North American Monsoon Variability from Instrumental and Tree-Ring Data: A Progress Report

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Photos: Dan Griffin

Research Goal: to investigate the long-term variability of the US North American Monsoon, both spatially and temporally, using instrumental data and paleoclimatic data from tree-ring widths and stable-carbon isotopes

Objectives:

• Develop a US network of tree-ring partial width tree-ring chronologies

• Use latewood width and δ13C data from tree rings to reconstruct NAM variability

• Investigate NAM characteristics, relationship to winter precipitation, ENSO, and other climate features

• Compare downscaled general circulation model (GCM) simulations with NAM reconstructions to assess variability

• Partner with water resource managers to develop applications of NAM reconstructions for resource management and decision making

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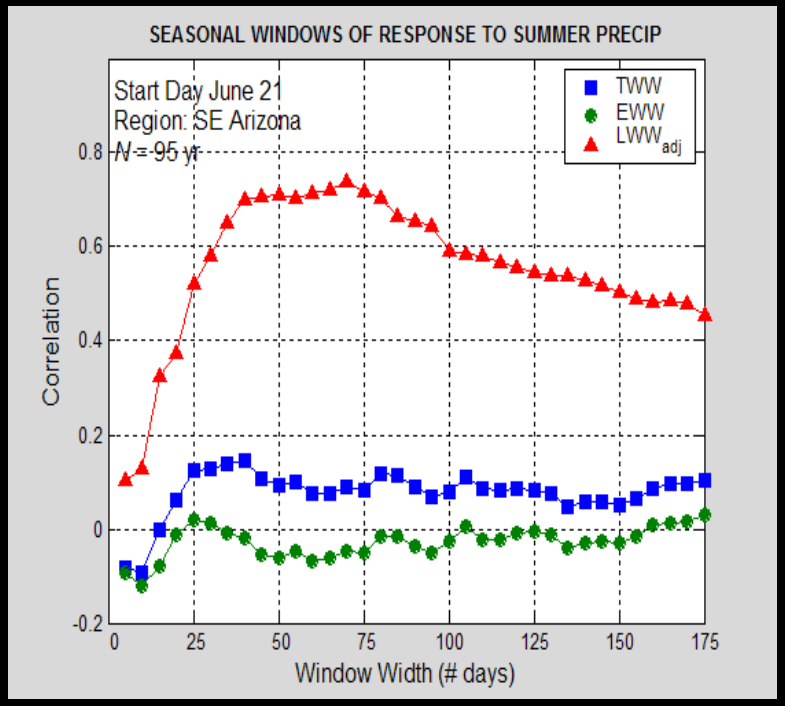
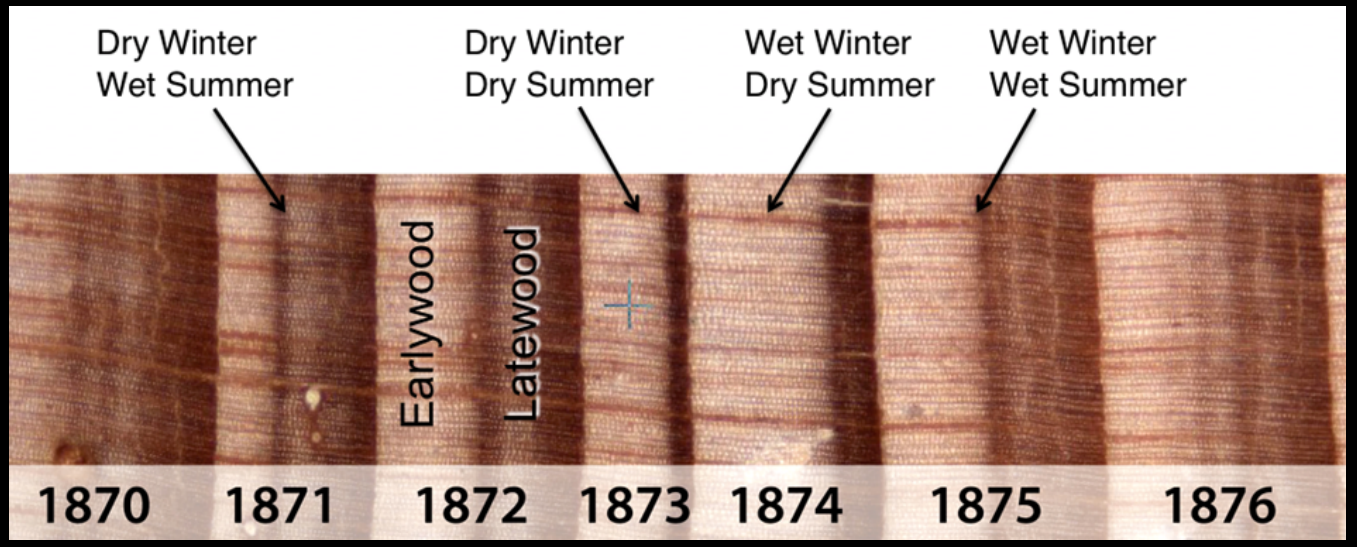
Basis for monsoon reconstructions

- typical approach: measure width of entire annual ring
- annual rings can be divided into earlywood and latewood
- Meko and Baisan (2003) demonstrated latewood formation corresponds to summer precipitation

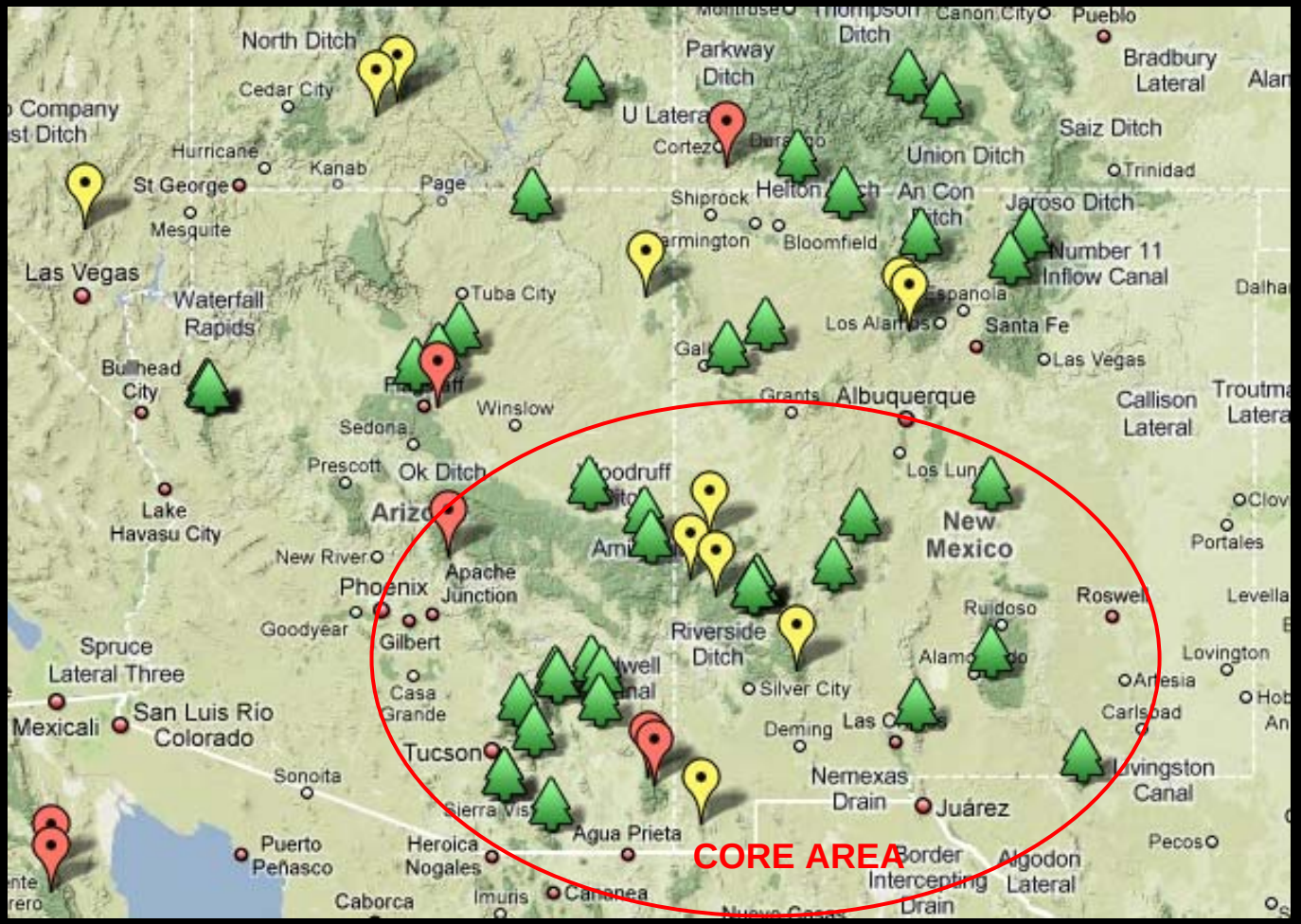




The tree-ring chronology network

Strategy:

- Geographic focus: “core” and “fringe” areas
- Species: ponderosa pine and Douglas-fir
- Rely on existing collections; update and target younger trees



Green= sampled; red = sampling planned; yellow = sampling considered

To date:

- **41 sites have been sampled for ring widths and 3 for carbon isotopes**
- **16 sites have been processed (dated and measured)**
- **4 preliminary sets of chronologies have been generated**

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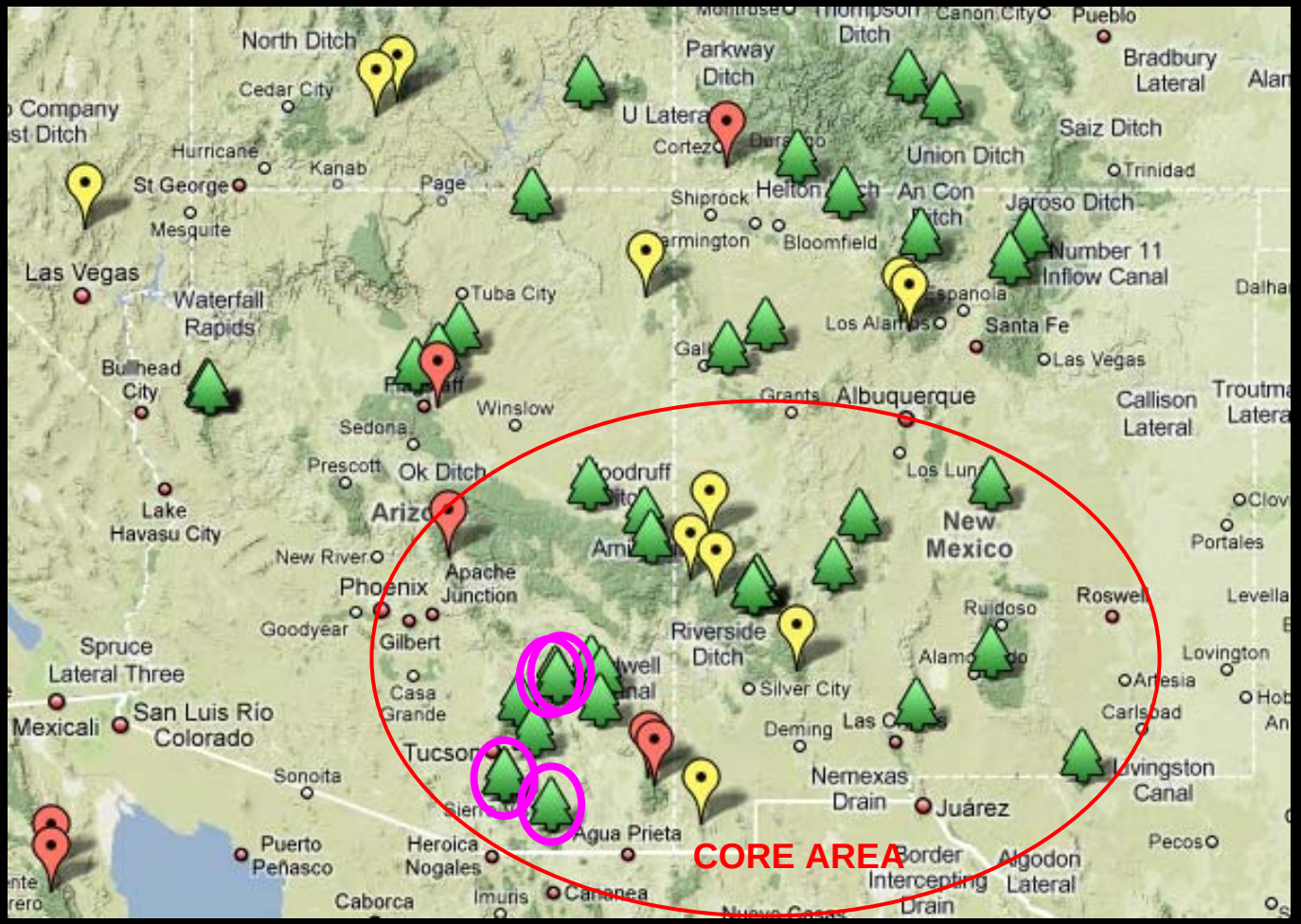

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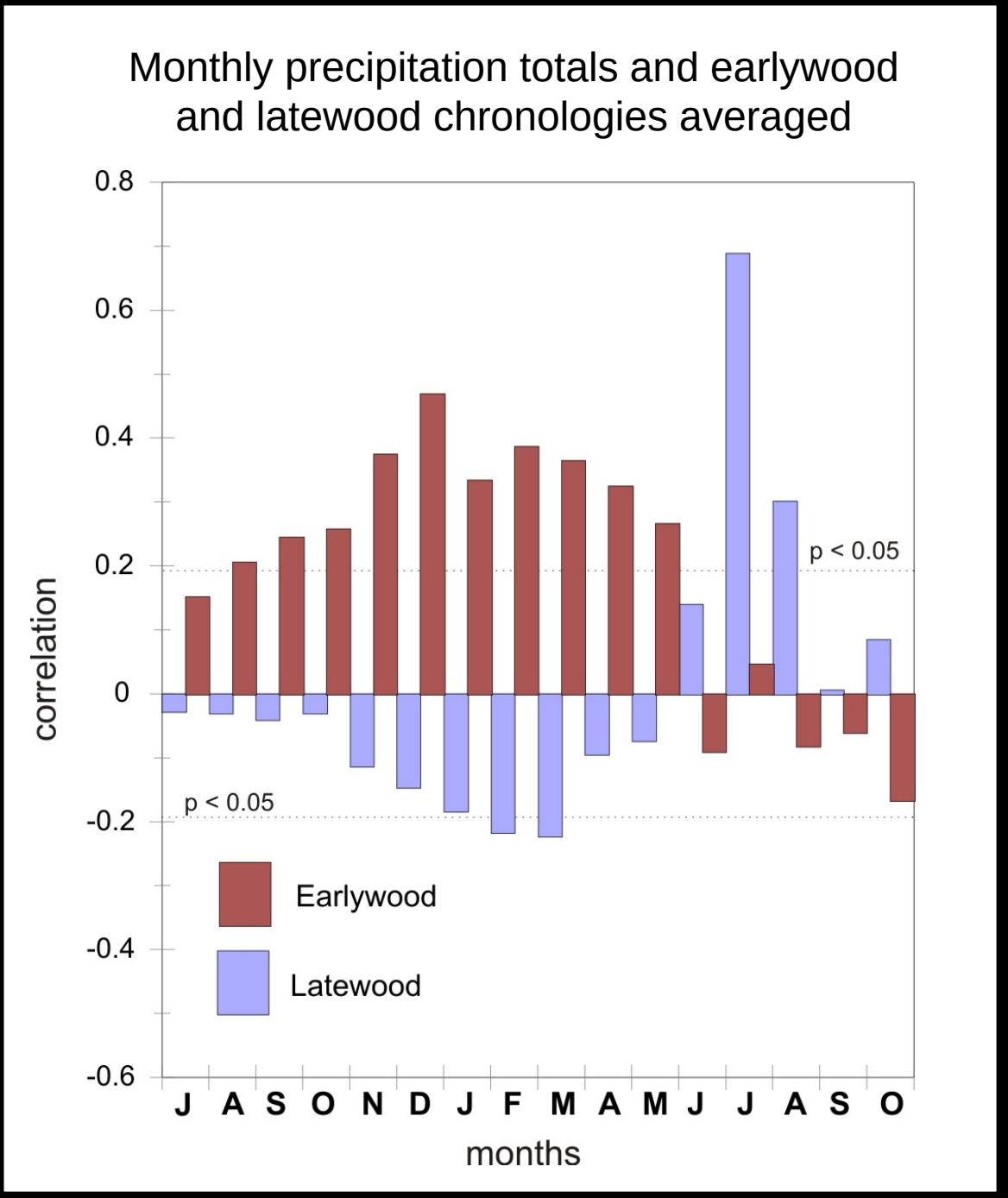
Field and laboratory methods

- Increment borers to collecting cores; ~20 trees per site, 2 cores per tree
- Cores are crossdated to exact calendar years
- Full ring, earlywood and latewood components are measured
- Chronology compilation: see Dan Griffin's poster
- Sampling for isotopic analysis at three of the sites (two species at one site)
- Carbon isotope analysis

Climate information from earlywood and latewood:

- Tree-Ring data: Regional averages for earlywood and latewood chronologies for the 4 sites
- Climate data: monthly precipitation for a region west of Tucson (PRISM), 1895-2008
- Earlywood widths correlate with November-April precipitation
- Latewood widths correlate with July and August precipitation



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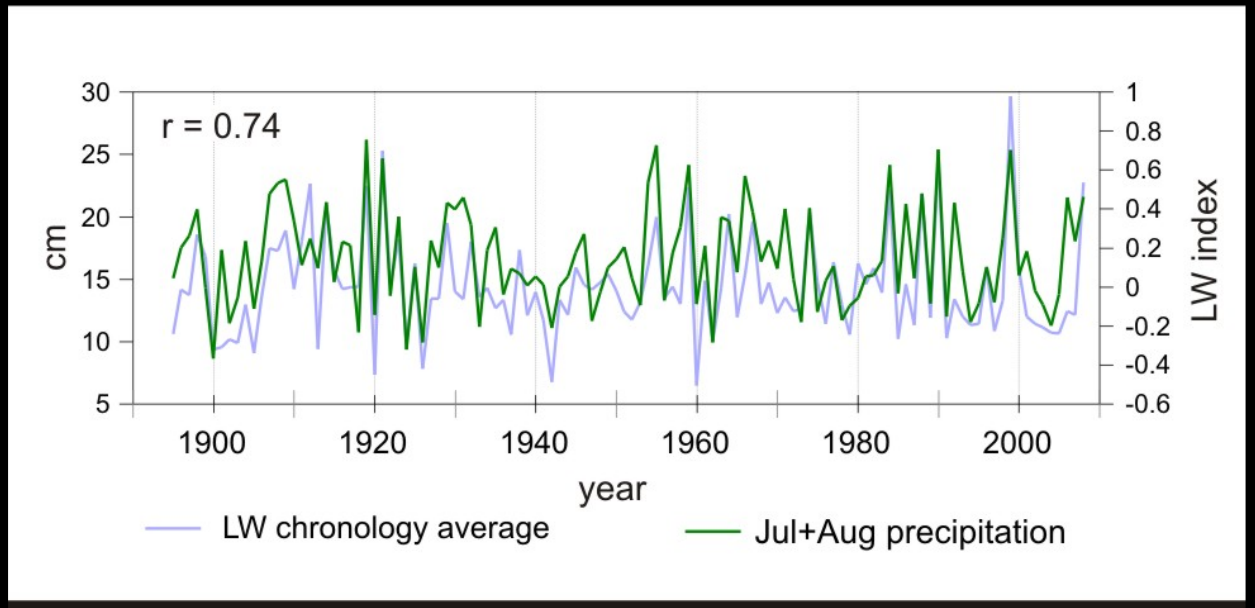
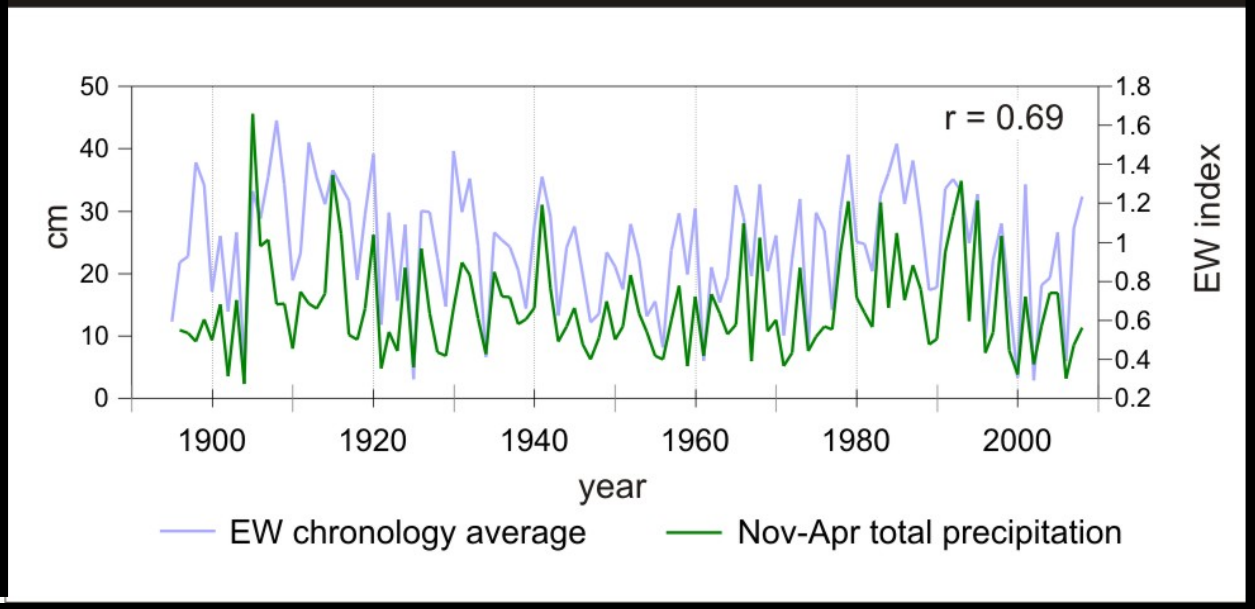
Observed precipitation and regional latewood and earlywood chronology averages





Extracting the monsoon signal: carbon isotopes

Stable-carbon isotope composition of rings should be related to moisture because under dry conditions leaf stomata close down and more ^{13}C gets fixed by tree.

First Isotope Site in Santa Catalina Mts. (Bear Canyon)

- Latewood of each ring separated from two cores of four trees
- Latewood pooled from all trees, except ca. every 20th year when trees were analyzed separately
- Alpha-cellulose component isolated for isotope analysis

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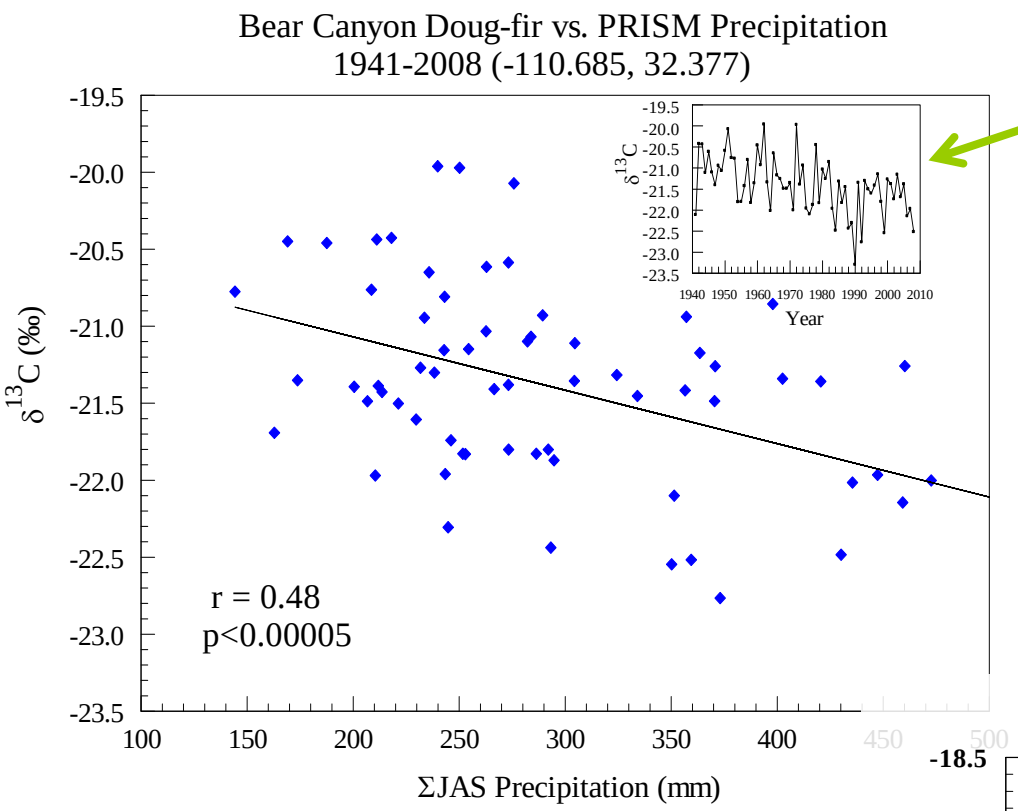
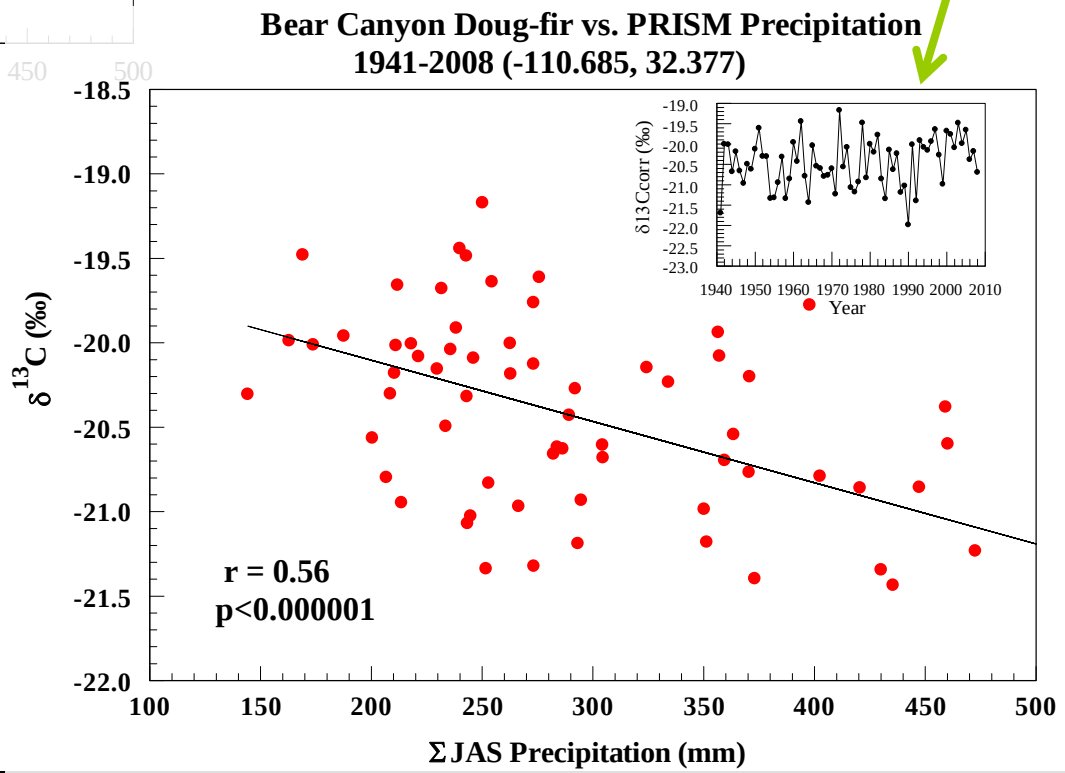


Raw Values

Raw Values Corrected for $\delta^{13}C_{air}$



Tree-ring d^{13}C and Total Jul-Sept precipitation (Bear Canyon PRISM grid point)

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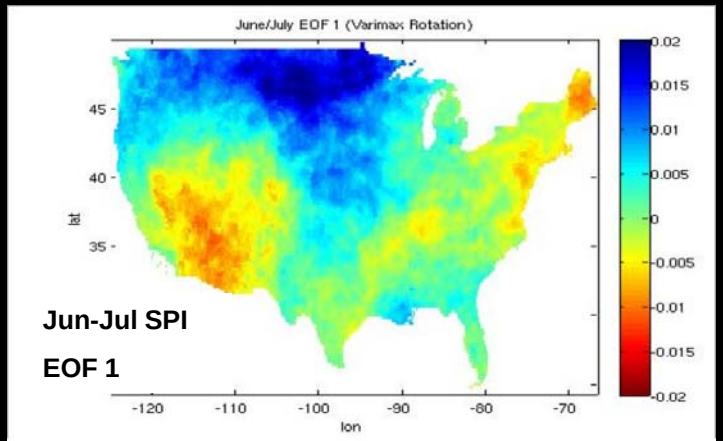
Selecting a monsoon region and variable(s) for reconstruction

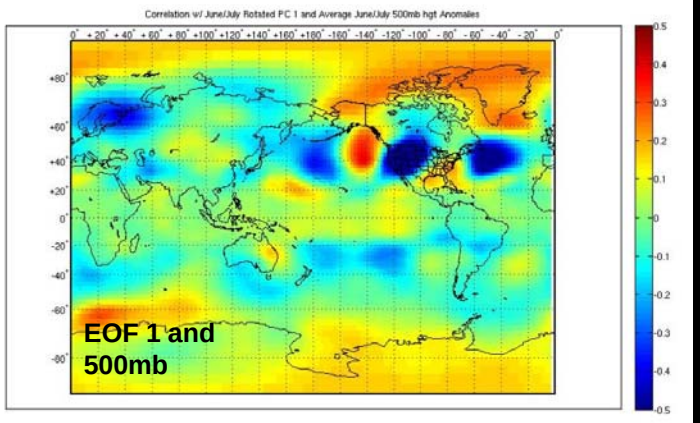
Instrumental data for spatial analysis and calibration:

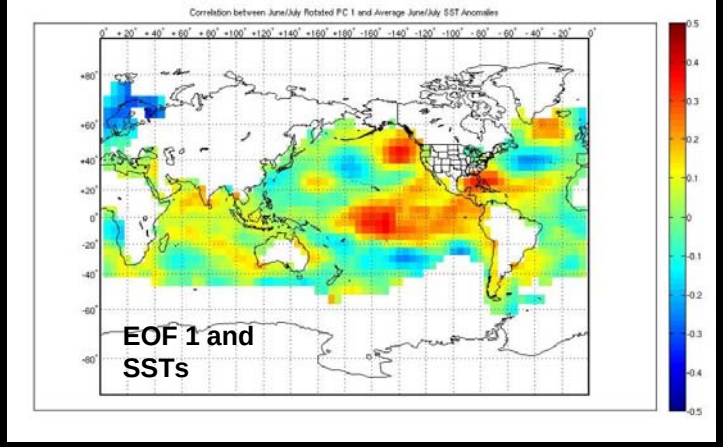
- Standard Precipitation Index (SPI) calculated using PRISM precipitation data
- combinations of 2 and 3 month SPI, June-Sept

Defining the ‘core’ monsoon region: 2 approaches

- spatial analysis of SPI
- spatial analysis of latewood chronology







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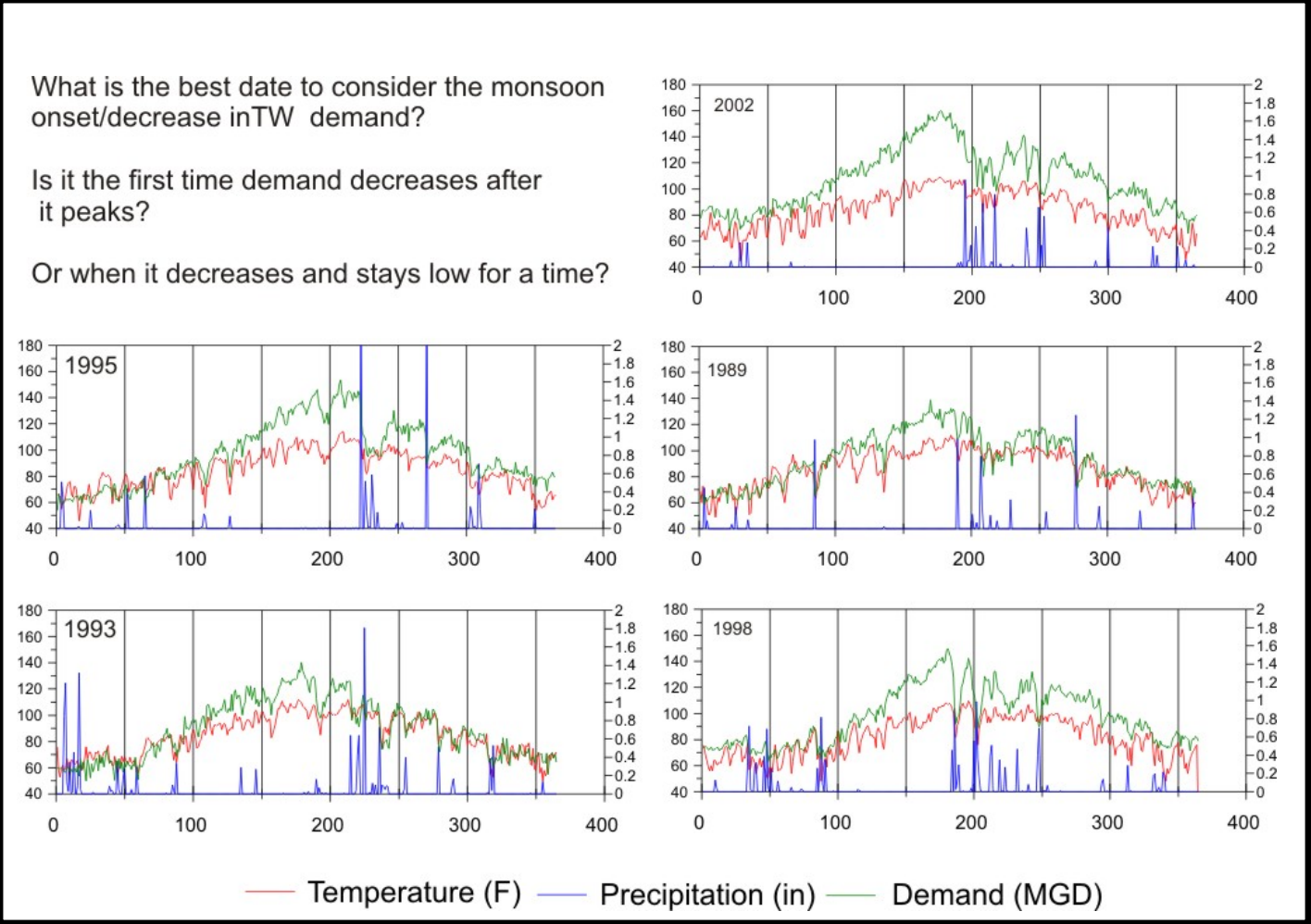
Partnering with regional water managers: Tucson Water

Since monsoon onset closely coincides with decrease in water demand, Tucson Water is interested in the long-term variability of onset timing.

There will be some challenges…



Summary

Accomplished to date:

- Most of field work completed
- Chronology development strategy
- Climate data compilation and initial analysis

Next steps:

- Chronology network development
- Reconstructions for monsoon and winter precipitation
- Treatment of fringe area
- Work with resource managers to determine useful metrics to reconstruct