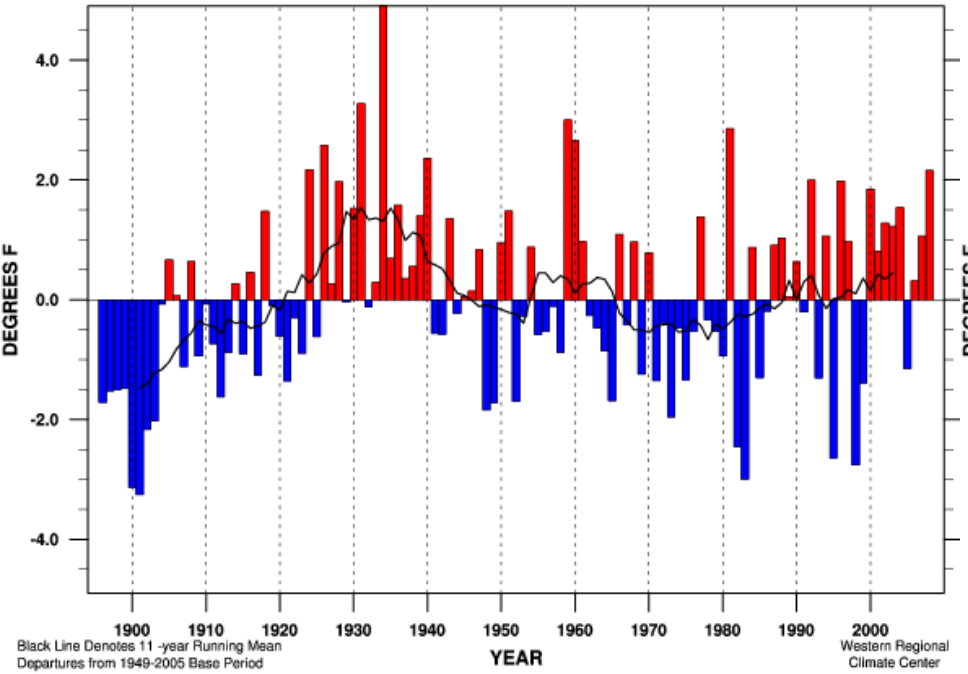


Linear Trend 1895-present	+ 1.52 ± 0.63 °F/100yr		
Linear Trend 1949-present	+ 2.56 ± 1.68 °F/100yr		
Linear Trend 1975-present	+ 5.36 ± 4.31 °F/100yr		
Warmest Year	52.4 °F (+ 3.4 °F) in 1934	MEAN	49.0 °F
Coldest Year	46.8 °F (- 2.3 °F) in 1948	STDEV	1.15 °F
Oct-Sep 2008	51.4 °F (+ 2.3 °F)	RANK	112 of 113



Sierra Region

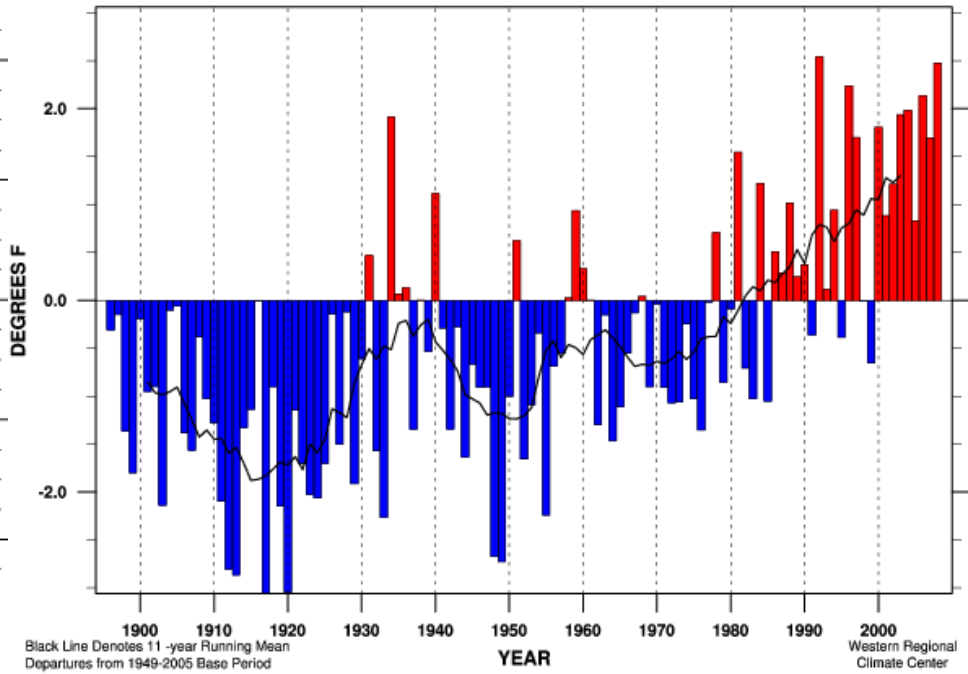
Maximum Temperature Departure Oct-Sep



Linear Trend 1895-present	+ 0.76 ± 0.83 °F/100yr		
Linear Trend 1949-present	+ 0.74 ± 2.18 °F/100yr		
Linear Trend 1975-present	+ 3.68 ± 5.65 °F/100yr		
Warmest Year	66.4 °F (+ 4.9 °F) in 1934	MEAN	61.5 °F
Coldest Year	58.2 °F (- 3.3 °F) in 1901	STDEV	1.41°F
Oct-Sep 2008	63.7 °F (+ 2.2 °F)	RANK	105 of 113

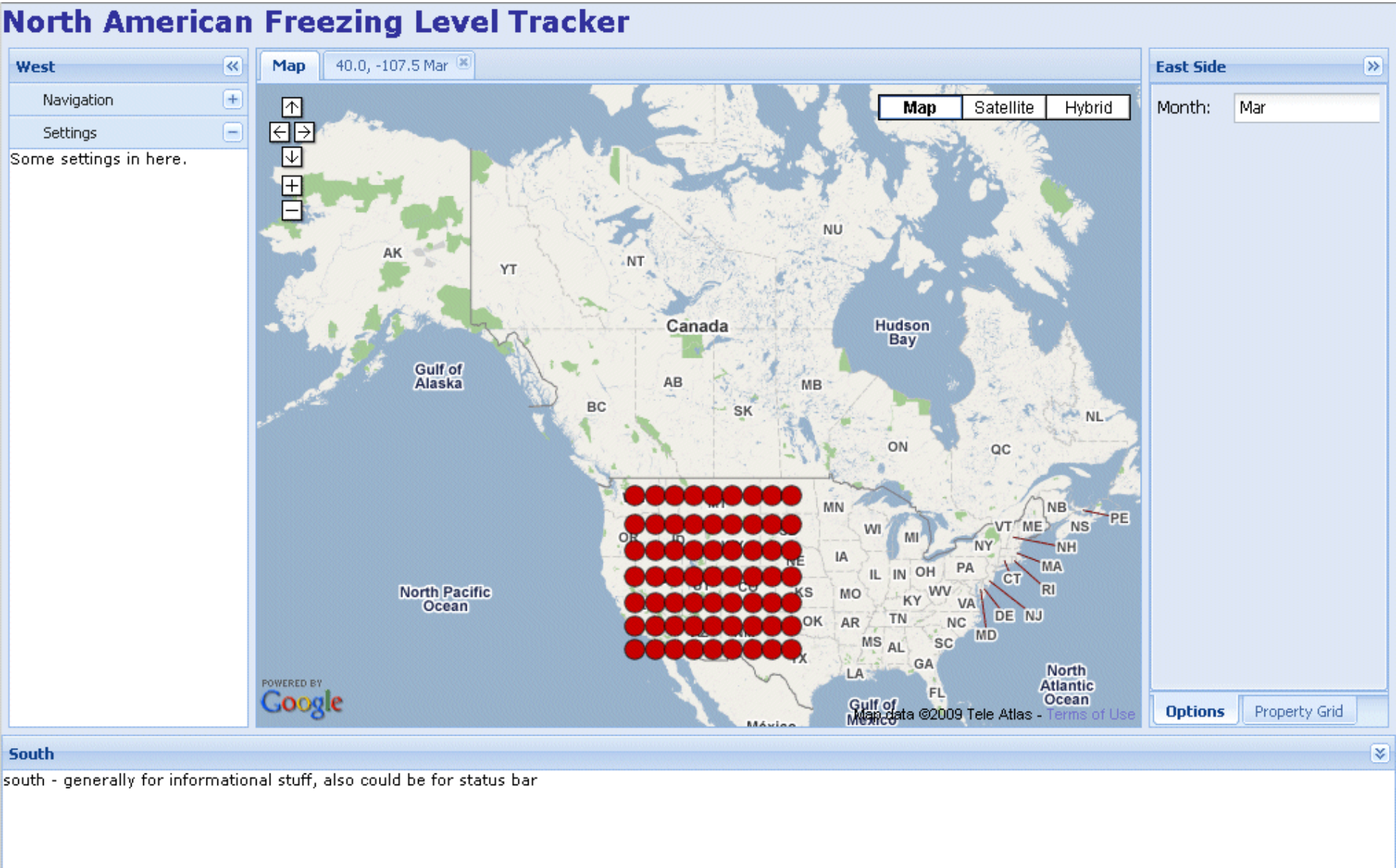
Sierra Region

Miniumum Temperature Departure Oct-Sep



Linear Trend 1895-present	+ 2.28 ± 0.57 °F/100yr		
Linear Trend 1949-present	+ 4.38 ± 1.33 °F/100yr		
Linear Trend 1975-present	+ 7.04 ± 3.36 °F/100yr		
Warmest Year	39.1°F (+ 2.5 °F) in 1992	MEAN	36.6 °F
Coldest Year	33.5 °F (- 3.1°F) in 1917	STDEV	1.12 °F
Oct-Sep 2008	39.0 °F (+ 2.5 °F)	RANK	112 of 113

Not online yet. Mockup of home Page. Temporary Test Grid from Reanalysis.



Select type of product, set up display parameters, select location for time series or domain for map.

North American Freezing Level Tracker

West

Navigation

Hi. I'm the west panel.

Time Series

Monthly

Fixed temperature

Fixed height

Pct precip as snow

Daily

Fixed temperature

Fixed height

Maps

Monthly / Daily

Fixed temperature.

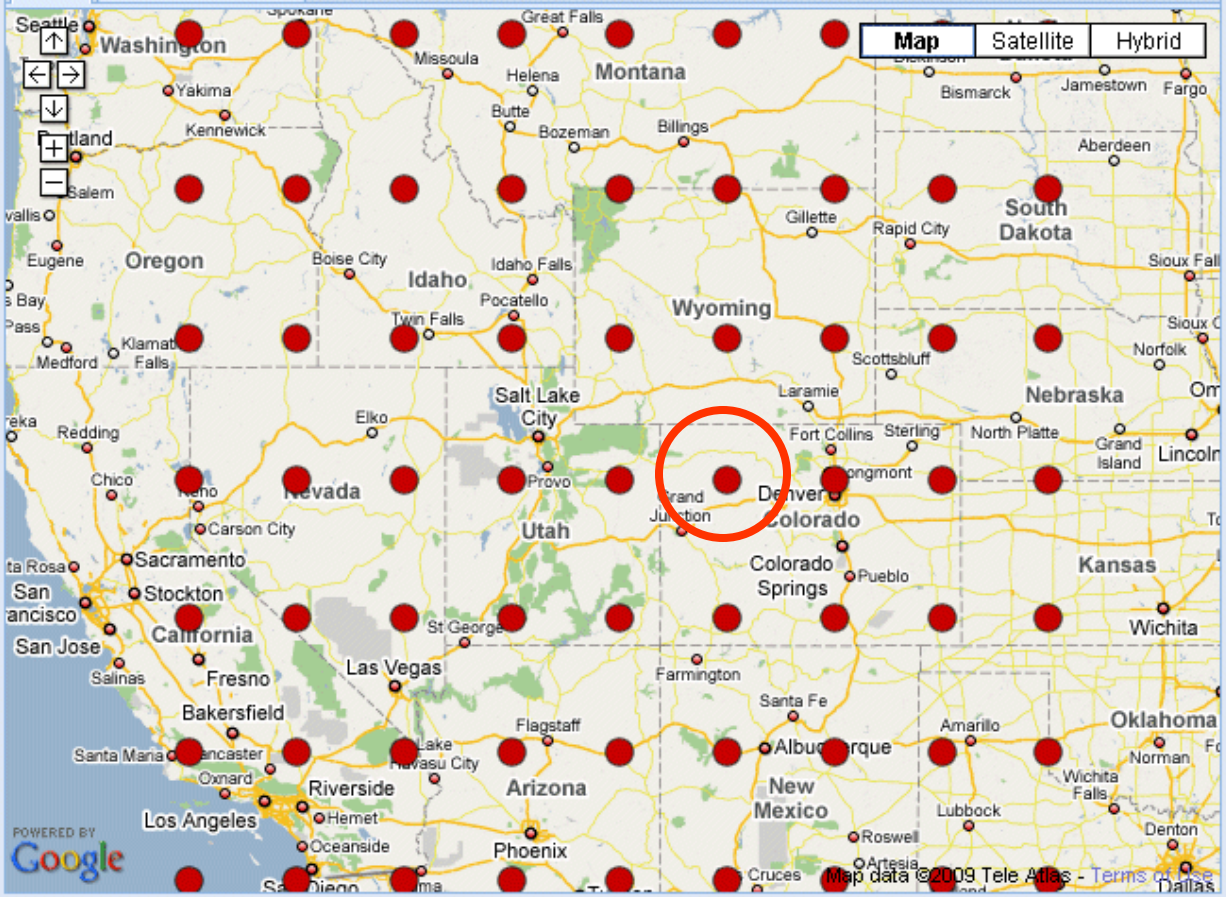
Mean / departure

Fixed height

Mean / departure

Settings

Map | 40.0, -107.5 Mar



East Side

Month: Mar

Product Setup

Graph parameters

Period / duration

Color scheme

Absolute vs departure

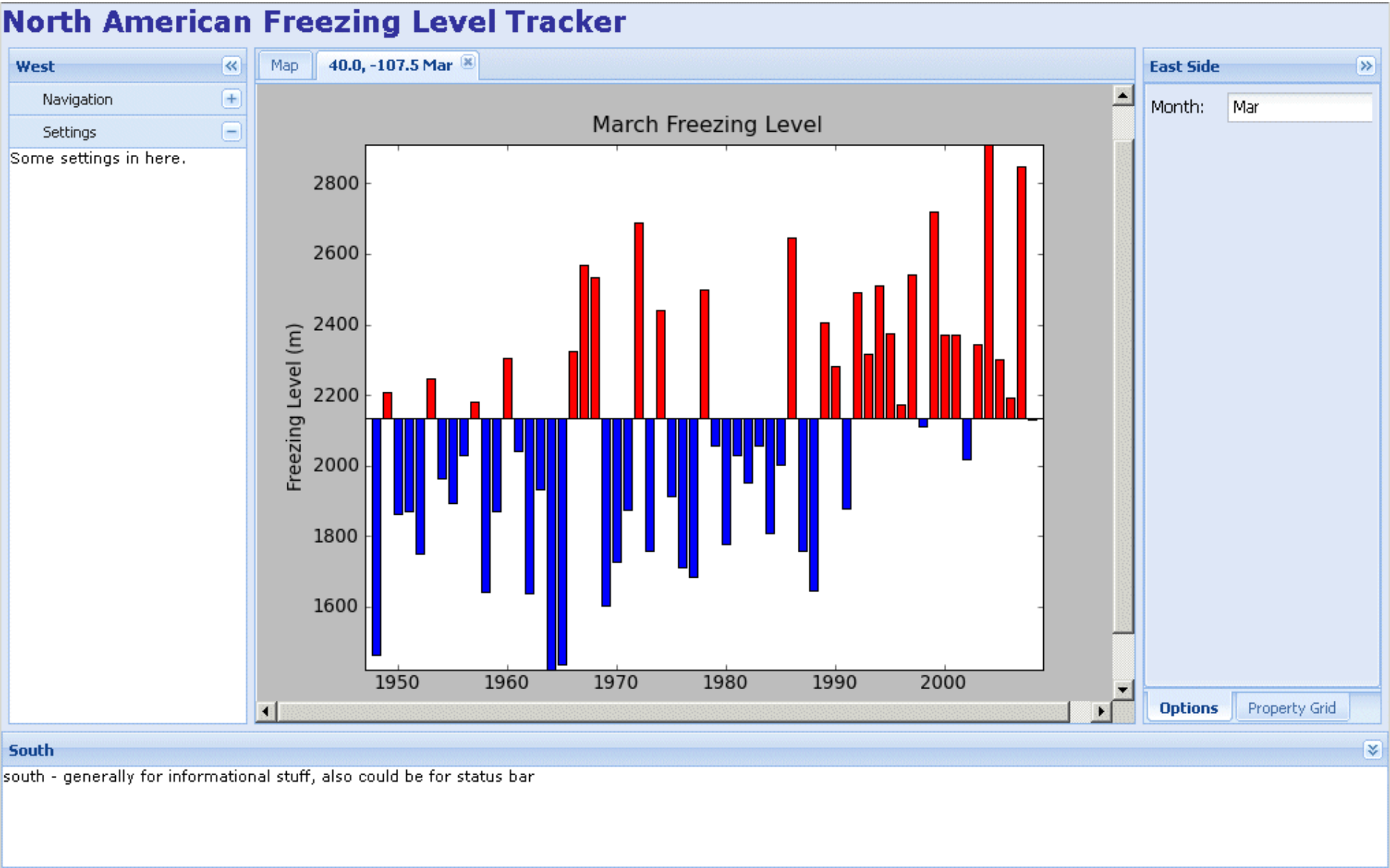
Options | Property Grid

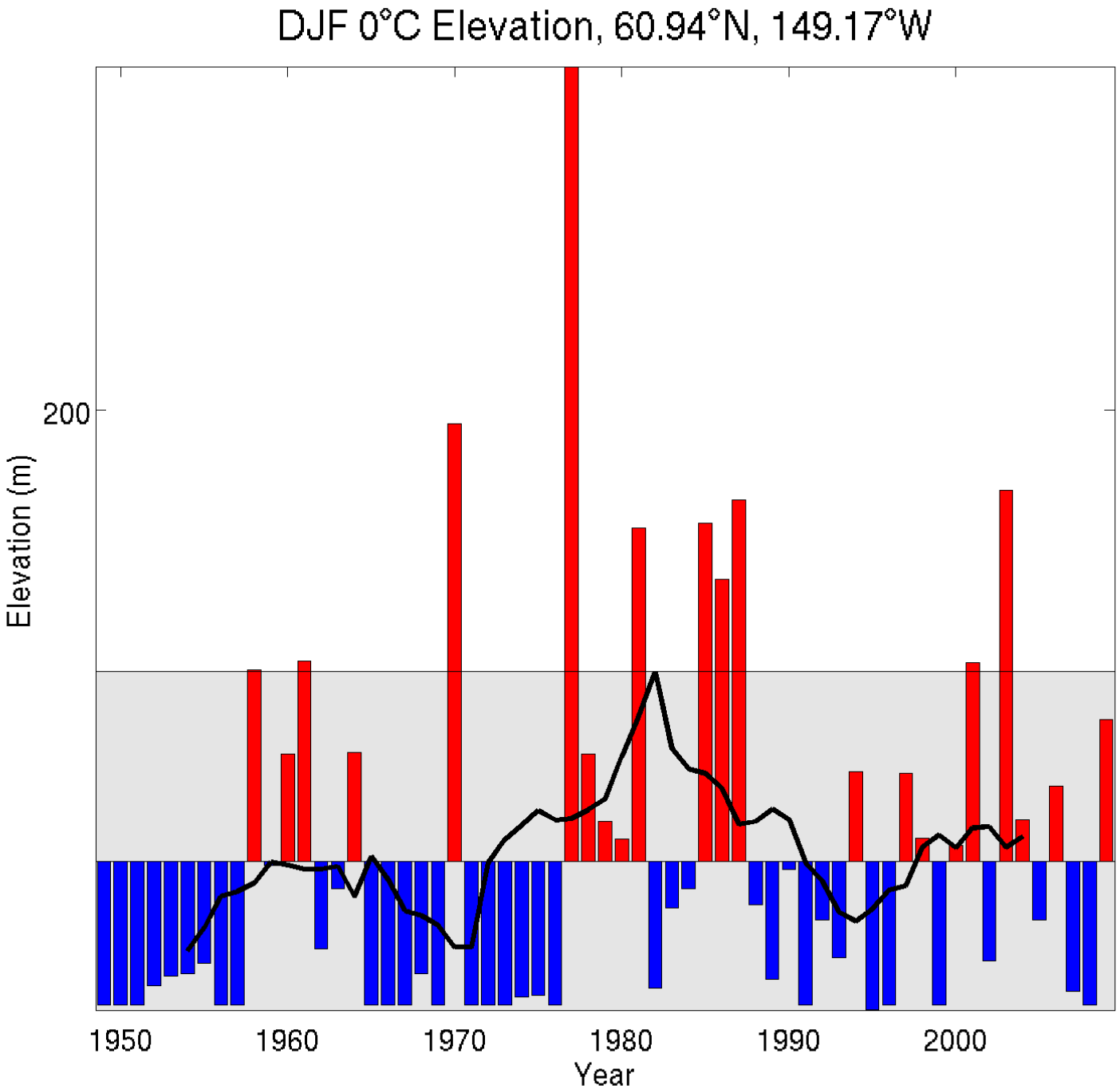
South

south - generally for informational stuff, also could be for status bar

Selected a location over NW Colorado, or Upper Colorado River Basin.

Time series for March from 1948 through 2008.



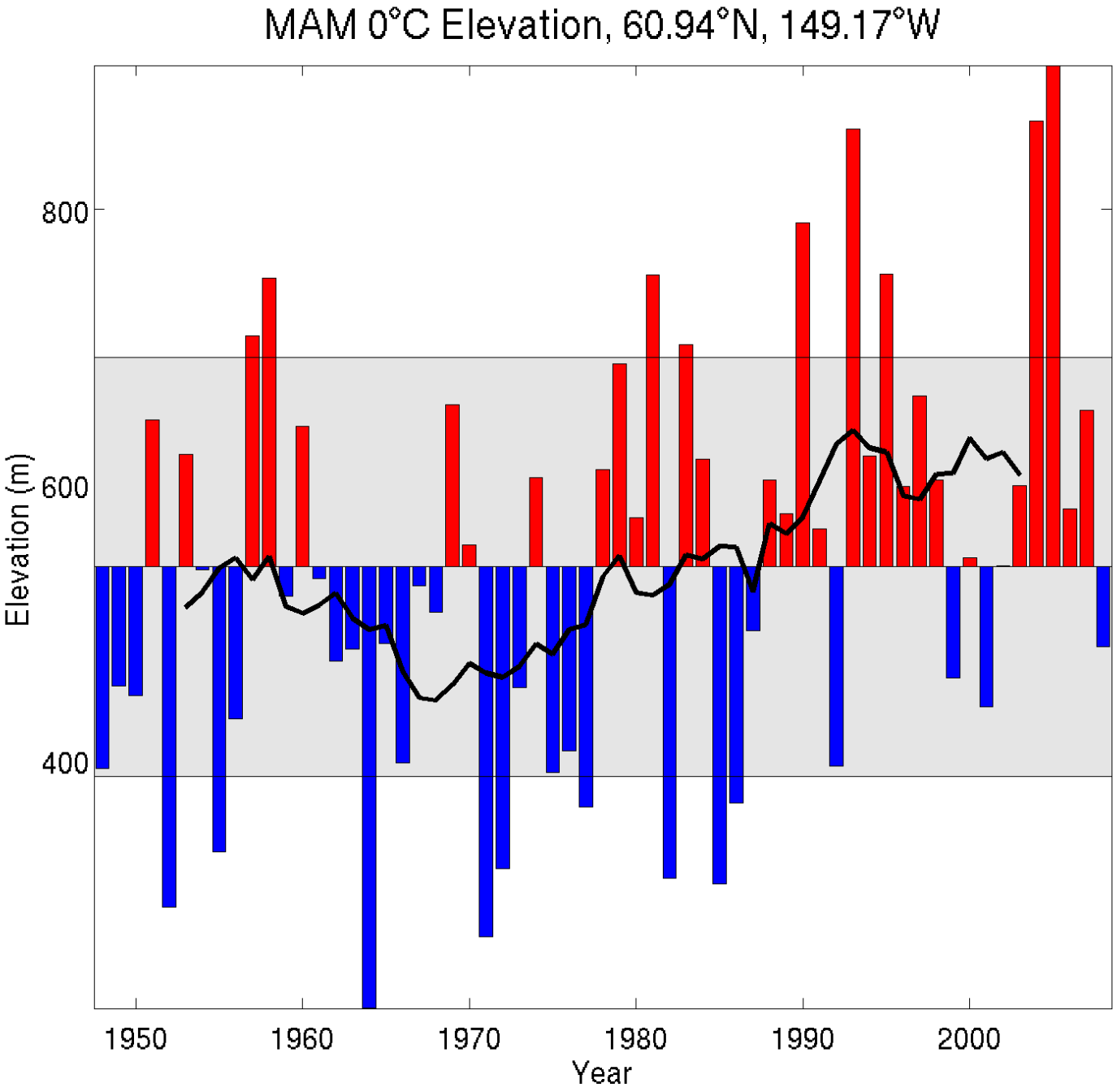


Girdwood.

Winter (DJF)

History of freezing level Height.

1948-2009.

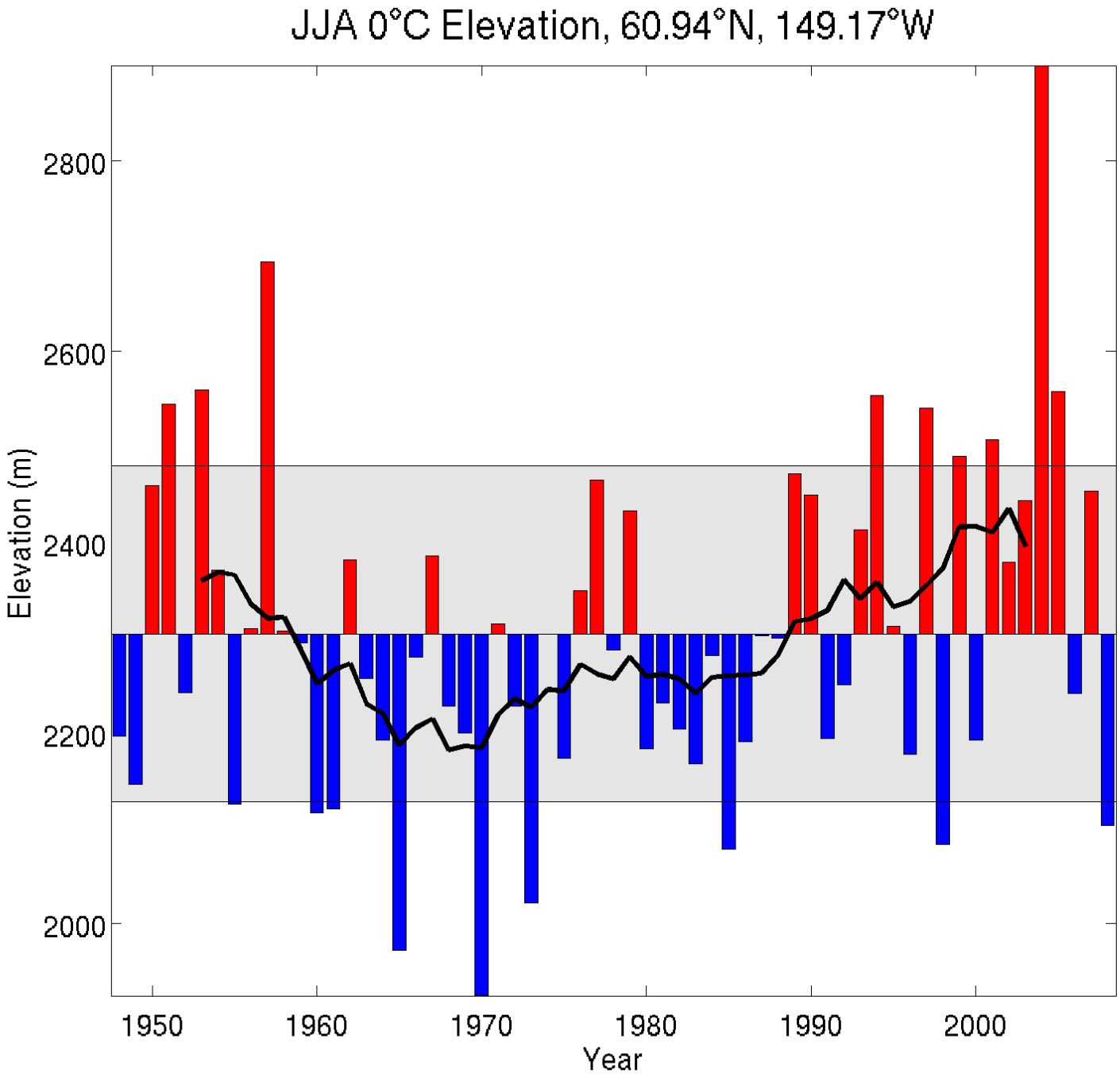


Girdwood.

Spring (MAM)

History of freezing level Height.

1948-2009.

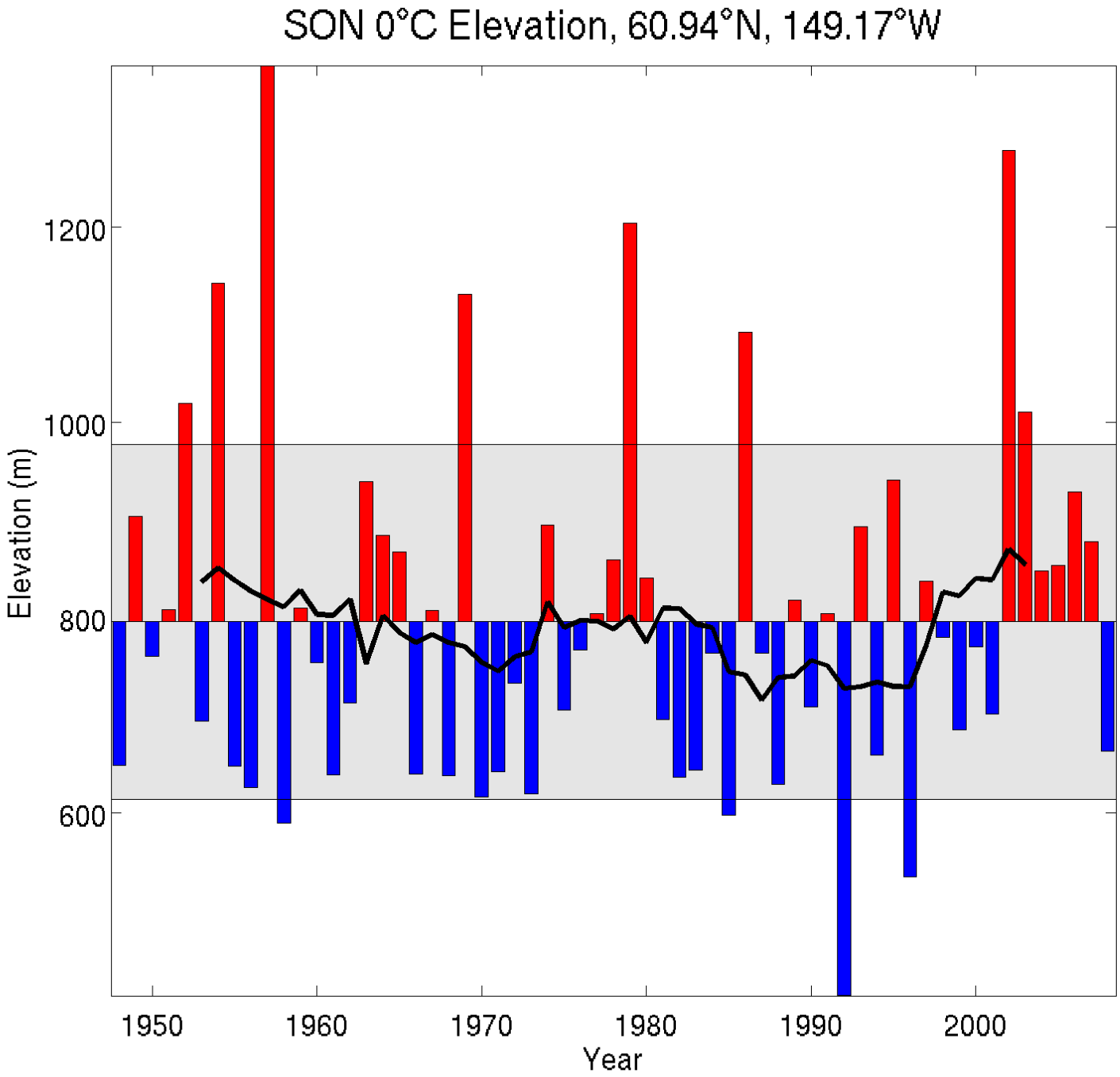


Girdwood.

Summer (JJA)

History of freezing level Height.

1948-2009.

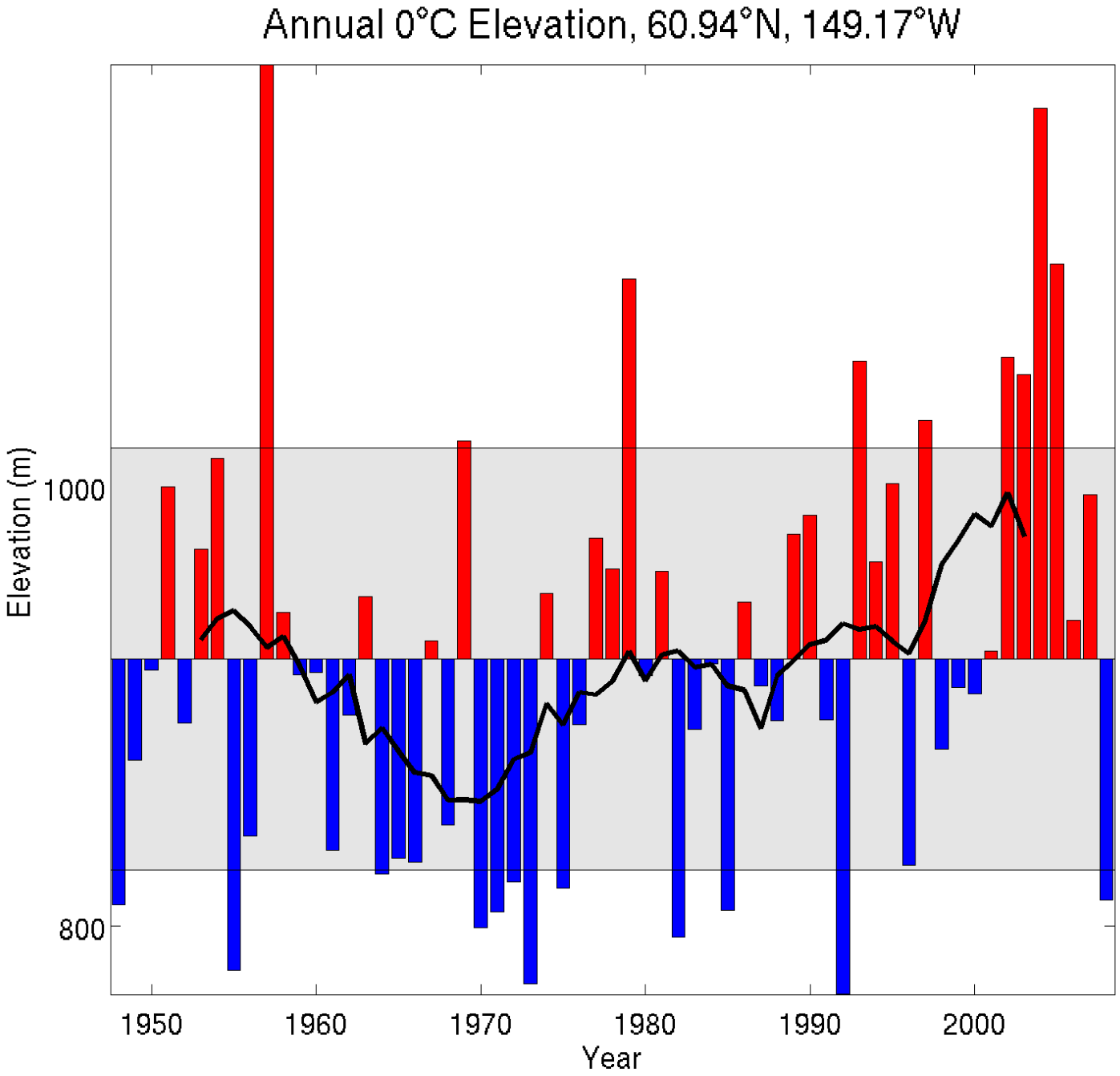


Girdwood.

Autumn (SON)

History of freezing level Height.

1948-2009.

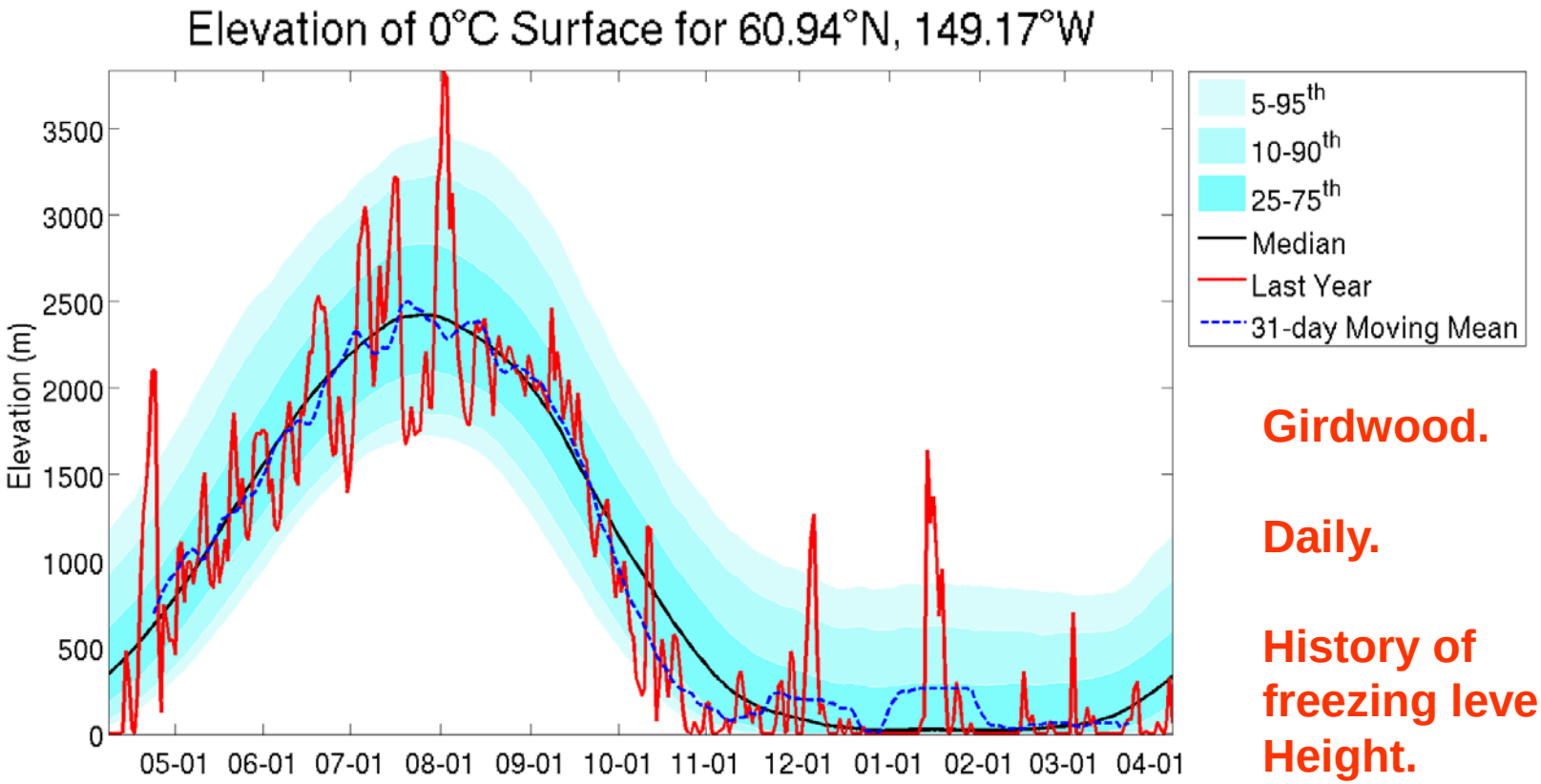


Girdwood.

Annual

History of freezing level Height.

1948-2009.



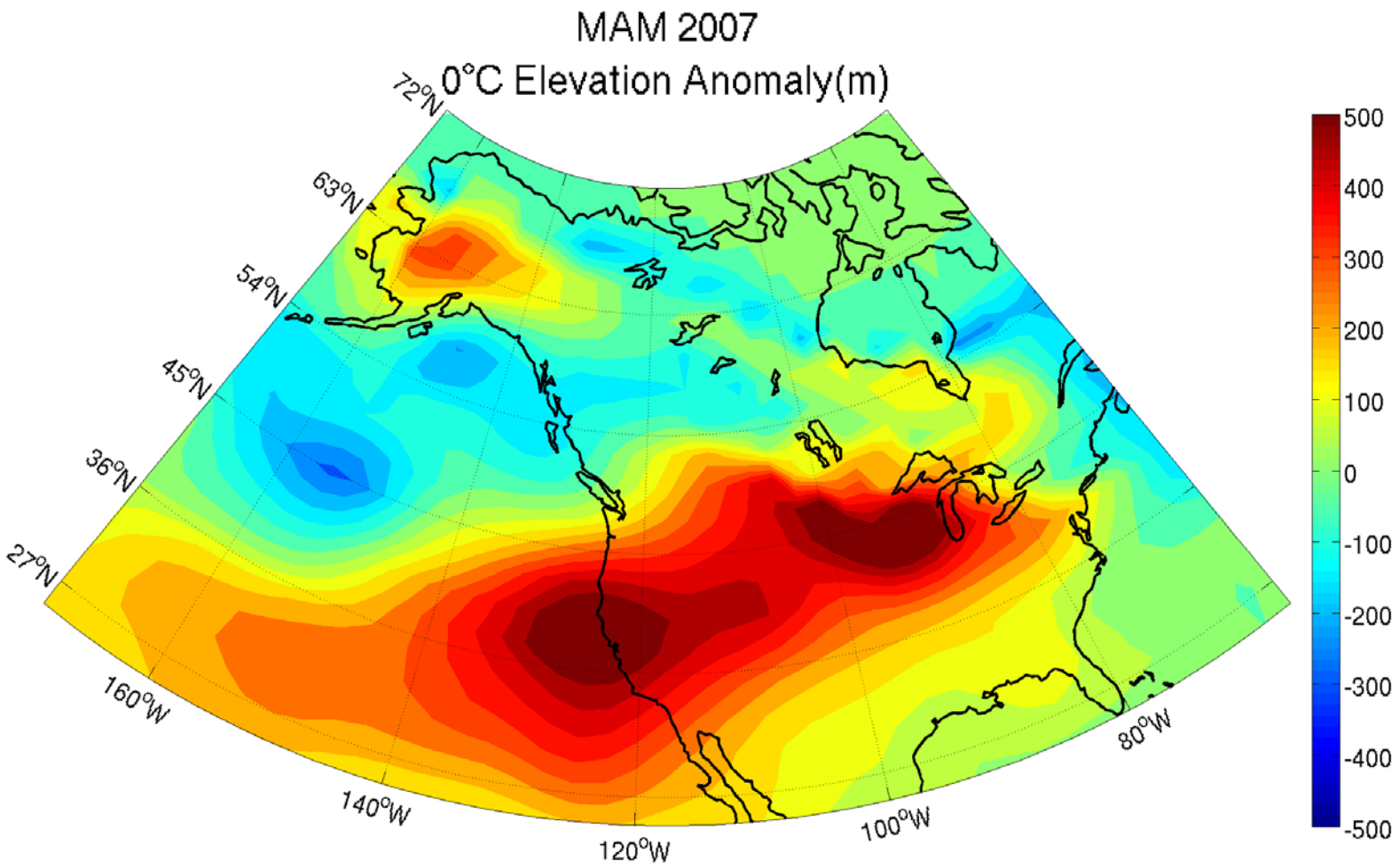
Girdwood.

Daily.

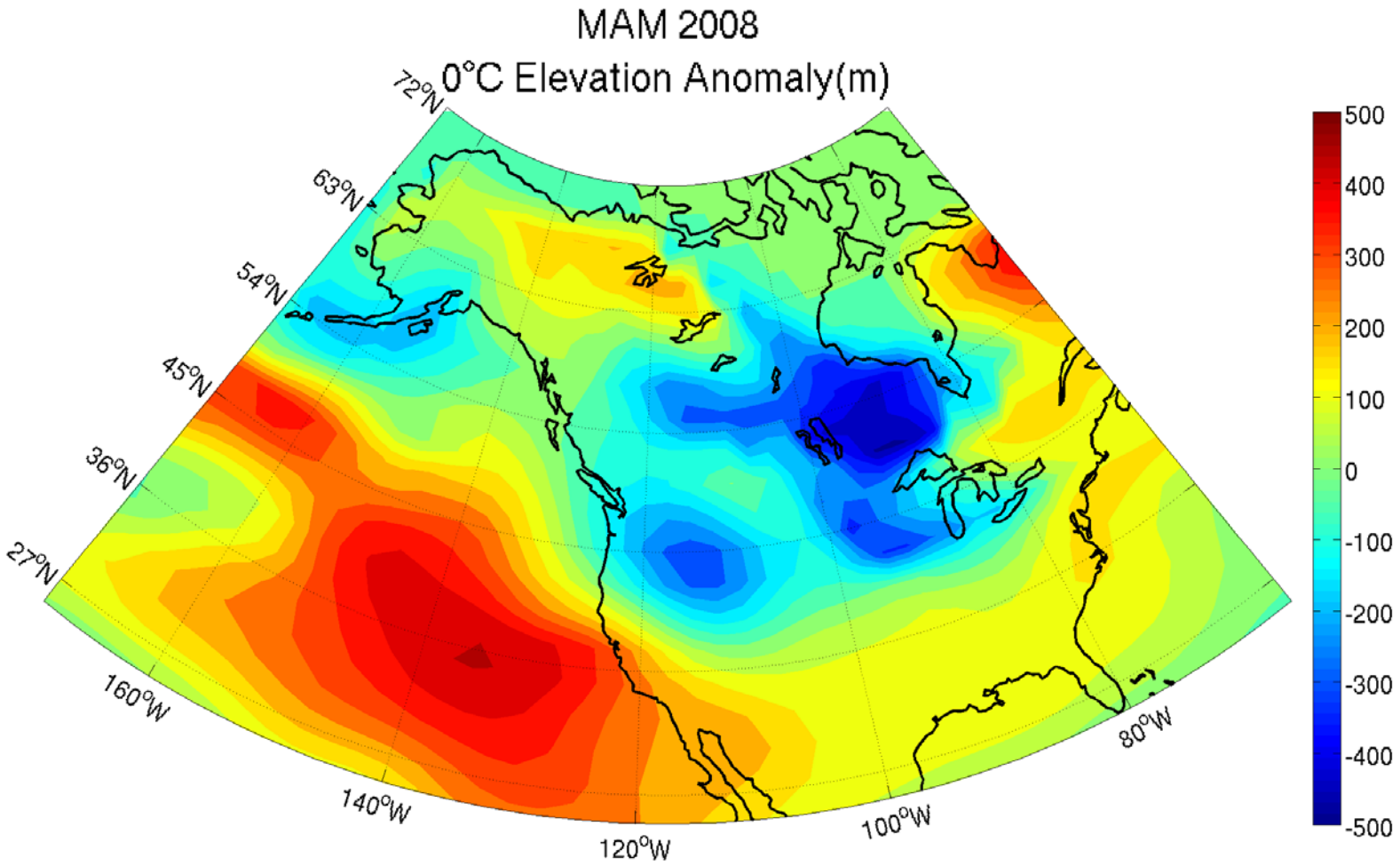
History of freezing level Height.

365 days prior to 2009 Apr 01.

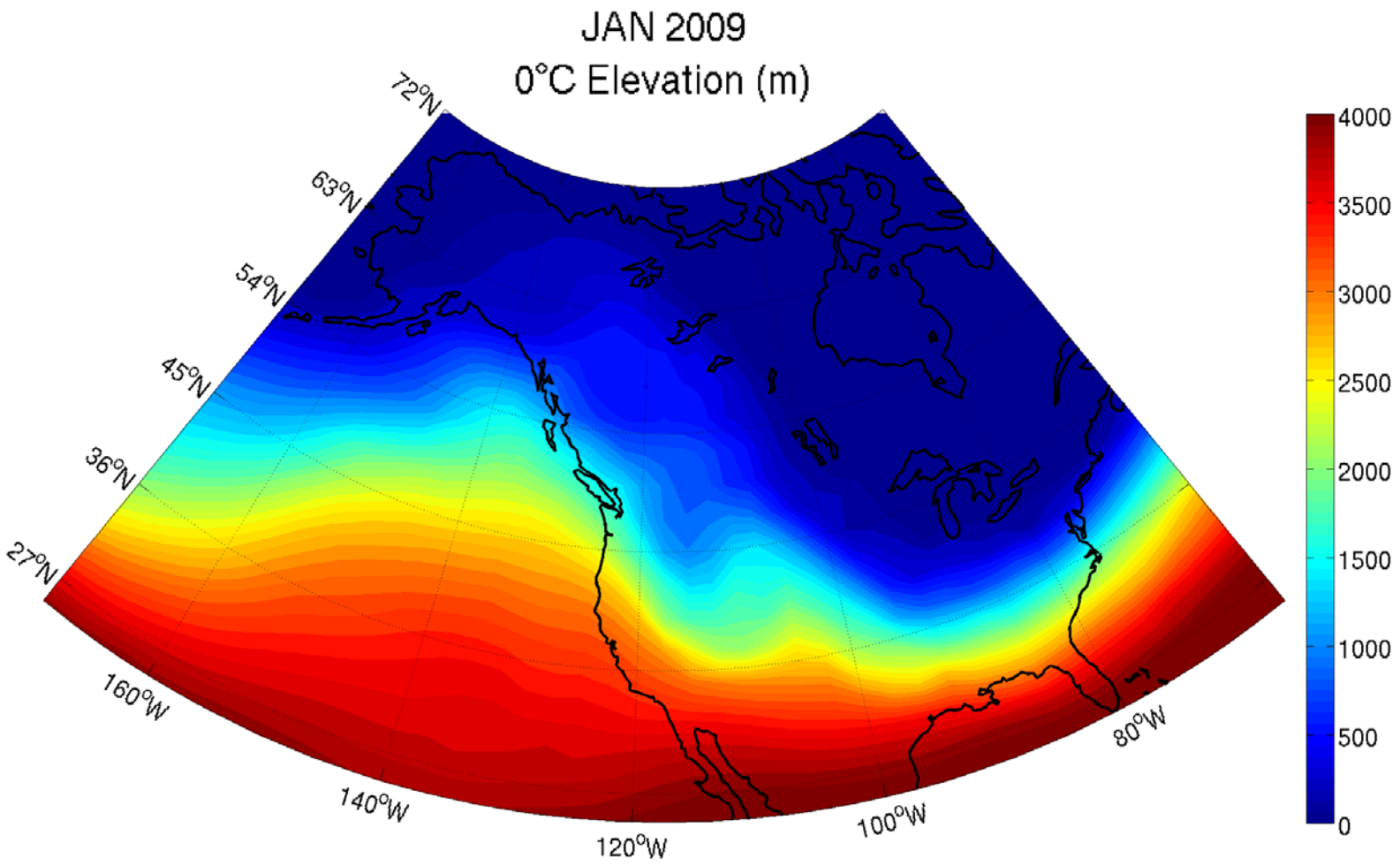
Elevation of Freezing Level. North America. Spring 2007.
Relative height (departure from average). NCEP Reanalysis.



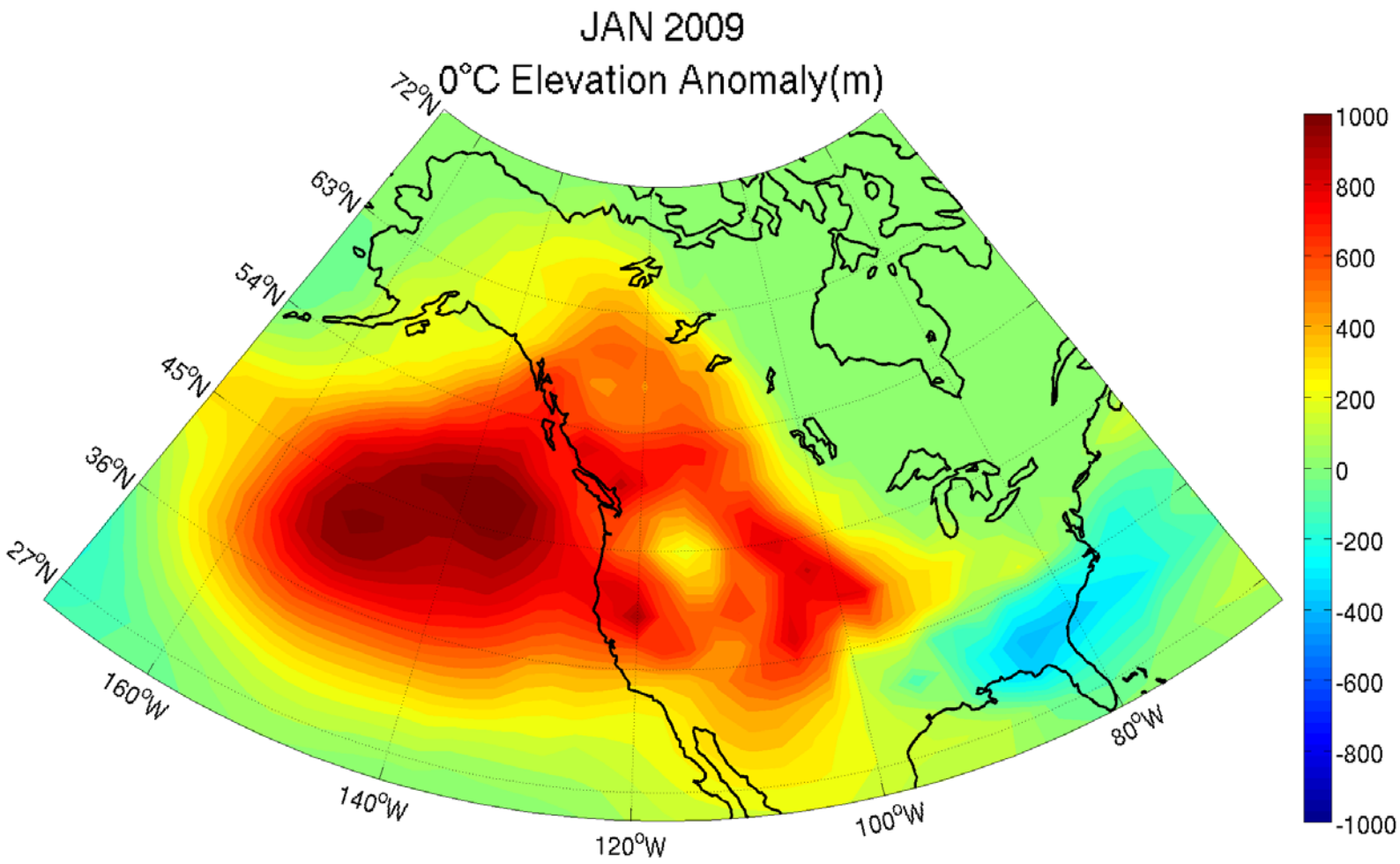
Elevation of Freezing Level. North America. Spring 2008.
Relative height (departure from average). NCEP Reanalysis.



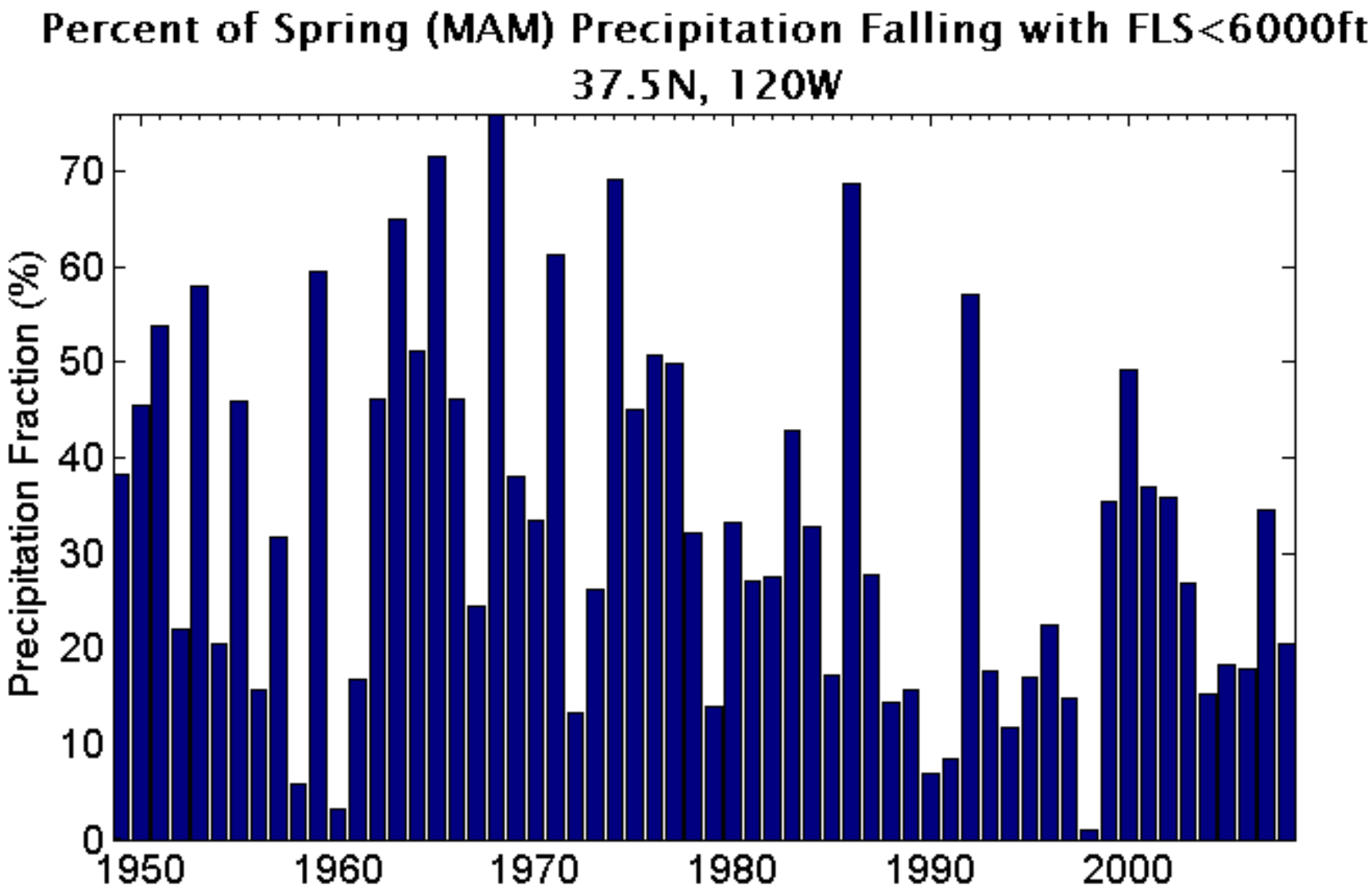
Elevation of Freezing Level. North America. January 2009. Absolute height. NCEP Reanalysis.



Elevation of Freezing Level. North America. January 2009.
Relative height (departure from average). NCEP Reanalysis.



Percent of Spring Precipitation Falling with Freezing Level Below 6000 feet.
Larger fraction implies more precipitation as snow, less as rain.
Yosemite National Park. 1948-2008. NCEP Reanalysis Precipitation and Temperature.



Some Big Picture Issues

The vast majority of monitoring efforts are not hypothesis-driven

Most monitoring efforts are in support of operations and management

- Decision centric environment

Most agency monitoring efforts are in support of a basic mission

- Different missions, equipment, maintenance, data pathways, archival, QC

Not so many multi-purpose generalized monitoring efforts

- These have tended to be within NOAA
- NOAA measurements usually insufficient
  - Too sparse, people centric, commerce-centric, biased sampling,

Most major long-term networks are federal (taxpayer supported)

Gap analyses needed, what are we missing, for what purpose?

Original data have some value, but …

- Data have much more value when turned into information

Some issues (climate change) require very strict measurement standards

Present “climate observing network” was not set up to observe climate change

Some Big Picture Issues

Most monitoring is geared toward “what?” rather than “why?”

Attribution is an issue of increasing interest (“why?”)

Some monitoring is useless without metadata

- Metadata not just a snapshot, but is a history
- Metadata has numerous QC issues too

Quality Control:

- The identification and improvement of imperfect information by making of other imperfect information

Why monitor?

- Documentation of conditions for future reference
- Identification of important events and processes thru retrospective analysis
- Operational management and decision-making
- Public safety and outreach
- Provide baseline reference-quality measurements to assist in interpretation of other supplemental measurements
- Assist with translation to gridded formats

A few more thoughts

With complicated topography, we can never have enough stations

Therefore, what is the most judicious placement of stations?

Redundancy is bad, costs resources.

Redundancy is good, helps QC and data credibility and fills gaps.

Current quality control of daily data. Very difficult in western terrain. Estimate nationwide by Ken Hubbard of HPRCC is that 60 percent of all daily coop data edits are Type I errors (good data are judged to be bad). More mistakes introduced than fixed.

Quality control: Best bang for the buck is to produce high quality data right out of the starting gate, rather than fix the data later on downstream.

Some “networks” are haphazard ad-hoc opportunistic confederations of stations with a variety of purposes, interests, methods, and equipment.

Observational networks are as much people networks as hardware networks. For sustained operation, observations need constituencies.

Combining networks for a de facto mesonet: Local versus central needs

Locally perceived and defined needs, and funding

- More often funding is mainly for deployment
  - Not often the luxury of identifying maintenance source
    - (deployment becomes deplorement)

Centrally perceived and defined needs

- What is the incremental value of a station to a <u>system</u> ?
  - A very common problem, nobody has solved it.
- Value may occur from contribution to a grid (eg, forecast initialization)
  - Hard to quantify value, if it clearly exists
  - Forecast and modeling grids are getting finer and finer
    - This drives up the need for fine scale ground truth

Biggest issue – how to apportion costs when benefits are distributed

- Station benefits provided to, and received from, other communities

Network X as a contributor to a network of networks

In the face of a continual push toward more fine scale information demand …

How can we edge toward greater coordination of station networks?

- Joining with other networks
  - ASOS, AWOS, Snotel, Coop Modernization, RAWS, special mesonets
    - Have broached this with other agencies, such as USDA Snotel
  - A national mesonet consortium ?
  - Cost / benefit assessments have difficult time with whole-system analysis
- Leveraging of assets and activities across federal agencies
- Different missions and justification processes

Who's looking at the big picture ?

Value of a tree (station) vs. Value of a forest (network)

- Different species of trees, too. (Different agencies)

Full quantification impossible – expert judgment and intuition are essential

Logical venue to work these issues out? Grass roots, to start with. Has never been dealt with from the top.

Other thoughts

WeatherCoder III entry of NWS manual measurements

- Currently run and maintained by WRCC for NWS and RCCs nationwide
- Will become more distributed (using ACIS framework; rcc-acis.org)

Citizen networks can help some, especially to fill in gaps

- Adherence to standards expected, but cannot be forced
- Often lots of enthusiasm. Some of it lingers.
- Low cost, low tech
- Web pages exist to manage data
- CoCoRAHS now about 13,0000 observers
- Similar to National Phenology Network

Climate platforms in national wildlife refuges: “Thanks for the roost!” anon bird

Back to Multiple Scales

Spatial scales: Planetary to organism 10,000,000 m to 0.1 m

Temporal scales: minutes to centuries

Spatial scales

- Organism: where climate effects are most directly experienced
- Organisms are affected indirectly by a succession of scales
  - What portion of locally experienced climate is ascribable to other scales

Temporal scales

- Change happens
  - Slowly and steadily
  - In bursts and episodes
  - When accumulated strains exceed some threshold
    - Slow accumulation, instantaneous exceedance
  - From stochastic events: Climatic disturbances
    - Seconds to years

Spatial scales, a little more

Obtaining sufficient network density

- Long-term dense networks extremely rare, hard to maintain, hard to justify

Transects and clustering: Incremental value of new locations

Fine scale spatial structure of climatic characteristics

Large gradients in surface climate

- In complex terrain
- Near coastlines
- When it’s cold
- Alaska has all three

Implication and observations:

- Climate histories at closely spaced sites may vary greatly from one another

However, fine scale spatial correlation depends upon

- Season
- Location
- Topography
- Presence / absence of snow cover

So, you wanna run a climate network?
A Checklist
Guidelines prepared for CIRMOUNT Mountain Climate Network, and for NPS

Climate versus Weather

Climate measurements require ***consistency through time.***

Network Purpose

Anticipated or desired lifetime.
Breadth of network mission (commitment by needed constituency).
Dedicated constituency—no network survives without a dedicated constituency.

Site Identification and Selection

Spanning gradients in climate or biomes with transects.
Issues regarding representative spatial scale—site uniformity versus site clustering.
Alignment with and contribution to network mission.
Exposure—ability to measure representative quantities.
Logistics—ability to service station (Always or only in favorable weather?).
Site redundancy (positive for quality control, negative for extra resources).
Power—is AC needed?
Site security—is protection from vandalism needed?
Permitting often a major impediment and usually underestimated.

Running a network - 2

Station Hardware

Survival—weather is the main cause of lost weather/climate data.
Robustness of sensors—ability to measure and record in any condition.
Quality—distrusted records are worthless and a waste of time and money.
- High quality—will cost up front but pays off later.
- Low quality—may provide a lower start-up cost but will cost more later (low cost can be expensive).

Redundancy—backup if sensors malfunction.
Ice and snow—measurements are much more difficult than rain measurements.
Severe environments (expense is about two–three times greater than for stations in more benign settings).

Communications

Reliability—live data have a much larger constituency.
One-way or two-way.
- Retrieval of missed transmissions.
- Ability to reprogram data logger remotely.
- Remote troubleshooting abilities.
- Continuing versus one-time costs.

Back-up procedures to prevent data loss during communication outages.
Live communications increase problems but also increase value.

Running a network - 3

Maintenance

Main reason why networks fail (and most networks do eventually fail!).
Key issue with nearly every network.
Who will perform maintenance?
Degree of commitment and motivation to contribute.
Periodic? On-demand as needed? Preventive?
Equipment change-out schedules and upgrades for sensors and software.
Automated stations require skilled and experienced labor.
Calibration—sensors often drift (climate).
Site maintenance essential (constant vegetation, surface conditions, nearby influences).
Typical automated station will cost about $2K per year to maintain.
Documentation—photos, notes, visits, changes, essential for posterity.
Planning for equipment life cycle and technological advances.

Maintaining Programmatic Continuity and Corporate Knowledge

Long-term vision and commitment needed.
Institutionalizing versus personalizing—developing appropriate dependencies.

Running a network - 4

Data Flow

Centralized ingest?
Centralized access to data and data products?
Local version available?
Contract out work or do it yourself?
Quality control of data.
Archival.
Metadata—historic information, not a snapshot. Every station should collect metadata.
Post-collection processing, multiple data-ingestion paths.

Products

Most basic product consists of the data values.
Summaries.
Write own applications or leverage existing mechanisms?

Funding

Prototype approaches as proof of concept.
Linking and leveraging essential.
Constituencies—every network <u>needs</u> a constituency.
Bridging to practical and operational communities? Live data needed.
Bridging to counterpart research efforts and initiatives—funding source.
Creativity, resourcefulness, and persistence usually are essential to success.

Final Comments

Deployment is by far the easiest part in operating a network.
Maintenance is the main issue.
Best analogy: Operating a network is like raising a child; it requires constant attention, and the kid never leaves home.

Source: Western Regional Climate Center (WRCC)

Thank You