Improving pollen-based tree cover **reconstructions**

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Introduction

Understanding past vegetation dynamics is important for predicting future vegetation trajectories and their climatic and societal impacts. Pollen in sediment cores holds temporarily resolved information about past vegetation. But this information is biased due to taxa specific pollen productivity and dispersal. The REVEALS model (Sugita, 2007) was developed to correct for this bias in pollen records and produce more realistic vegetation estimates.

- How well can REVEALS reconstruct the tree cover of the northern hemisphere?
- And can we further improve these reconstructions?

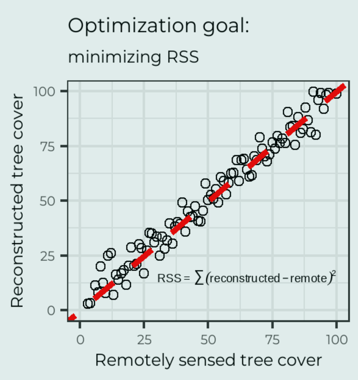
Methodology

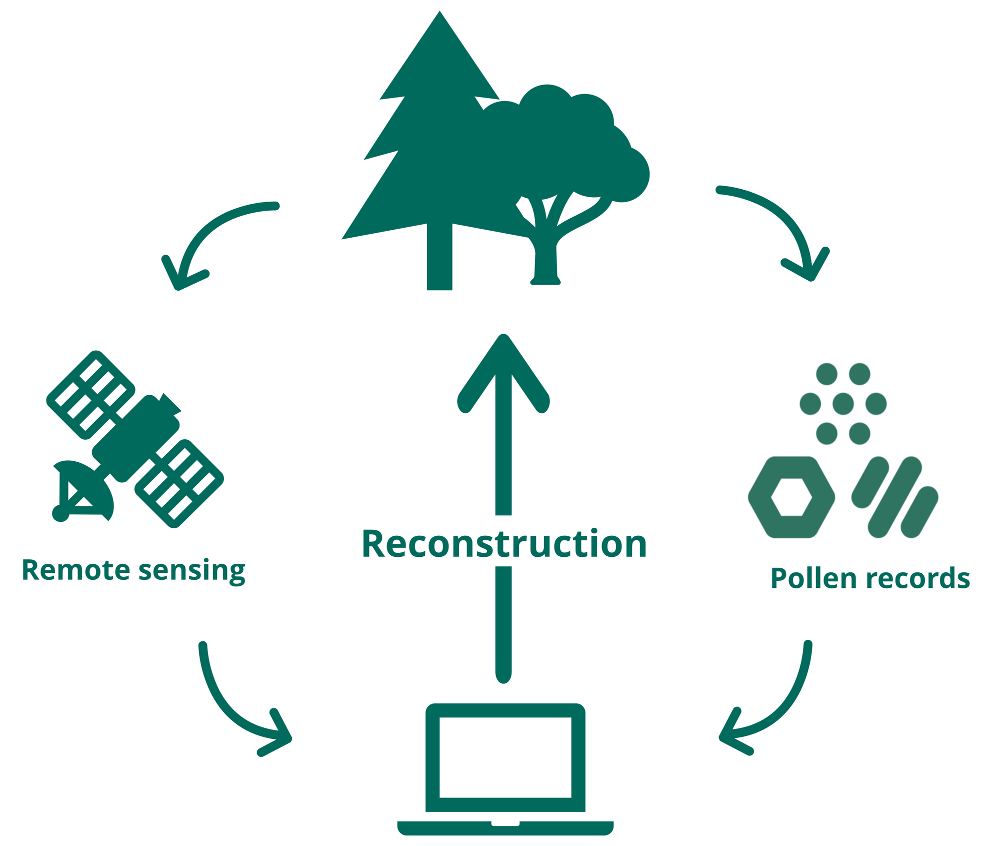
- Validating REVEALS:
  - Extracted remotely sensed tree cover for pollen source areas
  - Compared with reconstructed tree cover from original pollen records and REVEALS output
- Creating the optimized model:
  - Correction coefficients for most common taxa
  - Optimized to fit the reconstructed tree cover to the remotely sensed tree cover
  - Validated simplified model with optimized correction coefficients
- Compared mean absolute error for reconstructions from original pollen, REVEALS, and the optimization

$$\boldsymbol{vegetation_i = \frac{pollen_i}{\alpha_i}}$$

α … *taxon specific correction coefficient*

$$\boldsymbol{tree\ cover = \frac{\sum corrected\ tree\ taxa}{\sum all\ corrected\ taxa}}$$

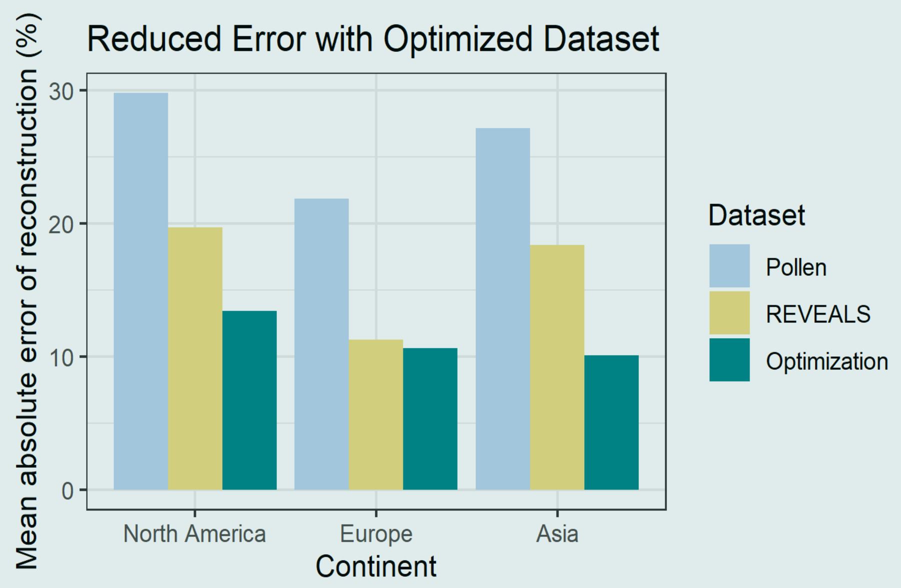




Remote sensing can help optimize **reconstructions** of past **vegetation,** even with **simplified** models.

Results

- REVEALS improves reconstructions of tree cover compared to original pollen records
- The optimized model reduces the MAE further
- Better reconstructions possible
- Taxon-specific corrections can be estimated using remote sensing and pollen data



Outlook

- Reconstruction of past forest cover with optimized correction coefficients
- Analysis of past tree cover dynamics
- Comparison of reconstructed forest cover with modelled forest cover

Open Questions?

How does REVEALS work?

- Needs estimates of taxon-specific pollen productivity and fall speeds

Regional **e**stimates of **ve**getation **a**bundance from **l**arge **s**ites (Sugita, 2007)

$$\hat{V}_i = \frac{n_{i,k} \Big/ \hat{\alpha}_i \int_R^{Z_{max}} g_i(z)dz}{\sum_{j=1}^{m} \left(n_{j,k} \Big/ \hat{\alpha}_j \int_R^{Z_{max}} g_j(z)dz \right)} = \frac{n_{i,k}/\hat{\alpha}_i K_i}{\sum_{j=1}^{m} (n_{j,k}/\hat{\alpha}_j K_j)}$$

Estimate of regional vegetation abundance for taxon i

Pollen counts of taxon i at site k

Estimate of pollen productivity (RPP = relative pollen productivity)

Pollen dispersal-deposition coefficient of taxon i from the border of the study site to Zmax

What does the simplified model look like?

- Only uses one correction coefficient for each taxon
- Coefficients for the 10 most common taxa are derived during the optimization

$$v_i = \frac{p_i}{\alpha_i * \sum_{j=1} \frac{p_j}{\alpha_j}}$$

$v_i = vegetation\ estimate\ of\ taxon\ i$
$p_i = pollen\ percentage\ of\ taxon\ i$
$\alpha_i = correction\ coefficient\ for\ taxon\ i$

How can we correct for landscape openness?

- openness correction was derived from modern CCI Landcover
- Non-vegetated pixels within the pollen source area help correct the fraction of arboreal taxa to tree cover

$$openness\ correction\ (oc) = 1 - \frac{n_{unvegetated}}{n_{total}}$$

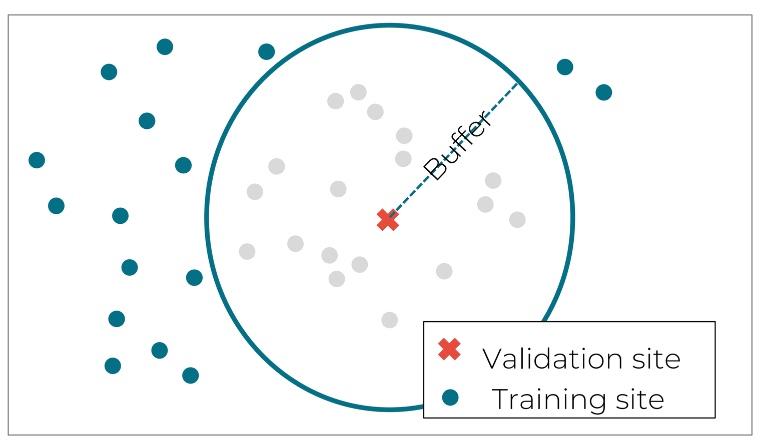
$$tree\ cover = oc * \sum_{i\ \epsilon\ tree\ taxa} v_i$$

How does the optimization work?

- Parallelized optimization using the L-BFGS algorithm
- Optimization of coefficients for each continent separately
- Optimization bounds derived from REVEALS output to avoid overfitting
- Added range to leave room for optimization

How was the optimized model validated?

- Spatial-Leave-One-Out Cross validation with 100 folds per continent
- Accounts for spatial autocorrelation



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