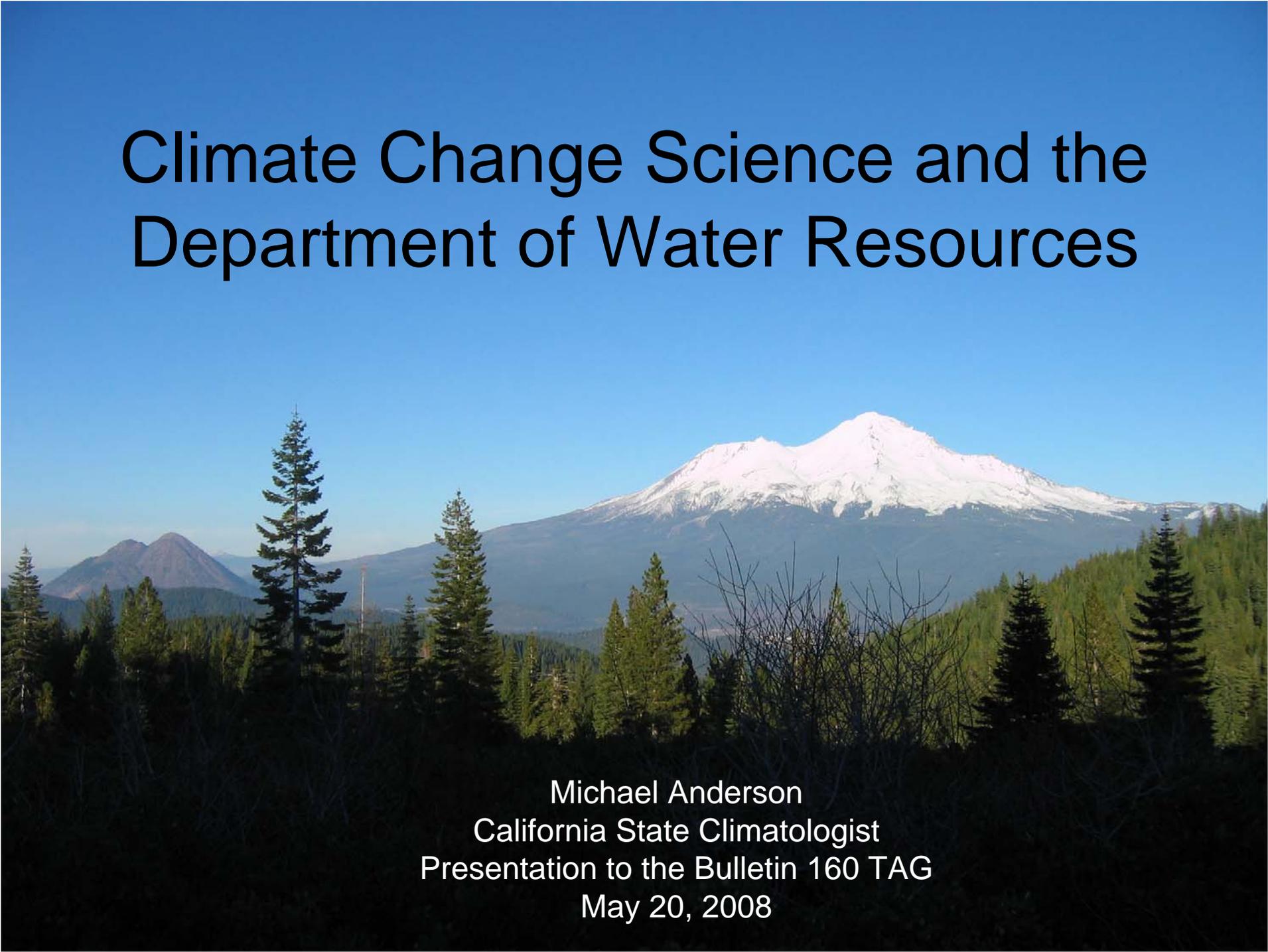


Climate Change Science and the Department of Water Resources



Michael Anderson
California State Climatologist
Presentation to the Bulletin 160 TAG
May 20, 2008

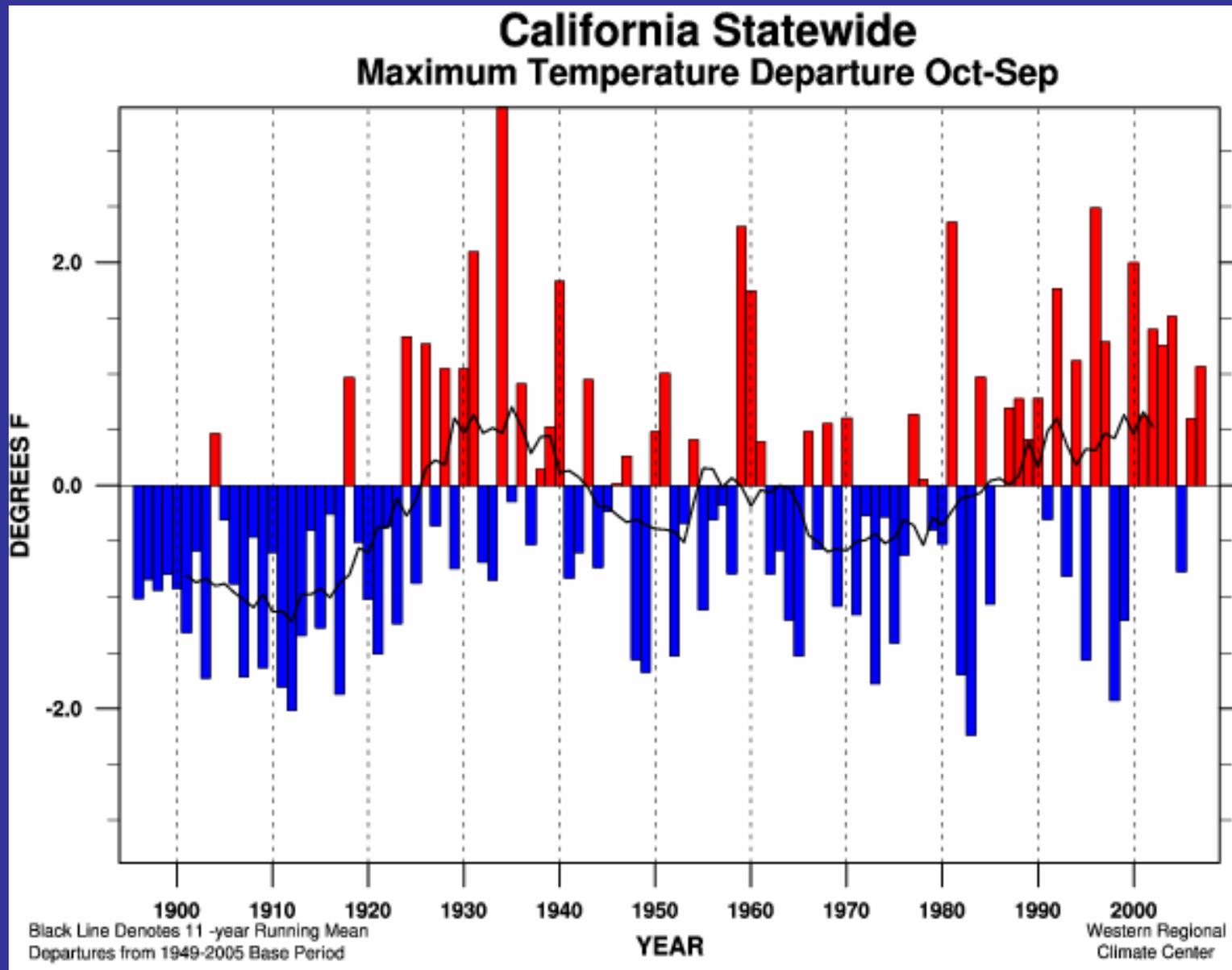
Talk Overview

- Climate – Where we're at
- Science in Action – Our Sources
- Climate Change – What we are expecting
- Action Items
- Feedback

Climate – Where we are at

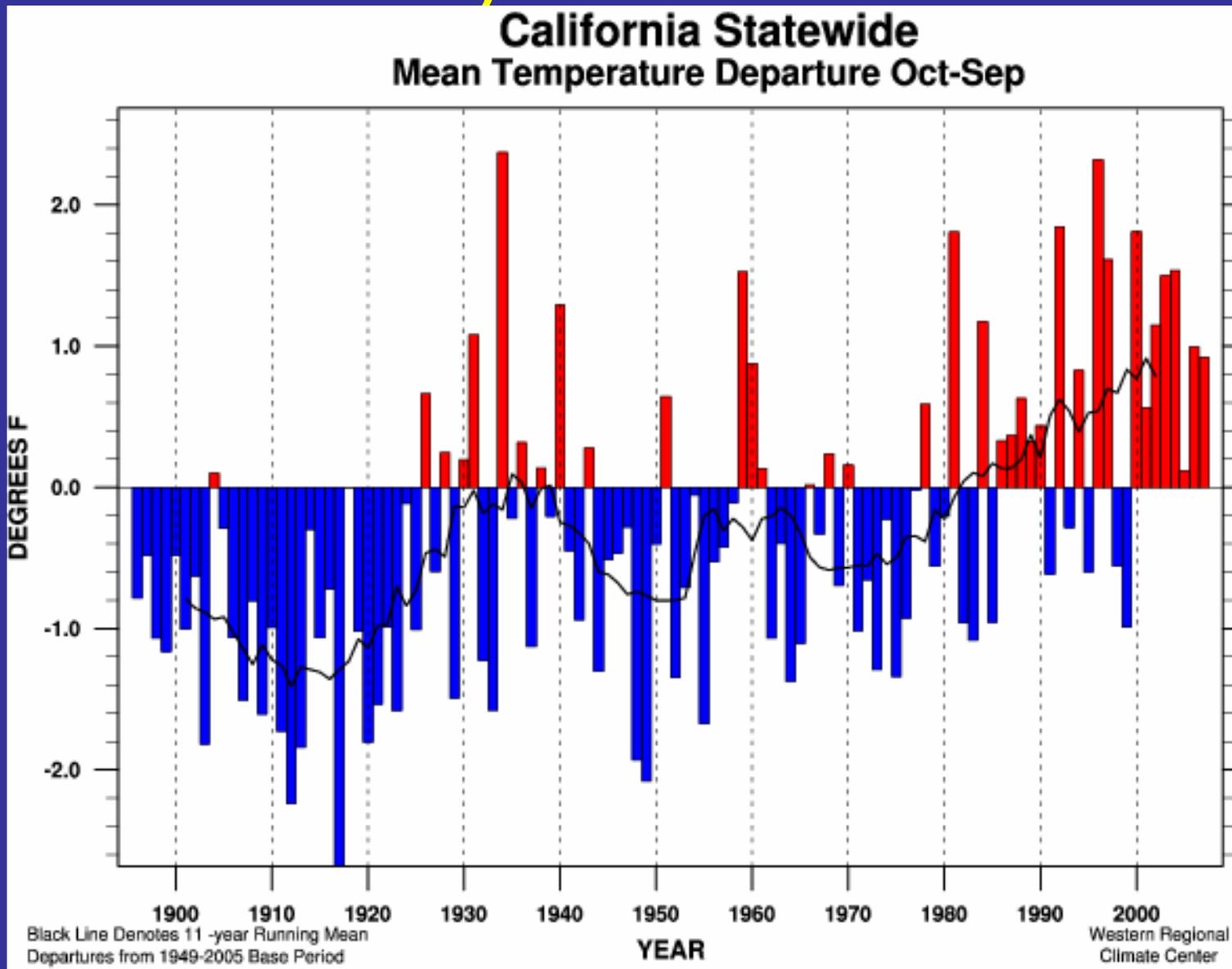
- Temperature
- Precipitation
- April 1 SWE
- Sacramento and San Joaquin Runoff
- Annual Flood Peak Statistics
- Sea Level Change

20th Century California Climate



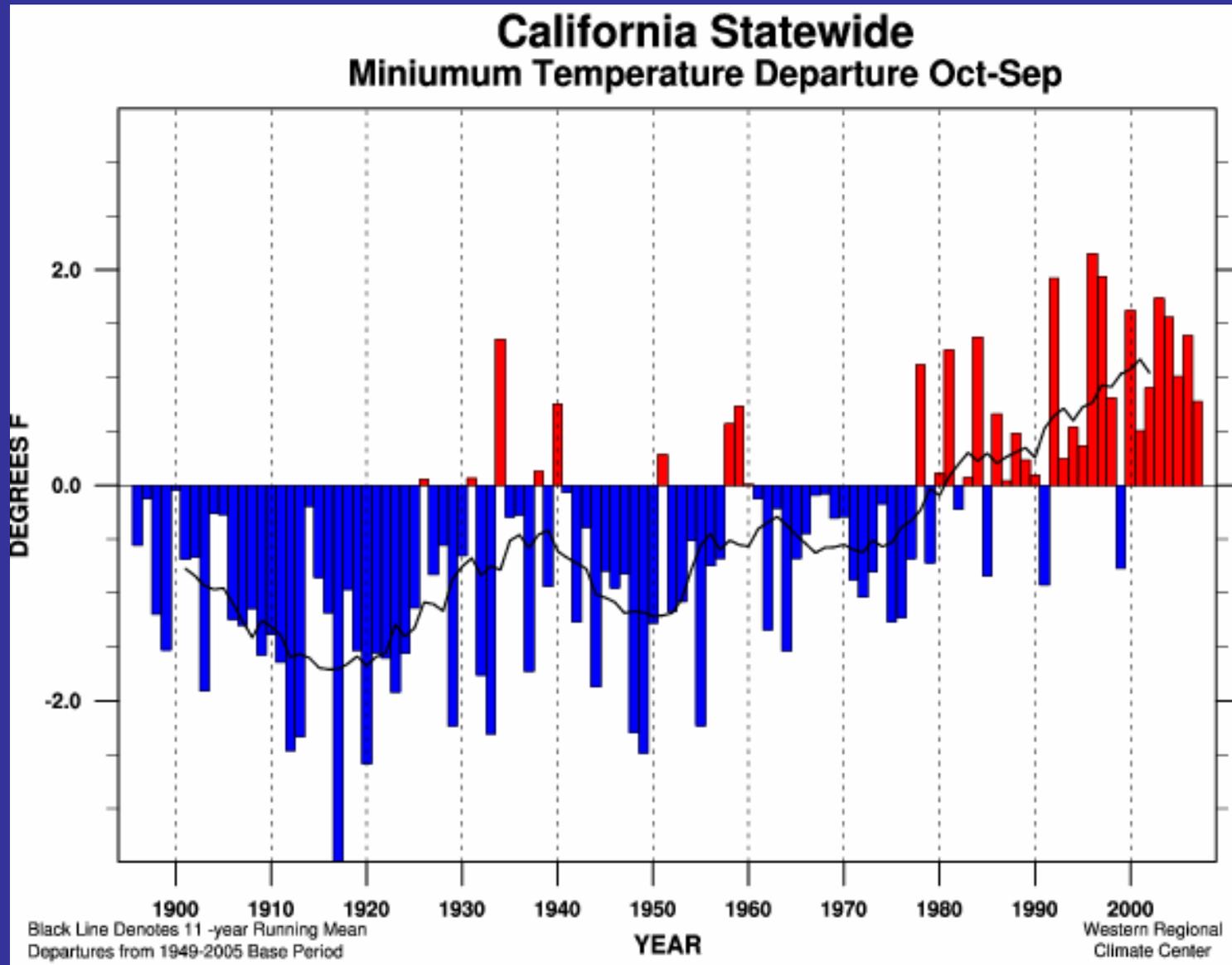
Source: California Climate Tracker, Western Region Climate Center

20th Century California Climate



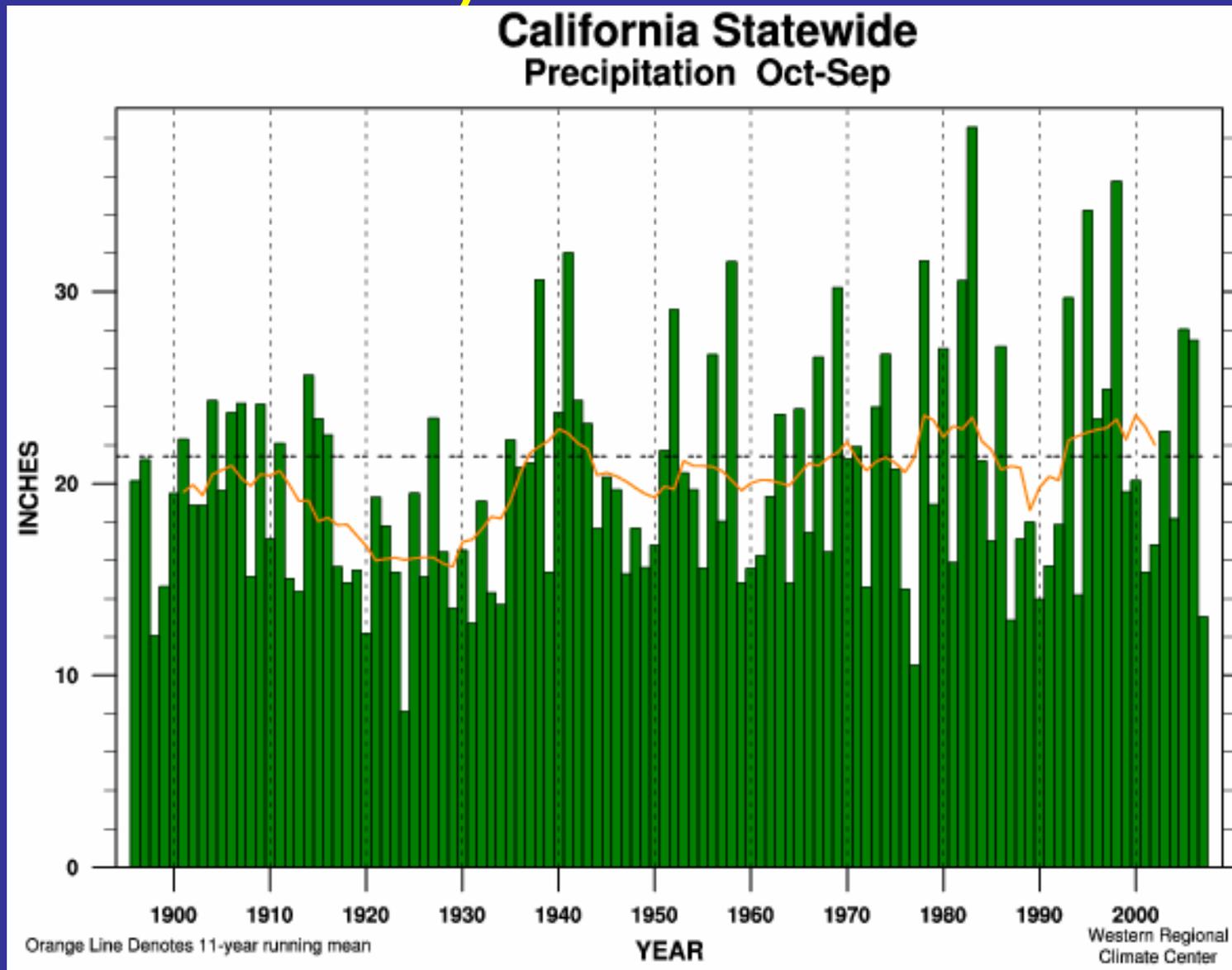
Source: California Climate Tracker, Western Region Climate Center

20th Century California Climate



Source: California Climate Tracker, Western Region Climate Center

20th Century California Climate



Source: California Climate Tracker, Western Region Climate Center

Average April 1 Water Content at 223 California Snow Courses with 60 years of record between 1930 and 2001

Elevations Ranging from 4850 to 11350 feet

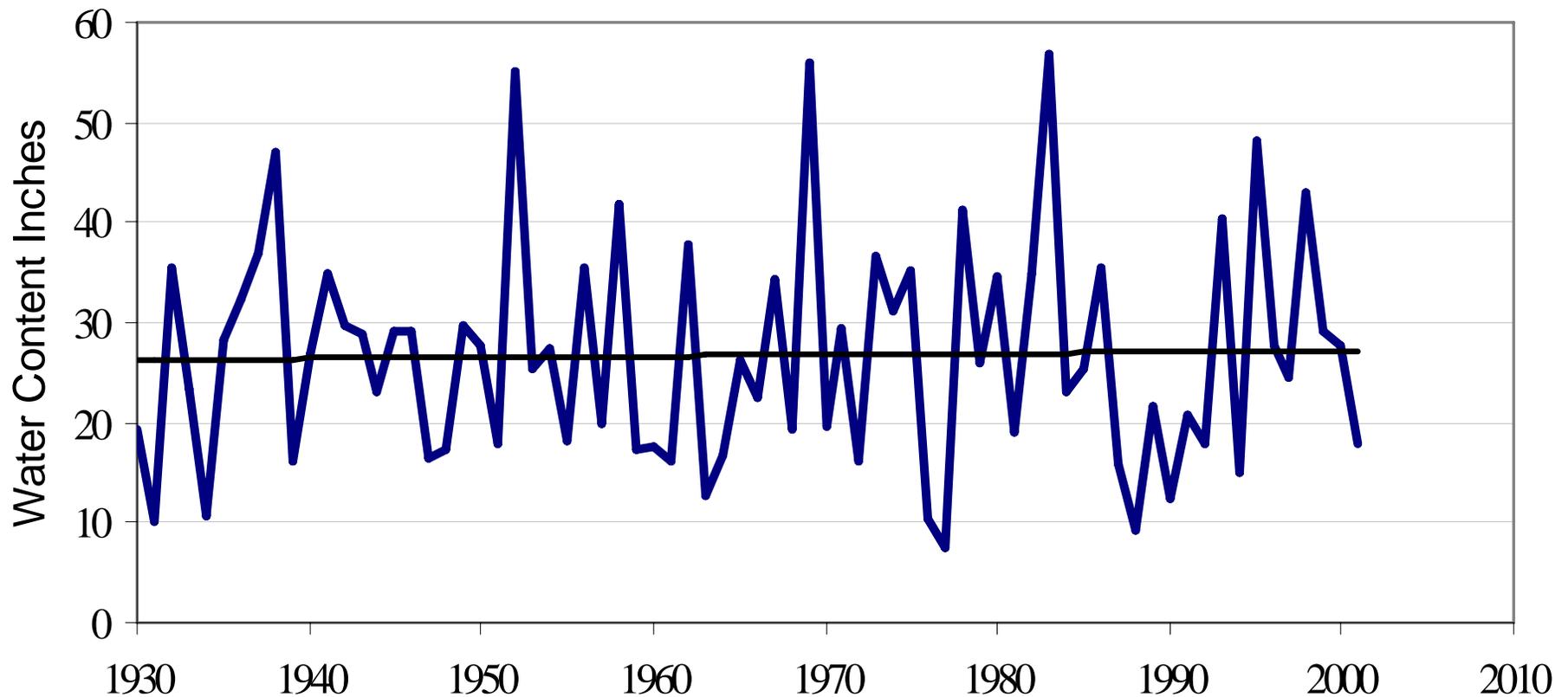
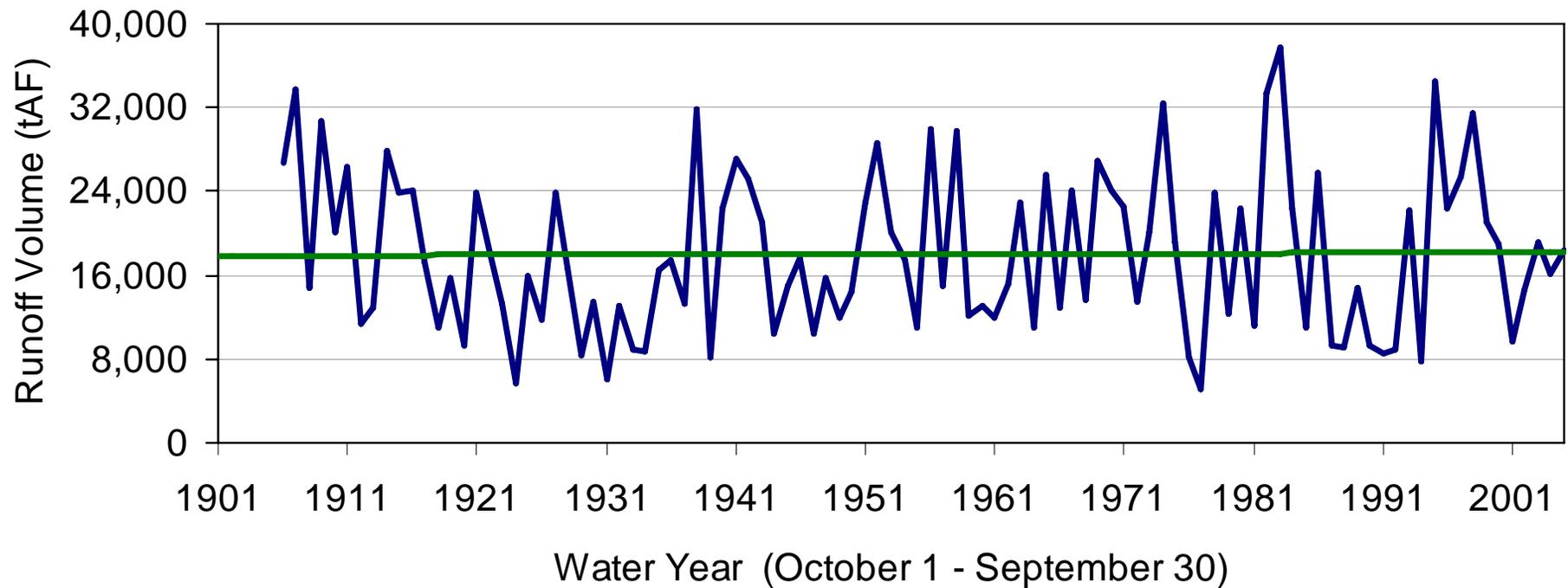


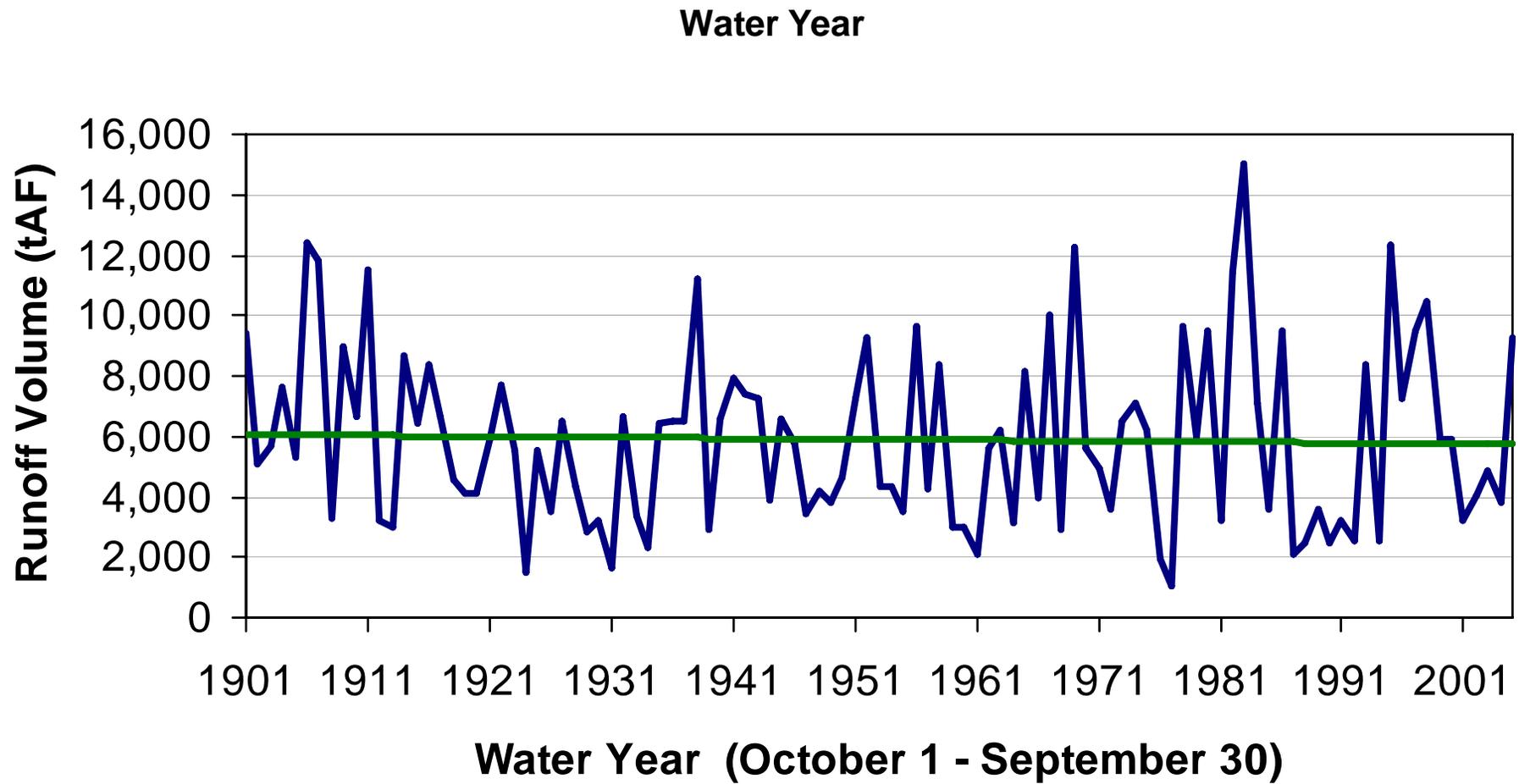
Chart from Jim Goodridge

Annual Runoff Volume – Sacramento River

Water Year Runoff

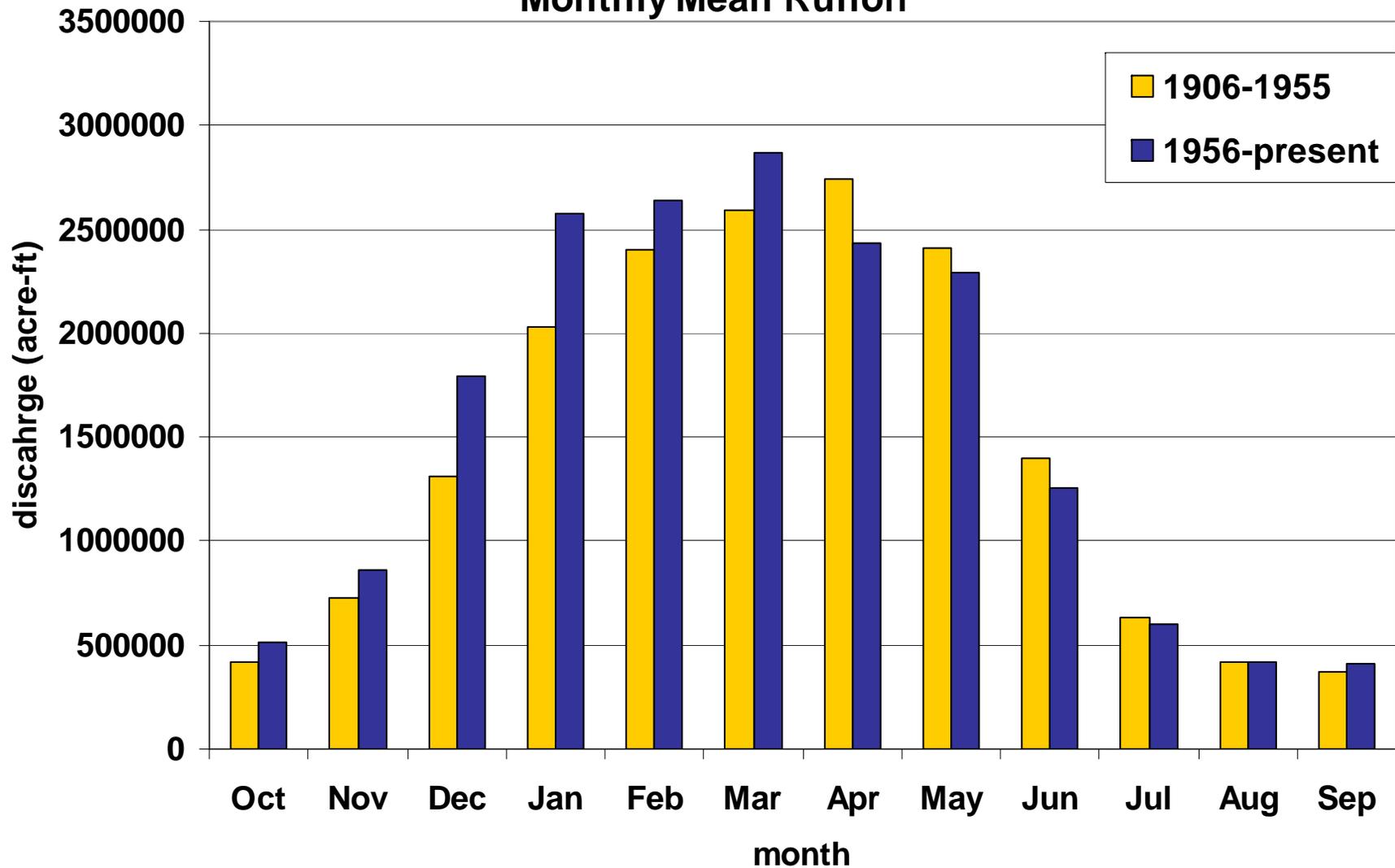


Annual Runoff Volume – San Joaquin River



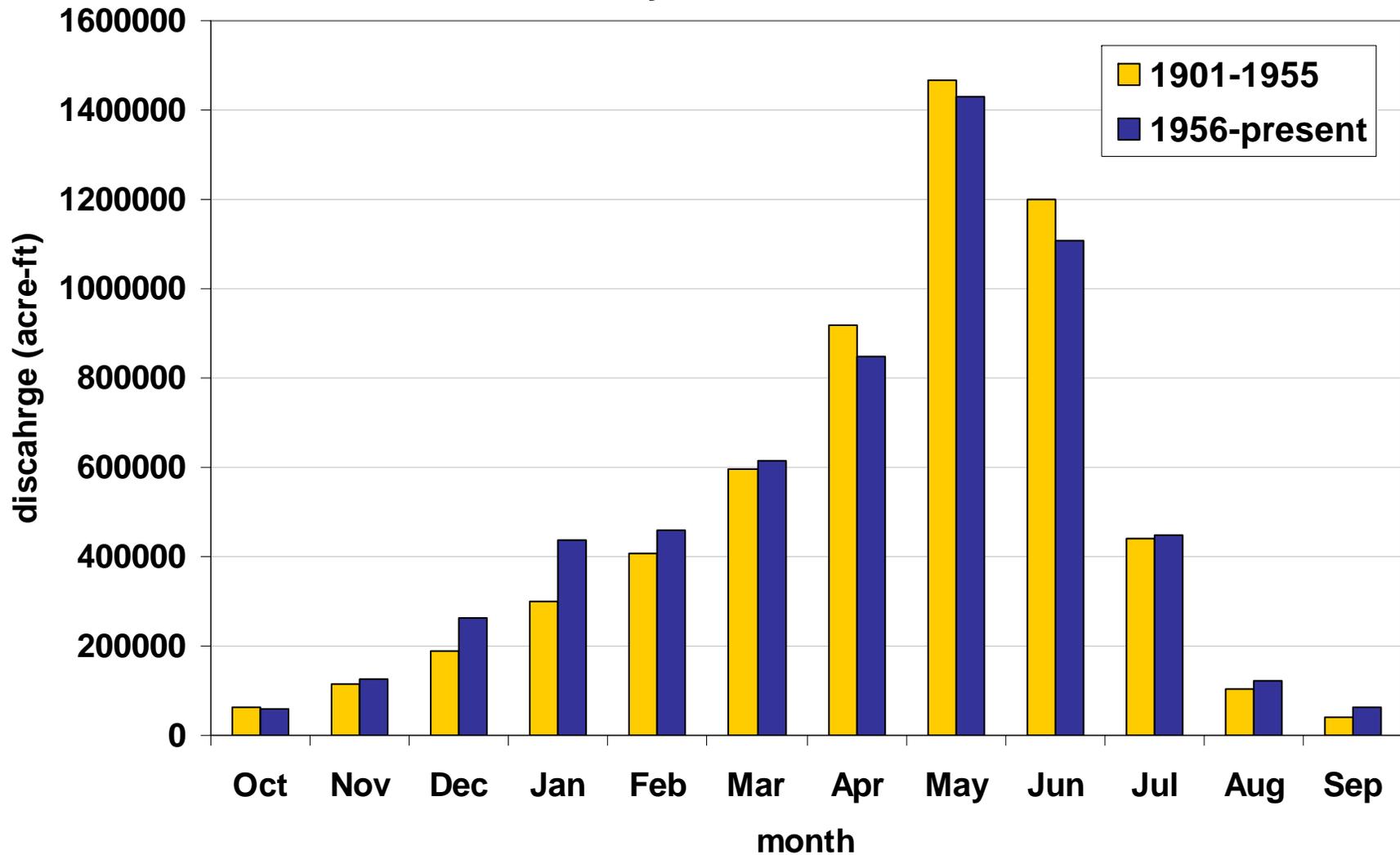
20th Century California Climate

Sacramento River Monthly Mean Runoff



20th Century California Climate

San Joaquin River Monthly Mean Runoff

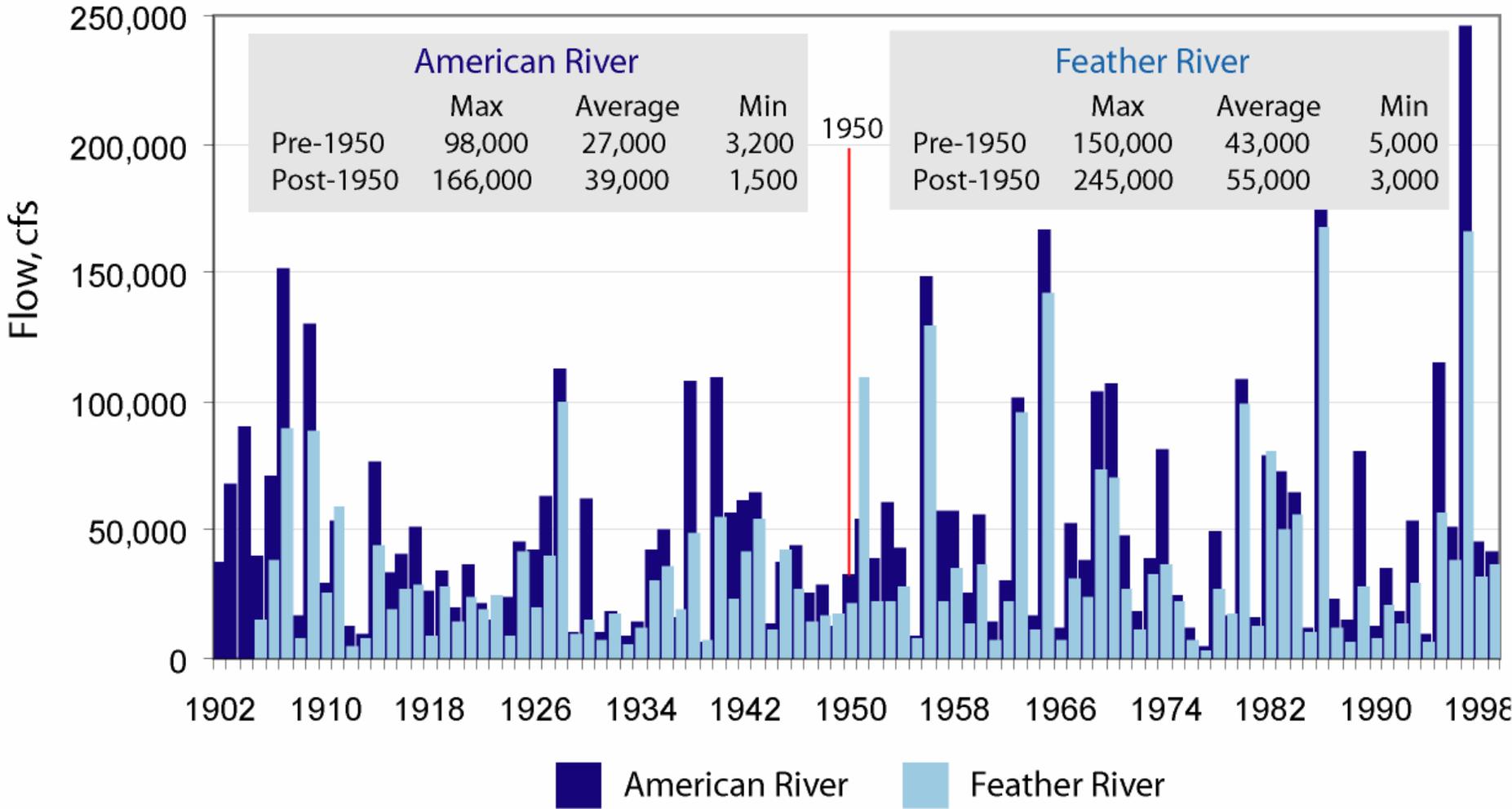


Observed Changes in Peak Runoff Statistics

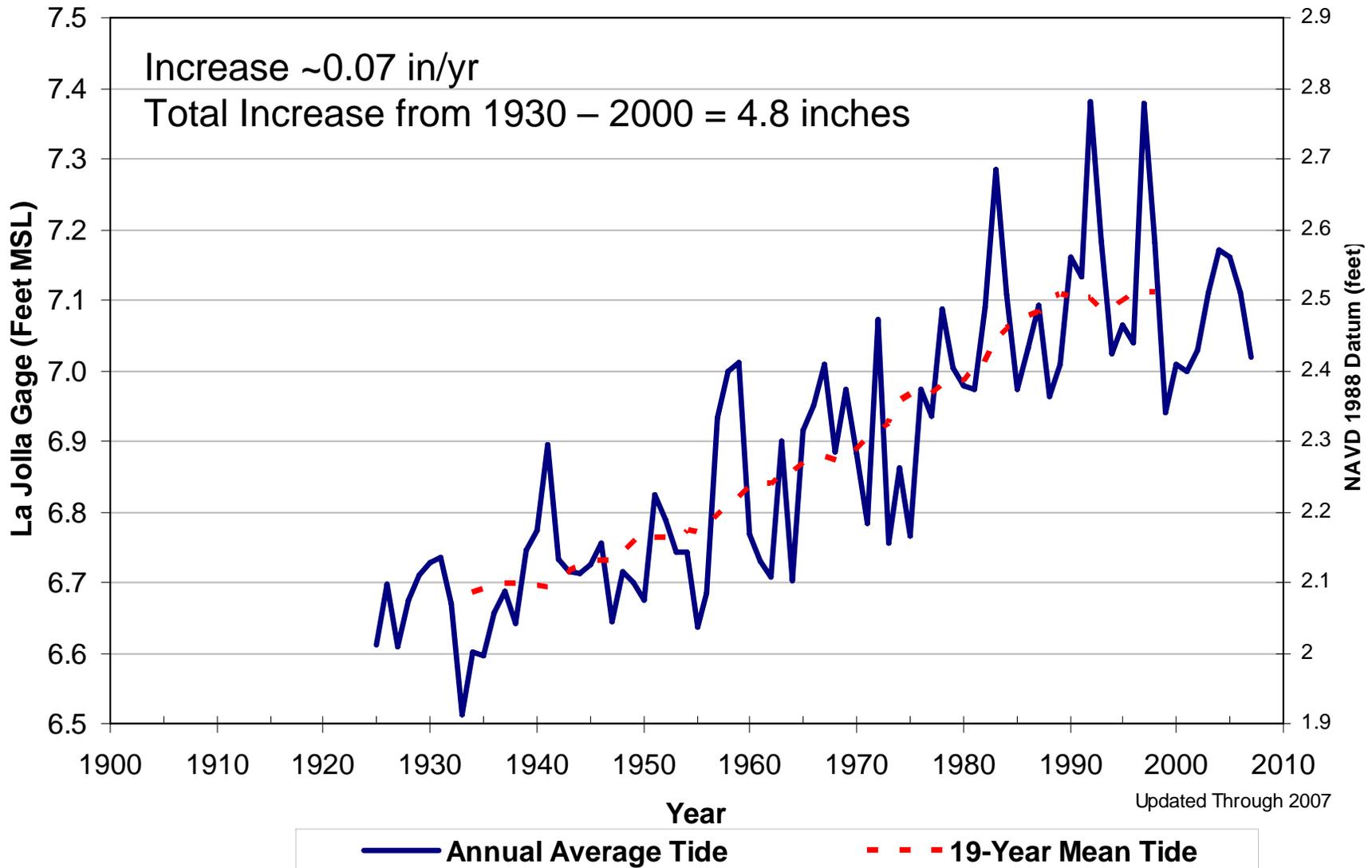
Pre/Post 1955	Feather	Tuolumne	Eel
Mean	42/52	12/17	93/123
Standard Deviation	33/50	11/19	48/84
Range	145/232	52/91	165/489

Values in 1000 cfs for annual peaks of 3-day average flows
1904-2004 data used for analysis
Range is maximum-minimum values for time period

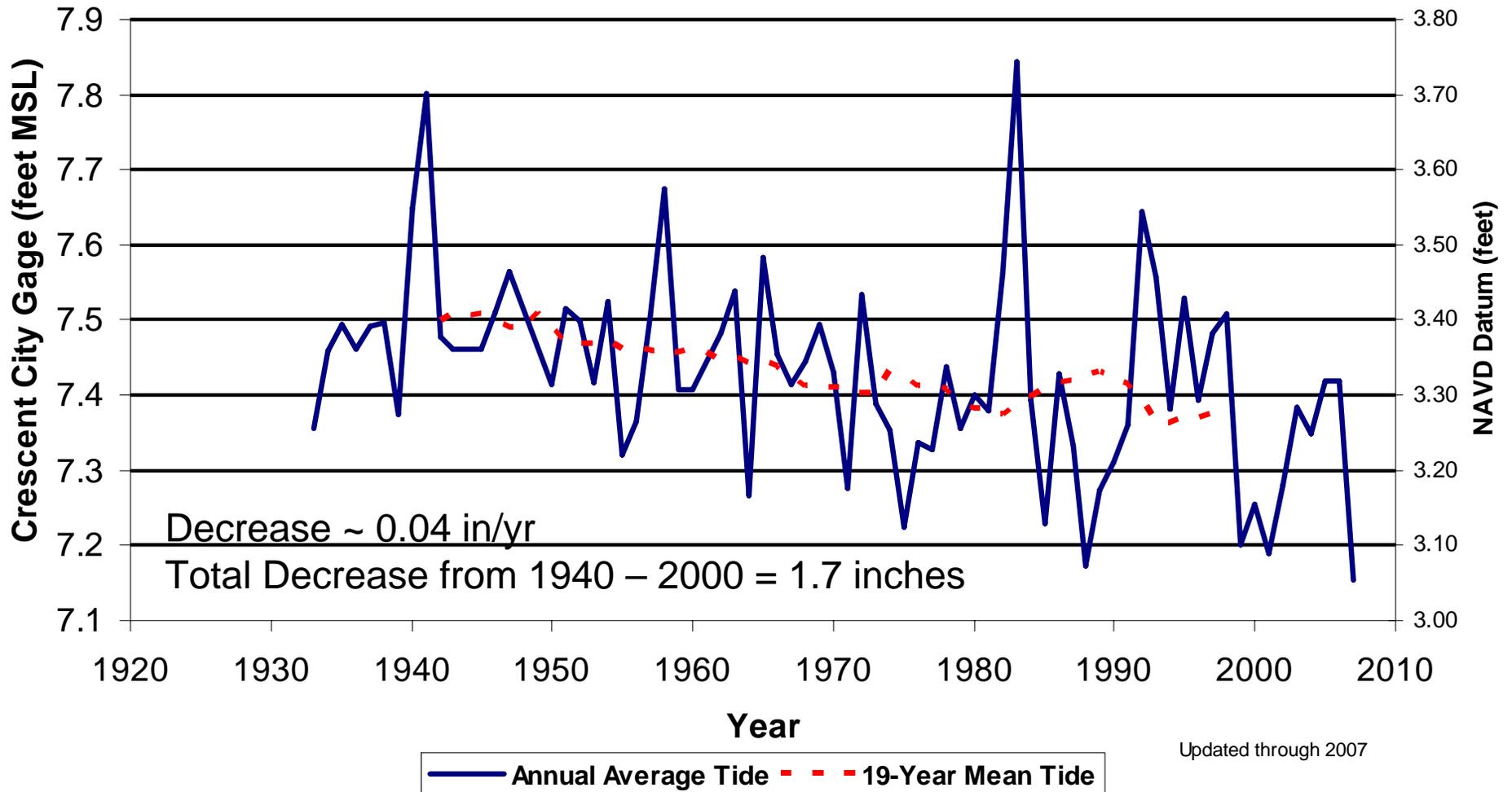
20th Century Annual Peak 3-Day Flows without the Influence of Reservoirs



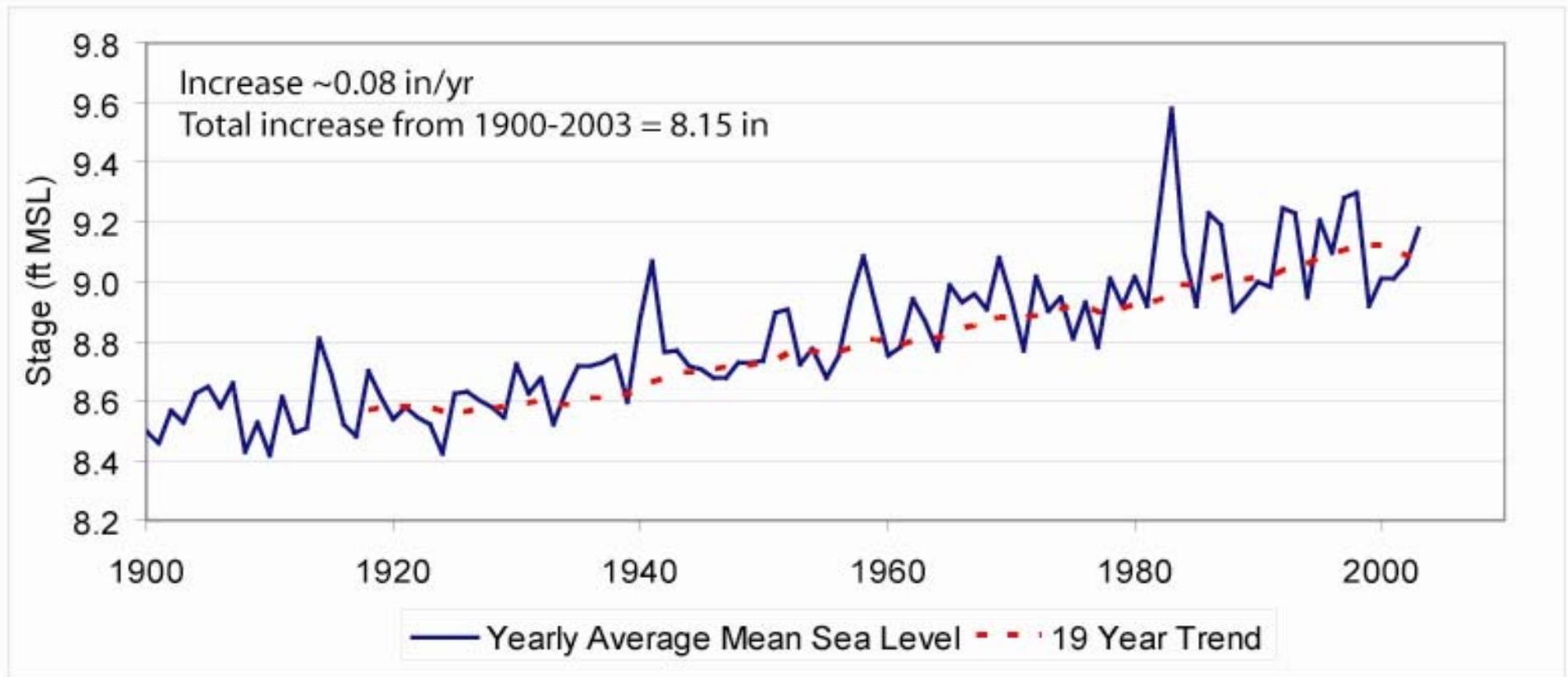
Sea Level Change – La Jolla



Sea Level Change – Crescent City



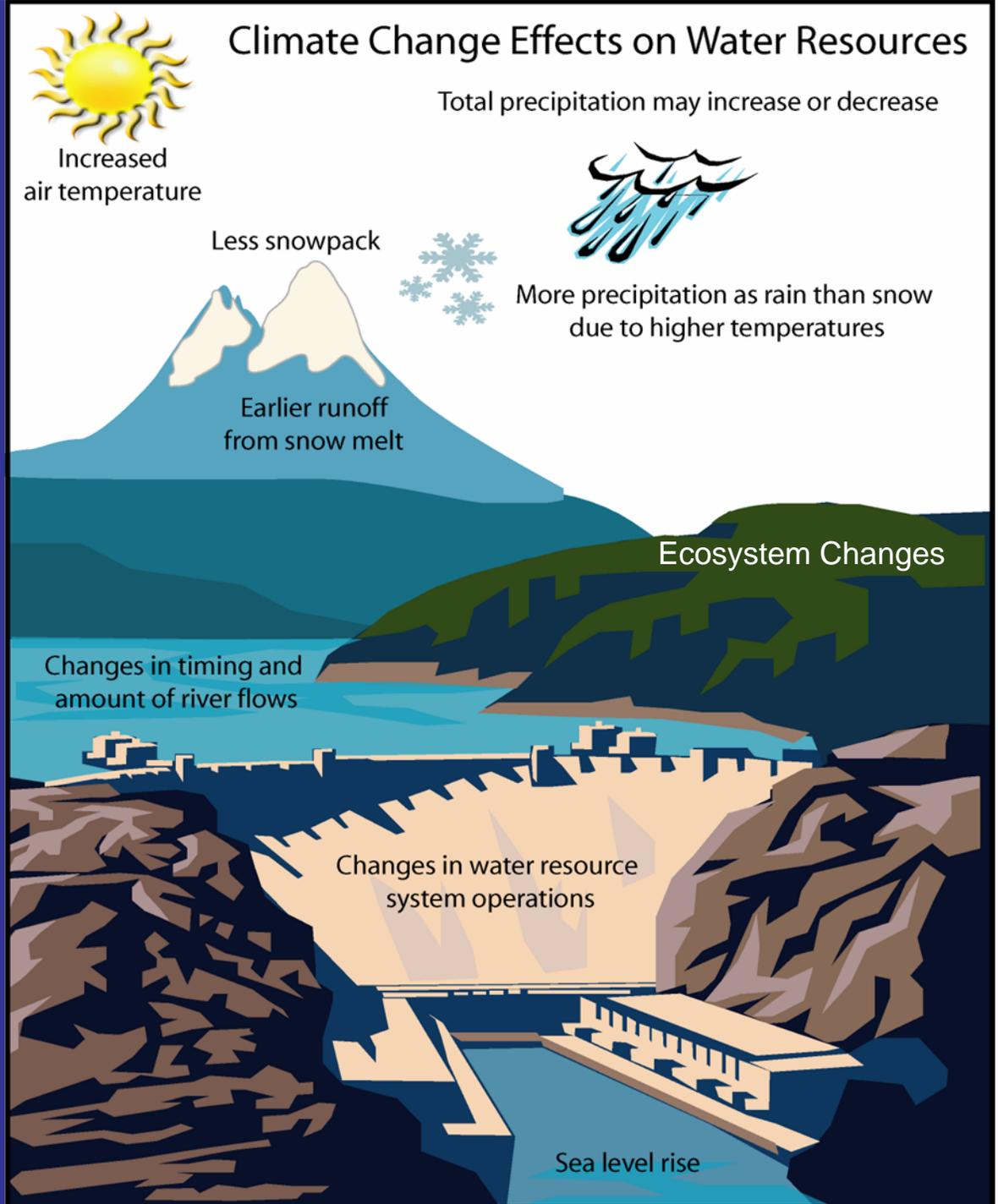
Sea Level Change – Golden Gate



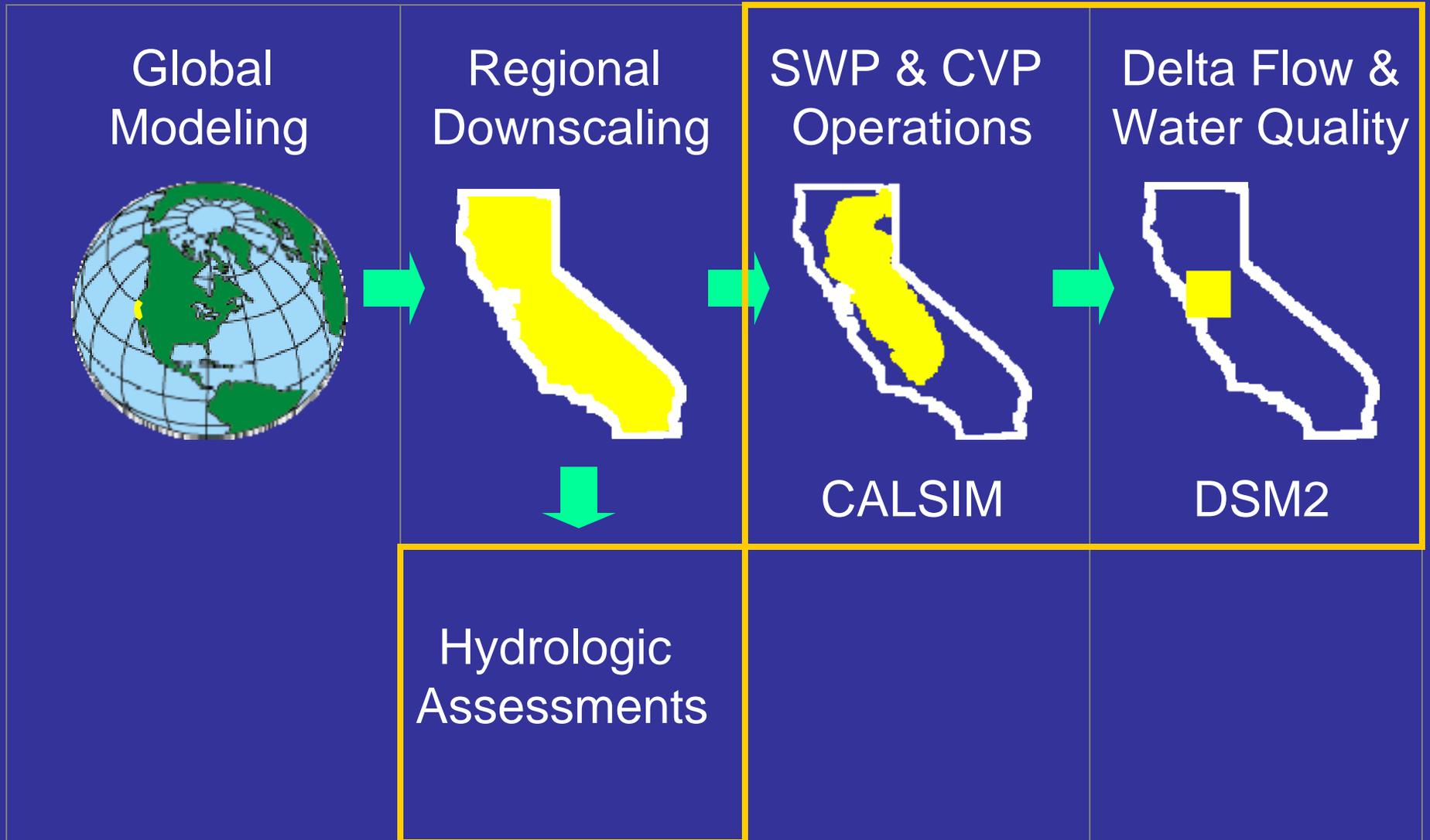
Putting Science in Action

- IPCC Fourth Assessment
- California Climate Action Team
- CEC PIER Program
- California Applications Program
- California Climate Change Center
- BCSD and CA Downscaling Data
- Rahmstorf Sea Level Rise Projection

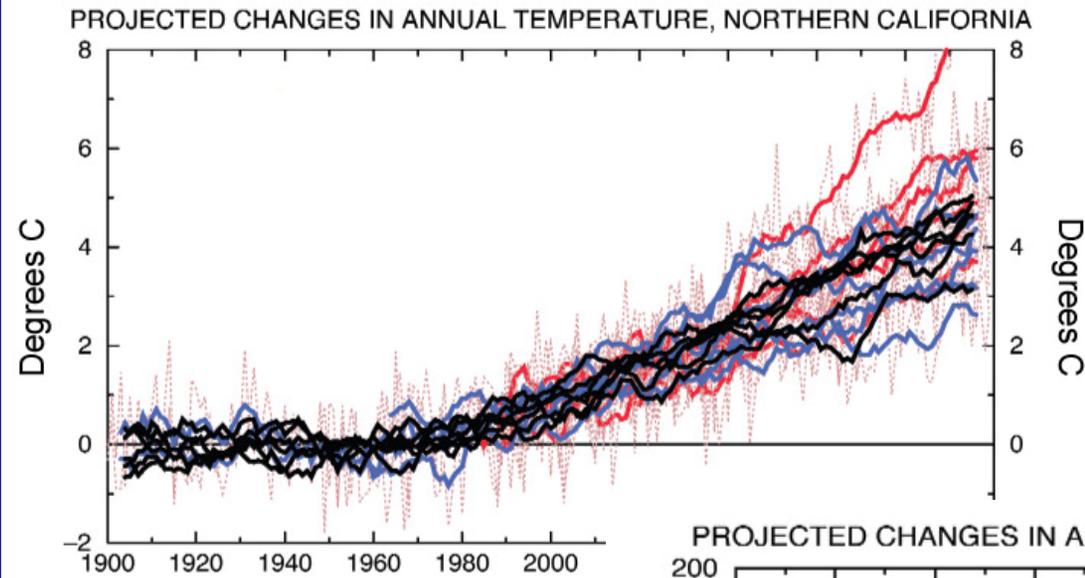
Climate Change – What's Expected



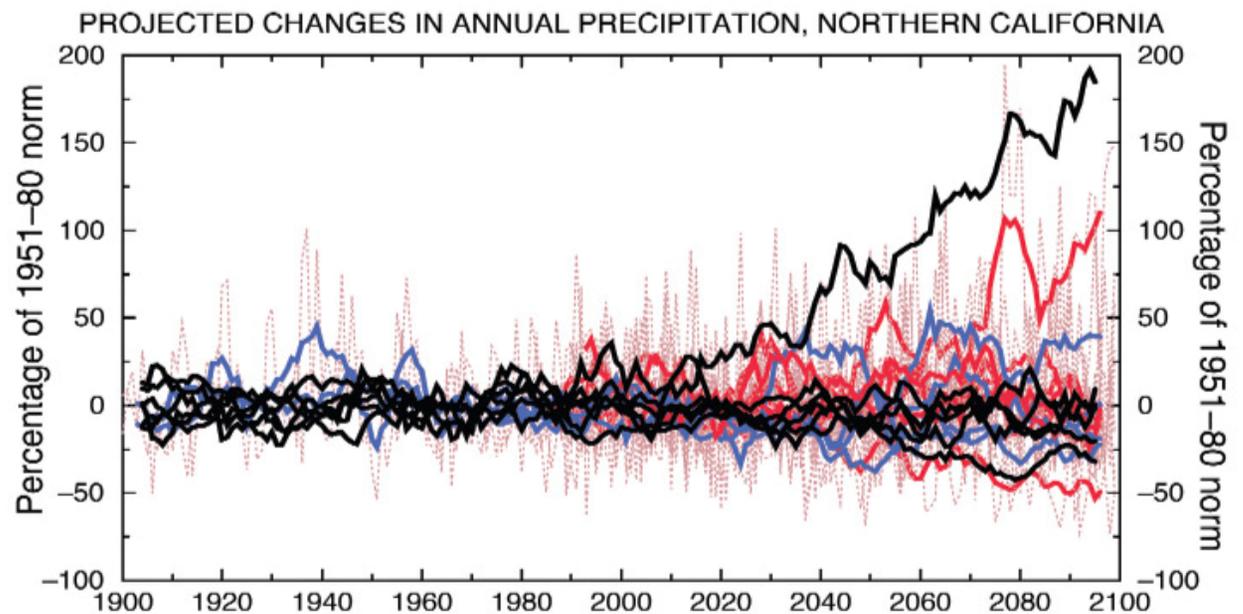
Analysis Process



Looking to the Future



Graphs from
Mike Dettinger, 2005



Future joint P-T distribution

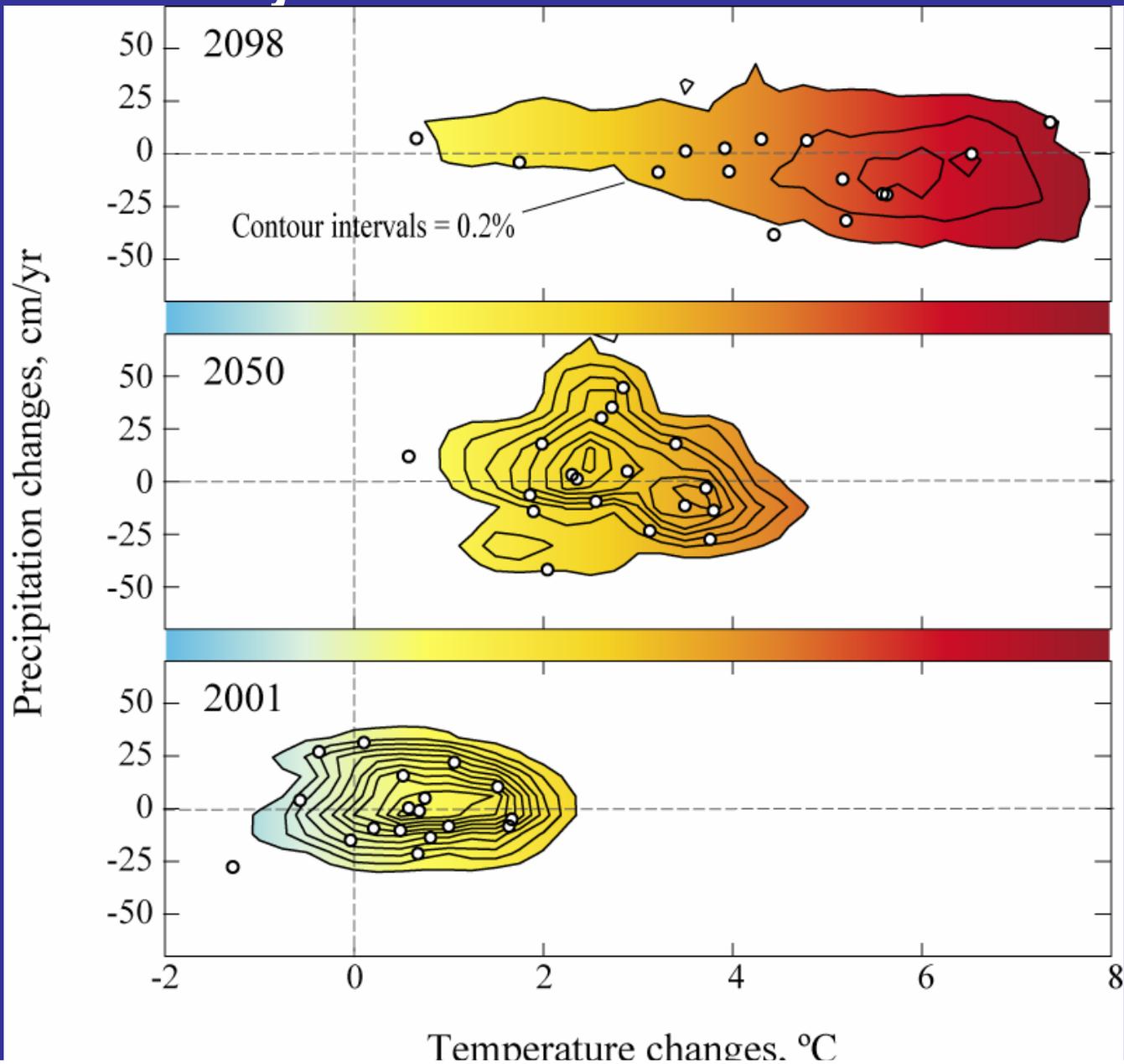
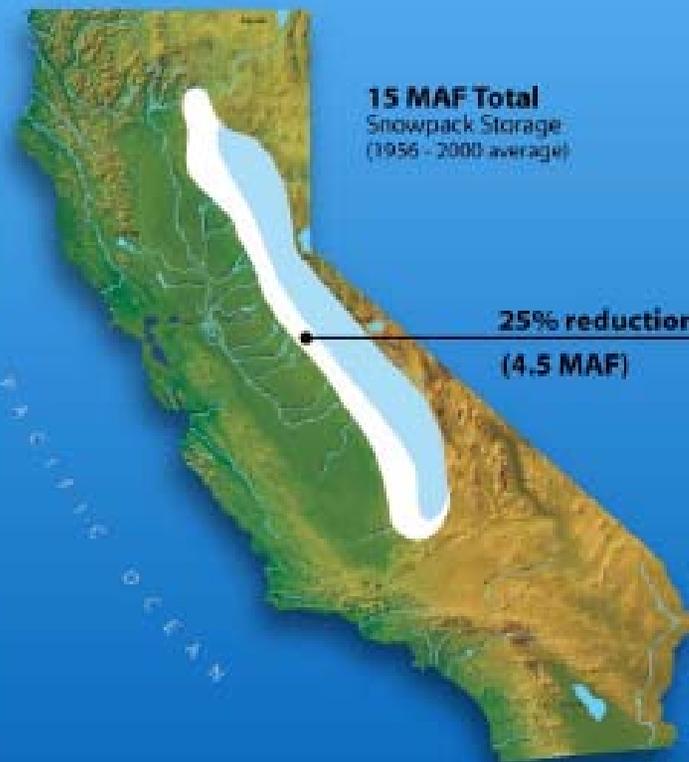
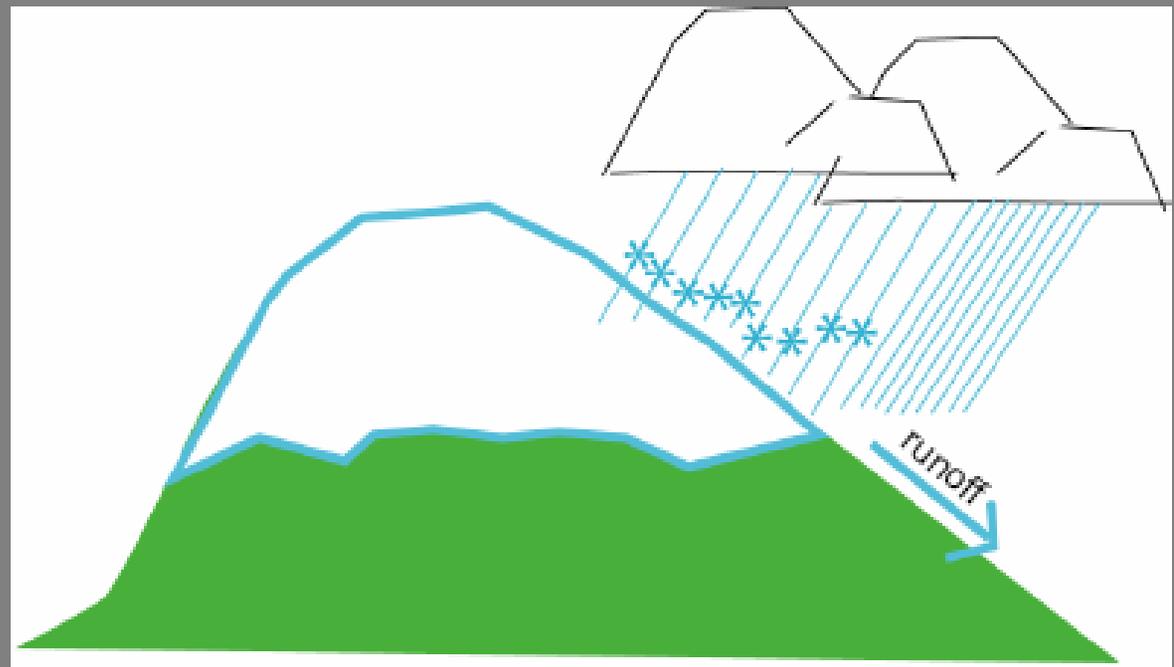


Image from Mike
Dettinger, 2005

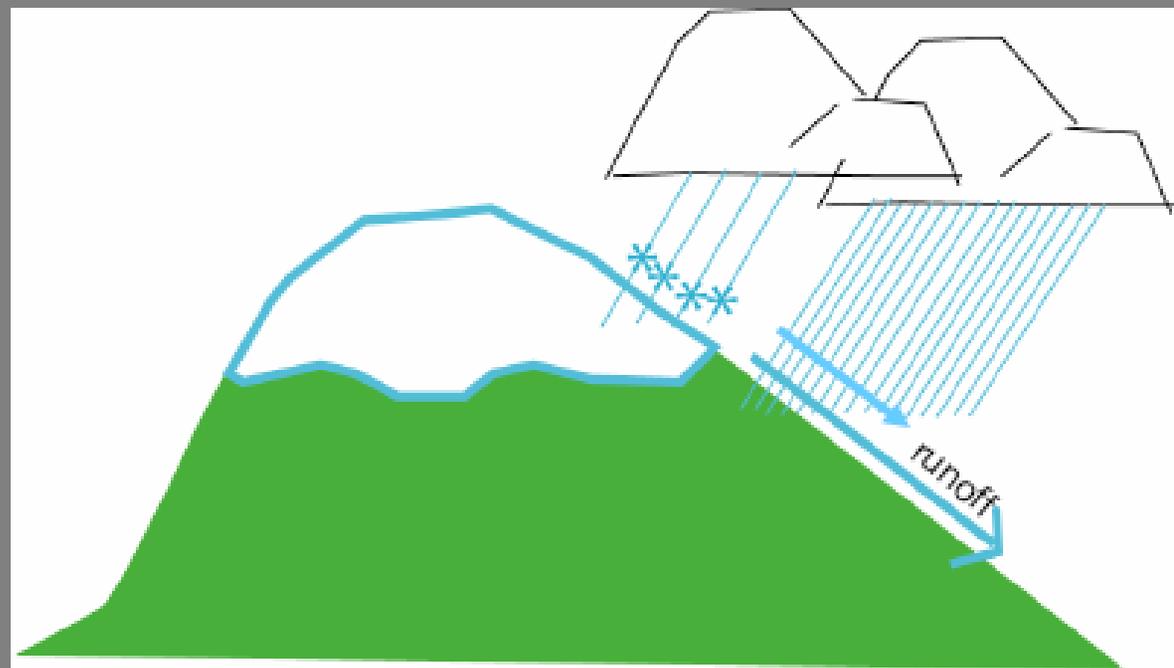
Range of Snowpack Reductions Projected by 2050



historically:
“Cool” storms
contribute
immediate runoff
from smaller areas
of the river basin
(the rest goes into
snowpack for later)



In a warmer climate:
Warm storms
contribute
immediate runoff
from larger areas
of the river basin

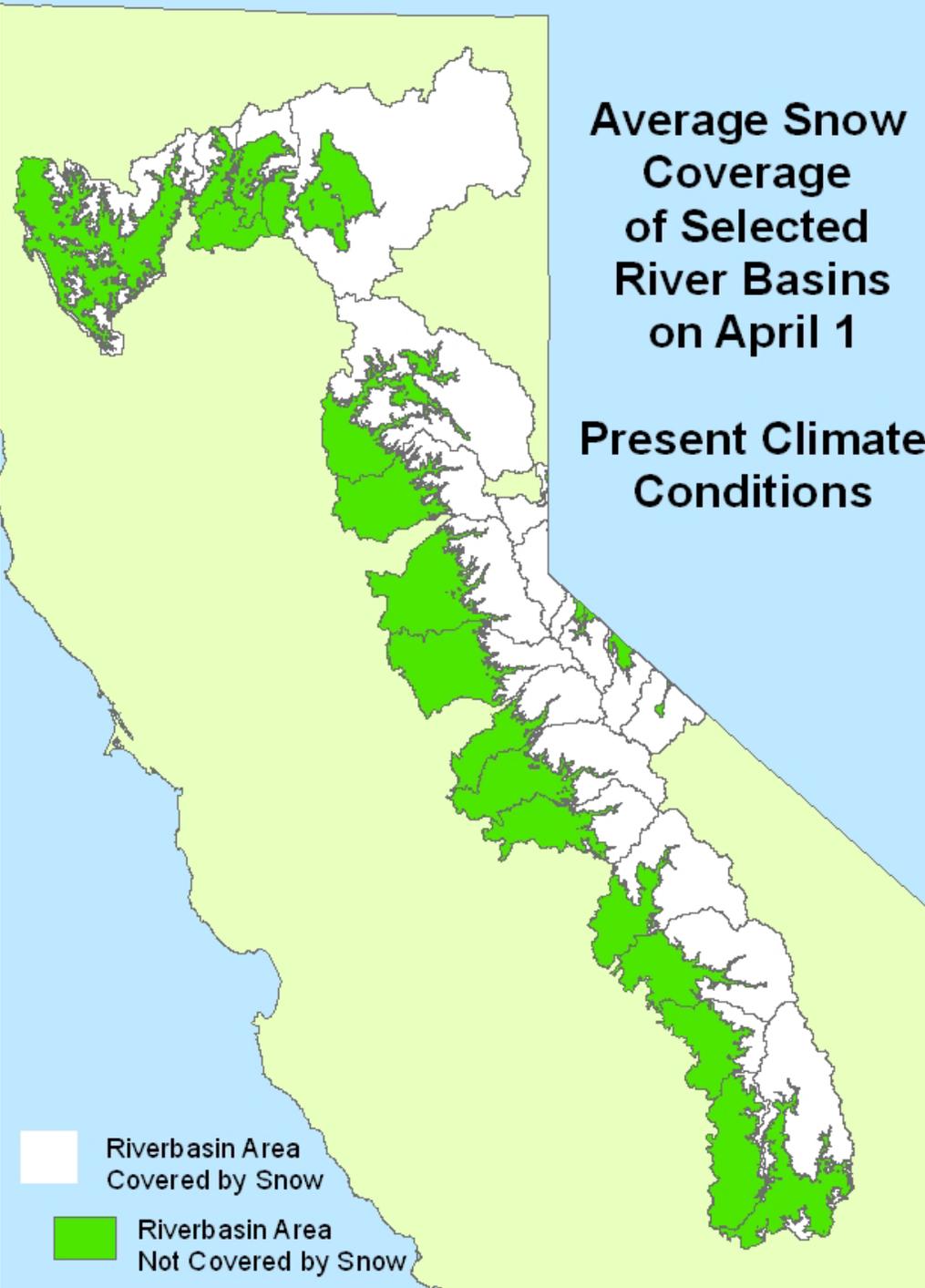


**Average Snow
Coverage
of Selected
River Basins
on April 1**

**Present Climate
Conditions**

-  Riverbasin Area Covered by Snow
-  Riverbasin Area Not Covered by Snow

Image by Jane
Schafer-Kramer
DWR-Bay Delta Office



**Average Snow
Coverage
of Selected
River Basins
on April 1**

**1° C
Global
Temperature
Rise**

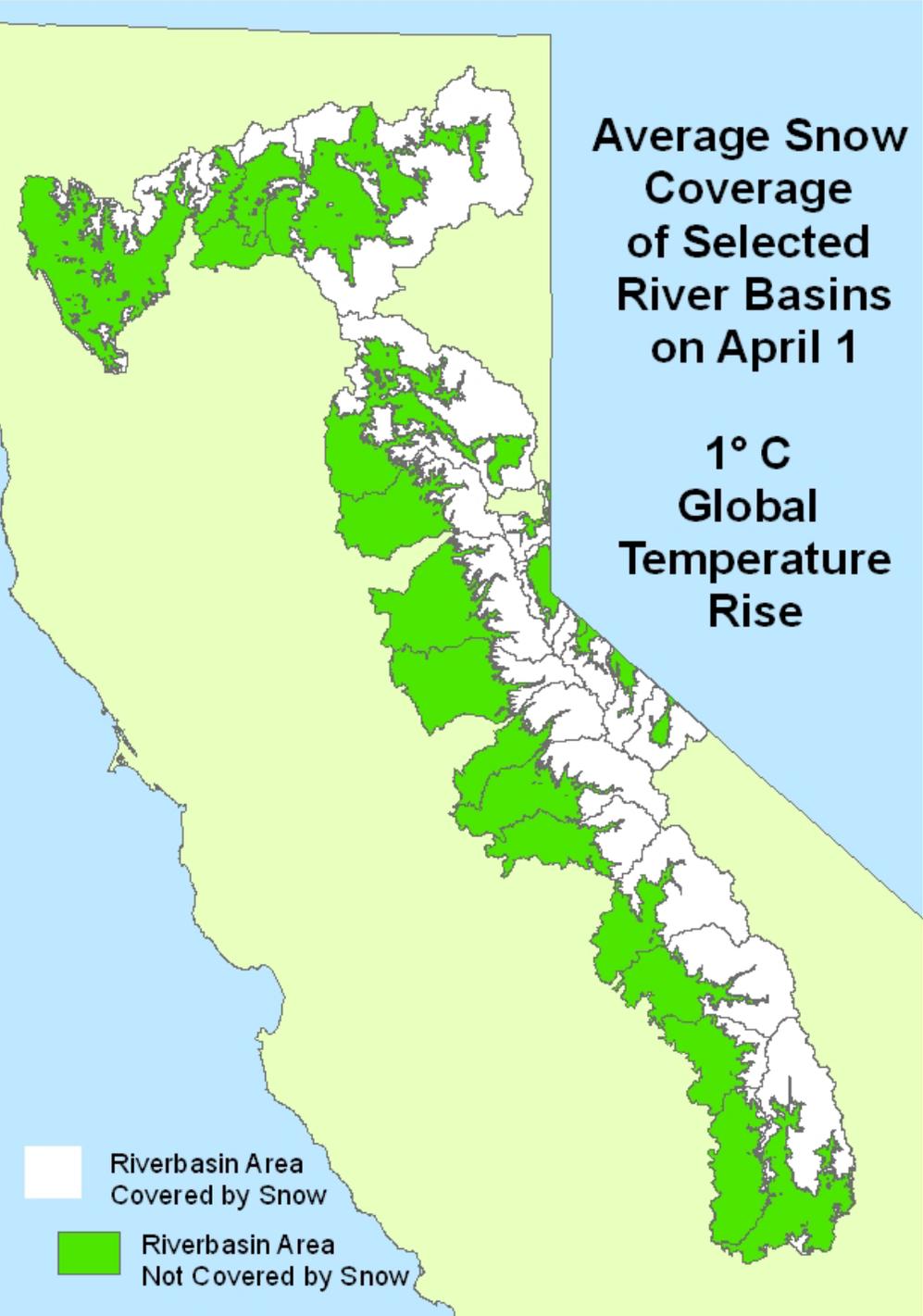


Image by Jane
Schafer-Kramer
DWR-Bay Delta Office

**Average Snow
Coverage
of Selected
River Basins
on April 1**

**2° C
Global
Temperature
Rise**

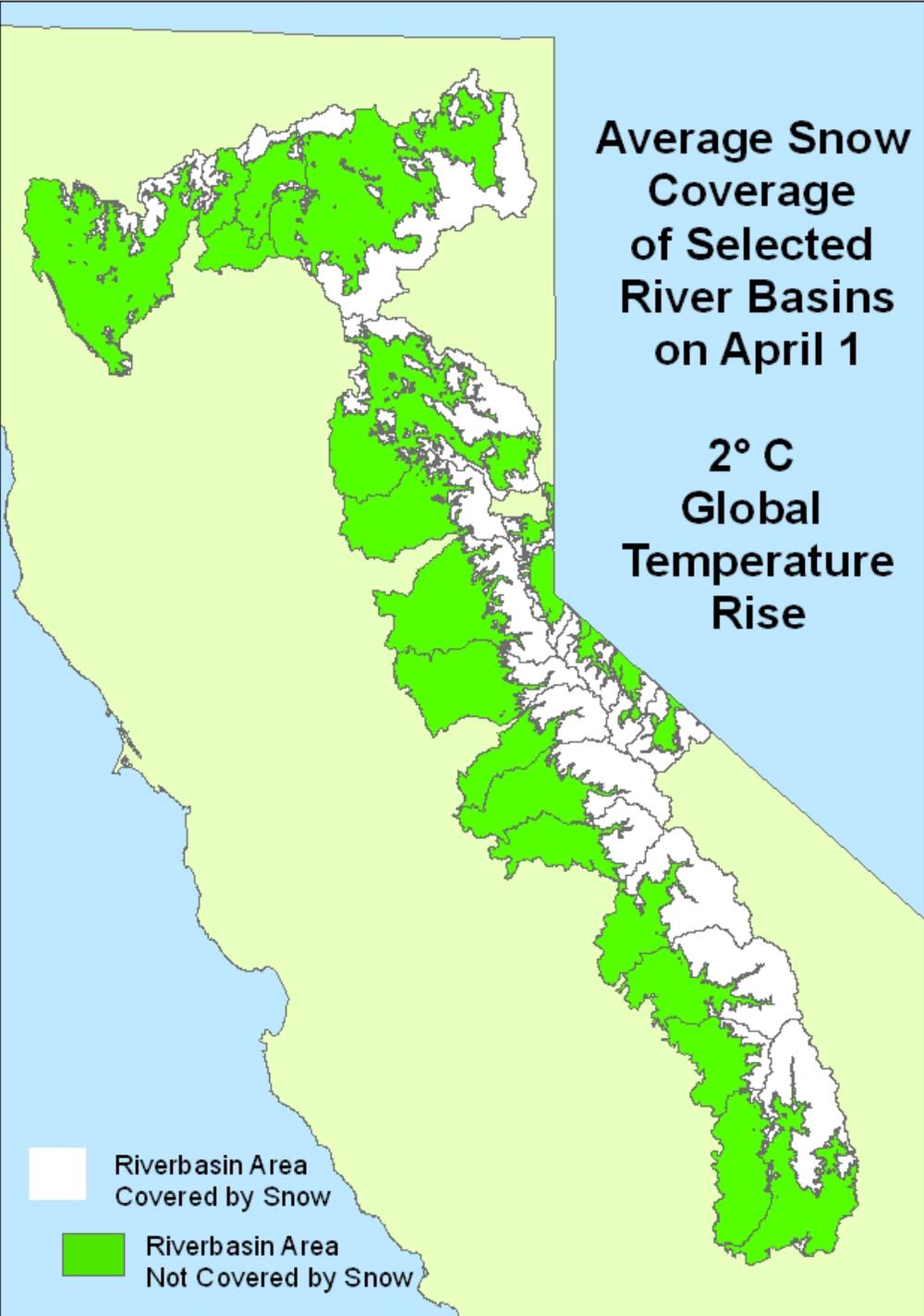


Image by Jane
Schafer-Kramer
DWR-Bay Delta Office

**Average Snow
Coverage
of Selected
River Basins
on April 1**

**3° C
Global
Temperature
Rise**

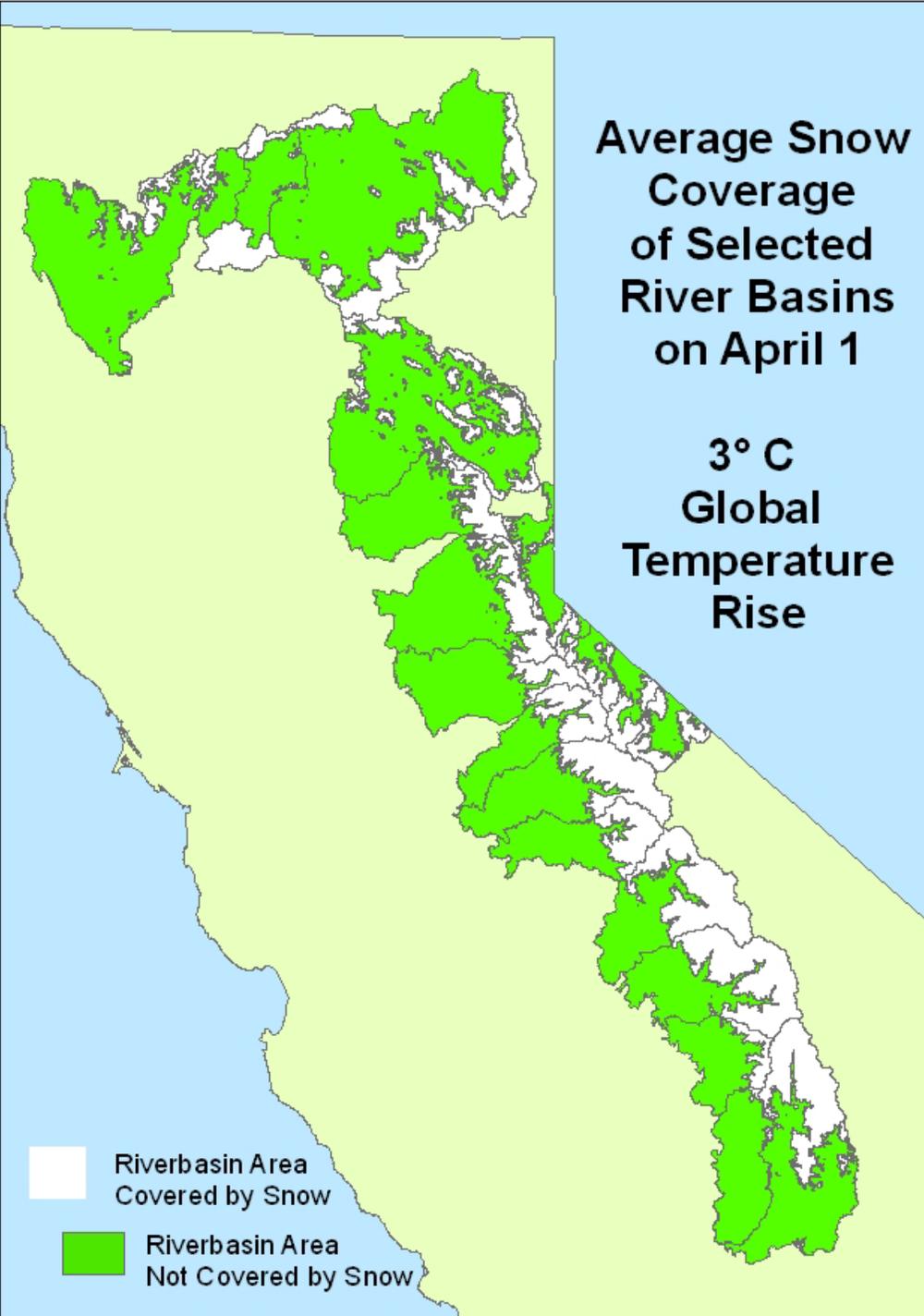


Image by Jane
Schafer-Kramer
DWR-Bay Delta Office

**Average Snow
Coverage
of Selected
River Basins
on April 1**

**4° C
Global
Temperature
Rise**

-  Riverbasin Area Covered by Snow
-  Riverbasin Area Not Covered by Snow

**Average Snow
Coverage
of Selected
River Basins
on April 1**

**5° C
Global
Temperature
Rise**

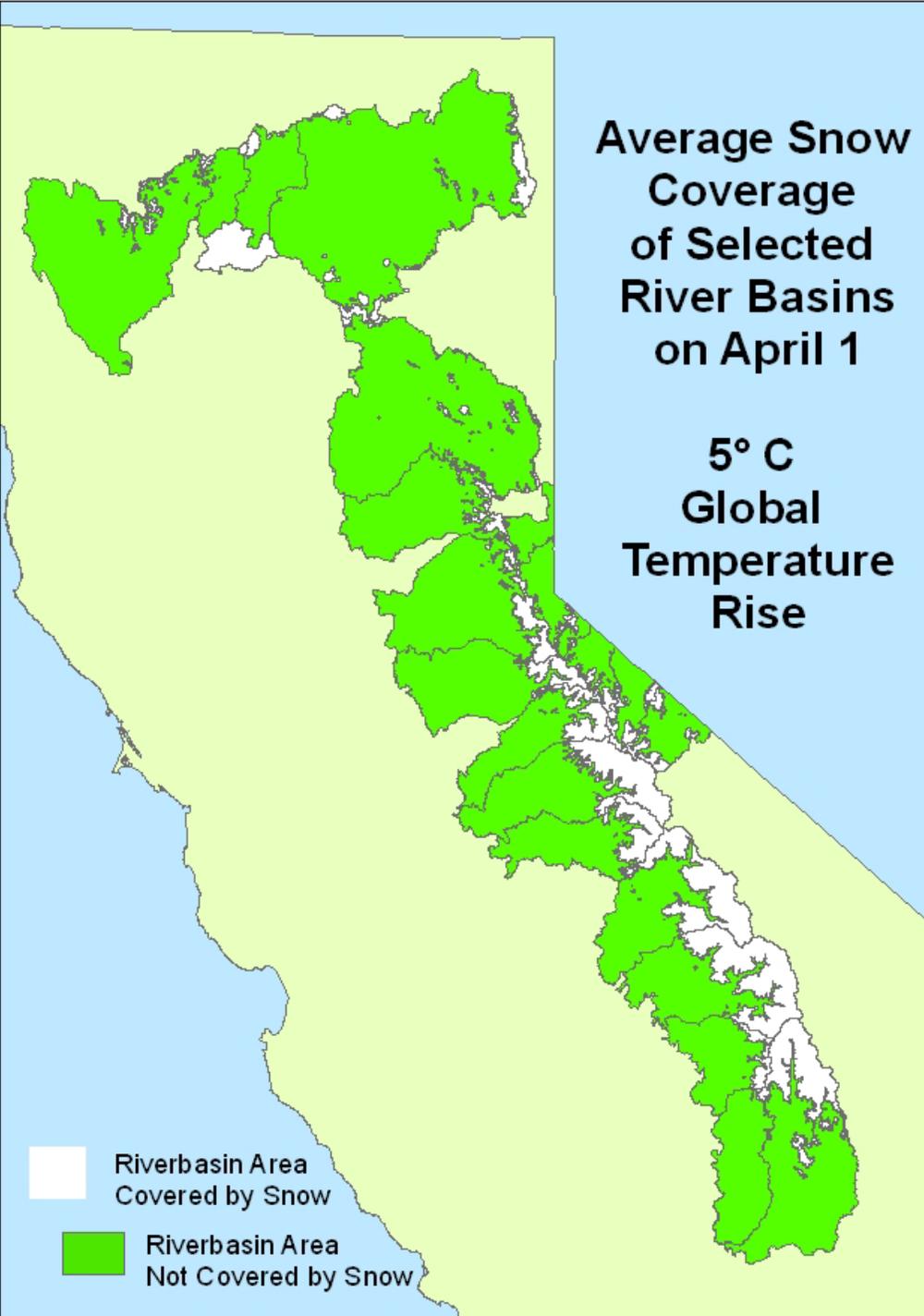
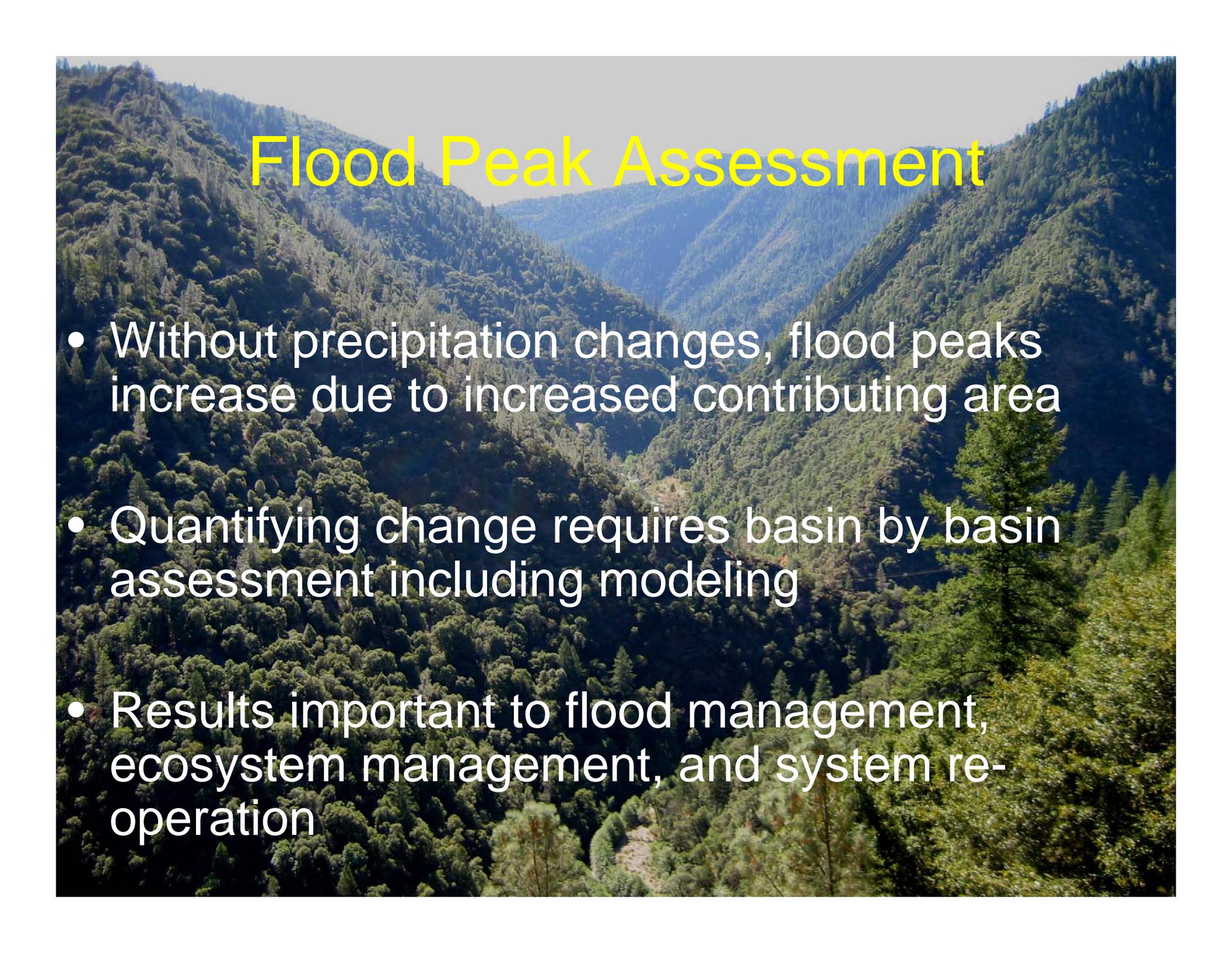


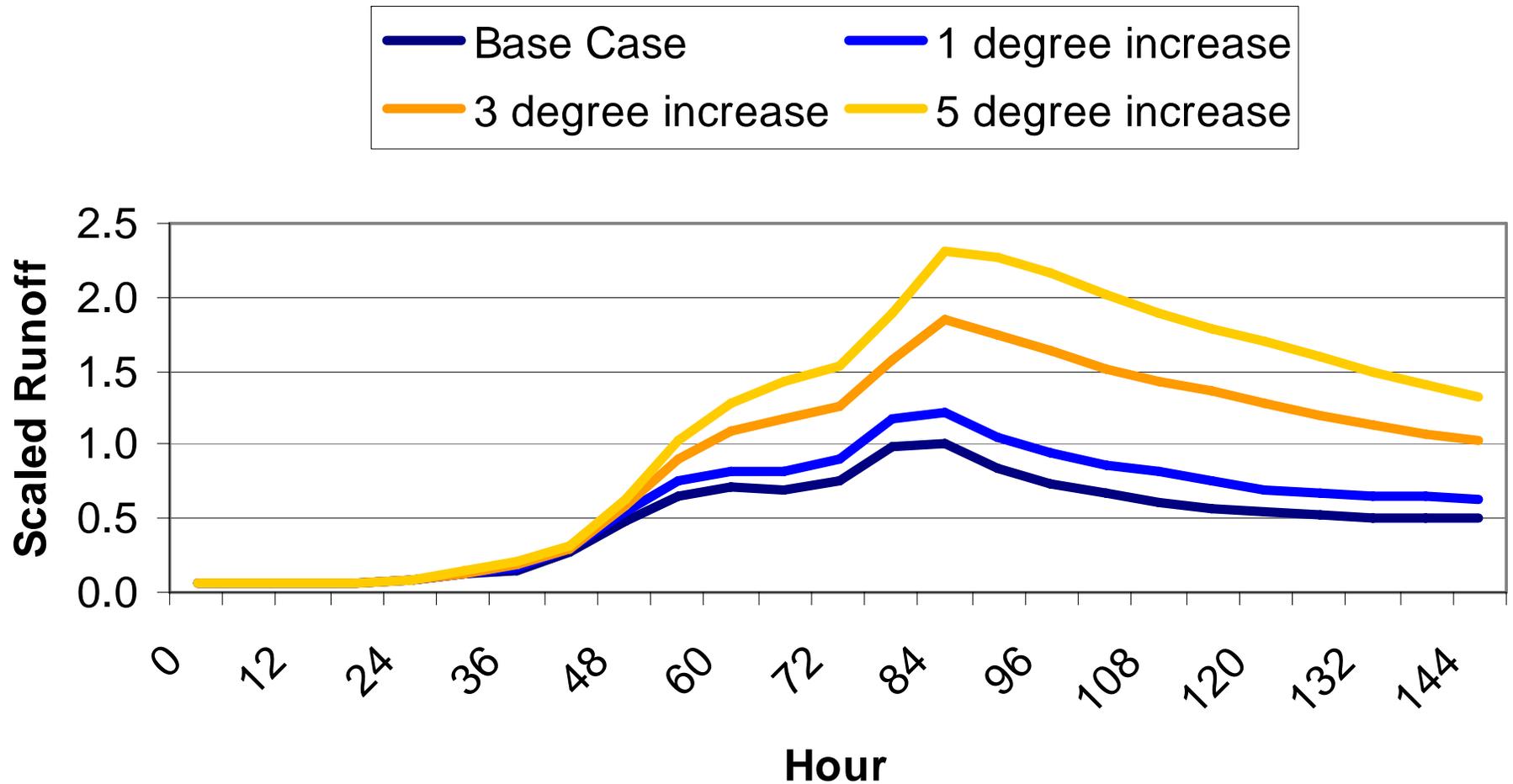
Image by Jane
Schafer-Kramer
DWR-Bay Delta Office

An aerial photograph of a vast, densely forested mountain valley. The terrain is rugged with steep slopes covered in thick green trees. The valley floor is visible in the distance, and the sky is clear and blue. The text 'Flood Peak Assessment' is overlaid in yellow at the top center.

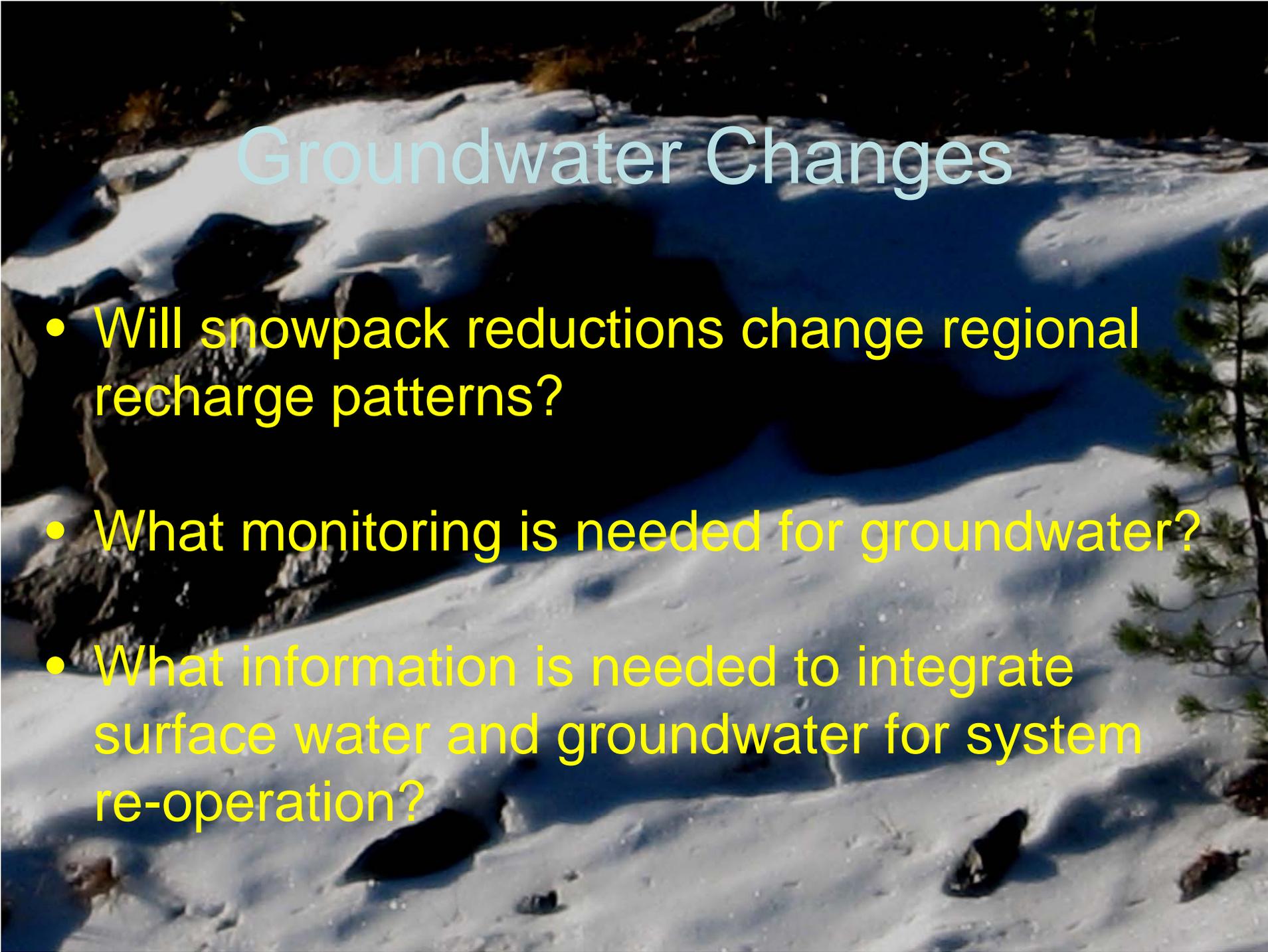
Flood Peak Assessment

- Without precipitation changes, flood peaks increase due to increased contributing area
- Quantifying change requires basin by basin assessment including modeling
- Results important to flood management, ecosystem management, and system re-operation

Feather River Runoff Assessment



No Change in Rainfall Pattern or Amount



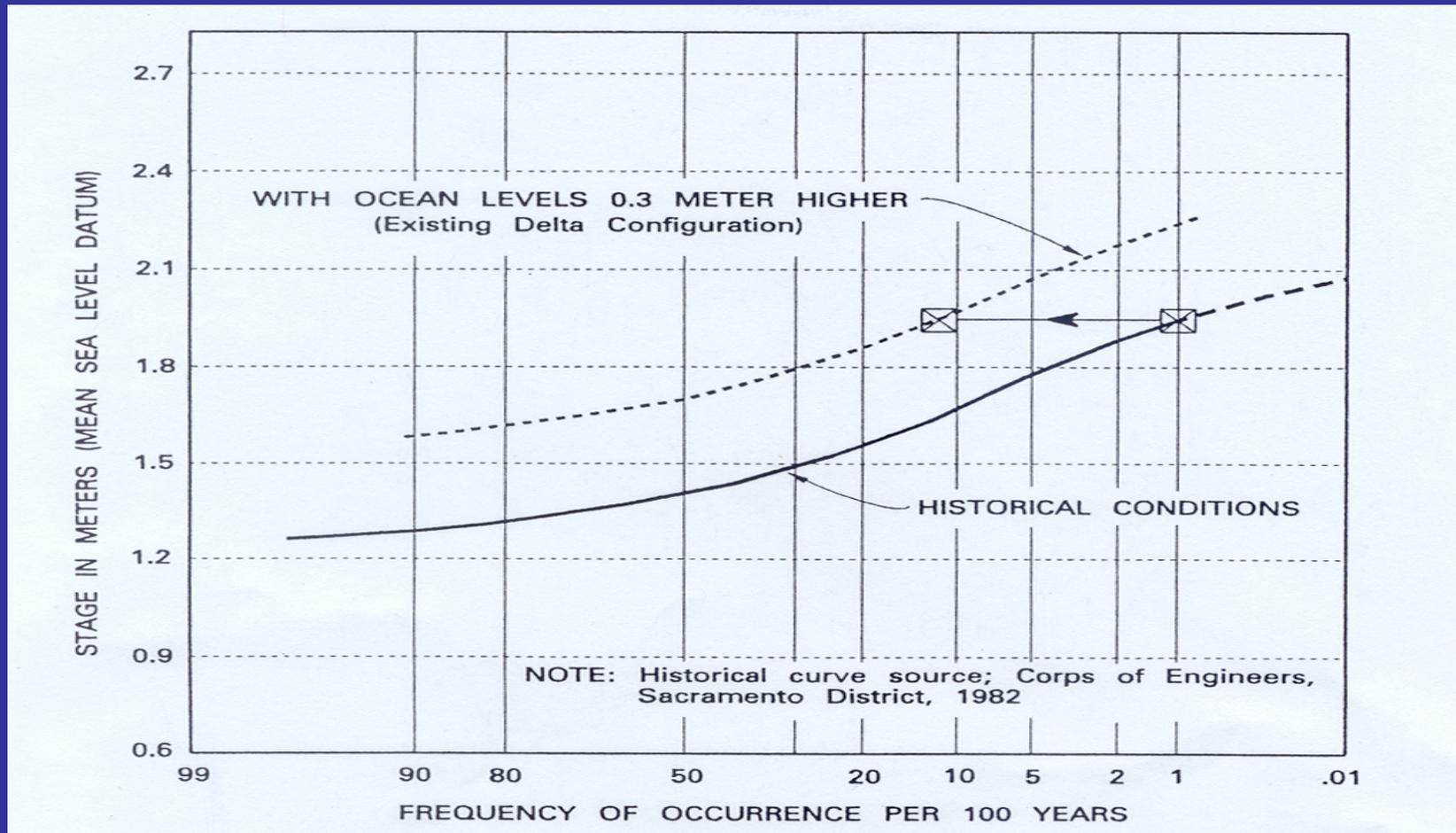
Groundwater Changes

- Will snowpack reductions change regional recharge patterns?
- What monitoring is needed for groundwater?
- What information is needed to integrate surface water and groundwater for system re-operation?

Sea Level Change Assessment

- Need to evaluate changes to sea level, tidal range and tidal range frequency
- Important to water supply, ecosystem management, flood management and system re-operation

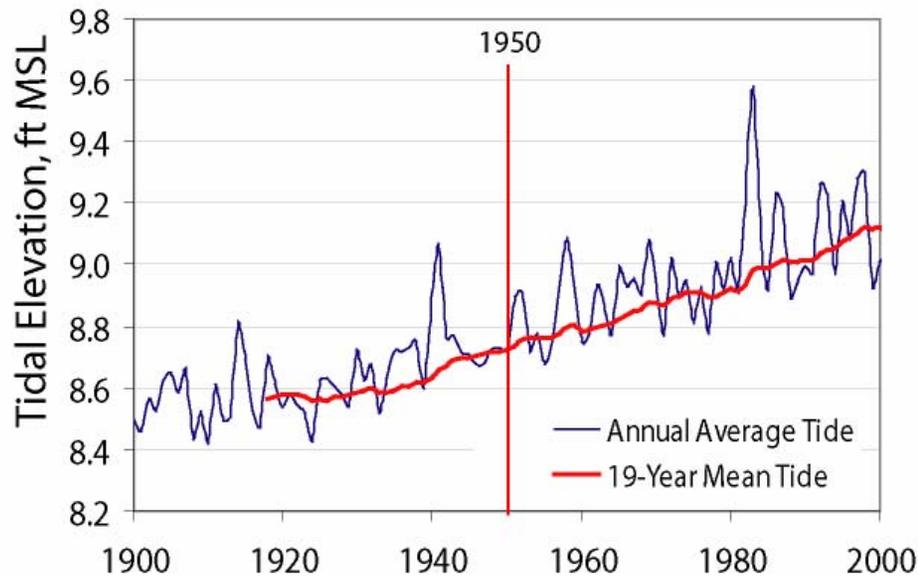
Antioch Stage Frequency Chart



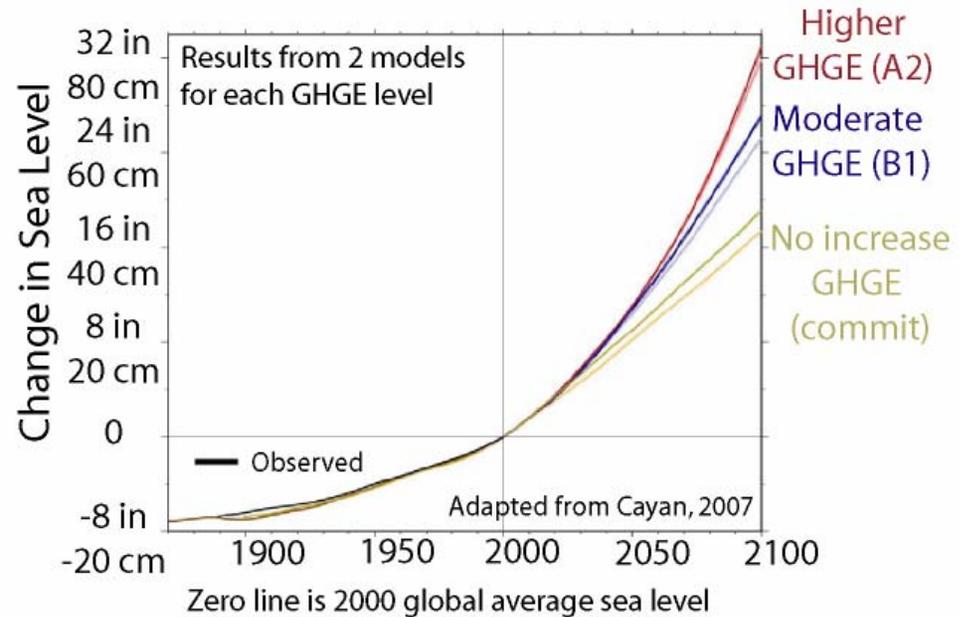
A one foot (.3m) rise in sea level causes a 1/100 year stage to become a 1/10 year stage at Antioch

Sea Level Change

20th Century Tidal Elevations at Golden Gate



Historic and Projected Global Sea Level Rise



Changes in 19-yr Trend

	Total Rise	Rate of Rise
Pre-1950	1.9 in	0.060 in/yr
Post-1950	4.6 in	0.095 in/yr

Abbreviations:

GHGE=Green House Gas Emissions
MSL=Mean Sea Level

Action Items

- Extreme Precipitation/Flooding
- Snowpack Reduction
- Groundwater
- Sea Level Change
- Water/Energy Nexus
- System Re-Operation
- IRWM Strategies



An aerial photograph of a vast, flat, blue landscape, possibly a salt flat or a desert, under a clear sky. The terrain is mostly uniform in color, with some subtle variations in tone and texture. The word "Feedback?" is centered in the image in a purple font.

Feedback?