Use of Gridded Meterological Data Sets and Hydrologic Simulation Models in Paleological Streamflow Reconstructions

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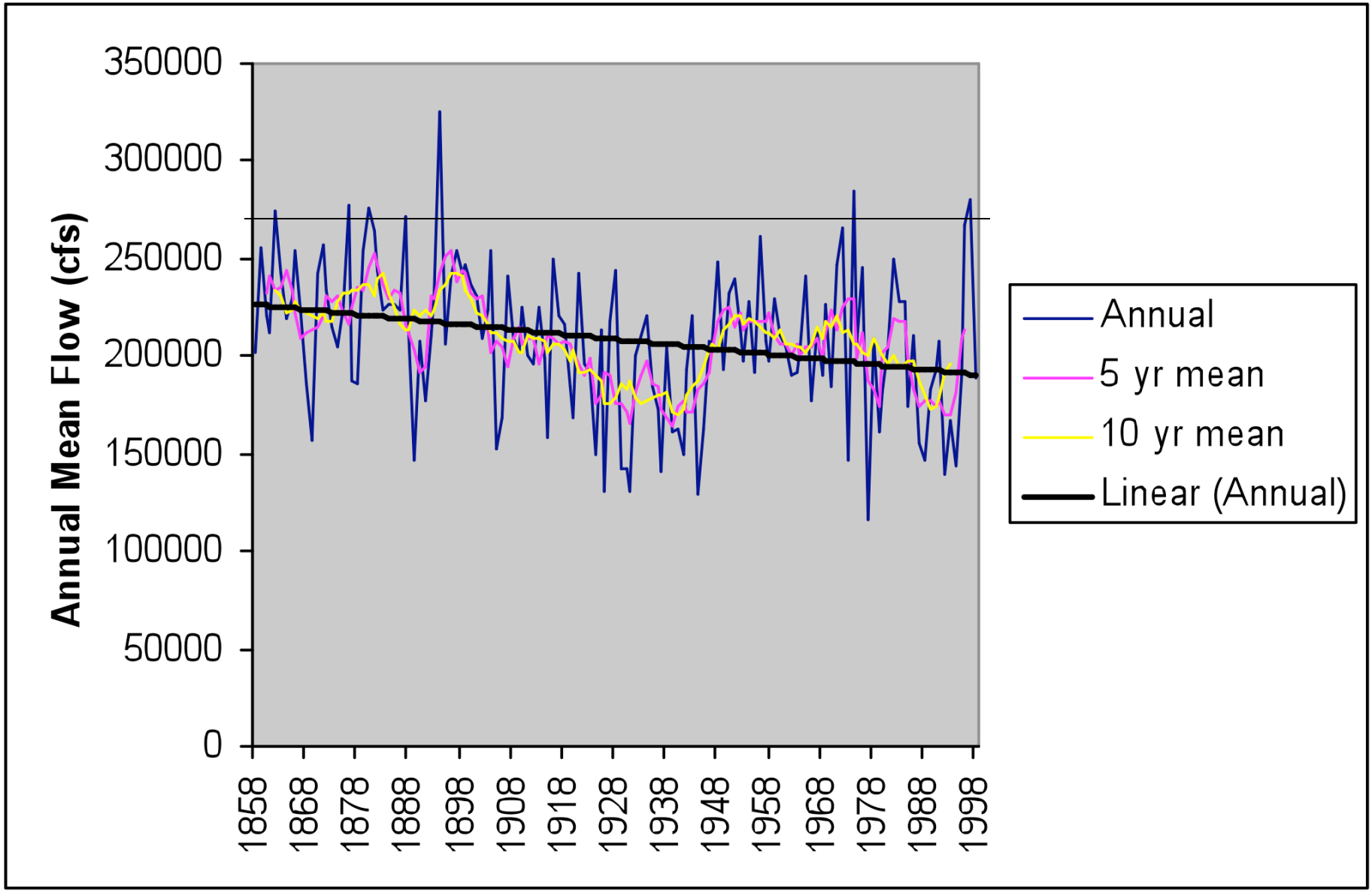
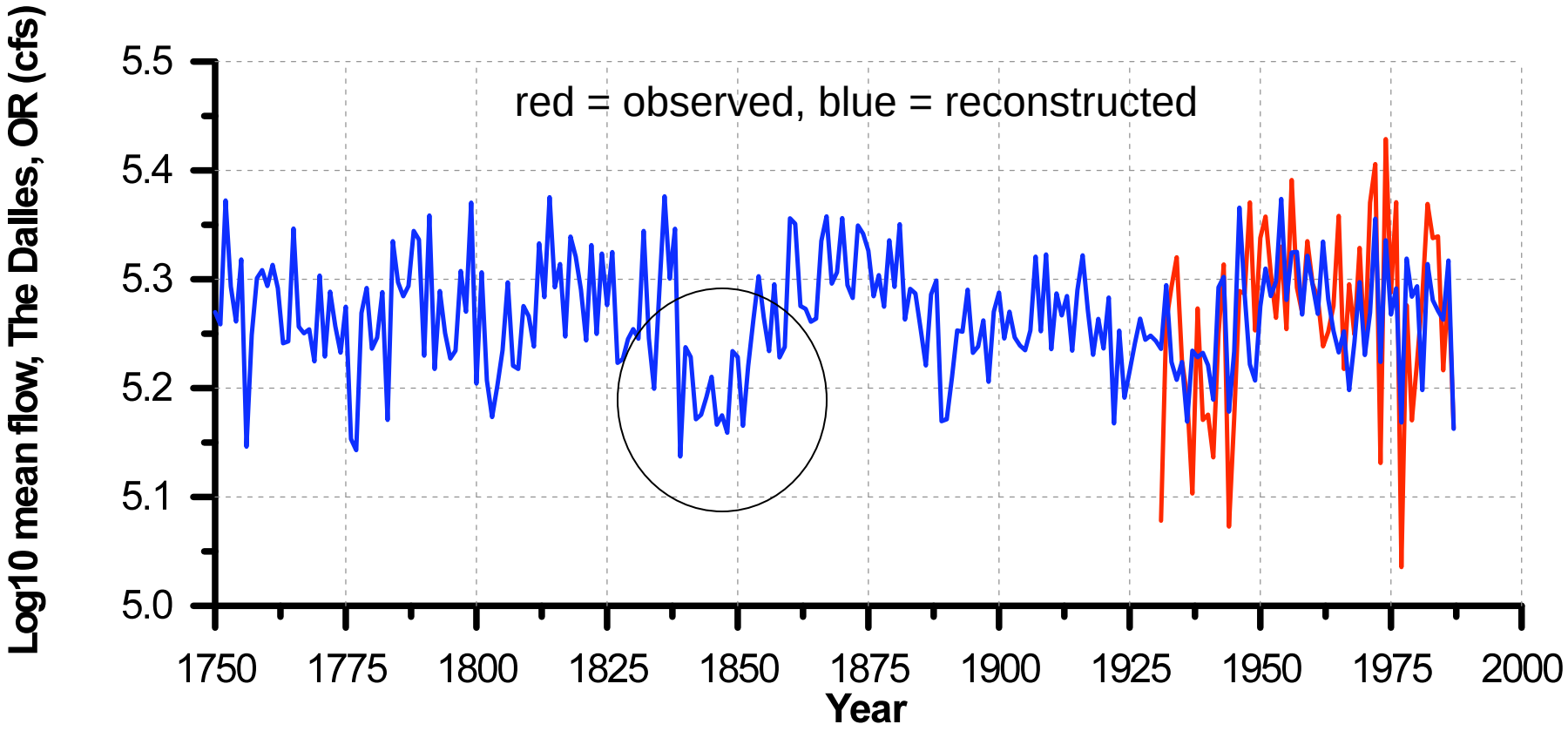
Motivation

Trends in Annual Streamflow at The Dalles from 1858-1998 are strongly downward.



Past Reconstructions Suggested that the Dust Bowl was probably not the worst drought sequence in the past 250 years



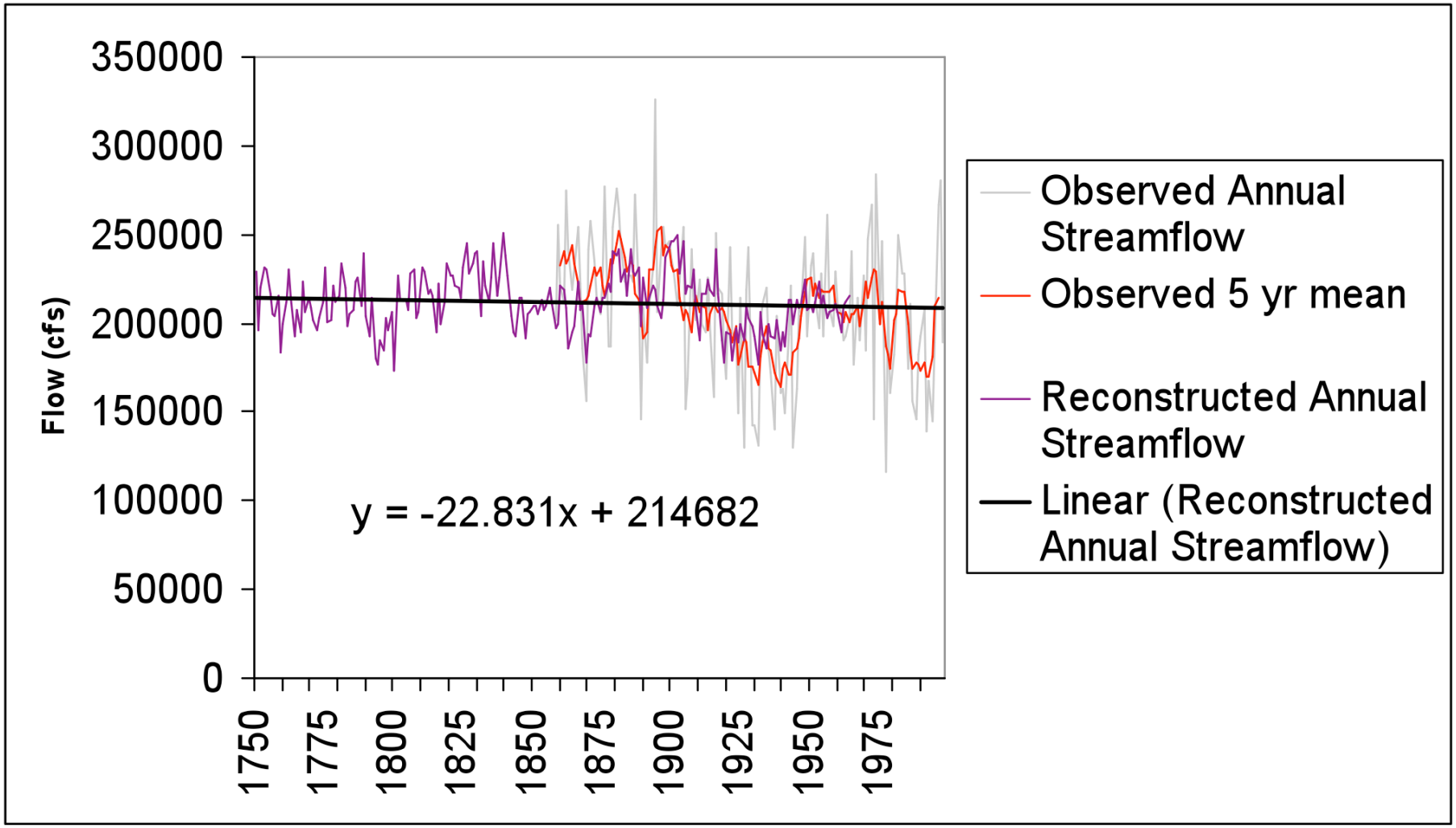
Source: Gedalof, Z., D.L. Peterson and Nathan J. Mantua. (in review). Columbia River Flow and Drought Since 1750. Submitted to Journal of the American Water Resources Association.

Was there a drought in the 1840s?

According to newspaper accounts and other sources there were major floods in the Willamette River in 1813, 1843, 1844, 1849 and 1853, as well as 1861. Most winters, if there is a major Willamette flood, there is also a strong spring CR flow. (Source: David Jay, PSU)

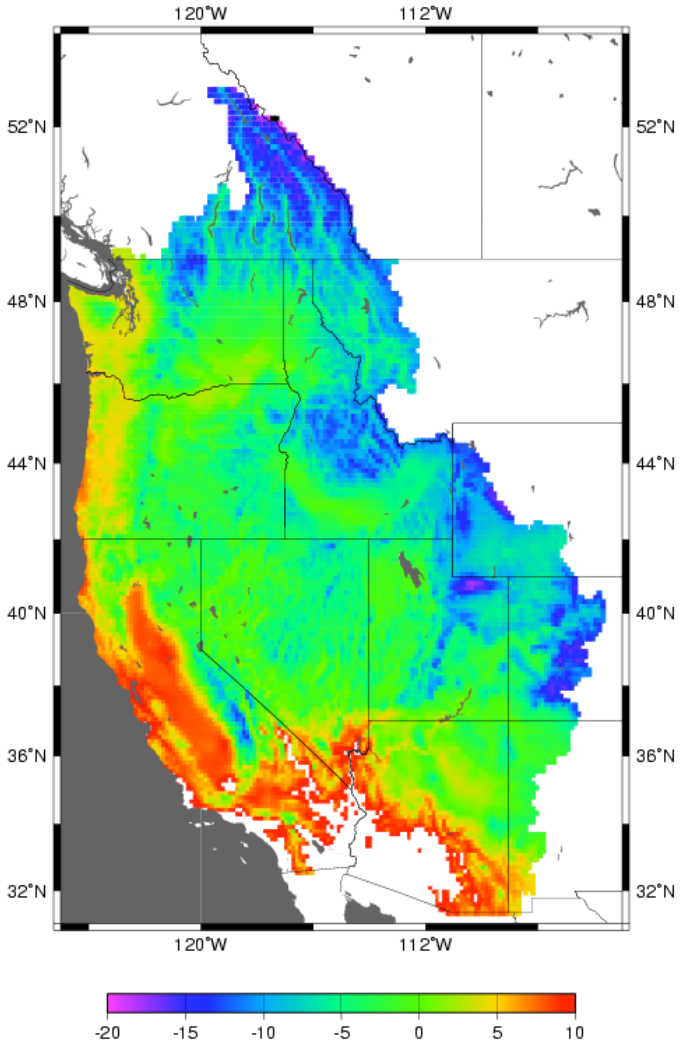
Year	Salem Ht, in ft
1813	37
1843	31
1844	34
1849	31
1853	30
1861	39
1881	36.3
1890	37.1

Annual streamflow reconstructions at The Dalles, OR using tree ring growth indices from derived from douglas-fir and limber pine from SE British Columbia - Kamloops to Banff/Jasper (1750-1964)

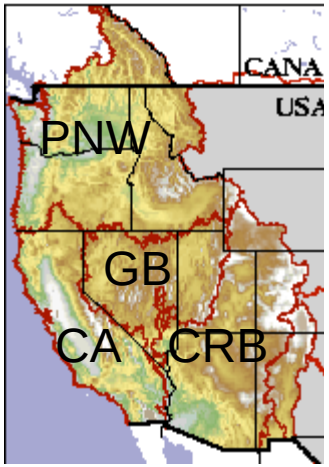


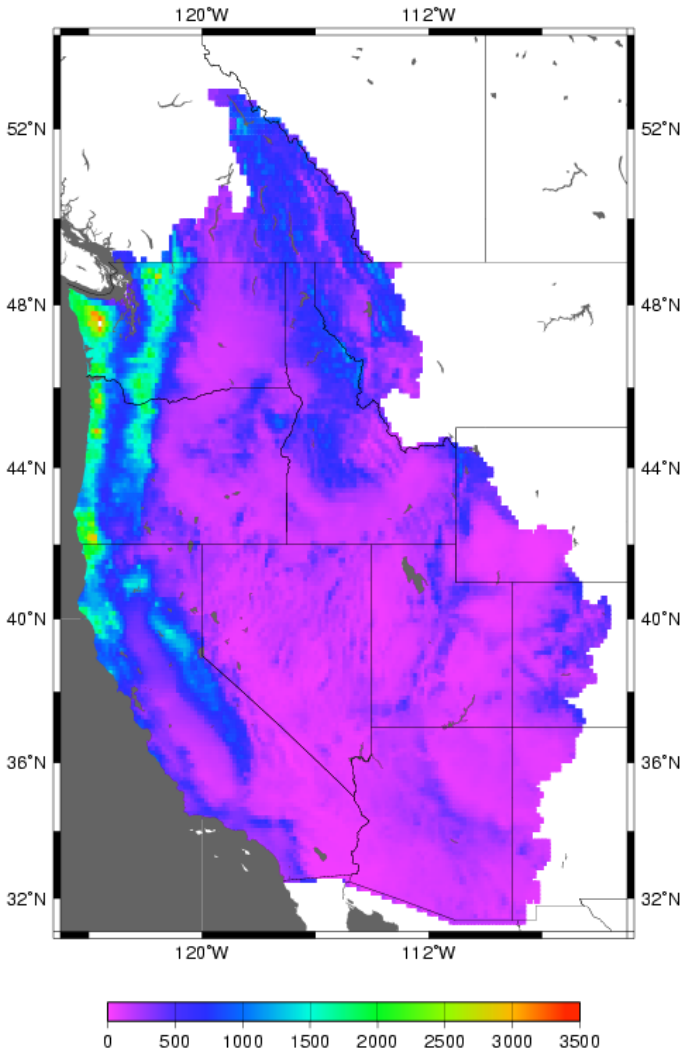
Hydroclimatology of the Pacific Northwest

Cool Season Climate of the Western U.S.

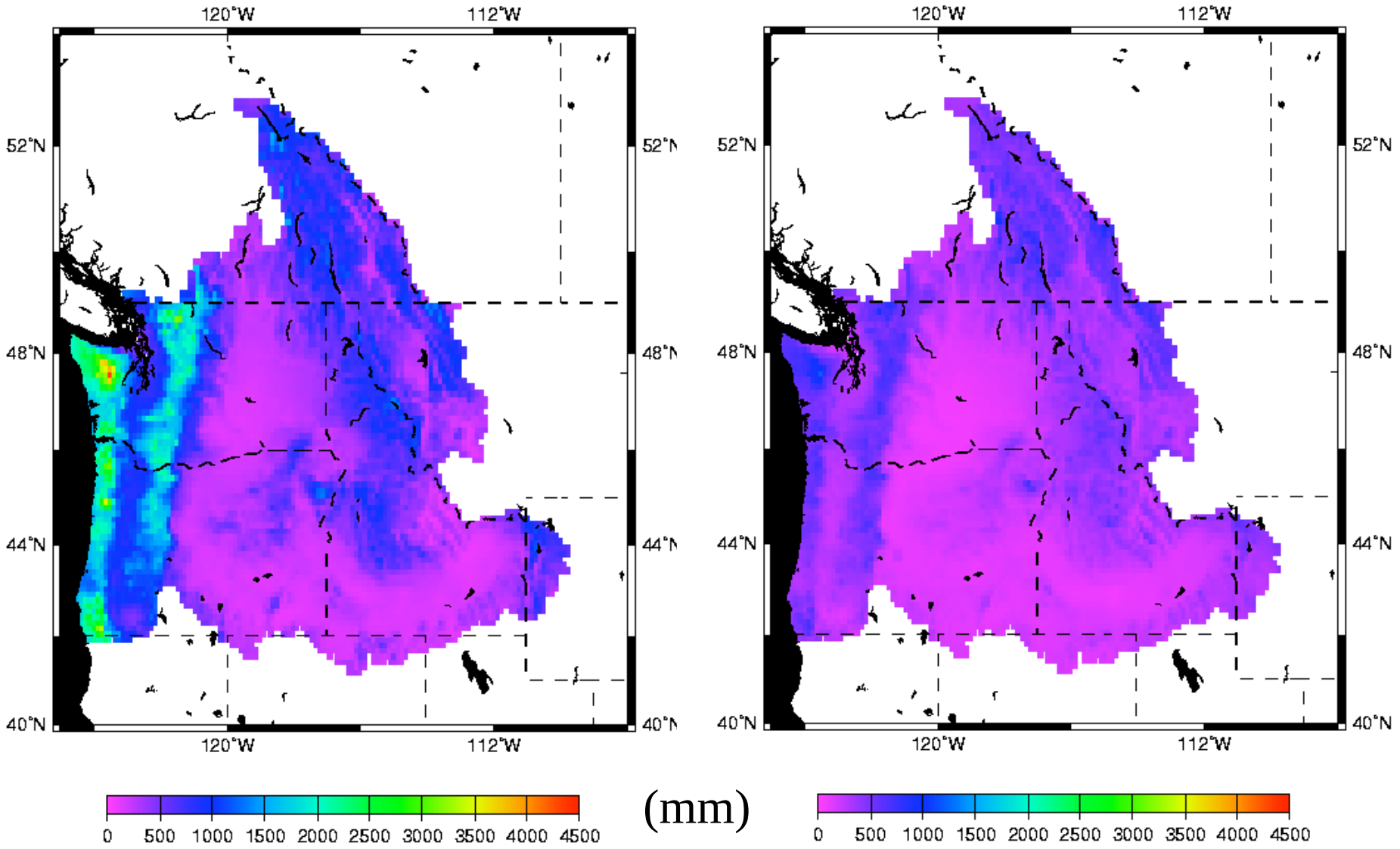


DJF Temp (°C)





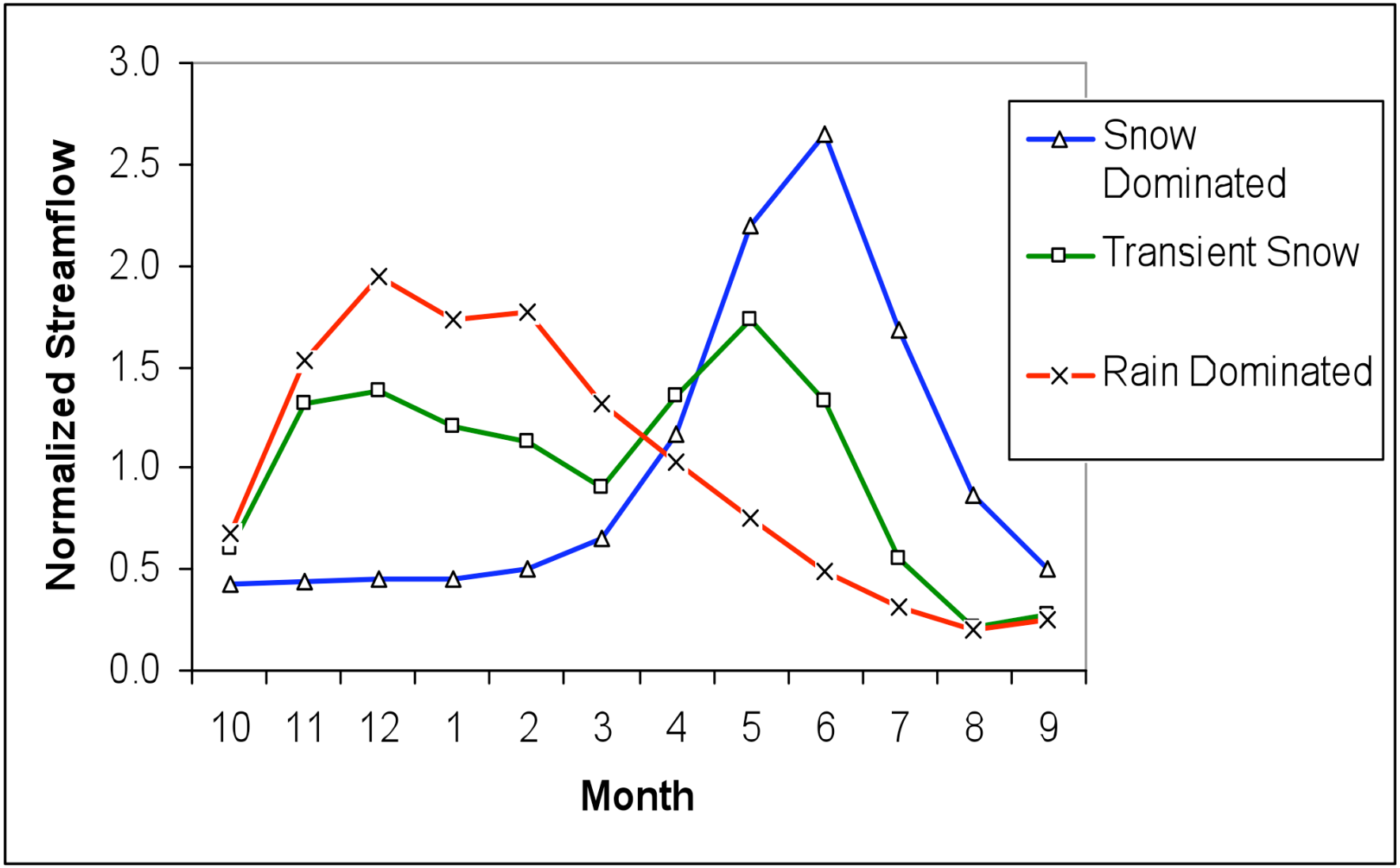
NDJFM Precip (mm)



Winter Precipitation

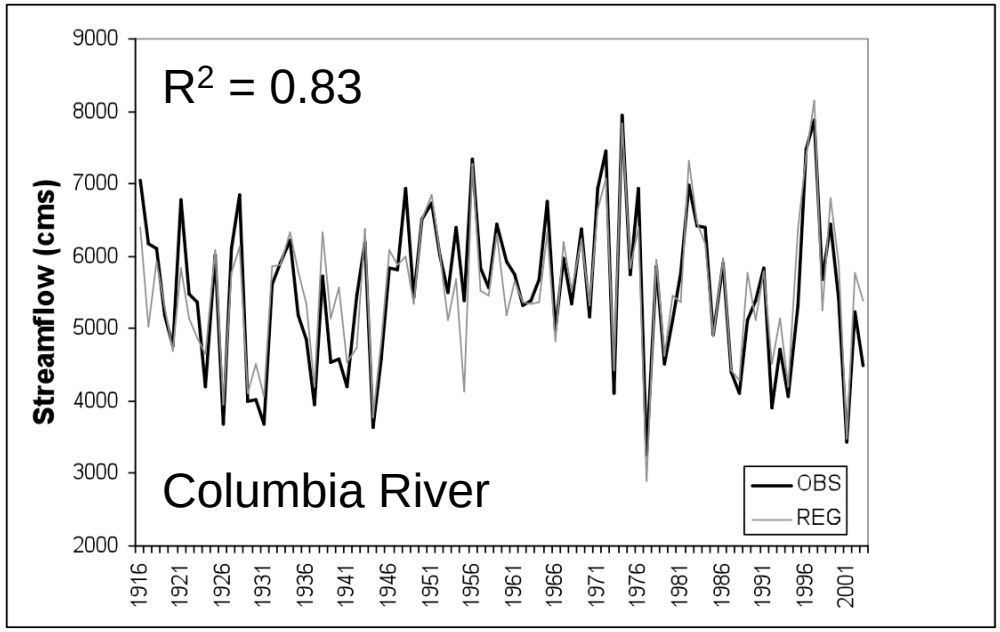
Summer Precipitation

Hydrologic Characteristics of PNW Rivers

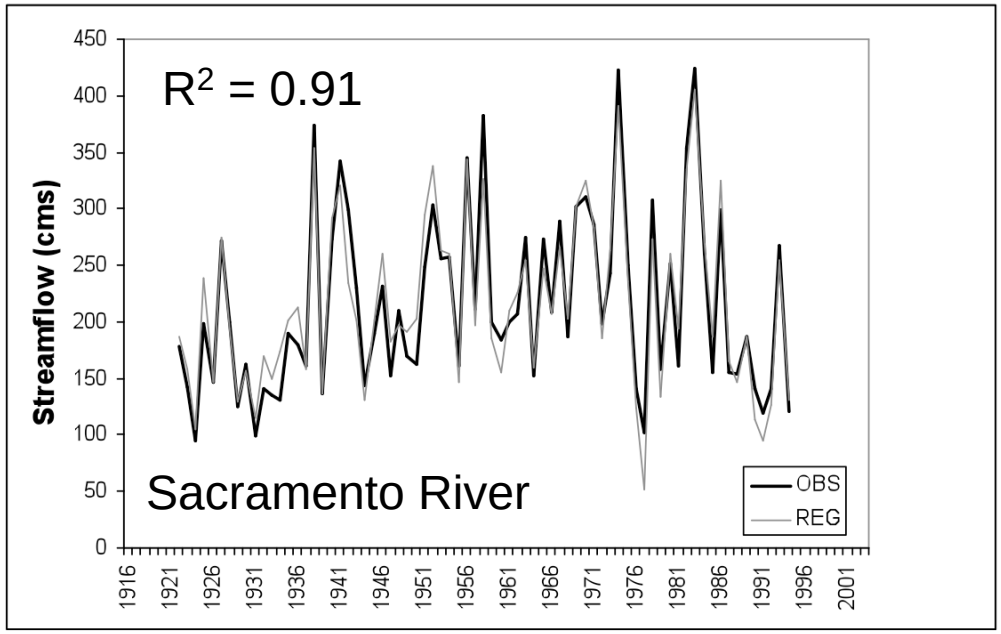


Cool Season Precipitation Explains Most of the Variability in Annual Flow in the PNW and CA

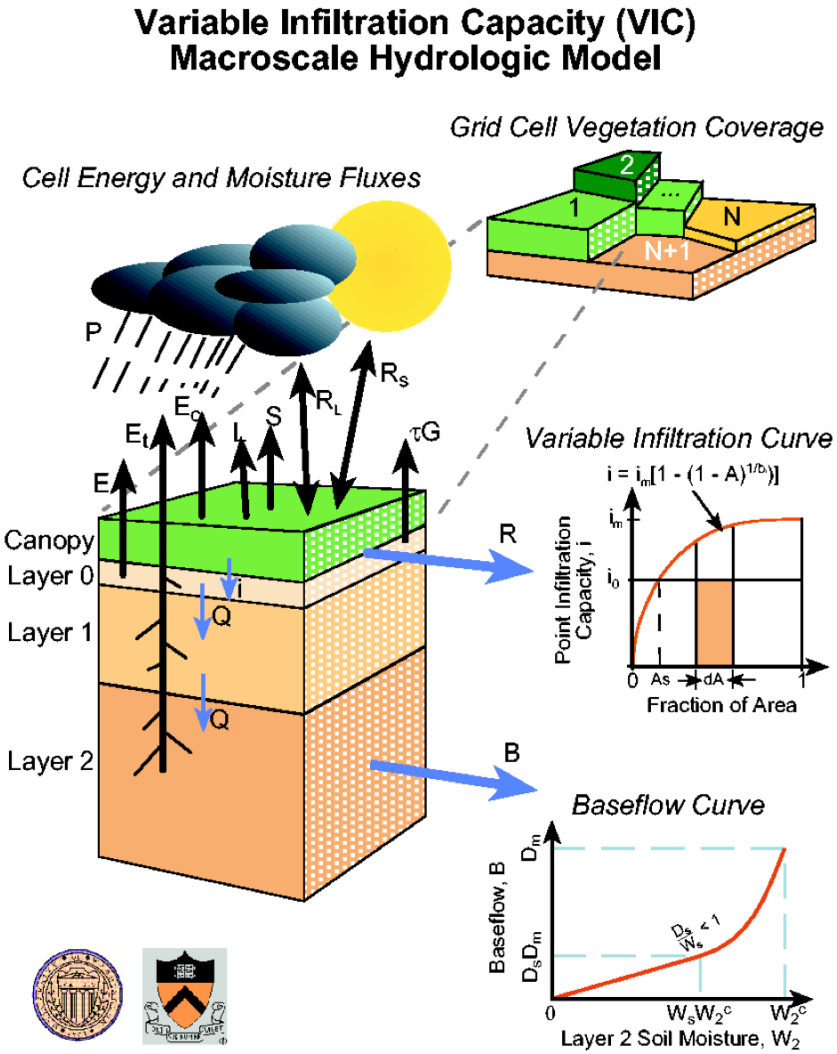
Relationship Between Annual Flow and Cool Season Precip.

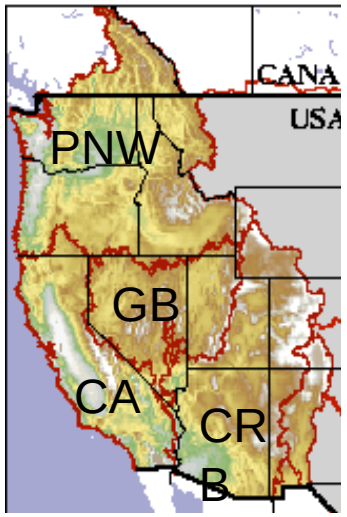


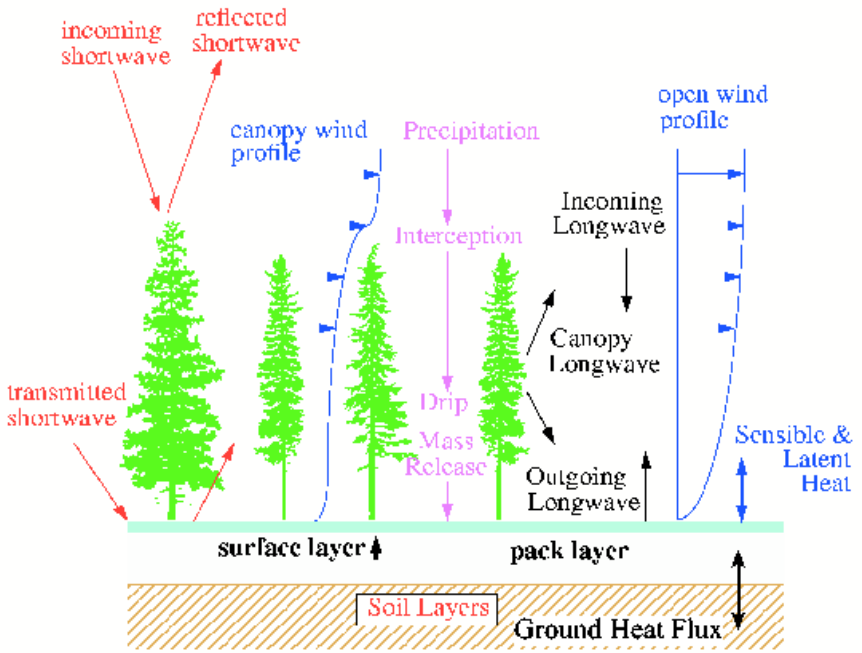
Relationship Between Annual Flow and Cool Season Precip.



Schematic of VIC Hydrologic Model and Energy Balance Snow Model

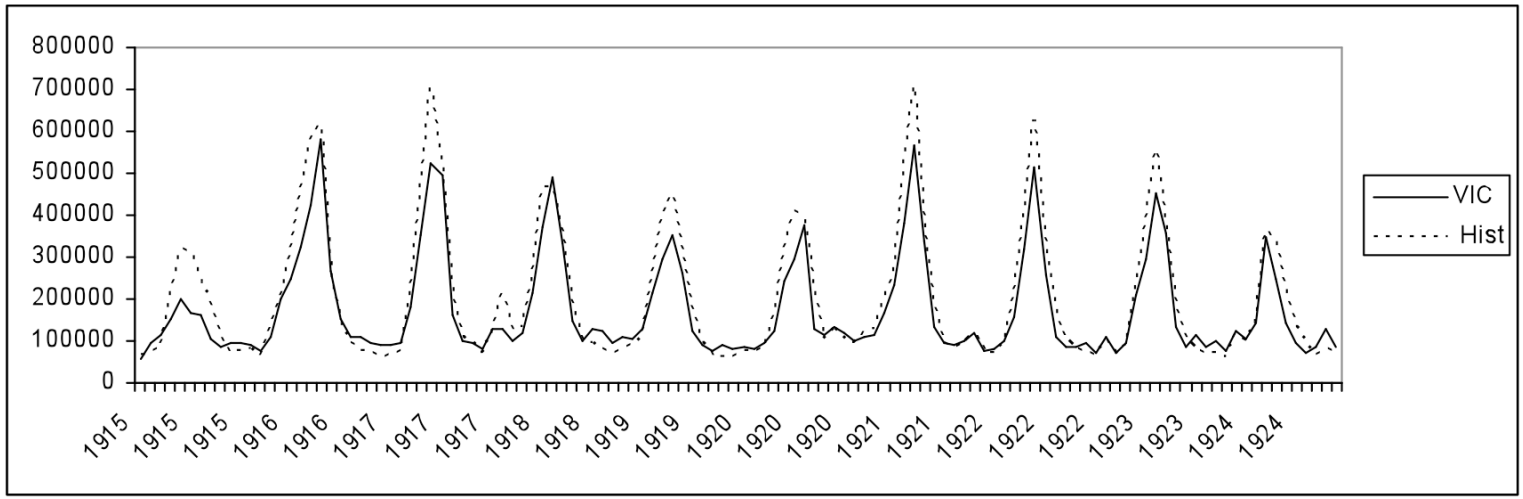


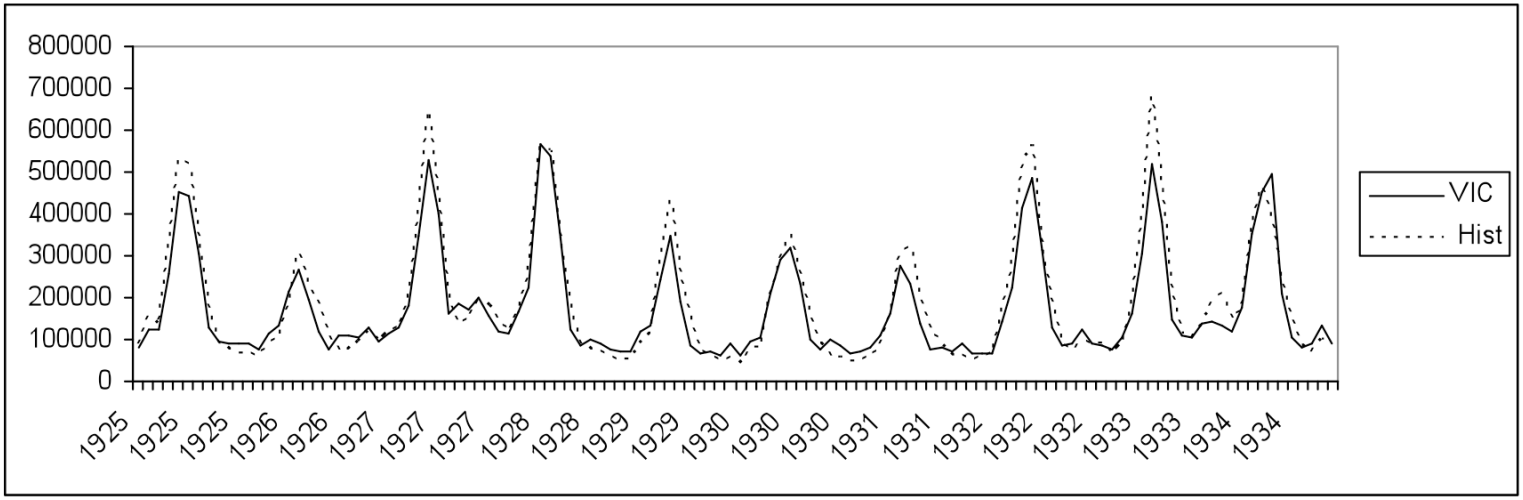


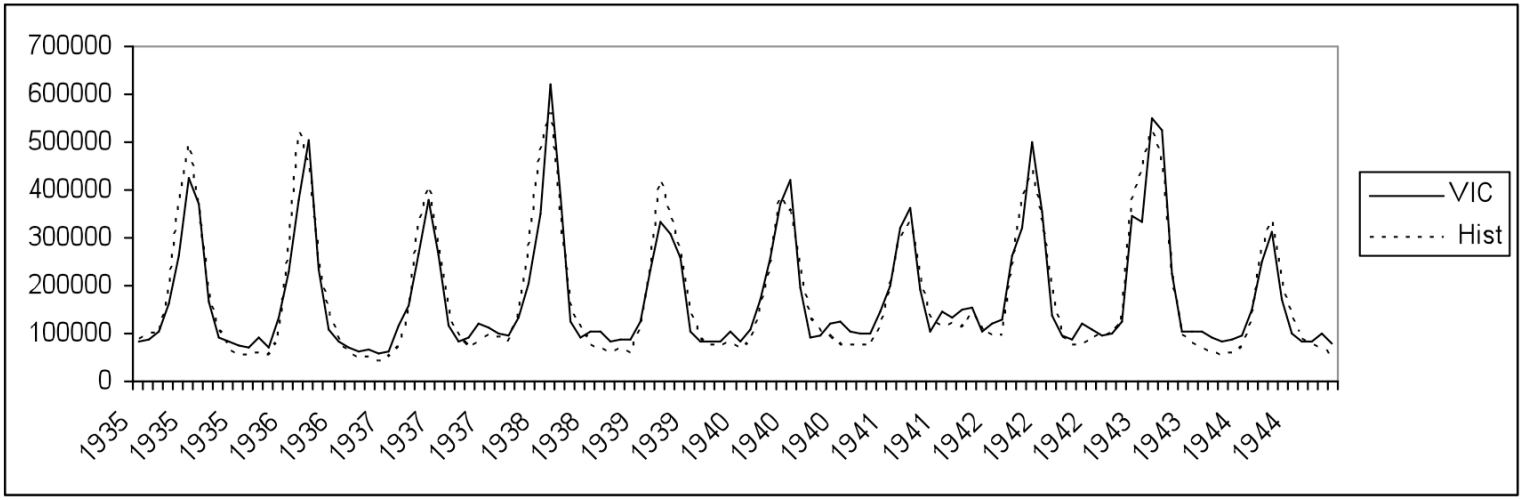


Snow Model

Evaluation of Streamflow Simulations of the Columbia River at The Dalles, OR



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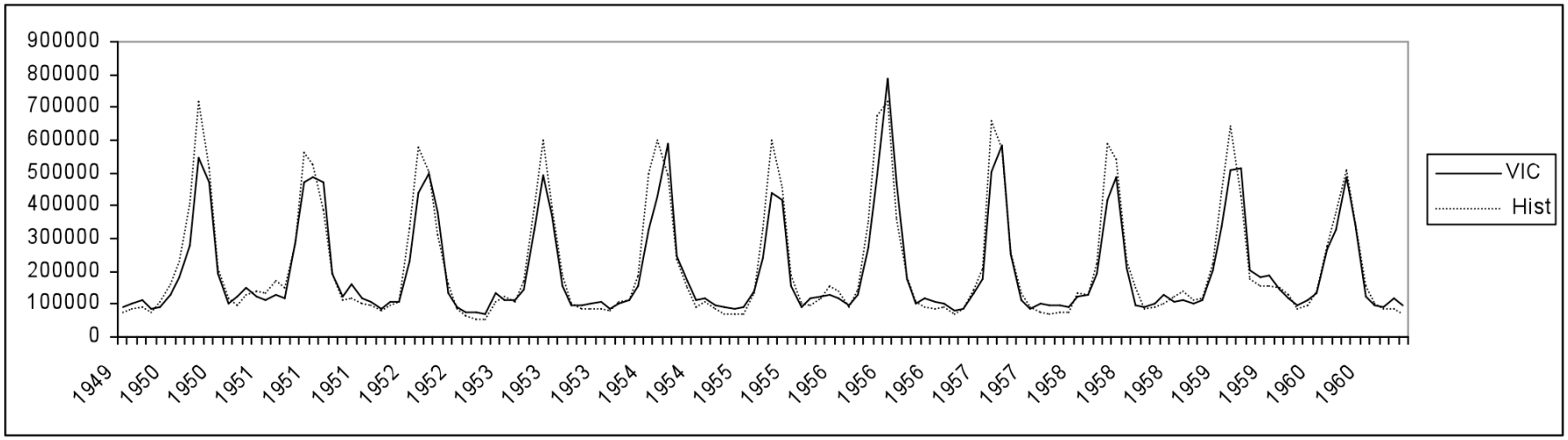
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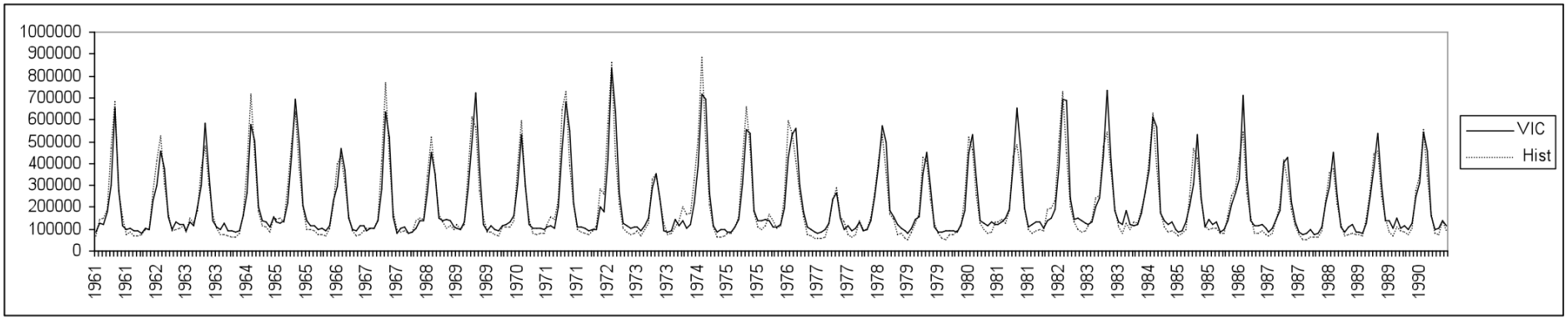
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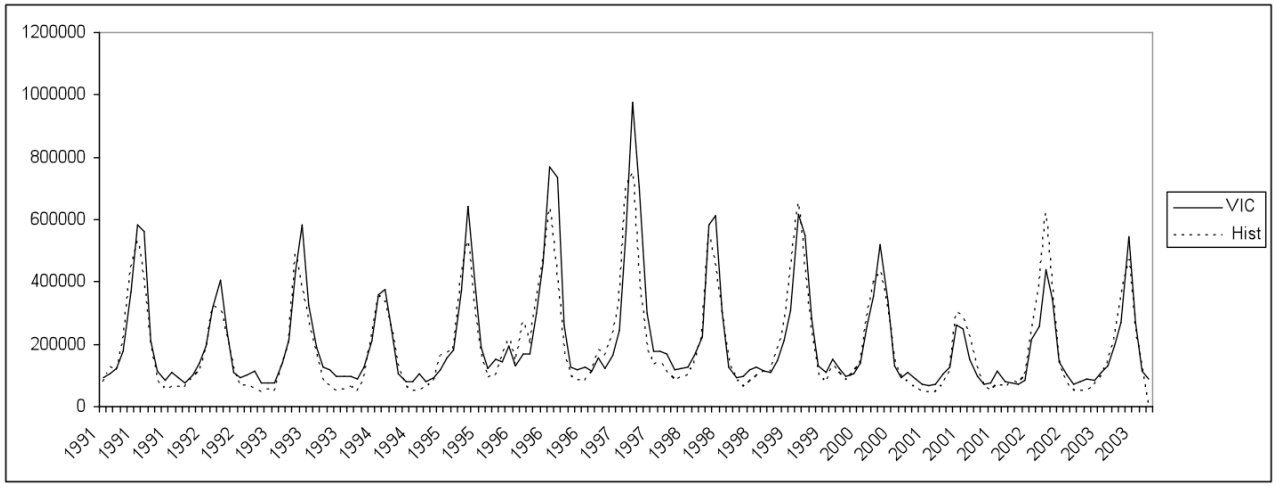
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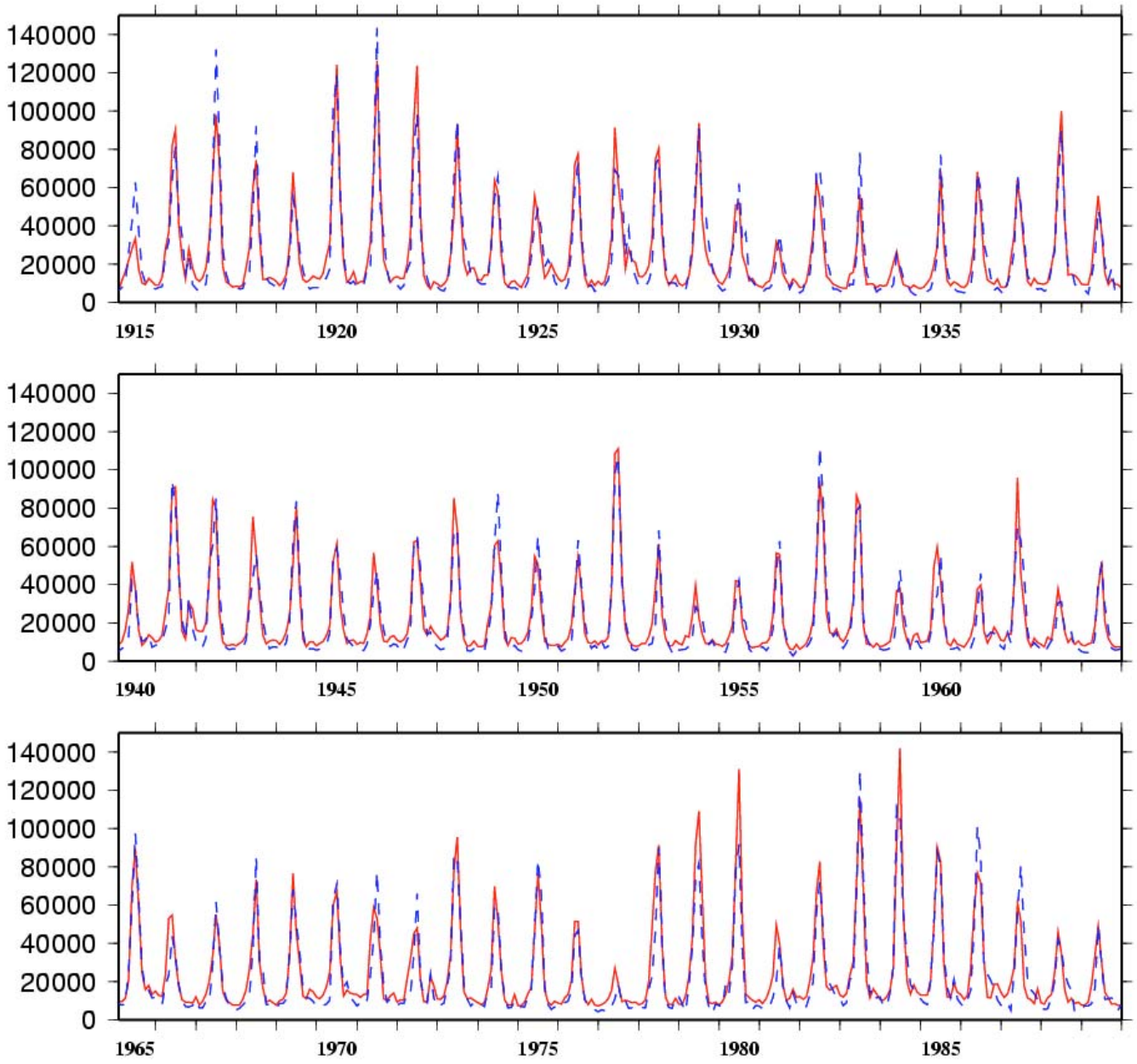
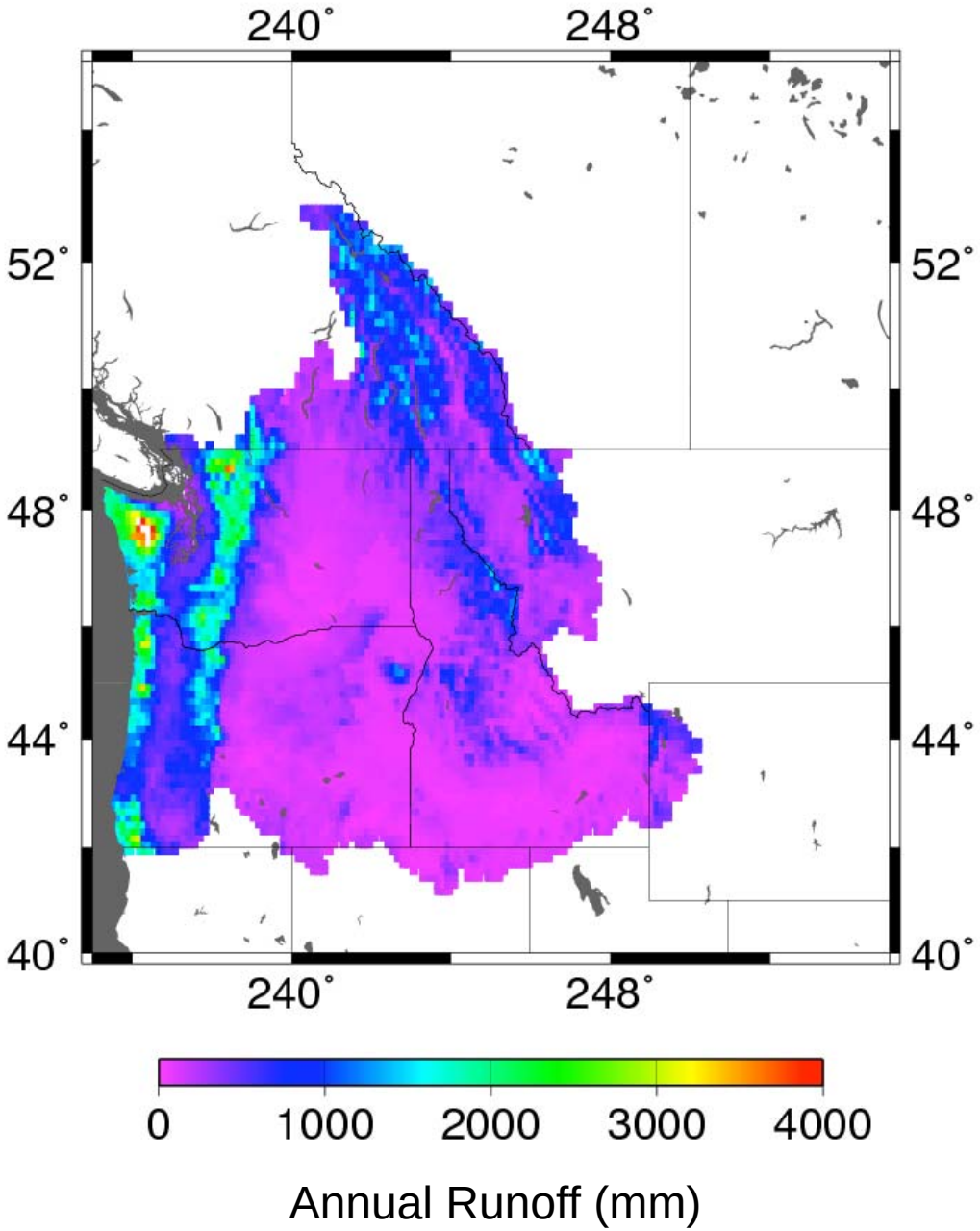
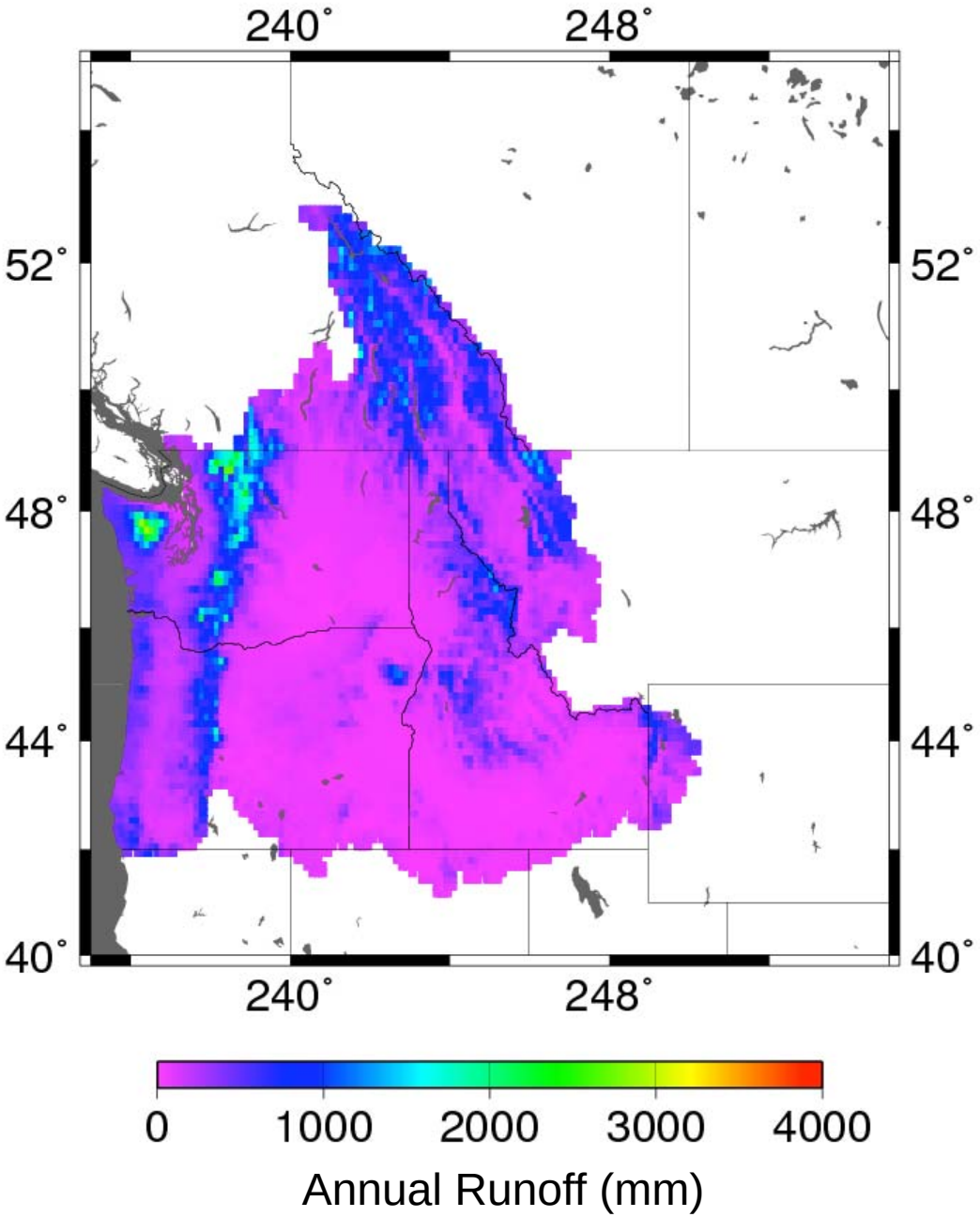
Evaluation of Streamflow Simulations of the Colorado River at Lee's Ferry, AZ



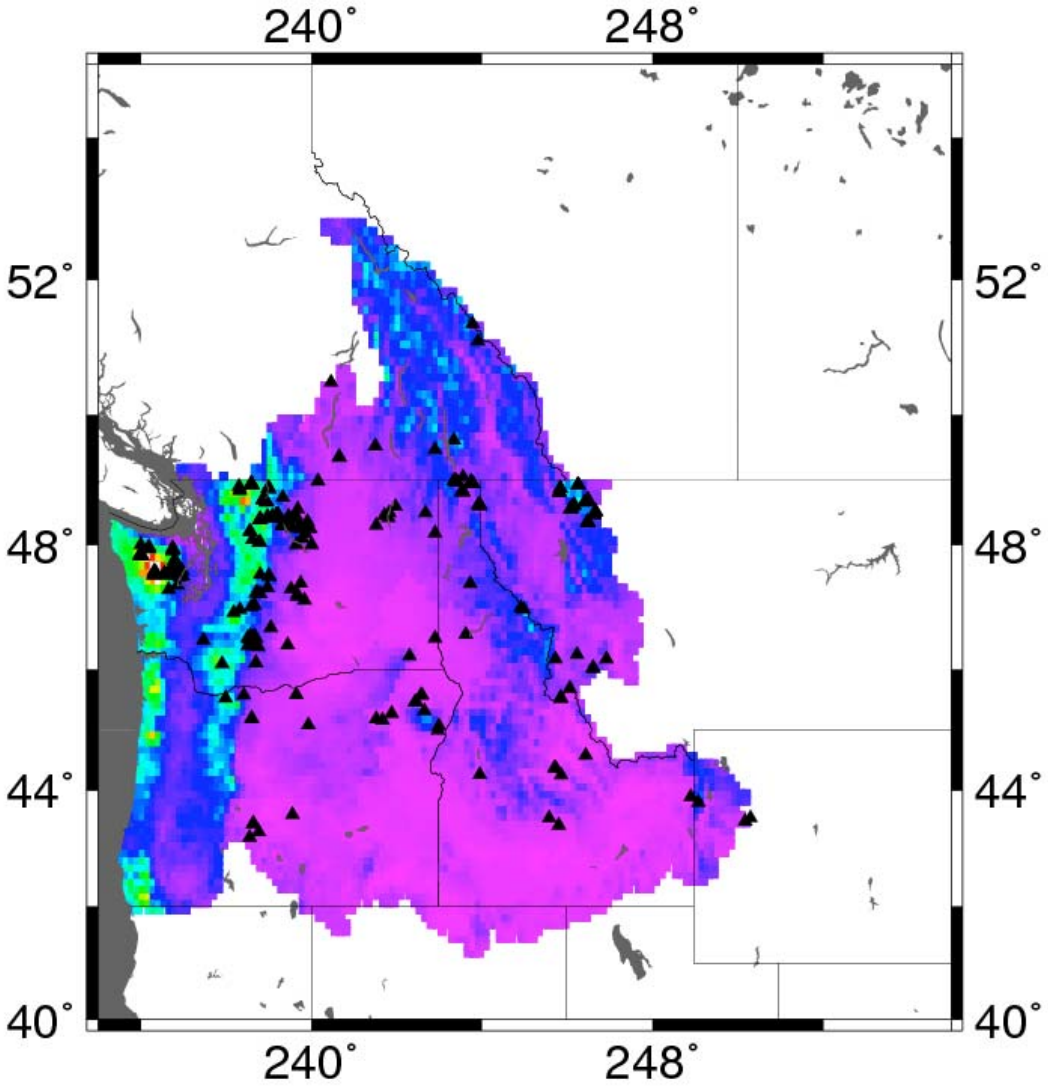
Spatial Distribution of Annual Runoff 1916-2003 from VIC Simulations



Spatial Distribution of Apr-Sept Runoff 1916-2003 from VIC Simulations



Spatial Distribution of Annual Runoff (1916-2003) from VIC Simulations with Tree Ring Sites



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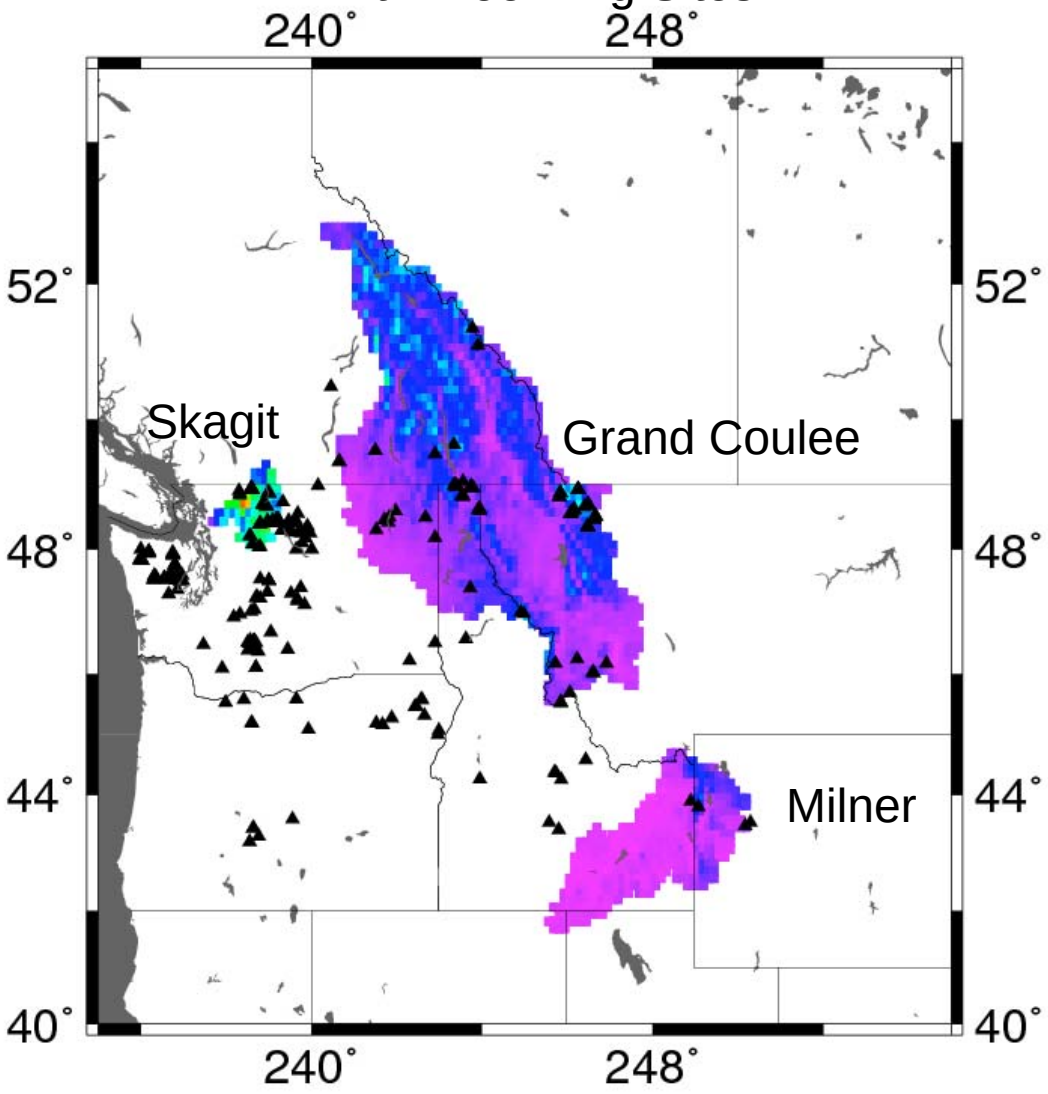
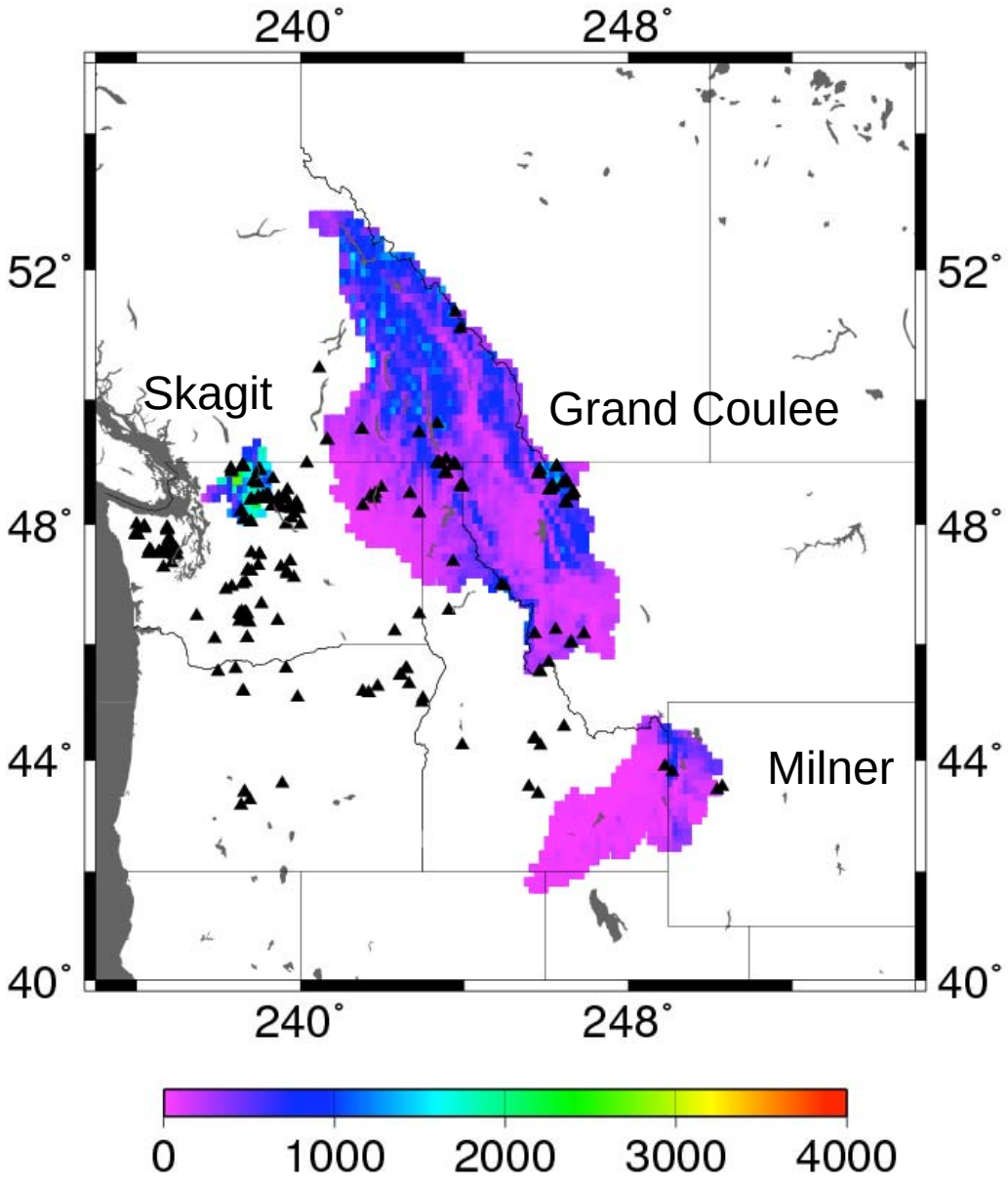
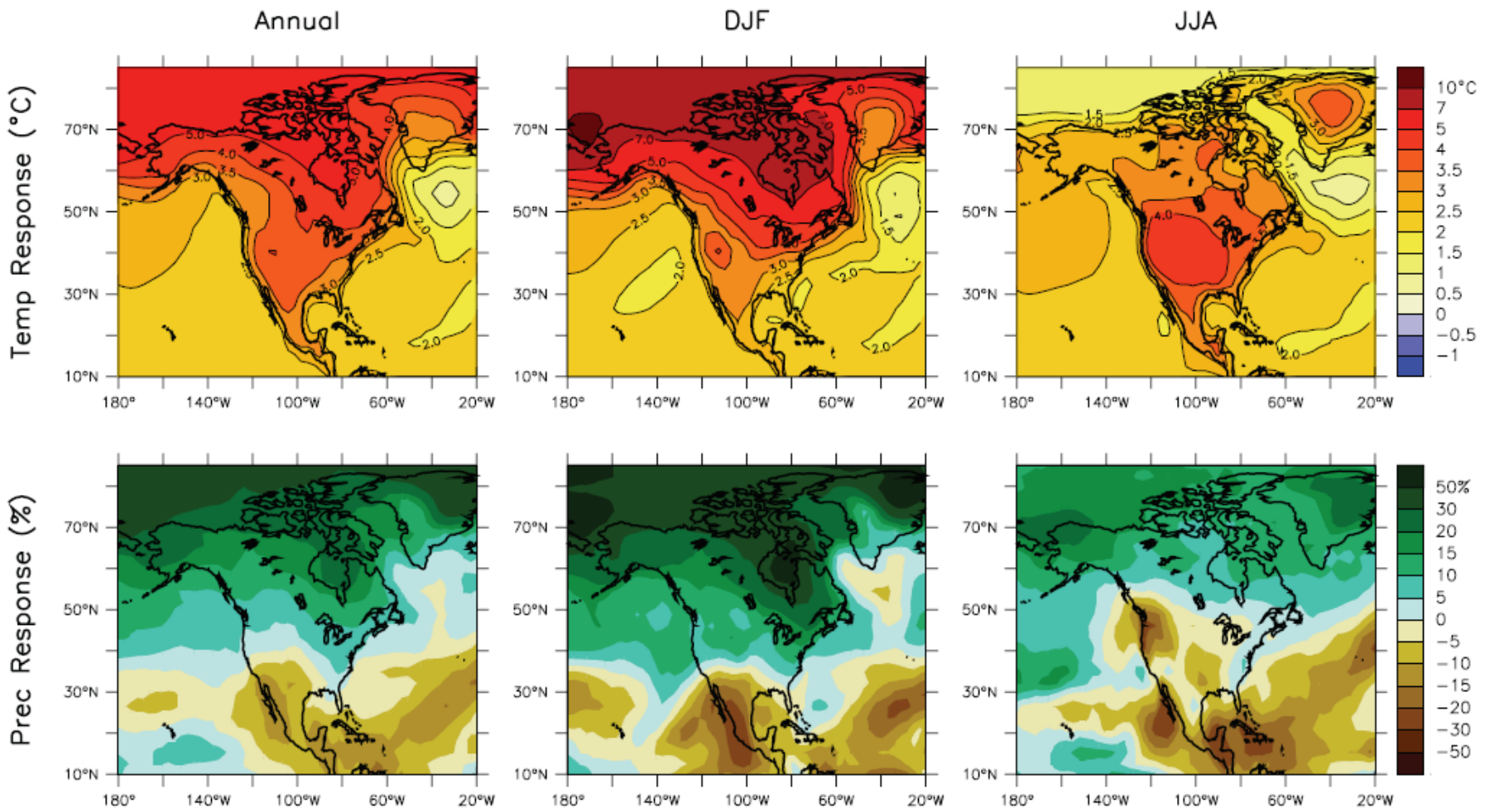


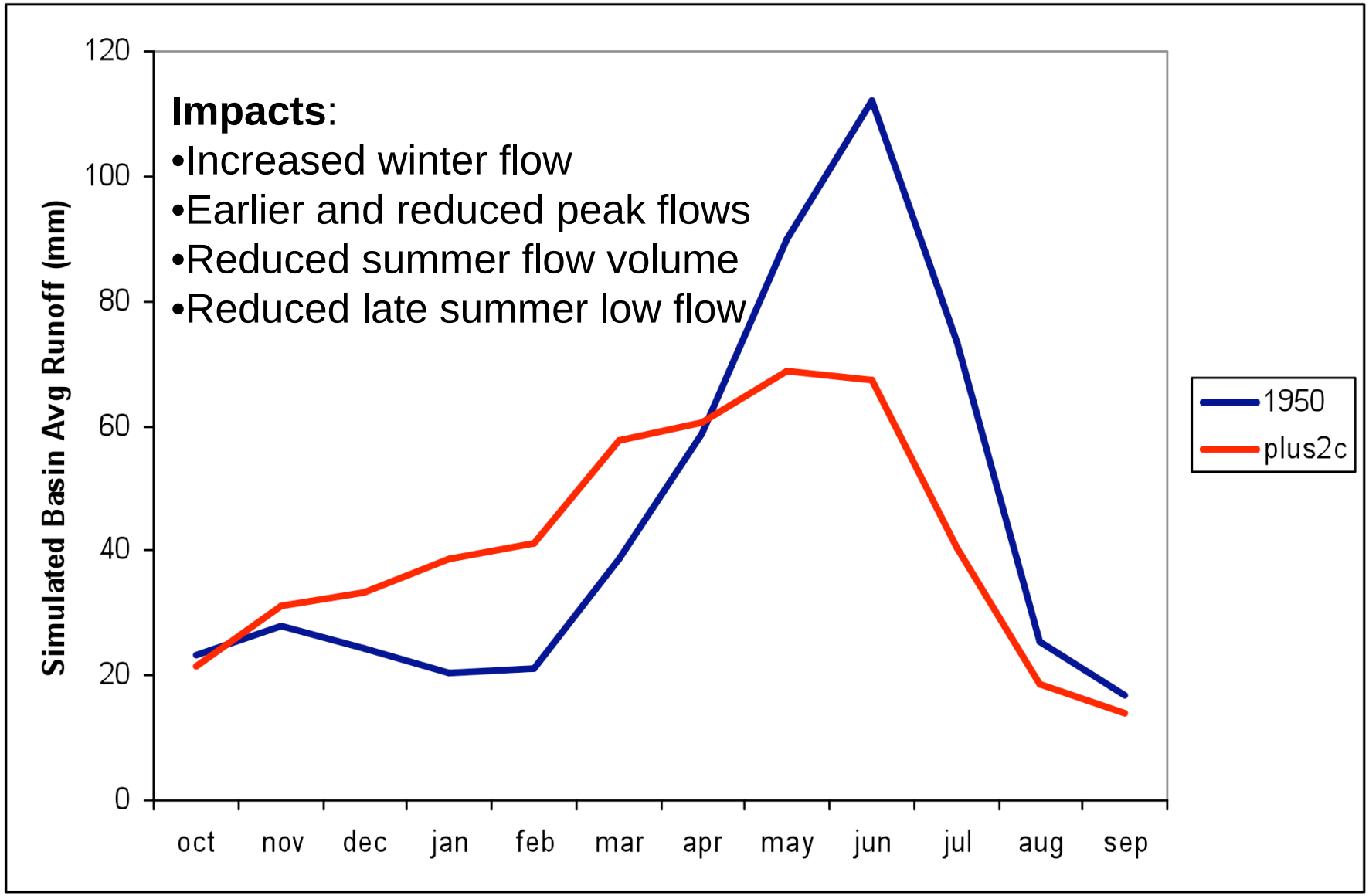
Spatial Distribution of Apr-Sept Runoff (1916-2003) from VIC Simulations with Tree Ring Sites



Consensus Forecasts of Temperature and Precipitation Changes from IPCC AR4 GCMs



Simulated Changes in Natural Runoff Timing in the Naches River Basin Associated with 2 C Warming



Conclusions

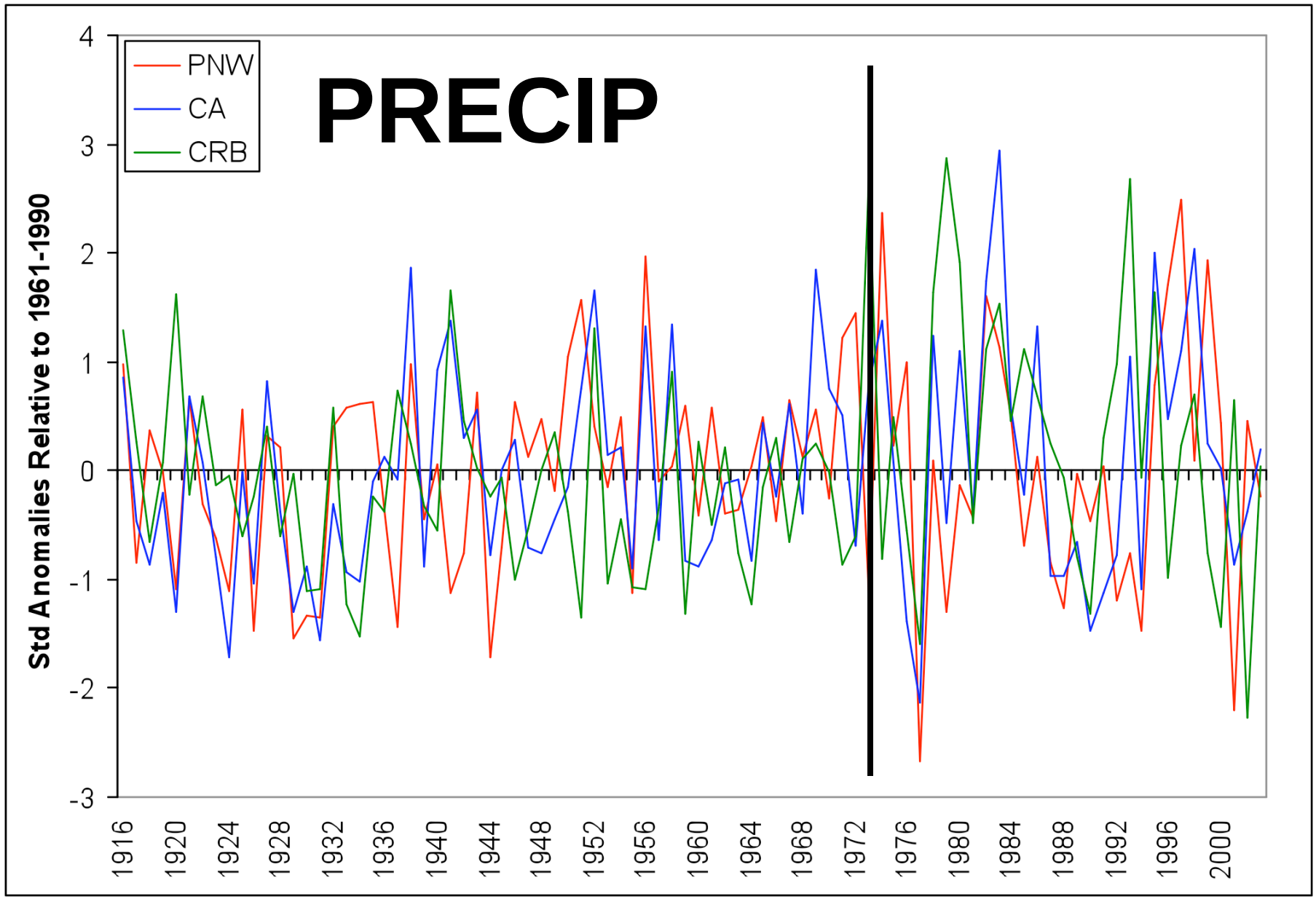
Use of gridded meteorological data sets in conjunction with physically based hydrologic models can:

- Identify important runoff producing areas (both annually and in warm season),
- Create accurate long-term time series of cool season precipitation for particular basins, and
- Quantify the effects of changing temperatures on runoff timing in warm season associated with climate change.

These data and information will be used in selecting tree ring chronologies that are well-correlated with cool season precipitation variability and runoff production in a particular river basin, and to account for changes in seasonal runoff timing with climate change.

Use of Streamflow Paleoreconstuctions in Hydrologic Studies

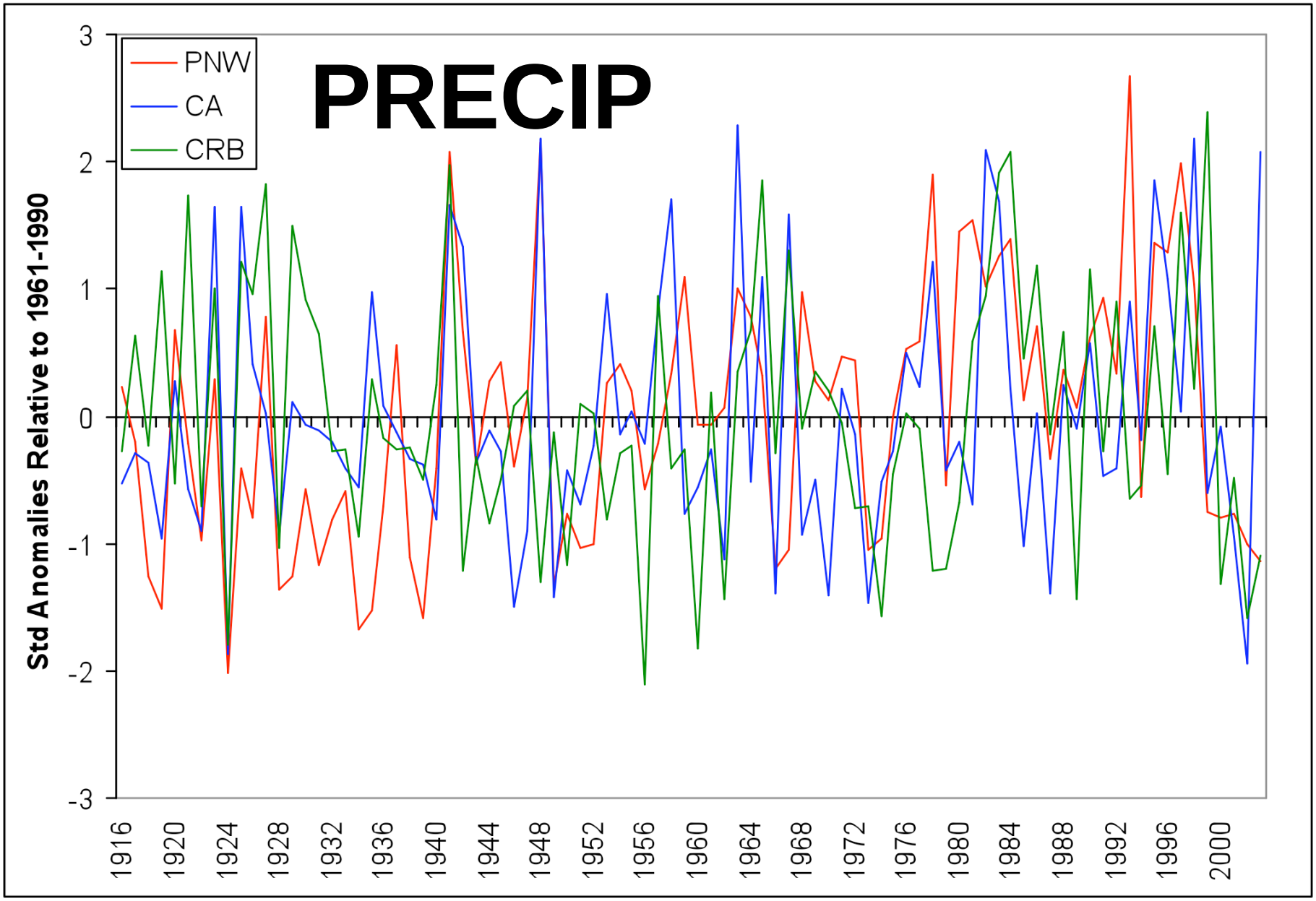
Regionally Averaged Cool Season Precipitation Anomalies



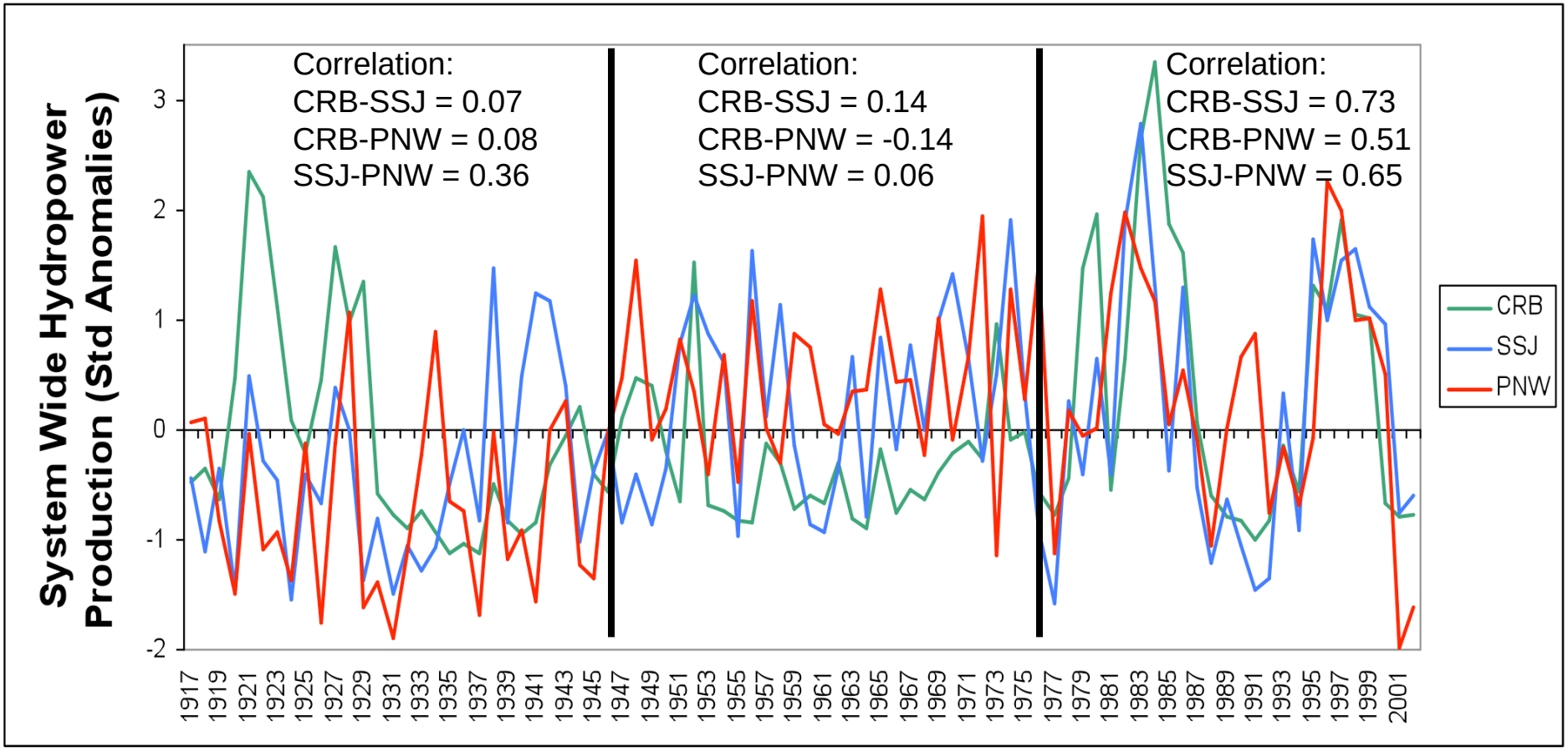
Summary Statistics for Regionally Averaged Cool Season

		PNW	SSJ	CRB
1916-1946	mean (mm)	574.7	443.9	174.7
	variance	88.8	100.1	30.6
	CV	0.15	0.23	0.17
	lag 1auto corr	-0.15	0.06	0.11
	trend (% per decade)	-1.1	6.9	-3.5
1947-1976	mean (mm)	640.3	477.1	168.6
	variance	84.4	99.3	34.0
	CV	0.13	0.21	0.20
	lag 1auto corr	-0.42	0.12	-0.29
	trend (% per decade)	1.5	2.8	3.8
1977-2003	mean (mm)	594.3	488.1	190.8
	variance	126.2	141.9	50.8
	CV	0.21	0.29	0.27
	lag 1auto corr	0.22	0.12	0.15
	trend (% per decade)	4.2	2.4	-9.7

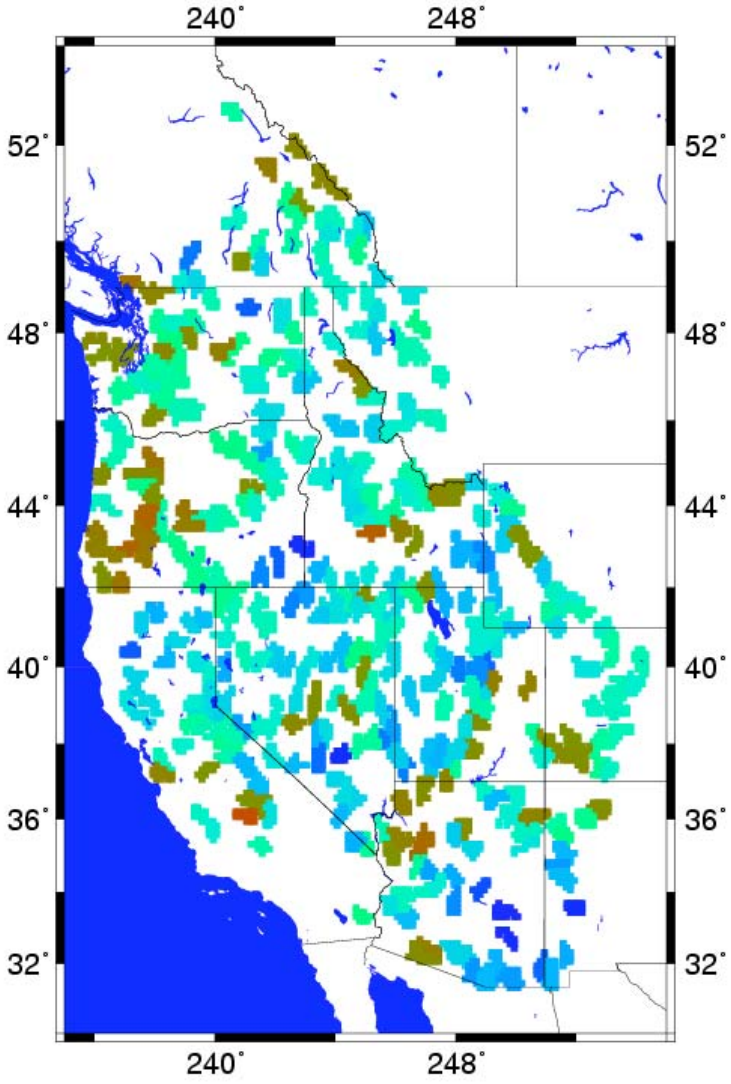
Regionally Averaged Warm Season Precipitation Anomalies



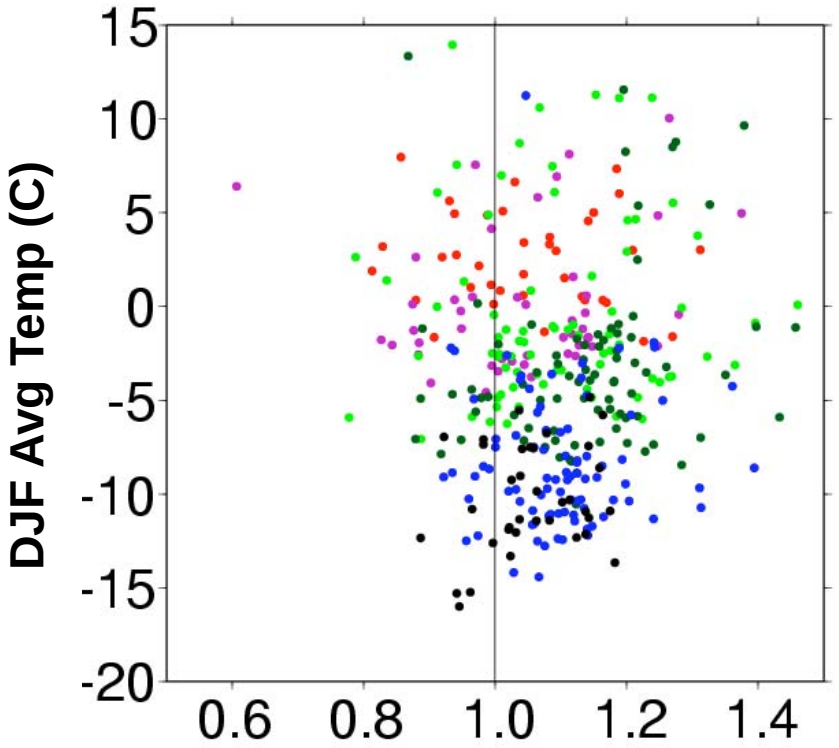
Simulated Changes in System Wide Energy Production in the Western U.S.



20-year Flood for “1973-2003” Compared to “1916-2003” for a Consistent Late 20th Century Temperature Regime



X_{20} ’73-’03 / X_{20} ’16-’03



X_{20} ’73-’03 / X_{20} ’16-’03

Hamlet A.F., Lettenmaier D.P., 2007: Effects of 20th Century Warming and Climate Variability on Flood Risk in the Western U.S., *Water Resour. Res.*, 43, W06427

Are the changes in variability that have been observed in the last third of the 20th century consistent with normal patterns of variability?

Long-Term Comparison of Annual Flow Records from Observations and Paleo Reconstructions

PNW:

Observed (naturalized) annual flow in the Columbia River at The Dalles, OR

1858-1877 (reconstructed from observed peak river stage)

1878-2003 (naturalized from observed monthly records)

CA:

Reconstructed combined annual flow in the Sacramento/San Joaquin basin from tree-ring records.

(Overlapping period 1858-1977)

(Meko, D.M., 2001: Reconstructed Sacramento River System Runoff From Tree Rings, Report prepared for the California Department of Water Resources, July)

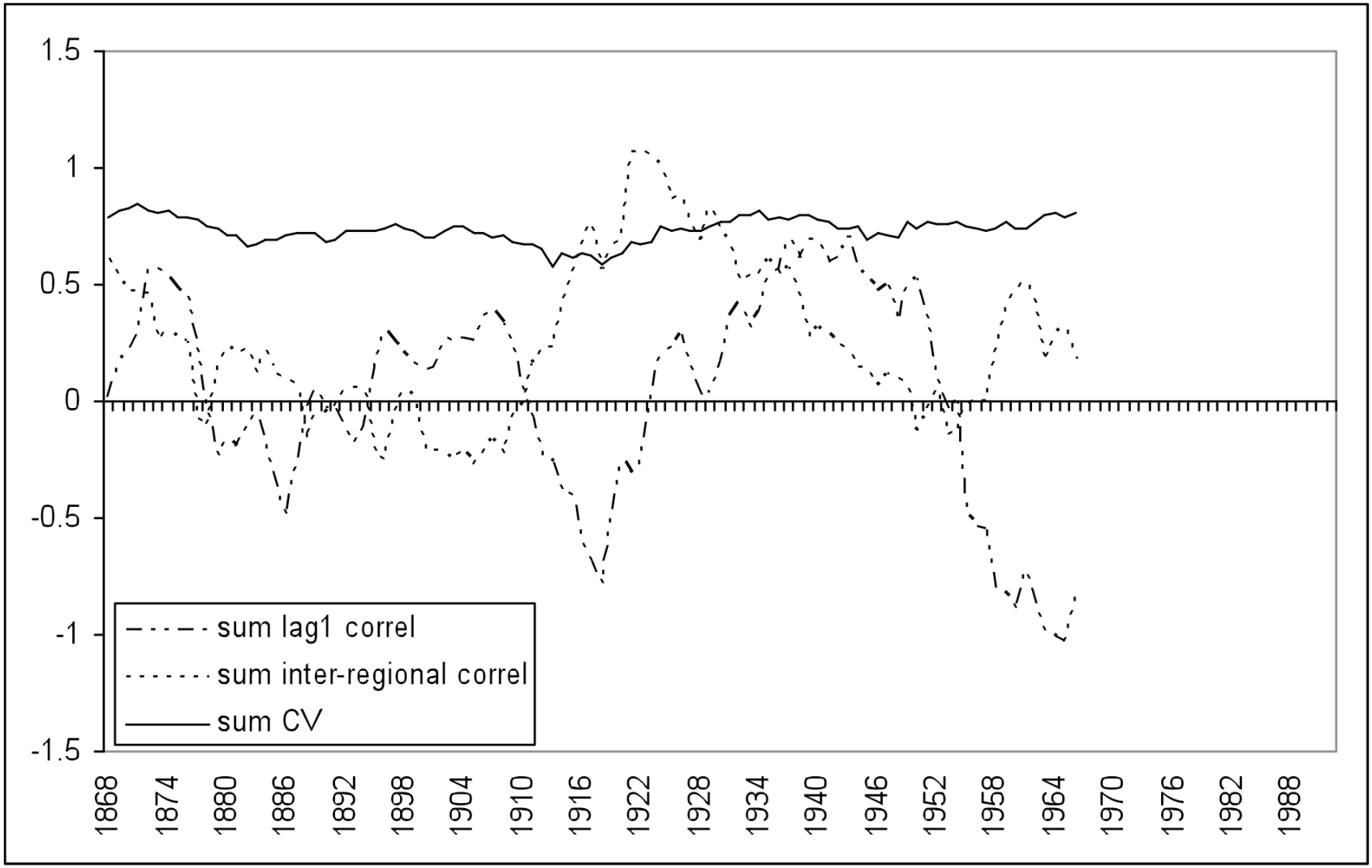
Colorado River Basin:

Reconstructed annual flow in the Colorado River at Lees Ferry, AZ from tree ring records.

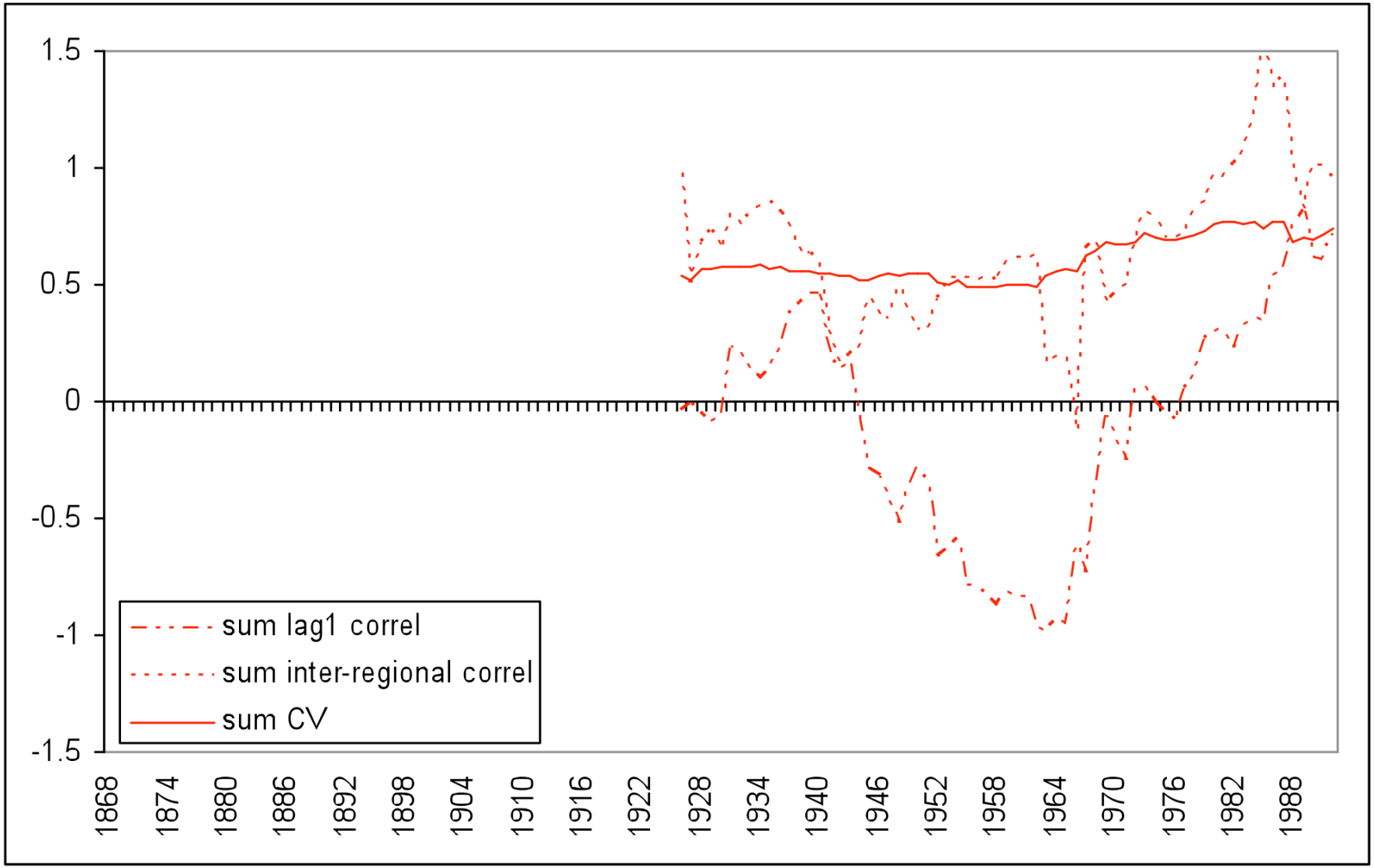
(Overlapping period 1858-1977)

(Woodhouse, C.A., S.T. Gray, and D.M. Meko, 2006: Updated Streamflow Reconstructions for the Upper Colorado River Basin, Water Resources Research, Vol. 42, W05415)

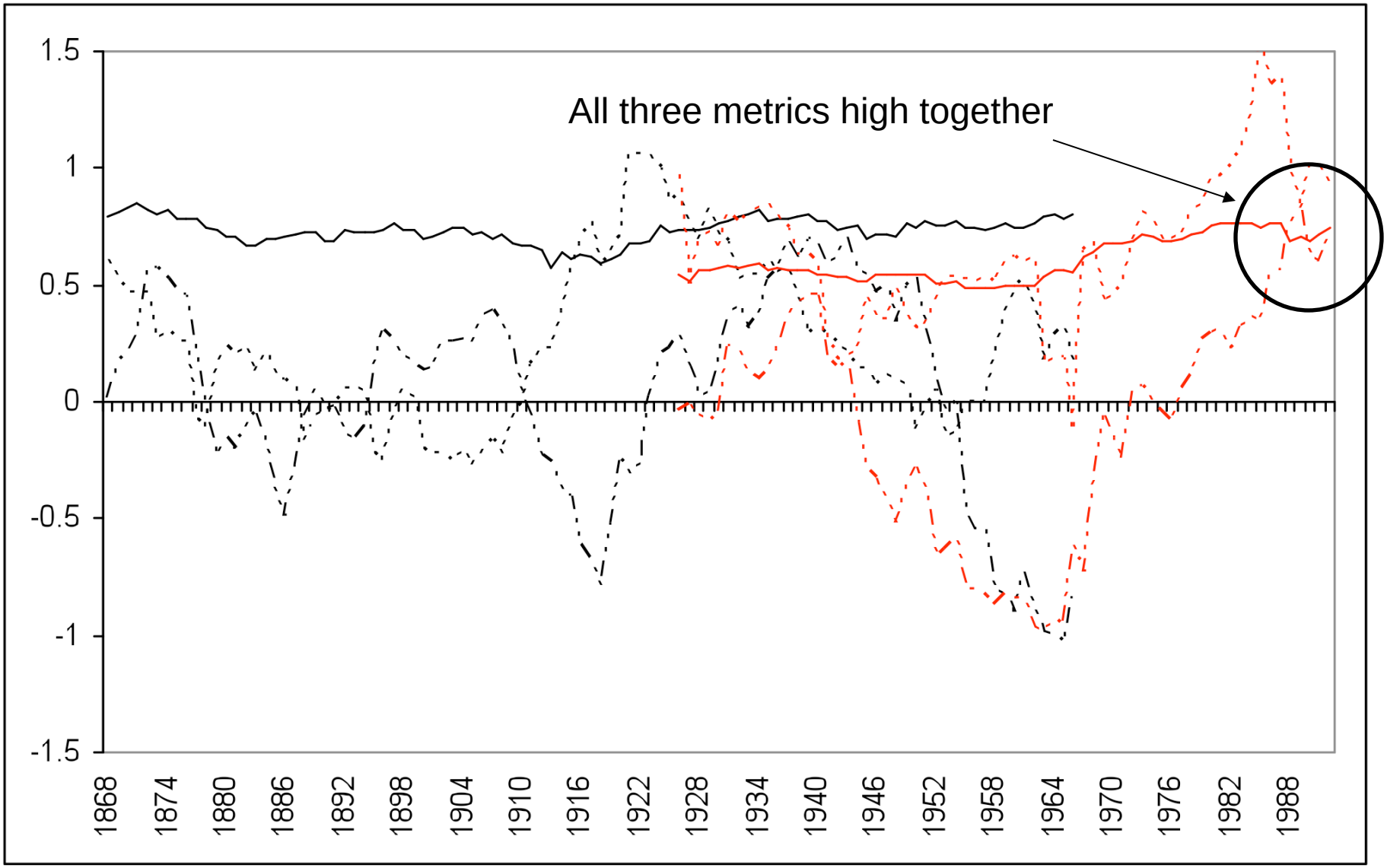
Changes in Streamflow Variability from Long-Term Observations and Paleo Reconstructions (1858-1977)



Changes in Streamflow Variability from VIC Simulations of Annual Flow (1916-2003)



Changes in Streamflow Variability from Combined Paleo Reconstructions and VIC Simulations of Annual Flow (1916-2003)



Paleo and VIC Reconstructions for Sacramento San Joaquin and Colorado River Basin