DIAGNOSIS OF CHANGING COOL SEASON PRECIPITATION STATISTICS IN THE WESTERN U.S. FROM 1916-2003

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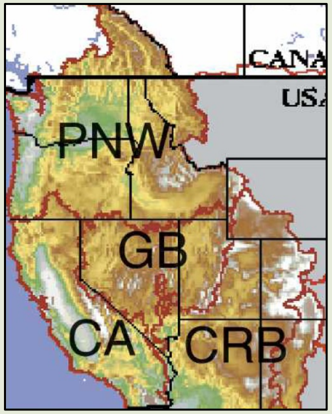
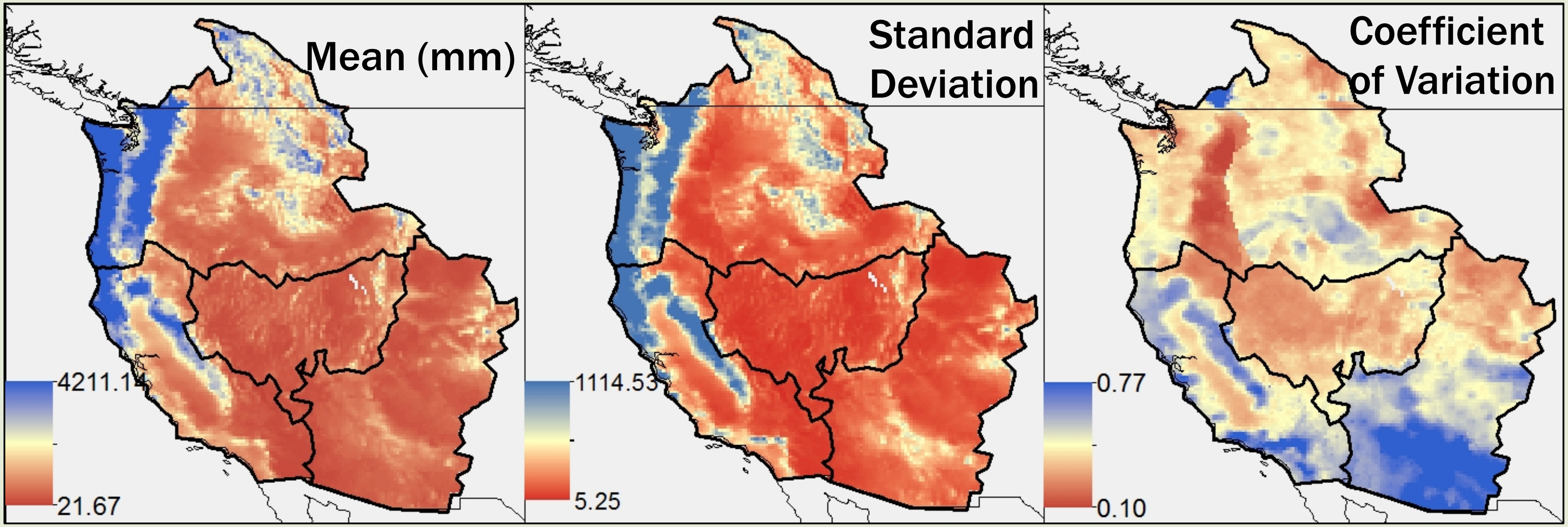
OUTLINE

- Motivation
  - Why we're studying cool season precipitation statistics.
- This Study (Part 1): Telling the Statistical Story
  - Trying to answer questions about trends and changes in variance.
  - We'll throw around cool season statistics and a few colorful graphs.
- This Study (Part 2): EOF Analysis
  - What can we learn from the leading modes?
  - Interested in the reduced dipole signal.
- Conclusions
  - Implications of changing precipitation regimes.
  - What does the paleo-record tell us?
  - Can we distinguish between green house gas forced climate change and natural variability?

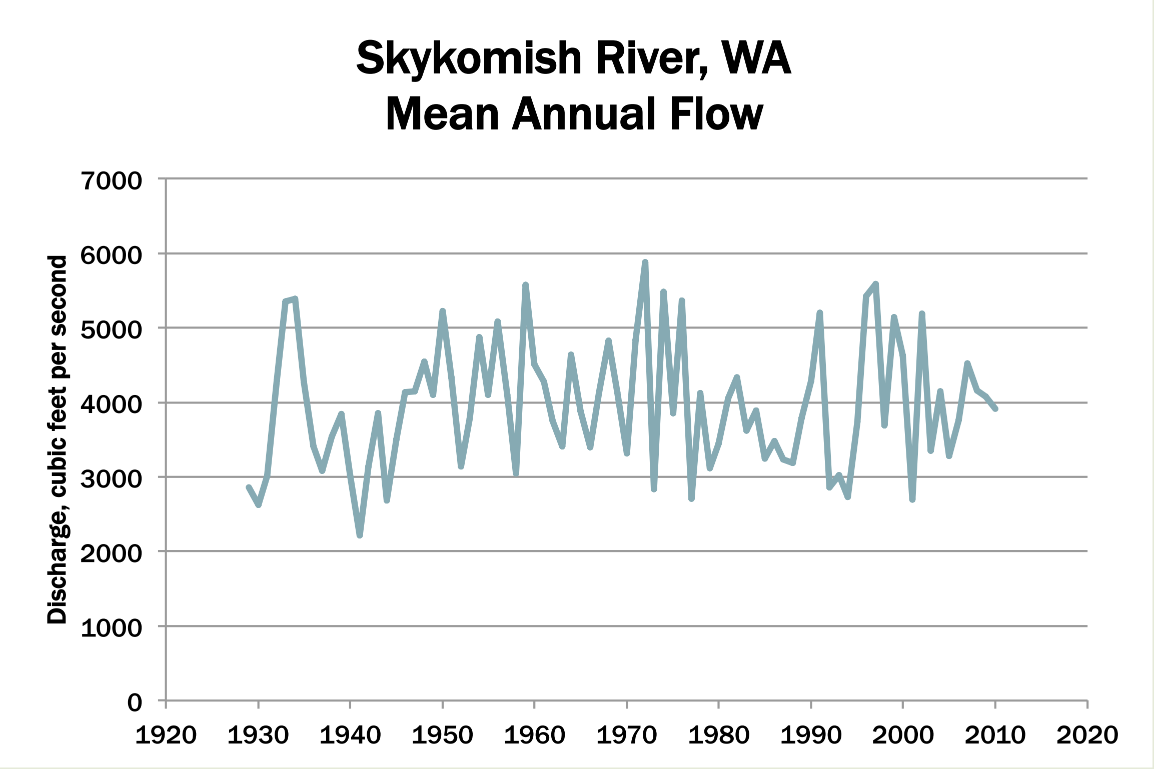
THE DATA

- Source:
  - Hamlet, A. F., & Lettenmaier, D. P. (2005). Production of Temporally Consistent Gridded Precipitation and Temperature Fields for the Continental United States. Journal of Hydrometeorology, 330-336.
- $1/16^{th}$ degree grid cells
- Cool Season (Oct – Mar) totals for each grid cell
- Period of Record: 1916 - 2003



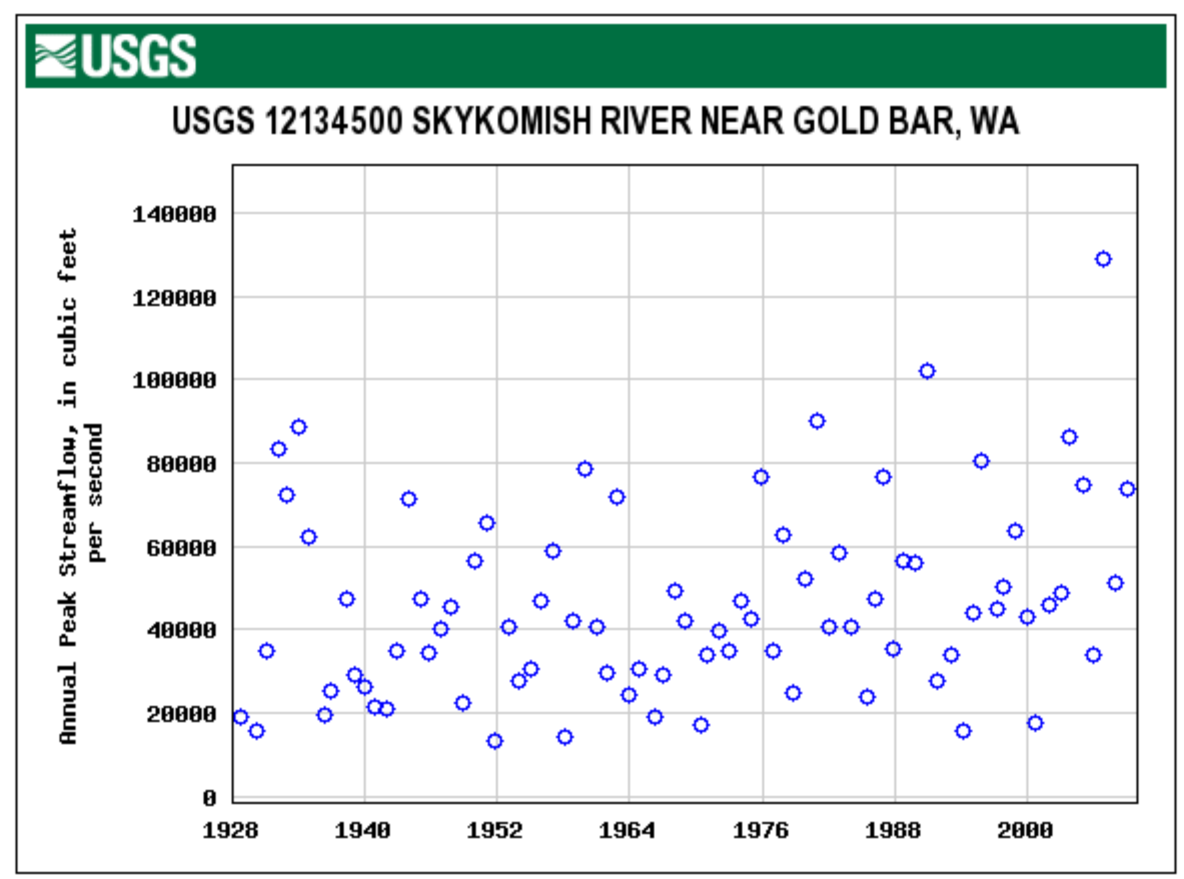


MOTIVATION



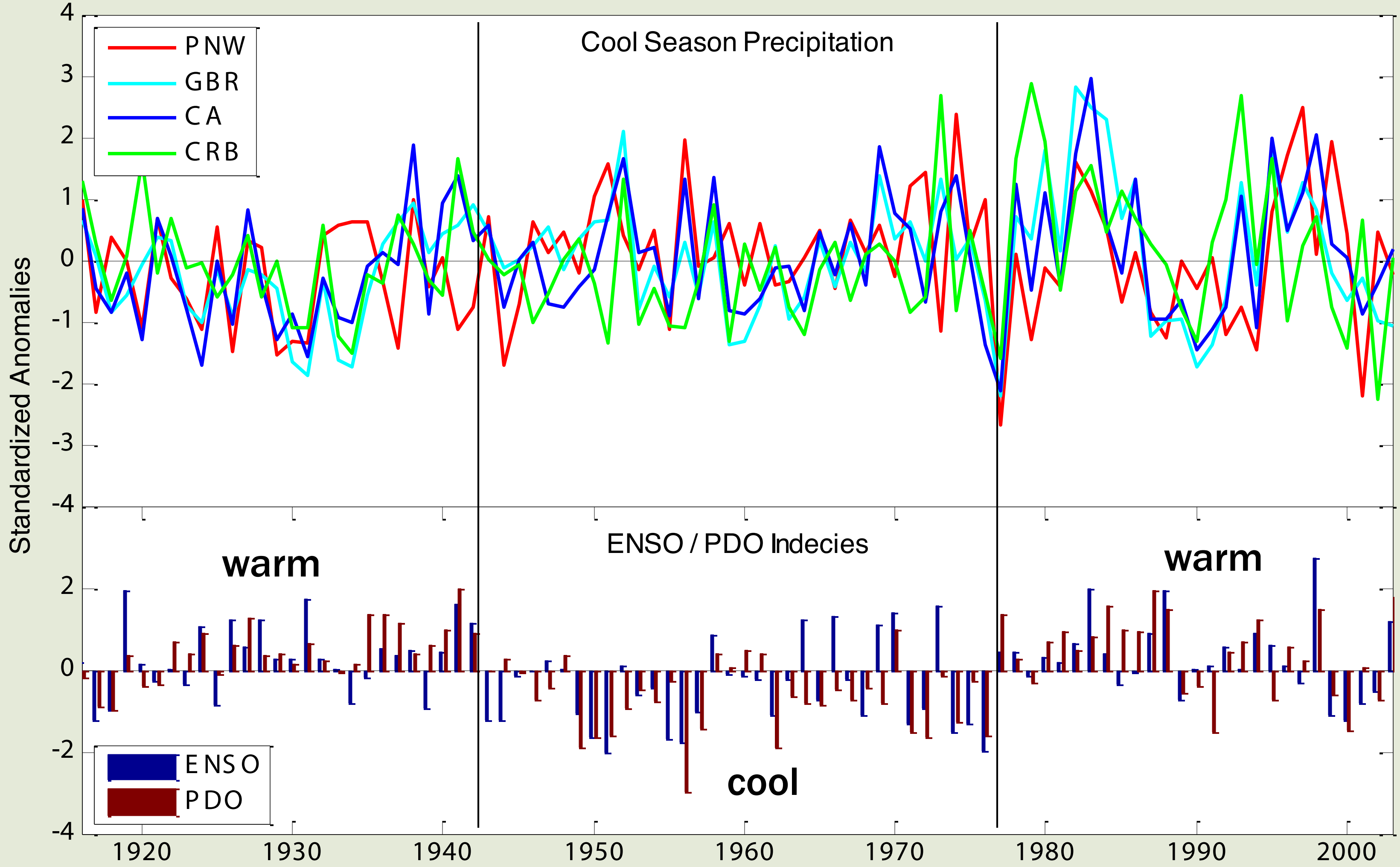
- Mean Annual Streamflow
  - Strong interannual variability
  - Mountainous west is heavily dependent on winter precip for summer flows
  - Implications for hydropower, agricultural and in stream uses

MOTIVATION



- Peak Annual Streamflow
  - Observed expanded variance
  - Implications for flood control
- Is this increase in variance part of natural variability?

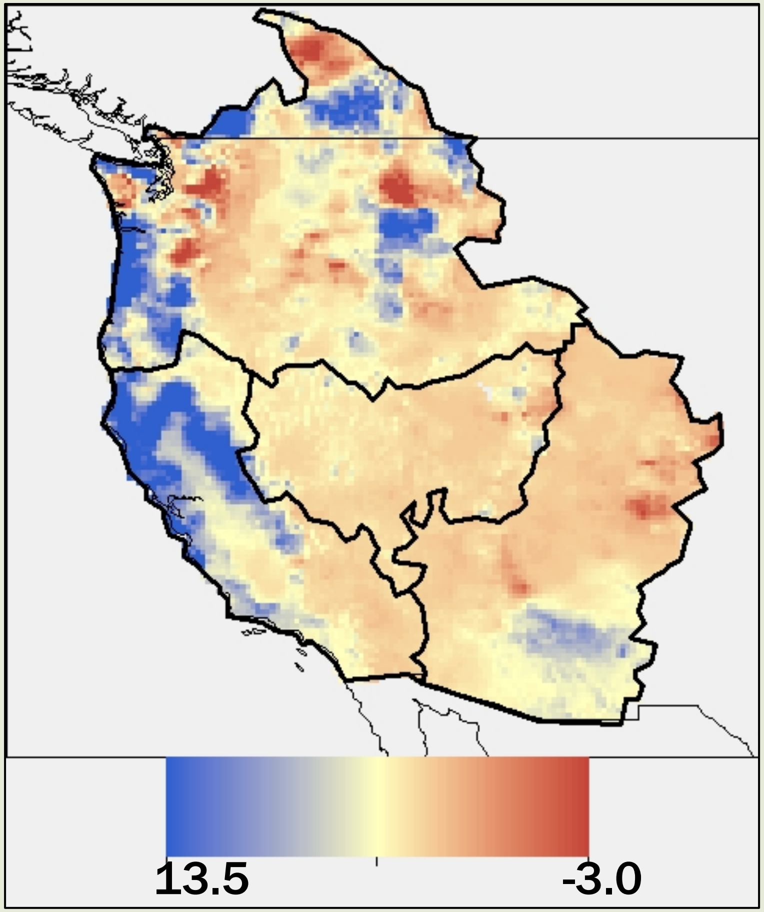
MOTIVATION



Cool Season Precipitation
PNW
GBR
CA
CRB
Standardized Anomalies
4
3
2
1
0
-1
-2
-3
-4
ENSO / PDO Indecies
warm
cool
warm
2
0
-2
-4
ENSO
PDO
1920
1930
1940
1950
1960
1970
1980
1990
2000

TRENDS IN COOL SEASON PRECIPITATION

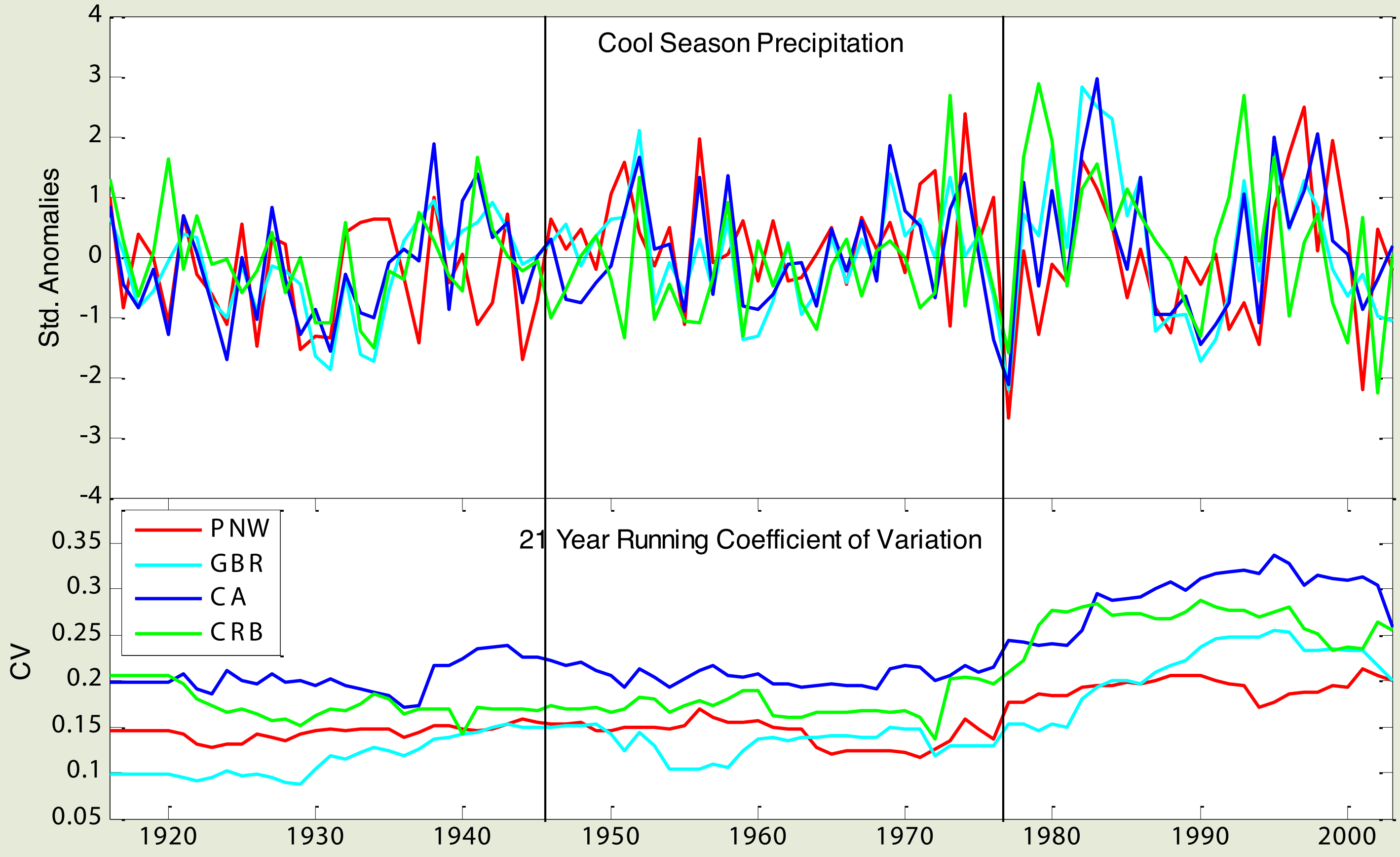
- Largest positive trends are along coast
- All 4 regions were wetter after 1977
  - Regional trends are only significant in the Colorado River Basin post 1977
  - Other regions do not show significant changes post 1977



Cool season precipitation trends (1916-2003)

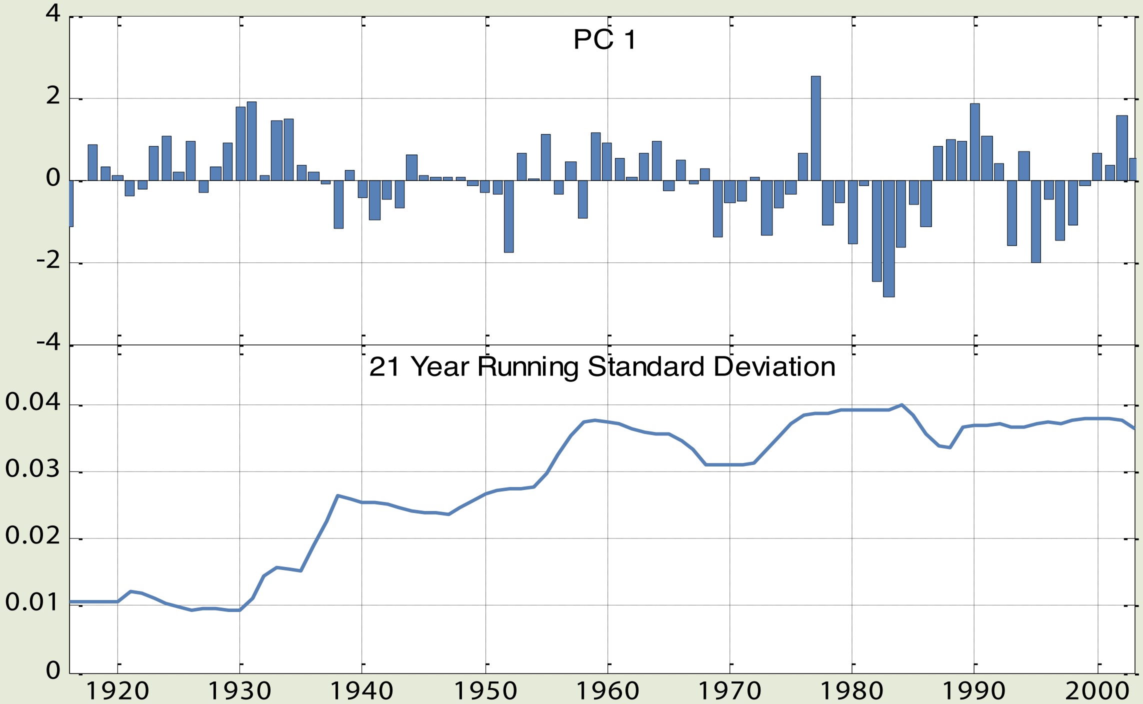
OBSERVED CHANGES IN VARIANCE

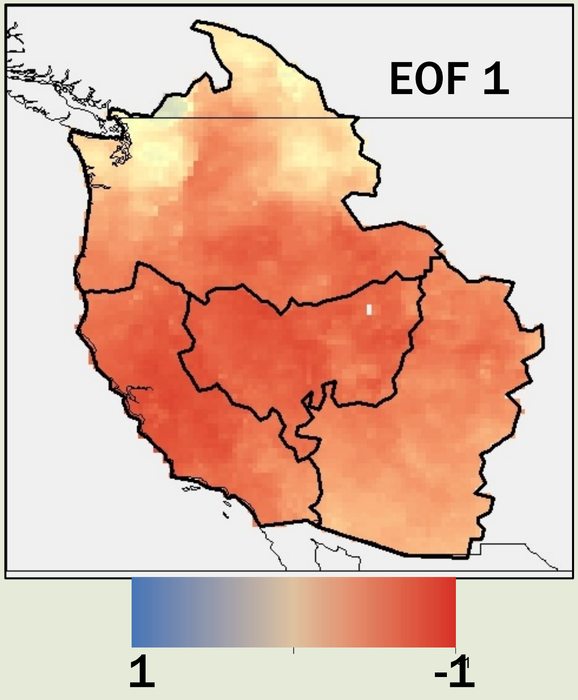
- Statistically significant change in variance ($p < 0.05$) in all four regions after 1977.



EOF ANALYSIS
MODE 1

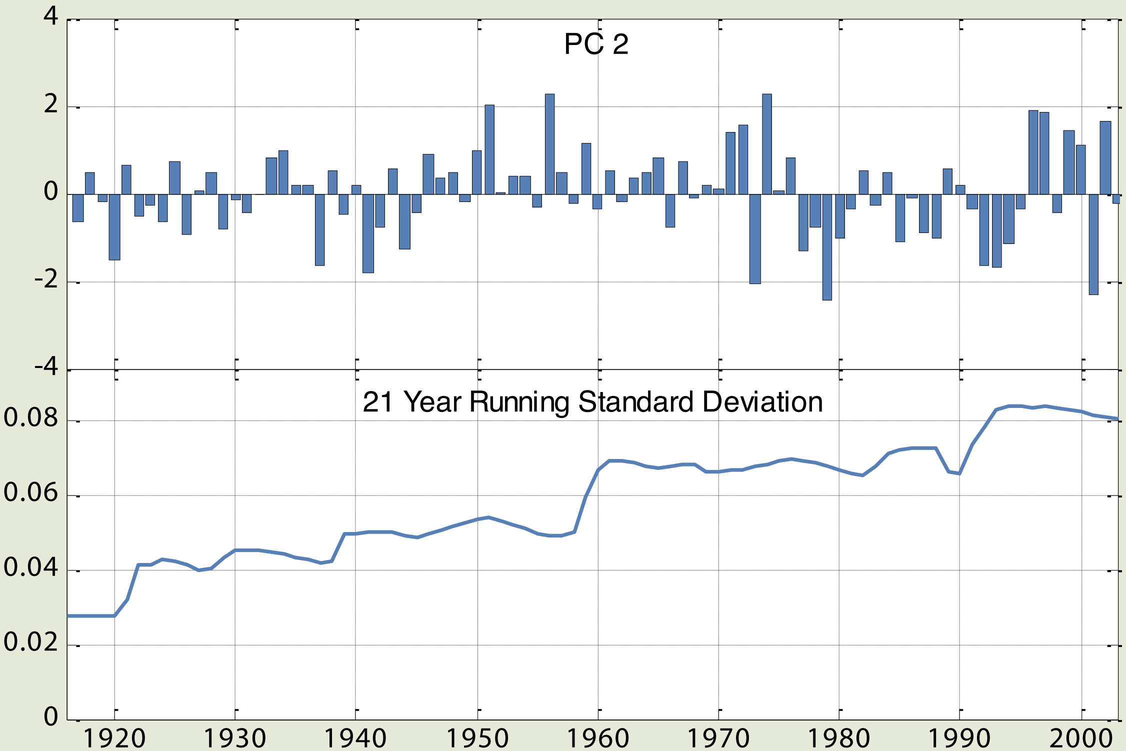
- Represents west wide synchronicity.
- Variance increases earlier than in observed record.
- The expansion of variance in PC1 explains both increased variance and increased regional coherence in the regional average time series.
- PC1 shows more red noise characteristics post 1975 indicating increasing persistence and amplitude of cohesion throughout the west.

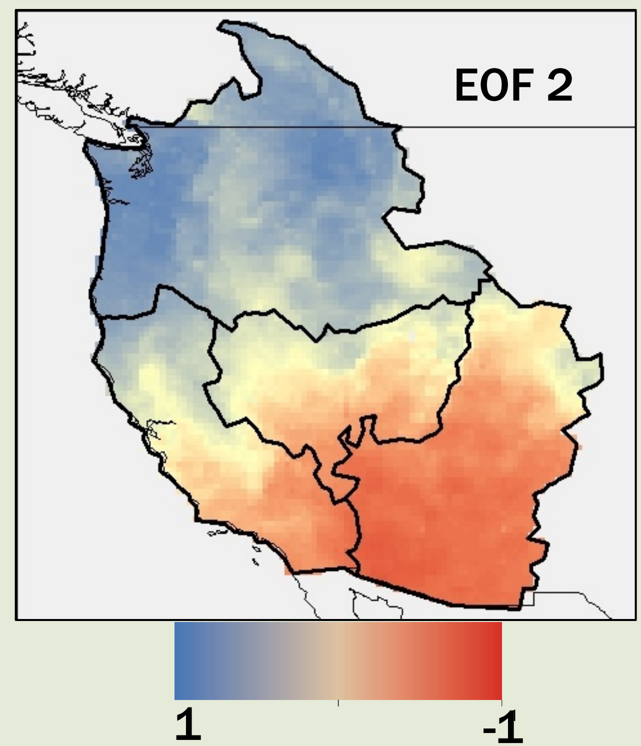




EOF ANALYSIS
MODE 2

- Dipole structure between southwest and northwest
- Steady increase in variance
- PC2 seems to be functioning more on interannual time scales and exhibits less long-term persistence.





IMPLICATIONS AND FUTURE RESEARCH

- Implications on Hydropower Production
  - Expanded variance
  - Increased inter-regional correlation

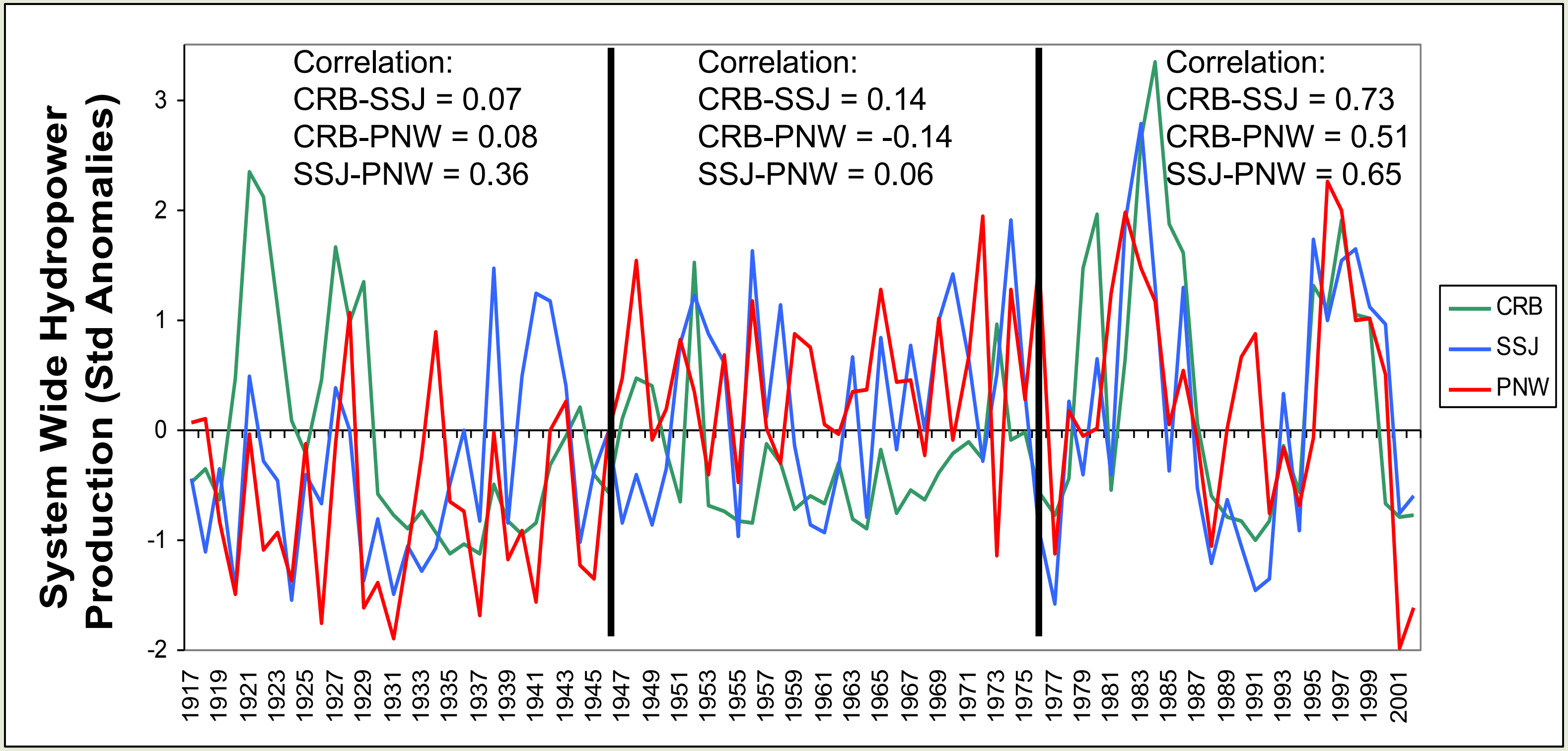
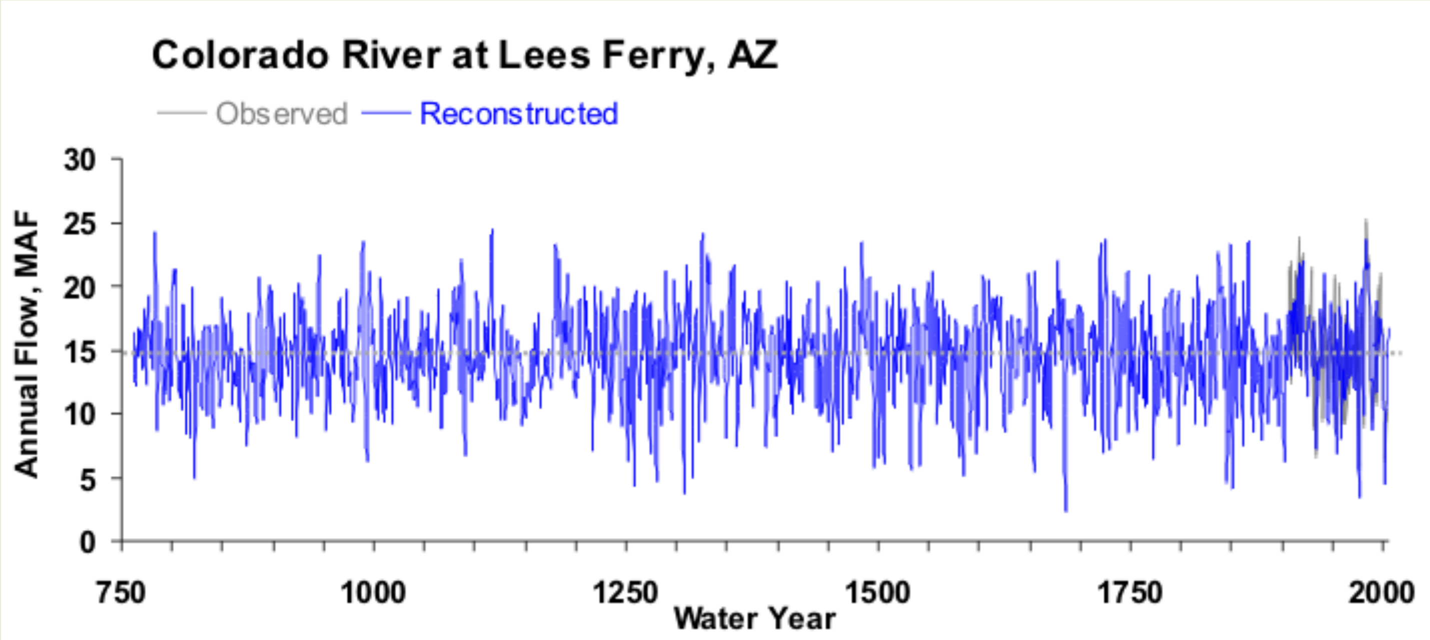


Figure: Alan Hamlet

IMPLICATIONS AND FUTURE RESEARCH

- Paleo Records
  - Paleological records support the argument that natural variability is sufficient to explain the late 20th century patterns in the CORB and SSJ.
  - Currently, paleological records are being developed for the other basins



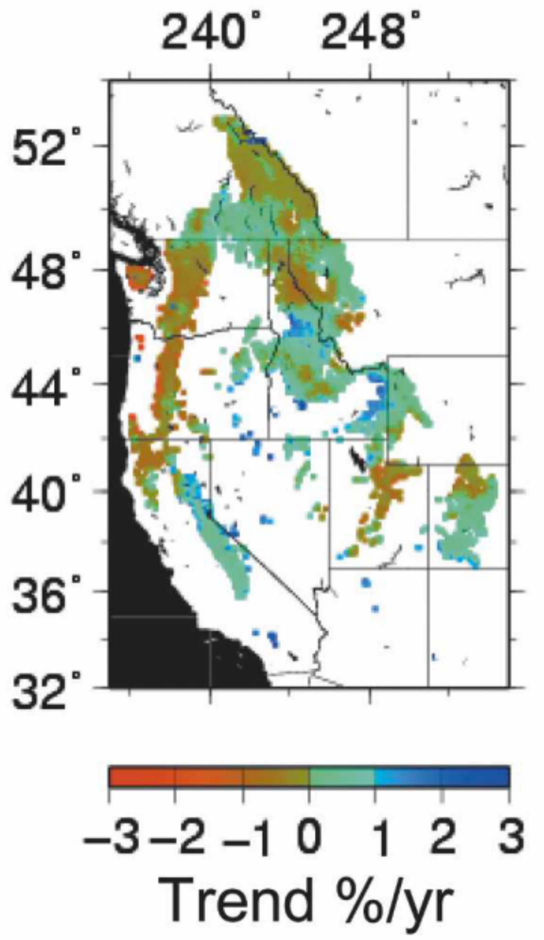
CONCLUSIONS

- Strong spatial and temporal correlations between the leading EOFs and the ENSO/PDO patterns further confirm the role of these patterns in Western U.S precipitation.
- Marked changes in statistics coincide with statistically significant changes in the variance associated ENSO and PDO.
- It remains unclear whether global climate change is contributing to the effects.
  - GCMs do not reliably simulate the changes in precipitation variability seen in the observed record, thus conventional detection and attribution studies typically fail in the initial step. However, this could also be related to other factors such as GCM deficiencies in simulating cool season precipitation variability at the regional scale.
- There is currently little evidence to support the hypothesis that recent changes in cool season precipitation variability are an expression of global greenhouse forcing.

QUESTIONS?

- Questions?

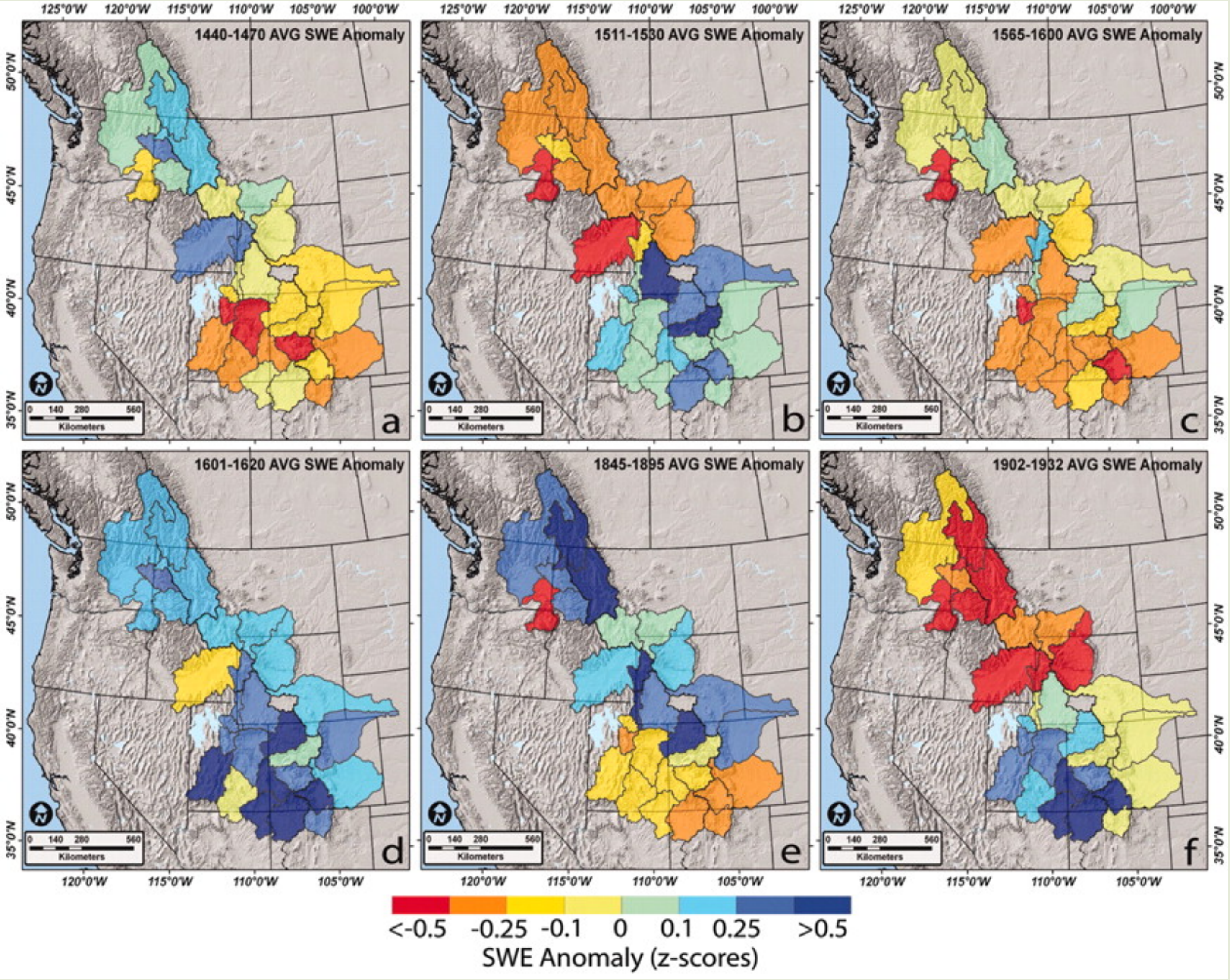
SNOWPACK



- Snowpack
  - Produced by cool season precipitation
  - Important in terms of annual flows and flooding

←Figure: Effects of precipitation trends on April 1 SWE excluding temperature changes, 1916-2003. (Hamlet et al., 2005)

Fig. 2 Decadal departures in reconstructed 1 April SWE for watersheds predominately within the U.S. portion of the North American cordillera.



G T Pederson et al. Science 2011;333:332-335