Pacific Basin ensemble SST field reconstructions from marine paleoproxy data

Michael N. Evans (University of Maryland – College Park)
mnevans@geol.umd.edu
Alexey Kaplan (Lamont-Doherty Earth Observatory, Columbia University)
alexeyk@ldeo.columbia.edu

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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)

e.g. Weber and Woodhead, 1972; deVilliers et al. 1994; Barnes and Lough, 1990; Lough and Barnes, 1997; Barnes et al.

<table>
<thead>
<tr>
<th>proxy type</th>
<th>“process model”</th>
<th>number</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\delta^{18}$O</td>
<td>$f(T, \delta^{18}O_{sw})$</td>
<td>55</td>
</tr>
<tr>
<td>Sr/Ca</td>
<td>$f(T, Sr/Ca_{sw})$</td>
<td>8</td>
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<tr>
<td>Mg/Ca</td>
<td>$f(T, Mg/Ca_{sw})$</td>
<td>1</td>
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<tr>
<td>Ba/Ca</td>
<td>$f(T, Ba/Ca_{sw}) \sim$ nutrients/upwelling</td>
<td>1</td>
</tr>
<tr>
<td>Density</td>
<td>$f(T, \Phi, nutrients)$</td>
<td>1</td>
</tr>
<tr>
<td>Extension rate</td>
<td>$f(T, \Phi, nutrients)$</td>
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<td>Calcification rate</td>
<td>$\rho^*extension rate$</td>
<td>1(71)</td>
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<tr>
<td>Luminescence</td>
<td>$f(S)$</td>
<td>4</td>
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</table>
Proxy data availability: 1500-1950

WDC-A for Paleoclimatology, 2007-2011 and unpublished data contributors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

Calibrated patterns

pattern 1: 69% covariance

pattern 1: 14% covariance
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
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
Beta results via Ingrid

crec11 allt_marine

crec11 allt_marine.

**Grids**

- **nreal**
  - grid: /nreal (unitless) ordered (1.) to (100.) by 1. N= 100 pts :grid

- **Time**

- **Longitude**
  - grid: /X (degree_east) periodic (112.5E) to (67.5W) by 5. N= 37 pts :grid

- **Latitude**
  - grid: /Y (degree_north) ordered (87.5S) to (87.5N) by 5. N= 36 pts :grid

**Other Info**

- missing value

Done
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.