Desert Research Institute

Exploring Hydroclimate Time Series

Some Issues of Perception

Kelly T. Redmond

Western Regional Climate Center

Desert Research Institute

Reno Nevada

Improving Drought Prediction at Seasonal to Inter-Annual Timescales

Western States Water Council & California Department of Water Resources

Western Governors Association

San Diego, CA 2013 April 29 - May 1

Western Regional Climate Center

Southwest Climate Science Center

CNAP

But first ...

May 3rd 2013

at

DRI
Desert Research Institute

Great Basin Climate Forum

9am-4pm

A discussion of current climate conditions in the Great Basin

The California Nevada Applications Program (CNAP), Great Basin Landscape Conservation Cooperative (GBLCC), and the Western Regional Climate Center (WRCC) will be hosting the 4th Great Basin Climate Forum. This year's forum topics will revolve around on-going drought conditions in the Great Basin with in-depth presentations. This year, there will be no webinar, but all presentations will be recorded.

Agenda

9:00am	Introduction, Tamara Wall, California Nevada Applications Program/DRI. ***Review of climate services, past Great Basin Climate Forums, and were the series is headed***
9:15am	Kelly Redmond, Regional Climatologist, Western Regional Climate Center ***Climate and Hydrology: Winter Review, Current Conditions, Upcoming Prospects***
10:10am	Break
10:40am	Mike Jenkins, Associate Professor, Quinney College of Natural Resources, Utah State ***Managing Forest Disturbance in a Changing Global Ecosphere: metaphysical, socio-political and ecological opportunities and constraints***
11:30am	Alan B. Shepherd, Nevada Wild Horse and Burro Lead, BLM Nevada State Office ***Wild Horse and Burro Management and Drought - What are the Potential Impacts***
12:00-1:00pm	Lunch
1:00pm	Bill Elliott, Nevada Division of Emergency Management Lead Planner ***Nevada's State Drought Plan and Response***
1:15pm	Nina Oakley, Assistant Climatologist, Western Regional Climate Center ***WRCC Drought Dashboard Introduction, Testing and Response***
2:40pm	Break
3:00pm	Report out on table group discussions by moderators and suggestions/discussion on drought information needs and agency responses
3:45pm	Wrap- up
4:00pm	Adjourn

There is no cost to attend, but please register at:

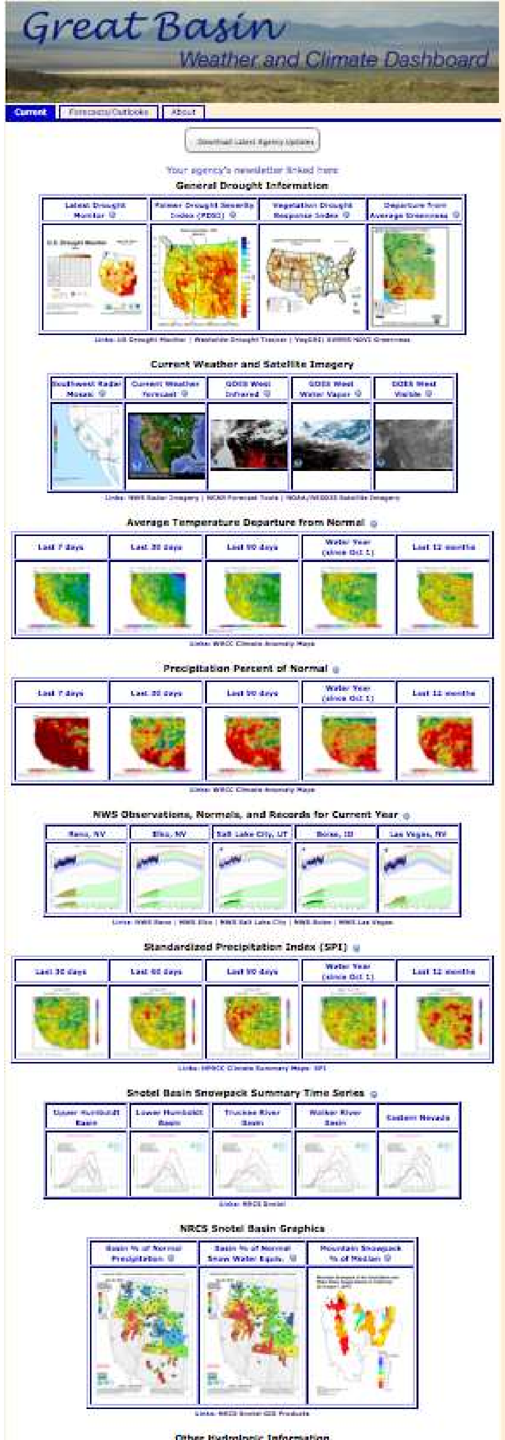
http://GBCF2013.doattend.com

For more information please contact:
Tamara Wall
tamara.wall@dri.edu
775-674-7059

California Nevada Applications Program CNAP

Western Regional Climate Center

Great Basin Landscape Conservation Cooperative

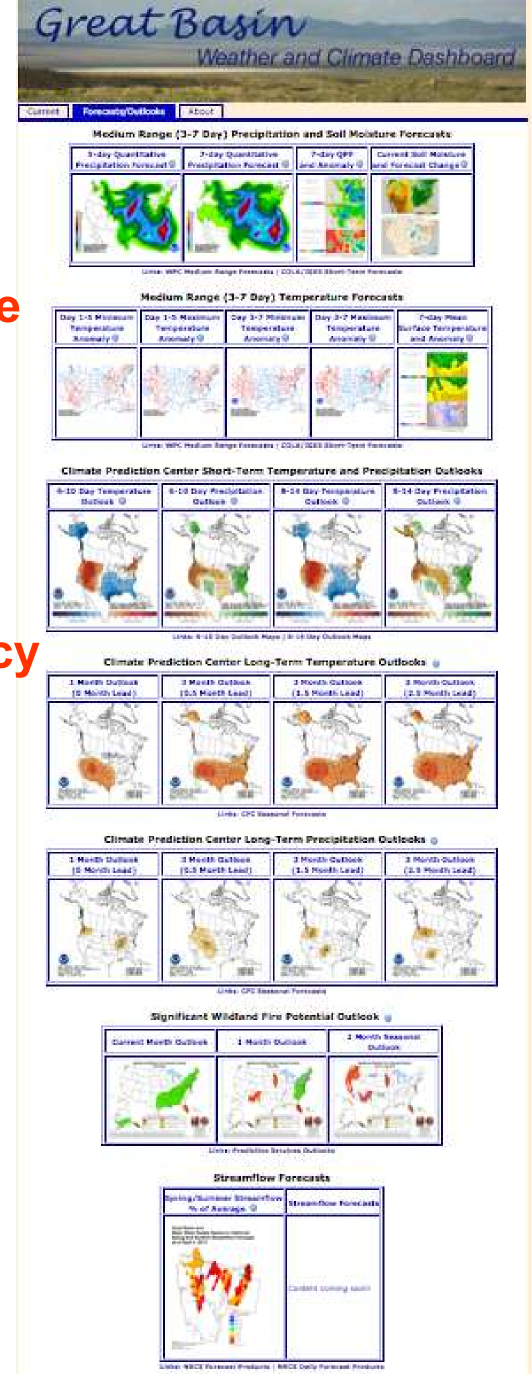


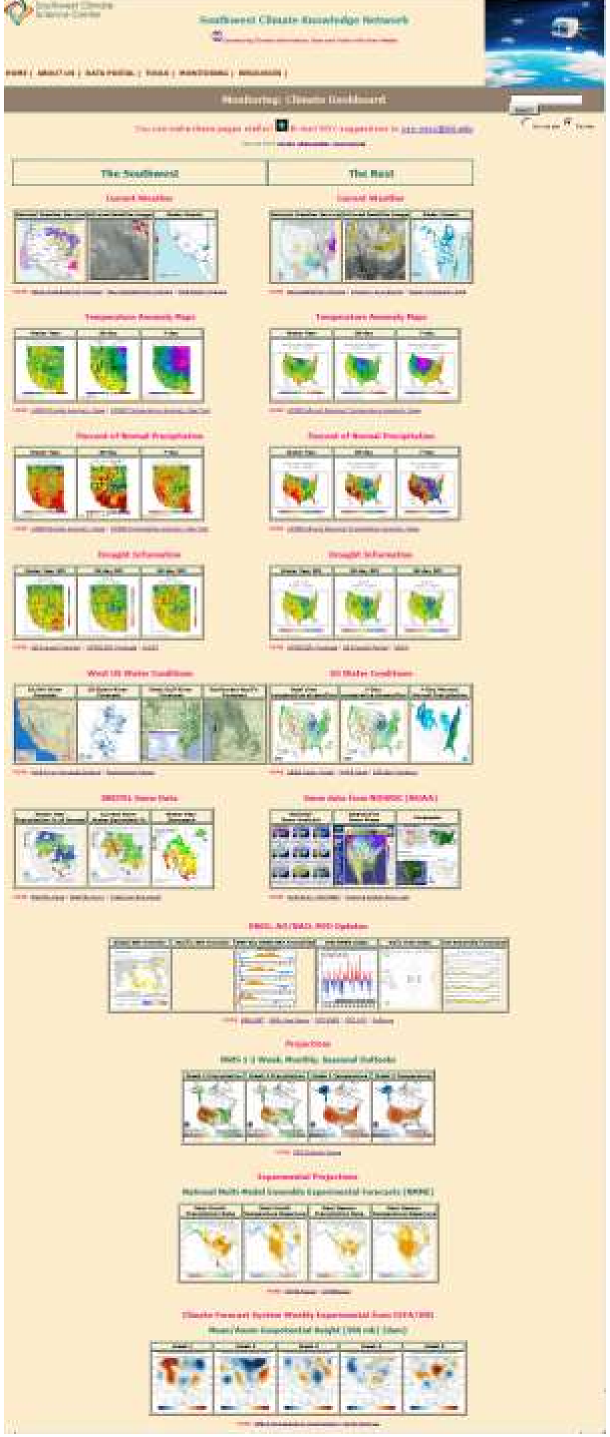
Great Basin Weather and Climate Dashboard

In support of

USDA Farm Services Agency and other Drought Activities

gbdash.dri.edu





Also

Department of Interior

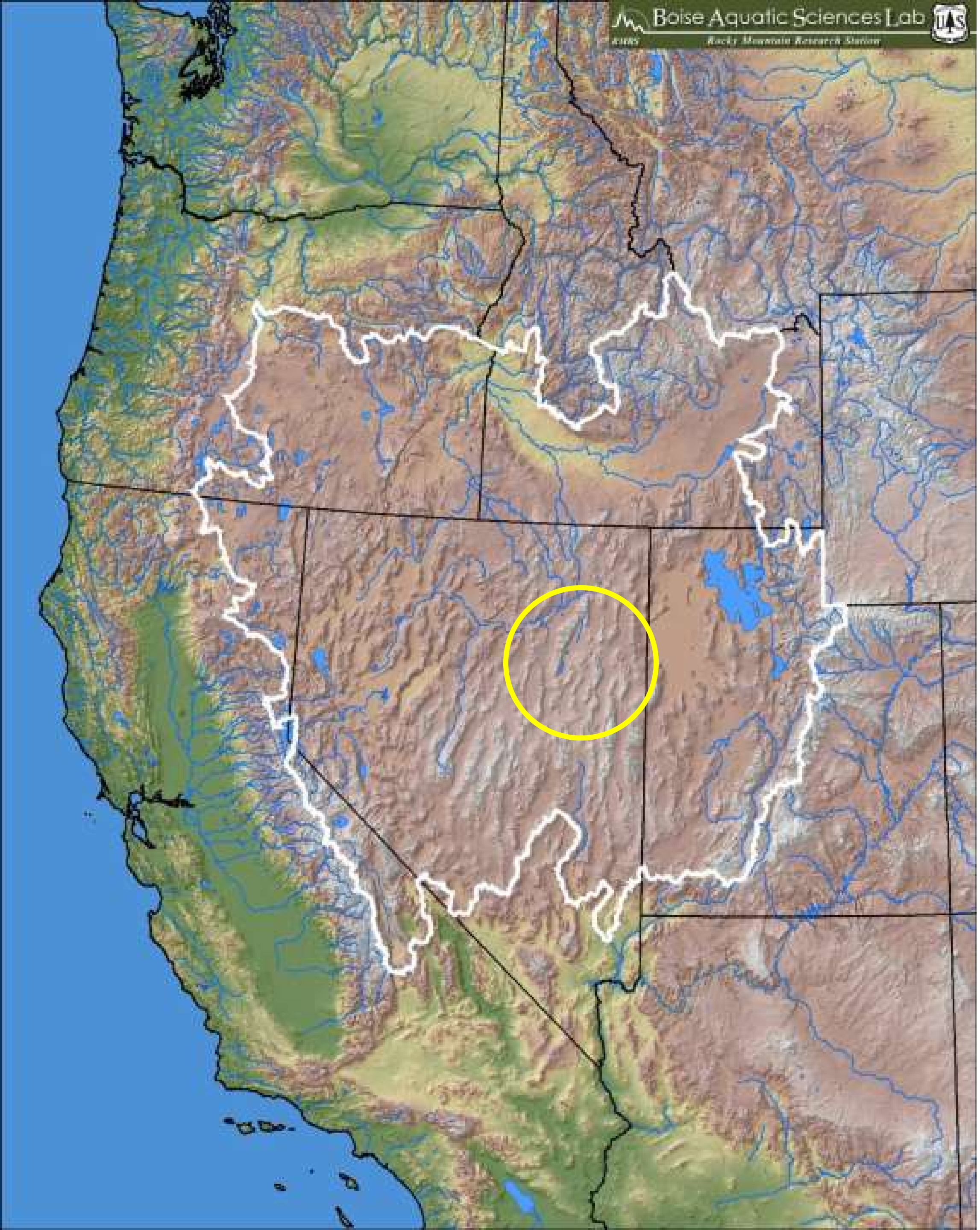
Southwest Climate Science Center

Climate Monitoring Dashboard

A quick glance of recent, current, future conditions, with access to more detail.

For

Southwest (left) Rest of USA (right)



Central Great Basin

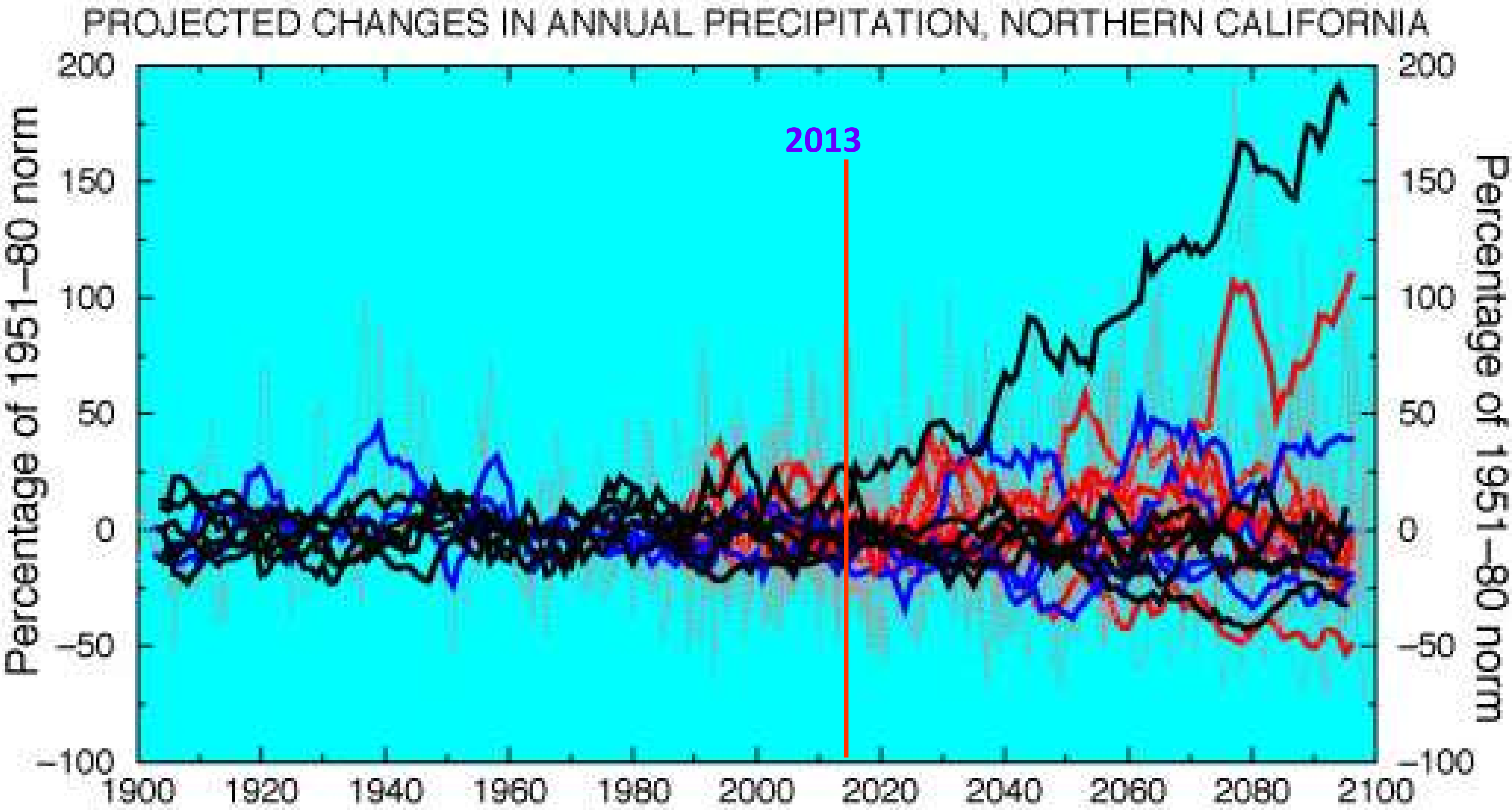
2000 - 2100

Temp and Precip

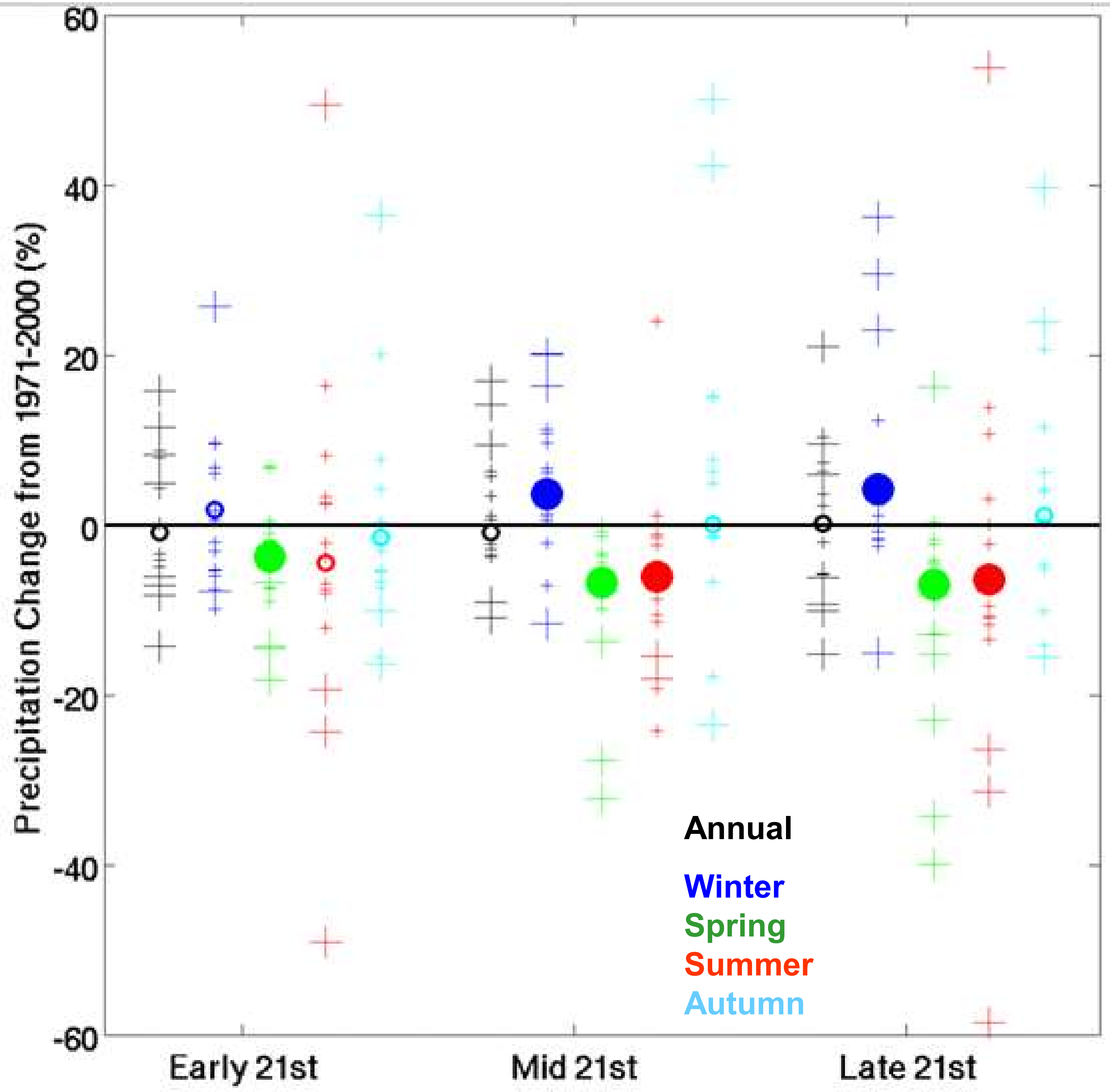
Projections

Another style of presentation

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



East Central Nevada

Projected

Precipitation

Changes (%)

Early 21st

2011-2040

Middle 21st

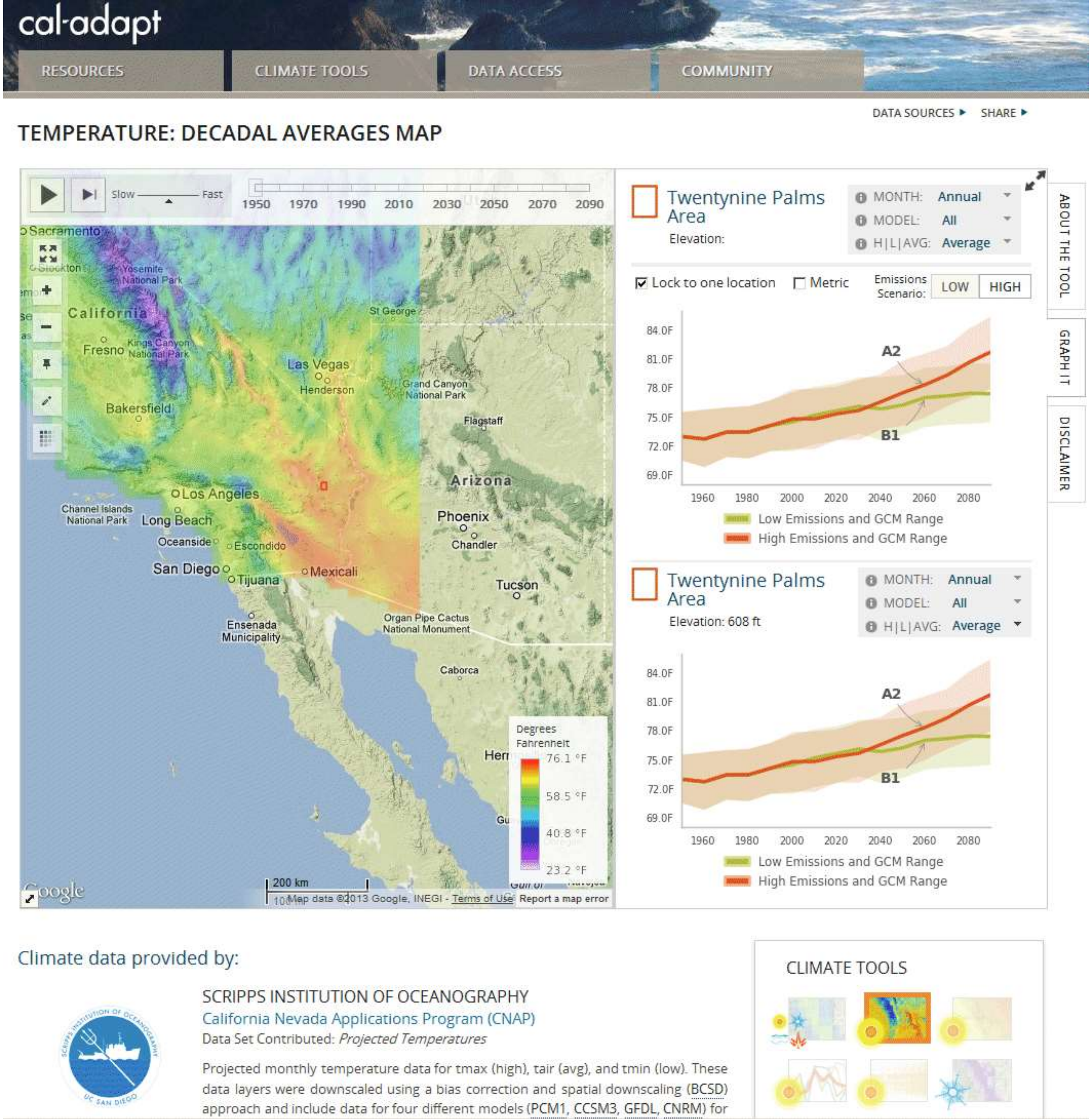
2041-2070

Late 21st

2071-2100

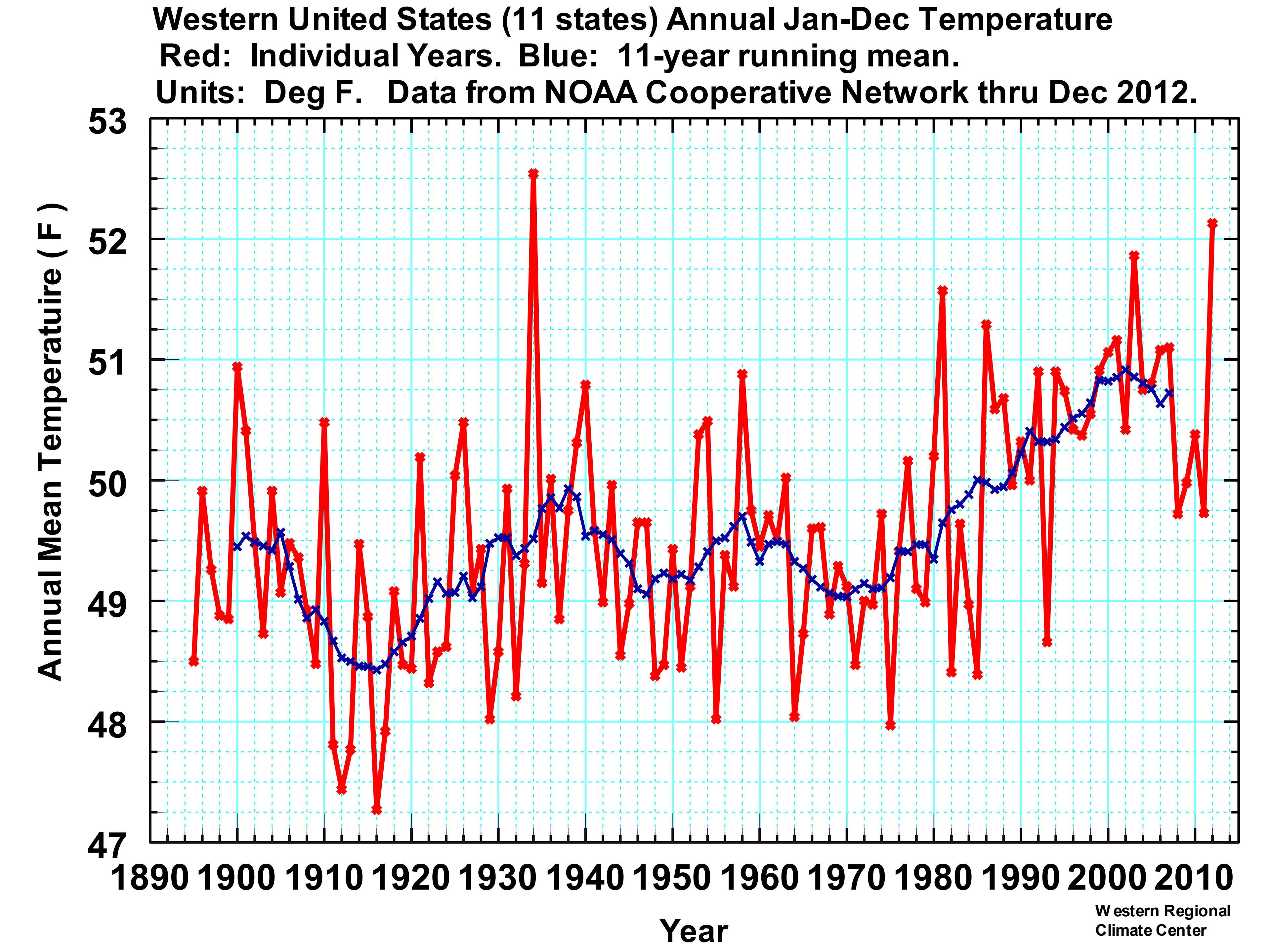
Figure:

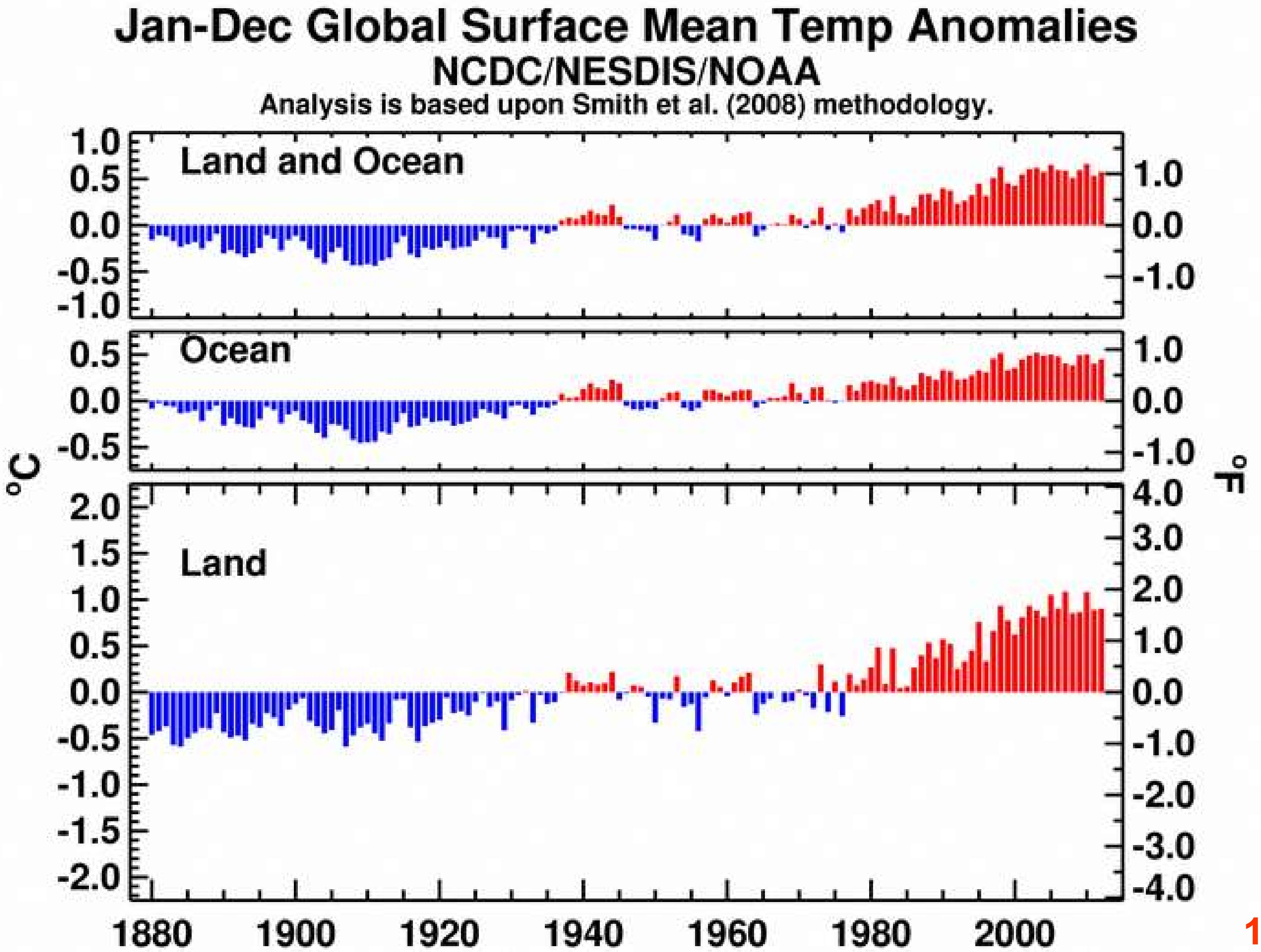
John Abatzoglou



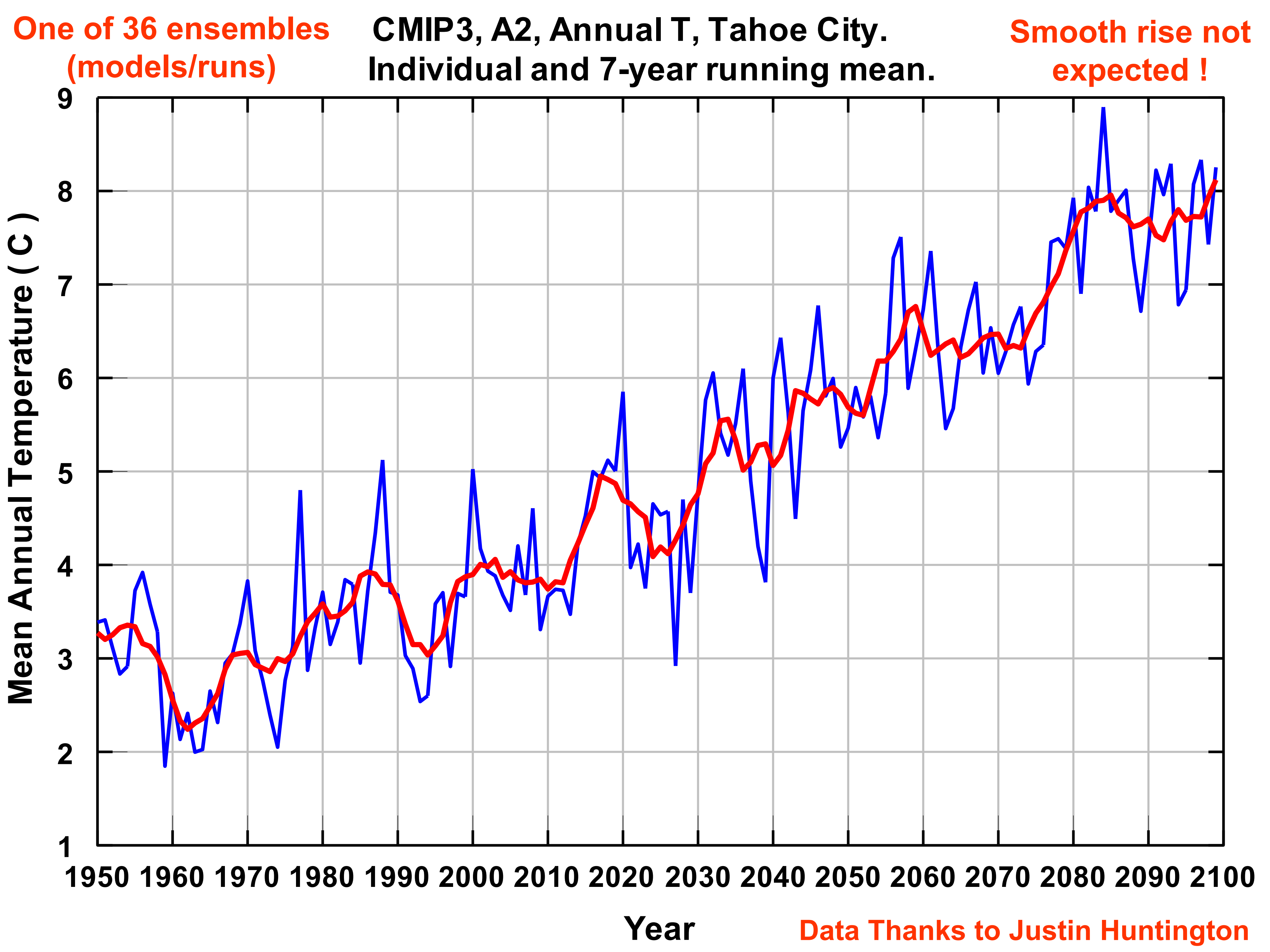
Future climate projections are usually shown as smooth.

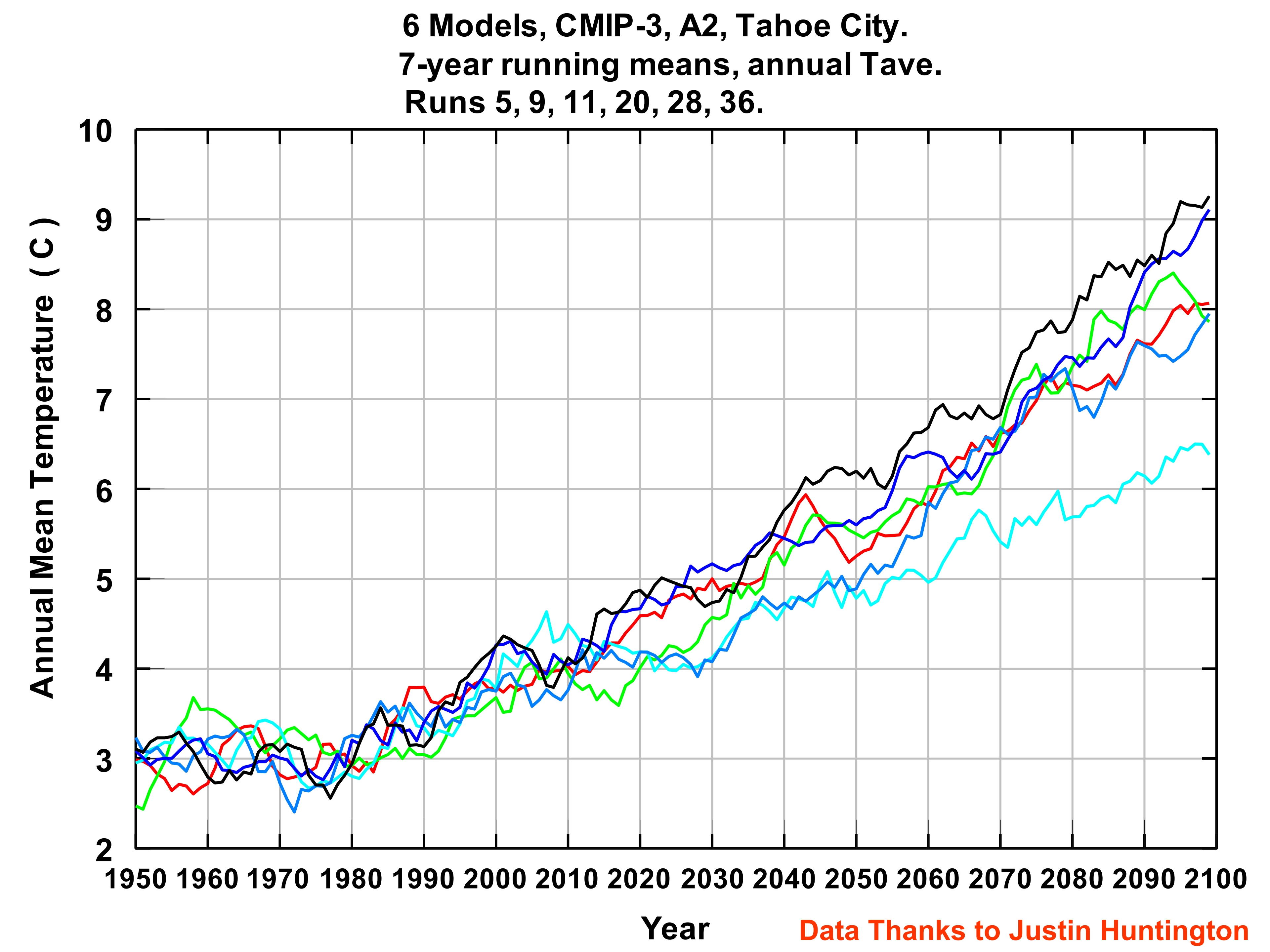

COPYRIGHT © 1997 by RAY STERNER


Western United States (11 states) Annual Jan-Dec Temperature
Red: Individual Years. Blue: 11-year running mean.
Units: Deg F. Data from NOAA Cooperative Network thru Dec 2012.
Annual Mean Temperatuire (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



Annual
1880 - 2012
from
NOAA
NCDC


One of 36 ensembles
(models/runs)
CMIP3, A2, Annual T, Tahoe City.
Individual and 7-year running mean.
Smooth rise not
expected !
Mean Annual Temperature (C)
9
8
7
6
5
4
3
2
1
1950
1960
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090
2100
Year
Data Thanks to Justin Huntington

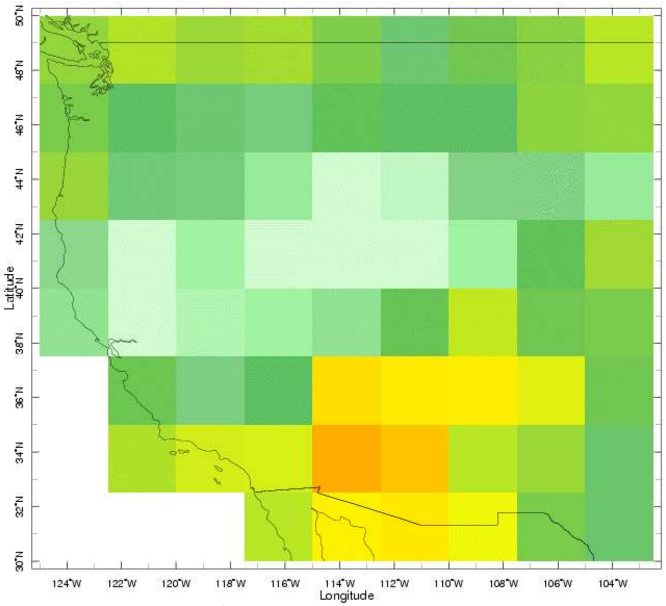


6 Models, CMIP-3, A2, Tahoe City.
7-year running means, annual Tave.
Runs 5, 9, 11, 20, 28, 36.
Annual Mean Temperature (C)
10
9
8
7
6
5
4
3
2
1950
1960
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090
2100
Year
Data Thanks to Justin Huntington

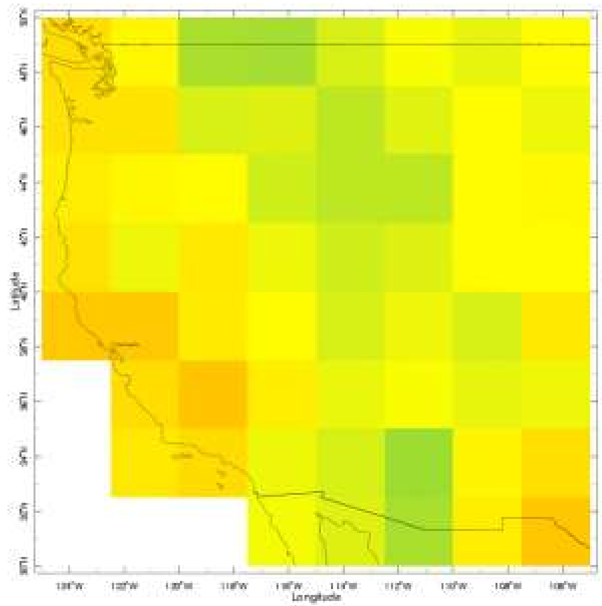
Climate Fluctuates on Different Time Scales for Different Reasons

IRI Time Scales Map Room Exploratory Tool

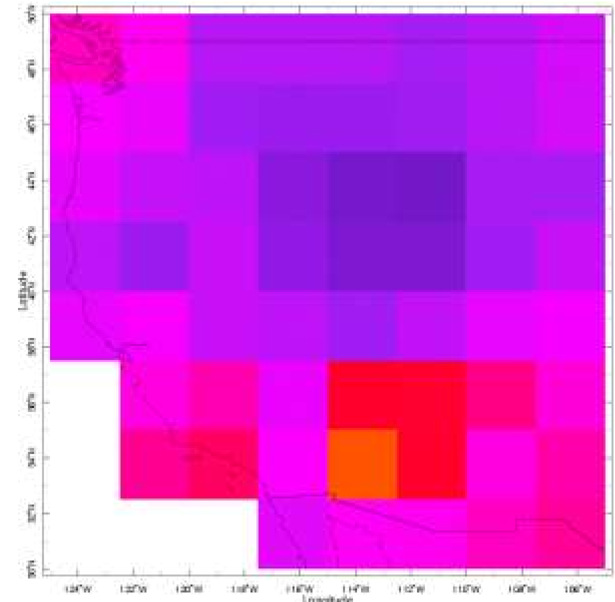
Slowly Changing Trend

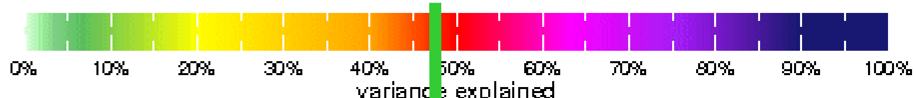


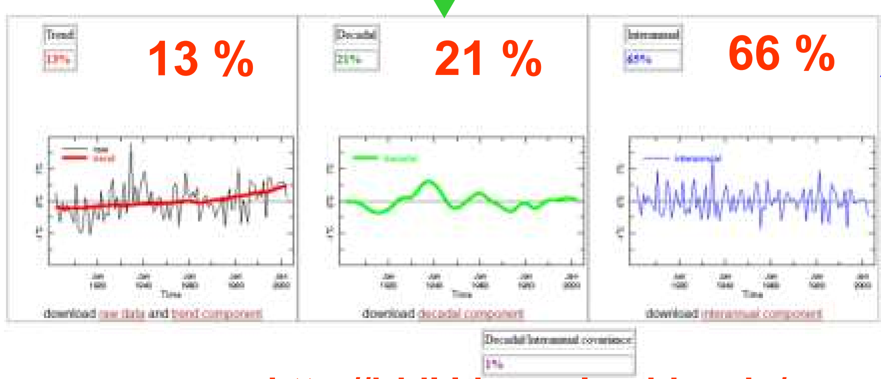
Decadal Scale Variability



Year-to-Year Variability







Graphs are averages of domain above

Annual Mean Temperature

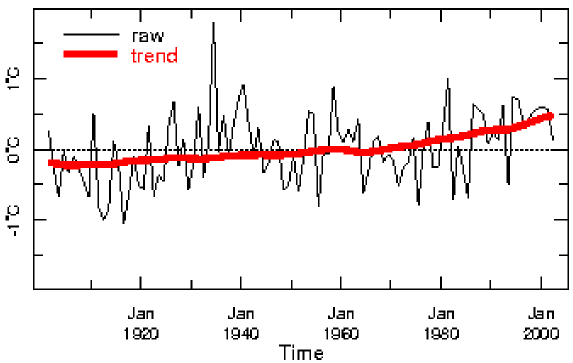
http://iridl.ldeo.columbia.edu/maproom/.Global/.Time_Scales/

Trend

13%

13 %

1900 2000



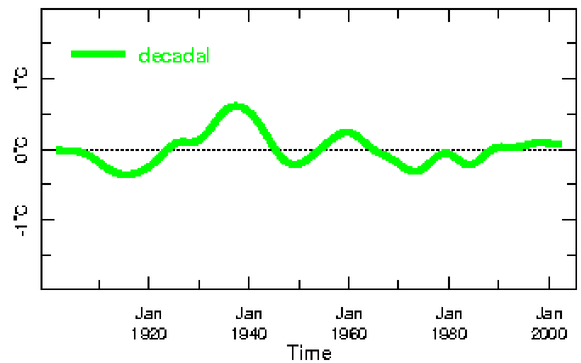
download raw data and trend component

Decadal

21%

21 %

1900 2000



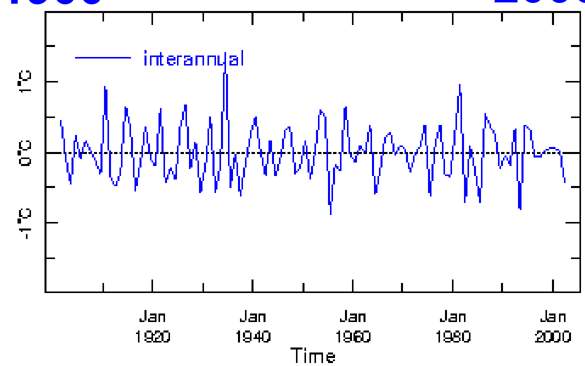
download decadal component

Interannual

65%

65 %

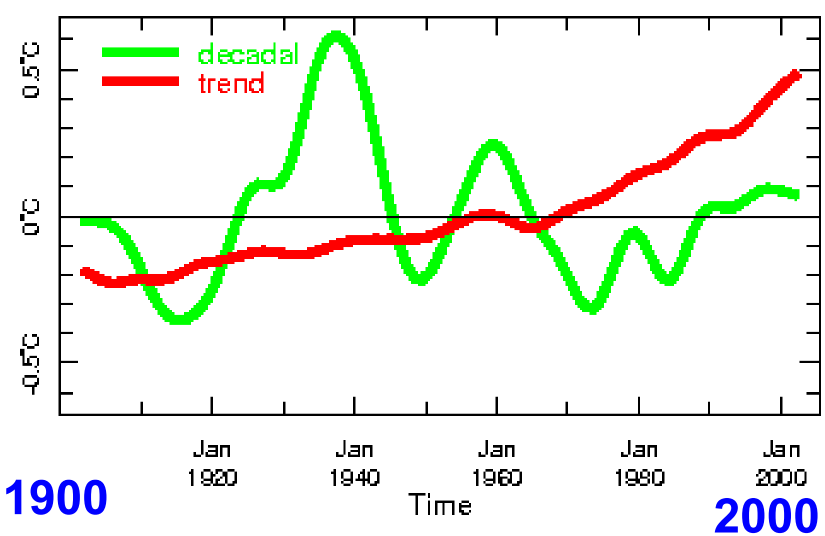
1900 2000



download interannual component

Decadal/Interannual covariance
1%

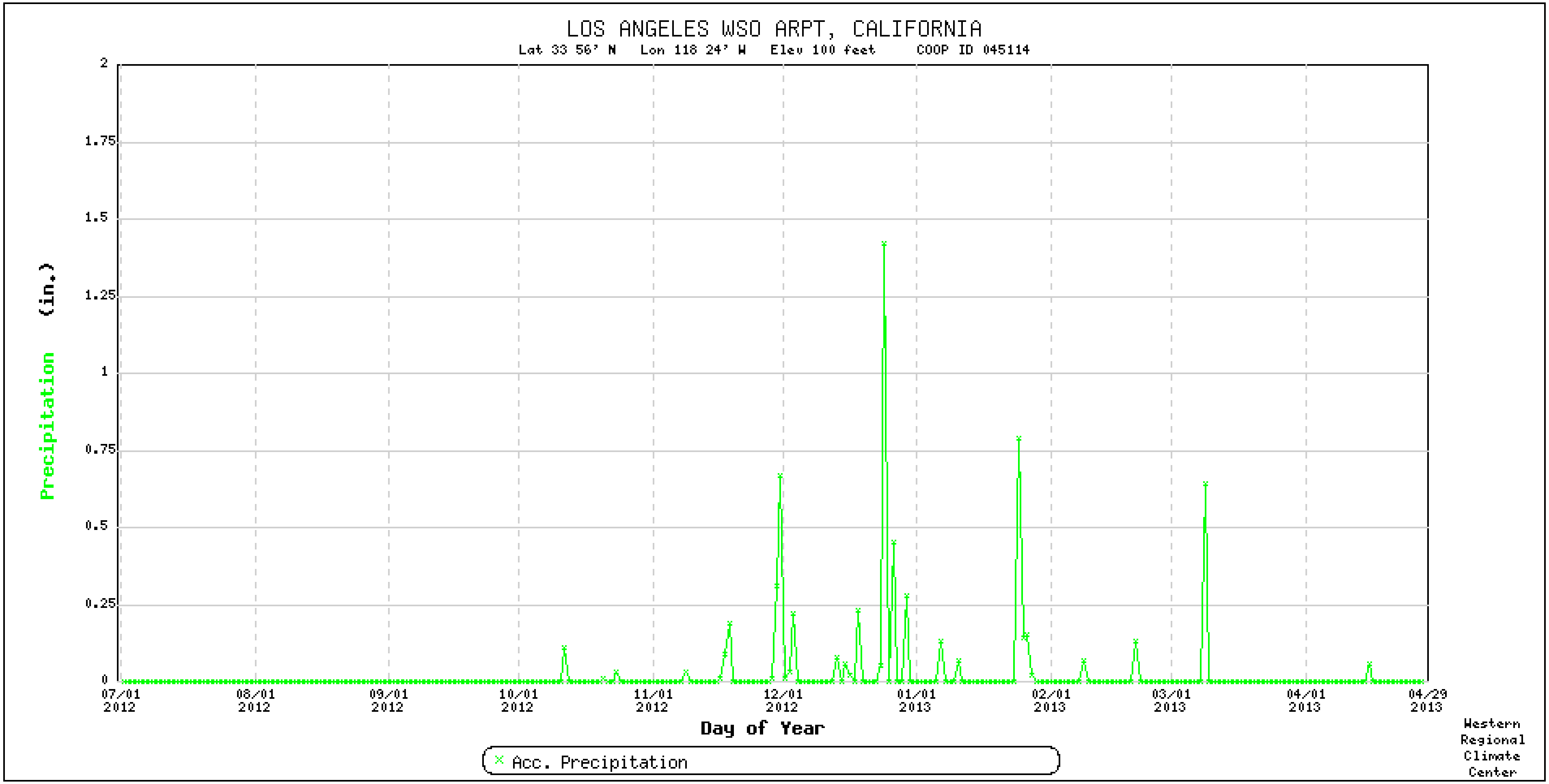
Zoom on Trend and Decadal scales



Climate variability remains a very big deal!

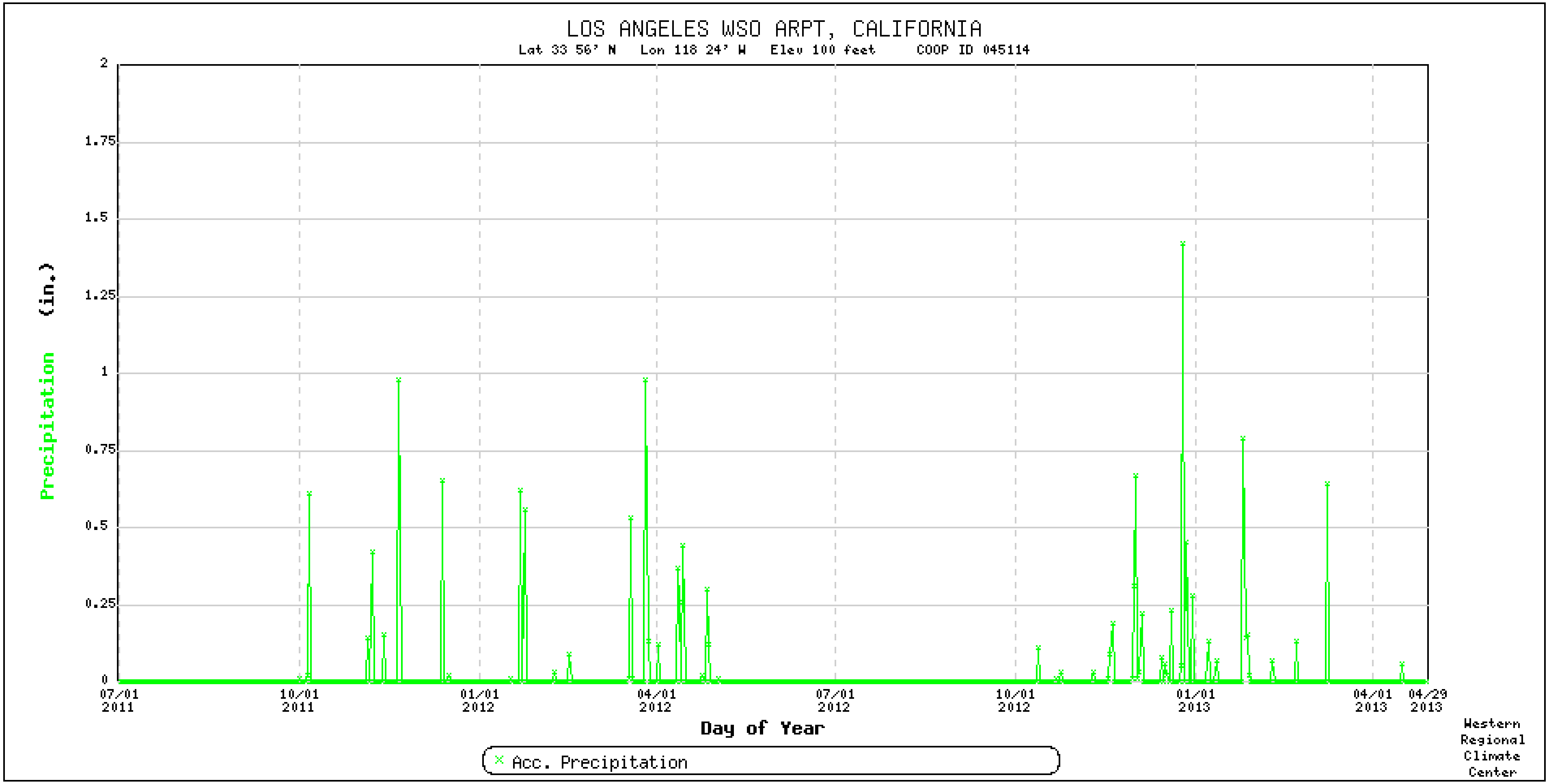
A.M. Green, L. Goddard, R. Cousin. Web Tool Deconstructs Variability in Twentieth-Century Climate. Nov 2011. EOS, AGU, 92(45), 397-398.

LAX Daily Precipitation
Past 1 Winter since July 1, 2012



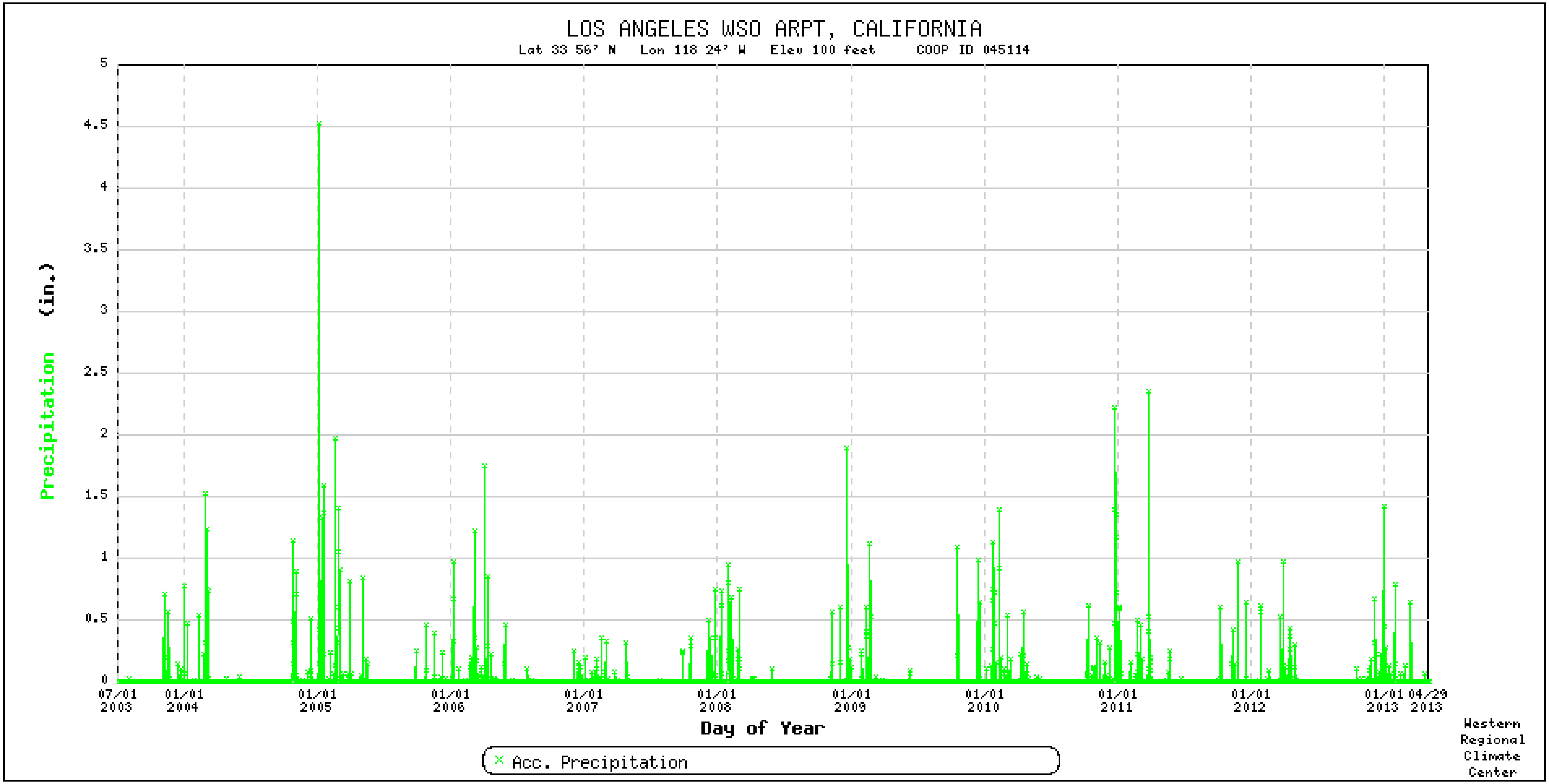
2012 Jul 1 **2013 Apr 28**

LAX Daily Precipitation
Past 2 Winters since July 1, 2012



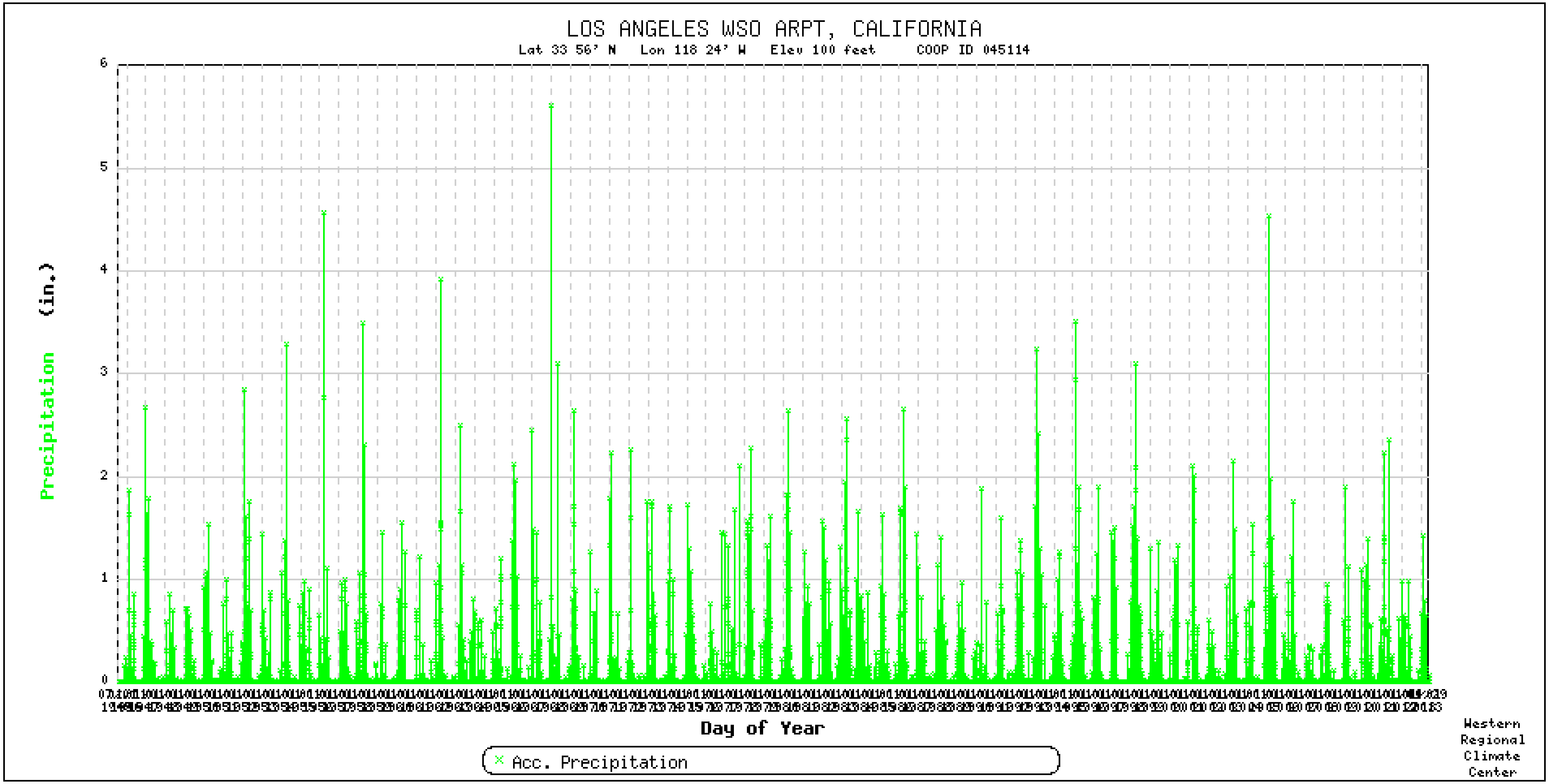
2011 Jul 1 **2013 Apr 28**

LAX Daily Precipitation
Past 10 Winters since July 1, 2003

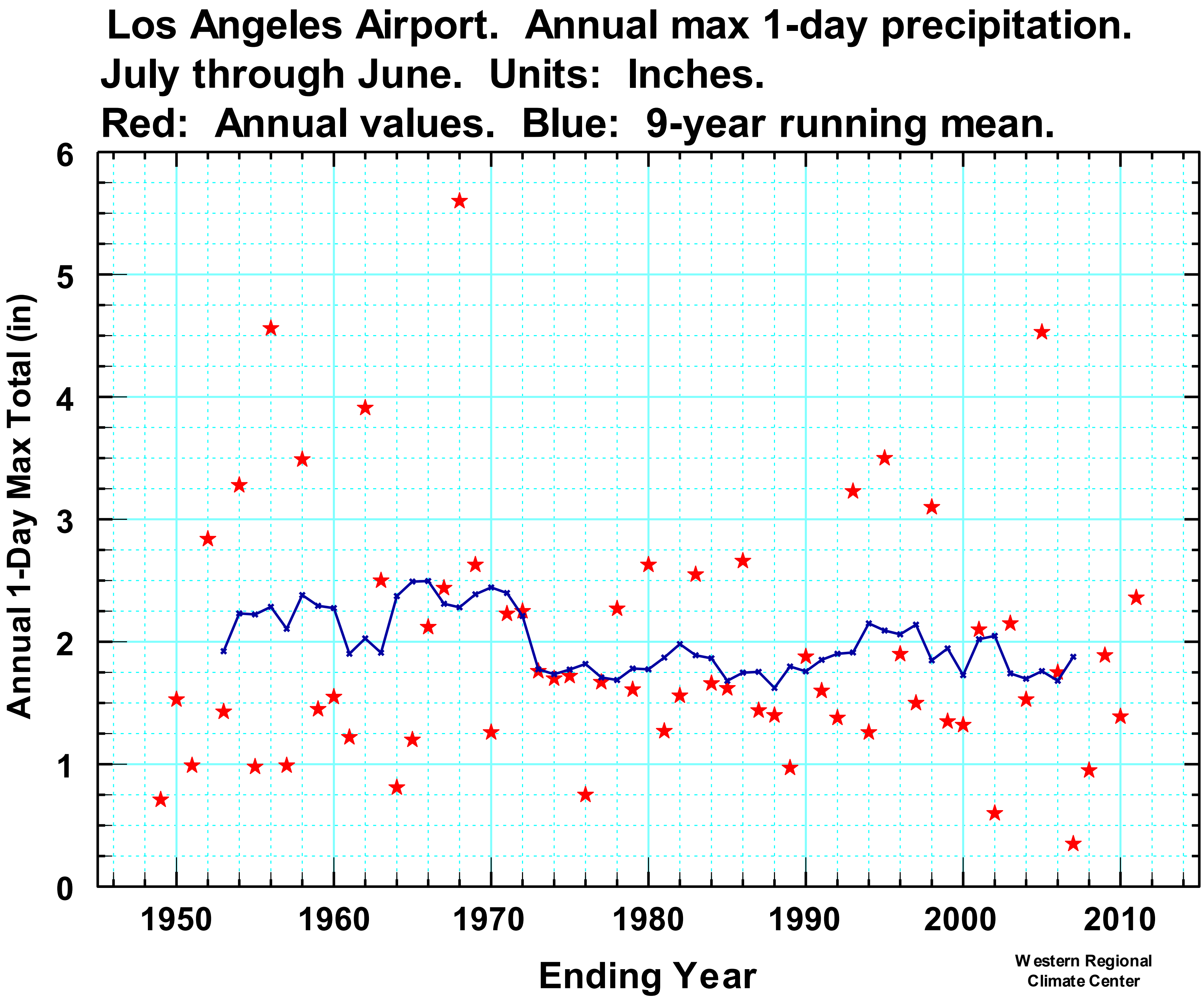


2003 Jul 1 **2013 Apr 28**

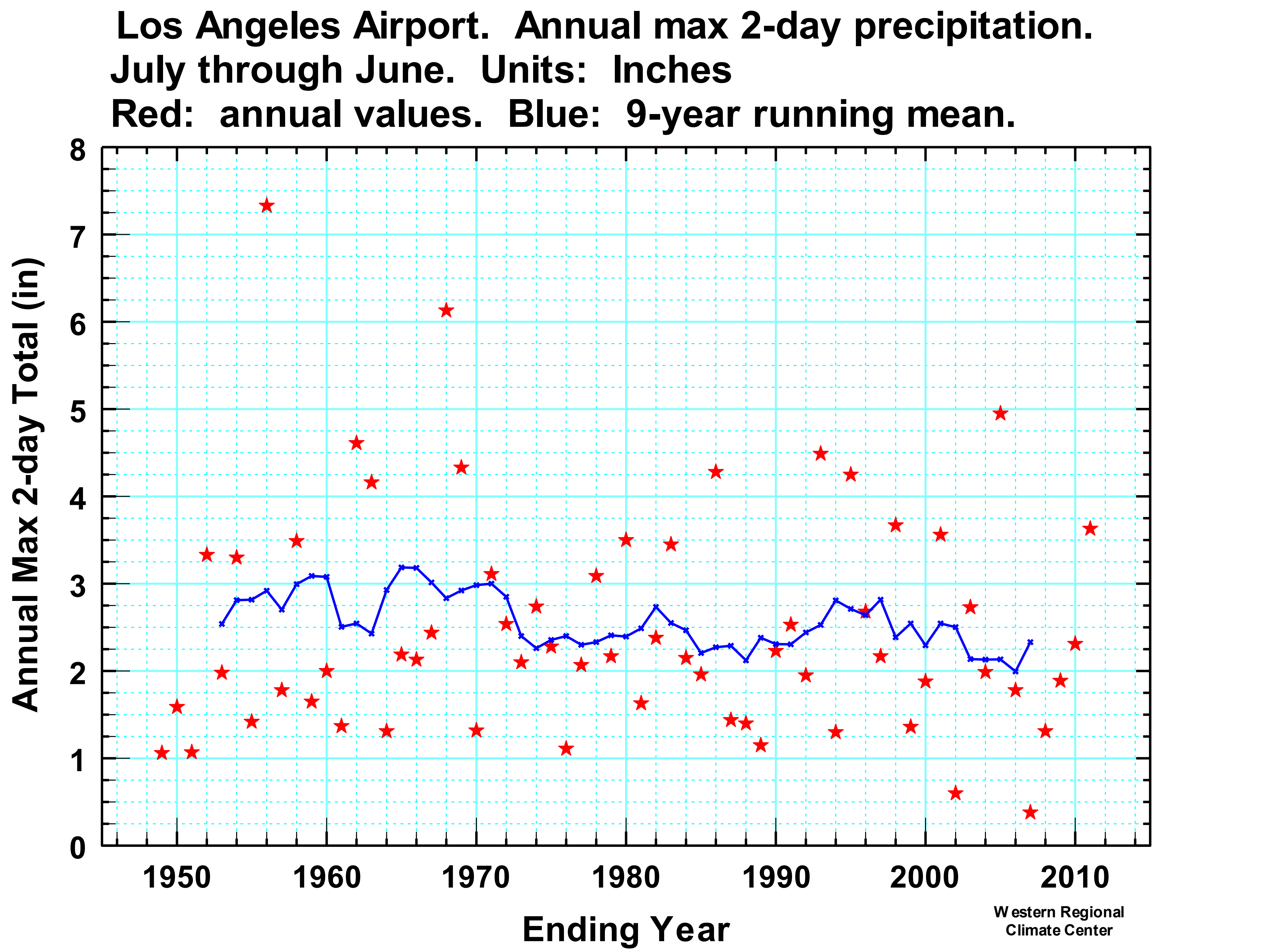
LAX Daily Precipitation
Past 68 Winters since July 1, 1945
Approx 35 x 68 = 2400 days out of ~ 25,000 days total



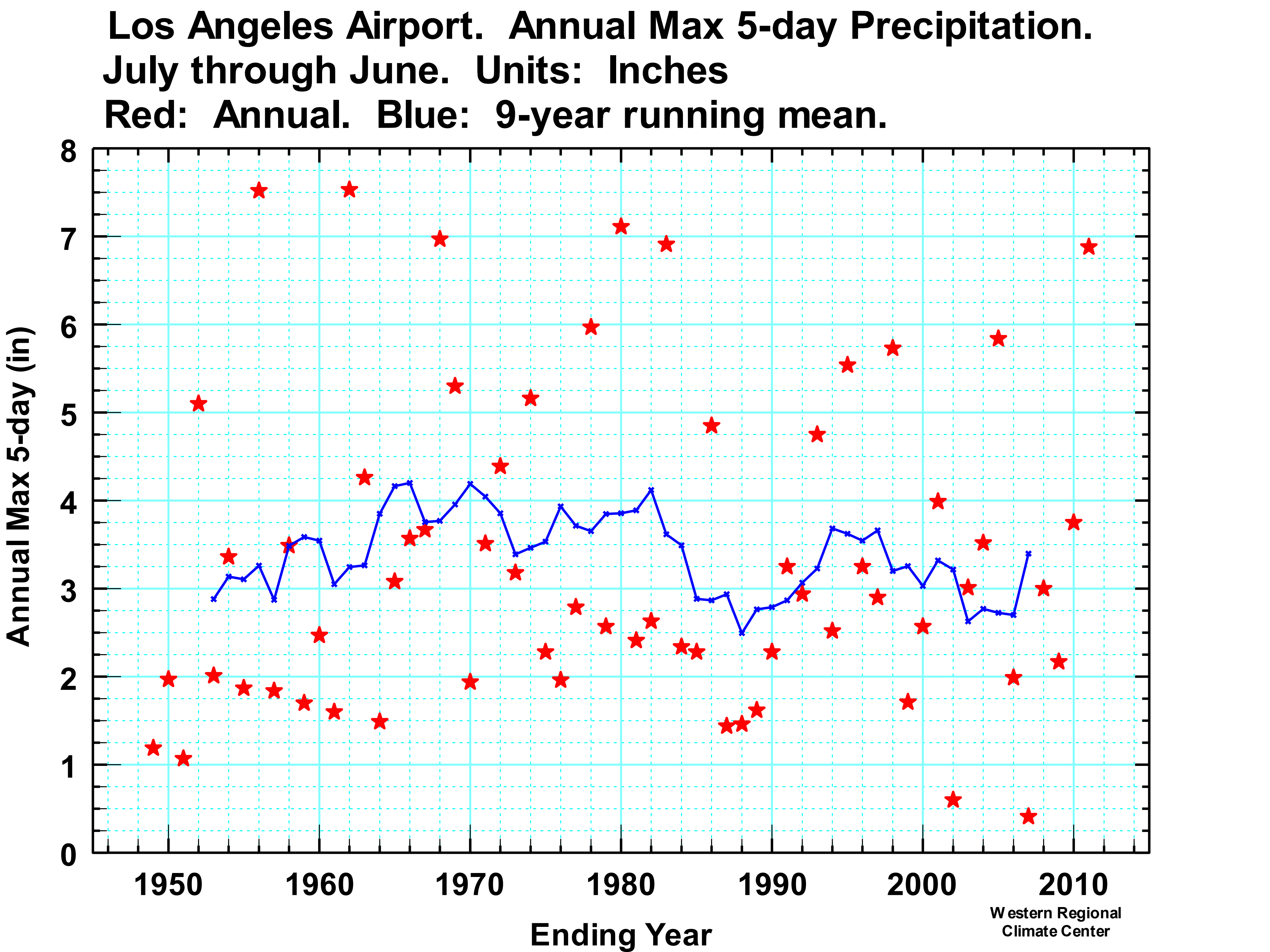
1945 Jul 1 **2013 Apr 28**



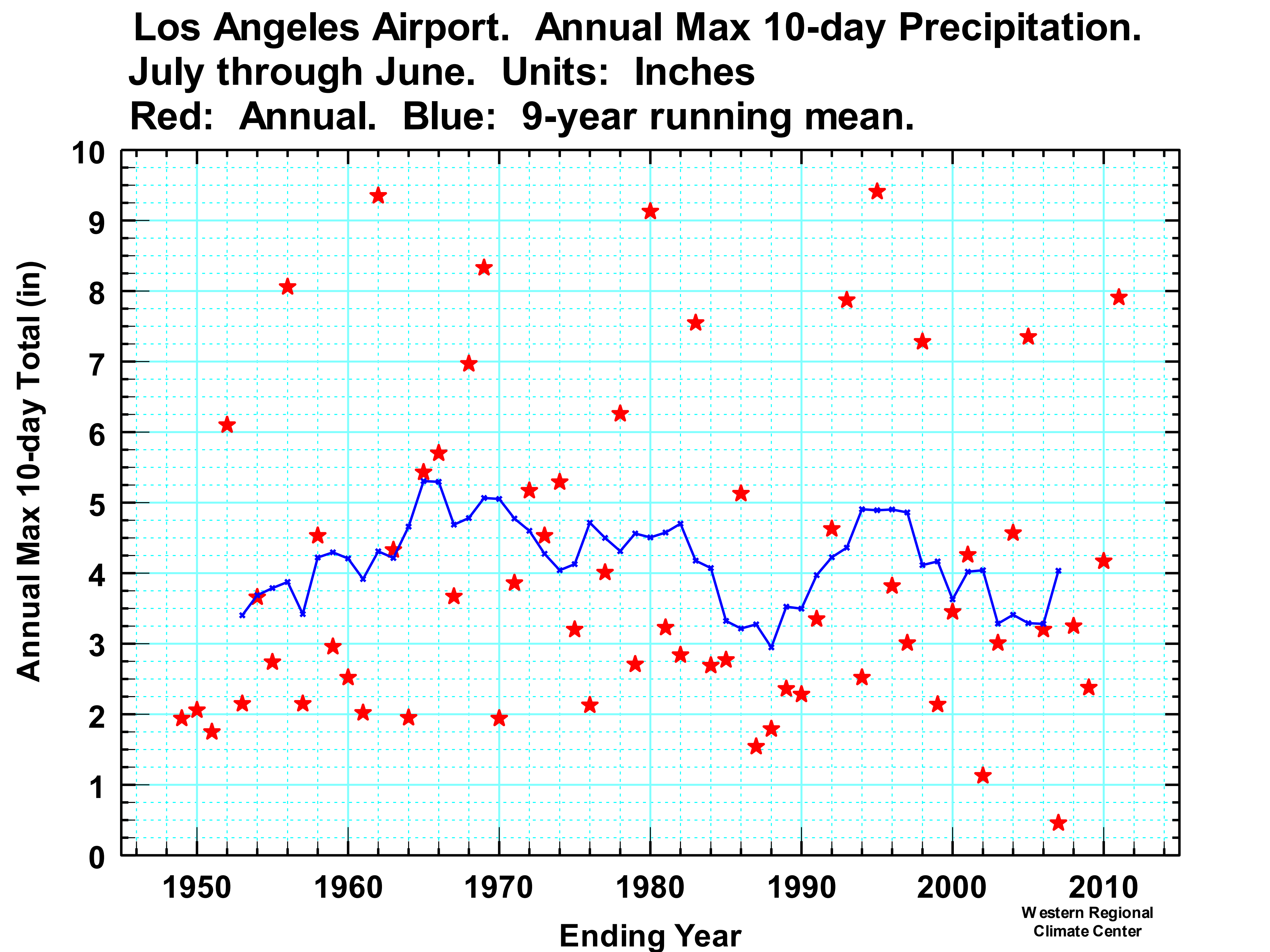
Los Angeles Airport. Annual max 1-day precipitation.
July through June. Units: Inches.
Red: Annual values. Blue: 9-year running mean.
Annual 1-Day Max Total (in)
0
1
2
3
4
5
6
1950
1960
1970
1980
1990
2000
2010
Ending Year
Western Regional
Climate Center

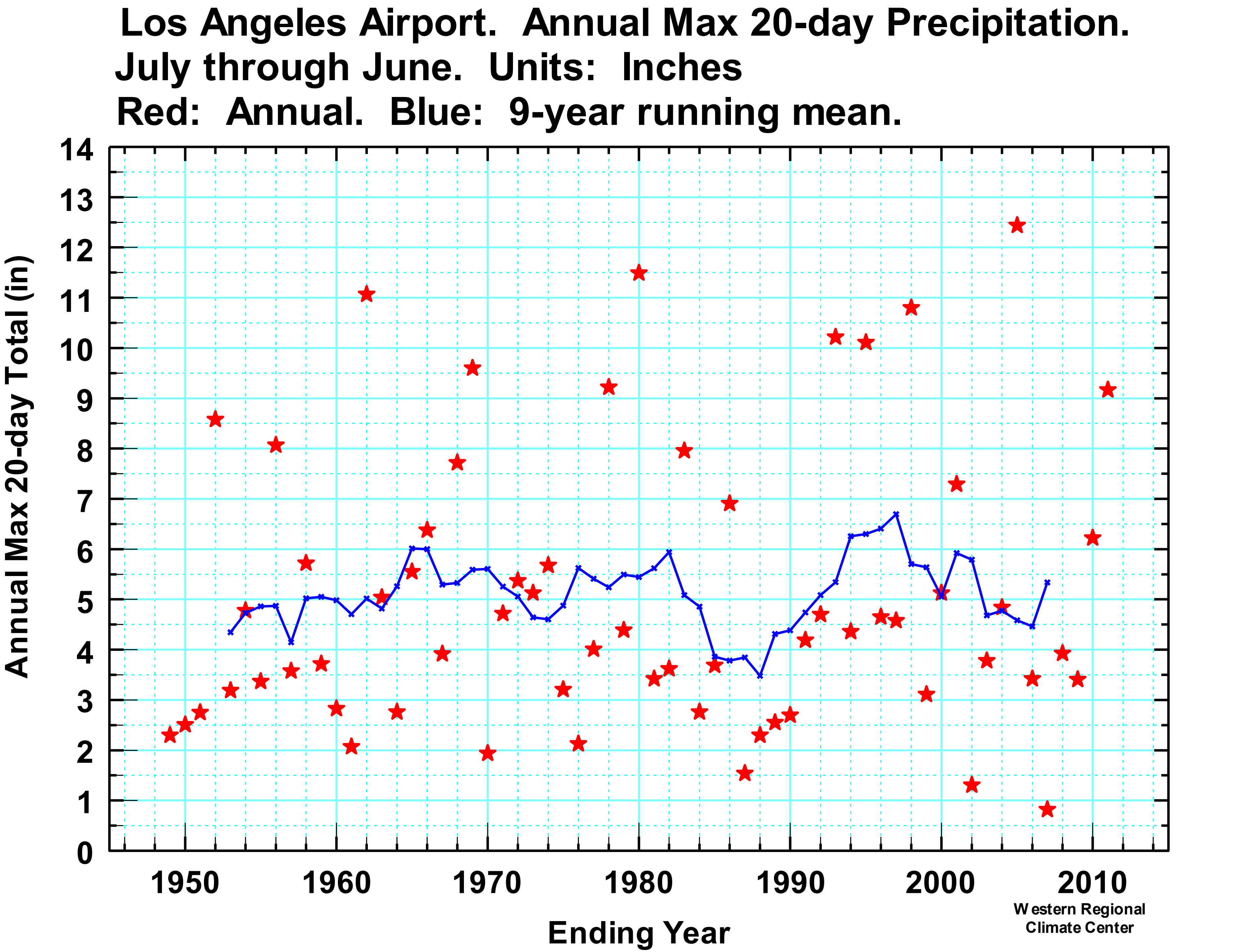


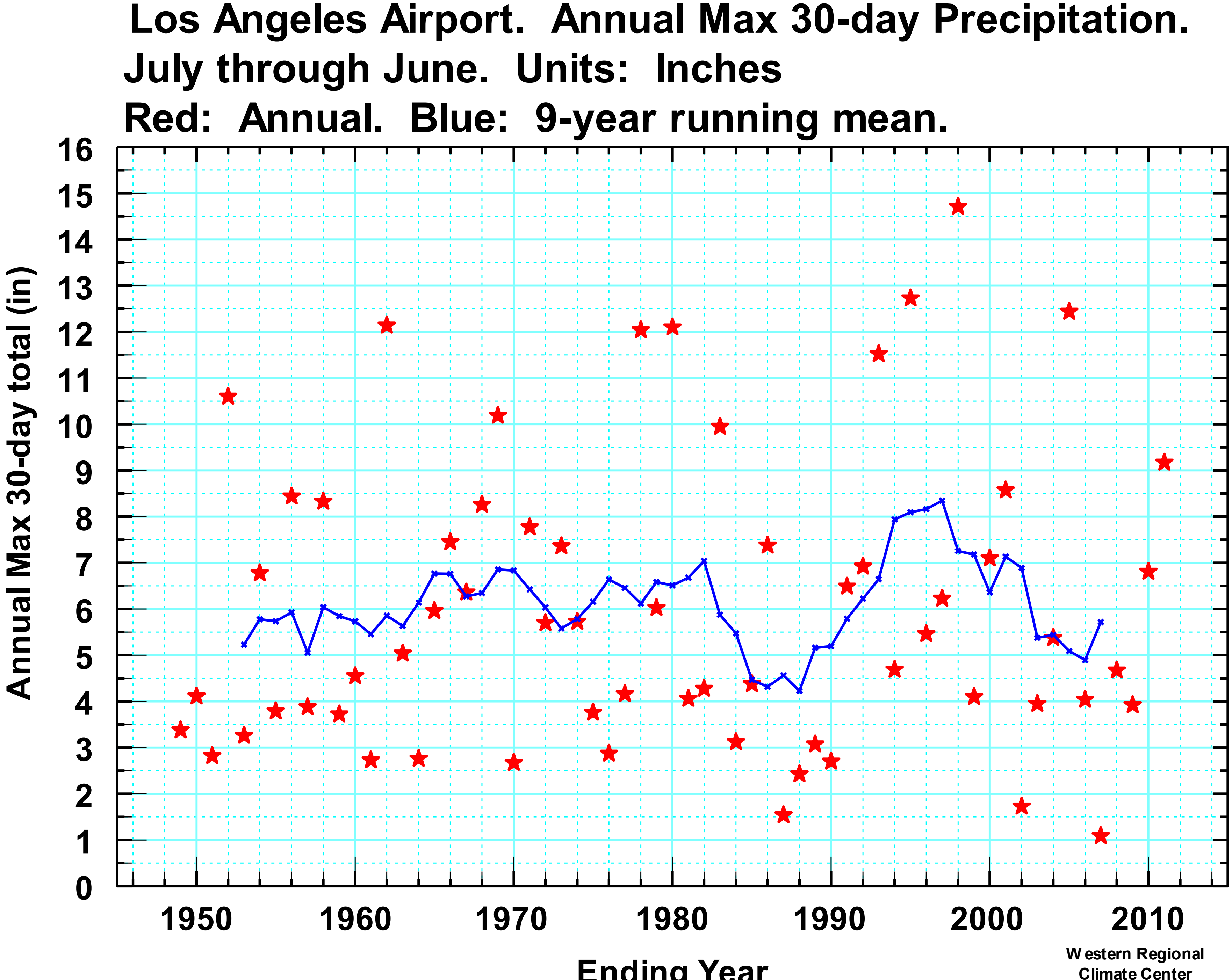
Los Angeles Airport. Annual max 2-day precipitation.
July through June. Units: Inches
Red: annual values. Blue: 9-year running mean.
Annual Max 2-day Total (in)
0
1
2
3
4
5
6
7
8
1950
1960
1970
1980
1990
2000
2010
Ending Year
Western Regional
Climate Center



Los Angeles Airport. Annual Max 5-day Precipitation.
July through June. Units: Inches
Red: Annual. Blue: 9-year running mean.
Annual Max 5-day (in)
0
1
2
3
4
5
6
7
8
1950
1960
1970
1980
1990
2000
2010
Ending Year
Western Regional
Climate Center

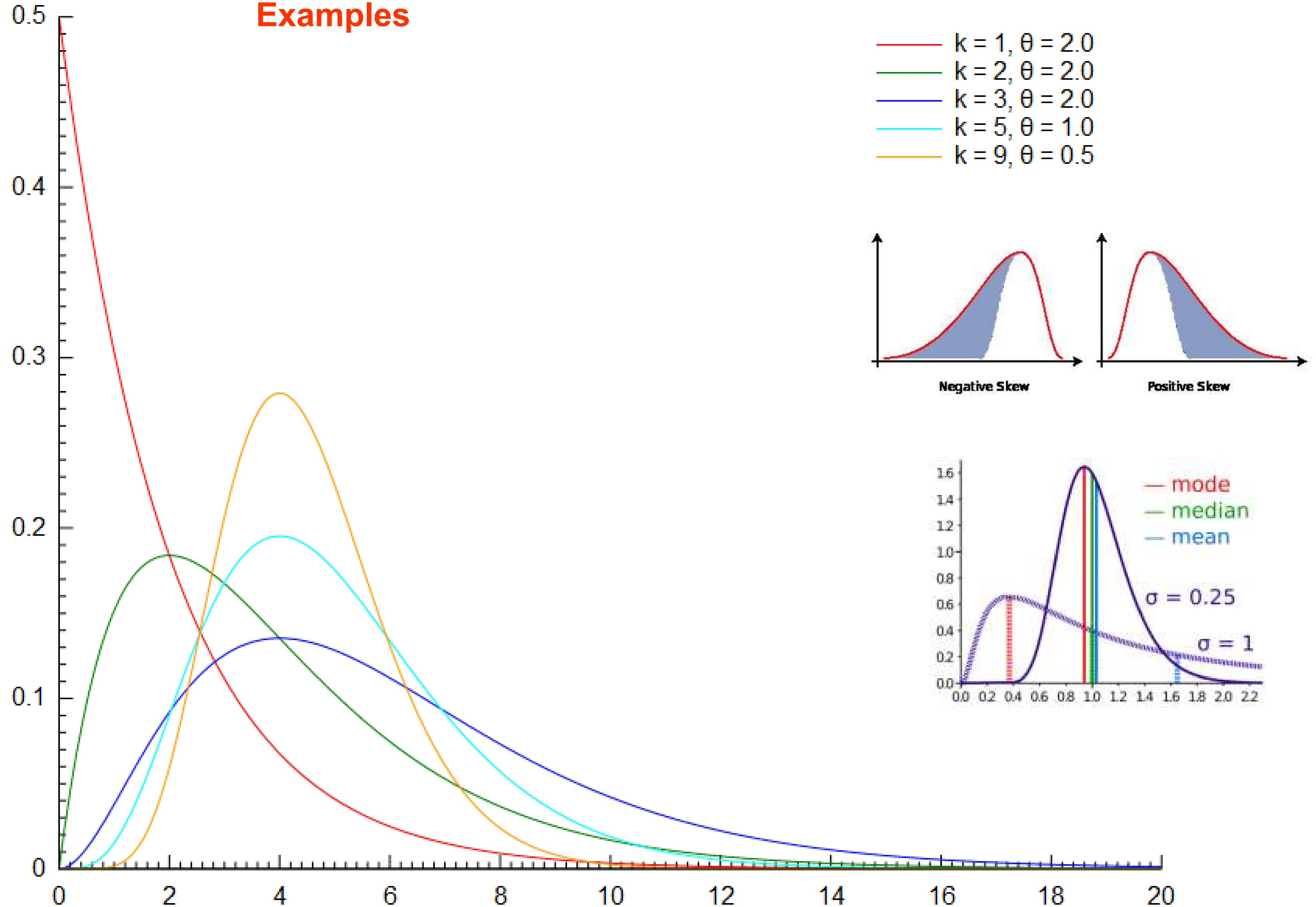

Los Angeles Airport. Annual Max 10-day Precipitation.
July through June. Units: Inches
Red: Annual. Blue: 9-year running mean.
Annual Max 10-day Total (in)
0
1
2
3
4
5
6
7
8
9
10
1950
1960
1970
1980
1990
2000
2010
Ending Year
Western Regional
Climate Center


Los Angeles Airport. Annual Max 20-day Precipitation.
July through June. Units: Inches
Red: Annual. Blue: 9-year running mean.
Annual Max 20-day Total (in)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
1950
1960
1970
1980
1990
2000
2010
Ending Year
Western Regional
Climate Center



Los Angeles Airport. Annual Max 30-day Precipitation.
July through June. Units: Inches
Red: Annual. Blue: 9-year running mean.
Annual Max 30-day total (in)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
1950
1960
1970
1980
1990
2000
2010
Ending Year
Western Regional
Climate Center

Gamma (2 parameter) Examples



Method

Obtain Frequency Distribution
Parameters from a Real Place
for an N-day duration (N=1 here)

Los Angeles Airport   (well, it's sort of real)

Wettest 1-day each winter from 1945-46 thru 2012-13
68 winters, 68 values

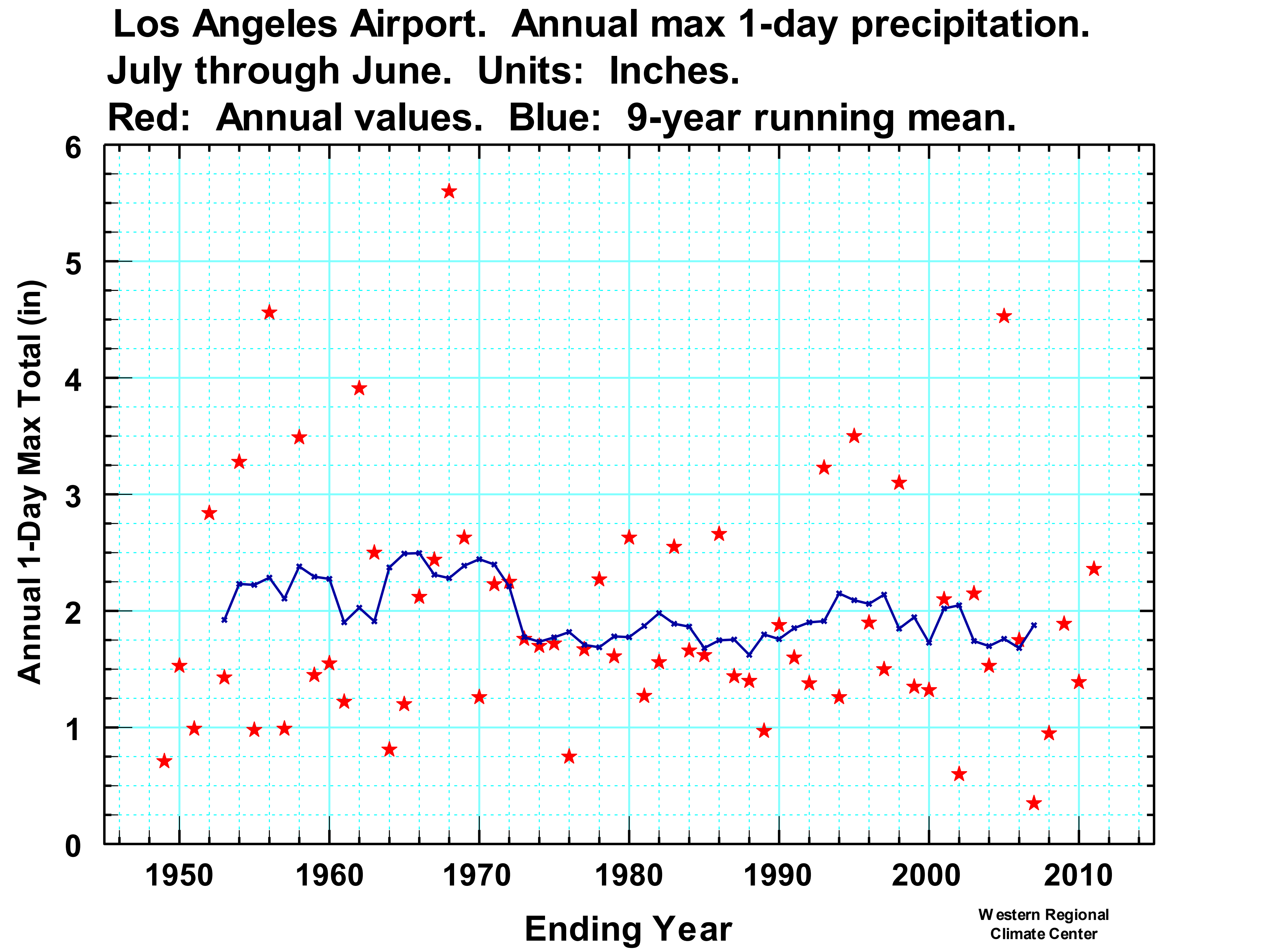
Use Pearson III distribution
and
Frequency Factor Table Approach

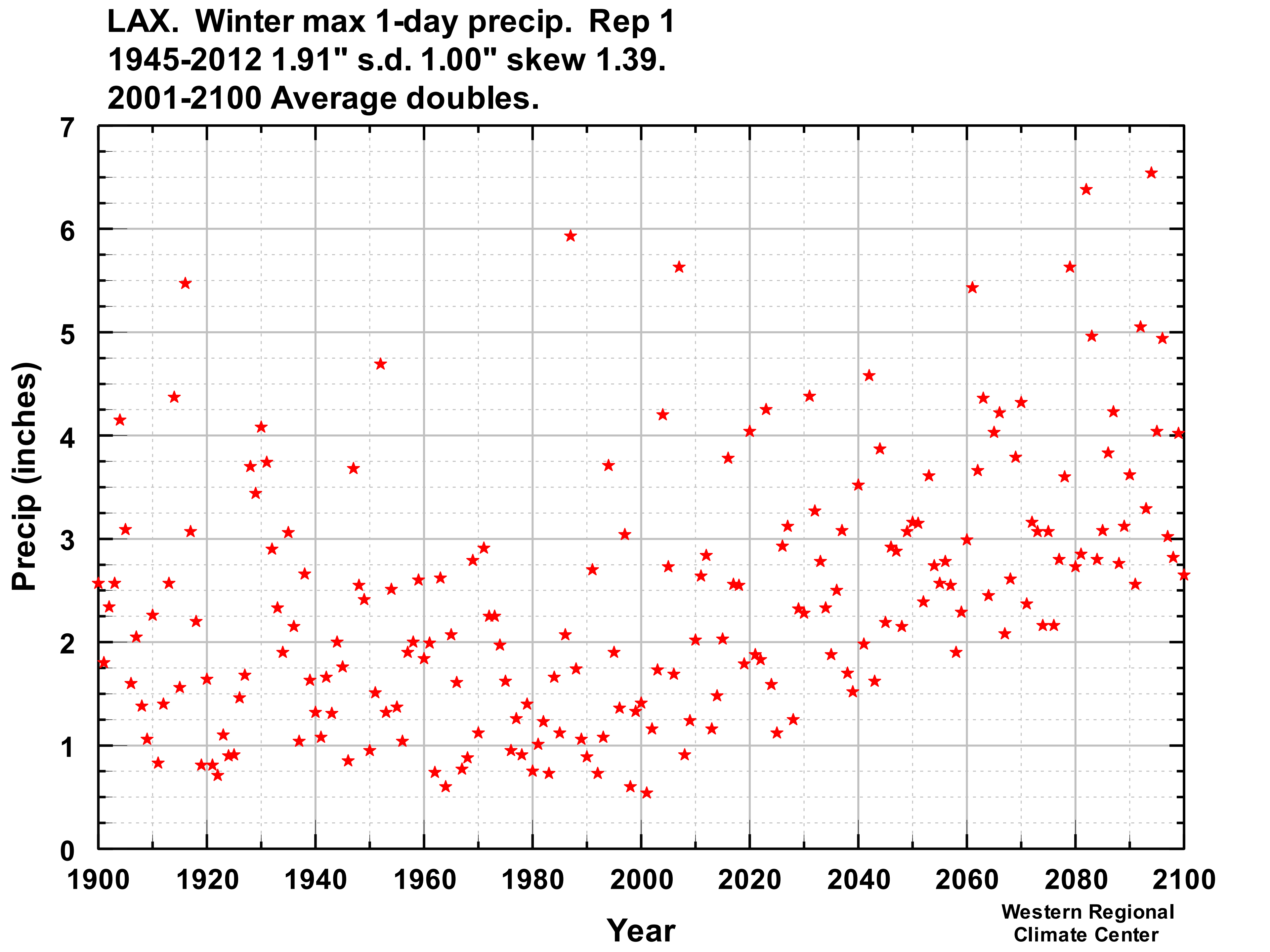
Needs: mean, std deviation, skewness

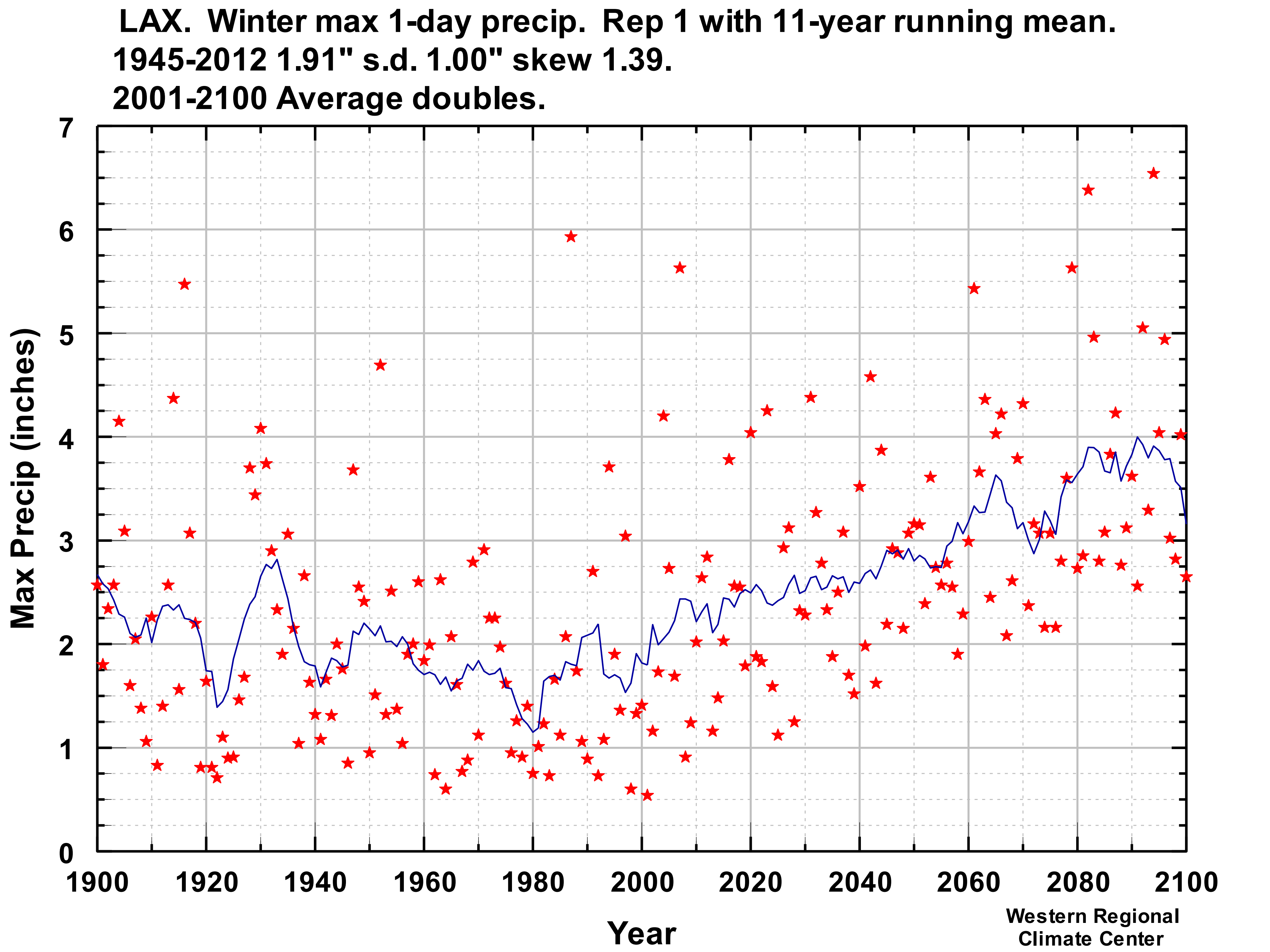
Generate climate from historical parameters for 1900-2000, then
ramp up a parameter (mean, sigma, or skew) for 2001-2100 future

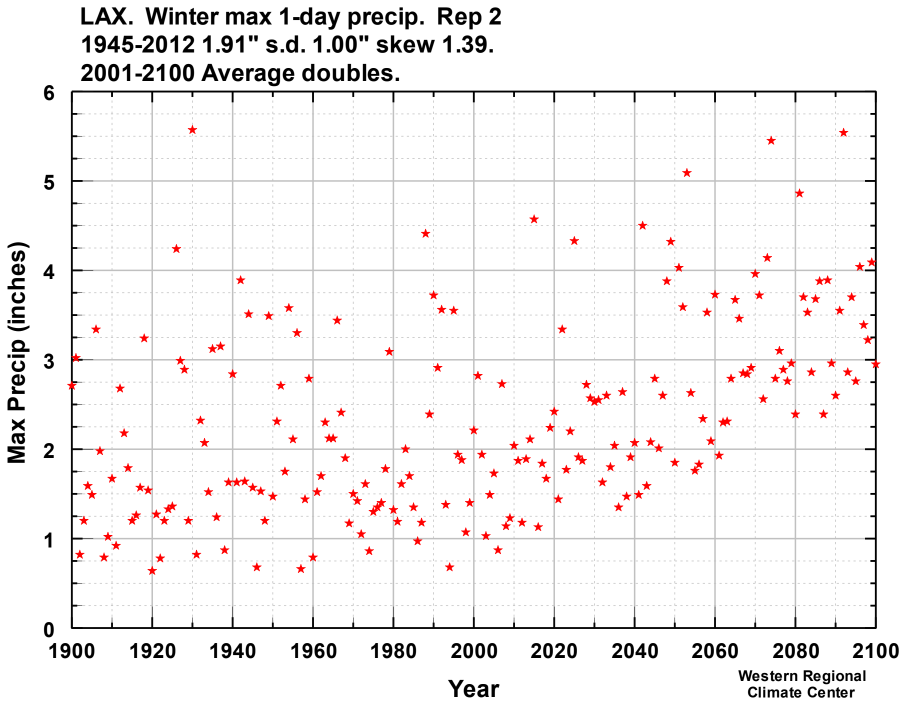
Randomly select a percentile (0.01 % thru 99.99 %) during 2001-2100
Find simulated annual max value from the known distribution
Plot resulting time series. 5 repetitions for each parameter combination.

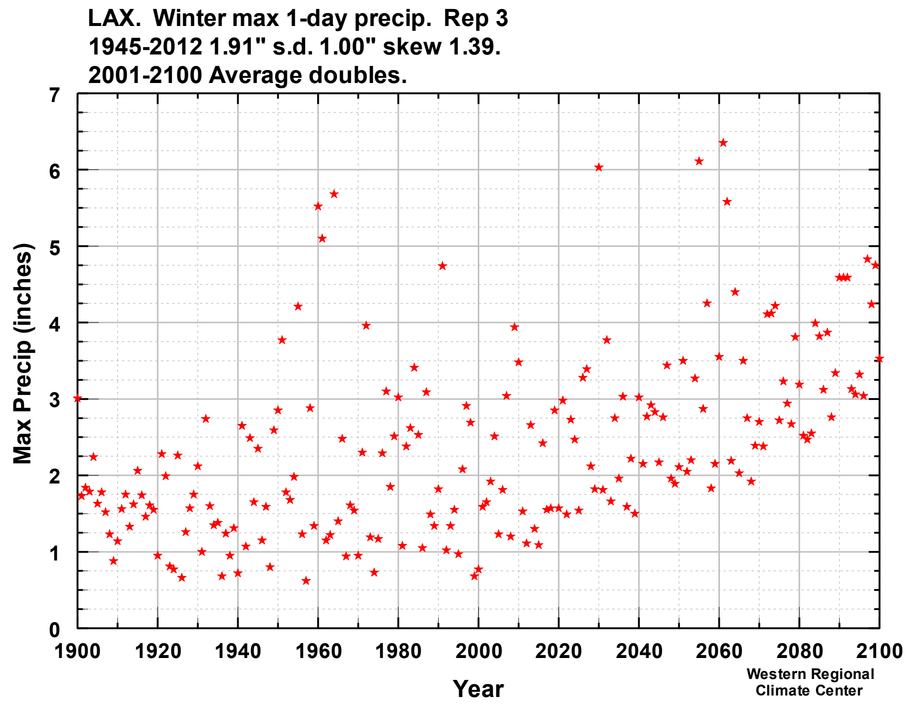
Period 1900-2000 always drawn from exact same frequency distribution
We "know" that climate.

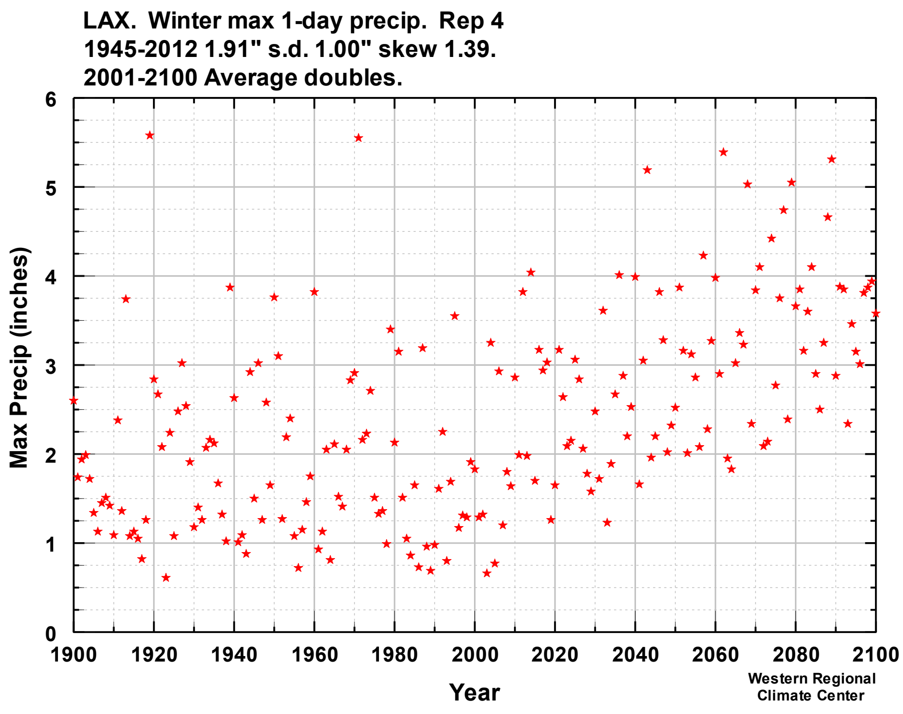

Los Angeles Airport. Annual max 1-day precipitation.
July through June. Units: Inches.
Red: Annual values. Blue: 9-year running mean.
Annual 1-Day Max Total (in)
0
1
2
3
4
5
6
1950
1960
1970
1980
1990
2000
2010
Ending Year
Western Regional
Climate Center

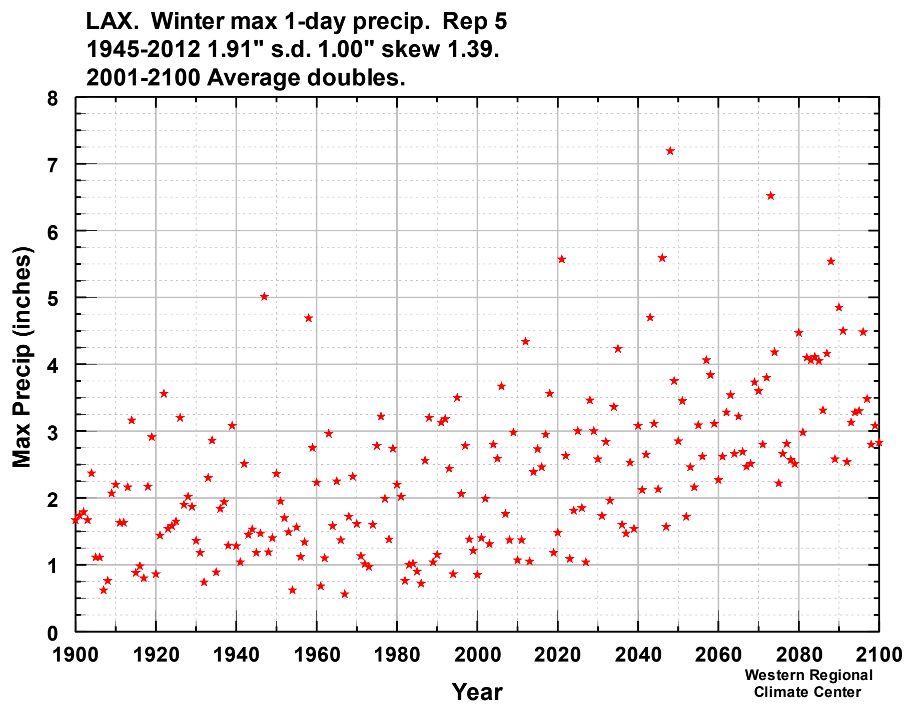

LAX. Winter max 1-day precip. Rep 1
1945-2012 1.91" s.d. 1.00" skew 1.39.
2001-2100 Average doubles.
Precip (inches)
0
1
2
3
4
5
6
7
1900
1920
1940
1960
1980
2000
2020
2040
2060
2080
2100
Year
Western Regional
Climate Center


LAX. Winter max 1-day precip. Rep 1 with 11-year running mean.
1945-2012 1.91" s.d. 1.00" skew 1.39.
2001-2100 Average doubles.
Max Precip (inches)
Year
0
1
2
3
4
5
6
7
1900
1920
1940
1960
1980
2000
2020
2040
2060
2080
2100
Western Regional Climate Center


LAX. Winter max 1-day precip. Rep 2
1945-2012 1.91" s.d. 1.00" skew 1.39.
2001-2100 Average doubles.
Max Precip (inches)
Year
Western Regional Climate Center


LAX. Winter max 1-day precip. Rep 3
1945-2012 1.91" s.d. 1.00" skew 1.39.
2001-2100 Average doubles.
Max Precip (inches)
Year
Western Regional Climate Center


LAX. Winter max 1-day precip. Rep 4
1945-2012 1.91" s.d. 1.00" skew 1.39.
2001-2100 Average doubles.
Max Precip (inches)
Year
Western Regional Climate Center


LAX. Winter max 1-day precip. Rep 5
1945-2012 1.91" s.d. 1.00" skew 1.39.
2001-2100 Average doubles.
Max Precip (inches)
Year
Western Regional Climate Center

```
STATION NUMBER 045114
LOCATION :
ELEMENT : PRECIP   UNITS : .01 'S INCHES
DURATION :   1 DAY(S).    START MONTH :   7
AVERAGE =    1.921   ST DEV =  0.997   SKEWNESS =  1.373
ADJUSTMENT OF 1.00 APPLIED FOR CLOCK EFFECTS
USES OBSERVATION DAYS ONLY

  Prob of    Prob of       Return     Value in       Value in
Nonxceednce Exceedance Interval (yr)  Std. Dev.    Absolute units
----------- ---------- ------------- ------------- -----------------


PN = 0.0001 P = 0.9999 T =    1.0001 PSD =  -1.444 VALUE =     0.48"
PN = 0.0002 P = 0.9998 T =    1.0002 PSD =  -1.439 VALUE =     0.49"
PN = 0.0003 P = 0.9997 T =    1.0003 PSD =  -1.433 VALUE =     0.49"
PN = 0.0004 P = 0.9996 T =    1.0004 PSD =  -1.427 VALUE =     0.50"
PN = 0.0005 P = 0.9995 T =    1.0005 PSD =  -1.422 VALUE =     0.50"
PN = 0.0010 P = 0.9990 T =    1.0010 PSD =  -1.412 VALUE =     0.51"
PN = 0.0020 P = 0.9980 T =    1.0020 PSD =  -1.401 VALUE =     0.52"
PN = 0.0025 P = 0.9975 T =    1.0025 PSD =  -1.396 VALUE =     0.53"
PN = 0.0033 P = 0.9967 T =    1.0033 PSD =  -1.387 VALUE =     0.54"
PN = 0.0040 P = 0.9960 T =    1.0040 PSD =  -1.380 VALUE =     0.54"
PN = 0.0050 P = 0.9950 T =    1.0050 PSD =  -1.369 VALUE =     0.56"
PN = 0.0100 P = 0.9900 T =    1.0101 PSD =  -1.336 VALUE =     0.59"
PN = 0.0200 P = 0.9800 T =    1.0204 PSD =  -1.284 VALUE =     0.64"
PN = 0.0250 P = 0.9750 T =    1.0256 PSD =  -1.264 VALUE =     0.66"
PN = 0.0333 P = 0.9667 T =    1.0344 PSD =  -1.234 VALUE =     0.69"
PN = 0.0400 P = 0.9600 T =    1.0417 PSD =  -1.211 VALUE =     0.71"
PN = 0.0500 P = 0.9500 T =    1.0526 PSD =  -1.181 VALUE =     0.74"
PN = 0.1000 P = 0.9000 T =    1.1111 PSD =  -1.045 VALUE =     0.88"
PN = 0.2000 P = 0.8000 T =    1.2500 PSD =  -0.830 VALUE =     1.09"
PN = 0.2500 P = 0.7500 T =    1.3333 PSD =  -0.735 VALUE =     1.19"
PN = 0.3000 P = 0.7000 T =    1.4286 PSD =  -0.640 VALUE =     1.28"
PN = 0.3333 P = 0.6667 T =    1.4999 PSD =  -0.572 VALUE =     1.35"
PN = 0.4000 P = 0.6000 T =    1.6667 PSD =  -0.437 VALUE =     1.48"
PN = 0.5000 P = 0.5000 T =    2.0000 PSD =  -0.227 VALUE =     1.69"
PN = 0.6000 P = 0.4000 T =    2.5000 PSD =   0.025 VALUE =     1.95"
PN = 0.7000 P = 0.3000 T =    3.3333 PSD =   0.313 VALUE =     2.23"
PN = 0.7500 P = 0.2500 T =    4.0000 PSD =   0.514 VALUE =     2.43"
PN = 0.8000 P = 0.2000 T =    5.0000 PSD =   0.715 VALUE =     2.63"
PN = 0.8333 P = 0.1667 T =    5.9988 PSD =   0.924 VALUE =     2.84"
PN = 0.8750 P = 0.1250 T =    8.0000 PSD =   1.186 VALUE =     3.10"
PN = 0.9000 P = 0.1000 T =   10.0000 PSD =   1.343 VALUE =     3.26"
PN = 0.9500 P = 0.0500 T =   20.0000 PSD =   1.937 VALUE =     3.85"
PN = 0.9600 P = 0.0400 T =   25.0000 PSD =   2.125 VALUE =     4.04"
PN = 0.9666 P = 0.0334 T =   29.9401 PSD =   2.295 VALUE =     4.21"
PN = 0.9750 P = 0.0250 T =   40.0000 PSD =   2.512 VALUE =     4.43"
PN = 0.9800 P = 0.0200 T =   50.0000 PSD =   2.702 VALUE =     4.62"
PN = 0.9900 P = 0.0100 T =  100.0001 PSD =   3.254 VALUE =     5.17"
PN = 0.9950 P = 0.0050 T =  200.0002 PSD =   3.808 VALUE =     5.72"
PN = 0.9960 P = 0.0040 T =  249.9995 PSD =   4.122 VALUE =     6.03"
PN = 0.9966 P = 0.0034 T =  294.1152 PSD =   4.311 VALUE =     6.22"
PN = 0.9975 P = 0.0025 T =  400.0004 PSD =   4.593 VALUE =     6.50"
PN = 0.9980 P = 0.0020 T =  500.0064 PSD =   4.751 VALUE =     6.66"
PN = 0.9990 P = 0.0010 T = 1000.0129 PSD =   5.065 VALUE =     6.97"
PN = 0.9995 P = 0.0005 T = 1999.9065 PSD =   5.584 VALUE =     7.49"
PN = 0.9996 P = 0.0004 T = 2499.9578 PSD =   5.890 VALUE =     7.80"
PN = 0.9998 P = 0.0002 T = 5000.6606 PSD =   6.504 VALUE =     8.41"
PN = 0.9999 P = 0.0001 T = 9998.3408 PSD =   6.810 VALUE =     8.71"
```

How about an increase in Annual Max Precip

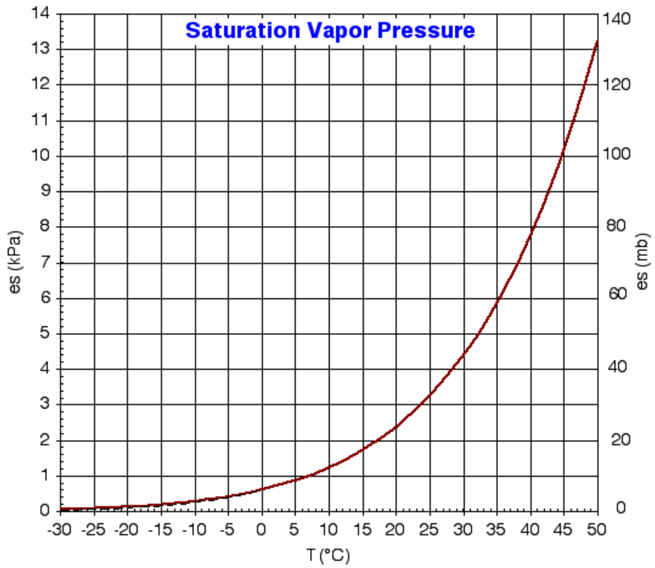
that is a little less drastic ?

eg +35 % in atmospheric water content

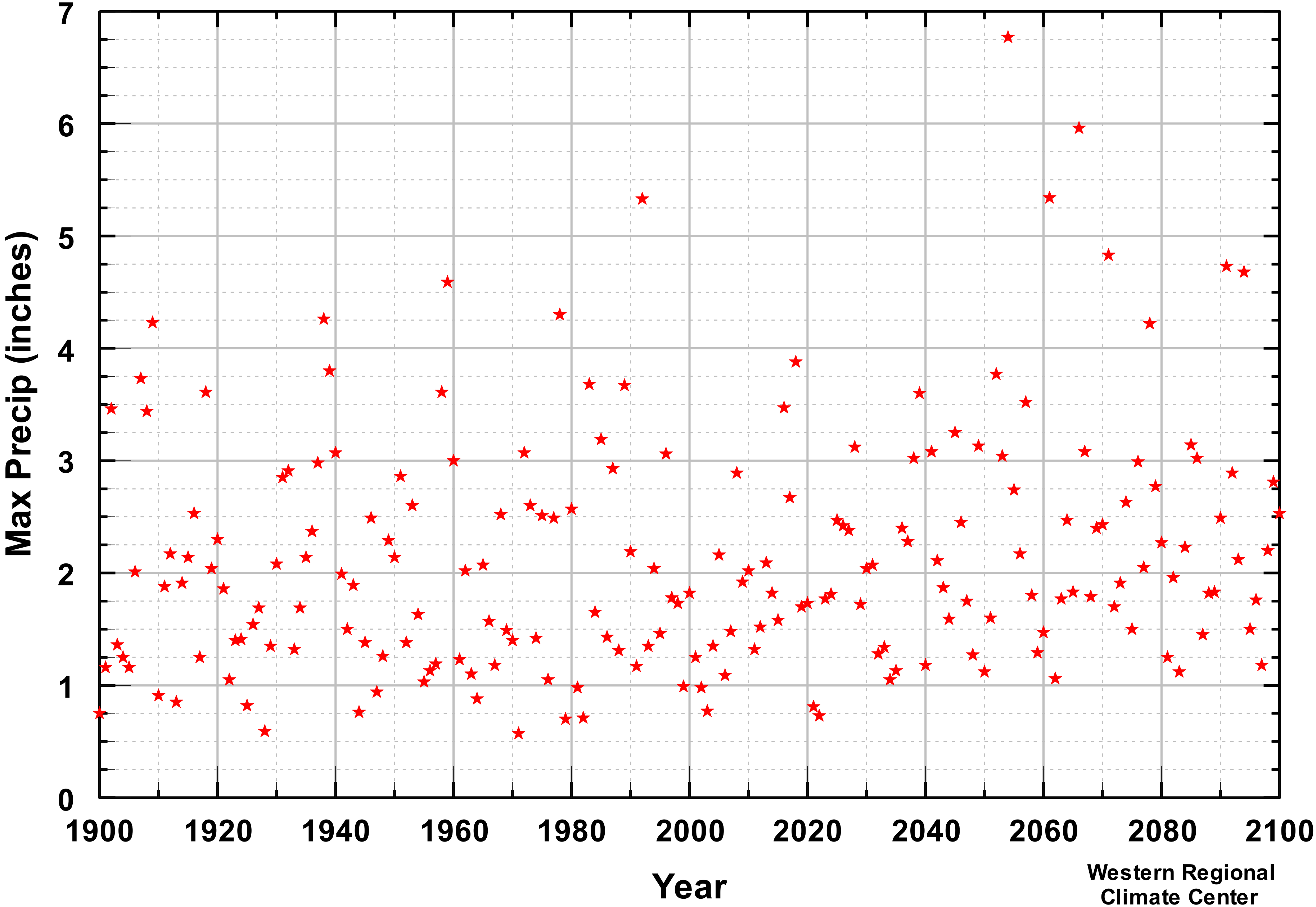
Clausius Clapyron for Temp Increase of +5 C

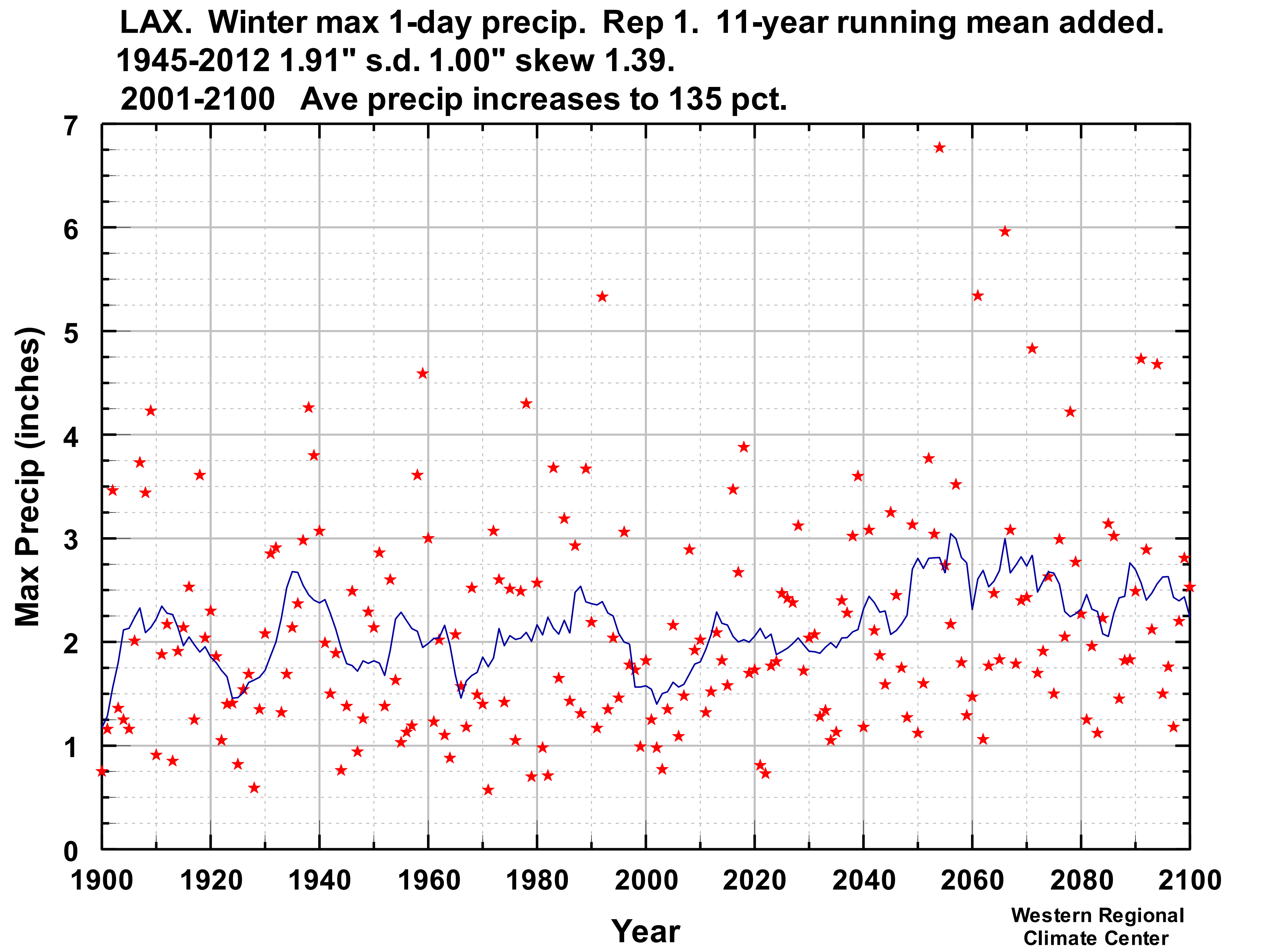
a la

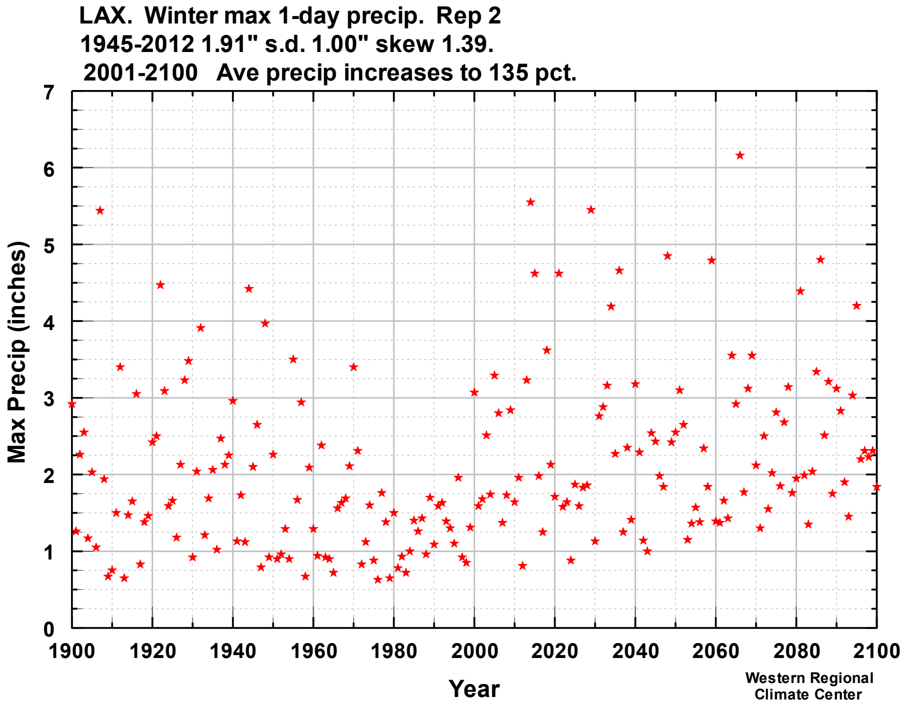
Kunkel, Karl, Easterling, Redmond, Young, Yin, Hennon.
Probable Maximum Precipitation (PMP) and Climate Change.
GRL, 2013.

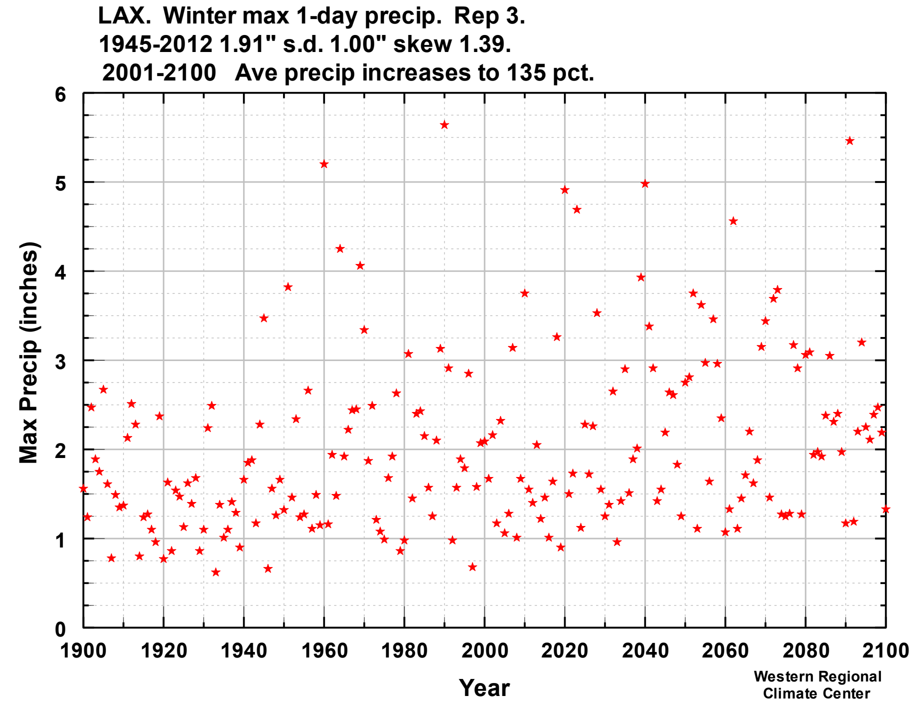


LAX. Winter max 1-day precip. Rep 1
1945-2012 1.91" s.d. 1.00" skew 1.39.
2001-2100 Ave precip increases to 135 pct.




LAX. Winter max 1-day precip. Rep 1. 11-year running mean added.
1945-2012 1.91" s.d. 1.00" skew 1.39.
2001-2100 Ave precip increases to 135 pct.
Max Precip (inches)
0
1
2
3
4
5
6
7
1900
1920
1940
1960
1980
2000
2020
2040
2060
2080
2100
Year
Western Regional
Climate Center


LAX. Winter max 1-day precip. Rep 2
1945-2012 1.91" s.d. 1.00" skew 1.39.
2001-2100 Ave precip increases to 135 pct.
Max Precip (inches)
Year
Western Regional Climate Center


LAX. Winter max 1-day precip. Rep 3.
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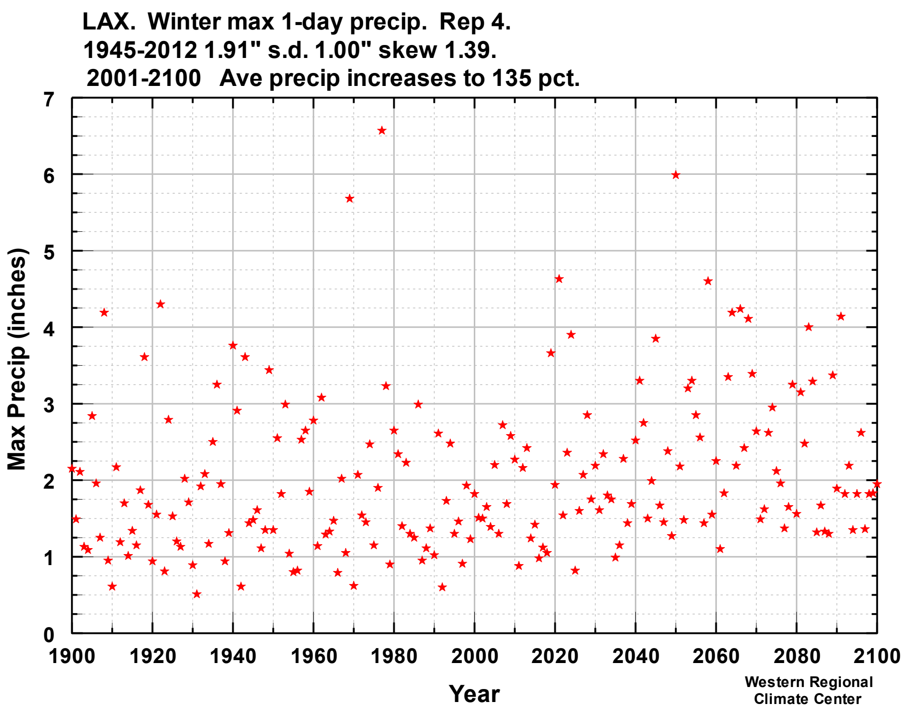
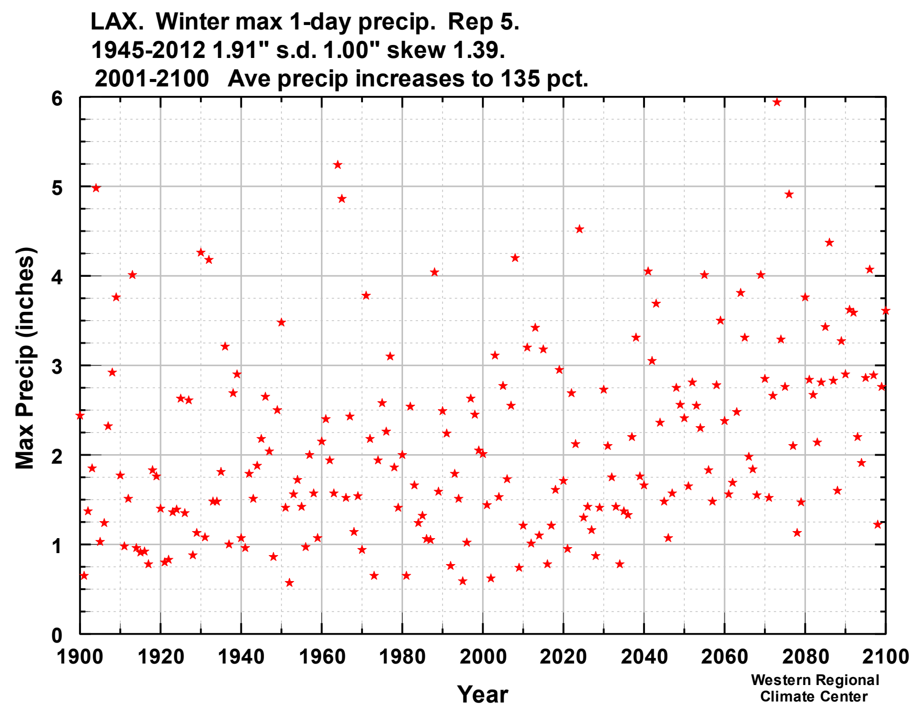
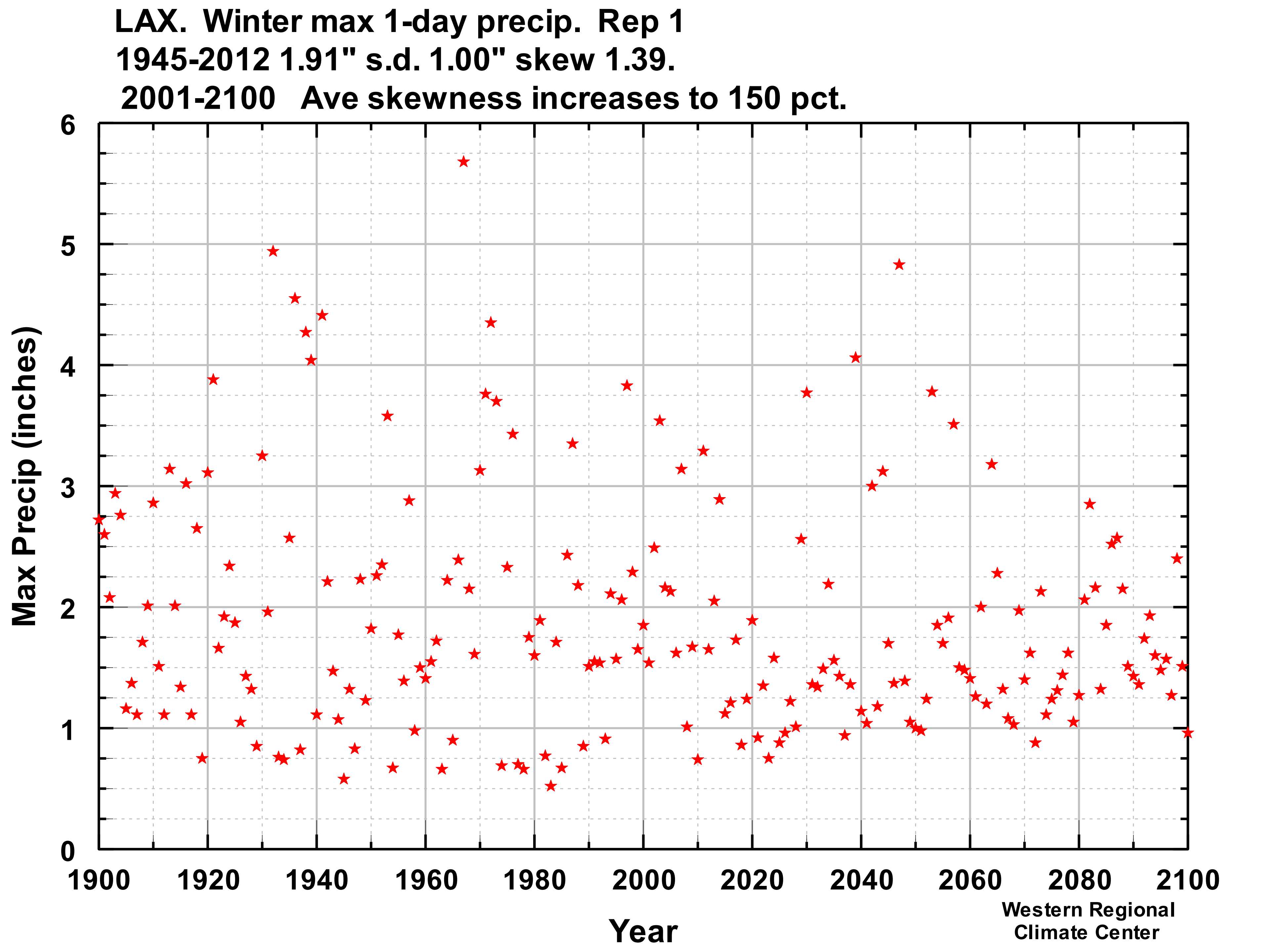
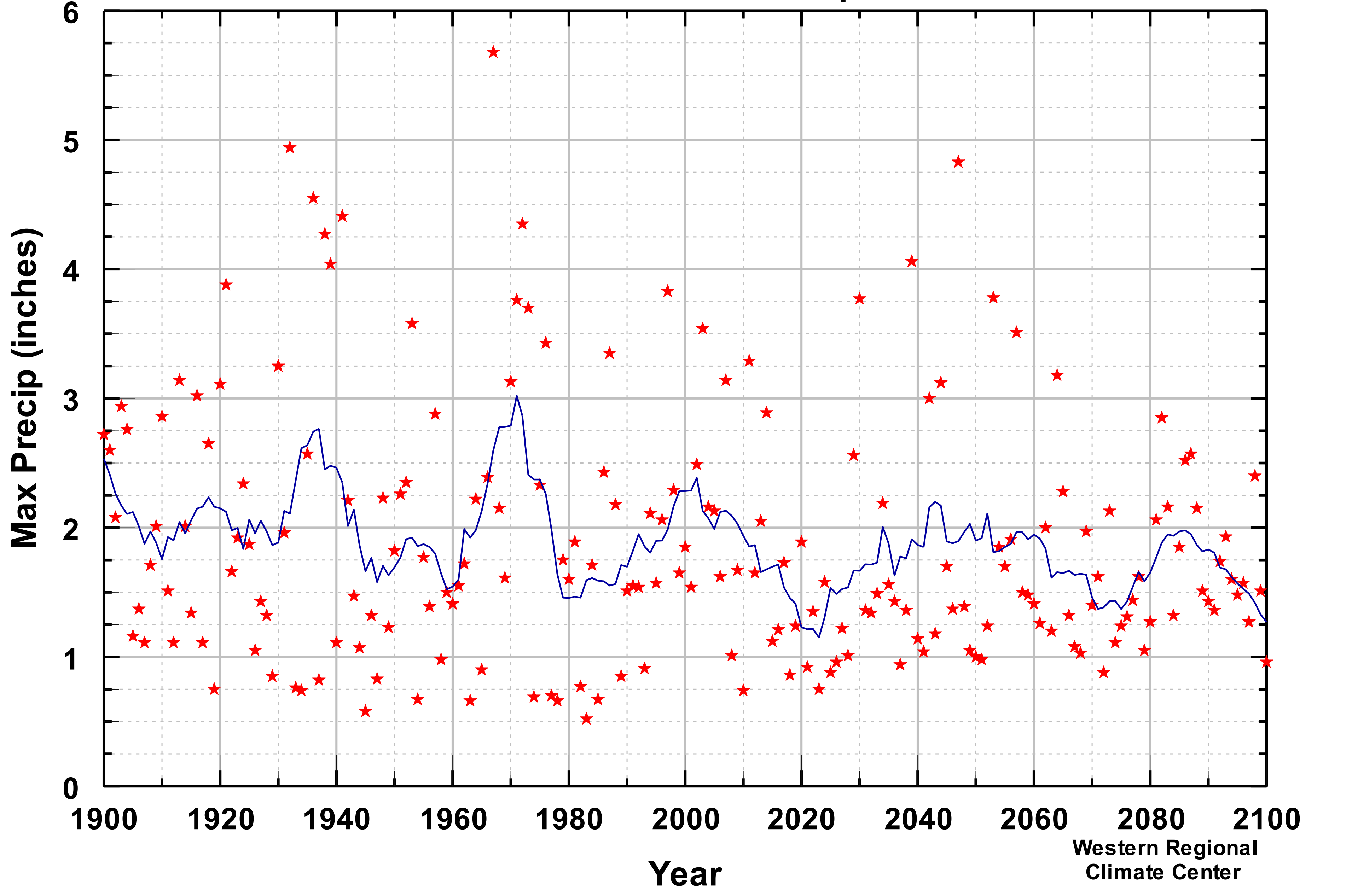
2001-2100 Ave precip increases to 135 pct.
Max Precip (inches)
Year
Western Regional Climate Center

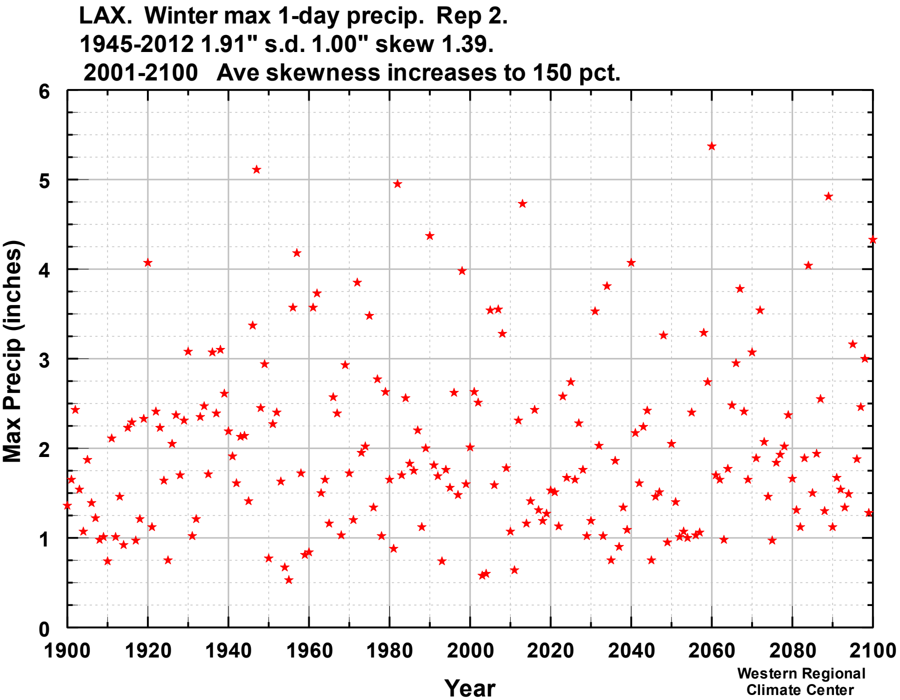

LAX. Winter max 1-day precip. Rep 4.
1945-2012 1.91" s.d. 1.00" skew 1.39.
2001-2100 Ave precip increases to 135 pct.
Max Precip (inches)
Year
Western Regional Climate Center

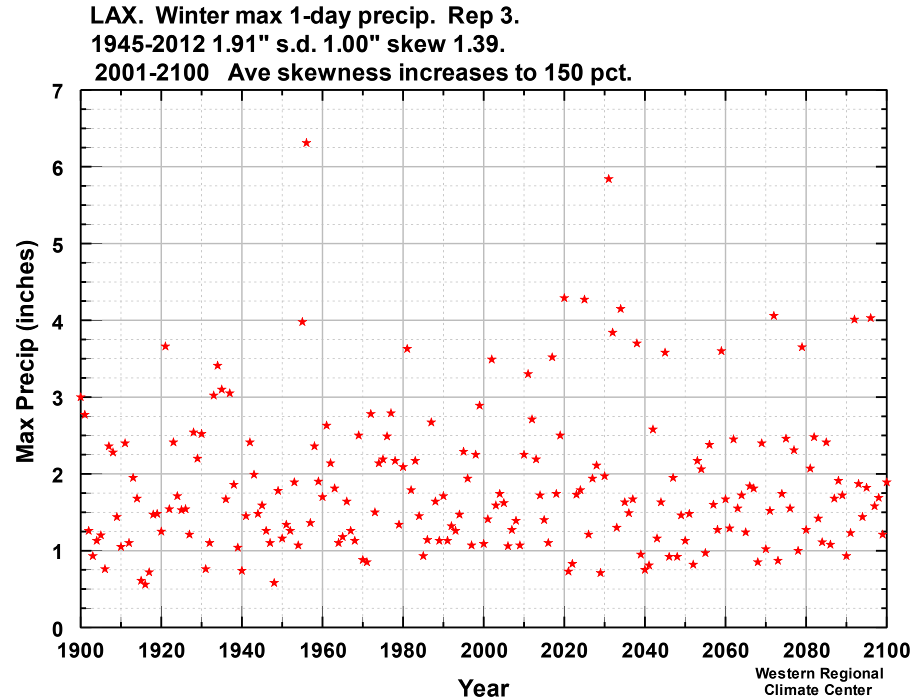

LAX. Winter max 1-day precip. Rep 5.
1945-2012 1.91" s.d. 1.00" skew 1.39.
2001-2100 Ave precip increases to 135 pct.
Max Precip (inches)
Year
Western Regional Climate Center

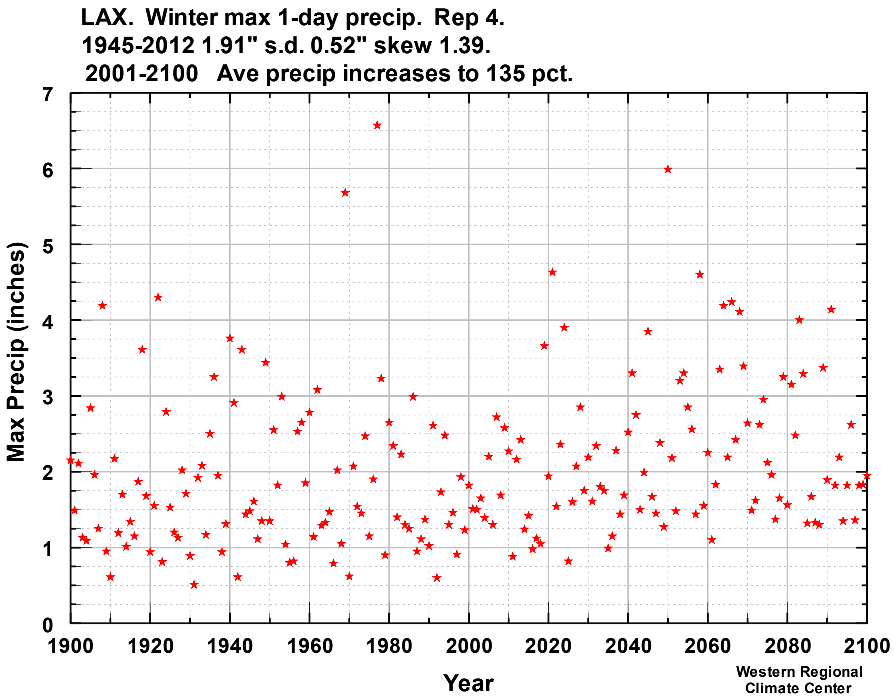

LAX. Winter max 1-day precip. Rep 1
1945-2012 1.91" s.d. 1.00" skew 1.39.
2001-2100 Ave skewness increases to 150 pct.
Max Precip (inches)
0
1
2
3
4
5
6
1900
1920
1940
1960
1980
2000
2020
2040
2060
2080
2100
Year
Western Regional
Climate Center

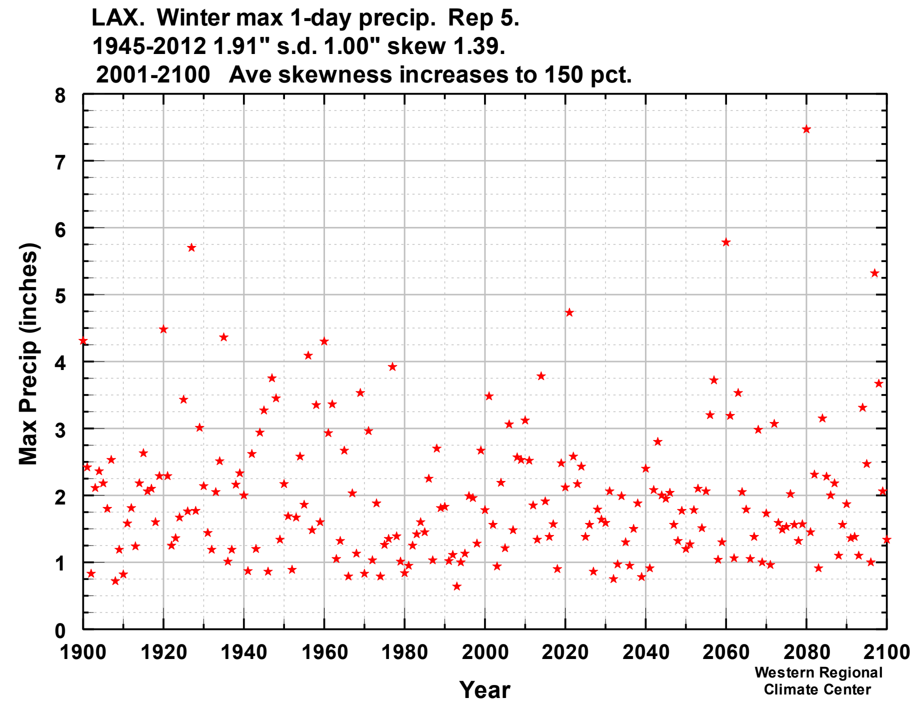
LAX. Winter max 1-day precip. Rep 1. With 11-yr running mean.
1945-2012 1.91" s.d. 1.00" skew 1.39.
2001-2100 Ave skewness increases to 150 pct.

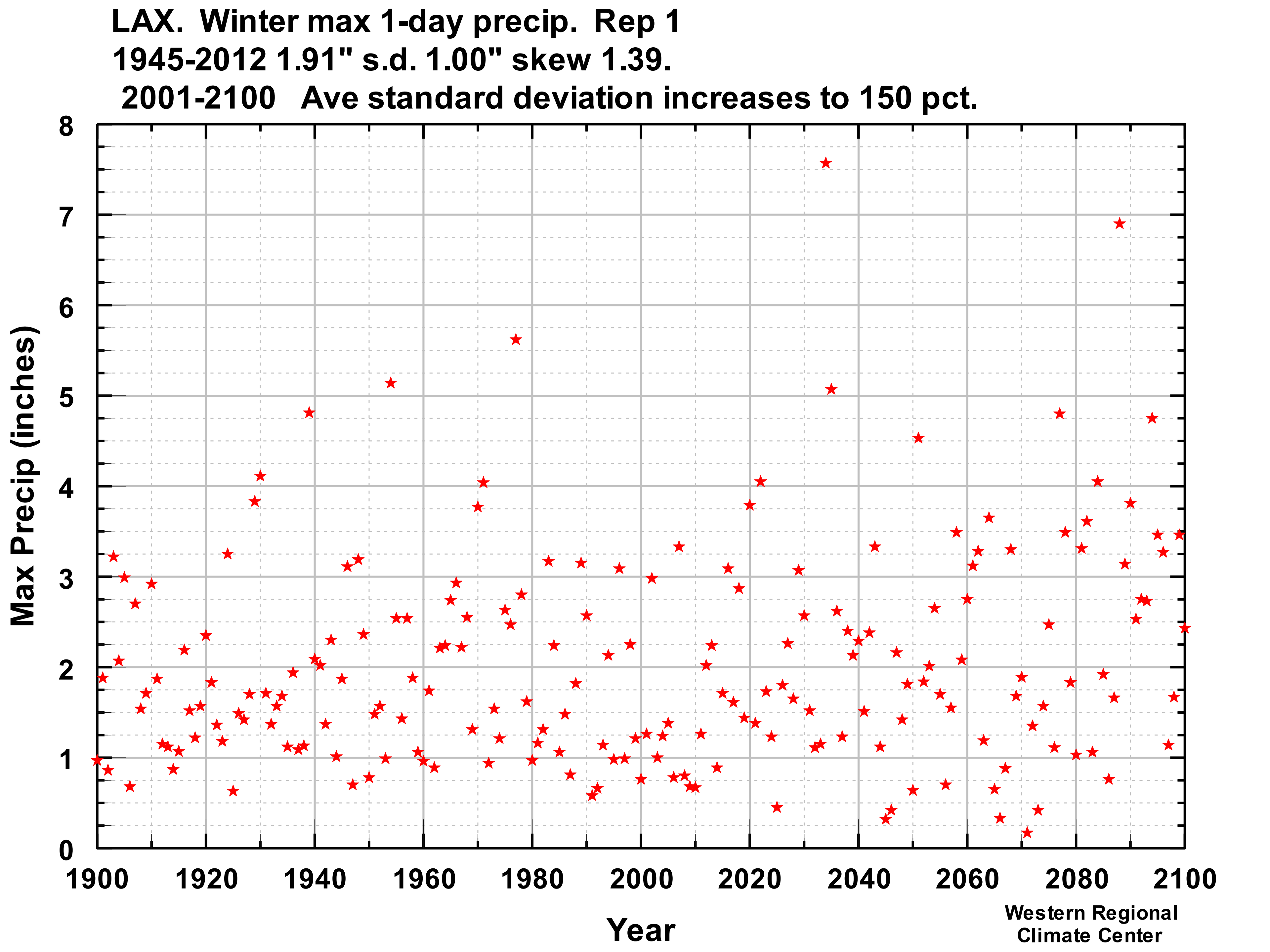



LAX. Winter max 1-day precip. Rep 2.
1945-2012 1.91" s.d. 1.00" skew 1.39.
2001-2100 Ave skewness increases to 150 pct.
Max Precip (inches)
Year
Western Regional Climate Center

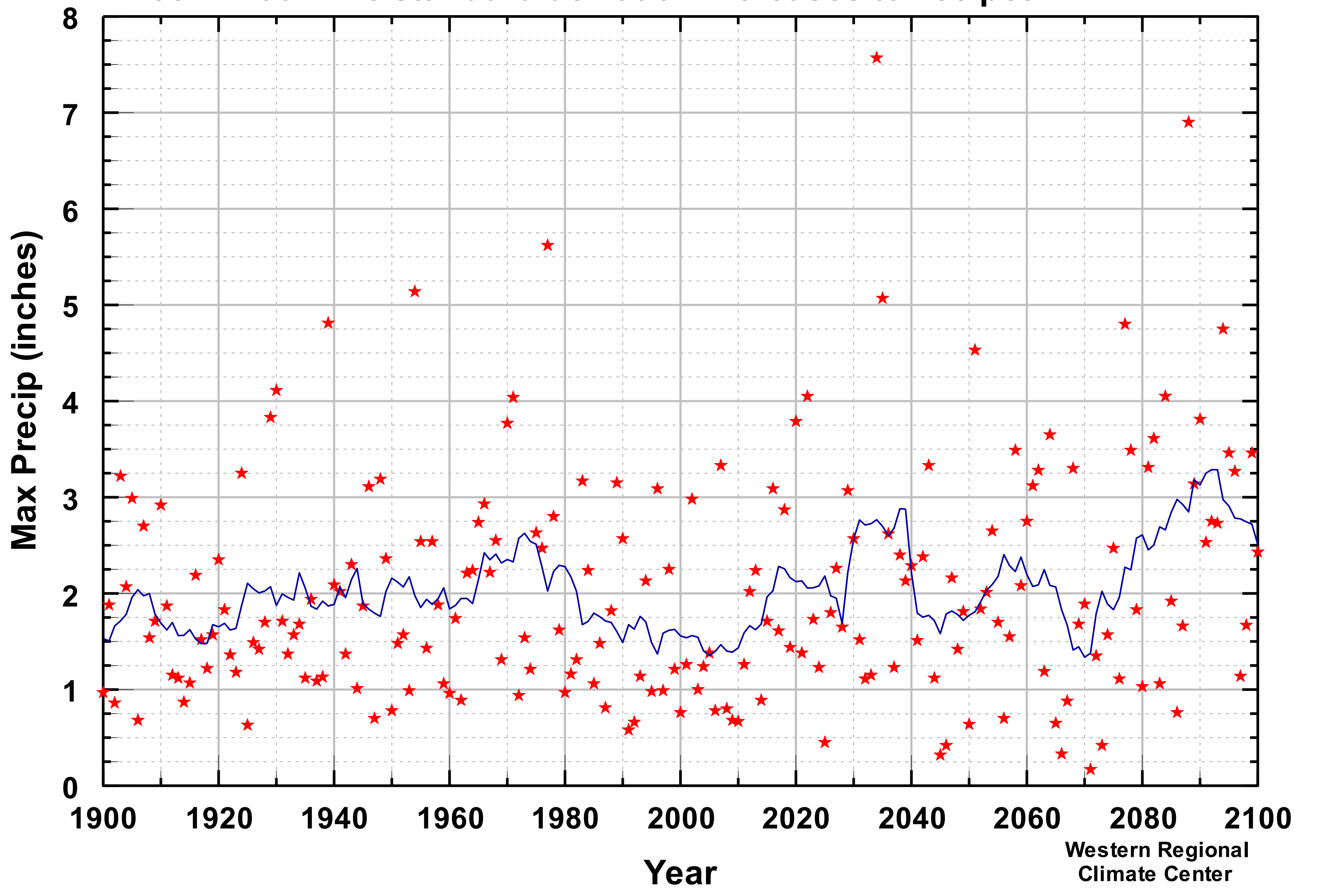

LAX. Winter max 1-day precip. Rep 3.
1945-2012 1.91" s.d. 1.00" skew 1.39.
2001-2100 Ave skewness increases to 150 pct.
Max Precip (inches)
Year
Western Regional Climate Center


LAX. Winter max 1-day precip. Rep 4.
1945-2012 1.91" s.d. 0.52" skew 1.39.
2001-2100 Ave precip increases to 135 pct.
Max Precip (inches)
Year
Western Regional Climate Center

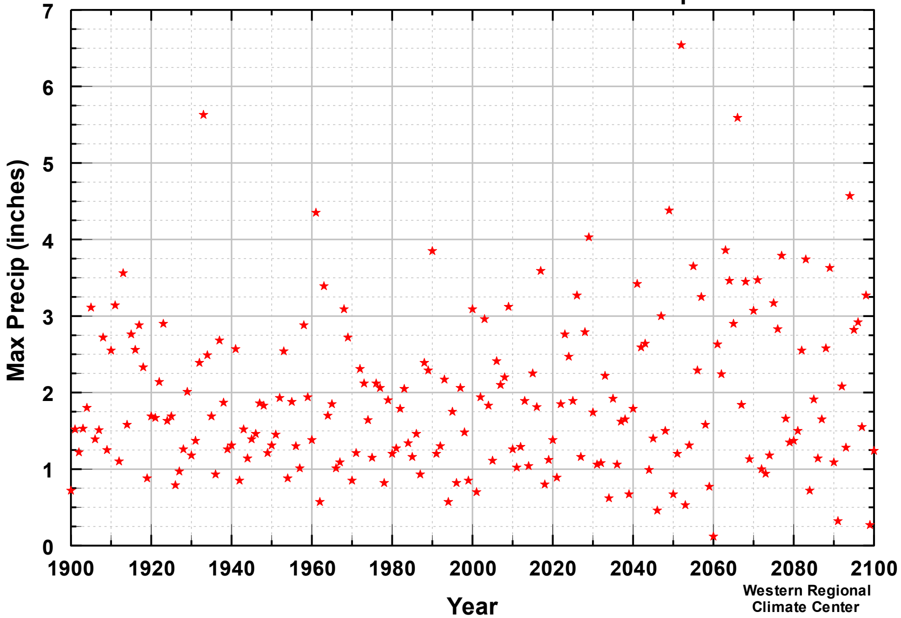

LAX. Winter max 1-day precip. Rep 5.
1945-2012 1.91" s.d. 1.00" skew 1.39.
2001-2100 Ave skewness increases to 150 pct.
Max Precip (inches)
Year
Western Regional Climate Center


LAX. Winter max 1-day precip. Rep 1
1945-2012 1.91" s.d. 1.00" skew 1.39.
2001-2100 Ave standard deviation increases to 150 pct.
Max Precip (inches)
0
1
2
3
4
5
6
7
8
1900
1920
1940
1960
1980
2000
2020
2040
2060
2080
2100
Year
Western Regional
Climate Center

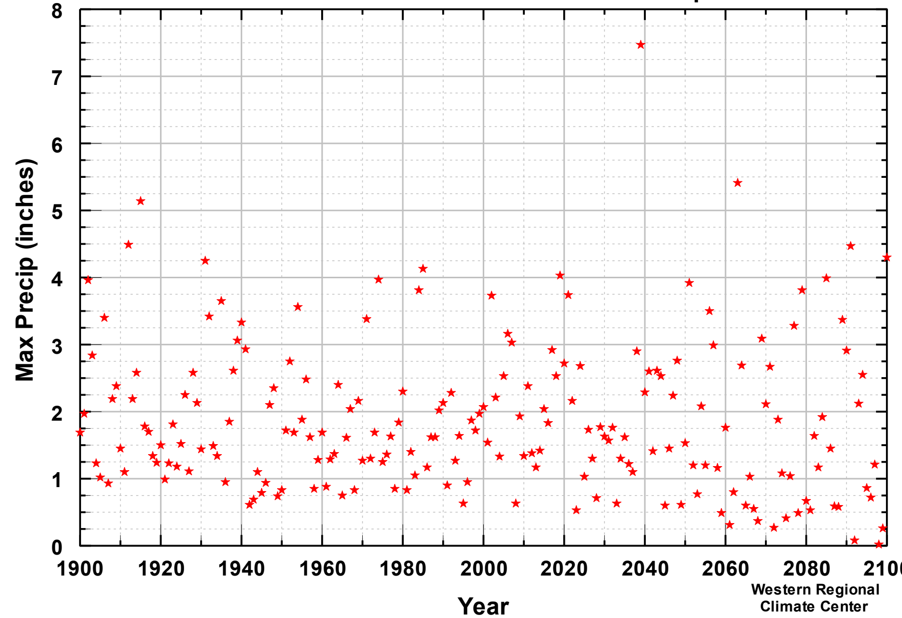
LAX. Winter max 1-day precip. Rep 1, with 11-year running mean.
1945-2012 1.91" s.d. 1.00" skew 1.39.
2001-2100 Ave standard deviation increases to 150 pct.



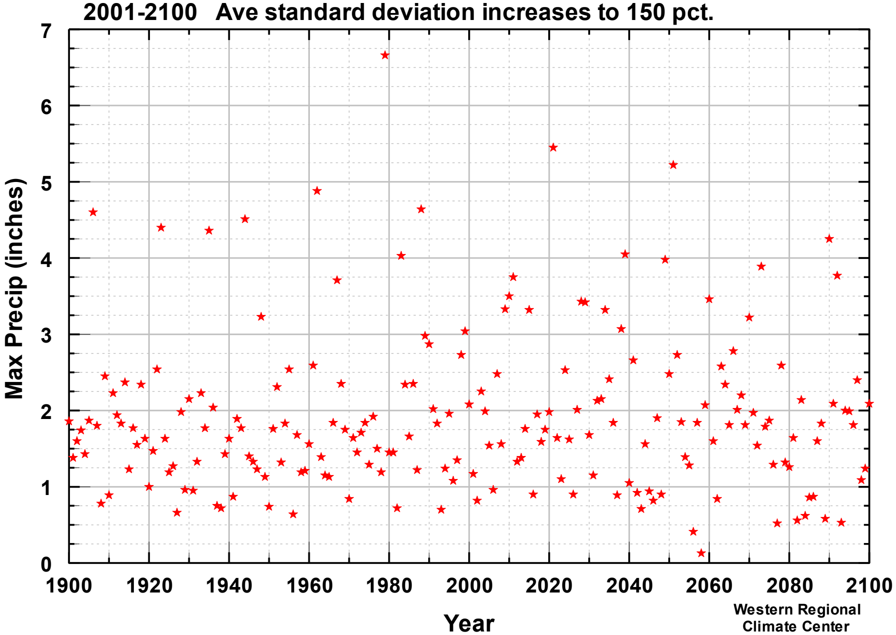
LAX. Winter max 1-day precip. Rep 2.
1945-2012 1.91" s.d. 1.00" skew 1.39.
2001-2100 Ave standard deviation increases to 150 pct.



LAX. Winter max 1-day precip. Rep 3.
1945-2012 1.91" s.d. 1.00" skew 1.39.
2001-2100 Ave standard deviation increases to 150 pct.



LAX. Winter max 1-day precip. Rep 4.
1945-2012 1.91" s.d. 1.00" skew 1.39.
2001-2100 Ave standard deviation increases to 150 pct.



LAX. Winter max 1-day precip. Rep 5.
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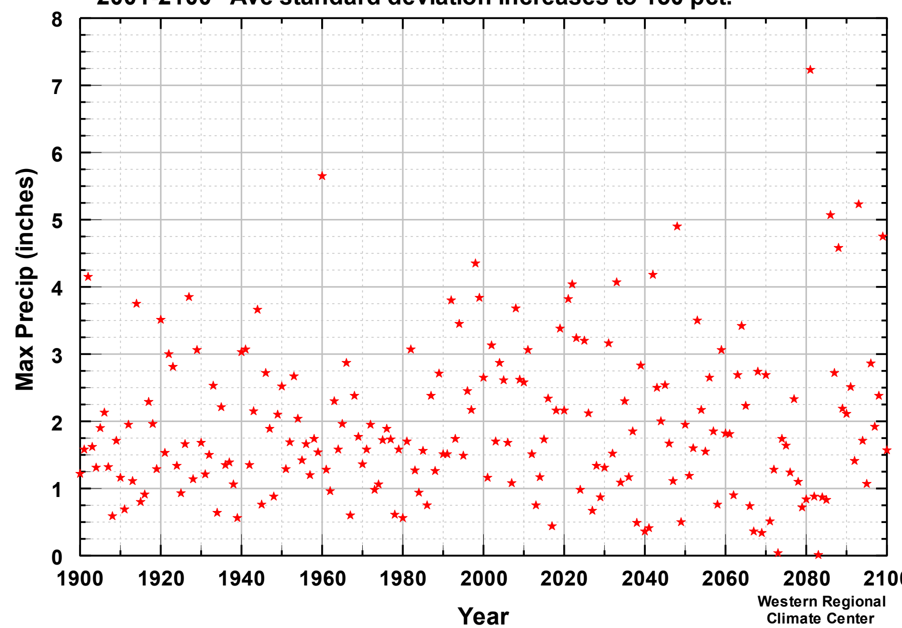
2001-2100 Ave standard deviation increases to 150 pct.



Earth Shattering Conclusions:

Jeez, this is SO interesting !!

Other Conclusions

- The climate of extremes (or other properties) can look like it is changing,

even when it is not (by construction)

- Given the amount of noise (random variation) in a typical real time series,

changes in the climate of extremes will be very difficult to detect (at individual stations)

... Unless, the change in statistical moment or parameter is quite large

- Attempts to read in inferences about trends in single-station climate extremes

can easily be completely without basis ... analysis of randomness


That’s it !
20130428 KTR