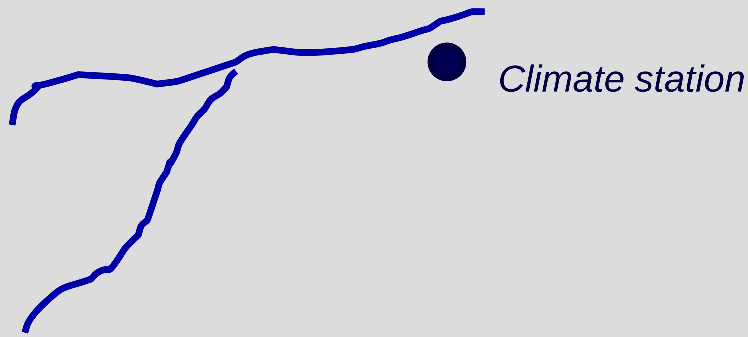
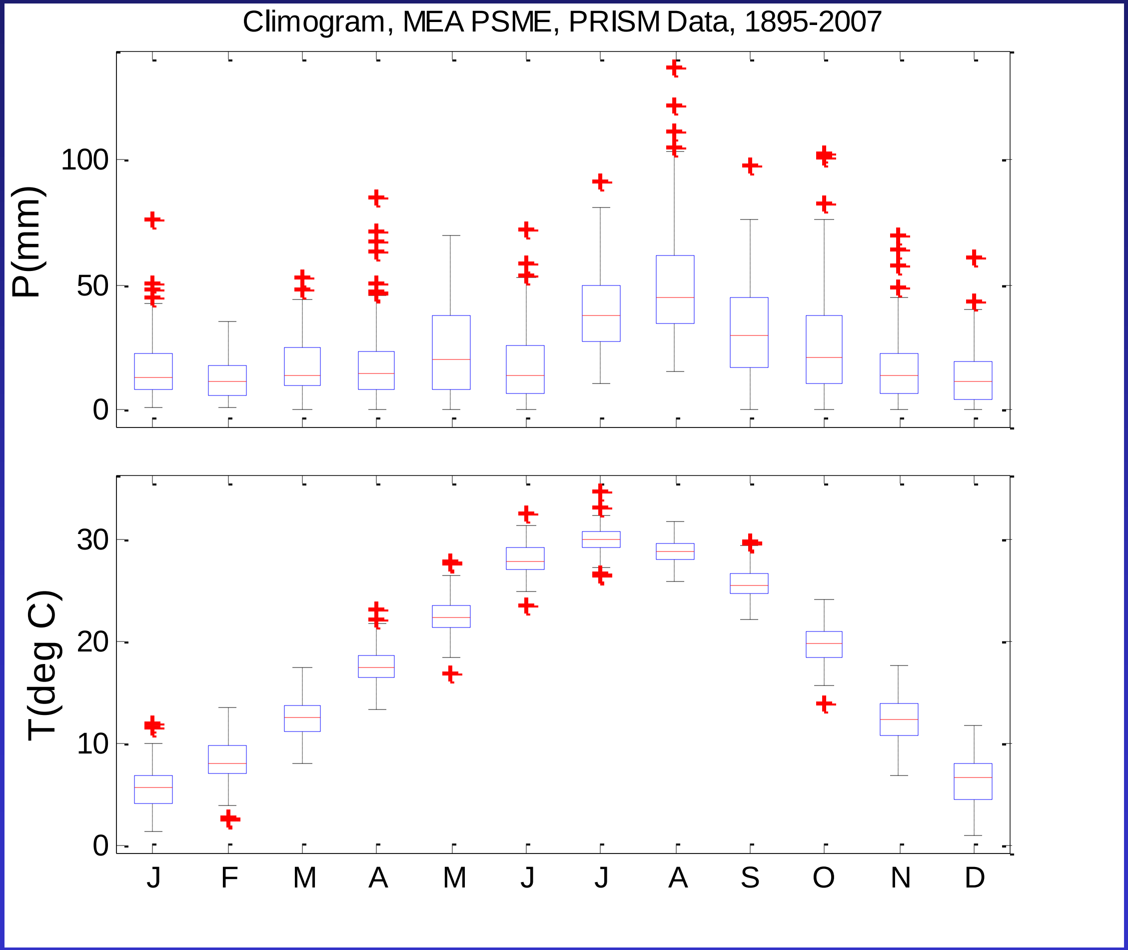
Seasonal Climate Signal

Climate Data



- Data length (n>30 yr), quality, completeness?
- Station climate representative of site climate?
- Use gridded or regional-average climate data instead?

Climatology



- Typical seasonal distribution of precipitation
- Variability of monthly precipitation from year-to-year (boxplot shows middle quatiles)
- Any outliers in the monthly precipitation?

Boxplots:

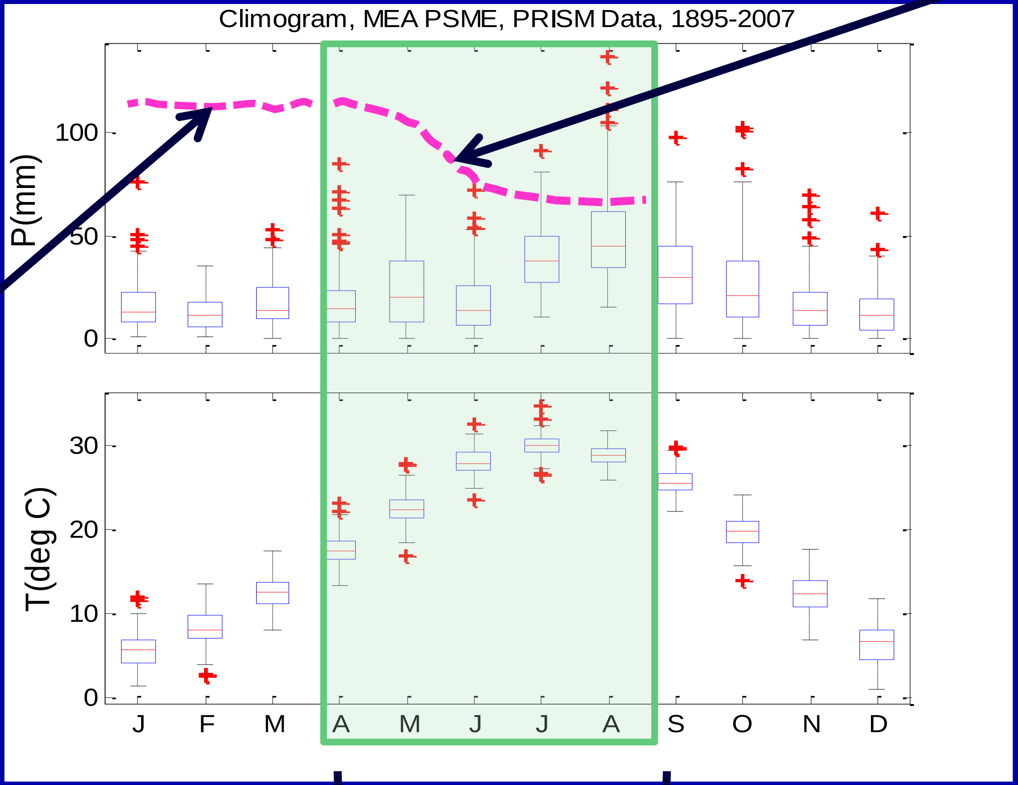
http://en.wikipedia.org/wiki/Box_plot

PRISM:

http://www.prism.oregonstate.edu/products/

Growth Year in Climate Context

Growth sensitivity to climate (unknown function)



Carryover effects (e.g., snowpack, soil-moisture, food storage)

Time window of cambial growth

Alternative approaches to estimating seasonal climate signal.

1. Correlation analysis
2. Response-function analysis

Correlation Analysis -- steps

- y_t = tree-ring index in year t
- $x_{t,i}$ $i=1,\ldots m$ = precipitation and temperature for m months or seasons leading up specified month of expected end of cambial growth
- Compute Pearson r between y_t and each of the x_i and plot result as bar chart of correlations and significance
- Significance level either theoretical or based on Monte Carlo simulations or bootstrapping

Correlation Analysis -implementation

- Spreadsheet (e.g., Excel, Minitab)
- Programming languages (e.g., Matlab, R)
- Specific application software: Precon, Dendroclim2002, Seascorr

Will now show correlation analysis with seascorr

Seascorr

1. A Matlab program: published in Computers and Geosciences
2. Correlation analysis: uses correlations and partial correlations
3. What is the “best” season for reconstruction of some specified climate variable?
4. Graphics windows deal with signal strength, autocorrelation, trend, temporal stability of signal
5. Required input data: a tree-ring chronology and monthly time series of a primary (e.g., precipitation) and secondary (e.g., temperature) climatic variables.

Seascorr Example

- Application to *Populus deltoides* climate signal in collection of trees from North Dakota

- Next slides from presentation of seascorr at 2012 meeting of American Association of Geographers (AAG) in New York City, February, 2012

Deciphering the Seasonal Climate Signal in Tree Rings

David Meko, Ramzi Touchan, Jonathan Friedman, Jesse Edmondson, Julian Scott, and Ellie Griffin

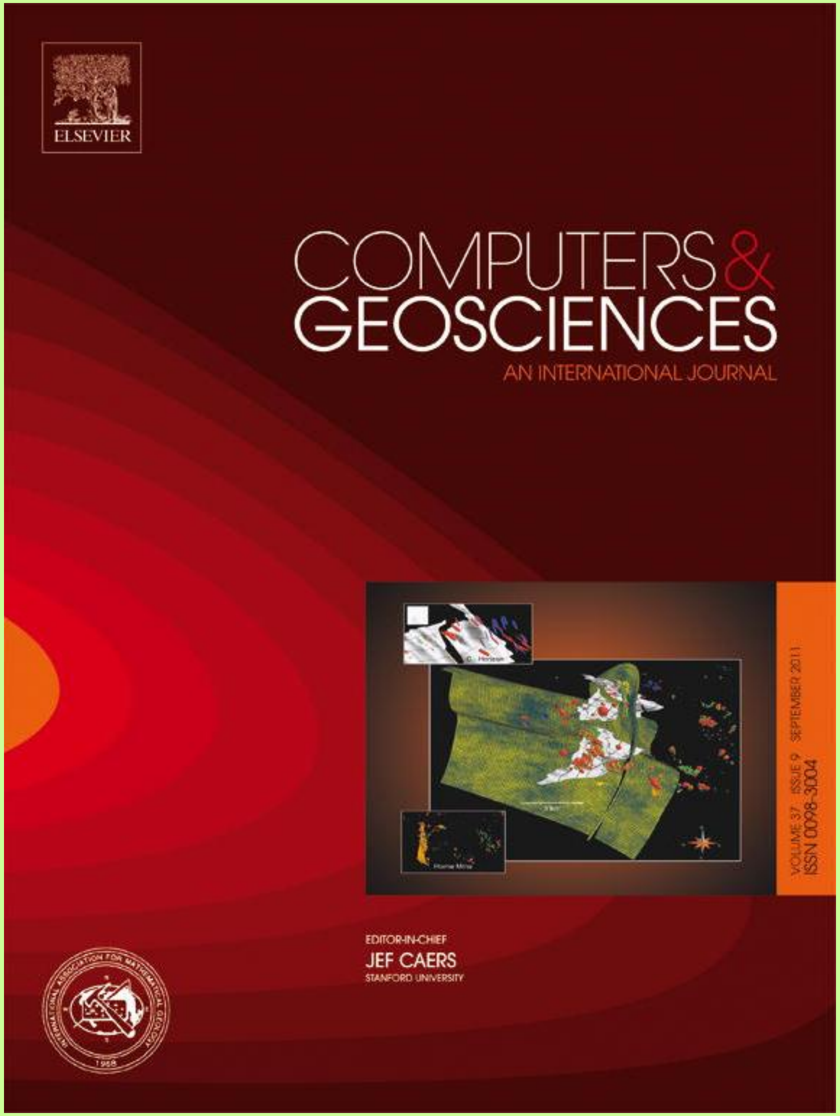
Research sponsored by U.S. Geological Survey

AAG Annual Meeting, New York City, Feb. 23-28, 2012

Considerations

1. Temporal integration
2. Covariation of climate variables
3. Linearity of relationship
4. Stability of relationship

Seascorr

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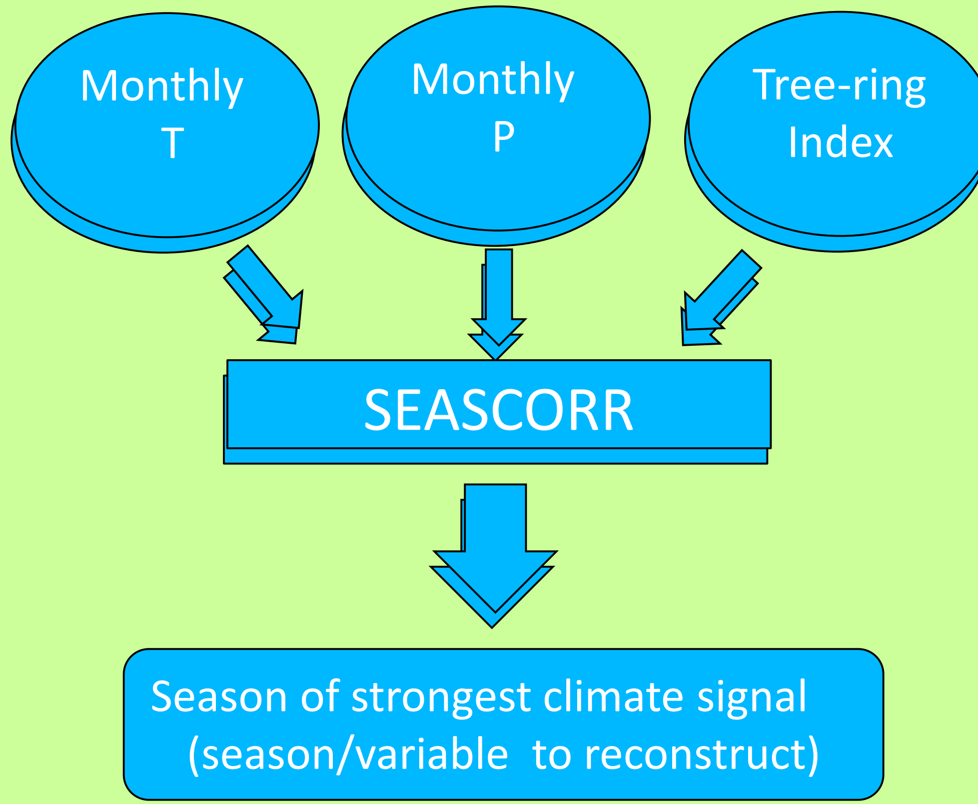
Seascorr: A MATLAB program for identifying the seasonal climate signal in an annual tree-ring time series ☆

D.M. Meko [a,*], R. Touchan [a], K.J. Anchukaitis [b]

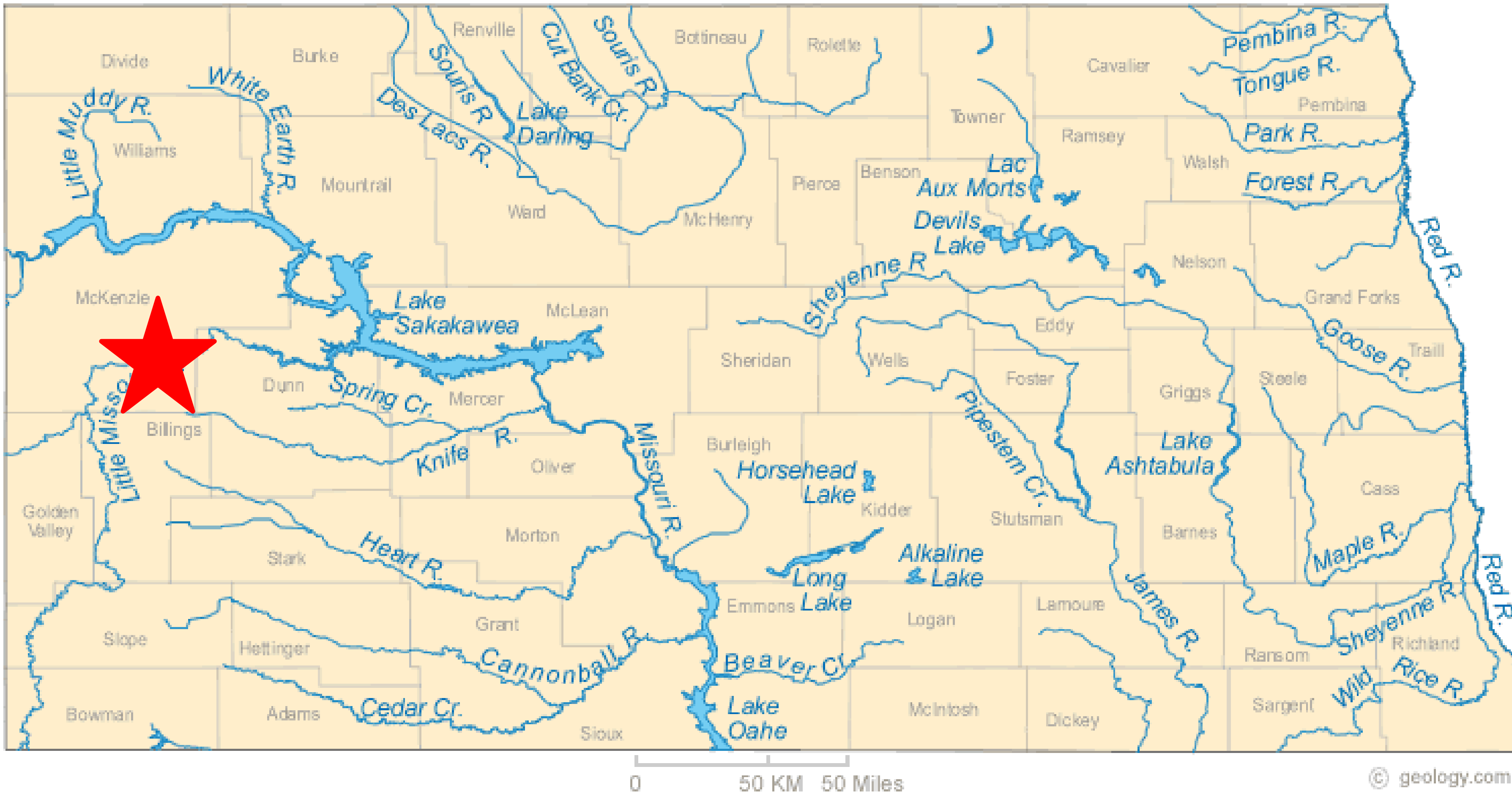
[a] Laboratory of Tree-Ring Research, 105 W Stadium, University of Arizona, Tucson, AZ 85721, USA
[b] Tree Ring Laboratory, Lamont Doherty Earth Observatory of Columbia University, 61 Route 9W, Palisades, NY 10964, USA



http://www.sciencedirect.com/science/article/pii/S009830041100104X

SAMPLE DATA

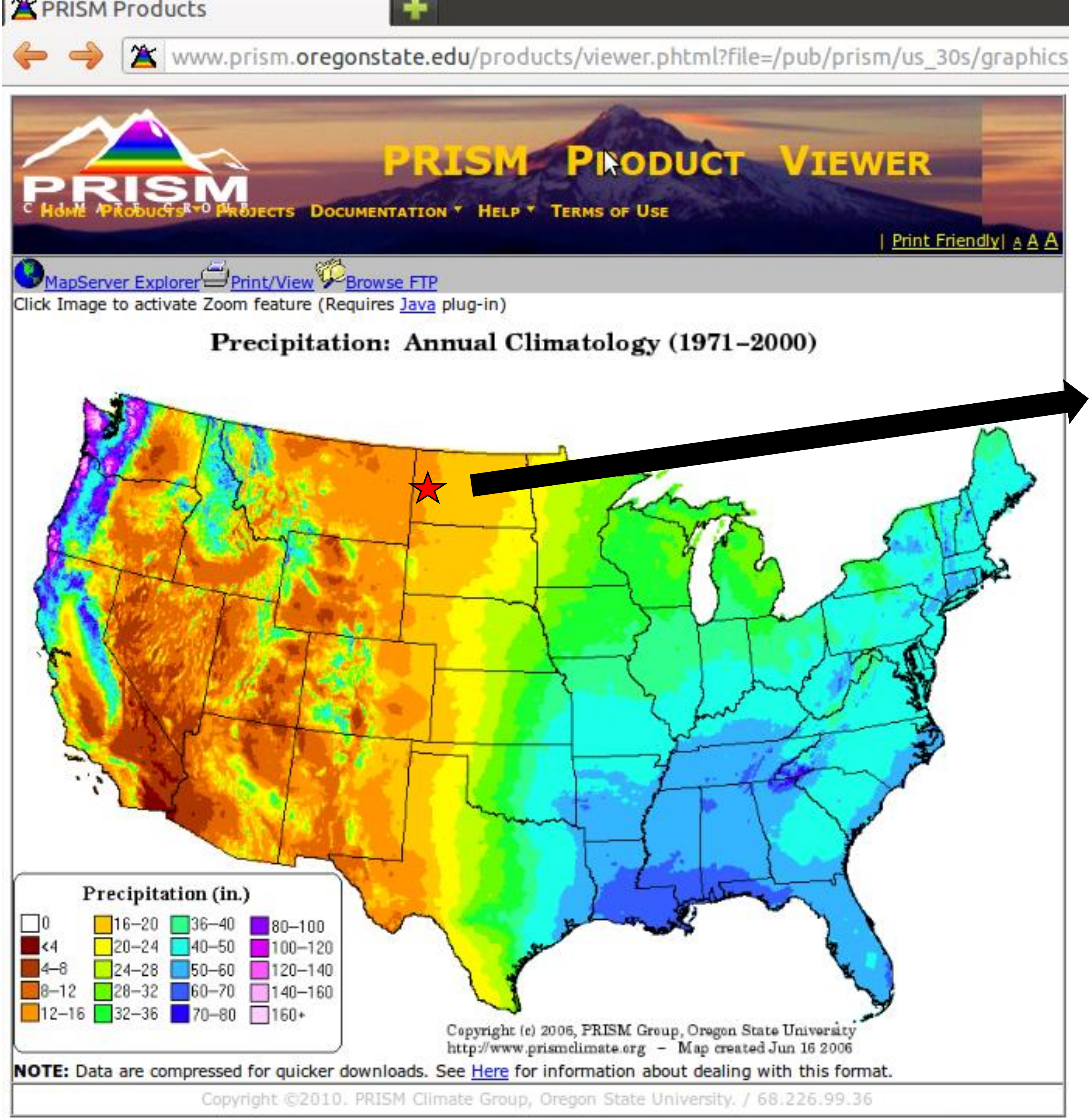
Cottonwood along Little Missouri River



Populus deltoides, subsp. monilifera


Residual chronology
195 trees
1643-2010


BUFFALO
ARE DANGEROUS
VIEW FROM A DISTANCE



Time series, 1895-2010

1) P
2) Tmax

APPLICATION

Seascorr

P.txt

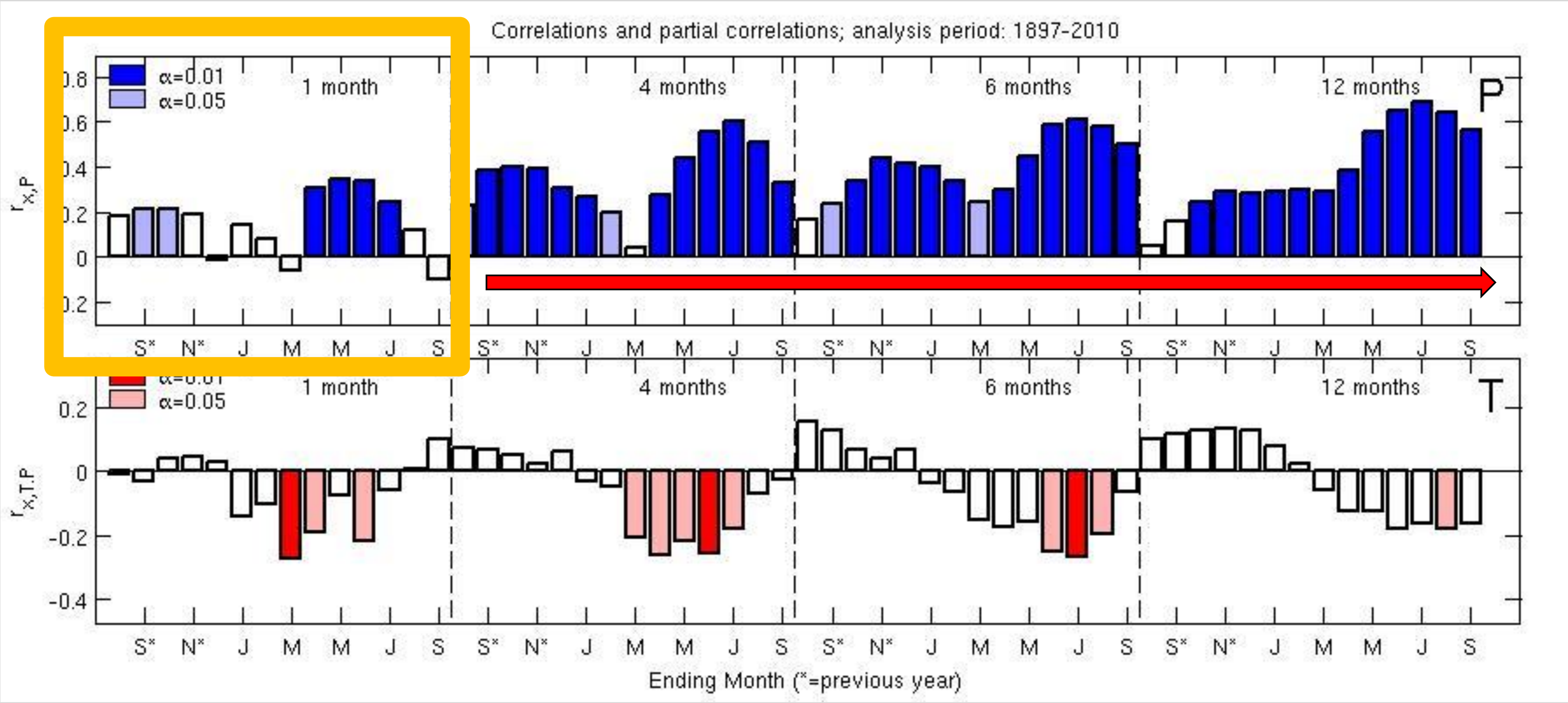
T.txt

Tree.crn

1. Point and click on files
2. Respond to menu prompts on season groupings
3. Get 1) correlation graphics window
   2) 10 supporting windows
   3) output statistics

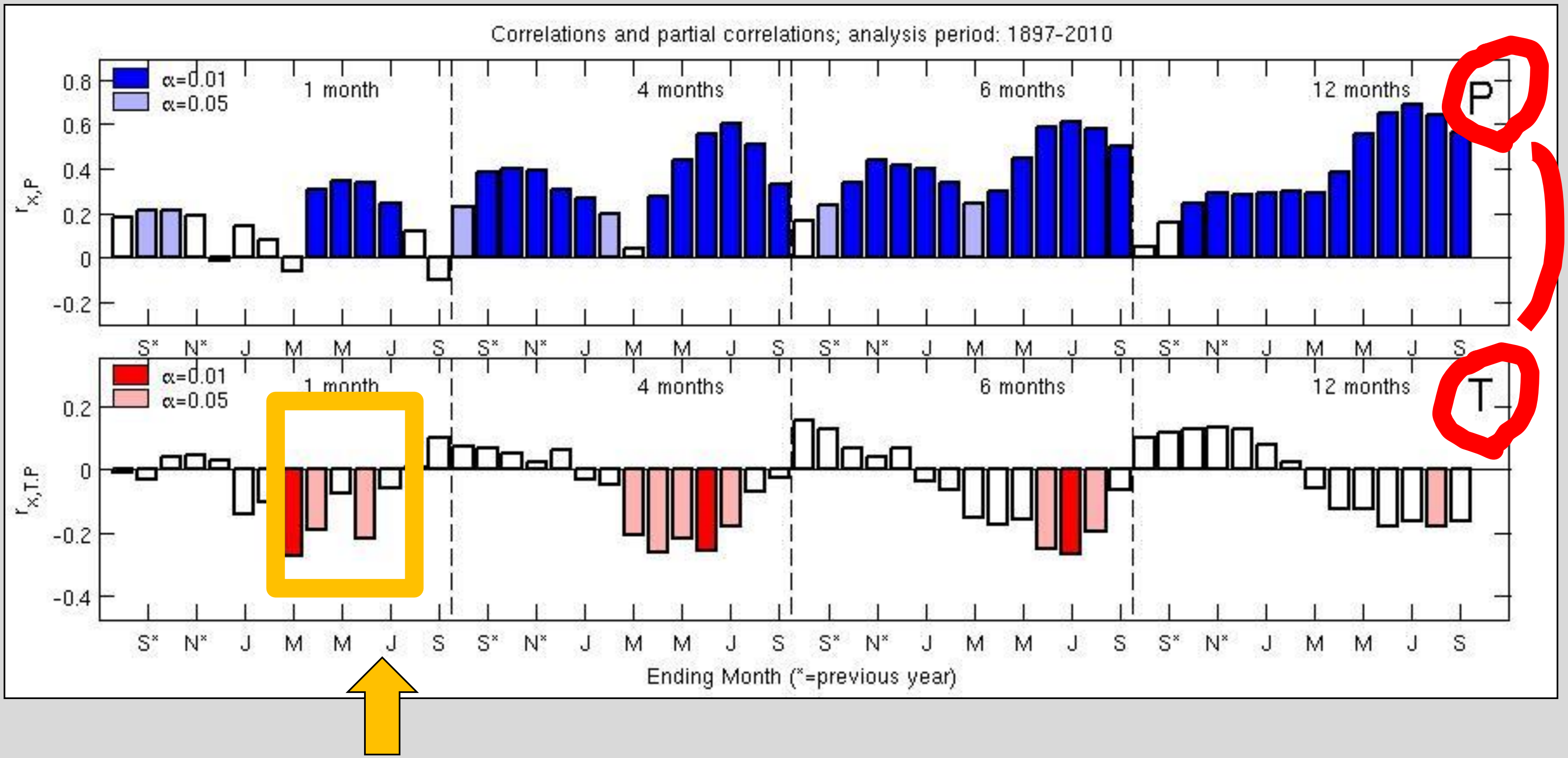
Correlations (Window 1)

1. Temporal Integration



Correlations (Window 1)

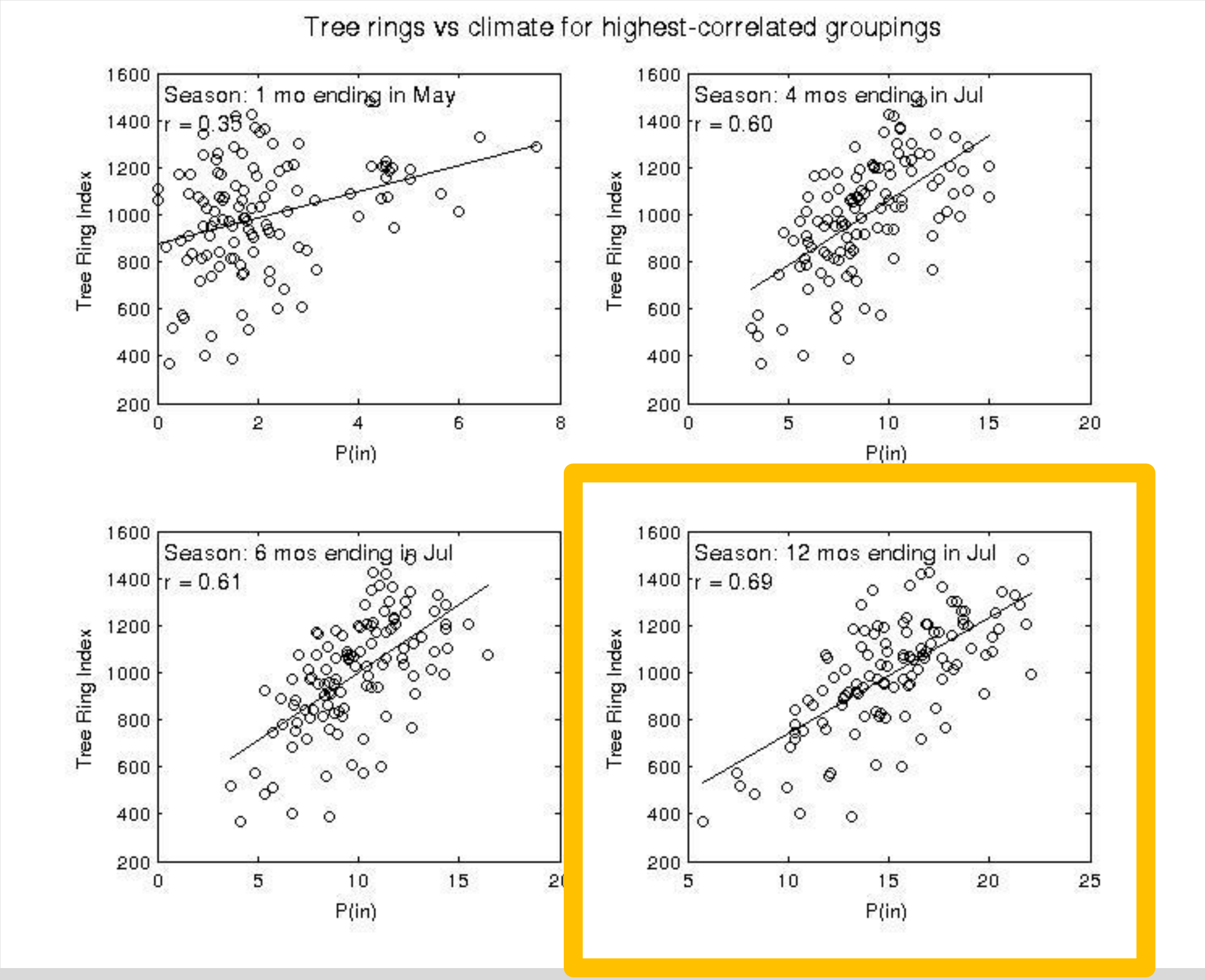
2. Covariation of climate variables



Secondary climate variabile (T) relationship summarized by *partial* correlations

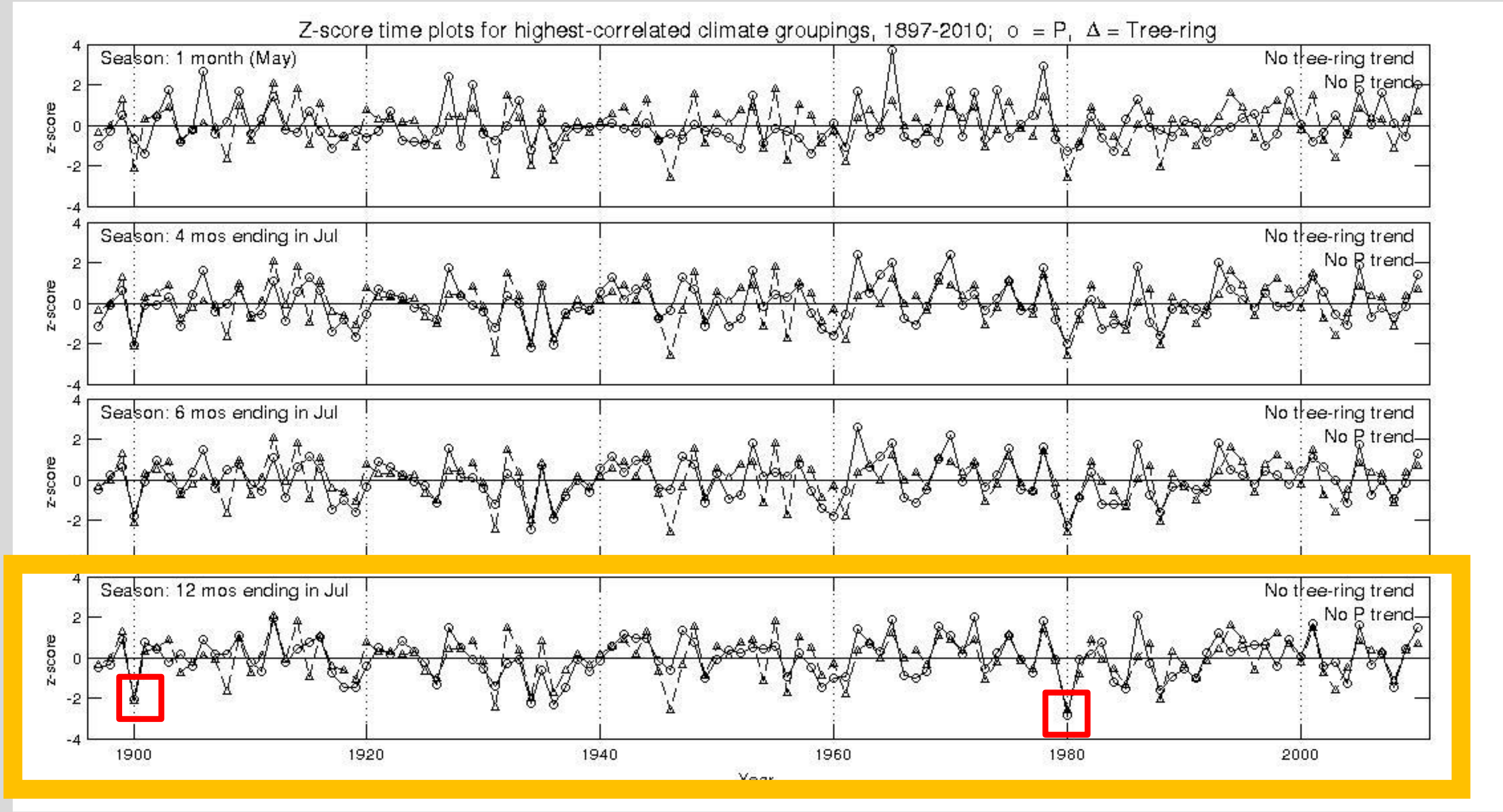
Scatterplots (Window 8)

3. Linearity



Time plots (Window 9)

2. Stability – graphical look



Difference-of-correlation test (Window 11)

4. Stability (statistical test)

TEMPORAL STABILITY OF CORRELATION FROM EARLY TO LATE SUB-PERIOD

Full = 1897-2010, Early = 1897-1953, Late = 1954-2010

Season[a]		Correlation[b]			Sample Size[c]		Test Results[d]	
Months	length	Full	Early	Late	N_1	N_2	ΔZ	p
May	1	0.35	0.40	0.31	57	57	0.1013	0.599
Apr-Jul	4	0.60	0.63	0.58	57	57	0.0752	0.696
Feb-Jul	6	0.61	0.64	0.59	57	57	0.0673	0.727
Aug*-Jul	12	0.69	0.68	0.70	57	57	-0.0493	0.798

[a]Season: start & end months and number of months in season; asterisk denotes year preceding tree-ring year.

[b]Correlation: Pearson correlation of tree-ring index with primary climate variable for full-period, early-period, and late-period.

[c]Sample Size: N_1 and N_2 are the effective sample sizes for the correlations computed on early and late sub-periods, respectively. Effective sample size is fewer than the number of observations if both time series have positive lag-1 autocorrelation. Autocorrelations for the assessment computed on the full analysis period. Sample-size adjustment after Dawdy and Matalas (1964).

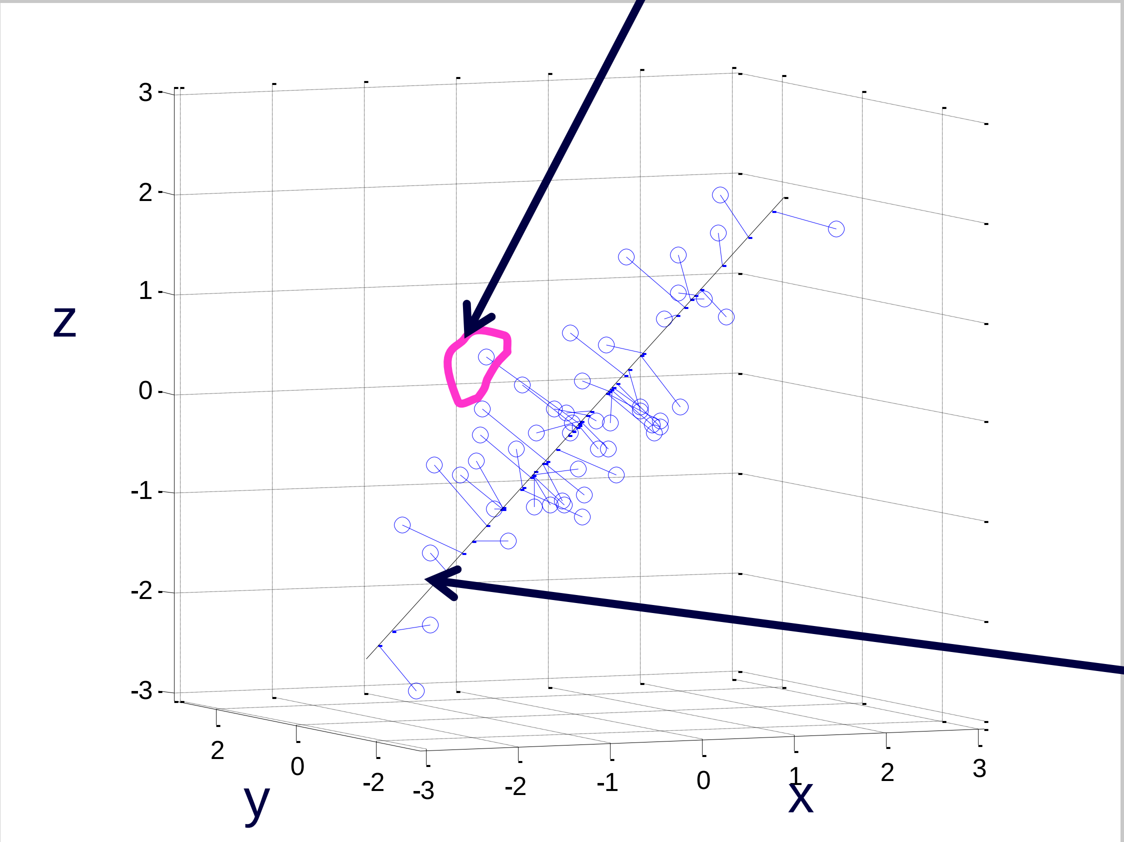
[d]Test Results: The test statistic (ΔZ) is the difference between transformed correlations for the early and late periods, following Panofsky and Brier (1968) and Snedecor and Cochran (1989). The last column is the p-value for a test of the null hypothesis that the population sample correlations for the early and late period are the same. A significant difference in sub-period correlations is indicated by a small p (e.g., $p<0.05$).

Response-Function Analysis -- steps

- y_t = tree-ring index in year t
- ${}_{m}C_{m}$: principal components (PCs) of m monthly or seasonal climate variables; each PC is a linear combination of the original climate variables; some $n<m$ of these effectively summarize the climate data
- Regress y_t on columns of matrix of V, where V is the matrix of "scores" or time coefficients of the n PCs
- Back-transform the regression weights into weights on the original monthly or seasonal climate variables
- Plot the weights and their significance

What is a principal component?

An observation in x,y,z space



- In climate reconstruction, {x,y,z} might be tree-ring index at three different sites
- In response function analysis, {x,y,z} might be three different climate variables (e.g., Precip in fall, winter and spring)

Draw a line such that the perpendicular distances from points to the line are lowest

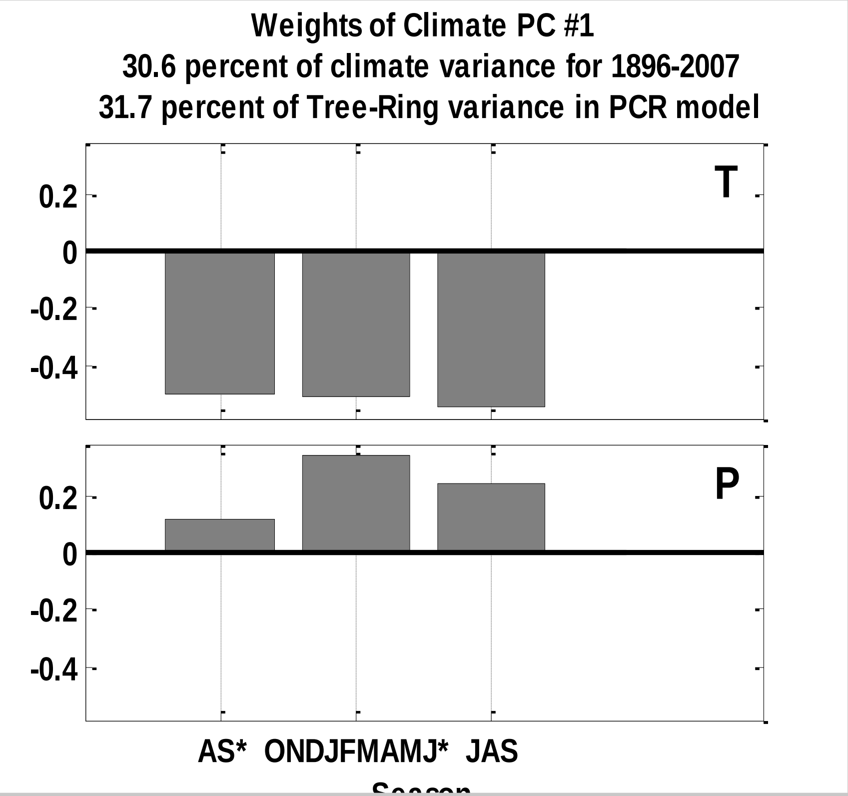
Rotate the axes so that one axis aligns with this line and that axis describes the first principal component

Response Function—Example

(Tree-ring chronology from New Mexico, USA ;

PRISM Explorer seasonal precipitation (P) and max temperature (T)

What does the first principal component (PC1) of seasonal climate variables represent?

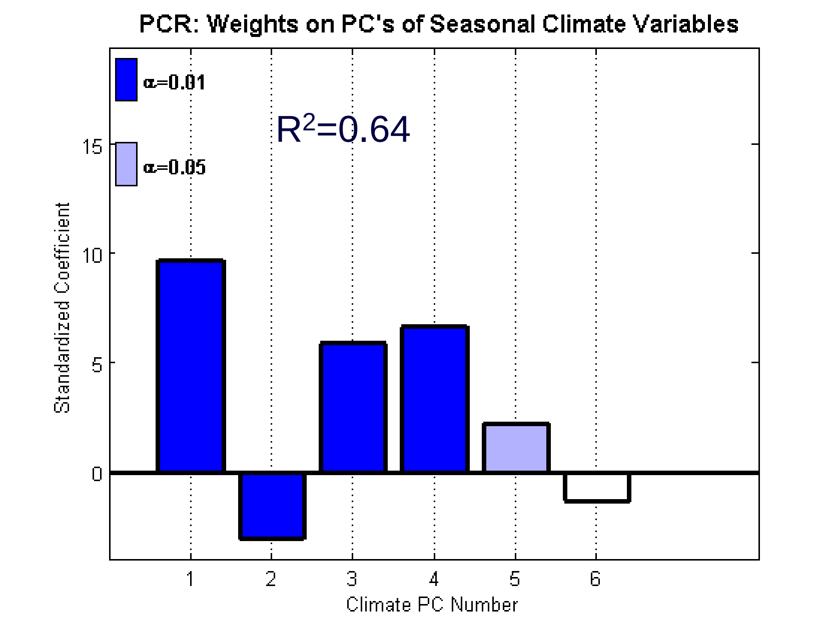


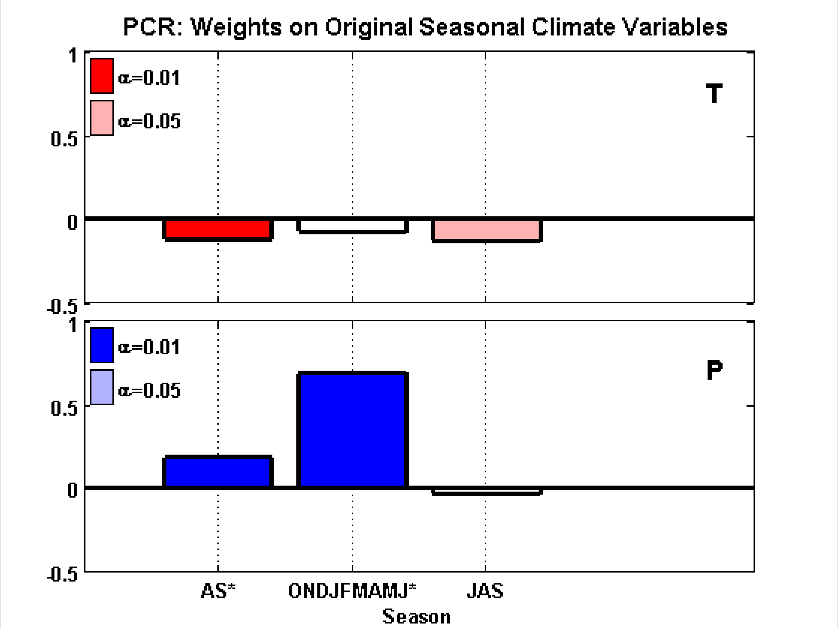
Season

- The weights describe a linear combination of the 6 seasonal climate variables
- The linear combination is a “transformed” climate variable
- Positive weights on P, negative on T: when the transformed variable is large positive, conditions are wet and cool in all seasons
- Response function analysis is based on a regression of the tree-ring index on this and the other transformed climate variables (higher-order PCs)

Response Function—Example, continued

(Tree-ring chronology from New Mexico, USA ; PRISM Explorer monthly P and maximum monthly T)





- Like the correlation analysis, indicates a cool-season drought signal
- Main difference for this example in the results of response function vs correlation is that the original climate variables (precipitation and temperature) have been transformed into linear combinations that take into consideration the covariation of temperature with precipitation
- Some researchers prefer correlation analysis over response function analysis and follow the 11th Commandment: “Thou Shalt Prefer Simple over Complex”

Response Function Analysis Implementation

- Spreadsheet (possible, but headache likely)
- Programming languages (e.g., Matlab, R)
- Specific application software: Precon, Dendroclim2002, DPL-R*

*functions for performing tree-ring analyses, IO, and graphics.

URL http://www.wwu.edu/huxley/treering/dplR.shtml,

http://R-Forge.R-project.org/projects/dplr/