Pollen-Climate Transfer Methods

Characterization of StatisticalUncertainty, and ForwardModeling for Integration into Bayesian Hierarchical Climate Reconstructions

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Requirements
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Physical understanding of the climate system

- Complex proxy-climate relation
- Spatio-temporal processes
- Multiple proxy variables
- Various sources of uncertainties
Objectives & Outline

1. Introduce recent spatio-temporal multi-proxy Bayesian Hierarchical Models (BHM)
2. Link known pollen-climate transfer concepts to BHM framework
3. Discuss the aspect of uncertainty
Bayesian Hierarchical Models

1. Introduce recent spatio-temporal multi-proxy BHM approaches

Random variables

Proxy variables $P$
Climate variables $C$
Parameters $\Theta$

Multi-proxy BHM approaches
(Li et al., 2010; Tingley and Huybers, 2010)

$$[C, \Theta | P] \propto [P | C, \Theta] \cdot [C | \Theta] \cdot [\Theta]$$

posterior data process prior

Advantages

- Model complexity through hierarchy
- Spatio-temporal processes
- Account for various sources of uncertainties

BHM Example (DAG)
Pollen-climate transfer concepts

2. Link known pollen-climate transfer concepts to BHM framework

Pollen realism in $[P|C, \Theta]$
- (Parametric) probability distributions
- Computational limitations

Known transfer concepts
- Focused on the palaeo archives $\leadsto$ complex, mechanistic
- Vast knowledge of the bio-geochemical processes

Rewrite in terms of $[P, V|C, \Theta] = [P|V, \Theta] \cdot [V|C, \Theta]$
- Regression methods
- Indicator taxa and mutual climatic range (MCR)
- Modern analogues (MAT)
- Plant functional types and biomisation (PFT)
Modern analogue technique

2. Link known pollen-climate transfer concepts to BHM framework

Modern analogue technique (MAT)

- Pollen \( \xrightarrow{\text{metric}} \) analogue \( \xrightarrow{\text{direct}} \) climate
- Relates to draws from a multinomial distribution
Pollen-ratio model

- Reduced complexity MAT \( \sim \) 2 taxa
- Temperature as covariate
- Logit link with binomial error (GLM)

Probabilistic reconstruction

- Sample GLM parameters (MCMC)
- Sample from pollen counts
- Reconstruction as sample via inverse model
3. Discuss the aspect of uncertainty

Single-site reconstruction for one of three nearby lakes in Wisconsin, USA
Pollen-ratio model

3. Discuss the aspect of uncertainty

Ensemble reconstruction for three nearby lakes in Wisconsin, USA
Summary

1. Introduce recent spatio-temporal multi-proxy BHM approaches
   - Versatile framework for a more complete picture of past climate
   - Conditional probability densities

2. Link known pollen-climate transfer concepts to BHM framework
   - Derived from classical methods (MCR, MAT, . . .)
   - Example of the pollen ratio model

3. Discuss the aspect of uncertainty
   - Account for as many random effects as possible
   - Pollen proxies and the assumption of ergodicity
   - Uncertainties most likely to be often underestimated

~~ Review of probabilistic pollen-climate transfer methods (Ohlwein and Wahl, in review)
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References

- Piecing Together the Past: Statistical Insights into Paleoclimatic Reconstructions
  (Tingley et al., 2010)

- A Bayesian Algorithm for Reconstructing Climate Anomalies in Space and Times
  (Tingley and Huybers, 2010)

- The value of multi-proxy reconstruction of past climate
  (Li et al., 2010)

- Reconstruction of Quaternary temperature fields by dynamically consistent smoothing
  (Gebhardt et al., 2007)

- Review of probabilistic pollen-climate transfer methods
  (Ohlwein and Wahl, in review)