Non-destructive increment core sampling

The Tree-Ring Record of Drought in the Southwest

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THE UNIVERSITY OF ARIZONA

LTRR Laboratory of Tree-Ring Research University of Arizona

CLIMAS Climate Assessment for the Southwest

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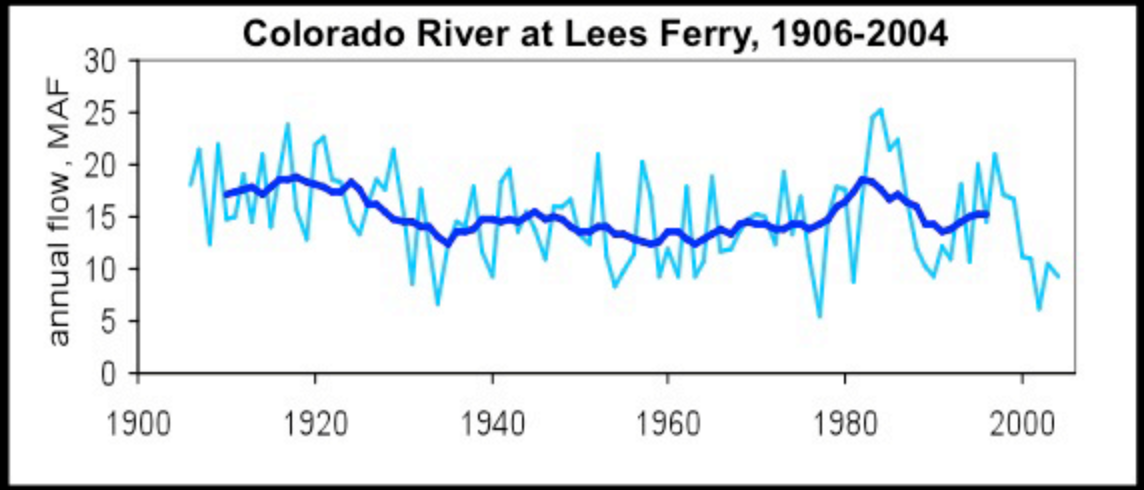
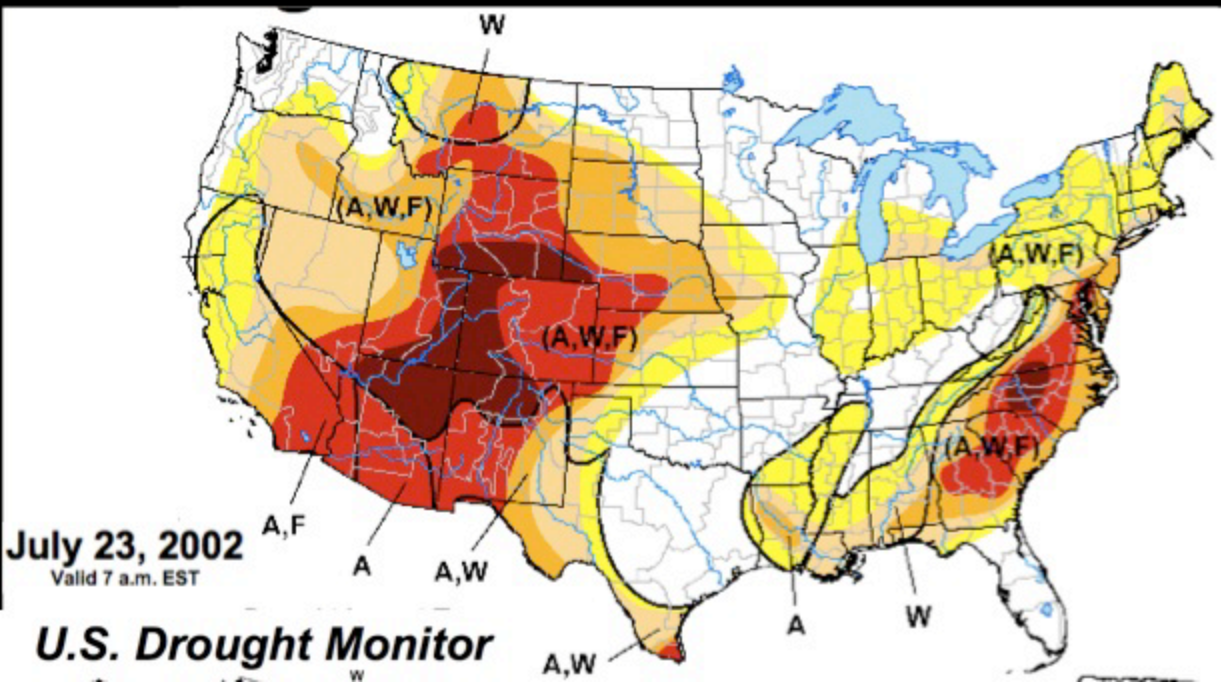
Historically, compacts, water policy and management have been based on the available gage records





Severe 21st century drought has prompted many managers to reconsider long-term drought variability

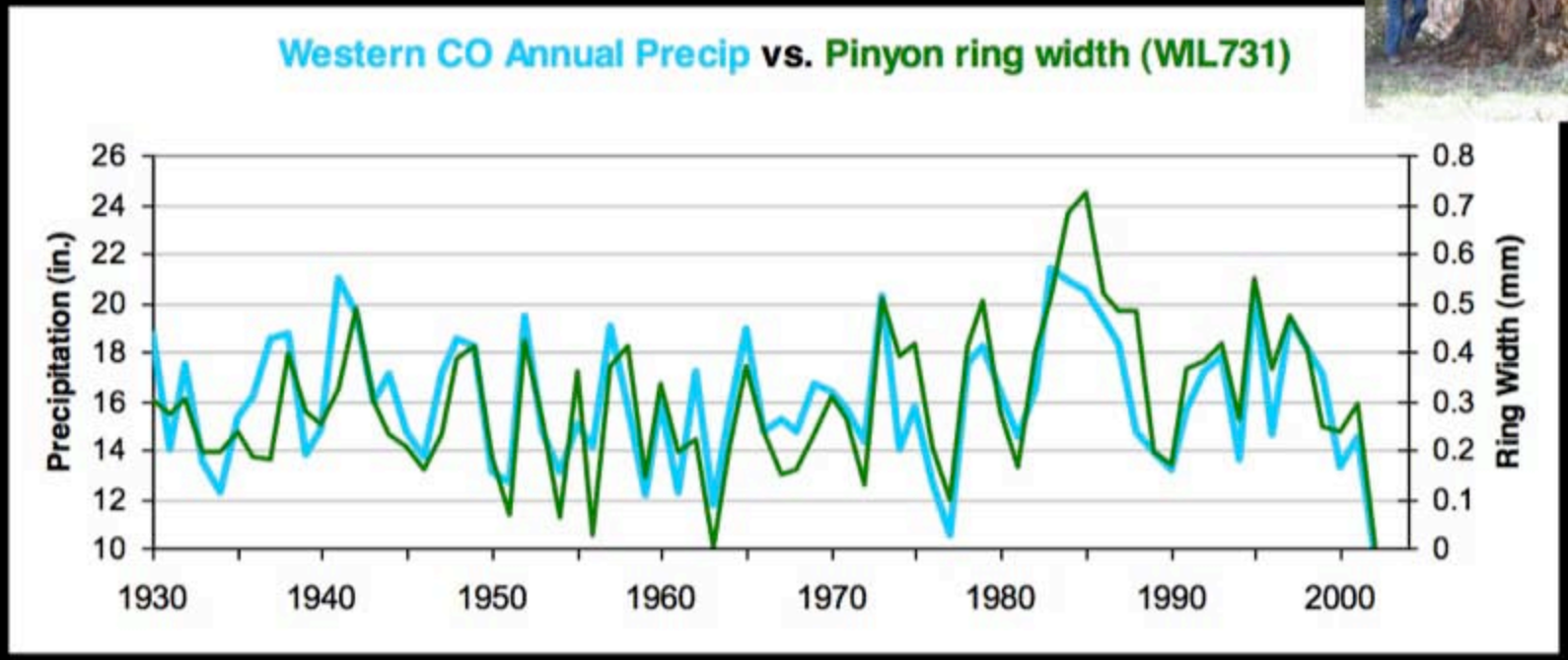
Trees form one ring per year

Ring width reflects environmental conditions

Climate is often the primary limitation on tree growth
(wide = good; narrow = bad)

Ring width can be used as a proxy for past climate

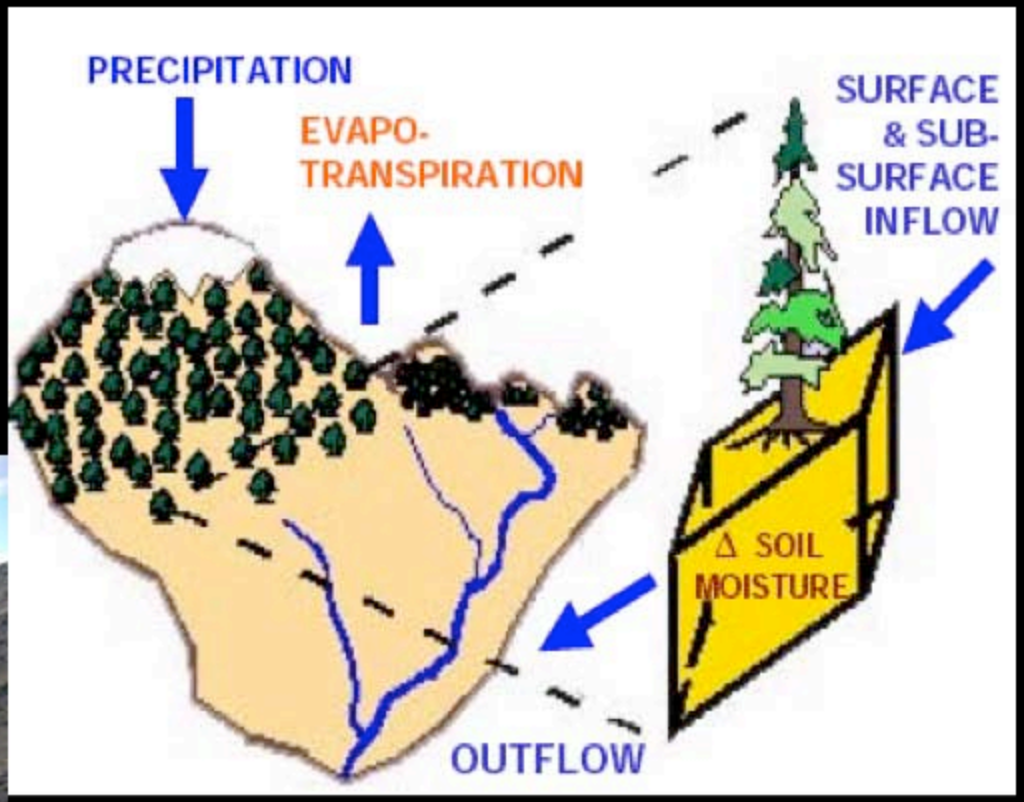
Moisture-stressed trees closely track variations in precipitation



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% (r = 0.78).

How can tree rings reflect variations in streamflow?

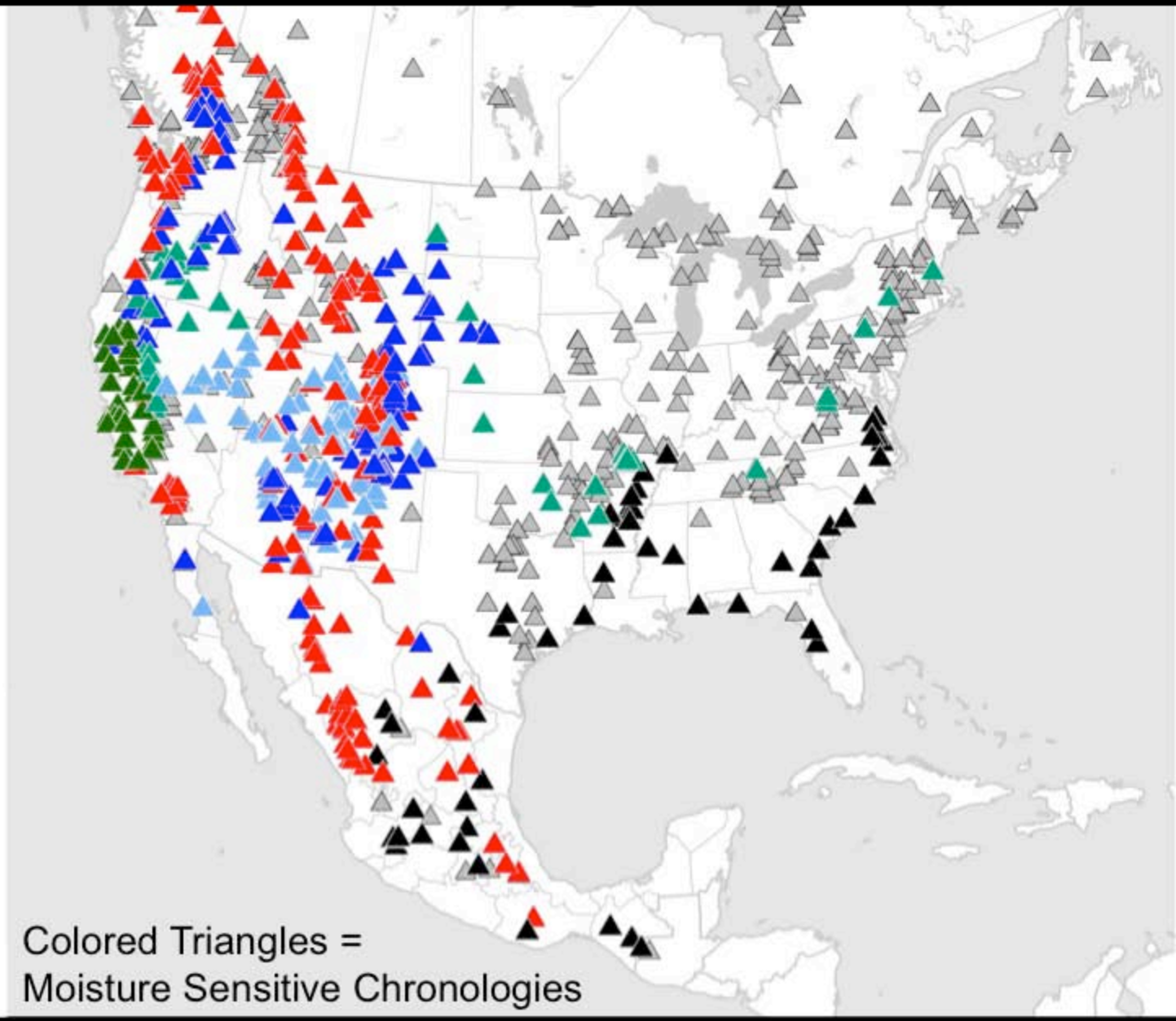
Ring widths and streamflow both integrate the effects of precipitation and evapotranspiration, as mediated by the soil, over the course of the water year.



North American Tree-Ring Chronologies > 200 years long

Species

- *JUOC*
- *JUSC*
- *JUVI*
- *PIAZ*
- *PIED*
- *PIMO*
- *PIPO*
- *PSMA*
- *PSME*
- *QUDG*
- *TADI*
- *TAMU*
- *other*



Colored Triangles =
Moisture Sensitive Chronologies

North American Tree-Ring Chronologies > 1000 years long

Species

- *JUOC*
- *JUSC*
- *JUVI*
- *PIAZ*
- *PIED*
- *PIMO*
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- *PSMA*
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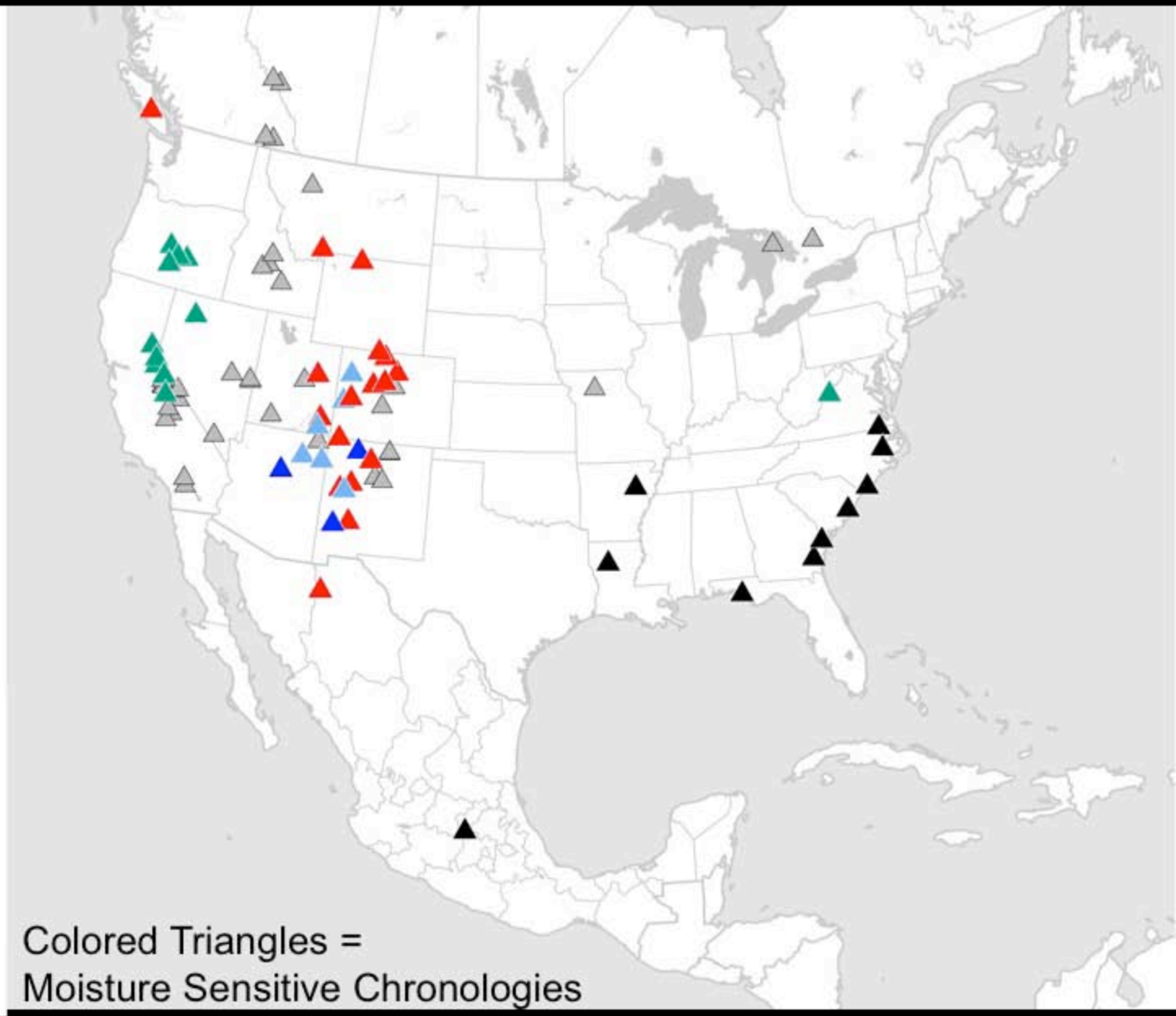
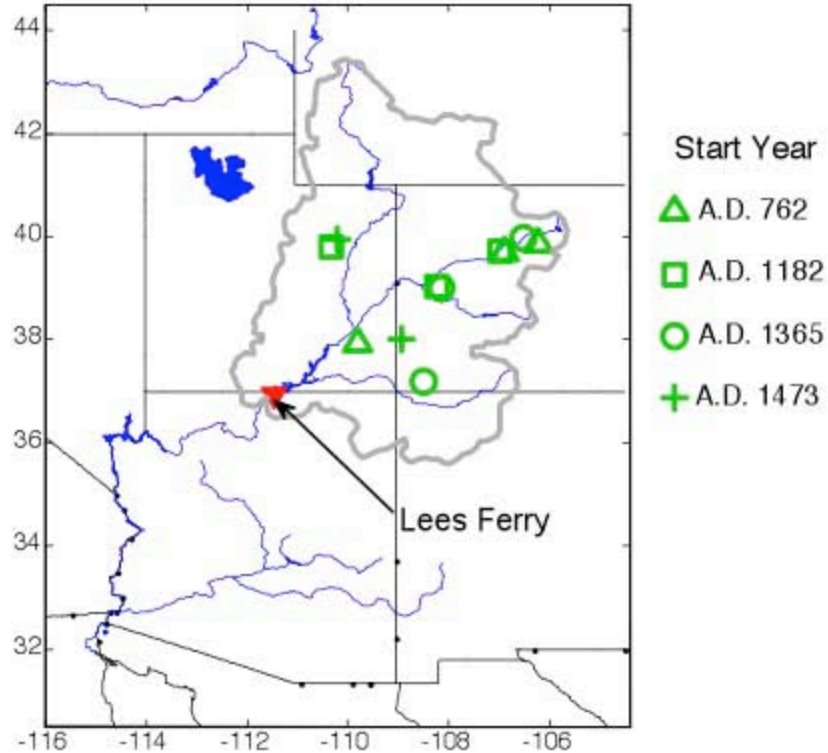


1,244 Year Tree-Ring Reconstruction of Colorado River Flow at Lee's Ferry

(Meko et al. 2007)

Locations of chronologies used in the extended Lees reconstruction



Medieval drought in the upper Colorado River Basin

David M. Meko,[1] Connie A. Woodhouse,[2] Christopher A. Baisan,[1] Troy Knight,[1] Jeffrey J. Lukas,[3] Malcolm K. Hughes,[1] and Matthew W. Salzer[1]

GEOPHYSICAL RESEARCH LETTERS, VOL. 34, L10705, doi:10.1029/2007GL029988, 2007

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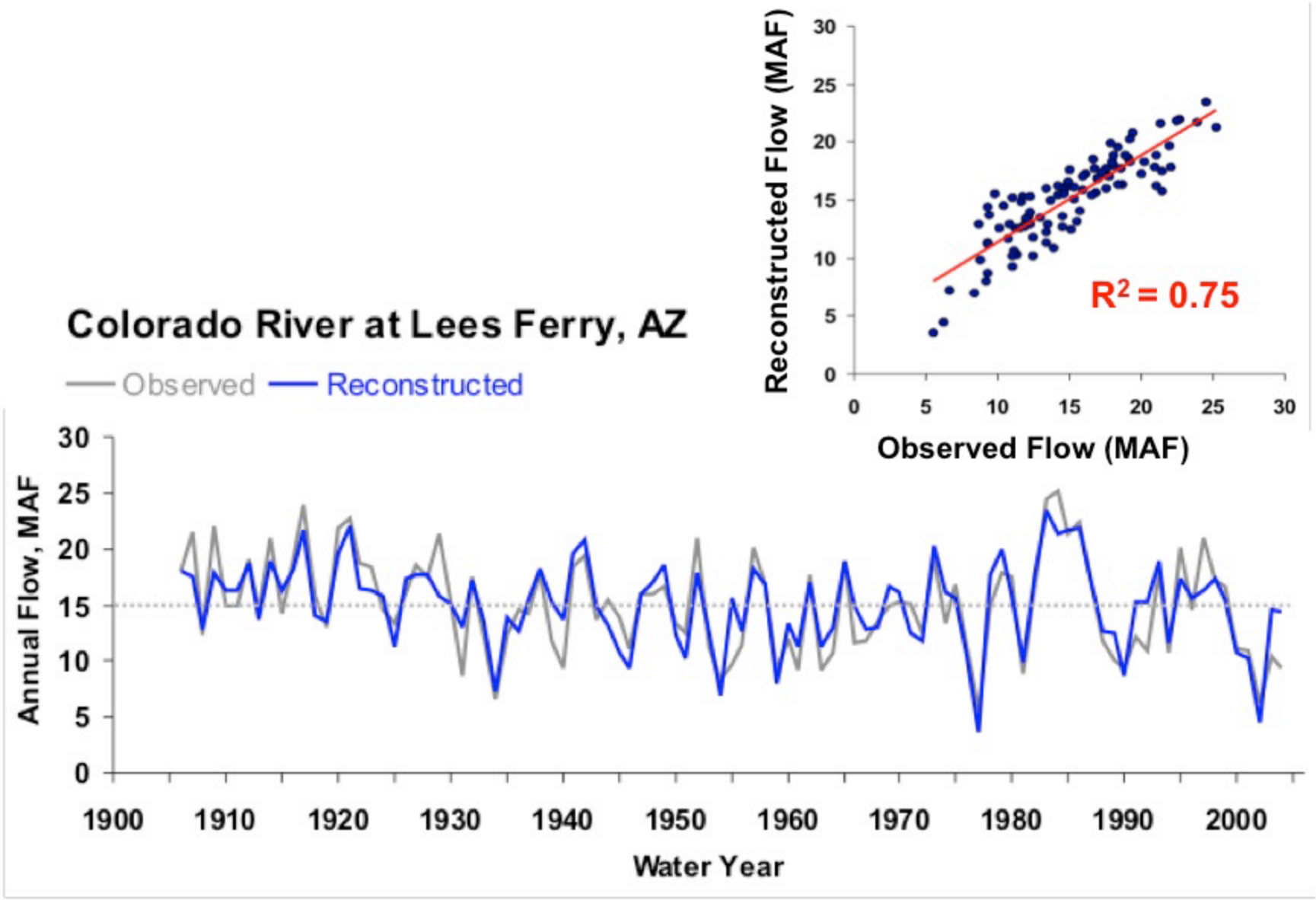

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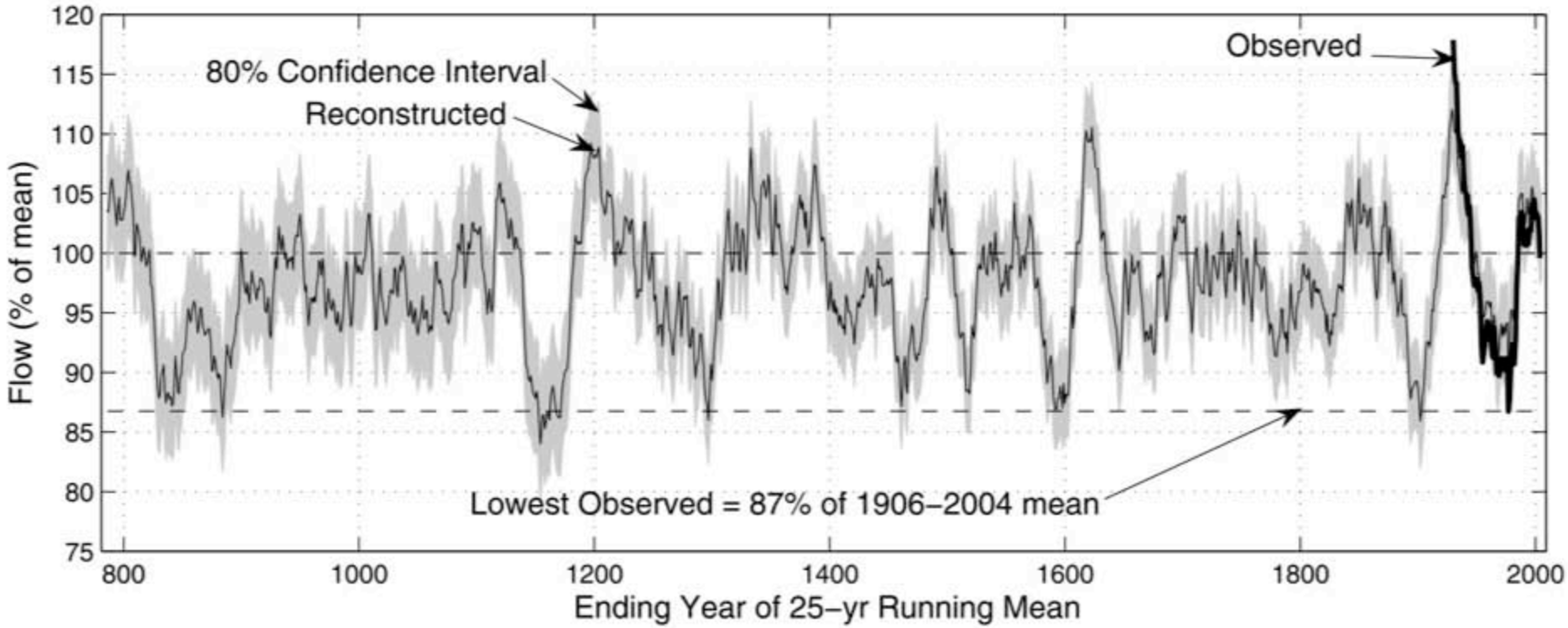

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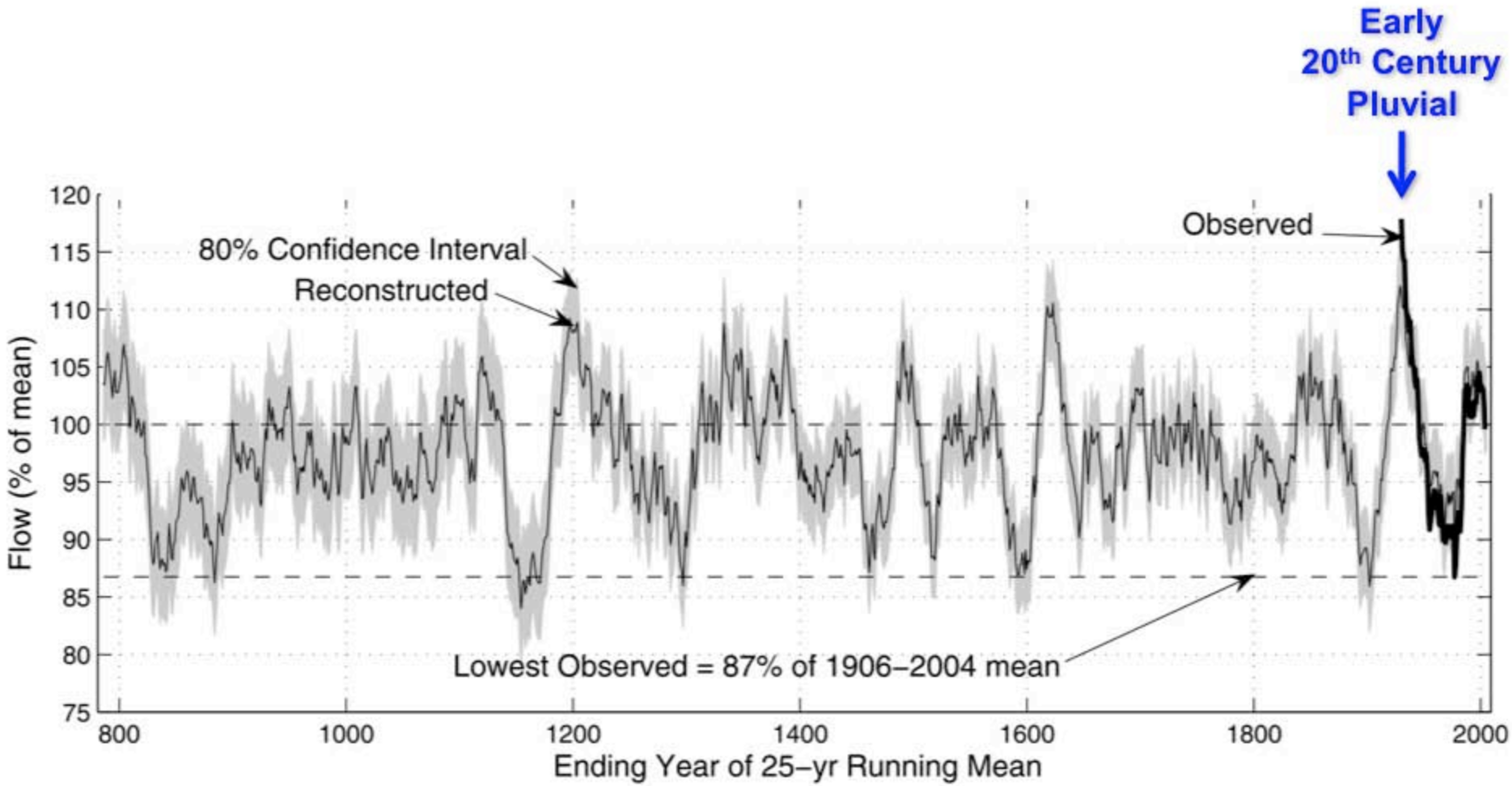

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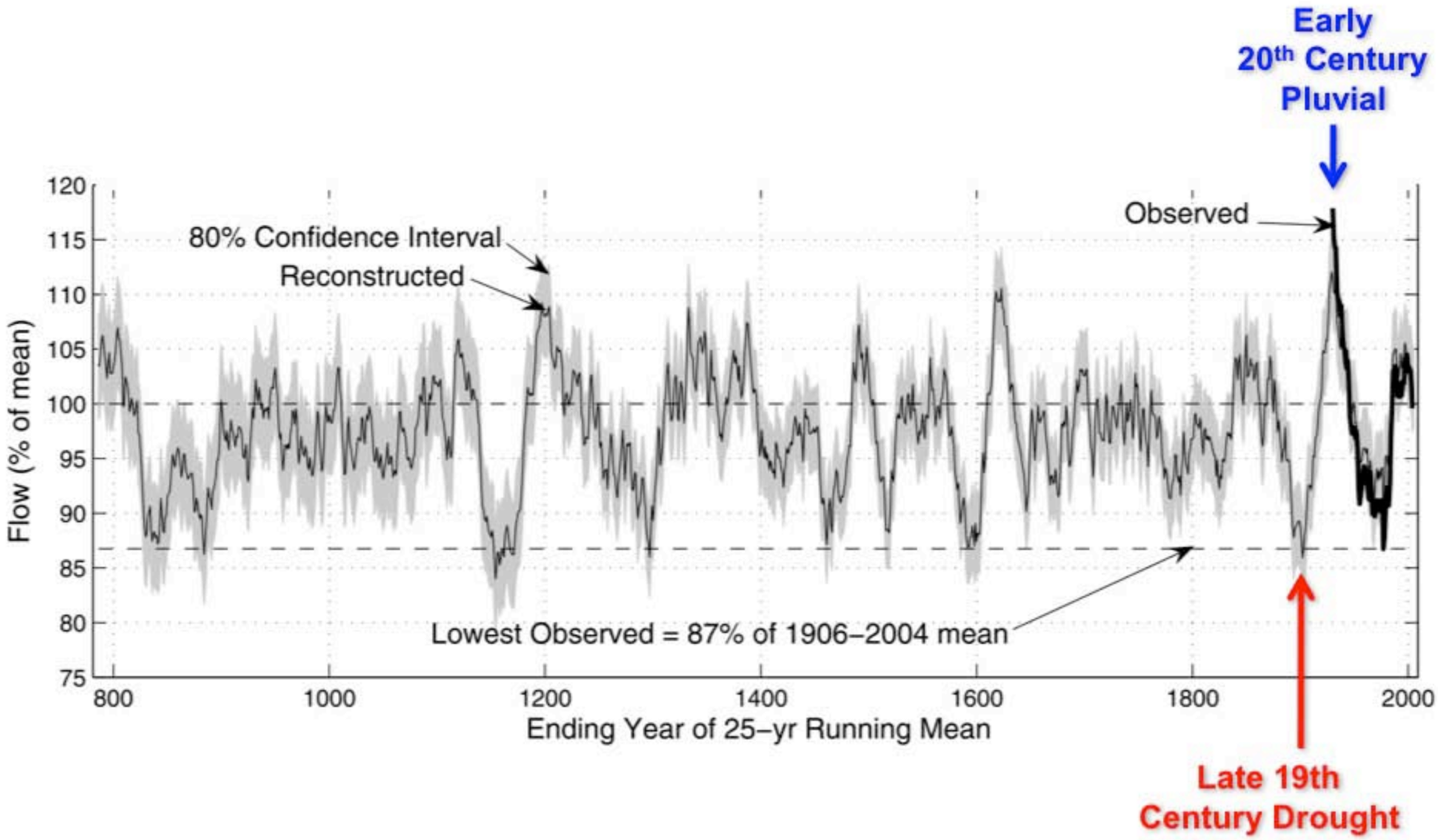

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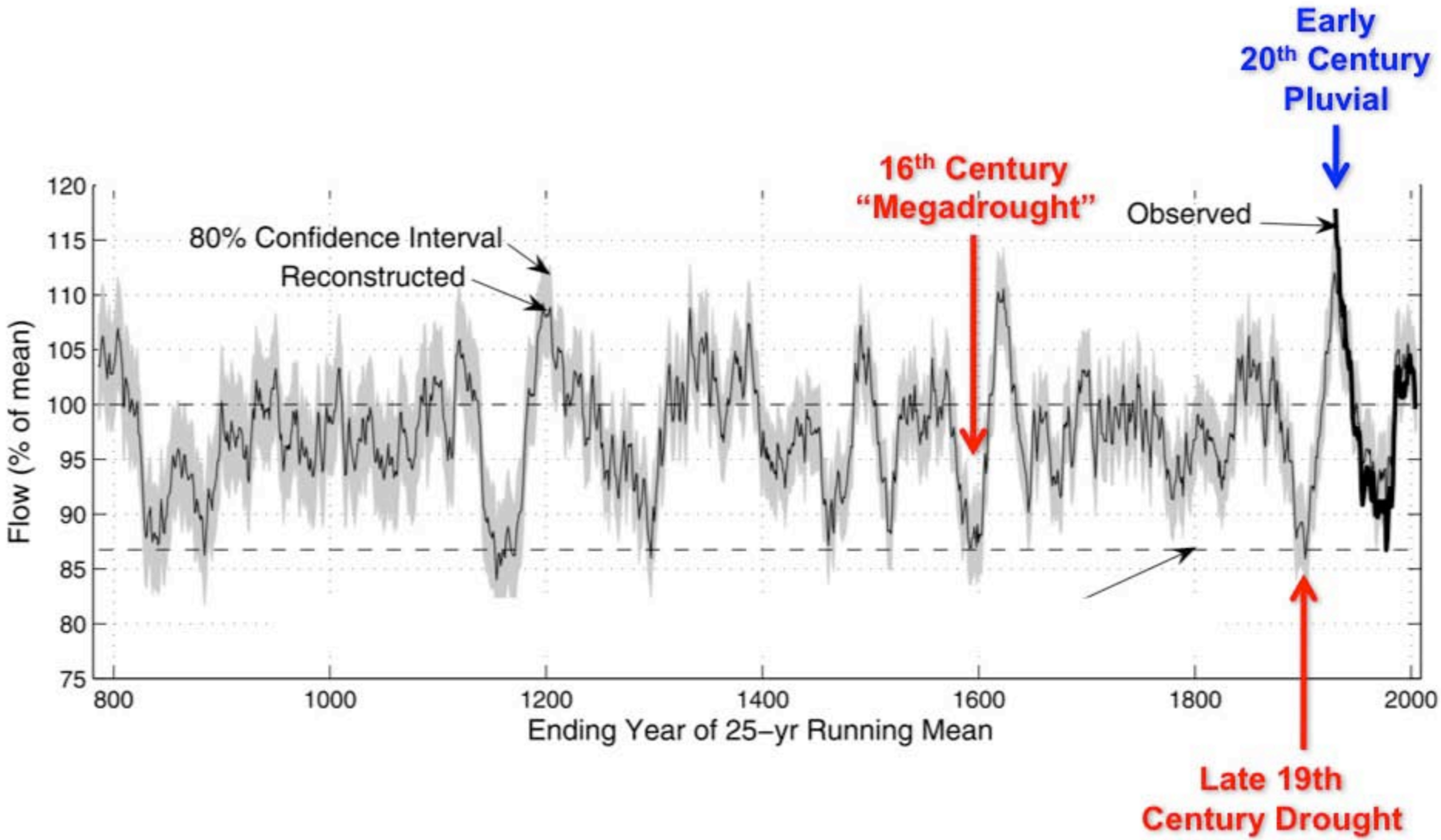

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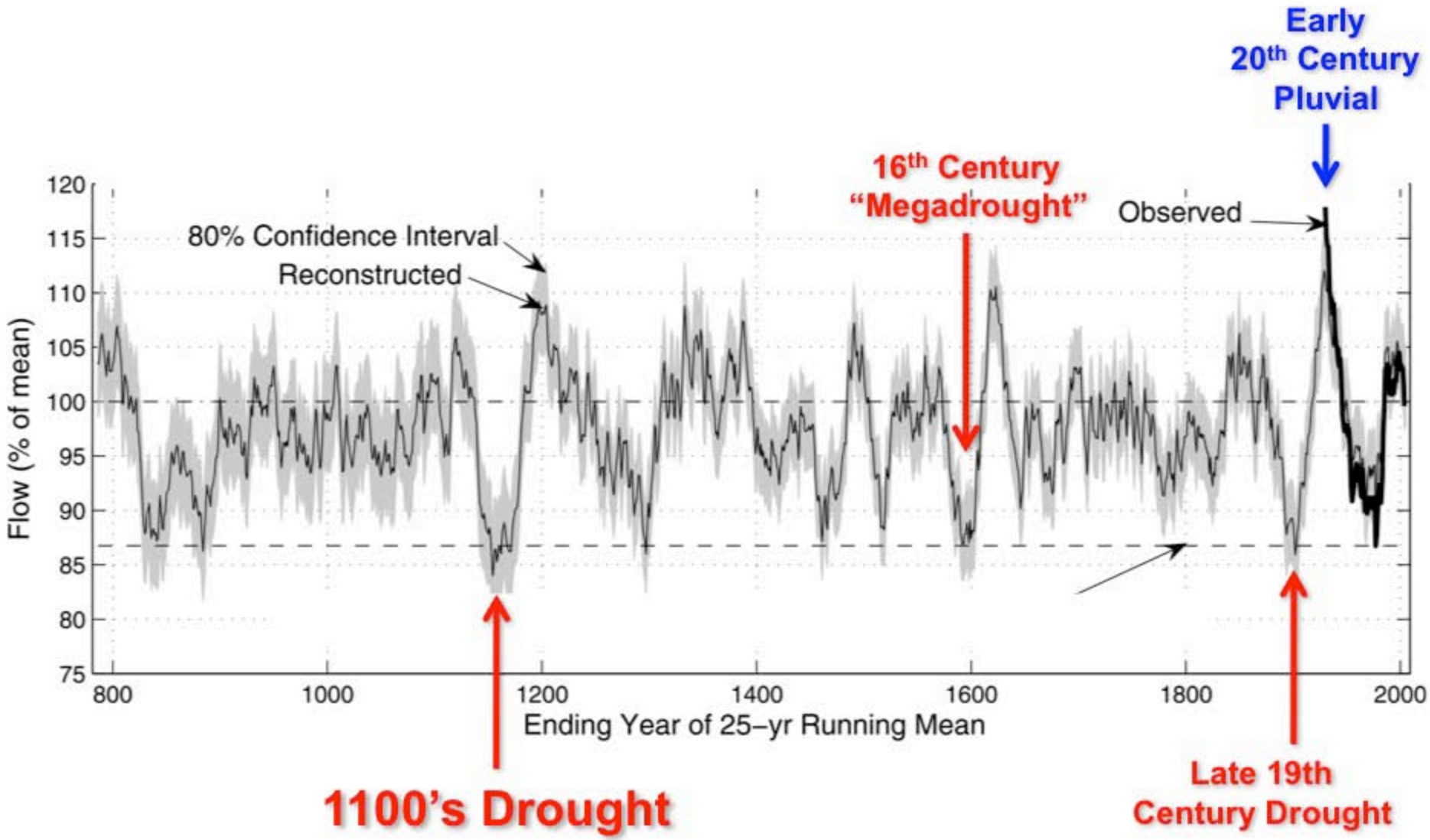

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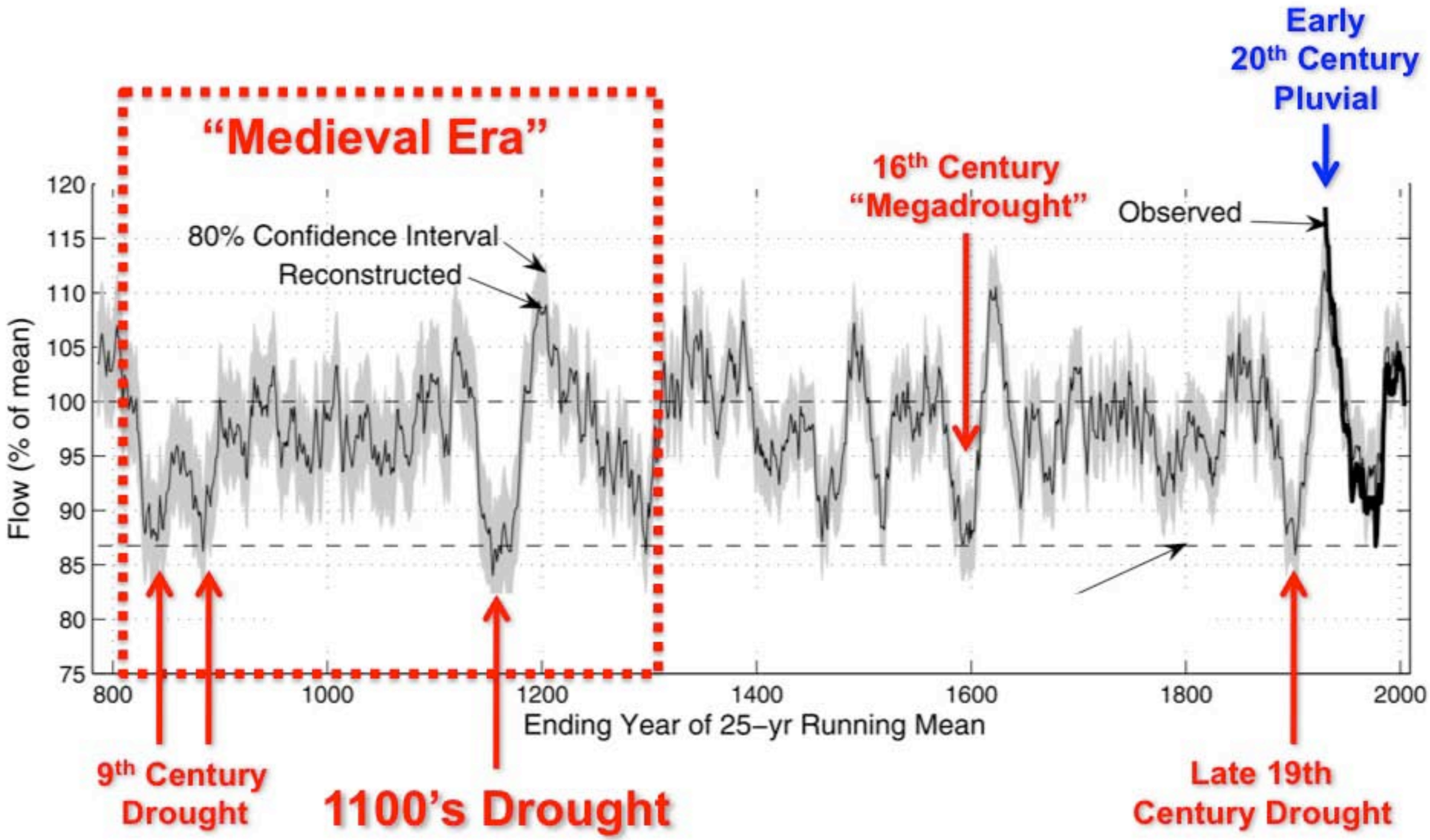

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1100's Drought

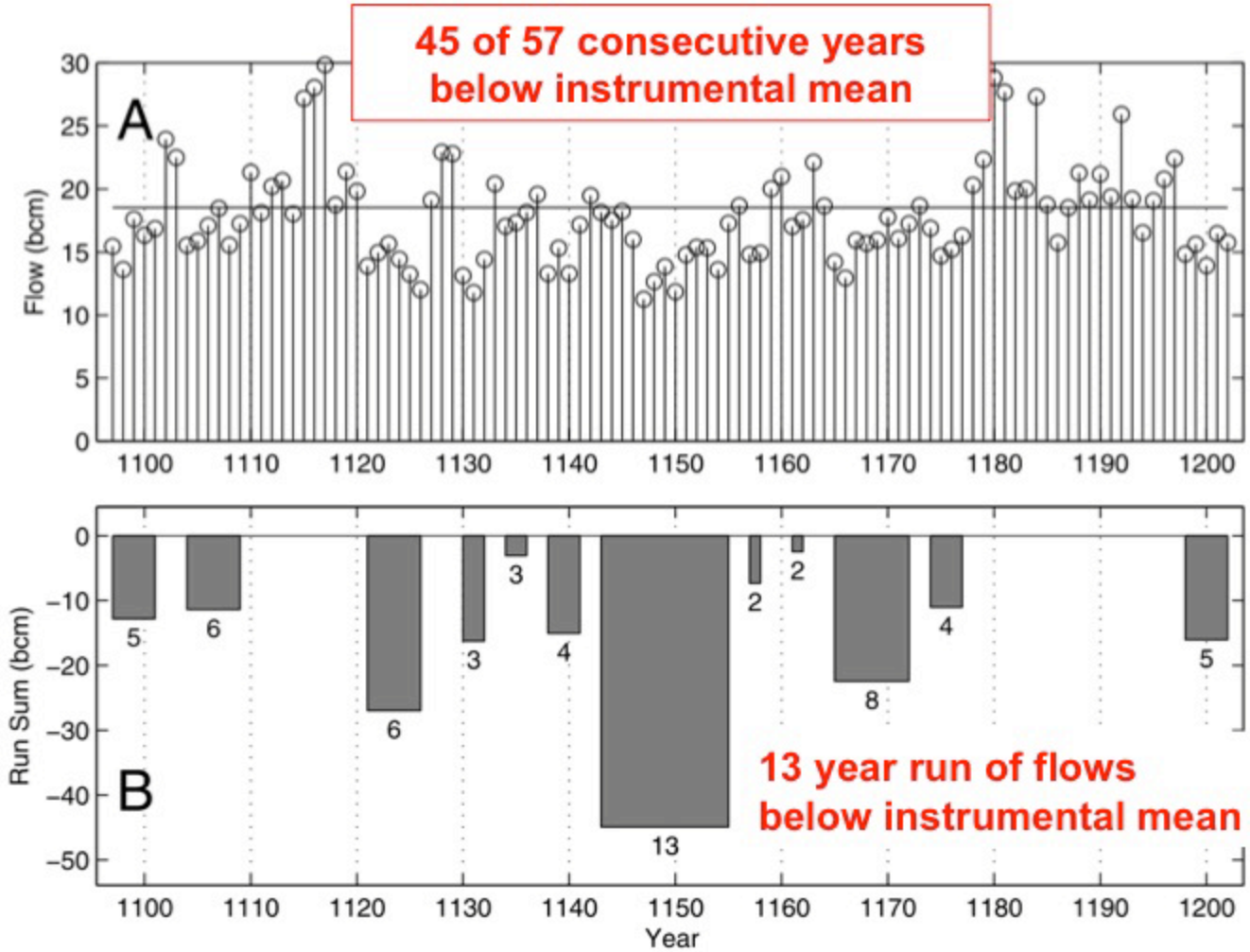

Figure 3. Runs properties of 1100s drought. (a) Time series of reconstructed flow in units of billion cubic meters (BCM) for segment A.D. 1098–1202. Horizontal line at 18.53 BCM is observed mean for 1906–2004. (b) Time series of runs below the observed mean flow. Bars mark runs of two-or-more years. Run-length annotated below bar. Run-sum (cumulative departure from mean) given by length of bar.

TreeFlow

streamflow reconstructions from tree rings

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

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.

Applications to Water Management

Tree-ring reconstructions are being used in water management and planning in a number of ways: to provide context for the observed flow record, for establishing more realistic worst-case drought scenarios, and as numerical input into water system models to test policies. For more information on applications of tree-ring reconstructions to water management, click here.

Technical Workshops

Our one-day workshops for water managers and stakeholders in Colorado, Utah, Wyoming, Arizona, New Mexico, and Nevada, have comprehensively covered the methods for developing streamflow reconstructions from tree rings. Each workshop has a page with a summary and links to the presentations. Click here for more information about these technical workshops.

Colorado River Streamflow: A Paleo Perspective

The Colorado River is the lifeline of the southwestern US. Over the years, much work has been done to assess the long-term variability in its streamflow, using tree rings and other environmental proxies. Click here for a multi-page feature providing a "paleo perspective" on Colorado River streamflow.

http://treeflow.info/

Data access
Background info
Examples of application

New Tree Ring/Monsoon Project

Leavitt et al. 2011
Quaternary International

- Develop the first network of monsoon-sensitive chronologies in the SW U.S.
- Investigate long-term monsoon variability across region
- Compare paleo records of summer and winter precipitation
- Evaluate tree-growth response to large-scale circulation (i.e. ENSO)
- Partner with regional stakeholders

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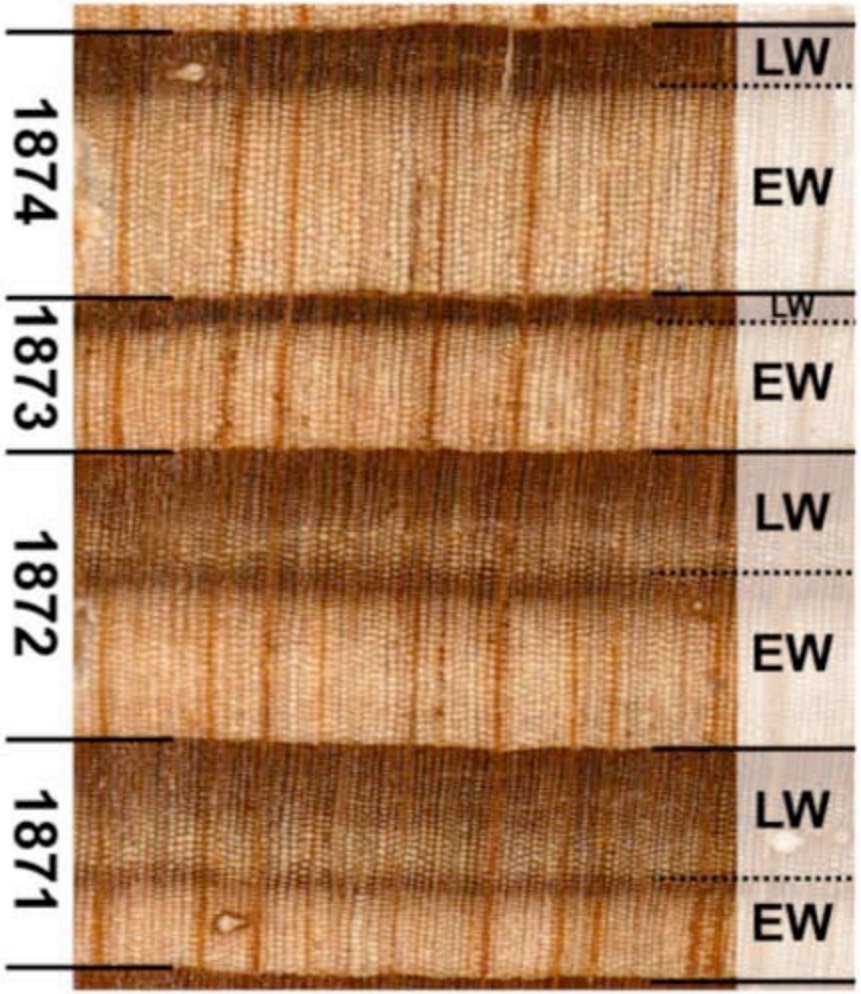
Earlywood & Latewood



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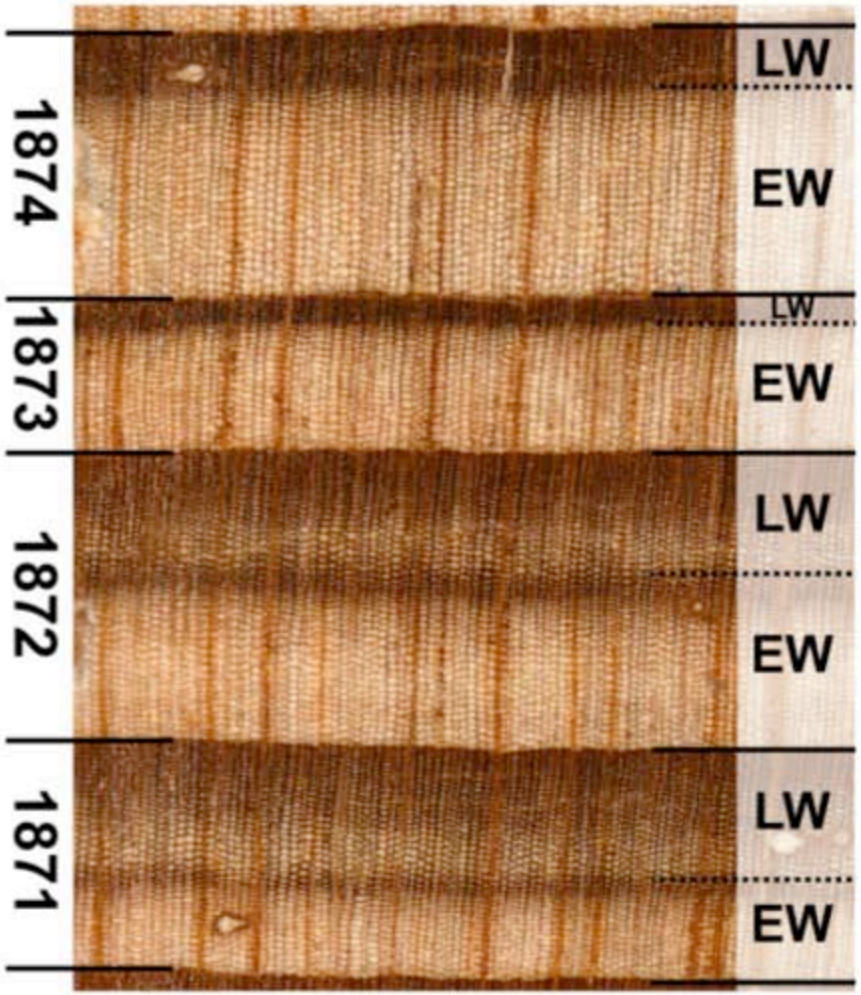

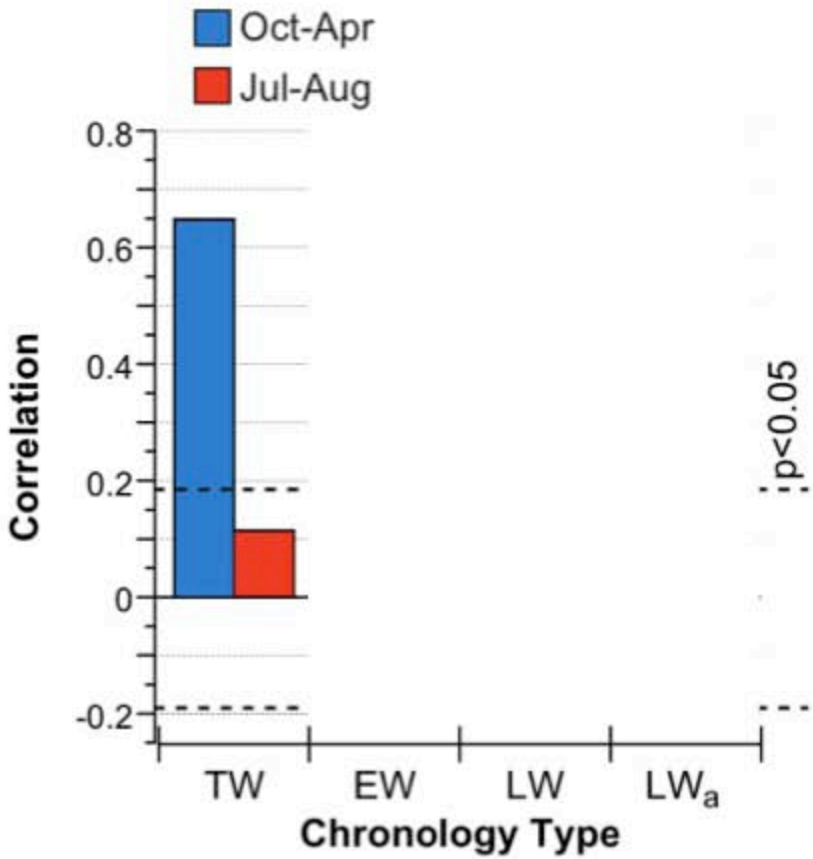

(Griffin et al. 2011 *Tree-Ring Research*)

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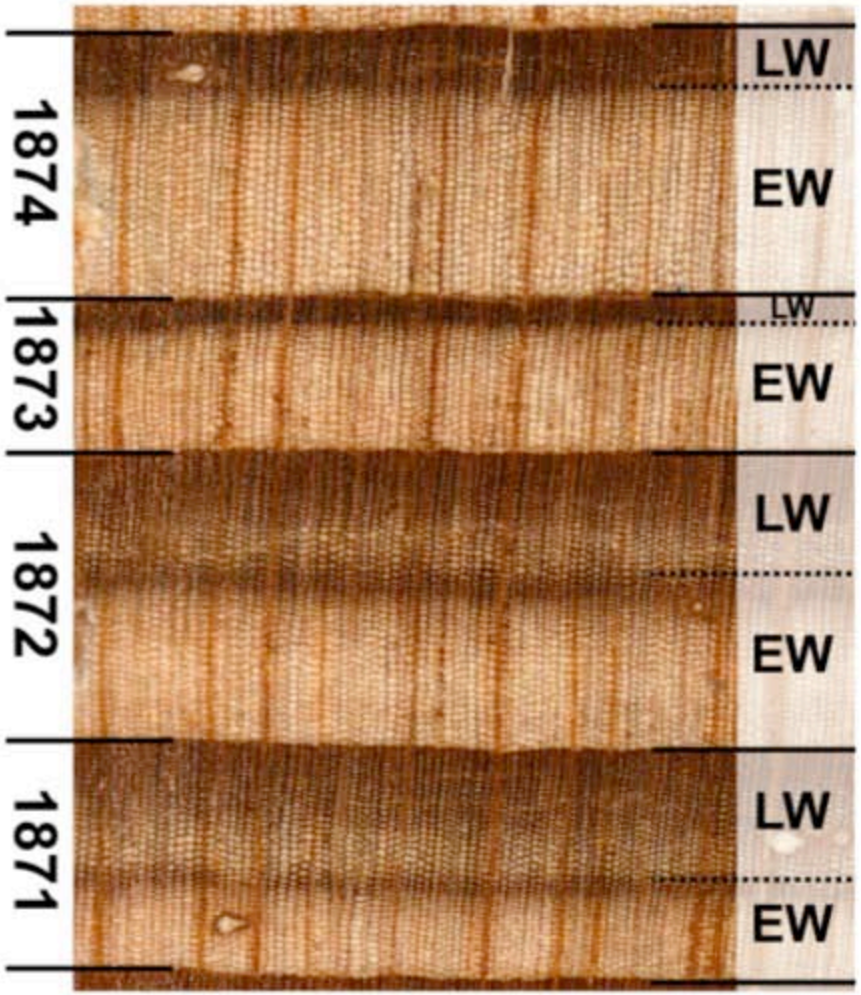

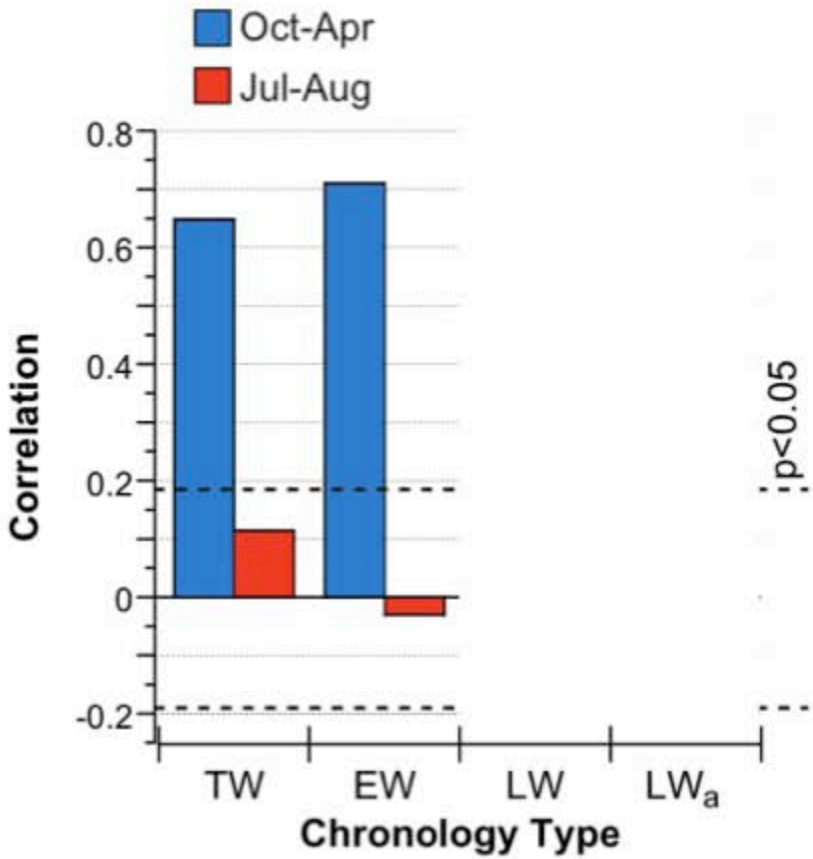

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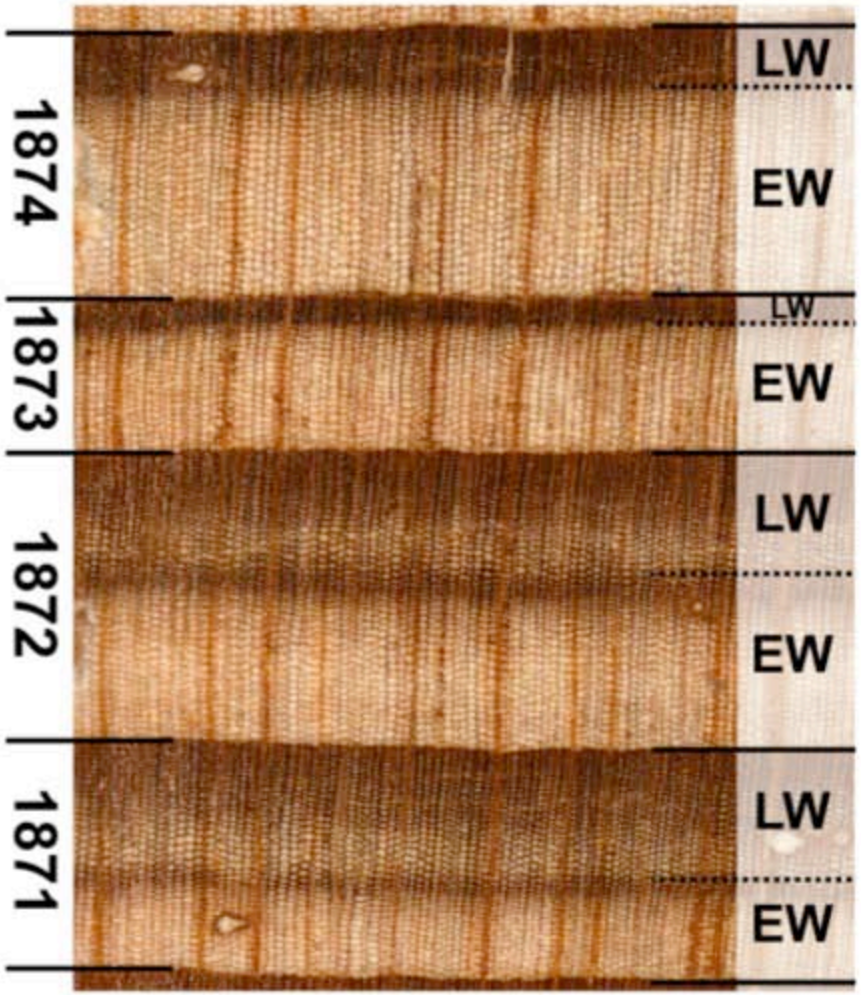

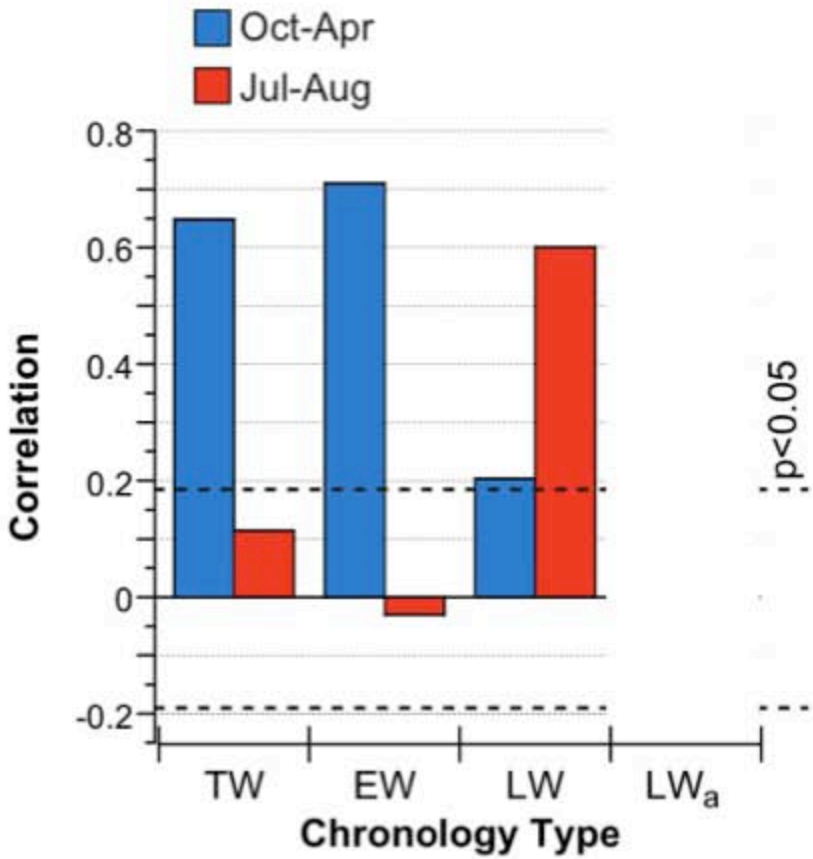

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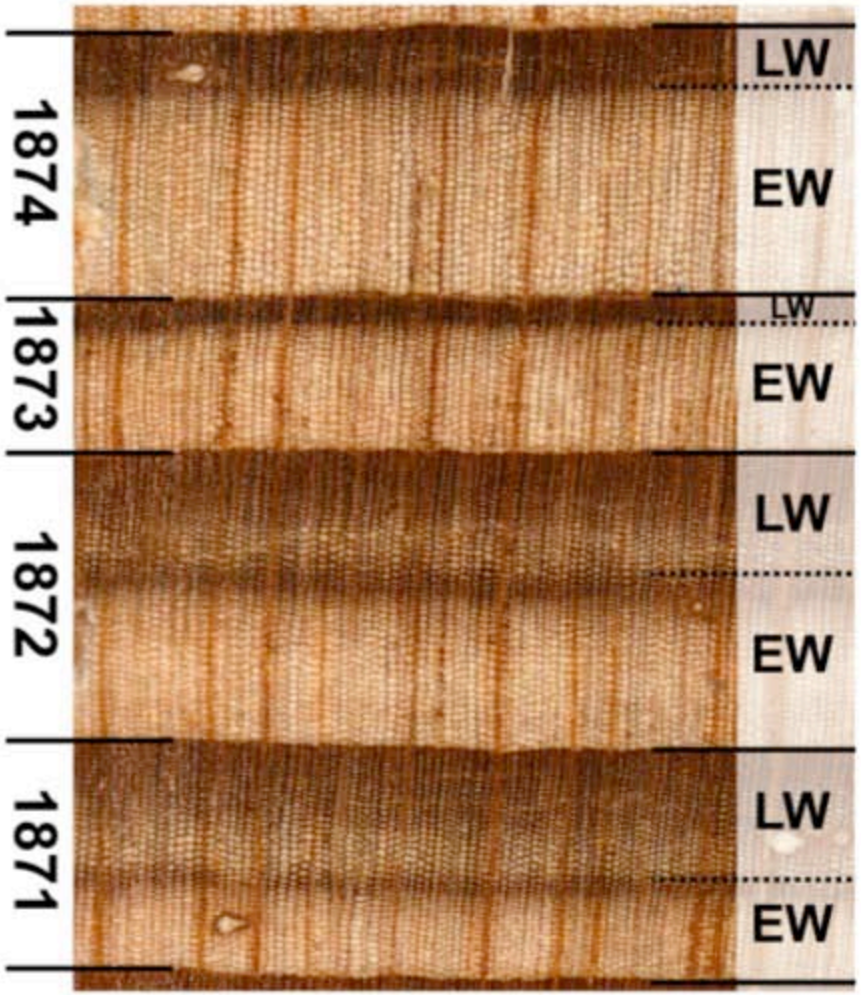

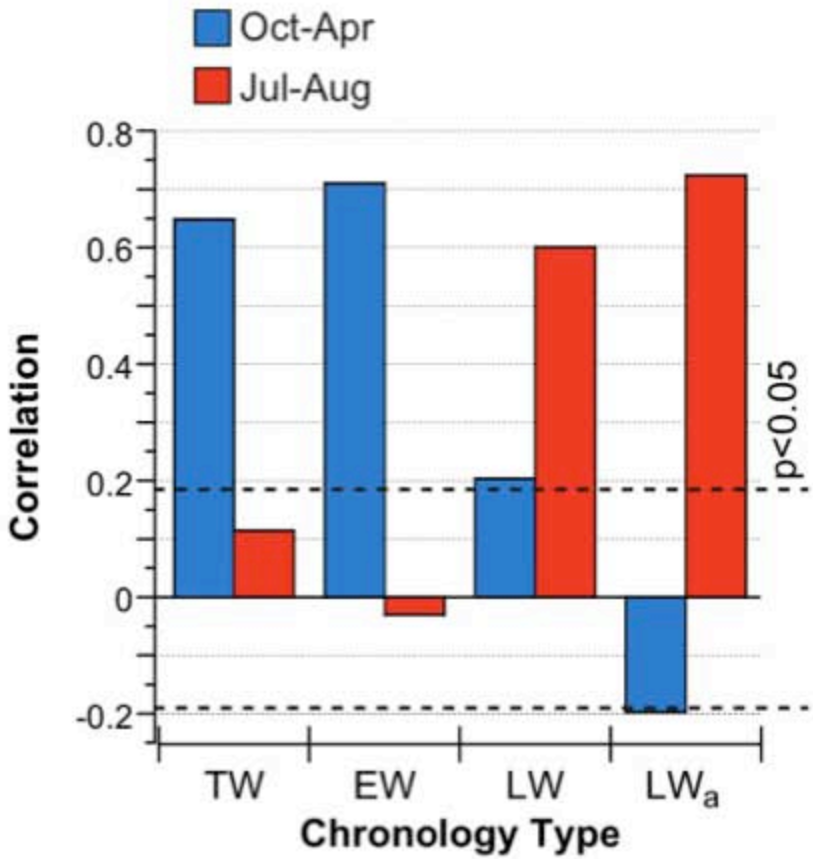

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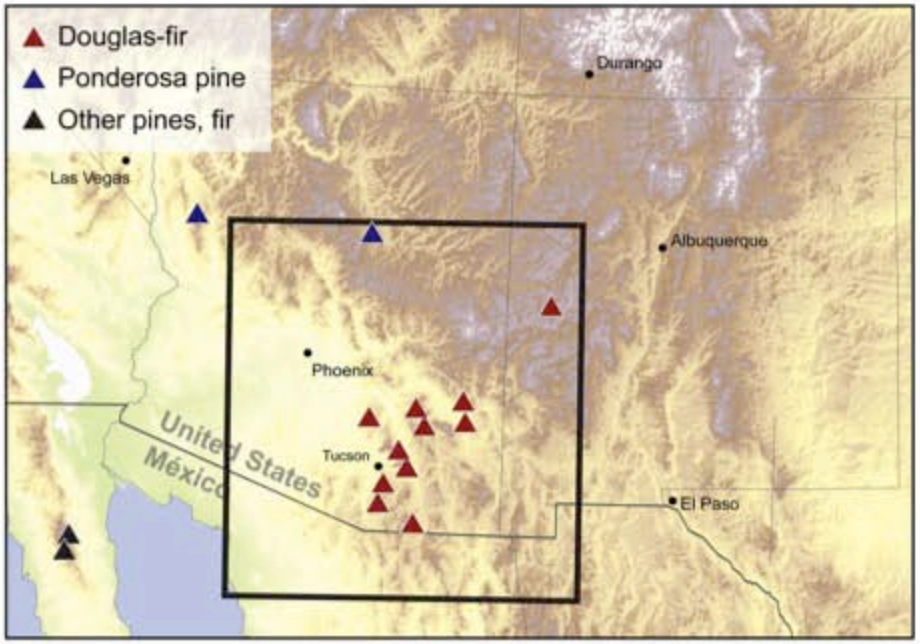
New Reconstructions

Summer Monsoon June-August Precip



- 15 Chronologies
- 662 Trees

New Reconstructions

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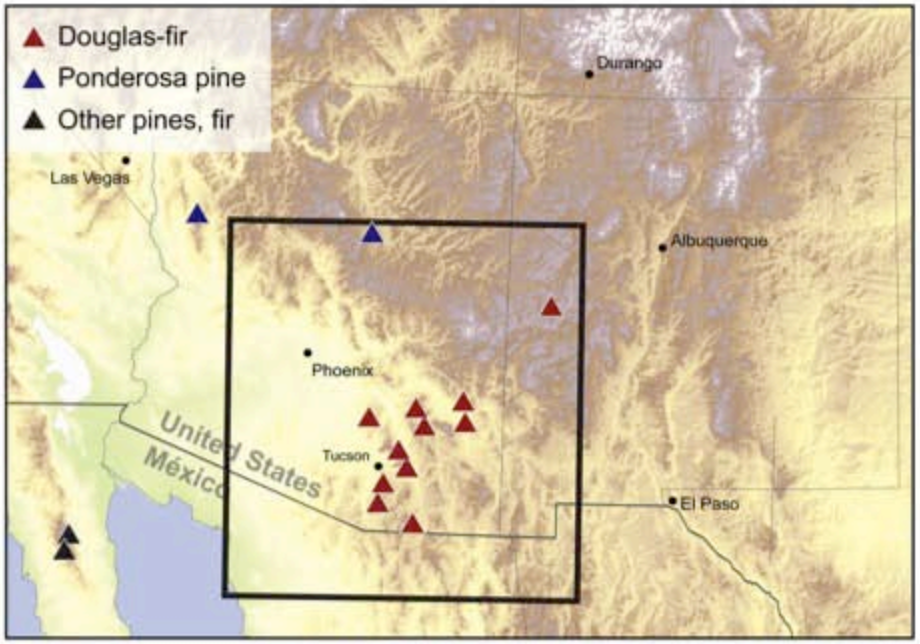
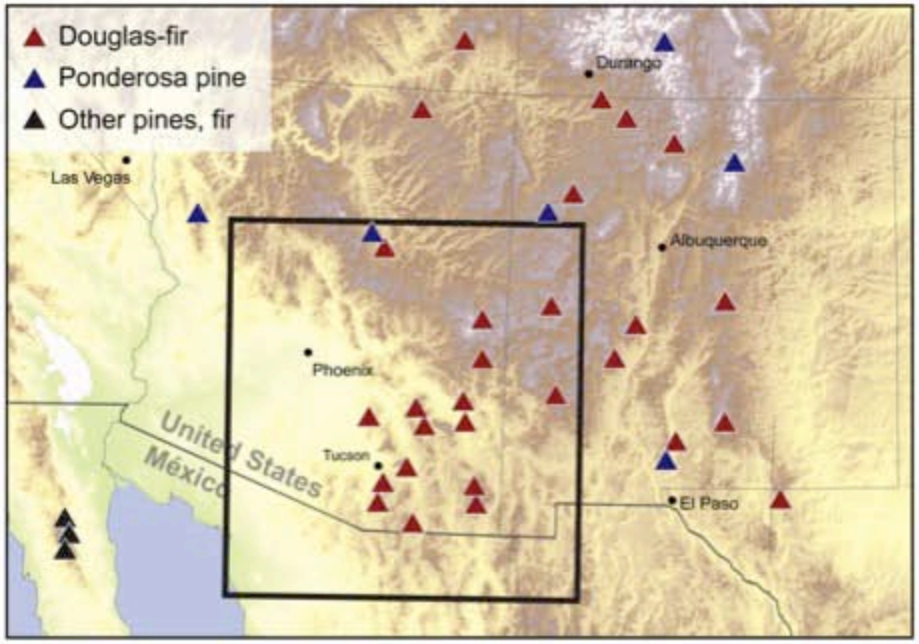


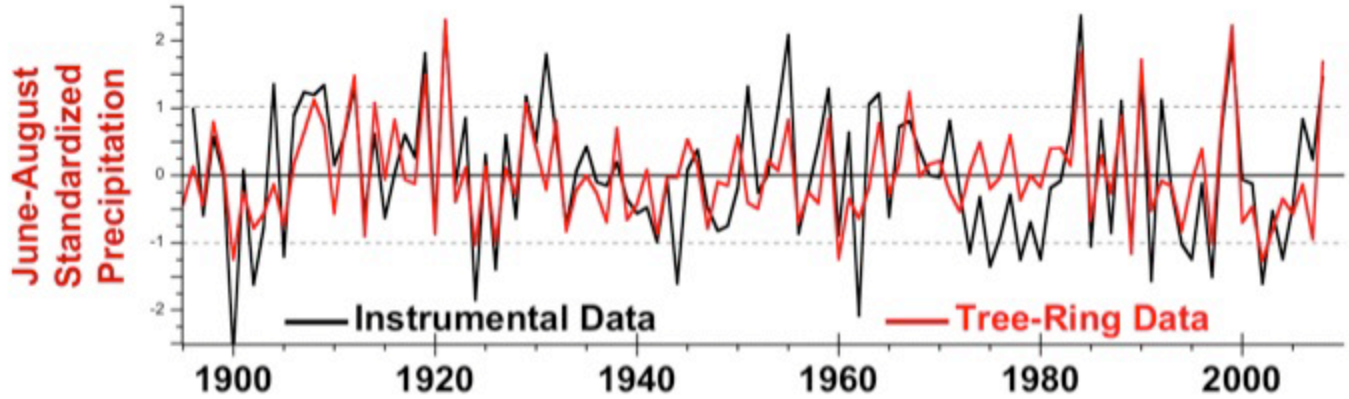
- 15 Chronologies
- 662 Trees

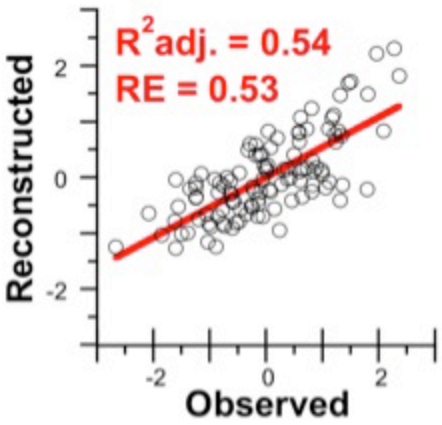
Winter Spring October-April Precip



- 37 Chronologies
- 1,605 Trees

NAME Region 2 SPI Reconstructions





Griffin et al. (in prep.)

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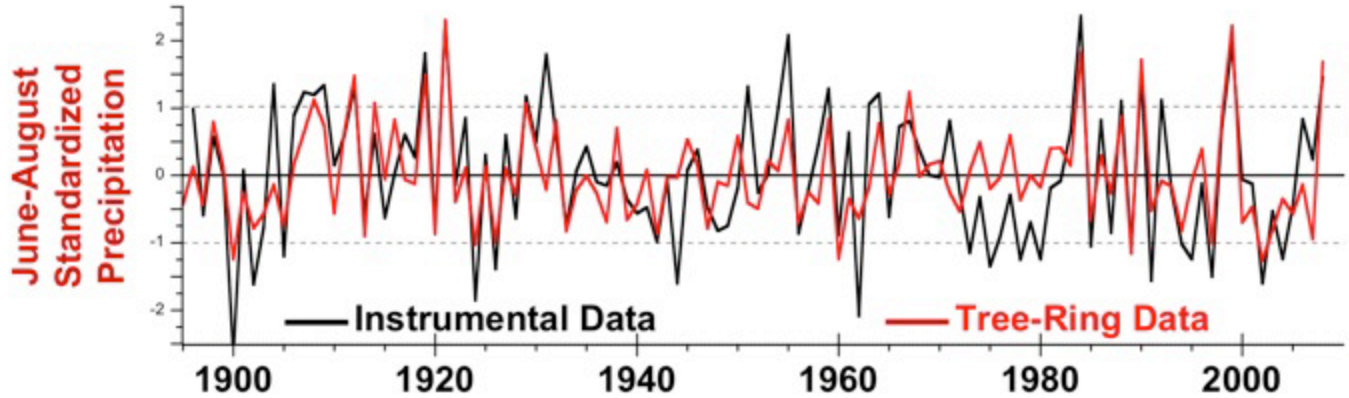
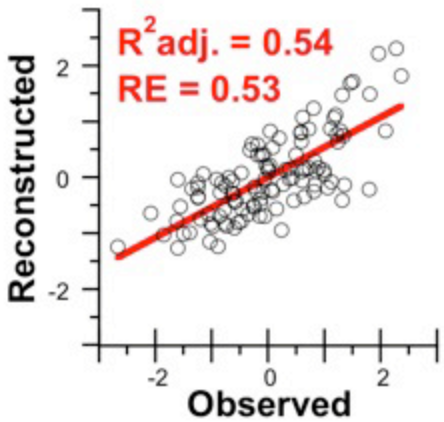
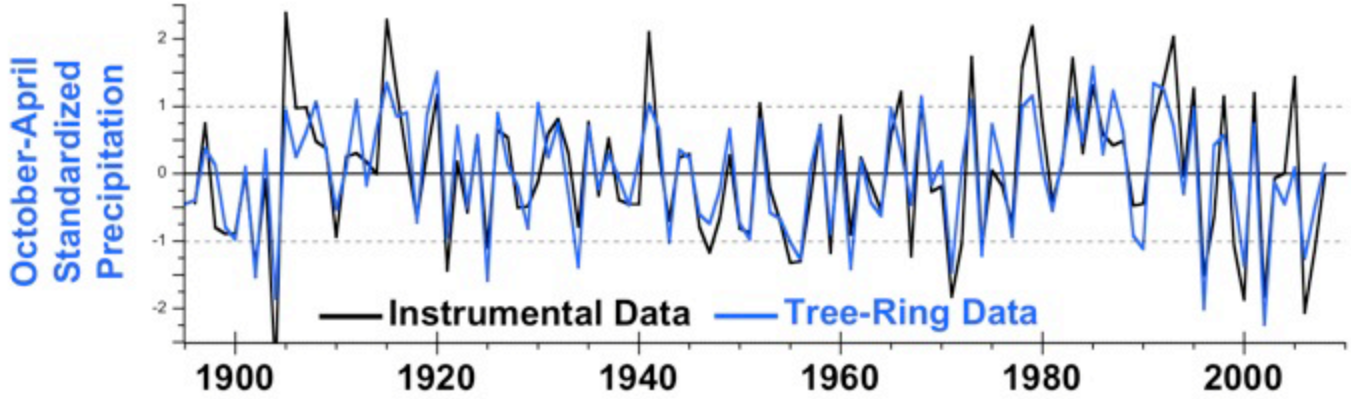
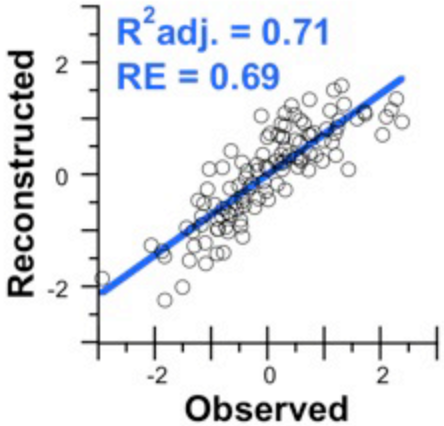




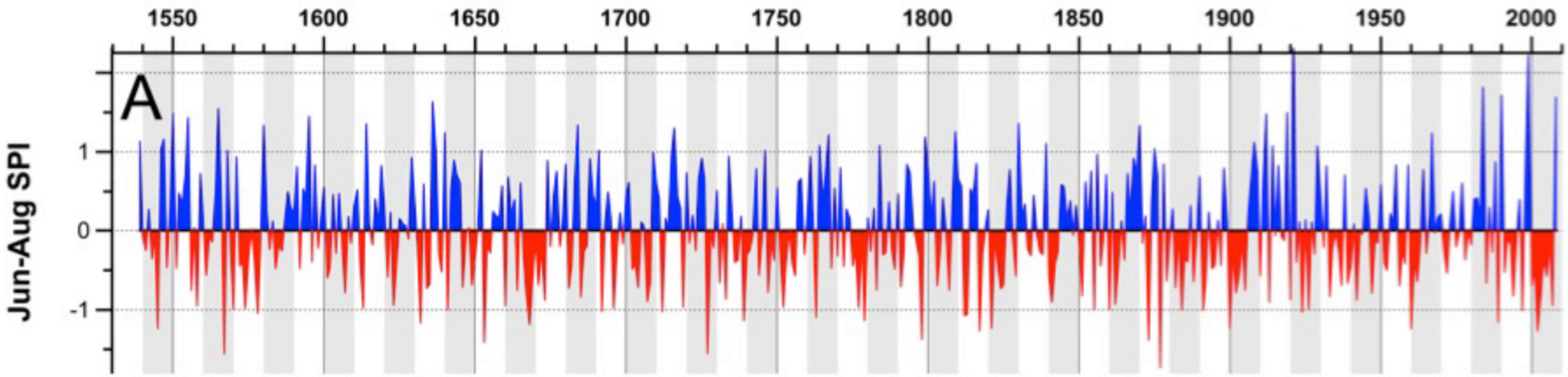




Griffin et al. (in prep.)

NAME Region 2 SPI Reconstructions: 1539-2008
Seasonality of Drought

Griffin et al. (in prep.)



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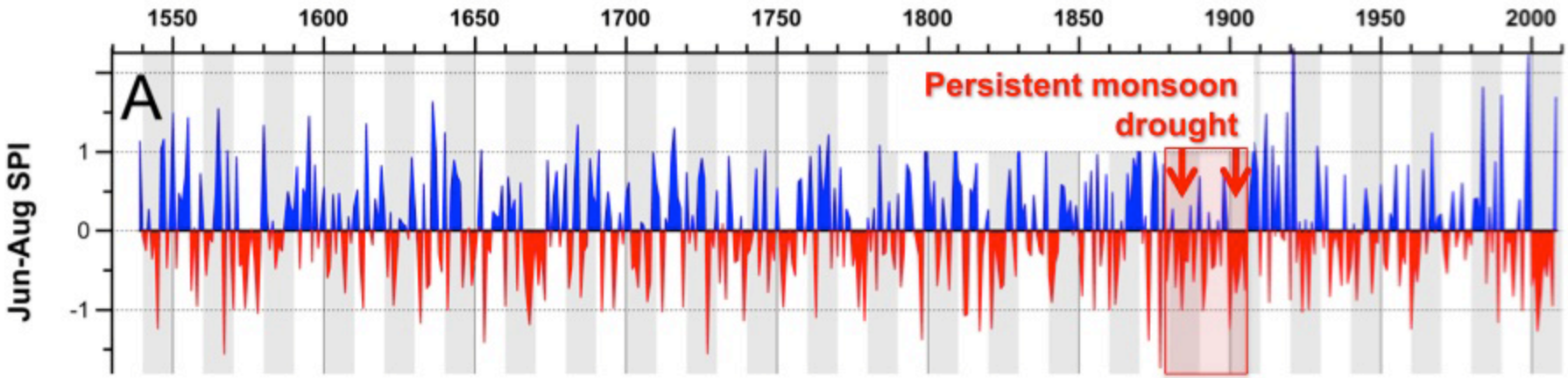

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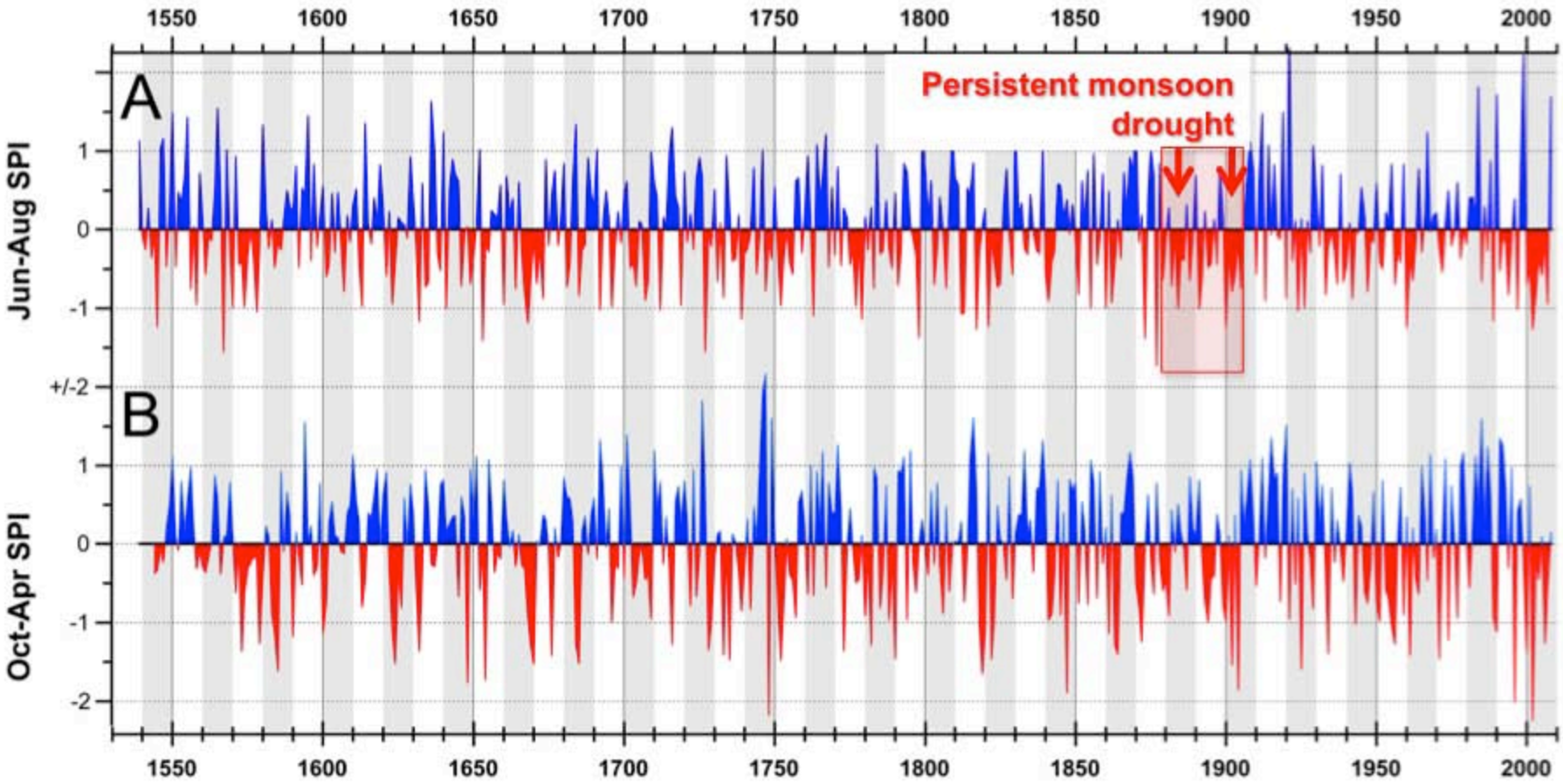

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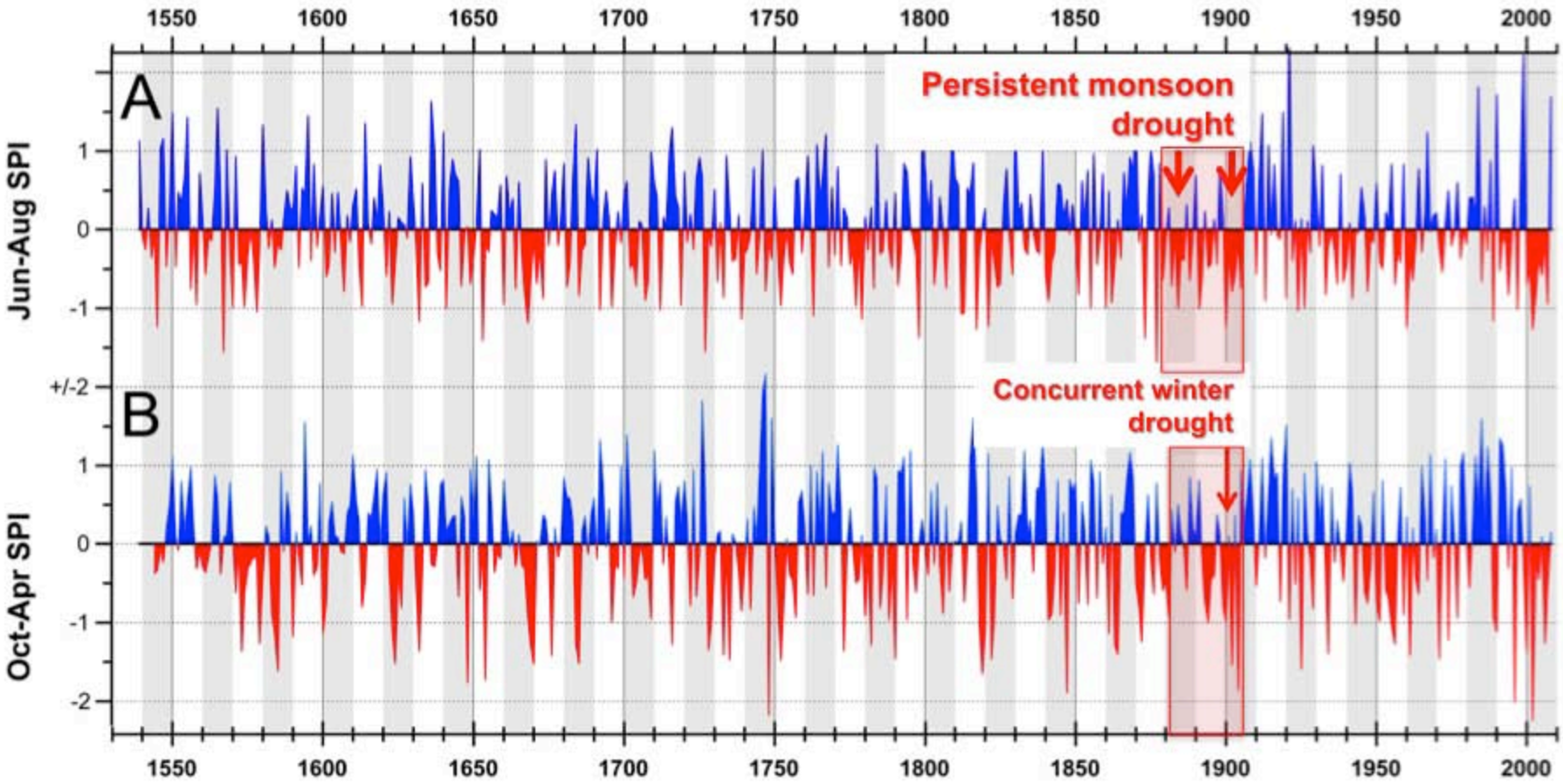

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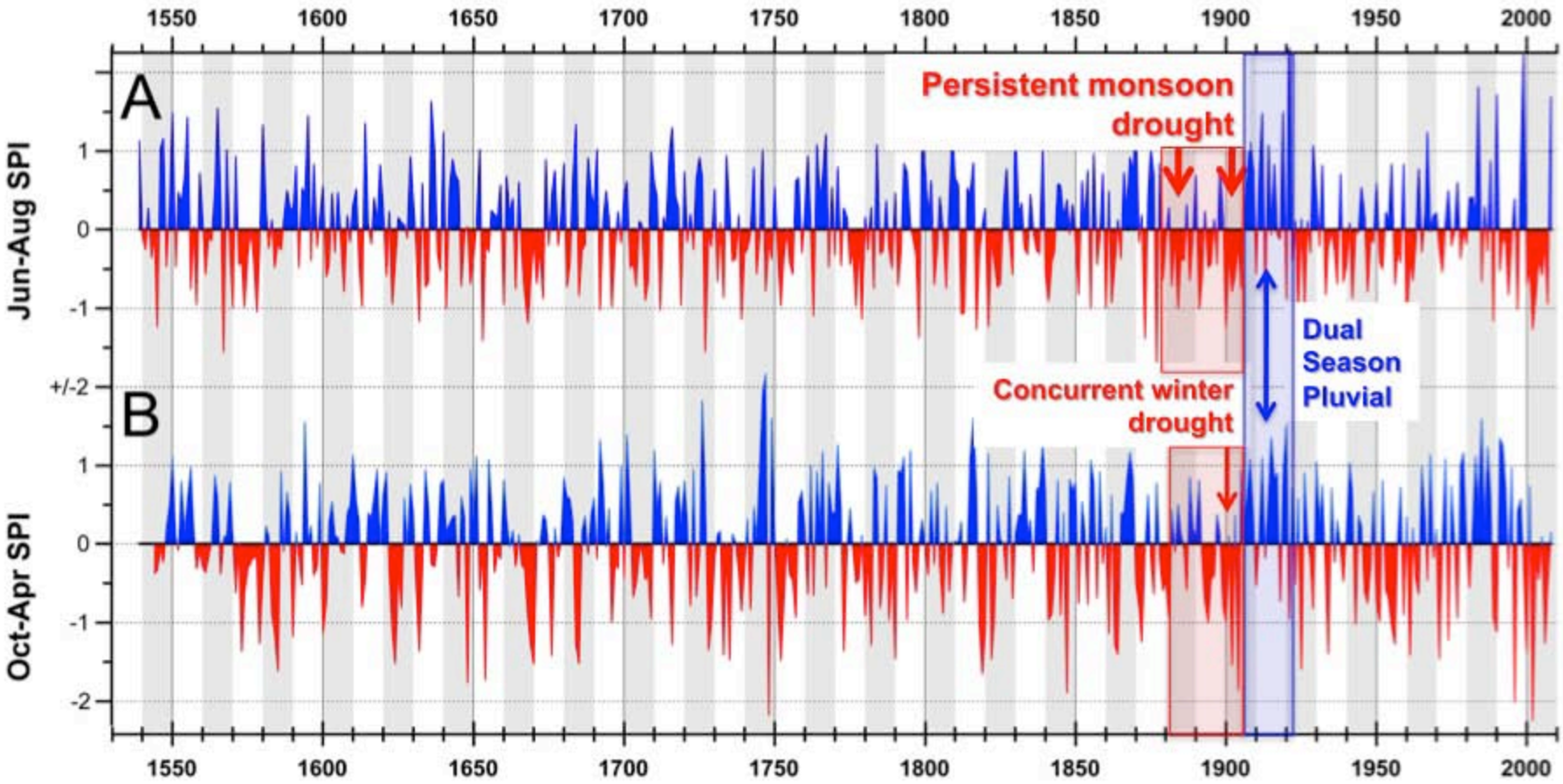

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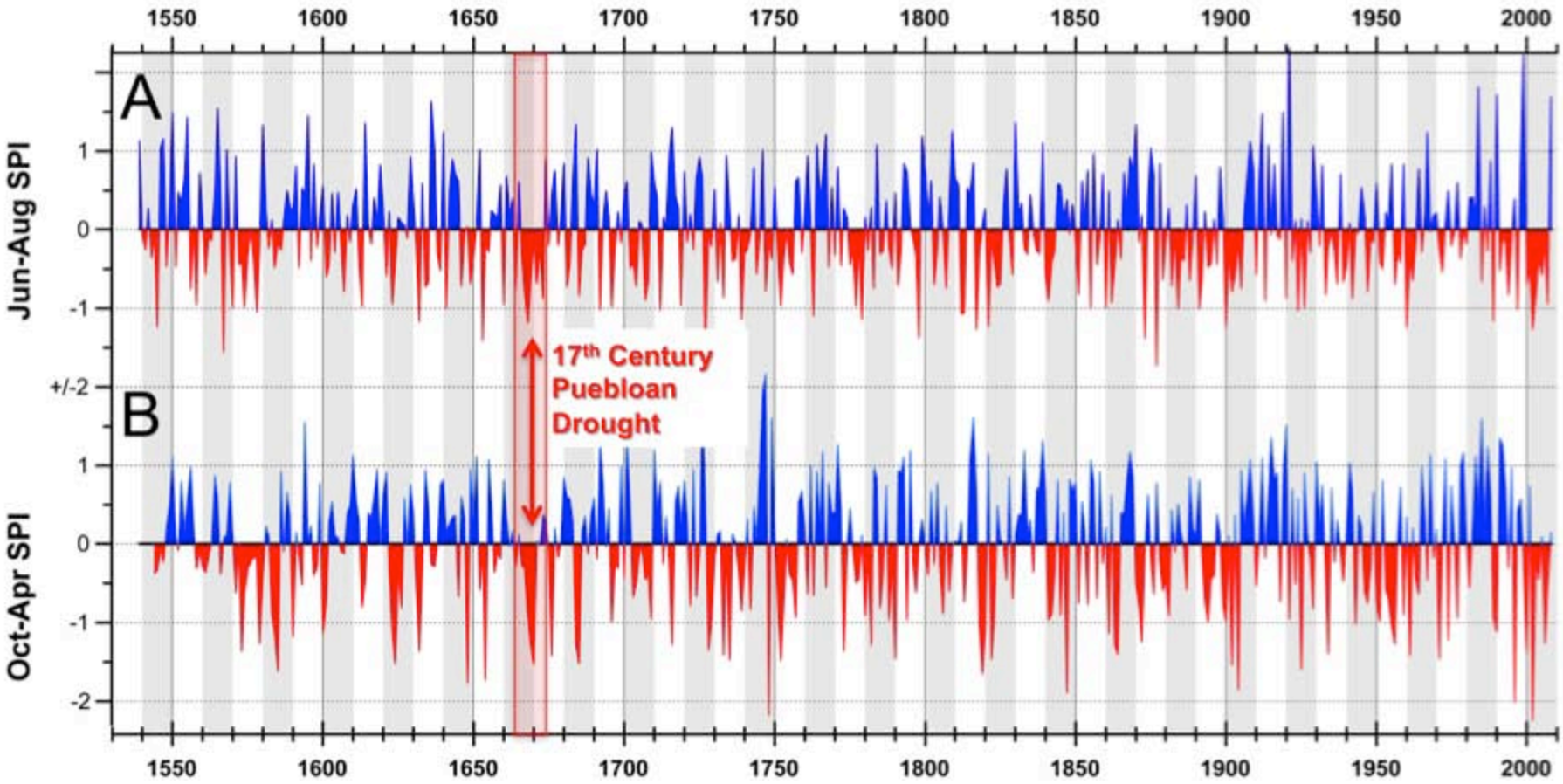

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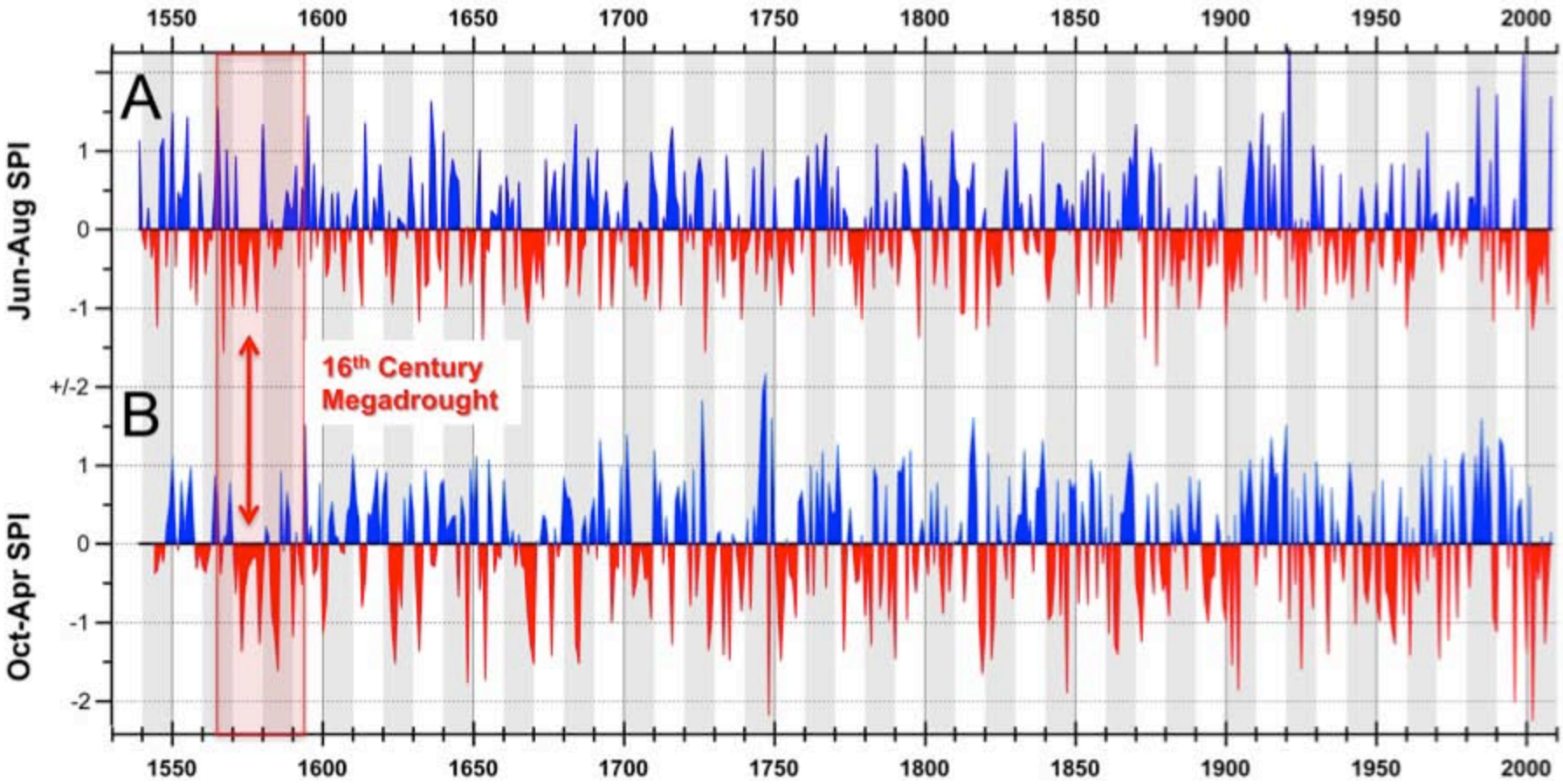

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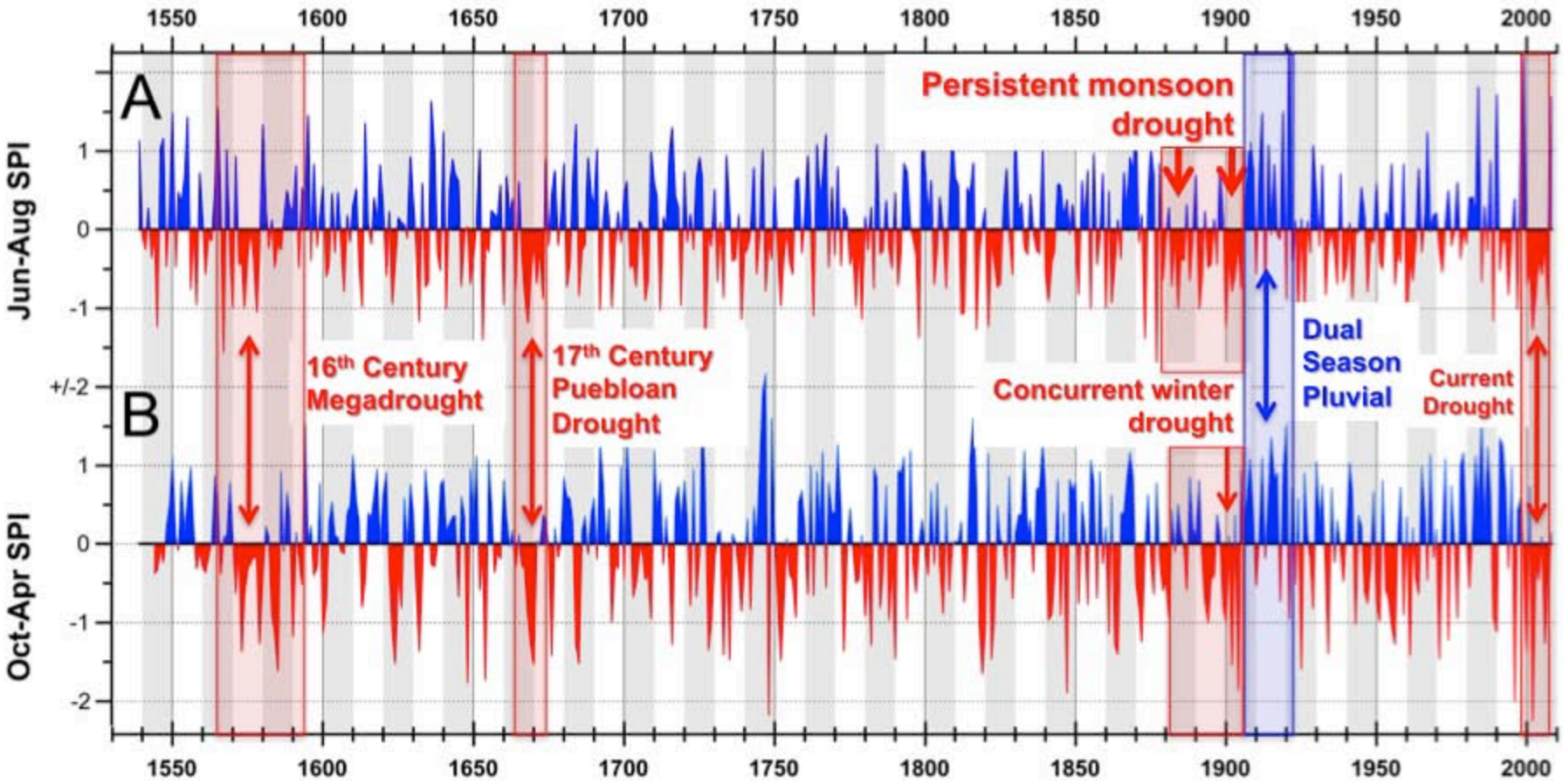

Concluding thoughts

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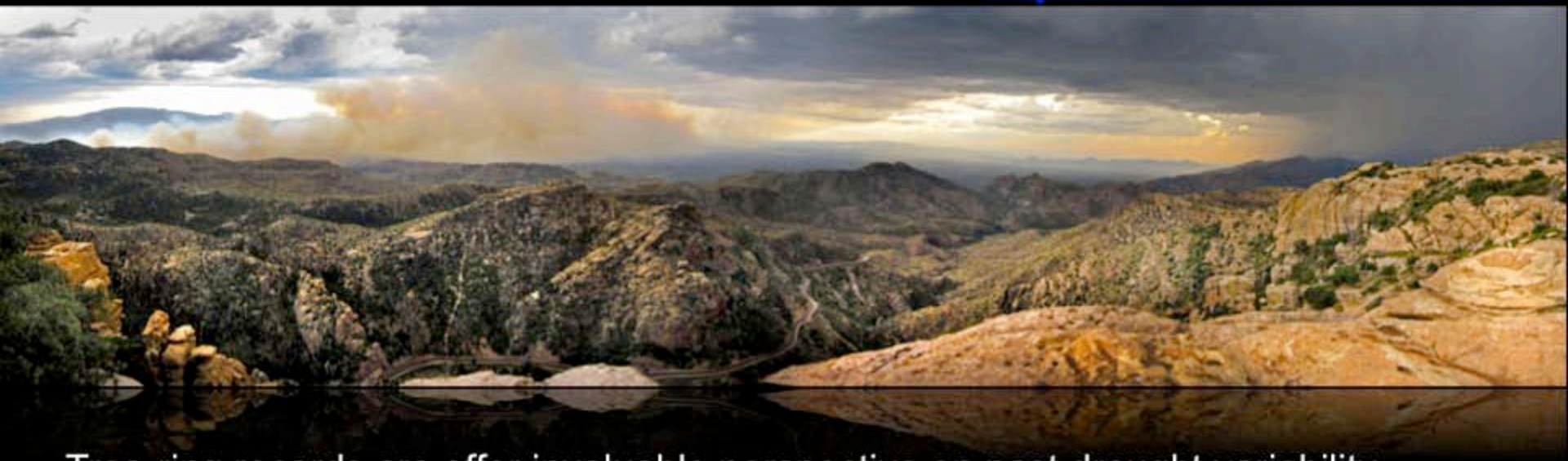

- Tree-ring records are offer invaluable perspective on past drought variability
- Extensive tree-ring research on the CO River
- Paleo droughts seem more severe and sustained than any witnessed during the instrumental era.
- New monsoon records indicates persistent drought often occurs during both seasons
- Results underscore importance of drought seasonality in the Southwest

THE UNIVERSITY OF ARIZONA. LTRR Laboratory of Tree-Ring Research University of Arizona CLIMAS Climate Assessment for the Southwest NSF EPA

Advisors / Collaborators

Connie Woodhouse
David Meko
Katie Hirschboeck
Christopher Castro
Carlos Carillo
Holly Faulstich

Funding

National Science Foundation
EPA STAR Fellowship
Salt River Project
U.S. Bureau of Reclamation
CA DWR
U.S. Geological Survey

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LTRR Laboratory of Tree-Ring Research University of Arizona

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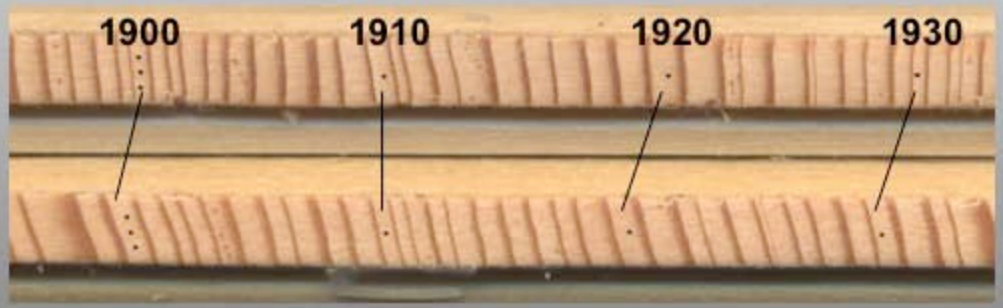
Tree-Ring Collection and Measurement

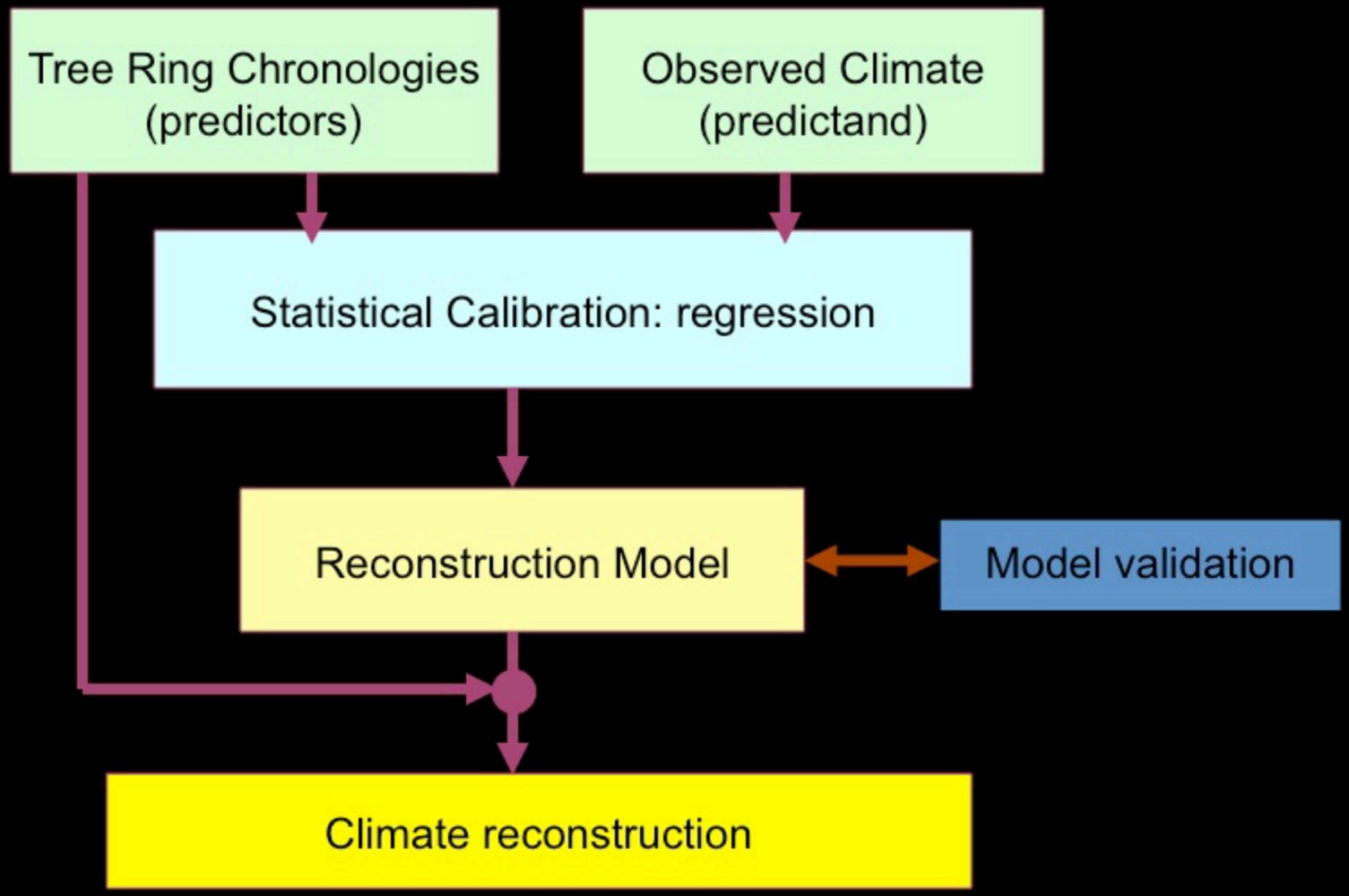
20-50 living trees are non-destructively sampled

Old wood is collected when possible

Samples are prepared and dated.
Ring widths are measured to the 0.001 mm.
Measurements are averaged into site tree-ring chronologies



Generating the climate reconstruction



based on Meko (2005)

GEOPHYSICAL RESEARCH LETTERS, VOL. 34, L10705, doi:10.1029/2007GL029988, 2007

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Medieval drought in the upper Colorado River Basin

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- Longest reconstruction to date
- "Low Frequency" chronology development
  - discard series less than 250 years
  - uber conservative spline detrending
  - 0.85 minimum subsample signal strength
  - Variance stabilization
- 11 "single site reconstructions" reduced with PCA to yield:
- 4 Nested regression models

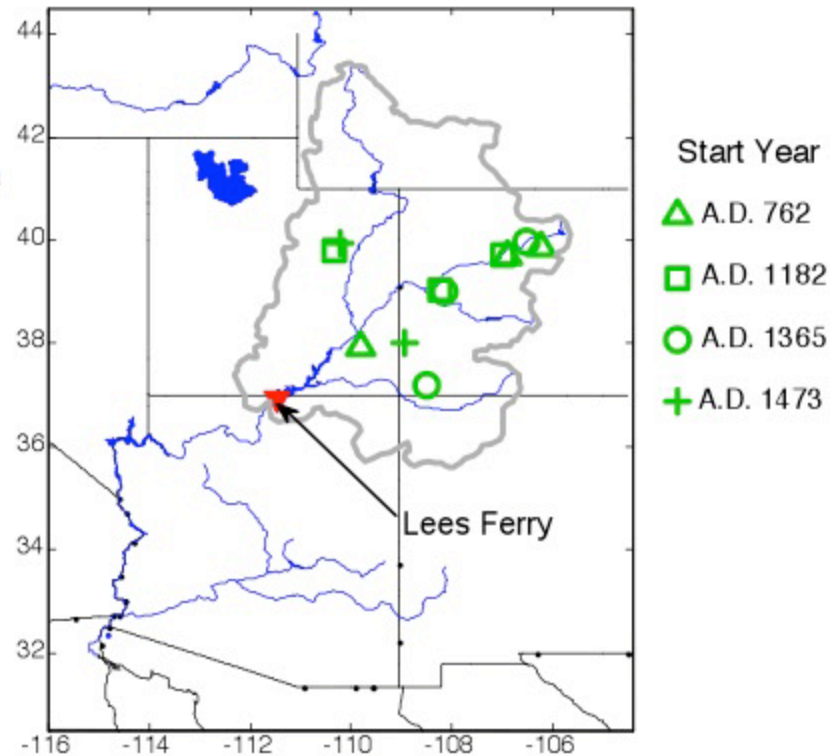
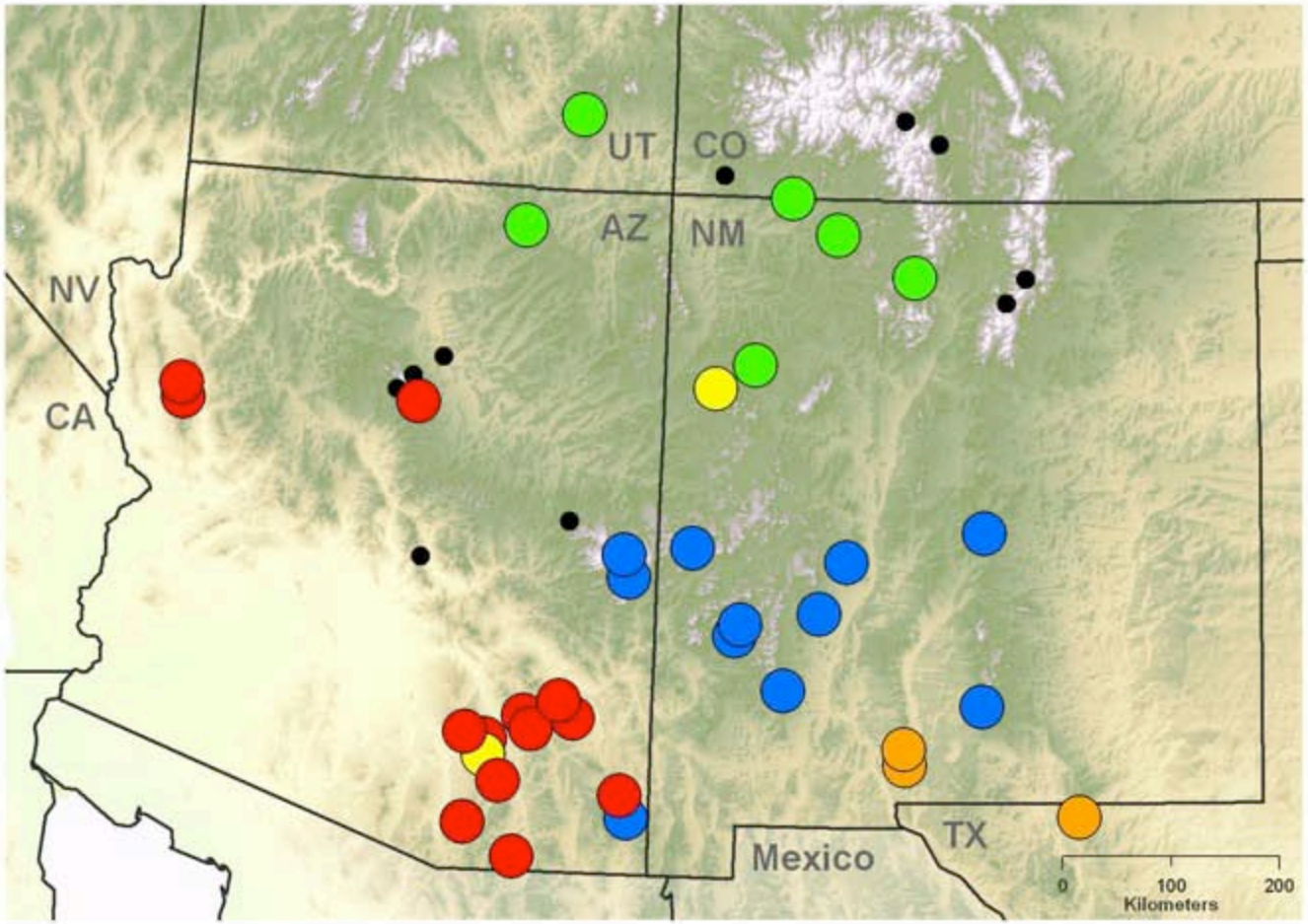


Table 1. Summary Statistics of Sub-Period Reconstruction Models

		Calibration[c]			Validation[d]		
Sequence[a]	Start[b]	Years	n-p-q	R^2_{adj}	m	RE	RMSE
1	762	1906–2003	3-3-1	0.60	9	0.58	3.46
2	1182	1906–2002	6-5-1	0.74	9	0.73	2.78
3	1365	1906–2002	9-4-1	0.77	9	0.76	2.64
4	1473	1906–2004	4-4-1	0.57	9	0.54	2.63

Chronology Network Status and PCA

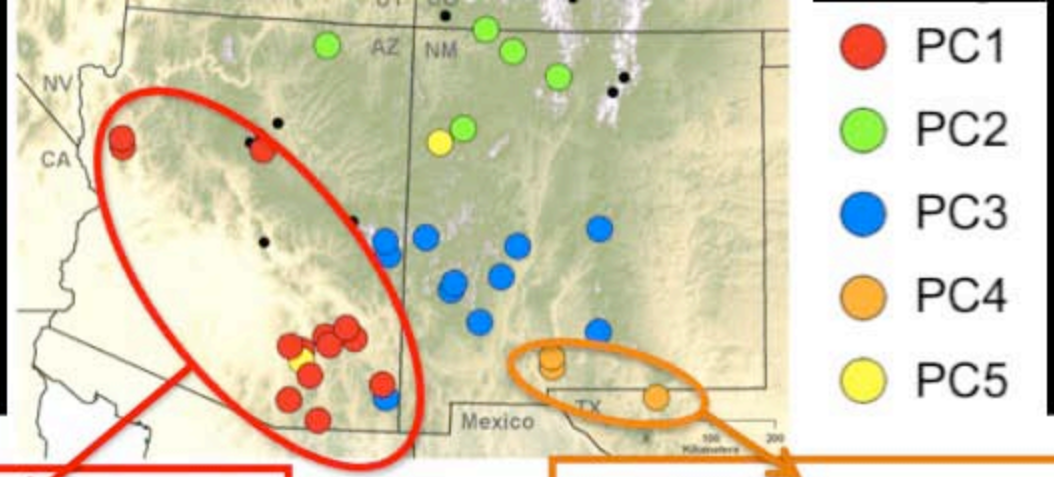


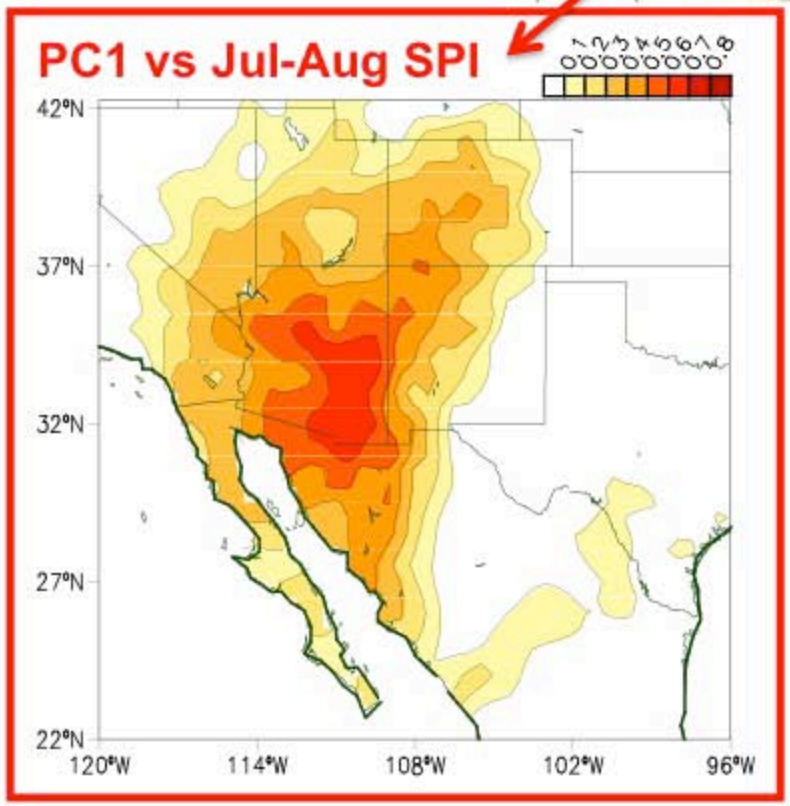
Maximum Loading

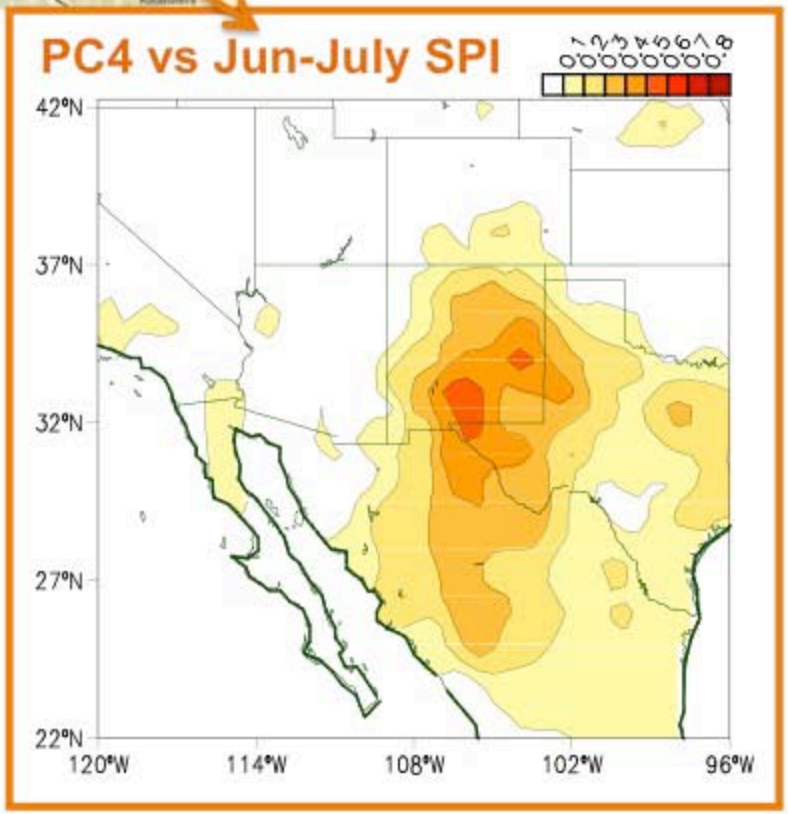
- PC1
- PC2
- PC3
- PC4
- PC5
- (in preparation)

PCA w/ Varimax Rotation
36 Chronologies (1895-2008)

Latewood Climate Response

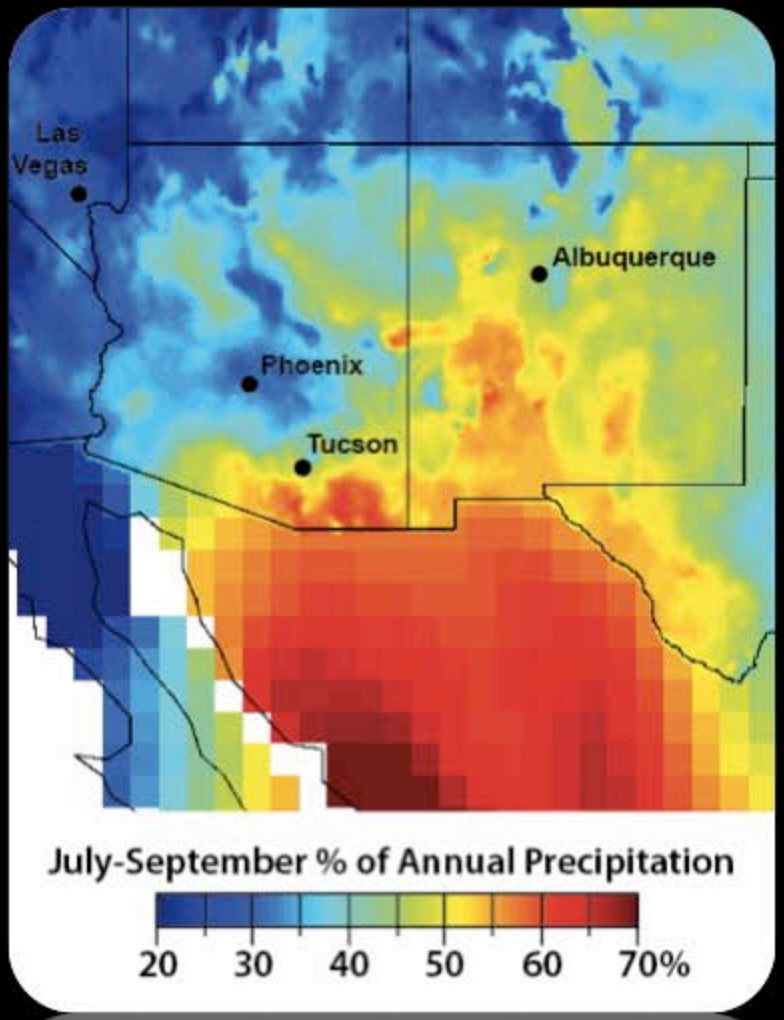






North American monsoon

- Summer season climate regime
- Synoptic-scale changes in pressure
- Shift in upper level wind direction
- Local-scale convective thunderstorms
- Emanates northward from Mexico
- Large fraction of annual precip in SW
- U.S. largely on fringe of influence
- Interannual variability dramatic over U.S.



US: PRISM
MX: Vose and Heim