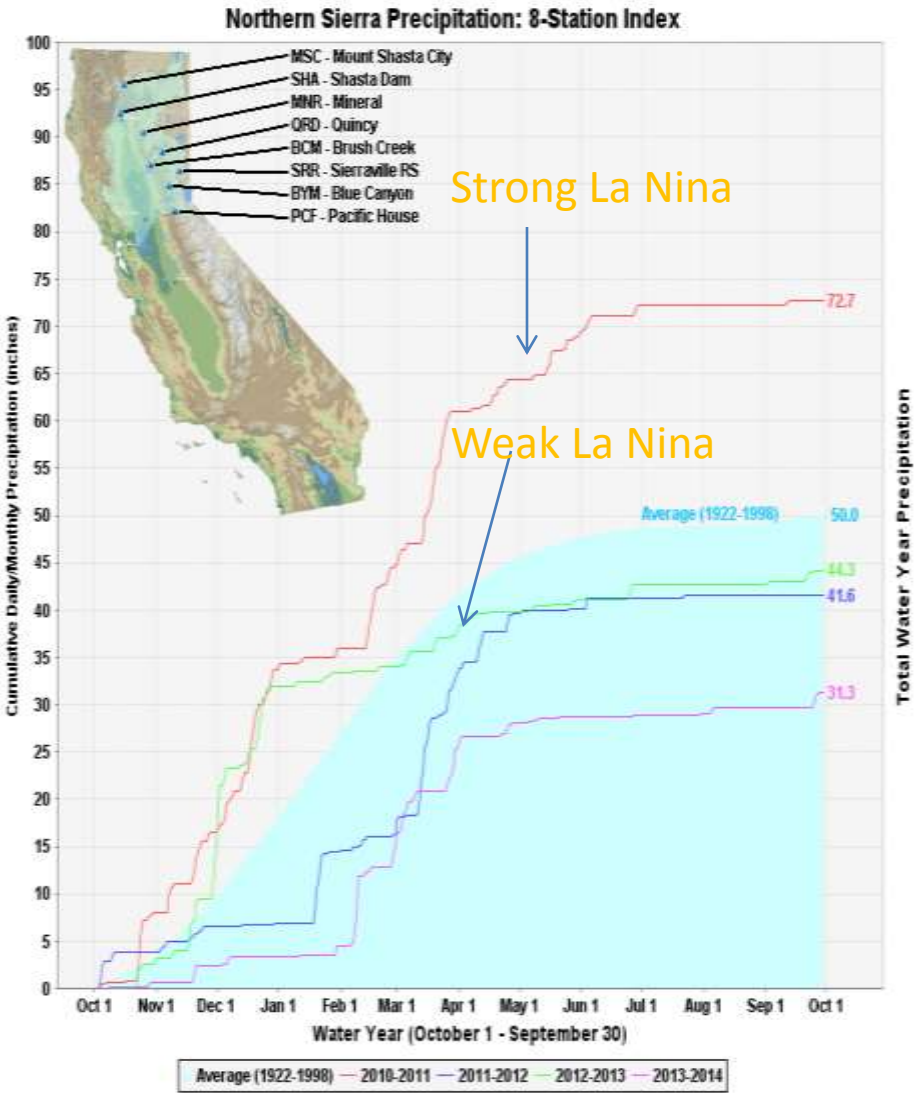
Quasi-decadal Oscillation in the CMIP5 and CMIP3 Climate Model Simulations: California case

Jianzhong Wang, Hongbing Yin, Erik Reyes and Francis Chung
Bay-Delta Office, Department of Water Resources, California

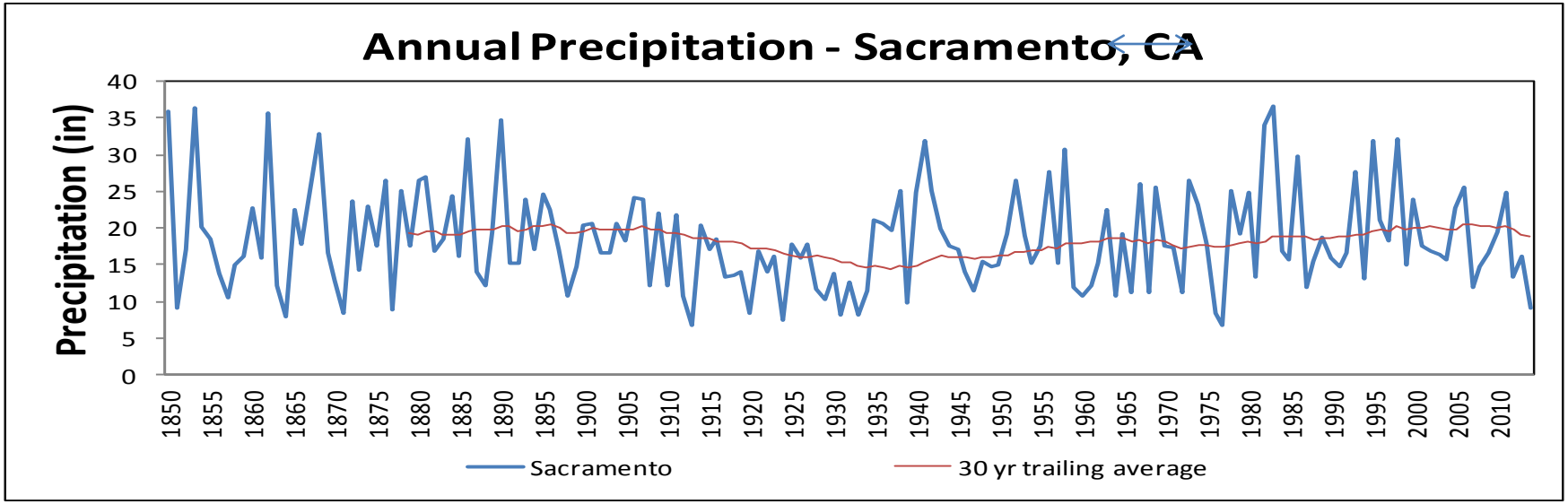
Why Are We Interested in It (QDO)?

- The intensity and length of drought is important to water resources planning in DWR.
  - dry years:1929-34, 1987-1992, 1976-1977
  - wet years: 1981-1986

- How do GCMs reproduce these dry/wet cycles?

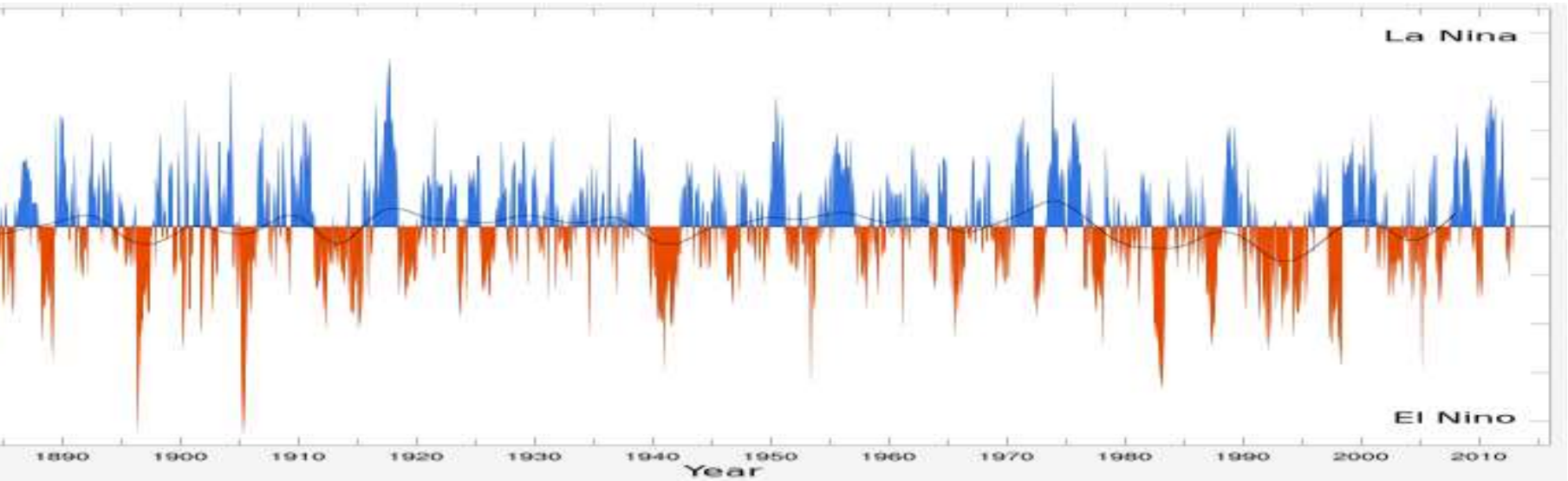


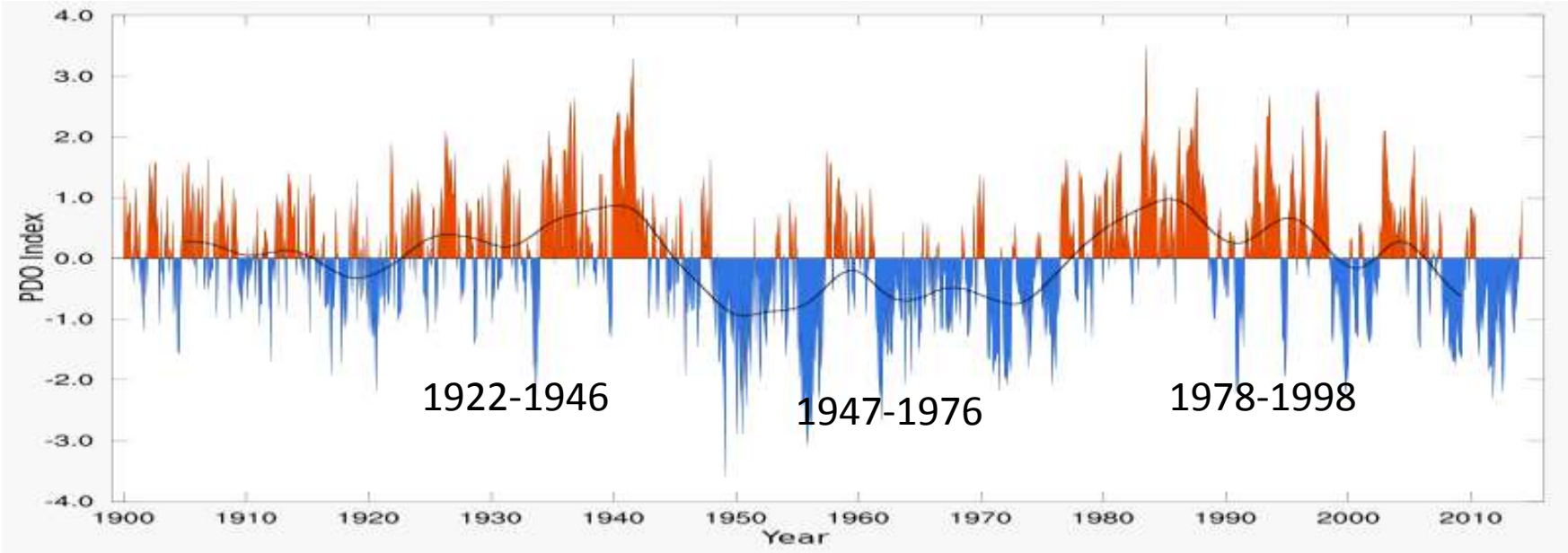
Interannual Variability in Historical Precipitation in Sacramento



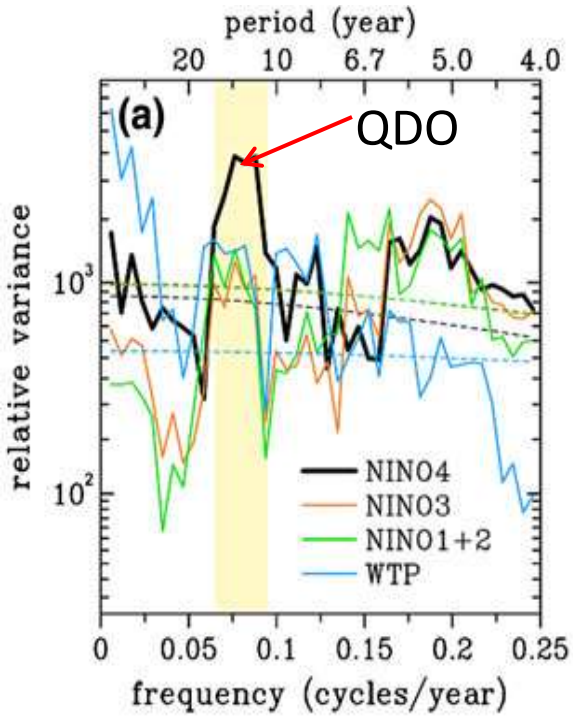
- 3-5 yrs (Period): ENSO
- 20-30 yrs (time scale): PDO, Pacific Decadal Oscillation
  - IDO: Interdecadal Oscillation
- 10-15 yrs (Period): Pacific Quasi-Decadal Oscillation, QDO

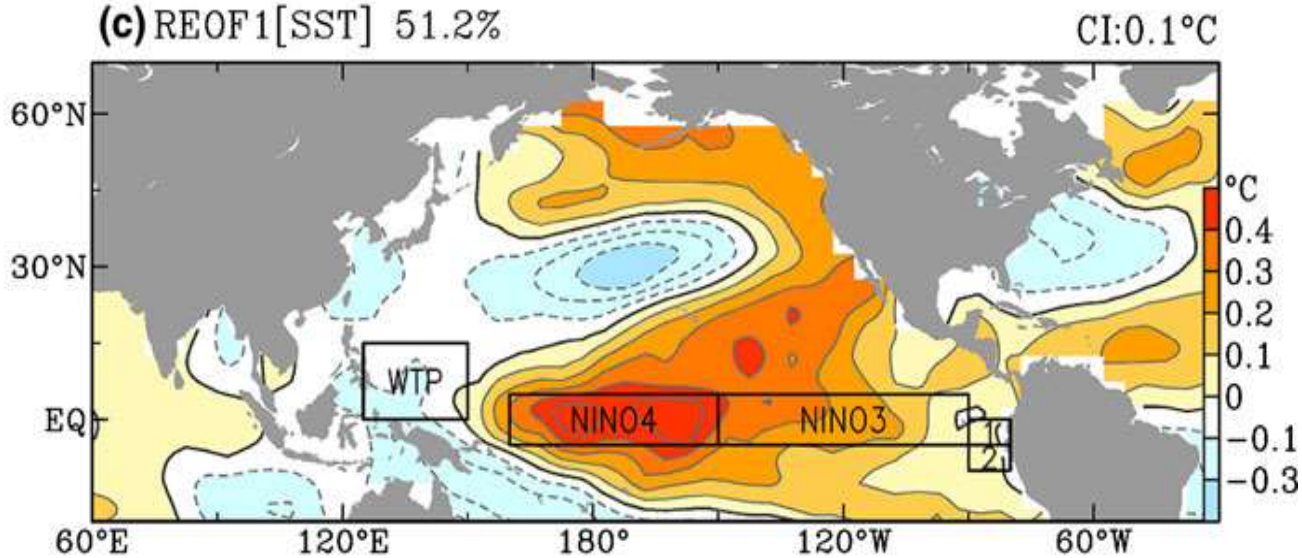
Interannual Variability: ENSO and PDO





Interannual Variability: Pacific Quasi-Decadal Oscillation

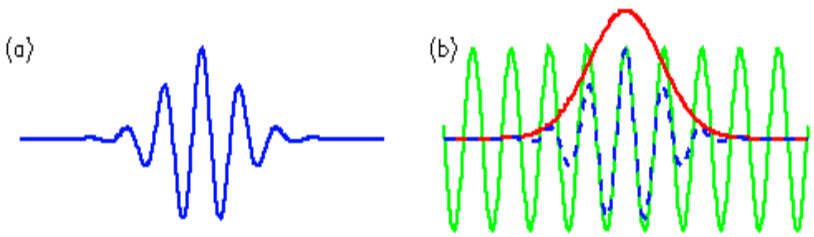


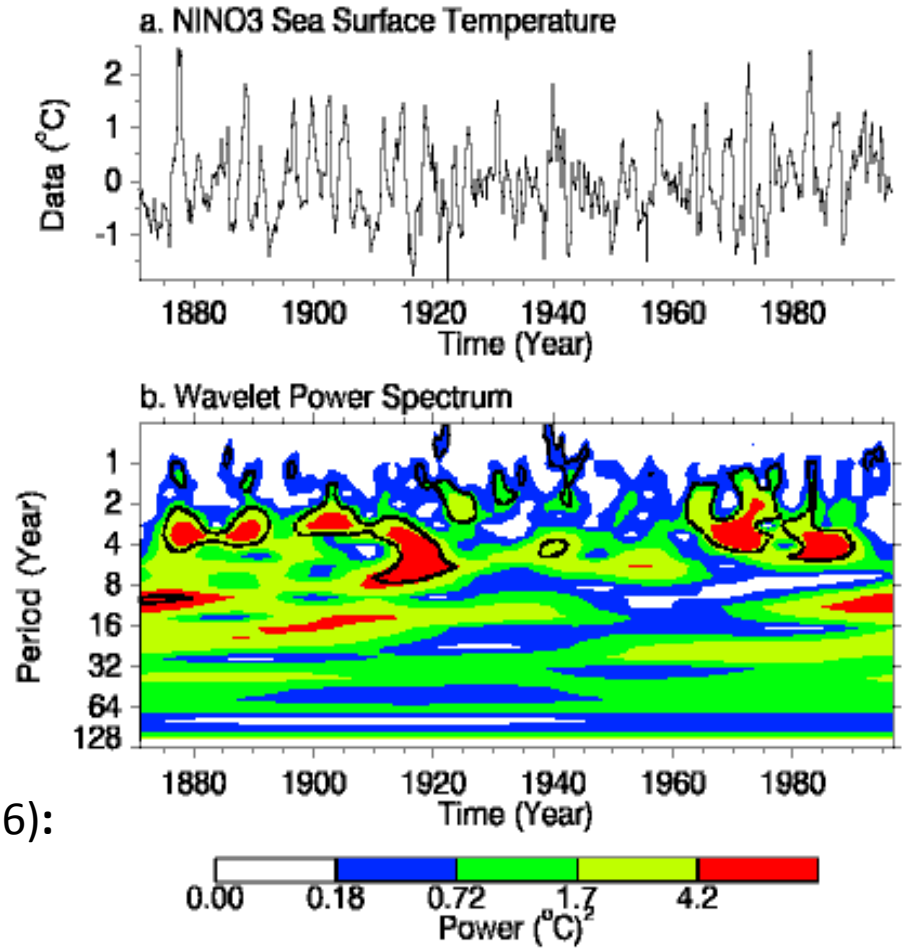


The word "oscillation" is used here to indicate any repeating fluctuation in the timeseries, regardless of whether the fluctuation repeats on a regular basis or not

Shih-Yu Wang et al

Wavelet Analysis





- Non-stationary time series

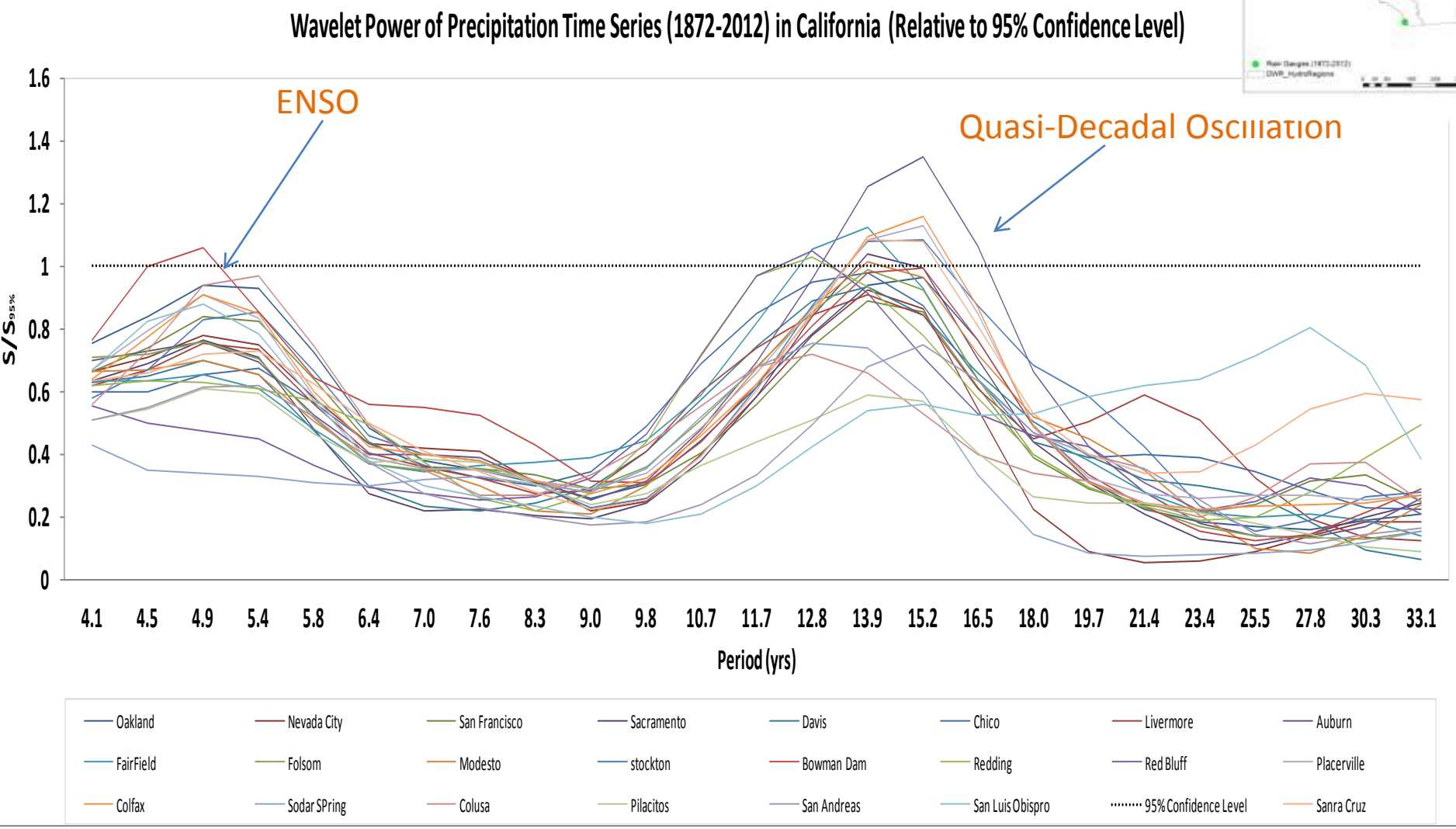
- **5% Significance test** (Mann and Lee, 1996)**:**

(1). White Noise

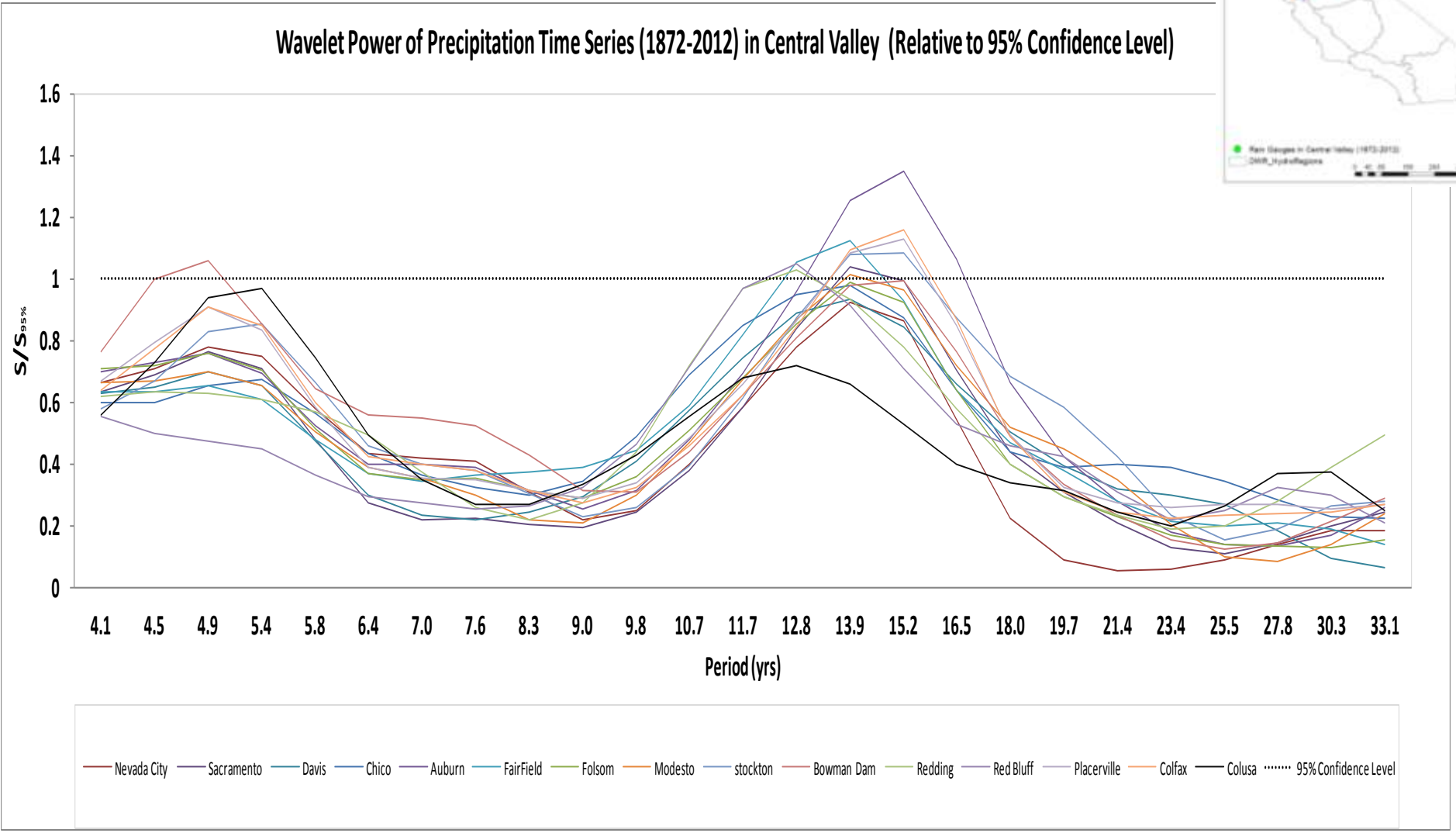
(2). Red Noise—Consider autocorrelation

http://paos.colorado.edu/research/wavelets/wavelet2.html

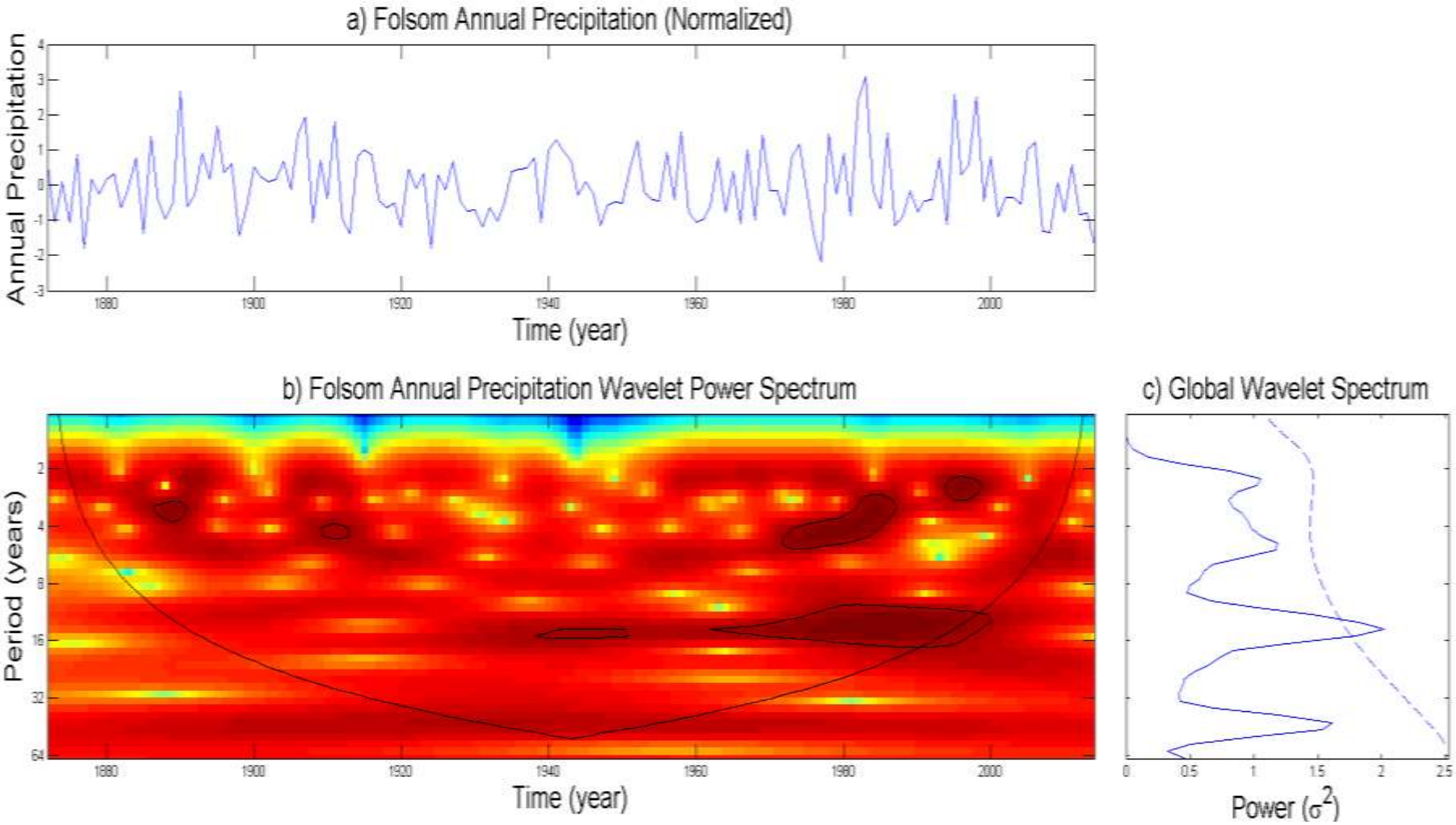
Interannual Variability in Historical Precipitation in California



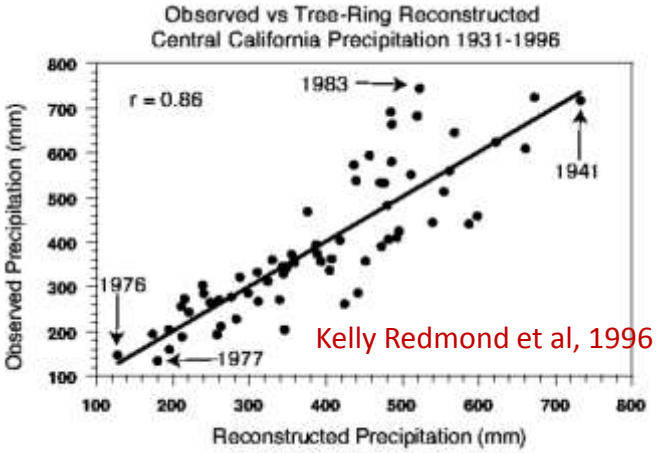
Interannual Variability in Historical Precipitation in Central Valley

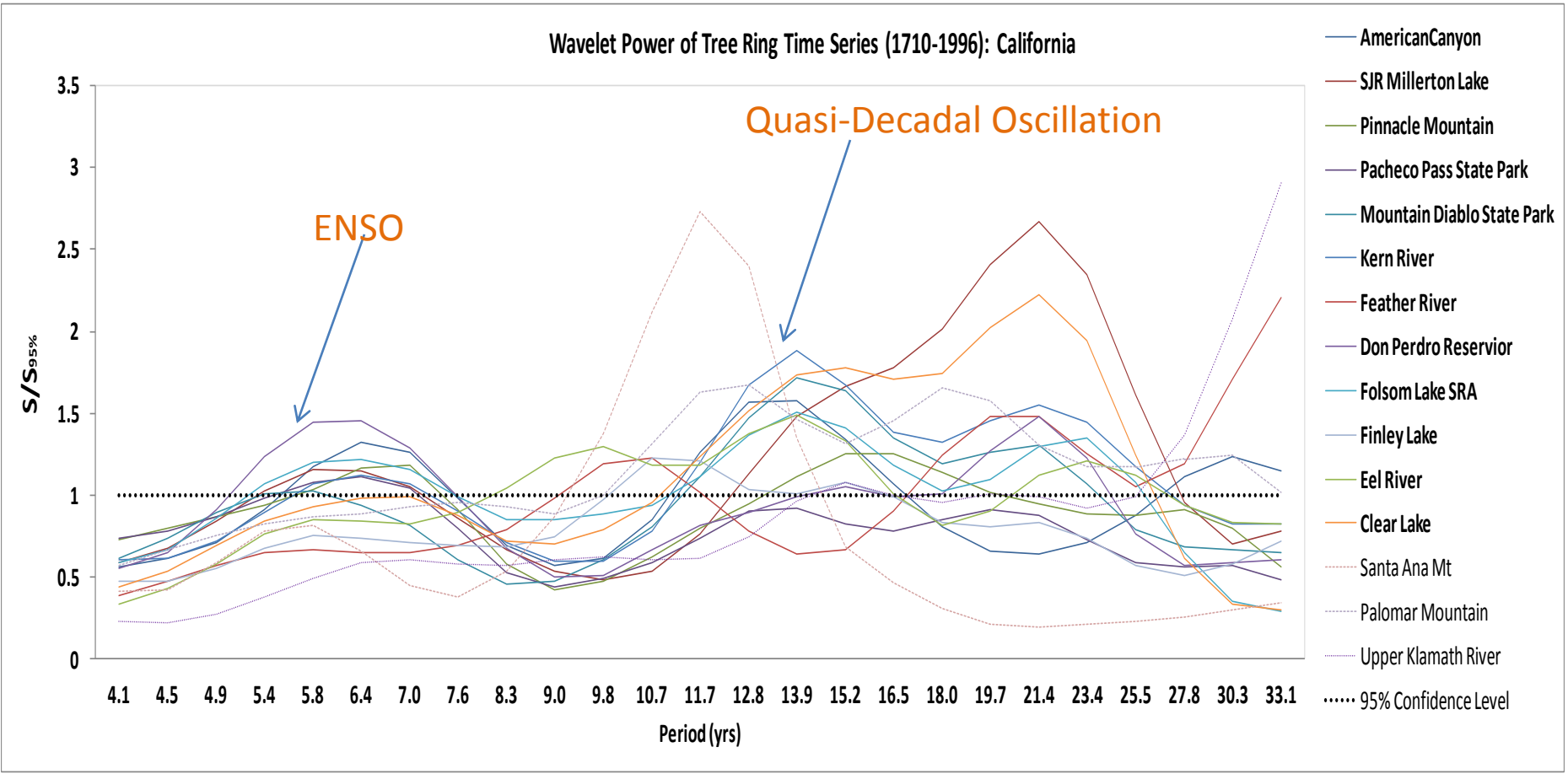


Interannual Variability in Historical Precipitation in Folsom (1872-2013)

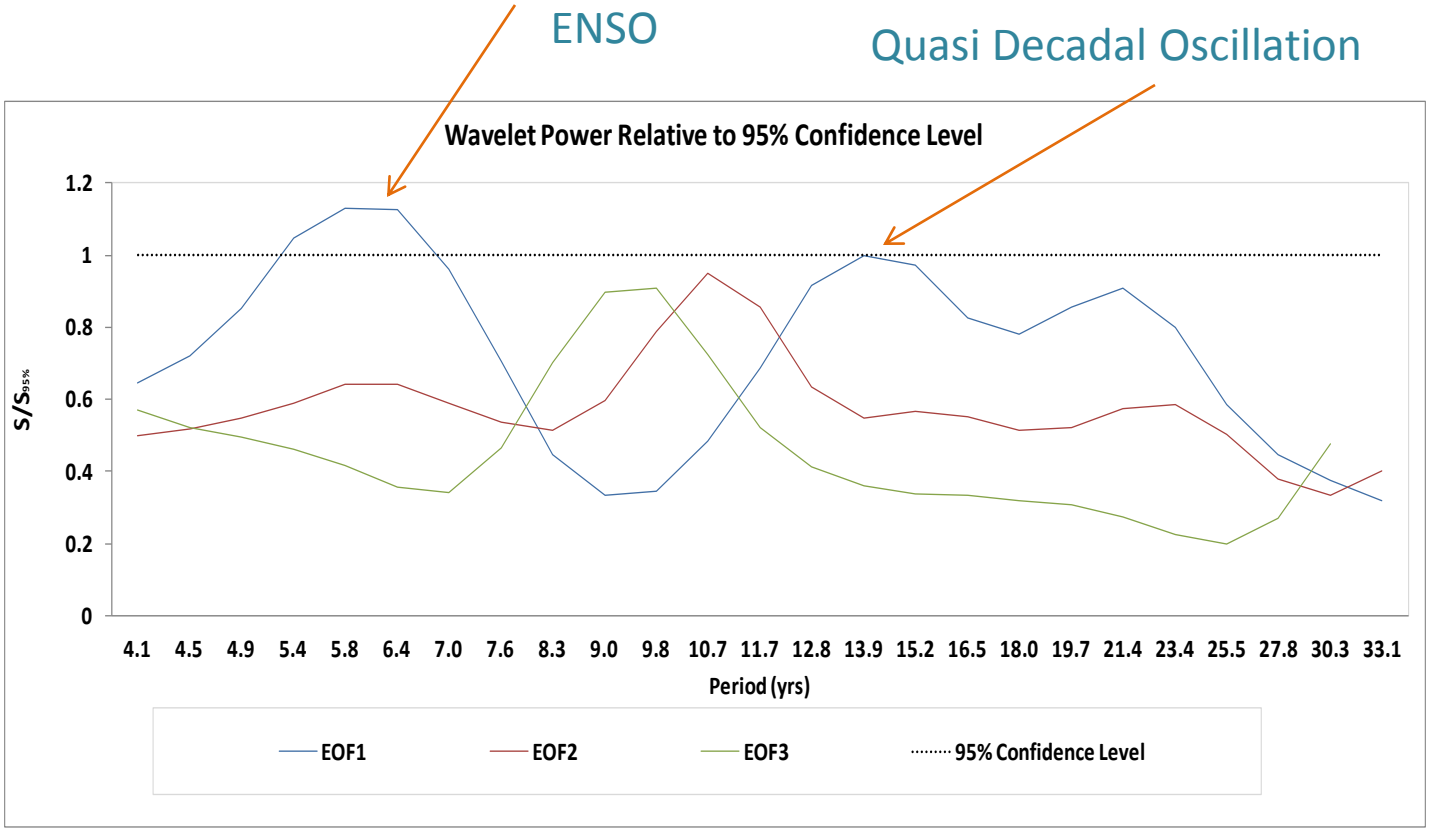


Interannual Variability in Tree Ring Records in California





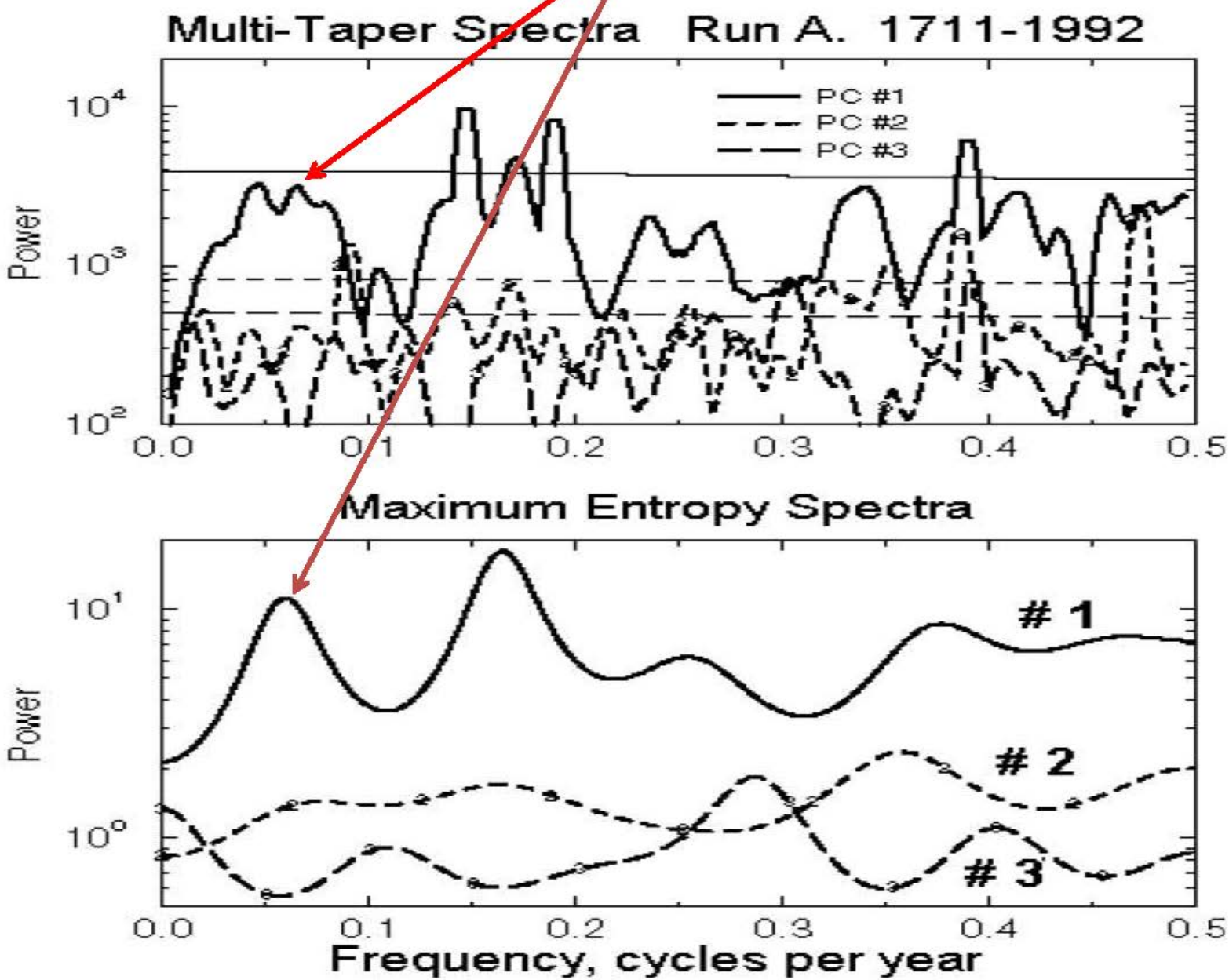
Wavelet Analysis on EOFs of 12 Tree Ring Time Series In Central Valley



EOF1 explains 57% of total variance,
EOF2 10%
EOF3 7%.

Kelly Redmond et al, 1996

Quasi-decadal Oscillation

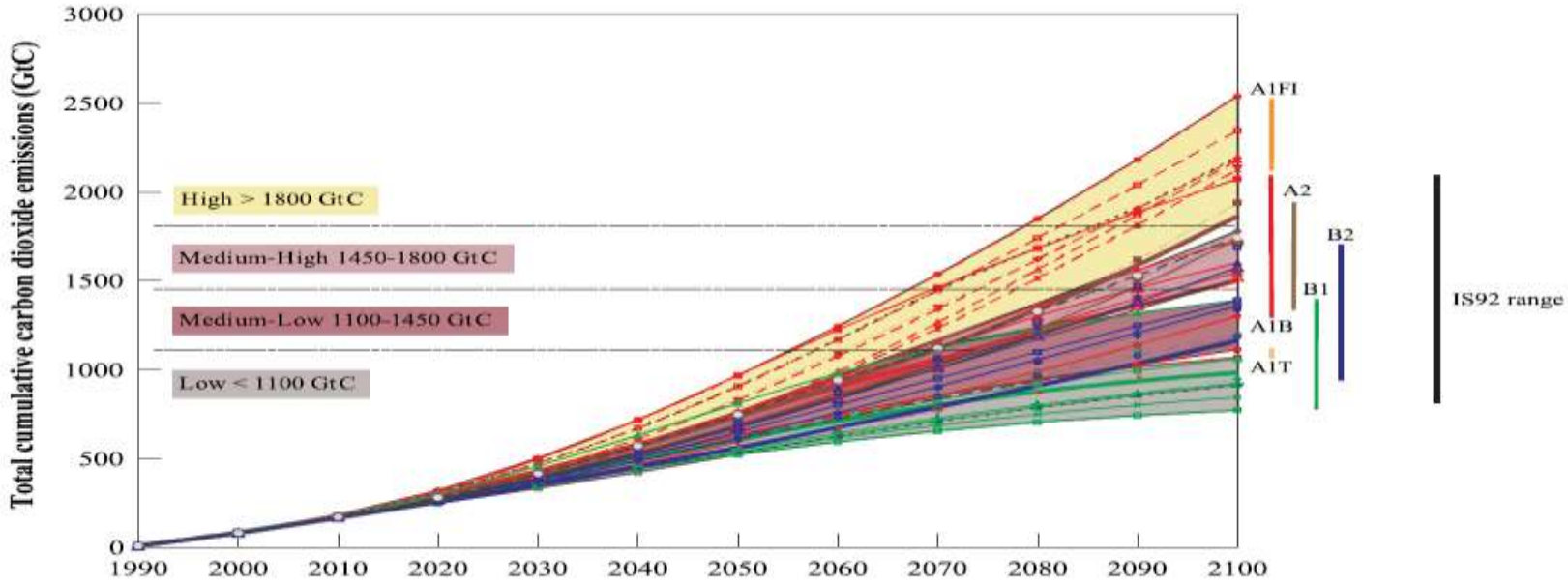


CMIP3 and CMIP5

- CMPI3:Coupled Model Intercomparison Project Stage 3, used for the Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC)
- CMIP5: Coupled Model Intercomparison Project Stage 5, used for the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC)

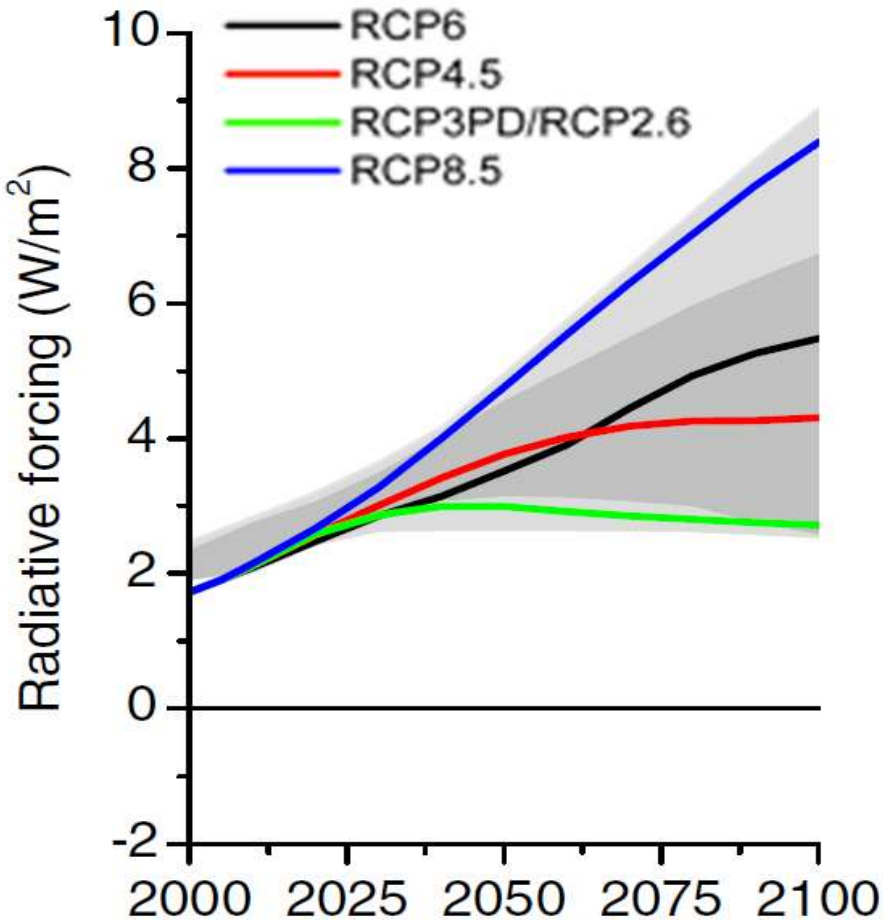
CMIP3 : AOGCMs and SRES

- 23 AOGCMs: Atmosphere-Ocean GCMs
- SRES: The Special Report on *Emissions Scenarios* (*SRES*)



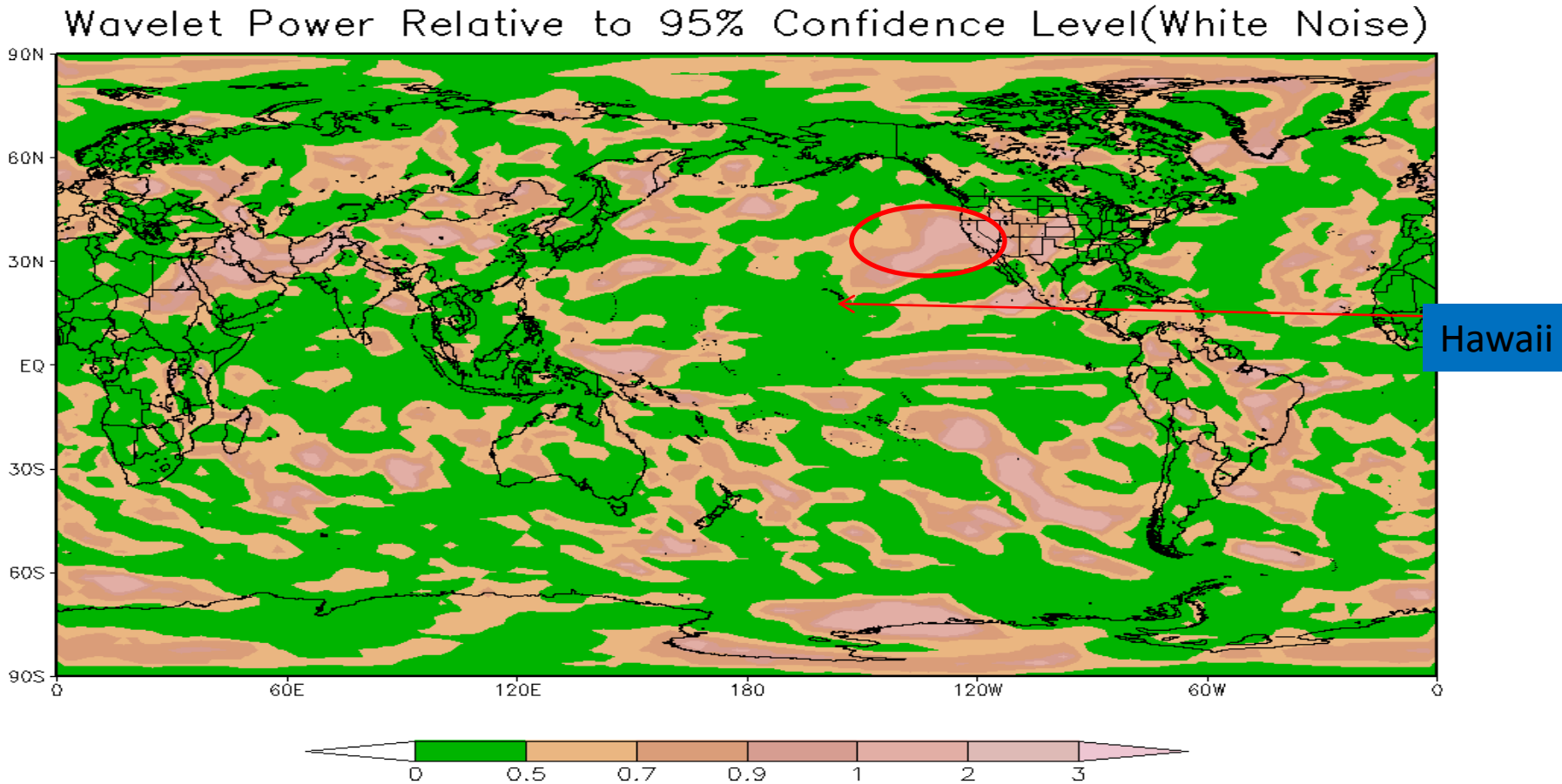
CMIP5: AOGCMs (or ESMs) and RCP

- 30 models
- Four RCPs (Representative Concentration Pathways): RCP 2.6, RCP4.5, RPC6.0 , and RCP 8.5

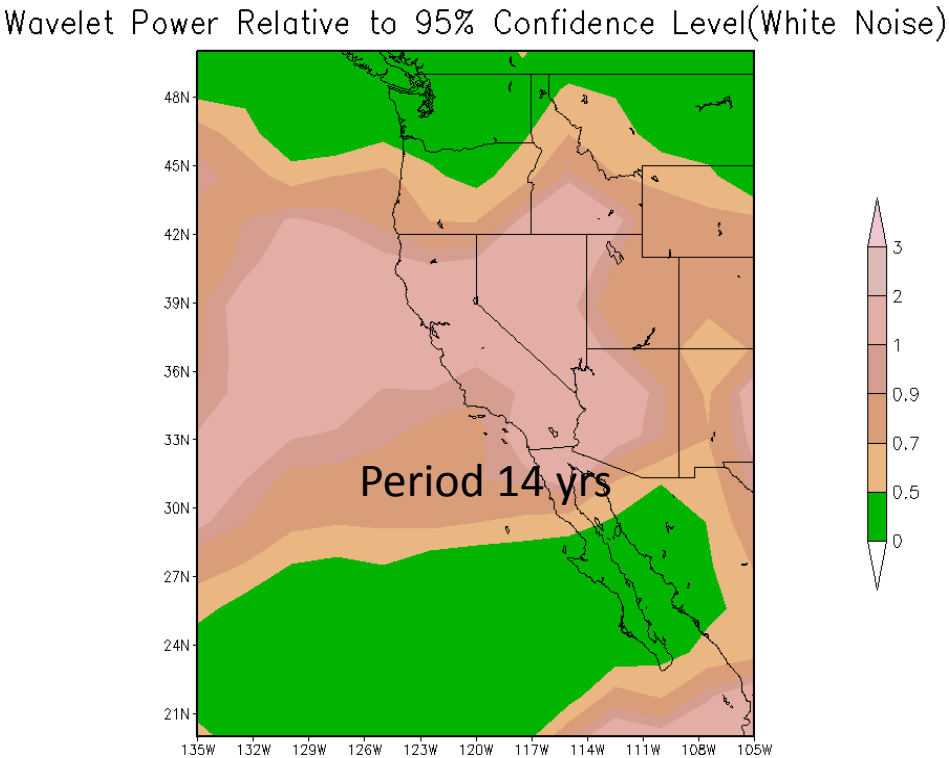


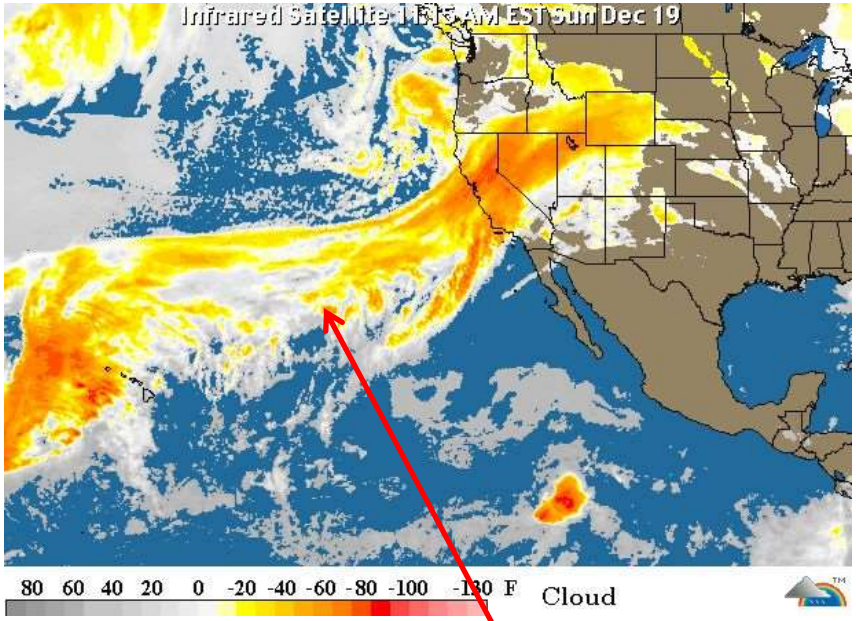
How well CMPI3 and CMIP5 simulate QDO in Precipitation in California?

- Only one climate model, NCAR CESM1-WACCM simulation (1850-2005) reproduces QDO (~14yr period) in Precipitation in California in terms of passing significant test (against white noise)



How well CMPI3 and CMIP5 simulate QDO in Precipitation in California? (Cont.)

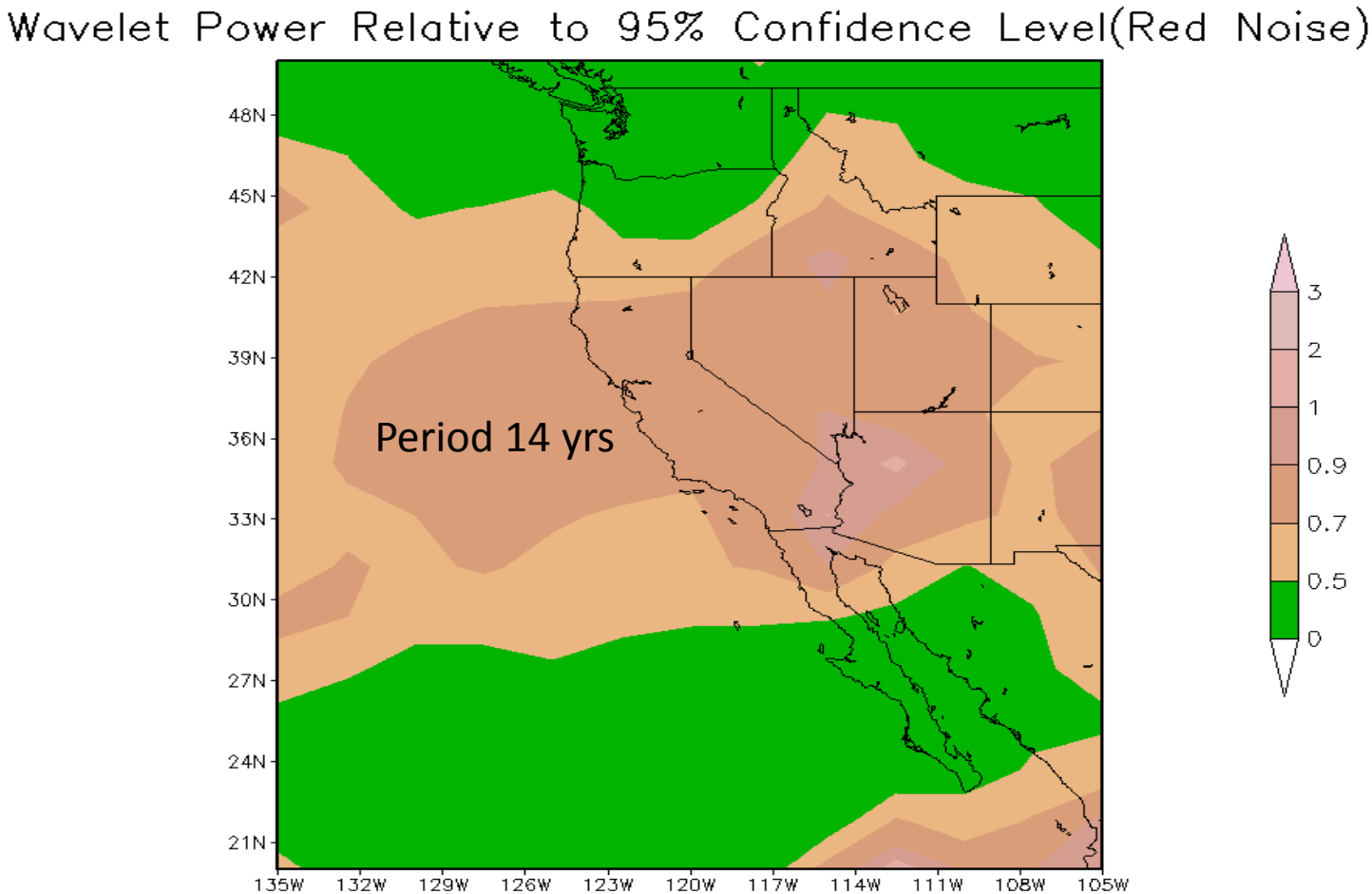




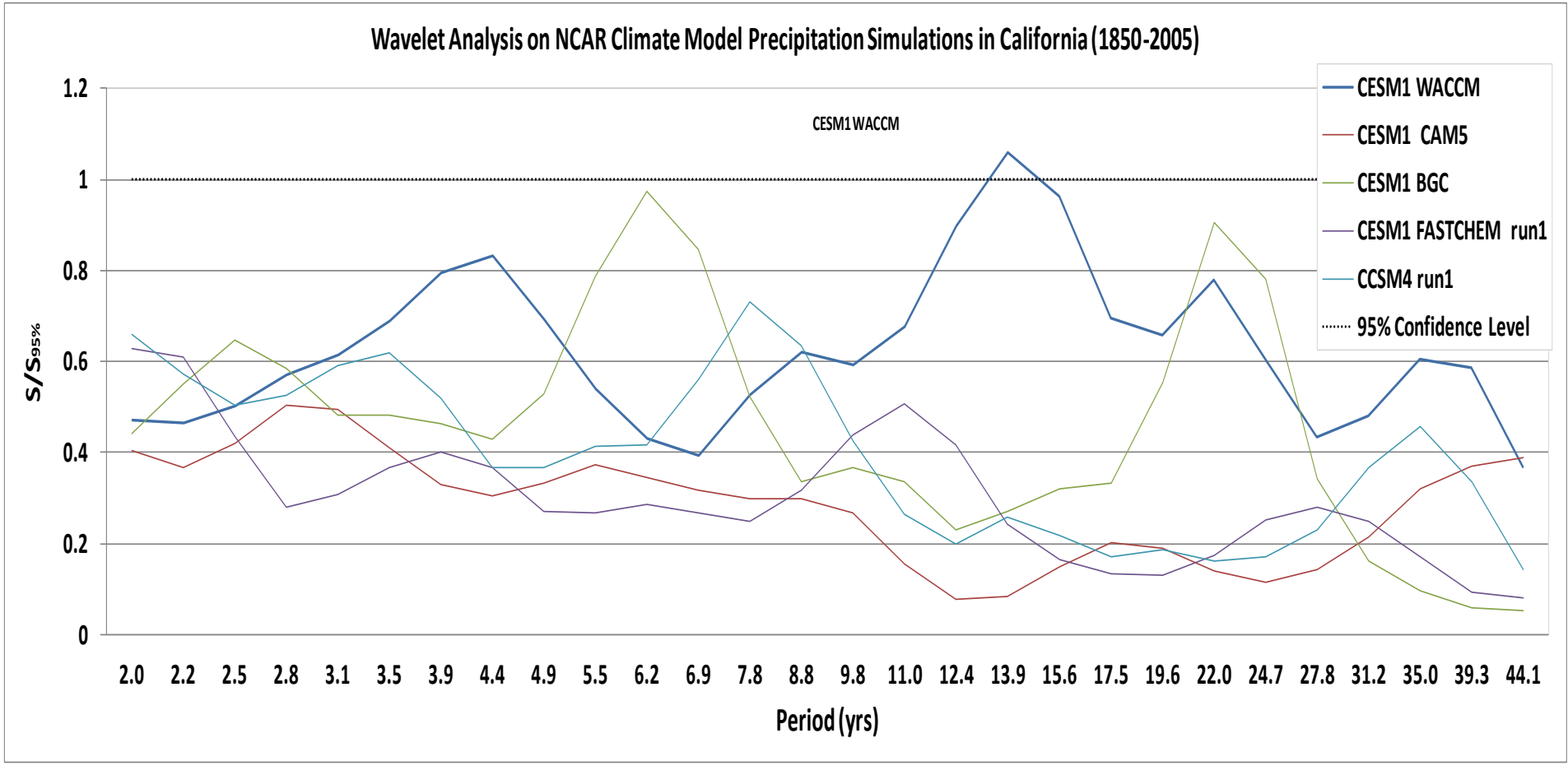
www.weather.com

Pineapple Express

How well CMPI3 and CMIP5 simulate QDO in Precipitation in California? (Cont.)



Wavelet Analysis on NCAR Climate Model Precipitation Simulations in Folsom (1850-2005)

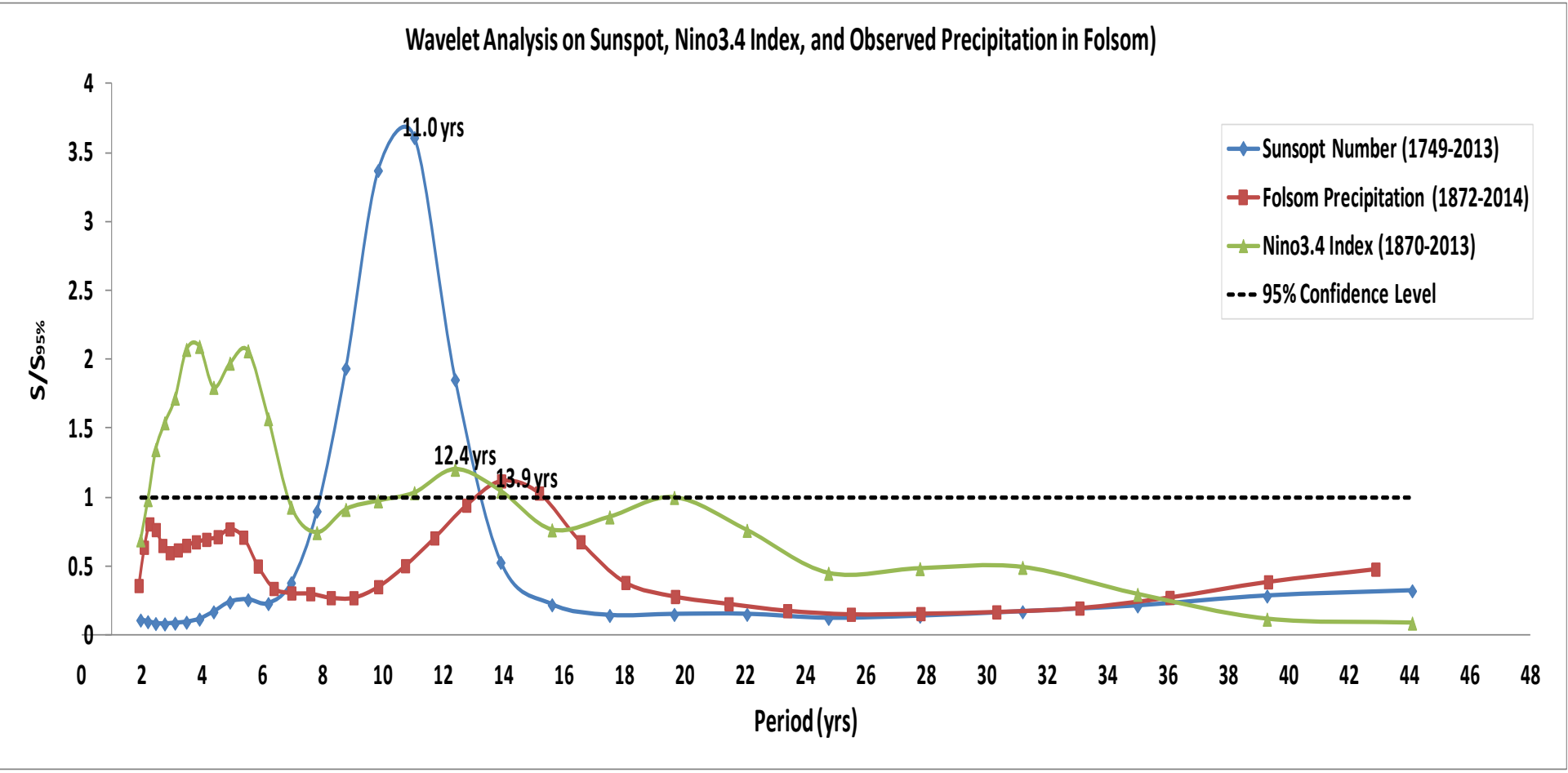


In CESM1 WACCM， a quasi-biennial oscillation may be imposed (as an option) by relaxing the winds to observations in the Tropic

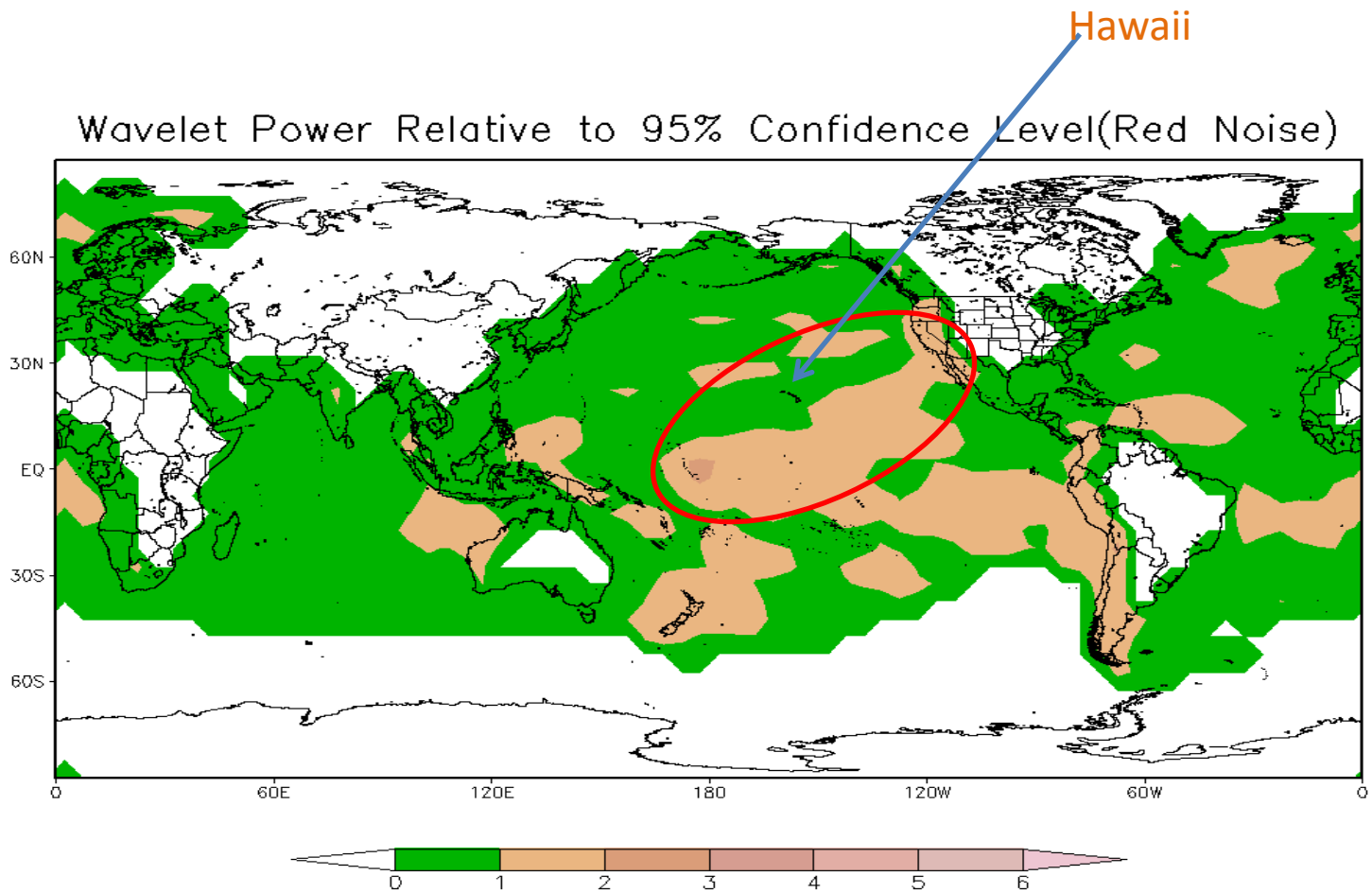
What Causes this QDO in Precipitation in California?

- External Forcing: Solar black spot?
  - CMIP5 all climate models use actual extraterrestrial solar irradiance data
  - The forcing of 0.2–0.3 Wm^{-2} is too weak
- Internal Variability of Coupled Atmospheric-Ocean System?
  - Niño 3.4 Index
- Both: Resonance

What Causes this QDO in Precipitation in California? (Conti.)

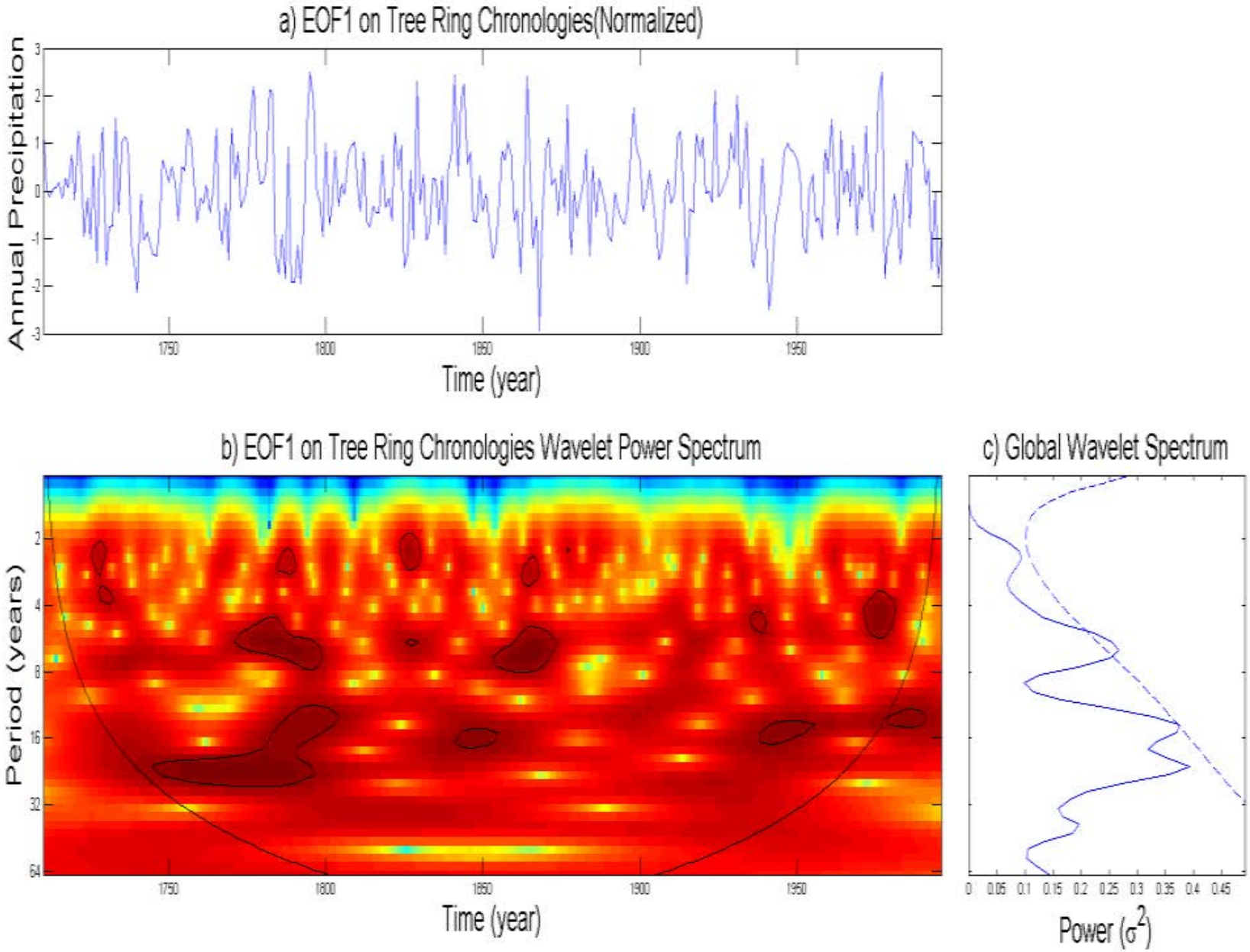


Wavelet Power of Observed SST Relative to 95% Confidence Level at the Period of 14 yrs



Summary

- Quasi-Decadal Oscillation is existing in precipitation in California (especially in Central Valley)
- This QDO in California Precipitation is non-stationary and is the most active in the period of 1930-2000.
- Among all the GCMs in the world, only the most recent version of NCAR climate model reproduces QDO in California Precipitation.


a) EOF1 on Tree Ring Chronologies(Normalized)
Annual Precipitation
3
2
1
0
-1
-2
-3
1750
1800
1850
1900
1950
Time (year)
b) EOF1 on Tree Ring Chronologies Wavelet Power Spectrum
Period (years)
2
4
8
16
32
64
1750
1800
1850
1900
1950
Time (year)
c) Global Wavelet Spectrum
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
Power (σ^2)