

The challenge of comparing pollen-based quantitative vegetation reconstructions with outputs from vegetation models – a European perspective

The authors implemented the quantitative tree-cover comparison in Europe from the middle to late Holocene through the top-down or forward (simulated estimates by the land surface model JSBASH in MPI-ESM 1.2 and the DGVM LPJ-GUESS) and bottom-up or inverse (pollen-based estimates using the REVEALS model) approaches. Concerning the temporal trends in most of Europe, tree cover was consistently greater during the middle Holocene and considerably less in the period close to the present. However, this study shows that pollen-based tree cover reduction began much earlier and was less abrupt than the top-down approach. Mismatches in tree cover between the two approaches potentially from inappropriate model settings, including parameterisation, not biases in the climate.

This study is very interesting and should be published in the *Climate of the Past*, but it needs refinements, additional information, and polishing to become more accessible to broader audiences. The necessary analysis has been completed, but the main text may need large rewriting. I describe the main concerns about this manuscript and then get into more detail by providing line-by-line comments, suggestions, or questions.

### **General comments**

- The text is too long and could be more to the point. This manuscript has a very long discussion (Section 4), but it contains more than what should be discussed. See specific comments.
- In the introduction, previous studies on pollen-based tree cover reconstructions are completely missing. I deduce that conventional pollen analysis did not work on tree-cover reconstructions, so the authors used pollen-based tree-cover reconstruction with the REVEALS model. However, this reconstruction strongly depends on the model used (i.e., REVEALS), and the model requires several assumptions for reconstructing tree cover. The authors address the issues in the discussion section (Section 4). But, known problems and assumptions for the reconstruction should be clearly stated in the introduction (Section 1) and methodology section (Section 2), as it is the basis for this study.
- Most methods for pollen-based climate reconstructions require that vegetation is in dynamic equilibrium with climate. What is the assumed relationship between vegetation and climate in the pollen-based tree-cover reconstruction using the REVEALS model? What about a top-down approach with JSBASH and LPJ-GUESS?
- In the previous study (Hengl et al., 2018), it seems that the problem of parameterisation of DGVM, one of the conclusions of this study, was already pointed out, but was this issue not taken into account in the experimental design of this study? Or, were the two models JSBASH and LPJ-GUESS used in this study as a result of consideration?
- English grammar issues, e.g. uses of hyphens. 'land use' is noun, and 'land-use' is adjective. Please also check the use of commas. It will make the text more readable.

### **Specific comments**

#### Abstract

L30. 'todays' to 'today' (?)

#### Introduction

After reading the introduction, the motivation for this study is clear, but unclear background of this study, including why it used the two models (JSBASH and LPJ-GUESS) and the pollen-based tree-cover reconstructions by the REVEALS model. Moreover, as there are probably many know

problems with the forward modelling approach and pollen-based reconstruction in previous studies, the main ones should be made explicit here.

L40. 'This requires also ...' to 'This also requires ...' What is this?

L47-49. 'This is one ... Comparison of DGVM...' It seems that there are two unrelated sentences. How are these sentences related? Why is it limited to the Holocene, not 'any palaeo'?

L55. 'Pollen-based vegetation reconstructions indicates ...' to 'Pollen analysis indicate ... (?)

L57. 'These land-use related land-cover changes ...' to 'Such human-induced land-cover changes ...'

L64. 'for the Early Holocene and over the last 6000 years' to 'during the Holocene'

L63-70. As mentioned above, what was the assumed relationship between vegetation and climate in the previous studies?

L75. Based on previous studies, it would be better to explain in the introduction why the authors used the two models, JSBASH and LPJ-GUESS. The authors should also briefly explain why the pollen-based tree-cover reconstructions by the REVEALS model were used instead of simple pollen analysis.

#### Methods

L90. '(PFT)' to '(PFTs)'

L90. 'Trees can either be tropical or temperate about bioclimatic limits and evergreen or deciduous about phenology.'

L90. 'Grassy' to 'Herbaceous' (?)

L91. '... C4 grass and the ...' to '... C4 grass, and the ...'

L89-92. Were 11 PFTs (8 natural PFT and 3 anthropogenic land-use types) used in this transient MPI-ESM1.2 simulation?

L123. As the other forcings, it is better to first describe what the forcing is (i.e., the anthropogenic land-use changes) and then describe the dataset, LUH2. The sentence 'This forcing begins 1100 BP, ... starting at 2100 BP' is unclear. The transient period (2100 BP to 1100 BP) is not based on LUH2? Is the anthropogenic land-use related PFTs used only after 2100 BP?

L143. The plant functional types are already defined as PFT(s) on L90. The authors do not need to repeat it.

L145. 'biomes' to 'trees' (?)

L155-160. Was there any explanation as to why it was Holocene? Is the authors' aim to evaluate the impact of anthropogenic land use or to quantitatively compare data and models on vegetation (here, tree cover)? Why do the authors need to make the equilibrium condition at each period? Please write down the assumption of this experiment first, for example, the relationship between vegetation and climate for the modelling and reconstruction. It is unclear if the way of running LPJ-GUESS is appropriate in data-model comparison.

L190. 'vegetation' to 'tree-cover' (?)

L190. This section (2.3) is unclear/confusing. First, did the authors re-perform the pollen-based tree-cover reconstructions with the REVEALS model in this study? Or did the authors use the data from any previous studies? On L225, the authors say, 'For the present study, we chose the REVEALS reconstructions from Marquer et al. (2017).' Is this about the data itself or the reconstruction method? If the authors used datasets from the previous study, the model description could be shortened. In the introduction, it would also be good to describe previous studies on tree-cover reconstructions. In reconstructing tree cover from pollen samples using the REVEALS model, does the approach require that the relationship between vegetation and climate is equilibrium?

L192-. There's something wrong with the wording. The first several sentences in this paragraph describe pollen analysis. The authors' point is that conventional pollen analysis does not adequately account for the pollen productivity of each species, so the authors used the REVEALS model. If readers get this point, the authors do not need to explain this model in detail because the REVEALS model itself was not used in this study. On the other hand, dataset details should be described.

L195-. How high-low is the temporal resolution of the pollen data?

L198-. The authors need a reference for the sentence 'Pollen productivity varies ...'

L215-. Apart from the gridded pollen-based tree-cover reconstructions with REVEALS (Marquer et al. 2019), did the authors use other data described here? Why was the information written here if the authors did not use them? In the methods/data section, it is sufficient to mention only the datasets used in this study. The authors can describe previous studies on pollen-based tree-cover reconstructions with the REVEALS model in the introduction (as mentioned above).

L233. If there is more than one pollen sample in the same time window at a grid point, were they treated equally in making the gridded data? Or, were they weighted, for example, based on the lake size?

L254. The plant functional types are already defined as PFT(s) on L90. The authors do not need to repeat it.

L258. The authors are better to rewrite the sub-subject title because there may be something wrong with the wording (?)

L268. 'To evaluate ..., the squared chord distance (Prentice, 1980) is calculate for each time window.' I understand what the authors try to do, but it's grammatically incorrect.

## Results

Given this study's purpose, I am unsure if Figure 3 is needed in the main text. Figures 4, 5, and 6 alone would be sufficient to characterise the simulated and pollen-based tree-cover estimates over Europe since 8ka. Even if the authors discuss simulation results in areas that cannot be compared to the reconstruction, it is impossible to determine whether they are true or wrong. Descriptions and redundancies regarding regions that are not comparable to the reconstruction may be omitted from the main text as much as possible.

L280. 'natural vegetation history' to 'natural vegetation variation' (?)

L286. '... LPJ-GUESS with fewer trees' to '... LPJ-GUESS, with fewer trees'

L298. 'in most of the represented regions with highest tree cover fractions' to 'in most regions with the highest tree cover fractions'

L337. 'the inter-model spread'

L380. 'as driver' to 'as a driver'

L400. What is 'This'?

### Discussion

Is it necessary to thoroughly discuss issues that had already been pointed out before this study began, for example, the 'effect of modern parametrization and tuning of the model to modern conditions' and 'a shortcoming of the REVEALS model and pollen-based plant cover reconstruction'? Shouldn't much description, especially on tree cover reconstructions (assumptions and methodology), be done in the introduction rather than in the discussion because they are known issues and should be the background to this study?

L407. 'the model agreement to' to 'the model agreement with'

L407. Remove 'that is different' (?)

L410. Remove 'the in'

L429. 'the Appendix B' to 'Appendix B'

L429. 'we compare basically the climate that is prescribed ...' to 'we compare the climate prescribed ...'

L430. 'We assume that summer temperature is the main climatic driver of the vegetation in the regions considered here, ...' The assumption and its analysis are a vital part of the study. They should be described in the methodology section (Section 2), and the analysis results should be written in the result section (Section 3). Only real arguments should be written here (Section 4).

L437. 'in the temperate and subarctic regions'

L507. 'there are various technical reasons that can lead ...' to 'various technical reasons can lead ...'

L515. Remove 'single'

L522. **the** establishment'

L537. 'the disregard of wetlands' to 'the disregard for wetlands'

L538. What is 'This'?

L541. About this subject, the authors introduce the following sentence in the introduction; 'the DGVM parametrization (bioclimatic limits, disturbance intervals, fire regimes, etc.) are commonly static and based on the current state of land cover although it is characterized by unstable vegetation composition due to rapidly changing natural and anthropogenic stressors (Hengl et al., 2018).' Is this a known issue? If this is a known problem, shouldn't this sensitivity experiment also be described first in Sections 2 and 3, not here?

L578. Basic information on European land cover change during the Holocene should be presented in the introduction first, as it is part of the background to this study.

L579. 'the first traces'

L580. '... 10000 years ago an its spread' to '... 10000 years ago and its spread'

L584. 'insights of' to 'insights into'

L585. 'a high (preferably annual) resolution'

L615. 'Many of the assumptions of the REVEALS model are violated in the "real world" and/or violated in the past, which has been described and discussed in detail earlier (references).' It is an important background for this study, and the authors should describe it in the earlier section, for example, introduction or method. The Pollen-based tree-cover reconstruction using the REVEALS model is the basis of the data-model comparison in this study.

L621. Remove 'as such'

L624. Remove 'that have been'

L626. 'Trondman et al., (2016) showed ... can' to 'Trondman et al. (2016) showed ...could'

L628. Remove 'do'

L637. 'advise to use' to 'advise using'

L648. What is 'This'?

L650. 'Beside' to 'Besides' (?)

L654. What is 'This'?

L661. What is 'This'?

L668. 'a few caveats of the REVEALS model and dataset used in this study can contribute ...' (?)

L713. Remove 'a'

### Figures

L760. It is not easy to figure out Figure 5. Maybe a table would be easier to understand than the diagram (?)

L765. It is not easy for some people to see the green-orange-red color scale in Figure 6. It may be better to change the colours.