Paleoclimate analysis for Northern New Mexico from tree rings

Dendroclimatology Class

Summer Tree Ring School, Laboratory of Tree Ring Research, University of Arizona,

May, 18 – June, 5 2009

Outline

1. Objectives
2. Site description
3. Methods, results, discussions:

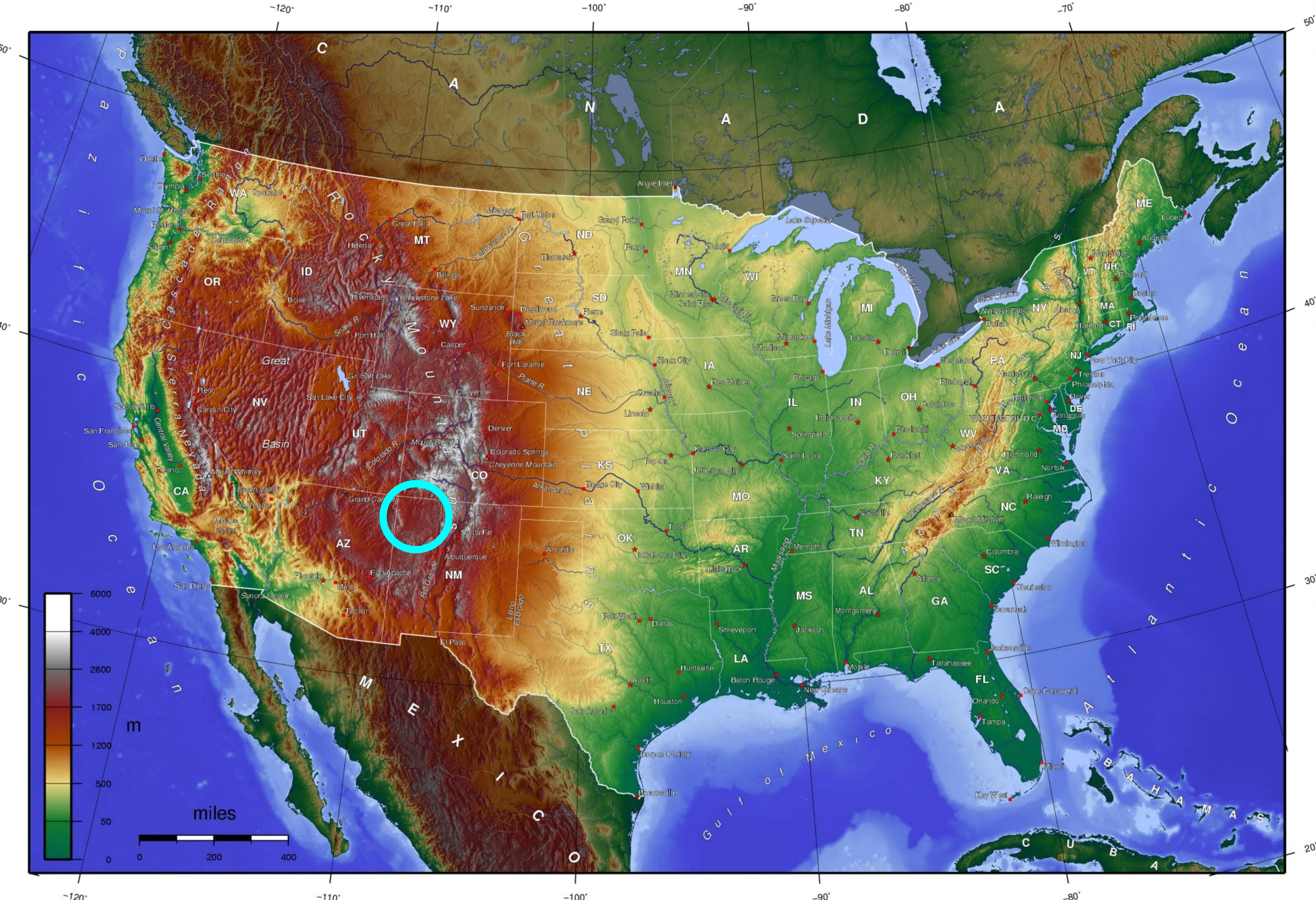
- Group 1: Reconstruction of climate conditions using PCI of individual site chronologies
- Group 2: Reconstruction of PDSI using individual site chronologies
- Group 3: Reconstruction of climate conditions using regional chronology

4. Conclusions

General Objectives

- Extend existing tree-ring chronologies for Northern New Mexico (Jemez Mts)
- Reconstruct climate conditions
- Analyze reconstructed climate conditions for extreme events, fire, atmospheric circulation patterns etc

Research area: New Mexico, USA

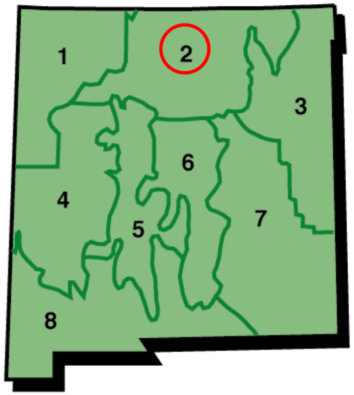


Research area: New Mexico, USA

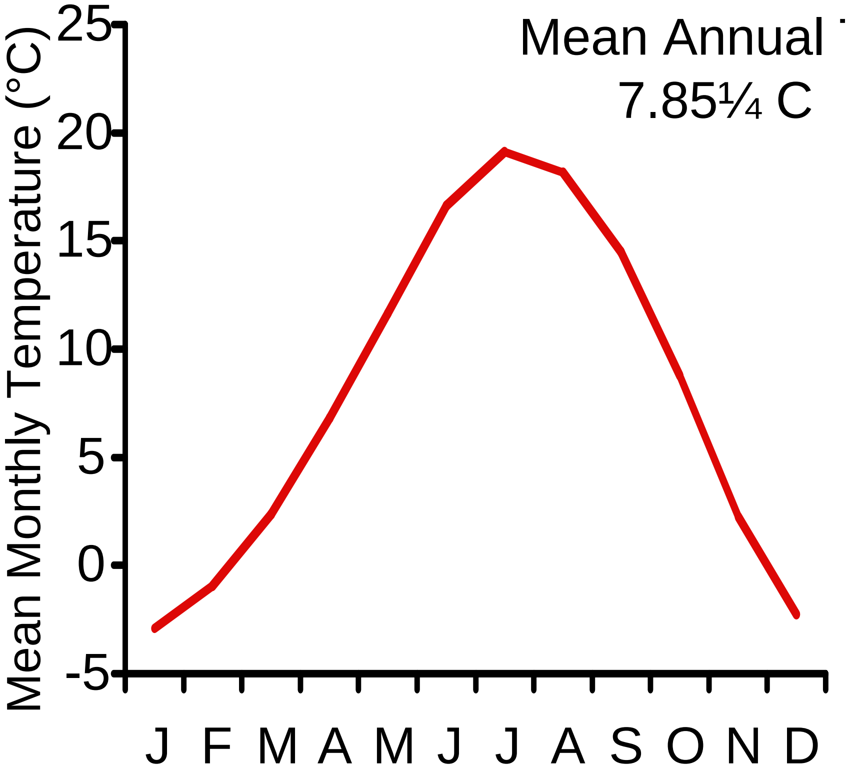
Table 1. Site information for northern New Mexico

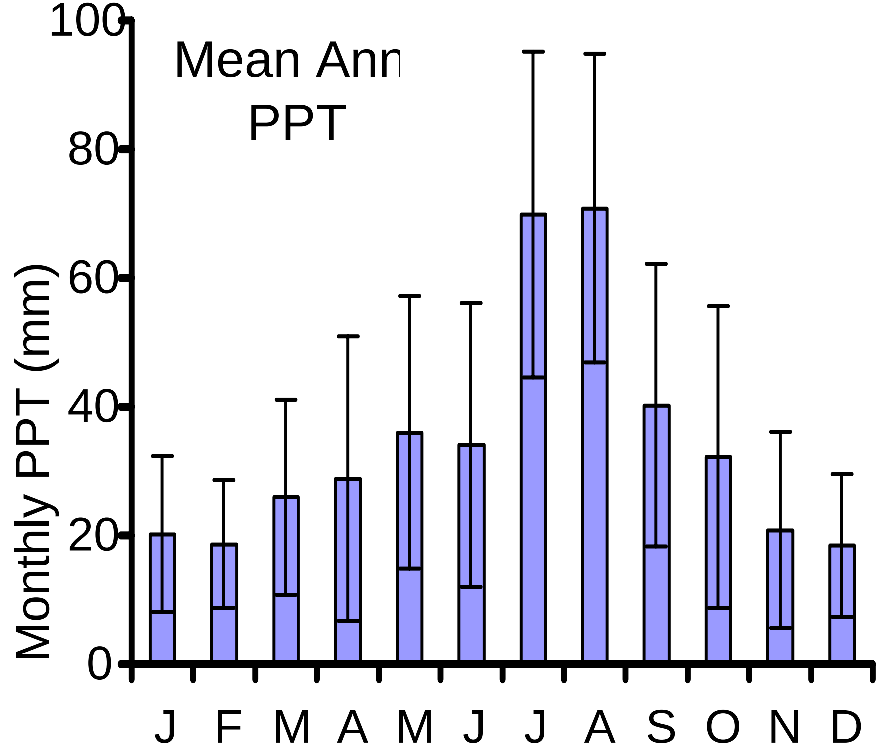
Site Name	Site Code	Species	Elevation (m)	Latitude	Longitude	Time Span	No. of trees	No. of Radii	Source
Echo Amphitheater	EAU	PSME[1]	2059	36°21'N	106°31'W	1295-2007	18	19	RT et al[5]
Mesa Alta	MEA	PIST[2]-PSME	2,525	36° 17'N	106° 37'W	644-2007	47	82	RT et al[5]
Alta Mesa	AMPN	PIED[3]	2438	36°16'	106° 37'W	1534-2005	19	22	RT & MS[6]
Bear Canyon Middle	BCM	PIST	2,597	35° 55'N	106° 40'W	1568-2007	24	45	RT et al[5]
Bear Canyon West	BCW	PIST-PSME	2561	35° 55'N	106° 41'W	1298-2007	30	56	RT et al[5]
Fenton Lake	FEN	PIPO[4]	2,529	35° 53'N	106° 41'W	1304-2007	37	66	RT et al[5]/TWS-TC[7]
Upper Los Alamos	ULA	*Pinus ponderosa*	2231	35° 52'N	106° 37'W	1659-2005	21	27	RT & MS[6]
Paliza campground	PCG	*Pinus edulis*	2,057	35°42'N	106°38'W	1645-2005	31	52	RT & MS[6]

[1]PSME= *Pseudotsuga menziesii*
[2]PIST= *Pinus strobiformis*
[3]PIED=*Pinus edulis*
[4]PIPO=*Pinus ponderosa*
[5]RT et al=Ramzi Touchan, David Meko, Connie Woodhouse
[6]Ron Towner and Mathew Salzer
[7]TWS-TC=Thomas W. Swetnam & Tony Caprio



Regional Annual Temperature and Precipitation Data



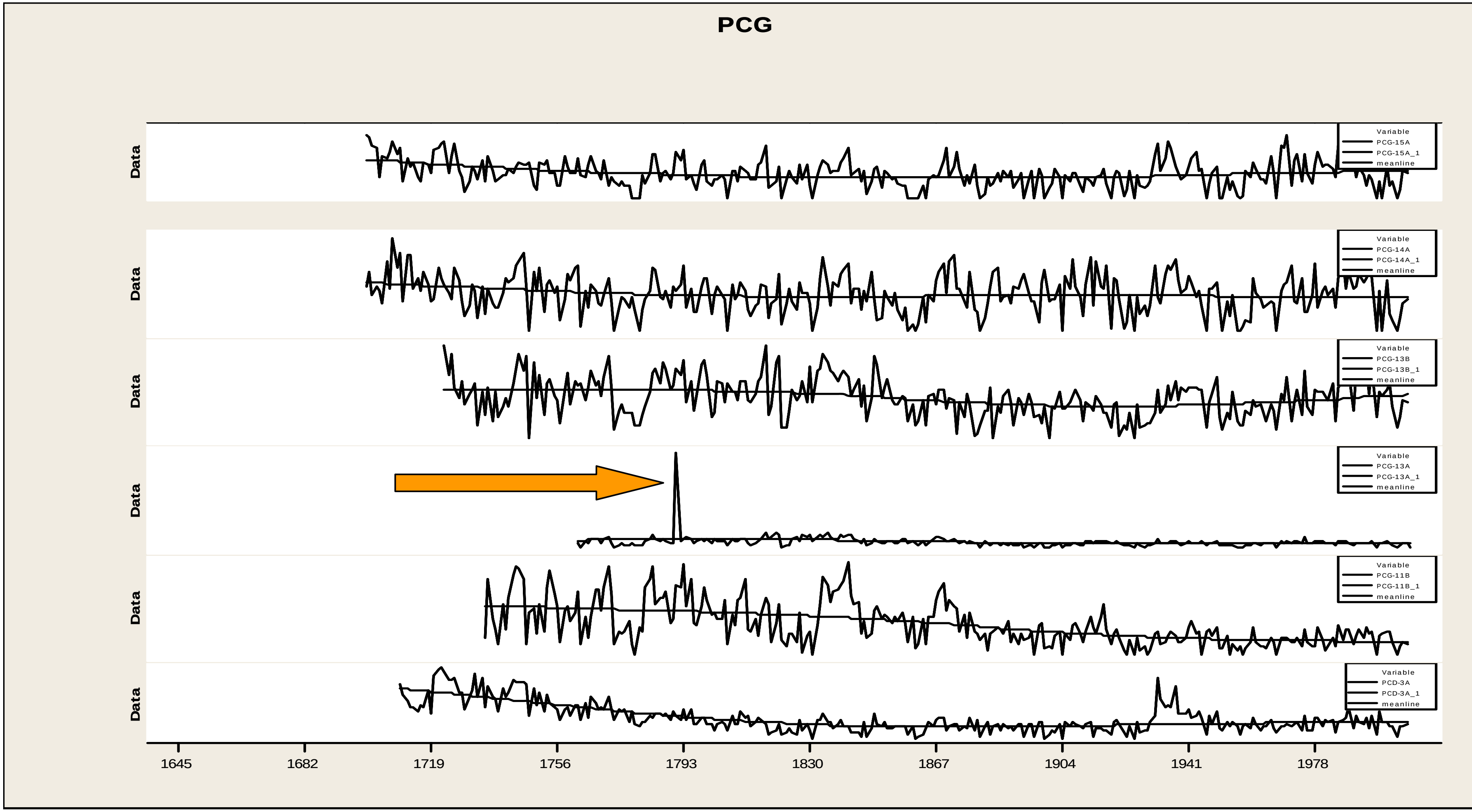


Group 1

Oct-June PCA Precipitation Reconstruction for Northern New Mexico (NM2)

Alana Belcon, Anna Coppola,
Ellis Margolis, Liz Palchak

Standardization and Detrending

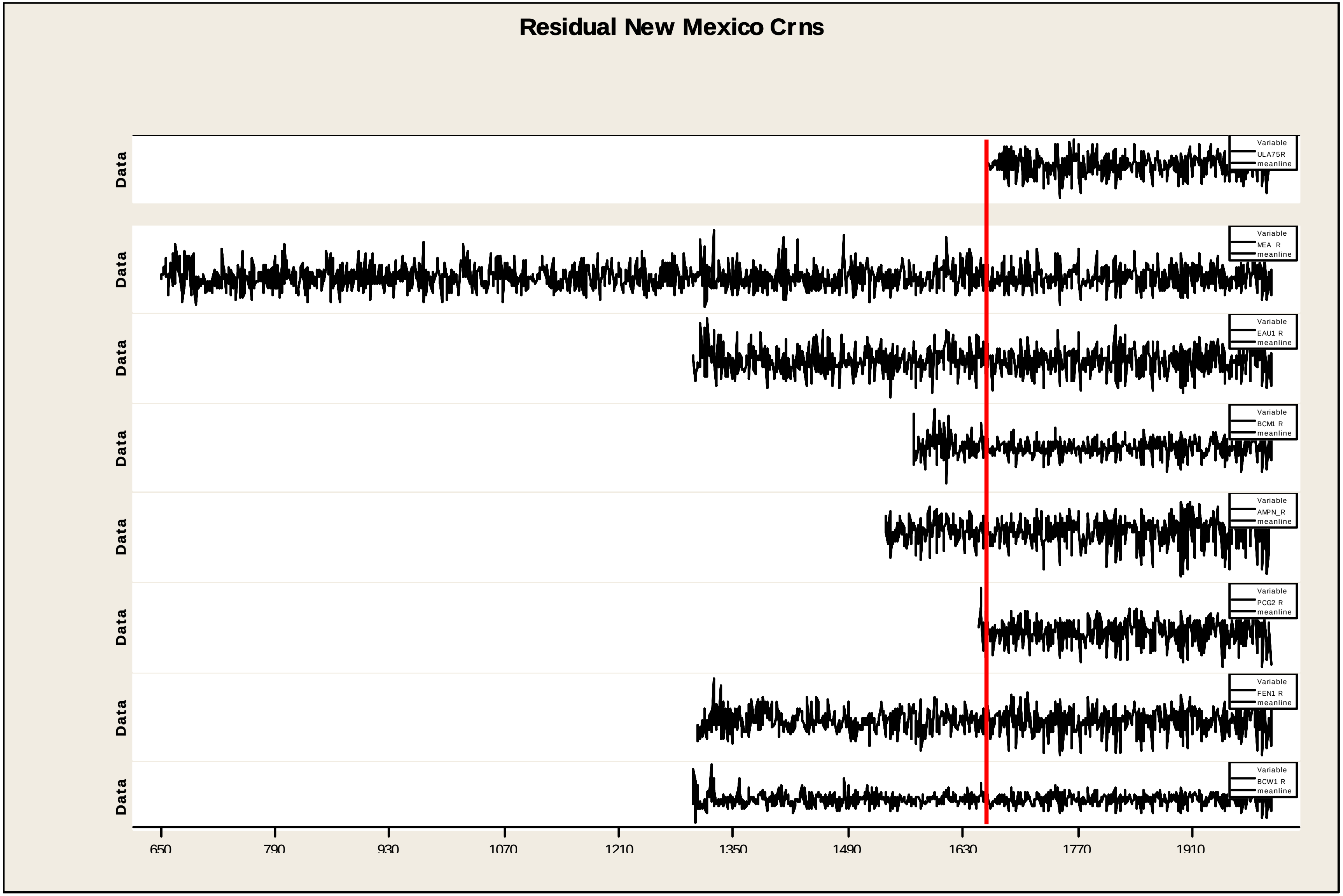


* 8 Chronologies

* Removed incorrect value

* Detrending: cubic smoothing spline 50% of the variance over 75%

Residual chronologies

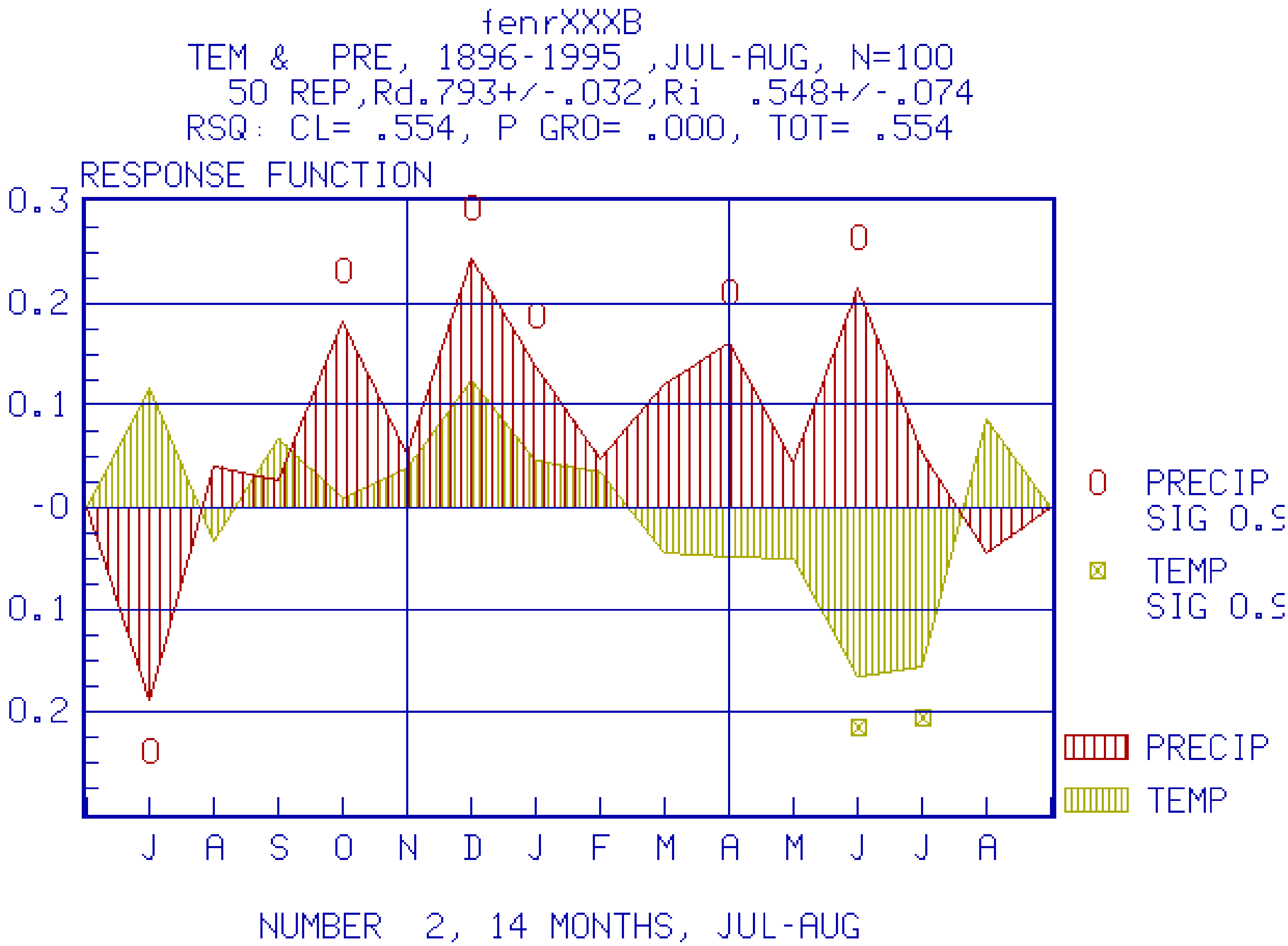


Response Function Analysis

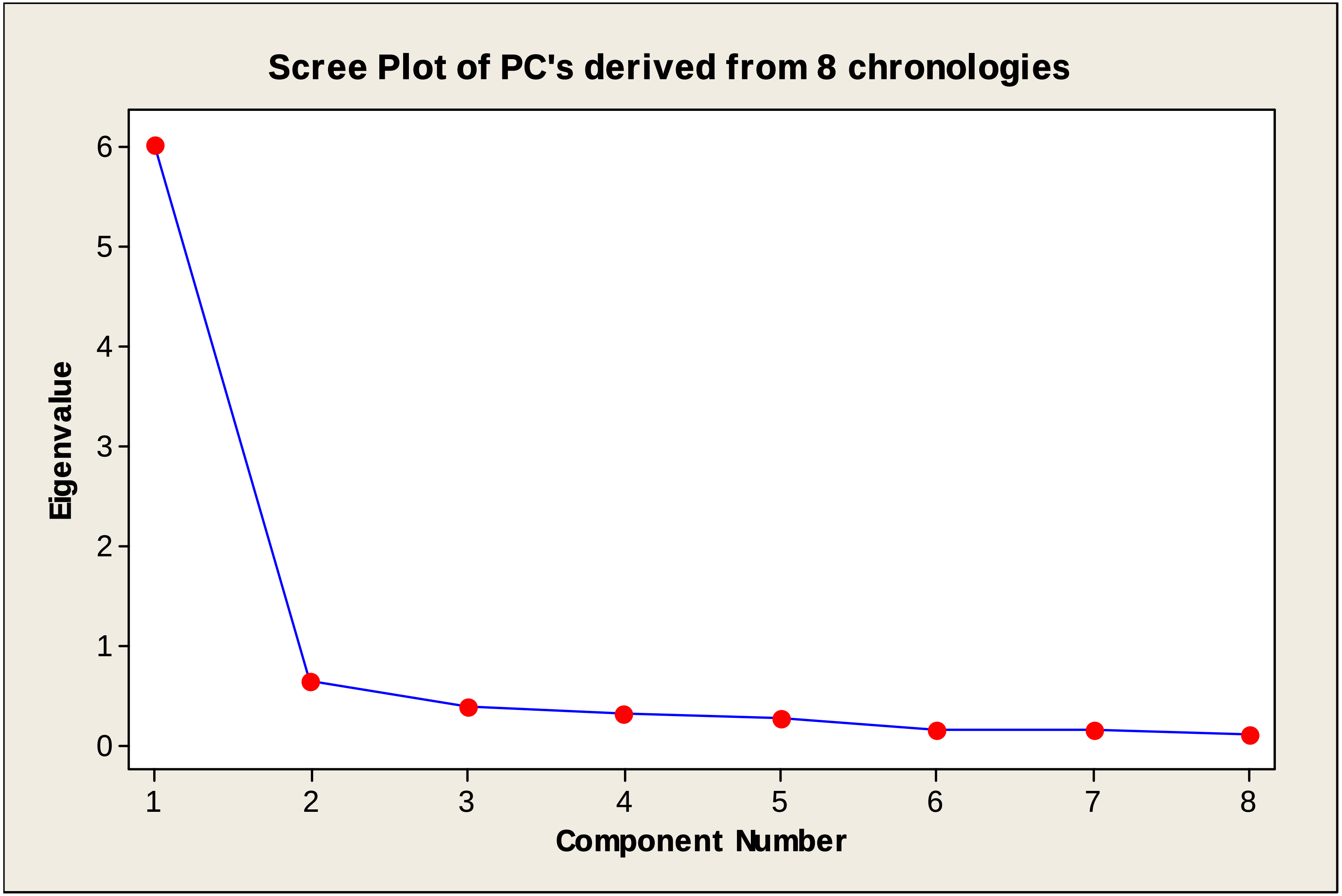
October-June

monthly PPT

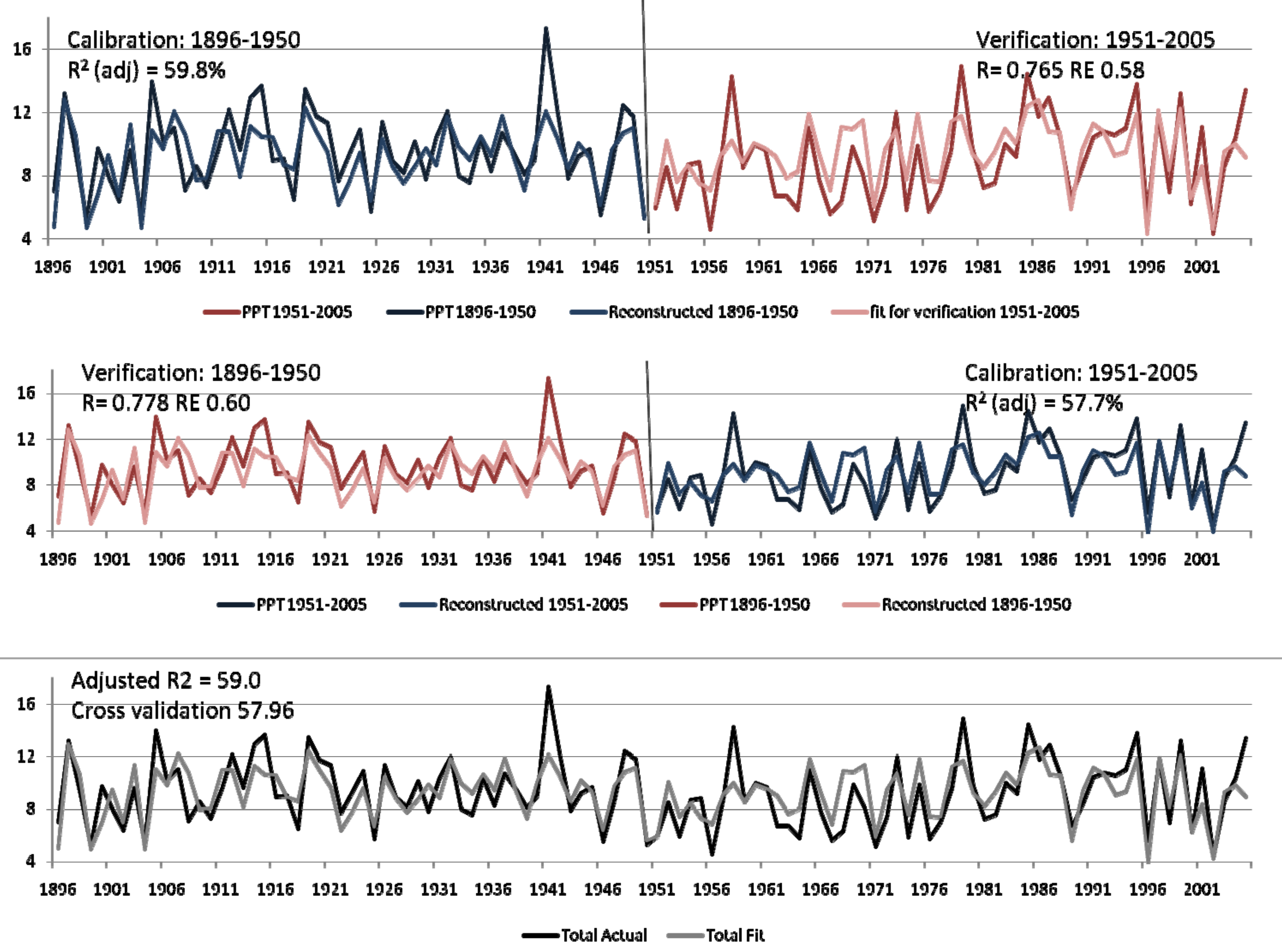
selected



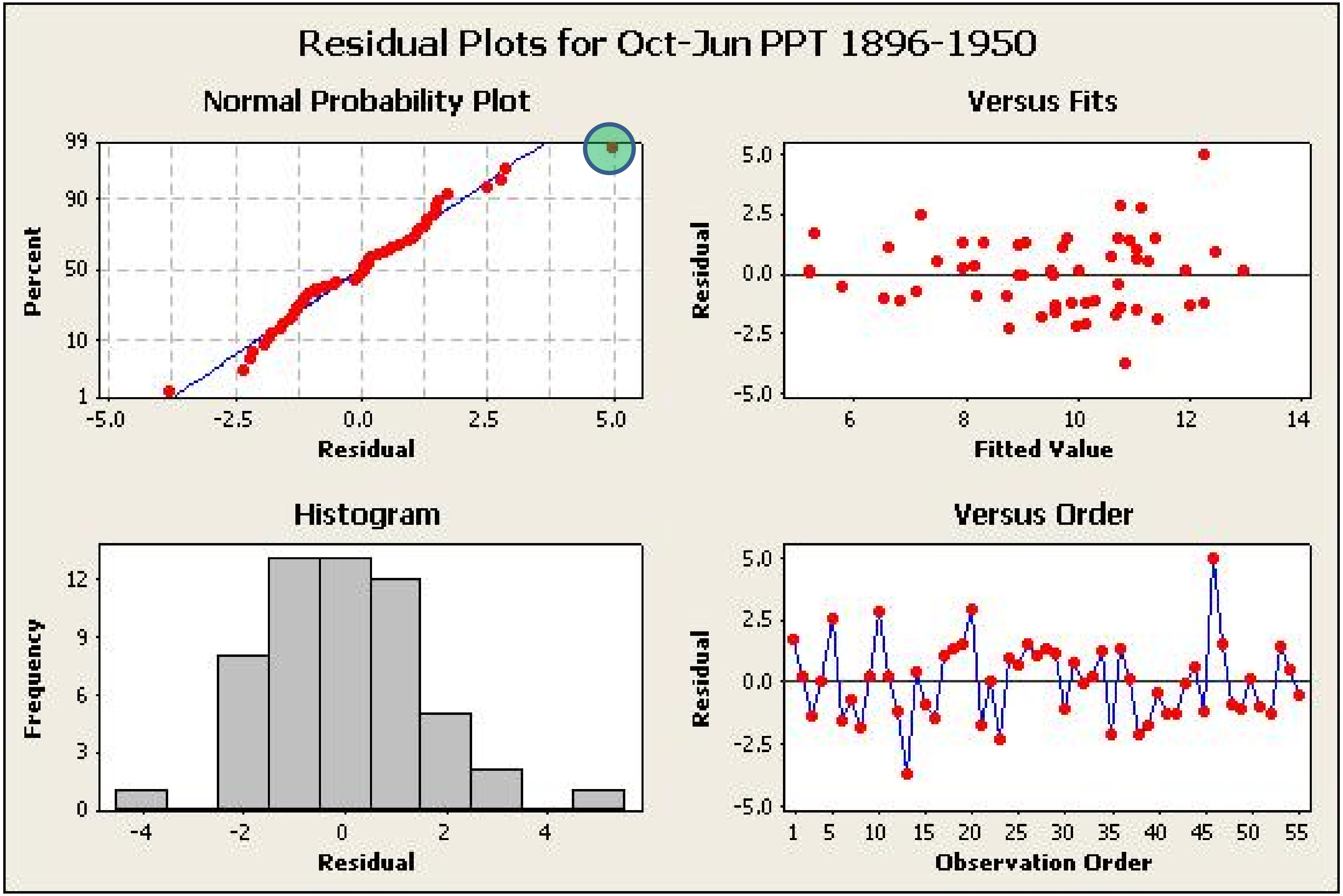
Principal Component Analysis



PC1 accounts for the 75% of variance

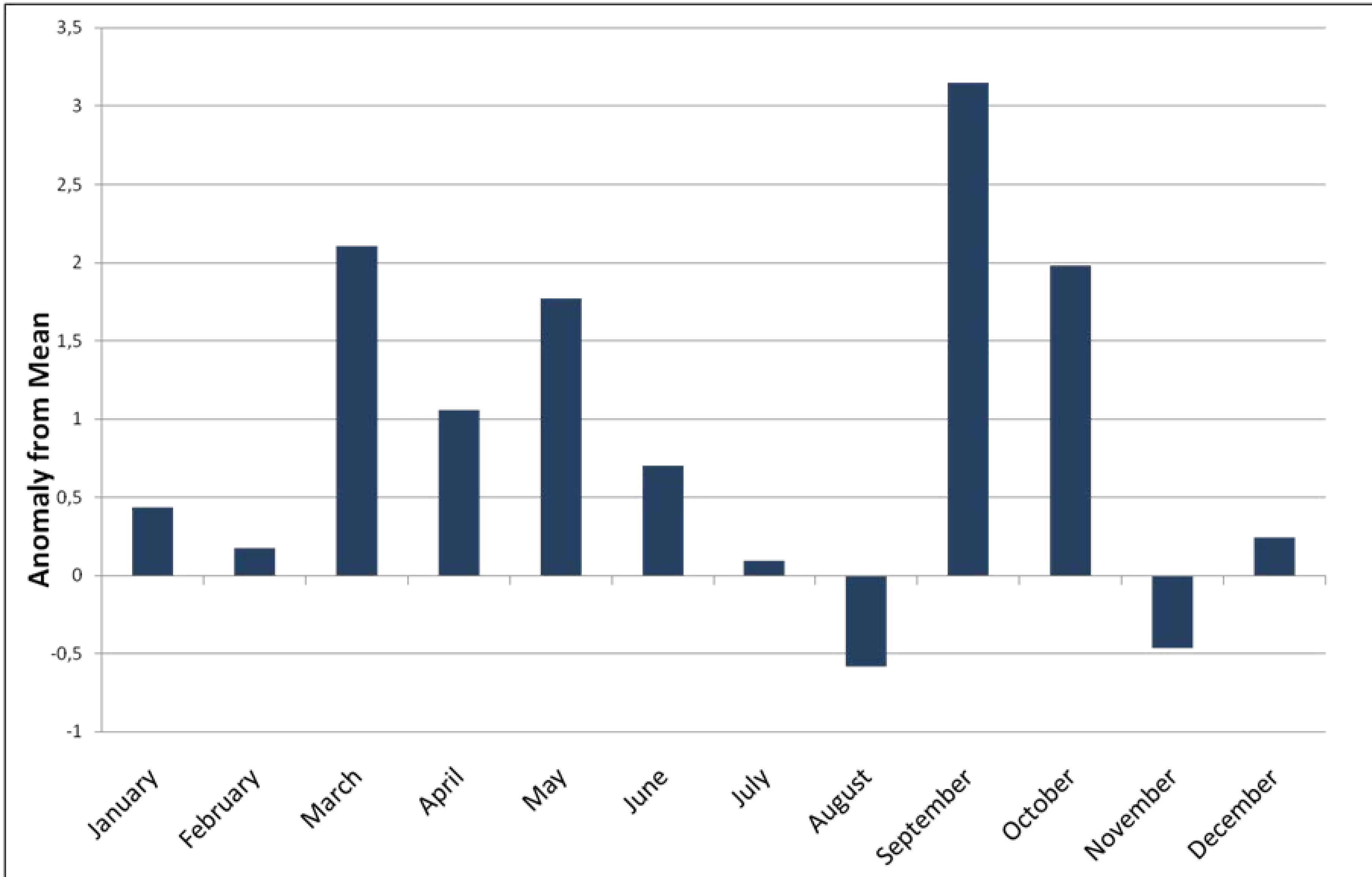


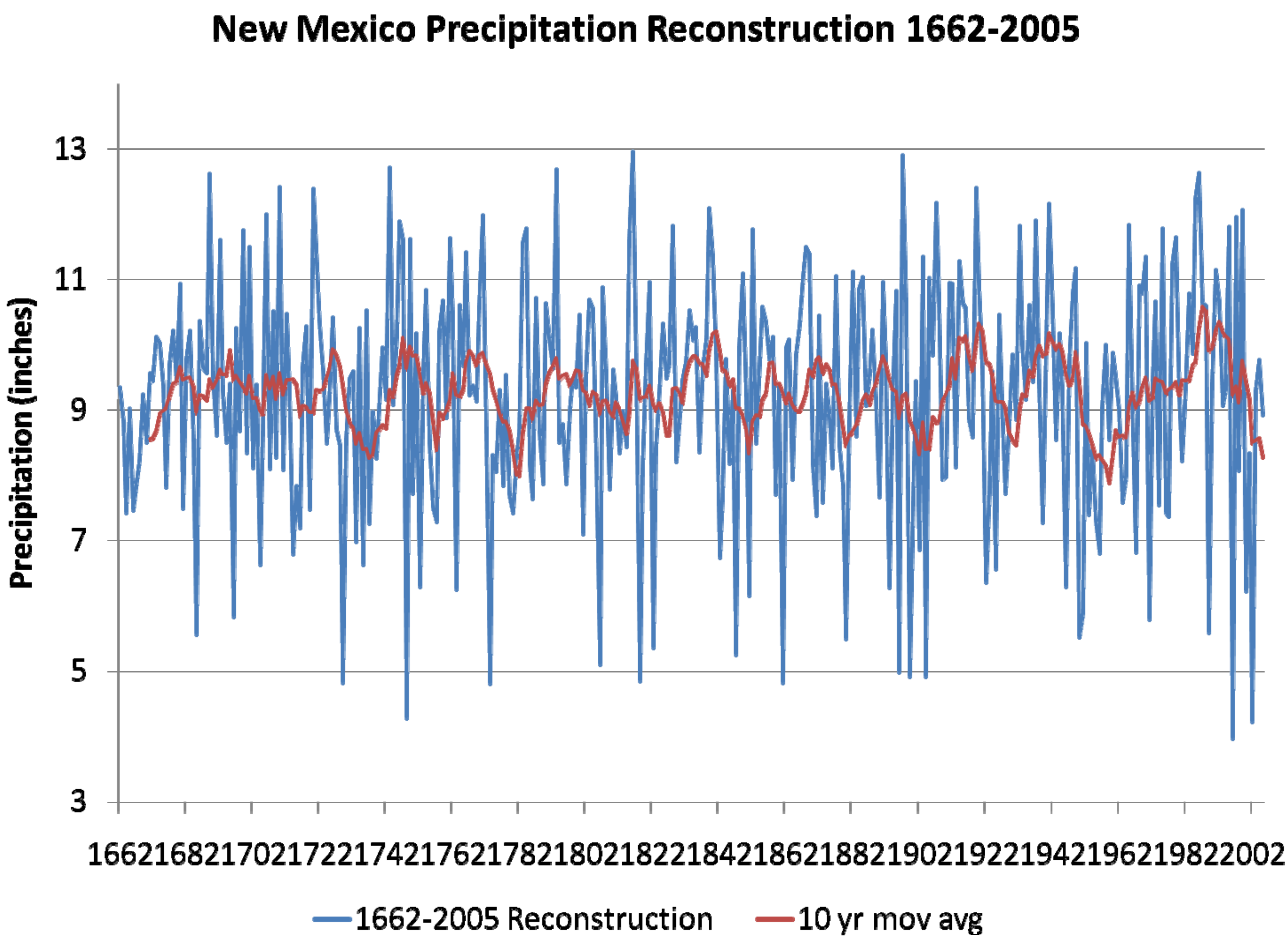
Calibration: 1896-1950
R² (adj) = 59.8%
Verification: 1951-2005
R= 0.765 RE 0.58
PPT 1951-2005
PPT 1896-1950
Reconstructed 1896-1950
fit for verification 1951-2005
Verification: 1896-1950
R= 0.778 RE 0.60
Calibration: 1951-2005
R² (adj) = 57.7%
PPT 1951-2005
Reconstructed 1951-2005
PPT 1896-1950
Reconstructed 1896-1950
Adjusted R2 = 59.0
Cross validation 57.96
Total Actual
Total Fit



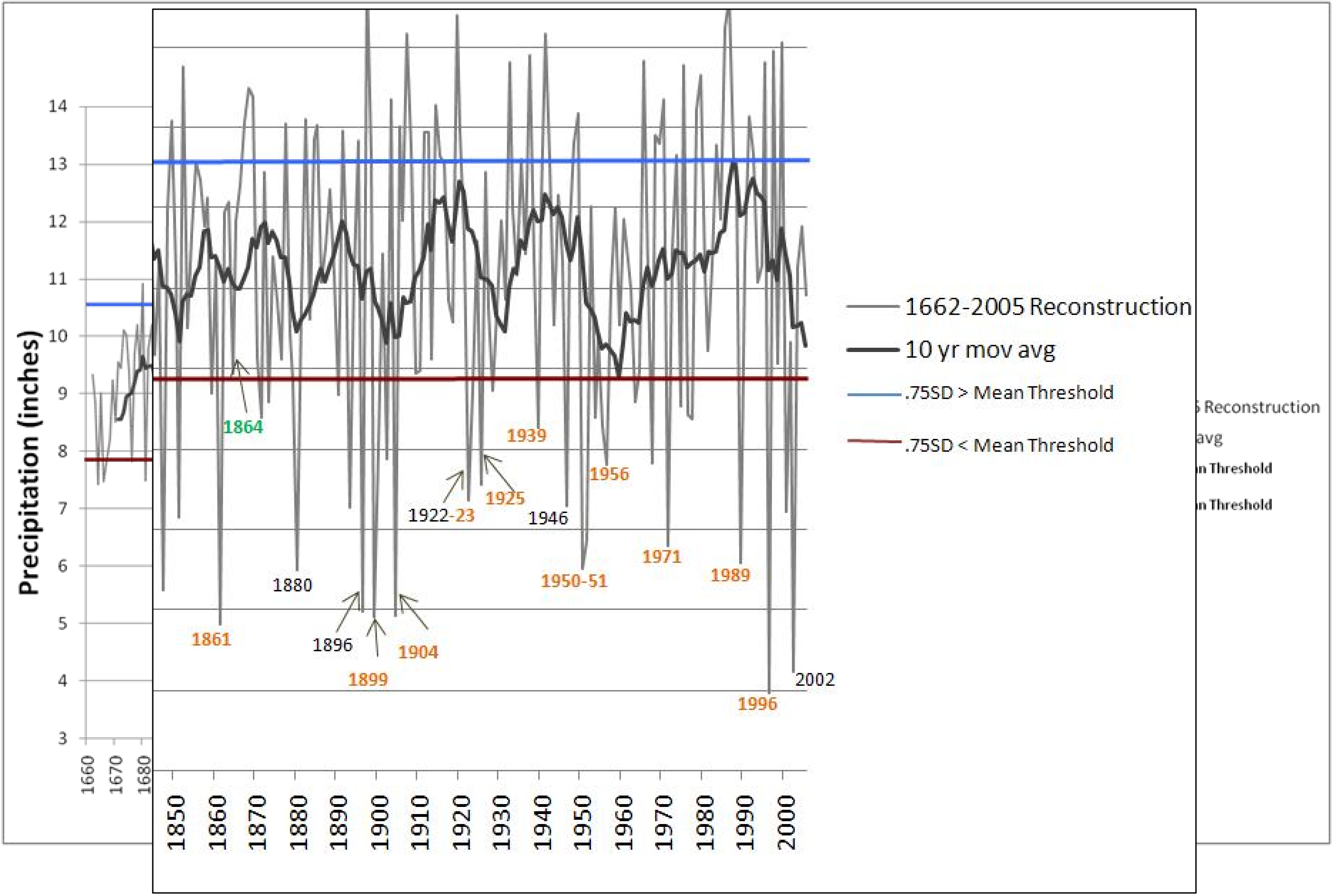
Residual Plots for Oct-Jun PPT 1896-1950
Normal Probability Plot
Percent
Residual
Versus Fits
Residual
Fitted Value
Histogram
Frequency
Residual
Versus Order
Residual
Observation Order

Monthly Anomalies of 1941 from the 1896-2005 Means

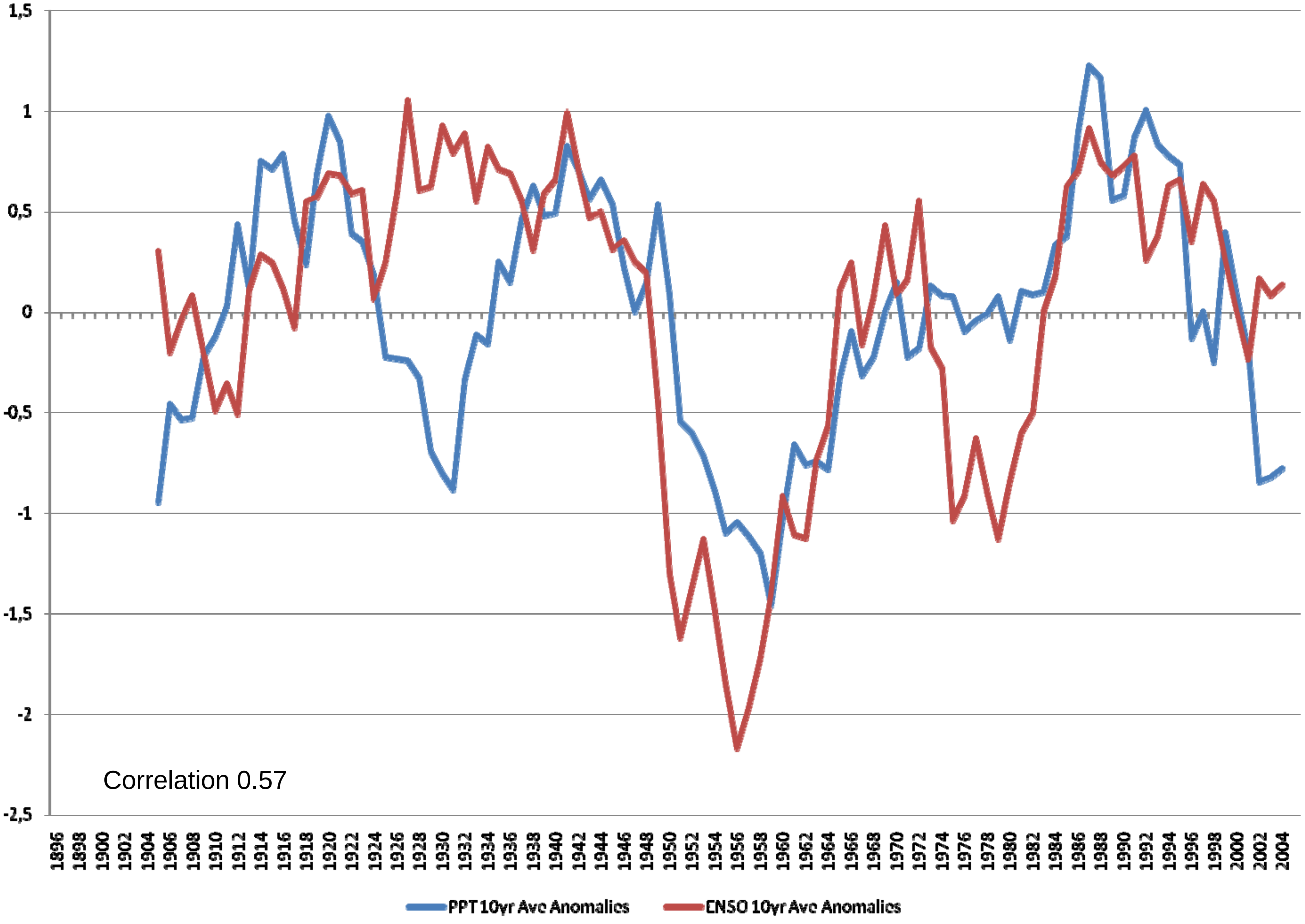



New Mexico Precipitation Reconstruction 1662-2005
Precipitation (inches)
13
11
9
7
5
3
1662
1682
1702
1722
1742
1762
1782
1802
1822
1842
1862
1882
1902
1922
1942
1962
1982
2002
1662-2005 Reconstruction
10 yr mov avg

New Mexico 1662-2005 Reconstruction Precipitation Values



Reconstructed Precipitation and ENSO Index 10yr moving avg anomalies



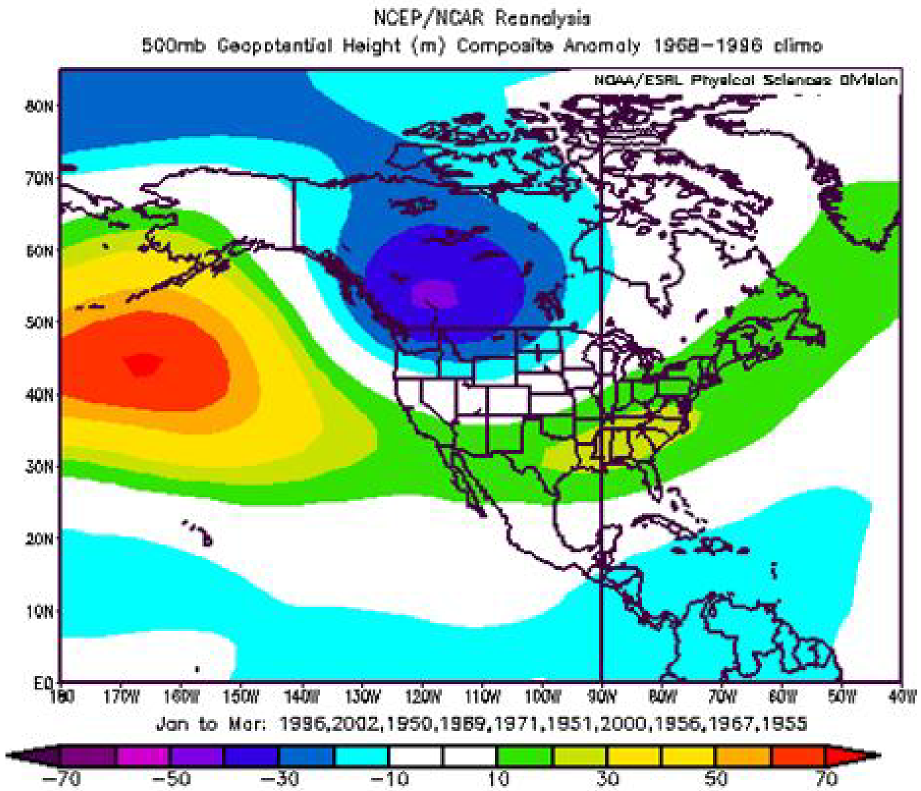
Ten driest years (Oct - June precip, 1949-2005)

yr	Instrumental (in.)	rank	yr	Reconstructed (in.)	rank
2002	4.32	1	1996	3.97089	1
1956	4.56	2	2002	4.22859	2
1971	5.11	3	1950	5.51863	3
1950	5.27	4	1989	5.59015	4
1996	5.44	5	1971	5.79255	5
1967	5.57	6	1951	5.86992	6
1976	5.7	7	2000	6.22218	7
1964	5.8	8	1956	6.81372	8
1974	5.85	9	1967	6.82305	9
1953	5.9	10	1955	7.29175	10

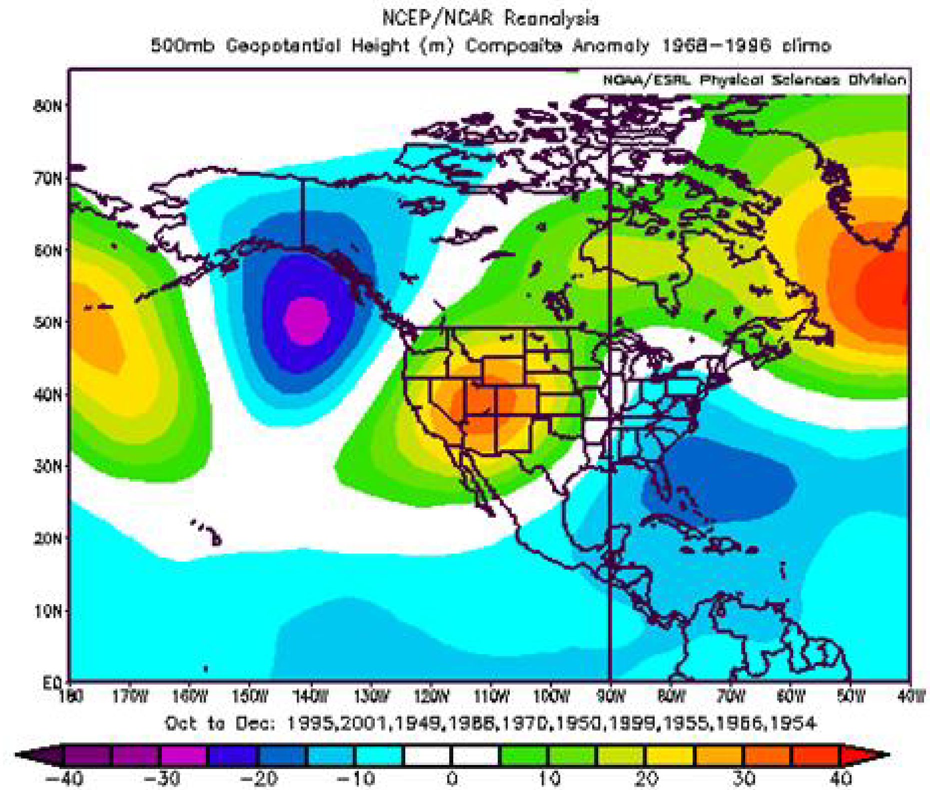
Ten wettest years

yr	Instrumental	rank	yr	Reconstructed	rank
1979	14.89	1	1986	12.6282	1
1985	14.4	2	1985	12.2279	2
1958	14.23	3	1999	12.0615	3
1995	13.76	4	1997	11.948	4
2005	13.4	5	1965	11.8213	5
1999	13.15	6	1995	11.7989	6
1987	12.88	7	1975	11.7697	7
1973	11.97	8	1979	11.638	8
1949	11.78	9	1970	11.3427	9
1997	11.78	10	1978	11.2244	10

Composite 500mb geopotential height anomalies – 10 driest yrs – Tree-ring reconstructed

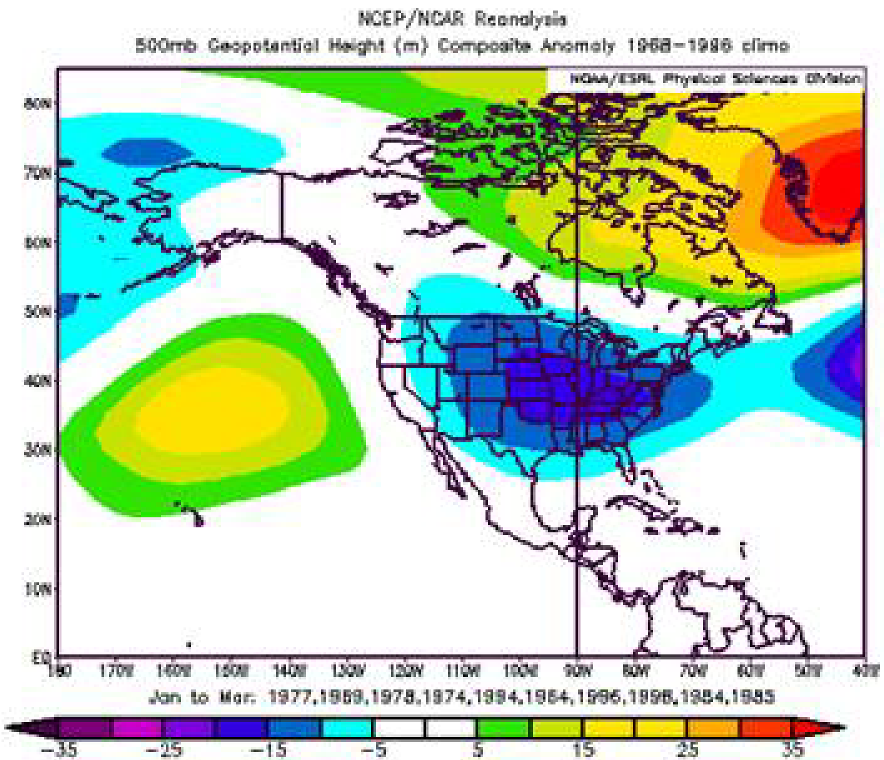


Oct-Dec

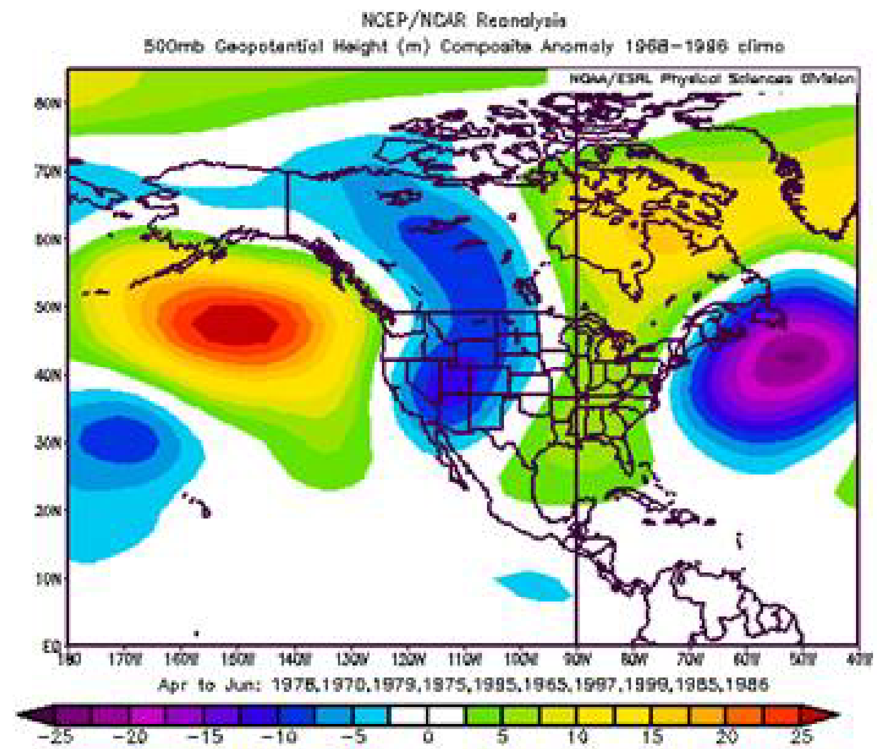


Jan-Mar

Composite 500mb geopotential height anomalies – 10 wettest yrs – Tree-ring reconstructed



Oct-Dec



Apr-Jun

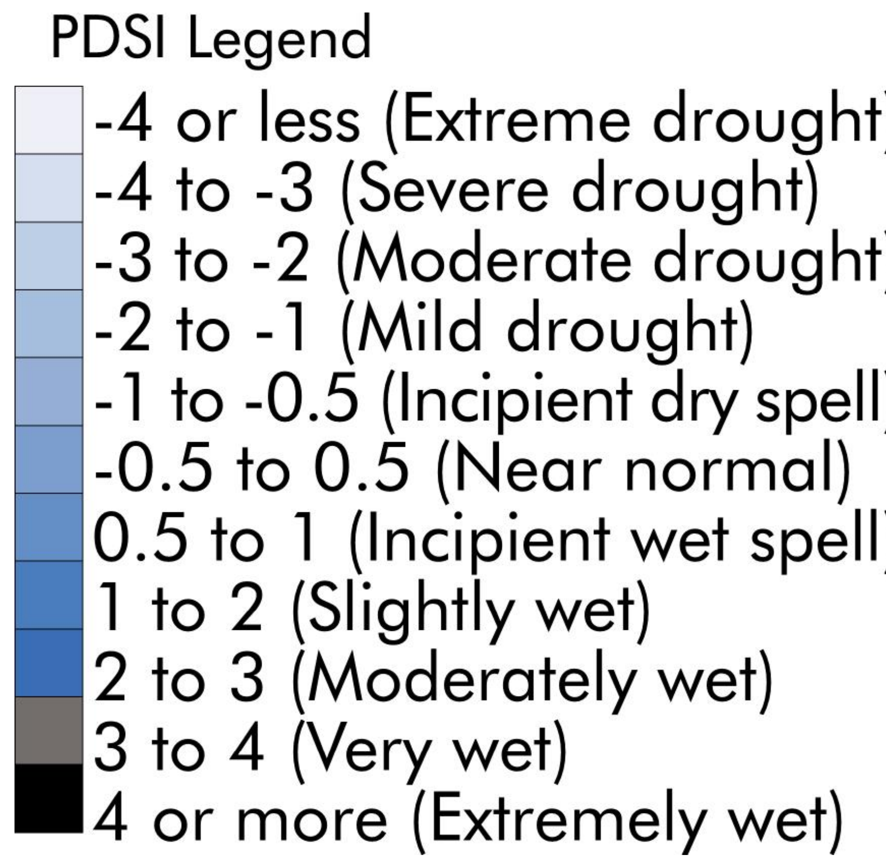
Group 2

May – July PDSI Reconstruction for Northern New Mexico (NM2)

Gunnar Carnwath, Nancy Li,
Stephanie McAfee & Lucy Mullin

What is PDSI?

- Dimensionless index of drought severity
- Function of temperature and precipitation in current and preceding months



Methods

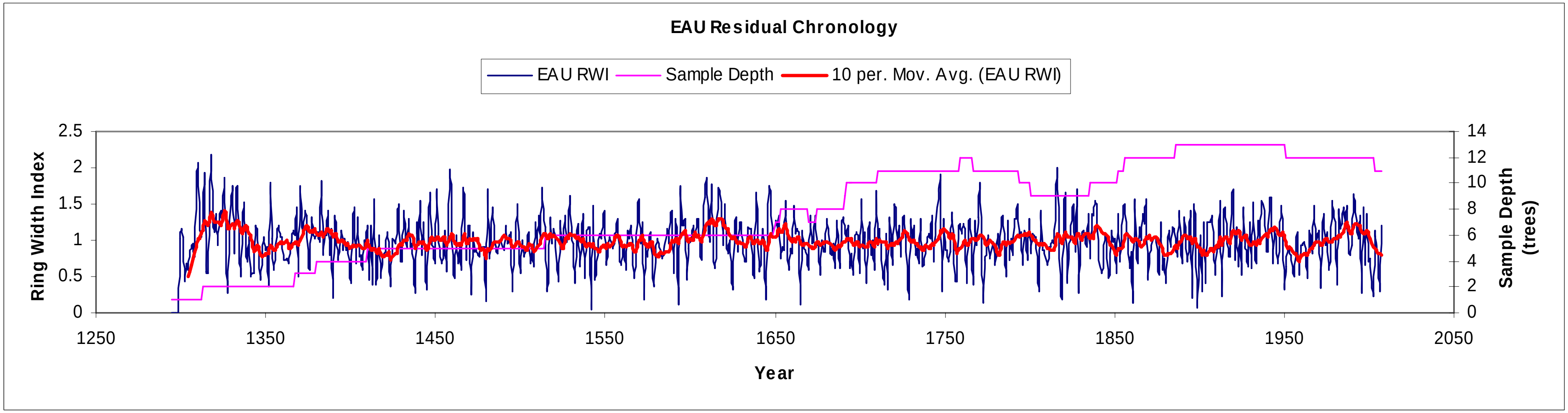
- Chronology Development: ARSTAN
- Identify Climate Signal: RFA
- Develop Transfer Function: Multiple Linear Regression
- Reconstruct PDSI
- Model Assessment

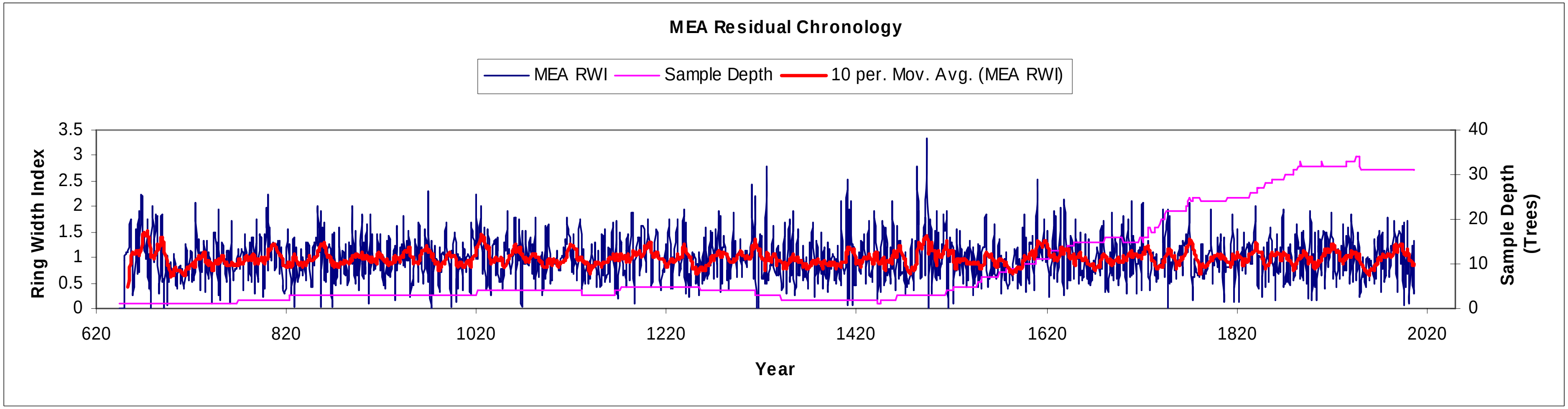
Chronology Statistics:

	Upper Los Alamos 1659-2005	Mesa Alta 644-2007	Echo Amphitheater 1295-2007
Mean series length	234.4	270.0	307.4
Mean sensitivity	0.48	0.52	0.43
Rbar	0.58	0.69	0.66
Variance due to AR	11.8%	14.1%	13.6%
EPS >0.85	1683 (3)	824 (3)	1367 (3)

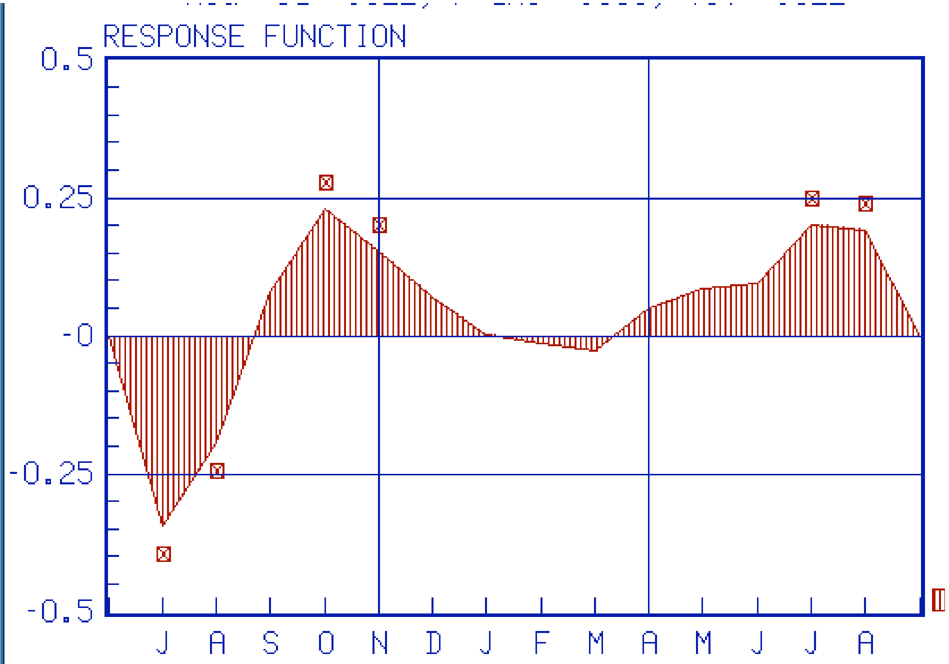
Chronology Development:

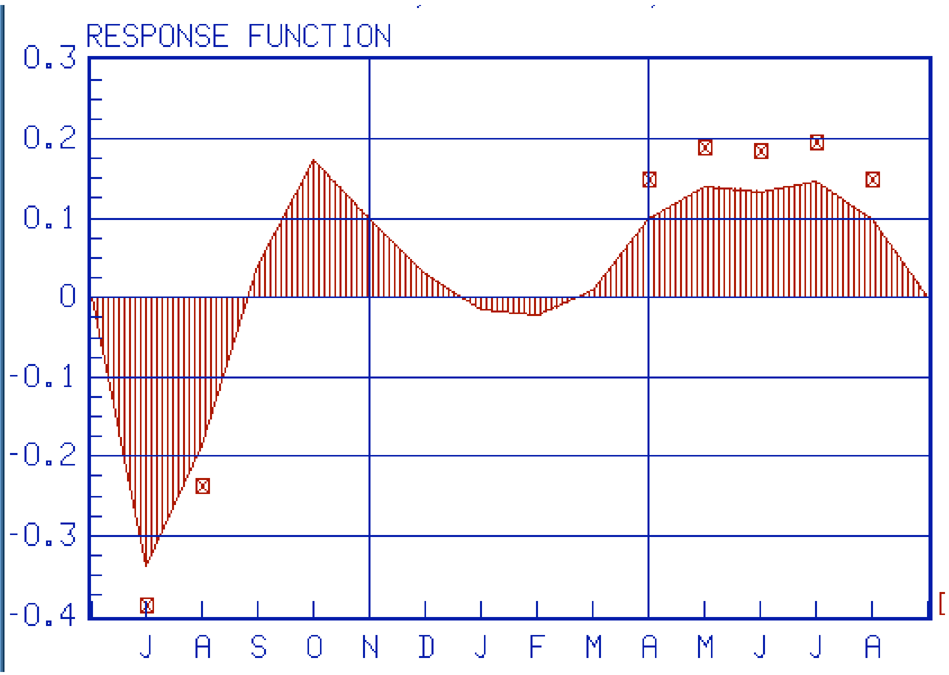
Standardize: 75% of series length spline

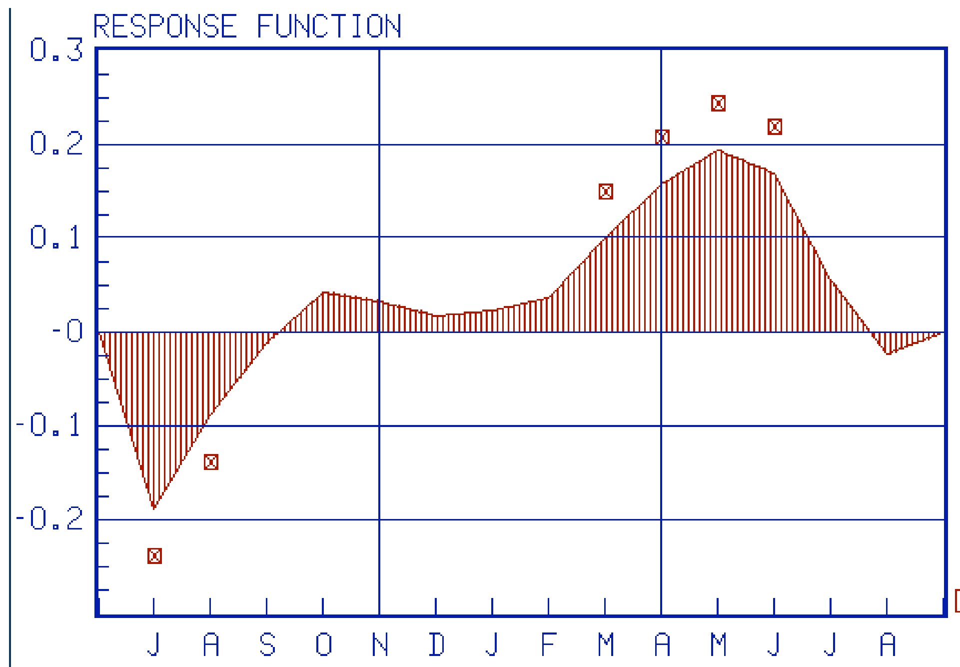




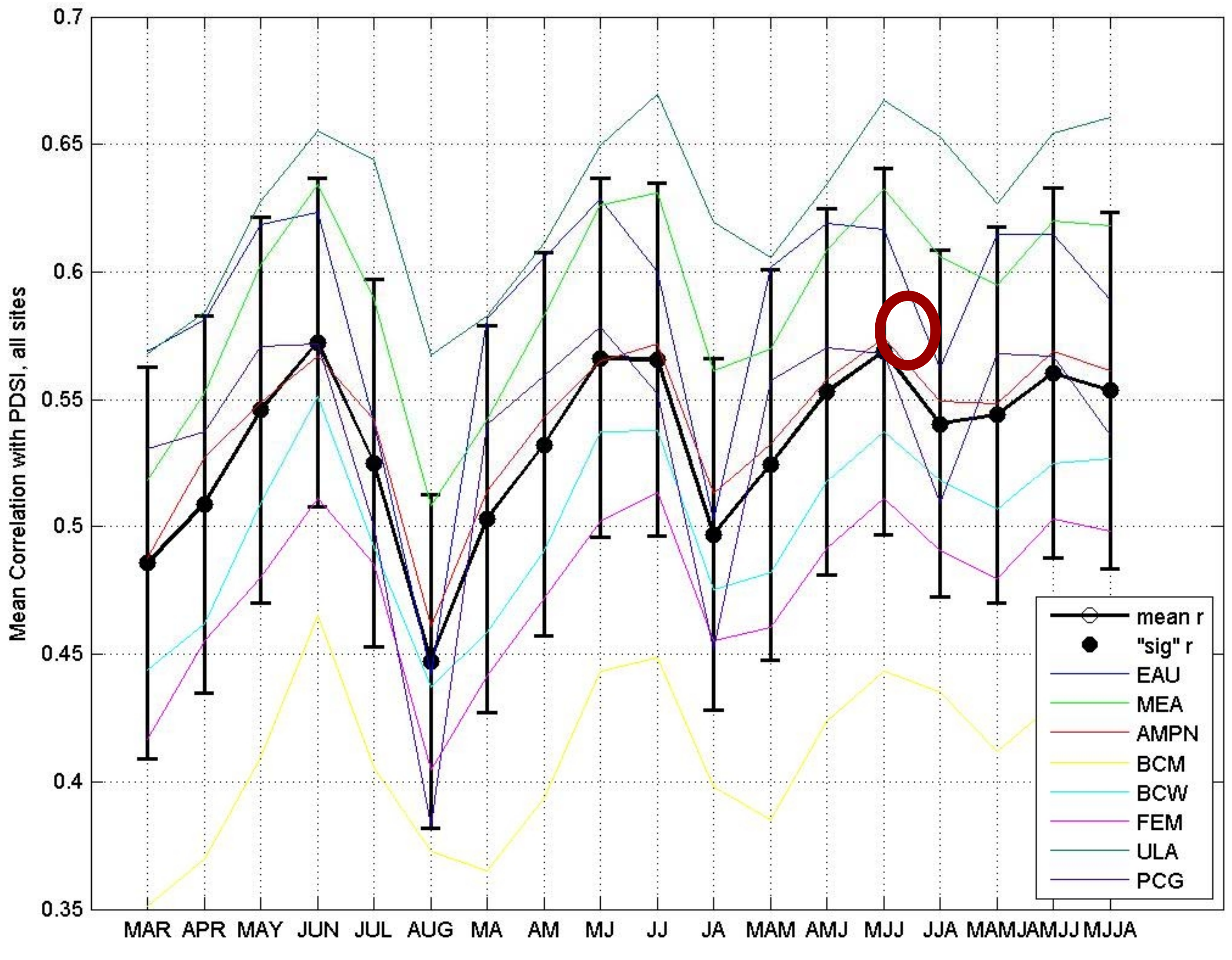
Response Function Analysis (RFA)







RFA: Correlation Analysis



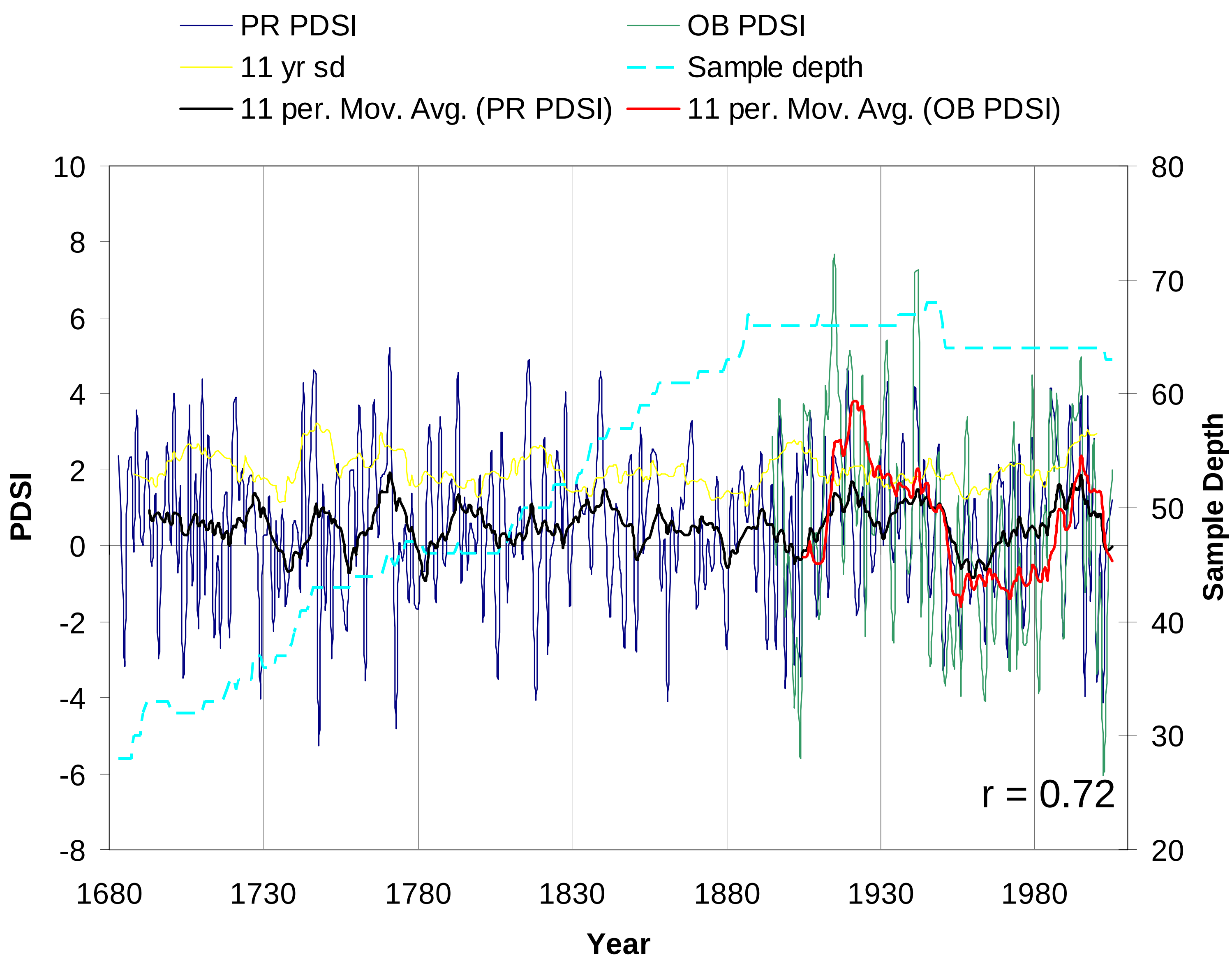
Develop Transfer Function:

Calibration & Verification		R^2_{adj}	R^2_{pred}	Correlation w/ Observed	Correlation w/ Verification	RE
MEA, EAU, and ULA	1895-1951	0.52	0.47	0.74	0.70	0.48
	1952-2005	0.48	0.41	0.71	0.73	0.48

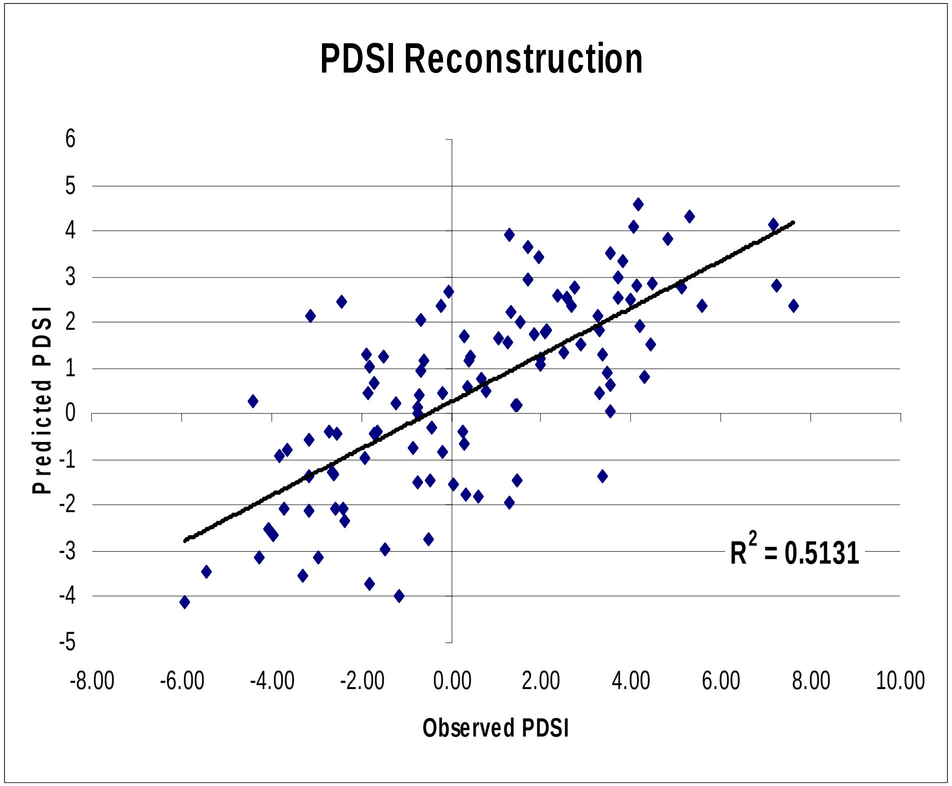
MJJ PDSI = -5.33 + 1.68EAU + 0.86MEA + 3.36ULA

Transfer Function	R^2_{adj}	R^2_{pred}	Correlation w/ Observed
1895-2005	0.50	0.47	0.72

Results: NM2 May – July PDSI

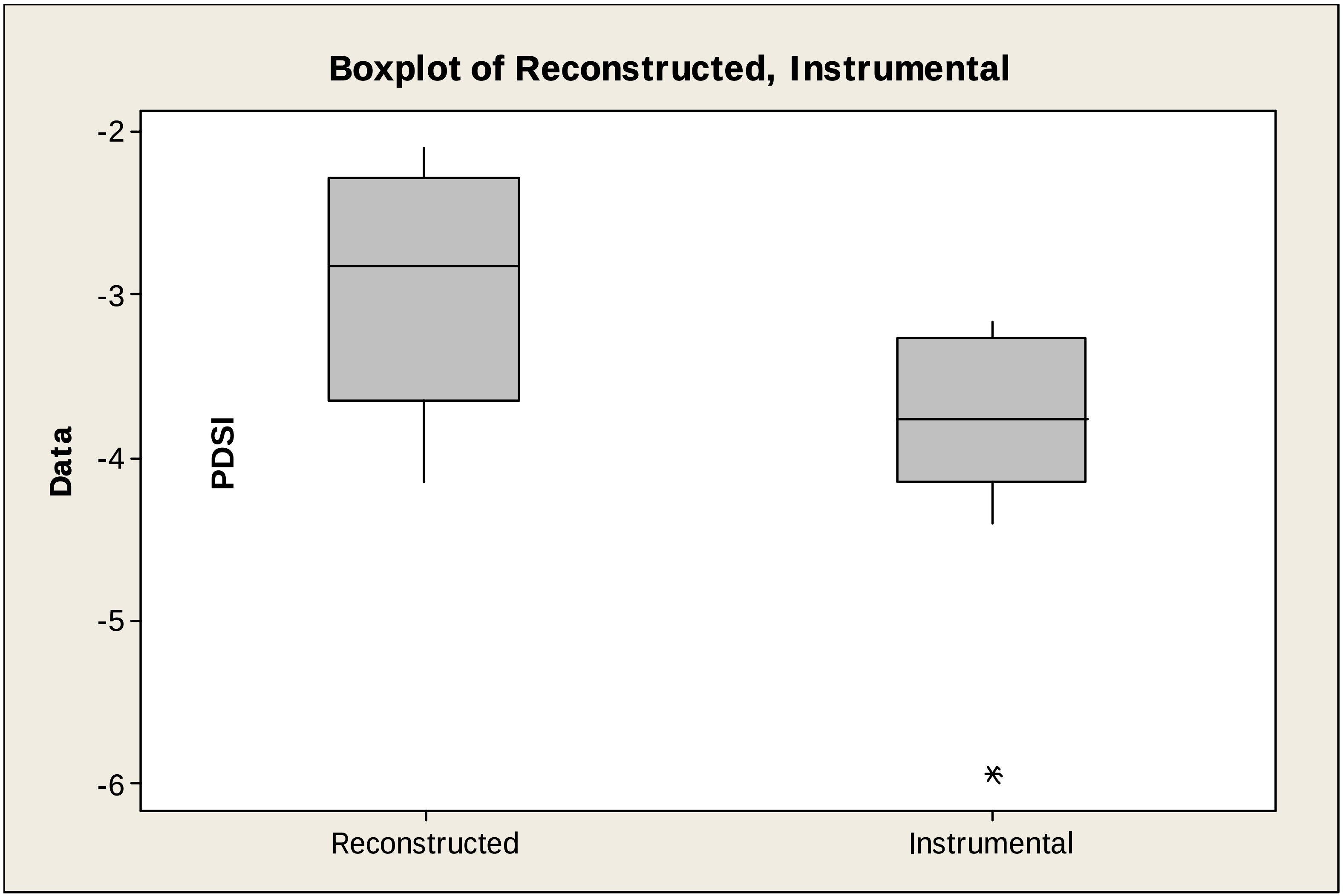


Evaluating the Chronology



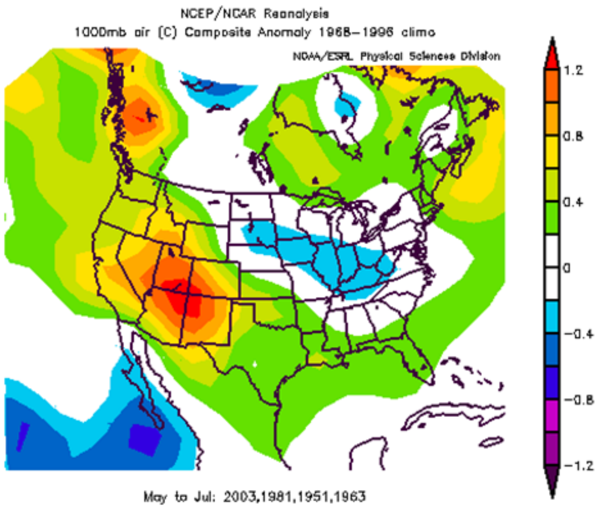
	OBSERVED PDSI	PREDICTED PDSI
Mean	0.55	0.55
Standard Error	0.28	0.20
Standard Deviation	2.93	2.10
Kurtosis	-0.58	-0.69
Skewness	0.12	-0.28
Minimum	-5.93	-4.13
Maximum	7.63	4.58
Confidence Level(95.0%)	0.55	0.39

Comparing the 10 driest years



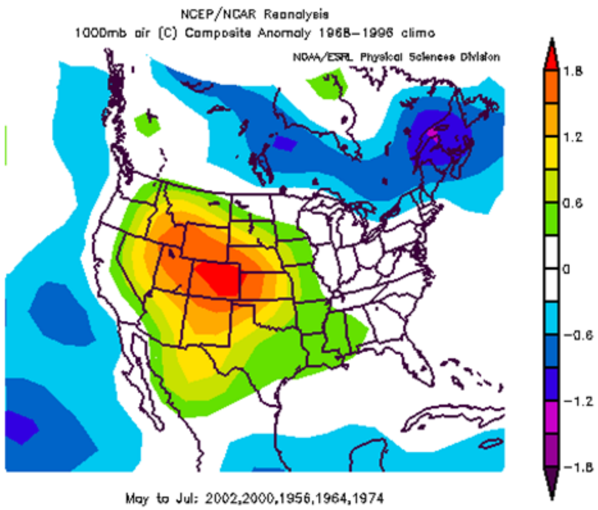
Differences in 10 driest years: May to July surface temperature

Only in instrumental record



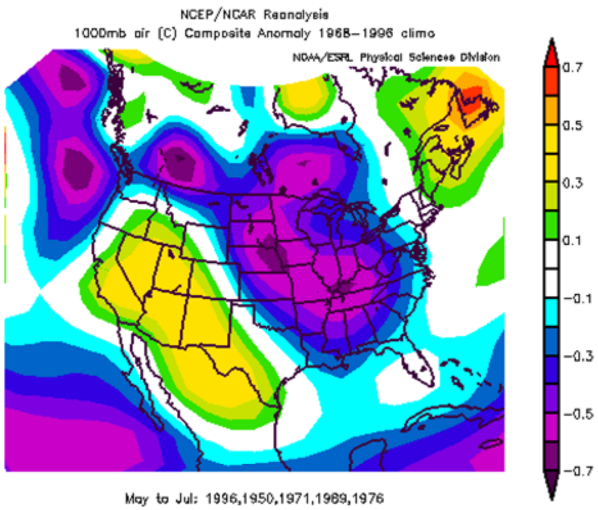
2003,1981, 1951,1963

Present in both



2002, 2000,1956,
1964, 1974

Only in reconstruction



1996,1950, 1971,
1989,1976

Group 3

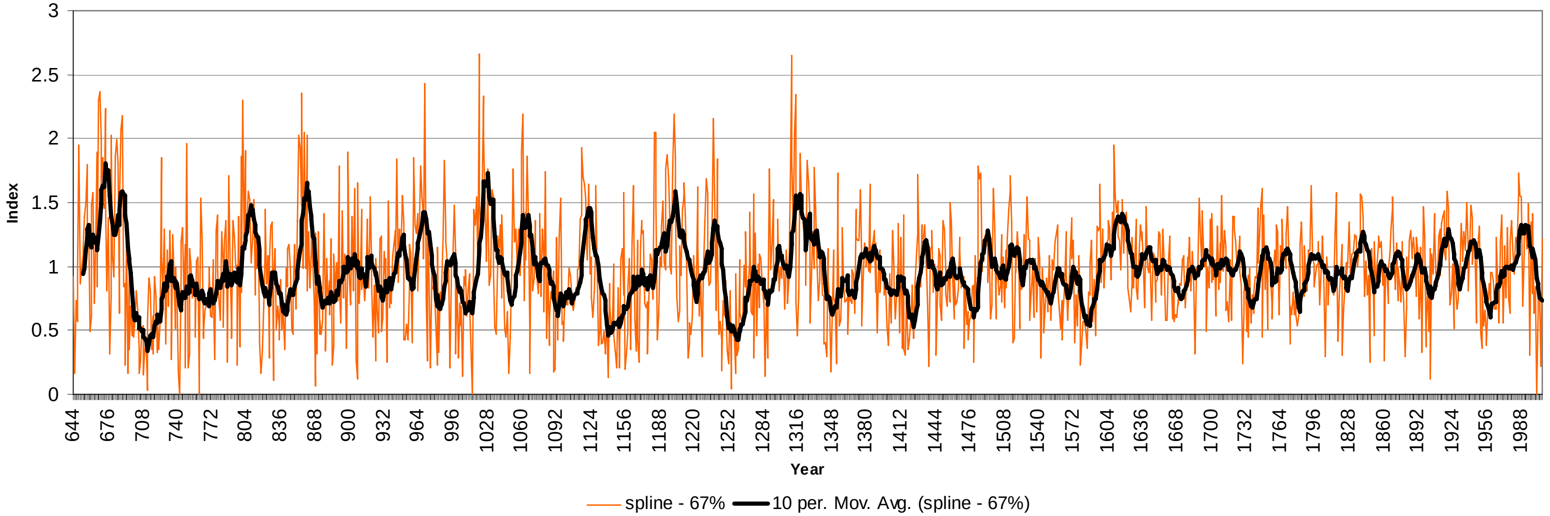
Objective:
Reconstruction of climate conditions using regional chronology

Ekaterina Kuznetsova

Giancarlo Marino

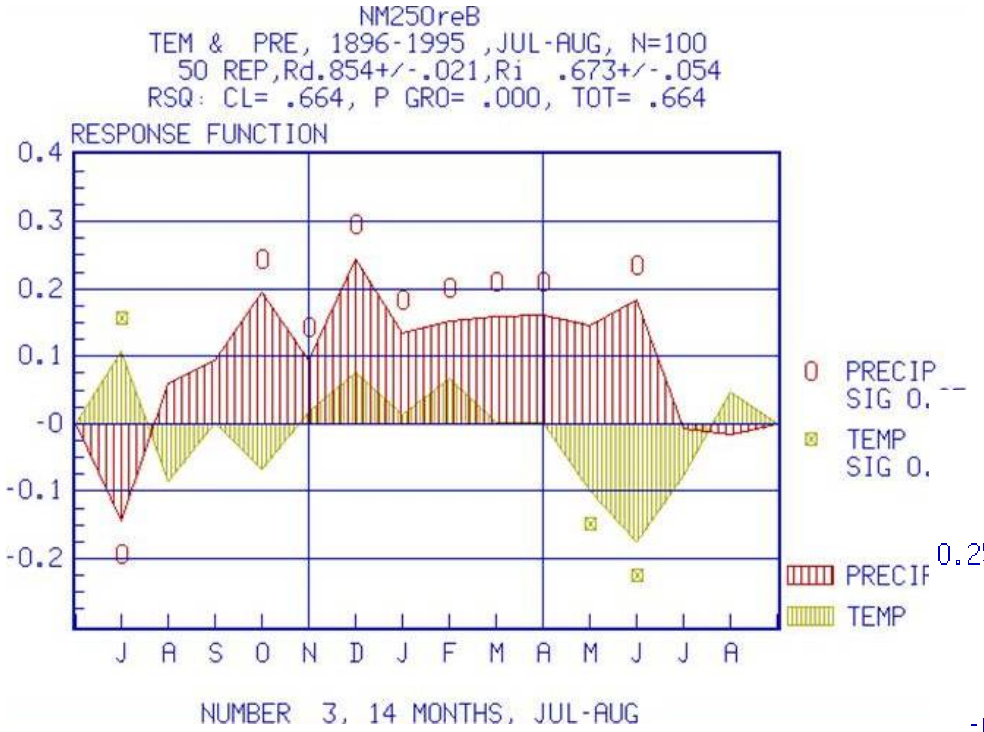
Piotr Owczarek

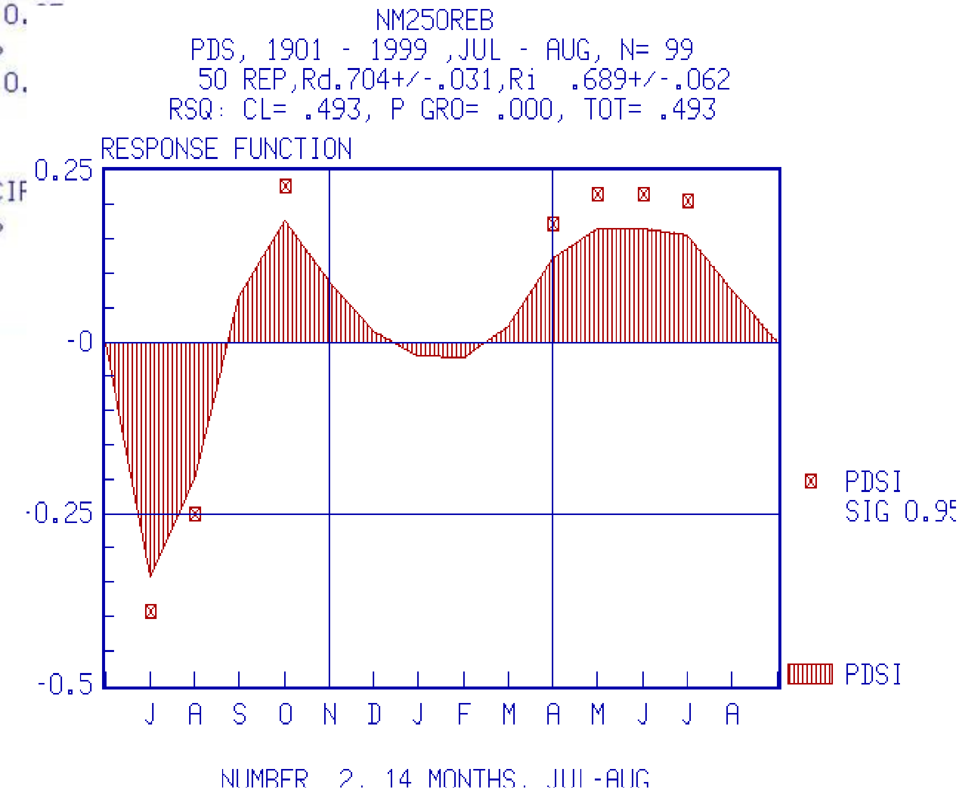
The Northern New Mexico tree-ring chronology



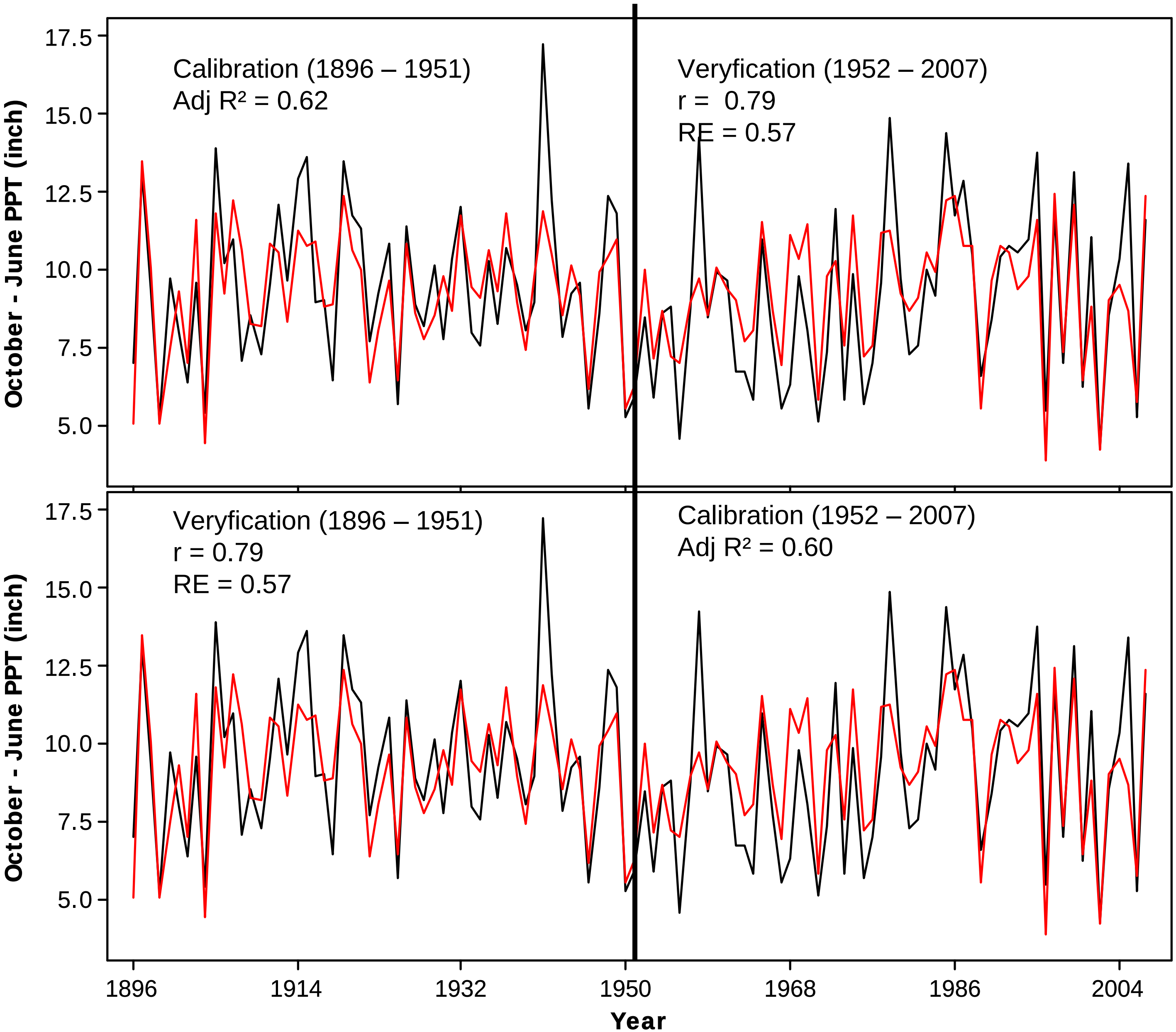
Number of trees: 47
Number of radii: 82
PIST – *Pinus strobiformis*
PSME – *Pseudotsuga menziensii*

Graphic of response function

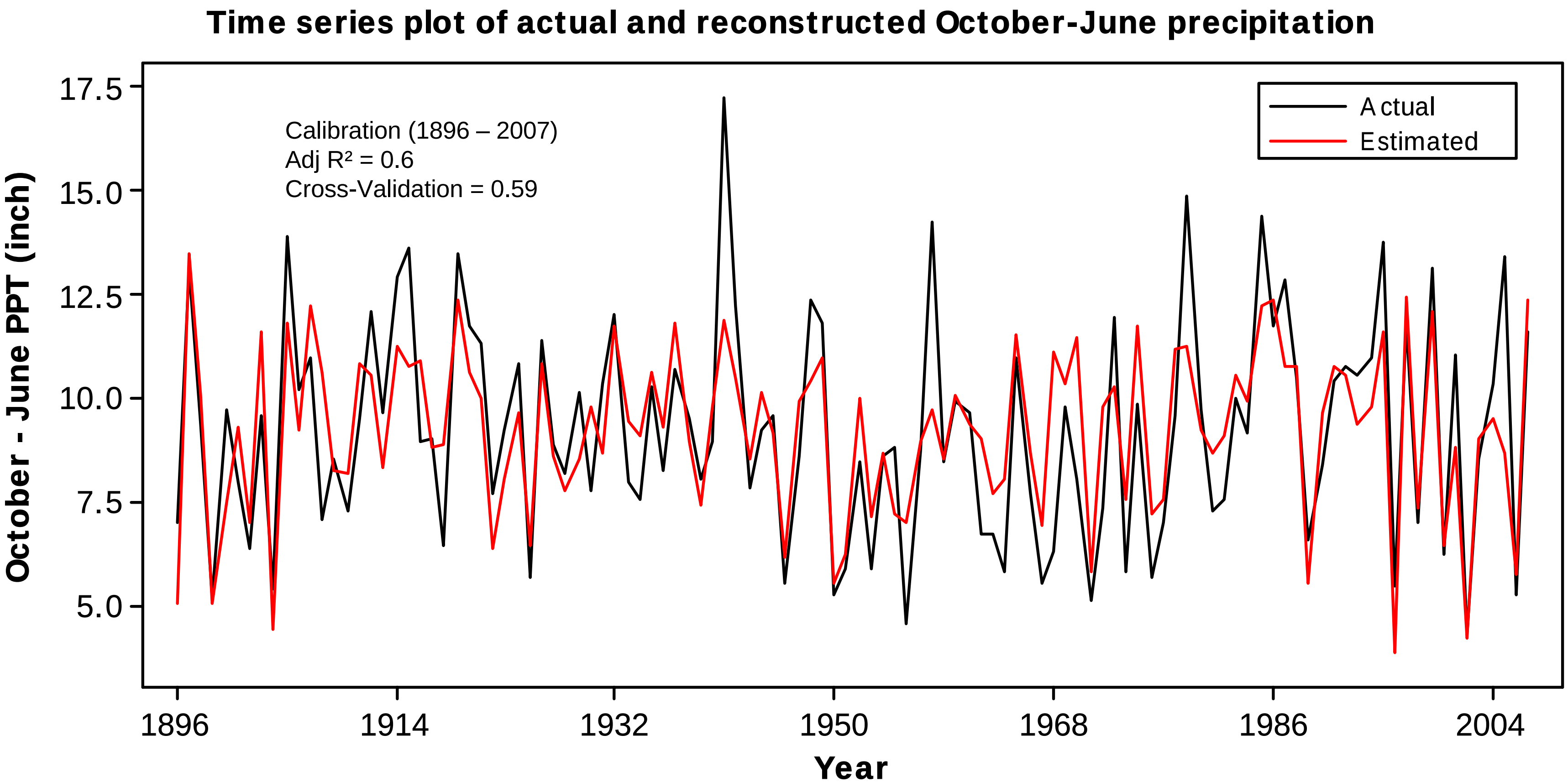


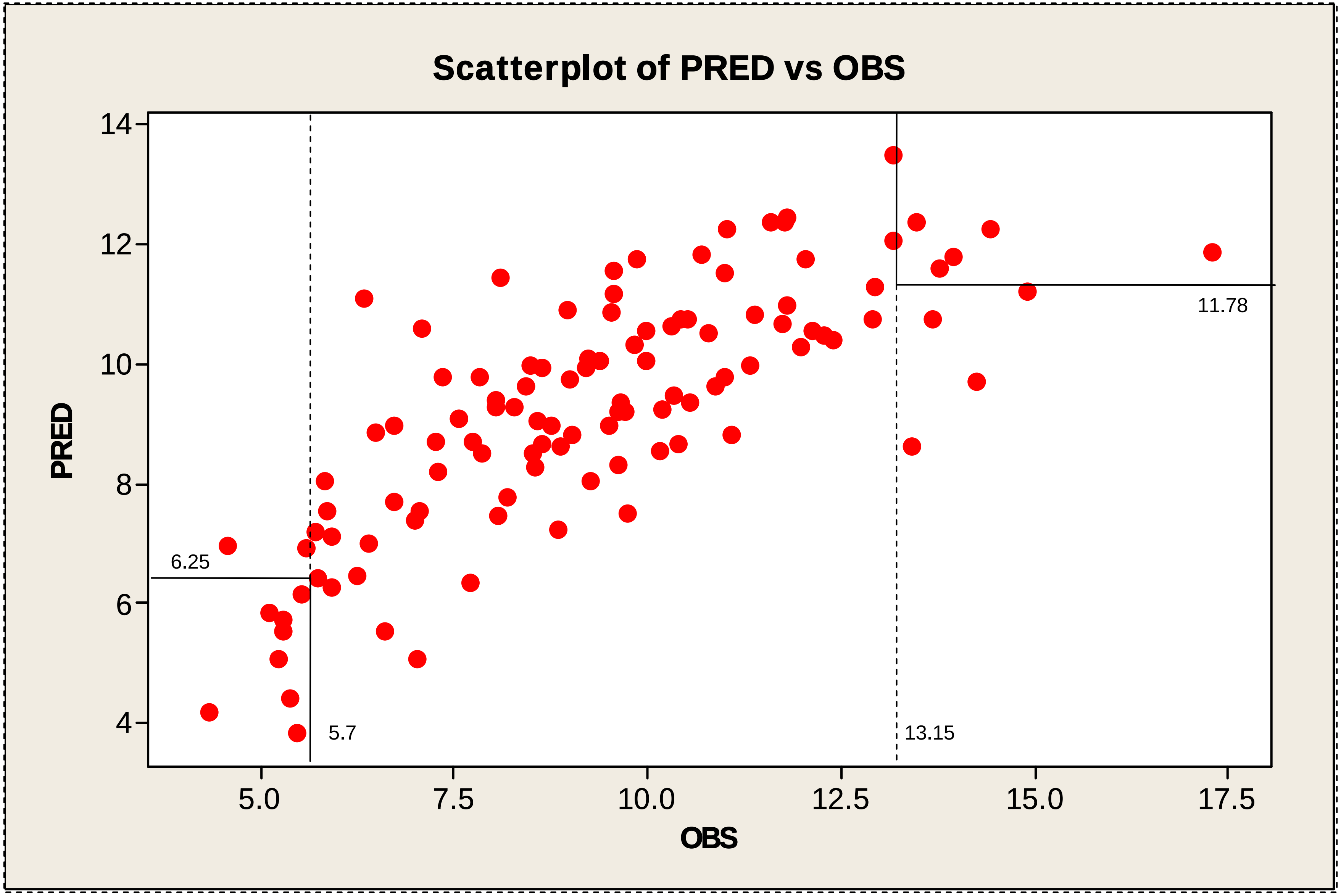


Calibration and verification of the model (a)



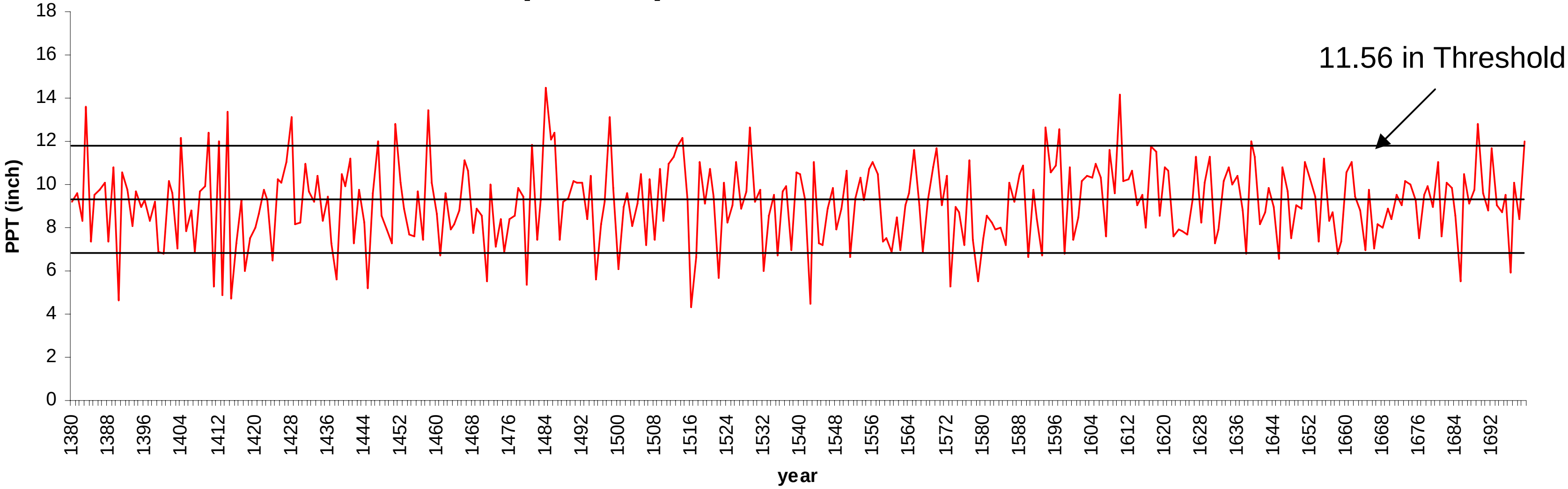
Calibration and verification of the model (b)

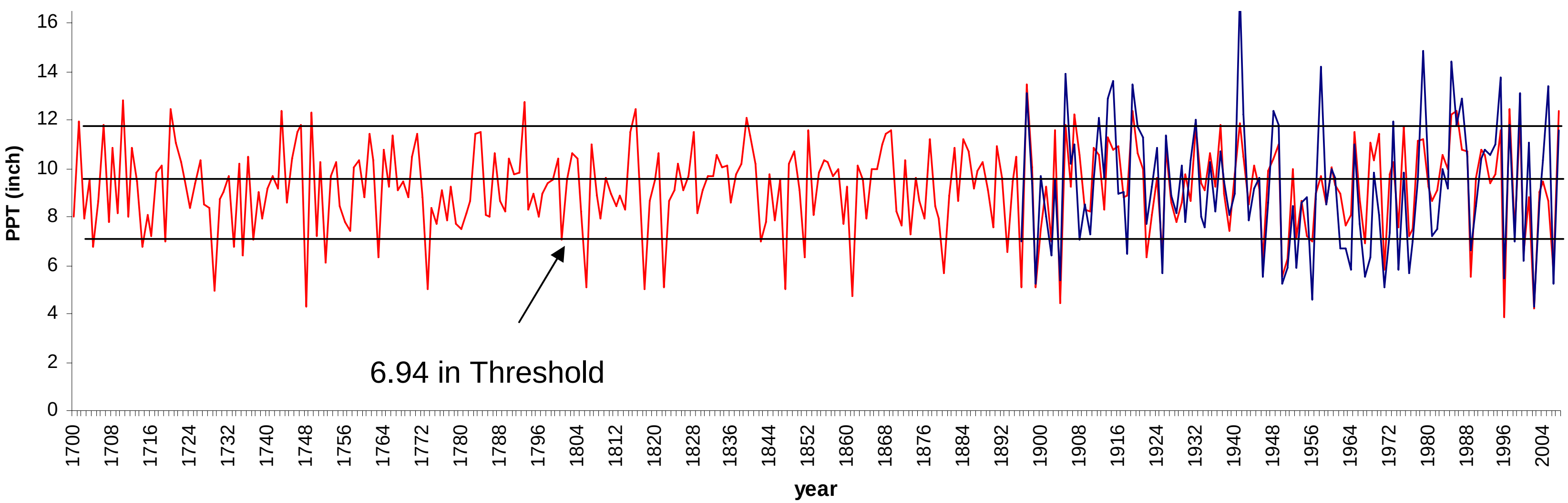




Scatterplot of PRED vs OBS
PRED
OBS
14
12
10
8
6
4
5.0
7.5
10.0
12.5
15.0
17.5
6.25
5.7
13.15
11.78

Time-series plot of reconstruction October – June precipitation, AD 1380 - 2007

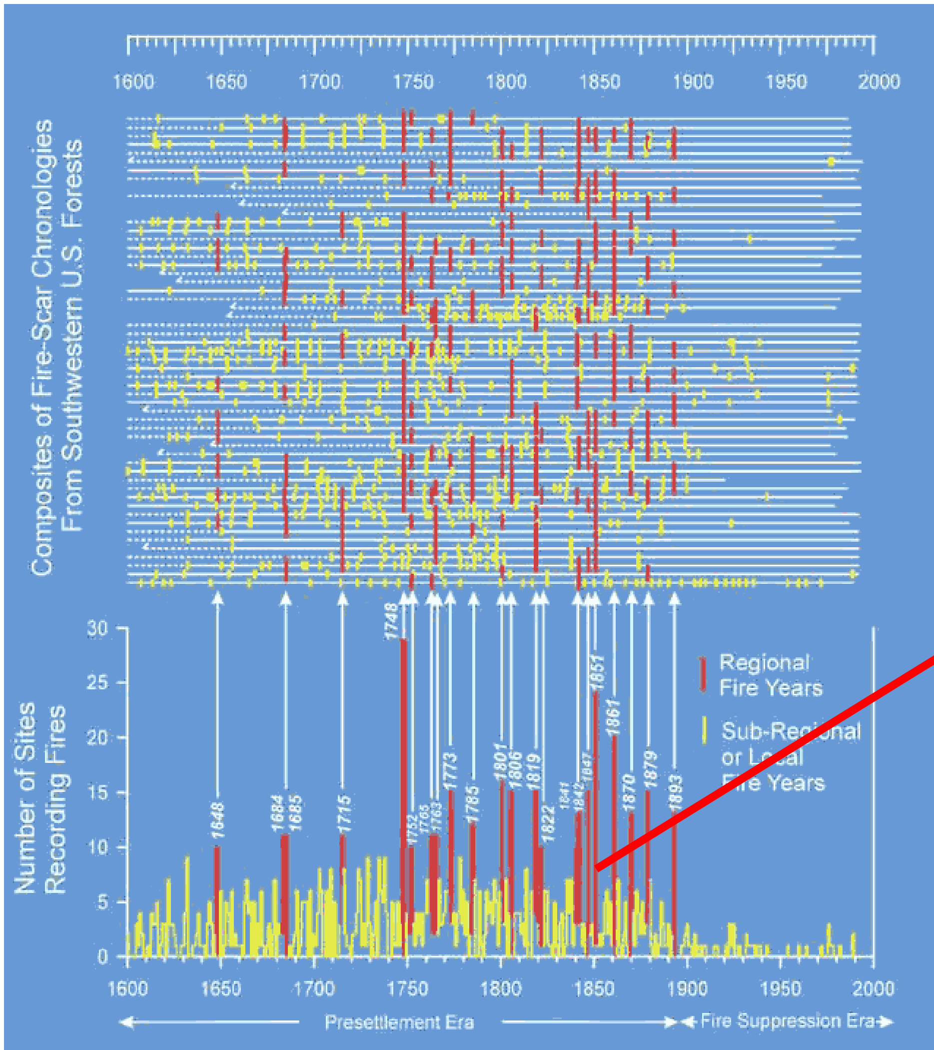




Estimated   Actual

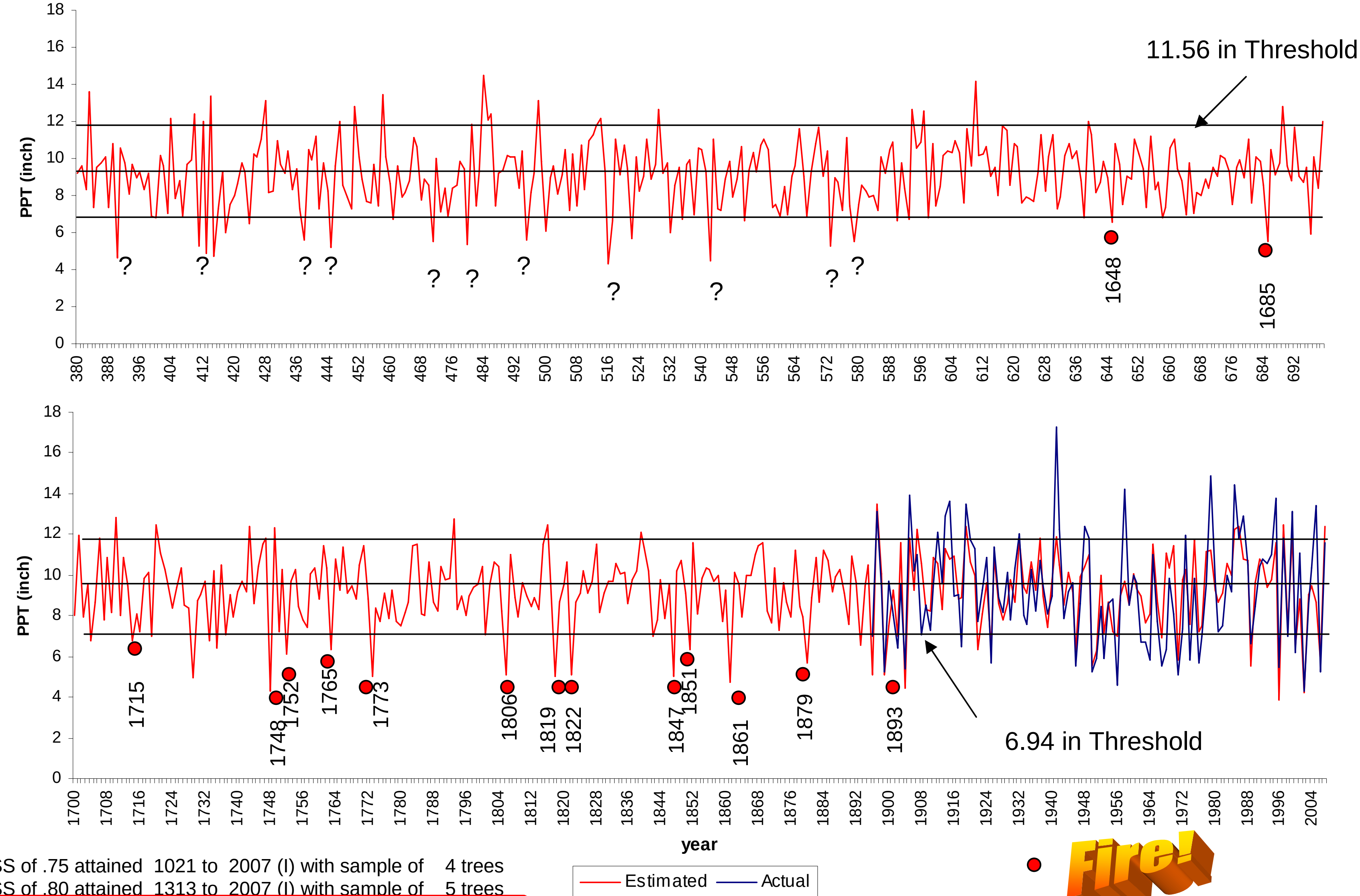
SS of .75 attained 1021 to 2007 (I) with sample of 4 trees
SS of .80 attained 1313 to 2007 (I) with sample of 5 trees
SS of .85 attained 1380 to 2007 (C) with sample of 6 trees
SS of .90 attained 1462 to 2007 (C) with sample of 10 trees

Fire in New Mexico



www.daylife.com/photo/04S3h2V35C76P

TW Swetnam, CD Allen and JL Betancourt, 1999, Applied historical ecology: using the past to manage for the future. Ecological Applications 9(4): 1189-1206.



SS of .75 attained 1021 to 2007 (I) with sample of 4 trees
SS of .80 attained 1313 to 2007 (I) with sample of 5 trees
SS of .85 attained 1380 to 2007 (C) with sample of 6 trees
SS of .90 attained 1462 to 2007 (C) with sample of 10 trees

Conclusions

- Analyzed chronologies are responding to climate - Primarily moisture sensitive for winter precipitation
- Tree rings reflecting patterns and processes at multiple scales:
  – Regional Disturbance Regimes
  – Sea surface and atmospheric circulation patterns
- Dendro is FUN!

Acknowledgements!

Thanks to:

Malcolm Hughes

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Rex Adams

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Ron Towner

Tom Swetnam

Lori Wilson

All LTRR faculty and staff

and all guest lecturers