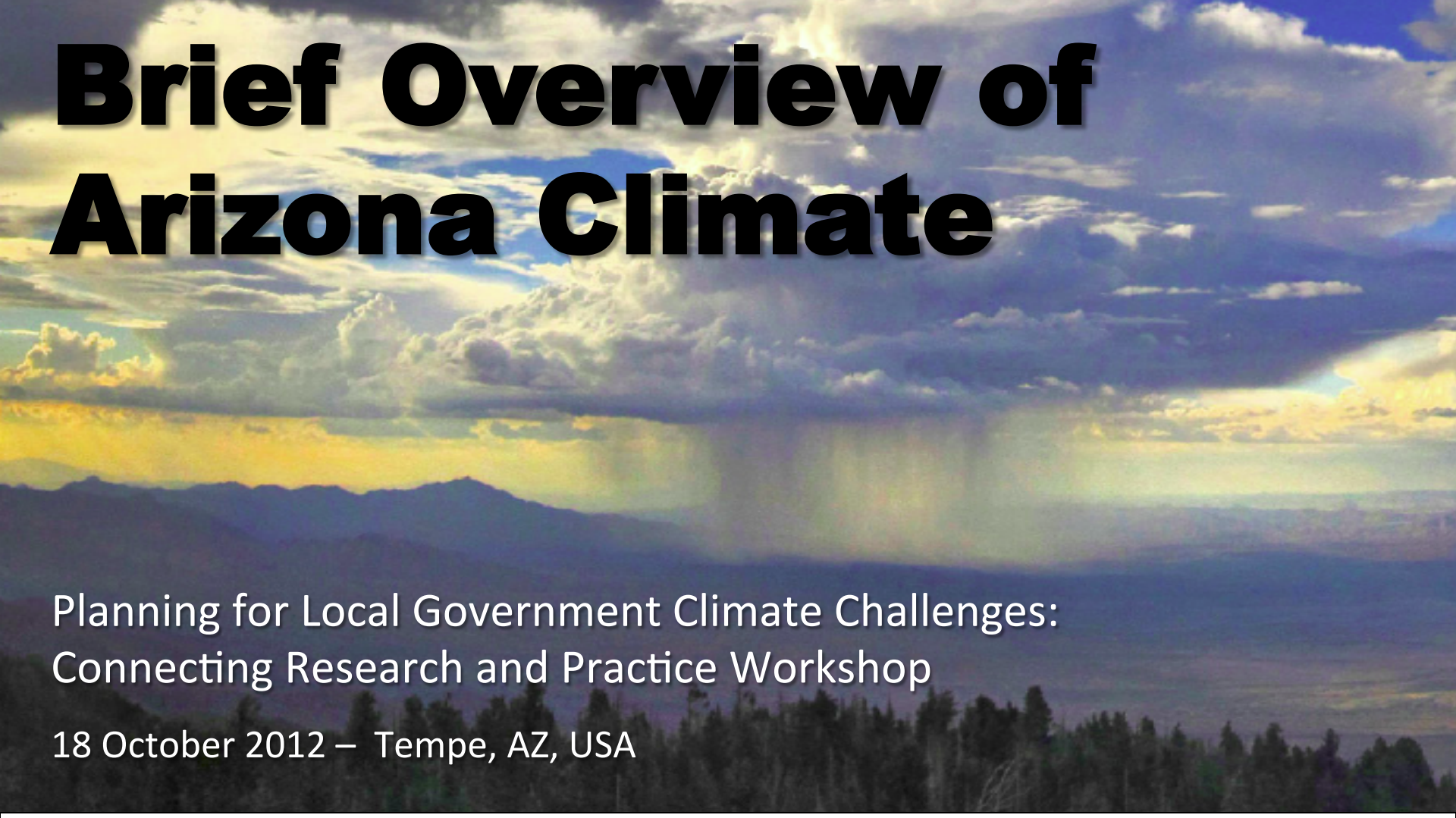
Brief Overview of Arizona Climate



Planning for Local Government Climate Challenges:
Connecting Research and Practice Workshop

18 October 2012 – Tempe, AZ, USA

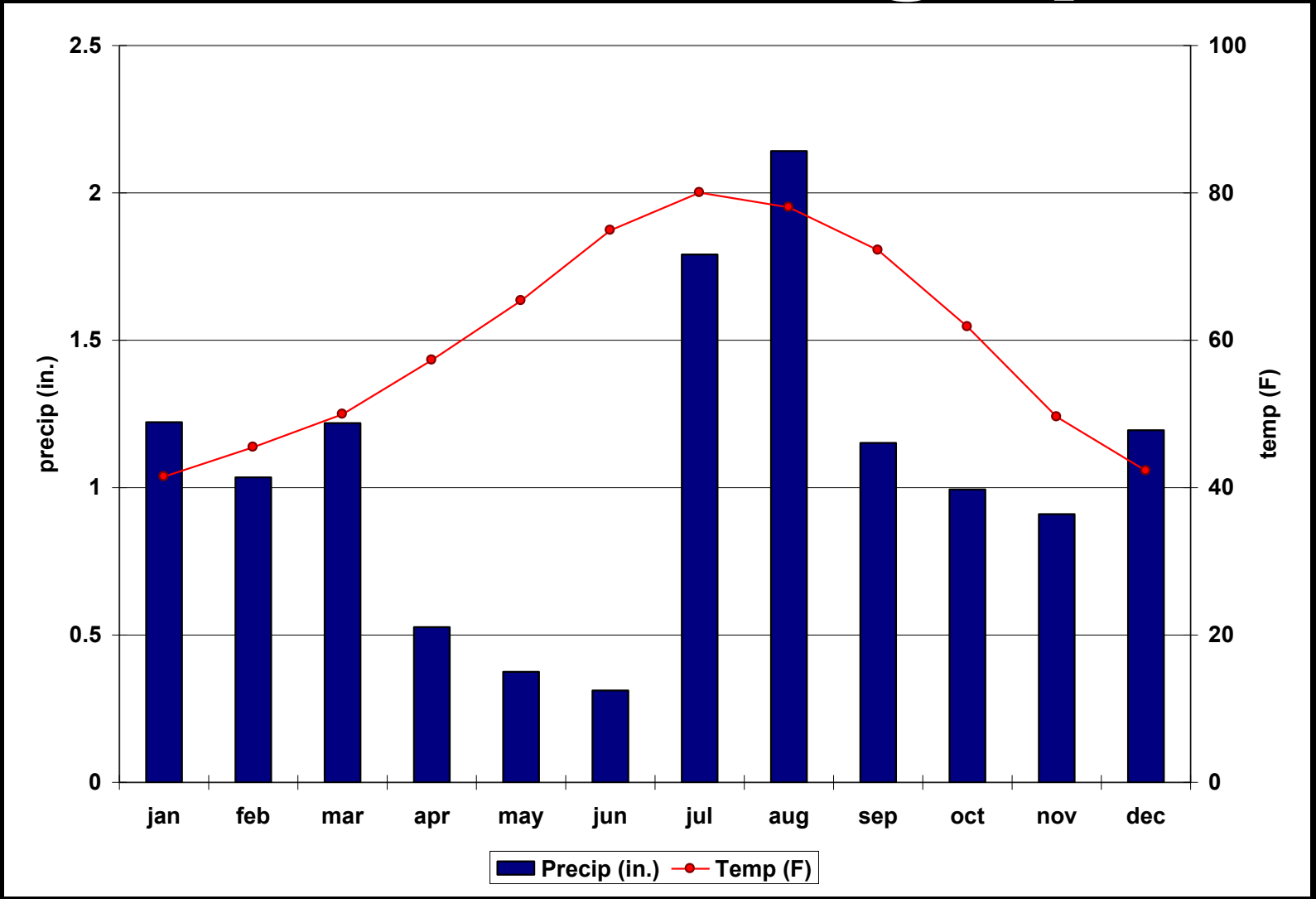
Gregg Garfin, The University of Arizona

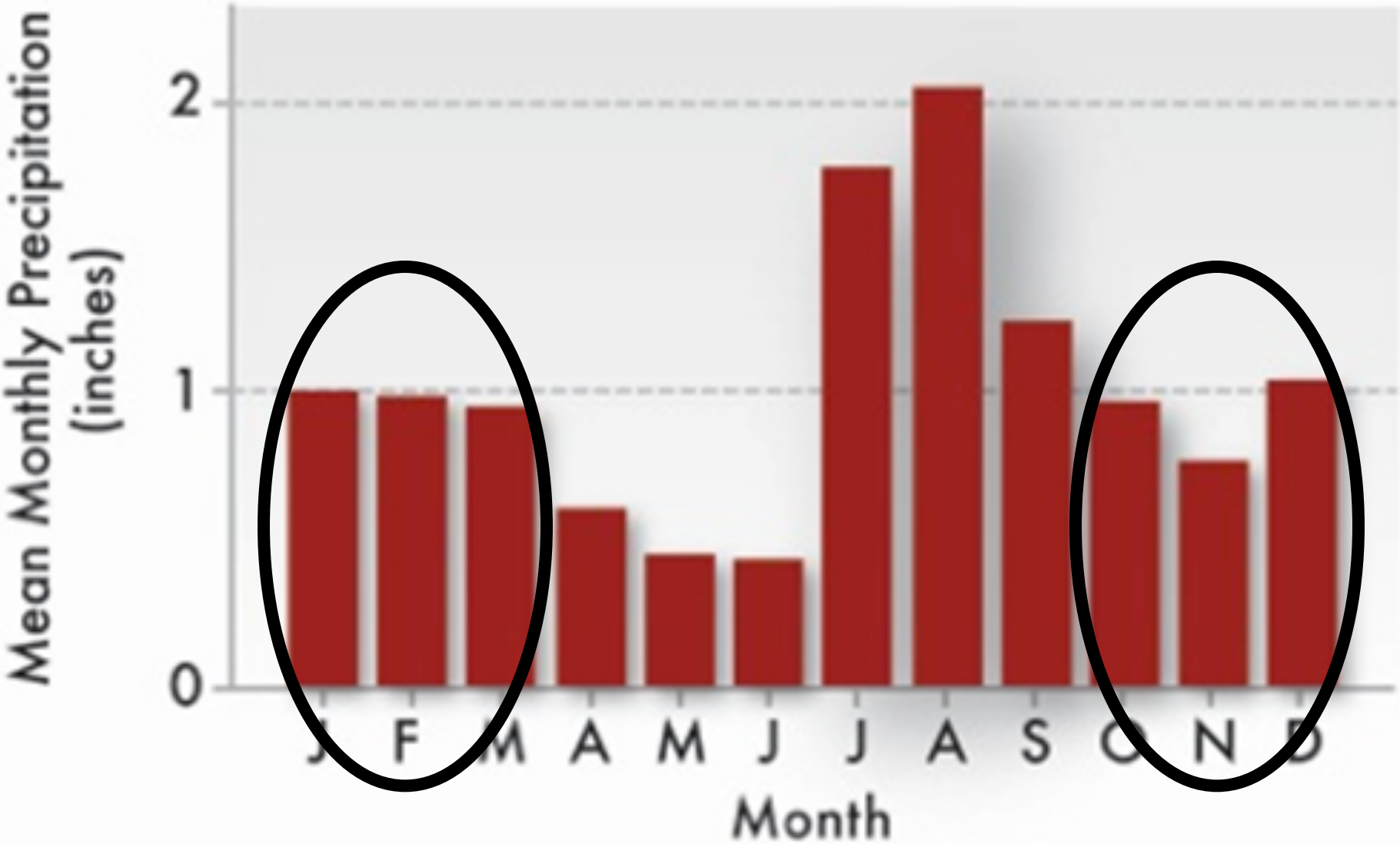
Institute of the Environment

CLIMAS
Climate Assessment for the Southwest

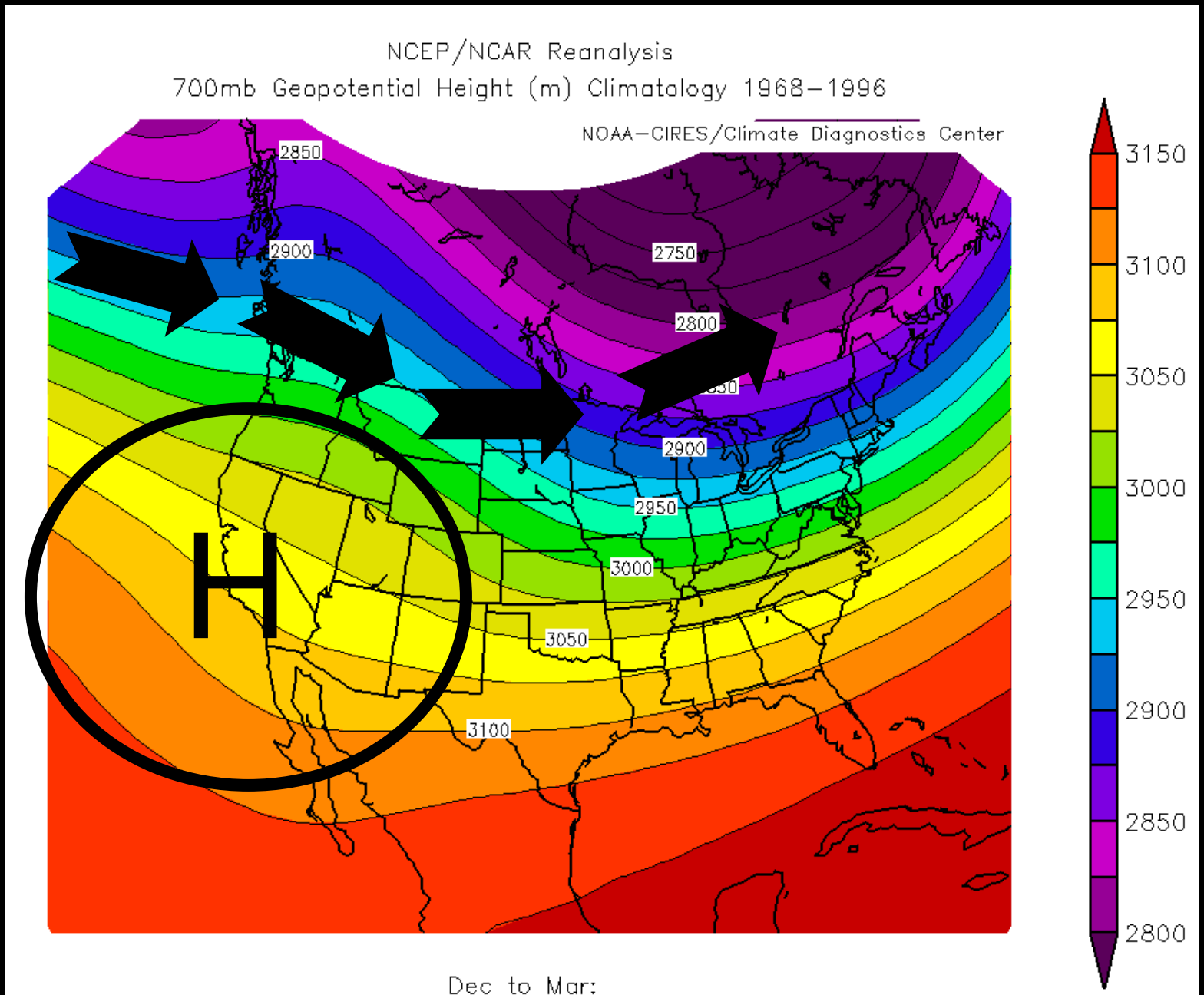
- AZ climate basics
- Observations
- Projections

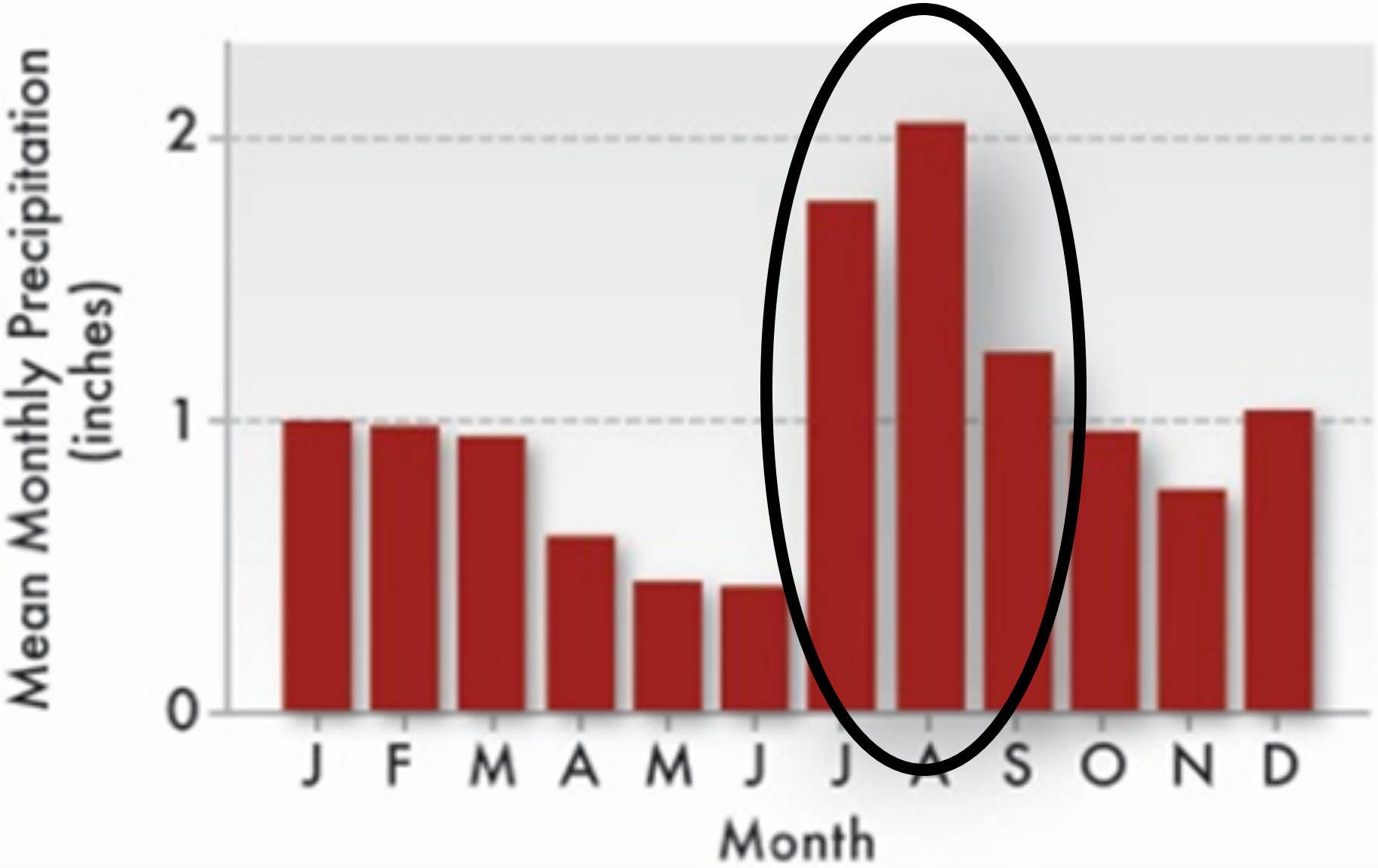
Arizona Climograph



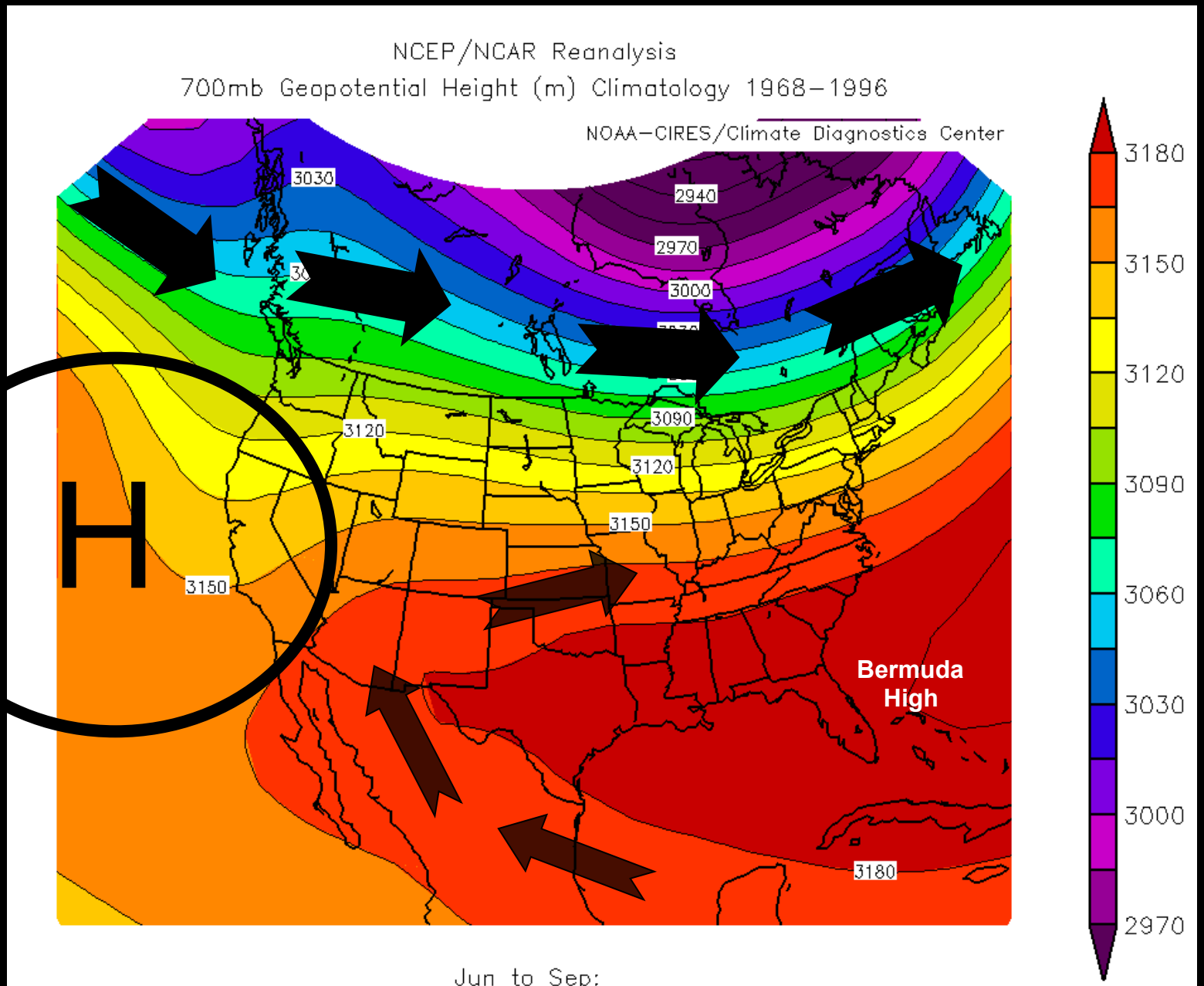

Mean Monthly Precipitation (inches)
2
1
0
J
F
M
A
M
J
J
A
S
O
N
D
Month

Winter


NCEP/NCAR Reanalysis
700mb Geopotential Height (m) Climatology 1968-1996
NOAA-CIRES/Climate Diagnostics Center
2850
2900
2750
2800
2900
2950
3000
3050
3100
H
3150
3100
3050
3000
2950
2900
2850
2800
Dec to Mar:


Mean Monthly Precipitation (inches)
2
1
0
J F M A M J J A S O N D
Month

Summer


NCEP/NCAR Reanalysis
700mb Geopotential Height (m) Climatology 1968–1996
NOAA–CIRES/Climate Diagnostics Center
3030
2940
2970
3000
3090
3120
3120
3150
3150
H
Bermuda High
3180
3180
3150
3120
3090
3060
3030
3000
2970
Jun to Sep:

Towering cumulonimbus clouds

Photograph by Corbis Premium Collection/Alamy

NATIONAL GEOGRAPHIC

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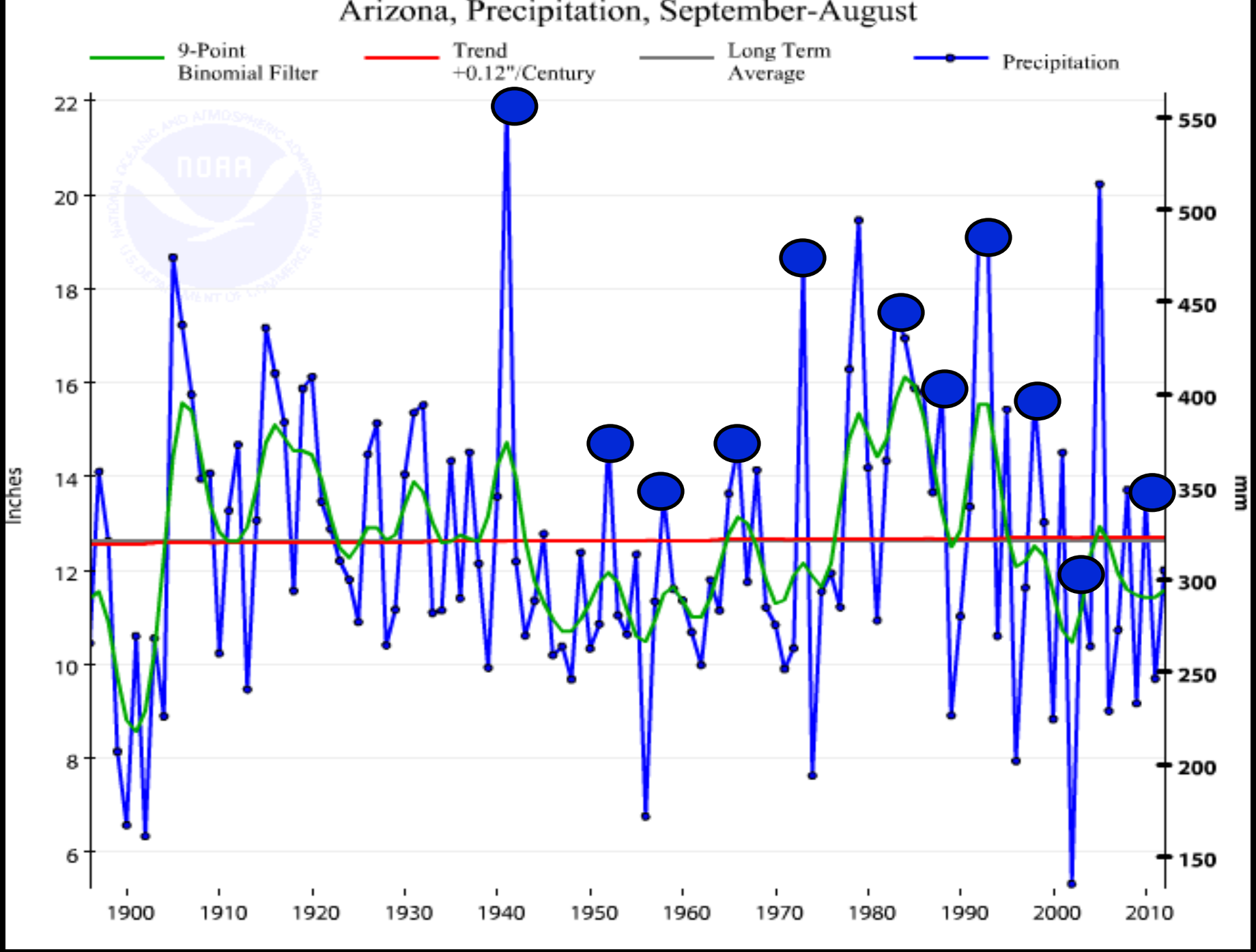
Arizona, Precipitation, September-August
9-Point Binomial Filter
Trend +0.12"/Century
Long Term Average
Precipitation
Inches
mm
22
20
18
16
14
12
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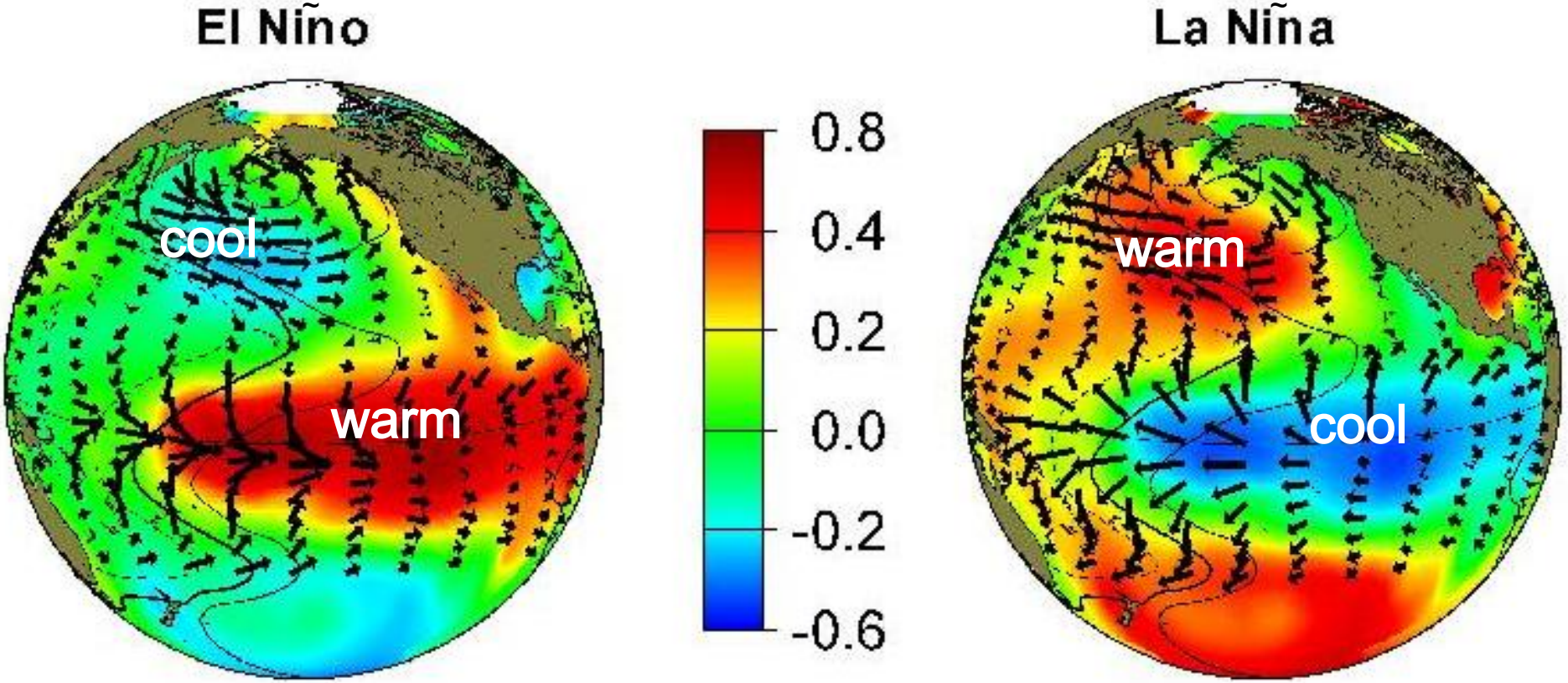
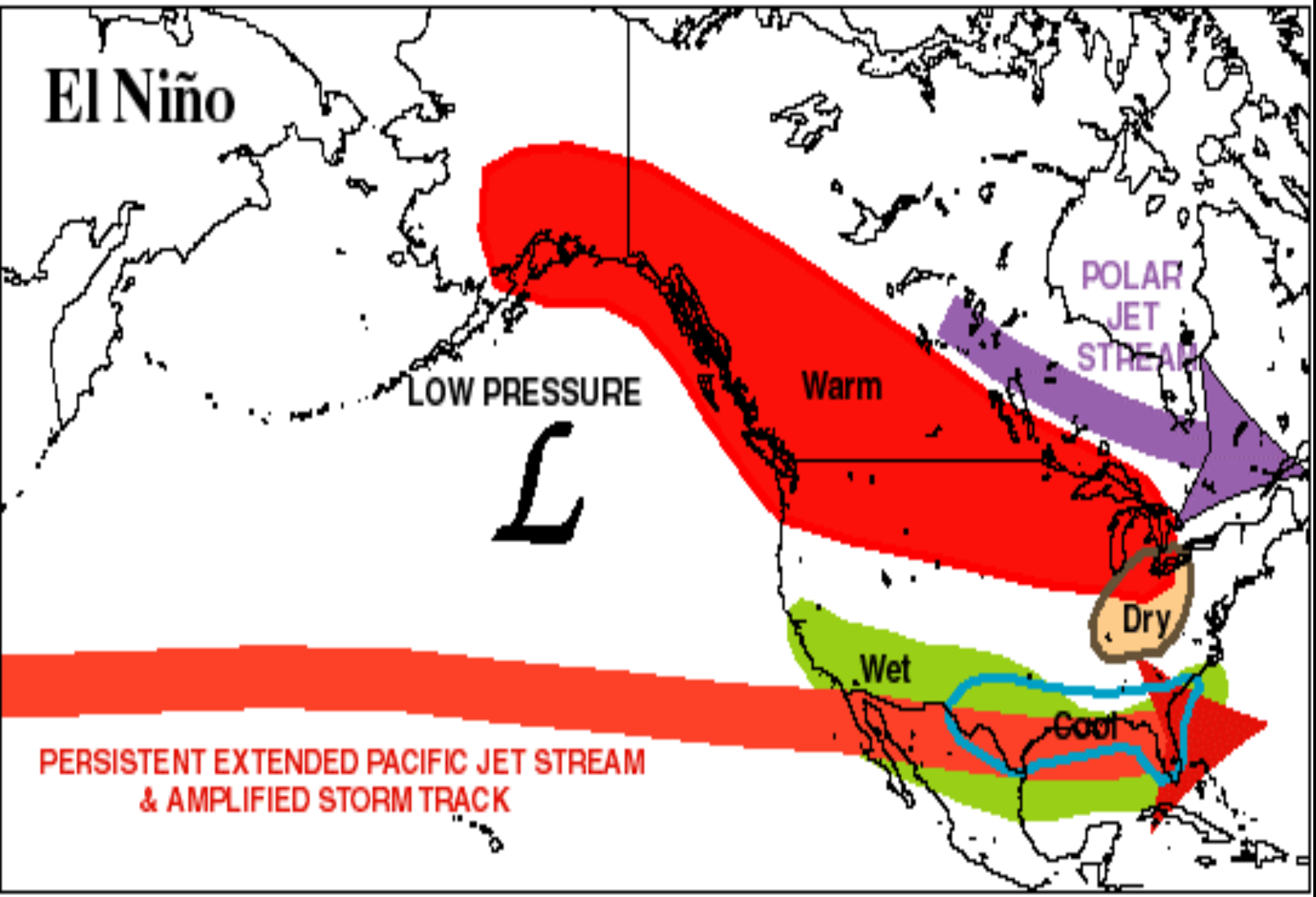
2010

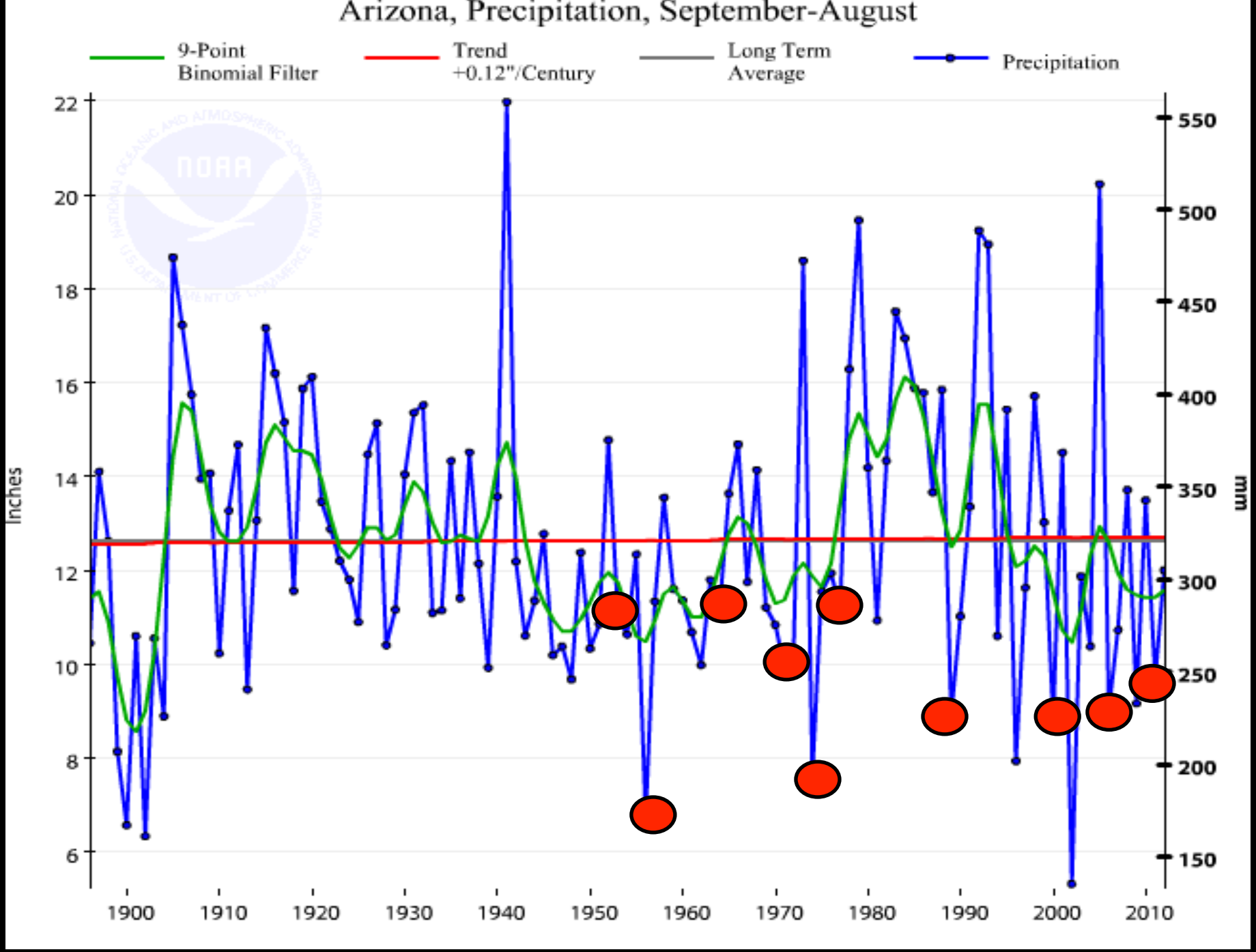
El Niño-Southern Oscillation (ENSO)



Slide courtesy of Greg McCabe, USGS



Source: NOAA Climate Prediction Center http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensocycle/winter25%25.gif


Arizona, Precipitation, September-August
9-Point Binomial Filter
Trend +0.12"/Century
Long Term Average
Precipitation
Inches
mm
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18
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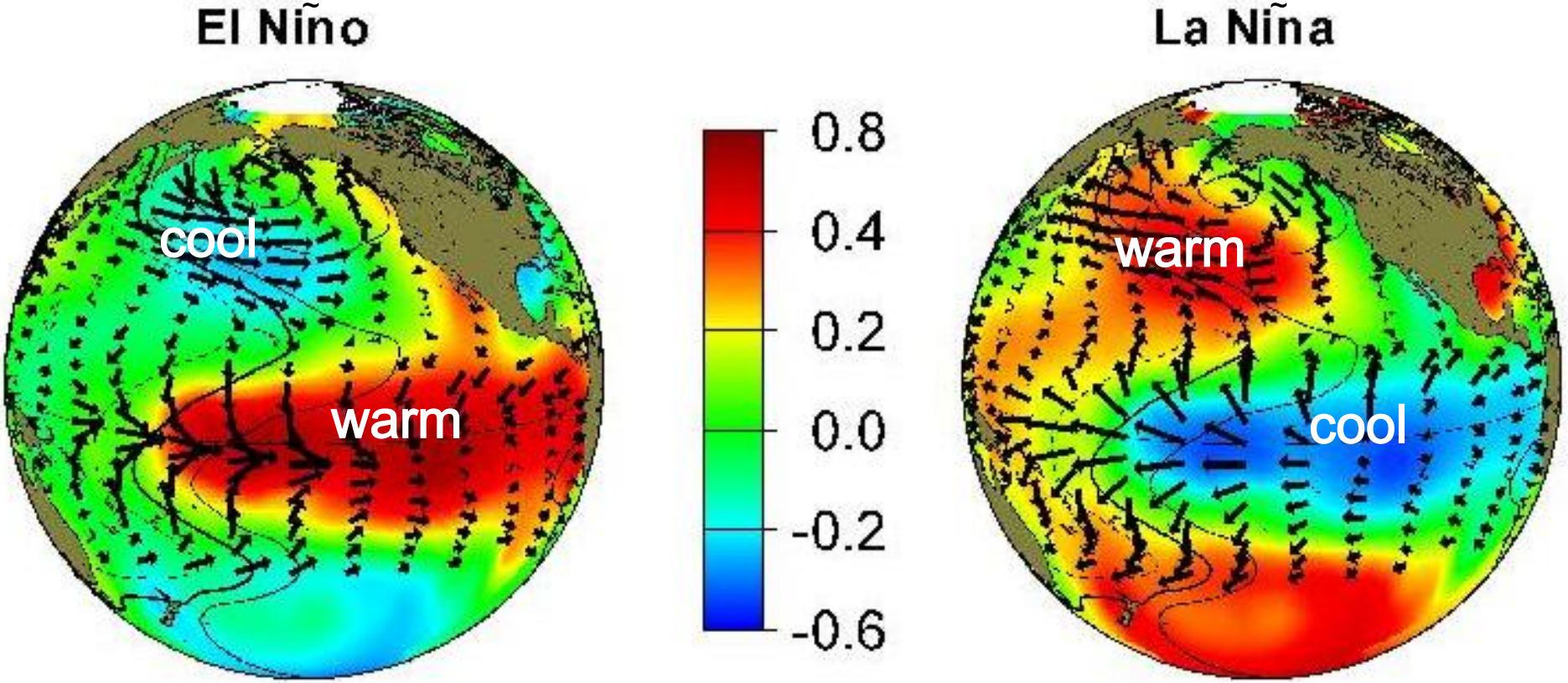
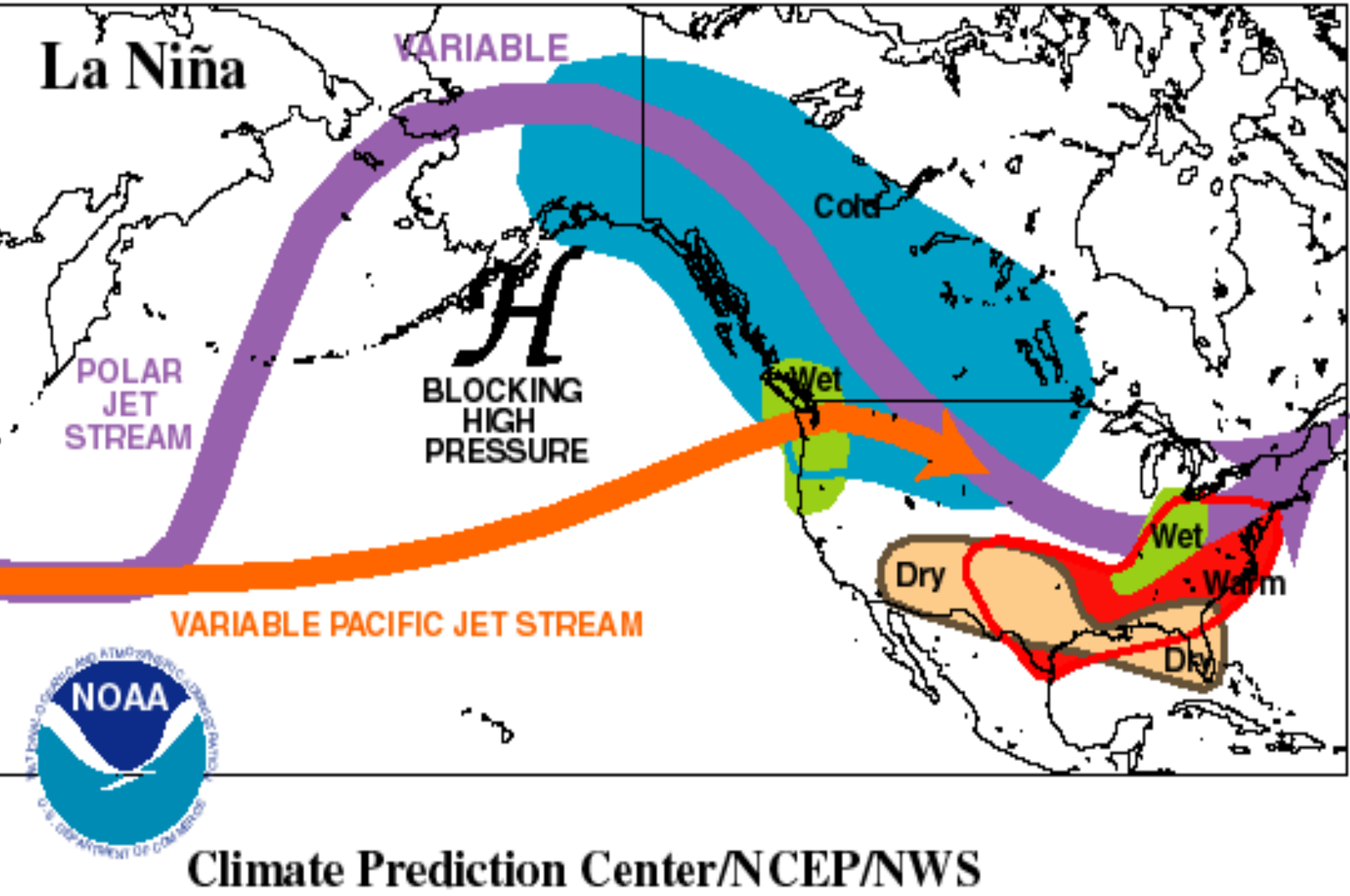
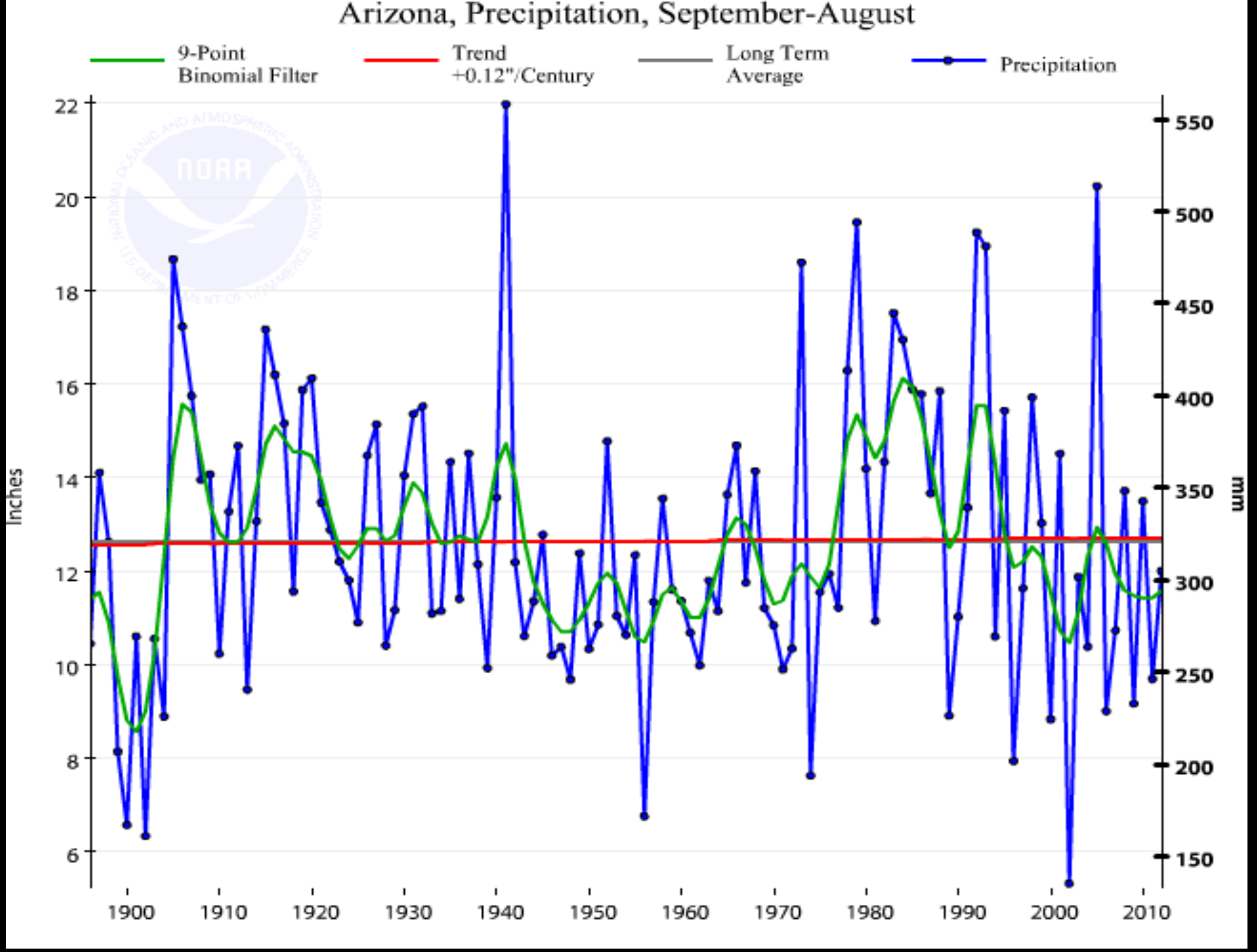
El Niño-Southern Oscillation (ENSO)



Slide courtesy of Greg McCabe, USGS



Source: NOAA Climate Prediction Center http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensocycle/winter25%25.gif


Arizona, Precipitation, September-August
9-Point Binomial Filter
Trend +0.12"/Century
Long Term Average
Precipitation
Inches
mm
22
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18
16
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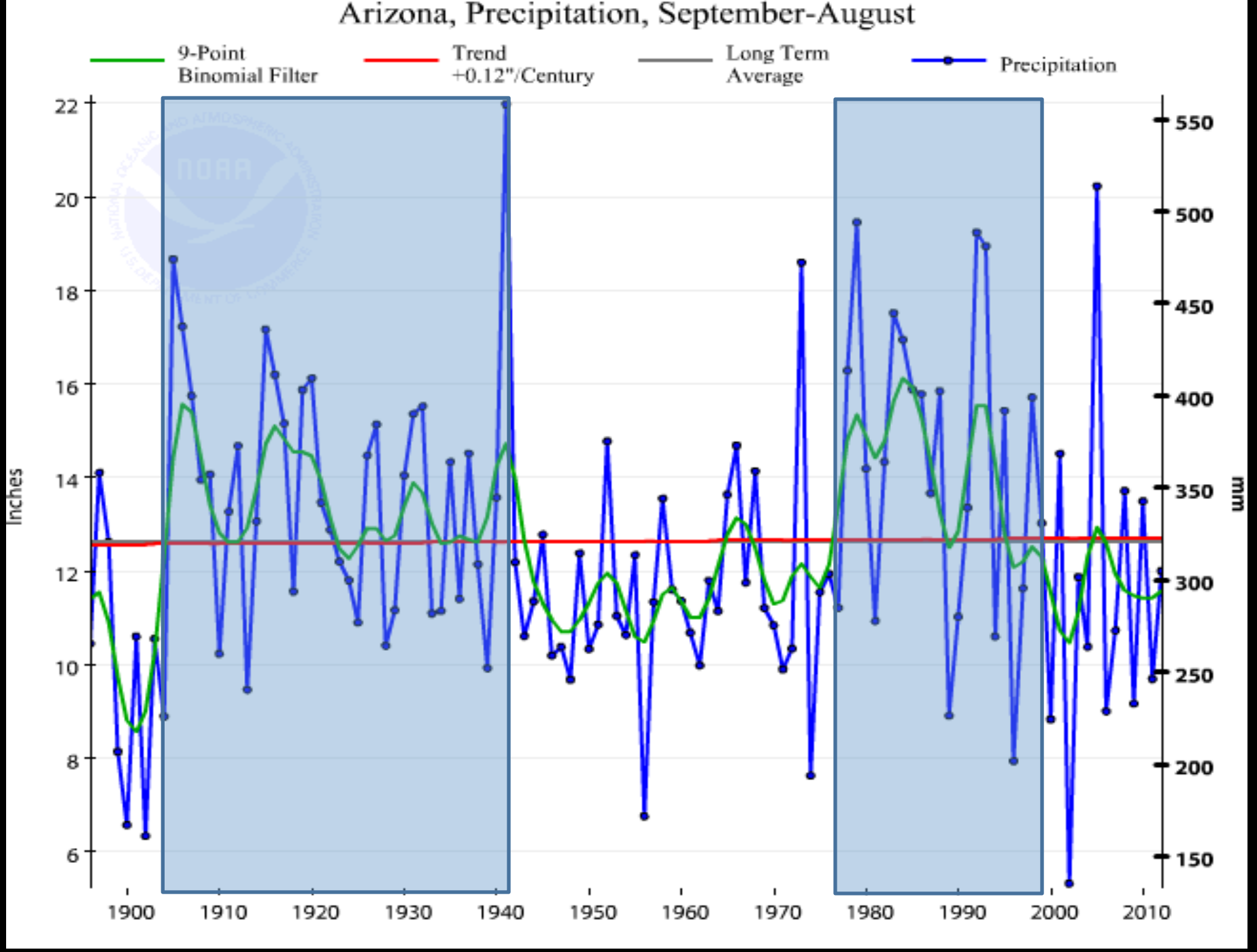
Arizona, Precipitation, September-August
9-Point Binomial Filter
Trend +0.12"/Century
Long Term Average
Precipitation
Inches
mm
22
20
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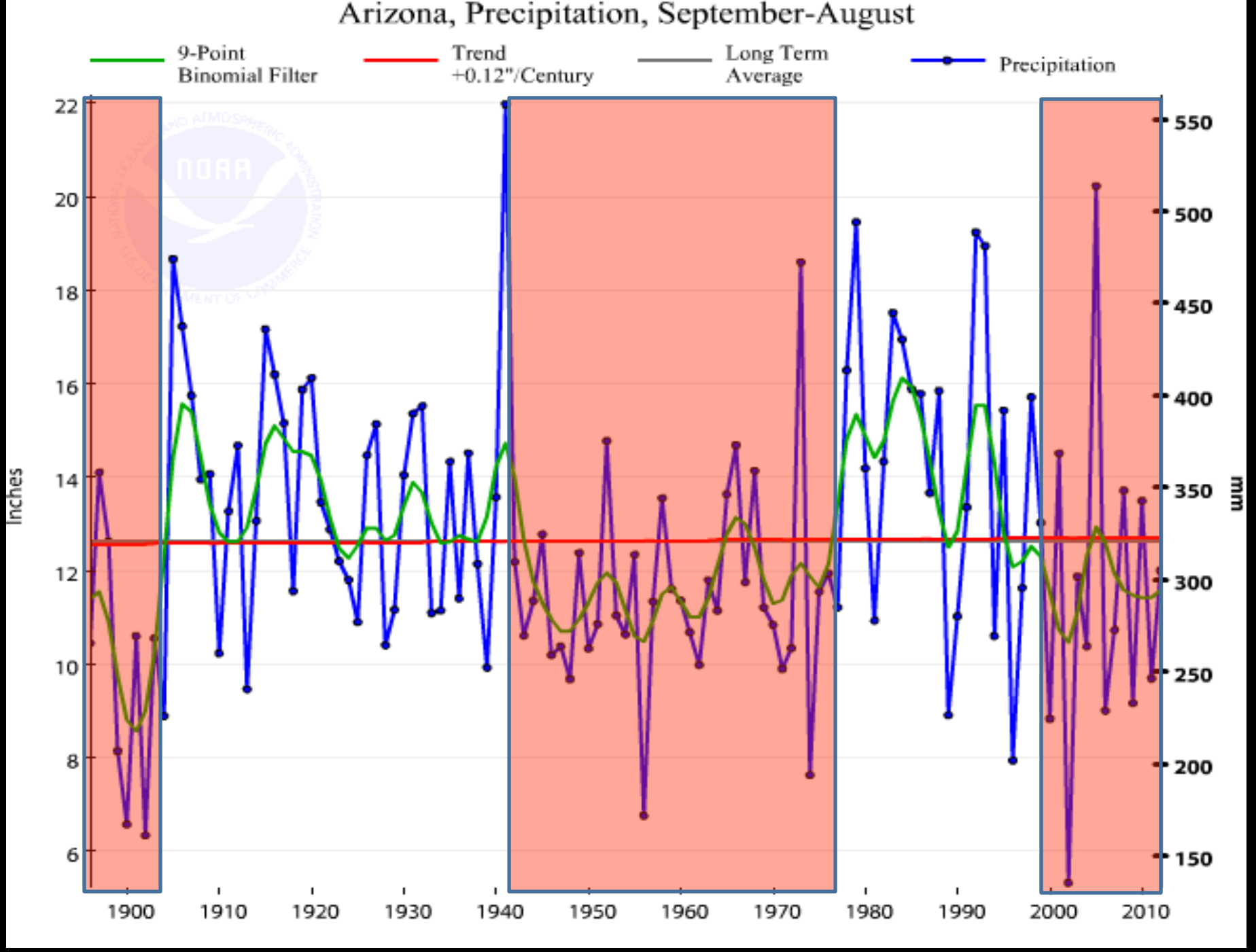
Arizona, Precipitation, September-August
9-Point Binomial Filter
Trend +0.12"/Century
Long Term Average
Precipitation
Inches
mm
22
20
18
16
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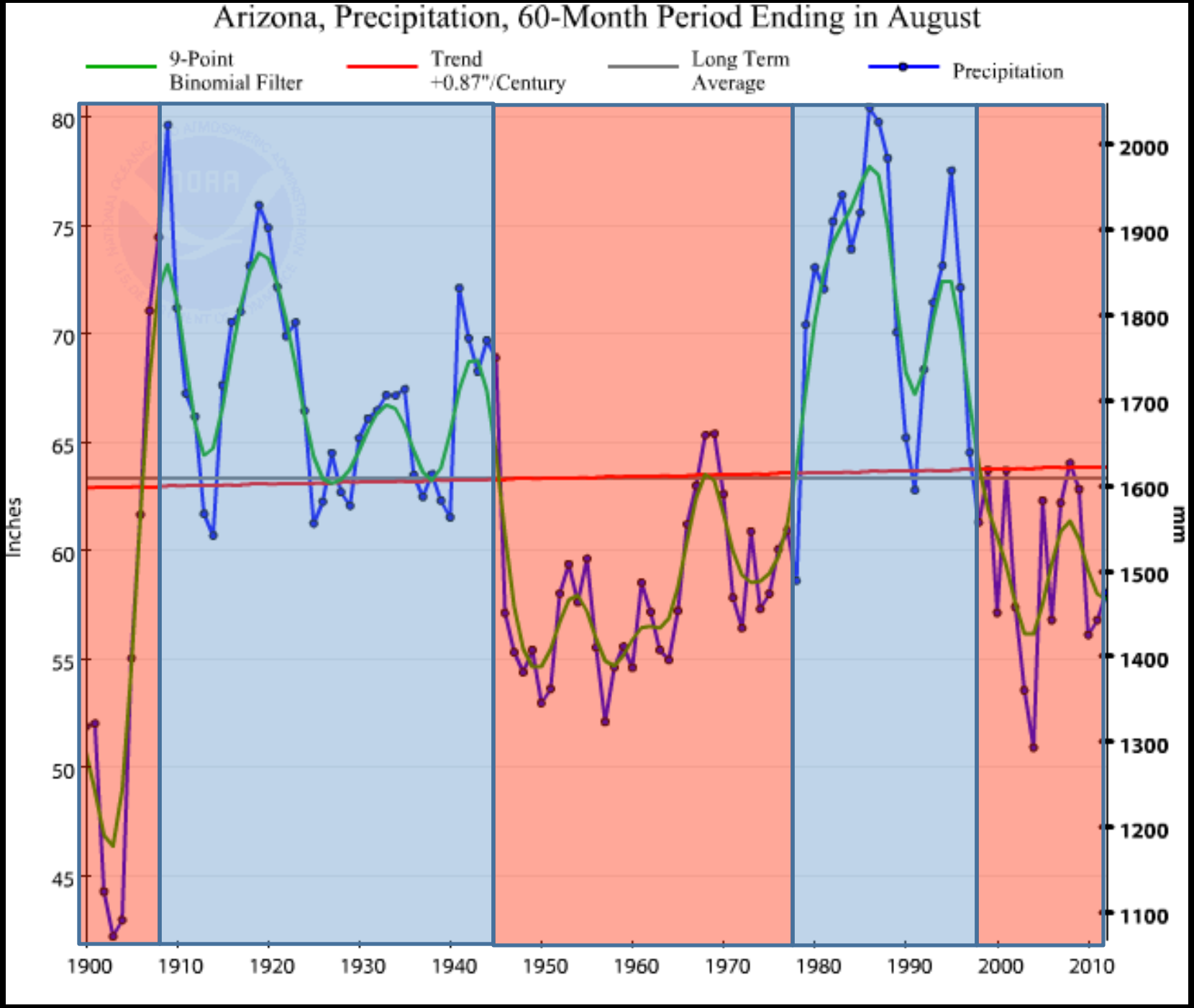
Arizona, Precipitation, 60-Month Period Ending in August
9-Point Binomial Filter
Trend +0.87"/Century
Long Term Average
Precipitation
Inches
mm
80
75
70
65
60
55
50
45
2000
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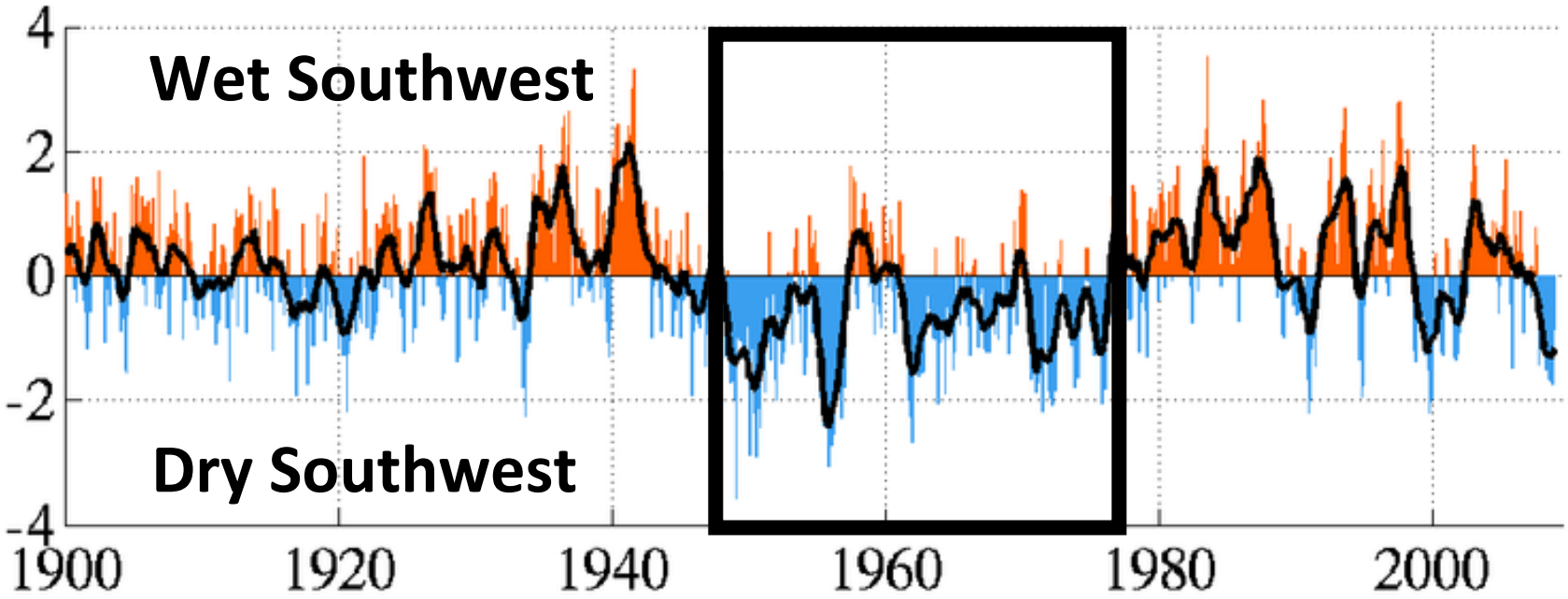
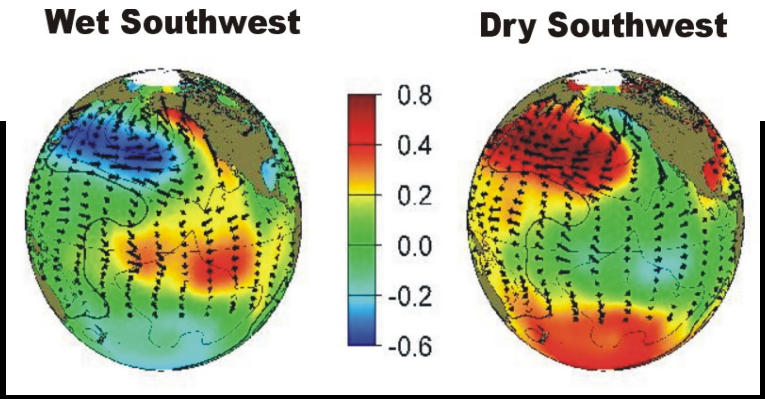
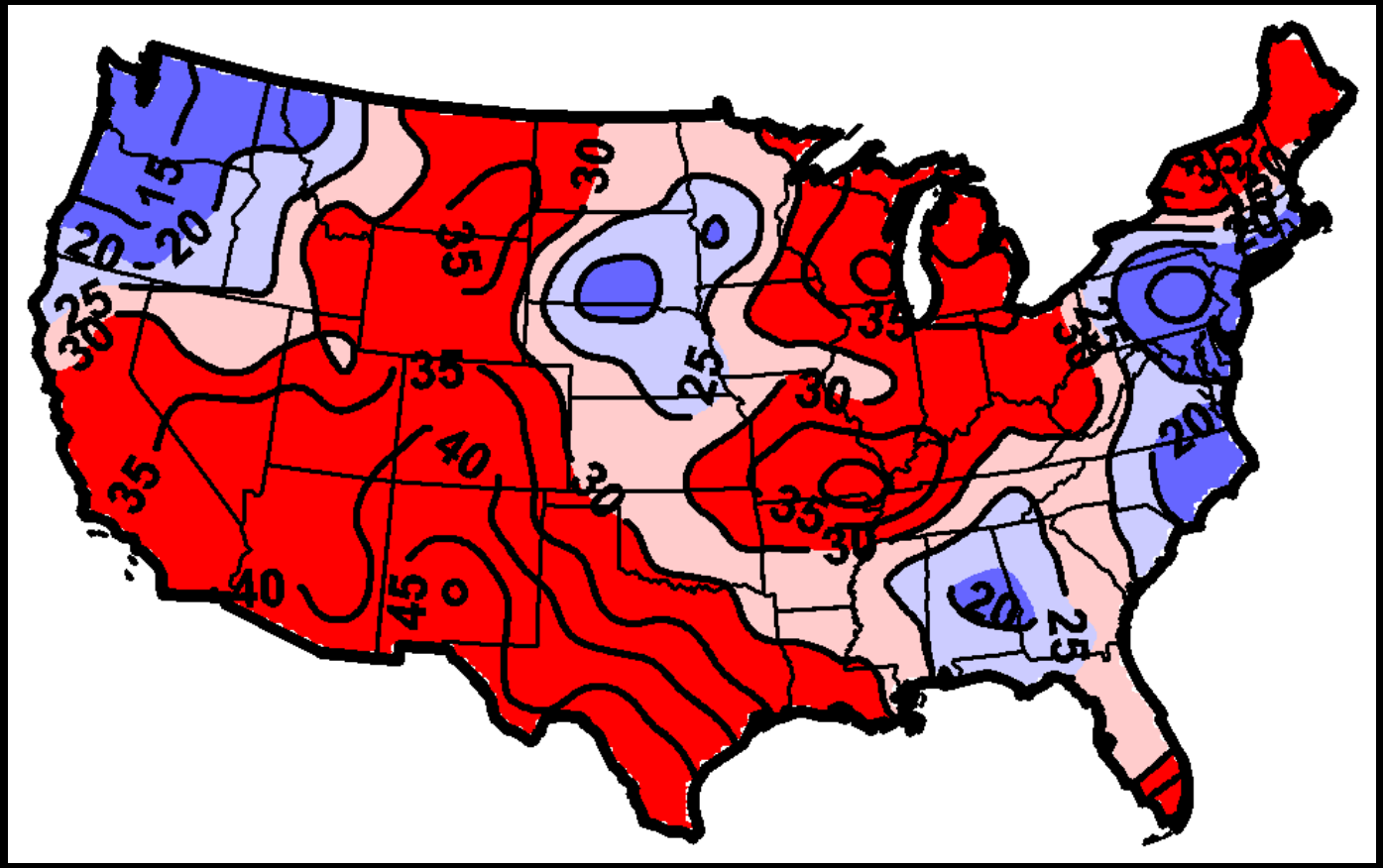
Pacific Decadal Variability - PDO





Joint Institute for the Study of the Atmosphere and Ocean
http://jisao.washington.edu/pdo/

Drought Frequency % (25 = expected)

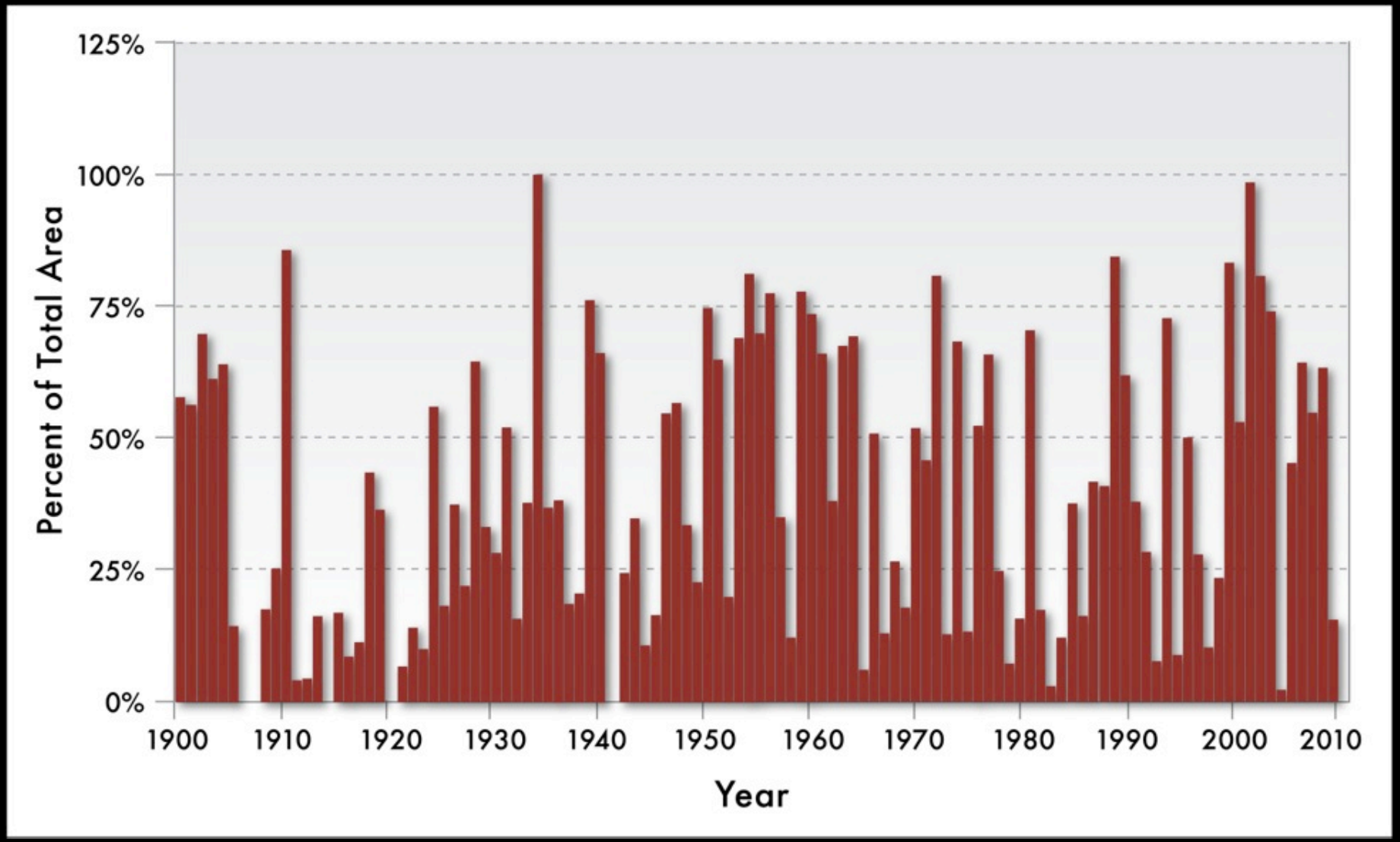


high drought frequency

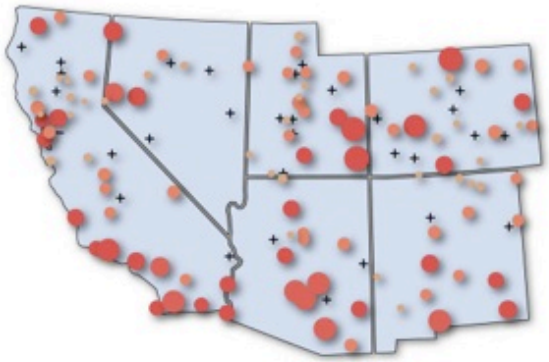
low drought frequency

McCabe et al., 2004 Proceedings of the National Academy of Sciences

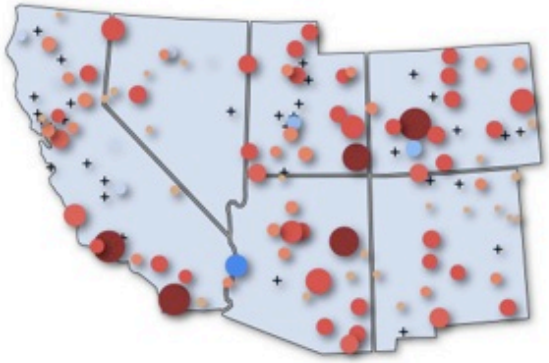
Areal drought coverage: 1900-2010



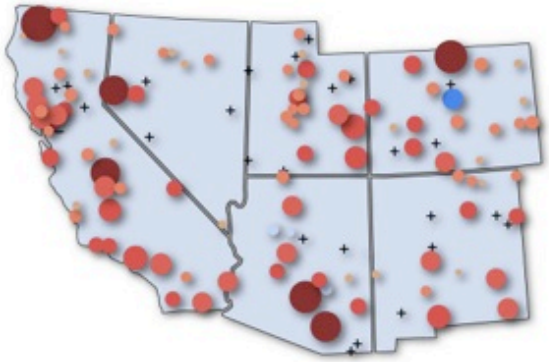
TAVG Trend

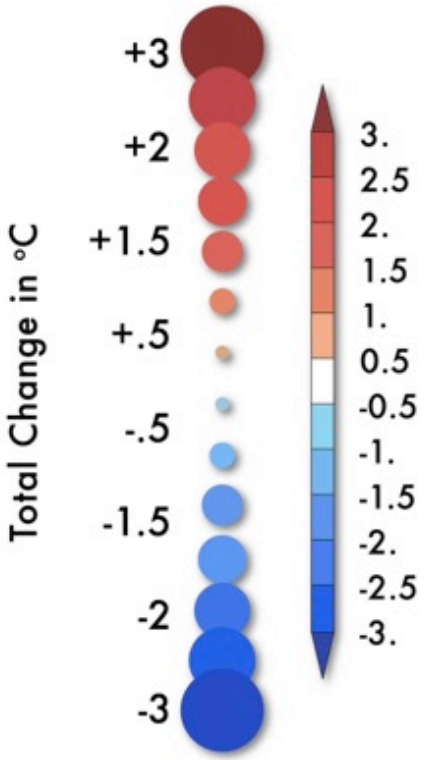


TMAX Trend



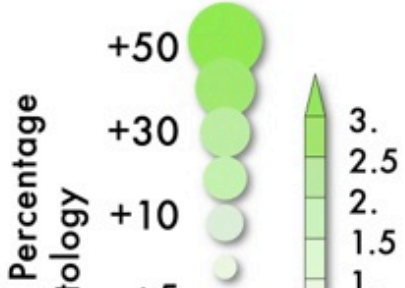
TMIN Trend

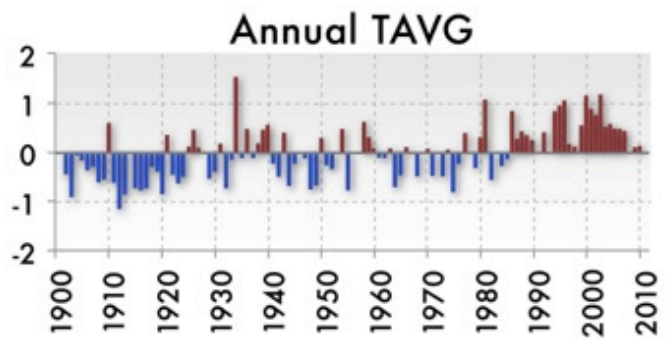


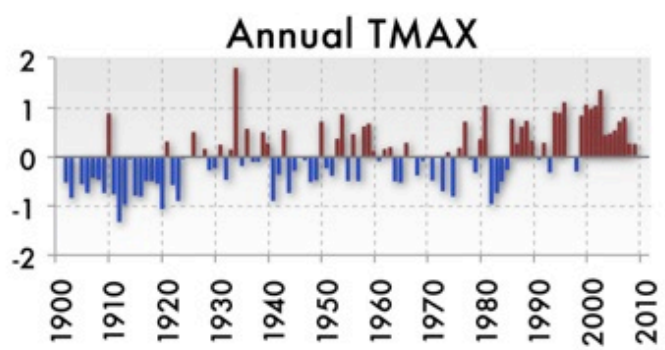


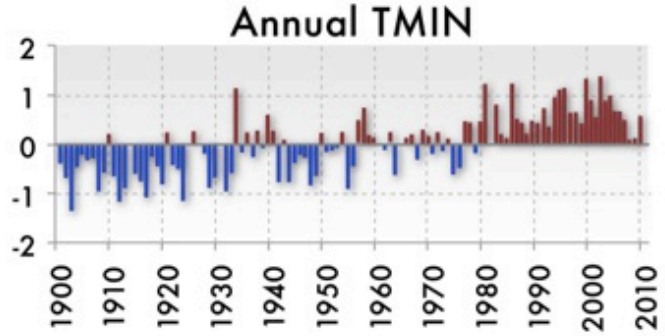
Significant Trends at 95% confidence based on a parametric t-statistic

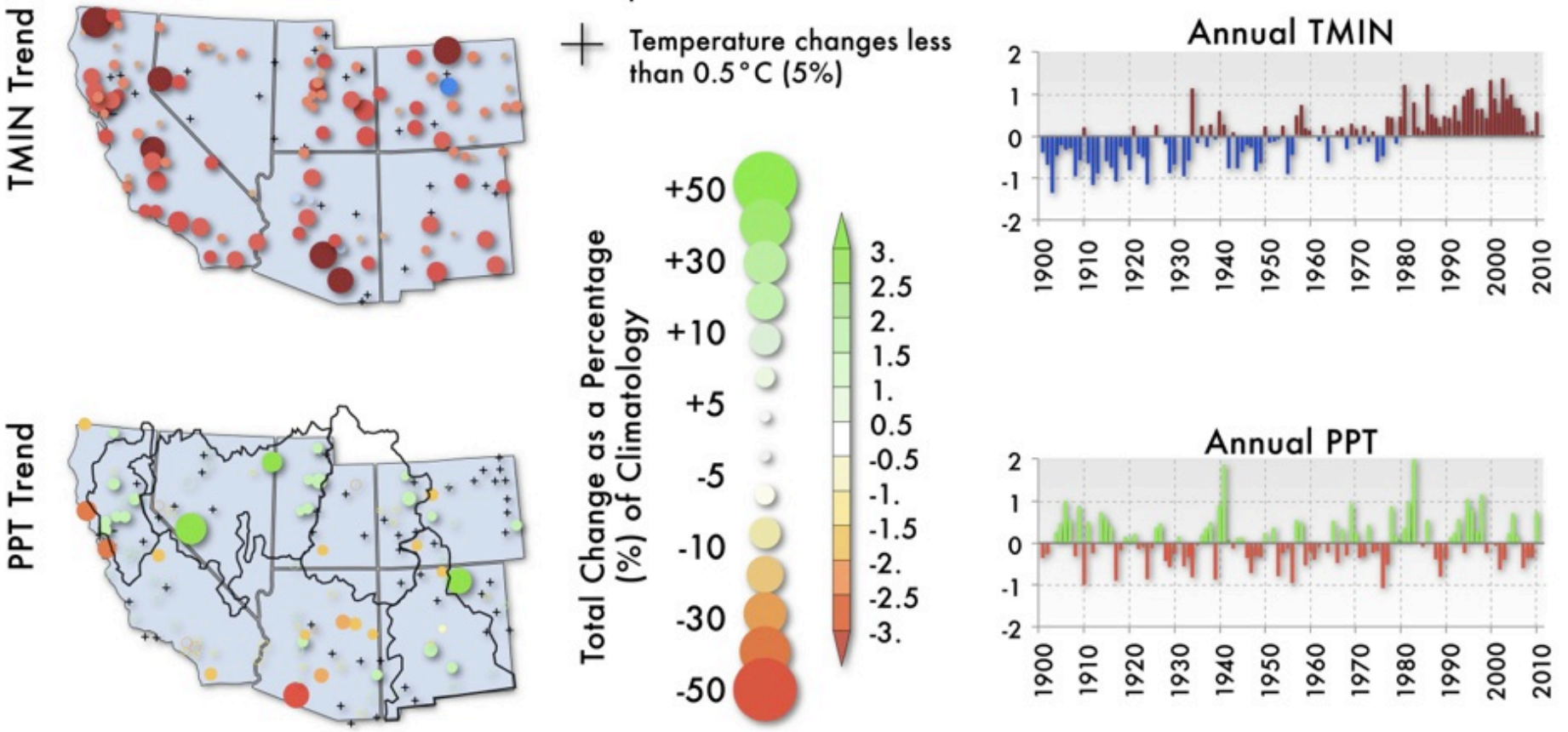
Temperature changes less than 0.5 °C (5%)










TMIN Trend
PPT Trend
Temperature changes less than 0.5°C (5%)
Total Change as a Percentage (%) of Climatology
+50
+30
+10
+5
-5
-10
-30
-50
3.
2.5
2.
1.5
1.
0.5
-0.5
-1.
-1.5
-2.
-2.5
-3.
Annual TMIN
Annual PPT
2
1
0
-1
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1900
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1980
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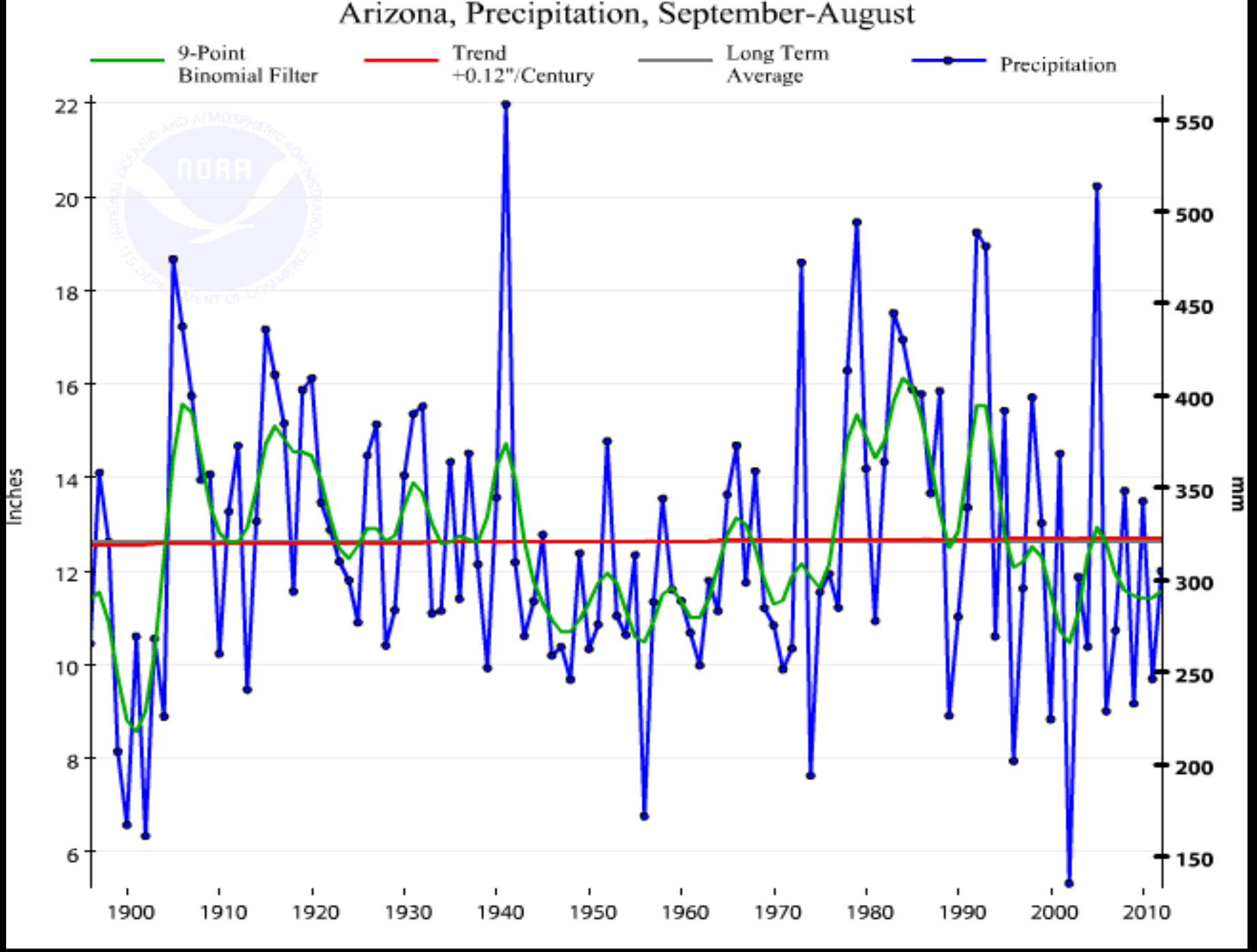
2000
2010


Arizona, Precipitation, September-August
9-Point Binomial Filter
Trend +0.12"/Century
Long Term Average
Precipitation
Inches
mm
22
20
18
16
14
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1900
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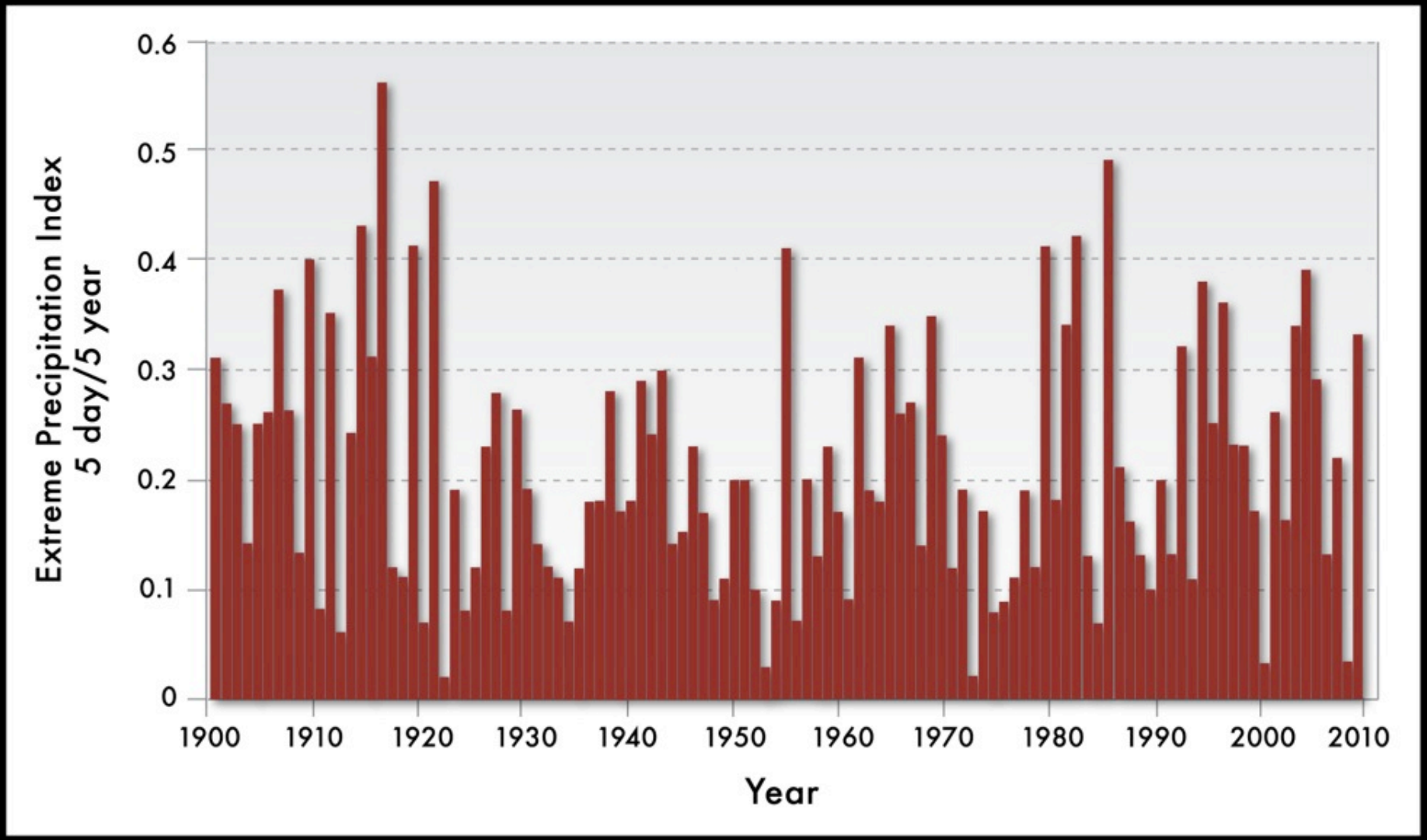
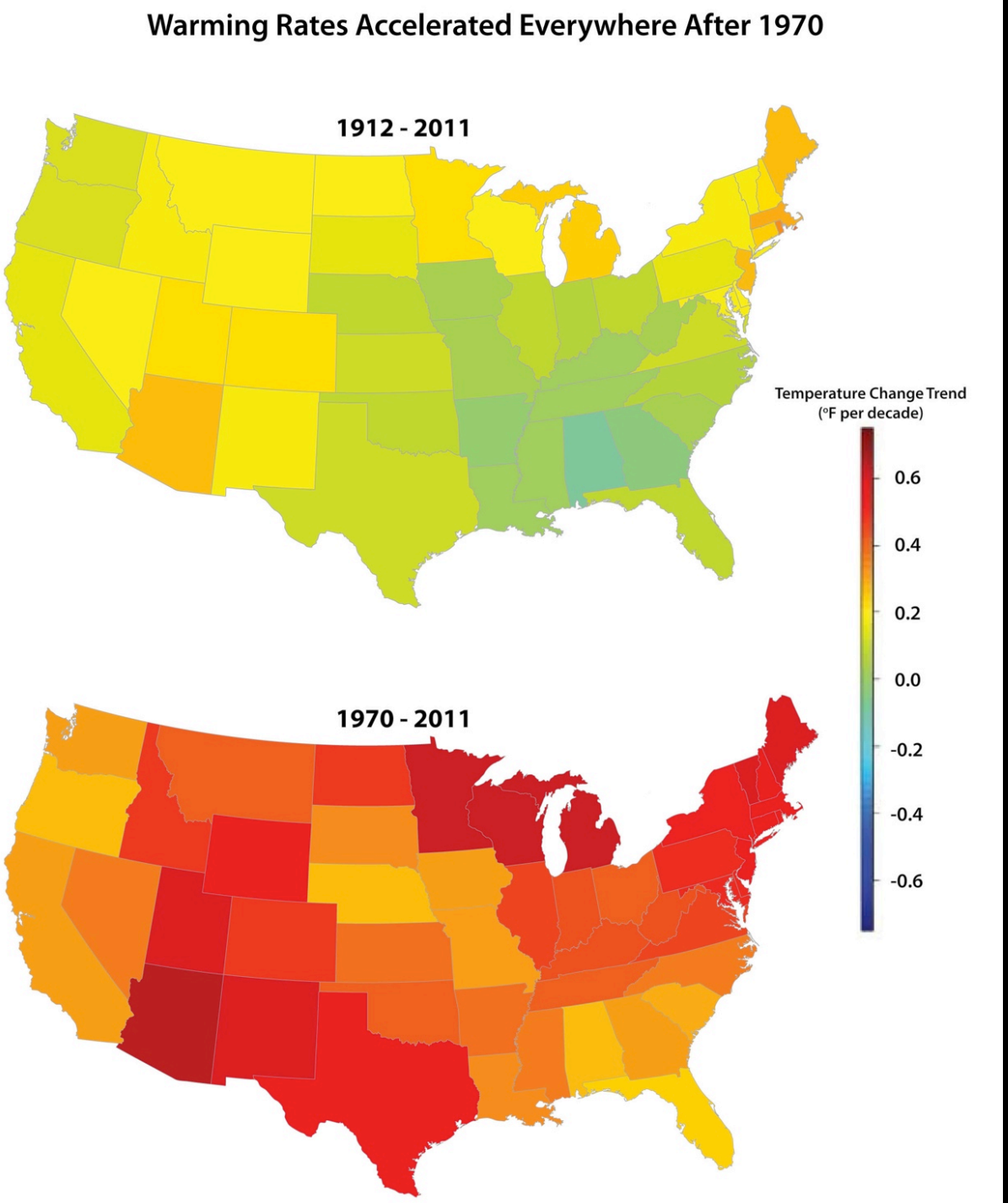
2000
2010

Extreme precipitation events: 1900-2010



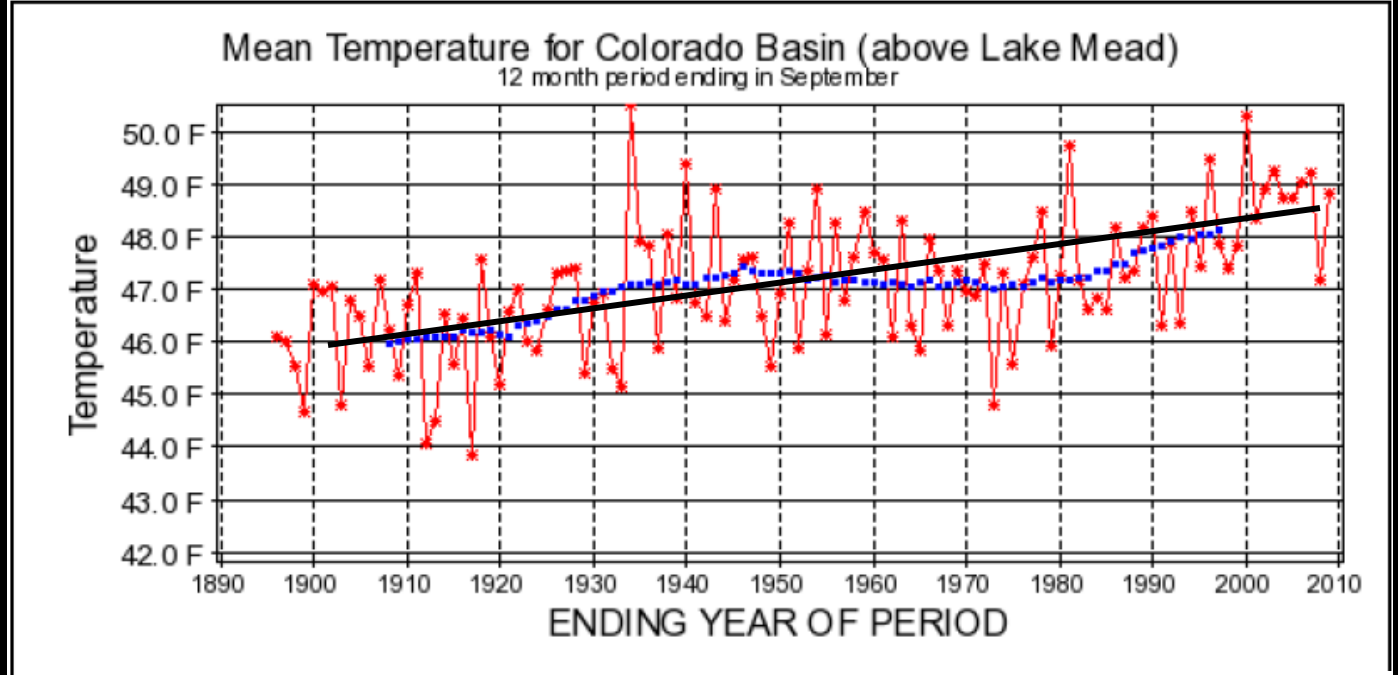


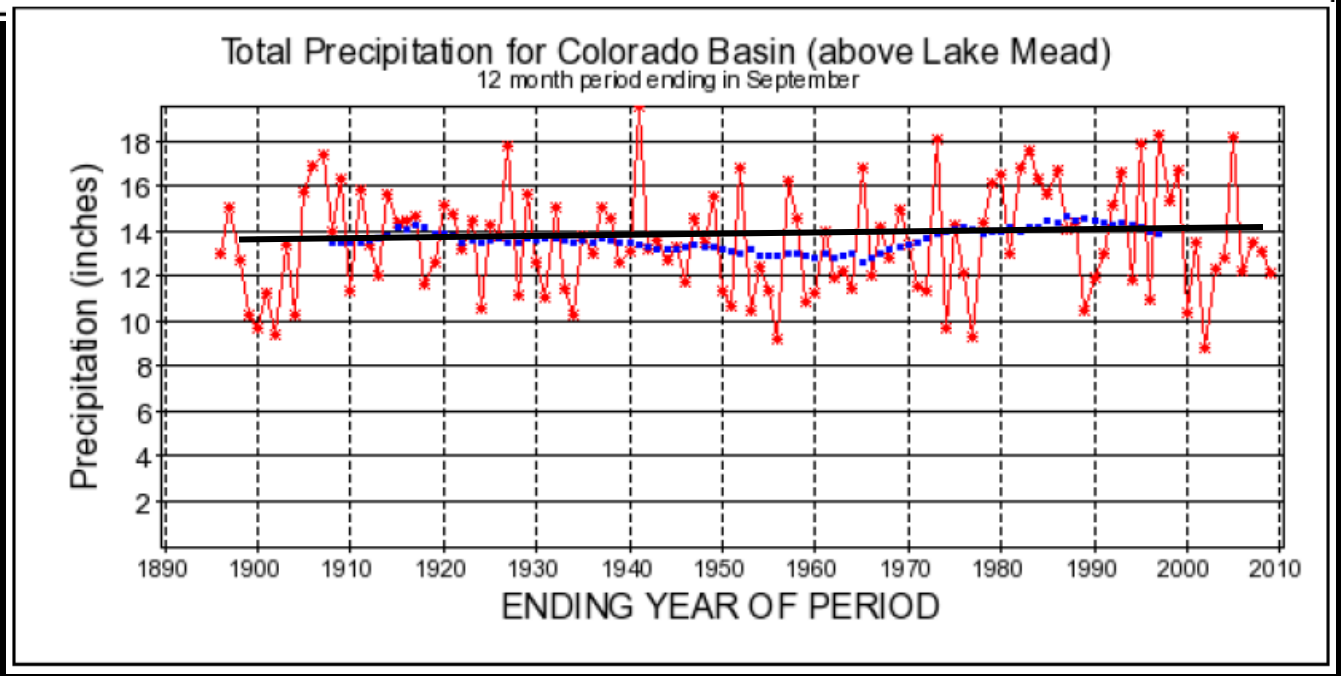
Arizona:

- Outpaced all other states

2001-2010

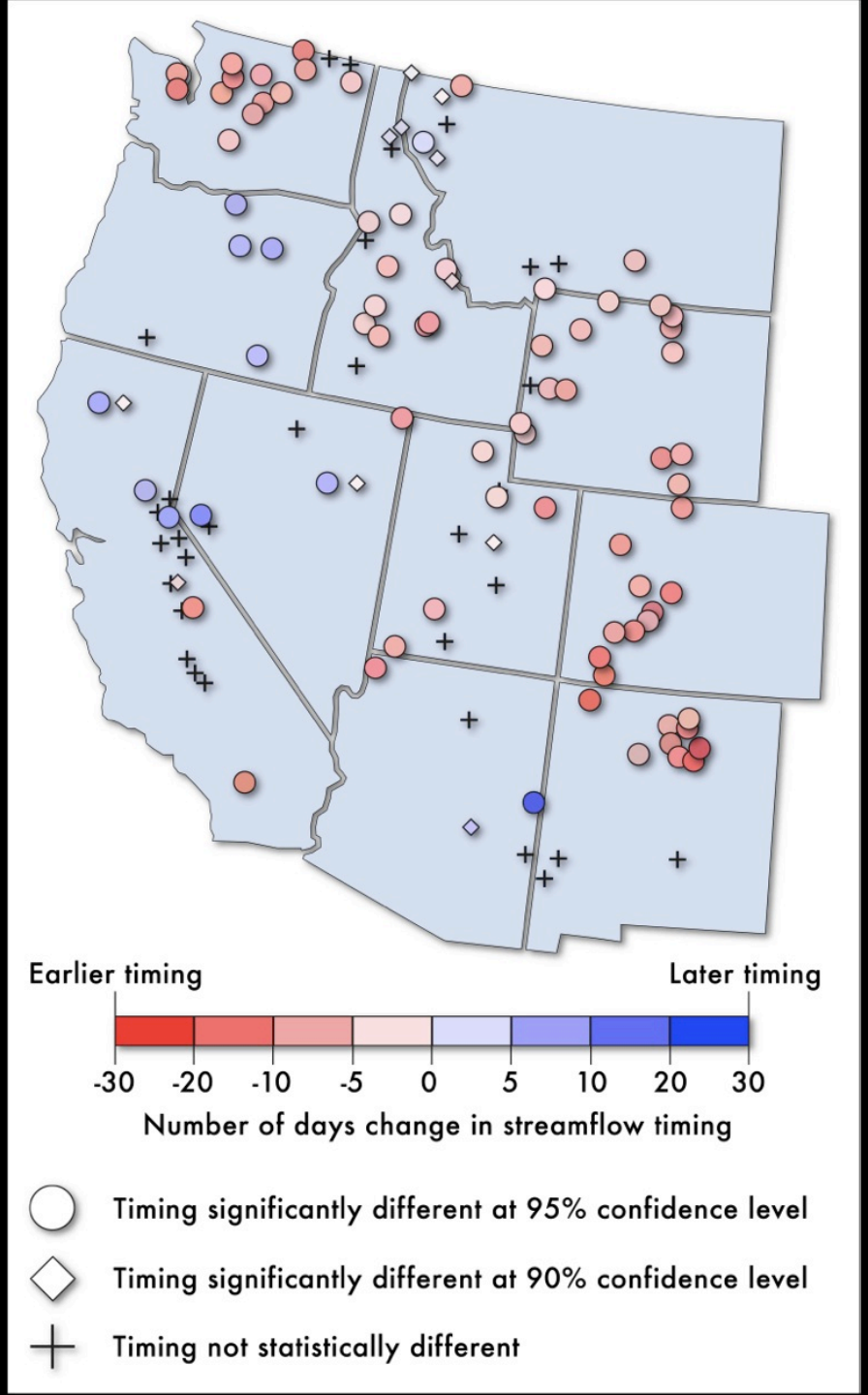
- Fewer cold waves
- More heat waves



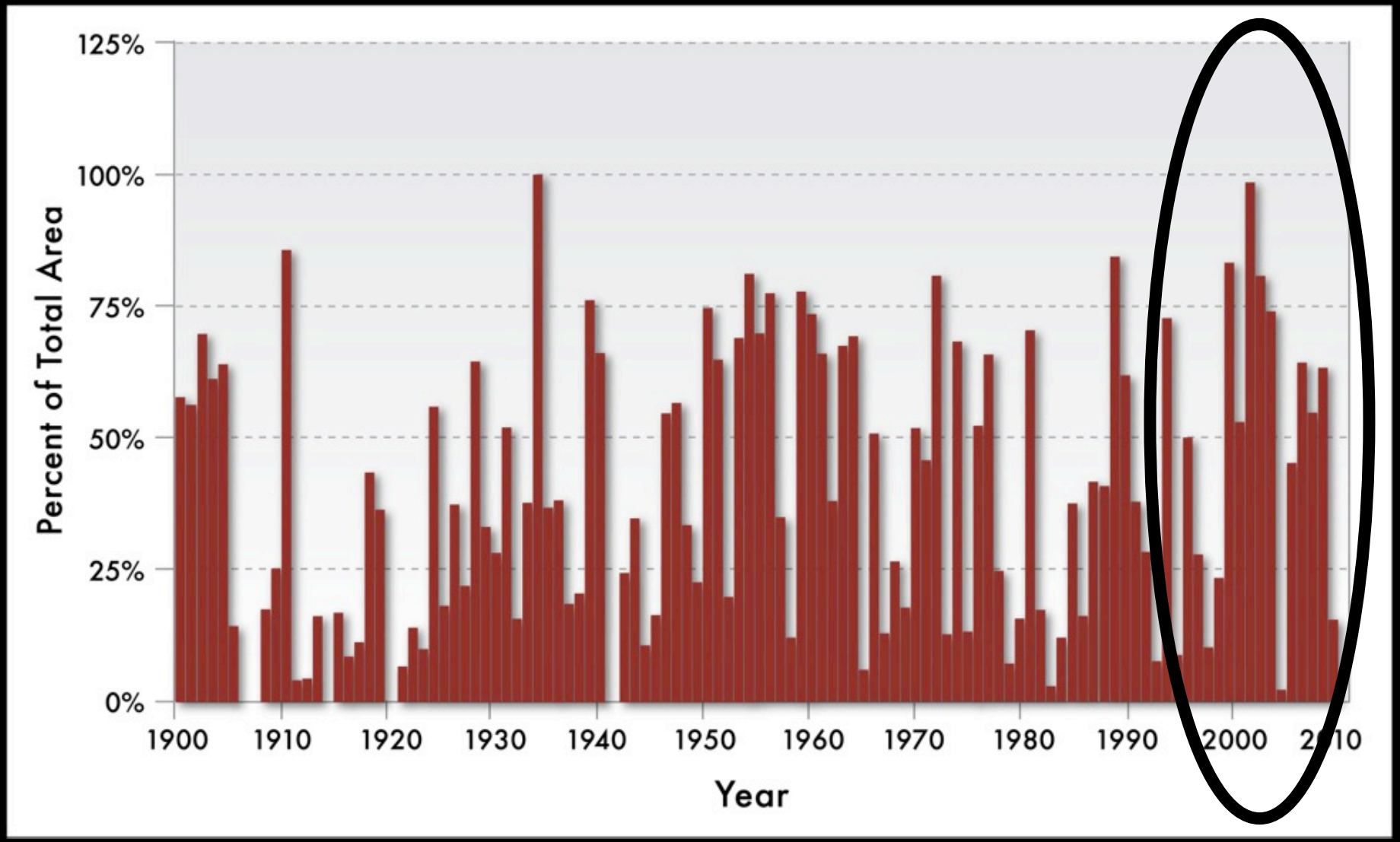


Reclamation – SECURE WATER Act Report, 2011

Changes in Streamflow Timing: 2000-2010 vs. 1950-2000



Areal drought coverage: 1900-2010



Massive pinyon pine dieback 2002-2004

Increased temperatures, decreased soil moisture, result in greater stress, longer insect breeding cycles. Once a threshold is crossed massive mortality occurs.

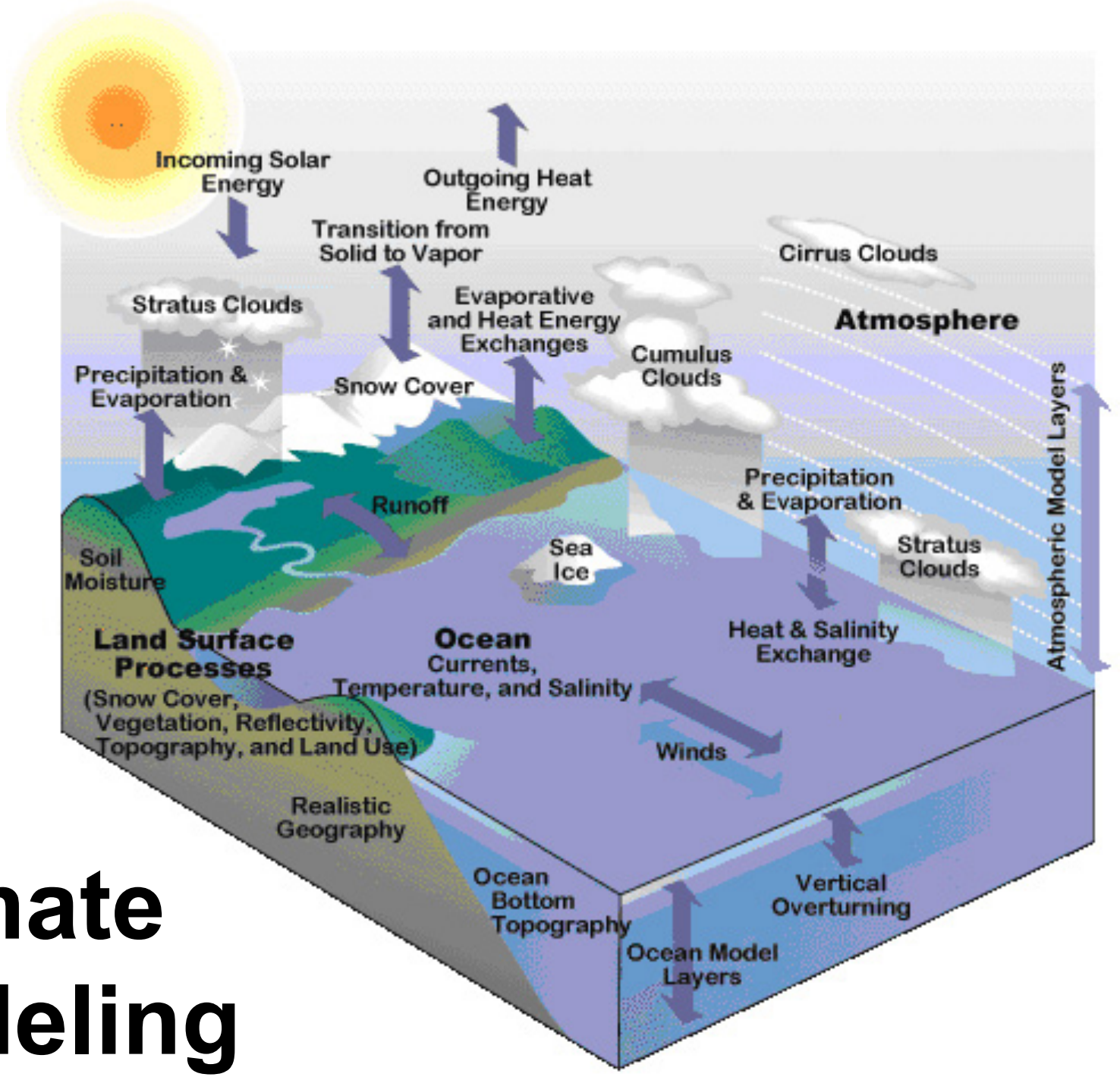
Near Flagstaff
N.S. Cobb

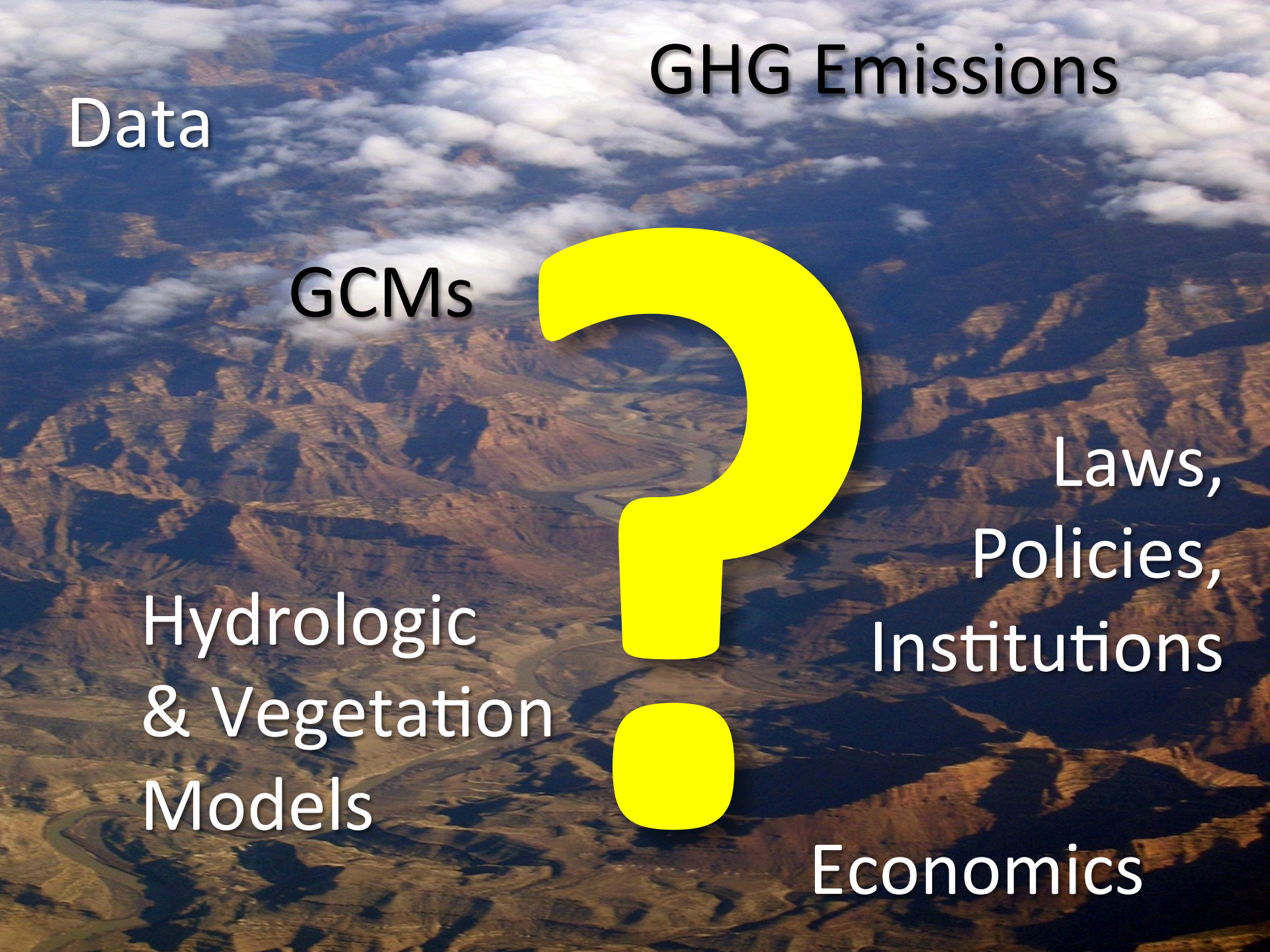
Westerling et al., 2006 *Science*

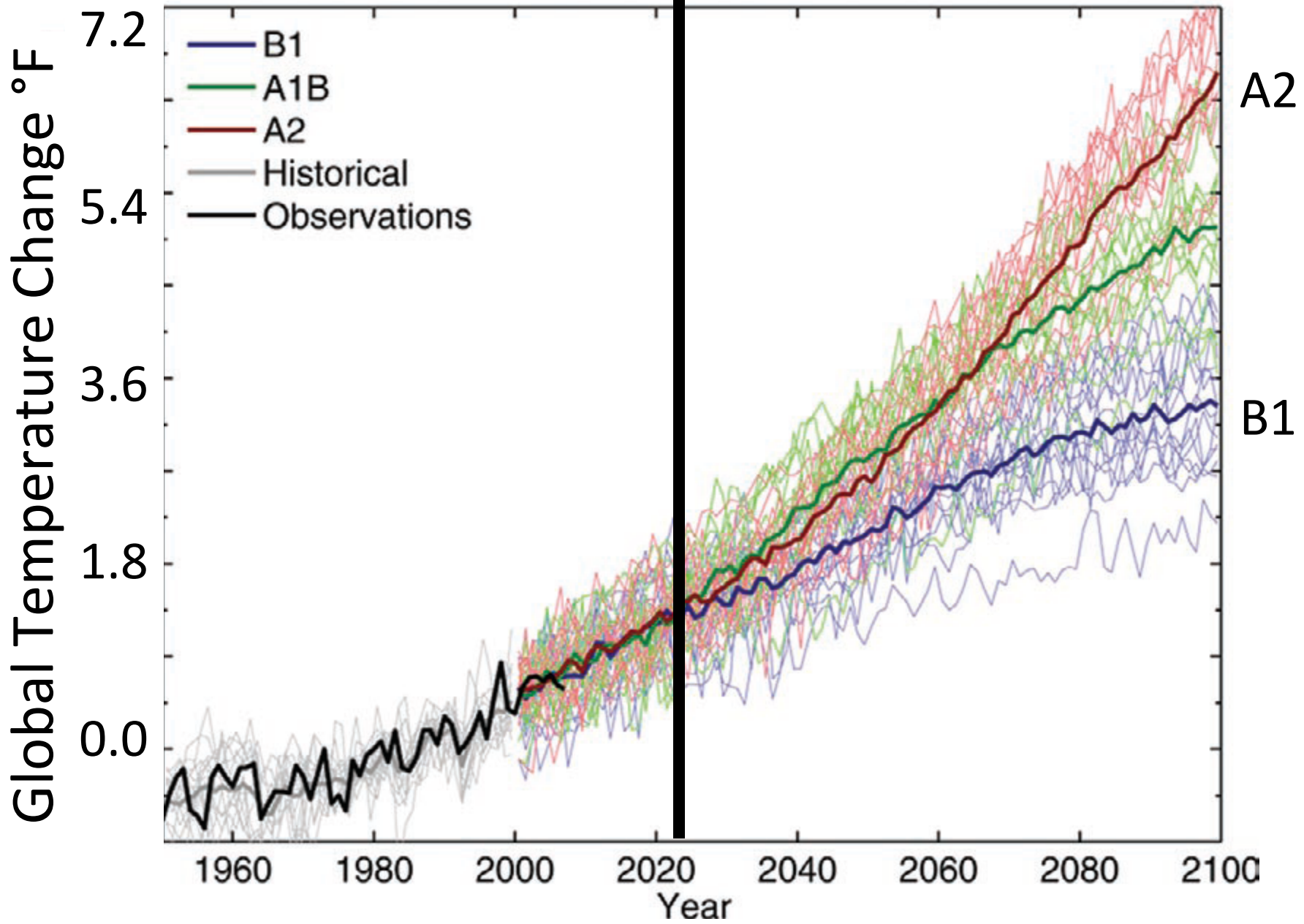
Temperature is a hydrologic variable

Climate Change Projections

Climate Modeling



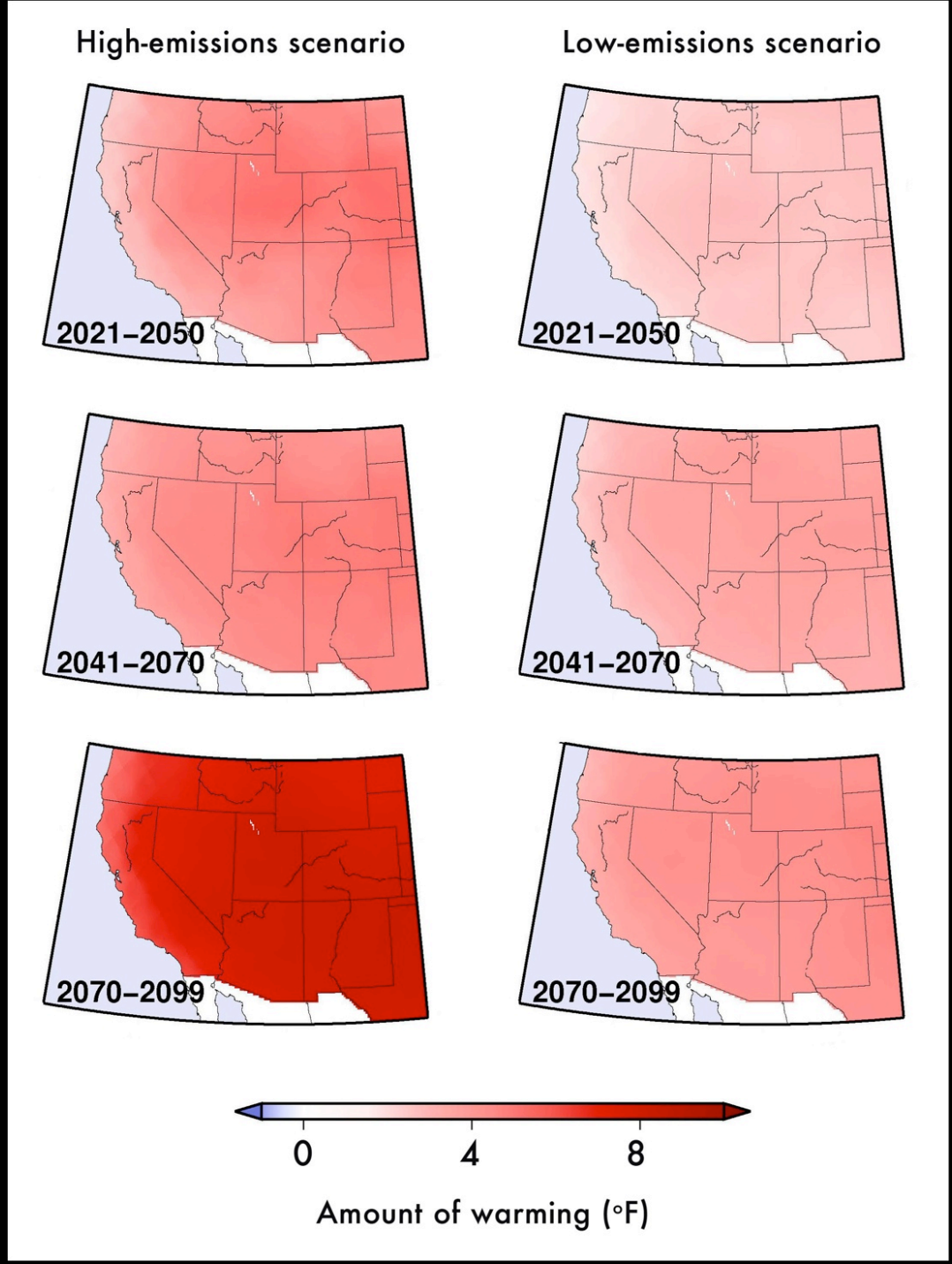

GHG Emissions
Data
GCMs
?
Laws,
Policies,
Institutions
Hydrologic
& Vegetation
Models
Economics

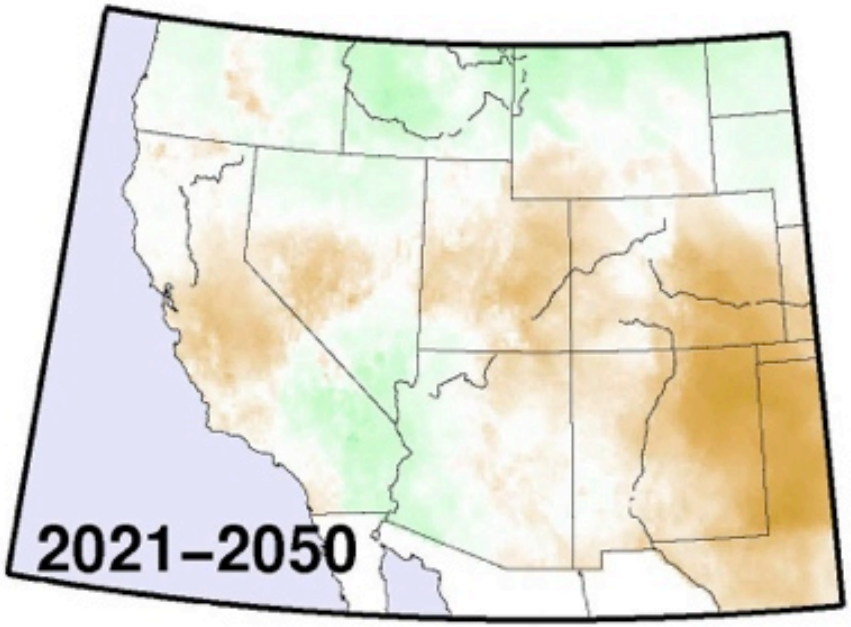


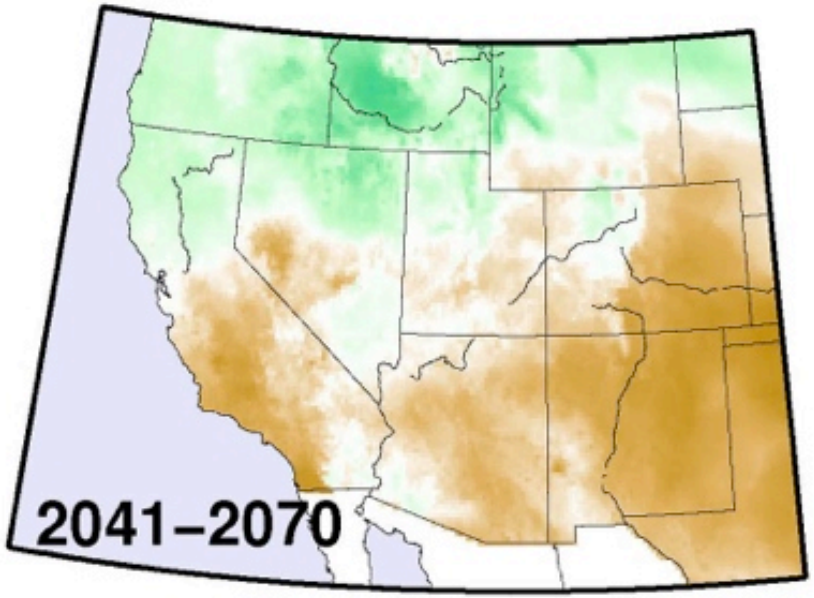
Hawkins and Sutton 2009. Bull. Amer. Met. Soc.

- Big spatial scales
- Temperature
- Not predictions

Hotter

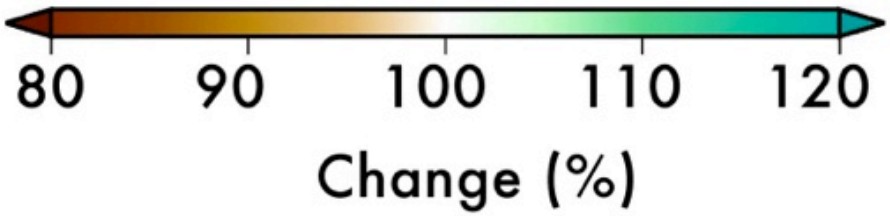

High-emissions scenario
Low-emissions scenario
2021–2050
2021–2050
2041–2070
2041–2070
2070–2099
2070–2099
0
4
8
Amount of warming (°F)

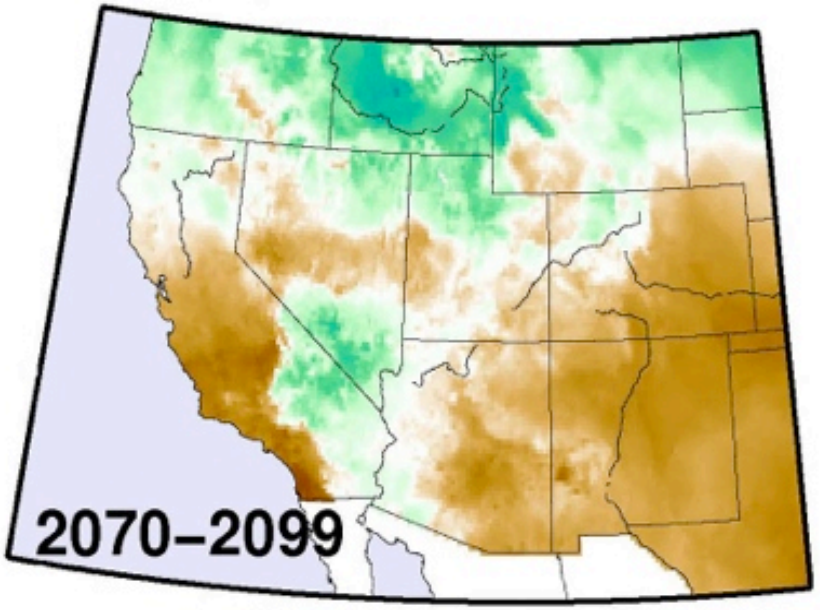




Drier?

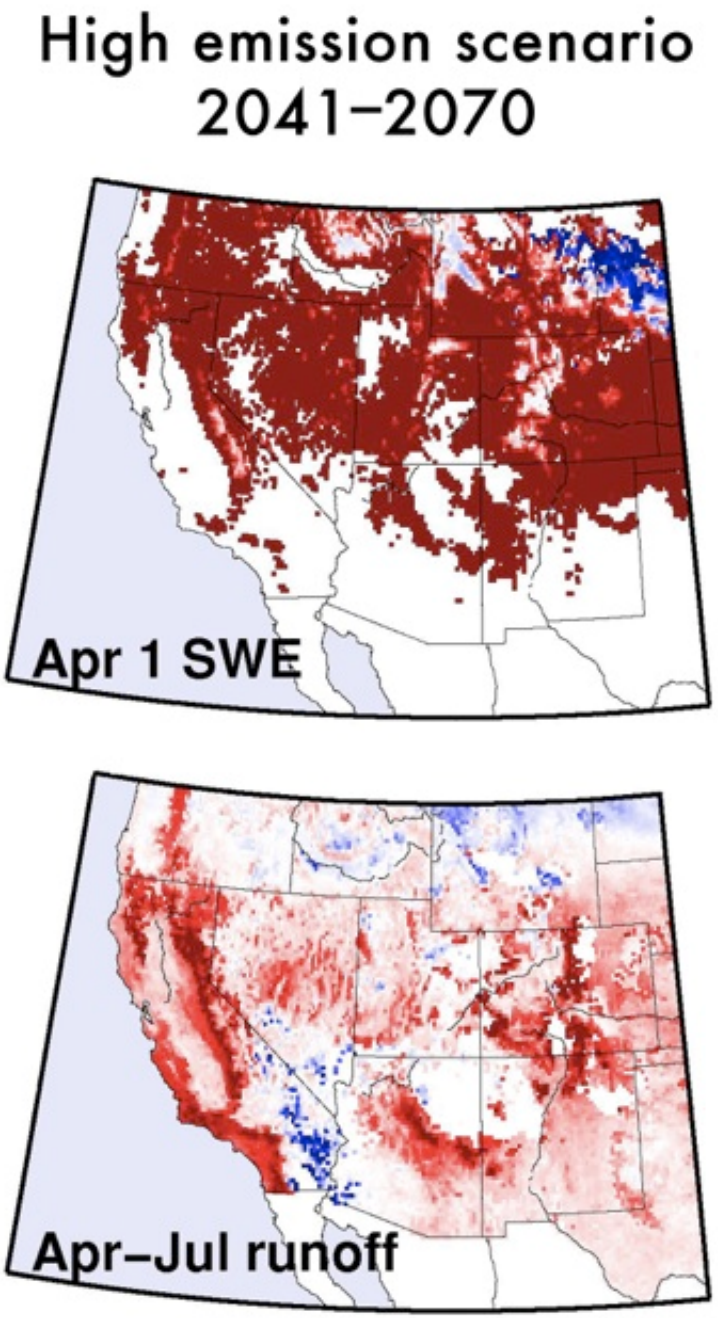
La Niña = YES!



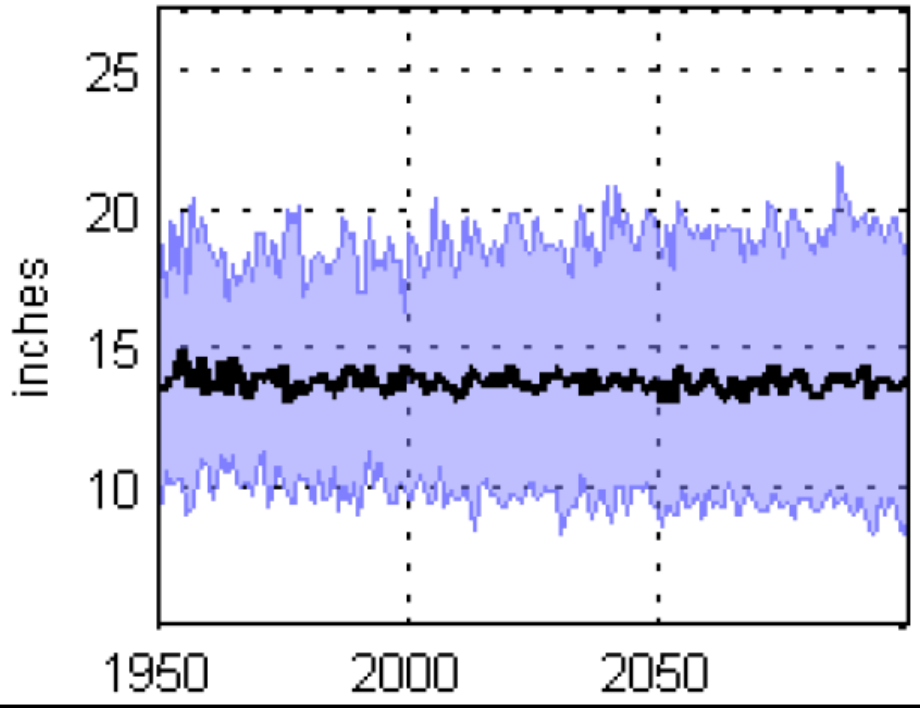


High Emissions Scenario

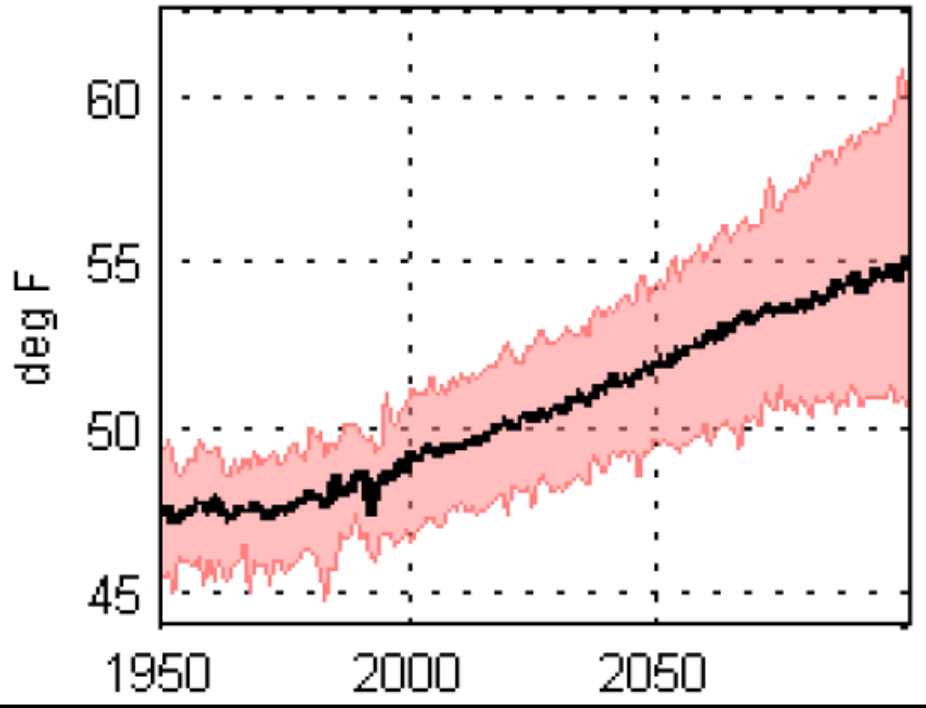
- **Less Snow**
- **Less Water in Arizona streams**



Annual Precipitation



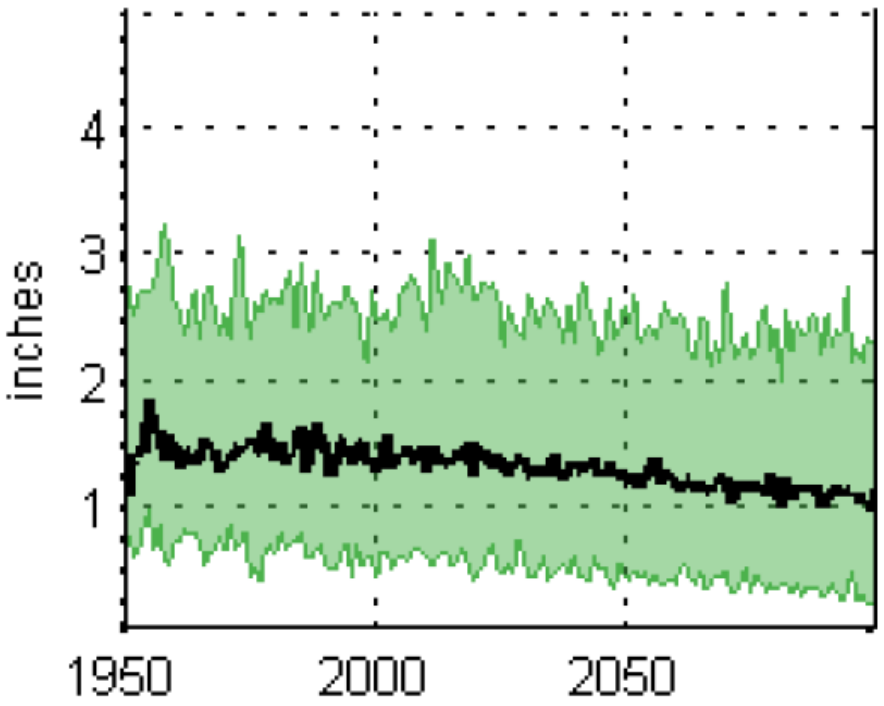
Annual Temperature



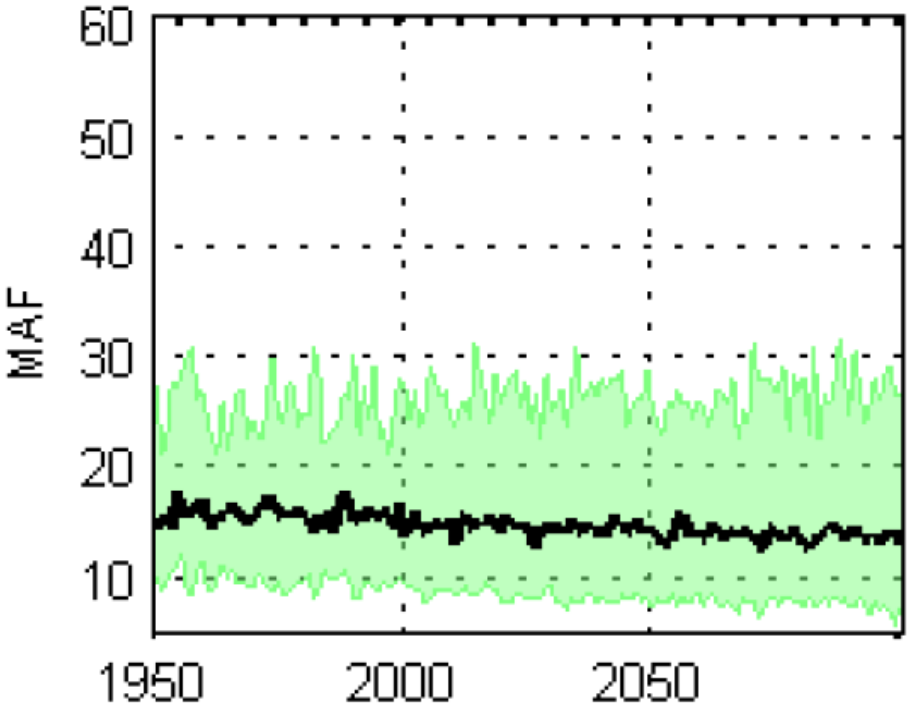
Upper Colorado River Basin

Reclamation – Westwide Climate Risk Assessments, 2011

April 1 Snow Water



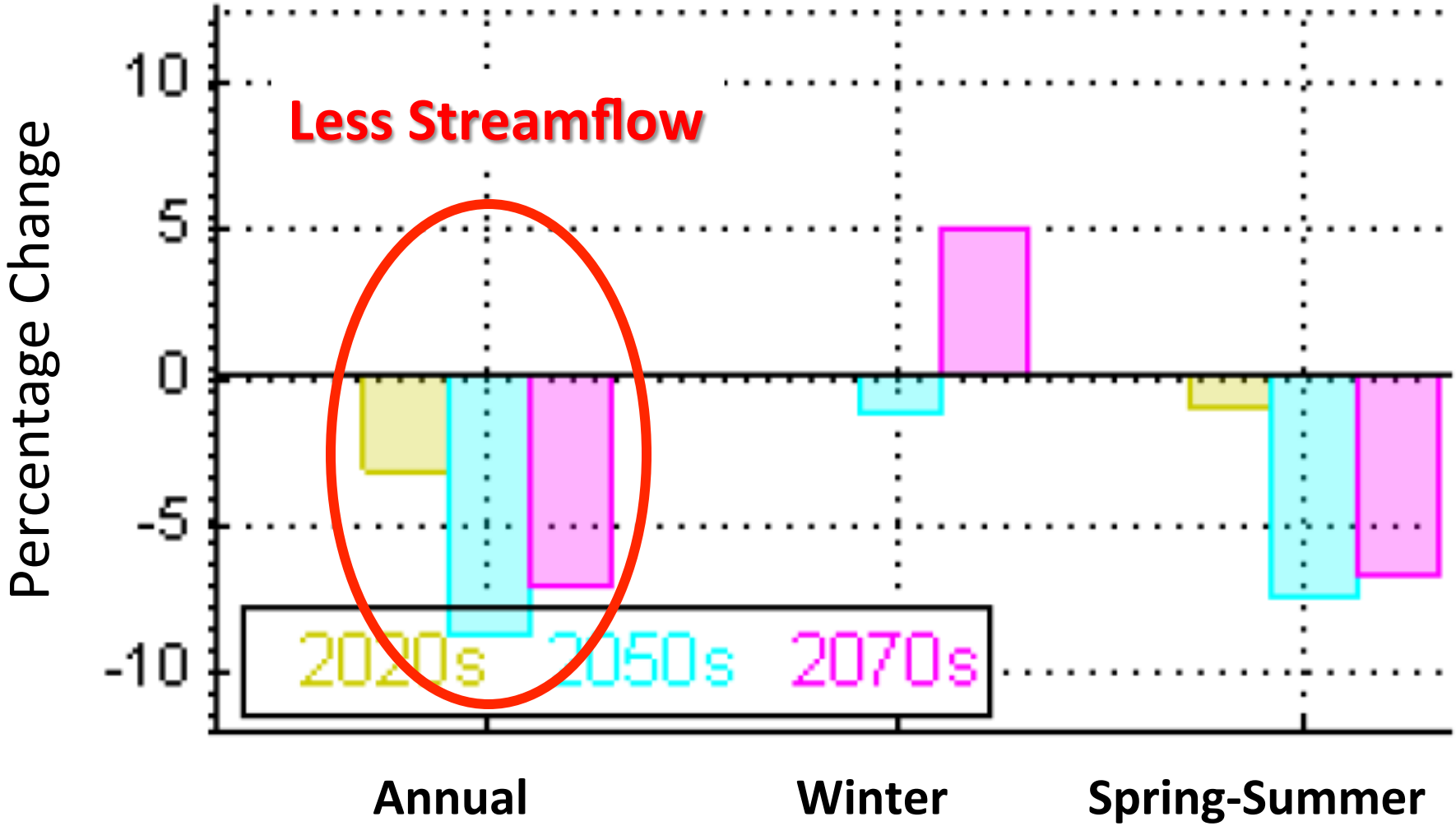
Annual Runoff



Upper Colorado River Basin

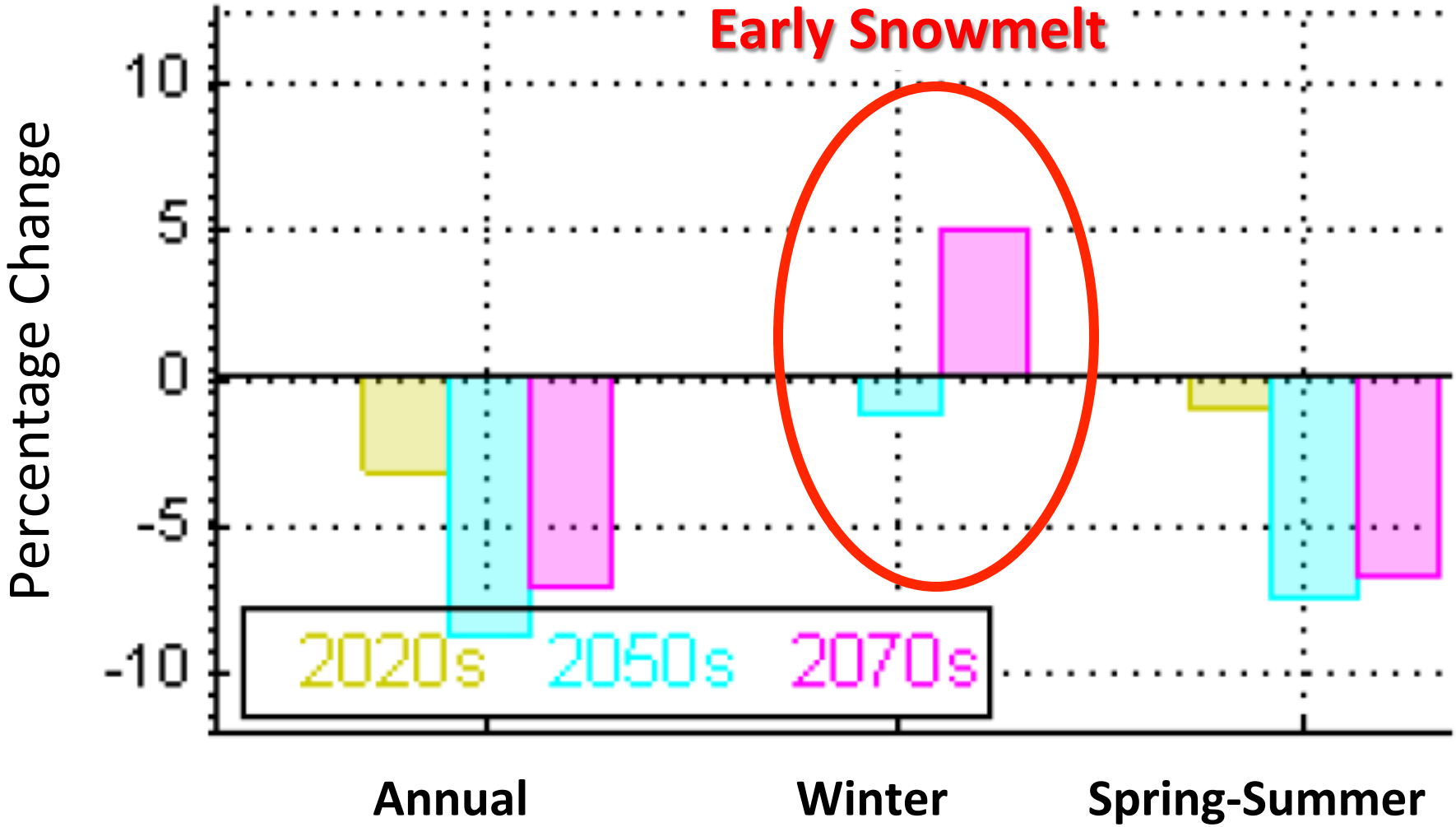
Reclamation – Westwide Climate Risk Assessments, 2011

Colorado River at Lees Ferry



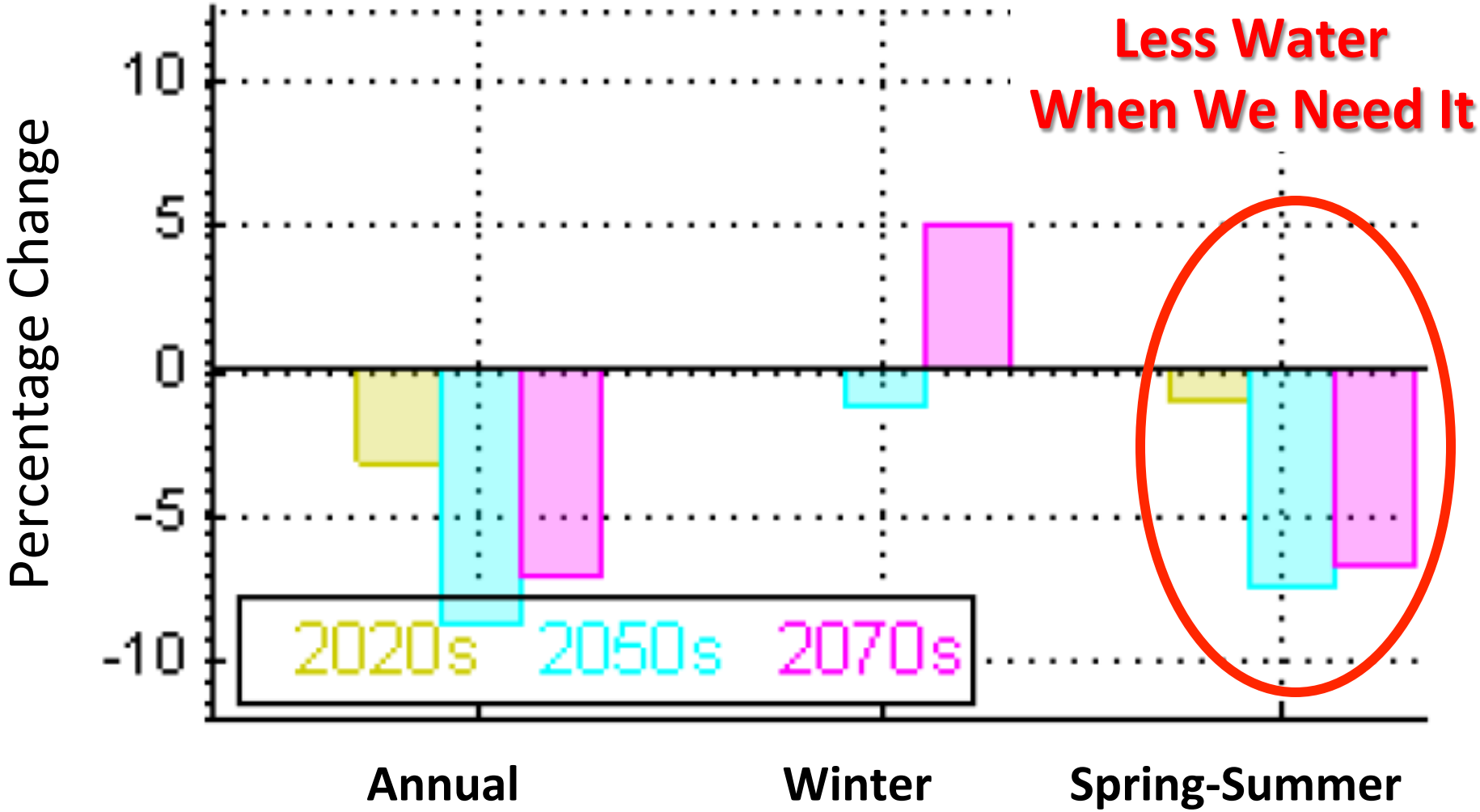
Reclamation – SECURE WATER Act Report, 2011

Colorado River at Lees Ferry

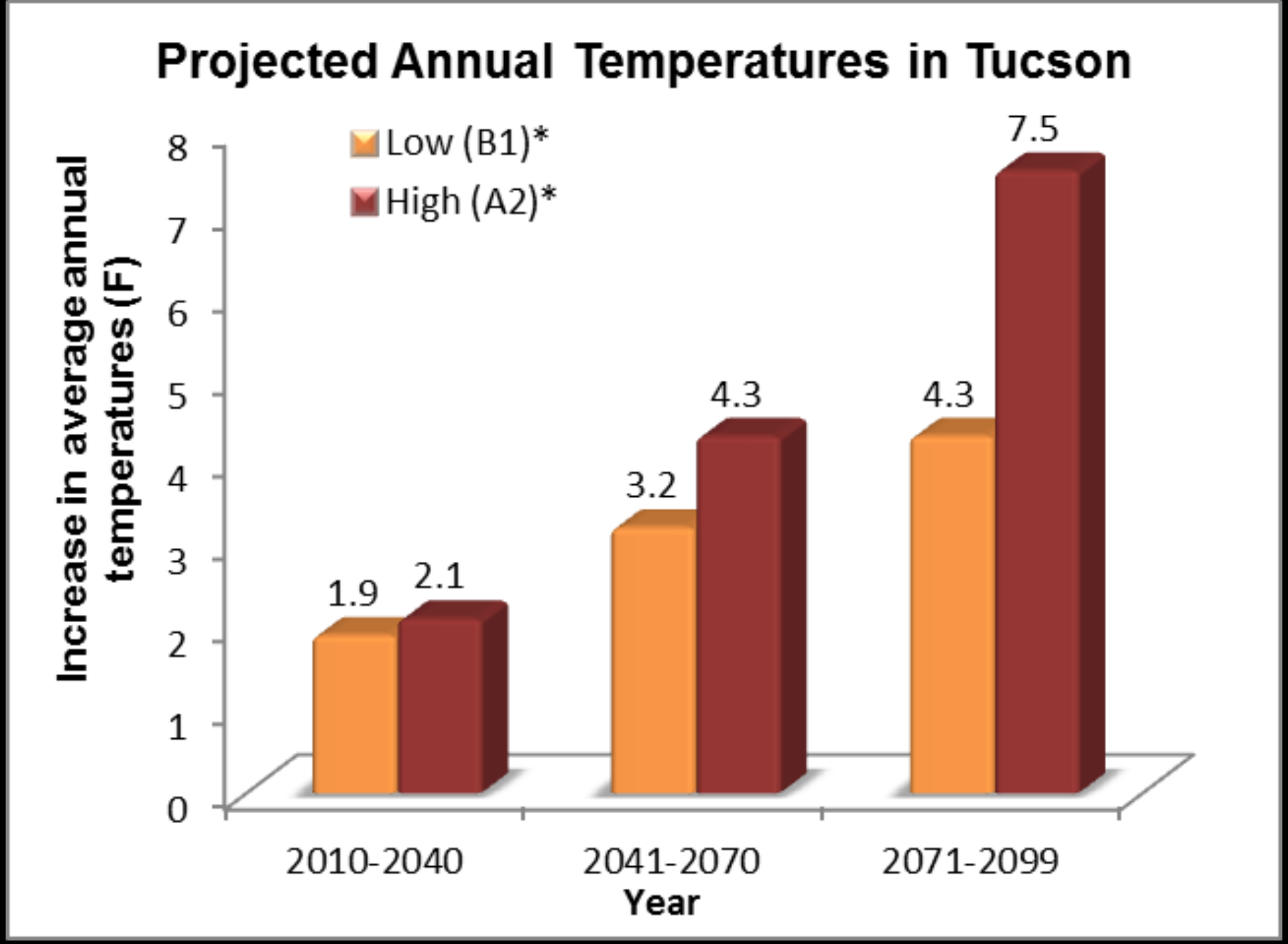


Reclamation – SECURE WATER Act Report, 2011

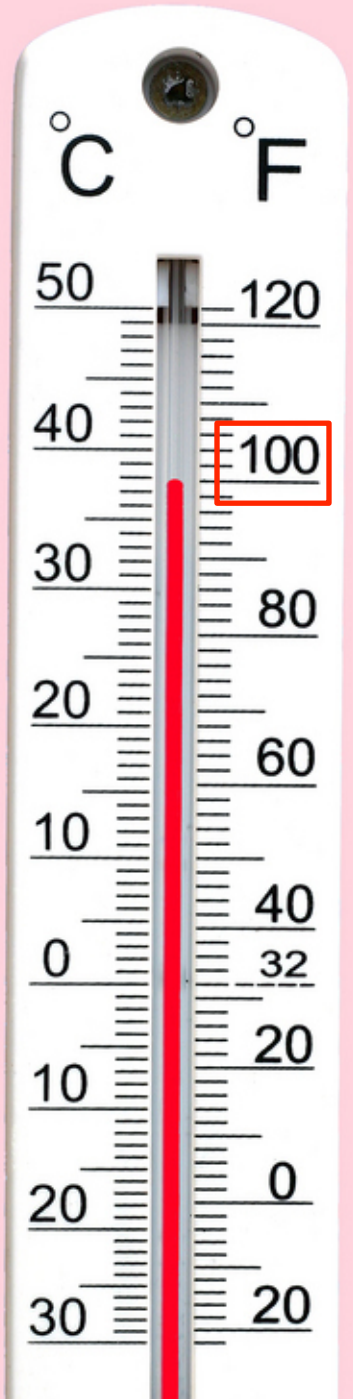
Colorado River at Lees Ferry



Reclamation – SECURE WATER Act Report, 2011



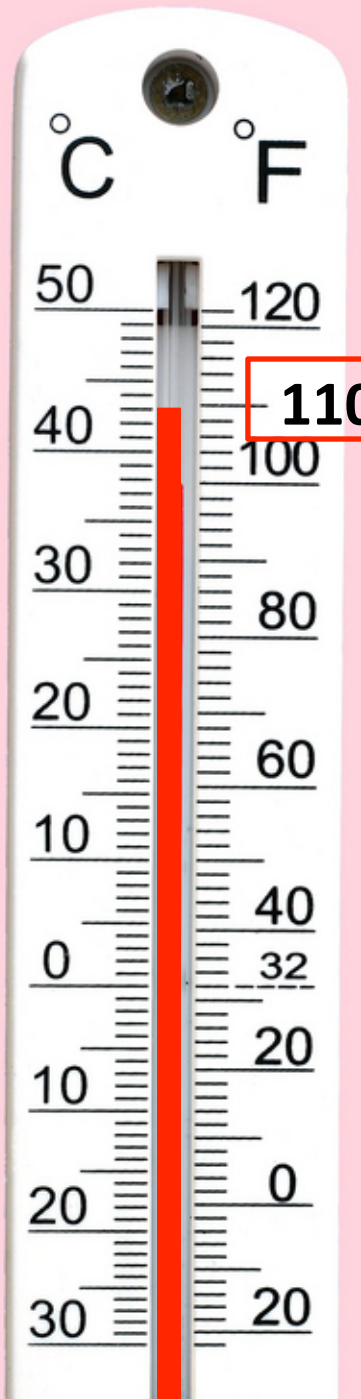
G. Garfin based on work performed by J. Weiss, University of Arizona (Geosciences)



34

more days per year

Projected temperature Extremes for Tucson, AZ
Preliminary analysis by
Carlos Carrillo
and Gregg Garfin,
Univ. of Arizona
Not peer-reviewed



25

more days per year

Max Water Use and Precipitation In Tucson

Towering cumulonimbus clouds
Photograph by Corbis Premium Collection/Alamy

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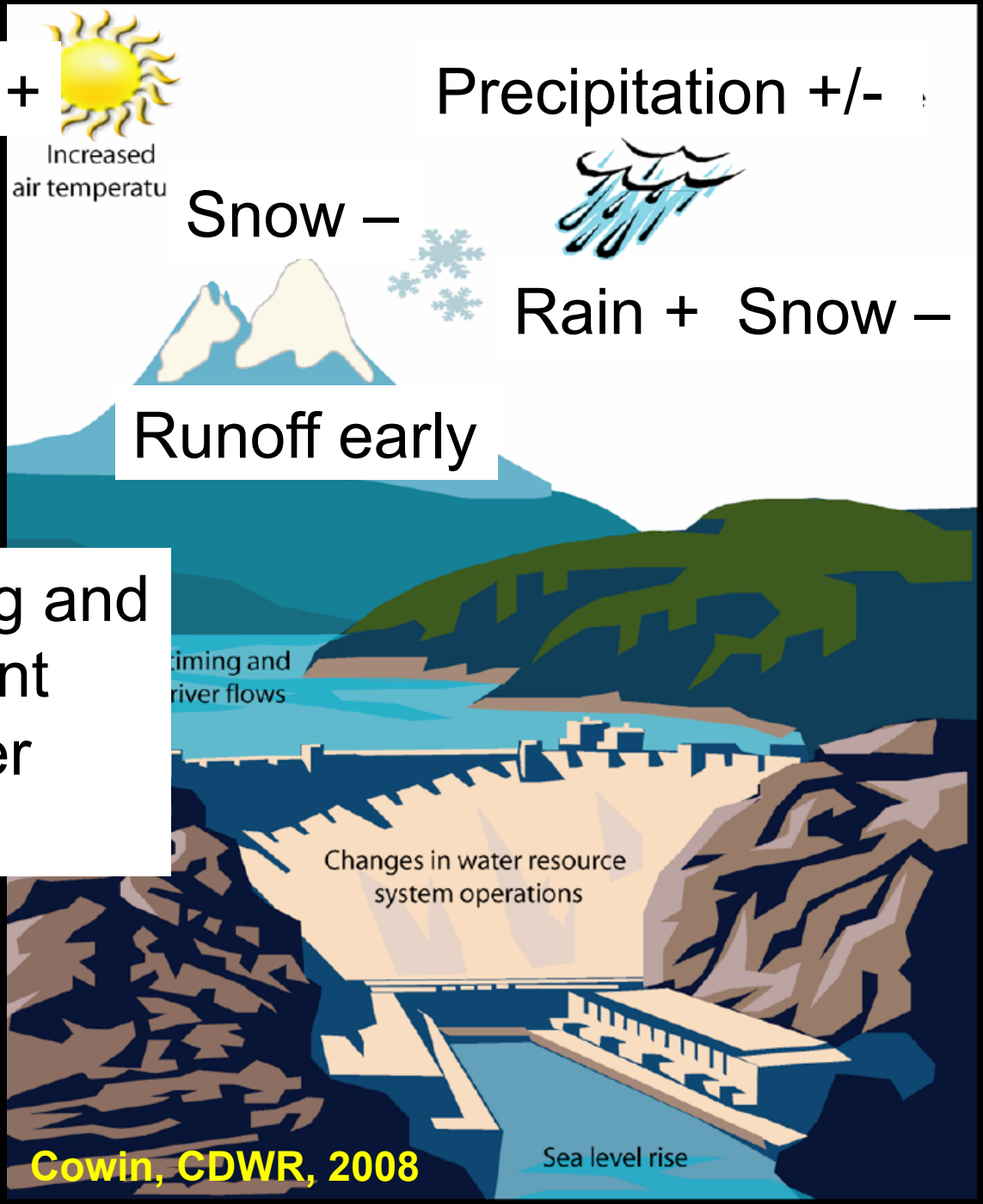


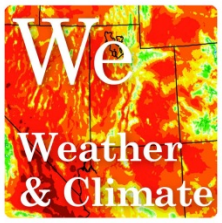
Temperature is a hydrologic variable

http://southwestclimatechange.org/

Southwest Sw Climate Assessment

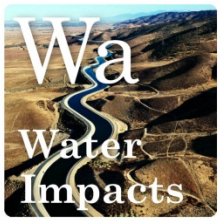
Climate Variability & Change

Science & Society



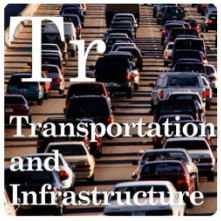
Impacts & Vulnerabilities

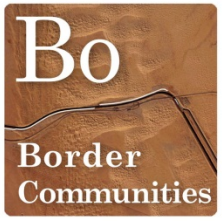
Trends in Climate



Mitigation & Adaptation Plans

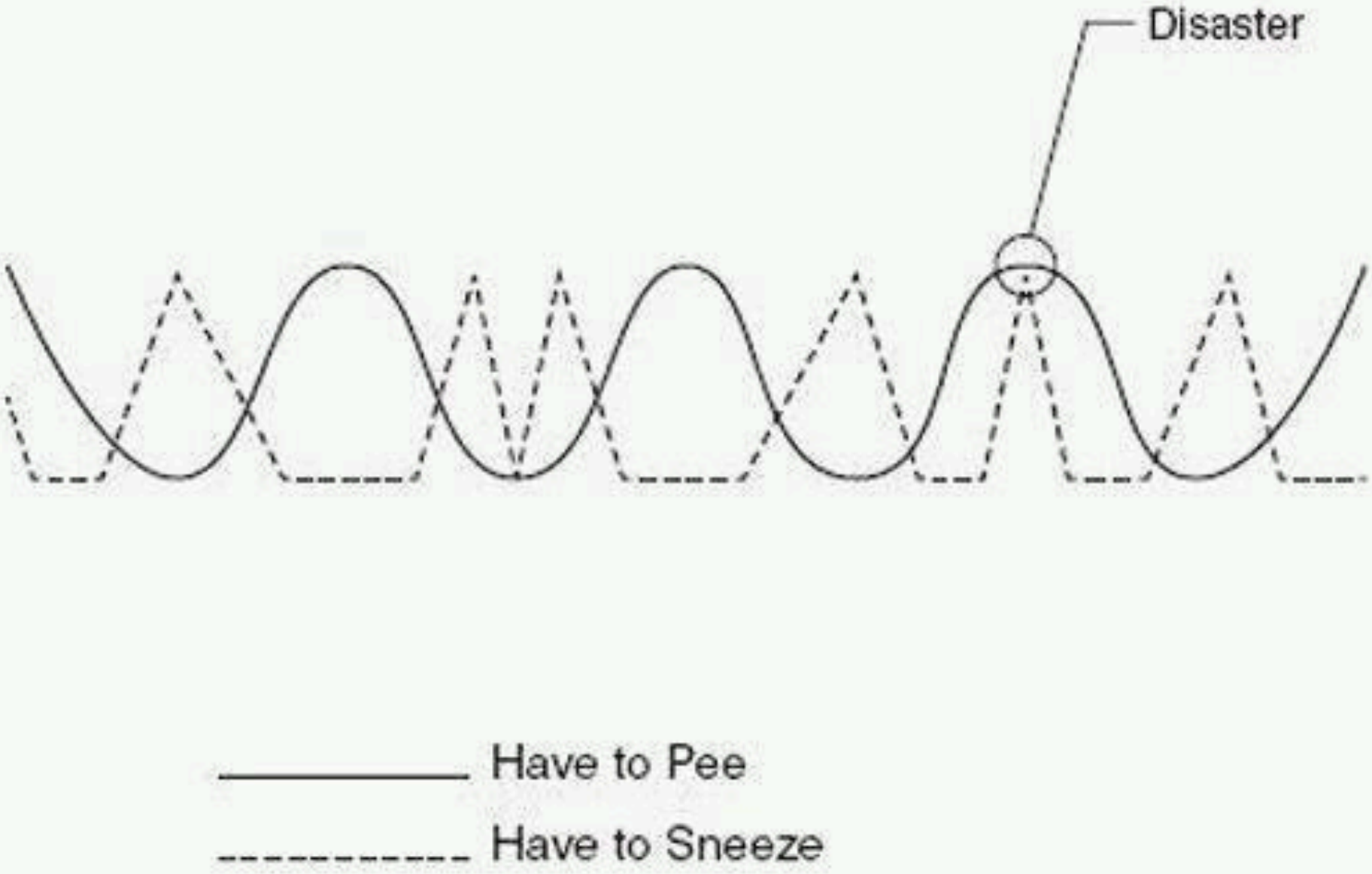
Climate Scenarios of the Future

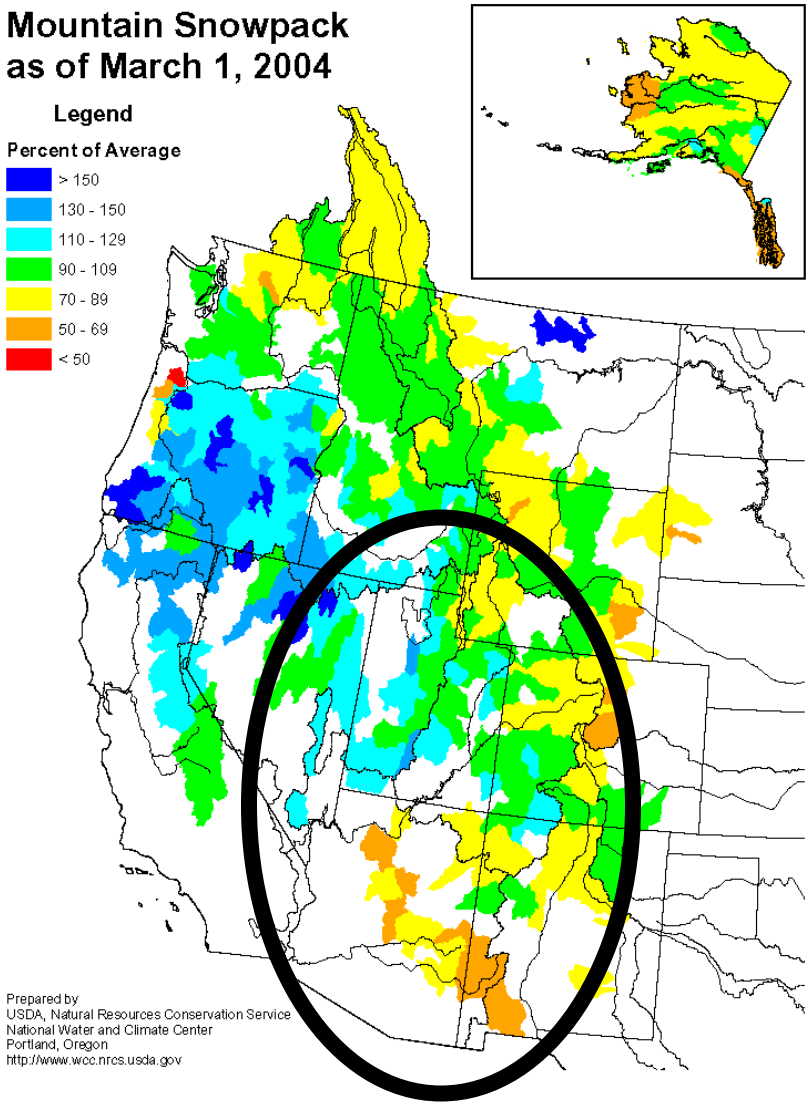


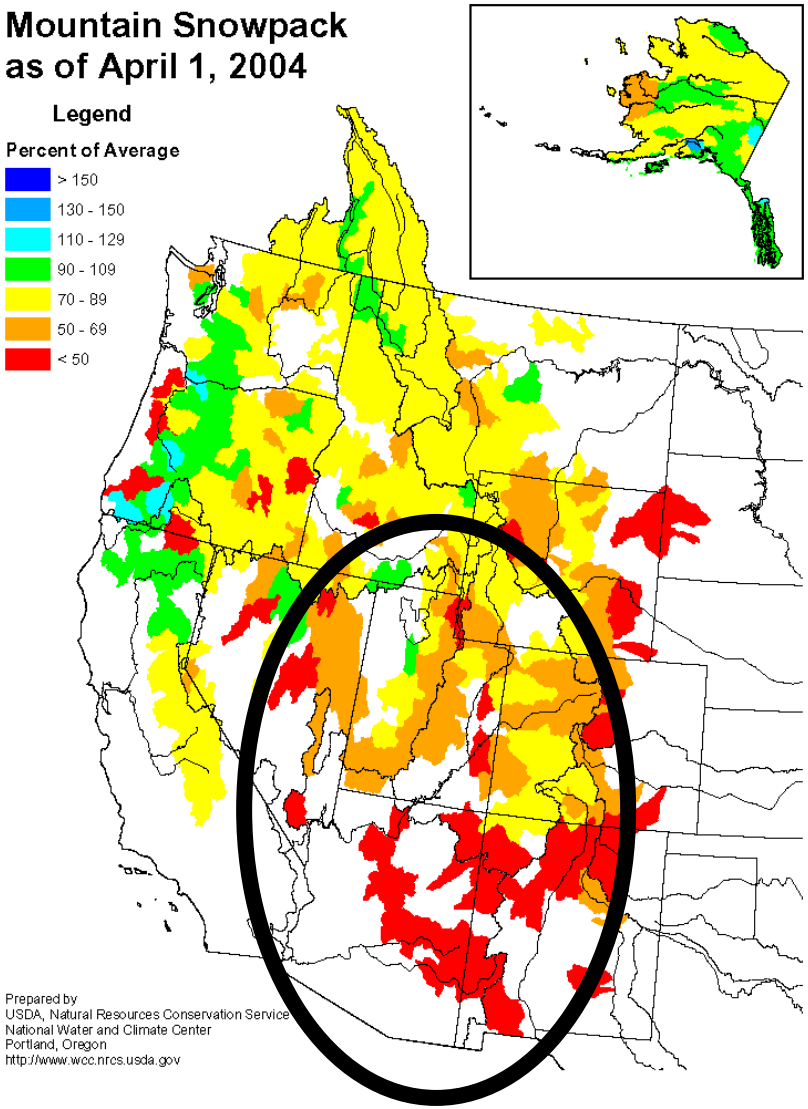


Research Strategies

Gregg Garfin
Institute of the Environment
The University of Arizona
gmgarfin@email.arizona.edu
520-626-4372

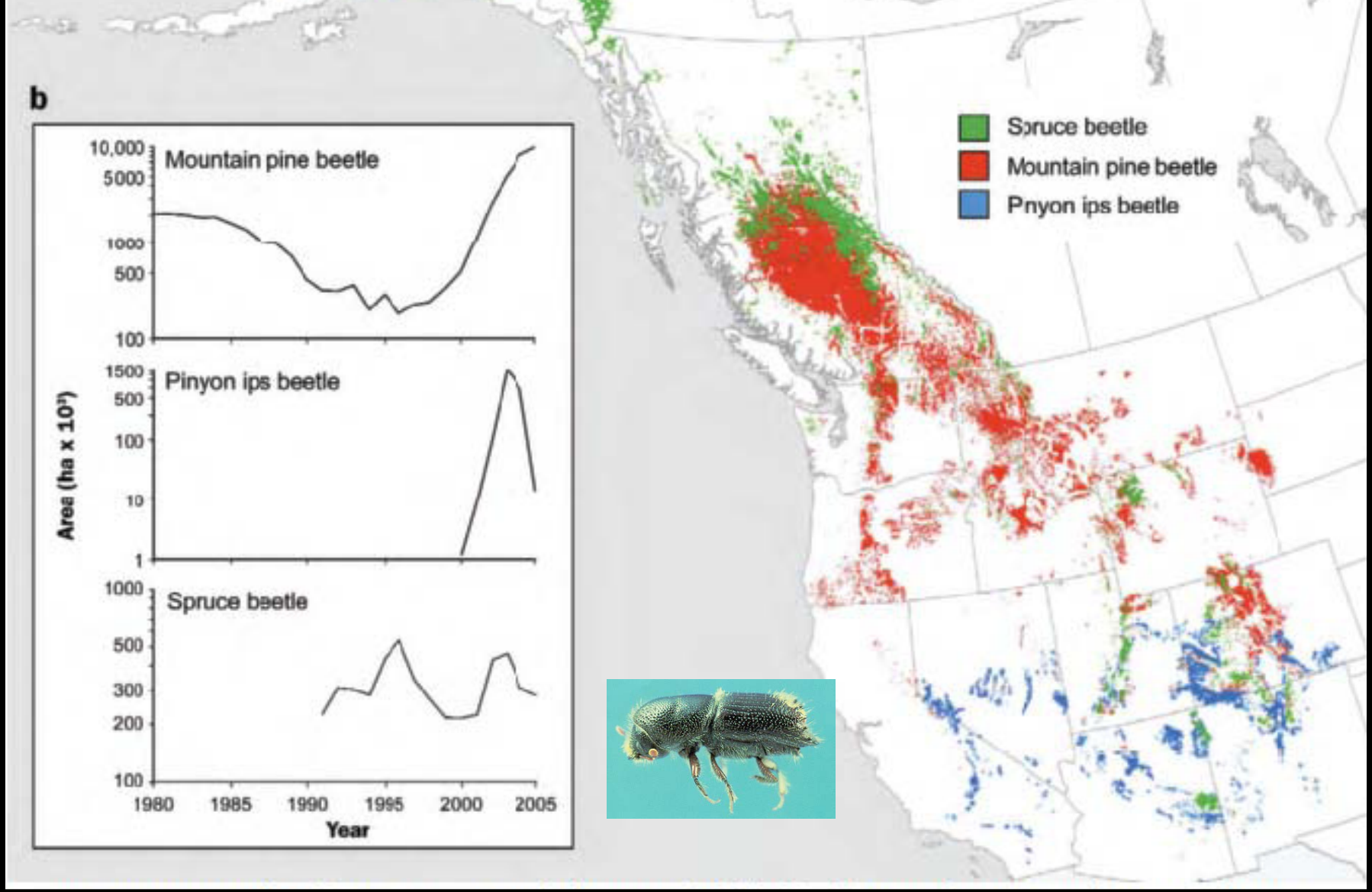

Disaster
Have to Pee
Have to Sneeze





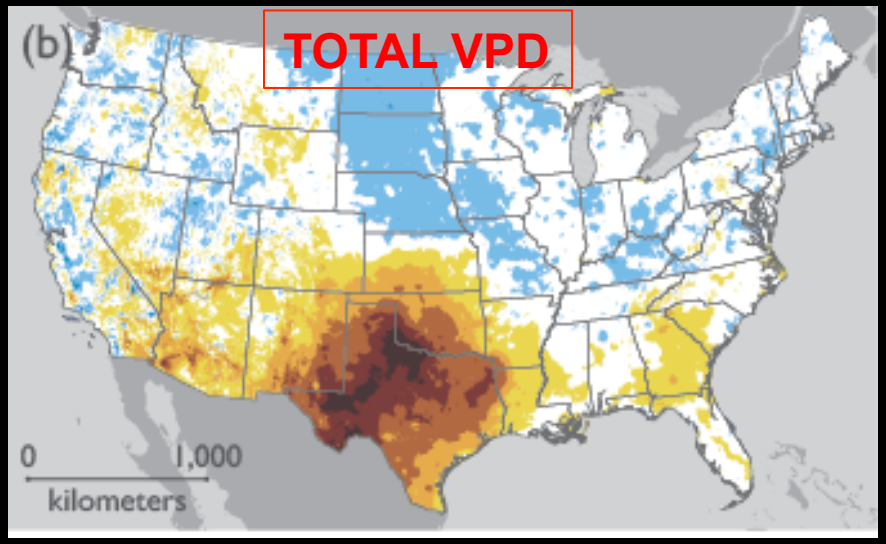
Losses of 30-60% Snow Water Equivalent

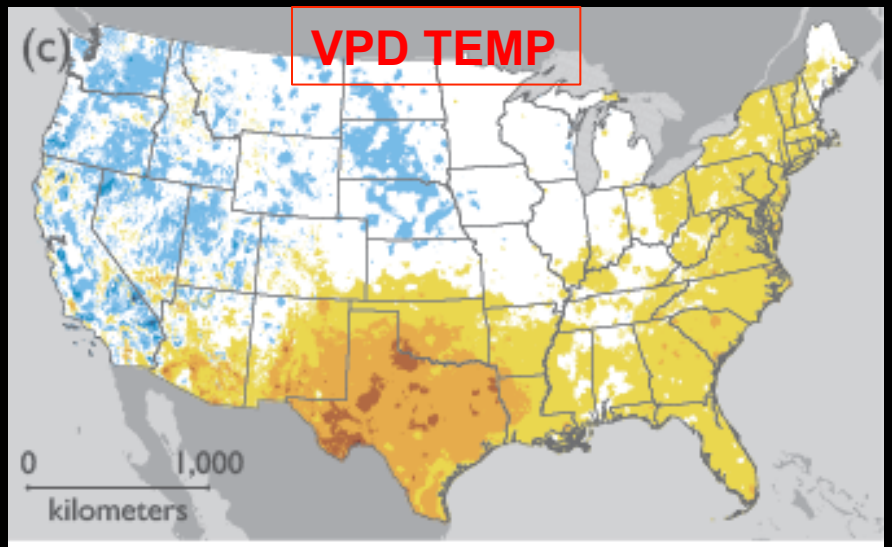
USDA-NRCS National Water and Climate Center
http://www.wcc.nrcs.usda.gov/wsf/

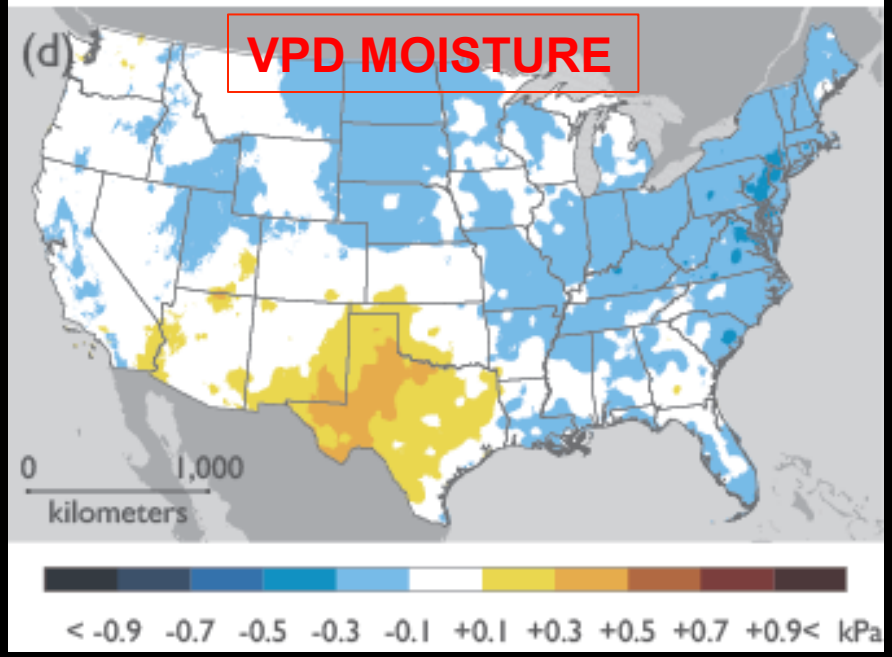


Raffa et al., 2008

Hotter Means Drier: 2011 Drought

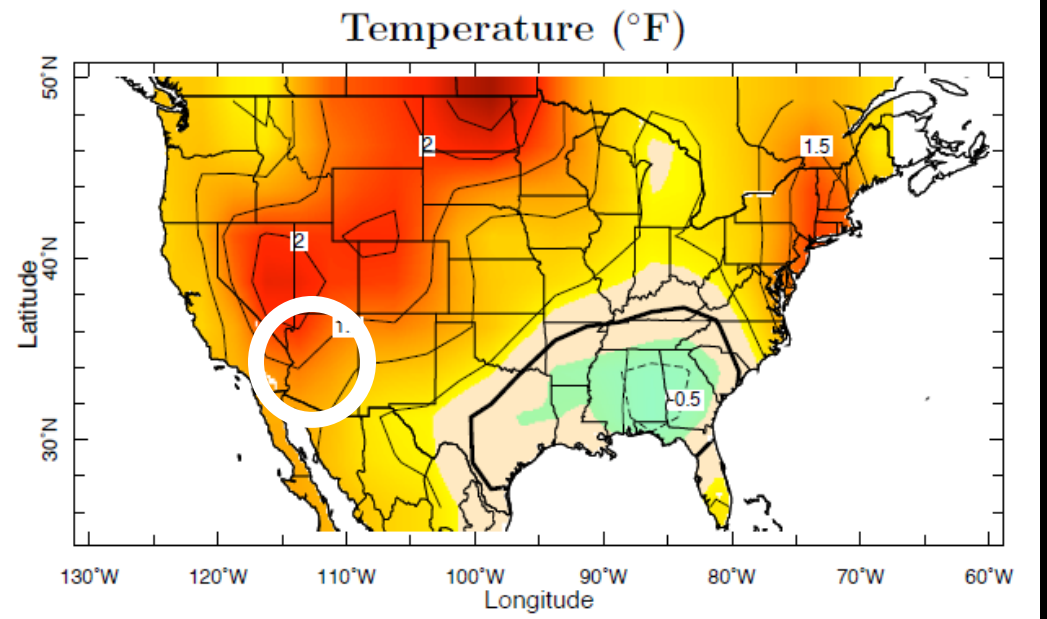


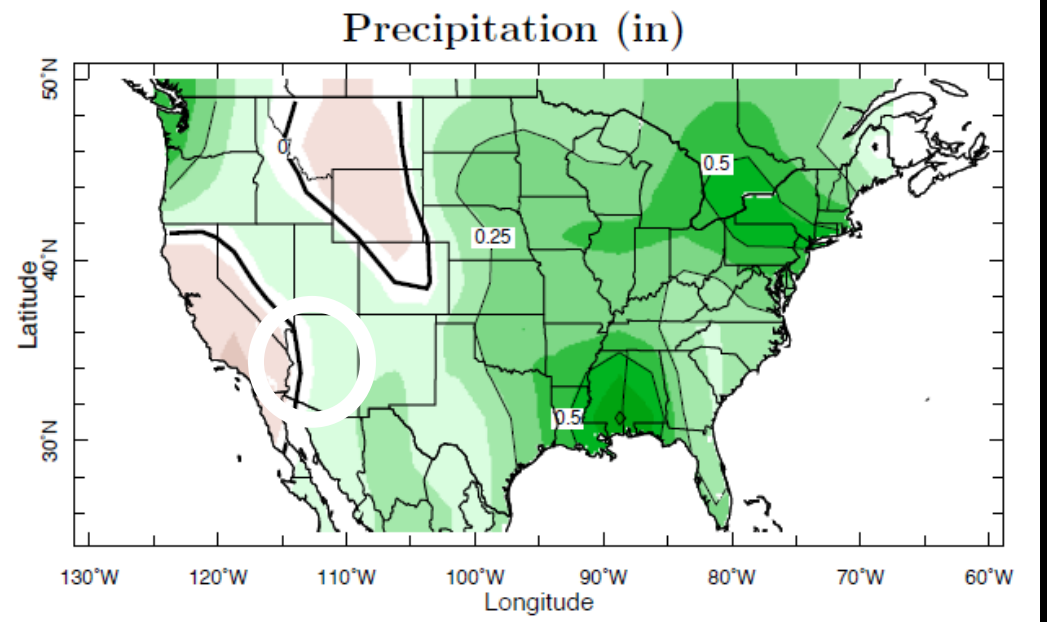




Analysis courtesy of Jeremy Weiss, Jonathon Overpeck, and Julie Cole, Univ. AZ, 2012

Trend Since 1895





R. Seager (presented at WGA Drought Workshop, September, 2010) Check http://www.westgov.org/water for PDF

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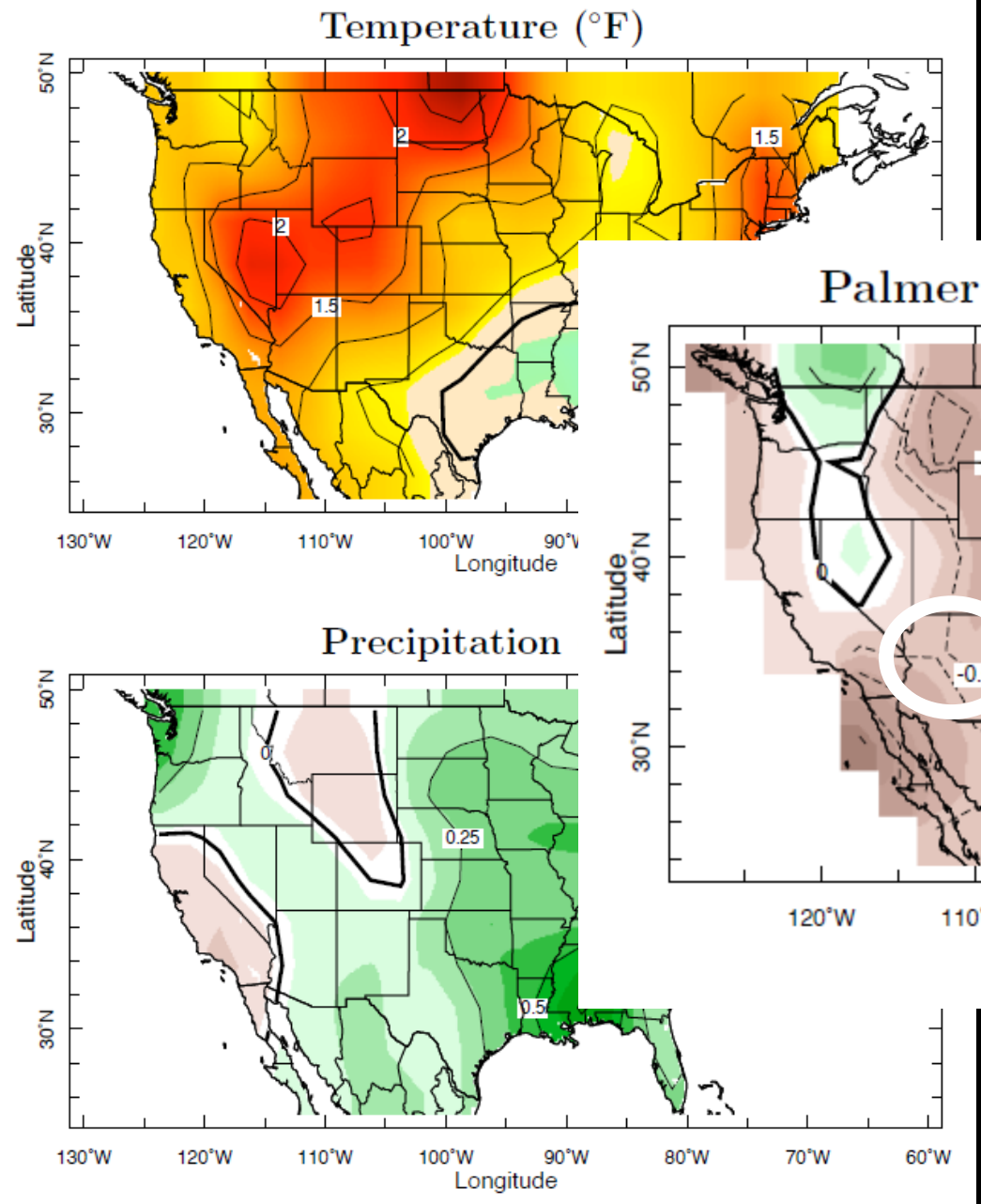
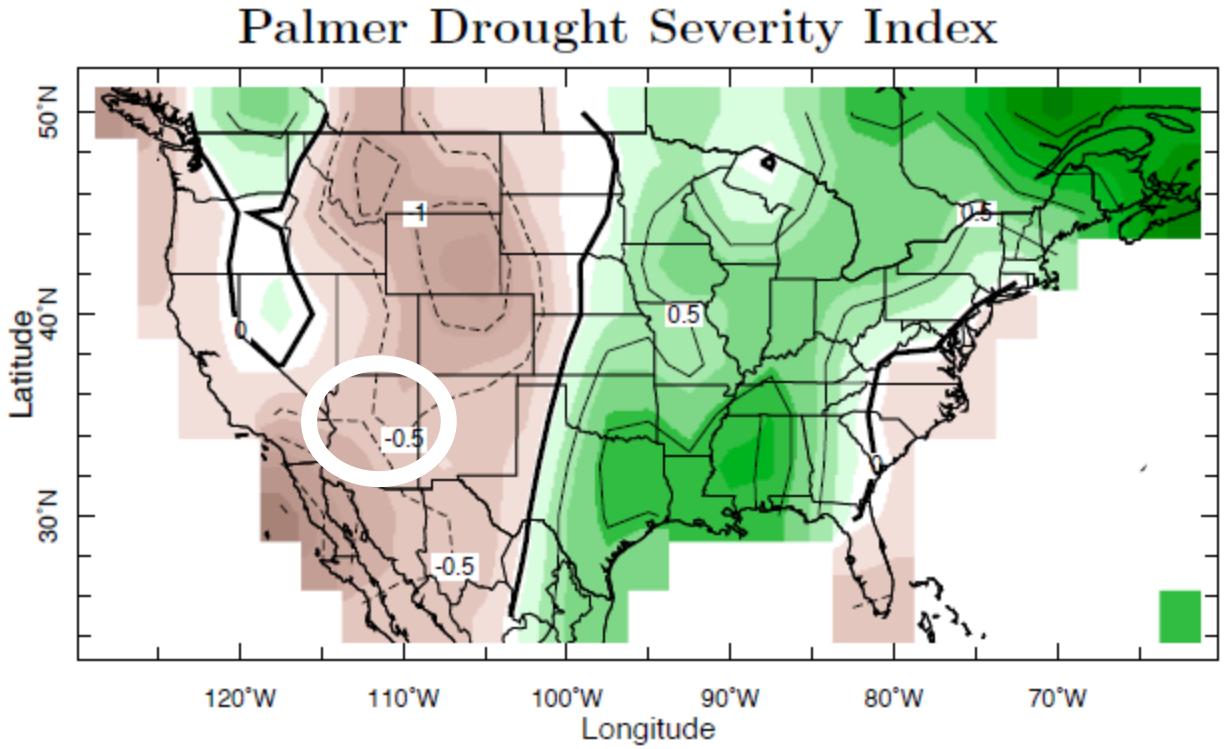
Arizona

Trend Since 1895





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