Pacific Basin ensemble SST field reconstructions from marine paleoproxy data

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Thanks: Richard Seager, Amy Clement, Konrad Hughen, Natalie Goodkin, Henning Kuhnert, Rosanne D'Arrigo, Rob Wilson, Ed Cook, Jason Smerdon, Kim Cobb, Joelle Gergis, Brendan Buckley, Pavla Fenwick, Anthony Fowler

Outline

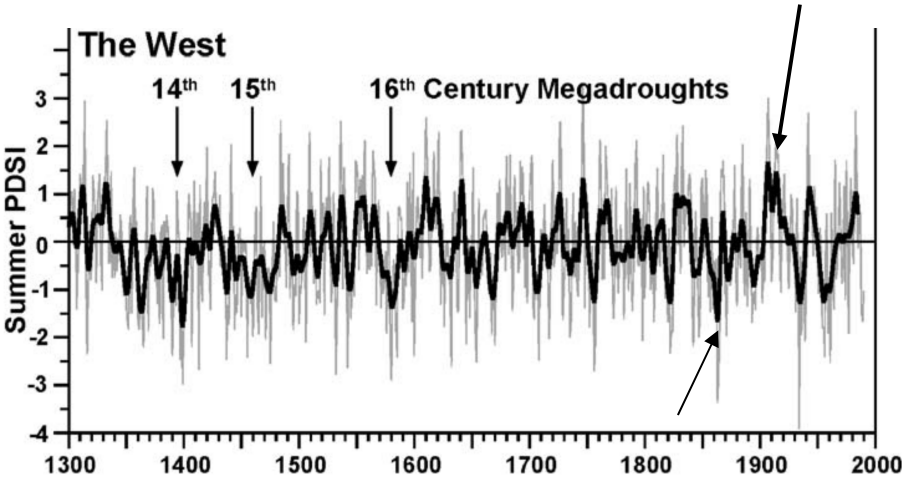
- Ensemble reduced space optimal interpolation scheme.
- Results:
  - Skill and uncertainty.
  - Comparison: SST and drought reconstructions.

Long-term hydroclimate variations in western North America: Tropical Pacific forcing?

SST reconstructions

AGCM

Drought reconstructions



Cook et al. 1999, 2004; Stahle et al., 2007; Seager et al 2007, 2008

Methodology

- *SVD-based, low-dimensional paleodata calibration*
- *Ensemble-OI climate field reconstruction*
  - *fit to error-weighted calibrated proxies and truncated description of modern SST variance*
  - *Ensemble generated from multivariate random normal error sampling*
  - *Error variance + signal variance ~ constant over time*
- *Diagnostics*
  - *Correlation and error fields*
  - *NINO34 SST anomaly index*
  - *Composites from drought and pluvial intervals*

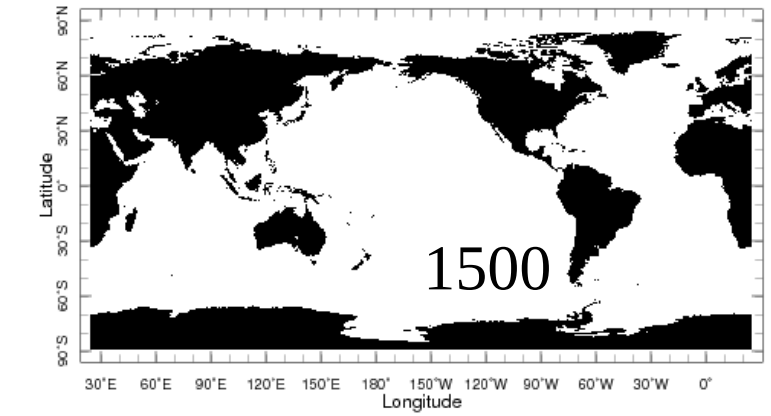
Paleo data set: 73 marine proxies

(68 corals*, 5 schlerosponges, ~44 distinct sites)

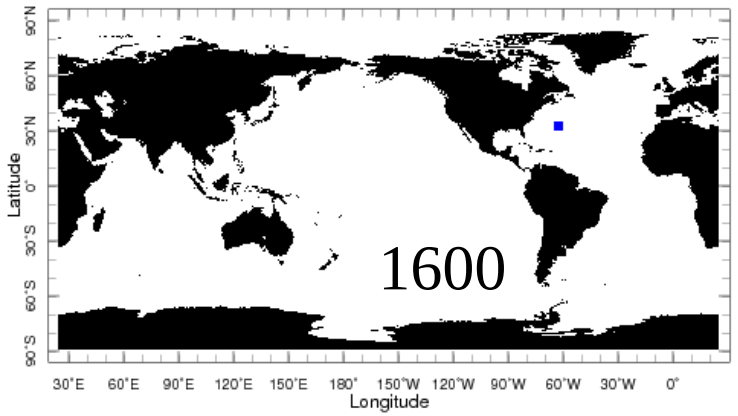
proxy type	"process model"	number
• $\delta^{18}O$	f(T, $\delta^{18}O_{sw}$)	55
• Sr/Ca	f(T, Sr/Ca_{sw})	8
• Mg/Ca	f(T, Mg/Ca_{sw})	1
• Ba/Ca	f(T, Ba/Ca_{sw}) ~ nutrients/upwelling	1
• Density	f(T, Φ, nutrients)	1
• Extension rate	f(T, Φ, nutrients)	2
• Calcification rate	ρ*extension rate	1(71)
• Luminescence	f(S)	4

e.g. Weber and Woodhead, 1972; deVilliers et al. 1994; Barnes and Lough, 1990; Lough and Barnes, 1997; Barnes et al. 2003). Data from: WDC-A for Paleoclimatology (2007-2008), H. Kuhnert, N. Goodkin and K.Hughen, pers. comm. 2007

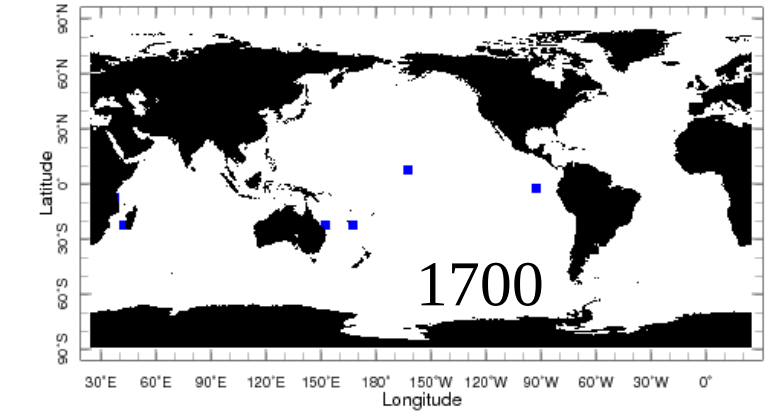
Proxy data availability: 1500-1950



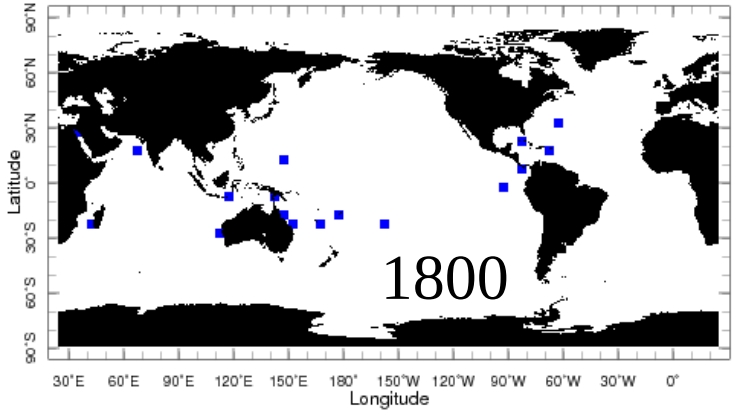
Apr 1499 - Mar 1500



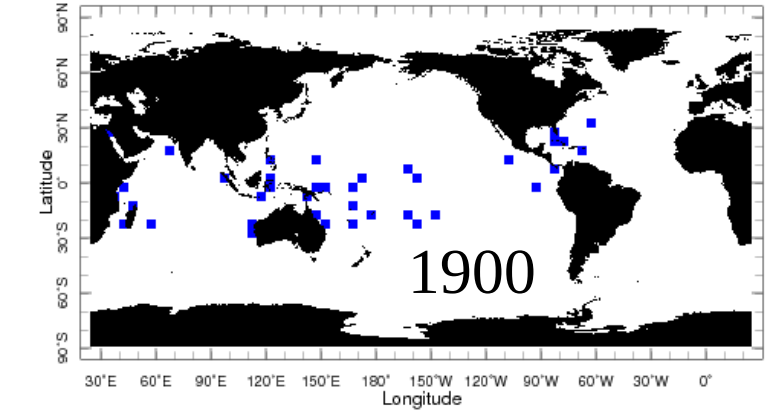
Apr 1599 - Mar 1600



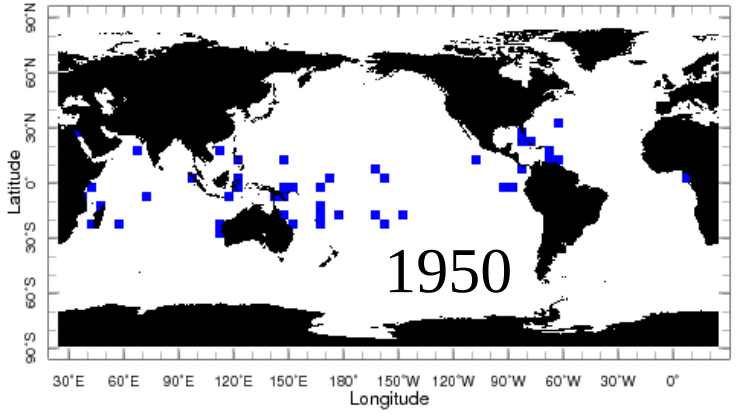
Apr 1699 - Mar 1700



Apr 1799 - Mar 1800



Apr 1899 - Mar 1900

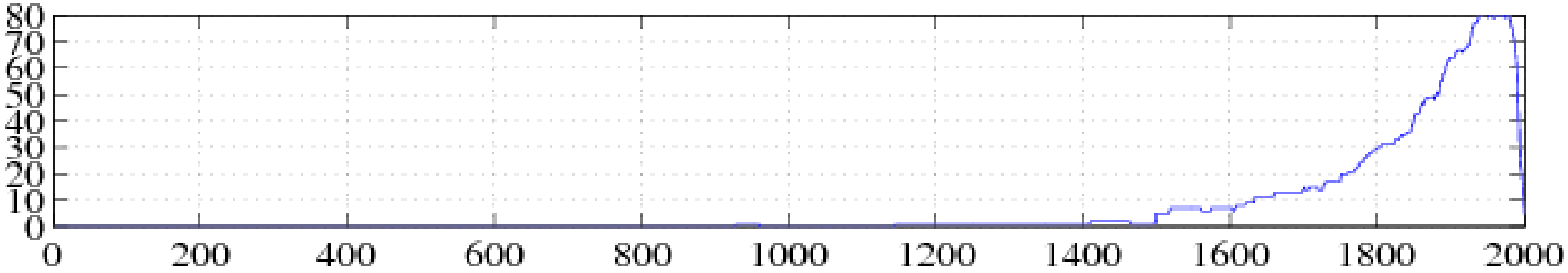


Apr 1949 - Mar 1950

WDC-A for Paleoclimatology, 2007-2011 and unpublished data contributors

Parameters

- Target climate field: latitude-weighted Pacific Basin SST, April-March averages, all latitudes, 110E-65W
- SST field space reduction: 95% of variance retained in 30 patterns
- Proxy preprocessing: standardization to calibration period mean + variance
- Proxy calibration period: 1923-1990; validation period: 1856-1922
- Number of calibrated patterns: 2
- Ensemble realizations performed: 100
- Reconstruction interval: 1-2000

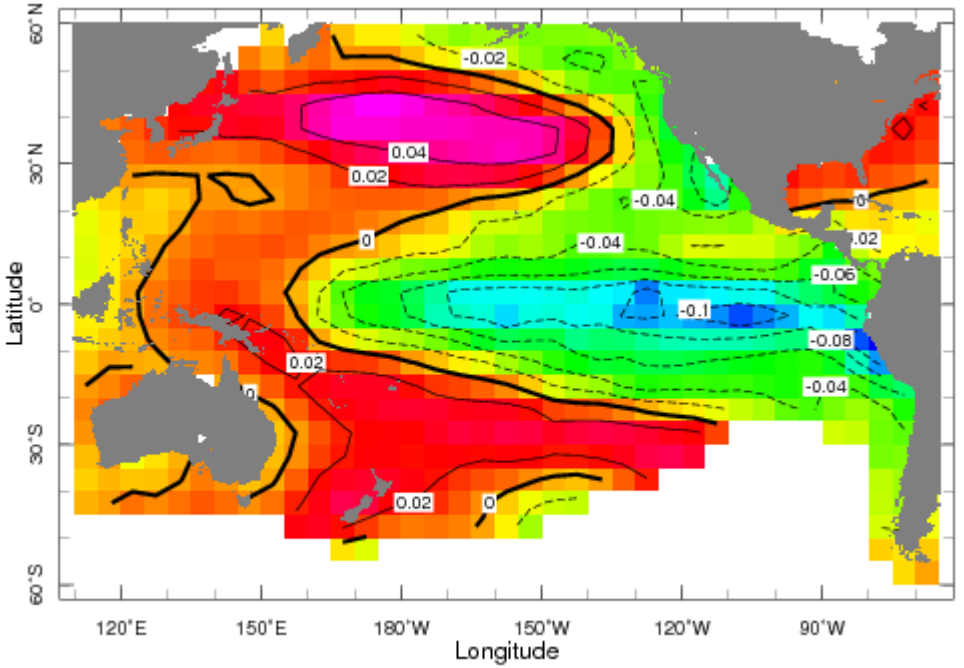


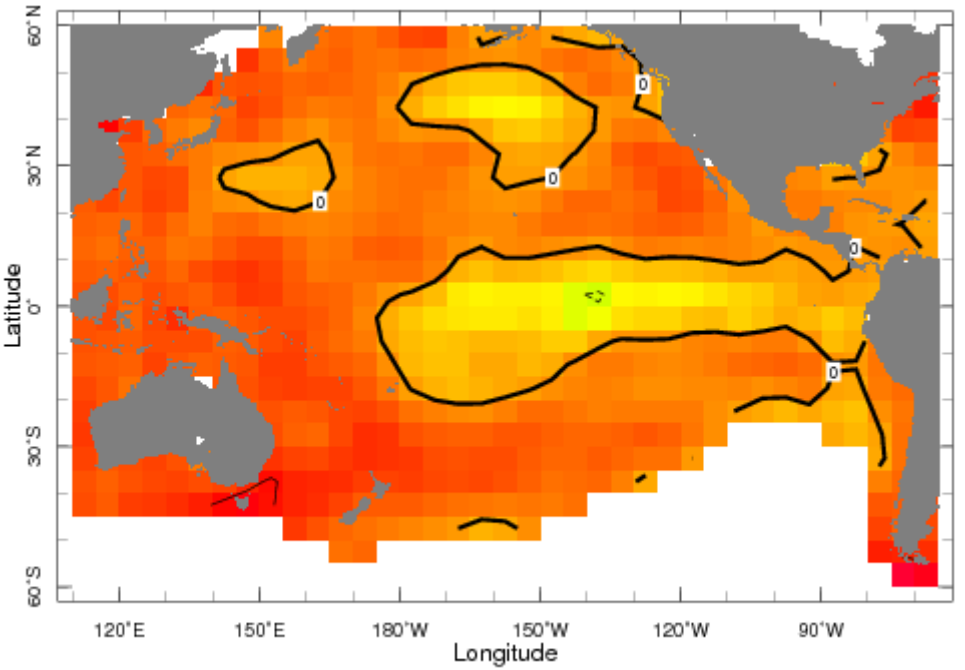
Kaplan et al. 1997, 1998, 1999; Evans et al. (1998, 2000, 2001, 2002); Evans and Kaplan (2011) in prep

Calibrated patterns

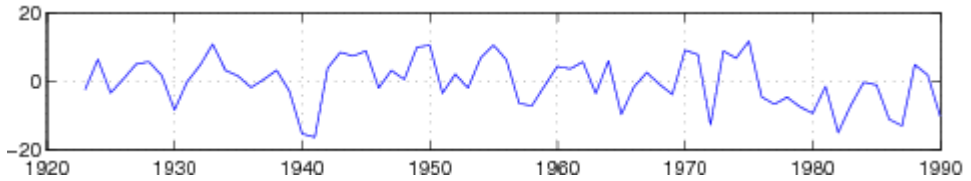
pattern 1: 69% covariance

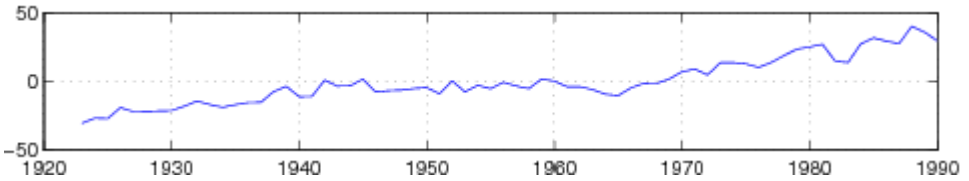
pattern 1: 14% covariance





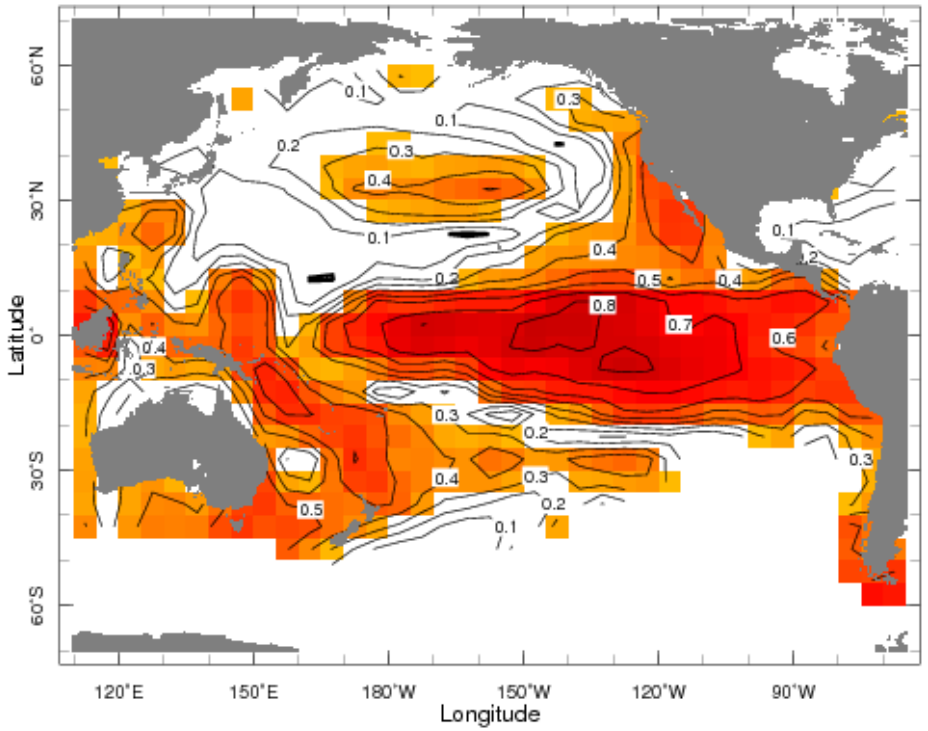
1.



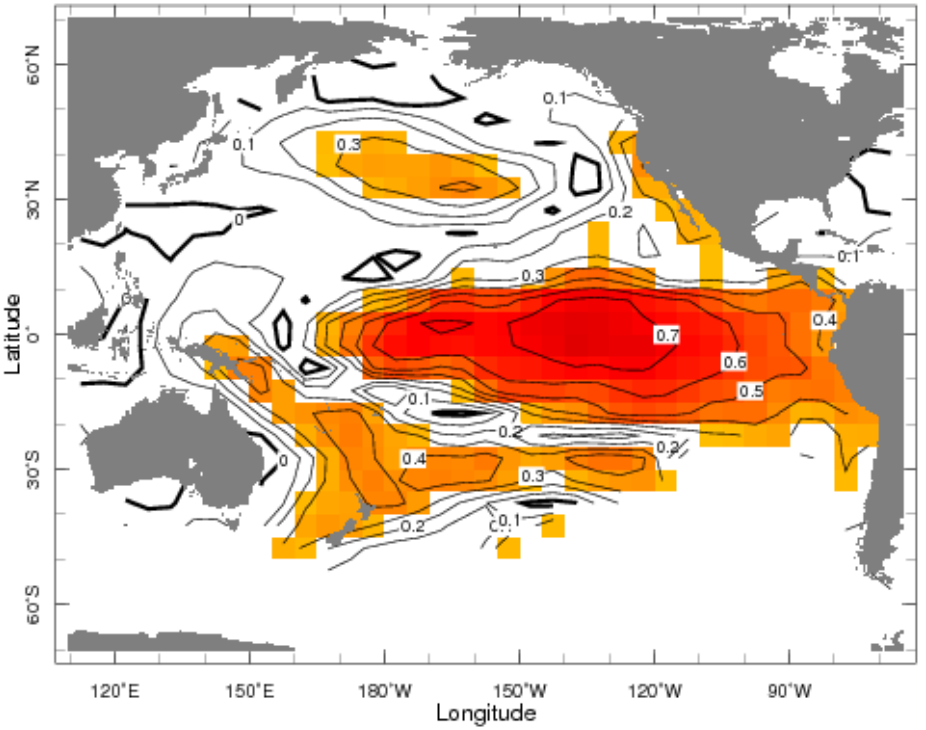


Ensemble average skill

calibration period: 1923-1990

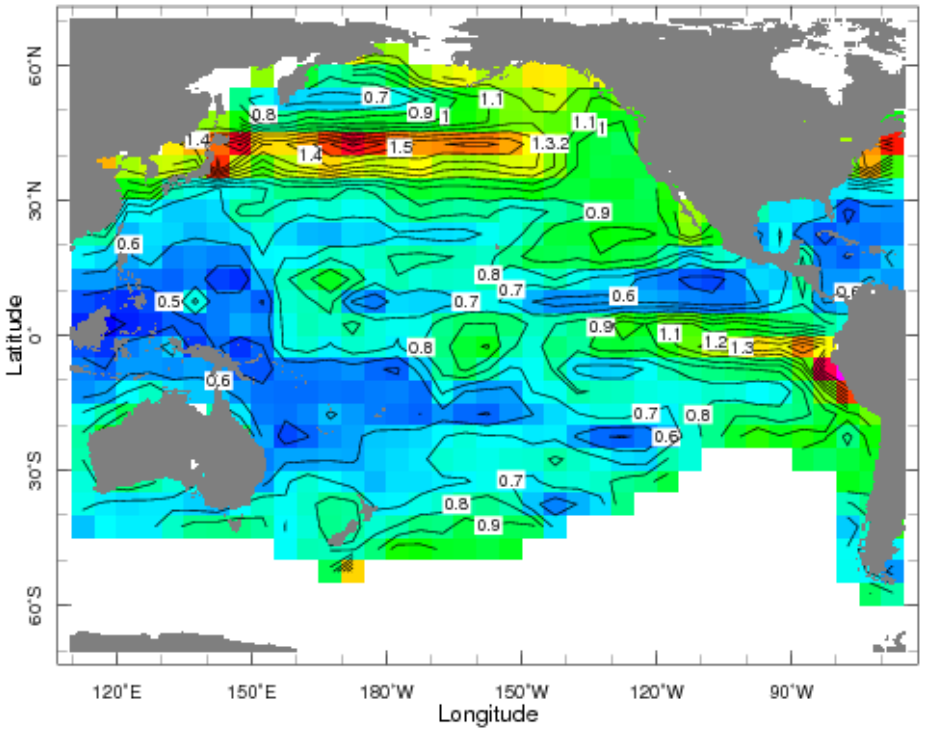


validation period: 1856-1922

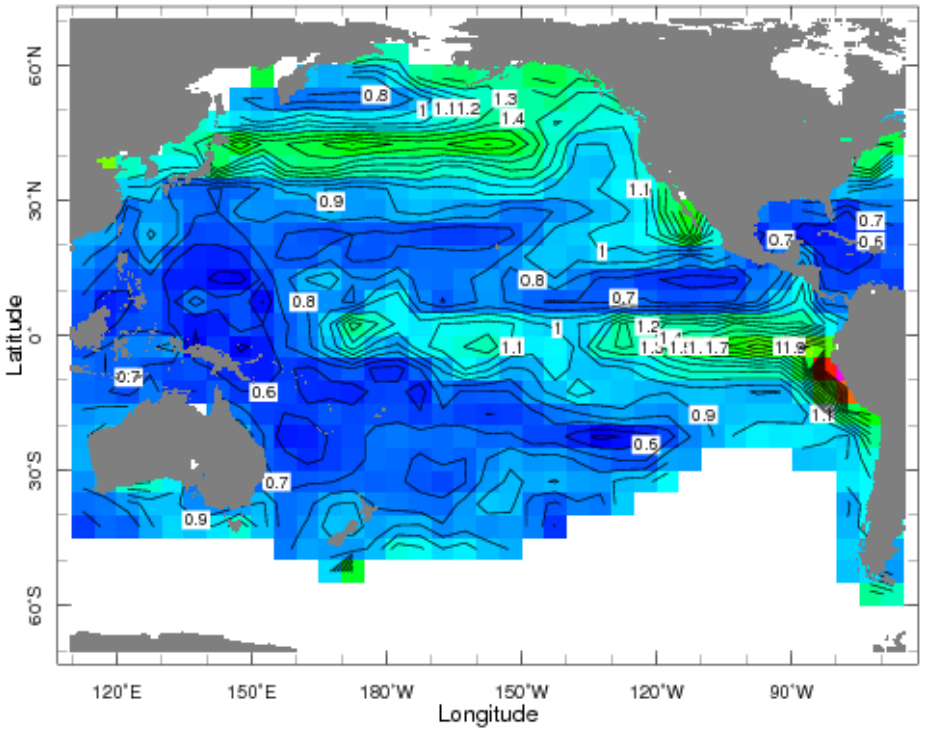


Ensemble average reconstruction error

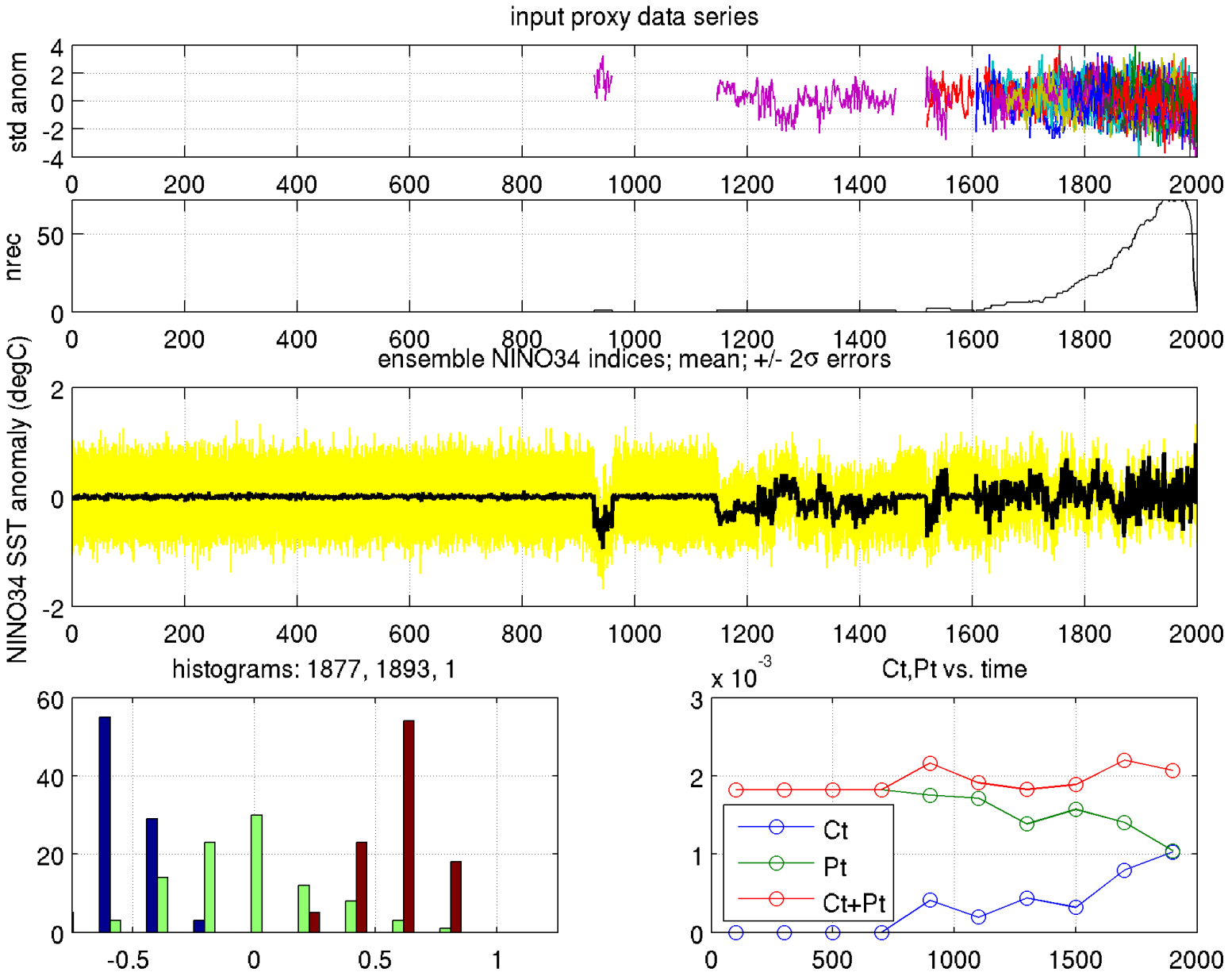
RMS SST K98, cal. pd.: 1923-1990



RMS SST rec., val. pd.: 1856-1922



Reconstructed NINO34



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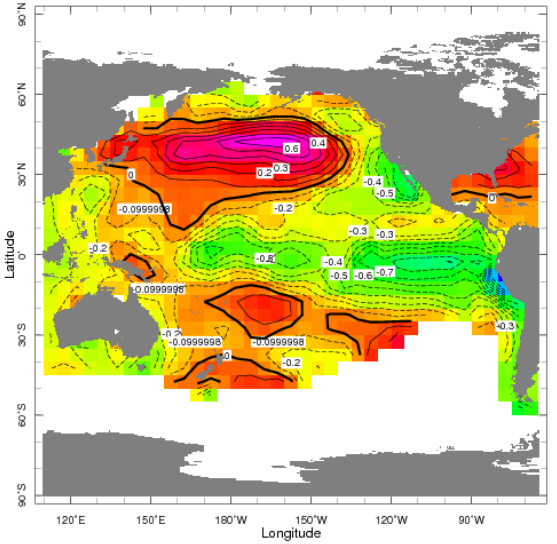
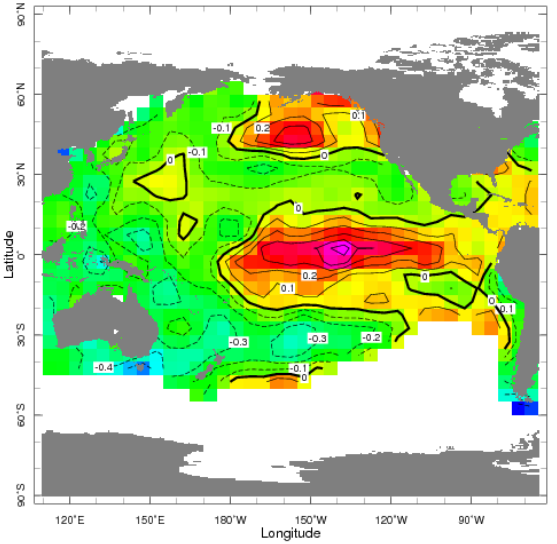
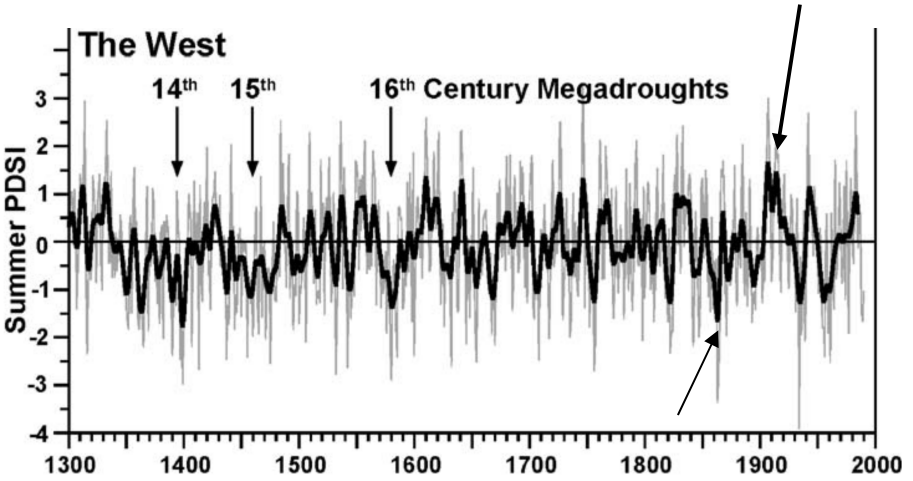
Drought reconstructions

1850-1860 average



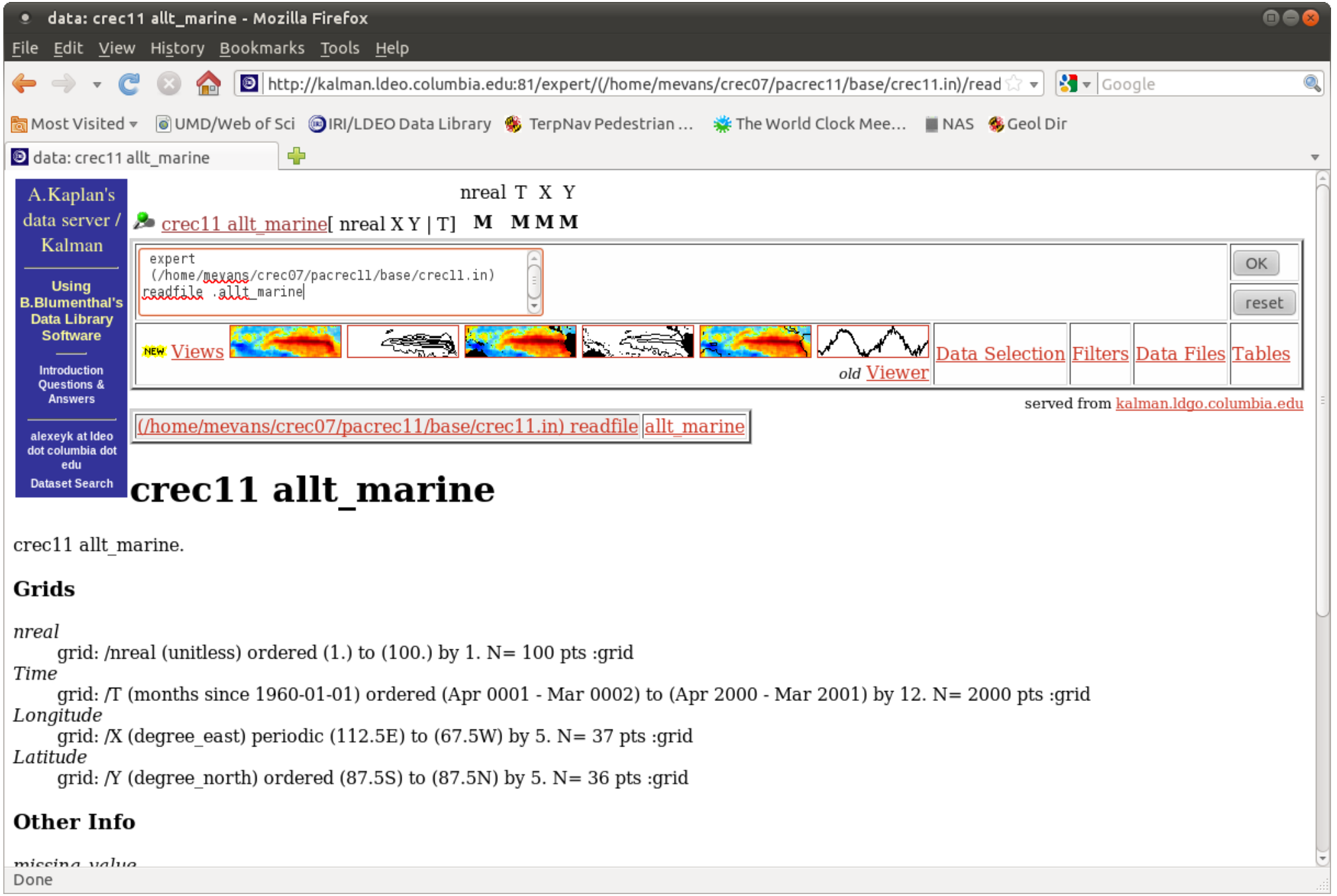
1901-1916 average





Cook et al. 1999, 2004; Stahle et al., 2007; Seager et al 2007, 2008

Beta results via Ingrid



Summary

- The OI-ensemble reconstruction algorithm allows us to create a set of SST forcing fields with uniform total variance, yet also represent the true change in uncertainty as the paleodata become sparser with time.
- Results suggest the 16th century drought in western North America was driven by ENSO cold phase conditions – forced AGCM experiments can be used to investigate the mechanisms. Two quasi-independent mechanisms for multiyear subtropical droughts may exist.
- Climate field reconstruction uncertainties are probably a function of at least sampling network, frequency, proxy type, and calibration. Validation of proxies/reconstructions as true representations of climate remains an outstanding challenge.