The peculiar properties of paleoclimate data

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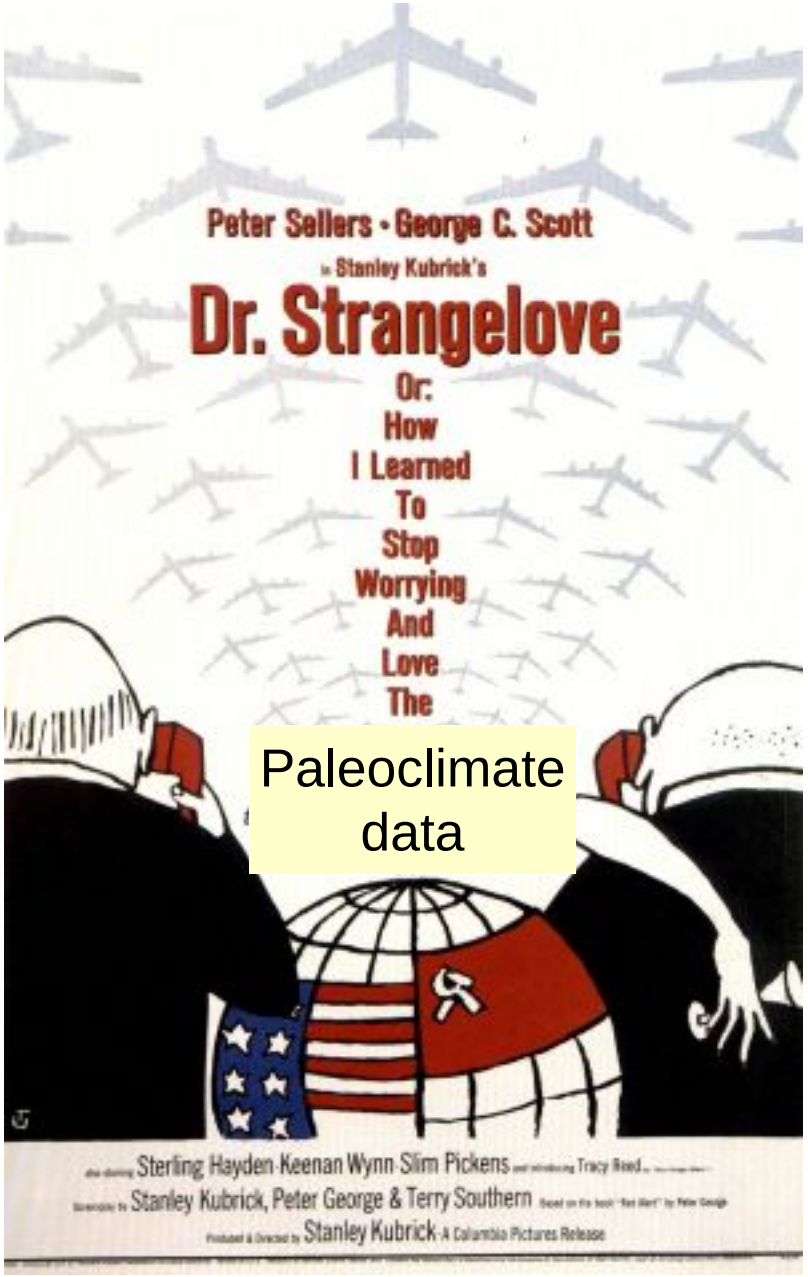
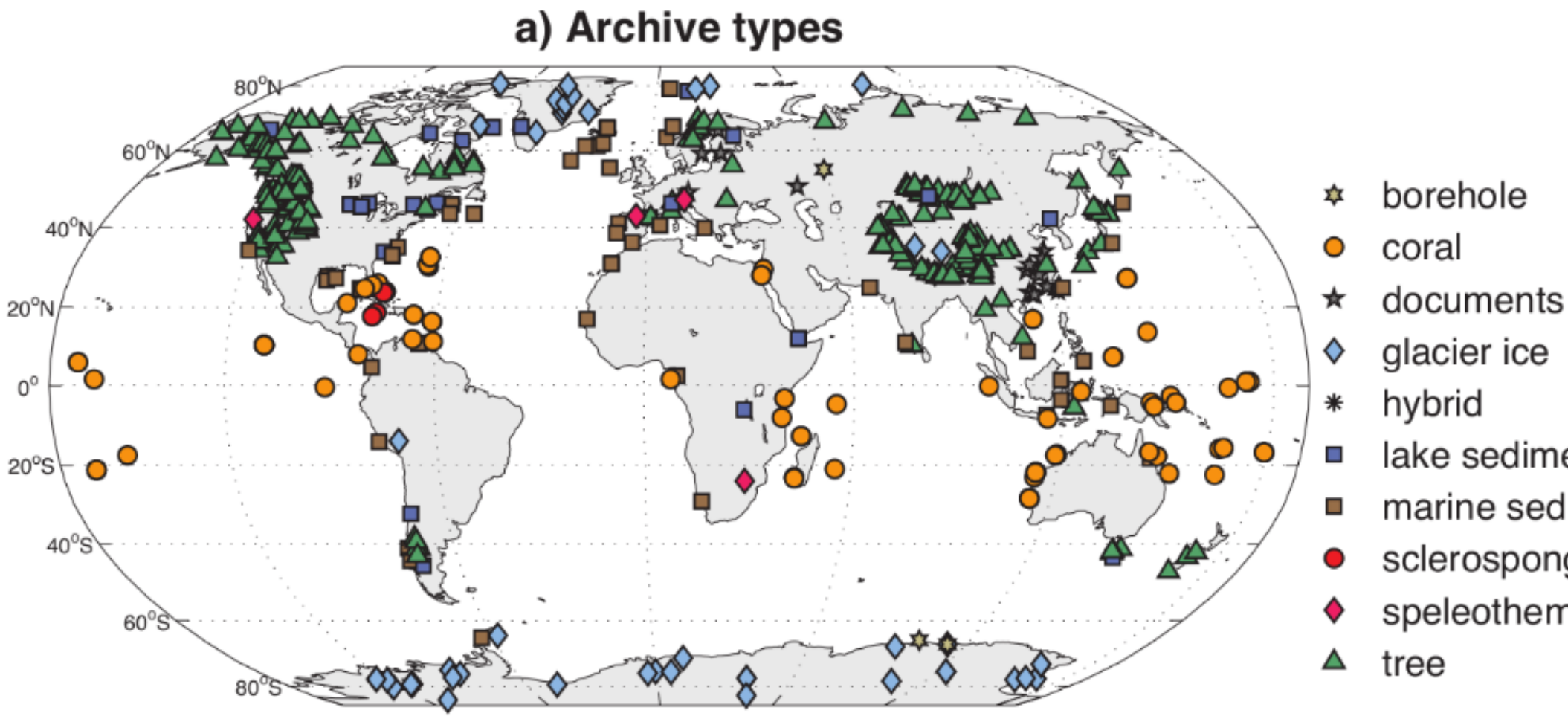
- How different is the paleoclimate/ paleoenvironmental DA problem?
  - Observations
  - Data (proxy system) models



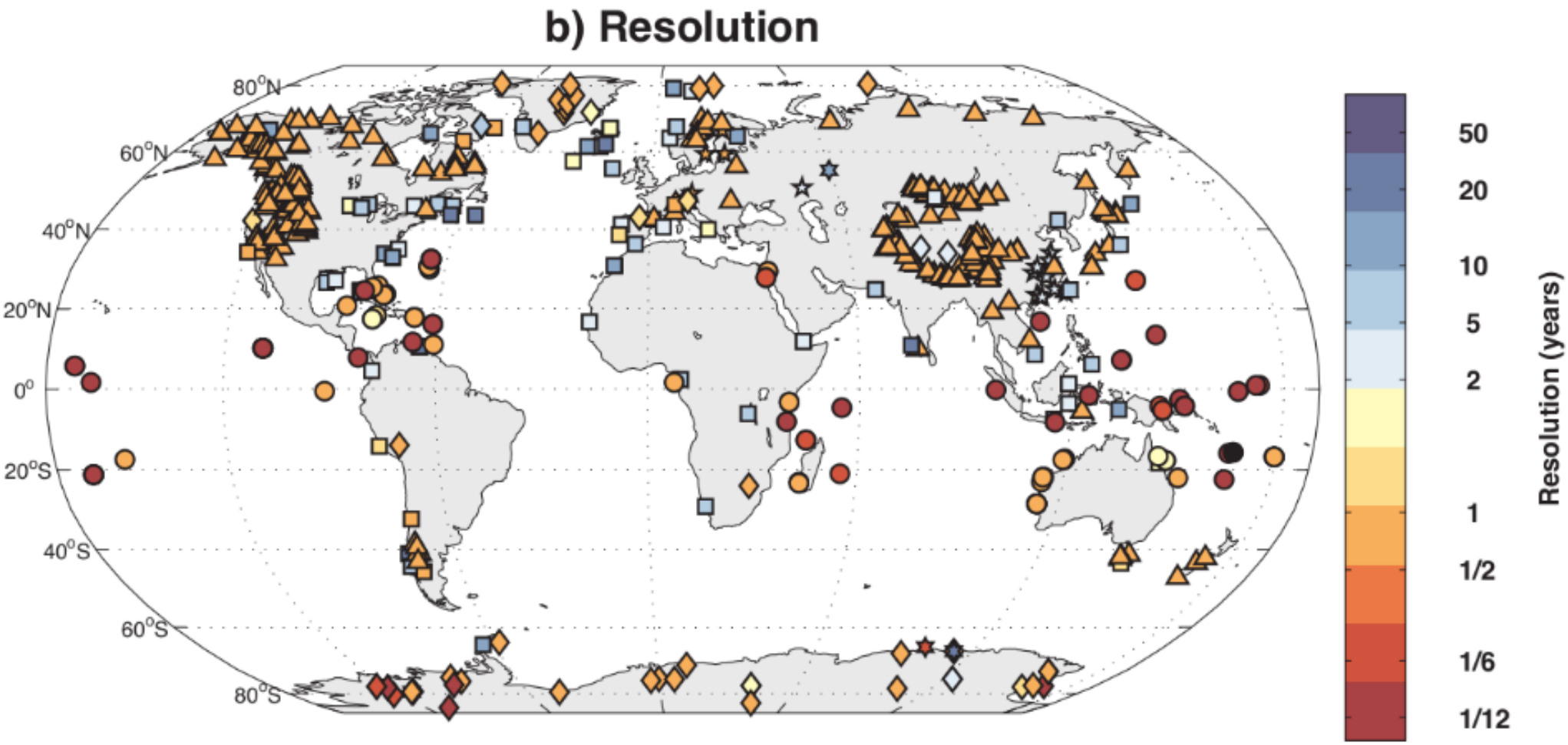
Wikipedia.org

Observing network



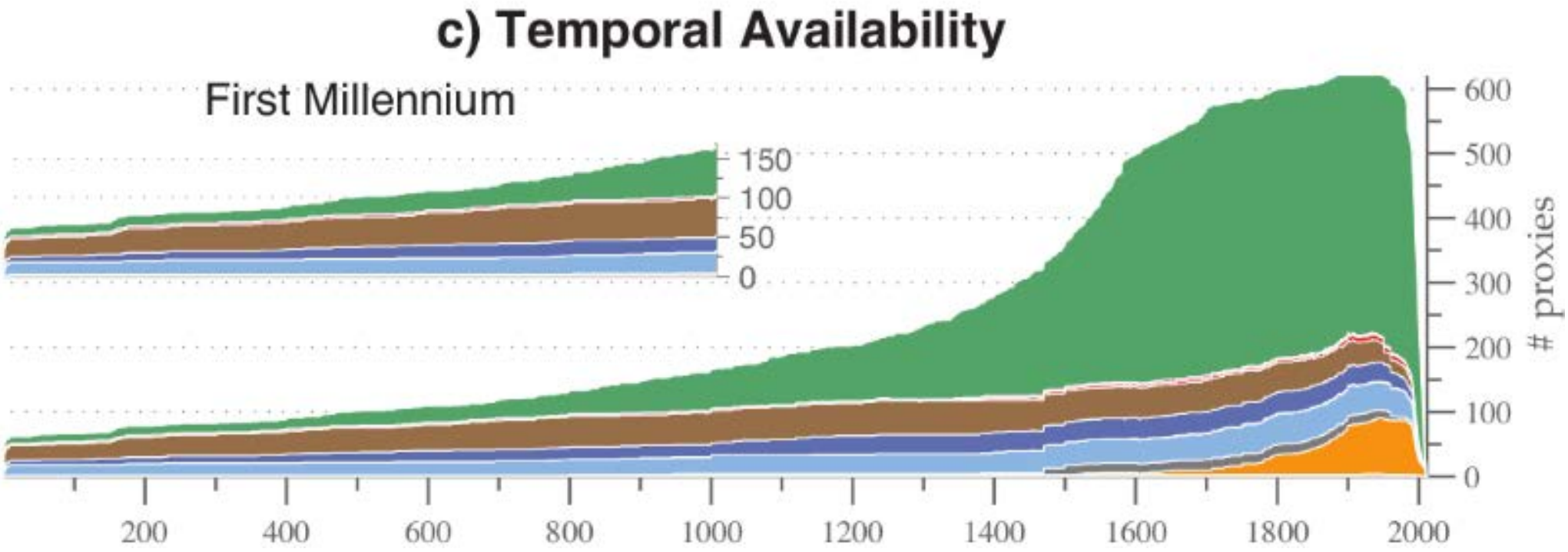
PAGES2K Consortium (2017, in press)

Observing network



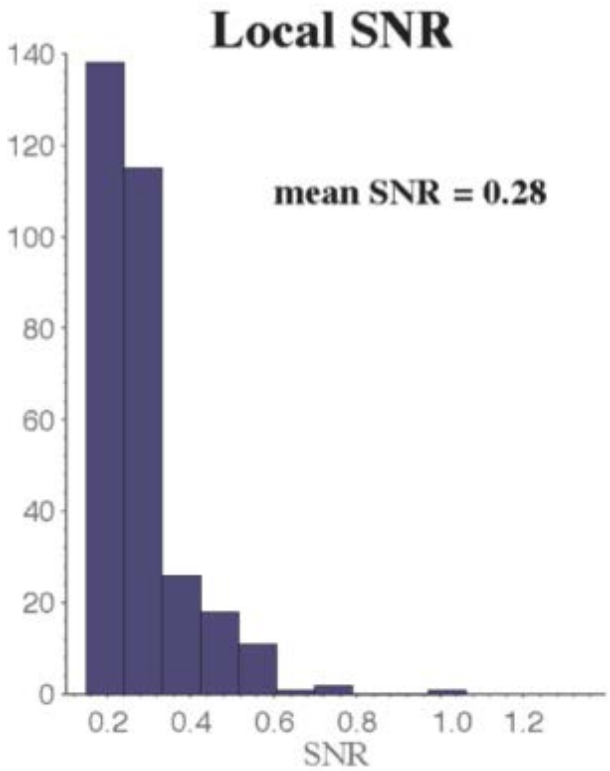
PAGES2K Consortium (2017, in press)

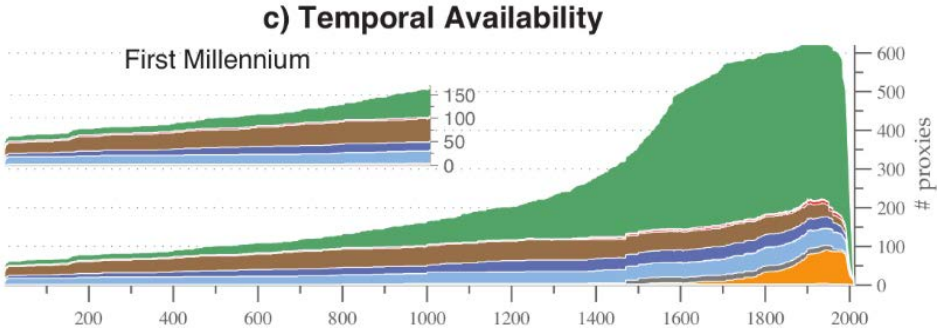
Observing network



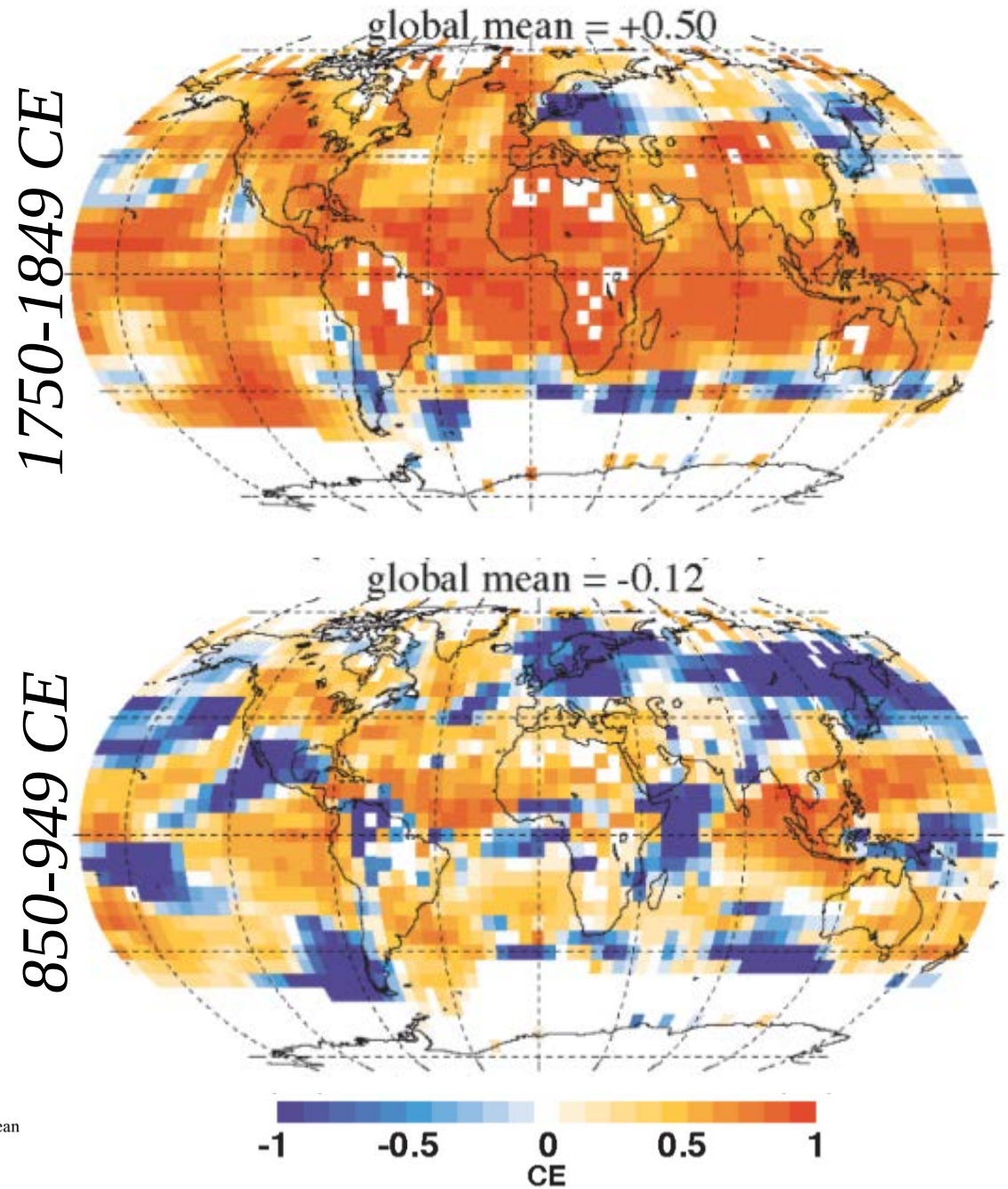
PAGES2K Consortium (2017, in press)

Observing network: effects on field reconstructions



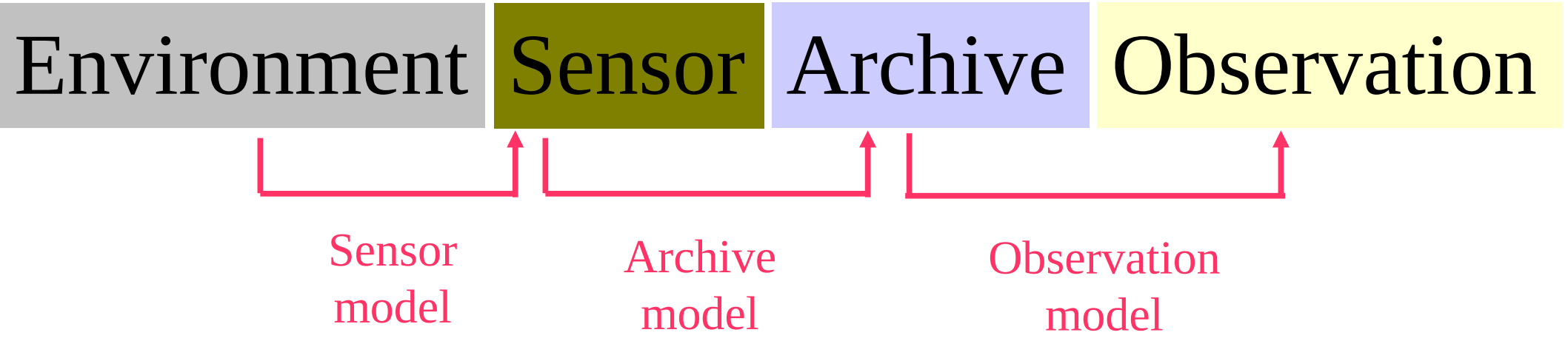


CE	$1 - \frac{\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}{\sum_{i=1}^{n}(y_i - \bar{y}_v)^2}$	$[-\infty, 1]$	Phase, amplitude and mean



CCA-based PPEs of SATA (Wang et al. 2014)

Generalized proxy system model

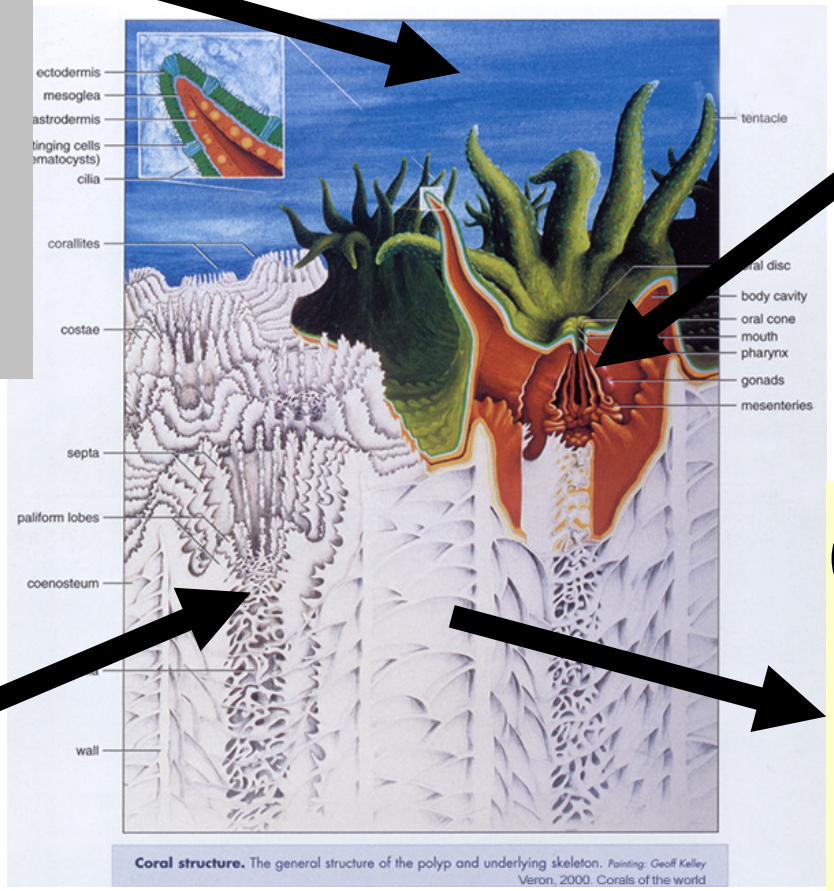


J. Rougier + SUPRaNet group (2008-2011); Evans et al (2013); Dee et al (2015)

Proxy system: physics, chemistry, biology, geology…

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

Sensor:
coral polyp,
zooxanthellae



Veron (2000);
painting by G. Kelly

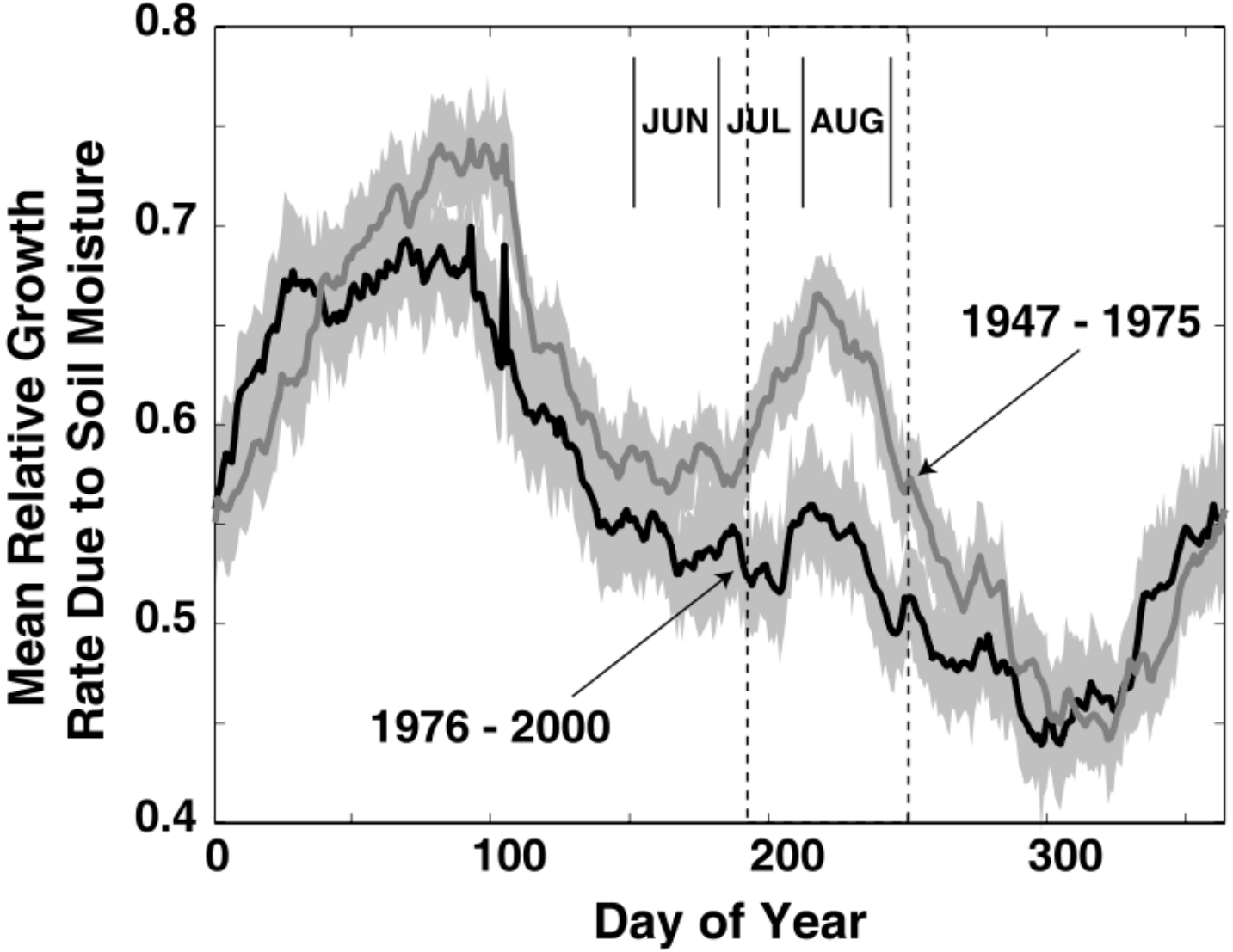
Archive:
aragonite

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

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

$$TRW = f\,(T, P, \Theta)$$

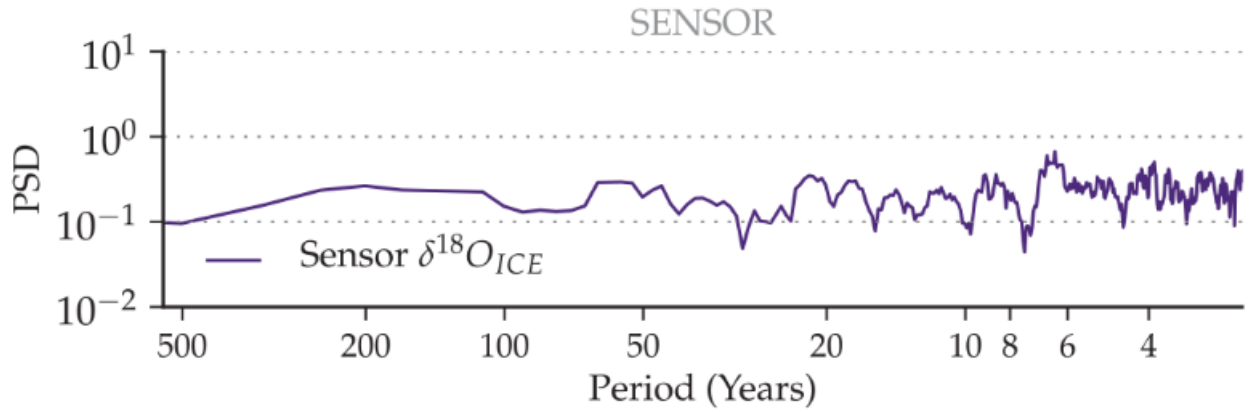


Anchukaitis et al., 2006; Evans et al 2006; Vaganov et al 2011

Archive modeling

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

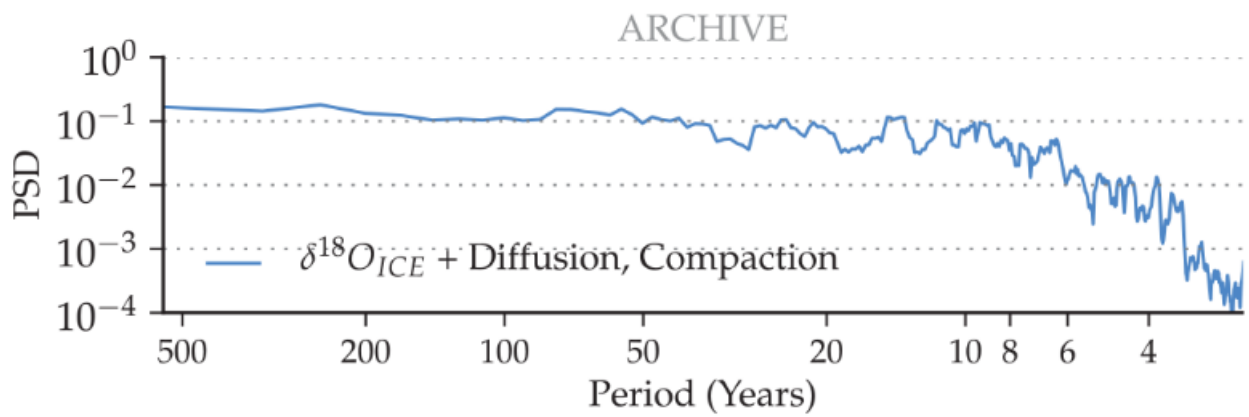
SENSOR:
precipitation weighting
altitude & temperature
bias corrections



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

ARCHIVE:
compaction
diffusion

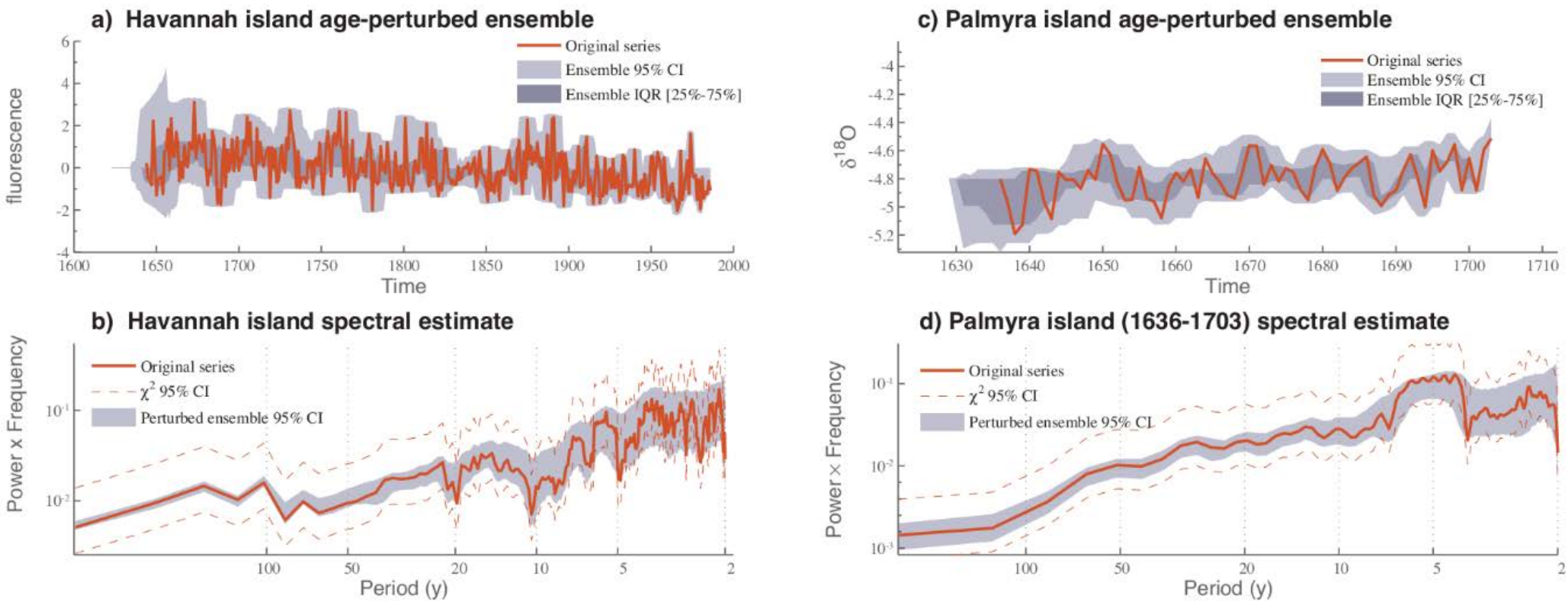
$$G = \frac{1}{\sigma\sqrt{2\pi}} \cdot e^{\frac{-z^2}{2\sigma^2}}$$



Dee et al (2015)

Observation modeling

$$t(\delta^{18}O_{coral}) = f\,(t_{i-1}, \Delta)$$



Comboul et al (2014)

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.