Validating Historical GCM Simulations of Climate Moisture Variability with Observed and Dendroclimatic Records

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PARC

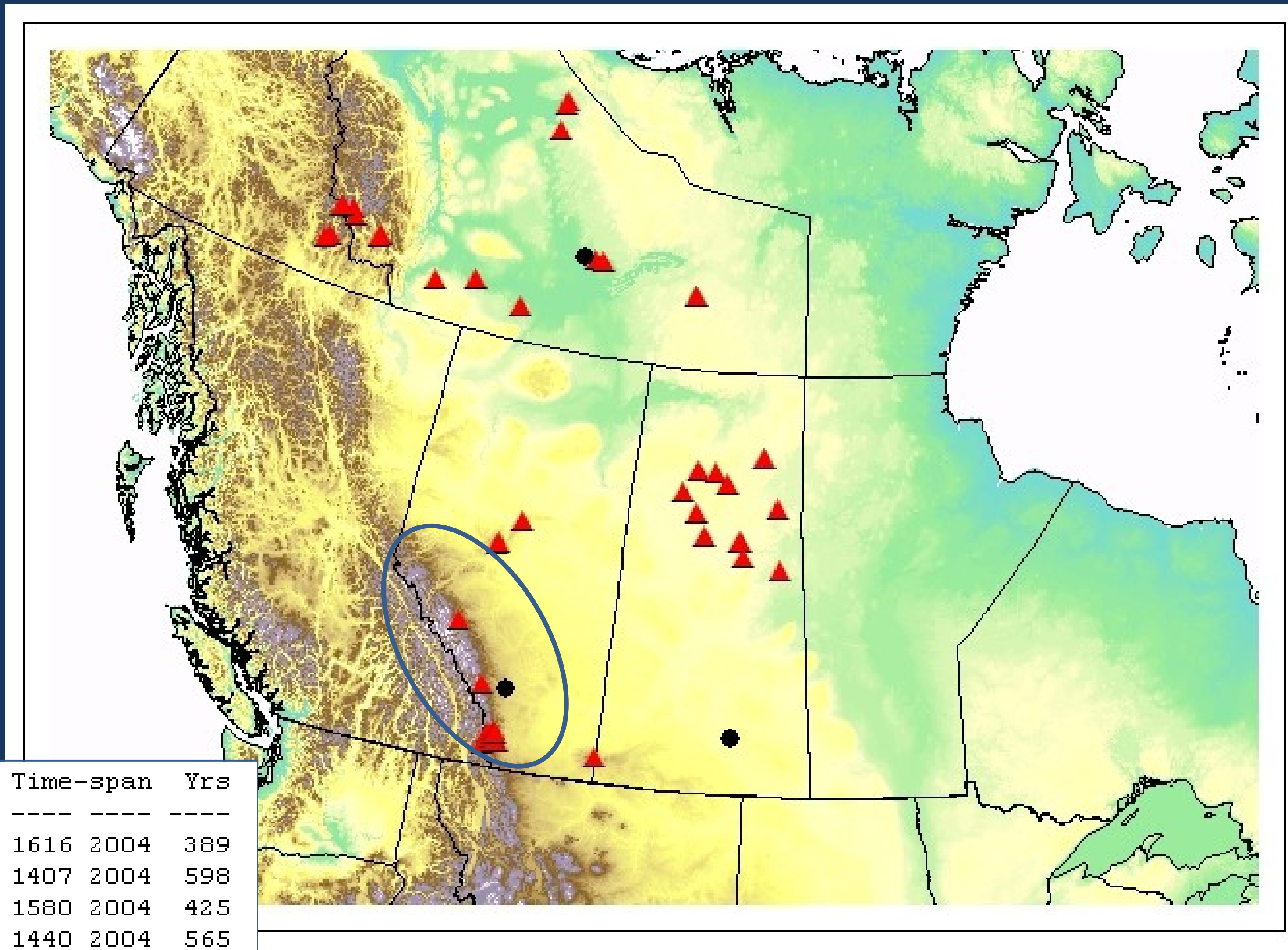
Objectives

1. Determine the relationships between observed climate and natural climate variability for SW Alberta;

3. Identify tree growth response to climate and influences of the large-scale climate forcings, and;

5. Compare and validate climate variability identified in a GCM control run to the observed and proxy climate variability.

Study Area



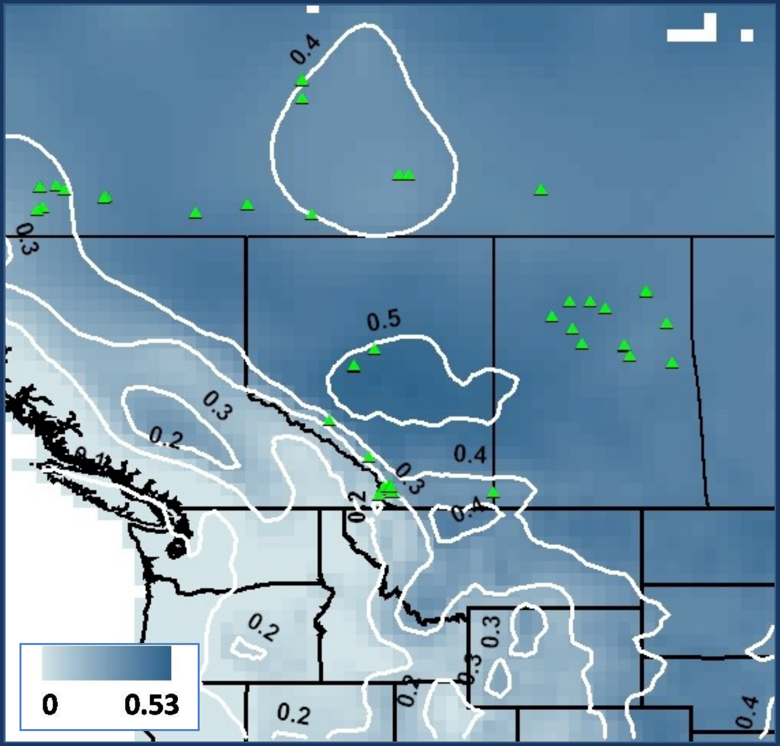
Ident	Seq	Time-span		Yrs
ELK	1	1616	2004	389
ORPf	2	1407	2004	598
BDC	3	1580	2004	425
CAB	4	1440	2004	565
CAL	5	1675	2004	330
DCK	6	1639	2004	366
LBC	7	1595	2004	410
SIP	8	1702	2003	302
WSC	9	1567	2004	438

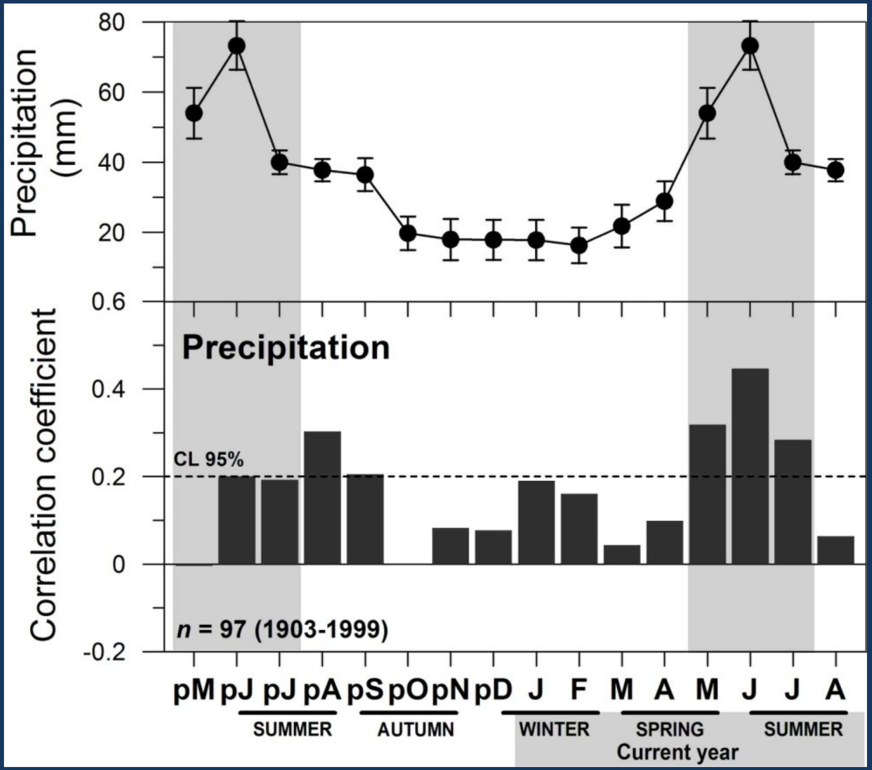
Total: 49 Chronologies

Analysis: 9 SW Alberta (PSME,PIFL)

(PC1): 1702-2003;72.6% variance

Summer/Annual Precipitation





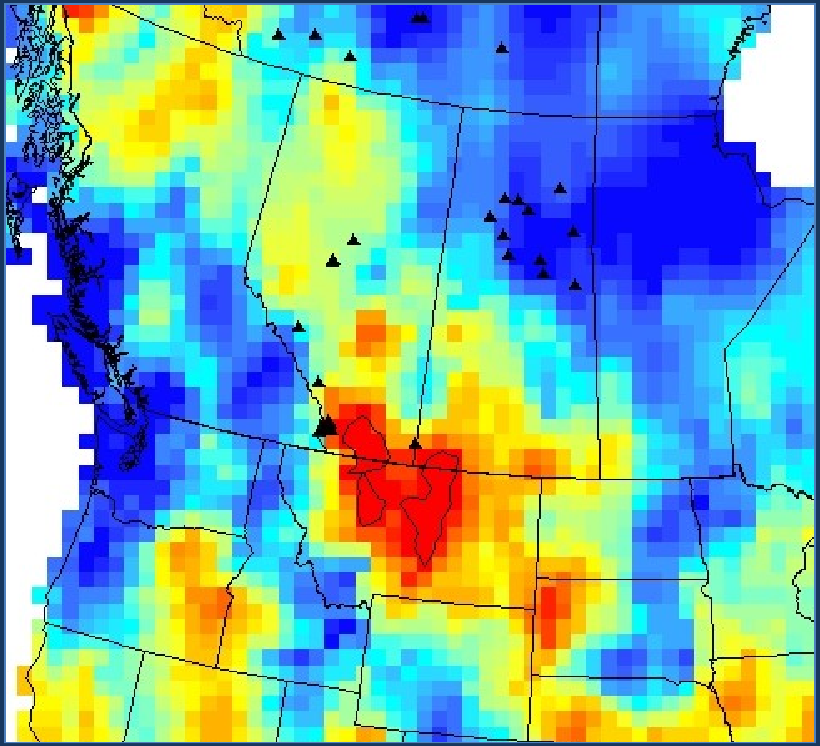
Respond to season of precipitation:

Spring-summer = 6 (LBC, BDC, DCK, SIP, CAB, CAL)

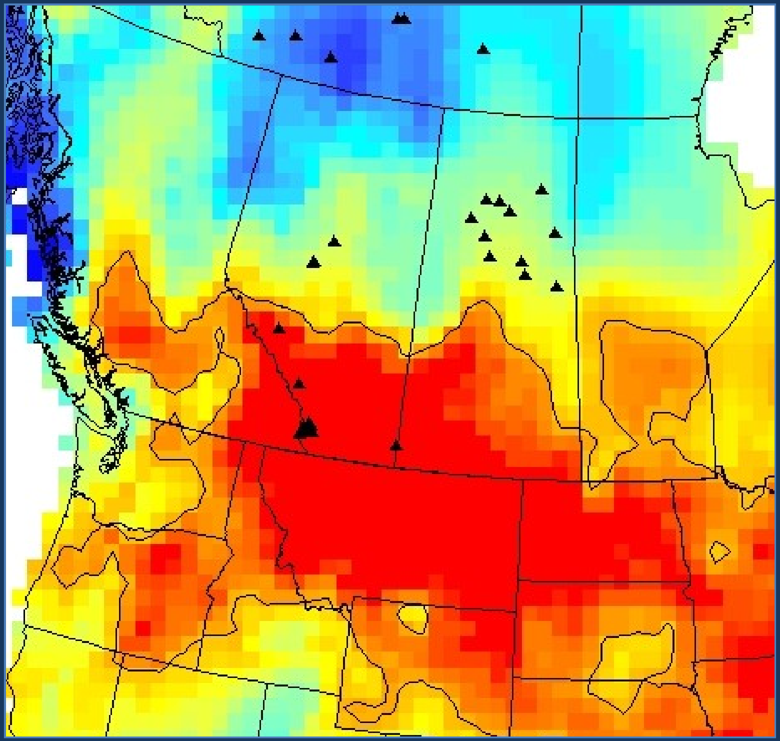
Spring-summer = 2 (**ORPf**, WSC)

Spring-summer = 1 (ELK)

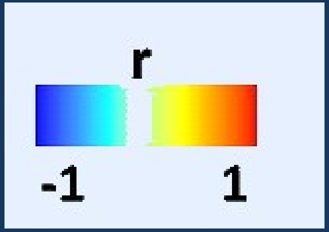
r (PC1,ppt: 1901-2000)

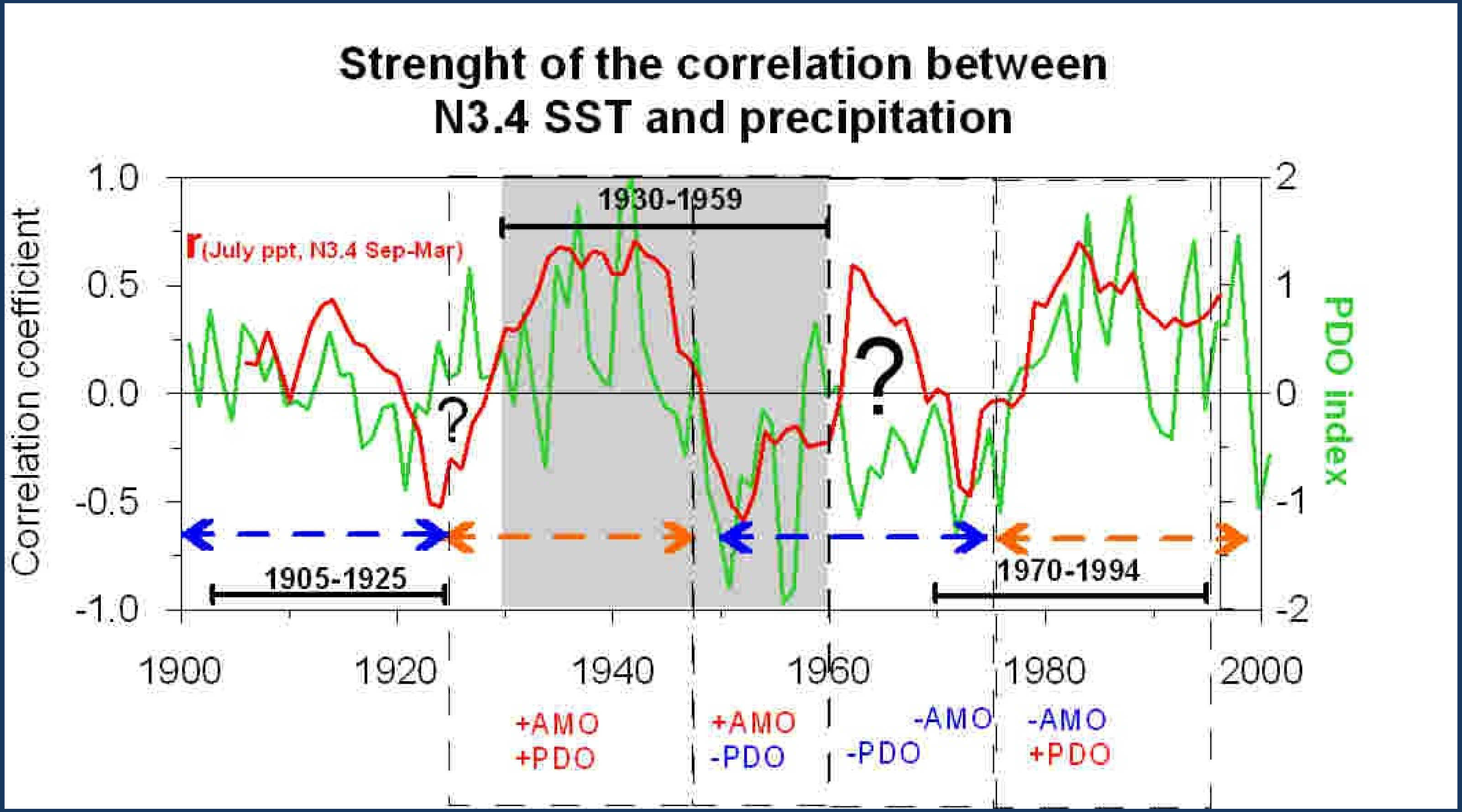


PC1 vs Jan-Feb ppt



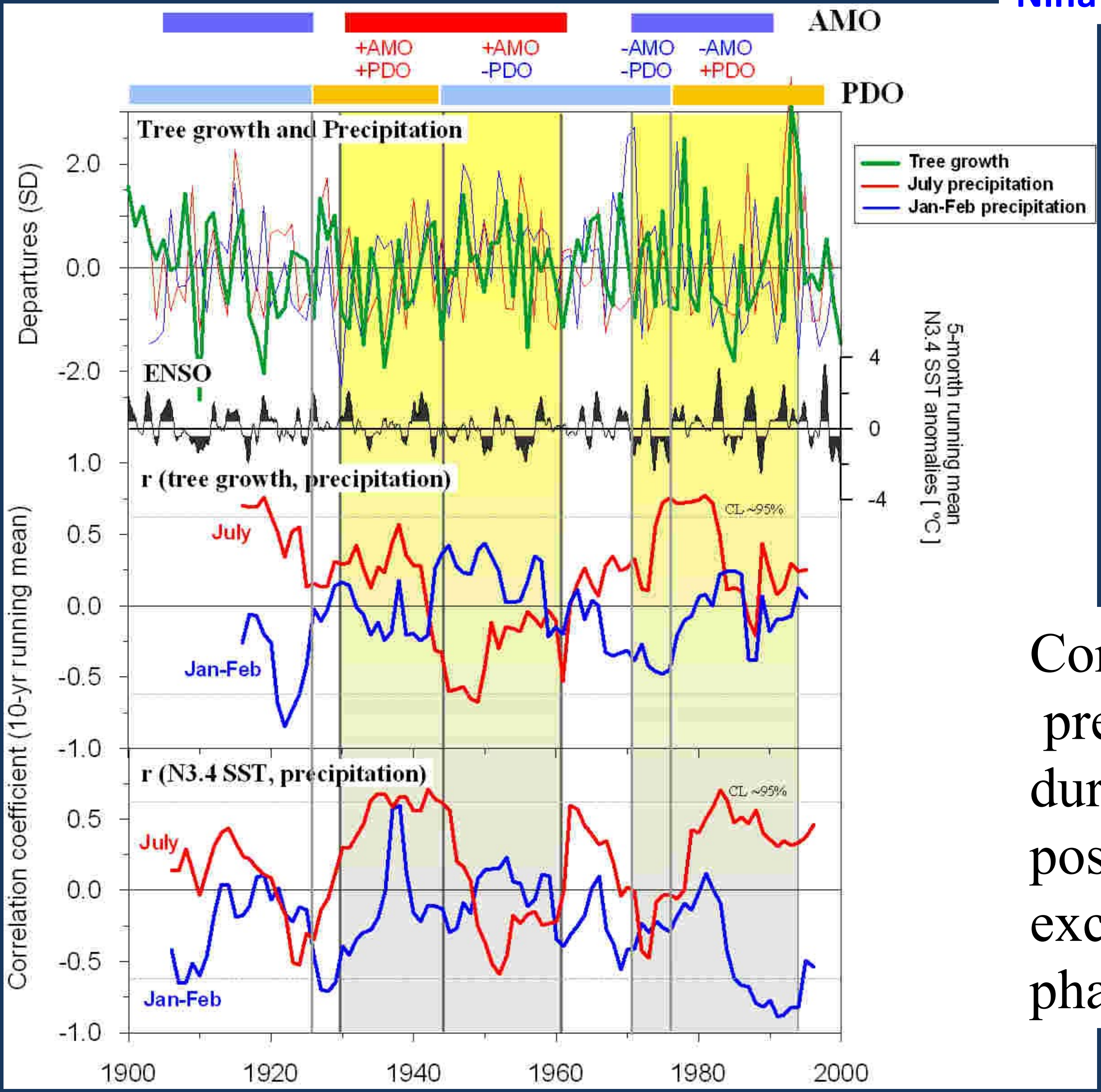
PC1 vs May-July ppt





Correlation of Sep-Mar N3.4 with summer precipitation corresponds to PDO except in 1920-30 and 1960-1970 during the AMO phase change from + to -

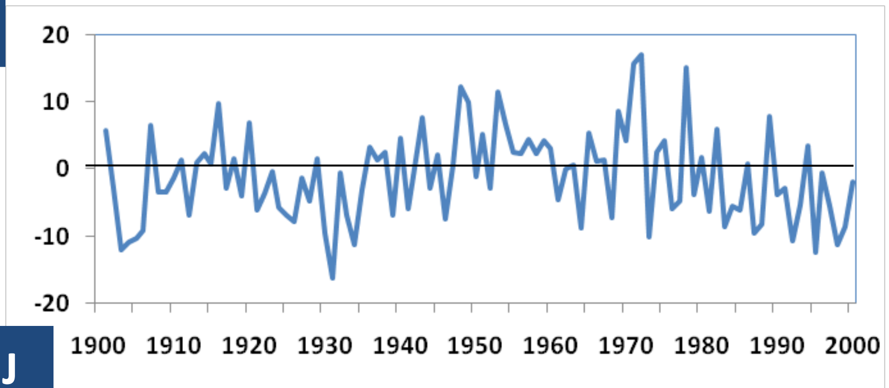
Niño→ summer (+); winter (-)
Niña→ summer (-); winter (+)

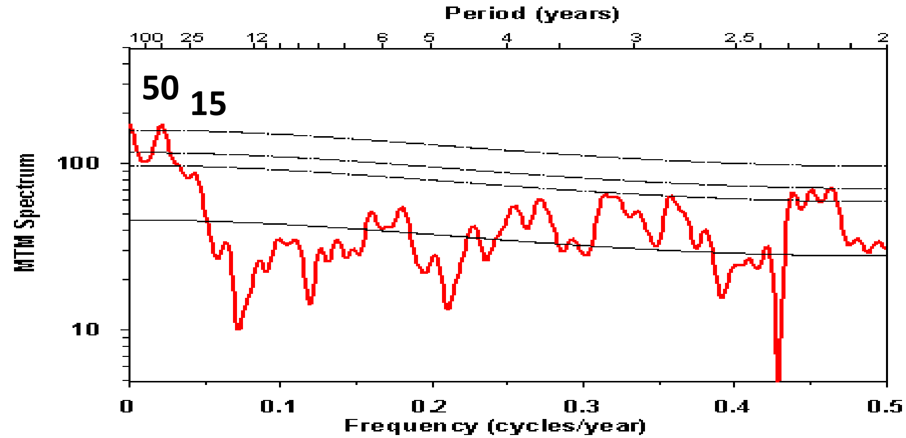


Correlation with summer precip is negative during - PDO and positive during + PDO except during AMO phase change (1960-70)

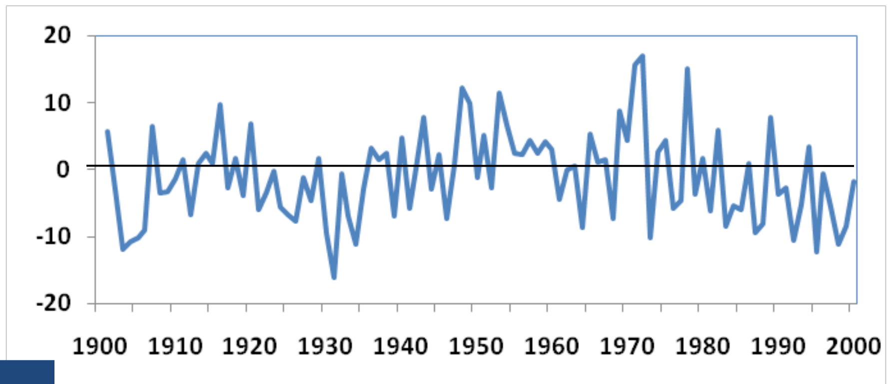
Observed ppt vs PC1

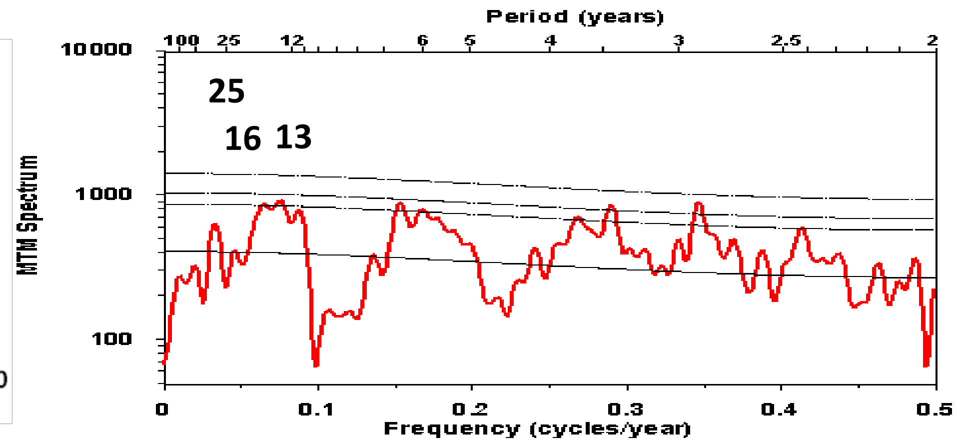
JF



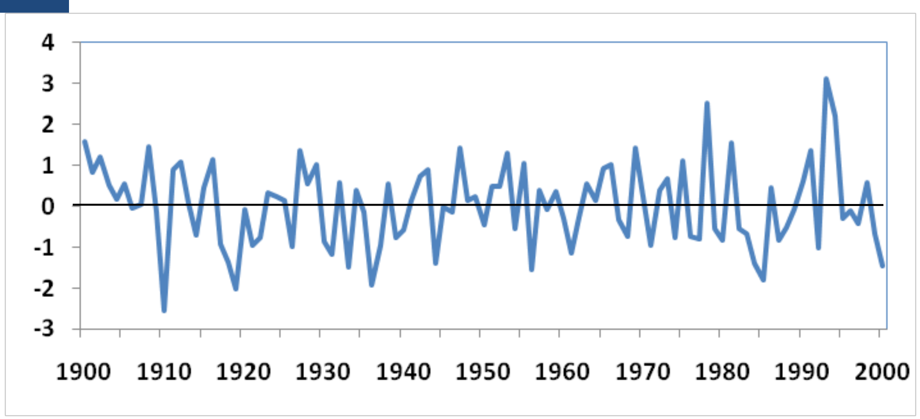


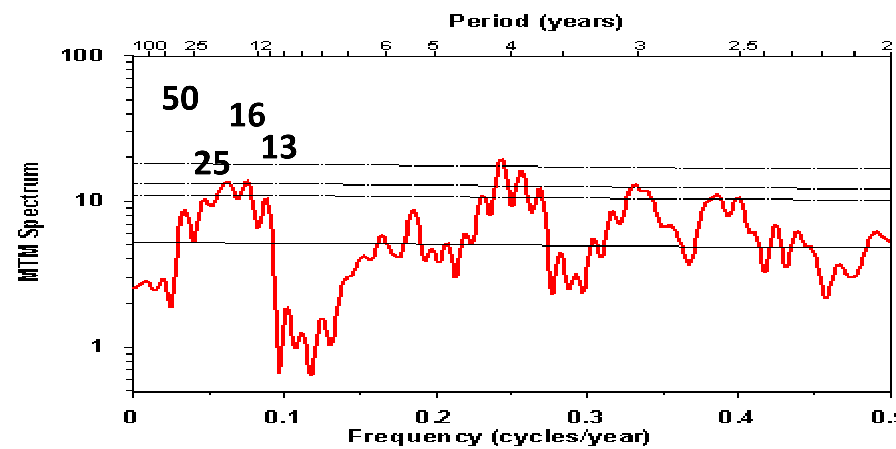
MJJ



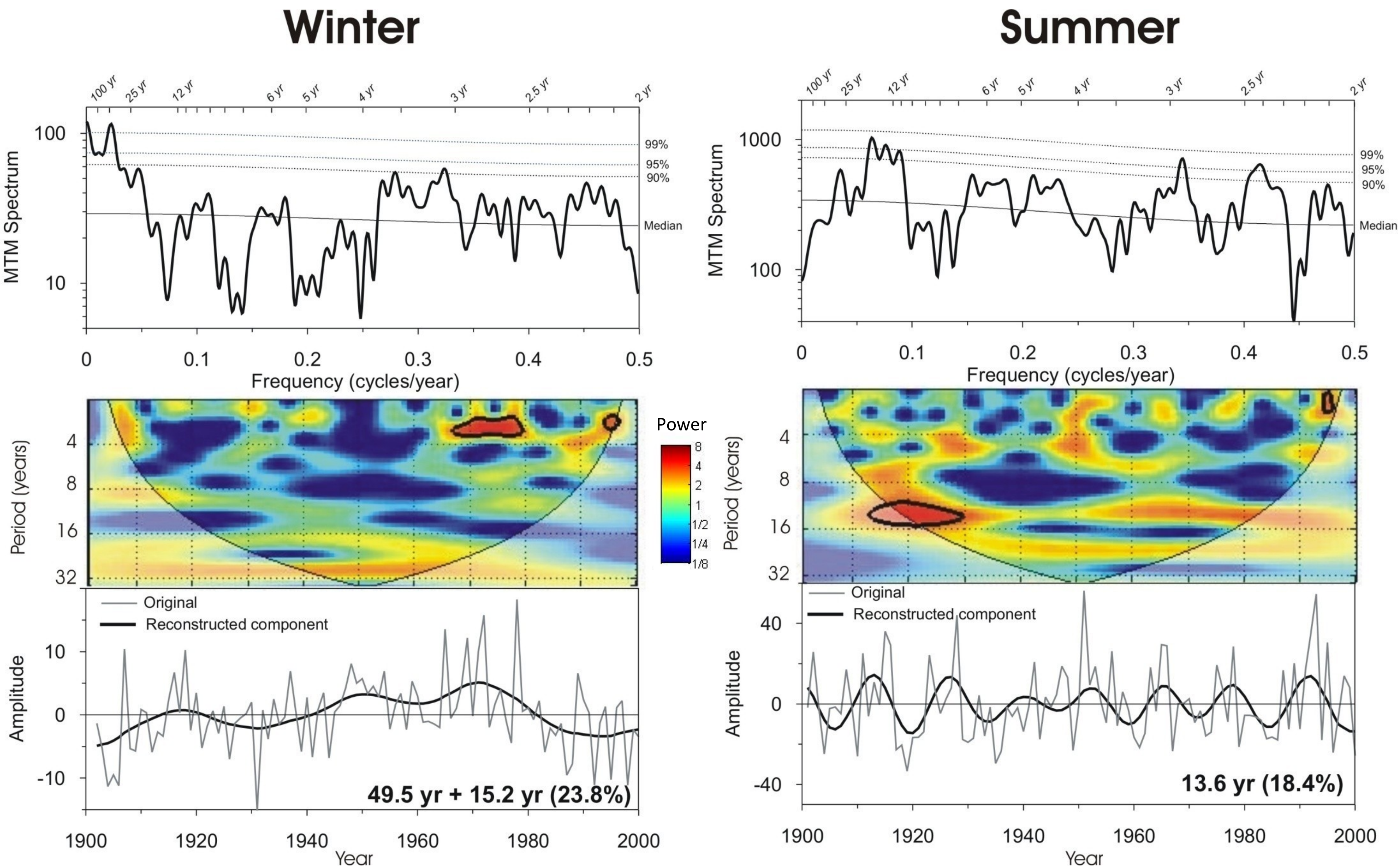


PC1



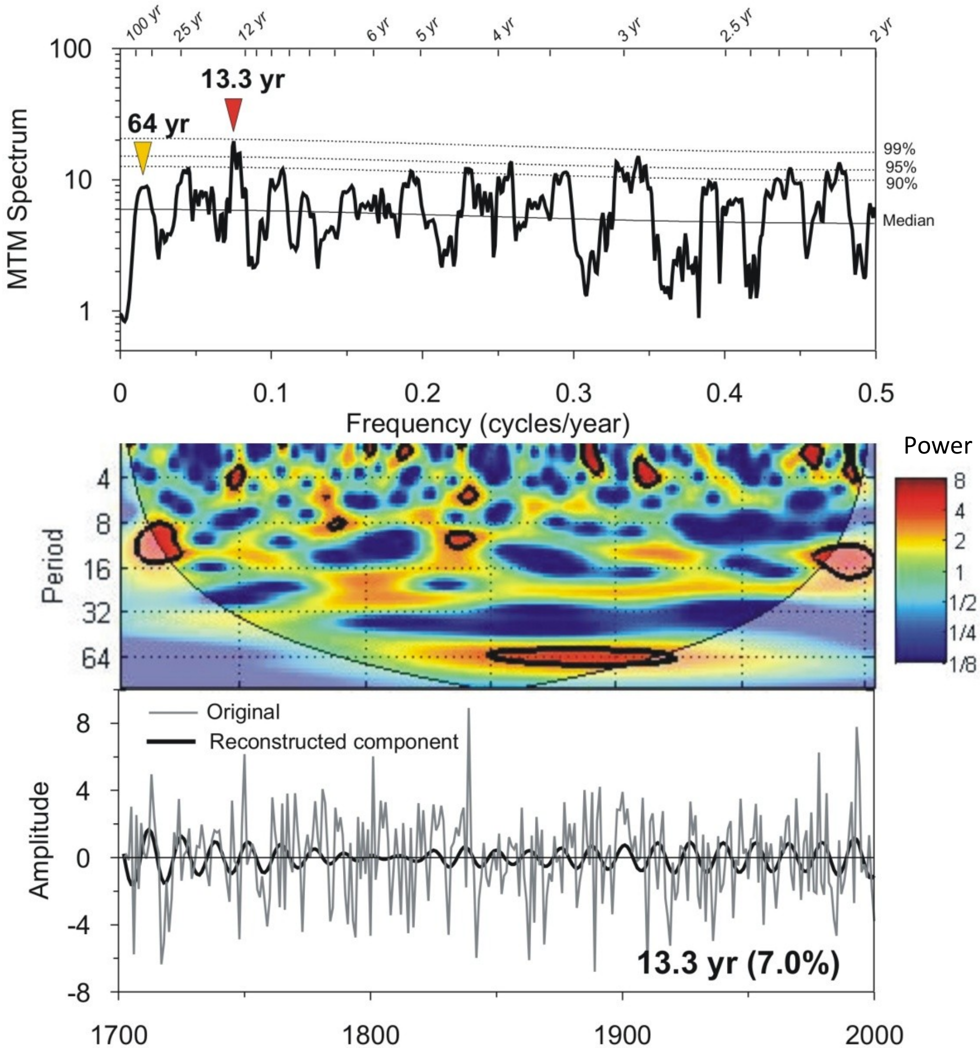


Different signals in winter and summer observed precipitation



Multidecadal modes in winter precipitation in contrast to summer where there is a strong decadal oscillation

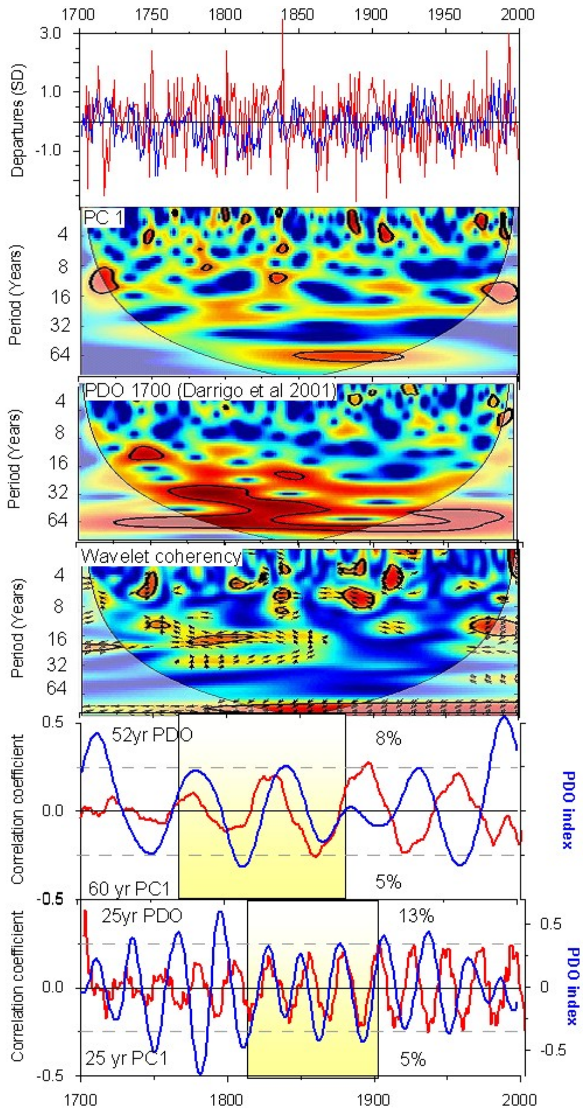
Low-frequency signals captured by the SW AB tree rings



Tree rings capture the 13.3 yr and ~64 yr summer and winter signals, respectively

The 13.3 yr signal is stronger than the multidecadal winter-related signal

Non stationary
PDO multidecadal tree-ring/moisture variability



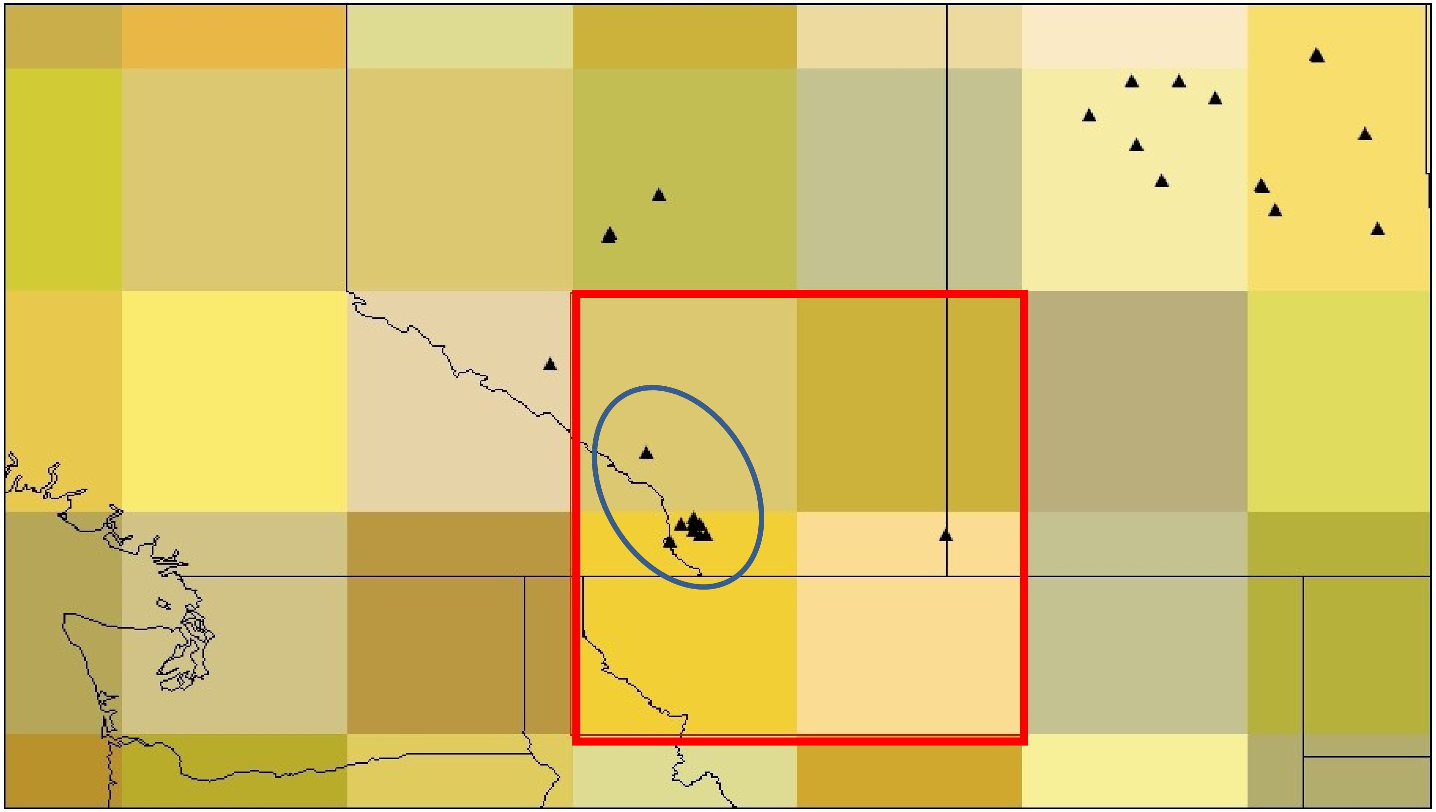
Tree rings are capturing decadal and multidecadal PDO signal representing winter precipitation.

Mantua and Hare (2002) identified "energetic" 15-25 and 50-70 year signals during the 20th Century.

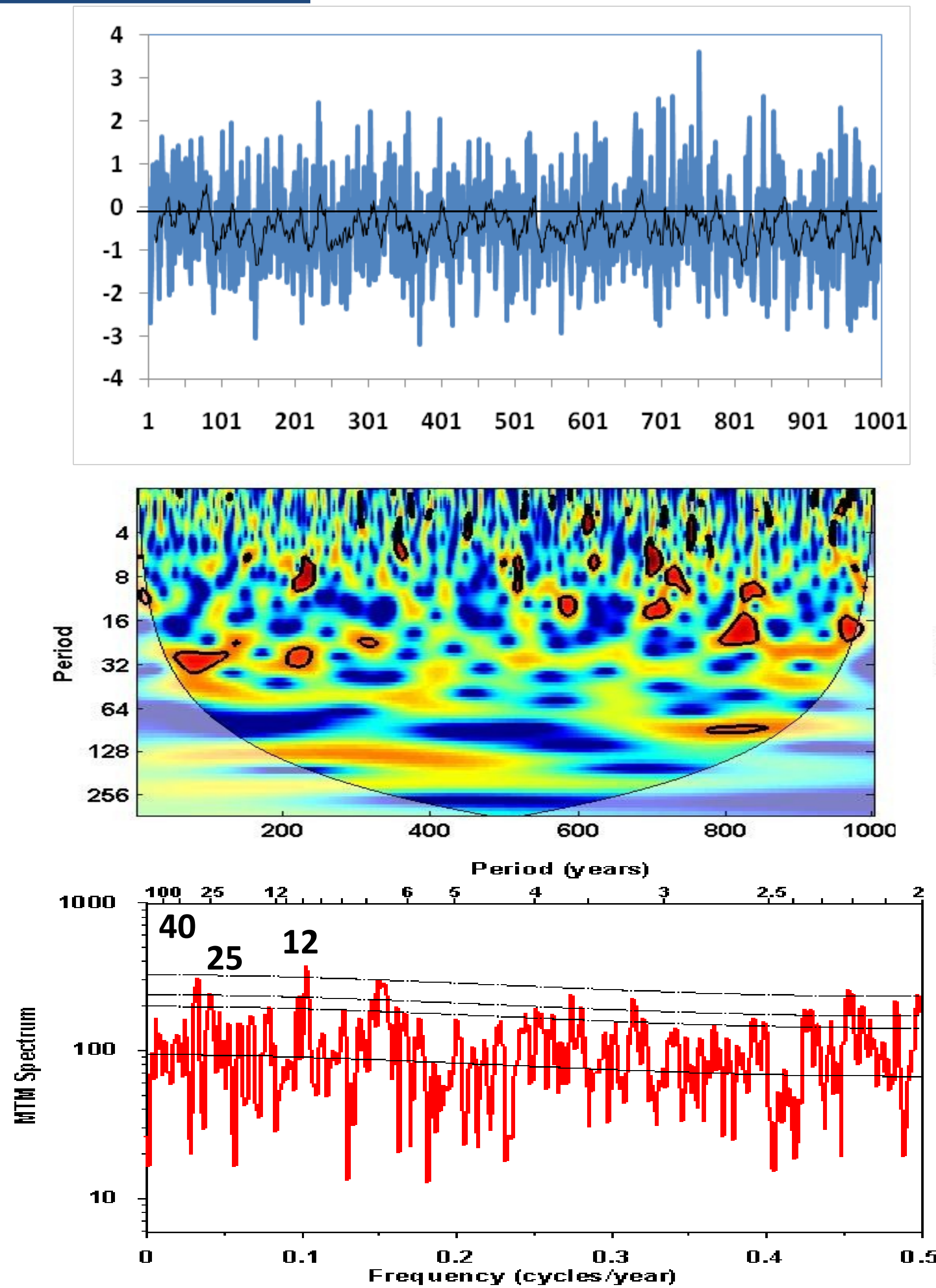
Comparing variability of GCM to tree-rings

CGCM3.1/T47: Pre-Industrial Control Run 1: 1001 yrs

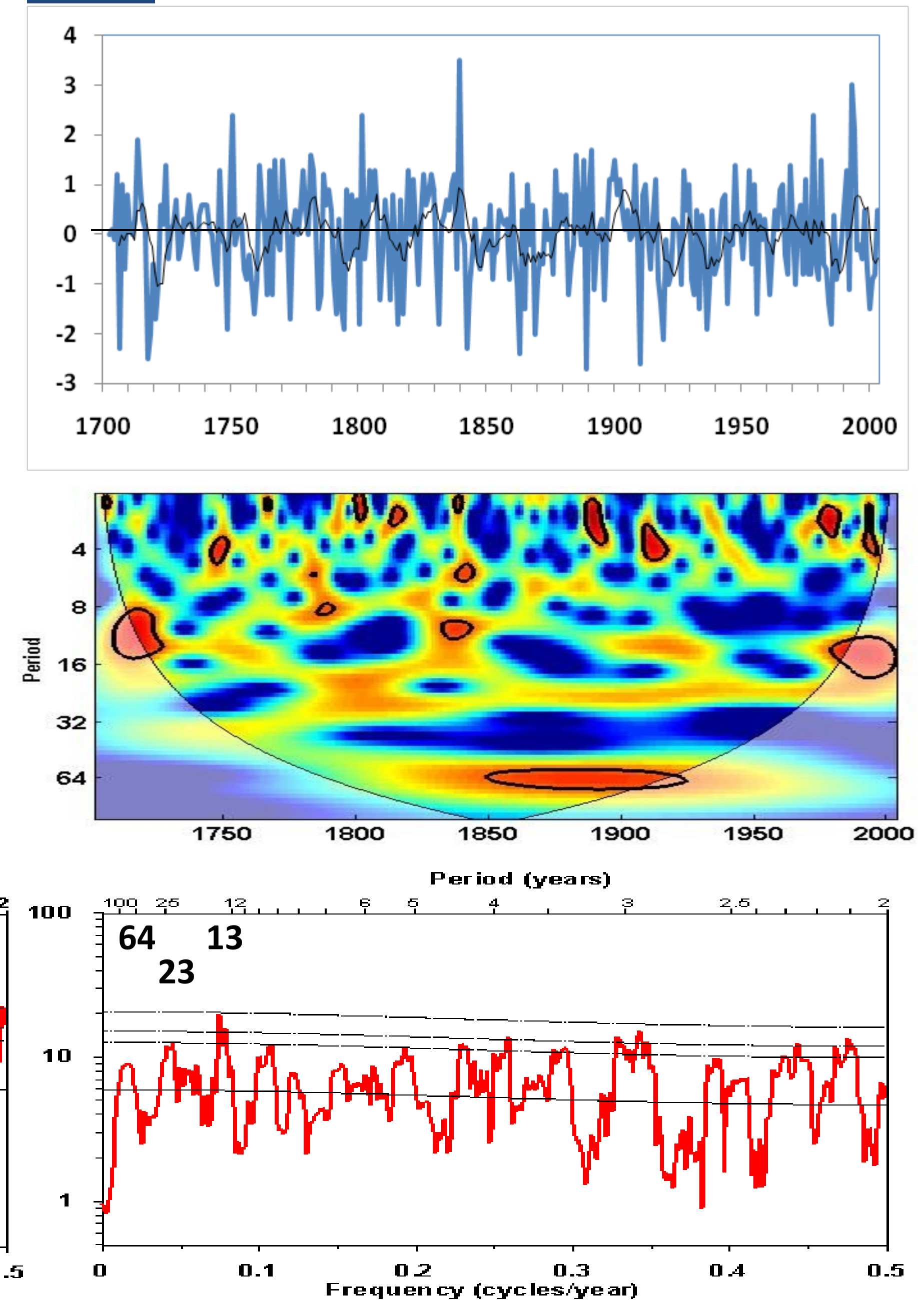
- unforced by changes in GHG and solar variability – represents the internal climate system variability
- important for detection, attribution, and prediction of climate change



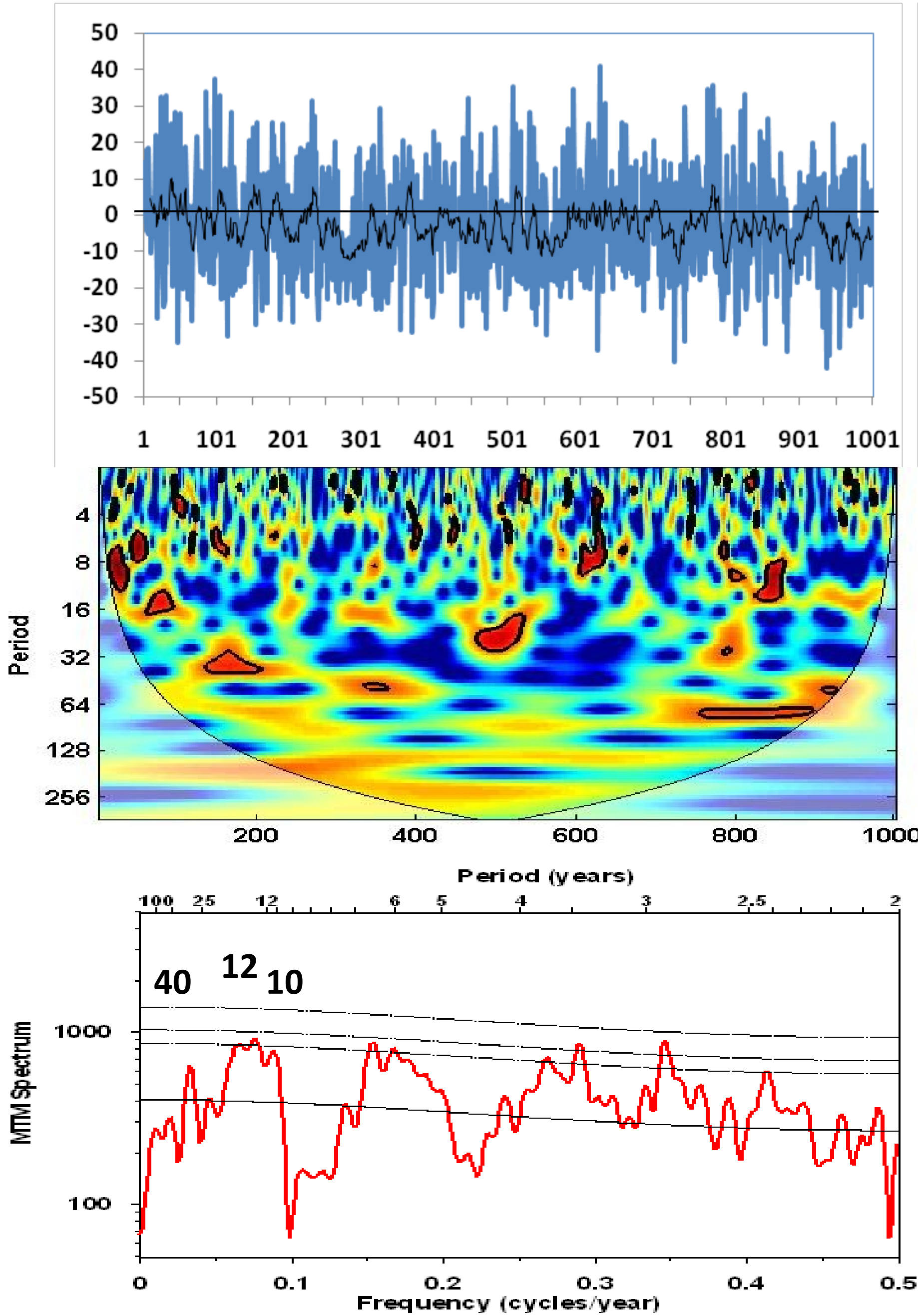
CGCM Jan Feb



PC 1

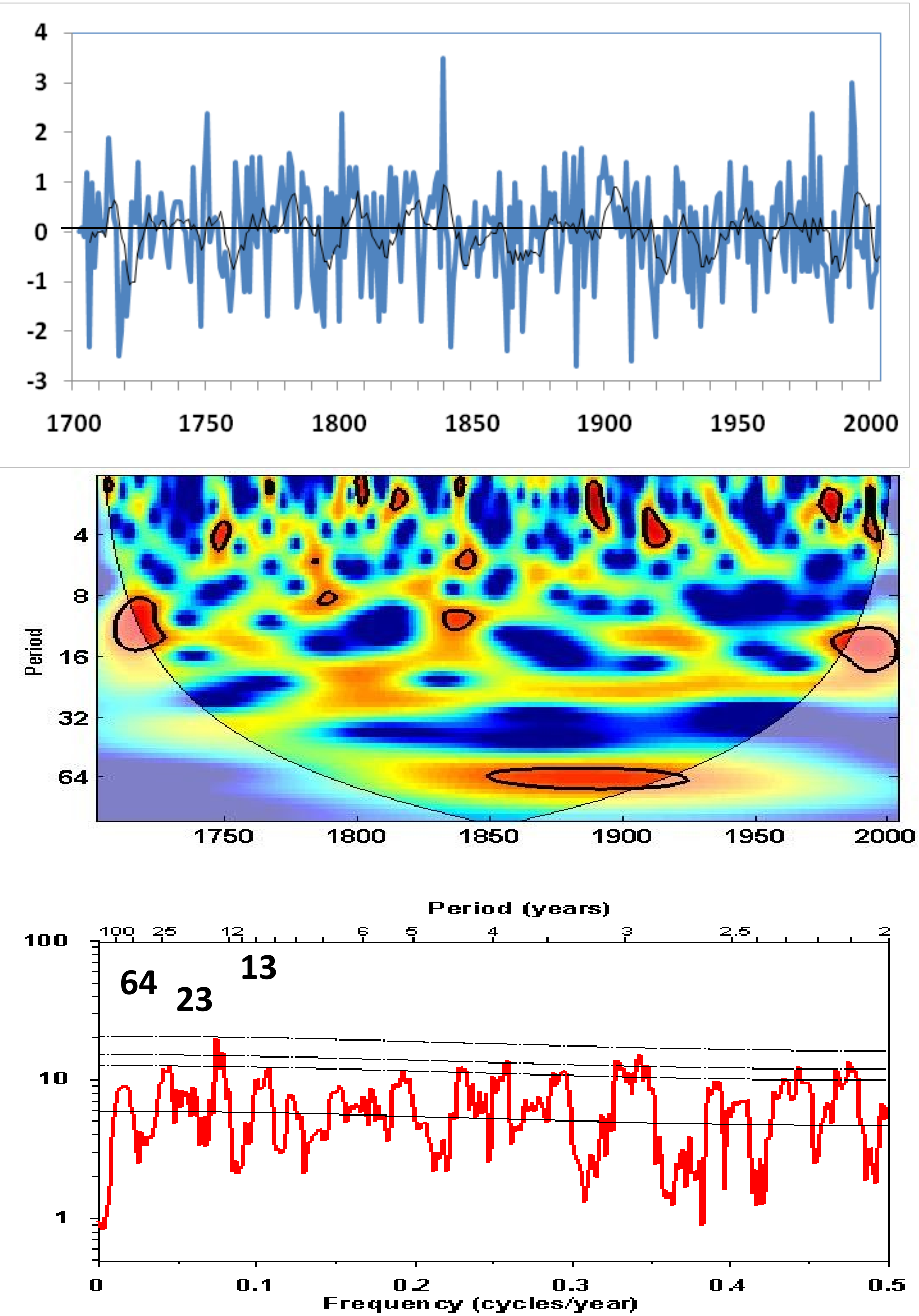


CGCM MJJ



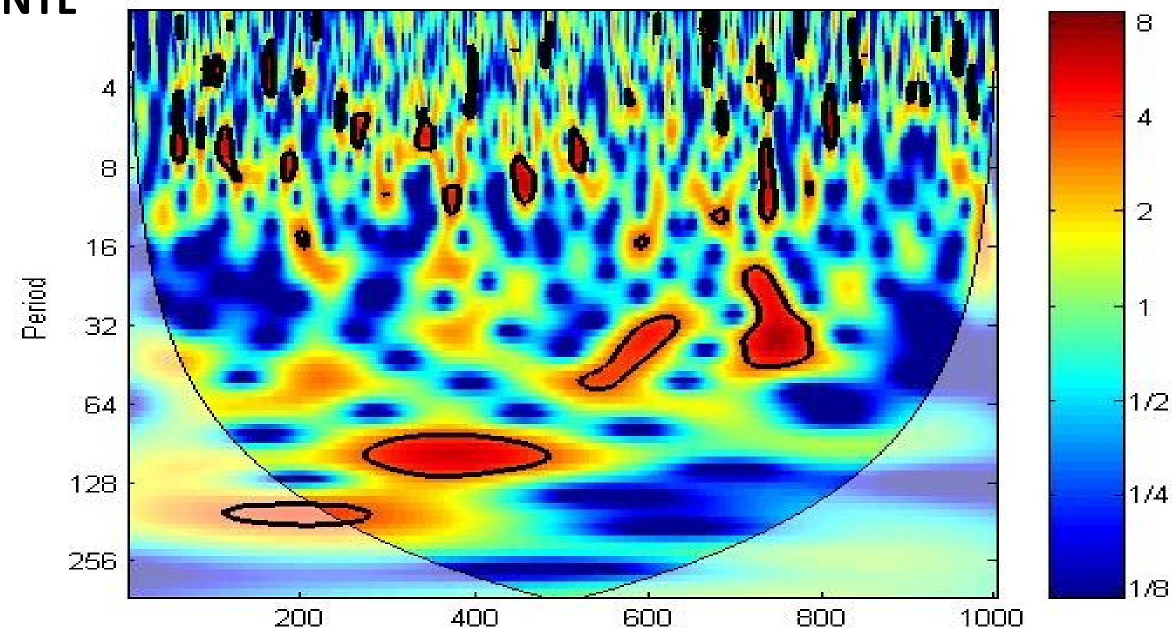
Period
Period (years)
40
12
10
MTM Spectrum
Frequency (cycles/year)

PC 1



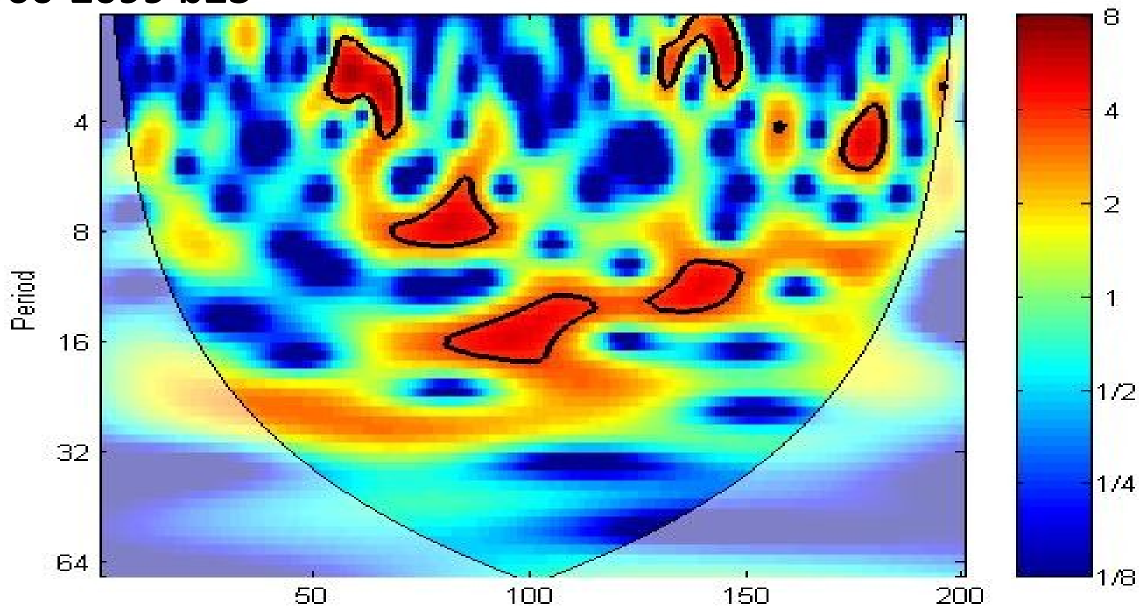
Period
Period (years)
64
23
13
Frequency (cycles/year)

CNTL



CGCM2 MJJ
P-PET (PC1)

1960-2099 b23



Summary

Western Canadian climate variability is linked to teleconnections
(PDO, AMO, ENSO)

Non-stationary climate

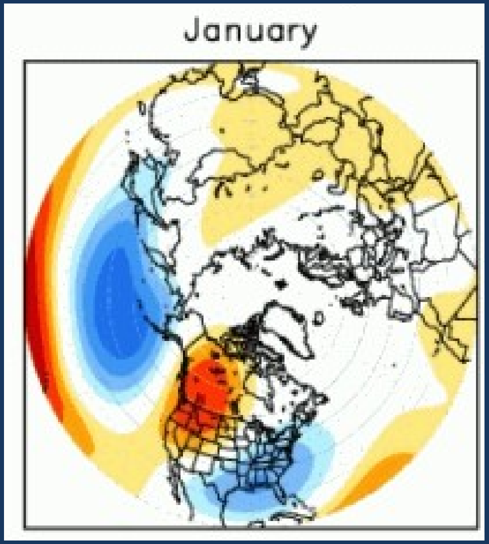
PC1 not capturing the power of the spectra from individual sites

The GCM control run appears to be capturing some of the large-scale variability for winter (25, 64 yr) and summer (12 yr) seasons

What's next??

Compare 20th Century and future GCM runs to the Control run - identify shifts in climate cycles related to anthropogenic forcings.

Identify monthly/seasonal circulation patterns to better understand the drivers of climate and precipitation – particularly drought.



www.cpc.noaa.gov

Acknowledgements

PARC: Prairie Adaptation Research Collaborative
NSERC : Natural Science and Engineering Research Council of Canada
AICWR: Alberta Ingenuity Center for Water Research
IAI CRN 11

Significance of work?

Drought events in western North America have been linked to natural climate variability modes such as ENSO, PDO, PNA and AMO

GCMs "... are the only credible tools currently available for simulating the response of the global climate system to increasing greenhouse gas concentrations" (IPCC-TGCIA, 1999) to forecast future climate scenarios

The credibility of a GCM depends on its ability to replicate past climate; therefore multicentury reconstructions are used to validate the variability of a climate model on century timescales

1. Data sets

- Gridded 0.5x0.5^{o} precipitation data (Canadian Forest Service)
- New tree-ring dataset (PARC)
- Observed Climate Indices:
  - PDO: http://www.atmos.washington.edu/~mantua/abst.PDO.html
  - AMO: http://www.cdc.noaa.gov/Timeseries/AMO/
- Reconstructed Climate Indices:
  - AMO: Gray et al. 2004 (1572-1985)
  - PDO: Darrigo et al 2001 (1700-1997)
- CGCM3.1 /T47 Pre-Industrial 1001 yr run: (www.cccma.ec.gc.ca)

2. Analysis

1.PC analysis of chronologies
2.Identify relations between forcing indices and precipitation
3.Wavelet/Spectral analysis: observed ppt for JF/MJJ identifing climate signals and periods
4.Compare spectra of observed ppt, tree-ring and climate indices
5.Spectral analysis: GCM seasonal precipitation
6.Compare spectra of GCM and seasonal ppt and tree-ring signal: test model reliability