

# Tree Rings and Water Resource Management in the Southwest

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Photo: D. Meko



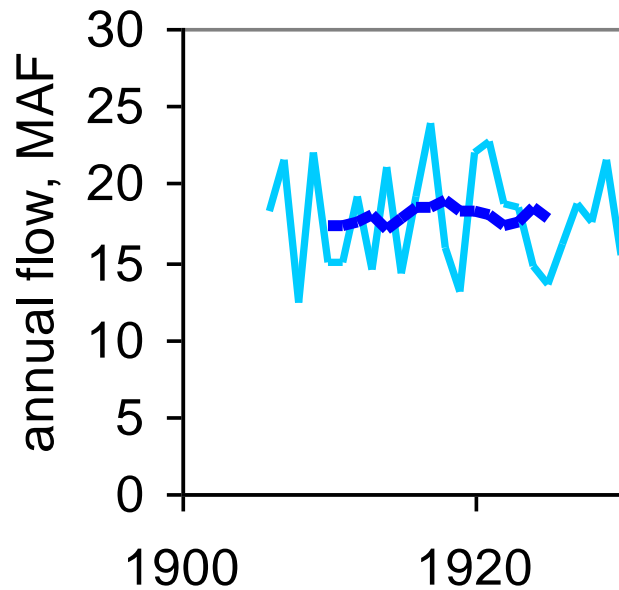
\*This presentation contains the  
contributions of many of my colleagues

This conference is on climate change. Why look at tree rings?

“The farther backward you can look,  
the farther forward you are likely to see.”  
- Winston Churchill

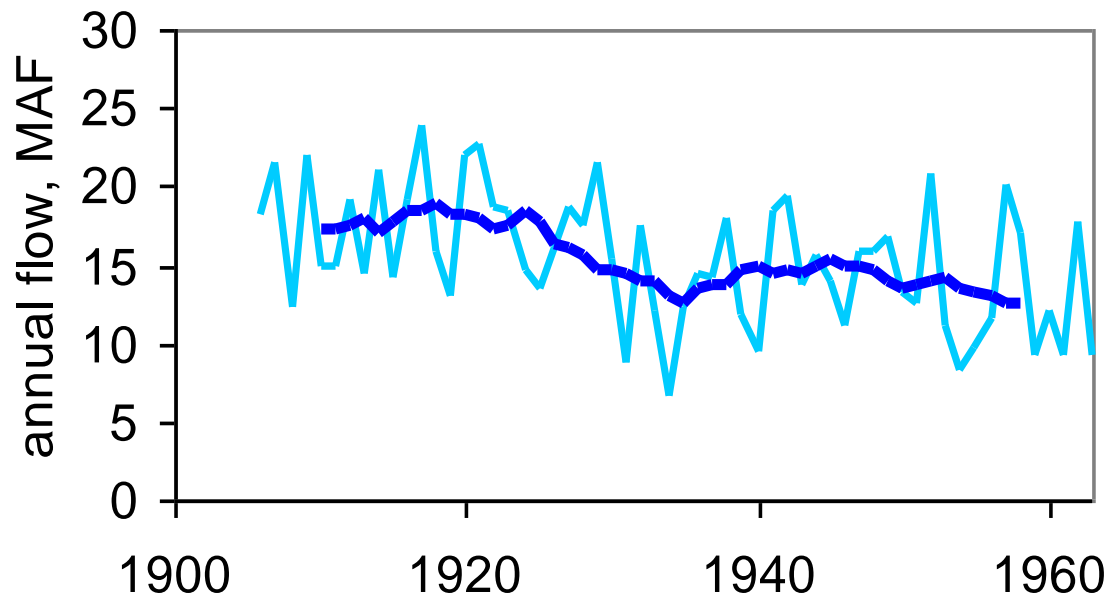


Historically, compacts, water policy and management have been based on the available gage and climate records



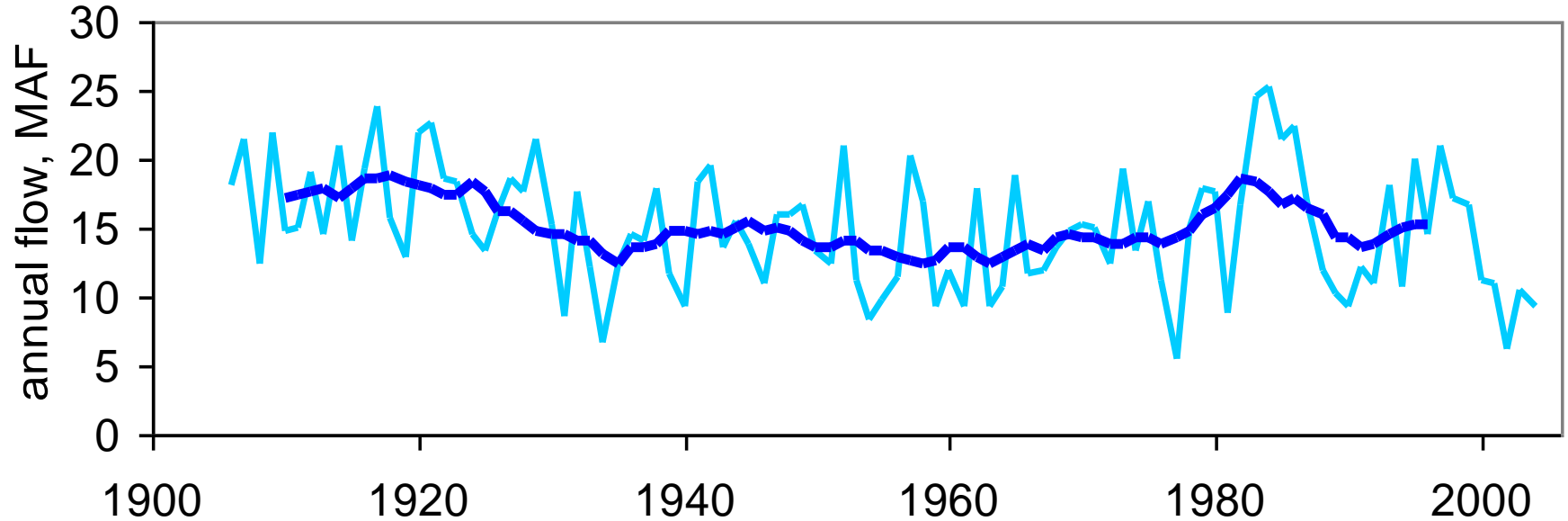
Colorado River at Lees Ferry, 1906-1930

Historically, compacts, water policy and management have been based on the available gage records



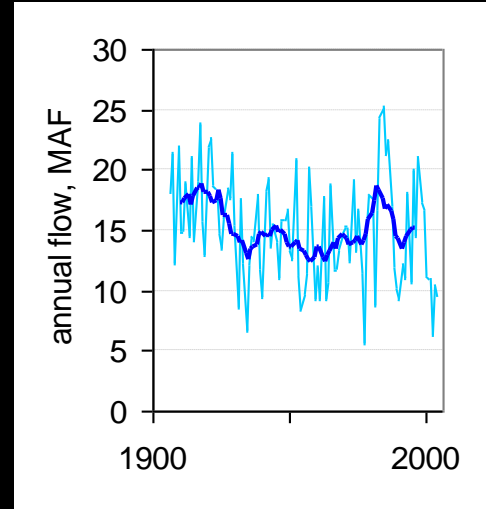
Colorado River at Lees Ferry, 1906-1960

Historically, compacts, water policy and management have been based on the available gage records



Colorado River at Lees Ferry, 1906-2004

How representative is the gage record over a longer time frame?

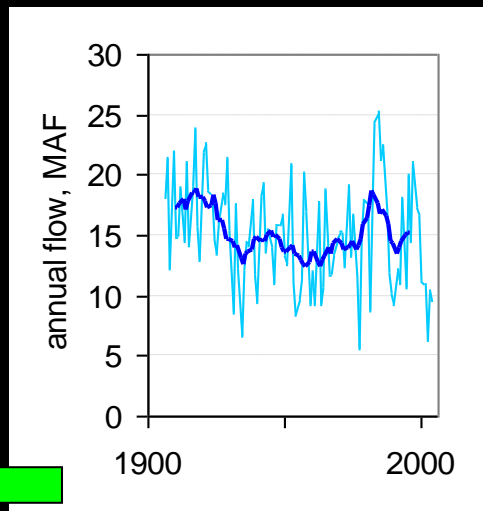


Colorado  
River at Lees  
Ferry,  
1906-2004

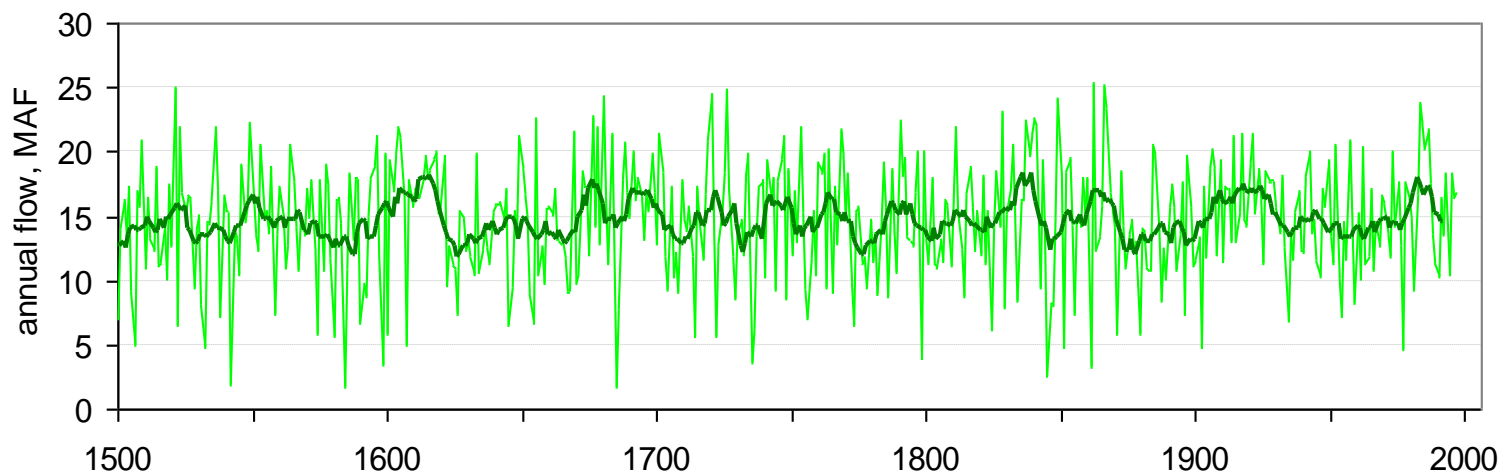
# How representative is the gage record over a longer time frame?

While the past can't be used to predict the future, it can be used to provide guidance for what may be expected.

The extended record of streamflow provides a more complete picture of the hydrologic variability that is possible.



Colorado River at Lees Ferry, 1906-2004



Tree-ring reconstruction of Colorado R., 1490-1997

# Overview

- Tree rings and climate
- Reconstruction of past streamflow for the upper and lower Colorado River basins
- Information the reconstructions provide
- New research: reconstruction of past monsoon rainfall
- How reconstructions of past hydroclimate are being used by resource managers





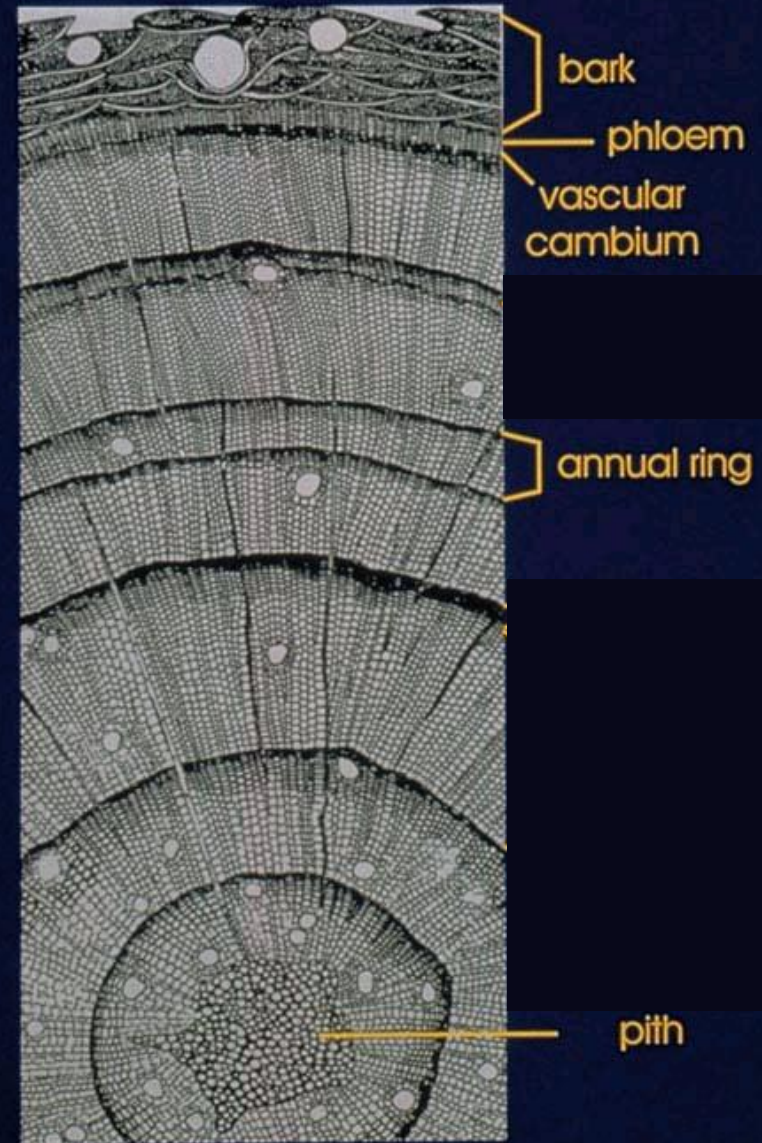
# A Quick Overview of Tree Rings and Climate

Variations in annual ring widths reflect the conditions that influence tree growth.

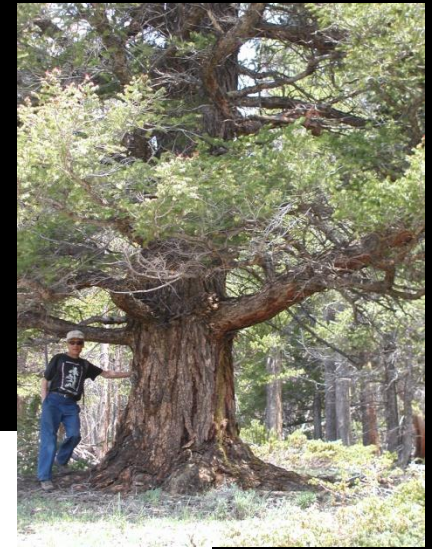
Climate is often the primary influence on growth.

Because of this, ring widths can be used as a proxy for past climate.

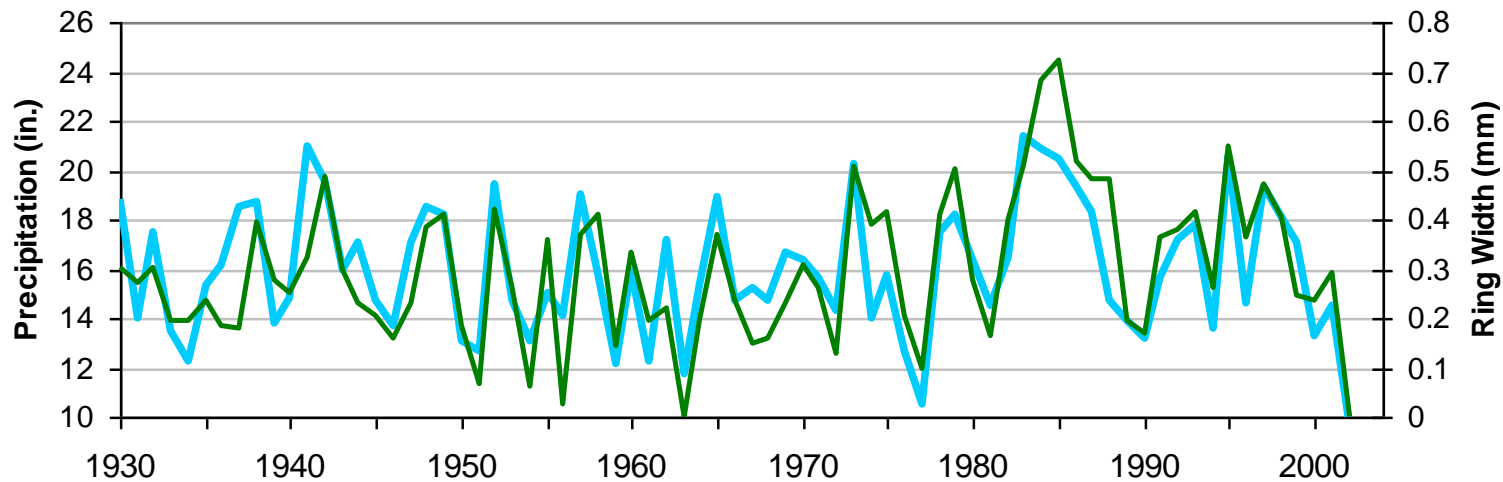
## CROSS SECTION of a CONIFER



# Moisture-stressed trees closely track variations in precipitation



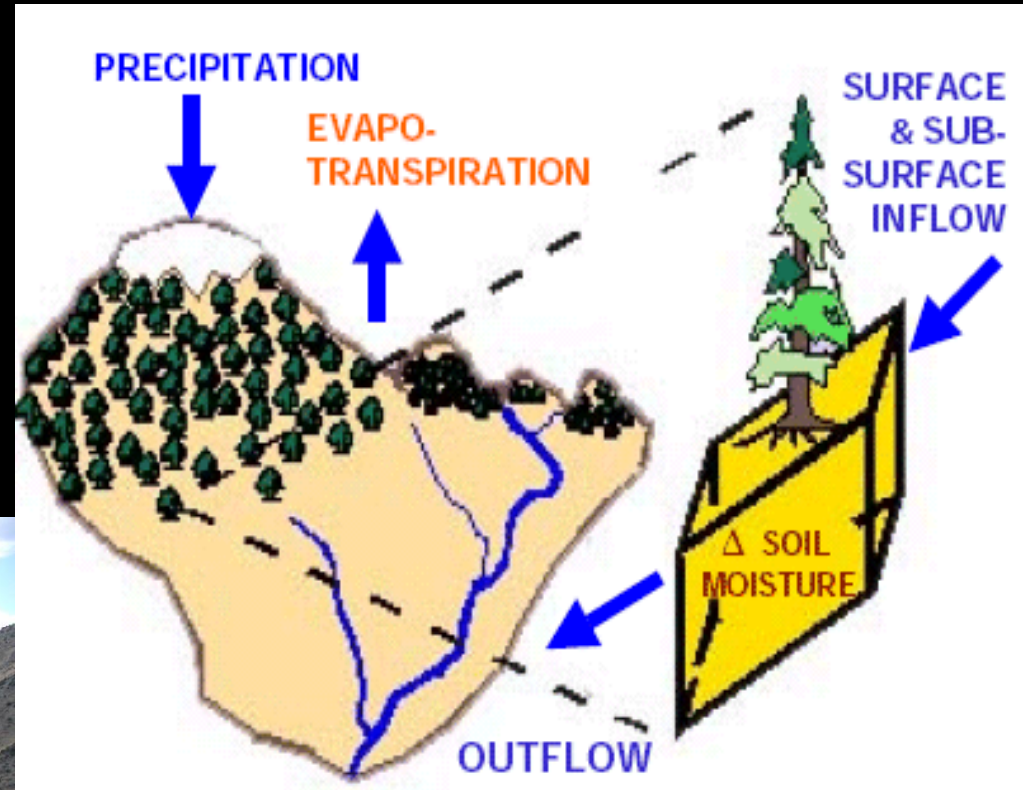
Western CO Annual Precip vs. Pinyon ring width (WIL731)



Ring widths from a single tree near Grand Junction, CO are plotted with annual precipitation in western Colorado. The correlation between the two is 78%.

# How can tree rings be used to reconstruct streamflow?

Ring widths and streamflow both integrate the effects of precipitation and evapotranspiration, as mediated by the soil, over the course of the water year.

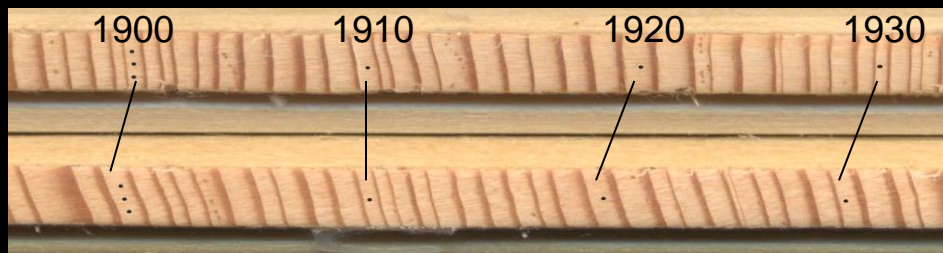




# Collecting tree ring data and compiling site tree-ring chronologies



An increment borer is used to sample cores from about 20 trees at a site



Cores mounted and sanded, then dated, measured, and averaged into site tree-ring chronologies



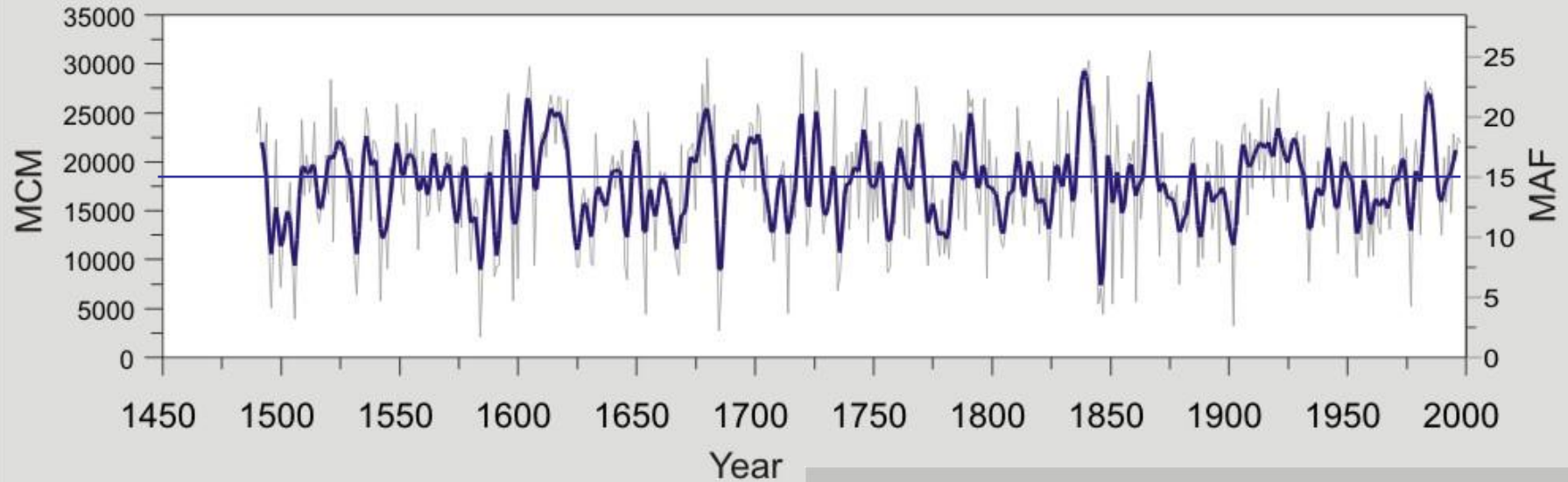
# Reconstructions for the Colorado River Basin

- Upper Colorado River  
(Lees Ferry gage)
- Lower Colorado River  
basin (Salt/Verde/Tonto  
Ck)

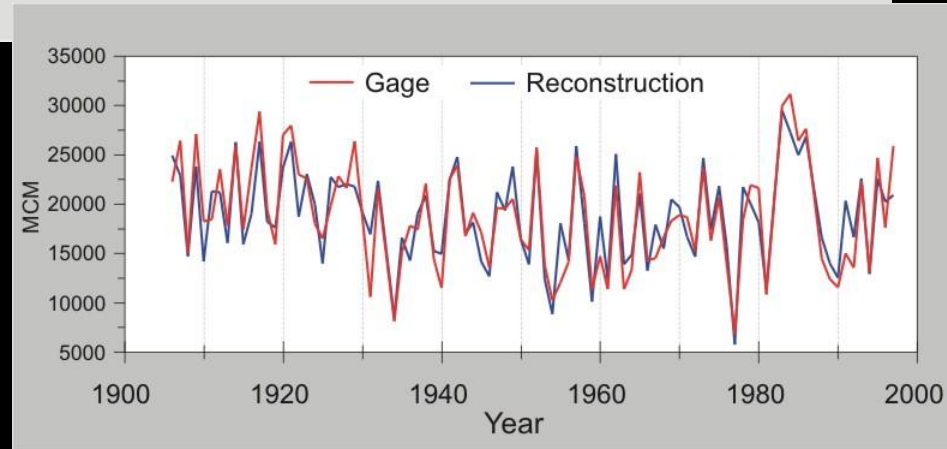




# Reconstruction of Colorado River at Lees Ferry, 1490-1997



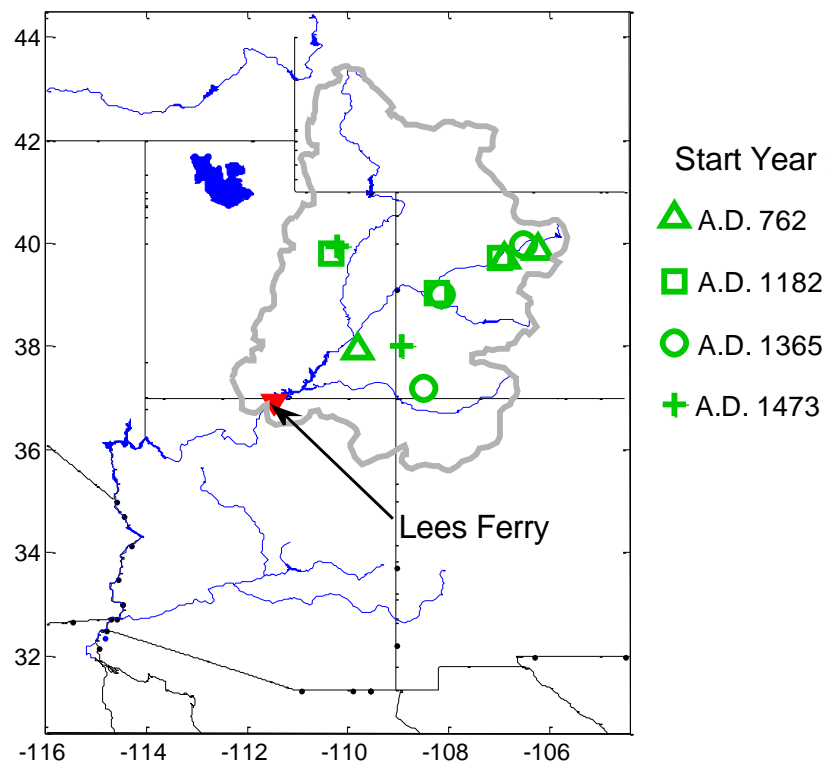
The reconstruction explains about 80% over variance in the gage record



The Lees Ferry reconstruction has now been extended even further back in time using stumps, logs, and remnants of wood



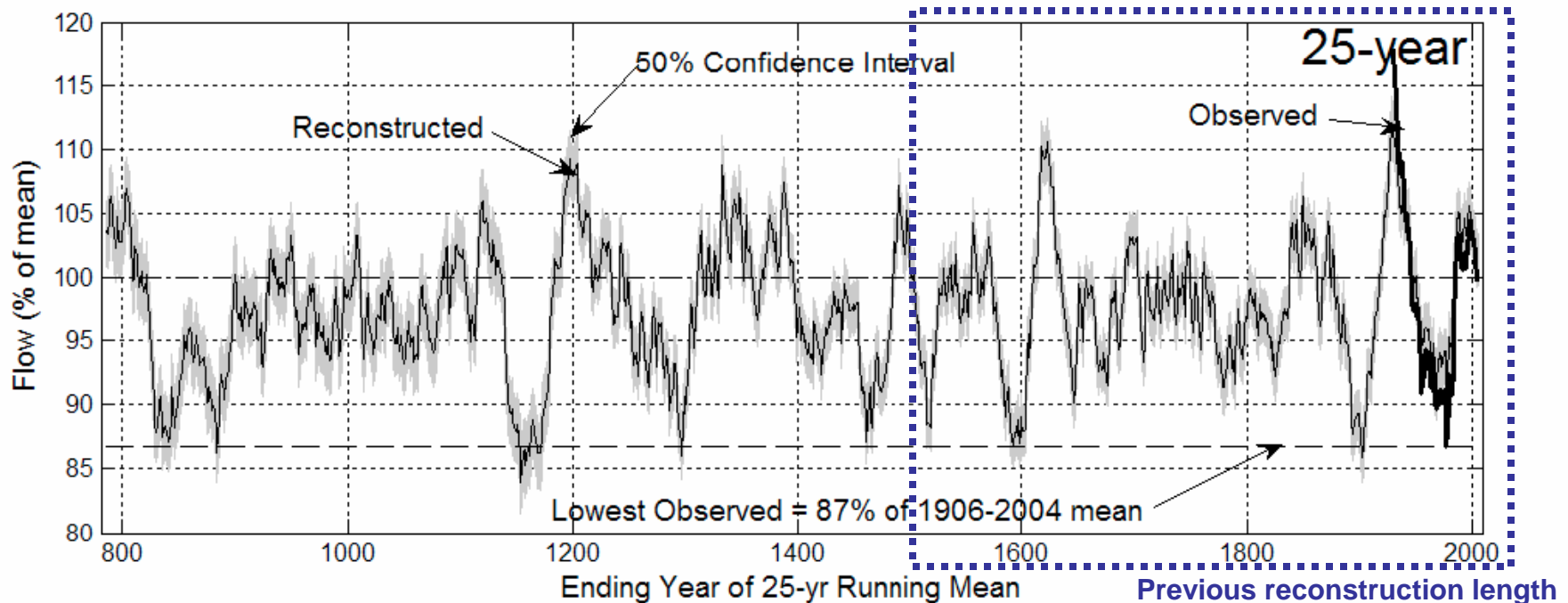
Locations of chronologies used in the extended Lees reconstruction



Meko et al. 2007

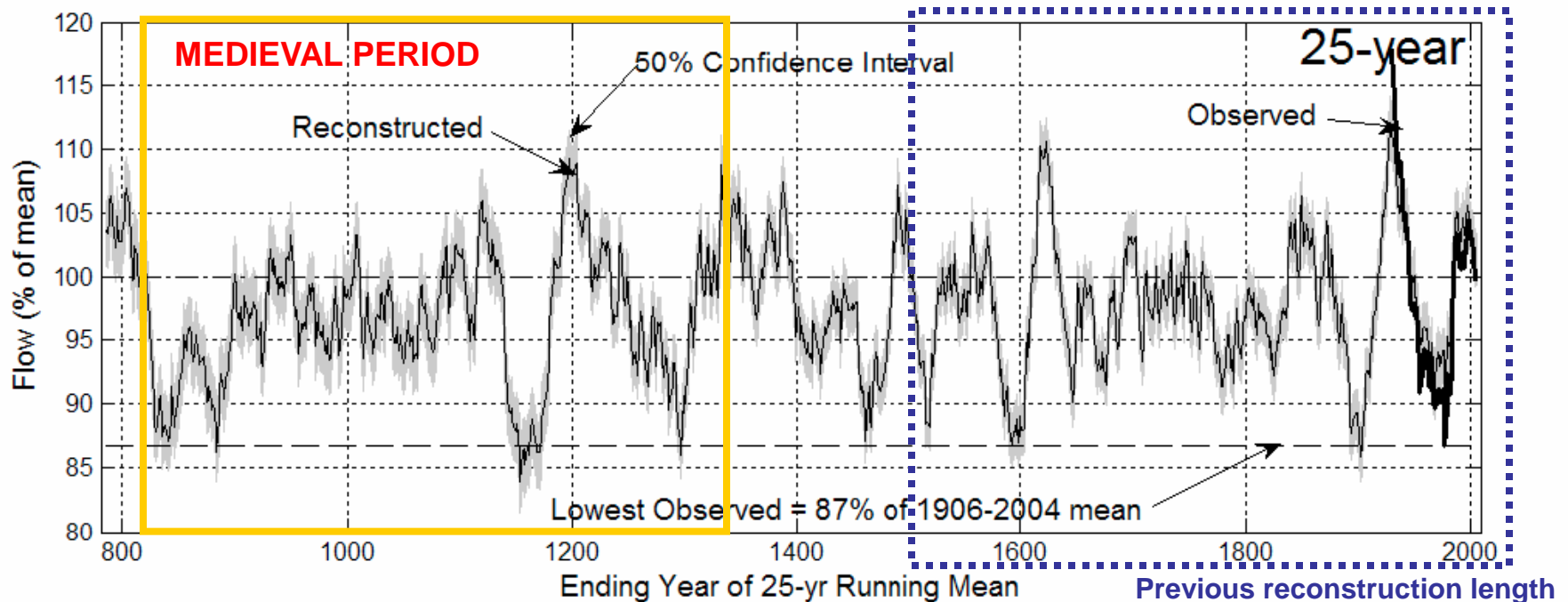


# Reconstruction of Colorado River at Lees Ferry, AD 762 - 2005



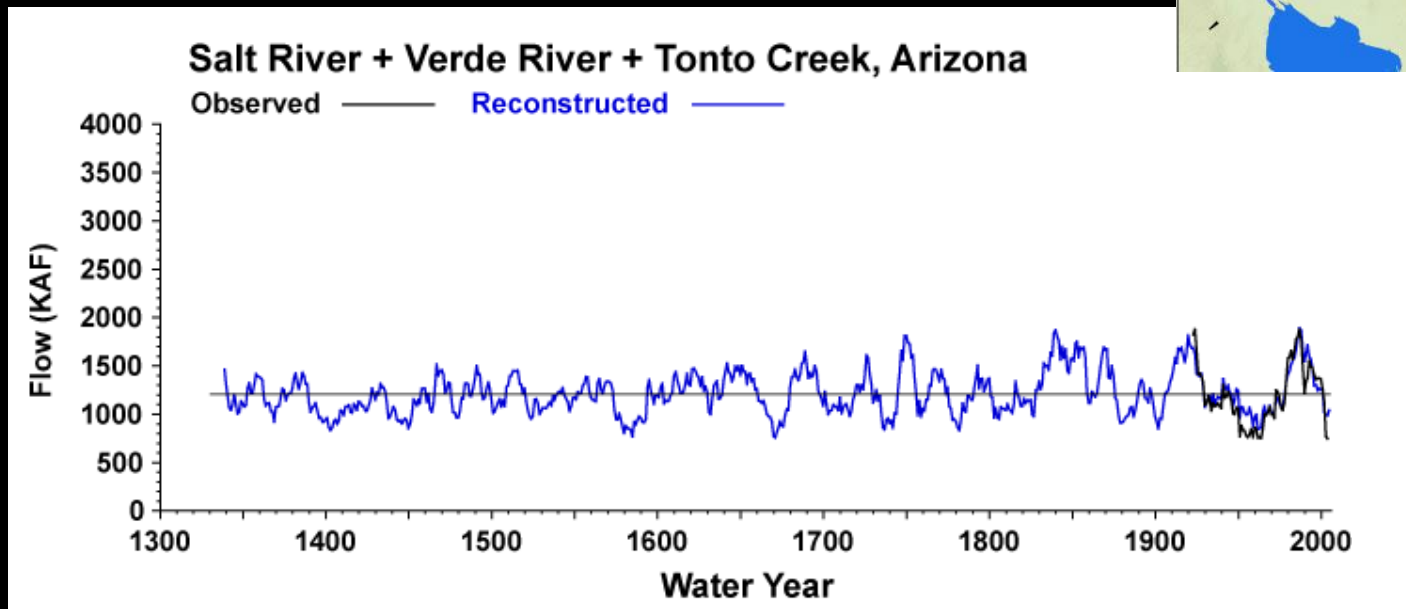
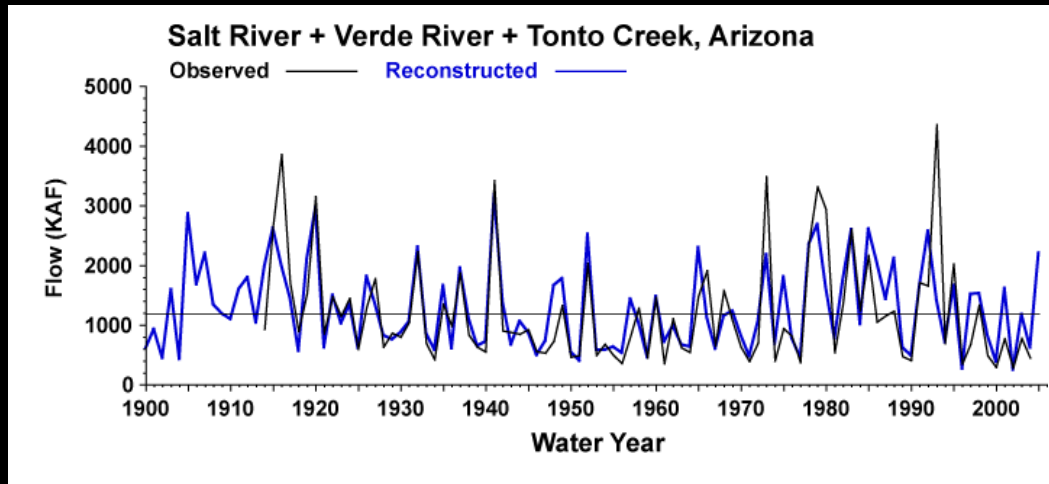
25-yr running means of reconstructed and observed annual flow of the Colorado River at Lees Ferry, expressed as percentage of the 1906-2004 observed mean (Meko et al. 2007).

# Reconstruction of Colorado River at Lees Ferry, AD 762 - 2005



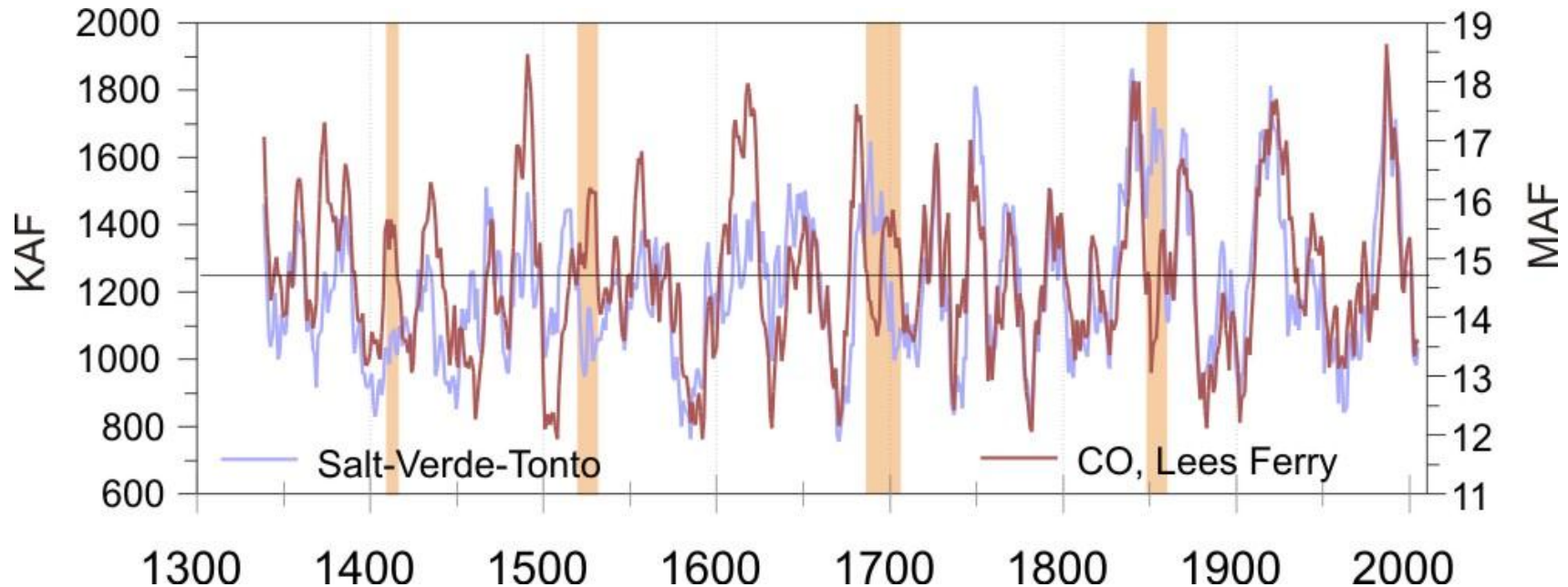
25-yr running means of reconstructed and observed annual flow of the Colorado River at Lees Ferry, expressed as percentage of the 1906-2004 observed mean (Meko et al. 2007).

# Reconstruction of Lower Colorado River tributaries, Verde R, Salt R. and Tonto Ck



10-yr running mean of Salt+Verde+Tonto, 1330-2005. The long term reconstructed mean is the horizontal black line.

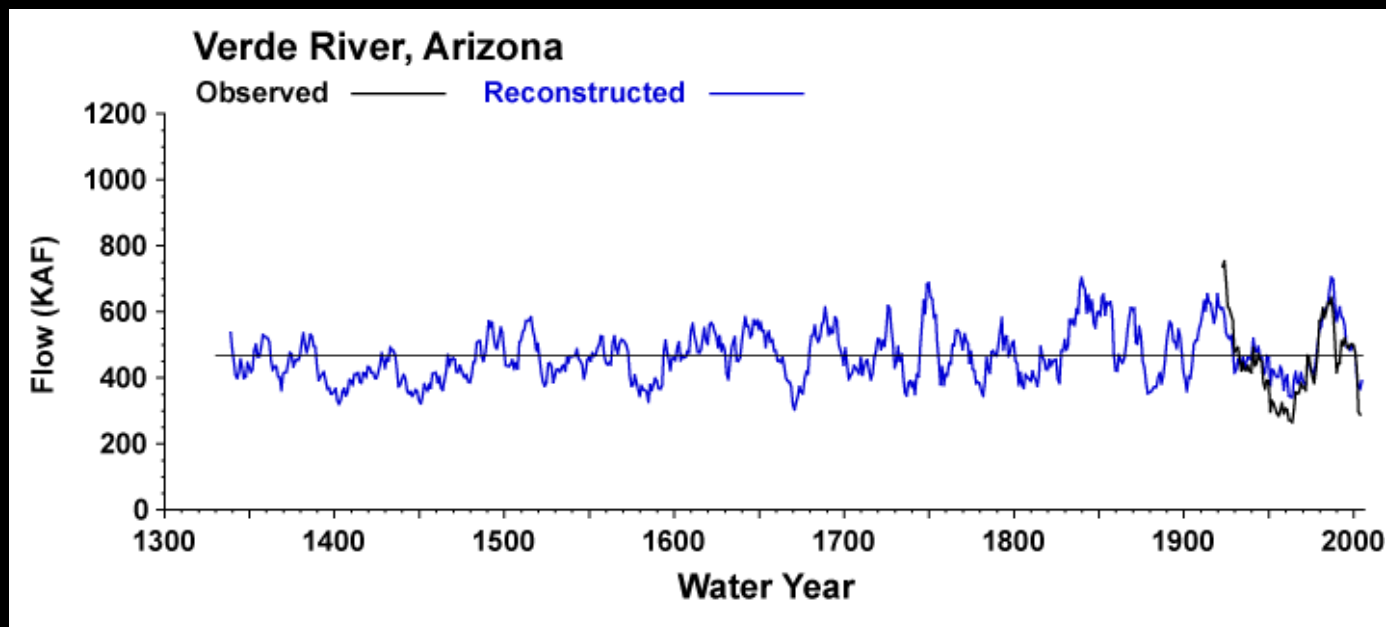
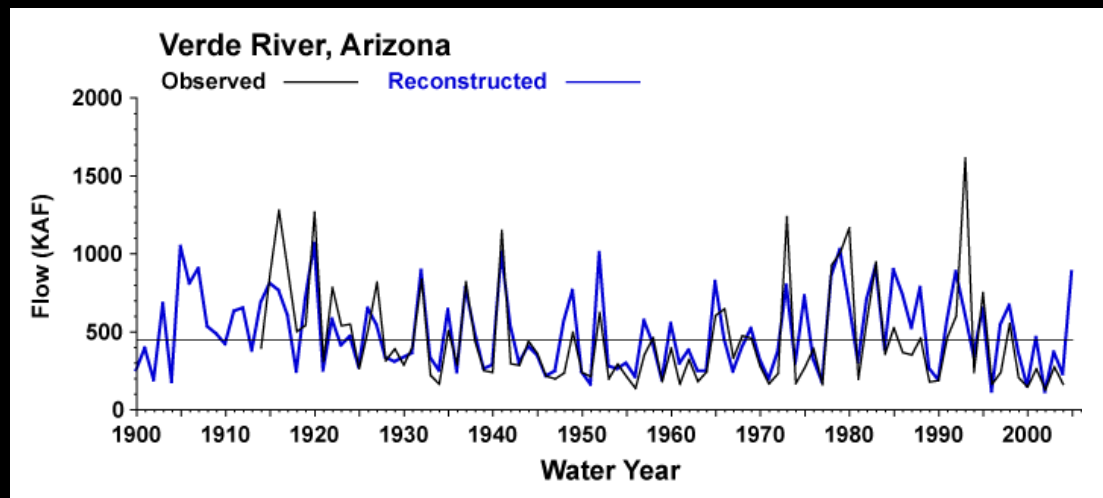
# Comparison of Upper and Lower (Salt-Verde-Tonto) Colorado River Reconstructions, 1330-2005



Droughts are mostly synchronous across the upper and lower Colorado River basins, but there are exceptions (pink bars)

# Verde River Flow Reconstruction

Verde River below Bartlett Dam(1914-1944) and Verde River below Tanglewood Creek/ above Horseshoe Dam (1945-2004)

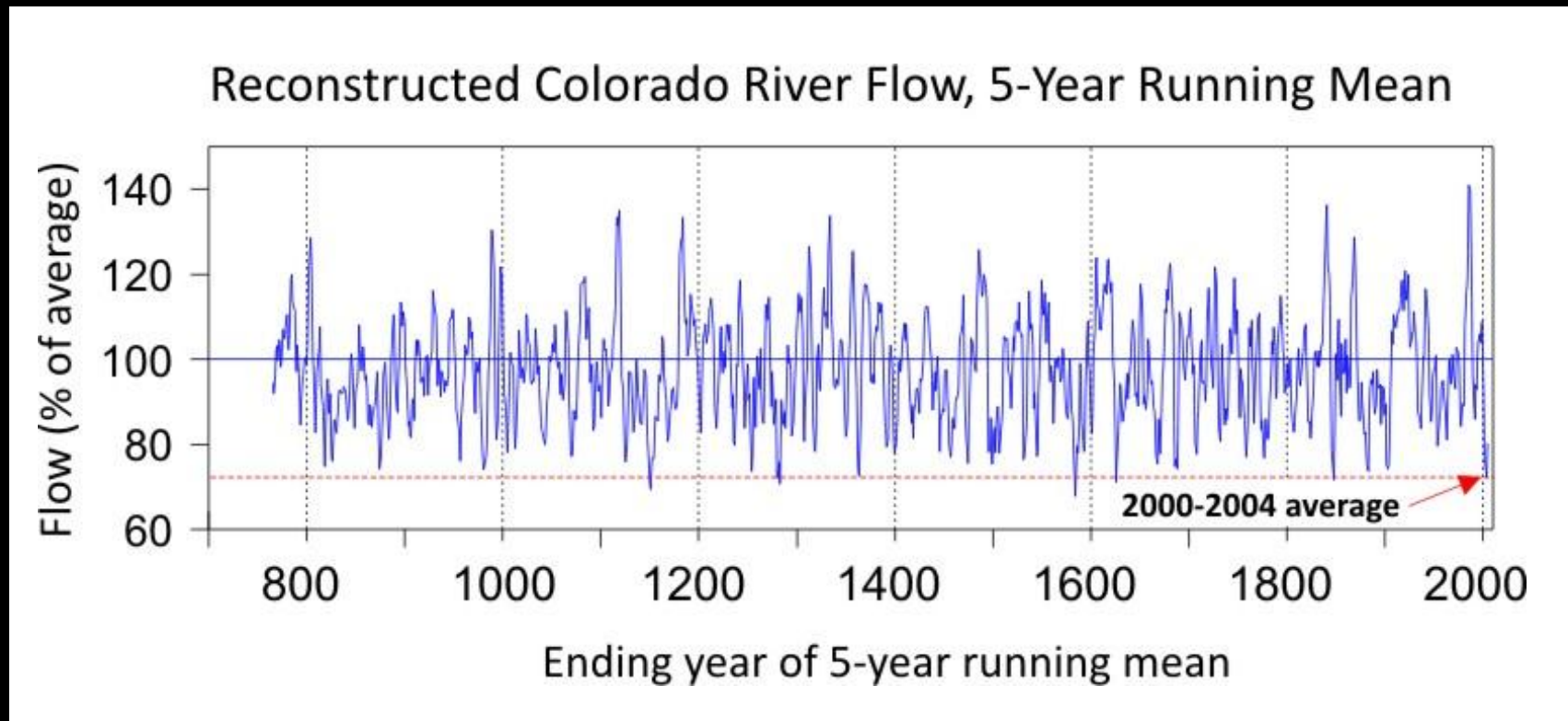


10-yr running mean of Salt Verde River flow, 1330-2005. The long term reconstructed mean is the horizontal black line.

# What do the reconstructions provide?

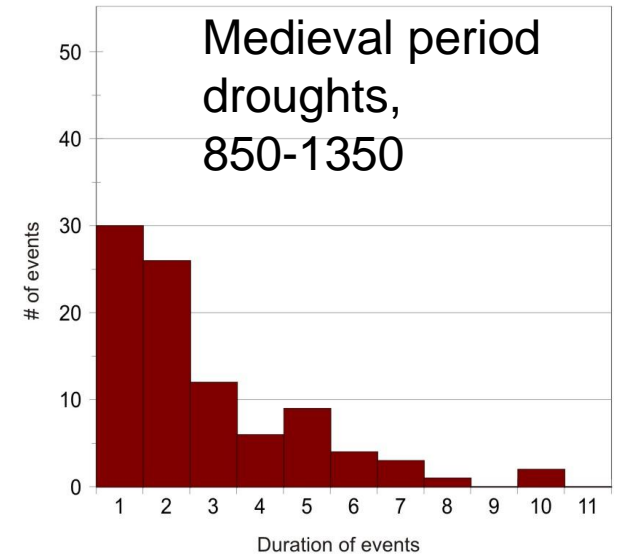
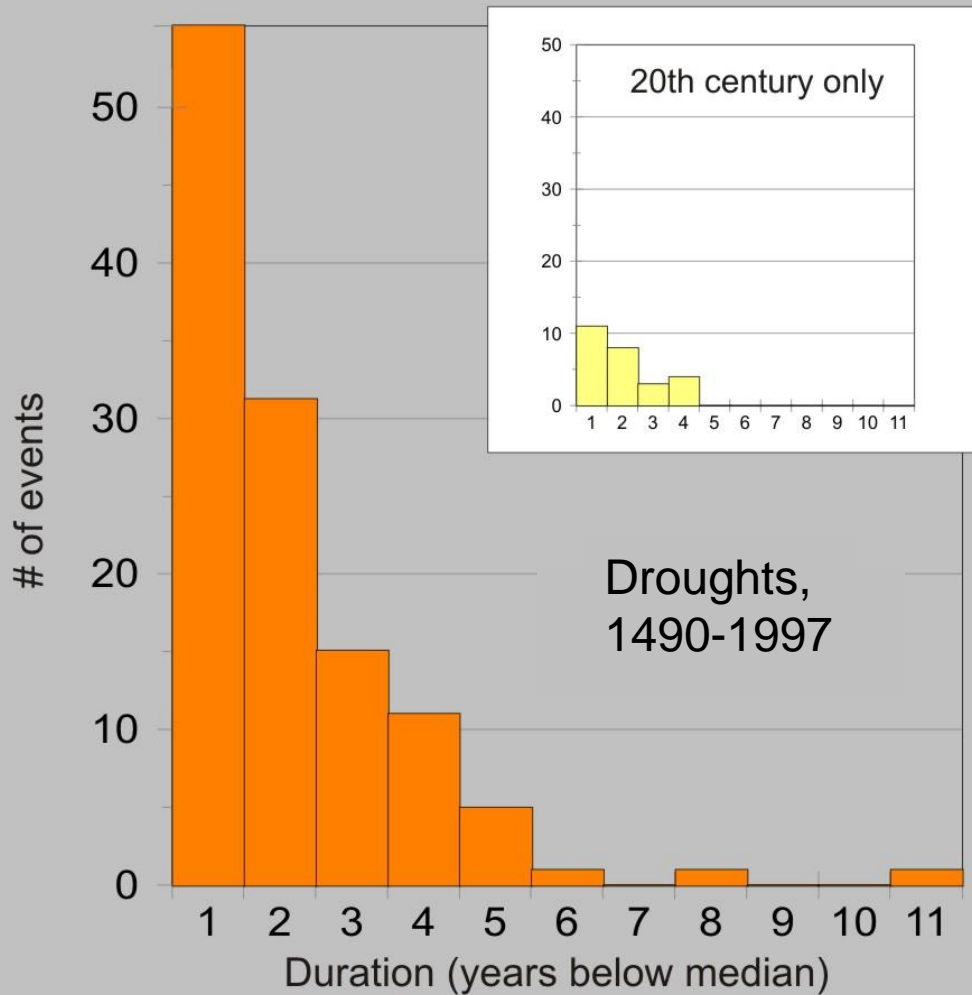
- Context for assessing gage record over a longer time frame
- A way to evaluate the recent drought in terms of natural variability over past centuries
- Framework for understanding the range of drought characteristics (intensity, duration, magnitude) that has occurred
- An understanding of the rich sequence of flows that has occurred over past centuries

# Assessment of the 2000-2004 drought in a millennial context





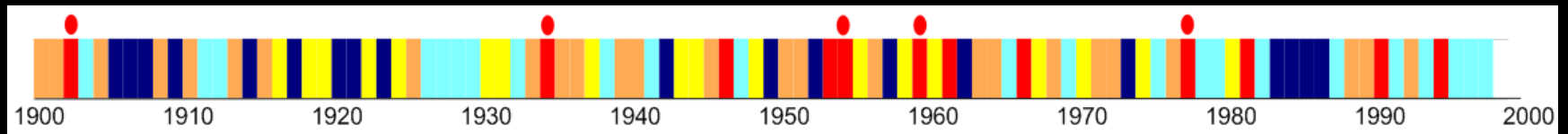
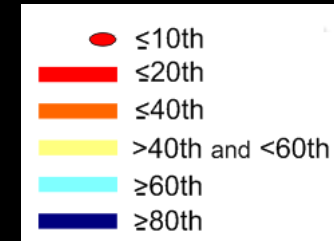
# Drought duration and frequency





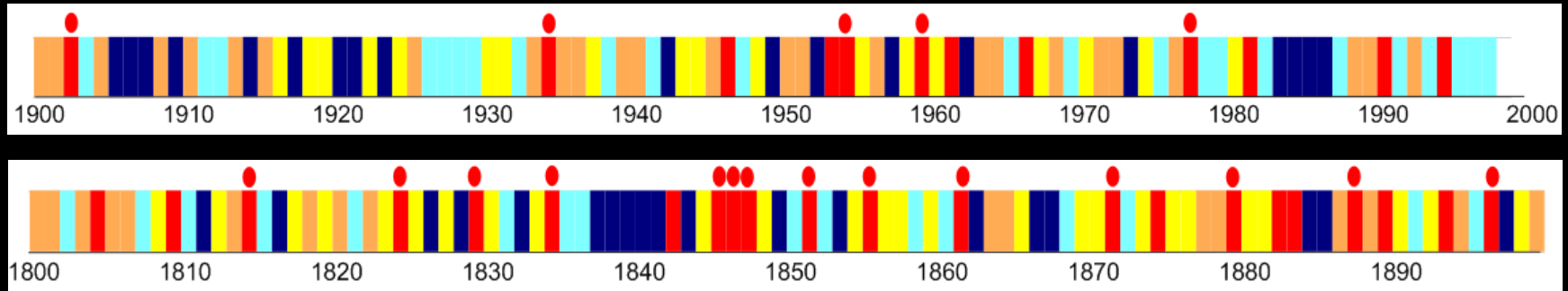
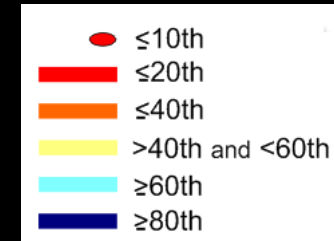
# A rich sequence of flows

## Lees Ferry Reconstruction Streamflow values categorized by percentile



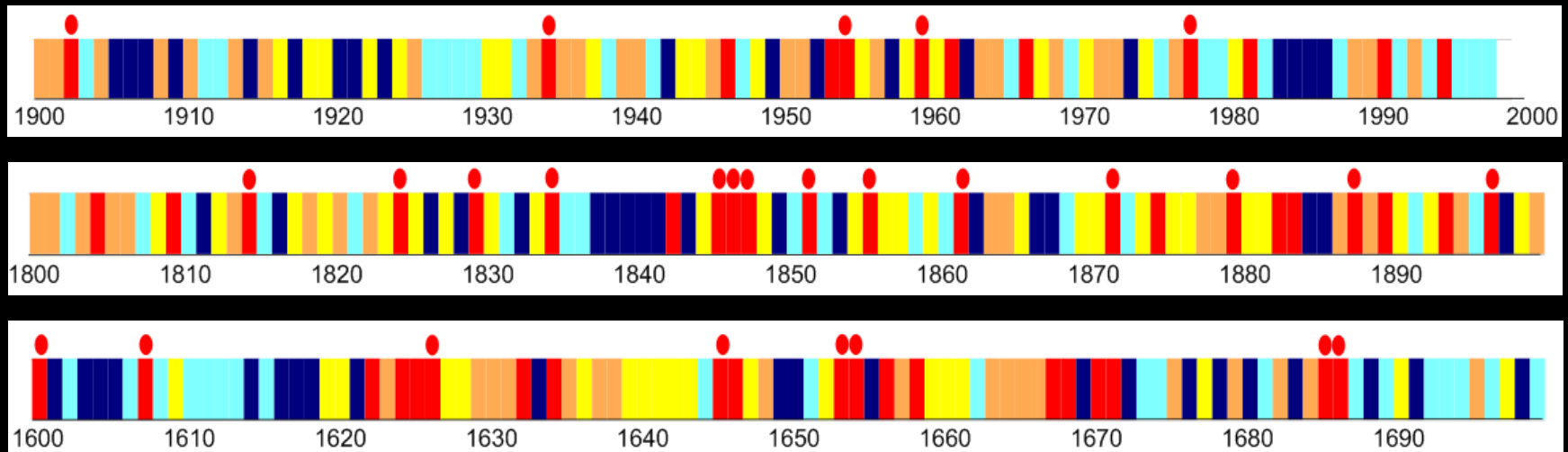
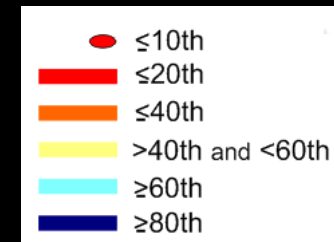
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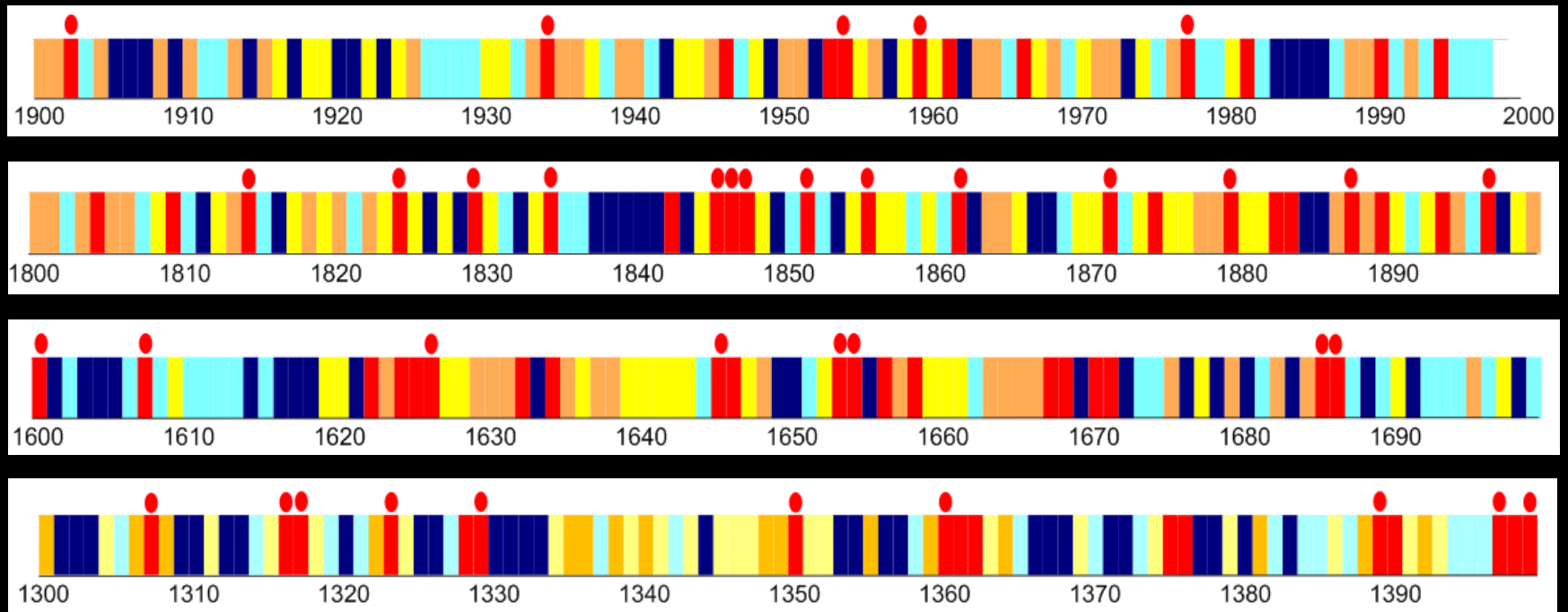
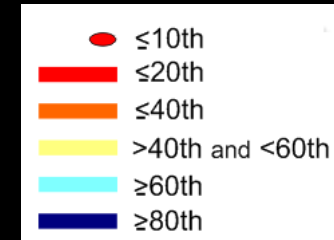
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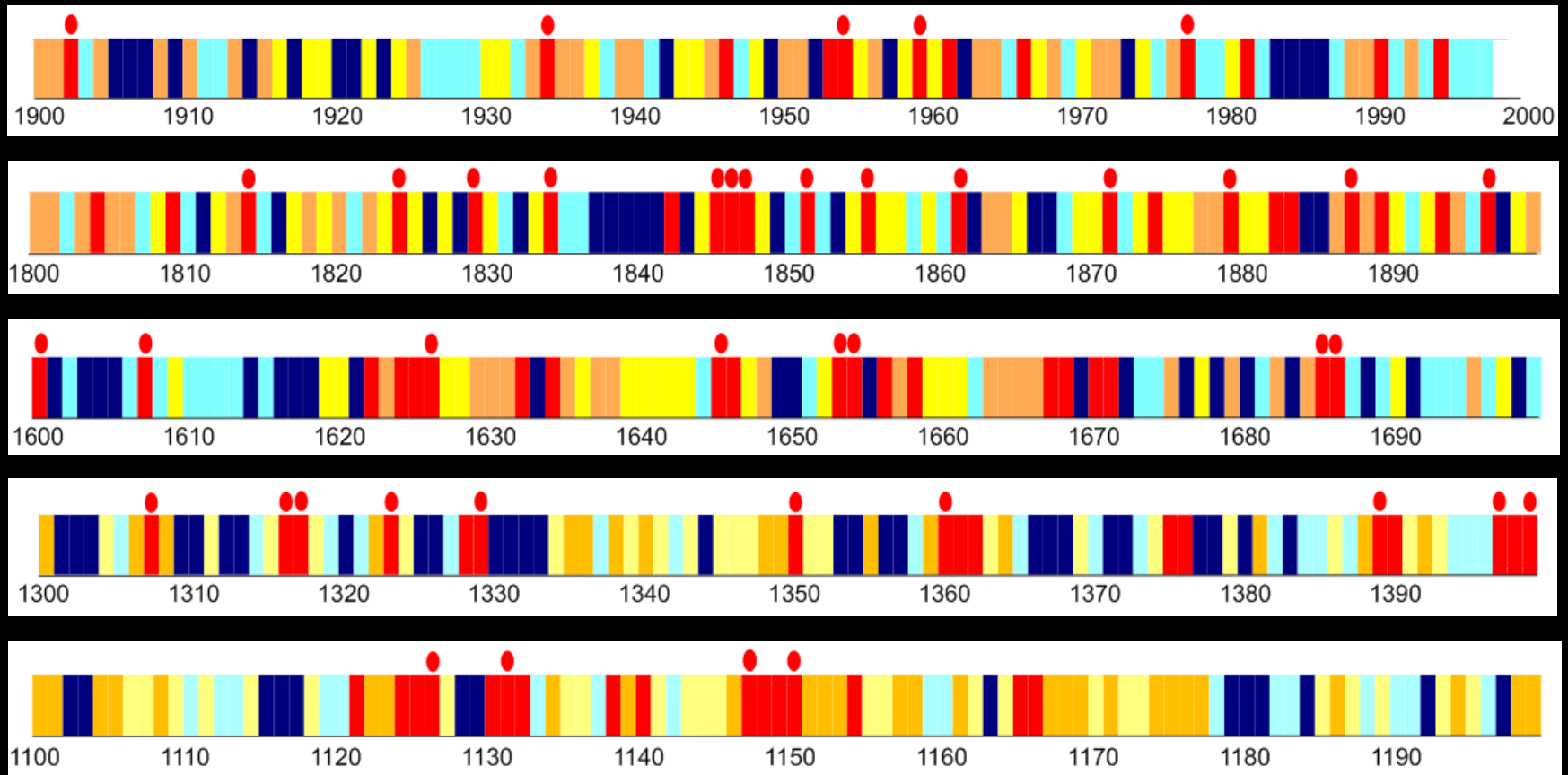
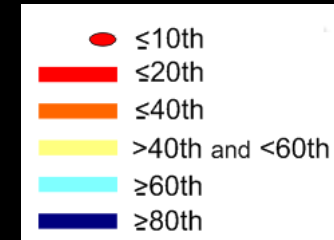
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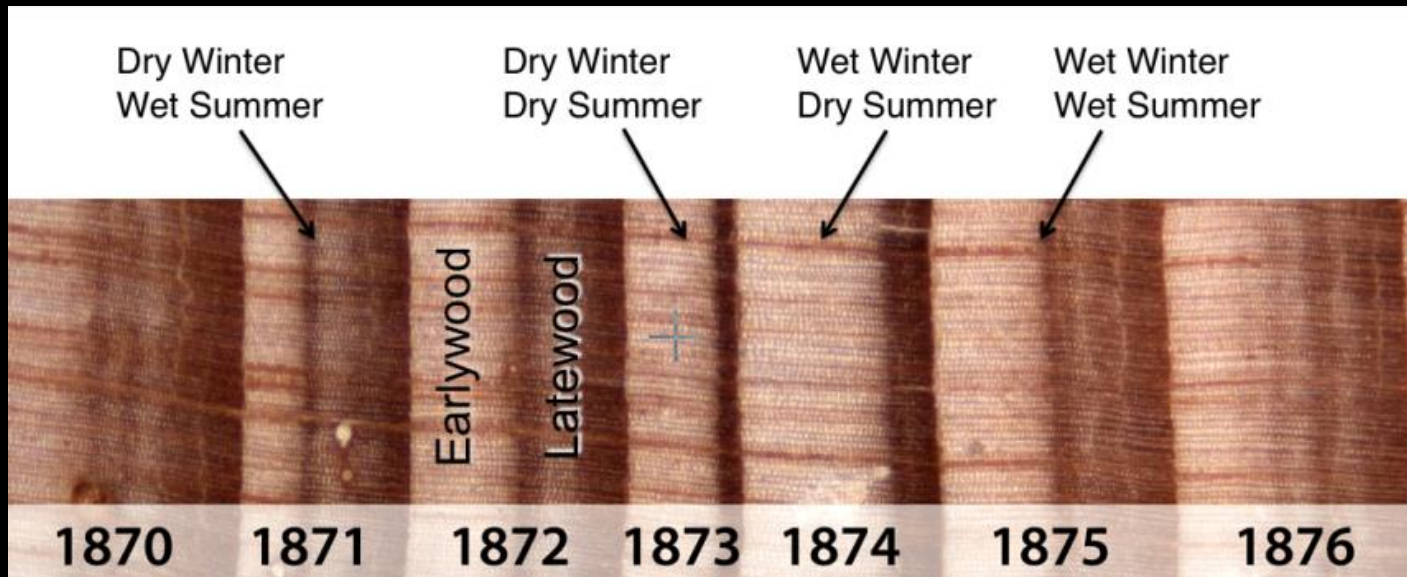
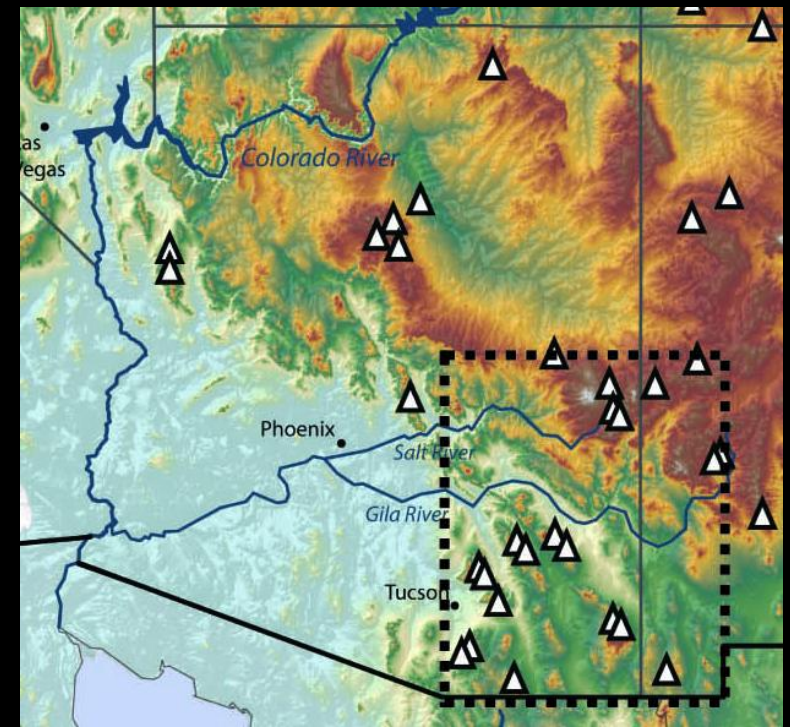
# A rich sequence of flows

## Lees Ferry Reconstruction Streamflow values categorized by percentile



# New Research: North American Monsoon

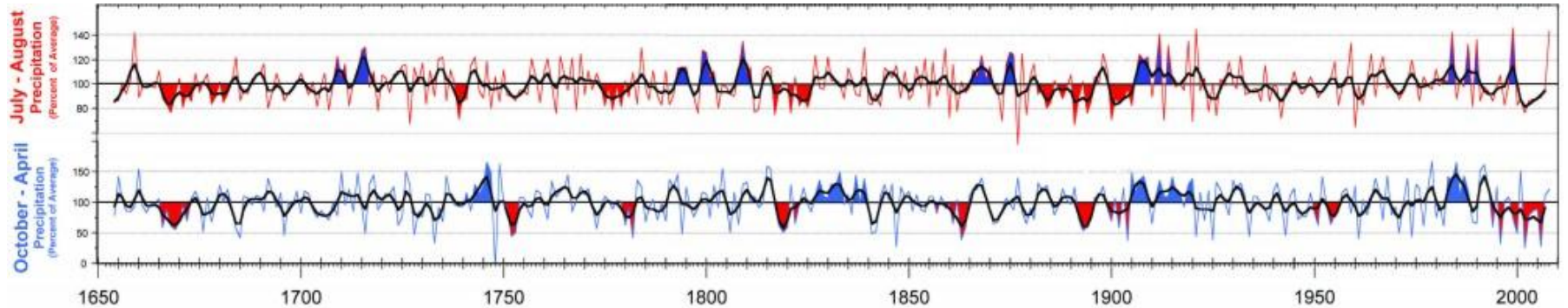
Reconstructions of winter and monsoon rainfall from early wood and latewood ring widths in Arizona and New Mexico



**Tree-ring  
chronology  
locations and  
region of  
reconstruction**

## PRELIMINARY RESULTS

# Reconstructions of Monsoon (July-August) and Winter (October-April) rainfall, 1654-2007 (% of average)



# Reconstructions of past streamflow and precipitation are being incorporated into resource planning and management in a variety of ways:

- To provide an awareness of a broader range of hydrologic variability than contained in the gage record
- As the basis for determining a drought “worst-case scenario”
- To test system reliability under a broader range of conditions by incorporating reconstruction data into water supply models
- When used in combination with climate change projections, to assess a range of plausible future scenarios
- To communicate risk or to aid in making recommendations
- Other ways: see <http://treeflow.info/applications.html>



# What information do tree rings provide for future planning?

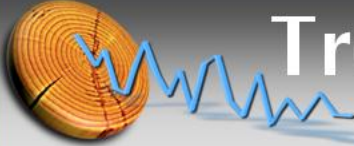
- By having a heads-up on what has occurred in the past, we get an idea of the range of conditions we may expect in the future.
- The past will not be an analogue for the future, but natural climate variability will be superimposed over the anthropogenic warming trend
- Information about both past climate and climate change projections is needed to anticipate and plan for the future.



# TreeFlow web pages: A resource for water managers

- tree-ring basics
- reconstruction and gage data
- workshop presentations
- applications examples
- references
- coming: tools for analysis

<http://treeflow.info/>




## TreeFlow


streamflow reconstructions from tree rings

- TreeFlow Home
- Basin Data Access »
- Background Info
- Applications
- Workshops
- Colo. R. Perspective
- Analysis Toolbox
- Other Resources
- About TreeFlow

### About TreeFlow

TreeFlow is a comprehensive web resource for tree-ring reconstructions of streamflow and climate, providing easy access to reconstruction data as well as information about how the data were developed, and can be used. [Click here to learn more about TreeFlow.](#)





### Data Access by Basin

Many tree-ring reconstructions of streamflow, and other hydroclimatic reconstructions, are now available for the western US. Data for the eastern US will be added in the future. [Click here to access the reconstructions and other information resources by hydrologic basin.](#)

### Tree-Ring Background Information

A tree-ring *reconstruction* is a best-estimate of past streamflows, based on the relationship between tree-ring data and observed streamflow over the modern period. [To learn more about how streamflow reconstructions are developed, click here.](#)

