The peculiar properties of paleoclimate data

M.N. Evans
University of Maryland, College Park
mnevans@umd.edu | one.geol.umd.edu

• How different is the paleoclimate/paleoenvironmental DA problem?
  • Observations
  • Data (proxy system) models
Observing network

PAGES2K Consortium (2017, in press)
Observing network

b) Resolution

PAGES2K Consortium (2017, in press)
Observing network

(c) Temporal Availability

First Millennium

PAGES2K Consortium (2017, in press)
Observing network: effects on field reconstructions

CCA-based PPEs of SATA (Wang et al. 2014)
Generalized proxy system model

Environment — Sensor — Archive — Observation

Sensor model — Archive model — Observation model

Proxy system: physics, chemistry, biology, geology...

Environment:
temperature, nutrients, PAR, seawater chemistry (atmospheric and oceanic circulation),...

Sensor:
coral polyp, zooxanthellae

Archive:
aragonite

Observation:
extension rate, $\rho$, $\Delta^{14}C$, Th/U, $\delta^{18}O$, $\delta^{13}C$, \{Sr,Mg,U\}/Ca, fluorescence, ...

Veron (2000);
painting by G. Kelly

Cole et al., 1999; Gagan et al., 2000; Lough, 2004; Cobb et al., 2008; Evans et al. 2013; Dee et al. 2015; this mtg
Sensor modeling

\[ TRW = f(T, P, \Theta) \]

Anchukaitis et al., 2006; Evans et al., 2006; Vaganov et al., 2011
Archive modeling

$\delta^{18}O_{\text{ice}} = f(z, \sigma)$

**SENSOR:**
precipitation weighting
altitude & temperature
bias corrections

$\delta^{18}O_{ICE} = \sum (p \cdot \delta^{18}O_P) / \sum p$

**ARCHIVE:**
compaction
diffusion

$G = \frac{1}{\sigma \sqrt{2\pi}} \cdot e^{-\frac{z^2}{2\sigma^2}}$

*Dee et al (2015)*
Observation modeling

\[ t(\delta^{18}O_{\text{coral}}) = f(t_{i-1}, \Delta) \]
Summary and Challenges

• How is the paleoenvironmental DA problem different?
  • observing network changes: space, time, observation type
  • data (proxy system) models may be multivariate, nonlinear filters on the environment.
  • perhaps most importantly: there is chronological uncertainty.

• Challenges include:
  • realistic specification of observational error
  • structural uncertainty in data (proxy system) models
  • identification of bias and other systematic error
Summary: Haiku version

Sparse observations
Proxy system modeling
Way forward: DAPS.